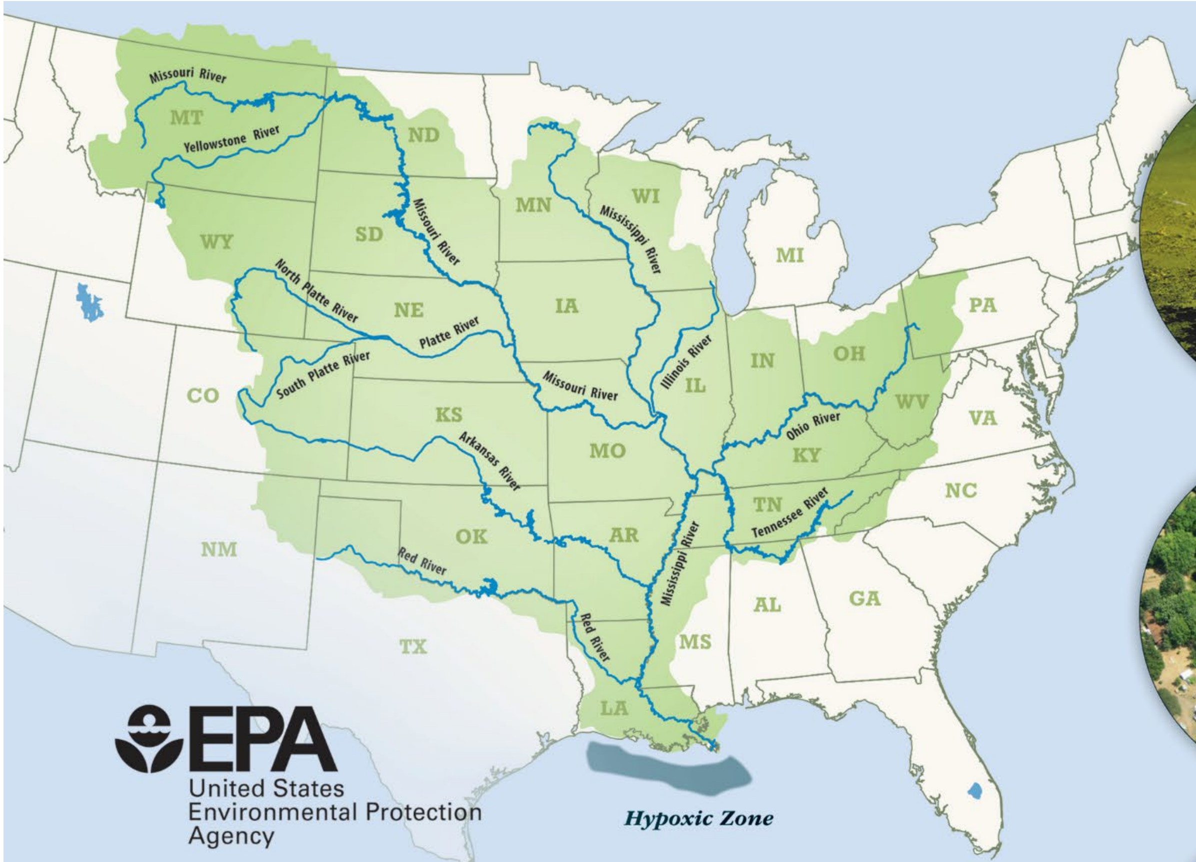

EPA
United States
Environmental Protection
Agency

Mississippi River/Gulf of Mexico Watershed Nutrient Task Force

2019/2021 Report to Congress

Acknowledgements

Special thanks go to the many federal, regional, and state representatives and their staff who support the efforts of the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force, also known as the Hypoxia Task Force (HTF). Their diverse knowledge and expertise contributed to the successful collaboration and consensus building needed to produce this report to Congress. The U.S. Environmental Protection Agency (EPA) appreciates the input provided by the HTF member agencies:

State Agencies

Arkansas Natural Resources Commission
Illinois Department of Agriculture
Indiana State Department of Agriculture
Iowa Department of Agriculture and Land Stewardship, State Co-Chair
Kentucky Department for Environmental Protection
Louisiana Governor's Office of Coastal Activities
Minnesota Pollution Control Agency
Mississippi Department of Environmental Quality
Missouri Department of Natural Resources
Ohio Department of Agriculture
Tennessee Department of Agriculture
Wisconsin Department of Natural Resources

Federal Agencies

U.S. Army Corps of Engineers
U.S. Department of Agriculture: Farm Production and Conservation
U.S. Department of Agriculture: Research, Education and Economics
U.S. Department of Commerce: National Oceanic and Atmospheric Administration
U.S. Department of the Interior: U.S. Geological Survey
U.S. Environmental Protection Agency

Tribes

National Tribal Water Council

Additional Entities Participating on the HTF's Coordinating Committee:

Lower Mississippi River Sub-basin Committee
Ohio River Valley Water Sanitation Commission
Upper Mississippi River Basin Association

Mississippi River/Gulf of Mexico Watershed Nutrient Task Force

2019/2021 Report to Congress

March 2022

Third Report

Contents

Executive Summary

The Harmful Algal Blooms and Hypoxia Research and Control Amendments Act of 2014 (HABHRCA) directs the U.S. Environmental Protection Agency (EPA) Administrator, through the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force (Hypoxia Task Force or HTF), to submit a progress report to the appropriate congressional committees and the President beginning no later than 12 months after the law's enactment, and biennially thereafter.

This combined 2019/2021 report is the third Report to Congress and describes progress made toward the goals of the *Gulf Hypoxia Action Plan 2008* (2008 Action Plan) (USEPA 2008) through activities directed by or coordinated with the HTF and carried out or funded by the EPA and federal and state partners; it provides updates since the 2017 Report to Congress, including actions, newly published science, and advancements.

This report is organized in accordance with the HABHRCA:

- The HTF and an Assessment of Progress Made toward Nutrient Load Reductions (Part 1)
- The Response of the Hypoxic Zone and Water Quality Throughout the Mississippi/Atchafalaya River Basin (Part 2)
- The Economic and Social Effects of the Hypoxic Zone (Part 3)
- Lessons Learned (Part 4)
- Recommended Appropriate Actions to Continue to Implement or, if Necessary, Revise the Strategy Set Forth in the *Gulf Hypoxia Action Plan 2008* (Part 5)

The HTF, its partners, and the scientific community have made tremendous strides in characterizing the hypoxic zone and many of the upstream, land-based factors that contribute to its annual formation. Among these factors, the effects of climate change are expected to result in more severe and prolonged periods of hypoxia and acidification. The HTF remains committed to its 2035 goal of reducing the five-year average areal extent of the hypoxic zone in the Gulf of Mexico (Gulf), to less than 5,000 square kilometers by 2035, with an interim target for reducing total nitrogen and total phosphorus loads by 20% by the year 2025. The HTF agrees that quantifying the nutrient loads from the Mississippi/Atchafalaya River Basin (MARB) to the Gulf is a key HTF metric for tracking progress towards its goals. Key scientific knowledge has advanced and the findings from recent Gulf models confirm that a dual strategy that reduces both nitrogen and phosphorus by 48% would be sufficient to meet the 2035 goal (Fennel and Laurent 2018). The federal HTF members continue to provide support to the scientific community to advance the knowledge of nutrient sourcing, fate and transport in the Basin and to the Gulf, the resource response of the hypoxic zone and water quality throughout the MARB, and economic and social effects of excess nutrients.

In the thirteen years since the HTF adopted its 2008 Action Plan, the HTF has engaged a wide range of partners in the public and private sectors. As states implement their nutrient reduction strategies, they work with diverse groups including universities, agricultural associations, business councils, conservation organizations, municipalities, wastewater utilities, non-profits, and private foundations. Accelerated implementation of State Nutrient Reduction Strategies continues to be the path forward and is supported by technical and financial support from federal HTF members, including support through Farm Bill Conservation Programs, the Clean Water Act (CWA), the Water Resources Development Act, and others, and with active participation by private sector, nongovernmental, and other partners and stakeholders at the MARB scale. State-specific summaries of progress are provided in this Report.

The HTF is focused on continuing to identify the highest priority nutrient source areas for conservation treatment using tools to target priority watersheds, inventory existing conservation practices, and estimate nutrient load reduction to help target scarce resources. Given the scale of work needed, the HTF is looking to more fully consider opportunities to expand the use of pay for performance as well as market-and community-based approaches to broaden the circle of partners who invest in reducing excess nutrients in the MARB. The HTF is working to communicate successes to producers and their networks of trusted advisors to further build their support for conservation investments. The HTF is sharing stories of success and working to acknowledge remaining challenges with the public at large. Better communication and engagement with the public is essential to sustaining and expanding the HTF's work.

This Report to Congress is an effective tool for the HTF to describe progress toward reducing nutrient loads to the northern Gulf, summarize lessons learned in implementing nutrient reduction strategies, and explain any adjustments to its strategies for improving water quality in the Gulf.

HABHRCA 2014: LANGUAGE REGARDING THE HTF[1]

PUBLIC LAW 113–124—JUNE 30, 2014

Public Law 113–124
113th Congress
An Act
To amend the Harmful Algal Blooms and Hypoxia Research and Control Act of 1998, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. SHORT TITLE.

This Act may be cited as the "Harmful Algal Bloom and Hypoxia Research and Control Amendments Act of 2014."

SEC. 7. NORTHERN GULF OF MEXICO HYPOXIA.

Section 604 is amended to read as follows:

''SEC. 604. NORTHERN GULF OF MEXICO HYPOXIA.

''(a) INITIAL PROGRESS REPORTS.—Beginning not later than 12 months after the date of enactment of the Harmful Algal Bloom and Hypoxia Research and Control Amendments Act of 2014, and biennially thereafter, the Administrator, through the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force, shall submit a progress report to the appropriate congressional committees and the President that describes the progress made by activities directed by the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force and carried out or funded by the Environmental Protection Agency and other State and Federal partners toward attainment of the goals of the Gulf Hypoxia Action Plan 2008.

"(b) CONTENTS.—Each report required under this section shall—

"(1) assess the progress made toward nutrient load reductions, the response of the hypoxic zone and water quality throughout the Mississippi/Atchafalaya River Basin, and the economic and social effects;

"(2) evaluate lessons learned; and

"(3) recommend appropriate actions to continue to implement or, if necessary, revise the strategy set forth in the Gulf Hypoxia Action Plan 2008."

[1] On Jan 7th, 2019, the HABHRCA 2014 was amended through the Harmful Algal Bloom and Hypoxia Research and Control Amendments Act of 2017 (Pub. L. 115-423, §9, Jan. 7, 2019, 132 Stat. 5462). Section 604, requiring the HTF reports to Congress, was unaffected by the 2017 amendments.

Part 1. The HTF and an Assessment of Progress Made Toward Nutrient Load Reductions

Each year, the Mississippi/Atchafalaya River Basin (MARB) (made up of 796,800,000 acres that spread across 31 states and two Canadian provinces) delivers enormous flows of water containing nitrogen and phosphorus to the northern Gulf of Mexico (Gulf), creating hypoxic conditions that can be inhospitable to life. These excess nutrients come from the daily activities of citizens throughout America's heartland, including urban land use, wastewater management and production agriculture on millions of acres of farmland. In 1997, federal and state agencies formed a Mississippi River/Gulf of Mexico Watershed Nutrient Task Force (Hypoxia Task Force or HTF) to lead collaborative efforts to reduce Gulf hypoxia and to improve water quality throughout the Basin.[2] Despite strong efforts, reducing nutrient loads from this vast landscape—one where tens of millions of people live and work—is an extraordinarily large task. The enormity of this challenge drives collaboration between states, federal partners, and stakeholders to scale up conservation and increase the use of innovative, community-based and market-based approaches to supplement traditional state and federal regulatory and grant programs and make more progress.

1.1 The HTF

The HTF is a federal, state, and tribal partnership that works collaboratively and voluntarily on reducing excess nitrogen and phosphorus loads delivered from the MARB and ultimately reducing the size of the hypoxic zone in the Gulf. Major efforts undertaken by the HTF are summarized on the HTF history web page.

1.1.1 Structure of the HTF

Members of the HTF include five federal agencies and 12 states bordering the Mississippi and Ohio rivers.[3] The National Tribal Water Council represents tribal interests on the HTF. The U.S. Environmental Protection Agency (EPA) is the HTF federal co-chair; the position of state co-chair, established in 2010, rotates among the state members. Iowa is the current state co-chair. Each HTF member state is represented by an official from its agriculture, pollution control, or natural resources agency. The representative state agency frequently works with all relevant agencies within the state to achieve HTF goals. Senior staff of each member agency and collaborating state agency meet as the Coordinating Committee and support HTF members.

The HTF membership structure facilitates HTF members partnering on local, state, and regional nutrient reduction efforts and encourages a holistic approach to reducing hypoxia in the Gulf and improving water quality in the MARB. This holistic approach includes addressing upstream sources as well as near-field and downstream impacts. Partnerships are key to scaling up the needed work, and the HTF strongly values the actions and collaboration of partners described throughout this report.

---

[2] The HTF was convened as an Interstate Management Conference under CWA Section 319(g)(1).

[3] Federal and state members: U.S. Environmental Protection Agency; U.S. Department of Agriculture Farm Production and Conservation and Research, Education and Extension; U.S. Department of Interior; National Oceanic and Atmospheric Administration; and the U.S. Army Corps of Engineers; and Arkansas, Illinois, Indiana, Iowa, Kentucky, Louisiana, Minnesota, Mississippi, Missouri, Ohio, Tennessee, and Wisconsin.

HTF members are supported by a Coordinating Committee; staff from each federal agency and the National Tribal Water Council, as well as staff from multiple state agencies in addition to the state member agency make up this committee. The Coordinating Committee meets regularly to share information on the state of science and communication in the MARB, and to keep each other informed on state-specific actions to implement nutrient reduction strategies. Ten HTF workgroups are staffed by Coordinating Committee members and their colleagues to further advance the areas of metric* development, policy advancement, funding opportunities, and communication coordination. The workgroups (with further discussion where appropriate) are:

- Nonpoint Source Metrics* (Part 1.2)
- Point Source Metrics* (Part 1.3)
- Water Quality Monitoring*
- Water Quality Trends* (Part 2.3.1)
- Ecosystem/Social Metrics* (Part 1.2)
- Research Needs (Part 4.1)
- Adoption of Innovative BMPs (Part 1.2)
- Communications (Part 5.3)
- Environmental Mitigation for Restoration Projects
- Funding, Traditional and Non-traditional

1.1.2 Public Engagement

The HTF conducts biannual public meetings (concurrently webcasted) throughout the MARB and periodically in Washington, DC. Recent public meetings were held virtually and in Washington, DC, in 2020, in Baton Rouge, Louisiana, in 2019, and in Arlington, Virginia, in 2018. During each in-person public meeting since 2016, the HTF has hosted a public networking session that provides an opportunity for informal engagement between the local community and HTF members.

In addition to these public meetings, stakeholders can engage with the HTF and its members on multiple levels, including by participating in state efforts as they implement their nutrient reduction strategies, interacting with land grant universities in partnership with HTF and state efforts, engaging in local watershed efforts, and contacting HTF representatives and their staff at any time throughout the year.

1.1.3 Goals

In 2001, the HTF first agreed, subject to the availability of resources, to meet a “coastal” goal of reducing the size of the hypoxic zone in the northern Gulf to a five-year annual average of less than 5,000 square kilometers by 2015. To achieve this goal, the HTF developed its first Action Plan (2001 Action Plan) (USEPA 2001), which described nitrogen reduction activities that HTF member states agreed to implement with federal member support at large sub-basin scales across the Mississippi River Basin (i.e., the Upper and Lower Mississippi and Ohio basins). Through the 2001 Action Plan, the HTF also agreed to restore and protect waters within the MARB and to improve the MARB communities and economic conditions, in particular the agricultural, fishery, and recreational sectors, through improved public and private land management using a cooperative, incentive-based approach (USEPA 2001).

In 2007, the HTF convened a Mississippi River Basin Science Advisory Board Panel to provide an updated science assessment to the HTF. The Panel estimated that a 45% reduction in total nitrogen *and* a 45% reduction in total phosphorus would be needed to reach the goal set by the HTF in 2001 (USEPA 2007).

In 2008, the HTF recognized state nutrient reduction strategies as the cornerstone for reducing nutrient loads to the Gulf and throughout the Basin, as only states have the authority, with strong support from federal partners, to achieve the nutrient loss reductions needed. Therefore, in the HTF's 2008 Action Plan, the first of 11 actions called for states to complete and implement comprehensive nitrogen and phosphorus loss reduction strategies. The 11th action calls for a reassessment of the Action Plan every five years. In the *Reassessment 2013: Assessing Progress Made Since 2008*, the HTF recommended accelerating the implementation of nutrient reduction activities and identifying ways to track and measure progress at a variety of scales. The Harmful Algal Blooms and Hypoxia Research and Control Amendments Act of 2014 (HABHRCA) requires this Report to Congress. The HTF uses this Report to Congress in place of the reassessments of its Action Plan.

In 2015, recognizing the enormity of the task of reducing nutrient loads on a subcontinental scale, the HTF affirmed its original goal of reducing the areal extent of the hypoxic zone in the Gulf, but extended the time for reaching that goal from 2015 to 2035. As part of its *New Goal Framework*, the HTF agreed to an interim target for reducing total nitrogen and total phosphorus loads from the MARB to the Gulf by 20% by the year 2025 and committed to regularly track progress towards its 2025 interim target and 2035 goal (USEPA 2015).

1.1.4 Tracking Progress Toward the 2025 Interim Target and 2035 Goal

To more effectively help track and measure progress towards the 2035 goal and 2025 interim target, the HTF has worked in recent years to establish and report on specific Gulf and basin wide water quality and nutrient reduction metrics at a variety of scales. The HTF relies on states to report state-level water quality and state-level actions taken toward meeting the 2035 goal and 2025 interim target (section 1.6), and relies on federal partners for research, monitoring, and modeling support. The HTF's metrics, discussed in the 2017 Report to Congress, include:

- Regular tracking of loading trends from nonpoint and point sources (sections 1.2 and 1.3);
- Ongoing work by states to quantify progress towards the 2035 goal and 2025 interim target through implementing State Nutrient Reduction Strategies (section 1.6);
- The five-year average areal extent of the hypoxic zone, based on the National Oceanic and Atmospheric Administration's (NOAA) annual hypoxic zone cruise that measures the areal extent (section 2.2);
- Water quality, river flow data, and trend analyses (section 2.3); and
- Modeled decadal riverine nutrient loading trends using U.S. Geological Survey (USGS) National Water Quality Network data (section 2.3.1) and U.S. Department of Agriculture (USDA) Conservation Effects Assessment Project (CEAP) models (section 2.3.2).

1.2 Tracking Progress and Scaling Up Work to Reduce Nonpoint Source Loads

Since 2014, the state-led Nonpoint Source Workgroup (the HTF NPS Workgroup) has coordinated HTF efforts to track progress in reducing nonpoint source loads of excess nutrients to the Gulf. In tracking progress, the HTF NPS Workgroup focused on developing a method of tracking conservation practice implementation. Examples of conservation practices include cover crops, conservation tillage, saturated buffers, riparian buffers, wetlands, conservation drainage water management, nutrient management, terraces, and sediment-trapping ponds.

The HTF published its first Nonpoint Source Progress Report in 2018. Findings in this report include the following:

- Many federal and state agencies collect, store, and report on conservation actions implemented throughout the MARB.
- There is no consistent framework for all 12 HTF states to use in reporting nonpoint source metrics. States currently use a variety of methods to store and report data on conservation practice implementation.
- A more consistent nonpoint source metric framework would allow HTF members to more effectively track and evaluate progress, and adaptively manage their programs; facilitate more effective collaboration with partners; and support improved communication about the HTF's work.

In addressing these findings, the HTF NPS Workgroup set two guiding principles for developing and implementing common metrics of nonpoint source progress:

- They must be reasonably reportable by all member states and federal agencies; and
- They must be meaningful metrics of nutrient load reductions to the Gulf.

The HTF NPS Workgroup examined several potential metrics and determined that a conservation practice inventory is the most fitting common metric to track the collective effort of practice implementation by state, federal, and local governments, and—to the greatest extent practicable—partners. The HTF would update the practice inventory on a recurring basis and use the inventory and load reduction modeling tools to track progress in reducing nonpoint source loads of excess nutrients.

Because so many entities are working to reduce nonpoint source nutrient loads to the Gulf—federal, state, and local agencies; individual landowners and producers; nongovernmental organizations (NGOs) and foundations; corporate sustainability programs; and others—developing a common approach to inventorying conservation practices and then estimating load reductions is a complex endeavor. However, with support from the Walton Family Foundation, this work is advancing through the leadership of researchers from the land grant universities in the 12 HTF states, working collaboratively in a group known as Southern Extension and Research Activities committee number 46 (SERA-46) (see section 4.1). SERA-46 researchers first worked with two pilot states, Arkansas and Indiana, to build a quantitative assessment of conservation practice implementation from state and federal sources. This work has now expanded to include three additional states: Illinois, Kentucky, and Minnesota.

At the May 2019 Public Meeting, the HTF heard presentations on new tools that use aerial photography, satellite imagery, and remote sensing techniques to track landscape-scale implementation of conservation practices. These tools can document where *all* of these practices are situated on the landscape, regardless of whether the practice was mandated, voluntary, or funded by a third party. The HTF NPS Workgroup is now considering how to integrate these tools into a nonpoint source reporting framework, even if they are not yet available in each state, and the HTF has published a compendium guide to share information on many of the tools that exist for use in the MARB. The HTF Ecosystems/Social Metrics Workgroup is exploring a subset of these tools to recommend additional ecosystem benefits, such as carbon sequestration, that can accrue with adoption of nutrient reduction practices and thus be tracked as HTF metric.

Since the 2017 Report to Congress, the significant challenge of scaling up conservation implementation throughout the MARB has been further explored (Rao and Power 2019). The scaling up process is defined as generally using watersheds as the scalable units for planning, priority setting, and implementation while recognizing the diversity of state and local opportunities and needs. For efficiency, planning and priority setting might occur at a larger scale such as an eight-digit hydrologic unit code (HUC-8) watershed, which is about 700 square miles. As Rao and Power (2019) note, however:

> [s]uccessful implementation of watershed plans requires strong, local networks to expand awareness of watershed issues and maintain trust. In the upper Midwest, these local social networks tend to be more similar in size to a HUC-10 (typically ranges in size from about 40,000-250,000 acres) or HUC-12 watershed (typically ranges in size from about 10,000-40,000 acres), therefore implementation at smaller scales tends to be necessary for success.

Key elements of successfully scaling up conservation implementation include skilled leadership and management; local champions; and policies and financial frameworks that incentivize and provide stable funding for scaling up work. Tracking social indicators as outcomes of focused skilled leadership and local champions elements support landscape-scale changes in the use of conservation practices and systems.

Another important opportunity to promote landscape scale deployment of conservation practices is harnessing the use of market forces, including water quality trading (WQT) as well as community-based and collaborative programs, to increase the scale of investment in nonpoint source reductions beyond the levels that have been achieved to date using regulatory and traditional grant and cost-share programs. These opportunities are discussed further in section 1.5.

1.3 Point Source Load Reduction Progress

As part of the HTF's Revised Goal Framework, the HTF also committed to tracking point source progress. The HTF Point Source Workgroup (HTF PS Workgroup) reported on two metrics in 2016: (1) the number and percentage of major sewage treatment plants (including publicly owned treatment works) that were issued National Pollutant Discharge Elimination System (NPDES) permits with monitoring requirements for nitrogen and/or phosphorus, and (2) the number and percentage of those that were issued NPDES permits with numeric discharge limits for nitrogen and/or phosphorus.

In January 2018, the HTF adopted an additional metric to track point source progress: estimated loads of nitrogen and phosphorus discharged by major sewage treatment plants and, in 2019, issued a second Point Source Progress Report. This report generally uses a common tool, the Water Pollutant Loading Tool to calculate or estimate facility discharge loads. Some notable findings include the following:

- Across the 12 HTF states, 70% of permits for major sewage treatment plants discharging to the MARB included monitoring requirements for both nitrogen and phosphorus, an increase from 56% in 2014. Eighty-six percent of permits for major sewage treatment plants included monitoring requirements for at least one nitrogen or phosphorus parameter, an increase from 71% in 2014.
- Thirty-two percent of the permits for major sewage treatment plants that discharge to the MARB have limits for nitrogen or phosphorus, an increase from 27% in 2014; most of these permits have phosphorus limits. Four percent of the permits for major sewage treatment plants include limits for both nitrogen and phosphorus.
- In sum, the 1,199 major sewage treatment plants that discharge to the MARB contributed 287,708,571 pounds of nitrogen and 44,972,256 pounds of phosphorus to nutrient loads in the MARB. For comparison, USGS calculates that the total nutrient loads from the MARB to the Gulf in Water Year 2017 were approximately 3,320,000,000 pounds of nitrogen and 314,000,000 pounds of phosphorus.

The third Point Source Report is in development. As noted in its 2019 report, the HTF PS Workgroup continues to examine options for deriving a common point source-specific loading baseline for the 1980–1996 period, which the HTF uses to track overall progress in reducing nutrient loads to the Gulf. Iowa undertook a pilot project to evaluate whether a 1992 point source data set developed by USGS could be used to reasonably estimate loads from that year. Results are promising; the HTF PS Workgroup is exploring whether other states can also use this USGS data set to estimate 1992 point source loads to establish a baseline.

1.4 Targeting Tools for Watershed Planning in Priority Nutrient Reduction Strategy Watersheds

As states implement Nutrient Reduction Strategies, they focus on priority watersheds. Since the 2017 Report to Congress, several planning and conservation-targeting tools are being more widely used throughout the MARB. As an example of how USDA integrates these types of tools into their technical and financial support opportunities, USDA is transitioning to a new Conservation Assessment and Ranking Tool (CART). CART is designed to assist conservation planners assess site vulnerability, existing conditions, and potential resource concerns on a unit of land (e.g., agricultural field). This screening-level assessment includes the use of geospatial data and other information to assist USDA staff and partner planners determine if additional conservation practices may be necessary on a particular unit of land. CART captures this information for use in prioritization for programs and funding.

1.4.1 Agricultural Conservation Planning Framework

A watershed targeting tool, the Agricultural Conservation Planning Framework (ACPF), founded on USDA's CEAP concepts and techniques (see Section 2.3.2. for further information), was released in 2015 by a USDA-led partnership and updated in 2019. ACPF includes tools to process Light Detection and Ranging (LiDAR)-based digital elevation models for: (1) hydrologic analysis and identification of agricultural fields most prone to deliver runoff directly to streams; (2) map and classify riparian zones to inform whole-watershed riparian corridor management; and (3) estimate the extent of tile drainage in a watershed. The software maps locations appropriate for installation of several types of conservation practices, including controlled drainage, grassed waterways, water and sediment control basins, and nutrient removal wetlands. This targeting tool is used by watershed planners for projects in several MARB states where appropriate data is available, including Illinois, Indiana, Iowa, Minnesota, and Wisconsin, to make progress on federal or State Nutrient Reduction Strategy projects (Tomer et al. 2013). USDA's Natural Resources Conservation Service (NRCS) has an agreement with USDA's Agricultural Research Service through FY2021 to provide support and assistance to NRCS staff and partners to use and adopt the ACPF, and to apply ACPF results in watershed planning and assessment to inform conservation practice implementation and outreach strategies for water quality efforts. Illinois, Indiana, Iowa, Missouri and Wisconsin NRCS are participating as pilots, and ACPF expansion into new geographic areas is supported through CEAP Watersheds. In FY 2021, NRCS provided funding for the establishment of a HUB for the ACPF tool and implementation as well as funding to enhance ACPF and address development opportunities.

1.4.2 Weather Forecast-Based Nutrient Application Tools

NOAA and USDA are supporting complementary efforts to develop state and local decision-support tools to minimize potential nutrient losses from watersheds due to various weather and precipitation conditions. NOAA and USDA are exploring possible collaboration on the development of an optimal approach for states using these tools.

Working with state partners, NOAA's National Weather Service (NWS) has developed Runoff Risk Advisory Forecasts across the Great Lakes region with the help of the Great Lakes Restoration Initiative. These tools guide farmers and producers on how the timing of fertilizer and manure applications can minimize nutrient losses. A significant percentage of annual nutrient losses can occur from only a few large precipitation events per year. Relying on NOAA's NWS modeling, on-farm research data, and multi-partner collaboration, these tools offer a science-based approach to nutrient application timing. The tools are currently available in Ohio, Michigan, Minnesota, and Wisconsin, with potential for expansion into New York and Indiana in the next couple of years. A newer Runoff Risk version based on the NWS National Water Model is also in development. If operationalized, this new version could offer potential coverage to the lower 48 states, pending state interest and collaboration. If Runoff Risk tools are implemented across the MARB, HTF member states would be able to encourage their use to enhance farm-scale nutrient management planning and help minimize nutrient loss to local water bodies and ultimately to the Gulf.

1.5 Federal Agency Collaboration and Assistance to HTF States and Tribes

1.5.1 National Leadership and Federal Programs Working Together

In December 2018, EPA and USDA jointly invited directors of state environmental and agricultural programs to engage with the federal agencies and identify local opportunities to reduce excess nutrients in waterways. In advance of the May 2019 HTF meeting, EPA convened an interagency leadership team from EPA, USDA, NOAA, U.S. Department of Interior, and the U.S. Army Corps of Engineers (USACE) in a nutrient roundtable discussion with national leaders in conservation financing and implementation. The nutrient roundtable discussion focused on the challenges and opportunities for reducing nutrient pollution in the Mississippi River Basin, with emphasis on how the federal agencies can better focus financial, scientific, and technical resources in working with states and collaborators to make greater progress in improving water quality in the MARB and across the country. As an outcome of this convening, the states submitted a letter to the federal agencies in June requesting additional action in several areas in order to make greater progress. In response, seven additional HTF workgroups were launched at the February 2020 HTF meeting in response to these state-identified needs (see Part 1.1.1).

USDA and EPA continue to partner on watershed-scale implementation of agricultural conservation practices for nutrients through the National Water Quality Initiative (NWQI). The program is supporting enhanced conservation planning in all NWQI watersheds. States report that more than 25% of NWQI watersheds with monitoring programs show improved water quality. States have also "delisted" nine more NWQI watersheds as no longer impaired by nutrient-related pollution.

In 2019, USDA expanded the scope of NWQI to include source water protection (SWP) as an additional focus area, including both surface and ground water sourced public water systems. EPA worked closely with USDA to assist partners in adapting and expanding SWP plans to identify critical source areas related to agricultural land uses. Twenty-three SWP projects have been selected to date for funding through 2023.

The Agriculture Improvement Act (the 2018 Farm Bill) placed an emphasis on collaboration between agriculture producers and the drinking water community and directs 10% of conservation dollars to activities that benefit drinking water source water. EPA works with USDA NRCS on opportunities to implement conservation and management practices that protect both surface and ground water drinking water sources from nutrient and other agriculture-related impacts. EPA is also working with NRCS to foster communication and partnerships among NRCS, state, and water utility leaders to capitalize on resources provided through the USDA's conservation programs to target source water concerns.

NOAA, EPA, and the Office of Science and Technology Policy (OSTP) co-chair the Interagency Working Group for the HABHRCA. This Interagency Working Group has made advances in the scientific understanding and ability to detect, predict, control, mitigate, and respond to harmful algal blooms (HABs) and hypoxia events. This group is tasked with coordinating and convening Federal agencies to discuss HAB and hypoxia events in the United States, and to develop action plans, reports, and assessments of these events. In addition to publishing several reports, they are working with communities, resource managers, and other stakeholders to allow managers to prepare well in advance through forecasts and monitoring and minimize impacts during an event.

In August 2019, EPA and four federal partners (USGS, USDA, the National Institute of Standards and Technology, and NOAA's U.S. Integrated Ocean Observing System) announced the winners of the Nutrient Sensor Action Challenge, a technology-accelerating water quality challenge that is focused on advancing nutrient management. The winners demonstrated how data from low-cost water quality monitoring sensors can be used to inform local-scale nutrient management decisions.

1.5.2 Ongoing EPA Program Work on Nutrient Reductions

In fiscal years (FYs) 2017 and 2018, EPA provided $94.9 million in grants to HTF states to support their work in reducing nonpoint source pollution. States are currently reporting that approximately 40% of these funds ($37 million) will go specifically toward reducing nutrient pollution. Most of the projects that states fund with these grants reduce excess nutrients, either directly or as a co-benefit. The HTF member states recorded 16 water bodies with waters primarily impaired by nonpoint source nutrient loads are now restored and meet state water quality standards.

EPA's Gulf of Mexico Division awarded $2 million for two grants in 2018 and $7.5 million for seven grants in 2019 to fund projects that improve water quality, habitat, and environmental education in the Gulf watershed, with a significant focus on reducing excess nutrients delivered to the Gulf.

In October 2019, EPA published, on behalf of the HTF, the first HTF Newsletter, highlighting recent state and federal activities that provide the public a summary of the activities HTF members are supporting and undertaking. The public can sign up to receive this newsletter. Through July 2021, eight newsletters have been published.

EPA continues to provide more than $1 billion each year in capitalization grants for state revolving fund (SRF) loan programs, which states can use to help communities reduce excess nutrients. Some states such as Iowa and Ohio use innovative "sponsorship projects" that pair towns with farmers to work on cost-effective nutrient conservation practices. States can use SRF loans for point or nonpoint source projects to improve water quality.

