Economic Analysis of Final Water Quality Standards for Nutrients for Lakes and Flowing Waters in Florida

November 2010

U.S. Environmental Protection Agency
Office of Water
Office of Science and Technology
1200 Pennsylvania Avenue N.W.
Washington, D.C. 20460

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Acronyms and Abbreviations

A^2/O	Anaerobic-anoxic oxidation
ANMP	Agricultural nutrient management plan
BMAP	Basin Management Action Plan
BMP	Best management practice
BNR	Biological nutrient removal
BOD	Biochemical oxygen demand
C&D	Construction and development
CAFO	Confined animal feeding operation
cfs	Cubic feet per second
CH	Chlorophyll a
COI	Cost of illness
CREP	Conservation Reserve Enhancement Program
CRP	Conservation Reserve Program
CSP	Conservation Stewardship Program
CTA	Conservation Technical Assistance
CWA	Clean Water Act
DACS	Department of Agriculture and Consumer Services
DOH	Department of Health
DPV	Downstream protection value
DO	Dissolved Oxygen
DOF	Department of Forestry
EAA	Everglades Agriculture Area
EPA	U.S. Environmental Protection Agency
EQIP	Environmental Quality Incentive Program
F.A.C.	Florida Administrative Code
FC	Fecal coliform
FDACS	Florida Department of Agriculture and Consumer Services
FDEP	Florida Department of Environmental Protection
FDOF	Florida Division of Forestry
FDOH	Florida Department of Health
F.S.	Florida Statutes
FWRA	Florida Watershed Restoration Act
GAC	Granulated activated carbon
GIS	Geographic information systems
GLCI	Grazing Land Conservation Initiative
HABs	Harmful algal blooms
HUC	Hydrologic unit code
IPM	Integrated pest management
IWR	Impaired Waters Rule
LSJR	Lower St. Johns River
MEP	Maximum extent practicable
MIB	2-methylisborneol
MLE	Modified Ludzack-Ettinger
MS4	Municipal separate storm sewer system

NO_2	Nitrate
NO_3	Nitrite
NOI	Notice of intent
NRCS	Natural Resource Conservation Service
NPDES	National Pollutant Discharge Elimination System
NWIS	National Water Information System
O&M	Operation and maintenance
OCBWG	Orange Creek Basin Working Group
OIG	Office of Inspector General
OSTDS	Onsite sewage treatment and disposal system
PAC	Powered activated carbon
PCS	Permit compliance system
Pt-Co	Platinum cobalt units
RA	Reasonable assurance
RBC	Rotating biological contactor
SBR	Sequencing batch reactor
SCR	Selective catalytic reduction
SDT	Secchi disk transparency
SDM	Secchi disk measurement
SFWMD	South Florida Water Management District
SIC	Standard industrial classification
SJWMD	St. Johns Water Management District
SMP	Strategic monitoring plans
SMZ	Special Management Zone
SSAC	Site specific alternative criteria
SWET	Soil and Water Engineering Technology, Inc.
SWIM	Surface Water Improvement and Management
SWMP	Stormwater management program
TMDL	Total maximum daily load
TN	Total nitrogen
TP	Total phosphorus
TSD	Technical Support Document for Water Quality-Based Toxics Control
TSI	Trophic state index
TSS	Total suspended solids
UCT	University of Cape Town
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WAFR	Wastewater facility regulation
WBID	Waterbody identification
WLA	Wasteload allocation
WOD	Works of the District
WQBEL	Water quality-based effluent limit
WQI	Water quality index
WQL	Water quality ladder
WQS	Water quality standards
WRF	Water reclamation facility

WTP	Willingness to pay
WWTP	Wastewater treatment plant

Executive Summary

The U.S. Environmental Protection Agency (EPA) is promulgating numeric nutrient criteria applicable to freshwater lakes and flowing waters in the state of Florida. EPA's criteria will supplement the state's existing narrative nutrient criterion. Although this rule does not establish any requirements directly applicable to regulated entities or other sources of nutrient pollution, EPA developed this economic analysis to provide information on potential costs and benefits that may indirectly be associated with state implementation of this rule including potential requirements that may be necessary to assure attainment of the criteria.

ES.1 Background and Purpose

The state of Florida currently uses a narrative criterion to protect waters from nutrient pollution. In January of 2009, EPA determined that new or revised WQS for nutrients in the form of numeric nutrient criteria are necessary in Florida to meet the requirements of the CWA (U.S. EPA, 2009a). In August of 2009 EPA entered into a phased Consent Decree with several environmental organizations that challenged the Agency for not having promulgated numeric nutrient criteria for the State of Florida. In that Consent Decree, EPA committed to issue a final numeric nutrient rule for Florida's inland waters by October 15, 2010 which was subsequently extended to November 14, 2010. This rule will satisfy that requirement of the Consent Decree.

EPA's rule establishes numeric water quality criteria for nitrogen and phosphorus applicable to lakes and flowing waters in defined regions of Florida to ensure the attainment of State designated uses. The rule does not establish any requirements directly applicable to regulated entities or other sources of nutrient pollution to these waters. Nonetheless, state implementation of the criteria may result in new or revised National Pollutant Discharge Elimination System (NPDES) permit conditions for point source dischargers and nutrient control requirements for other sources (e.g., agriculture, urban runoff, and septic systems). Therefore, to provide information on such potential impacts, this report provides estimates of the potential costs and benefits that may be indirectly associated with the rule.

ES.2 Baseline for the Analysis

The baseline for estimating the potential costs and benefits that may be associated with EPA's rule is the conditions and requirements that would exist without EPA's rule. These conditions include the current narrative nutrient criterion and procedures for identifying impaired waters, and the actions that would be needed to attain the narrative criterion (including those that have not yet been implemented). There are hundreds of lakes and flowing waters in Florida currently listed as impaired under the narrative criterion. FDEP has developed total maximum daily loads (TMDLs) for many of these waters, and has developed or is developing Basin Management Action Plans (BMAPs) to implement some of those TMDLs. Under TMDLs, point sources may receive revised water quality based effluent limits (WQBELs) for total nitrogen (TN) and/or total phosphorus (TP). Under BMAPs, nonpoint sources, including agriculture, urban stormwater, and septic systems, may be required to implement additional nutrient controls.

EPA believes that current requirements represent a useful baseline from which to evaluate potential actions that may be associated with the criteria in the rule. However, in July 2009 the Florida Department of Environmental Protection (FDEP) released draft numeric nutrient criteria for lakes and flowing rivers. Although the state of Florida has not adopted those numeric criteria provisions, EPA believes that

FDEP's draft numeric nutrient criteria may also represent a useful baseline from which to evaluate EPA's action. This document presents estimates under both baseline interpretations.

Point Sources

EPA's permit compliance system (PCS) database indicates that there are 198 municipal wastewater dischargers and 245 industrial dischargers with individual permits.[1] Some of these permittees discharge to estuarine waters, coastal waters, or South Florida canals that are not affected by the lakes and flowing waters rule. For example, of the 198 municipal wastewater treatment plants (WWTP), EPA determined that only 85 discharge to freshwater lakes and streams. Given the nature of influent wastewater at municipal WWTPs, it is likely that all WWTPs have the potential to discharge nutrients. To identify industrial dischargers likely to discharge nutrients, EPA identified those dischargers in PCS with either numeric effluent limits and/or monitoring requirements for nitrogen and phosphorus. Based on these industrial categories, **Exhibit ES-1** summarizes the number of NPDES-permitted wastewater dischargers in Florida that may be affected by the rule.

Exhibit ES-1: Summary of Dischargers in Florida Potentially Affected by Numeric Nutrient Criteria for Lakes and Flowing Waters[1]

Discharger Category	Major Dischargers	Minor Dischargers	Total
Municipal Wastewater	43	42	85
Industrial Wastewater[2]	57	51	108
Total	100	93	193

Source: U.S. EPA (2010a).
Major = generally discharge greater than 1 mgd and have the potential to discharge toxics in toxic amounts
Minor = generally discharge less than 1 mgd and do not discharge toxics in toxic amounts.
SIC = Standard Industrial Classification
TMDL = total maximum daily load
1. Excludes dischargers to oceans, estuaries, bayous, wetlands, and South Florida flowing waters (identified based on receiving waterbody name and information contained TMDLs, permits, and laboratory reports).
2. For majors dischargers includes SIC codes 1475, 1479, 2015, 2611, 2621, 2631, 2821, 2824, 2874, 2879, 2892, and 4911; for minor dischargers includes SIC codes 1099, 1422, 1475, 2033, 2034, 2037, 2082, 2085, 2491, 2499, 2611, 2869, 2873, 2874, 3582, 3679, 3699, 3822, 4011, 4226, 4931, 4941, 4952, 4953, 5146, 5169, 5171, 5541, 7996, 8422, 8733, 9511, and 9999.

Urban Sources

Urban runoff from fertilizers applied to lawns, gardens, and golf courses, decomposition of natural rock and soils, air deposition from vehicle exhaust or power plants, detergents used to wash cars on the street, and pet waste can account for significant nutrient pollution in watersheds. There are several rules in place that regulate these sources. For example, the state's Urban Turf Fertilizer Rule limits the nutrient content of turf fertilizers, which decreases the amount runoff from its application. Also, municipal separate storm sewer systems (MS4s) develop and implement management plans that include measures that may reduce runoff of nutrients such as public education and pollution prevention/good housekeeping activities. FDEP's 1982 Stormwater Rule also requires that all stormwater from new development and

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[1] There are also 34,508 dischargers covered under generic or general permits. FDEP regulate these dischargers based on categories of wastewater facilities or activities that involve the same or similar types of operations or wastes. EPA did not include these dischargers in its analysis.

redevelopment receive treatment prior to discharge. To date, FDEP has issued 27 Phase I (large and medium-sized) MS4 permits and 133 Phase II (small) MS4 permits in Florida.

Agricultural Sources

There are currently about 9.2 million acres of farmland in Florida. These lands may represent significant sources of nutrients from fertilizer and waste runoff, and are subject to several federal and state pollution control regulations. Confined animal feeding operations (CAFOs) must obtain NPDES permits. Also, the Florida Watershed Restoration Act (FWRA) established BMPs as the primary instrument for implementing Florida's TMDL program. Under the FWRA (Section 403.067, F.S.), implementation of BMPs that FDEP has verified as effective and Florida Department of Agriculture and Consumer Services (FDACS) has adopted by rule provides a presumption of compliance with state WQS. Under the program, landowners must maintain records and provide documentation regarding their implementation of BMPs and reasons why certain BMPs are not applicable to their specific situation. **Exhibit ES-2** shows the number of acres that farmers have enrolled in the FDACS BMP program.

Exhibit ES-2: Summary of Agricultural Lands Enrolled in FDACS BMP Program

FDACS BMP Program Type	Number of Acres
Citrus	509,553
Cow/Calf	448,602
Dairies	37,535
Equine	75
Grasses	3,271
Leatherleaf Ferns	144
Nursery	20,662
Poultry Feeding Operations	312
Row Crops	754,713
Sod Farms	33,813
Specialty Farms	306
Tri-County Agricultural Area	3,841
Total	1,812,827

Source: Based on GIS analysis of 2010 FDACS data on enrollments.

Many of these acres are in the Lake Okeechobee watershed where a number of regulations require farmers to implement BMPs to control dischargers of phosphorus to the watershed.

Forestry

Florida's Division of Forestry (FDOF) controls nonpoint forestry discharges of nutrients through the implementation of BMPs, as developed by the BMP Technical Advisory Committee and published in the *Silviculture Best Management Practices Manual* (FDOF, 2009). According to the manual, the BMPs reflect "the minimum standards necessary for protecting and maintaining the State's water quality as well as certain wildlife habitat values, during forestry activities," and address many sources of pollution including sedimentation, nutrients, and turbidity.

FDOF periodically conducts state-wide surveys of silviculture practices to assess compliance levels, identify areas and foresters in need of further education, and evaluate the effectiveness of BMPs. There have been 15 surveys since 1984, with the most recent in 2009. Over that period, the average compliance rate for all BMPs was 94%, with 84% in 1985 and 98% compliance in 2009. The 2009 survey also reported that the implemented BMPs are generally effective at preventing significant impacts to the relevant waterbodies (FDOF, 2010).

Septic Systems

According to a Florida Department of Health database, there are a total of 935,203 septic systems in Florida, of which 793,697 are active (FDOH, 2010a). Most of Florida's septic systems are over 30 years old and were installed under standards less stringent than current standards for septic system installations. As a result, Florida has identified approximately $10.3 billion in capital needs to address water quality or water quality-related public health problems from decentralized wastewater treatment systems (U.S. EPA, 2010b). These costs represent capital expenditures associated with the rehabilitation or replacement of septic systems and clustered (community) systems.

In Florida, the Bureau of Onsite Sewage Programs in the Florida Department of Health (FDOH) and the environmental health section of County Health Departments regulate the use of onsite sewage treatment and disposal systems (OSTDSs). Unless FDOH has granted a variance, it does not permit the use of an OSTDS where the estimated domestic sewage flow is over 10,000 gpd or the commercial sewage flow is over 5,000 gpd, where there is a likelihood that the system will receive toxic, hazardous or industrial wastes, where a sewer system is available, or if any system or effluent is currently regulated by FDEP.

Summary of Baseline Requirements

To estimate the potential incremental impacts that may be indirectly associated with the rule, EPA assumed that the following actions have been or will be implemented in the absence of the rule, and did not estimate costs associated with these actions as part of this analysis:

- Actions necessary to meet existing NPDES permit conditions for municipal and industrial wastewater
- Actions resulting from future TMDLs of 303(d) listed waters, draft or approved TMDLs, and draft or approved BMAPs
- BMPs for the forestry sector
- Controls required by the FDEP Dairy Rule and EPA CAFO regulations
- Requirements for the Lake Okeechobee watershed
- Phase I and Phase II MS4 permits.

EPA also estimated potential costs compared to a baseline of controls that could be needed to attain FDEP's July 2009 draft numeric nutrient criteria.

ES.3 Description of the Rule

EPA's rule establishes numeric criteria for TN, TP, and chlorophyll-a for freshwater lakes and flowing waters in Florida that are not to be exceeded more than once in a three year period. **Exhibit ES-3** summarizes these criteria, which vary by region (for streams) and characteristics of the waters (for lakes).

Exhibit ES-3: 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

Chl-a = chlorophyll-a
Pt-Co = platinum-cobalt
NA = not applicable
TN = total nitrogen
TP = total phosphorus
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 $CaCO_3$.

EPA's rule allows modification of lake criteria for chlorophyll a, TN and/or TP where the baseline chlorophyll a criterion-magnitude as an annual geometric mean has never been exceeded and sufficient ambient monitoring data exist for chlorophyll a and TN and/or TP for at least the three immediately preceding years. Sufficient data include at least four measurements per year, with at least one measurement between May and September and one measurement between October and April each year. Modified criteria are calculated as the geometric mean of all annual geometric mean concentrations from at least the immediately preceding three years in a particular lake. When the TN and/or TP criteria are modified, the chlorophyll a criterion must also be modified to reflect the same period of record for which TN and/or TP criteria are evaluated. Modified TP and TN criteria may not exceed criteria applicable to streams to which a lake discharges.

For streams that are upstream of lakes, a more stringent downstream protection value (DPV) may apply. The applicable DPV for TN or TP can be either a value derived from a water quality model [e.g. BATHTUB; USACE (2010)] or the applicable criterion of the downstream lake. For this analysis, EPA used the lake criteria as the DPV of applicable flowing waters. The applicable DPVs are expressed as an annual geometric mean value not to be exceeded more than once in a three year period.

ES.4 Potential Costs to Municipal WWTPs

Point source dischargers receive water quality based effluent limitations (WQBELs) in permits based on analysis of reasonable potential to exceed water quality criteria. Because untreated municipal wastewater is typically high in nutrients, for this analysis, EPA assumed that all municipal WWTPs would receive WQBELs consistent with no mixing zones or dilution (i.e., criteria applied end-of-pipe). Potential controls that would facilitate attaining these limitations include biological nutrient removal (BNR), chemical precipitation, and effluent reuse.

For this analysis, EPA also assumed that WWTPs would implement advanced BNR as the most cost-effective treatment option. Although other treatment options may be able to reduce TN and TP concentrations below the levels achieved by BNR, those options tend to be significantly more expensive.

EPA believes that other strategies to reduce nutrient loading to the watershed would likely be implemented before requiring these more expensive alternatives (in some cases, requiring dischargers to obtain a variance from meeting the criteria). Thus, EPA estimated the potential costs to WWTPs based on a range of estimated unit costs for BNR (U.S. EPA, 2008a).The results of this analysis suggest that total capital costs could be approximately $108 million to $219 million and annual operation and maintenance (O&M) costs could be approximately $12 million to $18 million (based on multiplying unit costs by flow reported in EPA's PCS database for those dischargers that do not already have advanced BNR). Costs (annualized capital at 7% over 20 years plus annual O&M) could be approximately $22 million per year to $38 million per year.

Using FDEP's 2009 draft numeric nutrient criteria as the baseline, annual incremental costs to municipal WWTPs would be zero because the treatment technologies needed to achieve the FDEP draft criteria are the same as those needed to achieve the criteria in EPA's rule.

ES.5 Potential Costs to Industrial Wastewater Sources

Unlike municipal WWTPs, all industrial facilities do not necessarily discharge nitrogen or phosphorus. Also, although some facilities may use the same treatments as WWTPs (such as BNR and chemical precipitation), treatment options for reducing nutrient loads from industrial sources can vary due to industry- or facility-specific conditions. In some cases, industrial facilities may also be able to pursue options such as BMPs, product substitution, process modification or optimization, or retention pond installation.

To estimate the potential costs to industrial facilities that may be indirectly associated with EPA's rule, EPA first assumed that costs to facilities discharging to 303(d) listed waters or waters covered under a TMDL are not attributable to the rule because those costs would occur in the absence of the rule. Of the remaining industrial facilities, EPA estimated the costs of additional nutrient controls for a representative sample of facilities in different industrial categories that may be necessary to meet EPA's criteria. EPA then extrapolated those representative costs to estimate the cost for the total flow associated with potentially affected dischargers in the same industrial category. The results of this analysis suggest that costs (annualized capital at 7% over 20 years plus annual O&M) could be approximately $25.4 million per year.

Using FDEP's 2009 draft numeric nutrient criteria as the baseline, annual incremental costs to industrial facilities would be zero because the treatment technologies needed to achieve the FDEP draft criteria are the same as those needed under EPA's rule, even if the criteria themselves differ somewhat..

ES.6 Identification of Incrementally Impaired Waters and Watersheds

To identify potential costs to control nutrients from urban stormwater, agriculture, and septic systems, and to identify the potential costs associated with developing additional TMDLs, EPA evaluated Florida's water quality monitoring database to assess which waters may be identified as impaired under EPA's rule. EPA analyzed the most recent five years of water quality monitoring data for each waterbody represented as a unique waterbody identification (WBID) number with sufficient monitoring data, and identified freshwater lakes and flowing waters that exceeded the numeric TN, TP, or chlorophyll-a criteria (based on annual geometric mean values). EPA also identified springs with a monthly geometric mean nitrate-nitrite concentration greater than the criterion as impaired. EPA removed from the resulting list of waters those that are currently listed as impaired on Florida's 303(d) list of impaired waters, resulting in those waters that may be identified as impaired under EPA's rule that are not already classified as impaired (referred to here as incrementally impaired waters). **Exhibit ES-4** summarizes this analysis.

Exhibit ES-4: Summary of Identification of Potential Incrementally Impaired Waters

Category	Number of WBIDs			Total
	Lake	Stream[1]	Spring	
Total in State	1,310	3,901	126	5,337
Not Listed/Covered by TMDL[2]	1,099	3,608	119	4,826
Nutrient Data in IWR Run 40[3]	878	1,273	72	2,223
Sufficient Data Available[4]	655	930	72	1,657
Potentially Exceeding Criteria[5]	148	153	24	325

IWR = Impaired Waters Rule
TMDL = total maximum daily load
WBID = waterbody identification
1. Includes blackwater.
2. As reported in TMDL documents and FDEP (2009c).
3. Data within last 5 years meeting data quality requirements.
4. Sufficient to calculate annual geometric means; based on at least 4 samples with at least one sample from May to September and one sample from October to April in a given year.
5. Based on annual geometric mean exceeding the applicable criterion more than once in a three year period.

To estimate the urban areas, agricultural land, and septic systems that may need controls to attain the numeric criteria for lakes and streams, EPA used GIS analysis to identify the watersheds [10-digit Hydrologic Unit Code (HUC)] associated with these incrementally waters. Each WBID in the state does not fall completely within a single 10-digit HUC. Thus, to ensure that lands (and sources) affecting water quality for each WBID are accounted for in the analysis and that incidental overlapping HUCs are not included, EPA identified watersheds containing at least 10% of an incrementally impaired lake or stream, excluding those watersheds that contain at least 10% of a lake or stream that is currently impaired or under a TMDL (to remove baseline impaired watersheds). 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 spring recharge areas potentially requiring additional nutrient controls as the incrementally impaired spring recharge areas identified as vulnerable to surface sources of contamination by the Florida Geological Survey Florida Aquifer Vulnerability Assessment.

ES.7 Potential Costs for Urban Stormwater Controls

Some areas served by MS4s in incrementally impaired watersheds may require additional nutrient controls. However, it is difficult to identify the additional controls that may be necessary to attain EPA's numeric nutrient criteria without site specific analysis. Full implementation of existing stormwater management programs could be sufficient to attain EPA's numeric nutrient criteria in some watersheds. In others, water quality monitoring after full implementation of existing stormwater management programs may indicate a need for additional controls.

Current nutrient-related TMDLs in Florida allocate between 5% and 85% nutrient load reductions from stormwater sources (the average is approximately 50%). Urban stormwater controls can remove up to 51% of TN and 75% of TP (Center for Watershed Protection, 2007). FDEP's 1982 Stormwater Rule establishes that stormwater design criteria adopted by FDEP and the water management districts shall achieve at least 80% reduction of the average annual load of pollutants that cause or contribute to violations of WQS (95% reduction for outstanding natural resource waters). In its evaluation of EPA's proposed numeric nutrient criteria rule, FDEP (2010b) assumed that nutrient reductions mandated in the 1982 Stormwater Rule would be sufficient to comply with EPA's numeric nutrient criteria. Using this same assumption, EPA assumed that the amount of urban land within Phase I MS4s that may require additional nutrient controls could range from none [current implementation of BMPs to the maximum extent practicable (MEP) is sufficient] to all Phase I MS4 urban land in incrementally impaired watersheds developed before 1982. Under these assumptions, EPA estimated through GIS analysis that additional stormwater controls may be needed on up to 48,100 acres of Phase I MS4 urban land.

Because over-application of fertilizers on lawns and gardens is the primary source of nutrient pollution from low density urban areas, EPA assumed that sufficient nutrient reductions could be achieved from low density Phase II MS4 areas and other low density urban areas not covered under EPA's NPDES stormwater program by full implementation of existing regulations such as the Urban Turf Fertilizer Rule. For higher density Phase II MS4 urban areas and other higher density urban areas not covered under EPA's NPDES stormwater program, EPA assumed that additional stormwater controls could be needed in incrementally impaired watersheds. Again, using FDEP's assumption that urban lands developed after 1982 would not need additional controls, EPA used GIS analysis to estimate that 30,700 acres of urban land within Phase II MS4s and 30,600 acres of urban land outside MS4s may need additional controls for nutrients in stormwater.

Urban runoff can be a significant source of nutrient pollution to Florida springs. However, efficient land application of nitrogen is the most cost-effective means of addressing nutrients from this source. The Urban Turf Fertilizer Rule is an example of one such source control effort. Other pollution prevention or source control activities include city or county-wide ordinances and public outreach and education campaigns (which are already required in MS4 NPDES permits). Thus, EPA assumed that implementation of existing (baseline) requirements would be sufficient to reduce nitrate-nitrite loads to springs from urban stormwater.

Costs for stormwater controls can vary widely and depend on the type of land requiring control. For this analysis, EPA estimated unit costs from data on existing stormwater projects in Florida obtained from FDEP (2010a). The cost of these projects ranges from $62 per acre to $60,300 per acre, with a median cost of $6,800 per acre. Using the median cost per acre and the estimated number of acres needing additional controls, EPA estimated that costs for additional nutrient controls for stormwater could range from $60.5 million per year to $108.0 million per year.

Using FDEP's 2009 draft numeric nutrient criteria as the baseline, annual incremental costs to urban stormwater could range from $13.7 million to $27.2 million.

ES.8 Potential Costs to Agriculture

About 19% of the land surrounding incrementally impaired waters is used for agriculture. BMPs control nutrient loadings from agricultural sources to lakes and flowing waters. For this analysis, EPA estimated the BMP programs that would be needed to attain the numeric criteria based on a study of agricultural BMPs to help meet TMDL targets in the Caloosahatchee River, St. Lucie River, and Lake Okeechobee watersheds (SWET 2008a). SWET (2008a) identified three types of BMP programs: an owner implemented program consisting of a set of practices that land owners might implement without incentives; a typical program consisting of practices that land owners might implement under a reasonably funded cost share program; and an alternative program of more aggressive controls to supplement the owner and typical programs if additional reductions are necessary. The BMPs in the owner implemented and typical program are similar to the BMPs adopted by FDACS. The alternative BMP program, which includes stormwater chemical treatment, is not yet required in the study basins which have significant contributions from agriculture. Thus, for this analysis, EPA assumed that nutrient controls for agricultural sources are best represented by the owner and typical programs.

EPA estimated potential nutrient control costs to agriculture by using GIS analysis to assess the amount of land used for different categories of agricultural operations in incrementally impaired watersheds, and the category-specific unit costs of the owner and typical BMP programs estimated by SWET (2008a). BMPs implemented under the FDACS program represent a level of control that is similar to the owner implemented and typical BMP programs. However, the level of compliance with the FDACS BMP program in incrementally impaired watersheds is uncertain (FDACS 2008, 2009). Therefore, EPA estimated a range of agricultural costs by including and excluding land enrolled in the FDACS BMP program. Using these assumptions, EPA estimated that the cost of additional agricultural BMPs that may be needed to attain EPA's numeric nutrient criteria in lakes and streams could range from $15.1 million per year to $18.2 million per year.

Agricultural practices could influence the water quality of springs many miles away because the groundwater aquifers that supply water to springs can be large and complex (USGS, 2010). Because nutrient management is a cost-effective way to reduce groundwater nitrogen and may even result in cost savings to farmers by reducing unnecessary fertilizer application, EPA assumed that all agricultural operations applying fertilizer to land would implement a nutrient management program to reduce levels of nitrogen in groundwater aquifers.

To estimate the additional incremental costs for nutrient management, EPA first estimated the amount of agricultural land where nutrient management would be applicable. EPA identified general agriculture and specialty crops as agricultural categories appropriate for nutrient management. EPA then used GIS analysis to identify the total land area used for these two agricultural categories after removing acreage in watersheds that are currently impaired for nutrients or under a nutrient TMDL (i.e., the baseline). EPA also removed land identified as within incrementally impaired watersheds to avoid double counting costs for BMPs to protect lakes and streams as described above. As a result of this analysis, EPA identified approximately 1.1 million acres of agricultural land as potentially implementing nutrient management to meet the new numeric criteria (approximately 1 million acres of general agriculture and approximately 0.12 million acres of specialty crops). Using unit costs of $10 per acre for general agriculture and $20 per acre for specialty crops (FL EQIP, 2009a), EPA estimated the cost for nutrient management could be approximately $4.7 million per year. Together with the estimated costs of additional agricultural BMPs to protect lakes and streams described above, total agricultural costs could range from approximately $19.9 million per year to $23.0 million per year.

Using FDEP's 2009 draft numeric nutrient criteria as the baseline, annual incremental costs to agriculture could be up to $2.1 million.

ES.9 Potential Costs for Septic Systems

Some nutrient reductions from septic systems may be necessary for incrementally impaired waters to meet EPA's numeric nutrient criteria. Properly operated and maintained systems usually provide treatment equivalent to secondary wastewater treatment (Petrus, 2003). However, even properly functioning septic systems could impact water quality. Implementation strategies could include greater use of inspection programs and repair of failing systems, upgrading existing systems to advanced nutrient removal, decentralized cluster systems where a responsible management entity would ensure reliable operation and maintenance, and connecting households and businesses to wastewater treatment plants. On the basis of current practice in the state of Florida, EPA assumed for this analysis that the most likely compliance strategy to reduce nutrients loads from septic systems will be to upgrade existing convention septic systems to advanced nutrient removal systems.

Septic systems in close proximity to surface waters are most likely to contribute the greatest nutrient load to the waterbody. Most of the existing nutrient-related TMDLs identify failing septic systems as contributing to nutrient impairments in surface waters. The Middle St. Johns River Nutrient TMDL considers wastewater from failed septic tanks within 50 feet as direct discharges of untreated wastewater to the stream network, and for those outside of the 50-feet boundary, FDEP combined septic system loads with the nonpoint source loading for residential areas (Gao, 2009). In addition, Florida Administrative Code requires that in most cases septic systems "shall not be located laterally within 75 feet of the boundaries of surface waterbodies" (FAC 64E-6.005(3)).

EPA assumed that some septic systems located near incrementally impaired lakes and streams may be required to upgrade to advance nutrient removal systems. However, the distance that septic systems can be safely located relative to these surface waters depends on a variety of site specific factors. In consideration of this uncertainty, EPA conservatively assumed that septic systems located within 500 feet of any lake or stream in incrementally impaired watersheds may require upgrading to account for some downstream transport of nutrients from nearby streams that may not be classified as incrementally impaired. GIS analysis indicates that there are 8,224 active septic systems within 500 feet of any lake or stream in watersheds associated with incrementally impaired waters.

Manufacturer estimates of capital costs to upgrade a conventional septic system to an advanced nutrient removal system (including installation costs) range from $2,000 per system to $6,500 per system, with annual O&M costs of $650 per year (Chang et al., 2010). Thus, annual costs could range from approximately $800 to $1,300 for each upgrade (capital costs annualized at 7% over 20 years plus annual O&M). Multiplying these unit costs by the total number of septic systems possibly needing upgrades (8,224) yields a cost estimate ranging from $6.6 million per year to $10.7 million per year.

For springs, the contribution of nitrogen from septic systems is highly uncertain and likely site specific. For example, Brown et al. (2008) found that the preponderance of nitrogen pollution in Florida springs appears to be from fertilizer sources; most of the accumulated evidence from mass balance computations and isotopic tracer studies suggests that mineral fertilizers, and therefore, not septic tanks and wastewater sprayfields, are the principal sources of nitrogen pollution in Florida springs. Thus, because EPA has already estimated costs for nutrient management on all crop land not already being controlled for existing or incremental impairments, EPA assumes that no additional controls would be needed for septic systems to attain the nitrate-nitrite criterion.

Using FDEP's 2009 draft numeric nutrient criteria as the baseline, annual incremental costs to septic systems could range from $0.2 million to $0.3 million.

ES.10 Government Expenditures

FDEP may incur costs associated with development of additional TMDLs. Because existing TMDLs cover an average of two waterbodies each, FDEP may need to develop 163 new TMDLs (325 incrementally impaired WBIDs ÷ 2 = 163 TMDLs). EPA (2001) indicates that TMDL development for two similar pollutants costs an average of approximately $47,000. Thus, total TMDL development cost could be $7.7 million, or $851,000 per year assuming FDEP adheres to its 9-year TMDL development cycle.

Using FDEP's 2009 draft numeric nutrient criteria as the baseline, annual incremental costs for TMDL development could be approximately $0.3 million.

ES.11 Summary of Costs

Exhibit ES-5 summarizes the estimates of potential annual incremental control costs for each source.

Exhibit ES-5: Estimates of Potential Annual Costs Associated with Numeric Nutrient Criteria (2010 dollars)

Source Sector	Type of Expenditure	Annual Costs (millions)
Municipal Wastewater[1]	BNR to reduce TN and/or TP	$22.3 - $38.1
Industrial Dischargers[2]	BNR to reduce TN and TP; chemical precipitation to reduce TP	$25.4
Urban Stormwater[4]	Stormwater controls	$60.5 - $108.0
Agriculture[5]	Owner/typical BMP program	$19.9 - $23.0
Septic Systems[6]	Upgrade to advanced nutrient treatment	$6.6 - $10.7
Government/Program Implementation	TMDL development[7]	$0.9
Total	--	$135.5- $206.1

Note: Detail may not add to total due to independent rounding.
BNR = biological nutrient removal; TMDL = total maximum daily load; TN = total nitrogen; TP = total phosphorus
1. Based on upgrading existing treatment processes to advanced BNR.
2. Based on extrapolation of average annual costs per flow for random sample of dischargers stratified by industrial category.
4. Based on median stormwater control costs from FDEP (2010a), and scenario of need for structural controls on land developed before 1982.
5. Based on implementing nutrient management on all crop land outside of incrementally and baseline impaired watersheds and scenarios in which all agricultural land not enrolled in the FDACS BMP program in incrementally impaired watersheds incurs owner/typical program costs from SWET (2008a) or all agricultural land in incrementally impaired watersheds incurs owner/typical costs based on SWET (2008a).
6. Based on upgrading to advanced nutrient removal active septic systems within 500 feet of water (based on GIS land use data) in incrementally impaired watersheds.
7. Based on average costs to complete TMDLs for incrementally impaired waters under a 9-year schedule.

Using FDEP's 2009 draft numeric nutrient criteria as the baseline, total annual incremental costs could range from $17.5 million to $27.2 million.

ES.12 Potential Benefits

Florida waters have historically provided recreational opportunities that are a vital part of the State's economy. The Florida Department of Environment (2008) reported that in 2007, over 4.3 million residents and over 5.8 million visitors participated in recreational activities related to freshwater beaches in Florida. Also, over 2.7 million residents and approximately 1 million visitors that used freshwater boat ramps, over 3 million residents and over 900,000 visitors participated in freshwater non-boat fishing, and over 2.6 million residents and almost 1 million visitors participated in canoeing and kayaking.

Tourism comprises one of the largest sectors of the Florida economy (VISIT Florida 2010). In 2006, Florida ranked first in the nation for the number of in-state anglers, angler expenditures, angler-supported jobs. In addition, Florida's freshwater springs are an important inter- and intra-state tourist attraction. In 2002, Blue Springs State Park estimated over 300,000 visitors per year.

Nutrient pollution has contributed to severe water quality degradation of Florida waters. In 2010, the State of Florida reported approximately 1,918 miles of rivers and streams, and 378,435 acres of lakes that were known to be impaired by nutrient pollution (FDEP 2010; the actual number of waters impaired for nutrients may be higher because many waters were not assessed). As water quality declines, water resources have less recreational value. Waters impaired by nutrient pollution may become unsuitable for swimming and fishing, and in some cases unsuitable for boating. Nutrient-impaired waters also are less likely to support native plant and animal species, further lowering their value as tourist destinations. Drinking water supplies may also be more expensive to treat as a result of nutrient impairments. Also, Florida citizens that depend on individual wells for their drinking water may need to consider whether on-site treatment is necessary to reduce elevated nitrogen levels. Freshwater springs are particularly at risk. Silver Springs, the largest of Florida's springs, has experienced reduced ecosystem health and productivity over the past half century, due largely to excessive nitrate and nitrite. Nutrient impairment, characterized by algal blooms, reduced numbers of native species, and lower water quality, in turn leads to reduced demand and lower values for these resources.

Reducing excess nitrogen in water can result in significant economic benefits to Florida citizens. These benefits include maintenance of Florida's valuable freshwater fishing and ecotourism industries and increased lakeshore and near-lakeshore property values. There could also be significant indirect economic benefits including reduction in healthcare costs (due to avoided harmful algal blooms), cleaner drinking water sources resulting in reduced water treatment costs. Other indirect economic benefits include the avoidance of costs associated with the need to find alternative recreational locations, enhanced opportunities for angling competitions, wildlife watching, and camping, and non-use values such as habitat protection. Numeric nutrient criteria can also result in avoidance of future restoration costs because numeric criteria are easily measurable qualities of water that can be used to assess whether or not waters are in danger of becoming impaired.

Some of the benefits of reducing nutrients can be monetized, at least in part, by translating changes in nutrient concentrations into an indicator of overall water quality (a water quality index, WQI) and valuing these improvements in terms of willingness to pay (WTP) for the types of uses that are supported by different water quality levels. To monetize benefits in this way EPA used an approach that links specific pollutant levels with suitability for particular recreational uses. The parameters used to formulate the WQI are based on waterbody type, scientific understanding of ecosystem response to varying conditions, and available data. To estimate benefits of water quality improvements associated with EPA's criteria, EPA calculated the post-compliance WQI assuming that all incrementally impaired waterbodies meet the numeric nutrient criterion, and that there are no water quality improvements in any non-incrementally impaired waterbodies. The difference in WQI between baseline conditions and compliance with the numeric TN and TP criteria is a measure of the change in water quality that may be attributable to the rule. EPA then conducted a regression analysis to determine average household Willingness to Pay (WTP) for increases in water quality. EPA calculated the average household WTP at the WBID-level for both full-time and part-time residents. EPA estimated total benefits at the WBID level by multiplying average household WTP with the number of households in each category and the percentage of miles or area that comprise a given WBID. As presented in Exhibit ES-6, EPA estimated total state benefits using current conditions as the baseline to be approximately $28.1 million per year ($21.6 million of improvements in flowing waters plus $6.56 million for improvements in lakes, using midpoint estimates). Although these monetized benefits estimates do not account for all potential economic benefits, they help to demonstrate the economic importance of restoring and protecting Florida waters from the impacts of nutrient pollution.

Exhibit ES-6: Estimated Total Average Annual Benefits for Water Quality Improvement to Freshwater Flowing Waters and Lakes in Florida (millions of 2010 dollars per year)

State Resident Type	Flowing Waters	Lakes	Total
Full Time FL Residents	$21.3	$6.5	$27.8
Part Time Winter Residents	$0.3	$0.1	$0.4
Total	$21.6	$6.6	$28.2

1. Introduction

The U.S. Environmental Protection Agency (EPA) is promulgating numeric nutrient criteria applicable to freshwater lakes and flowing waters in the state of Florida. EPA's criteria will augment the state's existing narrative nutrient criteria. Although this rule does not establish any requirements directly applicable to regulated entities or other sources of nutrient pollution, state implementation may result in new or revised National Pollutant Discharge Elimination System (NPDES) permit conditions for point source dischargers and/or requirements for nutrient pollution treatment controls on other sources. To provide information on the potential incremental costs associated with these related state actions, EPA conducted an analysis on the control costs and benefits associated with state actions that may be necessary to assure attainment of state water quality designated uses supported by the criteria in EPA's rule.

1.1 Requirement for the Rule

Section 303(c) of the Clean Water Act (CWA) requires states to adopt WQS for waters of the United States within their applicable jurisdictions. Section 303(c)(2)(A) and EPA's implementing regulations at 40 CFR part 131 require that state WQS include the designated use or uses to be made of the waters and the criteria necessary to protect those uses. EPA's regulations at 40 CFR § 131.11(a)(1) provide that states shall "adopt those water quality criteria that protect the designated use" and that such criteria "must be based on sound scientific rationale and must contain sufficient parameters or constituents to protect the designated use."

CWA section 303(c) also requires states to review their WQS at least once every three years and, if appropriate, revise or adopt new standards. States must submit these new or revised WQS to EPA for review and approval or disapproval. Section 303(c) also directs the EPA Administrator to promulgate WQS to supersede state standards that it has disapproved or in cases where it determines that a new or revised standard is needed to meet CWA requirements.

The state of Florida currently uses a narrative criterion to protect waters from nutrient pollution. In January of 2009, EPA determined that new or revised WQS for nutrients in the form of numeric nutrient criteria are necessary in Florida to meet the requirements of the CWA (U.S. EPA, 2009a). In August of 2009 EPA entered into a phased Consent Decree with several environmental organizations that challenged the Agency for not having promulgated numeric nutrient criteria for the State of Florida. In that Consent Decree, EPA committed to issue a final numeric nutrient rule for Florida's inland waters by October 15, 2010, which was subsequently extended to November 14, 2010. This rule will satisfy that requirement of the Consent Decree.

1.2 Purpose and Scope of the Analysis

The rule establishes water quality criteria applicable to lakes and flowing waters in defined regions within Florida. The rule does not establish any requirements directly applicable to regulated entities or other sources of nutrient pollution to these waters. Nonetheless, state implementation of the criteria may result in new or revised National Pollutant Discharge Elimination System (NPDES) permit conditions for point source dischargers and nutrient control requirements on other sources (e.g., agriculture, urban runoff, and septic systems). Therefore, the purpose of this analysis is to provide estimates (within the limits of uncertainties regarding implementation) of the potential costs and benefits that may ultimately be associated with the modified criteria to inform the public regarding these potential impacts. Actual impacts will depend on the particular implementation strategy pursued by the state.

This report provides an assessment of the potential costs associated with implementation of EPA's final rule above and beyond the costs that may result without the rule. EPA believes that the requirements currently in place represent a useful baseline from which to evaluate potential actions that may be necessary to attain these criteria. However, in July of 2009 the state of Florida released draft numeric nutrient criteria for lakes and flowing waters. Although the state of Florida subsequently did not proceed forward with those numeric criteria provisions, EPA evaluated the incremental impacts of its proposed rule in January 2010 using the Florida July 2009 draft criteria as the baseline. To similarly illustrate the difference between Florida's draft approach and the provisions of this final rule, EPA has conducted the same evaluation as part of this economic analysis. **Appendix A** provides estimates of potential incremental costs relevant to this alternative baseline.

It is possible that implementation of the narrative criteria would eventually lead to imposition of controls deemed necessary to comply with EPA's numeric nutrient criteria because both criteria target the same endpoint of "no imbalance of flora and fauna," such that the difference in costs is just a matter of timing. Under such a scenario, EPA's rule may result in cost savings by addressing the need for controls sooner rather than later and avoiding more costly restoration. However, with this analysis, EPA is conveying information related to the potential costs and benefits of implementing its numeric nutrient criteria as an "increment" to the costs and benefits associated with ongoing efforts to implement the existing narrative criterion. EPA refers to these existing conditions and requirements (e.g., narrative nutrient criterion, actions required under existing nutrient-related TMDLs) as the "baseline."

To identify the potential incremental impact above the baseline for the rule, EPA evaluated potential changes to NPDES permit conditions for municipal and industrial wastewater facilities since these point sources may receive water quality based effluent limitations (WQBELs). For nonpoint sources, EPA identified waters that may not meet EPA's criteria but are not currently listed by the state as impaired for nutrient-related causes, and used land use data surrounding incrementally impaired watersheds (that are not also in baseline impaired watersheds) as an indication of the types of controls that will be needed to attain the criteria. EPA based its estimates of the types of controls and costs for different sources that may be needed on those currently being required throughout the state in watersheds impaired under the narrative criterion. The data and methods behind each of these components of the analysis are described in detail within the report and appendices.

In addition, this analysis provides a description of the types and categories of benefits associated with attaining and maintaining nutrient criteria in lakes and flowing waters in Florida, and estimates of the potential magnitude of benefits that may be associated with the rule based on a benefits transfer approach. Numeric nutrient criteria provide a means of developing protective numeric effluent limits for wastewater point sources. Numeric nutrient criteria also provide information that may help in limiting loads from nonpoint sources to prevent impairment in waters that do not yet exceed the criteria. Thus, there is potential for benefits from attaining designated uses where such uses are impaired and protecting designated uses from future impairment and the associated loss of value. However, the estimates of costs and benefits in this report do not account for prevention of future impairments.

1.3 Organization of this Report

The remainder of this report is organized as follows:

- Section 2 describes the baseline for estimating potential incremental compliance actions.

- Section 3 provides a description of the rule, and potential implementation.
- Section 4 provides estimates of controls and costs for wastewater point source dischargers.
- Section 5 provides estimates of controls and costs for industrial point sources.
- Section 6 identifies potentially impaired waters under the rule.
- Section 7 provides discussion of the potential for incremental controls for urban runoff.
- Section 8 provides estimates of controls and costs for agriculture.
- Section 9 provides estimates of controls and costs for septic systems.
- Section 10 provides estimates of government expenditures.
- Section 11 summarizes the potential costs and describes the uncertainties of the analysis.
- Section 12 provides qualitative and quantitative analyses of potential benefits.
- Section 13 provides monetized estimates of potential benefits.
- Section 14 provides references.
- Appendix A provides an assessment of incremental impairments and costs of the rule compared to an alternative baseline represented by FDEP's July 2009 draft numeric nutrient criteria.
- Appendix B provides a sensitivity analysis of the potential impact on the estimated costs of assumptions related to the downstream protection values (DPVs) for lakes.
- Appendix C provides discharger-level detail of estimated municipal wastewater costs.
- Appendix D provides detailed analyses for the sample of industrial dischargers.
- Appendix E provides discussion of the potential effect of nutrient criteria on response indicators and biota.
- Appendix F provides an analysis of quantitative benefits associated with improvements in dissolved oxygen levels.

2. Baseline for the Analysis

As described in Section 1, this report conveys information related to the potential costs and benefits of implementing EPA's numeric nutrient criteria as an "increment" to ongoing efforts to implement Florida's existing narrative criterion. This section describes the baseline conditions, including the regulatory framework, pollution controls, and water quality. Because a number of existing programs and requirements are not fully implemented, existing water quality may not accurately represent the ultimate conditions that would result without the rule. This section describes the information and assumptions EPA used to establish the baseline for identifying the incremental requirements and costs that may be associated with EPA's numeric nutrient criteria for lakes, streams, and springs in Florida.

2.1 Current Regulatory Framework

The current regulatory framework for controlling nutrients in Florida waters includes existing WQS, and state and federal requirements for dischargers of nutrients.

2.1.1 Water Quality Standards

WQS include designated uses of waters (e.g., aquatic life support, recreation, drinking water), water quality criteria to protect the uses, and antidegradation policy. WQS also include implementation procedures, specifically addressing identification of impaired waters, to the extent the procedures further define designated uses and protective criteria.

Current Water Quality Criteria

For nutrients, FDEP water quality criteria are narrative in form: Chapter 62-302.530, Florida Administrative Code (F.A.C.), 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 flora or fauna." EPA's numeric nutrient criteria address this aspect of the narrative criterion. The narrative criterion also states that (for all waters of the state) "the discharge of nutrients shall continue to be limited as needed to prevent violations of other standards contained in this chapter (Chapter 62-302, F.A.C.). Man-induced nutrient enrichment (total nitrogen or total phosphorus) shall be considered degradation in relation to the provisions of Sections 62-302.300, 62-302.700, and 62-4.242, F.A.C." The principle of "other standard" referred to in this aspect of Florida's narrative is dissolved oxygen (DO). EPA expects that achieving the promulgated numeric nutrient criteria will also maintain DO levels consistent with Florida WQS in most cases; however, there remains the potential that the existing narrative criteria may need to be utilized to lower nitrogen and phosphorus levels further in specific waters.

CWA Section 303(d) Listing Procedures

The WQS also contain procedures for identifying impaired waters. FDEP first evaluates the existing water quality data to determine whether waters are potentially impaired and includes these waters on a Planning List for further assessment. FDEP then assesses waters on the Planning List through additional data gathering and strategic monitoring to determine if a waterbody is impaired and if the impairment is caused by pollutant discharges. FDEP places these waters on the Verified List which are included in the CWA Section 303(d) list of impaired waters that require a TMDL.

FDEP uses a trophic state index (TSI) and chlorophyll-a concentration as the primary means for assessing whether a waterbody should be assessed further for nutrient impairment. TSI measures the potential for algal or aquatic weed growth; its components include total nitrogen, total phosphorus, and chlorophyll.

FDEP also considers other information indicating an imbalance in flora or fauna due to nutrient enrichment, including, but not limited to, algal blooms, excessive macrophyte growth, decrease in the distribution (either in density or areal coverage) of seagrass or other submerged aquatic vegetation, changes in algal species richness, and excessive diel oxygen swings (Chapter 62-303, F.A.C.).

For example, a stream (which includes springs FDEP classifies as surface waters) shall be included on the planning list for nutrients if (Chapter 62-303.351, F.A.C.):

- algal mats are present in sufficient quantities to pose a nuisance or hinder reproduction of a threatened or endangered species, or
- the annual mean chlorophyll-a concentration is greater than 20 µg/L or if data indicate that annual mean chlorophyll-a values have increased by more than 50% over historical values for at least two consecutive years.

A lake shall be included on the planning list for nutrients for any of the following (Chapter 62-303.352, F.A.C.):

- for lakes with a mean color greater than 40 platinum cobalt (Pt-Co) units, the annual mean TSI for the lake exceeds 60, unless paleolimnological information indicates the lake was naturally greater than 60
- for lakes with a mean color less than or equal to 40 Pt-Co units, the annual mean TSI for the lake exceeds 40, unless paleolimnological information indicates the lake was naturally greater than 40
- for any lake, data indicate that annual mean TSIs have increased over the assessment period, as indicated by a positive slope in the means plotted versus time, or the annual mean TSI has increased by more than 10 units over historical values.

To be placed on the verified list, FDEP requires sufficient data from the last five years preceding the planning list assessment, combined with historical data (if needed to establish historical chlorophyll-a levels or historical TSIs). If data are sufficient, FDEP needs to collect additional data to meet the requirements. Once these additional data are collected, FDEP determines if there is sufficient information to develop a site specific threshold that better reflects conditions beyond which an imbalance in flora or fauna occurs in the water. If there is insufficient information, FDEP will reevaluate the data using the thresholds from the planning list. However, FDEP need not use these same thresholds in developing the TMDL.

Proposed Revisions to Nutrient Standards

In July 2009, FDEP published draft changes to its nutrient WQS (Chapters 62-302 and 62-303) to put in place numeric limits for phosphorus and nitrogen with plans to submit its numeric nutrient criteria to the Florida Environmental Regulation Commission by 2011 (State of Florida Numeric Nutrient Criteria Development Plan, FDEP 2009a). The numeric nutrient criteria for total nitrogen (TN) and total phosphorus (TP) are based on color for lakes and region for flowing waters (**Exhibit 2-1**)

Exhibit 2-1: FDEP July 2009 Draft Numeric Nutrient Criteria for Lakes and Streams

Region/Type of Water	TN Annual Geometric Mean Criteria (mg/L)	TP Annual Geometric Mean Criteria (mg/L)	Nitrate + Nitrite Monthly Median Criteria (mg/L)
Clear Lakes, < 50 mg/L $CaCO_3$[1]	0.85	0.015	NA
Clear Lakes, > 50 mg/L $CaCO_3$	1.0	0.030	NA
Colored Lakes[1]	1.23	0.050	NA
Panhandle Streams	0.82	0.069	NA
Northeast Streams	1.72	0.101	NA
North Central Streams	1.72	0.359	NA
Peninsula Streams	1.72	0.119	NA
Bone Valley Streams	1.72	0.75	NA
Springs	NA	NA	0.35

mg/L = milligrams per liter
NA = not applicable
Pt-Co = platinum-cobalt
TN = total nitrogen
TP = total phosphorus

1. FDEP (2009b) indicates color >40 Pt-Co is a colored lake; color <40 Pt-Co is a clear lake.
2. FDEP proposed a monthly median nitrate-nitrite criterion for clear flowing waters (which includes springs) that applies in months when the median color is less than 40 Pt-Co and is not to be exceeded more than 10% of the time (unless a site specific alternative criterion has been adopted).

FDEP also proposed to adopt many TMDL targets and allocations as site specific criteria.

For lakes, impairment is based on exceeding the annual geometric mean criteria more than once in any three calendar year period. For streams, the draft impairment procedures refer to a section that is missing, making it unclear how impairment would be determined for streams. For consistency with lakes, EPA assumed that more than one exceedance in a three year period would result in a stream being listed as impaired. Ambient geometric means shall be based on at least four total measurements, with at least one measurement taken between May and September and one measurement taken between October and April.

2.1.2 Restoration of Designated Uses in Impaired Waters

FDEP is implementing its current narrative nutrient criteria through TMDLs and the NPDES permit program (see Section 2.1.3). A TMDL is a calculation of the maximum amount of a given pollutant that a surface water can receive and still meet WQS, and an allocation of that amount to point and nonpoint source categories. Because the existing nutrient criteria are narrative, FDEP typically uses site specific data to translate the narrative criteria into numeric concentration targets, numeric load targets, or percent reduction requirements. Numeric nutrient concentration targets in TMDLs for TN and TP in freshwater lakes and flowing waters range from 0.6 mg/L to 3.0 mg/L and 0.015 mg/L to 0.16 mg/L, respectively.

To implement TMDLs, FDEP may develop Basin Management Action Plans (BMAPs) with local stakeholders. State law requires FDEP to adopt BMAPs by Secretarial Order. These Orders are enforceable. BMAPs set forth the strategy for achieving the pollutant reductions established in the TMDL, including permit limits on wastewater facilities, urban and agricultural best management practices (BMPs), conservation programs, financial assistance, and revenue generating activities.

FDEP has adopted five nutrient BMAPs to date (Upper Ocklawaha, Orange Creek, Long Branch, Lower St. John's River (LSJR), and Lake Jesup) that address broad areas. For example, implementation of the

Upper Ocklawaha BMAP addresses surface waters throughout Lake County and part of Orange County, including the Clermont Chain of Lakes connected by the Palatlakaha River, Lake Apopka, Lake Griffin, and the Harris Chain of Lakes. Similarly, the Orange Creek Basin is a tributary of the Ocklawaha River. Implementation of the Orange Creek BMAP addresses surface waters in Alachua and Marion Counties, including Orange Lake, Lochloosa Lake, Newnans Lake, Tumblin Creek, Sweetwater Branch, Hogtown Creek, Lake Wauberg, Paynes Prairie/Alachua Sink, and the Ocklawaha River.

Exhibit 2-2 provides a summary of the source categories and implementation measures proposed in the completed BMAPs.

