

Watershed Management Planning Guidebook



A COMPREHENSIVE GUIDE TO DEVELOPING A COASTAL WATERSHED MANAGEMENT PLAN



NORTH CAROLINA COASTAL FEDERATION

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For More Information

North Carolina Coastal Federation

3609 Highway 24
Newport, NC 28570
Tel: (252) 393-8185
Fax: (252) 393-7508
nccoast.org

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DISCLAIMER

This guidebook provides a suggested framework to develop watershed management plans to maintain, restore and protect surface water quality. This guidance is not a substitution for mandatory statutes or regulations by federal, state or local agencies. It is recommended that users of the guidebook work closely with their state and local agencies to ensure that their plans meet those requirements. Following the recommendations and steps provided can aid to ensure that plans include the six steps of watershed planning and the nine elements of a watershed management plan.

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Kristen Daly *Fellow for N.C. Coastal Federation*

Victoria Grose *UNC Chapel Hill, Intern for N.C. Coastal Federation*

Kimberly Hernandez *Duke University, Stanback Intern for N.C. Coastal Federation*

Morgan Piner *N.C. State University, Intern for N.C. Coastal Federation*

Mariko Polk *UNC Wilmington, Intern for N.C. Coastal Federation*

Amanda Santoni *Duke University, Stanback Intern for N.C. Coastal Federation*

Krista Shipley *Duke University, Stanback Intern for N.C. Coastal Federation*

Peter Zaykoski *Duke University, Stanback Intern for N.C. Coastal Federation*

Todd Miller *N.C. Coastal Federation*

Lauren Kolodij *N.C. Coastal Federation*

Ana Zivanovic-Nenadovic *N.C. Coastal Federation*

Rachel Bisesi *N.C. Coastal Federation*

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Paul Clark *N.C. Division of Water Resources*

Devon Eulie *University of North Carolina Wilmington, Department of Environmental Studies*

Patti Fowler *N.C. Division of Marine Fisheries, Shellfish Sanitation and Recreational Water Quality Section*

Hunter Freeman *WithersRavenel Engineers*

J.D. Potts *N.C. Division of Marine Fisheries, Shellfish Sanitation and Recreational Water Quality Section*

Mike Randall *N.C. Division of Water Resources*

Kathy Stecker *N.C. Division of Water Resources*

Daniel Wiebke *WithersRavenel Engineers*

Executive Summary

The Watershed Management Planning Guidebook seeks to provide detailed guidance to how a community can replicate natural surface water hydrology to improve water quality by determining the stormwater runoff volume of an entire coastal watershed in multiple land use scenarios and utilizing Best Management Practices (BMPs) techniques, specifically Low Impact Development (LID) to reduce the total volume of runoff. Stormwater runoff serves as a transport for pollutants, such as bacteria, nutrients, chemical and physical pollution. Rather than focusing on reducing sources of contamination or attempting to treat and remove bacteria and other pollutants from stormwater runoff, *the management techniques used in this guidebook focus on reducing the overall volume of stormwater runoff in order to limit the conveyance from the land into coastal waters.* This guidebook is intended to serve as a framework for local governments and coastal communities to develop coastal watershed management plans that will better position them to qualify for funding. This guidebook utilizes simple geographic information systems (GIS) techniques and the *Watershed EZ Tool* to quantify the stormwater volume reduction goal of a watershed.

Acronyms and Definitions

303(d) List	A list of water bodies that are too polluted or degraded to meet water quality standards.
319	A grant program funded by EPA and administered by DEQ to study impaired water
APPROVED AREA	An area determined suitable for the harvest of shellfish for direct market purposes
BIORETENTION AREAS	Also known as rain gardens, these provide onsite retention of stormwater through the use of vegetated depressions engineered to collect, store, and infiltrate runoff
BMP	Best Management Practice of stormwater management; also commonly referred to as <i>Stormwater Control Measure (SCM)</i> or <i>Stormwater Infiltration Practice (SIP)</i>
CAFO	Confined Animal Feeding Operation
CATCHMENT	A geographic unit within a subwatershed made up of a singular river, stream, or branch that contributes to a larger watershed.
CFU	Colony Forming Unit used to measure fecal coliform concentrations
CONDITIONALLY APPROVED CLOSED	An area subject to predictable intermittent pollution that may be used for harvesting shellfish for direct market purposes when management plan criteria are met generally during drought conditions
CONDITIONALLY APPROVED OPEN	An area subject to predictable intermittent pollution that may be used for harvesting shellfish for direct market purposes when management plan criteria are met, generally during low rainfall conditions
CWA	Clean Water Act
DCM	North Carolina Division of Coastal Management
DEGRADED WATERS	General description of surface waters that have elevated pollution levels, could include high bacteria levels, pathogens, sediment, low dissolved oxygen, and/or high nutrient levels. This is not a legal description of impairment (see impaired waters definition).

DEQ	North Carolina Department of Environmental Quality
DESIGNATED USE	A Clean Water Act term referring to the use, such as recreation or aquatic life support, that a water body has been designated with by the state. The water body may not actually be able to support its designated use.
DOT	Department of Transportation
EPA	Environmental Protection Agency
EXISTING USE	A Clean Water Act term referring to all current uses and any use the water body has been able to support since November 28, 1975.
FDA	U.S. Food and Drug Administration
FECAL COLIFORM	Bacteria that originate in the intestines of warm-blooded animals. Bacteria of the coliform group which will produce gas from lactose in a multiple tube procedures liquid medium (EC or A-1) within 24 plus or minus two hours at 44.5 degrees C plus or minus 2 degrees C in a water bath.
FLOW	The volume of water, often measured in cubic feet per second (cfs), flowing in a stream or through a stormwater conveyance system
GIS	Geographic Information Systems
GROWING WATERS	Waters that support or could support shellfish life
HUC	Hydrologic Unit Code
HYDROGRAPH	A graph showing changes in the discharge of a surface water river, stream or creek over a period of time
HYDROLOGIC CYCLE	The cycle by which water evaporates from oceans and other bodies of water, accumulates as water vapor in clouds, and returns to the oceans and other bodies of water as precipitation or groundwater. Also known as the water cycle.
HYDROLOGY	The science dealing with the waters of the earth, their distribution on the surface and underground, and the cycle involving evaporation, precipitation, flow to the seas, etc.
IMPAIRED	For the purposes of this Guidebook, any saltwater classified for

WATERS	shellfish harvest (SA) that is not managed as an “Approved Area” by the Division of Environmental Health, or any saltwater classified for swimming (SB) where swimming advisories are being issued. These waters have been listed as impaired on the state’s 303(d) list for EPA.
IMPERVIOUS COVER	A hard surface area, such as a parking lot or rooftop, that prevents or retards water from entering the soil, thus causing water to run off the surface in greater quantities and at an increased rate of flow.
LID	Low Impact Development is integration of site ecological and environmental goals and requirements into all phases of urban planning and design from the individual residential lot level to the entire watershed.
LULC	Land use/land cover
MAXIMUM EXTENT PRACTICABLE	According to EPA, available and capable of being done after taking into consideration cost, existing technology, and logistics in light of overall project purpose.
MS4	Municipal separate storm sewer systems
NEPA	National Environmental Policy Act
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source, diffused sources of pollution, where there is no singular distinct outflow point.
NRCS	Natural Resources Conservation Service
NSSP	National Shellfish Sanitation Program
RETROFITTING	Structural stormwater management measures for preexisting development designed to help reduce the effect of impervious areas, minimize channel erosion, reduce pollutant loads, promote conditions for improve aquatic habitat, and correct past efforts that no longer represent the best science or technology.
ROW	Right of Way
SA	Saltwater classified by the N.C. DEQ for shellfish harvesting. These are waters that should support aquatic life, both primary and secondary

	recreation (activities with frequent or prolonged skin contact), and shellfishing for market purposes.
SB	Saltwater classified by the N.C. DEQ for swimming.
SC	Saltwater classified by the N.C. DEQ for fish propagation and incidental swimming. The waters are safe for swimming but have a higher risk of pollution and human illness than SB waters.
SCM	Stormwater Control Measure, also more commonly known as a Best Management Practice (BMP) of stormwater management; also commonly referred to as <i>Stormwater Infiltration Practice (SIP)</i>
SHELLFISH SANITATION	Shellfish Sanitation and Recreational Water Quality Section, N.C. Division of Marine Fisheries, N.C. DEQ. In 2011 the N.C. General Assembly transferred the shellfish and recreational water quality functions of this agency from DEH to DMF.
SIP	Stormwater Infiltration Practice, also more commonly known as a Best Management Practice (BMP) of stormwater management; also commonly referred to as <i>Stormwater Control Measure (SCM)</i>
STORMWATER	Water from rain that flows over the land surface, picking up pollutants that are on the ground.
SUBWATERSHED	A geographic unit within a watershed made up of individual minor rivers, streams, or branches that contribute to a larger watershed.
TMDL	Total maximum daily load, the maximum amount of a pollutant that can be found in a water body and still meet federal Clean Water Act standards.
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
WATERSHED	The topographic boundary within which water drains into a particular river, stream, wetland, or body of water.
WATERSHED	All areas that drain to a waterbody, whether that be a lake, mouth of a river, or ocean
WQS	Water quality standards
WWTP	Wastewater Treatment Plant

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Guidebook Overview

This guidebook is comprised of eight chapters that lead the user through the watershed planning and implementation process. This includes a brief introduction on the purpose of targeting coastal watersheds and explains the logic behind using an overall stormwater runoff volume reduction as a goal for watershed management planning. Next the guidebook describes how to characterize a watershed, which is necessary before developing a watershed management plan. The guidebook culminates in instructions on how to successfully create, implement and evaluate a watershed management plan. The appendices offer additional resources and worksheets that are helpful throughout the planning process.

CHAPTER 1: VOLUME REDUCTION PHILOSOPHY

Stormwater runoff serves as a transport for pollutants, such as bacteria, nutrients, chemicals and physical pollution. Rather than focusing on reducing sources of contamination or attempting to treat and remove bacteria and other pollutants from stormwater runoff, *the management techniques used in this guidebook focus on reducing the overall volume of stormwater runoff in order to limit the conveyance from the land into coastal waters.*

CHAPTER 2: REGULATORY BACKGROUND

This chapter gives a brief overview of the Clean Water Act, Environmental Protection Agency (EPA) guidelines for watershed plans and Shellfish Sanitation. This chapter discusses water use classifications and 319 Program.

CHAPTER 3: IDENTIFY AND INTEGRATE PARTNERSHIPS

This chapter provides guidance on identifying and integrating partners and stakeholders and building community support through the development of outreach and education programs.

CHAPTER 4: SET PLANNING GOALS AND DEFINE THE WATERSHED

This chapter discusses how to set goals and objectives and how to clearly define the geographic extent of the watershed. This guidebook suggests utilizing one primary goal with multiple supporting objectives to accomplish the primary goal.

CHAPTER 5: GATHER DATA AND CREATE A WATERSHED INVENTORY

This chapter describes how to characterize the watershed and how to collect the data necessary to determine runoff volume and data organization. This research is integral to developing an estimated stormwater runoff volume reduction numeric value.

CHAPTER 6: ESTABLISH VOLUME REDUCTION GOAL

One of the most important steps in the planning process is the establishment of an estimated, numeric stormwater runoff volume reduction goal. This chapter will provide step-by-step instructions on data preparation and calculations necessary to determine total stormwater runoff changes between historical and current land use conditions of the watershed.

CHAPTER 7: STORMWATER REDUCTION TECHNIQUES

This chapter introduces the theory behind low impact development (LID) and discusses various LID techniques. It also discusses various factors to consider when evaluating which techniques may be right for watershed management plan.

CHAPTER 8: DESIGN THE WATERSHED MANAGEMENT PLAN AND IMPLEMENTATION PROGRAM

This chapter includes how to develop an implementation schedule, criteria for measuring progress, milestones, monitoring and evaluation. Additionally, this chapter discusses how to identify funding and technical resources necessary to implement the plan and addresses the need to constantly evaluate the process. This chapter also discusses the suggested sections that any watershed management plan should have.

APPENDIX A: PLAN CHECKLIST

A checklist of information that should be included in a watershed management plan with the corresponding chapter of where to find the information.

APPENDIX B: WATERSHED PLANNING RESOURCES

Additional sources of resources that will be beneficial during the development of a watershed management plan. The list includes

APPENDIX C: ADDITIONAL OUTREACH INFORMATION

Sources that can provide additional information regarding outreach and education materials and approaches.

APPENDIX D: METHODS OF WATERSHED DELINEATION

Alternative approaches to delineating a watershed boundary.

APPENDIX E: SOIL DATA ACQUISITION

Detailed instructions on how to acquire soil data in the state or county does not have geographic information systems (GIS) datasets available.

APPENDIX F: DATA TO CONSIDER INCLUDING

This appendix is supplemental to Chapter 5 and provides detailed information on watershed characteristic data to consider including and the logic of including the data.

APPENDIX G: ADDITIONAL LID INFORMATION

Sources of additional LID information such as installation and determining which LID measure would be best.

APPENDIX H: BRADLEY AND HEWLETTS CREEKS WATERSHED MANAGEMENT PLAN OBJECTIVES

This table outlines the six objectives of the plan, along with detailed actions to achieve objectives, partners involved, costs and an implementation timeline.

APPENDIX I: “GREEN STREET” STORMWATER MANAGEMENT DEVICES

This appendix provides multiple example of designs schematics of some stormwater runoff reduction techniques that can be used within public right of ways.

APPENDIX J: ABOUT THE NORTH CAROLINA COASTAL FEDERATION

A brief history of the North Carolina Coastal Federation.

Introduction

PURPOSE OF THIS GUIDEBOOK

The purpose of this guidebook is to provide clear and detailed guidance for the development of a coastal watershed management plan that aims to replicate the pre-impairment surface water hydrology and improve water quality. This is accomplished by quantifying the estimated stormwater runoff reduction volume and utilizing Best Management Practices (BMPs) necessary to reduce stormwater runoff that will in turn decrease pollutant loads in coastal watersheds. Instead of attempting to eliminate all sources of pollution, the guidebook focuses on reducing the transport of pollution to surface waters by reducing the volume of surface runoff.

This guidebook is unique from other watershed planning instructional guides because it utilizes stormwater runoff volume reduction instead of peak flow storage that conventional guides typically rely on. The methodology in this guidebook can be used to help satisfy requirements for funding, help address federal Clean Water Act requirements for water quality and provide a proactive measure to protect water quality. This guidebook is ideal for small watersheds that seek to restore, maintain or protect water quality.

Stormwater runoff is the primary cause of water quality impairment in coastal watersheds. Stormwater runoff increases as natural, vegetated environments are developed, increasing the amount of impervious surface. During storm events pollutants are transported downstream by stormwater runoff. As the intensity of land use increases, runoff carries increased amounts of bacteria, nutrients, chemicals and physical pollution into coastal waterways. Polluted water bodies negatively impact the environment, human health and the coastal fishing and tourism industries. Restoration and management techniques that rely on stormwater reduction volume and that mimic or restore natural hydrology can reduce pollutant loads.

North Carolina is known for its pristine waters and beautiful beaches; yet in 2016, 2,446,218 acres of marshes, sounds and lakes in the state and 2,222,694 acres of coastal shellfish and swimming waters are listed as legally impaired on the EPA 303(d) list due to high bacteria levels. This accounts for over 3,822 square miles of impaired state waters and 3,573 square miles of coastal waters that are closed for their designated uses for recreation or shellfishing. North Carolina beaches and inlets generate \$3 billion in revenue and directly support 39,000

jobs in coastal communities¹. Aquaculture alone makes up \$25 million of sales in the state and degraded waters jeopardize the shellfishing industry, which accounts for 21 percent of the United States oyster industry^{2,3}. Degraded water can harm oyster reef habitats, which support crabs and finfish that are worth over \$62 million⁴. Bacteria pollution (largely from stormwater runoff) is not unique to North Carolina, many coastal communities around the United States struggle with the same coastal water quality impairments.

The methods presented in this guidebook were initially developed by the North Carolina Coastal Federation to complete and implement watershed management plans in areas with surface waters that were impaired for swimming and shellfishing. These methods were applied in both urban and rural watersheds with land uses that included intense urban developments to rural agricultural watersheds. In 2016, the standardized practices found in this guidebook were further expanded upon and are continuously being refined based upon its use in practice.

GUIDEBOOK OBJECTIVES

A watershed management plan can provide a sound framework to protect and restore water quality. This guidebook provides detailed instruction for coastal communities to develop a watershed management plan that will:

1. Establish long-term goals for improving or protecting coastal waters and watersheds;
2. Develop strategies to accomplish established goals;
3. Ensure stakeholder participation;
4. Identify the estimated volume of stormwater runoff that should be reduced;
5. Measure water quality goals; and
6. Result in management measures to meet the desired objectives.

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1. North Carolina Department of Environmental and Natural Resources. (April 2011). NC Beach and Inlet Management Plan Final Report. Retrieved from <http://dcm2.enr.state.nc.us/BIMP/BIMP%20Executive%20Summary.pdf>
 2. North Carolina Department of Agriculture and Consumer Services. Marketing NC Seafood Aquaculture in North Carolina. Retrieved from <http://www.ncagr.gov/markets/seafood/general.htm>
 3. Blustein, Daniel. (2013, August 18). Made in NC: Oyster farmers work to propel aquaculture in NC. News & Observer. Retrieved from <http://www.newsobserver.com/2013/08/18/3118132/oyster-rising-farmers-work-to.html>
 4. City of Wilmington North Carolina. (2014). Recycling: Oysters. Retrieved from http://www.wilmingtonnc.gov/public_services/trash_recycling/trash_collection/recycling/oysters

FOCUSING ON SMALL COASTAL WATERSHEDS

This guidebook is designed for use in any coastal watershed. This guidebook favors small drainage areas, such as catchments or subwatersheds that are smaller than the 12-digit Hydrologic Unit Code (HUC) watersheds that are traditionally used in regional watershed planning. Planning on a small-scale allows communities to address stormwater management through community-level actions that reduce stormwater runoff volumes and water quality impairments. Small-scale coastal watershed management plans can be cost-effective and are easier for communities to manage long-term.

ADDRESSING TMDL STUDIES

When surface waters no longer comply with federal water quality classifications and standards, the federal Clean Water Act (CWA) mandates that steps be taken to mitigate the water quality impairment and restore water quality to acceptable levels. This normally involves conducting a Total Maximum Daily Load (TMDL) study to determine to what extent a pollutant must be reduced to meet water quality standards. TMDL studies can take several years to complete and can be costly; between \$26,000 to over \$500,000 with the average being \$52,000⁵. Once a TMDL study is complete, a watershed management plan then is devised to accomplish the necessary reduction in pollutant load.

For many coastal watersheds, pollution that affects water quality is transported by stormwater runoff from intense land uses. Scientific monitoring has repeatedly shown that altered watershed hydrology creates additional surface runoff that transports bacteria and other pollutants into downstream coastal waters. The methodology detailed in this guidebook allows communities to estimate the additional surface runoff created due to hydrologic modifications caused by impervious surfaces. This estimate establishes a numerical goal for how much runoff must be reduced to restore water quality to pre-impairment levels. The numerical overall volume reduction goal can serve as a benchmark if a TMDL report is not required or has yet to be completed for a water body. In addition to a numerical volume reduction goal, water quality monitoring data is necessary and documentation of the relationships among: intensity of land

⁵ United States Environmental Protection Agency. (2001). *The National Costs of the Total Maximum Daily Load Program* (EPA 841-D-01-003). Washington, DC: U.S. Government Printing Office.

uses, greater hydrologic modifications and increasing pollutant levels in downstream surface waters.

The TMDL reports and watershed management plans for the Lockwood Folly and White Oak Rivers were approved by the U.S. Environmental Protection Agency (EPA) and N.C. Department of Environmental Quality (DEQ). These plans served as a guide for the City of Wilmington to follow in developing the Bradley and Hewletts Creeks Watershed Management Plan, which is a 303(d) listed water body. Plans that are approved by the EPA and the state can potentially lead to more time for communities to accomplish restoration efforts and potentially avoid facing legal mandates.

OTHER USES

Utilizing this guidebook helps to ensure that coastal watershed management plans incorporate the nine minimum elements required by the EPA for management plans considering federal funding. Plans developed according to this guidebook can be effective in improving water quality in watersheds with surface waters that are considered degraded or at risk by the community, but are not “impaired” under the rules of the federal Clean Water Act, but are.

ADAPTING THIS GUIDEBOOK TO ANY WATERSHED

While this guidebook was developed to assist small coastal watersheds in North Carolina, the methods and concepts can easily be adapted to create a watershed management plan in any watershed impacted by stormwater runoff, in any location. This guidebook provides detailed instructions for determining a numerical stormwater runoff volume reduction goal that is applicable to any watershed. The partners and agencies mentioned in this guidebook may not be directly relevant to communities outside of North Carolina, but they can serve as suggestions for where to find similar information. Additionally, there are some state-specific watershed guidance documents that identify resources and regulatory information that should be referenced.

COMPARISON TO EPA WATERSHED HANDBOOK

Many aspects of this guidebook were adapted from the [EPA Handbook for Developing Watershed Plans to Restore and Protect Our Water](#). Similarities and differences include:

- I. This guidebook concentrates specifically on small coastal watersheds with impairments caused by stormwater runoff.

This allows implementation of management strategies tailored to the differing land use patterns and natural hydrology of coastal area. Watersheds are all areas that drain to a single point within a waterbody, whether that be a lake, mouth of a river, or ocean. Subwatersheds

are geographic units within a watershed made up of individual minor rivers, streams or branches that contribute to a watershed. By having a small project scope, in many cases even smaller than the 12-digit HUC watersheds, planning efforts can be focused and easily implemented.

- II. Instead of attempting to eliminate sources of pollutants and bacteria, the methods in this guidebook seek to reduce the transport of pollutants by reducing the volume of surface runoff.

Previous projects that tested this strategy, including those on the [White Oak River](#), [Lockwood Folly River](#), and [Hewlett and Bradley Creeks](#), show that one of the best ways to restore coastal water quality is to mimic natural hydrology and to reduce the overall volume of stormwater runoff. This technique reduces the overall pollutant loads deposited into waterways. This guide helps determine volume reduction goals and develop management strategies for meeting those goals in order to improve water quality.

- III. Following the methodology outlined in this guidebook will ensure management plans incorporate the six steps to watershed management planning and all nine elements required by EPA.

This guidebook emphasizes addressing each of the nine minimum elements. The nine minimum elements required by the EPA will be discussed frequently throughout this guidebook, and include:

1. Identification of causes of impairment and pollutant sources or groups of similar sources that need to be controlled to achieve needed load reductions, and any other goals identified in the watershed plan;
2. An estimate of the load reductions expected from management measures;
3. A description of the nonpoint source management measures that will need to be implemented to achieve load reductions, and a description of the critical areas in which those measures will be needed to implement this plan;
4. Estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon to implement this plan;
5. An information and education component used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the nonpoint source management measures that will be

implemented;

6. Schedule for implementing the nonpoint source management measures identified in this plan that is reasonably expeditious;
7. A description of interim measurable milestones for determining whether nonpoint source management measures or other control actions are being implemented;
8. A set of criteria that can be used to determine whether load reductions are being achieved over time and substantial progress is being made toward attaining water quality standards;
9. A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the established criteria.

Table 1 specifies which chapters address the six steps of watershed planning and the nine elements of a watershed management plan. The six steps of watershed planning were developed by the EPA as best practices to developing and comprehensive watershed management plan; these six steps are echoed within this guidebook.

Table 1

This table shows where the six steps of watershed planning and the nine elements of a watershed management plan are addressed as required by EPA.

Guidebook Chapters		Steps in the EPA Handbook for Watershed Planning	EPA Nine Minimum Elements
1	Volume Reduction Philosophy		
2	Regulatory Background		
3	Identify and Integrating Partnerships	Step 1 Build Partnerships	Develop Information and Education Component
4	Set Planning Goals and Define the Watershed	Step 2 Characterize the Watershed	Identify Causes and Sources of Pollution that Need to be Controlled
5	Gather Existing Data and Create a Watershed Inventory		
6	Establish Volume Reduction Goal	Step 3 Set Goals and Identify Solutions	Determine Load Reduction
7	Stormwater Reduction Techniques		Develop Management Measures to Achieve Goals
8	Design the Watershed Management Plan and Implementation Program	Step 4 Design Implementation Plan	Develop Interim Milestones to Track Management Measures
		Step 5 Implement Watershed Plan	Develop Criteria to Measure Progress Toward Meeting Watershed Goals
		Step 6 Measure Progress and Make Adjustments	Identify Technical and Financial Assistance Needed to Implement Plan
			Develop Implementation Schedule
		Develop Monitoring Component	

1 Volume Reduction Philosophy

1.1 CAUSES FOR IMPAIRMENT OF COASTAL WATERS

Coastal areas have undergone significant change as land use practices have intensified through the increase in agriculture, forestry and urban development. Historically, degradation of coastal waters was minimal because the natural hydrology limited transportation of bacteria and other pollutants to waterways. Prior to human alteration, most rainwater was absorbed into the ground, evaporated or used by vegetation. When rainwater is absorbed through the ground, bacteria and other pollutants are removed through percolation. Conventional land use practices circumvent natural hydrologic processes. Rainwater is transported rapidly over impervious surfaces and through connected conveyance systems, including ditches, pipes, parking lots and yards, circumventing natural hydrologic processes (Figure 1-1). Excess surface water from a rain event is known as stormwater. The result is that during and after storm events, rainwater passes quickly over the landscape collecting pollution before flowing directly into coastal waters.

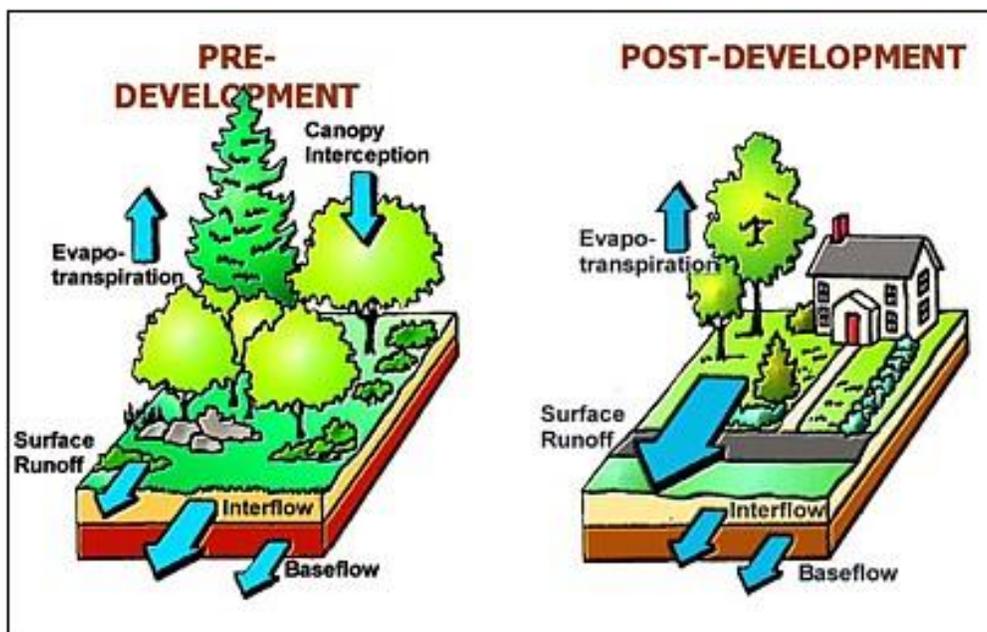


Figure 1-1. Surface runoff increases with intensifying land use (courtesy of the State of Maryland's StormwaterPrint).

Pollutants can enter waters through various outlets and the means of conveyance can be categorized as point and nonpoint sources. Point sources are those that come from a single outflow, or source, such as a pipe. In contrast, nonpoint sources of pollution do not come from

a discernible point, but generally from processes such as runoff. It is important to understand what pollutants may be contaminating a water body in order to adequately manage water quality. Stormwater runoff results in a variety of water pollution: chemical, organic, nutrient, bacterial, and sediment. By addressing stormwater runoff, it is possible to address both point and nonpoint sources of pollution. Additionally, preventing stormwater from reaching waterways limits water impairment issues.

1.2 CONVENTIONAL SOLUTIONS ARE INEFFECTIVE

Intense land uses overwhelm the effectiveness of conventional stormwater treatment systems. Conventional methods rely on peak flow storage but do not mitigate pollution and cannot keep up with increased pressure from land use. As impervious surfaces and stormwater runoff increase, hydrology is altered and can lead to an increase in sedimentation and erosion, ecosystem degradation and loss, loss of aquatic biodiversity, degradation of water quality and increased flooding. Ineffective conventional stormwater management practices negatively impact the environment, human health and coastal fishing and tourism industries.

Furthermore, the difficulty in preventing violations of bacteria standards for coastal waters is compounded by the unique challenges related to coastal hydrology and bacteria lifecycles. These include:

1. The two fecal coliform bacteria used as indicators of water quality, *Escherichia coli* (E. coli) and enterococcus, naturally occur across the terrestrial landscape. These bacteria originate in the feces of warm-blooded animals, such as birds, deer, raccoons and domestic pets. Although prudent measures should be taken to reduce the sources of bacteria, these efforts alone will not result in improvements in coastal water quality because of the unnatural levels of stormwater transporting the bacteria.
2. Treating stormwater runoff to remove bacteria pollution before it flows into shellfishing and swimming waters is not practical. Although some technology exists for treating bacteria levels in runoff, it is not able to reduce levels to ensure the pristine water quality necessary to allow shellfish harvest and swimming and at this time is unable to handle fluxes in runoff caused by storm events along the coast.
3. Treated runoff can easily be re-contaminated. Because of the ubiquitous nature of bacteria on the landscape, treated runoff, once discharged back on the landscape will simply pick up bacteria again. The result is that costly treatments are not effective.

1.3 PHILOSOPHY BEHIND STORMWATER VOLUME REDUCTION

Rather than focusing on reducing sources of contamination or attempting to treat and remove bacteria and other pollutants from stormwater runoff, *the management techniques used in this*

guidebook focus on reducing the overall volume of stormwater runoff in order to limit the conveyance from the land into coastal waters. Low-impact development (LID) and BMP practices can achieve this goal by replicating the natural hydrology and increasing infiltration of water into soils. LID practices are a form of stormwater management in land planning and engineering that primarily focuses on mimicking natural hydrology of the area to limit stormwater runoff. For already developed locations LID stormwater techniques can reduce the amount of stormwater entering waterways. The result of implementing LID BMP practices is that less bacteria and pollutants are transported off the land and into water systems.

Restoration or mimicry of pre-development, natural hydrology leads to less bacteria and other pollutants in coastal waterways. Bacteria and pollutants are affected by the following factors: the natural mortality of fecal coliform bacteria, the prevention of bacteria and pollutants from entering waterbodies and the reduction in the velocity of runoff resulting in lower flowrates. Infiltration of rainfall into the ground serves as an extremely effective filtration system of bacteria and pollutants. Additionally, once bacteria enter the landscape they are subject to higher rates of mortality due to bombardment by ultraviolet radiation from sunlight. By reducing the flow velocity of stormwater, the dissemination of bacteria and other pollutants downstream into shellfishing and swimming waters is reduced. Utilizing this guidebook to aid in the development of a coastal watershed management plan that address the overall reduction of stormwater runoff, in turn reduce pollutants that enter coastal waterways.

2 Regulatory Background

There are a number of federal and state regulatory rules and laws that relate to water, coastal zone management, and environmental conservation that may serve as a factor for developing a watershed management plan. The primary regulation that affects all surface waters is the federal Clean Water Act. Additional national regulations or programs that may be applicable to a coastal watershed include the Safe Drinking Water Act, the National Estuary Program, Coastal Zone Management Act, North American Wetlands Conservation Act and the Endangered Species Act. These additional regulations and programs do not necessarily apply to all watersheds. Furthermore, each state has additional programs or regulation that may be useful to consider when developing a coastal watershed management plan, especially if they might be sources of funding to implement management measures. It is important to develop partnerships with federal, state and local agencies to ensure that your management plan fully considers these programs.

2.1 CLEAN WATER ACT

Congress enacted the federal [Clean Water Act](#) (CWA) (33 U.S.C. §1251 et seq. (1972)) to establish regulations of pollution discharge and set water quality standards for surface waters with a purpose of protecting waters for drinking, fishing and recreation. Through the CWA, EPA set water quality standards for many contaminants and established pollution control programs.

2.1.1 National Pollutant Discharge Elimination System

As part of the CWA, it is unlawful for anyone to discharge point source pollution into waterbodies without a permit under the [National Pollutant Discharge Elimination System](#) (NPDES) program. NPDES only address point sources of pollution, any discernible direct conveyance of a pollutant, which include wastewater and stormwater pipes and channels, Concentrated Animal Feeding Operations (CAFO) pipes and channels, and vessel discharge. NPDES permits also cover general discharge over an area; these permits are typically given to construction or industrial sites. The intent of the permit is to quantify the amount of discharge than can occur without impairing water quality or human health. Each state maintains a list of NPDES permits. In North Carolina, the Division of Water Resources (DWR) maintains the [NPDES permit list](#). It may be relevant to consider NPDES permits in management plans as potential locations to incorporate retrofits and build partnership with permit holders to participate in mitigation and restoration within the community.

2.1.1.1 NPDES Stormwater Program

Within NPDES is the NPDES Stormwater Program, designed to manage certain discharge from municipal separate storm sewer systems (MS4s), construction sites and industrial sites.

Typically, these discharges need an NPDES permit, which almost all states administer directly; exceptions that are administered by the EPA include [certain territories, some tribal lands and a few states](#). Permits issued due to stormwater should be identified in the management plan as it may be relevant to consider incorporating retrofits or restoration efforts at sites or within local governments with NPDES permits if the sites or local governments themselves have not actively done so.

2.1.2 Impaired Waters

The CWA establishes use [designation classifications](#) that should protect water quality and the “existing uses” of coastal waters from degradation from point and nonpoint sources of pollution. The CWA defines existing uses as any water quality dependent activity that has occurred since November 28, 1975, including natural habitat that supports aquatic life. The “designated uses” are the current uses a water body can be safely used for. Each state has a list of designated uses, for example shellfishing or swimming, and each water body in the state should be assigned a designation from this list. Designated use codifications vary from state to state.

If waters are degraded, states are obligated to take a number of actions. States list the impaired water body on the [Section 303\(d\)](#) list, which publically lists all waters that are too degraded or polluted to meet minimum standards. Priority rankings for removing the impairments in water bodies must be developed through a TMDL study. Impaired waters can be found by state and watershed through the [National Summary of Impaired Waters and TMDL Information](#). It is relevant to know the designation of the waterbody(s) and what the existing uses are and incorporate reaching, maintaining, or exceeding standards for the existing use classification within a management plan.

In North Carolina, the DEQ [DWR](#) is responsible for [water use classification](#). The use classifications are based on rules set forth in the North Carolina Administrative Code and are regularly updated. Local governments are able to implement more stringent land or water protection regulation as they see fit. It is important to confer with local agencies when determining a water body’s uses. Significant surface water classifications that are relevant to coastal waters are listed in Table 2-1. Use classifications may have the intent to protect water quality, fish and wildlife, or other special characteristics and each use classification has an associated set of water quality standards that apply to waterbodies carrying that classification. It is possible for a water body to have multiple classifications.

To determine the classification of a North Carolina waterbody by use [N.C. Surface Water Classifications](#) dynamic map interface by zooming to the main waterbody of the watershed and then clicking directly on the waterbody. A pop-up box will appear with classification information.

North Carolina first adopted formal coastal stormwater management rules in 1988. These rules proved inadequate to stop the continued spread of bacteria pollution in coastal waterways. The failure of these rules was recognized in 2008 by the N.C. Environmental Management Commission when more robust rules were adopted. The rules include reducing the low-density threshold for implementing stormwater controls to manage runoff from a one-year, 24-hour storm for areas within a half-mile area of shellfishing waters (Class SA) from 25 percent to 12 percent. For areas outside a half-mile, the low-density threshold is 24 percent and must control the first 1.5 inches of rainfall. The new rules increased the amount of stormwater that must be controlled in all 20 coastal counties. Many stormwater systems that were installed prior to 2008, were outdated and ineffective in addressing new stormwater runoff regulation. By using Class SA waters as a standard, a management plan can focus on achieving the highest water quality that is regularly monitored.

Table 2-1. North Carolina surface water classifications. Full descriptions available on [DEQ](#)

Primary Use Classifications	
SA	Commercial Shellfishing
SB	Class SC and Primary Recreation in tidal salt water
SC	Aquatic Life, Secondary Recreation, and Fishing in tidal salt water
SWL	Coastal wetlands
Supplemental Use Classifications	
HQW	High Quality Waters
ORW	Outstanding Resource Waters
NSW	Nutrient Sensitive Waters
CA	Critical Area
UWL	Unique Wetland
+, @, #, *	Special Designations (variable based on river basin)

[Website.](#)

2.1.3 Waterbody Status Reporting

[Section 305\(b\)](#) of the CWA requires states to prepare a report describing the status of water bodies. These reports categorize all water bodies and detail specifically which water bodies have met water quality standards, the extent of any progress made in restoring water quality, and the problems that still need to be addressed. This information can be found through the [National Water Quality Inventory Report to Congress \[305\(b\) Report\]](#). A water body that does not meet the water quality standards for its existing use is considered impaired, and is included on the [303\(d\) list](#). The EPA suggests that states follow the standardized five reporting categories (with Category 4 having three subcategories) in designating the water quality of a water body. If a water body is designated impaired, it falls into status reporting Category 4 or Category 5. Confirm with state agencies what their reporting categories are and how they correlate to EPA reporting categories (see Table 2-2). This is relevant to note within grant proposals and important to integrate within a watershed management plan, particularly if a planned goal is to improve the category listed for a water body.

Standard Water Quality Reporting Categories	
<i>Category 1</i>	All designated uses are supported; no use is threatened
<i>Category 2</i>	Available data and/or information indicate that some, but not all of the designated uses are supported
<i>Category 3</i>	There is insufficient available data and/or information to make a designated use support determination and data will be required to assess the attainment status
<i>Category 4</i>	Available data and/or information indicate that at least one designated use is not being supported or is threatened, but a TMDL is not needed (three subcategories 4a, 4b, 4c exist within Category 4)
<i>Category 5</i>	Available data and/or information indicate that at least one designated use is not being supported or is threatened, and a TMDL is needed; required to be listed on the 303(d) list

Table 2-2. EPA water body status reporting categories used by most states.

