Review of the EPA's Economic Analysis of Final Water Quality Standards for Lakes and Flowing Waters in Florida

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Water Science and Technology Board

Division on Earth and Life Studies

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This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the National Research Council's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. We wish to thank the following individuals for their review of this report:

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Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations nor did they see the final draft of the report before its release. The review of this report was overseen by **Robert A. Frosch**, Harvard University and **John J. Boland**, Johns Hopkins University. Appointed by the National Research Council, they were responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the authoring committee and the institution.

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Summary

INTRODUCTION

Nutrients such as nitrogen and phosphorus have long been known to cause degradation of surface waters, as manifested by harmful algal blooms, the loss of submersed aquatic vegetation, and fish kills in waterbodies around the country. Stemming from agricultural operations, urban landscapes, wastewater, and atmospheric deposition, nutrients pollution often is addressed under the Clean Water Act through the use of narrative standards. However, States have recently been pushed toward numeric nutrient criteria under the assumption that this will accelerate and standardize the restoration of nutrient-impaired waters. In Florida, numeric criteria for nitrogen and phosphorus were proposed by the U.S. Environmental Protection Agency (EPA) following a 2009 lawsuit maintaining that Florida's narrative standard was not protective of Florida's waters.

Replacing the narrative standard with numeric nutrient criteria may result in new Florida waters being listed as impaired and the reevaluation of the Total Maximum Daily Load (TMDL) calculations for waters that are currently listed as impaired. These actions may lead to new or revised discharge permits for point sources such as municipal and industrial wastewater treatment plants, and/or nutrient control requirements for nonpoint sources of nutrients. Because of these implications, EPA was required to produce an economic analysis of the potential incremental implementation costs that might be incurred if numeric nutrient criteria replaced Florida's narrative standard for nutrients. In late 2010, EPA estimated the incremental cost to range from $135.5 to $206.1 million per year. Other stakeholder groups produced their own estimates of the cost of implementing the numeric nutrient criteria, with some estimating annual costs as high as $12 billion.

Shortly after producing its cost estimate, EPA requested that a committee of the National Research Council review the Agency's economic analysis of the incremental costs of state implementation of numeric nutrient criteria for lakes and flowing waters in Florida. Specifically, the Committee was asked to review and comment on the implications of:

1. EPA's assumption that costs should be determined only for waters that will be "newly impaired" as a result of the numeric nutrient criteria.

2. EPA's decision to estimate the costs of only those sources of pollution that would directly affect a "newly impaired" water—in particular the number of wastewater treatment plants, the acreage of agricultural land, the acreage of urban areas, and the number of septic systems included in the EPA analysis.

3. EPA's assumptions about the levels of control that could be used by certain point and nonpoint sources, such as wastewater treatment plants, industrial point sources, agricultural activities, and septic systems. Examples of these assumptions could include a decision to seek a regulatory exemption, implement reverse osmosis technology, or use conventional best management practices (BMPs) rather than more expensive water treatment options.

Item #1 is addressed primarily in Chapter 3 of this report, while Chapter 2 addresses the second and third items.

Several constraints were placed on the Committee that were necessary in order for it to produce its report by March 2012. First, the Committee was not asked to review the numeric nutrient criteria themselves. Second, the Committee was not asked to address the benefits of implementing the numeric nutrient criteria, such as potential improvement in water quality, nor the indirect costs associated with implementing the criteria, such as the number of jobs lost or gained, or how certain sectors of the economy will fare under the numeric nutrient criteria. Finally, the Committee was not asked to produce its own cost estimate. Rather, the report tackles the validity of the assumptions found in the EPA report (and those of various stakeholders) and provides findings and recommendations on the methods to be used in any future cost analyses. The Committee concluded that EPA was correct to calculate the costs of meeting the numeric nutrient criteria on an incremental basis. However, the Committee questioned how the incremental effect of the rule was defined by EPA, as described in detail in this report.

Although determining the incremental cost of the rule change (from narrative to numeric) was the correct analytical focus for EPA to have taken, presentations made to the Committee and later communication from stakeholders often confused the incremental costs of the rule change with the total costs to meet the designated uses of impaired waters, under any rule. Many of Florida's thousands of river miles and lakes and hundreds of springs already suffer from chronic nutrient pollution because of high population growth rates and resulting demands for water, land use changes from wetlands and forests to agriculture and urban areas, the state's tropical climate and flat topography, the potential for soil and geologic materials to serve as sources of nutrients, and the buildup of legacy nutrients. These factors have made and will continue to make nutrient management in Florida an important but formidable and costly challenge, regardless of the regulatory paradigm used. Indeed, the total costs to meet Florida water quality goals will exceed the reported incremental costs of the EPA analysis and also may exceed the costs of implementing the suite of practices currently used to control point and nonpoint source dischargers of nutrients. A statement to this effect from the FDEP could further the public's understanding of the scope of nutrient pollution in Florida and the challenges to its management, and overcome misunderstandings that have arisen during debate about EPA's numeric nutrient criteria.

Florida is in the process of trying to develop its own numeric criteria for nutrients that would supersede EPA's, if approved by the Florida Environmental Regulatory Commission, the Florida legislature, and EPA. As of the writing of this report, the FDEP has developed a hybrid approach that includes aspects of both the narrative and the numeric criteria. Although it is unclear whether the newly proposed Florida rule for nutrients will be accepted, the recommendations in this report should be useful regardless of what rule is ultimately adopted.

REVIEW OF EPA'S COST ANALYSIS

Chapter 2 provides the Committee's assessment of the EPA cost analysis, focusing on the efforts made by EPA to (1) identify permitted point sources that would be incrementally affected by the numeric nutrient criteria (NNC) rule, (2) define incrementally impaired waters and their associated watersheds, and (3) estimate the costs of reducing nutrient loads from those point sources and/or to those waters. Costs to comply with the NNC rule were estimated for the following sectors: municipal wastewater facilities, industrial wastewater facilities, agriculture lands, urban stormwater, and on-site septic systems. The associated costs of governmental administration were also estimated. Key assumptions made by EPA include the following:

- The definition of the incremental effect of the NNC rule was defined and limited to (1) waterbodies that would be newly listed and determined to be stressed by nutrients and (2) municipal and industrial sources that would receive certain concentration limits in their discharge permits;

- EPA assessed the incremental effect of the NNC rule at a single point in time, assuming no further changes would occur under the narrative process, rather than comparing the future outcomes of *both* processes over time;

- Waters currently listed as impaired based on the narrative criteria (either with or without a TMDL) were not considered in the cost analysis, because it was assumed that a TMDL exists or would be developed, and that this TMDL would serve as the basis for a site-specific alternative criteria (SSAC) determination; and

- Municipal and industrial wastewater treatment plants discharging at 3 mg/L for total nitrogen (TN) and 0.1 mg/L for total phosphorus (TP) were considered in compliance with the NNC rule.

Incrementally Impaired Waters and Watersheds

One component of how EPA defined the incremental effect of the NNC rule was to estimate the number of new waterbodies that would be in noncompliance with the numeric nutrient criteria, as well as to estimate the location and amount of land area that would need attention in the form of runoff controls to return those waterbodies to compliance. The following findings are made regarding this portion of the EPA analysis:

It is not valid to assume that the percent of unassessed waters that would be incrementally affected is zero. A more defensible approach would take into consideration the characteristics of the unassessed waterbodies and their drainage areas to predict the likelihood that they would fail to meet the narrative criteria or the numeric nutrient criteria. This conclusion has implications for the urban stormwater, agriculture, septic system, and government sector analyses.

The HUC10 delineation used to assess the acreage of various land uses that contribute to the potential impairment is too coarse. EPA should use the more refined HUC12 delineation to generate a more precise estimate of the acres to consider for BMPs in the agricultural and urban stormwater sectors.

Sector Analyses

For each sector that discharges to inland waters, EPA's method for determining the incremental cost of the NNC rule was based on calculating the product of (1) the number of newly affected units (or area) and (2) the unit cost to "treat" the discharge in those additional units. For municipal and industrial point sources, EPA identified the number of point sources that would have to improve treatment in response to the NNC rule, made assumptions about the technological upgrades that would be necessary, and assigned a cost for the upgrades. For the stormwater and agricultural sources, EPA estimated the corresponding acreage draining to the potential incrementally impaired waterbodies, reduced the acreage considered based on BMP programs that were already in place, selected a set of BMPs deemed to be adequate and cost-effective to comply with the NNC rule, and then assigned a unit cost to the resulting acreage to estimate the total cost for the two sectors. For septic systems, EPA determined the number of systems within 500 feet of a potential incrementally impaired waterbody and multiplied this number by the unit cost to upgrade septic systems to reduce their nutrient loads. Government costs were based solely on estimates of the administrative costs of developing additional TMDLs.

Municipal Wastewater Treatment Plants

There is significant uncertainty in the cost estimate for municipal wastewater treatment plants. First, the assumption that no plant will be required to treat to levels more stringent than 3 mg/L TN and 0.1 mg/L TP is unrealistic. Although it is uncertain what proportion of plants will be permitted to treat to 3 mg/L TN and 0.1 mg/L TP, it appears likely that at least some plants will have to treat to more stringent levels. Second, there is significant uncertainty in the cost estimate for municipal wastewater treatment plants because the unit treatment costs were not verified by comparison to the existing and extensive Florida advanced wastewater treatment experience. Efforts should be made to compare the unit costs used by EPA with cost data from Florida, and also to better estimate the percentage of plants that will be required to reach discharge limits more stringent than 3 mg/L TN and 0.1 mg/L TP by performing mass balance and dilution calculations for at least a representative proportion of plants, if not for all of the plants included in this analysis.

Industrial Plants

There is significant uncertainty about the incremental cost of the NNC rule for industrial plants for several reasons. EPA based its estimates on one or two selected facilities from each sector. This extrapolation led to some low-flow facilities exerting a disproportionate influence on the overall industrial costs. Furthermore, the same cost model and treatment processes were used for industrial facilities as were employed for municipal plants. For facilities with highly variable flows, flow equalization may be a more cost-effective solution than mechanical/chemical treatment, such that EPA may have overestimated costs for these facilities. On the other hand, some industrial facilities have higher unit costs than municipal plants. Finally, industries covered under general permits were not investigated, raising the question of whether there may be costs from those facilities that were not captured in EPA's estimates. Given the small number of industries involved, the cost analysis should be improved by analyzing each plant rather than extrapolating the results of one or two plants to the entire sector. As with the municipal wastewater treatment plants, efforts should be made to compare the unit costs used by EPA with cost data from Florida and to better estimate the percentage of plants that will be required to reach discharge limits more stringent than 3 mg/L TN and 0.1 mg/L TP.

Urban Stormwater

For the urban stormwater sector, the costs of complying with the NNC rule in those watersheds determined by EPA to be incrementally impaired are expected to be higher than EPA estimates. However, high uncertainty is prevalent throughout all aspects of this sector analysis. Published studies indicate that most traditional Florida urban BMPs will not be sufficient to comply with the numeric nutrient criteria. Furthermore, the per-acre costs of such BMPs are highly variable. EPA estimates of the affected land area are highly dependent on unverified existing BMP performance and compliance with urban stormwater rules. To improve the analysis, higher-efficiency BMPs should be considered, which have higher costs than traditional BMPs. The costs of retrofitting BMPs on developed land should also be considered.

Agriculture

For the agricultural sector, the costs of complying with the NNC rule in those watersheds determined by EPA to be incrementally impaired are likely to be higher than EPA estimates. The incremental land area needing treatment was likely underestimated, individual costs for the BMPs assumed to be sufficient were underestimated, and the more effective and costly BMPs and regional treatment systems likely required to meet numeric nutrient criteria were not included in the analysis. The need for more stringent BMPs and treatment systems has been demonstrated in many of the Basin Management Action Plans (BMAPs) developed for impaired waters in Florida. Other critical omissions that could lead to increased costs include the degree of actual BMP program participation by agricultural producers and the costs of maintaining BMPs over time.

Septic Systems

For septic systems, the costs of complying with the NNC rule in those waterbodies determined by EPA to be incrementally impaired are likely to be substantially higher than EPA estimates. The exclusion of septic systems in springsheds is a significant deficiency of

EPA's analysis. EPA received cost estimates from vendors of equipment capable of meeting a TN of 20 mg/L and TP of 10 mg/L, values which are much higher than EPA's numeric nutrient criteria. Efforts should be made to consider septic systems in springsheds and a wider range of treatment systems including permeable reactive barriers, which are known to be more effective in removing nutrients to levels consistent with the numeric nutrient criteria.

Government Costs

The incremental costs for the government sector are expected to be higher than EPA estimates. Unit costs were based on low-end estimates of costs from a 2001 study that focused on a broad range of TMDL work not specifically related to either Florida TMDL development or nutrient TMDL development. Efforts should be made to quantify costs for Florida-specific and/or nutrient-specific TMDLs to provide more accurate unit costs for TMDL development. Additional government costs should also be considered, including costs for developing or approving SSACs and variances, costs associated with downstream protective values effectively reducing upstream criteria, and consideration of additional waters becoming impaired in the future.

A FRAMEWORK FOR INCREMENTAL COST ANALYSIS OF A RULE CHANGE

In Chapter 2, the Committee accepted the EPA definition of the incremental effect of a rule change and provided a critique of the methods by which the incremental costs were estimated. Chapter 3, in contrast, proposes an alternative framework for cost analysis. In accordance with what is required in EPA guidelines for preparing economic analyses, the chapter first provides a comprehensive analysis of the differences between the narrative and numeric nutrient criteria rules, organized by five broad stages of water quality management. Indeed, discrepancies in the cost estimates of EPA and other analysts can be traced to different assumptions about how the rules would affect actions taken in each of those five stages. That discussion is followed by presentation of the alternative framework for predicting the incremental costs of the various rules. Use of the framework can highlight differences in assumptions, help to narrow differences in the cost estimates if similar assumptions can be agreed upon, and highlight how uncertainties can be reduced analytically or by clarification of ambiguities in the rules.

Comparing the Narrative and Numeric Nutrient Criteria Rules

For the purposes of comparison, water quality management was divided into five stages: (1) listing waters as impaired, (2) establishing the stressor as nutrients, (3) defining the level of nutrient load reduction and calculating the TMDL, (4) TMDL/BMAP implementation, and (5) the determination of use attainment. Table 3-1 summarizes the differences in how these five stages occur under the narrative rule (which is considered the baseline), under the EPA's NNC rule that was the motivation for this report, and, for completeness, under the recently proposed Florida rule. The following broad findings regarding these differences are made:

- Administrative costs for listing and TMDL development will be lower under the NNC rule than under the narrative or proposed Florida rules because there would be no biological assessment.

- Compared to the narrative and proposed Florida rules, under the NNC rule the pace of listing and the number of waters listed will increase, but the rate at which TMDLs and BMAPs are developed and implemented will not necessarily increase.

- Municipal and industrial wastewater dischargers may face substantial near-term increases in cost under the NNC rule.

- Over time, there is significant uncertainty in nonpoint source load control costs under all three rules because of uncertainty about the incremental increase in the number of listed waters, about the nutrient target levels for N or P, and about cost and effectiveness of nonpoint source load control actions.

How the Alternative Cost Analysis Works

A more comprehensive cost analysis requires comparing the future time paths of costs at each stage of water quality management under either the NNC rule or proposed Florida rule vs. the narrative rule (the baseline). The analysis would be comprised of several tasks:

Task 1 is to predict the decisions that would be made in each stage, for each rule. The predictions would be for specified time intervals, such as for five-year increments. The differences among the rules can lead to different decisions at each stage of water quality management, such as which waters are impaired. Prediction of these decisions requires making assumptions about both the likelihood of any particular decision and the relationship of that decision to others that follow in sequence.

Task 2 is to estimate the administrative and load control costs under each rule and for each future time period. Chapter 2 provides a detailed review of the EPA estimate of unit costs and lengthy discussion of the effectiveness of the load control methods. In the broader framework, there should also be at least a narrative statement of the predicted water quality outcomes at each point in time.

Task 3 is to characterize the uncertainties in Tasks 1 and 2 to determine if the costs of uncertainty are likely to be high. If so, formal probability analysis or scenario analysis should be conducted. Scenario analysis requires describing different combinations of uncertain future conditions that taken together can create different outcomes. Building scenarios can be a group activity that facilitates knowledge exchange and mutual understanding of central issues important to the results of the analysis.

Task 4 is to calculate the incremental difference in total costs (costs of proposed rule minus the costs of narrative rule) and relate this to the incremental differences in water quality outcomes at each time period.

All of the metrics mentioned above can be recorded in a decision-making template (such as Figure 3-1). The template can be used, for example, to describe when and how many waterbodies would be listed over a fixed time period, some metric of stressor evaluation, the number of TMDL plans developed, some metric of plan implementation, and the number of waterbodies meeting the designated use. The basis of the metrics should be explained (i.e., derived from trend analysis of historical records, predictive models, statistical equations, expert judgment) and should be based on how the rule governs these stages and the available funding. Costs are calculated by multiplying the load reduction effort by the cost per unit of effort and are also recorded in the template. Once complete, the template will reveal the total cost difference of a rule change, which could be compared to the incremental differences in water quality outcomes and interpreted in light of the uncertainty of the cost estimates. This can be done for each time period and would provide information important to formulating annual public budgets and forecasting when water quality results might be realized.

Findings about the Alternative Cost Analysis

The incremental costs of the NNC rule are attributable to more than an increase in waterbodies listed and a requirement that all NPDES-permitted municipal and industrial sources discharging to surface water have certain effluent concentration limits. In computing the incremental effect, the appropriate baseline should have been defined as what would have occurred over time under the existing (narrative) rule. Thus, an incremental cost is the difference in implementation costs between two (or more) alternative future implementation time paths.

Future cost analyses of rule changes would more fully represent areas of possible costs differences if they were more explicit in describing the differences between the rules *over time*. Administrative, load control, and water quality opportunity costs could be analyzed and reported as a cash flow over time, showing what sectors bear the costs as nutrient load reductions at different levels are pursued. Comparing the rules over time also can provide an opportunity to present a realistic picture of how the timing of water quality improvement actions might unfold with alternative rules, by illustrating the time lags between listing and achievement of water quality standards. Most importantly, reporting on timing would provide useful information for predicting annual budgetary requirements.

Uncertainty is pervasive in estimating the incremental cost of implementing the NNC rule and is inadequately represented in the EPA analysis. In future analyses, reporting the difference in the time paths for implementation of water quality management rules, and associated uncertainties, would provide a more transparent and realistic way to compare costs of the different rules and provide more useful information about where, when, and how costs diverge.

Some Florida stakeholders viewed the EPA cost analysis as being superficial or of limited scope, leading to reduced credibility. The result was to foster disagreement about embedded assumptions rather than using the analysis to isolate and possibly reconcile sources of disagreement. Cost analysis as outlined above can help convey cost estimates in a more transparent way and thus facilitate learning, reduce misunderstandings among stakeholders, and increase public confidence in the results.

Conducting an alternative cost analysis, with increased attention to careful assessment of rule differences, stakeholder engagement, and uncertainty analysis, might not have been possible with the budget and time EPA spent on it cost analysis. Any critique of the existing EPA cost analysis should recognize that some deficiencies may be traced to time and budget limitations.

Chapter 1

Introduction

Nutrients such as nitrogen and phosphorus have long been known to cause degradation of surface waters when supplied at rates above the assimilative capacity of the waterbody. Excess nutrient loading leads to the proliferation of algae, which are in turn degraded by bacteria that can deplete waters of their dissolved oxygen. Nutrient enriched waters exhibit a variety of ecological symptoms, from harmful algal blooms to loss of submersed aquatic vegetation to fish kills. Waterbodies suffering from nutrient enrichment are evident in every region of the United States, from lakes and streams in the Midwest, to the Chesapeake Bay estuary, to coastal waters of the Gulf of Mexico. Although there can be considerable debate about the relative sources of nutrients in any given location, nutrients are widely known to stem from agricultural operations, urban landscapes, municipal and some industrial wastewater, mining activities, and atmospheric deposition.

For decades Florida has experienced its share of nutrient related pollution issues, highlighted by pollution in Lake Okeechobee and the Everglades stemming principally from agriculture. Not surprisingly given its warm climate, topography, intense and varied agriculture, and rapid urbanization, hundreds of freshwater lakes and streams in Florida are polluted by nutrients to such an extent that natural populations of flora and fauna are out of balance. Florida has managed these waters using a narrative standard for nutrients. At the urging of the U.S. Environmental Protection Agency (EPA), states are moving toward the use of numeric water quality criteria for nutrients in an attempt to accelerate and standardize the restoration of nutrient-impaired waters. This report was written by a committee of the National Research Council charged with reviewing the economic implications of new numeric nutrient criteria developed by EPA for Florida's inland waters. In particular, the Committee was asked to evaluate EPA's method for estimating the incremental costs of implementing numeric criteria compared to the existing narrative standard. The issue has focused national attention on Florida, which is often the case in matters of water resources.

TECHNICAL CHALLENGES OF NUTRIENT MANAGEMENT IN FLORIDA

Florida has more than 11,000 miles of rivers and streams, over 7,700 lakes, and 27 first-magnitude springs (stateofflorida.com; see Figure 1-1 for the state's major water features). Many of these waterbodies suffer from nutrient pollution due to a unique convergence of human and environmental conditions. These include high population growth rates and resulting demands for water, land use changes from wetlands and forests to agriculture and urban areas, a tropical climate and flat topography, predominantly sandy soils and transmissive geologic

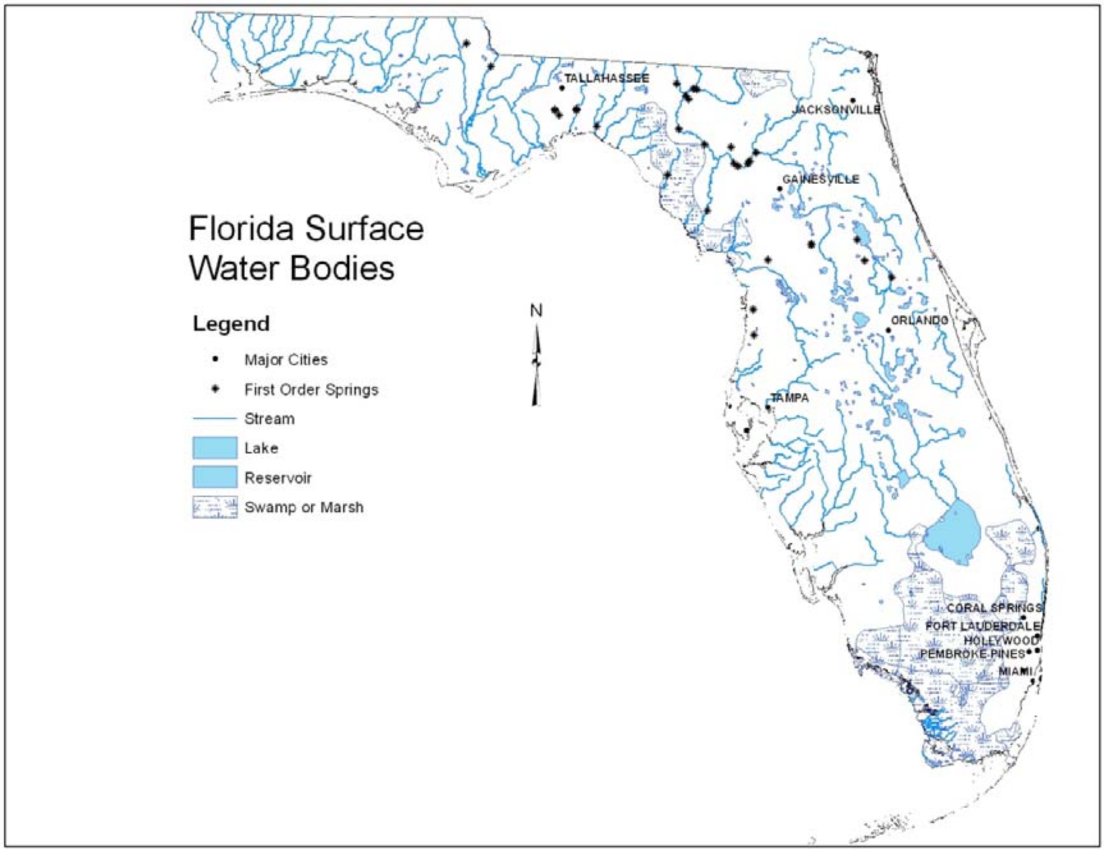


FIGURE 1-1 Major Florida lakes, rivers, and springs.
SOURCE: USGS National Hydrography Dataset 2011. http://nhd.usgs.gov/

materials, buildup of legacy nutrients, and competing value systems that influence perceptions of costs and risks of water quality impairment by Florida's diverse population. Combined with the fact that treatment technologies to restore nutrient-impaired waters can be very expensive, these issues have made and will continue to make nutrient management in Florida an important but formidable and costly challenge, regardless of the regulatory paradigm used.

Population Growth

Florida's population increased from 12.9 million people in 1990 to 18.8 million in 2010 (BEBR, 2010). In the next 20 years, Florida's population is expected to increase 15 to 35 percent (Figure 1-2), or to between 21.8 and 26.0 million people (BEBR, 2010). Population growth has the potential to affect transport of nitrogen and phosphorus from urban and suburban areas to surface waterbodies through increased discharge of stormwater and wastewater and loss of natural assimilative capacity.

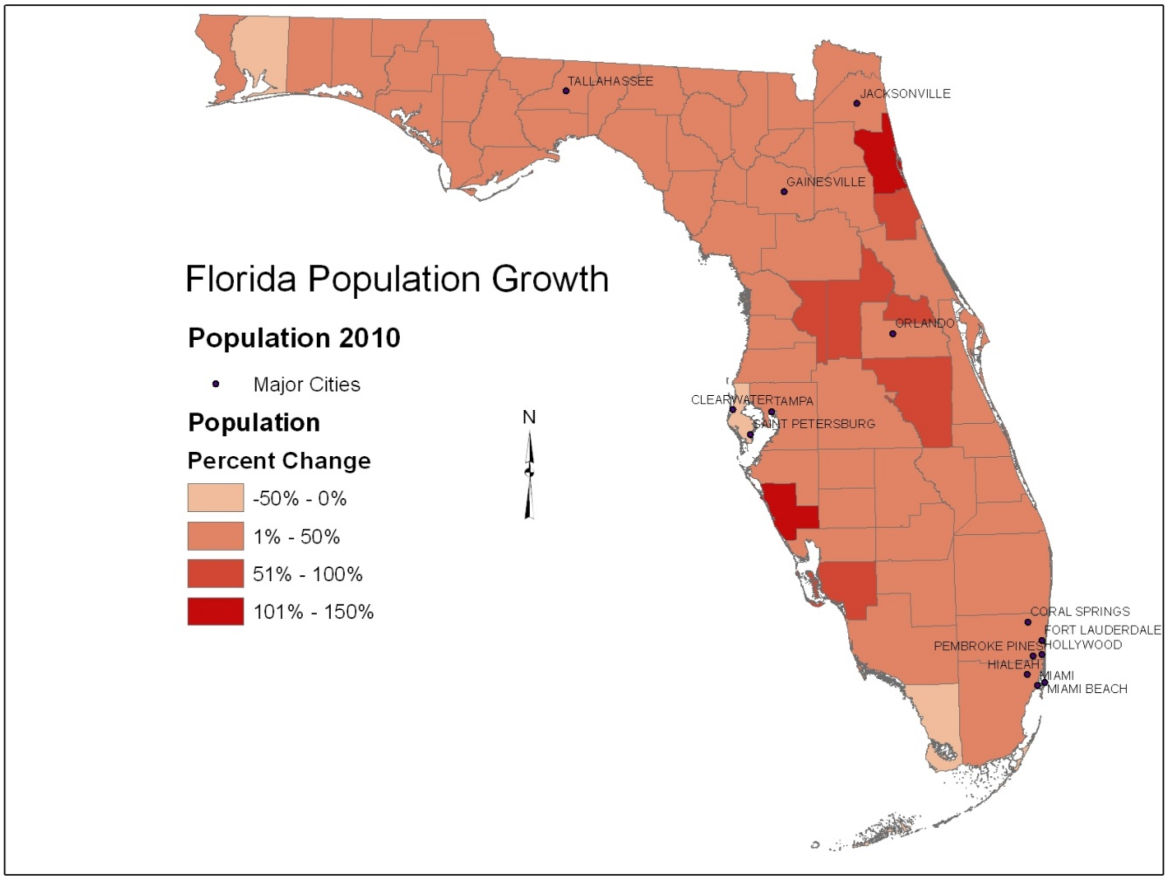


FIGURE 1-2 Projected changes in Florida population between 2010 and 2030 for moderate growth scenario.
SOURCE: BEBR (2010).

Land Use Change

As Florida's population increases, there will be secondary changes in land use (Figure 1-3) and land management practices that will affect water quality. Expansion of urban and suburban land uses into former agricultural land will cause shifts in agricultural production, primarily in citrus, vegetable, row crop, and cow/calf operations. Expansion of urban and suburban areas into forested landscapes will replace perennial vegetation on relatively permeable soils with urban landscapes that have more impervious surface area, potentially increasing nutrient exports. The specific impacts of these secondary changes are difficult to assess, as they depend specifically on which landscapes are affected and the connectivity between these landscapes and nearby surface waterbodies. Nonetheless, one can expect that nutrient loads to surface waters will increase as forested areas are converted to urban and suburban land (USGS, 1998). As agricultural lands are converted to urban and suburban land, a decrease in nutrient loads can be expected, although the exact direction and magnitude of the impact depends on many factors, including the type of agriculture practiced before conversion and the nature of the urban land use (e.g., industrial, low density residential, high density residential, park or golf course).

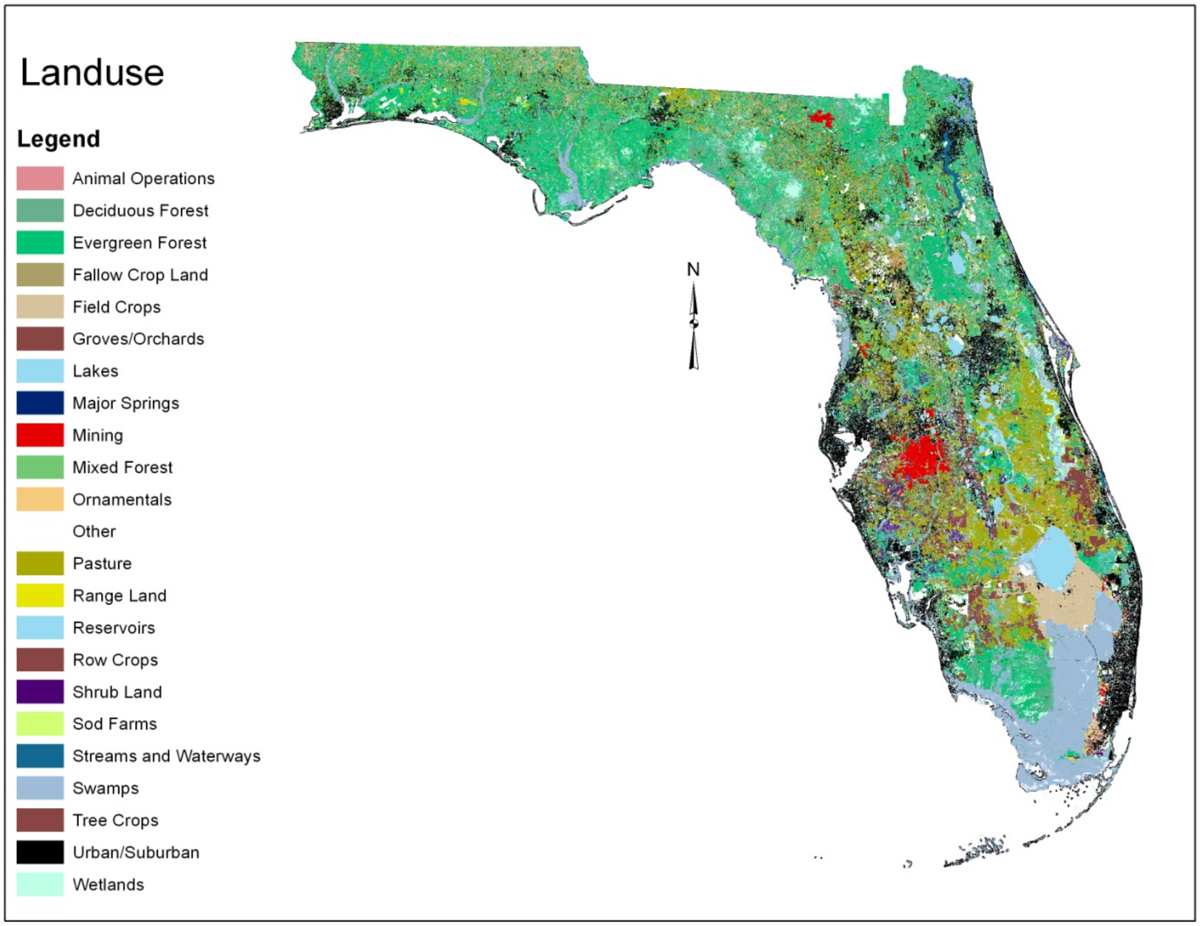


FIGURE 1-3 FDEP compiled Florida land cover data for 2004.

Climate and Topography

The effects of excess nutrients applied to the land surface, whether in agricultural or urban activities, are exacerbated by the climatic and topographic conditions particular to Florida. High temperatures prevail throughout a significant fraction of the year, oscillating from 61 ^{o}F to well over 95 ^{o}F, and can be a powerful driver for the growth of aquatic vegetation. Florida annually receives significant amounts of precipitation throughout the state, ranging from nearly 40 to over 60 inches (see Figure 1-4). Half of this precipitation occurs in a relatively short period from June to September in the form of highly localized intense thunderstorms as well as tropical storms, although there is variation in this seasonal distribution from north to south. Intense rainfall can produce heavy runoff (and associated pollutant loads) over short periods of time. Also, precipitation is a significant source of infiltration and groundwater recharge, which can carry excess nutrients to Florida's lakes, springs, and rivers.

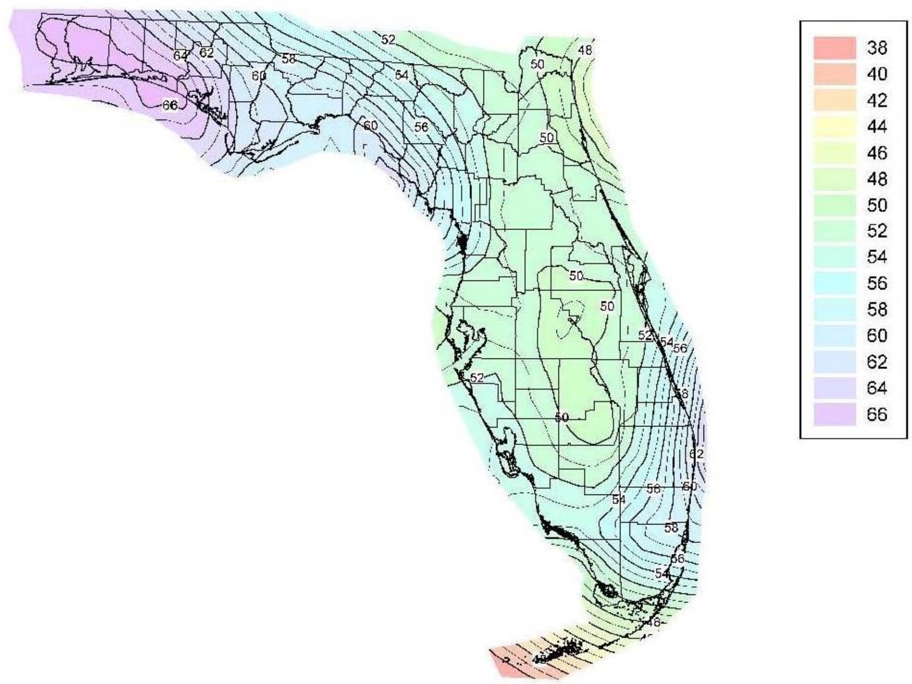


Figure 3-2. Isopleths of Mean Annual Precipitation in Florida from 1971-2000.

FDEP \STORMWATER TREATMENT REPORT

FIGURE 1-4 Annual Rainfall Distribution in Florida. Legend units are in inches.
SOURCE: ERD (2007).

Florida has relatively low-lying, flat topography (Figure 1-5), with a mean elevation of 100 feet. Heavy rainfall and a shallow water table are responsible for large areas of the state being covered historically by shallow swamps, wetlands, and marshes. In order to use the land for agriculture, many of these areas have been hydrologically altered such that excess nutrients are transported to surface waters through tile drains or drainage ditches and are no longer stored or processed in-situ. Thus, water quality management strategies in Florida often take on the challenging and expensive task of restoring drained swamps, wetlands, and marshes to regain their nutrient assimilation capabilities.

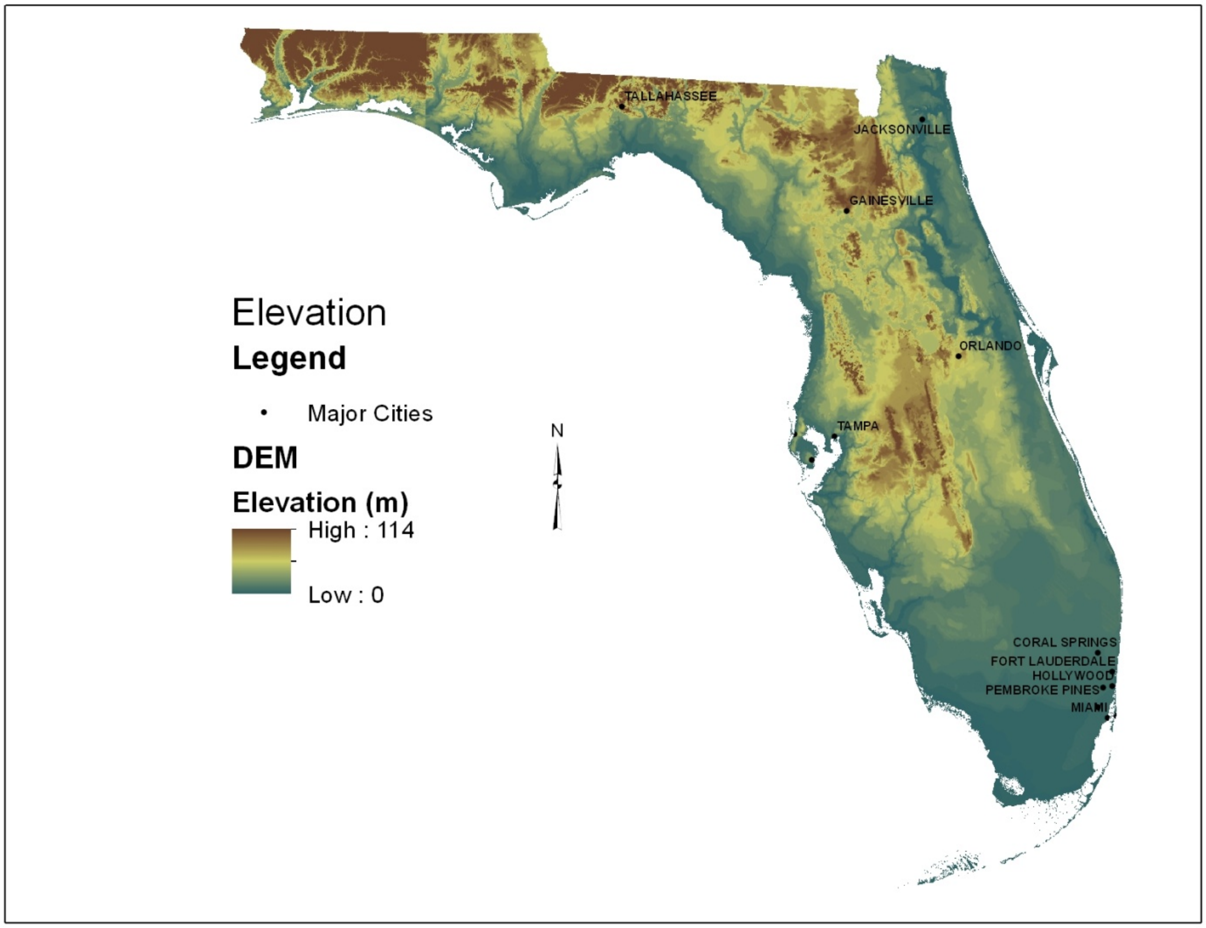


FIGURE 1-5 Florida elevation patterns.
SOURCE: USGS Digital Elevation Map Resources. http://data.geocomm.com/dem/demdownload.html

Soil and Geology

Florida water quality is strongly affected by natural variability in soil and geologic materials, as manifested in clear differences in lake physical, chemical, and biological characteristics across Florida's 47 Lake Ecoregions (Griffith et al., 1997). Florida's geology has been influenced by fluctuations in sea level. Because low-lying Florida was covered by oceans for millions of years, bedrock is composed mainly of carbonate rocks overlain by beach or dune sand. There are extensive localized deposits of phosphate rock that formed in ancient coral reefs. Lakes and rivers in these areas typically have elevated natural background levels of total phosphorus. Carbonate rocks have weathered to produce karst landscapes with many sinkholes and springs across wide regions of Florida. The majority of Florida lakes were formed in basins affected by dissolution of carbonate rock (Schiffer, 1998). Most of the inflow to these lakes arises from groundwater discharge rather than surface runoff.

