IMPLEMENTATION OF THE PETITION PROCESS FOR THE NPDES PHASE II STORMWATER PROGRAM IN NORTH CAROLINA

by

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Abstract

The North Carolina General Assembly recently passed Session Law 2006-246, which establishes the final administrative rules for the implementation of the EPA NPDES Phase II stormwater program in North Carolina. According to these rules, any person may petition the Environmental Management Commission to require an entity that discharges stormwater to obtain a Phase II stormwater permit. A methodology was developed to guide the collection of the required data for an adverse impact petition, based on a case study of the municipal separate storm sewer system of Morehead City, NC. This case study was then used to examine the key elements of this process in the context of their application to a Phase II petition in a coastal environment, and to explore the challenges arising during this process.

General petition provisions were originally included in the Phase II rules by the EPA to provide one of several opportunities for public participation in the NPDES stormwater program. It was initially thought that the detailed requirements regarding the petition process in North Carolina would enhance the ability of the general public to play a direct role in requiring more stringent stormwater management along the coast through the Phase II stormwater program. However, in developing the adverse impact petition methodology and applying it in a preliminary case study of Morehead City, it appears that the extensive requirements of the North Carolina petition rules may actually make the completion of a successful petition quite challenging, particularly for members of the general public. Thus, rather than simplifying the process, these rules may instead discourage the submission of Phase II petitions in North Carolina, at least in the near future, and limit their usefulness as a stormwater management tool.

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1.1 Objectives

In the summer of 2006, the North Carolina General Assembly passed Session Law 2006-246 in order to implement the National Pollutant Discharge Elimination System (NPDES) Phase II stormwater program. The legislation outlines the final rules for the Phase II program, which are unique to the state and include specific requirements regarding the Phase II petition process. A petition may be submitted to the North Carolina Environmental Management Commission (EMC) to request that a municipality or person that discharges stormwater be required to obtain a Phase II stormwater permit. The petitioner must show that the discharge contributes to an existing water quality impairment or provides a significant contribution of pollutants to receiving waters.

Along the North Carolina coast, the acreage of shellfishing waters closed to harvest each year has been increasing, despite the fact that the coastal stormwater rules of the North Carolina state stormwater program went into effect in 1988 (Reeder 2005). Because the new requirements of the Phase II stormwater program are more stringent than the current state program, the petition process offers a potentially useful tool that could be used to enhance stormwater management in those areas where stormwater discharges are having an adverse impact on coastal water quality. This project will examine the North Carolina Phase II petition process in detail and its potential application on the coast. The overall project objectives are:

- To provide background information on the impacts of stormwater runoff, the NPDES stormwater program, and the North Carolina Phase II rules,
- To examine the adverse impact petition process as outlined in the North Carolina Phase II rules and develop a methodology for submitting a credible petition for a municipal separate storm sewer system (MS4), and
- To analyze a preliminary application of this methodology in a coastal environment based on a case study of Morehead City, NC.

1.2 Stormwater Runoff

Over the past four decades, improving the quality of the nation's waters has been an important goal of environmental regulatory efforts in the United States. Events such as the Santa Barbara oil spill and the fire on the Cuyahoga River, both in 1969, served to catalyze the environmental movement as a whole and dramatically demonstrated the powerful and

problematic impacts of human activities on water quality (Cicin-Sain and Knecht 2000). Regulatory efforts since that time have been largely successful in reducing water pollution, especially from point source discharges, including industrial sources and municipal wastewater treatment. Yet, water pollution problems have persisted, and it has become apparent that nonpoint source pollution is also a significant cause of degraded water quality across the country (64 FR 68723). Stormwater, especially in areas of urban development and agricultural land use, is a major contributor of nonpoint source pollution, as runoff washes contaminants from the land into surface waters (Arnold and Gibbons 1996, Mallin et al. 2001).

According to the 2000 National Water Quality Survey, 13 percent of impaired rivers, 18 percent of impaired lakes, and 32 percent of impaired estuaries are primarily impacted by urban or suburban runoff (EPA 2005a). Impairment often occurs due to the high levels of contaminants being washed into surface waters during storm events, particularly urban areas where high amounts of impervious surface, such as rooftops, streets, sidewalks, driveways, and parking lots, prevent the infiltration of precipitation into the soil (Jennings and Jarnagin 2002). This runoff can result in higher in-stream concentrations of nutrients, such as phosphorous and nitrogen, total suspended solids (TSS), organic matter, heavy metals, oil and grease, and fecal coliform bacteria (Carle et al. 2005). As part of a 1983 study conducted through the Nationwide Urban Runoff Program (NURP), the United States Environmental Protection Agency (EPA) concluded that stormwater discharges from municipal storm sewers contained: ten times more total suspended solids than discharges from secondary wastewater treatment plants; higher chemical oxygen demand, total lead, total copper concentrations than secondary treatment plant effluent; and fecal coliform bacteria counts ranging from the tens to the hundreds of thousands per one hundred milliliters (64 FR 68725).

In addition to increased contamination, urban stormwater runoff can potentially alter the physical environment of streams and aquatic habitats. In a typical developed watershed, the rate and volume of stormwater runoff from the land surface increases. This increased flow can result in decreased groundwater recharge, rapid stream widening or down-cutting, increased bank erosion, and loss of the pool and riffle structure in streams (MDE 2000). Higher rates of runoff also increase the amount of sediment washed into surface waters from the land surface, which leads to a decline in the quality of in-stream habitat as the natural substrate is covered through sedimentation (Arnold and Gibbons 1996).

Overall, the biochemical and physical effects of urban stormwater runoff decrease the ecological health of aquatic communities and can result in the designated beneficial uses of a water body not being attained (64 FR 68724). The biological effects of polluted and sediment-laden stormwater include fish kills and the destruction of spawning and wildlife habitat. Polluted runoff can impact waters used for recreation and shellfishing and may cause navigational problems, the contamination of drinking water, and a loss of aesthetic value, all of which may have serious public health consequences or economic implications (EPA 2005a).

In coastal areas, stormwater runoff is mainly a concern due to its impacts on shellfishing and recreational uses of coastal waters. In 1995, the National Oceanic and Atmospheric Administration (NOAA) reported that harvesting was prohibited or restricted in 31% of United States shellfish growing areas (SGAs). Nearly one third of all regularly monitored recreational beaches were closed at some point during 2004 (Mallin 2006). The primary cause of these closures is the detection of high amounts of fecal coliform bacteria in coastal waters. In order to allow shellfish harvesting in a particular water body, the EPA requires that the geometric mean fecal coliform density is below 14 MPN per 100 milliliters of seawater. In recreational waters, seawater samples must have a geometric mean of fecal coliform of less than 35 MPN per 100 milliliters to be considered safe for swimming and other water-contact activities. The Center for Watershed Protection (1999) conducted an analysis that found that typical urban stormwater contains an average of 15,000 fecal coliform colonies per 100 milliliters, far above the water quality standards for these designated uses of coastal waters. While the study found a high degree of variability between samples from different storm events, even those taken from the same location, nearly all samples exceeded bacterial standards.

Coastal waters in North Carolina are not immune to the effects of urban stormwater runoff. In 2005, there were 56,446 acres of shellfishing waters closed to harvest, up from 52,000 acres in 1998. Also, 1,157 acres of Outstanding Resource Waters (ORW), a designation given to waters of exceptional ecological or recreational significance, have been closed to shellfishing since 1990 (Reeder 2005). Approximately ninety percent of these closed shellfishing areas in North Carolina show impacts from stormwater runoff (DWQ 2004). In 2001, seventy-two percent of swimming advisories for state beaches were due to excessive amounts of bacteria in recreational waters (NCNERR 2003). These high concentrations of fecal bacteria endanger public health and have detrimental economic effects on the state's commercial fishing,

recreational fishing, and tourism sectors. The population along the North Carolina coast is projected to grow by twenty percent between 1990 and 2010 (NCNERR 2003), which will only serve to exacerbate this problem because high bacterial counts in surface waters are closely linked to highly developed urban areas with high amounts of impervious surface (Mallin 2006).

The apparent link between stormwater runoff and these water quality issues led both the federal and state governments to begin regulatory programs to manage stormwater and mitigate these negative impacts. North Carolina began a state stormwater program in 1988, which included rules applying specifically to coastal shellfishing waters. The EPA also began the development of a comprehensive stormwater management program through the NPDES permitting program.

1.3 The National Pollutant Discharge Elimination System (NPDES) Stormwater Program

With the rise of the environmental movement in the United States, a number of progressive pieces of environmental legislation were passed by the U.S. Congress in the early 1970's. One of these was the Federal Water Pollution Control Act (33 USC §1251 et seq.), which was designed to address growing concerns regarding poor water quality around the country. It was later amended and renamed the Clean Water Act (CWA) in 1977. Section 402 of the CWA (33 USC §1342) established the basis for the NPDES program, which was to be administered by the EPA. This statute authorizes the EPA to regulate the discharge of pollutants into waters of the United States, prohibiting any discharge that is not permitted through the NPDES program.

Initially, the NPDES program targeted a variety of point sources of pollution for regulation, ranging from sewage treatment plants to industrial discharges. These efforts were largely successful; however, increasing concern over the significant adverse impacts of nonpoint source pollution on the nation's water quality led to further amendments of the CWA in 1987. These amendments required the development of a comprehensive program for stormwater management through the NPDES. The EPA responded by creating the NPDES stormwater program and developed rules to guide the process for permitting stormwater discharges from a number of sources.

The NPDES stormwater rules (40 CFR Parts 122-124) were implemented in two parts, Phase I and Phase II. The Phase I rules, promulgated in 1990, regulate stormwater discharges

from large and medium MS4s (serving populations of more than 250,000 and 100,000, respectively), large construction projects (disturbing more than five acres of land), and certain industrial activities, as required by Section 402(p)(1) of the CWA. The amendments to the CWA also required the EPA to develop criteria for the future designation of additional regulated stormwater discharges in Section 402(p)(6), which led to the Phase II stormwater rules being adopted on December 8, 1999 (64 FR 68731).

2.1 Overview of the Phase II Program

The federal Phase II final rule expanded on the Phase I stormwater program, in order to regulate additional stormwater discharges that negatively impact water quality. Small MS4s (serving less than 100,000 people) and small construction sites (disturbing between one and five acres of land) are regulated under these rules (64 FR 68722). The operators of small MS4s in urbanized areas, as indicated in the U.S. decennial census, and all small constructions sites are automatically designated as requiring a Phase II stormwater permit. The NPDES permitting authority, either the EPA regional office or an approved state government, must develop criteria for requiring additional entities to obtain a permit where stormwater controls are deemed necessary to protect water quality.

The Phase II construction program is primarily intended to address sediment runoff from construction sites and uses a permitting approach similar to that of the Phase I construction program, which requires the use of certain best management practices (BMPs) to control stormwater on regulated construction sites. On the other hand, the Phase II program for small MS4s takes a more novel approach to stormwater regulation. It requires the owner or operator of an MS4 to develop, implement, and enforce a stormwater management program designed to reduce the discharge of pollutants to the "maximum extent practicable," protect water quality, and satisfy the appropriate water quality requirements of the CWA. This stormwater management program must address six minimum measures: public education and outreach, public participation and involvement, illicit discharge detection and elimination, construction site runoff control, post-construction runoff control, and pollution prevention and good housekeeping (Table 1). A regulated entity must specify the BMPs it will implement to achieve measurable goals for each of these six minimum measures. Potential BMPs range from developing a public education program, to mapping the MS4 to assist in illicit discharge detection, to enforceable

ordinances limiting impervious surfaces in sensitive areas to control post-construction runoff (EPA 2005a).

The Phase II stormwater program for MS4s is designed to allow a flexible approach, in that specific BMPs are not required to be used as part of the permitted stormwater management program. The EPA provides a list of approved stormwater BMPs from which a municipality can select management practices to meet the six minimum measurements required by the Phase II rules (EPA 2007). This allows MS4 operators to choose the appropriate combination of BMPs that best address local water quality issues, rather than using a one-size-fits-all approach. Additionally, the Phase II rules support a watershed approach to stormwater management by encouraging neighboring or overlapping regulated jurisdictions to create a joint stormwater management plan for an entire watershed or sub-watershed, as opposed to the development of conflicting or redundant individual plans. This allows for a more ecosystem-based approach to stormwater management by encouraging the horizontal integration of county and local government planning efforts. Also, the rules allow a small MS4 operator to reference existing programs, such as state-level sediment and erosion control plans or county-level illicit discharge detection programs, to address the six minimum measures within their own management program. Again this avoids redundant management efforts and encourages some degree of cooperation between different levels of government (64 FR 68739).

While flexibility remains a key advantage of the Phase II rules, it is mandatory that a regulated entity develop a stormwater management program. The operator may be subject to enforcement actions, penalties, and potential lawsuits, if they are found to be out of compliance with permit requirements. The NPDES permitting authority also approves those BMPs proposed by the permit applicant and can require changes to the management program as part of the permit approval process. Additionally, an evaluation and assessment of the performance of the selected BMPs must be submitted periodically. Several of the minimum measures (illicit discharge detection, construction site runoff control, and post-construction runoff control) also require the adoption of enforceable ordinances, despite some concerns regarding whether all regulated entities have the legal authority adopt such ordinances (EPA 2005d).

Table 1: Summary of the six minimum measures required by the Phase II stormwater program and examples of corresponding best management practices (BMPs)

Minimum Measure	Requirements*	Potential BMPs**
Public Education and Outreach	Implement a public education program about stormwater	• Fact sheets or brochures • Recreational guides for outdoor activities • Educational programs in schools
Public Participation and Involvement	Comply with public notice requirements	• Public meetings/citizens panels • Volunteer water quality monitoring • Storm drain stenciling
Illicit Discharge Detection and Elimination	Develop an ordinance to prohibit illicit discharges and develop a storm sewer map	• Used oil recycling program • Septic system failure prevention program • Illicit discharge hotline
Construction Site Runoff Controls	Develop an ordinance to enforce proper erosion and sediment controls	• Contractor training and certification • Municipal construction inspection program • Structural runoff controls on construction sites
Post-construction Runoff Controls	Regulatory mechanism requiring the implementation of post-construction runoff controls	• Adequate site planning procedures • Minimization of disturbance and imperviousness • Structural stormwater treatment
Pollution Prevention and Good Housekeeping	Develop and operation and maintenance plan to prevent pollutant runoff from municipal operations and train staff	• Set maintenance schedules and long-term inspections procedures • Develop procedures for proper disposal of waste • Programs to minimize the use of pesticides and to ensure proper disposal of animal waste

* (EPA 2005b, EPA 2005c, EPA 2005e, EPA 2005f, EPA 2005g, EPA 2005h)
** (EPA 2007)

2.2 North Carolina Phase II Rules

The final Phase II rule promulgated by the EPA on December 8, 1999 required that all designated small MS4s obtain permit coverage from their NPDES permitting authority by March 10, 2003 (64 FR 68843). North Carolina is authorized to administer the NPDES program by the EPA, and the EMC has been given statutory authority by the North Carolina General Assembly as the NPDES permitting authority for the state (GS 143-215.3). The EMC began issuing Phase I permits in 1992, and was authorized to develop new administrative rules for the implementation of the Phase II stormwater program (NCDENR 2003). The EMC approved temporary rules in November 2002 (17 NC Register 960), initiating a lengthy administrative rule-making process over the next several years, which included the rejection of the rules by the North Carolina Rules Review Commission (RRC), temporary Phase II legislation being adopted (SL 2004-163), and a lawsuit being filed by the EMC (Envtl. Mgmt. Comm'n v. Rules Review Comm'n). The process eventually culminated in a legislative review of final Phase II stormwater rules, conducted by the North Carolina General Assembly in July 2006. Various interest groups were able to assert themselves in the rule-making process by negotiating the details of a bill to finalize the Phase II program for North Carolina. These negotiations resulted in the passage of Session Law 2006-246, which outlines specific requirements for issuing Phase II stormwater permits in North Carolina. Section 15 of the law states that any additional administrative rule-making will remain substantively the same as the rules outlined in the legislation (SL 2006-246).

The North Carolina Phase II stormwater rules will go into effect on July 1, 2007. These rules will serve to:

- implement the federal Phase II stormwater program requirements (40 CFR Part 122),
- provide the criteria for the delineation of regulated coverage areas and designation of regulated entities,
- outline the requirements for petitioning the EMC to include additional entities,
- specifically define the post-construction requirements for Phase II jurisdictions,
- describe waivers, exemptions, and exceptions from the requirements of the rules, and
- establish the legal authority for the development of local ordinances to enforce the Phase II stormwater management program (SL 2006-246).

In North Carolina, the designation of regulated entities may occur in one of four ways. The EPA automatically designates municipalities located in urbanized areas, as indicated by the

U.S. decennial census (64 FR 68722). An MS4 can be designated by the EMC based on the population, growth rate, and housing density within its jurisdiction, or due to water quality impacts of stormwater discharged from the MS4. State designations are updated as part of basin-wide water quality management planning that occurs every five years for each river basin in North Carolina (GS 143-215.8B). Also, when the stormwater discharge from an MS4 is listed as pollutant source in Total Maximum Daily Load (TMDL) plan, it is required to obtain a Phase II permit. Finally, any person may petition the EMC to require any person or operator of an MS4 that discharges stormwater to obtain a Phase II NPDES permit (SL 2006-246).

The requirements for compliance with the post-construction minimum measure in North Carolina are explicitly defined within the 2006 session law. These rules must be implemented within the jurisdiction of any MS4 designated as a regulated entity, as well as in other delineated coverage areas surrounding those designated entities. Because watersheds with as little as 10% impervious cover have shown degraded water quality (Schueler 1994), the post-construction requirements are based on limiting the amount of impervious surfaces created through new development projects that disturb one acre or more of land. Development is defined as "any land-disturbing activity that increases the amount of built-upon area or that otherwise decreases the infiltration of precipitation into the soil" (SL 2006-246). Projects are considered either low or high density depending on the percentage of built-upon area created through development. A project is defined as low-density if it is located within one-half mile of shellfishing waters and contains less than 12% impervious surface, or it is located more than one-half mile from shellfishing waters and contains less than 24% impervious surface. While low-density projects require only the use of vegetated conveyances to transport stormwater from the project site, all other projects are considered high-density and must use structural stormwater management systems meeting certain engineering specifications to treat and control stormwater runoff from the project site. In order to further protect water quality in shellfishing waters on the coast, the rules also prohibit new points of stormwater discharge to these waters, require the use of BMPs that increase fecal coliform die-off for structural systems, and require the implementation of a program to control sources of fecal coliform bacteria, such as a pet waste management or on-site sewage maintenance program (SL 2006-246).

While regulated entities must implement all six minimum measures within their jurisdiction, North Carolina requires other areas to meet only the Phase II post-construction

requirements outlined above, including the unincorporated area surrounding the jurisdiction served by a regulated MS4 in an urbanized area. Also, these requirements apply in certain regulated coverage areas surrounding an entity designated by the state. Counties that contain an urbanized area and meet other criteria must also enforce the post-construction measures in all unincorporated areas of the county, as must all incorporated municipalities within those counties (SL 2006-246).

3.1 Phase II Stormwater Petitions

Section 101(e) of the CWA reads: "Public participation in the development, revision, and enforcement of any regulation, standard, effluent limitation, plan, or program established by the Administrator or any State under this Act shall be provided for, encouraged, and assisted by the Administrator and the States" (33 USC §1251 et seq.). This establishes a national policy of public participation in the protection of water quality in the United States. The EPA has accordingly incorporated elements of public participation within the minimum measures of the Phase II stormwater program. Additionally, the EPA included a process within the NPDES stormwater rules through which the public may petition the permitting authority to require a stormwater permit. This provision was included because the agency "believes that public involvement is an important component of the NPDES program for stormwater and this provision encourages public participation" (64 FR 68746).

The federal Phase I stormwater rules stated that petitions may be submitted to the NPDES permitting authority to request that an entity be regulated under an NPDES stormwater permit in one of two ways (40 CFR Part 122.26(f)). First, the operator of a regulated MS4 may petition to have a separate permit required for any stormwater discharge that flows into the MS4. Second, any person may petition the NPDES permitting authority to require a permit for a stormwater discharge that contributes to the violation of a water quality standard or is a significant contributor of pollutants to waters of the United States or to designate of any large, medium, or small MS4 as regulated under the program. The Phase II rules carry over these provisions of the Phase I program and reiterate the fact that the operator or owner of a small MS4 may be the subject of a petition (40 CFR Part 122.32(b)).

Some state NPDES authorities in the southeast and mid-Atlantic regions, including Georgia, South Carolina, Maryland, and Delaware, do not specify any petition requirements in

their Phase II stormwater rules, while other states explicitly address petitions in their administrative code and supply criteria upon which determinations to require a permit will be made. In Virginia, the Phase II stormwater rules are implemented through the Virginia Pollutant Discharge Elimination System (VPDES), which provides minimal guidance regarding petitions. The Virginia Administrative Code (VAC) simply indicates the appropriate authority to receive a petition in Virginia and restates the federal rules (4 VAC 50-60-380). The Florida Administrative Code (FAC) outlines basic criteria to be used when considering a petition for the designation of an unregulated MS4. These criteria are based on the classification of the receiving waters of the discharge or the contribution of the MS4 to the pollutant load of an interconnected MS4 that was previously regulated (FAC 62-624.800).

The Washington State Department of Ecology provides a bit more detail on Phase II stormwater petitions and has developed criteria for evaluating a petition based on six factors:

- Factor 1: Does the municipal separate storm sewer discharge stormwater to impaired or sensitive waters?
- Factor 2: Is the municipal separate storm sewer a significant contributor of pollutants to waters of the United States?
- Factor 3: Does the municipal separate storm sewer serve a substantial population or area?
- Factor 4: Is the municipal separate storm sewer located contiguously to an already regulated municipal storm sewer?
- Factor 5: Is the municipal storm sewer physically interconnected to another, already regulated municipal storm sewer?
- Factor 6: Are the water quality impacts of municipal separate storm sewer already being addressed under other regulations of programs?

In order to address these factors, a petitioner would need to present information regarding water quality monitoring, the pollutant load of the discharge, landscape characteristics, population and growth statistics, and existing stormwater programs. The sixth factor allows the owner or operator the MS4 subject to the petition to show that the municipality already meets the requirements of the six minimum measures through existing programs, and in this way may be exempted from obtaining a permit (WDOE 2007).

Currently, no petition for the designation of an unregulated MS4 has been received by the NPDES permitting authority in any of these states. In North Carolina, a Phase I stormwater

petition was submitted in 2001 by the North Carolina Coastal Federation regarding the East-West Brunswick County Regional Wastewater Treatment facilities (WWRI 2001). However, no Phase II stormwater petitions have yet been submitted, despite the fact that the temporary Phase II rules and legislation (SL 2004-163) included similar petition requirements several years ago. The uncertainty surrounding the implementation of the Phase II rules in the state may have discouraged prior efforts to compile the necessary data for the submission of a Phase II petition; however, the current legislation should alleviate this uncertainty.

3.2 North Carolina Phase II Petition Requirements

Two types of petitions are allowed within the context of the North Carolina Phase II petition rules (Appendix A). First, a connected discharge petition may be submitted by the operator of a regulated MS4 to request that the EMC require a separate permit for a person who discharges into that MS4. Second, an adverse impact petition allows any person to petition the EMC to require a permit for any previously unregulated MS4 or stormwater discharge. The rules outline the criteria for granting a petition and the required evidence needed for an adverse impact petition, which includes elements similar to those considered by the Washington State Department of Ecology in evaluating petitions. A set of guidelines and time frames for petition submission and administration are included as well.

Section 6(2)(a) of the 2006 session law lists three primary criteria, based on which the EMC will grant an adverse impact petition and require a Phase II permit. Petitions are evaluated based on whether or not:

- the MS4 discharges or has the potential to discharge stormwater that may cause or contribute to a water quality standard violation,
- the MS4 provides a significant contribution of pollutants to receiving waters,
- the MS4 is specifically listed by name as a source of pollutants in a total maximum daily load (TMDL) implementation plan.

In order to meet one of the first two criteria, the petitioner must demonstrate that there is a link between the pollutants in the stormwater discharge and the receiving water impairment, or that the MS4 discharge is a "significant contributor of pollutants." The third criterion is slightly less burdensome because documentation of the MS4 being listed in a TMDL implementation plan may be sufficient. However, the TMDL criterion is likely to be less useful for the purpose of

petitioning after the state designation of regulated entities is complete. According to Section 5(3) of SL 2006-246 the state will designate all MS4s listed as a pollutant source in TMDL plans as requiring a permit, practically eliminating the need for a petition regarding these entities after the Phase II program has been fully implemented.

For an adverse impact petition, a great deal of evidence must be compiled, including background information, technical literature, and geographic, land use, and water quality data, in order to make the required showing to the NPDES permitting authority regarding the need for a Phase II permit. Section 6(2)(b) outlines the types of evidence necessary to show that a MS4 meets one of the first two criteria for petition evaluation. The requirements include:

- Monitoring data that includes, at a minimum, representative sampling of the municipal separate storm sewer system (MS4) or discharge and information describing how the sampling is representative. The petitioner must notify the owner or operator of the municipal separate storm sewer system (MS4) or the person who discharges stormwater of its intent to conduct monitoring activities prior to conducting those activities.
- Scientific or technical literature that supports the sampling methods.
- Study and technical information on land uses in the drainage area and the characteristics of stormwater runoff from these land uses.
- A map that delineates the drainage area of the petitioned entity; the location of sampling stations; the location of the stormwater outfalls in the adjacent area of the sampling locations; general features, including, but not limited to, surface waters, major roads, and political boundaries; and areas of concern regarding water quality.
- For stormwater discharges to impaired waters, documentation that the receiving waters are impaired or degraded and monitoring data that demonstrates that the municipal separate storm sewer system (MS4) or discharge contributes pollutants for which the waters are impaired or degraded.
- For stormwater discharges to nonimpaired waters, monitoring data that demonstrates that the owner or operator of the municipal separate storm sewer system (MS4) or the person who discharges stormwater is a significant contributor of pollutants to the receiving waters.

The final two requirements are related directly to the criteria for granting a petition. If the MS4 discharges to impaired waters, one must show a link between the characteristics of the discharge

and the impairment of the receiving waters. This shows, in effect, that the MS4 "discharges or has the potential to discharge stormwater that may cause or contribute to a water quality standard violation." When the MS4 discharges to nonimpaired waters, one must show that the discharge is a significant source of pollutants, essentially echoing the second criteria for granting a petition.

