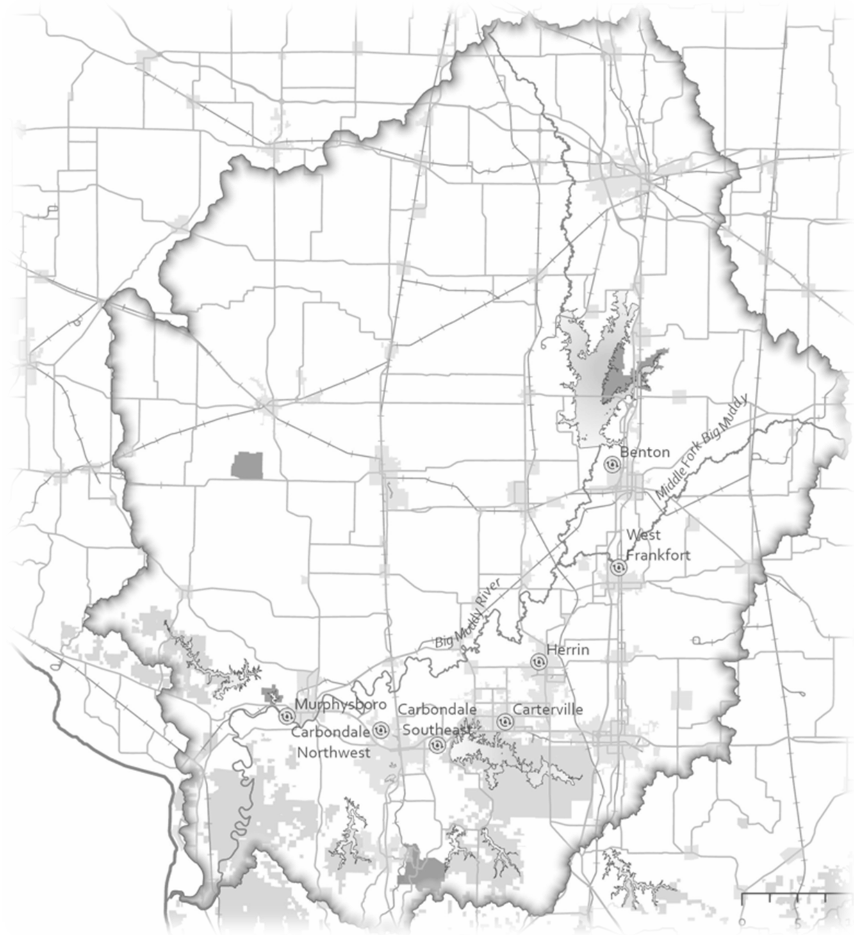
Big Muddy River Watershed

Nutrient Assessment Reduction Plan

Cities of Benton, Carbondale, Carterville, Herrin, Murphysboro, and West Frankfort



Greater Egypt RPDC

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Executive Summary

The Big Muddy River Watershed Nutrient Assessment Reduction Plan (NARP) was developed by the Cities of Benton, Carbondale, Carterville, Herrin, Murphysboro, and West Frankfort in partnership with the Greater Egypt Regional Planning and Development Commission to meet Illinois EPA requirements for addressing eutrophication risks in phosphorus-sensitive watersheds. The plan responds to statewide nutrient-reduction goals. Each participating municipality discharges to the Big Muddy River or its tributaries, and all were required under their NPDES permits to collaborate on a watershed-level nutrient reduction strategy supported by shared monitoring and coordinated management actions.

The planning process included two years of watershed sampling, data review, and stakeholder coordination. A comprehensive sampling plan was implemented for 2025, establishing upstream, outfall, and downstream monitoring locations at each wastewater facility and collecting key water-quality parameters such as phosphorus, chlorophyll-a, dissolved oxygen, and pH. Analysis of the resulting sampling plan little evidence that downstream conditions met the thresholds for eutrophication risk; however, several wastewater discharges, including Carterville's, showed elevated phosphorus levels relative to recommended limits. Modeling using EPA's Pollutant Load Estimation Tool (PLET) confirmed that nonpoint agricultural sources remain the dominant contributors of phosphorus throughout the Big Muddy watershed, though municipal point sources represent a significant portion of localized loads in some subwatersheds.

The NARP sets forth a coordinated watershed strategy emphasizing both point- and nonpoint-source solutions. For municipal discharges, recommended actions include biological nutrient removal, chemical phosphorus treatment, high-rate filtration, operational optimization, and sludge-handling improvements. For nonpoint sources, the plan promotes agricultural best management practices such as cover crops, conservation tillage, filter strips, grassed waterways, drainage water management, critical-area plantings, and livestock exclusion. These measures target high load subwatersheds identified in the PLET modeling.

The NARP also outlines available technical and financial assistance programs, including USDA conservation programs, Illinois EPA loan and grant resources, and potential watershed partnerships. An implementation schedule and monitoring plan describe how communities will track progress, evaluate effectiveness, and remain compliant with IEPA requirements. While challenges remain, including limited funding for planning, the large size of the watershed, and the difficulty of engaging nonpoint partners, the plan provides a practical blueprint for meeting nutrient-reduction goals and improving water quality within the Big Muddy River watershed.

1. Nutrient Assessment Reduction Planning (NARP)

1.1 NARP Background and Requirements

In 2020, the Illinois Environmental Protection Agency (IEPA), through the National Pollutant Discharge Elimination System Permits (NPDES), began enforcing the development of Nutrient Assessment Reduction Plans (NARP) for municipal facilities that discharge into waterbodies that are impaired by or at risk of eutrophication. Due to the cities' small populations and economic disadvantages, they do not have adequate staff or sufficient budget to create this plan internally.

A waterbody or stream segment is at risk for eutrophication if it meets one of the following criteria:

1. *Its **pH exceeds 9.0**, the upper limit of the water quality standard;*
2. *Its **median sestonic chlorophyll a is greater than 26 mg/L;** or*
3. *Its **pH exceeds 8.35** and its **dissolved oxygen is greater than 110% on the same day, for two or more days from** Illinois EPA sampling.*

The IEPA defines the purpose of the NARP as: "to identify phosphorus input reductions and other measures that can be implemented by a major municipal facility or group of major municipal facilities via a watershed workgroup to help ensure that dissolved oxygen and offensive aquatic algae and aquatic plant criteria are met throughout a watershed."
The IEPA lists eight requirements of a NARP:

> *A. The NARP shall be developed and submitted to the Agency by December 31, 2025. This requirement can be accomplished by the Permittee, by participating in an existing watershed group or by creating a new group. The NARP shall be supported by data and sound scientific rationale.*
> *B. The Permittee shall cooperate with and work with other stakeholders in the watershed to determine the most cost-effective means to address the risk of eutrophication. If other stakeholders in the watershed will not cooperate in developing the NARP, the Permittee shall develop its own NARP for submittal to the Agency to comply with this condition.*

C. In determining the target levels of various parameters necessary to address the risk of eutrophication, the NARP shall either utilize the recommendations by the Nutrient Science Advisory Committee or develop its own watershed-specific target levels.

D. The NARP shall identify phosphorus input reductions from point sources and non-point sources in addition to other measures necessary to remove the risk of eutrophication characteristics that will cause or may cause violation of a water quality standard. The NARP may determine, based on an assessment of relevant data, that the watershed does not have a risk of eutrophication related to phosphorus, in which case phosphorus input reductions or other measures would not be necessary. Alternatively, the NARP could determine that phosphorus input reductions from point sources are not necessary, or that phosphorus input reductions from both point and nonpoint sources are necessary, or that phosphorus input reductions are not necessary and that other measures, besides phosphorus input reductions, are necessary.

E. The NARP shall include a schedule for the implementation of the phosphorus input reductions and other measures. The NARP schedule shall be implemented as soon as possible and shall identify specific timelines applicable to the permittee.
F. The NARP can include provisions for water quality trading to address the phosphorus related risk of eutrophication characteristics in the watershed. Phosphorus/Nutrient trading cannot result in violations of water quality standards or applicable antidegradation requirements.

G. The Permittee shall request modification of the permit within 90 days after the NARP has been completed to include necessary phosphorus input reductions identified within the NARP. The Agency will modify the permit if necessary.

H. If the Permittee does not develop or assist in developing the NARP and such a NARP is developed for the watershed, the Permittee will become subject to effluent limitations necessary to address the risk of eutrophication. The Agency shall calculate these effluent limits by using the NARP and any applicable data. If no NARP has been developed, the effluent limits shall be determined for the Permittee on a case-by-case basis, so as to ensure that the Permittee's discharge will not cause or *contribute to violations of the dissolved oxygen or narrative offensive condition water quality standards.*

The wastewater treatment facilities of Benton, West Frankfort, Herrin, Carbondale, Carterville, and Murphysboro all discharge into the Big Muddy River, either directly or through a tributary. The Big Muddy River is listed on the EPA 303(d) list of impaired waterbodies and is also a priority watershed for non-point source phosphorus in the Illinois Nutrient Loss Reduction Strategy (NLRS). According to the US EPA Waterbody Reports, the Big Muddy River does not have phosphorus listed as a direct impairment. However, the river is listed in the IEPA NPDES permits for each participating city as being at risk of eutrophication and, as such, requires a NARP to be completed. The Big Muddy River is a direct tributary to the Mississippi River.

The Big Muddy watershed affects the water quality of the larger Mississippi basin and the Gulf. Nutrient inputs into these watersheds contribute to the annual Gulf Hypoxic Zone- an area with low dissolved oxygen caused by excessive algal growth that forms every summer in the Gulf of Mexico. The size varies yearly depending on weather patterns and nutrient inputs upstream, but the five-year average is 5,380 square miles. This area is also known as a “dead zone” because fish, shrimp, and other aquatic life cannot survive under such harsh conditions. This harms not only the ecosystem but the economy as well. The National Oceanic and Atmospheric Administration estimates that Gulf states' fishing and tourism industries lose $82 million each year due to the hypoxic zone. Illinois is part of the 12-state Mississippi River/Gulf of Mexico Watershed Nutrient Task Force and has a statewide Nutrient Loss Reduction Strategy (NLRS) of reducing total phosphorus and nitrogen input to the Mississippi River by 45 percent. The completion of this NARP will be a part of the larger state and national goal to improve the water quality and economic status of States in the Mississippi River Basin and Gulf Shores.

1.2 Local Planning

Each NPDES Permit requiring a NARP in the Big Muddy River watershed participated in the planning process. The participating cities, acting by and through their Publicly Owned Treatment Works (POTWs), entered into an intergovernmental agreement with Greater Egypt Regional Planning and Development Commission (Greater Egypt) to develop the required NARP. Greater Egypt is classified as an areawide Water Quality Planning Agency by the IEPA and provides water quality planning services to ten counties in southern Illinois. This group was referred to as the Big Muddy Watershed NARP Planning Committee. The following figure detail each representative on the planning committee.

Big Muddy River Watershed Planning Team Members		
Jurisdiction	**Name**	**Title**
City of Benton	Craig Miles	Water and Sewer Superintendent
	Shannon Toigo	WWTP Operator
HMG Engineers, Inc.	Sarah Tebbe	Senior Environmental Engineer
City of Carterville	Adam Decker	Superintendent
City of Carbondale	Tony Harrison	Director of Utilities
	Robert Hardin	Director of Public Works
CMT Engineering	Christy Crites	Vice President And Water Resources Group Manager
City of Murphysboro	Patrick Gladson	WWTP Operator
J.T. Blankenship, Inc	Ted Beggs	President
	Herold Sheffer	Owner/Engineer
City of Herrin	Tom Somers	Director of Public Works
	Randy Lattuada	WWTP operator
Farley Engineering	Ryan Farley	Owner/Engineer
City of West Frankfort	Michelangelo Sirena	WWTP Operator
Brown & Roberts, Inc.	Matt Tosh	Project Engineer
Greater Egypt RP&DC	Cary Minnis	Executive Director
	Tyler Carpenter	Environmental Planning Director
	Lilly Bolin	Environmental Planner
	Nick Keller	Environmental Planner
	Kelsey Bowe	Environmental Planning Coordinator

1.2.1 Project Area Cities

Benton, Illinois

Benton serves as the county seat of Franklin County and functions as an administrative and commercial hub for the surrounding rural communities. Benton's economy includes healthcare, government, education, light industry, and retail trade. The community is closely tied to regional outdoor recreation and agriculture, with Rend Lake—one of the largest reservoirs in Illinois—providing nearby opportunities for tourism, conservation, and water-related industries. The population as of 2020 was 6,709.

West Frankfort, Illinois

Historically a coal-mining town, West Frankfort still reflects that legacy. With a population of 7,275, the city has shifted over time from heavy industry toward a more diversified economy that includes healthcare, retail, and small manufacturing. Public facilities, parks, and schools remain key focal points, and the city's location near Interstate 57 provides regional connectivity to Marion and Mt. Vernon.

Herrin, Illinois

Herrin is one of the principal cities in Williamson County and part of the greater Marion–Carbondale economic area. Herrin has evolved into a community supported by healthcare, retail, service industries, and regional employment centers. The city is known for its active civic organizations, annual festivals, and a well-established downtown business district. Proximity to U.S. 13 and the regional medical center in Carbondale and Marion enhances its role as a residential and commercial hub for the surrounding region. Herrin has a population of 12,352.

Carterville, Illinois

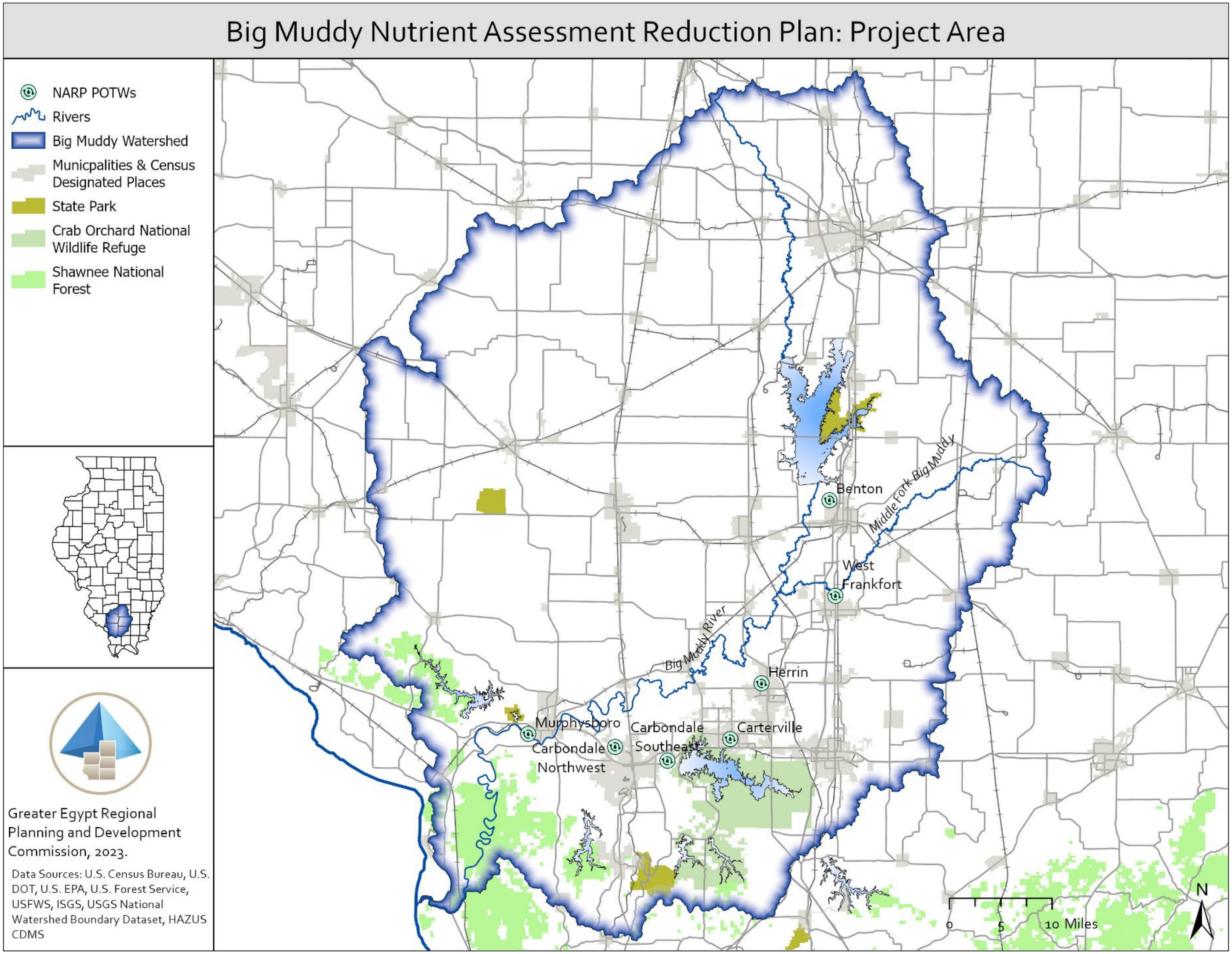
Carterville is a rapidly growing community situated between Carbondale and Marion. The city has experienced consistent growth driven by its school district, quality of life, and proximity to Southern Illinois University and major employment centers. The community benefits from access to Crab Orchard National Wildlife Refuge, which provides extensive recreational and conservation resources. The population is 5,848.

Murphysboro, Illinois

With a population of 7,093, Murphysboro is the county seat of Jackson County and sits along the Big Muddy River. Murphysboro's economy includes government services, small industry, manufacturing, and proximity to Carbondale's university-driven economy. The city is recognized for regional events, including its barbecue festival, and for access to nearby outdoor recreation areas such as the Shawnee National Forest, Riverside Park, and Lake Murphysboro State Park.

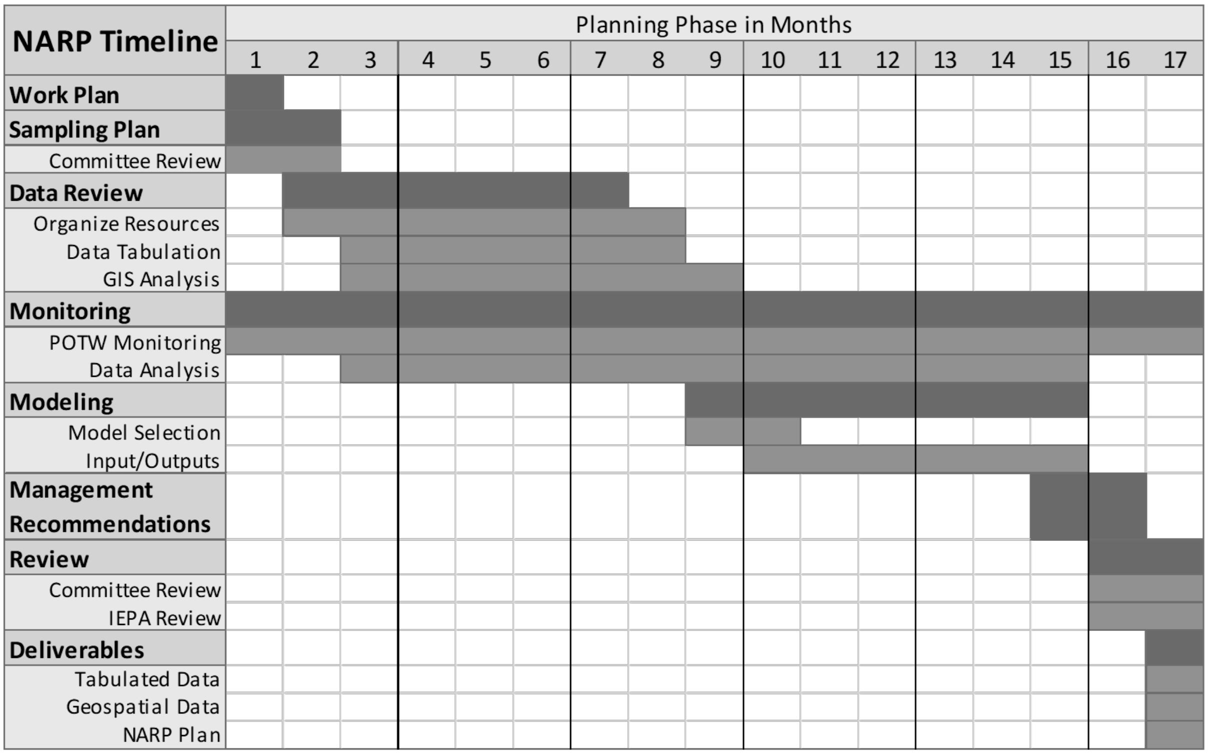
Carbondale, Illinois

Carbondale is the primary urban center in Jackson County and home to Southern Illinois University (SIU), which plays a major role in the community's economy, culture, and population. The city serves as a regional hub for education, healthcare, commerce, and transportation, with a diverse business environment, an intermodal transit station, and cultural venues associated with the university. As of 2020, the population was 20,899.


Big Muddy Nutrient Assessment Reduction Plan: Project Area
NARP POTWs
Rivers
Big Muddy Watershed
Municpalities & Census Designated Places
State Park
Crab Orchard National Wildlife Refuge
Shawnee National Forest
Greater Egypt Regional Planning and Development Commission, 2023.
Data Sources: U.S. Census Bureau, U.S. DOT, U.S. EPA, U.S. Forest Service, USFWS, ISGS, USGS National Watershed Boundary Dataset, HAZUS CDMS
Benton
Middle Fork Big Muddy
West Frankfort
Big Muddy River
Herrin
Murphysboro
Carbondale Northwest
Carbondale Southeast
Carterville
0
5
10 Miles
N

1.2.2 Public Participation

Big Muddy NARP Advisory Committee Meetings – Beginning in the summer of 2023, the Big Muddy River Watershed NARP Advisory Committee met on a regular basis until the end of the plan- December 2025. These meetings consisted of the planning teams and any interested parties. Meeting agendas and minutes can be found at this website. The following graph illustrates the timeline for the eighteen-month NARP planning process.



