Pine Knoll Shores

Nine Elements Watershed Restoration Plan

TOWN OF PINE KNOLL SHORES | North Carolina

Contributing Partners

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Guide to Nine Minimum Elements

This table serves as a quick reference guide to where the Environmental Protection Agency (EPA) Nine Minimum Elements are located within this watershed management plan.

	EPA Nine Minimum Elements	Section of Plan
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.	Section 1 Introduction Section 2 Watershed Characterization Section 3 Watershed Conditions
2	An estimate of the load reductions expected from management measures.	Section 4 Reduction Load Target
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.	Section 5 Goals Section 6 Management Strategies
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.	Section 6 Funding Cost and Technical Needs
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.	Section 5 Education and Outreach Program
6	Schedule for implementing the nonpoint source management measures identified in this plan that is reasonably expeditious.	Section 6 Implementation Schedule
7	A description of interim measurable milestones for determining whether nonpoint source management measures or other control actions are being implemented.	Section 6 Milestones
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.	Section 6 Evaluation
9	A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the established criteria.	Section 6 Monitoring

1 Introduction

This Watershed Restoration Plan provides a voluntary management framework to address water quality impairments in seven Pine Knoll Shores watersheds. The watersheds have experienced increased volumes of stormwater runoff from land use activities. This increased runoff transports bacteria and other pollutants causing surface water quality impairments. This plan includes strategies for restoring or mimicking the natural, pre-development hydrology of the watersheds prior to water quality impairment. Mimicking natural drainage processes can reduce runoff and nuisance flooding and help restore water quantity and quality requirements of receiving water bodies.

This restoration plan will be the beginning of a multi-year process to implement and maintain, manage, and mitigate stormwater runoff pollution. This plan combines low-cost, high-yield strategies such as community outreach initiatives and targeted retrofit projects aimed at reducing the impact of impervious surface by mimicking natural hydrology to reduce flooding, protect water quality, and provide the community with clean, usable waters. The nonregulatory *Pine Knoll Shores Watershed Restoration Plan* includes all Nine Minimum Elements of a watershed management plan as recommended by the EPA to qualify to be eligible to apply for federal 319 Grant funding opportunities. The information provided in this plan enables the participating partners to easily source technical information necessary to apply for other state and national grant opportunities.

This plan seeks to:

1. Restore and maintain the water quality of seven Pine Knoll Shores Watersheds;
2. Reduce instances of localized flooding to improve safety and protect property;
3. Prioritize cost effective Low Impact Development and stormwater retrofit techniques to address stormwater management.

The Pine Knoll Shores Watersheds have tremendous recreational and tourism value. Significant recreational and habitat areas surround the watersheds, including the Pine Knoll Shores Aquarium and the Theodore Roosevelt Natural Area. Bogue Sound borders the Town of Pine Knoll Shores to the north. In recent years, the increase in stormwater runoff following large rain events has resulted in an increase in the frequency of water quality impairments, indicating that stormwater runoff is transporting impairments downstream.

Improvements in water quality can be achieved by using stormwater reduction techniques that reduce the volume of stormwater runoff thereby effectively treating stormwater runoff from existing and new developments. This plan combines low-cost, high-yield strategies such as community outreach initiatives and lot level retrofit projects aimed at reducing the impact of impervious surface by mimicking natural hydrology to reduce flooding, protect water quality, and provide the community with clean, usable waters. By focusing on techniques that reduce, slow, and treat stormwater runoff, the plan can mimic the natural hydrology of the area before urban expansion and development. This document provides a framework for the restoration of Pine Knoll Shores Watersheds' water quality, by reducing the volume of stormwater runoff.

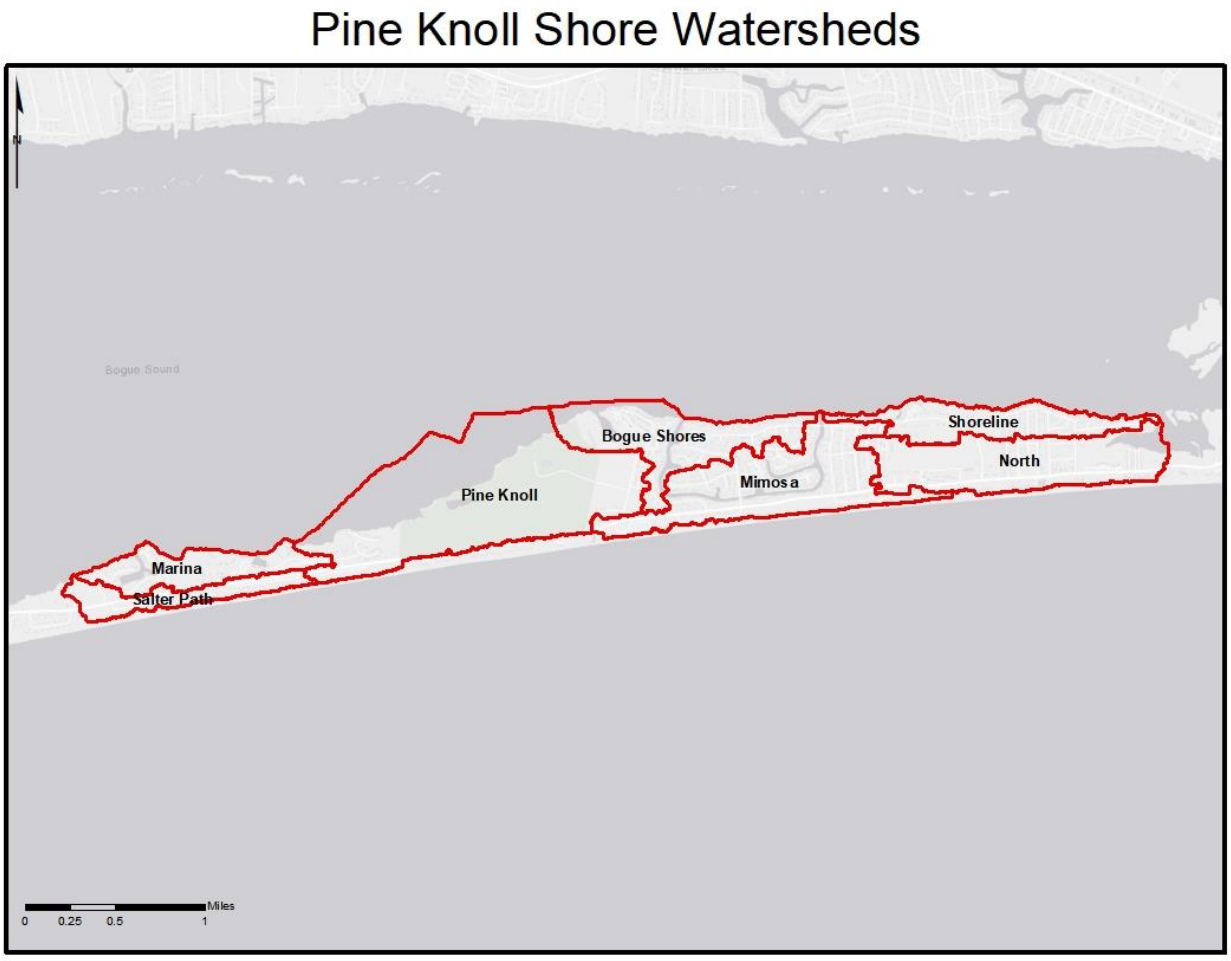


Figure 1-1. Map of Pine Knoll Shores Watersheds.

1.1 PLAN RATIONALE

Conventional management approaches rely on peak flow storage and attempt to manage onsite flooding by collecting and conveying stormwater from a site as quickly as possible. In this approach, stormwater is often directed to curb and gutter systems, where the untreated runoff is conveyed to the nearest receiving water. This approach can deter onsite, localized 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 polluted stormwater from discharging contaminants into waterways. Shellfish closures and swimming advisories are a result of increased surface runoff. Restoration of water quality in tidal waters depends upon reducing the volume of stormwater.

A stormwater volume reduction strategy recognizes that:

(1) Sources of fecal bacteria are widespread. Bacteria come from wildlife, pets, and other warm-blooded animals. While this is a human health problem and such sources should be removed, it is not feasible to reduce all sources significantly enough to improve degraded water quality.

(2) Improving shellfish and swimming waters by treating runoff to levels that comply with water quality standards for bacteria is not practical. While technology is available to treat stormwater runoff, tying in an already developed urban area with a stormwater treatment facility can be cost prohibitive to achieve sufficiently high removal rates necessary to meet designated water quality standards.

(3) Recontamination of treated runoff is extremely problematic. Even if it were cost effective to treat runoff to remove bacteria, any "clean" runoff discharged back onto the landscape would then become a vehicle to transport downstream bacteria, lessening the overall benefits of treatment.

Additionally, conventional stormwater control systems are often designed to manage peak flow during a singular major designed storm event, such as flood prone areas. These systems are often designed with the intent that large amounts of stormwater is quickly moved downstream into the receiving waterways slowing the impact of flooding in major storm events. Due to this, conventional stormwater control systems can degrade natural stream systems by causing bank erosion. Control systems that focus on larger storms are often overdesigned and do not address the management of runoff caused by smaller storm events or water quality. The proactive use of Low Impact Development (LID) and stormwater retrofits throughout an area can manage both small and larger storms by restoring an area's natural hydrology.

2 Watershed Characterization

The Pine Knoll Shores watersheds are located within the Town of Pine Knoll Shores and surrounding areas. These watersheds span across over **1,949 acres**. Residential and commercial development over the past decades has resulted in an increase in impervious surfaces throughout the watershed, which has increased the amount of flooding and stormwater runoff that is transported to Bogue Sound.

2.1 Physical and Natural Features

Pine Knoll Shores watersheds are in the Bogue-Core Sounds within Carteret County. The Pine Knoll Shores watersheds are surrounded by the Atlantic Ocean and Bogue Sound. There are three major watersheds within this area with their 12-digit HUCs: Salter Path-Jumping Run **030203010702**, Morehead City-Drum Shoals **030203010705**, and Bogue Banks-Shackleford Banks **030203010701** (Table 2-1).

Table 2-1. Watershed 12-HUC codes.

	PKS Watershed Name	12-HUC	12-HUC Formal Subwatershed Name
1	Marina	030203010701	Salter Path-Jumping Run
2	Shoreline	030203010702	Morehead City-Drum Shoals
3	North	030203010702	Morehead City-Drum Shoals
4	Mimosa	030203010701	Salter Path-Jumping Run
		030203010702	Morehead City-Drum Shoals
		030203010705	Bogue Banks-Shackleford Banks
5	Bogue Shores	030203010701	Salter Path-Jumping Run
		030203010702	Morehead City-Drum Shoals
6	Pine Knoll Shores	030203010701	Salter Path-Jumping Run
		030203010701	Morehead City-Drum Shoals
7	Salter Path	030203010701	Salter Path-Jumping Run

2.1.1 Natural Characteristics

The North Carolina Natural Heritage Program (NCNHP) of the Department of Environmental Quality (DEQ) has identified areas that are of biodiversity significance. These are often areas where rare or significant species and significant natural communities occur (Figure 2-1)[1]. The identified areas contain both terrestrial and aquatic habitats. The boundaries of these areas are based on field surveys by NCNHP staff and other professional biologists. The intent of the NCNHP data was to assist government agencies and others in developing management strategies. DEQ targeted these conservation areas when planning for restoration projects. As Figure 2-1 shows, the Pine Knoll Shore watersheds contain one natural area, the Theodore Roosevelt Natural Area. Water quality of these watersheds affect these tidal areas, particularly aquatic and shoreline habitat. Identifying the location of critical habitat areas is relevant for planning, and this information can be used to develop projects that can positively enhance these areas, in turn leading to potential funding opportunities.

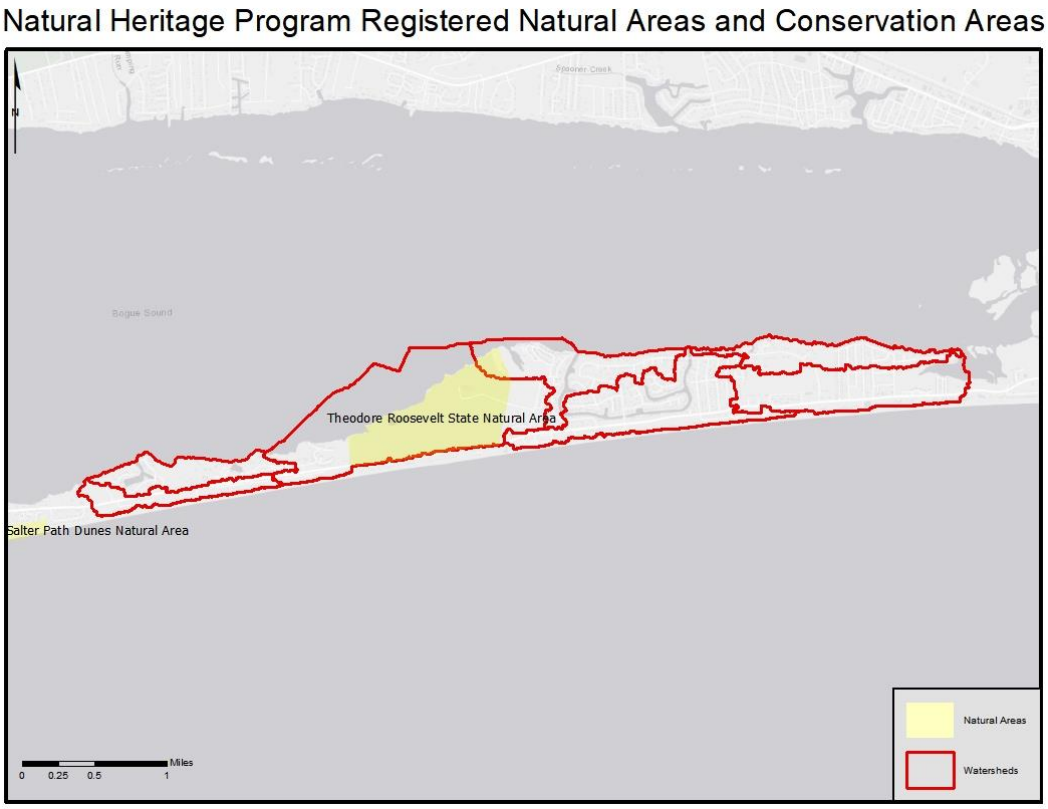


Figure 2-1. Map of important natural community areas. Data from October 2015.

[1] North Carolina OneMap. (2013, July). Biodiversity/Wildlife habitat assessment. *N.C. Natural Heritage Program, N.C. Department of Environment and Natural Resources, N.C. OneMap*. Retrieved from http://data.nconemap.com/geoportal/catalog/search/resource/details.page?uuid=%7BE85829D4-4D5F-4203-BCB3-D5A6346E7BC3%7D

The Pine Knoll Shores watersheds contain over 88 acres of submerged aquatic vegetation (SAV). SAV serve as important nursery habitat for fish, are a food source, absorb wave energy, produce oxygen, and aid in improving water quality by absorbing nutrients and stabilizing and settling sediment.

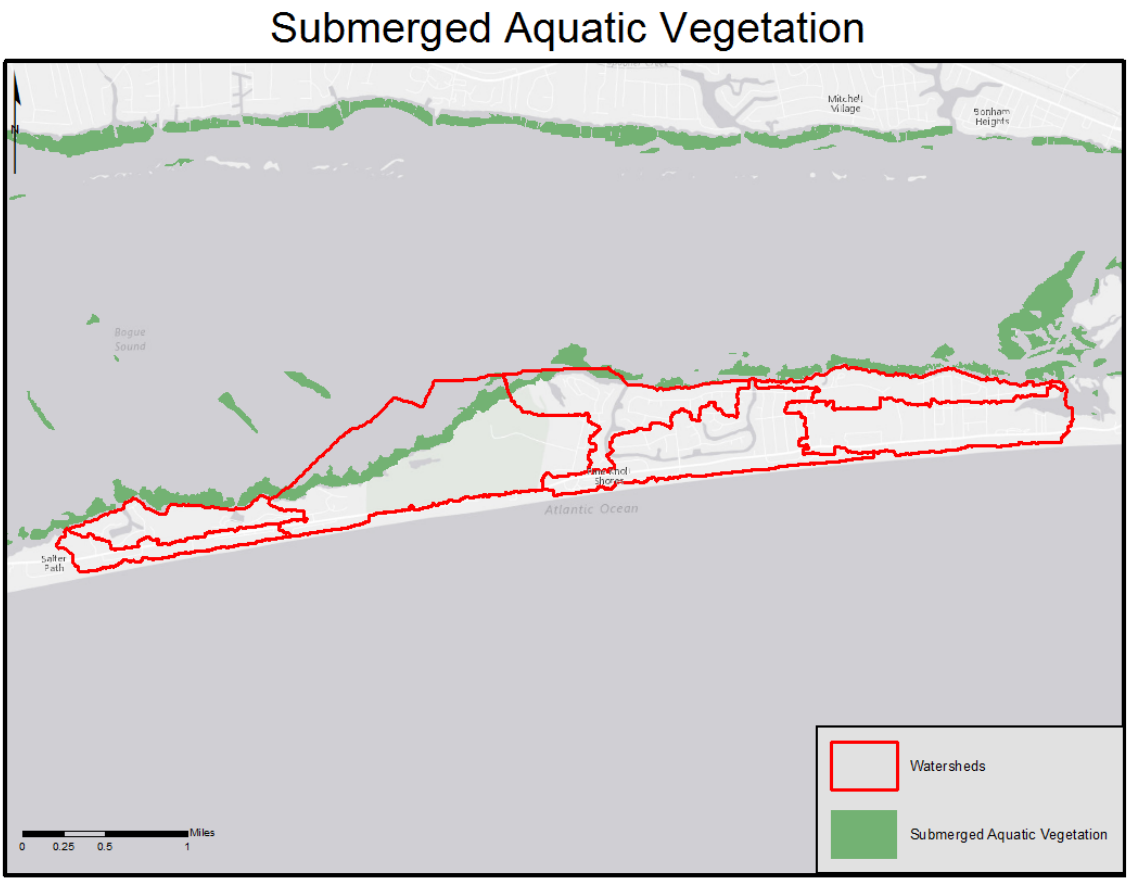
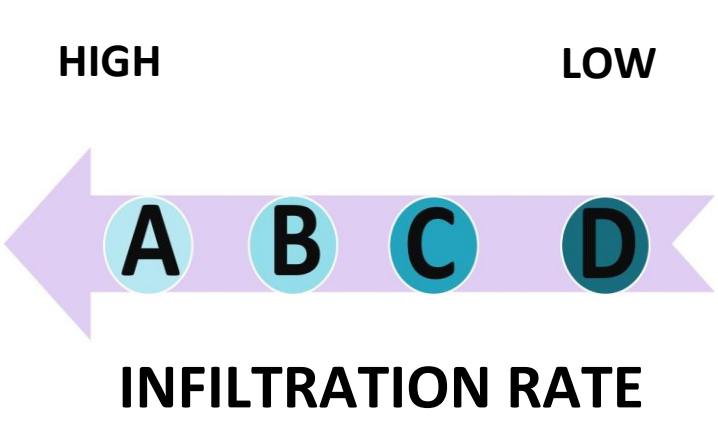


Figure 2-2. Submerged aquatic vegetation in and around Pine Knoll Shores Watersheds.

2.1.2 Soils

Pine Knoll Shores watersheds are predominated by Group A hydrologic soil per the United States Department of Agriculture Natural Resource Conservation Service (NRCS) data collected from Web Soil Survey (Figure 2-3). Soil Group A/D occurs primarily within low lying areas, such as tidal creeks and marshes, but can be seen underlying developed property in the western extent of the Pine Knoll Shores Watersheds. Four hydrologic groups (HSG; Groups: A, B, C, D) exist with progressively decreased infiltration potential characteristics; soils classified under Group A have the highest infiltration potential and are often the quickest draining soils, while soils classified under Group D have the lowest infiltration potential. It is possible to have a soil type that has characteristics from two hydrologic groups; for example, a soil can be designated as Group A/D, which means it has characteristics of both Group A and Group D. This is because of the changing nature of the soils when they are fully saturated by water. Once a hydraulic threshold is reached, the soil type converts to another hydrologic group because of the change of the available water capacity of the soil.

The following is the NRCS summary description for each soil group[2]:



- **Group A** soils are sands, loamy sands, or sandy loams. These soils have high infiltration rates even when thoroughly saturated. These soils consist of deep, well to excessively drained sands or gravels and have a high rate of water transmission.
- **Group B** soils are silt loams or loams. These soils have moderate infiltration rates when thoroughly saturated and consist of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures.
- **Group C** soils are sandy clay loams. These soils have low infiltration rates when thoroughly saturated and consist of soils with a horizon that impedes downward movement of water and possess moderately fine to fine texture.

[2] Natural Resources Conservation Service. (n.d.). Updated Hydrologic Soil Group. *United States Department of Agriculture Natural Resource Conservation Service*.

- **Group D** soils are clay loams, silty clay loams, sandy clays, silty clays, or clay. These soils have the highest runoff potential. These soils have very low infiltration rates when thoroughly saturated and consist of clay soils with a high swelling potential, soils with a permanent high-water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material.

HSG A predominates the Pine Knoll Shores watersheds and surrounding area. Some of the soil types have two hydrologic group categories. Some areas contain A/D soils, which can be indicative of wetland-type conditions. In these instances, if a soil needs to be characterized by one soil group, the lowest infiltration rating should be used as this represents the likely infiltration performance in these areas during significant rain events. NRCS soil surveys are ideal for watershed scale analysis and determining runoff volume rates. These data are used to calculate the runoff volume rates in this plan.

Soil survey data can be used when trying to determine which areas have the most ideal combined characteristics for retrofit projects. HSG, as with any characteristic, should always be tested through field surveys to determine the extent of characteristics at a project site. The partners' previous experiences installing retrofits along the coast have shown that a simple handheld auger tool samples to assess soils may not be sufficient and it may be necessary to take a deeper sample to break through a confining layer of Group D soil covering Group A soils. Refer to Appendix A for the list of soils and their associated HSG.

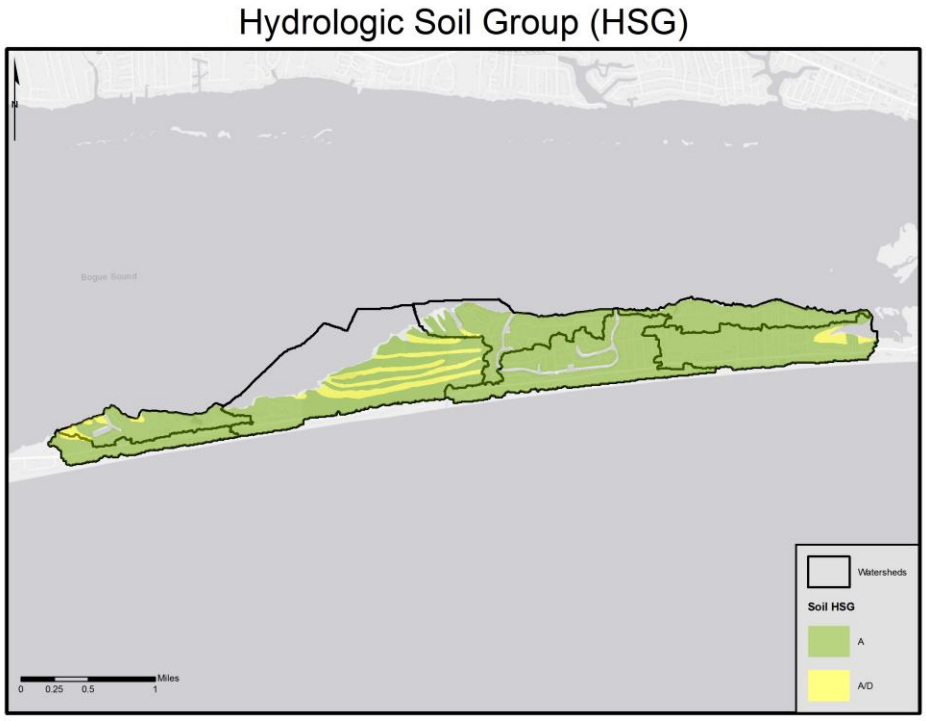


Figure 2-3. Hydrologic soil group map of Pine Knoll Shores watersheds.

2.2 LAND USE

The Pine Knoll Shores watersheds encompass parts of the following municipalities:

- Town of Pine Knoll Shores
- Carteret County
- Indian Beach
- Atlantic Beach

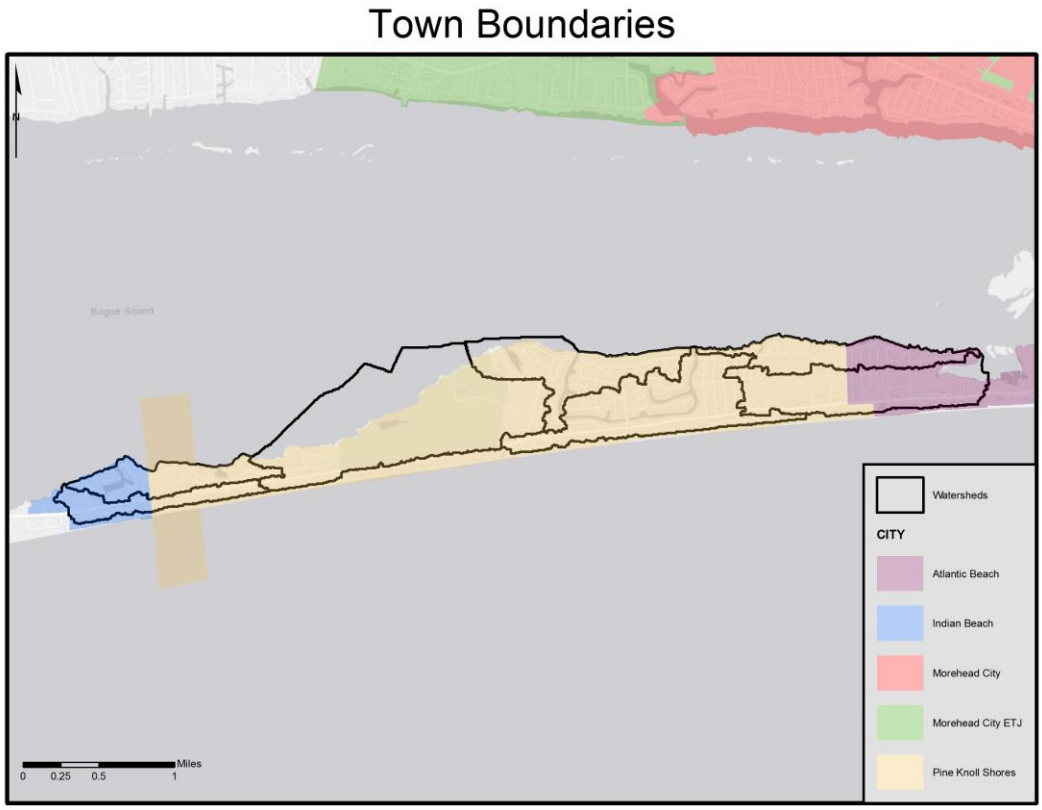


Figure 2-4. Political boundaries map of Pine Knoll Shore Watersheds.