Section 6(2)(c) provides the EMC with a mechanism to deny the petition if it finds that existing water quality programs offset the need for a Phase II permit for the MS4. This rule will allow the EMC to exercise its discretion in granting a petition, even if the required factual showing is made, thus placing a larger burden of proof on the petitioner. Procedurally, the EMC must also accept public comments on a petition, which allows the opportunity for the operator of an MS4 to challenge a petition based on existing measures that may be in place to address stormwater runoff within their jurisdiction. In order to resist such challenges, and make the strongest possible case for requiring a permit, it is important for the petitioner to demonstrate that existing stormwater programs are ineffective in protecting water quality, although this is not specifically required by the Phase II petition rules. It is also useful to show that the six minimum measures of the Phase II program can benefit stormwater management efforts if a permit is required for an MS4 or discharge.

4.1 Phase II Petition Methodology

In order to address the previously discussed aspects of the Phase II petition requirements, a methodology for the development of an adverse impact petition (Fig. 1) was created. There are three stages in the petition methodology: background research, stormwater discharge monitoring, and petition submission. In the first stage, it is essential to determine the viability of a petition based on in-depth background research, prior to beginning any stormwater discharge monitoring. This second stage of the process should not be undertaken if it appears unlikely that a petition would be viable, in order to avoid investing time and money in completing a petition project that is likely to be unsuccessful. The final stage involves compiling and summarizing all of the relevant information and data gathered throughout the development of the petition. General background information, potential sources of relevant data, and guidance regarding the petition process will be addressed, based on the development of a Phase II petition for an MS4 located on the North Carolina coast. A case study of the preliminary application of this methodology for the coastal town of Morehead City, NC will be discussed in later sections.

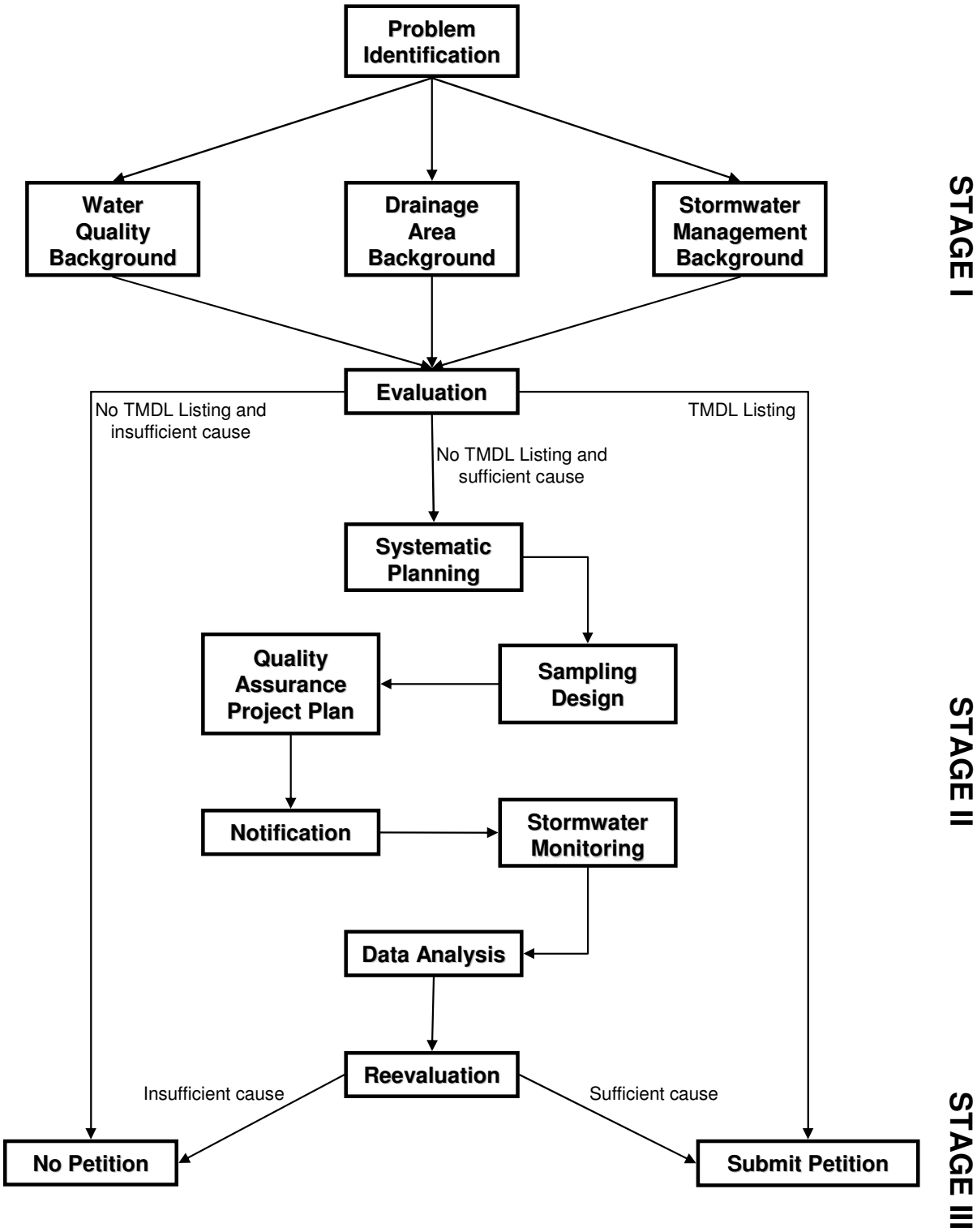

Problem Identification
Water Quality Background
Drainage Area Background
Stormwater Management Background
STAGE I
Evaluation
No TMDL Listing and insufficient cause
TMDL Listing
No TMDL Listing and sufficient cause
Systematic Planning
Quality Assurance Project Plan
Sampling Design
Notification
Stormwater Monitoring
STAGE II
Data Analysis
Reevaluation
Insufficient cause
Sufficient cause
No Petition
Submit Petition
STAGE III

Figure 1: Phase II stormwater program adverse impact petition model: Stage I- Background Research, Stage II- Stormwater Monitoring, and Stage III- Petition Submission

4.2 Phase II Petition Methodology: Stage I- Background Research

The first stage of the Phase II petition methodology involves identifying the petition subject, evaluating background information regarding the quality of receiving waters, the characteristics of the drainage area, and existing stormwater programs operating within the jurisdiction served by the MS4 in question.

4.2.1 Problem Identification

Identifying a potential stormwater quality issue and the source of stormwater discharge is the first step in the process of developing a Phase II NPDES adverse impact petition. This could include noting increased closures of shellfishing waters in the areas surrounding a town operating an MS4, high amounts of development in an area with particularly sensitive or exceptional coastal waters, or even repeated swimming closures near a certain stormwater outfall. This step is an informal identification of a water quality problem that could potentially be addressed through a Phase II petition, as opposed to a formal definition of a specific problem. It primarily involves identifying the stormwater discharge of concern, the jurisdiction of the MS4, and the owner or operator of the system. This initial identification catalyzes the background investigation that allows the petitioner to more specifically define the water quality problems in the area that may be related to stormwater discharges.

4.2.2 Water Quality Background Information

In North Carolina, all surface waters are given particular classifications given the existing or potential uses of the water body, which are assigned by the North Carolina Division of Water Quality (DWQ) under the authority of the EMC (15A NCAC 02B). Water quality standards for a variety of characteristics, ranging from pollutants to temperature, are assigned for each of these classifications. There are primary freshwater and tidal saltwater classifications, as well as supplemental classifications that impose more stringent water quality standards to protect unique or important uses.

On the coast, the most basic saltwater classification is SC, which is assigned to those waters used for secondary recreation (no contact), fishing, and the propagation and survival of aquatic life. All saltwaters must be classified to protect these uses at a minimum. In waters with

the SB classification, all SC uses, as well as primary recreation uses such as swimming must be protected. In SA waters, shellfish harvesting must be protected in addition to all other saltwater uses. There is also a SWL classification for all coastal wetlands and those wetland areas located adjacent to estuarine waters. The supplemental classifications that may apply to saltwater bodies include High Quality Waters (HQW), Outstanding Resource Waters (ORW), Nutrient Sensitive Waters (NSW), and Swamp Waters (Sw). In addition to primary nursery areas delineated by the North Carolina Division of Marine Fisheries (DMF) and those water bodies rated as Excellent by the Division of Water Quality, all SA waters are classified as HQW. Waters considered to be of exceptional significance and requiring special protection are classified as ORW, while waters requiring limits on nutrient inputs are considered NSW and waters of very low flow receive the supplemental Sw classification.

Water quality standards are assigned to each use classification by DWQ (Appendix B), as outlined in the North Carolina Administrative Code (15A NCAC 02B .0220 - .0225). These rules specify the values of water quality parameters, above or below which the designated beneficial use of the water is impaired. Existing water quality data can be compared to these standards in order to determine if there is a water quality violation occurring in the receiving waters or stormwater discharges of an MS4.

In order to characterize the water quality problems potentially caused by an MS4 discharge, as much information as possible should be collected regarding the water quality issues in its receiving waters. Existing water quality monitoring data and other information can be obtained from a variety of sources, which include the municipality itself, government agencies, research institutions, and non-governmental groups. The MS4 operator, often the town manager or public works department administrator, can be an important information source in identifying local water quality issues, and contact with the municipality also creates the opportunity for the development of a cooperative relationship. However, the degree of cooperation and amount of available information will vary widely. Other sources for local water quality information, many of which are available online, include:

- *CAMA Land Use Plans*- In North Carolina, each of the 20 coastal counties and many municipalities have land use plans, which were implemented in accordance with the Coastal Area Management Act (CAMA). These contain information regarding environmental issues facing coastal communities and land use policies that attempt to

address these concerns. Plans can be obtained from the municipal government, and many draft plans are available on the North Carolina Division of Coastal Management website (http://dcm2.enr.state.nc.us/Planning/under_review.htm).

- *Basinwide Planning Reports*- The water quality and use support ratings of the water bodies within each of the 17 river basins in North Carolina is assessed on a five-year cycle through the basinwide planning process. These reports contain data from ambient water quality monitoring stations and narrative descriptions of impaired water bodies. They are used to develop the 303(d) Integrated Report of Impaired Waters and prioritize the development of TMDL plans (DWQ 2007a). These reports can also be obtained online (http://h2o.enr.state.nc.us/basinwide/index.htm).
- *Section 303(d) List of Impaired Water Bodies*- This list includes a map and description of all water bodies that do not meet the water quality standards based on their beneficial use classification (http://h2o.enr.state.nc.us/tmdl/General_303d.htm).
- *Total Maximum Daily Load (TMDL) plans*- These plans guide the restoration of designated uses to these water bodies in the state. A list of TMDL field studies and final or draft plans can be found online (http://h2o.enr.state.nc.us/tmdl/TMDL_list.htm).
- *Shellfish Sanitation Surveys*- These reports summarize the results of surveys of delineated Shellfish Growing Areas (SGAs) along the coast, conducted every three years by the Shellfish Sanitation and Recreational Water Quality Section of the North Carolina Department of Environmental Health (DEH). This includes a hydrographic and a shoreline survey, as well as bacteriological data from monitoring stations in each SGA. These reports include maps of potential sources of pollution and closed shellfishing waters, providing documentation of degraded or impaired waters that are not meeting their designated use. Digital and paper copies of these reports can be obtained from the agency and maps of prohibited shellfishing areas are available online (http://www.deh.enr.state.nc.us/shellfish).
- *Federal Government Agencies*- The EPA and the United States Geological Survey (USGS) provide access to data collected at various monitoring stations around the country for a variety of water quality parameters and stream characteristics (http://www.epa.gov/storet and http://nc.water.usgs.gov). The usefulness of these

data may depend on the pollutant of concern, as certain water quality parameters are not tested at all monitoring stations.

- *Research institutions, non-governmental agencies, and volunteer monitoring projects*- This data may not be as easily accessible as that provided by public agencies; however, it can potentially be obtained by contacting the organizations directly.

4.2.3 Drainage Area Background

Background information regarding the characteristics of the drainage area is specifically required by the Phase II petition rules, including maps delineating the drainage area and maps of general geographic features such as political jurisdictions, important natural features, and the storm sewer infrastructure. Also, land use maps are necessary in order to assess the important land uses within the jurisdiction of the MS4 and to evaluate the characteristics of stormwater typically associated with those land uses. Additional data may exist regarding other important characteristics of the jurisdiction of the MS4. Population statistics, growth estimates and development trends can be found in CAMA land use plans and are also available through the North Carolina Department of Population and Statistics and the U.S. Census Bureau. These factors are considered as part of the state designation process and may provide valuable supporting evidence for a petition, as high rates of growth and development may signal the potential for future stormwater quality problems.

Hard copies of most geographic data can be obtained from municipal government planning departments, county government tax departments, and state agencies such as the Shellfish Sanitation and Recreational Water Quality Section. However, a large amount data is becoming more readily available in digital formats (Table 2), which can be extremely advantageous to the petitioner, if geospatial analysis software is available. The capability to manipulate geospatial data can allow for better visual depictions of the drainage area characteristics through map overlays and variations of scale. Also, more complex analyses can be performed, including the estimation of impervious surface area and delineation of sub-basins within the overall drainage basin of the MS4. Much of this geospatial data is available over the internet and from government agencies; however, care should be taken to obtain metadata for all data to ensure it is of high quality and that accurate analyses and overlays can be performed.

Table 2: Geospatial data sources for relevant drainage area characteristics

Data Source	Web Address	Description
NC One Map	www.nconemap.com	Numerous political, manmade, and natural feature shapefiles
NOAA C-CAP Program	http://www.csc.noaa.gov/crs/lca/ccap.html	Land use/land cover analysis and trends
National Land Cover Database	http://www.epa.gov/mrlc/nlcd.html	Land use/land cover data for the United States
Shellfish Sanitation Section	http://www.deh.enr.state.nc.us/shellfish	Closed and prohibited shellfish harvesting areas
County Government GIS Departments	N/A	Aerial photos, tax maps, general features
Municipal Government Planning Departments	N/A	Storm sewer infrastructure, existing land use maps

In addition to land use data, soil surveys from the Natural Resources Conservation Service, meteorological data from the National Weather Service, and hydrographic data are also relevant in assessing drainage area characteristics that affect the potential for significant impacts due to stormwater runoff. Based on these drainage basin characteristics and land use information, the scientific and technical literature should be examined to determine typical constituent pollutants, pollutant concentrations, and rates of runoff or discharge for MS4 drainage areas with similar characteristics, as specified in the Phase II petition rules.

4.2.4 Stormwater Management Background

According to the petition rules, the EMC may deny a petition if it determines that existing stormwater management programs effectively protect water quality and offset the need for a Phase II stormwater permit. Thus, information regarding existing management programs operating within the area served by the MS4 in question should be examined. In North Carolina, regulatory programs exist at the state level to manage stormwater, and local governments may also adopt their own stormwater management measures, as long as they are at least as stringent as the state rules.

In the 20 coastal counties of North Carolina, the state coastal stormwater rules apply to new development, and are designed similarly to the post-construction requirements of the Phase II program, in that the rules are based on low- and high-density development options and the

proximity of development to sensitive receiving waters. However, the coastal stormwater rules are much less stringent than the Phase II rules, and the DWQ has admitted that the program has been ineffective in protecting coastal water quality from the impacts of stormwater runoff since their implementation in the late 1980's (Reeder 2005). Currently proposed amendments to the coastal stormwater program would change these rules to mirror the post-construction requirements of the Phase II stormwater rules. It is estimated that these rules could potentially become effective in mid- to late 2008 (Reeder 2007).

Several other programs exist within the state that address stormwater runoff concerns for certain surface water classifications or particular water bodies. For example, specific post-construction requirements also apply in water supply watersheds and near ORW or HQW waters. Also, the nutrient reduction strategies for the Neuse and Tar-Pamlico river basins include more stringent riparian buffer rules and require stormwater management programs to be developed by municipalities and counties located in these watersheds (15A NCAC 02B .0200). These programs apply only in certain areas along the North Carolina coast.

The EMC recently approved rules for the Universal Stormwater Management Program (USMP) that became effective on January 1, 2007 (15A NCAC 02H .0120). The goal of the USMP is to provide a single management program that may be voluntarily adopted by a municipality, through which the community will be considered compliant with the post-construction requirements of all other stormwater management programs within the state. In particular, the rules can simplify stormwater management for jurisdictions that may be located in areas of overlapping coverage by multiple stormwater programs. These rules differ from other stormwater management programs in the state, in that they rely on engineered stormwater controls, rather than low- and high-density development options, and cap the impervious surface area allowed within 575 feet of shellfishing waters at 36 percent. In the coastal counties, a local government may request that DWQ implement and administer this program within their jurisdiction.

At a minimum, the requirements of the coastal stormwater rules must be met in all of the coastal counties. However, in some areas, more stringent state programs will apply, and local governments may adopt stormwater management ordinances within their own jurisdictions. CAMA land use plans are an important information source regarding local stormwater management policies, although these policies are generally just guidelines, as opposed to

enforceable ordinances. Local ordinances should be examined to determine if there is a local stormwater management program operating within the jurisdiction of the MS4, and the implementation of any stormwater BMPs by the municipality should be explored.

4.2.5 Evaluation

Once all the relevant background information has been gathered, an initial evaluation of the data collected in this stage should be conducted in order to decide how to proceed. The purpose of this step is to analyze the background information to determine whether the submission of a petition is justified and whether a stormwater monitoring study will be needed. Generally, this evaluation can be based on the following assessment questions:

- *Is the MS4 listed as a pollutant source in a TMDL implementation plan?*

  The Modeling and TMDL Unit of the DWQ is responsible for developing TMDLs for waters listed in the integrated 303(d) report of impaired water bodies and for writing implementation plans to guide the restoration of designated uses to these water bodies (DWQ 2007b). Each of these TMDL plans contains a section listing pollutant sources, and some include a load allocation for specific sources of the pollutant of concern.
- *Do receiving waters show evidence of water quality standards violations or degradation, or does the MS4 drain to water bodies listed as impaired?*

  Based on existing water quality data and the appropriate water quality standards, a determination should be made as to whether or not the designated uses of the receiving waters of the MS4 are impaired. This may involve the comparison of raw monitoring data to water quality standards, finding state agency documentation of impairment, or showing degradation evidenced by the presence of closed or conditionally approved shellfishing areas.
- *Based on the typical characteristics of stormwater runoff from the land uses found within the drainage basin, is stormwater likely to contribute to the degradation of surface waters?*

  In examining land use and land cover data, the extent and importance of different land uses within the jurisdiction should be considered in order to generally analyze pollutant contributions from the MS4 discharge to receiving waters. Based on any existing discharge monitoring data, or typical values from scientific or technical

literature, a determination should be as to the likelihood that the stormwater discharge is contributing to or causing a water quality violation.

- *Are existing stormwater programs within the jurisdiction effectively protecting water quality and will the Phase II program improve stormwater management practices?*

  Any local stormwater management programs must be taken into account when evaluating the potential of a petition. The overall effectiveness of existing programs will have to be evaluated on a case-by-case basis, and in each case, the improvements offered by the Phase II program should also be considered.

If the MS4 in question is specifically listed by name as a pollutant source in a TMDL implementation plan, then the third petition criterion is met, and a petition would be justified. Existing water quality information and maps can be used to supplement documentation in a TMDL as cause for requiring a permit, and the process would move directly to the petition submission stage (see Fig. 1). While it would seem unlikely, even if the MS4 is listed in a TMDL plan, the EMC may still deny the petition if it determines that existing programs are protecting water quality (SL 2006-246, Section 6(3)). Thus, it becomes important in this case to show that existing stormwater management programs are ineffective.

When the MS4 is not listed in a TMDL plan, the remaining three assessment questions regarding background information should be carefully examined. A determination must be made as to whether or not the background information supports a decision to continue to the second stage of the petition process. If water quality information does not show any significant degradation of surface waters or it seems unlikely that stormwater discharges are contributing pollutants to receiving waters, it may be more difficult to adequately demonstrate the need to require a Phase II permit for the MS4. In areas where existing storm water management programs closely resemble the Phase II program requirements, as in the case of the USMP, the EMC may be likely to deny the petition based on the water quality protection offset found in the Phase II rules. Therefore, these factors must be considered prior to continuing to the second stage of the petition process. Collection of background data, while time-consuming, costs relatively little. However, due to the labor-intensive and costly nature of a stormwater monitoring study, it may not be practical to invest time and money in collecting monitoring data if there does not initially appear to be sufficient cause to require a permit. Based on the judgment of the petitioner, if a Phase II petition appears to be unjustified for whatever reason, no

petition should be submitted. On the other hand, if the background research indicates that a permit appears to be justified, then the petitioner should move into the second stage of the petition process: the design and implementation of a stormwater discharge monitoring project.

4.3 Phase II Petition Methodology: Stage II- Stormwater Monitoring

The second stage of a Phase II petition involves planning and implementing a monitoring study to characterize the stormwater quality of discharges from the MS4 of interest. This stage involves a considerable degree of planning based on previously collected background information and may involve recruiting and training a team of volunteers to perform sample collection activities. These activities will include systematic planning of the monitoring project, development of a sampling design, writing a Quality Assurance Project Plan (QAPP), notifying the petition subject of monitoring activities, implementation of the monitoring program, and conducting data analysis.

4.3.1 Systematic Planning

The Phase II petition rules require that stormwater discharge monitoring data be presented with the petition that includes "at a minimum, representative sampling of the municipal separate storm sewer system (MS4) or discharge" (SL 2006-246). This sampling will allow the characterization of the types and amounts of pollutants in the discharge and an analysis of its water quality impacts (EPA 1992). A monitoring study requires the development of a sampling design, establishment of field and laboratory procedures, and definition of data quality objectives; however, the most important part of designing the project is the development of written study objectives and determining why the data are needed. Careful planning is then needed, based on preliminary problem assessments, regulatory mandates, and available resources, to ensure that the study objectives are met (Burton and Pitt 2002).

When planning a monitoring project, it is essential to take measures to ensure that high quality data is collected in support of the petition. It is likely that monitoring will be performed by individuals or volunteer groups working outside of governmental agencies. These types of projects, which then seek to apply study results within a regulatory decision-making process, will constantly deal with skepticism regarding the validity of the data (EPA 1996). For this reason, the EPA has developed non-regulatory guidance for the systematic planning of environmental

studies (EPA 2006) as part of a series of guidance documents regarding quality assurance in the collection of environmental data. These documents, which can be found on the EPA website (http://www.epa.gov/quality/qa_docs.html#guidance), provide assistance in preparing a plan that explicitly addresses setting project goals, developing data quality objectives, designing a sampling plan, outlining standard operating procedures for data collection, and implementing monitoring activities. This information is intended to be included in a QAPP, which can be examined by decision-makers to allow them to better evaluate the credibility of the data.

The systematic planning process (Fig. 2) can be applied in the design of a stormwater quality monitoring project. The first two steps, in which the problem is identified and the goals of the study are developed, are critical to developing a project that will obtain the proper data necessary to answer the study question. The following steps involve defining the data requirements, analytical techniques and scale of the study based on these study goals. While these decisions are all relatively qualitative, the final two steps are more quantitative in nature. These require the definition of data quality objectives and the development of a sampling design. The outputs from each step in the process can be directly applied to the development of a QAPP (EPA 2006). The first six steps of the systematic planning process will be discussed briefly in the context of a Phase II petition stormwater monitoring project. Sampling design will be addressed more specifically in Section 4.3.2. The EPA publication *Guidance on Systematic Planning Using the Data Quality Objectives Process* provides more detailed information on each of these steps in the data quality objectives process (EPA 2006).

Data Quality Objectives Process: Step 1- State the Problem

In the initial step of the systematic planning process, a description of the problem is formulated. This step will include a description of the water quality problem and the formulation of a conceptual model that describes the potential sources, transport processes and, potential hazards of the pollutants in the stormwater discharge, largely based on previously collected background information. Also, any resource limitations, the deadlines for collecting data, and potential sampling constraints, such as access, seasonality, and physical location of discharges, should be considered (EPA 2006).

The pollutant in the MS4 discharge that is suspected of causing or having the potential to cause water quality violations should be clearly identified in this step. Background information regarding impaired receiving waters, surface water classifications, and the expected

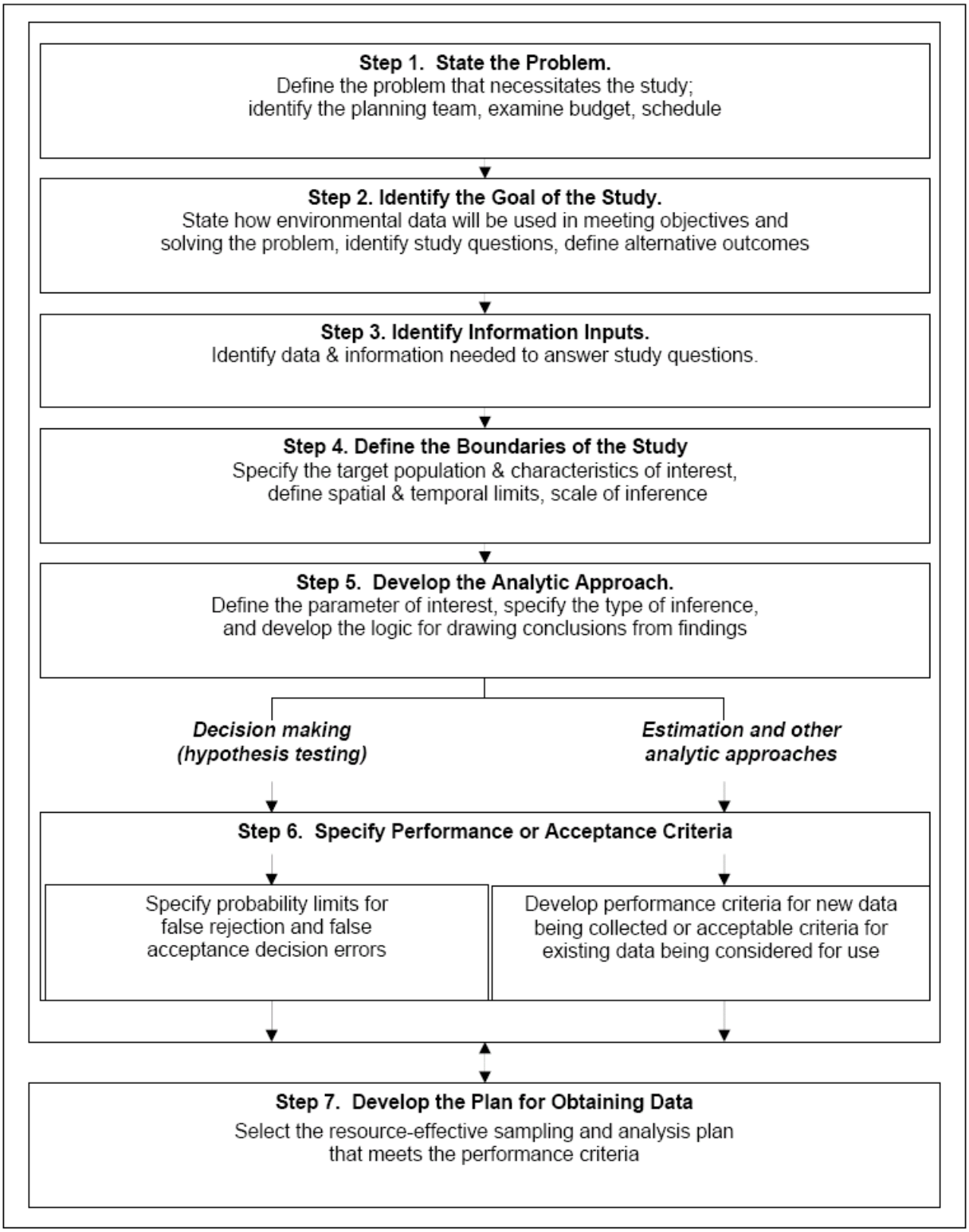


Figure 2: The Data Quality Objective Process (EPA 2006)

characteristics of the discharge is essential in making this determination. In light of the limited resources that are likely to be available for the monitoring project, it would be most effective to target a pollutant that is listed as a cause of impairment in receiving waters, with the goal of establishing a clear link between the water quality impairment and the pollutants contributed by the stormwater discharge. Focusing on a single pollutant will also be more efficient in reducing the costs of laboratory testing procedures, which could be significant.