Public Meeting - During the planning process, the public was invited to a public exhibit meeting with information about the NARP on September 18, 2025. Announcements were made in local media. The Shawnee Chapter – Sierra Club, Prairie Rivers Network, and other environmental agencies were forwarded the meeting announcement.

The public was explained the NARP, planning process, and activities following NARP submission. The meeting was exhibit-style with various figures, maps, and a running slideshow. Comments will be addressed in the final NARP. The slideshow can be found in **Appendix A – Public Participation.**

Agricultural Nonpoint Survey – Local agricultural service agencies, landowners, and public were encouraged to take a survey related to nonpoint source impacts in the Big Muddy River watershed. The survey questionnaire is displayed in **Appendix A.**

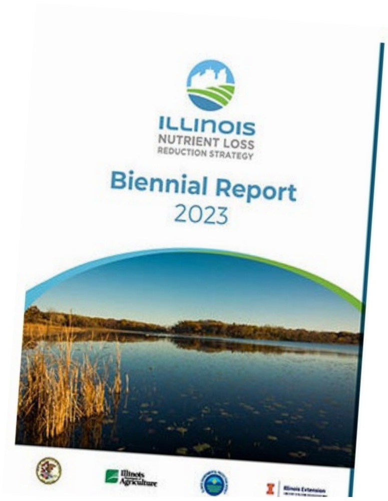
Respondents ranked water quality issues, gave information on management measures, and described challenges faced in implementing agricultural management measures including a lack of incentives and funding programs.

1.3 Other Planning Initiatives

While the NARP serves as the plan to mainly limit phosphorus at a watershed-wide scale, other initiatives have been developed to limit the nutrient and other impairments at the HUC-8 and smaller watershed scales.

1.3.1 IL Nutrient Loss Reduction Strategy (NLRS)

The Illinois Nutrient Loss Reduction Strategy (NLRS) is a statewide, science-based framework designed to reduce nitrogen (N) and phosphorus (P) losses from Illinois waterways and ultimately diminish contributions to the Gulf of Mexico hypoxic zone. It was collaboratively developed by the Illinois EPA, Illinois Department of Agriculture, academic researchers, wastewater agencies, agricultural groups, and non-governmental organizations.



Credit: IL EPA

Excessive nutrients contribute to local water-quality impairments—such as harmful algal blooms and low dissolved oxygen—and to the formation of the Gulf of Mexico “dead zone.” By reducing nutrient losses, Illinois aims to protect drinking water, aquatic ecosystems, and downstream environments while improving agricultural efficiency.

Long-term goals see a 45% reduction in nitrogen and phosphorus loads with interim goals of 15%, and 25% respectively. Strategies focus on agriculture, wastewater and urban stormwater. Regarding P limits, the plan encourages facility upgrades, implement P limits through NPDES permits, and provide financial support through Illinois EPA’s low-interest loan programs. The IL NLRS document and planning materials can be found by clicking here.

1.3.2 TMDL and Watershed-based Planning

Many subwatersheds within the larger Big Muddy have been involved in some form of planning. These initiatives include Total Maximum Daily Loads (TMDL) created by the Illinois EPA, or local watershed-based planning, generally assisted by Greater Egypt.

Total Maximum Daily Loads (TMDL)

The Big Muddy River watershed contains several streams, lakes, and subwatersheds that have undergone Total Maximum Daily Load (TMDL) development to address a range of water quality impairments. Across the watershed, the major issues identified in TMDL assessments include elevated metals such as manganese and iron, low dissolved oxygen, pH fluctuations, excessive sediment and total dissolved solids, sulfates, total phosphorus, and bacterial contamination.

Multiple TMDLs throughout the Big Muddy River watershed address impairments largely driven by nonpoint-source pollution, including metals, sulfates, total dissolved solids, low dissolved oxygen, bacteria, nutrients, sediment, and pH instability. Across the watershed—including the Big Muddy River main stem, Upper Big Muddy tributaries, Beaucoup Creek, Kinkaid Lake, Rend Lake, and the Crab Orchard Creek system—management strategies consistently emphasize reducing sediment and runoff, stabilizing streambanks and shorelines, restoring riparian buffers, improving septic systems, managing livestock waste, and implementing agricultural best management practices. Surrogate measures such as turbidity, sediment fines, phosphorus reduction targets, and BMP installation benchmarks are used to track progress toward pollutant load reductions. Most TMDLs rely on watershed-based planning, Section 319 programs, and phased monitoring to evaluate whether implemented practices are improving conditions related to metals, bacteria, dissolved oxygen, pH, and overall water quality.

Many of these TMDL need an update, with some of them being more than twenty years old. However, the management measures listed in them are still applicable in mitigating and correcting P and other nutrient loads in the Big Muddy River watershed.

Across all subwatersheds, the Big Muddy TMDLs share common themes: reliance on watershed-scale BMP implementation, use of surrogate indicators to track progress, emphasis on controlling nonpoint-source pollutants, and integration with local and regional watershed-based plans. These TMDLs form a coordinated framework for improving hydrologic and ecological conditions throughout the Big Muddy River basin.

Watershed-based Planning

The Greater Egypt Regional Planning and Development Commission (GERPDC) serves as the designated Areawide Water Quality Planning Agency for southern Illinois, working under the authority of the Illinois Environmental Protection Agency. In this role, the organization leads watershed-based planning efforts designed to improve local water quality, reduce nonpoint source pollution, and guide long-term resource management across the region. Their work is rooted in community engagement, technical analysis, and alignment with state and federal water-quality programs.

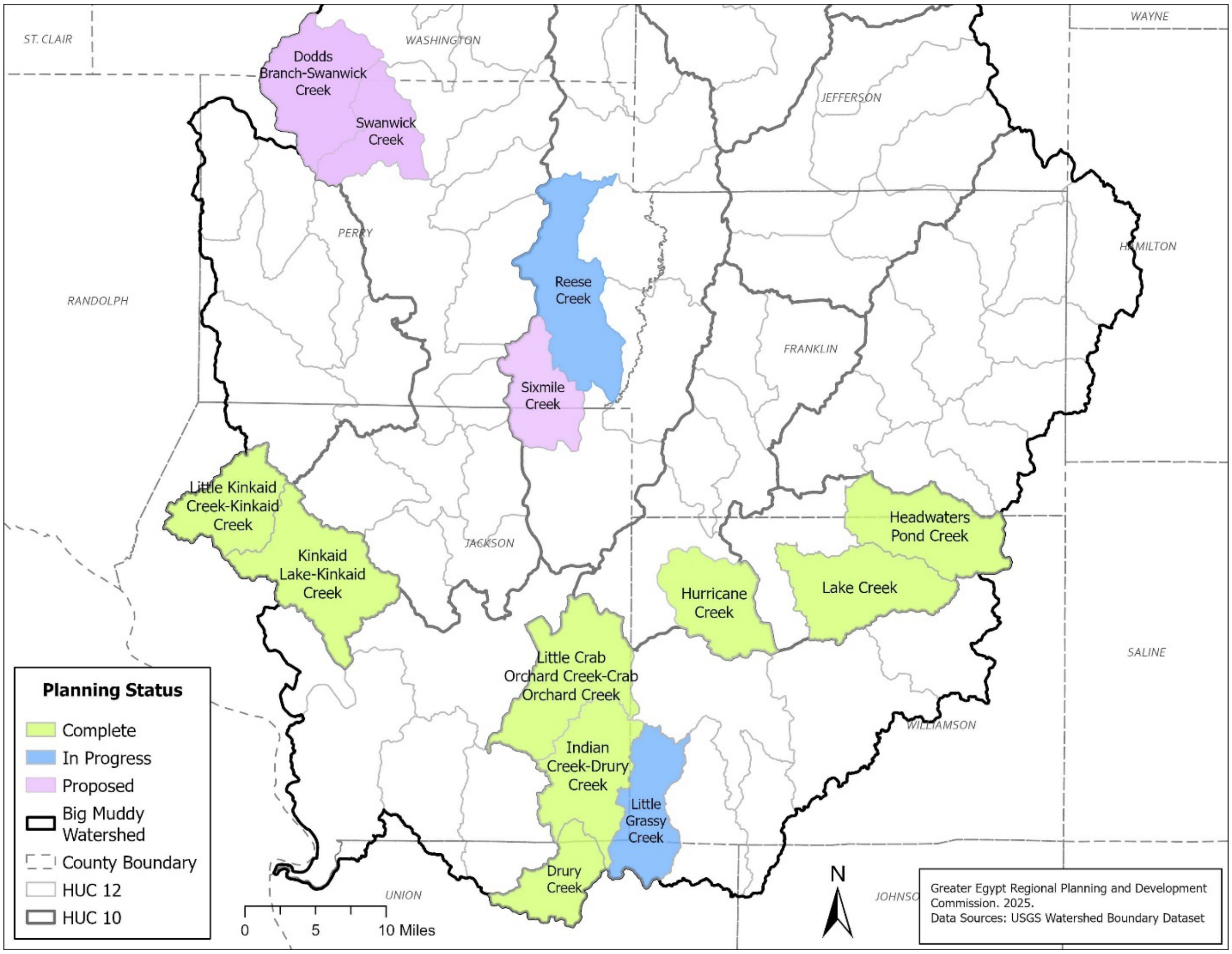
A central component of Greater Egypt's work is the development of watershed-based plans for priority watersheds throughout the region. These plans are created through stakeholder-driven processes that bring together local governments, landowners, environmental organizations, lake associations, public-works departments, and interested residents. To ensure eligibility for federal Clean Water Act Section 319 funding, Greater Egypt's plans follow the U.S. EPA's "Nine Minimum Elements," which include pollutant load assessments, identification of critical areas, selection and prioritization of best management practices (BMPs), and measurable goals for water-quality improvement.

GERPDC has completed watershed-based plans for several watersheds, including Kinkaid Creek, Western Crab Orchard Creek, Pond Creek, Lake Creek, and Hurricane Creek. Each plan contains a detailed inventory of local natural resources, land use patterns, hydrology, and water-quality impairments. The Commission uses tools such as GIS and the Spreadsheet Tool for Estimating Pollutant Loads (STEPL) to quantify nutrient and sediment loads and evaluate how specific management practices—such as riparian buffers, cover crops, grassed waterways, and streambank stabilization—can reduce pollution. Plans typically adopt reduction targets consistent with the Illinois Nutrient Loss Reduction Strategy, including goals for nitrogen, phosphorus, and sediment.

Beyond watershed planning, Greater Egypt coordinates Nutrient Assessment Reduction Plan (NARP) efforts for wastewater dischargers in sensitive watersheds such as the Big Muddy River and the Saline River. These advisory groups bring together municipal wastewater operators, engineers, regulators, and stakeholders to identify strategies for reducing nutrient discharges, particularly phosphorus. NARPs help communities evaluate feasible treatment technologies and build long-term nutrient-reduction pathways.

GERPDC also conducts nonpoint source pollution initiatives, including field studies that use drones to evaluate agricultural BMP performance and measure nutrient and sediment levels near treated fields. The Commission is active in stormwater education and outreach, producing materials that help residents and communities reduce pollution from urban runoff. In addition, Greater Egypt oversees the Volunteer Lake Monitoring Program for its multi-county region, training and coordinating volunteers who collect long-term data on lake water quality—data that directly supports watershed planning and evaluation.

Throughout its watershed-based efforts, Greater Egypt places strong emphasis on public education, stakeholder engagement, and long-term monitoring. Plans include strategies for funding implementation, timelines for adoption, and metrics for evaluating progress over time. While challenges such as diffuse agricultural runoff, legacy nutrient storage, and limited funding persist, the Commission's combination of technical expertise, community partnerships, and adherence to EPA planning standards positions as a key leader in protecting and improving water quality in southern Illinois.


ST. CLAIR
WASHINGTON
WAYNE
JEFFERSON
Dodds Branch-Swanwick Creek
Swanwick Creek
PERRY
RANDOLPH
HAMILTON
Reese Creek
FRANKLIN
Sixmile Creek
Little Kinkaid Creek-Kinkaid Creek
Kinkaid Lake-Kinkaid Creek
JACKSON
Headwaters Pond Creek
Lake Creek
Hurricane Creek
SALINE
Little Crab Orchard Creek-Crab Orchard Creek
Indian Creek-Drury Creek
Little Grassy Creek
Drury Creek
WILLIAMSON
UNION
JOHNSO
Planning Status
Complete
In Progress
Proposed
Big Muddy Watershed
County Boundary
HUC 12
HUC 10
0 5 10 Miles
N
Greater Egypt Regional Planning and Development Commission. 2025.
Data Sources: USGS Watershed Boundary Dataset

1.4 Challenges to Planning

Plan Funding – Currently, no grant or state assistance exists to assist communities with funding NARP planning. In 2023, Greater Egypt submitted a grant application for the Delta Regional Authority's Strategic Planning Grant Program. Unfortunately, this was not awarded.

The planning partners funded the NARP through a collaborative pool. Along with funding the planning, each operator was required to take a chlorophyll sample twice a month, costing around an additional $200 per month during the planning process.

Watershed-wide Planning – The Big Muddy River watershed is around 2,400 square miles. Variables like the weather can affect planning. Even with a sampling plan (Section 3.1) in place, some data was not taken. This can tend to skew data and results.
Sustaining NARP or other watershed committees, continuing project implementation, and measuring success of the plan can be difficult. The Big Muddy basin is massive; containing many other cities and municipalities that are not represented in the NARP. Coordination will need to be continuous through plan implementation. If needed, additional cities with a NARP requirement may be added to the existing Big Muddy River Watershed NARP Committee.

Nonpoint Planning Partners - Traditional nonpoint planning partners include large landowners and farmers. Nonpoint source pollution (particularly from agriculture) is complex and diffuse, making implementation of BMPs and behavior change difficult. Because many of the management measures in this plan are agricultural, an approach will need to be created to discuss these measures to the target audience.

2. Big Muddy Watershed

The Big Muddy River watershed is a Hydrologic Unit Code (HUC) 8 watershed encompassing the floodplain and waterbodies connected to the Big Muddy River. This includes a total of 112 named waterbodies, with the largest being Rend Lake at 69 sq km, Crab Orchard Lake at 29.51 sq km, and Kinkaid Lake at 9.4 sq km. This report will reference the Big Muddy River and any waterbodies directly associated with the NARP treatment plants as the planning, or study area.

2.1 Watershed Geography and Land Use

The Big Muddy River watershed encompasses portions of nine counties, but the study area focuses on Jefferson, Franklin, Williamson, and Jackson Counties. The study area originates north of Rend Lake in association with Benton's wastewater treatment plant, following the course of the Big Muddy River and a few notable tributaries before ending 15 miles away from where the Big Muddy River meets the Mississippi River southwest of Murphysboro.
While there are several municipalities within the planning area, the only ones extensively discussed in this plan are the ones with WWTPs participating in the NARP planning process. Benton, West Frankfort, Herrin, Carterville, Carbondale, and Murphysboro all sit well within the boundaries of the Big Muddy River watershed and greatly contribute to the watershed planning area.

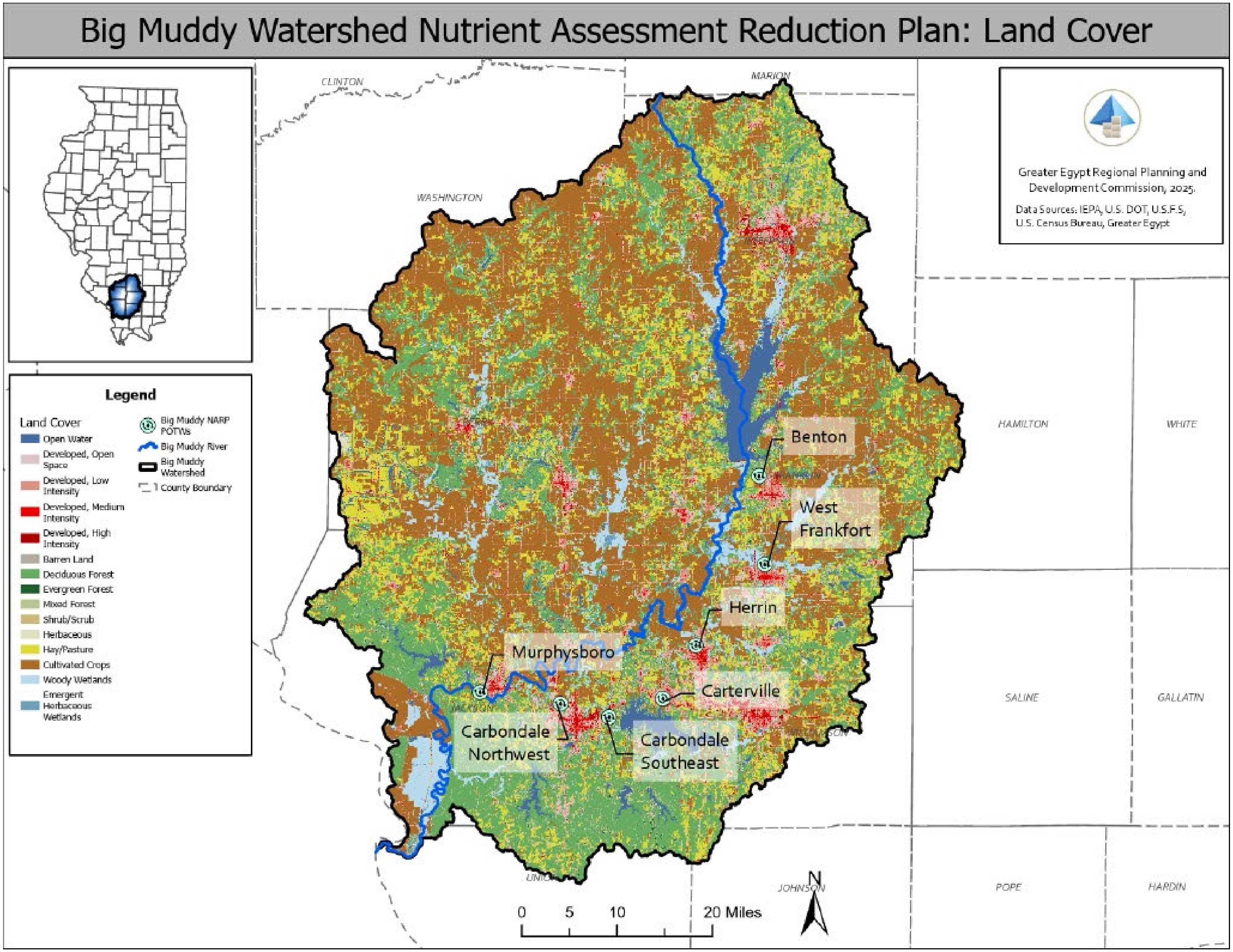
The climate in the Big Muddy River watershed experiences a humid continental climate marked by warm, humid summers, variable winters, and active transitional seasons. Winters are generally cool with mixed precipitation and occasional Arctic cold snaps, while springs are among the wettest periods, bringing frequent thunderstorms and rapidly changing weather that drives high streamflow. Summers are hot and humid, with temperatures often reaching the upper 80s to mid-90s °F and storms that deliver intense, short-duration rainfall leading to quick runoff responses. Autumn begins with mild, dry conditions before shifting to cooler, wetter weather as frontal systems return. Across the year, the watershed receives 40–50 inches of precipitation, much of it in storm-driven bursts, producing the flashy hydrology and seasonal flooding typical of the Big Muddy basin.

During the spring and summer months, damaging storms and heavy rainfall can be expected. Heavy rainfall usually leads to regional and localized flooding. More severe occurrences of flooding take place along the Big Muddy River and larger tributaries that feed into the waterbody, which can impact water quality in ways out of the control of WWTPs within the planning area. Like most areas in the Midwest, the watershed is susceptible to tornadoes. Winters occasionally bring accumulations of snow and ice, which can cause similar water quality changes when melting.

Land cover is largely agricultural, with 53 percent of the watershed being classified as cultivated crops and pasture/hay. Notably, most of the agricultural sources are north of the Big Muddy River where municipalities are not required to be part of the NARP. The major tributaries of Beaucoup Creek and Little Muddy River convey large P loads into the Big Muddy at the confluences near the Southern Illinois Airport.

Color Code	NLCD Land Cover Class	Area (sq miles)	Percent of total area
	Barren Land	3.0	0.12
	Evergreen Forest	3.2	0.13
	Shrub/Scrub	4.7	0.20
	Developed, High Intensity	7.4	0.31
	Emergent Herbaceous Wetlands	11.4	0.48
	Herbaceous	15.7	0.66
	Developed, Medium Intensity	29.0	1.21
	Mixed Forest	43.8	1.83
	Developed, Low Intensity	86.4	3.62
	Open Water	88.4	3.71
	Developed, Open Space	102.1	4.28
	Woody Wetlands	113.8	4.77
	Hay/Pasture	373.7	15.66
	Deciduous Forest	612.9	25.69
	Cultivated Crops	890.1	37.31

With a quarter of the watershed being forested, this is mainly exhibited in the southern portion of the watershed along the northern border of the Shawnee National Forest. Development is represented by municipalities and the road network of southern Illinois.