In 2019 and 2020, EPA provided $2.4 million dollars in grants to the twelve HTF member states to help them implement tailored and effective plans to reduce excess nutrients in the MARB, including updating nutrient management plans, developing water quality trading programs and demonstrating best practices in high-priority watersheds. State grant outcomes include the following key themes:

- Reporting and communicating of state progress to HTF member states and the public
- Prioritization of high-impact watersheds: Determine approach for identifying major sources of nutrients in state
- Identification and adoption of state-level actions and programs to better support nutrient reductions
- Deployment of staff to plan, prioritize, engage partners and stakeholders in priority watersheds, and manage progress tracking mechanisms
- Assessment of progress: Identify and develop accountability measures
- Assessment of progress: Develop and deploy a system for tracking and reporting progress
- Support State Science Assessment

In February 2019, EPA signed a Memorandum of Understanding (MOU) with the Water Research Foundation to develop affordable technologies to recycle nutrients from manure. This MOU builds on successes achieved through the Nutrient Recycling Challenge, a competition launched by EPA with the Foundation and others to develop affordable technologies to recycle nutrients from livestock manure.

In August 2021, EPA published revised ambient water quality criteria to address nutrient pollution in lakes and reservoirs. These Clean Water Act Section 304(a) recommended ambient water quality criteria are part of EPA's ongoing effort to help states and authorized tribes in adopting numeric nutrient criteria into their water quality standards to protect public health and the health of pets and aquatic life from the adverse effects of nutrient pollution and harmful algal blooms. The criteria represent the latest scientific knowledge of the concentrations of nitrogen and phosphorus that are protective of drinking water sources, recreational uses and aquatic life in lakes and reservoirs. EPA developed national statistical models that provide a flexible approach for identifying appropriately protective numeric nutrient criteria. States and authorized tribes can use the national models or incorporate local data into them to help develop numeric nutrient criteria that are consistent with national relationships while accounting for unique local conditions. These criteria replace EPA's previously recommended ambient nutrient criteria for lakes and reservoirs that were published in 2000 and 2001.

1.5.3 Ongoing USDA Program Work on Nutrient Reductions

USDA's NRCS offers financial and technical assistance to help landowners implement voluntary conservation practices through various programs, including the Environmental Quality Incentives Program (EQIP), Regional Conservation Partnership Program (RCPP), Conservation Stewardship Program, and Agricultural Conservation Easement Program. From FY 2009 through FY 2020, NRCS invested $13.9 billion in voluntary conservation programs and conservation technical assistance in HTF states.

Beginning in the 2008 Farm Bill, NRCS developed several landscape conservation initiatives that target voluntary conservation program funding to areas with critical natural resource concerns. Design and delivery approaches of these initiatives has been informed by CEAP watershed studies and CEAP-based assessment tools. These water quality initiatives also intersect with MARB, cross geopolitical boundaries, take a science-based approach to addressing resource concerns on a landscape scale, and rely on strong planning and partnerships to enhance and accelerate conservation system implementation.

- There are over 80 NWQI priority watersheds within the 12 HTF states. From 2012 through 2021, NRCS obligated $106 million through NWQI to address nutrient and sediment runoff, supporting farmers in treating over 370,000 acres.
- The Mississippi River Basin Healthy Watersheds Initiative (MRBI) priorities are aligned with and support each state's nutrient reduction strategy. From 2010 through 2021, MRBI supported conservation on almost 1.7 million acres, with EQIP obligations totaling $403 million.
- RCPP projects for water quality within the 12 HTF states since 2017, totaling over $143 million in financial assistance for water quality efforts, included partners such as watershed improvement districts, irrigation districts, soil and water conservation districts (SWCDs), American Farmland Trust, Ducks Unlimited, The Conservation Fund, and state agencies.
- USDA's Farm Service Agency (FSA) administers the Conservation Reserve Program (CRP), a voluntary program through which participating landowners convert highly erodible and environmentally sensitive cropland into conservation covers. There were 6.9 million acres enrolled in CRP in the 12 HTF states as of July 2018.
- NRCS provided the HTF NPS Workgroup with EQIP implementation data from 2009 to the present. NRCS will annually provide certified EQIP data for the 12 MARB states in the format requested by the HTF NPS Workgroup.

USDA's Office of Environmental Markets supports the development of market-based programs across the country, evaluates the economics of markets, and develops tools and resources such as the Nutrient Tracking Tool (NTT) to help landowners estimate environmental services of conservation efforts and participate in markets, where available. NTT is a field-specific tool developed to estimate nutrient and sediment losses and estimate yield impacts, helping to inform conservation decisions on the farm. NRCS supports the development of environmental markets and conservation finance approaches through its programs such as Conservation Innovation Grants and the RCPP. USDA's National Institute of Food and Agriculture (NIFA) also provides funding for environmental market related research, including water quality trading.

1.6 State Implementation of Nutrient Reduction Strategies[4]

1.6.1 Arkansas

The Arkansas Nutrient Reduction Strategy is a strategic framework that outlines both regulatory and voluntary opportunities to improve overall aquatic health and viability in Arkansas waters for recreational, economic, environmental, and human health benefits. The strategic framework recognizes that achievement of water quality goals requires iterative and collaborative processes that, when implemented over time, result in incremental progress toward improvement goals. Those processes adhere to the following guiding principles:

- Strengthening existing programs;
- Promoting voluntary, incentive-based, cost-effective nutrient reduction metrics;
- Incorporating adaptive management and flexible strategic planning;
- Leveraging available financial and technical resources; and
- Pursuing market-based opportunities and solutions.

Arkansas Nutrient Reduction Strategy Update

In 2018, Arkansas initiated a stakeholder process to update and revise the Arkansas Nutrient Reduction Strategy. The update to the Arkansas Nutrient Reduction Strategy will build on the successes of the original strategy and will focus on establishing a new method of measuring overall progress, targeting nutrient-focus watersheds, and reporting nutrient reductions from nonpoint source practices.

Measuring Success

As part of the process to update the Arkansas Nutrient Reduction Strategy, it was determined that a revised method for measuring success toward meeting the goals of the Strategy should be established. It was agreed that Arkansas will measure progress/success by analyzing the directional change of 75% of all total nitrogen and total phosphorus concentration data within each 8-digit HUC from 1990 to the present. Based on a preliminary analysis of phosphorus concentrations throughout Arkansas since 1990, 33% of Arkansas 8-digit HUC watersheds have exhibited significant reductions in phosphorus concentrations, whereas only one Arkansas 8-digit HUC watershed has exhibited a significant increase in phosphorus concentrations. Additional analysis of Arkansas's progress/success will be performed and presented in the forthcoming update to the Arkansas Nutrient Reduction Strategy.

Targeting Nutrient Focus Watersheds

One important aspect of the strategy update is to focus limited resources in watersheds that have the potential to result in the greatest reduction in nutrient loading. For that reason, focus watersheds will be identified for the purpose of prioritizing resources.

[4] These summaries were drafted by HTF states and incorporated into this document with very little editing; the summaries reflect state actions as described by the states.

Focus watersheds will be identified by analyzing site-specific trends in nutrient concentrations at the Arkansas Department of Environmental Quality's ambient monitoring stations as well as select roving stations when adequate concentration and flow data exist. Water quality trends will be evaluated using a three-step process: (1) water quality data will be log-transformed, (2) nutrient concentrations will be flow-adjusted using LOESS smoothing techniques, and (3) flow-adjusted concentration data will be evaluated for changes over time.

The categorization of watersheds will be based upon several levels of information including site-specific trends and trends in percentile nutrient concentrations at the HUC-8 and ecoregion level. The goal is to evaluate trends of nutrient concentrations relative to those observed within the watershed and ecoregion watershed-wide. This will help determine if the watershed should be a priority for concentrating nutrient reduction efforts or for data collection. Once focus or priority watersheds are identified, resources to address both point and nonpoint sources of excess nutrients will be focused in those watersheds with the goal of measuring significant instream nutrient reductions. This strategy has proven highly effective in the Illinois River watershed and Arkansas seeks to expand that success to additional targeted watersheds throughout the state.

Nutrient Reduction Measurement Framework

As part of the update to the Nutrient Reduction Strategy, it was determined that a common framework should be developed for the purpose of tracking and measuring progress in reducing excess nutrients from agricultural management practices (i.e., best management practices (BMPs)) applicable for the Lower Mississippi River Basin. The general approach for formulating an Arkansas Nutrient Reduction Measurement Framework was as follows: A panel of experts was convened to identify nutrient reduction practices used in Arkansas row crop and animal production systems and reach consensus on expected reduction efficiencies for these practices. Irrigation water management practices and their expected nutrient reduction efficiencies were included, as were suites of BMPs implemented in Arkansas agriculture and their collective nutrient reduction efficiencies. Commonly used BMPs and suites of BMPs that require additional research before inclusion in the Arkansas Framework were also identified. Results of this effort will be incorporated into the updated Strategy.

1.6.2 Illinois

The Illinois Nutrient Loss Reduction Strategy (INLRS or Strategy), which was released in 2015, is based on an assessment of available science and uses the input of Illinois stakeholders.

In 2017, Illinois released their first *Nutrient Loss Reduction Strategy Biennial Report*. That report describes the actions taken to achieve the nutrient reduction goals since the release of the INLRS. Illinois has been able to make significant progress in many areas despite no new state or federal funding. This progress was made due to the numerous partnerships that leveraged resources and refocused efforts to meet nutrient loss reduction goals. As the program matures and more stakeholders and organizations become engaged, continued progress and growth is expected. A second biennial report covering more recent efforts was released in the fall of 2019.

Updates on INLRS Implementation

The INLRS established several workgroups responsible for implementing the actions recommended within the Strategy. These workgroups meet two to three times each year. Updates for each workgroup are summarized below:

- Policy Working Group–The Policy Working Group continues to meet twice per year to provide oversight and recommendations for implementing the overall Strategy. Close to 30 organizations are represented in this group, representing point source, agriculture, urban stormwater, and conservation/environmental groups. The Policy Working Group was focused on developing the *2019 Biennial Report*.
- Performance Benchmark Committee–This committee has previously focused on benchmarks for point sources, but in 2018 began to discuss benchmarks and adaptive management approaches for nonpoint source pollution as well. This resulted in a new chapter featured in the *2019 Biennial Report* called "Adaptive Management and Measuring Progress." This chapter compares water quality goals with observed water quality data as well as implementation goals for point and nonpoint sources compared to current implementation levels.
- Nutrient Monitoring Council–The Nutrient Monitoring Council continues to meet three times per year. USGS provides updates on the performance of the network of nine "super gauges" in Illinois that continuously measure flow, nutrients, and other parameters. Members also provide updates and results from ongoing monitoring efforts being conducted by other agencies and organizations.
- Nutrient Science Advisory Committee–A committee of six experts was convened to guide the Illinois Environmental Protection Agency (EPA) on the development of numeric nutrient criteria for Illinois streams and rivers based on the best available science. A final report to Illinois EPA was released in early 2019 and was made available for public review and comment. Based on the comments provided by stakeholders, Illinois EPA is currently determining whether the recommendations should be proposed to the Illinois Pollution Control Board to begin the rulemaking process.
- Agriculture Water Quality Partnership Forum–Members representing the agriculture sector continue to meet two to three times per year. Partnerships and collaborations continue to develop. The forum seeks to identify new paths for tracking the adoption of conservation practices and new streams of revenue to offset implementation costs.
- Urban Stormwater Working Group (USWG)–The USWG has added two subcommittees: an education subcommittee and a tracking subcommittee. The Education Subcommittee works to identify outreach materials focusing on nutrient loss reduction that can be easily distributed to stormwater managers throughout the state. The Tracking Subcommittee is identifying options for tracking practices that reduce nutrient loads from urban stormwater.
- Communication Subgroup–The Communications Subgroup was stood up at the beginning of 2018 based on Policy Working Group recommendations. This subgroup had two objectives: (1) develop a presentation that anyone can use to inform the general public about the INLRS, particularly segments of the public that traditionally have not been a part of INLRS discussions; (2) write a letter, signed by directors of the Illinois EPA and Illinois Department of Agriculture, to be sent to members of the Illinois General Assembly and Senate, along with copies of the INLRS and the *2017 Biennial Report*, to build awareness about the program. Both objectives were met by the spring of 2018.

Agriculture Nonpoint Sources Programs and Projects

Besides traditional state and federal cost-share programs, most of the outreach and implementation activities are initiated through partnerships and collaborations within the agriculture industry and related organizations. Many of these are highlighted in the INLRS and the *2017 and 2019 Biennial Reports*. The programs and projects presented below highlight both new and ongoing initiatives.

S.T.A.R. Program

Developed by the Champaign County Soil and Water Conservation District, Saving Tomorrow's Agriculture Resources (S.T.A.R.) is a free tool to assist farm operators and landowners in evaluating their nutrient and soil loss management practices on individual fields. The purpose of S.T.A.R. is to motivate those making cropping decisions to use the BMPs that will ultimately meet the goals of the INLRS. At the end of 2019, 45 counties offered the program through county Soil and Water Conservation Districts and county Farm Bureaus. The goal is to make S.T.A.R. available in every county in Illinois.

Illinois Sustainable Agriculture Partnership

The Illinois Sustainable Agriculture Partnership is a coalition of partners who have come together to promote soil health, cover crops, water quality, nutrient management, and conservation issues to meet the goals of the INLRS. A network of regionally based soil health specialists has been established, as well as training for those working directly with farmers such as the Advance Conservation Drainage Training and Advance Soil Health Training held during 2018 and 2019. Other programs include the S.T.A.R. Program and Illinois Corn Growers Association's Precision Conservation Management.

Nutrient Stewardship Grant Program

Since 2016, the Illinois Farm Bureau Board of Directors has dedicated $100,000 annually to the Nutrient Stewardship Grant Program to empower county farm bureaus to work with local partners to implement the INLRS in a meaningful way in their areas. Projects include education and outreach activities, and on-farm evaluation and installation of both infield and edge-of-field practices. Learn more.

4R4U

In 2016, the Illinois Farm Bureau and GROWMARK announced this initiative to demonstrate and investigate right source, right rate, right time, right place (4R) nutrient stewardship practices at the local level. This statewide collaboration focuses on highlighting on-farm nutrient management practices and data that show how 4R nutrient stewardship optimizes crop yield while reducing environmental impacts. The Illinois Farm Bureau and GROWMARK provide financial and programmatic support for the project; FS Systems member companies (agricultural service providers) and 11 County Farm Bureaus carry out the 4R field demonstrations at the local level.

Nutrient Research & Education Council

The Illinois Nutrient Research & Education Council (NREC) was created by state statute in 2012. Funded by a 75-cent per ton assessment on bulk fertilizer sold in Illinois, NREC provides financial support for nutrient research and education programs to ensure the discovery and adoption of practices that address environmental concerns, optimize nutrient use efficiency, and ensure soil fertility. A 13-member NREC Council annually solicits, reviews, and funds projects that fulfill the organization's mission. Annual assessments tend to generate an average of $3.5 million. To date, 40 projects have been funded for a total of almost $16 million.

National Agriculture Statistics Service Survey 2019

The National Agriculture Statistics Service (NASS) created and distributed a statewide survey to a random sample of 1,900 farmers in the state. The survey gaged farmer knowledge on practices recommended in the INLRS and the level at which these practices were implemented in 2011 (baseline year) and 2015. A summary of the survey results is in the *2017 Biennial Report*. NASS distributed this survey again in early 2019, to gage practices implemented in the 2017 growing season, with the results being summarized in the *2019 Biennial Report*.

Illinois Fertilizer & Chemical Association 4R Survey

The Illinois Fertilizer & Chemical Association (IFCA), which represents the companies in Illinois that manufacture, distribute, and apply commercial fertilizers, is preparing a fertilizer use survey for their agriculture retail members who sell and custom-apply fertilizers. The survey will focus on the 4Rs of nutrient stewardship: right source, right rate, right time, right place. A certified crop advisor (CCA) with the retail company will review and approve each agrichemical facility's responses before submitting results. IFCA aggregated the data to share the results with all nutrient stakeholders in Illinois and this information was included in the INLRS *2019 Biennial Report*.

University of Illinois Extension Watershed Coordinators and Science Team

In 2017, Illinois EPA entered into a five-year agreement with the University of Illinois Extension to hire two watershed coordinators to work in priority watersheds identified in the INLRS. Both watershed coordinators were hired in the spring of 2018. One watershed coordinator works at the Extension office in Effingham and focuses on the Embarras River and Little Wabash River watersheds, addressing phosphorus loss. The other watershed coordinator works at the Extension office in Galva and focuses on the Lower Rock River and Mississippi River (Flint-Henderson) watersheds, addressing nitrate loss. The agreement also provides funding for a Science Team, composed of University of Illinois researchers who work in the College of Agricultural, Consumer, and Environmental Sciences to develop and implement a process for adding new conservation practices to the INLRS and to update conservation practice performances based on new research. That process was established in early 2019.

Point Source Programs and Projects

Illinois currently has 213 major municipal dischargers (facilities with a design average flow (DAF) greater than 1 million gallons per day (MGD)) permitted in the state. Ninety-three percent of the permits require nutrient monitoring. Thirty percent have an effluent limit of 1.0 milligram per liter (mg/L) of total phosphorus and these dischargers represent over 80% of the state's DAF. Facility improvements at some of the major facilities in Illinois have promoted nutrient loss reduction. As part of the NPDES permit renewal process, Illinois EPA requires major dischargers to submit feasibility and optimization studies for reducing total phosphorus levels to 0.1 mg/L and 0.5 mg/L. The number of permits with total phosphorus effluent limits and nutrient monitoring will continue to grow as existing major facility permits are up for renewal.

As stated in the *2019 Biennial Report*, from 2011 to 2018, the statewide point source total phosphorus load was reduced by 4.3 million pounds annually, representing a 24% reduction. Statewide point source total nitrogen loads were reduced by 10%. These calculations were determined using the USEPA nutrient loading tool and direct measurements from individual municipal and industrial wastewater treatment facilities. Illinois EPA intends to use this tool annually to track and report nutrient reductions from point sources.

Starting in the fall of 2018, a new requirement went into effect that requires all major municipal facilities to meet an annual total phosphorus effluent limit of 0.5 mg/L by 2030 if their treatment method is biological phosphorus removal. If a chemical phosphorus removal option is chosen, the facility shall meet an annual phosphorus effluent limit of 0.5 mg/L and a monthly average total phosphorus effluent limit of 1.0 mg/L by the end of 2025. If a biological nutrient removal option is chosen, the facility shall meet an annual total phosphorus effluent limit of 0.5 mg/L by 2035. There are some exceptions to these requirements, such as if the construction of these facilities causes widespread social and economic hardship for the community.

Under these 2018 requirements, a major facility might also be required to develop a Nutrient Assessment Reduction Plan (NARP). A NARP will be required for all major municipal facilities that are upstream of a segment listed as impaired for aquatic algae, aquatic plants (macrophytes), or dissolved oxygen (DO) that has the signature of excess algae (above 100% DO saturation and below the DO water quality standards within a 24-hour period). A NARP will also be required for all major municipal facilities that are causing or contributing to “risk of eutrophication” in the receiving stream. An interim total phosphorus effluent limit of 1.0 mg/L will be included in future permit renewals for facilities discharging upstream of a water body with an impairment due to excess nutrients. The interim 1.0 mg/L effluent limit will remain in effect until the future 0.5 mg/L total phosphorus effluent limit goes into effect as described above or a completed NARP determines that a more stringent total phosphorus effluent limit is required.

Urban Stormwater

The USWG is focusing on two areas: education and tracking.

- Education: USWG members adapted the Calumet Stormwater Collaborative’s resource repository to include additional educational links; the total number of resource links is 182. The Illinois Association for Floodplain and Stormwater Management will house the repository on their website. USWG also made a template for a “Stormwater 101” presentation that local governments can use. Partner education projects include the Illinois-Indiana Sea Grant’s Lawn to Lake Program, which recently collaborated with University of Illinois Extension and received a grant to create outreach materials tailored to two nutrient priority watersheds. Another partner, Parkland College in Champaign, IL, recently became a training center for the Water Environment Federation’s National Green Infrastructure Certification Program. The inaugural class began in January 2019.
- Tracking: USWG’s 2018 meetings included a conference call with the Chesapeake Bay Network’s Tom Schueler to learn how that region addresses tracking. By the end of the year, USWG began discussions on how to select appropriate nutrient reduction efficiency numbers. USWG partner DuPage County has developed a geographic information system (GIS) stormwater basin and BMP inventory system and shared their experience with members. In 2019 the University of Illinois Extension mined information from over 350 Illinois municipal separate storm sewer

system (MS4) annual inspection reports to summarize urban stormwater practices statewide. An additional goal of this project is to use GIS layers to overlay MS4 locations with other existing statewide data such as Illinois State Water Survey rainfall and floodplain maps to find areas of need to which to target outreach efforts.

1.6.3 Indiana

Indiana's State Nutrient Reduction Strategy (SNRS) is the product of an inclusive effort of the Indiana Conservation Partnership (ICP) under the leadership of the Indiana State Department of Agriculture (ISDA) and the Indiana Department of Environmental Management (IDEM). The SNRS aims to capture statewide present and future endeavors in Indiana that positively impact the state's waters, as well as to gauge the progress of conservation, water quality improvement, and soil health practice adoption in Indiana.

The SNRS represents Indiana's commitment to reduce nutrient runoff into waters from point and nonpoint sources alike. The main objectives of Indiana's Strategy are included in the executive summary of the SNRS.

The Indiana SNRS underscores the importance of continual outreach and education to conservation partnerships and the public regarding stewardship of Indiana's waters. The Strategy acknowledges that the great potential to reduce nitrogen and phosphorus entering state waters depends on the cooperation of state, federal, and local organizations' agricultural and urban programs and initiatives, as well as private sector and citizen endeavors. The Strategy identifies measures such as the proper location and types of conservation practices on productive agricultural ground and at the edge-of-field, efficient nutrient management, and managed drainage. In addition, septic system management, appropriate residential fertilizer applications, erosion control at construction sites, and urban BMPs (e.g., green infrastructure) will be key to controlling nutrient runoff. Consequently, there will always be a need for continued conservation, education, outreach, and research efforts to maintain progress.

Key Developments Since Release of the 2016 SNRS

- ISDA developed 10 GIS Story Maps, one for each of the major river and lake basins in Indiana, to help tell the story of conservation and showcase Indiana's efforts to enhance water quality within those basins. These Story Maps make Indiana's SNRS more interactive. Learn more.
- IDEM, as part of the Indiana Water Monitoring Council (InWMC), has been working to improve the ambient water quality monitoring network throughout the state to determine nutrient loads entering and leaving Indiana. In 2017, the InWMC, USGS, and IDEM completed a white paper titled *An Assessment for Optimization of Water-Quality Monitoring in Indiana, 2017*, which was compiled to document existing river and stream water quality networks within Indiana and to identify potential sites of redundancy and gaps in the network of monitoring sites. This assessment contributes to a more in-depth understanding of nutrient sources and loading in the state. An example of an outcome of this white paper is a USGS super gage was installed on the Wabash River in New Harmony, IN, to better capture the nutrient loads in the Wabash River.

- *Indiana's Great Lakes Water Quality Agreement (GLWQA) Domestic Action Plan (DAP) for the Western Lake Erie Basin (WLEB)* to reduce phosphorus to the WLEB was released February 28, 2018. A HUC-12 watershed prioritization process was piloted in the WLEB to target efforts and define next actions within the plan, and this successful process will be used within the other watershed basins in Indiana.
- Members from the ICP, Agriculture Commodity groups, Indiana Farm Bureau, Agribusiness Council of Indiana, and The Nature Conservancy formed a workgroup and worked to develop what was referred to as the "nutrient management and soil health strategy," which complemented Indiana's SNRS and was used as an agricultural industry implementation plan. As a result of this effort, a new initiative and group was created in 2018 called the Indiana Agriculture Nutrient Alliance (IANA). The formation of IANA from the nutrient management and soil health strategy workgroup is an example of a key refinement of adaptively managing our needs. These groups actively work toward the same goal—to reduce nutrient loss and improve water quality. IANA focuses on bridging multi-partner efforts to create practical, cohesive, and significant effects across Indiana.
- In November 2018, ISDA held the Nutrient Reduction Estimation Framework (NREF) Workshop to bring together researchers, experts, and staff to discuss how to strengthen Indiana's current method of nutrient load reduction estimation and tracking, which led to the development of an Indiana Science Assessment. The Indiana Science Assessment Core Team was formed with partners around the state.
- Under Component 1 of the Indiana Science Assessment, a subcommittee of members from USGS, IDEM, ISDA, and TNC was formed to discuss water quality monitoring locations and data that could be used in determining nutrient load trends in Indiana. Analysis was conducted at pour points at the state border and within the major river and lake basins using the USGS WRTDS model. Results of this work and analysis will be available in 2021.
- ISDA received a grant from the EPA through the HTF to work with Purdue University's College of Agriculture and other members of the Science Assessment Core Team to help carry out Component 2 of the Indiana Science Assessment. A research associate was hired to compile, review, and analyze research that will be used to identify or develop a standardized tool for calculating nutrient load reductions; the research will also be used to determine the percent efficiency of certain conservation practices on reducing nitrogen and phosphorus loads.
- The 4R Nutrient Stewardship Certification Program was launched statewide in November 2020. It is a voluntary program for Indiana Agribusiness Council members that encourages agricultural retailers, nutrient service providers, and other independent crop consultants to adopt proven BMPs and use the 4Rs, which refers to using the Right Source of nutrients at the Right Rate at the Right Time in the Right Place. It was launched with five companies in the state that went through a pilot audit process.

Nonpoint Sources

Nutrient Load Reduction Tracking

The ICP is using EPA's Region 5 Nutrient Load Reduction model, which estimates sediment, nitrogen, and phosphorus load reductions from individual BMPs on the ground, to determine the impact of assisted conservation efforts statewide. Each year, Indiana collects conservation practice data such as type of practice, practice locations, measurements, and other necessary parameters from ICP partners for all federal, state, and local programs, including federal Farm Bill practices, state-level conservation projects (e.g., those funded by Conservation Reserve Enhancement Program (CREP), Clean Water Indiana, the Lake and River Enhancement program, and CWA section 319), and local conservation efforts by SWCDs. Through the process of data collection, we can see the impact of the number of conservation practices that are implemented annually. The collected data are then run through the Region 5 model to analyze the sediment, nitrogen, and phosphorus load reductions for specific practices. While this model is project-specific, it provides a valuable perspective on a larger scale when showing the collective reductions of practices across several programs. The accountability/verification and annual reporting on implementation are current expectations among the ICP partners and are regularly being refined and improved. The ICP uses the end products of this process to help establish baselines, measure load reduction trends by watershed for each calendar year, and serve as a tangible component of the Indiana SNRS.

Load reductions estimated by the model for Indiana each year are published in annual accomplishments reports, including watershed maps showing the nitrogen, phosphorus, and sediment reductions. These annual reports can be found on ISDA's Indiana SNRS web page. The estimates, paired with monitoring by state and federal partner agencies, as well as continued assessment of Indiana's CWA 303(d) list of impaired waters, will inform watershed prioritization and conservation resource management for the ICP's efforts and Indiana's SNRS.

Strengthening and Improving Our Method

The Region 5 model is used to determine nitrogen and phosphorus load reductions that are tied directly to sediment. Nutrients that are dissolved and carried by runoff waters are not accounted for in the model; as a result, we are missing dissolved nitrate and phosphorus. Also, there are several conservation practices that cannot be run through the model because the practice is not tied to sediment (e.g., nutrient management). The ICP would like to strengthen and improve how nutrient load reductions are accounted for so that we can account for more accurate estimates of reductions and better assess the progress being made on improving water quality.

The effort to strengthen the method to account for nutrient reductions is supported through Component 2 of the Indiana Science Assessment. Monitoring conducted around the Midwest and in Indiana provides new understanding of the effectiveness of in-field and edge-of-field conservation practices in reducing nitrogen and phosphorus loads from agricultural fields. This research will be compiled, reviewed, and used to improve the method that Indiana uses to calculate reductions in sediment, nitrogen, and phosphorus loads. Indiana will identify or develop a standardized tool and procedure for calculating nutrient load reductions from conservation practices, which can help determine the percent efficiency of certain conservation practices load reduction.

Targeted Implementation Efforts

Conservation Reserve Enhancement Program

One of the initiatives that is part of Indiana's SNRS is CREP. It is a voluntary federal and state conservation program that aims to improve water quality and address wildlife issues by reducing erosion, sedimentation, and excess nutrients and enhancing wildlife habitats within specified watersheds in the Wabash River system.

CREP in Indiana was first announced in 2005 across three HUC-8 watersheds in the state and was expanded in 2010 to include 11 HUC-8 watersheds in Indiana, covering a total of 65 Indiana counties. Indiana's CREP enrollment goal is 26,250 acres and, according to the state's tracking system, as of December 2020, over 20,019 acres had been enrolled in the program and over 919 linear miles of

waterways have been protected. The ISDA and its partners have invested over $8.8 million in state funds to implement these conservation practices and, for every state dollar that is invested, $4–$13 federal dollars are matched through CRP incentives available through the USDA FSA. In 2018, The Nature Conservancy committed more than $300,000 over the next five years in support of expanding the Indiana CREP program. In 2020, the Indiana Wildlife Federation and the American Electric Power company provided $500,000 to support implementation of conservation practices through the Indiana CREP.

INfield Advantage Program

INfield Advantage (INFA) provides farmers who participate access to tools to collect and analyze on-farm, field-specific data. Peer-to-peer group discussions, local aggregated results, and collected data allow participants to make more informed decisions and implement personalized BMPs. INFA offers growers the chance to participate in multiple projects depending on their own specific concerns. Many growers will enroll fields in more than one study. Current projects include nutrient management for either corn or beans; the impact of cover crops, both late-season seeding and in-season interseeding; and manure management. Participating farmers use precision agricultural tools and technologies to conduct research on their own farms such as aerial imagery and the corn stalk nitrate test to determine nitrogen use efficiency in each field that they enroll. The program began in Indiana in 2010 and, in 2018, the impact had grown to include over 1,000 fields in more than 60 counties.

Point Sources

NPDES Measures

To reduce significantly the discharge of nutrients to surface waters of the state and to protect downstream water uses, IDEM set a practical state treatment standard of 1.0 mg/L total phosphorus for sanitary wastewater dischargers with design flows of 1 MGD or greater. This policy became effective January 1, 2015.

Applying the 1 mg/L total phosphorus limit will amount to a nearly 45–50% reduction of total phosphorus loads from major sanitary dischargers over the next few permit cycles.

Additionally, IDEM will implement Total Maximum Daily Load (TMDL) load reductions as written and approved for total phosphorus upon the renewal of any affected permit and will continue to implement phosphorus removal as required by Title 327 Indiana Administrative Code (IAC) Article 5-Rule 10-Section 2.

For nitrogen, effective January 1, 2019, IDEM requires all major sanitary permits with an average design flow rating of 1.0 MGD or greater to monitor for total nitrogen. It requires total nitrogen be reported and sampled at a minimum of one time monthly for both effluent mass (loading) and concentration via 24-hour composite sampling.

For all major sanitary dischargers, Total Nitrogen shall be determined by testing Total Kjeldahl Nitrogen (TKN) and Nitrate + Nitrite and reporting the sum of the TKN and Nitrate + Nitrite results (reported as N). Nitrate + Nitrite can be analyzed together or separately. Monitoring for Total Nitrogen is required in the effluent only.

The data collected will be used to garner a better understanding of nitrogen loadings in Indiana waters and aid the State of Indiana with future updates of its nutrient reduction efforts.

1.6.4 Iowa

The Iowa Nutrient Reduction Strategy (NRS or Strategy) is a research- and technology-based approach to assess and reduce excess nutrients delivered to Iowa waterways and the Gulf. The Strategy outlines opportunities for efforts to reduce excess nutrients in surface water from both point sources such as municipal wastewater treatment plants and industrial facilities and nonpoint sources, including agricultural operations and urban areas, in a scientific, reasonable, and cost-effective manner.

The NRS and the *Annual Progress Report* are a collaboration of representatives of the Iowa State University College of Agriculture and Life Sciences, Iowa Department of Natural Resources (DNR), and Iowa Department of Agriculture and Land Stewardship (IDALS). The Water Resources Coordinating Council, a body of governmental agencies that coordinate around water-related issues in Iowa, is presented with the *Annual Progress Report* each year.

The NRS documents, including each year's *Annual Progress Report*, can be accessed on Iowa State University's Iowa Nutrient Reduction Strategy web page.

Updated Baseline Assessment

In 2017, researchers at ISU and Iowa DNR conducted parallel studies to quantify Iowa's average annual nutrient load during the 1980–1996 period summarizing the results detailed in the two studies: *Assessment of the Estimated Non-Point Source Nitrogen and Phosphorus Loading from Agricultural Sources from Iowa During the 1980-96 HTF Baseline Period*, and *Nitrogen and Phosphorus Load Estimates from Iowa Point Sources During the 1980-96 HTF Baseline Period* (see Table 1-1). Both studies are available on the Strategy Documents web page for ISU's Iowa Nutrient Reduction Strategy. A brief summary of the studies' methods and results is also available on the same web page.