Exhibit 2-2: Summary of Completed Nutrient Basin Management Action Plans

BMAP (Date)	Description	Sources/Controls
Lake Jesup (2010)	No. of WBIDs: 2 Pollutants targeted: TP (actions will achieve TN reductions) Targets: TP = 0.096 mg/L; TN = 1.27 mg/L Implementation Plan: Necessary reductions spread over 15-year period; current BMAP only addresses reductions for the first 5-year period.	Municipal WWTPs: City of Samford Site 10 (only source) has discontinued application of biosolids and will reduce the use of reclaimed water on the site. Urban: implement BMPs through existing MS4 permits (15 of 17 entities have MS4 permits) Agriculture: 100% of targeted citrus, nurseries row crops, sod, and horse farms and cow/calf operations enrolled in FDACS BMP program in 5 years Septic Systems: Studies to better determine contributions; remove tanks <75 feet from waters in certain areas
Long Branch (2008)	No. of WBIDs: 1 Pollutants targeted: TN and TP Targets: TP = 0.14 mg/L; TN = 0.87 mg/L Implementation Plan: Unable to identify specific sources. Focus on implementation of existing programs and studies to identify sources; as such the TMDL will not be achieved in the near term.	Industrial Dischargers: Orlando Speedworld will identify procedures in place to ensure proper management of wastewater during events Agriculture: continue implementation of FDACS BMP manuals Urban: continue implementation of MS4 permits; Septic Systems: Sanitary survey to determine contributions to nutrient loads
Lower St. Johns River (2008)	No. of WBIDs: 5 (freshwater); 8 (marine) Pollutants targeted: TN and TP Targets: concentration targets not specified for freshwater portion; TN = 5.4 mg/L for marine Implementation Plan: Reductions needed from point and nonpoint sources; full implementation of BMAP and achieving TMDL will take many years.	Municipal WWTPs: Allows for aggregate permits (combined allocations with MS4 allocations); likely requires upgrade to advanced water treatment. Industrial Dischargers: Industrial effluent monitoring at Seminole Electric and other industrial sources Agriculture: Implement FDACS BMP manuals; regional stormwater facilities Urban: Continue implementation of MS4 permits; designate certain non-MS4 areas as Phase II MS4s; voluntary permit trading scheme Septic Systems: Phase-out projects

Exhibit 2-2: Summary of Completed Nutrient Basin Management Action Plans

BMAP (Date)	Description	Sources/Controls
Orange Creek (2008)	No. of WBIDs: 4 Pollutants targeted: TN and TP Targets: 0.031 mg/L to 0.16 mg/L for TP; 0.97 mg/L to 1.48 mg/L for TN Implementation Plan: Most activities recently completed or currently ongoing; several key projects/studies may extend past first 5-year cycle, and TMDLs may not be achieved in the near term.	Municipal WWTPs: Gainesville Regional Utilities (only source) to implement wastewater reuse and restoration of collection system to minimize releases. Industrial Dischargers: Small power plant will monitor discharges Agriculture: Implement FDACS BMP manuals; cooperation with private sector for implementation and monitoring Urban: Continue implementation of MS4 permit Septic Systems: Evaluation/studies of septic tanks in areas where most prevalent
Upper Ocklawaha (2007)	No. of WBIDs: 18 Pollutants targeted: TP (actions will achieve TN reductions) Targets: 0.02 mg/L to 0.055 mg/L TP; TN = 0.78 mg/L (1 TMDL) Implementation Plan: Most activities recently completed or currently ongoing; several key projects/studies may extend past first 5-year cycle, and TMDLs may not be achieved in the near term.	Agriculture: Implement FDACS BMP manuals; Marion County Clean Farms Initiative Urban: Continue implementation of MS4 permits (includes stormwater retrofits most of which were started or completed before final BMAP published); Orange County agreement with Parks Department to reduce use of phosphorus fertilizer and herbicide applications on all parklands Septic Systems: Ordinances for tank maintenance (not directly addressed in first phase because relatively small percent of load) Other: Nutrient reduction facility to treat releases from Lake Apopka; harvesting gizzard shad to reduce recycling of nutrients; re-establishing natural water level fluctuations and flows; restoring aquatic/wetland habitats at former muck farms; most projects started prior to BMAP (ongoing)

BMAP = Basin management action plan
BMPs = Best management practices
FDACS = Florida Department of Agriculture and Consumer Service
MS4 = municipal separate storm sewer system
TMDL = total maximum daily load
TN = total nitrogen
TP = total phosphorus
WBID = waterbody identification

The BMAPs rely heavily on existing programs [e.g., NPDES program, BMP manuals (see Section 2.1.5)]. For example, existing BMAPs for the LSJR, Orange Creek watershed, and Upper Ocklawaha River rely on voluntary implementation of BMPs by farmers through the Florida Department of Agriculture and Consumer Services (FDACS) BMP program. However, Subsection 403.067(7)(b), F.S., requires that nonpoint pollutant sources (such as agriculture) included in a BMAP demonstrate compliance with pollutant reductions established to meet a TMDL either by implementing BMPs or by conducting water quality monitoring prescribed by FDEP or a water management district. Thus, if necessary, farmers could be required to implement approved BMPs.

Note that a June 2008 FDEP Office of Inspector General (OIG) audit of the TMDL program indicated that the Ocklawaha River is the only waterbody currently undergoing BMAP implementation, no waterbodies have been removed from the impaired list, and it may take a number of years before demonstrable effects of the program can be measured and FDEP removes waterbodies from the impaired waters list (FDEP OIG, 2008). Factors that may affect the progress of implementation include the time it takes for local governments and residents to reach consensus on difficult issues, and the time it takes to acquire the necessary land (FDEP OIG, 2008).

2.1.3 Existing Regulations for Point Source Dischargers

Rules 62-620.320(1) and 62-620.620(1)(g), F.A.C., establish that a permit shall be issued only if the applicant affirmatively provides FDEP with reasonable assurance (RA) that the construction, modification, or operation of the discharge facility will not discharge or cause pollution in contravention of WQS. As part of the permit application process, the applicant must supply data characterizing the pollutants that may be discharged and provide RA that the discharge will not violate water quality criteria in the receiving water.

FDEP's permit writer's guidance manual (FDEP, 2006a) indicates that at a minimum permit writers should include limits in permits for a parameter if there is evidence that the discharge could cause or contribute to instream violations. However, FDEP may include limits based on EPA's reasonable potential approach, which requires sufficient effluent data as described in its Technical Support Document (TSD) (U.S. EPA, 1991), or based on the judgment of the permit writer that a limit is necessary to provide RA that the facility will operate in a way that will not cause water quality violations (FDEP, 2006a). For example, for the current narrative nutrient criterion, permit writers determine whether the discharge contains phosphorus or nitrogen and examine the ambient water quality of the receiving water and any other affected waters with regard to nutrient levels and biological impacts.

Based on this analysis, permit writers determine the level of nutrients that would "cause an imbalance in natural populations of aquatic flora or fauna" and translates those levels into numeric "targets" for the receiving water and any other affected waters. If there is reasonable potential, permit writers calculate permit limits to ensure that such a discharge will not cause or contribute to an exceedance of the nutrient target levels. FDEP's permit writer's guidance manual (FDEP, 2006a) indicates that water quality based effluent limits (WQBELs) are calculated based on EPA's TSD (U.S. EPA, 1991). If sufficient data are not available to determine reasonable potential, the permit can be issued with an effluent limit based on Florida's water quality criteria and an administrative order attached to the permit that requires the studies necessary to determine RA with a schedule to return the facility to compliance with the final permit limits (FDEP, 2006a).

2.1.4 Existing Regulations for Urban Areas

Stormwater runoff from urban areas may contain phosphorus and nitrogen, primarily from fertilizers applied to lawns and golf courses, decomposition of natural rock and soils, air deposition from vehicle exhaust or power plants, detergents used to wash cars on the street, and pet waste. A number of rules and programs regulate discharges from urban areas.

Urban Turf Fertilizer Rule

To address nutrients from fertilizers, the FDACS adopted the statewide Urban Turf Fertilizer Rule, which limits the phosphorus and nitrogen content in fertilizers for urban turf and lawns. The rule requires that all fertilizer products labeled for use on urban turf, sports turf, and lawns be limited to the amount of nitrogen and phosphorus needed to support healthy turf maintenance. FDACS estimated a 20% to 25% reduction in nitrogen and a 15% reduction in phosphorus in every bag of fertilizer sold to the public. The rule also protects water quality by restricting phosphorous and nitrogen application rates in fertilizers.[2] The rule became effective December 31, 2007, with a requirement for fertilizer labels to reflect compliance by July 1, 2009.

EPA Stormwater Program

EPA's Phase I stormwater rule covers large and medium-size MS4s [Clean Water Act Section 402(p) sources], and the Phase II rule covers small MS4s (systems serving less than 100,000 people). Generally, Phase I MS4s are covered by individual permits and Phase II MS4s are covered by a general permit. There are 28 Phase I NPDES MS4 permits in Florida and 131 Phase II permittees.

Each regulated MS4 is required to develop and implement a stormwater management program (SWMP) to reduce the contamination of stormwater runoff and prohibit illicit discharges. The MS4 Program contains elements called minimum control measures that when implemented should result in a significant reduction in pollutants discharged into receiving waters:

- Public Education/Outreach – includes educating the community on the pollution potential of common activities, increasing awareness of the direct links between land activities, rainfall-runoff, storm drains, and local water resources, and providing the public clear guidance on steps and specific actions that they can take to reduce their stormwater pollution-potential through use of brochures/pamphlets, mailers, posters, and training for local business employees
- Participation/Involvement – build on community capital to help spread the message on preventing stormwater pollution, to undertake group activities that highlight storm drain pollution, and contribute volunteer community actions to restore and protect local water resources; includes facilitating opportunities for direct action, educational, and volunteer programs such as riparian planting days, volunteer monitoring programs, storm drain marking, or stream-clean up programs
- Illicit Discharge Detection and Elimination – develop a program to detect and eliminate illicit discharges which primarily includes developing a storm sewer system map, an ordinance prohibiting illicit discharges, a plan to detect and address these illicit discharges, and an education program on the hazards associated with illicit discharges
- Construction Site Runoff Control – develop a program to reduce pollutants in stormwater runoff for construction sites disturbing one or more acres which primarily includes developing an ordinance, requirements to implement erosion and sediment control BMPs, requirements to control other waste at the construction site, procedures for reviewing construction site plans, procedures to receive and consider information submitted by the public, and procedures for inspections and enforcement of stormwater requirements at construction sites.
- Post-Construction Runoff Control – address post-construction stormwater runoff from new development and redevelopments that disturb one or more acres which primarily includes

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[2] A maximum of 0.25 lbs phosphorus oxide (P_2O_5) per 1000 sq. ft. per application and not to exceed 0.5 lbs P_2O_5 per 1000 sq. ft. per year. Application rates above these levels would require a soil sample of the application site to justify an increase in P_2O_5. A maximum of 0.7 lbs of readily available nitrogen per 1000 sq. ft. at any one time based on the soluble fraction of nitrogen formulated in the fertilizer. A maximum of 1 lb TN per 1000 sq. ft. to be applied at any one time, not exceeding the annual nitrogen recommendations in the Fertilizer Guidelines for Established Turf Grass Lawns in Three Regions of Florida. Application rates above these levels would require a turf tissue test at the application site to justify the increase in TN.

developing strategies to implement a combination of structural and non-structural BMPs, an ordinance to address post-construction runoff, and a program to ensure adequate long-term operation and maintenance of BMPs.

- Pollution Prevention/Good Housekeeping - develop inspection and maintenance procedures and schedules for stormwater BMPs, implement BMPs to treat pollutants from transportation infrastructure, maintenance areas, storage yards, sand and salt storage areas, and waste transfer stations, establish procedures for properly disposing of pollutants removed from the MS4, and identify ways to incorporate water quality controls into new and existing flood management projects.

Florida Stormwater Rule

Florida's 1982 stormwater rule [as authorized in Chapter 403, Florida Statues (F.S.)] requires treatment of stormwater from new development and redevelopment prior to discharge. The rule is a technology-based program that relies on the implementation of BMPs designed to achieve a specific level of treatment (i.e., performance standards). The rule also requires that older systems be managed as needed to restore or maintain the beneficial uses of waters, and that water management districts establish stormwater pollutant load reduction goals to be adopted as part of a Surface Water Improvement and Management (SWIM) plan, other watershed plan, or rule.

In addition, Chapter 62-40, F.A.C., "Water Resource Implementation Rule," establishes that stormwater design criteria adopted by FDEP and the water management districts shall achieve at least 80% reduction of the average annual load of pollutants that cause or contribute to violations of WQS (95% reduction for outstanding natural resource waters). The rule also states that the pollutant loading from older stormwater management systems shall be reduced as necessary to restore or maintain the designated uses of waters.

2.1.5 Existing Requirements for Agriculture

Phosphorus and nitrogen in agricultural runoff come from application of fertilizer to crops and pastures, and animal wastes. A number of rules and programs address nutrient discharges from these sources.

FDEP Dairy Rule and CAFO Requirements

Chapter 62-670, F.S. requires all concentrated animal feeding operations (CAFOs) in the state of Florida that discharge water offsite to file an application for a NPDES permit with FDEP. It also prohibits discharge of process wastewater and runoff from any major egg production facility to surface waters except in the event of a 25-year, 24-hour storm event. In addition, dairy operations within the Lake Okeechobee Drainage Basin [as defined in 62-670.200(8)] and its tributaries are also required to implement BMPs for the purpose of reducing phosphorus inputs to the lake. Specifically, dairy farms in the Lake Okeechobee Drainage Basin must provide fencing to keep dairy cows away from surface water and have a system for waste collection, storage, and treatment, particularly in areas of high-intensity use.

The rule also contains requirements for land application of waste, setback distance from surface water sources, and groundwater monitoring. The Dairy Rule does not establish a specific off-site phosphorus discharge concentration limitation, but rather requires BMPs to be incorporated into the operation of dairies. These BMPs need to provide reasonable assurances that each dairy could meet state water quality standards and that acceptable phosphorus levels in off-farm discharges would be achieved (Chapter 62-670, F.A.C.). Although the Interim Lake Okeechobee SWIM Plan (SFWMD, 1989) established a maximum discharge limitation of 1.2 mg/L total phosphorus, the dairies are exempt from permitting and enforcement under the Works of the District (WOD) Program[3], since they are under the jurisdiction of the Dairy Rule.

The national CAFO rule, 40 CFR 122.23(d), requires CAFOs that have the potential to discharge be evaluated on a case-by-case assessment to determine whether the CAFO, due to its individual attributes, discharges or has potential to discharge. Discharges from the CAFO include discharges of manure, litter, or process wastewater from land application areas under the control of the CAFO. Agricultural stormwater discharges from CAFO areas (i.e., areas where animal waste has been applied in accordance with site specific nutrient management practices that ensure appropriate agricultural utilization of the nutrients) are exempt.

2.1.5.2 Agricultural BMP Manuals

In 1999, the Florida Watershed Restoration Act (FWRA) established BMPs as the primary instrument for implementing Florida's TMDL program. Under the FWRA (Section 403.067, F.S.), implementation of BMPs that FDEP has verified as effective and FDACS has adopted by rule provides a presumption of compliance with state WQS. Participation in this program also provides a release from the provisions of Section 376.307(5), F.S. which requires that funds be paid for damages from the discharge of pollutants.

As part of the manual development process, FDEP verifies the BMPs as effective at reducing pollutant loading to waters. Under the program, landowners maintain records and provide documentation regarding the implementation of BMPs utilized and reasons why certain BMPs are not applicable to their specific situation. The BMP manuals provide assessment tools to assist operators in determining the appropriate and applicable BMPs according to the type of farm and the basin where the farm is located.

For example, the BMPs for cow/calf operations are divided into three levels. Level I BMPs are those that are largely applicable to all ranchers, and include nutrient management, alternative water sources for cattle, grazing management, general erosion and sediment control, water resource management, animal mortality disposal, conservation buffers and fences, integrated pest management (IPM), and wellhead, wetlands, and springs protection. Ranchers may have to implement Level II and III BMPs based on assessments identifying water quality risk features that require special attention or protection; these BMPs focus on high intensity areas, livestock use exclusion, and address the need for grade stabilization structures for sediment control and list situations that require comprehensive grazing management practices.

For container nurseries, BMP practices include erosion control, fertilization management, irrigation management, pesticide management, nursery layout, waste management, and container substrate and planting practices. FDACS requests that nurseries assess current practices to identify which BMPs are already in practice and to identify any additional BMPs necessary.

Sod growers must implement a minimum number of BMPs to establish a foundation for environmental protection. Depending on the farm's site specific conditions or geographic location, the farmer could be exempt from implementing some of the minimum BMPs. As part of minimum BMP requirements farms must implement nutrient management, irrigation scheduling and maintenance, sediment and erosion control measures, integrated pest management, wellhead, wetlands and springs protection, ditch construction and maintenance, conservation buffers, stormwater management and mowing management.

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[3] Each of the five water management districts in Florida has a WOD program. WOD represent canals, water control structures, rights-of-way, lakes and flowing waters and other water resources for which each district has responsibility or owns.

In addition, growers must also use the BMP decision-tree in the manual to identify other BMPs that are applicable to their farming operation. For example, growers who run seasonal sod farming operations may have fewer BMPs, while those farming in spring recharge basins or special regulatory areas may have additional BMPs that apply.

There are several citrus BMP manuals for different locations such as Gulf citrus, Indian and Peace River citrus, and Florida Ridge citrus. For citrus growers, the suggested BMPs include reducing the impact of pesticide use, reducing excessive nutrients, minimizing sediment transport and growth of aquatic plants, and reducing runoff flowing off-site.

For vegetable and agronomic crops, farmers first must inventory current farm practices and then use the manual to identify additional BMPs applicable to their farming operation. These may include farm ponds, filter strips, flood protection, IPM, irrigation scheduling, maintenance and evaluation, fertilization management, riparian buffers, erosion control measures, wellhead and wetlands protection, access road mitigation, and ditch construction and maintenance.

Under the FDACS program, farmers must submit a notice of intent (NOI) identifying the approved BMPs they intend to implement. Implementing the approved BMPs provides a presumption of compliance with state WQS and makes producers eligible for cost-share for certain BMPs.

Lake Okeechobee Watershed Regulatory Program

There are several statutes and regulations governing the discharge of phosphorus in the Lake Okeechobee watershed.

Northern Everglades and Estuaries Protection Program

The Northern Everglades and Estuaries Protection Program (formerly the Lake Okeechobee Protection Act; Section 373.4595, F.S.) is a phased watershed program to reduce phosphorus loads and implement long-term solutions to meet the TMDL for Lake Okeechobee and its tributaries. The initial phase of phosphorus load reductions is based on the District's Technical Publication 81-2 and WOD program, with subsequent phases of phosphorus load reductions based on the TMDLs (the TMDL boundary corresponds to the revised rule boundary).

Under the statute, where FDACS adopts agricultural nonpoint source BMPs by rule, owners or operators of agricultural nonpoint sources must either implement BMPs or demonstrate compliance with the South Florida Water Management District's (SFWMD) WOD program by conducting monitoring prescribed by the FDEP or SFWMD. For nonagricultural nonpoint sources, BMPs or interim measures adopted by FDEP or SFWMD must also be implemented. To verify the effectiveness of BMP implementation, SFWMD or FDEP is to monitor representative sites throughout the watershed. In cases where water quality problems persist despite the appropriate implementation of adopted BMPs, FDACS, SFWMD, or FDEP, in consultation with the other coordinating agencies and affected parties, can reevaluate the BMPs and make appropriate changes to the rule adopting BMPs.

Chapter 40E-61, F.A.C.

SFWMD is responsible for implementing the SWIM Plan for Lake Okeechobee, establishing a program to protect the water quality of Lake Okeechobee and reducing the total phosphorus loading to Lake Okeechobee (to an average annual target load of 360 metric tons/year). Chapter 40E-61, F.A.C. addresses the reduction of phosphorus to Lake Okeechobee, and is based on the goals, objectives, and strategies contained in the SWIM Plan. According to 40E-61.041, each parcel of land within the Lake Okeechobee Watershed is presumed to connect to or make use of the WOD within the Lake Okeechobee Watershed, and therefore, the rule requires them to obtain a general or individual permit, and to comply with applicable water quality performance limitations.

Chapter 40E-61 requires individual permits for parcels of land used for improved pasture (including heifer farms and dairies not covered by the FDEP Dairy Rule), vegetable farms (including row crops) and hog, poultry or goat farms located in certain sub-basins. Individual permit requirements include meeting interim annual average phosphorus limits (based on meeting the SWIM plan goal of 360 metric tons of phosphorus per year) and bi-weekly monitoring (performed by SFWMD until it determines compliance with the phosphorus limits). If the permittee exceeds the phosphorus limits, SFWMD may request that additional measures be taken to comply.

Parcels of land used for urban stormwater, nurseries, golf courses, land spreading of sludge, sugar cane, sod farms, or horse farms located in individual permit sub-basins must obtain a general permit under the current rule. General permit requirements include submitting an application or NOI with a statement indicating how phosphorus discharges will be controlled and meeting off-site phosphorus discharge concentration limits.

Landowners located in other sub-basins are also covered under a general permit, however, they do not have to submit an application/NOI assuming they do not exceed applicable phosphorus discharge limits (referred to as a No Notice General Permit). If monitoring data indicate that a discharger or sub-basin exceeds the limits, the landowner would be required to submit an application for a General or an Individual Permit, depending on land use.

The current rule exempts the following entities from obtaining a permit regardless of phosphorus discharge levels:

- Dairy farms subject to and operated and maintained in compliance with the requirements of a valid permit issued pursuant to the FDEP dairy rule
- Stationary installations regulated by the FDEP
- Activity on land units less than one-half acre in size which cannot reasonably be expected to discharge water in violation of the criteria in the rule
- Septic tanks, except for those that collectively create a local source of phosphorus that significantly impacts Lake Okeechobee as demonstrated by competent substantial evidence
- Activities exempt from permitting pursuant to Section 403.813(2), F.S., except when the District has a proprietary interest in the work.

Unless revoked or otherwise modified, the duration of an individual or general permit is three years from the date of issuance. SFWMD extends these permits automatically for another three year period, unless it notifies the permittee otherwise. Permits not automatically extended expire three years from the date of issuance unless an application for a renewal is filed. General permits remain effective until the rule is amended or the District notifies a permittee that the permit is revoked.

Chapter 40E-63, F.A.C.

Chapter 40E-63 requires that any lands in the Everglades Agriculture Area (EAA) which release water that ultimately is discharged to the WOD (e.g., specifically named water control structures, rights-of-way, canals, and other water resources which the SFWMD owns) within the Everglades must have a general, individual, or master permit. The ultimate goal of the permits is to reduce total phosphorous loads discharged from the EAA by 25%.

A parcel of land qualifies for a general permit if it is a residential property less than 40 acres in size, not served by a central drainage system, or if it is commercial or industrial property less than 5 acres not served by a central drainage system. No NOI, permit application, or application fee is required for a general permit.

Individual permits are required for all structures which discharge or release water to one of the WOD that do not qualify for a general or master permit. In the permit application, permittees must provide a description of BMP implementation and operation, including a description of rationale, consideration of BMPs provided in rule, a fertilization and water management plan for each crop, a monitoring plan to verify BMP effectiveness, an education and training program regarding BMPs, and a schedule for BMP plan implementation. Permittees must also provide a water quality monitoring plan which includes a description of monitoring program, and collection, sampling and testing method.

Master permits are allowed for lands that are contiguous, have interconnected drainage systems, or proposed coordinated BMP plans. The requirements for a master permit are the same as those for an individual permit. In addition, permittees must provide information which demonstrates that the applicant entity or cooperating group of landowners possesses the legal, financial, and institutional authority and ability to carry out the terms of the permit.

Rule 5M-3, F.A.C.

Under F.A.C. Rule 5M-3, the FDACS oversees implementation of BMPs for agricultural producers in the Lake Okeechobee watershed. The rule defines the phosphorus management requirements of agricultural producers necessary to receive a presumption of compliance with state water quality standards including those established under TMDLs. The following BMPs are approved for the Lake Okeechobee watershed:

- FDACS BMP manual for the Indian River Area citrus groves
- FDACS BMP manual for cow/calf operations
- FDACS BMP manual for vegetable and agronomic crops
- Site specific conservation plan, as defined in Rule 5M-3.002, F.A.C.
- Site specific agricultural nutrient management plan (ANMP), as defined in Rule 5M-3.002, F.A.C., developed for a dairy or other concentrated animal feeding operation.

However, farmer implementation of the BMP manuals provides a presumption of compliance with WQS for those pollutants addressed by the practices. It also releases farmers from the provisions of Section 376.307(5), F.S. which requires that funds be paid for damages from the discharge of pollutants.

Agricultural Assistance Programs

To encourage implementation of BMPs and various conservation measures, there are several national programs including:

- Conservation Stewardship Program (CSP) – a voluntary conservation program that identifies and rewards through incentives those farmers and ranchers who meet the highest standards of conservation and environmental management on their operations
- Conservation Reserve Enhancement Program (CREP) – program in which farmers receive payment to convert cropland and marginal pastureland to native grasses, trees, wetlands, and related conservation buffer practices to improve water quality, soil, and wildlife habitat

- Conservation Technical Assistance (CTA) – program through which Natural Resource Conservation Service (NRCS) and its partners provide help to land users to address opportunities, concerns, and problems related to the use of natural resources and to help land users make sound natural resource management decisions on private, tribal, and other non-federal lands
- Environmental Quality Incentives Program (EQIP) – a voluntary conservation program for farmers and ranchers that offers financial and technical help to assist eligible participants install or implement structural and management practices on eligible agricultural land
- Grazing Land Conservation Initiative (GLCI) – NRCS provides financial and technical assistance to landowners to support improved management of grazing land resources; successful in assisting landowners apply new technology to improve livestock production efficiency while maintaining or improving their natural resources.

2.1.6 Existing Requirements for Forestry

Florida's Division of Forestry (FDOF) controls nonpoint forestry discharges of nutrients through the implementation of BMPs, as developed by the BMP Technical Advisory Committee and published in the *Silviculture Best Management Practices Manual* (FDOF, 2009). According to the manual, the BMPs reflect "the minimum standards necessary for protecting and maintaining the State's water quality as well as certain wildlife habitat values, during forestry activities," and address many sources of pollution including sedimentation, nutrients, and turbidity. The manual contains 143 BMPs, within 14 categories organized by their application to different land types, waterbodies, activities, and special conditions.

One of the BMPs included in the manual is the designation and management of Special Management Zones (SMZs), which are areas associated with particular waterbodies that are subject to specific criteria to protect the water from nutrient, debris, and other sources of pollution. Each waterbody type may have one or more applicable SMZ, including the primary zone (where some forestry activity may be allowed, but subject to stringent restrictions), the secondary zone (where forestry is not restricted but has some special requirements), and the stringer (which is a row of trees left at the bank to act as a barrier).

The manual describes other BMPs according to the waterbody affected or the activity being performed in close proximity to it, and many pertain to the SMZs. The most relevant of these with regard to nutrient loading are those that relate to the application of fertilizer. For example, there can be no aerial application or transfer/loading stations in the primary zones (which are the most sensitive areas adjacent to waterbodies). There are also stated guidelines about how much fertilizer should be applied, and at what times, to minimize the potential for unintended migration of nutrients to the water, and stated maximum per-acre application rates.

Currently, BMPs are implemented primarily through educational outreach efforts such as workshops, demonstrations, and "master logger" certification classes offered through the Florida Forestry Association (FDOF, 2010). FDOF periodically conducts state-wide surveys of silviculture practices to assess compliance levels, identify areas and foresters in need of further education, and evaluate the effectiveness of the BMPs. There have been 15 surveys since 1984, with the most recent in 2009. Over that period, the average compliance rate with all BMPs has been 94%, with 84% in 1985 and 98% compliance in 2009. The 2009 survey report also indicated that the implemented BMPs were generally effective at preventing significant impacts to the relevant waterbodies, although the report presented little data to support this conclusion (FDOF, 2010).

2.1.7 Existing Requirements for Septic Systems

Nutrients from poorly maintained or failing septic systems or onsite sewage treatment and disposal systems (OSTDSs) can threaten both surface and groundwaters. In addition to runoff to surface water from mounded leach fields, nutrients can leach into groundwater beneath the system and be carried to nearby surface waters.

In Florida, the Bureau of Onsite Sewage Programs in the Florida Department of Health (FDOH) and the environmental health section of County Health Departments regulate the use of OSTDSs. FDOH does not permit the use of an OSTDS where the estimated domestic sewage flow is over 10,000 gpd or the commercial sewage flow is over 5,000 gpd, where there is a likelihood that the system will receive toxic, hazardous or industrial wastes, where a sewer system is available, or if any system or flow is currently regulated by FDEP, unless a variance from these prohibitions has been granted by FDOH.

2.1.8 Existing Requirements for Air Sources

Atmospheric deposition of nitrogen can be a significant source of nutrient loadings to lakes and flowing waters. However, the specific sources of atmospheric nitrogen are not typically well known and can originate from local, regional and international sources, including automobiles, power plants, volcanoes, and industrial air emissions.

Florida Air Quality Regulations place an ambient air quality limit on nitrogen dioxide of 0.05 ppm (F.A.C. 62-204.240(5)). The major source of nitrogen dioxide is motor vehicle exhaust. Other sources include electricity generation, emissions from poultry litter, and other manufacturing processes. There are no other nitrogen- or phosphorus-based pollutants that have air quality standards in Florida, and atmospheric deposition is not considered to be a primary source of nutrient loading in the Southeastern United States (USGS, 2010).

2.1.9 Legacy Sources

Historic discharges of nutrients also provide current loadings in Florida waters. To the extent that legacy sources are identified and assigned load reductions in TMDLs, implementation plans identify control scenarios. In most cases, FDEP assumes that legacy sources will dissipate naturally, although this could take a long time. Consequently, BMAP controls may include temporary regional treatment systems. For example, in Lake Okeechobee, it may be necessary to integrate upland phosphorus control practices with regional treatment systems on the lower tributaries to meet the lake TMDL (SWET, 2008b). In time the accumulated phosphorus in these systems will wash out to establish a new equilibrium with the inflow phosphorus levels. Thus, the regional treatment systems would only be needed until the lakes and flowing waters come to equilibrium with the tributary loads. Jeppesen et al (2005; as cited in SWET 2008b) estimates that sloughs respond within 5 years to 20 years as compared to the larger lakes that could take much longer to establish a new equilibrium.

2.1.10 Summary and Assumptions

The current regulatory framework in Florida with respect to nutrients in lakes and flowing waters includes a narrative water quality criterion and procedures for identifying waters as exceeding the nutrient WQS. FDEP is addressing current impairments through requirements on a range of sources, established in BMAPs. In addition, regulations of specific sources (e.g., stormwater, certain agricultural producers) address nutrients and other pollutants in discharges, and require actions that will reduce nutrient pollution in lakes and flowing waters.

Because the cost of nutrient controls required by existing regulations (e.g., MS4 permit requirements, FDEP dairy rule) and BMAPs are expected without this rule, EPA included these costs in the baseline for this analysis. EPA also assumed that additional controls would not be needed for waters listed as impaired or covered under TMDLs for which FDEP has not completed a BMAP because nutrient reductions would be necessary in the absence of EPA's rule. Thus, EPA did not include in this analysis costs associated with the following:

- Actions necessary to meet existing NPDES permit conditions for municipal and industrial wastewater
- Control actions established in existing BMAPs
- Control actions needed to reduce nutrients in waters on the 303(d) list or covered under TMDLs
- BMPs for the forestry sector
- Controls required by the FDEP Dairy Rule and EPA CAFO regulations
- Requirements for the Lake Okeechobee watershed
- Phase I and Phase II MS4 Permits
- Requirements for urban areas developed after 1982 under Florida's stormwater rule
- Urban Turf Fertilizer Rule.

Given these requirements, EPA identified the level of new requirements that may be needed in each source sector to meet EPA's numeric criteria.

2.2 Existing Nutrient Discharges to Freshwater Lakes and Flowing waters

Sources of nutrient discharges to freshwater lakes and flowing waters include wastewater point sources (e.g., municipal wastewater treatment plants (WWTPs), industrial facilities), urban stormwater, agricultural runoff, septic systems, atmospheric deposition, and legacy sources.

2.2.1 Wastewater Point Sources

EPA's permit compliance system (PCS) database indicates that there are 198 municipal wastewater dischargers and 245 industrial dischargers with individual permits.[4] Some of these permittees discharge to estuarine waters, coastal waters, or South Florida flowing waters and are not affected by the lakes and flowing waters rule. Also, not all industrial dischargers are likely to have the potential to discharge nutrients.

Given the nature of influent wastewater at municipal WWTPs, it is likely that all WWTPs have the potential to discharge nutrients. To identify industrial dischargers likely to discharge nutrients, EPA identified those dischargers in PCS with either numeric effluent limits and/or monitoring requirements for nitrogen and phosphorus (**Exhibit 2-3).** Based on these industrial categories, **Exhibit 2-4** summarizes the number of NPDES-permitted wastewater dischargers in Florida that may be affected by the rule. Based on

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[4] There are also 34,508 dischargers covered under generic or general permits. FDEP regulate these dischargers based on categories of wastewater facilities or activities that involve the same or similar types of operations or wastes. EPA did not include these dischargers in its analysis.

FDEP (2010) analysis, EPA assumed that stormwater treatment areas and drinking water treatment plants would not be affected by the rule.[5]

Exhibit 2-3: NPDES Dischargers with Numeric Effluent Limits and Monitoring Requirements for Nitrogen and Phosphorus in Florida[1]

SIC Code	SIC Code Description	No. with Nutrient Effluent Limits[1]		No. with Nutrient Monitoring Requirements[1]	
		Majors[2]	Minors[3]	Majors[2]	Minors[3]
0174	Citrus Fruits	1	0	1	0
1099	Miscellaneous Metal Ores, NEC	0	0	0	1
1422	Crushed and Broken Limestone	0	0	0	1
1475	Phosphate rock	14	1	15	5
1479	Chemical and fertilizer mineral mining, NEC	1	0	1	0
2015	Poultry slaughtering and processing	1	0	1	0
2033	Canned fruit and vegetables	1	1	1	1
2034	Dried and Dehydrated Fruits, Vegetables, and Soup Mixes	0	1	0	1
2037	Frozen Fruits, Fruit Juices, and Vegetables	0	0	0	1
2082	Malt beverages	0	2	0	2
2085	Distilled and blended liquors	0	1	0	2
2491	Wood Preserving	0	0	0	2
2499	Wood Products, NEC	0	0	0	1
2611	Pulp Mills	2	3	0	0
2621	Paper Mills	0	0	1	0
2631	Paperboard Mills	0	0	2	0
2821	Plastics Materials, Synthetic Resins, and Nonvulcanizable Elastomers	0	0	1	0
2824	Manmade Organic Fibers, Except Cellulosic	0	0	2	0
2869	Industrial Organic Chemicals, NEC	0	1	0	1
2873	Nitrogenous fertilizers	0	1	0	2
2874	Phosphatic fertilizers	12	16	1	1
2879	Pesticides and agricultural chemicals, NEC	1	0	1	0
2892	Explosives	1	0	1	0
3582	Commercial Laundry, Drycleaning, and Pressing Machines	0	0	0	1
3679	Electronic Components, NEC	0	0	0	1
3699	Electrical machinery, equipment, and supplies, NEC	0	1	0	1
3822	Automatic Controls for Regulating Residential and Commercial Environments and Appliances	0	0	0	6
4011	Railroad haul line operating	0	2	0	2
4226	Special Warehousing and Storage, NEC	0	0	0	1
4911	Electric services	6	0	13	0

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[5] FDEP (2010) assumed that reject wastewater from drinking water facilities (SIC 4941) will be disposed by other means than surface water discharge and that stormwater treatment areas (SIC 3822) developed for Everglades restoration efforts within the Everglades Protection Area have separate criteria and are not included.

Exhibit 2-3: NPDES Dischargers with Numeric Effluent Limits and Monitoring Requirements for Nitrogen and Phosphorus in Florida[1]					
SIC Code	**SIC Code Description**	**No. with Nutrient Effluent Limits[1]**		**No. with Nutrient Monitoring Requirements[1]**	
		Majors[2]	**Minors[3]**	**Majors[2]**	**Minors[3]**
4931	Electric and Other Services Combined	0	0	0	1
4941	Water supply	0	8	0	20
4952	Wastewater treatment plants	78	0	46	53
4953	Refuse Systems	0	1	0	2
4959	Sanitary Services, NEC	1	0	1	0
5146	Fish and Seafoods	0	0	0	1
5169	Chemicals and Allied Products, NEC	0	0	0	1
5171	Petroleum Bulk stations and Terminals	0	0	0	1
5541	Gasoline Service Stations	0	0	0	1
7996	Amusement parks	0	4	0	6
8422	Arboreta and Botanical or Zoological Gardens	0	0	0	1
8733	Noncommercial Research Organizations	0	0	0	1
9511	Air and Water Resource and Solid Waste Management	0	0	0	2
9999	Nonclassifiable	0	1	0	0
Total		119	44	88	123

Source: U.S. EPA (2010a), accessed June 2010.
Major = generally discharge greater than 1 mgd and have the potential to discharge toxics in toxic amounts
Minor = generally discharge less than 1 mgd and do not discharge toxics in toxic amounts.
NEC = not elsewhere classified
SIC = Standard industrial classification
1. Including TN, ammonia, nitrate, and organic nitrogen, and TP .

Exhibit 2-4: Summary of NPDES Dischargers in Florida Potentially Affected by Numeric Nutrient Criteria for Lakes and Flowing Waters[1]			
Discharger Category	**Major Dischargers**	**Minor Dischargers**	**Total**
Municipal Wastewater	43	42	85
Industrial Wastewater[2]	57	51	108
Total	100	93	193

Source: U.S. EPA (2010a).
SIC = Standard Industrial Classification
TMDL = total maximum daily load
1. Excludes dischargers to oceans, estuaries, bayous, wetlands, and South Florida flowing waters (identified based on receiving waterbody name and information contained TMDLs, permits, and laboratory reports).
2. For majors dischargers includes SIC codes 1475, 1479, 2015, 2611, 2621, 2631, 2821, 2824, 2874, 2879, 2892, and 4911; for minor dischargers includes SIC codes 1099, 1422, 1475, 2033, 2034, 2037, 2082, 2085, 2491, 2499, 2611, 2869, 2873, 2874, 3582, 3679, 3699, 3822, 4011, 4226, 4931, 4941, 4952, 4953, 5146, 5169, 5171, 5541, 7996, 8422, 8733, 9511, and 9999.

2.2.2 Stormwater

There are 27 Phase I MS4 permits and 133 Phase II MS4 permits in the state. Most of these entities have discharges to both fresh and marine waterbodies. Under existing permits, these entities implement stormwater controls that target a number of pollutants including nutrients. **Exhibit 2-5** shows stormwater control projects conducted under TMDL Water Quality Restoration Grants in 2009 (FDEP, 2010a).

Exhibit 2-5: MS4 Stormwater Control Projects in Florida

Entity	Control	Project Cost	Area Treated (acres)	TN Reduction (lbs/yr)	TP Reduction (lb/yr)
Titusville, City of	Alum injection	$1,655,169	114	1014.2	145.2
City of Palatka	Baffle boxes	$360,000	399	796.4	187
City of Ocala	Dry retention +Wet pond (four phases)	$2,536,248	738.27	3995.2	649
Lee County	Offline filter marsh	$2,194,520	7907	4191	220
Escambia County	Wet detention pond	$701,833	1375	470.8	473
Walton County	Swales, wet detention pond, and 2nd generation baffle box	$265,836	37	105.6	26.4
Maitland, City of	Wet detention pond	$2,586,301	120.8	237.6	228.8
Seminole County	Wet detention pond	$3,019,227	518.56	1606	147.4
Lake Worth	Nutrient separating baffle boxes	$1,000,000	280	2635.6	83.6
Lake County Water Authority	Wet detention pond	$1,628,699	27	501.6	77
Ocoee, City of	Wet detention pond	$2,600,000	124	413.6	63.8
Winter Park, City of	Liquid/Solid separation chamber	$1,364,000	95	574.2	57.2
Port St Lucie, City of	Baffle boxes, stormwater treatment area, sediment removal	$1,822,000	244	4083.2	1430
Martin County	Wet detention, marshes, channel drainage improvement	$2,902,518	107	286	90.2
Seminole County	Wet detention pond	$7,875,190	2801.61	1133	200.2
Deltona, City of	Wet detention pond	$2,227,448	430	481.8	167.2
Leesburg, City of	Wet detention pond	$1,429,000	132.4	380.6	132
Pinellas County	Alum injection	$2,990,533	920	2761	871.2
Lake County	Dry retention pond	$311,000	42	501.6	77
Jacksonville, City of	Wet detention pond	$4,384,800	1512	60585.8	545.6
Stuart, City of	Wet detention pond, dredging	$1,758,008	271	937.2	382.8
Marion County	Dry retention pond	$1,873,500	297	453.2	48.4
Rockledge, City of	Wet detention pond expansion	$931,500	685.5	4122.8	752.4
Gulfport, City of	Dry retention pond	$1,290,715	57.5	178.2	63.8
Port Orange, City of	Wet detention pond, swales, plantings,	$4,000,000	1720	827.2	272.8
Winter Garden, City of	Wet detention pond with Alum treatment	$3,075,127	549	2987.6	671
Sarasota, City of	Wet Detention	$16,873,000	3973.8	1507	723.8
Ocoee Public Work, City of	Wet Detention Ponds/Generation Baffle Boxes	$2,800,000	75	156.2	167.2
City of Titusville	Wet Pond + Baffle Box	$1,563,126	554.1	48.4	146.3
Tavares, City of	NuRF Flow Data BMP'S Installed	$7,400,000	119773	69040.4	10494

Exhibit 2-5: MS4 Stormwater Control Projects in Florida

Entity	Control	Project Cost	Area Treated (acres)	TN Reduction (lbs/yr)	TP Reduction (lb/yr)
Martin County Office of Water Quality	Wet detention ponds	$6,825,000	540	1326.6	198
Martin County Office of Water Quality	Nutrient separating baffle boxes	$788,000	169.29	167.2	83.6
Town of Surfside	Drainage wells	$1,747,000	131.8	1285.24	166.32
Atlantic Beach	Wet pond	$2,075,806	54.4	81.4	41.8
City of South Daytona	Wet Detention/Littoral Zone	$4,417,977	476	226.6	83.6
City of Maitland	Exfiltration Trenches	$1,098,365	20.3	37.4	8.14
Lake County Public Works	Wet Detention Pond	$2,340,000	125.5	596.2	107.8
SJRWMD	Dry Retention/Wet Pond	$3,000,000	8,343	33092.4	9504
Brevard County of Office Resources	Wet Detention Pond	$1,600,000	189	12.76	3.3
Lake County	Wet Detention Pond	$1,578,463	46.4	215.6	37.4

Source: FDEP (2010b).

2.2.3 Agriculture

The 2007 Census of Agriculture (USDA NASS, 2009) indicates that there are 47,463 farms and 9.2 million acres of farmland in Florida. Three million of these acres are cropland, of which 1.6 million acres are irrigated. Livestock and poultry inventory includes 1.7 million cattle; 20,000 hogs and pigs; 11.8 million layers; and 73 million broilers and other chickens.

Farmers implement BMPs as part of the FDACS BMP program described in Section 2.1.5. **Exhibit 2-6** shows the number of acres that farmers have enrolled in the FDACS BMP program.

Exhibit 2-6: Summary of Agricultural Lands Enrolled in FDACS BMP Program

FDACS BMP Program Type	Number of Acres
Citrus	509,553
Cow/Calf	448,602
Dairies	37,535
Equine	75
Grasses	3,271
Leatherleaf Ferns	144
Nursery	20,662
Poultry Feeding Operations	312
Row Crops	754,713
Sod Farms	33,813
Specialty Farms	306
Tri-County Agricultural Area	3,841
Total	1,812,827

Source: Based on GIS analysis of 2010 FDACS data on enrollments.

The Florida Farm Bureau has documented a number of BMP successes throughout the state (FFB, 2010):

- A watermelon farm achieved a farm-record yield using BMP irrigation and nutrient management tools; the amount of nitrogen used to grow the crop was 25% less than Institute of Food and Agricultural Sciences (IFAS)-recommended rates
- A strawberry farm was using three times the IFAS-recommended fertilizer rate (about 1.5 lb /acre/day) in order to fertilize plants because his irrigation practices led to leaching much of the applied nutrients; after implementing an evapotranspiration-based irrigation schedule and using BMP irrigation management tools, the farm's fertilizer use is now below the IFAS-recommended rate (less than 0.5 lb/acre/day)
- A corn grower reduced nitrogen inputs by 30 lbs/acre on 70 acres using BMPs; this was a reduction of 2,100 lbs of nitrogen with no yield loss, and the grower has since reduced rates on all his fields
- A North Florida grower used soil moisture equipment for irrigation management as part of a BMP demonstration project; based on the soil moisture data, the grower modified his irrigation practices for perennial peanut, saving approximately 22.8 million gallons of water from one center pivot (reducing volume of water that runoffs off farm reduces the amount of nutrients to streams).

However, farmers have submitted NOI to implement BMPs on less than 25% of all agricultural acres in the state, and attempts to verify implementation are limited. In the Suwannee River Basin and the Lake Okeechobee Watershed, dedicated staff from the Office of Agricultural Water Policy (OAWP) conduct site visits to ensure implementation, including follow-up visits to those farms deemed to be implementing BMPs unsatisfactorily (OAWP, 2009). As of October 2009, OAWP had visited 32 out of 40 enrolled dairies and 109 out of 119 enrolled poultry farms in the Suwannee River Basin, and about 21% of enrolled acres in the Lake Okeechobee Watershed.

Due to limited resources, implementation assurance throughout the rest of the state has been primarily composed of mailed surveys to producers who submitted NOIs (with a response rate of about 64% for producers reporting citrus BMPs), as well as randomly selected site visit spot checks (OAWP, 2009). To date, OAWP has only done this for citrus producers, although OAWP has a schedule for implementing surveys and spot checks for producers enrolled in BMPs for vegetables/agronomic crops (Summer 2010), container nurseries (Fall 2010), sod (2011), cow/calf (2012), and equine and specialty fruit/nut (within 3-4 years of manual adoption) (OAWP, 2009).

2.2.4 Septic Systems

There are 935,203 septic systems in Florida, of which 793,697 are active (FDOH, 2010a). Most of Florida's septic systems are over 30 years old and were installed under standards less stringent than current standards. In the 2008 Clean Watershed Needs Survey (U.S. EPA, 2010b), the state identified approximately $10.3 billion in capital need for decentralized wastewater treatment to address a water quality or a water quality-related public health problem existing as of January 1, 2008, or expected to occur within the next 20 years. These costs represent capital expenditures associated with the rehabilitation and replacement of septic systems and clustered (community) systems. For example, the LSJR TMDL Executive Committee (2008) indicates that the City of Jacksonville is implementing a phase-out of its septic systems by 2023. The phase out plan will address nutrients in addition to fecal coliform bacteria.

The relative source contribution to nutrient impairments from septic systems is often unknown or highly uncertain and current TMDLs use a wide variety of approaches to estimate it. For example, Petrus (2003) notes that in Lake County, there are about 63,000 septic systems leaking 8.59 mgd of nutrient-rich discharge (assuming 135 gallons per day per tank and a 1% failure rate, based on the number of repairs divided by the number of installed systems). TMDLs for Alachua, Newnans, and Orange Lakes use the methods described by the Watershed Management Model (WMM) which assumes that failing septic system effluent increases TN concentrations to waterbodies by up to 30 mg/L and TP loading by up to 4 mg/L (the high end of the approximate range was used in all cases) and that 5% of septic systems are failing at any given time (Gao and Gilbert, 2003a; Gao and Gilbert, 2003b; Gao et al., 2006). Thus approximate nutrient loads from septic systems range from 2-5% for TN and 3-8% for TP (percentage is of the total existing nutrient load).

The Juniper Creek TMDL assumes a higher concentration of these nutrients in untreated septic system effluent (50.5 mg/L for TN and 9.0 mg/L for TP; Wieckowicz et al. 2008). The authors also calculate the failure rate for Gadsden County using the number of septic tanks and the number of repair permits in a given period of time. Baniukiewicz and Gilbert (2004) also use a different approach in their development of a TMDL for Lake Hunter, basing their analysis on Haith et al. (1992) which calculates TN loading based on nutrients per person per day (12 g), plant nutrient uptake rates (1.6 g/d), the number of households with septic systems, and failure rate. Unlike for the other TMDLs in which researchers assume that failing septic systems represent a potential source of phosphorus loading, this approach reflects the assumption that phosphorus is adsorbed and retained by the soil and does not reach surface waters.

Because of the uncertainty and inconsistency of current septic system nutrient loading estimates in many impaired waters, implementation plans primarily focus on septic system studies and research to better characterize nutrient loads and contributions. For example, preliminary data indicate that septic systems account for a relatively small percentage of the nutrient load in the Upper Ocklawaha River. Accordingly, the BMAP does not directly address septic systems during the first five years of implementation. However, FDEP acknowledges that the relative importance of loadings from septic tanks will increase after implementation of the management actions for other more significant sources (UOBWG, 2007).

2.2.5 Atmospheric Deposition

Atmospheric deposition of nutrients from fossil fuel combustion, open pit mining, wind erosion, and other activities can represent a substantial source of nutrient loading to Florida's waterbodies (Grimshaw and Dolske, 2002; Paerl et al. 2002). In current TMDLs, FDEP calculates deposition rates primarily by using published values for TN and TP rainfall concentrations throughout Florida (then multiplying by the precipitation volume and the surface area of the waterbody). In the nutrient budget for Lake Apopka, Stites et al. (2001; Gao, et al., 2006; Gao and Gilbert, 2003a; Gao and Gilbert, 2003b) found average TN and TP concentrations of 0.1 mg/L and 0.05 mg/L, respectively in rainwater; FDEP used these concentrations to calculate atmospheric nutrient loading for Alachua, Newnans, Orange, and Trout Lakes (Gao et al. 2006; Gao and Gilbert 2003a; Gao and Gilbert 2003b).

Ahn and James (1999, as cited in Gao, 2006) found average concentrations of 0.630 mg/L for TN and 0.05 mg/L for TP in agricultural areas. Because the area surrounding Lake Jesup has similar land uses, FDEP used these concentrations in atmospheric nutrient deposition modeling for its TMDL development (Gao, 2006). In developing a TMDL for Lake Hunter, regulators used rainfall samples collected from the nearby Winter Haven Chain of Lakes to estimate nutrient loading. Compared with the published values used for other TMDLs, they found similar concentrations of TN (0.680 mg/L) but lower concentrations of

TP (0.026 mg/L) (Baniukiewicz and Gilbert, 2004). Given the various deposition concentrations throughout Florida, it is uncertain whether such sources would be significant contributors to impairments.

2.2.6 Legacy Sources

Some controls are in place to address legacy sources of nutrients. For example, in Lake Apopka in Florida, the sedimentary store of available phosphorus and the moderate hydraulic detention time (2.5 years) resulted in a slow recovery (SJRWMD, 2003). To hasten reduction efforts, the St. Johns River Water Management District (SJRWMD) constructed a wetland system adjacent to the waterbody to remove phosphorus from lake water and permanently bury it in marsh sediments. Algae, resuspended sediments, and particle-bound nutrients are removed from lake water and sent through 13 independent marsh cells where phosphorus is removed (buried in marsh sediments). The phosphorus-reduced water then flows back to the lake (SJRWMD, 2003).

The measured loads from for a particular watershed may not be fully representative of the potential nutrient load to the watershed. For example, in Lake Okeechobee, reducing upstream sources of phosphorus may not produce immediate results in downstream systems that have assimilated phosphorus for years because these systems may begin to release native or legacy accumulated phosphorus to come into equilibrium.

2.2.7 Summary and Assumptions

Municipal WWTPs and industrial wastewater dischargers in certain sectors have a reasonable potential to discharge nutrients at levels that may contribute to the exceedance of EPA's numeric nutrient criteria. Nonpoint sources, including urbanized and developed land, agricultural land, and septic systems are also possible sources of nutrients. Due to the extent of implementation of BMPs in forestry however, EPA assumed that loads from forest land are not likely to be substantial. Thus, this analysis is based on the following assumptions:

- All municipal wastewater dischargers are potentially affected by the rule (a total of 84 dischargers)
- Industrial dischargers in sectors that include dischargers with current effluent limits or monitoring requirements for nutrients are potentially affected by the rule (a total of 108 dischargers)
- Urban and agricultural land and septic systems may need controls for waters to attain standards.

EPA conducted more detailed analyses of municipal and industrial dischargers (presented in Sections 4 and 5) to determine the potential need for additional nutrient controls by these dischargers above and beyond existing permit requirements (as noted in Section 2.1.3). In sections 2.1.4, 2.1.5, and 2.1.7, EPA similarly identifies the possible additional nutrient controls that may be needed above and beyond existing requirements for urban sources, agricultural sources, and septic systems, respectively. Although atmospheric deposition and legacy loads (e.g., sediments) may contribute measurable amounts of nutrients to some waters, what little data are available suggest that overall they are a relatively minor source.

2.3 Current Water Quality

FDEP has previously determined that several waterbodies exceed the existing narrative nutrient WQS. These waters are identified on the state's CWA Section 303(d) list.

2.3.1 Category 5 Waters on State 303(d) List

Exhibit 2-7 shows the number of waterbody segments or count of waterbody identification (WBIDs) labels listed as impaired for nutrients and/or dissolved oxygen (DO). TMDLs for DO impairments typically limit TN and/or TP concentrations as a means of achieving the DO targets, although DO impairments could also be due to excessive biological oxygen demand or other sources not related to excess TN or TP. Category 5 waters are those impaired waters for which a TMDL is needed but has not yet been completed. Thus, the list in Exhibit 2-7 does not include WBIDs for which FDEP or EPA has developed a draft or final TMDL (see Section 2.3.2 for list of TMDLs). The exhibit also shows impairments to estuaries that are not subject to this rule because controls are often needed on upstream lakes and streams to achieve necessary reductions in the impaired waterbody.

Exhibit 2-7: Summary of CWA Section 303(d) Listed Impairments for Nutrients in Florida[1]

Impairment Listing	Number of WBIDs[1]				
	Lake	Stream[2]	Spring	Estuary[3]	Total
Nutrients[4]	130	77	8	38	253
DO	12	110	3	23	148
Both (Nutrients and DO)	11	57	2	26	96
Total	153	244	13	87	497

Source: FDEP (2009d)
TSI = trophic state index
WBID = waterbody identification
1. Does not include those waterbodies for which a TMDL has already been approved.
2. Includes flowing waters and blackwater.
3. Includes estuaries, coastal waterbodies, and beaches.
4. Specific nutrient-related pollutants in the 303(d) list include TSI, chlorophyll-a, algae, algal mats, macrophytes, and other information.

2.3.2 Nutrient TMDLs

There are approximately 168 WBIDs covered under TMDLs in Florida, 117 of which are for lakes and flowing waters. **Exhibit 2-8** summarizes the approved and draft TMDLs for nutrients for lakes, streams, and springs. In Florida, TMDL implementation plans are developed in BMAPs and not as part of the TMDL. Only about 25% of the WBIDs shown below have accompanying implementation plans for achieving the target reductions/loads (other WBIDs covered under BMAPs do not have load allocations under TMDLs).