In 2002, the EPA began to encourage states, territories, and tribes to submit integrated water quality monitoring and assessment reports that combined 303(d) and 305(b) reports into one

document. Both individually or as an integrated report must be updated every two years. By using [integrated reports](#), states create more succinct reports that can be used to determine whether a TMDL study is necessary.

2.1.4 Total Maximum Daily Load

A TMDL is the total amount of a given pollutant that a water body can contain while meeting its water quality standards. The TMDL accounts for all pollutant sources (point, nonpoint, and background), a margin of error, and the potential for future growth. Once a pollutant's TMDL is established, states establish management plans aimed at reducing pollutants to be at or below the TMDL for the impaired waterbody. Section 303(d) of the federal Clean Water Act requires states to develop TMDLs for impaired water bodies. The TMDL study findings help regulators devise action plans necessary to meet water quality standards by identifying and quantifying the individual sources contributing to a particular water quality problem. TMDL studies can take several years to complete and can be costly; between \$26,000 to over \$500,000 with the average being \$52,000⁶. Once a TMDL study is complete, a watershed management plan then is devised to accomplish the necessary reduction in pollutant load. TMDL studies are costly and time consuming and ultimately result in the necessity of an accompanying watershed management plan to guide restoration measures. Proactive communities can take measures and develop watershed management plans for waters that have a completed TMDL or are on the 303(d) list. By taking action, communities have the potential to prevent further ecological, health, and economical damage that is caused by impaired water bodies.

The EPA maintains a database of water quality assessments and TMDL information, which can be accessed using the [MyWATERS Mapper](#) dynamic mapping interface (for step-by-step instructions on how to use MyWATERS Mapper see Section 5.1) Each state also maintains its own list of completed TMDL studies. Existing TMDL reports for North Carolina waters are found through the [North Carolina TMDL](#) section of the DEQ website.

If TMDL reports are not available for a watershed, a management plan should include sources of water quality impairment as well as specific pollutants and their sources. State 303(d) lists and TMDL reports are reviewed for approval by one of ten regional offices ([find local office](#))

⁶ United States Environmental Protection Agency. (2001). *The National Costs of the Total Maximum Daily Load Program* (EPA 841-D-01-003). Washington, DC: U.S. Government Printing Office.

[here](#)). Successful watershed management plans that can even mitigate the need for a TMDL study.

2.1.5 Section 319 Grant Program

[Section 319](#) of the CWA establishes the Nonpoint Source Management Program that provides guidance to institute pollution management programs focused on nonpoint source pollution. The program provides grant money to support various activities designed to address nonpoint source pollution (NPS) management. Current guidelines and guidance for 319 grant program through CWA Section 319(h) can be found [here](#). Funds are awarded to the state by the EPA once the state's plan has been approved. Final grant decisions are made by the state. Each state will have different requirements that applicants must meet; for example, timelines for applications or requirements to qualify for grant consideration may vary state to state and often change yearly. Specific details regarding application for 319 grant program can be found through each state's [NPS coordinator](#).

In North Carolina, the NPS Planning section in the DEQ DWR manages the 319 grant program. On an annual basis the DWR announces [Requests for Proposals \(RFP\)](#) for entities and communities; the RFP will contain detailed guidelines. For proposals to qualify to be reviewed, watershed restoration plans in North Carolina must include the nine EPA watershed restoration plan elements.

2.1.5.1 *Combined EPA and N.C. DEQ Guidelines*

Below is a compiled list of criteria by the EPA and N.C. DEQ ([find more details here](#)). All of the criteria listed are addressed by following the recommendations of this guidebook.

1. Identification of impairment, pollutant, causes and sources of pollution that need to be controlled. Pollution sources that need control measures should include estimates of their presence in the watershed
 - a. Include a map of the watershed
 - b. Identifies the major stressors and sources of impairment, spatial visualize the information in map form
 - c. Identify Point vs. Nonpoint sources
 - d. Identify the indicators to be measured
 - e. Review existing water quality or biological data
 - f. Perform a field assessment
2. Identify and detail reduction load and the measures necessary to meet water quality standards
 - a. Indicate the quantitative reduction load

- b. Prioritize proposed activities/projects and identify critical areas that need management
 - c. Describe future and current management measures within the watershed
 - d. Document relevant authorities that may have a role in management plan
 - e. Management activities should address the indicators
3. Detailed management activities and the expected outcome
 - a. Describe what the indicators will be for each management measure
 - b. Establish what the expected potential pollutant load reductions by each project will be
4. Identification of technical and financial assistance needed to implement as well as long-term operation and maintenance measures
 - a. Estimate amount of technical assistance needed
 - b. Estimate amount of financial assistance needed, ideally utilizing a detailed cost list
 - c. Identify federal, state, local, and private funds or resources that could potentially assist
5. Education and information plan for the watershed
 - a. Clearly identify stakeholders
 - b. Programs should have multifaceted involvement from local, state and federal programs and agencies; there should be a range of information and education options available
6. Plan implementation schedule
 - a. Identify timeline of implementation of actions with specifics on what entity will accomplish the actions including monitoring
 - b. Schedule should address short-, mid- and long-term actions
7. Implementation and tracking of measurable milestones to ensure benchmarks of success are being addressed
 - a. Milestones should be measurable and have a clear timeframe on when the milestone should be measured
8. Indicator to measure progress toward meeting watershed goals
 - a. Direct measurements (such as bacterial counts) and indirect measurements (such as number of beach closings) that can indicate whether substantial progress is being made
 - b. Should address how to proceed/modify strategies if interim goals are not being met
9. Monitoring component to evaluate effectiveness of plan
 - a. Monitoring should be of the load reduction goals to measure progress towards water quality improvement

2.2 EPA GUIDANCE FOR WATERSHED PLANS

The EPA's [Handbook for Developing Watershed Plans to Restore and Protect Our Waters](#) provides in depth details regarding each of the nine minimum elements. It is useful to refer to the EPA handbook in combination with this guidebook to gain a better understanding of each of the nine elements. There are a handful of states with state specific watershed documents that include resources and regulation information specific to that state that should be utilized along with this guidebook.

2.2.1 Re-categorizing Impaired Waters

If a water body has a water quality reporting category status of Category 5 it is listed on the 303(d) list and is required to have a TMDL study completed. In the event that a TMDL study has not yet been completed, it is possible to develop a watershed management plan that is comprehensive and can result in the water body being reclassification as Category 4b. Category 4b waters are those that are impaired but have pollution control measures in place to resolve the pollution problems and do not require a TMDL. The EPA reviews reclassification of water bodies by state agencies on a case-by-case basis. State policies on the rationale to reclassification water bodies are stringent to justify that pollution control requirements are capable of improving water quality in a reasonable amount of time. The EPA provides that the rationale of reclassification should address the six elements in Table 2-3. Policies regarding reclassification from Category 5 to Category 4b vary from state to state.

Table 2-3. The six elements that must be addressed in the rationale to reclassification a water body from Category 5 to Category 4b.

Six Elements to Meet Category 4b Categorization	
1	Identification of segment(s) and statement of problem causing the impairment(s)
2	Description of the pollution controls and how they will achieve WQS, including a description of the pollutant loads needed to meet WQS and a description of the requirements under which the controls will be implemented
3	An estimate or projection of the time when WQS will be met
4	Schedule for implementing pollution controls
5	Monitoring plan to track effectiveness of pollution controls
6	Commitment to revise pollution controls, as necessary

In North Carolina, the DWR regulates Category 4b categorization. The DWR oversees [requests for reclassification](#) and conducts assessments, which can lead to formal consideration to reclassify a water body. In addition to including the six elements for reclassification, the DWR requires that a number of additional requirements be met to demonstrate that reclassification is appropriate. Guidance on the additional requirement by DWR are updated regularly.

2.3 RECREATIONAL WATER QUALITY

In 2012, the EPA released new recommendations for [recreational water quality](#) criteria to protect human health. The EPA recommends states adopts guidelines of a geometric mean (GM) 35 per 100 milliliters for Enterococci and 126 per 100 milliliters for E. coli. Each state has the discretion to adopt the new standard or a scientifically defensible criterion. Procedures of notification of violation and what state agency monitors also varies from state to state.

In North Carolina, coastal waters standards are [GM 35 per 100 milliliters](#) for Enterococci. In the event of a violation of water quality at a North Carolina beach, notification procedures as outlined in the [Coastal Recreational Waters Monitoring, Evaluation and Notification](#) rules are followed. In North Carolina, [Shellfish Sanitation and Recreational Water Quality](#) (Shellfish Sanitation) section of the Division of Marine Fisheries (DMF) is responsible for monitoring the bacteria levels in coastal waters and has the authority to close waters to shellfishing and issue swimming advisories when bacterial levels are unacceptable.

2.4 SHELLFISH SANITATION

Shellfish harvesting water quality standards are stricter than the standards used to issue swimming advisories because shellfish are filter feeders that concentrate bacteria present in the water. This presents the potential for serious health issues since shellfish are often eaten raw. Shellfish waters that are closed to harvest on a conditional or permanent basis are classified as “impaired” by EPA.

Under the U.S. Food and Drug Administration (FDA), sanitation regulation of interstate commercial shellfish sold for human consumption is regulated through the National Shellfish Sanitation Program (NSSP). The NSSP works in partnership with state sanitation agencies to develop uniformity in sanitation regulation to minimize the risk of disease. Both shellfish growing and non-growing states participate in NSSP. Shellfish sanitation regulations vary from state to state and meet the minimum qualifications of the NSSP.

In North Carolina, Shellfish Sanitation section of DMF is responsible for monitoring the bacteria levels in coastal waters and has the authority to close waters to shellfishing and issue swimming advisories when bacterial levels are unacceptable. This is accomplished through monitoring water quality conditions at over a thousand stations for shellfishing and 240 stations for swimming. See Table 2-2 for the growing area classifications used by Shellfish Sanitation.

Table 2-2. Classifications used by Shellfish Sanitation for shellfish harvesting waters.

North Carolina Shellfish Sanitation Growing Area Classifications	
Approved	These areas are always open to shellfish harvesting and close only after rare heavy rainfall events such as hurricanes. The median fecal coliform Most Probable Number (MPN) or geometric mean MPN of water shall not exceed 14 per 100 milliliters, and the estimated 90th percentile shall not exceed an MPN of 43 per 100 mL for a five-tube decimal dilution test.
Conditionally Approved-Open Shellfish Areas	Sanitary Survey indicates an area can meet approved area criteria for a reasonable period of time, and the pollutant event is known and predictable and can be managed with a plan. These areas are open to harvest much of the year, but are immediately closed after certain sized rainfall events.

<p>Conditionally Approved-Closed Shellfish Areas</p>	<p>Sanitary Survey indicates an area can meet approved area criteria during dry periods of time, and the pollutant event is known and predictable and can be managed with a plan. This growing area classification allows harvest when fecal coliform bacteria levels are lower than the state standard in areas that otherwise might be closed to harvesting. These areas are regularly monitored to determine if temporary openings are possible.</p>
<p>Prohibited Shellfish Harvest Areas</p>	<p>Sanitary Survey is not routinely conducted because previous sampling data did not meet criteria for Approval or Conditional Approved. Area may also be closed as a matter of regulation due to the presence of point source discharges or high concentrations of boats with heads.</p>

In addition, every three years N.C. Shellfish Sanitation staff survey the entire shoreline of shellfish growing areas to document current and potential pollution sources. The data collected by Shellfish Sanitation is publicly available and is a source of historical and present day information regarding water quality of an area. By utilizing data that has already been collected, communities can research and develop plans without implementing extensive and costly data collection and monitoring programs. Shellfish closure area information can be used by communities to determine what waterways are impaired and to what extent the waterway is being affected. Additionally, communities that have multiple watersheds within their boundaries can determine the level of impairment or the number of years a waterway has had that status to develop a list of watersheds to focus on or develop a prioritization list.

3 Identify and Integrate Partnerships

All major interests within coastal watersheds should be included in planning and implementing watershed management plans to connect the community to the watershed issues being addressed. Partners and stakeholders may appear to be synonymous but they serve different purposes and contribute to the watershed management plan’s success differently. Connecting with community leaders, elected officials, government and non-government organizations, local businesses, and academics can result in all sectors of the community invested in the plan (see Appendix B for a detailed list of potential partners and stakeholders and their roles). For example, the Hewletts and Bradley Creek Watershed Plan was a collaborative effort involving the City of Wilmington, Town of Wrightsville Beach, North Carolina Coastal Federation, WithersRavenel Engineers, DEQ agencies, New Hanover County Soil and Water District, and the University of North Carolina at Wilmington.

3.1 PARTNERSHIP INTEGRATION

A partner is any individual, organization, agency or academia engaged in the development of watershed restoration plan and share in the actions, efforts and rewards of a successful project. Partners hold equal responsibility in the outcome of the plan and projects. Partners are at the core of decision-making processes. Effective partnerships help identify watershed concerns, obstacles and opportunities for restoration. Partners are invested to the plan and the projects associated with the plan. Collectively, participating partners can bring a wealth of information and opportunities to the table such as the donation of time, knowledge, material goods, financial support, use of technology or equipment, and much more.

Partners should be encouraged to clearly define at what capacity they are able to participate and their roles annotated within the planning process. Partnerships should include those who help make decisions and those who will be affected by those decisions. An inclusive process increases awareness and understanding of the watershed restoration issues at hand. Collaborative efforts help ensure the environmental, social, political and

Potential roles of partners

- Accounting
- Area Information/Knowledge
- Conflict Mediation
- Funding
- Fundraising
- Grant Writing
- Implementation
- Installation of BMPs
- Legal Expertise
- Long-term Management
- Media Relations
- Monitoring
- Plan Writing
- Potential Partner Contributions
- Project Designs
- Public Education/Outreach
- Public Relations
- Regulations
- Stakeholder Liaison
- Technical Knowledge (GIS, water quality testing, engineering, planning, etc.)

economic concerns associated with water quality impacts are addressed.

Partnerships can be built with a variety of individuals and entities. Some communities have stormwater departments or watershed coordinators who educate the public on stormwater issues and management techniques. Watershed coordinators or managers may sometimes hold a position at town or county offices, local academia, or nonprofit organizations. Some local governments have engineers who can be helpful in the planning and implementation of complex projects. Local cooperative extension programs can assist in public outreach and information distribution. Local Soil and Water Conservation district agents can provide valuable information which will assist in understanding the nature of watershed impairments and in focusing restoration work on the most appropriate areas. Consider reaching out to conservation and educational non-profit organizations in the region.

Developing partnerships with the local and state agencies will form the core project team of restoration efforts and should be contacted and brought on as active members of the project. Although it is good to garner as many partnerships as possible, it is important to identify partnerships that will be integral to the development, implementation, and monitoring of the plan.

Along coastal North Carolina, it will be beneficial to involve the Shellfish Sanitation Section as early as possible in order to coordinate planning and monitoring efforts. Local [Soil and Water Conservation](#) will be helpful in providing area information and history. The DEQ can serve as advisors during planning stages by providing valuable information about local water quality. The local [N.C. Cooperative Extension](#) Service agent can provide help in information distribution. For more suggestions on potential

Potential partners include

- Business Representatives
- Citizen Groups
- Community Residents
- Community Service Groups
- Conservation Groups
- Cooperative Extension Programs
- Engineering Firms
- Environmental Consultants
- EPA Regional Offices
- Federal Agencies
- Fishing and Wildlife Officials
- Government Representatives
- Land Management Offices
- Landowners
- Local, County, and State Agencies
- Non-profit Organizations
- Parks and Recreation Department
- Planning and Zoning Programs
- Planning Councils
- Religious Groups
- Schools
- Shellfish Sanitation
- Soil and Water Conservation Agencies
- Stormwater Department
- Transportation Officials
- Universities and Colleges
- Utility Companies
- Water and Sewer Departments
- Water Quality Officials
- Watershed Coordinator

partnerships in North Carolina see Appendix B and the [Use Restoration Watersheds Program](#).

3.2 STAKEHOLDER INTEGRATION

The stakeholders are all individuals of the community; this includes anyone who would be affected, lives within or is interested in the watershed plan and projects.

Stakeholders are informed on the activities of the watershed plan but do not participate in decision-making processes nor do they hold equal responsibility in the outcomes. Stakeholders will be key to the long-term success of the watershed management plan as stakeholders are often the ones that live within the watershed and experience the effects of a successful management plan. Stakeholders can provide a wealth of knowledge and skills to the management plan.

Not all stakeholders will have equal knowledge about watershed management or hydrology. It will be important to educate stakeholders on the relationship between a community and its watershed as well as to develop a clear, concise and detailed vision of the project.

3.2.1 Stakeholder Outreach

Once partners have agreed to take part in the management plan process, begin organizing stakeholder group meetings. Coordinate which partner would be best suited to contact a specific stakeholder group. Meetings can be informal or formal and should be open to all interested parties, not just those previously identified as stakeholders. The level of decision-making power given to stakeholders should be addressed before meetings begin; some councils allow stakeholders broad decision-making powers while others maintain stakeholders as advisors and supporters with no decision-making power.

Once identified, begin to make contact with stakeholders. It is important to organize an initial meeting with stakeholders in person; arrange the meeting to discuss the importance of the work and the necessity of their support in order to complete the project. It will be advantageous to discuss expected community benefits of the proposed projects such as healthier shellfish and swimming waters along the coast. Positive relationships

Stakeholders skills include

- Accounting
- Advocacy
- Equipment
- Facilities
- Fundraising
- Graphic and Media Design
- Knowledge
- Public Relations
- Technical Support
- Volunteers

Ideas on how to engage with Stakeholders

- Education Seminars
- E-mails
- Listserv
- Local Newspapers
- Meetings
- Newsletters
- Press Releases
- Regular Updates
- Requests for Feedback
- Social Media
- Webpage

are more likely to be forged if stakeholders can perceive direct benefit to themselves, their organization or their community. It may also be useful to distribute a short summary of the proposed project including coastal water quality impairments, general goals of the project and planned meetings or site visits. At initial meetings, it is important to ask attendees to identify any groups they perceive to be stakeholders that are not currently represented.



Any identified stakeholders should be contacted and included in the process.

From the beginning, be clear and honest with stakeholders about what their roles in the process will be. Establishing specific roles and responsibilities early will help reduce confusion and potential conflicts as the project progresses. Stakeholders should be greatly encouraged to attend this initial meeting and voice their opinions. This is also an opportunity to gain intimate local knowledge about the watershed and surrounding communities. For example, longtime residents may know the location of drainage ditches that cannot be seen in aerial photography.

A public information session should be hosted to present the problems within the watershed and to assess goals, needs, and concerns of the community. This session should be used to promote the importance and benefits of the project and get the stakeholders excited and interested in the plan. Community input should be respectfully considered when the project partners reconvenes to draft the restoration plan. Although not all community concerns can be addressed within the scope of the plan, any feasible recommendations should be considered. Remember the importance of honesty and transparency during the stakeholder process and remain open to differing opinions on the issues involved in watershed planning. Conflicts can arise; a plan should be in place for mediating conflicts and fostering an atmosphere of cooperation and collaboration between stakeholders.

Once the plan has been drafted, a second meeting should be arranged with stakeholders. This meeting should be informational in nature, the community should be presented with the finalized watershed restoration plan, but no further input should be elicited. This will likely be the first of several public information meetings that will take place over the life of the restoration. Additional outreach activities should also be conducted in order to keep stakeholders abreast of the progress of the restoration.

3.3 ESTABLISH COMMITTEES

An advisory committee and, if necessary, specialized subcommittees can be established to lead the coordination and project management effort. The committee should be made up of partners and representatives from key stakeholder groups. The responsibilities involved with serving in a committee or subcommittee should be clearly laid out for those interested in participating prior to the selection process. The committee's authority, purpose and scope should be clearly defined before members are selected.

Committee members are charged with ensuring the project stays on tasks, decision making and strategizing direction. The committee should also develop a mission statement that reflects the purpose of the project and reflect that decisions made by the committee should best

serve the mission of the watershed management plan. However broad the representation, do not assign committees responsibilities that are outside member abilities. Allow stakeholders the freedom to be involved in the process as little or as much as they prefer and be prepared to work with partners to determine the level of involvement that best suits their capabilities and interests.

Committees responsibilities can include

- Clearly outlining the mission
- Information Development
- Media Relations
- Monitoring Project Milestones
- Organize Meetings to Update Stakeholders
- Organize Volunteers
- Seek New Partnerships
- Update Local Officials That Are Not Partners

3.4 BUILDING COMMUNITY SUPPORT THROUGH EDUCATION AND OUTREACH

Continued community involvement is essential for project success, educational and outreach messages are one of the most influential ways to establish this connection. Outreach can be used to provide understanding on stormwater, generate excitement about installation and monitoring projects and promote action for restoring the watershed. For detailed information regarding developing an outreach program see Appendix C. Within the nine minimum EPA components, Element 8 focuses on developing information and education components, and is used to:

- Enhance public understanding of the project.
- Encourage early and continued involvement in selecting, designing, and implementing nonpoint source management measures to be put into practice
- To enhance public understanding, create outreach messages, which relate coastal watersheds to stormwater runoff. Tailor messages in ways that clearly represent how

reducing runoff volumes will benefit target audiences while tying in overarching goals and to communicate volume reduction.

- To encourage involvement, provide messages that highlight simple ways others can join project efforts.

There may be preexisting community educational programs that foster water quality protection. Working alongside these programs early on can be beneficial in maintaining outreach efforts within the community.

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3.4.1 Developing an Education and Outreach Program

When developing an education program, follow these six steps:

1. Define outreach goals;
2. Identify and analyze the target audiences;
3. Create the messages for each audience;
4. Package the messages for various audiences;
5. Distribute the messages;
6. Evaluate the Information/Education program.

Detailed step-by-step instruction on how to achieve these six steps can be found in the EPA's [Getting in Step](#) manual for conducting watershed outreach campaigns. The manual provides detailed instruction on how to complete tasks such as analyzing attitude and behavior patterns of target audiences, how to convey information using different mediums, how to develop unique messages, and much more. It is recommended that the *Getting in Step* manual be utilized throughout the outreach development process.

To begin, create outreach and educational goals that are clear, focused, measurable, and specific. This will make it easier to evaluate your program and to track progress along the way. An example

Educational goals can include

- Educate stakeholders and community members about their watershed and how stormwater runoff is generated;
- Encourage involvement in reducing the amount of stormwater entering the waterways;

Outreach mediums include

- Direct Communication with the Homeowners Association
- Displays at Community Events
- Newspaper and Magazines
- Presentations
- Presentations to Appointed and Elected Boards
- Printed Materials (Mailings, Brochures, Factsheets, Posters, and Flyers)
- Radio
- Signage at Project Sites
- Social Media
- Television
- Tours or Fieldtrips to Project Sites
- Website

outreach goal may be to promote behavior changes toward LID and BMPs within the community. Make sure these goals reflect and support the overall project goals. Start by looking at your project goals (discussed in Chapter 4) and then decide how outreach goals can most successfully convey project goals.

Next, decide who educational efforts will target or focus on, refer to stakeholders for insight into what audience should be considered. Consider the demographics of those who live and work within the watershed; for example, homeowners, decision makers, developers, farmers, fishermen, or business owners.



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Figure 3-1. The North Carolina Coastal Federation partnered with students, parents, and teachers at White Oak Elementary School (Left) and with the Town Hall of Cedar Point (Right) to create showcase rain gardens. These rain gardens provide educational displays and encourage Best Management Practices for visitors.

Since watershed planning incorporates environmental, economic, and health-related components, people may be interested in the project for different reasons. Choose messages that are relatable to the intended audience, and emphasize things that will motivate them to take action. For example, highlighting time or cost savings of LID use will be of interest to planners, developers or homeowners building new homes. While promoting cleaner water may resonate with fishermen, tourism-based businesses and residents at large.

Once an educational message and curriculum has been developed, consider mediums that cater specifically to the target audience, since certain groups may be more receptive to phone calls or personal contact rather than to emails or social media. Using public spaces, such as parks, schools, or community centers to present BMP designs is a great way to reach the community. The use of example and display projects such as rain gardens, bio-retention areas, and additional BMP techniques in public spaces can showcase how individuals and businesses can positively influence water quality. Educational signage at these sites is an important educational tool.

Lastly, it is important to evaluate the outreach and education program. Proper evaluation will give an idea of how well the intended audience received messages and if the messages actually achieved their goals. Evaluation should be included in the beginning of outreach planning to make sure insightful feedback is received after messages are delivered. Evaluations will show which aspects worked and which did not. Feedback will enable adjustments to be made to the program to ensure the message is appropriate and meets the goals of the education and outreach program and the project goals as a whole.

Ways to evaluate outreach

- Track participation
- Surveys (before, during and after)
- Interviews
- Commentary and Feedback
- Questionnaires
- Track number of visits to webpage

4 Set Planning Goals and Define the Watershed

The primary goal of creating a watershed management plan is to restore and protect water quality through stormwater volume reduction. Depending on the characteristics of the watershed, additional secondary goals that can be reached may need to be considered. For example, if the community identifies flood control as a secondary concern, it can be addressed through volume reduction as well but should be designated as a secondary goal.

4.1 DEFINING GOALS AND OBJECTIVES

The goals of a watershed management plan should define the desired results. Objectives support goals by defining the actions necessary to successfully achieve a goal. Actions are specific steps that must occur to accomplish each objective. A successful plan will have a list of objectives that clarify how the goal will be achieved. Actions are the specific steps that must happen for an objective to be achieved. Once partners and stakeholders have been identified, their input will be used to develop primary and secondary goals of the watershed management plan.

4.1.1 Primary Goals and Objectives

The primary goal of a coastal watershed management plan to improve water quality through stormwater volume reduction, with specific focus on improving shellfish harvesting and swimming waters. For example, if the watershed has impaired shellfishing waters, the watershed management plan's primary goal would be to improve water quality. Likewise, if the watershed has swimming waters with regular swimming advisories, particularly after storm events, the goal would be to reduce stormwater runoff volume.

Some examples of objectives include

- Develop and maintain community involvement
- Develop and maintain partnerships
- Preserve or improve water quality
- Reducing stormwater runoff volume
- Restore shellfish and/or swimming usage
- Utilize cost effective management strategies

The primary goal should be supported by multiple objectives to define what is necessary to accomplish the goal. An example of an objective is to improve water quality over time so that the existing Shellfish Sanitation shellfish growing areas are reopened. If a TMDL report has been developed for the watershed, the TMDL goals outlined in the TMDL report should also be included in the management plan. It is also important to incorporate any past and current watershed management efforts within the new objectives. If past watershed management plans exist, the goals from that plan should be included or expanded upon. Incorporating already existing plan objectives or goals helps prevent redundancy.

The primary goal of a coastal watershed management plan designed using this guidebook will be to improve water quality through stormwater volume reduction, with specific focus on shellfish harvesting and swimming areas.

The focus of stormwater volume reduction is very encompassing. In order to achieve this, multiple objectives that are specific and measurable need to be developed to determine whether the goal has been reached. Table 1 represents the suggested primary goal and six objectives that should be included in any watershed management plan. The primary goal and objectives should be tailored to the watershed’s needs. These are only suggested objectives and some may not be applicable to the needs of the watershed. For example, a watershed may not have any existing program, in this instance Objective 1 should be removed or replaced with a more applicable objective.

Table 1. The suggested primary goal and objectives of the watershed management plan.

Primary Goal	
Reduce stormwater runoff volume to restore impaired water quality within the watershed.	
OBJECTIVES	
1	Continue existing programs that address water quality impairments in the watershed
2	Determine appropriate water quality classifications and designated uses where water quality impairment exists
3	Reduce the transport of bacteria and other pollutants from land to water by reducing the volume of stormwater runoff
4	Promote/focus stormwater reduction efforts in locations where they yield the greatest and most cost effective stormwater volume reductions
5	Form and maintain partnerships to carry out the plan
6	Evaluate success and modify plan based upon results

These six objectives are steps toward meeting the larger primary goal of volume reduction and are used as a framework for developing a management plan. Each of these six objectives should have sub-objectives, known as actions. Actions are tasks that must be taken to successfully complete the objective.

4.2 INCORPORATE INDICATORS

An indicator is a measurable variable that can be used to determine the condition of water quality. The primary goal of a coastal watershed management plan designed using this guidebook will be to improve water quality through stormwater volume reduction and the

primary indicator will be bacteria. Due to sanitation regulation, the primary water quality indicator that results in shellfish harvest areas being closed is fecal coliform. For swimming waters, water quality is typically measured by a bacterial such as enterococci or E. coli levels. Recall from Chapter 2 the North Carolina bacteria standards (these are also EPA suggested minimum standards):

- **Shellfish Harvesting** fecal coliform cannot exceed 14 colonies per 100mL
- **Recreation (swimming, skin contact)** Enterococci cannot exceed 35 colonies per 100mL

Although other pollutants may be present, they are not monitored as frequently as these two indicators in North Carolina. Due to this, other pollutants should be considered secondary indicators that can be addressed through secondary goals and may be addressed when reducing the amount of stormwater runoff entering coastal water bodies.

Secondary indicators should be quantifiable and the progress of the indicator feasibly monitored as part of the objectives of the secondary goal. Without a way to measure progress for the specific indicator, it will be difficult to know the effectiveness of the management plan. For example, if a secondary goal is to decrease sedimentation in the watershed through stormwater volume reduction, turbidity or total suspended solids (TSS) will need to be monitored. Further examples can be seen in Table 4-1. If there are multiple goals, consider creating a worksheet that emulates Table 4-1 to assist in developing objectives and actions.

Table 4-1. Identifying and linking concerns, causes and indicators. This can be used as a worksheet to help develop project goals.

Issue	Source	Desired Outcome	Indicator
Not suitable for shellfishing or swimming	Bacteria from stormwater runoff	Meet water quality standards for class SA and SB waters	Fecal coliform and enterococci levels, shellfish closure and beach advisory data, waterbody classifications
Eroding banks	High Peak Flow due to stormwater from impervious surfaces	Stabilize banks	Hydrographs, water velocity
Sediment in water	Sediments from stormwater runoff	Attain clear water	Turbidity, TSS



Pause



Now is an excellent time to bring in a partner who has Geographic Information Systems (GIS) technical skills

4.3 WATERSHED LOCATION

A watershed is an area of land that catches precipitation and drains into a marsh, river or stream. They are typically the highest areas of elevation draining to the lowest. By delineating these areas, it becomes easier to determine possible pollution sources since the geographic area that drains into the waterbody. Even though a watershed may be part of a larger regional watershed or river basin, communities and local governments can greatly decrease the volume of stormwater runoff entering coastal water bodies by focusing efforts on smaller watersheds, subwatersheds or catchments.

Utilizing geographic information systems (GIS) early on is an excellent way of managing data. GIS will be a critical component in calculating stormwater runoff reduction volume. It will also ease the processing and analysis of the watershed and spatial information about the watershed. Not all data collected will necessitate GIS usage; however, it is highly recommended that from this point forward until the culmination of Chapter 6 that a partner skilled in GIS be incorporated into the project. Certain aspects of data collection and analysis can be eased by utilizing GIS to create maps that visualize the data.

4.3.1 Hydrologic Unit Codes

Defining the geographical extent of a watershed ensures a focused, efficient and effective management plan. Most federal and state agencies use the U.S. Geological Survey (USGS) categorization of hydrological units to distinguish spatial scopes drainage areas. Some states, such as North Carolina, may also use different codification to define the spatial scope of a drainage area. It is important to know the scale of the project watershed in relation to USGS categorization and state categorizations to determine whether preexisting management plans are available, whether there is preexisting data and research on the watershed, whether TMDL studies has been developed and whether unique funding exists for watersheds that are part of a specific drainage area.

The United States is divided into 21 major geographic drainage regions. Each major drainage region contains multiple basins that are subdivided into successively smaller hydrologic units in the following order: region, sub-regions, basins, sub-basins, watersheds and subwatersheds. A unique USGS hydrologic unit code (HUC) defines a hydrologic unit. There are six levels of designation nested within a full 12-digit HUC: region (2-digits), sub-regions (4-digits), basins (6-digits), sub-basins (8-digits), watersheds (10-digits) and subwatershed (12-digits).

The USGS standard coding system defines watershed drainage areas and allows for cooperation and mutual understanding between agencies in regard to boundaries, landscape functions and water quality impairments. The 12-digit subwatersheds typically drain areas from five to 10 square miles, this guidebook was designed to focus on watersheds that are smaller than the USGS 12-digit watersheds. Due to the small-scale scope that the methods of this guidebook favors, the watershed the management plan is being developed for will likely not have its own HUC digit. The USGS often refer to watersheds that are smaller than the 12-digit HUC watersheds as catchments. Figure 4-1 is a pictorial representation of the scale of an example project site in relation to the 12-digit watershed.

In North Carolina, both the USGS HUC system and a river system based categorization is used. The state specific system relies on categorizing based on major river basins. North Carolina contains [17 major river basins](#), which it designates by the name of the major river (i.e. Cape Fear River Basin, White Oak River Basin). These river basins do not coincide with USGS 6-digit HUC basin designation and often have multiple HUC designations. Knowing the river basin that the watershed is part of will help with understanding the geographic, geologic, biologic and historic background that will impact the decisions made in the management plan. Watershed management plans may qualify for unique funding, resources or technical assistance through the [Water Quality Management Planning Grant in North Carolina](#) or through the [Regional Council of Governments](#) depending on the river basin the watershed is within.

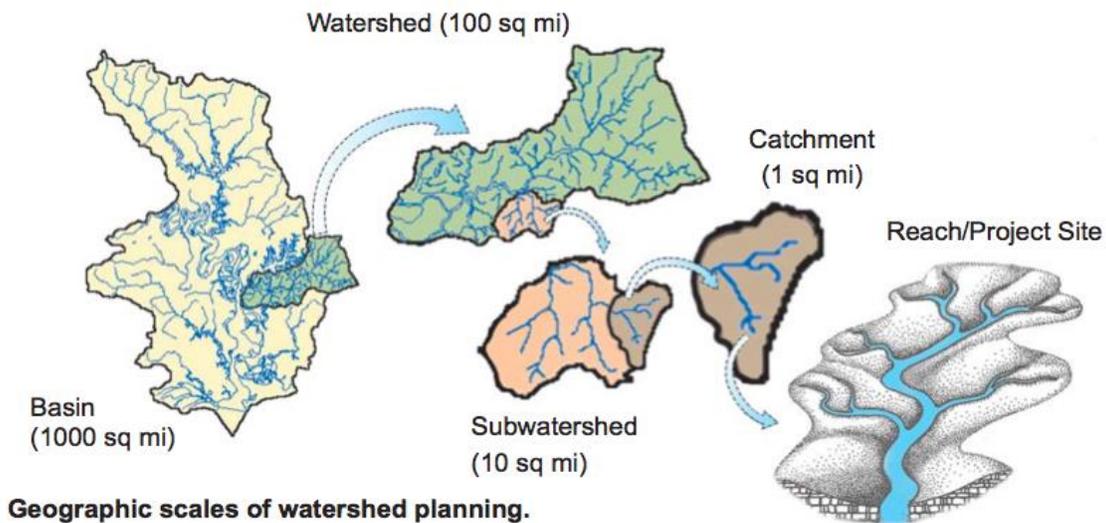


Figure 4-1. Diagram of the geographic scales watershed plans can encompass. This guidebook favors small-scale watersheds or catchments. Courtesy of the State of [New York's Guidebook for](#)

Pause It is possible to determine the 12-digit HUC by utilizing the instructions in:

Section 4.3.2 Using MyWATERS Mapper to Determine HUC Information
OR

Section 4.3.3 Using GIS to Determine HUC Information

Section 4.3.2 does not require GIS software or skills, while Section 4.3.3 requires GIS software and skills to complete. It is not necessary to do both sections, although data within each website will be beneficial later in Chapter 5. As such, it is beneficial to read through each section.

[Watershed Plans to Protect and Restore Water Quality.](#)

4.3.2 Using MyWATERS Mapper to Determine HUC Information

The most direct way to determine a watershed's 12-digit HUC is via the EPA's [MyWATERS Mapper](#). The MyWATERS Mapper is a dynamic interface that displays EPA Office of Water program data for the entire United States. In addition to determining HUC information, MyWATERS Mapper can be used to collect data on the watershed, which is described in further detail in Chapter 5. The interface can provide a plethora of information including: water

impairment information, water monitoring data, TMDL information, NPDES permit facility locations and more.

The following instructions are to determine the 12-digit HUC using MyWATERS Mapper.

1. **Access [MyWATERS Mapper](#).**
2. **Find the community and watershed.** Use the navigation functions on the left-hand side of the webpage to zoom to the area the watershed is located (see yellow box in Figure 4-2). Alternatively, use the **Go To** search function on the left-hand side to enter either the state, zip code or address of the community or watershed (see orange box in Figure 4-2). Use the navigation tools or panning option (Left-clicking on the mouse and dragging it across the screen) to center the watershed. Zoom in as much as possible so that the entire watershed is visible.
3. **Turn on the Watershed Boundary layer.** Once zoomed to the area of interest, expand the **Other EPA Water Data** dropdown menu located on the right-hand side of the screen (see red box in Figure 4-2). Check the box next to **Watershed Boundaries (WBD)**.

Note The MyWATERS Mapper sometimes takes a moment to load. Be patient and allow the watershed boundaries time to render.

4. **Determine 12-digit HUC.** Click within the purple boundary that surrounds the watershed. A popup window will appear displaying the 12-digit HUC and watershed name. Refer to this HUC and/or name throughout out planning process to designate the project location. See Figure 4-2 for an example of a search of a watershed in Beaufort, North Carolina.

Note If the HUC does not have 12-digits then the map is likely not zoomed in enough. Zoom in to the maximum extent possible while still being able to see the watershed end point, where all of the waters of the watershed converge (likely at the mouth or confluence of a stream).

5. **Manage data.** It is critical to manage data that is collected appropriately. Determining the 12-digit HUC will be the start of a substantial data collection that will be developed for the watershed over the course of the coming chapters.

Note One way to manage files is to develop a spreadsheet of the data collected and the file names and paths associated with the data.