The Pine Knoll Shores watersheds are centrally located in southern Carteret County. Four of the seven watersheds are shared with bordering municipalities. Marina, Salter Path, North, and Shoreline Watersheds extend into other municipalities, while Bogue Shore, Pine Knoll, and Mimosa watersheds exist solely within the Town of Pine Knoll Shores.

The Pine Knoll Shores area has been a virtually untouched barrier island habitat up until the early 1940's when the first major developments began. This was due to ownership of the property upon which the town was built being historically owned by conservationists who strove to not only protect maritime forest habitat, but also refused to sell the land to developers. Development in the 1940's was not very expansive. It was not until the late 1950's

that Pine Knoll Shores began to experience increased development. The spirit of conservation in Pine Knoll Shores has pervaded through the decades. Pine Knoll Shore was awarded its first Tree City USA award in 2000 and has had a stringent tree and habitat protection ordinance since the town was chartered in 1973.

Understanding the past and present land uses of the watersheds enhances this plan's ability to address education and outreach and to tailor stormwater reduction techniques that address community needs. For example, if a watershed is predominately residential then it may be more effective to develop strategies that address stormwater and future growth from a residential perspective.

Pine Knoll Shores' watersheds are used for various purposes, but are predominated by residential, commercial (any business, commercial, or industrial), undeveloped, and institutional uses (state or federal land use). Residential is the highest land use in Pine Knoll Shores, but institutional land uses take up a considerable amount of acreage as well, as seen in table 2-2. Figure 2-5 provides a visual depiction of the land uses in Pine Knoll Shores.

Table 2-2.
Simplified land use categories by acreages of the Pine Knoll Shores Watersheds as of 2016.

Watersheds	Commercial (acres)	Institutional (acres)	Residential (acres)	Undeveloped (acres)
Shoreline Watershed (162 acres)	45.96	2.85	85.36	10.87
North Watershed (301 acres)	83.77	.86	120.04	39.52
Mimosa Watershed (342 acres)	0	10.46	207.92	40.03
Bogue Shores Watershed (239 acres)	0	46.99	107.45	27.68
Pine Knoll Watershed (665 acres)	2.62	293.94	81.32	12.77
Marina Watershed (141 acres)	0	34.11	79.21	18.51
Salter Path Watershed (98 acres)	0	12.90	54.04	16.10

Note: Rights of Ways have been removed and are not included as part of the totals. Additionally, these numbers include conservation areas that may have an HSG category of "water" because they are part of a waterbody, wetland, or have intertidal (area that is covered by water during high tide and uncovered during low tide) acreage that is designated as "water." As such, these totals will vary from other acreages listed within this plan, particularly with the acreage totals listed in Section 3 Runoff Calculations.

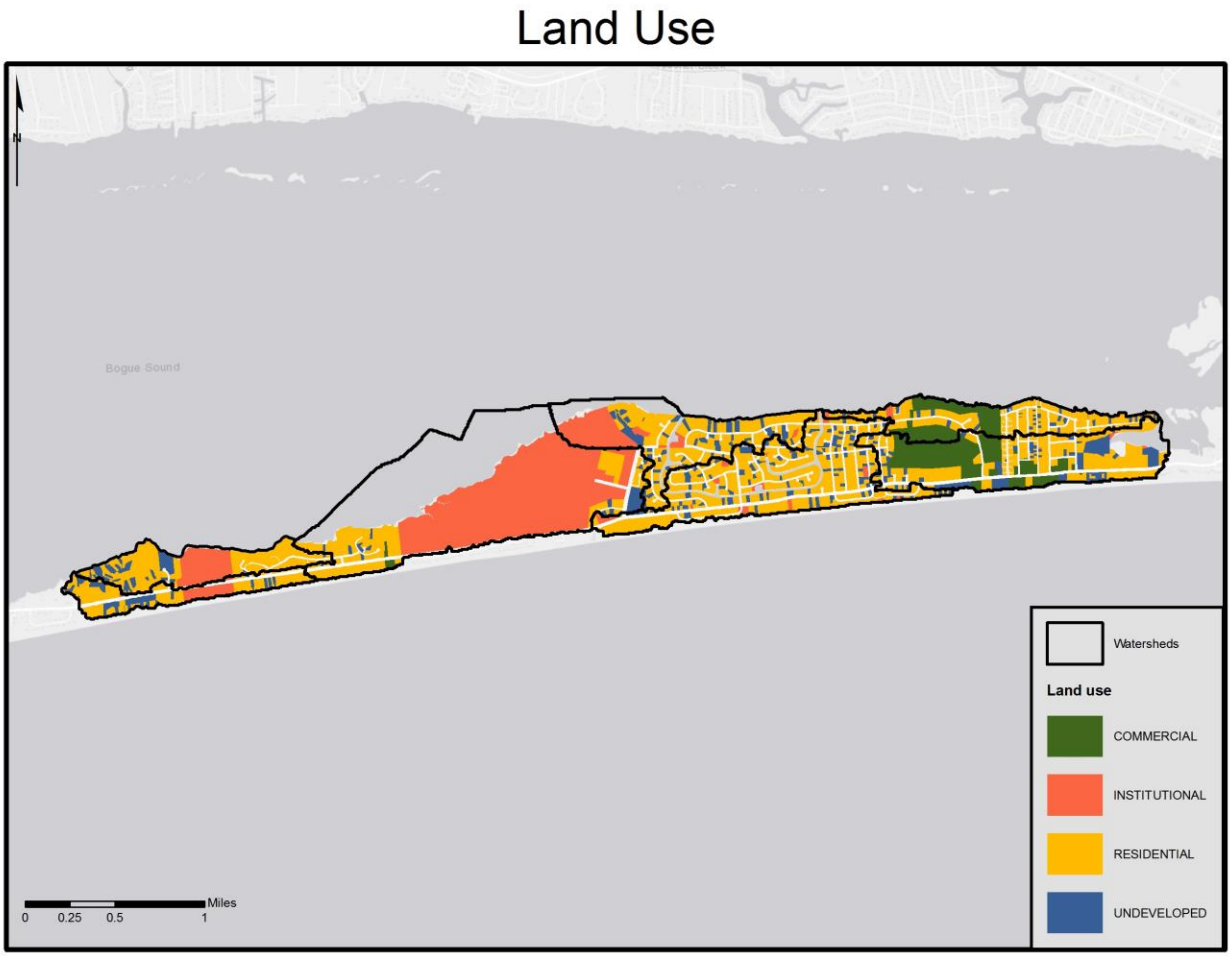


Figure 2-5. Land usage categories of Pine Knoll Shores Watersheds.

3 Watershed Conditions

3.1 WATER QUALITY

North Carolina uses various methods to measure water quality. This plan uses two: the state's water classification system, which is reported on the 303(d) list, and swimming usage tier scale system (refer to Appendix B for detailed guide of water quality classification).

The tier scale effects the prioritization of sampling and the minimum water quality in swimming waters with Tier 1 being the highest priority and are locations that are used daily. Tier 2 are not used as heavily and see the most use on the weekend, and Tier 3 sites are used less frequently (refer to Table 3-1). These tiers coincide with sampling requirements and maximum observation of bacteria. There are no sampling sites for swimming usage in the Pine Knoll Shores watersheds. However, it should be noted that there are four sampling sites at the ocean beach in the Pine Knoll Shores area.

Table 3-1. Bacteriological Water Quality Standards for North Carolina Quick Guide. Refer to Appendix B for a complete guide to water quality standards.

Bacteriological Water Quality Standards for North Carolina Quick Guide

Shellfishing

For waters to be approved as Class SA area of harvest for direct consumption the following criteria must be met:

(1) the shoreline survey has indicated that there are no significant sources of contamination;

(2) the area is not so contaminated with fecal coliform that consumption of the shellfish might be hazardous;

(3) the area is not so contaminated with radionuclides or industrial wastes that consumption of the shellfish might be hazardous; and

(4) the median fecal coliform Most Probable Number (MPN) or the geometric mean MPN of water shall not exceed **14 per 100 milliliters**, and the 90th percentile shall not exceed 43 per 100 milliliters (per five tube decimal dilution) in those portions of areas most probably exposed to fecal contamination during most unfavorable hydrographic conditions.

Swimming

("swimming season" April 1 – October 31)

The following standards apply to coastal North Carolina waters:

- **Tier I**
  "*A swimming area used daily during the swimming season, including any public access swimming area and any other swimming area where people use the water for primary contact, including all oceanfront beaches"*
  A geometric mean of at least five samples in 30 days that results in **35 enterococci per 100 ml** of water ***OR*** a single sample of **104 enterococci in a 100-ml** sample
- **Tier II**
  "*A swimming area used an average of three days a week during the swimming season*"
  Single sample of **276 enterococci in a 100-ml** sample
- **Tier III**
  "*A swimming area used an average of four days a month during the swimming season*"
  Two consecutive samples of **500 enterococci in each 100-ml** sample

Stormwater runoff results in high bacterial counts. Persistently high counts have degraded water quality to a level that no longer meets the standards for the water's designated uses. This has led to waters within the watersheds being placed on the EPA Waterbody Quality Assessment Report 303(d) List (Appendix B). Shellfish closures and swimming advisories are indicators of poor water quality from bacteria contamination. Table 3-1 is a summary of the water quality for all the watersheds, Figure 3-1 depicts the shellfish closure boundaries, and Figure 3-2 shows the status assessment and designated use of waters.

Table 3-2. Current water quality summary of Pine Knoll Shores Watersheds.

Watershed	*Designated Use*	*Shellfish Sanitation Closure Year*	*Current Shellfish Status*	*Nearest Monitoring Station*
Salter Path	SA; HQW	-	-	E-2 Stations: • 29
Pine Knoll	SA; ORW; HQW; SW; C	-	-	E-2 Stations: • 17
Marina	SA; HQW	1989	Prohibited	E-2 Stations: • 29 • 30
Bogue Shores	SA; ORW; HQW; SW; C	1990	Prohibited	E-2 Stations: • 17 • 19A
Mimosa	SA; HQW	1990	Prohibited	E-2 Stations: • 17 • 19A
Shoreline	SA; HQW	2002	Prohibited	E-3 Stations: • 41 • 42
North	SA; HQW	1988	Conditionally Approved- Closed	E-3 Stations: • 6 • 6A

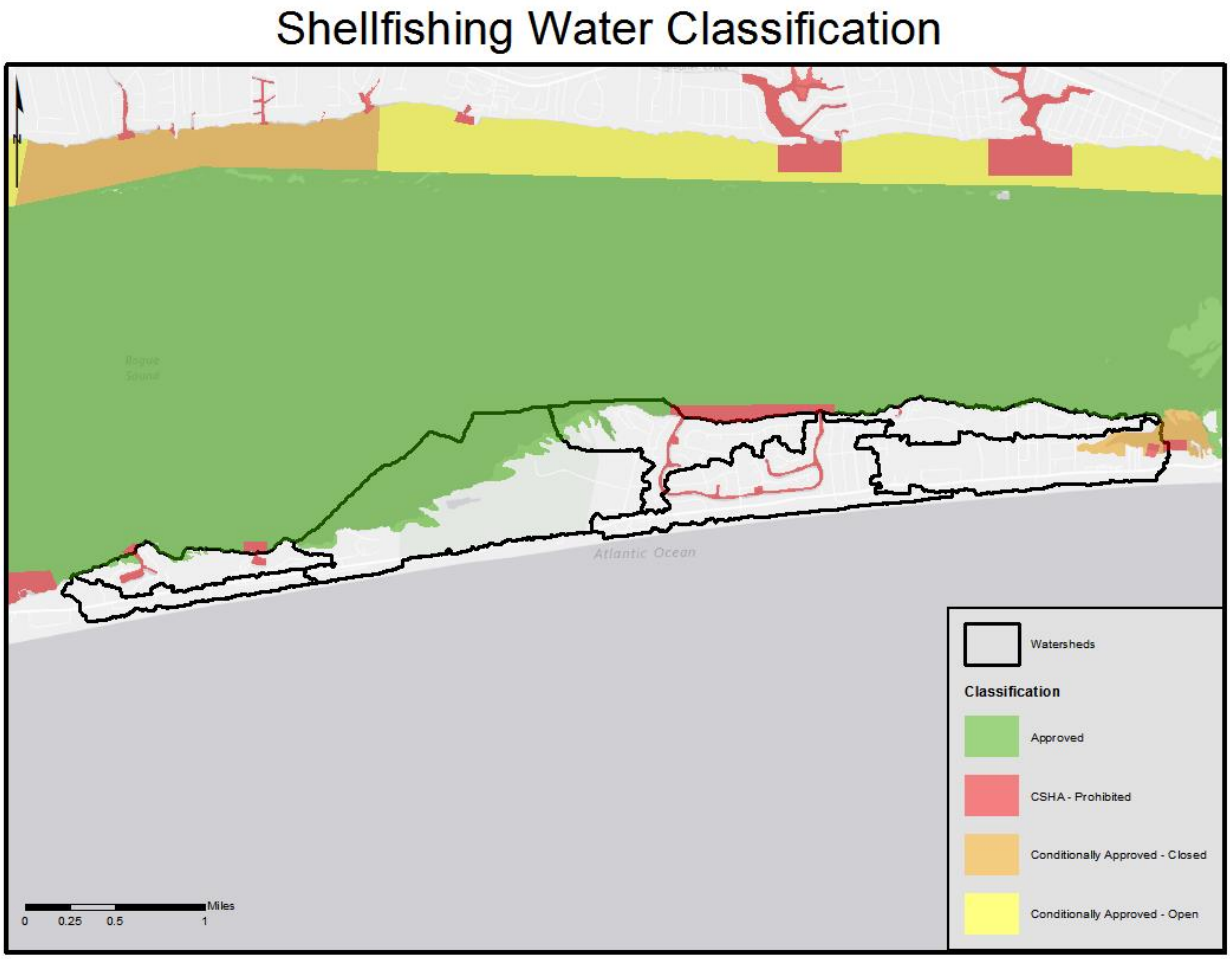


Figure 3-1. Prohibited and approved shellfishing waters

The North Carolina Department of Environmental Quality of Water Resources classified all coastal waters of Pine Knoll Shores as class SA water. The water quality standards of class SA are designed to maintain pollutant levels for safe commercial shellfishing purposes. This class also designates waters that may be used for activities involving extended body contact with water on a frequent basis. Class SA water has the supplemental classification of High Quality Water (HQW) due to excellent biological and physical/chemical characteristics. This supplemental classification is intended give extra protections to valuable freshwater and marine ecosystems.

The Roosevelt Natural area is designated as class SA waters and as an Outstanding Resource Water (ORW) due to it having excellent water quality and exceptional recreational and ecological significance (Figure 3-2). Despite the Pine Knoll Shores watersheds being classified SA waters, portions of the watershed deal with water quality issues that can affect shellfish, fish, and humans.

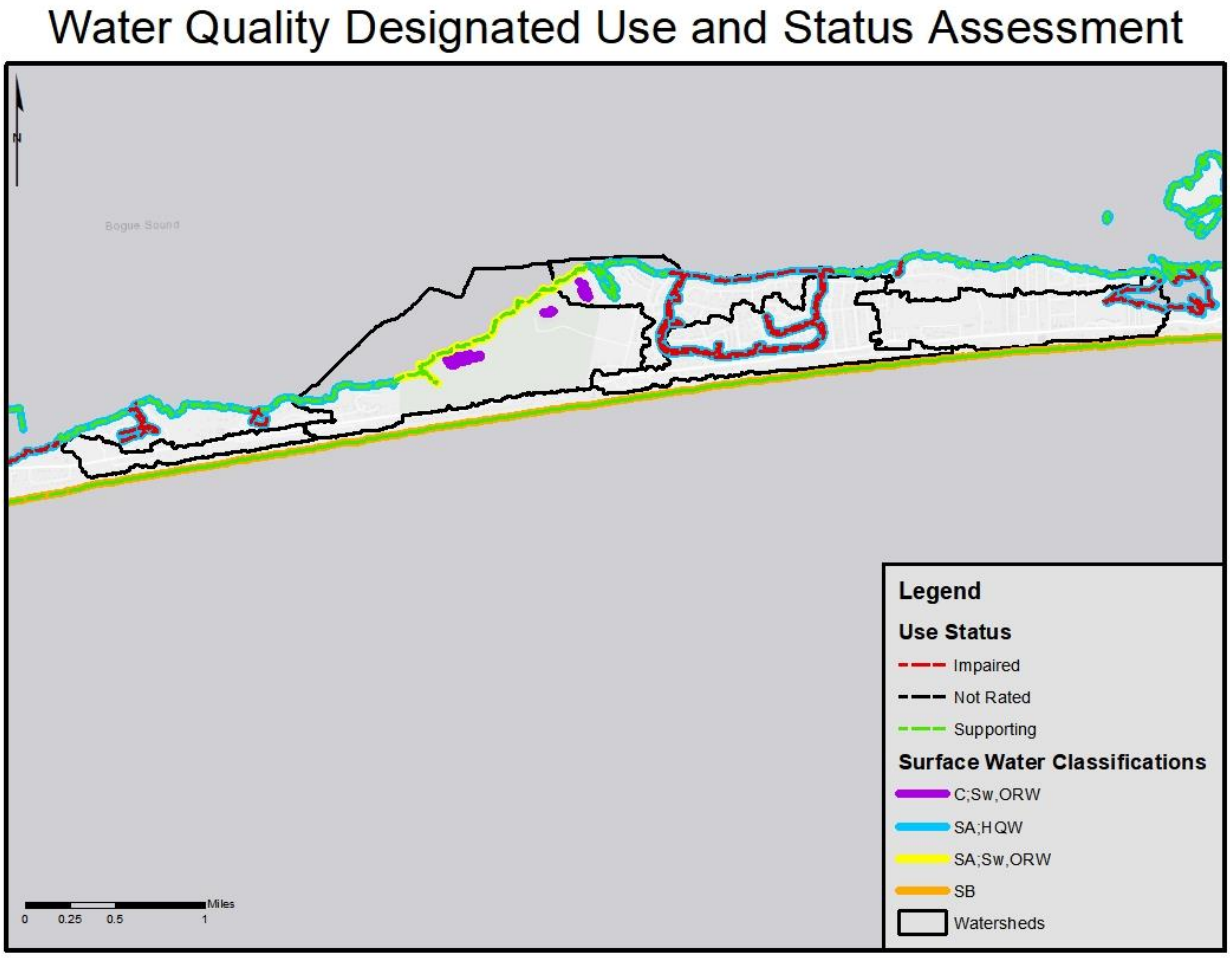


Figure 3-2. Water Classifications of Pine Knoll Shores Watersheds and impairment status

Records from the N.C. Division of Water Resources and Shellfish Sanitation Section of the N.C. Division of Marine Fisheries show that increased pathogenic loading in the creeks corresponds to water quality impairments within the watersheds. Partners and stakeholders agree that reduction of stormwater volume is the most beneficial and cost-effective way to eliminate bacteriologic pollutants. The following is a list of waterbodies in the region currently on the 2016 303(d) List waterbodies:

Table 3-3. Waterbodies in the region currently on the 2014 303(d) list and draft 2016 303(d).

Assessment Unit Number	Description	Acres	Year Placed on 303(d)	Cause
20-36-(8.5)a8	From a line across Bogue Sound from the southwest side of mouth of Gales Creek to Rock Point to Beaufort Inlet excluding the DEH Conditionally Approved Closed area near Jumping Ru. Pine Knoll Shores Area	1.3	2008	Fecal Coliform
20-36-(8.5)a9	From a line across Bogue Sound from the southwest side of mouth of Gales Creek to Rock Point to Beaufort Inlet excluding the DEH Conditionally Approved Closed area near Jumping Ru. Bogue Pines Boat Basin	0.4	2008	Fecal Coliform
20-36-(8.5)d	DEH closed area in unnamed bay approximately 2500 meters east of line across Bogue Sound from the southwest side of mouth of Gales Creek to Rock Point	8.0	2002	Fecal Coliform
20-36-(8.5)e	DEH closed area in unnamed bay approximately 3500 meters east of line across Bogue Sound from the southwest side of mouth of Gales Creek to Rock Point	4.9	2002	Fecal Coliform
20-36-(8.5)f	DEH closed area in unnamed bay area near Hoophole Woods approximately 7400 meters east of line across Bogue Sound from the southwest side of mouth of Gales Creek to Rock Point	81.0	2002	Fecal Coliform
20-36-(8.5)i	DEH closed area near Hoophole Creek west of Atlantic Beach	41.3	2002	Fecal Coliform

3.2 SOURCE ASSESSMENT

The primary source being addressed through this restoration plan will be stormwater runoff, which carries pollutants such as bacteria, the most predominate water quality impairment as identified by state reports and TMDL studies.

3.2.1 Nonpoint Source Pollution

Due to rapid urban development and alteration of natural hydrology within the watershed, bacterial pollutants have been found to be the primary issue as reported in water quality assessments and Shellfish Sanitation reports. The difficulty in preventing violations of bacteria standards for coastal waters caused by stormwater runoff is compounded by the unique challenges related to coastal hydrology and bacteria pollution. These are:

1. The two bacteria used as indicators of water quality, fecal coliform and enterococcus, naturally occur across the terrestrial landscape. These bacteria are found 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 satisfactory improvements in coastal water quality due to unnatural levels of stormwater being discharged.
2. Treating stormwater runoff to remove bacteria pollution before it flows into shellfishing and swimming waters is impractical. Although some technology exists for decreasing bacteria levels in runoff, it is not able to reduce levels to ensure water quality necessary to allow shellfish harvest and swimming.
3. Treated runoff can easily be re-contaminated. Due to the ubiquitous nature of bacteria on the landscape, treated runoff, once discharged back on the landscape, will simply pick up more bacteria. The result is ineffective and costly treatment.

A more practical approach is to reduce the volume of stormwater entering waterways. Stormwater runoff can convey a variety of nonpoint source pollutants from a variety of causes. Nonpoint Source are diffused sources of pollution, where there is no singular distinct outflow point. Potential nonpoint sources range from animal sources to connected conveyance systems.

Few sources of nonpoint animal sources exist within the watersheds that can contribute to the degradation of water quality. There are no domesticated farm animals with the watershed, making domestic cats, dogs, birds and wildlife the most likely contributors to non-point animal pollution. Relatively little forested land exists on the west side of the watershed, so only animals adapted suburban settings are common.

The Pine Knoll Shores aquarium has multiple discharges from their exhibits that drain into wetlands behind the property. The large ocean tank discharges 20,000 gallons a month and the otter dank discharges 3,000 gallons a month. Both tanks' outflows are tested regularly to assure the waste water is free of contamination. The ocean tank discharge is generally free of fecal coliform, but the otter tank discharge averages between 20 and 30 MPN. The otter tank discharge is not of high concern due to the low volume of discharge, and there is no direct hydrological connection between the discharge and the sound. The aquarium is contacted annually by Shellfish Sanitation to ensure procedures and sampling results have not changed. An emergency stormwater pumping site is the only pollution area of concern within the watersheds.

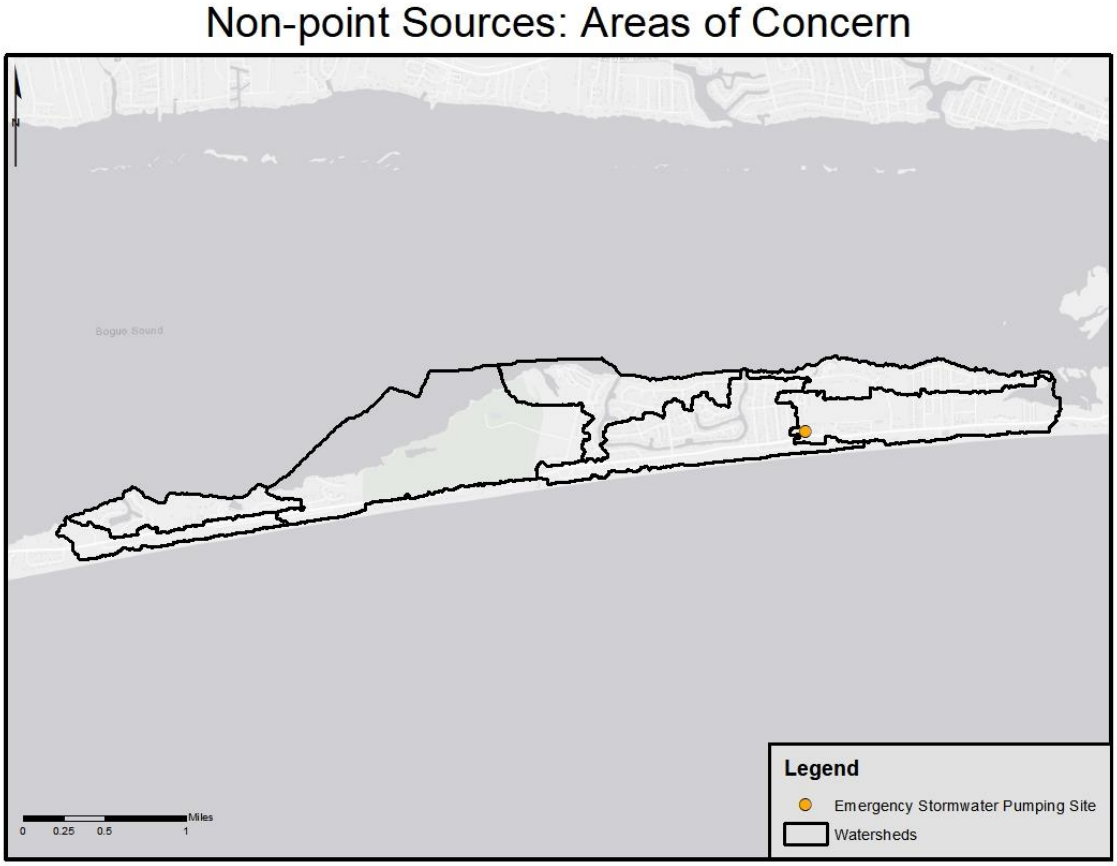


Figure 3-3. Potential non-point source areas of concern.