Soils in Florida are primarily spodosols or entisols, with a smaller portion being histosols and ultisols (Collins, 1985). Spodosols are coarse textured soils with an amorphous mixture of organic matter and aluminum, underlain by a gray eluvial (leached) layer where water has removed most of the organic matter. These soils are often used for production of citrus, and in the wet season are artificially drained to lower the water table. Entisols are poorly developed sandy soils without horizons. They have rapid infiltration and are often irrigated. Both soil and geologic conditions can produce high background levels of nutrients in Florida waterbodies that make meeting numeric water quality criteria a challenge (as discussed in a subsequent section).

Legacy Nutrients

Legacy nutrients, primarily stemming from agriculture, exist in large quantities in many Florida soils, wetlands, lakes, streams, and aquifers. These legacy nutrients are the result of many decades of phosphorus transport from upland contributing areas in the case of lakes and wetlands, or many decades of nitrate leaching to aquifers, which has resulted in a significant impact on spring water quality. Legacy nutrient flows can dominate a watershed's nutrient flows decades after nutrient additions have been curtailed. For example, Reddy et al. (2010) estimated total phosphorus (TP) storage in upland and wetland soils in the Lake Okeechobee basin to be 215,000 metric tons. Approximately 80 percent of the stored phosphorus (or 169,800 metric tons) was estimated to be located in soils and stream sediments, with the remainder stored in lake sediments in the Upper Chain of Lakes, Lake Istokpoga, and Lake Okeechobee. Reddy et al. (2010) evaluated the potential long-term role of this legacy phosphorus on loading to Lake Okeechobee. Based on conservative estimates of phosphorus leaching rates and the amount of stored reactive phosphorus in the watershed, the authors predicted that legacy phosphorus could maintain a phosphorus load to Lake Okeechobee of 500 metric tons per year for the next 22 to 55 years. This loading rate considers only legacy phosphorus stored in the soils and sediments and does not take into account new phosphorus additions in the basin.

Internal nutrient loads from sediments in Lake Okeechobee to the water column are also significant. Based on several earlier research reports, Reddy et al. (2010) estimated the internal flux from mud sediments to the water column to be 112 metric tons of phosphorus per year continuing for 12 to 31 years.

Waterbodies suffering from legacy nutrients generally require very stringent and costly BMPs in order to meet water quality goals similar to the numeric nutrient criteria. Examples of this situation, highlighting the more expensive actions required, are presented in Box 2-1 for Lake Okeechobee and for the Everglades Agricultural Area.

IMPAIRMENT OF FLORIDA'S INLAND STREAMS, LAKES, AND SPRINGS

Given the conditions described above, it is not surprising that impairment of Florida waters caused by nutrient overenrichment is widespread and mostly growing. Determinations of waterbody impairment for each State are required by the Clean Water Act Section 305b every two years. For the Florida 2008 305b report, there were sufficient data to evaluate (by area or length) 53 percent of the state's rivers and streams and 81 percent of its lakes (FDEP, 2008); poor water quality (for all causes except mercury) was found in 28 percent of the river and stream miles and 25 percent of the lake acres. Approximately 2,565 total maximum daily load (TMDL) calculations will be required for 1,688 Florida waters. The 2008 report revealed that nutrients are the most prevalent pollutant in lakes, accounting for 349,248 impaired lake acres (157 lakes). For rivers and streams, nutrients are preceded by dissolved oxygen deficits (which can be driven by nutrients), mercury, and fecal coliform bacteria as major pollutants. At least 128 rivers and streams, accounting for 1,049 stream miles, violate the narrative nutrient standard. Median phosphorus in monitored Florida waters is around 0.05 mg/L, after having risen steadily in the 20th century until the mid-1980s when the state adopted its Stormwater Rule (FDEP, 2011). Water quality in many springs has also declined steadily since the 1970s. Thirty six (36) springs that have been monitored over the last 30 years have had increasing levels of nitrate-N, such that the combined median value has doubled (and ranges from 1 to 5 mg/L).

Regarding the number of waterbodies requiring a TMDL because of nutrients, EPA (2010) states that there are approximately 168 waterbodies (denoted WBIDs[1] in Florida) covered under nutrient TMDLs in Florida, 117 of which are for lakes and flowing waters. An accounting of those waterbodies in the EPA report reveals 89 TMDLs because most TMDLs cover more than one WBID (see Exhibit 2-8 in EPA, 2010). Another 497 waterbodies in Florida are listed as impaired and await nutrient TMDL development (EPA, 2010, Exhibit 2-7). Higher values are reported by the Florida Department of Environmental Protection (FDEP). FDEP considers 720 WBIDs as impaired and in need of a TMDL; most have been listed as impaired based on a nutrient assessment, but others are impaired based on violations of the dissolved oxygen standard (personal communication, Frank Nearhoof, FDEP, 2011). There are 122 WBIDs for which a TMDL has already been developed (personal communication, Frank Nearhoof, FDEP, 2011).

As shown in Figure 1-6, the state has adopted nine Basin Management Action Plans (BMAPs) to implement dozens of TMDLs across the state (not just for nutrient-impaired waters). This process requires that pollutant loads be allocated among various sectors, including point sources like industrial and wastewater treatment plants, as well as more diffuse sources such as agriculture, stormwater from urban areas, and septic systems. The contributions of nitrogen and phosphorus vary substantially by sector and by basin; examples are given in Figures 1-7 and 1-8 of nutrient loadings to the Wekiva River and the lower St. Johns River. Furthermore, each polluting sector operates under different legal and regulatory requirements, as described in greater detail in Chapter 2.

[1] WBID refers to a Water Body Identification Number, but it includes more than just a waterbody. For a multitude of water resource purposes, Florida was divided up into polygons that roughly delineate the drainage basins surrounding individual waterbody assessment units, and each polygon was assigned a unique Water Body Identification Number. The assessment units are lakes or portions of lakes, springs, rivers and streams, segments of rivers and streams, and coastal, bay and estuarine waters in Florida. Thus, each WBID contains both water and the surrounding drainage basin. Note that many FDEP documents use the term WBID when discussing impaired waters; this use of the term should not be confused to mean that a WBID is only the waterbody.

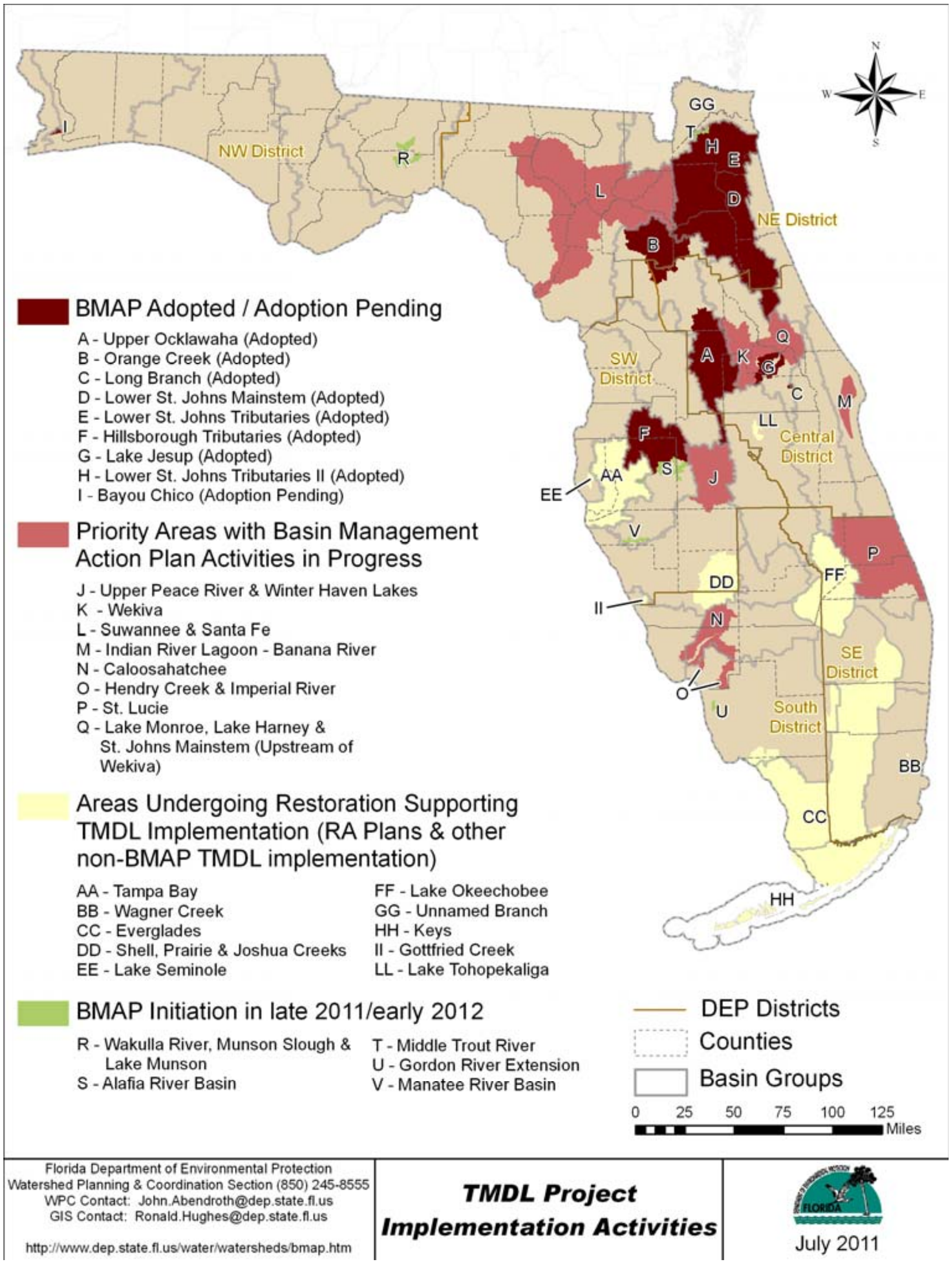


FIGURE 1-6 TMDL Project implementation via Basins Management Action Plans.
SOURCE: Florida Department of Environmental Protection (2011).

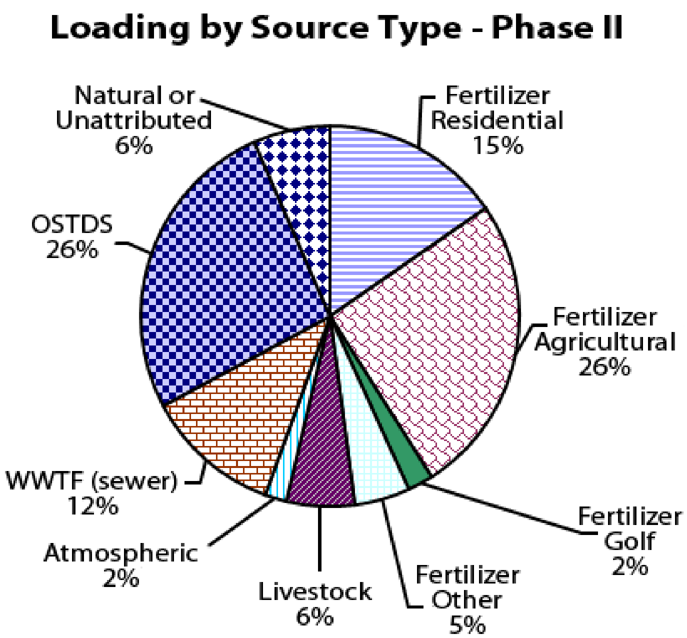
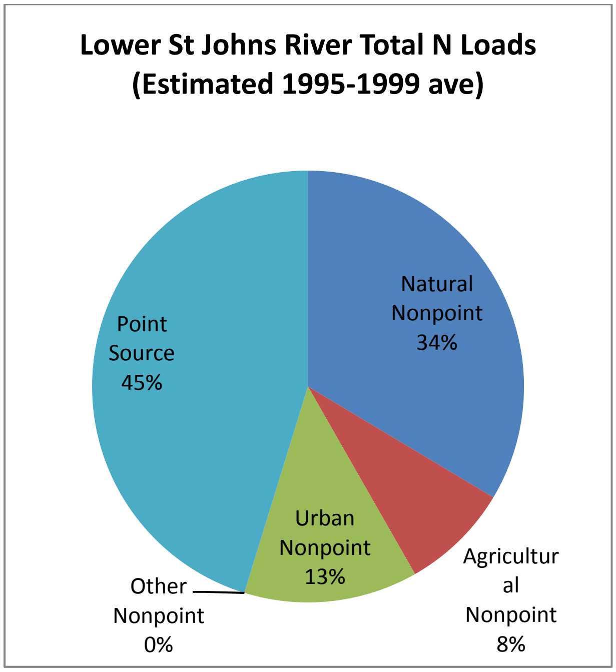


FIGURE 1-7 Relative Contribution of the Nitrogen Load by Sector to the Wekiva River in the middle St. Johns basin. OSTDS = on-site sewage treatment and disposal system (septic system). Legacy nutrients were not specified in this analysis.
SOURCE: MACTEC (2010).



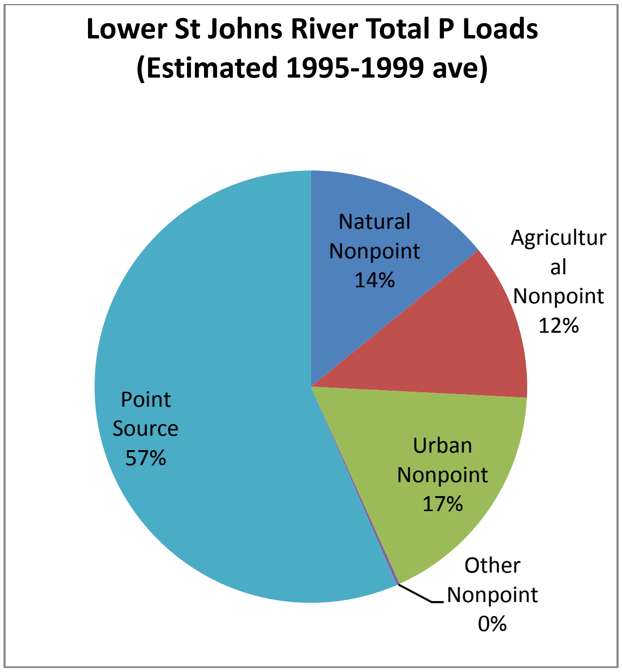


FIGURE 1-8 Relative Contribution of the Nitrogen Load and Phosphorus Load by Sector to the Lower St. Johns River. Legacy nutrients were not specified in this analysis.
SOURCE: Hendrickson et al. (2002).

WATER QUALITY STANDARDS AND THE TMDL PROCESS

The Clean Water Act (CWA) addresses the protection and restoration of the nation's waters through four major programs—water quality standards, point source permitting of wastewater dischargers via the national pollutant discharge elimination system (NPDES), total maximum daily loads (TMDLs), and the implementation of best management practices to control nonpoint sources of pollution. In their water quality standards, States establish the objectives for how waters are used (i.e., designated beneficial uses), along with the chemical, physical, and biological qualities of those same waters that would protect their designated uses. Designated uses include aquatic life support, recreation, drinking water supply, etc. The chemical, physical, and biological qualities of waters are collectively referred to as criteria. The criteria can be narrative, i.e., a description of the desired condition, or they can be specific numeric values. The CWA specifies that individual states set their own water quality standards, with those standards subject to approval by EPA. EPA can promulgate water quality standards for states if EPA determines that state standards are insufficient to meet the requirements of the CWA.

When waterbodies fail to meet their standards, the TMDL program is implemented, the objective of which is attainment of water quality criteria by controlling both NPDES-permitted point sources and nonpoint sources of pollution. Nonpoint sources primarily consist of agricultural runoff, unregulated urban runoff, and atmospheric deposition of pollutants. A TMDL establishes the total pollutant load for both point and nonpoint sources. Load reductions for point sources are referred to as *waste load allocations* (WLA) while load reductions for nonpoint sources are referred to as *load allocations* (LA). Due to the uncertainty in the response of the waterbody to loading reductions, a margin of safety (MOS) is also included in the TMDL calculation. The pollutant load reduction required to meet the TMDL is the difference between the existing watershed loads and the loads specified by the TMDL.

Load reductions for point and nonpoint sources are spelled out in TMDL implementation plans. In Florida, the Department of Environmental Protection develops comprehensive TMDL implementation strategies through BMAPs. BMAPs define permit limits for wastewater facilities to address the WLA portion of the TMDL as well as identifying urban, suburban, and agricultural best management practices and regional treatment systems required to meet the LA established by the TMDL. BMAPs are developed in conjunction with local stakeholders and seek to equitably allocate load reductions necessary to meet the TMDL. BMAPs rely on local involvement for successful implementation and once developed are adopted as enforceable documents by the FDEP Secretary.

Because the CWA authorizes states to develop and implement water quality programs, each state implements those authorities subject to its own state laws and regulations. In general, however, Figure 1-9 provides a simplified diagram illustrating the general interaction of water quality standards, NPDES permitting, and TMDLs applicable to all states. Box 1-1 contains definitions of important water quality management terms.

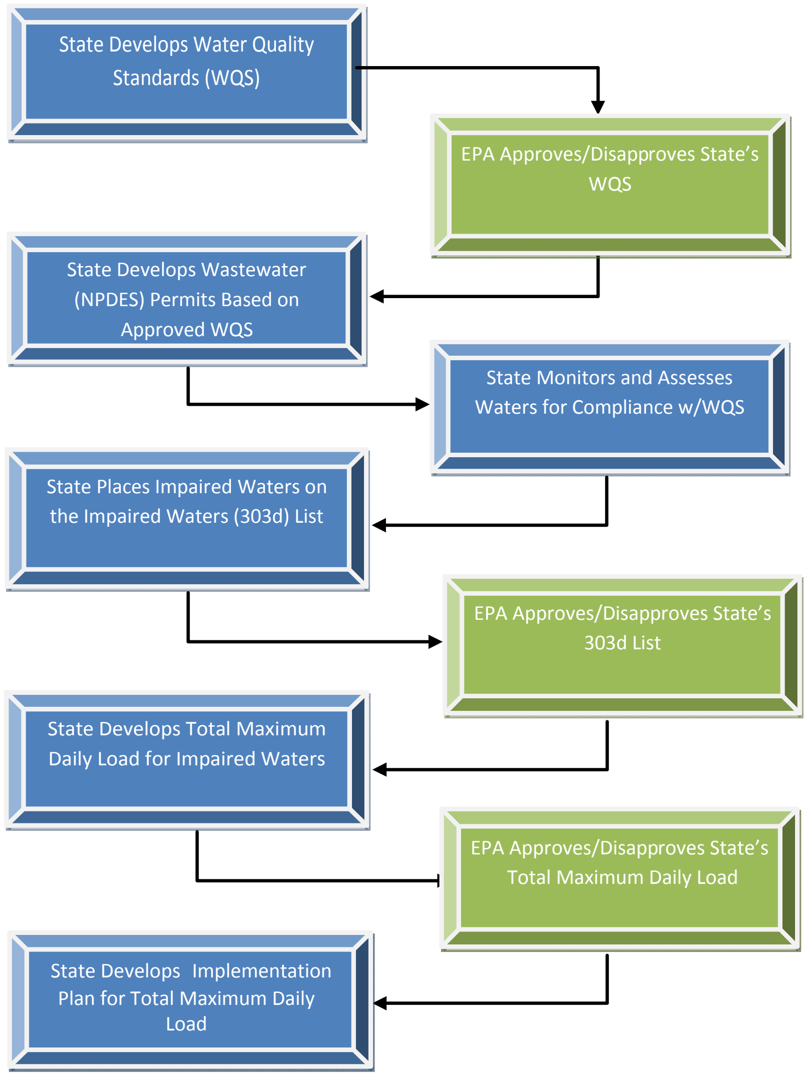


FIGURE 1-9 General Overview of the Clean Water Act WQS and TMDL Process.

Box 1-1 Definitions of Selected Water Quality Management Terms

1. *Water Quality Standards*—State or Federal regulatory requirements for surface and ground waters falling under the jurisdiction of the Clean Water Act. The standards consist of three parts - a designated use or uses, water quality criteria based upon on designated uses, and an antidegradation policy.

2. *Criteria*—Elements of State water quality standards, expressed as constituent concentrations, levels, or narrative statements, representing a quality of water that supports a particular designated use.

3. *Designated Uses*—Elements of State water quality standards that specify the uses for each water body whether or not a specific use is currently being attained. Mandatory Clean Water Act uses include aquatic life and recreation support. Other common uses are drinking water, irrigation, and industrial water supply support.

4. *Numeric Nutrient Criteria*—Criteria that define the maximum nitrogen and/or phosphorus concentration in a water body that will maintain its designated use.

5. *Narrative Criteria*—Narrative statements that define a desired condition of a water. For nutrients, in Florida the narrative criterion has been "no imbalance of flora or fauna" which can be determined by measuring biota, changes in dissolved oxygen, changes in pH, or other indicators related to nutrient pollution.

6. *Biological Criteria or Biocriteria*—Numeric values or narrative expressions of the desired biological condition of aquatic communities in a waterbody.

7. *Independent Applicability*—A concept put forth in EPA policy that states an exceedance of either chemical **or** biological water quality criteria provides irrefutable evidence of nonattainment of water quality standards regardless of the results of other types of assessments.

8. *Target*—Generally, a non-regulatory narrative or numeric goal established to achieve or maintain a water's designated uses.

9. *Nutrient Threshold*—A concentration of nutrients against which ambient nutrient concentrations are compared to assess impairment of a water's designated uses. In Florida's proposed rules, nutrient thresholds only apply to streams.

10. *Water Body Identification Number (WBID)*—Florida was divided up into polygons that roughly delineate the drainage basins surrounding individual waterbody assessment units, and each polygon was assigned a unique Water Body Identification Number. The assessment units are lakes or portions of lakes, springs, rivers and streams, segments of rivers and streams, and coastal, bay, and estuarine waters in Florida. Thus, each WBID contains both water and the surrounding drainage basin. Note that many FDEP documents use the term WBID when discussing impaired waters; this use of the term should not be misinterpreted to mean that a WBID is only the waterbody.

11. *Total Maximum Daily Load (TMDL)*—the maximum pollutant load that a waterbody can receive and not violate its water quality standard. The TMDL also specifies how the load will be allocated among point and nonpoint source dischargers to that waterbody.

12. *Basin Management Action Plan (BMAP)*—A plan that outlines how a TMDL will be implemented. BMAPs can include revised permit limits for point sources as well as new pollutant control requirements for nonpoint sources.

13. *Site-Specific Alternative Criteria (SSAC)*—If the characteristics of a receiving water allow attainment of designated uses with nutrient concentrations higher than EPA's numeric nutrient criteria, site specific alternative criteria may be developed that could result in less stringent effluent limitations. Because dischargers may be required to obtain additional data to assess the appropriateness of SSAC, the extent to which dischargers use this mechanism to obtain regulatory relief is uncertain.

NUMERIC NUTRIENT CRITERIA IN FLORIDA

Like most other states, Florida currently uses a narrative criterion to protect its waters from nutrient pollution, which states that "[in] no case shall nutrient concentrations of a body of water be altered so as to cause an imbalance in natural populations of aquatic flora and fauna." Implementing this standard entails detailed biological assessments for individual waterbodies. Thus, this criterion has been implemented on a case-by-case and site-by-site basis for identifying and listing impaired waters, establishing TMDLs, and deriving appropriate NPDES permit limits for point sources.

In 2009 EPA determined that numeric, rather than narrative, nutrient criteria would be necessary in Florida to meet the requirements of the CWA (EPA, 2009). This determination stemmed from a Consent Decree between EPA and several environmental organizations (the Florida Wildlife Federation, the Conservancy of Southwest Florida, the Environmental Confederation of Southwest Florida, St. John's Riverkeeper, and the Sierra Club) that had sued EPA, maintaining that Florida's narrative nutrient criteria were not protective of Florida's waters. Their argument was that the narrative, site-by-site approach to address nutrient pollution problems in Florida was taking too much time and too many resources to allow the state to effectively and expeditiously address its thousands of stream miles and lake acres that violate the narrative nutrient standard. The environmental groups cited EPA's 1998 *National Strategy for the Development of Regional Nutrient Criteria* calling for states to develop numeric nutrient criteria by 2003 as the rationale for requiring such criteria for Florida's waters. Furthermore, they cited section 303 of the CWA, which requires EPA to "promptly prepare and publish" new or revised water quality standards "in any case where the Administrator determines that a revised or new standard is necessary to meet the requirements of this Act [the Clean Water Act]."

The main fundamental difference between the narrative and numeric nutrient standards is that under the narrative standard waters are listed as impaired because of an imbalance of flora and fauna, which is based on biological condition assessment. Only subsequently are nutrients investigated as the cause of unacceptable biological conditions, and, if that determination is made, the state creates targets for N or P or both either in terms of allowable loads or concentrations. Under the numeric nutrient standard, simple chemical monitoring of a waterbody when compared to the numeric standards can lead to a water being listed as impaired, regardless of the associated biological condition of the water. (The reader is referred to the beginning of Chapter 3 for a more in-depth explanation of the differences between the narrative and numeric nutrient criteria.) The numeric nutrient standards established for Florida by EPA on November 14, 2010, are for nitrogen and phosphorus in lakes and flowing waters for different regions of the state, as shown in Table 1-1 (Federal Register, December 6, 2010, 75 FR 75762).

This report does not evaluate the underlying scientific basis of the numeric nutrient criteria found in Table 1-1. Nonetheless, it is useful to consider the overall feasibility of meeting the given numeric nutrient criteria in Florida's inland lakes under current conditions. As discussed in Box 1-2, a cursory analysis of lake data suggests that the numeric nutrient criteria will be difficult to attain in some (but not all) ecoregions due to differences in natural geology, soil, landscape, and hydrologic factors. Whether these results apply to streams as well is uncertain. Interestingly, a comparison of the numeric nutrient criteria with typical TMDL targets in impaired streams and lakes suggests that the numeric criteria are usually less stringent than the TMDL targets that have been developed under the narrative process, except for lakes with phosphorus pollution (see Box 3-1 in Chapter 3).

TABLE 1-1 Numeric Nutrient Criteria for Lakes and Flowing Waters in Florida

Region/ Type of Water	Chlorophyll-*a* (mg/L)	TN Criteria (mg/L)	TP Criteria (mg/L)	Nitrate + Nitrite Criteria (mg/L)
Colored Lakes[1]	0.020	1.27	0.050	NA
Clear Lakes (high alkalinity)[2]	0.020	1.05	0.031	NA
Clear Lakes (low alkalinity)[3]	0.006	0.50	0.011	NA
Panhandle East Flowing Waters	NA	1.03	0.18	NA
Panhandle West Flowing Waters	NA	0.67	0.06	NA
North Central Flowing Waters	NA	1.87	0.30	NA
West Central Flowing Waters	NA	1.65	0.49	NA
Peninsula Flowing Waters	NA	1.54	0.12	NA
Springs	NA	NA	NA	0.35

NA = not applicable
[1]Long-term Color > 40 Pt-Co
[2]Long-term Color ≤ 40 Pt-Co and Alkalinity > 20 mg/L $CaCO_3$.
[3]Long-term Color ≤ 40 Pt-Co and Alkalinity ≤ 20 mg/L $CaCO_3$.

SOURCE: EPA (2010).

It should be noted that Florida is still in the process of trying to develop its *own* numeric criteria for nutrients that would supersede Table 1-1 if approved by the Florida Environmental Regulatory Commission (which occurred December 8, 2011), the Florida legislature, and EPA. As of the writing of this report, FDEP has developed a hybrid criteria approach that includes aspects of both the current Florida narrative criteria and the EPA numeric criteria. The FDEP proposal would establish generally applicable numeric nutrient "thresholds" as an additional interpretation of the Florida narrative criteria for streams, but would only use the threshold values to make impairment decisions if there is concurrent confirmation of biological impairment. In addition, if a site-specific "numeric nutrient interpretation" exists, such as a site-specific numeric criterion or an approved numeric TMDL target, the site-specific interpretation is used in lieu of the applicable numeric nutrient threshold. Compared to the EPA's numeric nutrient criteria, this hybrid approach has more flexibility for dealing with natural background nutrient sources and variability in site-specific conditions at finer scales.

The newly proposed FDEP criteria would also include a new antidegradation-type provision for assessing impairment. This provision would place waters on the State's impaired waters planning list if they show an adverse or worsening trend in biological response variables or dissolved oxygen (DO)—even if waters did not fail any of the biological indicators. The listing of waters based on adverse nutrient response trends would provide FDEP the opportunity to proactively address worsening nutrient conditions prior to observing an actual impairment of waters' designated uses. The incremental costs of implementing Florida's hybrid criteria approach are being evaluated by Florida State University—an effort for which the results of this report should be useful.

Box 1-2
Challenges in Meeting the Numeric Nutrient Criteria in Lakes

The Committee conducted a cursory analysis of lake data (which incidentally were not used by EPA in its economic analysis) to determine what percentage of Florida lakes would likely violate the numeric nutrient criteria (NNC). Note that this analysis was approximate because the lake data did not necessarily use the same threshold values as the NNC. Nonetheless, the analysis suggests that it will be challenging to meet the NNC in many Florida lakes.

Florida has over 7,700 lakes (Griffith et al., 1997). The aquatic ecoregion framework developed nationally by Omernik (1987) has proven useful for lake water quality assessment and management in Minnesota (Heiskary and Walker, 1988; Hatch et al., 2001; Birr and Mulla, 2002) and Ohio (Fulmer and Cooke, 1990). Griffith et al. (1997) divided Florida into 47 level IV aquatic ecoregions to describe regional variations in Florida lake water quality characteristics. For each ecoregion, lake water quality characteristics were summarized.

For colored lakes the numeric nutrient criteria proposed by EPA (2010) are 0.050 mg/L TP and 1.27 mg/L TN. Using data compiled by Griffith et al. (1997) these standards can be met by most lakes in ten of thirteen of Florida's level IV aquatic ecoregions having colored lakes. The greatest difficulty will be in the Southwestern Flatlands ecoregion, where 75% of the lakes exceed 0.075 mg/L TP and 1.25 mg/L TN. This is a coastal lowland region, with citrus, pasture and urban development. Numeric criteria will also be difficult to attain in the Northern Peninsula Karst Plains ecoregion, where 50% of the lakes exceed 0.074 mg/L TP. There are widespread phosphatic sand deposits in this region. In the Central Valley ecoregion 50% of lakes exceed 1.4 mg/L TN, so the numeric criteria for TN will be widely violated. This is a region of large, shallow eutrophic lakes with nutrient enriched soils.

For clear alkaline lakes the numeric nutrient criteria proposed by EPA are 0.031 mg/L TP and 1.05 mg/L TN. There are eight level IV aquatic ecoregions with these types of lakes in Florida. Numeric criteria can likely be met in six of these ecoregions. The remaining ecoregions are characterized by extensive geologic deposits of phosphatic sands or clays, where attaining numeric nutrient criteria is probably difficult. In the Lakeland/Bone Valley ecoregion, for example, there is extensive mining for phosphate deposits. The vast majority of lakes in this ecoregion exceed 0.12 mg/L TP and 1.7 mg/L TN. In the Orlando Ridge ecoregion half of the lakes exceed 0.031 mg/L TP.

For clear non-alkaline lakes the numeric nutrient criteria proposed by EPA are 0.011 mg/L TP and 0.5 mg/L TN. There are thirteen Level IV aquatic ecoregions in Florida with these types of lakes. The numeric nutrient criteria can likely be met in six of these ecoregions. Attaining these criteria in the other seven ecoregions will be challenging, if feasible at all. For example, 75% of lakes in the North Brooksville Ridge ecoregion exceed 0.008 mg/L TP and 0.57 mg/L TN. This area is characterized by thick sands underlain by phosphatic deposits. In the Weeki Wachee Hills ecoregion, 75% of the lakes exceed 0.009 mg/L TP and 0.63 mg/L TN.

The results of this analysis suggest that meeting the NNC in lakes of Florida will be challenging, because TP concentrations in some lakes are controlled by natural geologic, soil and hydrologic factors (Bachmann et al., 2010) in addition to anthropogenic factors. It will be especially challenging to meet the NNC for TP in lakes within ecoregions where phosphatic deposits occur (e.g., North Peninsula Karst Plains, Lakeland/Bone Valley, and North Brooksville Ridge). It should be noted that FDEP rules allow for exceptions to meeting numeric standards given natural background conditions, using the site-specific alternative criteria (SSAC) process.

Estimates of the Incremental Cost to Implement the Numeric Nutrient Criteria

EPA's numeric nutrient criteria for Florida may result in new impaired waters listings and reevaluation of the TMDLs for the waters that are currently listed as impaired. These actions may lead to new or revised NPDES permit conditions for point source dischargers, and/or nutrient control requirements or best management practice (BMP) guidance on other pollutant sources, although the numeric nutrient criteria rule itself does not establish requirements directly applicable to such entities. Therefore, EPA was required to produce an economic analysis of the potential incremental costs and benefits that may be associated with implementation of the numeric nutrient criteria rule, taking into account existing federal and Florida regulations.

EPA's economic analysis (EPA, 2010) is an assessment of the potential incremental cost of implementing the numeric nutrient criteria, taking into account technologies and other controls that may be used to meet the criteria in waters newly identified as impaired as a result of the new criteria. The analysis assumes that affected parties will make use of various site-specific criteria adjustment processes and Florida's ability to re-designate beneficial uses, grant variances, and establish load allocations in TMDLs. EPA's stated annual combined incremental cost estimates range from $135.5 to $206.1 million per year, which is a total of $1.4 to $2.2 billion over a 20-year period (EPA, 2010).

Other stakeholder groups have produced their own estimates of the cost of implementing the numeric nutrient criteria, with some having estimated costs as high as to $12 billion (FDEP, 2010). Like the EPA report, reports from FDEP (2010) and Cardno ENTRIX (2010a,b) on behalf of the Florida Water Quality Coalition cover all pollutant sectors. Other groups targeted specific portions of the EPA economic analysis, including reports from the Florida Water Environment Association Utility Council (municipal point sources; Carollo Engineers, 2010), the Florida Department of Agriculture and Consumer Services (agriculture; Budell et al., 2010), the Florida Pulp and Paper and the Florida Phosphate reports (industrial point sources; AWARE Environmental Inc. and AquAeTer Inc., 2010, and ENVIRON, 2010, respectively).

The discrepancies between the EPA and other analyses arise from many factors (as discussed in greater detail in Chapter 2). First, EPA considers only those additional waters that that are newly identified as impaired based on the numeric nutrient criteria and does not consider waters that Florida has already determined to be impaired based on existing FDEP assessment methodologies. Second, EPA and other stakeholders made different assumptions about which point and nonpoint source activities to include in their cost analyses. Third, there are differing opinions about the level of technology that will be needed and thus the cost necessary to meet the numeric criteria. The EPA economic analysis assumes that available regulatory exemptions will be sought, while other analyses assume that more expensive technologies will be required. The cost discrepancies between the EPA analysis and others are presented in Table 1-2.

Part of the controversy in Florida has been that the media, the public, and also perhaps decision makers have been misinterpreting the EPA incremental cost estimate as the *total* cost needed to reduce nutrient loads to levels that would meet designated uses within impaired waterbodies. Indeed, several of the competing stakeholder analyses that approach the billion dollar annual level (see Table 1-2) are clearly a reflection of attempts to estimate the total cost, not the incremental cost. A second point of controversy is that EPA implicitly assumes that the implementation activities included in its cost analysis would be adequate to meet the numeric nutrient criteria in both the incrementally impaired waters and in those already be identified as

TABLE 1-2 Cost Discrepancies between the EPA Economic Analysis and other reports.

Nutrient Source	**Stakeholder Estimates**	**EPA (2010)**	**Cardno ENTRIX (2011b)**
Municipal WWTPs	\$2–4.6 billion/yr (Carollo, 2010)	\$22.3–38.1 million/yr	\$41–395 million/yr
Industrial Facilities	\$2.1 billion/yr[1] (FDEP, 2010)	\$25.4 million/yr	\$270–1,973 million/yr
Urban Stormwater	\$2.0 billion/yr (FDEP, 2010)	\$60.5–108 million/yr	\$61–629 million/yr
Agriculture	\$0.9–1.6 billion/yr (Budell et al., 2010)	\$19.9–23 million/yr	\$33–969 million/yr
Septic Systems	\$0.9–2.9 billion/yr (FDEP, 2010)	\$6.6–10.7 million/yr	\$8–65 million/yr
Government Expenditures		\$0.9 million/yr	\$1–11 million/yr[2]

[1]This does not include the costs determined by the Pulp and Paper Industry and the Phosphate Industry found in AWARE Environmental Inc. and AquAeTer Inc., 2010, and ENVIRON, 2010, respectively.
[2]These numbers came from a spreadsheet Cardno ENTRIX made available at their ftp site. The range is the low end of their "BMP/LOT" analysis and the high end of their "End of Pipe" analysis.

nutrient stressed under the narrative process. That is, the EPA cost analysis fails to acknowledge the possibility that what Florida historically required will be insufficient to achieve the numeric nutrient criteria. Chapter 2 makes it clear that what has been implemented in the past has made some water quality improvements in some sectors, but in general has not led to attainment of designated uses.

