Report to the Florida Legislature: Basin Management Action Plan Monitoring

Florida Department of Environmental Protection

June 11, 2021

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Executive Summary

During its 2020 session, the Florida Legislature passed the Clean Waterways Act (Chapter 2020-150, Laws of Florida), which requires the Florida Department of Environmental Protection (DEP) to report on water quality monitoring in the area of each basin management action plan (BMAP) adopted to resolve nutrient pollution. The Legislature rightly identifies nutrients—primarily nitrogen and phosphorus—as Florida's most confounding water quality problem. This report describes current monitoring; identifies monitoring gaps; proposes changes that would fill those gaps; and estimates the costs of the improvements.

Monitoring is DEP's primary mechanism for identifying and prioritizing water quality problems, understanding their characteristics, and evaluating the effectiveness of restoration programs. DEP, along with its partner local and regional entities across Florida, devotes substantial resources to surface water, groundwater, and biological monitoring so that the results can be used to develop restoration strategies and measure the success of the resulting projects and actions.

Most of this report comprises summaries of monitoring in each of the 29 nutrient BMAP areas, including maps of monitoring locations and identification of the actions needed to fill the gaps. As background, the report characterizes the harm excessive nutrients inflict on Florida's aquatic systems and describes the programs DEP implements to restore those systems. It outlines monitoring objectives, different types of monitoring, and the considerations that went into developing BMAP monitoring plans. The report also reviews the physical aspects of monitoring, including water quality sampling, sample handling protocols, and laboratory analyses.

The report concludes with cost estimates for potential adjustments to BMAP monitoring. While the current monitoring structure is adequate to determine restoration progress in each BMAP area, it also is clear that changes in certain areas would enable agency staff to better identify pollutant sources and capture water quality trends, which would expedite restoration. In six of the 29 BMAPs, no changes are proposed. For most surface water BMAPs, a few relatively inexpensive changes would make a difference. Several larger surface water systems, including Lake Okeechobee and the Lower St. Johns River, would benefit from more substantial changes. The same is true for most of the springs BMAPs because of the complex interactions between surface water and groundwater and the difficulty in isolating pollutant sources.

The recommended changes—more monitoring stations and wells, more frequent sampling, new equipment, expanded biological monitoring—are estimated to cost $2.9 million. Even carefully prioritized smaller investments would improve DEP's ability to evaluate the impact of nutrient loadings on Florida's surface water and groundwater and work with local stakeholders to develop more effective restoration strategies. DEP will take advantage of any resources the Legislature makes available to accomplish this work, including "water quality enhancement and accountability" funds (line item 1613 of the 2021 General Appropriations Act).

Basin Management Action Plan Monitoring

Introduction

On March 11, 2020, the Florida Legislature passed the Clean Waterways Act, Senate Bill 712, signed into law on June 30, 2020, as Chapter 2020-150, Laws of Florida. Among its water quality provisions, new Subsection 403.0671(2), Florida Statutes (F.S.), requires the following:

> *403.0671 Basin management action plan wastewater reports. —*
>
> *(2) By July 1, 2021, the department shall submit a report to the Governor, the President of the Senate, and the Speaker of the House of Representatives that provides an assessment of the water quality monitoring being conducted for each basin management action plan implementing a nutrient total maximum daily load. In developing the report, the department may coordinate with water management districts and any applicable university. The report must:*
>
> *(a) Evaluate the water quality monitoring prescribed for each basin management action plan to determine if it is sufficient to detect changes in water quality caused by the implementation of a project.*
>
> *(b) Identify gaps in water quality monitoring.*
>
> *(c) Recommend water quality monitoring needs.*

The Legislature's continuing commitment to restoring Florida's rivers, lakes, springs, and estuaries is essential to success. Monitoring is DEP's primary mechanism for identifying and prioritizing water quality problems, understanding their characteristics, and judging the effectiveness of restoration programs in solving them. DEP, Florida's five water management districts (WMDs), and local governments across the state invest substantial personnel and financial resources to collect samples, protect their integrity, analyze them according to strict scientific protocols, and use the results to develop and refine restoration strategies.

This report begins with a discussion of nutrients and the harm they cause to Florida's aquatic systems and continues with an overview of DEP's water quality restoration programs. It describes monitoring and its objectives, the different types of monitoring in BMAP areas, and the considerations that go into developing each monitoring plan. It also outlines the practicalities associated with sampling and analyses. After reviewing the considerations guiding the assessment of current monitoring and identifying monitoring gaps, the bulk of the report is devoted to detailing the situation for each BMAP, including the actions needed to fill the gaps. The report concludes with an estimate of the costs to fill those gaps.

Nutrients

The Legislature rightly focused its requirement for a BMAP monitoring report on nutrient pollution in Florida's surface water and groundwater—forms of nitrogen and phosphorus[1] that exist naturally in the aquatic environment but which, in excessive amounts caused by human activity, are destructive. Elevated nutrient levels are defined, in effect, by Florida's water quality standards,[2] adopted by rule at statutory direction to protect public health and aquatic life:

- **Groundwater nitrogen criterion –** 10 milligrams per liter (mg/L).[3] There is no numeric phosphorus criterion; the groundwater "free from" standard established in Rule 62-520.400, F.A.C., applies to contaminants without numeric criteria.[4]

- **Springs nitrogen criterion –** 0.35 mg/L of nitrate-nitrite at the spring vent. Spring runs fall within the definition of surface waters, which have nitrogen and phosphorus limits.

- **Surface water standards –** Nutrient criteria are numeric or narrative depending on circumstances, such as waterbody type or location. Criteria reflect levels of nutrients that cause an imbalance in populations of native aquatic flora and fauna.

Nutrients are Florida's most confounding water quality problem. Even relatively low nitrogen and phosphorus levels can be disastrous, causing rapid algal growth and blocking light essential for aquatic plant life; exacerbating algal blooms, potentially toxic to human and aquatic life; and depleting dissolved oxygen when algae and plants die, which in turn kills fish, crabs, oysters, and microscopic life. Disruption of the natural biological balance results in profound economic, social, and environmental harm—declining tourism, fewer recreational opportunities, depressed real estate values, lost fishing and shellfish harvesting revenues, and lower quality of life.

Nutrient BMAPs focus on actions to reduce nutrient loading from the following primary sources:

- **Agriculture** – Fertilizers contain high levels of nitrogen and phosphorus; when overapplied, the nutrients are not fully taken up by crops and leach into groundwater or are carried into surface water by runoff. In addition, animal feeding operations generate enormous volumes of waste that contribute excess nutrients to the environment when not properly managed. In 2017, Florida had 47,000 commercial farms and ranches, occupying about 9.45 million acres.[5]

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[1] Forms include total nitrogen, ammonia, nitrate-nitrite, organic nitrogen, total phosphorus, and orthophosphate.
[2] Florida's surface water standards are found in Rule 62-302, F.A.C., while groundwater standards are in Rules 62-520 and 62-550, F.A.C. All rules cited are available at https://flrules.org.
[3] A limit of 20 mg/L may be allowed if the groundwater will not be used as a drinking water source.
[4] Groundwater must at all places and times be free from human-induced discharges in concentrations that, alone or in combination, are toxic or otherwise harmful to native flora and fauna, including as they may impair adjacent waters. See Rule 62-520.400, F.A.C.
[5] See https://www.fdacs.gov/Agriculture-Industry/Florida-Agriculture-Overview-and-Statistics.

- **Urban fertilizer** – Lawn and other plant fertilizers used on urban and suburban landscapes, neighborhood and commercial, contain nutrients. People routinely overapply and improperly dispose of fertilizers, and the nutrients end up in surface water and groundwater. There are more than 5.2 million single-family homes in Florida.[6]

- **Stormwater** – In addition to carrying agricultural and urban fertilizer, rainwater washes across rooftops, driveways, sidewalks, parking lots, roads, and lands of all sorts and carries nutrients from these sources into local waterways.

- **Wastewater** – There are an estimated 2.1 - 2.6 million conventional onsite sewage treatment and disposal systems (OSTDS) in Florida.[7] Conventional OSTDS remove minimal nitrogen and phosphorus before they discharge to groundwater, or indirectly into surface water. The problem is significant where conventional OSTDS are densely clustered on smaller lots in vulnerable areas with porous geology and soils, high water table, and close to surface water, as is common throughout Florida. There also are central facilities, often older ones, served by leaking collection systems or prone to wastewater spills. Even properly functioning facilities add to the nutrient load in many watersheds.

- **Air deposition** – Fossil fuels for electric power generation, transportation, and other industries—many of them out of state—pump nitrogen into the air, which is deposited into surface waters. This nutrient load generally cannot be directly addressed through DEP's water quality programs and must be compensated for when restoring a waterbody.

- **Legacy loads** – In many aquatic systems, current nutrient problems are compounded by legacy loads from years of discharges and runoff from urban and agricultural areas before modern management practices were (or are) implemented. Legacy loads may take years to break down or be transported out of a watershed, or they may settle as sediments to be periodically rereleased. Current load reduction projects generally cannot fix legacy loads.[8]

[6] See https://data.census.gov/cedsci/table?q=florida%20housing&tid=ACSDP1Y2019.DP04&hidePreview=false.
[7] According to the Florida Department of Health (FDOH) website, at http://www.floridahealth.gov/environmental-health/onsite-sewage/index.html, the number of septic systems is 2.6 million; however, FDOH has provided DEP with geographic information system (GIS) coverage that includes 2.1 million septic systems.
[8] Removing sediment buildup in waterbodies may be possible, such as during a lake drawdown, but it is often impractical or prohibitively expensive.

DEP's Restoration Program

DEP has a series of legal responsibilities that govern its restoration program. DEP adopts water quality standards that define threshold pollution problems. It monitors and assesses statewide water quality to determine where there are verifiable water quality problems, including excess nutrients. DEP then applies scientific data analyses and mathematical modeling to set pollutant load reduction goals (total maximum daily loads, or TMDLs). BMAPs are developed to attain these water quality targets. As BMAPs are implemented, DEP measures progress through various kinds of chemical and biological monitoring and adjusts restoration strategies based on the results. Several key restoration steps are summarized in more detail below.

Assessment

Under Section 403.067, F.S., DEP uses the best available information to regularly assess and identify Florida surface waters—rivers, streams, springs, lakes, estuaries, and coastal waters, or segments of these waterbodies—that are "impaired," meaning they do not meet water quality standards because of specific pollutants. Assessments evaluate "ambient" water quality, including seasonal and other natural variations. In this context, ambient conditions are typical or normal conditions that can be considered generally representative, even if they are affected **indirectly** by human activities or upstream discharges. *The importance of ambient conditions is fundamental to understanding the discussion of BMAP monitoring later in the report.*

The assessment process and the data requirements to ensure valid impairment determinations are set forth in Chapter 62-303, F.A.C., *Identification of Impaired Surface Waters*. Chapter 62-302, F.A.C., *Surface Water Quality Standards*, includes the numeric and narrative criteria for pollutants, including nutrients, along with the designated beneficial uses of waterbodies to be protected.

Total Maximum Daily Loads

For waterbodies determined to be impaired, DEP prioritizes the establishment of TMDLs, scientifically derived targets for the maximum amount of specific pollutants (nutrients, bacteria, metals, etc.) a given waterbody can receive from all sources and still meet water quality standards. TMDL development uses water quality data and mathematical models to account for the pollutant loading from domestic and industrial wastewater discharges, urban and agricultural rainfall runoff, and conventional OSTDS, for example,[9] along with a margin of safety to account for uncertainty. TMDLs must, by law, be coordinated with affected stakeholders and must adhere to strict data quality standards.

A TMDL typically establishes limits on the amount of nitrogen and phosphorus that a waterbody can assimilate and remain healthy. The difference between the nutrient load target and the current nutrient loading from all sources determines the reductions necessary to achieve the TMDL and restore the waterbody. Under Subsection 403.067(6), F.S., each TMDL must be adopted by rule; the rules are included in Chapter 62-304, F.A.C.

Basin Management Action Plans

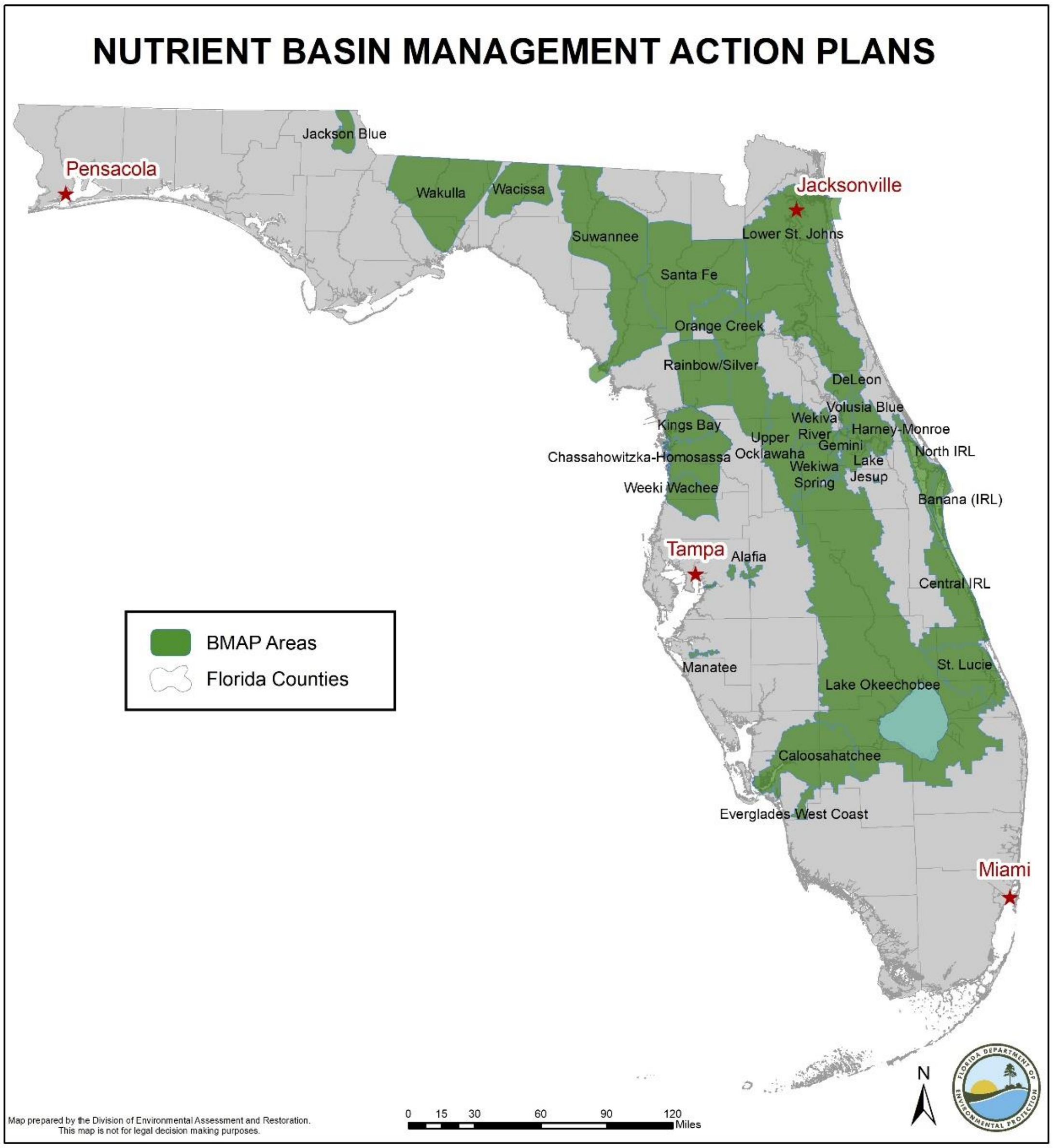
To implement a TMDL, Subsection 403.067(7), F.S., authorizes DEP to develop a BMAP encompassing the watershed(s) tributary to the impaired waterbody or waterbody segment. Each BMAP is a framework for reducing pollutant loading through cost-effective projects and strategies. BMAPs may identify the need for more stringent wastewater effluent limits, new wastewater or stormwater infrastructure, upgraded OSTDS, urban and agricultural best management practices, and other actions necessary to reduce pollutant loads. The plans are developed together with local stakeholders; they rely on local commitment to be successful. DEP adopts BMAPs by Secretarial Order.

Each BMAP defines the area it encompasses and may identify smaller areas for specific purposes, like springs priority focus areas or subwatersheds related to project implementation. The BMAP allocates expected load reductions from pollutant sources necessary to meet the TMDL restoration target, projects to implement those reductions, an implementation schedule, a monitoring plan to evaluate progress, and adaptive management strategies so that monitoring results can be translated into better implementation. Full restoration typically takes years, and BMAPs often are structured in 5-year increments with at least a 20-year horizon.

[9]A more complete list of pollutant sources includes wastewater discharges and spills; sewer system leaks; industrial discharges; stormwater systems; conventional OSTDS; landscape runoff, including golf courses and athletic fields; animal feeding operations; pastures, rangelands, and other agriculture; construction sites; and atmospheric deposition.

BMAPs Implementing Nutrient TMDLs

There are 29 nutrient BMAPs, identified on the map and table below. BMAPs collectively encompass about 15,551,000 watershed acres, or 24,300 square miles.



BMAPs implementing a nutrient TMDL

Alafia River
Caloosahatchee River
Crystal River–Kings Bay
DeLeon Springs
Everglades West Coast
Gemini Springs
Chassahowitzka–Homosassa
Indian River Lagoon (IRL)–
Banana River Lagoon
IRL Central
IRL North
Jackson Blue Spring
Lakes Harney–Monroe
Lake Jesup
Lake Okeechobee
Long Branch
Lower St. Johns River
Main Stem
Manatee River
Orange Creek
St. Lucie River
Upper Ocklawaha River
Wakulla Springs
Wacissa Springs
Weeki Wachee Springs
Wekiva River
Santa Fe River
Silver/Rainbow Springs
Suwannee River
Volusia Blue Springs
Wekiwa–Rock Springs

BMAP Monitoring Background

In the BMAP-by-BMAP monitoring analysis that concludes this report, it is essential to recall that waterbody impairment is determined by assessing ambient water quality conditions, including seasonal and other natural variations. To determine whether restoration is successful, then, DEP must monitor comparably ambient conditions, where project activities or discharges will not distort the water quality measurements. DEP also conducts monitoring in BMAP areas for other purposes, to identify nutrient sources and detect trends, for example, but this monitoring is to refine implementation rather than determine ultimate success.