There are numerous docks and boat ramps within the Pine Knoll Shores watersheds (Figure 3-4). Issues concerning nonpoint source pollution from dockages stem from boat cleaners, litter, and fuel discharge. These are being noted here if they become issues in the future. (Note: Marinas are defined by state regulations as having more than 10 boat slips) (see Appendix C for definition of each dockage). Dockage sites are monitored by Shellfish Sanitation, which publishes its report every five years for Area E-2 and E-3. It may be worthwhile to consider working closely with dock and marina managers to promote best management practices to ensure that potential risks are minimized.

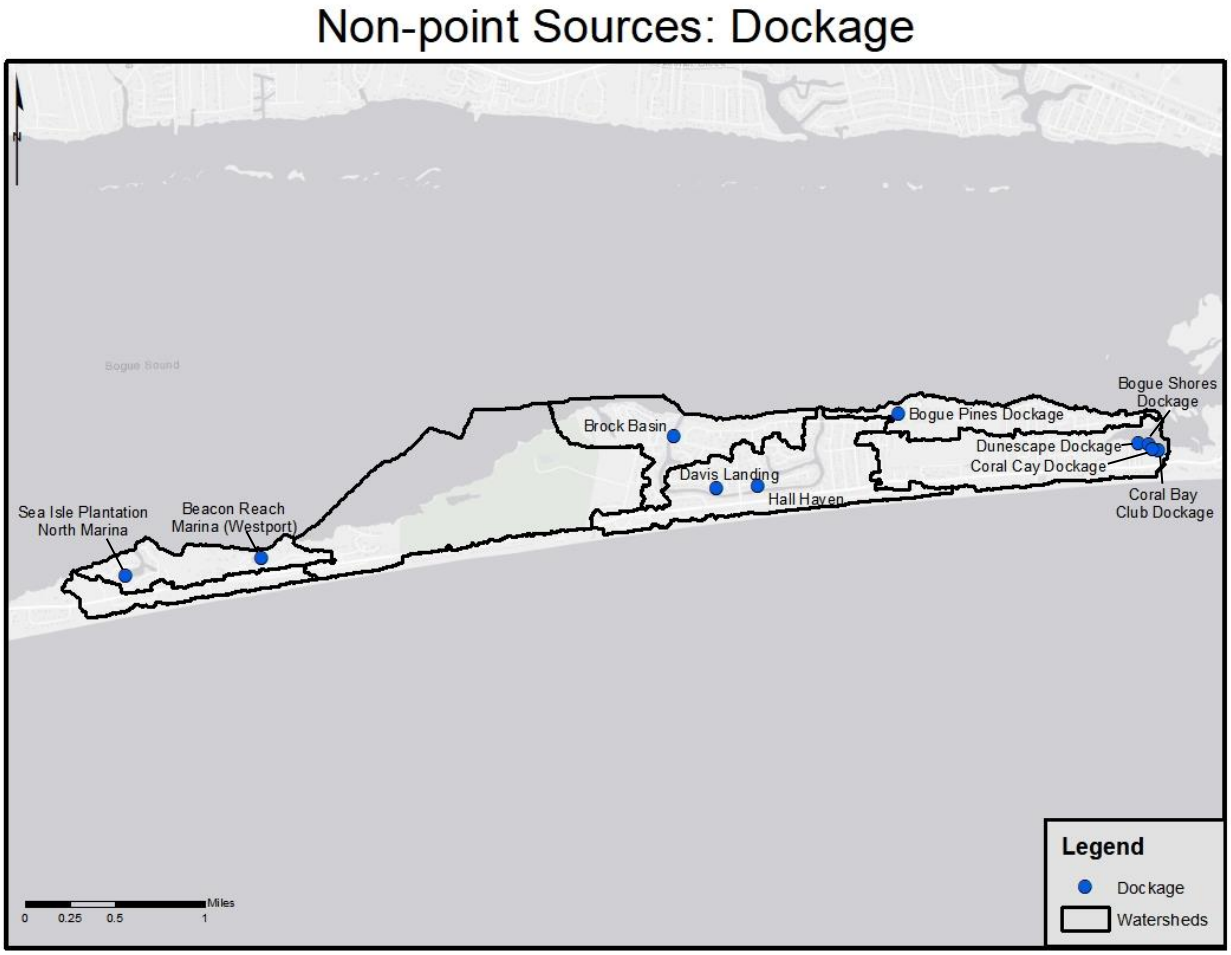


Figure 3-4. Potential non-point dockage sources. See Appendix C for definition of dock type.

There are various connected conveyance systems that enable direct access of stormwater to the waterbodies of the watershed (Figure 3-5). These access points include curb and gutters, connected ditches, connected swales, and pipe systems that quickly transport stormwater runoff. In total, there are 14 sites within the watersheds. Monitoring of these sites is currently conducted by Shellfish Sanitation and the findings are released every three years in the reports for Area E-2 and E-3. Disconnecting connected conveyance systems are some of the most effective measures to reduce the volume of stormwater runoff reaching waterways. It is recommended that future projects should consider further review of these points for solutions.

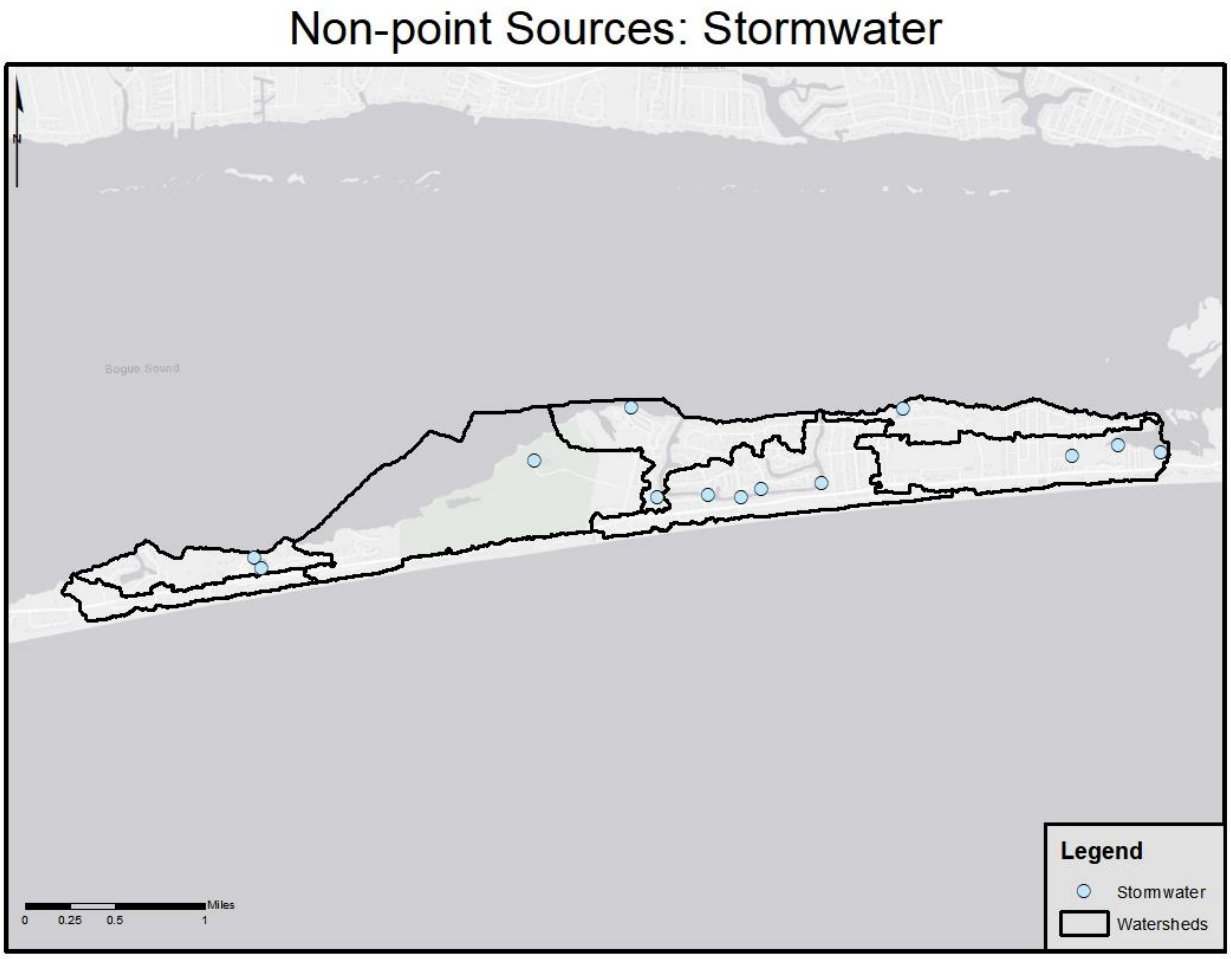


Figure 3-5. Potential non-point stormwater access point sources. See Appendix C for definition of conveyance type.

There are 14 subdivisions that are potential sources of non-point source pollution (Figure 3-6). Pollutants from subdivisions have the potential to be concentrated due to the number of residences in a small area and significant hydrology alteration. Subdivisions can often be a source of concentrated loads of pollution from fertilizer nutrients, pesticides, yard debris, and bacteria from domestic pets. Subdivisions often use conventional stormwater management such as downspouts to impervious surfaces and connected conveyance systems. Monitoring is currently conducted by Shellfish Sanitation and the findings are released every five years in the reports for Area E-2 and E-3. It is recommended that future partnerships be developed with home owners' associations and that an education and outreach program be designed that emphasizes residential based solutions.

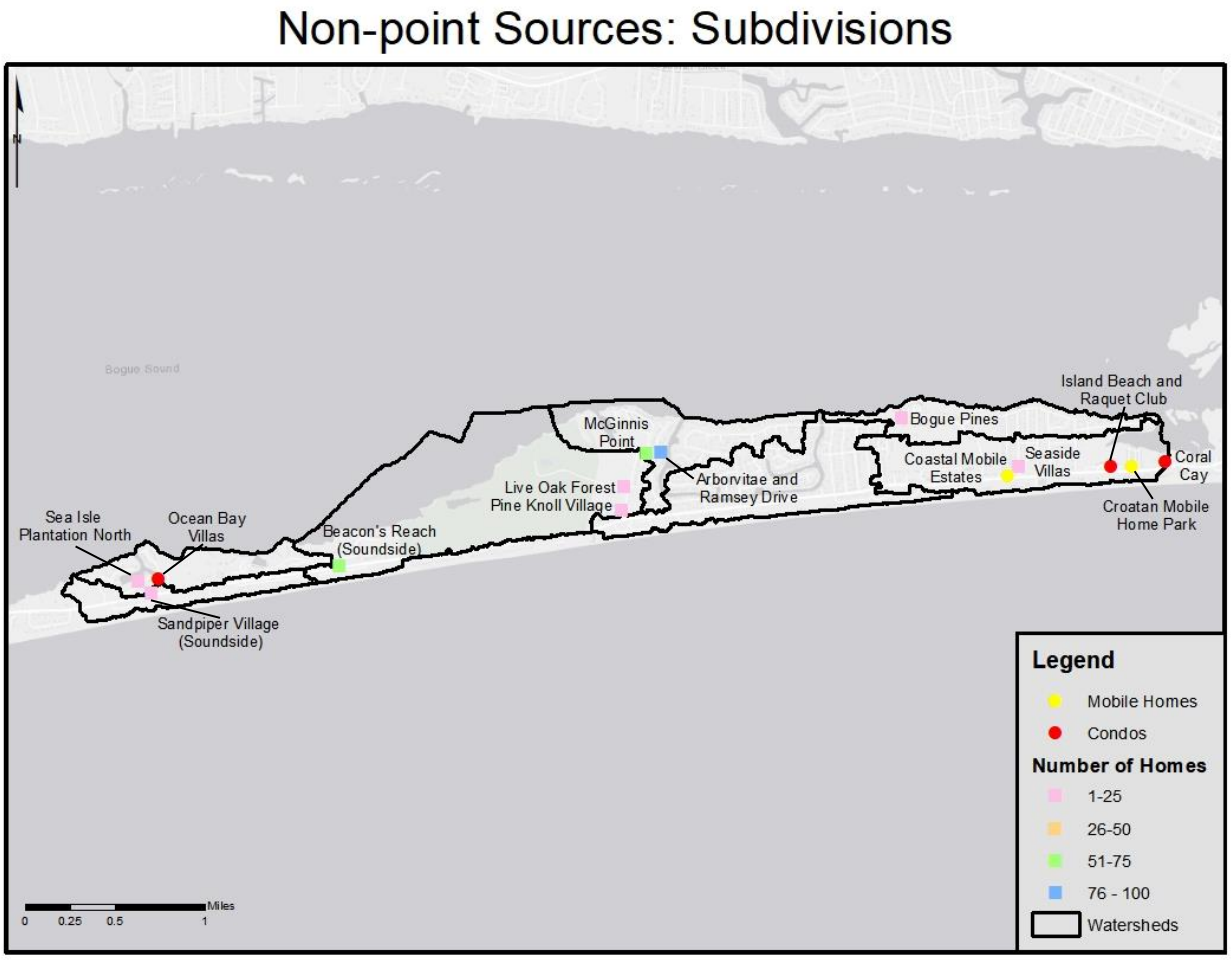


Figure 3-6. Potential non-point subdivision sources.

3.2.2 Point Sources

Point sources of pollution, unlike the diffuse non-point sources, are any single identifiable source of pollution from which pollutants are discharged, such as a pipe or ditch. They can pollute the water, but their effects can often be lessened or eliminated through management strategies. There are 44 state stormwater permits and one permitted National Pollutant Discharge Elimination System (NPDES) Wastewater Facility in the Pine Knoll Shores watersheds.

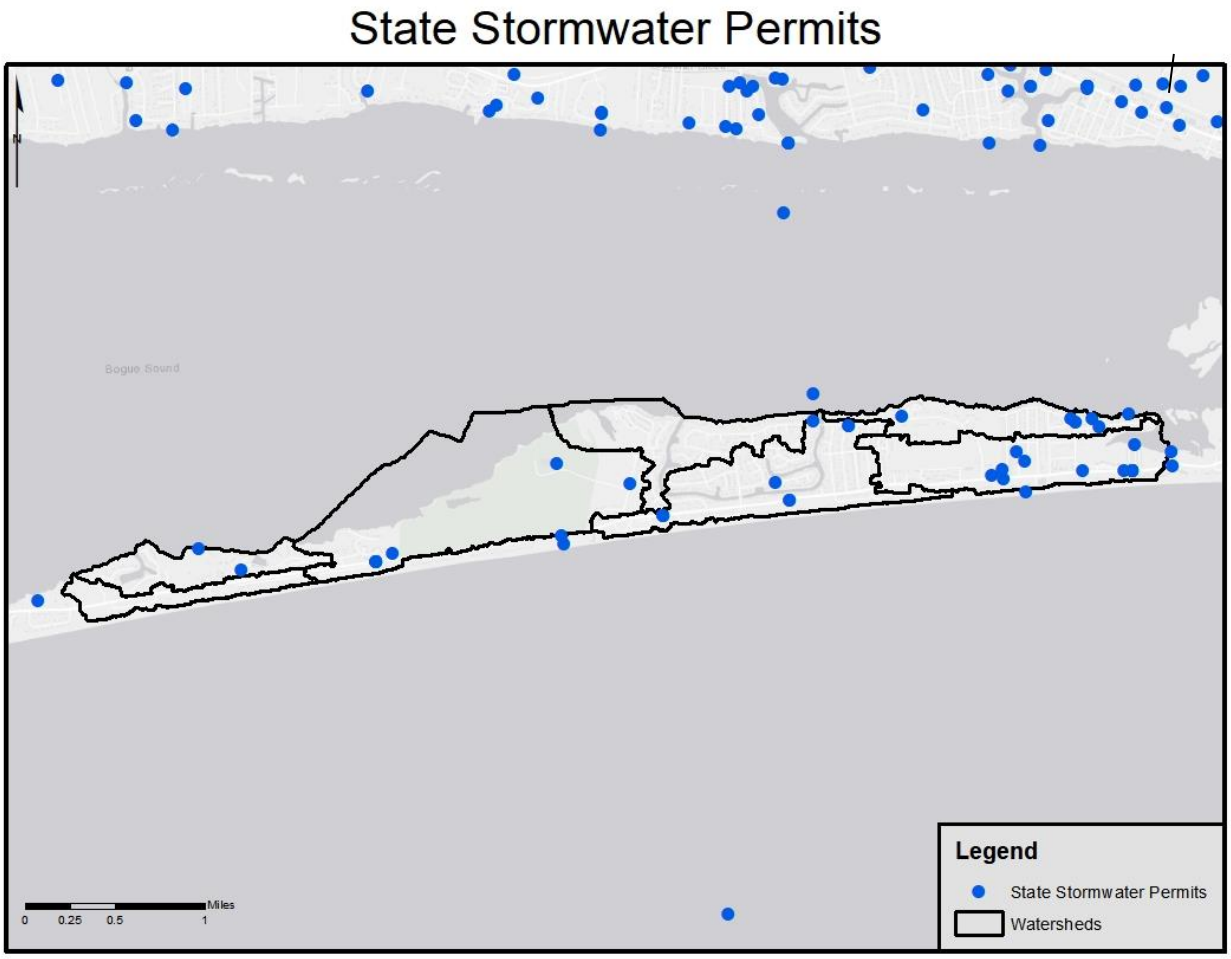


Figure 3-7. State and nationally permitted stormwater facilities.

Table 3-4. NPDES sites.

Facility Name	Permit No.	Receiving Stream
Pine Knoll Shores Wastewater Treatment Plant	NC0082520	Bogue Sound, White Oak River Basin

3.2.3 Additional Sources

There are no known Brown Fields, CERCLA sites, mining, or RCRA sites. Two additional sources are PCS/ICIS being the North Carolina Aquarium at Pine Knoll Shores and Pine Knoll Shores WTP, both without violation. The Pine Knoll Shores WTP SIC code is 4941- Water Supply. There are multiple Underground Storage Tanks (UST) found in Pine Knoll Shores and can be seen in Table 3-4. There are 2 USTs that had accidents within the past 10 years within the watersheds: White Sands Minimart and Plaza 58 (incident number 32751) and Scotchman #189 (incident number 32041).

Table 3-5. Underground storage tanks in Pine Knoll Shores.

Name	Address	UST No.	Risk
White Sands Mini Mart and Plaza 58	2610 Salter Path Road	WI-7659	Low
White Sand Mini Mart	710 Salter Path Road	WI-1357	Low
Town of Pine Knoll Shores	Rt. 3	WI-927	Low
Scotchman #189	2510 W. Fort Macon	WI-2294	Low
Holiday Inn (Jim Dandy)	118 Salter Path Road	WI-810	Low
Fast Fare #533	2510 W. Fort Macon	WI-1136	Low

4 Runoff Volume Reduction

Rather than focusing on reducing sources of pollutants from stormwater runoff, *the proven management techniques used in this plan focus on reducing the overall volume of stormwater runoff to limit the conveyance from the land into coastal waters.* Low-impact development (LID) and stormwater reduction techniques can achieve this goal by replicating the natural hydrology and increasing infiltration of water into soils. LID practices are a form of land planning and engineering that primarily focus on mimicking natural hydrology of the area to limit stormwater runoff. For already developed locations stormwater reduction techniques can reduce the amount of stormwater entering waterways. The result of implementing stormwater control practices is that less bacteria and pollutants are transported off the land and into water systems. The primary issue to be addressed through the stormwater runoff volume reduction methodology is the reduction of fecal coliform contamination caused by urban development within the watershed (Table 4-1).

Table 4-1. Identifying and linking concerns, causes and indicators.

Issue	Source of Issue	Quantify Issue Indicators
Water quality is impaired and not meeting its Designated Use standard of Class SA	Non-point source bacteria transported by stormwater runoff	• Fecal coliform cannot exceed GM of 14/100 ml
Instances of localized flooding	Volume of stormwater runoff due to impervious surfaces	• Volume of water

4.1 Stormwater Volume Reduction Calculation Methodology

The process of calculating stormwater runoff volume reduction goals has been standardized utilizing instructions developed by the North Carolina Coastal Federation, a non-profit organization dedicated to preserving and protecting North Carolina's coast, and WithersRavenel, a civil and environmental engineering firm. This methodology is described in a Watershed Restoration Planning Guidebook that can be found at www.nccoast.org.

The year 1993 was selected as the baseline year for several reasons. There are excellent aerial images available that provide high enough resolution at a scale of 1:2,500 to conduct a land use classification with good accuracy. It was also the earliest year that aerial imagery that was georeferenced was readily available that covered the entire area. In addition, many permanent and temporary shellfish closures in Bogue Sound started to occur in 1988, 1989, 1990, and 2002. For all these reasons, it was decided that 1993 would give a good approximation of when runoff volumes increased to such an extent that impaired waters became a persistent problem. It is important to keep in mind that the estimate for reducing the volume of runoff is not expected to be precisely accurate, but rather provide a ballpark goal for the amount of runoff that needs to be eliminated to see improvements in water quality. Further review and evaluation of water quality as management measures are implemented will provide the opportunity to further refine and adjust volume reduction targets as the plan is carried out.

Utilizing this 1993 aerial imagery for the baseline year, land characterization was conducted by delineating parcel information, development (pervious, impervious), and soil characteristics (HSG) for each land use scenario (each aerial imagery year). The delineated land use parcels were then analyzed to estimate the average percent impervious coverage. Summations were calculated of overall percent coverage based on land use and soil. From this information, the runoff curve number is calculated then runoff depth is calculated for the 1-year, 24-hour depth of precipitation using formulas developed by the United States Department of Agriculture Natural Resource Conservation Service (USDA NRCS) in the *TR-55 Manual*. A runoff curve number (commonly referred to as CN) is a numeric parameter derived from combining the effects of soil, watershed characteristics, and land use.

The following curve numbers were utilized:

Land Use Classification	**HSG**			
	A	**B**	**C**	**D**
Impervious	98 CN	98 CN	98 CN	98 CN
Open Space	39 CN	61 CN	74 CN	80 CN
Woods	30 CN	55 CN	70 CN	77 CN

The following designations were utilized to categorize land use:

Land Use Classification	Designation
Impervious	Areas with distinctive impervious coverage from paved parking lots, roofs, driveways, curbs, etc.
Open Space	Grassy areas where there is 75% or more grassy space such as from lawns, parks, golf courses, cemeteries, fields, pastures, etc.
Woods	Forested areas with thorough coverage, these areas are often protected from grazing, and forest litter and brush adequately cover the soil.

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 replicate pre-impairment conditions.

NOAA precipitation frequency models state that a 1-year, 24-hour storm results of **3.67 inches of precipitation** and the results for a **2-year, 24-hour storm is 4.46 inches** (Table 2-6). The 1-year, 24-hour storm and 2-year, 24-hour storm estimations are used because it has been established as the maximum storm parameter possible to protect shellfishing waters (Class SA) in North Carolina by DEQ. The 2-year, 24-hour storm event depth of precipitation will also be necessary as part of developing hydrographs of the data.

Table 4-2. NOAA precipitation frequency table for Pine Knoll Shores Watersheds.

PRECIPITATION FREQUENCY ESTIMATES (Time/years) IN INCHES										
Duration	**1**	**2**	**5**	**10**	**25**	**50**	**100**	**200**	**500**	**1000**
5-min:	0.49	0.58	0.66	0.75	0.84	0.92	1	1.07	1.17	1.26
10-min:	0.78	0.92	1.06	1.2	1.34	1.47	1.59	1.7	1.85	1.98
15-min:	0.98	1.16	1.35	1.51	1.71	1.86	2	2.15	2.33	2.48
30-min:	1.34	1.6	1.91	2.19	2.53	2.8	3.07	3.35	3.71	4.02
60-min:	1.67	2.01	2.45	2.85	3.36	3.79	4.23	4.69	5.32	5.87
2-hr:	2.04	2.47	3.1	3.68	4.46	5.15	5.87	6.65	7.75	8.73
3-hr:	2.21	2.67	3.36	4.03	4.93	5.76	6.63	7.6	9.02	10.3
6-hr:	2.69	3.25	4.1	4.91	6.05	7.07	8.18	9.41	11.21	12.86
12-hr:	3.17	3.84	4.87	5.87	7.27	8.56	9.96	11.53	13.86	16.01
24-hr:	**3.67**	**4.46**	5.77	6.88	8.55	10	11.61	13.41	16.13	18.48
2-day:	4.26	5.17	6.63	7.9	9.81	11.49	13.35	15.45	18.64	21.41
3-day:	4.53	5.48	7	8.29	10.2	11.85	13.68	15.71	18.82	21.52
4-day:	4.79	5.79	7.36	8.67	10.59	12.22	14.01	15.97	19.01	21.65
7-day:	5.55	6.69	8.41	9.83	11.89	13.62	15.47	17.48	20.4	22.86

4.2 Runoff and Volume Reduction Calculations

The volume reduction results represent base numbers of volumetric changes between the years based on land use changes. These volumetric reduction goals do not take into consideration more complex nuances, such as changes in stormwater regulation or minor or major stormwater reduction and retrofit projects. This subtly is addressed through the goals and objectives discussed in the following section, where an inventory of stormwater reduction measures throughout the watersheds should be taken and volumetric credit should be accounted for towards meeting the volume goals. These general reduction volumetric goals represent an overarching and consistent pattern throughout the watersheds of land use changes resulting in an increase in stormwater runoff and an increase in the number of closures.

The final numeric total stormwater runoff reduction volume goal is 2,478,807 gallons This is the target goal that management and restoration plans seek to achieve.