6. **Explore.** Expand the other drop down menus on the right of the map and explore the additional information that can be found for the watershed. The additional information will be collected and revisited in Chapter 5.

Note The Water Impairments for 'pathogens' in North Carolina is incomplete. Refer to N.C. Shellfish Sanitation impairment data to obtain more comprehensive dataset.

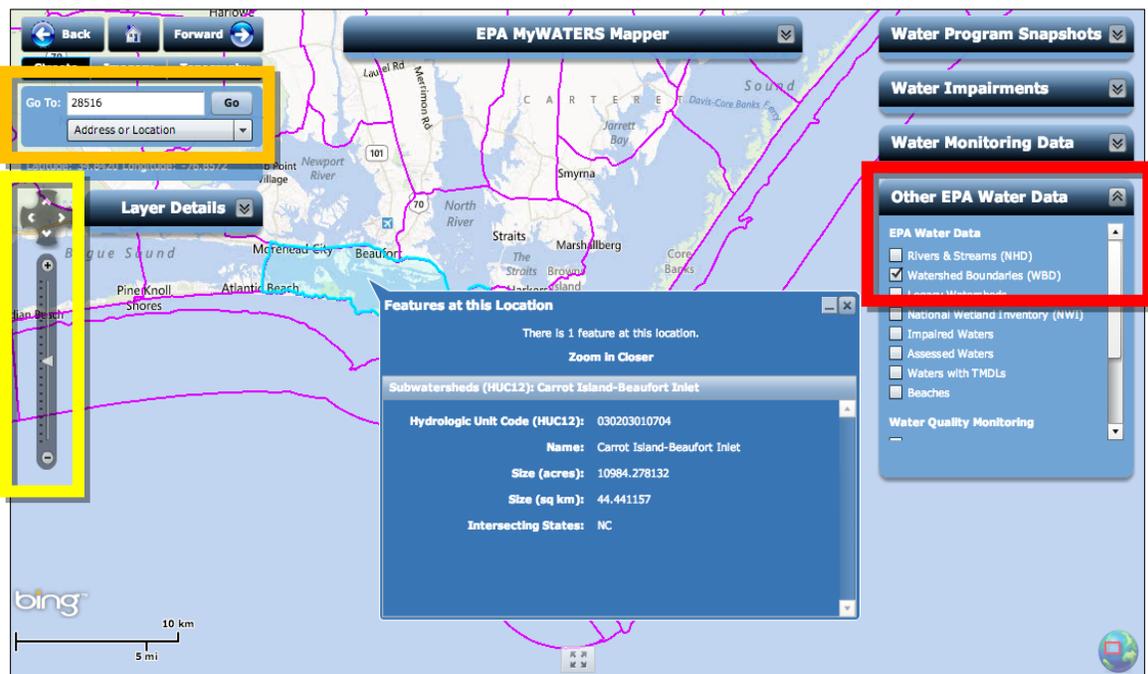


Figure 4-2. EPA MyWATERS Mapper results for 12-digit HUC watershed. The yellow box outlines the location of the navigation tool, the orange box is the location of the address search tool and the red box shows the box to check to turn on the watershed boundaries.

4.3.3 Using GIS to Determine HUC Information

To utilize GIS software to determine the 12-digit HUC information, the USGS maintains a user-friendly [Watershed Boundary Dataset](#) through the [Geospatial Data Gateway](#). The datasets represent the nationwide drainage network and include the geographic extent of the 12-digit HUC watershed. Additionally, the Geospatial Data Gateway has datasets on precipitation, temperature, existing easements, elevation, geology, hydrography, land use and land cover, and soils by state and county. To minimize extraneous data searching by county is the most ideal option. It is important to note that some watersheds can be part of multiple counties and it may be necessary to search Geospatial Data Gateway by multiple counties. The benefits of utilizing GIS at this time is that initial spatial data collection can begin. GIS users can begin downloading datasets early on and begin file management to maintain the collected data in an organized manner until it is used in Chapter 5. Use the following steps to obtain GIS compatible datasets to determine the 12-digit HUC and HUC boundaries:

1. **Access [Geospatial Data Gateway](#).**
2. **Navigate to data link.** On the bottom right-hand corner of the page, under *I Want To...* select *Order by County/Counties*.
3. **Select the state.** In the center of the page, select the state.
4. **Select the county.** Select county(s) of interest and add them to the Selected Counties list by clicking the >> right arrows. Click *Submit Selected Counties* button.

Note Some watersheds may fall into multiple counties.

5. **Find HUC data.** In the center column, scroll down to Hydrologic Units and check the box next to *12 Digit Watershed Boundary Dataset in HUC8*. At the bottom of the center column (with the page scrolled to the bottom), select the green button that says *Continue*.
6. **Request the data** in the appropriate file types. Note: Typically, this would be an *ESRI Shapefile* format, projected in the format most commonly used in the state, for North Carolina that is *State Plane North Carolina NAD83*.
7. **Unzip data.** Once the files have been requested and downloaded, the files must be unzipped before being uploaded into the GIS software environment ESRI ArcMap.

8. **Attribute table.** Data regarding 12-digit HUC will be found in the attribute table of the shapefile. The information can also be found by using the *Identify Tool* in the Tools toolbar clicking within the polygon the watershed is located.

Notice

From this point forward, GIS instructions will be written to accommodate the use of ESRI ArcMap software environment. ArcMap is one of the most commonly used GIS environments in academia and the public sector. Those who prefer other GIS software environments will need to adjust their methodology.

4.4 HOW TO DELINEATE A WATERSHED BOUNDARY

Watershed delineation will determine the full geographic extent of the watershed. A variety of methods exist to delineate a watershed by using GIS software or by using online platforms. Of these methods, using an online platform is the most user friendly and convenient way to perform a watershed delineation.

The [USGS StreamStats](#) website links to a dynamic interface map for each state. At this time, some states are not part of StreamStats; in this instance, refer to Appendix D for alternative ways of delineating a watershed. In addition to watershed delineation, StreamStats can calculate estimates peak flows and provide stream gage information.

This section will guide you step-by-step how to use the StreamStats interface to draw a watershed boundary.

1. **Access [USGS StreamStats](#).**
2. **Select by state.** Use the drop down menu at the top of the page to choose a state OR use the map at the bottom of the page to select a state. Once a state is selected, the state's StreamStats page will open.

Note At this time, some states are not part of StreamStats; in this instance, refer to Appendix D for alternative ways of delineating a watershed.

3. **Open the Interactive Map.** Scroll to the down on the state's StreamStats webpage. Towards the bottom there will be a link titled *Interactive Map*. Select the link to open the map. Once selected, a new window will open to the state's StreamStats application. A secondary pop-up window may open notifying the user of what version of the

program is running, this window can be closed.

4. **Find the watershed.** Use the navigation tools in the toolbar located in the upper left corner of the map (see Figure 4-3).



Zoom In
Pan
Zoom Out

Identify
Gage Info

Figure 4-3. Streamstats navigation tool bar.

5. **Set the scale.** Utilizing the zooming and panning tools, zoom to the drainage outflow point of the watershed (the location where all water drains). Zoom in until the **scale is 1:24,000** or smaller. The scale is located on the left column above the extent map (see Figure 4-4). Once at this scale, blue vector lines will appear representing streams.

Note At this point the entire watershed will likely not be visible and this is not an issue. The key to focus on the drainage point in this step.

6. **Delineate.** Using the **Delineate Watershed from a Point** tool (see yellow box in Figure 4-5), click directly on the **blue vector** for the creek (see red box in Figure 4-5). Since the tool draws the boundary of the

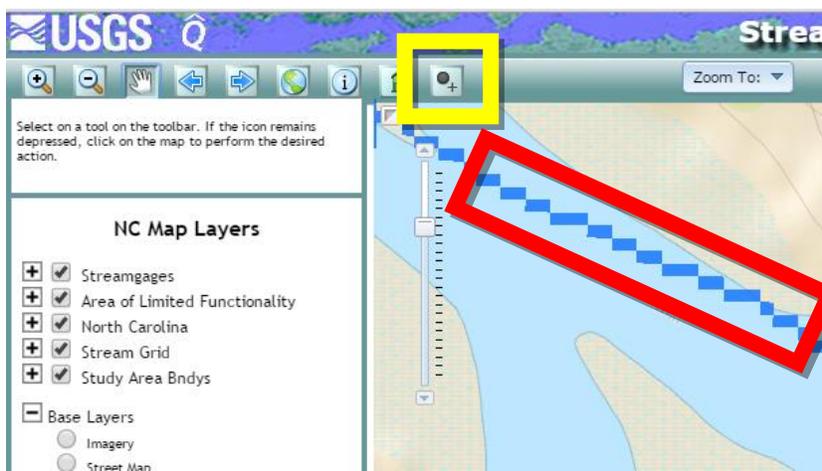
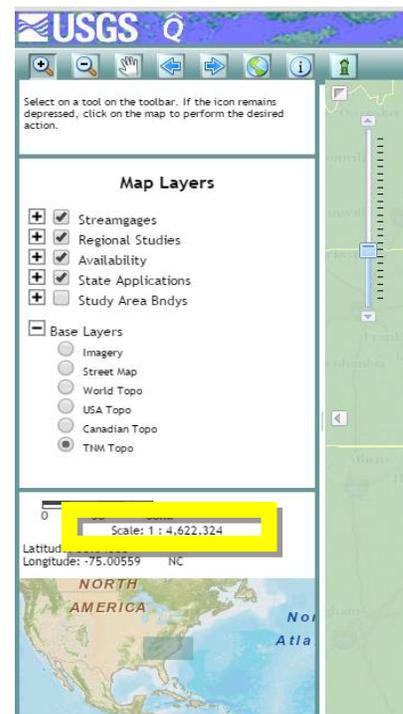


Figure 4-4. The yellow square depicts the “Delineate Watershed from a Point” tool. The red box depicts the blue vector line that represents the stream. Click anywhere along the stream near the drainage area of the watershed.

watershed upland (landward) from the point selected, click, it is critical to click the tool on a location toward the mouth of the creek (seaward). When the watershed is done rendering it will automatically zoom out and the entire watershed will be highlighted on the map.

Note For further clarity zoom to the scale of 1:10,000 to more accurately control the drainage point being selected. Select only once, clicking multiple times will result in the map attempting to restart the rendering of the watershed. It may take a few minutes for the watershed to render. If the pop-up window that says Delineation Results says that it is completed but the map has not zoomed out and the watershed is not highlighted, this likely means that a point along the blue stream vector line was not correctly selected. Attempt to reselect and move the cursor a few pixels above or below the original selected location.

7. **Download the watershed.** Once the watershed has rendered, the extent will automatically zoom to show the entire watershed and a *Delineation Results* window will be visible. The bottom left corner will have three icons, select the third icon to **Download** the data (see red box in Figure 4-6). Once the Download icon is selected a pop-up window will appear. Select *Shapefile* then select the **Download button**. Watershed will download as a zipped file; this may take a few minutes. Unzip the folder before using the shapefile in ArcMap. Save the watershed shapefile, it will be used later in Chapter 6.

Note The first two icons, *Compute Basin Characteristics* and *Compute Flow Statistics* (see yellow box in Figure 4-6), will provide insightful information regarding the watershed's characteristics that can be incorporated into the watershed management plan. Once the icons are selected pop-up windows will appear, after a few minutes of processing, the results will appear in these windows. Save or print these results.

8. **Print.** Print the webpage or digitally save (using the computer's Print Screen command) so that there is a visual frame of reference that can be used while collecting data in Chapter 5. This is highly recommended unless a map of the watershed was created using ArcMap by the GIS specialist.

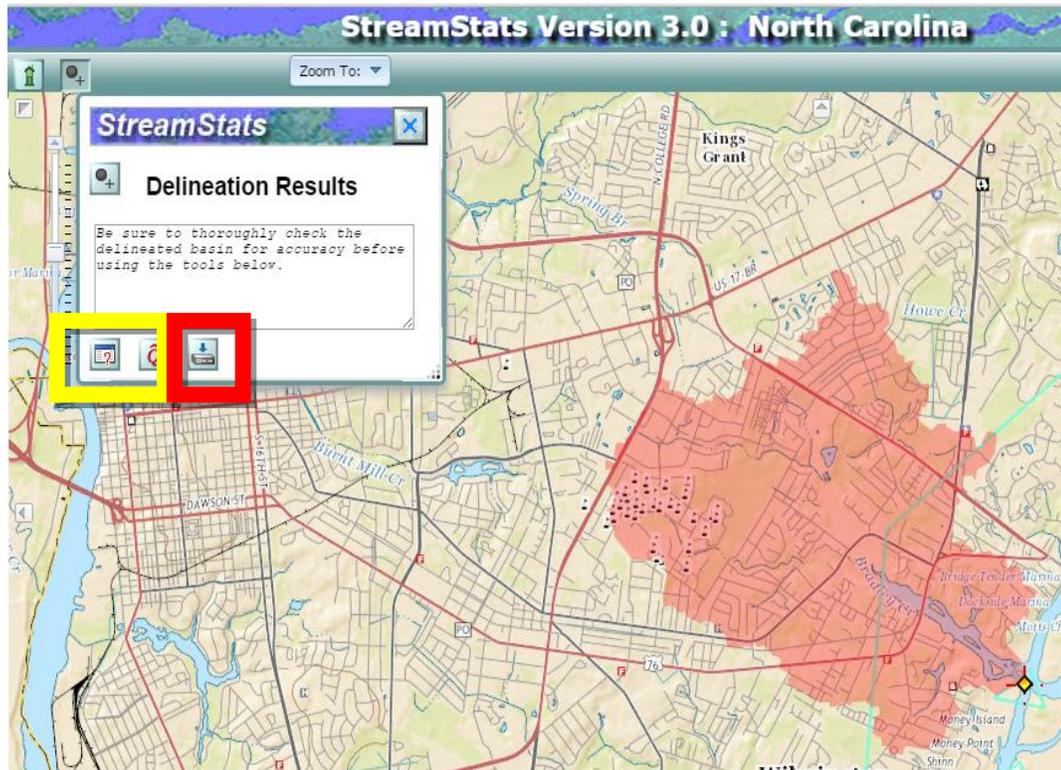


Figure 4-6. The yellow square depicts the “Compute Basin Characteristic” and “Compute Flow Statistics” tools. The red square depicts the “Download” tool.

5 Gathering Data and Creating a Watershed Inventory

Research must be conducted to characterize the watershed in order to become familiar with the activities and related pollutants of the area. The data described below will aid in determining the overall stormwater runoff volumes. Chapter 6 contains a detailed procedure on how to calculate stormwater runoff levels. In order to effectively assess the needs of the target watershed, the baseline water quality and watershed information must be determined. Many state, federal, and local agencies have established monitoring sites and have detailed data publically available. Although a vast amount of data may exist for the target watershed, only some will be pertinent to achieve the flow reduction goals of the watershed management plan. All other information will be necessary in determining management strategies discussed in Chapters 7 and 8.

5.1 INITIAL RESEARCH

By this point, certain information such as the main waterbody of the watershed, the 12-digit HUC and the geographic boundary of the watershed (see Chapter 4) should be known. The waterbody's state and federal classification should also be known (see Chapter 2).

In addition to determining HUC information, MyWATERS Mapper can be used to collect data on the watershed, including water impairment information, water monitoring data, TMDL information, NPDES permit facility locations, and more.

Use GIS to determine the classification of a North Carolina waterbody by downloading the [Water Quality Classification](#) shapefile

OR

Use [N.C. Surface Water Classifications](#) dynamic map interface by zooming to the main waterbody of the watershed and then clicking directly on the waterbody. A pop-up box will appear with classification information.

The following instructions are to determine the Impairment status using MyWATERS Mapper.

1. Access [MyWATERS Mapper](#).
2. **Find the community and watershed.** Use the navigation functions on the left-hand side of the webpage to zoom to the area the watershed is located (see yellow boxes in Figure 5-1). Alternatively, use the **Go To** search function on the left-hand side to enter either the state, zip code or address of the community or watershed (see yellow boxes in Figure 5-1). Use the navigation tools or panning option (Left-clicking on the mouse and dragging it across the screen) to center the watershed. Zoom in as much as possible so

that the entire watershed is visible.

3. **Turn on information of interest layers.** Once zoomed to the area of interest, expand the **Other EPA Water Data** dropdown menu located on the right-hand side of the screen (see red box in Figure 5-1). Check the boxes next to all information categories deemed relevant to the watershed. Expand the **Water Impairments** dropdown menu and do the same to explore sediment, nutrient, and pathogen impairment issues. Expand the other drop down menus on the right of the map and explore the additional information that can be found for the watershed.

Note The MyWATERS Mapper sometimes takes a moment to load. Be patient and allow the watershed boundaries time to render. Some states do not have completed information on MyWATERS Mapper. For example, the Water Impairments for 'pathogens' in North Carolina is incomplete. Refer to N.C. Shellfish Sanitation impairment data to obtain more comprehensive dataset.

4. **Select the main waterbody.** Click along a segment of the main waterbody of the watershed. A pop-up window will appear displaying the report(s) available for that waterbody.

Note It may be necessary to do these steps multiple times for the same waterbody because some waterbodies only have impairments or reports available for certain segments. For example, some streams may be more impaired upstream than they are downstream due the areas tidal and inundation patterns.

5. **Access reports.** To access the reports, select each feature within the pop-up window that has appeared. Each feature will have a **Get More Details on this Feature** button. Select these buttons to automatically open a new webpage with further details and reports. Information within these reports should be analyzed and key information such as: **water impairment information, water monitoring data, locations of water monitoring stations** (including the name of the agency responsible for it and station number), **TMDL information, NPDES permit facility locations** and other data that appears relevant to the watershed planning process should be recorded. This information will be incorporated into the watershed management plan as part of the preliminary research of the watershed.

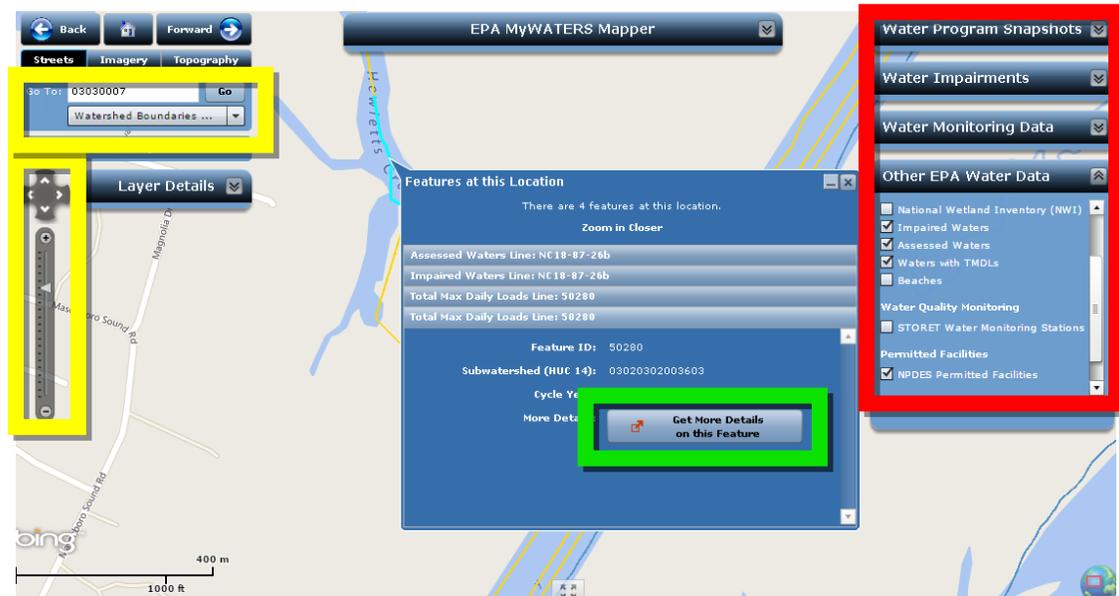


Figure 5-1. EPA MyWATERS Mapper results. The yellow boxes outline the location of the navigation and address search tools. The red box shows the exploratory information to select. The green box shows the button to select to get more information including detailed reports regarding the information of interest.

By now the following data should have been collected

- Identify the main waterbody of the watershed
- Watershed boundary (delineate the watershed Section 4.3)
- 12-Digit HUC (Section 4.3)
- State water quality classification (Chapter 2)
- Federal water quality classification (Chapter 2 and MyWATERS Mapper)
- Impairments (Chapter 2 and Section 5.1, using MyWATERS Mapper)
- TMDL information (Chapter 2 and Section 5.1, using MyWATERS Mapper)
- NPDES permitted facilities (Chapter 2 and Section 5.1, using MyWATERS Mapper)
- Water monitoring stations (Section 5.1, using MyWATERS Mapper)
- State basin or watershed (if applicable, Section 4.3)
- 303(d) and 305(b) Reports (Chapter 2)

5.2 DATA MANAGEMENT

Naturally, as a watershed management plan develops, research is done to answer questions that arise while developing any sort management plan. It is important to manage and organize research and data collected. An inventory should be kept and updated regularly as new data is acquired. Data management will ensure that the research that is collected is addressing the needs of the plan and is not extraneous. It will also ensure that duplication is avoided, ensure completeness, and increase efficiency. These aspects of data management ensure that valuable time and resources are not wasted. Data management is especially important from a GIS perspective, where quality is imperative to the accuracy of the data being geospatially analyzed.

Collected data should be electronically stored with file names and file paths that make sense to the individuals using the data. If necessary, a separate file should be kept that codifies and explains any unique acronyms or naming system that is developed. A separate document or spreadsheet should be developed that catalogues metadata. Metadata is data that gives a standardized, descriptive context to the researched data. Metadata allows for resource discovery by enable data to be found based on relevant criteria without having to open each individual data source. Table 5-1 describes the data category and the accompanying metadata that should be catalogued.

Table 5-1. Data categories and the accompanying metadata that should be catalogued.

<p>Tabular Datasets</p>	<ul style="list-style-type: none"> • Topic (monitoring, geographic, etc.) • Source of data (agency) • Number of monitoring stations • Collection start date • Collection end date • Number of samples/observations • Parameters • Frequency • Known quality assurance issues with the data • Special comments/notes • File name • File Path
<p>Reports and Anecdotal Information</p>	<ul style="list-style-type: none"> • Topic (monitoring, geographic, etc.) • Document title • Date

	<ul style="list-style-type: none"> • Source/Author • Description • Web site (if applicable) • File name • File Path
GIS Data	<ul style="list-style-type: none"> • Topic (land use, soils, station locations, etc.) • Data format (shapefile, GDB, DEM, Raster, etc.) • Source/agency • Date (date or original date coverage is based depicting) • Data Resolution • Projection (UTM, state plane, etc.) • Description • File name • File Path

5.2.1 Data Theme

From an organizational perspective, it may be beneficial to further categorize and consider data by the theme that it addresses. There are five themes: physical and natural properties, land use and population characteristics, waterbody and watershed conditions and pollutant sources (Table 5-2). Physical and natural properties include watershed boundaries, hydrology and wildlife data. Land use and population characteristics consist of information about how people have changed the land and include land use and demographics. Water conditions are the physical and chemical properties of the water itself and include water quality standards such as pH, nitrogen, phosphorous, and temperature. Pollutant sources are all point and nonpoint sources that are in existence.

Table 5-2. Themes of potentially useful data for establishing initial research for a watershed management plan (Adapted from EPA Handbook for Developing Watershed Plans to Restore and Protect Our Waters, 2008).

<i>Data Themes</i>				
Physical and Natural Properties	Land Use and Population Characteristics	Waterbody and Watershed Conditions	Pollutant Sources	Waterbody Monitoring

1 yr./ 24 hr. storm	Aerial photography	Impairments	Point sources	Biology
Habitat	Demographics	303(d) and 305(b) report	Nonpoint sources	Flow
Hydrology	Existing management strategies	Source Water Assessments		Geomorphology
Soils	Land use	TMDL report		Water quality
Topography	Development trends	Water quality standards		
Watershed boundaries				
Wildlife				

5.3 ANALYSIS DATA REQUIREMENTS

Conventional methods rely on peak flow storage but do not mitigate pollution from reach coastal waterways. This guidebook utilizes storm water reduction volume and mimicry of natural hydrology to reduce the amount of stormwater runoff and reduce pollutant loads. Overall stormwater runoff reduction volume is calculated using geospatial analysis and requires the following data sources:

1. ***Watershed boundary (see Section 4.4)***
2. ***Baseline year***
3. ***Current and historical aerial photography***
4. ***Parcel Data***
5. ***Zoning Data****
6. ***Hydrologic Soil Group (HSG) data***
7. ***1-year, 24-hour depth storm model***

*If the information is not included in the Parcel data.

At this time, the focus will be on collecting these datasets in file formats that are usable in ArcMap.

5.3.1 Baseline Year

Stormwater runoff reduction volume goals are calculated based on the land use changes before and after (or, presently) the water body was deemed impaired; as such, any year can be used as a baseline year. Determining what year to use as a baseline is based on the objectives of the watershed. The stormwater runoff reduction goal will aim to mimic the water quality of the baseline year.

Ideally, the true baseline year would be the year prior to first development within the area. Unfortunately, this is often not feasible as a baseline year as aerial photography or data may not exist this far in the past. Typically, the last year that the water body was considered unimpaired should be considered the baseline year.

For example, if the stream was determined to be impaired for its designated use in 2005 then the year prior (2004) would be considered the baseline year.

If the watershed is not considered impaired by state or federal agencies and aerial imagery from 1975 or later does not exist, the watershed management plan goals should be used to devise a baseline year. For example, if one of the goal objectives is to have less swimming advisory notices, research the history of the watershed and determine a time period when swimming advisory notices were consistently not an issue and utilize the earliest year as the baseline year. If the goal is to reduce stormwater runoff discharge in an unimpaired watershed, research stream gage data to determine a consistent period where flow rate discharge was significantly less than present day discharge. Due to limited data availability, it may not be possible to obtain data on pristine water conditions. Instead, baseline information is often taken from a year in which water quality was higher than present levels.

Information may be found through the EPA [STORET](#) database for ground and surface water quality data. This includes data for water quality and biological and physical parameters. The EPA [Watershed Assessment, Tracking & Environmental Results System \(WATERS\)](#) includes an interactive map and web services to perform analysis on data. Additionally, [federal level beach monitoring](#) can give insight into the quality of nearby waters. State shellfish sanitation, water resources, and water quality agencies can provide a wealth of information to help determine what an ideal baseline year would be



for the watershed based on the goals and objectives.

In North Carolina, N.C. Shellfish Sanitation can provide current and historical information on coastal waterways (see Chapter 2 for more information). The primary pollutant monitored by N.C. Shellfish Sanitation is fecal coliform. They also conduct shoreline surveys ground truthing potential pollution sources and maintain detailed and extensive records of water quality on coastal waters across North Carolina (Figure 5-3). Many of these reports are now available through the [North Carolina Library's Digital Collections](#).

Note Upon completion of Section 5.3.1, the following data should be collected:

- Baseline Year

5.3.2 Aerial Photography

Aerial photographs called orthoimages, which are aerial photographs that are geometrically scale corrected, will be used to infer land use changes over time by approximating the amount of impervious surfaces at a given location (Figure 5-3). They can also be used to show the progression of development through time.

It is important to obtain aerial photographs from before significant impairment occurred in the watershed, present day and time periods in between. Older imagery can be difficult to obtain or use, so adjustments or assumptions may need to be made using the best available data. From the orthoimagery a before-after comparison can occur that will represent the overall stormwater runoff volume reduction goal. Including time steps in between the baseline year and present day will make it possible to develop interim stormwater runoff volume reduction goals. Time steps should range between every two to five years depending on the number of years between the baseline year and present year. Additionally, if it is known that the area has seen extensive development during a certain time period, time steps of every two to three years are ideal to create interim reduction goals. It is possible to only calculate an overall stormwater runoff volume reduction goal; however, it is strongly recommended that at least one additional year between the baseline year and current year be used.

Figure 5-2. An example of the detailed water quality maps maintained by N.C. Shellfish Sanitation.

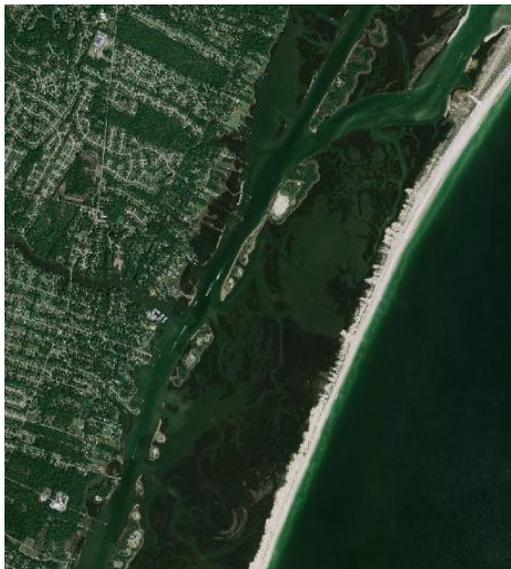


Figure 5-3. Orthoimagery of Masonboro Sound and creeks in New Hanover County, NC obtained from The National Map.

Typically, orthoimagery and other GIS data can be found at state or county GIS offices. In North Carolina, [NC OneMap](#) maintains a robust orthoimagery catalogue. At the national level, the USGS maintains a variety of orthoimagery through [The National Map](#). The [Army Corps of Engineers](#) maintains extensive historic aerial photographs; however, the images will likely need to be georeferenced, which is not suggested without extensive GIS knowledge.

When selecting orthoimagery files, ensure that the image files fully cover the entire watershed. Refer back to the watershed boundary image that was printed or saved from Section 4.4. The file format extension (GeoTIFF, IMG, etc.) is not an issue if the aerial photograph is georeferenced properly. This can be done by reviewing the metadata associated with the image and ensuring that it maintains the same projections as the rest of the geospatial data being collected. It is important to take into consideration data quality; ideally, images should be usable at a scale of 1:24,000 or finer to see detailed changes in land use.

Note Upon completion of Section 5.3.2, the following data should be collected:

- Aerial photography from the baseline year or earlier
- Aerial photography from the present year (or most recent available imagery)
- Aerial photographs from time periods between the baseline year and present year (at least one additional year)

5.3.3 Parcel Data

Parcel datasets are vector files of local boundaries of property lots and accompanying attribute information of the lots. Parcel data is used to determine right-of-ways and boundaries in the stormwater runoff reduction volume calculations. This information is available at the county level, often through the county GIS department, but is not always free of cost. Some town and city agencies may maintain parcel maps as well through their planning or GIS department. Some counties or local agencies have this information available through their town or county websites, others will require contacting their department to request the data. Parcel data is often in shapefile or geodatabase formats. When Parcel data is found, it is important to check the attribute table to determine if the table contains zoning information. If the parcels layer does have zoning information, it is important to contact the local agency who the data was sourced from to get a key or guide that can distinguish what zoning codes mean. For example, some zoning information is presented by acronyms like CB for commercial business or R5 for Residential Rural Low lot.

Note Upon completion of Section 5.3.3, the following data should be collected:

- Parcel dataset
- Zoning code guide or key document

Check Review the parcel dataset's attribute table and see if zoning information is already included within the parcel dataset. If zoning data is included, then it will not be necessary to search for Zoning Data as described in Section 5.3.4

5.3.4 Zoning Data

Zoning datasets are vector files of local boundaries of property lots and the authorized land usage classification for those lots. Typically, zoning information will be part of the attribute information included in the parcel dataset. In some instances, zoning data is not included in Parcel datasets, in this instance it will be necessary to obtain a zoning dataset. Zoning data is used to develop a basic categorization between residential and commercial lands to determine the stormwater runoff reduction volume calculations. This information is available at the county level, often through the county GIS or planning department, but is not always free of cost. Some town and city agencies may maintain zoning datasets as well through their planning or GIS department. Some counties or local agencies have this information available through their town or county websites, others will require contacting their department to request the data. Zoning data is often in shapefile or geodatabase formats. It is important to contact the local agency who the data was sourced from to get a key or guide that can distinguish what zoning codes mean. For example, some zoning information is presented by acronyms like CB for commercial business or R5 for Residential Rural Low lot.

Note Upon completion of Section 5.3.4, the following data should be collected:

- Zoning dataset (If this information is not included in the parcel dataset)
- Zoning code guide or key document

5.3.5 Soils

Soil data are an important component of thorough watershed modeling. It is useful for determining water infiltration rates and the amount of runoff that is occurring. Soils are grouped into hydrologic soils groups (HSG) according to their infiltration potential. Four hydrologic groups (A, B, C, D) exist with progressively increased infiltration potential; soils classified under Group A have the highest infiltration potential, while soils classified under Group D have lowest infiltration potential.

Many counties have data pertaining to soils through their GIS department. If data is sourced from county or local sources, ensure that the vector file format type is a shapefile or geodatabase. Review the dataset's attribute table to ensure that HSG categories have been designated.

If the county does not have HSG categories or if they do not have soil datasets available, then data can be downloaded through the USDA Natural Resource Conservation Service (NRCS) using a variety of methods. The following methods can be used to obtain soil data:

- (1) Utilize the ArcGIS add-on platform [Soil Data Viewer](#), created by the USDA NRCS. The add-on platform must be downloaded and installed within ArcGIS and the NRCS provides an [extensive guide](#) on how to do this. Spatial and tabular data

must then be downloaded from [Web Soil Survey](#) or the [Geospatial Data Gateway](#).

Note This method is beneficial if there is a need for extensive soil information beyond the soil taxonomy and HSG. This method can be time consuming. There can also be issues with the add-on rendering data if there is not enough data available for the search area.

- (2) Utilize [Web Soil Survey](#) to download a soil vector file and manually input the HSG categorizations into the attribute table. See Appendix E for detailed instructions on how to do this.

Note Upon completion of Section 5.3.5, the following data should be collected:

- Soil dataset

5.3.6 Storm Model Depth

The depth of a 1-year, 24-hour storm model in inches is necessary to quantify the amount of rain that will inundate the watershed that will be used to determine the stormwater runoff reduction volume. The model represents the depth of precipitation in a storm that occurs, on average, once a year and lasts 24-hours. The 1-year, 24-hour storm event is used because it has been established the maximum storm parameter possible to protect shellfishing waters (Class SA) in North Carolina by DEQ.

Other states may have stricter standards, in this event use the watershed's state standards. If the standards are less strict, use the 1-year, 24-hour storm parameter for best water quality goals.

Precipitation frequency can be found at NOAA National Weather Service [Precipitation Frequency Data Server](#). The following methods can be used to determine precipitation frequency:

1. **Access [Precipitation Frequency Data Server](#).**
2. **Select the state.** Using the interactive mapping platform select the appropriate state. A new website window will automatically open for that state.
3. **In the data description section at the top of the page, select "Precipitation Depth"**

4. **Find the watershed.** Utilize the zoom tools in the bottom right of the map and the pan tool to navigate to the watershed.
5. **Find the outflow point.** Grab and drag by holding down the left mouse button OR double click to center the crosshair marker at the desired outflow point. The crosshair marker should be placed at the approximate location that the end of the watershed were all water flows out.
6. **Reading the results.** Once the crosshair marker has been placed, a table will automatically render below the map. Find the 1-year (first column), 24-hour (10 row) results. Save the precipitation depth estimate.
7. **Print.** Print the page or print to PDF utilizing the *Print Page* button on the upper right corner of the table.
8. **Repeat.** Repeat these instructions for a 2-year, 24-hour storm model, which is required for *Watershed EZ tool*.

Note Upon completion of Section 5.3.6, the following data should be collected:

- Precipitation depth of a 1-year, 24-hour storm model (in inches)
- Precipitation depth of the 2-year, 24-hour storm model (in inches)

5.4 SOURCE ANALYSIS DATA

After the stormwater runoff volume reduction has been calculated in Chapter 6, it will still be necessary to analyze the results to develop the coastal watershed management plan in Chapters 7. Additional, non-GIS and GIS data will be necessary to develop appropriate action strategies. These include consideration of data regarding:

1. *Land management*
2. *Pollutant sources*

5.4.1 Land Management Practices

Determining existing land use management practices is an important consideration as it can help to categorize current watershed threats and assist in the identification of management strategies that may work within the watershed. Land use management practices may take the

form of: state and [federal laws](#) and regulations, stormwater projects, resource management plans and legal agreements, such as environmental easements. Land use management practices ensure that issues like erosion, deforestation, loss of cultural heritage, loss of biodiversity and loss of watershed function do not occur. Public lands are generally managed through a Bureau of Land Management (BLM) [Resource Management Plan](#) (RMP).

States and local communities both have regulation regarding land management; these regulations are often found within agencies that manage zoning, planning, and land use. Land management regulation can be complex and often times state and local regulations overlap; it is strongly encouraged to develop partnerships with local planning and land use agencies to assist in navigating through local land management practices, local issues associated to land management and how these practices can be improved to enhance the watershed.

Environmental easement, which is a legally binding agreement in which a landowner agrees to give up certain rights for development or other activities on their land, have grown in popularity over recent years. It is important to consider the incorporation or expansion of environmental easements in a watershed management plan as forms of mitigation and buffers to connected impervious surfaces. [Environmental easement](#) boundaries are available through the USDA, the [Geospatial Data Gateway](#), as well as through local land conservation organizations. In North Carolina, organizations such as the [N.C. Coastal Land Trust](#) help protect coastal waterways from impacts of development through numerous conservation easements.

Note Upon completion of Section 5.4.1, the following data should be collected:

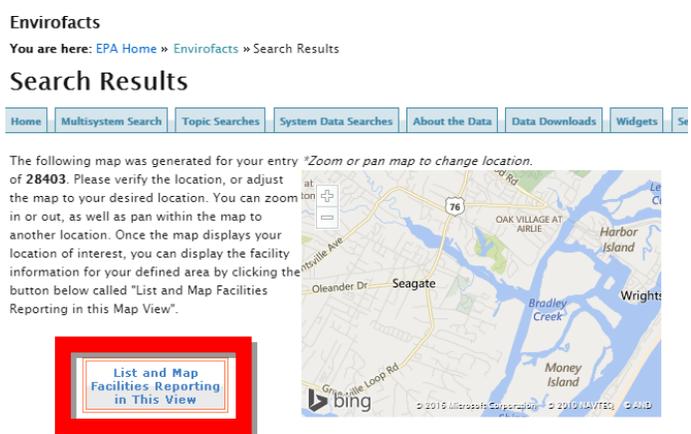
- Data on land use management practices within the watershed
- Data on local issues associated to land use
- Data on how these practices can be improved

5.4.2 Pollutant Sources

Various types of pollution can occur due to stormwater runoff including: chemical, organic, nutrient, bacterial, and sediment. These pollutants can negatively impact human health, ecosystem function, fishing and tourism industries, and community wellbeing. Chemical pollution is harmful to humans and wildlife and can make water bodies unusable or uninhabitable. Nutrient pollution can lead to eutrophication, an increase in nutrients that promotes algae growth, effectively altering ecosystem functions and damaging fisheries. Likewise, sediment and organic debris pollution can alter ecosystem functions rendering habitats uninhabitable for wildlife, which can also damage fisheries. Bacterial pollution can put human health at risk through the spread of bacteria like *Escherichia coli* (E. coli) and render shellfishing waters unusable. By addressing stormwater runoff, it is possible to address both point and nonpoint sources of pollution. Additionally, preventing stormwater from reaching waterways limits water impairment issues.