Big Muddy Watershed Nutrient Assessment Reduction Plan: Land Cover
Legend
Land Cover
Open Water
Developed, Open Space
Developed, Low Intensity
Developed, Medium Intensity
Developed, High Intensity
Barren Land
Deciduous Forest
Evergreen Forest
Mixed Forest
Shrub/Scrub
Herbaceous
Hay/Pasture
Cultivated Crops
Woody Wetlands
Emergent Herbaceous Wetlands
Big Muddy NARP POTWs
Big Muddy River
Big Muddy Watershed
County Boundary
CLINTON
MARION
WASHINGTON
HAMILTON
WHITE
SALINE
GALLATIN
POPE
HARDIN
JOHNSON
Benton
West Frankfort
Herrin
Murphysboro
Carterville
Carbondale Northwest
Carbondale Southeast
0
5
10
20 Miles
N
Greater Egypt Regional Planning and Development Commission, 2025.
Data Sources: IEPA, U.S. DOT, U.S.F.S, U.S. Census Bureau, Greater Egypt

2.2 Waterbodies and Drainage

The Big Muddy River watershed (HUC 07140106) in southern Illinois features a complex drainage network shaped by rolling uplands and hydrology highly responsive to seasonal precipitation. The main stem rises near the divide separating the Big Muddy and Skillet Fork/Kaskaskia basins in Jefferson County and flows southwest through Franklin and Jackson Counties before entering the Mississippi River south of Grand Tower.

Along its course, the river receives flow from major tributaries including the Little Muddy River, Beaucoup Creek, Casey Fork and the Rend Lake tributary system, Crab Orchard Creek, and Kinkaid Creek. Rend Lake, the largest reservoir in the watershed, regulates flows, reduces peak discharges, and supplements base flows. The river's channel shifts from gently meandering; low-gradient reaches upstream to deeply incised, bluff-bounded sections near the Mississippi, with high seasonal flow variability, low-flow periods in late summer and fall, and occasional backwater effects during Mississippi River floods. Flooding is common, driven by slow-draining soils and agricultural runoff.

The watershed faces significant environmental challenges, including legacy pollution, nonpoint-source nutrient loading, and habitat degradation. Water quality impairments include sedimentation from agricultural runoff, elevated nitrogen and phosphorus from fertilizers and wastewater, low dissolved oxygen, elevated sulfates and metals in mining-impacted tributaries, and pathogens in urbanizing areas.

Ongoing management challenges include streambank erosion, nutrient contributions to Mississippi River hypoxia, stormwater management in rural drainage systems, and sediment accumulation in reservoirs. Current management strategies include agricultural best management practices, streambank stabilization, wetland restoration, monitoring by Illinois EPA and USGS, and land conservation and habitat restoration in the Shawnee National Forest and surrounding areas.

2.3 Demographics and Stakeholders

To assess the demographics of the Big Muddy River watershed planning area, each county was individually examined. The planning area spans portions of Jackson, Williamson, and Franklin Counties, encompassing many different townships and municipalities, though this plan will focus only on cities directly participating in the NARP planning process.

Population

According to American Community Survey data for 2018-2022, the population of Jackson County is 52,706, Williamson has a population of 66,902, and Franklin has 37,541. The tables below show a basic overview of the populations of the three participating counties based on a report produced by JOBS EQ. The data set used in this section represents the counties and municipalities in their entirety, not just the sections contained within the Big Muddy River watershed.

County	Population (Pop Estimates)	Population Annual Average Growth	People per Square Mile
Jackson	53,199	-1.10%	91.2
Williamson	67,064	-0.10%	159.6
Franklin	37,033	-0.60%	90.6

Municipality	Population (Pop Estimates)
Benton	6,709
West Frankfort	7,275
Herrin	12,352
Carterville	5,848
Carbondale	21,857
Murphysboro	7,093

Median Age and Income

The tables below summarize the median age and income for Jackson, Williamson, and Franklin Counties, as well as the participating municipalities. Much of southern Illinois experiences high poverty rates including Jackson and Franklin Counties. These rates of poverty indicate a need to find funding sources for implementation, so municipalities do not pass costs onto the citizens through utility increases.

County	Median Age	Median Household Income
Jackson	32.9	$45,572
Williamson	41.4	$65,521
Franklin	43.3	$53,471

Municipality	Median Age	Median Household Income
Benton	42.2	$51,349
West Frankfort	39.9	$48,143
Herrin	40.1	$58,501
Carterville	39.9	$65,238
Carbondale	24.9	$29,670
Murphysboro	40	$42,367

Employment

As of August 2025, the unemployment rate for Jackson County was 5.1%, Williamson County was at 4.6%, and Franklin County was at 5.3%. All three counties had a higher unemployment rate than the state average of 4.5%. The JobsEQ database was used to gather employment information for the three participating counties. The table below shows more information on the employment statistics of each county.

County	Unemployment Rate	Total Employment	Top Three Industries
Jackson	5.1	29,444	Educational Services, Health Care and Social Assistance, Public Administration
Williamson	4.6	31,047	Health Care and Social Assistance, Manufacturing, Retail Trade
Franklin	5.3	10,070	Health Care and Social Assistance, Retail Trade, Accommodation and Food Services

3. Water Quality Assessment

The water quality assessment for the NARP includes a sampling plan, additional water quality data analysis, and mapping/modeling of the watershed, specifically phosphorus outputs.

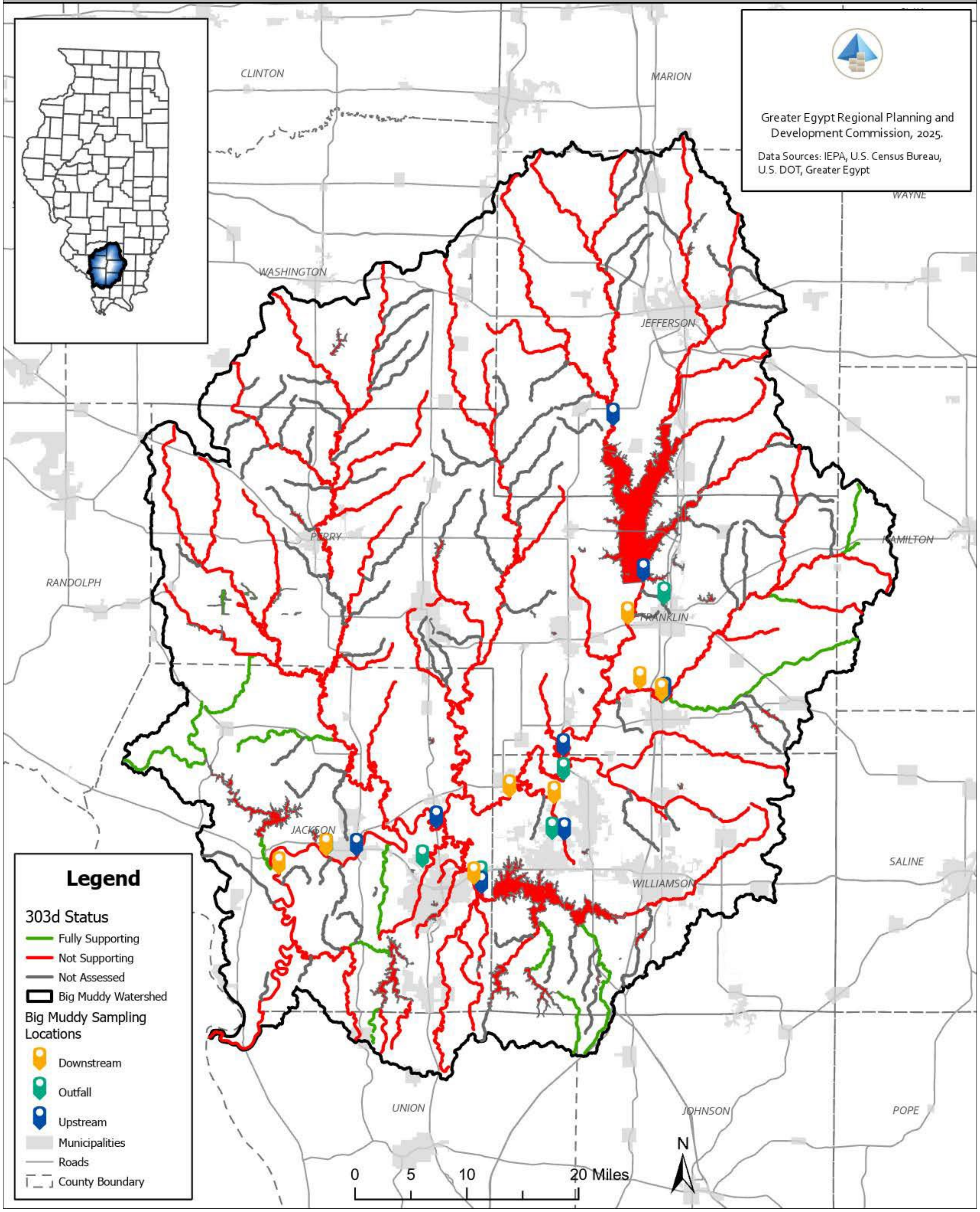
3.1 Water Quality Impairments and Monitoring

Many waterbodies in the Big Muddy watershed are included in the Illinois EPA's 303d List of Impaired waterbodies. This includes many segments of rivers and streams within the NARP Sampling plan including the Big Muddy River.

Waterbody	Assessment Unit ID	Size (Miles)	Impaired Designated Use(s)	Causes of Impairment(s)
Big Muddy River	IL_N-06	15.20	Aquatic Life	Sedimentation/Siltation, Cause Unknown
Big Muddy River	IL_N-06	15.20	Fish Consumption	Aldrin, Dieldrin, Endrin, Heptachlor, Mercury, Mirex, Polycarbondated Biphenyls (PCBS), Toxaphene
Big Muddy River	IL_N-08	40.04	Aquatic Life	Cause Unknown
Big Muddy River	IL_N-08	40.04	Fish Consumption	Mercury
Big Muddy River	IL_N-08	40.04	Primary Contact	Fecal Coliform
Big Muddy River	IL_N-11	11.48	Aquatic Life	Sedimentation/Siltation, Total Suspended Solids (TSS), Cause Unknown
Big Muddy River	IL_N-11	11.48	Fish Consumption	Aldrin, Dieldrin, Endrin, Heptachlor, Mercury, Mirex, Polycarbondated Biphenyls (PCBS), Toxaphene
Big Muddy River	IL_N-12	15.19	Fish Consumption	Aldrin, Dieldrin, Endrin, Heptachlor, Mercury, Mirex, Polycarbondated Biphenyls (PCBS), Toxaphene
Big Muddy River	IL_N-12	15.19	Aquatic Life	Dissolved Oxygen, Sedimentation/Siltation, Total Suspended Solids (TSS)
Big Muddy River	IL_N-16	11.79	Aquatic Life	Dissolved Oxygen, Sedimentation/Siltation
Big Muddy River	IL_N-16	11.79	Fish Consumption	Mercury
Big Muddy River	IL_N-17	21.48	Fish Consumption	Mercury
Big Muddy River	IL_N-99	29.22	Fish Consumption	Aldrin, Dieldrin, Endrin, Heptachlor, Mercury, Mirex, Polycarbondated Biphenyls (PCBS), Toxaphene

Waterbody	Assessment Unit ID	Size	Impaired Designated Use (s)	Causes of Impairment(s)
Lake(s)		(Acres)		
Benton	IL_RNO	67.6	Aesthetic Quality	Phosphorous, Total
Carbondale City Lake	IL_RNI	135.6	Aesthetic Quality	Phosphorous, Total
Carbondale City Lake	IL_RNI	135.6	Fish Consumption	Mercury
Campus	IL_RNZH	40.0	Aesthetic Quality	Total Suspended Solids (TSS)
Campus	IL_RNZH	40.0	Fish Consumption	Aldrin, Dieldrin, Endrin, Heptachlor, Mercury, Mirex, Polychlorinated Biphenyls (PCBS),
Crab Orchard	IL_RNA	6965	Aesthetic Quality	Total Suspended Solids (TSS)
Crab Orchard	IL_RNA	6965	Fish Consumption	Mercury, Polychlorinated Biphenyls (PCBS)
Herrin New	IL_RNZC	46.1	Aesthetic Quality	Phosphorous, Total
Little Grassy	IL_RNK	1000	Fish Consumption	Mercury
Murphysboro	IL_RND	143	Fish Consumption	Mercury
Rend	IL_RNB	18900	Aesthetic Quality	Phosphorous, Total
Rend	IL_RNB	18900	Fish Consumption	Mercury
West Frankfort Old	IL_RNP	146	Fish Consumption	Mercury
West Frankfort New	IL_RNQ	214	Fish Consumption	Mercury
Stream(s)		(Miles)		
Crab Orchard Creek	IL_ND-01	10.41	Fish Consumption	Dioxin, Mercury
Crab Orchard Creek	IL_ND-11	1.01	Aquatic Life	Dissolved Oxygen, pH, Cause Unknown
Drury Creek	IL_NDC-01	19.39	Aquatic Life	Dissolved Oxygen
Drury Creek	IL_NDC-02	1.43	Aquatic Life	Dissolved Oxygen
Eek Creek	IL_NDBA-01	3.61	Aquatic Life	Dissolved Oxygen, Water Temperature
Hurricane Creek	IL_NF-01	11.21	Aquatic Life	Lindane, Sedimentation/Siltation, Cause Unknown
Indian Creek	IL_NDCB-01	4.37	Aquatic Life	Dissolved Oxygen
Indian Creek	IL_NDCB-01	6.84	Aquatic Life	Dissolved Oxygen
Little Crab Orchard Creek-West	IL_NDA-01	13.92	Aquatic LIfe	Methoxychlor
Piles Fork	IL_NDB-03	7.2	Aquatic Life	Methoxychlor, Dissolved Oxygen
Pond Creek	IL_CC-FF-C3	7.33	Aquatic Life	Cause Unknown
Pond Creek	IL_ATHE	9.21	Aquatic Life	Dissolved Oxygen

Big Muddy Nutrient Assessment Plan: Assessed Waterbodies



3.2 Sampling Plan

The sampling plan was a coordinated effort between all planning partners in the Big Muddy watershed. The sampling plan goes beyond the traditional outfall monitoring, creating an upstream and downstream water quality monitoring location for each partner involved. The plan was forwarded to Illinois EPA in 2024 to be fully implemented in 2025. The Sampling Plan is summarized below. See **APPENDIX B** for all contents of the *Big Muddy River Watershed NARP Sampling Plan* submitted to Illinois EPA.

The Big Muddy Watershed Nutrient Assessment Reduction Plan (NARP) Sampling Plan was developed after the Illinois Environmental Protection Agency required several municipal wastewater operators to participate in a coordinated watershed effort to address the risk of eutrophication in local streams driven largely by elevated phosphorus. In response, six municipalities—Benton, Carbondale (both plants), Carterville, Herrin, Murphysboro, and West Frankfort—formed the Big Muddy NARP Advisory Group in 2023 and partnered with the Greater Egypt Regional Planning and Development Commission to guide planning, coordination, and compliance activities. Early efforts focused on organizing the group, outlining objectives for the full NARP, assessing available data, and establishing a unified approach to monitoring, modeling, and eventual nutrient-reduction recommendations. A central early milestone was the creation of a comprehensive sampling plan for review by IEPA.

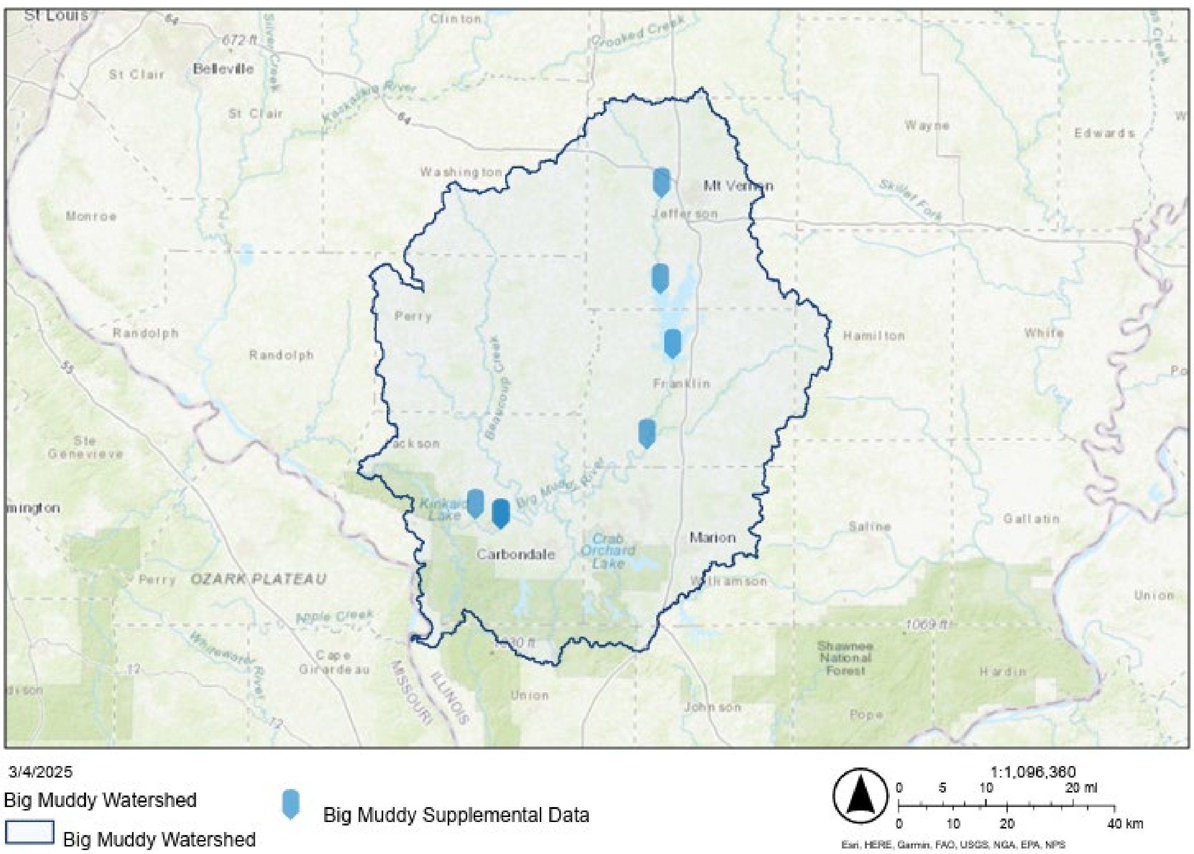
The sampling plan establishes a watershed-wide monitoring framework built around consistent measurement of key water-quality parameters that indicate nutrient impacts and potential eutrophication. These include phosphorus, nitrogen forms, dissolved oxygen, pH, suspended solids, fecal coliform, temperature, $CBOD_5$, chlorine residual, and chlorophyll-a—the latter collected from April through October to help evaluate algal productivity. All laboratory analyses, including chlorophyll-a, will be conducted through Pace Analytical to maintain data consistency. Sampling will take place twice monthly, on the first and third Tuesday at 10:00 a.m., with flexibility for communities that must sample as close as possible to the designated time.

To capture conditions around each wastewater treatment plant, sampling locations are set upstream, at the outfall, and downstream. Where necessary, new sites were selected based on access and stream crossings. Additional stations were added at the Big Muddy River above Rend Lake and downstream near Town Creek Road to bracket the watershed with an upstream and downstream anchor. These distributed monitoring sites provide a comprehensive picture of nutrient conditions throughout major tributaries, including the Big Muddy River, Crab Orchard Creek, Little Crab Orchard Creek, Hurricane Creek, Sugar Creek, and Middle Fork.

The data generated from this coordinated effort will feed into water-quality modeling, support evaluation of eutrophication risk, and ultimately guide phosphorus-reduction strategies and best management practices. The full NARP, incorporating monitoring, analysis, modeling, and recommended input reductions, is scheduled for submission to IEPA by December 31, 2025.