Soil Type	Land Use	1993 Total Area	2014 Total Area	Difference
A	Open	180	200	+20
A	Impervious	383	500	+117
A	Woods	882	746	-136
B	Open	-	-	-
B	Impervious	-	-	-
B	Woods	-	-	-
C	Open	-	-	-
C	Impervious	-	-	-
C	Woods	-	-	-
D	Open	25	48	+23
D	Impervious	3	8	+5
D	Woods	102	75	-27

Table 4-3. Two-year land classifications

Pine Knoll Shores Watersheds				
Year	Condition Peak Flow (cubic feet per second)	Reduction Goals		
		Runoff Volume (ac-ft)	Volume Change from Baseline Conditions (ac-ft)	Target Volume Reduction (gal/ft^2)
1993	201.53	39.54	--	--
2014	510.48	63.32	+ 23.78	**0.04**
Total Acres		1,577.00		
Runoff Reduction Goal		7.61 acre-feet		
Runoff Reduction Goal		2,478,807 GAL per 1-yr, 24-hr storm		

Runoff Volume per Acre	1,566 gal/ac

Table 4-4 Volume reduction goals

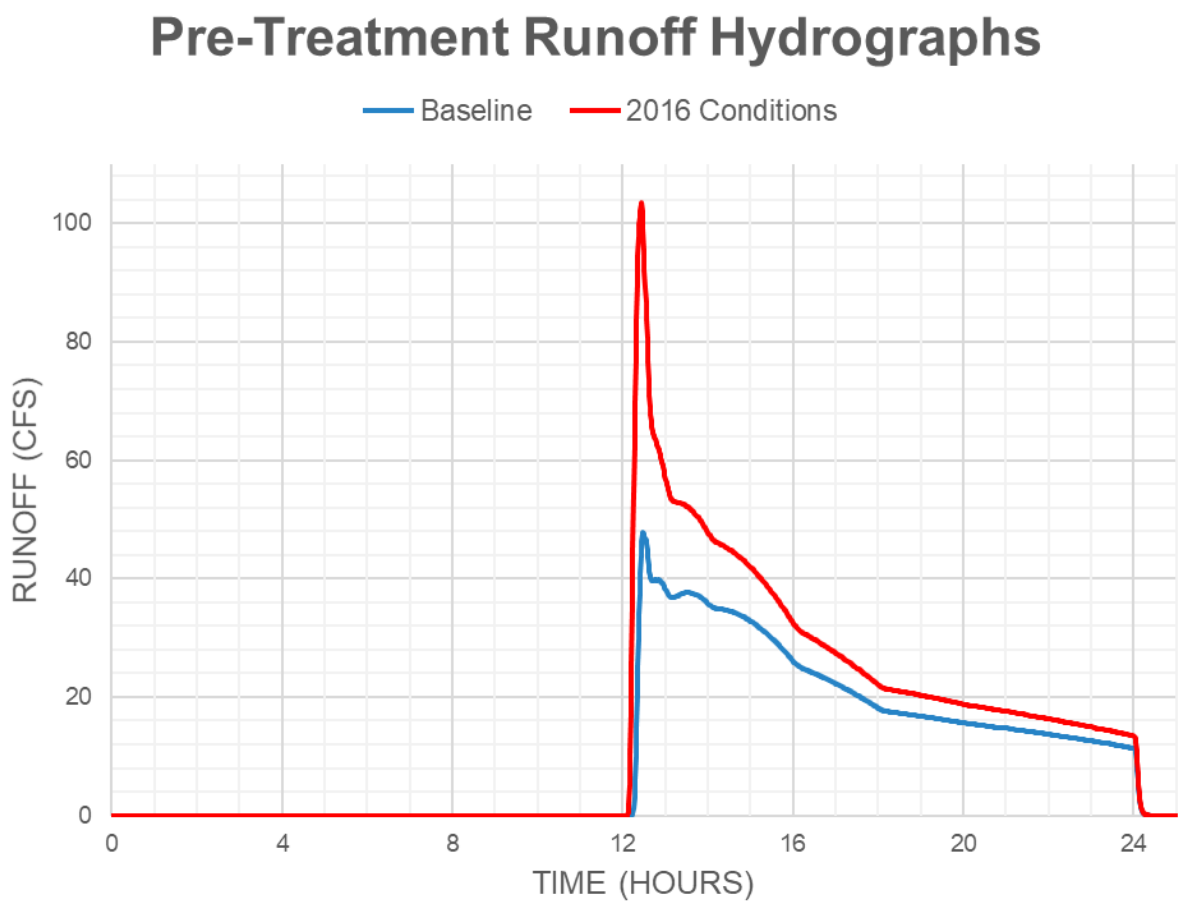


Figure 4.1 Hydrograph

5 Goals

The Pine Knoll Shores Watershed partners seek to utilize various stormwater reduction techniques to reduce the volume of stormwater runoff reaching coastal waters. The target volume reduction goal is 2,478,807 gallons or about **0.1 gallons per square foot of impervious surface** during a 1-year, 24-hour event to reach 1993 water quality conditions. Volume reduction will be achieved by:

(1) Tallying the volume that is currently being collected by existing stormwater retrofit (current projects are not included in the reduction estimate);
(2) Installing new targeted stormwater reduction projects in the watersheds;
(3) Engaging the community in plan implementation.

5.1 Primary Goal

The goal of this plan will be accomplished by combining cost-effective, high-yield strategies such as active groundwater management strategies as well as lot level and street-wide retrofit projects that reduce the impact of impervious surface by mimicking natural hydrology to reduce flooding, protect water quality, and provide the community with clean, usable waters. Over time, reductions in the volume of stormwater runoff will be achieved through implementation of this plan and will result in measurable water quality improvements. This restoration plan uses the innovative approach of reducing runoff volumes within the region's watersheds to reduce existing water quality impairments and restore water quality. As with other plans that incorporate this volume reduction philosophy, this plan emphasizes five restoration objectives to accomplish its goals (Table 4-1).

Table 4-1. The primary goal of the watershed management plan and the objectives.

Primary Goal ***Improve water quality in Pine Knoll Shores Watersheds and reduce permanent shellfish closures in Bogue Sound.***	
OBJECTIVES	
1	New development and redevelopment does not create additional water quality impairments.
2	Stormwater reduction techniques are applied on public properties.
3	The volume of stormwater runoff is reduced from existing private land uses.
4	Conduct periodic monitoring and review to ensure the goals and objectives of the plan are being met.
5	The community is educated about stormwater pollution and volume reduction needs and engaged in accomplishing the plan objectives.

5.1.1 Objective 1

This objective aims to ensure that new development and redevelopment do not produce additional water quality impairments to the watershed.

Objective 1. New development and redevelopment does not create additional water quality impairments.	
Action #	**Specific Action**
1-1	The newly appointed Town of Pine Knoll Shores Stormwater Subcommittee (c. 2018) will review existing town codes and ordinances to determine impediments to low impact stormwater designs for new development and redevelopment. The findings will be presented to the Town with any suggested amendments and discussion of any potential incentive plans.
1-2	The Town will determine the need for a locally adopted stormwater management program to supplement gaps in the state's stormwater program and the Town's needs. Some gaps identified thus far include: • Redevelopment • Smaller projects not covered under the State's Stormwater Program • Oversight of installation and maintenance of State permitted systems
1-3	The Town will coordinate stormwater management practices with maritime forest management practices to ensure evapotranspiration by already present vegetation is optimized.

5.1.2 Objective 2

The volume of stormwater runoff being transported over land to waterways needs to be reduced to restore water quality. The goal is to reduce the volume of stormwater conveyed to levels that occurred prior to the baseline year of 1993. By focusing one of the objectives on efforts at public lands and conveyance systems, the Town can demonstrate commitment to improving watershed health to the community.

Objective 2. Stormwater reduction techniques are applied on public properties.	
Action #	**Specific Action**
2-1	Identify feasibility of potential stormwater reduction measures at town streets, buildings, public beach accesses, parking lots, drainage systems, and other public properties. Prioritize retrofits at public buildings and properties that can serve as demonstration sites of stormwater retrofits.
2-2	Utilize town rights-of-ways to maximize stormwater reduction measures.
2-3	Evaluate existing stormwater systems on public properties for potential volume reduction enhancements, and if feasible, retrofit them to achieve volume reduction.
2-4	Secure funds for retrofits at public properties.
2-5	Incorporate, where practical, *Green Street Designs* (see Appendix) or similar low-impact design strategies into future capital improvements of the town.
2-6	Pursue strategy with state agencies to incorporate retrofits to state properties. Pursue strategies with N.C. Department of Transportation (DOT) to incorporate retrofits into the Highway 58 drainage system and that any new road upgrades or maintenance plans include plans for reducing runoff.

5.1.3 Objective 3

This objective is intended to address existing stormwater runoff from private land use by identifying and promoting cost effective strategies private residences and businesses can incorporate.

Objective 3. The volume of stormwater runoff is reduced from existing private land uses.	
Action #	**Specific Action**
3-1	Identify retrofit sites with private partners, prioritizing sites by potential for volume reduction cost-benefit; such as sites identified as exceptional because of the physical and natural characteristics, accessibility, cost, public outreach opportunity, and current land uses.
3-2	Work with governmental agencies and NGOs to secure grants to provide funding to install lot-level, low-cost retrofits that disconnect impervious surfaces and enhance stormwater infiltration.
3-3	Seek funding for stormwater retrofit projects that have been identified.
3-4	Provide landowners incentives to disconnect impervious surfaces or minimize stormwater runoff from their property.
3-5	Explore opportunities with N.C. Soil and Water Conservation's Community Conservation Assistance Program (CCAP).

5.1.4 Objective 4

Accomplishing the actions in this plan requires monitoring of performance of the plan and projects that are implemented. Progress made in achieving water quality improvements will be measured. This plan will be adapted as necessary based upon the results of this monitoring.

Objective 4. Conduct periodic monitoring and review to ensure the goal and objectives of the plan are being met.

Action #	Specific Action
4-1	Monitor Shellfish Sanitation Sanitary Report data as reports are produced (reports available every 3 years).
4-2	Review the plan every threeyears to evaluate findings from water quality data and the status of implementation. Conduct scheduled assessment of the plan and progress made to date with the project team.
4-3	Maintain a simple inventory of retrofits and monitor performance of stormwater reduction retrofits that have been installed within the watersheds.
4-4	Document the volume of stormwater reduced by each retrofit by utilizing the *Runoff Reduction Calculator Tool* or *Watershed EZ*, or similar volume reduction calculation tools.
4-5	Coordinate with academic partners, such as UNC-IMS, ECU, Duke University, and NCSU, to conduct periodic monitoring of water quality.
4-6	Explore opportunities to utilize community members to conduct citizen science-based monitoring of stormwater reduction retrofits and inventory already installed retrofits.

5.1.5 Objective 5

Community education will be a necessary component to achieving the primary goal of this plan. Education of all members of the community including residents, property owners, developers and others can help ensure understanding of the issues and need for action.

Objective 5. The community is educated about stormwater pollution and volume reduction needs and engaged in accomplishing the plan objectives.

Action #	Specific Action
5-1	Collaborate with partners to educate and engage property owners, businesses, and K-12 students and their families on stormwater management. For example, facilitating the circulation of *Smart Yards*, a stormwater retrofit education guide for homeowners created by the North Carolina Coastal Federation.
5-2	Facilitate technical training opportunities for planners, engineers, developers, landscapers and local government staff on techniques to reduce volume of stormwater within the town.
5-3	Work with existing water quality outreach professionals, including: North Carolina Coastal Federation, UNC Institute of Marine Sciences, and Duke University Marine Laboratory on a stormwater education initiatives.
5-4	Include education signage at select retrofits and place emphasis on highlighting the town's commitment to reducing stormwater.

6 Management Strategies

Reducing the volume of runoff by approximately 2.5 million gallons from a 1-year, 24-hour storm event will require management strategies that enhance the ability of the landscape to infiltrate stormwater. The non-regulatory "natured based" management strategies within this section seek to identify potential retrofit opportunities based on the information compiled during the development of this restoration plan. The number one priority is to find ways to make the landscape infiltrate as much stormwater as practical.

Conventional Stormwater Control Measures (SCM) listed in the Table 6-1 are ranked based upon their effectiveness in lowering fecal coliform bacteria in impaired coastal waters. Approximate construction and annual costs of these measures are listed as well.

Table 6-1. Conventional SCM Performance for Bacteria Reduction on HSG Type 'A' Soil [a]

Practice	Removal of Bacteria	% Annual RO Eliminated (ETI) [d]	Approximate Annual Cost Per-Acre Treated ($/Ac/Yr)
Rainwater Harvesting [c]	Good - Excellent	<100%	
Bioretention w/IWS [b]	Excellent	85%	$700 - $870
Silva Cell	Excellent	85%	
Infiltration	Excellent	84%	$330 - $450
Permeable Pavement, Infiltrating [b]	Excellent	84%	
Green Roof	Good	60%	
Disconnected Impervious Surface	Good	58%	
Level Spreader-Filter Strip	Poor	54%	$500 - $1,150
Wet Grass Swale	Poor	36%	$360 - $420
Stormwater Wetland	Good	34%	$225 - $350
Dry Grass Swale	Poor	22%	$360 - $420
Wet Pond	Fair	21%	$460 - $560
Sand Filter, Open	Good	9%	$2,500 - $2,600
Dry Pond	Poor	8%	$460 - $560

[a] Values for practices designed per DEMLR Minimum Design Criteria (15A NCAC 2H .1000) unless stated otherwise.
[b] Design variants available w/performance estimated by Hyper Tool.
[c] All designs are custom w/performance estimated by Rainwater Harvesting Tool.
[d] From DEMLR Stormwater Control Measure Credit Document and as calculated by DWR SNAP Tool v 4.1.

In addition to these individual on-site SCM measures, the Town is also pursuing active management of groundwater levels in low-lying neighborhoods with seasonally high groundwater tables. It has developed a preliminary design for an active pumping system that will lower water tables within a five block residential area of town that has chronic flooding. The system is designed to draw down the water table prior to significant rainfall events, and to infiltrate that pumped water within the town's golf course ponds and greens. This management system is designed to improve the ability of these neighborhoods to absorb approximately three inches of rainfall within a 24-hour period without creating flooding issues even during wet periods of the year. A proposal to construct this active water management pumping system has been submitted to the N.C. Clean Water Management Trust Fund in its current funding cycle. It is estimated by the design engineer that this system will reduce runoff levels during wet period of the year between 400,000 to 1.17 million gallons in a 1-year, 24-hour storm event.

Specific project selection to install SCMs will be based on field assessments that include site feasibility, site specific soils, proximity of project to impaired waters and project costs. Figure 6-1 shows the location of more than 100 potential sites where SCM can be used. These sites have been evaluated based upon the soil type where they are located, the type of retrofit they will require, their existing fecal coliform loading rates, and their proximity to shellfish growing waters. Table 6-3 provides an individual list of these sites including some of the evaluation criteria that will be used in their selection.

Figure 6-1. Map of Potential SCMs.

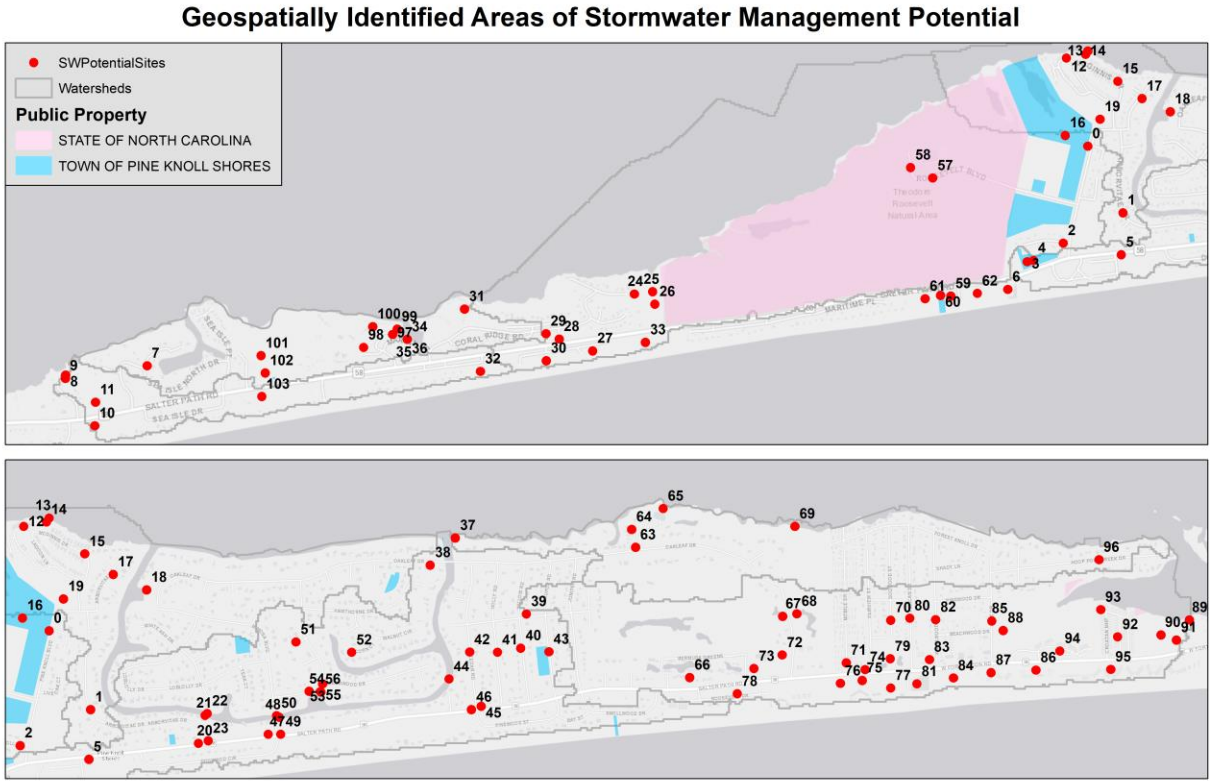


Table 6-2 List of Potential SCMS.

ID	Summary	Hydrologic Soil Group	Conveyance Type	Fecal Coliform Load	Distance (m) to the SGA Code
0	Cleared or high impervious surface present	A	CURB/GUTTER TO PIPE	MEDIUM	323.6162746
1	CURB/GUTTER TO PIPE	A	CURB/GUTTER TO PIPE	MEDIUM	0
2	Some downspouts draining directly to driveway, low vegetation	A	CURB/GUTTER TO PIPE	MEDIUM	283.6342975
3	High impervious surface, near stormwater conveyance	A	CURB/GUTTER TO PIPE	MEDIUM	485.6908202
4	Sediment runoff from unpaved dirt lot, near stormwater conveyance	A	CURB/GUTTER TO PIPE	MEDIUM	454.7920446
5	High impervious surface, near stormwater conveyance	A	CURB/GUTTER TO PIPE	MEDIUM	158.735576
6	Dense imperious and open space area	A	CURB/GUTTER TO PIPE	MEDIUM	638.3632318
7	Reduction in vegetation	A	CURB/GUTTER TO PIPE	LOW	360.22172
8	Reduction in vegetation	A	CURB/GUTTER TO PIPE	LOW	0
9	Near stormwater conveyance	A	CURB/GUTTER TO PIPE	LOW	0
10	Dense imperious area	A	CURB/GUTTER TO PIPE	LOW	227.4260419
11	Large open space at waste water	A	CURB/GUTTER TO PIPE	LOW	141.9108748
12	High impervious surface	A	OTHER-SEE COMMENTS	LOW	47.50447404
13	upland transitional buffer has been cleared	W	OTHER-SEE COMMENTS	LOW	0
14	COMMUNITY STORMWATER PONDS DRAIN TO SOUND HERE, NEAR STORMWATER CONVEYANCE	A	OTHER-SEE COMMENTS	LOW	0
15	Drain present	A	OTHER-SEE COMMENTS	LOW	158.6596664
16	Drain present	A	OTHER-SEE COMMENTS	LOW	365.33365
17	Cleared or high impervious surface present	A	OTHER-SEE COMMENTS	LOW	306.3810345
18	Boat Ramp	A	OTHER-SEE COMMENTS	LOW	457.6549639
19	Riparian or upland vegetation serving as upland buffer being mowed	A	OTHER-SEE COMMENTS	LOW	280.5969862
20	Ditch/swale connected to drainage pipe near canal	A	DITCH/SWALE TO PIPE	MEDIUM	80.86765831
21	Near stormwater conveyance	A	DITCH/SWALE TO PIPE	MEDIUM	0
22	DRAINS HIGHWAY TO CANAL, NEAR STORMWATER CONVEYANCE	A	DITCH/SWALE TO PIPE	MEDIUM	0
23	Ditch/swale connected to drainage pipe near canal	A	DITCH/SWALE TO PIPE	MEDIUM	65.01795931
24	Dense impervious and compacted dirt parking surface	A	CURB/GUTTER TO PIPE	LOW	1101.464159
25	Riparian or upland vegetation serving as upland buffer being mowed	A	CURB/GUTTER TO PIPE	LOW	1192.15116
26	Large open space at waste water	A	CURB/GUTTER TO PIPE	LOW	1193.383979
27	Dense imperious area	A	CURB/GUTTER TO PIPE	LOW	873.9715735
28	Open space median	A	CURB/GUTTER TO PIPE	LOW	705.8044708
29	Dense imperious area	A	CURB/GUTTER TO PIPE	LOW	640.1804496
30	Dense imperious area	A	CURB/GUTTER TO PIPE	LOW	649.3669935
31	Dense impervious surface areas	A	CURB/GUTTER TO PIPE	LOW	271.4405999
32	Dense imperious area	A	CURB/GUTTER TO PIPE	LOW	346.9223427
33	Dense imperious area	A	CURB/GUTTER TO PIPE	LOW	1134.22073
34	TWO EIGHT INCH PIPES DRAIN TO MARINA BASIN, NEAR STORMWATER CONVEYANCE	A	CURB/GUTTER TO PIPE	LOW	0
35	TWO EIGHT INCH PIPES DRAIN TO MARINA BASIN, NEAR STORMWATER CONVEYANCE	A	CURB/GUTTER TO PIPE	LOW	0
36	Near stormwater conveyance	A	CURB/GUTTER TO PIPE	LOW	0
37	Boat Ramp	A	DITCH/SWALE TO PIPE	LOW	542.9690146
38	Swale connected to drainage pipe near canal	A	DITCH/SWALE TO PIPE	LOW	434.5078196
39	Some downspouts draining directly to driveway, some homes with low vegetation	A	DITCH/SWALE TO PIPE	LOW	373.7513689
40	Swale connected to drainage pipe	A	DITCH/SWALE TO PIPE	LOW	278.1519119
41	Swale connected to drainage pipe near canal	A	DITCH/SWALE TO PIPE	LOW	181.7334737
42	Swale connected to drainage pipe near canal	A	DITCH/SWALE TO PIPE	LOW	92.2820381
43	Swale connected to drainage pipe	A	DITCH/SWALE TO PIPE	LOW	384.2754003
44	Near stormwater conveyance	A	DITCH/SWALE TO PIPE	LOW	0
45	Ditch/swale connected to drainage pipe near canal	A	DITCH/SWALE TO PIPE	LOW	126.7132879
46	Ditch/swale connected to drainage pipe near canal	A	DITCH/SWALE TO PIPE	LOW	108.5470404
47	Ditch/swale connected to drainage pipe near canal	A	DITCH/SWALE TO PIPE	MEDIUM	35.58163449
48	Near stormwater conveyance	W	DITCH/SWALE TO PIPE	MEDIUM	0
49	Ditch/swale connected to drainage pipe near canal	A	DITCH/SWALE TO PIPE	MEDIUM	30.0620179
50	DRAINS HIGHWAY TO CANAL, NEAR STORMWATER CONVEYANCE	A	DITCH/SWALE TO PIPE	MEDIUM	0
51	Some downspouts draining directly to driveway, some homes with low vegetation	A	CURB/GUTTER TO PIPE	LOW	182.5551477
52	Drain present	A	CURB/GUTTER TO PIPE	LOW	160.8250619
53	Drain present	A	CURB/GUTTER TO PIPE	LOW	0
54	Boat Ramp	A	CURB/GUTTER TO PIPE	LOW	0
55	Near stormwater conveyance, cleared area, boat marina	W	CURB/GUTTER TO PIPE	LOW	0
56	Near stormwater conveyance	A	CURB/GUTTER TO PIPE	LOW	0
57	High impervious surface, near stormwater conveyance	D	OTHER-SEE COMMENTS	LOW	71.58669816
58	RETENTION BASINS FOR PARKING LOT DRAIN HERE, NEAR STORMWATER CONVEYANCE	A	OTHER-SEE COMMENTS	LOW	0
59	Large cleared open spaces	A	OTHER-SEE COMMENTS	LOW	618.9664925
60	Impervious public parking with inclined drive	A	OTHER-SEE COMMENTS	LOW	601.5609836
61	Dense imperious and open space area	A	OTHER-SEE COMMENTS	LOW	605.8491117
62	Dense imperious area, curb systems in parking lot	A	OTHER-SEE COMMENTS	LOW	658.4782784
63	Near golf course, cleared area.	A	CURB/GUTTER TO PIPE	LOW	26.33676232
64	Near stormwater conveyance	A	CURB/GUTTER TO PIPE	LOW	0
65	Near golf course, upland transitional buffer has been cleared	A	CURB/GUTTER TO PIPE	LOW	108.6524073
66	Dense imperious area	A	CURB/GUTTER TO PIPE	LOW	617.4484324
67	Near golf course	A	DITCH/SWALE TO PIPE	LOW	404.6534554
68	Near golf course	A	DITCH/SWALE TO PIPE	LOW	345.7870756
69	Near golf course, upland transitional buffer has been cleared	A	DITCH/SWALE TO PIPE	LOW	508.5354987
70	Low vegetative cover in area, near stormwater conveyance	A	DITCH/SWALE TO PIPE	LOW	0

71	Cleared or high impervious surface present	A	DITCH/SWALE TO PIPE	LOW	214.1202745
72	High impervious surface, near stormwater conveyance	A	DITCH/SWALE TO PIPE	LOW	431.7222965
73	Cleared or high impervious surface present	A	DITCH/SWALE TO PIPE	LOW	561.7982202
74	Cleared or high impervious surface present	A	DITCH/SWALE TO PIPE	LOW	190.5622877
75	Cleared or high impervious surface present	A	DITCH/SWALE TO PIPE	LOW	236.8049742
76	Large cleared open spaces	A	DITCH/SWALE TO PIPE	LOW	295.5858763
77	Cleared or high impervious surface present	A	DITCH/SWALE TO PIPE	LOW	241.5290054
78	Large cleared open spaces	A	DITCH/SWALE TO PIPE	LOW	667.9810928
79	Cleared or high impervious surface present	A	DITCH/SWALE TO PIPE	LOW	118.7890801
80	Low vegetative cover in area, near stormwater conveyance	A	DITCH/SWALE TO PIPE	MEDIUM	0
81	Dense imperious area	A	DITCH/SWALE TO PIPE	MEDIUM	227.5168654
82	Low vegetative cover in area, near stormwater conveyance	A	DITCH/SWALE (D/S)	MEDIUM	0
83	Cleared or high impervious surface present	A	DITCH/SWALE (D/S)	MEDIUM	127.4201636
84	Dense impervious and compacted dirt parking surface	A	DITCH/SWALE (D/S)	MEDIUM	213.6705911
85	Low vegetative cover in area, near stormwater conveyance	A	DITCH/SWALE (D/S)	MEDIUM	0
86	Cleared or high impervious surface coverage with limited vegeation	A	DITCH/SWALE (D/S)	MEDIUM	227.4527109
87	Dense imperious area	A	DITCH/SWALE (D/S)	MEDIUM	166.8156324
88	upland transitional buffer has been cleared	A	DITCH/SWALE (D/S)	MEDIUM	11.5864003
89	upland transitional buffer has been cleared	A	CURB/GUT TO PIPE	MEDIUM	0
90	Enhance marsh upland vegetation buffer	A	CURB/GUT TO PIPE	MEDIUM	118.5663303
91	Improve vegetation coverage of region, high impervious surface	A	CURB/GUT TO PIPE	MEDIUM	83.14527045
92	Cleared or high impervious surface present	A	OTHER-SEE COMMENTS	MEDIUM	85.10226264
93	DRAINS MHP; SW RUNS DOWN ROAD AND DISCHARGES TO MARSH, NEAR STORMWATER CONVEY	A	OTHER-SEE COMMENTS	MEDIUM	0
94	Cleared or high impervious surface present	A	OTHER-SEE COMMENTS	MEDIUM	193.4983196
95	Dense imperious area	A	OTHER-SEE COMMENTS	MEDIUM	204.1399519
96	Near stormwater conveyance	A	CURB/GUT TO PIPE	MEDIUM	0
97	Boat Ramp	A	CURB/GUT TO PIPE	LOW	0
98	Dense impervious parking surface	A	CURB/GUT TO PIPE	LOW	139.9136213
99	Near stormwater conveyance	A	CURB/GUT TO PIPE	LOW	0
100	Dense imperious area	A	CURB/GUT TO PIPE	LOW	71.4118397
101	Dense impervious rooftop area	A	CURB/GUT TO PIPE	LOW	639.0198573
102	Large open space at waste water	A	CURB/GUT TO PIPE	LOW	640.2271382
103	Dense imperious area, long inclined driveway	A	CURB/GUT TO PIPE	LOW	701.0186708

Table 6-3 provides a list of all the attributes that have been collected on the 103 potential SCMs identified in Table 6-2. All these attributes will be used to prioritize the order in which SCMs are installed.