Often, pollution of water bodies is directly due to land based activities and are transported to waterways through point or nonpoint source conveyance. Sources of pollution can be separated into two categories: point sources and nonpoint sources. Point sources are those that come from a single outflow, or source, such as a pipe. In contrast, nonpoint sources of pollution do not come from a discernible point, but generally from processes such as runoff. Stormwater runoff is classified as nonpoint source pollution. Understanding pollutant sources is integral to any watershed management plan, this includes activities concerning land use, waste management, toxins, facilities use and other activities. Much of this information can be found on the EPA's comprehensive [Envirofacts](#) platform. Utilize the following instructions to search Envirofacts:

1. **Access [Envirofacts](#).**
2. **Search for the watershed.**
Using the location search engine on the left of the platform, enter in the zip code or general location of the watershed. Click **Search** button. The page will automatically generate a webpage showing the search results.



Using the map, Pan and Zoom to adjust the area shown within the map. Ensure that the entire watershed is within the map. Then select the **List and Map Facilities Reporting in This View** button (see red box). The page will automatically generate with a larger map showing all the facilities. If necessary, readjust the map and click the **Update facilities on map** button located in the upper left corner of the map.

3. **Explore the results.** Below the map, a table will appear with links to **View Reports** if a report is available on a listed facility. Explore the reports available on each facility to determine whether there are facilities that may affect the watershed. Depending on the issue and the mitigation that has been taken, these facilities may be interested in assisting with watershed enhancement. These reports will also queue into general pollution themes that would be worth addressing within the coastal watershed management plan. For example, there may be an abundance of marinas or industrial facilities within the watershed, each would utilize different strategies to improve water quality.

5.4.2.1 **Point Sources**

A majority of point source pollutants are regulated through the national NPDES, a permitting system in which individuals or companies must acquire a permit to discharge pollutants into a surrounding water body. Permits can be issued for stormwater. Although stormwater itself is a nonpoint source of pollution, once a permit is obtained, the stormwater exiting from that specific permitted site is considered a point source. Some point sources are managed through state permitting systems. Active North Carolina [state stormwater permits](#), as well as NPDES stormwater permits, can be found through the DWR. The Division of Energy, Mineral and Land Resources maintains an interactive [map of stormwater permits](#) in the state.

Wastewater permits are another large point source of pollution. North Carolina [Division of Waste Management](#) has multiple [maps and GIS data](#) including: active disaster debris staging sites, brownfields, underground storage tanks, dry cleaning solvent cleanup act sites, hazardous waste treatment storage and disposal, and other waste management facilities.

5.4.2.2 **Nonpoint Sources**

Unlike point sources, nonpoint sources cannot be traced to a single outflow conveyance source. Nonpoint source pollution can include sources from stormwater, agriculture practices, urbanization, silviculture and non-discharging onsite wastewater systems. The nature of nonpoint sources of pollution makes the data more difficult to ascertain or permit. Many states or regions have [nonpoint source pollution programs](#).

Along coastal waterways, stormwater runoff from urban develop is often the primary source of impairment issues. As areas are developed, impervious surfaces and connected conveyance systems increase and in turn increase the amount of runoff reaching coastal waters. Precipitation events on areas of high impervious surface cause a large surge of water, overwhelming natural infiltration systems. This water carries pollutants that have been deposited on impervious surfaces, like roadways and parking lots, such as heavy metals, oil, sediment, trash and persistent organic pollutants. Urbanized areas contribute nutrients from pet waste and chemicals from pesticides. Impervious surfaces can cause thermal pollution due to the high temperatures from solar radiation resulting in stormwater runoff being warmer than the water body it is discharged into. Bacterial pollution from pet waste and wildlife is a common impairment for urban watersheds. Landscaping practices also impact water quality; pesticides increase chemical pollutants, fertilizers increase nutrient loads, which can result in algae blooms, and organic landscaping debris, such as grass and tree trimmings, can result in dissolved oxygen depletion. Onsite wastewater systems such as residential septic systems can add to urban pollution as well.

Livestock operations, especially in high densities within a watershed, can lead to excess nutrients and bacteria in surrounding waterways. North Carolina has an interactive map of [all](#)

[animal feeding operations](#) within the state. The USDA [Census of Agriculture](#) also has current and historical information on animal operations.

Conventional cropland practices alter the hydrology of the land and are another source of nonpoint source pollution by introducing excess nutrients from fertilizers and pesticides. The USDA [Census of Agriculture](#) has broad level statistics on farming operations. The USDA provides an interactive mapping platform [CropScape](#) that has GIS compatible data that can be downloaded for analysis. In North Carolina, information regarding agricultural lands can be found through the [Department of Agriculture and Consumer Services](#).

Wildlife populations are a naturally occurring source of pollution. Knowing where large populations reside can be important for knowing what might be present in runoff. Local and state wildlife agencies are useful for determining local animal populations. For North Carolina, the Wildlife Resources Commission ([WRC](#)), DEQ and [local offices of the USFWS](#) are good places to look for this information. If you are located in a different state, you can find your offices in this [list of state and federal wildlife agencies](#).

Note Upon completion of Section 5.4.2, the following data should be collected:

- Permitted facilities within the watershed
- List of potential sources of point and nonpoint pollution

5.5 ADDITIONAL DATA TO INCLUDE

Based upon the goals of the project, consider the type of data that would be necessary to achieve each goal and objective. Consider brainstorming an extensive list of all possible data that could be necessary to meet the goals and from this list determine what data is the most pertinent to the success of each goal and objective as time and resources are likely limited. For example, as the major goal of the watershed plan is to improve water quality through stormwater runoff volume reduction, it is necessary to gather data on fecal coliform levels and sanitary shoreline surveys. Some examples of that may not be necessary is: extensive demographic data or stream geomorphology. See Appendix E for detailed information on additional data and research

ADDITIONAL INFORMATION TO RESEARCH BASED ON THE GOALS OF THE WATERSHED INCLUDE

- Biology
- Demographics
- Geomorphology
- Habitat
- Hydrology
- Land Use and Land Cover
- Physical and Natural Properties
- Source Water Assessments
- Topography
- Water Quality Standards
- Waterbody Conditions
- Waterbody Monitoring Data
- Watershed boundaries
- Wildlife

that may be worth including based on the goals and objectives of the watershed.

Data are available from many local, state, and governmental agencies and are found in a variety of reports, management plans, and raw data. The area specific data will likely be found at the local and state levels. Local organizations, such as universities, town agencies, environmental groups, and non-profit organizations, may already have a database with data of the watershed. State agency sources of information can often be obtained from environmental agencies, with most states having agencies dedicated to water quality and coastal states generally having a coastal management department. In North Carolina several agency websites with a plethora of information that may be worth exploring for data including:

- [Department of Environmental Quality](#)
- [Conservation Planning and Community Affairs](#)
- [Department of Agriculture and Consumer Services](#)
- [Division of Coastal Management](#)
- [Division of Marine Fisheries](#)
 - [Shellfish Sanitation and Recreational Water Quality](#)
- [Division of Water Resources](#)
- [Waste Management](#)

There are an overwhelming number of places to find data that may or may not be relevant to the watershed. Table 5-3 organizes potential data sources based on data themes discussed in Section 5.2.1:

Table 5-3. Sources of useful data for watershed planning.

Sources of Data for Watershed Planning			
Theme	Topic	Data	Sources
and Natural	Watershed Boundaries	HUC Codes	EPA MyWATERS Mapper*
		Watershed Boundaries* River Basin Boundaries	USGS Watershed Boundary Dataset (WBD)

		<i>* State watershed boundaries may differ from HUC boundaries and both will differ from the project watershed</i>	USGS Stream Stats State and local GIS agencies * See Chapter 4 for watershed delineation instructions
Hydrology	Primary waterbodies of watershed Stream Shapefiles		Geospatial Data Gateway State and local GIS agencies N.C. OneMap N.C. DEQ
	Hydrography		USGS National Hydrography Dataset USGS National Map Geospatial Data Gateway State and local GIS agencies N.C. OneMap
Topography	GIS Topo Layers		USGS National Map State and local GIS agencies N.C. OneMap
Soils	HSG categories		Web Soil Survey Geospatial Data Gateway State and local GIS agencies N.C. OneMap
Storm Model	1-yr/24-hr Precipitation Depth		NOAA Precipitation Frequency Data Server
Habitat	Wetlands		USFWS NWI National Heritage Program N.C. DEQ Coastal Wetlands
	Protected Areas and Habitat Conservation Plans		N.C. WRC Conservation USFWS Conservation USGS GAP

			State and local agencies N.C. OneMap
		Rare, Threatened, Endangered Species	USFWS Endangered Species State and municipal agencies N.C. Wildlife Resources N.C. OneMap
		Biological Assessment	State and local GIS agencies N.C. DEQ Community Macroinvertebrate Assessments
Land Use and Population Characteristics	Land Use and Land Cover	Orthoimagery	USGS National Map Orthoimagery State and local GIS agencies N.C. OneMap DCM Land Management DCM Planning
		Land Cover	USGS National Map USGS GAP Geospatial Data Gateway State and local GIS agencies N.C. OneMap
	Existing Land Management	Nonpoint Source Programs	NPDES NPDES permit list N.C. Stormwater

	319 Grants	EPA 319 NPS coordinator State agencies DEQ Division of Water Resources
	Management Laws Zoning Parcel Environmental Easement Boundaries	Bureau of Land Management USDA Easements Geospatial Data Gateway N.C. Coastal Land Trust County and local Planning and Zoning agencies
	Resource Management Plans	USFWS Conservation N.C. WRC Conservation
	Demographics	Census Data

Waterbody and Watershed Conditions	Water Quality Standards	Water Quality Designations	National Summary of Impaired Waters and TMDL Information N.C. Division of Water Resources
		Water Quality Standards	EPA Standards CWA Designation Classifications
	305(b) and 303(d) Reports	305(b) and 303(d) Reports	303(d) list National Water Quality Inventory Report to Congress [305(b) Report] N.C. DEQ Reports
	Existing TMDL Reports	NC TMDL	N.C. DEQ TMDL
	National TMDL	EPA TMDL MyWATERS Mapper	

	Source Water Assessments	NC SWA	N.C. DEQ Source Water Assessment Programs
Pollutant Sources	Point Sources	Hazardous Waste	EPA Hazardous Waste Envirofacts N.C. DEQ Wastewater N.C. DWM Facilities
		Stormwater Permitting	N.C. Stormwater Permits Envirofacts EPA NPDES N.C. Stormwater Permits
	Nonpoint Sources	Livestock Sources	USDA Census of Agriculture Envirofacts nonpoint source pollution programs N.C. Livestock
		Croplands	USDA Census of Agriculture USDA CropScape N.C DACS Ag Lands
		Wildlife	Local USFWS Office Wildlife Agencies N.C. WRC N.C. DEQ
		Stormwater	Nonpoint source pollution programs State and local agencies N.C. DEQ Stormwater
	Water Quality and Flow	Shellfish/Beach Closures	N.C. DMF Shellfish Sanitation
		Ambient Monitoring Stations	USGSW Ambient AWQ and Flow

			USGS STORET EPA WATERS N.C. DEQ AMS
Biology	Shellfish and Beach Closures		N.C. DMF Shellfish Sanitation
	Stream/Fish Assessments		N.C. DEQ-SFCAP
	Invertebrate Assessments		N.C. DEQ Bio Assessment
	Fish Kill Events		N.C. DEQ Fish Kills
Geomorphology	Fluvial Geomorphology		USGS Fluvial Geomorphology

5.6 IDENTIFYING DATA GAPS

Once data has been collected, ensure that there are no spatial, temporal, or informational gaps (Table 5-4). The lack of data may make it difficult to achieve certain goals and objects or may impede decision making processes.

Table 5-4. Types of data gaps.

Informational	A lack of data to inform a specific goal set by stakeholders or for an indicator that was selected to evaluate present watershed conditions. <i>Ex. No baseline data exists against which to measure improvements.</i>
Temporal	The timeframe the existing data were collected in is not relevant to the analysis. <i>Ex. Data is too old or not collected during the correct season.</i>
Spatial	Data has not been collected at the necessary locations or the proper spatial distribution for conducting the analyses. <i>Ex. Data is needed from upstream and downstream regions to effectively compare restoration efforts.</i>

Some important questions to ask to determine relevance of data include:

- Has data been collected to address the goals and objectives appropriately?
 - Are there alternative ways to address the goals and objectives?
- Are there gaps in the timeline of data?
 - Is there enough data?
- What is the quality of the data?
 - Is there confounding information?

The primary goal of a coastal watershed management plan designed using this guidebook will be to improve water quality through stormwater volume reduction, with specific focus on shellfish harvesting and swimming waters. In North Carolina this means that Shellfish Sanitation will be a source for historical and present conditions as well as future monitoring. If data is missing to appropriately address a secondary goal, refer to Table 5-3 and Appendix E to determine the most suitable sources of data or develop a sampling plan to collect relevant data. The EPA provides information and guidance for designing a sampling plan in their [Guidance on Choosing a Sampling Design for Environmental Data Collection](#). Before creating a sampling plan for secondary goals, it is important to remember that collecting data is usually a time consuming process and therefore sampling should only be conducted to address concerns of great importance.

6 Establish Volume Reduction Goal

One of the most important steps in the planning process is the establishment of numeric stormwater runoff volume reduction goals. To formulate these goals, will consider how the total runoff in the watershed has changed with intensifying land use. Estimated stormwater runoff volumes are calculated using a combination of GIS analysis and tabular calculations. This chapter will provide step-by-step instructions on data preparation and calculations necessary to determine total stormwater runoff changes in historical and current land use conditions of the watershed.

6.1 ANALYSIS DATA

By this point, the data necessary to calculate the estimated stormwater runoff volume should have been collected. The following data is necessary:

1. **Watershed boundary** (see Section 4.4)
 - Single shapefile or geodatabase file
2. **Baseline year** (see Section 5.3.1)
 - Single year
3. **Current and historical aerial photography** (see Section 5.3.2)
 - One aerial photography from the baseline year or earlier
 - One aerial photography from the present year
 - Aerial photographs from time periods between the baseline year and present year (at least one additional year)
4. **Parcel Data** (see Section 5.3.3)
 - Single Parcel polygon shapefile or geodatabase file
 - Zoning code guide or key document⁷

****If the information is not included in the Parcel data.***

5. Zoning Data* (see Section 5.3.4)

- Single Zoning polygon shapefile or geodatabase file
- Zoning code guide or key document

6. Hydrologic Soil Group (HSG) data (see Section 5.3.5)

- Single Soil polygon shapefile or geodatabase file

7. 1-year, 24-hour storm model precipitation depth (see Section 5.3.6)

- Single numerical value in inches

6.2 OVERVIEW OF THE PROCESS

The process of calculating the stormwater runoff volume reduction goal has been automated through the *Watershed EZ Tool*. Utilizing GIS, the development (pervious, impervious), soil characteristics (HSG), and zoning (residential, commercial) for each land use scenario (each aerial imagery year) are analyzed using the *Watershed EZ Tool* to determine a runoff curve number. The runoff curve number is calculated then runoff depth is calculated for the 1-year, 24-hour rainfall event using formulas developed by the United States Department of Agriculture Natural Resource Conservation Service (USDA NRCS). The resulting value is then multiplied by the area of the watershed, which will give the total estimated stormwater runoff volume anticipated in response to the prescribed depth of rainfall over a 24-hour period. The volume difference between the baseline year and the analyzed year is calculated to determine the estimated volume of stormwater runoff that needs to be reduced to result in a watershed that responded to rainfall in a manner that mimics the baseline year.

6.3 GIS METHODS

The GIS process uses aerial photography to estimate the amount of area that is covered by impervious surfaces, open space, right-of-way (ROW), or marsh and water for each year. These areas are further categorized by HSG (A, B, C, D).

The following GIS instructions are specifically written for the ESRI ArcGIS environment:

1. Organize the data

a. Create folders

- i. Name the main folder **WatershedName_WMP**
- ii. Within the WatershedName_WMP folder create two separate folders:
 1. Data
 2. Calculations

- iii. Add the previously collected data into the Data folder
 1. Watershed Boundary shapefile
 2. At least 3 aerial imagery rasters
 3. Parcels polygon shapefile
 4. Zoning polygon shapefile (if information is not part of parcels)
 5. Soil polygon shapefile

Note The *green italic* segments of a filename are meant for the GIS user to input their own file naming designation. For example, if the instructions state to create a new shapefile called “Land_Use_*Year*” for the data, name the file “Land_Use_2002.”

Note It is recommended that these data be copied and saved in a secondary back-up file to maintain the integrity of the original data in the even that errors are made during the processing of the data.

2. Set up the map and focus the data

a. Import data into ArcMap

- i. Open ArcMap and create a new map and Save As “*WatershedName*_WMP.mxd” into the same
- ii. File > Map Document Properties > Check box next to ***Store relative pathnames to data sources***
- iii. Select Add Data from the Toolbar and add all the data from the GIS data folder

b. Correct coordinate systems, projections and perform geographic transformations

- i. Ensure that all data are projected correctly
Table of Contents > Right-click data file > Properties > Source Tab > scroll down and make note of the projections
- ii. If projection is different, transform the data
Arc Toolbox > Data Management Tools > Projections and Transformations > Feature > Project. Select the appropriate inputs and coordinate system

c. Clip the data to the watershed boundary

- i. Select Geoprocessing from the menu bar > Clip
- ii. Input Feature > Select the data that is to be clipped down (everything except the aerial images)
- iii. Clip Features > watershed boundary

- iv. Output Feature Class > Save in Data folder. Save the name as *data_clip.shp* (ex: parcels_clip, soil_clip, and zoning_clip)
- v. Remove the non-clipped Parcels, Soils, and Zoning from the Table of Contents, only the clipped shapefiles will be used.

3. Create Right-of-Ways (ROW)

- i. Typically, Parcels data will have the ROW already removed and will strictly show parcels only (ROWS will not have polygons on them). In this instance use the following instructions:
 - 1. Arc Toolbox > Analysis Tool > Overlay > Erase
 - 2. Input Feature > Watershed boundary
 - 3. Erase Feature > Parcels Data
 - 4. Output Feature Class > Save in Data folder. Save the name as ROW_ *year*.shp (used the year of the newest aerial image)
 - 5. Verify visually that all ROW polygons displayed in ROW_ *year* exist in the newest aerial image by changing the symbology so it has no fill.
 - 6. If there are areas of ROW that are do not exist in the most recent aerial photo then being an edit session using the *Editor* toolbar and select *Start Editing* under the Editor dropdown menu. Select the ROW_ *year* data edit. and use the *Cut Polygons* tool on the editing toolbar to break those polygons into pieces, which can subsequently remove. Save the edit session and stop editing.
 - 7. Repeat these steps for each year of aerial imagery, changing the file name year accordingly. There should be three or more ROW_ *year*.shp, one for the baseline, one for the most recent year, and one (or more) for the time steps.

- ii. If the Parcels data does not have ROW removed (ROWS will be represented by polygons in the Parcels data) use the following instructions:
 - 1. Right-click Parcels in the Table of Contents > Open Attribute Table. Explore the attribute table and determine which field and designation/codification is given for ROW. Typically, it is in a field called ROW, Feature, etc. and is codified as 'ROW' or 'Right of Way'.
 - a. If a field describing ROW cannot be found, it may be necessary to contact the GIS agency the data was sourced from and ask them for a Legend for the designations they used. They also may have a ROW shapefile already that they can share.
 - 2. It may be necessary to manually select each ROW polygon by comparing it to the aerial image (this will be repeated for every image year).

3. Once it appears all ROW are selected: Right-click Parcels in the Table of Contents > Data > Export Data > Export: Selected Features > Output feature class: Save in Data folder. Save the name as ROW_*year*.shp (used the year of the aerial image).
4. Repeat these steps for each aerial image year. There should be three or more ROW_*year*.shp, one for the baseline, one for the most recent year, and one (or more) for the time steps.

4. Prepare data

a. Prepare Soils_clip

- i. Right-click Soils_clip in the Table of Contents > Open Attribute Table. At this point the Soils_clip data should have a field in the attribute table that contains the HSG designation. See Section 5.3.5 and Appendix E.
- ii. Being an edit session using the **Editor** toolbar and select **Start Editing** under the Editor dropdown menu. Select the Soils_clip data edit. Begin to manually edit the field containing the HSG field in the attribute table.

If the soil is defined with a combination HSG (e.g. A/D, B/D, C/D), assign the lower of the two classes (e.g. HSG D if the initial classification was HSG A/D). Visually confirm if any soils designated W (for water) are actually part of waterbodies or are inundated areas (e.g. marsh, wetlands) by comparing it to the aerial image of the area. If they should not be designated W then refer to the surrounding HSG to determine the best HSG designation for that polygon.

Note Edit multiple fields at a time by select the rows that have similar HSG and right-clicking the field column and selecting **Field Calculator...** and inputting the HSG in the code block and selecting **OK**.

- iii. Finish edit session. Upon completion, return to the Editor toolbar and under the Editor dropdown menu, select **Save Edits**. Once saved, select **Stop Editing**.
- iv. With the attribute table open, begin deleting all fields except for the Soil HSG field. Select a field column > right-click > Delete Field.

b. Prepare Zoning_clip

- i. If Parcels_clip does have zoning information, skip Step 5.b
- ii. If the Parcels_clip data does not have zoning information, use the following instructions:

- iii. Arc Toolbox > Data Management Tool > Fields > Delete Fields.
 - 1. Input Table: Select Zoning_clip
 - 2. Drop Fields: Check mark all field EXCEPT the field with the zoning information

c. Prepare Parcels_clip

- i. Arc Toolbox > Data Management Tool > Fields > Delete Fields.
 - 1. Input Table: Select Parcels_clip
 - 2. Drop Fields: Check mark all field EXCEPT the field with the zoning information

5. Create the Land Use shapefile

a. Intersect data

- i. Arc Toolbox > Analysis > Intersect
 - 1. Input Features: Add Soils_clip **and** Zoning_clip **and** Parcels_clip
 - a. Rank:
 - i. Parcel_clip = 1
 - ii. Zoning_clip = 2
 - iii. Soils_clip = 3
 - 2. Output feature class: save in Data folder as: LandUse_Orig.shp

b. Create Fields

- i. Right-click LandUse_Orig in the Table of Contents > Open Attribute Table
 - 1. Review the table and ensure that the only field columns are:
 - a. Soil HSG information field
 - b. Zoning information field
 - 2. Delete any extra field columns such as FID, Shape_length or Shape_Area, etc.
- ii. Select the Table Options drop-down menu > Add Field
 - 1. Name: Land_Use
 - 2. Type: Text
- iii. Select the Table Options drop-down menu > Add Field
 - 1. Name: Impervious
 - 2. Type: Double
- iv. Select the Table Options drop-down menu > Add Field
 - 1. Name: Acres
 - 2. Type: Double
- v. Select the Table Options drop-down menu > Add Field

1. Name: Total_Imp
 2. Type: Double
- vi. Select the Table Options drop-down menu > Add Field
1. Name: Total_Open
 2. Type: Double

c. Duplicate the shapefile

1. Right-click LandUse_Orig in the Table of Contents > Data > Export Data
2. Export: All features
3. Output feature class: Save in Data folder as: LandUse_*year*.shp
Change year to match the aerial image *year*
4. Repeat this for every year of aerial image. There should be three or more LandUse_*year* shapefiles; one for the baseline, one for the most recent year, and one (or more) for the time steps.

d. Remove ROW

- i. If LandUse_*year* does not have ROW (ROWS are not represented by polygons). Skip Step 5.d
- ii. If the LandUse_*year* still has ROW (ROW are represented by polygons) then use the following instructions:
 - a. Arc Toolbox > Analysis Tool > Overlay > Erase
 - b. Input Feature > LandUse_*year*
 - c. Erase Feature > ROW_*year* (make sure this is the same year as the LandUse_*year*)
 - d. Output Feature Class > LandU_*year* (use LandU_*year* from here on whenever it says LandUse_*year*)
 - e. Repeat these steps for every year of aerial imagery.

6. Characterize Land Use

a. Being an edit session

- i. Using the *Editor* toolbar and select *Start Editing* under the Editor dropdown menu. Select the LandUse_*year* data to edit.
- ii. Right-click LandUse_*year* in the Table of Contents > Open Attribute Table.

b. Begin to manually edit the field containing the Land_Use

- i. Categorize each parcel based on the Zoning code. Categorize the parcel as “R” or “C” based on the following:

1. **R**: Represents residential land uses, indicative of low density housing such as single family homes. Agricultural lands and golf courses should be considered R for the purpose of this calculation due to the low density of structures and limited impervious surfaces. Easements, protected areas and parks should be categorized as R.
2. **C**: Commercial land use, indicative of high density usages such as businesses, industry, parking lots and high density residential housing (condo or apartment complexes). Public buildings, such as town halls, libraries and community centers, should be categorized as C.

Note Use the zoning guide or key from the local agency who the data was sourced from to distinguish what the zoning codes mean.

Note If there is question as to which category a parcel should be in, utilize best judgement as to what category it would be most appropriate. If a parcel is built upon and is commercial or public use in nature it should likely be categorized a C. If a parcel is minimally built upon and appears undeveloped it should be categorized as R.

Note Edit multiple fields at a time by sorting the field with the Zoning information by double-clicking on the select the rows that have similar Zoning codes. Hold down the CTRL key while selecting with the mouse each row with similar Zoning. Right-clicking the field column and selecting **Field Calculator...** and input: **"R"** or **"C"** (include the quotations) in the code block and selecting **OK**.

c. Finish the Edit session

- i. Upon completion, return to the Editor toolbar and under the Editor dropdown menu, select **Save Edits**. Once saved, select **Stop Editing**.

7. Characterize Impervious Surfaces

a. Begin an edit session

- i. Using the **Editor** toolbar and select **Start Editing** under the Editor dropdown menu. Select the LandUse_year data to edit.
- ii. Right-click LandUse_year in the Table of Contents > Open Attribute Table.

b. Begin to manually edit the field Impervious

- i. Double-click the symbology of LandUse_year in the Table of Contents. Change the symbology so there is no fill color, then increase the Outline Width and change the Outline Color so it is easier to see.
- ii. Turn on the aerial image that is the same year as the LandUse_year
- iii. Visually approximate the percentage of impervious coverage in increments of 5. Represent the number in decimal form (range 0.00-1.00) by multiply the percentage by 1/100. For example, if the impervious coverage is determined to be 5% then type in 0.05 in the field for that parcel. Impervious coverage includes: roofs, sheds, roads, sidewalks, decks, pavement and other manmade structures that are not pervious.

Note This is based on the best approximation by the user. To minimize user error margin, the same user should determine impervious coverage for all LandUse_year shapefiles.

Note Edit multiple fields at a time, hold down the CTRL key and on the actual map, select each parcel that is similar in impervious percentage. Then, in the attribute table right-clicking the Impervious field column and selecting **Field Calculator...** and inputting **the decimal value** in the code block and selecting **OK**. Each time be sure to unselect the previously selected features.

c. Finish the Edit session

- i. Upon completion, return to the Editor toolbar and under the Editor dropdown menu, select **Save Edits**. Once saved, select **Stop Editing**.

8. Characterize Acreage

a. Determine the Acreage

- i. Right-click LandUse_year in the Table of Contents > Open Attribute Table
- ii. Right-click on the Acres field column > Calculate geometry... > Select Yes to edit outside of a session
 1. Property: Area
 2. Units: Acres US [ac]

9. Characterize Total Impervious and Pervious surfaces

a. Determine the Total Impervious Surface

- i. Right-click LandUse_year in the Table of Contents > Open Attribute Table.
- ii. Right-click on the Total_Imp field column > Field Calculator > Select Yes to edit outside of a session

- iii. In the code block input: ***[Impervious]*[Acres]***
- iv. Select OK

b. Determine the Total Pervious Surface

- i. Right-click LandUse_year in the Table of Contents > Open Attribute Table.
- ii. Right-click on the Total_Open field column > Field Calculator > Select Yes to edit outside of a session
- iii. In the code block input: ***[Acres]-[Total_Imp]***
- iv. Select OK

10. Repeat for all LandUse_year

- a. Repeat Steps 6-9 for all LandUse_year shapefiles. Changing to the appropriate aerial image year to match the LandUse_year.

11. Export attribute tables

a. For each LandUse_year shapefile, export the attribute table

- i. Right-click LandUse_year in the Table of Contents > Open Attribute Table
- ii. Click the drop-down Table Options menu > Export...
 - 1. Export: All records
 - 2. Output Table: In the Calculations folder (made in Step 1), save as:
 - a. Name: LandUse_Totals_year
 - b. Save as file type: Text File

12. Determine Total Impervious and Pervious surfaces

a. Open LandUse_Totals_years

- i. Start Excel
- ii. File > Open > LandUse_Totals_year.txt
 - 1. The file may open or render as a CSV file. In this instance, start Excel > Open > LandUse_Totals_year.csv (make sure "All Files" are showing in the drop down file type menu)
 - a. Keep everything on Step 1 of 3 as the default (Delimited, Start import at row: 1) > Next
 - b. Step 2 of 3: Check the box next to Comma > Next
 - c. Step 3 of 3: Select Finish

b. Sort

- i. Home Tab > Edit tool bar > Click the Sort and Filter drop-down menu > Custom Sort

1. Sort Level 1: Column: Soil_HSG > Sort On: Values > Order: A to Z
2. Select the Add Level button
3. Sort Level 2: Column: Land_Use > Sort On: Values > Order A to Z
4. Select OK

c. Determine the Sums

- i. Now that the excel spreadsheet is sorted by Soil Type and Land Use and is more manageable to calculate, find the sum of each of the following:

Soil Type	Land Use	Total Area	Soil Type	Land Use	Total Area
A	R Open		A	C Open	
A p	R Impervious		A	C Impervious	
B	R Open		B	C Open	
B t	R Impervious		B	C Impervious	
C	R Open		C	C Open	
C h	R Impervious		C	C Impervious	
D	R Open		D	C Open	
D	R Impervious		D	C Impervious	

or all LandUse_Totals_year.txt files

6.4 USING WATERSHED EZ TOOL

The North Carolina Coastal Federation has developed *Watershed EZ Tool* to accompany this guidebook. *Watershed EZ* uses the land use information collected in the previous sections of this guidebook to generate a hydrograph and calculate estimated stormwater runoff volumes for each land use scenario.

1. **Open *Watershed EZ*.** The tool is compatible with most versions of Microsoft Excel.
2. **Explore.** *Watershed EZ* is broken into four sheet tabs: **Summary, Watersheds, BMPs and References.**

3. **Input information in the Summary sheet tab.** The first sheet tab includes Project Information and Site Information that should be filled out.

Precipitation Data must be filled out with the appropriate information previously collected in Section 5.3.6 (see red box in Figure 6-1).

Determine the desired hydrograph shape by filling in the Hydrograph Data. Refer to Figure 6-2 to determine what rainfall distribution pattern best suits the watershed based on its location. Most coastal areas in the southeastern United States should use a **Type III hydrograph**. A **5-minute** Time Interval is recommended; however, the user may change that as desired (see red box in Figure 6-1).

Project Information	
Project Name:	
Project Address:	
Designer:	
Site Information	
Type of Development:	
Total Site Area (Ac):	
Total Proposed Impervious Area (Ac):	
River Basin:	
Regulatory Watershed:	
Precipitation Data	
Frequency (yr):	10
Duration (hr):	24
Precipitation Amount (in):	2.88
2-Year, 24-Hour Rainfall (in):	2.00
Hydrograph Data	
Rainfall Distribution Type:	Type II
Time Interval (min):	3.36

Figure 6-1. Watershed EZ first sheet tab.

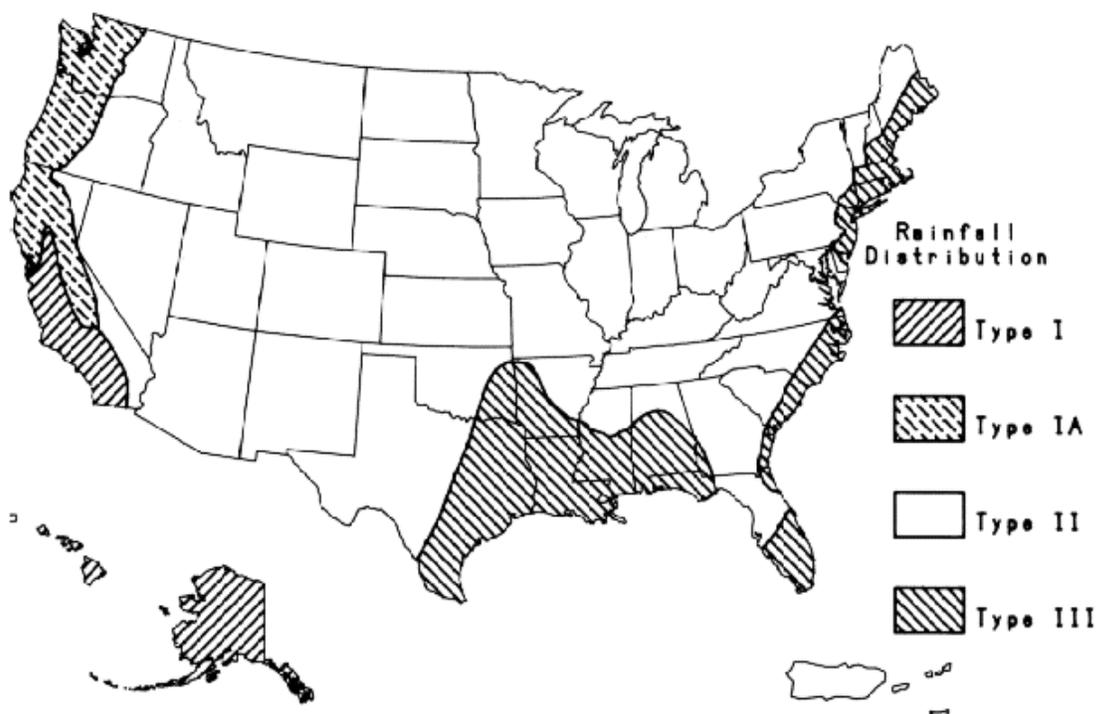


Figure B-2.—Approximate geographic boundaries for SCS rainfall distributions.

Figure 6-2. Rainfall distribution pattern types (Source NRCS).

4. **Input information in the second Watershed sheet tab.** The Watershed tab requires the user to enter the land use data collected in Section 6.3. The user enters areas according to soil type and land cover in the *Baseline Land Uses* and *Goal # Land Use Conditions* (see red box in Figure 6-3). *Watershed EZ* can accommodate one Baseline land use condition, and up to three Goal conditions, although the number of Goal intervals may vary by plan. Data is entered into the *green* shaded cells. Data is entered into the Green shaded cells. Common land covers are included in pull down menus; however, if the user wants to enter data that is not included in the pull down menu, a user defined section is included.

5. **Input the time of concentration.** Below the land use data is a calculation form to compute the *pre-* and *post-development* time of concentration (see orange box in Figure 6-3). Default settings and calculations are currently provided in this section.

Watershed EZ also allows the user to manually enter Time of Concentration if the user chooses to use a third party software program or alternate method to estimate the total flow time.

The time of concentration is an estimate of the time it would take runoff to flow from the top of the watershed to the analysis point. The calculator follows the procedures listed in Chapter 3 of the *TR-55 Manual*. The manual can be found here [TR-55 Manual](#).

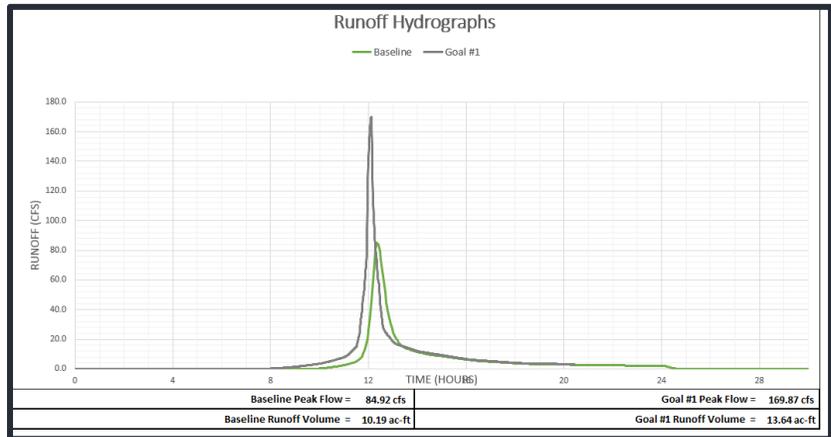
- a. **Sheet Flow** is very shallow, unconcentrated flow over relatively smooth surfaces. It generally occurs at the headwaters of a watershed before there is enough runoff to create a channel or gully. The depth of flow is generally less than 1 inch. Sheet flow generally cannot be maintained for lengths greater than 300 feet, although that distance may be shorter based on the roughness and slope of the land. The length of flow is the distance runoff would travel before becoming concentrated or achieving a flow depth greater than 1 inch.

The slope is the average slope of the land where sheet flow occurs (length / change in elevation). The surface cover is a pull down list with general land cover attributes. This value references *Table 3-1* of the *TR-55 Manual* to look up the roughness coefficient, which is reflective of the degree to which flow will be slowed down due to surface conditions.