3.3 Data Review

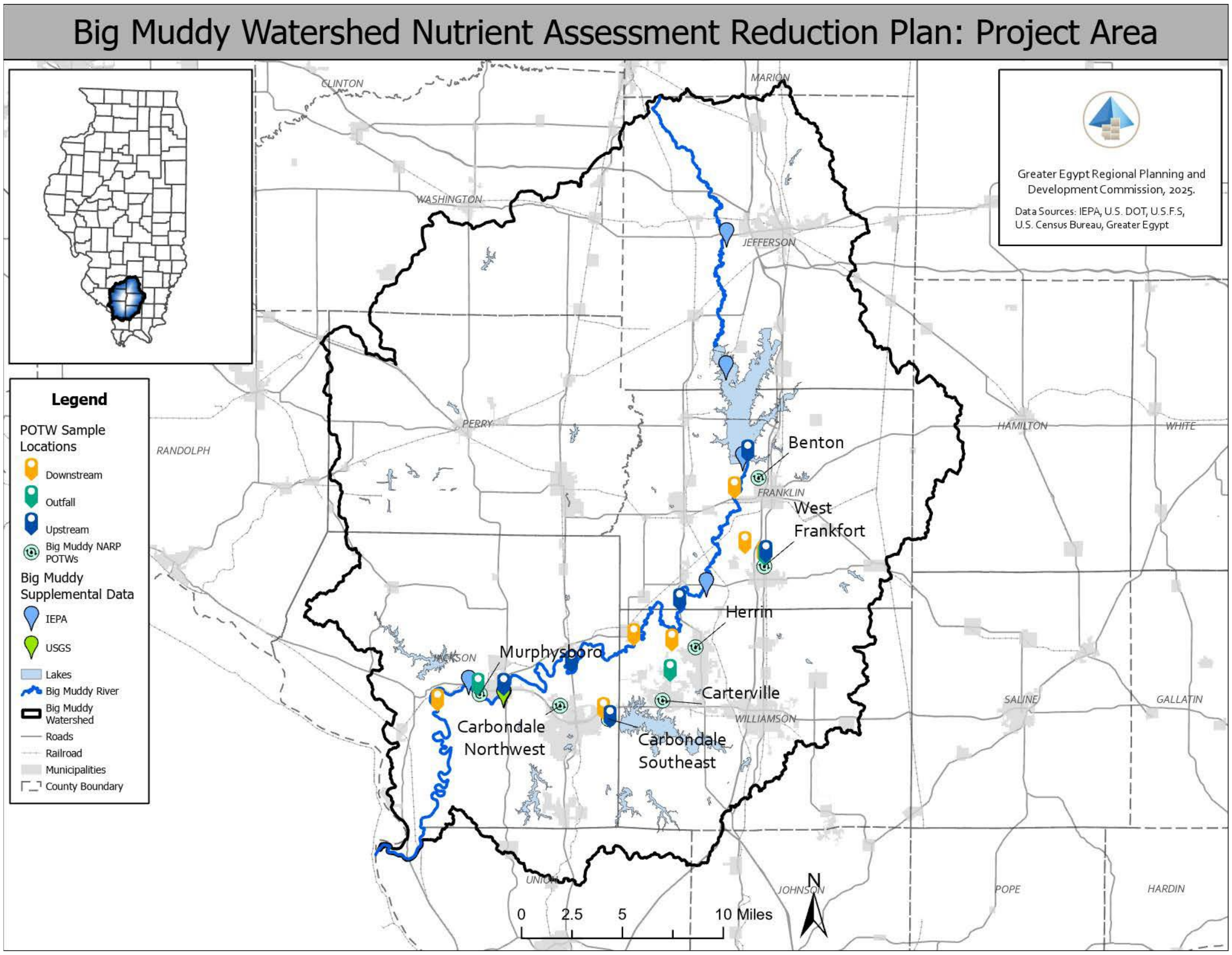
While samples were collected directly by the participating WWTPs over the course of the NARP planning process, additional data points were sourced from the National Water Quality Monitoring Council for the sake of gathering more extensive data from a longer period. Locations were chosen based on relevance and sampling dates. Some data points recorded nutrient data starting in 1999, and the most recent extended to 2023. The figure below represents the locations of each supplementary data points, and the corresponding table shows the location, source, years, and types of information included in each point.



Site ID	Organization	Start Year	End Year	Latitude	Longitude	Data Types
IL_EPA_WQX-B90135500	IEPA	1999	2022	38.30974	-88.98837	Phosphorous, Nitrogen, Nitrate, Nitrite
IL_EPA_WQX-B90009800	IEPA	1999	2022	37.75787	-89.32728	Phosphorous, Nitrogen, Nitrate, Nitrite
IL_EPA_WQX-B90021400	IEPA	1999	2022	37.89145	-89.01973	Phosphorous, Nitrogen, Nitrate, Nitrite
IL_EPA_WQX-S601762	IEPA	2006	2018	37.77425	-89.38062	Phosphorous, Nitrogen
IL_EPA_WQX-S812579	IEPA	2008	2018	38.15107	-88.98949	Phosphorous, Nitrogen
IL_EPA_WQX-S805972	IEPA	2008	2018	38.04256	-88.96397	Phosphorous, Nitrogen
USGS-05599490	USGS	2015	2023	37.758333	-89.32777	Phosphorous, Nitrogen, Nitrate, Nitrite

3.4 Sampling Plan Results

Wastewater Treatment Plants (WWTPs) took part in the monitoring effort from April 2024 to September of 2025, with the sampling plan going into effect in 2025. The goal of this NARP monitoring effort was to examine the effects WWTPs on eutrophication levels in the watershed. Due to the cost of monitoring, a discrete monitoring sample plan was developed. Each required WWTP was scheduled to collect two samples per month, taken on Tuesdays at approximately 10:00 a.m. This consistent sampling schedule was established to maintain comparability across facilities and to minimize temporal variability related to plant operations or diurnal flow patterns. The location where these samples were recorded can be seen in the figure below.



While most WWTPs adhered to the sampling frequency, several inconsistencies were noted in the dataset. Some facilities did not collect samples at all designated monitoring locations, resulting in partial spatial coverage. In other cases, some WWTP did not report any samples during some months leading to gaps in the final dataset. Consequently, the completeness of the data varied among facilities, and some locations have fewer recorded results than originally planned. When and where the inconsistencies of the data occur can be seen in the table below. Where green squares mean all data was submitted, yellow squares mean partial data was submitted, and red squares mean no data was submitted.

WWTP	May 24	Jun 24	Jul 24	Aug 24	Sep 24	Oct 24	Nov 24	Dec 24	Jan 25	Feb 25	Mar 25	Apr 25	May 25	Jun 25	Jul 25	Aug 25	Sep 25	Oct 25	Nov 25
Benton																			
Carbondale																			
Carterville																			
Herrin																			
Murphysboro																			
West Frankfort																			

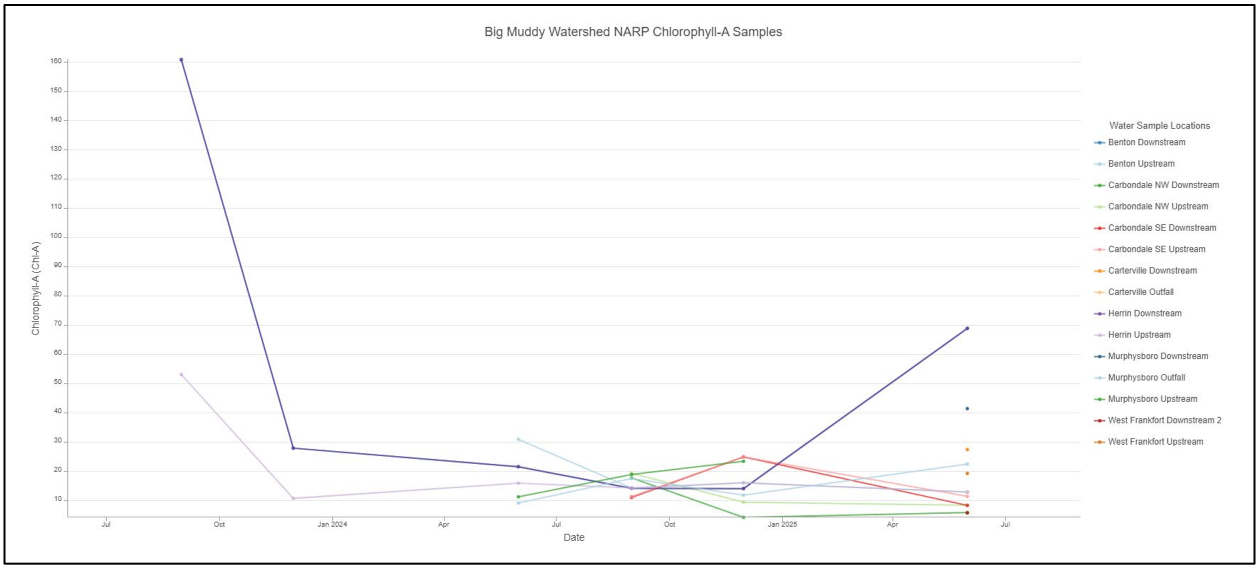
There were nine total measurements collected at these sample sites. They were pH, Temperature, Dissolved Oxygen, Chlorophyll-A (Chl-A), Phosphorus, Ammonia Nitrogen (A.N.), Nitrate, Nitrite and Total Kjeldahl Nitrogen (TKN). All samples were set to be collected throughout the entirety of the plan except for Chl-A, which was only planned to be sampled from April through October.

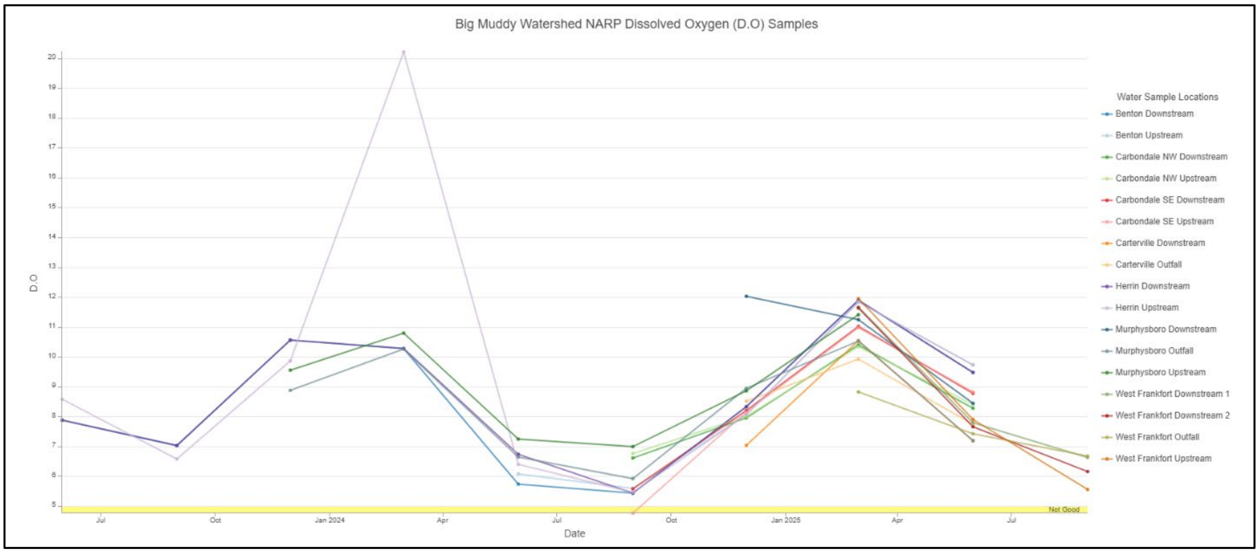
To visualize the change in the water samples over the time frame of this study, the data from each water sample location was averaged over a three-month period to smooth visualizations of the changes in the watershed that occur over the year. The risk for eutrophication criteria are:

- Its pH exceeds 9.0, the upper limit of the water quality standard;
- Its median sestonic chlorophyll a is greater than 26 mg/L; or
- Its pH exceeds 8.35 and its dissolved oxygen is greater than 110% on the same day, for two or more days from Illinois EPA sampling.

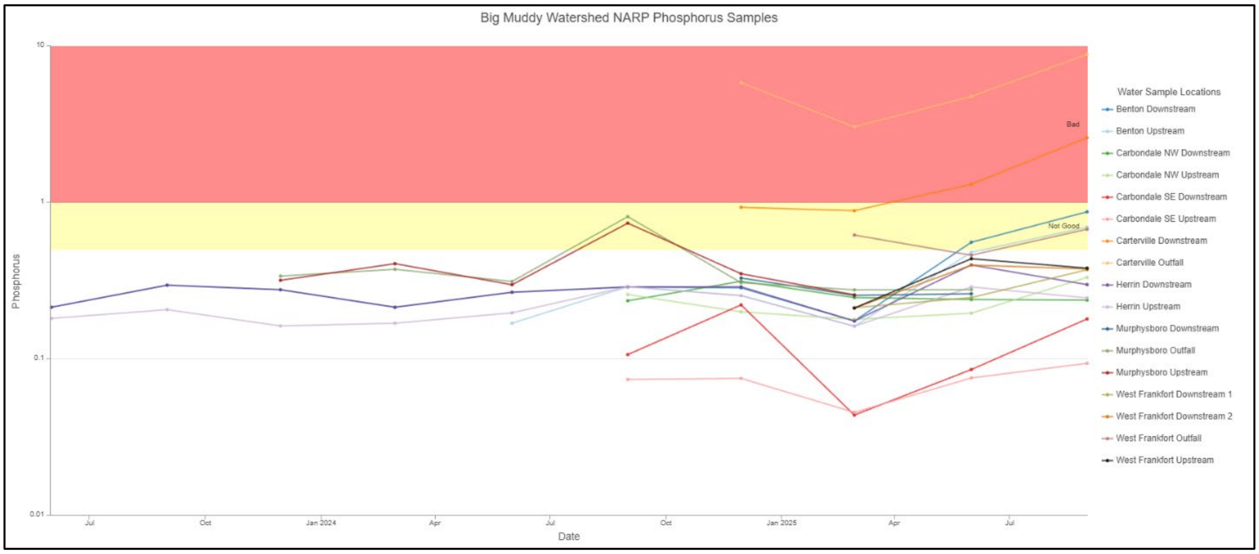
None of the sample locations had any samples that were above the single reporting threshold for pH. Neither were the median Chl-A samples. There were some samples that recorded above that 26 mg/l, but they were outliers for the dataset, with all median Chl-A samples being below the threshold. The last of the criteria was not met either. There was only one pH sample over the 8.35 threshold, it was 8.36. At the time of that sample the dissolved oxygen saturation was 93.83%. Based on those three criteria, the samples indicate no evidence of eutrophication. However, there was one WWTP that had consistent phosphorus samples above the recommended limit and that was the Carterville location.

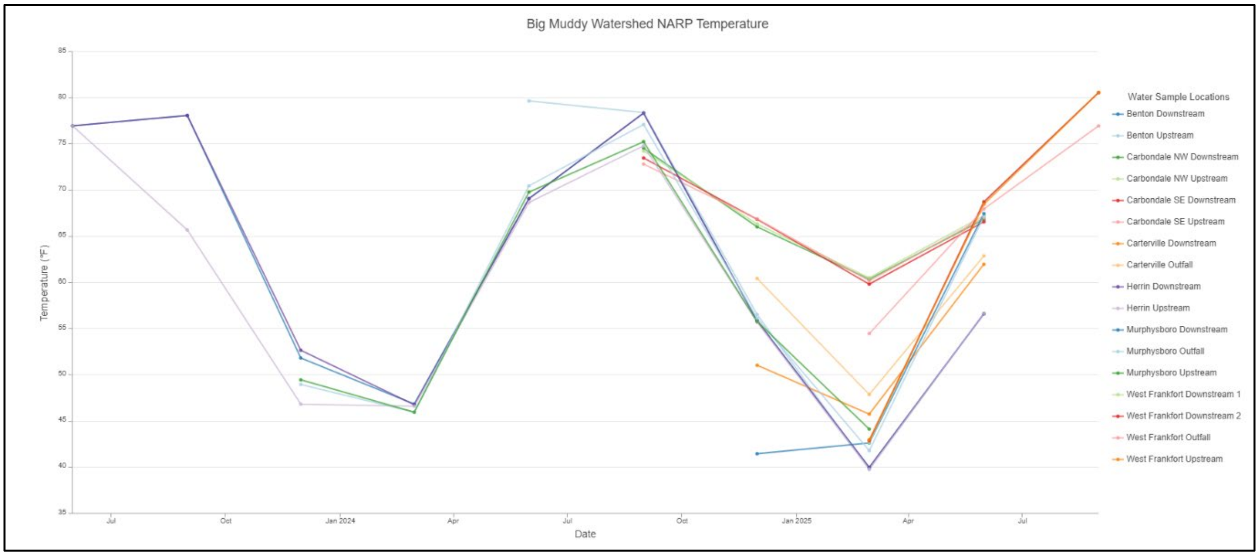
Carterville's outfall phosphorus samples were all above the 1 mg/l threshold, this can be seen in the figures below. With these high phosphorus loads further analysis was done to compare specific point source phosphorus vs. the non-point source phosphorus loads. The results of this comparison can be seen in the following modeling section. This issue is currently being addressed with Carterville's WWTP undergoing major changes. Those specific changes are discussed in Section 4, Management Measures.

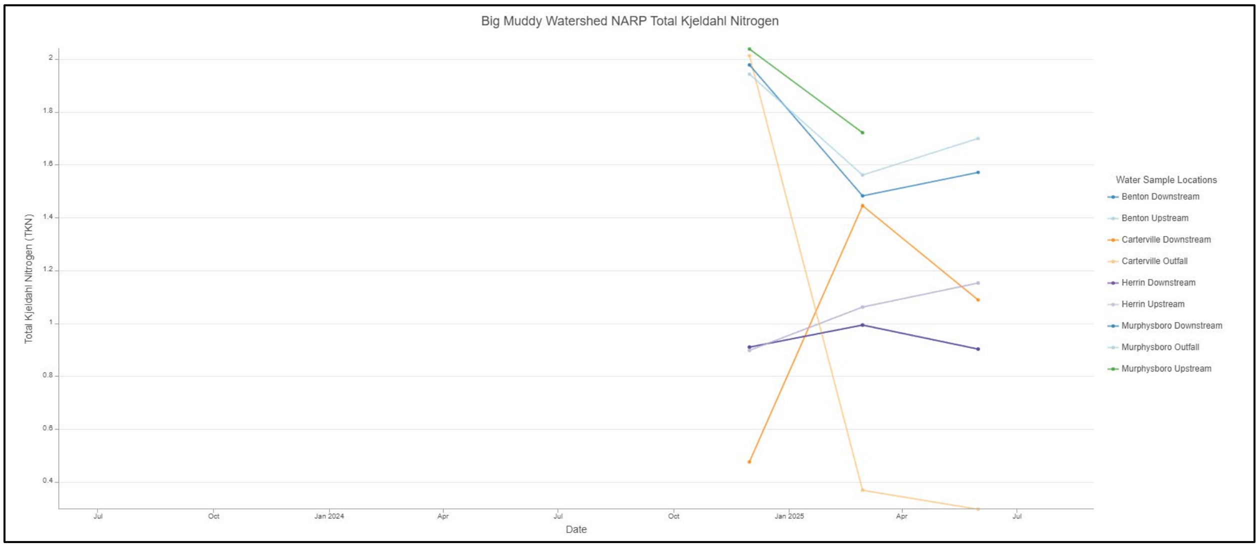

Big Muddy Watershed NARP Chlorophyll-A Samples
Chlorophyll-A (Chl-A)
Date
Water Sample Locations
Benton Downstream
Benton Upstream
Carbondale NW Downstream
Carbondale NW Upstream
Carbondale SE Downstream
Carbondale SE Upstream
Carterville Downstream
Carterville Outfall
Herrin Downstream
Herrin Upstream
Murphysboro Downstream
Murphysboro Outfall
Murphysboro Upstream
West Frankfort Downstream 2
West Frankfort Upstream


Big Muddy Watershed NARP Dissolved Oxygen (D.O) Samples
D.O
Date
Not Good
Water Sample Locations
Benton Downstream
Benton Upstream
Carbondale NW Downstream
Carbondale NW Upstream
Carbondale SE Downstream
Carbondale SE Upstream
Carterville Downstream
Carterville Outfall
Herrin Downstream
Herrin Upstream
Murphysboro Downstream
Murphysboro Outfall
Murphysboro Upstream
West Frankfort Downstream 1
West Frankfort Downstream 2
West Frankfort Outfall
West Frankfort Upstream


Big Muddy Watershed pH Samples
pH
Date
Water Sample Locations
Benton Downstream
Benton Upstream
Carbondale NW Downstream
Carbondale NW Upstream
Carbondale SE Downstream
Carbondale SE Upstream
Carterville Downstream
Carterville Outfall
Herrin Downstream
Herrin Upstream
Murphysboro Downstream
Murphysboro Outfall
Murphysboro Upstream
West Frankfort Downstream 1
West Frankfort Downstream 2
West Frankfort Outfall
West Frankfort Upstream


Big Muddy Watershed NARP Phosphorus Samples
Phosphorus
Date
Bad
Not Good
Water Sample Locations
Benton Downstream
Benton Upstream
Carbondale NW Downstream
Carbondale NW Upstream
Carbondale SE Downstream
Carbondale SE Upstream
Carterville Downstream
Carterville Outfall
Herrin Downstream
Herrin Upstream
Murphysboro Downstream
Murphysboro Outfall
Murphysboro Upstream
West Frankfort Downstream 1
West Frankfort Downstream 2
West Frankfort Outfall
West Frankfort Upstream


Big Muddy Watershed NARP Temperature
Temperature (°F)
85
80
75
70
65
60
55
50
45
40
35
Jul
Oct
Jan 2024
Apr
Jul
Oct
Jan 2025
Apr
Jul
Date
Water Sample Locations
Benton Downstream
Benton Upstream
Carbondale NW Downstream
Carbondale NW Upstream
Carbondale SE Downstream
Carbondale SE Upstream
Carterville Downstream
Carterville Outfall
Herrin Downstream
Herrin Upstream
Murphysboro Downstream
Murphysboro Outfall
Murphysboro Upstream
West Frankfort Downstream 1
West Frankfort Downstream 2
West Frankfort Outfall
West Frankfort Upstream


Big Muddy Watershed NARP Total Kjeldahl Nitrogen
Total Kjeldahl Nitrogen (TKN)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
Jul
Oct
Jan 2024
Apr
Jul
Oct
Jan 2025
Apr
Jul
Date
Water Sample Locations
Benton Downstream
Benton Upstream
Carterville Downstream
Carterville Outfall
Herrin Downstream
Herrin Upstream
Murphysboro Downstream
Murphysboro Outfall
Murphysboro Upstream