DEP employs various types of monitoring, any or all of which may be conducted in a BMAP:

- **Surface water monitoring –** Samples and measurements collected at strategic locations ("stations") to be analyzed for a suite of core and secondary analytes.

- **Groundwater monitoring –** Samples and measurements collected at strategic well locations to be analyzed for a suite of core and secondary analytes.

- **Biological monitoring –** Evaluation of the biological balance of aquatic systems. Different methods consider the fate of small benthic (bottom-dwelling) aquatic animals and larval stages of insects; quantify the extent and abundance of algae; characterize aquatic plants based on nativity and sensitivity to stressors; or assess health of seagrasses, microalgae, and other benthic vegetation. Biological monitoring often better reflects system health than water quality measurement alone.

- **Stage and flow monitoring –** Measuring the height of a water surface at a given location (stage), the quantity of water passing the location (flow), and the relationship between the two, to estimate a waterbody's overall discharge. Stage and flow data inform water quality evaluations, in part by serving as inputs to water quality models.

All monitoring must follow quality assurance procedures contained in DEP rules and guidance.[10, 11] Many samples are shipped to DEP's Central Laboratory for analysis. Strict handling protocols apply to ensure the reliability and validity of the reported results. Samples analyzed by other laboratories must meet equivalent quality assurance requirements.

Water Quality Monitoring in Nutrient BMAPs

The Florida Legislature charged DEP to evaluate the success of BMAP implementation through various mechanisms, including monitoring. As already noted, measuring progress in attaining restoration targets means monitoring ambient water quality conditions, the same conditions used to determine impairment in the first place. Other BMAP monitoring may focus on different objectives. DEP establishes a monitoring program for each BMAP as it is being developed, generally selecting from existing surface water stations and groundwater wells that DEP and WMDs use for other purposes.[12] The proper number and location of monitoring sites and adequate sampling frequency are critical to reliable determinations of water quality changes and BMAP progress.

BMAP Monitoring Goals

As noted, the primary goal of BMAP monitoring is to determine whether the impaired waterbodies targeted for restoration are, in fact, being restored. Rivers, lakes, springs, and estuaries may react to similar nutrient levels differently because of depth, flow, shoreline conditions, aquatic habitat, clarity, salinity, etc. Therefore, monitoring programs must account for these differences. They must be able to separate "noise" in the ecosystem from normal conditions, including natural variations, to understand true progress in returning to a healthy, well-balanced system that meets water quality standards.

There are other monitoring objectives common to BMAPs. One is to detect trends, whether water quality is improving or declining over time. Another is to identify nutrient sources in a watershed, which can determine where different types of projects will be most effective in reducing nutrient loading. Achieving these objectives is one reason for the variety of chemicals and conditions that may be monitored (see the section on "Water Quality Analytes" below).

BMAP projects may also be monitored. Larger stormwater treatment areas, for example, may be monitored if they have discrete discharge points. Wastewater projects, too, are monitored through compliance with their effluent discharge limits. Most projects, however, cannot be monitored directly or practically because their impacts are too diffuse or cannot be teased apart from the effect of other projects and activities. This is true for most best management practices, many stormwater systems, OSTDS, fertilizer application restrictions, and street-sweeping,

[10] See DEP's Chapter 62-160, Quality Assurance Rule, at https://www.flrules.org/gateway/ChapterHome.asp?Chapter=62-160. A variety of other sampling and implementation guidance also governs aspects of monitoring.
[11] See https://floridadep.gov/dear/florida-dep-laboratory/content/dep-laboratory-quality-assurance-manual-and-sops.
[12] Purposes include DEP's Status and Trends Networks that report on statewide water quality, surface water stations used in DEP's assessment program, and stations and wells used by the WMDs for regional purposes.

among other project types. DEP can estimate the nutrient loading impact of these sorts of projects based on scientific literature or computer modeling values, for example.

Even for projects that can be monitored directly, the results are not representative of water quality in the impaired system being restored. Projects, activities, and discharges that would skew the picture of ambient water quality cannot be part of the measurement.

BMAP Monitoring Considerations

Monitoring must be tailored to account for differences in aquatic environments, but there are fundamental considerations that apply broadly:

- Given that water quality impairment—not meeting standards—is the impetus for BMAP development, adequate monitoring must occur in each impaired segment.
- Sampling must be in the appropriate locations and at the right depths (geospatial distribution) to accurately represent watershed conditions.
- Sampling must be frequent enough to conduct trend analyses (is water quality getting better or worse?) and represent seasonal differences.[13]
- Enough data must be collected reliably to determine whether restoration targets are being attained and overall BMAP compliance is assured.
- Biological data must be robust enough to support the assessment of water quality and reflect whether the system has a healthy balance of native flora and fauna.
- There must be enough relevant data from the right places to identify nutrient sources.

Water Quality Analytes

Depending on whether the BMAP is for fresh surface water, brackish estuaries, or spring systems fed by groundwater, the suite of chemicals or conditions sampled may vary. Even within BMAPs addressing the same general type of waterbody, there may be reasons to focus on different analytes to best understand water quality changes. Because spring systems are fed by groundwater and emerge as surface water, both surface water and groundwater parameters are monitored; the same may be true for surface water systems, both lakes and rivers, if they are fed by or otherwise interact with groundwater.

[13] In considering sample size (the number of data points) and monitoring frequency, staff are guided by well-established statistical tests that reveal water quality trends with a known confidence level.

The following table lists the analytes most likely to be sampled in a BMAP monitoring program focused on nutrients.

Typical Surface Water and Groundwater Analytes

Surface Water	Groundwater
Alkalinity	Nitrate + nitrite (as N)
Ammonia (N)	Water temperature
Biochemical oxygen demand (BOD)	pH
Carbon – organic	Specific conductance
Carbon – total	Dissolved oxygen
Chlorophyll *a*	Sampling depth
Color	Discharge
Dissolved oxygen (DO)	Total nitrogen – includes TKN, nitrate, ammonia
DO saturation	Total phosphorus
Flow	Orthophosphate
Nitrate-nitrite (N)	Total organic carbon
Nitrogen – Total Kjeldahl (TKN)	15N and 18O isotopes
Nitrogen – total	Boron
Orthophosphate (P)	Calcium
pH	Magnesium
Phosphorus – total	Sodium
Specific conductance/salinity	Potassium
Temperature, water	Chloride
Total suspended solids (TSS)	Sulfate
Turbidity	Fluoride
	Alkalinity
	Total dissolved solids (TDS)
	Total suspended solids (TSS)
	Turbidity
	Color
	Field turbidity (NTU)[14]
	Depth to water
	Purge rate
	Volume purged

What Does Water Quality Sampling Entail?

Before samples can be taken, sites must be evaluated for suitability, access and safety. Sampling should only be conducted under representative conditions. Localized flooding and adverse weather—common in Florida—may prevent samples from being collected or biology being evaluated. Generally, sampling requires two samplers, although three may be needed for more complicated assessments. Staff must document the details of each sampling event to ensure the resulting data can be validated.

[14] Nephelometric turbidity units.

Criteria Guiding Recommendations for Additional Monitoring

In general, there must be enough data from the right locations gathered frequently enough, across seasons, to determine the current state of water quality and whether it is improving or declining over time. Are TMDL restoration targets being achieved? Is there enough biological monitoring to reflect the balance of native flora and fauna? Is there adequate nonambient monitoring to identify and understand contributions from different sources of nutrients?

What is Involved in Expanding Monitoring?

Adding monitoring sites, adding (or contracting for) staff to conduct additional monitoring, and purchasing equipment can be costly. Sites must be investigated. Proper field and, perhaps, laboratory equipment must be identified and sourced, the costs of which are based on market conditions and state contracts. If additional staff are needed, they must be trained in DEP's standard operating procedures.

DEP's Central Laboratory must determine it has the capacity to receive, track, store, analyze, and report on the additional samples to be generated. If other laboratories conduct the analyses, they must be certified by the FDOH Environmental Lab Certification Program for the types of samples to be analyzed, and they must be paid.

Entities other than DEP performing monitoring must comply with DEP protocols throughout the process of gathering, handling, shipping, and having samples analyzed and reported, including entering analytical results into DEP's Watershed Information Network (WIN).

BMAP-by-BMAP Monitoring Analysis

DEP reviewed each nutrient BMAP to determine where monitoring gaps exist and what actions would be required to fill them. It considered the following three types of nutrient BMAPs:

- **Springs BMAPs**, because they are fed by groundwater and emerge as surface waters, have different characteristics and water quality criteria than surface water systems, and are governed by unique statutory requirements in Part VIII of Chapter 373, F.S.

- **South Florida BMAPs** address surface water systems, several with major estuaries. They are grouped together because of their settings in a densely populated and agriculturally rich part of Florida and because, for several, implementation is governed by unique statutory requirements in Part IV of Chapter 373, F.S.

- **Other surface water BMAPs** address systems that may interact with groundwater, but it is their surface water characteristics and restoration targets that determine how restoration success is measured.

Each of the three sections is introduced with a summary of the similarities and differences in BMAPs; unique statutory provisions, if any; and monitoring recommendations, if any, that apply generally to the BMAPs in that section in order to reduce redundancy in the narratives.

Each BMAP is discussed on a separate page (or pages) and includes:

- Map(s) of the BMAP area and existing monitoring locations.
- Description of the location and areal extent of the BMAP.
- Description of the existing monitoring program.
- Key recommendations for monitoring improvements.

A note about the maps: The current monitoring network for each BMAP is depicted with various symbols. The scale of the maps and proximity of some monitoring sites means that sites may overlap (hide) one another. The maps are intended only to provide a visual impression of monitoring locations in service to the narrative descriptions.

After the BMAP summaries, the report concludes with a section identifying the estimated cost of implementing the monitoring recommendations and filling the identified gaps.

Outstanding Florida Springs BMAPs

In addition to Subsection 403.067(7), F.S., the development and implementation of BMAPs for Outstanding Florida Springs are governed by unique requirements in Part VIII of Chapter 373, F.S. Spring systems are especially vulnerable to harm from excessive levels of nutrients, particularly the nitrate form of nitrogen. Healthy springs nitrate concentrations historically were less than 0.2 mg/L, and the aquatic flora and fauna native to these systems developed to depend on low-nutrient environments with typically clear water and limited algae. Nitrate concentrations now are often an order of magnitude higher than those historical levels.

Each springs BMAP includes one or more priority focus areas based on groundwater travel time to the spring, hydrogeology, nutrient load, and other factors that may lead to water quality degradation.[15] Within these uniquely vulnerable areas, various statutory requirements and prohibitions apply.

For spring systems, DEP typically collects surface water quality data at or near the spring vent to determine if nitrate reduction targets are being achieved, flow data to support calculating and tracking changes in nitrogen loading from the springshed, and well data because groundwater

[15] DEP developed a data-driven GIS tool to determine these priority focus areas by estimating the relative nitrogen contributions from various sources, considering the transport pathways and processes affecting the forms of nitrogen, including nitrate, as they move from land through soil and geologic strata to the aquifer(s).

will reflect nitrate concentration changes before spring vents do. Well data also help identify the relationship between nitrate levels and different land uses and recharge rates.

The following additional monitoring recommendations apply broadly to all springs BMAPs:

- Conduct groundwater sampling at a minimum number of wells (generally, 15) at least quarterly to evaluate seasonal trends and collect enough data for statistically reliable trend analysis. The number of additional wells and sampling frequency may vary; differences are noted in the individual summaries.

- Collect core and supplementary analytes at all monitoring sites.

- Conduct isotope sampling to evaluate nitrogen contributions from organic and inorganic sources.[16] (Isotopes are different forms of the same elements that can identify groundwater origin and its connection to other aquifer or surface water systems.)

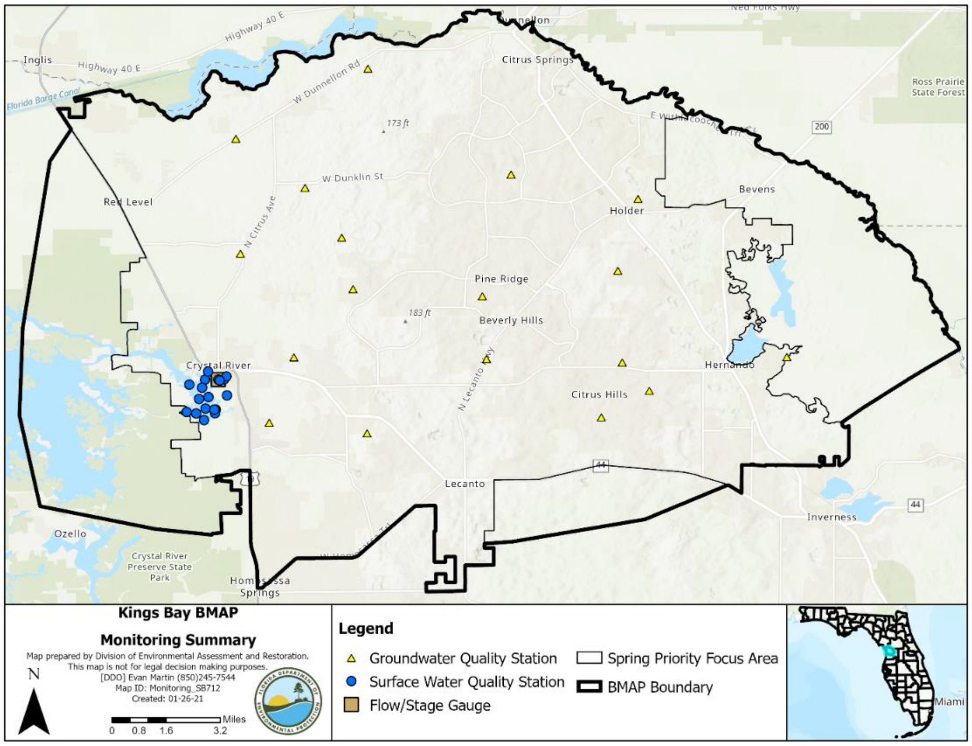
- Expand biological monitoring to identify responses of flora and fauna to changes in nitrate levels, a better reflection of system health than water samples alone.

- Expand well networks to capture the nutrient impacts of different land uses, including different types of agricultural and urban settings. The number of additional wells and sampling frequency may vary; differences are noted in the individual summaries.

Each springs BMAP summary includes "key additional recommendations" in some way unique to that system, which may expand on or modify the general recommendations above.

[16] Organic compounds have a carbon atom, while most inorganic compounds do not, and are associated with living beings. Inorganic compounds arise from natural or synthetic processes unrelated to life forms.

KINGS BAY/CRYSTAL RIVER

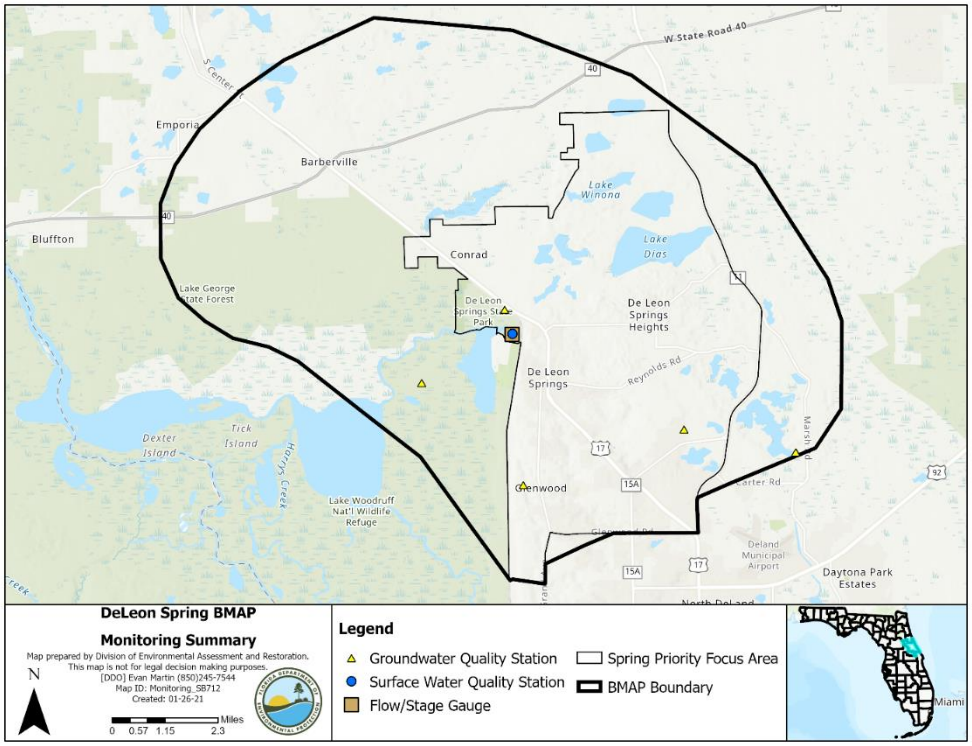


The BMAP area encompasses 180,282 watershed acres, including a large priority focus area. It overlays the groundwater contributing areas for the Crystal River and Kings Bay spring complex, which contains more than 70 springs. Water quality is monitored at 12 surface water stations and 18 groundwater wells in the Floridan Aquifer system. Spring vent sampling occurs at 5 sites. There are 2 continuous stations, 1 measuring discharge and water elevation, the other measuring gauge and tide height.

Key Additional Recommendation

- Add nitrate and orthophosphate sensors to one of the existing continuous monitoring stations to provide consistent data to assess water quality restoration targets. (Nitrate and orthophosphate are key parameters to track progress in decreasing nutrient concentrations in groundwater and water flowing from the spring vents to Kings Bay.)