- b. **Shallow Concentrated Flow** is an intermediate step between sheet flow and recognizable surface water channels. Shallow concentrated flow is flow which may still be dispersed across a landscape, but small rills, gullies, and flow paths are visible on the land. To compute the flow time for shallow concentrated flow, the user again enters the length and slope of the flow path, and indicates whether the flowpath is paved or unpaved.
- c. **Open channel flow** is flow in streams, channels, and ditches. This flow is concentrated, and occurs when there is enough runoff to form a channel, or when flow has been channelized due to increased development. As

6. **Review Hydrographs.**

Once land use data and time of concentration data is complete, hydrographs are shown at the bottom of the page along with summary results for the watershed.



7. **Input scenarios in the BMP sheet tab.** The third tab is used to estimate the effect that stormwater reduction measures have on the hydrograph. Estimates of total volume reduction can be entered by the user, or can be calculated using the **Runoff Reduction Scenario Tool**, which accompanies *Watershed EZ*. A separate instruction manual is included with the *Runoff Reduction Scenario Tool*.

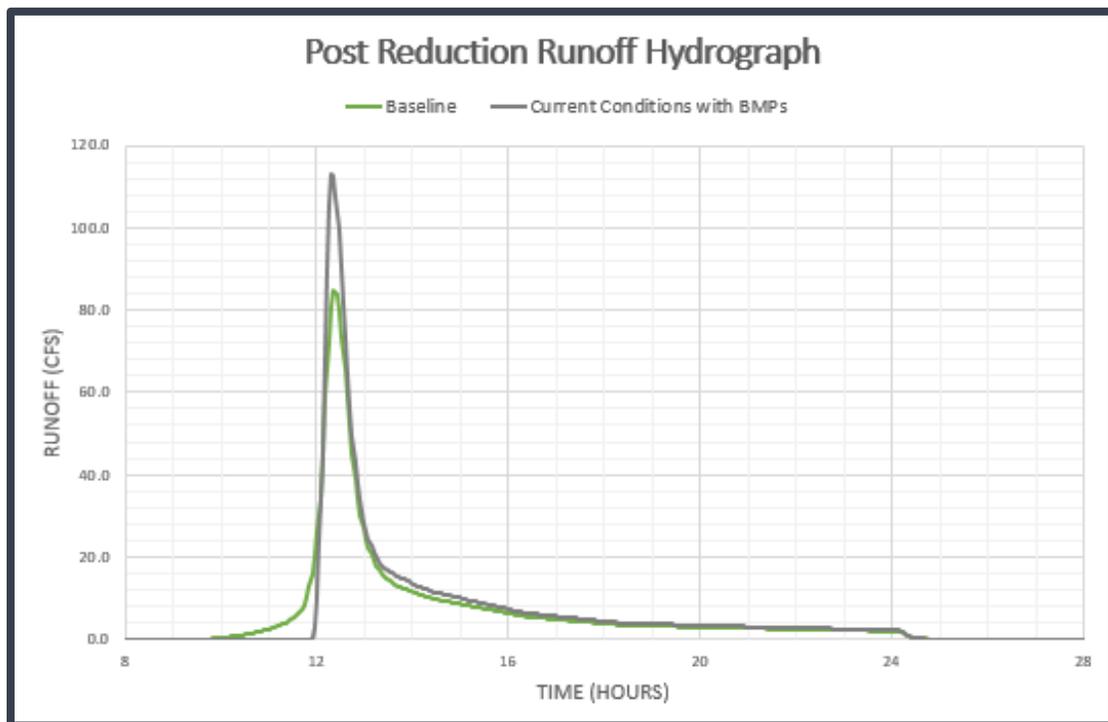


Figure 6-4. Hydrograph with LID BMP measures included.

8. **Review References tab.** The final tab in the spreadsheet includes the results of the analysis and summary data listing the volume reduction goals based on land use and BMPs which have been identified on the BMP sheet. The page also includes references to the equations used to calculate the runoff hydrograph data.

7 Stormwater Reduction Techniques

Once the estimated stormwater runoff reduction volume has been quantified, it is necessary to understand the stormwater reduction techniques available in order to develop a strategy to address the volume reduction goal. The techniques discussed below focus on volume reduction of stormwater runoff.



Pause

Now is an excellent time to rely on partners who are planners, stormwater managers, engineers, technicians, or resource managers for their insight



7.1 LOW IMPACT DEVELOPMENT

LID is an approach to stormwater management that makes use of a variety of techniques to replicate the natural hydrologic function of the landscape especially by focusing on micro-scale management of land development. Micro-scale management is done through the emphasis of parcel-level management on replicating predevelopment processes such as evapotranspiration, infiltration, filtration and storage to minimize the flow of stormwater to connected conveyance systems. In addition to being an effective strategy, LID techniques are cost effective and save in construction time. A 2007 EPA study of 17 LID case studies found that life cycle costs of

For every inch of rain that falls on a 1,200 square foot area, approximately 748 gallons of stormwater runoff is produced.

When trying to preserve the health of the local watershed, the best place to start is to enhance and preserve the natural stormwater treatment areas such as marshes, wetlands, and coastal forests.

LID overall are less than conventional practices with total capital cost savings reaching up to 80%⁸.

The key elements of LID highlight the use of creative site management and small, decentralized planning approach to infiltration techniques to minimize stormwater runoff (Figure 7-1). The key elements of LID are versatile and can be applied to most types of land uses including industrial, commercial, residential, mixed use development, individual lots, public lands, roads and parking facilities.

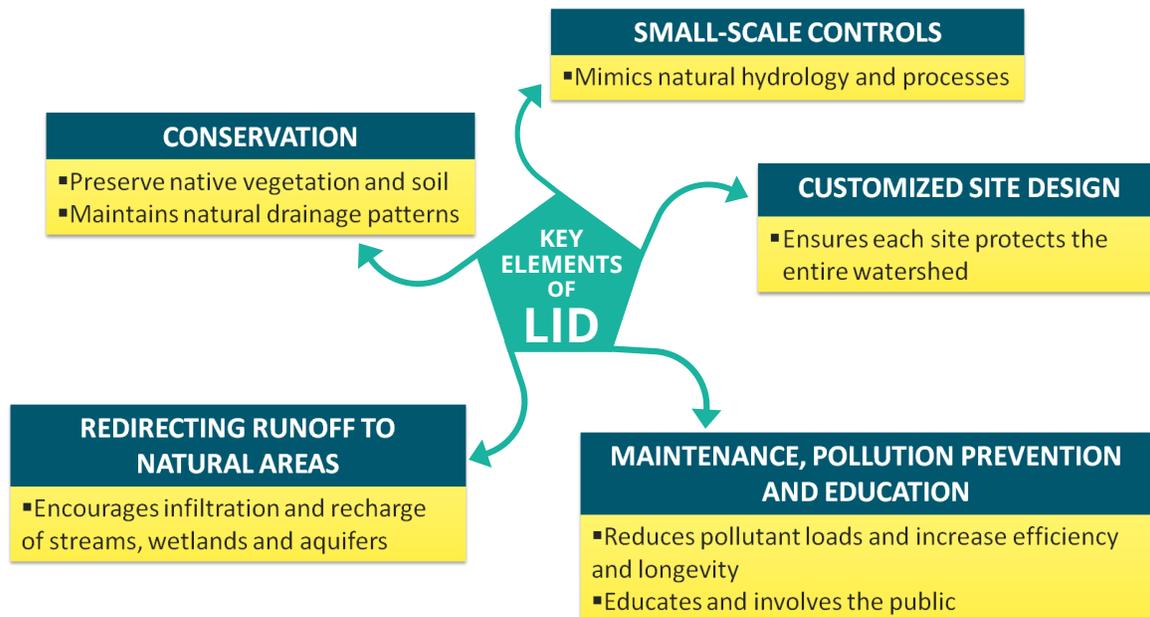


Figure 7-1. The five Key Elements of LID.

⁸ Environmental Protection Agency. (2007). Reducing stormwater costs through Low Impact Development (LID) strategies and practices. Publication Number: EPA 841-F-07-006. Retrieved from http://www.epa.gov/sites/production/files/2015-10/documents/2008_01_02_nps_lid_costs07uments_reducingstormwatercosts-2.pdf

LID techniques should be used for new development projects and to reduce existing volumes of stormwater runoff. LID site design for new development includes identifying important natural features, strategically placing buildings, roads and parking areas, as well as designing a stormwater management system that works with the site to maintain or mimic the predevelopment hydrology. The attention to natural hydrology, stormwater micromanagement and integrated use of the landscape results in a more attractive, multifunctional landscape. Unlike conventional strategies that treat stormwater as a secondary component of site design, LID incorporates the natural slope, soils and hydrology into the site design during the conceptual design phase. In 2015, the Governors South Atlantic Alliance released the [Coastal Water Quality Best Management Practices Compendium](#), a resource for professionals working on land based activities that contribute to nonpoint source pollution, particularly in the southeastern U.S. coastal region. In North Carolina, the DEQ has a [Stormwater Best Management Practices Manual](#). See Appendix G for LID design and retrofit techniques.

7.2 LID PRACTICES

The goal of simple stormwater reduction measures is to use the soil, plants and stormwater collection techniques to capture the rain before it has a chance to become polluted runoff. Some techniques, such as rain gardens, absorb the runoff, while others, such as rain barrels, catch the runoff for later use. It is important to note that many of the techniques discussed below complement one another and may be implemented concurrently, such as the creation of a rain garden and the use of native vegetation.

The following sub-sections are a selection of popular methods and features (Table 7-1).

Table 7-1. Stormwater reduction techniques (in alphabetical order).

Practice	Description
Bioswale	Open, linear channels with dense vegetation, used in place of curb and gutter systems
Box Planters	Often used in highly developed areas with minimal space, box planters are intended to store excess stormwater from roadways, sidewalks or rooftops
Cisterns	Form of rainwater harvesting utilizing cisterns that collect rooftop runoff through downspouts; cisterns are located either above or below ground; ideal residential, commercial and industrial rooftops
Constructed	Utilizing hydric soils and wetland plants that is inundated for a

Wetland	majority of the year; used to retain stormwater and create habitat
Disconnection	Disconnecting conveyances, decentralize the movement of stormwater; slow the conveyance of stormwater
Downspout Retrofit	The use of downspout extenders to redirect stormwater from flowing on impervious surfaces (like driveways) to permeable areas, such as lawns and rain gardens.
Dry Well	A gravel medium backfilled well that is connected below ground to a down spout or the down spout is redirected to the dry well to capture rooftop runoff
Green Roofs	Using vegetation coverage on rooftops to retain rainfall
Impervious Area Management	Manage impervious areas by reducing the square footage by focusing of parking lots, street or sidewalk. Disconnect impervious areas by transporting stormwater to LID or BMP structures instead of using curb and gutter systems that directly transport stormwater to the nearest receiving waters.
Infiltration Basin	Flat, permeable basin used to retain stormwater for a short period of time to allow infiltration into the soil allowing for the settling and removal of pollutants
Low Berms	Raised berm used to directly impede the flow of stormwater that is flowing to areas of low elevation; stormwater will collect behind the berm, retaining it on land for a longer period of time allowing for the opportunity for infiltration to occur
Native Vegetation	Native vegetation is more adept as surviving and creating habitat for birds and small animals. Vegetative coverage has been shown to generate much less runoff than open, grassy lawns
Natural Drainage Systems	Conveyance systems that utilize natural features such as vegetation, wetland zones and lower elevation to convey stormwater over permeable surface instead of pipe systems
Permeable Pavement	Porous pavement or pavers often used with grass, gravel or porous medium; used as an alternative to roadways, sidewalks or parking lots
Preservation	Limiting the removal of natural vegetation and tree coverage and minimizing the loss of hydrologic function by minimizing land disturbance
Rain Barrels	Form of rainwater harvesting utilizing barrels that collect rooftop runoff through downspouts; ideal for single-family homes
Rain Garden	Type of bioretention area, indicative of a shallow ponding area with select vegetation and permeable soils
Sand Filter Basin	Like an infiltration basin, the basin is used to retain stormwater for a short period of time but utilizes sand medium for stormwater to infiltrate through this is an option used when underlying soils have

	poor infiltration qualities
Shade Trees	Utilized to slow the transport of stormwater; aids in filtration and preventing erosion
Site Fingerprinting	A practice that uses the site design as a stormwater management tool by reducing land disturbance, preserving soil structure, and using use natural areas for runoff management
Vegetation Buffers	Dense vegetation can be used to filter stormwater and slow the transportation of stormwater downstream

7.2.1 Disconnect Impervious Surfaces

Rooftops, parking lots and other impervious surfaces often drain directly to pipe systems or ditches, thereby increasing runoff and preventing rainwater from soaking into the ground. Disconnected impervious areas are those that divert or direct stormwater to naturally vegetated areas. This reduces pollution by slowing down runoff and increasing filtration, allowing runoff to filter through vegetation. Sloping parking lots, roofs and sidewalks into landscaped areas are examples of this technique. This includes creating LID designs that avoid the use of curb-and-gutter systems or in developed areas, removing sections of curb to allow runoff to be conveyed into natural areas like bioswales, rain gardens or constructed wetlands. As a retrofit, the process of removing sections of curb is sometimes referred to as “curb cuts” to allow for runoff flow into vegetation. During small storms, disconnected impervious areas can reduce runoff volume by 30 to 100 percent. In addition to reduced runoff, disconnected impervious surfaces can also reduce the need for irrigation, provide better aesthetics, and lower infrastructure costs.

7.2.2 Site Fingerprinting

Site Fingerprinting is a practice that uses the site design as a stormwater management tool by reducing land disturbance, preserving soil structure, and using use natural areas for runoff management. Rather than grading land to fit a desired development type, the type of development is dictated by the existing conditions of the site, resulting in developed sites which use the land to maintain and protect the natural balance of the surrounding ecosystem. Site Fingerprinting can be done during the planning process for no additional cost and can often lead to lower infrastructure costs. For example, the Ridgefield Redesign of residential housing in New Hanover County, North Carolina, utilized site fingerprinting (Figure 7-2). From diverting stormwater to natural areas to incorporating LID techniques, the project was able to gain four additional lots, save \$1 million in fill and grading, eliminate five infiltration basins and five monitoring wells, which resulted in savings and reduced construction time. See Appendix I for more design schematics. **Error! Reference source not found.****Error! Reference source not**

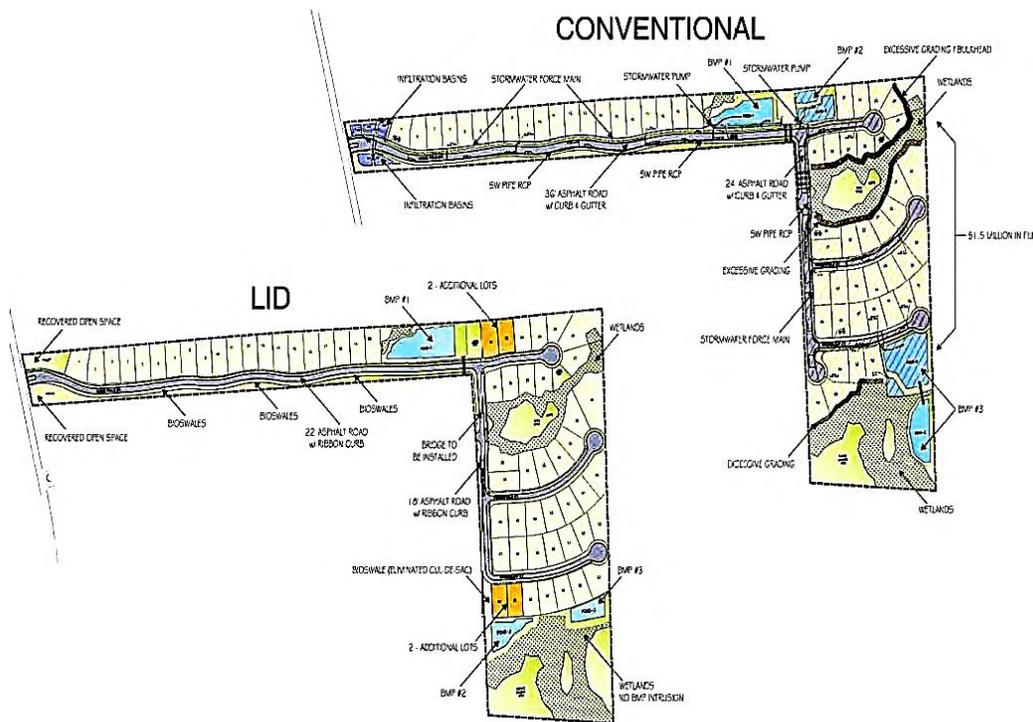


Figure 7-2. Schematics of the Ridgefield Redesign in New Hanover County using various techniques, including site fingerprinting

found.

7.2.3 Permeable Pavement

Permeable pavement is any paving material that allows rainwater to soak through the pavement and infiltrate the soil (Figure 7-3). Permeable paving comes in various forms –

pervious concrete, pervious asphalt, and concrete pavers are some of the most popular materials. The permeable paving system utilizes a washed stone base that aids in increasing water runoff storage volume as well as structural support. Permeable pavements can be used in conjunction with underground detention or rainwater harvesting systems to gain additional stormwater reduction benefits. Benefits of permeable pavement increased infiltration which reduced runoff without loss of parking, and the option of artistic design with pavers. Permeable pavement is a great option for a retrofit project. See Appendix I for more design schematics.

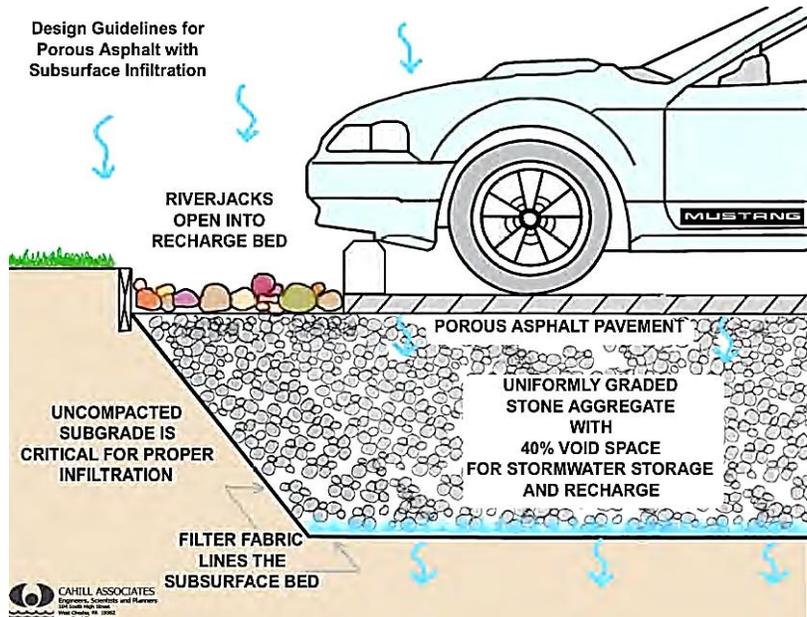


Figure 7-3. Diagram of the use of porous asphalt pavement in a parking lot.

7.2.4 Reroute Downspouts

Downspouts directed to driveways, sidewalks or parking lots increase the volume of polluted runoff by an average of 50 percent (Figure 7-4). Instead of contributing to stormwater pollution, rain water can be put to good use by rerouting downspouts for use in lawn and garden maintenance. Rerouting downspouts is a simple retrofit that disconnects impervious surfaces. Direct downspouts to areas that water can infiltrate the ground at least five feet from a structure's foundation. This technique reduced stormwater volume in Portland Oregon by 1.3 billion



Figure 7-4. An example of rerouting a downspout that dumps onto an impermeable surface so that it dispels water onto vegetation.

gallons per year when the city disconnected over 56,000 downspouts from 1993-2011 through their Downspout Disconnection Program.

7.2.5 Rain Barrels

Rain barrels are containers that collect and store rainwater from roofs that would otherwise contribute to runoff (Figure 7-5). They typically include a drum, a vinyl hose, PVC couplings and a screen to keep debris and insects out. A quarter inch of rain produces enough runoff to fill a typical, 55 gallons, rain barrel hooked up to one downspout. One and one rain barrel holds a week's worth of water for a 10-foot by 10-foot garden. Not only does using a rain barrel cut down on runoff, but it can also reduce water bills and provide water for plants during periods of drought.

7.2.6 Cisterns

Cisterns are large water harvesting systems that collect rainwater and store it for later use. In contrast with a rain barrel, cisterns are sized to capture large volumes of water and can be installed above or below ground. The captured water can be reused for larger scale irrigation, industrial processes and/or commercial reuse. There are many benefits to cisterns, including lower water bills, reduced runoff and access to water during drought conditions. For high water consumption users, cisterns can be a financially profitable investment, paying for themselves by reducing or even eliminating water bills for non-potable uses. Be sure to check local building codes before construction/installation.

Cisterns can be used as a retrofit, but if rainwater is to be used inside a building for non-potable uses, dual plumbing systems are needed.



Figure 7-5. An example of a rain barrel receiving water from a downspout.

Properties with trees are valued 5 to 15 percent higher than comparable properties without trees.

7.2.7 Native Landscaping

Native landscaping includes the use of plants that occur naturally in the project area which have adapted to the geography, hydrology, and climate of the region. Native plants are well suited to local soils and will need minimal care once established.



Figure 7-3. A house with a rain garden utilizing native landscaping. Notice the curb cut that allows street runoff to reach the rain garden.

7.2.8 Rain Gardens

A rain garden is a shallow vegetated area where rainwater collects during storms; they are often referred to as bioretention areas. Rain gardens are typically six to 12 inches lower than the surrounding landscape and act as a ponding area that collects runoff (Figure 7-7). Ideally, native plants are used in combination with permeable soil mixture of sand, fines and organic matter. The plants and soil soak up the rain water before it becomes polluted runoff. Rain gardens can reduce stormwater runoff by 90 percent. For maximum benefit, observe water flow patterns during rain events to determine potential areas for rain gardens, use native plants for low maintenance and make sure that water from rooftops and driveways is directed to the garden. Rain gardens can also increase the visual appeal of an area.

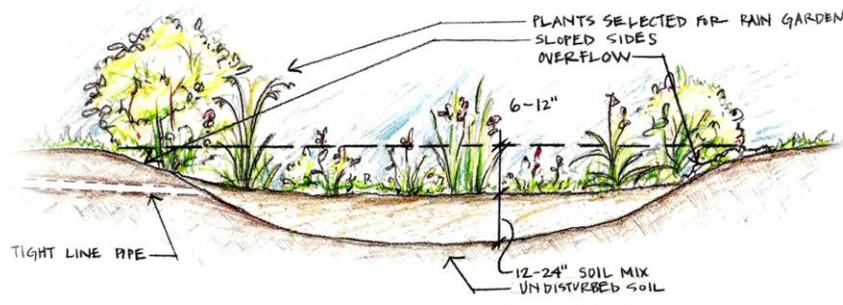


Figure 7-7. Diagram of a rain garden

7.2.9 Constructed Wetlands

Constructed wetlands are artificial wetlands that are created to keep stormwater runoff on land longer and promotes infiltration. Constructed wetlands can range in size from multi-acre community projects to small, sand box sized homeowner projects called backyard wetlands. Backyard wetlands are depressed wet areas that are planted with native wetland plants. They are designed to capture and treat stormwater similar to a rain garden but in locations with high water tables and hydric soils. Constructed wetlands would be ideal in areas that usually remain wet for several days following a rain event. In addition to runoff capture and filtration, backyard wetlands also enhance the landscape and can provide bird and butterfly habitat.

7.2.10 Planter Boxes

Planter boxes are filled with well-draining medium to control and treat runoff from rooftops, small parking lots or roadways. Runoff flows through a sandy soil mix, which traps solids and pollutants. As their name suggests, planter boxes also use vegetation to help absorb the water trapped by the soil. The plants also create a mini ecosystem within the soil, fostering healthy microbes that aid in breaking down oil and grease. There is also the added aesthetic benefit of greenery. Planter boxes are often used in highly developed areas with minimal space.

7.3 EVALUATE OPTIONS AND MANAGEMENT STRATEGIES

Multiple stormwater reduction techniques will likely be implemented over the watershed management plan's life cycle. Different techniques are more feasible for certain situations. The techniques employed will be affected by many variables, such as the timeline of the management plan, cost effectiveness of various techniques, the magnitude of the watershed impairment, soils, proximity to impaired waters, land cover and types of development present. It is also important to prioritize implementation efforts for optimal effectiveness. Since all of these factors will play into which techniques are most likely to be effective, the planning process should consider them all. No matter which techniques are employed, it is important to make sure that the overall flow reduction goals determined in Chapter 6 are met. Chapter 8 provides *Runoff Reduction Scenario Tool* that will assist in determining which techniques or combination of techniques will best reach reduction goal.

The two main variables to consider when prioritizing LID BMP strategies are soil type and proximity to impaired waters. If the soil type at a location is not conducive to water infiltration there may be less effect on runoff volume. Group A and B soils are the best at infiltrating water. Group D soils have the poorest infiltration capabilities and should be considered. Although a recent study from NCSU found that even in poor draining clay soils, simple disconnection of impervious surfaces reduced runoff volumes by up to 90%.

7.3.1 Magnitude of Impairment

Stormwater reduction techniques have different levels of effectiveness in stormwater runoff reduction. The table below shows some common techniques and their effectiveness in different scenarios (Table 7-3). See Appendix G for further details on effectiveness of various techniques.

Table 7-3. Various techniques and their effect on stormwater flow reduction and their ability to be used with a high water table as well as with poorly drained soils.

LID Technique	Effect on Stormwater Flow	Effective with High Water Table	Effective with Poorly Drained Soils
Constructed Wetland	High	Yes	Yes
Disconnect Impervious Surfaces	Medium	Yes	Yes
Permeable Pavement	Low	No	Yes
Plant Trees	Low	No	No
Rain Garden	High	No	No
Rainwater Harvesting	Medium	Yes	Yes
Reroute Downspout	Medium	Yes	Yes
Riparian Buffer	Medium	No	No
Rooftop Disconnect	Medium	Yes	Yes

7.3.2 Cost Effectiveness

The cost of stormwater reduction techniques varies between techniques. Some, such as permeable paving can potentially save money in the long run but may have higher upfront cost. Techniques such as rerouting downspouts are relatively inexpensive (on a per unit basis). LID techniques often costs less overall when factors of life cycle cost, such as planning, design, installation, operation and maintenance are considered.

Table 7-2. Approximate cost per unit of various LID BMP techniques.

LID BMP Technique	Cost per unit
Rain garden	\$3-\$12 per ft ²

Backyard wetland	\$170-\$550 depending on surface area
Rainwater harvesting	\$200/rain barrel \$1,000/1400 gal cistern \$10,000/10,000 gal cistern
Reroute downspout	\$9/downspout
Permeable pavement	\$8-\$12/ft ² of pavement

8 Design the Watershed Management Plan and Implementation Program

Now that the watershed is fully characterized and various management techniques have been identified, the watershed management plan can be drafted. At this point in the planning process watershed data should already be gathered and stormwater runoff calculations should be complete. This chapter will explain how to put all of the pieces together, plan for implementation, and develop an implementation schedule.

8.1 SELECT MANAGEMENT STRATEGIES

As discussed in Chapter 7, there are many community and environmental concerns that need to be considered when choosing which management strategies to use. At this point a decision should be made as to what stormwater reduction techniques will sufficiently reduce runoff to accomplish plan goals. To assist with this determination an Excel toolset has been developed, the *Runoff Reduction Scenario Tool* will help optimize the combinations of strategies that can be used by providing an estimate of volume reduction and associated costs.

8.2 DEVELOP MONITORING PROGRAM

A monitoring program should be developed to ensure that the plan is effective, milestones are being met and that the plan is on track. Quantitative, numerical monitoring data should be used as a primary measure of improved water quality. Numerical, measurable data of water quality indicators is necessary to ensure that the appropriate stormwater reduction techniques were used to reduce the volume of stormwater entering surface waters of the watershed. Additional forms of monitoring include tracking the number of shellfish closures and swimming or water quality advisories. Often, monitoring will already be conducted by a partner, stakeholder or government agency, such as North Carolina's Shellfish Sanitation Section of the Division of Marine Fisheries. Pre-existing water quality monitoring is an easy and cost-effective way of integrating monitoring into the watershed management plan. Pre-existing monitoring programs can provide current and future measurements and historic water quality measurements. If it is necessary to develop a monitoring program to address the goals and objectives of the watershed management plan, the EPA provides information and guidance for designing monitoring and sampling plans through their [Guidance on Choosing a Sampling Design for Environmental Data Collection](#).

The primary goal of this guidebook is stormwater runoff volume reduction to restore water quality (Table 8-1). As such two indicators will be measured; first, a water quality indicator that is appropriate for the watershed needs to be monitored. Secondly, volume reduction as

calculated from stormwater reduction techniques installed compared to original stormwater runoff values.

Table 8-1. The primary goal of the watershed management plan and the indicators and how to measure the indicators.

Primary Goal		
Reduce stormwater runoff volume to restore water quality		
	Indicator	Measured by...
1	Water quality parameter (fecal coliform count, etc.)	Comparing numerical before and after measurements of the water quality indicator parameter or pollutant loads (if TMDL has been conducted) that is appropriate for the watershed, until baseline year levels or non-impaired levels are reached
2	Stormwater Runoff Volume	Applying LID and BMP techniques and determining how much stormwater is reduced by the techniques; these measures should attempt to reduce current stormwater runoff volume to the levels of the baseline year

8.2.1 North Carolina Water Quality Monitoring Program

Success of the watershed management plan can be tracked through the progressive enhancement of water quality. It can also be monitored through the progressive opening of shellfish harvesting waters, conditionally approved closed, conditionally approved open, to approved. Shellfish Sanitation is responsible for monitoring the waters of the state with a special focus on shellfish harvesting and swimming waters. Areas that exceed the bacterial standard, or are adjacent to a known threat of pollution are closed to shellfish harvest by the state. The shoreline surveys done by Shellfish Sanitation are conducted every three years. Additional monitoring sites can be requested from Shellfish Sanitation in order to monitor progress in the project area. The standardized and regular intervals of Shellfish Sanitation’s monitoring program make it ideal to use as part of the plan’s monitoring component. As part of the monitoring component, coordinate with Shellfish Sanitation to reopen any abandoned stations. Data from these stations can provide further evidence of water quality improvement in the vicinity of the watershed.

In North Carolina, Recreational Water Quality Program conducts regular water quality testing along shorelines. As part of the monitoring component of the watershed plan, track the number of swimming advisories posted near the restoration site. A reduction in the number of

advisories within the vicinity of the project area will serve as an indication that the restoration efforts are having a positive effect on coastal water quality.

8.3 ESTABLISH AN EVALUATION CRITERIA

One of the nine EPA's key elements for a watershed management plan is to establish criteria with which to evaluate progress toward meeting watershed goals. This simply means that projects and activities should demonstrate advancement of the primary goal and should be evaluated to improve efficiency and quality. The key to developing evaluation programs is to ensure that the evaluation utilizes a before-and-after comparison approach. Regular evaluations ensure that the plan continues to meet the needs of the watershed and the community. Evaluations should focus on determining the effectiveness of the plan. Evaluations should be conducted on education and outreach programs as well. Evaluation criteria can be qualitative and quantitative in nature. For example, an evaluation criterion could be evaluating stakeholder attitudes towards the watershed at the beginning of the plan, midway through the plan and at the end of the plan.

In North Carolina, the main criteria for evaluating progress will be by using Shellfish Sanitation's monitoring data pertaining to fecal coliform counts and related water quality standards and shellfish closures. This can be quantified in the classification of water (Class SA, SB, SC). Success of the watershed management plan can be evaluated through the progressive opening of waters from being closed to shellfish harvesting, conditionally approved closed, conditionally approved open, to approved.

8.4 ESTABLISH MILESTONES

Another one of the EPA's nine key elements of a watershed plan is a description of interim, measurable milestones for determining whether management measures are helping to achieve goals. A milestone in this context can be seen as an action that shows progression through the life of the plan. These are generally achievements that will show the community and the stakeholders that actions are being implemented and having an effect. It is important to develop milestones that are specific, measurable and achievable. Milestones should be developed for short-term, mid-term, and long-term periods. Short-term projects should be highly visible in order to demonstrate early success, but should also be achievable. See Appendix H for Bradley and Hewletts Creek partnership and objectives table, which also shows milestones and timelines to accomplish these milestones.

Primary milestones for restoring water quality through volume reduction of surface runoff can be:

- A certain number of gallons reduced;
- The number of shellfish harvesting areas reopened;
- The number of acres no longer impaired;
- The number of community members educated on stormwater runoff, LID and BMP techniques.
- Number and duration of swimming advisories

Additional milestones may also be created for secondary goals within the watershed. It is crucial to determine how the milestone will be evaluated, and how data will be collected and maintained. For example, it would be meaningless to set a milestone of educating 10,000 citizens if no one is record keeping and monitoring the number of participants in workshops. Similarly, there should be a system in place for when milestones are not being met, to re-evaluate the progress of the management plan.



Figure 8-1. A contractor places oyster domes into the sound as part of a living shoreline installation for a 2011 coastal watershed management plan.

8.5 CREATE AN IMPLEMENTATION BUDGET

A critical component of plan implementation is a well-developed budget. The project budget may not perfectly reflect actual costs associated with the plan, but is necessary for defining the scope of the project and is often a required component when applying for funding and grants.

In order to ensure funding will cover all expenses, it is wise consider all aspects in the plan process, including: permitting fees, staffing, labor, equipment, education and outreach activities and any outsourced work. Use the *Runoff Reduction Scenario Tool* to roughly approximate the cost and reduction load of LID and BMP techniques that will be implemented.

8.5.1 Identify Technical Assistance

In conjunction with cost estimates, consider the necessary technical assistance needed for the monitoring. Partners may be able to provide technical assistance in the form of: project implementation and management tools, education and outreach material, monitoring data, training material and data management (see Chapter 3 and Appendix C for more details). Partners may also be a source of equipment, laboratory services, logistical support, and technical equipment training.

If the plan calls for large construction projects, seek partners and stakeholders as some may have existing relationships with vendors and contractors who can assist with such projects (Figure 8-1). When these resources cannot be obtained through partnerships, it may be necessary to entertain bids for the work. In fact, federal funding often requires a competitive bid process be completed before the grantee can disburse project funds. One technique to secure data necessary for a grant submission is to conduct a competitive bid process for work to be done during the project prior to submission of a grant request. Sometimes, a stipulation in a grant submission is that an organization is willing to complete some of the baseline work needed in order to apply for funding. For example, if large amounts of water quality data are missing, a local organization may be willing to use their resources to conduct the necessary baseline sampling if they are chosen to be the designated grant project partner that will be compensated for water quality monitoring during the life of the plan. If bids are entertained, be forthcoming about the scope of the work and rely on partners with appropriate expertise to oversee the bidding. This will decrease the chances of incurring unforeseen costs due to miscommunication or mishandling of the process.

For larger scale projects, check with relevant government agencies to ensure you have all required permits have been acquired before work begins.

8.5.2 Identify Funding Resources and Opportunities

Funding is can predicate the scope of implementation plans. Utilizing this guidebook will help to ensure that all necessary elements are included to better position communities to qualify for consideration when applying for funding. As with any grant, funding is not guaranteed or may not cover all project expenses. Consider researching funding possibilities and the federal, state and local levels. Also, consider if the watershed management plan and the stormwater reduction projects may qualify for funding under other projects or other watershed or water quality grants that are on-going within the area. Understanding the scope of the watershed, the HUC codification, river basin information, the applicable regulatory information, impairment issues and other background information on the watershed helps when seeking funding. It could be possible that at the state level there is funding for water quality enhancement projects within a certain river basin or region. Examples of other potential funding sources are listed in Table 8-2. This is not an exhaustive list and funding for environmental projects constantly change. See Appendix B for more information on potential funding sources at the national, state and local levels.

Table 8-2. Potential funding opportunities.

National

<u>EPA Catalog of Federal Funding Sources for Watershed Protection</u>	Searchable database of financial aid
<u>Grants.gov</u>	Unified source to find and apply for federal grants. Utilize basic and advanced searches as well as search by grant category and agency. In addition, sign up to receive daily emails containing newly released grant notices that meet advanced settings.
<u>National Fish and Wildlife Foundation (NFWF)</u>	NFWF offers grants to promote conservation (“thematic and geographically based”).
<u>NOAA Fisheries Office of Habitat Conservation Grant Database</u>	Grants for state and local governments, non-profits, and academia for the advancement of research and conservation

North Carolina

<u>319 Funding</u>	Established by Section 319 of the Clean Water Act, this grant provides funding for efforts to reduce nonpoint source pollution.
<u>Community Resource Information System (CRIS)</u>	Financial assistance for North Carolina communities
<u>DEQ: Financial Resources for Watersheds</u>	A source for water quality grants, cost shares, and loans.
<u>DEQ Financial Assistance</u>	Provides a list of grant opportunities, tax credits, and other financial assistance available from the N.C. DEQ.
<u>Water Quality Management Planning Grant in North Carolina</u>	Resources, technical assistance and potential funding
<u>Regional Council of Governments</u>	Resources, technical assistance and potential funding

8.6 DEVELOP THE IMPLEMENTATION SCHEDULE

An important component to the success of a management plan is developing an implementation schedule. The schedule will lay out a detailed plan for meeting the goals and objectives of watershed restoration. In order to develop a successful implementation schedule, consider incorporating the following elements:

- Actions that needs to be completed;
- Partner who is responsible for completing the actions;
- Time frame to complete the action;
- Maintenance schedule;
- Cost;
- Funding source;
- Indicator of success.

These elements can ensure that plans are encompassing and thorough. Addressing all of these elements shows management and foresight regarding the project and the work necessary, which can be beneficial when applying for funding. When developing a specific action, keep in mind the milestones and ultimate goals that have been outlined for the restoration plan. The implementation schedule should also include outreach and education action. This will serve to keep actions focused and specific. Each action should be assigned a timeline, which can be ongoing, yearly or over the course of several years. Furthermore, the partners who will assist in accomplishing each action should be included in the schedule. Be as precise and realistic as possible when drafting this schedule.

See Appendix H for Bradley and Hewletts Creek partnership and objectives table, which also shows milestones and timelines to accomplish these milestones. Developing an implementation schedule that is a matrix table can help visualize the information (see Table 8-3 for example).