This is not meant to suggest that the EPA analysis was wrong in focusing on the incremental costs; indeed, this was the most appropriate approach to take (although EPA was not comprehensive—see Chapter 3). Nonetheless, subsequent to EPA releasing its economic analysis a period of confusion ensued, during which stakeholders argued primarily about the total cost and confused incremental cost with total cost. It is certain that the total costs of attaining water quality standards in Florida waters impaired by nutrients will be enormous, not only because of ongoing polluting activities and the current state of water quality impairment in Florida but because of natural background sources of nutrients, legacy sources that are unlikely to be remediated by common nonpoint source BMPs, and ongoing changes in population, land use, and the economy. These total long-term costs of restoring impaired surface waterbodies are going to be much higher than either the incremental costs of the EPA's numeric nutrient criteria or the historic costs already incurred for TMDLs and BMAPs in waters impaired under Florida's narrative criteria, regardless of the future regulatory framework. If FDEP made a statement to that effect, it would further the public's understanding of the scope of nutrient pollution in Florida and the challenges to its management, and overcome misunderstandings that have arisen during debate about EPA's numeric nutrient criteria.

REQUEST FOR NATIONAL RESEARCH COUNCIL STUDY

Resolution of the discrepancies between various stakeholders described above is critical to moving forward with implementation of the numeric nutrient criteria. Thus, EPA requested that the National Research Council (NRC) conduct a review of the Agency's economic analysis of the incremental costs of state implementation of final numeric nutrient criteria for lakes and flowing waters in Florida. In response to this request, the NRC formed a committee to evaluate the cost estimates of implementing the numeric criteria, including the relevance and validity of certain assumptions and methodologies used in the economic analysis. The Committee's statement of task is found in Box 1-3.

There were a number of constraints placed on the Committee that were necessary in order for it to produce a report by the March 2012 deadline imposed by EPA. First, it should be noted that the Committee was not asked to do an assessment of the rule per se. This is important because the actual numeric values have been the source of considerable controversy in Florida for the last few years, and at one point the State of Florida requested the NRC's involvement in determining what the numbers should be (although this request was never fully realized). For the purposes of this study, the numeric criteria in Table 1-1 were assumed to be unmovable. An EPA Science Advisory Board panel has issued a report evaluating the scientific merit of the proposed numeric standards (EPA, 2011).

Second, the Committee was not asked to address the benefits of implementing the numeric nutrient criteria, despite the existence of a chapter in the EPA report devoted to a consideration of benefits and considerable interest from some stakeholders. Nor does the Committee address the important but indirect costs associated with implementing the numeric criteria, such as the number of jobs lost or gained, how certain related sectors of the economy will fare under the numeric criteria like real estate and tourism, etc. The committee considered all of these topics beyond the scope of the study given the statement of task and the very short time frame in which it was operating.

Finally, the Committee was not asked to do its own cost estimate; i.e., there is no new calculation of the estimated costs of implementing the criteria in this report. Rather, the report focuses on the methods to be used in any future analyses, and it evaluates the validity of assumptions found in the EPA report and the reports of various stakeholders.

The Committee made use of a wide variety of sources, most importantly the economic analyses produced by EPA and other stakeholder groups. The Committee held two open meetings, one in Orlando, Florida, in July 2011, and one in Washington, DC, in October 2011, to hear from these groups, including open-microphone sessions to take comments from the interested public at both meetings. The third committee meeting held in December 2011 was entirely in closed session. Additional background materials were also gathered from the Florida Department of Environmental Protection, the main agency responsible for water quality management in Florida, and from the EPA Office of Science and Technology. Given the detailed technical and regulatory nature of the subject, the primary audience for this report is EPA, FDEP, and the stakeholder groups mentioned above.

Chapter 2, which addresses the second and third items in the statement of task, comprehensively discusses the EPA's and others' assumptions and incremental cost estimates for five pollutant sectors, including municipal and industrial wastewater treatment plants, agriculture, urban stormwater, and septic systems. The incremental costs to government of implementing the NNC rule are also considered. Chapter 3 tackles the first item in the statement of task by providing an alternative framework for the cost analysis that could be used by EPA for future work in Florida and elsewhere. The conceptual framework provides an alternative way to (1) more accurately characterize baselines and consequently the incremental effect of the NNC Rule and (2) address the timing and uncertainty of costs of a proposed rule change. Taking into

Box 1-3
NRC Committee Statement of Task

In response to a request from the U.S. Environmental Protection Agency, this study undertaken by a special committee organized and overseen by the NRC's Water Science and Technology Board is reviewing EPA's analysis of the costs of state implementation of final numeric nutrient criteria for lakes and flowing waters in Florida. Because the numeric nutrient criteria rule is scheduled to take effect March 6, 2012, the EPA needs input quickly on a number of important issues. The committee will evaluate the cost estimates of implementing the numeric criteria, including the relevance and validity of certain assumptions and methods used in the economic analysis. The evaluation will give special attention to those assumptions that may account for discrepancies between EPA's analysis and those of several stakeholder groups. Specifically, the committee will review and comment on the implications of:

1. EPA's assumption that costs should only be determined for waters that will be "newly impaired" as a result of the numeric nutrient criteria.

2. EPA's decision to estimate the costs of only those sources of pollution that would directly affect a "newly impaired" water—in particular the number of wastewater treatment plants, the acreage of agricultural land, the acreage of urban areas, and the number of septic systems included in the EPA analysis.

3. EPA's assumptions about the levels of control that could be used by certain point and nonpoint sources, such as wastewater treatment plants, industrial point sources, agricultural activities, and septic systems. Examples of these assumptions could include a decision to seek a regulatory exemption, whether to implement reverse osmosis technology, or to use conventional best management practices rather than more expensive water treatment options.

consideration the narrative process, the numeric nutrient criteria, and the proposed FDEP hybrid approach, the chapter highlights the importance of evaluating the key differences in the three processes and the resulting implications for overall cost, including the critical issue of timing. The findings and recommendations in this report should be useful regardless of whether the EPA's NNC rule or the proposed FDEP rule is ultimately adopted.

REFERENCES

AWARE Environmental Inc. and AquAeTer Inc. 2010. Treatment Technologies Assessment for Removal of Nitrogen and Phosphorus in Pulp and Paper Wastewater. Prepared for the Florida Pulp and Paper Association. April 2010.

Bachmann, R. W., M. V. Hoyer and D. E. Canfield, Jr. 2010. Draft alternative nutrient criteria for Florida lakes. Florida LAKEWATCH whitepaper. Univ. Florida. Gainesville, Fl.

Birr, A. S., and D. J. Mulla. 2002. Relationship between lake and ground water quality patterns and Minnesota agroecoregions. Hydrological Sci. Tech. 18(1-4):31-41.

Budell, R., et al., A. W. Hodges et al., and D. Bottcher. 2010. Economic Impacts and Compliance Costs of Proposed EPA Water Quality Standards for the State of Florida's Lakes and Flowing Waters. April 27, 2010.

Bureau of Economic and Business Research (BEBR). 2010. Population studies. http://www.bebr.ufl.edu/ Univ. FL. Gainesville, FL.

Cardno ENTRIX. 2011a. Economic Analysis of the Proposed Federal Numeric Nutrient Criteria for Florida. Prepared for the FL Water Quality Coalition by Cardno ENTRIX, June 2011.

Cardno ENTRIX. 2011b. Addendum to the Economic Analysis of the Federal Numeric Nutrient Criteria for Florida. Prepared for the Florida Water Quality Coalition by Cardno ENTRIX, July, 2011.

Carollo Engineers. 2010. Costs for Utilities and Their Ratepayers to Comply With EPA Numeric Nutrient Criteria for Freshwater Dischargers. Prepared for the Florida Water Environment Association Utility Council. November 2010.

Collins, M. E. 1985. Key to Soil Orders in Florida. Gainesville, FL: University of Florida.

ENVIRON. 2010. Assessment of Financial Impact on Phosphate Mining and Mineral Processing: Complying with EPA's Proposed Nutrient Water Quality Standards for Florida. Prepared for the Florida Phosphate Industry. April 2010.

Environmental Research & Design, Inc. 2007. Evaluation of Current Stormwater Design Criteria within the State of Florida. Final Report prepared for Florida Department of Environmental Protection, Orlando, FL. http://www.dep.state.fl.us/water/nonpoint/docs/nonpoint/SW_TreatmentReportFinal_71907.pdf

Florida Department of Environmental Protection (FDEP). 2008. Integrated Water Quality Assessment for Florida: 2008 305(b) Report and 303(d) List Update, October 2008.

FDEP. 2010. Review of EPA's "Preliminary Estimate of Potential Compliance Costs and Benefits Associated with EPA's Proposed Numeric Nutrient Criteria for Florida." April 28, 2010.

FDEP. 2011. An Overview of Nutrient Management in Florida, Working Draft – April 2011.

Fulmer, D. G., and G. D. Cooke. 1990. Evaluating the restoration potential of 19 Ohio reservoirs. Lake Reserv. Manage. 6:197-206.

Griffith, G. E., D. E. Canfield, Jr., C. A. Horsburgh, and J. M. Omernik. 1997. Lake regions of Florida. EPA/R-97/127. US EPA. NHREEL. Western Ecology Division. Corvallis, OR.

Hatch, L. K., A. P. Mallawatantri, D. Wheeler, A. Gleason, D. J. Mulla, J. A. Perry, K. W. Easter, P. Brezonik, R. Smith, and L. Gerlach. 2001. Land management at the major watershed - agroecoregion intersection. J. Soil Water Conservation 56:44-51.

Heiskary, S., and W. W. Walker, Jr. 1988. Developing phosphorus criteria for Minnesota lakes. Lake Reserv. Manage. 4:1-9.

Hendrickson, J., N. Trahan, E. Stecker, and Y. Ouyang. 2002. Estimation and assessment of the current and historic external load of nitrogen, phosphorus and organic carbon to the Lower St. Johns River for the fulfillment of TMDL and PLRG objectives. Palatka, Florida: St. Johns River Water Management District, Department of Water Resources

MACTEC. 2010. Final Report Wekiva River Basin Nitrate Sourcing Study. Prepared for the SJRWMD and FDEP. March 2010.

Omernik, J. M. 1987. Ecoregions of the conterminous United States. Annals Assoc. Am. Geog. 77:118-125.

Reddy, K. E., S. Newman, T. Z. Osborne, J. R. White, and C. Fitz. 2010. Legacy phosphorus in the Everglades ecosystem: Implications to management and restoration. Critical Reviews in Environmental Science Technology (in review).

Schiffer, D. 1998. Hydrology of Central Florida lakes-A primer. U.S. Geological Survey circular 1137. Denver, CO. U.S. Govt. Printing Office.

U.S. Environmental Protection Agency (EPA). 2009. Letter from Benjamin Grumbles, Assistant Administrator, Office of Water to Michael Sole, Secretary, Florida Department of Environmental Protection. January 14. http://www.epa.gov/waterscience/standards/rules/fl-determination20090114.pdf.

U.S. EPA. 2010. Economic Analysis of Final Water Quality Standards for Nutrients in Lakes and Flowing Waters in Florida. Environmental Protection Agency; November, 2010.

U.S. EPA. 2011. Methods and Approaches for Deriving Numeric Criteria for Nitrogen/Phosphorus Pollution in Florida’s Estuaries, Coastal Waters, and Southern Inland Flowing Waters. US EPA. Washington, DC. http://yosemite.epa.gov/sab/sabproduct.nsf/fedrgstr_activities/DCC3488B67473BDA852578D20058F3C9/$File/EPA-SAB-11-010-unsigned.pdf.

USGS. 1998. Water Quality in the Georgia-Florida Coastal Plain, Georgia and Florida, 1992-96. By Marian P. Berndt, Hilda H. Hatzell, Christy A. Crandall, Michael Turtora, John R. Pittman, and Edward T. Oaksford. U. S. Geological Survey Circular 1151.

Chapter 2

Assessment and Commentary on EPA's Analysis

As indicated in Chapter 1, the intent of the U.S. Environmental Protection Agency's (EPA) analysis was to assess the differential costs of nutrient load reduction under the numeric nutrient criteria (NNC) rule vs. Florida's narrative rule. This chapter accepts the EPA definition of the incremental effect of the NNC rule and focuses on the way EPA estimated that effect and the costs for different sectors including municipal wastewater facilities, industrial facilities, agriculture lands, urban stormwater, and septic systems. The associated costs of governmental administration are also discussed. This chapter also includes some initial descriptions of the current regulatory requirements for each sector and how regulatory uncertainties can lead to different assumptions about the effect of the NNC rule on the level and timing of costs. Chapter 3 provides an expanded discussion of the incremental effect of the rule and how uncertainty about the rule change can affect incremental costs.

EPA COST ANALYSIS METHODS: OVERVIEW

The first part of EPA's analysis was conducted for point sources, identifying the number of point sources that would have to improve treatment in response to the NNC rule, the likely technological upgrades that would be implemented, and the cost of upgrades based on unit costs multiplied by the actual flow rate of each point source. The next step in the EPA analysis was to determine the potential incrementally impaired waterbodies—that is, an estimate of those waters that may be expected to be in noncompliance with the numeric nutrient criteria, but that would not be impaired under the narrative rule. Once this set of waters was defined, the analysis proceeded to estimate the location and amount of land area that would require load controls to meet the numeric nutrient criteria in the waterbody. For the stormwater and agricultural sources, EPA identified the corresponding acreage draining to the potential incrementally impaired waterbodies, reduced the acreage considered based on best management programs that were already in place, selected a set of BMPs that EPA staff deemed adequate and cost-effective, and then applied a unit cost to the resulting acreage to estimate the total cost for the two sectors. For septic systems EPA determined the number of systems within 500 feet of a potential incrementally impaired waterbody and multiplied this number by unit cost to upgrade septic systems to reduce their nutrient loads.

Several key regulatory assumptions were made by EPA and are discussed in the subsequent sector analyses only if the Committee took issue with them. These assumptions include:

- Impaired waterbodies where a total maximum daily load (TMDL) has already been developed based on the narrative criteria were not considered, assuming that the TMDLs would serve as the basis for site-specific alternative criteria (SSAC), if needed;
- Waters that are currently listed as impaired based on the narrative criteria were also not considered, because it was assumed that a TMDL for nitrogen (N) and/or phosphorus (P) would be developed and that this TMDL would serve as the basis for an SSAC determination;
- Municipal and industrial plants discharging at 3 mg/L for total nitrogen (TN) and 0.1 mg/L for total phosphorus (TP) were considered "in compliance"; and
- The cost of actions to reduce pollutant loads associated with implementation of the statewide Stormwater Rule, the Urban Turf Fertilizer Rule, the Florida Department of Environmental Protection (FDEP) Dairy Rule, and Concentrated Animal Feeding Operation (CAFO) Requirements would not necessarily be accruable to the NNC rule, since these programs are already in place.

Three analytical assumptions of the EPA analysis were accepted for this chapter (and are returned to in Chapter 3):

- The definition of the incremental effect of the NNC rule was defined and limited to (1) waters that would be newly listed and determined to be stressed by nutrients and (2) National Pollutant Discharge Elimination System (NPDES) municipal and industrial sources that would receive certain concentration limits in their discharge permits;
- EPA assessed the incremental effect of the NNC rule at a single point in time, assuming no further changes would occur under the narrative process (which was the baseline), instead of comparing the future outcomes of *both* processes over time; and
- The analysis assumed constant temporal conditions in such factors as population, land use, crop types, management practices, industrial activities, and climate were assumed, even though the analysis acknowledged that the effects would occur over time (for example, there was a 20-year horizon for amortizing capital costs).

Determination of Incrementally Impaired Waters

EPA defined one incremental effect of the NNC rule as the number of waterbodies that would be listed as impaired under the numeric nutrient criteria but not under the narrative criteria. Had monitoring data for N and P concentrations been available for all waterbodies, this would be a simple exercise. However, out of a total of 3,765 freshwater stream segments in Florida, a very large fraction (84 to 89 percent) lacks sufficient monitoring data on N and P concentrations to make an assessment, based on the application of Florida's Impaired Waters Rule (IWR) (FDEP, 2011). For the 1,444 lake segments in Florida, 59 to 78 percent lack sufficient information to be assessed (FDEP, 2011), which covers a substantial area of the state, particularly in the north and northwest (see Figure 2-1). Thus, of the 5,209 freshwater WBIDs in Florida (see Chapter 1 for the definition of a WBID), approximately 77 to 86 percent cannot currently be assessed.[1] Despite a long record of water quality monitoring in Florida, the vast majority of the waterbodies have insufficient information to determine whether action is needed.

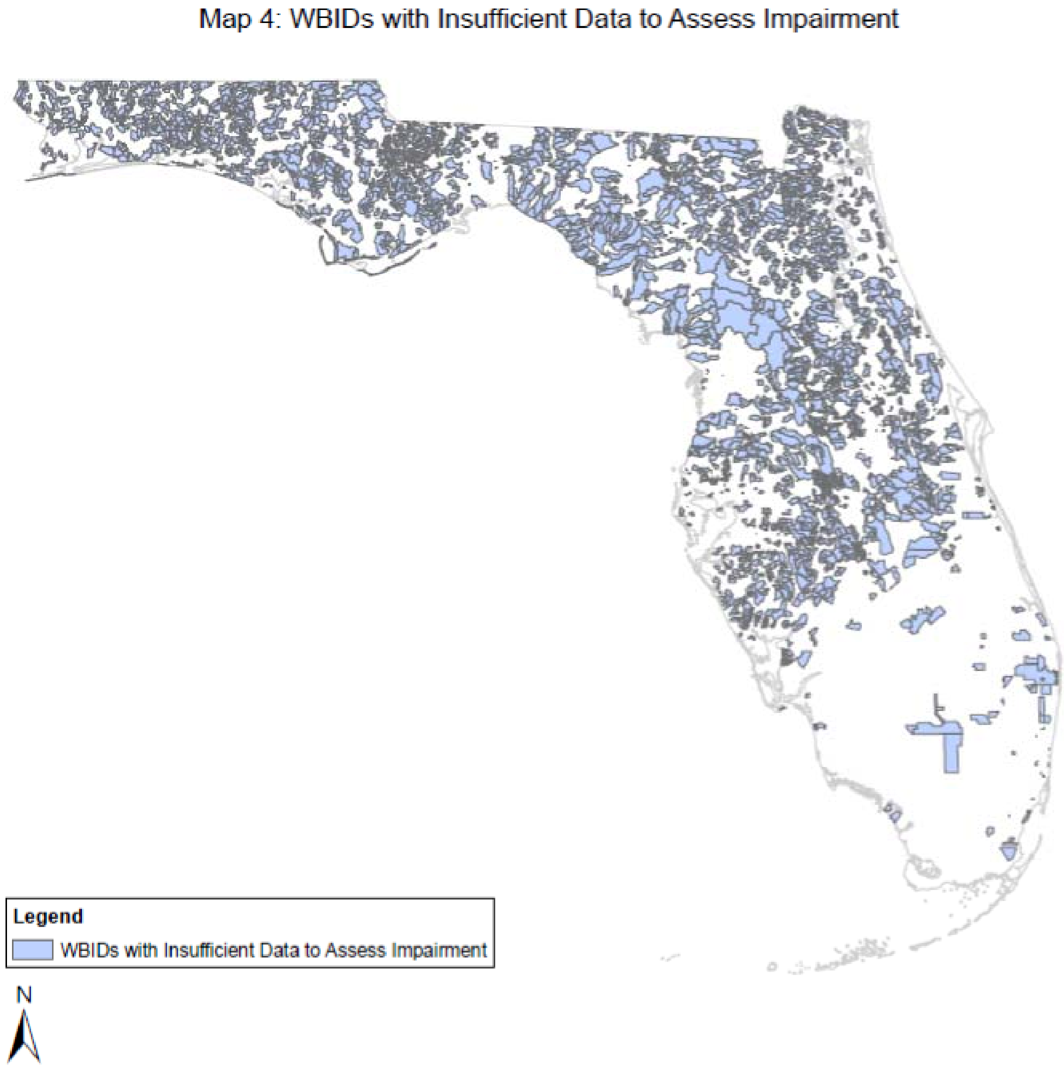


FIGURE 2-1 WBIDS with insufficient data to assess impairment.
SOURCE: Karen Milam, EPA.

[1] The range in unassessed segments reflects the difference in the amount of information required to assess under the current narrative criteria (one year of data) compared to the NNC (three years), as well as differences in the quality of the data that EPA and FDEP considered necessary to determine whether a WBID can be assessed. Furthermore, the sentence is not implying that 77 to 86 percent of Florida waters have no monitoring data, just that there is not enough data to make a determination of impairment based on the requirements of the IWR.

Streams and Lakes[2]

Faced with this limitation, EPA opted for the following approach to estimate the number of incrementally impaired streams and lakes. Using the FDEP database of WBIDs and monitoring data for the past five years from IWR Run 40 (a subset of Florida's water quality data), EPA first identified potentially impaired waterbodies by comparing their monitoring data to the numeric nutrient criteria. WBIDs where a nutrient-related TMDL had already been established were excluded, based on the assumption that FDEP would seek SSACs for those WBIDs and/or that "controls to reduce nutrients already required in the absence of EPA's rule would be sufficient". In addition, EPA identified WBIDs adjacent to lakes to which downstream protective values could apply[3]. Finally, all of the unassessed waters were excluded by EPA from consideration as potentially impaired due to the new rule by assuming that unassessed waterbodies are likely to be unimpaired, given Florida's focus on monitoring the most polluted streams and lakes. In other words, EPA assumed that if a waterbody were likely to be impaired, Florida would have already known about it and monitored it under the existing program of narrative criteria. Using these assumptions, EPA determined that only 325 WBIDs potentially exceed the numeric nutrient criteria [see Exhibit ES-4 in EPA (2010)]. Given EPA's assumptions, the Committee considers the EPA estimate to be a lower bound on the number of incrementally impaired waters that would be listed due to the new rule[4].

FDEP used a different approach for estimating the number of potentially impaired waters that would be listed due to the new rule and determined that there are between 424 and 546 incrementally impaired WBIDs under the NNC rule (FDEP, 2011). The FDEP approach was based on a statistical analysis, using the failure rate of assessed waterbodies under the current narrative criteria to predict the number of unassessed waterbodies that would fail under the numeric nutrient criteria. FDEP developed different statistics for the various "nutrient watershed regions" identified by EPA in the new rule (see Table 1-1). While using regionalized statistics acknowledges biogeographic and climate differences, no other consideration was given to the characteristics of a watershed that may result in impairment. It is unknown whether prior information from the currently listed WBIDs is a good predictor of the status of the unassessed WBIDs. The size and land use composition of WBIDs varies substantially, which can lead to a significant over- or underestimate of the impaired acreage. Thus, it is not possible to determine whether this approach represents an upper bound on the incremental number of potentially impaired waters due to the new rule.

A more defensible approach than either of the previous ones would take into consideration the characteristics of the various WBIDs to predict the likelihood that they would fail to meet the narrative criteria or the numeric nutrient criteria. For example, using the land use data and land use management statistics of the assessed WBIDs, one could establish a relationship between the likelihood of impairment and the level of urbanization, number of septic systems, loading from NPDES-permitted sources, agricultural production, the level of adoption

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[2] In this section, WBID and waterbody are interchangeable. WBID is used when citing data on the number and status of impaired waterbodies from the EPA and FDEP documents. Also, TMDLs are developed for individual or groups of WBIDs, so this term is also used when discussing the TMDL process.

[3] The NNC rule requires the application of a downstream protective value when choosing the criterion for a stream segment that enters directly into a lake. That is, if a stream directly enters a lake and the lake criterion is more stringent, then the lake criterion would apply to the stream.

[4] Assuming EPA's definition of incrementally impaired.

of agricultural and stormwater BMPs in a given WBID, etc. The land use information for such an analysis is readily available in GIS format. FDEP has a database of septic systems in each WBID. Land management information could be obtained from FDACS (for agricultural BMPs implemented) or from MS4 permittees (for stormwater BMP adoption). While this approach also entails a certain level of uncertainty, the uncertainty should be easier to estimate and report. In addition, since the potential incrementally impaired WBIDs can be identified, their specific acreage can be considered for the analysis, reducing this source of uncertainty.

Springs

EPA identified springs with any monthly geometric mean nitrate-nitrite concentration greater than the numeric nutrient criterion as impaired. As with streams and lakes, EPA removed from the resulting list of springs those that are currently on Florida's 303(d) list of impaired waters. This analysis resulted in 24 incrementally impaired springs (see Exhibit ES-4 in EPA, 2010a). Waters with insufficient data to determine compliance were assumed to be unimpaired under the numeric nutrient criteria. Thus, the same issues that were discussed above for lakes and streams regarding unassessed waters also potentially hold for springs (in terms of the EPA number being a lower bound).

Acreage of Land Draining to Incrementally Impaired Watersheds

After estimating the incrementally impaired WBIDs, the next step was to determine the acreage of various land uses that contribute to the potential impairment. EPA used a relatively coarse "grid", by considering the 10-digit hydrologic units code (HUC10) watersheds, as defined by the USGS. Because WBIDs may not fall within a single HUC10, to estimate the incremental acreage EPA considered all the HUC10 watersheds containing at least 10 percent of an incrementally impaired lake or stream, which may lead to a significant overestimate of the incremental acreage (EPA, 2010a). On the other hand, EPA excluded all of those HUC10 watersheds that contain at least 10 percent of a lake or stream that are currently impaired or under a TMDL. This could lead to an underestimate of the incremental acreage. The Committee's evaluation of maps showing the incrementally impaired WBIDs and their associated HUC10s did not lead to an obvious conclusion that the HUC10 units are an over- or under-estimate of the acreage.

The HUC10 watersheds are generally too coarse for TMDL analysis, which is typically done with a delineation closer to the USGS HUC12 subwatershed level. Figure 2-2 provides an example of the resolution of the WBIDs for the Santa Fe River in Central Florida. As can be seen, there are dozens of WBIDs within this single basin, of varying sizes. Figure 2-3 presents the HUC10s for this same region. There are only seven large HUC10s within this basin. Figure 2-4 presents the HUC12 delineation for the region. Although there is no direct correspondence between the HUC12s and Florida's WBIDs, the size of the WBIDs is generally much closer to the HUC12s. Thus, a more precise estimate of the potential incrementally affected acreage due to the new rule could have been performed using the same assumptions but with the HUC12 delineation of the areas contributing to the various WBIDs. Alternatively, EPA could have used the area for each specific WBID for their analysis.

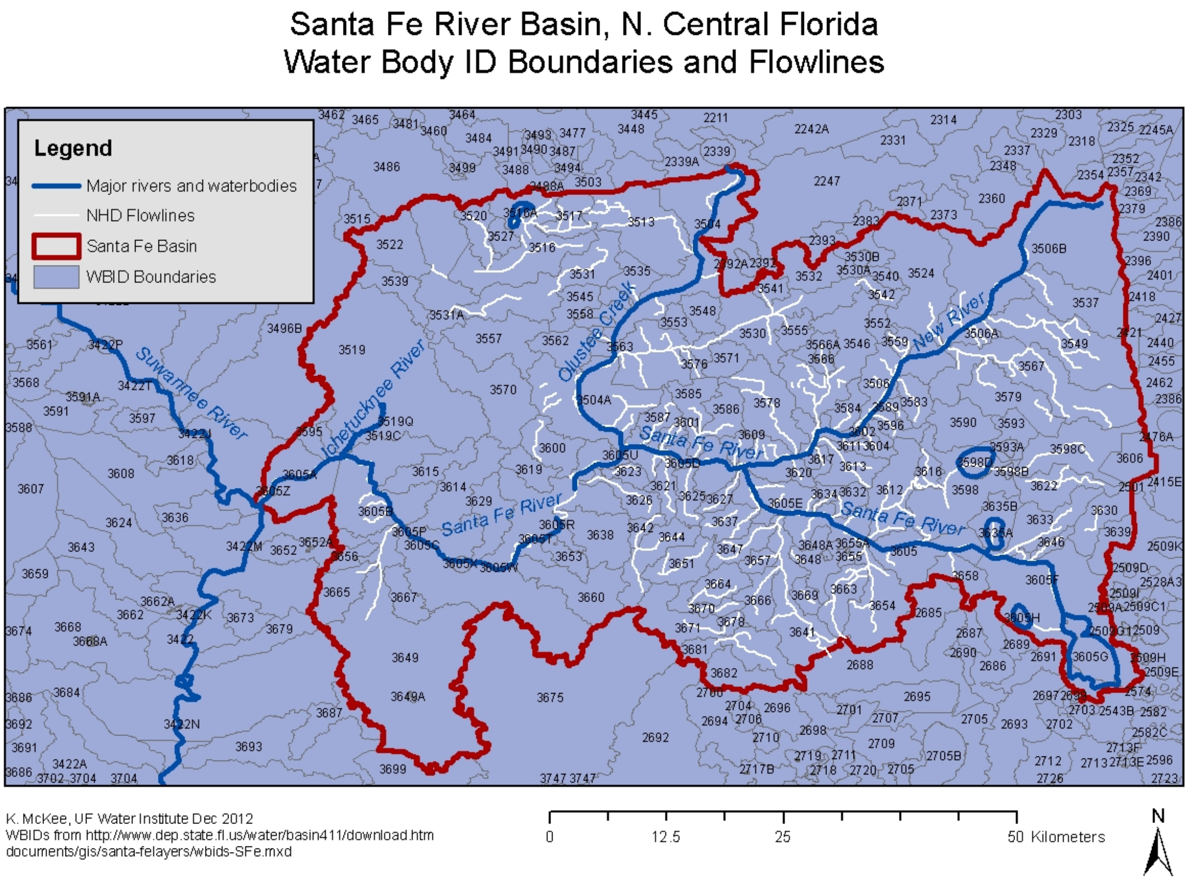

FIGURE 2-2 WBIDs in the Santa Fe River.
SOURCE: McKee (2011).

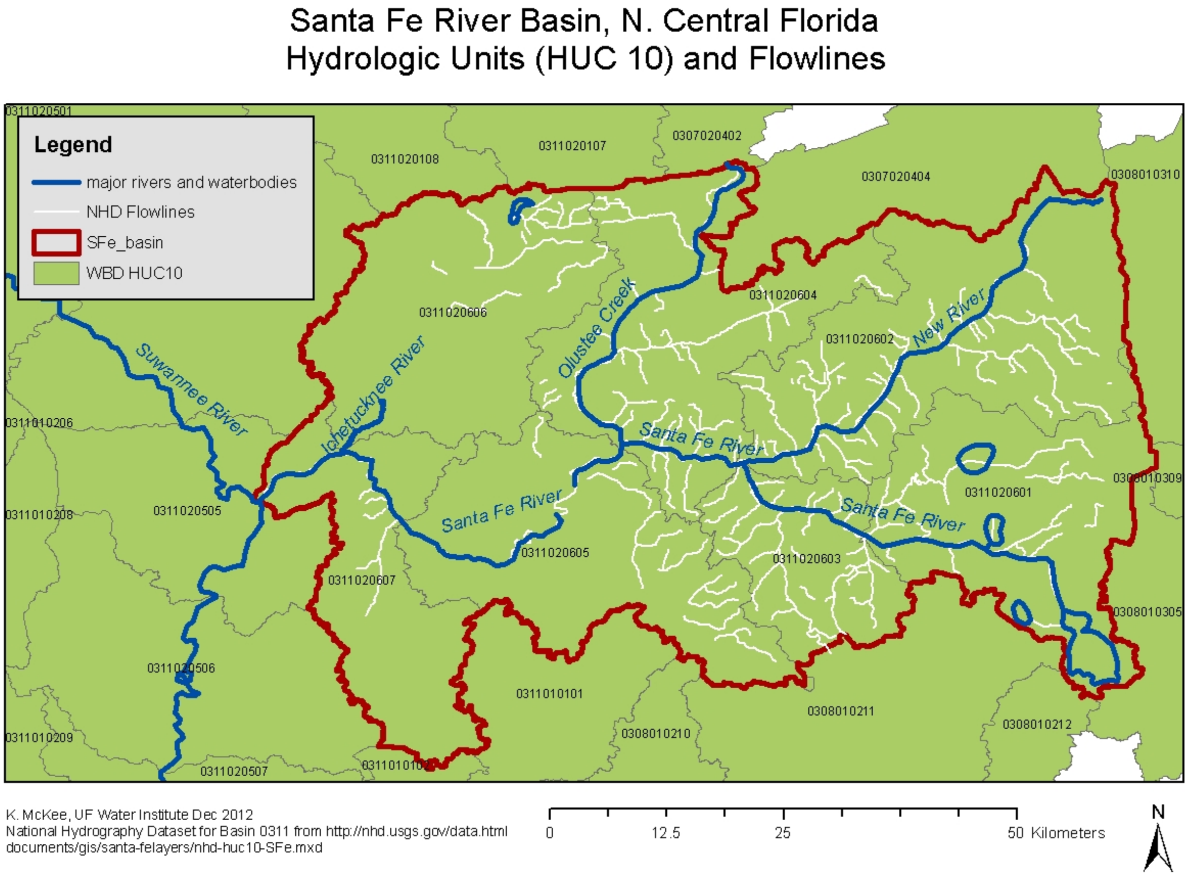

FIGURE 2-3 HUC 10 delineation for the Santa Fe river in Central Florida.
SOURCE: McKee (2011).

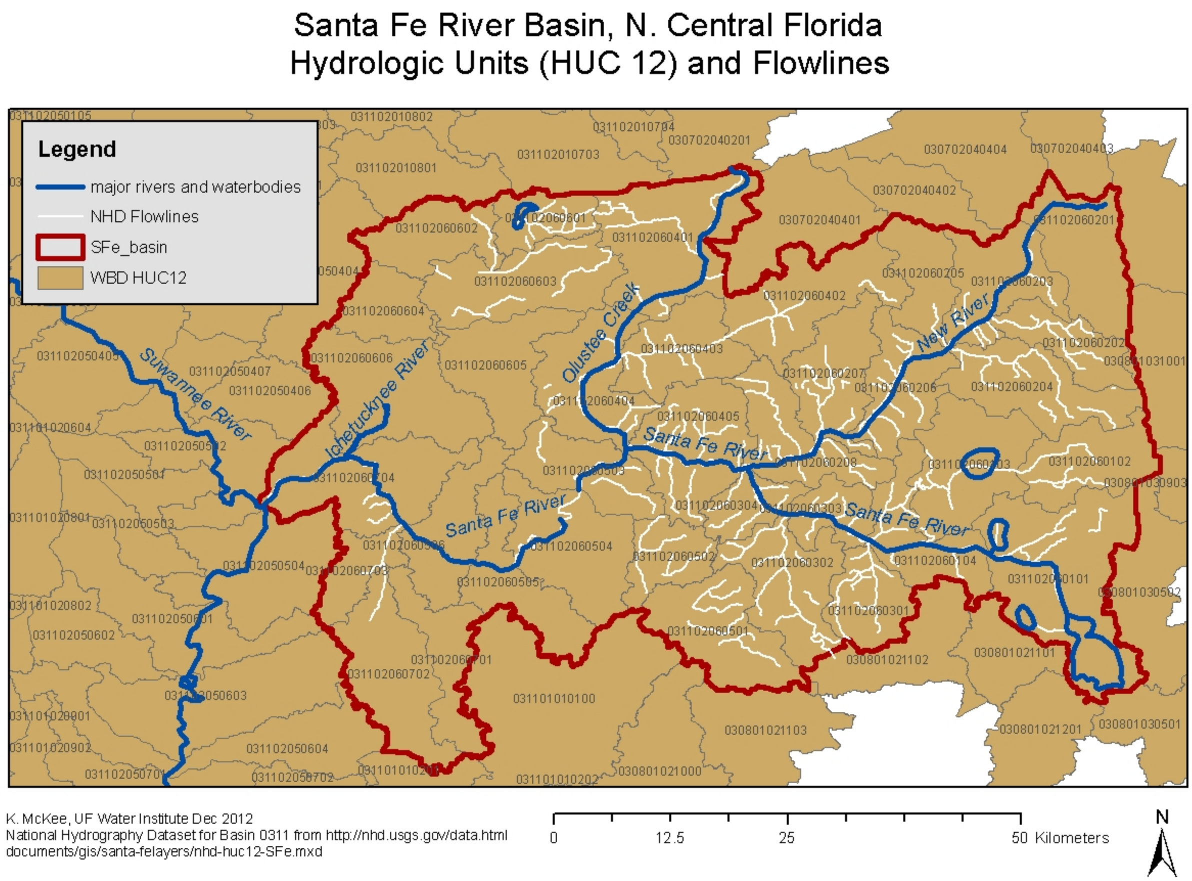

FIGURE 2-4 Comparable HUC 12 delineation for the Santa Fe river in Central Florida. SOURCE: McKee (2011).

In addition to considering a relatively coarse grid for the analysis, EPA considered that every acre of agricultural and urban land in a HUC10 contributes equally to in-stream loading. While it is likely that the characteristics of Florida's WBIDs in some regions, such as artificial drainage and highly transmissive soils, may lead to contributions from fields further away from the WBID than in other regions around the United States, the coarseness of the grid makes this assumption much less valid. While a robust analysis would require a full fate-and-transport calculation, an intermediate approach would have considered a distance/travel time weighting factor between the contributing croplands and the WBIDs. Using the more refined HUC12 delineation of subwatersheds would also reduce the error in these estimates of land areas that contribute to water quality degradation.

To estimate the urban areas, agricultural land, and septic systems that may need controls to attain the numeric nutrient criteria for springs, EPA obtained GIS data on land areas where groundwater aquifers supply water to springs (spring recharge areas or springsheds) from FDEP's Florida Geological Survey. EPA identified incrementally impaired spring recharge areas as those vulnerable to surface sources of contamination by the Florida Geological Survey Florida Aquifer Vulnerability Assessment (Arthur et al., 2007). The Committee has no concerns with this approach.

Determination of Incrementally Affected NPDES-Permitted Municipal and Industrial Sources

EPA made the conservative assumption that municipal and industrial wastewater point sources would be potentially affected by the NNC rule regardless of the impairment status of the WBID in which they are located. To determine the incremental effect of the NNC rule on these sources, EPA assumed that wastewater treatment plants (WWTPs) would be considered to be in compliance with the NNC rule if they could treat their discharges with advanced wastewater treatment (AWT) to reach 3 mg/L for TN and 0.1 mg/L for TP as annual averages. This level of performance was selected based on a judgment regarding demonstrated technology that has been used at sufficient scale and can be reasonably applied in Florida (see discussion below under the subsection entitled "Effectiveness of Control Methods"). These targets for WQBELs for all WWTP permittees assume some dilution and assimilation within the receiving waters to meet the numeric nutrient criteria at the point of compliance. Whether more stringent effluent limits will be required, approaching or in fact equaling the appropriate numeric nutrient criterion, is a matter of dispute and is discussed further in this chapter and in Chapter 3.

From the Committee's reading of EPA (2010), it appears that only municipal and industrial point sources that discharge to freshwater lakes and streams were considered in the analysis. Municipal and industrial point sources that discharge to groundwater via effluent spray fields or rapid infiltration basins were not considered, although they have the potential to lead to nitrate impairment in springs. For example, both Ichetucknee and Wakulla springs are suspected to be impacted by municipal wastewater effluent spray fields. Lake City's spray field disposes 3 MGD of wastewater effluent in the Ichetucknee springshed. The City of Tallahassee's municipal effluent sprayfield disposes of about 20 MGD in the Wakulla springshed. A more conservative analysis would have identified all municipal and industrial facilities with effluent sprayfields and rapid infiltration basins in incrementally impaired springsheds and assumed that some level of additional treatment might be required before disposal of their wastewater. Discussions with EPA indicated that they were aware of this possibility, but that available data did not allow them to unambiguously identify all relevant municipal dischargers that would affect springs (although the data suggested that the number of such dischargers and their capacity was relatively small). Thus, EPA judged that exclusion of these dischargers from the cost analysis would not materially affect the total cost estimate. The quantitative assessment on which this assumption was based was not presented by EPA, making it difficult to determine whether the assumption was reasonable, especially from a water quality (as opposed to a cost) standpoint.