3.5 Watershed Analysis

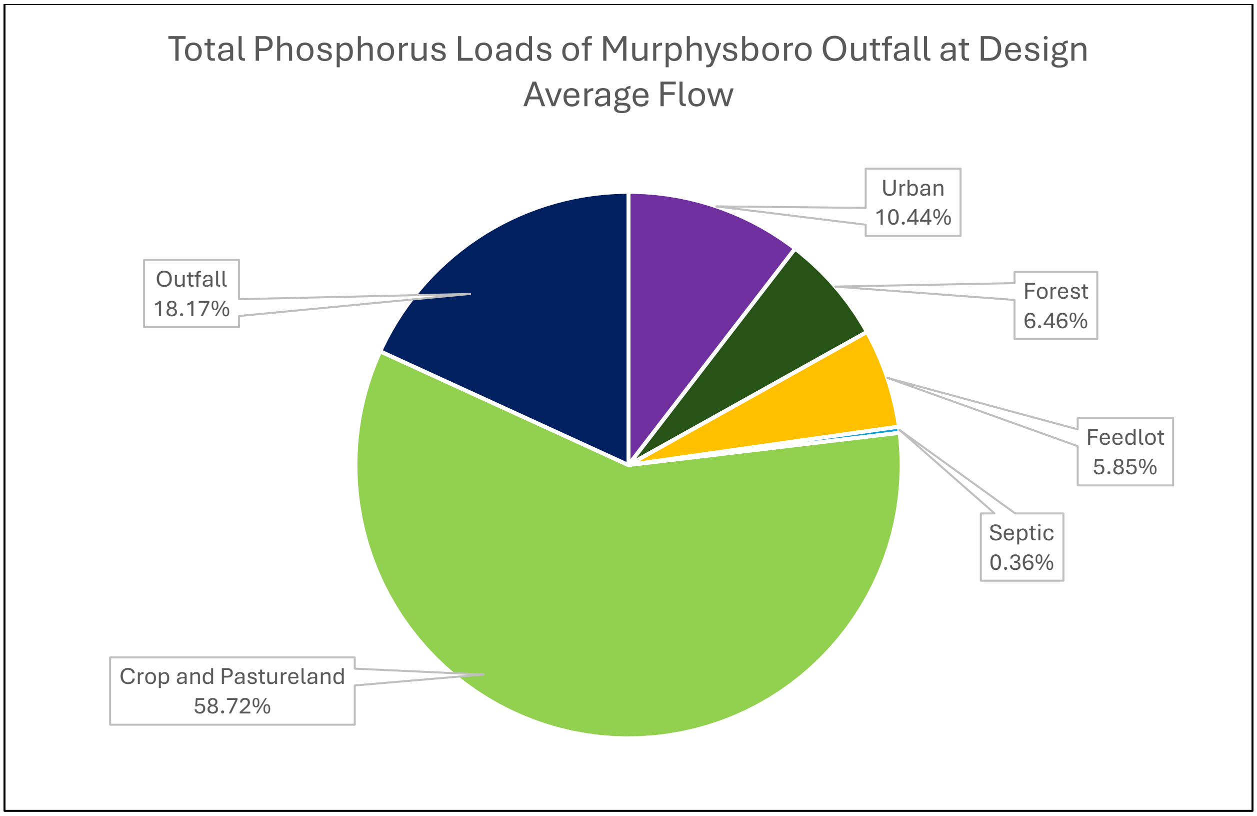
Using the Pollutant Load Estimation Tool (PLET) from the EPA, non-point source pollution estimated for the sub watersheds corresponding with the WWTP water sample locations. To conduct a comparison of the point-source pollution, WWTP's, and non-point source pollution. There were two types of comparisons to the PLET. The first being a direct comparison between the outfall of the WWTPs to the PLET models. The yearly average of the WWTP outfall samples were converted to the same value as the PLET models (lbs./year). The outfall samples were calculated at the average design flow of the outfall pipe and the maximum design flow of the outfall pipe. The flow values came from the NPDES permits of each WWTP.

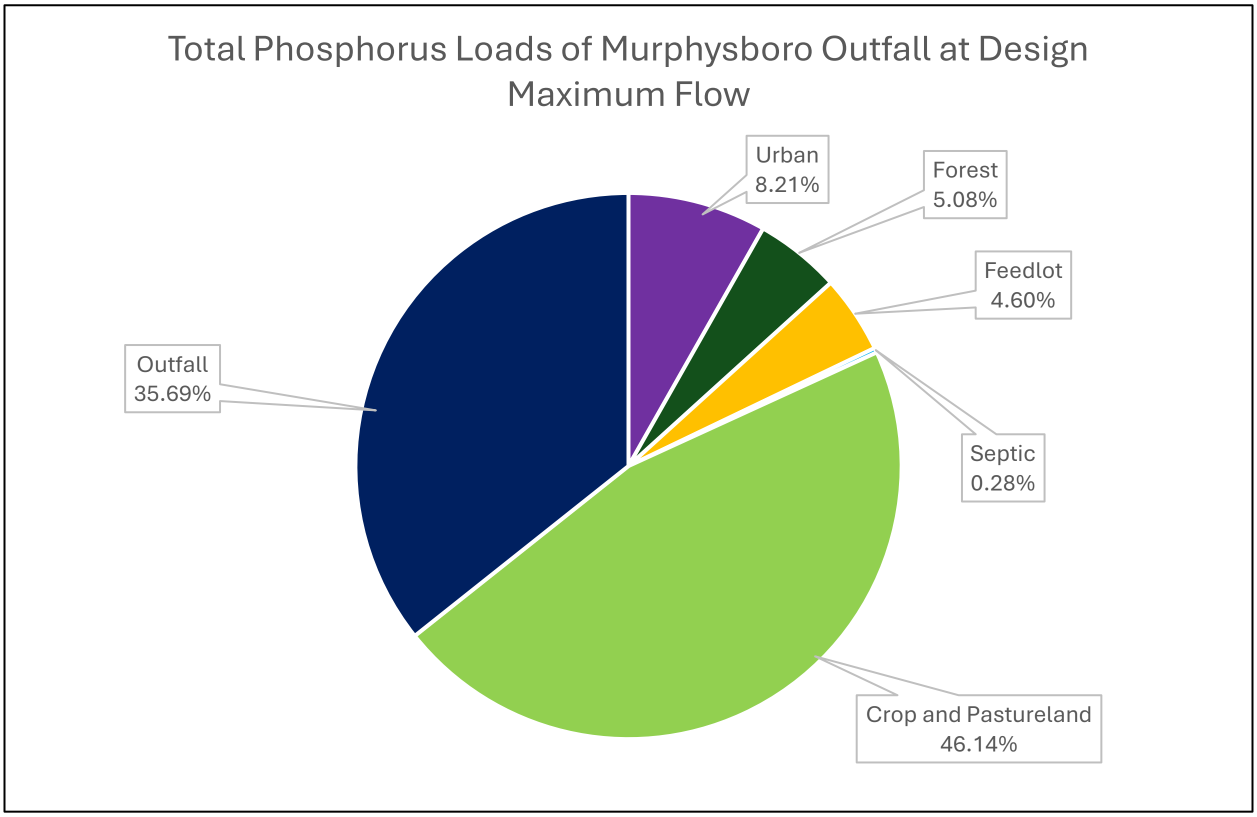
The calculations can be seen in the table and charts below. Of the three WWTP that submitted outfall water samples two of the three at average flow contributed less than 15% of the estimated total phosphorus loads in their respective HUC 12s. The other WWTP, Carterville, had high and high average of phosphorus samples, which were 5.85 mg/l. When compared to total phosphorus loads, at the average flow from the outfall this would have contributed to 41% of the estimated phosphorus in that HUC 12. With those high levels of phosphorus. This shows that Carterville is constantly above the acceptable level of phosphorus. Even with the average phosphorus sample being greater than five times the acceptable limit with the average flow, it is still less than half of the phosphorus contribution in its HUC 12. Carterville already has plans to upgrade their WWTP.

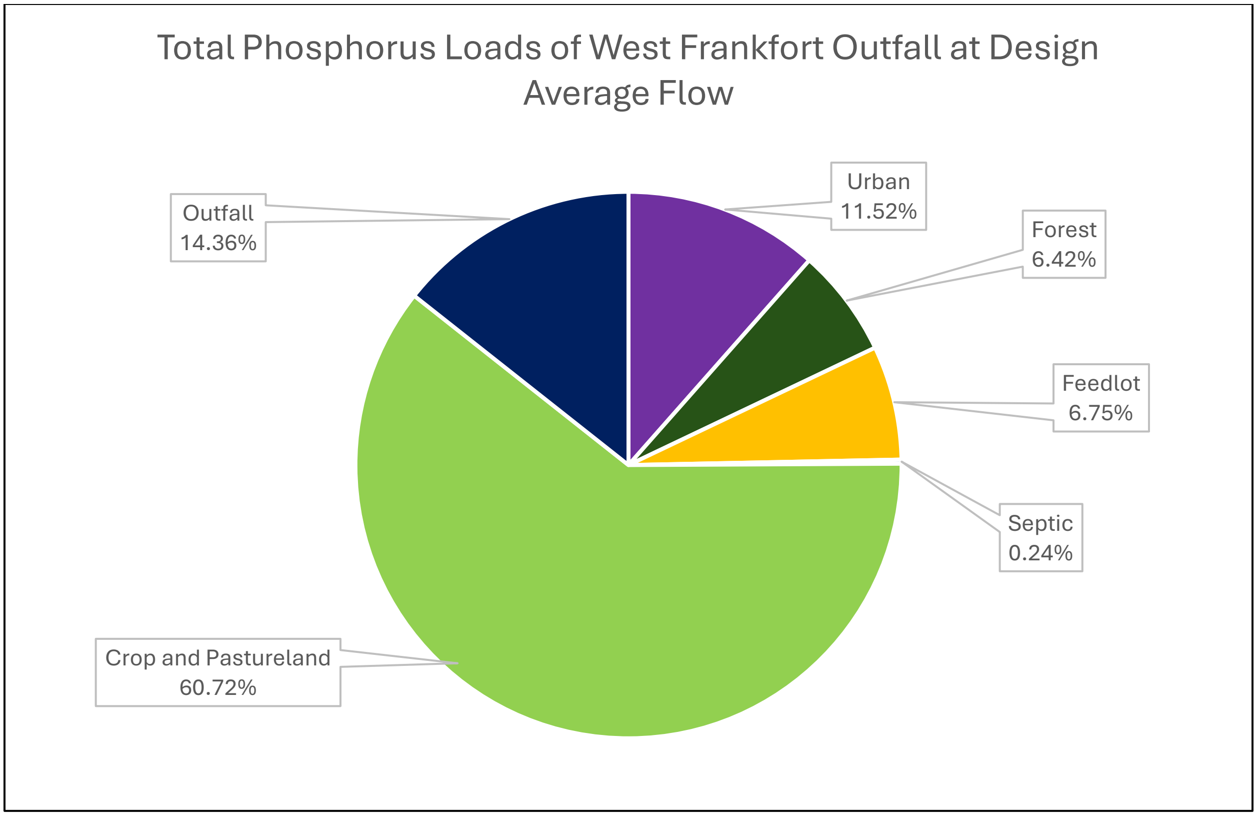
Outfall PLET Comparisons

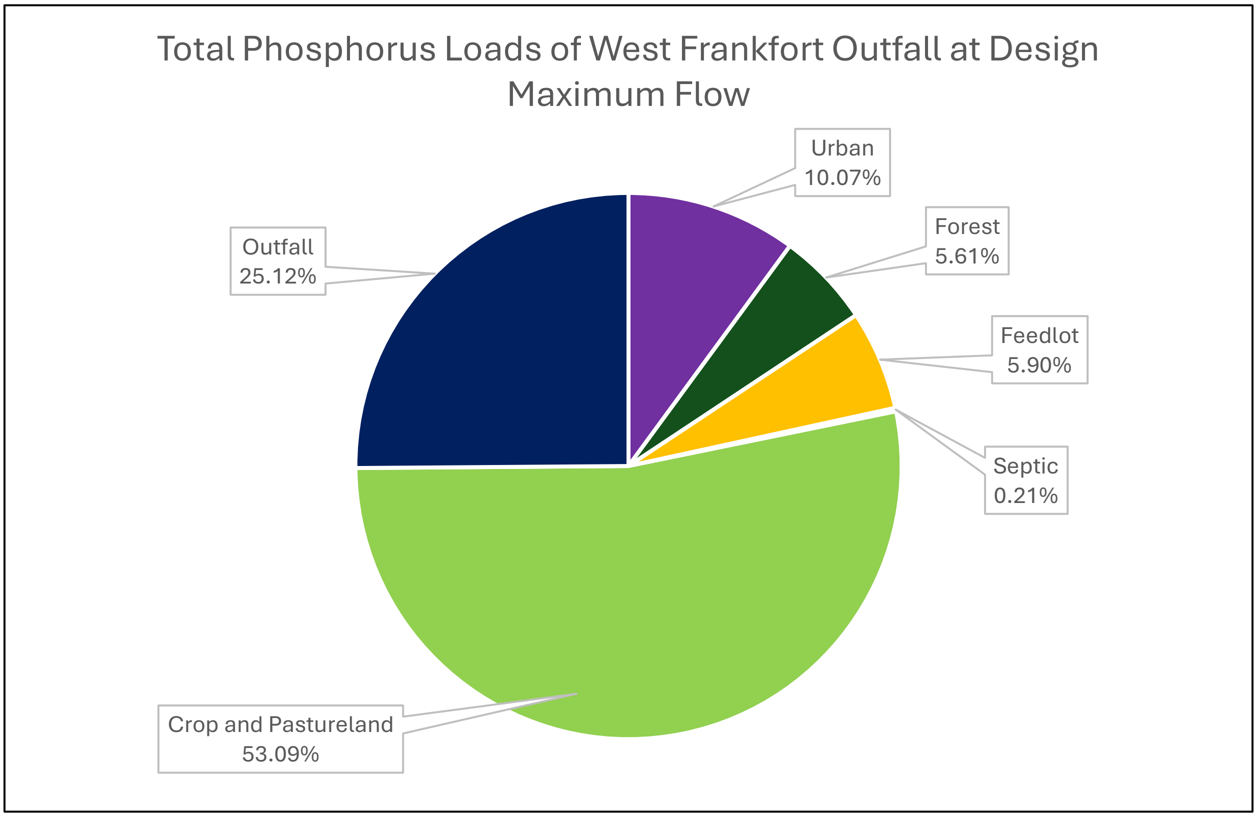
	Murphysboro Outfall (P)	Carterville Outfall (P)	WF Outfall (P) (2025)
Avg 2024 (mg/l)	0.47	5.85	0.61
P (lbs./year) at Design Max Flow	10,070	18,706	5,158
P (lbs./year) at Design Average Flow	4,028	12,471	2,579
Total P Load for Respective HUC 12 PLET	18,146	14,005	15,378
Total P PLET + Outfall at Design Max Flow	28,216	36,852	20,536
Total P PLET + Outfall at Design Average Flow	22,174	30,617	17,957
Outfall % of Total P at Design Maximum Flow	36%	58%	25%
Outfall % of Total P at Design Average Flow	18%	47%	14%

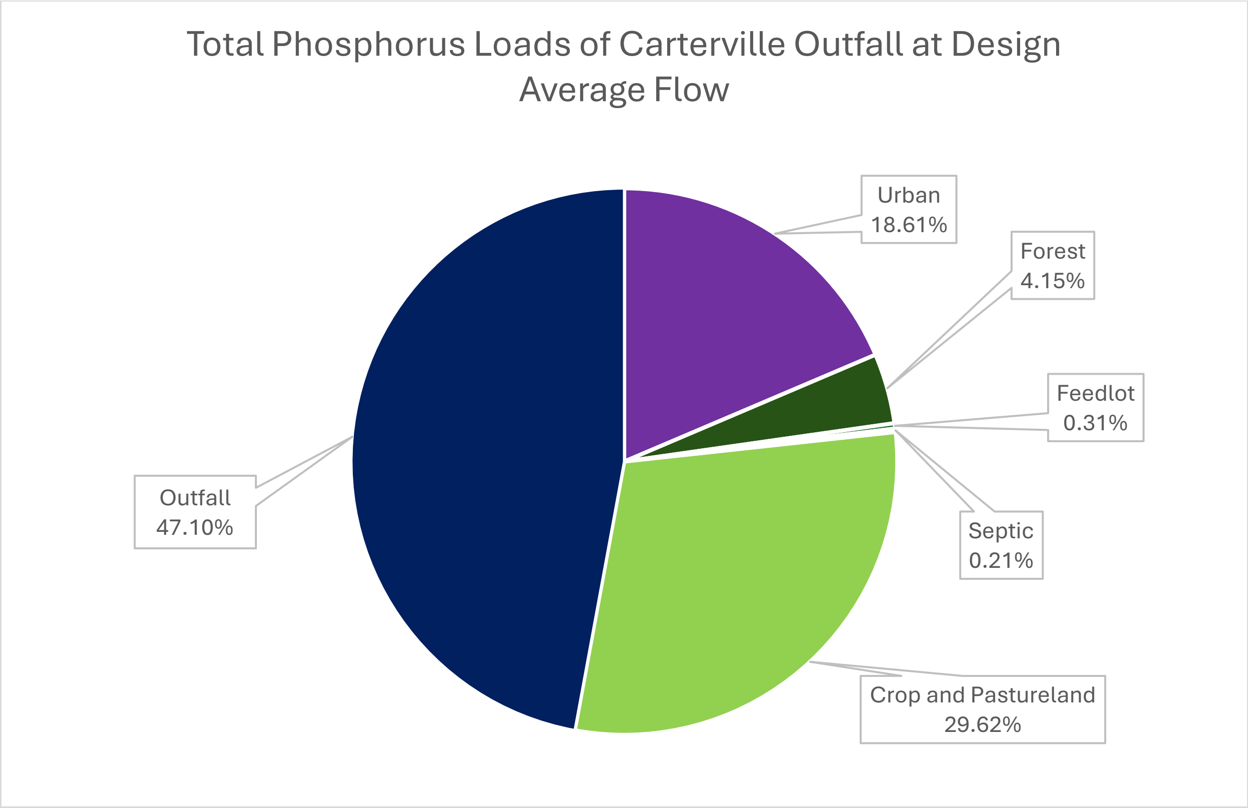
Watershed	Mud Creek-Big Muddy River		Hurricane Creek		Green River-Middle Fork Big Muddy River	
HUC 12	071401061201		071401060705		071401060410	
WWTP	Murphysboro Outfall		Carterville Outfall		West Frankfort Outfall	
Scenario	Total Phosphorus at Outfall Design Average Flow (2.8 MGD)	Total Phosphorus at Outfall Design Maximum Flow (7.0 MGD)	Total Phosphorus at Outfall Design Average Flow (0.7 MGD)	Total Phosphorus at Outfall Design Maximum Flow (1.05 MGD)	Total Phosphorus at Outfall Design Average Flow (1.4 MGD)	Total Phosphorus at Outfall Design Maximum Flow (2.8 MGD)
Outfall Phosphorus (lbs./year)	4,028	10,070	12,471	18,706	2,579	5,158
Outfall	18.17%	35.69%	47.10%	57.19%	14.36%	25.12%
Urban Phosphorus (lbs./year)	2,316	2,316	4,926	4,926	2,068	2,068
Urban	10.44%	8.21%	18.61%	15.06%	11.52%	10.07%
Cropland Phosphorus (lbs./year)	11,686	11,686	6,584	6,584	9,727	9,727
Cropland	52.70%	41.42%	24.87%	20.13%	54.17%	47.37%
Pastureland Phosphorus (lbs./year)	1,334	1,334	1,258	1,258	1,176	1,176
Pastureland	6.02%	4.73%	4.75%	3.85%	6.55%	5.73%
Forest Phosphorus (lbs./year)	1,432	1,432	1,099	1,099	1,152	1,152
Forest	6.46%	5.08%	4.15%	3.36%	6.42%	5.61%
Feedlot Phosphorus (lbs./year)	1,298	1,298	83	83	1,212	1,212
Feedlot	5.85%	4.60%	0.31%	0.25%	6.75%	5.90%
Septic Phosphorus (lbs./year)	80	80	55	55	43	43
Septic	0.36%	0.28%	0.21%	0.17%	0.24%	0.21%
Crop and Pastureland Phosphorus (lbs./year)	13,020	13,020	7,842	7,842	10,903	10,903
Crop and Pastureland	58.72%	46.14%	29.62%	23.97%	60.72%	53.09%
PLET Total Phosphorus (lbs./year)	18,146	18,146	14,005	14,005	15,378	15,378
Total Phosphorus (lbs./year) PLET + Outfall	22,174	28,216	26,476	32,711	17,957	20,536