Table 8-3. Implementation schedule matrix table format.

Primary Goal: Reduce stormwater runoff volume to restore water quality						
Objective 3						
Reduce the transport of bacteria from land to water by reducing the volume of stormwater runoff.						
Action	Partner	Time	Maintenance Schedule	Cost	Funding Source	Indicator
Action 1: Install downspout retrofits at public buildings with educational signage in front of the most popular buildings						
Install downspout retrofits at public buildings	Town Hall	1 year	Once a year, check for wear. Include as part of building's regular inspections	\$1,000; installed by volunteers	Town Hall	# of 23 buildings with retrofits installed

Install Education signage for downspout retrofits	Town Hall	1 year	Once a year, check for wear. Include as part of building's regular inspections	\$1,000; designed and installed by contractor	Grant	# of 5 signs installed at: <ul style="list-style-type: none"> • Town Hall • Library • Com Center • Park 1 • Park 2
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The implementation schedule should encompass all of the nine minimum essential elements of a watershed management plan. Consider the implementation schedule as a map that charts out the plan for reestablishing coastal water quality through stormwater runoff reduction techniques.

8.7 TRACKING PROGRESS

In order to track the progress of the restoration, compare the reality of watershed conditions to the timeline of the implementation schedule. Depending on the size, scope and time frame of actions, it is important to continue to carry on monitoring and gauging the progress of the watershed management plan through scheduled meetings where partners can review project progress and address issues.

Regularly obtain new data of the watershed over the course of the restoration work. It will be necessary to obtain data on the primary water quality indicator being used and it will also help to know data on shellfish area designation status changes, swimming advisories and volume reduction.

8.7.1 Volume Reduction Data

Based on the methods of this guidebook, reductions in the volume of stormwater runoff entering the watershed will be a primary indicator for determining the success of the plan. While it may take decades to meet water quality improvement goals, significant decreases in the volume of runoff entering the watershed can be realized relatively quickly. To determine the level of reduction achieved by LID and BMP techniques, use the *Watershed EZ Tool* associated with this handbook. In addition to providing cost estimates, the tool measures the reduction in surface runoff associated with several landscape modifications; for example, a single rain garden can absorb 100 cubic feet of surface runoff. The Runoff Reduction Scenario Tool also measures percent of volume reduction in relation to project goals. As LID and BMP techniques are installed, track the volume of water that is no longer reaching the surface waters of the watershed during storm events. These features facilitate the evaluation of actions, milestones and ultimately restoration goals.

8.8 DRAFT THE PLAN

The key to an effective watershed management plan is to keep the plan realistic. Given available resources, the plan should indicate plausible solutions that are citizen-focused and partnership-based. A comprehensive plan will address all the possible stormwater runoff inputs and take into consideration the varying range of conditions found within the watershed. It is important that the plan be specific on volume reduction targets and management goals. To aid in the plan writing process, utilize the *Watershed Management Plan Writing Template* designed to be used in conjunction with this guidebook.

Keep the EPA's nine minimum elements in mind when the management plan is being written. If the guidebook has been followed all nine elements should be addressed. If further detail on the nine minimum elements is necessary, refer to the EPA Watershed Handbook. Clearly ensuring that none of the elements are left out of the plan will better position communities to be considered for funding. Work closely with the watershed's EPA NPS Coordinator and the state agency responsible for grant requests.

The coastal watershed management plan should contain the following seven major sections:

1. **Executive Summary**
2. **Introduction**
3. **Watershed Description**
4. **Watershed Conditions**
5. **Runoff Volume Reduction**
6. **Goals**
7. **Management Strategies**
8. **Implementation Program**

8.8.1 Executive Summary

The executive summary provides a clear and concise highlight of the watershed characterization, numeric target goals, and the proposed management recommendations. Aim to maintain a summary that is four pages or less. The executive summary is intended to provide a quick overview of the plan as a whole, without excessive detail. The executive summary should be written after the entire plan has been written.

8.8.2 Introduction

The introduction should provide a project manager a comprehensive overview of the targeted project. The goal of this section is to give the reader a basic understanding of the plan. The following information should be included:

- Introduce the location of the watershed surrounding communities

- State, County, City/Town
- Political boundaries for regulatory ordinances (what county(s)/communities does the watershed fall under)
- Discuss the vision for the watershed and how this project will improve on that vision
- Discuss stormwater runoff issue

8.8.3 Watershed Description

Include a short paragraph description of the watershed as whole. This section should address physical and natural features of the watershed. This section will also describe current and past land use. Applicable regulatory rules and programs that may apply to the watershed should be discussed in this section. Stakeholders and partners should be noted and their roles acknowledged in this section. This should include:

- Hydrology
 - Include map of all hydrologic features
 - Locations of water monitoring stations, include who manages the stations and how regularly data is collected
 - State watershed or river basins that the project watershed is contained within
 - Name and description of the major waterbody
 - Major stream
 - Out flow location
 - 12-Digit HUC
 - Geomorphology
- Aerial Photography
- Soils
- Geopolitical location of the watershed
- Past and present uses of the watershed area; such as agriculture, lumber harvest/silviculture, military uses, etc.

8.8.4 Watershed Conditions

This plan seeks to address water quality through the management of stormwater runoff. Summarize how this relates to the watershed in this section. This includes a detailed review of water quality. The primary source being addressed through this management plan will be stormwater runoff, which carries pollutants. That being said, it is important to recognize sources of pollution and to consider solutions that can prevent both point and nonpoint source pollution from entering waterways. Summarize how these relate to the watershed.

8.8.5 Runoff Volume Reduction

This section should address the following: provide the numerical value of the stormwater runoff volume for the baseline year, most recent year estimated and the reduction goal. Discuss the water quality indicator parameters (fecal coliform count), comparing numerical before and after measurements of the water quality indicator parameter or pollutant loads (if TMDL has been conducted) that is appropriate for the watershed, until baseline year levels or non-impaired levels are reached.

8.8.6 Goals

Once partner and stakeholder relationships are developed, goals that are mutually beneficial to those involved will need to be developed. Understanding the partners, stakeholders and their desired outcomes will help in defining how extensive of a watershed management plan should be developed and the scope of a particular watershed. For example, perhaps the desired watershed is focused on a specific branch of a stream as opposed to the stream as a whole. This is something that should be clarified and discussed when determining the goals. The primary goal is to reduce stormwater runoff volume there by reducing the indicator in order to restore water quality. Describe in detail the goal and how the objective support this goal.

8.8.7 Management Strategies

Utilizing stormwater reduction techniques will reduce stormwater runoff. The *Runoff Reduction Scenario Tool* what strategies would be appropriate and how many would need to be applied to achieve appropriate runoff reduction. Conventional management methods rely on peak flow storage and the mitigation of on-site flooding by removing stormwater from the site as quickly as possible. In this approach, stormwater is quickly moved through curb and gutter systems, often over impervious surfaces, where the untreated runoff is conveyed to the nearest receiving water. This approach is effective at deterring on-site flooding but the downstream effects result in an increase in the magnitude and frequency of flooding. Conventional efforts to manage runoff throughout the coast have failed to prevent stormwater runoff pollution; particularly from increased bacterial pollution, which causes contamination of shellfish and swimming waters. In this section address the volume reduction measures, current control measures in place and the education and outreach program.

8.8.8 Implementation Program

Summarize the proposed implementation program schedule, monitoring and milestones that will support the application of the LID and BMP techniques. Discuss all milestones that have been chosen. Clarify time line and implementation priorities. Discuss all proposed monitoring strategies. Discuss all costs, budget and technical assistance necessary to achieve this plan. Discuss all available funding and all proposed funding.

Conclusion

Overall, the Watershed Management Planning Guidebook:

- Provides instruction for understanding an impaired watershed;
- Prepares for community connection;
- Outlines steps to repair water quality through runoff reduction measures.

Previous chapters supply a comprehensive framework for the setup and implementation of watershed restoration in a simple yet effective way. The techniques described focus on reducing stormwater runoff volume and explain how to replicate natural hydrology in a timely and cost efficient manner. The chapters within this guidebook can help ensure watershed plans include all nine EPA elements and using the steps provided will set the tone for successful water quality restoration within coastal communities. In addition, these measures can be used to protect coastal water quality that is not yet impaired by pollution.

Reflected throughout the guidebook are lessons learned from previously prepared and implemented watershed restoration plans that the North Carolina Coastal Federation has helped to develop. These plans provide real-world and tangible examples of how diverting stormwater to restore natural hydrology can positively influence coastal water quality.

As demonstrated by these projects, to successfully reach restoration goals it is necessary to:

- Research and gain an understanding of the watershed
- Encourage outside participation and incorporate outreach efforts
- Pool together quality data
- Generate realistic goals for stormwater volume reduction
- Identify management techniques
- Plan ahead for project implementation
- Monitor and Evaluate efforts along the way

With 320 miles of ocean beaches and more than 12,000 miles of shoreline around our coastal sounds, rivers and creeks, the North Carolina coast is one of the largest, most productive and spectacular coastal areas in the United States. While the coast remains relatively healthy, water quality impairments are spreading due to changes in hydrology caused by land use practices that create more runoff. Being intentional to restore these environments now will help ensure their health for future generations. Since traditional uses, such as fishing and swimming, are increasingly threatened, it has become ever pressing to find efficient solutions for restoring our waters. The methods illustrated in this guidebook can be used to reduce the volume of stormwater entering watersheds in both urban and rural landscapes, and provide meaningful opportunities for coastal communities to work together for a healthy coast.

Appendix A: Plan Checklist

Below is a checklist of information that should be included in a watershed management plan. This is a very brief checklist, and more information regarding each portion of the process can be found within the guidebook itself.

- **Identify potential partnerships (Chapter 3)**
 - ✓ Develop a core project team
 - ✓ Identify other stakeholders
 - ✓ Stakeholder integration/public information session
 - ✓ Consider community input
- **Build support through outreach and education (Chapter 3)**
 - ✓ Enhance public understanding of the project
 - ✓ Encourage early and continued involvement in selecting, designing, and implementing nonpoint source management measure to be put into practice
 - ✓ Define outreach goals
 - ✓ Identify and analyze the target audience
 - ✓ Create the messages for each audience
 - ✓ Package the messages for various audiences
 - ✓ Distribute the messages
 - ✓ Evaluate the information/education program
- **Set planning goals (Chapter 4)**
 - ✓ Primary goal: To improve water quality through stormwater volume reduction, with a specific focus on shellfish harvesting and swimming waters
 - Indicators (ex. Fecal coliform, enterococci, other pollutants)
- **Characterize the watershed (Chapter 4 and 5)**
 - ✓ Delineate the watershed
 - ✓ Determine the applicable classifications for the waterbody
 - ✓ Is the waterbody on the 303d impaired list?
 - ✓ Has a TMDL has been established for the watershed?
- **Find Data (Chapter 5)**
 - ✓ Historical and current water quality data from the Shellfish Sanitation Section of DMF
 - ✓ Aerial photography
 - ✓ Parcel Data
 - ✓ Soils
 - ✓ Model storm parameters for a 1-year, 24-hour storm
 - ✓ Zoning
 - ✓ Existing land management strategies

- ✓ Pollutant sources
 - Point sources
 - Nonpoint sources
- ✓ Other data as needed
- **Organize Data (Chapter 5)**
 - ✓ Make a data inventory
 - ✓ Is there data for all the essential indicators that were selected?
 - ✓ Is there missing data from a certain time frame or area?
 - Ex. Shellfish Sanitation may have closed areas for monitoring in or around the watershed. In this case, submit a request to have these areas reopened for monitoring.
 - ✓ Is the Data Accurate?
 - Ex. Is your waterbody classified correctly? If the waterbody is classified incorrectly there should request sampling form DEQ to consider reclassification.
- **Establish volume reduction goals (Chapter 6)**
 - ✓ Formalize a baseline year
 - ✓ Characterize current and historic land use
 - ✓ Use the *Watershed EZ Tool* to calculate volume reduction goals
- **Identify potential management techniques (Chapter 7)**
 - ✓ Low Impact Development (LID)
 - Site fingerprinting
 - Native landscaping
 - Disconnect impervious surfaces
 - Reroute downspouts
 - Rain barrels
 - Cisterns
 - Permeable pavement
 - Planter boxes
 - Rain gardens
 - Backyard wetlands
- **Evaluate options and management strategies and select using the *Watershed EZ Tool* (Chapter 5, 6, and 7)**
 - ✓ Extent of impairment
 - ✓ Cost effectiveness
 - ✓ Land cover and types of development
 - ✓ Soil type

- ✓ Effectiveness
- ✓ Prioritization of LID techniques
- **Design the watershed management plan (Chapter 8)**
 - ✓ Establish criteria to measure progress toward meeting watershed goals
 - ✓ Develop measurable milestones to track management measures
 - ✓ Develop a monitoring component if necessary
 - ✓ Define partner responsibilities
 - ✓ Create an implementation budget
 - ✓ Identify necessary technical assistance
 - ✓ Identify funding resources and opportunities
- **Develop the implementation schedule (Chapter 8)**
 - ✓ Create management objectives
 - ✓ Develop achievable actions
 - ✓ Plan for measuring progress throughout the project
- **Draft the plan (Chapter 8)**
 - ✓ Include the following EPA and N.C. DEQ requirements
 - Identify impairment and causes and sources of pollution that need to be controlled
 - Load reductions needed to meet water quality standards
 - Detailed management measures to achieve necessary load reductions determined in component II
 - Plan implementation schedule
 - Interim, measurable milestones to track implementation of management measures
 - Criteria to measure progress toward meeting watershed goals
 - Monitoring component to evaluate the effectiveness of implementation over time
 - Information/education component
 - Identification of technical and financial assistance needed to implement as well as long-term operation and maintenance measures
 - Commitment to revise pollution controls, as necessary, if progress toward WQS is not shown through the monitoring
 - ✓ Major sections to include in the plan
 - Executive summary
 - Introduction
 - Characterization of the watershed
 - Management Recommendations
 - Implementation strategy

- Monitoring and measuring progress

Appendix B: Watershed Planning Resources

There are a variety of potential planning resources for a watershed management project. Websites are included and potential needs they could fulfill are italicized. For those new to watershed management, additional resources and education is available through the EPA's [Watershed Academy](#).

National

Entity	Resource	Website
Association of Clean Water Administrators	<ul style="list-style-type: none"> • General Information • Outreach and education 	www.acwa-us.org/
Bureau of Land Management	<ul style="list-style-type: none"> • Land records 	www.blm.gov/
Bureau of Land Management	<ul style="list-style-type: none"> • Information on land use 	http://www.blm.gov/
Environmental Protection Agency	<ul style="list-style-type: none"> • Guidelines • Grants • Clean Water Act • General Information 	water.epa.gov
EPA Stormwater Program	<ul style="list-style-type: none"> • NPDES Information • Outreach 	water.epa.gov/polwaste/npdes/stormwater/index.cfm
EPA Wetlands Protection Program	<ul style="list-style-type: none"> • Outreach and education • Regulatory information • Resources 	http://www.epa.gov/owow/wetlands
Forest Service	<ul style="list-style-type: none"> • Information on land use and resources 	http://www.fs.fed.us/
National Estuary Program	<ul style="list-style-type: none"> • Regulatory information • General information 	http://www.epa.gov/owow/estuaries
National Fish and Wildlife Foundation	<ul style="list-style-type: none"> • Species Information • Grants 	www.nfwf.org/
NOAA Coastal Service Center	<ul style="list-style-type: none"> • Geospatial data • Training tools • General Information • Technical assistance 	coast.noaa.gov/
NOAA Habitat Restoration Center	<ul style="list-style-type: none"> • Information on federal projects 	www.habitat.noaa.gov/

	<ul style="list-style-type: none"> • Grants 	
NOAA/ EPA Smart Growth Program	<ul style="list-style-type: none"> • General Information 	www2.epa.gov/smartgrowth
Sea Grant	<ul style="list-style-type: none"> • General Information • Outreach and education 	seagrant.noaa.gov/
The Online Catalog of Federal Domestic Assistance	<ul style="list-style-type: none"> • Grants • Funding 	www.cfda.gov
The Wetlands Regulation Center	<ul style="list-style-type: none"> • Regulatory information 	http://www.wetlands.com/reg/s/tlpge00a.htm
US Army Corps of Engineers	<ul style="list-style-type: none"> • Funding • Regulatory information 	http://www.usace.army.mil/
US Department of Agriculture	<ul style="list-style-type: none"> • Current programs • Possible funding/grants 	www.usda.gov/
US Department of Agriculture Natural Resources Conservation Services	<ul style="list-style-type: none"> • Funding • Regulatory information • Outreach and education 	http://www.nrcs.usda.gov/wps/portal/nrcs/site/national/home/
US Department of Transportation	<ul style="list-style-type: none"> • Stormwater Information • Possible funding/grants 	www.transportation.gov/ http://www.environment.fhwa.dot.gov/ecological/eco_index.asp
US Fish and Wildlife	<ul style="list-style-type: none"> • Threatened and Endangered Species Protection Program information • Resources • Funding 	http://endangered.fws.gov/partners.html
US Fish and Wildlife Coastal Program	<ul style="list-style-type: none"> • General Information 	www.fws.gov/coastal/
US Fish and Wildlife Partners for Fish and Wildlife Protection	<ul style="list-style-type: none"> • Technical Information • Funding • Resources 	http://www.fws.gov/partners
USDA Wetland Reserve Program	<ul style="list-style-type: none"> • Outreach and education • Monitoring Coordination 	www.nrcs.usda.gov/wps/portal/nrcs/main/national/program

		s/easements/
USGS Coastal Restoration	<ul style="list-style-type: none"> • General Information 	http://www.nwrc.usgs.gov/about/crab/crab.htm

State (North Carolina)

Entity	Resource	Website
Albemarle-Pamlico National Estuary Partnership	<ul style="list-style-type: none"> • Informational resource • Assist in protection of natural resources, including waters 	http://www.apnep.org/
Division of Energy, Mineral and Land Resources Erosion and Sediment Program	<ul style="list-style-type: none"> • Information when sediment is an issue 	http://portal.ncdenr.org/web/lr/erosion
Division of Water Resources Basin Planning Branch	<ul style="list-style-type: none"> • Outreach and education • Information • Monitoring 	http://portal.ncdenr.org/web/wq/ps/bpu
Division of Water Resources Public Water Supply Section	<ul style="list-style-type: none"> • Outreach to water utilities 	http://www.ncwater.org/?page=9/
N.C. Association of Conservation Districts	<ul style="list-style-type: none"> • Informational resource • Assist in protection of natural resources, including waters 	http://www.ncaswcd.org/
N.C. Coastal Federation	<ul style="list-style-type: none"> • Coordination and planning • Outreach and education • Potential volunteers • Active participants 	http://www.nccoast.org/
N.C. Conservation Districts	<ul style="list-style-type: none"> • Technical assistance • Information • Outreach and education • Potential volunteers 	www.nacdnet.org/north-carolina

N.C. Cooperative Extension Offices	<ul style="list-style-type: none"> • Coordination & planning • Water quality information • Outreach and education 	www.ces.ncsu.edu/local-county-center
N.C. Department of Environmental Quality	<ul style="list-style-type: none"> • Baseline data • Monitoring • Information on environmental regulations • Partner for grants 	www.ncdenr.gov
N.C. Department of Health and Human Services On-Site Water Protection Branch	<ul style="list-style-type: none"> • Inspection and regulation of wastewater systems 	http://ehs.ncpublichealth.com/oswp/
N.C. Department of Transportation	<ul style="list-style-type: none"> • Infrastructure • Project funding • Information • Technical assistance • Grants 	www.ncdot.gov www.ncdot.gov/programs/environmental http://www.ncdoj.gov/Top-Issues/Improving-the-Environment/Environmental-Grants/Grant-Recipients.aspx
N.C. Division of Coastal Management	<ul style="list-style-type: none"> • Zoning Regulation • GIS • Monitoring • Outreach and education 	http://portal.ncdenr.org/web/cm/
N.C. Division of Marine Fisheries	<ul style="list-style-type: none"> • Information on oyster shell sanctuaries and restoration • Data source 	http://portal.ncdenr.org/web/mf/
N.C. Division of Public Health	<ul style="list-style-type: none"> • Information 	http://publichealth.nc.gov/
N.C. Division of Water Resources	<ul style="list-style-type: none"> • Information • Financial assistance through grants and loans • Outreach and education 	www.ncwater.org
N.C. Ecosystems Enhancement Program	<ul style="list-style-type: none"> • Information on wetland and waterway restoration 	http://portal.ncdenr.org/web/eep
N.C. National Estuarine Research Reserve System	<ul style="list-style-type: none"> • Outreach and education • Monitoring 	http://www.nccoastalreserve.net/
N.C. Natural Resources Conservation Service	<ul style="list-style-type: none"> • Information on conservation practices 	http://www.nrcs.usda.gov/
N.C. Nonpoint Source	<ul style="list-style-type: none"> • Technical assistance 	http://portal.ncdenr.org/web/

Management Program	<ul style="list-style-type: none"> • Funding 	wq/ps/nps
N.C. Regional Councils of Government	<ul style="list-style-type: none"> • Outreach and education 	http://www.nctomorrow.org/regional-councils/
N.C. Source Water Assessment and Protection (SWAP) Programs	<ul style="list-style-type: none"> • Information • Funding • Resources 	www.enr.state.nc.us/flighttest/pages/swap.htm
N.C. TMDL Program	<ul style="list-style-type: none"> • Water impairment 	http://portal.ncdenr.org/web/wq/ps/mtu/tmdl
N.C. Wildlife Resources Commission	<ul style="list-style-type: none"> • Information • Potential volunteers • Monitoring 	www.ncwildlife.org
North Carolina Resource Conservation and Development	<ul style="list-style-type: none"> • 501c(3) grant fiscal agent • Project management • Grant research • Grant administration • Technical assistance • Grant writing • Project planning 	www.capefearrcd.org
Regional Council of Governments	<ul style="list-style-type: none"> • Grant Writing • GIS service • Program and grant management assistance 	http://www.ncregions.org
Shellfish Sanitation Program	<ul style="list-style-type: none"> • Baseline data • Historical data • Information • Monitoring 	http://portal.ncdenr.org/web/mf/shellfish-sanitation
State Grant Database	<ul style="list-style-type: none"> • Information on state grants 	www.ncgrants.gov/NCGrants/Home.jsp

Educational Institutions

The following North Carolina institutions also have water resource or coastal and marine programs. These institutes also have departments capable of conducting GIS analysis. These institutions may be of interest when planning watershed management in coastal specific environments:

Educational Institute Coastal/Marine or Water Resource Programs	
Duke University	Nicholas School of the Environment: Marine Lab 135 Duke Marine Lab Rd, Beaufort, NC 28516 (252) 504-7503 http://www.nicholas.duke.edu/marinelab/
East Carolina University	*Inter-university research institute Coastal Studies Institute PO BOX 699, Manteo, NC 27954 Research and Education Campus: 850 NC 345, Wanchese, NC 27981 (252) 475-5400 http://csi.northcarolina.edu/
North Carolina State University	Center for Marine Sciences and Technology 303 College Cir, Morehead City, NC 28557 (252)222-6302 http://www.cmast.ncsu.edu/
	Water Resources Research Institute 1575 Varsity Drive, Module 7, NCSU Campus Box 7912, Raleigh, NC 27695 (919) 515-2815 http://www.ncsu.edu/wrri/
University of North Carolina at Chapel Hill	UNC Institute of Marine Sciences 3431 Arendell St, Morehead City, NC 28557 (252) 726-6841 http://ims.unc.edu/
University of North Carolina Wilmington	UNCW Center for Marine Science 5600 Marvin K Moss Ln, Wilmington, NC 28409 (910) 962-2301 http://uncw.edu/cms/
	Department of Environmental Studies 601 S. College Rd, Wilmington, NC 28409 (910) 962-7675 http://uncw.edu/evs/

Appendix C: Additional Outreach Resources

The following table is a list of sources that can provide additional, detailed information on outreach:

EPA GETTING IN STEP: A GUIDE TO EFFECTIVE OUTREACH IN YOUR WATERSHED
http://cfpub.epa.gov/npstbx/files/getnstepguide.pdf
IOWA DNR: CREATING A PUBLIC OUTREACH PLAN
http://www.iowadnr.gov/portals/idnr/uploads/water/watershed/files/ieguidepart2.pdf
EXAMPLE OUTREACH PLAN FOR THE CODORNICES CREEK WATERSHED IN CALIFORNIA
http://www.codornicescreekwatershed.org/Outreach%20Plan%20for%20Codornices%20Watershed.pdf
N.C. COASTAL FEDERATION SMART YARDS HANDOUT
http://nccoast.org/uploads/documents/Media%20Room/Special%20publications/SmartYards_online%20version.pdf
CITY OF WILMINGTON STORMWATER WEBSITE
http://www.wilmingtonnc.gov/public_services/stormwater
USE RESTORATION WATERSHEDS PROGRAM
http://portal.ncdenr.org/c/document_library/get_file?uuid=ddab2b71-e34e-44fd-94c9-3b0eef0b56c6&groupId=38364

Appendix D: Methods of Watershed Delineation

A variety of methods exist to delineate a watershed by using GIS software and using online platforms. Of these methods, using an online platform, such as USGS StreamStats, is the most user friendly and convenient to incorporate into ArcGIS software. Some states are not part of StreamStats, some states may have their own watershed delineation online platform. To determine whether a state may have its own platform that can delineate a watershed online, contact the state's USGS [Water Science Center](#). If a state does not have a means of delineating a watershed, it is possible to delineate a watershed using ArcMap. A digital elevation model (DEM) dataset is necessary, which are often available through state GIS databases.

At a minimum, the following is required:

- DEM
- ArcGIS Spatial Analyst Extension

Utilizing the DEM it is possible to single out the desired watershed and delineate a single watershed utilizing online tutorials made available through a number of universities. The following table are some of the tutorials:

TRENT UNIVERSITY: WATERSHED DELINEATION WITH ARCGIS 10.2.X
https://www.trentu.ca/library/sites/default/files/documents/WatershedDelineation_10_2.pdf
UNIVERSITY OF TEXAS: WATERSHED AND STREAMS NETWORK DELINEATION
http://www.ce.utexas.edu/prof/maidment/giswr2012/Ex4/Ex42012.pdf
UNIVERSITY OF WASHINGTON: WATERSHED DELINEATION
http://courses.washington.edu/gis250/lessons/hydrology/exercise/

Appendix E: Soil Data Acquisition

If the county does not have HSG categories or if they do not have soil datasets available, then the following methods can be used to obtain soil data:

1. Access [Web Soil Survey](#).
2. Select the green **Start WSS** button.
3. Navigate to the watershed. Utilize the **Address** search option under **Quick Navigation** on the left side of the webpage to enter the approximate address of the watershed **or** utilize the **Zoom** and **Pan** tools located on the toolbar above the map.

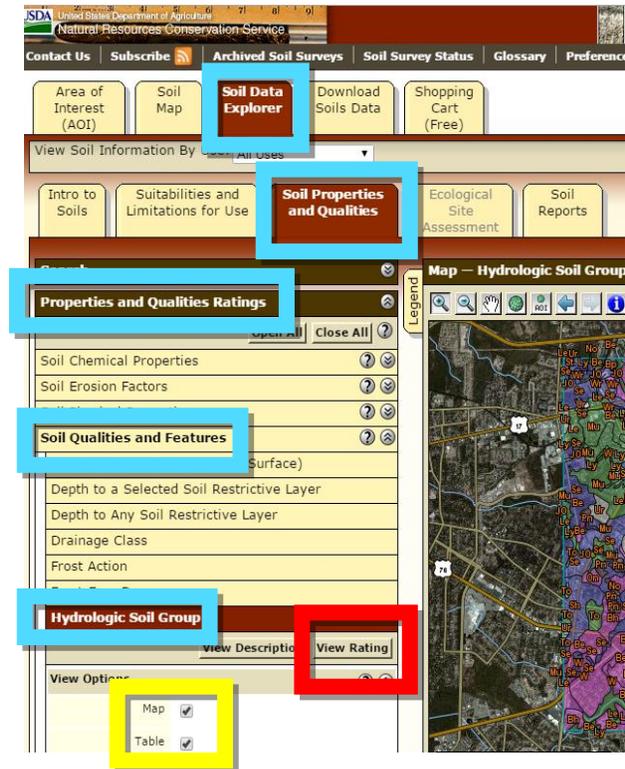


Zoom Pan

AOI Rectangle
AOI Polygon

4. Select the **Area of Interest (AOI)**. Utilizing the **AOI Rectangle** or **AOI Polygon** selection tools to select an area larger than the watershed.

5. **Navigate to HSG data.** At the top half of the page, select the third tab **Soil Data Explorer**. Then select the third tab **Soil Properties and Qualities**. Then in the left column expand **Properties and Qualities Ratings**. Then expand **Soil Qualities and Features**. Then select **Hydrologic Soil Group**.



6. **Select HSG data.** Check the boxes next to **Map** and **Table** (see yellow box) and then select the **View Rating** button (see red box).

Below the map of the HSG, a table will render with the soil taxonomy and acronym and the HSG rating. Print or save the table.

7. **Download data.** At the top of the page, select the fourth tab *Download Soils Data*. Make sure *Your AOI (SSURGO)* is expanded and select the *Create Download Link* button. Once rendered, a zip file link will appear on the left bottom of the webpage under *Download Link*. Click on the link to automatically download the zipped file.

8. **Unzip the folder.**

9. **Open in ArcMap.** Add the data through ArcMap, navigate to the unzipped folder. There will be multiple files and folders within the main folder. Open the *Spatial* folder. Then select *soilmu_a_aoi.shp*.

Note Add the watershed boundary and compare the watershed boundary to the soils shapefile and confirm that the entire watershed is within the boundary of the soils shapefile. If it is not, repeat the above steps and be careful to ensure that the entire watershed is within the boundaries of the soils AOI.

10. **Add to the attribute table.** Access the shapefile's attribute table and *Add Field*. Name the field *Soil_HSG* and select *Text* for type.

11. **Sort soil taxonomy.** Sort the soil taxonomy acronym field *MUSYM* alphabetically.

12. **Edit Soil_HSG.** Being an edit session using the *Editor* toolbar and select *Start Editing* under the Editor dropdown menu. Select the *soilmu_a_aoi.shp* to edit. Begin to manually edit the *Soil_HSG* field in the attribute table.

Use the HSG table printed or saved in Step 6 as a guide. Only assign a single letter HSG to each soil. If the soil is defined with a combination HSG (e.g. A/D, B/D, C/D), assign the lower of the two classes (e.g. HSG D if the initial classification was HSG A/D). Visually confirm that any soils designated W (for water) are actually part of waterbodies or are inundated areas (e.g. marsh, wetlands) by comparing it to the aerial image of the area.

Note Edit multiple fields at a time by select the rows that have similar HSG and right-clicking *Soil_HSG* and selecting *Field Calculator...* and inputting the HSG in the code block and selecting *OK*.

13. **Finish edit session.** Upon completion, return to the Editor toolbar and under the Editor dropdown menu, select *Save Edits*. Once saved, select *Stop Editing*.

Appendix F: Data to Consider Including

PHYSICAL AND NATURAL PROPERTIES

The physical and natural features of a watershed are the first data to gather when developing a management plan. These data will allow for characterization of the watershed and highlight complexities of the system. The physical and natural features of a watershed can include data such as watershed boundaries, hydrology, topography, soils, climate, habitat, and wildlife.

WATERSHED BOUNDARIES

The first step in learning about the physical features of the target watershed is to determine its boundaries as well as the Hydrologic Unit Code (HUC). This process was outlined in Chapter 4.3 using the EPA's [MyWATERS Mapper](#), the USGS [Watershed Boundary Dataset](#), [USDA Geospatial Data Gateway](#) and the [USGS StreamStats](#). Knowing the physical boundaries is extremely important for any watershed plan, as it may shed new light on tributaries contained within the watershed in addition to potential sources of pollution. This is extremely important in coastal regions because it is vital to know which tributaries ultimately outflow to important estuarine waters and eventually to the ocean.

HYDROLOGY

Determining the hydrology of the target watershed is also important for determining management strategies. The hydrology of the watershed can show the spatial relationship between water bodies as well as connectivity between them. This information can help create a picture of how the system of water bodies interacts to create a single watershed.

Stream shapefiles for North Carolina are available through the [Department of Water Quality](#). These GIS data include all primary surface water classifications, as well as supplemental classifications and special designations given by DEQDEQ. This site also has a hydrologic list of waterbodies for each North Carolina river basin with respective classifications.

[The National Hydrography Dataset](#) is another invaluable source of information regarding waterbodies such as lakes, ponds, rivers, canals, dams, and stream gauges. This can help to trace water discharge and water quality and link them with downstream effects. The data can be downloaded, by state, subregion, watershed, or watershed. The USGS National [Map-hydrography data](#) is another helpful source of information. Floodplain maps can be obtained through [FEMA](#). These maps are intended for insurance providers, but give a detailed view of past and present floodplain areas.

BIOLOGY

Information regarding the species present within your watershed is a very important indicator of health. As noted earlier, macroinvertebrates are an important indicator of stream health and information can be found on DEQ's [Benthic Macroinvertebrate Assessment Data](#) website.

Different types of macroinvertebrates are sensitive to different types of pollution, which may be a key piece of information when determining priorities for your watershed. In North Carolina, biological assessments are conducted for each river basin, and include analyzed benthic macroinvertebrate data, and rare taxa found. There are also data available on North Carolina [fish kill events](#) and [shellfish health](#).

Most of this information can only be found at the state or local level. At the federal level, some biological samples are taken with the water quality data, but in many cases it is not a priority. Some biological data may be found through the [USGS water quality assessments](#).

GEOMORPHOLOGY

Geomorphologic data are those that give the physical characteristics (geological and morphological) of the system. This data is often not available for a specific location, but there is a chance that there will be some data in proximity to your watershed. Some studies and information on [fluvial geomorphology](#) can be found through the USGS.

TOPOGRAPHY

Topography, or the mapping of surface features, can be used to determine elevation changes and find areas that are unstable. Topographic GIS layers are available for North Carolina through the [NC OneMap](#). This site contains both data compatible with GIS software and data that is presented as an interactive online map. Additional data that will be discussed later is also available from North Carolina OneMap including coastal imagery, orthophotography, parcel data and street vector data. Topographic data may also be obtained from the USGS National Map-[US Topo](#). These data are available for most of the United States and can be viewed in contiguous quadrangles, and is useful for watersheds that are located in more than one state or region.

HABITAT

Habitat data are useful for identifying areas of conservation, and for preserving important areas that are not yet protected. Having protected areas can help improve water quality through decreased runoff as well as maintaining infiltration of stormwater. These data may also be used for the protection of critical species that use certain habitats. For example, diamondback terrapins inhabit salt marshes, which serve to filter surface runoff. Therefore using habitat classifications to identify potential areas of habitat for this species is an important consideration.

Wetlands habitat data are available through NC DEQ [Coastal Wetlands Mapping](#) site, as well as through the U.S. Fish and Wildlife Service (USFWS) [National Wetlands Inventory](#). The Coastal Wetlands Mapping site has an interactive mapping feature showing coastal wetlands including marshes, swamps, bottomland hardwoods, and pocosins and contains information about wetland site restoration and enhancement potential. The National Wetlands Inventory was created in 1974 to map the wetlands in the entirety of the contiguous United States. The data from the National Wetlands Inventory is viewable as GIS polygon data or through the interactive wetlands mapper. Broad level data is also available through the USDA National Resources Inventory-[Wetland Dataset](#).

Other habitat data such as the status of rare, threatened, and endangered plants is available through the [National Heritage Program](#). These data are available through an interactive map viewer, as a database, as well as GIS shapefiles. USFWS [Habitat Conservation Plans](#) are another source of habitat data showing areas important for conservation. States also have specific habitat conservation programs, which for the state of North Carolina can be found through the N.C. [Wildlife Resource Commission- Habitat Conservation Program](#).

WILDLIFE

Wildlife data are crucial for watershed management plans in order to identify endangered, protected, and economically important species. Wildlife, especially waterfowl, may also contribute to nutrient and bacteria loading. Knowing the distribution of wildlife within the target watershed will allow for identification of potential sources of bacteria and nutrients.

Wildlife data can be found from some of the same sources used to find habitat data. A good place to start looking is the [National Heritage Program](#), where you can look at what species are present at the county level. These data also include state and federal statuses for each species, making it easy to determine if there may be any species in or around your watershed that are of importance. These data are available through an interactive map viewer, as a database, as well as GIS shapefiles. Federally listed [endangered species](#) can also be found through the USFWS, at the state and county level.

[Habitat Conservation Plans](#) for endangered or threatened species are also useful to determine if there are any plans already in place for important organisms within your watershed. [N.C. Habitat Conservation Plans](#) are available through the N.C. Wildlife Resource Commission (WRC). A comprehensive list of [wildlife agencies and organizations](#) can be found through the USFWS, and are delineated by state.

Assessments of wildlife species such as fish, macroinvertebrates, and other important indicator species can be used not only for conservation reasons, but also as indicators of health. North Carolina [Stream and Fish Community Assessments](#) through DEQ include more than 918 sites

throughout the state where fish assessments are conducted and fish community data has been assembled by individual river basins. Similarly, DEQ has [Benthic Macroinvertebrate Assessment Data](#) report that has been collected from every level-IV ecoregion, county, and river basin in the state. Like the fish community assessments, the macroinvertebrate data are also available for individual river basins in North Carolina macroinvertebrates may not seem like the most interesting organisms to look at when creating a watershed management plan, but they can give a great deal of insight into the health of a river or stream. Macroinvertebrates are important because they ingest leaf litter, algae and other small food sources and make this energy available to larger species through predator/prey interactions. Different types of macroinvertebrates are sensitive to different types of pollution, which may be a key piece of information when determining priorities for your watershed. In North Carolina, biological assessments are conducted for every river basin and include analyzed benthic macroinvertebrate data as well as rare taxa found.

[GAP data](#) available through the USGS aims to determine the extent with which plants and animals are being protected through conservation lands. These data are available for GIS software as well as through an interactive map data viewer. There are GAP data for species range, predicted habitat distribution, aquatic GAP analysis, land cover, and protected areas.