Table 6-3 Attributes Collected on Each Potential SCM Location

Column Name	Description
ID	Identification number affiliated with number on map. This point represents a point or area that has been identified as potentially having stormwater concerns. A point does not necessarily mean that a site does have stormwater issues.
Summary	Summary description of area issue. Issue was identified by Shellfish Sanitation or via remote sensing. Shellfish Sanitation has ground truthed issue, remote sensed areas have not been confirmed via ground truthing yet.
Soil Species Acronym	Acronym of the soil species per USDA Soil Survey mapping.

Hydrologic Soil Group	Hydrologic soil group: Group A, B, C, and D; with A having the highest infiltration rate and D having the lowest.
Latitude	In decimal degrees, works in Google Maps.
Longitude	In decimal degrees, works in Google Maps.
Nearest Street	Identified nearest street to navigate to area.
Parcel Description	Description affiliated with the nearest parcel.
Area Owner	General owner affiliated with the area.
Parcel Use Description	General use affiliated with the area.
Shellfish Growing Area Code	Identification code associated with the Conveyance type, System Size, Fecal C. Concentration, Fecal C. Load, and Distance columns; by Shellfish Sanitation.
Conveyance Type	Conveyance type as identified by Shellfish Sanitation.
System Size	General size of stormwater system as identified by Shellfish Sanitation. This data field serves as an indicator of the size of the area drained by the conveyance being evaluated. If a pipe diameter can be determined, then the following criteria will be used to determine system size: • Low = ≤ 18 inches • Medium = 19-35 inches • High = ≥ 36 inches
Fecal Coliform Concentration	General concentration amount of fecal coliform as identified by Shellfish Sanitation. This data field serves as an indicator of the potential peak bacteria concentration discharged by the conveyance being evaluated. It is a subjective measure based on your experience, although some relative guidelines are provided: • Low = Drains a small area or an area with low-impact land uses; good buffers; little to no potential inputs; good filtering prior to discharge • Medium = Drains a larger area or an area with mixed impact land-uses; some buffers; some potential inputs, none major; little filtering prior to discharge

	• High = Drains a large area or an area with predominantly high impact land-uses; little to no buffer; numerous potential sources or major sources; little to no filtering prior to discharge
Fecal Coliform Load	General load amount of fecal coliform as identified by Shellfish Sanitation. This data field is a composite of the "System Size" and "FC Concentration" fields, and indicates the relative contribution of this particular stormwater conveyance to the total bacterial load within the growing area. Average the values determined for "System Size" and "FC Concentration" to determine this value.
Distance (m) to the SGA Code	The distance in meters to the Shellfish Growing Code that has been identified as being closest. For example, a 0 indicates that the ID point is directly on the SGA Code. A 80 indicates that the ID point on the map is within 80 m of a Stormwater Conveyance issue that was identified by Shellfish Sanitation.

Table 6-4 presents an illustration of the types of projects that will be installed by the Town to reduce runoff volumes from specific properties. These sites contribute large amounts of stormwater runoff in their current condition.

Table 6-4. Illustration of stormwater management strategy ideas.

Site ID	Description
1, 5	Curb/gutter to pipe and high impervious area. HWY 58 via Arborvitae to canal. Explore creating infiltration area.
37	Boat launch at McNeil. Explore redirecting runoff from asphalt parking lot to grass instead so it no longer flows directly down the boat ramp. Place swale near ramp.
43	Swale connected to drainage pipe near Yaupon Road and Hester Woods. Actively manage groundwater levels to increase capacity of swale to infiltrate stormwater.
52	Drain present at Acorn Street. Increase infiltration by: • Installing swales • Disconnecting downspouts • Diverting runoff from driveways into grass • Installing pervious concret in cul-de-sac center • Installing pervious asphalt bottom to the first seam of each driveway on the court • Connecting two municipal drains under asphalt with porous pipe
69	CCCC golf course redesign to increase infiltration to include: • Use of Level Spreader at outlet • Enlarging collection area • Moving discharge back to alternative section of pipe • Reshaping collection area to allow for longer residence timeLining bottom of infiltration basin with sand to encourage further filtration

Figure 6-1 Potential stormwater retrofit sites

6.1 FUNDING COST AND TECHNICAL NEEDS

The Town expects to implement the plan in three-year increments or a 22 year period. It takes the Town about three years to identify, plan, fund, design, permit and then build a suite of SCMs that can infiltrate somewhere between 300,000 gallons and 1 million gallons of runoff from a one-year, 24-hour storm. The Town projects that the total cost of these measures for each three-year period will run between $300,000 to $2 million, depending on site conditions, complexity of design and other factors that influence final cost figures. The Town will actively seek outside financial support to help pay for these measures, and understands that at a minimum, it must be prepared to cover matching cost requirements for outside grants. These matching requirements can be as high as 50 percent of project costs. As the Town becomes more proficient in installing these measures, it will seek to do as much of the work itself using it's own town public works and administrative employees. The costs of this in-house labor and equipment are included in the cost estimates outlined above to implement this plan.

Presently, technical needs for all projects include the need for engineering services, skilled construction expertise for technically difficult projects, surveying needs, and assistance with securing grants and loans. Town officials have engaged in continuing education to learn more about stormwater management, including design, operation and maintenance requirements. Additional technical needs include the development of project partnerships with state agencies, local organizations, or academia professionals who can provide expertise. The Maintenance Schedule column of Table 6-2 should be taken into consideration as part of the technical considerations of the plan as maintenance requires forethought to ensure funding and technical skills are available for the duration of the life cycle of the projects. Table 6-2 should be taken into consideration when determining maintenance costs of each project. Other various project-based needs include receiving advanced knowledge of groundwater conditions. A partnership with East Carolina University has already resulted in the installation and monitoring of groundwater wells throughout the Town. The Town will continue to rely on Shellfish Sanitation and the UNC Institute of Marine Sciences for water quality and fisheries data and studies it will need to determine if the plan is successful.

Table 6-5. Approximate cost per unit of various stormwater retrofit techniques.

Stormwater Retrofit Technique	Approximate Cost per Unit[3]	Maintenance Cost[3]
Amend Soil	$15-$60 per cubic yard	$.02 per cubic yard
Curb Cuts	$5-$25 per ft^2	$.30-$.60 per ft^2
Bioswale (for parking lot or roadside)	$6-$24 per ft^2	$.06-$.21 per ft^2
Native Plants	$.02-$.15 per ft^2	$.03-$.08 per ft^2

[3] Cost average approximation derived from:
Green Values Stormwater Calculator. (2016). Center for Neighborhood Technology. Retrieved from http://greenvalues.cnt.org/national/cost_detail.php

Permeable pavement	$5-$12 per ft^2	$.01-$.22 per ft^2
Planter Boxes	$.55-$24 per ft^2	$.04-$1 per ft^2
Rain garden	$5-16 per ft^2	$.30-$.60 per ft^2
Rainwater harvesting	$200/rain barrel $1,000/1400-gal cistern $10,000/10,000-gal cistern	$0 $0 $0
Reroute downspout	$9/downspout	$0
Tree Box Filter	$70-$600 per ft^2	$3-$14 per ft^2
Trees	$100-400 each	$20 each
Vegetated Filter Strips	$.03-$3.33	$.07 per ft^2

Note: Estimations from Green Values National Stormwater Management Calculator[3] based on national averages.

6.2 EDUCATION AND OUTREACH

The targeted audience of education and outreach for the community, which include residents of the watershed, business owners and K-12 students. Partnerships with public schools are an effective means of engaging the community and implementing education and outreach objectives. The area has a mixture of renters and homeowners residing within its boundaries. Residents, whether renting or homeowners, can be encouraged to understand how their homes and properties contribute to the water quantity and quality of the watersheds. This information can potentially be disseminated to residents through the following techniques, further research and collaboration with environmental educators should be considered before beginning an outreach project:

- Distribution of the *Smart Yards* informational booklet developed by the North Carolina Coastal Federation. The *Smart Yards* booklet can be mailed directly to all residents or can be made available at public buildings like the Town Hall.
- Presentations on residential solutions at public town meetings on a regular basis.
- Encourage residents to attend or participate in project demonstrations and installation at public buildings to learn how to install retrofits.
- Install educational signs about stormwater runoff at public areas.
- Outreach to subdivision homeowner's associations to encourage stormwater and water quality education and disconnecting impervious surfaces.

6.2.1 Businesses, Developers, and Commercial Land Owners

There are many businesses and commercial land owners within the area. Commercial areas account for some of the largest continuous, non-disconnected areas of impervious surfaces. Businesses could be encouraged to participate in retrofits at public and commercial properties. Education and outreach to businesses, developers, real estate agents, landscapers, and commercial landowners can focus on the disconnection of impervious surfaces, capital improvements, and LID techniques for new development. Various methods could be used to educate the business community, examples include:

- Encourage businesses to host *Smart Yards* or other stormwater information for distribution to the community.
- Meet with businesses to encourage participation and discuss potential retrofits that align with their capital improvement plans.

- Conduct meeting for businesses and commercial land owners to educate them on stormwater issues and to promote LID techniques.
- Encourage businesses, developers, and others to attend *Low Impact Development for Water Quality Protection Workshop*, hosted by NC Coastal Reserve, or similar workshops that educate attendees on stormwater management solutions.
- Invite businesses to participate or sponsor events, such as stormwater retrofit installations, to encourage community involvement and cooperation.
- Encourage those who are interested in retrofits that increase green space and permeable surfaces. Retrofits can vary from small-scale solutions like planting shade trees, installing box planters or installing rain gardens to large-scale solutions like converting retention ponds into constructed wetlands.
- Encourage businesses with large parking lots to remove curbed medians and replace them with rain gardens, swales, or permeable pavement.
- Encourage businesses to install signs of their retrofit accomplishments. Create a recognition award for those who install retrofits.

6.2.2 K-12 Students

Water quality education for students is not only beneficial for the long-term integrity of the watershed but for North Carolina. Education and outreach to students can focus on stormwater, water quality, and non-structural retrofit lessons that students can relay to their families or strategies they can implement at their homes. Students can be encouraged to understand their role within the watersheds. Collaboration with environmental educators should be considered before beginning an outreach plan:

- Development of age appropriate lessons associated with demonstration sites in the watershed.
- Encourage class participation in the installation of rain gardens, downspout disconnection, and other retrofit techniques as service projects or field trips.
- Present an article in the school's newsletter for parents to encourage family discussion.

6.3 MONITORING

Shellfish Sanitation and Recreational Water Quality 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. Every three years Shellfish Sanitation staff ground truth 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. These up-to-date surveys and monitoring station data will be the primary source of information. Monitoring will be conducted by using the indicators listed in Section 5.

Table 6-6. The primary indicators and how to measure the indicators.

Primary Indicators
Reduce stormwater runoff volume to restore water quality

	Indicator	Measured by	Collected by	Collection Cycle
1	Fecal Coliform	Comparing numerical historical data and modern measurements of fecal coliform for changes in impairment frequencies and quantity of bacteria per sample.	Shellfish Sanitation	Yearly; reports released every 3 years.
2	Stormwater Runoff Volume	Applying stormwater reduction 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.	Partners	Upon completion of projects.

The following is a list of existing water monitoring stations identified through N.C. Shellfish Sanitation.

Table 6-7. Water quality monitoring stations.

Waterbody	Station Name	Station No	Organization
Bogue Sound	By old dock, Hoffman Estate	17	N.C. Shellfish Sanitation
Bogue Sound	Middle of closed Pine Knoll Shores closed area	19C	N.C. Shellfish Sanitation
Bogue Sound	Outside of eastern Pine Knoll Shores canal opening	28	N.C. Shellfish Sanitation
Bogue Sound	100 yds. north of mouth to Sea Isle Plantation Marina	29A	N.C. Shellfish Sanitation
Bogue Sound	150 yds. off entrance to Beacons Reach Westport Marina	30A	N.C. Shellfish Sanitation
Bogue Sound	By Coral Bay Dock	6	N.C. Shellfish Sanitation
Bogue Sound	Outside Closure Line - North of Station #6	6B	N.C. Shellfish Sanitation
Bogue Sound	900 Yards Northwest Mouth of Coral Bay Creek	41	N.C. Shellfish Sanitation
Bogue Sound	1600 Yards West of Station #41	42	N.C. Shellfish Sanitation
Bogue Sound	600 Yards West of Station #42 Off Golf Course	42A	N.C. Shellfish Sanitation

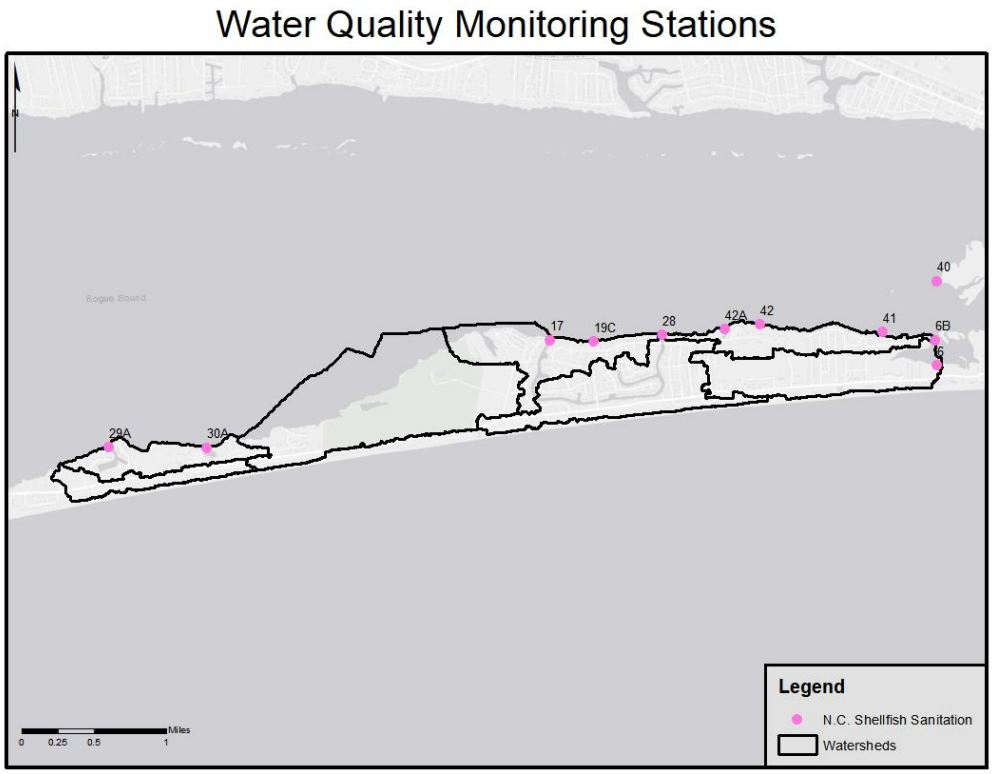


Figure 6-2. Location of monitoring stations within the area as registered through Shellfish Sanitation's system.

Within the Pine Knoll Shores watersheds, stations exceeding fecal coliform levels of Class SA (GM >14/100 ml; specifically, fecal coliform group not to exceed a median MF of 14/100 ml and not more than 10 percent of the samples shall exceed an MF count of 43/100 ml in those areas most probably exposed to fecal contamination during the most unfavorable hydrographic and pollution conditions; Appendix B) vary in frequency over the course of the last two decades. Understanding how often water quality stations have exceeded a single sample reading of 14/100 ml aid in the development of milestones and assist in the monitoring of progress.

Table 6-8. Frequency of shellfish sanitation stations exceeding 14/100 ml of fecal coliform.

Survey Report Cycle	1993-1997	1995-2000	2000-2005	2003-2008	2007-2011	2010-2015	
Station No.	Percent of samples station exceeded 14/100 ml out of 30 samples						
E-2 #17	17%	37%	30%	23%	30%	13%	
E-2 #19C	-	-	-	-	12.5% (1 of 8 samples)	3%	
E-2 #28	47%	-	-	-	25% (2 of 8 samples)	10%	
E-2 #29A	-	-	-	-	-	33% (2 of 6 samples)	
E-2 #30A	-	-	-	-	-	0% (0 of 6 samples)	
Survey Report Cycle	**1991-1994**	**1994-1999**	**1997-2002**	**2002-2007**	**2005-2010**	**2009-2014**	**2012-2017**
Station No.	Percent of samples station exceeded 14/100 ml out of 30 samples						
E-3 #6	33% (5 of 15 samples)	33%	30%	27%	33%	37%	43%
E-3 #6B	-	-	-	-	20% (3 of 15 samples)	20%	13%
E-3 #41	13% (2 of 15 samples)	13%	10%	33%	17%	23%	0%
E-3 #42	7% (1 of 15 samples)	17%	7%	37%	13%	17%	10%
E-3 #42A	-	-	-	-	7% (1 of 15 samples)	20%	10%
>50% of samples exceed SA standard		25-49% of samples exceed SA standards		10-24% of samples exceed SA standards		<10% of samples exceed SA standards	

Note: These numbers represent a single sample in which 14/100ml was exceeded.

Note: E-2 Stations #19C, #29A, and 30A, and E-3 Stations #6B and #42A are new stations and no historic data exists for these stations and reports from these stations should be included in the future. E-2 Station #28 stopped was decommissioned from 1995-2007. Reporting cycles were not standardized in all Shellfish Harvest Areas until 2001.

Within the Pine Knoll Shores watersheds, fecal coliform levels should not to exceed a geometric mean of 43/100 ml (MF count; Appendix B). This is part of Class SA standards for water quality in which "fecal coliform group not to exceed a median MF of 14/100 ml and not more than 10 percent of the samples shall exceed an MF count of 43/100 ml in those areas most probably exposed to fecal contamination during the most unfavorable hydrographic and pollution conditions."

Table 6-9. Frequency of shellfish sanitation stations exceeding 43/100 ml of fecal coliform.

Survey Report Cycle	1993-1997	1995-2000	2000-2005	2003-2008	2007-2011	2010-2015	
Station No.	Percent of time station exceeded 43/100 ml out of 30 samples						
E-2 #17	7%	20%	7%	3%	10%	0%	
E-2 #19C	-	-	-	-	0% (0 of 8 samples)	0%	
E-2 #28	23%	-	-	-	13% (1 of 8 samples)	3%	
E-2 #29A	-	-	-	-	-	33% (2 of 6 samples)	
E-2 #30A	-	-	-	-	-	0% (0 of 6 samples)	
Survey Report Cycle	**1991-1994**	**1994-1999**	**1997-2002**	**2002-2007**	**2005-2010**	**2009-2014**	**2012-2017**
Station No.	Percent of time station exceeded 43/100 ml out of 30 samples						
E-3 #6	10% (2 of 20 samples)	7%	10%	13%	17%	10%	3%
E-3 #6B	-	-	-	-	0% (0 of 15 samples)	3%	7%
E-3 #41	0% (0 of 20 samples)	0%	0%	7%	3%	3%	0%
E-3 #42	0% (0 of 20 samples)	3%	0%	7%	7%	3%	0%
E-3 #42A	-	-	-	-	0% (0 of 15 samples)	0%	0%

>50% of samples exceed 43/100 ml	25-49% of samples exceed 43/100 ml	10-24% of samples exceed 43/100 ml	<10% of samples exceed 43/100 ml

Note: These numbers represent a single sample in which 43/100ml was exceeded.
Note: E-2 Stations #19C, #29A, and 30A, and E-3 Stations #6B and #42A are new stations and no historic data exists for these stations and reports from these stations should be included in the future. E-2 Station #28 stopped was decommissioned from 1995-2007. Reporting cycles were not standardized in all Shellfish Harvest Areas until 2001.

Implementation Schedule

Pine Knoll Shores will work with partners to implement the goals, objectives, actions and management strategies identified in this watershed restoration plan.

The following provides an overview of the general implementation schedule that will be pursued from Year 1 through Year 22.

Overview of General Implementation Schedule.

Actions	Timeframe
1-1 The newly appointed Town of Pine Knoll Shores Stormwater Subcommittee (c. 2018) will review existing town codes and ordinances to determine impediments to low impact stormwater designs for new development and redevelopment during year one. *The findings will be presented to the Town with any suggested amendments and discussion of any potential incentive plans.*	Year 1
1-2 The Town will determine the need for a locally adopted stormwater management program to supplement gaps in the state's stormwater program and the Town's needs. Some gaps identified thus far include: Redevelopment, Smaller projects not covered under the State's Stormwater Program, Oversight of installation and maintenance of State permitted systems. *This will be completed in the first two years of implementation. The Town will consider utilizing a graduate intern for assistance with this project.*	Year 1 - 2
1-3 The Town will coordinate stormwater management practices with maritime forest management practices to ensure evapotranspiration by already present vegetation is optimized. *This can be conducted during regularly scheduled planning board meetings to keep issue on the agenda*.	Annually
2-1 Identify feasibility of potential stormwater reduction measures at town streets, buildings, public beach accesses, parking lots, drainage systems, and other public properties. Prioritize retrofits at public buildings and properties that can serve as demonstration sites of stormwater retrofits. *This will begin with the reconvening of the project team to determine a specific list of priority sites that will be targeted for phase I funding. Remaining projects will be reviewed annually for annual grant applications for implementation. See milestones section for detailed timeline.*	Year 1, Annually
2-2 Utilize town right-of-ways to maximize stormwater reduction measures. *This is a priority of the town and builds on a commitment to reduce roadside runoff. Secure funding Year 1, implement phase 1 project year 2, monitor and promote year 3, secure additional funding year 3 until feasible ROWs in town are retrofitted throughout the duration of the planning period.*	Monthly, Annually
2-3 Evaluate existing stormwater systems on public properties for potential volume reduction enhancements, and if feasible, retrofit them to	Quarterly, Year 1, Annually as Part of

achieve volume reduction. *This evaluation will be discussed at quarterly project team meetings with specific plans for enhancements determined.*	Prioritization of Retrofits
2-4 Secure funds for retrofits at public properties. *Annually apply for funding to install retrofits from sources such as 319 and CWMTF.*	Annually
2-5 Incorporate, where practical, *Green Street Designs* or similar low-impact design strategies into future capital improvements of the town. *This will be matched with annual Capital Improvement Planning and utilized when feasible.*	Year 1, annually
2-6 Pursue strategy with state agencies to incorporate retrofits at state properties. Pursue strategies with N.C. Department of Transportation (DOT) to incorporate retrofits into the Highway 58 drainage system and that any new road upgrades or maintenance plans include plans for reducing runoff. *The Town will build the existing relationship with N.C. DOT to identify and pursue funding and support for retrofits in the linear system.*	Year 1, annually
3-1 Identify retrofit sites with private partners, prioritizing sites by potential for volume reduction cost-benefit; such as sites identified as exceptional because of the physical and natural characteristics, accessibility, cost, public outreach opportunity, and current land uses. *This will begin with the reconvening of the project team to determine a specific list of priority sites that will be targeted for phase I funding during Year 1. Remaining projects will be reviewed annually for grant applications for implementation.*	Year 1, Annually
3-2 Work with governmental agencies and NGOs to secure grants to provide funding to install lot-level, low-cost retrofits that disconnect impervious surfaces and enhance stormwater infiltration. *Grant applications will be identified annually. Bringing in project partners will help strengthen application interest.*	Year 1, Annually
3-3 Seek funding for stormwater retrofit projects that have been identified. *Annually identify funding to install retrofits from sources such as 319 and CWMTF.*	Annually
3-4 Provide landowners incentives to disconnect impervious surfaces or minimize stormwater runoff from their property. *This will begin with education and outreach during the first quarter of plan implementation. Project partners will help identify the potential for incentives to disconnect during second and third quarter.*	Year 1, annually
3-5 Explore opportunities with N.C. Soil and Water Conservation's Community Conservation Assistance Program (CCAP). *The project team will*	Year 1, annually

match up potential private landowner or public site retrofit projects with this annual cost share program to attempt to fund small scale retrofits.	
4-1 Monitor Shellfish Sanitation Sanitary Report data as reports are produced. *The Town will review the Shellfish Sanitation Reports as they are produced every 3 years.*	Year 3, 6, 9, 12, 15, 18, 21
4-2 Review the plan every three years to evaluate findings from water quality data and the status of implementation. Conduct scheduled assessment of the plan and progress made to date with the project team. *This will take place at project team level and include town council and members of the public. This will occur every 3 years beginning in 2022.*	Year 3, 6, 9, 12, 18, 21
4-3 Maintain a simple inventory of retrofits and monitor performance of stormwater reduction retrofits that have been installed within the watersheds. *The Town will keep an ongoing inventory of retrofits as they are installed.*	Year 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22
4-4 Document the volume of stormwater reduced by each retrofit by utilizing the *Runoff Reduction Calculator Tool* or *Watershed EZ*, or similar volume reduction calculation tools. *Documentation will be prepared utilizing tools and outreach on the reduction will take place immediately following the implementation of individual projects by the Town and Coastal Federation*	Year 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22
4-5 Coordinate with academic partners, such as UNC-IMS, ECU, Duke University, and NCSU, to conduct periodic monitoring of water quality. *The Town will actively coordinate with academic partners to identify opportunities monitoring.*	Year 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22
4-6 Explore opportunities to utilize community members to conduct citizen science-based monitoring of stormwater reduction retrofits and inventory already installed retrofits. *The project team will identify the potential for citizen – science monitoring as part of the grant application process that will occur about every 1-2 years.*	Year 2, 4, 6, 8, 10, 12, 14, 16, 18
5-1 Collaborate with partners to educate and engage property owners, businesses, and K-12 students and their families on stormwater management. For example, facilitating the circulation of Smart Yard, a stormwater retrofit education guide for homeowners by N.C. Coastal Federation. *An annual community education and engagement strategy will be developed and implemented via the Town and community partners. This strategy will be developed year one of Plan implementation discussed annually.*	Year 1, annually
5-2 Facilitate technical training opportunities for planners, engineers, developers, landscapers and local government staff on techniques to reduce volume of stormwater within the town. *The Town will work with*	Year 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22

project team to determine annual opportunities for trainings then work plan events approximately every two years.	
5-3 Work with existing water quality outreach professionals, including: North Carolina Coastal Federation, UNC - IMS and Duke University Marine Laboratory on stormwater education initiatives. *The Town will build on existing collaborations with academia and NGOs in Carteret County to identify, develop and offer education initiatives in the Town and County.*	Year 2, 4, 6, 8, 10 , 12, 14, 16, 18, 20, 22
5-4 Include education signage at select retrofits and place emphasis on highlighting the town's commitment to reducing stormwater. *The Town will work with the Coastal Federation to develop signs utilizing outreach funding that is secures as part of retrofit implementation funding.*	Year 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22

Site specific stormwater retrofit selection will be based on additional field assessments that include determination of site feasibility, site specific soils, proximity of project to impaired waters and project costs. Implementation of each strategy will involve the following steps and timeline.