A potential additional industrial cost could exist due to the large number of general permits utilized by Florida. A footnote on Page 2-15 of the EPA analysis states there are 34,508 dischargers covered under general permits in Florida and that EPA did not include those dischargers in the analysis. General permits are used to cover a common class of dischargers in a streamlined fashion with minimal cost to the permitting authority and the permittee. There is no further information regarding the classes of dischargers covered by the general permits. However, if any of those general permits relate to industrial facilities discharging nutrients, those facilities could potentially lose general permit coverage and be required to obtain individual permits. Compliance costs for holders of individual permits are generally higher than for general permits. A related uncertainty of this type arises with stormwater sources. At present, most of these sources are deemed to be outside the NPDES-regulated process where WQBELs apply. However, if this changes due to regulation or third party lawsuits *and* if the discharge limits that would result are more stringent under the NNC rule than under the narrative rule, then these sources could realize greater costs.

What is assumed about all these regulatory uncertainties has a direct influence on the cost estimates reported by EPA and others. Chapter 3 provides a discussion of the regulatory setting, and how to best incorporate regulatory and other uncertainties in a cost analysis. The sections that follow here focus on uncertainty related to unit costs and effectiveness of controls by sector.

SECTOR COST ASSESSMENTS

This review of the EPA economic analysis considered the following issues for each sector. First, the overall methods to determine costs were analyzed, focusing on the number of affected units and the per unit cost of treatment. For example, for the agricultural sector the review considers whether EPA estimated the affected agricultural acreage correctly and the costs of BMPs that would be needed for that acreage. Each section discusses the effectiveness of the proposed control methods, where appropriate. In doing so, the Committee used the numeric nutrient criteria as a threshold for to evaluating the efficacy of BMPs, in the absence of any other logical benchmark. Each section describes the relevant sources of uncertainty in the cost estimate, including variability in per unit costs, uncertainty in BMP performance, and regulatory behaviors. It should be noted that some of the uncertainties discussed are not unique to using numeric nutrient criteria (as opposed to narrative criteria); nonetheless, they are discussed here because of their potential effect on the cost estimate for a given sector. Finally, the results of other competing cost analyses are given and compared to those of EPA.

Municipal Wastewater Discharges

EPA estimated that \$22.3 to \$38.1 million/year would be the cost to municipal wastewater sources to comply with the proposed NNC rule in Florida. The EPA analysis assumed that municipal wastewater dischargers would be in compliance with the NNC rule if they could meet the definition of AWT as presented above (discharge limits of 3 mg/L for TN and 0.1 mg/L for TP as annual averages). It is important to note the use of an annual averaging period for TN and TP in EPA's cost estimate. Annual averaging means that seasonal variability in wastewater discharge pollutant concentrations is averaged out over the course of a year. There has been some effort at EPA to enforce average monthly and weekly permit limits based on interpretation of 40 CFR 122.45(d) requiring average monthly and weekly permit limits if "practicable". Monthly and weekly limits are not as applicable for pollutants such as TN and TP, which do not exhibit toxic effects, as they are for other pollutants typically regulated by NPDES permits and which exert their impacts over shorter timeframes than do TN and TP. However, if monthly and/or weekly permits were required for TN and TP, the cost of compliance would increase due to the need to build increased reliability into treatment plant design.

Methods to Determine Costs

EPA considered that every municipal WWTP had "reasonable potential" under the NNC rule, meaning that they might discharge pollutants at levels that would prevent associated receiving waters from achieving the numeric nutrient criteria. Thus, their analysis focused on determining whether existing plants had already installed removal technologies that could meet the targets of 3 mg/L for TN and 0.1 mg/L for TP as annual averages. When both TN and TP removal technologies were already installed at a particular WWTP, it was assumed that additional modifications were unnecessary and that no cost was associated with these facilities to comply with NNC rule. Likewise, when either TN or TP removal technology was installed, only the cost to install and operate technology to remove the alternate nutrient was attributed to these facilities. This approach is reasonable, as costs for nutrient removal capabilities already in place can be attributed to existing nutrient control requirements, not the proposed NNC rule.

Effectiveness of Control Measures

AWT technology, as defined by EPA, is an effective and proven approach to achieve the specified level of performance, 3 mg/L TN and 0.1 mg/L TP on an annual average basis. Effluent TP can be further lowered with similar chemical treatment technology, although at increasing cost. TN removal is limited for existing biological treatment technology by the presence of soluble, non-biodegradable organic nitrogen which remains in biological treatment effluents and is not removable using treatment approaches conventionally applied at municipal WWTPs. Soluble non-biodegradable organic nitrogen represents one component of the effluent TN and is present at a concentration which is generally in the 1 to 2 mg/L as N range, which is sufficiently high to prevent reliable compliance with TN effluent limits *below* about 3 mg/L.

Removal technologies such as RO and activated carbon either with or without advanced oxidation are available but are in various stages of development and have not been generally applied for this purpose in municipal applications. Microfiltration (MF) followed by RO has been proposed by some and has been implemented for potable quality reuse applications in Orange County, California, and other locations overseas.

In situations where treatment beyond AWT standards might be required, it is also possible that reuse of various types might be an attractive alternative. In fact, reuse is widely practiced in Florida to both augment water supplies and to limit direct surface water discharges (although reuse for irrigation can infiltrate surficial groundwater and indirectly discharge to lakes, streams, and springs).

These possibilities suggest that simply assuming that MF/RO will have to be applied to all municipal dischargers affected by the NNC rule, which is the position taken by the Florida Water Environment Association Utility Council (Carollo Engineers, 2010), is also not a reasonable assumption. In circumstances such as these, costs to municipal dischargers are often limited to established affordability criteria, which would represent one approach to estimate upper bound costs for this class of dischargers.

The footnotes to EPA's Exhibit 4-3 indicate that WWTPs with the MLE, A^2/O, or modified UCT processes[5], and oxidation ditches were considered to be able to comply with the 3

[5] MLE = Modified Ludzack-Ettinger; A^2/O = anaerobic-anoxic oxidation; and UCT = University of Cape Town.

mg/L TN limit; consequently, no costs for TN removal were attributed to them. However, evidence exists that MLE, A^2/O, and modified UCT processes are not able to reliably comply with a 3 mg/L TN effluent limit (Grady et al., 2011; WEF, 2009), such that further upgrade would likely be required for these facilities. Subsequent discussions with EPA made it clear that the footnotes were inaccurate, and that in all cases it was assumed that the four-stage or five-stage Bardenpho process was required to comply with the 3 mg/L TN limit.

Range of Unit Costs

Unit costs were applied to those NPDES-permitted facilities that were identified by EPA as needing upgrades to comply with AWT discharge requirements (see EPA, 2010a, Appendix C). EPA estimated the costs for a variety of nutrient control upgrades to existing WWTPs using a computerized cost estimating program called CAPDETWorks. Capital, operation and maintenance (O&M), and annual costs were determined and expressed on a unit cost basis ($/gpd of capacity). The detailed basis for their unit cost development is not presented in the economic analysis, but the results can be evaluated as outlined below.

A variety of upgrade approaches was assumed for the three types of required upgrades, including TN only, TP only, and TN and TP, as summarized in EPA's Exhibit 4-4. A reasonable range of technologies appears to have been assumed for the TP-only and TN-and-TP upgrade scenarios. The range of approaches was used to establish a range of upgrade costs for each category of reduction needed and are summarized in EPA's Exhibit 4-5.

As noted by EPA, numerous AWT facilities exist in the state of Florida. Logically the costs associated with these Florida-specific upgrades would provide the primary source of data to establish unit costs. Conversations with EPA indicated that efforts were made to compare their CAPDETWorks results with Florida-specific data, and this limited effort indicated that the CAPDETWorks data were consistent with Florida experience. As noted by EPA in these discussions, the costs specifically associated with nutrient upgrades must be segregated from other project costs when analyzing actual cost data. Alternate data were supplied by the Florida Water Environment Association Utility Council suggesting significantly higher AWT upgrade unit costs. This Committee is not in a position to determine which set of unit costs are correct, although as noted by EPA such data must segregate nutrient upgrade-related costs from other costs included in the subject projects. It does suggest, however, that direct examination of actual state of Florida AWT upgrade unit costs could resolve this matter. Collaboration between EPA and the Florida Water Environment Association Utility Council seems a prudent step forward.

Sources of Uncertainty

Two sources of uncertainty are potentially significant for this sector. The first relates to the unit treatment costs. Significant and relevant experience exists in the State of Florida concerning the costs required to upgrade municipal WWTPs to comply with AWT treatment requirements of 3 mg/L TN and 0.1 mg/L TP. This information could have been compared to the unit costs estimated using CAPDETWorks to determine whether the estimates developed using CAPDETWorks were of the proper order of magnitude. Data provided by the Florida

Water Environment Association Utility Council suggests that Florida-specific unit costs may be significantly greater than those based on CAPDETWorks and used by EPA in their analysis.

The second significant source of uncertainty is regulatory, specifically the proportion of WWTPs that would be required to treat to levels more stringent than 3 mg/L TN and 0.1 mg/L TP, perhaps approaching numeric nutrient criteria values in their discharge. EPA assumed that no WWTP would be required to treat to levels more stringent than AWT. While this assumption makes the analysis simpler to complete, it has been challenged by others, and the basis for those critiques is explained as follows (and explored further in Chapter 3).

Past experiences suggest that the "default" expectation for municipal WWTPs that are discharging to waters not meeting established ambient water quality criteria is for them to treat their effluent to levels equal to the established ambient water quality criteria. There is no reason to suppose this expectation to be different if numeric nutrient criteria are established. Nonetheless, EPA assumed that SSACs, variances, or use designation modification would be pursued and obtained. (Variances are a regulatory tool to temporarily waive the numeric nutrient criteria and they are typically used to relax point source permit limits while the point source accrues capital to make treatment upgrades.) However, even if approved, these decisions are subject to third-party law suits. Thus, it is reasonable to think that, in at least some instances, treatment to levels beyond the specified AWT performance standards would be required, resulting in greater cost.

As noted above, treatment technologies to achieve end-of-pipe compliance with the numeric nutrient criteria are not well developed and demonstrated, suggesting that significant advances in technology would be required before this becomes an option for municipal dischargers to reliably pursue. Also, past experience suggests that pursuing SSAC, variances, and use designation modifications can be a long and expensive process with little certainty of a successful outcome. Developing alternate effluent management options such as reuse has been successfully pursued in Florida, but this requires time as they must achieve public acceptance and must be integrated into an overall water supply and management strategy for the community. Furthermore, one must consider the possible indirect movement of enriched reuse water through the subsurface to receiving waterbodies.

Other Analyses

An alternate analysis of the costs associated with municipal wastewater discharges complying with the NNC rule was developed for the Florida Water Environment Association Utility Council (FWEAUC) by Carollo Engineers (2010). Carollo's estimate was significantly higher than EPA's for several reasons:

- 85 municipal WWTPs were included in the EPA analysis, while 110 were included in the Carollo analysis.
- The unit costs for upgrading WWTPs to AWT used by Carollo were significantly higher than those used by EPA.
- Carollo assumed that municipal WWTPs would need to meet the numeric nutrient criteria at the "end-of-pipe" and thus assumed that microfiltration and reverse osmosis (MF/RO) along with brine processing would be needed for all municipal WWTPs. In contrast, EPA assumed that municipal WWTPs would not need to meet numeric nutrient criteria at the "end of pipe," but rather the targets of 3 mg/L for TN and 0.1 mg/L for TP as annual

averages. Clearly a more thorough analysis than either of these would indicate that some, but not all, plants included in this evaluation would be required to upgrade to effluent limits more stringent than 3 mg/L for TN and 0.1 mg/L for TP. Efforts could, and should, have been made by both parties to estimate the proportion of plants for which this would be the case.

- Because of their assumption about the needed technology, and in some cases the unit costs, the overall costs estimated by Carollo were significantly higher than those of EPA.

Industrial Facilities

EPA estimated that $25.4 million/year would be the cost to industrial wastewater sources to comply with the proposed NNC rule in Florida. The agency identified 108 industrial dischargers that would have the potential to be affected by the NNC rule by assuming that any dischargers with a Standard Industrial Classification (SIC) that matched those of another plant with either existing numeric effluents limits for nutrients or a monitoring requirement for nutrients would have similar potential. The potentially affected industrial dischargers represented six major industrial categories and 29 different SIC codes. The 108 was winnowed down by eliminating 38 plants that have a Waste Load Allocation (WLA) under the existing TMDL program. As with municipal WWTPs, EPA assumed that site-specific alternative criteria would be granted to those dischargers. EPA also found that 14 of the 108 plants discharge to waters already deemed impaired, and thus did not include these plants in their analysis, resulting in 56 remaining plants.

Methods to Determine Costs

For the 56 industrial plants, EPA estimated implementation costs by reviewing design and performance data from 12 “representative” plants gleaned from the permit compliance system. For each industrial category, EPA calculated the average treatment unit cost per MGD of flow treated by dividing the total cost for the representative facility by the total flow of that facility. EPA then multiplied the average unit cost by the total flow reported in the permit compliance system for each of the potentially affected facilities in the applicable category. For example, ten mining industrial discharges were evaluated. Two of the ten were sampled to develop a cost per MGD of treated discharge, and these numbers were then multiplied by the total flow of all ten plants to determine the total cost to this industrial category (about $16 million). The average unit cost, in $/MGD/year, depended on (1) the nutrient concentration in the discharge of the representative plant and how those concentrations compared to the targets of 3 mg/L N and 0.1 mg/L P, (2) the combined flows within the sampled industrial category, and (3) the annualized cost of the technology chosen to treat those discharges. For example, the Packaging Corporation of America was chosen as the representative plant for the pulp and paper category. That plant was determined to only need P reductions to meet the targets, and chemical addition and filtration were the chosen technologies.

Limiting the total industry sample size to 12 restricted the primary data (principally flow) from which EPA established unit costs and overall industrial point source cost estimates. Given the diversity of industries and the variability of their operations and discharges, use of the broader resource database that is available under the permit compliance system would have been useful for establishing more accurate cost estimates for the individual industries. It is not clear why EPA did not conduct the analysis for all 56 plants. Note that in many cases Basin Management Action Plans (BMAP) for existing TMDLs may also provide a broad resource for nutrient control cost estimates for both point and nonpoint sources.

Additional effort should be put into estimating the costs and impacts of the significant dischargers. There are 29 phosphate rock major dischargers (SIC 1475) and 13 phosphate fertilizer majors and 17 minors (SIC 2874)**,** as per Exhibit 2-3 of EPA's economic analysis report. Excluding wastewater treatment plants, this is half of the major facilities determined by EPA to have nutrient effluent limits or having nutrient monitoring requirements and, according to Exhibit 5-3, constitutes 65 percent of the total industrial cost and 8.5 percent of the total affected flow. However, a single facility (Mosaic Fertilizer) was used for the entire cost estimate for this industrial category with an average flow of 5.24 MGD. Ultimately Mosaic Fertilizer, with a flow contribution of less than 0.44 percent of the total industrial flow, exerted a hugely disproportionate bearing on the final industrial cost figure.

In the industrial analysis (Appendix D of EPA, 2010a), it was suggested that end-of-pipe effluent limits should be based on the assimilative capacity of the receiving stream (see examples for Pilgrim's Pride, the Packaging Corporation of America, and St. Mark's Powder). It is unclear if or how assimilative capacity was accounted for in the unit cost development; it should only be considered on a site-specific basis and not toward broad industrial sector cost estimation.

Effectiveness of Control Measures

The issues discussed previously for the municipal wastewater discharges also apply to industrial wastewater discharges.

Range of Unit Costs

EPA used the same nutrient control unit cost data established for municipal wastewater treatment to estimate industrial treatment costs (Exhibit 4-4). The principal problem with applying the Exhibit 4-4 data to industrial wastewater treatment costs is the 10 MGD flow basis used to establish the unit costs. Industrial wastewater flow rates tend to be much less than 10 MGD, generally in the 1 MGD or smaller range, such that unit costs tend to be higher and highly variable. For example, in Utah's 2009 nutrient cost study (CH2M Hill, 2010), unit costs to upgrade 1 MGD plants for P removal only to an effluent concentration of 0.1 mg/L had an average unit cost of about $3.50 per gallon per day design capacity with a range of about $0.50 to $4 per gallon per day design capacity. Above 10 MGD, the average unit cost was about $2 per gallon per day design capacity and the range narrowed to about $1.50 to $2.50 per gallon per day design capacity. EPA's unit costs for treatment were generally about $1 per gallon per day design capacity, significantly lower than the unit cost in the Utah study.

EPA's cost estimate to add chemical addition and filters for the 55 MGD Packaging Corporation of America was $17.7 million, which is low compared to the Utah nutrient cost study (CH2M Hill, 2010), where costs to implement similar improvements at five municipal facilities of comparable size ranged from $55 to $110 million.

Sources of Uncertainty[6]

Industrial wastewater treatment cost estimates did not take into account nutrient loadings, which can be considerably more variable and dynamic in industrial treatment facilities than in municipal wastewater treatment facilities. Differences in nutrient loading, even within an industrial category, are extremely difficult to characterize at this level of analysis. One simple way of establishing a safety factor to account for industrial discharger load variations would be to estimate the requirements for flow attenuation via equalization and include this in the cost model. EPA recognized that representative discharger Mosaic Fertilizer (Appendix D) had highly variable flows, but it specifically excluded equalization costs from the cost estimate for this industry.

As suggested above, there is considerable uncertainty in sampling only a subset of the industries that would be affected by the NNC rule and using it to derive the cost estimate. For the Chemical and Allied Products category, Mosaic Fertilizer's flow contribution towards the total flow of the two samples in that sector was 95 percent [13.9 MGD/14.69 MGD] but no nutrient removal cost was determined to be necessary at that facility; only for St. Marks Powder, Inc. ($206,800/year). Yet the latter's flow contribution was only 0.79 MGD. Thus the average unit cost for that sector was estimated to be $14,077 [($206,800 + $0)/(0.79 MGD + 13.9 MGD)]. This figure is skewed considerably lower due to using the cost figure from St. Marks Powder but the combined flow from both facilities. Had the average unit cost been determined using solely the cost and flow elements from St. Marks Powder, the average unit cost for that sector would have increased nearly twenty fold to $261,772 [$206,800/0.79 MGD] and the resulting total annual sector cost would have been approximately $20,760,000, not $1,116,800. On the other hand, some 34 percent of industrial dischargers reported no flows in the permit compliance system. Averaging within the category and discharge type was conducted, which tended to bias the costs high, particularly for the major discharger type. EPA should more carefully consider how the total annual sector costs may be skewed either higher or lower due to cost or flow elements of a small number of individual sector facilities.

In its random selection of "representative" dischargers, the Anguila Fish Farm was not included by EPA. The flows from this fish farm constitute one-third of the food sector's flows. It is not unreasonable to assume that a fish farm may need to remove significant amounts of phosphorus and nitrogen to achieve the numeric nutrient criteria. Thus, not including this single facility in the sector sample may have significantly underestimated the total annual cost for the food sector.

Other Analyses

Several alternate cost analyses, of varying detail, were performed to estimate industry costs to meet EPA's numeric nutrient criteria including Environ International Corp. (EIC), on behalf of the Florida Phosphate Industry; Cardno ENTRIX, on behalf of the Florida Water Quality Coalition; and FDEP. These cost estimates were significantly higher than EPA's estimate of $25.4 million/year because EPA underestimated both the capital and O&M costs to meet the numeric nutrient criteria, while the other stakeholders overestimated the costs by

[6] The same NPDES regulatory uncertainty that was described for the municipal sources applies here as well.

making very conservative assumptions about the technology that would need to be employed and the number of facilities that would need to be upgraded.

EIC's analysis was limited to the phosphate industry. Its analysis considered treatment endpoints of 1.479 mg/l for TN and 0.359 mg/l for TP and included the cost of treatment for both process water *and* stormwater. On the other hand, EPA considered treatment endpoints of 3.0 mg/l for TN and 0.1 mg/l for TP and evaluated only industries which have either numeric effluent limits and/or monitoring requirements for TN and TP. EIC's cost estimate was $1.6 billion in capital costs and $59 million/year for O&M which, when combined, equates to an annualized cost of $163.1 million/year (this figure was not presented in its report but rather was calculated, for comparison purposes, assuming a 30-year payment period and 5% PVDR).

In the Cardno ENTRIX cost estimate, mean annual costs for industrial discharges were calculated to be $1.97 billion to meet EPA's numeric nutrient criteria at the "end-of-pipe," or just $270 million/year for those plants in newly impaired areas to reach the less stringent goal of "limits of technology" treatment. Cardno ENTRIX applied a 25 percent contingency factor to its estimated cost of compliance, which inflated the results.

FDEP's cost analysis assumed reverse osmosis, a costly treatment alternative, rather than biological nutrient removal and chemical precipitation. A second difference is that EPA assumed a 20-year payment period and FDEP assumed a 30-year payment period. Thus, FDEP estimated the cost of implementing EPA's numeric nutrient criteria for industrial plants to be $2.1 billion/year.

Urban Stormwater

In the EPA analysis of costs, the urban stormwater sector was the most expensive, accounting for approximately 50 percent of the total costs (EPA, 2010a, p. 11-1). To calculate this cost, EPA determined the land areas thought to be incrementally impaired under the NNC rule and then, based on GIS data, estimated the acreage of urban land that would contribute to a potential impairment.

Methods to Determine Costs

Some of the challenges to estimating urban stormwater costs for compliance with the NNC rule are related to the amount of urban land that drains to incrementally impaired waters, the type of urban development, and the historical timeline of that development. First, EPA considered that any area urbanized after 1982 would comply 100 percent with FDEP's existing Stormwater Rule (Florida Administrative Code Chapter 62-40.432). This Rule states that stormwater management systems must "achieve at least 80 percent reduction of the annual average load of pollutants that would cause or contribute to violations of state water quality standards;" the requirement for "Outstanding Florida Waters" is 95 percent. Any pollutant that can cause impairment to state waters, including N and P, falls under this standard (EPA, 2010a). Thus, EPA excluded from its analysis all land developed after 1982, which comprised 28 percent of the urban areas in Florida. In doing so, they assumed that stormwater control measures (SCMs) designed according to the required state criteria are in compliance with the 80 percent reduction standard.

Second, EPA assumed that all low-density residential areas would fully comply with the existing Urban Turf Fertilizer Rule, and thus should be excluded from the analysis. Because low density residential areas represent 58 percent of Phase II MS4 urban areas and 65 percent of non-MS4 urban land, another significant fraction of the acreage was taken out of consideration. Scientifically, it is not possible to know the impact of this Rule on meeting the numeric nutrient criteria. Nutrient prevention programs are notoriously difficult to quantify, especially when stormwater nutrient concentrations rather than load reductions are sought.

The Phase I MS4 permitting program requires municipalities of greater than 100,000 to reduce their stormwater discharges to the maximum extent practicable by a variety of measures (NRC, 2009). Given the qualitative nature of the Phase I MS4 permitting program, EPA was unsure about whether the acreage covered under that program should be considered to be already complying with the NNC rule. To address this uncertainty, EPA used a range in affected land area from the assumption of no Phase I MS4 areas to the assumption all Phase I MS4s, and this range was propagated through the entire cost analysis.

While it is true that if these existing state rules were fully implemented the nutrient contributions from these areas would be much lower, possibly leading to attainment of the numeric nutrient criteria in the corresponding waters, a more robust analysis would assume a certain level of non-compliance. The urban areas that may require additional expenditures to meet the numeric nutrient criteria may thus be significantly greater than the 23 to 41 percent estimated by EPA. On the other hand, it is also unlikely that 100 percent of urban areas would be affected due to the new NNC rule, in part because stormwater control measures (SCMs) have already been implemented in many urban areas (especially Phase 1 MS4s), and in part because not all urban areas contribute equally to the loading of nutrients to potential incrementally impaired waters. The use of the more refined HUC12 delineation of sub watersheds would improve the estimates of the contributing areas.

Although EPA acknowledges that urban runoff can be a significant source of nutrient pollution to Florida springs, they assume that "efficient land application of nitrogen" will be an effective means of addressing nutrients from urban runoff and cite the Urban Turf Fertilizer Rule, city- or county-wide fertilizer ordinances, and public outreach and education campaigns as good examples of such nutrient source control efforts. Thus, EPA assumed that implementation of existing requirements would be sufficient to reduce nitrate-nitrite loads to springs from urban stormwater enough to achieve compliance with the 0.35 mg/L NO_3-N criteria. Unfortunately, there is little empirical evidence that the nutrient source control efforts cited above will reduce nitrate from urban runoff/infiltration in springsheds to levels which (when combined with nonpoint source nitrate from agricultural land uses in the springshed) will achieve less than 0.35 mg/L in springs.

Effectiveness of Control Measures

The efficiencies of SCMs vary widely depending on their type, design, placement, and age. Correspondingly, the costs of implementing SCMs to manage urban areas in Florida will vary widely on a per-acre basis. Whether the SCMs proposed in EPA (2010) will be sufficient to comply with the NNC rule is evaluated by considering the quality of urban stormwater and what is known about the effectiveness of SCMs in Florida.

Florida Urban Water Quality. A detailed report on urban stormwater in Florida was completed in 2007 for the FDEP (ERD, 2007). This document provides a wealth of information relevant to Florida stormwater quality and treatment. Detailed evaluation of water quality for N and P was presented for six types of urban land use (along with other land uses). Urban stormwater pollutant concentrations typically vary by more than an order of magnitude from storm to storm and tend to be log-distributed (NRC, 2009). Average concentrations of N and P runoff discharge in Florida from urban land uses are presented in Table 2-1.

All nutrient concentrations listed in Table 2-1 are means, taken from various Florida research studies. The variability in these concentrations, presented as the standard deviation, was calculated from the mean for each individual study evaluated in the report, and is relatively high, on the order of 50 percent of the mean value. Although unlikely, it is possible that all land use sectors would be required to directly meet the numeric nutrient criteria in their discharges (see subsequent section on agriculture). The proposed numeric nutrient criteria range from 0.5 to 1.87 mg/L TN and from 0.01 to 0.49 mg/L TP, depending upon waterbody type and region. As demonstrated in Table 2-1, the urban runoff means for TN ranges from about equal to several times higher than the numeric nutrient criteria. For P, the runoff is generally about 3 to 16 times greater than the proposed numeric nutrient criteria.

Stormwater Control Measures. The science and engineering of understanding SCM performances is still in its infancy. Specific performance of SCMs for pollutant removals are notoriously difficult to quantify due to variations in design, configuration, drainage area land use, climate and weather, and surrounding hydrogeology. As a result, from a regulatory perspective, urban stormwater control technologies have long been used and operated in a "narrative" mode with performance inferred based only on compliance to designing technologies based on specific requirements. Most states do this, including Florida. Jurisdictional legislation requires a percent

TABLE 2-1 Average ± Standard Deviation Nitrogen and Phosphorus Concentrations in Runoff from Various Land Uses in Florida

Urban Land Use Category	Mean Runoff Concentration (mg/L)					
	Total N	80% N Reduction	25% N Reduction	Total P	80% P Reduction	65% P Reduction
Single-Family	2.07±1.02	0.41	1.55	0.327±0.126	0.065	0.114
Multi-Family	2.32±1.24	0.46	1.74	0.520±0.017	0.104	0.182
Low Intensity Commercial	1.13±0.045	0.24	0.89	0.188±0.064	0.036	0.063
High Intensity Commercial	2.40±1.03	0.48	1.80	0.345±0.329	0.069	0.121
Light Industrial	1.20±0.015	0.24	0.90	0.260±0.178	0.052	0.091
Highway	1.64±0.85	0.33	1.23	0.220±0.146	0.044	0.077

SOURCE: ERD (2007, pg 4-12, 4-15, 4-16, 4-17, 4-18, 4-19).
Standard Deviations calculated from data in ERD (2007).

reduction of a specific pollutant (e.g., 80 percent removal), but does not specify required numeric pollutant concentrations. Because of the variability of natural wet weather events, the use of percent removal to describe SCM performance is scientifically weak, and performance summaries based on percent removal exhibit high variability. Use of percent removal, however, is prevalent and the science to move to another metric is not yet mature.

Both national and local databases have been created for quantitative monitoring studies of urban SCMs. In many cases, the data sets remain small. In all cases, the data are highly variable. Different rainfall events will have variable stormwater runoff water quality due to land activities, climate, antecedent dry period, and other parameters that remain poorly understood. Small, short duration storms may be treated effectively and discharge low pollutant concentrations, or even produce no discharge at all. However, large events will result in short effective treatment times and resulting poor performance.

In Florida, variability in urban runoff quality and SCM performance is expected geographically throughout the state (ERD, 2007). Most of this is due to variability in annual rainfall (Figure 1-4), which averages from about 38 to 66 inches per year. Higher areas of rainfall require more expensive treatment, or treatment will be less effective. More runoff is expected in the panhandle than in other parts of the state because of the higher annual rainfall, requiring greater investment in treatment. Note from EPA Exhibit 3-2 that this region has the most stringent numeric nutrient criteria.

Feasibility of Achieving the Numeric Criteria. Table 2-1 indicates that a reduction of 80 percent in the N concentration, which is required by the Florida stormwater regulations, would *on average* reduce the N concentration below the proposed numeric nutrient criteria. An 80 percent reduction of the average P concentration would not comply with the numeric nutrient criteria for all regions. (While this simple analysis has disputed scientific support, it is currently the best tool available for an analysis such as this.) Because of the log-distribution of runoff concentrations and treated SCM discharges, meeting specific concentration criteria for urban stormwater runoff would need to be evaluated on the basis on probability and exceedence distributions.

A large amount of evidence is available to suggest that 80 percent removal of pollutants, including P, is difficult to meet with current SCM technology. EPA (2010) acknowledges the wide range of pollutant removal efficiencies expected for SCMs (5 to 85 percent, p.7-2). The EPA report assumes that 50 percent N and P reduction would result in nutrient reduction necessary to meet proposed numeric nutrient criteria, but Table 2-1 suggests that this is not the case. The recent FDEP evaluation of commonly used Florida SCMs (ERD, 2007) suggests that wet ponds can accomplish a 65 percent annual mass removal for total P and 25 percent removal of TN. A recent NRC report on urban stormwater indicates 45 percent removal for TP and 20 percent removal for TN for wet ponds and wetlands (NRC, 2009). For dry retention, Florida estimates about 53-63 percent P removal; NRC reports 10-20 percent P removal for dry ponds. The differences in dry retention pond performances are primarily due to expected greater infiltration in Florida soils. Table 2-1 shows that these treatment efficiencies are mostly inadequate for reaching the proposed numeric nutrient criteria.

A removal performance of greater than 93 percent for TP and from 58 to 80 percent for TN would be necessary to meet the most stringent numeric nutrient criteria. Traditional technologies may not be available to consistently meet these criteria. Greater probability of meeting these higher treatment efficiencies could likely be obtained through the use of more advanced SCMs, such as bioretention (up to 80 percent removal of TN and 85 percent removal of TP in high-infiltration soils) or other vegetated infiltration practices (NRC, 2009), which may be more costly than the per-acre costs populating the existing FDEP database.

Range of Unit Costs

The range of costs for stormwater SCMs varies greatly because of the differing value of urban lands, the difficulties of construction in (sub)urban areas, and different technologies employed as the SCM. Currently, SCMs used in Florida are predominantly detention and retention ponds (personal communication, Eric Livingston, FDEP; ERD, 2007).

A small but valuable database on costs for stormwater control is held by FDEP and was used in the EPA analysis. Costs for 40 projects were evaluated; more than half were wet detention ponds, followed by dry ponds. The mean is $12,570 per acre, with a standard deviation of $14,509 per acre. The median is $6,836 per acre, which is the fixed value used in the EPA analysis. (The 10 and 90 percentiles are $863 and $34,350 per acre, demonstrating the large variability in unit costs.)

Traditional SCMs like detention and retention ponds may not be able to meet the numeric nutrient criteria themselves, such that urban retrofit of other technologies may be necessary. New and evolving technologies may be able to provide better performance for N and P removal. Such filtration and infiltration SCMs can have significantly greater per-area costs than traditional pond and storage systems (Weiss et al., 2007). A recent article has quoted costs between $125,000 and $200,000 per impervious acre for urban retrofit in the Washington, DC suburbs in attempts to meet more stringent Chesapeake Bay water quality criteria (Medina and Curtis, 2011). In retrofit situations, costs for land acquisition must also be included and could be significant in urban areas.

Sources of Uncertainty

The focus of uncertainty in the EPA report was entirely based on the area of land impacted. While this uncertainty is real, it may not be the only or largest uncertainty in the stormwater analysis, especially when one considers the inherent variability of rainfall and pollutant accumulations on the landscape, in conjunction with variable SCM treatment performance. There are several sources of uncertainty other than the one EPA addressed.

With respect to the land area considered, EPA appropriately considered the urban land area developed prior to the 1982 stormwater regulations separately from land developed later. An uncertainty, however, is the extent to which land developed after 1982 is actually complying with the required 80 percent reduction of N and P; as discussed already, recent studies indicate that much poorer performance has been measured (along with a significant degree of variability). In addition, new stormwater regulations are anticipated in the next few years that are expected to provide greater environmental protection. Gathering information on regulatory compliance and SCM longevity and maintenance [all of which can be poor (NRC, 2009)] would provide another layer of detail to the cost analysis.

As noted earlier, the unit area costs for urban SCMs have a very large range. The EPA analysis selected only the median value from the FDEP database. Unit costs will vary widely depending on the technology selected, on the cost of the land being used for the SCM, and other factors. This cost category is expected to be the greatest uncertainty in the stormwater analysis. Interestingly, the EPA analysis used unit cost variability as a prime uncertainty metric for other sectors, such as agriculture, but did not carry this methodology to the urban sector. In analyzing the other sectors, the land area or unit was always fixed by EPA and the variability was captured in the unit cost.

Finally, refining the cost analysis geographically (by considering rainfall distributions), based on the type of urban development and by regional numeric nutrient criteria, would reduce uncertainty.

Other Analyses

Two stakeholder reports with cost estimates for urban stormwater were made available to the Committee, one by the Florida Department of Environmental Protection and the other by Cardno ENTRIX (which included a 2011 Addendum). A simple summary of the differences among the reports is provided in Table 2-2. The large difference between costs results from the land area assumed to require stormwater management. The land areas used by FDEP and the Cardno ENTRIX EOP scenario incorrectly include all urban area developed before 1982. These two analyses do not limit their focus to incrementally affected areas. The Cardno ENTRIX BMP/LOT scenario and EPA appropriately used estimates of the incrementally affected urban area only.

TABLE 2-2 Comparison of Urban Stormwater Costs for the EPA Analysis and Two Others.

Cost Analysis	Approximate Affected Acres (thousands)	Approximate Cost per Affected Acre	Approximate Total Capital Costs (M)	Estimated O&M	Approximate Annual Cost (M)
EPA	61.3–109.4	$6,800	$419–$748	5%	$61–$108
Cardno ENTRIX BMP/LOT scenario	180	$5,120	$922	5%	$61
Cardno ENTRIX EOP scenario	1,878	$5,120	$9,620	5%	$630
FDEP	2,344	$7,295	$17,100	5%	$1,967

BMP/LOT scenario entails Best Management Practices for diffuse sources and the Limits of Technology for point sources. EOP scenario assumes that both point and diffuse sources would be required to meet the numeric nutrient criteria at the end-of-pipe or edge-of-field.

Agriculture

Agricultural nonpoint sources known to cause nutrient pollution to nearby waterways (as identified in Florida TMDL studies) include animal livestock (dairy, cow/calf pastures, poultry), citrus, vegetable, and sod farms. For years, BMPs have been developed and implemented for agricultural activities to reduce nutrient discharges to nearby waterbodies. A BMP is defined as a practice or combination of practices that is technologically and economically effective in reducing pollutant loads generated by nonpoint sources to a level that meets water quality goals (Mulla et al., 2008)[7]. Typically, a BMP reduces pollutant loads while maintaining agricultural productivity and being economically feasible to adopt. Adoption of agricultural BMPs is voluntary in Florida. Agricultural BMPs have been adopted on over 3 million acres of agricultural land in Florida (FDACS Office of Water Policy, 2011a).

Methods to Determine Costs

In addressing agriculture, EPA (2010) acknowledges that Florida's implementation of the NNC rule may result in additional BMP requirements to control agricultural nonpoint nutrient sources. A primary assumption made by EPA is that the BMPs for agricultural nutrients detailed in the Florida Department of Agriculture and Consumer Services' (FDACS) BMP manuals will reduce agriculture's contribution to the problem sufficiently to meet the NNC rule when combined with other source control strategies.

EPA estimated the incremental cost of new agricultural BMPs only for those agricultural lands in "incrementally impaired watersheds"—some 805,793 acres (as estimated by EPA) of the 13+ million acres in agriculture throughout the state (EPA, 2010a, p. 8-1). EPA also estimated that there is an additional 1.1 million acres of crop or specialty agriculture that would be required to adopt nutrient management BMPs to attain EPA's numeric nutrient criteria for springs. In terms of the per acre costs, EPA recognized three levels of activities that agricultural producers might undertake to make nutrient reductions: the "owner" program which would likely be adopted without compensation, the "typical" program which would include government or NGO incentives or cost sharing, and the "alternative" program which would be more aggressive and costly (and also involve cost sharing). In their analysis EPA assumed that implementing "owner" and "typical" BMPs on all agricultural acres in the incrementally impaired watersheds and springsheds would be sufficient. The BMP cost estimates of "owner" and "typical" BMPs were taken from SWET (2008a).

[7] Florida defines BMPs as cost-effective and practicable management actions for improving water quality and water conservation, developed through research, field testing, and expert review. They can be structural (e.g., fencing, stormwater ponds) or nonstructural (e.g., managing fertilization and irrigation rates), and may be developed for both urban and agricultural use. Agricultural BMPs focus on managing inputs (fertilizer, water, pesticides, herbicides) to provide for economic, environmental and agronomic efficiency in production agriculture. SOURCE: FDACS (2011b).

Effectiveness of Control Measures

BMP effectiveness can be evaluated through a variety of techniques, including water quality trend monitoring and analysis, plot or farm-scale evaluations, paired watershed studies, or watershed modeling (Mulla et al., 2008). Each of these approaches has strengths and weaknesses. Many farm-scale BMP field studies suffer from (1) a lack of replication; (2) spatial heterogeneity in crop management, crop productivity, soils and aquifer properties; (3) year-to-year climate variability; and (4) budget constraints that limit the spatial extent and temporal duration of sampling and thus confound rigorous statistical analysis. Nevertheless these studies can provide representative examples of surface and groundwater nutrient concentrations measured on farms.

Table 2-3 summarizes some representative water quality measurements from farm-scale BMP studies in Florida. In general these measurements represent on-farm measured or modeled water quality *after* BMP implementation. In almost all cases the studies indicate that on-farm surface and groundwater samples significantly exceed the EPA numeric nutrient criteria. (As a point of reference in reviewing Table 2-3, the numeric nutrient criteria range from 0.5-1.27 mg/l TN and 0.011-0.050 mg/l TP for lakes, 0.67-1.87 mg/l TN and 0.06-0.49 mg/l TP for flowing waters, and 0.35 mg/l NO_3+NO_2-N for springs.) These data, along with experience in ongoing efforts to reduce nutrient loads to the Everglades and Lake Okeechobee (see Box 2-1), Lake Apopka (Bachmann et al., 1999), and the Lower St. Johns River Basin (FDEP, 2008a), do not support the EPA's assumption that typical "owner" implemented on-farm BMPs will achieve the proposed numeric nutrient criteria. Rather, Table 2-3 suggests that treatment measures beyond typical on-farm BMPs will be required to achieve the proposed numeric nutrient criteria. This is further supported by a recent assessment of BMP costs and impacts on water quality in the Caloosahatchee River and St. Lucie River watersheds in Florida (SWET, 2008a). Discussed extensively in the next section with regard to costs, information on BMP effectiveness in SWET (2008a) suggests that the percent reduction in nutrient concentration typically required in a Florida TMDL could not be achieved by the implementation of "owner," "typical," or "alternative" BMPs (see Table 2-4).