Exhibit 2-8: Summary of Nutrient-Related TMDLs for Lakes and Flowing Waters in Florida

TMDL/Waterbody	TMDL Year	WBIDs	Total Nitrogen			Total Phosphorus		
			TMDL (lbs/yr)	Percent Reduction	Target (mg/L)	TMDL (lbs/yr)	Percent Reduction	Target (mg/L)
Alachua Sink: dry	2006	2720A	204,870	46%	1.48	21,804	46%	0.16
Alachua Sink: wet	2006	2720A	256,322	45%	1.34	27,157	70%	0.15
Alligator Lake	2008	3516A	42,595	28%	1.16	3,050	61%	0.07
Butcher Creek	2005	2322	3,617	22%	-	-	-	-
Crane Strand Drain	2005	3014	29,828	29%	0.69	-	-	-
Elevenmile Creek	2007	489	-	-	0.74	-	-	-

Exhibit 2-8: Summary of Nutrient-Related TMDLs for Lakes and Flowing Waters in Florida

TMDL/Waterbody	TMDL Year	WBIDs	Total Nitrogen			Total Phosphorus		
			TMDL (lbs/yr)	Percent Reduction	Target (mg/L)	TMDL (lbs/yr)	Percent Reduction	Target (mg/L)
Fenholloway River	2009	3473B	3,025,850	24%	-	219,000	19%	
Fishing Creek	2005	2324	39,697	22%	-	-	-	-
Imperial River	2008	3258E	18,865	25%	0.74	-	-	-
Gordon River Extension	2008	3278K, 3259C	34,822	29%	0.74	-	-	-
Hendry Creek	2008	3258B	55,283	32%	0.74	-	-	-
Juniper Creek	2008	682	296,728	18.18%	0.72	-	-	-
Lake Hunter	2004	1543	6,579	80%	0.871	489	80%	0.061
Lake Jesup	2006	2981, 2981A	545,203	50%	1.27	41,888	34%	0.096
Newnans Lake	2003	2705B	85,470	74%	0.97	10,924	59%	0.062
Lake Harris	2003	2838A, 2338B	-	-	-	18,302	32%	0.026
Lake Griffin	2003	2814A	-	-	-	26,901	66%	0.032
Lake Eustis	2003	2817B, 2817A	-	-	-	20,286	43%	0.025
Lake Dora	2003	2831B	-	-	-	13,230	67%	0.031
Lake Carlton	2004	2837B	-	-	-	195	59%	0.032
Lake Beauclair	2003	2834C	-	-	-	7,056	85%	0.032
Lake Apopka	2003	2835D	-	-	-	35,054	75.60%	0.055
Lake Okeechobee	2001	3212A, 3212B, 3212C, 3212D, 3212E, 3212F, 3212G, 3212H, 3212I	-	-	-	308,647		0.04
Lake Trafford	2008	32559W	56,617	60%	1.09	3,348	77%	0.025
Lake Wauberg Outlet	2003	2741	2,062	51%	1.01	374	50%	0.056
Lake Yale	2003	2807A	-	-	-	2,844	10%	0.02
Little Weikiva Canal	2008	3004	42,624	45%	1.02	-	-	-
Long Branch	2005	3030	10,400	17%	0.87	1,480	30%	0.14
Lower St. Johns River: marine	2008	2213A, 2213B, 2213C, 2213D, 2213E, 2213F, 2213G, 2213H	1,376,855	-	5.4	-	-	-
Lower St. Johns River: freshwater	2008	2213I, 2213J, 2213K, 2213L, 2213M	8,571,563	-	-	500,325	-	-
Munson Slough	2008	807D	-	8.35%	0.72	-	17.53%	0.15
Munson Lake	2008	807C	95,074	46%	0.6	5,439	82%	0.037
New River	2008	3506	-	13%	1.3	-	38%	0.13
New River	2008	3506B	-	38%	1.3	-	-	-
Orange Lake	2003	2749A	-	-	-	15,262	45%	0.031
Palatlakaha River	2003	2839	16,696	5.2%	-	2,207	7.2%	-
Peace River above Bowlegs Creek	2007	1623J	24,750	30%	-	-	-	-

Exhibit 2-8: Summary of Nutrient-Related TMDLs for Lakes and Flowing Waters in Florida

TMDL/Waterbody	TMDL Year	WBIDs	Total Nitrogen			Total Phosphorus		
			TMDL (lbs/yr)	Percent Reduction	Target (mg/L)	TMDL (lbs/yr)	Percent Reduction	Target (mg/L)
Suwannee Basin	2008	3422, 3422J, 3422L, 3422R, 3422S, 3422T, 3422U, 3422Z, 3605A, 3605B, 3605C	Nitrate TMDL	-	-	-	-	-
Thirty Mile Creek	2004	1639	-	-	3.0	-	-	-
Trout Lake	2006	2819A	9,733	60%	-	521	80%	-
Upper Lake Lafayette	2003	756A	34,669	-	1.0	3,946	39%	0.12
St. John's River above Lake Poinsett	2006	2893L	-	-	-	178,000	37%	0.09
Lake Hell n' Blazes	2006	2893Q	-	-	-	88,000	52%	0.09
St. Johns River ab. Sawgrass Lake	2006	2893X	-	-	-	114,000	32%	0.09
South Prong Alafia River	2009	1653	339,279	0%	-	254,890	50%	-
Spring Lake	2008	2987A	8,551	30%	0.959	1,810	65%	0.021
Lake Florida	2008	2998A	8,377	34%	0.699	571	69%	0.023
Lake Orienta	2008	2998C	6,092	42%	0.814	451	74%	0.022
Lake Adelaide	2008	2998E	3,003	40%	0.711	228	72%	0.027
Lake Lawne	2008	3004C	21,692	26%	1.107	2,005	49%	0.055
Silver Lake	2008	3004D	6,241	24%	0.575	370	70%	0.015
Bay Lake	2008	3004G	1,428	39%	1.108	109	66%	0.019
Wekiva River (u/s)	2008	2956	-	-	-	-	61%	0.065
Wekiva River (d/s)	2008	2956A	-	-	-	-	57%	0.065
Little Wekiva River	2008	2987	-	-	-	-	78%	0.065
Black Water Creek	2008	2929A	-	-	-	-	36%	0.065
Lake Cannon	2007	1521H	-	-	-	315	54%	-
Lake Howard	2007	1521F	-	-	-	315	62.5%	-
Lake Idylwild	2007	1521J	-	-	-	141	43%	-
Lake Jessie	2007	1521K	-	-	-	309	50%	-
Lake Lulu	2007	1521	-	-	-	185	55%	-
Lake May	2007	1521E	-	-	-	194	57.5%	-
Lake Mirror	2007	1521G	-	-	-	121	27.5%	-
Lake Shipp	2007	1521D	-	-	-	214	65%	-
C-24 Canal	2006	3197	579,620	28%	1.2	48,180	75%	0.1
Lake Parker	2006	1497B	151,684	57.4%	-	30,481	57.1%	-
Lake Lena	2006	1501	17,602	41%	-	681	41%	-

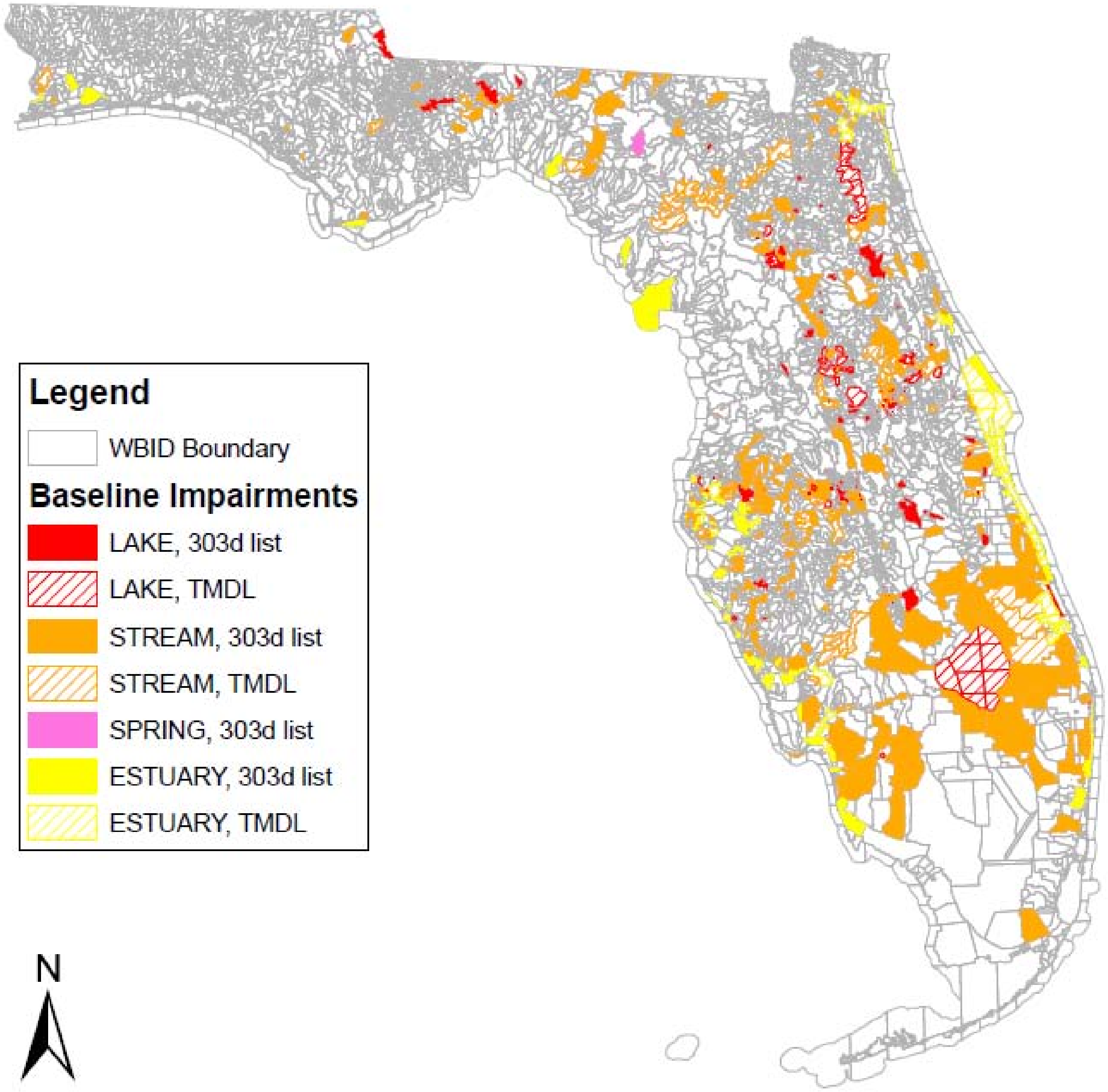
Exhibit 2-8: Summary of Nutrient-Related TMDLs for Lakes and Flowing Waters in Florida

TMDL/Waterbody	TMDL Year	WBIDs	Total Nitrogen			Total Phosphorus		
			TMDL (lbs/yr)	Percent Reduction	Target (mg/L)	TMDL (lbs/yr)	Percent Reduction	Target (mg/L)
Lake Hancock-Lower Saddle Creek	2006	1623L, 1623K	702,167	75.2%	-	224,320	75.5%	-
Lake Bonny	2006	1497E	14,523	57.7%	-	1,921	57.7%	-
Banana Lake Canal	2006	1549A, 1549B	34,717	79.4%	-	56,510	79.5%	-
Saint Joe's Creek	2008	1668A	43,286	60%	-	12,985	0%	-
Pinellas Park Ditch No. 5	2008	1668B	2,541	70%	-	915	0%	-
West Clark Lake	2005	1971	7,611	59.3%	1.018	1,480	10.8%	-
Little Charlie Creek	2009	1774	19,929	61%	-	4,840	61%	-
Bear Branch	2009	1948	2,705	43%	-	396	43%	-
Prairie Creek	2009	1962	231,709	23.7%	-	55,486	23.69%	-
Myrtle Slough	2009	1995	74,233	24.3%	-	17,721	24.38%	-
Hawthorne Creek	2009	1997	185,622	29.6%	-	44,333	29.61%	-
North Prong Alligator Creek	2009	2071	3,672,778	27.2%	-	878,350	27.23%	-
Little Lake	2003	2838B	-	-	-	18,302	32%	0.026
Little Gully	2009	1039	-	11%	0.63	-	11%	0.056
Lake Harney	2009	2964A	3,355,570	-	1.18	241,026	-	0.07
St. Johns River d/s of Lake Harney and above Lake Jesup	2009	2964, 2893F	3,741,990	-	1.18	276,141	-	0.07
St. Johns River above Lake Monroe and Lake Munroe	2009	2893D, 2893E	4,171,255	-	1.18	315,512	-	0.07
St. Johns River above Wekiva River	2009	2893C	4,202,340	-	1.18	318,236	-	0.07
North Prong Alafia River	2009	1621E	-	-	-	-	90%	0.415
Smith Canal	2009	2962	-	-	-	3,900	-	0.1

TMDL = total maximum daily load
WBID = waterbody identification
“-“ = value not specified or determined in TMDL

Exhibit 2-9 provides a map of the WBIDs that are either on the state’s CWA Section 303(d) list for nutrients or for which a nutrient-related TMDL has been proposed or approved.

Exhibit 2-9: Map of Baseline Impairments in Florida



EPA overlaid the WBIDs with 10-digit hydrologic units (HUCs) and land use/land cover data to identify land use surrounding the baseline impaired waters [i.e., waters on the state's CWA Section 303(d) list for nutrients including those covered by a TMDL].[6] Land use provides indication of the types of sources that will need to be controlled to remove existing impairments. **Exhibit 2-10** summarizes the acres of each land use category for these waters.

Exhibit 2-10: Summary of Land Use for Baseline Impairments

Land Use Category	Total Acres	% of Total Baseline Impaired Acres
Wetlands	5,523,931	25%
Agriculture	5,073,898	23%
Forest	4,433,810	20%
Urban	3,354,217	15%
Water	1,493,478	7%
Other	1,248,117	6%
Industrial	410,659	2%
Transportation Corridors	255,684	1%
Communications and Utilities	112,851	<1%
Total	21,906,645	100.0%

2.3.3 Summary and Assumptions

FDEP has already listed numerous lakes and flowing waters for nutrient-related impairment under the existing narrative nutrient criteria, and developed TMDLs for many of these waters. Some of these TMDLs established TN and TP targets, and these targets are either higher or lower than the EPA numeric criteria. In estimating the incremental impacts associated with the rule, EPA made the following assumptions with respect to current water quality:

- The costs and benefits of nutrient controls for point and nonpoint sources that are already required under existing nutrient-related TMDLs for lakes and flowing waters are not attributable to this rule.
- Development of TMDLs for lakes, flowing waters, and springs on the current 303(d) list for nutrient-related impairment and the costs and benefits of nutrient controls needed to attain future TMDL targets associated with these impaired waters are not attributable to this rule.
- FDEP will likely pursue approval of TN and TP targets established under existing TMDLs as site specific alternative criteria (SSAC) such that this rule will not result in incremental costs or benefits to waters under existing TMDLs.

Using these assumptions, EPA identified waters that would be identified as impaired under the rule but are not currently on the 303(d) list or under a TMDL. EPA refers to these waters as potential incremental impairments. EPA then estimated the costs and benefits of the nutrient controls needed to meet EPA's numeric nutrient criteria for urban areas, agricultural land, and septic systems in surrounding watersheds; controls for municipal and industrial wastewater dischargers are based on attaining WQBELs reflecting the numeric nutrient criteria. The analysis of incrementally impaired waters is presented in Section 6, and

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[6] Based on 10-digit hydrologic units containing at least 10% of a WBID that is listed on the state's CWA Section 303(d) list for nutrients or covered by a TMDL].

the analyses of controls for the different source sectors in Sections 4, 5, 7, 8, and 9. Note that because point sources receive WQBELs in NPDES permits, point sources are potentially affected regardless of the impairment status of the receiving waters.

3. Description of the Rule

This section describes the rule establishing numeric nutrient criteria for lakes, streams, and springs in Florida, and discusses potential state implementation of these criteria in NPDES permits, CWA Section 303(d) listing and TMDLs, and requirements for nonpoint sources.

3.1 Water Quality Criteria

EPA's rule establishes numeric criteria for TN and TP for freshwater lakes and streams in Florida, and a nitrate-nitrite criterion for springs. **Exhibit 3-1** shows the waterbodies affected by the rule (designated by WBID numbers).

Exhibit 3-1: Summary of Florida Waters

Waterbody Type	Number of WBIDs	Miles of Water	Acres of Water
Lake	1,310	32	1,454,542
Spring	126	176	-
Stream, Excluding South Florida Streams	3,794	20,983	167,076
Total	5,230	21,191	1,621,618

Source: FGDL (2009).
WBID = waterbody identification

EPA derived nutrient criteria for lakes on the basis of water color and alkalinity. Nutrient criteria for flowing waters are based of five geographically distinct regions that exclude the South Florida Region. The criteria are not to be exceeded more than once in a three year period. **Exhibit 3-2** summarizes EPA's numeric nutrient criteria for Florida lakes and flowing waters.

Exhibit 3-2: 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

Chl-a = chlorophyll-a
Pt-Co = platinum-cobalt
NA = not applicable
TN = total nitrogen
TP = total phosphorus
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 $CaCO_3$.

EPA's rule allows modification of lake criteria for chlorophyll a, TN and/or TP where the baseline chlorophyll a criterion-magnitude as an annual geometric mean has never been exceeded and sufficient ambient monitoring data exist for chlorophyll a and TN and/or TP for at least the three immediately preceding years. Sufficient data include at least four measurements per year, with at least one measurement between May and September and one measurement between October and April each year. Modified criteria are calculated as the geometric mean of all annual geometric mean concentrations from at least the immediately preceding three years in a particular lake. When the TN and/or TP criteria are modified, the chlorophyll a criterion must also be modified to reflect the same period of record for which TN and/or TP criteria are evaluated. Modified TP and TN criteria may not exceed criteria applicable to streams to which a lake discharges.

Exhibit 3-3 shows the locations of lake WBIDs in Florida and their classification under EPA's rule. Note that color data are not available for several lakes. **Exhibit 3-4** shows the nutrient criteria regions for streams under the rule.

Exhibit 3-3: Lake Types in Florida

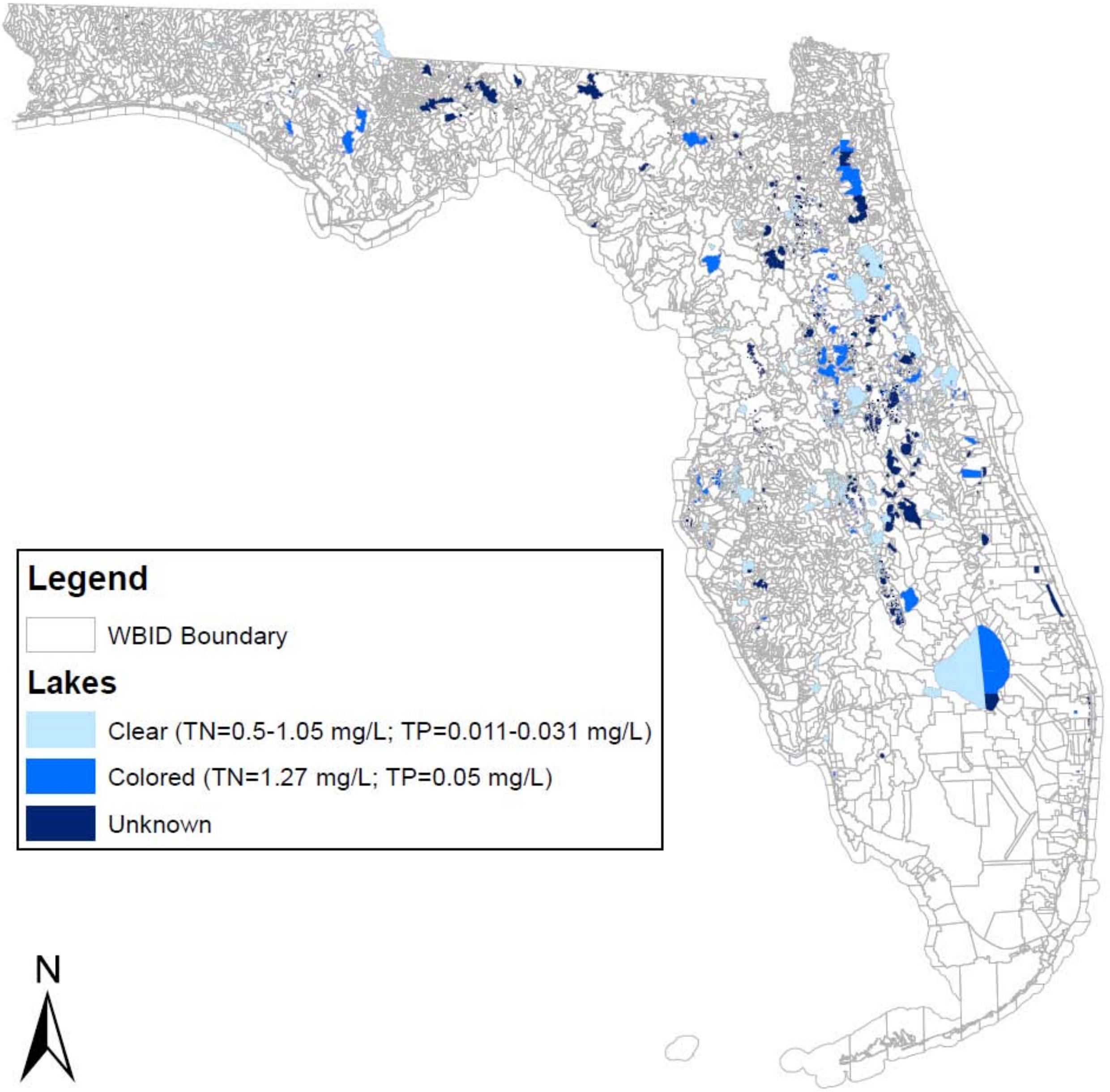
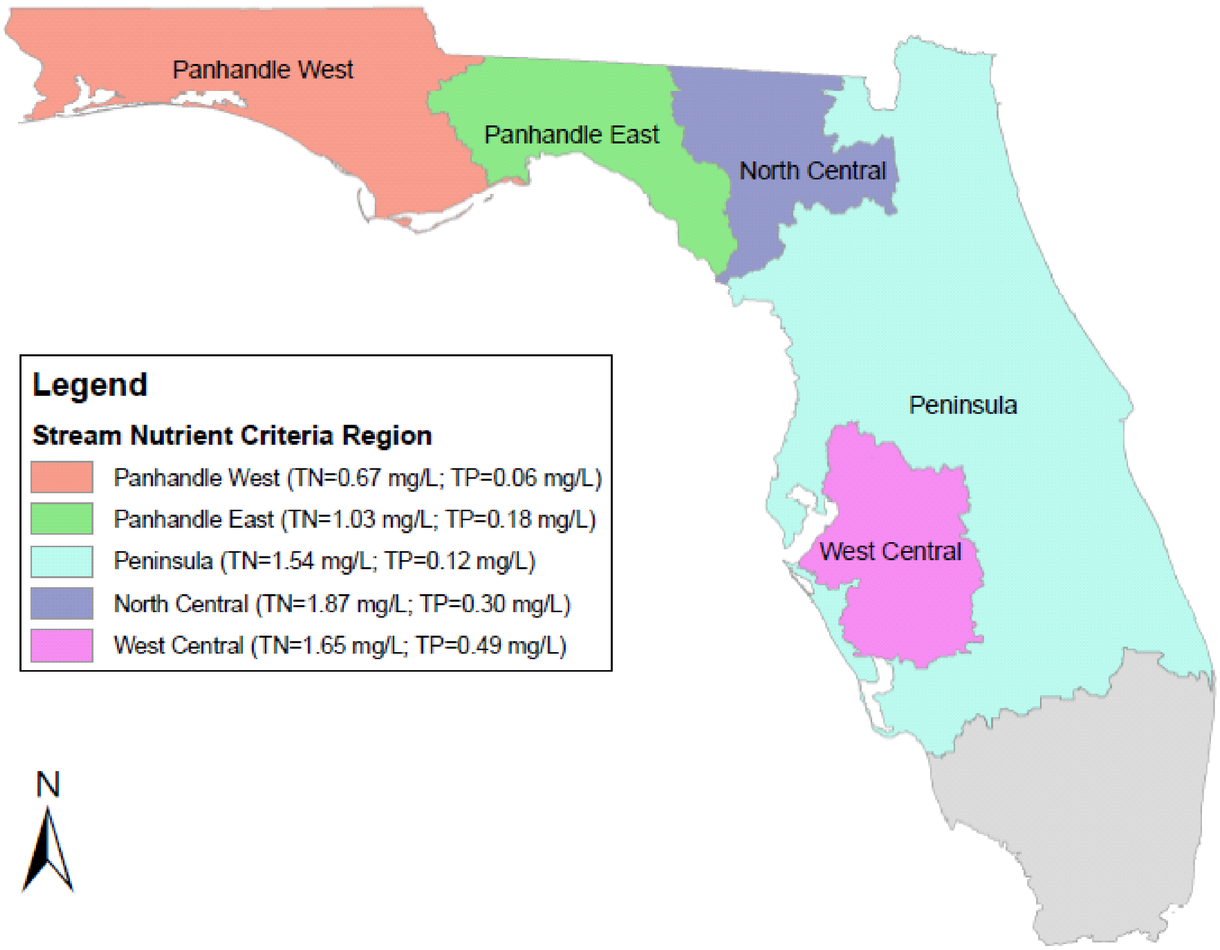


Exhibit 3-4: Numeric Nutrient Criteria Regions for Streams in Florida



To ensure the protection of downstream lakes, EPA's rule also requires that the applicable criteria in streams that discharge into lakes must be the more stringent of the instream TN and TP stream criteria and either the concentration of TN and TP derived to be protective of the lake [from application of BATHTUB (USACE, 2010) or another scientifically defensible model] or the lake criteria values for TN and TP. The applicable criteria are annual geometric mean values that are not to be exceeded more than once in a three year period.

3.2 Potential Implementation

WQS include designated use of the waters, criteria to protect those uses, and antidegradation policy. As described in Section 2.1.1, Florida WQS currently contain narrative nutrient criteria to protect designated uses, and FDEP assesses use attainment based on TSI, chlorophyll-a concentration, and other information indicating an imbalance in flora or fauna due to nutrient enrichment. EPA's rule contains numeric criteria to protect the use; thus, assessment of impairment will also be based on numeric TN and TP measurements. This section discusses the potential impact of the criteria for implementing WQS in Florida.

3.2.1 Impaired Waters and TMDLs

With the establishment of numeric criteria for TN and TP for lakes and flowing waters, FDEP may place additional waters on the state's existing 303(d) list as impaired for nutrients. FDEP will have to develop TMDLs for waters that it identifies as impaired. EPA assumes that FDEP will use existing procedures for attaining TMDLs for newly impaired waters, which consist of developing a BMAP to implement the TMDLs.

Waters that exceed the new EPA criteria may also be exceeding the current narrative criteria but may not yet be listed for impairment because FDEP has not completed the process of identifying, verifying, and listing waters. In these cases, the impact of EPA's rule could be to identify impaired waters sooner rather than later due to having appropriate numeric criteria for the assessment process. Implementing controls sooner and preventing additional degradation may result in cost savings and make restoration of designated uses more feasible compared to allowing excessive nutrient pollution to continue or increase.[7]

3.2.2 Controls for Point and Nonpoint Sources

Numeric nutrient criteria provide a basis for WQBELs in NPDES permits. Thus, FDEP may reopen permits for municipal and industrial wastewater sources to add WQBELs, or include WQBELs upon permit reissuance. Municipal WWTPs are likely to have reasonable potential to exceed the criteria and thus receive WQBELs; industrial dischargers may or may not have reasonable potential depending on industrial sector. WQBELs for point sources may require nutrient concentrations in effluent equal to the criteria, or allow higher nutrient concentrations in effluent because of dilution by receiving waters (e.g., in unimpaired waters).

Note that for impaired waters, FDEP's TMDL Protocol (FDEP 2006b)[8] establishes an initial focus of control efforts on nonpoint sources because FDEP believes point sources are already highly regulated. As illustrated by the efforts underway to reduce nutrient loadings from agriculture in the Lake Okeechobee watershed, such efforts have taken the form of making voluntary BMP programs mandatory, and iterative, performance-based approaches to attaining target watershed loadings.

Because criteria apply to entire waterbodies and not individual dischargers, TMDLs can be implemented in the most cost effective manner to attain the criteria. When controls are not cost effective and would result in substantial and widespread economic and social impacts, implementation may include temporary variances from WQS that require the highest level of control that would not result in such economic impacts. Use attainability analyses that lead to modification of the designated use may also be appropriate in certain circumstances.

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[7] Social discounting would result in costs today worth more than costs incurred in the future. However, pollution prevention is also less costly than restoration (if full restoration is even possible), and so more costs may need to be incurred if controls are initiated later.

[8] FDEP (2006b) presents example standard protocols and references that may be considered for use by practitioners for conducting TMDL analyses and preparing TMDLs. FDEP developed the protocol report as a modular tool and reference.

4. Potential Costs for Municipal Wastewater Sources

Municipal sources of wastewater to freshwater lakes and streams receive WQBELs in NPDES permits. This section describes how EPA identified the municipal wastewater dischargers with the potential to receive revised effluent limitations for TN and TP as a result of state implementation of EPA's rule and the resulting potential pollution control costs.

4.1 Data

EPA's permit compliance system (PCS) database contains a list of municipal WWTPs with NPDES permits in Florida. Receiving waterbody name and information in permits, fact sheets, and laboratory reports indicate whether the WWTP discharges to a freshwater lake or stream. The applicable TN and TP criteria depend on the receiving waterbody type (e.g., clear/colored lake or stream) and the location of the waterbody (e.g., for streams, criteria vary based on nutrient region). **Exhibit 4-1** summarizes the number of WWTPs discharging to each waterbody type and criteria region (if applicable) and the applicable TN and TP criteria.

Exhibit 4-1: Summary of Applicable Criteria for Municipal WWTP Discharging to Freshwater Lakes and Streams

Criteria Region/ Lake Type	TN Criterion (mg/L)	TP Criterion (mg/L)	Major Dischargers[1]	Minor Dischargers[1]	Total Dischargers
Clear Lake	0.5 – 1.0	0.01 – 0.03	1	0	1
Colored Lake	1.23	0.05	1	2	3
North Central	1.87	0.30	2	1	3
Panhandle East	1.03	0.18	4	1	5
Panhandle West	0.67	0.06	6	3	9
Peninsula	1.54	0.12	20	27	47
West Central	1.65	0.49	9	8	17
Total	NA	NA	43	42	85

1. As designated in EPA's PCS database. Major dischargers are generally greater than 1 mgd and have the potential to discharge toxic pollutants in toxic amounts; minor discharges are typically less than 1 mgd and not likely to discharge toxic pollutants in toxic amounts.

4.2 Method

This section describes how EPA estimated the potential controls for municipal WWTPs to meet effluent limits based on EPA's numeric nutrient criteria.

4.2.1 Reasonable Potential

NPDES permitting authorities determine the need for WQBELs for point sources based on analysis of reasonable potential to exceed the water quality criteria. EPA's rule does not include implementation procedures for determining reasonable potential. However, FDEP generally follows the procedures in EPA's Technical Support Document for Water Quality-Based Toxics Control (TSD) for other pollutants with numeric criteria. For example, for aquatic life criteria, the TSD recommends finding a permittee has reasonable potential if it cannot be demonstrated with a high confidence level that the upper bound of the lognormal distribution of effluent concentrations is below the criteria at specified low-flow conditions (U.S. EPA, 1991).

Medium to highly concentrated untreated domestic wastewater typically contains 40 mg/L to 70 mg/L of TN and 7 mg/L to 12 mg/L of TP (Metcalf and Eddy, 2003). Effluent concentrations of TN and TP in treated domestic wastewater depend on the treatment used. For example, activated sludge with single stage nitrification results in typical TN concentrations of 20 mg/L to 30 mg/L and TP concentrations of 6 mg/L to 10 mg/L (Metcalf and Eddy, 2003). For advanced nutrient removal, technologies are available to reliably attain an annual average of 3 mg/L for TN and 0.1 mg/L or less for TP. (U.S. EPA, 2008). Effluent concentrations of 3 mg/L for TN and 0.1 mg/L for TP are the target levels of treatment for this analysis.

Site specific data such as instream nutrient concentrations and low flow conditions would be required to precisely determine reasonable potential for each facility. However, this information was not available for every potentially affected WWTP. Thus, on the basis that most WWTPs are likely to discharge nutrients at concentrations above applicable criteria, EPA assumed that all WWTPs would have reasonable potential under the rule.

4.2.2 Water Quality Based Effluent Limits

Based on TSD procedures, dischargers with reasonable potential would receive WQBELs that would take into account dilution, if available. Because data on water low flow conditions and other site specific data are not available for every discharger, EPA assumed for this analysis that dischargers would receive effluent limits equal to the numeric nutrient criteria (i.e., assumption of no dilution). Applying criteria end-of-pipe would also prevent a discharger from causing an additional impairment. Furthermore, EPA assumed that all WWTPs would receive WQBELs of approximately 3 mg/L for TN and 0.1 mg/L for TP, consistent with current cost-effective nutrient removal technology.

4.2.3 Potential Compliance Options

Potential controls to reduce TN and TP in WWTP effluents include biological nutrient removal (BNR), chemical precipitation, and effluent reuse. The specific level of performance achieved through implementation of advanced wastewater treatment systems can vary based on factors such as influent water quality, climate, and operator experience. For example, EPA (2008a) reports WWTPs are achieving average TN values ranging from 3.5 mg/L to 1.3 mg/L and TP values ranging from 0.43 mg/L to 0.09 mg/L with advanced nutrient removal technologies that target both nitrogen and phosphorus.

EPA recognizes that all numeric nutrient criteria for TN and the TP criteria for all lakes and streams in the Panhandle West regions are below the 3 mg/L TN and 0.1 mg/L TP target performance levels. In these cases, EPA assumed that the discharger will either implement technology consistent with levels that attain an annual average of 3 mg/L for TN and 0.1 mg/L or less for TP and achieve performance at levels that meet the WQBEL, or cannot achieve the required performance level and pursue other means of complying with WQS such site specific criteria, variances, or use designation modifications. In rare cases, where none of these mechanisms are appropriate, the state may require alternative technology or more costly solutions.

BNR

BNR removes TN and TP from wastewater through the use of microorganisms under different environmental conditions in the treatment process (Metcalf and Eddy, 2003). There are a number of BNR process configurations available. Some BNR systems are designed to remove only TN or only TP, while others remove both. BNR configurations vary in their sequencing of environmental conditions (i.e., aerobic, anaerobic, or anoxic)[9] and timing (Jeyanayagam, 2005). Common BNR system configurations include:

- Modified Ludzack-Ettinger (MLE) Process – continuous-flow suspended-growth process with an initial anoxic stage followed by an aerobic stage; used to remove TN
- Anaerobic-Anoxic Oxidation (A^2/O) Process – MLE process preceded by an initial anaerobic stage; used to remove both TN and TP
- Step Feed Process – alternating anoxic and aerobic stages; however, influent flow is split to several feed locations and the recycle sludge stream is sent to the beginning of the process; used to remove TN
- Bardenpho Process (Four-Stage) – continuous-flow suspended-growth process with alternating anoxic/aerobic/anoxic/aerobic stages; used to remove TN
- Modified Bardenpho Process – Bardenpho process with addition of an initial anaerobic zone; used to remove both TN and TP
- Sequencing Batch Reactor (SBR) Process – suspended-growth batch process sequenced to simulate the four-stage process; used to remove TN (TP removal is inconsistent)
- Modified University of Cape Town (UCT) Process – A^2/O Process with a second anoxic stage where the internal nitrate recycle is returned; used to remove both TN and TP
- Oxidation Ditch – continuous-flow process using looped channels to create time sequenced anoxic, aerobic, and anaerobic zones; used to remove both TN and TP.

Exhibit 4-2 provides a comparison of the TN and TP removal capabilities of common BNR configurations. Because the performance of each process is dependent on site specific conditions, this exhibit represents only a general comparison of treatment performance among different BNR configurations.

Exhibit 4-2: Comparison of Common BNR Configurations

Process	Nitrogen Removal	Phosphorus Removal
MLE	Good	None
A^2/O	Good	Good
Step Feed	Moderate	None
Four-Stage Bardenpho	Excellent	None
Modified (Five-Stage) Bardenpho	Excellent	Good
SBR	Moderate	Inconsistent
Modified UCT	Good	Excellent
Oxidation Ditch	Excellent	Good

Source: Jeyanayagam (2005).
A^2/O = anaerobic-anoxic oxidation
BNR = biological nutrient removal
MLE = Modified Ludzack-Ettinger
SBR = Sequencing Batch Reactor
UCT = University of Cape Town

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[9] Anoxic is a condition in which oxygen is available only in the combined form (e.g., NO2- or NO3-). However, anaerobic is a condition in which neither free nor combined oxygen is available (WEF and ASCE/EWRI, 2006).

Most large treatment plants should be able to achieve at least 3 mg/L for TN and 0.1 mg/L for TP (Jeyanayagam, 2005; CBP, 2002). However, site specific conditions may allow some facilities to achieve concentrations lower than these levels. For example, the city of Clearwater, Florida, operates two five-stage Bardenpho WWTPs. The second anoxic zone in the process provides denitrification of the nitrates created in the aeration zone (U.S. EPA, 2008a). TP is removed biologically in the anaerobic zone, and alum is fed to the second anoxic zone (the fourth reaction basin) for the dual purpose of phosphorus polishing and meeting the state requirement of low-level trihalomethane levels in the reuse water (U.S. EPA, 2008a). In addition, a gravity sand filter is used to remove phosphorus tied to suspended solids in the final effluent. The annual average concentrations are 2.32 mg/L TN and 0.11 mg/L TP at the Marshall Street plant, and 2.04 mg/L TN and 0.20 mg/L TP at the Northeast plant. Both plants operate with high efficiency and low variability (U.S. EPA, 2008a). In addition, the Lee County, Fiesta Village WWTP employs oxidation ditches with methanol addition prior to denitrification filters to achieve an annual average TN concentration of 1.38 mg/L (U.S. EPA, 2008a). To achieve average effluent TP concentrations of 0.1 mg/L, the facility uses alum addition and the denitrification filters to remove particulate phosphorus (U.S. EPA, 2008a).

Chemical Precipitation

Chemical precipitation primarily uses aluminum and iron coagulants or lime to form chemical flocs with phosphorus. These flocs then settle out to remove phosphorus from the wastewater (Viessman and Hammer, 1998). Compared to biological removal of phosphorus, however, chemical processes have higher operating costs, produce more sludge, and result in added chemicals in sludge (Metcalf and Eddy, 2003). When TP levels close to 0.1 mg/L are required, a combination of biological and chemical processes may be less costly than either process by itself. In addition, chemical precipitation can be coupled with filtration to achieve levels at or below 0.1 mg/L. For example, EPA (2008a) provides the following examples of WWTPs with low TP effluent concentrations:

- Lee County, Florida: Oxidation ditch with denitrification filter with alum, TP = 0.098 mg/L
- Chelsea, Michigan: Chemical addition with flocculating clarifier, TP = 0.09 mg/L (full-year data)
- McMinnville, Oregon: Chemical addition with tertiary clarifier and filter, TP = 0.058 mg/L (seasonal, 6 months of data)
- Pinery, Colorado: 5-Stage Bardenpho with chemical and filter, TP = 0.031 mg/L
- Breckenridge, Colorado: Enhanced biological phosphorus removal with chemical addition and filter, TP = 0.01 mg/L (literature report)
- Brighton, Michigan: Chemical addition with tertiary filter and infiltration basin, TP = 0.01 mg/L (full year data)

Effluent Reuse

Effluent reuse does not reduce the concentration of nutrients in the effluent. However, partial effluent reuse (e.g., a portion of the wastewater is discharged to the receiving water and a portion is used in reuse applications) can decrease the volume of nutrient-containing wastewater discharged, decreasing the total nutrient load to the receiving water sufficient to meet the WQS. If the waterbody has no assimilative capacity, only 100% effluent reuse (i.e., no discharge to the receiving water) would be allowable.

Effluent water can be reused for several nonpotable purposes including agricultural and landscape irrigation, industrial uses, and groundwater recharge. Costs associated with reuse applications include conveyance systems and storage tanks for reuse water as well as additional treatment that may be needed to meet reuse standards (e.g., low bacteria and turbidity concentrations). FDEP has adopted reused water standards that ensure protection of human health, such as the APRICOT Act of 1994 that contains provisions for backup water discharges and groundwater injection. However, the feasibility of effluent reuse as a control option for reducing nutrient loads to receiving waters depends on demand for reuse water.

Site Specific Alternative Criteria

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 (SSAC) 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. However, there may be a greater likelihood of pursuing SSAC in cases where using data and scientific evaluations associated with previous TMDL development efforts can result in significant cost savings.

Variance

Section 120.542, F.S. indicates that FDEP is authorized to grant variances to requirements of their rules or to rules required by EPA with approval of the variance from EPA. Under Chapter 62-110.104, F.A.C. a discharger must demonstrate that any hardship asserted as a basis for the need to receive a specific variance is peculiar to the affected property and not self-imposed, and that the grant of a variance will be consistent with the general intent and purpose of Chapter 403, F.S. (Environmental Control Chapter of Florida Statutes), as applicable.

To demonstrate the need for a variance under these statutes and procedures, dischargers would likely prepare documentation of the conditions warranting the variance. For example, to evaluate the potential for control costs to cause economic and social hardship, dischargers are likely to follow EPA's (1995) Interim Economic Guidance for Water Quality Standards Workbook which provides worksheets and instructions for public and private sector entities. Following EPA (1995), dischargers conduct a two-step analysis, first determining whether the control costs would have a substantial adverse financial impact and, if so, whether that impact would cause widespread adverse impacts on the surrounding community.

4.2.4 Potentially Affected Sources

Completed TMDLs for lakes and flowing waters provide wasteload allocations (WLAs) for both TN and TP for 18 municipal WWTPs, for only TN for 7, and for only TP for 2. EPA assumed that FDEP would likely seek to adopt the current TMDL nutrient targets as SSAC because scientific analysis has determined that they represent the maximum allowable nutrient concentrations for these waters. Because these dischargers are currently required to meet allowable nutrient discharge requirements, EPA assumed that additional treatment would not be needed for dischargers under a nutrient-related TMDL.

In addition, EPA also identified 12 municipal WWTPs discharging to waters listed as impaired for nutrients and/or DO on Florida's current 303(d) list. EPA assumed that in the absence of its rule, these dischargers would be given WLAs under a TMDL. Thus, costs to reduce nutrients at these WWTPs would be attributable to the existing impairment and not EPA's rule.

The FDEP's Wastewater Facility Regulation (WAFR) database and electronically available permits indicate that there are several WWTPs in Florida already operating treatment processes capable of achieving the targeted levels of 3 mg/L for TN and 0.1 mg/L for TP. For example, dischargers operating treatment processes that remove both TN and TP to the target levels of treatment (e.g., A^2/O, modified Bardenpho, modified UCT, oxidation ditches or other BNR coupled with chemical precipitation) would likely be in compliance with WQBELs based on numeric nutrient criteria. Dischargers operating treatment processes that remove only TN to levels consistent with performance of MLE and four-stage Bardenpho processes or TP to levels consistent with chemical precipitation without BNR would likely be in compliance with WQBELs based on numeric criteria for TN and TP, respectively. Municipal WWTPs without these configurations or those not operating BNR would likely need to retrofit or expand existing treatment to reduce nutrients to the necessary levels.

Exhibit 4-3 summarizes the varying levels of treatment that could be required by municipal WWTPs under EPA's rule on the basis of existing TMDL WLAs and effluent treatments.

Exhibit 4-3: Potential Treatment Required for Municipal Wastewater Treatment Plants[1]

Discharge Category	Number of Dischargers				
	Reduce TN and TP[1]	Reduce TN Only[2]	Reduce TP Only[3]	No Reductions[4]	Total
Major	11	2	9	21	43
Minor	19	1	3	19	42
Total	30	3	12	40	85

Source: Based on treatment train descriptions in FDEP (2009c) and permits and WLA in TMDLs, assuming dischargers would have to install advanced BNR for compliance under the rule.
A^2/O = anaerobic-anoxic oxidation
BNR = biological nutrient removal
MLE = Modified Ludzack-Ettinger
TMDL = total maximum daily load
TN = total nitrogen
TP = total phosphorus
UCT = University of Cape Town
WLA = wasteload allocation

1. Includes dischargers without treatment processes capable of achieving the target levels or existing WLA for TN and TP, or for which the treatment train description is missing or unclear.
2. Includes dischargers with chemical precipitation only and those with WLA under a TMDL for TP only.
3. Includes dischargers with MLE, four-stage Bardenpho, and BNR specified to achieve less than 3 mg/L and those with WLA under a TMDL for TN only.
4. Includes dischargers with A^2/O, modified Bardenpho, modified UCT, oxidation ditches, or other BNR coupled with chemical precipitation and those with WLAs under a TMDL for both TN and TP.

4.2.5 Potential Control Costs

On the basis of the above estimates of potentially affected WWTPs and their current treatment processes, EPA estimated potential costs required for all municipal WWTPs to implement advanced BNR associated with EPA's numeric nutrient criteria. EPA (2008a) provides unit cost estimates for BNR retrofits and expansions for various TN and TP performance levels. **Exhibit 4-4** shows retrofit and expansion costs for estimates EPA (2008a) derived from wastewater treatment cost estimating software (CAPDETWorks). Note that EPA excluded site specific estimated project costs from areas outside of Florida because costs for colder climate facilities (especially those in the Northeast) could be much greater than those for warmer climate facilities. Also, the costs for those facilities represent estimated design costs and not actual installed process costs.

Exhibit 4-4: BNR Capital and O&M Unit Costs (2010 dollars)[1]

Source of Costs	Flow (mgd)	Description	Capital Unit Cost ($/gpd)	O&M Unit Cost ($/MG)	Annual Unit Cost ($/gpd/yr)
TN Less than 3 mg/L					
CAPDETWorks	10	Phased oxidation ditch retrofit	$0.52	$49	$0.07
CAPDETWorks	10	MLE retrofit	$0.79	$91	$0.11
CAPDETWorks	10	Step-feed retrofit	$0.72	$101	$0.10
CAPDETWorks	10	Denitrification filter retrofit	$0.79	$173	$0.14
		Average	$0.70	$103	$0.11
TP Less Than 0.1 mg/L					
CAPDETWorks	10	Fermenter, sand filtration, and 1-pt chemical addition retrofit	$0.52	$118	$0.09
CAPDETWorks	10	2-pt chemical addition and filter retrofit	$0.32	$238	$0.12
CAPDETWorks	10	2-pt chemical addition and filter expansion	$0.32	$238	$0.12
CAPDETWorks	10	A/O with fermenter, filter, and chemical addition expansion	$1.72	$431	$0.32
		Average	$0.72	$256	$0.16
TN Less Than 3 mg/L and TP Less Than 0.1 mg/L					
CAPDETWorks	10	PID retrofit with 1-pt chemical addition, clarifier, and filter	$0.99	$221	$0.17
CAPDETWorks	10	5-stage Bardenpho and chemical addition retrofit	$1.44	$284	$0.24
CAPDETWorks	10	Nitrification, chemical addition, and denitrification filter retrofit	$0.83	$497	$0.26
CAPDETWorks	10	Nitrification with 1-point chemical addition and denitrification filter expansion	$0.75	$448	$0.23
CAPDETWorks	10	5-stage Bardenpho, chemical addition, and filter expansion	$2.48	$477	$0.41
		Average	$1.30	$385	$0.26

Source: U.S. EPA (2008a)
A/O = anaerobic/oxic
gpd = gallons per day
MG = million gallons
mgd = million gallons per day
mg/L = milligrams per liter
O&M = operation and maintenance
TN = total nitrogen
TP = total phosphorus
WWTP = wastewater treatment plant

1. Capital and O&M costs updated from original reported year dollars (May 2007 and July 2007) to June 2010 dollars using the Engineering News Record Construction Cost Index (index values of 7942, 7959, and 8566 for May 2007, July 2007, and June 2010, respectively).

The treatment level needed is based on the required pollutants reductions (Exhibit 4-3). **Exhibit 4-5** summarizes the range of costs applicable to each type of discharger [the low end represents the average of unit costs and the high end represents costs for treatment processes that results in the highest annualized costs, based on annualizing capital at 7% over 20 years plus operation and maintenance (O&M) costs].

Exhibit 4-5: Treatment Level and Costs for Municipal Wastewater Treatment Plants

Reductions Needed	Proposed Treatment Level	Capital Cost ($/gpd)[1]	O&M Cost ($/MG)[1]
Both TN and TP	TN <3 mg/L; TP <0.1 mg/L	$1.30 - $2.48	$385 - $477
TP only	TP <0.1 mg/L	$0.72 - $1.72	$256 - $431
TN only	TN <3 mg/L	$0.70 - $0.79	$103 - $173
None	None	No costs	No costs

mg/L = milligrams per liter
O&M = operation and maintenance
TN = total nitrogen
TP = total phosphorus

1. Low end represents average of unit costs; high end represents costs for treatment processes that results in the highest annualized costs, based on annualizing capital at 7% over 20 years plus O&M.

Assuming the range of control costs shown in Exhibit 4-5 are indicative of those that similar facilities in Florida would incur to retrofit or expand existing treatment trains to implement advanced BNR, total capital costs could range between approximately $108 million to $219 million and annual O&M costs could range between approximately $12 million to $18 million. Total annual costs could range between approximately $22 million to $38 million (annualized capital at 7% over 20 years plus annual O&M). These estimates reflect the unit costs multiplied by total flows contained in EPA's PCS database, as shown in **Appendix C**. Note that the total does not include costs for three master reuse systems classified as municipal WWTPs in PCS. These systems receive inflow from several WWTPs which have or could need to install advanced BNR; thus, any discharges to surface waters from the master reuse systems should meet numeric nutrient criteria.

Under the FDEP 2009 draft nutrient criteria baseline, annual incremental costs to municipal WWTPs could be zero because the treatment technologies needed to achieve the FDEP draft criteria are the same as those needed under EPA's rule.

5. Potential Costs for Industrial Wastewater Sources

Industrial sources of wastewater to lakes and streams receive WQBELs in NPDES permits on the basis of their potential to discharge pollutants at levels that could cause or contribute to exceedance of a WQS. Unlike municipal WWTPs, however, not all industrial dischargers are likely to discharge nutrients because industrial processes, treatments, and waste stream compositions vary widely. This section describes how EPA identified industrial wastewater with the potential to receive revised effluent limitations for TN and TP as a result of state implementation of EPA's rule and the resulting potential pollution control costs.

5.1 Data

EPA's PCS database provides information on numeric effluent limits and permit monitoring requirements for industrial dischargers in Florida (Exhibit 2-3). EPA assumed that any discharger (both major and minor) with a standard industrial classification (SIC) matching that of other dischargers with either a numeric effluent limit or monitoring requirement for nutrients has the potential to discharge nutrients. This analysis resulted in identification of 108 industrial dischargers that discharge to freshwater lakes and streams potentially affected by the rule.

Completed nutrient and DO TMDLs for lakes and flowing waters indicate that 38 of the 108 potentially affected dischargers have WLAs for nutrients. As with municipal WWTPs, EPA assumed that FDEP would likely seek to adopt the current TMDL nutrient targets as SSAC because scientific analysis has determined that they represent the maximum allowable nutrient concentrations for these waters. Because these dischargers are currently required to meet allowable nutrient discharge requirements, EPA assumed that additional treatment would not be needed for dischargers under a nutrient-related TMDL. In addition, EPA also identified 14 industrial dischargers out of the 108 potentially affected facilities that discharge to waters listed as impaired for nutrients and/or DO on Florida's current 303(d) list. EPA assumed that in the absence of its rule, these dischargers would be given WLAs under a TMDL. Thus, costs to reduce nutrients at these facilities would be attributable to the existing impairment and not EPA's rule.

Exhibit 5-1 provides a summary of the number of dischargers of the remaining 56 possibly subject to WQBELs as a result of EPA's criteria in each industrial sector that EPA identified as having the potential to discharge nutrients and incur incremental costs under the rule.

Exhibit 5-1: Summary of Potentially Affected Industrial Dischargers

SIC	Industrial Category	Major Dischargers	Minor Dischargers	Total Dischargers
1099	Mining	-	2	2
1422	Mining	-	4	4
1475	Mining	3	-	3
1479	Mining	1	-	1
2015	Food	1	-	1
2033	Food	-	2	2
2037	Food	-	1	1
2082	Food	-	1	1
2085	Food	-	1	1
2491	Pulp and Paper	-	2	2
2499	Pulp and Paper	-	1	1

Exhibit 5-1: Summary of Potentially Affected Industrial Dischargers

SIC	Industrial Category	Major Dischargers	Minor Dischargers	Total Dischargers
2631	Pulp and Paper	1	-	1
2824	Chemicals and Allied Products	1	-	1
2869	Chemicals and Allied Products	-	3	3
2874	Chemicals and Allied Products	2	1	3
2879	Chemicals and Allied Products	1	-	1
2892	Chemicals and Allied Products	1	-	1
3582	Other	-	1	1
3679	Other	-	1	1
3699	Other	-	1	1
4011	Other	-	2	2
4911	Electric Services	9	-	9
4931	Other	-	2	2
4953	Other	-	3	3
5146	Food	-	1	1
5171	Other	-	5	5
7996	Other	-	1	1
8422	Other	-	1	1
9511	Other	-	1	1
Total	--	20	36	56

U.S. EPA (2010a).

5.2 Method

Treatment to reduce nutrient levels from industrial sources is facility-specific and varies on the basis of process operations, existing treatment train, and composition of waste streams. Thus, EPA evaluated the potential for control costs for a sample of dischargers and then applied these representative costs to all potentially affected dischargers.

5.2.1 Sample Dischargers

EPA selected a random sample of dischargers not already covered under nutrient-related TMDLs stratified by industrial category. **Exhibit 5-2** shows the number of sample dischargers selected compared to the total number in each industrial category.

Exhibit 5-2: Summary of Industrial Sample by Category

Industrial Category	Major Dischargers		Minor Dischargers	
	Total	Sample	Total	Sample
Chemicals and Allied Products	5	2	4	0
Electric Services	9	2	0	0
Food	1	1	6	1
Mining	4	1	6	1
Other	0	0	17	3
Pulp and Paper	1	1	3	0
Total	20	7	36	5

To estimate potential control costs, EPA first determined whether each sample discharger has reasonable potential to cause or contribute to an exceedance of the numeric TN and TP criteria using effluent data for discharge flows, TN, and TP from EPA's PCS database and other information in the NPDES permits. For those with reasonable potential, EPA analyzed effluent data to determine compliance with potential revised WQBELs for TN and TP (calculated based on available dilution, if any). If current data indicated that the facility would not be in compliance with the potential revised WQBEL, EPA determined the pollution controls most likely necessary for compliance and the cost of those controls. **Appendix D** provides the detailed analysis for each sample discharger.