DeLeon Springs



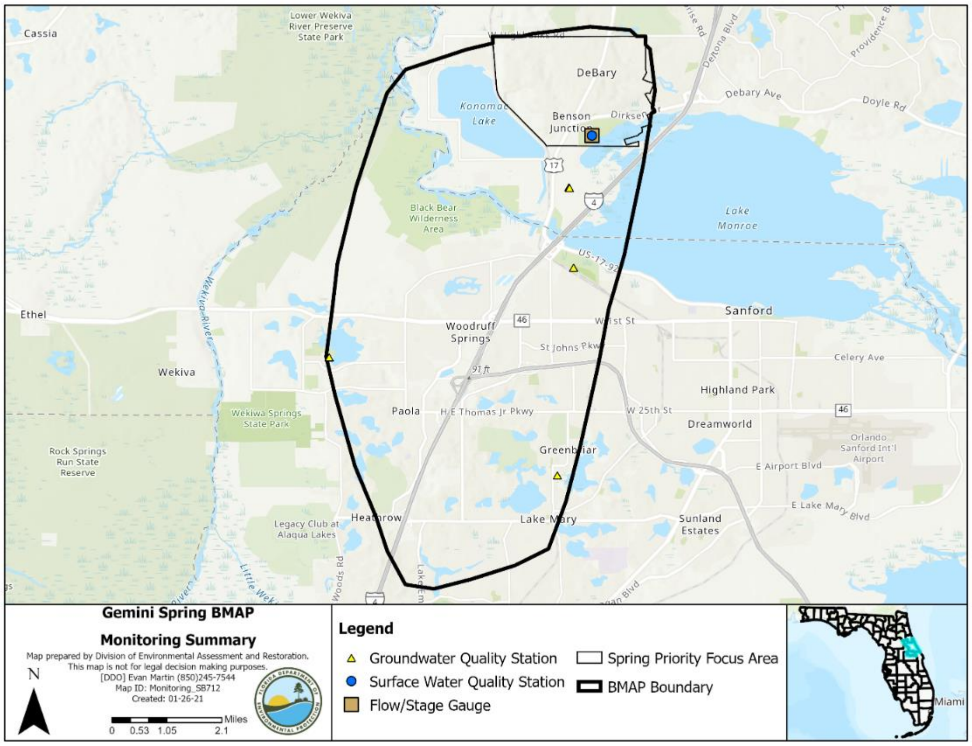
The BMAP area encompasses 65,392 watershed acres in Volusia County. DeLeon Spring is a second magnitude spring in DeLeon Spring State Park, 5 miles northwest of DeLand. A series of lakes and creeks connects the headspring to the St. Johns River 12 miles downstream. The BMAP area includes a 24,437-acre priority focus area.

Samples at the spring vent are collected monthly at one station. The St. Johns River WMD records discharge measurements daily. Eight Upper Floridan aquifer system wells are sampled annually. There is no biological monitoring.

Key Additional Recommendations

- Add at least three surface water monitoring locations, to be sampled monthly.
- Add at least 7 wells to enable continuing the sampling of a minimum of 15 wells within the priority focus area to monitor groundwater nutrient trends, consistent with the general recommendation for all springs BMAPs.

GEMINI SPRINGS



The BMAP area encompasses 27,290 acres in Seminole and Volusia Counties and includes a 3,096-acre priority focus area.

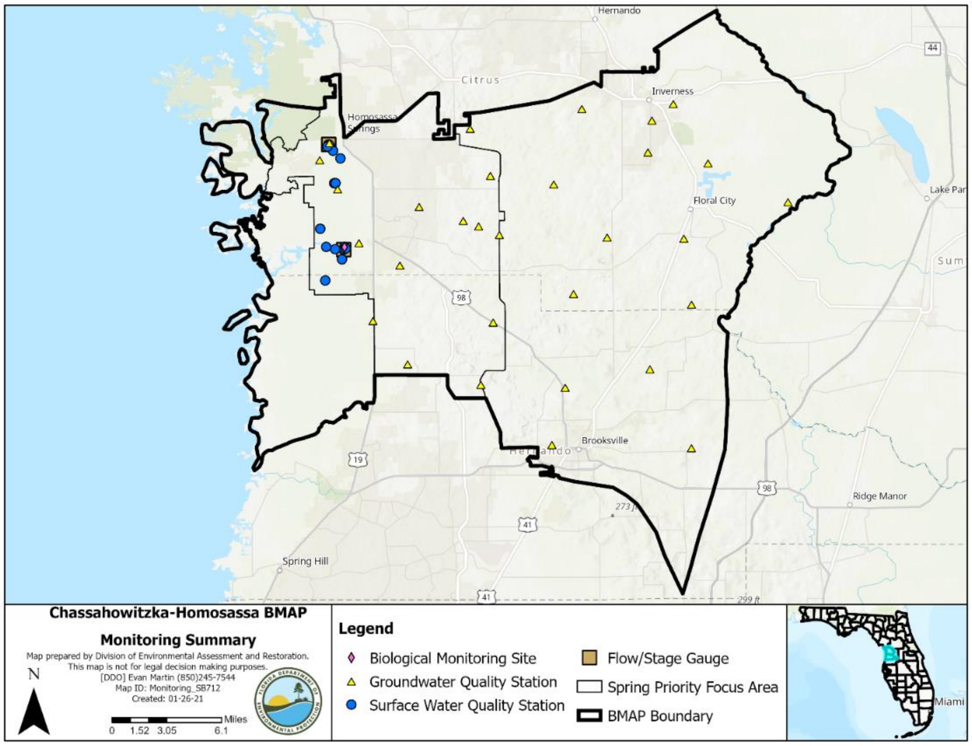
Samples at the spring vent are collected monthly at one station, the northernmost (upper) spring vent. The St. Johns River WMD records discharge measurements daily. Eight Upper Floridan aquifer system wells are monitored annually.

Key Additional Recommendations

- Add monthly sampling at the second (east) spring vent to determine if it is discharging similar water quality as the northwest vent. If both vents produce nearly identical water quality over time, sampling at the east vent could be scaled back or discontinued.

- Add at least 7 wells to enable continuing the sampling of a minimum of 15 wells within the priority focus area and overall springshed to monitor groundwater nutrient trends, consistent with the general recommendation for all springs BMAPs.

HOMOSASSA/CHASSAHOWITZKA



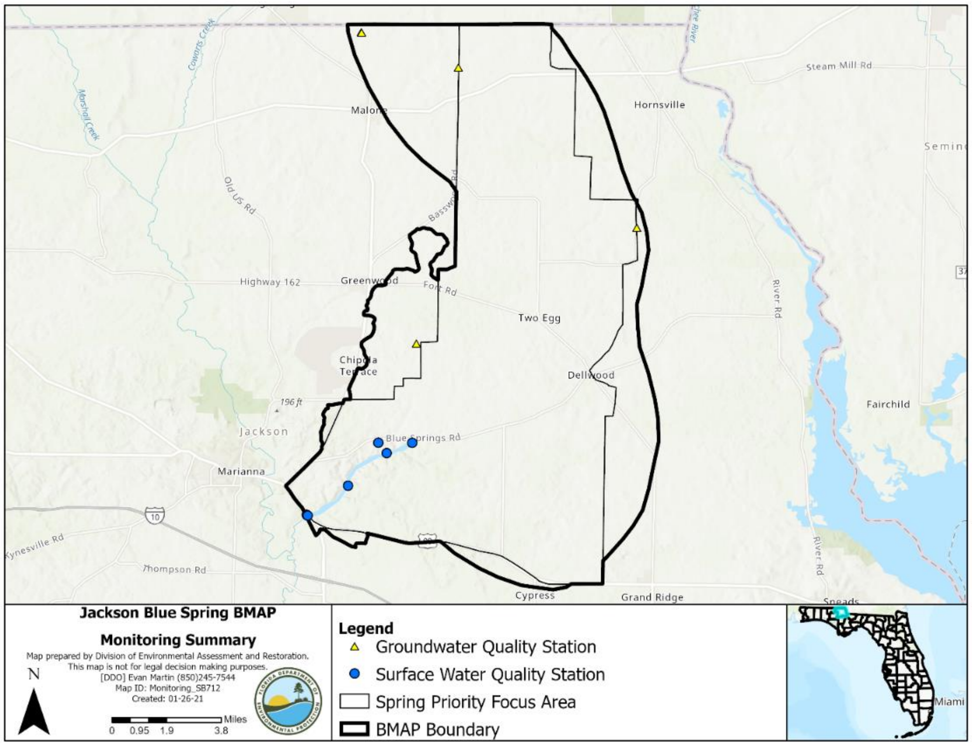
The BMAP area encompasses 325,982 acres in southern Citrus and northern Hernando Counties. It contains both the Homosassa Spring Group, the source waters for the Homosassa River, and the Chassahowitzka Spring Group, headwaters of the Chassahowitzka River. The BMAP area includes a 77,732-acre priority focus area.

Sampling takes place at 23 surface and spring vent stations, at varying frequencies, and regularly at 30 Floridan aquifer system wells. Some biological monitoring occurred in the past.

Key Additional Recommendations

- Expand spring vent sampling at all impaired springs to provide consistent data to assess the water quality restoration targets.
- Add four wells in the Chassahowitzka Springs Group to support calculation of nutrient loading targets and to evaluate progress toward monthly nitrate concentration targets.

JACKSON BLUE SPRING



The BMAP area encompasses 92,683 acres in Jackson County, east of Marianna. About 8 % of the springshed is in Alabama, outside the BMAP scope. The priority focus area comprises 67,517 acres. Jackson Blue Spring and 7 additional named springs contribute to Merritts Mill Pond, the headwaters of Spring Creek, which is a tributary to the Chipola River, a designated Outstanding Florida Water. (Designation is intended to protect existing, generally good water quality in waterbodies with unique natural attributes.)

Monitoring is performed at six surface water and spring vent stations and five Floridan aquifer system wells. Monitoring of surface water and spring vents occurs quarterly at five stations and continuously at one station. Wells are monitored quarterly. DEP conducts annual biological monitoring for Merritts Mill Pond.

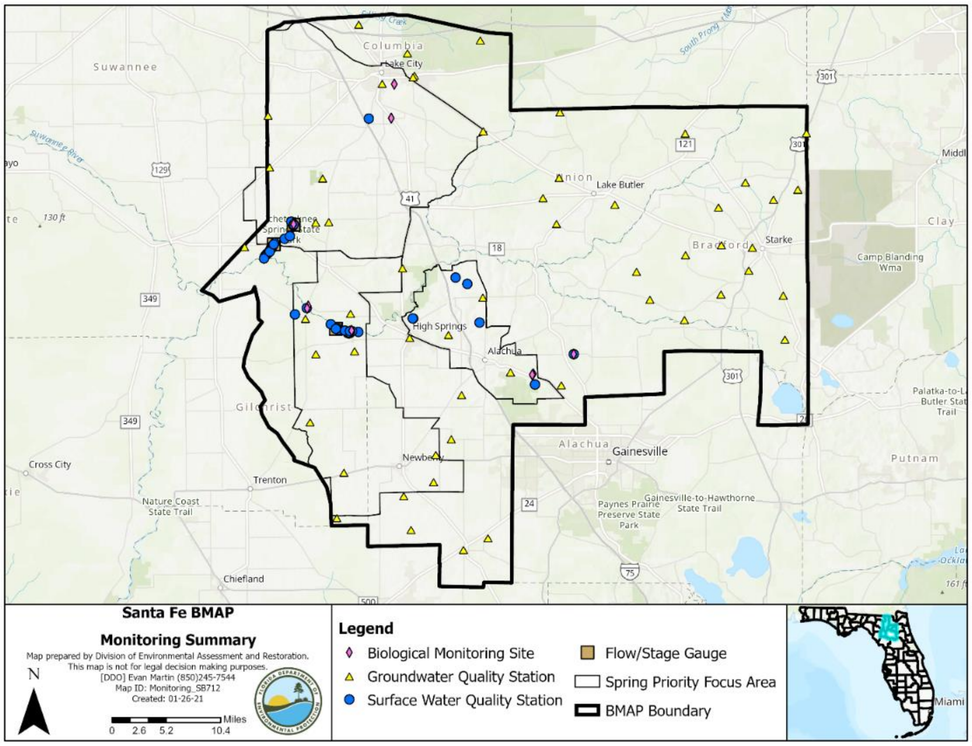
Key Additional Recommendations

- Add at least one surface water monitoring location to provide consistent data to assess water quality restoration targets.
- Increase sampling frequency to monthly for Merritts Mill Pond to provide enough data to evaluate progress toward the monthly average nitrate concentration target.
- Increase spring vent sampling frequency to monthly (or continuously).

- Reactivate the U.S. Geological Survey (USGS) gauge station to monitor the Jackson Blue spring vent discharge.

- Add at least 10 wells to enable continuing the sampling of a minimum of 15 wells in the priority focus area and springshed to monitor groundwater nutrient trends, consistent with the general recommendation for all springs BMAPs.

SANTA FE RIVER



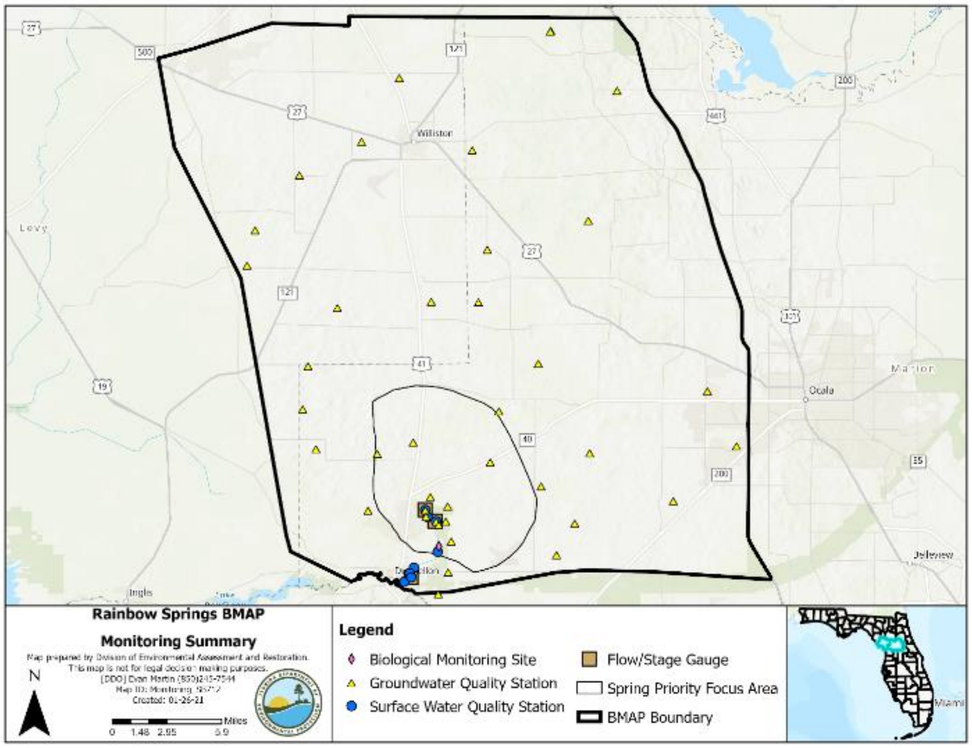
The BMAP encompasses 1,076,657 acres in Alachua, Bradford, Columbia, Gilchrist, and Union Counties. The Santa Fe River Basin includes 3 impaired Outstanding Florida Springs (Devil's Ear, Hornsby, and the Ichetucknee Spring Group). Three other Outstanding Florida Springs in the area are not impaired (Poe, Columbia, and Treehouse). There are 3 priority focus areas (Devil's Complex, Hornsby, and Ichetucknee) comprising 358,000 acres.

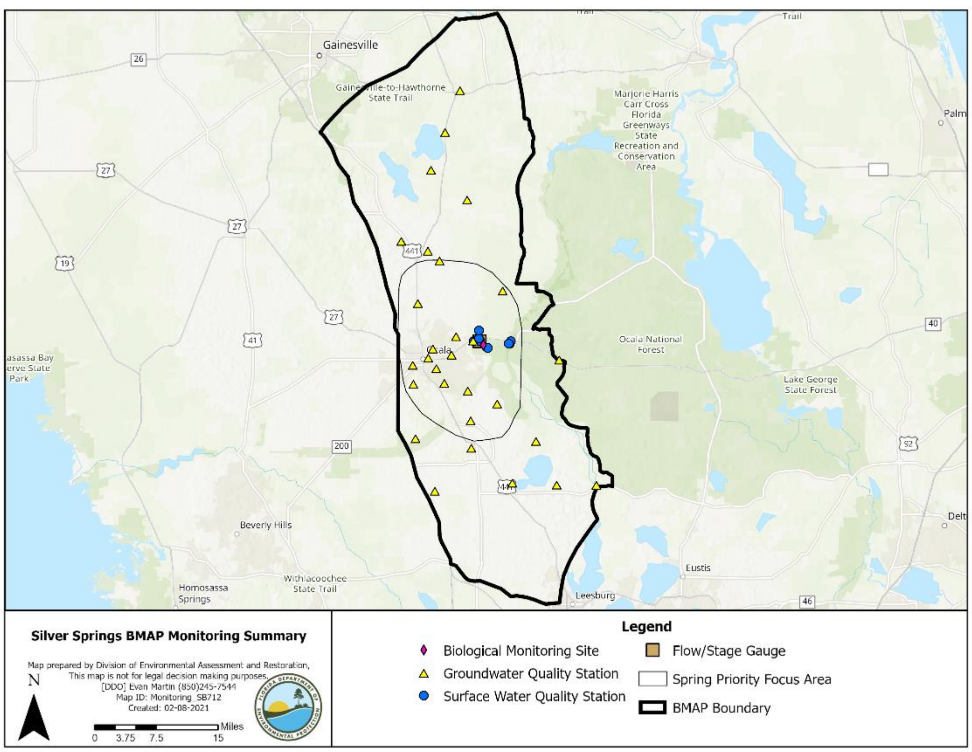
Surface water monitoring is performed at 26 stations in the Ichetucknee Springshed, 23 stations in the Devil’s Ear Springshed, and seven stations in the Hornsby Springshed. There are 68 monitoring wells in the BMAP area. DEP conducts biological monitoring annually for the Lower Santa Fe River and conducted biological monitoring for the Ichetucknee River in the past.

Key Additional Recommendations

- Add continuous nitrate monitoring in the upper portion of the BMAP area to determine trends from upstream to downstream.
- Add monthly sampling for nitrate in all three springsheds to support calculation of monthly averages, with monthly to quarterly sampling for other analytes.
- Add 5 wells to enable continuing the sampling of 15 wells in the priority focus area and springshed to monitor groundwater nutrient trends, consistent with the general recommendation for all springs BMAPs.