TABLE 2-3 Representative Water Quality Measurements and Model Predictions from Farm-Scale BMP studies in Florida.

Crop	Range of measured [N] (mg/l)	Range of measured [P] (mg/l)	Situation	Reference
Central Florida Ridge Citrus (Groundwater)	4.6-14.0 mg/l NO_3-N	NA	Measured Post-Nutrient and Irrigation Management BMPs	Lamb et al., 1999
Central Florida Ridge Citrus (Groundwater)	3-8 mg/l NO_3-N	NA	Modeled Post-Nutrient and Irrigation Management BMPs	Harrison et al., 1999
Central Florida Flatwoods Citrus (Groundwater)	0.01-0.07 mg/l NO_3-N	NA	Measured Post-Nutrient and Irrigation Management BMPs	Lamb et al., 1999
Okeechobee Basin Cow-Calf (SW)	2.39-4.26 mg/l TN	0.94-2.25 mg/l TP	Measured Post-ditch fencing and wetland water retention BMPs	Shukla et al., 2011a,b
Okeechobee Basin Cow-Calf Improved Summer Pastures (SW)	3.35-3.9 mg/l TKN	0.58-0.69 mg/l TP	Measured over range of stocking densities	Capece et al., 2007
Okeechobee Basin Cow-Calf semi-improved winter Pastures (SW)	3.16-3.88 mg/l TKN	0.11-0.19 mg/l TP	Measured over range of stocking densities	Capece et al., 2007
Suwannee River Basin Row Crops (Groundwater)	23.2-26.5 mg/l NO_3-N	NA	Measured Post-Nutrient and Irrigation Management BMPs	Graetz et al., 2008
Suwannee River Basin Dairy (Groundwater)	0.8-159.5 mg/l NO_3-N 0.01-81.44 mg/l NH_4-N	0.04-8.45 □μg/l SRP	Measured over range of land uses with Dairy Farm	Graetz et al., 2008
Suwannee River Basin Poultry (Groundwater)	1.6-19.2 mg/l NO_3-N 0.01-0.09 mg/l NH_4-N	0.01-0.09 μg/l SRP	Measured over range of land uses with Poultry Farm	Graetz et al., 2008
Sugarcane Everglades Agricultural Area (SW)	NA	0.044-0.170 mg/l TP	Measured Post-Nutrient and Water Management BMPs	Daroub et al., 2011
Mixed Sugarcane and vegetables Everglades Agricultural Area (SW)	NA	0.101-0.165 mg/l TP	Measured Post-Nutrient and Water Management BMPs	Daroub et al., 2011
TriCounty Agricultural Area Row Crops Lower St Johns River Basin. (SW)	1-30 mg/l TN	1-14 mg/l TP	Measured Post-Nutrient and Water Management BMPs	Livingston-Way et al., 2001
TriCounty Agricultural Area Row Crops, Lower St. Johns River Basin (SW)	4-15 mg/l TN	0.36-0.99 mg/l TP	Modeled Post-Nutrient and Water Management BMPs	Livingston-Way et al., 2001

NA = not applicable; SW = surface water; SRP = soluble reactive phosphorus

Box 2-1

Case Studies of Water Quality Improvements Resulting from Implementation of Agricultural BMPs in Florida

In 1987, the Surface Water Improvement and Management (SWIM) Act was passed by the Florida Legislature as a framework for protecting and restoring Florida waters. Its primary focus at the time was the restoration of Lake Okeechobee, which is upstream of the Everglades National Park. On the northern side of Lake Okeechobee, the primary source of TP to the lake at that time was dairy operations (Bottcher et al., 1995). The primary BMPs for controlling this source of pollution are (1) collection, pumping, and treatment of drainage waters from High Intensity Areas of grazing to adjacent cropland (60-95% reduction in TP concentrations at a cost of $15 to $40/lb of P; SWET, 2008b), and (2) collection and land application of barnyard manure on adjacent cropland based on soil testing (10-90% reduction in TP). Implementation of diary BMPs on half the land in Taylor Creek, a tributary to Lake Okeechobee, was started in 1981. By 1991, these BMPs produced an 84% reduction in TP concentrations and a 40% reduction in TP loads discharged to Lake Okeechobee from this tributary (Anderson and Flaig, 1995). Additional measures required to further reduce TP loads included construction of a 30,000 ac-ft. reservoir to intercept and treat discharge from Taylor Creek (EPA, 2008).

South of Lake Okeechobee is the 700,000 ac Everglades Agricultural Area (EAA). An extensive series of agricultural BMPs were installed for sugar cane and vegetable production in this region from 1991 through the present (Wan et al., 2001), including both water and nutrient management BMPs. Water management BMPs included spatial and temporal water table level controls to reduce drainage losses from EAA farms. Nutrient management BMPs included reductions in rate of phosphorus application and adjustments in placement and timing of application. Tens of thousands of acres have constructed to be Stormwater Treatment Areas. As a result of these actions, TP concentrations declined from 173 ppb in the period from 1980-1991 to 69 ppb in Water Year 2004 (Daroub et al., 2005). This corresponds to a 64% reduction in TP loads from the EAA. Despite these improvements in water quality, the U.S. Sugar Corp. entered an agreement in 2010 to sell the State of Florida 73,000 ac (10%) of sugar cane and citrus land in the EAA at a cost of $536 million ($7,400/ac). These lands are to be used for wetland restoration and water storage and treatment practices that will further improve water quality in the EAA.

TABLE 2-4 Comparison between % reductions in TN or TP required by TMDL studies for Florida lakes or rivers and % reductions potentially achievable with implementation of Owner, Typical or Alternative agricultural BMPs.

TMDL Study	**Percent Reduction in TN**	**Percent Reduction in TP**
Lake TMDL Reductions	24-80	10-85
River TMDL Reductions	8-45	11-90
BMP Scenario		
Owner	10-20	9-40
Typical	5-40	5-29
Alternative	30-52	25-52

SOURCE: SWET (2008a). The numbers in the columns are the nutrient reduction percentages actually achieved by different types of BMPs (bottom three rows) as compared to that percentage reduction required by the TMDL (top two rows).

Range of Unit Costs

EPA estimated only the costs associated with the "owner" and "typical" BMPs currently practiced in Florida that were assumed to be required in the incrementally impaired watersheds and springsheds. A more complete analysis would have also considered the costs for downstream regional treatment efforts that may be required to further reduce nutrient levels and are often much more expensive. In addition, agricultural land acquisition to limit nutrient intensive activities may be a part of a nutrient reduction strategy and, depending on the crop produced on the land being restored, that can be very expensive. For example, evidence from the Everglades Agricultural Area, Lake Okeechobee, and Lake Apopka restoration programs indicates the need to acquire and convert significant areas of agricultural production land into regional treatment systems at land costs ranging from $5,575/ac to $7,400/ac.

The basis for EPA's unit costs was SWET (2008a), a recent assessment of BMP costs and impacts on water quality in the Caloosahatchee River and St. Lucie River watersheds in Florida. The dominant land uses in these watersheds are pasture and citrus in the west and urban and residential areas in the east. Unfortunately, these watersheds are not necessarily representative of the soils, geology, and land uses in large portions of Florida, including the Panhandle, North and West Central, and West Central Regions.

According to SWET (2008a), "BMP implementation costs were typically not provided with the research studies and therefore had to be developed by SWET, Inc. Cost estimates took into account the following factors: saved fertilizer, equipment and construction, operation and maintenance, energy/fuel, crop yield reduction, crop displacement, and land purchases. In agriculture, when a BMP requires additional land, such as for retention/detention systems, the area is typically carved out of existing land holdings such that there are costs are associated with lost crop production (displacement)." Based on these statements it is apparent that SWET (2008a) estimated costs contain considerable uncertainty, especially if they are extrapolated from southern Florida to the rest of the state.

As mentioned above, there are three scenarios for BMP implementation: owner implemented, typical cost share incentives, and alternative BMPs including regional treatment systems and other practices that take crop land out of production. Cost and effectiveness information on all three strategies is given in Tables 2-5 and 2-6 for N and P. "Owner" initiated BMPs are the least costly, but result in the smallest water quality benefits. "Typical" BMP programs are more costly, but should result in larger water quality benefits. "Alternative" BMP programs are more costly than the "typical" incentive-based BMPs, but would also result in larger water quality benefits.

There are many limitations of the approach taken by EPA (2010) to estimate costs of BMP implementation in agricultural areas incrementally affected by numerical nutrient criteria. First is that the costs of implementing BMPs for water quality benefits are likely to vary considerably in different regions of Florida. The SWET (2008a) estimates are based primarily on experience with BMPs in the Lake Okeechobee region of southern Florida. Second, is that EPA (2010) assumed that BMPs described in the SWET (2008a) owner or typical incentive BMP scenarios would be sufficient (in combination with nutrient reduction efforts from other sectors) to attain numerical nutrient water quality goals. BMP practices in the alternative BMP scenario described by SWET (2008a) will almost certainly be needed in many locations in order to attain the numeric nutrient criteria. Thus, it is likely that the actual annual per acre costs of

TABLE 2-5 Percent Reductions in ***Nitrogen*** and BMP Costs for Three Levels of BMP Implementation in Different Crop and Animal Production Systems

	Owner Initiated BMPs			**Typical Incentivized BMPs**			**Alternative BMPs**		
Production System	% Reductions	Cost ($/ac)	Establishment Costs ($/ac)	% Reductions	Cost ($/ac)	Establishment Costs ($/ac)	% Reductions	Cost ($/ac)	Establishment Costs ($/ac)
Cow/Calf Production									
Improved Pastures	17	4	11	10	12	38.5	30	35	110
Unimproved Pastures	11	1	2.2	8	4	11	43	18	55
Row Crops	30	3.5	11	30	66.9	209	50	141	440
Sugar Cane	10	1	3	23	34	108	52	88	275
Citrus	10	6.4	20	5	150.4	470	52	77	242
Dairy Production	20	0.7	2.2	40	334	1043	48	240	750
Hay Production	15	4	11	25	15	47	36	35	110

SOURCE: SWET (2008a).

TABLE 2-6 Percent Reductions in ***Phosphorus*** and BMP Costs for Three Levels of BMP Implementation in Different Crop and Animal Production Systems

	Owner Initiated BMPs			**Typical Incentivized BMPs**			**Alternative BMPs**		
Production System	% Reductions	Cost ($/ac)	Establishment Costs ($/ac)	% Reductions	Cost ($/ac)	Establishment Costs ($/ac)	% Reductions	Cost ($/ac)	Establishment Costs ($/ac)
Cow/Calf Production									
Improved Pastures	11	4	11	19	12	38	38	35	110
Unimproved Pastures	11	1	2.2	29	4	11	43	18	55
Row Crops	30	3.5	11	30	66.9	209	50	141	440
Sugar Cane	10	0	2.2	23	34	108	52	88	275
Citrus	12	0	5.5	5	24.6	77	52	77	242
Dairy Production	9	2	2.2	28	334	1043	48	176	550
Hay Production	40	15.8	50	15	4	11	25	12	39

SOURCE: SWET (2008a).

implementing BMPs on agricultural land to meet EPA's proposed numerical nutrient criteria will be much larger than their estimates.

Sources of Uncertainty

An underlying assumption by EPA is that the agricultural lands that would require TMDLs and BMAPs under existing state narrative standards would require *the same controls* to meet the proposed numeric nutrient criteria. There is uncertainty as to whether more restrictive (or less restrictive) controls would have to be implemented in order to meet the numeric criteria. Indeed, one could ask whether the application of "owner" and "typical" BMPs to agricultural lands in Florida would actually be sufficient to allow lakes and flowing waters to meet either the narrative or numeric standards. If "alternative" measures are required to meet the numeric nutrient criteria, the costs and complexities of such efforts increase dramatically. Such measures would likely include off-site treatment and the retiring of agricultural lands, as was necessary in some of the examples referred to above.

A second source of uncertainty relates to the effectiveness of the FDACS BMP program. Producers who implement and maintain FDACS-adopted BMPs receive a presumption of compliance with state water quality standards. The FDACS Office of Agricultural Water Policy employs a small staff to follow up with producers to confirm that they are conducting the BMPs applicable to their operations. However, enforcement is difficult, and it is not yet possible to get an accurate assessment of whether the BMPs selected by the producers are being properly implemented and effectively maintained, and to what degree they are improving water quality. Other reasons for limited effectiveness include the fact that system complexity and implementation costs can be high, labor and especially management requirements are usually underestimated, planning horizons tend to be short, and the availability and accessibility of supporting resources is limited (Nowak, 1992). Critical to effectiveness are successful implementation and then long-term maintenance for the practice or technology. While a farm in Florida in an impaired watershed is required to adopt BMPs, which BMPs the grower must implement are not specified. There is a substantial gap between what may be required, what may be economically feasible, and what may be sufficient to meet the NNC rule that may not be filled by voluntary action.

Other Analyses

The EPA analysis estimated significantly lower costs for the agriculture sector than the analyses of Cardno ENTRIX and FDACS. EPA grouped its agriculture land uses somewhat differently: (1) EPA had three classes of cow calf production compared to one for Cardno ENTRIX and (2) EPA classified what Cardno ENTRIX calls sugarcane land use as cropland and pasture land. This is a fairly important difference because the cost for sugarcane BMPs is about twice as much as that for cropland and pasture. Furthermore, the sugarcane land use accounts for 30 percent of Cardno ENTRIX's costs of meeting the NNC rule.

Citrus and hay are the other two large contributors to the cost (about 50 percent), and they were treated quite differently by EPA and Cardno ENTRIX. Hay is important because it covers a large number of acres, and citrus is important because of the relative high assumed costs per acre for BMPs. In Cardno ENTRIX's BMP/LOT scenario, their high estimate was that 937,513 acres of hay land would be affected by the NNC rule compared with 284,378 acres estimated by EPA. For citrus, Cardno ENTRIX's high estimate was 90,142 acres as compared with EPA's 27,343. This discrepancy resulted from Cardno ENTRIX including additional acres draining to waters that were "unassessed" and thus not included by EPA. Repeating this across all agricultural land use categories resulted in a total difference of about 1.8 million acres between the EPA land estimate and that of Cardno ENTRIX. The differences in per acre BMP costs cited by EPA and Cardno ENTRIX are large for two reasons: (1) different cost estimates for the same BMPs and (2) because of which BMPs were considered necessary to meet the nutrient criteria. Furthermore, it is not clear whether the EPA costs included the same extent of maintenance and other cost components as Cardno ENTRIX did. While EPA almost surely underestimated costs by choosing low-cost BMPs, Cardno ENTRIX's "end-of-pipe" scenario is beyond what would likely be required to meet the NNC rule and represents an overestimation of BMP costs (and acres to be treated).

Both the number of acres requiring BMPs and the cost per acre for BMPs are clearly highly uncertain. It is always difficult to predict which BMPs farmers will elect to adopt and how well they will maintain them even when they are mandated by regulatory programs. Furthermore it is uncertain whether Florida can effectively enforce the adoption and maintenance of agricultural BMPs. Both the need for farmer cost-share incentives and the need for effective state enforcement will result in transaction costs that neither EPA nor Cardno ENTRIX have adequately considered. How much these transaction costs will add to total costs is unclear, but it could be as high as an additional 25 to 35 percent (McCann and Easter, 2000).

On-site Septic Systems

Onsite Sewage Treatment and Disposal Systems (OSTDS) refer to conventional septic tank soil absorption systems and include more complex technologies called Performance-Based Treatment Systems. Regardless of their complexity, OSTDS have the following fundamental distinguishing feature: they treat and return wastewater to the hydrologic cycle close to the point where the wastewater was generated (Crites and Tchobanoglous, 1998. pg 2). This commonality was schematically represented by Bouma (1979) and is reproduced below as Figure 2-5. The figure has been modified to represent septic tank requirements in Florida and to demonstrate a septic-tank soil absorption system adjacent to a flowing stream.

As shown in Figure 2-5, renovated septic tank effluent (percolate) rejoins groundwater immediately below the soil absorption area. Due to the slight groundwater table gradients found in Florida, a plume of septic-influenced groundwater moves very slowly away from the discharge point.

The average home in Florida on an OSTDS discharges approximately 11 pounds of nitrogen per person per year (FDOH, 2010a), and approximately 4 pounds of phosphorus per person per year (Lowe et al., 2009). As percolate from an OSTDS moves down gradient, microbiological and chemical reactions convert nearly all the nitrogen to nitrate while phosphorus is held back in the effluent plume due to adsorption and precipitation reactions (Wilhelm et al., 1994).

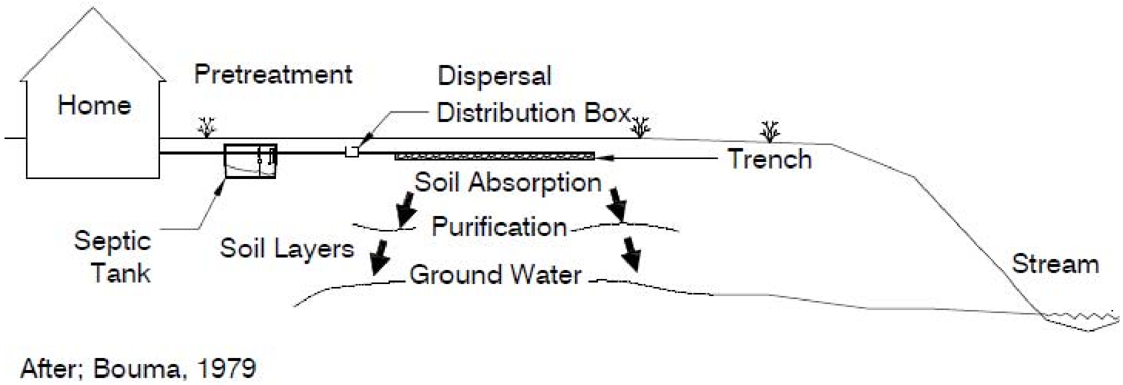

FIGURE 2-5 Idealized Individual On-Site Sewage Treatment and Disposal System Flow Diagram. SOURCE: Bouma (1979).

Methods for Determining Costs

To determine the costs of implementing the NNC Rule for septic systems, EPA considered the 793,697 active septic systems in the FDEP database, and then determined which of those systems lie within the potential incrementally impaired WBIDs. Acknowledging that septic systems contribute differentially depending on subsurface transport distance to the waterbody, EPA considered only those septic systems that are within 500 feet of a potential incrementally impaired waterbody. This reduced the number of septic systems considered for the EPA cost analysis to 8, 224, or just over 1 percent of all the systems in the state of Florida. For the 8,224 OSTDS, EPA assumed that they would require upgrades for nitrogen and phosphorus removal to comply with the NNC rule.

Although necessary to facilitate their analysis, choosing 500 feet as the cutoff distance for OSTDS nitrogen and phosphorus impacts is a critical and as-yet unsubstantiated assumption in EPA's analysis. A greater distance (e.g., 1000 ft) would take into consideration the specific hydrogeologic conditions in Florida. For example, in areas within the Biscayne Aquifer or in karst geologies, groundwater velocities are so rapid that a 500-ft setback distance could be traversed in just a few days. However, for the vast majority of the state 500 feet is a realistic starting point. That is, it would require months for nutrients discharged 500 ft from a stream or lake to reach the waterbody and in that intervening time, both dilution and removal (adsorption of P, denitrification of N) would likely reduce the ultimate concentration discharged.

EPA assumed that no additional controls would be needed for septic systems to attain the nitrate-nitrite criterion for springs, claiming that the contribution of nitrogen from septic systems is highly uncertain and likely site specific. They cited Brown et al. (2008) as indicating that the preponderance of nitrogen pollution in Florida springs appears to be from fertilizer sources, not septic tanks and wastewater sprayfields. Although Brown et al. (2008) do state that the preponderance of N pollution appears to be from fertilizer sources, they also explain that there are several reasons to treat this finding as an over-generalization, and point out that there remains significant uncertainty about the interpretation of bulk stable isotope measurements (that are used to distinguish nitrate from mineral sources versus municipal effluent or septic tanks) in complex karst hydrologic systems. A more conservative assumption would have been for EPA to assume that all septic tanks in incrementally impaired springsheds would require upgrade to advance nutrient removal systems.

Effectiveness of Control Measures

EPA recommended the use of advanced nutrient removal systems for the 8,224 OSTDS that would require upgrades to comply with the proposed NNC rule. The effluent standards for this designation were not given and EPA said it was unclear whether retrofit technologies could be used. The Performance-Based Treatment Systems technologies mentioned in EPA's report are capable of meeting advanced secondary effluent standards of 20 mg/L TN and 10 mg/L TP. Although further reduction in both parameters are likely in soil absorption and transport, achievement of the actual numeric nutrient criteria is not guaranteed before an OSTDS plume reaches the property line.

EPA did not consider the use of permeable reactive barriers, which were found to be low cost in the Chesapeake Bay watershed and able to achieve a nitrate discharge of 5 mg/L (EPA, 2010b). They are the only known technology likely to be able to approach the proposed numeric nutrient criteria in their discharge. However, permeable reactive barriers have their own limitations, since they have to be replaced on a timed schedule and the longevity of the media is not well understood (Robertson and Cherry, 1995). In the Florida Keys a layer of phosphorus-absorbing media 24 inches thick was used directly beneath the soil absorption area to achieve phosphorus removal to less than 1 mg/L (Ayres Associates, 2000); it was predicted to have a lifespan of 10 years. Unfortunately, no media performs both nitrogen and phosphorus removal simultaneously.

Range of Unit Costs

Using interviews with manufacturers and published cost data, EPA estimated the annualized capital cost of upgrades, assuming 7 percent interest over 20 years, to be between $800 and $1,300 per OSTDS. It is not clear that this simple analysis took in account a number of important factors that should be included in estimating the costs of OSTDS upgrades. Under Florida law, all such upgrades would be considered Performance-Based Treatment Systems, which must be designed by a Florida Licensed Professional Engineer. Typical design fees range from $1,000 to $2,000. Permit fees for Performance-Based Treatment Systems are $125 for the initial application and $100 for a biennial operating permit. Performance monitoring of Performance-Based Treatment Systems, including laboratory analysis, can be expected to range from $400 to $800 per year. In the Florida Keys, which has the highest proportion of Performance-Based Treatment Systems in the state, total annual construction and operational costs for nitrogen and phosphorus reducing systems were estimated at between $1,730 and $2,841 (Ayres Associates, 2000).

In order to install a permeable reactive barrier a hydrologic survey including determination of groundwater elevations would be necessary. Typical fees for such services range from $500 to $1500. In the Chesapeake Bay watershed (EPA, 2010b) anticipated installation costs of permeable reactive barriers ranged from $5,000 to $15,000 per home.

Sources of Uncertainty

Of the two metrics that need to be estimated to determine the range of costs for septic systems to implement the NNC rule, the number of units affected is the more uncertain than the per unit cost because springs areas were excluded from the analysis. There is also regulatory uncertainty. Unlike for the other sectors, implementation of the NNC rule for septic systems could not occur as quickly and unilaterally because the FDEP must work through the Florida Department of Health (FDOH), which has responsibility for regulating OSTDS in the state of Florida. The two agencies interact formally through an interagency Memorandum of Understanding (MOU) and meet monthly to discuss issues of mutual interest. FDOH rulemaking involves the in-depth participation of a stakeholder group called the Technical Review Advisory Panel (TRAP). All meetings of the TRAP are conducted in accordance with Florida's Sunshine Law. Any person can bring forward proposed rule revisions for consideration by the FDOH and discussion by the TRAP. Florida's OSTDS rule (64E-6, Florida Administrative Code) has been revised approximately once every two to four years over the last decade.

Other Analyses

In responding to EPA (2010), FDEP made several extreme assumptions regarding actions needed to make septic systems compliant with the NNC rule. First, it assumed that conventional septic systems on lots larger than three acres would automatically comply with the NNC rule, and thus assumed no additional costs on three-acre or larger lots. A review of the FDOH permitting databases indicates that approximately 83 percent of new septic systems and approximately 90 percent of older systems were on lots less than 3 acres. FDEP chose an overall estimate that 85 percent of septic systems were on lots less than three acres.

Rather than assume a specific cutoff distance from an incrementally impaired waterbody, FDEP assumed that 75 percent of all septic systems discharge to groundwater that eventually becomes surface water. Thus, the number of septic systems in Florida that they included in the cost estimate was 1,687,500 (as opposed to EPA's estimate of 8,224) (FDOH, 2010b). Although EPA's assumption of a 500-ft setback can be criticized as an arbitrarily low cut-off for septic systems that might contribute nutrients (given the prevalent and highly transmissive soils and karst geology), FDEP's assumption that nutrient contributions from throughout the state will impact flowing waters in Florida equally is also questionable.

FDEP assumed that all affected septic systems would be upgraded in the first year (called instant replacement), which is extremely expensive. Even assuming a more reasonable 5 percent per year replacement over 20 years, FDEP's annual cost estimates ranged from $0.9 to 2.9 billion because of the larger number of systems considered.

Cardno ENTRIX revised their economic analysis in July 2011 and made major changes in their analysis regarding septic systems to take into account additional geospatial data on septic tanks and new FDOH information on the likely incremental compliance costs associated with septic systems. Cardno ENTRIX accepted a 500-ft setback in refining the number of septic systems affected. Their overall estimate of annual compliance costs for septic systems was between $2 to $18 million dollars, with a mean estimated annual cost of $8 million dollars. This estimate is much closer to the $1.3 to $2.2 million estimated by EPA.

Government Costs

EPA (2010) assumed all incremental costs to government associated with the promulgation of the NNC rule would accrue exclusively in the development of total maximum daily loads (TMDLs). EPA reviewed potential incremental costs associated with developing site-specific alternative criteria and ambient monitoring, but determined these costs were insignificant. The incremental cost of TMDL development was reduced to a function of the numbers of incrementally impaired waters requiring TMDLs and the estimated cost of TMDL development. As noted previously, the key cost variable is likely to be the number of impaired waters. The potential number of incrementally impaired waters varies widely depending on the assumptions used to identify impairment. Thus, the number of impaired water/pollutant combinations significantly affect the government cost component as well as have a cascading effect on the overall cost estimate.

Methods for Determining Costs

The methodology for determining government costs is found in Chapter 10 of EPA's economic analysis performed in support of promulgation of numeric nutrient criteria for Florida (EPA, 2010a). Since the primary variable in the cost analysis is the number of incrementally impaired waters, Chapter 10 ties back directly to Chapter 6 where the estimate of incrementally impaired waters requiring TMDLs can be found. Exhibit 6-1 of the EPA analysis presents data in a tabular format summarizing EPA's analysis of incrementally impaired waters and arrives at a total of 325 waters that include streams, lakes, and springs. EPA further assumed that multiple waters would be included in a single TMDL document. Based on the average of previous Florida TMDLs, EPA estimated two waterbodies would be incorporated into each TMDL bringing the number of new TMDLs associated with the NNC rule incremental impairment to 163.

Several assumptions are used to estimate the number of incrementally impaired waters, including two key assumptions that eliminate certain groups of waters. Those key groups include waters with existing or proposed TMDLs for nutrients and those waters with insufficient data. If EPA accepts all existing nutrient TMDLs as a means for reaching endpoints compatible with the NNC rule, then the assumption that no additional TMDL work will be required *for those waters with preexisting TMDLs* is valid. If any of those existing TMDLs are challenged as not reaching suitable endpoints, then there will be added cost for modifying those TMDLs.

The larger uncertainty lies with the elimination of waters determined by EPA to lack sufficient nutrient data. As reported in EPA's Exhibit 6-1, only 34 percent of the waters without existing or pending TMDLs were thought to have sufficient data. Thus, 66 percent or 3,169 waters were eliminated for lack of sufficient data. As described earlier in this chapter, FDEP later tried to determine which of the 3,169 waters with insufficient data would potentially be identified as impaired using EPA's numeric nutrient criteria and concluded that 1,018 of the 3,169 currently un-assessed waters would potentially be listed as impaired and require TMDLs when assessed against the numeric nutrient criteria. Using EPA's estimate of two waters per TMDL, an additional 509 TMDLs would potentially need to be developed, more than tripling the current EPA cost estimate. This Committee advocates for an alternate approach to determining the number of unassessed waters likely to be out of compliance with the numeric nutrient criteria, which takes into consideration the characteristics of the various WBIDs.

Range of Unit Costs

The cost estimate for completing a TMDL was estimated based on a draft EPA document evaluating TMDL program costs (EPA, 2001a). EPA utilized an average cost per impairment of $28,000 based on a range of $6,000 to $154,000 per impairment. Those costs represent an aggregate of costs for all pollutants with no indication as to whether nutrient TMDLs would be more or less costly than other pollutants. EPA further assumed that each TMDL would be written for two impairments, TN and TP. This is a reasonable assumption because most of the incrementally impaired waters would be impaired for both TN and TP. The cost of the second impairment was discounted because much of the background information would have been collected for the first impairment. The second impairment was estimated to cost $6,000 (the low end from the 2001 EPA document). The costs of the two impairments were added and the total was brought forward to 2010 dollars resulting in a unit cost of $47,000 per TMDL.

The EPA (2001a) document included multiple cost ranges for developing TMDLs: the cost for single impairments; the cost for waterbodies with single to multiple impairments; and the cost per state submission which included multiple TMDLs for clustered waters. Interestingly, in the *Executive Summary* of the 2001 document, EPA references only the *waterbody* cost estimates in approximating aggregate national TMDL unit costs. Those unit costs utilized for the national estimate range from $26,000 to $500,000 per TMDL with an average of $52,000 dollars. Inflating that average cost to 2010 dollars using EPA's multiplier yields an average cost of $72,000, or 1.5 times the cost used in EPA's analysis. It is not clear why the 2010 EPA economic analysis did not use the $52K cost, as the 2001 document is frequently cited, which implies that $52K is the best overall nationwide estimate of TMDL development costs. Perhaps there was a sound reason for the selection of a lower unit cost, however no reason was stated. The 2010 cost analysis also notes that the additional costs for monitoring needed to develop TMDLs were not included in the cost estimates.

Although not cited in the EPA analysis, the support document for the TMDL program costs (EPA, 2001b) provided additional detail on the methodology used to compute costs. A matrix of costs was developed based on the degree of complexity of a TMDL and the efficiencies realized by performing TMDLs for multiple pollutants and/or waterbodies versus single pollutants. The data indicate the cost for a single pollutant, single waterbody TMDL ranged from $36,284 for a simple TMDL to $69,924 for a moderately complex TMDL to $123,476 for a complex TMDL. All costs are in 2000 dollars. Those costs inflated to 2010 dollars are $50,240; $96,500; and $170,400, respectively. Costs for a second parameter at each of the complexity levels are estimated to be $11,978; $28,779; and $56,741 in 2000 dollars, respectively. Inflating those costs to 2010 dollars and adding them to the costs for the original parameters yields the total costs for two parameter TMDLs on single waterbodies as $66,800 for a simple TMDL, $136,200 for a moderately complex TMDL, and $249,000 for a complex TMDL. These estimates range from 1.4 to 5.3 times higher than the analysis used in EPA (2010).

Regardless of the unit cost selected, the TMDL cost data discussed above are over a decade old. Bringing the cost of the original estimates up to current dollars may be acceptable as an estimate. However, use of contemporary or Florida-specific data may have provided a more accurate estimate of actual TMDL costs. The FDEP Office of Inspector General (FDEP, 2008b) produced a report detailing FDEP TMDL program costs, including operations funding, for the program through 2007. Based on operations funding and the numbers of TMDLs completed, it appears a Florida-specific cost estimate for TMDL development could have been developed. To develop a crude but rapid understanding of what the number would have been, the following calculations are provided:

- Operations costs from FY02-06 were 21.51% of the total TMDL program costs. Operations costs included "…expenditures such as staff salary, travel, monitoring, contractor services, TMDL development and BMAP implementation." The BMAP implementation and follow up monitoring would go beyond TMDL development costs, but the numbers provided in the report did not go into additional detail.

- Total TMDL costs through FY08 totaled $156.5M. So the estimate of operating costs = $156.5M X 0.2151 = $ 33,663,150.00

- As of the 2008 OIG report, there are 156 TMDLs adopted, 100 TMDLs in the process of being adopted, and 83 TMDLs being developed. So one could estimate 256–339 TMDLs developed. Thus, the range of average cost = $33.6M/339 to $33.6M/256 or $99,000 - $131,000/TMDL.

In terms of more contemporary data, EPA has contracted with various consultants for TMDL development throughout the country. It is likely contemporary cost estimates for TMDL development could be calculated based on those contractual arrangements. It may also be possible to parse out the specific cost of developing nutrient TMDLs from those data. At a minimum, the value of the contracts could be used to gauge the general accuracy of the 2000 cost estimates.

Other Cost Considerations

Other costs associated with complying with the NNC rule could have potential fiscal impacts to government bodies other than TMDL development. This document will not attempt to quantify those costs, only to identify the possible additional costs to government. In addition to the potential costs mentioned below, there could conceivably be new administrative, monitoring, and enforcement costs if FDEP ramps up its efforts to address waters newly impaired under the numeric nutrient criteria, but these are not discussed further.

SSAC Development Costs. In the section on municipal and industrial wastewater treatment plants, the EPA analysis assumed there would be liberal acceptance of variances or SSACs to replace the promulgated numeric nutrient criteria on a case-specific basis. SSAC development costs could be borne by government sector or the private sector, but the possibility of the former was not factored into the government sector analysis done by EPA. Regardless of who develops the SSAC, government time and resources would have to be spent evaluating and ruling on the acceptance or denial of the SSAC, and on evaluating variance requests, but these costs were not considered in the EPA analysis. The history of using SSACs and variances for nutrient issues is virtually unwritten on a national level. Thus, their use in Florida would be breaking new ground.

Second round and later costs for TMDLs. EPA assumes all TMDL costs occur over a nine-year period and then end. In reality, many adaptively managed TMDLs will have to be evaluated after the nine-year period and adjustments made to the TMDL to further reduce nutrients. While not as costly as the original TMDL development, there are costs involved in the re-evaluation of those TMDLs.

Potentially Lower Stream Criteria Based on Downstream Protective Values. Once EPA promulgates numeric nutrient criteria for estuaries, those criteria could force lower nutrient concentrations in streams in order to meet the estuary criteria. Lower mandatory stream concentrations could result in additional waters being assessed as impaired, thus increasing the number and complexity of the TMDLs which must be developed.

Sources of Uncertainty

Government costs as analyzed by EPA are tied exclusively to TMDL development. Thus, a significant uncertainty for the government sector is the number of waterbodies that may be impaired and require a TMDL. Different estimates put that number between 325 and 1,018. While there is also a large percentage difference in the unit cost of each TMDL estimated by EPA as compared to others, the gross cost per TMDL is small in comparison to implementation costs in other sectors.

Another significant unknown is that FDEP maintains they will be unable to develop TMDLs and BMAPs for waters deemed impaired according to the EPA numeric nutrient criteria due to Florida state law prohibitions on the use of criteria not contained in state rule (FDEP, 2010). If that is the case, EPA will be forced to take the lead in both identifying nutrient impaired waters and developing TMDLs and BMAPs. Since EPA has no track record of developing nutrient TMDLs, it is unclear what an EPA TMDL would look like, how it would be implemented, and what it would cost. All of EPA cost estimates assume the State of Florida will implement the numeric nutrient criteria. It is anticipated that costs could be significantly higher if EPA were responsible for a nutrient TMDL program because EPA would have initial start up costs in establishing an infrastructure capable of assessing Florida's waters, developing TMDLs, and following up on BMAP implementation.

Other Analyses

Cardno ENTRIX (2011) performed an analysis of government cost as a part of their overall review of EPA's cost analysis. Their Monte Carlo analysis of the data led to a prediction of 902 additional waters would be listed as impaired under the numeric nutrient criteria. The analysis also estimated a higher unit cost for each TMDL using EPA's minimum and maximum unit costs as model inputs. Based on the analysis, Cardno ENTRIX estimated a TMDL unit cost of $64,000 as opposed to the EPA estimate of $47,000.

To determine the total government costs, Cardno ENTRIX considered two scenarios—(1) Best Management Practices for diffuse sources and the Limit of Technology for point sources (BMP/LOT) and (2) End-of-Pipe (EOP) assumption that both point and diffuse sources would be required to meet the numeric nutrient criteria at the end-of-pipe or edge-of-field. The results of the Monte Carlo simulation, which provide a range of cost from low to high, are given in Table 2-7 and range from $1 million to $11 million with a mean of $6 million. The EPA cost estimate of $0.9 million is near the low-end Cardno ENTRIX estimate.

While the difference between $0.9 million and $6 million is very significant in terms of state government budgeting, the government costs are a small fraction of the overall cost of implementation—less than 1 percent. Therefore, the government costs play an insignificant role in terms of the total costs for implementing numeric nutrient criteria.

TABLE 2-7 Cardno ENTRIX Total Government Cost Analysis

	Millions $						
	Estimated Annualized Cost			Estimated Present Value Cost: 2011-2040			
Assumption	**5th Percentile**	**95th Percentile**	**Mean**	**5th Percentile**	**95th Percentile**	**Mean**	**Monte Carlo Output**
BMP & LOT	$1	$4	$2	$11	$65	$32	$29
End of Pipe Criteria	$3	$11	$6	$43	$175	$93	$85

FINDINGS AND RECOMMENDATIONS

The first set of findings and recommendations pertain to the determination of the number of incrementally impaired waters, and as such have repercussions for several of the sector analyses. A second set of findings and recommendations are provided that are specific to each sector, preceded by a summary table. All of these findings and recommendations are based on the assumption that EPA would use the same basic method for any future economic analyses, with the intent of making suggestions for improvements.

Incrementally Impaired Waters and Watersheds

FINDING: The HUC10 delineation used to assess the acreage of various land uses that contribute to the potential impairment is too coarse.

RECOMMENDATION: EPA should use the more refined HUC12 delineation to generate a more precise estimate of the acres to consider for the BMPs in the various land uses.

FINDING: It is not valid to assume that the percent of unassessed waters that would be incrementally affected is zero. A more defensible approach would take into consideration the characteristics of the various WBIDs to predict the likelihood that they would fail to meet the narrative criteria or the numeric nutrient criteria.

Sector Analyses

Table 2-8 summarizes the Committee's assessment of EPA's economic analysis by sector. The color coding of Table 2-8 entries reflects the Committee consensus of the accuracy of the EPA evaluation. Green indicates a satisfactory job in addressing the issue, yellow indicates only moderate agreement, and pink indicates unsatisfactory assessment.

The table is based on the cost method used in the EPA analysis, in which the total sector cost was calculated as the product of the number of affected units (or area) and the unit cost. The second column refers to how well EPA determined the number of affected units, including judgments on assumptions used for the number of point discharges that will require treatment upgrades and land areas that will need to have new BMP technologies implemented. The third column deals with the accuracy of unit costs assessments.