5.2.2 Potential Compliance Options

Potential controls to reduce TN and TP in industrial effluents may include BNR, chemical precipitation with or without filtration, and source control. BNR, chemical precipitation, site specific criteria, and variances are discussed in Section 4.2.3.

Source control targets reductions in pollutants at the source of entry into the wastewater system or within a specific treatment process rather than targeting reductions in total effluent. In most cases, it is more cost effective for industrial dischargers to control the source of nutrients in the effluent through BMPs, product substitution, process modifications, or process optimization than to treat the entire effluent prior to discharge. For example, in the Chesapeake Bay most industrial dischargers have reduced nutrient loads through pollution prevention (CBP, 2004).

Source control can include a wide variety of activities. For example, to meet its WLA under the LSJR TMDL, Anheuser Busch improved pond nutrient removal with hyacinth management, a baffle system to improve retention time, and the use of aeration in some zones at its Lem Turner location. At its Main Street location, the discharger reduced the nutrient load by improving/modifying the site nutrient management plan and increasing the crop area to which they land applied a portion of the wastewater to reduce the nutrient load per acre (personal communication with T. Busby, Wildwood Consulting, August 2009). Similarly as a result of the LSJR TMDL, Georgia Pacific reduced the amount of nutrients added to its treatment ponds (personal communication with T. Busby, Wildwood Consulting, August 2009).

5.2.3 Potential Control Costs

To estimate total statewide costs, EPA calculated the average treatment unit cost in dollars per mgd of flow treated for each industrial category by dividing the total costs for the sample facilities in each industrial category by the total flow of the sample facilities in that group. EPA then multiplied the average unit cost by the flow reported in PCS for each of the potentially affected facilities in the applicable category. For those facilities for which flow is not reported in PCS, EPA used the average flow of the other major or minor facilities in that industrial category (as shown in Appendix D). **Exhibit 5-3** shows EPA's estimate of potential statewide industrial discharger costs.

Exhibit 5-3: Estimated Statewide Annual Industrial Control Costs

Industrial Category	Total Annual Sample Cost ($/yr)	Flow of Sample Dischargers (mgd)	Average Unit Cost ($/mgd/yr)[1]	Total Flow of Affected Dischargers (mgd)[2]	Total Annual Costs ($/yr)[3]
Chemicals and Allied Products	$206,800	14.7	$14,100	79.3	$1,116,800
Electric Services	$0	133	$0	929	$0
Food	$394,700	3.2	$123,300	11.3	$1,390,000
Mining	$1,092,400	6.8	$160,600	102	$16,442,300
Other	$0	1.2	$0	17.1	$0
Pulp and Paper	$6,454,100	55	$117,300	55.1	$6,466,800
Total	NA	214	NA	1,194	$25,415,900

Note: Detail may not add to total due to independent rounding.
NA = not applicable
1. Calculated by dividing total annual sample discharger costs by total sample discharger flow. Note that where flow for a sample discharger is not available, EPA used the average flow for dischargers in that category and discharger type (i.e., major or minor).
2. For the 34% of dischargers with no flows reported in PCS, EPA used the average flow for dischargers in the same category and discharger type (i.e., major or minor).
3. Represents average sample discharger unit cost multiplied by total flow of dischargers affected by the rule in each industrial category.

Under the FDEP 2009 draft nutrient criteria baseline, annual incremental costs to industrial dischargers could be zero because the treatment technologies needed to achieve the FDEP draft criteria are the same as those needed under EPA's rule.

6. Potential Incrementally Impaired Waters and Watersheds

To estimate the potential incremental impact of the rule on nonpoint sources, EPA first identified freshwater lakes, streams, and springs that may exceed the numeric nutrient criteria in the rule. Next, EPA identified land areas associated with these incrementally impaired waters to estimate the controls and costs that could be indirectly associated with attaining WQS. This section describes EPA's analysis to identify potentially incrementally impaired waters and watersheds under the rule.

6.1 Data

FDEP maintains a database of ambient water quality monitoring data for waters across the state and periodically updates this database under the impaired waters rule (IWR). The IWR database does not contain data for every WBID potentially affected under the rule because FDEP has not monitored all waters. However, the IWR database is the most extensive source of nutrient monitoring data available.

In 1996, FDEP redesigned its watershed monitoring approach, segregating water quality monitoring into three tiers:

- Tier 1 includes regular monitoring, using a probabilistic monitoring design to estimate water quality across the state on the basis of a representative subsample of waterbodies.
- Tier 2 provides more intensive monitoring of waterbodies identified as impaired or at risk; FDEP implements it through strategic monitoring plans (SMPs) at the state water management district level.
- Tier 3 monitoring is intensive monitoring for the development of TMDLs or the investigation of variances or site specific alternative criteria (SSAC).

Tier 1 is implemented through two mechanisms: the Status Network and the Trend Network. There are 52 basins in Florida, divided into 5 districts. Through the Status Network, one basin from each district is assessed each year. FDEP established the ordering of these assessments on the basis of various priority factors such as whether the water includes surface water drinking sources, whether a TMDL must be developed for the water, or whether SWIM plans are underway. FDEP divides waterbodies into categories (large lakes, small lakes, large rivers, small rivers, confined aquifers, and unconfined aquifers) and randomly chooses a selection of each for monitoring.

Surface water monitoring through the Trend Network consists of 75 fixed location sites in flowing waters that are sampled on a monthly basis. These sites enable FDEP to obtain chemistry, discharge, and loading data at the point where land use activities may have a large effect on the watershed. In addition, some sites are located at or near the Florida State boundary with Alabama and Georgia to obtain chemistry and loading data for major streams entering Florida. The sites are not designed to monitor point sources of pollution and are specifically located away from known outfalls or other regulated point source dischargers.

Special monitoring is also done on a subset of waterbodies that are identified as impaired or potentially impaired. After regular monitoring, FDEP identifies data gaps regarding these waterbodies and determines the number of samples for each parameter that are needed to allow assessment using the IWR process as described in Section 2.1.1. FDEP then prioritized these needs according to EPA's categories for identifying monitoring needs:

- Any WBID on the 1998 303(d) list of impaired waters.
- Potentially impaired waters for which additional data are needed, including those identified by the IWR.
- Waters for which verified impaired threshold has been met, but monitoring must be maintained.
- Waters for which data are insufficient.
- Waters for which there are no data.

FDEP tracks (but does not necessarily monitor) each waterbody it identifies as needing special monitoring every quarter to ensure sufficient data to conduct IWR assessment.

The IWR Run 40 database (made available May 2010) contains measurements of TN, TP, and/or chlorophyll-a from January 2005 through February 2010 for 877 lakes and 1,346 streams in Florida. It also contains nitrate-nitrite data for 72 springs for the same time period.

6.2 Method

Compared to current conditions, potential incrementally impaired waters under the rule represent those waters that exceed EPA's criteria that FDEP has not already developed a TMDL or listed as impaired for nutrients and DO (because TMDLs for DO often target nutrient reductions). [Appendix A provides an assessment of incremental impairments compared to numeric nutrient criteria representative of what could have been adopted in the absence of the rule (FDEP July 2009 draft numeric nutrient criteria baseline).] Using the last 5 years of data (2005-2010) from IWR Run 40, the method for identifying potential incrementally impaired lakes, streams, and springs entailed:

- Identifying all state WBIDs
- Excluding WBIDs for which this rule is not applicable (e.g., estuaries, beaches, coastal waters, and streams in South Florida)
- Excluding WBIDs for waters on the 303(d) list or for which there is a draft or approved nutrient-related TMDL (because EPA assumes controls to reduce nutrients already required in the absence of EPA's rule would be sufficient)
- Excluding monitoring data flagged for quality concerns (e.g., result codes indicating QA/QC issues)
- Identifying specifically applicable criteria for each WBID on the basis of waterbody type (lake, stream, spring), location (nutrient criteria region for streams), and color (assuming the more stringent clear lakes criteria apply if color is not available)
    - Identifying WBIDs adjacent to lakes to which DPVs could apply (because DPVs will not apply to all waters intersecting lakes, including those flowing out of lakes; **Appendix B** provides a sensitivity analysis of the impact of this conservative assumption on costs).
- Calculating the annual geometric mean of TN, TP, and chlorophyll-a values and monthly geometric mean nitrite-nitrate concentrations, and comparing to the applicable criteria.

EPA used FDEP's 2009 draft data requirements for calculating annual geometric means and excluded data from years that did not contain at least four samples, with at least one in the summer season (May to September) and at least one in the winter season (October to April). This requirement ensures that assessments represent seasonal variations in nutrient concentration. In comparison, monthly geometric mean values can be based on a single sample result. EPA assigned nondetects a value of one-half of the detection level in these calculations. This procedure ensures that waters with nutrient concentrations below the detection level are not erroneously categorized as not assessed due to insufficient data. For this analysis, EPA did not evaluate lake water quality monitoring data to determine the applicability of the lake criteria modification procedures specified in the rule.

More than one annual geometric mean greater than the applicable numeric criterion for TN, TP, or chlorophyll-a in a three year period represents a potential impairment. For springs, any monthly geometric mean nitrate-nitrite concentration greater than the applicable criterion represents a potential impairment. FDEP's assessment methodology specifies that waters with insufficient data are not to be listed as impaired. EPA followed this same methodology and did not consider waters with insufficient data as potentially impaired.

6.3 Results

Exhibit 6-1 summarizes the potential incrementally impaired waters under the rule.

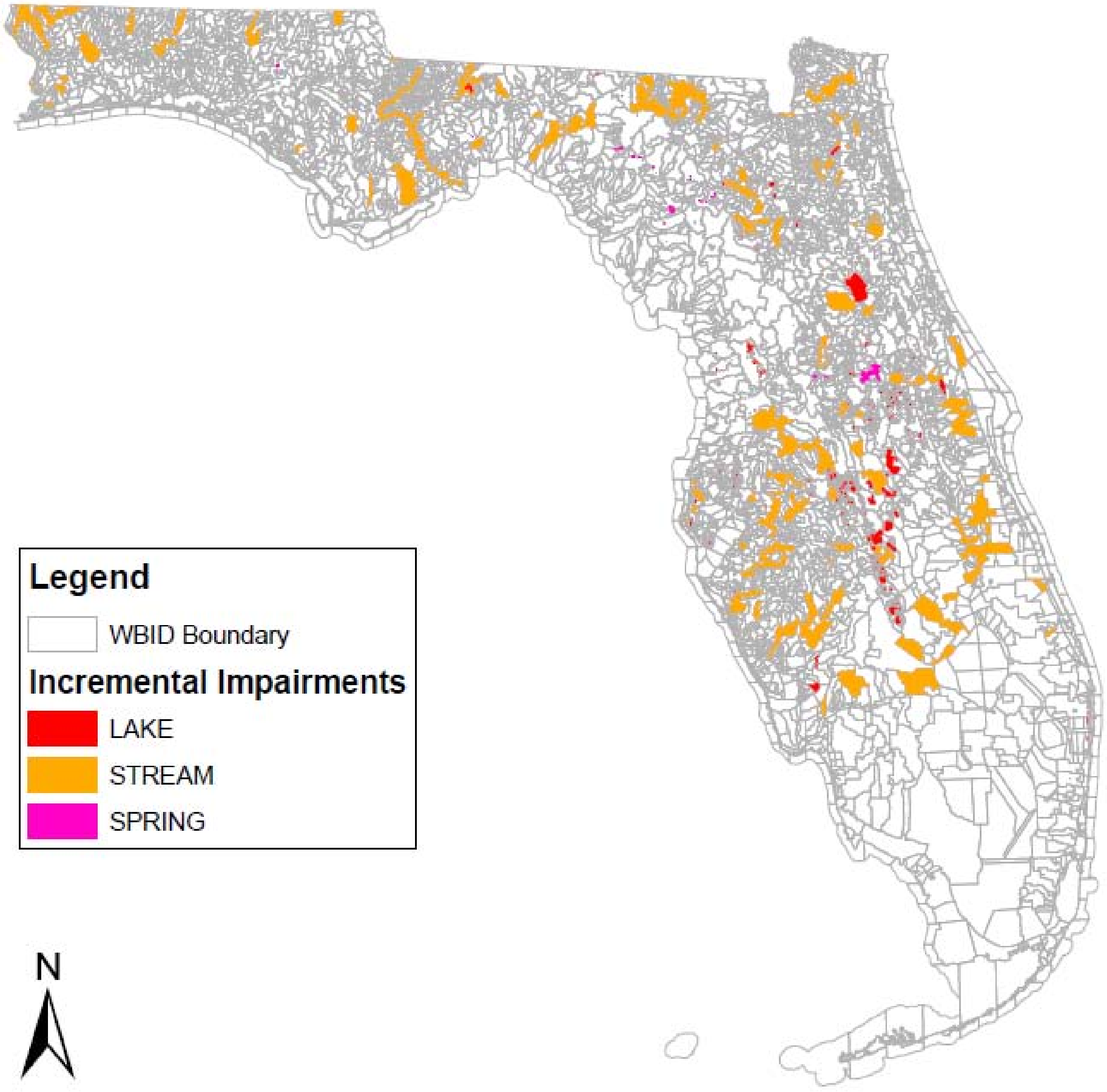
Exhibit 6-1: Potential Incrementally Impaired Waters

Category	Number of WBIDs			Total
	Lake	Stream[1]	Spring	
Total in State	1,310	3,901	126	5,337
Not Listed/Covered by TMDL[2]	1,099	3,608	119	4,826
Nutrient Data in IWR Run 40[3]	878	1,273	72	2,223
Sufficient Data Available[4]	655	930	72	1,657
Potentially Exceeding Criteria[5]	148	153	24	325

IWR = Impaired Waters Rule
TMDL = total maximum daily load
WBID = waterbody identification
1. Includes blackwater.
2. As reported in TMDL documents and FDEP (2009c).
3. Data within last 5 years meeting data quality requirements.
4. Annual geometric means based on at least 4 samples with one sample from May to September and one sample from October to April in a given year. For monthly geometric mean, there are no data requirements.
5. Based on annual geometric mean exceeding the applicable TN, TP, or chlorophyll-a criterion more than once in a three year period; for springs, based on more than one exceedance of the monthly nitrate-nitrite geometric mean criterion.

Note that some lake and stream WBIDs are impaired for TN, TP, and chlorophyll-a while others are only impaired for a single pollutant. For the purpose of estimating controls for nonpoint sources, EPA did not distinguish among the pollutants causing the impairment and assumed that controls to reduce TN, TP and chlorophyll-a are the same. **Exhibit 6-2** shows the locations of incrementally impaired lakes and flowing waters in Florida.

Exhibit 6-2: Map of Potential Incrementally Impaired Waters Affected by the Rule



6.4 Land Use

Land use surrounding the potential incrementally impaired waters provides information on the types of controls that may be needed to attain EPA's criteria. EPA used 10-digit hydrologic unit codes (HUCs) to represent the watersheds for each impaired WBID. However, each WBID does not fall completely within a single 10-digit HUC. Thus, to ensure that lands (and sources) affecting water quality for each WBID are accounted for in the analysis, EPA identified watersheds containing at least 10% of an incrementally impaired lake or stream, excluding those watersheds that contain at least 10% of a lake or stream that is currently impaired or under a TMDL (to remove baseline impaired watersheds). EPA chose the 10% overlap factor to screen the incidental boundary mismatch type of overlap from real watershed overlaps. **Exhibit 6-3** summarizes the area of land in different use categories that surround potential incrementally impaired waters.

Exhibit 6-3: Summary of Land Use for Potential Incrementally Impaired Watersheds

Land Use Category	Total Acres	Percent of Total
Forest	1,851,396	43%
Wetlands	1,171,382	27%
Agriculture	805,793	19%
Urban	263,499	6%
Water	83,790	2%
Other	48,765	1%
Industrial	31,951	1%
Transportation Corridors	18,544	<1%
Communications and Utilities	15,837	<1%
Total	4,290,958	100%

Note: Detail may not add to total due to independent rounding.

For springs, 10-digit HUC watersheds may not reflect the area influencing water quality. Rather, spring water quality is dominated by groundwater and surrounding aquifers which generally do not correspond to watershed boundaries. Spring recharge areas can be much larger than surface watersheds, and are much more complex, with great variability in distances that water travels to the outlet (USGS, 1999; 2010). Several factors tend to impede the precise delineation of spring recharge areas, often times making it difficult or impossible to distinguish a spring recharge area for a single outlet from a larger cluster of springs (Cohen, 2008; Upchurch, et al., 2008). For example, spring recharge area delineation is based on groundwater elevation, which is much flatter than the terrain used to delineate surface watersheds. Also, the boundaries of spring recharge areas can be dynamic, shifting based on rainfall patterns and recharge rates (USGS, 1999; Cohen, 2008).

Florida spring recharge areas are especially difficult to delineate given the area's karstic geology, which is characterized by sinkholes, cavities, siphons, conduits, uneven limestone topography, disappearing springs, and many other features that create a dynamic system of surface and groundwater flows (USGS, 1999; Cohen, 2008). Some underground conduit systems can spread out for many kilometers (USGS, 1999; 2010) and these (along with surface waters) can carry rainwater out of one spring recharge area into another in a distant location, often very rapidly (Cohen, 2008; Upchurch, 2008). Given these complexities, EPA determined potentially relevant nutrient sources for springs based on the individual source category rather than by utilizing 10-digit HUCs as in the case of surface waters.

7. Potential Costs to Urban Stormwater Sources

State implementation of EPA's numeric nutrient criteria may affect urban stormwater dischargers through changes to NPDES permit requirements, and the development of TMDLs and BMAPs. This section provides estimates of potential control actions and costs. These estimates are only approximate and for informational purposes only because actual control actions, if any, will depend on site specific conditions and control strategies.

7.1 Data

As shown in Exhibit 6-3, urban land use (excluding industrial land, mine land, and inactive/undeveloped land) accounts for approximately 6% of the land use in the incrementally impaired watersheds. Under the baseline, a number of urban areas are already required to control nutrients in stormwater discharges through BMP implementation under MS4 NPDES permits. As described in Section 6.3, EPA identified potentially affected urban land by overlaying land use data with the 10-digit HUCs EPA determined to be near incrementally impaired waters. EPA further identified MS4 permit boundaries around this urban land by analyzing these data using GIS permit boundary data from the Florida Geographic Data Library (FGDL). **Exhibit 7-1** summarizes EPA's analysis identifying urban areas in incrementally impaired watersheds. Note this land use data may not be applicable to incrementally impaired springs.

Exhibit 7-1: Urban Land Area in Incrementally Impaired Watersheds

NPDES Permit Type	Estimated Land Areas
Phase I MS4	61,800
Phase II MS4	93,000
No permit (Non-MS4)	112,000
Total	266,800

Note: Detail may not add to total due to independent rounding.

7.2 Method

The incremental controls that may be necessary based on state implementation of EPA's numeric nutrient criteria will depend on existing permit requirements and regulations dictating BMP implementation, as well as the relative contribution of nutrients to impaired waters from urban runoff.

7.2.1 Controls for Lakes and Streams

This section describes how EPA estimated the potential cost of additional controls that may be required to meet EPA's numeric nutrient criteria in incrementally impaired lakes and streams based on the baseline permit requirements noted in Section 2.1.4.

Phase I MS4 Urban Land

Under existing regulations, NPDES permits for Phase I MS4s require implementation of BMPs to the maximum extent practicable (MEP) and do not generally require compliance with numeric effluent limits. For example, the Seminole County MS4 permit does not contain numeric effluent limits. In fact, EPA's PCS database indicates that none of the Phase I MS4s in Florida have numeric effluent limits. While states have the authority to include numeric limits in MS4 permits, most rely solely on implementation of BMPs. The Seminole County MS4 permit indicates that each permittee must implement a comprehensive stormwater management plan that includes pollution prevention measures, treatment or removal techniques, stormwater monitoring, and use of legal authority and other appropriate means to control the quality of stormwater discharged from the MS4. The Seminole County MS4 permit requires that any stormwater structural controls (e.g., controls that reduce volume and pollutants by the capture and reuse of stormwater, the infiltration of stormwater into porous surfaces, and the evaporation of stormwater) shall be operated in a manner to reduce the discharge of pollutants to the MEP. However, it is unclear what level of treatment the MEP represents. Thus, it is uncertain whether current stormwater pollution controls to the MEP are fully implemented in Phase I MS4 areas.

Although urban runoff is currently regulated under the statutes and rules described above, EPA's numeric nutrient criteria may result in changes to MS4 NPDES permit requirements or additional TMDLs and BMAPs that require additional pollution controls for urban runoff through state implementation. However, the combination of additional pollution controls necessary will likely depend on the specific nutrient reduction targets, the BMPs already in place, and the relative amounts of nutrients contained in the urban runoff at each particular location. As a result, stormwater programs usually use an iterative approach for assessing compliance that begins with implementation of BMPs followed by monitoring and re-evaluation. Estimating the complete set of pollution controls required to meet a particular water quality target would usually require site specific analysis.

Although it is difficult to predict the complete set of potential additional urban runoff BMPs that may be needed to meet EPA's numeric nutrient criteria, EPA estimated potential costs for additional treatment by assessing the amount of urban land in incrementally impaired watersheds on which additional pollution controls for stormwater could be implemented based on land use data from the FGDL using GIS analysis.

FDEP's existing stormwater rules already require at least an 80% reduction in pollutant loads from urban areas developed after 1982, and FDEP (2010b) indicated that stormwater runoff from this land should be in compliance with EPA's numeric nutrient criteria. FDEP (2010b) also estimated that approximately 78% of all urban land in the state was developed prior to 1982. Furthermore, nutrient reductions associated with previous completed nutrient-related TMDLs in Florida indicate that, on average, nonpoint source pollution load reductions of approximately 50% are necessary to meet TMDL targets for nutrients (range of 5% to 85%; see Exhibit 2-8). In the absence of site specific analysis, the type and location of pollution controls capable of achieving a 50% reduction are uncertain. However, urban stormwater controls can remove up to 51% of TN and 75% of TP (Schueler, et al., 2007). Thus, EPA assumed that installation of stormwater pollution controls would result in the nutrient reductions necessary to attain EPA's numeric nutrient criteria.

Using FDEP's assumptions that all urban land developed after 1982 would not need to implement additional stormwater controls to comply with EPA's numeric nutrient criteria, EPA estimated that between 0 acres (current controls to the MEP are sufficient) to 48,100 acres (61,800 acres of urban land in incrementally impaired watersheds × 78% of urban land developed before 1982) of Phase I MS4 urban land may require additional stormwater pollution controls.

Phase II MS4 Urban Land

NPDES permits for Phase II MS4s require development of a stormwater management plan and implementation of BMPs based on six minimum control measures detailed in Section 2.1.4. For example, the Phase II Okaloosa MS4 stormwater management plan details BMPs the City plans to implement or that are already being implemented under each of the minimum control measures. Most of the BMPs in the stormwater management plan are nonstructural; thus, implementation of structural BMPs (e.g., baffle boxes, detention basins) may not be prevalent throughout Phase II MS4 areas.

GIS analysis of land use data from the state of Florida (as described in Section 7.1) indicates that approximately 58% of land in Phase II MS4 areas is low density residential (based on land use codes identifying low density residential land). The primary source of nutrients from low density residential land is from over-application of fertilizers on lawns and gardens. Thus, full implementation of the Urban Turf Fertilizer Rule should result in further reductions in nutrient loadings to surface waters (existing ambient monitoring data may not yet fully reflect nutrient reductions because the rule has only been in effect since July 2009). Other BMPs that target quantity of stormwater runoff from low density residential land may not be as cost-effective as the Urban Turf Fertilizer Rule which reduces the source of nutrients in stormwater runoff.

For the urban land that is not low density residential (42% in Phase II MS4s), some additional structural BMPs may be necessary to comply with EPA's numeric nutrient criteria (existing TMDLs indicate that needed reductions in nonpoint source pollutant loads range from 5% to 85%, with an average of 50%; see Exhibit 2-8). Because nutrient reductions from low density residential land under the existing Urban Turf Fertilizer Rule are likely sufficient, and the state of Florida asserts that urban land developed after 1982 is already in compliance with EPA's numeric nutrient criteria, EPA estimated that approximately 30,700 acres of Phase II MS4 urban land may require additional stormwater control [93,000 acres of Phase II MS4 land × (100% - 58%) of Phase II MS4 land not low density residential × 78% of urban land developed before 1982].

Urban Land Outside MS4s

Some urban land is not covered under EPA's NPDES stormwater program. However, regulations such as the Urban Turf Fertilizer Rule are applicable, although existing ambient monitoring data may not yet reflect nutrient reductions related to this regulation because it has only be fully in effect since July 2009. GIS analysis of land use data from the state of Florida (as described in Section 7.1) indicate that approximately 65% of non-MS4 urban land is low density residential. The primary source of nutrients from low density residential land is the over-application of fertilizers on lawns and gardens. Thus, full implementation of the Urban Turf Fertilizer Rule should result in further reductions in nutrient loadings to surface waters. Other BMPs that target quantity of runoff from low density residential land may not be as cost-effective as the Urban Turf Fertilizer Rule which reduces the source of nutrients in stormwater runoff.

Because nutrient reductions from low density residential land under the existing Urban Turf Fertilizer Rule are likely sufficient, and the state of Florida asserts that urban land developed after 1982 are already in compliance with EPA's numeric nutrient criteria, EPA estimated that approximately 30,600 acres of urban land outside of MS4 areas may possibly require additional stormwater controls to meet EPA's numeric nutrient criteria [112,000 acres of non-MS4 land × (100% - 65%) of non MS4 land that is not low density residential × 78% of urban land developed before 1982]. Note that under TMDLs, FDEP may designate areas that are outside of MS4s and are significant contributors to pollutant loads as Phase II MS4s, and require those areas to obtain NPDES permits.

Summary of Potentially Affected Area

Exhibit 7-2 summarizes the acres of urban land in the incrementally impaired watersheds for lakes and streams that could potentially need incremental controls based on the assumptions described above.

Exhibit 7-2: Urban Land in Incrementally Impaired Watersheds Potentially Needing Controls

Land Type	Estimated Acres in Incrementally Impaired Watersheds	Estimated Acres Potentially Needing Controls[1]
MS4 Phase I Urban	61,800	0 – 48,100
MS4 Phase II Urban	93,000	30,700
Non-MS4 Urban	112,000	30,600
Total	266,800	61,300 – 109,400

Note: Detail may not add to total due to independent rounding

1. Phase I MS4s range represents implementation of BMPs to the MEP resulting in compliance with EPA's rule or controls needed on all pre-1982 developed land; Phase II MS4s and urban land outside of MS4s represent controls needed on all pre-1982 developed land that is not low density residential.

7.2.2 Controls for Impaired Springs

Reducing or eliminating land applications of nitrogen is the most cost-effective means of addressing potential nitrogen contributions from urban runoff in springs. The Urban Turf Fertilizer Rule is an example of one such source control effort. Other pollution prevention or source control activities include city or county-wide ordinances and public outreach and education campaigns for fertilizer BMP (both of which are already required in MS4 NPDES permits). Thus, EPA did not estimate costs for stormwater controls for urban areas surrounding incrementally impaired springs, and assumed that implementation of existing (baseline) requirements would be sufficient for reducing nitrogen (including nitrate-nitrite) loads from urban runoff.

7.2.3 Potential Costs

Unit costs for stormwater treatment controls may vary based on the type of land needing controls (e.g., pervious versus impervious, high density versus low density). FDEP (2010a) provides unit costs in dollars per acre treated for completed stormwater retrofit projects throughout the state. Costs range from $62 per acre treated to $60,300 per acre treated depending on site specific characteristics, with a median cost of $6,800 per acre. Specific information regarding the characteristics of land potentially requiring controls is not available. Thus, EPA estimated control costs based on median unit costs from FDEP (2010a), with O&M costs equal to 5% of capital costs [consistent with FDEP (2010b) assumption of O&M equal to 5% of capital costs]. These estimates are shown in **Exhibit 7-3**.

Exhibit 7-3: Estimated Incremental Urban Stormwater Cost Scenarios

Land Type	Acres Needing Controls[1]	Capital Cost (millions $)[2]	O&M Cost (millions $)[3]	Annual Cost (millions $)[4]
MS4 Phase I Urban	0 – 48,100	$0 - $329.1	$0 - $16.4	$0 - $47.5
MS4 Phase II Urban	30,700	$210.0	$10.5	$30.3
Non-MS4 Urban	30,600	$208.8	$10.4	$30.2
Total	61,300 – 109,400	$418.8 - $747.9	$20.9 - $37.4	$60.5 - $108.0

1. See Exhibit 7-2. Phase I MS4s range represents implementation of BMPs to the MEP resulting in compliance with EPA's rule or controls needed on all pre-1982 developed land; Phase II MS4s and urban land outside of MS4s represent controls needed on all pre-1982 developed land that is not low density residential.
2. Represents acres needing controls multiplied by median unit costs of stormwater retrofit costs from FDEP (2010b).
3. Represents 5% of capital costs.
4. Capital costs annualized at 7% over 20 years plus annual O&M costs.

Under the FDEP 2009 draft nutrient criteria baseline, annual incremental costs to urban stormwater could range from $13.7 million to $27.2 million, as described in Appendix A.

8. Potential Costs to Agricultural Sources

Agricultural dischargers in Florida do not generally receive discharge permits unless specific regulations require them (e.g., the South Florida Water Management District WOD program). However, state implementation of EPA's numeric nutrient criteria may result in additional BMP requirements for these dischargers through the identification of additional nutrient-impaired waters and subsequent TMDLs and BMAPs. Existing nutrient TMDLs and BMAPs indicate that wastewater point sources may not be the primary source of nutrients to impaired waters. FDEP's TMDL Protocol (2006b) asserts that most point source dischargers are already providing a high level of wastewater treatment and that initial control strategies may focus generally on stormwater and nonpoint sources. Thus, it is possible that controls on nonpoint sources such as agriculture may be needed to meet EPA's numeric nutrient criteria.

This section describes provides estimates of agricultural land that may require additional nutrient controls as a result of state implementation of EPA's rule and potential control costs. These estimates are only approximations for informational purposes; actual costs will depend on site specific conditions and control strategies.

8.1 Data

As shown in Exhibit 6-3, EPA estimated that agricultural land accounts for approximately 19% of land near potential incrementally impaired waters (excluding land near existing baseline impaired waters). **Exhibit 8-1** shows the agricultural acreage near potential incrementally impaired waters subdivided into the specific type of agricultural operation that presently occurs there.

Exhibit 8-1: Agricultural Land Use in Incrementally Impaired Watersheds

Agricultural Land Use	Area (acres)	% of Total Area
Animal Feeding	1,846	<1%
Citrus Crop	27,343	3%
Cow Calf Production, Improved Pastures	168,665	21%
Cow Calf Production, Rangeland and Wooded Pasture	51,057	6%
Cow Calf Production, Unimproved Pastures	75,790	9%
Cropland and Pasture Land (general)	160,814	20%
Dairies	621	<1%
Field Crop (Hayland) Production	215,168	27%
Horse Farms	1,632	<1%
Ornamental Nursery	840	<1%
Row Crop	9,808	1%
Sod/Turf Grass	2,007	<1%
Other	67,364	8%
Land not in production	22,839	3%
Total	805,793	100%

Source: Based on GIS analysis of land use data from five water management districts in Florida.
Note: Detail may not add to total due to independent rounding.

8.2 Method

When developing nutrient TMDLs for impaired waters, site specific analysis is generally needed to determine the nutrient reductions required from agricultural nonpoint sources and to identify the appropriate agricultural BMPs capable of attaining the necessary reductions. For example, EPA's Chesapeake Bay Program Office developed detailed watershed modeling of sources of nutrients and sediment affecting water quality in the Chesapeake Bay that it used to identify control scenarios for attaining water quality standards (U.S. EPA, 2003a). The reductions obtained from any one practice will vary with onsite conditions including soils and proximity to waters, BMP implementation, and nutrients used or produced.

Because this type of analysis for incrementally impaired watersheds is beyond the scope of this analysis, EPA estimated the potential incremental costs of additional agricultural BMPs that may be necessary to meet EPA's numeric nutrient criteria using a study of BMP requirements and costs performed by Soil and Water Engineering Technology, Inc. (SWET, 2008a) in the development of nutrient TMDLs for the Caloosahatchee River and St. Lucie River (SWET, 2008a). SWET (2008a) develops three types of BMP programs: the set of BMPs that land owners would likely implement without incentives (owner program); the set of BMPs that would be implemented under a reasonably funded cost share program or modest regulatory approach (typical program); and more aggressive and costly controls (alternative program) that could be needed if additional nutrient reductions are required.

The BMPs in SWET's (2008a) owner and typical programs are similar to the BMPs adopted in FDACS BMP manuals (Section 2.1.5) and those detailed in existing BMAPs [although it is uncertain whether the mix of BMPs farmers are implementing under the FDACS BMP manuals reflect the same level of control as the SWET (2008a) owner/typical program in all cases]. **Exhibit 8-2** shows the BMP program components SWET (2008a) estimated would be appropriate for each type of agricultural activity.

Exhibit 8-2: Example Agricultural BMP Program Elements for the Caloosahatchee River and St. Lucie River Watersheds

Land Use	Owner/Typical Program
Citrus	Reduced fertilization/nutrient management, grass management between trees, additional stormwater retention, and limited wetland restoration/retention
Cow Calf, Improved Pastures	P reduced to zero/nutrient management, rotational grazing, new water facilities, retention basin by working pens, improved grass management, feed placement, critical area fencing, and moderate wetland restoration/retention
Cow Calf, Unimproved Pastures	Some rotational grazing, new water facilities, retention basin by working pens, improved grass management, feed placement, and moderate wetland restoration/retention
Cow Calf, Rangeland and Wooded Pasture	Some rotational grazing, new water facilities, retention basin by working pens, improved grass management, feed placement, and moderate wetland restoration/retention
Dairies	Stormwater R/D and wetland restoration feed management
Field Crop (Hayland) Production/Other Areas	P reduced to zero/nutrient management, rotational grazing, new water facilities, retention basin by working pens, improved grass management, feed placement, critical area fencing, and moderate wetland restoration/retention
Ornamental Nursery	Reduced P fertilization, water management, additional stormwater retention, cover crop, and limited wetland restoration/retention
Row Crop	Reduced P fertilization, water management, additional stormwater retention, cover crop, and limited wetland restoration/retention

Exhibit 8-2: Example Agricultural BMP Program Elements for the Caloosahatchee River and St. Lucie River Watersheds

Land Use	Owner/Typical Program
Sod/Turf Grass	Reduced P fertilization, water management, additional stormwater retention, and limited wetland restoration
Horse Farms	P reduced to zero/nutrient management, rotational grazing, new water facilities, retention basin by working pens, improved grass management, feed placement, critical area fencing, and moderate wetland restoration/retention

R/D = retention/detention
Source: SWET (2008a).

SWET (2008a) estimates costs for an alternative program which it indicates may be necessary if additional nutrient reductions are needed beyond what the owner/typical program could obtain. However, these alternative practices, which include stormwater chemical treatment are not yet required in historically nutrient impaired watersheds with significant contributions from agriculture (e.g., Lake Okeechobee). Thus, it is highly uncertain whether such controls would ever be required. Therefore, for this analysis, EPA believes it is reasonable to assume that costs to the agricultural sector are best represented by the owner and typical BMP program unit costs described above.

FDEP must verify that FDACS BMPs are reasonably expected to be effective [Section 403.067(7)(c)(3), F.S.]. However, it is unclear whether all necessary BMPs are implemented in all cases because individual agricultural operators apply the FDACS BMP manuals with little state oversight. Therefore, EPA estimated potential incremental costs by applying unit costs only to agricultural acres near incrementally impaired waters that are not currently enrolled in the FDACS BMP program (assuming that acreage currently enrolled in FDACS BMP program do not require additional BMPs) and by applying costs to all agricultural acres near incrementally impaired waters whether or not they are currently enrolled in the FDACS BMP program (assuming that acreage currently enrolled in FDACS BMP program may require additional BMPs, although such an estimate may double count some costs).

Agricultural practices, particularly the application of mineral fertilizers, can be substantial contributors to nitrate loads in springs (USGS, 1999; 2010; Cohen, 2008). The risk of nutrient contamination to spring recharge areas is especially high where the aquifer underlying the surface application is unconfined and there is a high degree of hydraulic connectivity between the surface and the aquifer (Cohen, 2008; USGS, 2010). Nitrate concentrations of over 100 mg/L have been observed just downgradient from row crops and dairy farms (Cohen, 2008), and groundwater nitrate concentrations are generally the highest in shallow wells below agricultural sources (USGS, 2010).

Fertilizer application and other agricultural practices can significantly increase nitrate loadings to springs, especially those with relatively large source water aquifers (USGS, 2010). For example, over 2,000 square miles of land provide the source of water to the portion of the Floridan Aquifer that discharges to Wakulla Spring (and its neighboring springs) (Chelette, et al., 2002). In land areas most immediately draining to the spring (over 700 square miles in Wakulla and Leon Counties), at least 40,300 acres (16,300 hectares) of fertilized farmland overlie unconfined and semi-confined portions of the aquifer, contributing 25% of anthropogenic nitrate to Wakulla Spring (Chelette, et al., 2002). Thus, farms many miles away can significantly affect spring water quality.

Because nutrient management is a cost-effective way to reduce groundwater nitrogen and may even result in cost savings to farmers by reducing unnecessary fertilizer application (see Section 2 for examples), EPA assumed that all agricultural operations applying fertilizer to land would implement a nutrient management program to reduce levels of nitrogen in groundwater aquifers. Nutrient management reduces over application of fertilizers by determining realistic yield expectations and the nutrient requirements necessary to obtain those yields, and adjusting application methods and timing to minimize nutrient pollution (USDA, 1998; U.S. EPA, 1993). Fertilization requirements vary by crop across the state (UF/IFAS, 2009).

8.3 Potential Costs

This section describes how EPA estimated potential incremental costs to agricultural operations that may be required as a result of state implementation of EPA's numeric nutrient criteria.

8.3.1 Lakes and Streams

Exhibit 8-3 shows estimates of the potential incremental costs to agriculture that may be needed to reduce nutrients to levels that attain EPA's criteria. EPA derived these estimates by multiplying the number of potentially affected acres in each category of agricultural operation with the unit costs of the owner plus typical programs from SWET (2008a).

Exhibit 8-3: Potential Agricultural Control Costs Associated with Incrementally Impaired Lakes and Streams

Agricultural BMP Category	Area (acres)[1]	Owner plus Typical Program Unit Cost ($/ac/yr)[2]	Total Owner plusTypical Program Costs ($/yr)
Animal Feeding	1,814 - 1,846	$18.56	$33,700 - $34,300
Citrus	15,482 - 27,343	$156.80	$2,427,700 - $4,287,300
Cow Calf Production, Improved Pastures	153,978 - 168,665	$15.84	$2,439,000 - $2,671,700
Cow Calf Production, Unimproved Pastures	49,054 - 51,057	$4.22	$207,200 - $215,700
Cow Calf Production, Rangeland and Wooded	74,449 - 75,790	$4.22	$314,500 - $320,100
Row Crop	7,846 - 9,808	$70.40	$552,400 - $690,500
Cropland and Pastureland (general)[3]	152,976 - 160,814	$27.26	$4,169,500 - $4,383,100
Sod/Turf Grass	2,007	$35.20	$70,600
Ornamental Nursery	840	$70.00	$58,800
Dairies	583 - 621	$334.40	$194,800 - $207,800
Horse Farms	1,632	$15.84	$25,900
Field Crop (Hayland) Production	194,181 - 215,168	$18.56	$3,604,000 - $3,993,500
Other Areas[4]	54,499 - 67,364	$18.56	$1,011,500 - $1,250,300
Total[5]	709,340 - 782,954	--	$15,109,400 - $18,209,500

Exhibit 8-3: Potential Agricultural Control Costs Associated with Incrementally Impaired Lakes and Streams

Agricultural BMP Category	Area (acres)[1]	Owner plus Typical Program Unit Cost ($/ac/yr)[2]	Total Owner plusTypical Program Costs ($/yr)

Note: Detail may not add to total due to independent rounding.
1. Based on GIS analysis of land use data from five water management districts (for entire state) and FDACS BMP program NOI GIS data layer. Low end reflects acres in incrementally impaired HUCs (that are not included in HUCs for baseline impairment) that are not enrolled in BMPs under FDACS; high end reflects all acres in incrementally impaired HUCs, regardless of FDACS BMP enrollment.
2. Cost estimates from SWET (2008a); representative of 2010 prices (personal communication with D. Bottcher, 2010).
3. Owner/typical BMP unit costs based on average costs for improved pastures, unimproved/wooded pasture, row crops, and field crops.
4. Includes FLUCCS Level 3 codes 2160, 2200, 2230, 2400, 2410, 2500, 2540, and 2550.
5. Excludes land not in production.

8.3.2 Springs

Florida's Environmental Quality Incentive Program (EQIP) provides 100% cost share payments for the installation of BMPs (FL EQIP, 2009a). The payment amounts reflect statewide average costs of implementing the practices on a scale and scope typical in Florida (personal communication with J. Bartine, USDA NRCS Florida State Office, July 2009). Payments for nonstructural practices reflect a one year practice lifespan (e.g., one year of rotating crop, maintaining records). For nutrient management, EQIP provides a payment of $10 per acre for general agriculture and $20 per acre for specialty crop (FL EQIP, 2009a).[10] EQIP (2009b) notes that this amount is an incentive payment which includes the cost of soil sampling, testing and monitoring; the rate is established to encourage the participant to adopt the management practice. Note that these costs do not include any cost savings associated with decreased fertilizer use or cost of potential crop loss due to under fertilization, and thus EPA may be overstating costs. Nutrient management plans may need to be developed every three years.

EPA estimated the cost of nutrient management on land categorized as general agriculture and specialty crop. EPA's GIS analysis of land use data for the state of Florida indicate that these two categories of agricultural operations account for approximately 5.9 million acres (4.9 million acres categorized as general agriculture plus 1 million acres categorized as specialty crop). Additional analysis of these 5.9 million acres indicates that 4.2 million acres are in watersheds that are already impaired for nutrients or under a TMDL leaving 1.7 million acres potentially affected by EPA's rule. Furthermore, approximately 0.6 million of these 1.7 million acres are within incrementally impaired watersheds and thus costs for additional BMPs for this land has already been estimated as described in Section 8.3.1. Therefore, EPA estimates that at most 1.1 million additional agricultural acres in Florida may potentially require nutrient management to attain EPA's numeric nutrient criteria for springs.

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[10] FDACS defines specialty crops as fruits, vegetables, tree nuts, dried fruits, horticulture (including floriculture and turfgrass sod).

Exhibit 8-4 shows EPA's estimate of the potential incremental cost of additional nutrient management to protect Florida springs that may result from implementation of EPA's numeric nutrient criteria. EPA estimated these costs by multiplying the number of potentially affected agricultural acres with the unit costs described above. Note that this estimate does not account for the actual locations of incrementally impaired springs, and may exceed actual costs.

Exhibit 8-4: Potential Agricultural Control Costs Associated with Incrementally Impaired Springs

Nutrient Management Program Type	Total Acres in Florida[1]	Acres Needing Nutrient Management[2]	Unit Cost ($/acre)[3]	Total Cost	Annual Cost ($/year)[4]
General Agriculture	4,885,643	1,003,973	$10	$10,039,700	$3,825,700
Specialty Crop[5]	1,057,107	120,558	$20	$2,411,200	$918,800
Total	5,942,750	1,124,531	--	$12,450,900	$4,744,400

1. Excludes unimproved and woodland pastures, abandoned groves, aquaculture, tropical fish farms, open rural lands, and fallow cropland.
2. Calculated by subtracting agricultural land in incrementally impaired watersheds needing controls and agricultural land types participating in FDACS BMP program (assuming all Tri-county agricultural area land is regular nutrient management land) from total land use area in Florida.
3. Source: FL EQIP (2009a).
4. Costs annualized at 7% over 3 years.
5. Specialty crop land use types include row crops, citrus groves, fruit orchards, other groves, nurseries and vineyards, sod farms, and floriculture.

8.4 Summary of Potential Costs to Agricultural Sources

Exhibit 8-5 summarizes the estimated costs to agricultural operations that could potentially be indirectly associated with EPA's numeric nutrient criteria.

Exhibit 8-5: Potential Annual Incremental Control Costs for Agricultural Sources

Waterbody Type	Acres Needing BMPs	Annual Costs[1]
Lakes and Streams	709,340 - 782,954	$15,109,400 - $18,209,500
Springs	1,124,531	$4,744,400
Total	1,833,871 – 1,907,485	$19,853,900 - $22,953,900

1. For lakes and flowing waters, low cost reflects owner/typical BMP program estimated by SWET (2008a) for the Caloosahatchee River and St. Lucie River watersheds for all acres in incrementally impaired watersheds not enrolled in FDACS BMP program; high cost represents a more aggressive level of control on all agricultural acres in the incrementally impaired watersheds based on the alternative program from SWET (2008a). For springs, costs represent implementation of nutrient management on all farms in the state not located in a baseline or incrementally impaired watershed.

Under the FDEP 2009 draft nutrient criteria baseline, annual incremental costs to agricultural sources could be up to $2.1 million, as described in Appendix A.

9. Potential Costs for Septic Systems

Discharges from septic systems in Florida do not require surface water discharge permits. However, state implementation of EPA's numeric nutrient criteria may affect these systems through the identification of additional impaired waters and subsequent TMDLs and BMAPs. This section provides estimates of potential controls and costs that may be needed to attain EPA's criteria. These estimates are only approximations for informational purposes; actual costs will depend on site specific conditions and control strategies.

9.1 Data

EPA obtained the locations of septic systems in Florida from the FDOH GIS data file of OSTDSs inspected by the Department's Bureau of Onsite Sewage (FDOH, 2010a). Although FDOH published these data in April 2010, the FGDL metadata indicate that they represent septic systems as of 2007. These data indicate that there are 935,203 septic systems in Florida, of which 793,697 are active. However, FDOH also reports that 2.67 million permit applications for new septic systems have been cumulatively received (FDOH, 2009). Because the cumulative number of new septic system permits does not reflect septic systems taken out of service, and the FDOH does not provide the locations of these systems, EPA used the data from the 793,697 active septic systems provided by FDOH (2010a) to estimate the septic systems near incrementally impaired waters.

9.2 Method

Nutrient reductions from septic systems could be necessary under EPA's rule. Implementation strategies could include upgrading existing systems to advanced nutrient removal and connecting households and businesses that use septic systems to centralized wastewater treatment. The feasibility of connecting to centralized treatment compared to septic upgrades would depend on existing wastewater treatment capacity and the costs of the connections. For example, Monroe County estimates that it would cost approximately $15,000 per household to connect to a sewer system, including costs for connection and sewer piping, septic tank destruction, and treatment plant construction and upgrades.

Because of the cost, time, and issues associated with new wastewater treatment plant construction, EPA assumed that upgrading septic systems would in most cases be the lower cost and more feasible compliance strategy for nutrients. In areas where existing centralized treatment capacity is available, typical connection costs are also likely to exceed average septic system upgrade costs. For example, the City of Jacksonville (2003) estimates that connection costs average $17,840 per house ($15,000 in 2003 dollars, updated to 2010 dollars using Southern Region CPI), while the Florida Government Utility Authority (2009) estimates a range of $5,130 to $15,140 per house for 188 houses in Lehigh Acres. These costs are significantly higher than upgrading existing septic systems as described in Section 9.3.

9.2.1 Lakes and Streams

Most of the existing nutrient-related TMDLs for lakes and streams identify failing septic systems as contributing to nutrient impairments in surface waters. Those septic systems in close proximity to surface waters are likely to contribute the greatest load to the waterbody. For example, for the Middle St. Johns River Nutrient TMDL, FDEP included wastewater from failed septic tanks within 50 feet as direct discharges of untreated wastewater to the stream network; for those outside of the 50-feet boundary, FDEP combined septic system loads with the nonpoint source loading for residential areas (Gao, 2009).

Properly operated and maintained systems usually provide treatment equivalent to secondary wastewater treatment (Petrus, 2003). However, even properly functioning septic systems could impact water quality, depending on septic system location. Site specific data would be needed to determine which septic systems are contributing to nutrient impairments and the magnitude of that contribution. In the absence of site specific data on the contributions of septic systems to nutrient loadings in the incrementally impaired watersheds, EPA assumed that systems located within 500 feet of waterbodies in the incrementally impaired watersheds may need to reduce nutrient loads. The GIS analysis indicates that there are approximately 8,224 septic systems within 500 feet of water in the incrementally impaired watersheds.

9.2.2 Springs

The contribution of nitrogen from septic systems to springs is highly uncertain and likely site specific. For example, Brown et al. (2008) found that the preponderance of nitrogen pollution in Florida springs appears to be from fertilizer sources; most of the accumulated evidence from mass balance computations and isotopic tracer studies suggests that mineral fertilizers, and therefore, not septic tanks and wastewater sprayfields, are the principal sources of nitrogen pollution in Florida springs. Thus, because EPA has already estimated costs for nutrient management on all crop land not already being controlled for existing or incremental impairments, EPA assumes that no additional controls would be needed for septic systems to attain the nitrate-nitrite criterion for springs.

9.3 Potential Costs

Repair of failed septic systems would be necessary with or without EPA's numeric nutrient criteria (system failure is generally manifest by failure of wastes to be discharged from interior pipes). However, these repairs would not necessarily include upgrades to systems that could reduce nutrient loadings to surface and groundwater. Therefore, EPA estimated the cost to upgrade conventional septic systems to advanced nutrient-reducing systems regardless of existing functionality.

Biomicrobics manufactures the RetroFAST system as a retrofit of existing septic systems to improve nutrient removal (the system is added to existing septic tank and drainfield systems). The system is a fixed-film activated sludge process and ranges from $1,650 plus an additional $400 to $500 for installation (Wastewater Technologies, 2010). Capital cost for the upgrade could range from approximately $2,000 to $2,100. Anderson et al (1998) indicated that the system can achieve average TN concentrations less than 11 mg/L and TP concentrations of 5.4 mg/L. SeptiTech also manufactures an onsite wastewater treatment system utilizing fixed film biological filters. The system costs approximately $3,000 to $4,000 to install (Everhart, 2009) and can consistently achieve effluent TN concentrations less than 10 mg/L in warmer weather (14 mg/L average over 12 month study period in Massachusetts) (U.S. EPA, 2003c).

Aquapoint manufactures the Bioclere onsite wastewater treatment system which uses a fixed film biological trickling filter and clarifier to remove organics and nutrients from domestic wastewater. EPA (2003b) indicated that TN concentrations from a Bioclere system averaged 16 mg/L over a 13-month study period of residential wastewater in Massachusetts. During warmer months effluent concentrations were consistently below 10 mg/L. Installation of the system for a single family home to a new or existing conventional septic system costs approximately $6,500 (this cost does not include the septic tank and drainfield that are already present with existing systems) (McNeer, 2009).

Pursuant to section 369.318, F.S., the Department of Health (DOH) studied onsite disposal system standards needed to achieve nitrogen reductions protective of groundwater quality within the Wekiva Study Area. DOH (2004) reported that a conventional septic tank and drainfield costs from $5,500 to

$7,000 for a three-bedroom home, and a comparable nitrogen-reducing system with a drip irrigation drainfield costs from $7,500 to $9,000 (based on estimates from licensed contractors and engineers that design and install nutrient-reducing systems in the area). However, details on the nitrogen-reducing system components are insufficient to estimate the incremental costs of upgrading to nitrogen removal. For example, it is not clear whether the existing septic tank could be used and the nitrogen-reducing technology could be retrofitted or whether the entire system would need to be replaced.

Based on this information, EPA estimated that capital costs for upgrading existing septic systems to achieve nutrient removal could range from $2,000 (approximate cost of RetroFAST system for 250 gallons/day) to $6,500 (cost of fixed film biological trickling filter). For O&M costs, EPA relied on a study that compared the annual costs associated with various septic system treatment technologies including conventional OSTDS and fixed film activated sludge systems similar to those described above (Chang et al., 2010). Chang et al. (2010) estimated the incremental O&M costs for an advanced system to be $650 per year. Thus, based on annual O&M costs of $650 and annualizing capital costs at 7% over 20 years, annual costs could range from approximately $800 to $1,300 for each upgrade.

9.4 Results

EPA estimated that there are 8,224 active septic systems within 500 feet of water in 10-digit HUCs in watersheds that could be identified as impaired based on FDEP's narrative criterion. The potential annual costs associated with upgrading septic systems for attainment of EPA's criteria may range between approximately $6.6 million to $10.7 million.

Under the FDEP 2009 draft nutrient criteria baseline, annual incremental costs to septic systems could range between $1.3 million and $2.2 million, as described in Appendix A.

10. Governmental Expenditures

State implementation of EPA's numeric nutrient criteria may result in additional costs related to the development of TMDLs for waters added to Florida's 303(d) list of impaired waters. This section describes how EPA estimated potential incremental costs associated with increased government expenditures to develop additional TMDLs.

10.1 New TMDLs

EPA determined that existing nutrient-related TMDLs in Florida address an average of approximately two WBIDs each. Using the average number of WBIDs per TMDL, EPA estimated that 163 additional nutrient TMDLs may be required (e.g., 325 incrementally impaired WBIDs ÷ 2 WBIDs per TMDL).

The process for developing TMDLs in Florida includes (FDEP, 2005):

- gathering and analysis of data
- meeting quality assurance specifications
- computer modeling
- adoption through state's public rulemaking process
- public hearing before adoption
- development of a BMAP with detailed implementation strategies (1-2 year process after adoption with additional public meetings).

FDEP may also hold public meetings after data collection and prior to development of a draft TMDL.

EPA had previously estimated the cost of developing TMDLs based on performing eight basic steps (U.S. EPA, 2001):

- characterizing the watershed
- modeling and analyzing the waterbody and its pollutants to determine the reduction in the pollutant load that would eliminate the impairment
- allocating load reductions to the appropriate sources
- preparing an implementation plan
- developing a TMDL support document for public review
- performing public outreach
- conducting formal public participation and responding to it
- management (including tracking, planning, legal support, etc.).

EPA (2001) indicates that the average cost per cause of impairment is approximately $28,000 nationally, but can typically range from about $6,000 to $154,000. The lower end of the range ($6,000) reflects the typical cost associated with TMDLs that are the easiest to develop and also have the benefit of maximum efficiencies (e.g., a TMDL for another pollutant in the same waterbody). The higher end of the range represents the cost associated with TMDLs that are most difficult to develop, and for which there is no benefit of related work done on other TMDLs for the waterbody or the watershed. Although the establishment of numeric nutrient criteria may reduce these higher end TMDL costs, EPA did not account for these reductions in this analysis.