LAND USE AND LAND COVER (LULC)

Human alteration of the natural environment for various land usages can affect the hydrology of surrounding systems. For example, historically, wetlands were ditched and drained for agricultural purposes. Land use and related activities within a watershed directly affect the types of pollutants that enter the water. For instance, the creation of housing subdivisions may generate pollution from septic tanks, fertilizer, oil, or pet sources, agricultural lands may contribute fertilizer and pesticides, while urbanized areas may generate pollution from oil and heavy metals. Land use and land cover maps can be derived from satellite imagery through a few different GIS techniques, and some areas have existing maps that have already been classified.

State level data of LULC can be obtained through the [N.C. DCMN.C. DCM](#), who oversee local land use plans in the 20 coastal counties identified by CAMA. LULC data are also available through various federal agencies including the USGS [National Map-Land Cover](#) dataset discussed previously. These data include LULC types such as urban, agricultural, rangeland, forest, surface waters, wetlands, barren lands, percent developed impervious surface, and percent tree canopy density. Land use and land cover data are also accessible from the USGS Multi-Resolution Land Characteristics Consortium ([MRLC](#)) and from the USGS [GAP](#)-Land Cover and Protected Areas datasets. These are based on satellite imagery, however survey based LULC data for agricultural and livestock purposes can be found from the USDA [Census of](#)

[Agriculture](#). There are also specialized datasets for the coast through the [NOAA Digital Coast](#) database.

Beyond land use and land cover maps, the [National Resources Inventory](#) has analyzed land use data into various reports. This includes information such as land use status and trends, development of non-federal rural land, soil erosion and cropland status, wetlands inventories, and rangeland assessments. This information may also be inferred from [boundary](#) data and [orthoimagery](#) from the USGS National Map.

DEMOGRAPHICS

Demographic data are information about the human population within your watershed. This can include information such as raw population, spatial representation of the population, age, economic conditions, employment, education, income, and even road usage. Knowing this information about the people within your watershed can give insight into existing problems, as well as help to identify ways to prevent pollution through education and outreach.

Most states have this information available on the web through their census bureau. Data for North Carolina is available through the N.C. Office of State Budget and Management-[Census and Survey Data](#). Data is also available through the [U.S. Census Bureau](#).

POPULATION CHARACTERISTICS

Demographics of human populations can help inform planning as well since densely populated areas tend to have more impervious surface, stormwater runoff, and sources of pollution. With land use and population characteristics, it is extremely important to obtain current data given that coastal areas are developing quickly and many areas are experiencing rapid population growth.

WATERBODY AND WATERSHED CONDITIONS

Water quality data can include designations for use, standards, 305(b) reports, 303(d) lists, TMDL reports, and Source Water Assessments (SWA). Identifying the water quality problems within a watershed can shed light on the complexity of the system and pinpoint the most important issues.

WATER QUALITY STANDARDS

States have different water quality standards depending on the designated uses for the waterbody. Knowing the standards of a watershed is integral in determining if the water is in compliance. By comparing existing water quality parameters to these standards, the condition of the watershed will become clear. North Carolina has a plethora of [water quality designations](#)

specific to potential uses discussed in Chapter 2. These designations have an accompanying set of water quality standards that the waterbody must meet. The EPA also has links to various [state water quality standards](#) through a clickable map, which also gives information on federal standards in place for each state.

SOURCE WATER ASSESSMENTS (SWA)

Source Water Assessments (SWA) are conducted by states to provide a comprehensive look at the drinking water within each public water system. In North Carolina, SWAs are available from NCDEQ-[Source Water Assessments](#) NCDEQ-[Source Water Assessments](#). Surface Water Assessments for other states are generally found through local water utility websites and links to other drinking water programs are found through the EPA-[Drinking Water](#) website.

WATERBODY MONITORING DATA

Some of the most important data to gather for your watershed are waterbody monitoring data such as that done by the Shellfish Sanitation office described previously. Water monitoring data are also the most difficult to attain for specific locations and may include gaps in spatial or temporal coverage. For example, there may only be in stream data available in one location of your watershed, or there may only be monthly data spanning a few years. It is important to know what data is available in order to know what information is lacking.

Appendix G: Additional LID Information

The following table is a list of sources that can provide additional, detailed information on LID and BMP practices:

EPA: STORMWATER RETROFIT TECHNIQUES FOR RESTORING URBAN DRAINAGES
https://www3.epa.gov/region1/npdes/stormwater/assets/pdfs/BMPRetrofit.pdf
NORTH INLET NERR CENTER FOR WATERSHED PROTECTION: EIGHT-STEP APPROACH TO STORMWATER RETROFITTING: HOW TO GET THEM IMPLEMENTED
http://www.northinlet.sc.edu/training/media/resources/Eight-Step%20Approach%20to%20Stormwater%20Retrofitting.pdf
CENTER FOR WATERSHED PROTECTION: URBAN STORMWATER RETROFIT PRACTICES
http://chesapeakestormwater.net/wp-content/uploads/downloads/2012/06/Urban-Stormwater-Practices.pdf
EPA: GREEN INFRASTRUCTURE DESIGN AND IMPLEMENTATION
http://www.epa.gov/green-infrastructure
http://www.epa.gov/green-infrastructure/green-infrastructure-design-and-implementation
EPA: LOW IMPACT DEVELOPMENT A LITERATURE REVIEW
http://www.lowimpactdevelopment.org/pubs/LID_litreview.pdf

Appendix H: Bradley and Hewletts Creeks Watershed Management Plan Objectives Table

Objective 1. Continue Existing Programs that Address Water Quality Impairments in Both Watersheds

Action #	Specific Action	Timeline	Partners
1-1	Implement and enforce existing stormwater requirements for new development and redevelopment	On-going	City of Wilmington – Stormwater Services, Engineering, Development Services; NC DEQ, WB
1-2	Continue to promote LID designs	On-going	City of Wilmington – Stormwater Services, Engineering, Development Services; NC DEQ, WB
1-3	Continue to cooperate with CCAP	On-going	City of Wilmington – Engineering, Development Services; NCCF, WB, New Hanover Soil and Water
1-4	Maintain existing educational programs	On-going	City of Wilmington - Stormwater Services; NCCF, New Hanover Soil and Water, WB
1-5	Reflect plan in other City plans and NPDES annual permit report	As plans are updated	City of Wilmington – Stormwater Services, Engineering, Development Services: WB, NCCF
1-6	Continue education and code enforcement programs that reduce and eliminate sources of bacteria and pathogens related to human and pet wastes	On-going	City of Wilmington – Stormwater Services; WB

Objective 2. Determine Appropriate Water Quality Classifications and Designated Uses Where Water Quality Impairment Exists

Action #	Specific Action	Timeline	Partners
2-1	Work with SS, UNCW, WB and NCCF to conduct preliminary evaluations of water quality to determine where more intensive state (SS) water quality investigations are needed	Year 1, establish preliminary monitoring	City of Wilmington – Stormwater Services; UNCW, SS, WB, NCCF
2-2	Work with SS to establish new monitoring stations within impaired waters influenced by the Bradley Creek watershed	Year 2 based upon preliminary monitoring	City of Wilmington – Stormwater Services; UNCW, SS, WB, NCCF
2-3	Work with SS to establish new monitoring stations within impaired waters influenced by the Hewletts Creek watershed	Year 2 based upon preliminary monitoring	City of Wilmington – Stormwater Services; UNCW, SS, WB, NCCF
2-4	Evaluate the results of bacterial source monitoring in Banks Channel that is being conducted by UNC-CH	Study underway, evaluate results in Year 1	WB, UNC-CH, UNCW, NCCF
2-5	Request Use Attainability Study on SA waters along Wrightsville Beach shoreline in Banks Channel. These waters are automatically closed to Shellfish Harvest due to marinas, and have been polluted since 1947.	Year 2	WB, NCCF, NC DEQ
2-6	Request Use Attainability Study on SB waters now “Approved” for shellfish harvest in waters influenced by the Bradley Creek Watershed	Year 2	City of Wilmington, WB, NCCF, NC DEQ

2-7	Determine if there is potential to restore shellfish harvest in any additional waters classified as SB that are influenced by the Bradley Creek watershed	Years 4-5	City of Wilmington – Stormwater Services; UNCW, SS, WB, NCCF
2-8	Evaluate the status and trends in bacterial contamination within the entire Hewletts Creek watershed based upon more intensive data collected as part of plan implementation	Year 5	City of Wilmington – Stormwater Services; UNCW, SS, NC DEQ, NCCF

Objective 3. Track the Reduction of the Transport of Bacteria from Land to Water

Action #	Specific Action	Timeline	Partners
3-1	Secure and budget funds for retrofits in the Bradley Creek watershed, determine volume that can be reduced with funds, and track actual reductions using measurement tools	Secure funds years 1 and 2, design retrofits year 3, install and track reductions years 4 and 5	City of Wilmington – Stormwater Services; UNCW, SS, NC DEQ, NCCF
3-2	Secure and budget funds for retrofits in the Hewletts Creek watershed, determine volume that can be reduced with funds, and track actual reductions using measurement tools	Secure funds years 1 and 2, design retrofits year 3, install and track reductions years 4 and 5	City of Wilmington – Stormwater Services; UNCW, SS, NC DEQ, NCCF

Objective 4. Promote Stormwater Reduction Efforts

Action #	Specific Action	Timeline	Partners
4-1	Promote use of GIS web based retrofit Atlas	Each year	City of Wilmington – Stormwater Services, Engineering, Development Services; WB, NCCF
4-2	Investigate cost effective methods of working with landowners to disconnect impervious surfaces	Year 1 and 2	NCCF, City of Wilmington, WB
4-3	Promote LID retrofits within private development	Each year	City of Wilmington – Stormwater Services, Engineering, Development Services; WB, NCCF. Use existing educational programs to promote retrofits for volume reduction
4-4	Promote tree planting and retention	Each year	Wilmington Tree Commission; City of Wilmington - Development Services, Stormwater Services; Keep New Hanover Beautiful, NCCF, Cooperative Extension, WB
4-5	Promote stormwater reduction measures on City streets in future capital improvement projects	Dependent on Capital Improvement schedule	City of Wilmington - Stormwater Services, Engineering, Streets Divisions, Development Services; WB, NCCF
4-6	Pursue strategy with NCDOT to incorporate retrofits into highway upgrades	Years 1 – 5	City of Wilmington - Development Services, Stormwater Services; NCDOT, NCCF, WB

4-7	Promote LID retrofits in future publicly funded maintenance or redevelopment of City owned buildings, parks, parking lots, and drainage systems	Based upon project schedules	City of Wilmington – Engineering, Stormwater Services, Community Services, Development Services; WB, NCCF
4-8	Promote and assist with LID retrofits at county schools	Ongoing based upon efforts at schools	NCCF, New Hanover County School System, CCAP
4-9	Encourage UNC-W to develop campus wide master plan to retrofit to reduce stormwater volume	Year 3	City of Wilmington - Stormwater Services, Development Services; UNCW, NCCF
4-10	Evaluate properties for retrofit or restoration potential.	Year 2	City of Wilmington - Stormwater Services, Development Services; WB
4-11	Evaluate existing stormwater ponds on public and private properties for potential volume reductions enhancements, and if feasible, retrofit them to achieve volume reductions	Years 3 - 5	Evaluation potential retrofits, funds to retrofit will come through annual budgeting or from outside grant sources. City of Wilmington - Stormwater Services; WB, NCCF

Objective 5. Form and Maintain Partnerships

Action #	Specific Action	Timeline	Partners
5-1	Work with partners to educate stakeholders	Years 1 – 5	City of Wilmington - Stormwater Services, Development Services; NCCF, New Hanover Soil and Water, WB
5-2	Work with government agencies and NGOs to secure grants for retrofits and other programs	Years 1 – 5	City of Wilmington – Stormwater Services; Development Services; NCCF, WB, Cape Fear Public Utilities
5-3	Provide strategies and policies for city departments to carry out plan by incorporating runoff reduction strategies into the CIP process.	Years 1 – 5	City of Wilmington - Stormwater Services; Development Services, and Finance Depts.; NCCF
5-4	Promote use of atlas among key City departments in their routine business	Years 1 – 5	City of Wilmington - Stormwater Services, Development Services; NCCF, WB
5-4	Promote existing technical training opportunities to advance plan	Years 1 – 5	Special training arranged by partners using their own funds and grants, City of Wilmington - Stormwater Services, Development Services; WB, NCCF
5-5	Work with UNCW on retrofit projects	Years 1 – 5	grants, capital improvements - City of Wilmington - Stormwater Services; UNCW, NCCF

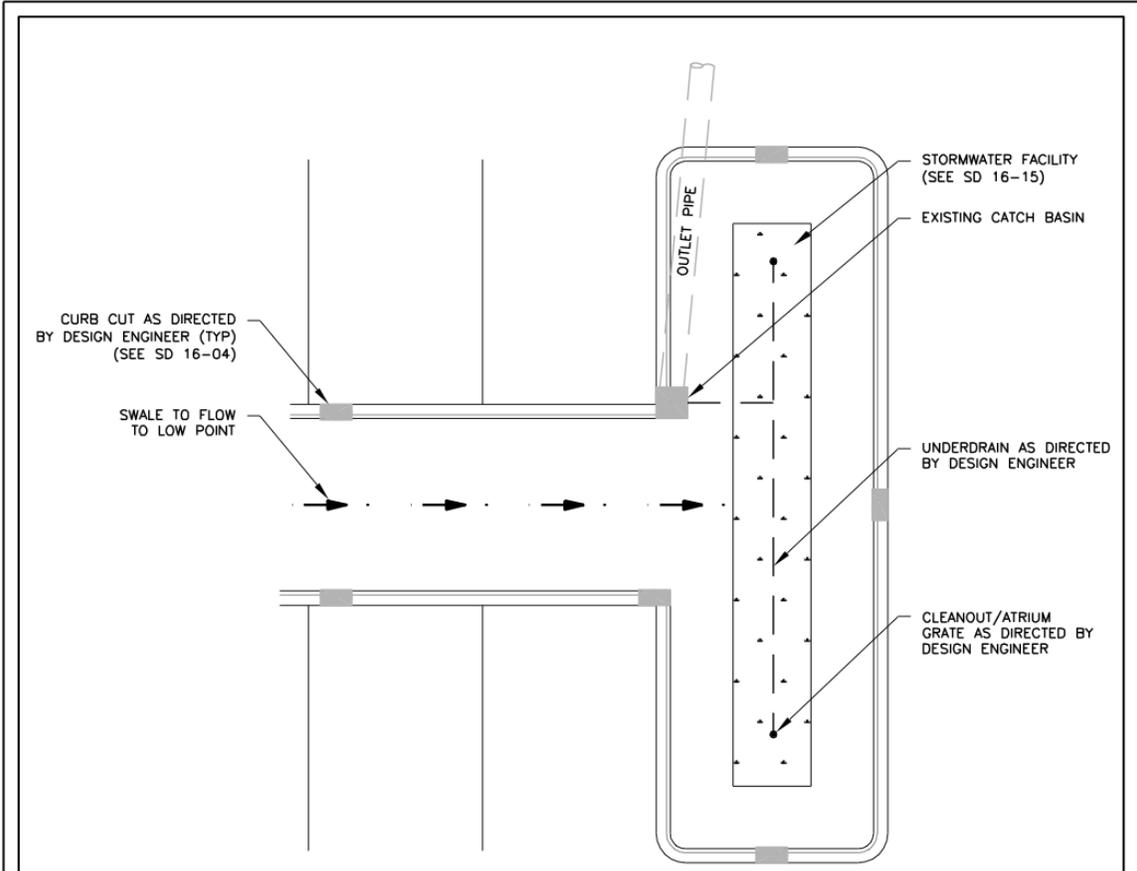
Objective 6. Measure Success and Adapt Plan Based Upon Results

Action #	Specific Action	Timeline	Partners
6-1	Use atlas accounting system to track progress toward watershed goals.	Years 1 – 5	City of Wilmington - Stormwater Services, Development Services; NCCF, WB
6-2	Work with SS, WB, and UNCW to monitor water quality status and trends	Years 1 – 5	City of Wilmington - Stormwater Services, Development Services; NCCF, WB, UNCW
6-3	Conduct annual and five year assessment of plan's success and modify plan as needed	Yearly	City of Wilmington - Stormwater Services, Development Services; NCCF, WB, UNCW

Appendix I: *Green Street* Stormwater Management Devices

The purpose of this appendix is to provide example designs of typical stormwater runoff reduction practices that can be used within the public right of way. The measures shown are examples of the techniques and processes encouraged with the watershed management plan.

These details are intended to serve as the starting point for stormwater retrofits alongside active roadways. These details outline the major design elements of curbside stormwater management facilities. Roadside safety, pedestrian safety, maintenance, gutter spread and other factors must still be evaluated prior to implementation. Additionally, existing utilities or environmental conditions may make it necessary to modify or revise the standard designs to fit each individual BMP location. Curbside stormwater management may not be feasible in all locations.

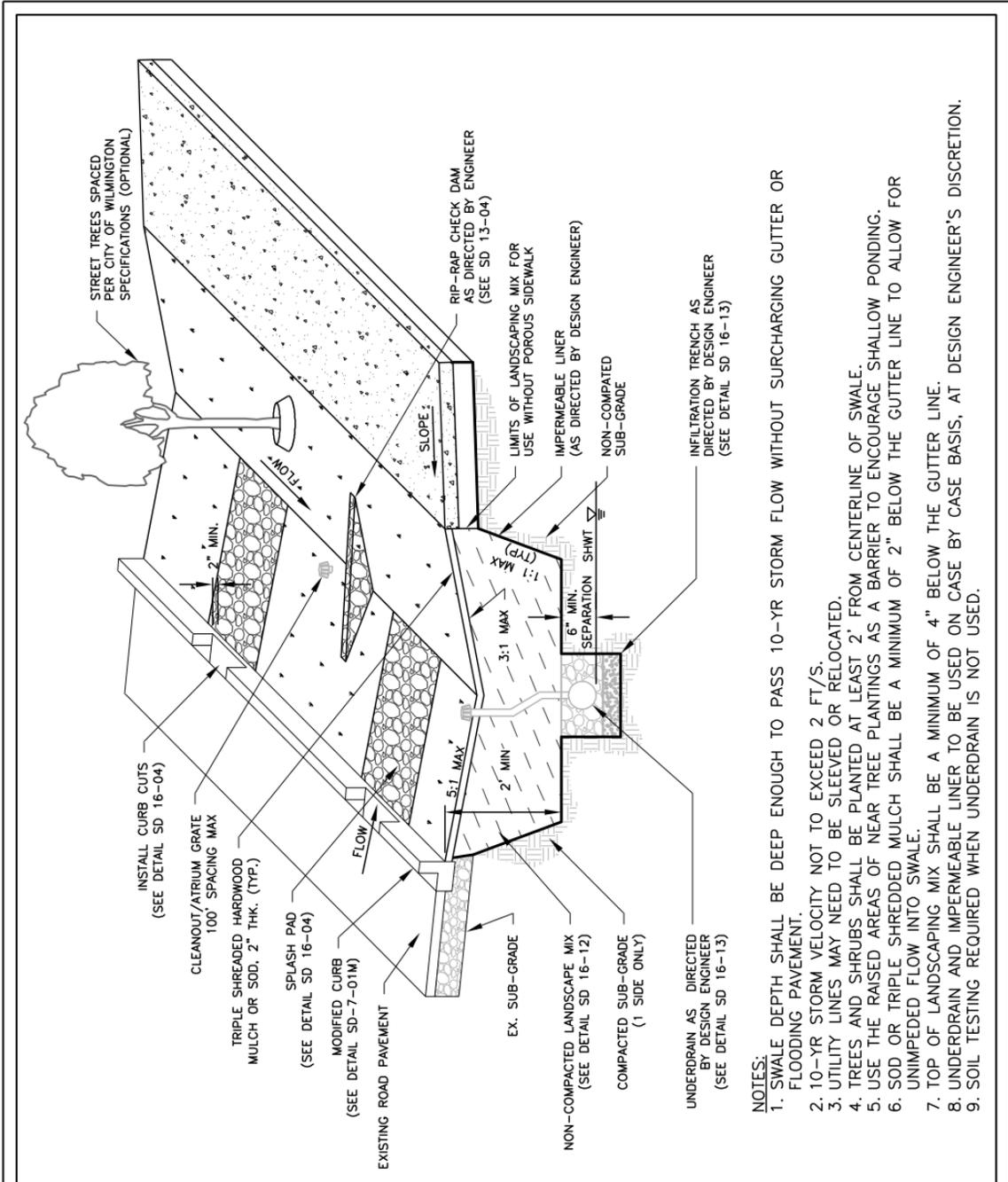


NOTES:

1. DESIGN ENGINEER TO PROVIDE DIMENSIONS OF ISLANDS.
2. SWALE DEPTH SHALL BE DEEP ENOUGH TO PASS 10-YR STORM FLOW WITHOUT SURCHARGING GUTTER OR FLOODING PAVEMENT.
3. 10-YR STORM VELOCITY NOT TO EXCEED 2 FT/S.
4. MAXIMUM PONDING DEPTH SHALL BE 6".
5. UTILITY LINES MAY NEED TO BE SLEEVED OR RELOCATED.
6. TREES AND SHRUBS SHALL BE PLANTED AT LEAST 2' FROM CENTERLINE OF SWALE.
7. SOD OR TRIPLE SHREDDED MULCH SHALL BE A MINIMUM OF 2" BELOW THE GUTTER LINE TO ALLOW FOR UNIMPEDED FLOW INTO SWALE.
8. TOP OF LANDSCAPING MIX SHALL BE A MINIMUM OF 4" BELOW THE GUTTER LINE.
9. UNDERDRAIN AND IMPERMEABLE LINER TO BE USED ON CASE BY CASE BASIS, AT DESIGN ENGINEER'S DISCRETION.
10. SOIL TESTING REQUIRED WHEN UNDERDRAIN IS NOT USED.

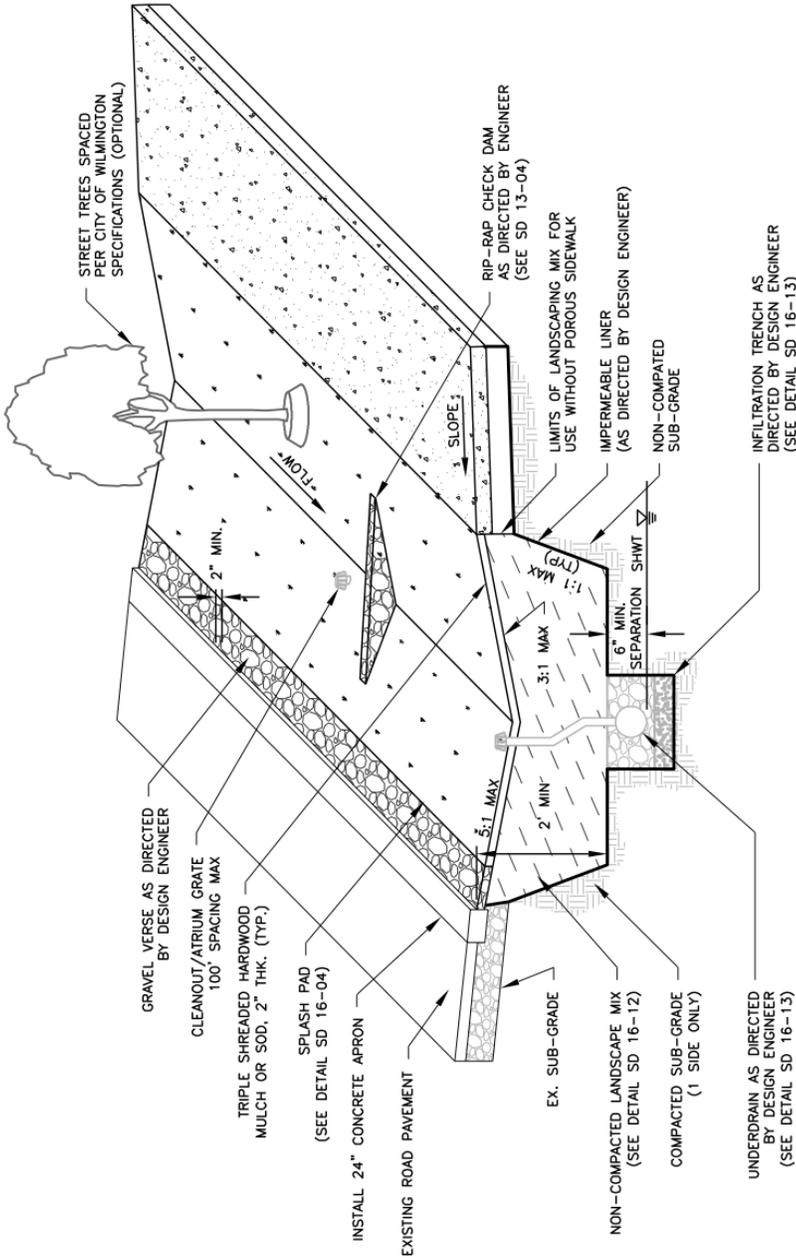
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DATE:	2012	
DRAWN BY	TLM	
CHECKED BY	HCF	
SCALE	NOT TO SCALE	
<h2 style="margin: 0;">STORMWATER PARKING ISLAND</h2>		



- NOTES:
1. SWALE DEPTH SHALL BE DEEP ENOUGH TO PASS 10-YR STORM FLOW WITHOUT SURCHARGING GUTTER OR FLOODING PAVEMENT.
 2. 10-YR STORM VELOCITY NOT TO EXCEED 2 FT/S.
 3. UTILITY LINES MAY NEED TO BE SLEEVED OR RELOCATED.
 4. TREES AND SHRUBS SHALL BE PLANTED AT LEAST 2' FROM CENTERLINE OF SWALE.
 5. USE THE RAISED AREAS OF NEAR TREE PLANTINGS AS A BARRIER TO ENCOURAGE SHALLOW PONDING.
 6. SOD OR TRIPLE SHREDED MULCH SHALL BE A MINIMUM OF 2" BELOW THE GUTTER LINE TO ALLOW FOR UNIMPEDED FLOW INTO SWALE.
 7. TOP OF LANDSCAPING MIX SHALL BE A MINIMUM OF 4" BELOW THE GUTTER LINE.
 8. UNDERDRAIN AND IMPERMEABLE LINER TO BE USED ON CASE BY CASE BASIS, AT DESIGN ENGINEER'S DISCRETION.
 9. SOIL TESTING REQUIRED WHEN UNDERDRAIN IS NOT USED.

STANDARD DETAIL		<h2 style="margin: 0;">SIDEWALK SWALE WITH CURB & GUTTER</h2>	<div style="border: 1px solid black; padding: 5px; display: inline-block;">SD 16-01</div>
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DRAWN BY	TLM		
CHECKED BY	HCF		
SCALE	NOT TO SCALE		



- NOTES:
1. SWALE DEPTH SHALL BE DEEP ENOUGH TO PASS 10-YR STORM FLOW WITHOUT SURCHARGING GUTTER OR FLOODING PAVEMENT.
 2. 10-YR STORM VELOCITY NOT TO EXCEED 2 FT/S.
 3. UTILITY LINES MAY NEED TO BE SLEEVED OR RELOCATED.
 4. TREES AND SHRUBS SHALL BE PLANTED AT LEAST 2' FROM CENTERLINE OF SWALE.
 5. USE THE RAISED AREAS OF NEAR TREE PLANTINGS AS A BARRIER TO ENCOURAGE SHALLOW PONDING.
 6. SOD OR TRIPLE SHREDDED MULCH SHALL BE A MINIMUM OF 2" BELOW THE CONCRETE APRON TO ALLOW FOR UNIMPEDED FLOW INTO SWALE.
 7. TOP OF LANDSCAPING MIX SHALL BE A MINIMUM OF 4" BELOW THE CONCRETE APRON.
 8. UNDERDRAIN AND IMPERMEABLE LINER TO BE USED ON CASE BY CASE BASIS, AT DESIGN ENGINEER'S DISCRETION.
 9. SOIL TESTING REQUIRED WHEN UNDERDRAIN IS NOT USED.

STANDARD DETAIL

SIDEWALK SWALE
WITHOUT CURB & GUTTER

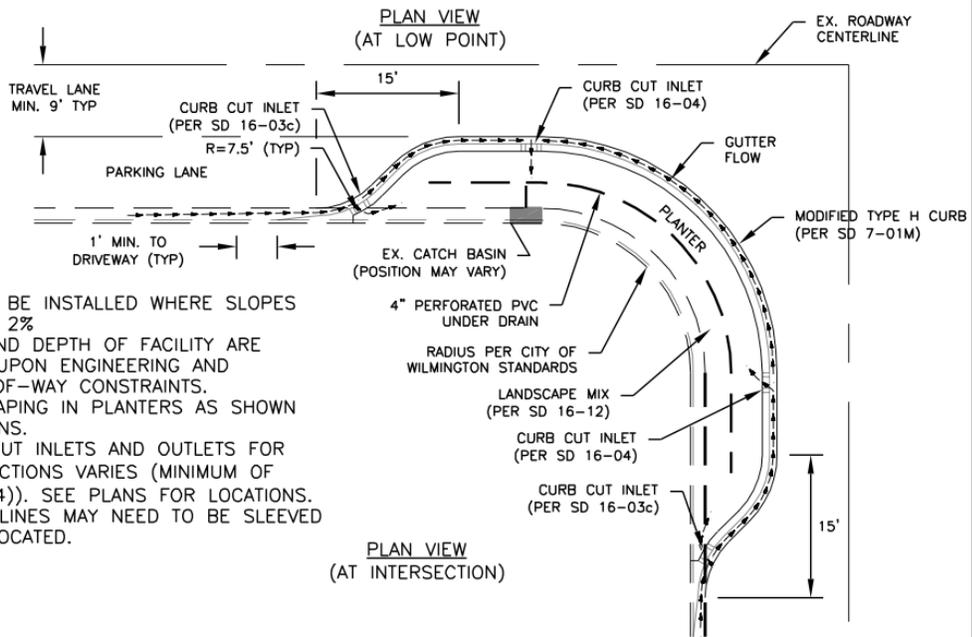
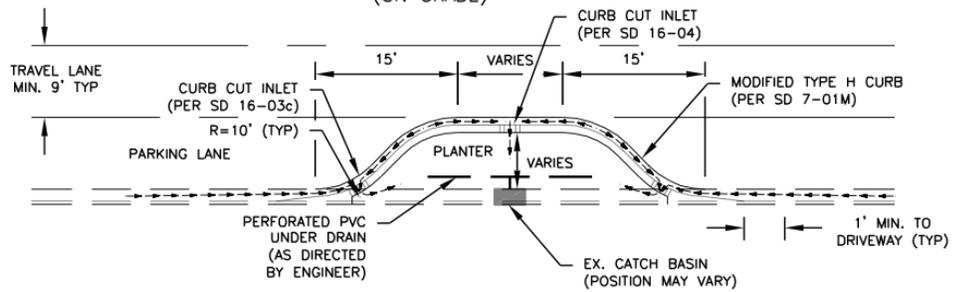
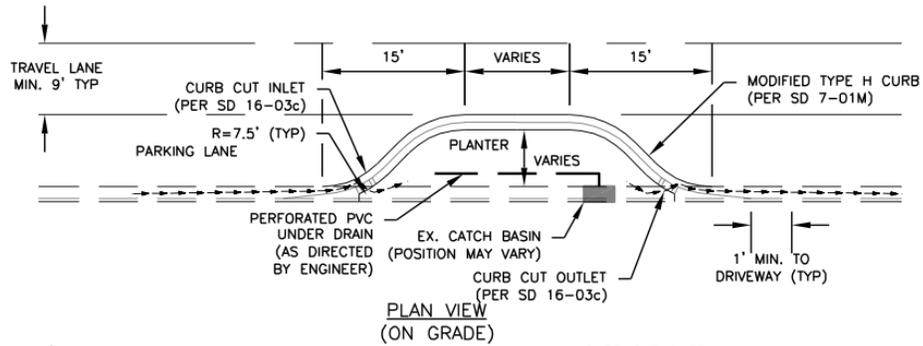
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DATE: 2012

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CHECKED BY HCF

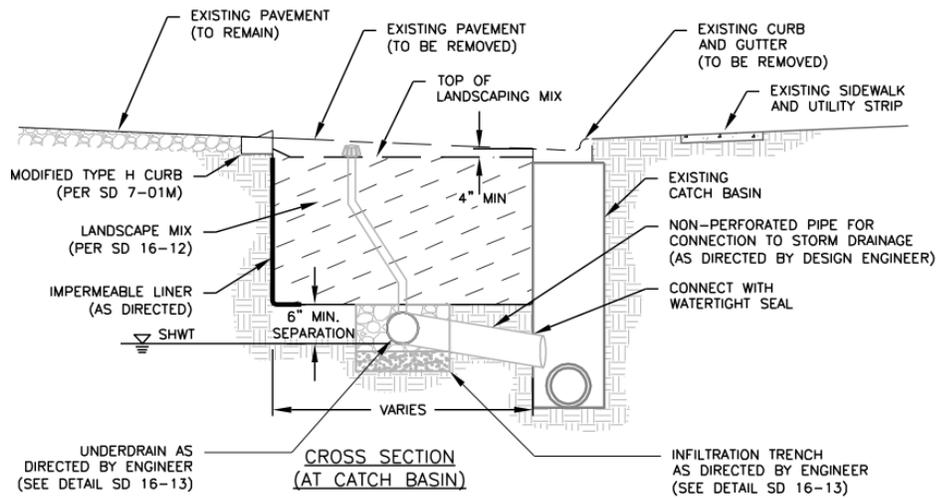
SCALE NOT TO SCALE



- NOTES:**
1. NOT TO BE INSTALLED WHERE SLOPES EXCEED 2%
 2. AREA AND DEPTH OF FACILITY ARE BASED UPON ENGINEERING AND RIGHT-OF-WAY CONSTRAINTS. LANDSCAPING IN PLANTERS AS SHOWN ON PLANS.
 3. CURB CUT INLETS AND OUTLETS FOR INTERSECTIONS VARIES (MINIMUM OF FOUR (4)). SEE PLANS FOR LOCATIONS.
 4. UTILITY LINES MAY NEED TO BE SLEEVED OR RELOCATED.