Table 1-1. Baseline (1980–1996) and Benchmark (2006–2010) Average Annual Loads from Nonpoint and Point Sources

		1980-96 Baseline Load (tons)	2006-10 Benchmark Load (tons)	Change, 1980-96 to 2006-10	
Nitrogen	NPS	278,852[a]	293,395	5.2%	Increase
	PS	13,170	14,054	6.7%	Increase
	Total	**292,022**	**307,449**	**5.3%**	**Increase**
Phosphorus	NPS	21,436	16,800	21.6%	Decrease
	PS	2,386	2,623	9.9%	Increase
	Total	**23,822**	**19,423**	**18.5%**	**Decrease**

Notes: PS = point sources; NPS = nonpoint sources.

[a] The method used to derive the total nitrogen estimate of 292,022 tons indirectly reflected the point source contributions.

BMP Mapping

A statewide effort to identify and map six types of conservation practices (ponds, grassed waterways, terraces, water and sediment control basins, contour buffer strips/prairie strips, and contour strip cropping) has been completed and provides a comprehensive inventory of conservation practices in the state by watershed.

The initial number of practices identified by the mapping project include the following:

- 114,400 pond dams
- 327,900 acres of grassed waterways
- 506,100 terraces stretching 88,874 miles
- 246,100 water and sediment control basins stretching 12,555 miles
- 557,700 acres of contour buffer strips
- 109,800 acres of strip cropping

This mapping effort shows the scale and investment made by farmers, landowners, state and federal agencies, conservation partners, and many others over several decades to reduce erosion and protect our natural resources. While the practices identified are focused on reducing soil erosion and phosphorus loss, seeing the progress that has been made illustrates how we can make similar progress with a long-term focus and investment in proven conservation practices targeted at reducing nitrogen loss.

Maps and additional information about the project can be found on the Iowa BMP Mapping Project page.

Recent Highlights

Recent NRS highlights can be accessed on the Strategy Documents web page for ISU's Iowa NRS.

Recent Funding or Program Announcements

In 2018, the Iowa Legislature passed and Governor Kim Reynolds signed into law new legislation that will provide more than $270 million for water quality efforts in Iowa over the next 12 years. This long-term funding source will provide significant additional resources for water quality programs in the state.

IDALS and the USDA Risk Management Agency are continuing the partnership project aimed at expanded usage of cover crops in conjunction with federal crop insurance. The program provides an additional premium discount for acres in cover crops not already covered by current state or federal programs. More information can be found on the IDALS's Crop Insurance Discount Program web page.

Current Challenge: The Capacity for Acceleration

The capacity for accelerating the availability of these financial inputs remains a distinct challenge. New, dedicated long-term funding approved in 2018 will help. Stability and predictability of funding sources coupled with increased funding can assist the acceleration of NRS implementation. In the long term, grant and annual funding, which accounted for 55% of reported funding, may be most appropriate for trials of innovative new approaches and studies, but are difficult to rely upon for long-term management programs that maintain ongoing NRS progress.

The Conservation Infrastructure (CI) Initiative was started with this challenge in mind. A broad cross-section of leaders within and outside of the agriculture industry came together to help identify barriers and opportunities associated with advancing the Iowa NRS. Since announcing the initiative in August 2016, more than 100 representatives from the public and private sectors have been engaged in defining and developing the initiative. This includes rural and urban organizations; agricultural associations; conservation and environmental groups; agribusinesses; food companies; engineering firms; farmers; academic institutions; and federal, state, and local governments.

Water Monitoring

Monitoring of nitrogen and phosphorus in streams and rivers throughout Iowa is an essential element of the Iowa NRS. Water monitoring has provided the basis for the NRS Science Assessment of the performance of various practices on their ability to reduce excess nutrients. Monitoring also provides information related to nutrient loading and important data for assessing critical locations and/or watersheds in which to focus efforts.

In August 2016, Iowa completed a report titled *Stream Water-Quality Monitoring Conducted in Support of the Iowa Nutrient Reduction Strategy*. The report improves understanding of the multiple nutrient monitoring efforts with available data and can be compared to a nutrient water quality monitoring framework to identify opportunities and potential data gaps to better coordinate and prioritize future nutrient monitoring efforts. The report can be found on the Strategy Documents web page for ISU's Iowa NRS.

In 2013, the NRS intended to define the process for providing a regular nutrient load estimate based on Iowa's fixed-station stream water quality monitoring network. A technical workgroup was tasked with determining the most appropriate estimation method by assessing the quality of existing data that was to be used to evaluate methods, creating a process for making future adjustments based on the latest information and advancements in science and technology, and considering resource efficiency. The outcome of this investigation, titled "Variability of nitrate-nitrogen load estimation results will make quantifying load reduction strategies difficult in Iowa," was published in 2017 (Schilling et al. 2017). The annual load estimates are displayed along with streamflow, as streamflow amounts have the largest known impact on nutrient loading.

Source Water Protection

In February 2018, EPA contractors completed SWP plans with a focus on reducing nutrient and sediment discharges into the lakes used by the cities of Winterset and Spirit Lake, IA. These plans have been approved by the Iowa DNR as Phase 2 SWP plans. The plans identified resources that the communities could engage as implementation and coordinating partners. The plans, using the ACPF model and Iowa State University BMP mapping project, targeted BMPs that can be funded and deployed on the landscape. Both plans received USDA NRCS NWQI funds for implementation and two additional SWP plans for surface water drinking water sources are under development in the state. As a result of the SWP plan, the Winterset area was able to employ a watershed coordinator to help implement projects identified in the SWP plan for Cedar Lake.

In addition to proactively addressing drinking water quality through a voluntary plan, the SWP plans (1) focus on nutrient loading from the contributing drainage area, (2) work to implement the phosphorus and nitrogen goals of the Iowa Nutrient Reduction Strategy, and (3) complement the implementation of existing planning efforts, such as TMDLs.

Nutrient Trading: Recent Innovative Approaches

The Iowa League of Cities was awarded a USDA NRCS Conservation Innovation Grant in October 2015 to develop a water quality credit trading (WQCT) framework as a means to advance the goals of the NRS and beyond. This work has led to the development of a pre-regulatory compliance strategy titled the Nutrient Reduction Exchange (NRE) that could serve as a tracking system and would allow nutrient sources across the state to register and track nutrient reductions resulting from installed BMPs that target NRS goals. In addition to nutrient reduction, the NRE acts as a registry to track additional benefits that drive watershed investment such as flood mitigation and development of SWP plans. It is anticipated that this effort will accelerate the development of partnerships between cities and the agricultural community to further reduce nonpoint source nutrient loads in a variety of ways. Currently four communities (Ames, Cedar Rapids, Dubuque, and Storm Lake) have entered into a Memorandum of Understanding (MOU) with the Iowa DNR and three communities (Des Moines, Ames, and Cedar Rapids) have registered practices resulting from watershed investments into the NRE.

Iowa Nutrient Research Center

The Iowa Nutrient Research Center (INRC) was established in 2013 to help manage nonpoint source nitrogen and phosphorus pollution. The INRC was established by the Iowa Board of Regents in response to legislation passed by the Iowa Legislature. The INRC pursues science-based approaches to nutrient cycling that include evaluating the performance of current and emerging nutrient management practices and providing recommendations on implementing existing practices and developing new practices.

Since 2013, the INRC has awarded more than 76 grants among Iowa's three Regent Schools (University of Iowa, University of Northern Iowa, and Iowa State University). The awards total slightly over $8.7 million, with approximately 67% of the funds going toward nitrogen and phosphorus research, and approximately 33% going to water quality monitoring projects overseen by IIHR–Hydroscience and Engineering at the University of Iowa.

Addition of New Practices in the NRS

As research on nonpoint source conservation practices is conducted, new insights are developed regarding the effectiveness of practices in reducing nitrogen and phosphorus loss. This data can be submitted to the NRS Science Team to review the effectiveness of conservation practices in the same manner in which the original NRS Science Assessment was conducted.

In the 2016 reporting period, saturated buffers were approved as an NRS practice. In the 2017 reporting period, blind tile inlets were approved. Multi-purpose oxbows were added to the practice list in 2019.

1.6.5 Kentucky

Kentucky continues to work with stakeholders to refine and implement the state's Nutrient Reduction Strategy (Strategy). The Kentucky Energy and Environment Cabinet's Division of Water (DOW) is working to update the existing state Strategy, which can be accessed on the Kentucky Nutrient Reduction Strategy web page. The Strategy was developed with input from stakeholders representing a broad perspective of interests: agriculture, industry, environmental advocacy, municipalities, conservation organizations, and federal and state partners. The Strategy encompasses reduction from both point and nonpoint sources, as well as a variety of regulatory and cooperative approaches.

DOW's 2021 Strategy Update focuses on reducing nutrient loads from wastewater point sources, and improving implementation of the Kentucky Agriculture Water Quality Act (AWQA) with the help of an EPA HTF grant. To guide the trajectory of the Strategy Update, DOW conducted a study in 2019 of average nutrient loads and yields in Kentucky watersheds using DOW's Ambient Monitoring Network data. In 2021, DOW updated this Loads and Yields Study to include 2018–2019 DOW water quality data and expanded analyses (see Figure 1-1 and Figure 1-2). The 2021 and 2019 studies are available on DOW's web page and through an interactive dashboard.

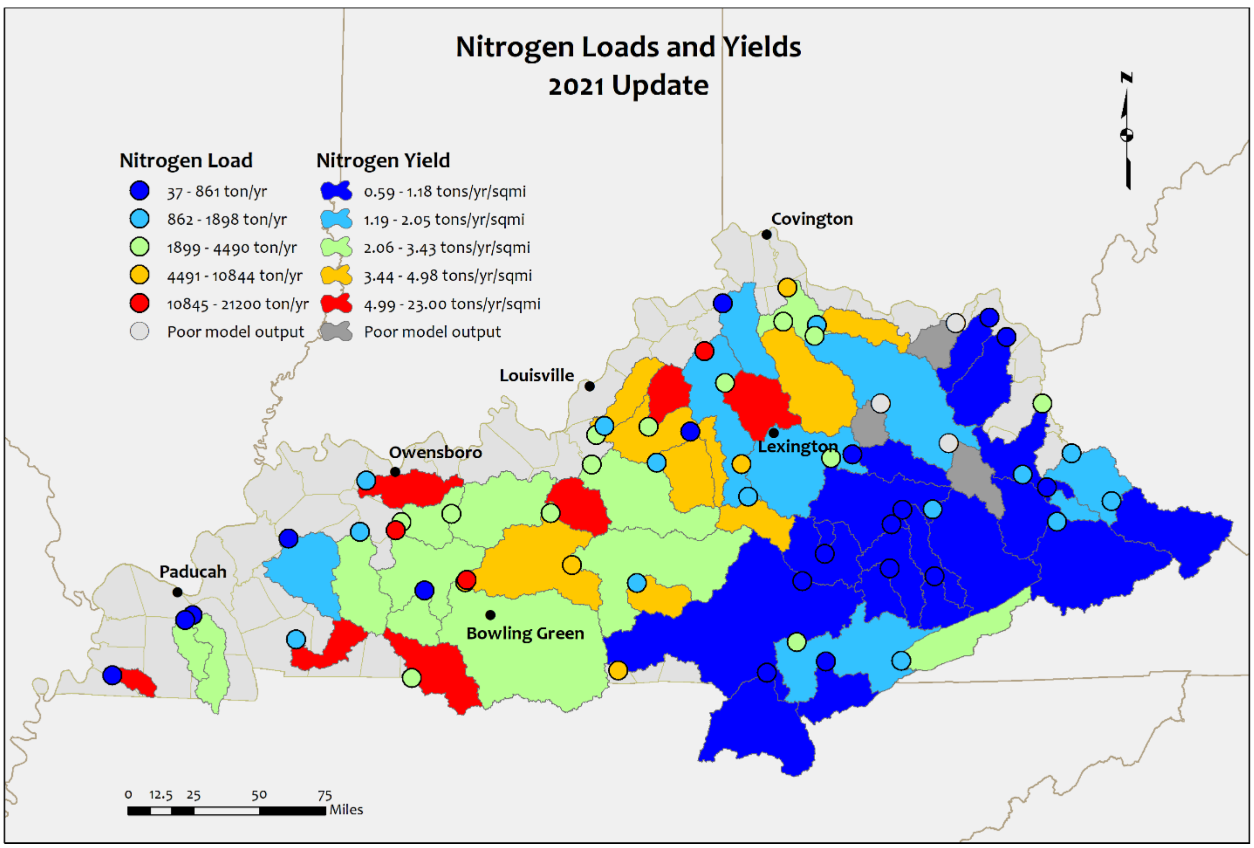

Figure 1-1. DOW monitored nitrogen loads and yields in 2005–2019.

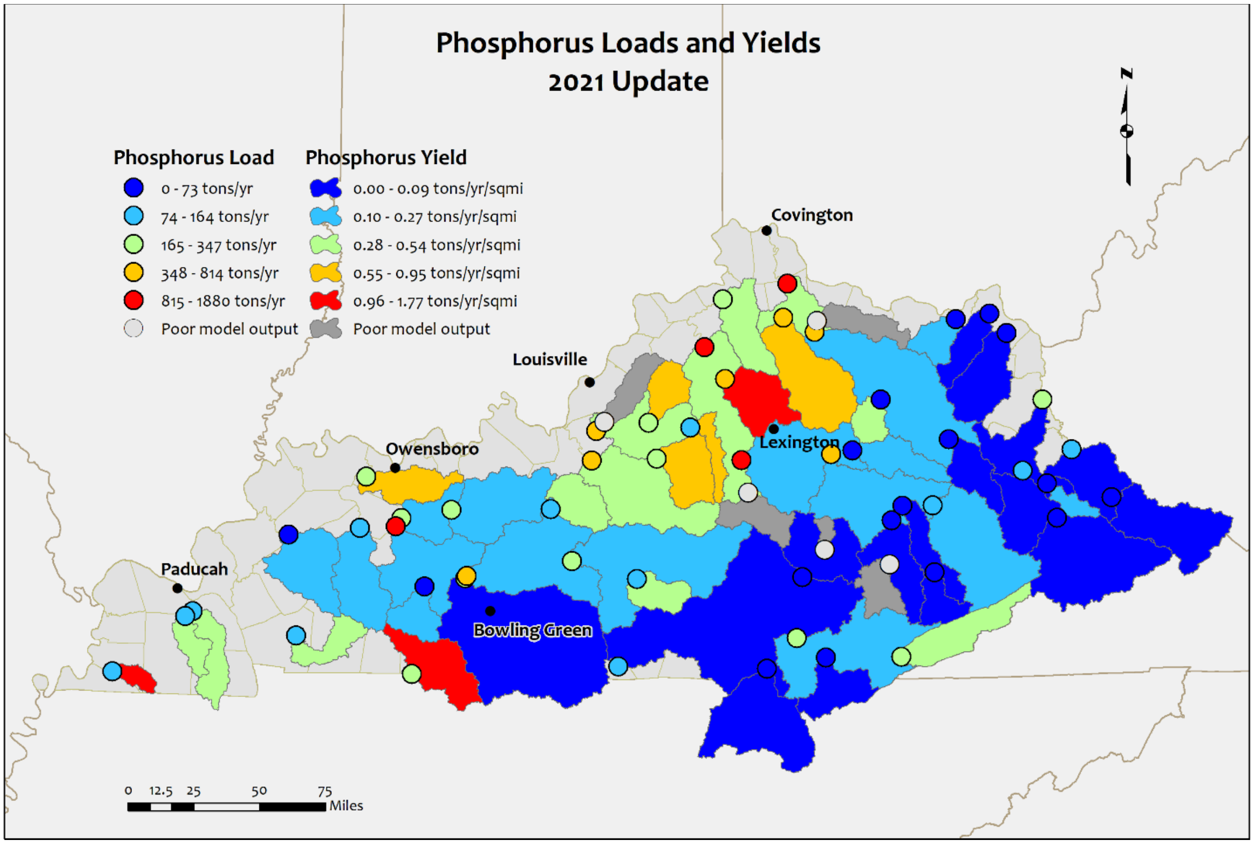

Figure 1-2. DOW monitored phosphorus loads and yields in 2005–2019

Point Sources

DOW continues to work to address nutrient loads in wastewater effluent by identifying new technologies and ways to optimize facilities for enhanced nutrient removal. In 2015, DOW assembled a team of universities, associations, and state and federal agencies to conduct nutrient and energy efficiency management audits for Kentucky wastewater facilities. This Wastewater Treatment Plant (WWTP) Optimization Program Team leveraged an EPA grant initiative to provide these audits at no cost to participating facilities. The WWTP Optimization Program Team members include representatives from:

- Division of Water
- Division of Compliance Assistance
- Division of Enforcement
- Office of Energy Policy
- Kentucky Infrastructure Authority
- Kentucky-Tennessee Water Environment Association
- Kentucky Rural Water Association
- University of Kentucky Industrial Assessment Center
- University of Memphis
- EPA Region 4

This Optimization Program provides free nutrient and energy audits and provides recommendations for facility optimization of nutrient treatment methods to reduce nutrients and costs. Each year from 2016 through 2018, three new facilities participated in the program. Facilities that implemented recommendations or portions of recommendations all saw a decrease in their energy demand costs, with some wastewater facilities seeing results with a cost saving of ~30% a month on their utility bills. The December 2019 edition of Streamlines magazine highlighted optimization success at three Kentucky facilities. After a year of implementing optimization, the Lawrenceburg WWTP reduced total nitrogen discharge by 63% (18,600 lbs/yr) and total phosphorus by 39% (1,000 lbs/yr), and the WWTP realized a 16% cost savings in reduced energy demand. Additionally, the Princeton WWTP and Greenville WWTP reduced total nitrogen in effluent by 55% (30,000 lbs/yr) and 33% (12,700 lbs/yr), respectively. The optimization team continues working with facilities to track nutrient reduction through the program.

Additionally, DOW convenes a Wastewater Advisory Council (WWAC), which provides a forum for the wastewater community to discuss infrastructure funding, regulatory impacts, and other issues. This collaborative stakeholder group is comprised of public utility representatives providing wastewater treatment services to Kentucky's citizens. This WWAC forum also provides DOW an opportunity to discuss permit changes, such as DOW's decision to require all municipal and sanitary sewer permittees to monitor and report nitrogen and phosphorus concentrations from influent (source) and effluent (finish) waters. As a result, regulatory decisions are more data-driven and transparent with the regulated community.

HABs Monitoring and Reporting

DOW continues to work with partner agencies to monitor and issue advisories of HABs and to develop protocols and thresholds for HAB-related public advisories. DOW regularly convenes a HAB Workgroup with partners from state and federal agencies, including the Kentucky Department for Public Health, Kentucky Department of Parks, Kentucky Department of Fish and Wildlife, USGS, and USACE to coordinate response, resources, and advisories to algal blooms across the state. DOW developed a "HAB Viewer" that allows users to quickly identify locations of HAB advisories and sample results from reported HABs. DOW provides guidance and technical assistance to public water systems that are experiencing HABs in source waters or who rely on HAB-susceptible source waters.

To improve detection of algal blooms, DOW uses remote sensing techniques to help assess waters for HABs and to alert the agency of developing HABs. DOW and partners conduct regular water quality sampling and screening where HABs have been identified or suspected. DOW partnered with Watershed Watch in Kentucky (a nonprofit organization of citizen scientists that conducts water quality monitoring as education and outreach to communities) to develop a volunteer lake monitoring program to assess water quality in lakes and reservoirs. Volunteers collect field data and observations coincident with satellite data, which allows for field verification and model calibration. The Kentucky Water Watch Volunteer Lake Sampling Results map viewer can be accessed via the Kentucky Geological Survey web page.

Nutrient Criteria Development

In 2013, Kentucky's narrative nutrient criteria were updated to better represent expectations for water quality to protect designated uses. Most significantly, this update strengthened the definition of eutrophication to identify specific indicators of nutrient over-enrichment such as large diurnal oxygen swings, algal blooms, and displacement of diverse aquatic communities with species known to be tolerant of nutrient enrichment. Applying these new criteria results in more robust designated use assessments and improved metrics to restore and protect Kentucky waters.

Kentucky's work towards development of numeric nutrient criteria is ongoing. This work includes compilation and cleanup of historical data, performing preliminary analyses, assessing data and knowledge gaps, and conducting focused studies to address these gaps. In addition, most routine monitoring programs in the state have added or expanded nutrient data collection as part of their program design. While the level of progress toward numeric criteria varies among water body classes (e.g., streams, rivers, lakes), there have been common challenges in defining precise protective nutrient levels. One of these challenges is that existing historical data have often not well characterized the effects (i.e., response indicators) across Kentucky's diverse regions and water body types. Additional data collection and studies that better target response indicators have been a focus in recent years.

Nonpoint Sources

Kentucky's Nonpoint Source Pollution Control Program coordinates efforts to minimize nutrient loss at a statewide level through multiple partnerships with federal, state, and local organizations. DOW coordinates closely with the state NRCS on NWQI watersheds, including the 2021 planning phase for the Rockhouse Creek, Wades Creek-Clarks River, and Almo-Clarks River watersheds. DOW also has a long-term collaborative relationship with the state Division of Conservation (DOC) to align common program objectives and work together on state soil and water cost-share practice implementation. All CWA section 319 watershed-planning projects, as well as any associated state soil and water cost-share projects, generate estimated load reductions for excess nutrients on an annual basis. DOW estimates that the CWA section 319-funded projects cumulatively reduced loads by 325 tons/year of nitrogen and 59 tons/year of phosphorus from fiscal years 2017 to 2020. The Nonpoint Source Annual Report, which discusses implementation of the Kentucky Nonpoint Source Management Plan, is on Kentucky's Nonpoint Source Pollution web page.

DOW also developed a (water quality) Success Program, working with partners to track and monitor projects where nutrient reductions are anticipated. The state NRCS office and the DOC regularly provide DOW with reports on water quality management practices implemented at the HUC-12 scale, which are critical to tracking water quality improvements. Through the state Agriculture Water Quality Authority (AWQA), Kentucky updated the State Water Quality Plan in December 2020. DOW is working with DOC and the AWQA to roll out an electronic tool to assist farmers with plan development. This tool incorporates updates to the State Water Quality Plan and includes BMP visuals to streamline conservation planning.

Recent legislation created the Kentucky Water Resources Board to address agricultural and rural water quantity issues. This group works to develop and fund programs that help address agricultural water sustainability issues of concern. Members of this board are currently working with the Governor's Office of Agricultural Policy and DOW to implement an On-Farm Water Resiliency Program. This program promotes water resilience on farms by funding projects that develop innovative water management best practices and helping producers implement the practices on their farms.

1.6.6 Louisiana

The collaborative of Louisiana's Coastal Protection and Restoration Authority (CPRA), Department of Agriculture and Forestry (LDAF), Department of Environmental Quality (LDEQ), Department of Natural Resources, USDA NRCS Louisiana, and Louisiana State University Agricultural Center (LSU AgCenter) released an updated Louisiana Nutrient Reduction and Management Strategy in 2019 (the Strategy). The Strategy provides a framework of strategic components with underlying actions that guide implementation of nutrient reduction and management across the state to protect, improve, and restore water quality in Louisiana's inland and coastal waters. Implementation of the Strategy has focused on six key areas: (1) river diversions, (2) nonpoint source management, (3) point source management, (4) incentives, (5) leveraging opportunities, and (6) new science-based technologies/applications.

Nutrient Management Strategy Implementation

The interagency collaborative that developed the Louisiana Nutrient Reduction and Management Strategy team continues to jointly implement and monitor the progress of the Strategy in Louisiana. In addition to EPA, other collaborative partners include: U.S. Business Council for Sustainable Development, Louisiana Water Synergy Group, LDAF Soil and Water Conservation, Barataria-Terrebonne National Estuary Program, and the Lake Pontchartrain Basin Foundation (among others). The Louisiana Nutrient Reduction and Management Strategy Interagency Team compiles annual reports which document the nutrient reduction and management implementation activities in the state. The Strategy annual reports can be accessed on Louisiana's Nutrient Reduction and Management Strategy web page.

Nutrient Monitoring

LDEQ routinely monitors surface waters for nitrogen and phosphorus in their Ambient Water Quality Monitoring Program. Regarding water permitting, LDEQ's goals are to incorporate nutrient monitoring into all individual sanitary permits and landfills, industrial permits that are a source of excess nutrients, and general permits for which nutrient monitoring is required by a TMDL. Nutrient monitoring has been included in 1,166 facility permits to date (637 general permits and 529 individual permits). This information is based on permits that are coded into EPA's Integrated Compliance Information System (ICIS).

Alternatives to TMDLs/New Vision for 303(d) Program

EPA's 2013 *A Long-Term Vision for Assessment, Restoration, and Protection under the Clean Water Act Section 303(d) Program* is a collaborative framework and vision that enhances the overall efficiency of the CWA 303(d) listing and TMDL program, encourages focusing attention on priority waters, and acknowledges that states have flexibility in using available tools to attain water quality restoration and protection. Under this vision, LDEQ began implementation of alternative restoration strategies for monitoring and reduction of nutrient loads in Yellow Water River (subsegment 040504). LDEQ also began planning alternative restoration strategies to address excess nutrients in Natalbany River (subsegment 040503).

Water Quality Credit Trading

Louisiana developed a Louisiana Water Quality Credit Trading (WQCT) program to address excess nutrients and other appropriate parameters. LDEQ made available a draft guidance document in December 2017, held six stakeholder meetings in 2018, and proposed and finalized rulemaking in 2019.

Nonpoint Source

Currently through the Nonpoint Source Management Program, LDEQ is working in collaboration with the state's agricultural partners at LDAF to refine techniques for calculating load reduction in implementation project areas. The goal of this collaborative effort is to compare estimated load reductions from implementation with loads calculated at sampling sites in priority watersheds through monitoring during the duration of implementation and one year following completion of implementation projects.

Statewide agricultural programs institutionalize nonpoint source goals and objectives into all of the state's agencies' programs. For example, LDEQ and USDA have coordinated their watershed programs and used water quality data to identify water bodies that are eligible for implementation of federal cost-share programs. EQIP, the Wetlands Reserve Program (WRP), CREP, and CRP have been implemented in watersheds identified as impaired by agricultural nonpoint sources in the state's integrated report. Most recently, USDA and LDEQ partnered on USDA's MRBI to target practices that reduce excess nutrients such as nitrogen and phosphorus entering the Gulf. MRBI allowed states that border the Mississippi River to implement these types of nonpoint source controls that could be expanded to adjacent watersheds to reduce the size of hypoxia in the Gulf.

Louisiana's state Nonpoint Source Management Program is consistent with the federal CWA section 319 program. Federal agencies participate in the Nonpoint Source Interagency Committee to coordinate their programs to meet CWA water quality goals. Two examples of this federal/state partnership are NRCS and U.S. Forest Service. Both of these agencies have partnered with LDEQ on coordination of projects to reduce the concentration and/or loading of sediment, excess nutrients, and other pollutants associated with agricultural and forestry activities, respectively.

Federal and state agricultural agencies in Louisiana have taken leadership roles in addressing agricultural nonpoint source pollution. Through Farm Bill programs that USDA administers each year, thousands of acres of BMPs have been implemented across the state to reduce the amount of sediment and excess nutrients entering the state's water bodies. LDEQ participates in the USDA State Technical Advisory Committee (STAC) to ensure water quality improvements continue to be a top priority for USDA's Farm Bill Conservation Programs. Through USDA's ranking criteria, which have been provided to local stakeholders and field offices, water quality and habitat protection remain key factors in selecting which lands are included in Farm Bill programs. Members of the STAC are provided an opportunity to vote on the list of resource concerns addressed by Farm Bill Conservation Programs in the same manner as members of local stakeholder groups. This process keeps water quality priorities at the top of the list of issues that need to be addressed through Farm Bill programs. Each of the following statewide programs has a nutrient management component: Agricultural Statewide Program, Forestry Statewide Program, Urban Runoff Statewide Program, Hydromodification Statewide Education Program, and Coastal Nonpoint Pollution Control Program.

Source Water Protection

Louisiana DEQ's SWP Program (SWPP) staff assist Louisiana's communities in protecting aquifers and surface waters (e.g., rivers, lakes) that are sources of drinking water. The staff also works on environmental water quality issues that might arise related to drinking water sources. In addition, Louisiana SWPP staff assist Louisiana Nonpoint Source staff in watershed areas where watershed implementation plans are completed as part of the watershed coordination team effort.

Numerous areas of Louisiana have experienced rapid growth and development; therefore, emphasis has been placed on working with parishes to establish a drinking water protection ordinance that protects their source water from nonpoint source pollutants. SWPP has collaborated with the Nonpoint Source Management Program to educate the public on the importance of preventing nonpoint source pollution and maintaining On Site Disposal Systems.

Coastal Protection and Restoration

CPRA continues to work with universities, federal agencies (USACE, USGS, and NOAA), nongovernmental organizations, and private industry to improve the science surrounding river diversions and nutrient assimilation. In 2017 to 2019, CPRA scientists worked collaboratively with leading academics to review, document, and synthesize diversion effects on receiving basin open water bodies and wetlands. A special issue of the journal *Estuarine, Coastal and Shelf Science* contains peer-reviewed synthesis papers developed by this effort. The goal of this special issue is to summarize the relevant state of the science with respect to predicting the response of deltaic plain emergent wetlands and estuarine open water bodies to freshwater and sediment diversions and siphons.

Louisiana's Comprehensive Master Plan for a Sustainable Coast (2017) (the Master Plan) includes the construction of additional river diversions with the intent to deliver high sediment loads and river water into more areas of deltaic wetlands. Sediment diversion projects will result in the flow of Mississippi and Atchafalaya river nutrients, freshwater, and sediment to bays, marshes, and estuaries. Intercepting excess nutrients via river diversions by filtering them through coastal basins before they exit the mouth of the Mississippi River might ultimately reduce the concentrations of nutrients that reach the Gulf. To assess potential changes in water quality dynamics and spatial and temporal patterns in nutrient transformation, one of the subroutines of the Master Plan model focuses on nitrogen uptake to evaluate the potential fate of nitrogen in different types of wetlands and open water bodies. Removal for different future scenarios is calculated, including future with and without project conditions for the ability to compare nitrogen uptake under various scenarios. Higher resolution project-specific numeric water quality models (e.g., for the Barataria, Breton, and Maurepas diversions) have also been further refined.

To determine baseline conditions, support the development and calibration/validation of models, and increase understanding of how Louisiana's coastal basins might respond to the influx of nutrients from a future Mississippi River diversion, CPRA is also designing and implementing the System-Wide Assessment and Monitoring Program (SWAMP). The development of SWAMP ensures that relevant water quality data are collected both prior to and following the construction and operation of new river diversion projects. As part of SWAMP implementation in Barataria Basin, CPRA initiated water quality data collection in 2015 by adding 23 discrete monitoring stations (measuring nitrogen, phosphorus, turbidity, DO, and chlorophyll) and upgrading four existing real-time USGS data collection platforms to include chlorophyll, turbidity, and DO. CPRA also worked with USGS to install three additional real-time monitoring stations within Barataria Basin to improve the availability of spatial and temporal water quality data. In 2017–2018, CPRA installed an additional 37 discrete water quality data collection stations east of the Mississippi River in the Breton and Pontchartrain basins.

1.6.7 Minnesota

During 2017–2019, Minnesota made many strategy implementation advancements, several of which are highlighted below. During 2019–2020, Minnesota worked to develop a comprehensive five-year Minnesota Nutrient Reduction Strategy (NRS) progress report. The complete accounting of activities and outcomes for the 2014–2018 period are available in the progress report. The Minnesota NRS and the five-year progress report can be found on Minnesota's NRS web page. Initial reporting on strategy implementation is found in the 2017 Report to Congress.

Activities Advanced during 2017–2018

- **Tracking BMP Adoption**–Minnesota established a new system and web tool to track government-assisted BMP adoption. Access the watershed-level tracking tool and the state-level tracking tool.
- **State Assistance for BMP Implementation**–Over the 2018–2019 biennium, Minnesota's 25-year Clean Water Legacy funding provided approximately $53 million per year for nonpoint source implementation and $9 million per year for point source implementation. A considerable portion of this money is directed toward nutrient-reduction practices and efforts. More information can be found in the 2020 Clean Water Fund Performance Report (MCWFT 2018).
- **Minnesota Agricultural Water Quality Certification**–Minnesota has continued its certification program that provides regulatory certainty and prioritized cost-share for farms certified to meet BMP standards for water quality protection. Private industry (e.g., Land O'Lakes SUSTAIN and others) has partnered with agencies to promote and use this program. Recent progress (May 2021) shows that 1,058 producers are certified, representing 756,990 acres; 2,131new practices; and over 49,000 pounds (lbs) of phosphorus loss prevented. Access more information here.
- **Mandatory Riparian Buffer Initiative**–50-foot perennially vegetated buffers on all public waters in Minnesota are now over 99% compliant with the 2015 buffer law; 17-foot buffers on all public ditches are over 90% compliant. Learn more about the initiative.
- **Groundwater Protection Rule to Address Groundwater Nitrate from Fertilizer**–The Minnesota Department of Agriculture adopted a groundwater protection rule in 2019 that outlines how an initial voluntary approach can become regulatory in high-nitrate drinking water supply management areas where fertilizer BMPs are not adopted or groundwater nitrate levels increase. The new rule also restricts nitrogen fertilizer applications in the fall and on frozen soils in both vulnerable groundwater areas and drinking water supply management areas with elevated nitrate.
- **Water Quality Standards**–Eutrophication standards for lakes (2008) and rivers (2015) have been a major driver affecting wastewater facility phosphorus effluent limits. Phosphorus effluent limit reviews have been completed for half of the watersheds throughout Minnesota. Total phosphorus effluent limits have been set for 370 wastewater facilities, which represent over 90% of the waste stream. Learn more about the eutrophication standards. Minnesota currently requires wastewater nitrogen monitoring at 477 wastewater facilities, representing 94% of the domestic effluent flow. Recent scientific studies on aquatic-life toxicity impacts from nitrate are currently under review as Minnesota evaluates potential water quality nitrate standards.