SILVER AND RAINBOW SPRINGS





The BMAP area encompasses 1,067,613 acres, with 632,809 acres in the Silver Springs area and 434,804 acres in the Rainbow Springs area. DEP combined and updated two separate BMAPs for these areas because the groundwater contributing areas overlap, most of the area is in one county (Marion), and the management actions to restore the spring systems are largely the same.

The Silver Springs area includes the Silver Springs Group and the Upper Silver River, with at least 30 named springs that contribute river flow. The system is mostly in central Marion County but extends into Alachua and Putnam Counties. The Ocala National Forest runs along the eastern border. The Rainbow Springs area includes the Rainbow Springs Group and the Rainbow River, with at least 11 named springs contributing flow to the Upper Rainbow River. The system is mostly in western Marion County, with portions extending into Levy County.

DEP established the priority focus areas based on primary protection zones adopted by Marion County ordinance to ensure consistency between BMAP strategies and local policies.

DEP obtains nitrate data from a continuous nitrate recorder in the Silver Springs Group and periodic sampling in Mammoth Spring and the Upper Silver River. Other analytes are collected bimonthly at Mammoth Spring and the Silver River upstream of the Ocklawaha River, quarterly at one station each in the Upper Silver River and downstream Silver River, and at least quarterly for Half Mile Creek and the Ocklawaha River.

For the Rainbow Springs Group, DEP collects nitrate and other water quality data quarterly at three spring vents and one Rainbow River station and, for the spring run, at four spring and two river stations. Another five stations are sampled farther downstream in the Rainbow River. Continuous nitrate level and discharge recorders are in place just downstream of the spring run and farther downstream near the mouth of the river. Other continuous recorders measure other water quality parameters or water elevation.

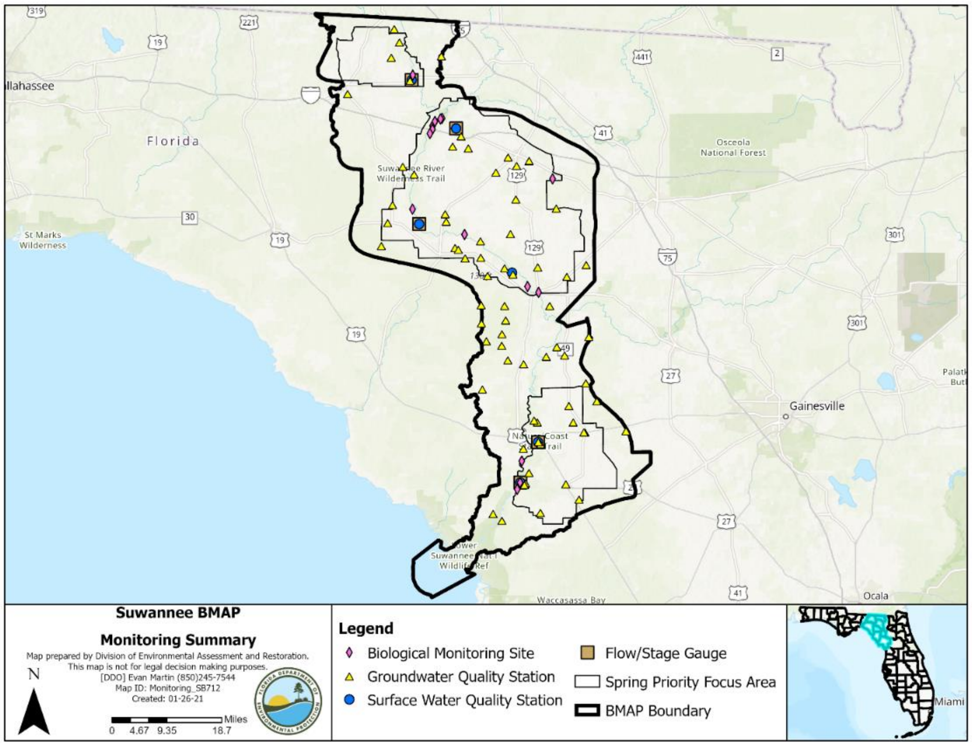
There are 35 monitoring wells in the Silver Springs area, 30 of which are in the Upper Floridan aquifer. Future access to five of these is problematic. There are 38 wells in the Rainbow Springs area, all in the Upper Floridan. Wells are sampled annually to track nitrate concentration changes. The wells are geographically dispersed among different land uses and recharge rates.

Key Additional Recommendations

- Increase surface water monitoring frequency to monthly to better determine progress in meeting water quality restoration targets.
- Add continuous monitors in the Rainbow Springs Group and run, Upper Silver River, and Mammoth Spring to evaluate progress toward monthly nitrate concentration targets.
- Increase groundwater monitoring frequency in both springsheds to quarterly.

- Add three wells to the Rainbow monitoring network and five wells to the Silver monitoring network in land use and recharge areas not currently represented to track implementation of nitrogen reduction activities.
- Rotate quarterly monitoring for a year each at 25 more springs in the Silver Springs system and 10 more in the Rainbow Springs system for 5 years (5 Silver, 2 Rainbow each year) to track long-term nitrate concentration trends. (Limited historical nitrate data have yielded anomalous results that warrant investigation.)

SUWANNEE RIVER



The BMAP area encompasses 1,344,855 watershed acres mostly in Suwannee County, with portions in eastern Dixie, eastern Madison, western Hamilton, northeast and eastern Lafayette, western Levy, western Gilchrist, and small pockets of Taylor and Columbia Counties. There are seven impaired Outstanding Florida Springs in the Suwannee River Basin: Fanning, Manatee, Falmouth, Troy, Lafayette Blue, Madison Blue, and Peacock.

Three priority focus areas total almost 840,000 acres, one addressing Fanning and Manatee springs (Lower Suwannee River Subbasin); another for Troy, Peacock, Lafayette Blue, and Falmouth Springs (Middle Suwannee River Subbasin); and a third for Madison Blue Spring (Withlacoochee River Subbasin).

The Withlacoochee portion of the BMAP area has 1 continuous monitoring station at the Madison Blue Spring vent. There are 3 continuous surface water monitoring stations and 6 other surface water stations in the Middle Suwannee River, while the Lower Suwannee has 2 continuous surface water stations and 2 other surface water stations. There are 75 monitoring wells in the BMAP area, varying in number and sampling frequency in the 3 subbasins. DEP conducts annual biological monitoring for 1 segment of the Suwannee River.

Key Additional Recommendations

- Collect nitrate data downstream of Manatee Spring, the southernmost impaired spring contributing to the Suwannee River. (The existing downstream station is too far away.)

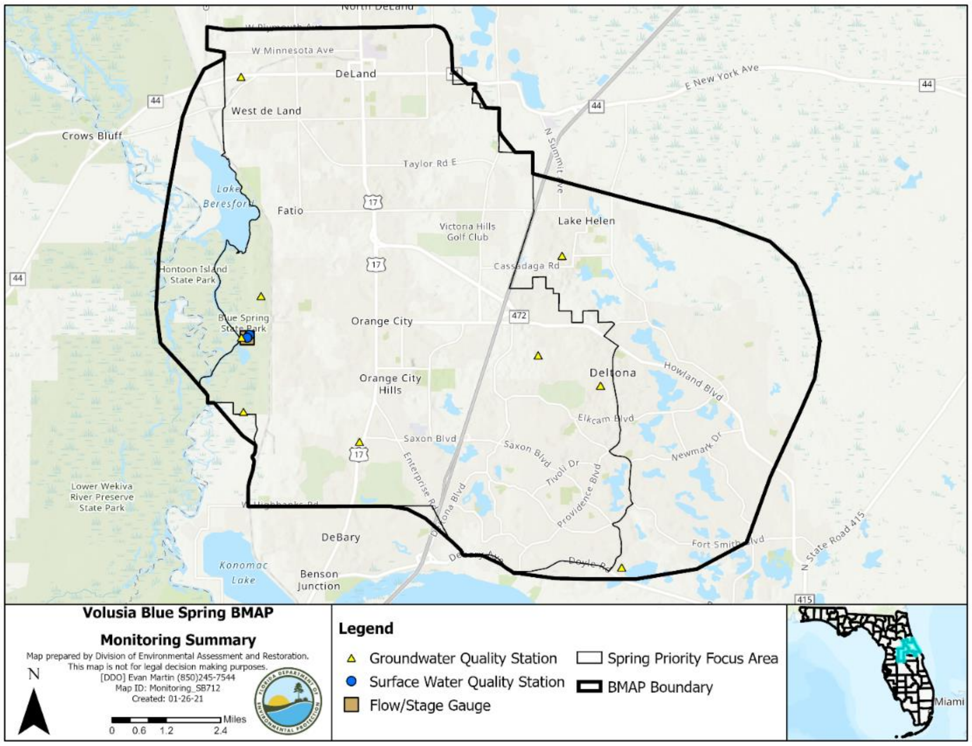
- Sample nitrate monthly to support calculation of monthly averages, with monthly to quarterly sampling for remaining analytes.

- Add at least 12 monitoring wells in the Withlacoochee Subbasin, mostly in the eastern portion of the priority focus area, closer to Madison Blue Spring.

- Conduct groundwater sampling monthly (quarterly at a minimum) at 45 wells, 15 in each subbasin, to determine if nutrient source reductions are reaching groundwater. The additional wells would ensure representative coverage of priority focus areas, land uses, and recharge rates. (Many existing wells do not fall within the focus areas.)

- Conduct dye tracing in the two tunnels of Manatee Springs that are already monitored to delineate sub-springshed areas. (Water from the tunnels appears to be coming from different areas of the springshed.)

VOLUSIA BLUE SPRINGS



The BMAP area encompasses 69,047 acres in Volusia County. The priority focus area covers most of the BMAP area in and around Orange City, DeLand, DeBary, Deltona, and unincorporated portions of the county.

Surface water samples are collected monthly at one station. A continuous monitoring sonde (automated probe) is in place in the spring vent to monitor nitrate, and another sonde and flow gauge are in the spring run. The USGS measures spring discharges daily. There are 17 wells monitored annually in the Upper Floridan and surficial aquifers. Annual algae surveys are conducted in the spring run, and other biological monitoring occurred in the past.

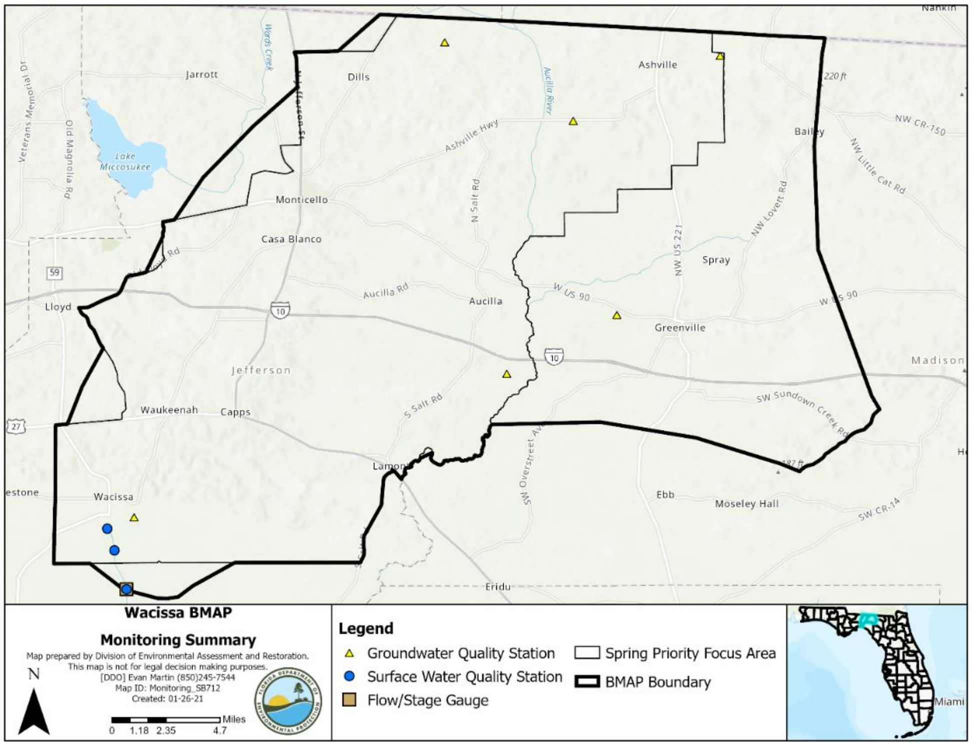
Key Additional Recommendations

- Resume monthly sampling at the park’s lower swim dock, a site formerly monitored by both St. Johns River WMD and Volusia County. There is a large amount of historical data useful for tracking water quality changes over time.

- Add at least 4 wells to enable continued sampling of a minimum of 15 wells in the springshed to monitor groundwater nutrient trends, consistent with the general recommendation for all springs BMAPs.

- Conduct groundwater sampling quarterly at 21 sites to provide insights into seasonal trends and establish enough data points for useful statistical trend analysis, consistent with the general recommendation for all springs BMAPs.

WACISSA RIVER AND WACISSA SPRING GROUP



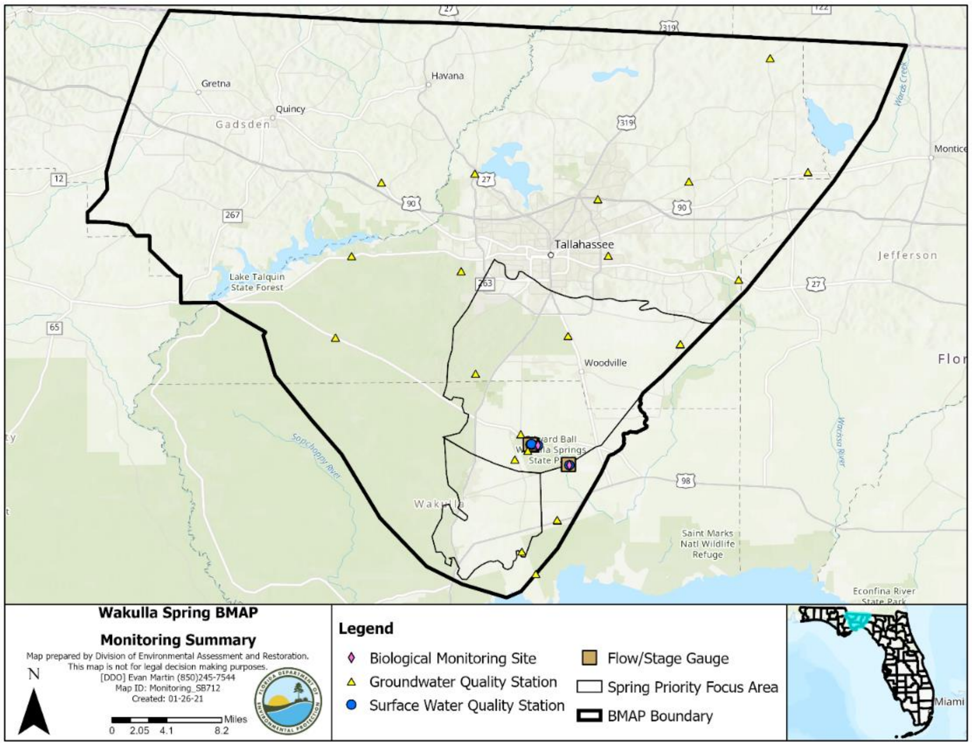
The BMAP area encompasses 327,586 watershed acres in Madison and Jefferson Counties, including a 217,200-acre priority focus area in Jefferson County.

There is one continuous surface water monitoring station on the Wacissa River, and quarterly samples are collected at Wacissa Spring #2 and Big Blue Spring. The Suwannee River WMD has sampled six groundwater wells over the last two years, and the Northwest Florida WMD sampled one well in 2019. DEP monitored six wells in the priority focus area from 2017 to 2019 and conducts annual biological monitoring for the Wacissa River.

Key Additional Recommendations

- Add one surface water station, sampled monthly, to capture water quality between the head springs and the existing USGS continuous monitoring station.
- Add at least five monitoring wells in the priority focus area's southwestern region, between Monticello and the Wacissa Springs Group, to capture various agricultural impacts.

UPPER WAKULLA RIVER AND WAKULLA SPRINGS



The BMAP area encompasses 848,488 watershed acres in Gadsden, Jefferson, Leon, and Wakulla Counties. Wakulla Spring is the main source of water to the Wakulla River, which flows southward and joins the St. Marks River before discharging into Apalachee Bay. There are two priority focus areas in the southern BMAP area, one extending into Leon County.

DEP collects data at the spring vent twice per quarter. DEP also collects monthly samples at two river sites, Upper Bridge and Recreation Area Boat Dock, and quarterly samples at tunnel sites. The USGS collects quantity and quality data at two sites, while the Northwest Florida WMD collects continuous discharge information at the spring vent. Thirty-two wells in the Wakulla Spring groundwater contributing area are monitored annually. DEP also conducts quarterly biological monitoring at two Wakulla River locations.

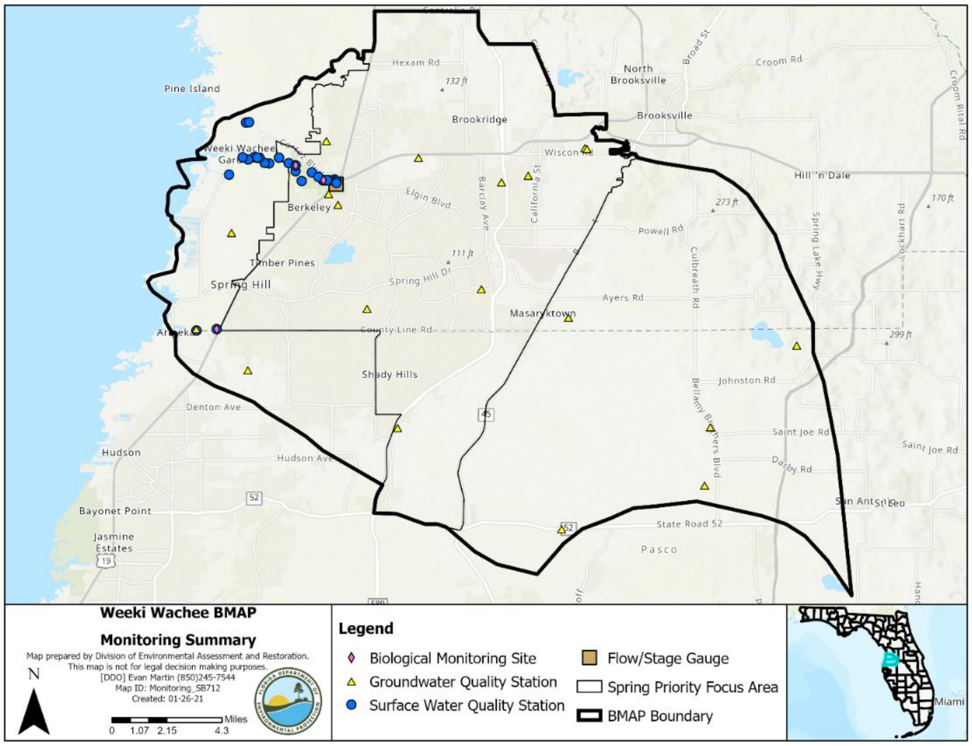
Key Additional Recommendations

- Add quarterly monitoring for smaller springs in the system (e.g., Sally Ward, Indian Spring, the Spring Creek Springs Group) to track long-term nitrate concentration trends, which may be expressed differently at different spring vents.