Data Quality Objectives Process: Step 2- Identify the Goal of the Study

The study question should be clearly defined at this point in the planning process. Although the monitoring study is a part of the overall petition project, the study question should focus more narrowly on the goals of the monitoring effort itself. The purpose of monitoring will most likely be to estimate the concentration or load of a particular pollutant in the stormwater discharges from the MS4 subject to the petition. The potential outcomes of the monitoring study (high/low concentrations, above/below water quality standards) should be considered and stated, as well as any prior assumptions about the findings of the study.

Data Quality Objectives Process: Step 3- Identify the Information Inputs

Data requirements should be explicitly defined, and the use of existing data sources should be considered. Water quality, meteorological, hydrographic, geographic, and land use data, most of which will have been gathered in the first stage of the petition process, will be relevant to planning the monitoring project and developing a sampling plan. New data collection efforts will focus on acquiring monitoring data on pollutant concentrations and flow rates of the stormwater discharge, and potentially other variables of interest (EPA 2006).

Analytical methods for measuring the variables of interest should be outlined in this step. The EPA specifies the required procedures for the analysis of environmental pollutants in the Code of Federal Regulations. These regulations include information on sampling techniques (automatic or manual), required collection container materials (glass, plastic, etc.), and laboratory procedures for a variety of water pollutants (40 CFR Part 136). Most likely, a monitoring study for the purposes of a petition will use grab sampling methods due to the high costs of automatic sampling equipment. Numerous other technical resources exist that describe field and laboratory methods for the collection and analysis of water samples. These include the *Standard Methods for the Examination of Water and Wastewater* (APHA 1998), the *Stormwater Effects Handbook* (Burton and Pitt 2002), the EPA report *Microbiological Methods for*

Monitoring the Environment: Water and Wastes (EPA 1978), and the *NPDES Stormwater Sampling Guidance Document* (EPA 1992), among many others. If financial resources permit, state-certified laboratories should be contracted to conduct lab analysis of stormwater discharge samples, in order to enhance the credibility of the test results. These laboratories have their own QAPP for laboratory testing procedures and sample handling in order to ensure the quality of the data. A list of laboratories certified by DWQ is included in Appendix C.

Data Quality Objectives Process: Step 4- Define the Boundaries of the Study

The target sample population, spatial and temporal boundaries, and practical constraints should also be identified. The sample population in a monitoring project to support a Phase II petition will be the population of all outfalls from the MS4 that discharge into waters of the United States or state waters. The jurisdiction served by the MS4 specifically defines the spatial boundaries of the monitoring study. Temporal boundaries related to the timing of sample collection are a consideration, and the project schedule should account for expected seasonal variations in rainfall, budgetary constraints, and volunteer availability. Several of these aspects, in addition to practical constraints, are further addressed in the context of developing a sampling design.

Data Quality Objectives Process: Step 5- Develop the Analytic Approach

A parameter that will be estimated to describe the variables of interest will need to be determined. For example, the parameter may be a mean, median, or maximum value of the water quality variable that will be determined through sample analysis, or the parameter measured may be the proportion of samples that are above or below a water quality standard (EPA 2006). Subsequent data analysis needs should be taken into account when selecting the parameter of interest.

Data Quality Objectives Process: Step 6- Specify the Performance or Acceptance Criteria

The sixth step involves defining data quality objectives by evaluating the acceptable level of error in the study results and defining it quantitatively. In statistical terms, this means defining the acceptable probability of incorrectly rejecting a hypothesis that is actually true (a Type I error) and the acceptable probability of incorrectly accepting a hypothesis that is actually false (a Type II error). The acceptable error level will vary depending on the study and the expected effects accompanying each type of error. For example, for a monitoring study estimating the contribution of a pollutant from a stormwater discharge, the hypothesis may be

that the discharge does not contribute to the violation of a water quality standard. There would be certain costs associated with finding that the discharge has an impact when it actually does not (Type I error), for example, the administrative costs of requiring a permit unnecessarily. On the other hand, there are potential ecological and human health risks associated with finding that the discharge has no impact when it actually contributes to a violation (Type II error) because it would not be regulated. Generally, the importance of these risks and costs must be balanced when selecting the acceptable error levels for the monitoring study. Based on these acceptable error levels, an expected confidence interval with a given degree of confidence in the study results can then be defined. It is important to keep in mind that setting these data quality objectives will have a direct impact on the amount of sampling effort necessary to achieve them, and resource limitations may also need to be accounted for within this process. A more detailed account of these statistical concepts is beyond the scope of this report, but can be found in the *Stormwater Effects Handbook* (Burton and Pitt 2002) and EPA guidance documents (EPA 2002, EPA 2006).

4.3.2 Sampling Design (Data Quality Objectives Process- Step 7)

The final step in the systematic planning process is the development of a plan for obtaining data, or a sampling design. The purpose of a sampling design is to ensure the representativeness of the data collected during a study, or that the data accurately and precisely represent a characteristic of the sampled population (EPA 2002). However, while standard field collection methods and laboratory techniques have been developed for assessing water quality, there are no standards for the collection of a representative sample (Monroe et al. 2004). There is wide variation in magnitude, frequency, duration, and types of pollutant loading in different watersheds, which are influenced strongly by site-specific meteorological and hydrologic conditions, as well as terrestrial processes and land use activities (Burton and Pitt 2002). This makes developing a standard procedure for representative sampling more difficult, however certain general principles can be applied to the process.

According to Burton and Pitt (2002), sampling designs in water quality studies primarily fall into four main categories: haphazard (or nonrandom) sampling, judgmental sampling, probabilistic sampling, and search sampling. Nonrandom sampling, often due to sampling at convenient times, for example, only during good weather conditions, may introduce bias into the

measurements of the parameters of interest. Judgmental sampling is used when only a specific subset of the population is examined without attempting to extrapolate the results to the overall population. Probabilistic sampling uses a statistical approach to attempt to measure the true value of a characteristic of the overall population by sampling a random subpopulation, and this includes simple and stratified random sampling strategies, as well as cluster and multi-stage sampling techniques. Search sampling is used primarily when specific conditions are known to exist and stresses sampling for the presence or absence of a condition only in areas where sampling efforts are likely to be successful.

The EPA more simply classifies sampling designs as either probability-based or judgmental. In order to draw statistically significant conclusions from a study, which can be extrapolated to the overall study population or other populations, a probability-based sampling plan is needed. Probability-based sampling designs include simple random, stratified random, systematic and grid, ranked set, adaptive cluster, and composite sampling, among others. On the other hand, judgmental designs are based on expert knowledge and opinion, and conclusions that can be drawn from the data are limited (EPA 2002). There are a number of factors (Fig. 3) that determine the type of sampling design and effort undertaken in a study, the principal constraints being schedule and budget.

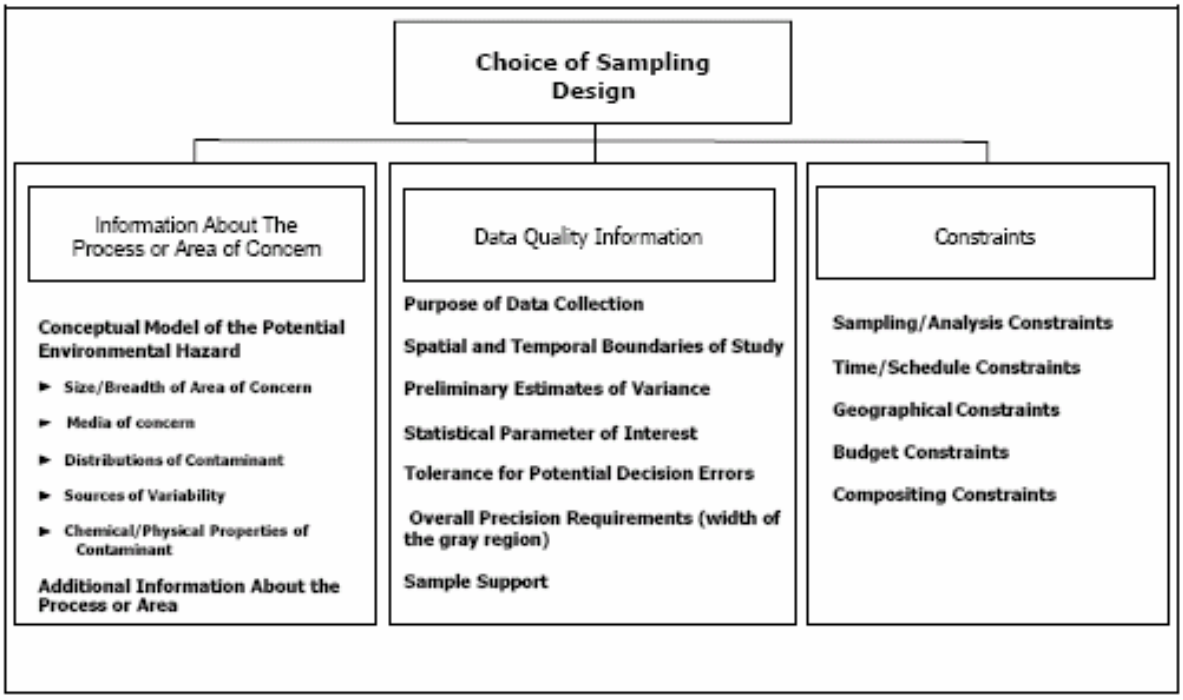


Figure 3: Factors in selecting a sampling design (EPA 2002)

For the purposes of a stormwater quality monitoring study, the determination of the number of samples needed for a probabilistic sampling design is related to the expected variability in measurements of a given water quality characteristic interest and the allowable error in the results. The higher the expected variability in the measurements, the larger the number of samples required to achieve a high degree of confidence in reaching statistically relevant conclusions. A number of equations exist for the approximation of the number of samples needed for a study based on the allowable error, the variance of the observations, and the degree of confidence desired. One basic equation for a simple random sampling design is as follows (from Burton and Pitt 2002):

$$n = [COV(Z_{1-\alpha} + Z_{1-\beta})/(error)]^2 \qquad \text{[Eq. 1]}$$

where
n = number of samples needed
α = false positive rate ($1 - \alpha$ is the degree of confidence. A value of α of 0.05 is usually considered statistically significant, corresponding to a $1 - \alpha$ degree of confidence of 0.95, or 95%)
β = false negative rate ($1 - \beta$ is the power. If used, a value of β of 0.2 is common, but it is frequently ignored, corresponding to a β of 0.5)
$Z_{1-\alpha}$ = Z score (associated with area under normal curve) corresponding to $1 - \alpha$. If α is 0.05 (95% degree of confidence), then the corresponding $Z_{1-\alpha}$ score is 1.645 (from standard statistical tables).
$Z_{1-\beta}$ = Z score corresponding to $1 - \beta$ value. If β is 0.2 (power of 80%), then the corresponding $Z_{1-\beta}$ score is 0.85 (from standard statistical tables). However, if power is ignored and β is 0.5, then the corresponding $Z_{1-\beta}$ score is 0.
error = allowable error, as a fraction of the true value of the mean
COV = coefficient of variation (sometimes noted as CV), the standard deviation divided by the mean. (Data set assumed to be normally distributed.)

This approximation assumes that the sampling data will have a normal distribution; however, measurements of many water quality parameters will need to be log transformed in order to meet this assumption. In the above equation, the value of α corresponds to the probability of a Type I error, while β corresponds to the probability of a Type II error. Thus, as previously mentioned, the choice of data quality objectives based on acceptable levels of these types of error will have a direct impact on the sampling effort required. The coefficient of variation (COV) is related to the expected variability of the parameter of interest and can be estimated based on statistical techniques, preliminary sampling data, or values from the scientific literature. Care should be taken to ensure that the analytical techniques used to obtain any existing data used as a basis for these estimates are equivalent to those proposed for use in the

current project, because different analytical techniques will have different levels of measurement variability (Burton and Pitt 2002).

For the purposes of a Phase II petition monitoring study, the use of a probability-based sampling plan would be preferable. Sampling at a large number of randomly selected locations over a large number of sampling events, and testing for a variety of pollutants would greatly increase the quality of the data. However, "the value of these additional data must be assessed compared to the cost of obtaining them" (Tufford and Marshall 2002). Given the short-term objectives, resource limitations, and potential sampling location restrictions facing the petitioner, the use of strictly probabilistic sampling strategy for monitoring stormwater discharges from an MS4 may not be feasible, or even possible. Despite these limitations, a judgmental sampling design based on the background information collected during the first stage of the Phase II petition process can be developed to ensure that representative sampling is incorporated into a stormwater quality monitoring project. In order to maximize the representativeness of the data collection effort, spatial, temporal, and quantitative design elements must be considered during the development of the sampling design.

Sampling Design: Spatial component

A monitoring study sampling design must first address the number and location of the outfalls of the MS4 that will be sampled. The number of sampling locations for the purposes of a petition will be constrained by the labor and financial resources available for the project, especially given the fact that without the use of expensive automatic samplers, monitoring may require travel by the petitioner or a group of volunteers to remote sites during adverse weather conditions, with little advance warning (Harmel et al. 2003). One would ideally sample at the point where a conveyance discharges stormwater to state or federal waters. However, there are a number of problems associated with access to these sampling locations, including inability to reach an outfall on foot or by boat, hazardous outfall locations that are difficult to access under adverse weather conditions when sampling may occur, and outfalls that are underwater or flooded by tides (EPA 1992). Additionally, monitoring outfalls that must be accessed through, or are located on, private property will not be possible without the explicit consent of the property owner. These conditions will restrict both the number and location of sampling stations, and therefore, it will not be possible to randomly sample a subset of the total population of outfalls in order to characterize the pollutant concentrations and loading in stormwater

discharge from the MS4. Because a probabilistic sampling design is not feasible, a judgmental sampling design will be required for determining the number and location of sampling stations.

Some guidance exists regarding the appropriate number of sampling sites needed to characterize the quality of stormwater discharges from an MS4. The NPDES Phase I stormwater permit application for large and medium municipal storm sewer systems requires quantitative data on stormwater characteristics to be obtained from 5 to 10 outfalls within the MS4 jurisdiction (EPA 1992). For example, Los Angeles County, California has designed a long-term stormwater monitoring project in support of its NPDES stormwater discharge permit. The initial sampling plan includes only nine sampling stations; four mass emission monitoring stations, located at drainage points into the ocean from four large sub-watersheds, were selected to monitor trends over time, and five land use monitoring stations were initially selected to characterize discharges from relatively homogenous land use areas (Burton and Pitt 2002). This guidance for large and medium MS4s indicates that the EPA would likely consider this number of sampling stations adequate to characterize the stormwater discharged from a small MS4 potentially covered under the Phase II rules.

Due to the practical constraints on accessing certain sampling locations, background information can play key role in selecting sampling stations that ensure the sampling design is representative of conditions within the overall drainage area. In the Los Angeles study, five major land use categories with varying impervious surface characteristics were selected for monitoring: high density single-family residential, vacant land, light industrial, transportation, and retail and commercial. Sampling stations were placed at points where a sub-basin of relatively homogenous land use drained into surface waters (Burton and Pitt 2002). For the purposes of a Phase II petition, a similar approach to site selection based on land use could be adopted. A limited number of outfalls draining each of the major land uses in the drainage area of the MS4 could be selected based on land use maps and field surveys. This allows some flexibility in site selection to account for access restrictions and ensures that the sampling design will adequately characterize the variety of stormwater discharge conditions in the jurisdiction of the MS4. Once outfalls are selected for monitoring, a more in-depth description of the immediate drainage area at each location should be documented to allow a comprehensive evaluation of the representativeness of sampling stations by the regulatory agency. Geospatial analyses can be done, if the capability exists, which delineate the sub-basins draining to these

outfalls and allow quantitative analysis of the land use and impervious surface area characteristics of those sub-basins.

Sampling design: Temporal component

The temporal component of the sampling design relates to the duration of the sampling and when a sample should be collected at the selected sampling locations based on determining which storm events should be sampled. If at all possible, sampling duration should span different seasons to account for seasonal changes in precipitation and runoff volume. Regarding the determination of which storm events should be sampled, the EPA guidance for the NPDES Phase I permit application states that sampling should be performed during a "representative storm event." Such an event meets the following criteria:

- the depth of the storm must be greater than 0.1 inch accumulation,
- the storm must be preceded by at least 72 hours of dry weather,
- where feasible, the depth of the rain and duration of the event should not vary by more than 50 percent from the average depth and duration (EPA 1992).

These criteria are intended to ensure that there will be a measurable discharge, allow some buildup of pollutants during dry weather, and ensure that the storm is typical for the area in terms of intensity, depth, and duration (EPA 1992). The state of North Carolina also includes similar language in its state stormwater program permits describing a representative storm event: "A storm event that measures greater than 0.1 inches of rainfall and that is preceded by at least 72 hours in which no storm event measuring greater than 0.1 inches has occurred. A single storm event may contain up to 10 consecutive hours of no precipitation. For example, if it rains for 2 hours without producing any collectable discharge, and then stops, a sample may be collected if a rain producing a discharge begins again within the next 10 hours" (pers. comm., Bennett 2006).

These criteria provide useful guidelines to ensure that the storm events sampled for the purpose of a Phase II petition will be considered representative by the EMC. As part of the background information gathered in support of the petition, meteorological data from the National Climatic Data Center (NCDC) can be gathered and used to determine the average depth and duration of storm events in the area. The average can then be used to calculate a range within which an event would be considered representative, based on the 50 percent variance criteria established in the EPA guidance. The low end of this range should then be used to trigger a sampling event. For example, if the average amount of rainfall per storm event is 0.5

inches, then the range of rainfall amounts considered to be representative would be any event totaling between 0.25 and 0.75 inches. Thus, within the sampling plan, an event expected to total greater than 0.25 inches of rainfall would trigger a sampling event. For the purposes of a petition, data should be collected from as many events as possible, even if the total precipitation amount exceeds the calculated maximum rainfall depth for a representative storm. Unrepresentative events can either be removed from the analysis, if enough additional data is collected, or noted as exceeding the criteria for a representative event in the analysis.

The storm duration criteria is less important for the purposes of this a Phase II petition monitoring study, because grab samples only allow one to estimate a given parameter at a particular time during the storm. However, the timing of the sample collection event may be important. The Phase I permit application for industrial stormwater discharges requires that grab samples be collected within the first thirty minutes of the beginning of the rainfall event, but does not include this requirement for monitoring MS4s (EPA 1992). While not required, this may be a useful guideline for ensuring consistency in the timing of sample collection at different sites, especially when samples are collected by a group of volunteers. Also, this would allow the measurement of the "first flush" of pollutants being discharged during a storm event.

Sampling design: Quantitative component

The quantitative component of a monitoring project involves determining the number of samples necessary to ensure that the estimate of the parameter of interest is representative of the discharge at each sampling location. In general, the error in the results of a monitoring project should improve with a larger number of samples (Tufford and Marshall 2002). As discussed previously, it is possible to calculate an approximate number of samples necessary to achieve the data quality objectives defined for the project and draw statistically based conclusions about the results with a certain level of confidence. This approximation is directly related to the estimated variance of measurements of the parameter of interest and the allowable error expected in the results.

Pitt et al. (2003) have compiled a large quantity of data that has been collected over a ten year period, in support of over 200 NPDES Phase I permits, and developed a national stormwater quality database. Analysis of this data has indicated that variance is very high for many of the stormwater quality parameters; however, these variance estimates are compounded by the wide variety of site conditions affecting the data. The authors conclude:

> It is expected that the final data analyses for this project will identify separate stratifications of data (possibly considering the combination of land use, geographical area, and season factors) to significantly reduce the variations in each category. It is expected that COV values in the range of 0.5 to 1.0 will be common for many of these data stratifications. With a reasonable confidence of 95% (α=0.05) and power of 80% (β= 0.20), and a commonly accepted allowable error of 25%, the number of samples needed to characterize conditions would likely range from about 25 to 50. If only 12 samples are obtained for each category (strata), the allowable errors would range from about 50% to 100% (Pitt et al. 2003).

It is important to note that relaxing the requirements for the desired amount of confidence, power, or acceptable error for the estimated parameter leads to a smaller number of samples being needed, and vice versa. This can be accounted for in developing the data quality objectives for the project (EPA 2006).

Very little guidance exists to assist in determining whether or not the collected number of stormwater discharge samples would be considered representative by a regulatory agency. The EPA requires sampling of three representative storm events to characterize stormwater discharges for the Phase I NPDES permit application (EPA 1992), and this should be considered the minimum number of samples for a Phase II petition monitoring program. In North Carolina, sampling is performed at stations throughout each SGA by the Shellfish Sanitation and Recreational Water Quality Section to determine the geometric mean concentration of fecal coliform bacteria. The estimate is based on either a minimum of 30 samples collected through a stratified random sampling strategy, or 15 samples collected under an adverse conditions sampling strategy (NSSP 2005). DWQ may consider at least ten to twelve samples from each sampling location to be necessary in order for the data to be considered sufficiently representative of stormwater discharge from an MS4 (pers. comm., Bennett 2006).

The project budget and schedule will dictate the number of samples that can be actually be gathered. Given the fact that a monitoring program for a Phase II petition is likely to be short-term and operating on a small budget, the number of representative storm events occurring during the monitoring project and the costs of collecting and analyzing samples will be limiting factors on the actual number of samples collected. It may not be possible to collect the estimated number of samples needed for a probabilistic sample. However, a smaller number of samples is still valid, so long as the actual levels of confidence and error present in the data are analyzed and explicitly presented with the results. For the purposes of a Phase II petition, there is no

required number of samples and the data from any monitoring program will have to be evaluated on an individual basis. This makes it very important, no matter how many samples are collected, to evaluate the quality of the data actually obtained through the monitoring project, in order to explain and defend any limitations of the data within the petition.

4.3.3 Quality Assurance Project Plan (QAPP)

Prior to the implementation of the monitoring project, it is recommended that a Quality Assurance Project Plan (QAPP) be developed in order to document the data collection process and reassure decision-makers that the data are of good quality, collected and analyzed using standardized techniques, and comparable to data collected in other assessments using the same methods (EPA 1996). All projects that receive EPA funding are required to submit a QAPP for approval, and therefore several guidance documents exist that provide detail on the preparation of a suitable QAPP (EPA 1996, EPA 2001). The outputs of the data quality objectives process for systematic planning of environmental assessments can be directly applied in writing a QAPP (EPA 2006).

A QAPP is "a document describing in comprehensive detail the necessary QA [quality assurance], QC [quality control], and other technical activities that must be implemented to ensure that the results of the work performed will satisfy the stated performance criteria" (EPA 2001). According to the EPA, there are 24 elements included in this written plan that will document the organization of the project team and the key elements of the systematic planning process, including project goals, sampling and analysis methods, data quality objectives, and sampling design. While the sampling design addressed potential error from unrepresentative sampling, the QAPP outlines the quality control procedures used to minimize measurement error. This is done by specifying steps that will ensure the use of proper equipment, the collection of quality control samples to monitor sample contamination (replicates, field blanks, etc.), and the procedures for instrument calibration. These quality control procedures are defined in a standard operating procedure (SOP), and many SOPs already exist for water quality monitoring projects and may be readily referenced in the QAPP written for a Phase II petition (EPA 1996).

Assuming that state-certified laboratories will be conducting the lab analysis of samples for a Phase II petition project, the QAPP will primarily address the field methods for sample collection, monitoring logistics, and the sampling design. For the purposes of a Phase II

stormwater petition, it is not necessary to receive approval from either the EPA or DWQ; however it is recommended that feedback on the plan be obtained prior to implementation of the project. State and EPA Regional volunteer monitoring coordinators, Quality Assurance Officers, EPA project officers, and other data users such as the DWQ, may be available to review a draft plan and offer feedback (EPA 1996). EPA guidance materials (EPA 1996, EPA 2001) should be consulted for further detail on the preparation of a QAPP.

4.3.4 Notification

According to the petition requirements, the "petitioner must notify the owner or operator of the municipal separate storm sewer system (MS4) or the person who discharges stormwater of its intent to conduct monitoring activities prior to conducting those activities." At a minimum, a letter notifying the owner or operator of the MS4 of the intent to conduct stormwater monitoring activities is required, although it is not necessary to obtain permission to conduct monitoring activities in publicly accessible locations or in public trust waters. In some cases, the MS4 operator or local government officials can provide valuable information, including potential sampling locations and existing monitoring data, although, as mentioned previously, the level of cooperation may vary.

4.3.5 Stormwater Monitoring

This step in the process involves putting the monitoring plan into action. The schedule, project team, standard operating procedures, and logistics of sampling were established in previous steps. This monitoring effort may require the coordination of volunteers to collect samples in the field, and the project manager should ensure that the QAPP is adhered to for the duration of the sampling effort. The project manager should compile laboratory test results for use in the data analysis phase of the project.