- **Watershed Strategies and Planning**–Minnesota uses watershed monitoring, modeling, and other assessments to develop problem-solving strategies for local and downstream waters. Water quality conditions have been intensively monitored in all 80 watersheds, and restoration/protection strategies (WRAPS) have been developed for more than 65 of the 80 watersheds, with the others currently under development. The technical reports and strategies are being used by partnerships of local governments to develop prioritized, targeted, and measurable implementation plans within the watersheds (known as One Watershed, One Plan). More information is available about Minnesota watersheds.
- **Nitrogen Smart Program**–As part of a new educational program called "Nitrogen Smart," 36 nitrogen fertilizer management educational events were conducted around Minnesota between 2016 and 2018. The events reached over 500 farmers and over 100 agronomists. When farmers were surveyed several months after the events, 75% indicated that they intended to make a change in the way they manage nitrogen during the next growing season. Estimated nitrogen fertilizer reductions from these changes exceed 2 million lbs per year. More information is available about the Nitrogen Smart Program.
- **Improving Continuous Living Cover Options**–The Forever Green Initiative brings together researchers from multiple departments at the University of Minnesota, including Plant Breeding, Agronomy, Food Science, and Economics. The university has made considerable progress in developing new high-value commodity crops for conservation purposes. Many of these new crops fit into a corn and soybean rotation, thereby providing ground cover between fall harvest and spring emergence. Learn more about the initiative.
- **Discovery Farms**–The farmer-led Discovery Farms effort to gather field-scale water quality information has increased the number of its core farms to 11 farms across different parts of Minnesota. The goal is to provide practical, credible, site-specific information to enable better farm management.
- **CREP**–The Minnesota CREP easement program began in 2017 with a goal of creating 60,000 acres of buffers, restored wetlands, and protected wellheads for drinking water. Farmers and agricultural landowners can voluntarily enroll land in the program, which is funded with $350 million from USDA and $150 million from the State of Minnesota.
- **Soil Health Initiative**–In 2018, the University of Minnesota in collaboration with the Board of Water and Soil Resources initiated a Minnesota Office of Soil Health and hired a soil health specialist. The Soil Health office will work to build local soil health and conservation expertise (with agricultural and conservation professionals), create regionalized economic data related to practices that improve soil health, and build and expand partnerships.
- **Point-Nonpoint Trading**–Point-nonpoint trading policies and guidance have advanced in Minnesota during the past two years, and new trading opportunities are being considered in several parts of the state.
- **Source Water Protection Program (SWPP)**–In 2017, the Minnesota Legislature appropriated funds to the Minnesota Department of Health (MDH) to develop a surface water SWPP to protect public water supply systems that rely on surface water for their source of drinking water. Approximately 25% of Minnesotans get their drinking water from surface water from 23 community public water suppliers.

- **CWA Section 319 Nonpoint Source Pollution Program**–The federal CWA section 319 pollution program was recently restructured in Minnesota to provide 16 years of stable local resources for small watersheds. The program focuses on relatively small watersheds to make it more manageable to get the detailed assessment needed for goal setting, source identification, critical area identification, implementation targeting, and performance evaluation monitoring. The first 10 watersheds were selected in 2018; by 2020, 30 watersheds were selected.
- **25 by 2025 Governor's Initiative**–In 2017, Minnesota's Governor Mark Dayton hosted a series of town hall meetings to promote 25% improvements in Minnesota's water quality by 2025. The meetings were attended by more than 2,000 people who discussed excess nutrients and other water pollution issues. Attendees provided over 3,500 suggestions on how to improve Minnesota's water quality by 2025.

Outcomes

- **Point Source Nutrient Reductions**–Between 2005 and 2017, wastewater point source phosphorus discharges were reduced 72 percent in areas ultimately draining to the Mississippi River and 9 percent in areas draining to Lake Winnipeg (see Figure 1-5). More information is available at the wastewater phosphorus loads interactive map and the 2020 pollution report to the legislature.
- **River Monitoring Trends**–A 37% phosphorus load (flow-adjusted) decrease was found over the period 1999–2018 in the Mississippi River just upstream of Lake Pepin. River phosphorus concentration trends have shown decreases during the past two decades at 21 of 28 river sites throughout Minnesota, and only one of 21 sites showed an increase. River nitrate and total nitrogen concentrations have been increasing at half of the sites assessed for 20-year trends, and only three of 28 sites showed decreasing nitrate trends. Additional water quality monitoring results are available.

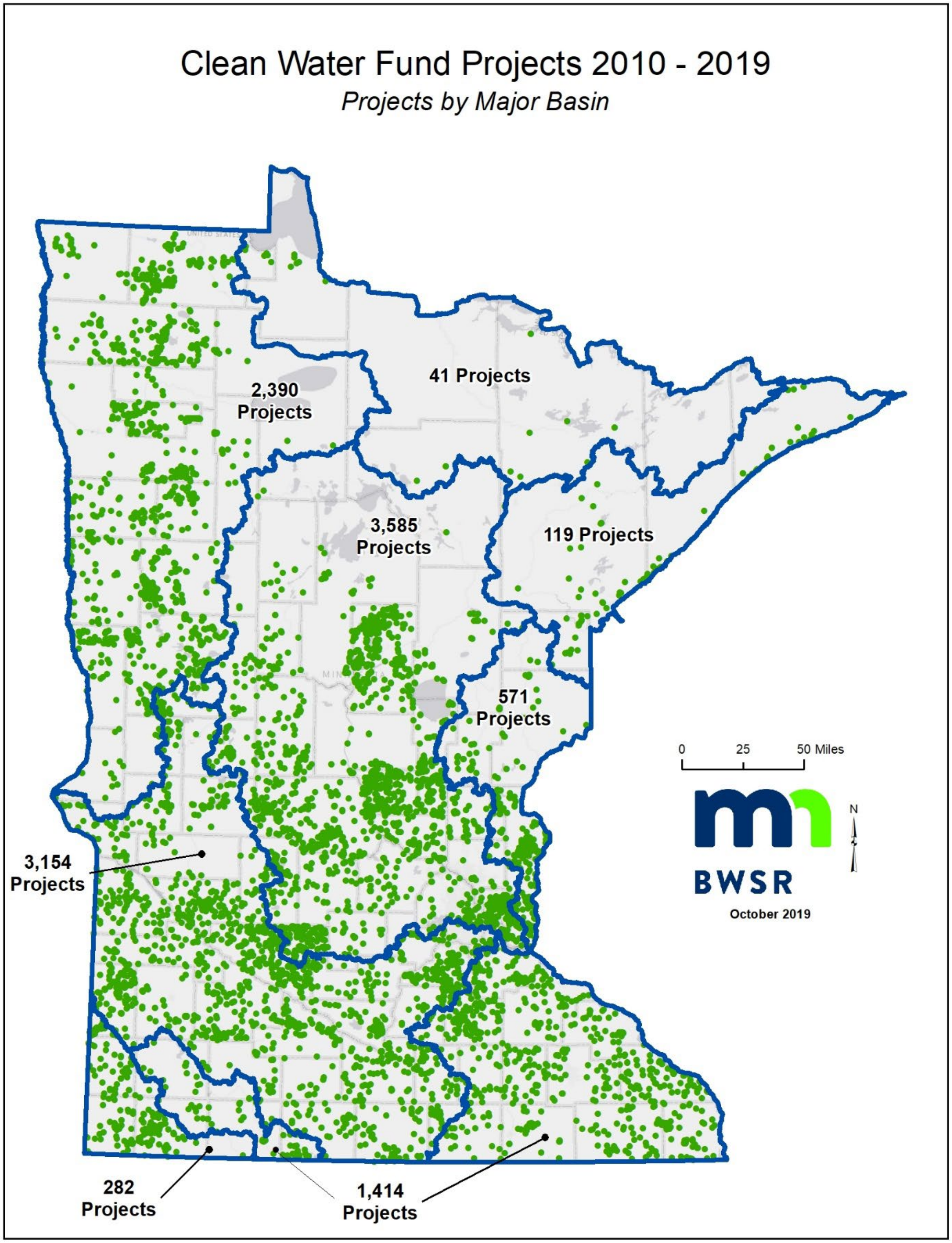

Figure 1-3. State assistance for BMP implementation (MCWFT 2020).

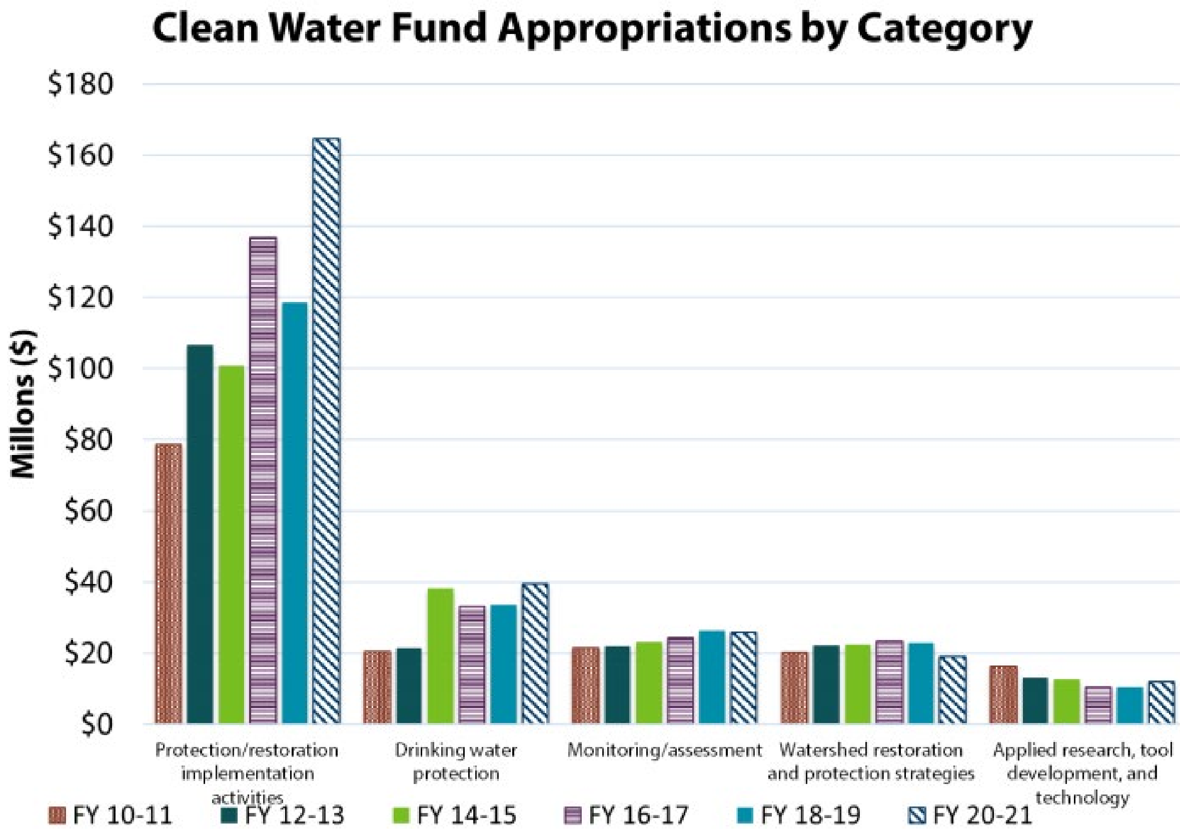

Figure 1-4. State assistance for BMP implementation (MCWFT 2020).

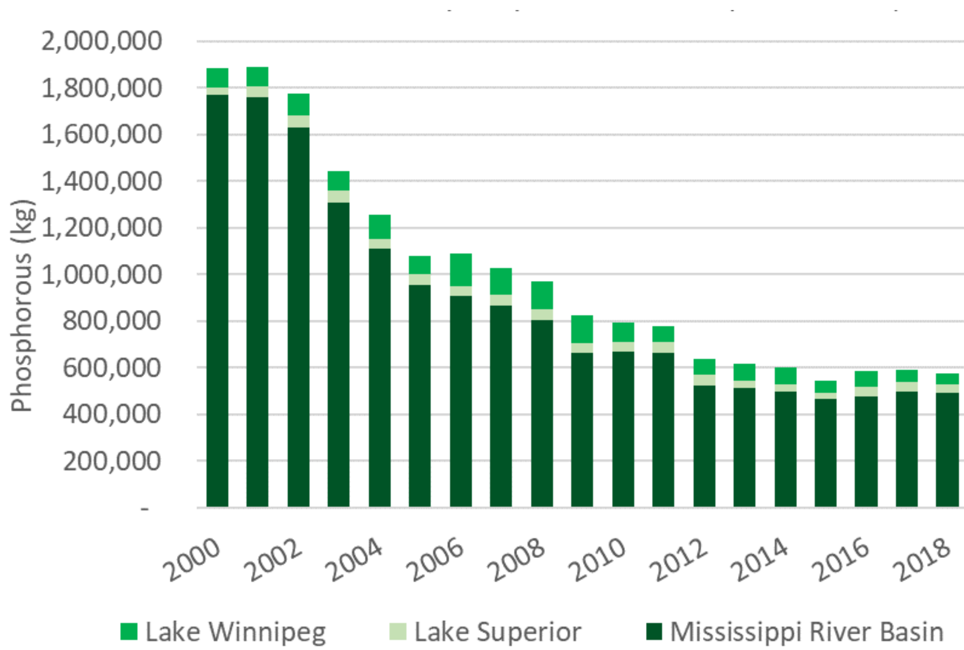

Figure 1-5. Minnesota wastewater phosphorus discharge trend from 2000 to 2018 (MCWFT 2020).

1.6.8 Mississippi

Nutrient Reduction Strategies

Mississippi developed both a statewide strategy and a regionally specific strategy to address nutrient concerns on state lands and in state waters. These strategies focus on land-use practices and characteristics that are unique to each region of the state: the Mississippi Delta (Alluvial Plain), upland areas, and coastal areas of the state. As individual watershed projects are developed, the Nutrient Reduction Strategies are used to guide the development and implementation of watershed restoration and protection plans to ensure all plans include activities necessary to mitigate nutrient contributions to state waters and the Gulf.

Mississippi Department of Environmental Quality (MDEQ), working with resource partners, has implemented at least one nutrient reduction pilot project in each of the regions defined in the Nutrient Reduction Strategies. As part of the process, a project-specific monitoring plan was developed for each pilot project area. Working with the USGS and others, MDEQ has been collecting physical, chemical, biological, and meteorological data in the project areas. Also, the monitoring design included sampling to represent both storm and routine stream flows. To ensure consistency, the monitoring strategy outlined in the Nutrient Reduction Strategies was used to guide the process.

The focus of Mississippi's Nutrient Reduction Strategies, developed in conjunction with stakeholder input and recommendations, is to work toward answering the following questions:

- What levels of nutrient reduction are achievable?
- What will they cost?
- What is the value to each stakeholder from these nutrient reductions?
- What levels of nutrient reduction will protect state water bodies and benefit the Gulf?

Working with partners, producers, and researchers, MDEQ is making progress toward answering those questions in the strategies. Taking a data-driven approach, the agency and partners have been collecting water quality data in watersheds in which nutrient reduction practices have been implemented following the monitoring approaches outlined in the strategies. These data, collected pre- and post-implementation and representing varying flow regimes, will be used to determine the nutrient load reductions achieved by the practices. Once load reductions are calculated, progress can be made on determining the costs and values associated with nutrient reduction practices.

Nutrient Monitoring

MDEQ collects water samples at 37 bridge sites within the state each year under the Fixed Station Monitoring Program as part of status and trends monitoring. The network of statewide ambient, primary fixed stations provides systematic water quality sampling at regular intervals and for uniform parametric coverage to monitor water quality status and trends over a long-term period. These locations are sampled monthly for routine water chemistry, including nutrient parameters, and quarterly for metals.

For wadeable streams, Mississippi uses a calibrated index of biotic integrity to assess the health of benthic macroinvertebrate communities in streams outside of the Mississippi Alluvial Plain. As part of this monitoring program, MDEQ collects biological community data along with habitat metrics and water quality on approximately 100 streams annually.

Annually, MDEQ collects samples from 20 publicly accessible lakes larger than 100 acres in size Depending on the size of the lake/reservoir, one to five monitoring locations are sampled during a sampling event. Lakes are monitored for traditional physical, chemical, and biological water quality parameters during the summer index period (May–November). Lakes/reservoirs are sampled on a rotating cycle until all water bodies larger than 100 acres have been monitored.

As part of the Mississippi Coastal Assessment Program, MDEQ annually collects samples at 25 randomly selected sites along with 12 static sites. Coastal assessment monitoring is conducted during the late summer index period (July–September). Sample sites are selected using a probabilistic site selection methodology. At the end of the five-year reporting period, MDEQ will have monitoring data from a total of 125 sites that can be used to assess water quality in the coastal and estuarine waters in the state.

Water Quality Standards

MDEQ's goal is to develop scientifically defensible numeric nutrient water quality criteria that are appropriate and protective of Mississippi's surface waters. Numeric nutrient criteria development efforts continue for each of Mississippi's various water body types: lakes/reservoirs, rivers/streams, coastal waters, and waters of the Mississippi Alluvial Plain. The criteria developed for each water body type will be coordinated with the water quality criteria for other water body types to ensure consistency across the state and protection from downstream impacts.

Highlights of MDEQ's numeric nutrient criteria development efforts:

- While MDEQ continues criteria development efforts across all water body types, the overall plan is to move forward in a sequenced approach, addressing the water body types in the following order: (1) Mississippi lakes and reservoirs, (2) Mississippi coastal and estuarine waters, (3) wadeable streams, and (4) delta waters (all surface waters within the Mississippi Alluvial Plain.

Criteria for Mississippi's large, nonwadeable rivers will be developed through site-specific evaluations. Timing of criteria development for large, nonwadeable rivers will be based on prioritization and available agency resources.

- MDEQ is committed to following a defensible, scientifically driven process for deriving protective criteria. Mississippi's Nutrient Technical Advisory Group is made up of technical experts representing various state agencies, federal agencies, and academia. This group provides technical expertise and regional knowledge to inform and support the criteria development process.
- MDEQ is applying a multiple-line-of-evidence approach to the development of numeric nutrient water quality criteria across all water body types. This weight-of-evidence approach uses various criteria development methods that are considered collectively to produce criteria with greater scientific validity. MDEQ is evaluating potential criteria through four methods: (1) reference approach, (2) stressor-response approach, (3) mechanistic modeling, and (4) scientific literature.
- Significant progress has been made to develop numeric nutrient water quality criteria for Mississippi lakes and reservoirs (outside the Mississippi Alluvial Plain). In order to translate Mississippi's narrative criteria into numeric values, MDEQ selected the endpoints of chlorophyll *a* and DO concentrations for analyses. A range of numeric nutrient criteria for total nitrogen and total phosphorus concentrations have been developed to be protective of these endpoints. EPA is currently working to develop updated recommendations regarding numeric nutrient criteria for lakes. MDEQ will review and incorporate the new information into our criteria development work as we finalize numeric nutrient criteria for lakes and reservoirs.
- Endpoints for evaluation have also been selected for other water body types. At this time, total nitrogen and total phosphorus concentrations are being evaluated in Mississippi coastal and estuarine waters based on chlorophyll a and DO endpoints. For Mississippi wadeable streams, in addition to DO, the Mississippi Benthic Index of Stream Quality (M-BISQ) is providing an additional endpoint for criteria development through a measure of the instream biological health using benthic macroinvertebrate communities.
- MDEQ continues to strive for a transparent, well-documented process related to nutrient water quality criteria development. Stakeholders are updated regarding the status of nutrient criteria development through numerous efforts, including active participation in Mississippi's Basin Team meetings across the state, presentations at water resource conferences (e.g., Mississippi Water Resources Research Institute, Mississippi Manufacturer's Association, Mississippi Water and Environment Association). In addition, MDEQ has held multiple Numeric Nutrient Criteria Update Sessions since June 2012. These sessions include technical updates to the group as well as time set aside for answering any questions stakeholder might have regarding the topic. Information has also been shared through MDEQ's web page and the monthly MDEQ External Newsletter. These efforts promote and encourage open communication between MDEQ staff and our stakeholders.
- MDEQ continues to develop the plan for implementing numeric nutrient water quality criteria. In addition to developing the numeric nutrient criteria themselves, MDEQ also focuses efforts on exploring concerns and questions raised by both MDEQ staff and stakeholders. MDEQ will continue to work concurrently on both criteria development and implementation planning.
- MDEQ continues to collect data, conduct studies, and develop water quality models to support nutrient criteria development across the state.

Nonpoint Source

The state's strategy for the management and abatement of nonpoint source pollution relies on statewide and targeted watershed approaches. These approaches are implemented through both regulatory and nonregulatory programs on the federal, state, and local levels. The implementation of program activities or categories that are not regulated rely primarily on the voluntary cooperation of stakeholders and are supported financially through federal assistance programs such as CWA section 319 and available state resources. The strategy for addressing nonpoint source pollution on a statewide level includes education/outreach, monitoring and assessment, watershed planning activities, BMP demonstrations, BMP compliance, technology transfer, consensus building, and partnering. Implementation of the nonpoint source Program is done in cooperation with numerous agencies, organizations, and groups at all levels of government and in the private sector. Priority is given to activities that promote consensus building and resource leveraging opportunities to increase the overall effectiveness of Mississippi's Nonpoint Source Program.

The Nonpoint Source Management Program implements strategies that target priority watersheds throughout the state. Prioritization of these watersheds is an evolving process identified in coordination with resource agency partners as part of the Basinwide Approach to Water Quality Management. Mississippi's collaborative and leveraged approach to reducing excess nutrients and their impacts focuses on the development and implementation of appropriate nutrient reduction strategies. The target audience for the strategic planning and implementation includes local agencies and organizations with a mission of environmental and water quality restoration and protection, and local, state, and federal agencies with the authority to develop and implement nutrient reduction plans and practices. CWA section 319 funding has been used increasingly to support nutrient reductions in large watersheds. The strategy behind this approach is to use the committed CWA section 319 resources to attract additional leveraging opportunities that together create a greater potential to achieve quantifiable reductions in nutrient concentrations/loadings.

Point Sources

Through the NPDES Permitting Program, Mississippi has been implementing nutrient monitoring and/or limits for total nitrogen and/or total phosphorus based on the following criteria:

- Effluent monitoring of total nitrogen and total phosphorus for all municipal NPDES permitted facilities with discharge rates greater than 1.0 MGD.
- Influent monitoring of total nitrogen and total phosphorus for all municipal NPDES permitted facilities with discharge rates greater than 1.0 MGD.
- Effluent limits for total nitrogen and/or total phosphorus for NPDES permitted facilities that discharge into receiving waters that have nutrient TMDLs.

In addition, as part of the MS4 process, Mississippi is requiring entities to incorporate nutrient reduction strategies into stormwater management plans. Figure 1-6 and Figure 1-7 are maps showing permitted facilities with nutrient (total nitrogen and/or total phosphorus) monitoring and those with nutrient permit limits. Note: Data used to generate maps came from June 2019 ICIS data retrieval.

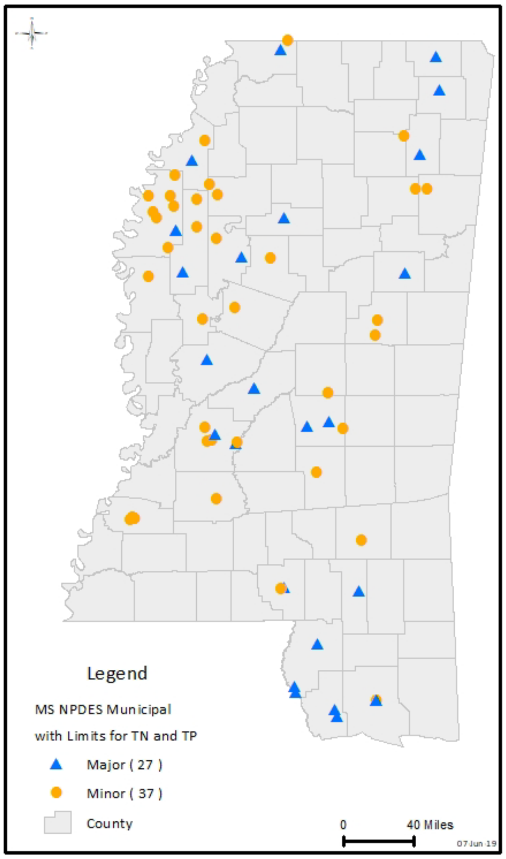

Figure 1-6. Permitted facilities with nutrient limits.

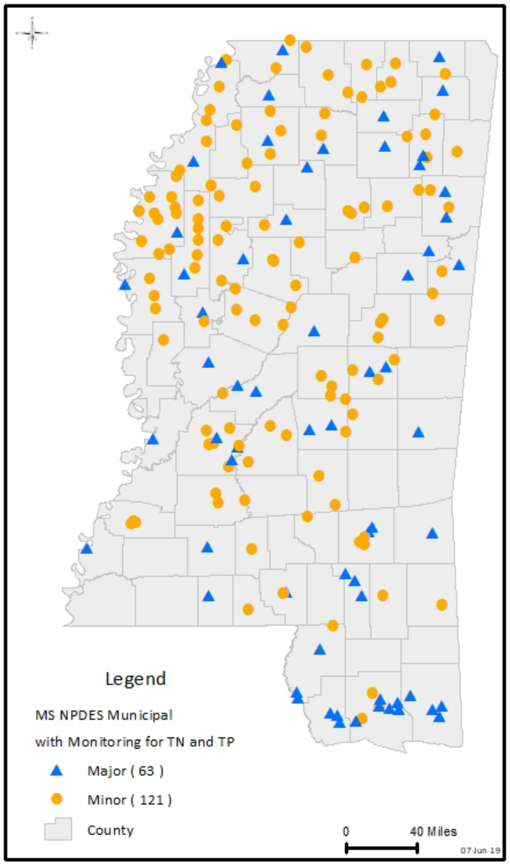

Figure 1-7. Facilities with nutrient monitoring (June 2019 ICIS data retrieval).

TMDLs and Modeling

Mississippi has 191 water bodies with TMDLs for total nitrogen and/or total phosphorus statewide. Whenever a discharger is located in a watershed with an applicable nutrient TMDL, the facility, at a minimum, is required to monitor their discharge for nutrients. Based on the TMDL loading requirements, those facilities might also be required to have nutrient limits. Additionally, as intensive water quality models are developed for state waters for which data of sufficient quality and quantity exist and the models are calibrated and verified; model outputs are used to provide nutrient limits for new or expanding dischargers. Figure 1-8 is a map showing the total nitrogen and/or total phosphorus TMDLs statewide.

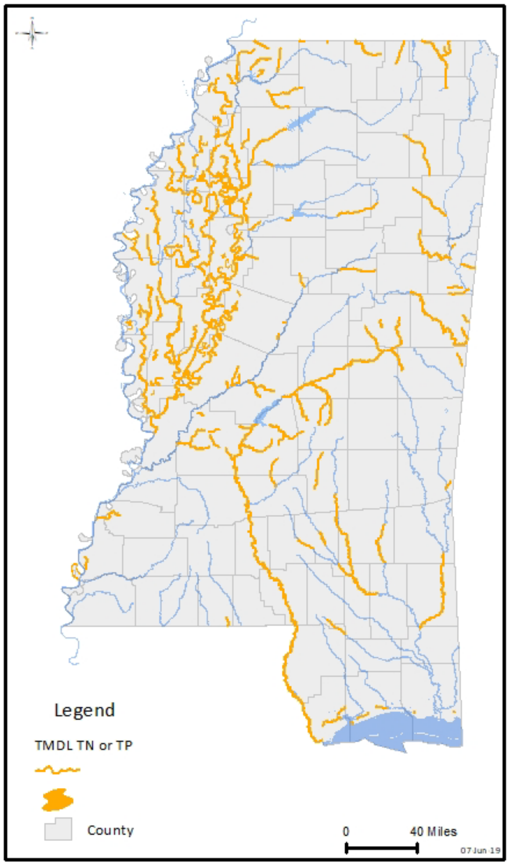

Figure 1-8. TMDLs for TN or TP.

1.6.9 Missouri

The Missouri Nutrient Loss Reduction Strategy was developed over a 3-year period from 2011 through 2014 using a CWA section 104(b)(3) grant and funding from existing state, federal, local, and private resources. A committee composed of representatives from state agricultural, environmental, and natural resource organizations was formed to develop recommendations for reducing nutrient loads to surface water and groundwater in Missouri through an open, consensus-building process. An internal workgroup consisting of staff from the Missouri Department of Natural Resources (Department) Water Protection and Soil and Water Conservation programs meets quarterly to discuss the progress being made toward the goals of Missouri's Strategy. There are many recommended actions listed in the Strategy, making prioritization important to focusing Department resources. Meetings are being held in an effort to identify areas in which coordination would be beneficial. The workgroup will produce biennial reports to communicate progress to the public. The first report was published in 2018.

Parks, Soils and Water Sales Tax

In Missouri, the Parks, Soils and Water Sales Tax is a statewide one-tenth of 1% sales tax that provides funding for Missouri state parks and historic sites as well as soil and water conservation efforts. Due to the efforts of the Missouri Soil and Water Conservation Program, Missouri has saved more than 179 million tons of soil over the past 30 years.

In FY 2018, the Soil and Water Conservation Program processed 8,147 contracts for installing agricultural BMPs for a total of $40 million (100% of appropriation). That is the largest percentage of the Parks, Soils and Water Sales Tax used to fund BMPs since the tax was implemented in 1984.

During the drought in the summer of 2018, the efforts of the Soil and Water Conservation Program substantially improved in implementing cover crops on the landscape.

Monitoring Efforts

The Department is working toward advancing understanding of Missouri's nutrient contributions through data collection and analysis.

Agricultural Water Quality Monitoring Program

The Department has committed $1 million from CWA section 319 grant funding to monitoring efforts in partnership with the USDA RCPP. This funding provides support where monitoring is not an eligible cost under the USDA RCPP.

The Department has a cooperative agreement with the Missouri Corn Merchandising Council in partnership with the Missouri Soybean Merchandising Council to form a collaborative monitoring partnership that will conduct farm-scale edge-of-field agricultural runoff monitoring of nutrients and sediment to study effectiveness, demonstrate benefits of agricultural conservation practices, and support water quality efforts aimed at meeting state soil and water stewardship goals.

Figure 1-9. Monitoring station in grassed waterway.

Edge-of-field water quality monitoring of relevant BMPs provides power through data, analysis, and communication of critical information that supports historical, current, and future recommendations and guidance of water quality improvement strategies. BMPs that address nutrient and sediment loss reduction strategies include vegetative filter strips, grassed waterways, constructed wetlands, terraces, tillage, grazing, crop rotations, manure management, field borders, subsurface tile, riparian buffer strips, cover crops, and, in some cases, combinations of those practices. Data from this monitoring program will also be analyzed to inform numerical simulation(s) such as the APEX model to support BMP recommendations as well as to document expected reduction/water quality improvement of existing BMPs. Figure 1-9 shows an example of a monitoring station in a grassed waterway.

These BMPs have been implemented in a wide array of circumstances for the purpose of conserving soil and water integrity and improving the sustainability of production agricultural methods. In an attempt to understand the extent to which these practices have an impact, Missouri's Department of Natural Resources selected approximately seven Missouri farms representing typical row crop farming practices for implementation of an edge-of-field monitoring study. As part of this study, a field approach will be used (as represented in Figure 1-10), comparing two similar fields/plots at each of the seven locations: the study containing an identified BMP and the control employing conventional methods. Aside from the differences resulting from BMP implementation, all other factors pertaining to the fields/plots will be as close to identical as possible.

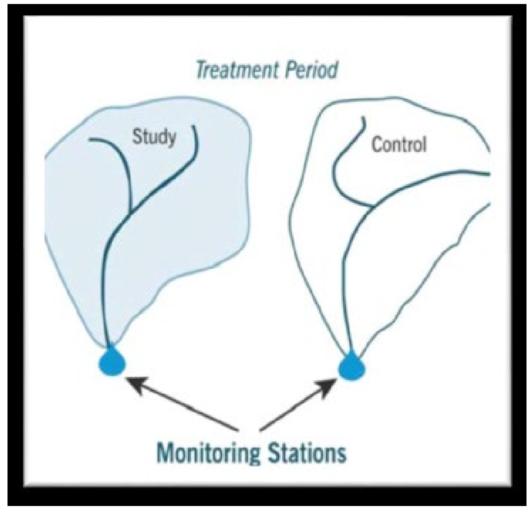

Figure 1-10. Study design comparing BMP to control site employing conventional methods.