- Ensure the continued local monitoring of Lake Jackson (Porter Sink) and Upper Lake Lafayette (Fallschase Sink) and evaluate whether additional sampling is needed. There are hydrologic connections between the sinkholes and spring.

- Add at least three wells to enable continued sampling of a minimum of 15 wells to monitor groundwater nutrient trends in the priority focus area and springshed, consistent with the general recommendation for all springs BMAPs.

WEEKI WACHEE



The BMAP area encompasses 213,773 watershed acres in southern Hernando and northern Pasco Counties. It contains the Weeki Wachee Spring Group, including many smaller springs. Weeki Wachee Spring is the primary source of the Weeki Wachee River, an Outstanding Florida Water. The area also includes the Magnolia–Aripeka Springs Group, Wilderness–Mud–Salt Springs Group, and Jenkins Creek Spring. A 90,400-acre priority focus area is in the western springshed.

The Southwest Florida WMD samples surface water quality parameters quarterly along the Weeki Wachee River at 5 stations; the Florida Springs Institute samples 15 stations. There is 1 continuous monitoring gauge that collects stream-level data. The WMD also collects samples annually at 2 stations and quarterly at 4 stations at Magnolia–Aripeka Springs Group, Wilderness–Mud–Salt Springs Group, and Jenkins Creek Spring. There are 19 Floridan aquifer wells sampled in the BMAP area. DEP also conducts regular biological monitoring near the Weeki Wachee Spring vent and along the river.

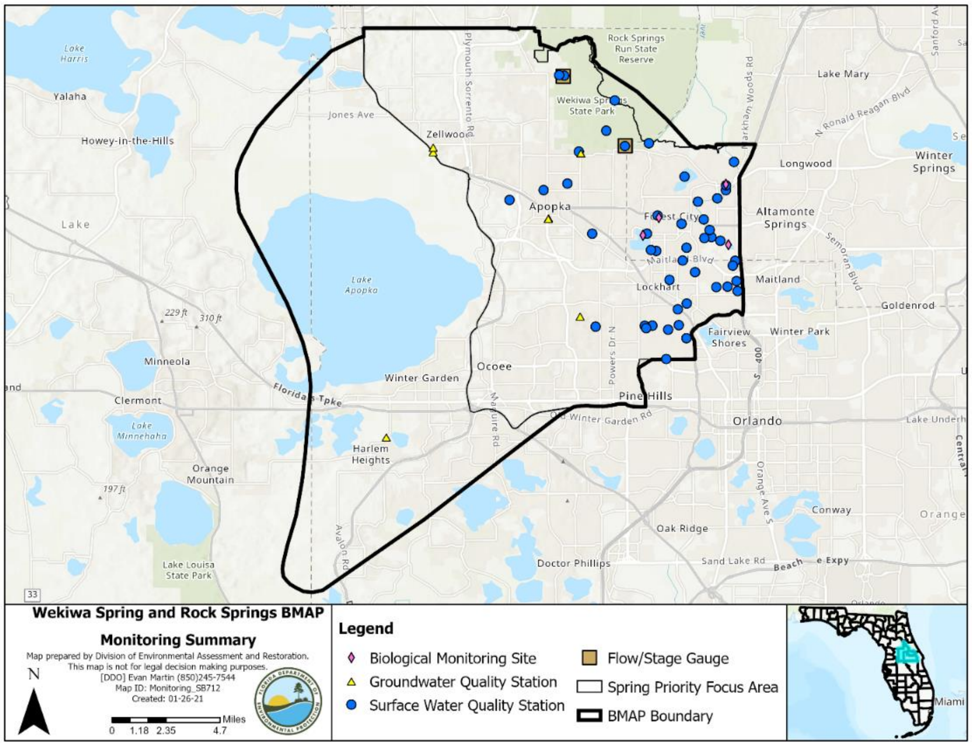
Key Additional Recommendations

- Implement continuous nitrate monitoring at the Weeki Wachee Spring vent.
- Implement quarterly sampling at the nine impaired springs.

- Add sampling at Mud Spring and Aripeka Spring to account for different nitrate targets in the three springs clusters, giving a more complete picture of springshed nitrate levels.

- Add four Floridan aquifer wells in the priority focus area to represent currently missing land uses; further reconnaissance may indicate the need for additional wells.

WEKIWA AND ROCK SPRINGS



The BMAP area encompasses 192,284 watershed acres in Lake, Orange, and Seminole Counties. Wekiwa Spring forms the headwater of the Wekiva River, a tributary to the St. Johns River. Rock Springs Run also joins the Wekiva River. The BMAP includes a priority focus area in its northeastern section. This BMAP is related to the Wekiva River, Rock Springs Run, and Little Wekiva Canal surface water BMAP discussed later in the section.

The St. Johns River WMD monitors Wekiwa Spring monthly, while Orange County monitors it quarterly. The WMD monitors Rock Springs quarterly. Sondes monitor nitrate continuously at each spring vent, and discharge data are collected daily at both springs. There are 14 wells in the BMAP area, all monitored annually. DEP conducts annual algae surveys in the Wekiva River and Rock Springs Run and conducted other biological monitoring in the past.

Key Additional Recommendations

- Increase frequency of monitoring to monthly to support determination of progress in meeting water quality restoration targets.
- Add phosphorus monitoring at spring vents.
- Add at least 6 wells to enable continued sampling of a minimum of 20 wells to monitor groundwater nutrient trends in the springshed, consistent with the general recommendation for all springs BMAPs.

South Florida BMAPs

These seven BMAPs have various similarities. Most are entirely or partially in the heart of densely populated south Florida, all of them border the coast or have a coastal connection, and some of Florida's most intensive agriculture runs through them.

- Three BMAPs—Lake Okeechobee, St. Lucie River and Estuary, and Caloosahatchee River and Estuary—are governed by the Northern Everglades and Estuaries Protection Program, Section 373.4595, F.S. The law establishes unique requirements over and above the fundamental BMAP requirements in Section 403.067, F.S. Significantly, the St. Lucie and Caloosahatchee systems cannot be restored if Lake Okeechobee is not restored because of the enormous impact of nutrient-rich freshwater releases from the lake to the river and estuary systems, over and above local pollutant loadings.

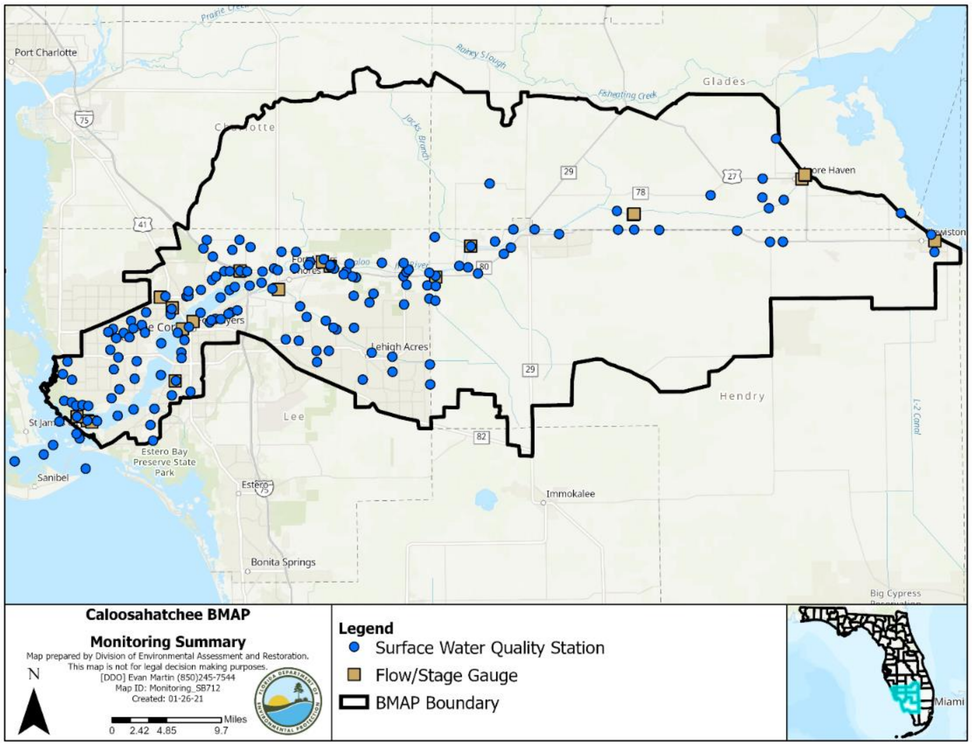
- Five BMAPs—St. Lucie, Caloosahatchee, and the three Indian River Lagoon plans—are intimately tied to coastal systems with expansive estuaries, along with major urban centers. Their characteristics pose different challenges than restoration in inland surface water systems.

- The Everglades West Coast drains into Estero Bay, a shallow lagoon separated from the Gulf of Mexico by barrier islands. It encompasses a substantially smaller area than other south Florida BMAPs, but it borders the Caloosahatchee system.

- Lake Okeechobee is unique because of its enormous size, its intimate connection with the Everglades ecosystem and Florida Bay, its releases to the St. Lucie and Caloosahatchee systems, and an expansive agricultural community.

While there are certain general similarities among some of the monitoring recommendations for these BMAPs, the recommendations generally stand alone because of the specific number of stations or sampling frequency at issue. In addition, there generally are not as many gaps to fill in the monitoring programs for these BMAPs as there are in the springs BMAPs described above.

CALOOSAHATCHEE RIVER AND ESTUARY



The BMAP area encompasses 893,940 watershed acres in Charlotte, Collier, Glades, Hendry, and Lee Counties. The Caloosahatchee River runs from Lake Okeechobee through a series of locks to San Carlos Bay. Its freshwater segment runs from Lake Okeechobee to the Franklin Lock (S-79). The marine segment extends from the Franklin Lock to Shell Point, adjacent to San Carlos Bay, with Pine Island Sound to the northwest and Estero Bay to the southeast. The watershed is split into 3 subwatersheds (east, west, and tidal).

There are nearly 200 monitoring stations in the watershed, including surface water quality and flow/stage stations. Because of the system's size and complexity, DEP implements a targeted restoration area approach, which uses data collected at representative sites throughout the watershed to evaluate nitrogen and phosphorus concentrations. Representative sites are locations determined to best represent the quality of water leaving the subwatersheds (basins). Other, nonrepresentative monitoring sites are used for trend analysis and to better understand upstream nutrient sources in a basin.

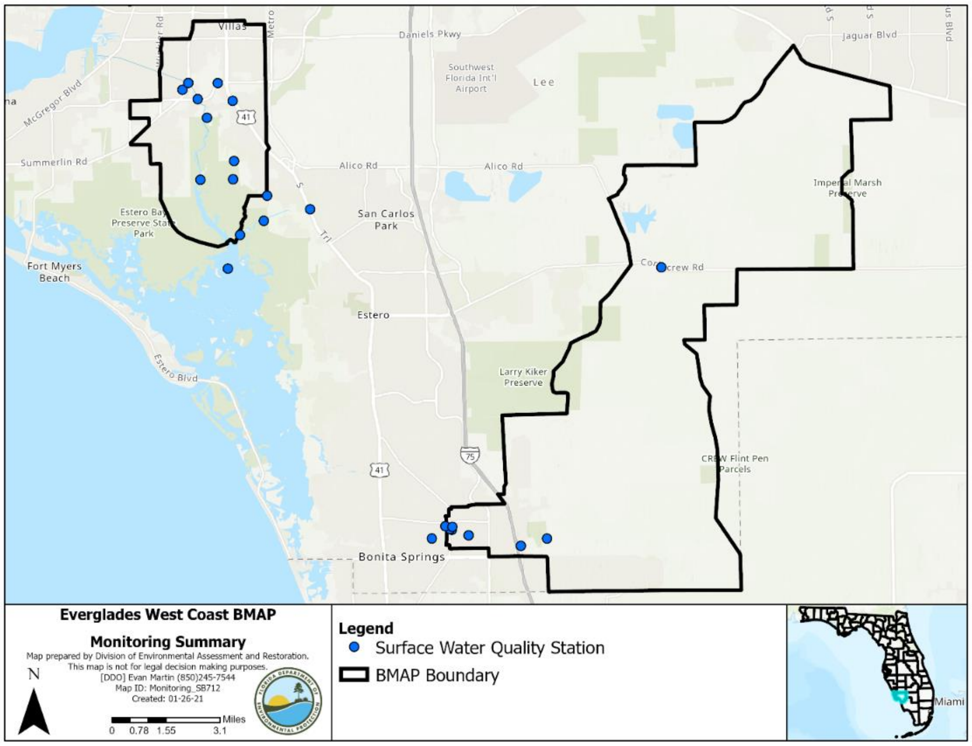
Key Recommendations

- Increase frequency of surface water quality samples at 14 representative sites to monthly, at a minimum.

- Collect nitrogen and phosphorus data at two additional representative stations so that each representative site is collecting both analytes.

- Add two monitoring stations in the Caloosahatchee River between S-77 and S-79.
- Ensure that nonrepresentative sites are sampled quarterly for nitrogen and phosphorus.

Everglades West Coast Basin



The BMAP area encompasses 55,470 watershed acres in Lee County, split between the Hendry Creek and Imperial River Watersheds.

There are 23 monitoring stations in the BMAP area, including surface water quality and flow/stage stations: 14 stations are in Hendry Creek, with 9 in the Imperial River. All existing stations are monitored regularly.

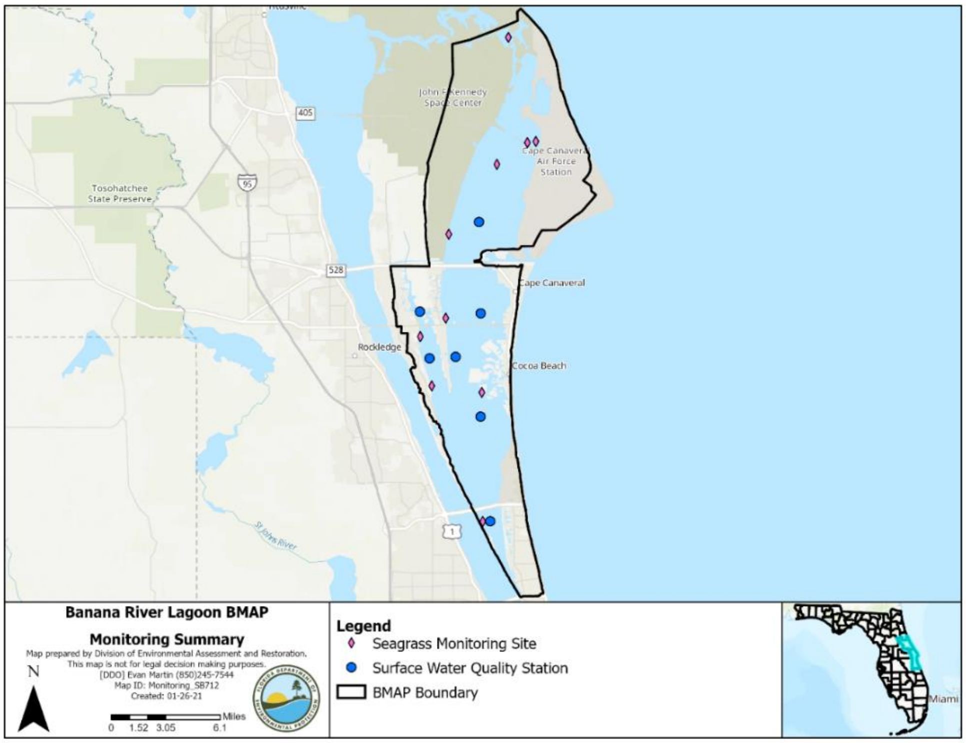
Key Recommendations

- Add at least two monitoring stations in Imperial River between the existing KEHLGR and IMPR90 stations.
- Restore, and potentially revise, the historical groundwater monitoring in the Hendry Creek and Imperial River Watersheds because of the interrelationship between area surface water and groundwater.

INDIAN RIVER LAGOON

In order to effectively resolve nutrient impairments in the Indian River Lagoon (IRL), DEP divided the watershed into three subbasins, and three BMAPs, that correspond to unique hydraulic characteristics. The three BMAP areas are the Banana River Lagoon (97,139 watershed acres), North IRL (211,398 watershed acres), and Central IRL (476,469 watershed acres).