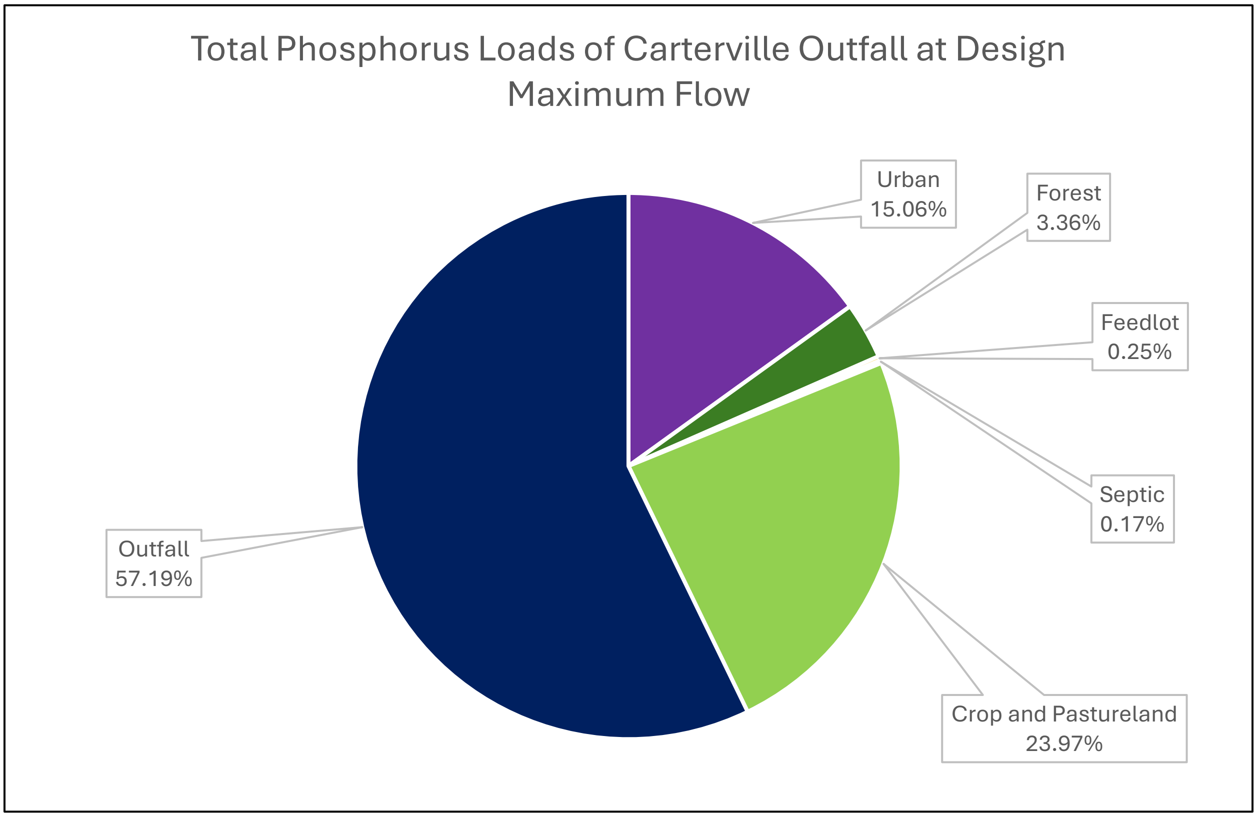

Total Phosphorus Loads of Murphysboro Outfall at Design Average Flow
Urban 10.44%
Forest 6.46%
Feedlot 5.85%
Septic 0.36%
Outfall 18.17%
Crop and Pastureland 58.72%


Total Phosphorus Loads of Murphysboro Outfall at Design Maximum Flow
Urban 8.21%
Forest 5.08%
Feedlot 4.60%
Septic 0.28%
Outfall 35.69%
Crop and Pastureland 46.14%


Total Phosphorus Loads of West Frankfort Outfall at Design Average Flow
Urban 11.52%
Forest 6.42%
Feedlot 6.75%
Septic 0.24%
Crop and Pastureland 60.72%
Outfall 14.36%


Total Phosphorus Loads of West Frankfort Outfall at Design Maximum Flow
Urban 10.07%
Forest 5.61%
Feedlot 5.90%
Septic 0.21%
Crop and Pastureland 53.09%
Outfall 25.12%


Total Phosphorus Loads of Carterville Outfall at Design Average Flow
Urban 18.61%
Forest 4.15%
Feedlot 0.31%
Septic 0.21%
Crop and Pastureland 29.62%
Outfall 47.10%


Total Phosphorus Loads of Carterville Outfall at Design Maximum Flow
Urban 15.06%
Forest 3.36%
Feedlot 0.25%
Septic 0.17%
Crop and Pastureland 23.97%
Outfall 57.19%

PLET Results from HUC12s in NARP Sampling Plan

Watershed	Cambon Lake-Big Muddy River	Crab Orchard Lake-Crab Orchard Creek	Drummond Creek-Middle Fork Big Muddy River	Green River-Middle Fork Big Muddy River	Hurricane Creek	Little Crab Orchard Creek-Crab Orchard Creek	Mud Creek-Big Muddy River	Sugar Creek-Big Muddy River	Town Creek-Big Muddy River	Town of Cambria-Big Muddy River
HUC	071401060704	071401060806	071401060406	071401060410	071401060705	071401060809	071401061201	071401060702	071401061205	071401060706
Urban Phosphorus (lbs./year)	1,274	5,146	0	2,068	4,926	7,799	2,316	4,135	6,354	0
Urban	8.41%	37.86%	0.00%	13.45%	35.17%	36.94%	12.76%	18.95%	24.43%	0.00%
Cropland Phosphorus (lbs./year)	13,279	5,904	11,037	9,727	6,584	9,385	11,686	11,035	11,777	17,085
Cropland	87.70%	43.44%	85.47%	63.25%	47.01%	44.45%	64.40%	50.58%	45.29%	90.65%
Pastureland Phosphorus (lbs./year)	0	1,269	0	1,176	1,258	1,492	1,334	2,300	3,223	0
Pastureland	0.00%	9.34%	0.00%	7.65%	8.98%	7.07%	7.35%	10.54%	12.39%	0.00%
Forest Phosphorus (lbs./year)	0	1,111	730	1,152	1,099	1,797	1,432	2,799	4,517	1,436
Forest	0.00%	8.17%	5.65%	7.49%	7.85%	8.51%	7.89%	12.83%	17.37%	7.62%
Feedlot Phosphorus (lbs./year)	569	113	1,118	1,212	83	541	1,298	1,504	118	295
Feedlot	3.76%	0.83%	8.66%	7.88%	0.59%	2.56%	7.15%	6.89%	0.45%	1.57%
Septic Phosphorus (lbs./year)	19	49	29	43	55	98	80	46	16	31
Septic	0.13%	0.36%	0.22%	0.28%	0.39%	0.46%	0.44%	0.21%	0.06%	0.16%
Crop and Pastureland Phosphorus (lbs./year)	13,279	7,173	11,037	10,903	7,842	10,877	13,020	13,335	15,000	17,085
Crop and Pastureland	87.70%	52.77%	85.47%	70.90%	55.99%	51.52%	71.75%	61.12%	57.68%	90.65%
Total Phos. (lbs./year)	15,141	13,592	12,914	15,378	14,005	21,112	18,146	21,819	26,005	18,847

PLET Results for Comparison HUC12s

Watershed	Dodds Creek-Casey Fork	Atchinson Creek-Rend Lake	Town of Mount Vernon-Casey Fork	Dodds Branch-Swanwick Creek	Swanwick Creek	Opossum Creek-Beaucoup Creek	Town of Vergennes-Beaucoup Creek	McElvain School-Beaucoup Creek
HUC	071401060301	071401060302	071401060103	071401061005	071401061006	071401061011	071401061013	071401061016
Urban Phosphorus (lbs./year)	0	1,490	9,050	1,310	747	0	720	815
Urban	0.00%	8.47%	38.50%	3.78%	5.18%	0.00%	3.54%	3.47%
Cropland Phosphorus (lbs./year)	10,490	13,523	9,778	24,998	11,207	27,828	14,593	19,537
Cropland	95.12%	76.90%	41.60%	72.20%	77.77%	84.00%	71.72%	83.23%
Pastureland Phosphorus (lbs./year)	0	1,281	2,521	2,231	1,033	1,887	1,823	1,731
Pastureland	0.00%	7.28%	10.73%	6.44%	7.17%	5.70%	8.96%	7.37%
Forest Phosphorus (lbs./year)	0	800	1,534	2,387	1,049	2,668	2,534	1,076
Forest	0.00%	4.55%	6.53%	6.89%	7.28%	8.05%	12.45%	4.58%
Feedlot Phosphorus (lbs./year)	518	468	516	3,692	369	707	668	305
Feedlot	4.70%	2.66%	2.20%	10.66%	2.56%	2.13%	3.28%	1.30%
Septic Phosphorus (lbs./year)	20	23	105	4.36	5.81	37	9.82	10
Septic	0.18%	0.13%	0.45%	0.01%	0.04%	0.11%	0.05%	0.04%
Crop and Pastureland Phosphorus (lbs./year)	10,490	14,804	12,299	27,229	12,240	29,715	16,416	21,268
Crop and Pastureland	95.12%	84.19%	52.33%	78.65%	84.94%	89.70%	80.68%	90.60%
Total Phos. (lbs./year	11,028	17,585	23,504	34,622	14,411	33,127	20,348	23,474

To compare other sample locations that are not at the outfall. The average flow data from the USGS stream gages were used to calculate the amount of phosphorus in lbs./year that passed through that location, using the same formula as the outfall calculations. To get a better comparison of the sample location to the HUC 12 PLET the phosphorus load per year was divided by the area that is drained into that location. The results of these calculations can be seen below.

These sample locations were chosen for the comparisons to the PLET models as they were the only ones that were sampling from streams that had continuous flow data. To get an estimate for the locations that were directly sampled near a USGS continuous flow site, the flow was adjusted based on the area of acres that are drained into that location.

Phos. Lbs./acre/year

	Murphysboro Upstream	Mud Creek-Big Muddy River PLET	Herrin Upstream	Cambon Lake-Big Muddy River PLET	Benton Upstream	Benton Downstream	Sugar Creek-Big Muddy River
Avg Phos. (mg/l)	0.46	-	0.24	-	0.25	0.26	-
Phos. (lbs./year)	1,602,229.70	18,146.00	227,934.67	15,141.00	143,133.58	158,926.37	21,819.00
Phos. (lbs./acre/year)	1.16	0.49	0.45	1.18	0.46	0.48	1.04

To further examine the comparison the land use of each of these areas was calculated. The results can be seen in the following table. The reason for the examination of land use is the belief that areas with a higher crop and pasture usage would have higher phosphorus readings due to the number of fertilizers applied on that land. The PLET models that showed highest reading in the HUC 12s was 1.18 pounds of phosphorus per acre per year this HUC 12 also had the highest percentage of crop and pastureland land use at 64%. The higher percentage of crops and pastureland led to higher phosphorus readings in the water sample locations except for the Murphysboro location which had 1.16 lbs./acre/year. The Murphysboro location is also the furthest downstream of the WWTP sample locations. Being the furthest downstream their upstream sample location is negatively impacted by all WWTP outfalls and any crop and pastureland upstream of them, which is majority of the

Big Muddy Watershed. Visual comparisons of the water samples and PLET models can be seen in the figures below.

To compare other areas of the Big Muddy Watershed that were not required to be a part of the NARP, PLET models of other HUC 12s were compared to the required areas. To further analyze the effects of crops and pastureland on the amount of phosphorus in the watershed. The results of the additional PLET models can be seen in the following table. Similar to the HUC 12s that are in the required POTW areas crop and pastureland above 50% land use had over .6 and above pounds of phosphorus per acre per year.

Comparison PLETS

	Dodds Creek-Casey Fork	Atchinson Creek-Rend Lake	Town of Mount Vernon-Casey Fork	Dodds Branch-Swanwick Creek	Swanwick Creek	Opossum Creek-Beaucoup Creek	Town of Vergennes-Beaucoup Creek	McElvain School-Beaucoup Creek
Phos. (lbs./year)	11,028	17,585	23,504	34,622	14,411	33,127	20,348	23,474
Acres	18,060	24,541	20,767	21,518	13,542	34,986	11,510	12,463
Phos. (lbs./acre/yr)	0.61	0.72	1.13	1.61	1.06	0.95	1.77	1.88
Crop and Pastureland Land use	95%	84%	52%	79%	85%	90%	81%	91%

PLET Land Cover

Land Cover Class	Area Drained at Stream Gage Rte. 127	Area Drained at Stream Gage Plumfield	Mud Creek-Big Muddy River (HUC 12)	Cambon Lake-Big Muddy River (HUC 12)	Sugar Creek Big Muddy River (HUC 12)
Open Water	3.62%	4.96%	2.90%	1.79%	1.30%
Developed, Open Space	4.39%	4.56%	8.50%	4.01%	5.82%
Developed, Low Intensity	3.81%	3.72%	6.20%	4.46%	6.82%
Developed, Medium Intensity	1.30%	1.18%	2.29%	0.97%	2.57%
Developed, High Intensity	0.34%	0.33%	0.44%	0.20%	0.79%
Barren Land	0.12%	0.14%	0.03%	0.01%	0.12%
Deciduous Forest	23.37%	20.85%	40.07%	17.26%	22.65%
Evergreen Forest	0.13%	0.06%	0.06%	0.03%	0.07%
Mixed Forest	1.83%	2.39%	1.39%	0.54%	0.97%
Shrub/Scrub	0.19%	0.11%	0.23%	0.00%	0.08%
Herbaceous	0.69%	0.63%	0.41%	0.31%	0.53%
Woody Wetlands	4.20%	4.83%	3.79%	6.07%	17.26%
Emergent Herbaceous Wetlands	0.46%	0.44%	0.42%	0.46%	2.73%
Crop + Pasture	55.57%	55.81%	33.25%	63.88%	38.29%

4. NARP Strategy and Work Plan

The following section outlines the strategy to implement the NARP. This includes point and non-point source management recommendations, breakdown of technical and financial assistance needed, implementation and monitoring strategy, and detailing how the current NARP meets the IEPA requirements.

4.1 Management Actions

Management measures for the plan have been separated into point and nonpoint sources. These measures have been taken from each municipality's Phosphorus Optimization Plans or other NPDES Planning requirements. Current implementation is also being reported such as the construction of the new wastewater facility in Carterville. Measures have also been categorized as biological or mechanical. Implementation will be based on the potential increase of phosphorus standards from Illinois EPA; with the highest limits (0.1 mg/L) requiring more comprehensive measures such as structural components.

4.1.1 Point Sources

Point source management actions have been described to mitigate and reduce phosphorus loads at the treatment facilities. These actions vary on levels of p reduction, so larger actions requiring more funding are reserved for more stringent restrictions like 0.1mg/L,

Planning

Phosphorus Reduction Planning

A detailed assessment of causes for phosphorus from a variety of land use settings including industrial, commercial, and municipal. The assessment would also determine the best opportunities for phosphorus reduction including training and education and limiting or changing certain processes in industrial settings.

Biological

Chemical Treatment

This is one main treatment of phosphorus and other nutrients. Traditionally, this includes aluminum, iron, and calcium-based chemicals to function as binding agents for dissolved phosphorus. Treatment can happen at the headworks, aeration, filters, and sludge dewatering.

Filtration

Upgrade facilities with new high rate upflow filtration devices utilizing compressible, synthetic fiber spheres as the medium. This can assist the operators in achieving lower P values in effluent. The size of the filtration is dependent on the facility. Fuzzy and Disc Filters (see City of Carterville WWTP) can also be utilized.

Mechanical

Flocculation Basin

A flocculation (floc) basin is a calm, gently mixed basin where fine suspended particles are encouraged to come together and form larger, heavier clusters—called *floc*—that can be more easily removed downstream. After coagulants or other chemicals are added to destabilize the small particles in the water, the flow enters the flocculation basin. The basin is usually divided into multiple stages, each with slightly different mixing intensities. As the floc becomes larger and more cohesive, it becomes heavy enough to settle out in the next tank, often a sedimentation or clarification basin.

Sludge Dewatering System

After solids settle out in primary and secondary clarifiers, they are thickened and conveyed to the dewatering area. Here, the sludge is conditioned with polymers to help particles clump together, making water easier to separate. The separated liquid, known as centrate or filtrate, is returned to the plant's headworks for additional treatment. In this way, the dewatering system plays a critical role in overall plant efficiency and ensuring solids are handled safely.

City of Carterville WWTP

During the planning process, the City of Carterville was actively in the construction period of their new wastewater treatment plant. This new facility will provide multiple positive impacts including those reducing and mitigating phosphorus.

The new Carterville Wastewater Treatment Plant will utilize the Carrousel AlternatIR technology for Biological Nutrient Removal as the main treatment process. After settling in the Final Clarifiers, the treated water will undergo filtration via the Fuzzy Filter System for further nutrient reduction. Chemical coagulant addition for enhanced settling and filtration will also be utilized as needed.

Carrousel System:

The Carrousel System is a biological treatment technology designed to meet stringent BOD, nitrogen, and phosphorus limits by combining high-performance aerators and mixers with flexible nutrient removal capabilities. Its Excell® Aerator uses a dual-impeller design that efficiently aerates and mixes while allowing power turndown to as low as 10–20 percent during low-load conditions. For enhanced nitrogen and phosphorus removal, the system can incorporate anoxic zones equipped with EliminatIR™ or divertIR™ automated gates, which manage internal flows without the need for MLSS pumps. Performance and energy efficiency are further supported by the Oculus™ process control platform, which integrates targeted instrumentation, plant-specific presets, operator guidance, and optional remote monitoring to optimize treatment as conditions change.

Fuzzy Filter™ System:

The Fuzzy Filter™ System is a compact, high-rate filtration technology that uses a compressible synthetic media bed to provide fine solids removal down to approximately four microns while operating at hydraulic loading rates up to 45 gpm/ft^2. Its adjustable media porosity allows operators to match filtration performance to influent conditions, reducing wash water use, maintenance needs, and overall footprint compared to conventional filters. Cleaning is achieved through air and water scouring that removes captured solids without media loss. When paired with upstream phosphorus removal strategies, the Fuzzy Filter™ serves as an effective polishing step capable of achieving very low effluent phosphorus levels for municipal applications.

In addition to the facility updates, three neighboring municipalities will also utilize the new plant. Since the Villages of Cambria, Colp, and Crainville will be added to the Carterville system, their existing lagoon-based wastewater operations will be deactivated. This will provide further benefits in the form of phosphorus and other nutrient reduction.

4.1.2 Non-Point Sources

With large amounts of phosphorus originating from nonpoint sources, management measures will include agricultural and urban considerations. Since large landowners and agricultural operations are generally outside city jurisdictions, there is little restriction on management. However, landowners have traditionally taken advantage of USDA programs such as the Wetland Reserve program and various initiatives of Environmental Quality Incentives Program (EQIP). Partnerships will need to be developed to implement large-scale implementation in the Big Muddy River watershed. This includes critical areas in subwatersheds where high phosphorus and other nutrient loads are present. The figure on the following page represents the critical watersheds in the Big Muddy basin. While this list is not exhaustive, it includes some major measures to mitigate phosphorus through source and transport.

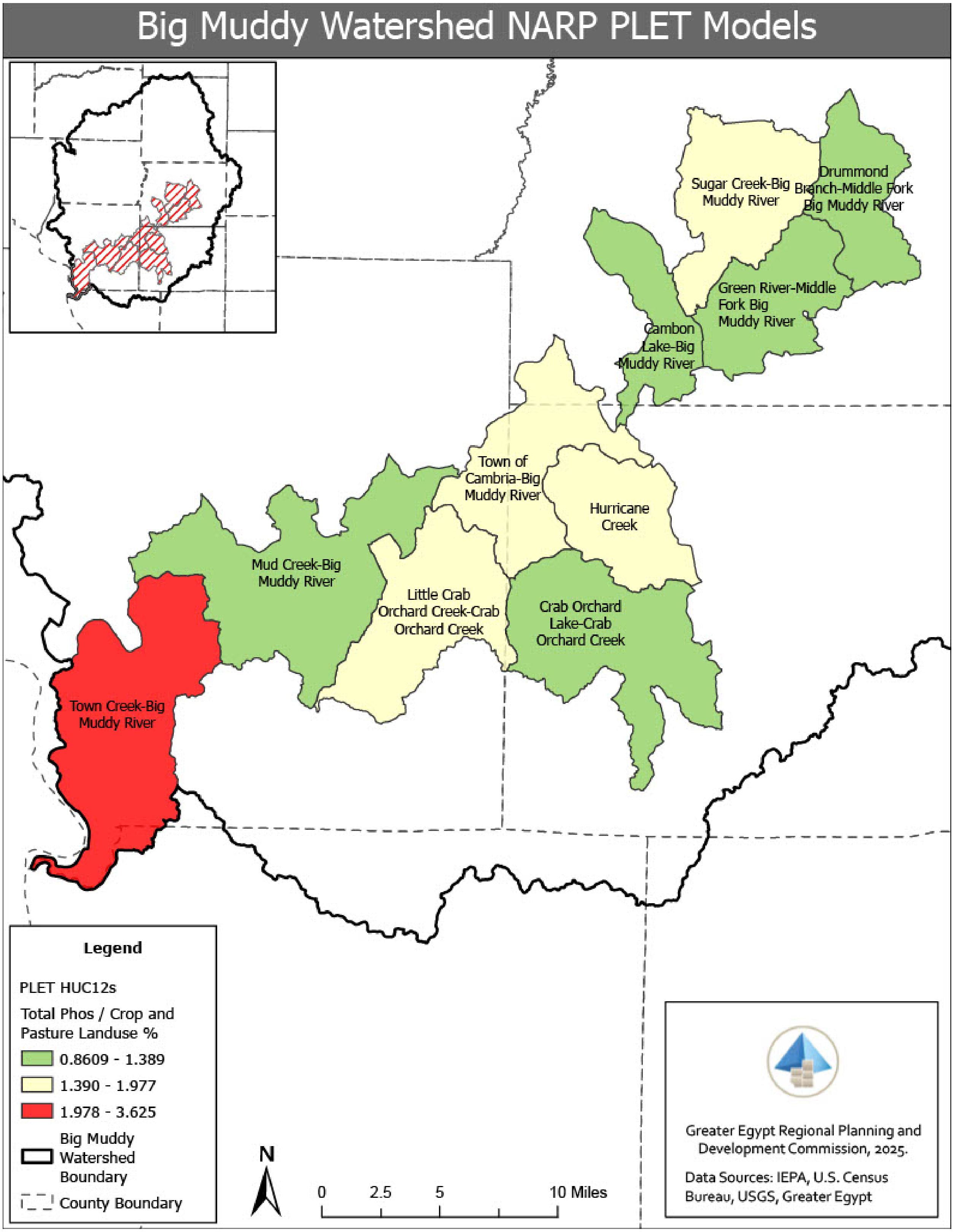
Agricultural Runoff Measures

Agricultural Filter Strips

Agricultural filter strips protect water quality by naturally filtering nutrients and sediment. With the amount of agricultural runoff taking place within the watershed, agricultural filter strips are particularly effective in reducing pollutant loads.