The RCPP promotes partnerships among environmental and agricultural stakeholders in Missouri. Partners in this monitoring project include the Department, Missouri Soybean Merchandising Council, Missouri Corn Merchandising Council, USDA, University of Missouri, and Waterborne Environmental.

Point Source Monitoring

An increasing number of Missouri's point sources will be required to sample and report nutrient discharges. Missouri's effluent regulation was revised in 2014 to require facilities with a design flow greater than 100,000 gallons per day to monitor discharges for total phosphorus and total nitrogen quarterly. These monitoring requirements are being incorporated into permits as they are renewed. Recently, further nutrient monitoring requirements for point sources in the state's effluent regulation were approved by the Missouri Clean Water Commission. These revisions went into effect in February 2019 and expand the monitoring requirements in the following ways:

- Facilities with a design flow greater than 1 MGD are required to monitor monthly instead of quarterly.
- Instead of reporting total nitrogen, facilities are to report nitrogen's constituents as total Kjeldahl nitrogen (TKN), nitrate plus nitrite, and ammonia.
- Facilities are to monitor influent for a period of time, in addition to effluent.

Surface Water Monitoring

In addition to collecting data from point source dischargers, the Department collects surface water data from multiple sources statewide. Along with nutrient data collected by the Department's Monitoring and Assessment Unit (sites highlighted in Figure 1-11), the University of Missouri's Statewide Lake Assessment and Lakes of Missouri Volunteer programs sample and provide lake nutrient data to the Department.

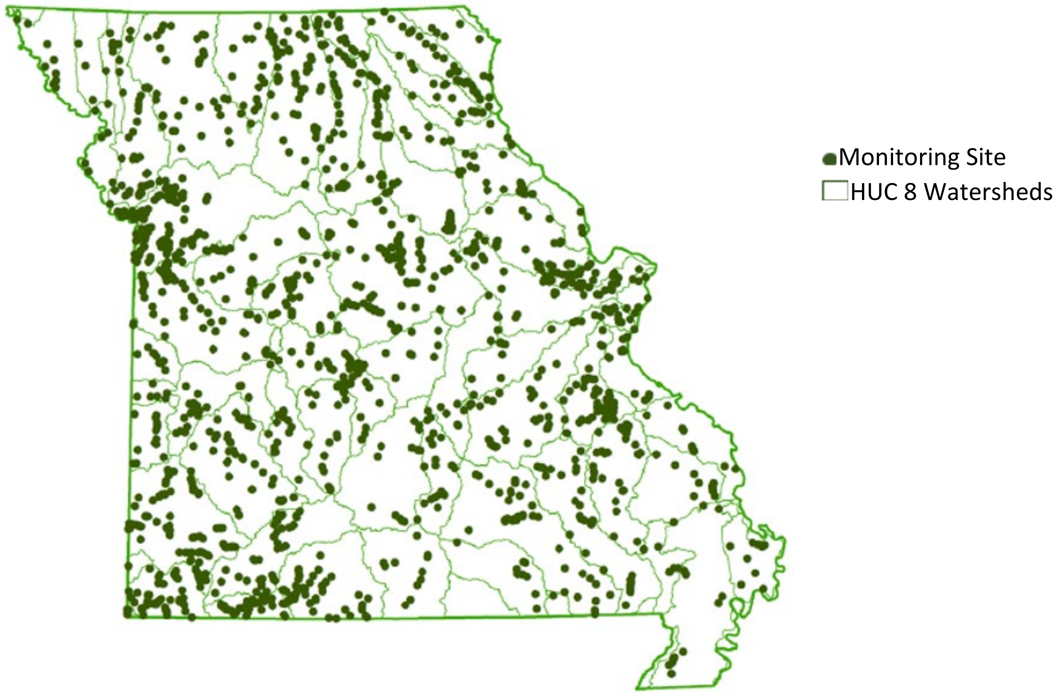

Figure 1-11. Nutrient monitoring sites on lakes and streams in Missouri.

Water Quality Standards

Nutrient criteria for lakes and reservoirs were adopted as part of Missouri's water quality standards rule in 2009. In August 2011, EPA denied approval of a substantial part of this rule, expressing some technical issues with the criteria that were proposed. The Department has since worked to address these concerns and has promulgated water quality standards that include numeric nutrient criteria for lakes and reservoirs. These criteria were approved by EPA on December 14, 2018. The Department has developed a Nutrient Criteria Implementation Plan that describes how it intends to implement nutrient criteria in accordance with the newly revised water quality standards.

For more information on the Department's efforts to reduce nutrient pollution, see the Water Protection Program's nutrient web page and the Soil and Water Conservation Program's web page.

1.6.10 Ohio

Ohio is wrestling with severe nutrient issues in many areas of the state, especially those which have come to the forefront in contributing to HABs. The effect of cyanotoxins on drinking waters and popular recreational areas has increased targeting of state and federal resources toward nutrient reduction and monitoring. Although many efforts in Ohio are being targeted toward the Western Lake Erie Basin (WLEB), the following describes monitoring and implementation efforts that influence the Ohio River Basin and, subsequently, the Mississippi River Basin. While this information is focused primarily on nonpoint source monitoring and efforts, it should be noted that more than 20 WWTPs in the Ohio River watershed have updated permits for technology reasons or to meet more stringent nutrient standards.

Monitoring

In 2018, Ohio produced its second biennial report (required by state law) on the mass loading of nutrients delivered to Lake Erie and the Ohio River from Ohio's point and nonpoint sources. The [2018 Nutrient Mass Balance Study for Ohio's Major Rivers] provides estimated nutrient loading (total phosphorus and total nitrogen) and is divided into major contributing sources for nine watersheds in Ohio based on monitoring and covering 66% of the land area of Ohio. Much of this monitoring is being performed by the [National Center for Water Quality Research,] which is measuring pollutant export from watersheds. Within the Ohio River Basin (contributing to the Mississippi River Basin), there are three major watersheds being monitored for this ongoing mass balance nutrient study—the Great Miami, Scioto, and Muskingum watersheds (see Figure 1-12). This study notes several factors that influence watershed loading such as watershed size, annual water yield, nonpoint source yield, land use, per capita yield, and population density. These factors help describe the total load from a watershed and provide the breakdown of sources contributing to those loads.

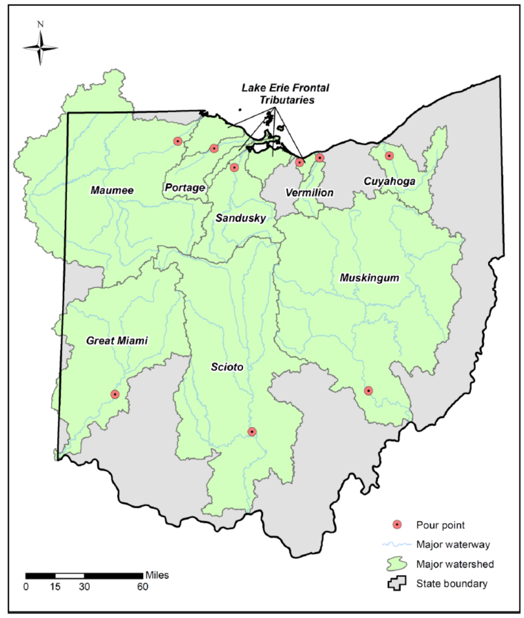

Figure 1-12. Ohio River watersheds being monitored for State of Ohio Nutrient Mass Balance Study.

For Ohio River watersheds, nonpoint sources contributed an average of 79% of the total nitrogen load. When considering the three Ohio River watersheds together, the total nitrogen load was 61,600 metric tons per year averaged over the 5 water years. The maximum and minimum loads estimated for the three watersheds draining to the Ohio River Basin are shown in Table 1-2 followed by watershed descriptions.

Nutrient Mass Balance—The Great Miami River Watershed

Agricultural land use dominates this watershed at 68%. Nonpoint source is the largest proportion of the total phosphorus and total nitrogen load as shown in Table 1-2.

Table 1-2. Maximum and Minimum Total Phosphorus and Total Nitrogen Loads Estimated for Three Watersheds Draining to the Ohio River Basin

Watershed	Total N Loads Water Years 13-17 (metric tons per year)		Total P Loads Water Years 13-17 (metric tons per year)	
	Maximum	Minimum	Maximum	Minimum
Great Miami	22,139 wy17	14,733 wy16	1745 wy14	883 wy16
Scioto	28,083 wy17	17,784 wy16	2,402 wy14	1,485 wy16
Muskingum	22,153 wy14	12,578 wy16	1,630 wy14	883 wy16

Notes: N = nitrogen; P = phosphorus; wy = water year.

Monitoring of Public Drinking Water Systems

Ohio requires public drinking water systems (PDWS) to monitor for cyanotoxins with results posted for both PDWS and recreational waters. The Public Water System Harmful Algal Bloom Response Strategy was last updated in 2017. In 2017, nitrate and microcystins were responsible for 14 impairments of PDWS in the Ohio River Basin, eight of which were new.

Monitoring of Watersheds for TMDL

Ohio's TMDL Program plans watershed assessment and TMDL development and is closely tied to the Ohio Integrated Water Quality Monitoring and Assessment Report, which summarizes water quality conditions in the State of Ohio. Seven HUC-12 watersheds in the Ohio River Basin were surveyed or assessed in 2017. No new TMDLs have been approved in the Ohio River Basin since 2012,[5] although several are under development. Of the 34 existing TMDLs approved since 2002 in the Ohio River Basin, 29 appear to have nutrient- or sediment-related criteria (total phosphorus, nitrate, ammonia, total nitrogen, DO, carbonaceous biochemical oxygen demand, sediment, or total suspended solids).

Legislation and Other Efforts

Ohio Senate Bill 150 (passed in 2014) mandated that, after September 2017, fertilizer applicators affecting parcels of land more than 50 acres must be certified and educated about the handling and application of fertilizer. To date, 17,375 Ohio fertilizer applicators have taken the 2- or 3-hour training (depending upon pesticide certification) and been certified by the Ohio Department of Agriculture (ODA). The training covers a variety of agricultural- and nutrient-related issues such as precipitation forecasts, water quality impairments, summary of edge-of-field studies, and recommendations for phosphorus and nitrogen application and management.

The Grand Lake St. Marys watershed continues to receive additional technical assistance and have special rules developed related to the application of manure and nutrients. This area was designated a watershed in distress in 2011 and one of the special rules requires nutrient management plans for large appliers of manure (more than 350 tons or 100,000 gallons annually) and, from December 15 to March 1, does not allow manure or fertilizers to be applied on frozen or snow-covered ground or when more than one-half inch of precipitation is expected.

[5] TMDL formulation was suspended in 2015 until an Ohio House Bill (HB 49) reconciled issues regarding the TMDL process, rulemaking, and stakeholder involvement in June of 2017. For more information about these changes, a TMDL factsheet is available.

Nonpoint Source Efforts, including Watershed Planning and Implementation Projects

The development of approved Nine-Element Nonpoint Source Implementation Strategic (NPS-IS) Plans is encouraged throughout Ohio to tie known water resource impairments to potential actions that will work toward delisting impaired waters or protecting high-quality waters of the state. Ohio EPA's Division of Surface Water (DSW) and ODA's Division of Soil and Water Conservation (DSWC) provide financial and technical assistance for the development of watershed plans. Thirteen Ohio River Basin watersheds have completed or are in the process of completing watershed plans. Having a completed NPS-IS plan or equivalent is a condition of being eligible for CWA section 319 funding for implementation of nonpoint source reduction in impaired waters or projects protecting high-quality waters.

Focused technical assistance is being provided to agricultural producers within the Grand Lake St. Marys watershed through ODA DSWC and through SWCDs across the state. This assistance focuses on providing nutrient management training and education; assisting in the development of nutrient management plans; and the engineering, design, and implementation of nutrient treatment BMPs. In the Ohio River Basin, Comprehensive Nutrient Management Plans covering 37,412 acres were developed from 2017 through this period.

Scioto Conservation Reserve Enhancement Program

The Scioto CREP began in 2005 as a partnership between USDA and ODA to provide increased incentives for priority agricultural conservation reserve practices. This program provided 15-year conservation reserve contracts on more than 69,200 acres of farmland. The program was suspended in 2017, but efforts are being made to renew the program. Additional information can be found on the SWCD Watershed Program Grant Updates web page

Muskingum Watershed Program

Since 2011, the Muskingum Watershed Conservancy District and ODA DSWC have administered $1,931,275 in project dollars to private landowners and local SWCDs by providing cost-share dollars to agricultural producers in the watershed to reduce runoff, sedimentation, and loss of nutrients from crop and pasture fields. Additional information can be found on the SWCD Watershed Program Grant Updates web page

CWA Section 319 Nonpoint Source Implementation Grants

Table 1-3 shows CWA section 319 implementation grants that have been provided in the Ohio River Basin since the 2017 Report to Congress along with estimated load reductions.

Table 1-3. CWA Section 319 Nonpoint Source Implementation Grants and Estimated Load Reductions in the Ohio River Basin

Project Sponsor	Project Title	Watershed	Project Total	N lbs/yr	P lbs/yr	Sed tons/yr
Holmes SWCD	Water Quality Efforts in the South Fork of the Sugar Creek	South Fork of Sugar Creek	$288,500	1,977	480	96
City of Wyoming	Cilley Creek Stream Restoration at Stearns Woods	Congress Run Mill Creek	$310,218	3	1	16
City of Cincinnati	Mill Creek Low-Head Dam Mitigation	Congress Run Mill Creek West Fork Mill Creek	$512,405	4,900	2,300	1,900
Mercer County Commissioners	West Branch Beaver Creek Stream Restoration	Beaver Creek	$510,908	510	255	255
Summit Metro Parks	Pond Brook Phase 3 Stream Restoration	Tinker's Creek	$400,000	1,391	1,182	2,365
Ohio DNR-Mineral Resources Management	Appalachian Ohio Watershed Support	Appalachian Ohio	$166,667	Y	Y	N/A
City of Mount Vernon	Armstrong Run (Kokosing River) Restoration Project	Armstrong Run (Kokosing River)	$560,518	1,476	737	641
Mercer SWCD	Phosphorus Reduction and Edge-of-Field Practice Plans	Beaver Creek	$362,366	12,566	519	1,584

Notes: lbs/yr = pounds per year; N = nitrogen; P = phosphorus; Sed = sediment; tons/yr = tons per year; Y = quantified reductions not yet reported.

Highlighted CWA Section 319 Project

In 2015, the Mercer County Commissioners and the Grand Lake St. Marys Lake Facilities Authority applied to Ohio EPA for CWA section 319 funding to establish a 39-acre vegetative biofilter to enhance sediment and nutrient removal in Beaver Creek. This application was selected and $312,500 of the funds were matched with $260,000 of local funding to construct a 0.5-MGD lift station to take flow from Beaver Creek ditch into 39 acres of roughened and vegetated floodplain.

1.6.11 Tennessee

Ambient Monitoring for Nutrients

The Tennessee Department of Environment and Conservation (TDEC) performs water quality monitoring for nitrate/nitrite, TKN, and total phosphorus as part of their ambient water monitoring program, which included sampling for nutrients at 298 sites across Tennessee in FY 2018. Monitoring sites are chosen jointly by the eight environmental field offices and the central office to ensure representation of the watershed. Sites are sampled according to TDEC's watershed approach schedule.

Point Source: WWTP Optimization for Nutrient Removal

Training and technical support was given to TDEC and municipal employees (by The Water Planet Company, now CleanWaterOps) to assist them in the optimization of nutrient removal at municipal WWTPs. TDEC staff training and technical support was provided as classroom training, videoconferences, meetings, site visits, emails, and telephone calls. Municipal WWTP support was similarly provided as classroom training, videoconferences, meetings, site visits, emails, and telephone calls. Using newly acquired knowledge and ongoing technical support, and by challenging themselves to operate existing equipment differently, two-thirds of the municipal wastewater facilities involved in the 2016 and 2014 training efforts are meeting anticipated nitrogen and phosphorus nutrient limits or have demonstrated the capability to do so.

A Summary Report on these training and technical support actions is available.

Harmful Algal Bloom Workgroup

TDEC led the formation of a total nitrogen HAB workgroup in July 2018. The workgroup consists of stakeholders and representatives from state and federal agencies, and land grant universities and was formed to develop monitoring, reporting, and research activities related to HABs. The partners involved are USACE, the Tennessee Valley Authority, USGS, the Tennessee Department of Health, TDEC, the Tennessee Department of Agriculture, Tennessee State University Extension, University of Tennessee Extension, Tennessee Technological University, Middle Tennessee State University, Vanderbilt University and Metro Nashville Water Services. Other partnerships are being formed, and much research is underway in support of creating a Tennessee-specific Harmful Algal Bloom response plan, public reporting and data collection, and toxicity research and evaluation.

Pollutant Trading

With Tennessee Valley Authority funding, Tennessee contracted with University of Tennessee-Extension to conduct a preliminary feasibility study on nutrient trading in the Tennessee Valley. The study identified potential trading zones that might have potential as pilot markets if Tennessee establishes a trading system.

Nonpoint Source Summary

Tennessee Department of Agriculture continues to partner with qualifying entities to fund projects under the CWA section 319 Program to lessen impacts to Tennessee waters from nonpoint sources, including excess nutrients. As required by EPA, staff are modeling load reductions on CWA section 319-funded projects and have chosen to use EPA's STEP-L model. Success stories are documented on EPA's Nonpoint Source Success Stories web page for Tennessee.

State funds are provided through the Agricultural Resources Conservation Fund Incentive Program to provide financial support for Tennessee farmers to install conservation practices to lessen soil erosion, reduce livestock impacts to state waters, and to improve land management on Tennessee farms. There has been a significant increase in the requests for funding for the planting of cover crops, due to the promotional work by USDA NRCS across Tennessee. The Land and Water Stewardship section is also estimating load reductions using the STEP-L model on all these practices.

Benchmark Data from 2017 U.S. Census of Agriculture

An important function in beginning to implement Tennessee's Nutrient Framework is to determine benchmarks as a means of gauging progress. The following are some key benchmarks from the 2017 U.S. Census of Agriculture (the Census)[6]:

- 109,000 acres of Tennessee farmland is tile drained (about 1% of cropland total).
- 79.8% of planted acres in Tennessee used No-Till practices.
    - 16.2% of planted acres in Tennessee used a conservation tillage practice.
    - 4% of planted acres in Tennessee used conventional tillage practices.
- 340,000 acres of cover crop acres planted, up 85% over 2012 Census totals.

Federal- and state-funded cover crop acreages totaled 195,000 acres in 2017, which when compared to the acreage reported in the Census, could indicate 42% of total cover crop acres planted are privately funded.

Partnerships with NGOs and Land Grant Universities

The Tennessee Department of Agriculture is negotiating with The Nature Conservancy and the Soil Health Partnership to fund several full partner and associate partner sites for in-depth soil health applied research and analysis. University of Tennessee Agricultural Research is collaborating with the Soil Health Partnership on this effort and also on a companion research project through the university. This work will begin in Calendar Year 2019.

From Our Farmers

Work continues with the Tennessee Association of Conservation Districts to develop narratives of the experiences Tennessee crop producers have had concerning all facets of soil health and cover crops. These stories are very enlightening and useful, in that they are written from the farmer's perspective, and provide on-farm details of what has worked and not worked for them with respect to cover crops, and the lessons learned. Planting of cover crops and the improvements that come from increasing soil health have enormous potential benefits to reducing nutrient flux.

[6] The U.S. Census of Agriculture is a count of U.S. rural and urban farms and ranches raising and selling more than $1,000 of fruit, vegetables, or food animals during the Census year. The Census, taken only once every five years, looks at land use and ownership, operator characteristics, production practices, income and expenditures. The census can be used for many different reasons, including by farmers and ranchers to make informed decisions about the future of their own operations, by companies and cooperatives to determine where to locate facilities to serve agricultural producers, by community planners to target needed services to rural residents, or by legislators when shaping farm policies and programs.

Multidisciplinary Nutrient Strategy Task Force

Tennessee has begun a process to review and revise its Nutrient Reduction Framework. Stakeholders representing wastewater, stormwater, agriculture, industry, and nonprofit environmental groups have come together to create a Multidisciplinary Task Force. The Task Force meets quarterly and held a kick-off meeting on February 12, 2019, to discuss the current Nutrient Reduction Framework, learn the science behind the framework, and explore ways to expand the framework via stakeholder-led discussion and voluntary engagement. The May 14, 2019, follow-up meeting included presentations on current practical applications of nutrient reduction by agricultural, municipal, and stormwater practitioners and led to the creation of five working groups tasked with setting goals for the Task Force, collecting data, identifying best practices, and implementing pilot projects to support revision of the state Nutrient Framework. Working groups provided an initial report to the Task Force at the August 2019 meeting.

1.6.12 Wisconsin

In addition to Wisconsin's ongoing efforts described in the 2017 Report to Congress, implementation continues to be focused on phosphorus reduction through existing state regulations, discharge permits, and TMDLs. Wisconsin's Nutrient Reduction Strategy (2013) and Implementation Progress Report (2017) can be viewed on Wisconsin's Nutrient Reduction web page.

Monitoring

Wisconsin routinely collects data on nutrient concentrations as well as documentation of waterbody responses. Looking statewide, long-term trend data reported in the 2018 Integrated Report showed generally decreasing trends for phosphorus and flat or increasing trends for nitrate. Figure 1-13 shows the areas of Wisconsin with notable changes in phosphorus, and Figure 1-14 provides a similar illustration for nitrogen.

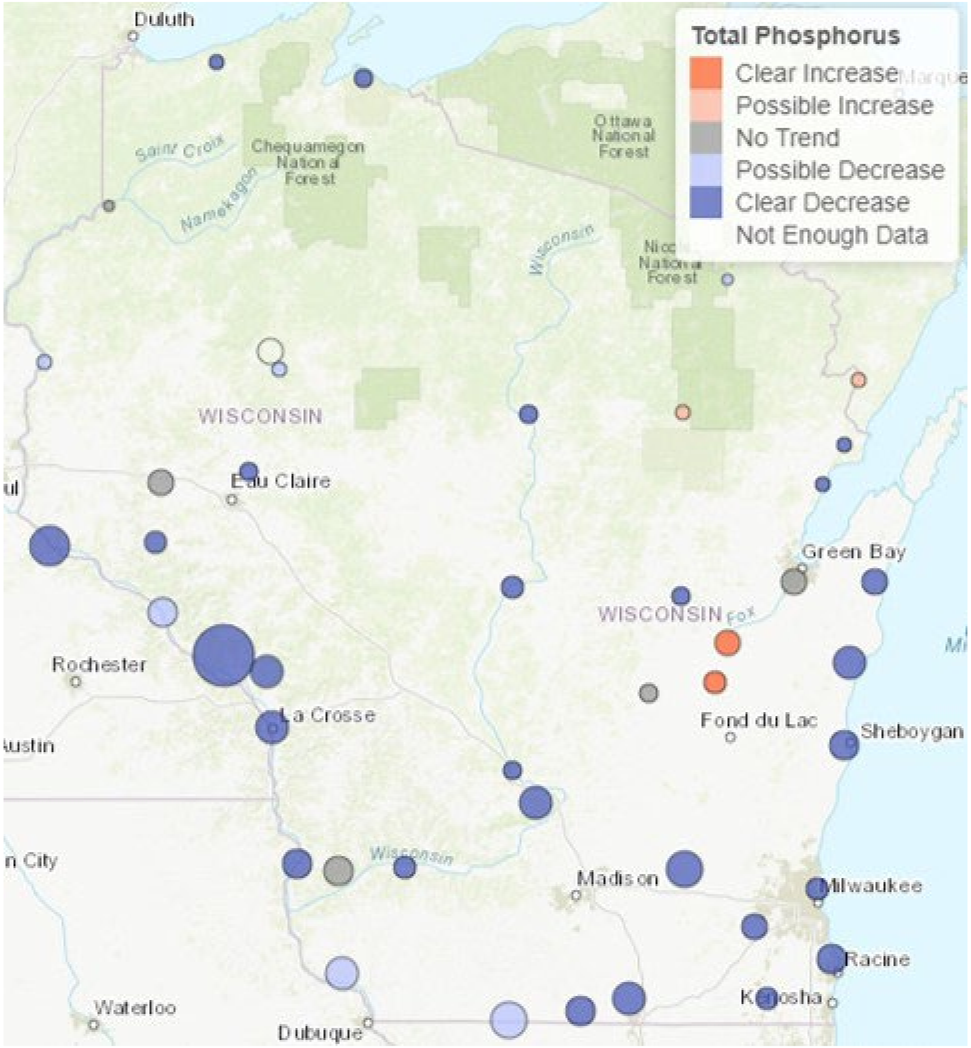

Figure 1-13. Notable concentration increases or decreases in phosphorus levels.

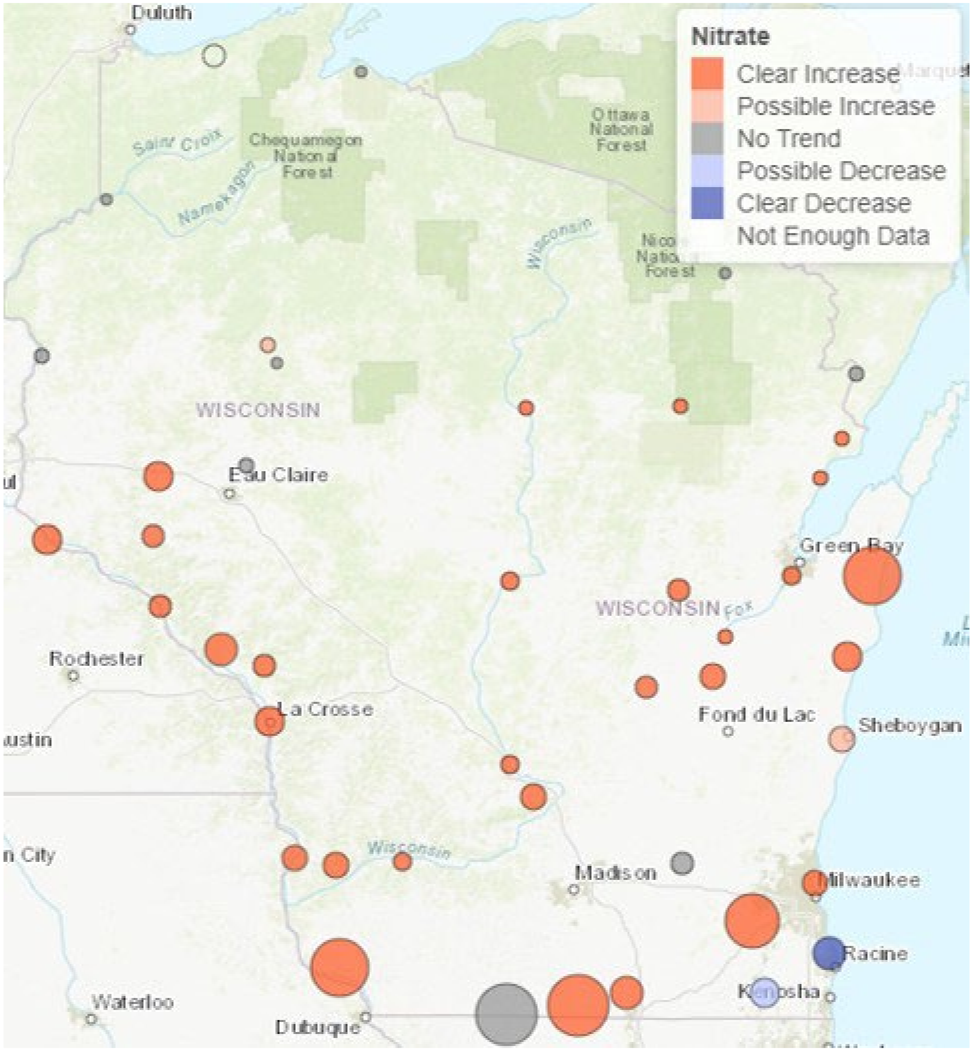

Figure 1-14. Notable concentration increases or decreases in nitrogen levels.

Looking at the watershed scale, results are variable, but the Rock River is an example of a watershed in which phosphorus reduction activities have been going on for some time (see Figure 1-15). Actions included implementing a technology-based effluent limit of 1 mg/L total phosphorus for point sources (effective in 1997), water quality-based effluent limits (WQBELs) pursuant to a phosphorus standard beginning in 2010, and phosphorus TMDL implementation beginning in 2011.

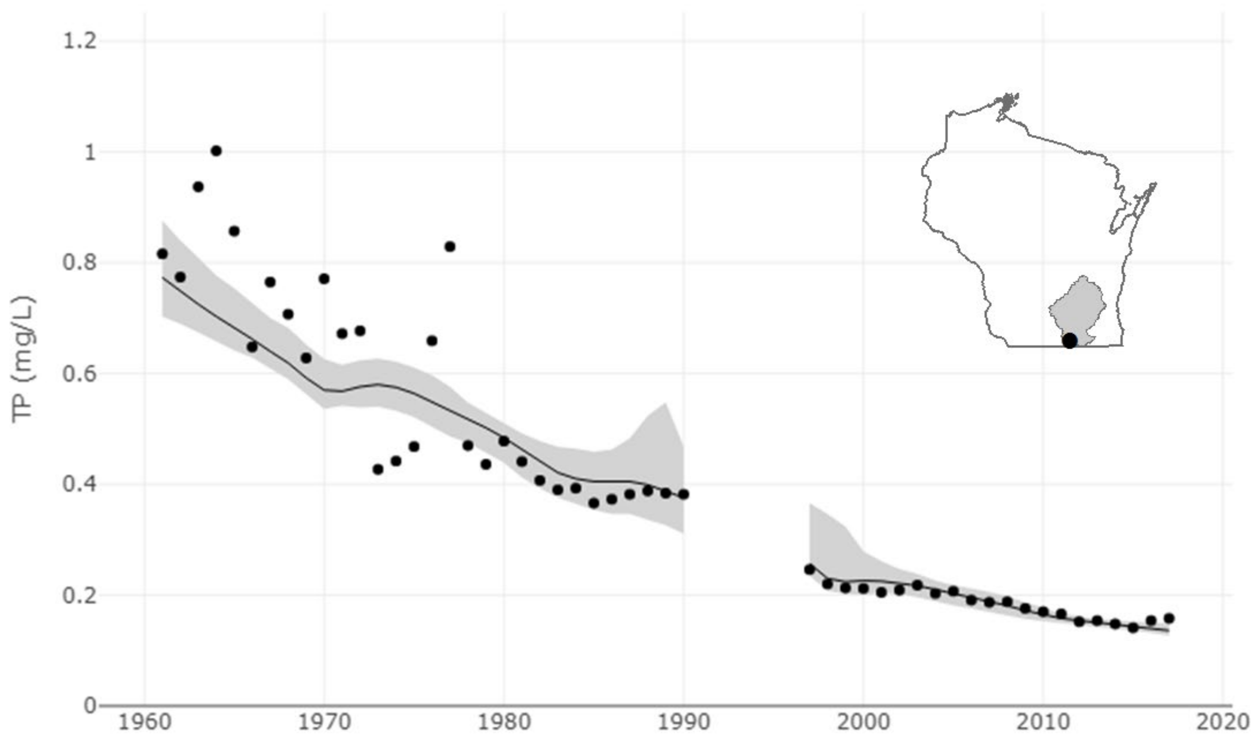

Figure 1-15. Rock River long-term trend monitoring site at Afton, WI.

Point Source Phosphorus Reduction Options

Since December 2010, the Wisconsin Department of Natural Resources (WDNR) has been including WQBELs in Wisconsin Pollutant Discharge Elimination System (WPDES) permits to comply with Wisconsin's water quality standards for phosphorus. Wisconsin's Phosphorus Implementation Guidance provides a detailed discussion of the phosphorus standards and implementation procedures for those standards in WPDES permits.

To help address shortfalls in funding for nonpoint source reductions and help offset the often-costly point source reductions, WDNR, in collaboration with its stakeholders, developed innovative compliance options as part of the 2010 phosphorus rulemaking to reach water quality goals in a more economically efficient manner. This spurred the development of Wisconsin's Adaptive Management and WQT programs. The premise behind these compliance options is that point source dischargers could invest a smaller amount of money towards nonpoint source pollution control projects and while achieving a greater water quality benefit. These programs are considered to be a viable solution for many point sources working towards phosphorus compliance.

Although similar, adaptive management is different than WQT. In both cases, point sources can take credit for phosphorus reductions within the watershed towards phosphorus compliance. Because the practices used to generate phosphorus reductions may be the same, these compliance options are often confused with one another. Adaptive management and WQT have different permit requirements, however, making them different from permitting and timing standpoints:

- Adaptive management and trading have different end goals. Adaptive management focuses on achieving water quality criteria for phosphorus in the surface water; trading focuses on offsetting phosphorus from a discharge to comply with a permit limit.
- Monitoring. Because adaptive management focuses on water quality improvements, in-stream monitoring is required under adaptive management; this is not required under trading.
- Timing. Practices used to generate reductions in a trading strategy must be established before the phosphorus limit takes affect; adaptive management is a watershed project that can be implemented throughout the permit term.
- Quantifying reductions needed. Trading requires trade ratios be used to quantify reductions applied to offset a permit limit; the reductions needed for adaptive management are based on the receiving water, not the effluent, and trade ratios are not necessary in this calculation.
- Eligibility. Adaptive management and trading have different eligibility.