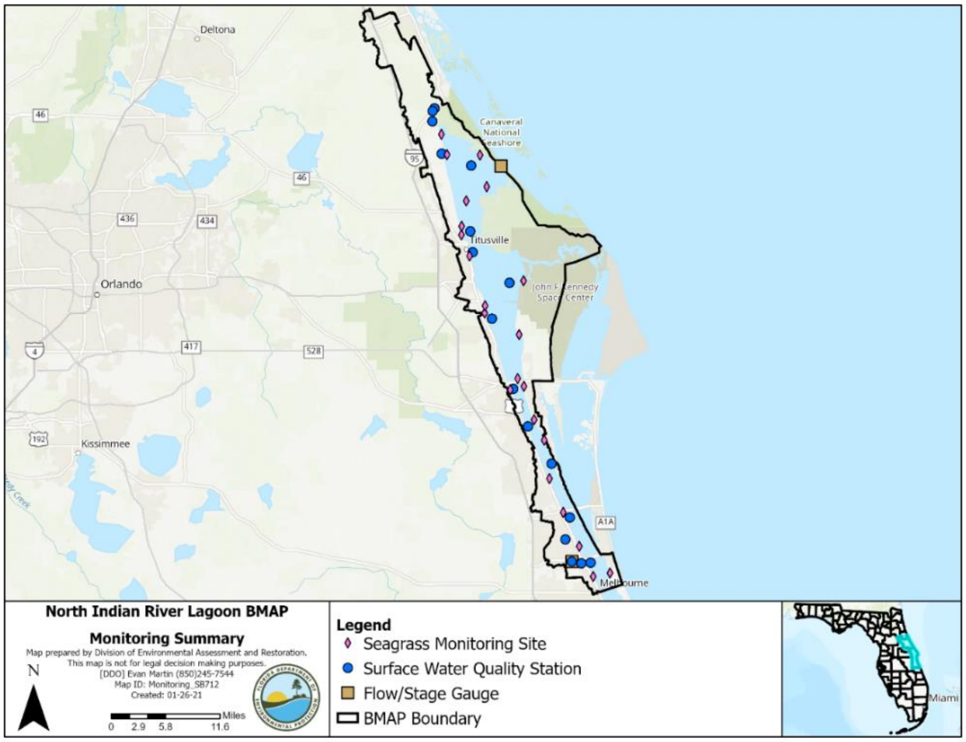
Banana River Lagoon



The Banana River Lagoon runs along the barrier island communities of Cape Canaveral, Indian Harbour Beach, and Merritt Island, and connects to the IRL at its southern end. It has a limited outlet to the Atlantic Ocean through the Port Canaveral lock. Water flows from the IRL into the Banana River Lagoon, which is a "negative estuary" characterized by low freshwater inflows and poor flushing.

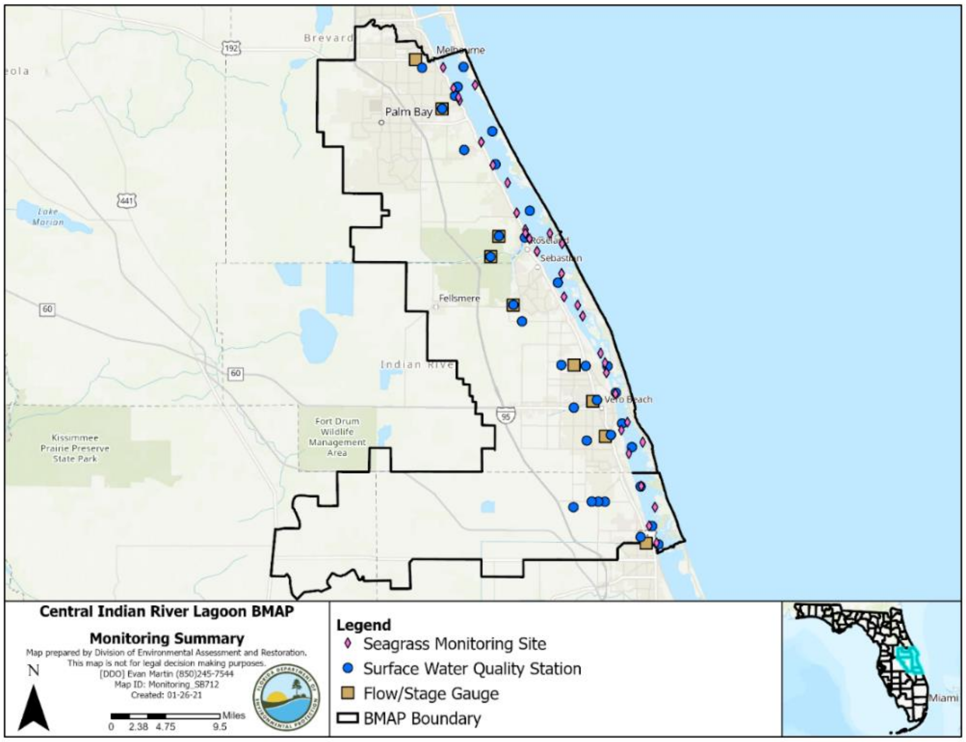
For restoration purposes, the Banana River Lagoon is divided into two "project zones" the boundaries of which are based on the distinct hydrology in different areas of the subbasin and their corresponding annual residence times. Zone A is the area north of and including the State Road 528 Causeway; Zone B is the area south of the causeway. The zones are important because flushing times vary and influence how nutrient reductions, and the projects designed to achieve those reductions, differentially affect them.

North Indian River Lagoon



The main stem of the North IRL Subbasin extends from Turnbull Creek in Volusia County to the Melbourne Causeway in Brevard County. The North IRL is divided into project zones: Zone A includes Turnbull Creek to NASA Causeway (State Road 405), and Zone B runs from NASA Causeway to Melbourne Causeway (U.S. Highway 192). As in the Banana River Lagoon, flushing times vary in the zones and influence how nutrient reductions differentially affect them.

Central Indian River Lagoon



The main stem of the Central IRL Subbasin extends from the Melbourne Causeway in Brevard County to the boundary between Indian River and St. Lucie Counties. The Central IRL also is divided into project zones based on distinct hydrology in different areas of the basin and corresponding annual residence times: Zone A runs from Melbourne Causeway (U.S. Highway 192) to the north tip of Grant Farm Island; Zone SEB runs from Grant Farm Island to Wabasso Causeway (County Road 510); and Zone B runs from Wabasso Causeway to the boundary between Indian River and St. Lucie Counties. As in the two other IRL systems, flushing times vary and influence how nutrient reductions differentially affect the zones.

Overall Monitoring Notes for the IRL BMAPs

As noted, the BMAPs are divided into project zones. Because of the importance of seagrass health as a measure of BMAP success, DEP also divided the BMAPs into seagrass distribution segments based on the location of causeways that span the IRL and Banana River Lagoon. Salinity and turbidity (relative water clarity), important for understanding seagrass growth and distribution, differ among the segments.

There are 71 surface water monitoring stations throughout the 3 subbasins that are monitored continuously, monthly, or quarterly depending on location. In addition, the St. Johns River WMD maintains 63 seagrass assessment sites used to supplement aerial distribution data. Seagrass growth is a key indicator of the IRL's health. Rapid algal growth and sedimentation from erosion or resuspension reduce light availability in the habitat where seagrass grows, reducing seagrass distribution. Excess nutrients exacerbate algal growth.

Key Recommendations

- Add at least one monitoring station in eight waterbody segments, sampled at least quarterly, to assure robust trend analysis across project zones in each subbasin.
- Update bathymetry (depth) data to better understand seagrass growth progression as sea-level rise occurs. Seagrass depth targets may need to be adjusted if the threshold for optimal seagrass growth has changed.

LAKE OKEECHOBEE

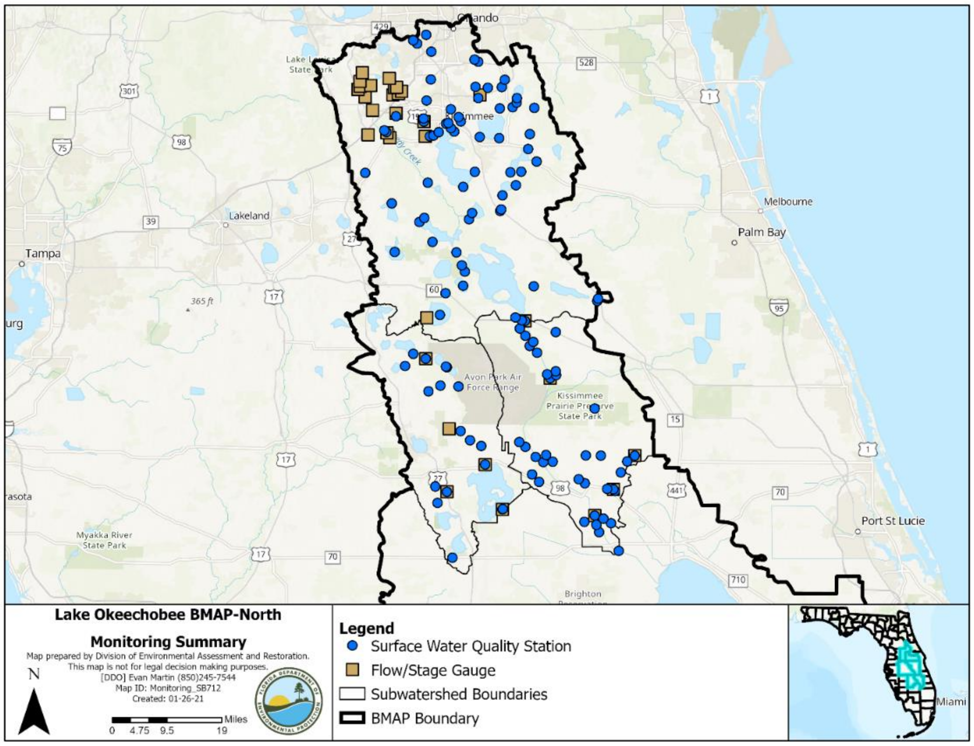
The BMAP encompasses by far the largest area of all DEP BMAPs at 3,898,194 acres. Lake Okeechobee is the largest lake in the southeastern United States covering 730 square miles, with an average depth of nine feet. It provides drinking water, irrigation, and frost protection for agricultural lands; recharge for aquifers; fresh water for the Everglades; fish and wildlife habitat; flood control; navigation; and recreation.

The watershed is in subtropical south-central Florida in Glades, Hendry, Highlands, Martin, Okeechobee, Orange, Osceola, Palm Beach, and Polk Counties. It has been subjected to hydrologic, land use, and other anthropogenic modifications over more than a century, which have degraded its water quality and that of the connected Caloosahatchee and St. Lucie Rivers and Estuaries. Without restoration of Lake Okeechobee, the estuaries cannot be restored. To manage restoration, DEP divided the Lake Okeechobee Watershed into nine subwatersheds and three primary areas: north, central, and south.

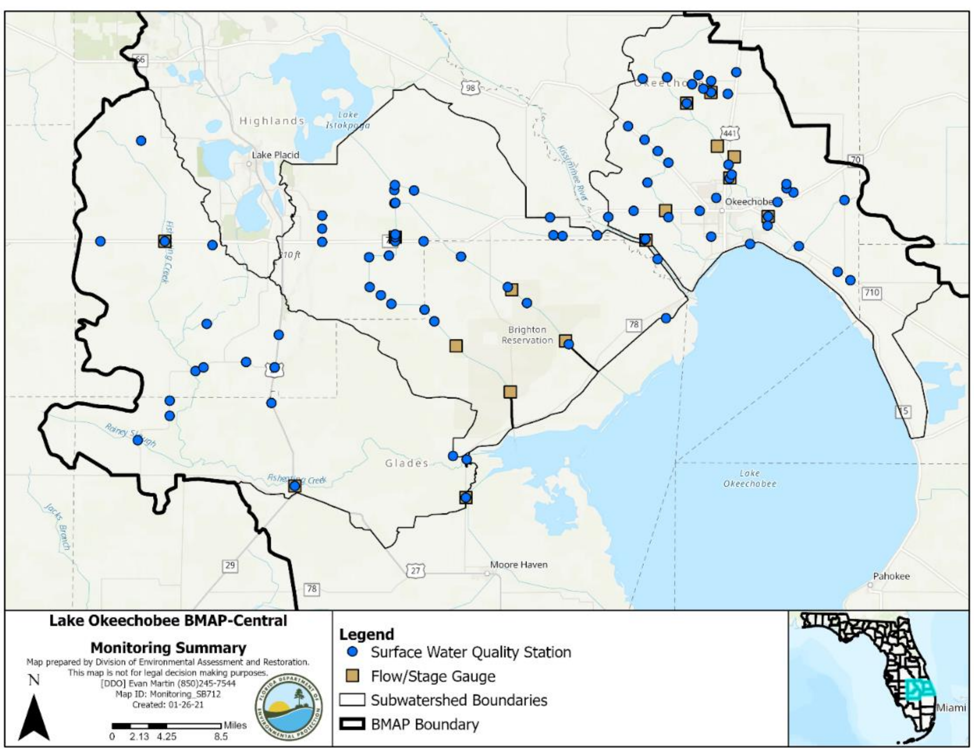
There are more than 300 surface water quality and flow stations in the BMAP monitoring network, all of which are monitored regularly. (Other sites outside the BMAP network evaluate in-lake water quality and are reported annually in the South Florida Environmental Report.[17]) The monitoring network is reflected in the three maps that follow.

17 The report is available from the South Florida WMD at https://www.sfwmd.gov/science-data/scientific-publications-sfer.

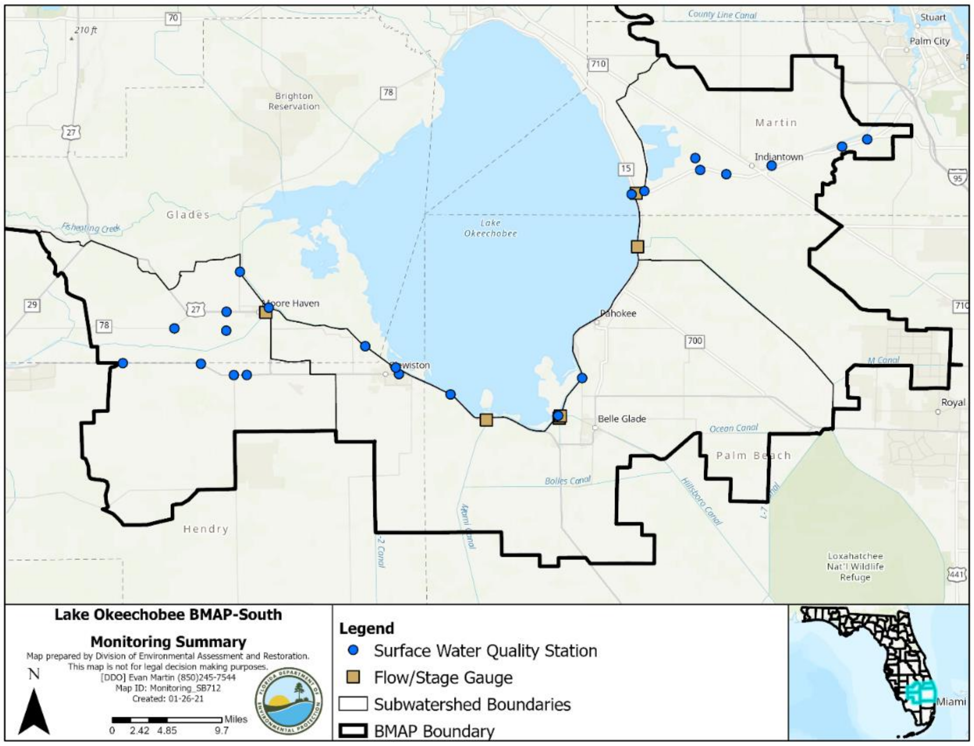
Lake Okeechobee North



Lake Okeechobee Central



Lake Okeechobee South



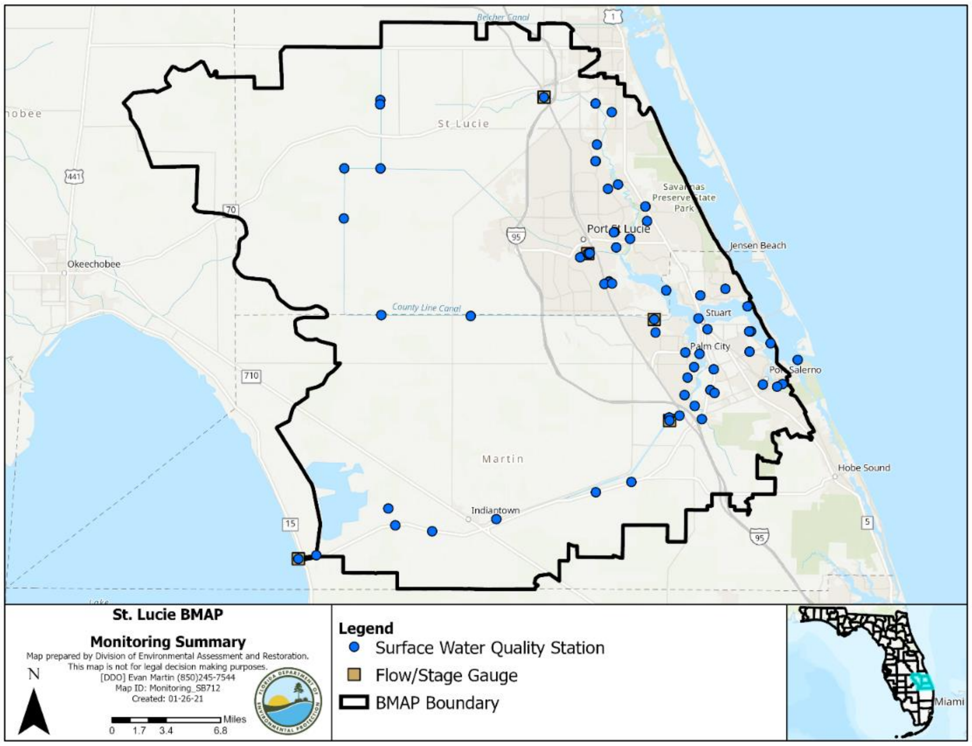
Because of Lake Okeechobee's size and complexity, DEP implements a targeted restoration area approach, which uses data collected at representative sites throughout the watershed to evaluate nitrogen and phosphorus concentrations. Representative monitoring sites comprise locations determined to best represent water quality leaving the subwatersheds (basins). Other, nonrepresentative sites are used for trend analysis and to better understand the upstream nutrient sources in a basin.

Key Recommendations

- Add two representative monitoring sites to ensure that each basin has at least one representative site.
- Reestablish the nine representative stations that did not collect nitrogen and phosphorus data over the last two years or add an equivalent number of new sites.
- Monitor all representative sites monthly, at a minimum; therefore, 24 of the representative stations should be sampled more frequently.
- Collect nitrogen and phosphorus data at two additional stations so that each representative site is collecting both analytes.