4.3.6 Data Analysis

The data collected will consist of measurements of a particular stormwater quality characteristic of the discharge at several outfalls within the jurisdiction of the MS4 over a series of sampling events. The mean pollutant concentrations or loads will likely be calculated for each of the outfall locations, which should then be compared to applicable water quality standards to

determine if the discharge is causing or contributing to a water quality violation in the receiving waters. If any comparisons are to be made to existing in-stream monitoring data, or the results of past studies, care should be taken to ensure that the same data analysis parameters (mean, median, proportion of violations, etc.) and general analytical techniques were used in the petition and past monitoring studies. Comparison to existing in-stream data may be useful in determining a link between the receiving water impairment and the stormwater discharge, while comparison to other similar stormwater studies can demonstrate that the current study results are consistent with other assessments.

Because a judgmental sampling design is used to select sampling locations, the data from different sampling locations cannot be combined to directly estimate a parameter for the MS4 as whole, and the data from each sampling location must be evaluated separately. Also, the number of samples collected may be limited by the schedule or budget, and therefore the estimate may not be statistically conclusive at the expected level of confidence or allowable error. As previously stated, this makes it essential to describe the characteristics of the land drained at each sampling station as well as limitations in the data, including the actual level of confidence and error in the results, in order to allow a complete evaluation by the regulatory agency of the study results presented as part of the adverse impact petition.

4.3.7 Reevaluation

Once the monitoring project is complete and the data have been analyzed, a reevaluation of all relevant information should be conducted to determine if a Phase II petition is justified. The same four assessment questions should again be considered, taking into account the newly acquired monitoring data. Within this evaluation, it is also important to account for any regulatory action or changes that may have may have occurred during the course of the monitoring project and affected stormwater management within the jurisdiction of the MS4 in question. Based on the judgment of the petitioner, if it is determined that a petition to require a Phase II permit for the MS4 is justified, one should be submitted as part of the third stage of the petition process.

4.4 Phase II Petition Methodology: Stage III- Petition Submission

The third stage of the Phase II petition methodology is the submission of the petition to the EMC. The petition administration process is outlined in Section 6(3) of the Phase II stormwater management session law (SL 2006-246). The first requirement is that a petition be submitted on departmental forms; however, there are currently no such forms available, and until these are developed the DWQ will accept petitions in other formats (pers. comm., Bennett 2006). Separate petitions must be filed for each MS4 in question, and a copy of the petition must be provided to the owner or operator of the MS4 within 48 hours of its submission to the EMC. The EMC will determine the completeness of the petition within 90 days of submittal and then accept public comment for at least 30 days. The EMC may also hold a public hearing on the petition; a hearing must be held if a written request for one is received during public comment period. The public comment period provides the opportunity for the public to participate in the decision-making process, but also allows the petition subject to challenge the petition by submitting information regarding the reasons that they should not be required to obtain a Phase II permit. Therefore, all background information and monitoring data should be carefully considered prior to submitting a petition to ensure that there is sufficient cause for the EMC to require a Phase II permit for the MS4 and in order to make the strongest possible case with the petition. The EMC will review a petition within 180 days of the date on which it is determined to be complete, and if a permit is deemed necessary, the MS4 owner or operator will be notified within 30 days of the decision. A permit application must then be submitted for approval within 18 months of that notification.

5.1 Phase II Petition Case Study: Stage I- Background Research

In order to examine the process of developing a Phase II stormwater petition for an MS4 located on the North Carolina coast, the town of Morehead City, NC, was chosen as a case study. The petition methodology model is used to frame both the compilation of the relevant background data and a preliminary discussion of the monitoring study and sampling design considerations for potential future implementation of the second stage of the process.

5.1.1 Problem Identification

The town of Morehead City, NC, is located in Carteret County on a peninsula surrounded by the waters of Bogue Sound to the south and the Newport River to the east and north (Fig. 4). The town is the largest municipality in the county, and although not classified as an urbanized area in the 2000 census, its jurisdiction includes areas of intense commercial and residential development. The town owns and operates an MS4 within its city limits and in the extra-territorial jurisdiction (ETJ) that falls under the purview of its CAMA land use plan. There are large areas of prohibited and conditionally approved shellfish harvesting areas in local receiving waters, and several water bodies are listed on the 303(d) list of impaired water bodies prepared by the DWQ. The degree of urbanization and the degradation of surface waters raise concerns about the impacts of stormwater discharges from the MS4 operated by the town. For this reason, Morehead City should be considered as a candidate for the Phase II stormwater program.

5.1.2 Water Quality Background

Morehead City is located within a sub-basin of the White Oak River Basin (WOK03), and the major receiving waters of discharges from its MS4 include Calico Creek, the Newport River, and the eastern half of Bogue Sound. The majority of the waters in the vicinity of Morehead City are classified SA HQW (Fig. 5), with the exception of Calico Creek (SC HQW) and waters surrounding the North Carolina State Port Facility (SC). Primary uses of these water bodies include shellfishing, recreation, and aquatic life support. The major threats to water quality include stormwater runoff and discharges from the Morehead City Wastewater Treatment Plant (WWTP) in Calico Creek (Morehead City 2006). The Morehead City WWTP currently holds a major NPDES permit for the discharge of up to 2.5 MGD, and the North Carolina State Port Facility has two minor NPDES permits (DWQ 2007e). Fecal coliform bacteria pollution is considered an important water quality issue, especially in the Newport River and its tributaries (Morehead City 2006).

The Shellfish Sanitation and Recreational Water Quality Section of the North Carolina Division of Environmental Health (DEH) conducts bacteriological monitoring efforts at sampling locations (Fig. 6) throughout the receiving waters of the Morehead City MS4, in order to recommend the temporary or permanent closure or opening of shellfishing waters. The majority of the drainage from the Morehead City MS4 enters the E-3 and E-4 SGAs.

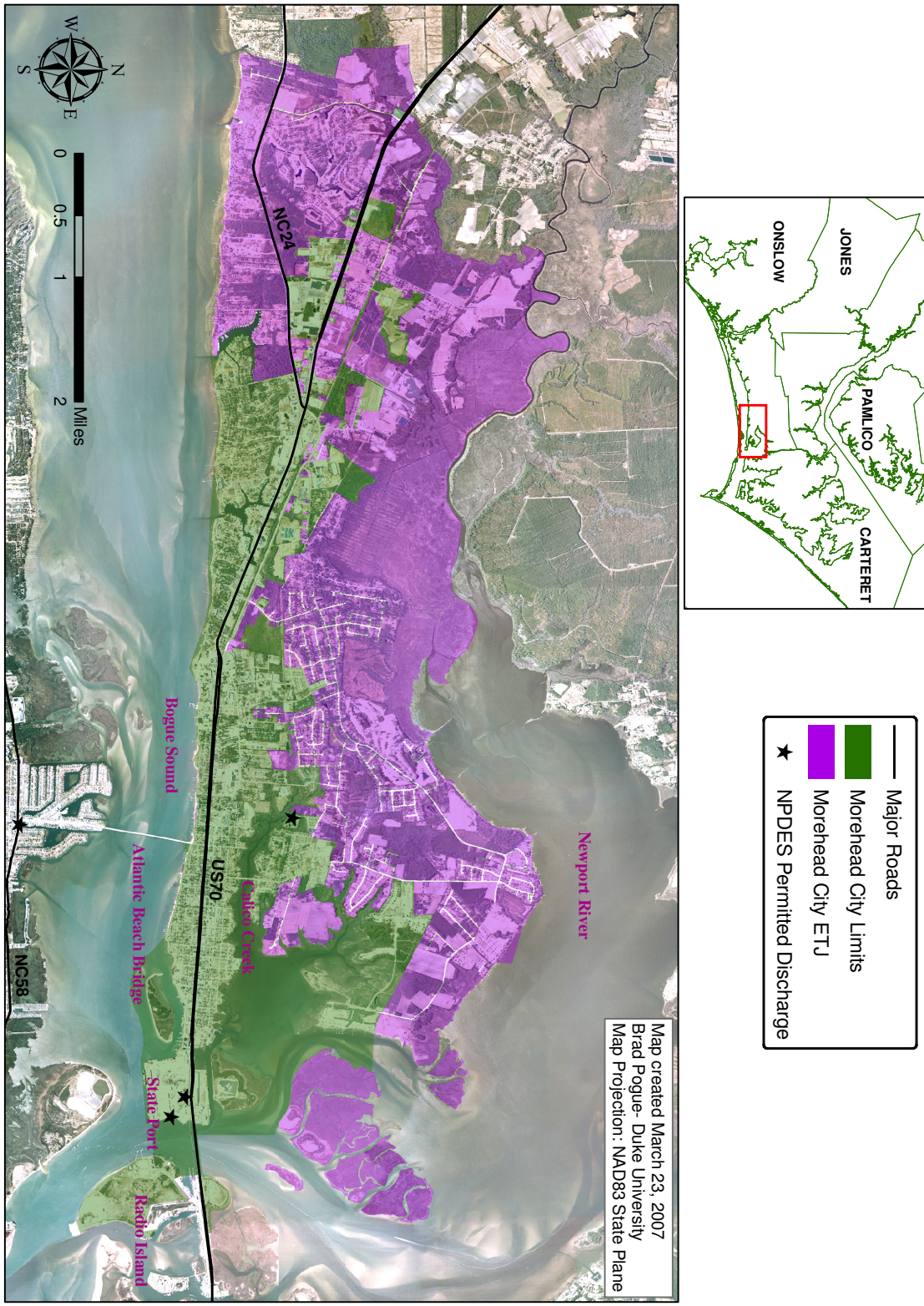


Figure 4: Morehead City, NC- City limits, extra-territorial jurisdiction (ETJ), and general features

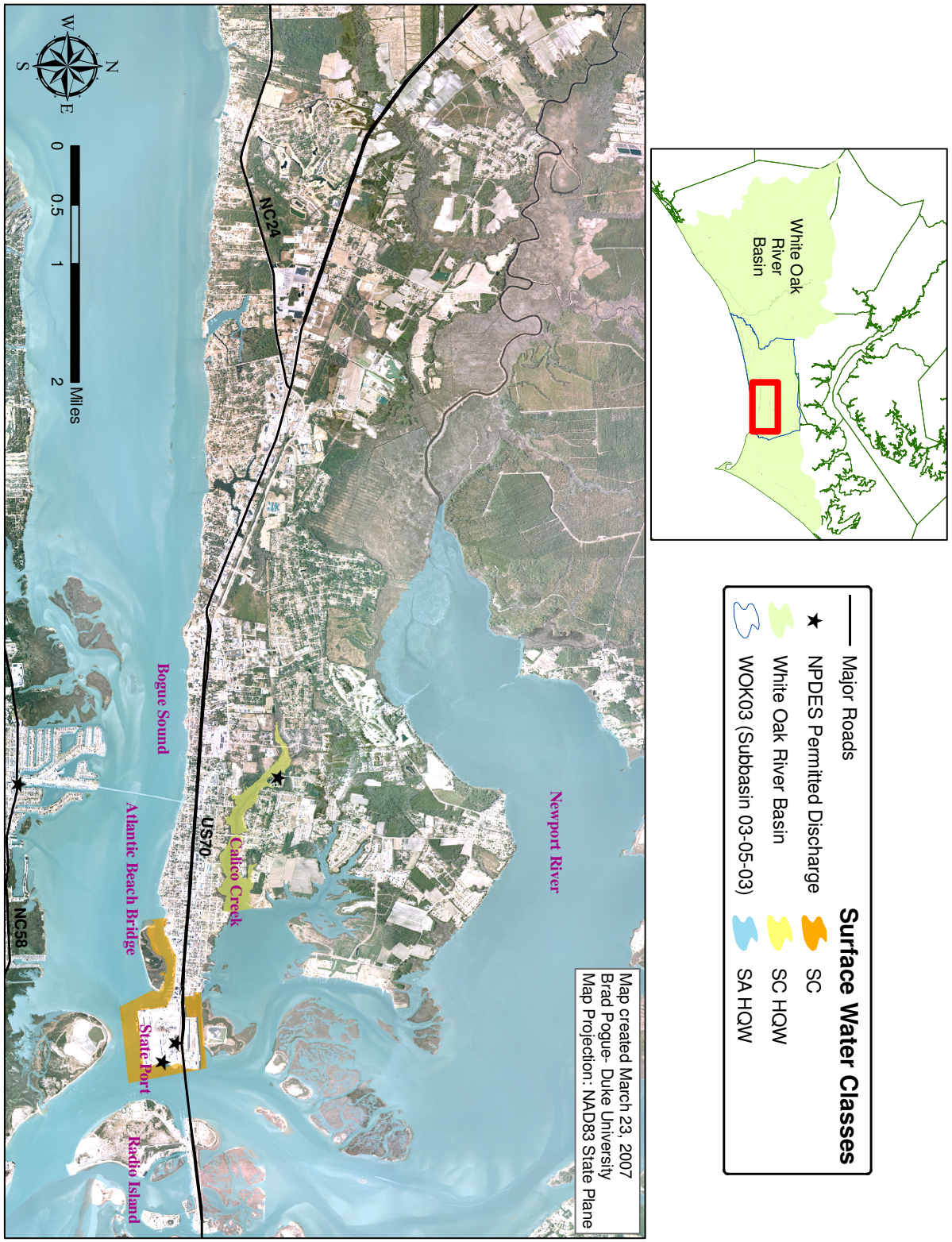


Figure 5: North Carolina DWQ surface water classifications around Morehead City, NC

Bacteriological monitoring data is used to calculate the geometric mean fecal coliform density and a 90th percentile value for the stations in each growing area. Based on certain criteria (Table 3), waters within each SGA are classified as Prohibited, Restricted, Conditionally Approved- Closed, Conditionally Approved- Open, or Approved for the harvesting of shellfish, in accordance with the results of the shellfish sanitary surveys. Several stations in the E-3 and E-4 SGAs show levels of bacteria that violate water quality standards and waters around these stations are recommended for closure (Table 4 and Table 5).

The DWQ collects water quality data at five ambient monitoring stations in the WOK03 sub-basin, which monitor a variety of parameters including dissolved oxygen, turbidity, nutrients, heavy metals, and fecal coliform bacteria. Two stations are located in Calico Creek in the immediate vicinity of Morehead City. For the purposes of the current draft basin-wide planning report, monitoring data collected at these stations between September 1, 1999 and August 31, 2004 was evaluated. This data showed that water quality violations, based on the SC beneficial use classification, occurred for fecal coliform bacteria, dissolved oxygen, and turbidity (Table 6). The Morehead City WWTP is a major contributor to these violations; however, stormwater runoff may exacerbate these problems.

Table 3: Shellfish Growing Area Classifications (DWQ 2007e)

NC DEH Classification	Criteria
Approved (APP)	The median fecal coliform Most Probable Number (MPN) or geometric mean MPN of water shall not exceed an MPN of 14 per 100 milliliters, and the estimated 90th percentile shall not exceed an MPN of 43 per 100 milliliters for a five tube decimal dilution test.
Conditionally Approved-Open (CAO)	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 by a plan.
Conditionally Approved-Closed (CAC)	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 by a plan.
Restricted (RES)	Sanitary Survey indicates a limited degree of pollution, and the area is not contaminated to the extent that consumption of shellfish could be hazardous after controlled depuration or relaying.
Prohibited (PRO)	No Sanitary Survey; point source discharges; marinas; data does not meet criteria for Approved, Conditionally Approved or Restricted Classification.

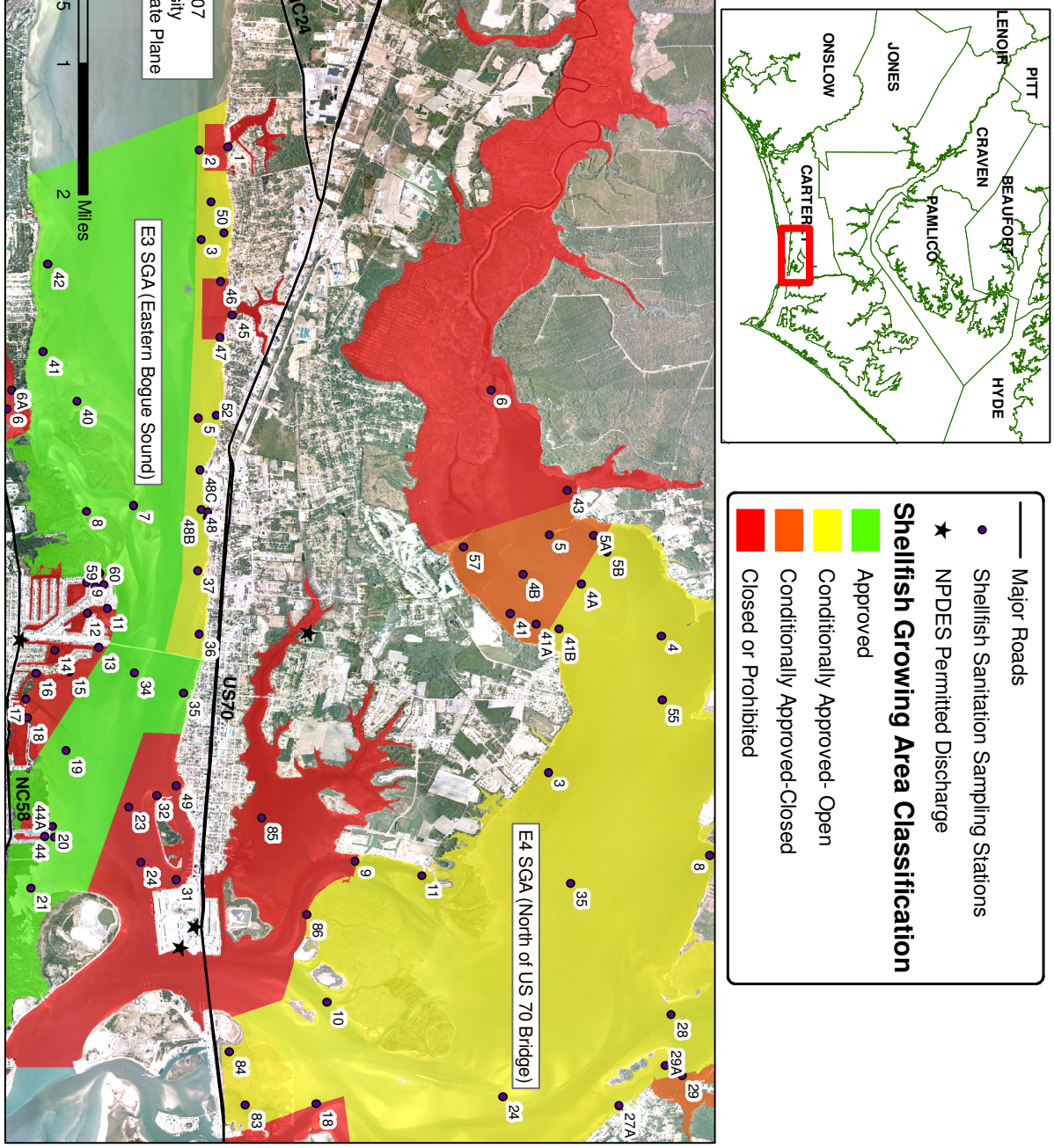


Figure 6: Shellfish Sanitation bacteriological sampling stations and E3 and E4 SGA classifications

Table 4: Geometric mean fecal coliform MPN per 100 mL and 90th percentile value for sampling stations in the E-3 shellfish growing area from 1999-2002

STATION	GEOMEAN	EST 90TH
1	13.67	108
2	3.79	10
3	3.76	11
5	3.35	8
6	9.83	54
6A	12.19	62
7	7.28	30
8	8.78	36
9	8.35	38
10	11.71	67
11	10.58	48
13	9.76	37
15	11.38	40
18	8.75	39
19	3.86	9
20	6.46	24
21	6.27	36
23	2.44	5
24	2.54	5
34	4.45	17
35	4.92	14
36	4.23	12
37	4.68	18
40	8.90	34
41	6.27	28
42	7.04	36
44A	6.67	34
45	20.83	160
46	5.68	23
47	7.31	31
48	4.60	15
48A	8.04	-
48B	7.80	-
48C	6.49	-
49	4.36	13
50	3.51	10
51	6.64	24
52	6.42	20
59	13.05	66
60	6.83	28

Table 5: Geometric mean fecal coliform MPN per 100 mL and 90th percentile value for sampling stations in the E-4 shellfish growing area from 2002-2005

STATION	GEOMEAN	EST 90TH
3	4.73	16.0
4	5.56	19.0
4A	10.01	43.0
4B	13.18	65.0
5	12.48	71.0
5A	11.35	54.0
7	10.99	43.0
8	6.51	26.0
8A	7.53	27.0
9	4.00	11.0
10	2.41	4.0
11	5.24	18.0
14A	4.77	19.0
16A	5.17	19.0
18	3.73	14.0
24	4.25	13.0
25	6.10	32.0
27A	9.82	43.0
28	4.17	12.0
29	7.93	47.0
35	5.44	17.0
41	12.70	80.0
41A	9.50	55.0
55	4.37	15.0
56	4.16	13.0
83	3.80	15.0
84	4.92	25.0
85	4.85	13.0
86	3.14	9.0

Orange = Borderline
Yellow = Violation

Table 6: Water quality violations in Calico Creek (DWQ 2005)

Station ID	Location	Class	Parameter (Evaluation Level)	% Exceedance	% Confidence
P8750000	Calico Cr SR 1243 at Morehead City	SC HQW	Fecal Coliform (>20%>400)	86.20%	100%
			Fecal Coliform (Geomean>200)	Geomean: 1344	
			Turbidity >25	39.10%	100%
P8800000	Calico Cr SR 1176 at Morehead City	SC HQW	Fecal Coliform (>20%>400)	30.00%	94%
			Dissolved Oxygen (<5.0)	17.40%	93%
			Turbidity >25	34.80%	100%

Several areas in the receiving waters surrounding Morehead City are listed on the 303(d) list of impaired waters (Fig. 7). The primary reason for listing of these waters is high levels of fecal coliform bacteria, which leads to permanent or temporary closures of these areas to shellfish harvesting. According to the current assessment methodology, the determination of the use support rating (Supporting or Impaired) for SA waters is based on their classification by the DEH. Only waters classified as Approved for shellfishing are rated as Supporting, and all other waters are considered Impaired (DWQ 2006). The map of impaired waters taken from the 2006 draft 305(b) and 303(d) Integrated Report does not delineate large areas of Conditionally Approved- Open SA waters as Impaired, but the reason for this discrepancy is unknown.

According to the Morehead City draft land use plan (2006), approximately 25% of the town's waters were closed to shellfish harvesting due to runoff from urban stormwater and other sources, including construction, failing septic systems, and agricultural runoff. Sanitary surveys of the area indicated that high bacteria counts followed moderate to heavy rain (DEH 2005), another indication that stormwater runoff is likely an important contributor to the pollution of shellfishing waters around Morehead City.

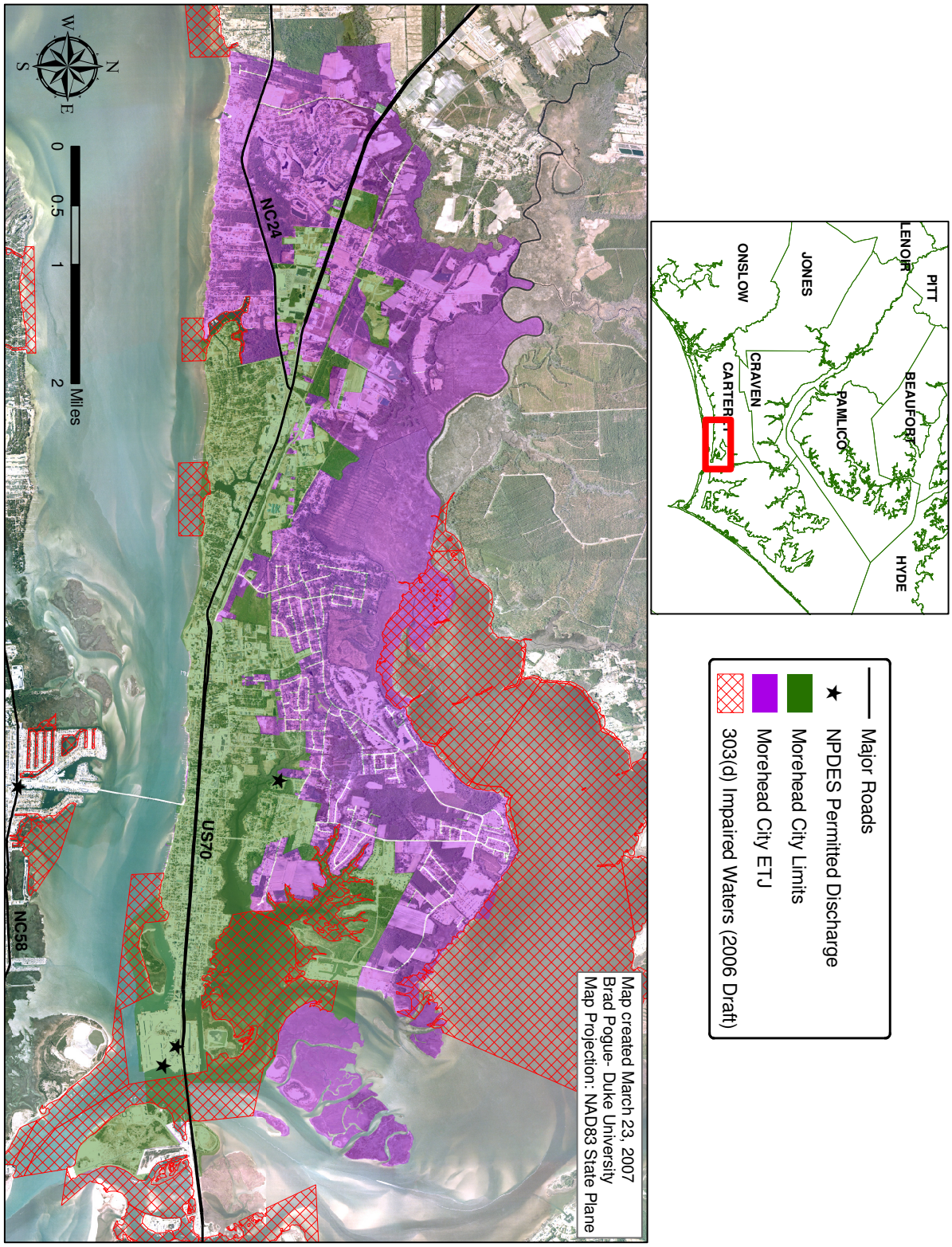


Figure 7: Impaired waters in the vicinity of the Morehead City, NC MS4 listed in the 303(d) report to the EPA (DWQ 2007e)

5.1.3 Drainage Area Background

As noted earlier, Morehead City has the largest permanent population of any incorporated municipality in Carteret County. There is also a large seasonal population due to the town's popularity as a coastal tourist destination. According to the CAMA land use plan for Morehead City (2006), the estimated permanent population in 2002 was 7,726 persons, while the estimated population within the ETJ was 14,000 persons, with an estimated seasonal population of 3,146 persons. The Morehead City population grew 27.2% between 1990 and 2000, while the ETJ grew 33.8% during the same period. The peak population, including the ETJ and the seasonal population projections, is expected to reach 22,480 by 2010.