Because most incrementally impaired waters exceed both TN and TP criteria, EPA assumed that both pollutants would be addressed in the TMDL analyses for each set of impaired WBIDs. Thus EPA estimated the total cost of TMDLs for each set of impaired WBIDs as the cost of a TMDL for one nutrient plus the cost of a second TMDL for the second nutrient. Using this method, EPA estimated TMDL costs for each set of impaired WBIDs as approximately $34,000 (the average TMDL cost of $28,000 for the first nutrient, plus the low end TMDL cost of $6,000 for the second nutrient). Escalating this cost to June 2010 dollars[11], average per TMDL costs could be approximately $47,000. Multiplying the average cost per TMDL ($47,000) by an 163 additional TMDLs results in an estimated total cost of approximately $7.7 million.

Currently, FDEP operates its TMDL schedule based on a five-phase cycle that rotates through the five basins over five years (FDEP, 2003). Under this schedule, completion of TMDLs for high priority waters will take 9 years; it will take an additional 5 years to complete the process for medium priority waters. Thus, assuming all the incremental impairments are high priority and FDEP develops the new TMDLs over a 9-year period schedule, annual costs would be approximately $851,000.

Under the FDEP 2009 draft nutrient criteria baseline, annual incremental costs to develop additional TMDLs could be approximately $0.3 million, as described in Appendix A.

10.2 Site Specific Alternative Criteria

As part of FDEP's 2009 proposed nutrient criteria revisions, FDEP proposed to adopt many nitrogen and phosphorus TMDLs as SSAC. Under EPA's rule, the state could adopt TMDL targets as SSAC as part of its triennial review process for minimal costs. Furthermore, costs to develop SSAC under EPA's rule are likely to be similar to what SSAC development costs have been under Florida's current narrative nutrient criteria. Thus, EPA assumed that incremental costs associated with SSAC, if any, would be minimal.

10.3 Ambient Monitoring

Existing TMDLs and the "Comment" field in the current 303(d) list indicate that state and local agencies are regularly monitoring TN and TP in ambient waters. Florida monitors TN and TP levels even though the existing criterion is narrative because Florida's nutrient impairment listing method uses a TSI that is calculated based on TN, TP, and chlorophyll-a concentrations. These nutrient criteria data are the basis of the extensive IWR database FDEP maintains and which provided baseline water quality data for the analyses in this report. Because Florida is currently monitoring TN, TP, and chlorophyll-a concentrations in many waters, EPA's rule is unlikely to have a significant cost impact on monitoring activities throughout the state.

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[11] Escalated using the Bureau of Labor Statistics Employment Cost Index for state and local government workers (2001 Index = 83.6; 2010 Index = 115.4).

11. Summary of Potential Costs

The potential costs that may be associated with state implementation of EPA's numeric nutrient criteria for freshwater lakes and flowing waters in Florida may include incremental compliance and government resource costs. This section provides a summary of EPA's estimates of these potential costs. Note that these estimates may be overstated because some waters identified as incrementally impaired under EPA's numeric criteria may be currently impaired but unidentified as such under existing narrative criteria.

11.1 Potential Costs Associated with Incremental Impairments

Exhibit 11-1 summarizes EPA's estimates of potential annual incremental costs for both point and nonpoint sources. For point sources, costs reflect upgrading existing treatment to meet WQBELs based on EPA's numeric nutrient criteria. Urban stormwater costs reflect a scenario of implementing stormwater controls on all land developed prior to 1982. Agriculture costs reflect implementing owner/typical BMP programs developed by SWET (2008a) on all applicable lands in watersheds containing incrementally impaired lakes and streams, and costs of applying nutrient management on crop land throughout the state (where such activities are not already needed or occurring) to address nitrate-nitrite concentrations in springs. Costs for septic systems represents costs of upgrading septic systems within 500 feet of water in incrementally impaired watersheds and septic systems located in the most vulnerable incrementally impaired spring recharge areas. Government expenditures reflect developing additional TMDLs.

Exhibit 11-1: Summary of Potential Annual Costs Associated with Numeric Nutrient Criteria (2010 dollars)

Source Sector	Type of Expenditure	Annual Cost (millions)
Municipal Wastewater[1]	BNR to reduce TN and/or TP	\$22.3 - \$38.1
Industrial Dischargers[2]	BNR to reduce TN and TP; chemical precipitation to reduce TP	\$25.4
Urban Stormwater[4]	Stormwater controls	\$60.5 - \$108.0
Agriculture[5]	Owner/typical BMP program	\$19.9 - \$23.0
Septic Systems[6]	Upgrade to advanced nutrient treatment	\$6.6 - \$10.7
Government/Program Implementation	TMDL development[7]	\$0.9
Total	--	\$135.5 - \$206.1

Note: Detail may not add to total due to independent rounding.
BNR = biological nutrient removal; TMDL = total maximum daily load; TN = total nitrogen; TP = total phosphorus

1. Based on upgrading existing treatment processes to advanced BNR.
2. Based on extrapolation of average annual costs per flow for random sample of dischargers stratified by industrial category.
4. Based on median stormwater control costs from FDEP (2010a), and scenario of need for structural controls on land developed before 1982.
5. Based on implementing nutrient management on all crop land outside of incrementally and baseline impaired watersheds and scenarios in which all agricultural land not enrolled in the FDACS BMP program in incrementally impaired watersheds incurs owner/typical program costs from SWET (2008a) or all agricultural land in incrementally impaired watersheds incurs owner/typical costs based on SWET (2008a).
6. Based on upgrading to advanced nutrient removal active septic systems within 500 feet of water (based on GIS land use data) in incrementally impaired watersheds.
7. Based on average costs to complete TMDLs for incrementally impaired waters under a 9-year schedule.

Under the FDEP 2009 draft nutrient criteria baseline, total annual incremental costs could range from $17.5 million to $27.2 million, as described in Appendix A.

11.2 Uncertainties of Analysis

The estimates of potential incremental costs associated with state implementation of EPA's numeric nutrient criteria for lakes and flowing waters in Florida are based on several assumptions that may over- (+) or underestimate (-) actual costs. **Exhibit 11-2** provides a summary of the key uncertainties.

Exhibit 11-2: Uncertainties of the Analysis

Uncertainty/Assumption	Potential Impact on Cost Estimates	Comment
Waters under nutrient-related TMDLs and on the 303(d) list of impaired waters due to nutrient-related causes represent all waters currently impaired for nutrients.	+	Some currently impaired waters that are as yet unidentified could eventually be identified as impaired under Florida's narrative criteria absent EPA's rule. Costs associated with these impairments are attributed to EPA's rule in the current analysis.
Inadequate information on treatment train for all WWTPs.	+	Assumed need upgrade if information was inadequate. These WWTPs may in fact already have treatment capable of achieving TN and/or TP levels equal to advanced BNR.
Costs for urban runoff are based on installing structural controls on all pre-1982 land potentially needing reductions.	+	Many baseline requirements under other regulations have not been fully implemented (e.g., MS4 SWMPs). Thus, additional reductions from pre-1982 land may not be necessary.
Costs of nutrient management not reflective of potential cost savings.	+	Nutrient management may result in net cost savings.
Costs for municipal WWTPs based on upgrade to advanced BNR.	–	More costly controls could be required.
Costs estimated only to dischargers in Florida.	–	Dischargers in upstream states could potentially receive revised effluent limits on the basis of EPA's numeric nutrient criteria for Florida.
Identification of incrementally impaired WBIDs are based on FDEP's 2009 proposed data requirements for calculating annual geometric means (i.e., at least 4 observations per year, one from each season).	?	The listing method ultimately adopted is uncertain. If less stringent data requirements are used to determine impairments, the number of impairments could change.
Agricultural costs include scenario of farms implementing owner and typical BMP programs on all acres in incrementally impaired watersheds.	?	In some watersheds, point source controls may be sufficient to achieve the necessary reductions. In other watersheds, a more aggressive level of controls for agriculture may be needed.

Exhibit 11-2: Uncertainties of the Analysis

Uncertainty/Assumption	Potential Impact on Cost Estimates	Comment
Costs to industrial dischargers are based on random sample of dischargers stratified by industrial sector.	?	Discharger sample may not be representative of all dischargers in each sector. Actual costs may be higher or lower than average sample costs.
Costs for urban runoff are based on average load reductions needed from urban sources in existing TMDLs (50%).	?	Actual reductions and acres needing controls in incrementally impaired waters could be lower or higher (based on existing TMDLs, the contribution of urban sources to total nutrient loadings varies from 5% to 85%).
Costs for municipal WWTPs are based on design flow despite only portion of effluent discharging to surface waters.	?	Dischargers may only need to size treatment to discharge flow if a portion of the effluent is used for reuse applications.
TMDL costs do not reflect reduced efforts provided by the establishment of numeric criteria.	+	Numeric criteria may reduce costs associated with modeling and analysis to determine the reduction in the pollutant loads required.

BMPs = best management practices
BNR = biological nutrient removal
FDEP = Florida Department of Environmental Protection
MS4 = municipal separate storm sewer system
TN = total nitrogen
TP = total phosphorus
WBID = waterbody identification
WWTP = wastewater treatment plant
Key:
“+” = impacts likely overstated
“–“ = impacts like understated
“?” = direction of impact is uncertain

12. Description of Benefits of Reducing Nutrient Loads to Lakes and Flowing Waters in Florida

Elevated concentrations of nutrients in lakes and flowing waters in Florida may result in adverse ecological effects, and, as a result, decrease provision of environmental goods and services and impair designated uses. Conversely, reduction in nutrient concentrations to meet numeric standards will improve ecological function and enhance provision of environmental goods and services and help to attain or maintain designated uses. The following sections discuss the general effects of nutrients on lakes and flowing waters and qualitatively assess the potential for benefits from nutrient reductions and future limitation that may result from implementation of the rule.

12.1 Effect of Nutrients on Lakes and Flowing Waters

The influence of growth-limiting chemical or nutrients, particularly nitrogen and phosphorus, on water quality, biota, and habitats of freshwater aquatic ecosystems is profound. When supplied in excess amounts by man's activities, elevated nutrient concentrations can lead to a series of predictable changes in the chemical and physical environment with resultant shifts in water quality and aquatic communities, a process which is commonly referred to as anthropogenic eutrophication (Smith 1999, Wetzel, 2001). The following sections provide general information on the ecological impacts of nutrients and the eutrophication process on lakes and flowing waters.

12.1.1 Ecological Effects

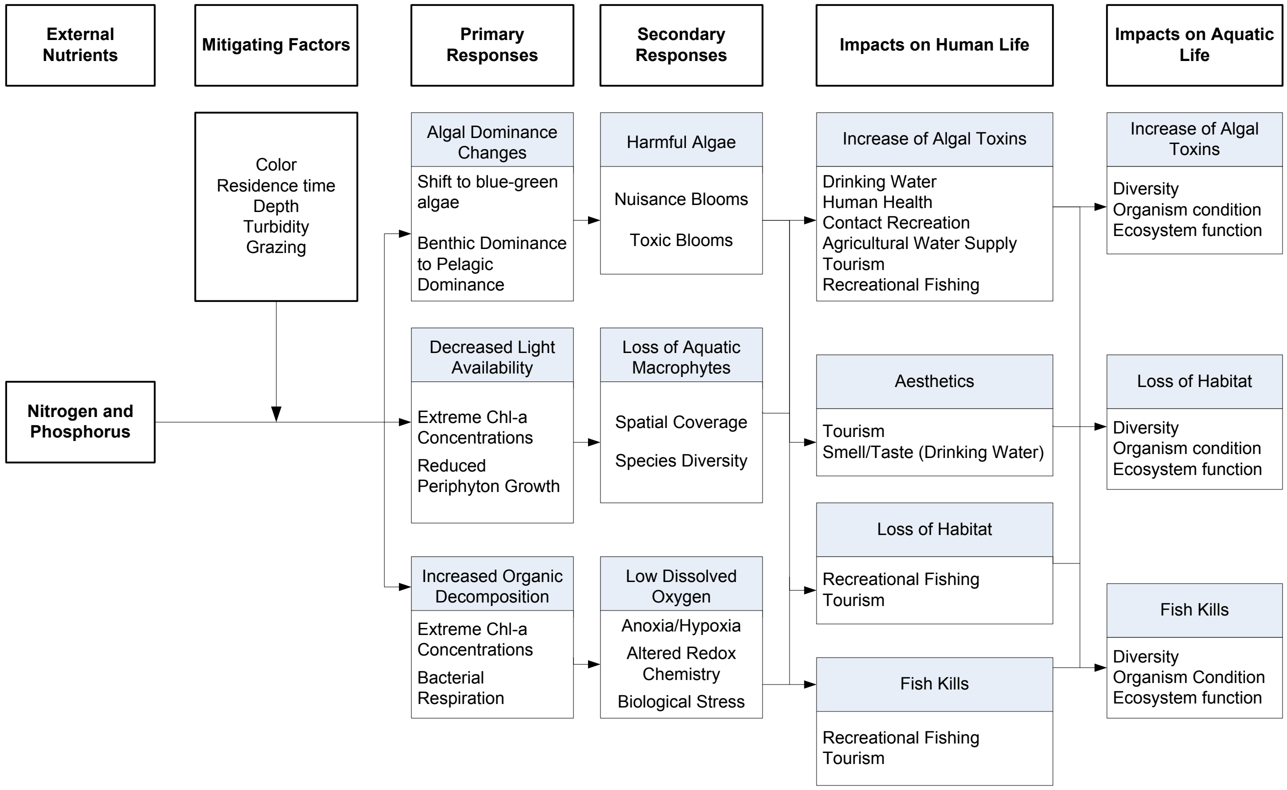
Eutrophication is defined as an increase in organic carbon to an aquatic ecosystem caused by primary production stimulated by excess nutrients, typically compounds containing nitrogen or phosphorus (U.S. EPA, 2010c). Eutrophication is a major concern for many lakes and flowing waters within the United States and is particularly severe for many Florida inland waters. Florida's 2008 Integrated Report reported approximately 1,000 miles of flowing water and 350,000 acres of lakes impaired for nutrients, with nutrients ranked as the fourth most common source of impairment (FDEP, 2008).

For most freshwater environments, the growth-limiting nutrient (i.e., the chemical which largely controls the rate of primary production) is phosphorus such that it is the reduction in the supply of phosphorus that is the primary focus of most freshwater nutrient TMDLs. Nitrogen can be growth-limiting under certain circumstances and may play an important seasonal role in freshwater production and shifts in algal taxa dominance (e.g., in late summer), but nitrogen is generally more important in estuaries or marine coastal waters.

Eutrophication can lead to a predictable sequence of ecological effects and ultimately to environmental degradation, including increases in the occurrence and intensity of water column phytoplankton, including harmful algal blooms (e.g., nuisance and/or toxic species), loss of critical submerged rooted aquatic plants (or macrophytes), and reduced and/or diurnally variable DO. In turn, ecological degradation can lead to significant losses in environmental goods and services provided by the affected waterbodies (e.g., reduced recreational fishing and swimming opportunities and reduced quality of drinking water sources). **Exhibit 12-1** provides a conceptual model of the potential ecosystem response to nutrients and how the resulting ecological effects translate into impacts to benefits and services.

As illustrated in Exhibit 12-1, external nutrient loads are the driving factor in the ecological impacts, but their relative impact can be significantly affected by mitigating factors of light (color, turbidity), river and lake hydrodynamics (hydraulic residence time, depth), and biotic interactions (e.g., zooplankton grazing). It is typically the interplay between nutrients and the mitigating factors that produces a site specific response for a particular lake or river, such that equal amounts of phosphorus may have quite variable growth responses in different environmental settings.

Exhibit 12-1: Eutrophication Impacts and Responses for Lakes and Flowing Waters



Source: Adapted from Dodds et al. (2009).

Exhibit 12-1 shows the primary responses of eutrophication, categorized as algal dominance changes, decreased light availability, and increased organic decomposition. As nutrients increase, the primary responses can lead to more severe and problematic secondary responses, which are typically the more readily observable manifestations of ecosystem degradation. These secondary responses include harmful algal blooms, loss of submerged aquatic macrophytes, and low DO. In flowing wadeable or shallow waters, nutrient enrichment can lead to increases of attached benthic algae (i.e., periphyton); whereas deeper or slow-flowing waters will develop phytoplankton blooms more similar to lakes. The sections below provide additional discussion of these primary and secondary responses to eutrophication; Appendix C contains specific details on the quantitative relationship between nutrients and some of the primary and secondary responses.

12.1.2 Primary and Secondary Eutrophication Responses

Increases in the supply of phosphorus and nitrogen can lead to increased amounts of primary production in the form of phytoplankton in the water column. The strong positive relationship between phosphorus supply and increased algal growth (often measured as concentrations of the primary photopigment chlorophyll-*a*) has been well-developed and modeled for lakes (e.g., Vollenweider, 1968; Dillon and

Riegler, 1974; Schindler, 1974; Smith et al., 1999), including Florida lakes (Brown et al., 2000). As nutrient loading increases, lake trophic state can change from a poorly-fertilized, low productivity waterbody (termed oligotrophic) to a moderately-fertilized, moderately productive (mesotrophic) to a well-fertilized, highly productive (eutrophic) system, or even an extremely productive, highly degraded (hyper-eutrophic) system (Wetzel 2001).

Eutrophic lake systems typically maintain high concentrations of phytoplankton (i.e., algal blooms) during the growing season, which for Florida is essentially year-round. Increasing eutrophication often shifts the water column phytoplankton community to one dominated by bloom-forming blue-green algae species (e.g., *Anabaena, Anacystis, Aphanizomenon, Microcystis*) which often have physiological advantages over other phytoplankton taxa under conditions of low light, high grazing, warm temperatures, and low nitrogen to phosphorus supply ratios (Smith, 1999). High concentrations of blue-green algae (cyanobacteria) constitute harmful algal blooms (HABs) due to their potential to form nuisance surface scums, sharply reduce light penetration into the water, provide poor grazing material for zooplankton and young-of-year fish, and produce irritating or toxic compounds (e.g., cyanotoxins). High concentrations of cyanotoxins have been found to cause acute and chronic health problems in humans and fatal poisoning in other animals, fish, and birds (Williams et al., 2001). Florida lake systems which contain persistent cyanobacterial blooms include Lake Okeechobee, the Harris chain of lakes (Apopka, Griffin, Eustis, and Harris) and the St. Johns, St. Lucie, and Caloosahatchee rivers (FWRI, 2009).

The relationship between nutrients, algal dominance and flowing waters is more complicated since, in some systems, other limiting factors such as light availability, substrate type, and hydrologic regime are more critical for growth. However, Smith et al. (1999) considered nutrient limitation in flowing waters to be common and widespread. Nutrient enrichment of flowing waters can lead to increases in the biomass of suspended and attached algae or periphyton (Dodds et al. 1998). McCormick et al. (1996) looked at the relationship between periphyton growth and water quality along a nutrient gradient in waterways in the northern Florida everglades. These investigators noted reductions in algal growth potential and bioaccumulation best statistically explained by decreasing levels of total phosphorus.

In shallow or wadeable waters, nutrients can lead to accumulation of thick, filamentous green algae (e.g., *Cladophora*), which can adversely affect stream metabolism and biotic communities or decrease the aesthetic appeal of the waters (Smith, 2003). In deeper and slower flowing river systems, nutrient-fueled phytoplankton accumulation in the upper waters may be more similar to lake settings and can reduce the growth of attached periphyton due to light limitation. This light limitation shifts the location of major primary production from the bottom (benthic) to the water column (pelagic) environment.

The reduction of light levels (i.e., decreased depth to which light penetrates or eutrophic zone) due to water column algal blooms and turbidity also can adversely affect submerged aquatic macrophytes in a lake, including their spatial coverage, species composition, and amount of primary production. The depth of maximum depth of macrophyte colonization is dependent on the water clarity, as indicated by Secchi disk transparency (SDT) depth, in Florida lakes and elsewhere (Canfield et al. 1985). Eutrophication can cause a shift in shallow lakes from a clear water, aquatic vegetation-dominated lake (i.e., most of primary production coming from rooted aquatic plants) to a highly turbid, phytoplankton-dominated lake with little or no submerged aquatic vegetation (Scheffer, 2001). In addition to the loss in primary production and reduced food for herbivorous wildlife (e.g., muskrats, manatees), the loss of the aquatic vegetation has the additional ecosystem effect of reducing refuge habitat for zooplankton against fish predators. This condition may exacerbate the turbidity of the water, as the reduced herbivorous zooplankton population no longer controls phytoplankton biomass by grazing.

Eutrophication can lead to increased levels of organic carbon accumulations in the water column (Smith, 2003). When the algal blooms die, sink, and decay, the decomposition of the excess organic carbon leads to increased bacterial respiration, particularly in the lower depths of lakes or in the sediments. This increased oxygen demand can greatly reduce DO resulting in conditions of hypoxia (reduced DO) below water quality standards or even anoxia (lack of DO) in the deep or overlying waters. Shallow eutrophic waters may also be subject to large diurnal swings in DO as highly productive waters produce excess oxygen via photosynthesis during daylight hours which is driven to low levels at night by elevated respiratory demand. These diurnally variable conditions can lead to biological stress with alteration or complete elimination of aquatic biota (e.g., fish kills).

In addition to the biological stress it produces, reduced or absent DO can also lead to altered reduction-oxidation (redox) chemistry. Low redox conditions can result in increased ammonia concentrations in the water column and internal recycling of phosphorus from the sediment. The former can be toxic to aquatic life under certain temperature and pH conditions and the latter can be problematic to lake restoration since reduction in nutrient concentrations in the incoming water (due to the numeric criteria) may not be sufficient to overcome internal recycling of accumulated phosphorus in the sediment for many years, unless the latter input is treated.

12.1.3 Mitigating Factors

As indicated in Exhibit 12-1, there are several mitigating factors that will potentially influence the degree or magnitude of response of a waterbody to eutrophication. The amount of color in the water (i.e., the tint due to dissolved substances, independent of suspended material) influences the potential nutrient-based productivity. Highly colored waters will not be as susceptible to nutrient addition as the depth of light penetration will be attenuated and primary productivity lessened. This is one of the bases for distinguishing between color and clear waterbodies with regard to nutrient criteria (U.S. EPA, 2010c). Turbidity due to suspended inorganic particles (silts and clays) will also tend to reduce productivity due to both light limitation and the adsorption of phosphorus to the clay particles.

Hydraulic residence time (sometimes expressed as its reciprocal, the flushing rate) can mitigate the effect of nutrients, particularly in flowing waters. If the residence time is sufficiently short, algal blooms will not develop as the growing cells are quickly washed downstream and do not accumulate in the water column. At the same time, where such nutrient-laden flowing waters are detained by impoundments, residence time increases, and significant algal blooms may develop.

Depth is an important factor in determining the level of production since deeper lakes tend to be less productive than shallow lakes. This is due to the euphotic zone (i.e., depth to which light penetrates) occupying a greater proportion of the volume of a shallow lake, as well as the greater probability for thermal stratification to occur in deeper lakes. Algae sinking in a thermally stratified lake are much less likely to be re-suspended than in a shallow one.

Grazing refers to the ingestion of the phytoplankton by herbivorous zooplankton. Zooplankton can be an important controlling mechanism for preventing algal blooms to develop. In flowing waters and river, grazing is conducted by benthic macroinvertebrates feeding off the accumulated periphyton. In either setting, the fish community can greatly influence the biomass and effectiveness of the grazers in controlling the primary producers. This influence is the basis for lake restoration through the technique of biological manipulation.

12.2 Impacts of Nutrients on Environmental Goods and Services

Eutrophication of lakes and flowing water may have a significant impact on the value of environmental goods and services provided by the affected waterbodies. Dodds et al. (2009) estimated that the potential annual value of losses to recreational water usage, waterfront real estate, spending on recovery of threatened and endangered species, and drinking water treatment due to eutrophication of freshwaters in the United States is about $2.2 billion per year.

In Florida's environment and economy, the goods and services provided by springs are particularly valuable. The state has more first-magnitude springs than any other state or country, and these are used for a variety of recreational activities including swimming, tubing, kayaking, scuba diving, camping, canoeing, and snorkeling (Bonn and Bell, 2003). They also serve as critical habitat for manatees, and as such are popular manatee-watching destinations. These characteristics make spring water quality maintenance particularly important to Florida's economy. For example, Bonn and Bell (2003) conducted an economic valuation study of four of Florida's largest springs (Wakulla, Ichetuknee, Homosassa, and Volusia Blue Springs). They found that spending by visitors at each of these springs ranged from $10 million to over $23 million in 2002 (see Section 12.3.2 for a more detailed discussion of tourism sector impacts).

12.2.1 Impacts of HABs

Exhibit 12-1 shows the link between eutrophication in lakes and flowing waters and the provision of environmental goods and services. For example, the occurrence of nuisance or toxic HABs adversely affects a number of designated water uses including: drinking water supply, contact recreational activities, fishing, and agricultural water supply, and may also pose human health risks. Reductions in recreational opportunities (e.g., decrease in catch rates), decline in aesthetic value, adverse public perceptions of the safety of polluted water, and potential exposure to health risks may also adversely affect tourism, both locally and at the state level.

The major HAB group of concern for lakes and flowing waters are the blue-green algae (Cyanophyta) which pose a toxic risk to mammalians including wildlife, livestock, pets, and humans due to the presence of cyanotoxins and other toxic compounds released when the algae decay. Blue-green algae toxins are classified according to mode of action and include hepatotoxins (e.g., microcystins), neurotoxins (e.g., anatoxins), skin irritants, and others (WHO, 2003). Microcystins, in particular, have been associated with acute liver damage and possibly liver cancer in laboratory animals. Severe morbidity and mortality in domestic animals due to toxin-contaminated drinking water has been documented (WHO, 2003). Researchers are identifying increasing numbers of cyanotoxins (over 70 and growing), and the potential implications to human health are not fully understood at this time (WHO, 2003).

Contact recreation includes swimming and other activities (e.g., jet-skiing, kayaking) where direct exposure of skin to water is likely. Swimmers' direct contact with water makes them susceptible to irritants or toxins associated with certain types of HABs that may occur with nutrient pollution (Fleming and Stephan 2001). A massive blue-green bloom in the St. Lucie River (probably associated with discharge of nutrient-rich water from Lake Okeechobee) led to the posting of health warning signs by the Martin County Health Department cautioning the public to avoid contact with the affected water (Earthjustice, 2006; U.S. EPA, 2010d).

Williams et al. (2001) surveyed the levels of toxins occurring in a large number of Florida's lakes. The study sampled 167 sites throughout the state, and found that the phytoplankton community in 88 of the samples, taken from 75 different bodies of water, were dominated by toxigenic (toxin-producing) cyanobacteria. Decreased levels of nutrients associated with the numeric nutrient criteria would reduce the number of HABs and thus reduce toxin levels and health risk to swimmers.

Elevated nutrient levels can also significantly affect the potability of water for livestock, particularly if they facilitate the growth of high concentrations of blue-green algae. Numerous occasions of livestock poisoning have been noted from Australia (Stewart et al, 2008) but the earliest record of algal toxins in Florida were reported in association with the death of cattle near Lake Okeechobee in the 1980s (Carmichael, 1992). Dead cattle, toxic responses in laboratory mice, and contact irritation were found in association with *Anabaena* and *Microcystis* blooms. The Florida Cooperative Extension notes that cattle will avoid drinking from ponds overgrown with algae in favor of other water sources. If no other sources exist, cattle will decrease their water intake, resulting in poorer growth and lactation (IFAS Extension, undated).

12.2.2 Impacts of Aquatic Vegetation Loss

The loss of aquatic vegetation macrophytes may reduce habitat for zooplankton and young-of-year fish, and may shift the fish community towards open-water pelagic species rather than benthic fish species typically associated with bottom or weed beds. Investigation of fish and trophic states in Florida lakes suggested that fish biomass of recreationally important species may be less affected by increases in nutrients than in northern temperate lakes, but that community shifts do occur (Bachmann et al., 1996).

12.2.3 Impacts of Degraded Water Quality

Low ambient DO concentrations or anoxia adversely affects fish growth and reproductive success and can result in shifts in a fish community to low DO tolerant species, reduced growth rates, and more frequent fishkills. In stratified lakes with an anoxic bottom layer (i.e., hypolimnion), the available volume of open water habitat for fish and zooplankton is reduced. Excess, decaying organic material and low DO often lead to unsightly or aesthetically-unpleasing shorelines (sight and/or odor) that discourage beach recreational activities and tourism. Unsightly or aesthetically-unpleasing shorelines may also affect property values of lakefront housing.

As noted in Exhibit 12-1, the combination of the presence of HABs, loss of aquatic macrophytes, and low DO conditions will impact ecological services such as biodiversity (i.e., the number of species and habitats present), organism health (i.e., population viability and reproduction), and ecosystem function (e.g., carbon sequestration, nutrient cycling, waste assimilation). The effects of eutrophication in altering these types of ecological functions are well-documented (e.g., Smith 2003; Dodds et al. 2009).

12.3 Types of Benefits Associated with Nutrient Reductions

Implementing nutrient criteria and reducing nutrient concentrations in lakes and flowing waters should reduce or prevent the adverse effects of eutrophication and, as a result, enhance the environmental goods and services that these waters provide. For impaired lakes and flowing waters, the restoration goal is to move these waters from a nutrient-rich, eutrophic state to a mesotrophic or oligotrophic state closer to the natural condition of the waterbody. For unimpaired waters, the criteria establish benchmarks for limiting loads and preventing a loss of designated uses in the future, thus maintaining beneficial uses.

Exhibit 12-2 shows the types of benefits often associated with environmental policies, including improvements in water quality, and the types of methods that can be used to assign value to such benefits. Categories that may be applicable to nutrient reductions in Florida include human health, ecological, and other benefits. The sections below discuss the potential for benefits in these categories.

Exhibit 12-2: Types of Benefits Associated with Environmental Policies

Category	Examples	Valuation Methods
Human Health Improvements		
Mortality risk reductions	Reduced risk of fatality from cancer and acute risks	Averting behavior, hedonics, stated preference
Morbidity risk reductions	Reduced risk of nonfatal illness	Averting behavior, hedonics, stated preference
Ecological Improvements		
Market products	Harvests or extraction of food, fuel, fiber, timber, fur, and leather	Production function
Recreation activities and aesthetics	Wildlife viewing, fishing, boating, swimming, hiking, scenic views	Production function, averting behaviors, hedonics, recreation demand, stated preference
Valued ecosystem functions	Climate moderation, flood moderation, groundwater recharge, sediment trapping, soil retention, nutrient cycling, pollination by wild species, biodiversity, water filtration, soil fertilization, pest control	Production function, averting behaviors, stated preference
Nonuse values	Relevant species populations, communities, or ecosystems	Stated preference
Other Benefits		
Aesthetic improvements	Visibility, taste, odor	Averting behaviors, hedonics, stated preference
Reduced materials damage	Reduced soiling and corrosion	Averting behaviors, production function, cost function

Source: U.S. EPA (2000)

Note that there may be a lag (5 to 15 years) between nutrient reductions and associated benefits in lakes and flowing waters. Jeppesen et al. (2005) evaluated the long-term effects of reduced nutrient loading in 35 lake restoration case studies from around the world, separating the effects for shallow (less than 5m) and deep (greater than 5m) lakes. Florida lakes are largely shallow and polymictic (i.e., non-seasonally stratified). For shallow lakes, Jeppesen et al. (2005) predicted that 10 to 15 years are typically needed to have TP concentrations move to a new steady state reflective of the reduced nutrient loads while TN response time is faster (typically less than 5 years).

12.3.1 Human Health Improvements

High concentrations of HABs can pose potential health risk associated with irritants, gastrointestinal diseases, and other concerns. Several Florida freshwater areas appear to have chronic cyanobacteria blooms, including Lake Okeechobee, the Harris Chain of Lakes (Apopka, Griffin, Eustis and Harris) and the St. John and St. Lucie Rivers (Burns, 2008). In May 2010 a health warning was issued to all recreational users of the St John River, because of large scale fishkills resulting from toxic cyanobacteria in the river. Exposure to the water or dead fish may result in burning eyes, respiratory irritation, or skin rash (FDOH, 2010b). To the extent that the criteria and associated nutrient reductions reduce current exposures and illness and prevent future exposures and illness, society values these types of reduced health risks. The cost of illness (COI), including treatment costs and lost wages, can provide a lower bound on societal value as a measure of avoided costs (rather than the preferred willingness-to-pay measure of benefits that includes the value of avoided pain and suffering as well as out-of-pocket costs). COI values represent a lower bound value because these costs do not include the value of avoiding pain and suffering.

12.3.2 Ecological Improvements

Ecological benefits that may arise from nutrient reductions include market benefits, including those associated with withdrawal uses, such as drinking water supplies and agricultural use, and benefits to other markets such as ecotourism; recreational uses, such as boating, fishing, and swimming; ecosystem functions, such as nutrient cycling and biodiversity; and benefits that are not associated with use of the resources (nonuse benefits), such as preservation of species for future generations (existence and bequest values).

Market Products

Impacts on Drinking Water Supplies

Reduced nutrient loading to the lakes and moving waters of Florida should improve potable water supply by reducing adverse impacts associated with toxins from blue-green algal (Cyanophyta) species (e.g., *Microcystis*, *Cylindrospermum*) and the costs of drinking water treatment processes needed to eliminate these toxins. The drinking water treatment technology or processes employed to remove cyanotoxins depend on the total concentration of the algal toxins, the form of the toxin, and whether it is intracellular or extracellular (Westbrick, 2008). Conventional water treatment (coagulation/sedimentation/filtration) is generally sufficient to deal with removal of intact algal cells and intracellular toxins. However, removal of extracellular toxins due to lysed cells often requires more extensive or advanced treatment processes such as application of powered activated carbon (PAC) or granulated activated carbon (GAC), ultraviolet light (UV) treatment, and membrane filtration (Westbrick, 2008).

The temporary or permanent installation of these additional treatments will increase the capital and operating costs for the water treatment plant (Steffensen, 2008). For example, Burns (2008) reports that PAC during a cyanobacterial bloom costs an average of $10,000 per day, and such blooms typically last several weeks. In June 2008, a water treatment plant serving 30,000 people was shut down after a toxic blue-green algae bloom on the Caloosahatchee River in Florida threatened the plant’s water supply (Earthjustice 2006, U.S. EPA, 2010d).

Other algal blooms may not be directly harmful to humans but may still affect drinking water treatment costs. For example, the increased levels of organic material arising from algal blooms of any taxa can also increase treatment costs and the resulting concentrations of chlorination disinfection by-products (DBPs), including haloacetic acids and trihalomethanes, in treated drinking water (U.S. EPA, undated).

DBPs are particularly challenging for water treatment operators since they occur at the end of the water treatment process and there are often few practicable alternatives to chlorine disinfection for many plants. The primary strategies for reducing DBPs are reducing precursor organic material (particularly humic and fulvic acids) in the raw water source through watershed protection, reducing nutrients, or in-reservoir use of algaecides (Kitchell, 2001). The numeric nutrient criteria will help reduce the amount of phytoplankton organic carbon, reduce generation of DBPs, and decrease treatment costs.

Increased levels of organic material associated with algal blooms can also clog drinking water intakes and cause unpleasant tastes and odors in drinking water (Boyd, 1990). Geosmin and 2-methylisborneol (MIB) are organic compounds released by cyanobacteria that impart taste and odor to waters at low concentrations, and which are not addressed by conventional drinking water treatment. Chronic taste and odor problems can require advanced water treatment such as ozonation, which can be costly.

The benefits of reducing algal blooms (both HABs and non-HABs) are the reduction in health risk, reduced water treatment costs (both algaecides in the raw water supply and post-intake treatments), and the avoided need to develop alternative raw water sources. If adequate water treatment is not available, a temporary water source will need to be substituted (if available). If an alternative water supply is not at hand, urban areas may need to be supplied with bottled or tankered water, as has been the case in Australia and elsewhere (Steffensen, 2008). Long-term solutions might require the development of new raw water supplies, which would involve investments for acquisition of land (if available), regulatory review and permitting, development of infrastructure (dams, pumps, pipes), and watershed protection.

Impacts on Agricultural Water Use

Florida's freshwaters provide irrigation water for crops and livestock watering supplies. While elevated nutrient concentrations in irrigation water would not adversely affect its usefulness for plants (in fact, a slight benefit might occur), concerns exist for potential residual effects due to contaminants entering the food chain. More importantly, eutrophication sponsors cyanobacterial blooms that can kill livestock and wildlife that drink the contaminated surface water.

The reduction of nutrients due to adoption of the numeric criteria would provide benefits in increased cattle production or avoided cost due to cattle sickness or death. However, it would be difficult to attribute benefits to the adoption of nutrient criteria since the ultimate source of the water and the nutrients in the livestock water supply may be difficult to trace due to the presence of fertilizers or cattle manure in fields adjacent to the water source or from the groundwater (i.e., related BMPs for manure control or fertilization may provide the bulk of benefits).

Impacts on Tourism Sector

High concentrations of HABs can lead to public health department posting of water quality advisories due to potential health risk associated with irritants, gastrointestinal diseases, and other concerns. Reductions in inland beach closures due to reducing the magnitude and duration of HABs linked to excess nutrients will prevent losses to local economies. Several Florida freshwater areas appear to have chronic cyanobacteria blooms, including Lake Okeechobee, the Harris Chain of Lakes (Apopka, Griffin, Eustis and Harris) and the St. John and St. Lucie Rivers (Burns, 2008). Although analysis of the cost of an inland beach closure in a Florida lake is not available, the impact of HABs in other parts of the country has been significant.[12] Since lake and beach closures are highly localized and substitute swimming beach locations may be available, additional information would be necessary to estimate the economic benefits (of avoided lost recreational revenue, monitoring and response activities, health care, etc.) of preventing HAB outbreaks in freshwater waters.

Freshwater fishing is a major attraction for both native Floridians and tourists and is a substantial boon to the Florida economy. Over three million Floridians and over 900,000 out of state tourists partook in freshwater nonboat (i.e., shoreline) fishing in 2007 (FDEP, 2008). Another nearly 2.8 million Floridians and nearly one million tourists utilized freshwater boat ramps in 2007, and some of these users are also

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[12] For example, Seewer (2010) reports that outbreaks of blue-green algae blooms in Grand Lake St. Marys, the largest inland lake in Ohio, is adversely affecting the local economy as tourism in the area declines, falling from 737,000 visitors per year to 687,000 visitors last year. Tourism, in particular visitors to the lake, contributes an estimated $216 million to the local economy. The poor water quality has resulted in lost jobs and income at marinas and restaurants, and reduced demand for camp sites, cottages, and property. Ohio Department of Natural Resources warned people to avoid contact with the water. Those at greatest risk are swimmers who accidentally ingest the water, and people on Jet Skis and boats that are splashed repeatedly.

anglers. Florida ranks number one nationwide in number of in-state anglers, angler-supported expenditures, and angler-supported jobs (FWC, 2010).

Another source of fishing-related economic impact is tournament fishing. Freshwater fishing tournaments, particularly for largemouth bass, are common and widespread in Florida (Florida Sportsman, 2010) and can generate substantial revenues. While no Florida-specific dollar estimates were available, values are available for bass tournaments in a neighboring state which may be comparable. The Georgia Department of Natural Resources (2008) estimates that a major bass tournament can have a $4 to $5 million dollar impact on the community in which it is held, and that a championship can have an impact of as much as $27 million. Improving water quality in Florida's freshwater fisheries will increase their appeal as tournament sites and may bring additional tournament revenue to Florida.

Ecotourism is an important sector in Florida's economy and one which is highly vulnerable to the adverse impacts of eutrophication. Water quality aesthetics are directly linked to ecotourism, since tourists are drawn by the untouched natural beauty or uniqueness of a particular ecosystem. Florida has many unique environments and species which are attractions including major spring areas and manatee congregation areas. Thus, the principal benefits to ecotourism are avoiding loss of tourist dollar arising from declining attendance at natural attractions or income generated by increased tourism to natural attractions where water quality has been restored.

These natural attractions are vulnerable to increased nutrients as documented in springs where water clarity has declined so far that glass-bottom boat tours are no longer run. For example the poor water quality in Wakulla Spring resulting from increased nitrogen levels and algal blooms has stopped all glass-bottom boat tours in the state park (Florida Geological Survey, 2010). Vegetation favored by manatees has been shaded out by nuisance epiphytes or phytoplankton. There is a strong indication that elevated nitrogen (nitrate levels) is the major nutrient stressor for many of these springs (UFWI, 2008), based on experimental laboratory data and field evaluations that document the response of nuisance algae to nitrate-nitrite concentrations. Controls that reduce nutrient levels in surface waters and applied to the watershed (e.g., fertilizer reductions, septic system upgrades) may also reduce nutrients that seep into groundwater as well as reduce runoff directly into springs (see Section 8.3.2 and 9.3).

Preventing deterioration of water quality will avoid the costs associated with a loss of tourism dollars associated with reduced clarity and wildlife presence. For example, Bonn (2004) estimated total annual direct spending by visitors at 8 different springs at $65 million, generating over $13 million in wages created by 1,100 jobs. Bonn and Bell (2003) reported direct economic income from four major Florida springs which ranged from $10 million to $23 million, with visitors spending between $19/day to $89/day. Freshwater springs are a major attraction for tourists in Florida. There are an estimated 700 freshwater springs in Florida including 33 major springs where upwelling groundwater flowing at greater than 100 cubic feet per second (cfs) provides water of exceptional clarity, fairly constant temperature, and ecological richness (FGS, 2004). These properties have created some unique attractions such as glass-bottom boat tours, kayaking tours, and snorkeling "with the manatees."[13]

Impacts on Property Value

Due to population growth and development, there has been significant development of lakeshore and riverfront properties in Florida. This access to natural waterbodies has been increased by the development

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[13] See http://www.swimwithmanatees.com/ and http://www.snorkelwithmanatees.com/ for examples.

of marinas and canal systems that provide boating access in many residential areas. Previous studies suggest that waterfront property is more desirable when located near unpolluted water, and therefore property values increase with improved water quality and decreased algal blooms and vice versa. Improvement of water quality following implementation of the numeric nutrient criteria should result in improved water quality and increase waterfront property values.

Researchers use hedonic property valuation models to quantify the precise difference in property value for a given change in water quality in a particular locale. Hedonic models allow estimation of the implicit price of a characteristic, which expresses the impact of a unit change in the characteristic on property prices. Since water quality in local lakes is a property characteristic, hedonic models can estimate its implicit price. For example, Walsh et al. (forthcoming) estimated the property price impacts of changes in TN, TP, chlorophyll a (CH), and a compound indicator of water quality, trophic state index (TSI), in lakes in Orange County, Florida. The results indicate that improvements in water quality could be worth thousands of dollars to individual Orange County properties. It is important to note, however, that this method does not account for nonuse values and that there may be some overlap with other values.

Walsh et al. (forthcoming) used a data set of 55,000 property sales in Orange County during the time period 1996-2004, and includes all property sales within 1,000 meters of 146 lakes in the analysis. Walsh et al. (forthcoming) merged the property sales data with several GIS layers to control for spatial characteristics, as well as census block socio-economic data, and matched water quality data from EPA's STORET database and several local municipalities to the lakes using GIS. These multiple data sets allow a thorough analysis of the determinants of property prices. In addition to the three variables from the numeric standards, Walsh et al. (forthcoming) included the compound indicator TSI, a non-continuous combination of TN, TP, and chlorophyll that accounts for the nutrient limiting concept.[14] The state of Florida uses TSI in several lake regulations.

Walsh et al. (forthcoming) specified the following econometric model:

$$P = \rho WP + \beta_0 + \beta_1 WF + \beta_2 WQ + \beta_3 WF * WQ + \beta_4 Distance + \beta_5 Distance * WQ$$
$$+ \beta_6 Area * WQ + \gamma' S + \phi' N + \psi' \mathbf{l} + \delta' \mathbf{t} + \varepsilon$$

In the model,

P = property value

ρWP = spatially lagged variable

WF = waterfront indicator

$Distance$ = distance to the nearest lake

$Area$ = lake area

WQ = quality indicator

S = property structural attributes

N = location and neighborhood variables

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[14] Concerns with correlation between the three indicators prevent their simultaneous use in a single hedonic model. The use of TSI theoretically allows for a more complete representation of water quality than any of the other individual indicators.

T = vector of time dummy variables

l = vector of lake dummy variables.

All continuous variables enter in their natural log form; Walsh et al. (forthcoming) found this to be the best functional form for the data. Water quality enters several places in the model; this allows the implicit price of water quality to vary over lakefront and non-lakefront homes, distance to the nearest lake, and lake area. Finally, Walsh et al. (forthcoming) estimated the full model as a spatial lag model, illustrated by the spatially lagged variable (ρWP) on the right side of the equation. This model controls for detected spatial dependence in the property prices, which can arise from appraisal practices, neighborhood codes and covenants, and similar builders (see LeSage (1998) for more information).

Lakefront homes have the highest implicit prices; nonetheless, sales of non-lakefront homes as far as 600 meters from a lake can be affected by nutrients. Implicit prices are found to increase with lake size and decrease with distance to the nearest lake. **Exhibit 12-3** contains the average implicit prices of lakefront and non-lakefront homes (represented by homes 250 meters from the lake, a midpoint of distances at which non-lakefront homes show property value effects). The values correspond to a 17% change in the water quality variable.[15] TSI has the highest average lakefront implicit price, while TN has the highest average non-lakefront implicit price.

Exhibit 12-3: Mean Implicit Price of a 17% Change in Water Quality

Pollutant	Lakefront[1]	Non-Lakefront (250 m)[1]
TSI	$9,761.59	$766.36
TN	$8,066.43	$941.21
TP	$5,883.09	$256.23
Chlorophyll	$3,261.50	$222.35

1. Price in 2002 dollars

To better illustrate the impact of water quality, **Exhibit 12-4** contains graphs of the non-lakefront implicit price gradients, which show average implicit prices at different distances from the lake.

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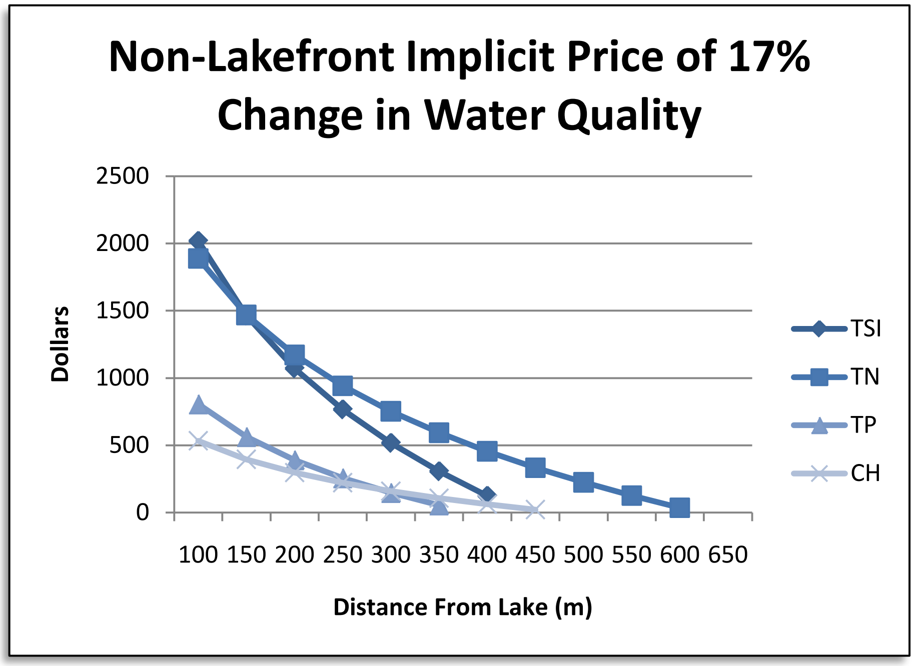
[15] A 17% change in average Secchi disk transparency (a popular visibility water quality indicator) for Orange County lakes corresponds to a one foot improvement. To compare these results with other studies, this was chosen as the marginal change.

Exhibit 12-4: Implicit Price Gradients



These results imply that the water quality improvements mandated by the nutrient standards could yield considerable property benefits throughout Florida. Although the present results are specific to Orange County, it is likely that they are at least similar to other metropolitan areas with comparable population density and real estate markets. **Exhibit 12-5** contains implicit prices from past hedonic studies of lake water quality, representing much less populated areas than Orange County. The results in Exhibit 12-5 suggest that rural areas in Florida could also see gains in property prices from the nutrient standards. For example, Poor et al. (2001) estimate that a one-meter improvement in secchi disk measurement (SDM) is worth $3,069 - $10,606 to rural Maine properties. For the same change in SDM, Gibbs et al. (2002) find a range of implicit prices of $1,497 - $13,096 (varying over town) in small New Hampshire Towns. Overall, a consistent link between water quality and property sales has been found in the literature.

Exhibit 12-5: Implicit Price of Lake Water Quality in Other Studies

Paper	Implicit Price Range[1]	Location	Units	Setting
Michael, et al. (2000)	$-1,035 - $12,312	ME	SDM – 1 m	Rural
Boyle and Taylor (2001)	$2,361 - $9,444	ME	SDM – 1 m	Rural
Poor, et al. (2001)	$3,069 - $10,606	ME	SDM – 1 m	Rural
Gibbs, et al. (2002)	$1,497 - $13,096	NH	SDM – 1 m	Small Towns

1. All prices have been adjusted to 2002 dollars using the CPI, obtained from www.bea.gov

Nonmarket Benefits

Recreation and Aesthetics

The degradation of water resources resulting from high nutrient concentrations may negatively impact recreational opportunities. As stated above, high levels of HABs can lead to beach closures, because of potential health risk, reducing the occurrence or quality of recreational activities. In addition to health and safety concerns, eutrophication may lead to the aesthetic degradation of water resources. Algal and cyanobacterial blooms, and particularly surface scums are unsightly and can have unpleasant odors, causing beachgoers to go elsewhere even when a beach is not closed, diminishing recreational values. The color, clarity, and taste of water adversely impact many recreational activities, including recreational fishing, boating, and swimming.

Eutrophication reduces the amount of DO in a waterbody, leading to fish kills. This in turn leads to fewer and smaller fish, and a reduction of the game fish population. Florida ranks number one nationwide in number of in-state anglers, angler-supported expenditures, angler-supported jobs, and state and local tax revenues derived from fishing (FWC, 2010). In 2007, approximately 3.0 million residents participated in non-boat freshwater fishing (FWC, 2010). Approximately 2.8 million Floridians use freshwater boat ramps (FWC, 2010). In addition, 2.6 million state residents use non-motorized boats such as kayaks or canoes (FWC, 2010).

Activities that take place near water, such as hiking, jogging, picnicking, wildlife watching, camping and hunting, may also be adversely affected by nutrient discharges into the water. While these activities do not involve contact with the water, murky and visually unpleasant water and odors may greatly detract from the enjoyment gained through these activities. Decreases in fish populations may cause a reduction in wildlife near the resource, affecting wildlife viewing and hunting. Additionally, toxic cyanobacteria may poison birds and mammals, greatly reducing the wildlife population near a waterbody. For example, alligator and bird mortality events during cyanobacterial blooms in Florida lakes may be due to exposure to neurotoxic compounds produced during the bloom (Burns, 2008). Pollutants may negatively affect local flora and fauna, reducing the aesthetic appeal of the area near the resource and negatively impacting wildlife viewing.

Improved water quality from reducing nutrient discharges will enhance the recreational uses of water resources, thereby resulting in welfare gain to recreational users of these resources. Improved water quality from reducing nutrient concentrations may translate into three components of recreational benefits: (1) an increase in the value of a recreational trip resulting from a more enjoyable experience, (2) an increase in recreational participation, and (3) and increase in the available recreational sites.

Valued Ecosystem Functions

Attainment of the nutrient criteria should improve ecological functions such as biodiversity and protection of sensitive species. Since eutrophication tends to drive ecosystems to physical and chemical conditions (turbidity, low DO, highly organic sediments) which are tolerated by a smaller suite of biota, reduction in nutrients will likely allow the re-invasion of pollution-intolerant species and increase overall biodiversity of species. The reduction of selected fish species due to increasingly more eutrophic states was shown in 65 Florida lakes (Bachmann et al., 1996). Increased species diversity is often linked to ecological resistance to disturbance.

Richter et al. (1997; as reported in Dodds et al., 2009) reviewed 135 threatened, endangered or special concern freshwater species nationwide and found that elevated nutrients were a major stressor in about 30% of historical and 25% of current cases. Working on the assumption that 25% of all aquatic special concern species are nutrient-impacted and, thus, 25% of the cost of species recovery (i.e., restoration) costs are due to anthropogenic eutrophication, Dodds et al. (2009) postulated that $44 million per year was spent to prevent eutrophication-linked loss of aquatic biodiversity. Information is not available on the quantity of threatened, endangered or special concern freshwater species that are found in Florida to apportion a percentage of the annual national cost to the state.

Attempting to isolate the effects of nutrients from other stressors of special concern in Florida and elsewhere is difficult. Symbolic threatened and endangered species such as the Florida manatee and Florida snail kite are affected somewhat by water quality and nutrient conditions as they affect food items (e.g., aquatic macrophytes, apple snails), although other factors (e.g., water temperature, hydrological variation) are also important.

In the case of the Florida manatee, preferred manatee habitat is characterized by the availability of good quality SAV (Smith 1993). In springs, manatees feed primarily on submerged aquatic macrophytes such as Myriophyllum spp. and hydrilla (Hydrilla verticillata). As described above, nutrient loading (e.g., nitrates) from residential and agricultural sources to springs has promoted the growth of epiphytic algae and decreased light transparency, thus reducing available winter forage for manatee in these refuges (USFWS 2001). Reduced watershed loadings (see Sections 8 and 9) to meet the nitrate criterion will improve the quality of the preferred habitat for this keystone species.

Losses of sensitive species are generally linked to loss of their habitat, either by outright modification or elimination or by the alteration of the highly specific combination of physical, chemical or biological factors that provide the specialized niche. These changes can be attributed to a variety of causes but eutrophication can be a major factor since changes in the nutrient regime can lead to differences in the way competitive interactions occur between species and shifting dominant species can lead to major shifts.

Nonuse Values

Even if no human activities or uses are affected by environmental changes caused by nutrient runoff, such environmental changes may still affect social welfare. For a variety of reasons, including bequest, altruism, and existence motivations, individuals may value the knowledge that water quality is being maintained, that ecosystems are being protected, and that populations of individual species are healthy independent of any use. It is often difficult to quantify the relationship between changes in pollutant discharges and the improvements in societal well-being that are not associated with current use of the affected ecosystem or habitat. That these values exist, however, is indisputable, as evidenced, for example, by society’s willingness to contribute to organizations whose mission is to purchase and preserve lands or habitats to avert development (although some portion of these donations may be motivated by use values). Notwithstanding challenges involved in estimation of nonuse values, there is a substantial literature devoted to such issues (Bateman et al., 2006). This literature provides insight into analysts’ ability to estimate nonuse values within various types of policy contexts, and for various types of resources

Various studies have found that individuals are willing to pay for water quality improvements, including nutrient reductions affecting wildlife habitat regardless of whether or not they are direct uses (e.g., anglers). Shrestha and Alavapati (2004) found that Floridians WTP for water quality improvements in the form of phosphorus runoff reductions was $30.24 per household for a “moderate” improvement (31% to 60%) and $71.17 for a “high” improvement (61% to 90% percent). The authors found values of $49.68 and $41.06, respectively, for qualitative improvements in wildlife habitat. A recent EPA study found that households in EPA Region 4 (which includes Florida) were willing to pay between $4.39 and $7.87 per household for water quality improvements resulting from reductions in sediment and nutrient runoffs in flowing waters (U.S. EPA, 2009b).