First 6 months– year one - *review site for feasibility, rank priority based on soils, impaired waters, infiltration potential, projected costs, approving partners and level of difficulty (see Section 5)*

Year one – *apply for funding for prioritized sites in accordance with RFP schedule.*

Year one- two – *funding secured, begin outreach and design phase of project*

Year two - three – *construct, monitor, engage community and promote success*

Repeat management strategy funding and implementation steps

6.4 MILESTONES

Milestones are measurable accomplishments utilized to track positive changes and success of the plan. If a milestone is not met, an assessment will be conducted at the time of the annual plan review to determine the cause and the appropriate steps that can be taken to address any shortcomings or unforeseen circumstances. The milestones for restoring water quality through volume reduction of surface runoff are:

6.4.1 Short-Term (< 3 years)

- Reduce at least 600,000 gallons of stormwater runoff that occurs during a one-year, 24-hour storm event through the implementation of stormwater reduction techniques that have already been identified and prioritized by the Town. (reference Objective 2 and 3)
- : (reference Objective 1 Actions 1-1 to 1-3)
- : Identify potential new stormwater reduction measures that can be installed during years 4 to 6 years of the plan will reduce stormwater runoff by another 400,000 gallons for the design storm
- (reference Action 2-1)Ensure that Action 2-5 is regularly incorporated into future capital improvements.
- ReviewShellfish Sanitation triannual report and evaluating the plan for any needed changes. (reference Actions 4-1 and 4-2)
- Develop a simply inventory of retrofits that have already been installed. (reference Action 4-3
- An educated and engaged community (reference Goal 5)

6.4.2 Mid-Term (4 to 6 years)

- Reduce at least 400,000 gallons of stormwater runoff that occurs during a one-year, 24-hour storm event through the implementation of stormwater reduction techniques. (reference Objective 2 and 3) .
- Identify potential new stormwater reduction measures that can be installed during years 7 to 10 years of the plan will reduce stormwater runoff by another 350,000 gallons for the design storm. (Reference Action 2-1)
- Ensure ongoing actions, such as Action 5-2, continue to be supported. (reference Objective 5).
- ReviewShellfish Sanitation triannual report and evaluate the plan for any needed changes. (reference Actions 4-1 and 4-2)

6.4.3 Long-Term (7 to 10 years)

- Reduce at least 350,000 gallons of stormwater runoff that occurs during a one-year, 24-hour storm event through the implementation of stormwater reduction techniques. (reference Objective 2 and 3).

- Identify potential new stormwater reduction measures that can be installed during long term years of the plan to reduce stormwater runoff by another 300,000 gallons for the design storm. (reference Action 2-1)
- by ReeviewShellfish Sanitation triannual reports and evaluating the plan at year 25 and year 30. (reference Actions 4-1 and 4-2
- Accomplish all actionable Actions in Objectives 1-5.

6.4.4 Longer-Term until plan is fully implemented (11-22 years)

- In three-year increments, continue to install SCMs that will reduce at least another 300,000 gallons of stormwater runoff (in each three-year increment) that occurs during a one-year, 24-hour storm event. (reference Objective 2 and 3)
- Accomplish all actionable Actions in Objectives 1-5.

6.5 Evaluation and Progress Criteria

To ensure that the plan is meeting the needs of the watershed and community, the management plan should be evaluated every three years when Shellfish Sanitation issues its new Sanitary Survey for the Town. The Town will track progress on plan implementation by maintaining an inventory of SCMs it installs, a cumulative total of reductions in stormwater runoff achieved by the projects it installs, and by review the status of shellfish closures (acres of permanently closed waters, and number of days each year temporary closures of waters occur. In addition, the town will maintain a log of its pumping operations to keep records on gallons pumped, costs of pumping, and days that pumping results in automatic closures of shellfish waters.

Table 6-10. Evaluation of the Watershed Management Plan.

Evaluation	Indicator
Calculate the approximate volume reduced by stormwater retrofits that are installed	Utilize *Watershed EZ*, *Runoff Reduction Calculator*, or similar tool to determine a volumetric total of projects installed.
Mid-course evaluation	Conduct full assessment of plan with suggestions on ways to enhance or redirect the plan
Publicize successes	Update community on successes to increase commitment, motivation, and morale. Publish report on watershed health. Recognize past, current and future projects for the year.

Ultimately, the success of this plan will be determined by whether impairments of shellfish waters are reduced. This will be determined by the Sanitary Survey that is completed by Shellfish Sanitation every three years, and the extent of permanent and temporary shellfish

harvest closures that are required. It is projected that it will take approximately 20 years to fully reduce the volume of runoff by approximately 2.5 million gallons. These reductions in the volume of stormwater runoff will occur incrementally with SCM projects that will each take about three years to plan, design, fund and construct. The Town will work in three year increments, and has set volume reduction goals for each of these three-year time periods.

As the volume of stormwater is reduced, the Town expects to see two outcomes in terms of impaired water quality. The extent of permanent closures in Bogue Sound will begin to shrink. It is expected that the rate of reduction of impairment will roughly correlate with the percent of the 2.5-million-gallon reduction goal that is achieved. Second, the number of temporary closures should go down as the number of days that the Town is forced to pump stormwater due to emergency conditions is reduced. The groundwater management system that the Town plans to install should result in this reduced need to discharge floodwaters. Finally, the Town does not expect the closed shellfish waters within its canals to ever be opened to harvest. This closure is due to the number of boats docked in the canals and the potential for discharges of sewage, and is automatically enforced by the State whether or not water quality monitoring indicates any improvements.

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Acronyms and Definitions

303(d) List	A list of waterbodies in each state that are too polluted or degraded to meet water quality standards. States are required to update their lists every two years.
319 Grant	A grant program, named after Section 319 of the Clean Water Act, funded by EPA and administered by NC DEQ to study and find solutions to 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 using vegetated depressions engineered to collect, store, and infiltrate runoff.
BMP	Best Management Practice of stormwater management; also, commonly referred to as *Stormwater Control Measure (SCM)* or *Stormwater Infiltration Practice (SIP)*.
CAFO	Confined Animal Feeding Operation
CATCHMENT	A geographic unit within a sub watershed made up of a singular river, stream, or branch that contributes to a larger watershed.
CFU	Colony Forming Unit, used to measure fecal coliform bacteria concentrations.
CONDITIONALLY APPROVED CLOSED	This management strategy by North Carolina Shellfish Sanitation, refers to shellfish-growing waters that are closed to harvest because of high bacteria concentrations but can be opened temporarily, usually during periods of drought, when bacteria levels are low enough to make the shellfish safe to eat.
CONDITIONALLY APPROVED OPEN	This management strategy by North Carolina Shellfish Sanitation, refers to shellfish growing areas that are open to harvest but are temporarily closed after periods of moderate or heavy rain.
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 swimming, shellfish harvesting or aquatic life support, that a waterbody has been designated with by the state. The waterbody 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 waterbody has supported since November 28, 1975.
FDA	U.S. Food and Drug Administration
FECAL COLIFORM	These bacteria are found in the intestines of warm-blooded animals. They are not normally harmful to humans, but if found in a waterbody they could indicate the presence of harmful bacteria. Because they are easy to detect in the environment, these bacteria have been used for decades to determine the suitability of shellfish-growing waters.
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 WATERS	This Clean Water Act term refers to waters that no longer meet their designated uses. That would include conditionally approved and conditionally closed waters and any water 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.
INTERTIDAL	Area of land that is submerged during high tide and exposed at low tide.
LAND USE	The management and modification of natural environment or wilderness into built environment such as settlements and semi-natural habitats such as arable fields, pastures, and managed woods.
LID	Low Impact Development refers to management strategies that attempt to mimic conditions to reduce the flow of stormwater. To be successful, they should be integrated 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	This term appears in many state and federal pollution regulations. It generally refers to pollution controls that are technologically available and capable of being done after taking into consideration cost and logistics.
MS4	Municipal separate storm sewer systems
NEPA	National Environmental Policy Act
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
Nonpoint Source (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
Point Source	A singular, identifiable discharge source of pollution.
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
RUNOFF CURVE	A runoff curve number is a numeric parameter derived from combining the effects of soil, watershed characteristics, and land use.
SA	This is a state salt water classification intended for shellfish harvesting. These are waters that should also support aquatic life, both primary and secondary recreation (activities with frequent or prolonged skin contact), and shellfishing for market purposes. It is one of the highest water classifications in the state.
SB	This is a state salt water classification intended for swimming.
SC	This is a state salt water classification intended 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 *Stormwater Infiltration Practice (SIP)*
Shellfish	"Shellfish" as referenced in this document means molluscan shellfish, oysters and clams.

SHELLFISH SANITATION	Shellfish Sanitation and Recreational Water Quality Section, N.C. Division of Marine Fisheries, N.C. DEQ.
SIP	Stormwater Infiltration Practice, also more commonly known as a Best Management Practice (BMP) of stormwater management; also, commonly referred to as *Stormwater Control Measure (SCM)*.
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 waterbody and still meet federal Clean Water Act standards.
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
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

Appendix A Regulatory Water Quality Standards

When implementing projects consideration should be given to Coastal Area Management Act (CAMA). Some projects may require CAMA permits, consideration of the should be given when developing a timeline for project completion.

Congress enacted the federal Clean Water Act (CWA) (33 U.S.C. §1251 et seq. (1972)) to establish regulations on water quality standards for waters with a purpose of protecting surface waters for drinking, fishing and recreation. The EPA set water quality standards for many contaminants in surface waters as well as established pollution control programs. The CWA establishes use designations that mandate that waters maintain their designated usage. In North Carolina, the Department of Environmental Quality Division of Water Resources is responsible for delegating water quality designations. When waters do not meet this, they are listed on the 303(d) lists.

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 new rules increased the amount of stormwater that must be controlled in all 20 coastal counties, especially within one-half mile of Class SA waters (North Carolina's Surface Water Classification designation for commercial shellfishing waters and one of the highest designations given). By using Class SA waters as a standard, a management plan can focus on achieving the highest water quality that is regularly monitored.

WATER QUALITY STANDARDS

Further information regarding 303(d) List and its reporting categories[4]:

> *"The term "303(d) list" or "list" is short for a state's list of impaired and threatened waters (e.g. stream/river segments, lakes). States are required to submit their list for EPA approval every two years. For each water on the list, the state identifies the pollutant causing the impairment, when known. In addition, the state assigns a priority for development of Total Maximum Daily Loads (TMDL) based on the severity of the pollution and the sensitivity of the uses to be made of the waters, among other factors (40 C.F.R. §130.7(b)(4)).*
> *In general, once a water body has been added to a state's list of impaired waters it stays there until the state develops a TMDL and EPA approves it. EPA reporting guidance provides a way to keep track of a state's water bodies, from listing as impaired to meeting water quality standards. This tracking system contains a running account of all the state's water bodies and categorizes each based on the attainment status. For example, once a TMDL is developed, a water body is no longer on the 303(d) list, but it is still tracked until the water is fully restored."*

Table 1. EPA 303(d) List Integrated Report Categories

Category/Subcategory	Description
Category 1	**Meets tested standards for clean waters.** All designated uses are supported, no use is threatened.
Category 2	**Waters of concern.** Available data and/or information indicate that some, but not all, designated uses are supported.

[4] Environmental Protection Agency. Retrieved from https://www.epa.gov/tmdl/program-overview-303d-listing

Category 3	**Insufficient data.** There is insufficient available data and/or information to make a use support determination.
Category 4	**Polluted waters that do not require a TMDL.** 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.
Category 4a	**Has a TMDL.** A State developed TMDL has been approved by EPA or a TMDL has been established by EPA for any segment-pollutant combination.
Category 4b	**Has a pollution control program.** Other required control measures are expected to result in the attainment of an applicable water quality standard in a reasonable period of time.
Category 4c	**Is impaired by a non-pollutant.** The non-attainment of any applicable water quality standard for the segment is the result of pollution and is not caused by a pollutant.
Category 5	**Polluted waters that require a TMDL or other WQI project.** Available data and/or information indicate that at least one designated use is not being supported or is threatened, and a TMDL is needed.

DWR PRIMARY SURFACE WATER CLASSIFICATIONS

All surface waters in North Carolina are assigned a primary classification by the N.C. Division of Water Resources (DWR). All waters must at least meet the standards for Class C (fishable / swimmable) waters. The other primary classifications provide additional levels of protection for primary water contact recreation (Class B) and drinking water (Water Supply Classes I through V). To find the classification of a water body you can either use the BIMS database or contact Adriene Weaver of the Classifications & Standards/Rules Review Branch. To view the regulatory differences between the currently implemented classifications for freshwaters, click here for the freshwater classifications table. To view the regulatory differences between the currently implemented classifications for tidal salt waters, click here for the tidal saltwater classifications table.

Table 2. North Carolina surface water classifications. Full descriptions available on DEQ Website.

Primary Use Classifications	
SA	Commercial Shellfishing
SB	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)

Class C
Waters protected for uses such as secondary recreation, fishing, wildlife, fish consumption, aquatic life including propagation, survival and maintenance of biological integrity, and agriculture. Secondary recreation includes wading, boating, and other uses involving human body contact with water where such activities take place in an infrequent, unorganized, or incidental manner.

Class B
Waters protected for all Class C uses in addition to primary recreation. Primary recreational activities include swimming, skin diving, water skiing, and similar uses involving human body contact with water where such activities take place in an organized manner or on a frequent basis.

Water Supply I (WS-I)
Waters protected for all Class C uses plus waters used as sources of water supply for drinking, culinary, or food processing purposes for those users desiring maximum protection for their water supplies. WS-I waters are those within natural and undeveloped watersheds in public ownership. All WS-I waters are HQW by supplemental classification. More information: Water Supply Watershed Protection Program Homepage

Water Supply II (WS-II)
Waters used as sources of water supply for drinking, culinary, or food processing purposes where a WS-I classification is not feasible. These waters are also protected for Class C uses. WS-II waters are generally in predominantly undeveloped watersheds. All WS-II waters are HQW by supplemental classification. More information: Water Supply Watershed Protection Program Homepage

Water Supply III (WS-III)
Waters used as sources of water supply for drinking, culinary, or food processing purposes where a more protective WS-I or II classification is not feasible. These waters are also protected for Class C uses. WS-III waters are generally in low to moderately developed watersheds. More information: Water Supply Watershed Protection Program Homepage

Water Supply IV (WS-IV)
Waters used as sources of water supply for drinking, culinary, or food processing purposes where a WS-I, II or III classification is not feasible. These waters are also protected for Class C uses. WS-IV waters are generally in moderately to highly developed watersheds or Protected Areas. More information: Water Supply Watershed Protection Program Homepage

Water Supply V (WS-V)
Waters protected as water supplies which are generally upstream and draining to Class WS-IV waters or waters used by industry to supply their employees with drinking water or as waters formerly used as water supply. These waters are also protected for Class C uses. More information: Water Supply Watershed Protection Program Homepage

Class WL
Freshwater Wetlands are a subset of all wetlands, which in turn are waters that support vegetation that is adapted to life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas. These waters are protected for storm and flood water storage, aquatic life, wildlife, hydrologic functions, filtration and shoreline protection.

Class SC
All tidal salt waters protected for secondary recreation such as fishing, boating, and other activities involving minimal skin contact; aquatic life propagation and survival; and wildlife.

Class SB
Tidal salt waters protected for all SC uses in addition to primary recreation. Primary recreational activities include swimming, skin diving, water skiing, and similar uses involving human body contact with water where such activities take place in an organized manner or on a frequent basis.

Class SA
Tidal salt waters that are used for commercial shellfishing or marketing purposes and are also protected for all Class SC and Class SB uses. All SA waters are also HQW by supplemental classification.

Class SWL

These are salt waters that meet the definition of coastal wetlands as defined by the Division of Coastal Management and which are located landward of the mean high water line or wetlands contiguous to estuarine waters as defined by the Division of Coastal Management.

DWR SUPPLEMENTAL CLASSIFICATIONS

Supplemental classifications are sometimes added by DWR to the primary classifications to provide additional protection to waters with special uses or values.

Future Water Supply (FWS)

Supplemental classification for waters intended as a future source of drinking, culinary, or food processing purposes. FWS would be applied to one of the primary water supply classifications (WS-I, WS-II, WS-III, or WS-IV). Currently no water bodies in the state carry this designation.

High Quality Waters (HQW)

Supplemental classification intended to protect waters which are rated excellent based on biological and physical/chemical characteristics through Division monitoring or special studies, primary nursery areas designated by the Marine Fisheries Commission, and other functional nursery areas designated by the Marine Fisheries Commission.

The following waters are HQW by definition:

- WS-I,
- WS-II,
- SA (commercial shellfishing),
- ORW,

Primary nursery areas (PNA) or other functional nursery areas designated by the Marine Fisheries Commission, or Waters for which DWR has received a petition for reclassification to either WS-I or WS-II.

Outstanding Resource Waters (ORW)

All outstanding resource waters are a subset of High Quality Waters. This supplemental classification is intended to protect unique and special waters having excellent water quality and being of exceptional state or national ecological or recreational significance. To qualify, waters must be rated Excellent by DWR and have one of the following outstanding resource values:

- Outstanding fish habitat and fisheries,
- Unusually high level of water-based recreation or potential for such kind of recreation,
- Some special designation such as North Carolina Natural and Scenic River or National Wildlife Refuge,
- Important component of state or national park or forest, or
- Special ecological or scientific significance (rare or endangered species habitat, research or educational areas).

For more details, refer to the Biological Assessment Branch homepage.

Nutrient Sensitive Waters (NSW)

Supplemental classification intended for waters needing additional nutrient management due to being subject to excessive growth of microscopic or macroscopic vegetation.

Swamp Waters (Sw)

Supplemental classification intended to recognize those waters which have low velocities and other natural characteristics which are different from adjacent streams.

Trout Waters (Tr)

Supplemental classification intended to protect freshwaters which have conditions which shall sustain and allow for trout propagation and survival of stocked trout on a year-round basis. This classification is not the same as the NC Wildlife Resources Commission's Designated Public Mountain Trout Waters designation.

Unique Wetland (UWL)

Supplemental classification for wetlands of exceptional state or national ecological significance. These wetlands may include wetlands that have been documented to the satisfaction of the Environmental Management Commission as habitat essential for the conservation of state or federally listed threatened or endangered species.

Table 3. North Carolina water quality classification and standards.

Classification	Description
Class SA	Tidal salt waters that are used for commercial shellfishing or marketing purposes and are also protected for all Class SC and Class SB uses. All SA waters are also HQW by supplemental classification. The following water quality standards apply to surface waters that are used for shellfishing for market purposes and are classified SA. Water quality standards applicable to Class SC waters as described in Rule .0220 of this Section also apply to Class SA waters. (1) Best Usage of Waters. Shellfishing for market purposes and any other usage specified by the "SB" or "SC" classification; (2) Conditions Related to Best Usage. Waters shall meet the current sanitary and bacteriological standards as adopted by the Commission for Health Services and shall be suitable for shellfish culture; any source of water pollution which precludes any of these uses, including their functioning as PNAs, on either a short-term or a long-term basis shall be considered to be violating a water quality standard; (3) Quality Standards applicable to Class SA Waters: a. Floating solids; settleable solids; sludge deposits: none attributable to sewage, industrial wastes or other wastes; b. Sewage: none; c. Industrial wastes, or other wastes: none which are not effectively treated to the satisfaction of the Commission in accordance with the requirements of the Division of Health Services; d. **Organisms of coliform group: fecal coliform group not to exceed a median MF of 14/100 ml and not more than 10 percent of the samples shall exceed an MF count of 43/100 ml in those areas most probably exposed to fecal contamination during the most unfavorable hydrographic and pollution conditions.**
Class SB	Tidal salt waters protected for all SC uses in addition to primary recreation. Primary recreational activities include swimming, skin diving, water skiing, and similar uses involving human body contact with water where such activities take place in an organized manner or on a frequent basis. The following water quality standards apply to surface waters that are used for primary recreation, including frequent or organized swimming, and are classified SB. Water quality standards applicable to Class SC waters are described in Rule .0220 of this Section also apply to SB waters. 1. Best Usage of Waters. Primary recreation and any other usage specified by the "SC" classification; 2. Conditions Related to Best Usage. The waters shall meet accepted sanitary standards of water quality for outdoor bathing places as specified in Item of this Rule and will be of sufficient size and depth for primary recreation purposes; any source of water pollution which precludes any of these uses, including their functioning as PNAs, on either a short-term or a long-term basis shall be considered to be violating a water quality standard; 3. Quality Standards applicable to Class SB waters: a. Floating solids; settleable solids; sludge deposits: none attributable to sewage, industrial wastes or other wastes; b. Sewage; industrial wastes; or other wastes: none which are not effectively treated to the satisfaction of the Commission; in determining the degree of treatment required for such waters discharged into waters which are to be used for bathing, the