This population growth has led to increased development in Morehead City. The portions of each 14-digit hydrologic unit (HUC-14) watersheds that fall under town jurisdiction have all experienced high levels of development (Table 7). This growth has occurred very rapidly, as indicated by a 700% increase in the number of seasonal units since 1980 and twenty-six new subdivisions constructed in the Morehead City planning jurisdiction between 1999 and 2003 (Morehead City 2006). The high amount and rate of development within this drainage area could have a significant effect on the quality and volume of stormwater discharged by the Morehead City MS4 and signals the potential for impacts on the quality of surface waters due to stormwater runoff.

Table 7: Developed acreage in the Morehead City jurisdiction by HUC-14 watershed (Morehead City 2006)

HUC-14 Watershed	Land in Jurisdiction	Developed	Undeveloped	Percent Developed
03020106030070	9564 ac	4858 ac	4706 ac	50.8
03020106030060	367 ac	260 ac	107 ac	70.8
03020106030020	1346 ac	921 ac	425 ac	68.4

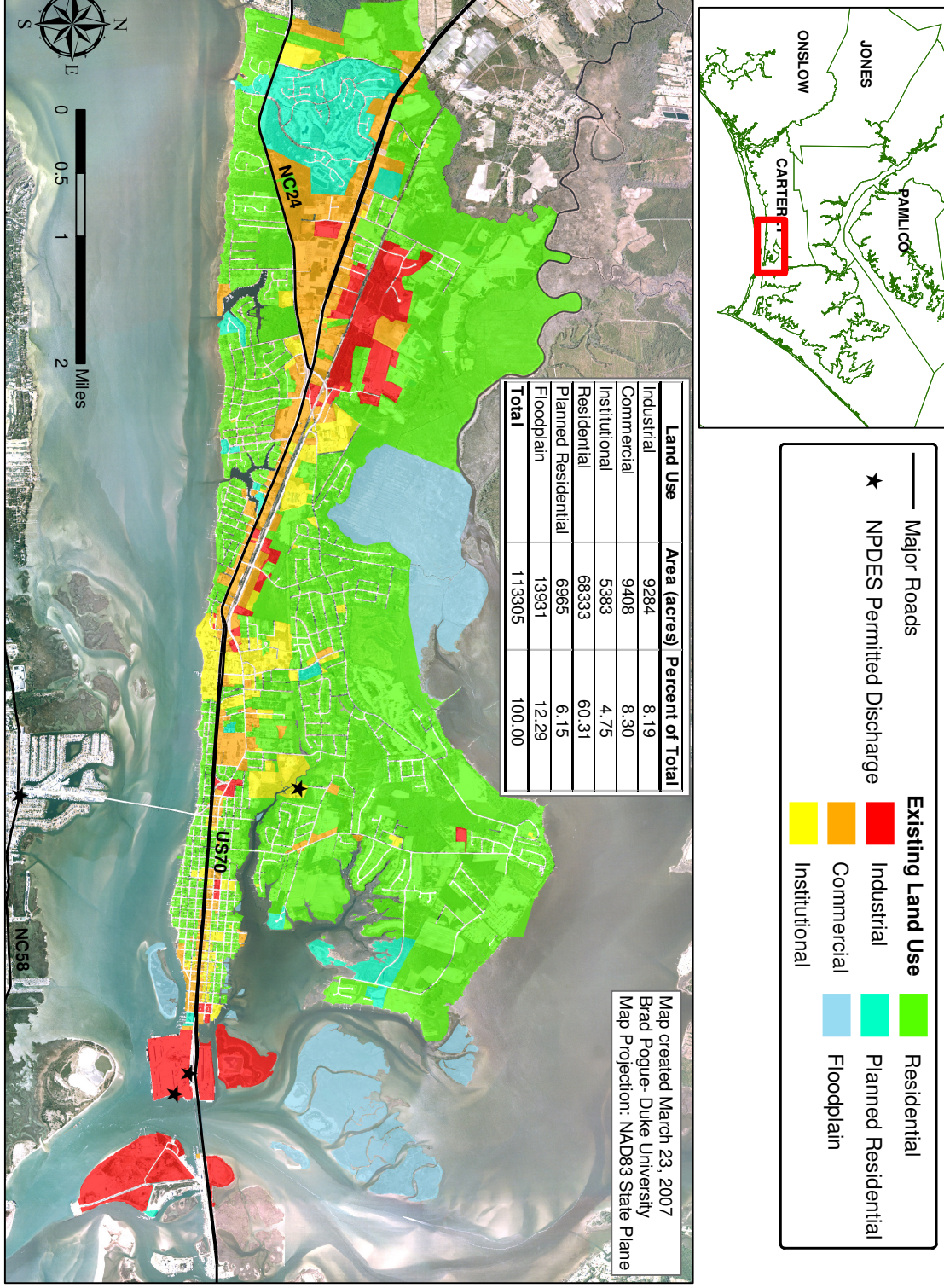
The current draft of the Morehead City CAMA land use plan (2006) describes existing land uses within the planning jurisdiction, including areas of residential, commercial, industrial, institutional, agricultural development, as well as open space and undeveloped areas. Nearly half of the total land area within the planning jurisdiction is classified as undeveloped, while the primary land use category in developed areas is residential (Table 8). A separate map of the existing land uses in Morehead City was obtained from the Planning Department indicating the extent and distribution of five major land uses in the area (Fig. 8).

Table 8: Morehead City Existing Land Uses (acres)

Land Use	Description	Area	Percent of Total
Undeveloped	Floodplain, wetlands	5,342	49.20%
Residential	Low- to high-density residential homes and apartments	3,244	29.80%
Commercial	Strip malls, restaurants, shops	593	5.50%
Industrial	Port and industrial complexes	313	2.90%
Institutional	Hospitals and educational institutions	431	4.00%
Agricultural/ Open Space	Farms, parks recreation areas, and golf courses	945	8.70%
Total		10,868	100%

Additional land use and land cover geospatial data for the Morehead City planning jurisdiction was obtained from the NOAA Coastal Change Analysis Program (CCAP) database and from the National Land Cover Data (NLCD) database of the Multi-Resolution Land Characteristics Consortium (MRLCC). These programs use relatively similar classification schemes (Table 9) to classify various land uses and land cover types through the analysis of remotely sensed satellite imagery. These land cover classes differ from those in the Morehead City land use plan, primarily in the fact that the classification incorporates vegetated land cover classes. Despite these different classification schemes and observation dates (the CCAP data is now ten years old), these maps generally show similar characteristics in the location of intensely developed areas, near US-70 and downtown Morehead City, and less densely developed residential and undeveloped areas in the ETJ (Fig. 9 and Fig. 10).

The MRLCC has also developed a map estimating the percent impervious cover within each mapping unit (30 x 30 meter pixels) using a regression tree model to analyze Landsat Thematic Mapper satellite imagery, in conjunction with high spatial resolution imagery. The model was calibrated based on classification of three initial study areas of varying levels of development and impervious surface coverage (Yang et al. 2003) and then applied in other areas of the country to estimate the percent impervious cover. A map of the estimated percent impervious cover was obtained for the Morehead City planning jurisdiction, which was derived using the NLCD model based on 2001 Landsat TM imagery (Fig. 11).



Land Use	Area (acres)	Percent of Total
Industrial	9284	8.19
Commercial	9408	8.30
Institutional	5383	4.75
Residential	68333	60.31
Planned Residential	6965	6.15
Floodplain	13931	12.29
Total	113305	100.00

Figure 8: Existing land use map from the Town of Morehead City Planning Department

Table 9: Description of CCAP and NLCD land use and land cover classes in the Morehead City planning jurisdiction

NOAA CCAP Classes	Description	NLCD Classes	Description
Low Intensity Developed	Urban land cover with greater than 25 percent and less than 75 percent impervious surface	*Developed, Low Density*	Impervious surfaces account for 20-49 percent of total cover.
		Developed, Medium Density	Impervious surfaces account for 50-79 percent of the total cover.
High Intensity Developed	Urban land cover with greater than 75 percent impervious surface	*Developed, High Density*	Impervious surfaces account for 80 to100 percent of the total cover.
		Developed, Open Space	Impervious surfaces account for less than 20 percent of total cover.
Cultivated Land	Active agriculture, orchards, and vineyards	*Cultivated Crops*	Areas used for the production of crops.
Grassland	Both managed and unmanaged grasslands	*Pasture/Hay*	Pasture/hay vegetation
		Grassland/ Herbaceous	Areas dominated by grammanoid or herbaceous vegetation.
Deciduous Forest	Hardwood forest with a pronounced seasonal dormancy period	*Deciduous Forest*	More than 75 percent of the tree species shed foliage seasonally.
Evergreen Forest	Forest without a pronounced seasonal dormancy period	*Evergreen Forest*	Canopy is never without green foliage.
Mixed Forest	Forest not dominated by either deciduous or evergreen species	*Mixed Forest*	Neither deciduous nor evergreen species are greater than 75 percent of total tree cover.
Scrub/Shrub	Woody vegetation less than 20 feet tall	*Shrub/Scrub*	Areas dominated by shrubs.
Palustrine Forested Wetland	Freshwater wetland forest	*Woody Wetlands*	Areas of forest or shrub vegetation where the substrate is periodically saturated with or covered with water.
Palustrine Scrub/ Shrub Wetland	Freshwater wetland scrub/shrub		
Palustrine Emergent Wetland (Persistent)	Freshwater wetland-rooted emergent species (marsh, lilies, etc.)	*Emergent Herbaceous Wetlands*	Areas of perennial herbaceous vegetation where the substrate is periodically saturated with or covered with water.
Estuarine Emergent Wetland	Saltwater wetland emergent species (Spartina marsh, juncus grass, etc.)		
Unconsolidated Shore	Tidal flats, shoals, and intertidal areas		
Bare Land	Bare exposed rock, sand, and soil	*Barren Land (Rock/Sand/Clay)*	Vegetation accounts for less than 15% of total cover.

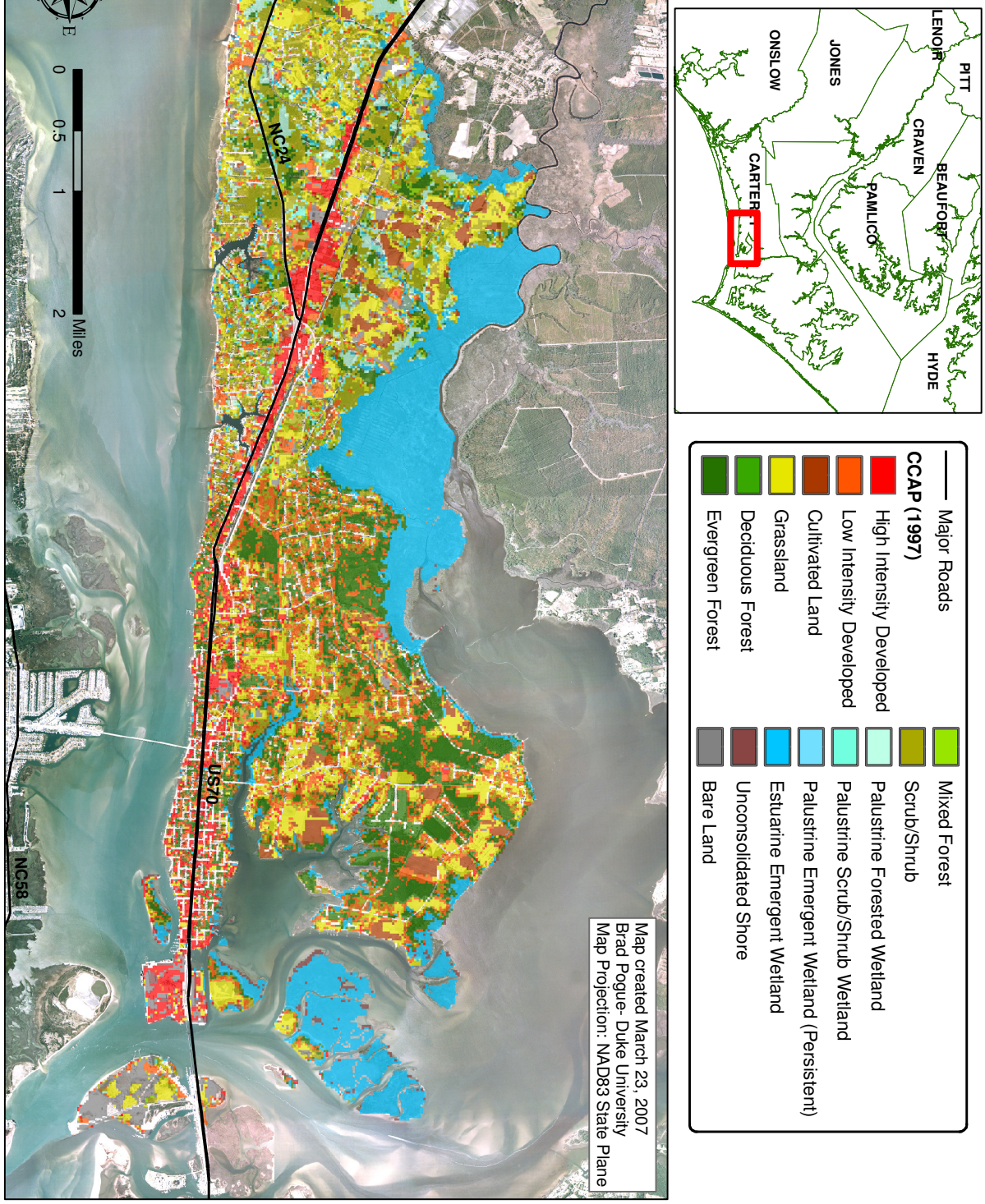


Figure 9: CCAP 1997 land use and land cover classifications for the Morehead City planning jurisdiction (NOAA 2007)

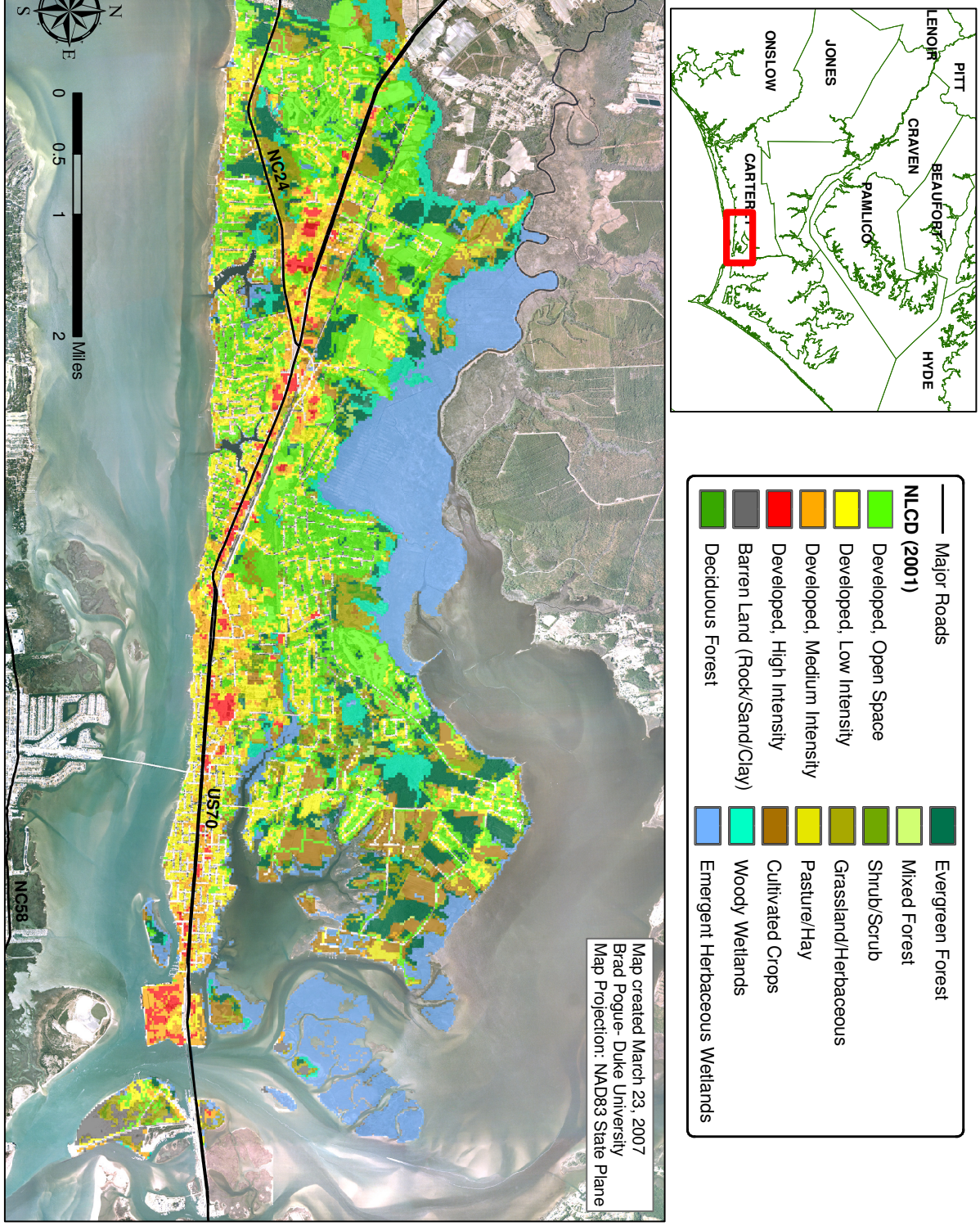


Figure 10: NLCD 2001 land use and land cover classifications for the Morehead City planning jurisdiction (MRLCC 2007)

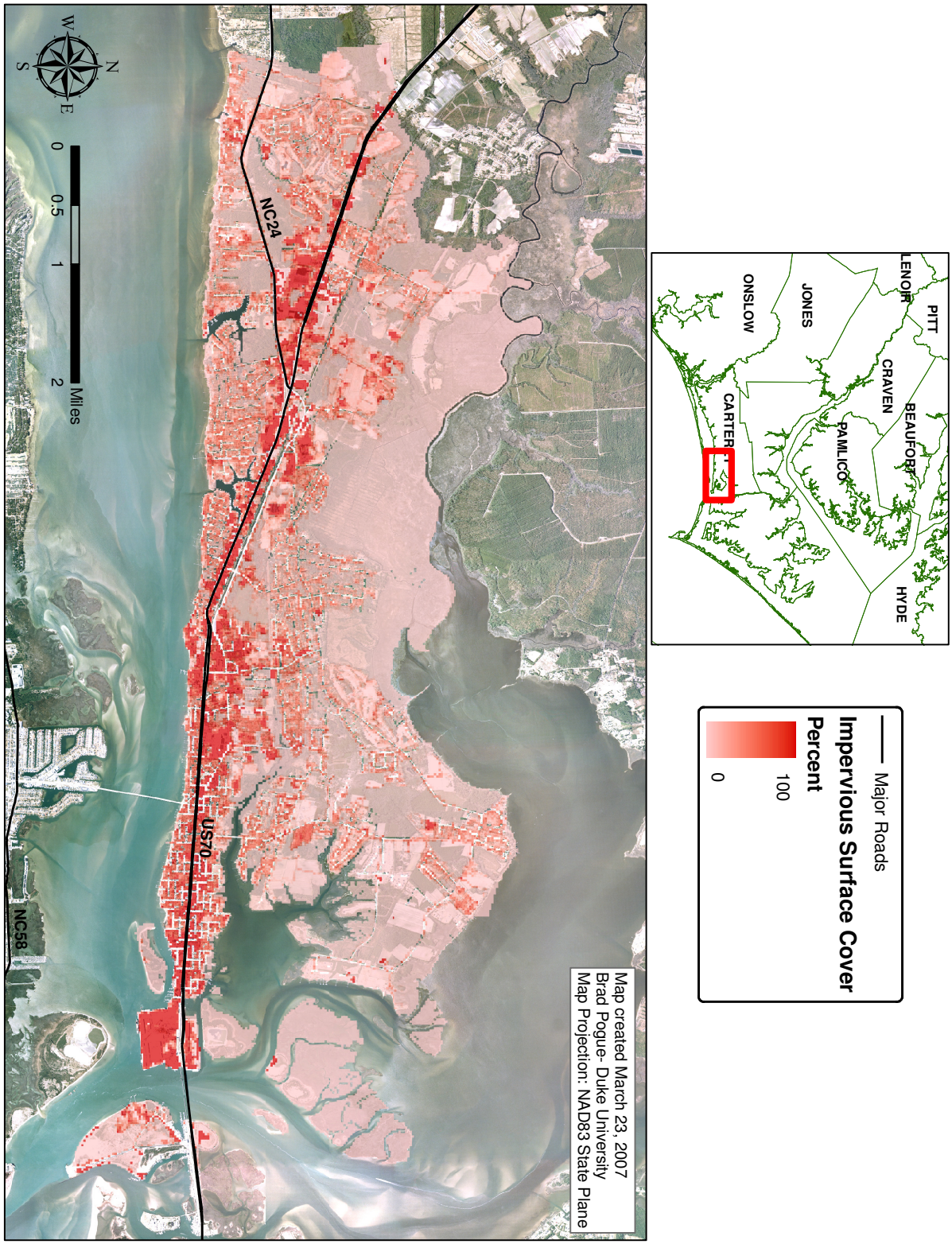


Figure 11: NLCD 2001 estimated percent impervious cover per pixel for the Morehead City planning jurisdiction, excluding roads (MRLCC 2007).

The MS4 operated by the town of Morehead City consists of 22.8 miles of piping and 1080 catch basins, as well as an extensive network of drainage ditches and swales throughout its planning jurisdiction (Fig. 12). Outfalls to waters of the state have been mapped in the ETJ, but are not indicated within the city limits on the existing storm sewer system map maintained by the town. This system drains the various land uses discussed above, which influences the characteristics of the stormwater discharge entering the receiving waters of the Newport River and Bogue Sound.

5.1.4 Stormwater Management Background

In addition to the state coastal stormwater program enforced by the DWQ, there are local stormwater management measures in place within the Morehead City jurisdiction. The local stormwater management program includes (from Morehead City 2006):

- Maintenance of existing ditches
- Use of low impact development designs for city projects
- Updating stormwater facilities during street improvement projects
- Maintenance of a database and map of the existing infrastructure
- Identification of illicit discharge areas
- Reporting malfunctioning stormwater ponds to the state
- Development of a draft stormwater management ordinance; the ordinance has not been adopted due to inadequate staffing for enforcement.

These measures are primarily related to the maintenance of the existing system. The town notes in its current draft CAMA land use plan that "the existing drainage system has deteriorated and is not large enough to handle stormwater runoff in many areas" (Morehead City 2006), which increases the risk of flooding during heavy rains.

The town of Morehead City has also agreed to several voluntary measures to mitigate the expected impacts of increased stormwater runoff as a result of increased development accompanying the expansion of the Morehead City WWTP. These voluntary measures include:

- prohibition of sewer service expansion into certain sensitive areas,
- development and implementation of a local stormwater management program that utilizes the six minimum measures of the NPDES Phase II stormwater program,

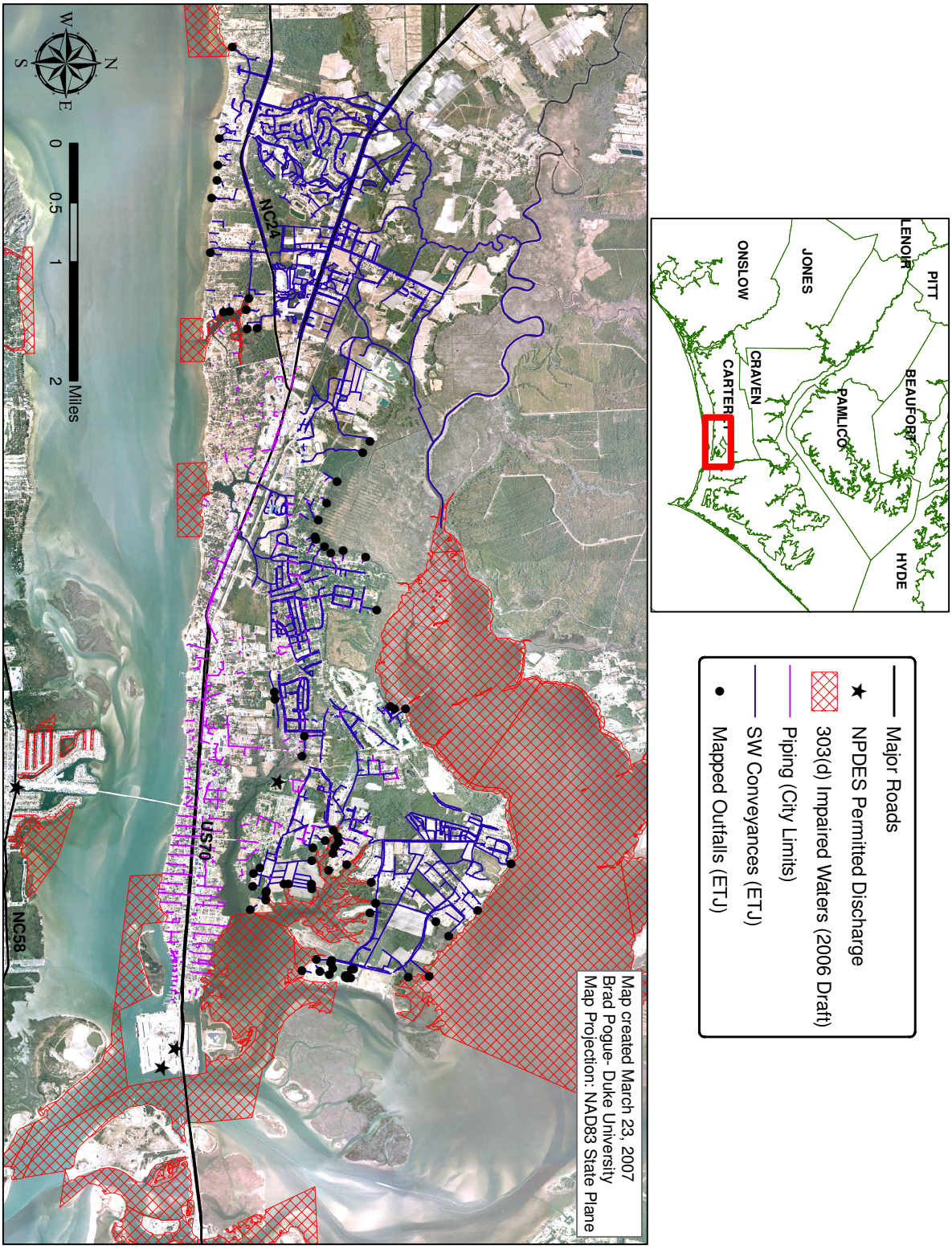


Figure 12: Overview of Morehead City, NC stormwater infrastructure including outfalls to state waters in the Morehead City ETJ (Maps obtained through the Morehead City Planning Department)

- exploration of grant funding opportunities for stormwater projects in environmentally sensitive areas,
- enhancement of the Carteret County Advanced Identification of Wetlands project,
- continuing cooperative efforts with state agencies and environmental groups to improve stormwater management in the town,
- prohibition of additional or enlarged stormwater discharge points into SA waters,
- conducting an inventory of the existing MS4 and evaluation of retrofit opportunities,
- implementation of staff training to assist the state in monitoring stormwater projects, and
- conducting a self-evaluation of existing ordinances (Morehead City 2006).