Conservation Tillage

Conversation tillage can include mulch-till, no-till, and strip-till practices. These forms of conservation tillage usually leave a residual of the previous layer of crops. Each method varies in practice, but the benefits are typically consistent with the others. Any form of conservation tillage paired with contour farming brings added benefit. Major benefits of implementing some form of conservation tillage include reduction in soil erosion and improved water quality. This management practice is a low to moderate cost to place within the area of interest.


Big Muddy Watershed NARP PLET Models
Sugar Creek-Big Muddy River
Drummond Branch-Middle Fork Big Muddy River
Green River-Middle Fork Big Muddy River
Cambon Lake-Big Muddy River
Town of Cambria-Big Muddy River
Hurricane Creek
Mud Creek-Big Muddy River
Little Crab Orchard Creek-Crab Orchard Creek
Crab Orchard Lake-Crab Orchard Creek
Town Creek-Big Muddy River
Legend
PLET HUC12s
Total Phos / Crop and Pasture Landuse %
0.8609 - 1.389
1.390 - 1.977
1.978 - 3.625
Big Muddy Watershed Boundary
County Boundary
N
0
2.5
5
10 Miles
Greater Egypt Regional Planning and Development Commission, 2025.
Data Sources: IEPA, U.S. Census Bureau, USGS, Greater Egypt

Cover Crops

Cover crops provide benefits to agricultural land by improving water quality and reducing erosion. These are usually planted following seasonal harvests. Cover crops serve to protect soil surface from raindrop impact, improve infiltration relative to bare soil, and trap eroded particles. Cover crops are typically small grains, specifically planted to provide soil cover during the winter. This practice is tailored to the specific crop benefits and/or soil concerns of the farmer. Cover crops control erosion by protecting the soil from wind and water. They can also be used for excess nutrient uptake, increased soil nutrients and organic matter, and weed suppression.

Critical Area Planting

Critical Area Planting involves establishing permanent vegetation on land that is currently eroded or expected to erode soon. Usually, these are places that are highly eroded and are unable to be farmed. This practice is mostly used on steep slopes and areas of bare ground, especially along streams, channels, and shorelines. The benefit of this practice is to increase soil cover and reduce erosion from wind or rain. Areas where this BMP may apply include active or abandoned mined lands, areas needing stabilization before or after natural disasters such as floods, hurricanes, tornados, and wildfires, eroded banks of natural channels, banks of newly constructed channels, and lake shorelines. Establishing permanent cover helps to stabilize the soil structure, therefore reducing runoff and improving water quality.

Crop Rotation

Crop rotation involves cycling two or more crops on the same ground over a period of time. The changing sequence of crops between years allows for increased soil health, as well as reducing sheet, rill and wind erosion. Rotating another crop into the cycle with a larger rooting depth will support further intake of excess nutrients the previous crop could not reach. The outcome is enhanced water quality due to nutrients being used for their intended purpose of crop production instead of running off into nearby waterways. Using cover crops during fallow seasons provides additional nutrient retention. Crop rotation can be combined with many other conservation efforts for enhanced benefits to land and streams.

Drainage Water Management

Drainage water management (DWM) is a practice used in conjunction with existing tile drained fields on flatter landscapes. A water control structure is installed which allows for control of water level by draining excess water or retaining it for future use. This allows for seasonal variation of the crops water needs. By retaining water for future use, crops are given the opportunity to capture water and nutrients for their benefit; thus, decreasing direct flow of nutrients into surrounding waterbodies. This aids in crop production, as well as improved water quality. DWM is most effective on flat uniform fields that already have tile drainage systems in place.

Grassed Waterways

Grassed waterways prevent erosion in areas prone to consistent water flow. They can also serve as a filtering mechanism for nutrients. Implementation of grassed waterways is assuming at least a 60-foot width per gully.

Livestock Crossings

Livestock frequently crossing through a stream can cause erosion to the streambank and impair the water via increased sedimentation and nutrient loading. Livestock crossings can be constructed by varies means, but with the purpose in mind to stabilize the stream. In many cases, farmers will fence off a portion of the stream to help minimize disturbance.

Pasture/ Hay Planting

A pasture is an area planted with grass or legumes to provide forage for livestock. As a best management practice, specific species are selected to improve forage production, enhance livestock nutrition, and protect the soil from erosion. Converting cropland into pasture or hay production not only benefits local wildlife but improves water quality as well. The hay/pasture fields filter out nutrients and sediment before entering the stream.

Riparian Buffers

A riparian buffer is land following along streams, lakes, and wetlands that is managed for perennial vegetation (grass, shrubs, and/or trees) to improve and guard aquatic resources from the hostile impacts of agricultural practices. Riparian buffers are similar to filter strips and have additional benefits. Like filter strips, buffers reduce sediment and nutrients by filtering the water that flows through it. Since buffers are generally larger than agricultural filters, they can reduce the flow of water at a higher pace. Since implementation of buffers are more expensive than normal filter strips, they were suggested sparingly.

Water & Sediment Control Basins

Water and Sediment Control Basins (WASCOB) function quite like terraces but are more geared towards irregular topography where farmers cannot easily plow on the contours. An earth embankment is constructed perpendicular to a gently sloped waterway to trap runoff. The sediment is allowed to settle within the basin, while the remaining runoff slowly releases into a stable outlet. The WASCOB prevents rill erosion and increased sedimentation in waterways by slowing down runoff, especially after heavy rain.

Urban Stormwater Management Measures

Municipalities in the plan can promote stormwater management practices to reduce phosphorus. Stormwater management planning is encouraged and may involve incentives to residents implementing low impact development projects.

Raingardens/Bioswales

Raingardens and Bioswales hold or slow down excess stormwater, relieving stress on sewer systems. They also act as a filter for stormwater pollutants. Swales are effective in trapping sediment and other nutrients before releasing the water flow into other areas. Depending on the contributing area for the practice, bioswales are generally a suitable structure to reduce total suspended solids.

Street Sweeping

Municipalities can adopt a street sweeping schedule to remove sources of phosphorus-rich debris like leaf matter. This reduces the amount of P entering surface water from stormwater drainage. This can also prevent clogging of stormwater infrastructure and waterbodies.

Urban Trees

Urban trees can reduce stormwater flow, lower risk of flash floods, and improve water quality by filtering pollutants. Urban trees also reduce the Urban Heat Island effect, improve air quality, reduce energy usage of nearby buildings, provide wildlife habitat, and improve city aesthetics.

Rain Barrels/ Cisterns

Rain barrels are containers which capture the rain flowing off your roof through a downspout. It is safe to use for watering gardens, lawns, and trees, and for washing cars or outdoor areas. Rain barrels with a drainage valve can be used to store water for use between rain events. When the valve is opened, the water can empty from the barrel slowly, thus reducing the amount of runoff and increasing infiltration during storm events.

4.2 Technical and Financial Assistance

Each management measure in the plan has also been described by the technical and financial assistance needed to implement each measure. While technical assistance comes from a few select groups, the financial assistance for management measures comes from a variety of different sources. It is important to note that most measures will need to be configured to the specific location and needs of the agency overseeing the implementation. Detailed costs will be determined from stakeholders, contractors, engineers, and materials suppliers and are outside the scope of this Plan. Technical and Financial Assistance is further detailed in the corresponding graph labeled Table 4.1.

4.2.1 Technical Assistance

The labor to execute the management measures will largely come from local municipalities, public works, and contractors. State and federal agencies such as the Il EPA, US EPA, USDA/NRCS and the Jackson, Williamson County Soil and Water Conservation Districts will also be utilized.

The type of technical assistance largely depends on which type of BMP is being implemented. For agricultural BMPs, the USDA and Soil and Conservation Districts will be able to provide their services. If the BMP is municipal, local public works can offer their support. However, for most management measures, drawings and surveys will likely be required by an engineer.

4.2.2 Financial Assistance

Most of the management measures described in the plan will require funding. The major source of funding will be through the US EPA and Illinois EPA by State Loans, Clean Water Act Section 319 Grant Program, and other major funding sources.

Point Source Management Measures

A municipality pursuing wastewater system improvements typically draws on a combination of state and federal grant and loan programs, as well as local revenue strategies, to fund planning, design, and construction. The Illinois State Revolving Fund (SRF) is often a primary source, providing low-interest loans, and in some cases principal forgiveness, to finance major treatment plant upgrades, collection system rehabilitation, nutrient removal improvements, and other eligible infrastructure. Municipalities commonly use the SRF to fund costly capital components because it offers long repayment terms and predictable financing.

For smaller or rural communities, the USDA Rural Development Water and Waste Disposal Loan and Grant Program can cover needs that exceed local financial capacity. This program combines grants with long-term, low-interest loans to support the construction, expansion, or replacement of wastewater systems, making it especially beneficial for communities with limited user bases or lower median household incomes. Municipalities may pursue USDA funding when SRF financing alone would create an excessive rate burden.

The Illinois Department of Commerce and Economic Opportunity (DCEO) Community Development Block Grant (CDBG) program offers another key resource, providing grant funds for wastewater system improvements in low- to moderate-income communities. These funds are often used to reduce the total project cost, improve affordability, or support critical components such as main replacements, lift station improvements, or rehabilitation required to address public health or compliance issues.

For unsewered areas facing failing onsite systems, the Illinois EPA Unsewered Communities Grant provides grant funding for planning and constructing first-time wastewater collection and treatment systems. Municipalities may use this program to extend sewer service to underserved areas, complete design studies, or build decentralized or centralized systems that eliminate environmental health risks.

Municipalities typically supplement external funding with an increase in municipal utility rates to ensure long-term financial sustainability. Rate adjustments are often required to meet SRF loan repayment obligations, cover ongoing operation and maintenance, and build adequate reserves. By combining state and federal assistance with locally supported rate structures, municipalities can implement comprehensive wastewater upgrades while maintaining regulatory compliance and ensuring long-term reliability.

Nonpoint Source Management Measures

While 319 funding covers many nonpoint management measures in the plan, other funding sources must be considered for the remaining measures. The USDA Natural Resource Conservation Service offers many funding and easement opportunities through programs such as: Agriculture Management Assistance (AMA), Conservation Stewardship Program (CSP), Environmental Quality Incentives Program (EQIP), and Agricultural Conservation Easement Program (ACEP).

Through the USDA Farm Service Agency (FSA), funding is offered through programs such as: Conservation Reserve Program (CRP), Conservation Reserve Enhancement Program (CREP), and Farmable Wetlands Program (FWP). Emergency Conservation and Emergency Forest Restoration Programs offer funding and technical assistance, also through USDA FSA, to restore lands that have been damaged by natural disasters.

The Illinois Department of Agriculture offers funding such as: Conservation Practices Program (CPP), Well Decommissioning Program (WDP), Streambank Stabilization and Restoration (SSRP), Nutrient Management Program (NMP), Soil and Water Conservation District Grants Program, and Vegetative Filter Strip Assessment Law. Another funding source aimed particularly at reducing soil loss and protecting water quality is offered through the Bureau of Land and Water Resources through the Partners for Conservation Program.

Other grants offered through the Illinois Department of Natural Resources include Open Space Lands Acquisition & Development and Land & Water Conservation Programs, Park and Recreational Facility Construction Grant Program, and Federal Recreational Trails.

Illinois EPA provides multiple funding opportunities to finance the design and construction of both, wastewater and nonpoint source pollution projects through grants and low-interest loan programs that include Illinois Green Infrastructure Grant Program for Stormwater Management (IGIG), Nonpoint source Grants, and Wastewater/Stormwater and Drinking Water Loans.

In most cases, these programs will not cover the entire cost of the selected BMPs. The remaining costs would have to be funded by landowners, municipalities, businesses, and other entities. In cases where there are no grants or funding assistance for components such as chemical treatment, utility rates would need to be raised, causing concerns for municipalities that are already under financial stress.

Table 4.1

		Management Measures	Technical Assistance	Financial Assistance	Note	Source:
Point Source	WWTP Operations	**Chemical Treatment**	Provided by operators and plant staff	•Illinois State Revolving Fund		
		Filtration	Provided by operators and plant staff	•USDA Rural Development Water and Waste Disposal Loan and Grant		
		Flocculation Basin	Consultant, Construction Team	•Illinois DCEO Community Development Block Grant		Local Planning
		Phosphorus Reduction Planning	Plant Staff, City Staff, Planning Commission, Public	•Illinois EPA Unsewered Communities Grant		NARP Planning
		Sludge Dewatering System	Consultant, Construction Team	•Increase Municipal Utility Rates		
Nonpoint Source	Agricultural	**Agricultural Filter Strip**	Farm Bureau, Landowner, NRCS, SWCD	IEPA 319, NRCS, USDA		
		Conservation Tilage				
		Cover Crops	Farm Bureau, NRCS, USDA, SWCD	IEPA 319, NRCS, USDA		
		Critical Area Planting	NRCS, USDA	IEPA 319, NRCS, USDA		
		Crop Rotation				
		Drainage Water Management	Farm Bureau, NRCS, USDA	NRCS, USDA		
		Grassed Waterways				
		Livestock Crossings				
		Pasture/Hay Planting				
		Riparian Buffers				
		WASCOBS				
	Urban	**Raingarden/Bioswale**	Landowner, NRCS, SWCD	IEPA 319, NRCS, USDA		
		Street Sweeping	Municipality			
		Urban Tree Planting	Landowner, SWCD	IEPA 319, NRCS, USDA		
		Rain Barrels/ Cisterns	Landowner, NRCS, USDA	IEPA 319, NRCS, USDA		

4.3 Implementation Schedule

The implementation schedule reflects the general goals in the Big Muddy Watershed NARP. These components can be seen in the following implementation schedule.

Phase I signifies the short-term actions to be taken in the first two years of the plan. This includes continuing NARP planning functions which would serve to implement the plan and track progress.

Phase II constitutes the mid-term implementation of the plan. While current IEPA guidance is 1.0 mg/L, future guidance may be more stringent at 0.5 mg/L. Components in this phase should be completed within the sixth year of plan implementation.

Key elements of this phase include the continuation submitting grant applications for BMPs for phosphorus removal for nonpoint sources suggested in the plan. The implementation and execution of BMPs will also occur under this segment of the plan.

Phase III indicates the final stage of the plan. This is characterized by continuing efforts in BMP implementation and evaluating accomplishments throughout the plan. If Illinois EPA standards are set even lower at 0.1 mg/L, further management measures will need to be introduced including the mechanical components of the point source management section.

Implementation Schedule										
Target	**Phase I**		**Phase II**				**Phase III**			
	1.0 mg/L		**0.5 mg/L**				**0.5 - 0.1 mg/L**			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Coordinate Annual NARP Meeting/Update										
Outreach to Nonpoint Source - Ag										
Outreach to Nonpoint Source - Urban										
Nonpoint Source Measures										
Point Source Measures										
Point Source Measures +										

4.4 Evaluation and Monitoring

Along with the implementation schedule, water quality benchmarks and a monitoring component are presented to evaluate the implementation and the overall success of the NARP and phosphorus reduction actions. Evaluation criteria are based on current phosphorus standards set by Illinois EPA (1.0 Mo Avg) while the monitoring component is based on available water quality data.

The Big Muddy NARP Planning Committee will meet annually to discuss plan implementation, progress, and evaluation. If needed, the NARP can be amended and resubmitted to IEPA.

4.4.1 Evaluation Criteria

The benchmarks provided in Table 4.2 are based on the implementation of management measures in the plan and continued best management practices. Determining success and achieving these benchmarks will be dependent on the number of measures that are being implemented in the planning period. Goals are taken from various sources including IL NLRS, NPDES requirements and current guidance. While the current standards indicate a phosphorus monthly average of 1.0 mg/L, future guidance may suggest a lower limit of 0.5, or even 0.1.

Table 4.2 Benchmarks for Determining Plan Progress

	Benchmark Reduction Targets				
Benchmark Period	**P IL NLRS Watershed-wide**	**P NARP**	**Mo AVG P NPDES**	**12-MO MEAN TP**	
2 Year (Phase I)	15	5	1.0	0.5	Chemical P
5 Year (Phase II)	15	10	1.0	0.5	Bio P
10 Year (Phase III)	45	15-45	1.0	0.5	EXT Mod (P+N)

4.4.2 Monitoring Component

A monitoring component is essential to determine progress in achieving water quality. Several elements represent the monitoring component for the plan. These items will provide water quality data that can be used to assess the efficacy of the Big Muddy NARP. The monitoring strategy components are as follows:

1. **NPDES Permit Requirements** – The plant and operators will continue to sample according to their NDPES Permit. This requires water quality adherence to certain standards and submission through NetDMR. Average monthly phosphorus limits in NPDES Permits are currently 1.0 mg/L. Samples can be examined for indicators of eutrophication.

2. **NARP Sampling** – Although the sampling plan of the NARP ended in October 2025, WWTP Operators in the plan are encouraged to continue taking pH, chlorophyll and dissolved oxygen readings along the additional NARP sampling points.

3. **Ambient Water Quality Monitoring Network (AWQMN)** - 146 fixed stations are set up along streams throughout Illinois to routinely collect water quality data. Water samples are collected in 6-week intervals and are analyzed for a variety of parameters, including temperature and dissolved oxygen. Since the planning area experiences various impairments including phosphorus and dissolved oxygen, the AWQMN would be an important component in monitoring the progress of water quality in the watershed.

4. **Dissolved Oxygen Monitoring** – Measuring dissolved oxygen can be a good indicator for other water quality impairments including eutrophication. Maintaining a healthy aquatic environment is also key for the river's recreational uses. Dissolved oxygen measurements would likely be taken from operators or IEPA sampling.

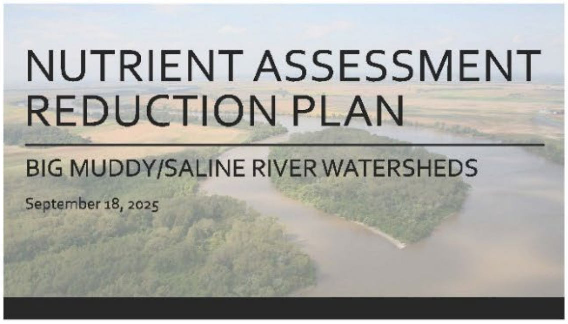
5. **Intensive River Basin Surveys** - Every five years IEPA and IDNR conduct intensive basin surveys of various watersheds in Illinois. IDNR completes testing of aquatic species while the IEPA monitors instream habitats and water quality. The TMDL for the Upper Big Muddy Watershed was completed in 2018.

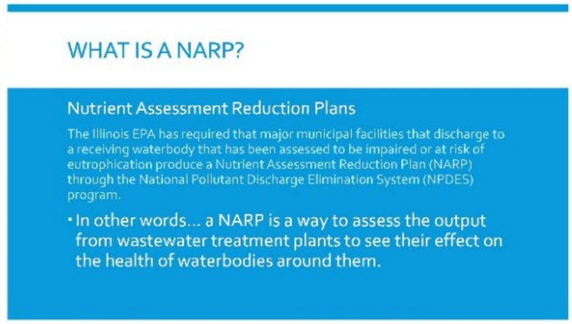
4.5 Meeting IEPA Requirements

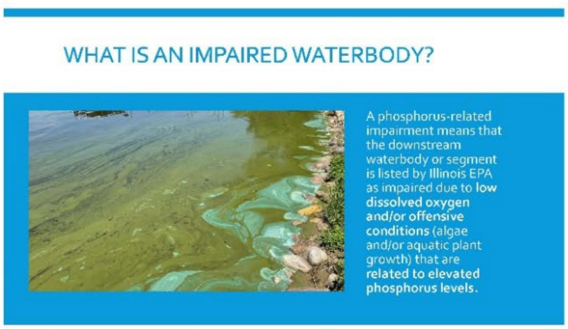
Through the NARP Planning Process, the Big Muddy Planning Committee has met each of the eight requirements outlined in the NPDES of the participating municipalities. While some of these requirements were more easily obtainable, others will continue to follow the process reported in this plan to achieve the goal.