The fourth column considers whether the numeric nutrient criteria could be met by existing technologies at the "end-of-pipe" or "edge-of-field" for each sector. The EPA analysis assumes that in every case assimilative capacity exists somewhere in the watershed or waterbody, or that administrative relief is available, such that the each sector does *not* have to meet the numeric nutrient criteria at the end-of-pipe or edge-of-field. Yet the EPA has not employed watershed modeling to determine if implementing all assumed technologies would allow the numeric nutrient criteria to, in fact, be met. From the regulatory standpoint, if a waterbody violates the numeric nutrient criteria, its assimilative capacity is considered to already be exceeded. Thus, the numeric nutrient criteria were used in this column because no other

TABLE 2-8 Summary of Key Findings by Sector

	EPA estimate of the area affected or number of units	EPA estimate of the unit cost of BMPs	Can chosen tech-nologies/BMPs meet the NNC?	Strategies to improve the analysis
Municipal Plants	All WWTPs included due to "reasonable potential" provisions of regulations	CAPDET Works cost estimates not verified using Florida-specific experience	Assumed that WWTPs would only be required to treat to 3 mg/L TN and 0.1 mg/LTP and none will treat to NNC at end of pipe	1. Ground truth unit costs based on significant existing Florida experience. 2. More realistically reflection of the proportion of WWTPs receiving administrative relief to avoid treating beyond 3 mg/L TN and 0.1 mg/L TP.
Industrial Plants	Established by averaging flows from only a limited number of facilities and extrapolating to others.	CAPDET Works program (used for municipal facilities) was misapplied to industries.	Same as for municipal WWTPs	Should not have investigated only 1 or 2 plants per SIC but rather analyzed each plant
Agriculture	EPA likely under estimated the area of incrementally impaired watersheds as well as the number of springs affected	Costs from SWET report not representative; need more site-specific cost estimates	No. Alternative BMPs will likely be required along with land retirement	Use existing TMDLs and restoration plans to identify the BMPs and regional treatment needed to meet the criteria
Urban Stormwater	Assumed Urban Turf Rule would insure compliance on all low-density residential land and that all land after 1982 is already in compliance.	EPA used low end of a very wide range of unit costs	Assumed traditional BMPs would meet NNC and assumed 100% compliance and functionality for urban BMP implementation. NNC may necessitate more advanced BMPs.	Consider advanced BMP implementation throughout most developed land area.
Septic Systems	Excluded systems beyond 500 ft and springs areas	Reasonable for technologies evaluated.	Not necessarily, but other technologies may.	Consider wider range of systems and updated per unit costs.
Government Costs	Did not consider other government costs like SSAC approval, variances, etc.	Used old TMDL cost data not specific to FL	NA	1. Use contemporary, Florida and nutrient-specific TMDL development costs. 2. Consider costs of SSACs, TMDL revision, etc.

logical benchmark is available with which to compare the performance of technologies and BMPs.

An important consideration not well captured in this summary table (but returned to in Chapter 3) is the degree of uncertainty and variability expected in each of the sector categories.

In many cases, uncertainty is expected to be exceedingly high. While some uncertainty is captured in the EPA analysis, it is not considered to be adequate to describe the vast complexity inherent in many of the parameters critical to the economic analysis. In some of the sectors, especially with agriculture and with urban stormwater, technology and implementation unit costs can vary by factors approaching two orders of magnitude. Placing the assessment accuracy results summarized in Table 2-8 in the context of the high uncertainty and variability of many of the categories leads to even greater concern with the EPA economic analysis.

Municipal Wastewater Treatment Plants

FINDING: There is significant uncertainty in the cost estimate for municipal wastewater treatment plants because (1) the unit treatment costs were not verified by comparison to the existing and extensive Florida AWT treatment experience and (2) the assumption that no plant will be required to treat to levels more stringent than 3 mg/L TN and 0.1 mg/L TP is unrealistic. While the proportion that will be able to avoid treating to levels more stringent than 3 mg/L TN and 0.1 mg/L TP is uncertain, there is a real possibility that at least some WWTPs will have to treat to more stringent levels.

RECOMMENDATION: Efforts should be made to compare the unit costs of CAPDETWorks with cost data from Florida. Efforts should also be made to better estimate the percentage of plants that will be required to reach discharge limits more stringent than 3 mg/L TN and 0.1 mg/L TP by performing mass balance and dilution calculations for at least a representative proportion of plants, if not for all of the plants included in this analysis.

Industrial Plants

FINDING: There is significant uncertainty about the incremental cost of the NNC rule for industrial plants for several reasons. EPA based its estimates on one or two selected facilities from each sector and ignored the diversity of industrial facilities within a sector. This extrapolation led to some low-flow facilities exerting a disproportionate influence on the overall industrial costs. Furthermore, the same cost model and treatment processes were used for industrial facilities as was employed for municipal WWTPs. For facilities with highly variable flows, flow equalization may be a more cost-effective solution than mechanical/ chemical treatment, such that EPA may have overestimated costs for these facilities. On the other hand, some industrial facilities have higher unit costs than municipal WWTPs. Finally, industries covered under general permits were not investigated, raising the question of whether there may be costs to remove nutrients from those facilities that were not captured in EPA's estimates.

RECOMMENDATION: Given the small number of industries involved, the cost analysis should be improved by analyzing each plant rather than extrapolating the results of one or two plants to the entire sector. As with the municipal wastewater treatment plants, efforts should be made to compare the unit costs of CAPDETWorks with cost data from Florida and to better estimate the percentage of plants that will be required to reach discharge limits more stringent than 3 mg/L TN and 0.1 mg/L TP.

Urban Stormwater

FINDING: For the urban stormwater sector, the costs of complying with the NNC rule in those watersheds determined by EPA to be incrementally impaired are expected to be higher than EPA estimates. However, high uncertainty and variability is prevalent throughout all aspects of this sector analysis, which would lead to a wide cost range and costs that are highly dependent on several critical assumptions. Most traditional Florida urban SCMs will not likely be able to comply with stringent numeric nutrient criteria, but newer, novel (and more expensive) technologies may. Per acre costs for traditional Florida SCMs are highly variable; broadening the SCM options increases the cost range even more. Many simplifying assumptions are employed to estimate urban land area incrementally affected by the NNC rule. Actual affected land area estimates are highly dependent on unverified existing SCM performance and compliance with urban stormwater rules and regulations.

RECOMMENDATION: To improve the cost analysis, higher-efficiency SCMs should be considered, which have costs higher than traditional SCMs. Costs of retrofitting SCMs into already-developed land should be considered.

Agriculture

FINDING: For the agricultural sector, the costs of complying with the NNC rule in those watersheds determined by EPA to be incrementally impaired are likely to be higher than EPA estimates. The incremental land area needing treatment was likely underestimated, individual costs for the BMPs assumed to be sufficient were underestimated, and the more effective and costly BMPs and regional treatment systems likely required to meet numeric nutrient criteria were not included in the analysis. The need for more stringent BMPs and treatment systems has been demonstrated in many of the BMAPs developed for impaired waters in Florida. Furthermore, there were some critical omissions that could well lead to increased costs, including the degree of actual participation by agricultural producers and the costs of maintaining BMPs over time.

RECOMMENDATION: To improve the cost analysis, actual experience from existing TMDLs should be used to identify the BMPs and regional treatment systems that were sufficient or insufficient to meet certain numeric targets.

Septic Systems

FINDING: For septic systems, the costs of complying with the NNC rule in those waterbodies determined by EPA to be incrementally impaired are likely to be substantially higher than EPA estimates. The Committee was comfortable with the 500-ft threshold assumption made by EPA; however, the exclusion of septic systems in springsheds is a significant deficiency of EPA's analysis. EPA received cost estimates from vendors of equipment capable of meeting a total nitrogen target of 20 mg/l and a total phosphorus target of 10 mg/L, values which are much higher than EPA's numeric nutrient criteria.

RECOMMENDATION: Efforts should be made to consider septic systems in springsheds and a wider range of systems including permeable reactive barriers, which are known to be more effective in removing nutrients to levels consistent with the numeric nutrient criteria.

Government Costs

FINDING: The incremental costs for the government sector are expected to be higher than EPA estimates. The key factors in determining government cost are the number of incrementally affected units (WBIDs requiring a TMDL) and the unit cost of a TMDL. In the EPA analysis, WBIDs with insufficient data were not used, thus potentially underestimating the number of incrementally impaired waters requiring TMDLs. Unit costs were based on low-end estimates of costs from a 2001 study that focused on a broad range of TMDL work not specifically related to either Florida TMDL development or nutrient TMDL development. The unit cost selected was less than the national unit cost referenced in the 2001 report.

RECOMMENDATION: Effort should be made to quantify costs for Florida-specific and/or nutrient-specific TMDLs to provide more accurate unit costs for TMDL development. Additional government costs should also be considered, including costs for developing or approving SSACs and variances, costs associated with downstream protective values effectively reducing upstream criteria, future costs of adaptively managed TMDLs, and consideration of additional waters becoming impaired in the future.

REFERENCES

Anderson, D. L., and E. G. Flaig. 1995. Agricultural Best Management Practices and surface water improvement and management. J. Wat. Sci. Tech. 31:109-121.

Arthur, J. D., H. A. R. Wood, A. E. Baker, J. R. Cichon, and G. L. Raines. 2007. Development and Implementation of a Bayesian-based Aquifer Vulnerability Assessment in Florida. Natural Resources Research 16(2):93-107.

Ayres Associates. 2000. Florida Keys Onsite Wastewater Nutrient Reduction System Demonstration Project, Phase II Addendum. Bureau of Onsite Sewage Programs, Tallahassee, FL, 28 pp. Retrieved September 6, 2011 from http://www.myfloridaeh.com/ostds/zip/keysnutrientdemoph2.zip

Bachmann, R. W., B. L. Jones, D. D. Fox, M. V. Hoyer, L. A. Bull, and D. E. Canfield, Jr. 1996. Relations between trophic state indicators and fish in Florida (U.S.A.) lakes. Can. J. Fish Aquat. Sci. 53:842-855.

Bachmann, R. W., M. V. Hoyer and D. E. Canfield, Jr. 1999. The restoration of Apopka Lake in relation to alternative stable states. Hydrobiol. 394:219-232.

Bachmann, R. W., M. V. Hoyer and D. E. Canfield, Jr. 2010. Draft alternative nutrient criteria for Florida lakes. Florida LAKEWATCH whitepaper. Gainesville, FL: University of Florida.

Bachmann, R. W., M. V. Hoyer, and D. E. Canfield, Jr. 2003. Predicting the frequencies of high chlorophyll levels in Florida lakes from average chlorophyll or nutrient data. Lake Reservoir Manage. 19:222-241.

Birr, A. S., and D. J. Mulla. 2002. Relationship between lake and ground water quality patterns and Minnesota agroecoregions. Hydrological Sci. Tech. 18(1-4):31-41.

Bottcher, A. B., T. K. Cremwell, and K. L. Campbell. 1995. Best Management Practices for water quality improvement in the Lake Okeechobee watershed. Ecol. Engin. 5:341-356.

Bouma, J. 1979. Subsurface applications of sewage effluent. Planning the Uses and Management of Land. Madison, WI: ASA-CSSA-SSSA. 665–703.

Brown, C. D., M. V. Hoyer, R. W. Bachmann and D. E. Canfield, Jr. 2000. Nutrient-chlorophyll relationships: an evaluation of empirical nutrient-chlorophyll models using Florida and north-temperate lake data. Can. J. Fish Aquat. Sci. 57:1574-1583.

Capece, J. C., et al. 2007. Soil Phosphorus, Cattle Stocking Rates and Water Quality in subtropical Pastures in Florida, USA. Rangeland Ecology and Management 60(1):19-3.

Cardno ENTRIX. 2011. Addendum to the Economic Analysis of the Federal Numeric Nutrient Criteria for Florida. July 2011.

Carollo Engineers. 2010. Costs for Utilities and Their Ratepayers to Comply With EPA Numeric Nutrient Criteria for Freshwater Dischargers. Prepared for the FL Water Environment Association Utility Council. November 2010.

CH2M Hill. 2010. Statewide Nutrient Removal Cost Impact Study. Prepared for the Utah Division of Water Quality, Salt Lake City, Utah. October 2010.

Chebud, Y., G. M. Naja, and R. Rivero. 2011. Phosphorus run-off assessment in a watershed. J. Environ. Monit. 13:66–73.

Crites, R., and G. Tchobanoglous. 1998. Small and Decentralized Wastewater Management Systems. McGraw-Hill Series in Water Resources and Environmental Engineering, Boston, MA, 1084 pp.

Daroub, S. H., T. A. Lang, O. A. Diaz, M. Chen, and J. D. Stuck. 2005. Everglades agricultural area BMPs for reducing particulate phosphorus transport. Everglades Agricultural Research and Education Center, Univ. Fl.

Daroub, S., et al. 2011. Best Management Practice and Long-Term Water Quality Trends in the Everglades Agricultural Area. Critical Reviews in Environmental Science and Technology 41(S1):608-632.

ERD (Environmental Research & Design, Inc.) 2007. Evaluation of Current Stormwater Design Criteria within the State of Florida. Final Report prepared for Florida Department of Environmental Protection, Orlando, FL. http://www.dep.state.fl.us/water/nonpoint/docs/nonpoint/SW_TreatmentReportFinal_71907.pdf

Florida Department of Agriculture and Consumer Services (FDACS) Office of Water Policy. 2011a. NSPM Annual Report.

FDACS. 2011b. Fact: Sheet "Protecting Florida's Water Resources with Agricultural Best Management Practices – What, Why, and How."

Florida Department of Environmental Protection. 2008a. Lower St. Johns River Basin Management Action Plan. Tallahassee, FL: Florida DEP. http://www.dep.state.fl.us/Water/watersheds/docs/bmap/adopted-lsjr-bmap.pdf

FDEP Office of Inspector General (OIG). 2008b. Total Maximum Daily Load Program Review, Division of Environmental Assessment and Restoration. Report # IA-03-14-2008-52.

FDEP. 2010. Memorandum - Department Comments on the Environmental Protection Agency's (EPA) Proposed Numeric Nutrient Criteria for Florida Lakes and Flowing Waters, January 26, 2010. Florida DEP, Tallahassee, FL. http://waterwebprod.dep.state.fl.us/nutrients/dep-comments/fdep_cover_letter.pdf

FDEP. 2011. Estimation of the Increase of Water Segment Impairments under the U.S. Environmental Protection Agency's Numeric Nutrient Criteria.

Florida Department of Health (FDOH). 2010a. Final Study and Report on phase 1 of the Florida Onsite Sewage Nitrogen Reduction Strategies Study (2008-2010). Bureau of Onsite Sewage Programs, Tallahassee, FL, 40 pp. Retrieved August 5, 2011 from http://www.myfloridaeh.com/ostds/pdfiles/forms/NitrogenReductionReport.pdf

Florida Department of Health (FDOH). 2010b. Bureau of Onsite Sewage GIS Data Files. http://www.doh.state.fl.us/Environment/programs/EhGis/EhGisDownload.htm.

Fulmer, D. G., and G. D. Cooke. 1990. Evaluating the restoration potential of 19 Ohio reservoirs. Lake Reserv. Manage. 6:197-206.

Grady, C. P. L., Jr., G. T. Daigger, N. G. Love, and C. D. M Felipe. 2011. Biological Wastewater Treatment, 3rd Edition. Boca Raton, FL: CRC Press.

Graetz, D., et al. 2008. Evaluating Effectiveness of Best Management Practices For Animal Waste and Fertilizer Management to Reduce Nutrient Inputs into Ground Water in the Suwannee River Basin Section 319 Nonpoint Source Pollution Control Program Education/Training Demonstration Project Final Report, January 2008.

Griffith, G. E., D. E. Canfield, Jr., C. A. Horsburgh, and J. M. Omernik. 1997. Lake regions of Florida. EPA/R-97/127. Corvallis, OR: EPA NHREEL Western Ecology Division.

Harrison, C. B., W. D. Graham, and S. T. Lamb. 1999. Evaluating the Impact of Alternative Nitrogen Management Practices on Groundwater beneath Central Florida Citrus Groves, 2. Computer Modeling. Transactions of the ASAE 42(6):1669-1678.

Hatch, L. K., A. P. Mallawatantri, D. Wheeler, A. Gleason, D. J. Mulla, J. A. Perry, K. W. Easter, P. Brezonik, R. Smith, and L. Gerlach. 2001. Land management at the major watershed - agroecoregion intersection. J. Soil Water Conservation 56:44-51.

Heiskary, S., and W. W. Walker, Jr. 1988. Developing phosphorus criteria for Minnesota lakes. Lake Reserv. Manage. 4:1-9.

Lamb S. T., W. D. Graham, and C. B. Harrison. 1999. Evaluating the Impact of Alternative Nitrogen Management Practices on Groundwater beneath Central Florida Citrus Groves, 1. Monitoring Data, Transactions of the ASAE 42(6):1653-1668.

Livingston-Way, P. 2001. Water Quality Monitoring and Assessment of Agricultural Best Management Practices in the Tri-County Agricultural Area Phase II Final Report, submitted to the Florida Department of Environmental Protection in fulfillment of Contract No. WM602.

Lowe, K. S., M. B. Tucholke, J. M. Tomares, K. Conn, C. Hoppe, J. E. Drewes, J. E. McCray, and J. Munkata-Marr. 2009. Influent constituent characteristics of the modern waste stream from single sources. Water Environment Research Foundation 04-DEC-1. Retrieved August 8, 2001 from http://www.decentralizedwater.org/documents/04-DEC-1/04DEC01web.pdf

McCann, L., and K. W. Easter. 2000. Estimates of Public Sector Transaction Costs in NRCS Programs. Journal of Agricultural and Applied Economics 32(3): 555-63.

McKee, K. 2011. National Hydrography Dataset Basin 311. University of Florida Water Institute.

Medina, D., and S. Curtis. 2011. Comparing LID and Stream Restoration. Stormwater 12(6):10-23.

Mulla, D. J., A. S. Birr, N. R. Kitchen, and M. B. David. 2008. Limitations of evaluating the effectiveness of agricultural management practices at reducing nutrient losses to surface waters. Pp. 189-212. In: (J. L. Baker, ed.), Final Report Gulf Hypoxia and Local Water Quality Concerns Workshop. Upper Mississippi River Sub-Basin Nutrient Hypoxia Committee (UMRSHNC). Am. Soc. Ag. Biol. Eng., St. Joseph, MI.

Nowak, P. 1992. Why Farmers Adopt Production Technology. Journal of Soil and Water Conservation, Jan-Feb 1992 47(1):14-16.

Omernik, J. M. 1987. Ecoregions of the conterminous United States. Annals Assoc. Am. Geog. 77:118-125.

Robertson, W. D., and J. A. Cherry. 1995. In situ denitrification of septic-system nitrate using reactive porous media barriers: field trials. Ground Water 33(1):99-111.

Shukla, S., D. Goswami, W. D. Graham, A. W. Hodges, M. C. Christman, and J. M. Knowles. 2011a. Water Quality Effectiveness of Ditch Fencing and Culvert Crossing in the Lake Okeechobee Basin, Southern Florida. Ecological Engineering, doi:10.1016/j.ecoleng.2011.02.013.

Shukla, S., W. Graham, D. Goswami, J. Knowles, A. Hodges, V. Nair, M. Christman, C. Wu. 2011b. Evaluation of Cow-Calf Best Management Practices with Regards to Nutrient Discharges in the Lake Okeechobee Basin. Final Report submitted to: Florida Department of Agricultural and Consumer Services & South Florida Water Management District.

Soil and Water Engineering Technology, Inc. 2008a. Tasks 1, 2 and 3: Nutrient loading rates, reduction factors and implementation costs associated with BMPs and technologies. Final Report for South Florida Water Management District. Gainesville, Fl.

Soil and Water Engineering Technology, Inc. 2008b. Task 4: Nutrient loading rates, reduction factors and implementation costs associated with BMPs and technologies. Final Report for South Florida Water Management District. Gainesville, Fl.

U.S. Environmental Protection Agency (EPA). 2001a. The National Costs of the Total Maximum Daily Load Program (Draft Report). EPA-841-D-01-003.

U.S. EPA. 2001b. The National Costs of the Total Maximum Daily Load Program (Draft Report): Support Document #1. EPA-841-D-01-004.

U.S. EPA. n.d. National Water Quality Assessment Report (n.d.). Retrieved from http://www.epa.gov/waters/ir/attains_q_and_a.html#content

U.S. EPA. 2008. Final Total Maximum Daily Load (TMDL) for Biochemical Oxygen Demand, Dissolved Oxygen, and Nutrients in the Lake Okeechobee Tributaries. Atlanta, GA: EPA Region 4.

U.S. EPA. 2010a. Economic analysis of final water quality standards for nutrients for lakes and flowing waters in Florida. Washington, DC: EPA Office of Water.

U.S. EPA. 2010b. Guidance for Federal Land Management in the Chesapeake Bay Watershed. Chapter 6—Decentralized Wastewater Treatment Systems. Washington, DC. EPA 841-R-10-002, May 12, 2010. Retrieved August 12, 2011 from http://www.epa.gov/owow_keep/NPS/chesbay502/pdf/chesbay_chap06.pdf

Wan, Y., M. Voich, and S. Trost. 2001. Effectiveness of Best Management Practices. Everglades Consolidated Report.

Water Environment Federation (WEF). 2009. Design of Municipal Wastewater Treatment Plants, 5th Edition, Manual of Practice No. 8, Alexandria, VA.

Weiss, P. T., Gulliver, J. S. and Erickson, A. J. 2007. Cost and Pollutant Removal of Storm-Water Treatment Practices. J. Wat. Res. Plan. Mgmt. 133(3):218-229.

Wilhelm, S. R., Schiff, S. L. and Robertson, W. D. 1994. Chemical Fate and Transport in a domestic septic system: unsaturated and saturated zone geochemistry. Environmental Toxicology and Chemistry 13(2):193–203.

Chapter 3

A Framework for Incremental Cost Analysis of a Rule Change

INTRODUCTION

EPA's estimate of the incremental cost from implementing numeric nutrient criteria in Florida was reviewed in Chapter 2. The EPA analysis first estimated which waters would be listed as impaired under the numeric nutrient criteria (NNC), but were not yet listed under the existing narrative rule. That estimation assumed that these waters would not have been listed as impaired under the narrative rule. The corresponding watersheds for these incrementally affected waters were then delineated, and their land uses were determined in order to predict the additional nutrient control actions various source sectors in that watershed would need to take for the numeric nutrient criteria to be met. In addition, EPA estimated how many National Pollutant Discharge Elimination System (NPDES)-permitted municipal and industrial sources that discharge to inland surface waters anywhere in the state would have revised concentration limits for nitrogen (N) and phosphorus (P) in their discharge permits. These two changes were how EPA defined the incremental effect of the NNC rule.

In writing its review in Chapter 2, the Committee accepted the EPA definition of the incremental effect and provided a critique of the methods by which that incremental effect was empirically developed. Chapter 2 reviewed the EPA estimates of the unit costs and effectiveness of EPA's chosen load reduction methods, concluding that there was much uncertainty about both the costs and effectiveness of the methods. Of course, that uncertainty would be present under any rule.

This chapter proposes an alternative framework for conducting a cost analysis, with an emphasis on defining the implementation time paths of the various rules and consideration of uncertainty. The chapter begins by describing the difference in the rules according to what is required in EPA's 2010 *Guidelines for Preparing Economic Analysis* (EPA, 2010a). Those guidelines call for first establishing a baseline "defined as the best assessment of the world absent the proposed regulation", including identifying starting and ending points over time for the baseline scenario (EPA, 2010a, p. 5-1, 5-2). To develop such a baseline for this chapter, the water quality management process is divided into five broad stages, and a description is provided of how the narrative rule, the NNC rule, and the proposed Florida rule would affect each stage over time. By comparing the three implementation time paths, with the narrative rule as a baseline, one can isolate the differences in the rules in order to determine how these differences might affect costs. In fact, many of the differences in cost estimates made by EPA and others can be traced to different assumptions made about how the rules would affect actions taken in each of the stages.

That discussion is followed by presentation of a framework for predicting incremental costs of the various rules. In describing the logic of the framework and graphically illustrating its application, the text demonstrates that predictions of costs over time depend on many assumptions about (1) current and future regulatory agency behavior, (2) future political and legal decisions and interpretations, (3) waterbody response to load reductions, (4) unit costs of current load reduction activities, (5) changes in cost and effectiveness of load reduction activities, and (6) socioeconomic, demographic, and land use change. Indeed, what was assumed about these various factors explains the differences in the EPA and stakeholder estimates of the cost of the NNC rule. Use of this framework can highlight differences in assumptions, help to narrow differences in the cost estimates if similar assumptions can be agreed to, and highlight how uncertainties can be reduced analytically or by clarification of ambiguities in the rules. What the framework also suggests is that the results of all cost analyses are contingent on the assumptions made by the analysts and that it is an unrealistic expectation of any analysis to produce a single, agreed upon cost estimate.

COMPARING THE NARRATIVE AND NUMERIC NUTRIENT CRITERIA RULES

For the purposes of this comparison, the water quality management process shown in Figure 1-8 was divided into five stages. This section summarizes the actions taken during those five stages under the narrative rule (which is considered the baseline), under the NNC rule that was the motivation for this report, and under the recently proposed Florida rule which EPA has agreed to consider as an acceptable replacement for the NNC rule. The following descriptions of the rules were derived from detailed flow charts created by the Committee for each rule (see Appendix A).

Description of the Rules

The five stages begin with the identification of impaired waters and end with an evaluation to ascertain when the designated use is met. The stages are shown as row headings in Table 3-1. The cells in the table are abbreviated descriptions of the rules' content.

Stage 1: List Waters as Impaired

Stage 1 establishes whether a waterbody is going to be listed as impaired. The narrative rule uses various biological condition indices (depending on the type of water body) as criteria to serve as a proxy measure for the designated use. The water is listed when evidence that the biological condition is unacceptable becomes compelling. To be deemed compelling, the data must be adequate in quantity and quality. If the monitoring data are deemed inadequate, the water is placed on a planning list for further evaluation, before it can be placed on the verified list of impaired waters.

The proposed Florida rule also requires violation of biological criteria for placement on the verified list, but streams will be placed on the planning list if nutrient concentrations exceed a threshold value. To move a waterbody from the planning list to the verified list requires confirmation of biological impairment. In addition, the proposed Florida rule includes a provision to place waters on the planning (not verified) list if they show an adverse trend in biological response variables or dissolved oxygen (DO), even if waters did not fail any of the biological indicators.

The NNC rule measures ambient concentrations of nutrients (N and P) in the water and compares those to ambient concentration criteria that were established for reference water bodies in the region, according to water body type. If the monitored concentration exceeds either criterion then the water is deemed to be impaired, even though there may be no measured biological impairment.

Because the NNC rule offers explicit limits for ambient nutrient concentrations, listing proceeds at a faster pace than under the narrative or the proposed Florida rule due to the more complex evaluation that is required under that latter two for biological assessments. However, the proposed Florida rule will place streams on a planning list if they exceed a nutrient threshold or show adverse trends in measurements of dissolved oxygen or biological condition. Thus, the proposed Florida rule could expedite the identification of waters that are likely to be impaired due to nutrients as well as the development of TMDLs and Basin Management Action Plans (BMAPs) for those waters, relative to the narrative (but not the NNC) rule.

Stage 2: Establish Stressor

Stage 2 in the narrative rule determines whether nutrients are the stressor causing the impairment. This determination is based on analytical procedures (stressor–response relationships) to establish whether N, P, or both are causing the impairment and at what levels might they be creating unacceptable biological conditions. The FDEP may also presume that nutrients are one stressor if the level of N or P is above a threshold concentration in reference waters. If the narrative rule determines that one or both nutrients are the cause of unacceptable biological conditions, *nutrient targets* as loads or concentrations are established as an outcome of the TMDL process during Stage 3. The proposed Florida rule is essentially the same as the narrative rule for this stage.

Stage 2 under the NNC Rule is less explicit because during Stage 1 the NNC Rule has already listed a water as impaired based on the presence and level of nutrients. However, the NNC Rule does recognize the possibility that there may be site-specific conditions that warrant different criteria and it allows for any entity to petition EPA for approval of site-specific alternative criteria (SSAC) for a specific location (http://www.epa.gov/region4/water/wqs/). The petition could result in a change in the nutrients to be controlled (to either N or P, as opposed to both) and/or changes to the ambient concentrations of either nutrient. This petition can be filed with EPA at Stage 2 (or at any other stage) after a water is listed as violating the numeric nutrient criteria. According to draft EPA guidelines (EPA, 2011), the FDEP can submit any waterbody with an existing TMDL-derived target (if expressed as a concentration) for approval as an SSAC. It is uncertain whether the TMDL targets will be accepted as SSACs, although EPA cites a memo that says targets can be SSACs for the interim purpose of setting NPDES permit limits.

TABLE 3-1 Comparison of Narrative, Numeric, and Newly Proposed Florida Rule For Nutrients.

Stage	**Narrative Rule**	**Numeric Nutrient Criteria Rule**	**Proposed Florida Rule**
1. List Waters as Impaired	Based on biological impairment for streams, lakes, and springs	N and P assumed to cause impairment if criteria are exceeded and water automatically placed on verified 303(d) list. *Streams and Lakes:* • N and/or P exceeding criteria • Point sources subject to permits containing N and/or P limits *Springs:* Nitrate exceeding criterion	*Streams and Lakes:* • Based on 1) biological impairment; 2) exceeding nutrient thresholds coupled with biological impairment, or 3) adverse nutrient trend *Springs:* Nitrate exceeding threshold
2. Establish Stressor	Determine if N and/or P are stressor(s) causing biological impairment	Petitioners have opportunity to seek EPA approval of site specific alternative criteria (SSAC) to replace the NNC for P, N or both.	*Streams and Lakes:* Determine if N and/or P are stressor(s) causing biological impairment • If stressor identified, water placed on verified 303(d) list for TMDL development; otherwise additional study required • If adverse nutrient trend is predicted to impair a water w/in 10 years, place water on 303(d) study list • If adverse nutrient trend predicted to impair a water w/in 5 years, place water on verified 303(d) list *Springs:* No stressor analysis if nitrate threshold exceeded
3. Define Level of Nutrient Reduction/Write TMDL	Model water quality conditions to relate desired biological condition to N and/or P loads; Determine N and or P targets	Model water quality to determine loads of N and P that result in ambient N and P numeric criteria concentrations	*Streams and Lakes:* Model water quality conditions to relate desired biological condition to N and/or P levels; Determine N and or P targets. *Springs:* Load reductions based on meeting nitrate threshold
4. Develop TMDL/ BMAP Implementation	BMAP process seeks WLA/LA load reduction balance across sources	WLA set by NPDES permitting process/ LA the remainder for non-point source.	BMAP process seeks WLA/LA load reduction balance across sources
5. Determine Use Attainment	Biological condition attained; N and P targets revised to be consistent with meeting required biological condition.	N and/or P ambient concentration of NNC or SSAC must be met. Biology may or may not remain impaired.	Biological condition attained; N and P targets revised to be consistent with meeting required biological condition.

Stage 3: Define Level of Nutrient Reduction/Write TMDL

At Stage 3, a narrative-rule-driven TMDL will establish concentration or load targets that are predicted to secure an appropriate biological index. The targets may be for N or P, but not necessarily both. It is also at this stage that the waste load allocation and load allocation are established. This division between the waste load allocation and load allocation is based on Florida policy (FDEP, 2001).

Stage 3 occurs similarly under the proposed Florida rule. As currently written, the proposed Florida rule affirms that a numeric TMDL target approved by EPA under the current narrative rule would be the numeric nutrient target for that waterbody. This is not a change from the narrative rule, but under the NNC rule the waters that already had a TMDL and a nutrient target would have still been required to define that target as a concentration (if it was only a load limit in the TMDL), relate the concentration to biological response, and submit that concentration as a proposed site-specific alternative criteria (SSAC) to EPA.

The TMDL analysis under both the narrative rule and the proposed Florida rule requires models that relate loads to ambient chemistry and then to the biological conditions. These will be more complex than the models required for an NNC-derived TMDL. The difference in TMDL model complexity and the different ways that the waste load allocation is defined between the NNC and the narrative rule may allow for the development of a TMDL more quickly under the NNC rule. Also, the NNC rule may accelerate the reduction of loads from NPDES-permitted municipal and industrial sources because a water quality-based effluent limit (WQBEL) may be set for those discharges independent of and prior to the TMDL.

The NNC-based TMDL will be established using models that relate nutrient loads to the ambient concentrations, as defined by the criteria. The NNC rule will establish a TMDL to assure that concentrations are met for *both* N and P, unless there is approval of a SSAC. These WQBELs may define the WLA with the residual load allocation being given to the non-NPDES permitted sources.

Stage 4: TMDL Development/BMAP Implementation

At Stage 4, the narrative rule and the proposed Florida rule implement load reductions by writing NPDES permit limits as a part of the BMAP to implement the TMDL. As the NPDES permits are issued to secure the waste load allocation, the plans for the non-NPDES sectors are prepared and implementation begins, employing the various tools available, to meet the load allocation.

Under the NNC rule, it is possible that permit limits for point sources may be established as early as Stage 1, thus focusing the TMDL on defining the load allocation. A key difference of opinion about the requirements in Stage 4 hinges on what is assumed about the way the NNC rule affects the NPDES permit limits and when that effect occurs. Otherwise the pace of development for the implementation plans is the same for all three rules.

Stage 5: Determine Use Attainment

Stage 5 tracks implementation and continues monitoring of ambient waterbody conditions. If the criteria are met then a determination is made that the designated use has been attained. However, monitoring does not stop and loads limits must continue to be maintained in the face of population and economic growth to assure that the water does not become impaired at a future date. The narrative rule and the proposed Florida rule focus their determination of attainment on ongoing bioassessment along with measurement of all stressors. If the TMDL target concentration is met, but biological conditions are not, the TMDL and implementation plan are revised to require further reductions in load, unless a Use Attainability Analysis is submitted and approved. If the biological criteria are met before the nutrient targets are met, the TMDL and implementation plan may be revised and further load reductions would not be required.

Under the NNC rule, monitoring for nutrient concentrations and load reductions will continue until the numeric nutrient criteria are met. There is always the opportunity to petition EPA for an SSAC to shows that reductions are no longer needed to meet the designated use.

Key Differences Among the Rules

Listing and Stressor Assessment

The selection of the biological criteria that best represent the designated use and the determination of "data sufficiency" to determine impairment are central to the execution of the narrative rule. If the criteria are acceptable proxies for the designated use[1], the determination of whether the data are sufficient to establish impairment is, in effect, a decision on acceptable error when making a listing and stressor assessment.

The narrative rule makes an impairment determination based on biological conditions and then moves to further analysis to determine if that the impairment is attributable to nutrients (N or P or both) and at what levels. This further analysis defines targets for N and P that are predicted to protect the designated use. A listing based on numeric nutrient criteria simultaneously concludes that either or both nutrients N and P (depending on ambient nutrient concentrations) are the cause of failure to meet the designated use.

In the language of statistics, the null hypothesis is that the water is not impaired. A type I error is concluding that the water is impaired when it is not. A type II error is concluding that the water is not impaired when it is. The likelihood of error is not of interest in itself; what is of interest is the cost of making that error. The cost of a type I error is making load control expenditures from a limited budget that were not necessary to meet the designated use of one or more waterbodies—called the cost of over-control. The cost of type II error is the water quality benefits that are lost when a waterbody is not listed as impaired when it is impaired and so load controls are inadequate—called the cost of under-control.

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[1] The extent to which the biological criteria are adequate in representing the designated use is one concern of critics of the narrative rule; that is, if the criteria are inadequate then the criteria may be met, but the designated uses will not be. The result will be that water quality benefits will be forgone, even as the criteria are met.

While it is not possible to clearly conclude which rule is more prone to which type of error, there are some general observations that can be made. The advocates for the narrative rule want to avoid making a type I error (that is, they want to avoid over-control). The proposed Florida rule continues this focus on avoiding type I error, but in an effort to recognize and accommodate the type II error it includes the modification to Stage 1 and 2, described earlier, in which waters with downward trends in chemical condition are put on a planning list. The NNC rule advocates want to avoid type II error (i.e., under-control), and in an effort to recognize and accommodate the possibility of a type I error, it includes the SSAC rule.

Table 3-2 further describes the differences in the rules as responses to the cost of error. Case 2 suggests that if the SSAC rule is not employed, the NNC-listed waters may be listed incorrectly for N, P, or both, leading to a misallocation of TMDL planning and load reduction efforts and costs. Cases 2, 3, or 4 suggest that the NNC rule can be too limiting, or not limiting enough, on discharges of P, N, or both. If the NNC rule were to replace the narrative rule, and if the SSAC option was not employed, there could be cases of both over control and under control, with the associated costs of each error. These are not hypothetical possibilities; rather a comparison of TMDL nutrient targets with the numeric nutrient criteria suggests these differences are real possibilities (see Box 3-1). All of this suggests that the SSAC rule, including its likely use and cost, is very important when describing the differences in the rules.

According to the draft guidelines (EPA, 2011), the SSAC rule would be based on analytical approaches that provide evidence, satisfactory to the EPA, that alternative levels of N, P, or both will protect the biological designated uses for both the waterbody and any downstream waters. It is reasonable to conclude from the draft guidelines that the analytical approaches that might be used to support a request for an SSAC are similar to those analyses already in use in the narrative rule. For example, a place-based stressor response analysis might be prepared for the SSAC application to demonstrate that a concentration of nutrients different from the numeric nutrient criteria would support the designated use. In the narrative rule, a similar place-based stressor response analysis is often used to identify what nutrient levels could exist and still be supportive of the designed uses (Stage 2).

TABLE 3-2 Narrative and Numeric Nutrient Criteria Rules Differences for a given waterbody.

	NNC not Exceeded	**NNC Exceeded**
Biological Condition Acceptable in WBID and downstream	Case 1. Neither rule would list the waterbody as impaired.	Case 2. Numeric rule would list the waterbody as impaired for N, P or both; some entity could petition EPA for a SSAC. Narrative rule would not list the water as impaired.
Biological Condition Not Acceptable in WBID and downstream	Case 3. NNC rule would not list the water as impaired. Narrative rule would list the waterbody, then ascertain if the stressor was nutrients and if so it would set nutrient targets.	Case 4. Both rules would list the waterbody. Narrative rule would develop targets that could be greater, equal to, or lower than NNC.

Box 3-1
Do Numeric Nutrient Criteria Differ Significantly From Nutrient TMDL Targets Developed Under Narrative Criteria?

Data were provided in Appendix H (Exhibit 2-8) by EPA (EPA, 2010b) for waters that have been through Stage 3 of the narrative process and already have nutrient targets assigned by the FDEP. These data were examined to draw a preliminary conclusion about whether the numeric nutrient criteria would differ from the nutrient targets. However, these conclusions cannot be extended to waters that have not been through Stage 3 of the narrative process because the results are not based on a random sample of impaired waters but rather are based on data from those waters that are already have targets. The narrative rule will put a priority on the places where the impairments are most obvious and so the existing narrative targets may not be representative of the targets that would be established for other waters in the future. Within this limitation, the results showed the following:

- Narrative TMDL targets for river nitrogen are generally lower (i.e., more stringent) than numeric criteria
- Narrative TMDL targets for river phosphorus are lower than numeric criteria
- Narrative TMDL targets for lake nitrogen are generally lower than numeric criteria
- Narrative TMDL targets for lake phosphorus are generally higher than numeric criteria

In general, additional load reductions will be required for lakes determined to be impaired for phosphorus under the NNC rule compared to the narrative rule. However, in the case of impairments for river nitrogen or phosphorus, or for lake nitrogen, lesser load reductions would be required by the NNC rule than with the narrative target.