These mitigation measures indicate a fairly proactive approach to stormwater management in Morehead City, however, it should be emphasized that all of these measures are voluntary.

5.1.5 Evaluation

- *Is the MS4 listed as a pollutant source in a TMDL implementation plan?*

  Although several areas of the receiving waters of the Morehead City MS4 are listed in the integrated 303(d) report of impaired water bodies, the MS4 is not currently listed as a pollutant source in a TMDL implementation plan.

- *Do receiving waters show evidence of water quality standards violations or degradation, or does the MS4 drain to water bodies listed as impaired?*

  Based on the water quality data and background information above, it appears that there are some significant surface water quality issues that could potentially be related to stormwater discharges from the Morehead City MS4. Fecal coliform counts are high, particularly after moderate to heavy rain events. For this reason, all shellfishing waters classified as conditionally approved open are subject to closure after significant rainfall events. In the E-3 area, 2.5 inches of precipitation triggers a closure, while in the E-4 area, 1.5 inches of rainfall is the threshold (DEH 2002, DEH 2005). According to the Shellfish Sanitation and Recreational Water Quality Section, "rainfall and the resultant runoff is the event most detrimental for shellfish water quality" in the area (DEH 2005). Thus, it appears very likely that the stormwater discharges from the Morehead City MS4 are potentially a significant contributor of pollutants to receiving waters, particularly for

fecal coliform bacteria. While water quality violations for other parameters, such as dissolved oxygen and turbidity, have occurred at the ambient monitoring stations in Calico Creek, fecal coliform is noted as the cause of impairment for all receiving waters of the Morehead City MS4 that are listed in the 303(d) report of impaired water bodies (DWQ 2006).

- *Based on the typical characteristics of stormwater runoff from the land uses found within the drainage basin, is stormwater likely to contribute to water pollution?*

While the town classifies nearly half of its planning jurisdiction as undeveloped, many areas, especially within the city limits are heavily urbanized. Using ArcGIS 9.1 geospatial analysis software, a zonal statistics analysis was conducted for each land use class in each of the three land use datasets: the Morehead City existing land use map, CCAP land use/land cover, and the NLCD land use/land cover. The analysis resulted in an estimate of the mean percent impervious surface for each land use class in the Morehead City planning jurisdiction (Tables 10, 11, and 12). The developed land use classes, especially commercial, institutional, and industrial areas, are noted to exceed levels of impervious coverage at which degradation of surface water quality begins to be observed, generally shown to occur with greater than 10% watershed impervious surface coverage (Schueler 1994). Mallin et al. (2000) show a strong relationship ($r^2 = 0.95$) between the geometric mean fecal coliform concentration and impervious surface coverage within each watershed of five tidal creeks in New Hanover County, NC (Fig. 13). This data shows standards being exceeded in a watershed having as little as 8.7 percent impervious surface cover.

Table 10: Estimated percent impervious cover per existing land use class in the Morehead City planning jurisdiction

Land Use	Mean Percent Impervious
Industrial	21.00
Commercial	37.01
Institutional	29.29
Residential	8.07
Planned Residential	11.36
Floodplain	0.15

Table 11: Estimated percent impervious cover for each CCAP land use/land cover class in the Morehead City planning jurisdiction

Land Use/Land Cover	Mean Percent Impervious
Developed, High Intensity	50.90
Developed, Low Intensity	17.17
Cultivated Land	6.12
Grassland	12.57
Deciduous Forest	14.69
Evergreen Forest	8.02
Mixed Forest	8.59
Scrub/Shrub	9.52
Palustrine Forested Wetland	6.24
Palustrine Scrub/Shrub Wetland	10.49
Palustrine Emergent Wetland (Persist	8.97
Estuarine Emergent Wetland	0.72
Unconsolidated Shore	13.23
Bare Land	23.47
Water	9.01

Table 12: Estimated percent impervious cover for each NLCD land use/land cover class in the Morehead City planning jurisdiction

Land Use/Land Cover	Mean Percent Impervious
Developed, Open Space	9.01
Developed, Low Intensity	30.30
Developed, Medium Intensity	59.90
Developed, High Intensity	85.34
Barren Land (Rock/Sand/Clay)	2.31
Deciduous Forest	0.00
Evergreen Forest	0.25
Mixed Forest	0.32
Shrub/Scrub	0.78
Grassland/Herbaceous	0.85
Pasture/Hay	0.46
Cultivated Crops	1.23
Woody Wetlands	0.24
Emergent Herbaceous Wetland	0.10

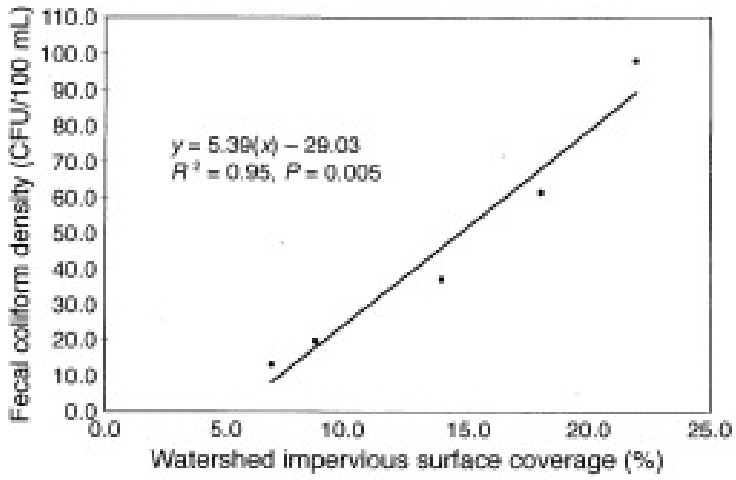


Figure 13: Geometric mean fecal coliform concentration versus watershed percent impervious cover for five coastal watersheds in the New Hanover County, NC area (in Mallin et al. 2000)

The National Stormwater Quality Database (Pitt et al. 2003) was developed to compile and analyze monitoring data gathered by large and medium MS4s for the purposes of Phase I stormwater permit applications. In the initial analysis of this data, a variety of parameters including the percent impervious cover and geometric mean fecal coliform counts were compiled and stratified according to land use (Table 13). While the variance in these data are quite high due to the wide variety of sampling locations and conditions, all of the land use classes show that high densities of fecal coliform, well above water quality standards, are present in the samples. Because these types of land use are present in Morehead City, fecal coliform levels in the stormwater discharge from the MS4 could also be expected to be high.

- *Are existing stormwater programs within the jurisdiction effectively protecting water quality and will the Phase II program improve stormwater management practices?*

The primary regulatory tool for stormwater management in Morehead City is the state coastal stormwater management program, which in conjunction with CAMA, is intended to protect coastal water quality. However, "since additional limitations on shellfish harvesting have occurred since CAMA has been promulgated, it is clear that these policies have not adequately protected water quality" (DWQ 2000). While amendments to these rules have been proposed that would make the requirements more

stringent, these changes would not take effect until at least mid-2008 (Reeder 2007), and it is uncertain what the final version of these proposed rules will require.

Table 13: Estimated percent impervious surface coverage and geometric mean fecal coliform count for large and medium MS4 stormwater discharges based on NPDES Phase I permit monitoring results

Land Use	% Impervious	Fecal Coliform (MPN)
Residential	37.0	8345 (n=446)
Mixed Residential	44.9	11000 (n=313)
Commercial	83.0	4300 (n=233)
Mixed Commercial	60.0	4980 (n=109)
Industrial	75.0	2500 (n=297)
Mixed Industrial	44.0	3033 (n=115)
Institutional	45.0	--
Freeways	80.0	1700 (n=49)
Mixed Freeways	--	730 (n=16)
Open Space	2.0	7200 (n=23)
Mixed Open Space	34.0	2600 (n=95)

The town of Morehead City has agreed to implement certain stormwater management measures in order to mitigate the expected impacts of increased development accompanying the expansion of its WWTP, which include the six minimum measures of the Phase II stormwater program. These measures go above and beyond any state requirements for stormwater management; however, the measures are voluntary and not enforceable regulations. The town has been unable to adopt a stormwater management ordinance due to insufficient staffing (Morehead City 2006), and it would seem likely that similar circumstances could prevent the full implementation of some of the voluntary measures agreed to by the town.

By requiring the town to obtain a Phase II stormwater permit, a regulatory tool is put into place to ensure that appropriate BMPs are selected and implemented in a timely manner in order to reduce the discharge of pollutants from the Morehead City MS4 to the "maximum extent practicable." The Phase II permit would require a formalized stormwater management program in the town of Morehead City, and even the DWQ

(2007e) has stated that "Morehead City should consider stronger ordinances to control stormwater runoff to Calico Creek, including the development of a Phase II stormwater program."

One of the main benefits of the Phase II program would be the full implementation of a public education and outreach program regarding the impacts of stormwater. DWQ has noted that "a significant part of reducing detrimental inputs to the waterways of North Carolina involves creating public awareness of runoff concerns and educating people about ways to reduce stormwater runoff (DWQ 2004). The public education minimum measure of the Phase II program would require Morehead City to implement an outreach program and encourage the town to take full advantage of the resources provided by the Runoff Education and Awareness Program developed as a part of the North Carolina Coastal Nonpoint Source Program. Also, the post-construction requirements of the North Carolina Phase II program would help to mitigate the impacts of rapid growth throughout the Morehead City planning jurisdiction. The impacts of increased impervious surface, primarily in less densely developed areas outside the city limits, could be mitigated by the development density-based runoff control requirements. New or expanded point discharges of stormwater from the MS4 into SA waters would be prohibited in all areas of the Morehead City jurisdiction and a fecal coliform source control program would be required (Section 9, SL 2006-246), directly addressing the primary threat to water quality in the shellfishing waters surrounding the town. Implementation of the good housekeeping and illicit discharge detection measures would require a thorough evaluation of the effectiveness of the current MS4 maintenance measures in the town's existing stormwater management program. Thus, a Phase II permit has the potential to directly address stormwater management issues that may threaten water quality in the receiving waters of the Morehead City MS4.

Based on the initial evaluation, it appears that a petition for a Phase II permit for Morehead City would be justified, and assuming that adequate resources are available, the second stage of the petition methodology should be implemented. There are water quality issues present, the drainage basin characteristics are typical of urbanized areas, existing mandatory stormwater programs have not effectively protected water quality, and the extent to which other

voluntary measures will be implemented is uncertain. If the implementation of the minimum measures of the Phase II program is required through a permit, there are several ways in which stormwater management could potentially benefit. However, two important factors should be accounted for prior to making the decision to proceed with the implementation of a stormwater discharge monitoring project.

First, in February 2007, a public notice was issued stating the following: "Pursuant to Session Law 2006-246, Section 5, the Town of Atlantic Beach, the Town of Emerald Isle, and Morehead City have been identified as candidates for designation as regulated Phase II public entities under the National Pollution Discharge Elimination System (NPDES) stormwater program" (DWQ 2007c). This indicates that DWQ is already considering the designation of Morehead City as requiring a Phase II permit through the state designation process. The public comment period regarding the potential designation of Morehead City as a Phase II community will end in March 2007, and a decision on the designation will be made by May 2007. If the town is designated, then no Phase II petition would be needed. For this reason, the premature investment of time, labor, and money in an unnecessary monitoring project should be avoided. On the other hand, if Morehead City is not designated, this may, in effect, place a larger burden of proof on the petitioner in showing that the decision by the DWQ not to designate the town as a Phase II community was incorrect. Therefore, the outcome of this designation process should be evaluated prior to implementing a stormwater monitoring study.

Secondly, the state coastal stormwater program is currently under review. While the proposed amendments are not expected to go into place until 2008 and final outcome of the process is uncertain, it is important to note that the current proposal mirrors the Phase II post-construction rules (Reeder 2007). If this proposal is adopted, it may be more difficult to convince the EMC that a separate Phase II permit is necessary for the town of Morehead City. In the event that a petition was being pursued, the likelihood of a successful petition should be considered in light of these pending changes to the stormwater management regime in Morehead City. It may be determined that undertaking the stormwater monitoring study for a Phase II petition may not be worthwhile.

5.2 Phase II Petition Case Study: Stage II- Stormwater Monitoring

It is likely that any effort at conducting a petition stormwater monitoring study for the purpose of a petition for Morehead City, or elsewhere along the North Carolina coast, will need to be postponed pending the completion of the state Phase II designation and the coastal stormwater program amendment processes. For the purposes of the case study, it will be assumed that a petition is still viable, and various preliminary aspects of a potential monitoring project within the second stage of the process will be discussed.

5.2.1 Systematic Planning

For the purposes of this case study, there is no plan to actively conduct a monitoring project to characterize the stormwater quality of the discharge from the Morehead City MS4. In the case of an actual petition, the systematic planning process discussed within the Phase II petition methodology would be used to develop a monitoring plan, and the products of this process could then be developed into a QAPP. The specifics of any future monitoring study must be developed by the project manager, once resources for sampling and laboratory testing have been acquired and a project or volunteer team has been assembled. Any resource limitations are likely to have a direct influence on the potential sampling effort and the duration of the monitoring project.

There are several general aspects of the strategic planning process that can be explored regarding a potential Phase II petition for Morehead City, which may also be relevant to petition planning efforts for other coastal areas experiencing extensive closures of shellfishing waters linked to fecal coliform bacteria and stormwater runoff. These include considerations for establishing monitoring objectives, the data requirements for a monitoring project, and general methods regarding fecal coliform sampling.

Project Objectives

Section 6(2)(b) of the 2006 Phase II legislation establishes that the petitioner must present monitoring data showing either that the stormwater discharge is contributing to or causing impairment (loss of beneficial use) or degradation (diminished beneficial use) of receiving waters, or that the stormwater discharge is a significant contributor of pollutants to unimpaired receiving waters (SL 2006-246). The key to meeting the first criterion is establishing the link between the pollutants impacting the receiving waters and the pollutants in the

stormwater discharge. In this case, given the fact that the in-stream water quality is already documented as impaired, it would only be necessary to characterize the quality of stormwater discharged from the MS4. The monitoring effort would focus on establishing that the stormwater discharged from the MS4 contains high concentrations of the pollutant impairing the beneficial use of receiving waters, for example, fecal coliform bacteria in the case of the shellfishing waters surrounding Morehead City. Ideally, the discharge would be sampled at outfall locations where it enters impaired shellfishing waters, and then submitted for laboratory analysis to determine if pollutant levels in the discharge violate the relevant water quality standards.

The second criterion is relatively vague, as the term "significant" is not well-defined and open to some degree of interpretation. Demonstrating the significance of stormwater discharges to waters that are not already considered impaired or degraded will be more difficult and complex. If water impairment has not been documented, the characterization of both the quality of receiving waters and the stormwater discharge may be necessary, in order to demonstrate that the MS4 discharge is significantly affecting receiving waters. In addition to stormwater discharge monitoring, receiving water characterization would require the measurement of in-stream water quality parameters or an ecological assessment of the condition of the stream to establish pollutant concentrations and determine if water quality standards are being violated. This adds to the cost and complexity of the project in that more samples would need to be tested, additional equipment, such as a boat, may become necessary, the sampling design issues may become more complex, and more data, labor, and field work will be required.

Therefore, it appears that undertaking a monitoring study for the purposes of a petition may only be feasible for areas in which an adequate amount of existing data or documentation of impairment already exists. This approach is much more cost-effective because it eliminates the additional costs of conducting in-stream monitoring. The fact that many available sources of existing water quality data are provided by government agencies bolsters the credibility of a petition using this data, relative to a petition in which original estimates of in-stream impairment are developed. Additionally, the uncertainty associated with the term "significant contribution" can be avoided if existing impairments are used as the basis for linking the stormwater discharge to receiving water quality problems.

In Morehead City, all of the impaired waters listed in the 303(d) report are documented as impaired by fecal coliform bacteria, which results in temporary or permanent loss of shellfishing uses in the receiving waters of the MS4. Nearly all of the receiving waters surrounding Morehead City are listed as impaired, or exhibit some degradation in shellfishing use. Conditionally Approved- Open areas are closed to harvest following significant storm events, and should therefore be considered degraded by fecal coliform pollution because they have experienced some loss of use, even if they are not specifically listed as impaired on the 303(d) list. Based on this assessment, the primary objective of the monitoring plan for a Phase II petition for Morehead City would focus on characterizing the quality of stormwater discharged into these impaired and degraded waters, primarily based on the estimation of fecal coliform bacteria density. This would be done to confirm or deny the hypothesis that the MS4 is contributing to fecal coliform pollution to the waters surrounding Morehead City.

Data Requirements and Analytical Methods

In the case of Morehead City, the parameters to be estimated through the monitoring project include the concentration and loading of fecal coliform bacteria in stormwater discharged from the MS4. Data collection will consist of obtaining an adequate sample of stormwater from several outfalls within the Morehead City planning jurisdiction to be tested for the density of fecal coliform bacteria in a state-certified laboratory. In order to calculate loading rates, measurements of the rate, depth, and size (cross-sectional area) of the stormwater flow will be needed. This data can then be used to calculate an instantaneous loading rate of fecal coliform, at the time of sampling, from a particular discharge. For each sampling event, the amount of precipitation would be measured directly, or obtained from the National Weather Service or other reliable source, in order to examine the loading and concentration of fecal coliform compared with the size of the storm event. Sample collection may be quite labor-intensive and will most likely require a team of volunteers to working at various sampling stations, in order to obtain the necessary number of samples at each location within a reasonable timeframe.

The methods for testing stormwater samples should follow the procedures outlined by the EPA in the Code of Federal Regulations (40 CFR Part 136). Because existing data of in-stream fecal coliform bacteria density from the Shellfish Sanitation and Recreational Water Quality Section is based on the Most Probable Number (MPN) method, this laboratory method should also be used to test stormwater discharge samples. For any comparison of the two datasets, this

will help to ensure that additional error is not introduced in the analysis due to the use of different analytical methods (Burton and Pitt 2002). Assuming that a state-certified laboratory will conduct the sample analysis, the primary requirements that must be addressed by the petitioner involve the use of proper equipment and sample collection techniques in the field. Collection bottles should be either sterilized plastic or glass with a water-tight seal, and this equipment can be provided by the laboratory in most cases. Samples for measurement of fecal coliform bacteria must be collected as grab samples, which will involve manual collection of approximately 500 milliliters of stormwater for each sampling event at each sampling station (EPA 1992). Upon collection, samples should be packed in ice, in order to maintain the samples at a temperature of 1 – 4 ˚C, and transported as quickly as possible to the lab. The maximum holding time allowed prior to the initiation of laboratory analysis procedures is six hours (EPA 1978). Accurate labels, identifying the sample, sampling location, and time, are extremely important, and if multiple persons are handling samples during their transportation, a chain-of-custody record is necessary for quality assurance purposes.

In order to calculate the pollutant load, several other field measurements will be required. According to EPA guidance (EPA 1992), flow volume (volume discharged per unit time) can be estimated using any number of simple techniques, including the float method in an open ditch (the amount of time it takes for a float to travel a given distance in the stormwater conveyance multiplied by the cross-sectional area of the conveyance) or the bucket and stop-watch method for an elevated pipe discharge (the time amount of time it takes for the discharge to fill a bucket of a given volume). Other techniques involve the use of handheld or automated flow meters to measure the flow rate of the discharge, which is then multiplied by the cross-sectional area of the discharge to estimate the flow volume. The cross-sectional area is determined by the distance across the conveyance at the water's surface and the contour of the bottom of the pipe or ditch. Flow rate measurements should be taken at the deepest part of the conveyance.

5.2.2 Sampling Design

Sampling design: Spatial component

The key issue in selecting a sampling design is to ensure that a representative sample is obtained. As previously discussed, it would be nearly impossible to conduct a study using a statistically random sample of the total population of outfalls from an MS4, for a number of

reasons, including high costs and access to outfalls. Based on EPA guidance for Phase I permit applications, five to ten sampling locations should be established in order to characterize the stormwater discharge from an MS4 (EPA 1992), and this range would be appropriate for the purposes of a Phase II petition, as well. A judgmental strategy, based on knowledge of the drainage area, would be most appropriate for determining the final number and location of sampling sites.

Due to a number of problems associated with access sampling locations, such as difficulty to reaching outfalls from land or by boat, hazardous outfall locations that are difficult to access under adverse weather conditions, outfalls that are submerged or flooded by tides, and problems gaining access to outfalls located on private property, it is difficult to outline a specific, step-by-step strategy to apply within the jurisdiction of any MS4 in the selection of sampling locations (EPA 1992). The specific location of sampling sites will have to be determined after field surveys or based on the knowledge of local officials, state agencies, and the petitioner. However, a general strategy based on the characteristics of the drainage basin can be used to establish the appropriate number of sites and general areas in which to focus preliminary field surveys. The primary objective of such a strategy is to select sampling locations that drain areas of homogenous land use within the drainage area served by the MS4.

The Morehead City CAMA land use plan shows five major land uses, primarily based on zoning ordinances, each with varying amounts of impervious surface. The 2001 NLCD land use/land cover map is classified into varying levels of development of all types, based on the amount of impervious surface. In examining the Morehead City existing land use map, several areas of relatively homogenous land uses can be identified, including distinct blocks of four land use classes: industrial, commercial, institutional, and residential development. A visual comparison of this map with the developed classifications of the 2001 NLCD and the percent impervious surface cover map shows that within certain land use classes, the intensity of development is relatively consistent.

On the NLCD map, industrial areas are generally classified as high intensity, commercial uses range from medium to high intensity, and institutional uses are generally medium intensity. Therefore, sampling at an outfall draining each of these land use classes could be considered representative sampling of the discharge from each of these three land uses. On the other hand, the residential land use class covers areas that vary from high intensity development to open

space or natural land use classifications on the 2001 NLCD map. The amount of impervious surface also ranges from very low to extremely high. Therefore, in order to obtain a representative sample of residential land uses, at least two or three sampling sites should be selected within areas of residential land use, in areas of varying development intensity. This assessment leads to an initial estimate of six sampling locations for the monitoring study, with the possibility that additional sites could be included.

Based on the above analysis, the location of initial field surveys to identify accessible outfalls can be more focused. Given the overall project objective of establishing a link between existing water quality impairment and the pollutant discharged in the stormwater, it is also important to locate outfalls in areas that discharge to impaired or degraded waters. Generally, all of the waters surrounding Morehead City are degraded or impaired based on the rating given by DWQ or the classification of shellfish harvesting status by DEH. However, it should be noted that according to the methodology of the Shellfish Sanitation and Recreational Water Quality Section, all brackish and salt waters are considered as potential shellfish harvesting areas and receive a shellfish harvesting classification. DWQ considers only those areas classified as SA waters as being potentially available for shellfishing uses (DWQ 2006). Therefore, Calico Creek, which receives the discharge from the Morehead City WWTP and falls under the SC HQW surface water classification, is not considered to be impaired by DWQ, and neither are the waters surrounding the North Carolina State Port Facility, which are classified as SC waters. The sampling effort should focus only on class SA waters that are impaired or degraded, and sampling locations discharging to the above water bodies should be avoided. Based on land use intensity, water impairments, and the location of outfalls within the stormwater infrastructure of Morehead City, six initial survey areas can be identified (Fig. 14).

Once accessible outfalls have been located, these sampling locations should be mapped as required by the Phase II petition rules. Ideally, location coordinates should be obtained using a handheld GPS unit and then mapped using geospatial analysis software such as geospatial analysis software. The area draining to each of these outfalls can then be estimated and delineated based on field surveys, aerial photos, or elevation data. The characteristics of each of these delineated sub-basins should be described based on impervious surface characteristics, land use maps, as well as field descriptions in order to develop a complete description of the conditions on the land draining to each sampling location.