	Commission shall take into consideration quantity and quality of the sewage and other wastes involved and the proximity of such discharges to the waters in this class; discharges in the immediate vicinity of bathing areas may not be allowed if the Director determines that the waste cannot be treated to ensure the protection of primary recreation; c. **Organisms of coliform group: fecal coliforms not to exceed a geometric mean of 200/100 ml (MF count) based on at least five consecutive samples examined during any 30-day period and not to exceed 400/100 ml in more than 20 percent of the samples examined during such period.**
Class SC	All tidal salt waters protected for secondary recreation such as fishing, boating, and other activities involving minimal skin contact; aquatic life propagation and survival; and wildlife. The water quality standards for all tidal salt waters are the basic standards applicable to Class SC waters. Additional and more stringent standards applicable to other specific tidal salt water classifications are specified in Rules .0221 and .0222 of this Section. 1. Best Usage of Waters. Aquatic life propagation and maintenance of biological integrity (including fishing, fish and functioning PNAs), wildlife, secondary recreation, and any other usage except primary recreation or shellfishing for market purposes. 2. Conditions Related to Best Usage. The waters shall be suitable for aquatic life propagation and maintenance of biological integrity, wildlife, and secondary recreation; Any source of water pollution which precludes any of these uses, including their functioning as PNAs, on either a short-term or a long-term basis shall be considered to be violating a water quality standard. 3. Quality standards applicable to all tidal salt waters: a. Chlorophyll a (corrected): not greater than 40 ug/l in sounds, estuaries, and other waters subject to growths of macroscopic or microscopic vegetation; the Commission or its designee may prohibit or limit any discharge of waste into surface waters if, in the opinion of the Director, the surface waters experience or the discharge would result in growths of microscopic or macroscopic vegetation such that the standards established pursuant to this Rule would be violated or the intended best usage of the waters would be impaired; b. Dissolved oxygen: not less than 5.0 mg/l, except that swamp waters, poorly flushed tidally influenced streams or embayment, or estuarine bottom waters may have lower values if caused by natural conditions; c. Floating solids; settleable solids; sludge deposits: only such amounts attributable to sewage, industrial wastes or other wastes, as shall not make the waters unsafe or unsuitable for aquatic life and wildlife, or impair the waters for any designated uses; d. Gases, total dissolved: not greater than 110 percent of saturation; **e. Organisms of coliform group: fecal coliforms not to exceed geometric mean of 200/100 ml (MF count) based upon at least five consecutive samples examined during any 30 day period; not to exceed 400/100 ml in more than 20 percent of the samples examined during such period**; violations of the fecal coliform standard are expected during rainfall events and, in some cases, this violation is expected to be caused by uncontrollable nonpoint source pollution; all coliform concentrations are to be analyzed using the MF technique unless high turbidity or other adverse conditions necessitate the tube dilution method; in case of controversy over results the MPN 5-tube dilution method shall be used as the reference method; f. Oils; deleterious substances; colored or other wastes: only such amounts as shall not render the waters injurious to public health, secondary recreation or to aquatic life and wildlife or adversely affect the palatability of fish, aesthetic quality or impair the waters for any designated uses; for the purpose of implementing this Rule, oils, deleterious substances, colored or other wastes shall include but not be limited to substances that cause a film or sheen upon or discoloration of the surface of the water or adjoining shorelines pursuant to 40 CFR 110.4(a)-(b);

g. pH: shall be normal for the waters in the area, which generally shall range between 6.8 and 8.5 except that swamp waters may have a pH as low as 4.3 if it is the result of natural conditions;
h. Phenolic compounds: only such levels as shall not result in fish-flesh tainting or impairment of other best usage;
i. Radioactive substances: (i) Combined radium-226 and radium-228: The maximum average annual activity level (based on at least four samples, collected quarterly) for combined radium-226, and radium-228 shall not exceed five picoCuries per liter; (ii) Alpha Emitters. The average annual gross alpha particle activity (including radium-226, but excluding radon and uranium) shall not exceed 15 picoCuries per liter; (iii) Beta Emitters. The maximum average annual activity level (based on at least four samples, collected quarterly) for strontium-90 shall not exceed eight picoCuries per liter; nor shall the average annual gross beta particle activity (excluding potassium-40 and other naturally occurring radio-nuclides) exceed 50 picoCuries per liter; nor shall the maximum average annual activity level for tritium exceed 20,000 picoCuries per liter;
j. Salinity: changes in salinity due to hydrological modifications shall not result in removal of the functions of a PNA; projects that are determined by the Director to result in modifications of salinity such that functions of a PNA are impaired will be required to employ water management practices to mitigate salinity impacts;
k. Temperature: shall not be increased above the natural water temperature by more than 0.8 degrees C (1.44 degrees F) during the months of June, July, and August nor more than 2.2 degrees C (3.96 degrees F) during other months and in no cases to exceed 32 degrees C (89.6 degrees F) due to the discharge of heated liquids;
l. Turbidity: the turbidity in the receiving water shall not exceed 25 NTU; if turbidity exceeds this level due to natural background conditions, the existing turbidity level shall not be increased. Compliance with this turbidity standard can be met when land management activities employ Best Management Practices (BMPs) [as defined by Rule .0202(6) of this Section] recommended by the Designated Nonpoint Source Agency (as defined by Rule .0202 of this Section). BMPs must be in full compliance with all specifications governing the proper design, installation, operation and maintenance of such BMPs;
m. Toxic substances: numerical water quality standards (maximum permissible levels) to protect aquatic life applicable to all tidal saltwaters: (i) Arsenic, total recoverable: 50 ug/l; (ii) Cadmium: 5.0 ug/l; attainment of these water quality standards in surface waters shall be based on measurement of total recoverable metals concentrations unless appropriate studies have been conducted to translate total recoverable metals to a toxic form. Studies used to determine the toxic form or translators must be designed according to the "Water Quality Standards Handbook Second Edition" published by the Environmental Protection Agency (EPA 823-B-94-005a) or "The Metals Translator: Guidance For Calculating a Total Recoverable Permit Limit From a Dissolved Criterion" published by the Environmental Protection Agency (EPA 823-B-96-007) which are hereby incorporated by reference including any subsequent amendments. The Director shall consider conformance to EPA guidance as well as the presence of environmental conditions that limit the applicability of translators in approving the use of metal translators. (iii) Chromium, total: 20 ug/l; (iv) Cyanide: 1.0 ug/l; (v) Mercury: 0.025 ug/l; (vi) Lead, total recoverable: 25 ug/l; collection of data on sources, transport and fate of lead shall be required as part of the toxicity reduction evaluation for dischargers that are out of compliance with whole effluent toxicity testing requirements and the concentration of lead in the effluent is concomitantly determined to exceed an instream level of 3.1 ug/l from the discharge; (vii) Nickel: 8.3 ug/l; attainment of these water quality standards in surface waters shall be based on measurement of total recoverable metals concentrations unless appropriate studies have been conducted to translate total recoverable metals to a toxic form. Studies used to determine the toxic form or translators must be designed according to the "Water Quality Standards Handbook Second Edition" published by the Environmental Protection Agency (EPA 823-B-94-005a) or

	"The Metals Translator: Guidance For Calculating a Total Recoverable Permit Limit From a Dissolved Criterion" published by the Environmental Protection Agency (EPA 823-B-96-007) which are hereby incorporated by reference including any subsequent amendments. The Director shall consider conformance to EPA guidance as well as the presence of environmental conditions that limit the applicability of translators in approving the use of metal translators. (viii) Pesticides: (A) Aldrin: 0.003 ug/l; (B) Chlordane: 0.004 ug/l; (C) DDT: 0.001 ug/l; (D) Demeton: 0.1 ug/l; (E) Dieldrin: 0.002 ug/l; (F) Endosulfan: 0.009 ug/l; (G) Endrin: 0.002 ug/l; (H) Guthion: 0.01 ug/l; (I) Heptachlor: 0.004 ug/l; (J) Lindane: 0.004 ug/l; (K) Methoxychlor: 0.03 ug/l; (L) Mirex: 0.001 ug/l; (M) Parathion: 0.178 ug/l; (N) Toxaphene: 0.0002 ug/l. (ix) Polycholorinated biphenyls: 0.001 ug/l; (x) Selenium: 71 ug/l; (xi) Trialkyltin compounds: 0.002 ug/l expressed as tributyltin. 4. Action Levels for Toxic Substances: if the Action Levels for any of the substances listed in this Subparagraph (which are generally not bioaccumulative and have variable toxicity to aquatic life because of chemical form, solubility, stream characteristics or associated waste characteristics) are determined by the waste load allocation to be exceeded in a receiving water by a discharge under the specified low flow criterion for toxic substances (Rule .0206 in this Section), the discharger shall be required to monitor the chemical or biological effects of the discharge; efforts shall be made by all dischargers to reduce or eliminate these substances from their effluents. Those substances for which Action Levels are listed in this Subparagraph may be limited as appropriate in the NPDES permit if sufficient information (to be determined for metals by measurements of that portion of the dissolved instream concentration of the Action Level parameter attributable to a specific NPDES permitted discharge) exists to indicate that any of those substances may be a causative factor resulting in toxicity of the effluent. NPDES permit limits may be based on translation of the toxic form to total recoverable metals. Studies used to determine the toxic form or translators must be designed according to: "Water Quality Standards Handbook Second Edition" published by the Environmental Protection Agency (EPA 823-B-94-005a) or "The Metals Translator: Guidance For Calculating a Total Recoverable Permit Limit From a Dissolved Criterion" published by the Environmental Protection Agency (EPA 823-B-96-007) which are hereby incorporated by reference including any subsequent amendments. The Director shall consider conformance to EPA guidance as well as the presence of environmental conditions that limit the applicability of translators in approving the use of metal translators. (a) Copper: 3 ug/l; (b) Silver: 0.1 ug/l; (c) Zinc: 86 ug/l.

Shellfish Sanitation Classifications

Table 4. 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.

Conditionally Approved-Closed Shellfish Areas	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.
Prohibited Shellfish Harvest Areas	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.

Recreational Water Quality Standards

Tier	Description
Tier I	"Tier I swimming area" means a swimming area used daily during the swimming season, including any public access swimming area and any other swimming area where people use the water for primary contact, including all oceanfront beaches. 1. The enterococcus level in a Tier I swimming area shall not exceed either: a. A geometric mean of 35 enterococci per 100 milliliter of water, that includes a minimum of at least five samples collected within 30 days; or b. A single sample of 104 enterococci per 100 milliliters of water. Tier I Swimming areas: (1) A swimming advisory shall be issued by the Division when samples of water from a swimming area exceeds a geometric mean of 35 enterococci per 100 milliliters during the swimming season. (2) A swimming alert shall be issued by the Division when a single sample of water from a swimming area exceeds 104 enterococci per 100 milliliters and does not exceed 500 enterococci per 100 milliliters during the swimming season. (3) A swimming advisory shall be issued by the Division when a sample of water from a swimming area exceeds a single sample of 500 enterococci per 100 milliliters during the swimming season. (4) A swimming advisory shall be issued by the Division when at least two of three concurrent water samples collected at a swimming area exceeds 104 enterococci per 100 milliliters during the swimming season. A Tier I swimming area advisory shall be rescinded when two consecutive weekly water samples and the geometric mean meet the bacteriological limits in Rule 18A .3402(a) of this Section. A swimming alert shall be rescinded within 24 hours of compliance with Rule 18A .3402(a)(2) of this Section.
Tier II	"Tier II swimming area" means a swimming area used an average of three days a week during the swimming season. The enterococcus level in a Tier II swimming area shall not exceed a single sample of 276 enterococci per 100 milliliters of water. Tier II swimming areas: (1) A swimming alert shall be issued by the Division when a single sample of water from a swimming area exceeds 276 enterococci per 100 milliliters and does not exceed 500 enterococci per 100 milliliters during the swimming season. (2) A swimming advisory shall be issued by the Division when a single sample of water from a swimming area exceeds 500 enterococci per 100 milliliters during the swimming season. A Tier II or Tier III swimming area advisory or alert shall be rescinded after water samples meet the bacteriological standard in Rule 18A .3402(b) or (c) of this Section.
Tier III	"Tier III swimming area" means a swimming area used an average of four days a month during the swimming season.

	Tier III swimming area with a water sample result of 500 enterococci per 100 milliliters or higher on the first sample shall be resampled the following day. If the laboratory results of the second sample exceed 500 enterococci per 100 milliliters a swimming advisory shall be issued by the Division. A Tier II or Tier III swimming area advisory or alert shall be rescinded after water samples meet the bacteriological standard in Rule 18A .3402(b) or (c) of this Section.
Swimming Season	April 1 through October 31 of each year. The enterococcus level in a Tier III swimming area shall not exceed two consecutive samples of 500 enterococci per 100 milliliters of water.
Winter Season	November 1 through March 31 of each year.

Appendix B Potential Stormwater Incentive Strategies

The following is an outline of potential stormwater incentive strategies that municipalities could consider to encourage early LID implementation.

Begin by reviewing the town's codes and ordinances utilizing the following worksheet:

https://www.scdhec.gov/HomeandEnvironment/docs/ModelOrdinances/CodesandOrdinancesWorksheet.pdf

Incentive Categories

The EPA has identified five basic incentive categories that can be utilized to encourage the reduction of stormwater[5]:

Incentive Type	Description
Stormwater Fee Discount	Require a stormwater fee that is based on impervious surface area. If property owners reduce need for service by reducing impervious area and the volume of runoff discharged from the property, the municipality reduces the fee.
Development Incentives	Offered to developers during the process of applying for development permits. Examples include: zoning upgrades, expedited permitting, reduced stormwater requirements and increases in floor area ratios
Grants	Provide direct funding to property owners and/or community groups for implementing a range of green infrastructure projects and practices.
Rebates & Installation Financing	Provide funding, tax credits or reimbursements to property owners who install specific practices. Often focused on practices needed in certain areas or neighborhoods
Awards & Recognition Incentive	Provide marketing opportunities and public outreach for exemplary projects. May include monetary awards. Emphasize LID projects on website, at Council meetings and in utility mailers.

[5] *Managing Wet Weather with Green Infrastructure Municipal Handbook: Incentive Mechanism*. 2009. US Environmental Protection Agency, EPA-833-F-09-001. Retrieved from https://www.epa.gov/sites/production/files/2015-10/documents/gi_munichandbook_incentives_0.pdf

Basic Strategies

The following is a compiled list of basic strategies and descriptions (summarized or quoted directly from Slo County[6] and EPA[7]; see Reference):

Strategy	Description
Adjustments to the Required Parking	Reducing parking is both a LID technique for reducing impervious surfaces as well to encourage more projects.
Dedicated Review Team	Create a LID review team that is familiar with and dedicated to LID projects.
Density bonuses	Allow greater residential densities with the implementation of LID techniques.
Disconnect of rooftop runoff credit	A credit is given when rooftop runoff is disconnected and then direction to a vegetated area where it can either infiltrate into the soil or filter over it. The credit is typically obtained by grading the site to promote overland filtering or by providing bioretention areas on single family residential lots.
Disconnection of Non-Rooftop Runoff Credit (aka Impervious Area Disconnection Credit)	This credit may be granted when impervious areas are disconnected from the stormwater control system via overland flow filtration/ infiltration (i.e., pervious) zones. These pervious areas are incorporated into the site design to receive runoff small impervious areas (e.g., driveways, small parking lots, etc.). This can be achieved by grading the site to promote overland vegetative filtering or by providing infiltration or "rain garden" areas.
Environmentally Sensitive Large Lot Neighborhood Credit (aka Environmentally Sensitive Development Credit)	This credit is targeted toward large lot residential developments that implement several Better Site Design practices to reduce stormwater discharges from the development. This credit may be granted when a group of environmental site design techniques are applied to low and very low-density residential development (e.g., 1 dwelling unit per 2 acres [du/ac] or lower). The credit can eliminate the need for structural stormwater controls to treat water quality volume requirements. The project must have a total impervious cover (including streets) of less than 15% of the total area. utilize grass channels to convey runoff versus curb and gutter, etc.
Exemptions from local stormwater permitting	Allow redevelopment projects from being exempt from local stormwater permitting requirements if they can: • reduce the total impervious cover by 40% from existing conditions • Where site conditions prevent reduction in stormwater practices, implement controls for at least 40% of the site's impervious area, or Where a combination of impervious area reduction and implementation of stormwater practices is used

[6] Slo County. n.d. *List of Potential Municipal LID Incentive Programs.* Retrieved from http://www.slocounty.ca.gov/Assets/PW/stormwater/Potential+LID+Incentives.pdf

[7] *Managing Wet Weather with Green Infrastructure Municipal Handbook: Incentive Mechanism*. 2009. US Environmental Protection Agency, EPA-833-F-09-001. Retrieved from https://www.epa.gov/sites/production/files/2015-10/documents/gi_munichandbook_incentives_0.pdf

	for redevelopment projects, the combination of impervious area reduction and area controlled by stormwater management practices is equal to or exceeds 40%.
Fast track of review process	Provide priority status to LID projects with decreased time between receipt and review.
Green Roof Bonus	Add one square foot of additional floor area for each square foot of green roof, if green roof covers at least 50% of roof area and at least 30% of the garden contains plants.
LID Point system	Require a certain number of LID points and provide points when using approved LID IMP practices.
Managed Conservation Area Credit	A credit may be granted when areas of managed open space, typically reserved for passive recreation or agricultural practices, are conserved on a site. Under this credit, a designer would be able to subtract conservation areas from total site area when computing water quality volume requirements.
Modify building and inspection codes to include LID	Municipal entities that enforce building and inspection standards can also modify these standards in ways that acknowledge LID. In this subsection, we list sources of information on modifying building and inspection codes to make them more LID friendly. The list includes sources specific to Oregon and the Pacific Northwest, as well as from outside the region. http://www.econw.com/media/ap_files/ECONorthwest_Publication_LID-Clackamas-County-Case-Study_2009.pdf
Natural Area Conservation Credit	Credit may be granted when undisturbed, natural areas are conserved on a site, thereby retaining their pre-development hydrologic and water quality characteristics. Under this credit, a designer would be able to subtract conservation areas from total site area when computing water quality volume requirements.
Property tax reduction	Reduce or waive property taxes on a LID project for a given number of years.
Reduction of municipal submittal fees	Projects that infiltrate 100 percent of stormwater receive up to 50% reduction in the stormwater utility fee
Steam and Vegetated Buffer Credit (aka Stream Buffer Credit or Sheet flow to Buffer Credit)	This credit may be granted when stormwater runoff is effectively treated by a stream buffer or other vegetated buffer. Effective treatment constitutes treating runoff as overland sheet flow through an appropriately vegetated and forested buffer. Under the proposed credit, a designer would be able to subtract areas draining via overland flow to the buffer from total site area when computing water quality volume requirements.
Tree canopy credit	Reduce stormwater treatment volume requirements as a ratio of the number of acceptably sized trees planted on the project
Vegetated Channel Credit (aka Grass Channel Credit (in	This credit may be granted when vegetated (grass) channels are used for water quality treatment. Site designers will be able to subtract the areas draining to a grass channel and

lieu of Curb and Gutter)	the channel area itself from total site area when computing water quality volume requirements.
Education Strategy	• Municipal sponsored public workshops on how to build rain gardens and emphasizing the increase in property value and curb appeal of LID landscaping • Municipal sponsored public workshops on how to make your own rain barrels • Municipal public education and outreach on how to conserve water and save money using rain barrels, rainwater harvesting water tanks, cisterns, and rain chains • Municipal sponsored contests with giveaways using rain barrels, rain harvesting water tanks, cisterns, and rain chains • Municipal sponsored gardening workshops promoting the value of rainwater harvesting, rain gardens, etc.
Business Outreach	Communication about grant opportunities, partnerships, awards, competitions, and regulations via email, newsletter, website, etc. directed directly at business owners and commercial land owners to encourage participation and encourage a vested interest in the community

Examples of LID-friendly Regulatory Language

"Several cities and counties list LID-friendly stormwater ordinances on their web sites. A recent Google search of "LID regulation" found the following LID ordinances:

- City of Sammamish, Washington: Ordinance 02008-236 Low Impact Development Regulations. An ordinance of the City of Sammamish, Washington, amending the City of Sammamish Municipal Code to create a Low Impact Development Chapter, and amending certain other Chapters of the City of Sammamish Municipal code to ensure consistency with the Low Impact Development Chapter. http://www.ci.sammamish.wa.us/Ordinances.aspx?ID=107 (accessed January 5, 2009).
- Fauquier County, Virginia: A zoning ordinance text amendment to Sections 5-006.5, 12-610 and 15-300 related to utilization of Low Impact Development techniques with site development. http://www.fauquiercounty.gov/government/departments/BOS/past agendas/02-14-08/lid_ord.htm (accessed January 5, 2009).
- Township of Lower Makefield, Pennsylvania: Ordinance No. 364. An ordinance of the Township of Lower Makefield, Bucks County, Pennsylvania, amending the Lower Makefield Township Codified Zoning Ordinance of 1996, as amended, to provide for Low Impact Development Standards. http://www.lmt.org/LID%20- %20ZONING%20v%206%20_4_.pdf (accessed January 5, 2009)."[8]
- Vermont utilizes a suite of stormwater regulations http://acrpc.org/files/2012/04/LID_For_VT_Towns.pdf

Discussion of challenges faced by developers and how municipalities can maximize the effectiveness of stormwater programs:

http://www.econw.com/media/ap_files/ECONorthwest_Publication_LID-Clackamas-County-Case-Study_2009.pdf

List of Cost savings from installed LID stormwater controls:

[8] ECONorthwest. 2009. Low Impact Development at the local level: Developer's experiences and city and county support. Retrieved from http://www.econw.com/media/ap_files/ECONorthwest_Publication_LID-Clackamas-County-Case-Study_2009.pdf

http://www.econw.com/media/ap_files/ECONorthwest_Publication_LID-Clackamas-County-Case-Study_2009.pdf

http://www.dep.wv.gov/WWE/Programs/stormwater/MS4/guidance/factsheets/Documents/Incorporating%20ESD%20into%20Municipal%20SW%20Programs.pdf

https://www3.epa.gov/region1/npdes/stormwater/assets/pdfs/IncorporatingLID.pdf

Reference

Slo County. n.d. *List of Potential Municipal LID Incentive Programs.* Retrieved from http://www.slocounty.ca.gov/Assets/PW/stormwater/Potential+LID+Incentives.pdf

Managing Wet Weather with Green Infrastructure Municipal Handbook: Incentive Mechanism. 2009. US Environmental Protection Agency, EPA-833-F-09-001. Retrieved from https://www.epa.gov/sites/production/files/2015-10/documents/gi_munichandbook_incentives_0.pdf

Doll, A., and G. Lindsey. 1999. Credits Bring Economic Incentives for Onsite Stormwater Management. Watershed and Wet Weather Technical Bulletin, January 1999, Water Environment Federation. http://stormwaterfinance.urbancenter.iupui.edu/PDFs/LindseyDoll.pdf

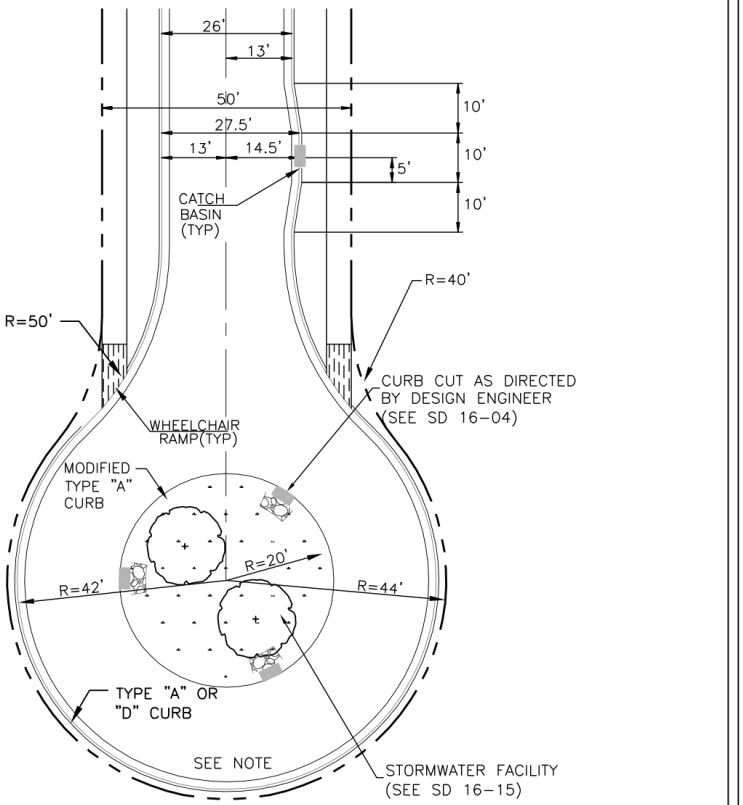
ECONorthwest. 2009. Low Impact Development at the local level: Developer's experiences and city and county support. Retrieved from http://www.econw.com/media/ap_files/ECONorthwest_Publication_LID-Clackamas-County-Case-Study_2009.pdf

Appendix C *Green Street* Stormwater Management Devices

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.



	STANDARD DETAIL	
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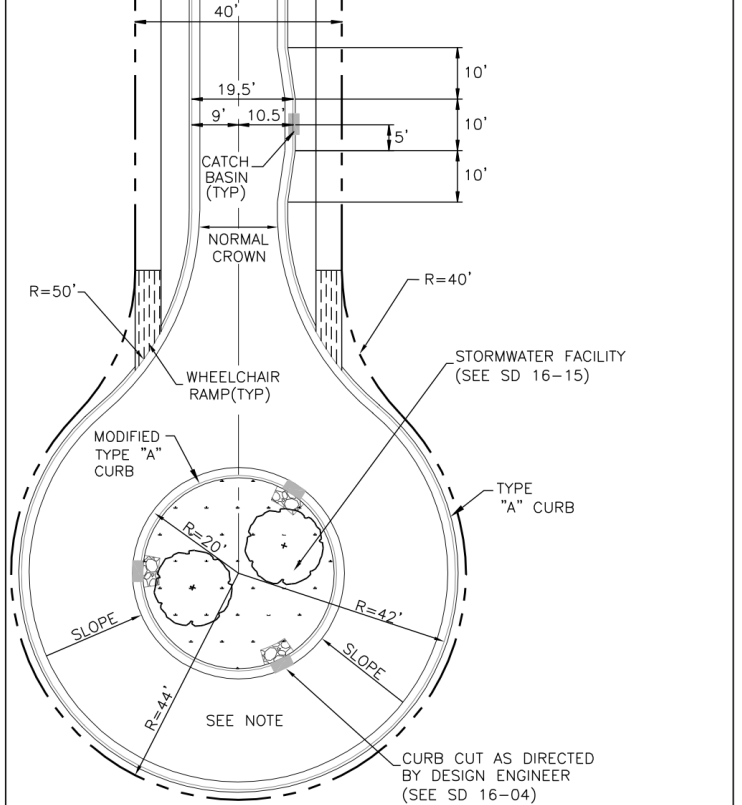
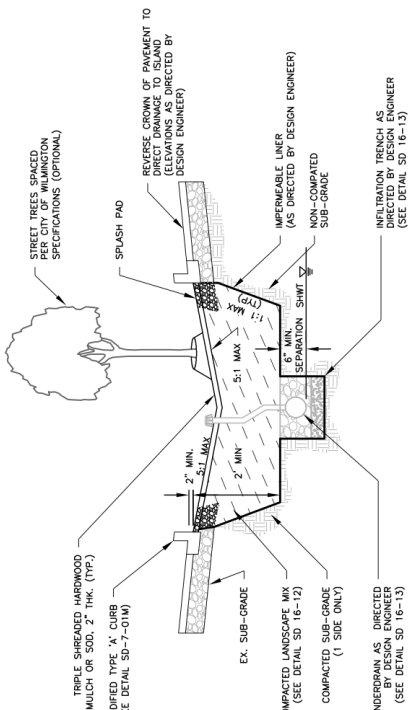
DRAWN BY TLM		
CHECKED BY HCF		
SCALE NOT TO SCALE		

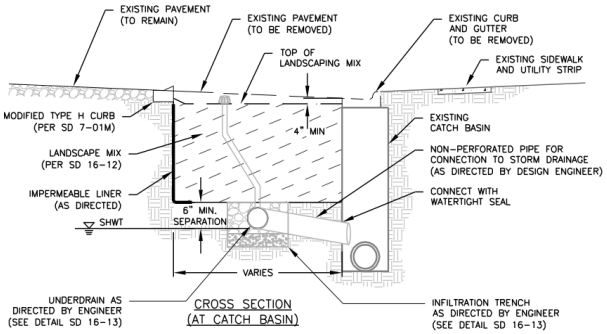


	STANDARD DETAIL	
DATE: 2012	LOCAL "A" & "B" CUL-DE-SAC OPTION "1" ISLAND, RESIDENTIAL (MODIFIED)	SD 1-11M
DRAWN BY TLM		
CHECKED BY HCF		
SCALE NOT TO SCALE		



NOTES:
1. 10-YR STORM VELOCITY NOT TO EXCEED 2 FT/S.
2. UTILITY LINES MAY NEED TO BE SLEEVED OR RELOCATED.
3. SOD OR TRIPLE SHREDDED MULCH SHALL BE A MINIMUM OF 2" BELOW THE GUTTER LINE TO ALLOW FOR UNIMPEDED FLOW INTO ISLAND.
4. UNDERDRAIN AND IMPERMEABLE LINER TO BE USED ON CASE BY CASE BASIS, AT DESIGN ENGINEER'S DISCRETION.
5. SOIL TESTING REQUIRED WHEN UNDERDRAIN IS NOT USED.
6. DRAINAGE STRUCTURE MAY BE REQUIRED TO PREVENT FLOODING DURING LARGE STORMS.