- Ensure that nonrepresentative sites are sampled quarterly for nitrogen and phosphorus.

St. Lucie River and Estuary



The BMAP area encompasses 539,744 watershed acres in Martin, St. Lucie, and Okeechobee Counties. The estuary is a major tributary to the southern IRL. The river and estuary have been subjected to hydrologic, land use, and other anthropogenic modifications over more than a century that have degraded its water quality.

The BMAP monitoring plan is divided into 11 subbasins based on hydrology in order better to understand basin loads, identify areas with high nutrient concentrations, and track water quality trends. There are 73 monitoring stations in the BMAP area, both surface water quality and stage and flow stations, all of which are monitored at least monthly and many of which are monitored more frequently.

Key Recommendations

- Increase sampling frequency at the SE 03 (Roosevelt Bridge) compliance station from monthly to biweekly, consistent with frequency in the tributaries, to better track estuary water quality conditions and determine BMAP compliance.

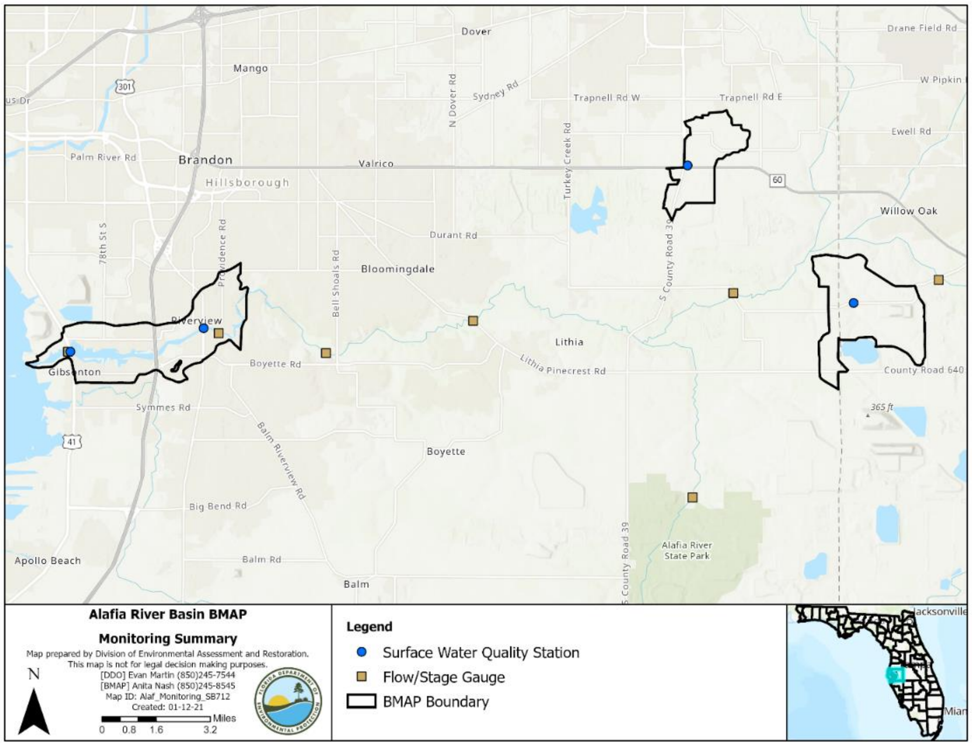
- Add one monitoring station each in the C-23, C-24, and Ten Mile Creek Basins, to be sampled monthly to identify potential sources of elevated nutrient concentrations.

Other Surface Water BMAPs

The remaining surface water nutrient BMAP areas are in a variety of lake and riverine settings. While they are all surface water systems, many of the watersheds are fed by or otherwise connected to the Floridan aquifer or surficial aquifer system. They include the second largest BMAP area, the Lower St. Johns River Main Stem, at more than 1.8 million acres, and the smallest, Long Branch, at just over 3,600 acres.

As with the south Florida BMAPs, these BMAPs include certain general similarities among some monitoring recommendations. However, they are not so similar that they can be distilled into one-size-fits-all recommendations. The number of stations and sampling frequency needed to fill monitoring gaps varies widely, and various other recommendations are unique to the individual systems. As with the south Florida BMAPs, there are not as many monitoring gaps in these BMAP areas as there are in the springs BMAPs.

Alafia River



The BMAP area encompasses 47,199 acres in Hillsborough and Polk Counties. The river originates in west-central Polk County and flows westward to Hillsborough Bay. It is tidally influenced as far as Bell Shoals Road, 11 river miles upstream from the mouth. During the dry season, much of the freshwater inflow to the tidal reach is contributed by groundwater inflows from Lithia and Buckhorn Springs. The watershed contains few natural lakes; many man-made lakes were created largely as a result of phosphate mining.

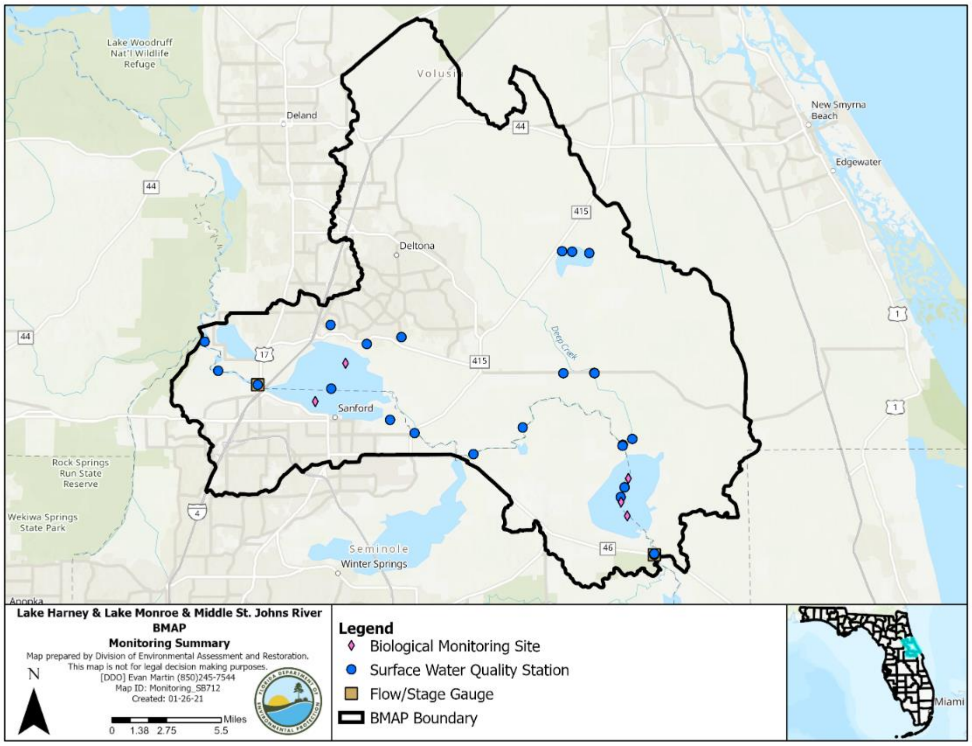
There are four surface water monitoring stations; those in the Alafia River above the Hillsborough Bay tidal segment are monitored monthly, while quarterly monitoring is performed in Mustang Ranch Creek and Thirtymile Creek. The USGS collects stage data at two sites and flow data at four sites, while several local entities conduct supplementary sampling.

Key Recommendations

- The Alafia is impaired because of low dissolved oxygen; the relationship between physical factors and oxygen levels requires further investigation.

- Reconsider existing data to determine whether nutrient hot spots can be identified. Source-specific monitoring, including use of nitrogen isotopes, sucralose, and other chemical tracers of human waste, along with DNA investigation of human and animal waste, may identify sources contributing to both nutrient and bacteria impairments.

LAKES HARNEY AND MONROE AND MIDDLE ST. JOHNS RIVER



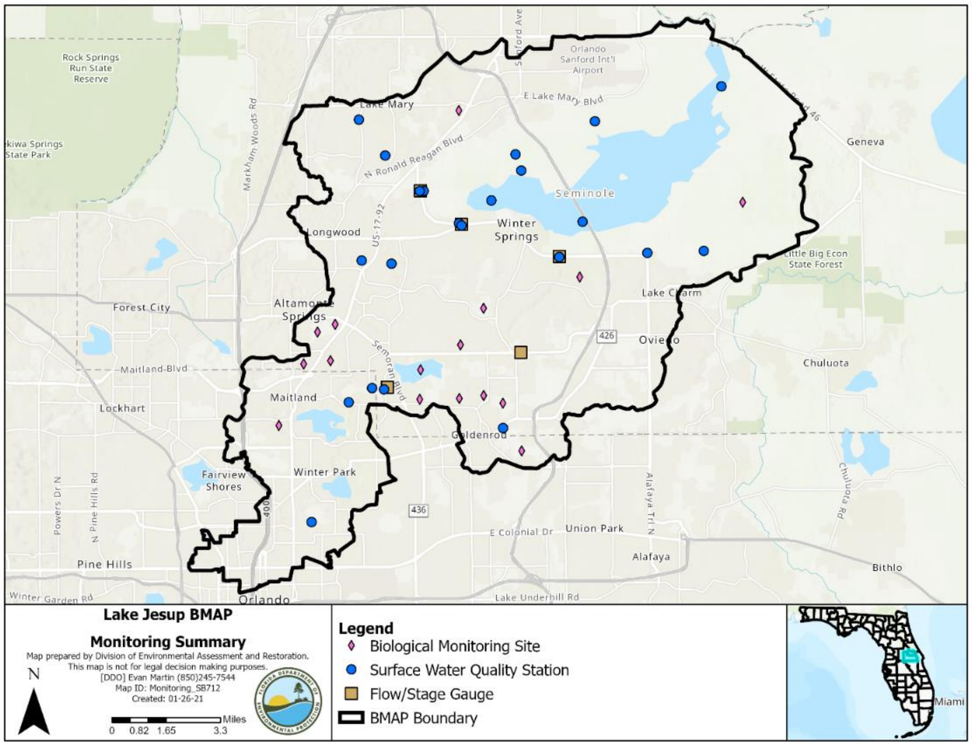
The BMAP area encompasses 241,928 acres in Seminole and Volusia Counties between the inlet of Lake Harney and the confluence of the St. Johns and Wekiva Rivers. These segments receive discharges from the Upper St. Johns and Econlockhatchee Rivers, Deep Creek, and Lake Jesup.

There are 14 surface water stations, which are monitored monthly. DEP also conducts biological and vegetation monitoring to determine the health of biological communities in the watershed, and biological data are collected quarterly or monthly at various stations in the basin. The USGS also collects flow data at two sites.

Key Recommendations

- Add upstream monitoring to track the impact of sources outside the watershed and determine reduction strategies. Because most of the nutrient loading to the Harney–Monroe and Middle St. Johns River systems comes from these upstream sources, reductions here are key to the success of restoration.

LAKE JESUP



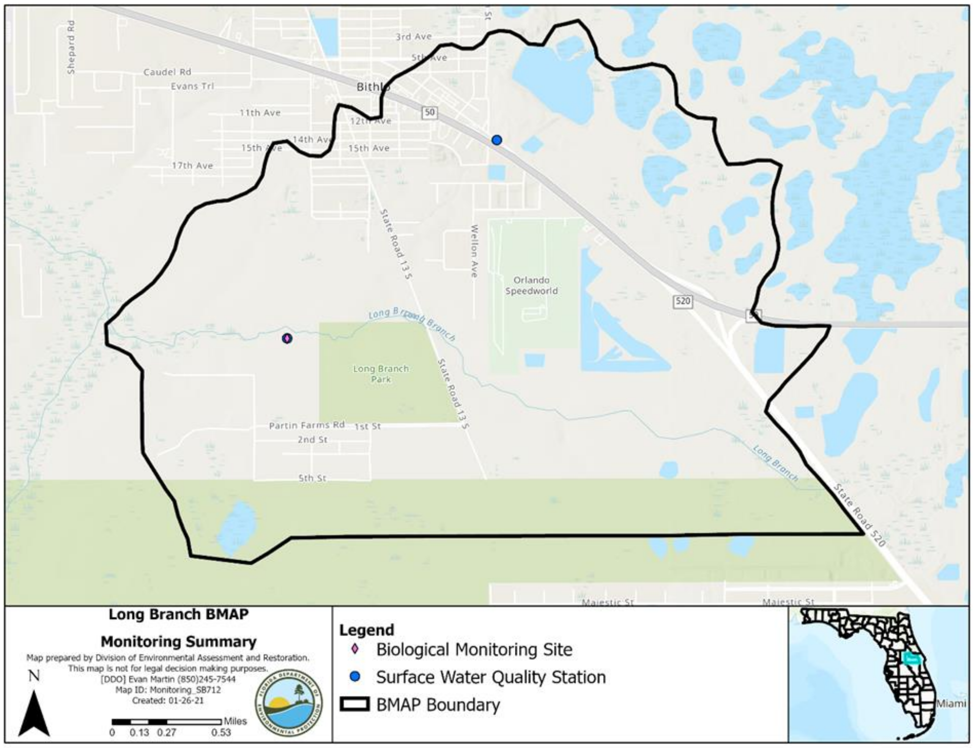
The BMAP area encompasses 95,718 acres. Lake Jesup is one Central Florida's largest lakes, at 10,660 acres. It is part of the St. Johns River system and drains a watershed of almost 86,400 acres, including much of Seminole County and a small portion of Orange County. At high stage, Lake Jesup has a surface area of as much as 16,000 acres.

There are 24 surface water stations, which are monitored monthly. DEP also conducts biological monitoring at 10 stations throughout the basin, with data collected annually at nine stations and biannually at one station. The USGS collects stage data at five sites. Several local entities conduct supplemental sampling.

Key Recommendations

- No additional monitoring is recommended. The current monitoring locations and frequency, including biological monitoring, are adequate to account for seasonal differences in water quality, meet data sufficiency needs to determine attainment of water quality targets, and support calculation of nutrient loadings on an annual average basis.

LONG BRANCH



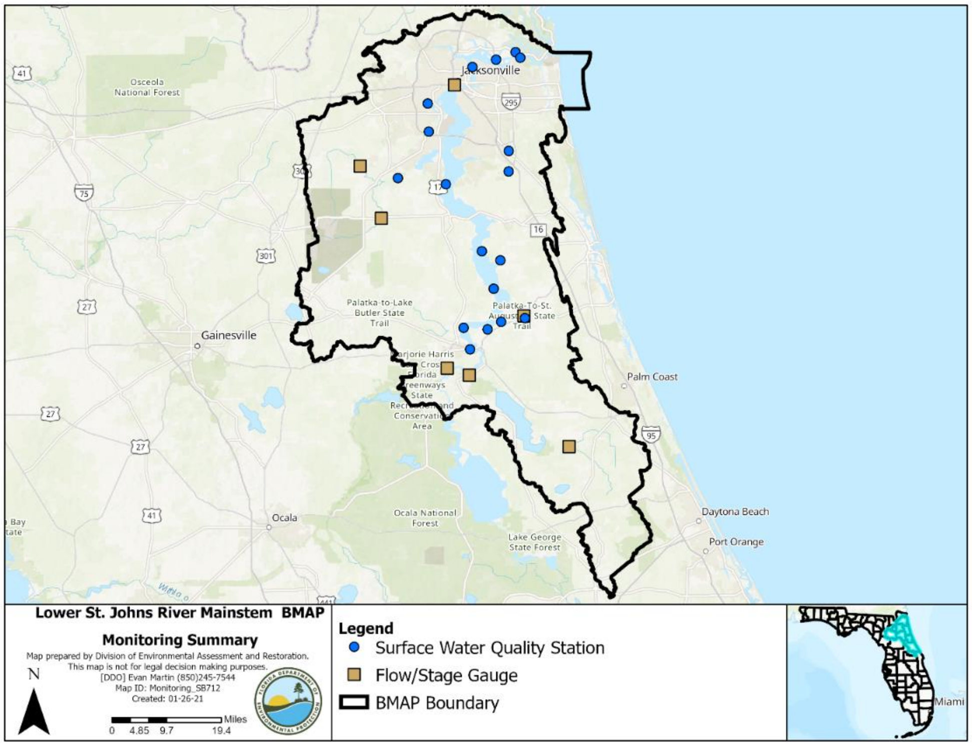
The BMAP area encompasses 3,628 acres in east central Orange County, within the Middle St. Johns Basin. It is DEP's smallest BMAP by area. The Long Branch is a tributary to the Big Econlockhatchee River.

DEP collects five water quality samples during the calendar year along with two biological assessments and continuous monitoring for dissolved oxygen one week each year.

Key Recommendations

- No additional monitoring is recommended. The current monitoring locations and frequency, including biological monitoring, are adequate to account for seasonal differences in water quality, meet data sufficiency needs to determine attainment of water quality targets, and support calculation of nutrient loadings on an annual average basis.
- Continue monitoring based on the current bacteria indicator criteria (*E. coli*) to gather enough data to determine whether the system is, in fact, impaired by bacteria. It was determined in the past to be impaired based on fecal coliform criteria, which are no longer used.

LOWER ST. JOHNS RIVER (MAIN STEM)



The BMAP area encompasses 1,807,401 acres surrounding the St. Johns River between the mouth of the Ocklawaha River, its largest tributary, and the Atlantic Ocean, a 2,750-square-mile drainage area. Within this reach, the St. Johns River is 101 miles long and has a water surface area of some 115 square miles. The BMAP encompasses parts of Volusia, Flagler, Putnam, Clay, St. Johns, and Duval Counties.

DEP divided the Lower St. Johns River mainstem into freshwater, marine, and tributary sections. There are five monitoring stations in the freshwater section, sampled monthly in the winter and biweekly during the growing season (April–October). Four stations collect data in the tributaries: Dog Branch, Deep Creek (continuous), Hastings Drainage District, and Tocoi Creek. From 2020 to 2021, the St. Johns River WMD has been conducting enhanced storm sampling to measure upstream nutrient loading, including from the Tri-County Agricultural Area (Putnam, St. Johns, and Flagler Counties). The USGS collects flow data at four sites. Several local entities also collect data.