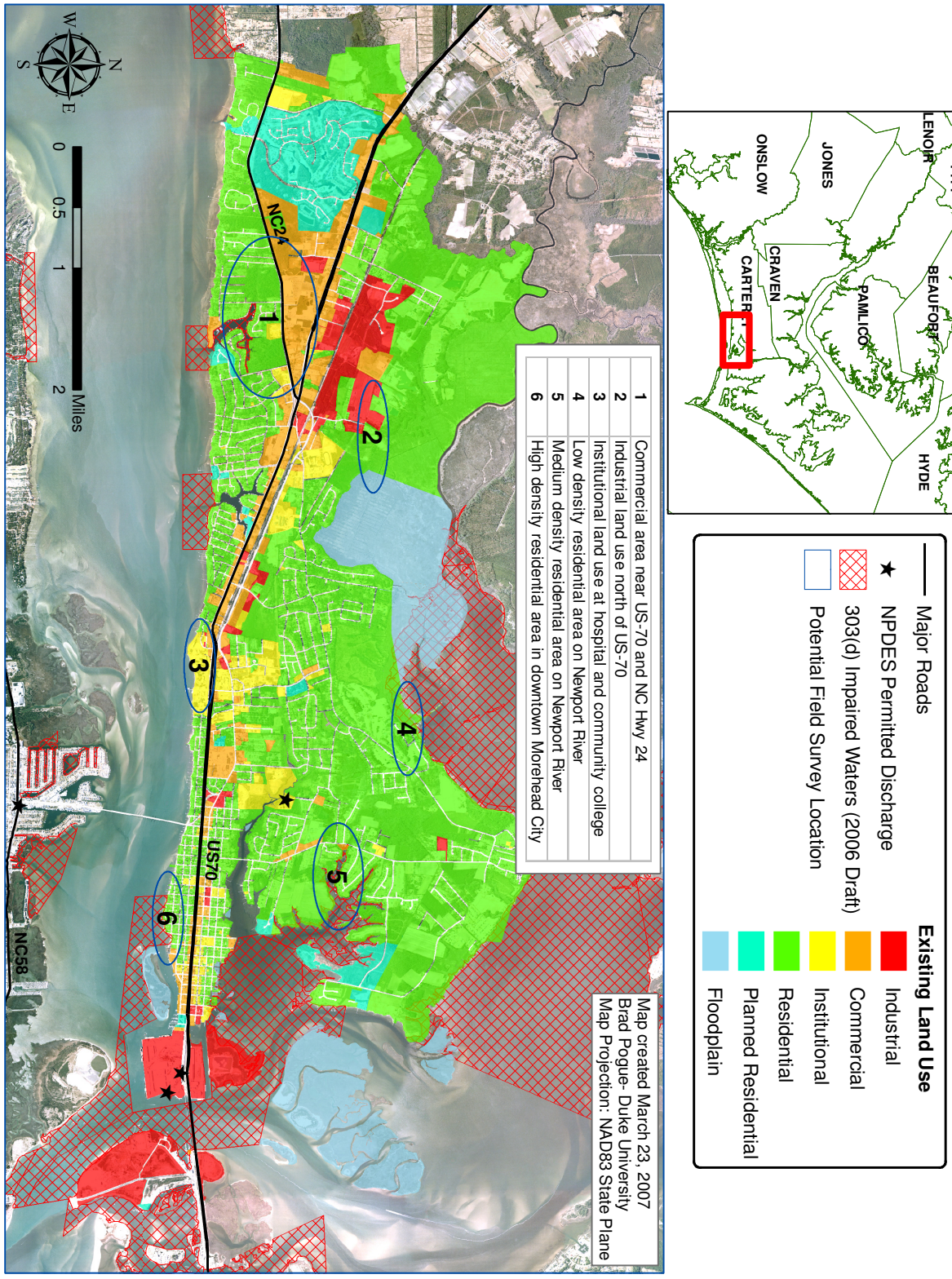


Figure 14: Proposed preliminary field survey areas for potential stormwater outfall sampling locations

Sampling design: Temporal component

The temporal aspects of the sampling design will be based generally on the EPA requirements for Phase I permit applications for large and medium MS4s regarding representative storms. Therefore, sampling events will occur for storm events that are greater than 0.1 inches depth and do not vary by more than 50% from the average depth and duration of storm events. Data collected between 1948 and 1999 by the National Climatic Data Center (NCDC) at the Morehead City 2 WNW observation station was obtained online (NCDC 2007). This data was used to calculate the maximum and minimum storm depth and duration of a representative event (Table 14) based on EPA stormwater sampling guidance (EPA 1992). For the sake of simplicity, the minimum rainfall amount that would trigger a sampling event could be rounded up to one-half inch. This would ensure that the event was large enough to be considered a representative storm according to EPA guidelines and that a measurable discharge would occur. Because grab sampling is required for estimating fecal coliform density, only instantaneous measurements of density and discharge flow will be taken, and the duration of the storm will not be used to select or eliminate sampling events. In order to measure first flush effects and ensure consistent sampling times between locations, samples would be gathered within 30 minutes of the beginning of the storm event.

Table 14: Rainfall statistics for the Morehead City 2 WNW monitoring station and calculated maximum and minimum storm depth and duration values

Rainfall Statistics	Mean	Representative Max	Representative Min
Annual Precipitation Total (Inches)	50.302	N/A	N/A
Annual Number of Storm Events	70.468	N/A	N/A
Monthly Average Storm Duration (Hours)	7.856	11.784	3.928
Monthly Average Storm Depth (Inches)	0.691	1.0365	0.3455

Sampling design: Quantitative component

Based on the existing sampling data collected by the Shellfish Sanitation and Recreational Water Quality Section for the E-3 and E-4 SGAs, an estimate of the number of sampling events needed to obtain a representative sample of fecal coliform density in the stormwater discharge at each location can be calculated. The log transformed fecal coliform data obtained for the sanitary surveys of these SGAs (DEH 2002, DEH 2005) can be used to estimate

a coefficient of variation (COV) for the data set. The mean COV for all 68 sampling sets is calculated as 0.59. Using the values of $\alpha = 0.05$ (95% confidence level), $\beta = 0.2$ (power of 0.8), and an allowable error of 25% to solve the above equation (Eq. 1) (Burton and Pitt 2002), the number of samples need is estimated to be approximately 35 samples per sampling site. By relaxing the allowable error to 50%, the estimated sampling effort becomes approximately nine samples per site. Greater sampling effort will improve the error in the resulting estimate of the geometric mean fecal coliform density in the stormwater discharge, but the actual number of samples collected will depend on the number of representative events during the time period of the study and the amount of money available for sample analysis. These estimates offer a general guideline for the sampling effort necessary to achieve the given level of confidence and error in the study results, and should be taken into account when determining the project schedule. If it is not possible to collect this many samples for some reason, it is important to include an explanation of why it was not done and an analysis of the actual level of confidence and error present in the results.

Sampling design: Summary

Based on the above analysis of sampling design factors, the monitoring study will sample six stations for fecal coliform density, located at outfalls draining the major land use classes within the Morehead City planning jurisdiction. Sampling events will be triggered by rainfall events expected to total greater than one half inch, and sampling will be conducted within 30 minutes of the beginning of the storm event. In order to obtain an estimate of the geometric mean fecal coliform density for the discharge from each outfall location, at least nine sampling events are estimated to be necessary at each sampling location to achieve a confidence level of 95% and an error level of 50% in the resulting estimates. Depending on the schedule and resource availability of the monitoring study, more samples may be gathered to achieve a lower error. The actual error and confidence level should be included with the results, especially if fewer samples are collected.

5.2.3 Quality Assurance Project Plan

As discussed previously, the monitoring study objectives, resources, schedule, sampling methods, sampling design, data quality objectives, and other outputs of the data quality objectives process will be documented in the QAPP in order to reassure decision makers that the

data collected during the project are of high quality. Also, quality control and assurance procedures will be included to ensure the detection of any measurement errors or sample contamination occurring during field collection procedures. The specifics of this document will be determined by the project team involved in any future monitoring efforts for the purposes of a Phase II petition for Morehead City. Based on EPA guidance, the North Carolina DWQ provides a checklist to ensure that all aspects of a QAPP are included (DWQ 2007d). This checklist is included in Appendix D.

A QAPP was developed for the Storm Drain Monitoring Project, a volunteer monitoring effort being coordinated by the North Carolina Coastal Federation (NCCF), many aspects of which could easily be adapted for a petition monitoring project (NCCF 2005). If the aforementioned sampling strategy is adopted for a monitoring study in Morehead City, a team of volunteers would be required to collect samples during sampling events. The NCCF project focuses on monitoring fecal coliform concentrations for several storm drains in Carteret County. Therefore, the project team organization and sampling methods used for a petition monitoring project in Morehead City will be similar to those documented by the NCCF.

5.2.4 Notification

Prior to beginning any monitoring activities in Morehead City, original copies of a notification letter should be sent via certified mail to the city manager, Mr. Randy Martin, and the storm sewer operator, Mr. David McCabe, at the Morehead City town hall. This letter should include any information deemed relevant, including the project purpose, sampling station locations, and a projected sampling schedule; however, the main purpose of the letter is to provide notification that a petition is being pursued and that monitoring activities will be conducted. Assuming there has been prior contact with city officials, it may already be understood that monitoring is planned; however, written notification is still necessary to meet the requirements of the Phase II rules (SL 2006-246). Again, it should be noted that permission for monitoring is not required as long, as monitoring activities are performed in legally and publicly accessible sites.

5.2.5 Stormwater Monitoring, Data Analysis, and Reevaluation

Once stormwater monitoring is completed, an analysis of the data should be conducted for the reevaluation of the viability of the petition. This will involve compiling the laboratory results of fecal coliform density for the individual samples at each sampling location, and calculating the geometric mean and 90th percentile values at each outfall. These values can then be used to determine if the stormwater is exceeding water quality standards for the receiving waters based on the SA waters classification. These values are calculated in the following way:

- Geometric mean (from Costa 2007):
  - (a) Calculate the logarithm (base 10) of each sample result
  - (b) Calculate the arithmetic mean of all sample result logarithms (base 10)
  - (c) Calculate the antilog (base 10) of the result in (b)
- Estimated 90th Percentile (from NSSP 2005):
  - (a) Calculate the arithmetic mean and standard deviation of the sample result logarithms (base 10)
  - (b) Multiply the standard deviation in (a) by 1.28
  - (c) Add the product from (b) to the arithmetic mean
  - (d) Take the antilog (base 10) of the results in (c) to get the estimated 90th percentile

If the results show a violation of water quality standards, and the outfall location is discharging into waters impaired or degraded fecal coliform bacteria, then it can be shown that the discharge is at least partially contributing to the degradation of receiving waters.

The calculation of the instantaneous loading of fecal coliform should be done by first calculating the flow volume as described previously and then multiplying by the fecal coliform density. This value indicates the load of fecal coliform (MPN) per unit time and can offer an estimate the quantity of bacteria entering the water at a particular point in time during a storm event. Without monitoring the flow rate of the discharge over the course of an entire storm event, this only provides an instantaneous loading rate and cannot be used to estimate the total amount of fecal coliform entering the receiving waters; however, it does provide some indication of the magnitude of the stormwater discharge pollutant contribution of bacteria to the receiving water body. Rainfall amounts should be recorded for each storm event to allow a general comparison of loading versus event precipitation, and to account for the representativeness of the storm event.

5.3 Phase II Petition Case Study: Stage III- Petition Submission

Finally, if the results of these analyses support the initial assumption that the discharge from the MS4 is contributing to fecal coliform pollution in shellfishing waters, then a petition should be submitted to the EMC. Background information should be summarized, monitoring data clearly presented, and maps and the QAPP included when submitting a petition. If department forms are made available, these should be used to complete the process.

6.1 Conclusions

The Phase II rules in North Carolina provide more detail than many other state NPDES permitting authorities, or the EPA, regarding the necessary data and background information required for the completion of a Phase II stormwater program adverse impact petition. The petition methodology outlined in this project is designed to meet all of these requirements, in order to construct a petition that will be deemed complete upon submission to the EMC, and potentially granted on its merits. This petition methodology is based on the use of existing government data and EPA guidance on the design of environmental studies, in order to provide reassurance to decision-makers that the petition data collected will be of high quality. Initially, it appeared that the detailed requirements of the North Carolina Phase II petition rules would simplify the process of submitting a Phase II stormwater petition and enhance the ability of the general public to play a direct role in requiring more stringent stormwater management along the North Carolina coast. But although the petition methodology appears relatively straight forward, further study based on the Morehead City, NC, MS4 showed that the petition rules may actually place a large burden of proof on the petitioner and several practical challenges to the successful completion of an adverse impact petition were revealed through this preliminary application of the petition methodology.

6.1.1 Challenges and Obstacles

The first challenge that becomes apparent is the potential lack of availability of data needed for the background research stage of the petition process. Water quality data may be sparse for certain time periods, may not exist for the location or stations of interest, may measure variables using different parameters, or may not address the variable of interest at all. For

example, the EPA STORET database lacked any fecal coliform density data for monitoring stations in the area of Morehead City. It appears that pollutants requiring grab samples may not be frequently measured and this data may be especially difficult to track down. As another example, Shellfish Sanitation and Recreational Water Quality Section sampling data provides a good background information source on areas of impairment; however, sampling is done during dry weather periods and does not reflect the wet weather conditions that are sampled at outfall locations, meaning only an indirect relationship can be established between the two data sets. The variety of methods used to measure parameters in water quality monitoring projects can also increase the variability in any analysis that combines data from disparate sources using different measurement techniques.

The availability of geospatial data and analysis capabilities, although increasingly common, can present additional challenges when compiling information for a Phase II petition. While a number of maps of general features are readily available online, it may be difficult to obtain up-to-date geospatial data or maps in a digital format for some areas, especially maps of the MS4 infrastructure, as local governments may lack the resources to collect or maintain this data in a digital format. Additionally, the application of the petition methodology for Morehead City involved the manipulation of geospatial data with ArcGIS software in order to overlay maps, calculate the area occupied by certain land uses within the planning jurisdiction, and determine the impervious cover percentage for different land use classes. These geospatial analysis capabilities may not be readily available to some individuals or groups outside of government agencies or research institutions, which limits the ability of the general public to comprehensively analyze the characteristics of the drainage area. This may also inhibit the use of these maps in developing a representative sampling strategy as described above, which was based on an assessment of land use intensity and the distribution of important land uses in the jurisdiction of the Morehead City MS4.

The financial costs of a monitoring study for the purposes of a petition could be a major road block to any future petition efforts. Based on the case study, the sampling effort necessary for a representative sample of the MS4 discharge could pose quite a financial burden. Beacham Laboratories in Jacksonville, NC, the state-certified laboratory nearest Morehead City, estimates the cost of sample analysis for fecal coliform bacteria at $21 per sample, which includes sterilized sampling containers. Based on the sampling design discussed above, approximately

nine samples at each of six sampling locations would be needed to obtain estimates of fecal coliform density in the stormwater discharge at each location with a 50% allowable error. This would cost the petitioner over $1,100 for testing alone. To achieve an error of 25% approximately 35 samples per outfall would be needed, increasing the costs to around $4,400. This doesn't include the cost of any additional safety equipment, supplies, or transportation costs. This financial burden is likely to be cost-prohibitive for members of the general public. While an environmental organization may find the costs more manageable, this may still discourage the submission of petitions given the significant investment required relative to the uncertain outcome of the petition process as a whole, once a study is completed.

Above and beyond financial investments, the labor-intensive nature of sample collection may prove to be an even larger obstacle. It appears almost certain that a team of volunteers would be needed to collect samples in the field at the six proposed sampling stations in and around Morehead City. Given the travel time between sites and the laboratory, the time needed to collect the samples at each site, and the maximum holding time of six hours for a fecal coliform sample prior to laboratory analysis, it would seem nearly impossible for an individual to cover all six sampling locations during a sampling event. Involving a team of volunteers in the project introduces its own challenges of recruitment, training regarding sampling techniques and safety in the field, and ensuring the availability of volunteers to conduct sampling on short notice. To reduce the number of volunteers needed, it may be possible to sample different sampling stations during separate storm events, but this could significantly extend the duration of the project.

Furthermore, the duration of a monitoring study will be directly impacted by the highly unpredictable nature of the local climate. Because sampling events would occur only during a representative storm, the frequency of these storms will dictate how long it takes to collect an adequate number of samples to obtain representative data on the characteristics of the MS4 discharge. If seasonal variations in rainfall are to be accounted for in the project design, the estimated timeframe for a project would be at least six months, and it could potentially run much longer, depending on the frequency of storm events. While a maximum project duration could be set, this may force the petitioner to settle for data with a higher degree of variability, and weaken the quality of the petition. Thus, the inherent nature of monitoring stormwater

discharges may prove to be an obstacle to the completion of a petition project in a timely and efficient manner.

Finally, as of yet, no Phase II stormwater petitions have been submitted in North Carolina or in any of the surrounding states, which means there is no precedent upon which to judge the perspective of the EMC on evaluating the merits of an adverse impact petition. This poses a challenge to the petitioner in identifying the most important background and water quality data to emphasize within the context of a petition. In particular, it remains to be seen how the EMC will exercise its discretion in evaluating the effectiveness of existing water quality protection programs. While the Phase II petition methodology presented here attempts to address some of these concerns, this element of uncertainty may discourage the submission of petitions given the substantial amounts of time and energy that must be invested in the process.

6.1.2 Future Implementation

In addition to these practical challenges, forces outside of the petition process itself, namely the proposed changes to the state coastal stormwater program and the ongoing implementation of the Phase II designation process, will impact the submission of petitions in the near future. The adoption of more stringent rules within the coastal stormwater program may make it much more difficult to convince the DWQ that an additional stormwater management program is necessary in many areas along the coast. Once the designation process is completed, it may also become harder to persuade the DWQ that they should have designated a community as requiring a permit, after a previous decision not to do so. It appears at this point that any substantial investment in a petition monitoring project and full implementation of the adverse impact petition process should be postponed pending the outcome of these processes. Any evidence that the EMC will be more likely to deny a petition based on the outcome of these external processes may have a strongly discouraging effect on potential submissions in the future.

Looking beyond these external factors, the next step in advancing this methodology, and an essential step toward its future implementation, will be the actual submission of a petition to the EMC. This methodology lays the groundwork for meeting the requirements specified in the Phase II petition rules. The procedural elements of petition administration are fairly straightforward, but how a petition will be judged by the EMC remains the biggest question mark

in the implementation of this process. The evaluation of any Phase II petition and feedback from the DWQ and EMC as petitions are processed in the future will provide useful insight that will allow this methodology to be fine-tuned, simplified, and potentially made more useful.

At the present time, however, it appears that Phase II stormwater petitions will have a delayed impact on stormwater management efforts in North Carolina, if they have any significant effect at all. Initially, it appeared that the petition requirements outlined by the Phase II rules would improve the ability of the general public or environmental organizations to use petitions as a tool to enhance stormwater management along the North Carolina coast. Given the ongoing degradation of shellfishing waters, high rates of coastal development, and admitted ineffectiveness of the current coastal stormwater rules, it seemed that the petition process could speed the implementation of more stringent controls on stormwater discharges in developed areas along the coast. However, through the development of an adverse impact petition methodology and its preliminary application to a case study of Morehead City, NC, it has been shown that these requirements pose a number of practical challenges that make the completion of a successful petition difficult, particularly for the general public. Thus, despite the inclusion of these petition provisions by the EPA to provide an opportunity for public participation in the NPDES stormwater program, these requirements, rather than clarifying the process, may instead discourage the submission of Phase II petitions in North Carolina in the near future and limit their usefulness as a stormwater management tool.

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7.1 References

Basinwide water quality management plans. North Carolina General Statutes, GS 143-215.8B.

Envtl. Mgmt. Comm'n v. Rules Review Comm'n. June 2005. Wake County Superior Court, 04-CVS-3157.

General Powers of Commission and Department. NC General Statutes, GS 143-215.3.

Municipal Separate Storm Sewer Systems. Florida Administrative Code, FAC 62-624.800.

Stormwater Discharges. Virginia Administrative Code, 4 VAC 50-60-380.

Surface Water and Wetland Standards. North Carolina Administrative Code, 15A NCAC 02B.

Universal Stormwater Management Program. North Carolina Administrative Code, 15A NCAC 02H .0120.

Federal Water Pollution Control Act (Clean Water Act). 1972. United States Code, 33 USC §1251 et seq.

National Pollutant Discharge Elimination System. 1977. United States Code, 33 USC §1342.

National Pollutant Discharge Elimination System-- Regulations and Revision of the Water Pollution Control Program Addressing Storm Water Discharges. 1999. United States Code of Federal Regulations, 40 CFR Parts 122-124.

Phase II Stormwater Management. 2004. NC General Assembly Session Law, SL 2004-163.

Guidelines establishing test procedures for the analysis of pollutants. 2006a. United States Code of Federal Regulations, 40 CFR Part 136.

Stormwater Management 2006. 2006b. NC General Assembly Session Law, SL 2006-246.

APHA. 1998. *Standard Methods for the Examination of Water and Wastewater, 20th Ed.* Washington, DC: American Public Health Association.

Arnold, C. L. and C. J. Gibbons. 1996. Impervious Surface Coverage: The Emergence of a Key Environmental Indicator. *Journal of the American Planning Association* 62(2): 243-258.

Bennett, B. 2006. Personal communication, December 21, 2006.

Burton, G. A. and R. E. Pitt. 2002. *Stormwater Effects Handbook: A Toolbox for Watershed Managers.* Boca Raton, FL: Lewis Publishers. 911 pp.

Carle, M. V., P. N. Halpin and C. A. Stowe. 2005. Patterns of Watershed Urbanization and Impacts on Water Quality. *Journal of the American Water Resources Association* 41(3): 693-708.

Cicin-Sain, B. and R. W. Knecht. 2000. *The Future of U.S. Ocean Policy: Choices for the New Century.* Washington, DC: Island Press. 398 pp.

City, M. 2006. *Town of Morehead City, North Carolina: 2005 Land Use Plan Update (DRAFT).* Prepared by The Wooten Company for the Town of Morehead City, December 4, 2006.

Costa, J. 2007. *Calculating Geometric Means*. Buzzards Bay National Estuary Program, March 23, 2007. http://www.buzzardsbay.org/geomean.htm.

DEH. 2002. *Report of Sanitary Survey Area E-3: September 1997 through April 2002*. Prepared by the Shellfish Sanitation and Recreational Water Quality Section of the NC Division of Environmental Health, August 2002.

---. 2005. *Report of Sanitary Survey Area E-4: February 2000 through May 2005*. Prepared by the Shellfish Sanitation and Recreational Water Quality Section of the NC Division of Environmental Health, September 2005.

DWQ. 2000. *A Citizen's Guide to Water Quality in North Carolina.* Raleigh, NC: NC Division of Water Quality. 156 pp.

---. 2004. *Nonpoint Source Pollution Reduction Report.* North Carolina Division of Water Quality.

---. 2005. *Basinwide Assessment Report- White Oak River Basin*. NC Division of Water Quality.

---. 2006. *North Carolina Water Quality Assessment and Impaired Waters List (2006 Integrated 305(b) and 303(d) Report) (PUBLIC REVIEW DRAFT).* Prepared by the Planning Section of the NC Division of Water Quality, January 2006.

---. 2007a. *Basinwide Planning Process: How is Water Quality Assessed in North Carolina*. NC Division of Water Quality, March 12, 2007. http://h2o.enr.state.nc.us/basinwide/UseSupportDecisions.htm.

---. 2007b. *The NC TMDL Program*. North Carolina Division of Water Quality, March 2, 2007. http://h2o.enr.state.nc.us/tmdl/General_TMDLs.htm.

---. 2007c. *Public Notice*. NC Division of Water Quality- Stormwater Permitting Unit, February 20, 2007. http://h2o.enr.state.nc.us/su/documents/MicrosoftWord-Atlantic_Beach_EmeraldIsle_MoreheadCity_Desig.pdf.

---. 2007d. *Quality Assurance Project Plan Checklist*. NC Division of Water Quality, March 23, 2007. http://www.ncwaterquality.org/nps/documents/DWQQAPPChecklist.doc.

---. 2007e. *White Oak River Basinwide Water Quality Plan (DRAFT)*. Prepared by the Planning Section of the NC Division of Water Quality, January 2007.

EPA. 1978. *Microbiological Methods for Monitoring the Environment: Water and Wastes*. EPA 600-8-78-017.

---. 1992. *NPDES Storm Water Sampling Guidance Document*. EPA-833-8-92-01.

---. 1996. *The Volunteer Monitor's Guide to Quality Assurance Project Plans*. EPA 841-B-96-003.

---. 2001. *EPA Requirements for Quality Assurance Project Plans*. EPA 240-B-01-003.

---. 2002. *Guidance on Choosing a Sampling Design for Environmental Data Collection for Use in Developing a Quality Assurance Project Plan*. EPA 204-R-02-005.

---. 2005a. *Stormwater Phase II Final Rule: An Overview*. In *Stormwater Phase II Final Rule Fact Sheet Series*. EPA 833-F-00-001.

---. 2005b. *Stormwater Phase II Final Rule: Construction Site Runoff Control Minimum Control Measure*. In *Stormwater Phase II Final Rule Fact Sheet Series*. EPA 833-F-00-008.

---. 2005c. *Stormwater Phase II Final Rule: Illicit Discharge and Detection Minimum Control Measure*. In *Stormwater Phase II Final Rule Fact Sheet Series*. EPA 833-F-00-007.

---. 2005d. *Stormwater Phase II Final Rule: Permitting and Reporting: The Process and Requirements*. In *Stormwater Phase II Final Rule Fact Sheet Series*. EPA 833-F-00-011.

---. 2005e. *Stormwater Phase II Final Rule: Pollution Prevention/Good Housekeeping Minimum Control Measure*. In *Stormwater Phase II Final Rule Fact Sheet Series*. EPA 833-F-00-010.

---. 2005f. *Stormwater Phase II Final Rule: Post-construction Runoff Control Minimum Control Measure*. In *Stormwater Phase II Final Rule Fact Sheet Series*. EPA 833-F-00-009.

---. 2005g. *Stormwater Phase II Final Rule: Public Education and Outreach Minimum Control Measure*. In *Stormwater Phase II Final Rule Fact Sheet Series*. EPA 833-F-00-005.

---. 2005h. *Stormwater Phase II Final Rule: Public Participation/Involvement Minimum Control Measure*. In *Stormwater Phase II Final Rule Fact Sheet Series*. EPA 833-F-00-006.

---. 2006. *Guidance on Systematic Planning Using the Data Quality Objectives Process*. EPA 240-B-06-001.

---. 2007. *National Menu of Stormwater Best Management Practices*. US Environmental Protection Agency, February 7, 2007. http://www.epa.gov/npdes/stormwater/menuofbmps.

Federal Register. December 8, 1999. Vol. 64, No. 235. pp. 68722-68851.

Harmel, R. D., K. W. King and R. M. Slade. 2003. Automated storm water sampling on small watersheds. *Applied Engineering in Agriculture* 19(6): 667-674.

Jennings, D. B. and S. T. Jarnagin. 2002. Changes in anthropogenic impervious surfaces, precipitation and daily streamflow discharge: a historical perspective in a mid-atlantic subwatershed. *Landscape Ecology* 17: 471-489.

Mallin, M. 2006. Wading in Waste. *Scientific American* 294(6): 53-59.

Mallin, M. A., S. H. Ensign, M. R. McIver, G. C. Shank and P. K. Fowler. 2001. Demographic, landscape, and meteorological factors controlling the microbial pollution of coastal waters. *Hydrobiologia* 460: 185-193.

Mallin, M. A., K. E. Williams, E. C. Esham and R. P. Lowe. 2000. Effect of Human Development on Bacteriological Water Quality in Coastal Watersheds. *Ecological Applications* 10(4): 1047-1056.