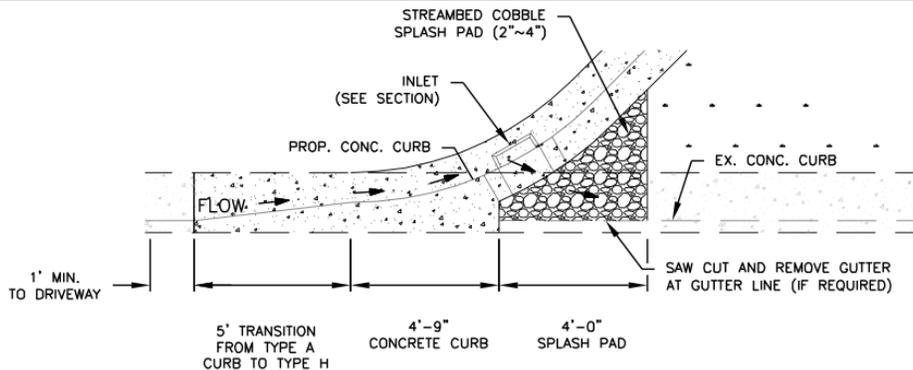
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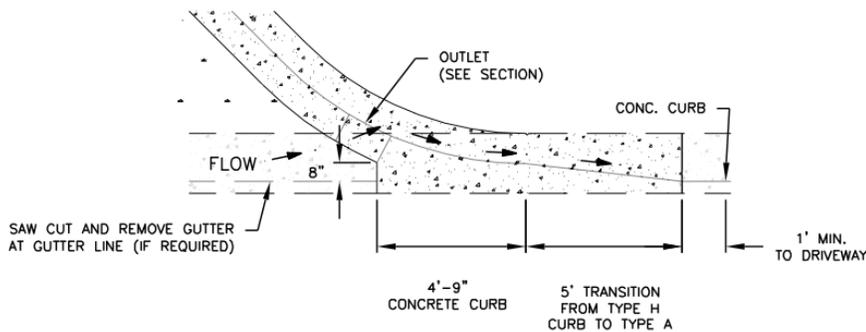


NOTES:
 SOIL TESTING REQUIRED WHEN NOT USING UNDERDRAIN

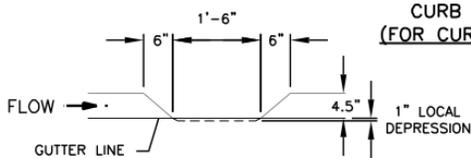
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DRAWN BY TLM		
CHECKED BY HCF		
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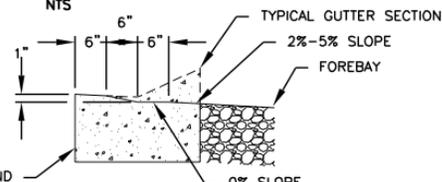
**CURB CUT INLET
(FOR CURB EXTENSIONS)**
NTS



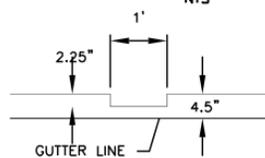
**CURB CUT OUTLET
(FOR CURB EXTENSIONS)**
NTS



INLET SECTION
NTS



CURB CUT INLET PROFILE
NTS

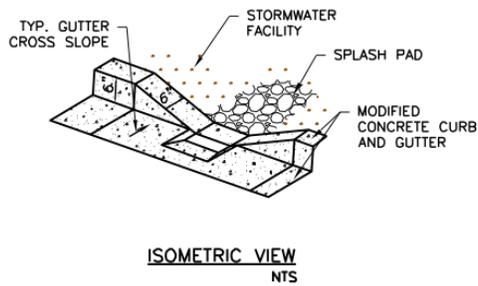
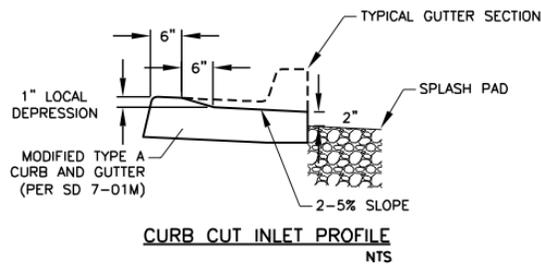
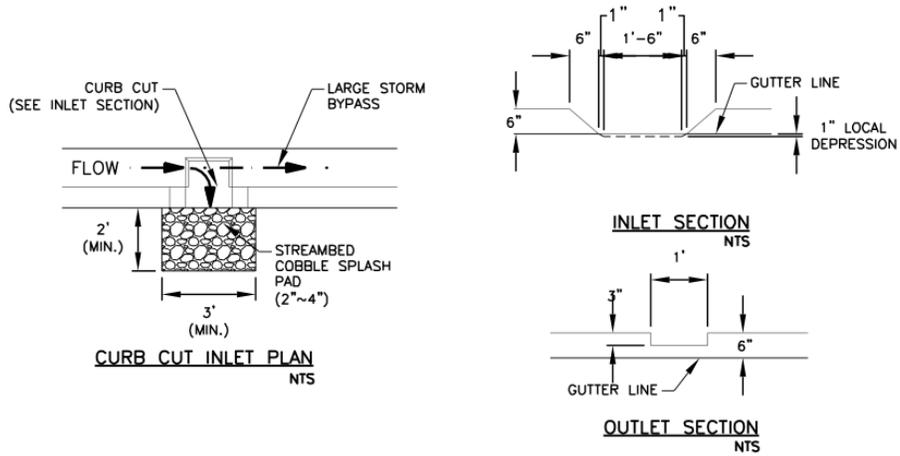


OUTLET SECTION
NTS

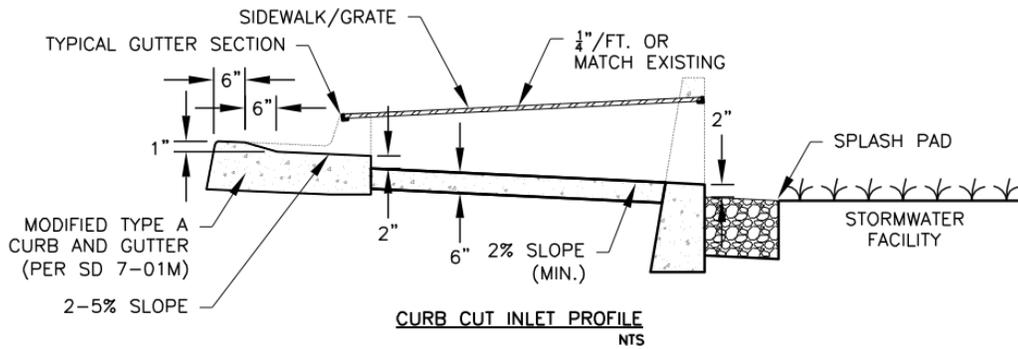
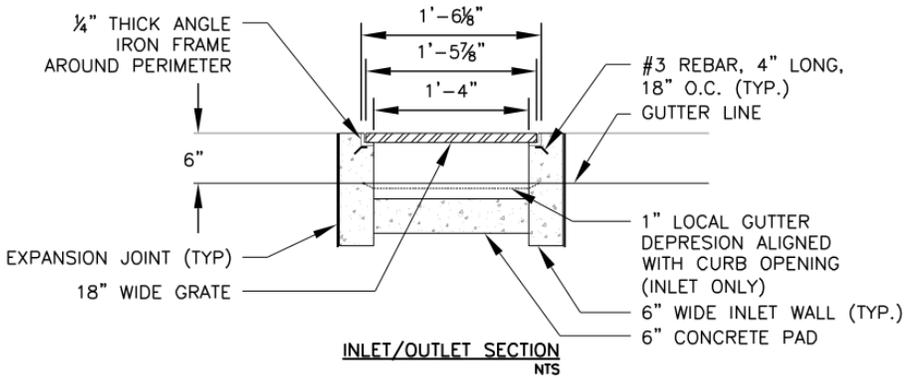
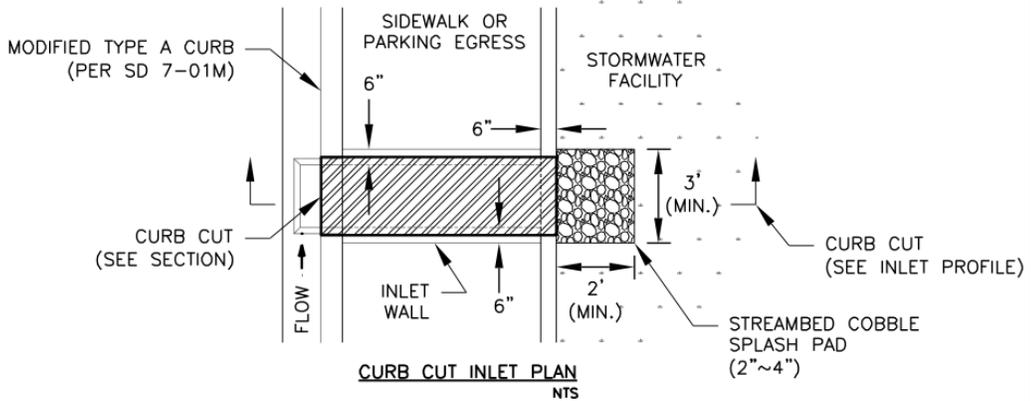
MODIFIED TYPE H CURB AND GUTTER (PER SD 7-01M)

- NOTES:**
1. TO PREVENT PONDING, POSITION INLET CLOSER TO EXISTING CURB IF THE STREET CROSS-SLOPE IS >2%. ADDITIONAL INLETS CAN BE ADDED AS APPROVED BY THE CITY OF WILMINGTON.

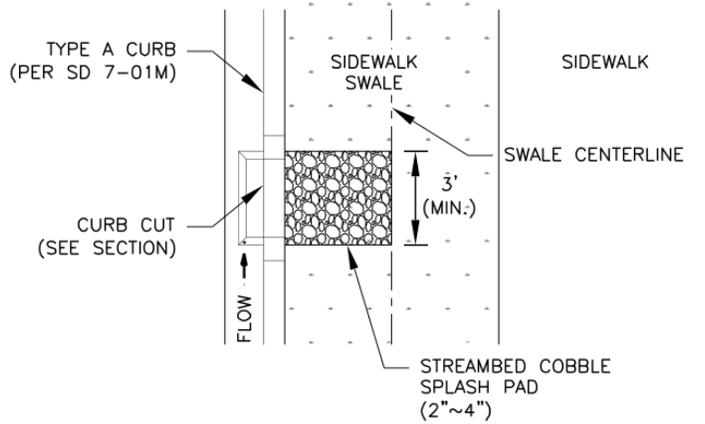
STANDARD DETAIL		<div data-bbox="609 1703 914 1778" data-label="Section-Header"> <p>CURB EXTENSION (3 OF 3)</p> </div>
DATE:	2012	
DRAWN BY	TLM	
CHECKED BY	HCF	
SCALE	NOT TO SCALE	
		SD 16-03c



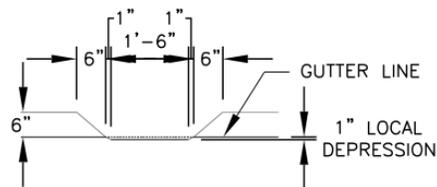
STANDARD DETAIL		
DATE: 2012	CURB CUTS (GENERAL)	
DRAWN BY TLM		
CHECKED BY HCF		
SCALE <u>NOT TO SCALE</u>		SD 16-04



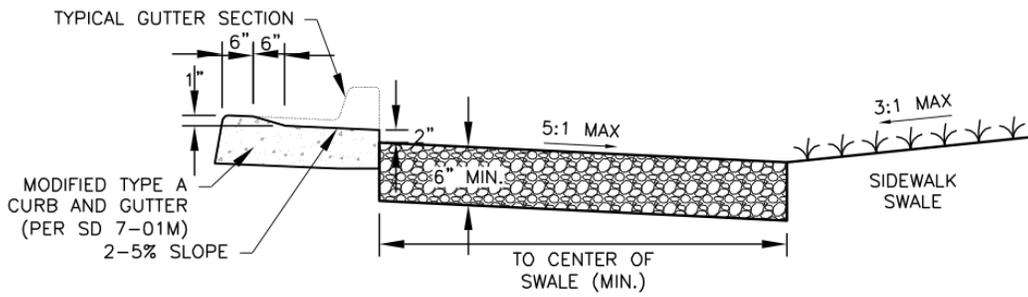
STANDARD DETAIL		<div data-bbox="565 1705 961 1780" data-label="Section-Header"> <h2 style="margin: 0;">CURB CUTS (CHANNEL AND GRATE)</h2> </div>
DATE:	2012	
DRAWN BY:	TLM	
CHECKED BY:	HCF	
SCALE:	NOT TO SCALE	
		SD 16-05



CURB CUT INLET PLAN
NTS

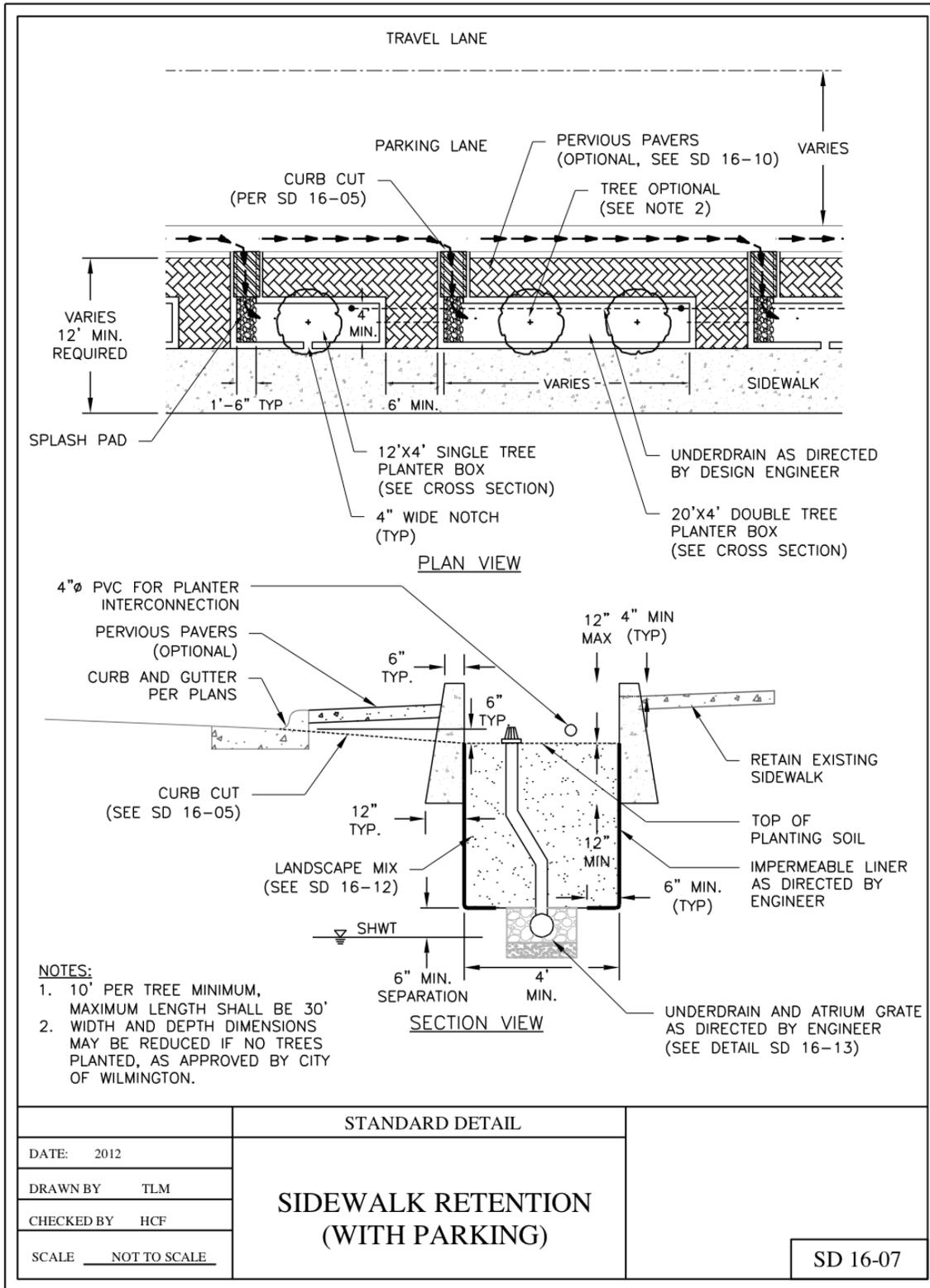


INLET SECTION
NTS

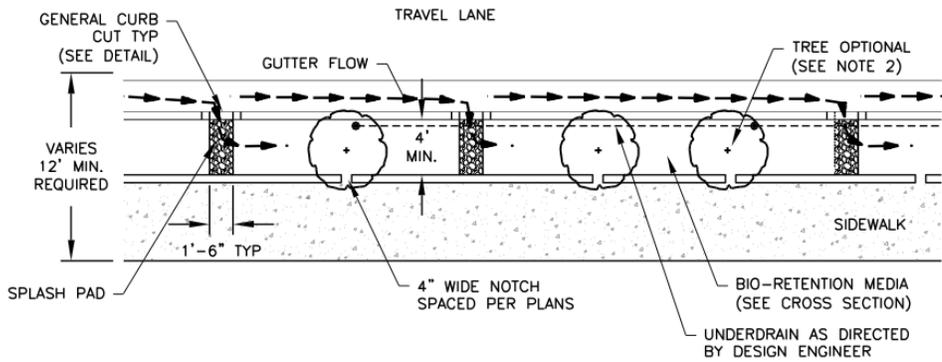


CURB CUT INLET PROFILE
NTS

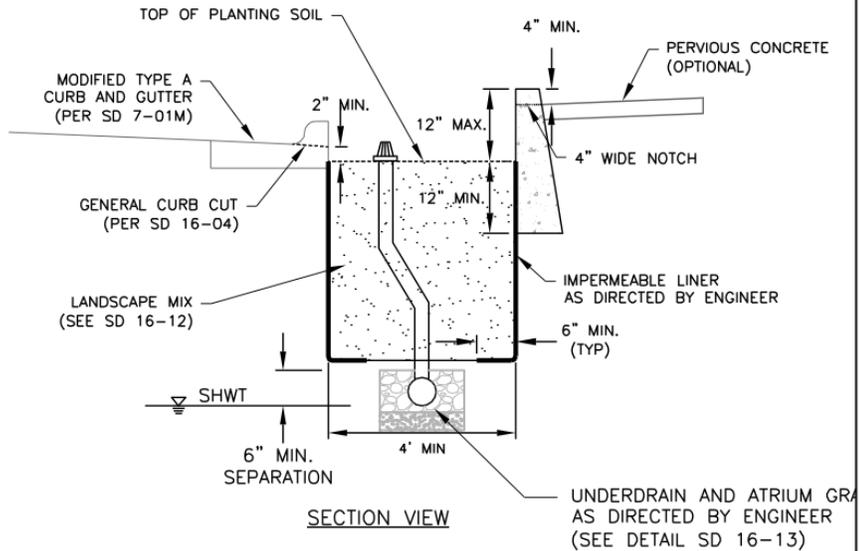
STANDARD DETAIL		
DATE: 2012	CURB CUTS (CHANNEL AND GRATE)	
DRAWN BY TLM		
CHECKED BY HCF		
SCALE <u>NOT TO SCALE</u>		SD 16-06



	STANDARD DETAIL	
DATE: 2012	SIDEWALK RETENTION (WITH PARKING)	SD 16-07
DRAWN BY TLM		
CHECKED BY HCF		
SCALE NOT TO SCALE		



PLAN VIEW



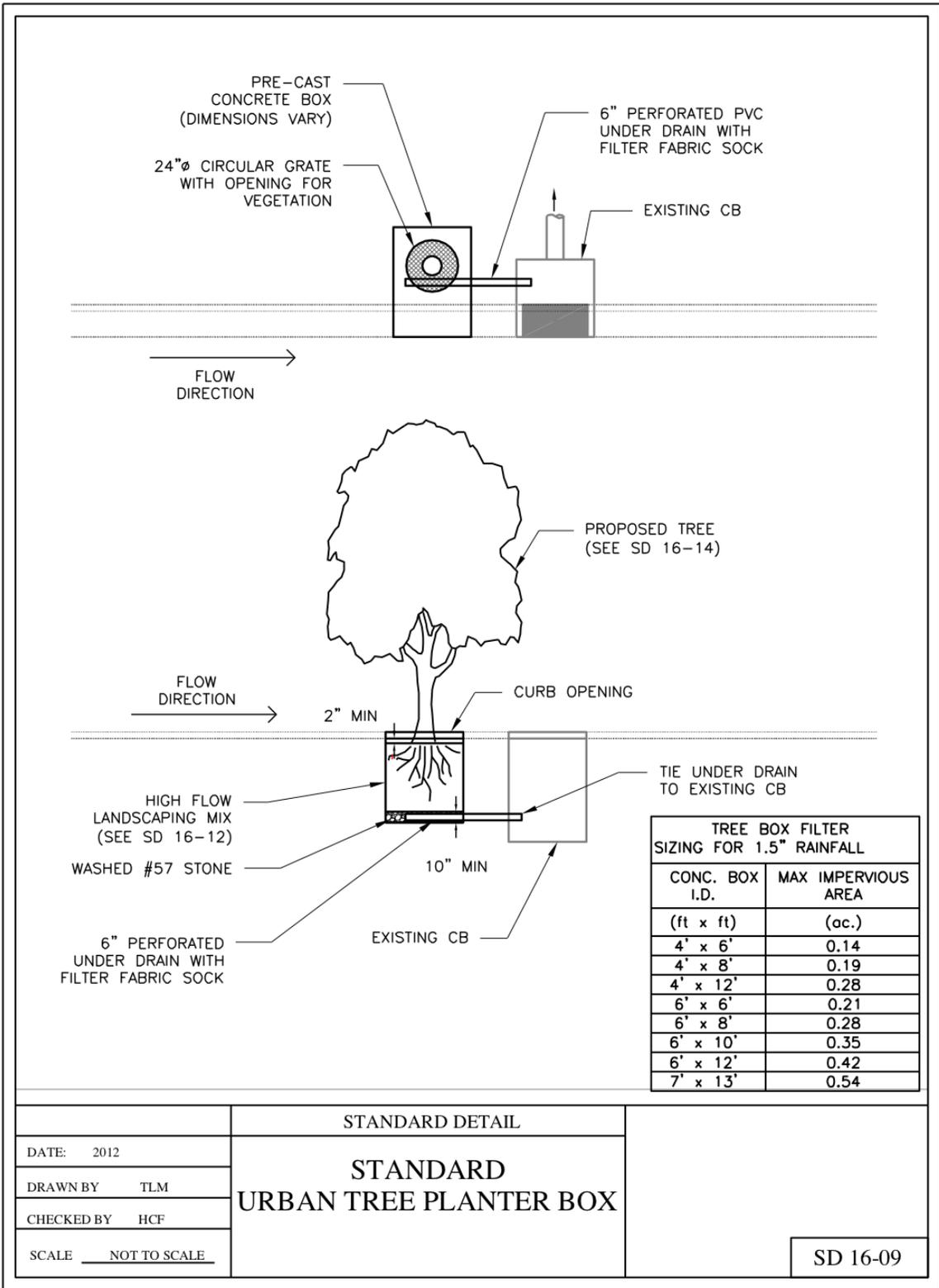
SECTION VIEW

NOTES:

1. 10' PER TREE MINIMUM, MAXIMUM LENGTH SHALL BE 30'
2. WIDTH AND DEPTH DIMENSIONS MAY BE REDUCED IF NO TREES PLANTED, AS APPROVED BY CITY OF WILMINGTON.

STANDARD DETAIL		<div data-bbox="568 1701 958 1785" data-label="Section-Header"> <h2 style="margin: 0;">SIDEWALK RETENTION (WITHOUT PARKING)</h2> </div>
DATE:	2012	
DRAWN BY	TLM	
CHECKED BY	HCF	
SCALE	NOT TO SCALE	

SD 16-08



TREE BOX FILTER SIZING FOR 1.5" RAINFALL	
CONC. BOX I.D. (ft x ft)	MAX IMPERVIOUS AREA (ac.)
4' x 6'	0.14
4' x 8'	0.19
4' x 12'	0.28
6' x 6'	0.21
6' x 8'	0.28
6' x 10'	0.35
6' x 12'	0.42
7' x 13'	0.54

DATE: 2012

DRAWN BY TLM

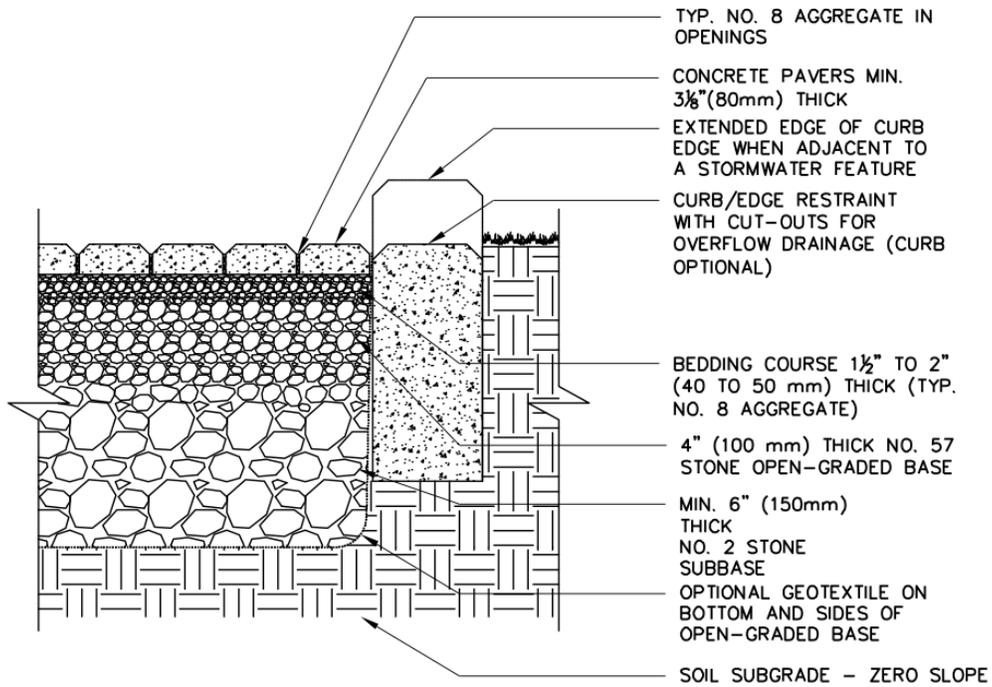
CHECKED BY HCF

SCALE NOT TO SCALE

STANDARD DETAIL

**STANDARD
URBAN TREE PLANTER BOX**

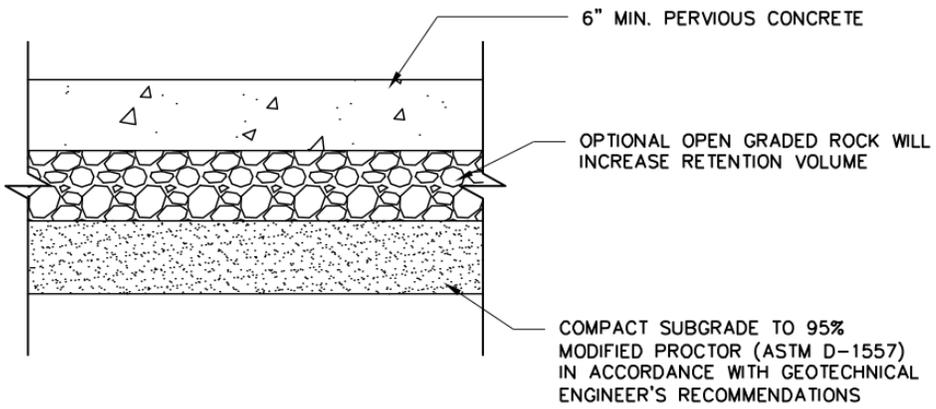
SD 16-09



NOTES:

1. 2 $\frac{3}{8}$ " (60mm) THICK PAVERS MAY BE USED IN PEDESTRIAN APPLICATIONS.
2. NO. 2 STONE SUBBASE THICKNESS VARIES WITH DESIGN. CONSULT ICPI PERMEABLE INTERLOCKING CONCRETE PAVEMENT MANUAL.
3. CURB EDGE MAY EXTEND 6" ABOVE GRADE WHEN ADJACENT TO STORMWATER FEATURE.

STANDARD DETAIL		<h2 style="margin: 0;">STANDARD POROUS PAVERS</h2>	<div style="border: 1px solid black; padding: 5px; display: inline-block;">SD 16-10</div>
DATE:	2012		
DRAWN BY	TLM		
CHECKED BY	HCF		
SCALE	NOT TO SCALE		



	STANDARD DETAIL	
DATE: 2012	STANDARD POROUS CONCRETE	
DRAWN BY TLM		
CHECKED BY HCF		
SCALE <u>NOT TO SCALE</u>		SD 16-11

NATURAL SOIL INFILTRATION

IN-SITU INFILTRATION MEDIA SHALL MEET THE REQUIREMENTS FOR INFILTRATION SYSTEMS AS DEFINED BY NCDWQ IN THE CURRENT VERSION OF THE BMP MANUAL. SOIL TESTS SHALL BE COMPLETED AND SUBMITTED WITH THE DESIGNS TO CONFIRM COMPLIANCE WITH THE SEPCIFICATIONS.

IN SITU SOIL SHALL MEET THE FOLLOWING SPECIFICATIONS

- 1. INFILTRATION RATE SHALL EXCEED 0.52 IN/HR, >3 IN/HR PREFERRED
- 2. P INDEX SHALL BE BETWEEN 10 AND 30
- 3. PARTICLE SIZE DISTRIBUTION
 - a. COARSE / VERY COARSE SAND 70% TO 80%
 - b. GRAVEL 10% TO 20%
 - c. CLAY / SILTS < 10%
- 4. SOIL SHALL BE FREE OF CONTAMINATION FROM HEAVY METALS
- 5. SEASONAL HIGH WATER ELEVATION SHALL BE AT LEAST 2' BELOW FINISHED SURFACE
- 6. AREAS USED FOR EROSION CONTROL SHALL BE CLEANED OF ALL ACCUMULATED SILTS, FINES, SEDIMENTS, AND DEBRIS PRIOR TO CONVERSION

LOW FLOW MEDIA MIXES

FOR INSTALLATIONS REQUIRING ENGINEERED MEDIA WITH INFILTRATION RATES BETWEEN 0.52 IN/HR AND 10 IN/HR, THE GENERAL STANDARDS OF "BIORETENTION MIX" AS DEFINED IN THE CURRENT VERSION OF THE NCDWQ BMP MANUAL SHALL APPLY.

THE ENGINEER SHALL PROVIDE SOILS SAMPLES, AND RESULTS OF LABORATORY SOIL TESTS DOCUMENTING COMPLIANCE WITH THE SOIL SPECIFICATIONS PRIOR TO FINAL PROJECT APPROVAL.

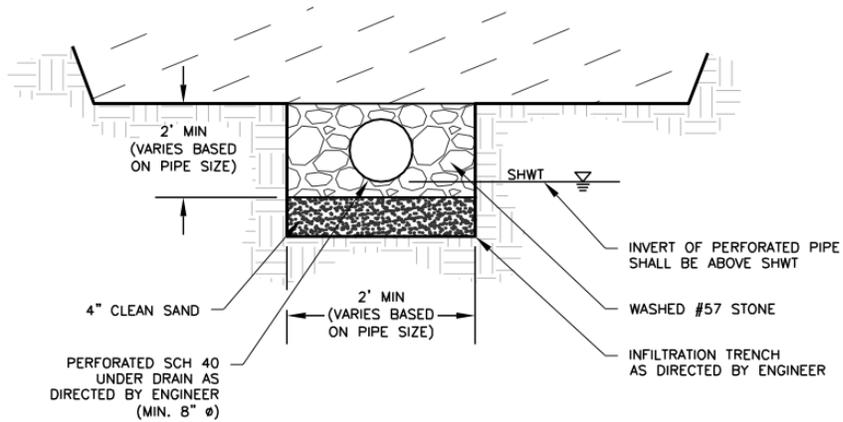
HIGH FLOW MEDIA MIXES

FOR URBAN INSTALLATIONS OR OTHER INSTALLATIONS WHERE HIGHER INFILTRATION RATES ARE NECESSARY, ENGINEERED HIGH FLOW MEDIA MIXES MAY BE REQUIRED. HIGH FLOW FILTER MEDIA IS SPECIALLY DESIGNED TO OPTIMIZE THE CAPTURE AND REMOVAL OF NUTRIENTS FROM URBAN RUNOFF THROUGH THE USE OF A HIGH PERFORMANCE PEAT / SAND FILTER MEDIA. THE MEDIA SUPPORTS MICROBIOLOGICAL ACTIVITY THAT CAPTURES NUTRIENTS FROM STORMWATER RUNOFF TO SUPPORT PLANT LIFE WHILE ALLOWING RUNOFF TO FLOW THROUGH THE MEDIA LAYERS AT A HIGH RATE.

ENGINEERED HIGH FLOW MEDIA SHALL MEET THE FOLLOWING SPECIFICATIONS

- 1. PEAT MOSS 15% BY VOLUME
 - a. LISTED BY ORGANIC MATERIALS REVIEW INSTITUTE
 - b. 100% NATURAL PEAT (NO COMPOSTED, SLUDGE, YARD OR LEAF WASTE)
 - c. TOTAL CARBON >85%
 - d. CARBON TO NITROGEN RATIO 15:1 TO 23:1
 - e. LIGNIN CONTENT 49% TO 52%
 - f. HUMIC ACID >18%
 - g. PH 6.0 TO 7.0
 - h. MOISTURE CONTENT 30% TO 50%
 - i. 95% TO 100% PASSING 2.0MM SIEVE
 - j. > 80% PASSING 1.0MM SIEVE
- 2. POLLUTANT REMOVAL MINIMAL PERFORMANCE
 - a. TSS 80%
 - b. TOTAL NITROGEN 43%
 - c. HEAVY METALS 58-82%
 - d. PHOSPHORUS 50 %
 - e. BACTERIA > 95%
- 3. GENERAL SAND PARTICLE SIZE DISTRIBUTION NECESSARY TO SUPPORT FLOW RATES OF > 50 INCHES / HOUR AT THE TIME OF INITIAL INSTALLATION.
 - a. SAND - FINE <5%
 - b. SAND - MEDIUM 10% - 15%
 - c. SAND - COARSE 15% TO 25%
 - d. SAND - VERY COARSE 40 % TO 45%
 - e. GRAVEL 10% TO 20%
 - f. CLAY / SILTS < 2%

STANDARD DETAIL		<div style="border: 1px solid black; padding: 10px; display: inline-block;"> <p style="font-size: 1.2em; margin: 0;">LANDSCAPE MIX SPECIFICATIONS</p> </div>
DATE:	2012	
DRAWN BY	TLM	
CHECKED BY	HCF	
SCALE	NOT TO SCALE	
		SD 16-12



STANDARD DETAIL		<div style="border: 1px solid black; padding: 5px; display: inline-block;">SD 16-13</div>
DATE: 2012	<h2 style="margin: 0;">STANDARD UNDERDRAIN AND TRENCH</h2>	
DRAWN BY TLM		
CHECKED BY HCF		
SCALE <u>NOT TO SCALE</u>		

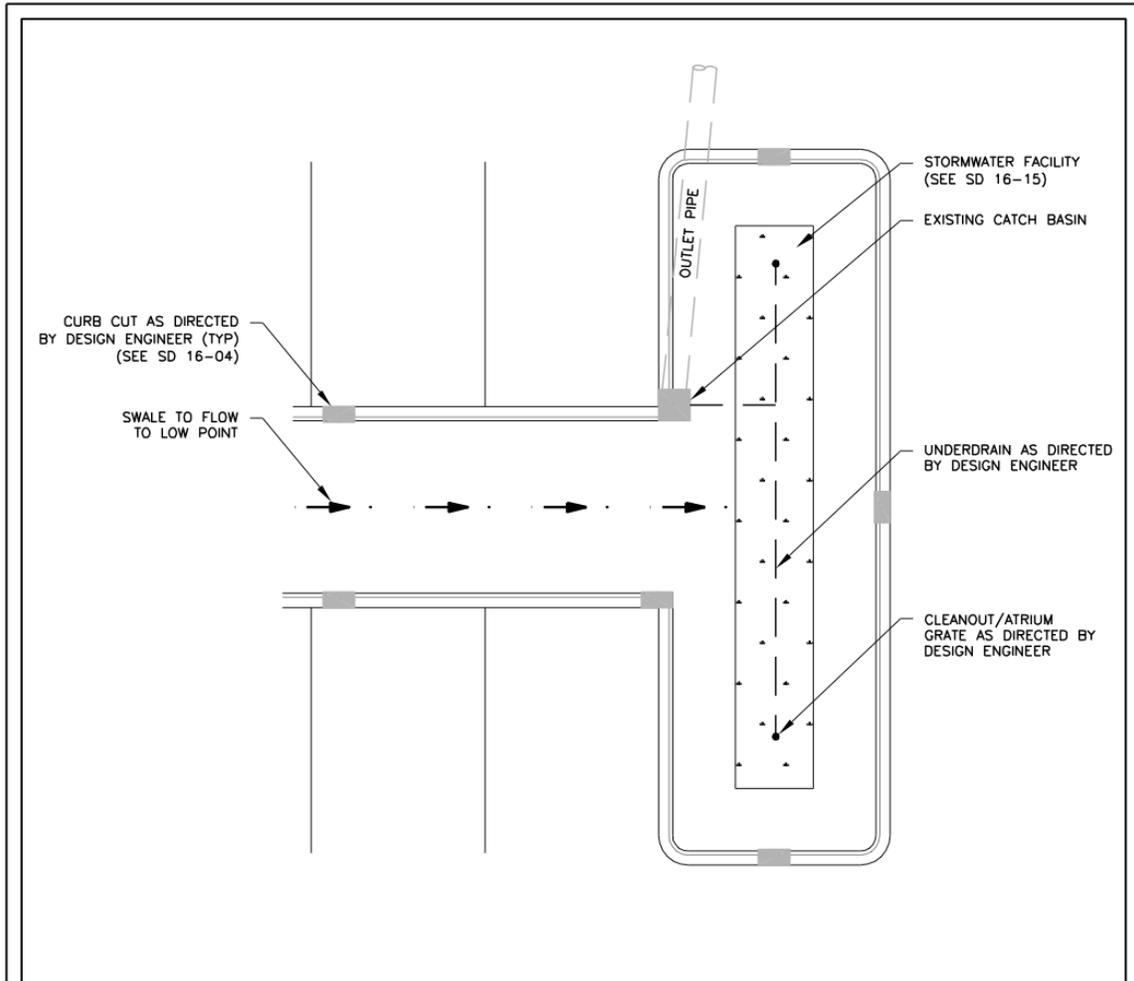
RECOMMENDED PLANTS LIST FOR ALL STORMWATER DETAILS:

<u>SCIENTIFIC NAME</u>	<u>COMMON NAME</u>
CERCIS CANADENSIS	RED BUD
CORNUS FLORIDA	DOGWOOD
ILEX ATTENUATA	FOSTER'S HOLLY
ILEX VOMITORIA	YAUPON HOLLY
LAGERSTROEMIA INDICA	CRAPE MYRTLE
MAGNOLIA SOULANGIANA	SAUCER MAGNOLIA
MAGNOLIA STELLATA	STAR MAGNOLIA
NYSSA SYLVATICA	BLACK GUM
TAXODIUM DISTICHUM	BALD CYPRESS

NOTE:

OTHER PLANTS, INCLUDING TREES, SHRUBS, AND GROUND COVERS, MAY BE PERMITTED ON A CASE BY CASE BASIS AS APPROVED BY CITY STAFF.

	STANDARD DETAIL	
DATE: 2012	RECOMMENDED STORMWATER PLANTING LIST	
DRAWN BY TLM		
CHECKED BY HCF		
SCALE <u>NOT TO SCALE</u>		
		SD 16-14



NOTES:

1. DESIGN ENGINEER TO PROVIDE DIMENSIONS OF ISLANDS.
2. SWALE DEPTH SHALL BE DEEP ENOUGH TO PASS 10-YR STORM FLOW WITHOUT SURCHARGING GUTTER OR FLOODING PAVEMENT.
3. 10-YR STORM VELOCITY NOT TO EXCEED 2 FT/S.
4. MAXIMUM PONDING DEPTH SHALL BE 6".
5. UTILITY LINES MAY NEED TO BE SLEEVED OR RELOCATED.
6. TREES AND SHRUBS SHALL BE PLANTED AT LEAST 2' FROM CENTERLINE OF SWALE.
7. SOD OR TRIPLE SHREDDED MULCH SHALL BE A MINIMUM OF 2" BELOW THE GUTTER LINE TO ALLOW FOR UNIMPEDED FLOW INTO SWALE.
8. TOP OF LANDSCAPING MIX SHALL BE A MINIMUM OF 4" BELOW THE GUTTER LINE.
9. UNDERDRAIN AND IMPERMEABLE LINER TO BE USED ON CASE BY CASE BASIS, AT DESIGN ENGINEER'S DISCRETION.
10. SOIL TESTING REQUIRED WHEN UNDERDRAIN IS NOT USED.

STANDARD DETAIL		<div style="border: 1px solid black; padding: 5px; display: inline-block;">SD 16-16</div>
DATE: 2012	<h2 style="margin: 0;">STORMWATER PARKING ISLAND</h2>	
DRAWN BY TLM		
CHECKED BY HCF		
SCALE NOT TO SCALE		

Appendix J: About the North Carolina Coastal Federation

The North Carolina Coastal Federation is a member-supported 501(c)3 that focuses on protecting and restoring the N.C. coast. For over 34 years, the Coastal Federation has been in the field restoring miles of coastline, training and educating students, adults and communities to take actions that result in cleaner coastal waters and advocating for an accessible, healthy, productive coast. With over 10,000 members, the federation promotes active stewardship of North Carolina's coastal water quality and natural resources by its residents and visitors. The Federation has a long and successful track record protecting and restoring coastal habitats and water quality through projects that acquire land and conservation easements, restore wetlands, riparian shorelines and oyster reefs, and through projects that install stormwater reduction measures. Partnerships include federal and state agencies, local governments, universities, as well as community, business and homeowner groups.