There are other key differences between the rules at Stage 2, if not in the analyses themselves. The SSAC occurs *after* a waterbody is listed as impaired for nutrients and is only completed at the discretion of a petitioner (such as a state agency, discharge source, or a nongovernmental organization, NGO) who would seek an alternative to the numeric nutrient criteria. Therefore, even though the SSAC opportunity exists, it may not be taken and so there may be no costs for the SSAC. In addition, under the NNC rule, waters that have an established nutrient TMDL target that is less stringent than the numeric nutrient criteria with respect to N or P loads would need to be submitted to EPA for approval as SSAC.

NPDES Permitting and BMAP Differences

The EPA economic analysis assumed that there would be no differences in NPDES permit concentration limits or when the limits would be established if the narrative criterion was replaced by the numeric nutrient criteria. Under the CWA, the presence of a numeric limit for an ambient concentration of a pollutant (in this case N and P) may replace the best-available-technology requirement in setting an NPDES permitted source effluent limit with a water quality based effluent limit (WQBEL). The WQBEL may come into effect as soon as a water is listed as impaired by the NNC rule (Stage 1), even if a TMDL has not been written and a BMAP put in place. Also the NNC rule creates the possibility that the ambient numeric nutrient criteria becomes an end-of-pipe concentration limit, or a limit that must be met at the edge of a defined mixing zone, if a mixing zone is allowed. For these reasons, it is reasonable for point source dischargers to assume that the numeric nutrient criteria, derived from outside a TMDL, eventually must become NPDES effluent concentration limits, although temporary variances are possible. This temporary relief may be extended if the source seeks and gains approval for a use attainability analysis or SSAC. Conversely, in the narrative rule the effluent limit for a point source is developed integral with the TMDL process, so until the TMDL is in place, the NPDES permit is based on the best available technology.

The TMDL process, once completed, assigns a waste load allocation to the NPDES-regulated sources; the waste load allocation may or may not result in effluent concentration limits equivalent to the numeric nutrient criteria, even for waters where the ambient target is more stringent than the numeric nutrient criteria, under the FDEP allocation (FDEP, *date*). At this point the TMDL and follow-on BMAP can allocate responsibility for load reduction to non-NPDES sources that might otherwise have been assigned to the NPDES sources under the NNC rule.

A COST ANALYSIS FRAMEWORK

The various cost estimations of EPA and other stakeholders differed according to the assumptions made about how the different rules are implemented. Conceptually, the incremental costs of adopting the NNC rule or the proposed Florida rule is the change in costs over what *would have occurred* under the existing narrative rule during all five stages of water quality management. Defining the baseline involves identifying both current and future conditions that would exist without the regulatory change over the period of analysis (EPA, 2010a). This requires making assumptions about the magnitude and timing of outcomes and costs for three alternative futures: one guided by the narrative rule, one under the NNC rule, and one under the proposed Florida rule.

Costs Defined

For the purposes of the new framework proposed in this section, three costs are defined as follows.

- *Nutrient load control costs* are the capital, operation, maintenance, and replacement costs incurred by dischargers to implement any action to reduce the discharge of N or P into a waterbody. These were the principal costs considered in the EPA analysis.

- *Administrative costs* are borne by public or private entities for ambient monitoring, assessment, developing plans (e.g., SSAC application and review, TMDL development, establishing a BMAP), permit issuance, permit compliance reporting and monitoring, negotiating and gaining agreement by landowners to implement BMPs, engaging in legal rules and challenges, etc.

- *Water quality opportunity costs* are the forgone benefits from not improving water quality to some particular level (see Box 3-2).

Box 3-2
Water Quality Benefits

The committee was asked to review those analyses that reported on the costs of possible nutrient load reduction actions. Other parts of the EPA (2010) report, not included in the committee task statement, included estimates of the water quality benefits from adoption of the NNC rule. By implication, the broader analysis implies that failure to adopt the NNC rule would result in water quality benefits being forgone; these forgone benefits being a "water quality opportunity cost" of continuing with the narrative rule. This opportunity cost argument was made to the Committee in several letters and presentations by Florida-based and national NGOs. They asserted that it was inappropriate and perhaps misleading to review only incremental load reduction and administrative costs. The Committee did not review the EPA described benefits of the NNC rule.

The continuing interest in this topic warranted the presentation in this chapter of the way to frame future analyses to accommodate these concerns. However, this is not a call for detailed water quality modeling for large and complex systems, followed by quantification of benefits (as was done in the EPA analysis). It is, rather, a recognition that a cost analysis will also need to report on assumptions about how different actions taken at different times are more or less likely to protect designated uses, with considerations to response lag times, legacy loads, and demographic and economic growth and change.

Timing and Cost Uncertainty

As discussed in the first section of this chapter, the three rules differentially affect the timing of the five stages of water quality management, and as a result, also the realization of administrative and load control costs and water quality outcomes. However, timing was not considered in the EPA and other reports. The EPA estimates the incremental cost of the NNC rule as the annualized present value of nutrient control costs to fully meet the numeric criteria for the incrementally impaired waters and for the incrementally affected point sources. No date is given when this level of implementation would be achieved, but the impression that is given is that these costs would be faced soon after implementation.[2]

In fact, timing was not considered even though the proposed NNC rule was explicitly described by EPA as a way to "increase the pace of listing," with the implication that this would then accelerate the TMDL and implementation stages (King, 2011)[3], and despite the well understood reality that implementation under either narrative or numeric rules is constrained by the time required to conduct the necessary studies and by limited budgets and staff. Articulating when costs would be incurred and what level of implementation across the two rules can be expected would provide a more realistic and transparent means to compare the two rules in order to estimate the incremental costs and water quality outcomes. Furthermore, a more explicit and quantitative consideration of timing in the cost analyses would acknowledge that predictions of future conditions under various rules have to be made and that any such predictions is accompanied by substantial uncertainty.

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[2] Note that EPA's guidance on conducting economic analysis (EPA, 2010a) discusses the need to identify both a start and end point for comparing baseline and alternative policy scenarios.
[3] The environmental NGO community has made a similar argument in letters to the Committee and in other public statements.

In general, predictions of administrative and load control costs over time, and the resulting water quality outcomes, depend on many assumptions including (1) regulatory agency behavior, (2) future political and legal decisions/interpretations, (3) watershed response to load reductions, (4) unit costs of currently known load reduction activities, (5) changes in cost and effectiveness of control technologies, and (6) socioeconomic, demographic and land use change. Uncertainty can be attributed to a lack of knowledge about the cost of relatively untried technologies or the level of implementation required to meet water quality criteria. Uncertainty can also arise because of unknown future economic conditions and how behavior may change when program rules and incentives change. For instance, substantial uncertainty exists on how the implementation of the numeric nutrient criteria will be translated into effluent limits for point sources. Many of these key uncertainties cannot be eliminated by more data collection or analysis.

Of course, uncertainty does not need to be taken into account when making a water quality management decision if the future costs of being wrong are trivial. It is only when the future costs of a wrong decision are significant that uncertainty takes on relevance when making the initial decision, and demands that an analysis characterize and communicate those uncertainties. Analysts can characterize and communicate these decision relevant uncertainties (i.e. uncertainties that affect costs) in different ways. EPA's analysis included some discussion of uncertainty about the assumptions used in its analysis. Cardno ENTRIX performed an uncertainty analysis on the level of treatment and unit costs, relying on a data-limited Monte-Carlo simulation. A cost analysis framework that fully recognizes and incorporates timing and uncertainty is presented next.

The Framework Description

A cost analysis requires comparing the future time paths of costs at each stage under either the NNC rule or proposed Florida Rule to the narrative rule (the baseline). This means predicting of the level of activities at each stage for a series of future dates, under each rule, and in turn the timing of future costs. The analysis would be comprised of several tasks.

Task 1. Predict the decisions that would be made in each stage, for each rule. The predictions would be for specified time intervals, such as for five-year increments. This prediction requires a clear understanding of the differences in the rules, as described in the beginning of this chapter. The differences among the three rules can lead to different decisions at each stage of water quality management including which waters are impaired; which waters are stressed by nutrients, and which nutrients are the stressors; at what level do the nutrients become a stressor and how this level gets reflected in the TMDL; what are the implementation actions for load reduction, when are the actions required, and what sectors bear the responsibility and costs for those actions; and when has the designated use been attained so that additional load controls are not needed. Prediction of these decisions requires making assumptions about both the likelihood of any particular decision, and the relationship of that decision to others that follow in sequence. These different assumptions about both the ways the rules will work in practice, as well as about the cost estimates for certain load control practices, are the source of the very different cost estimates found in the EPA report compared to the competing analyses. In addition, these same differences of view lead the environmental NGO community to assert that the narrative rule and the proposed Florida rule will result in significant loss of water quality benefits.

Task 2. Estimate administrative and load control costs under each rule and for each future time period. Chapter 2 provides a detailed review of the EPA estimate of unit costs and lengthy discussion of the effectiveness of the load control methods. In the broader framework, there should be at least a narrative statement of the predicted water quality outcomes at each point in time.

Task 3. Characterize uncertainties in Tasks 1 and 2. Determine if the costs of uncertainty are likely to be high. If so, determine whether it is possible to assign probabilities to outcomes and compute expected values (and other moments of the cost distribution) or whether to conduct scenario analysis. Scenario analysis is a method for considering the importance of the most uncertain future conditions affecting an analytical outcome. Unlike single factor sensitivity analysis, scenario analysis requires describing different combinations of uncertain future conditions that taken together can create different outcomes. Building scenarios can help to isolate those combinations of possible future conditions that are most likely to have significant effects on (in this case) costs. Building scenarios can be a group activity that facilitates knowledge exchange and mutual understanding of central issues important to the results of the analysis.

Task 4. Calculate the incremental difference in total costs (costs of the proposed NNC rule less costs of narrative rule) and relate this to the incremental differences in water quality outcomes at each time period. The costs for the existing narrative rule would serve as the baseline for any comparisons.

Task 5. Record each result in a decision-making display. Figure 3-1 illustrates a template for a single set of assumptions. The rows in grey are decisions and actions at each stage in a rule and are identical to the rows in Table 3-1. There would be templates created for each set of assumptions for the narrative rule (the baseline) and then one for each set of assumptions under the alternative rule (here the NNC).

The content of the grey shaded cells is a description of the level of administrative and load control effort and when the effort is predicted to occur. For example, the cells in each figure can be used to describe when and how many waterbodies would be listed (Stage 1) over a fixed time period. The metrics used for each stage [e.g., the number of waterbodies assessed and listed as impaired (Stage 1), metrics of the stressor evaluation (Stage 2), the number of TMDL plans developed (Stage 3), metrics of the implementation of plans (Stage 4), and the number of waterbodies meeting the designated use (Stage 5)] should be predicted and the prediction explained, based on how the rule governs these stages and the available funding. Costs are calculated by multiplying the load reduction effort (grey cells) by the cost per unit of effort. This is how the EPA analysis was completed, but unlike the EPA analysis, this framework would make explicit that costs will occur at different times under the two rules.

FIGURE 3-1 Timeline of Stages and Related Costs for a Rule

	Year 0	Year 5	Year 10	Year 15	Year 20	Year 25	Year n
Stage 1 List Waters as Impaired							
Stage 2 Establish Stressor							
Stage 3 Define Level of Nutrient Reduction/Write TMDL							
Stage 4 Develop TMDL/BMAP Implementation							
Stage 5 Determine Use Attainment							
Administrative Costs	$___	$___	$___	$___	$___	$___	$__
Load Control Costs	$___	$___	$___	$___	$___	$___	$__
Administrative plus Load Control Costs	$___	$___	$___	$___	$___	$___	$__
Water quality outcomes							

The content of the cells, as well as the costs and outcomes, can be based on trend analysis of historical records, predictive models, statistical equations, and expert judgment. Once complete, the costs of the narrative process could be subtracted from the numeric process to get a total cost difference, which could be compared to the incremental differences in water quality outcomes and interpreted in light of the uncertainty of the total cost estimates of each process. This can be done for each time period and would provide information on the implication for annual public budgets and when water quality results might be realized. Of course the total cost of either rule can still be calculated as the difference in the present value of the annual total cost between the two rules.[4]

If uncertainty was not going to be considered in the analysis, then the grey cells simply would record what assumptions were made to warrant the costs shown. However, if there are different assumptions made, then the analysis described above would be repeated for each set of assumptions and cost estimates and water quality outcomes for the narrative process, and then for the NNC process and the array of different outcomes described. These different outcomes might be assigned a probability of occurrence and an expected value, or they may be left as individual scenarios (see Task 3).

Most importantly, the framework encourages decision participants and analysts to explicitly discuss and test assumptions and transparently articulate the differences in costs that might result from these assumptions. For instance, the number of permits modified and stringency of controls within the permits over the period of analysis can be compared with and without the NNC rule. Such a comparison would clearly define what might occur under the

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[4] Also other outcomes of interest such as effects on employment could be made and reported in the same format.

baseline condition and transparently illustrate how the level and pace of activities would differ under an alternative rule and alternative assumptions.

How to Use the Cost Estimation Framework

This section offers illustrative examples of how an analyst might fill out the rows in the general framework described by Figure 3-1, for both the narrative (baseline) and the NNC rules. Because differences in the assumptions underlying how this might be done are often the source of disagreement, discussing how these tables are filled out can be an important means to clarify issues and create transparency in the evaluation of the various options. For exposition purposes, the proposed Florida rule is not included in this illustration.

Illustration 1: The Incremental Difference in Nutrient-Stressed Waters

This discussion illustrates how the incremental differences of the NNC rule at the end of Stage 3 can be described. Under the NNC rule EPA estimates that new waters would be listed (EPA, 2010b, p. 6-3) as nutrient impaired presumably almost immediately after the numeric nutrient criteria rule is adopted. However, it also is reasonable to assume that additional waters would be listed as nutrient impaired under the NNC rule in future years, since more than half of all waters could not be assessed due to insufficient data (note that EPA assumed no additional waters would be listed under the NNC rule beyond the initial assessment). An example of the time path of the number of nutrient-impaired waters listed (at the end of Stage 2) under the NNC rule is shown graphically by the blue line in Figure 3-2. The dashed lines indicate uncertainty bands on the estimate of new waters listed under the NNC rule.

Absent the implementation of the NNC rule, additional waters would also have been listed as biologically impaired under the narrative rule (in Stage 1), deemed to be stressed by nutrients (in Stage 2) and then assigned nutrient targets (in Stage 3). The total number of new waters deemed stressed by nutrients in the future under the narrative rule can also be estimated, as shown by the black line in Figure 3-2 (with associated uncertainty bars). The black line shows that a number of waters assessed and identified as stressed by nutrients will steadily be added to the impaired waters list under the narrative standard. FDEP conducts a number of WBID assessments each year and adds biologically impaired waters that are deemed nutrient stressed to its 303(d) impaired waters listed annually. Projecting this historical pace into the future, the number of new waterbodies assessed, listed, and identified as nutrient stressed under the existing Florida narrative rule could be estimated.

The incremental effect of the NNC rule on Stages 1-3 is the difference between the blue and black lines over time (see Figure 3-2). Because EPA's analysis did not evaluate an implementation time path, EPA effectively assumed that the only incremental change was the initial new listing of waters (the difference between the blue line and black lines at a single point in time).

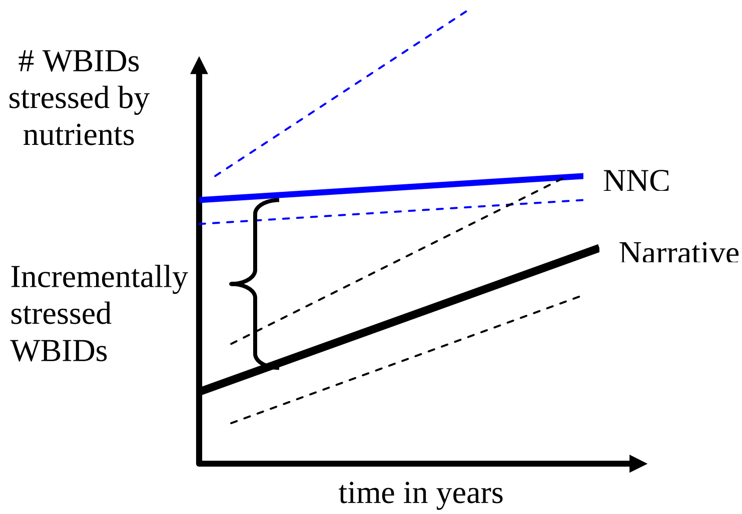


FIGURE 3-2 Illustration of Incrementally Listed Waters

A more complete analysis also would recognize that the narrative rule may list different waterbodies than the NNC rule and ultimately the narrative may require different nutrient targets than the numeric nutrient criteria. Conceptually more waters could be deemed nutrient stressed under the narrative rule at the end of the evaluation period if the NNC rule misses waters that are biologically impaired. Conversely, the NNC rule may deem more waters as nutrient stressed at the end of the evaluation period if the NNC rule includes waters that are not biologically impaired, or if the resource intensive, but budget constrained, narrative rule moves at a slow pace. These and other possibilities are the basis for creating the uncertainty bands. Assumptions and analysis regarding the different possible outcomes produced by the two rules will ultimately have consequences on estimates of nutrient control costs that will be incurred.

Illustration 2: Administrative Costs for Listing and Stressor Assessment

As described above, the two rules entail a number of activities, each requiring a resource commitment to assess and perhaps re-assess waters for possible nutrient impairments. These costs were not estimated in the EPA analysis, but as described above represent important differences between the two rules. These differences in turn, will generate incremental administrative cost differences between the narrative rule and proposed alternatives.

An illustrative example of the possible relative magnitude and time path of some administrative costs incurred by the narrative and NNC rules is shown in Figure 3-3. Two administrative costs are shown, one representing the cost of listing waters as impaired and the possible administrative costs of an SSAC rule. In each illustrative graph, the time path of annual administrative costs under the narrative rule is show in black while the time path of costs under

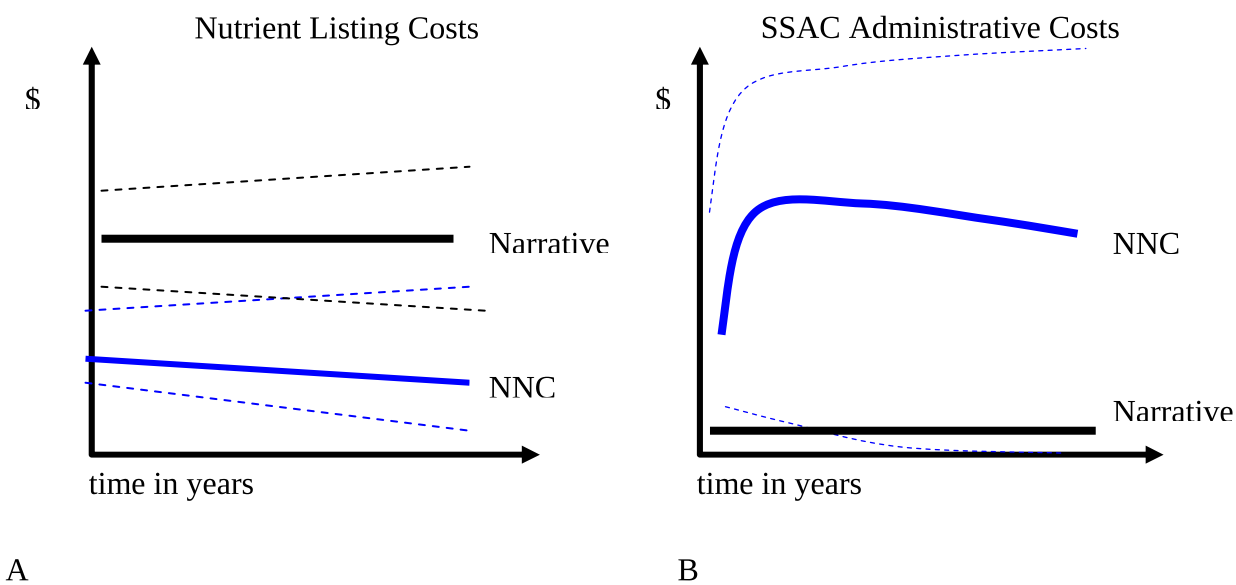


FIGURE 3-3 Illustration of Select Administrative Costs.

the NNC rule is shown in blue (the difference between the two represents the incremental cost of the proposed NNC rule).

Figure 3-3(A) shows the timing and uncertainty of possible future listing administrative costs under the narrative rule and NNC rule. The narrative rule requires a substantial commitment of staff and monitoring resources to identify waters of potential concern, biological monitoring, and stressor-response analysis to identify the cause of the biological impairment. Over time, the annual cost of listing activities may be fairly stable, but could increase or decrease over time (as shown by the uncertainty bands). The NNC rule avoids many of these costs and accelerates the determination of whether a waterbody is to be listed as nutrient impaired. The cost of making that determination is limited to the cost of chemical water quality monitoring and determined through a predefined sampling procedure. While the magnitude and direction of these listing costs under the NNC rule is uncertain, the relevant point is that it is reasonable to conclude that the NNC rule would produce a net incremental cost savings in the administrative costs associated with the listing (difference between two cost time paths).

The NNC rule allows numeric criteria to be adjusted to take site-specific conditions into account through an SSAC rule. Public and private costs, including administrative, analytical, and legal costs, would be incurred for the SSAC and need to be considered as a part of a cost analysis of the NNC rule. The SSAC cost would represent a potentially significant, but highly uncertain, new cost borne by those who would be expected to petition for an SSAC. Figure 3-3(B) illustrates what SSAC costs could be under the assumption that petitioners will challenge a portion of a large increase in newly listed waters under the NNC rule (solid blue line). SSAC administrative costs could then gradually decrease as the number of cases declines. By comparison, SSAC costs are modest under the narrative rule (black line). Also, as has been noted elsewhere, SSAC costs may also be incurred for waters already listed as impaired under the narrative standard. Possible legal challenges for the existing TMDLs could also potentially escalate SSAC administrative costs further.

The uncertainty bands surrounding SSAC costs under the NNC process are shown as large (especially the upper bound) because of higher type I (over-control) error rates under the NNC and the highly contentious nature of water policy in Florida, which might inflate legal and administrative costs of conducting SSACs.[5] On the other hand, the administrative costs incurred in the SSAC rule might be low because either type I errors are low or the barriers to SSAC participation are so high that petitioners avoid the rule entirely.[6] Regardless, this discussion illustrates that the NNC rule potentially creates significant new SSAC-related administrative costs.

EPA did not include costs for the SSAC process in its analysis, because it asserted that the SSAC-like costs associated with site-specific biological assessments are similar to those undertaken under the narrative rule [in other words, the higher costs in Figure 3-3(B) offset the lower costs in Figure 3-3(A)]. However, there are various legitimate reasons to believe this will not be the case. Given the untested nature of the SSAC rule, it is not clear that the total SSAC and administrative listing costs would ever be the same, yet it is certain that the party that would bear the costs is different.

Illustration 3: Timing of Municipal and Industrial Permits and Nutrient Control Costs

Chapter 2 reviewed the estimation of nutrient control costs and uncertainties for municipal and industrial wastewater plants with NPDES permits. This analysis builds on the previous chapter by highlighting the substantial cost differences between the narrative and NNC rule related to the timing of point source control costs. The general pattern of the timing of permit modification and future compliance costs under the NNC and narrative rules is shown in Figure 3-4. According to EPA's assumptions, all industrial and municipal point without sufficiently stringent nutrient limits would face new nutrient effluent limits in their permits under the NNC rule. Presumably, these permits would be modified within five years of adopting the NNC rule and implemented independently of a TMDL. Thus, the point source control costs would also be incurred soon after the NNC rule is adopted, with a WQBEL being set possibly at the level of the numeric nutrient criteria. Under the narrative rule, some point source permits would also be incrementally tightened, but this would occur gradually as TMDL plans are developed and implemented in watersheds with these point sources. The number of future permit modifications under the narrative rule could be estimated by obtaining the historical pattern of permit modifications. Figure 3-4(A) suggests that point sources would likely bear the brunt of cost increases in the initial stages of NNC Rule implementation.

The difference in point source control costs between the narrative and NNC rules is a function of the rate of permit modifications and differences in unit costs. Cost differences are magnified further when considering that the two rules will likely produce different levels of

[5] Similarly, administrative SSAC costs could be higher if the N or P targets in the existing TMDLs are not accepted as SSACs. If the TMDLs are not accepted as SSACs then there will be additional administrative and control costs by either conducting a new SSAC or due to additional nutrient targets imposed by the NNC.
[6] Given high administrative barriers and high type 1 errors, the NNC process could potentially increase the control costs faced by the different source sectors (see below) by increasing the amount of area covered by a TMDL.

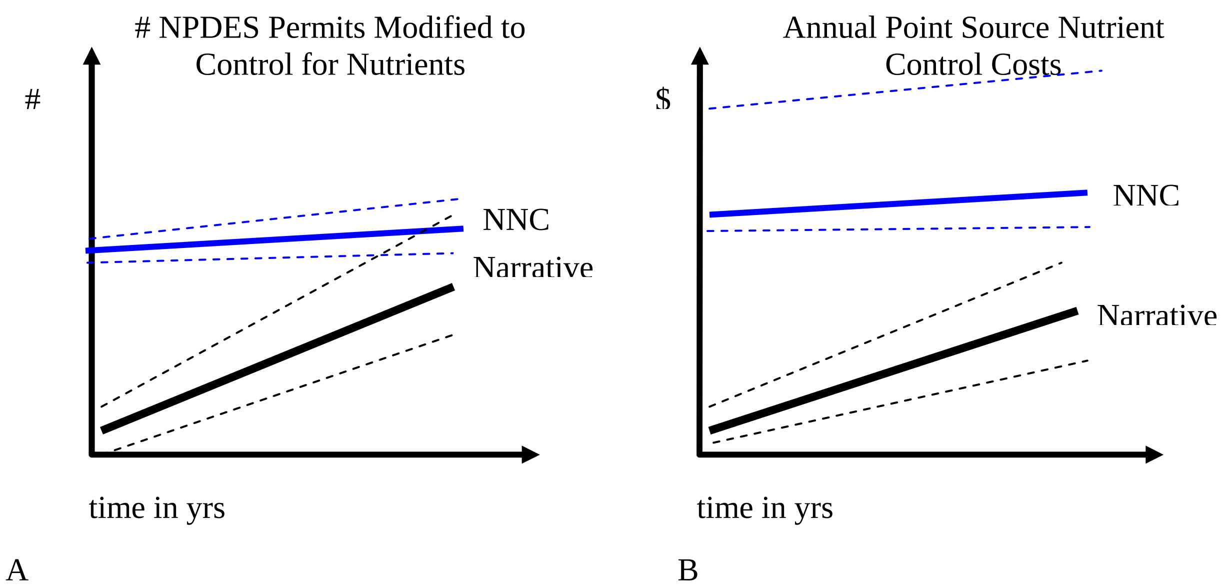


FIGURE 3-4: Illustration of the Timing and Uncertainty of Point Source Costs

control requirements; that is, at Stages 4 and 5 there might be significant differences in which nutrients have targets for a given waterbody and by how the targets differ from the numeric nutrient criteria. As Chapter 2 highlights, the upper bound estimates of costs to meet the numeric nutrient criteria themselves in plant discharges could be very high [see upper bound dashed blue line on Figure 3-4(B)]. Point source costs would increase more slowly under the narrative standard both because permit requirements are phased in over time and effluent limits would be established under Florida TMDL and BMAP rules (which historically has not required end-of-pipe level controls). Arguably there is less cost uncertainty under the narrative rule than the proposed NNC rule.

Illustration 4: Control Costs for Nonpoint Sources

A stated objective of the NNC rule is to accelerate the implementation of nutrient controls (King, 2010). Assuming that sources outside the NPDES program dominate loadings, under either the narrative or numeric process the majority of nutrient control efforts will be initiated via TMDL development and BMAP implementation (Stage 4 in Figure 3-1). EPA estimated the incremental costs of developing TMDLs and BMAPs that would occur under the NNC rule with no implementation time frame given and with no consideration to what would have occurred in the absence of the proposed rule.

If one considers the difference in costs across time, it is clear that the NNC process would create a larger number of listed waters immediately. However, conducting a TMDL analysis and developing a TMDL/BMAP plan are resource- and time-intensive, with the rate of implementation linked to the level of public cost share support for staff resources and the adoption of control practices. Faced with limited budgets, there already exists a backlog of listed waters without an implementation plan. Currently, only a relatively small portion of all waters listed as nutrient impaired have completed a TMDL and even fewer are under an active BMAP (EPA, 2010b, p. 2-23). Based on past rates of implementation, waters that might be listed immediately under a numeric rule may require years to develop TMDLs and BMAPs. Thus, the pace of TMDL/BMAP development under both rules is expected to be similar and to gradually increase over time [see the black and blue lines in Figure 3-5(A)]. The time path of plan development is shown as slightly lower under the narrative process because TMDLs may be more analytically challenging due to having biological endpoints. Nonetheless, the relevant point is that the incremental difference between the two rules in terms of when and how many waters will be under an active BMAP plan is predicted to be relatively small due to the existing implementation bottleneck [difference between the blue and black lines in Figure 3-5(A)].

The cost implication of these constraints and limitations on the TMDL/BMAP implementation process is that the cost differences between the NNC and the narrative rules could be small. Figure 3-5(B) shows the differences in nonpoint source control costs of implementing actions to meet the numeric nutrient criteria relative to meeting the narrative targets. Under both rules, nonpoint source control costs will be incurred and these costs will likely increase over time as more expensive efforts are pursued to achieve the water quality criteria. Yet, the difference between the NNC and narrative nonpoint source control curves, which is the incremental cost of the proposed rule, is small, assuming the funding and staffing constraints will be similar across processes.

Figure 3-5(B) also illustrates the substantial uncertainty associated with nonpoint source administrative and load control cost under either rule. Chapter 2 discussed the uncertainty surrounding nonpoint unit control costs for both agricultural and urban sources, as well as the level of application (number, type and effectiveness of BMPs) needed to achieve nutrient targets/criteria. However, these uncertainties exist under either future process and are arguably substantial. On the other hand, there are possible differences among rules that may lead to different costs for nonpoint sources. For example, the NNC rule requires the achievement of both nitrogen and phosphorus targets in a TMDL plan while the narrative standard may only target one nutrient. Achieving two targets will be more costly than achieving just one, thus increasing the incremental cost of the NNC rule (holding other factors constant). However, the stringency of the final nutrient limits that emerge in the TMDL process under the narrative process is itself uncertain. It is possible that more stringent nutrient requirements would be necessary to achieve biological criteria under the narrative rule (see Box 3-1), increasing the potential costs under the narrative and reducing or eliminating the cost differences between the two processes. What this suggests, and what is shown in Figure 3-5(B), is that the *incremental* increase in nonpoint control costs is highly uncertain.

Finally, such an analysis also clearly distinguishes between the incremental and the total cost of achieving nutrient standards. While the difference between nonpoint source control costs under the two rules can be analyzed and debated, it should be clear that the costs to reduce nonpoint source discharges to meet water quality standards *under either rule* are going to be high and the costs are only likely to increase over time if water quality criteria are to be achieved.

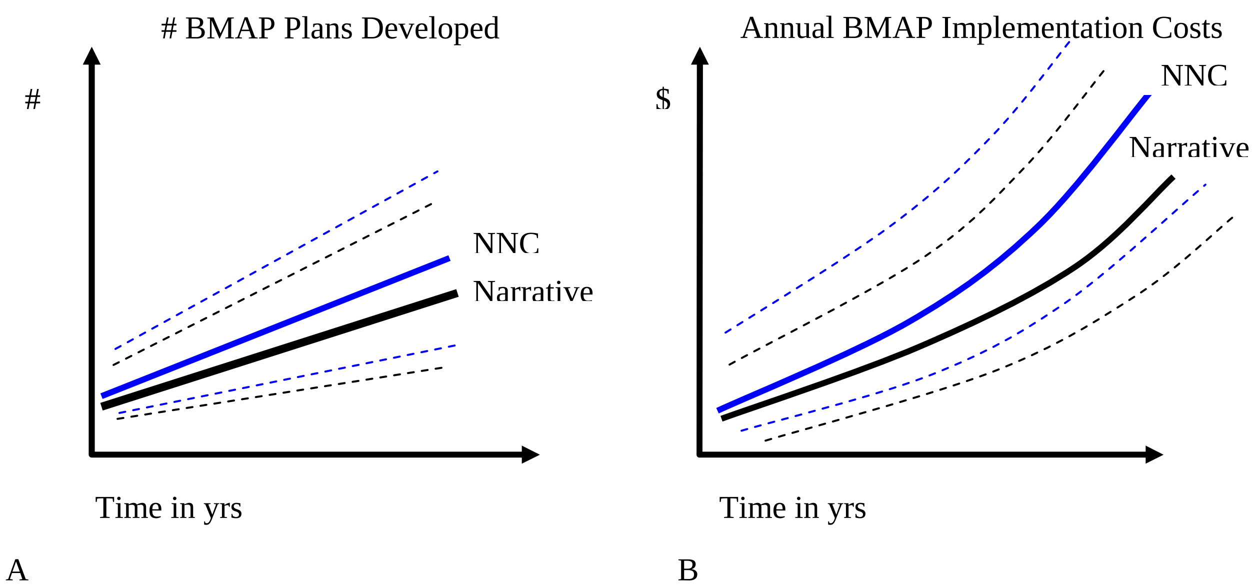


FIGURE 3-5: Illustration of the TMDL and NPS Control Costs Time Paths

Illustration 5: Ambient Water Quality Outcomes

A final illustration is provided regarding the pace of water quality outcomes under the narrative vs. the numeric process. In seeking to reduce the likelihood of type II error (undercontrol), the NNC rule accelerates both the pace of listing and the imposition of controls and costs for point sources. It is possible that reducing the delay in getting to the implementation stage under the NNC rule will reduce the risk of a loss of water quality benefits over the short or long term. That is, the NNC rule might be expected under some assumptions to result in incremental improvement in water quality outcomes and in more waterbodies meeting their designated uses at certain points in the future (see Figure 3-6).

On the other hand, the discussion above indicates that because the NNC rule does not alter the regulatory and budgetary constraints on nonpoint source controls, the acceleration of water quality improvements that occurs over time could be modest. Furthermore, as Chapter 2 points out, considerable uncertainty exists as to the extent and intensity of controls that will be necessary to achieve designated uses in impaired waters. This uncertainty has the potential to push achievement of water quality objectives further out into the future, such that the differences between the rates at which waters meet designated uses under the two rules might be modest or even nonexistent (see Figure 3-6).

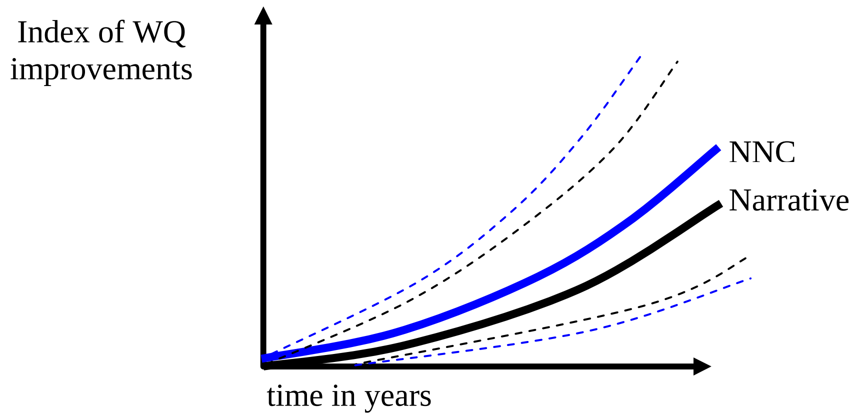


FIGURE 3-6: Progress toward Meeting the Designated Uses

TRANSPARENCY AND DISPUTE RESOLUTION UNDER THE PROPOSED FRAMEWORK

As has been emphasized, it is only when the future costs of a wrong decision are significant that analytical uncertainty is relevant to making a decision. In the water quality management context, one possible cost consequence of analytical error is that assessment decisions and subsequent control actions may lead to control of nutrients in places where nutrients were not the stressor or at levels that exceed those required to meet the designated use. If this was the result there would have been unnecessary load control costs placed on limited public budgets and on the financial viability of businesses. On the other hand, the argument offered by the environmental NGOs and supported by the EPA is that the narrative rule, in minimizing the possible error of over control of nutrients, makes water quality management too slow and inadequate in protecting designated uses. The dispute over the EPA cost analysis that was the reason for the formation of this Committee can be understood as a difference of viewpoints among agencies and stakeholders about the likelihood that different rules will lead to errors of over control or under control of nutrients and the cost consequences of those errors.

The cost analysis framework presented in the previous section can help to narrow disagreements over the assumptions that might be made to accommodate uncertainty over unit costs, effectiveness of load control, water quality response, and rule design. Thus, a report to decision makers organized around the likelihood and costs of analytical error serves a different purpose than the role often played by a traditional benefit–cost analysis, as represented by the EPA report. In the EPA analysis the rule was written and proposed and then a benefit–cost analysis was conducted to determine the justification for the rule as written. This is a standard application of benefit–cost analysis that proposes to answer a single question: “Is the rule change justified, or is it not?” To answer this question, different analyses had to make different assumptions (implicit or explicit) about how the rule would be implemented over time. The uncertainties in those assumptions could be reported in some fashion, as EPA and Cardno ENTRIX attempted to do in different ways. However, simply reporting uncertainty over benefits and costs, when the question is framed only as whether a predefined rule change is justified, does not contribute to stakeholders’ appreciation of uncertainty nor does it help develop water quality management processes to minimize the likelihood of both under-control and over-control of nutrients.

The analytical framework proposed in this chapter could be used in support of rule design and could then be transformed to provide an analysis of the justification of any given design. In fact, Florida's newly proposed alternative to the NNC rule remains focused on minimizing the possibility of load control cost error, although it seeks to address the criticism that the state has ignored the possibility of too little control on nutrients by having new listing and stressor assessment components during Stages 1 and 2. However, whether these modifications will achieve the desired result is unanalyzed, with the result that environmental NGOs are likely to oppose the new Florida rule. This is not to suggest that had EPA (and FDEP) followed the framework presented in this chapter that there would have been no opposition; however, it is the case that the analyses done to date have done little to bridge gaps that exist between stakeholders. Indeed, EPA conducted its cost analysis in a manner that led some Florida stakeholders to have concerns over its salience, legitimacy, and credibility (Jordan et al., 2011; Maguire, 2003).

The following are examples of different ways that reaching agreement on how the water quality management process would change under the various rules might have reduced differences in assumptions and narrowed the estimated cost differences:

- Increases in administrative budgets for assessment and monitoring could reduce the expected size of, and concern over, the costs of both type I and II errors (Shabman and Smith, 2003; NRC, 2001).
- The uncertainty about the SSAC guidelines led to wholly different assumptions by different stakeholder groups. Greater clarity and understanding about the SSAC process, which is central to the NNC rule, might lead to less divergence in assumptions about the cost of applying for SSAC and the likelihood of SSAC approval.
- There were different assumptions made regarding whether the numeric nutrient criteria would become WQBELs for NPDES permitted sources, with the EPA cost analysis assuming less stringent levels of control and being silent on when they would be imposed on NPDES regulated sources. Greater clarity and understanding of the way in which the NNC rule would affect NPDES permit limits might lead to less divergence in assumptions made about the resulting WQBELs.
- The implied assumptions in all analyses were that the TMDL and BMAP once set in motion by the NNC rule could not be altered by new information on costs, effectiveness, and water quality response. A more explicit inclusion of principles of adaptive implementation, and an associated budget commitment, may have lessened concerns about the costs type I and II errors (NRC, 2001; Shabman et al., 2007).