12.4 Avoided Habitat Restoration and Treatment Costs

Establishing numeric nutrient criteria implies that efforts will need to be made to restore waters that exceed the criteria. For those waters that do not exceed criteria, the numeric values provide targets with which to establish effluent limits and controls on nonpoint sources such that criteria are not exceeded in the future. Experience suggests that pollution prevention is less costly than restoration and clean up. Thus, in addition to the benefits associated with attaining WQS in the incrementally impaired waters, the benefits of the rule include the impact of the controls in reducing restoration and clean up costs in the future.

In addition, reductions in watershed application of fertilizers to help meet the nitrate criterion (e.g., springs) should also reduce the amount of nitrogen that is deposited atmospherically over the landscape in the relevant airshed (NADP, undated). Nitrogen derived from volatilization of ammonia into gaseous forms that fall associated with wet precipitation or nitrates transported in dust and fine airborne particles that are deposited as dryfall should be reduced by stricter fertilizer management, even though the precise level of reduction may not be measurable. This reduction in landscape-scale nitrogen deposition should help decrease general eutrophication.

This section describes the cost of efforts that have occurred or are underway to restore waters that are impaired under the current narrative criteria. To the extent that such costs are avoided in incrementally impaired waters, they represent benefits of implementing numeric nutrient criteria.

Restoration activities and instream or in-lake water treatment can also be used to reduce nutrients loads from historical or controlled sources. For example, in Lake Apopka in Florida, the sedimentary store of available phosphorus and the moderate hydraulic detention time (2.5 years) resulted in a slow recovery (SJRWMD, 2003). To hasten reduction efforts, the SJWMD constructed a wetland system adjacent to the waterbody reportedly to remove phosphorus from lake water and permanently bury it in marsh sediments. Algae, resuspended sediments, and particle-bound nutrients are removed from lake water as it flows through 13 independent marsh cells and returns to the lake (SJRWMD, 2003).

Another restoration effort that may improve water quality in certain lakes is rough fish harvesting (e.g., filter feeding species such as gizzard shad). The presence of filter-feeding species that thrive in turbid, algal-dominated water helps to maintain poor water quality conditions by increasing the rate at which phosphorus in the water is made available for algal growth, by stirring up loose bottom sediments, and removing the larger zooplankton grazers that more efficiently feed on blue-green algae (SJRWMD, 2003). Removal of the rough fish can significantly improve water quality, including reductions in total phosphorus, nitrogen, suspended solids, turbidity, and chlorophyll a concentrations and increased water clarity measured by Secchi disk (SJRWMD, 2003).

Exhibit 12-6 shows TP load reductions and project costs (i.e., potential avoided costs) for habitat restoration projects in the Upper Ocklawaha River Basin in Florida.

Exhibit 12-6: Habitat Restoration and Treatment Costs For Upper Ocklawaha River Basin, FL

Project	Description	TP Reduced (lb/yr)	Project Cost
LCWA Nutrient Reduction Facility	Water in Apopka-Beauclair Canal treated off-line with alum to removes TP from Lake Apopka discharge.	5,000	$5,200,000
Suction dredging of Western Lake Beauclair	Suction dredging to remove 1 million cubic yards of sediment in western end of Lake Beauclair	Unknown	$12,000,000

Exhibit 12-6: Habitat Restoration and Treatment Costs For Upper Ocklawaha River Basin, FL

Project	Description	TP Reduced (lb/yr)	Project Cost
Lake Beauclair gizzard shad harvest	Harvest of gizzard shad by commercial fishermen removes nutrient from lake, reduces recycling of nutrients from sediments, reduces sediment resuspension, and stabilizes bottom to reduce TSS.	Unknown	$150,000 (per year in 2005 and 2006)
Lake Dora gizzard shad harvest	Harvest of gizzard shad by commercial fishermen removes nutrient from lake, reduces recycling of nutrients from sediments, reduces sediment resuspension, and stabilizes bottom to reduce TSS.	Unknown	$150,000 (per year in 2005 and 2006)
Pine Meadows Restoration Area	Reduce TP loading from former muck farm; restore aquatic, wetland, and riverine habitat; chemical treatment of soil (alum) to bind phosphates; reduce nutrient outflow to feasible level of 1.1 kg/ha/yr of TP.	1,487 Lake Eustis; 726 Trout Lake	$1,300,000 (for both lakes)
Lake Griffin Emeralda Marsh Restoration	Wetland restoration, planting, alum treatment to bind phosphates in sediments; manage excess nutrient outflow.	41,450	$15,000,000 (for land acquisition)
Lake Griffin gizzard shad harvest	Harvest of gizzard shad by commercial fishermen removes nutrient from lake, reduces recycling of nutrients from sediments, reduces sediment resuspension, and stabilizes bottom to reduce TSS.	Unknown	$1,000,000 (spent since 2002 harvest)
Lake Harris Conservation Area	Restoration of former muck farm; chemical treatment of soil (alum) to bind phosphates for nutrient control; aquatic and wetland habitat restoration; reduce and manage nutrient outflow to Lake Harris to feasible loading of 1.1 kg/ha/yr, or about 1 lb per acre.	6,665	$550,000
Harris Bayou Conveyance Project	Modification of hydrodynamics to accommodate higher flows of water.	Unknown	$5,000,000
Lake Apopka Constructed Marsh flow-away Phase 1	Lake water pumped through marsh to remove particulates and nutrients from lake water; designed to treat about 150 cfs.	External: 4,864; flow-away: 17,640 to 22,050	$19,320,000 ($15 million in land acquisition; $4.32 million Phase 1 flow-away construction)
Lake Apopka North Shore Restoration	Wetland habitat restoration; remediate pesticide "hot spots" in soil.	99,960	$100,000,000 (mostly land acquisition)

Exhibit 12-6: Habitat Restoration and Treatment Costs For Upper Ocklawaha River Basin, FL

Project	Description	TP Reduced (lb/yr)	Project Cost
Lake Apopka Habitat Restoration	Planting of wetland vegetation in littoral zone, largely north shore to improve fishery, to improve water quality, and possibly reduce nutrient levels, stabilize bottom, and reduce TSS.	Unknown	$10,000 (annually)
Lake Apopka removal of gizzard shad	Harvest of gizzard shad by commercial fishermen removes nutrient from lake, reduces recycling of nutrients from sediments, reduces sediment resuspension, and stabilizes bottom to reduce TSS.	Unknown	$500,000 (annually)

Source: UOBWG (2007)
cfs = cubic feet per second
FWC = Florida Fish and Wildlife Conservation Commission
LCWA = Lake County Water Authority
SJRWMD = St. Johns River Water Management District

Wetlands can also reduce nutrient loadings to waterbodies from upstream tributaries and runoff sources. For example, as a result of discharges from the Main Street water reclamation facility (WRF) and Gainesville stormwater, there is an increased nutrient load to Paynes Prairie. There has also been a loss of the natural sheetflow in Sweetwater Branch, which shortens the hydroperiod. Both of these actions have adversely affected Alachua Sink, located downstream of Sweetwater Branch. The City has proposed to remove nutrients from water in Sweetwater Branch with a proposed project to return sheetflow to Paynes Prairie and creation of a wetland treatment system that involves (Wetland Solutions, Inc., 2007):

- Upgrades to the Main Street WRF – chemical alum treatment to reduce TP and mechanical equipment upgrades to optimize TN removal
- Construction of Sweetwater Branch enhancement wetland – 122-acre area with a channel diversion structure and sediment pond, four cells in two trains, and emergent marsh/open water
- Construction of a sheetflow distribution channel – 5,000 ft in length, 40-ft bottom width, and 11 outlet spillways
- Backfilling the Sweetwater Branch Canal – backfill 10,000 ft of existing Sweetwater Branch Canal, replant 33 acres with native wetland vegetation, and eliminate direct connection to Alachua Sink.

Exhibit 12-7 provides the planning level estimates for the various project components. The OCBWG (2008) estimates that the project will result in the point source reductions needed for compliance with the Alachua Sink TMDL.

Exhibit 12-7: Planning Level Estimates for Sweetwater Branch Sheetflow Restoration Project

Project Component	Construction	Mobilization, Contingency, Engineering[1]	Total Capital	O&M
Main Street WRF Upgrades	$1,300,000	$650,000	$1,950,000	$640,000
Sweetwater Branch Channel Improvements	$831,600	$415,800	$1,247,400	-
Sweetwater Branch Sediment Forebay/ Trashrack/Weir Diversion Structure/Sediment Removal	$485,450	$242,725	$728,175	$150,000
Sweetwater Branch Constructed Wetland	$7,320,600	$3,660,300	$10,980,900	$150,000
Sheetflow Distribution Channel	$2,898,702	$1,449,351	$4,348,053	$75,000
Sweetwater Branch Canal Restoration	$657,890	$328,945	$986,835	-
Public Use Amenities	$1,850,000	$925,000	$2,775,000	$150,000
Project Monitoring	$14,000	$7,000	$21,000	$100,000
Total	$15,538,242	$7,679,121	$23,037,363	$1,265,000

Source: PPPSP (2007)

1. Mobilization, contingency, engineering calculated as 50% of construction cost.

Also, in Florida, regional stormwater treatment facilities or areas combine stormwater BMPs such as wet detention ponds with habitat restoration projects such as constructed wetlands. Costs for these treatment controls vary based on influent quality, treatment area size, and location. **Exhibit 12-8** provides examples of regional treatment facilities throughout Florida.

Exhibit 12-8: Examples of Costs for Regional Stormwater Treatment Facilities in Florida

Project Name	Purpose	Area treated	Project Completion	Cost	Source
Seminole County					
Navy Canal RSF	Nutrient reduction	820 acres	Late 2006	$2.1 million	Williams, et al. (2007)
Cameron Ditch RSF	Nutrient reduction	344 acres	Early 2007	$1.6 million	Williams, et al. (2007)
Crane Strand Stormwater Treatment Pond	Flood control and water quality	2,300 acres	Dec-07	$1.53 million	Seminole County (2007)
Lockhart Smith RSF	Flood control and water quality	-	Construction in 2007	$2.33 million	Seminole County (2007)
Elder Creek RSF	Flood control and water quality	-	Mar-08	$5.46 million	Seminole County (2007)
Cassell Creek RSF	Flood control and water quality	830 acres	Sep-10	$2.4 million through FY2010	Seminole County (2007)

Exhibit 12-8: Examples of Costs for Regional Stormwater Treatment Facilities in Florida

Project Name	Purpose	Area treated	Project Completion	Cost	Source
Club II RSF	Flood control and water quality	-	Jun-07	$2.97 million through FY2007; $286,332 for FY2008.	Seminole County (2007)
Midway RSF	Flood control and water quality	-	Dec-08	$2.6 million	Seminole County (2007)
City of Ocoee					
Pioneer Key Regional Stormwater Pond	Nutrient reduction	124 acres	Funded in FY 2003/2004	$850,000	FL DEP (2006)
Sarasota County					
Catfish Creek RSF	Water quality	810 acres	Aug-09	$4 million	Sarasota County (2008)

Another alternative to constructed wetlands and regional stormwater treatment facilities is the Algal Turf Scrubber®. The system uses attached, primarily filamentous algae to capture the energy of sunlight and build algal biomass from carbon dioxide. Nutrients such as TN and TP are assimilated into the biomass during cellular production. In addition, precipitated pollutants and filtered particles are recovered within the algal turf, while ammonia may be volatilized and lost to the atmosphere. A major advantage of the turf scrubber is that pollutants are removed from the system on a regular basis through harvesting or recovery of biomass. Treatment performance is maintained since there is no build-up of pollutants within the system to reduce its effectiveness.

The Taylor Creek Algal Turf Scrubber® Nutrient Recovery Facility is designed to treat 15 mgd of water rerouted from Taylor Creek, a tributary to Lake Okeechobee. The facility is expected to remove 4,000 lbs of total phosphorus per year with capital costs of $3.05 million in capital and first year O&M costs of $281,610 (SFWMD, 2007).

In certain lakes, significant phosphorus reductions can be slowed by internal phosphorus loading from lake sediments. However, dredging of these sediments removes the legacy phosphorus pollution, resulting in more measurable load reductions from controls on point and nonpoint sources. MacTech (2007) indicates that dredging unit costs generally range from $1 to $25 per cubic meter of sediment removed for uncontaminated sediments and $5 to more than $25 per cubic meter for contaminated sediments. **Exhibit 12-9** provides examples of dredging project and unit costs for lakes in Florida.

Exhibit 12-9: Dredging Costs for Florida Lakes

Lake	Project Year	Volume Removed (m^3)	Total Cost (million $)	Unit Cost ($/$m^3$)	Source
Lake Hancock	2005	19,956,060	$107 to $128	$5.36 to $6.41	Madrid Engineering (2005)
Lake Hollingsworth	1996-2001	2,217,340	$10.95	$4.94	City of Lakeland (2005)
Lake Panasoffkee	2004	6,116,800	$26	$4.25	MacTech (2007)

13. Potential Incremental Benefits of the Numeric Nutrient Criteria

As discussed in Section 12, excessive nutrient concentrations may have a wide range of effects on water resources located in the state of Florida. These environmental changes affect environmental services valued by humans, such as recreational uses of the waters, and nonuse values. This section describes the potential magnitude of the benefits of reducing nutrient concentrations as a result of the rule. The magnitude of the potential benefits is quantified by translating these changes into an indicator of overall water quality (water quality index) and valuing these improvements. Water quality is calculated for both the baseline scenario and post compliance scenario, to calculate the improvements in water quality. This change in water quality is then valued in terms of WTP, based on a meta-analysis of valuation studies, for the types of uses that are supported by different water quality levels. [16]

13.1 Water Quality Index

To link potential water quality changes from reduced nutrient concentrations to effects on human uses and support for aquatic and terrestrial species habitat, EPA employed a water quality index (WQI) approach. The WQI translates water quality measurements, gathered for multiple parameters that are indicative of various aspects of water quality, into a single numerical indicator. The parameters used in formulating the WQI are determined based on waterbody type, scientific understanding of ecosystem response to varying conditions, and available data.

Most importantly for the present analysis, the WQI provides the link between specific pollutant levels, as reflected in individual parameters within the index, and the presence of aquatic species and suitability for particular recreational uses. For this analysis, EPA used an index composed of six parameters to represent major stream impairment categories: DO, biochemical oxygen demand (BOD), fecal coliform (FC), TN, TP, and total suspended solids (TSS). The WQI value, which is measured on a scale of 0 to 100, reflects varying water quality, with 0 for poor quality and 100 for excellent.[17]

For this analysis, EPA adjusted the index it had previously used in its analysis of the Construction and Development (C&D) regulation (U.S. EPA, 2009b) to more closely reflect Florida conditions and to be consistent with the nutrient regions and waterbody types used in formulating the criteria. EPA adapted an approach used by Cude (2001) to develop region-specific subindex curves for TN and TP and used it to develop a series of curves for clear and colored lakes and for the stream criteria regions. Implementing the WQI methodology involves three key steps described below: (1) obtaining water quality measurements for each parameter included in the WQI; (2) transforming measurements to subindex values expressed on a common scale; and (3) weighting and aggregating the individual parameter subindices to obtain an overall WQI value that reflects waterbody conditions across the parameters.

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[16] This analysis follows an approach used by EPA in the Environmental Impact and Benefits Assessment for Final Effluent Guidelines and Standards for the Construction and Development Category (U.S. EPA 2009). Technical details involved in the meta-analysis discussed in this chapter can be found in EPA (2009) as well as in sources such as Bateman and Jones (2003), Johnston et al. (2005, 2006), Shrestha et al. (2007), and Rosenberger and Phipps (2007).

[17] Numerous water quality indices have been developed and documented in the literature since the 1960s. A history of these studies is outlined in the Environmental Impact and Benefits Assessment for Final Effluent Guidelines and Standards for the Construction and Development Category (U.S. EPA, 2009c).

The first step involves gathering water quality data. EPA compiled water quality data for each parameter from three sources (in order of priority): FDEP IWR database, United States Geological Survey (USGS) National Water Information System, and EPA's Storage and Retrieval. This step of the methodology is described in greater detail in Section 13.1.2.

The second step in the implementation of the WQI involves the transformation of parameter measurements into subindex values that express water quality conditions on a common scale of 0 to 100. As mentioned above, EPA developed customized TN and TP curves for this analysis to convert nutrient concentrations into the subindex scores for each relevant category of waterbody (i.e., for lakes, the waterbody types, clear or colored; for flowing waters, the nutrient regions). The approach involved reviewing the distribution of the geometric mean of nutrient concentrations for waterbodies within a given region or waterbody type, and based on this distribution and nutrient criteria values, assigning the appropriate score.

In developing the curves, EPA assigned a score of 70 for the criterion and a score of 100 for the 10th percentile of the distribution corresponding to the "cleanest" waterbodies within each population. EPA assigned the numeric criteria a score of 70 to represent a high level of water quality, but not the pristine level of water quality that would correspond to a WQI score of 100. As indicated by the water quality ladder (Exhibit 13-6) that relates WQI values to designated uses, a WQI score of 70 corresponds to waters that are of sufficient quality to meet all human uses (boating, rough fishing, game fishing, and swimming), with the exception of drinking without treatment. **Exhibit 13-1** relates graphically the distribution of TN and TP concentrations for each relevant category of waterbody and selected threshold levels for the corresponding subindices.

EPA used a similar approach to adjust the DO transformation curve to reflect Florida conditions by tying the DO concentrations generally expected in Florida, based on approximate DO concentrations associated with waters supporting, partially supporting, or failing to support designated water uses. EPA assumed that DO concentrations of 3.1 mg/L or lower correspond to a score of 10, 6.3 mg/L corresponds to 70, and 8.5 mg/L or greater correspond to 100. For the other parameters, EPA used the curves as specified in the C&D analysis [U.S. EPA, 2009b, including TSS curves specific to the three U.S. EPA Level III ecoregions intersected by Florida].

Exhibit 13-1: Distribution of TN and TP Concentrations in Florida Lakes and Flowing waters and Corresponding Subindex (SI) Value.

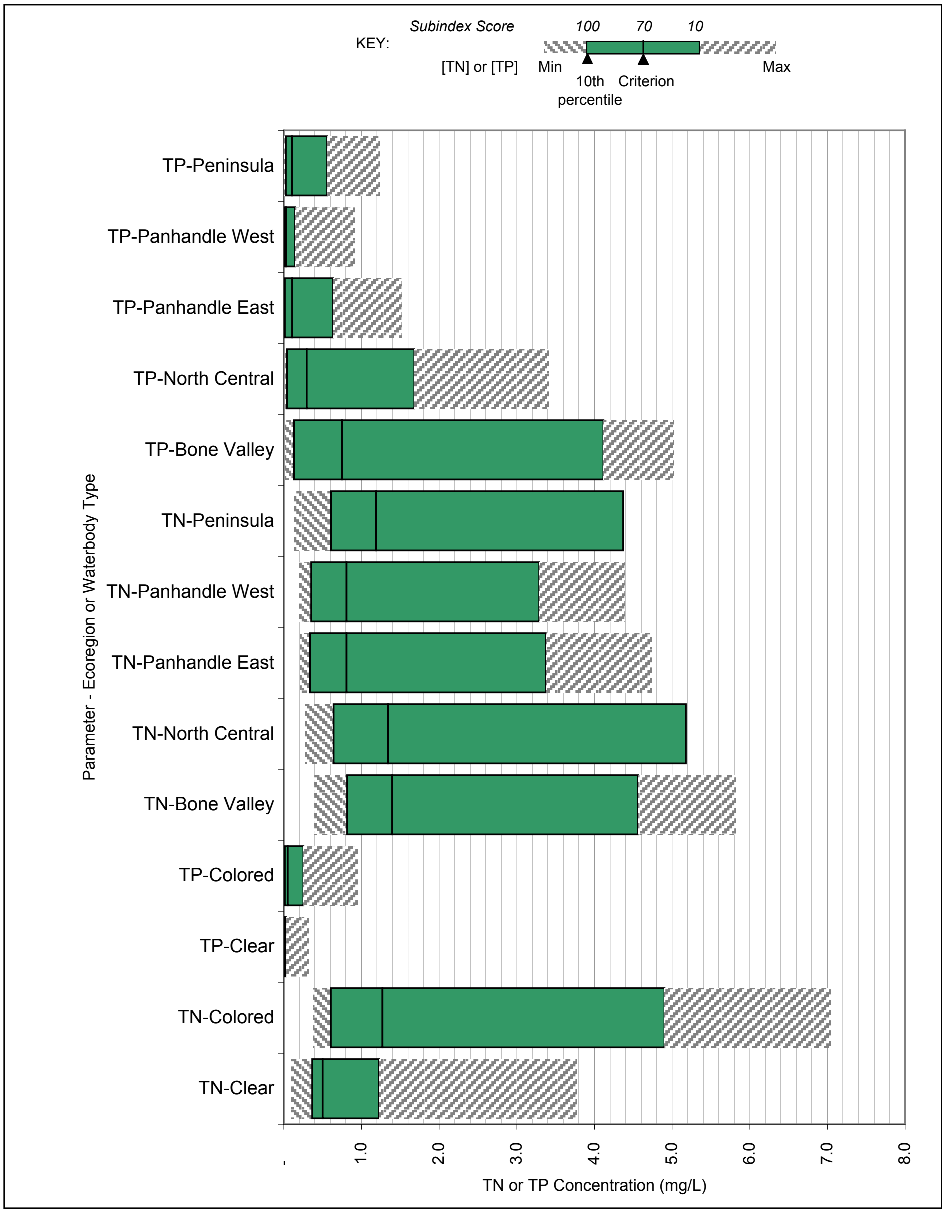


Exhibit 13-2 presents parameter-specific functions used for transforming water quality data into water quality subindices for freshwater waterbodies. The equation parameters for each TSS, TN, and TP subindex curves are provided in **Exhibit 13-3**. **Exhibit 13-4** shows the subindex curves for the six parameters graphically, including the several curves for TSS, TN, and TP.

Exhibit 13-2: Freshwater Water Quality Subindices[1]

Parameter	Concentrations	Concentration Unit	Subindex
DO			
DO saturation ≤100%	≤ 3.1	mg/L	10
DO saturation ≤100%	3.1 < DO < 8.5	mg/L	-0.947*DO^2 + 27.652*DO - 66.619
DO saturation ≤100%	≥8.5	mg/L	100
100% < DO saturation ≤ 275%	N/A	mg/L	100 * exp((DOsat - 100) *-1.197 E-2)
275% < DO saturation	N/A	mg/L	10
Fecal Coliform			
FC	≤ 50	CFU/100 mL	98
FC	50 < FC ≤ 1,600	CFU/100 mL	98 * exp((FC - 50) * -9.9178 E-4)
FC	> 1,600	CFU/100 mL	10
Total Nitrogen			
TN	$\leq \text{TN}_{10}$	mg/L	10
TN	$\text{TN}_{10} < \text{TN} \leq \text{TN}_{100}$	mg/L	a * exp(TN*b); where a and b are waterbody type or nutrient region-specific values
TN	$> \text{TN}_{100}$	mg/L	100
Total Phosphorus			
TP	$\leq \text{TP}_{10}$	mg/L	10
TP	$\text{TP}_{10} < \text{TP} \leq \text{TP}_{100}$	mg/L	a * exp(TP*b); where a and b are waterbody type or nutrient region--specific values
TP	$> \text{TP}_{70}$	mg/L	100
Total Suspended Solids			
TSS	$\leq \text{TSS}_{10}$	mg/L	10
TSS	$\text{TSS}_{10} < \text{TSS} \leq \text{TSS}_{100}$	mg/L	a * exp(TSS*b); where a and b are EPA Level III ecoregion-specific values
TSS	$> \text{TSS}_{100}$	mg/L	100
Biochemical Oxygen Demand, 5-day			
BOD	≤ 8	mg/L	100 * exp(BOD * -0.1993)
BOD	> 8	mg/L	10

BOD = biochemical oxygen demand
DO = dissolved oxygen
FC = fecal coliform
TSS = total suspended solids

1. TSS_{10}, TSS_{100}, TN_{10}, TN_{100}, TP_{10}, and TP_{100} are region or waterbody type-specific TSS or nutrient concentration values that correspond to subindex scores of Val_{10} and Val_{100}, respectively.

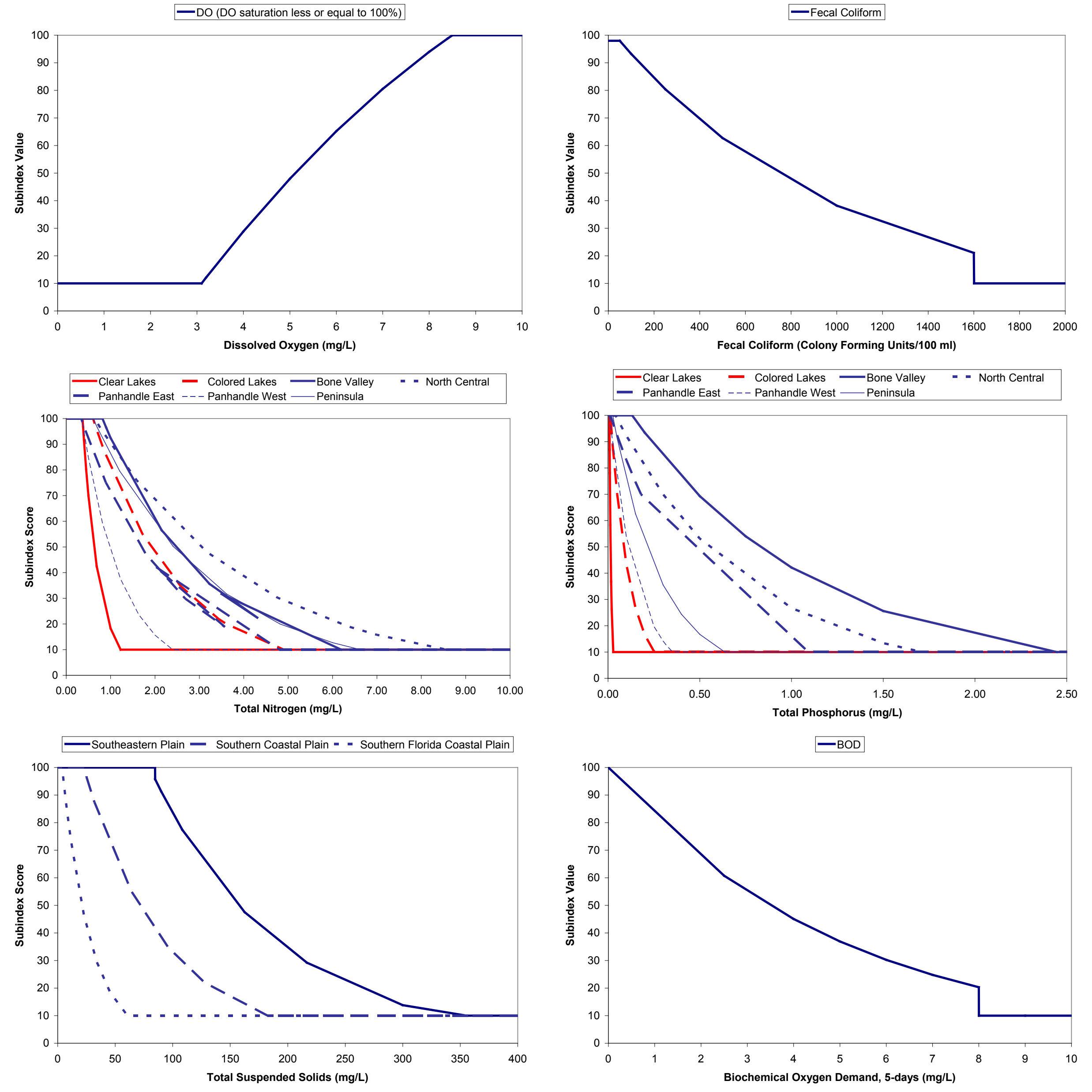
Source: BOD and FC: Cude (2001); TSS, TN, TP, and DO: U.S. EPA, based on Cude's methodology.

Exhibit 13-3: TSS, TN, and TP Subindex Curve Parameters

Region/Waterbody Type	a	b	Val_{100}	Val_{10}
TSS				
Southeastern Plains	205.300	-0.009	84.659	355.516
Southern Coastal Plain	138.62	-0.0144	22.6564	182.58
Southern Florida Coastal Plain	116.95	-0.0405	3.86341	60.7200
TN				
Lakes				
Clear Lakes	267.9	-2.6843	0.367	1.225
Colored Lakes	138.26	-0.5359	0.604	4.901
Flowing waters and Springs				
Bone Valley	141.87	-0.4281	0.817	6.196
North Central	120.47	-0.2903	0.641	8.573
Panhandle East	119.03	-0.5154	0.338	4.806
Panhandle West	148.83	-1.1258	0.353	2.398
Peninsula	126.12	-0.3823	0.607	6.630
TP				
Lakes				
Clear Lakes	232.35	-109.07	0.008	0.029
Colored Lakes	113.14	-9.6029	0.013	0.253
Flowing waters and Springs				
Bone Valley	114.02	-0.9957	0.132	2.444
North Central	105.81	-1.377	0.041	1.713
Panhandle East	102.75	-2.132	0.013	1.093
Panhandle West	104.31	-6.6485	0.006	0.353
Peninsula	110.05	-3.7706	0.025	0.636

1. “a” and “b” are ecoregion specific values that are used in the TSS, TN, and TP subindex equations.

Exhibit 13-4: Subindex Curves for the 6 WQI Parameters.



The final step in implementing the WQI involves combining the individual parameter subindices into a single WQI value that reflects the overall water quality across the parameters. Following McClelland's (1974) approach, EPA calculated the overall WQI for a given reach using a weighted geometric mean function:

$$WQI_r = \prod_{i=1}^{n} Q_i^{Wi} \qquad \text{(Eq. 13-1)}$$

Where:

WQI_r = the multiplicative water quality index (from 0 to 100) for reach r

Q_i = the water quality subindex measure for parameter i

W_i = the weight of the i-th parameter

n = the number of parameters

Exhibit 13-5 provides the weights used in aggregating the individual subindex values for the six parameters into the overall WQI. EPA (2009b) revised the weights originally developed by McClelland (1974) by redistributing the weights to the six parameters retained in the EPA WQI so that the ratio among the parameters is maintained and the weights sum to 1.

Exhibit 13-5: Original and Revised Weights for Freshwater WQI Parameters

Parameters	Weights
DO (% saturation and mg/L)	0.24
Fecal coliform (colony forming units/100 mL)	0.22
Biochemical oxygen demand, 5-day (mg/L)	0.15
Total nitrogen (mg/L)	0.14
Total phosphorus (mg/L)	0.14
Total suspended solids (mg/L)	0.11
Total	1.00

Source: U.S. EPA (2009b)

13.1.1 Relation between WQI and Suitability for Human Uses

Once an overall WQI value is calculated, it can be related to suitability for potential uses. Vaughan (1986) developed a water quality ladder (WQL) that can be used to indicate whether water quality is suitable for various human uses (i.e., boating, rough fishing, game fishing, swimming, and drinking without treatment). Vaughan identified “minimally acceptable parameter concentration levels” for each of these five potential uses. Water quality is deemed acceptable for each use if none of the six subindex values exceeds the threshold concentration levels. EPA converted Vaughan’s scale of zero to 10 to a WQI scale of zero to 100 to classify water quality based on its suitability for potential uses. **Exhibit 13-6** presents water use classifications and the corresponding WQL and WQI values.

Exhibit 13-6: Water Quality Classifications

Water Quality Classification	WQL Value[1]	WQI Value[2]
Drinking without treatment	9.5	95
Swimming	7.0	70
Game fishing	5.0	50
Rough fishing	4.5	45
Boating	2.5	25

1. Source: Vaughan (1986).
2. Equals Vaughan’s (1986) WQL value times 10.

13.1.2 Baseline Ambient Water Quality

For lakes and flowing waters, EPA used the following data sources to obtain ambient concentrations for the six parameters included in the WQI:

- FDEP IWR database (Run 40) (all parameters).
- USGS National Water Information System (NWIS) (FC, DO, and BOD concentrations for WBIDs for which the IWR does not contain data)

- EPA's Storage and Retrieval (STORET) (additional FC counts and BOD data (USEPA 2008b) for WBIDs for which NWIS does not contain data).

The IWR database contains baseline data for at least one WQI parameter for 2,048 of the 5,211 freshwater WBIDs in the state. While the IWR data includes TN, TP, and TSS values for most of these 2,048 WBIDs, there are only limited data for the other three WQI parameters.[18] For example, FC data are only available for two WBIDs. In cases where FC, DO, or BOD data are not available for a given WBID from FDEP IWR, EPA used the average of ambient concentrations reported by NWIS or STORET for waterbodies within the same 6-digit HUC level watershed to impute missing values to the WBID.[19] This approach assumes that waterbodies located in the same watershed generally share similar characteristics. Using this imputation approach, EPA was able to compile the necessary water quality data for the WQI-based benefits analysis for 2,153 freshwater WBIDs in the state, including 313 of the 325 incrementally impaired WBIDs (representing approximately 96% of all incremental impaired WBIDs in the state).

EPA calculated the WQI separately for lakes and flowing waters for several reasons. The first is that the fundamental differences between lakes and flowing waters may make it difficult to compare improvements in the different types of waterbodies. Flowing waters tend to be shallow, whereas lakes are relatively still and deep. In addition, the two waterbody categories differ in how their size is expressed -- lakes are reported based on area, whereas flowing waters are reported based on length. **Exhibit 13-7** shows the distribution of flowing waters by WQI value for the baseline scenario (existing conditions). **Exhibit 13-8** contains the baseline distribution of lakes by WQI value.

As shown below, under the baseline scenario the majority of flowing waters and springs have high water quality, with approximately 65% being classified as swimmable (WQI > 70). In comparison, the majority of lakes have low water quality under the baseline scenario, with approximately 52% of lakes being classified as suitable for boating, but not suitable for game fishing or swimming (25<WQI<50). This is to be expected because the stillness of lakes often results in eutrophication being a larger problem than in flowing waters where nutrients do not as readily accumulate in one place.

Exhibit 13-7: Estimated Percentage of Freshwater Flowing Water and Spring Miles in Florida by WQI Classifications: Baseline Scenario

Baseline WQ	Total Miles	Percent of Total
WQI<25	0	0.00%
25≤WQI<50	961	9.70%
50<WQI<70	2,466	24.90%
70<WQI	6,475	65.39%
Total Miles[1]	9,901	100.00%

1. Includes 1,280 of 34,027 flowing water and spring WBIDs for which data for all six WQI parameters is available or can be imputed from other sources.

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[18] Average concentrations over a 5-year period were generally used for each WQI parameter, with the exception of TN and TP for which EPA used the average of annual geometric means, consistent with the criteria specifications. In the case of incrementally impaired WBIDs, EPA used the average of geometric means for years during which the annual geometric means exceed the criteria.

[19] EPA did not impute TN or TP in cases where the FL IWR database did not provide sufficient information because EPA assumed that where data are insufficient to assess impairment, the water is not impaired (see Section 4.2).

Exhibit 13-8: Estimated Percentage of Lake Area in Florida by WQI Classification: Baseline Scenario

Baseline WQ	Total Acres	Percent of Total
WQI<25	147	0.01%
25≤WQI<50	623,815	52.23%
50<WQI<70	319,344	26.74%
70<WQI	251,125	21.02%
Total Area[1]	1,194,431	100.00%

[1] Includes 873 of 1,310 lake WBIDs for which data for all six WQI parameters is available or can be imputed from other sources.

13.1.3 Estimated Changes in Water Quality from Attaining Criteria

To estimate benefits of water quality improvements associated with the criteria, EPA calculated the post-compliance WQI assuming that all incrementally impaired waterbodies meet the numeric nutrient criterion, and there are no water quality improvements in any waters that are not incrementally impaired under the rule. Although these nutrient reductions may also change the levels of other water quality parameters, such as DO, that are included in the WQI, these ancillary improvements are not reflected in the change in index value. The potential effects of considering changes in DO are discussed in **Appendix F**.

Rather than establishing criteria for TN in springs, the rule establishes criteria for nitrate-nitrite concentrations ($NO_2 + NO_3$) in these waterbodies. To calculate the benefits associated with attaining these standards, EPA calculated the proportion of NO_2+NO_3 that comprises TN for each incrementally impaired spring WBID. EPA then calculated the post-compliance TN concentrations for each incrementally impaired WBID by reducing the NO_2+NO_3 concentrations to 0.35 mg/L (the EPA criterion) and assuming the ratio of NO2+NO3 to TN remains unchanged.

The difference in WQI (hereafter denoted as ΔWQI) between baseline conditions and compliance with the numeric TN and TP criteria is a measure of the change in water quality that may be attributable to the rule. To monetize benefits of the regulation, EPA calculated the improvement in water quality for all incrementally impaired waterbodies where ΔWQI is greater than de minimus (0.01 WQI units).

As shown in **Exhibit 13-9** and **Exhibit 13-10**, a total of 1,502 miles of flowing waters and springs and 150,438 acres of lake area, respectively, are potentially incrementally impaired under the numeric criteria and thus may attain higher water quality by coming into compliance with the criteria. These miles account for 6.1% of all freshwater stream and spring miles in the state and 1.5% of all water area in the state (all lake, beach, coastal, and estuary area). A total of 325 individual WBIDs may show improved water quality; however EPA was able to calculate possible improvements for 313 incrementally impaired WBIDs (96% of impaired WBIDs) where data for all six water quality parameters are available.

Exhibit 13-9: Potential Water Quality Improvements in Flowing waters and Springs

Change in WQI	No. of WBIDs Improved	Total Miles Improved	Percent of Total Miles in Analysis	Percent of Total Water Miles in State[1]
$0.01 < \Delta WQI < 1.0$	35	321	3.24%	1.31%
$1.0 < \Delta WQI < 5.0$	84	897	9.06%	3.65%
$5.0 < \Delta WQI$	47	284	2.87%	1.15%
Total	166	1,502	15.17%	6.10%

WBID = waterbody identification
WQI = water quality index
1. Percentage taken out of total river, blackwater, and spring miles in Florida (24,603 miles).

Exhibit 13-10: Potential Water Quality Improvements in Lakes

Change in WQI	No. of WBIDs Improved	Acres Improved	Percent of Total Area in Analysis	Percent of Total Water Area in State[1]
$0.01 < \Delta WQI < 1.0$	6	20,262	1.70%	0.20%
$1.0 < \Delta WQI < 5.0$	40	75,458	6.32%	0.74%
$5.0 < \Delta WQI$	101	54,717	4.58%	0.54%
Total	147	150,438	12.59%	1.48%

WBID = waterbody identification
WQI = water quality index
1. Water area includes lake, coastal, beach, and estuary area (10,179,200 acres).

13.2 Willingness to Pay for Water Quality Improvements

To estimate nonmarket benefits of water quality improvements resulting from the rule, EPA used a benefits transfer function based on meta-analysis results presented in EPA (2009b). The general approach follows standard methods used by EPA (2009b), Johnston et al. (2005) and Shrestha et al. (2007), among many others (see Rosenberger and Phipps, 2007). This function provides a means of forecasting WTP based on estimated values for model variables chosen to represent potential water quality improvements. The meta-analysis results imply a benefit function of the following general form:

$$\ln(\text{WTP}) = \text{intercept} + \sum(\text{coefficient}_i)(\text{Independent Variable Values}_i) \qquad \text{(Eq. 13-2)}$$

Here, ln(*WTP*) is the dependent variable in the meta-analysis—the natural log of WTP for water quality improvements. The metadata include independent variables characterizing specific details of the resources valued, such as the baseline resource conditions; the extent of resource improvements and whether they occur in estuarine or freshwater; the geographic region and scale of resource improvements (e.g., the number of waterbodies); resource characteristics (e.g., baseline conditions, the extent of water quality change, and ecological services affected by resource improvements); characteristics of surveyed populations (e.g., users, nonusers); and other specific details of each study. **Exhibit 13-11** provides the estimated regression equation *intercept* (5.71), variable coefficients ($coefficient_i$), and the corresponding independent variable names. EPA (2009b) provides detail on the metadata, model specification, and justification for the functional form.

EPA assigned a value to each model variable corresponding with theory, characteristics of the water resources, and sites affected by the regulation and the policy context. Exhibit 13-11 presents a complete list of assigned variable values.

EPA followed Johnston et al. (2006) in assigning values for methodological attributes (i.e., variables characterizing the study methodology used in the original source studies), which are set at mean values from the metadata except in cases where theoretical considerations dictate alternative specifications. This approach follows general guidance from Bergstrom and Taylor (2006) that meta-analysis benefit transfer should incorporate theoretical expectations and structures, at least in a weak form. In this instance, three of the methodology variables, *discrete*, *WQI_study*, and *outlier_bids* are all included with an assigned value of one. *Year_index* is given the value of 9.68, which corresponds to the mean year that the studies were conducted, 2002. *Nonparam* is set to zero because most studies included in metadata used parametric methods to estimate WTP values. Other study and methodology variables (*volunt, mail, lump_sum, non_reviewed, median_WTP)* are assigned a zero value.

EPA used state-specific median household income, as provided by the U.S. Census Bureau's 2006 American Communities Survey (U.S. Census Bureau 2006a), to assign a value for the income variable (income) for all full time residents in Florida. The annual income for seasonal residents is taken from Smith and House (2006). EPA used the Consumer Price Index to adjust the value from the 2006 survey and the 2006 study to 2010 dollars. The variable *nonusers* was set to zero because water quality improvements resulting from nutrient reductions would benefit both users and nonusers of the affected resources (See Section Exhibit 13-11).

The regulation is expected to affect water quality at the state level because the impaired waterbodies are located throughout the entire state. The dummy variable denoting multiple regions (*mr*) is set to zero because the water quality improvement will only be in the state of Florida. The Mountain Plain regional dummy variable (*mp*) is also set to zero because the magnitude of the regional effect suggests that spurious or otherwise unexplained effects (e.g., the effect of specific researchers who appear more than once in the data) may drive their overall magnitude. EPA (2009b) provides more detail on regression results.

To account for the regional scale of the water quality effect in fresh waterbodies resulting from the regulation, the variable *regional_fresh* is assigned a value of one. Other variables relating to waterbody type (i.e., *single_lake, single_river, salt_pond, multiple_river, num_riv_pond*) are set to zero.

Water quality improvements resulting from the regulation are likely to enhance a variety of water resource uses, including fishing, swimming, and boating. Therefore, variables denoting multiple uses (*allmult*) and recreational fishing (*fish_use*) are assigned a value of one, while the variable denoting nonspecified uses (*nonspec*) is set to zero. However, the variable *fishplus* is given a value of zero because it is unlikely that the regulation will cause more than a 50% increase in the fish population. Baseline water quality (*baseline*) and change in water quality (*quality_ch*) are assigned WBID-specific values as described in Sections 13.1.2 and 13.1.3. For a broader discussion of issues involved in the specification of variable levels for meta-analysis benefit transfer, see Johnston et al. (2005, 2006), among others.

Exhibit 13-11: Independent Variable Assignments

Variable	Coefficient	Assigned Value	Explanation
Study and Methodology Variables			
intercept	5.7109	N/A	N/A
year_index	-0.08043	9.68	Set to 9.68 to reflect the mean year that the studies in the data set were conducted.
discrete	-0.1248	1	Set to one to reflect survey efforts that employed discrete choice elicitation methods, which are preferred over other approaches, such as open-ended and payment card methods.

Exhibit 13-11: Independent Variable Assignments

Variable	Coefficient	Assigned Value	Explanation
volunt	-1.3233	0	Set to zero because hypothetical voluntary payment mechanisms are not even potentially incentive compatible (Mitchell and Carson 1989).
mail	-0.2013	0	Set to zero because mail surveys may be of less quality than in-person interviews.
lump_sum	0.5569	0	Set to zero because the policy option will be paid for over a period of years.
WQI	-0.3275	1	Set to one because of the methodological use of the WQI in the meta-analysis.
nonparam	-0.6698	0	Set to zero because most studies used in the meta analysis used regression analysis to calculate willingness to pay values.
non_reviewed	-0.2718	0	Set to zero to reflect a preference for studies published in peer-reviewed journals.
median_WTP	-0.5358	0	Set to zero because only average or mean WTP values in combination with the number of affected households will mathematically yield total benefits if the distribution of WTP is not perfectly symmetrical.
outlier_bids	-0.8837	1	Set to one because survey data that exclude such responses are preferable; outlier bids are often excluded from the analysis of stated preference data because these bids (often identified as greater than a certain percentage of a respondent's income) may indicate that a respondent did not consider his or her budget constraints and or supplementary goods.
Surveyed Population			
income	0.0000027	Varies	Median annual household income data from the 2006 American Communities Survey and Smith et al (2006); median household income values assigned separately for full time state residents and part time seasonal residents (U.S. Census Bureau 2006a and Smith ea al. 2006).
nonusers	-0.4036	0	Set to zero in order to estimate the total value for aquatic habitat improvements, including both use and nonuse values; for nonuser population, the total value of water resource improvements includes nonuse values only (Freeman 2003).
Waterbody Type Variables			
single_river	-0.4279	0	The criteria are only for fresh waterbodies, therefore *regional_fresh* is set to one because multiple fresh waterbodies within the state will be affected by the regulation.
single_lake	-0.06316	0	
multiple_river	-1.4752	0	
regional_fresh	0.1588	1	
salt_pond	0.9849	0	
Geographic Region and Scale Variables			
num_riv_ pond	0.1173	0	Indicates the number of rivers or salt ponds affected by a policy, and is set to zero because the criteria affect the entire state; this variable assignment is constant across study regions.
mr	-0.8846	0	Regional variables are omitted from the predictive portion of

Exhibit 13-11: Independent Variable Assignments

Variable	Coefficient	Assigned Value	Explanation
mp	1.6337	0	the analysis (i.e., set to zero) because the regression results suggest that these variables may be picking spurious or other unexplained effects (e.g., author’s effect).
Resource Improvement Variables			
allmult	-0.3728	1	Set to one because multiple species may benefit from water quality improvements
nonspec	-0.4042	0	Set to zero because multiple species may benefit from water quality improvements.
lnquality_ch	0.4065	Varies	Set to the natural log of the change in the WQI for a given WBID.
fish_use	-0.3317	1	Set to one because a variety of aquatic species may benefit , therefore enhancing recreational fishing opportunities.
fishplus	0.4432	0	Set to zero because a fish population change of 50% or greater is unlikely.
lnbase	0.02610	Varies	Set to the natural log of the base WQI for a given WBID

N/A means not applicable

Using this function, EPA calculated the estimated economic values of water quality improvements by WBID. For each WBID, coefficient estimates for each variable, taken from meta-analysis results (Exhibit 13-11, column 3) are multiplied by the variable levels chosen above (Exhibit 13-11, column 4). The sum of these products represents the predicted natural log of WTP (*ln_WTP*) for a given WBID, as indicated by Equation 13-2. The final step uses a standard formula to transform this predicted natural log into the desired WTP estimate. This formula is given by:

$$WTP = \exp(ln\_WTP + \sigma_e 2/2) \quad \text{(Eq. 13-3)}$$

Where:

exp(·) = the exponential operator

ln_WTP = the predicted natural log of WTP for WQ improvements in a given WBID

σ_e^2 = the model residual variance (0.1876) taken from EPA (2009b).

The total WTP regression model presented above can be used to predict WTP for each of the studies in the database; however, estimates derived from regression models are subject to some degree of error and uncertainty. To better characterize the uncertainty or error bounds around predicted WTP, EPA used a procedure described by Krinsky and Robb (1986). The procedure involves sampling the variance–covariance matrix of the estimated coefficients, which is a standard output of the statistical package used to estimate the meta-analysis model. WTP values are then calculated for each drawing from the variance–covariance matrix and an empirical distribution of WTP values is constructed. By varying the number of drawings, it is possible to generate an empirical distribution with a desired degree of accuracy (Krinsky and Robb, 1986). The low and high estimate of WTP values is then identified based on the 10th and 90th percentile of WTP values from the empirical distribution. These bounds may help decision-makers understand the uncertainty associated with the benefit results.

EPA used the Krinsky and Robb (1986) procedure to estimate the 10th, 50th, and 90th percentiles of total WTP for both full time and part time seasonal residents, based on the results of the total WTP regression model. It is estimated that seasonal residents will live in the state for approximately 4 months of the year, therefore household WTP value for seasonal residents were weighted by 25%. WTP to pay is calculated separately for both flowing waters and lakes, because of the different size units for the two categories (i.e., miles and acres). **Exhibit 13-12** presents the results of these calculations. Although the confidence limits for WTP estimates related to the covariance matrix of meta-analysis parameter estimates can be estimated, these limits do not assess the sensitivity of results to changes in meta-regression model assumptions or specifications (cf. Johnston et al., 2005; 2006) or assumptions implied in benefit aggregation (cf. Loomis, 1996; Loomis et al., 2000; Bateman et al., 2006). As noted above, however, a number of assumptions and specifications lead to conservative benefit estimates.

Exhibit 13-12: Estimated Average Annual Household WTP for Water Quality Improvement in Florida (2010$)

State Resident Type	Flowing waters			Lakes		
	10th Percentile	50th Percentile	90th Percentile	10th Percentile	50th Percentile	90th Percentile
Full Time Resident	$1.52	$2.94	$4.71	$0.49	$0.89	$1.32
Part Time Winter Resident	$0.39	$0.78	$1.28	$0.13	$0.24	$0.38

WTP = willingness to pay

As shown in Exhibit 13-9 and Exhibit 13-10, a total of 15.2% of water miles in the analysis (6.1% water miles in the state) and 12.6% of water area in the analysis (1.5% of all water area in the state) may improve as a result of the numeric nutrient criteria. Average annual household WTP for full time residents for these improvements may be approximately $2.94 (mid-point estimate) for improvements in flowing waters and $0.89 (mid-midpoint estimate) for improvements in lakes. Part time residents have smaller average annual household WTP, with mid-point estimates ranging from $0.24 per household for improvements in lakes to $0.78 for improvements in flowing waters and springs.

13.3 Estimating Total WTP for Water Quality Improvements

To calculate WBID-level WTP, EPA estimated mean per-household WTP for both full-time and part-time residents and both lakes and flowing waters by WBID, and then multiplied by the number of households in each category in 2006 and the percentage of miles or area that comprise a given WBID. EPA calculated the number of full time households in the state by dividing the population estimates by the average number of people per household (U.S. Census Bureau, 2006a; 2006b), and the number of part-time households by dividing the number of seasonal residents from Smith and House (2006) by the average number of people per household (U.S. Census Bureau, 2006b). The total WTP equation for each reach is provided below (Equation 13-4):

$$TWTP_{WBID} = WTP(WQI_{baseline}, \Delta WQI) \times StateHH \times PercentMiles) \qquad \text{(Eq. 13-4)}$$

Where:

$TWTP_{WBID}$ = the WBID-level welfare change from improved water quality

WTP = the estimated WTP for water quality improvement for a given WBID based on baseline WQI (WQI baseline) and the expected change in water quality under the post-compliance scenario (ΔWQI)

$StateHH$ = the number of full-time or seasonal households in Florida

PercentMiles = the percentage of total miles (for flowing water) or total miles squared (for lakes) in the state of Florida that are comprised of a given WBID.

Finally, EPA aggregated WBID-level benefits to the state level for full time and part time households. As presented in **Exhibit 13-13**, full time resident annual benefits range from $6.48 million (mid-point estimate) for improvements in lakes to $21.31 million (mid-point estimate) for improvements in flowing waters. Seasonal resident annual benefits are much smaller, with mid-point estimates of $0.26 and $0.08 million for improvements in flowing waters and lakes, respectively. Total state benefits are approximately $28.12 million per year ($21.56 million of improvements in flowing waters and $6.56 million for improvements in lakes).

Exhibit 13-13: Potential Annual Benefits for Water Quality Improvement to Freshwater Flowing Waters and Lakes in Florida (Millions of 2010$ per year)

State Resident Type	Flowing waters			Lakes		
	10th Percentile	50th Percentile	90th Percentile	10th Percentile	50th Percentile	90th Percentile
Full Time Residents	$11.04	$21.31	$34.14	$3.58	$6.48	$10.02
Part Time Winter Residents	$0.13	$0.26	$0.42	$0.04	$0.08	$0.12
Total	$11.17	$21.56	$34.56	$3.62	$6.56	$10.14

Note that a portion of these benefits would be attributable to baseline controls for urban stormwater that are not yet fully implemented but would result in reductions in nutrient concentrations. It is not possible to identify the water quality that would result after full implementation of such controls. Thus, the portion of benefits attributable to controls not included in the cost analysis (because they are part of the baseline and required in the absence of the rule) is uncertain.

13.4 Uncertainty and Limitations

A number of issues are common to all benefit transfers. Benefit transfer involves adapting research conducted for another purpose in the available literature to address the policy questions at hand. Because benefits analysis of environmental regulations rarely affords enough time to develop original stated preference surveys that are specific to the policy effects, benefit transfer is often the only option to inform a policy decision. As a result, they are nearly universal in benefit-cost analyses (Smith et al., 2002).

Benefit transfers are by definition characterized by a difference between the context in which resource values are estimated and that in which benefit estimates are desired (Rosenberger and Phipps, 2007). The ability of meta-analysis to adjust for the influence of study, economic, and resource characteristics on WTP can minimize, but not eliminate, potential biases (Smith et al., 2002; Rosenberger and Stanley, 2006; Rosenberger and Phipps, 2007). As is typical in applied benefit transfers, the meta-analysis model used in this analysis provides an imperfect match to the context in which values are desired. Therefore, some beneficial effects may not be accounted for while others may be overestimated.

Some related and additional limitations inherent to the meta-analysis model and the subsequent benefit transfer include the numerous uncertainties and associated assumptions required to aggregate WTP across spatial jurisdictions, as detailed by Loomis (1996), Loomis et al. (2000) and Bateman et al. (2006), among others. While these uncertainties are well known, the literature does not agree on appropriate, standardized guidance for benefit aggregations, and applied benefit-cost analysis almost universally requires simplifying assumptions in order to generate defensible welfare aggregations. In an ideal context, analysts would have information necessary to estimate spatially referenced distance decay relationships for all changes resulting from policies under consideration (cf. Bateman et al., 2006). However, even the most advanced literature provides only simple illustrations of such issues, and none methodologically sufficient to support regulatory analysis.