MDE. 2000. *Maryland Stormwater Design Manual, Vol. 1 & 2.* Baltimore, MD: Maryland Department of the Environment.

Monroe, M. R., W. J. Rogers and D. B. Parker. 2004. *Evaluation of Stream Sampling Methodologies For Fecal Coliform Bacteria.* Presented at the ASAE/CSAE Annual International Meeting, 2004.

MRLCC. 2007. *National Land Cover Data*. Multi-Resolution Land Characteristics Consortium (MRLCC), March 19, 2007. http://www.epa.gov/mrlc/nlcd.html.

North Carolina Register. November 15, 2002. Vol. 17, No. 10. pp. 933-1013.

NCCF. 2005. *Storm Drain Monitoring Project- Quality Assurance Project Plan*. North Carolina Coastal Federation, November 2005.

NCDC. 2007. *Hourly Precipitation Data Rainfall Event Statistics*. National Climatic Data Service, March 23, 2007. http://hurricane.ncdc.noaa.gov/cgi-bin/HPD/HPDStats.pl.

NCDENR. 2003. *Report of Proceedings on the Proposed Phase II NPDES Stormwater Rules.* Presented at the NC Environmental Management Commission Meeting, July 10, 2003.

NCNERR. 2003. *Addressing Microbial Pollution in Coastal Waters: A Reference for Local Governments.* Beaufort, NC: North Carolina National Estuarine Research Reserve. 54 pp.

NOAA. 2007. *Regional Data: North Carolina Land Cover Change*. National Oceanic and Atmospheric Administration- Coastal Change Analysis Program (CCAP), March 19, 2007. http://www.csc.noaa.gov/crs/lca/n_car.html.

NSSP. 2005. *Guide for the Control of Molluscan Shellfish*. National Shellfish Sanitation Program, March 9, 2007. http://www.cfsan.fda.gov/~ear/nss3-toc.html.

Pitt, R., A. Maestre and R. Morquecho. 2003. *The National Stormwater Quality Database (NSQD, version 1.1).* Presented at the National Stormwater Coordinators Meeting, April 2003.

Reeder, T. 2005. *Review of Effectiveness of Coastal Stormwater Rules.* Presented at the Water Quality Committee Meeting of the NC Environmental Management Commission, November 2005.

---. 2007. *Proposed Amendments to Coastal Stormwater Rules.* Presented at the Water Quality Committee Meeting of the NC Environmental Management Commission, January 2007.

Schueler, T. R. 1994. The importance of imperviousness. *Watershed Protection Techniques* 1(3): 100-111.

Tufford, D. L. and W. D. Marshall. 2002. Fecal Coliform Source Assessment in a Small Mixed Land Use Watershed. *Journal of the American Water Resources Association* 38(6): 1625-1635.

WDOE. 2007. *Petition Criteria*. Washington Department of Ecology, January 17, 2007. http://www.ecy.wa.gov/programs/wq/stormwater/municipal/petition_criteria.pdf.

WWRI. 2001. Petition for NPDES stormwater permit could signal things to come. *Water Resources Research Institute News*, March/April 2001.

Yang, L., C. Huang, C. G. Homer, B. K. Wylie and M. J. Coan. 2003. An approach for mapping large area impervious surfaces:synergistic use of Landsat-7 ETM+ and high spatial resolution imagery. *Candian Journal of Remote Sensing* 29(2): 230-240.

Appendix A: Session Law 2006-246, Section 6- Petition Process

SECTION 6. Petition Process. – A petition may be submitted to the Commission to request that an owner or operator of a municipal separate storm sewer system (MS4) or a person who discharges stormwater be required to obtain a Phase II National Pollutant Discharge Elimination System (NPDES) permit for stormwater management as follows:

(1) Connected discharge petition. – An owner or operator of a permitted municipal separate storm sewer system (MS4) may submit a petition to the Commission to request that a person who discharges into the permitted municipal separate storm sewer system (MS4) be required to obtain a separate Phase II National Pollutant Discharge Elimination System (NPDES) permit for stormwater management. The Commission shall grant the petition and require the person to obtain a separate Phase II National Pollutant Discharge Elimination System (NPDES) permit for stormwater management if the petitioner shows that the person's discharge flows or will flow into the permitted municipal separate storm sewer system (MS4).

(2) Adverse impact petition. – Any person may submit a petition to the Commission to request that an owner or operator of a municipal separate storm sewer system (MS4) or a person who discharges stormwater be required to obtain a Phase II National Pollutant Discharge Elimination System (NPDES) permit for stormwater management.

a. Petition review. – The Commission shall grant the petition and require the owner or operator of the municipal separate storm sewer system (MS4) or the person who discharges stormwater to obtain a Phase II National Pollutant Discharge Elimination System (NPDES) permit for stormwater management if the petitioner shows any of the following:

1. The municipal separate storm sewer system (MS4) or the discharge discharges or has the potential to discharge stormwater that may cause or contribute to a water quality standard violation.
2. The municipal separate storm sewer system (MS4) or the discharge provides a significant contribution of pollutants to receiving waters.
3. The municipal separate storm sewer system (MS4) or the discharge is specifically listed by name as a source of pollutants for urban stormwater in a total maximum daily load (TMDL) implementation plan developed in accordance with subsections (d) and (e) of 33 U.S.C. § 1313.

b. Types of evidence for required showing. – Petitioners may make the required showing by providing to the Commission the following information:

1. Monitoring data that includes, at a minimum, representative sampling of the municipal separate storm sewer system (MS4) or discharge and information describing how the sampling is representative. The petitioner must notify the owner or operator of the municipal separate storm sewer system (MS4) or the person who discharges stormwater of its intent to conduct monitoring activities prior to conducting those activities.
2. Scientific or technical literature that supports the sampling methods.
3. Study and technical information on land uses in the drainage area and the characteristics of stormwater runoff from these land uses.
4. A map that delineates the drainage area of the petitioned entity; the location of sampling stations; the location of the stormwater outfalls in the adjacent area of the sampling locations; general features, including, but not limited to, surface waters, major roads, and political boundaries; and areas of concern regarding water quality.
5. For stormwater discharges to impaired waters, documentation that the receiving waters are impaired or degraded and monitoring data that demonstrates that the municipal separate storm sewer system (MS4) or discharge contributes pollutants for which the waters are impaired or degraded.
6. For stormwater discharges to nonimpaired waters, monitoring data that demonstrates that the owner or operator of the municipal separate storm sewer system (MS4) or the person who discharges stormwater is a significant contributor of pollutants to the receiving waters.

c. Water quality protection program offset. – If the petitioner makes the required showing, the Commission shall review the effectiveness of any existing water quality protection programs that may offset the need to obtain a Phase II National Pollutant Discharge Elimination System (NPDES) permit for stormwater management. To determine the effectiveness of other applicable water quality protection programs, the Commission shall consider the water quality of the receiving waters and whether the waters support the uses set out in subsections (c), (d), and (e)

of 15A NCAC 2B .0101 (Procedures for Assignment of Water Quality Standards – General Procedures) and the specific classification of the waters set out in 15A NCAC 2B .0300, et seq. (Assignment of Stream Classifications). The Commission may deny the petition if it finds that existing water quality protection programs are adequate to address stormwater impacts on sensitive receiving waters and to ensure compliance with a TMDL implementation plan.

(3) Petition administration. – The Commission shall process petitions in the following manner:

a. The Commission shall only accept petitions submitted on Department forms.

b. A separate petition must be filed for each municipal separate storm sewer system (MS4) or discharge.

c. The Commission shall evaluate only complete petitions. The Commission shall make a determination on the completeness of a petition within 90 days of receipt of the petition, or it shall be deemed complete. If the Commission requests additional information, the petitioner may submit additional information; and the Commission will determine, within 90 days of receipt of the additional information, whether the information completes the petition.

d. The petitioner shall provide a copy of the petition and a copy of any subsequent additional information submitted to the Commission to the chief administrative officer of the municipal separate storm sewer system (MS4) or the person in control of the discharge within 48 hours of each submittal.

e. The Commission shall post all petitions on the Division Web site and maintain copies available for inspection at the Division's office. The Commission shall accept and consider public comment for at least 30 days from the date of posting.

f. The Commission may hold a public hearing on a petition and shall hold a public hearing on a petition if it receives a written request for a public hearing within the public comment period, and the Commission determines that there is a significant public interest in holding a public hearing. The Commission's determination to hold a public hearing shall be made no less than 15 days after the close of the public comment period. The Commission shall schedule the hearing to be held within 45 days of the close of the initial public comment period and shall accept and consider additional public comment through the date of the hearing.

g. An additional petition for the same municipal separate storm sewer system (MS4) or discharge received during the public comment period shall be considered as comment on the original petition. An additional petition for the same municipal separate storm sewer system (MS4) or discharge received after the public comment period ends and before the final determination is made shall be considered incomplete and held pending a final determination on the original petition.

1. If the Commission determines that the owner or operator of the municipal separate storm sewer system (MS4) or the person who discharges stormwater is required to obtain a Phase II National Pollutant Discharge Elimination System (NPDES) permit for stormwater management, any petitions for that municipal separate storm sewer system (MS4) or discharge that were held shall be considered in the development of the Phase II National Pollutant Discharge Elimination System (NPDES) permit for stormwater management.
2. If the Commission determines that the owner or operator of the municipal separate storm sewer system (MS4) or the person who discharges stormwater is not required to obtain a Phase II National Pollutant Discharge Elimination System (NPDES) permit for stormwater management, an additional petition for the municipal separate storm sewer system (MS4) or discharge must present new information or demonstrate that conditions have changed in order to be considered. If new information is not provided, the petition shall be returned as substantially incomplete.

h. The Commission shall evaluate a petition within 180 days of the date on which it is determined to be complete. If the Commission determines that the owner or operator of the municipal separate storm sewer system (MS4) or the person who discharges stormwater is required to obtain a Phase II National Pollutant Discharge Elimination System (NPDES) permit for stormwater management, the Commission shall notify the owner or operator of the municipal separate storm sewer system (MS4) or the person who discharges stormwater within 30 days of the requirement to obtain the permit. The owner or operator of the municipal separate storm sewer system (MS4) or the person who discharges stormwater must submit its application for a Phase II National Pollutant Discharge Elimination System (NPDES) permit for stormwater management within 18 months of the date of notification.

Appendix B: North Carolina Water Quality Standards (from DWQ 2005)

Table 3. Selected water quality standards for parameters sampled as part of the Ambient Monitoring System.[1]

Parameter (µg/L, unless noted)	Standards for All Freshwater			Standards to Support Additional Uses		
	Aquatic Life	Human Health	Water Supply Classifications	Trout Water	HQW	Swamp Waters
Arsenic		10				
Cadmium	2.0			0.4		
Chloride (mg/l)	230[2]		250			
Chlorophyll a (corrected)	40[3]			15[3]		
Chromium, total	50					
Coliform, total (MFTCC/100 ml)[4]			50[3] (WS-I only)			
Coliform, fecal (MFFCC/100 ml)[5]		200[3]				
Copper, total	7[2]					
Dissolved oxygen (mg/L)	5.0[6,7]			6.0		[3, 7]
Hardness, total (mg/L)			100			
Iron	1,000[2]					
Lead	25[3]					
Manganese			200			
Mercury	0.012					
Nickel	88		25			
Nitrate nitrogen			10,000			
pH (units)	6.0 - 9.0[3, 7]					[3, 7]
Solids, total suspended (mg/L)					10 Trout, 20 other[8]	
Turbidity (NTU)	50, 25[3]			10[3]		
Zinc	50[2]					

[1]Standards apply to all classifications. For the protection of water supply and supplemental classifications, standards listed under Standards to Support Additional Uses should be used unless standards for aquatic life or human health are listed and are more stringent. Standards are the same for all water supply classifications (Administrative Code 15A NCAC 2B 0200, eff. April 1, 2001).
[2]Action level.
[3]Refer to 2B.0211 for narrative description of limits.
[4]Membrane filter total coliform count per 100 ml of sample.
[5]Membrane filter fecal coliform count per 100 ml of sample.
[6]An instantaneous reading may be as low as 4.0 mg/L, but the daily average must be 5.0 mg/L or more.
[7]Designated swamp waters may have a dissolved oxygen less than 5.0 mg/L and a pH as low as 4.3, if due to natural conditions.
[8]For effluent limits only, refer to 2B.0224(1)(b)(ii).

Parameter (µg/L, unless noted)	Standards for All Saltwater			Standards To Support Additional Uses	
	Aquatic Life	Human Health[1]	Class SA[2]	HQW	Swamp Waters
Arsenic		10			
Cadmium	5.0				
Chlorophyll a (corrected)	40[3]				
Chromium, total	20				
Coliform, fecal (MFFCC/100ml)[4]		200[3]	14[3]		
Copper, total	3[5]				
Dissolved oxygen (mg/L)	5.0[9]			6.0	[3, 6]
Lead	25[3]				
Mercury	0.025				
Nickel	8.3				
PH (units)	6.8 - 8.5[6]				[3, 6]
Selenium	71				
Silver	0.1[5]				
Solids, total suspended (mg/L)				10 PNA[7], 20 other[8]	
Turbidity (NTU)	25[3]				
Zinc	86[5]				

[1]Standards are based on consumption of fish only unless dermal contact studies are available, see 2B.0208 for equation.
[2]Class SA = shellfishing waters, see 2B.0101 for description.
[3]See 2B.0220 for narrative description of limits.
[4]MFFCC/100ml means membrane filter fecal coliform count per 100 ml of sample.
[5]Values represent action levels as specified in 2B.0220.
[6]Designated swamp waters may have a dissolved oxygen less than 5.0 mg/L and a pH as low as 4.3 s.u., if due to natural conditions.
[7]PNA = Primary Nursery Areas.
[8]For effluent limits only, see 2B.0224.
[9]Swamp waters, poorly flushed tidally influenced streams, or embayments, or estuarine bottom waters may have lower values if caused by natural conditions.

Appendix C: North Carolina State-certified laboratories

State-certified laboratories		
Lab Name	**City**	**Telephone**
Tritest-Clemmons	Clemmons	336-766-7846
Research & Analytical Laboratories	Kernersville	336-996-2841
Pace Analytical Services, Inc.-Eden	Eden	336-623-8921
Meritech, Inc.	Reidsville	336-342-4748
Carolina Environmental Laboratories, LLC	Sanford	919-775-1880
Microbac Labs- Southern Testing Greensboro Div.	Greensboro	336-856-9710
CompuChem Division of Liberty Analytical Corp.	Cary	919-379-4100
Environmental Conservation Laboratories, Inc.	Cary	919-677-1669
Agronomic Division Laboratory - NCDA	Raleigh	919-733-2655
Tritest, Inc.	Raleigh	919-834-4984
LTH-3 Laboratories	Durham	919-383-4790
Environment 1, Inc.	Greenville	252-756-6208
Environment 1, Inc. Mobile Laboratory	Greenville	252-756-6208
Perdue, Incorporated	Lewiston	252-348-4326
Microbac Labs-Southern Testing	Wilson	252-237-5042
Environmental Chemists, Inc./Outer Banks Div.	Manteo	252-473-3513
Water & Sewer Authority of Cabarrus County	Concord	704-788-4164
PACE Analytical Services, Inc.	Huntersville	704-875-9092
Duke Power Analytical Laboratory	Huntersville	704-875-5274
Grant Creek Regional Wastewater Laboratory	Salisbury	704-638-5375
CMU - McAlpine Laboratory	Charlotte	704-391-5140
CMU - Brookshire Laboratory	Charlotte	704-391-5140
CMU - Hal Marshall Laboratory	Charlotte	704-391-5140
Prism Laboratories, Inc.	Charlotte	704-529-6364
K & W Laboratories	Charlotte	704-569-1800
PAR Laboratories, Inc.	Charlotte	704-588-8333
Fayetteville Cross Creek WWTP Lab	Fayetteville	910-223-4705
Microbac Environmental Lab.	Fayetteville	910-864-1920
Moore Co. Water Pollution	Aberdeen	910-281-3146
TBL	Lumberton	910-738-6190
Oxford Laboratories, Inc.	Wilmington	910-763-9793
Element One, Inc.	Wilmington	910-793-0128
Environmental Chemists, Inc. (Envirochem)	Wilmington	910-392-0223
Paradigm Analytical Laboratories, Inc.	Wilmington	910-350-1903
UNCW Center for Marine Science	Wilmington	910-962-2375
Meritech, Inc. - II	Southport	910-457-0289
Vann Laboratories	Wallace	910-285-3966
Beacham Laboratory	Jacksonville	910-347-5843
Craven County Health Dept. Environmental Health Laboratory	New Bern	252-636-4936
Water Quality Lab & Operations, Inc.	Banner Elk	828-898-6277

State-certified laboratories		
Lab Name	**City**	**Telephone**
Water Tech Labs, Inc.	Granite Falls	828-396-4444
Blue Ridge Labs	Lenoir	828-728-0149
Statesville Analytical	Statesville	704-872-4697
Cherokee WWTP Laboratory	Cherokee	828-497-6824
Environmental, Inc.	Cullowhee	828-293-9396
James & James Environmental Management, Inc.	Hendersonville	828-697-0063
Earth Environmental Services of Madison Co.	Marshall	828-649-9250
Environmental Testing Solutions, Inc.	Asheville	828-350-9364
PACE Analytical Services, Inc. Asheville	Asheville	828-254-7176
Earth Environmental Services	Murphy	828-479-6428

Appendix D: Quality Assurance Project Plan Checklist

Quality Assurance Project Plan

Required for certain US EPA funded grants and contracts that are awarded by the Division of Water Quality, NCDENR

NCDENR- DWQ QUALITY ASSURANCE PROJECT PLAN CHECKLIST

To first assess whether a Quality Assurance Project Plan is necessary, please answer the following four questions:

1. Is Federal money from the US EPA being spent on this activity? (*If the answer is "No" then a QAPP is not necessary; proceed to answer section A1 only. If "Yes" then proceed to # 2).* — ❑ **Yes** ❑ **No**

2. Will work require acquisition of environmental data generated from direct measurements activities (ie, water quality sampling), collected from other sources, or compiled from computerized databases? *(If the answer is "No", then a QAPP is not necessary; proceed to answer section A1 only. If "Yes" then proceed to # 3).* — ❑ **Yes** ❑ **No**

3. *Will all instream water quality samples be analyzed by a Laboratory certified by the State of North Carolina? Proceed to # 4.* — ❑ **Yes** ❑ **No**

4. Has a QAPP already been approved for your activity*? (If the answer is "No" then please complete Sections A-D on the following pages. If "Yes", then please answer section A1 and attach a copy of the approved QAPP, or provide a reference (including Agency, Telephone number, and Web Address, if available) for the complete approved QAPP, and return this form with attachments to your DWQ EPA Funds Manager*). — ❑ **Yes** ❑ **No**

Quality Assurance Project Plan Form

Adopted from the US EPA by the Division of Water Quality, NCDENR

A1. Project Title and Approval Sheet

_____
(Project Name)

_____
(Responsible Agency)

_____
(Date)

Project Manager Signature _____
(Name/Date)

Project QA Officer Signature _____
(Name/Date)

DWQ EPA Funds Manager

Signature of Receipt _____
(Name/Date)

Quality Assurance Project Plan Details and Explanation

All environmental projects that are funded, directly or indirectly, by the US Environmental Protection Agency (EPA) and which generate data from direct measurement activities, collect data from other sources or compile data from computerized data bases and information systems must have a Quality Assurance Project Plan (QAPP) approved prior to the collection of project data. QAPPs are required under Code of Federal Regulations 48CRF46, and 40CFR 30, 31 and 35. The QAPP documents the planning, implementation and assessment procedures of the project's data needs. Specifically, it describes and documents the collection methods, and type and quality of data to be gathered. These criteria will vary from project to project depending on the scope of the work, expectations for the end result and perhaps overall cost of the project. Some project QAPPs must follow the national consensus standard, (ANSI/ASQC E4-1994, Specifications and Guidelines for Environmental Data Collection and Environmental Technology Programs*) in order to be acceptable for their end use. Whereas other projects may use non-standardized or simplified data collection approaches because the end result, or use of the data, may not need to conform to existing data quality or may not be as critical for decision making .The overall purpose of the QAPP is to assure that appropriate methods of data collection are used and that documentation of the quality assurance approach is available for users of the data.*

EPA has established requirements for an acceptable QAPP. Details and explanations of these requirements can be found on EPA's web site at ***http://www.epa.gov/quality1/qapps.html.*** *Many of the required elements may already be found in your DWQ approved study proposals (e.g., Scope of Work). If so, please copy the appropriate information from your workplan to the attached DWQ/EPA QAPP form. The completed QAPP MUST be submitted to the DWQ BEFORE data collection activities begin.*

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A3. Distribution List

Names and telephone numbers of those receiving copies of this QAPP. Attach additional page, if necessary. (Name, Organization, Telephone)

i.

ii.

iii.

iv.

v.

A4. Project/Task Organization

Key project personnel and their corresponding responsibilities are listed below. Organization chart is Figure 1.

Name, Position	Project Title/Responsibility
	Advisory Panel (contact)
	Project Manager
	QA Officer
	Field/Sampling Leader
	Laboratory Manager/Leader

(a) Organization Chart

Replace this page with a page indicating the organizational makeup and relationships between project participants. Show relationships between management, data collectors, and staff responsible for interpretation and report preparation

Figure 1. Organization Chart.

Problem Definition/Background

Problem Statement - Explain the background of the project and the reasons for initiating the project

Intended Usage of Data - State the usage and outcomes expected from the information to be collected

A6. Project/Task Description

General Overview of Project - Summarize the work to be performed. Discuss resource and time constraints, as appropriate

Project Timetable - Work schedule indicating critical project points

Activity	Start Date	Known or Anticipated Date of Completion

A7. Quality Objectives and Criteria Identifies performance/measurement criteria for all information to be collected; and acceptance criteria, including project action limits and laboratory detection limits, and range of anticipated concentrations of each parameter of interest

Data Precision, Accuracy, Measurement Range

Express the degree to which sample results are repeatable

Matrix	Parameter	Measurement Range	Accuracy	Precision

Data Representativeness

Express the degree to which the data accurately represents the population or the environmental condition at the sampling location

Data Comparability

Express the degree of confidence that one data set can be compared to another at the sample location or to a sample taken at another location

Data Completeness

Measure of the amount of valid data needed to develop conclusions

Parameter	**No. Valid Samples Anticipated**	**No. Valid Samples Collected & Analyzed**	**Percent Complete**

A8. Special Training/Certification - General description of training requirements and needs

Training Logistical Arrangements

Training Topic(s)	Personnel Trained	Training/Certification Frequency

Description of Training and Trainer Qualifications

Training Topic(s)	Training Description	Trainer Qualifications

A9. Documents and Records - Identify all data reporting information and list all project documents, reports, and electronic files that will be produced

Recording Medium	Purpose	Responsible Party

B1. Sampling Process Design - Describe and justify the design strategy, indicating size of the area, volume, or time period to be represented by the samples and detail the type and total number of sample types/matrix or test runs/trials expected and needed

Rationale for Selection of Sampling Sites

Sample Design Logistics - Sample numbers and frequency

Type of Sample/ Parameter	Number of Samples	Sampling Frequency and Period

B2. Sampling Methods - Identify sampling equipment, collection methods and SOPs

Parameter	Sampling Equipment	Sampling Method

B3. Sample Handling and Custody - Identify how the samples will be physically handled, transported, and received; and describe the documentation of sample information handling and custody

B4. Analytical Methods Identify all analytical SOPs including field and laboratory procedures

B5. Quality Control - Identifiy QC activities which will be used for each type of sampling, analysis, or measurement technique; for example, blanks, spikes, duplicates, etc., and at what frequency

Field QC Checks

The following table outlines QC procedures

Activity	QC Procedure	Purpose

Laboratory QC Checks - Describe Laboratory QC procedures

Data Analysis QC Checks- Describe data analysis QC procedures

B6. Instrument/Equipment Testing, Inspection, and Maintenance - Identify field and laboratory equipment needing periodic maintenance, and the required inspection schedule

Equipment Type	Inspection Frequency	Type of Inspection

B7. Instrument/Equipment Calibration and Frequency - Identify equipment, tools, and instruments that should be calibrated, and the frequency and method for this calibration

Equipment Type	Calibration Frequency	Standard or Calibration Instrument Used

B8. Inspection/Acceptance of Supplies and Consumables Identify critical supplies and consumables for field and laboratory, and acceptance criteria

Equipment/Supply	Inspection/Maintenance Activity	Acceptance Criteria

B9. Non-Direct and Direct Measurements - Identify data sources, for example, computer databases or literature files, or models that will be accessed and used, data recording methods, and references for this information

Data Element/Measurement	Minimum Data Recording Method

References used as guidance for typical data collection

B10. Data Management Describe data management scheme from field to final use and storage, and describe the process for data archival and retrieval

Data Type	Management and Storage

C1. Assessments and Response Actions - List the number, frequency, and type of assessment activities that should be conducted. Specific response actions for the situations listed below will generally apply.

Situation	Response Action

C2. Reports to Management - Identify what project QA status reports are needed and how frequently they will be prepared

D1. Data Review, Verification and Validation - Describe the criteria that will be used for accepting, rejecting, or qualifying project data

D2. Verification and Validation Methods - Describe the process for data verification and validation, providing SOPs and indicate what data validation software will be used

Data Element	Typical Validation and Verification Methods

D3. Reconciliation with User Requirements and Data Quality Objectives

In accordance with Sections A5 and A7, data quality objectives are expressed as the following interrogatives:

- Who uses the data?
- How are the data used?
- Where are the data collected?
- What types of data are needed?
- When will data be collected?

Appendix E: Common acronyms

BMPs	Best Management Practices
CAMA	North Carolina Coastal Area Management Act
CCAP	Coastal Change Analysis Program
COV	Coefficient of Variation
CWA	Clean Water Act
DEH	North Carolina Division of Environmental Health
DMF	North Carolina Division of Marine Fisheries
DWQ	North Carolina Division of Water Quality
EMC	North Carolina Environmental Management Commission
EPA	United States Environmental Protection Agency
ETJ	Extra-territorial Jurisdiction
MRLCC	Multi-Resolution Land Characteristics Consortium
MS4	Municipal Separate Storm Sewer System
NCDC	National Climatic Data Center
NLCD	National Land Cover Database
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NURP	National Urban Runoff Program
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RRC	North Carolina Rules Review Commission
SGA	Shellfish Growing Area
SOP	Standard Operating Procedures
TMDL	Total Maximum Daily Load
USGS	United States Geological Survey
USMP	Universal Stormwater Management Program
WWTP	Wastewater Treatment Plant