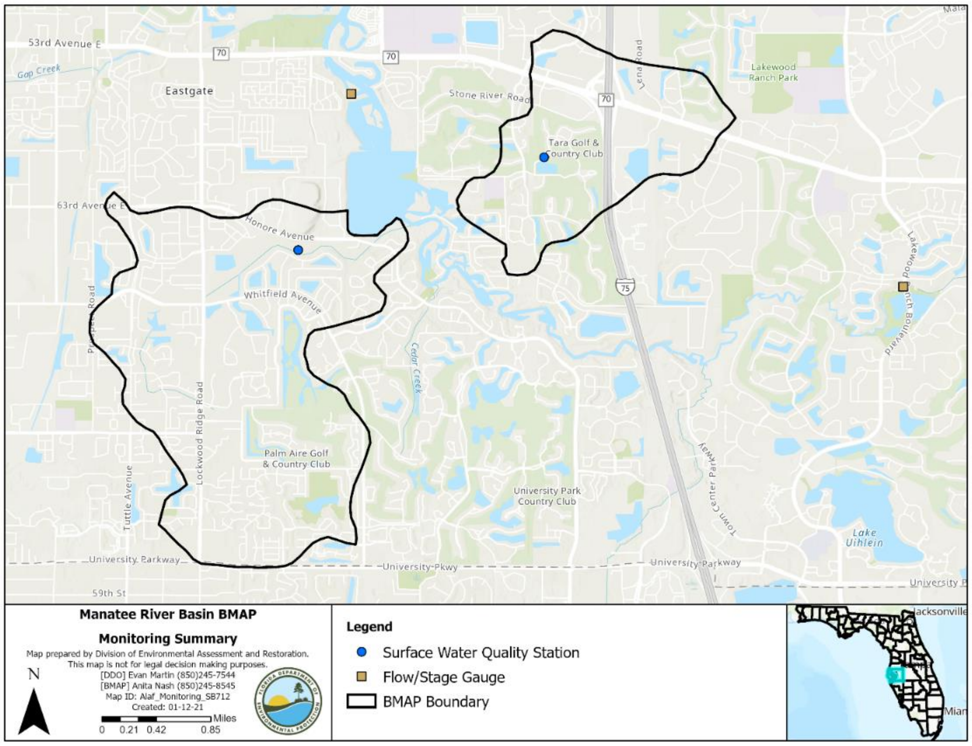
In the marine section (from Black Creek northward), two main stem stations are sampled monthly. Four stations in the marine tributaries collect bimonthly data from Cedar River, Ortega River, Durbin Creek, and Big Davis Creek, while one station in Black Creek collects data monthly. There are two continuous dissolved oxygen stations, at Clapboard Creek and Dames Point Bridge. The USGS collects flow data at three sites in the marine section. Several local entities also collect data.

Key Recommendations

- **Freshwater section –** Reinstitute and continue biweekly sampling of chlorophyll *a* during the growing season (prime algal bloom season). This sampling has been cut back in the past.

- **Marine section –** Restore ambient monitoring stations near the confluences with Black Creek, Doctor's Lake, and Cedar-Ortega to better understand (1) upstream nutrient concentrations and (2) the influence of the tributaries on main stem water quality.

MANATEE RIVER



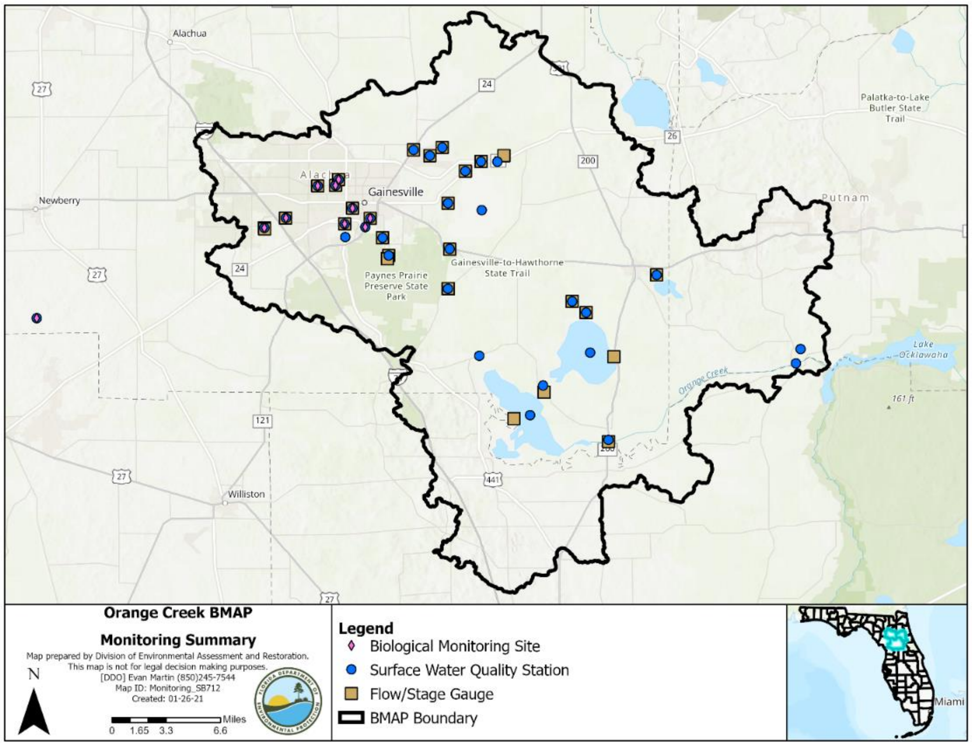
The BMAP area encompasses 16,028 acres in northeastern Manatee County. The Manatee River drains 360 square miles, flowing 45 miles westward and discharging to Lower Tampa Bay. Major tributaries include Gilley Creek, Gamble Creek, and the Braden River. The watershed includes two water supply reservoirs: Lake Manatee on the Manatee River provides potable water to Manatee County, and Bill Evers Reservoir on the Braden River supplies the City of Bradenton. The Manatee River is a tidal, estuarine waterbody downstream of the Lake Manatee Dam, as is the Braden River downstream of the Evers Reservoir.

Two monitoring stations, one each in Nonsense Creek and Rattlesnake Slough, are monitored monthly. The USGS collects stage data at one site and flow data at another. Several local entities conduct sampling.

Key Recommendations

- No additional monitoring is recommended. The current monitoring locations and frequency, including biological monitoring, are adequate to account for seasonal differences in water quality, meet data sufficiency needs to determine attainment of water quality targets, and support calculation of nutrient loadings on an annual average basis.

ORANGE CREEK



The BMAP area encompasses 385,271 acres in Alachua and northern Marion Counties. It is part of the Ocklawaha River Basin and includes six subbasins: Hogtown Creek, Paynes Prairie (including Alachua Sink, Lake Wauberg, Tumblin Creek, and Sweetwater Branch), Newnans Lake, Lochloosa Lake, Orange Lake, and Orange Creek (a tributary of the Ocklawaha River). There are 9 impaired surface waters in the watershed.

DEP collects water quality data at 22 lake and lake tributary stations. DEP collected some biological data in the past, including habitat mapping and vegetative surveys. Discharge, flow, or stage data are collected at 29 locations.

Key Recommendations

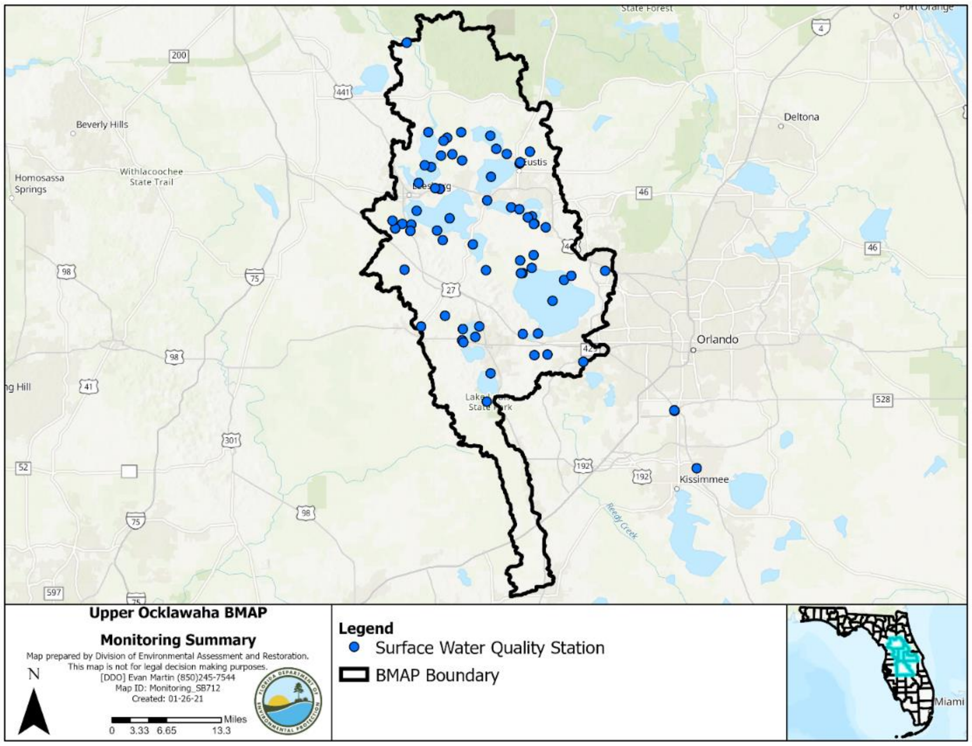
- Increase frequency of biological sampling, as it is a better indicator of system health than water quality parameters alone.

- Restore phytoplankton estimation periodically to evaluate long-term population shifts. (Phytoplankton are minute flora that drift in the current, use carbon dioxide and release oxygen, and serve as food for other aquatic organisms.)

- Increase Lake Wauberg monitoring from twice each year to quarterly.

- Continue monitoring based on the current indicator criteria (*E. coli*) to gather enough data to determine whether the system is, in fact, impaired by bacteria. Several waterbodies in the watershed were determined in the past to be impaired based on fecal coliform criteria, which are no longer used.

UPPER OCKLAWAHA



The BMAP area encompasses 562,000 acres primarily in Lake County, with portions in Orange, southern Marion, and northern Polk Counties. The basin includes Lake Apopka and the Apopka–Beauclair Canal, the Clermont Chain of Lakes connected by the Palatlakaha River, the Harris Chain of Lakes, Lake Griffin, Lake Yale, and the Yale–Griffin Canal. There are 13 impaired waterbodies in the watershed.

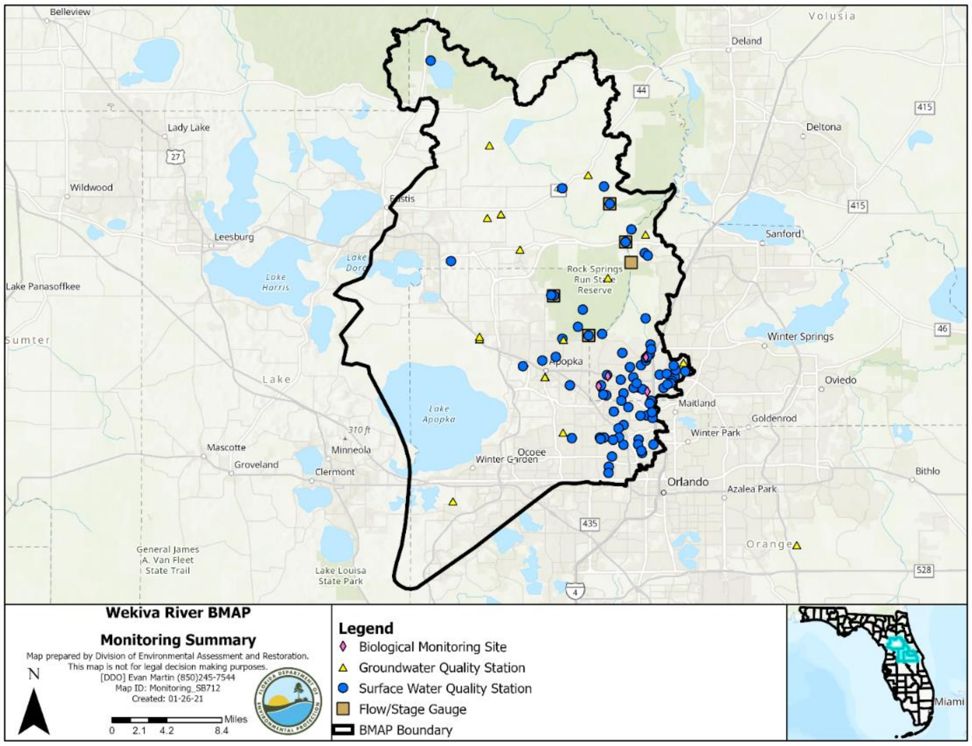
There are 38 surface water stations monitoring the impaired waterbodies and major inflows and outflows. Another 26 stations track water quality trends and provide nutrient loading estimates to Lake Apopka and the Harris Chain of Lakes from tributaries and other sources. Six stations provide both ambient and trend data. DEP periodically collects biological data, including habitat mapping and lake vegetation surveys for the larger lakes, to determine support of a healthy, balanced system.

Key Recommendations

- Add biochemical oxygen demand as an analyte at four Palatlakaha River stations.
- Add total organic carbon measurements at six lake stations.
- Add biological sampling on five lakes as a better indicator of healthy biological communities than water quality parameters alone.

- Restore lake phytoplankton estimation periodically to evaluate long-term population shifts.

WEKIVA RIVER, ROCK SPRINGS RUN, AND LITTLE WEKIVA CANAL



The BMAP area encompasses 391,339 watershed acres.[18] The Wekiva River originates in Wekiwa Springs State Park, in Orange County, at the confluence of Wekiwa Springs Run and Rock Springs Run, and meanders 14 miles through Lake, Seminole, and Orange Counties before entering the St. Johns River downstream of Lake Monroe. It receives discharges from major tributaries, including the Little Wekiva River and Blackwater Creek. The Little Wekiva Canal has an outfall to the Little Wekiva River 14 miles upstream of the confluence with the Wekiva River.

The monitoring network includes ambient groundwater stations in springshed areas and surface water or spring vent monitoring stations in the surface watershed area of the BMAP, which are sampled monthly or quarterly. There is extensive biological monitoring, along with a network to measure surface water flows and discharges from priority springs in the area. Biological assessments are routinely conducted in the basin.

Key Recommendations

- Increase monitoring frequency to monthly to account for seasonal differences in water quality, and support data sufficiency to determine compliance with water quality restoration targets.

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[18]This BMAP is related to the Wekiwa Spring and Rock Springs BMAP (discussed in the Outstanding Florida Springs BMAPs section).

- Add at least six wells to adequately monitor nutrient trends. (Other well monitoring needs are addressed in the Wekiwa Springs/Rock Springs BMAP.)
- Add biological monitoring on the Wekiva main stem and Rock Springs Run.

Estimated Cost of Monitoring Recommendations

Additional monitoring may involve new sites, which must be investigated; more frequent sampling; and additional equipment. Two or three staff are required per sampling event, depending on accessibility and sampling complexity. The table immediately below identifies unit costs for different sampling activities, which were used to prepare the estimates for each of the 29 nutrient BMAPs. Surface water costs include the south Florida BMAPs along with all other surface water systems.

Unit Costs for Sampling Activities

*Submerged aquatic vegetation – Physical/chemical sampling, macrophyte and algae sampling, and lab analysis.
**Cost *per year* includes reconnaissance and installation, data collection, and operation and maintenance per site.
***Based on Leon County Lake Vegetation Index; total cost depends on lake size, travel time, and number done in one day.

Sampling Type	Cost Per Site or Well – Field	Cost Per Site or Well – Lab	Cost Per Site or Well – Total
Surface water sampling	$460	$200	**$660**
Groundwater	$505	$216	**$721**
Algal survey	$135		**$135**
Quantitative submerged aquatic vegetation*	$2,900		**$2,900**
Continuous sampler**	$49,250		**$49,250**
Nitrate probe for continuous sampler	$10,710		**$10,710**
New well construction	$13,000		**$13,000**
15N and 18O isotopes		$128	**$128**
Lake Vegetation Index***	$2,000		**$2,000**
Biochemical oxygen demand		$47	**$47**
Total organic carbon		$14	**$14**

The following two tables estimate the additional cost of monitoring in the spring and surface water BMAPs, respectively. Costs are identified by the different monitoring activities that would be added or expanded and were calculated using the unit costs from the table above.

Estimated Cost for Additional Springs BMAP Monitoring

*Requires site-by-site investigation. (TBD = To be determined.)

Monitoring Activity	Estimated Cost
Continuous samplers for nitrate monitoring	$201,300
New surface water monitoring	$71,280
Increased frequency of surface water monitoring	$70,620
New spring monitoring	$88,440
Increased monitoring of spring vent(s)	$62,040
Refinement/addition of existing well locations*	$949,000
Increased frequency of well sampling	$817,500
Existing well reconnection	TBD*
Isotope sampling	$43,136
Submerged aquatic vegetation and algae survey	$8,910
Ecological Condition Study	$75,400
Total per year	**$2,387,626**

Estimated Cost for Additional Surface Water BMAP Monitoring

*Because of Wekiva River interconnection with Wekiwa and Rock spring system.

Monitoring Activity	Estimated Cost
New surface water monitoring	$264,884
Increased frequency of surface water monitoring	$197,632
Submerged aquatic vegetation and algae survey	$5,535
Lake Vegetation Index	$18,000
Isotope sampling, Wekiva only*	$4,608
Total per year	**$490,659**

Summary

Based on DEP's evaluation of the 29 nutrient BMAPs, the current monitoring structure is adequate to determine restoration progress in each BMAP. That said, additions or modifications in certain areas would enable staff to better identify pollutant sources and capture water quality trends, both of which would expedite restoration. As evidenced by the BMAP-by-BMAP summaries, many surface water BMAPs would benefit from a few relatively inexpensive adjustments to their current monitoring schemes, while more substantial changes are warranted in several of the larger surface water systems. Because of the complex interactions between surface water and groundwater and the difficulty in isolating pollutant sources, more monitoring changes are identified for the springs BMAPs. DEP will take advantage of any resources the Legislature makes available to fill monitoring gaps, including "water quality enhancement and accountability" funds (line item 1613 of the 2021 General Appropriations Act). DEP will prioritize those systems where water quality data are most lacking and use the additional information in concert with local stakeholders to develop more effective restoration strategies.