In analyzing benefits of the rule, EPA estimated benefits from nutrient reductions to Florida households only. Although residents of other states may hold values for water resources outside of their home state, if such resources have personal, regional, or national significance, EPA did not have sufficient information to estimate WTP for water quality improvements in Florida for out of state residents. As a result, the population considered in the benefits analysis of the rule does not represent all the households that are likely to hold values for water resources in the state of Florida. Even if per household WTP for out-of-state residents are small they can be substantial in the aggregate if these values are held by a substantial fraction of the population.

Some resource valuation studies have found that respondents in the typical contingent market situation may overstate their WTP compared to their likely behavior in a real-world situation. However, the magnitude of hypothetical bias on the estimated WTP is uncertain. Following standard benefit transfer approaches, including Meta-analysis transfers, this analysis reflects the assumption that each source study provides a valid, unbiased estimate of the welfare measure under consideration (cf. Moeltner et al., 2007; Rosenberger and Phipps, 2007). To minimize potential hypothetical bias, EPA set independent variable values to reflect best benefit transfer practices.

The estimation of WTP may be sensitive to differences in the environmental water quality measures. Studies that did not use the WQI were mapped to the WQI so a comparison could be made across studies. The dummy variable (*WQI*) captures the effect of a study using (*WQI*=1) or not using the WQI (*WQI*=0). It was found that studies that did not use the WQI had lower WTP values. This may indicate that there may have been some systematic biases in the mapping of studies that did not use the WQI. In analyzing the benefits of this regulation, EPA set the WQI to one to reduce uncertainty in WTP estimates associated with studies that did not include WQI as a native survey instrument. EPA (2009b) provides a detailed discussion of water quality measures used in the original studies included in the meta-analysis.

Transfer error may occur when benefit estimates from a study site are adopted to forecast the benefits of a policy site. Rosenberger and Stanley (2006) define transfer error as the difference between the transferred and actual, generally unknown, value. While meta-analysis is fairly accurate when estimating benefit function, transfer error may be a problem in cases where the sample size is small. While meta-analyses have been shown to outperform other function-based transfer methods in many cases, this result is not universal (Shrestha et al., 2007). This notwithstanding, results reviewed by Rosenberger and Phipps (2007) are “very promising” for the performance of meta-analytic benefit transfers relative to alternative transfer methods.

Additional limitations and uncertainties are associated with the use of the WQI to link water quality changes from reduced nutrient discharges to effects on human uses and support for aquatic and terrestrial species habitat. These include, for example, that the estimated changes in WQI reflect only water quality improvements resulting directly from reductions in nutrient loadings but do not include potential improvements in water quality indicators indirectly associated with nutrient loadings (e.g., DO). This omission is likely to result in the underestimation of the expected water quality changes resulting from the rule because the combined impact of several pollutants on ambient water quality is likely to be greater than the sum of the individual impacts of reducing concentrations of nutrients. Appendix D provides a comparative analysis that considers improvements in DO.

Benefits attributed to improvements in springs are likely to be over estimates because of the length of time it may take for springs to improve as a result of the nutrient criteria. Due to the high porosity of the karst geology in the area, the Floridian Aquifer has highly accessible storage, meaning that flows to springs are only weakly responsive to short-term weather patterns, and it takes a long time for water from the massive aquifer to reach the springs. This implies that changes in nutrient loading may take decades to affect water quality in the springs. The WTP values above are all annual present values and have been calculated under the assumption that reductions in nutrient loadings will result in immediate improvements in water quality. Because the improvements in springs may take decades, these benefits are likely overstated because empirical evidence suggests that people value immediate or near-term benefits at higher levels than those acquired in the distant future. However, because the proportion of benefits resulting from water quality improvements in springs is so small (approximately 2% of total benefits), it is likely this overestimation has a very small impact on total benefits.

In addition, there is uncertainly surrounding the water quality measurements used to calculate the WQI values. Specifically, the use of 6-digit HUC averages may over or underestimate the values of a given WQI parameter for a particular WBID, as these averages are based on data from many waterbodies within the HUC, as water quality may very greatly between waterbodies within the fairly large 6-digit HUC level. There is also additional uncertainty surrounding all water quality data because of possible sampling or human reporting error.

Finally, the methodology used to translate instream sediment and nutrient concentrations into sub-index scores employs nonlinear transformation curves. Water quality changes that fall outside of the sensitive part of the transformation curve (i.e., above/below the upper/lower bounds) yield no benefit in the analysis.

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Appendix A. Potential Incremental Costs Associated with EPA's Rule Compared to FDEP's 2009 Draft Numeric Nutrient Criteria

This Appendix provides an estimate of the potential incremental costs of attaining EPA's numeric nutrient criteria compared to a baseline of the FDEP's July 2009 draft nutrient criteria.

A.1 Incrementally Impaired Waters

EPA used the same data and method described in Section 6.1 and 6.2 to identify potential incremental impairments under the FDEP's July 2009 draft numeric nutrient criteria. The one exception to this method relates to evaluation of FDEP's 2009 draft nitrate-nitrite criterion for clear streams and springs. This criterion is based on a monthly median that only applies in months when the median color is less than 40 Pt-Co. Due to limited color data corresponding to the months for which nutrient data are available, EPA did not identify springs that would be impaired under the FDEP's draft July 2009 criteria.

Exhibit A-1 summarizes the potential incremental impairments under based on FDEP's July 2009 draft numeric nutrient criteria.

Exhibit A-1. Potential Incrementally Impaired Waters under FDEP July 2009 Draft Numeric Nutrient Criteria

Category	Number of WBIDs			
	Lake	Stream[1]	Spring	Total
Total in State	1,310	3,901	126	5,337
Not Listed/Covered by TMDL[2]	1,099	3,608	119	4,826
Nutrient Data in IWR Run 40[3]	878	1,273	72	2,223
Sufficient Data Available[4]	655	930	--	1,585
Potentially Exceeding Criteria[5]	114	111	--	225

IWR = Impaired Waters Rule
TMDL = total maximum daily load
WBID = waterbody identification

1. Includes blackwater.
2. As reported in TMDL documents and FDEP (2009c).
3. Data within last 5 years meeting data quality requirements.
4. Annual geometric means based on at least 4 samples with one sample from May to September and one sample from October to April in a given year. For monthly geometric mean, there are no data requirements.
5. Based on annual geometric mean exceeding the applicable TN or TP criterion more than once in a three year period.

Of the 225 waters shown in Exhibit A-1, 220 would also be impaired based on EPA's numeric nutrient criteria. Thus, the incremental number of impairments associated with EPA's rule that are over and above those that would be associated with FDEP's July 2009 draft criteria as the baseline is 325 – 220 = 105 (the difference between those shown in Exhibit 6-1 and the waters that would be impaired under the FDEP draft criteria as well as under EPA's rule).

Exhibit A-2 shows the land use surrounding these waters based on the method described in Section 6.4 of this report (acreage within 10-digit HUCs that include at least 10% of incrementally impaired waters that are not also included in the watersheds of waters already impaired under the narrative criterion).

Exhibit A-2. Summary of Land Use for Potential Incrementally Impaired Watersheds: EPA Rule Compared to FDEP July 2009 Draft Numeric Nutrient Criteria[1]

Land Use Category	Land Use Area	Percent of Total
Forest	1,114,155	38%
Wetlands	713,525	24%
Agriculture	736,024	25%
Urban	206,513	7%
Other	51,949	2%
Water	64,530	2%
Industrial	14,493	<1%
Transportation Corridors	13,259	<1%
Communications and Utilities	9,480	<1%
Total	2,923,929	100%

Note: Detail may not add to total due to independent rounding.
1. Represents 10-digit HUCs containing at least 10% of the 225 waters that are impaired under FDEP's July 2009 draft numeric nutrient criteria.

A.2 Municipal and Industrial Dischargers

Both FDEP's 2009 draft criteria and EPA's nutrient criteria are at or below the target treatment levels for TN and TP for municipal wastewater treatment plants (WWTPs) and industrial dischargers. Based on the methods described in Sections 4 and 5, EPA estimated that the cost to municipal and industrial dischargers to meet FDEP 2009 draft criteria are the same as the costs to municipal and industrial discharger to meet EPA's nutrient criteria, even though the criteria themselves are different. Thus, the incremental cost of meeting EPA's criteria would be zero compared to a baseline of the FDEP's July 2009 draft nutrient criteria.

A.3 Urban Stormwater

Based on the data and methods described in Section 7, EPA estimated acres of urban land in the incrementally impaired watersheds for lakes and streams based on FDEP's July 2009 draft nutrient criteria that could potentially need incremental controls. **Exhibit A-3** summarizes this analysis.

Exhibit A-3: Urban Land in Incrementally Impaired Watersheds based on FDEP's 2009 Draft Nutrient Criteria Potentially Needing Controls

Land Type	Estimated Acres in Incrementally Impaired Watersheds	Estimated Acres Potentially Needing Controls[1]
MS4 Phase I Urban	44,300	0 - 34,500
MS4 Phase II Urban	72,700	22,200
Non-MS4 Urban	91,200	25,100
Total	208,200	47,300 - 81,900

Note: Detail may not add to total due to independent rounding
1. Phase I MS4s range represents implementation of BMPs to the MEP resulting in compliance with EPA's rule or controls needed on all pre-1982 developed land; Phase II MS4s and urban land outside of MS4s represent controls needed on all pre-1982 developed land that is not low density residential.

Using the median cost for stormwater controls from FDEP (2010b) of $6,800 per acre and O&M costs equal to 5% of capital costs [consistent with FDEP (2010b) assumption of O&M equal to 5% of capital costs], EPA estimated the cost of controls for the acres potentially needing controls. These estimates are shown in **Exhibit A-4**.

Exhibit A-4: Estimated Urban Stormwater Cost Scenarios Associated with FDEP's July 2009 Draft Nutrient Criteria (2010 dollars)

Land Type	Acres Needing Controls[1]	Capital Cost (millions $)[2]	O&M Cost (millions $)[3]	Annual Cost (millions $)[4]
MS4 Phase I Urban	0 - 34,500	$0 - $236.0	$0 - $11.8	$0 - $34.1
MS4 Phase II Urban	22,200	$151.8	$7.6	$21.9
Non-MS4 Urban	25,100	$171.8	$8.6	$24.8
Total	47,300 - 81,900	$323.6 - $559.7	$16.2 - $28.0	$46.7 - $80.8

1. See Exhibit 7-2. Phase I MS4s range represents implementation of BMPs to the MEP resulting in compliance with EPA's rule or controls needed on all pre-1982 developed land; Phase II MS4s and urban land outside of MS4s represent controls needed on all pre-1982 developed land that is not low density residential.
2. Represents acres needing controls multiplied by median unit costs of stormwater retrofit costs from FDEP (2010b).
3. Represents 5% of capital costs.
4. Capital costs annualized at 7% over 20 years plus annual O&M costs.

Exhibit A-5 shows the calculation of incremental costs of EPA's rule compared to these baseline costs.

Exhibit A-5: Potential Incremental Urban Stormwater Costs: FDEP July 2009 Draft Criteria Baseline

Scenario	Total Annual Costs ($/yr)
Cost to Attain EPA's Rule[1]	$60.5 - $108.0
Costs to Attain FDEP 2009 Draft Criteria[1]	$46.7 - $80.8
Difference[2]	$13.7 - $27.2

1. Compared to baseline reflecting current impairments.
2. Represents difference between incremental costs needed for compliance with EPA's rule compared to the baseline reflective of current impairments and costs needed for compliance with FDEP's 2009 draft nutrient criteria compared to the baseline reflective of current impairments.

A.4 Agriculture

EPA used the data and methods described in Section 8 to estimate potential costs to agricultural operations associated with meeting FDEP's July 2009 draft nutrient criteria. **Exhibit A-6** shows estimates of the potential incremental costs to agriculture that may be needed to reduce nutrients to levels that attain FDEP's criteria for lakes and streams. EPA derived these estimates by multiplying the number of potentially affected acres in each category of agricultural operation with the unit costs of the Owner plus Typical programs from SWET (2008a).

Exhibit A-6: Potential Agricultural Control Costs Associated with Incrementally Impaired Lakes and Streams based on FDEP's 2009 Draft Nutrient Criteria

Agricultural BMP Category	Area (acres)[1]	Owner plus Typical Program Unit Cost ($/ac/yr)[2]	Total Owner plusTypical Program Costs ($/yr)
Animal Feeding	1,300 - 1,312	$18.56	$24,131 - $24,348
Citrus	17,637 - 53,962	$156.80	$2,765,475 - $8,461,215
Cow Calf Production, Improved Pastures	163,128 - 212,480	$15.84	$2,583,953 - $3,365,685
Cow Calf Production, Unimproved Pastures	44,484 - 51,883	$4.22	$187,902 - $219,154
Cow Calf Production, Rangeland and Wooded	67,796 - 79,109	$4.22	$286,369 - $334,155
Row Crop	14,637 - 18,859	$70.40	$1,030,446 - $1,327,700
Cropland and Pastureland (general)[3]	58,756 - 64,860	$27.26	$1,601,448 - $1,767,826
Sod/Turf Grass	2,063	$35.20	$72,624
Ornamental Nursery	849 - 993	$70.00	$59,413 - $69,483
Dairies	588 - 627	$334.40	$196,576 - $209,550
Horse Farms	1,190 - 1,191	$15.84	$18,854 - $18,860
Field Crop (Hayland) Production	168,271 - 195,878	$18.56	$3,123,114 - $3,635,491
Other Areas[4]	30,430 - 37,251	$18.56	$564,784 - $691,386
Total[5]	571,130 - 720,467	--	$12,515,087 - $20,197,475

Note: Detail may not add to total due to independent rounding.

1. Based on GIS analysis of land use data from five water management districts (for entire state) and FDACS BMP program NOI GIS data layer. Low end reflects acres in incrementally impaired HUCs (that are not included in HUCs for baseline impairment) that are not enrolled in BMPs under FDACS; high end reflects all acres in incrementally impaired HUCs, regardless of FDACS BMP enrollment.
2. Cost estimates from SWET (2008a); representative of 2010 prices (personal communication with D. Bottcher, 2010).
3. Owner/typical BMP unit costs based on average costs for improved pastures, unimproved/wooded pasture, row crops, and field crops.
4. Includes FLUCCS Level 3 codes 2160, 2200, 2230, 2400, 2410, 2500, 2540, and 2550.
5. Excludes land not in production.

In addition to agricultural controls to control lakes and streams, controls may also be needed on other agricultural land to meet FDEP's draft nitrate-nitrite criterion for clear streams and springs. Thus, based on the method described in Section 8.3.2, EPA assumed that nutrient management would be appropriate on all land categorized as general agriculture and specialty crop that is not impaired under the narrative criterion or would need controls to meet the draft lakes and streams criteria (1.2 million acres). **Exhibit A-7** shows the estimate of the potential cost of additional nutrient management to protect Florida springs.

Exhibit A-7: Potential Agricultural Control Costs Associated with Impaired Springs based on FDEP's 2009 Draft Nitrate-Nitrite Criterion

Nutrient Management Program Type	Total Acres in Florida[1]	Acres Needing Nutrient Management[2]	Unit Cost ($/acre)[3]	Total Cost	Annual Cost ($/year)[4]
General Agriculture	4,885,643	1,137,931	$10	$11,379,311	$4,336,105
Specialty Crop[5]	1,057,107	113,366	$20	$2,267,323	$863,967
Total	5,942,750	1,251,297	--	$13,646,634	$5,200,073

1. Excludes unimproved and woodland pastures, abandoned groves, aquaculture, tropical fish farms, open rural lands, and fallow cropland.
2. Calculated by subtracting agricultural land in incrementally impaired watersheds needing controls and agricultural land types participating in FDACS BMP program (assuming all Tri-county agricultural area land is regular nutrient management land) from total land use area in Florida.
3. Source: FL EQIP (2009a).
4. Costs annualized at 7% over 3 years.
5. Specialty crop land use types include row crops, citrus groves, fruit orchards, other groves, nurseries and vineyards, sod farms, and floriculture.

Exhibit A-8 summarizes the estimated costs to agricultural operations that could potentially be associated with FDEP's 2009 draft nutrient criteria.

Exhibit A-8: Potential Annual Control Costs for Agricultural Sources based on FDEP's July 2009 Draft Nutrient Criteria

Waterbody Type	Acres Needing BMPs	Annual Costs[1]
Lakes and Streams	571,130 - 720,467	$12.5 - $20.2
Springs	1,251,297	$5.2
Total	1,822,427 – 1,971,764	$17.7 - $25.4

1. For lakes and flowing waters, low cost reflects owner/typical BMP program estimated by SWET (2008a) for the Caloosahatchee River and St. Lucie River watersheds for all acres in incrementally impaired watersheds not enrolled in FDACS BMP program; high cost represents a more aggressive level of control on all agricultural acres in the incrementally impaired watersheds based on the alternative program from SWET (2008a). For springs, costs represent implementation of nutrient management on all farms in the state not located in a baseline or incrementally impaired watershed.

Exhibit A-9 shows the calculation of incremental costs of EPA's rule compared to these baseline costs.

Exhibit A-9: Potential Incremental Agriculture Costs: FDEP July 2009 Draft Criteria Baseline

Scenario	Total Annual Costs ($/yr)
Cost to Attain EPA's Rule[1]	$19.9 - $20.3
Costs to Attain FDEP 2009 Draft Criteria[1]	$17.7 - $25.4
Difference[2]	(-$2.4) - $2.1

1. Compared to narrative criterion baseline.
2. Represents difference between incremental costs needed for compliance with EPA's rule compared to the narrative criterion baseline and costs needed for compliance with FDEP's 2009 draft nutrient criteria compared to the narrative criterion.

A.5 Septic Systems

Based on the method described in Section 9, EPA estimated that there are 6,541 active septic systems within 500 feet of water in 10-digit HUCs in watersheds that could be identified as impaired based on FDEP's 2009 draft numeric nutrient criteria (that are not already on the 303(d) list for nutrients or under a TMDL). Thus, potential annual costs associated with FDEP's July 2009 draft nutrient criteria may range from $5.3 million to $8.5 million.

Exhibit A-10 shows the calculation of incremental costs of EPA's rule compared to these baseline costs.

Exhibit A-10: Potential Incremental Costs Associated with Upgrading Septic Systems: FDEP 2009 Draft Criteria Baseline

Scenario	Total Annual Costs ($/yr)
Cost to Attain EPA's Rule[1]	$6.6 - $10.7
Costs to Attain FDEP 2009 Draft Criteria[1]	$5.3 - $8.5
Difference[2]	$1.3 - $2.2

1. Compared to narrative criterion baseline.
2. Represents difference between incremental costs needed for compliance with EPA's rule compared to the narrative criterion baseline and costs needed for compliance with FDEP's 2009 draft nutrient criteria compared to the narrative criterion.

A.6 Government Costs

FDEP may incur costs associated with development of additional TMDLs. Because existing TMDLs cover an average of two waterbodies each, FDEP may need to develop 113 new TMDLs (225 impaired WBIDs ÷ 2 = 113 TMDLs). EPA (2001) indicates that TMDL development for two similar pollutants costs an average of approximately $47,000. Thus, total TMDL development cost associated with FDEP's draft nutrient criteria could be $5.3 million, or $590,000 per year assuming FDEP adheres to its 9-year TMDL development cycle. The incremental costs of TMDL development under EPA's rule compared to the FDEP draft numeric nutrient criteria baseline is approximately $0.3 million per year ($0.9 million - $0.6 million).

A.7 Summary and Comparison

Exhibit A-11 summarizes the incremental costs of EPA's rule based on the FDEP baseline, calculated as the difference between potential annual incremental costs of attaining EPA's criteria based on the narrative criterion baseline and the estimated incremental costs based on attaining FDEP's 2009 draft nutrient criteria compared to the narrative criterion baseline.

Exhibit A-11: Potential Incremental Costs Associated with EPA's Numeric Nutrient Criteria: FDEP 2009 Draft Criteria Baseline (2010 dollars)

Source Sector	Annual Cost (millions)		
	Cost to Attain EPA's Rule	Costs to Attain FDEP 2009 Draft Criteria	Difference
Municipal Wastewater[1]	$22.3 - $38.1	$22.3 - $38.1	$0.0
Industrial Dischargers[2]	$25.4	$25.4	$0.0
Urban Stormwater[4]	$60.5 - $108.0	$46.7 - $80.8	$13.7 - $27.2
Agriculture[5]	$19.9 - $23.0	$17.7 - $25.4	$2.1 - (-$2.4)
Septic Systems[6]	$6.6 - $10.7	$5.3 - $8.5	$1.3 - $2.2
Government/Program Implementation	$0.9	$0.6	$0.3
Total	$135.5 - $206.1	$118.0 - $178.9	$17.5 - $27.2

Note: Detail may not add to total due to independent rounding.

BNR = biological nutrient removal; FDEP = Florida Department of Environmental Protection; TMDL = total maximum daily load; TN = total nitrogen; TP = total phosphorus

1. Based on upgrading existing treatment processes to advanced BNR.
2. Based on extrapolation of average annual costs per flow for random sample of dischargers stratified by industrial category.
4. Based on median stormwater control costs from FDEP (2010a), and scenario of need for structural controls on land developed before 1982.
5. Based on implementing nutrient management on all crop land outside of incrementally and baseline impaired watersheds and scenarios in which all agricultural land not enrolled in the FDACS BMP program in incrementally impaired watersheds incurs owner/typical program costs from SWET (2008a) or all agricultural land in incrementally impaired watersheds incurs owner/typical costs based on SWET (2008a).
6. Based on upgrading to advanced nutrient removal active septic systems within 500 feet of water (based on GIS land use data) in incrementally impaired watersheds.
7. Based on average costs to complete TMDLs for incrementally impaired waters under a 9-year schedule.

Appendix B. Sensitivity Analysis: Potential Impacts without DPVs for Stream Criteria

This Appendix provides analysis of the sensitivity of incremental impairments and costs to the assumption that downstream protection value (DPV) criteria are applicable to all WBIDs intersecting lakes.

B.1 Incrementally Impaired Streams

EPA's estimates of incremental impairments and potential costs reflect the assumption that DPVs for lakes would apply in all streams intersecting lake WBIDs. However, the WBID data does not include information on direction of flow, and some stream segments may be downstream rather than upstream of lakes. Thus, the assumption that the DPV would apply to downstream WBIDs will overstate potential incremental impairments and costs. Also, even for upstream WBIDs, there may be instances in which the DPVs would not be relevant to the entire stream (some WBIDs are much larger than others).

To estimate the change in incremental impairments associated with exceedances of stream criteria without consideration of DPVs, EPA used the same data and method described in Section 6.1 and 6.2. **Exhibit B-1** summarizes the potential incremental impairments with and without considering DPVs.

Exhibit B-1: Potential Incrementally Impaired Streams with and without Consideration of DPVs

Category	Number of Stream WBIDs		
	DPVs Apply to Streams Intersecting Lakes[1]	DPVs Do Not Apply to Streams	Difference
Total in State	3,901	3,901	0
Not Listed/Covered by TMDL[2]	3,608	3,608	0
Nutrient Data in IWR Run 40[3]	1,273	1,273	0
Sufficient Data Available[4]	930	930	0
Potentially Exceeding Criteria[5]	153	121	32

IWR = Impaired Waters Rule
TMDL = total maximum daily load
WBID = waterbody identification
1. Based on meeting applicable DPV in all WBIDs intersecting lakes, without consideration of direction of flow or site specific modeling, which may overstate incremental impairments under the rule.
2. As reported in TMDL documents and FDEP (2009c).
3. Data within last 5 years meeting data quality requirements.
4. Annual geometric means based on at least 4 samples with one sample from May to September and one sample from October to April in a given year.
5. Based on annual geometric mean exceeding the applicable TN or TP criterion more than once in a three year period.

B.2 Municipal and Industrial Point Source Dischargers

The estimated costs to municipal WWTP and industrial dischargers remain the same with the exclusion of DPVs from the analysis.

B.3 Urban Stormwater

To estimate costs to urban stormwater sources, EPA used the methods described in Section 7 based on GIS analysis of urban land use surrounding waters impaired based on EPA's numeric nutrient criteria not accounting for DPVs for streams. **Exhibit B-2** shows the estimated number of acres, the acres potentially needing stormwater controls, and the annual costs of those controls.

Exhibit B-2: Estimated Incremental Urban Stormwater Costs: No DPVs

Land Type	Urban Acres	Acres Needing Controls[1]	Capital Cost (millions $)[2]	O&M Cost (millions $)[3]	Annual Cost (millions $)[4]
MS4 Phase I Urban	60,600	0 – 47,200	$0 - $322.5	$0 - $16.1	$0 - $46.6
MS4 Phase II Urban	86,700	29,600	$202.2	$10.1	$29.2
Non-MS4 Urban	95,700	26,500	$178.4	$8.9	$25.8
Total	243,000	55,700 – 103,200	$380.6 - $703.1	$19.0 - $35.2	$55.0 - $101.5

1. Phase I MS4s range represents implementation of BMPs to the MEP resulting in compliance with EPA's rule or controls needed on all pre-1982 developed land; Phase II MS4s and urban land outside of MS4s represent controls needed on all pre-1982 developed land that is not low density residential.
2. Represents acres needing controls multiplied by median unit costs of stormwater retrofit costs from FDEP (2010b).
3. Represents 5% of capital costs.
4. Capital costs annualized at 7% over 20 years plus annual O&M costs.

Compared to the results obtained considering potential applicability of DPVs, costs for control of urban sources may be on the order of $5.5 million to $6.5 million less if DPVs do not apply ($60.5 million - $55 million = $5.5 million; $108 million - $101.5 million = $6.5 million).

B.4 Agriculture

To estimate the costs to agriculture associated with EPA's numeric nutrient criteria not accounting for DPVs for streams, EPA used the methods described in Section 8. **Exhibit B-3** shows estimates of the potential costs to agriculture of implementing owner plus typical BMP programs from SWET (2008a) for the St. Lucie and Caloosahatchee TMDLs. The range of potentially affected acres represent 1) agricultural acres near incrementally impaired waters that are not currently enrolled in the FDACS BMP program and 2) all agricultural acres near incrementally impaired waters whether or not they are currently enrolled in the FDACS BMP program.

Exhibit B-3: Potential Incremental Agricultural Control Costs for Lakes and Streams: No DPVs

Agricultural BMP Category	Area (acres)[1]	Owner plus Typical Program Unit Cost ($/ac/yr)[2]	Total Owner plusTypical Program Costs ($/yr)
Animal Feeding	1,575 - 1,607	$18.56	$29,228 - $29,817
Citrus	15,429 - 27,290	$156.80	$2,419,333 - $4,279,024
Cow Calf Production, Improved Pastures	135,594 - 150,185	$15.84	$2,147,805 - $2,378,928
Cow Calf Production, Unimproved Pastures	43,481 - 45,483	$4.22	$183,664 - $192,121
Cow Calf Production, Rangeland and Wooded	66,310 - 67,572	$4.22	$280,093 - $285,425
Row Crop	7,488 - 9,449	$70.40	$527,139 - $665,240
Cropland and Pastureland (general)[3]	152,976 - 160,814	$27.26	$4,169,512 - $4,383,135
Sod/Turf Grass	1,977	$35.20	$69,587
Ornamental Nursery	840	$70.00	$58,783
Dairies	583 - 621	$334.40	$194,803 - $207,777
Horse Farms	1,285	$15.84	$20,359
Field Crop (Hayland) Production	173,070 - 193,357	$18.56	$3,212,186 - $3,588,706
Other Areas[4]	53,275 - 66,140	$18.56	$988,775 - $1,227,556
Total[5]	653,881 - 726,620	--	$14,301,260 - $17,386,457

Note: Detail may not add to total due to independent rounding.

1. Based on GIS analysis of land use data from five water management districts (for entire state) and FDACS BMP program NOI GIS data layer. Low end reflects acres in incrementally impaired HUCs (that are not included in HUCs for baseline impairment) that are not enrolled in BMPs under FDACS; high end reflects all acres in incrementally impaired HUCs, regardless of FDACS BMP enrollment.
2. Cost estimates from SWET (2008a); representative of 2010 prices (personal communication with D. Bottcher, 2010).
3. Owner/Typical BMP unit costs based on average costs for improved pastures, unimproved/wooded pasture, row crops, and field crops.
4. Includes FLUCCS Level 3 codes 2160, 2200, 2230, 2400, 2410, 2500, 2540, and 2550.
5. Excludes land not in production.

EPA estimated the costs of nutrient management to reduce nitrate-nitrite in springs as described in Section 8.3.2. As shown in **Exhibit B-4**, the nutrient management costs increase slightly when excluding DPVs from the analysis because fewer acres would need BMPs for lake and stream impairments.

Exhibit B-4: Potential Agricultural Control Costs Associated with Incrementally Impaired Springs: No DPVs

Nutrient Management Program Type	Total Acres in Florida[1]	Acres Needing Nutrient Management[2]	Unit Cost ($/acre)[3]	Total Cost	Annual Cost ($/year)[4]
General Agriculture	4,885,643	1,044,085	$10	$10,440,846	$3,978,502
Specialty Crop[5]	1,057,107	122,070	$20	$2,441,409	$930,303
Total	5,942,750	1,166,155	--	$12,882,255	$4,908,805

1. Excludes unimproved and woodland pastures, abandoned groves, aquaculture, tropical fish farms, open rural lands, and fallow cropland.
2. Calculated by subtracting agricultural land in incrementally impaired watersheds needing controls and agricultural land types participating in FDACS BMP program (assuming all Tri-county agricultural area land is regular nutrient management land) from total land use area in Florida.
3. Source: FL EQIP (2009a).
4. Costs annualized at 7% over 3 years.
5. Specialty crop land use types include row crops, citrus groves, fruit orchards, other groves, nurseries and vineyards, sod farms, and floriculture.

Exhibit B-5 summarizes the estimated costs to agricultural operations that could potentially be indirectly associated with EPA's numeric nutrient criteria not accounting for DPVs for streams.

Exhibit B-5: Potential Annual Incremental Control Costs for Agricultural Sources: No DPVs

Waterbody Type	Acres Needing BMPs	Annual Costs[1]
Lakes and Flowing waters	653,881 - 726,620	$14,301,260 - $17,386,457
Springs	1,166,155	$4,908,805
Total	1,820,036 – 1,892,775	$19,210,065 - $22,295,261

1. For lakes and flowing waters, low cost reflects owner/typical BMP program estimated by SWET (2008a) for the Caloosahatchee River and St. Lucie River watersheds for all acres in incrementally impaired watersheds not enrolled in FDACS BMP program; high cost represents a more aggressive level of control on all agricultural acres in the incrementally impaired watersheds based on the alternative program from SWET (2008a). For springs, costs represent implementation of nutrient management on all farms in the state not located in a baseline or incrementally impaired watershed.

Compared to the results obtained considering potential applicability of DPVs, agricultural control costs associated with attaining the criteria may be $0.6 million to $0.7 million less if DPVs are not applicable to streams intersecting lakes ($19.9 million - $19.2 million = $0.6 million; $23.0 million - $22.3 million = $0.7 million).

B.5 Septic Systems

EPA estimated that there are 8,043 active septic systems within 500 feet of water in 10-digit HUCs in watersheds that could be identified as impaired based on EPA's numeric nutrient criteria, not considering DPVs for streams intersecting lakes based on the method described in Section 9. Total potential annual costs could range from $6.4 million to $10.5 million.

Compared to the results obtained considering potential applicability of DPVs, septic system control costs associated with attaining the criteria if DPVs are not applicable to streams intersecting lakes are approximately $0.1 million to $0.2 million less per year ($6.6 million - $6.4 million = $0.1 million; $10.7 million - $10.5 million = -$0.2 million).

B.6 Government Costs

EPA determined that existing nutrient-related TMDLs in Florida address an average of two WBIDs each. Using the average number of WBIDs per TMDL, EPA estimated that 155 additional nutrient TMDLs may be required under the scenario in which DPVs for streams are excluded from the analysis (e.g., 309 incrementally impaired WBIDs ÷ 2 WBIDs per TMDL). Multiplying the average per TMDL cost of $47,000 by EPA's estimate of 155 additional TMDLs results in an estimated total cost of approximately $7.3 million, or approximately $809,000 per year based on a 9-year TMDL development schedule.

Compared to the results obtained considering potential applicability of DPVs, annual government costs for TMDL development may be $0.1 million less if DPVs are not applicable to streams intersecting lakes ($0.9 million - $0.8 million = $0.1 million).

B.7 Summary and Comparison

Exhibit B-6 summarizes EPA's estimates of potential annual incremental costs associated with excluding DPVs for streams from the analysis compared to the estimated incremental costs based on application of DPVs to any stream intersecting a lake.

Exhibit B-6: Comparison of Potential Annual Costs Associated with Numeric Nutrient Criteria (2010 dollars)

Source Sector	Annual Cost (millions)	
	No DPV Scenario	DPV Scenario
Municipal Wastewater[1]	$22.3 - $38.1	$22.3 - $38.1
Industrial Dischargers[2]	$25.4	$25.4
Urban Stormwater[4]	$55.0 - $101.5	$60.5 - $108.0
Agriculture[5]	$19.2 - $22.3	$19.9 - $23.0
Septic Systems[6]	$6.4 - $10.5	$6.6 - $10.7
Government/Program Implementation	$0.8	$0.9
Total	$129.1 - $198.6	$135.5 - $206.1

Note: Detail may not add to total due to independent rounding.
BNR = biological nutrient removal; DPV = downstream protection value; TMDL = total maximum daily load; TN = total nitrogen; TP = total phosphorus
1. Based on upgrading existing treatment processes to advanced BNR.
2. Based on extrapolation of average annual costs per flow for random sample of dischargers stratified by industrial category.
4. Based on median stormwater control costs from FDEP (2010a), and scenario of need for structural controls on land developed before 1982.
5. Based on implementing nutrient management on all crop land outside of incrementally and baseline impaired watersheds and scenarios in which all agricultural land not enrolled in the FDACS BMP program in incrementally impaired watersheds incurs owner/typical program costs from SWET (2008a) or all agricultural land in incrementally impaired watersheds incurs owner/typical costs based on SWET (2008a).
6. Based on upgrading to advanced nutrient removal active septic systems within 500 feet of water (based on GIS land use data) in incrementally impaired watersheds.
7. Based on average costs to complete TMDLs for incrementally impaired waters under a 9-year schedule.

As shown in the exhibit, excluding DPVs for streams from the analysis results in total annual costs approximately $6.4 million to $7.4 million less than the incremental costs EPA estimated taking DPVs for streams intersecting lakes into account.

Appendix C. Municipal WWTP Cost Estimates

Exhibit C-1 shows the cost estimates for municipal WWTP discharging to lakes or flowing waters in Florida.

Exhibit C-1: Potential Costs to Municipal WWTPs for Compliance with Numeric Nutrient Criteria

NPDES No.	Discharger Name	Flow (mgd)	Nutrient Region/ Lake Type	Reductions Needed		Total Capital Costs	Annual O&M Costs
				TN	TP		
Majors							
FL0037966	Orlando-Iron Bridge	40	Peninsula	No	No	$0	$0
FL0040436	Pinellas Co - S. Cross Bayou	33	West Central	No	No	$0	$0
FL0039772	W. Carl Dicks WWTP	13.7	Peninsula	No	No	$0	$0
FL0128937	Clearwater City of Northeast	13.5	West Central	No	No	$0	$0
FL0033251	Altamonte Springs/Swofford	12.5	Peninsula	No	No	$0	$0
FL0038849	Orange Cty-East Svc Area WWTP	11.2	Peninsula	No	No	$0	$0
FL0027821	River Oaks AWWTP	10	West Central	Yes	Yes	$13.0 – 24.8	$1.4 – 1.7
FL0026557	Plant City STP	8	West Central	Yes	No	$5.6 – 6.3	$0.3 – 0.5
FL0023493	JEA - Mandarin WWTF	7.5	Peninsula	No	Yes	$5.4 – 12.9	$0.7 – 1.2
FL0027251	Gainesville-Main St WTP 1 and 2	7.5	Peninsula	No	Yes	$5.4 – 12.9	$0.7 – 1.23
FL0020303	Deland/Wiley M. Nash Water	7.37	Peninsula	No	Yes	$5.3 – 12.7	$0.7 – 1.2
FL0020141	Sanford-Municipal WTP	7.3	Colored	No	No	$0	$0
FL0021369	Bradenton WTP	6	West Central	Yes	Yes	$7.8 – 14.9	$0.8 – 1.0
FL0040983	Hillsborough Cty Valrico WWTP	6	West Central	Yes	Yes	$7.8 – 14.9	$0.8 – 1.0
FL0036820	Hillsborough Cty - Dale Mabry	6	West Central	No	Yes	$4.3 – 10.3	$0.6 – 1.0
FL0025151	Clay Cty Miller St WWTP	5	Peninsula	No	Yes	$3.6 – 8.6	$0.5 – 0.8
FL0036048	Winter Haven #3 Wahneta	5	Peninsula	No	No	$0	$0
FL0043834	Fleming Island Reg. WWTF	4	Peninsula	No	Yes	$2.9 – 6.9	$0.4 – 0.6
FL0028061	Hillsborough Co-Southwest WTP	3.95	West Central	Yes	Yes	$5.1 – 9.8	$0.6 – 0.7
FL0041441	Venice - Eastside WWTP	3	West Central	Yes	Yes	$3.9 – 7.4	$0.4 – 0.5
FL0040061	Palatka WWTF	3	Peninsula	No	No	$0	$0
FL0036251	Wekiva Hunt Club STP	2.9	Peninsula	No	No	$0	$0
FL0023922	Orange Park-Ash St STP	2.5	Peninsula	No	Yes	$1.8 – 4.3	$0.2 – 0.4
FL0021903	Milton City of (STP)	2.5	Panhandle West	No	Yes	$1.9 – 4.3	$0.2 – 0.4
FL0042625	Seminole Cty Dept of	2.5	Peninsula	No	No	$0	$0

Exhibit C-1: Potential Costs to Municipal WWTPs for Compliance with Numeric Nutrient Criteria

NPDES No.	Discharger Name	Flow (mgd)	Nutrient Region/ Lake Type	Reductions Needed		Total Capital Costs	Annual O&M Costs
				TN	TP		
	Evio Srv						
FL0027511	William Tyson WWTP	2	Peninsula	No	No	$0	$0
FL0020109	Winter Garden STP	2	Clear	No	No	$0	$0
FL0039721	Clay Cty Ridaught Landing WWTP	1.875	Peninsula	No	No	$0	$0
FL0028126	Starke-Municipal STP	1.65	Peninsula	Yes	Yes	$2.1 – 4.1	$0.2 – 0.3
FL0026867	Blountstown-STP	1.5	Panhandle West	Yes	No	$1.1 – 1.2	$0.06 – 0.1
FL0029033	City of Quincy WWTP	1.5	Panhandle East	No	Yes	$1.1 – 2.6	$0.1 – 0.2
FL0027731	Bonifay STP	1.4	Panhandle West	Yes	Yes	$1.8 – 3.5	$0.2
FL0040495	MacClenny WTP	1.3	North Central	Yes	Yes	$1.7 – 3.2	$0.2
FL0031402	FL State Hospital	1.3	Panhandle East	Yes	Yes	$1.7 – 3.2	$0.2
FL0026387	Perry STP	1.25	Panhandle East	No	No	$0	$0
FL0027880	Jasper-WWTP	1.2	North Central	No	No	$0	$0
FL0038555	Fac1 of Graceville WWTP	1.1	Panhandle West	Yes	Yes	$1.4 – 2.7	$0.2
FL0103349	Titusville South – Blue Heron	4	Peninsula	No	No	$0	$0
FL0428523	North Bay WWTP	1.5	Panhandle West	No	No	$0	$0
FL0043214	Martin County Consolidated	1.97	Peninsula	No	No	$0	$0
FL0102679	BCUD/South Central	5.5	Peninsula	No	No	$0	$0
FL0038857	Apalachicola City	1	Panhandle West	No	No	$0	$0
FL0027839	Monticello-STP	1	Panhandle East	Yes	Yes	$1.3 – 2.5	$0.1 – 0.2
					Majors Total	$85.9 – 173.9	$9.6 – 13.9
Minors							
FL0186261	City of Clearwater - Master Reuse System	40	West Central	No	No	$0	$0
FL0127272	Pasco County Master Reuse System	26.75	West Central	No	No	$0	$0
FL0112895	G.R.U. STP #5-Kanapaha	10	Colored	No	Yes	$7.2 – 17.2	$0.9 – 1.6
FL0134589	Dolomite Utilities Fruitville	1.5	West Central	Yes	Yes	$1.9 – 3.7	$0.2 – 0.3
FL0043591	JEA - Julington Creek WWTF	1	Peninsula	No	Yes	$0.7 – 1.7	$0.1 – 0.2
FL0022853	USA Nat Guard Camp	0.9	Peninsula	Yes	Yes	$1.2 – 2.2	$0.1 – 0.2

Exhibit C-1: Potential Costs to Municipal WWTPs for Compliance with Numeric Nutrient Criteria

NPDES No.	Discharger Name	Flow (mgd)	Nutrient Region/ Lake Type	Reductions Needed		Total Capital Costs	Annual O&M Costs
				TN	TP		
	Blanding						
FL0020338	Mulberry STP	0.75	West Central	Yes	No	$0.5 – 0.6	$0
FL0020915	Green Cove Springs WTP	0.75	Peninsula	No	No	$0	$0
FL0021466	Auburndale Allred WWTP	0.65	Peninsula	No	No	$0	$0
FL0030210	Green Cove Spgs-Reynolds	0.5	Peninsula	No	No	$0	$0
FL0027669	Chattahoochee City of (STP)	0.5	Panhandle East	No	No	$0	$0
FL0040029	Avon Park Correctional Inst	0.5	Peninsula	Yes	Yes	$0.6 – 1.2	$0.07 – 0.09
FL0102202	Pace Water System Inc. WWTP #1	0.45	Panhandle West	No	No	$0	$0
FL0027812	Baldwin WWTF	0.4	Peninsula	Yes	Yes	$0.5 – 1.0	$0.06 – 0.07
FL0027791	Cross City-STP #1	0.4	North Central	Yes	Yes	$0.5 – 1.0	$0.06 – 0.07
FL0039896	Pebble Creek Village WWTF	0.4	West Central	No	No	$0	$0
FL0040291	Charlotte Co Util - East Port	0.385	Peninsula	No	No	$0	$0
FL0021610	Crescent City STP	0.35	Colored	No	No	$0	$0
FL0043079	Hilliard	0.32	Peninsula	Yes	Yes	$0.4 – 0.8	$0.04 – 0.06
FL0038407	Callahan Town of	0.3	Peninsula	Yes	Yes	$0.4 – 0.7	$0.04 – 0.05
FL0020907	Bunnell WTP	0.3	Peninsula	No	No	$0	$0
FL0117471	SJCUD - State Road 207 WWTF	0.25	Peninsula	Yes	Yes	$0.3 – 0.6	$0.04
FL0122076	Rice Creek Utility Company	0.225	West Central	No	No	$0.0	$0
FL0020125	Wewahitchka City of (STP)	0.2	Panhandle West	Yes	Yes	$0.3 – 0.5	$0.03
FL0042315	Hastings STP	0.12	Peninsula	No	Yes	$0.09 – 0.2	$0.01 – 0.02
FL0119644	Lake Suzy Utility WWTP	0.087	West Central	Yes	Yes	$0.1 – 0.2	$0.01 – 0.02
FL0040215	Brittany Estates MHP WWTP	0.06	Peninsula	No	No	$0	$0
FL0043389	Hiawatha Condominiums	0.036	Peninsula	No	No	$0	$0
FL0040207	Noma STP	0.025	Panhandle West	Yes	Yes	$0.03 – 0.06	$0.003 – 0.004
FL0043419	Study Estates	0.017	Peninsula	No	No	$0	$0
FL0043150	Napoli's Trailer Park	0.015	Peninsula	Yes	Yes	$0.02 – 0.04	$0.002 – 0.003
FL0042617	Point Buena Vista MHP	0.015	Peninsula	Yes	Yes	$0.02 – 0.04	$0.002 – 0.003
FL0023426	Ideal Mobile Home Park WWTF	0.011	Peninsula	No	No	$0	$0

Exhibit C-1: Potential Costs to Municipal WWTPs for Compliance with Numeric Nutrient Criteria

NPDES No.	Discharger Name	Flow (mgd)	Nutrient Region/ Lake Type	Reductions Needed		Total Capital Costs	Annual O&M Costs
				TN	TP		
FL0113743	Middleburg Bluffs	0.009	Peninsula	No	No	$0	$0
FL0043842	Cypress Landing WWTP	0.007	Peninsula	No	No	$0	$0
FL0032662	Goodbread MHP	0.005	Peninsula	Yes	Yes	$0.006 – 0.01	$0.0001
FL0043176	Paradise Point STP	0.005	Peninsula	Yes	Yes	$0.006 – 0.01	$0.0001
FL0117951	JEA – Ponte Vedra	0.5	Peninsula	Yes	Yes	$0.6 – 1.2	$0.07 – 0.09
FL0105066	Leesburg STP	3.5	Peninsula	Yes	Yes	$4.5 – 8.7	$0.5 – 0.6
FL0034789	Mid-County Services	0.9	West Central	No	No	$0	$0
FL0043109	State Road 16 WWTP	1.32	Peninsula	Yes	Yes	$1.7 – 3.3	$0.2
FL0115231	Bailey's MHP	0.003	Peninsula	Yes	Yes	$0.003 – 0.007	$0.0001
					Minors Total	$21.8 – 45.1	$2.5 – 3.6

BNR = biological nutrient removal
mgd = million gallons per day
MHP = mobile home park
NPDES = National Pollutant Discharge Elimination System
O&M = operation and maintenance
STP = sewage treatment plant
TMDL = total maximum daily load
TN = total nitrogen
TP = total phosphorus
WWTF = wastewater treatment facility
WWTP = wastewater treatment plant

Appendix D. Industrial Sample Discharger Analyses

Florida Rock Industries - Gulf Hammock Quarry

NPDES permit number:	FL0044300
Major/minor:	Minor
SIC code:	1422 (Crushed and Broken Limestone)
Industrial Category:	Mining
Design Flow:	Not reported
Average Flow:	1.8 mgd (October 2004 through September 2005)
Receiving Water:	Wekiva River

Description

The facility processes excavated limestone by crushing, screening, and washing. Process wastewater generated from the washing of limestone and on-site stormwater are discharged to settling ponds. The settling ponds provide for evaporation, percolation, and recycling of the wastewater for processing limestone. Discharge of wastewater from the settling ponds through Outfall D-001 to an unnamed tributary of the Class III freshwaters of the Wekiva River is intermittent and rainfall dependent.

Summary of Effluent Data and Limits

There are no nitrogen or phosphorus effluent data in EPA's PCS database for the facility. However, a 2005 bioassay report indicates that TN and TP concentrations were <0.42 mg/L and 0.013 mg/L, respectively.

Incremental Controls

The discharger is located in the Peninsula region, with TN and TP criteria of 1.54 mg/L and 0.12 mg/L, respectively. Based on effluent data from the 2005 bioassay report, the facility is likely discharging below these levels. Thus, incremental costs are zero for this discharger.

Mosaic Fertilizer - Hopewell

NPDES permit number:	FL0032590
Major/minor:	Major
SIC code:	1475 (Phosphate rock)
Industrial Category:	Mining
Design Flow:	1.3 mgd
Average Flow:	5.24 mgd (average of monthly flows; no discharge since Sept. 2008)
Receiving Water:	Medard Reservoir

Description

Operations include phosphate mining and beneficiation facilities, phosphatic clay settling areas, sand tailings disposal areas, and a mine water recirculation system. Wastewater treatment consists of gravity settling sands, clays, and other suspended solids within earthen-diked settling areas. Clarified water is decanted to the mine water recirculation system for reuse. The recirculation system discharges when the storage capacity is exceeded due to excess rainfall contributions to the system and inflow of groundwater into mining cuts.

Summary of Effluent Data and Limits

Exhibit D-1 summarizes average monthly effluent data for TN and TP from 2005 to 2010.

Exhibit D-1. Effluent Data Summary, Mosaic Fertilizer - Hopewell

Pollutant	Number of Observations		Average Effluent (mg/L)[1]	Permit Limit (mg/L)[2]
	Total	Nondetect		
Total nitrogen	25	0	0.66	3
Total phosphorus	26	0	0.77	5

Source: EPA (2010a)

1. TN and TP effluent data from 2005 to 2010. TN data represent average of maximum monthly values; TP data represent average of average monthly values.

2. TN and TP (mg/L) permit limit based on monthly maximum; average monthly TP limit is 3 mg/L.

Incremental Controls

There are no color data available in FDEP's IWR database for Medard Reservoir. Information from the Southwest Florida Water Management District report on the Alafia Basin (1996) indicates that the Medard Reservoir is a colored lake. Thus, EPA's criterion for TN is 1.0 mg/L and for TP is 0.05 mg/L. However, there are not sufficient data for TN and TP in FDEP's IWR database (only one data point for each pollutant) from which to determine impairment under the rule. Thus, under the scenario of no dilution (e.g., receiving water is incrementally impaired or discharge flow is too large to allow a mixing zone), the discharger would likely receive effluent limits based on criteria end-of-pipe. Effluent data indicate that the discharger is likely discharging TN at concentrations below the applicable criterion; for TP, the discharger is likely discharging above applicable criteria and may need to implement some incremental level of control for compliance with potential effluent limits under the rule.

EPA (2008a) provides evidence of WWTPs meeting TP concentrations at or below 0.05 mg/L using a combination of chemical precipitation and filtration (see Section 4.2.3). Assuming similar treatment controls could allow the discharger to meet effluent limits based on meeting the TP criterion of 0.05

mg/L, EPA estimated the cost of chemical precipitation and filtration. Flow data from EPA's PCS database indicate that discharge flows vary greatly among discharge periods/events. Thus, control costs are based on the average discharge flow over the last 5 years (not accounting for months in which there was no discharge); this likely overestimates system size requirements, although costs for equalization basins or additional storage are not included. Based on average treatment costs for chemical precipitation and filtration expansion systems capable of achieving the necessary levels from EPA (2008a) for wastewater treatment plants, capital costs to treat approximately 5 mgd could be approximately $5.1 million and annual O&M costs could be approximately $0.61 million (unit costs for chemical precipitation for this industrial category are not readily available). Total annual control costs could be approximately $1.1 million (based on annualizing capital costs at 7% over 20 years plus annual O&M).

Pilgrim's Pride, Live Oak Processing

NPDES permit number:	FL0001465
Major/minor:	Major
SIC code:	2015 (Poultry Slaughtering and Processing)
Industrial Category:	Food
Design Flow:	1.5 mgd
Average Flow:	1.42 mgd (based on average monthly flows from 2005 to 2010)
Receiving Water:	Suwannee River

Description

The discharger operates a poultry processing, hatching, and poultry by-product processing (into meal) facility. Wastewater treatment consists of dissolved air flotation, anaerobic lagoon/equalization basin, activated sludge (anoxic basin followed by aeration basin), secondary clarification, facultative polishing pond, denitrification filters, pH adjustment, and chlorination/dechlorination. Solids are aerobically digested and land applied by spray irrigation.

Summary of Effluent Data and Limits

Exhibit D-2 summarizes average monthly effluent data for TN and TP from June 2006 to 2010; the company installed new treatment technologies targeting nitrate reductions in June 2006, so data prior to that period is not representative of current discharge levels.

Exhibit D-2. Effluent Data Summary, Pilgrim's Pride

Pollutant	Number of Observations		Average Effluent (mg/L)[1]	Permit Limit[2]
	Total	Nondetect		
Total nitrogen	46	0	18	None
Total phosphorus	46	0	13	None

Source: EPA (2010a)

1. TN and TP effluent data from June 2006-2010. TN data represents average of average monthly values. TP data represents value of monthly maximum values.
2. Facility has an annual average load-based TN limit.

Incremental Controls

EPA's numeric TN and TP criteria are 1.87 mg/L and 0.30 mg/L, respectively. Analysis of ambient data for Suwannee River near the outfall indicates that the waterbody likely would not be impaired for either TN or TP under the rule. Thus, the discharger could receive a mixing zone for calculation of effluent limits which would result in effluent limits above criteria end-of-pipe. In addition, the waterbody was previously listed as impaired for DO and nutrients due to the presence of algal mats. FDEP delisted the water after acceptance of the Suwannee River Reasonable Assurance Document, which moved the water to EPA Category 4c, meaning no TMDL is necessary because proposed pollution control measure(s) provide reasonable assurance that designated uses will be restored in the future. In this instance, agricultural BMPs will be implemented to restore the waterbody. In this case, based on WLAs for point sources in TMDLs in which nonpoint sources are the main contributors to nutrient pollution, the discharger is likely to receive effluent limits that reflect existing loads.

However, to err on the side of overestimating potential costs, EPA assumed that the discharger may need to implement some level of incremental control to meet effluent limits under EPA's rule that reflect some level of dilution (due to a lack of existing implementation procedures for calculating effluent limits for nutrients in Florida, it is uncertain how to estimate available dilution ratios for the facility). Because the discharger is already operating activated sludge with denitrification (comparable to treatment found at a municipal WWTP), expanding/retrofitting the existing treatment train to advanced BNR is likely a feasible control option that would provide substantial reductions in effluent TN and TP concentrations. Based on unit costs for WWTPs, capital costs to treat 1.5 mgd with advanced BNR would be approximately $1.6 million and annual O&M costs would be approximately $0.2 million; annual control costs could be approximately $0.34 million (based on annualizing capital costs at 7% over 20 years plus annual O&M).

Imperial Brands Inc – Lake Alfred

NPDES permit number:	FL0029017
Major/minor:	Minor
SIC code:	2085 (Distilled and Blended Liquors)
Industrial Category:	Food
Design Flow:	1.4 mgd (Outfall 003)
Average Flow:	0.26 mgd (Outfall 003; average of monthly average flows)
Receiving Water:	Lake Haines

Description

The facility generates a maximum of 0.163 mgd of wastewater from distillation stills, fermenters, bottling operations, and boiler blowdown. Under its NPDES permit, the discharger may dispose of up to 0.103 mgd of treated wastewater onsite. Wastewater treatment consists of pH adjustment, extended aeration, and clarification. Treated wastewater is either spray-irrigated in 5.36 acres of sprayfield or discharged to a 0.51-ac percolation pond. The facility also discharges a maximum of 0.06 mgd offsite to the City of Lake Alfred. In addition to the process wastewater, the facility produces once through and recirculating non-contact cooling water (1.4 MGD), which is combined with stormwater and discharges to Lake Haines via Outfall 003.