In the end, the "cost" of error depends on what a decision maker believes about the likelihood of an effect of the rule change and their own judgment about the future severity of the adverse consequences. Analysis can narrow, but not eliminate, differences of view about the uncertainty surrounding these two determinants of costs. Some stakeholders will have preferences that make them unwilling to accept the possibility of costs of over-control, while others will not accept a rule that they believe will bring about a possible loss of water quality benefits. Analysis cannot bridge such gaps in preferences.

FINDINGS

FINDING: The incremental costs of the NNC rule are attributable to more than an increase in waterbodies listed and a requirement that all NPDES-permitted municipal and industrial sources discharging to surface water have certain effluent concentration limits. In computing the incremental effect, the appropriate baseline should have been defined as what would have occurred *over time* under the existing (narrative) rule. Thus, an incremental cost is the difference in implementation costs between two (or more) alternative future implementation time paths.

Future cost analyses of rule changes would more fully represent areas of possible costs differences (administration, load control, and water quality opportunity costs) if they were more explicit in describing the differences between the rules *over time*. This could be done by analyzing and reporting costs as a cash flow over time, showing what sectors bear the costs as nutrient load reductions at different levels are pursued. Comparing the rules over time also can provide an opportunity to present a realistic picture of how the timing of water quality improvement actions might unfold with alternative rules, by illustrating the time lags between listing and achievement of water quality standards. Most importantly, reporting on timing would provide useful information for predicting annual budgetary requirements.

FINDING: Uncertainty is pervasive in estimating the incremental cost of implementing the NNC rule and is inadequately represented in the EPA analysis. In future analyses, reporting the difference in the time paths for implementation of water quality management rules, and associated uncertainties, would provide a more transparent and realistic way to compare costs of the different rules and provide more useful information about where, when, and how costs diverge.

FINDING: Some stakeholders viewed the EPA cost analysis as being superficial or of limited scope, leading to reduced credibility. The result was to foster disagreement about embedded assumptions rather than use the analysis to isolate and possibly reconcile sources of disagreement. Cost analysis as outlined in this chapter can help convey cost estimates in a more transparent way and thus facilitate learning, reduce misunderstandings among stakeholders, and increase public confidence in the results.

FINDING: Based on the conceptual reviews in this chapter and on the content of Chapter 2, the following broad findings are made about the differences between the NNC and narrative rules:

- Administrative costs for listing and TMDL development for FDEP will be lower under the NNC rule because there would be no biological assessment (unless FDEP is the SSAC petitioner). In part, this administrative cost reduction is made possible by the NNC rule shifting the responsibility for SSAC-like analyses to SSAC petitioners and away from the FDEP.
- Compared to the narrative rule, under the NNC rule the pace of listing and the number of waters listed will increase, but the rate at which TMDLs and BMAPs are developed and load controls implemented to meet the designated use will not necessarily increase.
- Municipal and industrial wastewater dischargers may face substantial near-term increases in cost under the NNC rule.
- Over time, there is significant uncertainty in nonpoint source load control costs under either rule because of uncertainty about the incremental increase in the number of listed

waters, about the nutrient target levels for N or P, and about cost and effectiveness of nonpoint source load control actions.

FINDING: Conducting the cost analysis as outlined in this chapter, with increased attention to careful assessment of rule differences, stakeholder engagement, and uncertainty analysis, might not have been possible with the budget and time EPA spent on its cost analysis. Any critique of the existing EPA cost analysis should recognize that some deficiencies may be traced to time and budget limitations.

REFERENCES

FDEP. 2001. A Report to the Governor and the Legislature on the Allocation of Total Maximum Daily Loads in Florida.

Jordan, N. R., C. Shively Slotterback, K. V. Cadieux, D. J. Mulla, D. G. Pitt, L. Schmitt Olabisi, J. Kim. 2011. TMDL implementation in agricultural landscapes: A communicative and systemic approach. Environ. Management. 48(1):1-12.

King, E. 2011. Presentation to the NRC Committee. July 25, 2011 Orlando, FL.

Maguire, L. A. 2003. Interplay of Science and Stakeholder Values in Neuse River Total Maximum Daily Load Process. Journal of Water Resources Planning and Management 129(4):261-270.

National Research Council (NRC). 2001. Assessing the TMDL Approach to Water Quality Management. Washington, DC: National Academies Press.

Shabman, L., and E. Smith. 2003. Implications of Applying Statistically Based Procedures for Water Quality Assessment. Journal of Water Resources Planning and Management 129(4):330-336.

Shabman, et al. 2007. Adaptive Implementation of Water Quality Improvement Plans: Opportunities and Challenges. Durham, NC: Duke University Nicholas School of the Environment and Earth Sciences.

U.S. Environmental Protection Agency (EPA). 2010a. Guidelines for Preparing Economic Analyses. Washington, DC: EPA National Center for Environmental Economics, Office of Policy.

U.S. EPA. 2010b. Economic Analysis of Final Water Quality Standards for Nutrients in Lakes and Flowing Waters in Florida. Environmental Protection Agency; November, 2010.

U.S. EPA. 2011. Technical Assistance for Developing Nutrient Site-Specific Alternative Criteria in Florida. June 2011. Interim Draft.

Acronyms

AWT	advanced wastewater treatment
BMAP	Basin Management Action Plan
BMP	best management practice
CAFO	concentrated animal feeding operation
CWA	Clean Water Act
DO	dissolved oxygen
DPV	downstream protection value
EPA	Environmental Protection Agency
FDACS	Florida Department of Agriculture and Consumer Services
FDEP	Florida Department of Environmental Protection
FDOH	Florida Department of Health
FWEAUC	Florida Water Environment Association Utility Council
FWRA	Florida Watershed Restoration Act
GIS	geographic information system
HUC	hydrologic unit code
IWR	Impaired Waters Rule
LA	load allocation
MF	microfiltration
MGD	million gallons per day
MLE	Modified Ludzack-Ettinger
MOS	margin of safety
MOU	memorandum of understanding
NGO	nongovernmental organization
NNC	numeric nutrient criteria
NOI	notice of intent
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
OIG	Office of Inspector General
O&M	operation and maintenance
OSTDS	onsite sewage treatment and disposal systems
PRB	permeable reactive barrier
RO	reverse osmosis
SCM	stormwater control measure
SIC	Standard Industrial Classification
SSAC	site specific alternative criteria

SW	surface water
SWIM	Surface Water Improvement and Management Act
TMDL	Total Maximum Daily Load
TN	total nitrogen
TP	total phosphorus
TRAP	Technical Review Advisory Panel
UCT	University of Cape Town
USDA	U.S. Department of Agriculture
WBID	Waterbody Identification Number[1]
WLA	waste load allocation
WQBEL	water quality-based effluent limit
WWTP	wastewater treatment plants

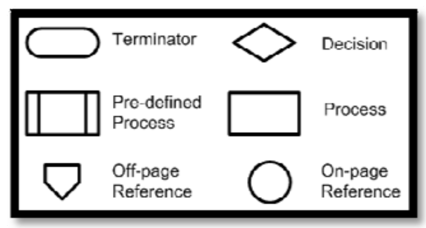
[1] WBID is used colloquially to refer to certain impaired waters, but technically the term also includes the surrounding drainage basin.

Appendix A

Narrative, Numeric, and Proposed Florida Nutrient Criteria Processes Illustrated

Figures A-1, A-2, and A-3 at the end of this Appendix describe the narrative, numeric, and proposed Florida nutrient criteria processes, respectively. The Committee was unable to find similar flow diagrams developed by either EPA or FDEP, so the diagrams were developed internally as a means to better understand the differences in the processes. The Committee does not contend that these diagrams precisely illustrate the manner in which EPA or FDEP would implement any of the three processes. Rather, the diagrams were developed at a level of detail sufficient to compare key steps in the processes and understand the sequence and timing of events necessary to implement nutrient criteria under each.

In each of the figures, common flow charting symbols are used. Rectangles represent processes, diamonds represent binary decision points (yes or no), while ovals represent terminal points in the process – a beginning or an ending. Circles and pentagons transfer the reader to other points in the processes where the next sequential step occurs if it does not directly follow the previous step in the overall process.



Figures A-1, A-2, and A-3 all reflect the continuing assessment process expected under the Clean Water Act (CWA). They begin with the identification and assessment of a waterbody. If that water is listed as impaired, steps follow leading to the development of a TMDL for the stressor; implementation of actions to reduce the pollutant loading (the basin management action plan or BMAP as required under Florida law); and finally a process to ascertain when the designated use is met (delisting in the CWA process). Beyond this general similarity, however, there are significant differences in the sequence of actions that occur in the three processes and what is assumed about the activities and the decisions encountered in each. These differences in assumptions can lead to differences in cost estimates.

In the current Florida narrative process (Figure A-1), it is apparent the process has additional steps for determining impairment compared to the EPA numeric nutrient criteria process (Figure A-2). First, the narrative process requires impairment identification for the narrative nutrient criteria – an imbalance of flora and fauna as determined by surrogate indicators. Once a determination is made regarding whether sufficient data exist and whether the data point to nutrients as a stressor, then the water is listed as impaired, a TMDL developed, and load reduction implemented through a BMAP. By contrast, the EPA numeric process (Figure A-2) simply determines impairment based on whether the N and P criteria are exceeded in ambient waters. If so, and if site-specific alternative criteria (SSAC) have not been developed, the water is listed as impaired and a TMDL developed and implemented.

In both processes, waters are determined to return to compliance and removed from the impaired waters list if the ambient water quality criteria are met. In the case of the narrative process, the water is removed once the water supports its biological use, while in the numeric process the waters are removed if the N and P criteria are met. The processes then begin another iteration of evaluating the waters for compliance with either the narrative or numeric criteria.

The proposed Florida process (Figure A-3) is significantly more complex than either the current narrative or EPA numeric nutrient criteria processes. The proposed process first ascertains if SSACs or TMDLs have been approved for a given waterbody. If a TMDL has already been developed, the process jumps forward to TMDL implementation or the BMAP process. If a TMDL has not been developed, but an SSAC has been approved, the waterbody is assessed against the SSAC. If an SSAC has not been approved, the waterbody is evaluated against "numeric interpretations of narrative nutrient criteria" (interpretations) and numeric nutrient thresholds. The thresholds are similar to numeric nutrient criteria in that numeric values are established for N and P. The main difference is that a failure of a threshold begins a process of additional study to see if biological impairments are manifested in the waterbody. If not, the waterbody is not deemed as impaired. If there is a biological impairment signal, the water is listed as impaired, a TMDL developed, and a BMAP developed and implemented.

Additionally, waters can be identified as impaired if there is an adverse trend in nutrients or nutrient indicators. In other words, if long-term data show a decline in water quality as evidenced by an adverse trend in either nutrient or nutrient indicator monitoring data, the water is studied further. If modeling indicates the adverse trend will result in a waterbody impairment within five years, the water is listed as impaired, a TMDL developed, and a BMAP developed and implemented.

Once a TMDL is triggered in the proposed process, the steps taken from that point on are essentially the same as the current narrative process. A TMDL will be developed and plan to implement the TMDL will be developed through the BMAP process.

As described in Chapter 3 of the report, both the narrative process and the proposed Florida process opt to minimize Type I error – listing a waterbody as impaired that is not truly impaired. Therefore, more study is required to identify biological impairments and to identify nutrients as stressors for the impairment. This additional study necessarily results in added time required to reach the TMDL stage in the overall process. The EPA numeric process opts to minimize Type II error – not listing a waterbody as impaired that is truly impaired. That practice moves more quickly to the TMDL stage of the process, but there is no apparent increase in the speed at which TMDLs will be developed and implemented.

Links to additional information on the three processes can be found as follow:

I. The current Florida narrative nutrient criteria process
   A. General historical information
      http://www.dep.state.fl.us/water/wqssp/nutrients/
   B. Rule 62-302 – Surface Water Quality Standards
      http://www.dep.state.fl.us/legal/Rules/shared/62-302/62-302.pdf
   C. Rule 62-303 - Identification of Impaired Surface Waters
      http://www.dep.state.fl.us/legal/Rules/shared/62-303/62-303.pdf

II. The EPA numeric nutrient criteria process
   A. General historical information
      http://edocket.access.gpo.gov/2010/2010-29943.htm
   B. EPA final rule adopting the Florida numeric nutrient criteria

http://water.epa.gov/lawsregs/rulesregs/florida_index.cfm

III. The proposed Florida nutrient criteria process
   A. General historical information
      http://www.dep.state.fl.us/water/wqssp/nutrients/
   B. Proposed Rule 62-302 – Surface Water Quality Standards
      http://www.dep.state.fl.us/water/wqssp/nutrients/docs/meetings/62_302_final.pdf
   C. Proposed Rule 62-303 - Identification of Impaired Surface Waters
      http://www.dep.state.fl.us/water/wqssp/nutrients/docs/meetings/62_303_final.pdf

Figure A.1: Process for Narrative Nutrient Criteria

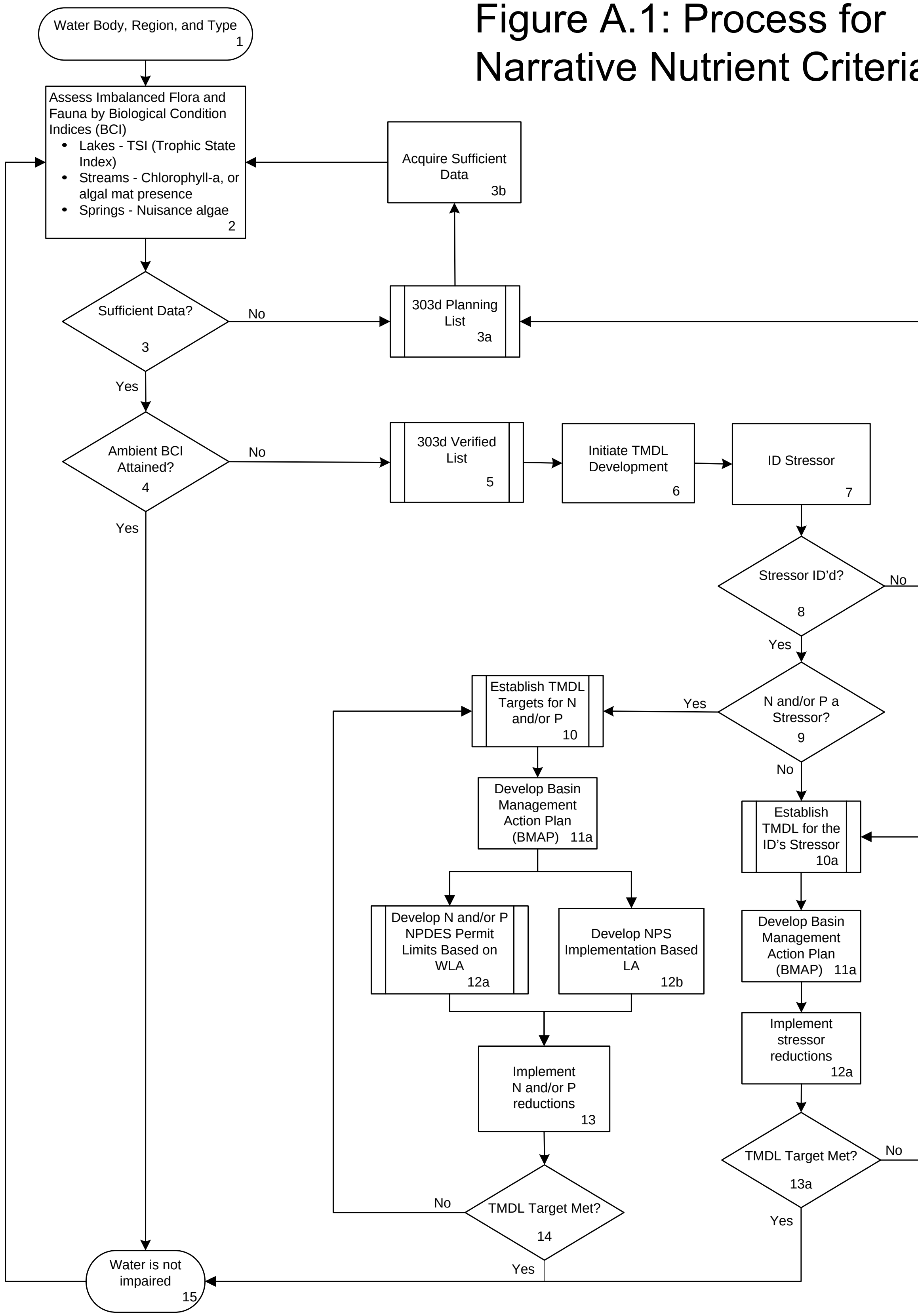


Figure A.2: Process for Numeric Nutrient Criteria in Flowing Waters

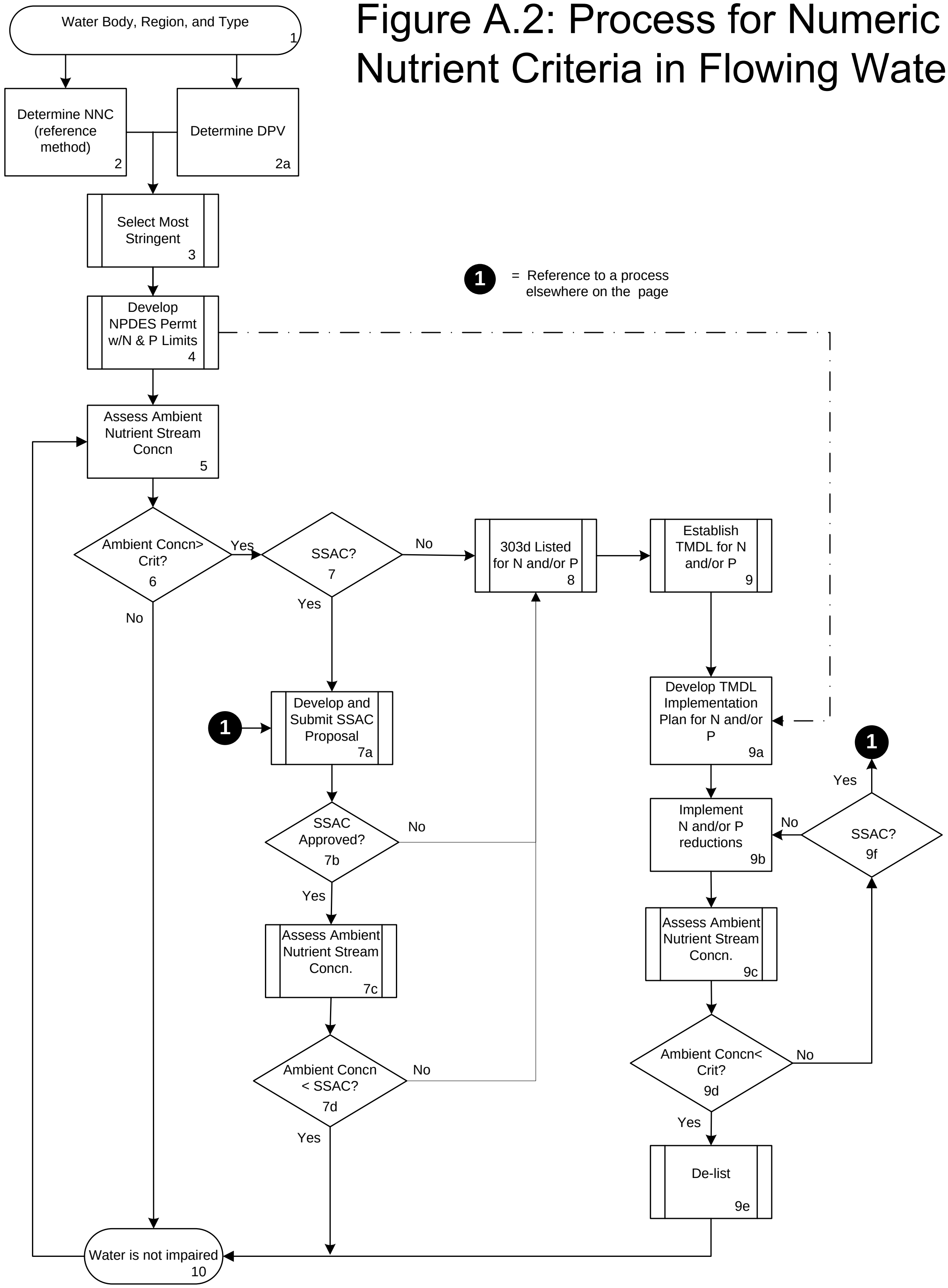


Figure A.3: Process for Florida's Proposed Nutrient Criteria

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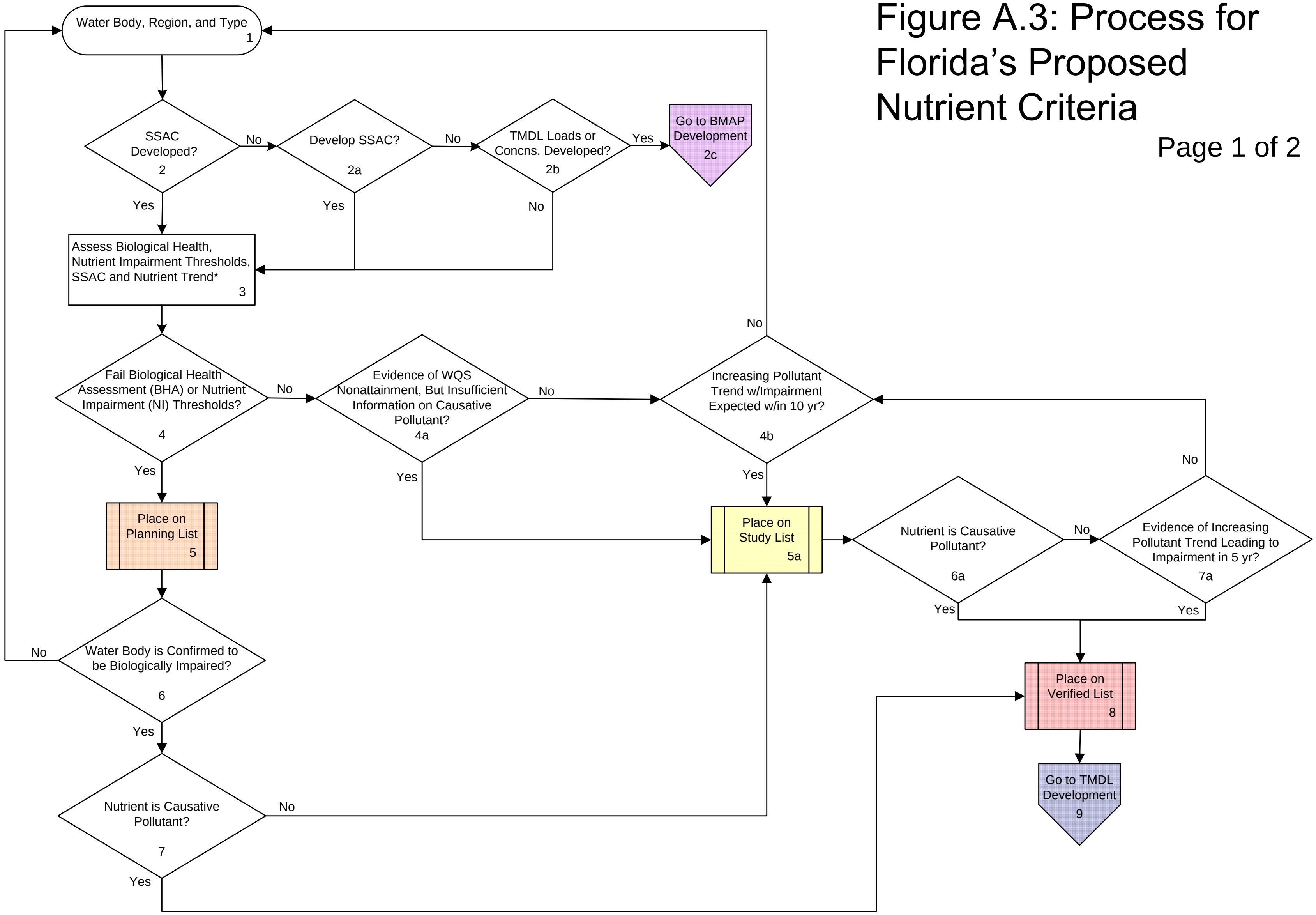

*** See notes on page 2**

Figure A.3: Process for Florida's Proposed Nutrient Criteria

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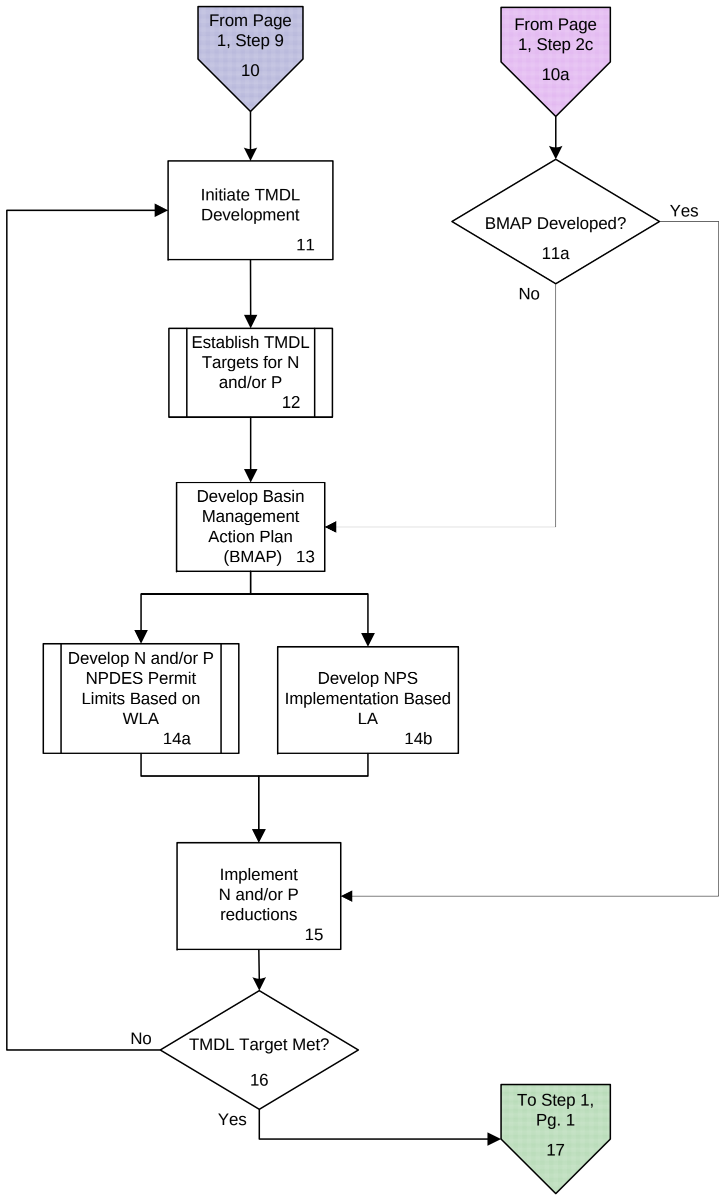

Notes: Biological Health Assessments/Numeric Interpretation of Narrative Criteria

I. ***Biological Health Assessment*** *= Stream Condition Index (SCI), Lake Vegetation Index (LVI), or Shannon-Weaver Diversity Index.*

II. ***Numeric Interpretations of Narrative Nutrient Criteria****.*

A. Lakes = chlorophyll a

B. Spring Vents = 0.35 mg/L of nitrate-nitrite (NO3 + NO2)

C. Streams = chlorophyll a levels, algal mats or blooms, nuisance macrophyte growth, or changes in algal species composition indicating imbalances in flora or fauna, and either:

1. SCI exceeded
2. Nutrient thresholds exceeded

D. Estuary = site-specific numeric interpretations

Appendix B

Biographical Sketches of Committee Members and Staff

Glen T. Daigger (National Academy of Engineering), *Chair*, is senior vice president with CH2M HILL in Englewood, Colorado. He serves as Chief Wastewater Process Engineer and is responsible for wastewater process engineering on both municipal and industrial wastewater treatment projects on a firmwide basis. Dr. Daigger is the first Technical Fellow for the firm, an honor which recognizes the leadership he provides for CH2M HILL and for the profession in development and implementation of new wastewater treatment technology. He is also the Chief Technology Officer for the firm's Civil Infrastructure Client Group, which includes the firm's water, transportation, and operations businesses. F rom 1994-1996, Dr. Daigger served as Professor and Chair of the Department of Environmental Systems Engineering at Clemson University. Dr. Daigger is a registered professional engineer in the states of Indiana and Arizona, and a board certified environmental engineer. Dr. Daigger received his B.Sc.E. degree, his M.S.C.E. degree, and his Ph.D. degree, all in environmental engineering, from Purdue University.

Otto C. Doering, *Vice Chair*, is a professor in the department of agricultural economics at Purdue University. He is a public policy specialist and has served the U.S. Department of Agriculture working on the 1977 and 1990 Farm Bills. In 1997, he was the Principal Advisor to USDA's Natural Resources Conservation Service for implementing the 1996 Farm Bill. In 1999, he was team leader for the economic analysis of the White House's National Hypoxia Assessment. Dr. Doering has overseas experience with the Ford Foundation and the National Academy of Sciences, primarily in Southeast Asia. He has been a Director of the American Agricultural Economics Association and Chairman of the National Public Policy Education Committee. He twice has received the AAEA's Distinguished Policy Contribution Award, as well as its Extension Economics Teaching Award. His recent publications have focused on economic linkages driving the responses to nitrogen over-enrichment, rationale of U. S. agricultural policy, and integrating biomass energy into existing energy systems. He served on the NRC Committee on the Mississippi River and the Clean Water Act. Dr. Doering received his M.S. degree in economics from the London School of Economics and his Ph.D. degree from Cornell University.

Leonard A. Shabman, *Vice Chair*, joined Resources for the Future in 2002 as a resident scholar after three decades on the faculty at Virginia Tech. His research and communications efforts are focused on programs and responsibilities for flood and coastal storm risk management, design of payment for ecosystem services programs, and development of evaluation protocols for ecosystem restoration and management projects, with special focus on the Everglades, Coastal

Louisiana and Chesapeake Bay. Among the specific topics related to these broader themes is applied research on permitting under Section 404 of the Clean Water Act, creating market-based incentives for water quality management and provision of ecosystem services, and design of collaborative water management institutions. He served for eight years on the National Research Council's Water Science and Technology Board, has chaired or been a member of several NRC committees and has been recognized as an Associate of the National Academy of Sciences.

Walter L. Baker is the director of the Division of Water Quality (DWQ) for the State of Utah, where he has worked for the past 26 years. He currently serves as the Vice-President of the Association of State and Interstate Water Pollution Control Administrators; as Chair of the Water Quality Committee of the Western States Water Council; as a member of the Utah Lake Commission; as a member of the Utah Soil Conservation Commission; and as the Executive Secretary of the Utah Water Quality Board. Mr. Baker is a licensed professional engineer and a graduate of Utah State University.

Allen P. Davis is a professor in the Department of Civil and Environmental Engineering at the University of Maryland. Dr. Davis' research interests are in aquatic environmental chemistry. He has been working on various issues related to urban storm water quality and the concept of low impact development (LID). Dr. Davis received the 2010 A. James Clark School of Engineering Faculty Outstanding Research Award, recognizing influential research accomplishments related to urban storm water quality, its management, and the LID concept. From 2001-2010, Dr. Davis served as the director of the Maryland Water Resources Research Center. He also has served as associate editor of Chemosphere, Science for Environmental Technology (2004-2010). Dr. Davis is a recipient of the National Science Foundation Young Investigator Award. He teaches courses in engineering sustainability, environmental process dynamics, and environmental engineering unit operations. He received his B.S. degree, his M.C.E. degree, and his Ph.D. degree from the University of Delaware.

K. William Easter is a professor of applied economics and has been on the faculty of the University of Minnesota since 1970. One of his positions at Minnesota was serving as Director of the Center for International Food and Agricultural Policy (1999-2003). His research interests include resource economics, economic development and environmental economics, with a focus on water and land problems and resource pricing issues. Dr. Easter received his B.S. and M.S. degrees from the University of California-Davis and his Ph.D. degree at Michigan State University.

Wendy D. Graham is the Carl S. Swisher Eminent Scholar in Water Resources in the Department of Agricultural and Biological Engineering at the University of Florida and director of the University of Florida Water Institute. Her research is focused on coupled hydrologic-water quality-ecosystem modeling; water resources evaluation and remediation; evaluation of impacts of agricultural production on surface- and groundwater quality; and development of hydrologic indicators of ecosystem status. She has previous NRC committee experience, having served on the Committee on Seeing Into the Earth: Non-Invasive Techniques for Characterization of the Shallow Subsurface for Environmental Engineering Applications, and as a member of the third Committee on Independent Scientific Review of Everglades Restoration Progress. Dr. Graham received her B.S.E. degree in environmental engineering from the

University of Florida and her Ph.D. degree in civil engineering from the Massachusetts Institute of Technology.

Arturo A. Keller is professor of biogeochemistry at the Bren School at the University of California, Santa Barbara. He holds a joint appointment in Mechanical and Environmental Engineering at UCSB. His research and teaching interests focus on water quality management and the fate and transport of pollutants in the environment. Dr. Keller also was the facilitator for the award-winning Nitrogen TMDL process for the Santa Clara River. He is also well-known for his expertise in the fate and transport of pollutants, including nanoparticles, organic liquids (NAPLs), and persistent organic pollutants associated with clay particles. Dr. Keller received a B.A. degree in chemistry and a B.S. degree in chemical engineering from Cornell University, an M.S. degree in civil engineering from Stanford University, and a Ph.D. degree in civil engineering from Stanford University.

David J. Mulla is professor and the W. E. Larson Chair for Soil and Water Resources in the Department of Soil, Water, and Climate at the University of Minnesota. He is also the director of the university's Precision Agriculture Center. Dr. Mulla's research covers a wide variety of topics regarding agriculture, soil erosion, and water quality, including: (1) nonpoint source surface water pollution and watershed management, (2) transport and modeling of water, solutes, trace metals, and organic chemicals in soil, surface and groundwater, (3) impacts of biofuel and alternative crop production systems, (4) measurement, modeling, and management of soil erosion, (5) phosphorus and nitrogen transport in soils, (6) agricultural best management practices, (7) soil, landscape, and terrain modeling for precision conservation, and (8) field-scale variability for precision farming. In 2007 he was appointed a Founding Fellow in the University of Minnesota's Institute on Environment. Dr. Mulla received his B.S. degree in Earth Sciences (with emphasis in geophysics) from the University of California at Riverside, and his M.S. and Ph.D. degrees in agronomy (emphasis in soil chemistry and physics) from Purdue University.

Kevin M. Sherman is the Director of Engineering at Quanics, Inc. in Campellsburg, Kentucky. Dr. Sherman has 24 years experience working as a researcher, regulator, educator, and designer in the onsite wastewater treatment industry. Dr. Sherman is a former president of the National Onsite Wastewater Recycling Association (NOWRA). From 1985-1999, he was a member of the staff at the Florida Department of Health and Rehabilitative Services, working in several capacities in the epidemiology and environmental health sections. He also served as a former president of the Florida Onsite Wastewater Association. Dr. Sherman received his B.S. degree in biology from the State University of New York at Stony Brook, another B.S. degree (civil engineering) from Florida State University, his M.S. degree in biology from the University of South Carolina, and his Ph.D. degree in oceanography from Florida State University.

Kurt Stephenson is an associate professor of environmental and natural resource economics in the Department of Agricultural and Applied Economics at the Virginia Polytechnic Institute and State University. His professional objective is to better integrate economic perspectives and analysis into decision-making related to water resource issues. Dr. Stephenson is particularly interested in application of economic analysis to interdisciplinary research of policy issues. The design and implementation of market-based policies to secure environmental objectives is a primary area of study within this context. He is currently involved in determining effective strategies for reducing nutrient loads in the Opequon Watershed in Virginia and West Virginia, including evaluating the cost effectiveness and feasibility of using urban nonpoint source controls (including stormwater management) as an offset to growth in point source loads. Dr. Stephenson received his B.S. degree in economics from Radford University, his M.S. degree in agricultural economics from Virginia Tech, and his Ph.D. degree in economics from the University of Nebraska.

Michael B. Tate is the Chief of Technical Services at the Kansas Department of Health and Environment. Mr. Tate is a licensed professional engineer with 20+ years experience in the environmental field. His technical expertise is in water quality and wastewater permitting, with additional experience in drinking water, solid waste, and hazardous waste. He manages a section responsible for establishing and enforcing water quality standards, and wastewater permitting in Kansas. Mr. Tate received his B.S. degree in civil engineering and his M.S. in bioenvironmental engineering, both from Oklahoma State University.

Alan H. Vicory serves as executive director and Chief Engineer for the Ohio River Valley Water Sanitation Commission (ORSANCO). His previous responsibilities were with the Commission staff as environmental engineer and manager of technical services which included establishment of regulatory requirements for discharges, water quality and biological monitoring systems, detection and response to spills, applied research, coordination of states and federal programs and public education and involvement. He is a Registered Professional Engineer and Board Certified in environmental engineering (water and wastewater) by the American Academy of Environmental Engineers. He is Past Chairman of the Board of the Water Environment Research Foundation (WERF) and former Chairman of the International Water Association's (IWA) Watershed and River Basin Management Specialist Group. He also is a Past President of the American Academy of Environmental Engineers (AAEE) and the Association of State and Interstate Water Pollution Control Administrators (ASIWPCA). Mr. Vicory received a B.S. degree in Civil Engineering from Virginia Military Institute.

LaJuana S. Wilcher is a Partner with the law firm English, Lucas, Priest & Owsley, L.L.P. in Bowling Green, Kentucky. Her previous positions included work with two international law firms in Washington, D.C.—Winston & Strawn (1993-1996) and LeBoeuf, Lamb, Greene & Mac Rae, L.L.P. (1996-2002). Ms. Wilcher served as the Assistant Administrator of Water for the United States Environmental Protection Agency from 1989 to 1993. While at the Office of Water (1989-1993), the agency promulgated new regulations addressing storm water, drinking water, biosolids (sewage sludge) and water quality standards for toxics, among other things. Ms. Wilcher helped lead EPA's watershed protection approach and Clean Water Act section 319 nonpoint source grant program. She also led EPA's involvement in the Exxon Valdez oil spill litigation negotiations. She received her B.S. degree in biology from Western Kentucky University, and her J.D. degree from Salmon P. Chase College of Law, Northern Kentucky University.

STAFF

Laura J. Ehlers is a senior staff officer for the Water Science and Technology Board of the National Research Council. Since joining the NRC in 1997, she has served as the study director for 16 committees, including the Committee to Review the New York City Watershed Management Strategy, the Committee on Bioavailability of Contaminants in Soils and Sediment, the Committee on Assessment of Water Resources Research, and the Committee on Reducing Stormwater Discharge Contributions to Water Pollution. Ehlers has periodically consulted for EPA's Office of Research Development regarding their water quality research programs. She received her B.S. from the California Institute of Technology, majoring in biology and engineering and applied science. She earned both an M.S.E. and a Ph.D. in environmental engineering at the Johns Hopkins University.