Many point sources are developing and/or implementing trading or adaptive management projects to seek phosphorus compliance in lieu of installing treatment technologies (see Figure 1-16). [Information about these and other projects is available]. It is anticipated that adaptive management and trading projects will continue to be developed over the next 5–10 years as point sources make compliance decisions.

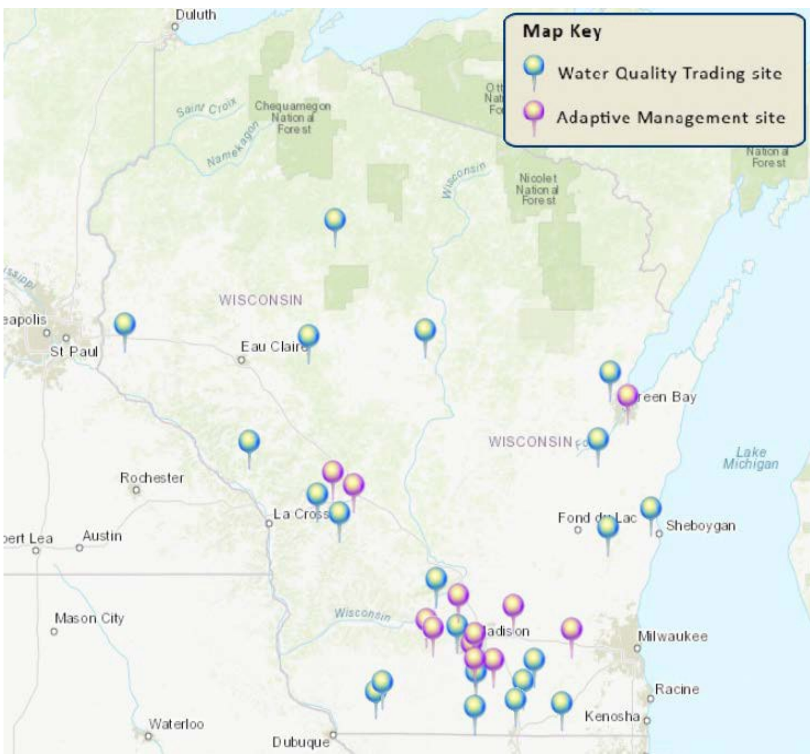

Figure 1-16. Adaptive management/WQT participants as of October 2018.

Despite the widespread need and relatively low costs associated with installation of nonpoint BMPs compared to other compliance options, some common hurdles have been identified for point sources during project development. In some instances, industrial or municipal wastewater treatment operations are not readily equipped to conduct watershed work to implement nonpoint source phosphorus reductions. The degree of uncertainty associated with relying on BMPs for compliance purposes is possibly higher than that associated with a facility upgrade. Likewise, spending pollution control dollars outside of the facility might be controversial in some situations.

To address some of these challenges, a variety of partnerships have formed among the conservation community. Local environmental organizations such as county land and water conservation departments, watershed and agricultural groups, and other NGOs have begun partnering with point sources to implement compliance-driven projects.

In some cases, point sources might seek an individual phosphorus variance based on substantial and widespread social and economic impacts. Facilities with an approved variance might be allowed to discharge higher concentrations of pollutant for a period of time, but also commit to making strides towards reducing effluent phosphorus and achieving eventual compliance with the final limit.

In anticipation of the expected increase in phosphorus variances associated with the 2010 rule change and the opportunities for watershed-based offsets, a multi-discharger variance (MDV) for phosphorus was established in 2017 to help streamline and improve the variance process. The MDV allows a discharger 5–20 years to comply with restrictive phosphorus limits, while making meaningful contributions to local water quality. During the variance term, point sources are required to optimize their treatment processes for phosphorus, make stepwise reductions in effluent phosphorus concentrations, and implement a watershed project through an MDV watershed plan.

Point sources can select one of three types of watershed projects eligible for the MDV: payments to county land and water conservation departments, an implementation agreement with WDNR for phosphorus reduction projects, or implementation with a third party for phosphorus reduction projects.

As of late 2018, 54 point sources had been approved for coverage under the MDV (see Figure 1-17). The vast majority of all MDV watershed plans use the county payment option. Because of this, an estimated $900,000 was available to county land and water conservation departments in 2019.

Future years are expected to see similar funding levels, increased due to additional dischargers seeking coverage under the MDV, but reduced payments from those already enrolled due to phosphorus optimization efforts. Many facilities enrolled in the MDV are also working towards compliance via trading or adaptive management over a longer time frame. More information about the multi-discharger phosphorus variance is available.

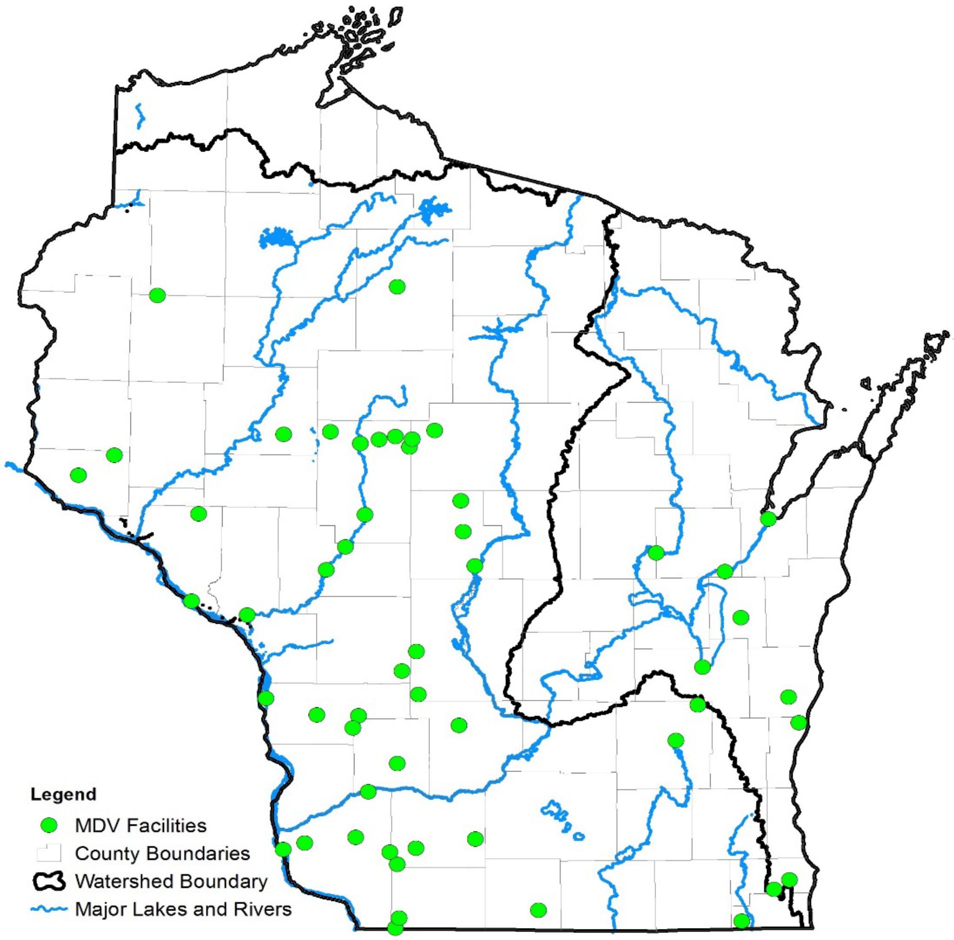

Figure 1-17. Wisconsin's phosphorus multi-discharger variance facilities (2018 list) and major basins.

Wisconsin River Basin TMDL: Edge-of-Field Agricultural Targets

WDNR has completed development of a TMDL for the Wisconsin River basin that covers 9,156 square miles (14% of the state). The TMDL addresses 109 river segments and eight lakes that are impaired for phosphorus. Several innovative modeling approaches were developed to assist in the TMDL development, including a unique approach that will assist in implementing the agricultural load allocation (LA) as well as potential WQT and adaptive management.

Agricultural LAs have always been challenging to effectively communicate because a lumped LA does not effectively allow translation of reduction requirements into needed implementation practices and actions. To address this issue, the WDNR has developed a framework for translating agricultural LAs, which are developed using the Soil and Water Assessment Tool (SWAT) watershed model, into edge-of-field total phosphorus targets (in lbs/acre/yr) that can be implemented by the Soil Nutrient Application Planner (SnapPlus) field-scale model.

Point sources can enter into trading agreements and receive credit for reducing phosphorus loss on agricultural fields. Crediting will depend on whether the agricultural field is currently exceeding the credit threshold of phosphorus. The total phosphorus target listed in the Wisconsin River TMDL document is the credit threshold for the corresponding subbasin. If the agricultural field is currently exceeding the credit threshold, adoption of additional conservation practices can generate “interim credits” for a maximum of five years for reductions that occur above the credit threshold; and if the practices reduce the agricultural field to below the credit threshold, “long-term credits” are generated.

More details on edge-of-field targets can be found in Appendix N of the TMDL.

Tracking Agricultural Nonpoint Source BMPs

WDNR and the Wisconsin Department of Agriculture, Trade, and Consumer Protection (DATCP) are currently developing a management system to facilitate the exchange of data between external entities and the departments. Nonpoint source pollution reduction implementation programs require external entities—such as counties, permittees, consultants, and others—to submit data regarding their use of State of Wisconsin and other funds to reduce nonpoint source pollution and meet state soil and water standards. Several programs necessitate and use this type of data. Such programs include the following: MDV for phosphorus options, TMDL implementation, Urban Nonpoint Sources grants, Targeted Runoff Management grants, Soil & Water Resources Management grants, adaptive management options, WQT options, NR 151 compliance tracking implementations, and nutrient reduction strategies. The development of a system that efficiently facilitates data submission and analysis will allow WDNR and DATCP to provide better transparency to the public as to how funds are being used. Through this program, WDNR and DATCP will be able to better track and show progress towards reaching nutrient reduction goals related to TMDLs; statewide Nutrient Reduction Strategy; and other WDNR, DATCP, and EPA reporting requirements.

The system is currently under development, and substantial progress has been made since the project’s inception. The MDV tracking system is now live and available for point sources to use. For the first year of MDV implementation, users will be encouraged to use the program but will still have the option to submit the existing paper forms. The MDV program fully replaced the existing forms in 2020. DATCP and WDNR have several program modules currently under development that will capture implementation information from their grant programs.

Part 2. The Response of the Hypoxic Zone and Water Quality Throughout the MARB

2.1 Impacts of Excess MARB Nutrients and Gulf Hypoxia

The largest hypoxic zone in the United States forms in the northern Gulf every summer and significantly disrupts the aquatic ecosystems there by lowering the DO levels beyond what most species need to survive. As described in the 2017 Report to Congress, the hypoxic zone is fueled primarily by excess nitrogen and phosphorus loads delivered from the MARB. These loads trigger an overgrowth of algae that rapidly consumes oxygen as it decomposes. A lack of mixing between the surface and subsurface water causes oxygen to be removed faster than it is replaced. These phenomena result in the annual hypoxic zone.

The nitrogen and phosphorus loads are from a variety of both anthropogenic and natural sources in the MARB upstream of the Gulf. Sources of nitrogen and phosphorus include agriculture (both row crop agriculture and animal feeding operations), urban runoff, and point sources such as WWTPs. Atmospheric deposition is an additional source of nitrogen. Stream channel erosion and natural soil deposits are additional sources of phosphorus. Other factors and actions can add to and enhance the delivery of excess nutrients to the Gulf such as land-use changes and development in the drainage basin; channelization, hydromodification, and impoundment of the Mississippi River, the Mississippi Delta, and other rivers and streams in the MARB; loss of coastal wetlands; changes in the hydrologic regime of the Mississippi and Atchafalaya rivers; and the timing of fresh water inputs that are critical to stratification (USEPA 2008).

While current anthropogenic sources of excess nutrients can generally be controlled through a variety of practices and are largely able to be measured, naturally derived and legacy anthropogenic sources of nutrients can be more challenging to manage and measure. Historic deposits of soil containing nitrogen and phosphorus that have built up in agricultural landscapes and settled in streambeds over decades and centuries have not been fully considered as potential sources of current nutrient loading. The timing and role of nitrate movement from groundwaters into surface water is also not fully understood. Due in part to the difficulty in measuring and assessing the nutrient loading from these sources, their overall contributions to hypoxic conditions in the Gulf have been difficult to quantify. More recently, due to advancements in measuring capabilities and modeling efforts, observations have revealed that these legacy nutrients have a large potential to be a source of nutrient loading currently and into the future. Models such as the processed-based ELEMeNT (Exploration of Long-tErM Nutrient Trajectories) model (Van Meter et al. 2018) are able to account for the effects of nitrogen legacies on long-term nutrient loading, something that previous models have been unable to adequately capture. Year-round data collection has also increased understanding of the effects of legacy nutrients on nutrient loading, as previously many studies have limited their data collection to just the growing season. Year-round data collection is needed to fully understand water and nutrient balances in waterbodies, as lag times for nutrient effects and transport can range from annual to decadal time scales (Sharpley et al. 2019). These legacy sources of nutrient loading present new and unique challenges to meeting the HTF's 2035 goal and 2025 interim target; better understanding of these sources is a significant research need.

2.2 The Response of the Hypoxic Zone to Excess Nutrients from the MARB

Since the 2017 Report to Congress, a better understanding of the extent and nature of the hypoxic zone and its potential economic impacts (Part 3) as well as tools for assessing progress in reducing the hypoxic zone size have been gained. In support of hypoxic zone management, NOAA has invested more than $47 million in enhanced research, forecasting, and monitoring capabilities since 1990. Activities involving many NOAA programs include the Nutrient Enhanced Coastal Ocean Productivity (NECOP) program (1990–1999), the HABHRCA-mandated Northern Gulf of Mexico Ecosystems and Hypoxia Assessment (NGOMEX) Program (2000–present), the Gulf of Mexico Hypoxia Watch collaborative project (2001–present), the Coastal and Ocean Modeling Testbed (COMT) program (2010–2017), and the Ocean Technology Transition (OTT) program (2020–present). These capabilities improved the understanding of scientific processes involved in hypoxia formation and ultimately led to improved predictive modeling tools. These investments enable the HTF and partners to make informed, proactive, and science-based decisions regarding mitigating the impact of hypoxia on the Gulf ecosystem and for assessing progress toward reaching the Action Plan goals.

New science includes improved hypoxic zone characterization, improved understanding and modeling of the nitrogen and phosphorus reductions necessary to observe a statistically significant reduction in the zone's size (Scavia et al. 2017; Fennel and Laurent 2018; Kim et al. 2020; Tian et al. 2020), identification of economic impacts of hypoxia on fisheries (Smith et al. 2017; Purcell et al. 2017), and improved modeling methods used to predict the hypoxic zone (Matli et al. 2020).

2.2.1 Scientific Developments in the Metrics Used for Assessing Gulf Hypoxia

The annual areal size of the hypoxic zone informs accounting for the HTF's goal through the five-year average size. New science continues to support that the size metric is an appropriate metric for assessing progress towards the 2035 goal (Matli et al. 2018).

Additional advancements in recent science can also help as the HTF considers metrics in addition to the five-year average hypoxic zone size. Multiple models now show great potential as tools for understanding the evolution of the hypoxic zone through space and time and can offer broader insight to the HTF. For example, some other dimensions of the hypoxic zone (e.g., severity, vertical extent) that reflect its impacts and connection to nutrient loading can now be modeled (Laurent and Fennel 2019; Scavia et al. 2017). The results of this modeling can provide critical information for understanding the large fluctuations in hypoxic zone sizes during 2017–2020 and in providing a model-simulated hypoxic area when there was no data in 2016.

Future climate conditions are also an important consideration when understanding what actions are needed to reach the HTF's 2035 goal and 2025 interim target and assessing related progress. The effects of climate change in the northern Gulf of Mexico are expected to exacerbate hypoxia and its impacts to aquatic life due to increased density stratification, reduced oxygen solubility, and enhanced bottom water acidification. Although these effects may vary interannually, overall patterns of rising sea surface temperature, increasing freshwater and nutrient inputs due to changes in precipitation patterns, and changes in the atmospheric carbon dioxide concentrations are likely to result in more severe and prolonged periods of hypoxia and acidification (Lehrter et al. 2017; Laurent et al. 2018; Del Giudice et al. 2019). Therefore, the potential influence of climate on the hypoxic zone is a major reason continued monitoring and model calibration is required over time, as these tools are critical for confirming appropriate nutrient reduction strategies.

The areal extent of the hypoxic zone is measured each summer during the annual hypoxic zone cruise, typically occurring during the last week of July. The HTF uses these measurements to track progress towards the 2035 goal. Starting in 1985 and continuing to present, monitoring has been supported by NOAA and, at times, EPA. The current five-year average (2015–2020) is approximately 14,000 square kilometers, which includes data from five years (2015, 2017, 2018, 2019, 2020) as there is no data for 2016 (see Figure 2-1). A five-year average is used, as opposed to an annual average to account for variability in hypoxic zone size from year to year.

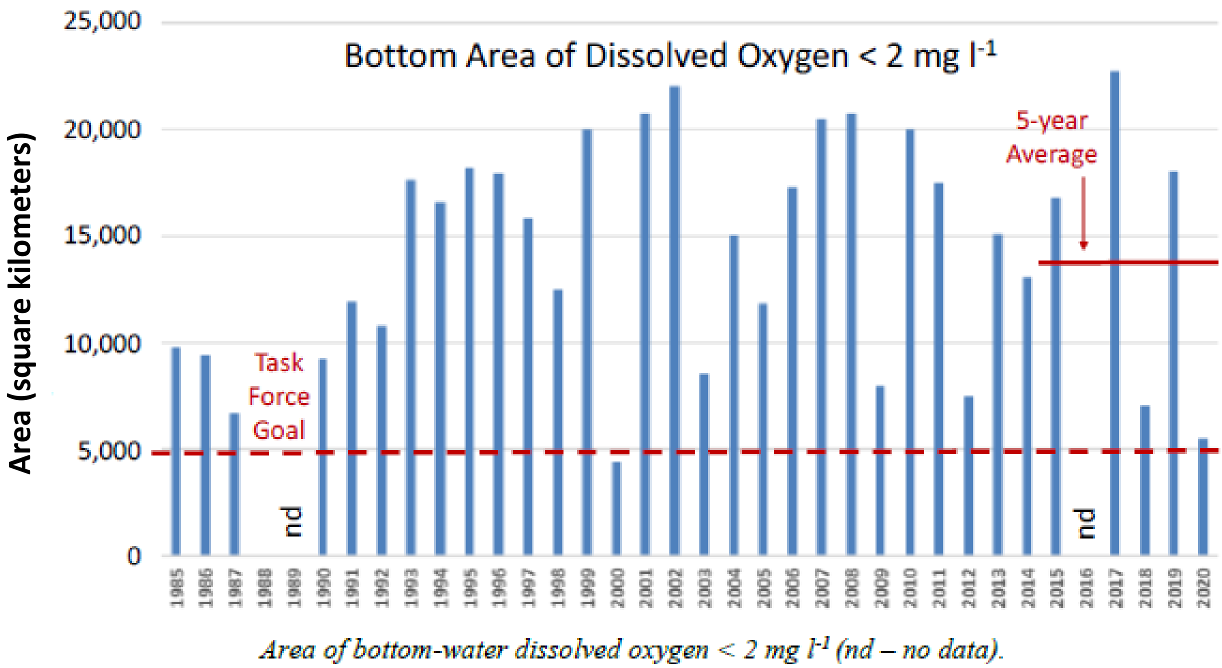

Figure 2-1. Historic size of hypoxia 1985–2020. The 2014–2020 (no data for 2016) five-year running average hypoxic zone size is 14,000 square kilometers. There are no data (nd) for 1989 and 2016. The value for 1988 is 39 square kilometers. (Dr. Nancy Rabalais [Louisiana Universities Marine Consortium or LUMCON] and Dr. Eugene Turner [LSU].)

Current Status of the Hypoxic Zone

Since the 2017 Report to Congress, there have been four annual measurements of the hypoxic zone. In 2017, the zone areal extent was 22,720 square kilometers (NOAA 2017a), the largest zone measured to date due to heavy May stream flows, resulting in high nutrient loads from the MARB (NOAA 2017a, 2017b). Then in 2018, the midsummer areal extent was 7,040 square kilometers (see Figure 2-2), despite May nutrient loads that were average compared to other years. Winds in the weeks preceding the cruise combined with winds and waves at the start of the survey likely resulted in a mixed water column and smaller zone size (NOAA 2018b). The 2019 Gulf survey cruise measured an 18,000 square kilometers hypoxic zone, one that was forecasted to be much larger but was disrupted by the passage of Hurricane Barry just prior to the cruise (NOAA 2019b). In 2020, the midsummer areal extent was 5,048 square kilometers, resulting in one of the smallest hypoxic zones measured, despite May nutrient loads that were high compared to previous years (Figure 2-3). Hurricane Hanna passed through the central and western Gulf days prior to the research cruise and mixed the water column, disrupting the hypoxic zone. Due to the proximity of the storm to the survey cruise, the hypoxic area was only able to partially reform before the end of the monitoring cruise, resulting in a patchy distribution across the Gulf. Dynamic models including the NOAA-supported Regional Ocean Modeling System (ROMS) and the Finite Volume Community Ocean Model (FVCOM) provided additional information to better understand and confirm the observed hypoxic zone conditions in 2017, 2018, 2019, and 2020, including the effect wind events had prior to the cruises and the role these events played in the smaller than anticipated measured dead zone sizes in 2018 and 2019 given the springtime nutrient loading.

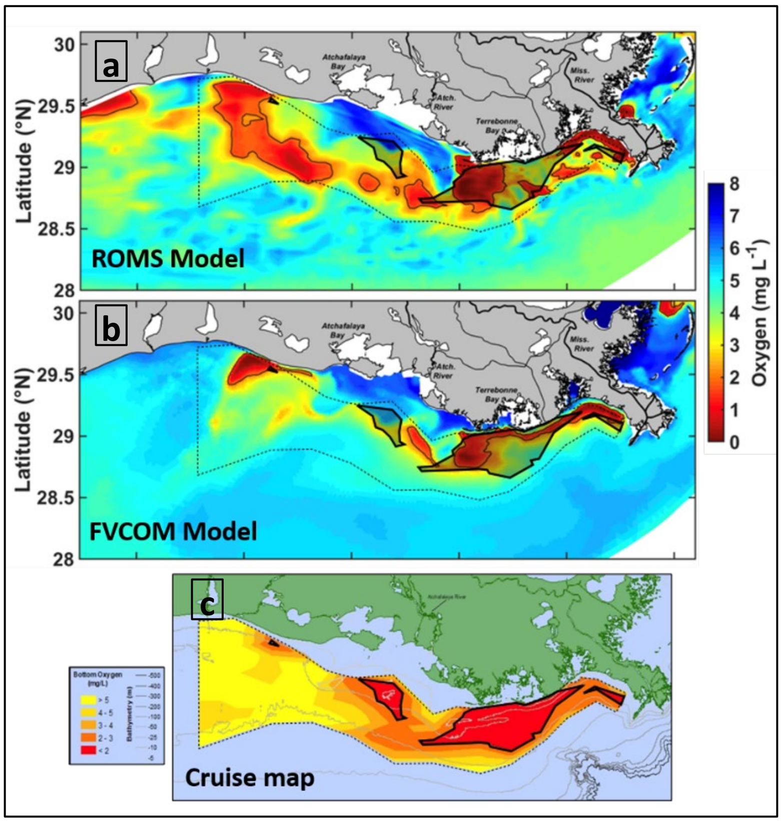

Figure 2-2. The hypoxic zone model predictions for the ROMS (a) and FVCOM (b) models at the time of the 2018 cruise (c) show that overall there is good spatial agreement in their estimate of the hypoxic zone extent. The black line on panels (a) and (b) indicate the regions of hypoxia determined from the cruise overlaid onto the model predictions. Model developed under support from NOAA's *NGOMEX* Program and the Coastal and Ocean Modeling Testbed (*COMT*) and courtesy of Katja Fennel (Dalhousie University) and Dubravko Justić (LSU).

The NOAA-supported annual hypoxic zone cruise remains one of the longest standing monitoring activities in the Gulf (see Figure 2-2). A new, formal standard operating procedure aims to ensure the continued, long-term sustainability of the cruise, independent of the ship platform, and expand collaborative support for monitoring activities.

In addition to the annual cruise survey, the Gulf of Mexico Hypoxia Watch collaborative project (2001–present) conducts separate annual cruises to provide scientists with difficult-to-obtain environmental and fishery-independent data. This information allows scientists to understand the effects of the physical environment on fish and other marine organisms. As part of these efforts, Hypoxia Watch disseminates near real-time data and maps of the hypoxic zone online from data collected during the annual SEAMAP summer ground fish surveys. These maps have been instrumental in monitoring changes in hypoxia throughout the Gulf outside of the cruise window and for providing much-needed data for hypoxia model calibration and validation.

NOAA, in partnership with the Northern Gulf Institute (NGI), continues to support efforts to advance research and management of hypoxia in the Gulf of Mexico as a member of the HTF and, more broadly, to implement the mandates of the Harmful Algal Bloom and Hypoxia Research and Control Act (HABHRCA). Funding is provided by the National Centers for Coastal Ocean Science and executed through the NGI, one of NOAA's Cooperative Institutes. NOAA and NGI collaborate along three main focal areas: (1) technical assistance; (2) observations and monitoring, and; (3) coordination with the goal to advance the science underpinning management of the large annual hypoxic zone in the northern Gulf of Mexico. Additional information can be found on the hypoxia national office website.

The 2017 Report to Congress noted that a NOAA-funded 2016 glider study used gliders to complement ongoing ship surveys and moored observation systems. The recent results of this study show that gliders are not ideally suited for hypoxia monitoring and mapping of the hypoxic zone due to challenges in navigating in the shallow, highly stratified, strong, and variable coastal current conditions found in the Gulf. This project resulted in a finding that, moving forward, a hybrid approach should be adopted for monitoring the hypoxic zone, one that uses a combination of buoyancy gliders and autonomous vehicles.

2.2.2 Advancements in Modeling and Monitoring the Hypoxic Zone

Research shows that both physical variables that affect water stratification and the decomposition of plankton and other organisms, whose biomass is increased by nutrient loading, contribute to the hypoxic zone size (Matli et al. 2018; Feng et al. 2012). These dynamics result in a changing hypoxic zone that can dissipate and reform over short time periods (hours to days) (Rabalais et al. 2007).

NOAA's NGOMEX Program has supported development of a suite of hypoxia forecast models over the past decade; this ensemble of models has been transitioned to NOAA from the developers that include teams of researchers at the University of Michigan, Louisiana State University, William and Mary's Virginia Institute of Marine Science, North Carolina State University, and Dalhousie University. After several years of testing, NOAA, in conjunction with academic partners, issued its first hypoxic zone forecast in 2018 (NOAA 2018a), a second in 2019 (NOAA 2019a), and a third in 2020 (NOAA 2020). With the transition of these models to NOAA, this forecasting capability will now be available for future HTF assessments of nutrient management reduction scenarios necessary to achieve the nutrient reduction goals of the HTF.

The inability to perform phosphorus modeling by all but one of the ensemble of models is an important and significant gap in the current suite of NOAA-supported forecast models that provide results to the HTF. Studies have shown that the inclusion of this important nutrient is warranted (Diaz and Rosenberg 2008; Fennel and Laurent 2018), in line with the 2007 Science Advisory Board recommendation to the HTF. Modeling results suggest that a 63% reduction of nitrogen alone would be required to reach the HTF's 2035 goal (Scavia et al. 2017), while a dual strategy that reduces both nitrogen *and* phosphorus by 48% would be sufficient (Fennel and Laurent 2018), confirming that the 2035 goal is appropriate.

In 2019 and 2020, an experimental coupled FVCOM and Water Analysis Simulation Program (WASP) model was run in forecasting mode a week ahead of the annual monitoring cruise to inform scientists conducting the measurement of the potential hypoxic zone size based on recent weather conditions. The coupled model incorporates surface wind forcing, tidal forcing, offshore remote forcing, heat fluxes, oxygen exchanges at the air-sea interface, solar radiation, and freshwater and nutrient (nitrogen and phosphorus) fluxes from the Mississippi and Atchafalaya Rivers (Justić and Wang 2014). These short-term forecasts have proven useful for efficiently planning and mapping the survey cruise.

In 2020, NOAA's OTT Program funded a project to develop a cost-effective technology to gather water-quality data throughout the water column of the Gulf hypoxic zone. This project will use autonomous surface vehicles, which can measure oxygen and other water quality parameters in depths from 5 meters to over 50 meters and provide the necessary near-bottom observations. Field trials are set to begin in summer 2022. These new capabilities, once operationalized, will augment the annual monitoring cruise and the generation of the metric used by the Hypoxia Task Force. Benefits of this effort will go beyond the one-time annual measurement, as these technologies can be mobilized quickly and used to monitor wherever hypoxic conditions persist, especially in shallow waters.

EPA has developed two complex biogeochemical simulation models, the Coastal Generalized Ecosystem Model (CGEM) and the Gulf of Mexico Dissolved Oxygen Model (GoMDOM), to simulate hypoxia in the northern Gulf of Mexico. These modeling tools have most recently been applied to compare the range and uncertainty of expected hypoxia response to reduced nutrient load scenarios (Jarvis et al. 2021; Feist et al. 2016). Model simulations have also been used to improve understanding of the drivers of hypoxia in space and time, thus informing future modeling of hypoxia under a range of physical and biological conditions.

2.3 New Science and Information on Water Quality throughout the MARB

The HTF looks to a combination of water quality monitoring and modeling in the MARB rivers to understand the link between riverine nutrient loading and the hypoxic zone size; therefore, quantifying the nutrient loads from the MARB to the Gulf is a key HTF metric for tracking progress in meeting the 2035 goal and 2025 interim target.

2.3.1 Advancements in Monitoring Water Quality and Nutrient Loads in the MARB

To track progress towards the HTF's 2035 goal and 2025 interim target, nutrient load reductions in the MARB rivers are measured against the average total nitrogen and total phosphorus loads delivered to the Gulf during the baseline period from 1980 to 1996. However, the amount of nutrient loading into the Gulf, and thus the hypoxic zone, is heavily influenced by the amount of water flowing from the MARB (i.e., higher streamflows carry more nutrients, contributing to a larger hypoxic zone). Thus, streamflow changes alone can increase or decrease nutrient loading to the Gulf each year, despite any point and nonpoint source controls, land-use change, population growth, or other changes simultaneously occurring in the watershed. Therefore, to more clearly track changes in nutrient loading to the Gulf due to human actions, the short-term variability in nutrient loading due to year-to-year changes in streamflow must be accounted for during analysis of long-term change.

The HTF has adopted two metrics for assessing the long-term changes in nutrient loading that minimize the variability due to year-to-year changes in streamflow. The first is the HTF's long-standing use of a five-year moving average load, which is computed in any given year as the average of the load in the current year and the preceding four years. Often, a five-year period will contain a mix of high, moderate, and low streamflow years, and the resulting average nutrient load over the five-year period will reflect a balance of high and low streamflows. However, a five-year period might contain more low or high streamflow years such as during a multi-year drought or other prolonged climatic condition. While multiple years of low streamflow will likely result in multiple years of low nutrient loading—and thus multiple years of a smaller hypoxic zone—nutrient loading and the size of the hypoxic zone will eventually increase again as streamflows naturally increase. Thus, a five-year moving average during a period with multiple years of higher or lower than average streamflows will reflect these prolonged natural climatic conditions more than sustained human progress in reducing nutrient loading to the Gulf.

For these reasons, a second, more robust metric that is less affected by these climatic situations was adopted in January 2018. This second metric is based on a method that "normalizes" loads to average streamflow conditions, using the USGS Weighted Regressions on Time, Discharge and Season (WRTDS) model (Lee et al. 2017; Hirsch et al. 2015, 2010). While the flow-normalized WRTDS loads can more robustly compensate for changes in streamflow, both metrics are used to assess progress because the five-year moving average metric is aligned with the five-year moving average method the HTF has used to evaluate its 2035 goal for reducing the size of the hypoxic zone since the early 2000s.

While the WRTDS method, like other load-estimation approaches, has strengths, it also has limitations. With WRTDS, estimates of flow-normalized load in previous years might vary as new data are incorporated; therefore, it can take several years of new data to stabilize the estimates in previous years. For this reason, estimates from the model are considered provisional until 10 years of new data have been added. This feature illustrates the importance of the HTF using multiple metrics to track progress in any given year.

The five-year moving average and the WRTDS flow-normalized loads from the Mississippi and Atchafalaya rivers during the period from 1980 to 2019 are shown in Figure 2-3 and Figure 2-4 (Lee et al. 2019). Total nitrogen loads have generally decreased since 1980 as indicated by flow-normalized total nitrogen loads, which were near the 20% interim reduction target in 2019 (see Figure 2-3). Overall, the change in flow-normalized total nitrogen loads between the baseline (1980–1996) and 2019 was estimated to be -16% (-17% of that was likely due to changes in upstream nitrogen sources and +1% from a long-term change in streamflow). In contrast, total phosphorus loads have increased somewhat since the late 1990s, and both metrics were still above the 20% interim reduction target in 2019 (see Figure 2-4). Overall, the change in flow-normalized total phosphorus loads between the baseline (1980–1996) and 2019 was estimated to be +7% (+6% of that was likely due to changes in upstream phosphorus sources and +1% from a long-term change in streamflow).