Summary of Effluent Data and Limits

Exhibit D-3 summarizes average monthly effluent data for TN and TP from 2005 to 2010.

Exhibit D-3. Effluent Data Summary, Imperial Brands – Lake Alfred

Pollutant	Number of Observations		Average Effluent (mg/L)[1]	Permit Limit
	Total	Nondetect		
Total nitrogen	16	0	0.41	None

Source: EPA (2010a)

1. TN and TP effluent data from March 2005 to March 2010. Represents average of average monthly values.

Incremental Controls

Based on color data from FDEP's IWR database (Run 40), Lake Haines is a colored lake; applicable EPA criteria are TN of 1.27 mg/L and TP of 0.05 mg/L. TN effluent data indicate that the facility is likely discharging below the applicable TN criterion. There are no TP criteria available, however, given that the facility is discharging noncontact cooling water it is unlikely that TP concentrations would be above the applicable criterion. Thus, incremental control costs are zero for this facility.

Packaging Corporation of America

NPDES permit number:	FL0000281
Major/minor:	Major
SIC code:	2631 (Paperboard mills)
Industrial Category:	Pulp and Paper
Design Flow:	55 mgd
Average Flow:	55 mgd (average of average monthly flows)
Receiving Water:	Withlachoochee River

Description

Current wastewater treatment system consists of a mechanical bar screen, primary clarifier, and 7 ponds covering 850 acres (with nutrient addition in the first and fourth ponds, coagulation at the discharge of the sixth pond for color reduction, and 4 anaerobic facultative ponds followed by an aeration basin). The facility dischargers treated effluent from Outfall 001 to Withlachoochee River. The facility treats process and non-process wastewater from mill manufacturing operations and stormwater.

Summary of Effluent Data and Limits

Exhibit D-4 summarizes average monthly effluent data for TN and TP from 2005 to 2010.

Exhibit D-4. Effluent Data Summary, Packaging Corporation of America

Pollutant	Number of Observations		Average Effluent (mg/L)[1]	Permit Limit
	Total	Nondetect		
Total nitrogen	20	0	2.75	None
Total phosphorus	6	0	0.74	None

Source: EPA (2010a)

1. TN and TP effluent data from June 2005 to June 2010. Represents average of average monthly values.

Incremental Controls

The discharger is located in the North Central region with an EPA TN criterion of 1.87 mg/L and TP criterion of 0.03 mg/L. Based on available data in FDEP's IWR database, the receiving water would not be impaired under EPA's rule. In addition, the facility's existing permit allows mixing zones in the calculation of effluent limits for dissolved oxygen, specific conductance, zinc, toxicity, pH, turbidity, ammonia, lead, transparency, and oil and grease. The permit specifies that the discharge is not to exceed 20% of the receiving water flow and data from PCS indicates that on average the discharge is about 12% of ambient flow. Thus, given available dilution and effluent TN and TP concentrations it is likely that the facility would be in compliance projected effluent limits for TN but may need to reduce TP concentrations to as low as 0.1 mg/L (reflects approximately a 3:1 dilution ratio). EPA (2008a) provides unit costs for chemical addition and filtration retrofits and expansion to reduce TP concentrations to 0.1 mg/L at WWTPs (see Exhibit 4-4). Assuming costs would be similar for this facility, capital costs could be approximately $17.7 million and O&M costs could be approximately $4.8 million per year; total annual costs could be $6.5 million (capital costs annualized at 7% over 20 years plus annual O&M).

Mosaic Fertilizer, New Wales North Stack

NPDES permit number:	FL0178527
Major/minor:	Major
SIC code:	2874 (Phosphatic Fertilizers)
Industrial Category:	Chemicals and Allied Products
Design Flow:	Not reported
Average Flow:	No discharge from Outfall 002 since 2001
Receiving Water:	George Allen Branch

Description

The facility is responsible for an unlined closed phosphogypsum stack which received phosphogypsum from 1975 through 2000. The current closed stack has a base area of approximately 377 acres. The top surface of the closed stack is comprised of two lined emergency surge ponds constructed with 60-mil thick HDPE which store either surplus process water from the active system or surplus stormwater collected within the closed stack system. Effluent is discharged to a natural wetland system prior to discharging to George Allen Branch through Outfall 002.

Summary of Effluent Data and Limits

The facility has not discharged to the receiving water since 2001. Thus, there are not effluent TN and TP data available.

Incremental Controls

Given the lack of discharge from the facility, it is unlikely the facility would incur incremental control costs associated with EPA's rule.

St. Marks Powder, Inc.

NPDES permit number:	FL0002518
Major/minor:	Major
SIC code:	2892 (Explosives)
Industrial Category:	Chemicals and Allied Products
Design Flow:	0.786 mgd
Average Flow:	0.79 mgd (based on average monthly flows from 2005 to 2010)
Receiving Water:	Big Boggy Branch Creek

Description

The facility manufactures small and intermediate arms propellant, and operates a 0.786 mgd design capacity industrial wastewater treatment system consisting of primary and secondary treatment. The primary treatment system includes dual high rate grit separators and a 750,000 gallon equalization tank to remove grit and equalize organic loading and hydraulic flows. The secondary treatment system includes an extended aeration unit, dual clarification, chlorination, digester, a belt filter press, four acre polishing pond, final chlorination with pH adjustment by carbon dioxide injection at the polishing pond discharge, and an eight acre spray irrigation field with overland flow to the plant ditch.

The treated effluent is normally processed through a reclaimed water system and pumped to the Purdom Generating Station. When the Purdom Generating Station cannot accept the reclaimed water, the treated effluent is pumped to a spray field with the runoff from the spray field (Outfall 003) going into the plant ditch. The v-notch weir in the plant ditch is the final discharge point (Outfall 002); it discharges to Big Boggy Branch Creek, which in turn empties into the Wakulla River. The discharge at Outfall 002 is made up of runoff from the spray field (Outfall 003), non-contact cooling water and stormwater runoff. The facility installed carbon filters at the polishing pond to remove nitroglycerin if detected in the clarifier effluent.

Summary of Effluent Data and Limits

Exhibit D-5 summarizes average monthly effluent data for TN from 2005 to 2010 for Outfall 002. Data from the facility's fact sheet indicate that the long term average TP concentration for Outfall 002 is 0.33 mg/L.

Exhibit D-5. Effluent Data Summary, St. Marks Powder Inc.

Pollutant	Number of Observations		Average Effluent (mg/L)[1]	Permit Limit
	Total	Nondetect		
Total nitrogen	51	0	8.9	None

Source: EPA (2010a)

1. TN effluent data from 2005-2010 representing average of average monthly values for Outfall 002.

Incremental Controls

The facility is located in the Panhandle East region with an EPA TN criterion of 1.03 mg/L and TP criterion of 0.18 mg/L. There is not sufficient data in FDEP's IWR (run 40) database to determine impairment status for Big Boggy Branch Creek. However, data from 2006 indicate that the geometric mean TN and TP concentrations are well below the applicable criteria (TN = 0.61 mg/L and TP = 0.019 mg/L). Thus, it is unlikely that the discharger would be required to meet effluent limits based on meeting criteria end-of-pipe due to the likely presence of assimilative capacity in the receiving water. Given the relatively high average effluent TN concentrations, EPA assumed that the discharger would need to implement controls to significantly reduce nutrient concentrations in the effluent to meet projected effluent limits under the rule.

Outfall 002 may or may not contain runoff from the spray field in addition to non-contact cooling water and stormwater runoff. In the months in which there is no discharge from the spray field (Outfall 003), average TN concentrations at Outfall 002 are 0.87 mg/L which is below the applicable TN criterion. Although there are no data from PCS for Outfall 002 for TP to determine the average concentration without contributions from Outfall 003, given the range of TP values for Outfall 003 (1.7 mg/L to 0.1 mg/L), the same relationship between concentrations and outfall contributions for TN may hold true for TP. Thus, assuming that the Purdom Generating Station cannot increase its reuse water demand from the facility, it would likely need to reduce TN and TP concentrations in Outfall 003 to prevent exceedances of projected effluent limits for Outfall 002 under EPA's rule.

The facility already has extended aeration and clarification units which could be retrofitted or expanded to accommodate advanced BNR treatment. Assuming average advanced BNR unit costs for WWTPs associated with achieving 3 mg/L TN and 0.1 mg/L TP are applicable to this facility's wastewater, capital costs to treat 0.786 mgd of wastewater from Outfall 003 may be approximately $1 million and O&M may be approximately $110,000 per year; annual costs may be $207,000 (annualizing capital costs at 7% over 20 years plus annual O&M).

Aramark Uniform and Career Apparel

NPDES permit number:	FL0178845
Major/minor:	Minor
SIC code:	3582 (Commercial Laundry, Drycleaning, and Pressing Machines)
Industrial Category:	Other
Design Flow:	0.096 mgd
Average Flow:	0.029 mgd (June 2005 through June 2010)
Receiving Water:	Stormwater drain
Existing Impairment:	None

Description

The facility is the site of a groundwater remediation system for petroleum products and dry cleaning solvents. Discharge from the site is intermittent. Groundwater is treated by air stripping and filtration. The purpose of filtration is to remove suspended particulate matter in order to meet the total recoverable iron standard at the point of discharge. Treated effluent is discharged through Outfall D-001 to a storm drain then to the Class III freshwaters of Deer Creek and then to the Class III waters of the St. Johns River.

Summary of Effluent Data and Limits

There are no phosphorus effluent data in EPA's PCS database for the facility. However, data from 2005 and 2009 bioassay reports indicate that TP concentrations range from <0.02 mg/L to 0.041 mg/L. **Exhibit D-6** summarizes TN data.

Exhibit D-6. Effluent Data Summary, Aramark Uniform and Career Apparel

Pollutant	Number of Observations		Average Effluent (mg/L)[1]	Permit Limit
	Total	Nondetect		
Total nitrogen	20	0	3.2	None

Source: EPA (2010a)

1. TN and TP effluent data from 2005 to 2010. TN data represent average of maximum monthly values; TP data represent average of average monthly values.

Incremental Controls

Given that the facility is discharging a relatively small volume treated of groundwater and is not adding nutrients prior to discharge (i.e., nutrients in effluent are from the groundwater), it is unlikely that additional controls would be needed under EPA's rule. Thus, incremental control costs are zero for this discharger.

Gulf Power, Scholz Generating Plant

NPDES permit number:	FL0002283
Major/minor:	Major
SIC code:	4911 (Electric Services)
Industrial Category:	Electric Services
Design Flow:	129.6 mgd
Average Flow:	105.5 mgd (based on average monthly flows from 2005 to 2010)
Receiving Water:	Apalachicola River

Description

The facility consists of two coal fired steam electric generating units with a total nameplate rating of 80 MW and a gross generating capacity of 98 MW. After chlorination, the facility discharges non-contact once-through condenser cooling water to an onsite discharge canal which flows to Apalachicola River. All other industrial (ash sluice water, water softener regeneration wastewater, boiler blowdown, and air preheater wash) and domestic wastewater streams discharge into an onsite ash pond. Overflow from the ash pond discharges to the onsite discharge canal.

Summary of Effluent Data and Limits

There are no nitrogen or phosphorus effluent data in EPA's PCS database for the facility.

Incremental Controls

The majority of the discharge is once-through cooling water from Apalachicola River. Thus, it is unlikely that the facility is increasing TN and TP loads to the receiving water. Thus, EPA assumed that the discharger would not likely incur incremental costs under EPA's rule.

Tampa Electric – Polk Power Station

NPDES permit number:	FL0043869
Major/minor:	Major
SIC code:	4911 (Electric Services)
Industrial Category:	Electric Services
Design Flow:	3.1 mgd
Average Flow:	1.05 mgd (Outfall 001 based on average flows from 2005 to 2010)
Receiving Water:	Little Payne Creek

Description

The facility is an electric generating plant with a total nominal generating capacity of 920 MW comprised of 5 electric generating units. The facility uses a recirculating cooling pond for heat dissipation with makeup from groundwater and continuous discharge to Little Payne Creek via an unnamed reclaimed lake. The industrial wastewater treatment system treats the slag pile leachate and treated water from the oily water separator using an oil/water separator, dissolved air flotation tank, equalization basin, slag runoff retention basins, and a sand filter. The cooling reservoir receives the treated effluent from the onsite industrial wastewater treatment system in addition to precipitation, groundwater seepage, reject from the reverse osmosis unit, boiler blowdown, laboratory wastes, washdown from materials storage areas, stormwater runoff, and recirculating cooling water. Effluent from the cooling pond is mixed and aerated in a sulfuric acid mixing sump and monitored in a pH monitoring sump prior to discharge via Outfall 001 to the unnamed reclaimed lake.

Summary of Effluent Data and Limits

Exhibit D-7 summarizes monthly effluent data for TN and TP from 2005 to 2010 for Outfall 001.

Exhibit D-7. Effluent Data Summary, Tampa Electric – Polk Power Station

Pollutant	Number of Observations		Average Effluent (mg/L)[1]	Permit Limit (mg/L)[2]
	Total	Nondetect		
Total nitrogen	14	0	1.5	2.93
Total phosphorus	46	4	0.13	None

Source: EPA (2010a)

1. TN effluent data from 2009-2010, representing average of maximum monthly values. TP effluent data from 2005-2010, representing average of monthly average values.
2. Represents both an average monthly and daily maximum effluent limit. Limit is based 1991 preconstruction monitoring Conditions of Certification PA 92-32 under the Power Plant Siting Act.

Incremental Controls

The facility dischargers in the West Central region with TN criterion of 1.65 mg/L and TP criterion of 0.49 mg/L. Both TN and TP average effluent concentrations are below the applicable criteria. Thus, the facility would not likely incur incremental costs under EPA's rule.

St. Lucie County Landfill

NPDES permit number:	FL0041483
Major/minor:	Minor
SIC code:	4953 (Refuse Systems)
Industrial Category:	Other
Design Flow:	Not reported
Average Flow:	No discharge from 1998-2010
Receiving Water:	Canal 96

Description

The landfill is a 331 acre site that receives and processes solid waste products from residents and commercial properties in St. Lucie County. The leachate from the Class I sanitary landfills at the facility is conveyed to two lined leachate storage ponds - Ponds No. 3 and No. 4. Leachate disposal is achieved by natural evaporation loss, and by pumping into the sanitary sewer system controlled by Fort Pierce Utility Authority (FPUA.) The discharger is allowed under an agreement (discharge permit renewed annually) with FPUA, to discharge 70 gpm or 100,800 gpd to their sewer system. In emergency situations, leachate can also be pumped out directly from the ponds to private tanker trucks, to be transported to FPUA, or other licensed wastewater recovery or disposal facilities. The discharger is only permitted to discharge to surface waters when rainfall depth exceeds that of a 25-year/72-hour storm event at 10.19 inches; leachate discharge first flows into an onsite stormwater management system that comprised a 2,400 foot long drainage ditch and a 16.5 acre retention pond, before being discharged.

Summary of Effluent Data and Limits

There are no nitrogen or phosphorus effluent data in EPA's PCS database for the facility.

Incremental Controls

Because there has been no discharge in over 10 years, it is unlikely that additional controls would be needed as a result of EPA's rule. Thus, incremental costs are zero for this discharger.

Universal Studios Florida

NPDES permit number:	FL0168581
Major/minor:	Minor
SIC code:	7996 (Amusement Parks)
Industrial Category:	Other
Design Flow:	0.05 mgd
Average Flow:	Flow data not reported since 2003
Receiving Water:	Shingle Creek

Description

The Jaws attraction is a water-based themed ride constructed in a concrete-lined basin that transports guests in ride vehicles shaped like boats. The facility filters the water in the attraction Lagoon and regulates the level of water when needed. The treatment system consists of an Actiflow filtration unit and draws water from the Lagoon, filters that water and returns it to the Lagoon. The filter system produces backwash at a rate of 15 gpm. The backwash is discharged to the City of Orlando sanitary sewer. Due to this change of operation the facility is reclassified as an intermittent discharger.

The facility is allowed to discharge from Lagoon to Shingle Creek after excessive accumulation of water in the attraction due to rainfall, to allow infrequent scheduled drawdowns of the Lagoon for maintenance, and for addressing emergency/unscheduled maintenance events. During maintenance events the Lagoon water is transferred to Pond A. The water in Pond A is then treated by aeration and tested. The water is then transferred to Pond C in a gravity pipe. At the completion of the Lagoon maintenance, the Jaws Lagoon is refilled by pumping water from Pond C.

Summary of Effluent Data and Limits

Exhibit D-8 summarizes average monthly effluent data for TP from 2005 to 2010. There are no TN data in EPA's PCS database from 2005 to 2010.

Exhibit D-8. Effluent Data Summary, Universal Studios Florida

Pollutant	Number of Observations		Average Effluent (mg/L)[1]	Permit Limit
	Total	Nondetect		
Total phosphorus (Outfall 002)	37	0	0.04	None

Source: EPA (2010a)

1. TP effluent data from 2005 to 2010. Represents average of maximum monthly values.

Incremental Controls

The discharge is located in the Peninsula region with TN criterion of 1.54 mg/L and TP criterion of 0.12 mg/L. Data from FDEP's IWR (run 40) database indicate that Shingle Creek (WBID 3169A) would not be impaired under EPA's rule for TN or TP. Thus, the discharger would likely receive dilution in calculation of effluent limits. Effluent TP data indicate that the facility is likely discharging below the applicable criterion and would not need additional controls. There are no TN data, however given the potential for dilution in calculating effluent limits and the fact that the facility's fact sheet indicates that nutrient concentrations are extremely low and as permitted it is not reasonably expected to significantly impact Shingle Creek, EPA assumed that the facility would not incur incremental costs of meeting effluent limits for TN.

Exhibit D-9 shows the potentially affected facilities and their applicable flows for the analysis of potential costs.

Exhibit D-9: Potentially Affected Industrial Dischargers and Applicable Flows

NPDES No.	SIC Code	Discharger Name	Discharger Type	Sample Discharger	Nutrient Criteria Region	Flow (mgd)
Chemicals and Allied Products						
FL0002488	2824	Solutia Inc.	Major	No	Panhandle West	27
FL0177130	2874	Riverview Closed Phosphogypsum	Major	No	West Central	13.9*
FL0178527	2874	IMC-Igrico Company	Major	Yes	West Central	13.9*
FL0034657	2879	Coronet Industries Inc	Major	No	West Central	13.9*
FL0002518	2892	St. Marks Powder Inc.	Major	Yes	Panhandle East	0.786
FL0000884	2869	Millennium Specialty Chemical	Minor	No	Peninsula	5
FL0001040	2869	IFF Chemical Holdings Inc	Minor	No	Peninsula	2.34*
FL0037800	2869	Montco Research Products Inc	Minor	No	Peninsula	0.012
FL0187313	2874	CF Industries Inc.-Tampa Ammonia Terminal	Minor	No	West Central	2.5
Electric Services						
FL0000183	4911	FL Power Corp-Suwannee Riv Steam	Major	No	North Central	342
FL0002283	4911	Gulf Power Scholz Steam	Major	Yes	Panhandle East	129.6
FL0032166	4911	FL Power and Light-Putnam Steam	Major	No	Peninsula	125
FL0002275	4911	Gulf Power Co-Crist Steam	Major	No	Panhandle West	18
FL0025518	4911	Arvah B. Hopkins Generating Station	Major	No	Panhandle East	1.87
FL0025526	4911	Sam O. Purdom Gen Station	Major	No	Panhandle East	103*
FL0030988	4911	FL Power and Light-Martin County Steam	Major	No	Peninsula	103*
FL0032174	4911	FL Power and Light-Manatee Steam	Major	No	West Central	103*
FL0043869	4911	Tampa Electric-Polk Power Station	Major	Yes	West Central	3.1
Food						
FL0001465	2015	Goldkist Inc - Live Oak Processing	Major	Yes	North Central	1.5
FL0175412	2033	Silver Springs Citrus/Spray Fields	Minor	No	Peninsula	1
FL0105643	2033	Florida's Natural Growers	Minor	No	Peninsula	0.8
FL0105619	2037	Cutrale Citrus Juice USA Inc.	Minor	No	Peninsula	0.9
FL0041556	2082	Anheuser Busch - New Sod Farm	Minor	No	Peninsula	1.7
FL0029017	2085	Imperial Brands Inc-Lake Alfred	Minor	Yes	Peninsula	1.7
FL0278076	5146	Anguilla Fish Farm	Minor	No	Peninsula	3.67
Mining						
FL0032590	1475	IMC-Agrico Co - Hopewell	Major	Yes	West Central	5

Exhibit D-9: Potentially Affected Industrial Dischargers and Applicable Flows						
NPDES No.	SIC Code	Discharger Name	Discharger Type	Sample Discharger	Nutrient Criteria Region	Flow (mgd)
FL0027600	1475	Mosaic Fertilizer - Ft Green/Payne Creek Mine	Major	No	West Central	16*
FL0033294	1475	Mosaic Fertilizer – Hookers Prairie Mine	Major	No	West Central	16*
FL0000655	1479	PCS Phosphate-White Springs, Suwannee Complex	Major	No	Peninsula	27.8**
FL0002119	1099	Iluka Resources Inc.	Minor	No	Peninsula	8
FL0435490	1099	Dupont North Maxville Expansion	Minor	No	Peninsula	5
FL0101192	1422	Dolomite Inc.	Minor	No	Panhandle West	9.7
FL0025569	1422	Dixie Lime and Stone-Sumterville	Minor	No	Peninsula	6.1*
FL0044300	1422	FL Rock Ind. - Gulf Hammock	Minor	Yes	Peninsula	1.8
FL0322890	1422	Mazak Limerock Mine	Minor	No	Peninsula	6.1*
Other						
FL0178845	3582	Aramark Uniform and Career Apparel	Minor	Yes	Peninsula	0.096
FL0552208	3679	Honeywell International - Sarasota	Minor	No	West Central	0.029
FL0171565	3699	Sprague Electronics GW Remediation	Minor	No	Peninsula	0.028
FL0032581	4011	CSX Transportation Inc.	Minor	No	West Central	0.05
FL0166154	4011	Csx Transportation Inc/Rockport Bulk Terminal	Minor	No	West Central	1.1*
FL0183750	4931	Indiantown Generating Plant	Minor	No	Peninsula	0.05
FL0039951	4931	Telogia Power	Minor	No	Panhandle East	1.1*
FL0037133	4953	Orange County Sanitary Landfill	Minor	No	Peninsula	3.7
FL0037877	4953	Volusia County San Landfill	Minor	No	Peninsula	0.11
FL0041483	4953	St. Lucie County - Landfill Site	Minor	Yes	Peninsula	1.1*
FL0001350	5171	Coastal Terminals	Minor	No	Peninsula	0.5
FL0032441	5171	Murphy Oil USA Inc – Freeport Terminal	Minor	No	Panhandle West	1.1*
FL0034622	5171	Amerada Hess Corp.-Tampa Terminal	Minor	No	West Central	1.1*
FL0123366	5171	Martin Gas Sales Inc.	Minor	No	West Central	1.1*
FL0343498	5171	Transmontaigne Product Services Tampa	Minor	No	Peninsula	1.1
FL0168581	7996	Universal Studios Florida/Jaws Lagoon	Minor	Yes	Peninsula	0.05
FL0569071	9511	Usace - Kissimmee River ASR Pilot Project	Minor	No	Peninsula	5
Pulp and Paper						
FL0000281	2631	Tenneco Packaging Corp.	Major	Yes	North Central	55

Exhibit D-9: Potentially Affected Industrial Dischargers and Applicable Flows						
NPDES No.	**SIC Code**	**Discharger Name**	**Discharger Type**	**Sample Discharger**	**Nutrient Criteria Region**	**Flow (mgd)**
FL0000221	2491	Southern Wood Piedmont Company	Minor	No	Peninsula	0.022
FL0133132	2491	Universal Forest Products Eastern Division	Minor	No	Peninsula	0.036*
FL0043567	2499	Cochran Forest Products	Minor	No	North Central	0.05

* Represents average flow for major/minor facilities in each industrial category because flow not available in EPA's PCS database.

**Flow in PCS reported as 200 mgd, but flow in permit reported as 27.8 mgd; EPA used flow as reported in permit.

Appendix E. Potential Effect of Nutrient Criteria on Response Indicators and Biota

The expected changes due to reduction of nutrients can be predicted with the relationships used to link the nutrients (TP, TN) with the response indicators [chlorophyll-a, Secchi disk transparency (SDT), probability of HABs] and other parameters. The expected changes in the response indicators to nutrient reduction can be used to infer improvements in provision of environmental goods and services and designated use attainment. Some of these useful relationships have been investigated for Florida waterbodies and are identified and described below.

- Water column chlorophyll-a vs. TP concentrations;
- Water clarity (e.g., SDT depth) vs. TP or TN concentrations;
- Coverage of aquatic macrophytes (% areal coverage) vs. SDT depth;
- Frequency of HABs vs. TP concentrations; and
- Fish production as a function of TP.

Brown et al. (2000) investigated the relationship between nutrients and chlorophyll-a in Florida lakes using data from 273 lakes collected over 10 years to develop several predictive relationships between TP and chlorophyll-a. A simple linear regression model between the annual average nutrient concentration and monthly chlorophyll-a (CHL) concentrations with reasonable fit (r2 = 0.76) was:

$$\log(\mathrm{CHL}) = -0.369 + 1.052\log(\mathrm{TP})$$

This equation was essentially equivalent to a third-order polynomial regression model with a slightly better statistical fit (0.78) over the total phosphorus range from 3 µg/L to 160 µg/L. Thus, the simple regression model is useful because it holds for the range of TP concentrations observed for 93% of the Florida lakes (273) studied. Use of this equation can provide an estimate of the amount of chlorophyll-a reduction that might be predicted for a reduction in TP due to the numeric criteria in most lakes (may be less accurate for high levels of TP in hyper-eutrophic lakes).

Bachmann et al. (2002) developed an equation predicting SDT as a function of nutrients (TN, TP), the mean depth (MD) and the percent area of bottom covered by macrophytes (PAC). Since inclusion of PAC data provided only a marginally better fit (r2 increased 0.03); the equation can be simplified to the following:

$$\log(\mathrm{SDT}) = 1.13 - 0.355\log(\mathrm{TP}) - 0.274\log(\mathrm{TN}) + 0.407\log(\mathrm{MD})$$

Use of this equation can provide an estimate of increase in SDT that might be predicted for a reduction in TP and TN due to the numeric numeric criteria. For mean depth, the geometric mean (2.7 m) derived from 318 study lakes by (Bachmann 2002) may be assumed as a generic waterbody characteristic to look at the increase in SDT just due to nutrients.

The maximum depth of macrophytes colonization (MDC) in Florida lakes as a function of available light (estimated as SDT depth) was studied by Canfield et al. (1985). They developed the empirical regression line predicting limiting depth of plant growth as (all units in meters):

$$\log(\mathrm{MDC}) = -0.42\log(\mathrm{SDT}) + 0.41$$

A more recent review of macrophyte biomass and trophic indicators in 318 Florida lakes found that the abundance of submerged aquatic macrophytes was only weakly determined by TP, TN, chlorophyll-a, or Secchi disk depth (Bachmann et al. 2002). The authors suggested that submerged macrophytes are absent only at very high chlorophyll-a concentrations in the water column. Overall, they found no predictable relationship between macrophyte abundance and trophic state in the lakes studied. However, they did note that all lakes with a water color value above 150 platinum-cobalt (PCU) units showed a distinct depression in both macrophyte and phytoplankton biomass. This is additional support for the separation of waterbodies into clear and colored classifications for numeric criteria application (75 FR 4174; January 26, 2010) such that colored lakes have higher baseline criteria for TP and TN then clear lakes.

Another benefit of nutrient reduction due to the implementation of the numeric numeric criteria is the reduced frequency of occurrence of HABs. Havens and Walker (2002) evaluated the frequency of occurrence of moderate (chl-a > 40 µg/L) and severe (chl-a >60 µg/L) blooms when considering target in-lake TP concentrations as part of the TMDL process for Lake Okeechobee. For example, they found that if TP averaged < 30 µg/L then the probability of a moderate bloom was < 3% and that for severe bloom < 1%. Therefore, application of the numeric TP criteria for clear lakes (10µg/L for clear acidic; 30 µg/L for clear, alkaline) could result in lowered frequency of HAB events.

One of the commonly predicted impacts of eutrophication is a change in the fish community due to the increasing turbidity of the waters and altered DO regimes (Smith et al. 1999). Investigation of the relationship between fish production and trophic state indicators by Bachmann et al. (1996) found that species numbers were positively correlated to lake size but not trophic state. The authors concluded that trophic state is less influential to fish community composition in Florida lakes than elsewhere, since the lakes are shallow, lack colder bottom layers, and their major recreationally important game fish are warmwater species (e.g., sunfish and bass). Therefore, reduced nutrient concentrations due to the numeric criteria are not likely to significantly change the game fish species although there could be a reduction in total fish biomass.

Appendix F. Quantitative Analysis of Benefits: Potential Value of Improvements in DO

Section 13 presents estimates of the potential magnitude of benefits from attaining the numeric criteria using a water quality index (WQI) approach to link changes in total nitrogen (TN) and total phosphorus (TP) to the corresponding improvements in designated uses and ecological benefits, and quantify those benefits based on WTP for improved water quality and function. This approach only values benefits derived from improvements in TN and TP. However, reductions in TN and TP may also have broader water quality effects and indirectly reduce ambient concentrations of other WQI parameters, particularly dissolved oxygen (DO).

As discussed in Section 13, nutrient levels may have an indirect effect on DO levels. As shown in Exhibit 13-5, DO has the highest weight or importance of all the parameters in the calculation of the WQI. While it is possible to insert reduced TN and TP values in the WQI based on numeric criteria, there is no similar simple mechanism for predicting DO changes. This appendix describes an approach to incorporating potential changes in DO that may be associated with improved TN and TP levels in the WQI and thus better reflect the total environmental benefit from attaining criteria, and the potential quantitative estimate of total benefits.[20]

F.1 Factors Affecting DO Concentration in Water

Maximum DO concentrations in water are based on the solubility of oxygen in equilibrium with the atmospheric concentration of oxygen. The solubility of oxygen at equilibrium (also known as 100% saturation) is dependent on three primary physical and chemical factors (Wetzel, 2001):

- **Temperature** – the solubility of oxygen is affected nonlinearly by temperature and increases markedly in cold waters;
- **Pressure** – the solubility of oxygen is dependent on the atmospheric partial pressure at the waterbody surface and decreases with decreasing atmospheric pressure (i.e., saturation concentrations decrease with increasing altitude); and
- **Salinity** – the solubility of oxygen in water is affected by salinity and salinity may therefore need to be considered in analyses of DO in inland saline or brackish waters.

While these factors are critical to estimating the expected DO in the water, they are not directly linked to ambient nutrient concentrations and thus would be largely neutral for purposes of estimating WQI changes following nutrient criteria implementation. Temperature is the most influential factor (i.e., has the most quantitative effect) for DO concentration in lakes and flowing waters. Accordingly, some investigators prefer to use the temperature-corrected percent DO saturation (% DO_{sat}) (i.e., a relative term indicating how much DO is present to that expected at atmospheric equilibrium) instead of, or combined with, the absolute DO concentration (mg/L). When DO is present in quantities > 100% saturation, the waterbody is termed "supersaturated."

Concentrations of DO in lakes and flowing water are also affected by additional factors, working either singly or in a combination, which may be highly significant at the local level:

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[20] Reductions in ambient nutrient concentrations could also lead to estimated reductions in chlorophyll-*a* levels, although this parameter is currently only used in the WQI for estuaries.

- **Flow velocity and turbulence** – higher turbulence increases the atmospheric transfer of oxygen across the air-water interface and can entrain addition DO into the water. Waters below high waterfalls may be supersaturated for some distance downstream;
- **Stratification –** thermally stratified (i.e., layered) lakes will have distinctly different DO conditions in top and bottom layers as a function of thermal differences and the greater amount of BOD and microbial metabolism in the lower layer as organic carbon sinks out of the productive upper layer (e.g., decaying algal remains);
- **Groundwater inputs** – waterbodies which receive a significant hydrologic input from groundwater (which is often at low DO levels) may have reduced DO levels in areas where the groundwater discharges to the waterbody;
- **BOD** – BOD is a functional water quality parameter that refers to the amount of DO that organic carbon and nitrogenous materials (e.g., wastewater discharges, manure inputs) could take up if the water sample were incubated in the laboratory under standard conditions, sealed from the atmosphere. BOD is generally identified by the length of the incubation (e.g. BOD_5 is the amount of DO consumed over a 5 day period). Thus, as BOD increases, the receiving waterbody DO should decrease, although in flowing system the expression of lowest DO may be some distance downstream from the original BOD input;
- **Dissolved Organic Carbon (DOC)** – dissolved organic substances in the water can also exert an oxygen demand such that highly colored waters (i.e., with high levels of humic and fulvic acids) arising in wetlands or slowing moving waterbodies will not reach fully 100% DO saturation (i.e., fully saturated) conditions;
- **Microbial metabolism –** the breakdown of organic carbon by bacterial communities consumes DO and may be responsible for areas of low or even absent DO at or near the sediment surface;
- **Photosynthesis –** oxygen generation by photosynthetic organisms (phytoplankton, periphyton, aquatic macrophytes) can increased local supplies of DO during daylight hours. Under eutrophic conditions, photosynthesis of actively growing plants can lead to DO supersaturation; and
- **Dark respiration –** respiratory activities from primary producers and consumers at night reduces DO. The cycle of high photosynthetic activity leading to elevated DO coupled with heavy dark respiration at night (coupled with accompanying changes in temperature) can lead to a highly variable diurnal (day-night) pattern.

F.2 Response of DO to Nutrient Reduction due to Numeric Nutrient Criteria

The response of DO to changes in nutrient concentrations resulting from compliance with the numeric numeric criteria is likely to be complex. Changes in DO concentration may not be directly linked to changes in TP and TN concentrations, even though highly elevated or depressed DO levels and high spatial and temporal variability are considered diagnostic symptoms of eutrophication. Eutrophic waters often have large internal difference in DO concentrations such as supersaturated conditions in the upper waters, low DO in bottom waters, as well as a high diurnal variability. [Note: some degree of diurnal variation in DO is normal and based on the variation in water temperature over the day].

Reducing ambient nutrient levels would theoretically be expected to reduce the frequency and magnitude of extreme DO conditions and lessen the diurnal variation. However, it is very difficult to produce a predictive relationship between DO concentrations and/or diurnal variability and nutrients that can be applied to multiple waterbodies, due to potential influence of the many factors described in Section 0. Some of the factors that tend to “uncouple” DO concentrations from nutrient levels include:

- DO measurements reflect instantaneous spatial and temporal conditions and not the averaged nutrient conditions over time;
- DO concentrations are a product of daily temperature, wind/wave action, and streamflow conditions which are unrelated to average nutrient concentrations;
- The potential for resupply from atmospheric transfers often makes DO deficits very transient;
- DO concentrations in clear and colored waterbodies could be quite different for the same amount of nutrients due to the influence of DOC;
- Data on DO diurnal variability (e.g., pre-dawn minimum, mid-day maximums) will likely not be available for many locations due to sampling program limitations (data may be available on well-studied lakes); and
- Local watershed inputs that consume DO (e.g., BOD) may be present and unrelated to average nutrient conditions.

Based on these difficulties, it would not be possible to predict DO improvement on the basis of reductions in TP and TN concentrations alone.

F.3 Alternative Approach for Estimating DO Response to Nutrient Criteria

An alternative approach to estimating DO response to the numeric nutrient criteria would be to assume a DO concentration based on the trophic state achieved by the numeric criteria. Ranges of TP and TN concentrations that are associated with various trophic states reflecting increasing fertilization stages (i.e., oligotrophic, mesotrophic, eutrophic, and hyper-eutrophic) are available (Wetzel 2001). The nutrient criteria may generally approximately delineate the mesotrophic-eutrophic boundary, where compliance with the nutrient criteria (or less) would shift a waterbody to a mesotrophic condition that is fully supportive of its designated water uses and that avoids the adverse effects associated with severe eutrophication.

Due to the various influencing factors described above, there are no recognized ranges of DO associated with a particular trophic state similar to those for TP and TN. However, it might be possible to *a priori* assume that nutrient compliance will result in mesotrophic waterbodies where DO conditions support all designated water uses to a satisfactory degree. It would be necessary to assume that compliance with such mesotrophic conditions meets the more stringent DO requirements for Class I and III waters under FAC Section 62-302.530. “Criteria for surface water quality classification” of 5 mg/L DO with normal variability allowed.

Thus, the alternative approach would be to simply assume a concentration of 5 mg/L for waters that exceed the criteria and then compare pre- and post-WQI values, with post WQI values calculated using changes in three parameters (DO, TN, and TP). This approach would result in an increase in the DO sub-index score within the WQI when ambient DO is currently < 5.0 mg/L. This assumption is highly conservative since the 5.0 mg/L requirement is based on a short-term minimum DO value while the actual average DO levels in mesotrophic waters could be significantly higher. If ambient DO already exceeds 5.0 mg/L, no change in the DO sub-index score would be calculated and the WQI would only reflect the reduced TP and TN concentrations.

As indicated by **Exhibit F-1**, the current EPA sub-index for DO assumes a curvilinear relationship between a highest score of 100 at 10.5 mg/L DO and a lowest score of 10 at 3.3 mg/L. The substitution of 5.0 mg/L for the DO concentration may not result in a sub-index score above 50. Based on the WQI definition, an overall WQI score below "50" may indicate water quality not supportive of game fish and/or inconsistent with an achievement of a "fishable" condition (EPA, 2009). This suggests that the DO sub-index curve may need to specific for Florida conditions. EPA used a FL specific curve in its WQI analysis found in Section 13 of this report.

Exhibit F-1 also considers the effects of supersaturation (% DO_{sat} > 100%) with declining water quality as % DO_{sat} reach up to 275%. However, it is rare to see field readings where % DO_{sat} > 150 % except as transient mid-day readings at the peak of algal photosynthesis. Further, if conditions where % DO_{sat} > 150 % are consistently measured, this would likely reflect physical aeration and entrainment such as below a waterfall or passage through a hydroelectric turbine and not be due to nutrient-related impairment.

Exhibit F-1: Freshwater Water Quality Sub-indices for DO

Parameter	DO Concentration (mg/L)	Subindex
DOsat ≤100%	≤3.3	10
	3.3<DO<10.5	-80.29+31.88*DO-1.401*DO^2
	10.5≤DO	100
100% < DOsat ≤275%	N/A	100 * exp((DOsat - 100) *-1.197 E-2)
275% < DOsat	N/A	10

Source: Based on EPA (2009).
DOsat = dissolved oxygen saturation.

To get a better assessment of the potential for application of the assumed DO concentration of 5.0 mg/L to Florida waterbodies, EPA considered DO concentration data representative of ambient conditions (calculated as geometric annual means) for incrementally impaired waters. However, this inspection indicates that DO concentration data are only available for a small number of waters (16 WBIDs) for which current monitoring data are available and thus does not provide sufficient data for a meaningful application.

However, review of the monitoring database (**Exhibit F-2**) indicates that sufficient data are available for the calculation of geometric means of WBIDs for % DO_{sat} for many lakes (148 or 11.3% of the lake WBIDs) and flowing waters (148 or 10.7% of the stream WBIDs). As noted above, % DO_{sat} provides an alternative parameter for relative DO availability and, if temperature is considered, may be used as a surrogate for compliance with minimum DO concentration requirements[21].

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[21] Absolute concentrations of DO can be back-calculated from % DO_{sat} value through appropriate correction based on the ambient temperature recorded in the field. However, this would require extensive individual value-specific comparison to field data and is not considered critical for the purposes of this preliminary analysis.

Exhibit F-2: Summary of Available %DOsat data by Waterbody Type

Category	Lake WBIDs	Stream WBIDs
Total WBID Category in State	1,310	3.901
# WBIDs with %DO_{sat} data	148	418
% WBIDs with %DO_{sat} data	11.3%	10.7%
Total WBID Category in State identified as incrementally-impaired	147	330
# WBIDs with %DO_{sat} data identified as incrementally-impaired	28	126
#%WBIDs with %DO_{sat} data identified as incrementally-impaired	19.0%	38.2%

DOsat = dissolved oxygen saturation
WBID = waterbody identification

F.3.1 Minimum DO Criterion

There is no Florida water quality standard for % DO_{sat}, but if the likely ambient water temperatures are considered, it may be possible to estimate the approximate level of % DO_{sat} that would be required to meet the minimum 5.0 mg/L DO criterion.

Due to the inverse relationship with temperature, the critical period to check for DO compliance is during the summer. The range of average annual maximum air temperature for selected locations throughout Florida is shown in **Exhibit F-3** and indicates a range approximately of 77 to 85^{o} Fahrenheit (or about 25 to 30^{o} Celsius (About.com 2010)). Due to the shallow nature of most Florida flowing waters and lakes it is reasonable to assume that water temperatures are in approximate equilibrium with air temperatures. The corresponding full saturated (i.e., 100% DO_{sat}) DO concentrations range from 8.26 to 7.56 mg/L (Wetzel, 2001). To meet a DO criterion of 5.0 mg/L at these water temperatures would require a minimum % DO_{sat} ranging from 60 to 66%.

Exhibit F-3: Florida Annual Temperatures

Location	Low Temp (°F)	High Temp (°F)
Daytona Beach	61	80
Fort Lauderdale	67	84
Fort Myers	64	84
Gainesville	58	82
Jacksonville	59	79
Key West	73	83
Lakeland	64	82
Melbourne	63	81
Miami	69	83
Naples	64	85
Ocala	59	83
Orlando	62	83
Pensacola	59	77
St. Petersburg	66	82
Sarasota	62	83
Tallahassee	56	79
Tampa	63	82
West Palm Beach	67	83

Source: About.com. Florida Climate and Weather

F.3.2 DO Threshold for Meeting Beneficial Uses

In addition to the minimum DO criterion, a secondary DO threshold for Florida flowing waters is attainment of a DO concentration judged sufficient to meet all beneficial uses. Florida Department of Environmental Protection (FDEP), as part of earlier CWA Section 305(b) assessments, has used its own water quality index to determine the quality of Florida's flowing waters, blackwaters, and springs. Index parameters include: water clarity, DO, BOD, nutrients, bacteria, and macroinvertebrate diversity. Looking only at the categorization of DO, the Florida index considers a DO value of 6.3 mg/L as fully meeting all uses; a DO value of 5.8 mg/L as partially meeting all uses; and a DO value of 5.3 mg/L as not meeting all uses (FL DEP, undated). Using the assumed Florida air and water temperature range discussed above, fully meeting all uses would require an approximate minimum % DO_{sat} ranging from 73 to 83%.

Other water quality indices explicitly include % DO_{sat}. For example, the San Francisco Bay Water Quality Index indicates that % DO_{sat} below 60% to 80% can be harmful to aquatic organisms in marine or brackish water environments (BISF, 2003). In freshwater situations, Said et al (2004) cited a % DO_{sat} value of 75% as a benchmark and Kaurish and Younos (2007) considered % DO_{sat} values from 70% to 79.9 % indicative of "fair" water quality and those from 80% to 89.9% indicative of "good" water quality.

Considering these factors, EPA considers a % DO_{sat} value of 80% an appropriate value to use assuming compliance with the numeric nutrient criteria will result in full attainment of all beneficial uses. Applying the % DO_{sat} of 80% to the range of annual high temperatures yields DO concentrations ranging from 6.0 to 6.6 mg/L; with a statewide average of 6.3 mg/L. This value is consistent with meeting both the Florida minimum DO criterion of 5.0 mg/L and reaching full attainment of beneficial uses under the stream WQI.

F.3.3 Potential Impact of DO Threshold on WQI values

Exhibit F-4 summarizes % DO_{sat} for WBIDs with available data. Low DO in colored lakes and blackwater flowing waters is attributable to the presence of natural organic compounds and acids and not necessarily a function of excess nutrients (Crisman et al., 1998). Clear lakes generally meet the 80% mean % DO_{sat} threshold. In contrast, flowing waters are more likely not to meet the mean % DO_{sat} threshold of 80%. Based on this assessment, the assumption of attaining the mean % DO_{sat} threshold of 80% after nutrient reduction would not greatly improve the WQI for most lakes, but could be a significant factor in increasing WQI values for flowing waters. However, these judgments are based on the assuming that the small percentage of incrementally-impaired WBIDs for which % DO_{sat} data are available is representative of the larger set for which we do not have DO data. Additional uncertainty factors are discussed below.

Exhibit F-4: Summary of DO_{sat} for Lakes and Flowing Waters

Category	No. WBIDs with %DOsat data	# Incrementally Impaired WBIDs (DOsat < 80%)	% of WBIDs with DOsat <80%
Lakes			
Clear	12	2	17%
Unknown (treated as clear)	9	0	0%
Colored	7	2	29%
Total	28	4	14%
Flowing Waters			
Flowing waters (excludes blackwater)	117	83	71%
Blackwater	9	7	78%
Total Flowing waters	126	90	71%

DOsat = dissolved oxygen saturation
WBID = waterbody identification

F.3.4 Uncertainties Associated with Assumption of 80% DO_{sat} following Nutrient Reduction

The assumption of a mean % DO_{sat} value of 80% as the expected DO condition following attainment of nutrient criteria should be treated as a "best-case" scenario and not a realistic expectation for all incrementally-impaired waterbodies meeting the criteria. As detailed in Section 13, there are numerous factors that can contribute or determine the actual DO concentration in a given waterbody at any given time, and many of those are not related to nutrients.

What this assumption provides is an upper bound estimate of the potential range of improvement in DO that might be possible following nutrient criteria implementation. However, there is no means presently available to estimate what fraction of this upper bound is expressed *in situ* in the waterbodies of interest. The actual level of water quality improvement arising from increasing DO is subject to significant uncertainty from a number of sources, including, but not limited to:

- Lack of DO water quality monitoring data for approximately 89-90% of the Florida lakes and inland waters so that any extrapolation of the results of this analysis to expected potential WQI benefits for these uncharted waters will be based on a limited sample size
- Recognition that DO_{sat} levels in incrementally-impaired waters may exceed 80% and may not realize any additional WQI improvement from criteria implementation (other than nutrient reductions)
- Use of annual average summer temperature to estimate the range of maximum water temperatures – instantaneous daily maximum temperatures would likely exceed 30^{o}C on some days
- Use of average water temperatures to assess compliance with minimum DO standards (5.0 mg/L), instead of assessing compliance based on the number and length of instantaneous temperature excursions over a period
- Recognition that there are numerous anthropogenic factors which lead to DO-consumption and that are not related to nutrients or which may not easily respond to a reduction in nutrients
- Recognition that there are numerous natural factors (e.g., dissolved organic compounds (DOC)) which lead to DO-consumption and that are not related to nutrients or which may not easily respond to a reduction in nutrients
- Exclusion of blackwater flowing waters and colored lakes in estimating DO-related benefits.

F.4 Evaluation of WQI-based Benefits with Changes in DO

Section 13 provides WQI-based estimates of potential benefits from attaining TN and TP criteria in lakes and flowing waters without accounting for any associated improvements in DO. This section provides estimates incorporating potential improvements in DO in the WQI value.

F.4.1 Improvements in Water Quality

As a preliminary estimate, EPA assumed a "best case" scenario that incrementally impaired WBIDs for which DO is below 6.3 mg/L will experience an increase in DO to 6.3 mg/L as a result of attaining TN and TP criteria (excluding colored lakes and blackwater flowing waters, for which low DO is natural).[22] As stated above, FDEP considers a DO value of 6.3 mg/L as fully meeting all beneficial uses. While the same number of total of miles and area is expected to improve when changes in DO are considered, large improvements in the WQI value results for a greater number of WBIDs when DO improvement is taken into account. **Exhibit F-5** and **Exhibit F-6** show these results.

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[22] EPA did not estimate improvements in DO for WBIDs with current DO levels above, 6.3 mg/L as these high DO levels are not a result of the proposed criteria.

Exhibit F-5: Potential Improvements in Flowing Water and Spring Miles

Change in WQI	Total number of WBIDs Improved		Total Miles Improved		Percent of Total Miles in Analysis		Percent of Total Water Miles in State[1]	
	Nutrient Improvement Only	Improvement in Nutrients and DO [2]	Nutrient Improvement Only	Improvement in Nutrients and DO [2]	Nutrient Improvement Only	Improvement in Nutrients and DO [2]	Nutrient Improvement Only	Improvement in Nutrients and DO [2]
0.01 < ΔWQI < 1.0	35	25	321	159	3.24%	1.61%	1.31%	0.65%
1.0 < ΔWQI < 5.0	84	76	897	798	9.06%	8.06%	3.65%	3.24%
5.0 < ΔWQI	47	65	284	545	2.87%	5.50%	1.15%	2.21%
Total	166	166	1,502	1,502	15.17%	15.17%	6.10%	6.10%

DO = dissolved oxygen

WQI = water quality index

1. Percentage taken out of total river, blackwater, and spring miles in Florida (24,603 miles)
2. Improvements in blackwater flowing waters do not consider a change in DO, as blackwater flowing waters are naturally impaired for DO.

Exhibit F-6: Potential Improvements in Lake Area

Change in WQI	Total number of WBIDs Improved		Total Square Miles Improved		Percent of Total Area in the Analysis		Percent of Total Water Area in the State[1]	
	Nutrient Improvement Only	Improvement in Nutrients and DO [2]	Nutrient Improvement Only	Improvement in Nutrients and DO [2]	Nutrient Improvement Only	Improvement in Nutrients and DO [2]	Nutrient Improvement Only	Improvement in Nutrients and DO [2]
0.01 < ΔWQI < 1.0	6	5	32	31	1.70%	1.66%	0.20%	0.20%
1.0 < ΔWQI < 5.0	40	30	118	109	6.32%	5.85%	0.74%	0.69%
5.0 < ΔWQI	101	112	85	95	4.58%	5.08%	0.54%	0.60%
Total	147	147	235	235	12.59%	12.59%	1.48%	1.48%

DO = dissolved oxygen

WQI = water quality index

1. Percentage taken out of water area in Florida, including lake, coastal, beach, and estuary area (10,179,200 acres)..
2. Improvements in colored lakes do not consider a change in DO, as colored lakes are naturally impaired for DO.

F.4.2 WTP for Improvements in Water Quality

Following the method described in Section 13, **Exhibit F-7** shows the estimated average household WTP for flowing waters and **Exhibit F-8** contains the average household WTP for lakes. Average annual household WTP for full time residents for attaining nutrient criteria may be approximately $3.61 (midpoint estimate) for improvements in flowing waters and springs, and $0.97 (midpoint estimate) for improvements in lakes, when improvements in DO are taken into consideration. Part time residents have smaller average annual household WTP, with mid-point estimates ranging from $0.26 per household for improvements in lakes to $0.96 for improvements in rivers and springs. Because people are willing to pay more for larger improvements in water quality, average household WTP is more when both improvements in DO and nutrients are taken into consideration than when only TN and TP reductions are considered, despite the fact that the same amount of water is improved in both scenarios.

Exhibit F-7: Potential Average Annual Household WTP for Water Quality Improvement in Flowing Waters in Florida (2010$)

State Resident Type	10th Percentile		50th Percentile		90th Percentile	
	Nutrient Improvement Only	Improvement in Nutrients and DO [1]	Nutrient Improvement Only	Improvement in Nutrients and DO [1]	Nutrient Improvement Only	Improvement in Nutrients and DO [1]
Full Time Resident	$1.52	$1.97	$2.94	$3.61	$4.71	$5.63
Part Time Winter Resident	$0.39	$0.50	$0.78	$0.96	$1.28	$1.53

DO = dissolved oxygen

WTP = willingness to pay

1. Improvements in blackwater flowing waters do not consider a change in DO, as blackwater flowing waters are naturally impaired for DO.

Exhibit F-8: Potential Average Annual Household WTP for Water Quality Improvement in Lakes in Florida (2010$)

State Resident Type	10th Percentile		50th Percentile		90th Percentile	
	Nutrient Improvement Only	Improvement in Nutrients and DO [2]	Nutrient Improvement Only	Improvement in Nutrients and DO [2]	Nutrient Improvement Only	Improvement in Nutrients and DO [2]
Full Time Resident	$0.49	$0.54	$0.89	$0.97	$1.38	$1.49
Part Time Winter Resident	$0.13	$0.14	$0.24	$0.26	$0.38	$0.41

DO = dissolved oxygen

WTP = willingness to pay

1. Improvements in colored lakes do not consider a change in DO, as colored lakes are naturally impaired for DO.

Exhibit F-9 and **Exhibit F-10** present the estimated total state benefits for improvements in WQ in rivers and lakes, when improvements in DO, TN, and TP are taken into consideration. Full-time resident benefits range from $7.03 million (midpoint estimate) for improvements in lakes to $26.50 million (midpoint estimate) for improvements in flowing waters and springs. Seasonal resident benefits are much smaller, with mid-point estimates of $0.31 and $0.08 million for improvements in rivers and lakes respectively. Total state benefits may be approximately $26.50 million of improvements in rivers and springs when change in DO is considered. This is a 23% increase in benefits from the total of $21.56 million when only nutrient improvements were taken into account. Total benefits for lakes increase from $6.56 million to $7.12 million (approximately 9% increase) when improvement in DO concentrations is taken into account.

Exhibit F-9: Potential Total Benefits for Water Quality Improvement to Freshwater Flowing waters in Florida (Millions of 2010$)

State Resident Type	10th Percentile		50th Percentile		90th Percentile	
	Nutrient Improvement Only	Improvement in Nutrients and DO [1]	Nutrient Improvement Only	Improvement in Nutrients and DO [1]	Nutrient Improvement Only	Improvement in Nutrients and DO [1]
Full Time FL Resident	$11.04	$14.27	$21.31	$26.18	$34.14	$40.81
Part Time Winter Resident	$0.13	$0.16	$0.26	$0.31	$0.42	$0.50
Total	$11.17	$14.43	$21.56	$26.50	$34.56	$41.31

DO = dissolved oxygen

1. Improvements in blackwater flowing waters do not consider a change in DO, as blackwater flowing waters are naturally impaired for DO.

Exhibit F-10: Estimated Total Benefits for Water Quality Improvement to Freshwater Lakes in Florida (Millions of 2010$)

State Resident Type	10th Percentile		50th Percentile		90th Percentile	
	Nutrient Improvement Only	Improvement in Nutrients and DO [2]	Nutrient Improvement Only	Improvement in Nutrients and DO [2]	Nutrient Improvement Only	Improvement in Nutrients and DO [2]
Full Time FL Resident	$3.58	$3.91	$6.48	$7.03	$10.02	$10.83
Part Time Winter Resident	$0.04	$0.05	$0.08	$0.08	$0.12	$0.13
Total	$3.62	$3.96	$6.56	$7.12	$10.14	$10.96

DO = dissolved oxygen

1. Improvements in colored lakes do not consider a change in DO, as colored lakes are naturally impaired for DO.

F.5 References

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