	STANDARD DETAIL	
DATE: 2012	STORMWATER ISLAND CROSS SECTION	SD 16-15
DRAWN BY TLM		
CHECKED BY HCF		
SCALE NOT TO SCALE		



CROSS SECTION (AT CATCH BASIN)

NOTES:
SOIL TESTING REQUIRED WHEN NOT USING UNDERDRAIN

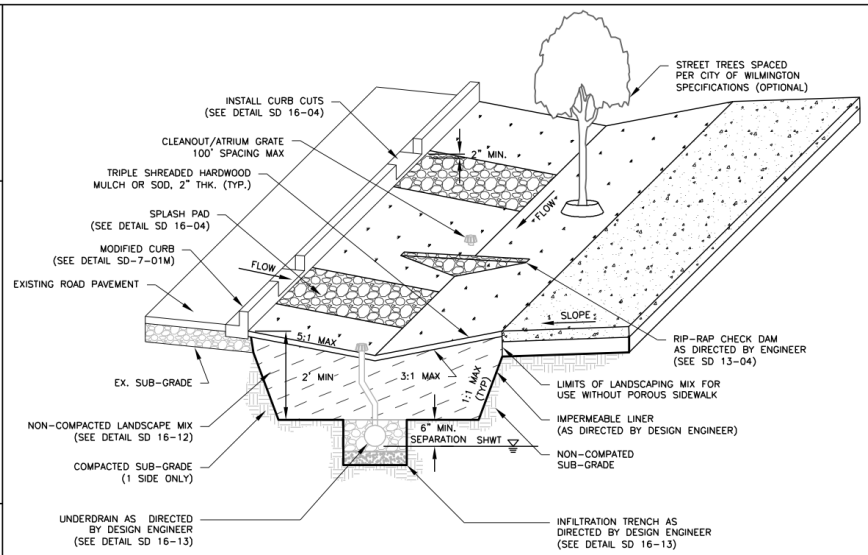
	STANDARD DETAIL	
DATE: 2012	CURB EXTENSION (2 OF 3)	SD 16-03b
DRAWN BY TLM		
CHECKED BY HCF		
SCALE NOT TO SCALE		

SCALE NOT TO SCALE
CHECKED BY HCF
DRAWN BY TLM
DATE: 2012

STANDARD DETAIL

SIDEWALK SWALE WITH CURB & GUTTER

SD 16-01



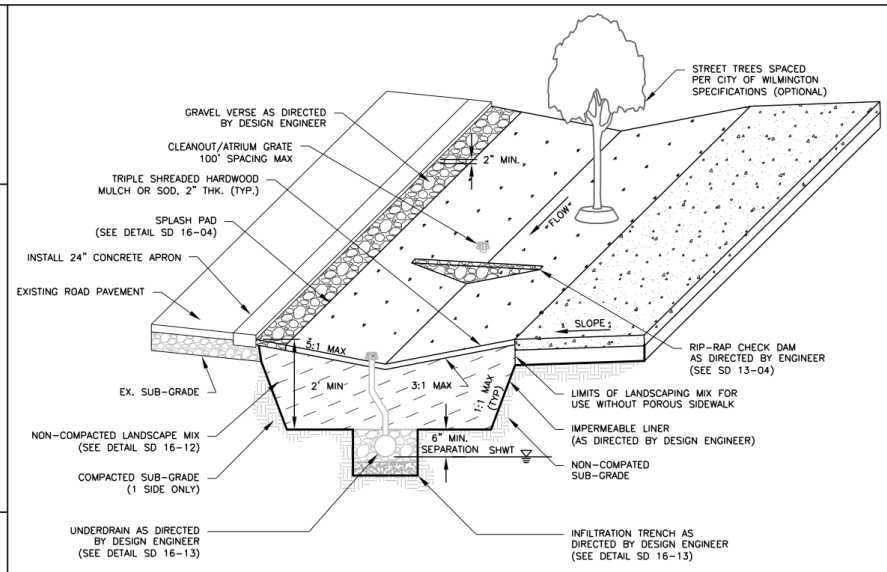
NOTES:
1. SWALE DEPTH SHALL BE DEEP ENOUGH TO PASS 10-YR STORM FLOW WITHOUT SURCHARGING GUTTER OR FLOODING PAVEMENT.
2. 10-YR STORM VELOCITY NOT TO EXCEED 2 FT/S.
3. UTILITY LINES MAY NEED TO BE SLEEVED OR RELOCATED.
4. TREES AND SHRUBS SHALL BE PLANTED AT LEAST 2' FROM CENTERLINE OF SWALE.
5. USE THE 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 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.

SCALE NOT TO SCALE
CHECKED BY HCF
DRAWN BY TLM
DATE: 2012

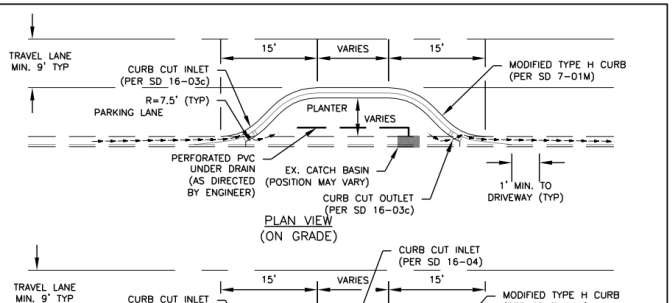
STANDARD DETAIL

SIDEWALK SWALE WITHOUT CURB & GUTTER

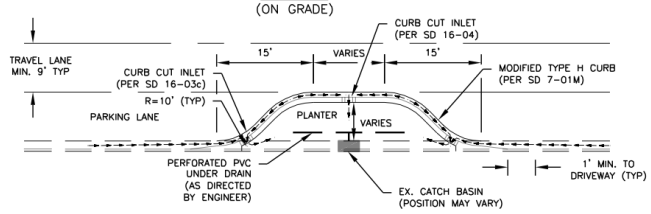
SD 16-02



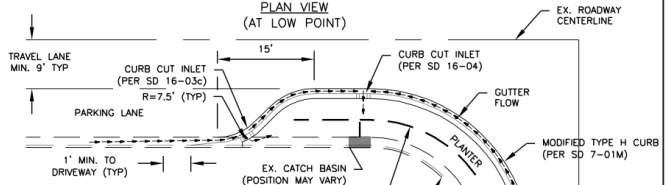
NOTES:
1. SWALE DEPTH SHALL BE DEEP ENOUGH TO PASS 10-YR STORM FLOW WITHOUT SURCHARGING GUTTER OR FLOODING PAVEMENT.
2. 10-YR STORM VELOCITY NOT TO EXCEED 2 FT/S.
3. UTILITY LINES MAY NEED TO BE SLEEVED OR RELOCATED.
4. TREES AND SHRUBS SHALL BE PLANTED AT LEAST 2' FROM CENTERLINE OF SWALE.
5. USE THE 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.



PLAN VIEW
(ON GRADE)



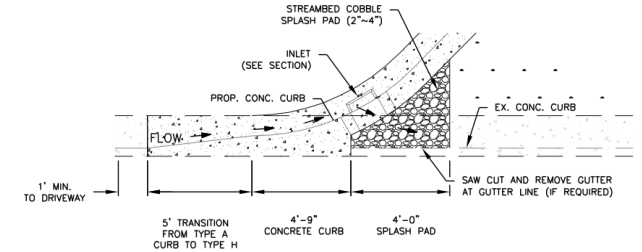
PLAN VIEW
(AT LOW POINT)



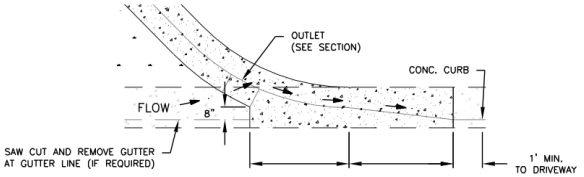
NOTES:
1. NOT TO BE INSTALLED WHERE SLOPES EXCEED 2%
2. AREA AND DEPTH OF FACILITY ARE BASED UPON ENGINEERING AND RIGHT-OF-WAY CONSTRAINTS. LANDSCAPING IN PLANTERS AS SHOWN ON PLANS.
3. CURB CUT INLETS AND OUTLETS FOR INTERSECTIONS VARIES (MINIMUM OF FOUR (4)). SEE PLANS FOR LOCATIONS.
4. UTILITY LINES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

PLAN VIEW
(AT INTERSECTION)

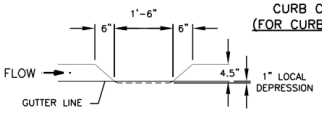
	STANDARD DETAIL	
DATE: 2012		
DRAWN BY TLM	CURB EXTENSION (1 OF 3)	
CHECKED BY HCF		
SCALE NOT TO SCALE		SD 16-03a



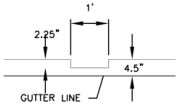
CURB CUT INLET
(FOR CURB EXTENSIONS)
NTS



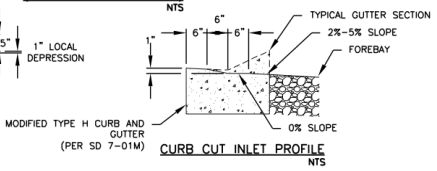
CURB CUT OUTLET
(FOR CURB EXTENSIONS)
NTS



INLET SECTION
NTS



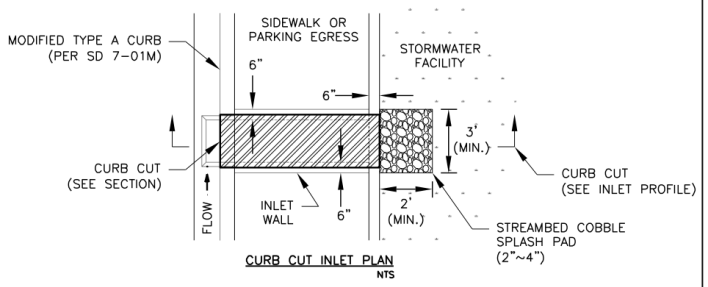
OUTLET SECTION
NTS



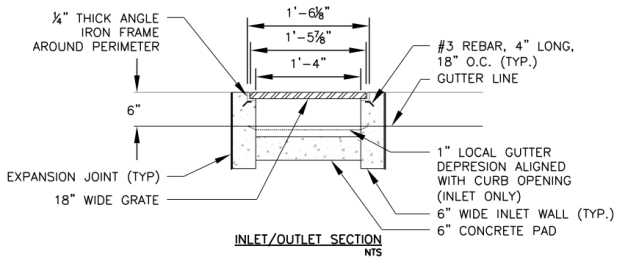
CURB CUT INLET PROFILE
NTS

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.

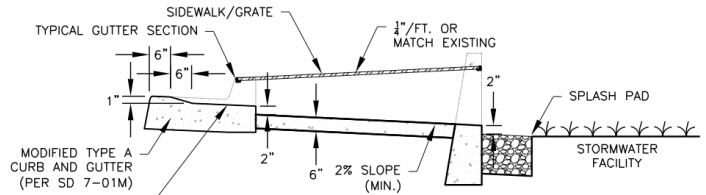
	STANDARD DETAIL	
DATE: 2012		
DRAWN BY TLM	CURB EXTENSION (3 OF 3)	
CHECKED BY HCF		
SCALE NOT TO SCALE		SD 16-03c



CURB CUT INLET PLAN
NTS

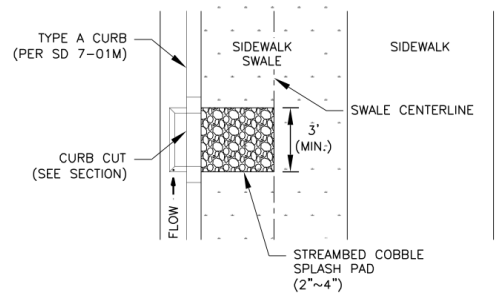


INLET/OUTLET SECTION
NTS

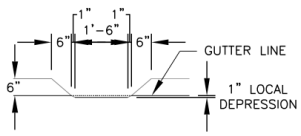


CURB CUT INLET PROFILE
NTS

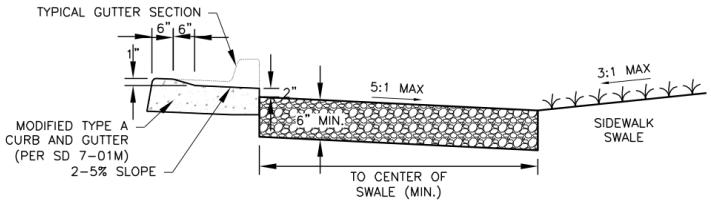
	STANDARD DETAIL
DATE: 2012	CURB CUTS (CHANNEL AND GRATE)
DRAWN BY TLM	
CHECKED BY HCF	
SCALE NOT TO SCALE	SD 16-05



CURB CUT INLET PLAN
NTS

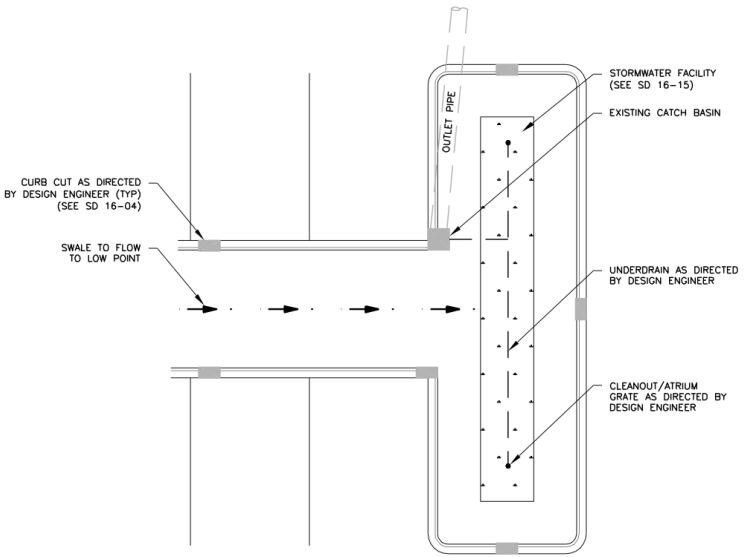


INLET SECTION
NTS



CURB CUT INLET PROFILE
NTS

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



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	
DATE: 2012	STORMWATER PARKING ISLAND	SD 16-16
DRAWN BY TLM		
CHECKED BY HCF		
SCALE NOT TO SCALE		

RECOMMENDED PLANTS LIST FOR ALL STORMWATER DETAILS:

SCIENTIFIC NAME	COMMON NAME
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	SD 16-14
DRAWN BY TLM		
CHECKED BY HCF		
SCALE NOT TO SCALE		

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 DISTRIBUTON
   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.

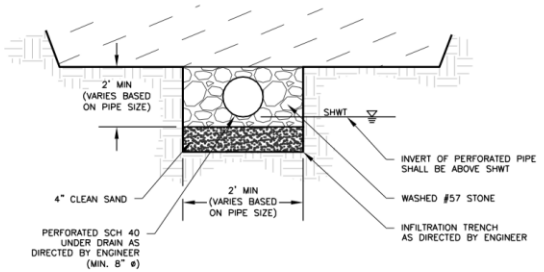
HIGH FLOW MEDIA MIXES

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.

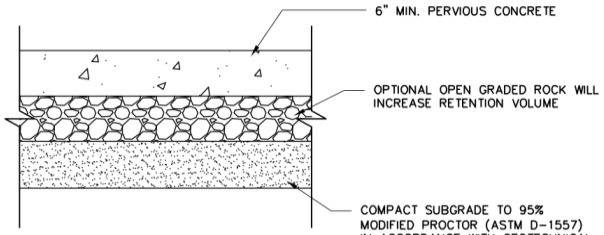
ENGINEERED HIGH FLOW MEDIA SHALL MEET THE FOLLOWING SPECIFICATIONS

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 > 50INCHES / 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%

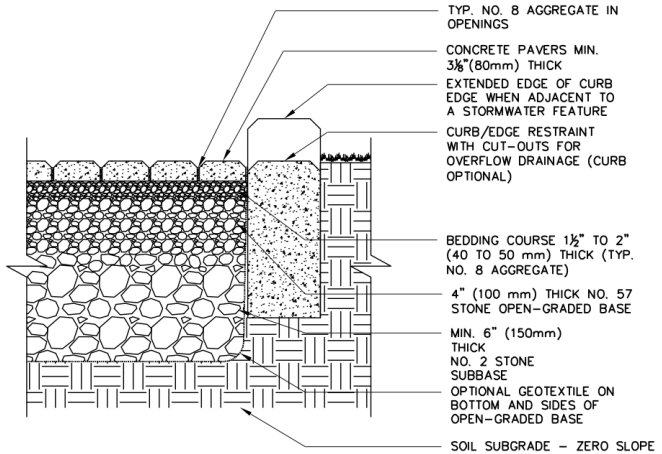
	STANDARD DETAIL	
DATE: 2012	LANDSCAPE MIX SPECIFICATIONS	
DRAWN BY TLM		
CHECKED BY HCF		
SCALE NOT TO SCALE		SD 16-12



	STANDARD DETAIL	
DATE: 2012	STANDARD UNDERDRAIN AND TRENCH	
DRAWN BY TLM		
CHECKED BY HCF		
SCALE NOT TO SCALE		SD 16-13

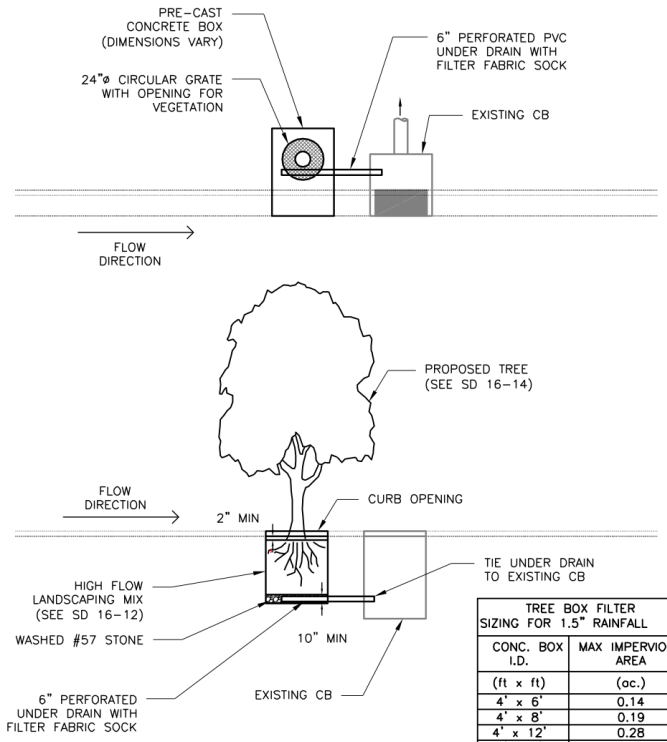


	STANDARD DETAIL	
DATE: 2012	STANDARD POROUS CONCRETE	
DRAWN BY TLM		
CHECKED BY HCF		
SCALE NOT TO SCALE		SD 16-11



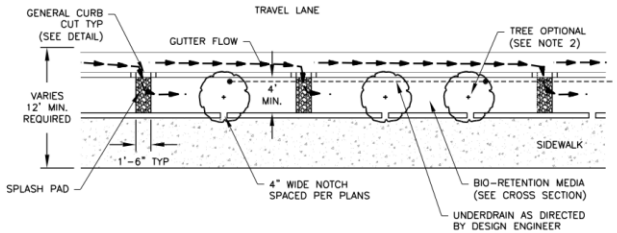
NOTES:
1. 2⅜" (60mm) THICK PAVERS MAY BE USED IN PEDESTRIAN APPLICATIONS.
2. NO. 2 STONE SUBBASE THICKNESS VARIES WITH DESIGN. CONSULT ICPI PERMEABLE INTERLOCKING CONCRETE PAVEMENT MANUAL.
3. CURB EDGE MAY EXTEND 6" ABOVE GRADE WHEN ADJACENT TO STORMWATER FEATURE.

	STANDARD DETAIL	
DATE: 2012	STANDARD POROUS PAVERS	
DRAWN BY TLM		
CHECKED BY HCF		
SCALE NOT TO SCALE		SD 16-10

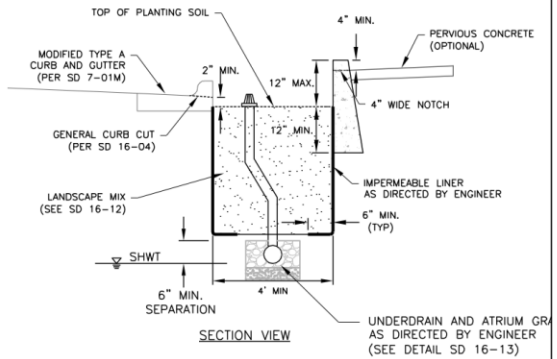


TREE BOX FILTER SIZING FOR 1.5" RAINFALL	
CONC. BOX I.D.	MAX IMPERVIOUS AREA
(ft x ft)	(ac.)
4' x 6'	0.14
4' x 8'	0.19
4' x 12'	0.28
6' x 6'	0.21
6' x 8'	0.28
6' x 10'	0.35
6' x 12'	0.42
7' x 13'	0.54

	STANDARD DETAIL	
DATE: 2012	STANDARD URBAN TREE PLANTER BOX	SD 16-09
DRAWN BY TLM		
CHECKED BY HCF		
SCALE NOT TO SCALE		



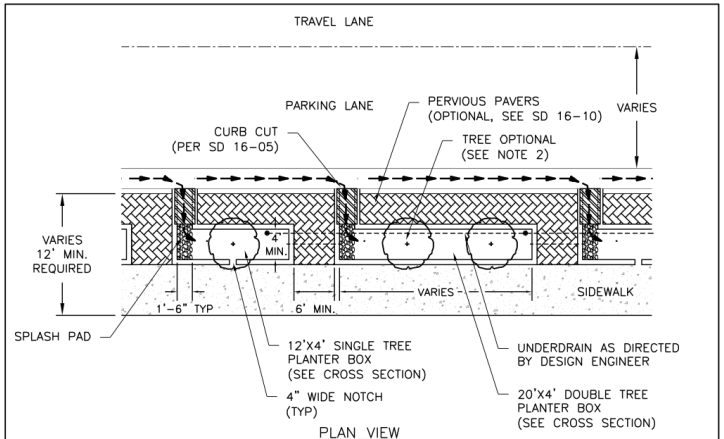
PLAN VIEW



SECTION VIEW

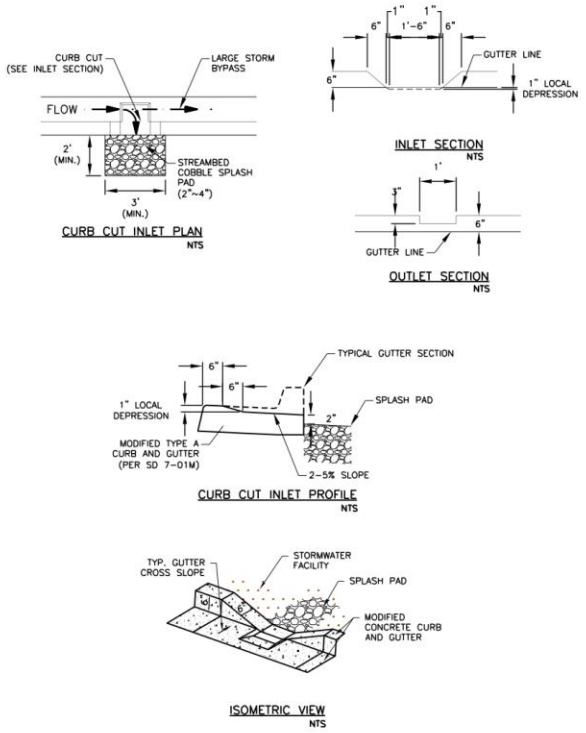
NOTES:
1. 10' PER TREE MINIMUM, MAXIMUM LENGTH SHALL BE 30'
2. WIDTH AND DEPTH DIMENSIONS MAY BE REDUCED IF NO TREES PLANTED, AS APPROVED BY CITY OF WILMINGTON.

	STANDARD DETAIL	
DATE: 2012	SIDEWALK RETENTION (WITHOUT PARKING)	SD 16-08
DRAWN BY TLM		
CHECKED BY HCF		
SCALE NOT TO SCALE		

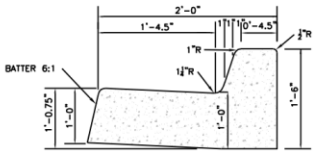


NOTES:
1. 10' PER TREE MINIMUM, MAXIMUM LENGTH SHALL BE 30'
2. WIDTH AND DEPTH DIMENSIONS MAY BE REDUCED IF NO TREES PLANTED, AS APPROVED BY CITY OF WILMINGTON.

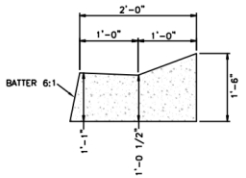
	STANDARD DETAIL	
DATE: 2012	SIDEWALK RETENTION (WITH PARKING)	SD 16-07
DRAWN BY TLM		
CHECKED BY HCF		
SCALE NOT TO SCALE		



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



MODIFIED TYPE "A" CURB AND GUTTER



MODIFIED TYPE "H" CURB AND GUTTER

NOTES:
1. MODIFIED CURB AND GUTTER TO BE USED WHEN ADJACENT TO SURFACE STORMWATER FACILITIES.
2. CURB EXPOSURE IS 6". VARY ONLY AS SHOWN ON PLANS OR AS APPROVED.

	STANDARD DETAIL	
DATE: 2012	MODIFIED CURB AND GUTTER TYPES "A" AND "H"	
DRAWN BY TLM		
CHECKED BY HCF		
SCALE NOT TO SCALE		SD 7-01M