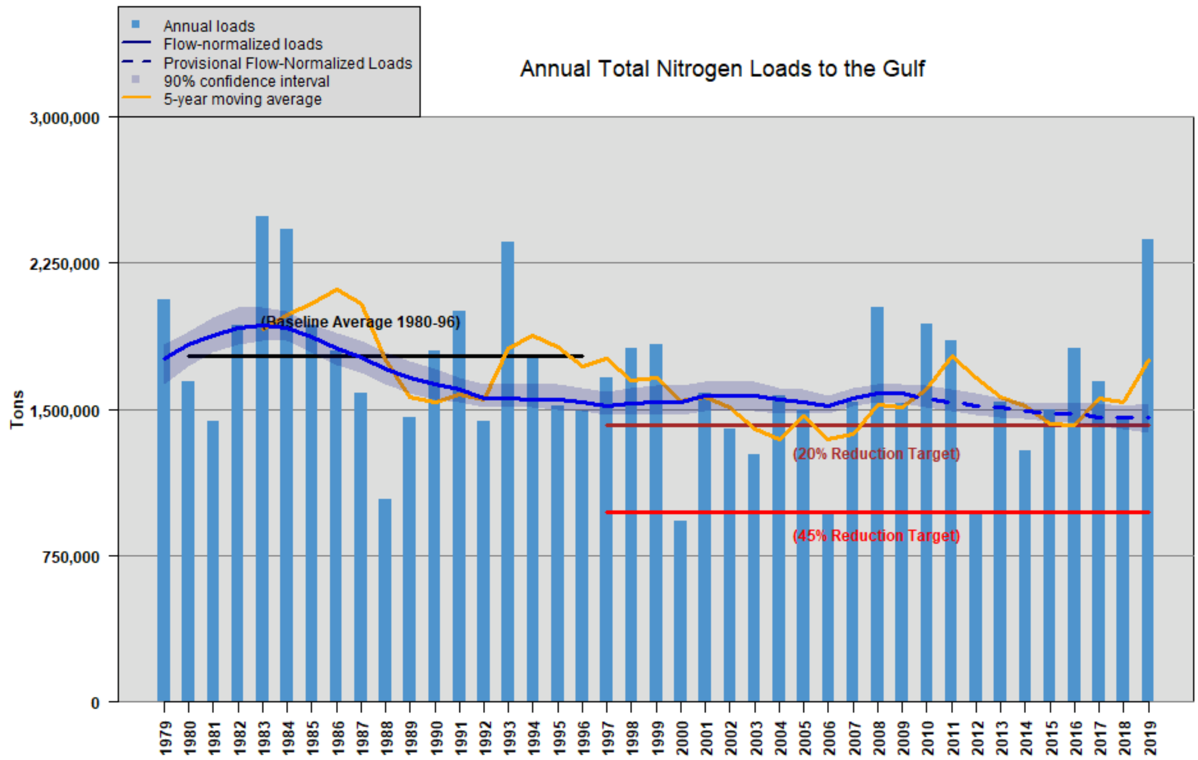

Figure 2-3. Total nitrogen loads to the Gulf from the Mississippi and Atchafalaya rivers between 1980 and 2019. Results from the two metrics used by the HTF to evaluate progress towards nutrient reduction targets—the five-year moving average loads and the flow-normalized loads—are shown.

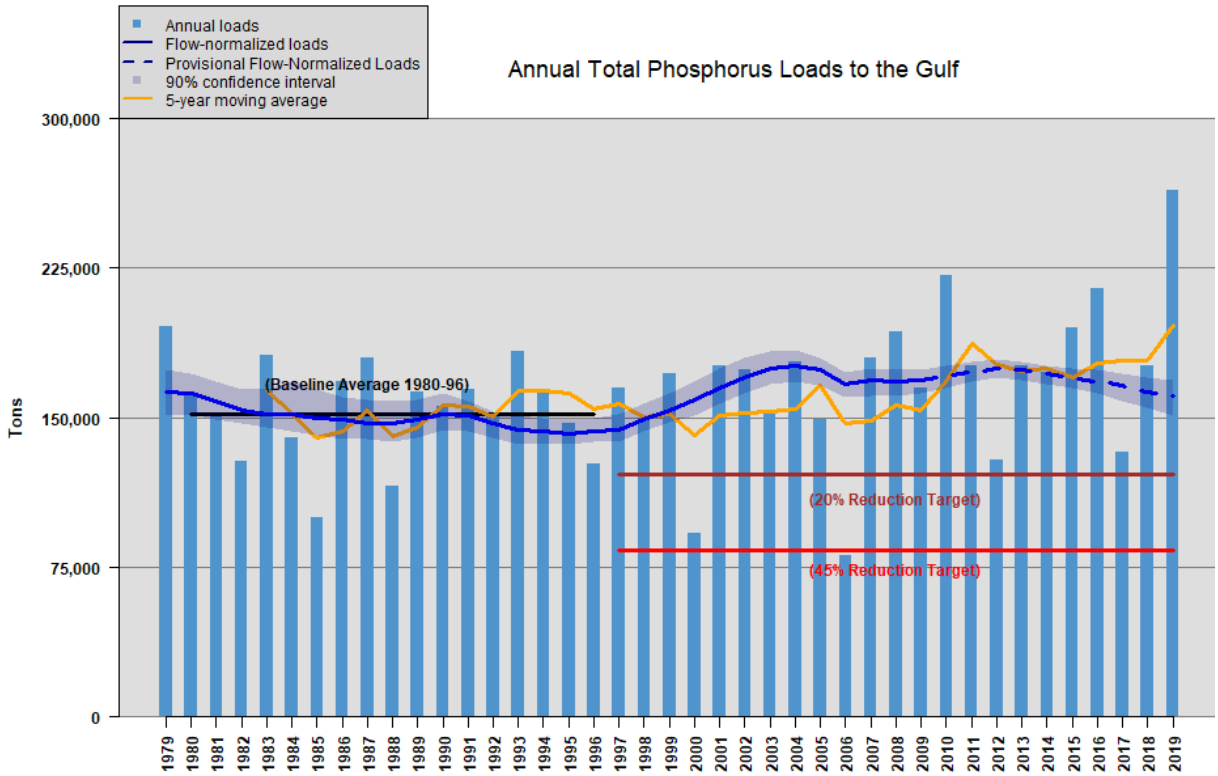

Figure 2-4. Total phosphorus loads to the Gulf from the Mississippi and Atchafalaya rivers between 1980 and 2019. Results from the two metrics used by the HTF to evaluate progress towards nutrient reduction targets—the five-year moving average loads and the flow-normalized loads—are shown.

In addition to these two metrics for tracking nutrient loading trends near the mouth of the Mississippi and Atchafalaya rivers, many of the HTF states have state-specific approaches for tracking water-quality progress (see section 1.6). The HTF is now considering whether to adopt one or more consistent water-quality metrics of progress within the basin, at a sub-basin scale. In May 2019, the HTF chartered a Trends Workgroup to compile current state water-quality metrics and develop options for one or more common approaches for tracking sub-basin water-quality trends. In January 2020, the HTF approved a plan for the Trends Workgroup to continue to engage with the National Great Rivers Research and Education Center (NGRREC) in a partnership to measure and display water quality trends for the public. NGRREC and the Trends Workgroup will continue to collaborate on this effort with guidance from the Coordinating Committee and HTF throughout the process.

2.3.2 Advancements in Modeling Water Quality throughout the MARB

The 2017 Report to Congress provided a detailed overview of MARB-scale modeling assessments using a mechanistic model, SWAT, and a hybrid regression-based model, SPARROW, led respectively by USDA and USGS. While SWAT model results at the MARB-scale have not been updated since the 2017 Report to Congress, work has continued on refining the input data sets, and USDA anticipates publishing updated results in the next year. USGS has updated the SPARROW results since the 2017 Report to Congress, and new results are described below. The HTF uses the data inputs to these models to assist in tracking point nonpoint source metrics along with the model outputs to better understand sources of and decadal trends in nutrient loads to the Gulf.

Conservation Effects Assessment Project Modeling using SWAT

USDA quantifies the effectiveness of conservation practices implemented through NRCS and other programs and uses models to predict impacts of those practices through CEAP. This assessment project provides valuable information to policymakers and conservation planners so they can more effectively allocate conservation dollars and assistance.

Section 3.1 of the 2017 Report to Congress discusses in-depth the USDA CEAP cropland assessment modeled water quality impacts of conservation work throughout the MARB. These assessments were completed for the five sub-basins of the MARB using 2003–2006 conservation data.

To develop the conservation data used in the CEAP assessments, USDA conducts a national survey of farmers. The first national survey of farmers was completed in 2006 and provided the data layer used in the model in the MARB assessments. A second national survey was recently completed in 2016, and USDA expects to publish the second CEAP results for the MARB in early 2022. These two national surveys will provide the HTF with a method to track progress represented by a decade of conservation adoption and highlight areas in which additional conservation will make the largest impact on reducing sediment and excess nutrients to the Gulf.

In addition to the CEAP cropland assessments, section 3.1 of the 2017 Report to Congress also included discussion of CEAP watershed studies that provide insight into the tools necessary to improve water quality at the watershed scale. Current CEAP watershed studies are underway as a complement to the broader scale CEAP cropland assessments and are examining lag time and conservation effects at multiple watershed scales. A new assessment of legacy phosphorus sources, processes and management options was funded in 2021.

Nutrient Modeling using SPARROW

USGS estimates total nitrogen and total phosphorus transport throughout the MARB and into the Gulf using the SPARROW model. USGS recently updated the total nitrogen and total phosphorus SPARROW models to a base year of 2012 (from the initial 2002 base-year model), which means they were developed based on source inputs and management practices similar to those existing during or near 2012 and hydrological conditions from the 2000 to 2014 period. Several updates and improvements were made to the model data inputs and statistical approaches, including the use of a higher resolution stream network (which resulted in a mean catchment size of 2.7 square kilometers compared to 480 square kilometers in the 2002 models); more detailed and updated wastewater treatment plant contribution estimates; inputs from background phosphorus sources that were not included in the 2002 model; and more accurate loads for calibration (Robertson and Saad 2019). Results from the new models can be viewed on-line.

Results from 2012 SPARROW models describe which areas of the MARB deliver the greatest amount of nutrients to the Gulf (Robertson and Saad 2021). For both total nitrogen and total phosphorus, the areas estimated to contribute the greatest loads downstream to the Gulf are in the north-central portions of the MARB (Figure 2-5 and Figure 2-6).

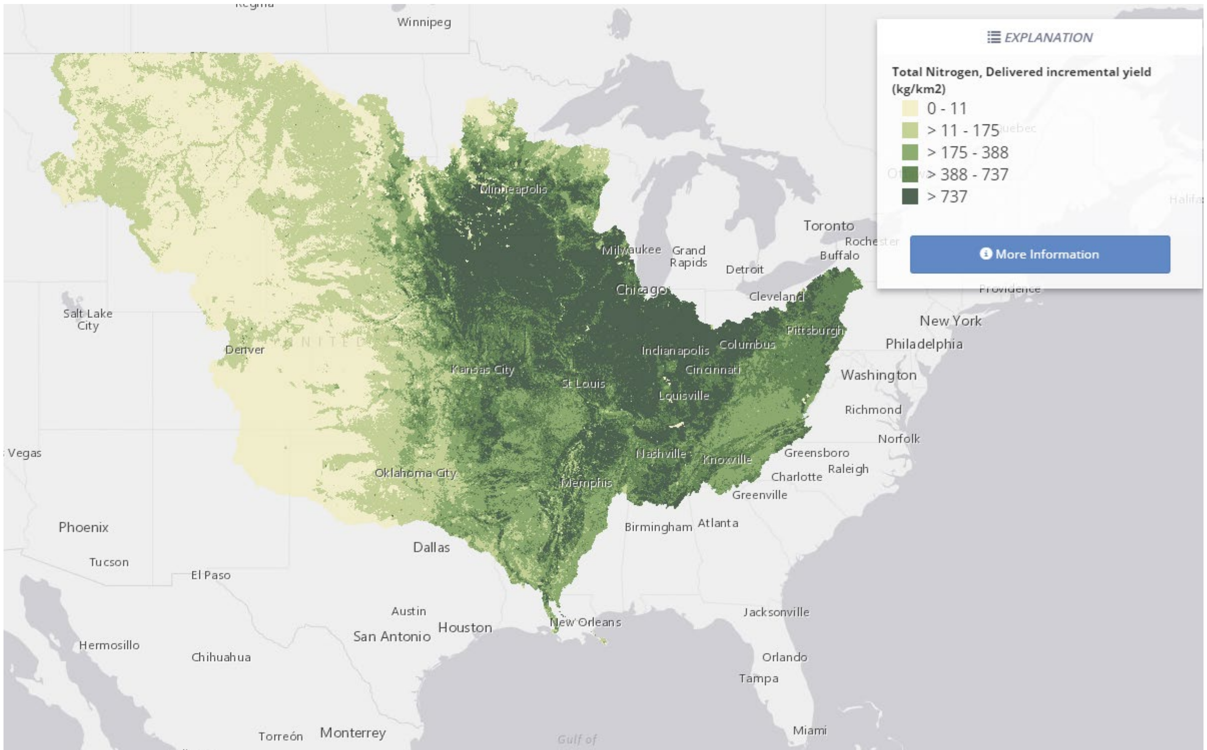

Figure 2-5. Distribution of incremental total nitrogen yields delivered to the Gulf from the Mississippi and Atchafalaya rivers, estimated by the SPARROW model.

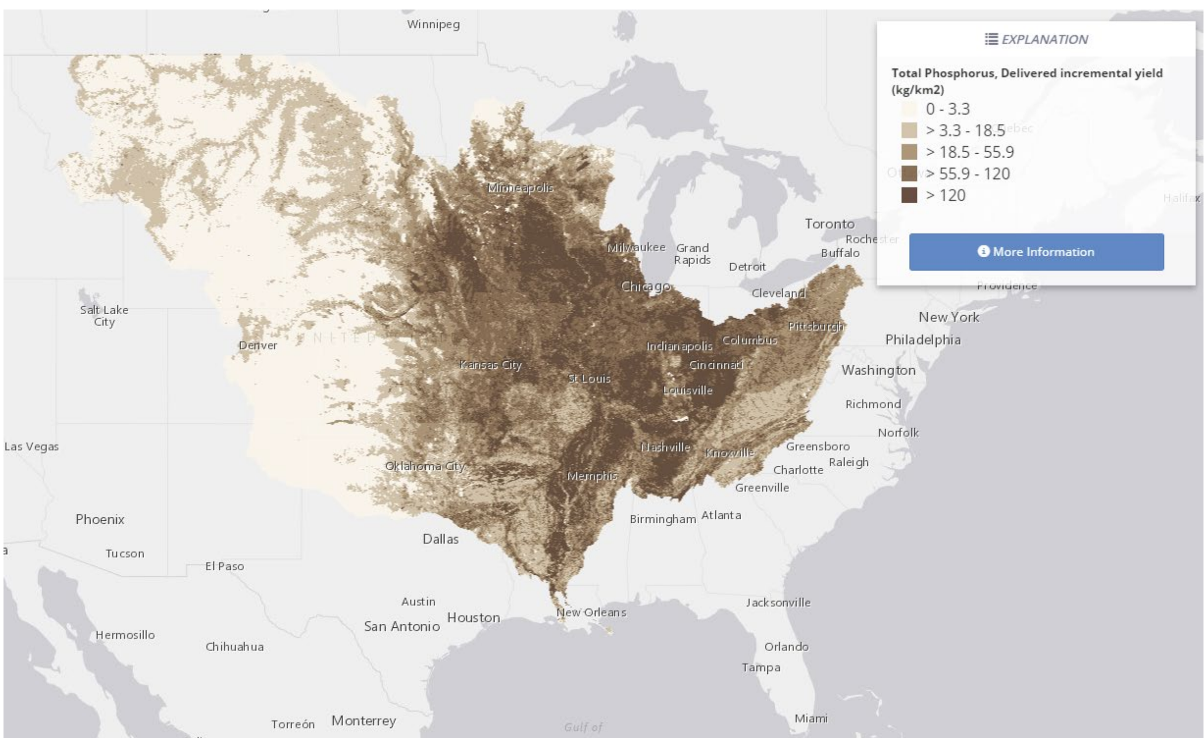

Figure 2-6. Distribution of incremental total phosphorus yields delivered to the Gulf from the Mississippi and Atchafalaya rivers, estimated by the SPARROW model.

Results from 2012 SPARROW models also describe the breakdown of major nutrient sources to the Gulf as a whole or from any specified region within the MARB (Robertson and Saad 2021). For total nitrogen, the major sources were estimated to be atmospheric deposition (33%), fertilizer applied to cropland (25%), nitrogen fixing crops (18%), manure (16%), municipal wastewater treatment discharge (5%), and urban land (2%) (see Figure 2-7). For total phosphorus, the major sources were estimated to be farm fertilizer (38%), natural sources (23%), manure (18%), municipal wastewater treatment discharge (13%), and urban land (8%) (see Figure 2-8). Therefore, agricultural contributions are the largest general source of nitrogen and phosphorus to the Gulf. Model results also indicated that agricultural BMPs reduce the delivery of nutrients to streams and rivers in the MARB (Robertson and Saad 2019; Robertson and Saad 2021).

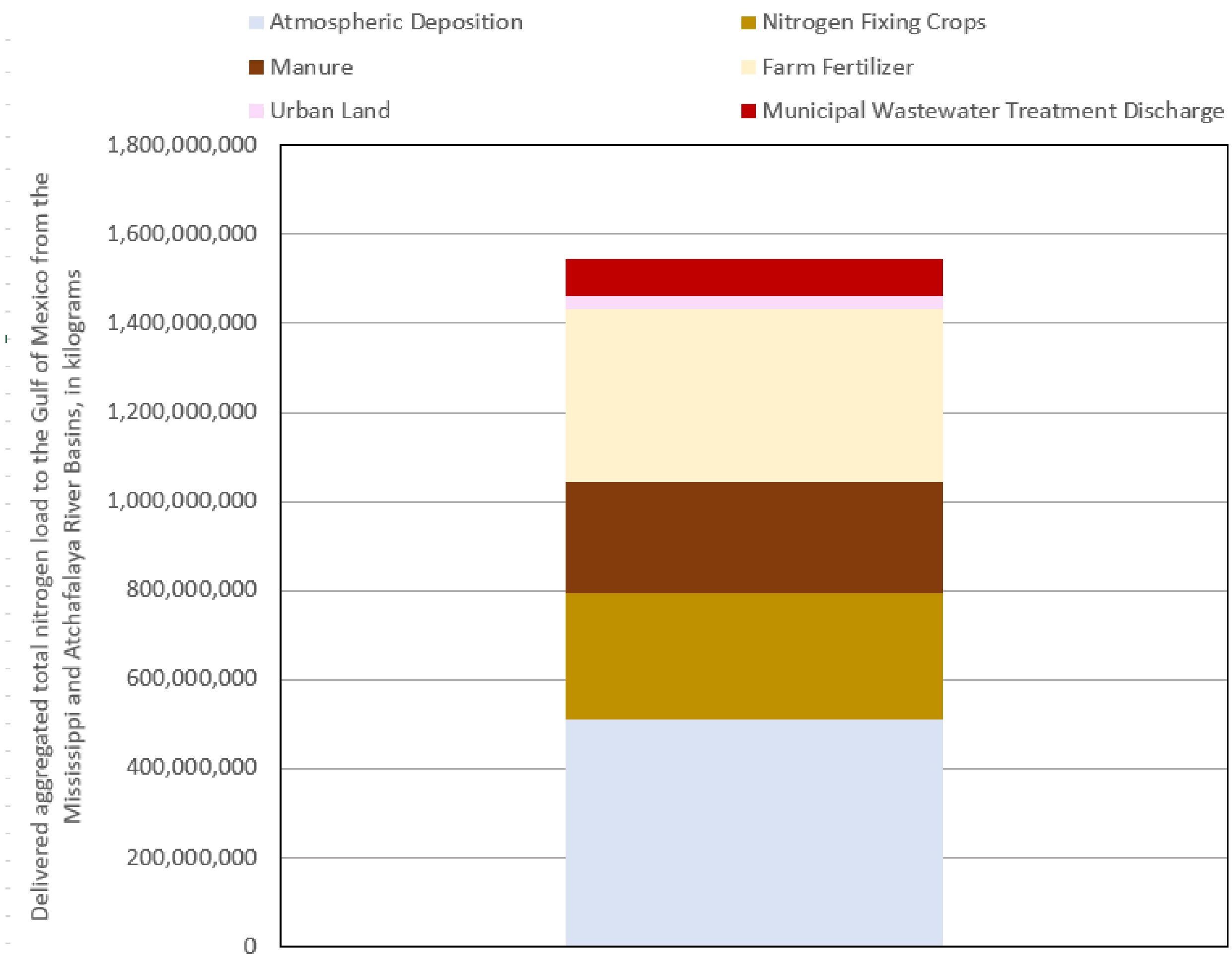

Figure 2-7. Breakdown of sources contributing to the total nitrogen load delivered to the Gulf from the Mississippi and Atchafalaya River Basins, estimated by the SPARROW model.

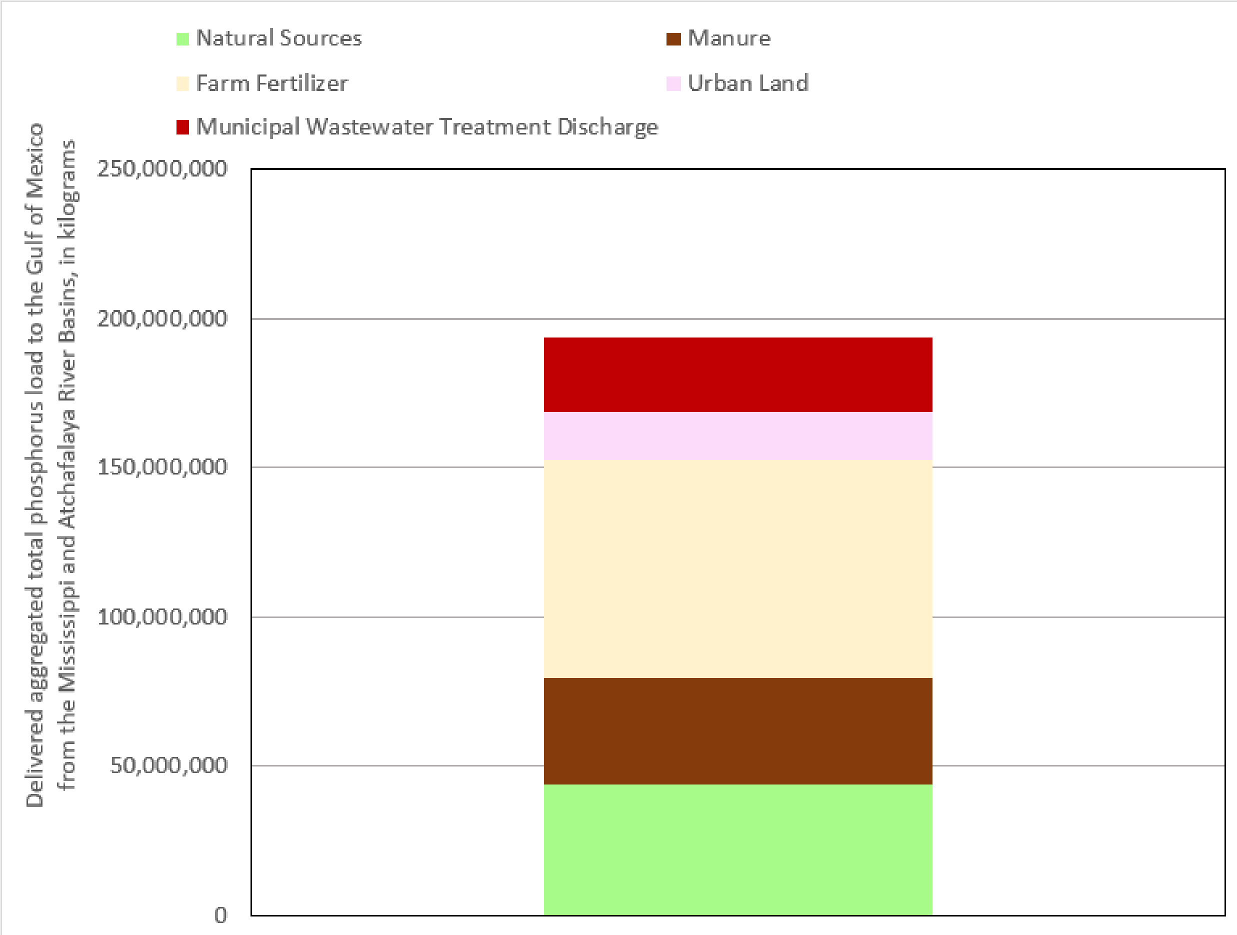

Figure 2-8. Breakdown of sources contributing to the total phosphorus load delivered to the Gulf from the Mississippi and Atchafalaya River Basins, estimated by the SPARROW model.

Part 3. The Economic and Social Effects of the Hypoxic Zone

Hypoxia in the Gulf is a serious environmental concern with much to be explored on the economic, social, and ecological impacts. However, recent and ongoing research investments have expanded the understanding of the effects of hypoxia on fish and fisheries, as well as on economic impacts. Advancements in this field are providing support for management decisions with new tools and forecasting capabilities, generating greater interest in hypoxia, and furthering the body of knowledge surrounding hypoxia.

By reducing the extent and quality of habitat for a variety of organisms, hypoxia affects valuable fisheries and disrupts sensitive ecosystems (Diaz and Rosenberg 2008; Breitburg et al. 2009). Hypoxia has a number of lethal and sublethal effects on ecosystems, such as increased mortality, reduced growth, shifts in fish diet, changes in migration patterns, barriers to spawning pathways, changes to species reproductive success, and sex ratios (Glaspie et al. 2019; LaBone et al. 2019; Rahman and Thomas 2018, 2017; Rose et al. 2017a, 2017b, Langseth et al. 2014; Thomas et al. 2015; Rahman and Thomas 2012; Craig 2012).

The impacts observed at the ecosystem level, in both the MARB and the Gulf, are complex and interwoven along with larger scale socioeconomic effects. The northern portion of the Gulf ecosystem contains almost half of the nation's coastal wetlands and supports commercial and recreational fisheries generating more than $2.8 billion annually. This environmentally significant and economically important geographic area has undergone profound changes due to nitrogen and phosphorus loads from the MARB. Previous NOAA-supported studies have demonstrated the economic impacts of hypoxia on seafood process and the shrimp fishing industry (Purcell et al. 2017; Smith et al. 2017). Analysis of monthly trends in the price of Gulf brown shrimp from 1990 to 2010 showed that hypoxia resulted in short-run price increases for large shrimp compared to the price of small ones (Smith et al. 2017). When the hypoxic zone is present, fishermen catch more smaller shrimp and fewer large ones, making small shrimp cheaper and larger ones more expensive. While the total quantity of shrimp caught could remain the same during hypoxic periods, a reduction in the highly valued large shrimp would lead to a net economic loss for fishermen.

Study results demonstrate that hypoxia alters the spatial dynamics of the Gulf shrimp fishery, and this has potential negative consequences for shrimp harvesting and the economic condition of the fishery (Purcell et al. 2017). Other fisheries affected by hypoxia likely undergo similar spatial fluctuations, and further studies are needed to understand how lethal and sub-lethal hypoxia effects, along with human decisions, can have an economic impact on affected fisheries.

3.1 Advancements in Modeling the Economic and Ecological Impacts of Hypoxia

Three ongoing NOAA-supported projects (2016–2022) are evaluating the impacts of hypoxia on fish and fisheries in the Gulf as well as considering what can be expected from the Gulf fisheries when the 2035 goal is met. The overall objective of these projects is to quantify, through multidisciplinary ecosystem models or other methods, the ecological and socioeconomic impacts of hypoxia, including an evaluation of the effects of alternative management strategies on ecosystem function and living resource populations. Projects include the following:

- Synthesis of long-term data sets and modeling of data to support fisheries and hypoxia management in the northern Gulf. This project is focused on exploring the consequences of hypoxia for regional fisheries and for fish community ecological indicators. Specific outcomes from this project will include:

  1) Estimates of hypoxic area and volume over the entire hypoxic season for the period of record (1985–present) based on the dissolved oxygen sampling data available from the monitoring cruise programs.

  2) A probabilistic biophysical hypoxia model capable of simulating and forecasting dissolved oxygen on multiple sections of the continental shelf over the entire hypoxic season and entire period of record. Results will have a strong empirical basis and quantified uncertainty.

  3) A new set of hypoxia metrics (area, volume, and duration, using multiple hypoxic thresholds: 1 mg/L, 2 mg/L, 3 mg/L) for multiple shelf sections, based on the results of the geostatistical and biophysical modeling.

  4) Evaluation of hypoxia effects on catch and effort from the region's two major commercial fisheries (Gulf menhaden, penaeid shrimp) that incorporates the new hypoxia estimates.

  5) Evaluation of hypoxia effects within the context of other environmental and anthropogenic stressors on ecological indicators of upper-trophic-level fish community currently in use to monitor the status of the Gulf ecosystem. (Project page).

- Linking models to connect nutrient pollution and impacts of diversions on hypoxia and the subsequent impacts on living resources. Modeling results will provide managers with new quantitative information about how nutrient reductions will affect fish populations, and how the combination of river diversions and hypoxia will affect fish and shrimp populations. A second outcome will be a tool that provides consistent and defensible predictions, from the watershed to the living resources. In the longer term, results will contribute to management decisions about watersheds and diversions that reduce the extent and severity of the hypoxic zone, based least partially on fishery population-level responses. (Project page).
- User-driven tools to predict and assess effects of reduced nutrients and hypoxia on living resources in the Gulf. These tools will predict how hypoxia could affect species-specific fish growth rate potential as a metric of Essential Fish Habitat and biomass and catch of ecologically and economically important living resources. The project will lead to an improved capability to assess the effects of alternative management strategies on ecosystem function, living resources, and fisheries revenue. (Project page).

The full project results are expected in the 2021–2022 timeframe and will be valuable to the HTF as it continues to implement the 2008 Action Plan.

Part 4. Lessons Learned

4.1 The Critical Role of Partnerships

Since the HTF adopted its 2008 Action Plan, the HTF has engaged a full range of public and private sector partners. States are implementing their nutrient reduction strategies by working with universities, agricultural associations, business councils, conservation organizations, municipalities, wastewater utilities, nonprofits, private companies, and private foundations.

The scope of the HTF's 2035 goal and 2025 interim target requires this wide array of partners. As noted in Part 1 of this report, reducing the nutrient load delivered to the northern Gulf every year is an extraordinary challenge, requiring conservation on millions of acres across nearly half the United States. Recent science confirms that meeting the HTF's 2035 goal for reducing the size of the Gulf hypoxic zone will require nitrogen and phosphorus reductions of about 48% (Fennel and Laurent 2018). The scope and scale of this challenge is driving the development of new levels of collaboration among states, federal partners, and stakeholders to widen the circle of engagement, accelerate innovation, and amplify efforts to achieve the results needed.

Further expansion of partnerships is necessary to support the many needs of the HTF. Research needs range from the social sciences (e.g., how to successfully promote the implementation of conservation practice systems) to the physical sciences (e.g., nutrient transport, transformation, and fate); the HTF Research Needs Workgroup has identified key research needs to effectively support state implementation of nutrient reduction strategies. Of these, they have noted seven needs as the most important for states to better understand and published these needs in a letter to the HTF in August 2020. Implementation requires partners who can provide planning, engineering, technical assistance, funding, and on-the-ground services. Partners are needed who can help national soil and water conservation efforts move to the next level, by fully integrating water quality considerations into activities across urban, suburban, industrial, and rural landscapes. Examples of these key partnerships and partner organizations include:

- Citizen Science Projects: Several states support volunteer citizen monitoring projects that vastly increase the amount of screening and other data available to agency personnel. In Kentucky, the Watershed Watch program, which is sponsored by Kentucky Division of Water (DOW) and its university and environmental group partners, involves hundreds of trained citizens who monitor more than 700 sites for a suite of parameters, including nutrients. Results are collected and posted online by the Kentucky Geological Survey and analyzed by university scientists and other professionals.
- Farmer-Led Watershed Projects: Across the Midwest, farmer-led watershed projects are assessing nutrient sources, and implementing conservation practices. The North Central Water Region Network's Southern Extension and Research Activities Committee number 46 (SERA-46): members, and other partners in multiple states are supporting these groups with technical assistance, seminars, and other resources.
- SERA-46: This consortium of university scientists serves as the research and extension arm of the HTF. SERA-46 is supported by USDA and land grant universities and brings together a multistate group of researchers and extension specialists to explore and inform future action on the environmental, social, and economic factors that contribute to reducing nutrient loss from agricultural lands.

- Nutrient Trading Partnerships: With USDA support and working with the Iowa DNR and Iowa Soybean Association, the Iowa League of Cities has built the Iowa Nutrient Reduction Exchange (NRE) to support water quality and multi-environmental benefit trading. In April 2020, the City of Dubuque and Iowa DNR, working with the Sand County Foundation, signed a memorandum of agreement that allows Dubuque to meet certain State of Iowa water quality requirements by working with farmers to implement farm conservation practices to reduce erosion and farm nutrient runoff instead of making expensive upgrades to its wastewater treatment plants.
- The Ecosystem Services Market Consortium was launched to bring together corporate and NGO stakeholders, sustainable agriculture experts, soil scientists, producers, buyers, and sellers to undertake the critical research and science for a viable, scalable, and cost-effective ecosystem services marketplace.
- Walton Family Foundation: This Arkansas-based foundation, which supports and maintains a broad portfolio of programs focused on healthy fisheries, is working to preserve coastal economies, improve water quality and availability, and restore wetlands. The foundation is supporting the HTF states and their partners by funding an ambitious effort to identify and inventory conservation practices across the Mississippi River Basin, so that nutrient reductions can be better quantified.
- The Nature Conservancy Floodplain Tool: The Nature Conservancy developed a Floodplain Prioritization Tool (FP Tool) for planners to optimize conservation and restoration investments; minimize the impacts of development on water quality, flooding, aquatic life, the economy, and quality of human life; and identify critical opportunities for floodplain conservation and restoration in the Mississippi River Basin. The FP tool is being applied by local planners in partnership with decision-makers, enhancing federal, state and local collaboration.
- Farmers Cooperatives: These types of cooperatives are advancing data driven conservation decision making on farms. Land O'Lakes, a farmer-owned cooperative of nearly 4,000 producers and retailers has developed an innovative model that brings together agricultural technology and on-farm business management to tailor conservation practices to individual farms. The system includes interactive digital platforms that help farmers advance their stewardship goals and monitor their return on investment in real time.

4.2 The Importance of Incorporating Scientific Advancements and New Findings into Nutrient Strategies

The HTF, its partners, and the scientific community have made tremendous strides in characterizing the hypoxic zone and many of the upstream, land-based factors that contribute to its annual formation. Research on the scope and scale of efforts for achieving the necessary nutrient reductions has been impressive, and the findings provide insight into expanding conservation implementation (Sharpley et al. 2019; Fennel and Laurent 2018; CAST 2019).

Because much of the nutrient load in the northern Gulf originates on agricultural land, research into the application, fate, and transport of fertilizer applied to Midwestern lands is critical. Researchers have found that "managing agricultural nutrients to achieve water quality goals involves complexities best organized around source and transport processes," because once nutrients are applied, "management outcomes are influenced by several factors across many scales, most uncontrollable, which must be considered when transferring science into policy" (Sharpley et al. 2019). Attempts to intercept, treat, or otherwise address nutrients after they are mobilized on the landscape is complex, difficult, and often costly. More effectively planning and calibrating nutrient applications provides the opportunity to improve both a producer's return on investment and water quality. For example, the Fertilizer Institute, The Nature Conservancy, and state partners promote optimized on-farm nutrient management using the 4Rs (SERA-46 2018). This educational approach highlights the key decision points in crop nutrient application, from selecting crop-specific blends of nitrogen and phosphorus to ensuring efficient uptake by plants. It also guards against practices that might lead to excessive fertilizer runoff, like applying fertilizer on frozen or wet ground before a storm. Nutrient management is challenging to scale up (Osmond et al. 2012), and this communication strategy is reaching many nutrient application decision makers. Recent work by a partnership in Iowa builds on the 4Rs of nutrient management to include additional elements of a conservation treatment system in a 4R Plus Program to further reduce nutrient losses.

States and the private sector are using science-based decisions for fertilizer application, tillage, and other crop management activities in planning and assessment methods. For example, the Operational Tillage Information System (OpTIS) uses publicly available remote sensing data to map and monitor tillage practices, plant residue, and cover crops (CTIC 2019). OpTIS and similar data-driven tools are being developed to aid farm planning, target conservation efforts, validate ecosystem market credits, model greenhouse gases, and track soil moisture and overall soil health. Iowa State University and its partners sponsor an online tool that calculates economic returns for nitrogen applications using variable nitrogen and corn prices to determine the optimum profitable application rate, given the estimated increase in production.

The HTF NPS Workgroup developed a list of key conservation practices, by working with SERA-46 and the Walton Family Foundation. The HTF NPS Workgroup is identifying, inventorying, and analyzing these practices to derive nutrient loss estimates using a Conservation Tracking Framework (Christianson 2019). The framework can be used across HTF states to ensure centralized, consistent, and accessible data sources for assessing progress. This framework can also be used to support each state as it implements its individual nutrient strategies and help ensure agricultural conservation practices adopted across the MARB are accurately and consistently reported.

4.3 The Value of State Strategies that Include Core Elements Adapted to Local Circumstances

While many sources contribute to excess nutrients in the MARB, much of the nutrients in MARB waterways and the Gulf come from nonpoint sources, a majority of which are from agricultural losses (Robertson and Saad 2021; Robertson and Saad 2019; White et al. 2014). During the 20-plus year history of the HTF, the federal policy and legal and regulatory framework for managing nonpoint source pollution has remained largely unchanged, relying on state strategies and programs; federal financial and technical assistance and investments in science; and some efforts to encourage market-based approaches, including trading between regulated point sources and unregulated nonpoint sources. This framework, which encompasses more than two decades of research, multiple conservation developments and implementation, wastewater treatment improvements, nutrient management innovation, and partnership building by the HTF and many others, shows that there is no *one-size-fits-all* approach to reducing excess nutrients. State-led nutrient reduction strategies—with each state using a combination of regulatory programs, financial and technical assistance, and community-based and innovative approaches that works best for that state and its partners and stakeholders, and supported by federal partners—continue to be the cornerstone of the HTF's strategic work. Still, while recognizing the need for flexibility and adaptability, there are common themes that emerge from these state-led efforts and inform the HTF's future directions. These include:

- Identifying and targeting the highest priority nutrient source areas for conservation treatment is necessary to make the most progress. Data-driven tools (e.g., remote sensing and analysis, modeling) that identify priority nutrient source areas, inventory existing conservation practices, and estimate nutrient load reduction can help target scarce resources.
- Nutrient management can provide a strong return on conservation investments and reduce costs for producers, providing an economic incentive for progress. Yet, in many areas, achieving nutrient reduction at the scale needed to meet the HTF's 2035 goal and local water quality objectives will require the use of additional elements of a comprehensive conservation system to also control and trap excess nutrients.
- Given the scale of work needed, the HTF should more fully consider opportunities to expand the use of market and community-based approaches to broaden the circle of partners who invest in reducing excess nutrients in the MARB.
- Communicating examples of success to producers and their networks of trusted advisors is critical for progress. Highlighting stories of success and of remaining challenges to the public at large is also essential to sustaining and expanding the HTF's work.

Part 5. Recommended Appropriate Actions to Continue to Implement or, if Necessary, Revise the Strategy Set Forth in the Gulf Hypoxia Action Plan 2008

5.1 Continue to Implement the 2008 Action Plan

Much has been accomplished since the HTF adopted its *2008 Gulf Hypoxia Action Plan* over a decade ago, and much more work remains to be done. However, state-of-the-art scientific and social knowledge has advanced significantly. The 2008 Action Plan set in motion scientific, technical, educational, and public policy activities to more thoroughly assess the problem and advance the adoption of solutions. The groundwork laid over the intervening years now provides a clear path forward. No significant changes are needed in the specific actions in the plan. State and federal members and their many partners and stakeholders should continue monitoring, assessing progress, taking action, and adaptively managing their work. This will include testing new approaches that can enlist additional partners and resources to help the HTF achieve its goals.

Activities set in motion by the 2008 Action Plan—supporting state nutrient loss reduction strategies, accelerating nutrient loss reduction, advancing the science, tracking progress, and raising awareness—remain relevant. Leveraging existing conservation and water management programs, promoting efficient and effective nutrient reduction practices, and scaling up successful watershed planning approaches are foundational to success (Rao and Power 2019). Harnessing the power of "big data" to assess nutrient impacts, quantify pollutant loads, prioritize management actions, track conservation practices, and evaluate programs and progress is essential.

Advancements in the scientific understanding of nutrient transport, transformation, and fate over the past 20 years have reduced some uncertainties regarding the dynamic processes associated with the challenges and solutions needed to advance implementation, but much work remains to be done (Sharpley et al. 2019). The HTF must continue to rely upon evidence to advance towards its goals.

Finally, more effective communication is necessary to increase awareness of Gulf hypoxia and build a broader understanding of the wide array of work being accomplished by the HTF states, the challenges they face, and the need for greater support and engagement by partners and stakeholders to make more progress. Example actions the HTF is taking to highlight these issues include a newsletter and release of a storymap to highlight success stories where states have reduced nutrients.

5.2 Accelerate Actions to Reduce Excess Nutrients

Accelerated implementation of State Nutrient Reduction Strategies supported by federal HTF members and with active participation by private sector, nongovernmental, and other partners and stakeholders continues to be the path forward. Examples of recent state actions that the HTF can build on to accelerate progress include the following:

- Arkansas, Kentucky, Louisiana, and Tennessee are now engaging their citizens, businesses, and producers in reviewing and revising their nutrient reduction strategies. For example, Tennessee brought together stakeholders representing wastewater, stormwater, agriculture, industry, and nonprofit environmental groups to create a Multidisciplinary Nutrient Strategy Task Force. The Task Force held a kick-off meeting on February 12, 2019 and will meet quarterly to discuss the current nutrient strategy framework, learn the science behind the framework, and explore ways to expand the framework via stakeholder-led discussion and voluntary engagement. Meanwhile these states continue to work to reduce nutrient losses. Louisiana is planning for massive river diversion/marsh creation projects that have the potential to sequester enormous levels of excess phosphorus and nitrogen.

- In Illinois, 28% of major municipal wastewater facilities, with more than 80% of the state's municipal discharge capacity, have a permit effluent limit of 1.0 mg/L for total phosphorus. All major municipal facilities are required to meet an annual total phosphorus effluent limit of 0.5 mg/L, with the timeframe for compliance (2025, 2030, or 2035) depending on the treatment process (sooner for chemical treatment, later for biological treatment). There are some exceptions such as if the upgrade would cause widespread social and economic hardship. All major municipal facilities that are upstream of a waterway impaired by nutrient-related pollution or that cause or contribute to a risk of eutrophication must develop a NARP.
- Indiana is tracking conservation practices and associated nutrient loss reduction tallies by county and posting its progress online through a series of locational and thematic maps.
- In Iowa, new legislation will provide more than $270 million for water quality efforts over the next 12 years to agricultural conservation practices and systems, WWTP improvements, outreach, education, monitoring, and research. The state has already reduced phosphorus loads by more than 18%.
- Minnesota's riparian buffer policy has achieved an implementation rate of more than 90% statewide. Between 2005 and 2017, wastewater point source phosphorus discharges were reduced 72% in areas draining to the Mississippi River.
- Mississippi is engaging with academic and nonprofit partners and taking a data-driven approach to advancing the understanding of agricultural conservation practice implementation and informing further investments. MDEQ and partners collect water quality data in watersheds where nutrient reduction practices have been implemented. This data, collected pre- and post-implementation and representing varying flow regimes, will be used to determine nutrient load reductions and evaluate costs and benefits.
- Missouri continues to use a portion of its state sales tax to support investment in watershed projects, including funding stream exclusion practices for pastured livestock. In FY 2018, the Soil and Water Conservation Program processed 8,147 contracts for installing agricultural BMPs for a total of $40 million (100 % of appropriation). That is the largest percentage of the Parks, Soils and Water Sales Tax used to fund BMPs since the tax was implemented in 1984. The state requires cost-share program participants to attend a "grazing school" to learn how to reduce nutrient losses from pasture lands.
- In Ohio, fertilizer application training and certification has reached more than 17,000 enrollees.
- Wisconsin is targeting high-priority watersheds and using point source-nonpoint source adaptive management and trading programs to lower the costs of reducing excess nutrients.

These are only a small sampling of state programs, policies, and activities underway across the MARB watershed. Scaling up progress throughout the MARB will require significantly broader engagement.

In addition to state efforts, USDA has committed to continue the Mississippi River Basin Healthy Watersheds Initiative and the National Water Quality Initiative, which support implementation of State Nutrient Reduction Strategies and efforts to address impaired waters, respectively. These initiatives provide accelerated funding for conservation practices, use of watershed planning/assessment tools and identification of critical source areas to help target outreach and implementation to areas most in need of treatment.

Many of the most promising prospects for future success will be realized through innovations underway among agricultural associations, producer organizations, supply chain consortiums, and other private sector entities. Farmer-led watershed management projects are of particular note. Farmers can lead the development of water quality monitoring, BMP targeting, and conservation implementation approaches via peer-to-peer consultation or through decision-making structures incorporating their input (Benning et al. 2019). Having peers and community members provide advice on the nature of the challenge, workable solutions, and how to seek out and use professional and technical information helps to reach and involve more producers in conservation activity. Leadership and development training is vital to further expand this important model.

A more robust use of market-based approaches has promise for increasing progress by encouraging investment in low-cost approaches to reducing excess nutrients and increasing return on investments in achieving reductions. An emerging concept that borrows from nutrient trading and wetland banking frameworks is selling ecosystem credits to investors and using the funds to pay for conservation practices and other environmental improvements. Purchasers of the credits could be corporations seeking to meet corporate sustainability goals, entities involved in enforcement actions, governmental units seeking remediation options for infrastructure projects, or other investors. The market for ecosystem credits from agriculture nationwide could be as high as $13.9 billion, according to some estimates. Credit sale income could support projects that contract with farmers and ranchers to adjust crop and livestock production systems in ways that improve water quality, increase carbon sequestration, and enhance other ecosystem services. A national credit market could promote sale of the credits, organize the payments to producers, and verify that conservation practices were installed and maintained (ESMC 2019).

While the HTF acknowledges the challenge of scaling up use of conservation systems on vulnerable lands, upgrading wastewater treatment, and reducing other sources of excess nutrients across a landscape as vast as the MARB, these examples provide a sense of the opportunities for further progress in improving local water quality and reducing Gulf hypoxia.

5.3 Better Communicate Results to the Public

Many HTF states and federal members regularly communicate to their constituencies about work they do to reduce excess nutrients in waterways, their scientific studies on Gulf hypoxia, and causes of hypoxia. To amplify and support these efforts, the HTF is implementing a communication strategy to highlight topics such as successful projects and programs that have the potential for replication in other states; case studies that result in demonstrable progress or measurable environmental results; opportunities to support markets to fund watershed improvements and establish nutrient trading programs; and innovative partnerships created by supply chain and other market-based entities.

EPA, on behalf of the HTF, recently began publishing a regular newsletter to highlight state and federal activities, upcoming events, and resources and to help build awareness of and support for implementing nutrient reduction strategies. The HTF Communications Workgroup is exploring opportunities to enhance public awareness of HTF accomplishments and promote and support actions that reduce nutrient inputs and improve water quality. They are working to develop tools and strategies and looking for opportunities to communicate with HTF partners and the public about progress, challenges, and needs for achieving the HTF hypoxic zone reduction goal.

5.4 Conclusion

This third report to Congress, required by the 2014 HABHRCA Amendments, describes the progress made by the HTF toward attainment of its goals since the 2017 Report to Congress. The members of the HTF continue to work collaboratively to implement the 2008 Action Plan. All HTF states are implementing strategies to reduce excess nutrients in the MARB that contribute to the hypoxic zone in the Gulf. The HTF is committed to making strong progress on implementing these strategies and other actions outlined in the 2008 Action Plan. Federal agencies are providing coordination support and technical and financial assistance and engaging in scientific investigations to support state and tribal efforts to reduce excess nutrients. The HTF continues to forge action-focused partnerships, employing innovative approaches, and investing in tracking progress. The HTF remains committed to meeting its 2025 interim target and its 2035 goal for reducing Gulf hypoxia.

References

Benning, J., J. Bonnell, M. Daniels, A. Gumbert, and R. Power. 2019. *Fostering and Facilitating Farmer Leadership in Watershed Management Projects: A Needs Assessment*. Mississippi and Atchafalaya River Basin Watershed Leadership Network, Madison, WI.

Breitburg, D.L., D.W. Hondorp, L.A. Davias, and R.J. Diaz. 2009. Hypoxia, nitrogen, and fisheries: Integrating effects across local and global landscapes. *Annual Review of Marine Science* 1:329–349.

CAST (Council for Agricultural Science and Technology). 2019. *Reducing the Impacts of Agricultural Nutrients on Water Quality across a Changing Landscape*. CAST Issue Paper Number 64, April 2019. Council for Agricultural Science and Technology, Ames, IA. https://www.cast-science.org/wp-content/uploads/2019/05/CAST_IP64_Nutrient-Loss.pdf.

Christianson, L. 2019. *Conservation Practice Tracking*. Illinois Drainage Research and Outreach Program (I-DROP) web page. Accessed August 2020. http://draindrop.cropsci.illinois.edu/index.php/i-drop-impact/mississippi-river-basin-nutrient-loss-reduction-measurement-framework/conservation-practice-tracking/.

Craig, J.K. 2012. Aggregation on the edge: Effects of hypoxia avoidance on the spatial distribution of brown shrimp and demersal fishes in the Northern Gulf of Mexico. *Marine Ecology Progress Series* 445:79–95.

CTIC (Conservation Technology Information Center). 2019. *OpTIS: Operational Tillage Information System. Using Remote Sensing Data to Map Conservation Practices* web page. Conservation Technology Information Center, West Lafayette, IN. https://www.ctic.org/OpTIS.

Del Giudice, D., V.R.R. Matli, and D.R. Obenour. 2019. Bayesian mechanistic modeling characterizes Gulf of Mexico hypoxia: 1968–2016 and future scenarios. *Ecological Applications*. doi.org/10.1002/eap.2032.

Diaz, R.J., and R. Rosenberg. 2008. Spreading dead zones and consequences for marine ecosystems. *Science* 321:926–929.

ESMC (Ecosystem Services Market Consortium). 2019. Ecosystem Market Services: Growing Resilience in Agriculture home page. Accessed August 2020. https://ecosystemservicesmarket.org/.

Feist, T.J., J.J. Pauer, W. Melendez, J.C. Lehrter, P.A. DePetro, K.R. Rygwelski, D.S. Ko, and Kreis, R.G. Jr. 2016. Modeling the Relative Importance of Nutrient and Carbon Loads, Boundary Fluxes, and Sediment Fluxes on Gulf of Mexico Hypoxia. *Environ. Sci. Technol*. 50, 8713-8721.

Feng, Y., S.F. DiMarco, and G.A. Jackson. 2012. Relative role of wind forcing and riverine nutrient input on the extent of hypoxia in the northern Gulf of Mexico. *Geophysical Research Letters* 39(9). doi.org/10.1029/2012GL051192.

Fennel, K., and A. Laurent. 2018. N and P as ultimate and proximate limiting nutrients in the northern Gulf of Mexico: Implications for hypoxia reductions strategies. *Biogeosciences* 15:3121–3131. doi.org/10.5194/bg-15-3121-2018.

Glaspie, C.N., M. Clouse, K. Huebert, S.A. Ludsin, D.M. Mason, J.J. Pierson, M.R. Roman, and S.B. Brandt. 2019. Fish diet shifts associated with the northern Gulf of Mexico hypoxic zone. *Estuaries and Coasts*. 42:2170. doi.org/10.1007/s12237-019-00626-x.

Hirsch, R.M., D.L. Moyer, and S.A. Archfield. 2010. Weighted regressions on time, discharge, and season (WRTDS), with an application to Chesapeake Bay River inputs. *Journal of the American Water Resources Association* 46:857–880. doi.org/10.1111/j.1752-1688.2010.00482.x.

Hirsch, R.M., S.A. Archfield, and L.A. De Cicco. 2015. A bootstrap method for estimating uncertainty of water quality trends. *Environmental Modelling and Software* 73:148–166. doi.org/10.1016/j.envsoft.2015.07.017.

Jarvis, B.M., R.M. Greene, Y. Wan, J.C. Lehrter, L.L. Lowe, and D.S. Ko. 2021. Contiguous Low Oxygen Waters Between the Continental Shelf Hypoxia Zone and Nearshore Coastal Waters of Louisiana, USA: Interpreting 30 Years of Profiling Data and Three-Dimensional Ecosystem Modeling. *Environ. Sci. Technol*. 55 (8), 4709-4719.

Justić, D., and L. Wang. 2014. Assessing temporal and spatial variability of hypoxia over the inner Louisiana–Upper Texas shelf: Application of an unstructured-grid three-dimensional coupled hydrodynamic-water quality model. *Continental Shelf Research* 72:163–179.

Kim, J., P. Chapman, R. Gilbert, S. Dimarco, and D. Thornton. 2020. Implications of different nitrogen input sources for potential production and carbon flux estimates in the coastal Gulf of Mexico (GOM) and Korean Peninsula coastal waters. *Ocean Science*. 16:45–63. doi.org/10.5194/os-16-45-2020.

LaBone, E., D. Justić, K. Rose, L. Wang, and H. Huang. 2019. Modeling fish movement in 3-D in the Gulf of Mexico hypoxic zone. *Estuaries and Coasts* 42(6):1662–1685. doi.org/10.1007/s12237-019-00601-6.

Langseth, B.J., K.M. Purcell, J.K. Craig, A.M. Schueller, J.W. Smith, K.W. Shertzer, S. Creekmore, K.A. Rose, and K. Fennel. 2014. Effects of changes in dissolved oxygen concentrations on the spatial dynamics of the Gulf menhaden fishery in the northern Gulf of Mexico. *Marine and Coastal Fisheries* 6:223–234.

Laurent, A., K. Fennel, D.S. Ko, and J. Lehrter. 2018. Climate change projected to exacerbate impacts of coastal eutrophication in the northern Gulf of Mexico. *Journal of Geophysical Research: Oceans* 123:3408–3426. doi.org/10.1002/2017JC013583.

Laurent, A., and K. Fennel. 2019. Time-evolving, spatially explicit forecasts of the northern Gulf of Mexico hypoxic zone. *Environmental Science & Technology*. doi.org/10.1021/acs.est.9b05790.

Lee, C.J., J.C. Murphy, C.G. Crawford, and J.R. Deacon. 2017. *Methods for Computing Water-Quality Loads at Sites in the U.S. Geological Survey National Water Quality Network*. Open File Report 2017–1120. U.S. Geological Survey. doi.org/10.3133/ofr20171120.

Lee, C.J., R.J. Henderson, and J.D. Deacon. 2019. *Nutrient loading for the Mississippi River Basin and subbasins*. U.S. Geological Survey web page. Accessed May 6, 2021. https://nrtwq.usgs.gov/mississippi_loads/.

Lehrter J.C., D.S. Ko, L.L. Lowe, B. Penta. 2017. Predicted Effects of Climate Change on Northern Gulf of Mexico Hypoxia. In: Justic D., K. Rose, R. Hetland, K. Fennel (eds) Modeling Coastal Hypoxia. Springer, Cham. doi.org/10.1007/978-3-319-54571-4_8.

Matli, V.R.R., S. Fang, J. Guinness, N.N. Rabalais, J.K. Craig, and D.R. Obenour. 2018. Space-time geostatistical assessment of hypoxia in the Northern Gulf of Mexico. *Environmental Science & Technology* 52(21):12484–12493. doi.org/10.1021/acs.est.8b03474.

MCWFT (Minnesota Clean Water Fund Team). 2020. *Clean Water Fund Performance Report*. https://www.legacy.mn.gov/sites/default/files/resources/lrp-f-1sy20.pdf.

NOAA (National Oceanic and Atmospheric Administration). 2017a. *Multi-pronged modeling yields new guidance to mitigate Gulf of Mexico 'Dead Zone'.* Accessed December 2017. https://coastalscience.noaa.gov/news/multi-pronged-modeling-yields-new-guidance-mitigate-gulf-mexico-dead-zone/.

NOAA (National Oceanic and Atmospheric Administration). 2017b. *Gulf of Mexico 'dead zone' is the largest ever measured*. Accessed September 2017. https://www.noaa.gov/media-release/gulf-of-mexico-dead-zone-is-largest-ever-measured.

NOAA (National Oceanic and Atmospheric Administration). 2018a. *Average sized dead zone forecast for Gulf of Mexico*. Accessed June 2018. https://www.noaa.gov/media-release/average-sized-dead-zone-forecast-for-gulf-of-mexico.

NOAA (National Oceanic and Atmospheric Administration). 2018b. *Below-average 'dead zone' measured in Gulf of Mexico.* Accessed September 2018. https://www.noaa.gov/media-release/below-average-dead-zone-measured-in-gulf-of-mexico.

NOAA (National Oceanic and Atmospheric Administration). 2019a. *NOAA forecasts very large 'dead zone' for Gulf of Mexico.* Accessed December 2019. https://www.noaa.gov/media-release/noaa-forecasts-very-large-dead-zone-for-gulf-of-mexico.

NOAA (National Oceanic and Atmospheric Administration). 2019b. *Large 'dead zone' measured in Gulf of Mexico.* Accessed December 2019. https://www.noaa.gov/media-release/large-dead-zone-measured-in-gulf-of-mexico.

NOAA (National Oceanic and Atmospheric Administration). 2020. *Larger-than-average 'dead zone' expected for Gulf of Mexico*. Accessed May 2020. https://www.noaa.gov/media-release/larger-than-average-dead-zone-expected-for-gulf-of-mexico.

Osmond, D.L., D.W. Meals, D.LK. Hoag, and M. Arabi, ed. 2012. *How to Build Better Agricultural Conservation Programs to Protect Water Quality: The National Institute of Food and Agriculture-Conservation Effects Assessment Project Experience*. Accessed October 2019. Soil and Water Conservation Society, Ankeny, IA. https://www.swcs.org/resources/publications/books/how-to-build-better-agricultural-conservation-programs-to-protect-water-quality.

Purcell, K.M., J.K. Craig, J.M. Nance, M.D. Smith, and L.S. Bennear. 2017. Fleet behavior is responsive to a large-scale environmental disturbance: Hypoxia effects on the spatial dynamics of the northern Gulf of Mexico shrimp fishery. *PLoS ONE* 12(8):e0183032. doi.org/10.1371/journal.pone.0183032.

Rabalais, N.N., R.E. Turner, B.K. Gupta, D.F. Boesch, P. Chapman, and M.C. Murrell. 2007. Hypoxia in the northern Gulf of Mexico: Does the science support the plan to reduce, mitigate, and control hypoxia. *Estuaries and Coasts* 30(5):753–772.

Rahman, M.S., and P. Thomas. 2012. Effects of hypoxia exposure on hepatic cytochrome P450 1A (CYP1A) expression in Atlantic croaker: Molecular mechanisms of CYP1A down-regulation. *PloS ONE* 7(7):e40825. doi.org/10.1371/journal.pone.0040825.

Rahman, M.S., and P. Thomas. 2017. Molecular and biochemical responses of hypoxia exposure in Atlantic croaker collected from hypoxic regions in the northern Gulf of Mexico. *PLoS ONE* 12(9):e0184341. doi.org/10.1371/journal.pone.0184341.

Rahman, M.S., and P. Thomas. 2018. Interactive effects of hypoxia and PCB co-exposure on expression of CYP1A and its potential regulators in Atlantic croaker liver. *Environmental Toxicology* 33(4): 411–421. doi.org/10.1002/tox.22527.

Rao, A., and R. Power. 2019. *Successful Watershed Management in the Midwest: Getting to Scale. Summit Report*. Sponsored by the North Central Region Water Network, University of Wisconsin, Conservation Technology Information Center, Madison, WI.

Robertson, D.M., and D.A. Saad. 2019. *Spatially Referenced Models of Streamflow and Nitrogen, Phosphorus, and Suspended-Sediment Loads in Streams of the Midwestern United States*. U.S. Geological Survey Scientific Investigation Report 2019–5114. Accessed August 2020. doi.org/10.3133/sir20195114.

Robertson, D.M., and D.A. Saad. 2021. *Nitrogen and phosphorus sources and delivery from the Mississippi/Atchafalaya River Basin: An update using 2012 SPARROW models*. Journal of the American Water Resources Association 1-24. U.S. Geological Survey Scientific Investigation Report 2019–5114. Accessed April 2021. doi.org/10.1111/1752-1688.12905.

Rose, K.A., S. Creekmore, D. Justić, P. Thomas, K. Craig, R.M. Neilan, L. Wang, M.S. Rahman, and D. Kidwell. 2017a. Modeling the population effects of hypoxia on Atlantic croaker (*Micropogonias undulatus*) in the northwestern Gulf of Mexico: Part 2—Realistic hypoxia and eutrophication. *Estuaries and Coasts* 41(1):255–279. doi.org/10.1007/s12237-017-0267-5.

Rose, K.A., S. Creekmore, P. Thomas, K. Craig, M.S. Rahman, and R.M. Neilan. 2017b. Modeling the population effects of hypoxia on Atlantic croaker (*Micropogonias undulatus*) in the northwestern Gulf of Mexico: Part 1—Model description and idealized hypoxia. *Estuaries and Coasts* 41(1):233–254. doi.org/10.1007/s12237-017-0266-6.

Scavia, D., I. Bertani, D.R. Obenour, R.E. Turner, D.R Forrest, and A. Katin. 2017. Ensemble modeling informs hypoxia management in the northern Gulf of Mexico. *Proceedings of the National Academy of Sciences* 114(33):8823–8828. doi.org/10.1073/pnas.1705293114.

Schilling, K.E., C.S. Jones, C.F. Wolter, X. Liang, Y.-K. Zhang, A. Seeman, T. Isenhart, D. Schnoebelen, and M. Skopec. 2017. Variability of nitrate-nitrogen load estimation results will make quantifying load reduction strategies difficult in Iowa. *Journal of Soil and Water Conservation 72*(4):317–325. doi.org/10.2489/jswc.72.4.317.

SERA-46 (Southern Extension and Research Activities Committee Number 46). 2018. *Hypoxia Task Force and LGU SERA-46 Priorities for Collaborative Work*. Updated May 2018. Accessed August 2020. https://www.epa.gov/ms-htf/hypoxia-task-force-work-land-grant-universities-priorities-collaborative-work.

Sharpley, A., M.J. Helmers, P. Kleinman, K. King, A. Leytem, and N. Nelson. 2019. Managing crop nutrients to achieve water quality goals. *Journal of Soil and Water Conservation*. 74(5):91A–101A.

Smith, M.D., A. Oglend, A.J. Kirkpatrick, F. Asche, L.S. Bennear, J.K. Craig, and J.M. Nance. 2017. Seafood prices reveal impacts of a major ecological disturbance. *Proceedings of the National Academy of Sciences* 114(7):1512-1517. doi.org/10.1073/pnas.1617948114.

Thomas, P., M.S. Rahman, M.E. Piche, and W. Tan. 2015. Impaired gamete production and viability in Atlantic croaker collected throughout the 20,000 km(2) hypoxic region in the northern Gulf of Mexico. *Marine Pollution Bulletin* 101(1):182–191. doi.org/10.1016/j.marpolbul.2015.11.001.

Tian, H., R. Xu, S. Pan, Y. Yao, Z. Bian, W. Cai, C. Hopkinson, D. Justić, S. Lohrenz, C. Lu, W. Ren, J. Yang. 2020. Long-Term Trajectory of Nitrogen Loading and Delivery From Mississippi River Basin to the Gulf of Mexico. *Global Biogeochemical Cycles*. 34(5). doi.org/10.1029/2019GB006475.

Tomer, M.D., S.A. Porter, D.E. James, K.M.B. Boomer, J.A. Kostel, and E. McLellan. 2013. Combining precision conservation technologies into a flexible framework to facilitate agricultural watershed planning. *Journal of Soil and Water Conservation* 68(5):113A–120A. doi.org/10.2489/jswc.68.5.113A.

USEPA (U.S. Environmental Protection Agency). 2001. *Action Plan for Reducing, Mitigating, and Controlling Hypoxia in the Northern Gulf of Mexico.* USEPA, Mississippi River/Gulf of Mexico Watershed Nutrient Task Force, Washington, DC.

USEPA (U.S. Environmental Protection Agency). 2007. *Hypoxia in the Northern Gulf of Mexico; an Update by the EPA Science Advisory Board*. USEPA, Science Advisory Board, Washington, DC.

USEPA (U.S. Environmental Protection Agency). 2008. *Gulf Hypoxia Action Plan 2008 for Reducing, Mitigating, and Controlling Hypoxia in the Northern Gulf of Mexico and Improving Water Quality in the Mississippi River Basin*. USEPA, Mississippi River/Gulf of Mexico Watershed Nutrient Task Force, Washington, DC.

USEPA (U.S. Environmental Protection Agency). 2015. *Hypoxia Task Force New Goal Framework.* Accessed August 2020. https://www.epa.gov/ms-htf/hypoxia-task-force-new-goal-framework.

White, M.J., C. Santhi, N. Kannan, J.G. Arnold, D. Harmel, L. Norfleet, P. Allen, M. DiLuzio, X. Wang, J. Atwood, E. Haney, and M. Vaughn Johnson. 2014. Nutrient delivery from the Mississippi River to the Gulf of Mexico and effects of cropland conservation. *Journal of Soil and Water Conservation* 69 (1):26–40. doi.org/10.2489/jswc.69.1.26.

Van Meter, K.J., P. Van Cappellen, and N.B. Basu. 2018. Legacy nitrogen may prevent achievement of water quality goals in the Gulf of Mexico. *Science* 360(6387):427–430