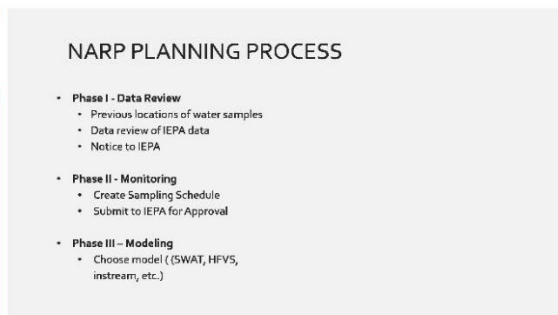
IEPA NARP REQUIREMENT	BIG MUDDY WATERSHED ACTIVITY	
A. The NARP shall be developed and submitted to the Agency by December 31, 2025. This requirement can be accomplished by the Permittee, by participating in an existing watershed group or by creating a new group. The NARP shall be supported by data and sound scientific rationale.	***The Big Muddy River Watershed NARP Plannning Committee was formed in the summer of 2023.***	***The Big Muddy River Watershed NARP was forwarded to IEPA on December 30, 2025. The NARP uses existing and sampled water quality data for mapping and modeling purposes.***
B. The Permittee shall cooperate with and work with other stakeholders in the watershed to determine the most cost-effective means to address the risk of eutrophication. If other stakeholders in the watershed will not cooperate in developing the NARP, the Permittee shall develop its own NARP for submittal to the Agency to comply with this condition.	***The Big Muddy Planning Committee collectively invested in NARP funding since grants were not awarded for this type of planning.***	***Management measures to mitigate eutrophication can be found in the BMP section of this report.***
C. In determining the target levels of various parameters necessary to address the risk of eutrophication, the NARP shall either utilize the recommendations by the Nutrient Science Advisory Committee or develop its own watershed-specific target levels.	***Watershed-wide specific targets will follow goals set in thh IL NLRS. This accounts for 45% reduction in P and N.***	***While some goals will be achieved on site, most goals are non-point source based.***
D. The NARP shall identify phosphorus input reductions from point sources and non-point sources in addition to other measures necessary to remove the risk of eutrophication characteristics that will cause or may cause violation of a water quality standard. The NARP may determine, based on an assessment of relevant data, that the watershed does not have a risk of eutrophication related to phosphorus, in which case phosphorus input reductions or other measures would not be necessary. Alternatively, the NARP could determine that phosphorus input reductions from point sources are not necessary, or that phosphorus input reductions from both point and nonpoint sources are necessary, or that phosphorus input reductions are not necessary and that other measures, besides phosphorus input reductions, are necessary.	***The NARP determined non-point sources to be a major factor in p sources in the Big Muddy watershed.***	***Samples taken during the sampling plan indicated p levels to be inconsistent during dry levels.***
E. The NARP shall include a schedule for the implementation of the phosphorus input reductions and other measures. The NARP schedule shall be implemented as soon as possible and shall identify specific timelines applicable to the permittee.	***The timeline for implementation and monitoring strategy is included in the plan.***	***P Input reduction methods will be focused on measures outlined in each operator's Phosphorus Optimization Plan and further measures outlined in this plan.***
F. The NARP can include provisions for water quality trading to address the phosphorus related risk of eutrophication characteristics in the watershed. Phosphorus/Nutrient trading cannot result in violations of water quality standards or applicable antidegradation requirements.	***The Big Muddy River watershed NARP does not contain provisions for water qualiyt/ nutrient trading.***	***If needed, the Planning Committee can amend the NARP to include water quality/ nutrient trading.***
G. The Permittee shall request modification of the permit within 90 days after the NARP has been completed to include necessary phosphorus input reductions identified within the NARP. The Agency will modify the permit if necessary.	***If needed, the Big Muddy River watershed Planning Committee will request modification of the plan within 90 days of submission.***	
H. If the Permittee does not develop or assist in developing the NARP and such a NARP is developed for the watershed, the Permittee will become subject to effluent limitations necessary to address the risk of eutrophication. The Agency shall calculate these effluent limits by using the NARP and any applicable data. If no NARP has been developed, the effluent limits shall be determined for the Permittee on a case-by-case basis, so as to ensure that the Permittee's discharge will not cause or contribute to violations of the dissolved oxygen or narrative offensive condition water quality standards.	***All Permittees within the Big Muddy River watershed with a NARP requirement in their NPDES Permit participated in the planning process from 2023-2026.***	***Effluent limits are outlined in the NARP.***

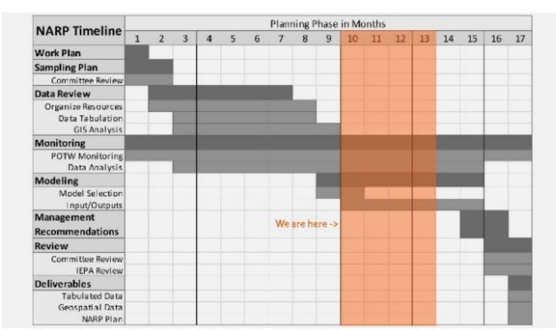
APPENDIX A – PUBLIC PARTICIPATION

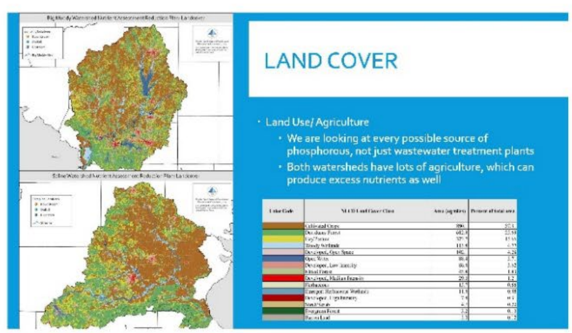










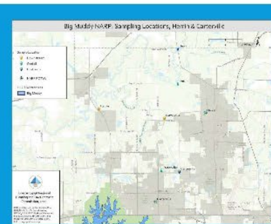


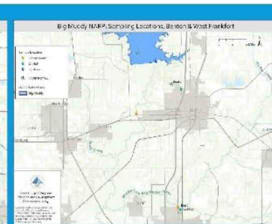
SAMPLING PLAN

- 2025 Sampling Season is still ongoing
- Chlorophyll (CHL-A) collection
  - Begins in April
  - Samples sent to Pace Analytics
    - Greater Egypt can assist if needed
- Results sent in as they are collected
- Model/Maps made based on submissions

https://greateregypt.maps.arcgis.com/apps/mapviewer/index.html?webmap=fb59fd4c11f44b0cbac13fe3cac2ca6e

SAMPLING LOCATIONS





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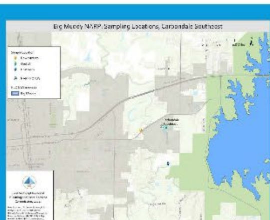
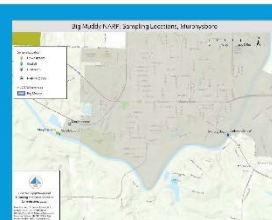
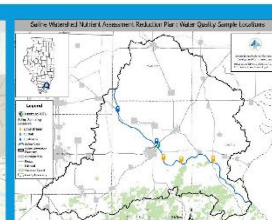


SAMPLING LOCATIONS





AFFP
The Greater Egypt Regional Pla

Affidavit of Publication

STATE OF IL }
COUNTY OF JACKSON } SS

Johnny Blazina, being duly sworn, says:

That he is Sales Manager of the The Southern Illinoisan, a daily newspaper of general circulation, printed and published in Carbondale, Jackson County, IL; that the publication, a copy of which is attached hereto, was published in the said newspaper on the following dates:

September 13, 2025

The Greater Egypt Regional Planning and Development Commission will be hosting an informational meeting
regarding the Nutrient
Assessment Reduction Plans (NARP) for the Big Muddy and Saline River watersheds. The meeting will be held on September 18, 2025, from 10:00 AM to 11:00 AM at the Greater Egypt Office – 3117 Civic Circle Blvd-Suite A, Marion, IL.

Attendees will learn more about the planning process for the NARPs; an Illinois EPA requirement for some
municipalities in which their wastewater facility is upstream of a waterbody with a phosphorus impairment.

For more information, please visit greateregypt.org/narp, or call the Environmental Planning Department at Greater Egypt at 618-997-9351.

That said newspaper was regularly issued and circulated on those dates.
SIGNED:

Sales Manager

Subscribed to and sworn to me this 13th day of September 2025.

Shellie Lea Koontz, Notary Public, Jackson County, IL

My commission expires: February 06, 2029

SHELLIE LEA KOONTZ
NOTARY
ID # KYNP96683
My Commission Expires
FEBRUARY 6, 2029
PUBLIC
STATE AT LARGE, KENTUCKY

70128273 71311775

Margie Mithell
Greater Egypt Regional Planning and Development Co
3117 Civic Circle Blvd, Suite A
Marion, IL 62959

NARP Survey for Agricultural Agencies - Big Muddy Watershed

This survey is intended to gather opinions from agricultural professionals on the status of the Big Muddy River Watershed. Responses will be summarized and published in the Big Muddy Nutrient Assessment Reduction Plan

tylercarpenter@greateregypt.org Switch account

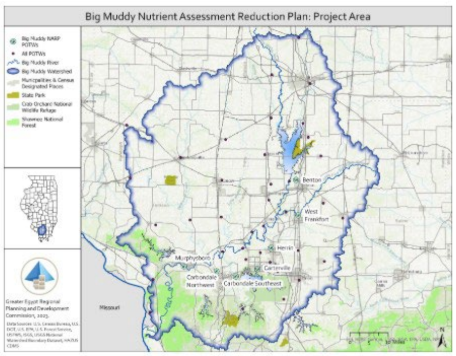
The name, email, and photo associated with your Google account will be recorded when you upload files and submit this form

* Indicates required question

Email *

☐ Record tylercarpenter@greateregypt.org as the email to be included with my response

Project Area Map



What is your name?

Your answer

What is your job title?

Your answer

What agency do you represent?

Your answer

How do you perceive the overall water quality of the Big Muddy River watershed?

◯ Poor
◯ Fair
◯ Good
◯ Excellent

Please rank the following issues in terms of how much they contribute to water quality issues in the Big Muddy River Watershed

	1 (not contributing at all)	2	3	4	5 (contributing the most)
Point source pollution: wastewater treatment plants	◯	◯	◯	◯	◯
Point source pollution: mining/industry/other	◯	◯	◯	◯	◯
Non-point source pollution: agricultural nutrient runoff	◯	◯	◯	◯	◯
Non-point source pollution: agricultural chemical runoff (i.e. pesticides/herbicide	◯	◯	◯	◯	◯
Non-point source pollution: agricultural sediment runoff/soil loss	◯	◯	◯	◯	◯
Non-point source pollution: urban sources (lawns, golf courses, other)	◯	◯	◯	◯	◯
Channel erosion and sedimentation	◯	◯	◯	◯	◯
Channelization	◯	◯	◯	◯	◯
Development	◯	◯	◯	◯	◯
Climate Change	◯	◯	◯	◯	◯

Are there other issues contributing to water quality issues in the Big Muddy River watershed? Describe below:

Your answer

What BMPs does your agency implement, or assist landowners in implementing? Check all that apply

☐ Filter strips
☐ Grassed waterways
☐ Riparian buffers
☐ Wetland creation/restorations
☐ No-till, strip-till, mulch-till practices
☐ Cover crops
☐ Critical area planting
☐ Crop rotation
☐ Terraced fields
☐ Water and sediment control basins (WASCOBs)
☐ Water control structures
☐ Livestock stream crossings
☐ Gully stabilization
☐ Streambank stabilization
☐ Conservation easements
☐ Habitat restoration
☐ Other:

Please list the funding sources or program names that BMPs are implemented through:

Your answer

Do you keep records of BMP implementation within your jurisdiction?

◯ yes
◯ no

Do you conduct any monitoring post implementation such as water/soil testing?

◯ yes
◯ no

What are the biggest challenges you face in implementing agricultural BMPs for water quality? Check all that apply

☐ Difficult to contact farmers/landowners
☐ Difficult to retain farmers/landowners in long term programs or relationships with my agency
☐ Lack of incentives for landowners/farmers to implement BMPs
☐ Lack of funding for programs
☐ Lack of staff to implement programs
☐ Lack of legislation and enforcement capabilities
☐ Other

If you selected other, please explain below:

Your answer

If you have any records or report summaries regarding agricultural BMPs in this watershed that you are able to share, please do so here, or submit to planning@greateregypt.org

Upload up to 5 supported files: PDF, document, or spreadsheet. Max 100 MB per file.

Add file

APPENDIX B - Big Muddy River Watershed NARP Sampling Plan

BIG MUDDY RIVER WATERSHED

NUTRIENT ASSESSMENT REDUCTION PLAN (NARP)

SAMPLING PLAN

GREATER EGYPT REGIONAL
PLANNING & DEVELOPMENT COMMISSION

1) Plan History and Partners

The Illinois Environmental Protection Agency (IEPA) is requiring certain municipal permittees to develop or be a part of a watershed group that develops a Nutrient Assessment Reduction Plan. This is in response to the Agency determining that the operator's treatment plant is upstream of a waterbody or stream segment that is at risk of eutrophication due to phosphorus levels in the waterbody.

Five municipalities in the Big Muddy watershed have this requirement with one being recommended to be a part of activities (Carterville):

- City of Benton
- City of Carbondale
  - SE STP, NW STP
- City of Carterville
- City of Herrin
- City of Murphysboro
- City of West Frankfort

Beginning in 2023, the municipalities formed the Big Muddy NARP Advisory Group (Group) to fulfill the requirements of the Agency. The Group has consulted with the Greater Egypt Regional Planning and Development Commission to coordinate the NARP efforts to fulfill all requirements of the IEPA.

Through meetings and various discussions with IEPA, the Group determined that the first action would be to create the sampling plan to be reviewed by IEPA.

2) Planning Process

Initial planning has consisted of determining primary actions. These include:

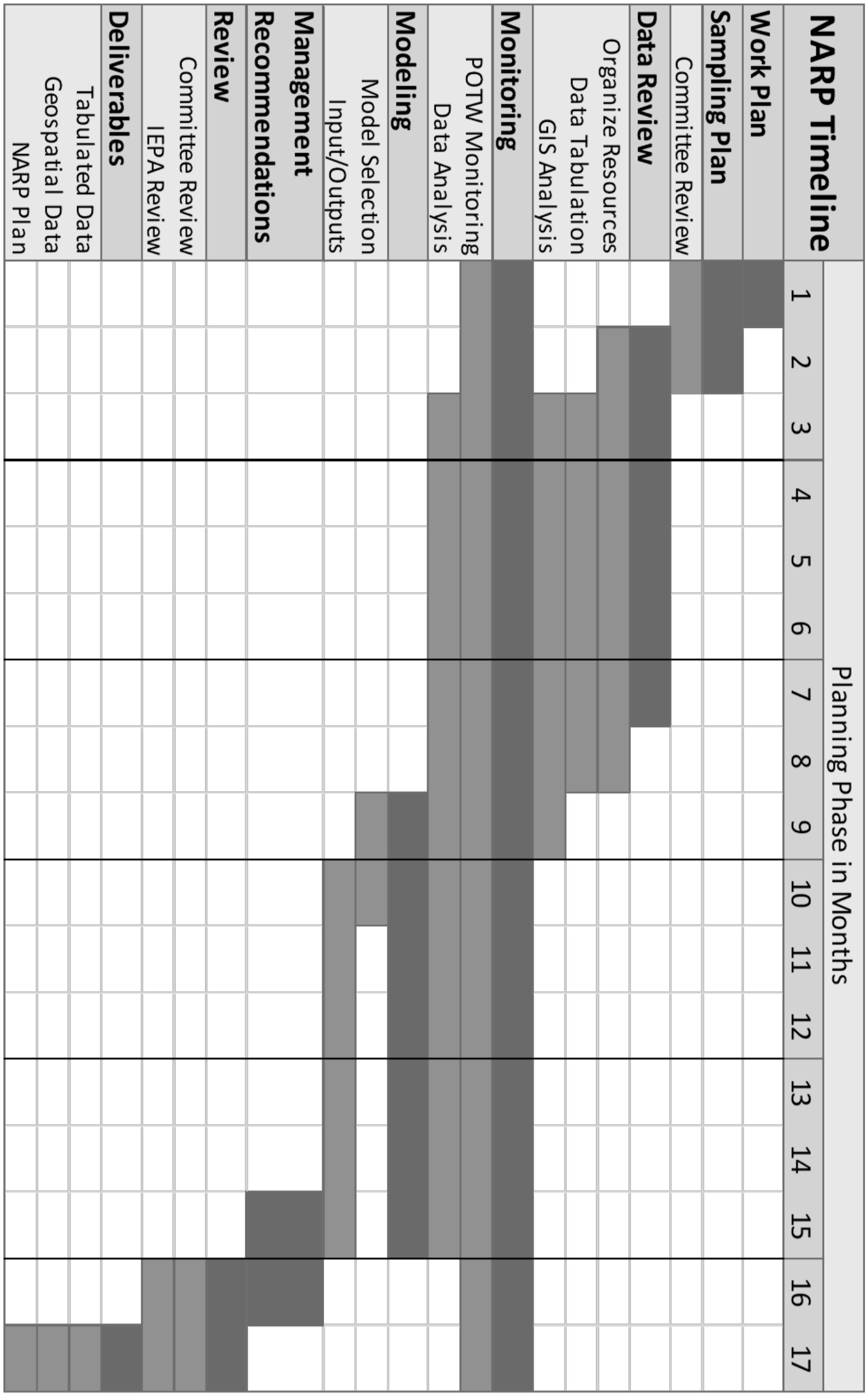
1. **Establish Watershed/NARP Group**
    a. Fulfills requirements A and B in the NPDES Permits of operators established by IEPA.
    b. All municipalities required, or recommended, to be part of a NARP are represented in the Big Muddy NARP Advisory Group

2. **Develop NARP Objectives**
    a. Develop Work Plan
        i. Includes organizing partners and groundwork for NARP objectives.
    b. Create Sampling Plan
        i. Coordinated effort by all partners.
        ii. Outlined later in this report
    c. Data Review
        i. Organize resources of existing data.
        ii. Data tabulation
        iii. Initial GIS and mapping components
    d. Monitoring
        i. Execution of sampling plan
        ii. Data analysis following data completion.
    e. Modeling
        i. Hydrologic and/or Hydraulic models will be chosen in the planning process.
        ii. SWAT, HFVS, HEC-RAS, HEC-HMS or similar modeling software
    f. Input Reductions and Management Recommendations
        i. Measures can include best management practices to limit phosphorus and other nutrients to mitigate risk of eutrophication.
    g. Review
        i. Reviews will be made by the Group, IEPA, and other interested parties.
    h. Deliverables
        i. The NARP will be delivered to IEPA by December 31, 2025.

See attached NARP Objectives Timeline on next page. These objectives will fulfill requirements C and D.

3. Establish Schedule

a. Schedule will be made for phosphorus input reductions recommended in the plan fulfilling requirement E.

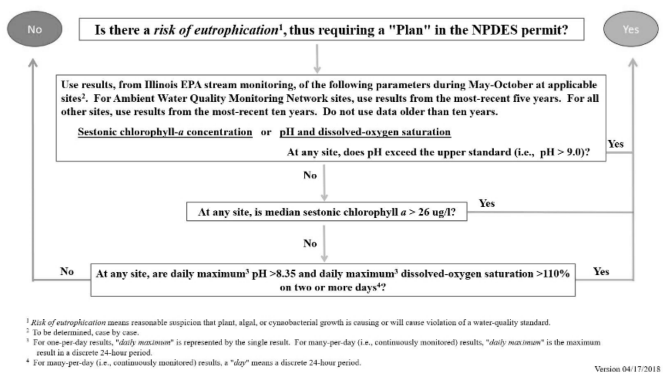

NARP Timeline
Planning Phase in Months
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
Work Plan
Sampling Plan
Committee Review
Data Review
Organize Resources
Data Tabulation
GIS Analysis
Monitoring
POTW Monitoring
Data Analysis
Modeling
Model Selection
Input/Outputs
Management
Recommendations
Review
Committee Review
IEPA Review
Deliverables
Tabulated Data
Geospatial Data
NARP Plan

3) Sampling Plan

The sampling plan is a coordinated effort between all Group partners in the Big Muddy watershed. While this is a massive undertaking for a watershed this size, a schedule will be followed with certain water quality features to be analyzed.

Water Quality Measurements

- ***$CBOD_5$***
- ***Chlorine Residual***
- ***Chlorophyll-A (CHL-A)***
    - The chlorophyll samples will be taken along with the other identified measures.
    - Since this is a separate analysis, each CHL-A sample costs around $75.00 beyond the normal analytics fees.
    - Taken April- October



- ***Dissolved Oxygen (D.O)***
    - CHL-A or pH and dissolved oxygen are used to determine if a risk of eutrophication in the receiving waterbody is present.
    - Dissolved oxygen meters may be utilized from local sources in the case the permittee does not have access to a unit. Calibration can be handled in-house.
- ***Fecal Coliform***
- ***Total Nitrogen (N)***
    - *Total Kjeldahl Nitrogen*
    - *Nitrates*
    - *N as Ammonia*
- ***pH***
- ***Total Phosphorus (P)***
- ***Suspended Solids***
- ***Temperature***
- ***Visual Report***
    - This will feature observational data which can include odor, turbidity, erosion, etc.

Lab Analysis and QA/QC

All Group members currently use Pace Analytical for water quality analysis. To ensure accurate data quality, CHL-A samples will also be analyzed by Pace Analytical. Results will be utilized during the modeling phase of the NARP.

Date and Time

Samples will be taken on the first and third Tuesday of each month at 10:00 AM. If a Group member cannot comply with this time and date, they will take it as close as possible to the set time and date.

Location(s)

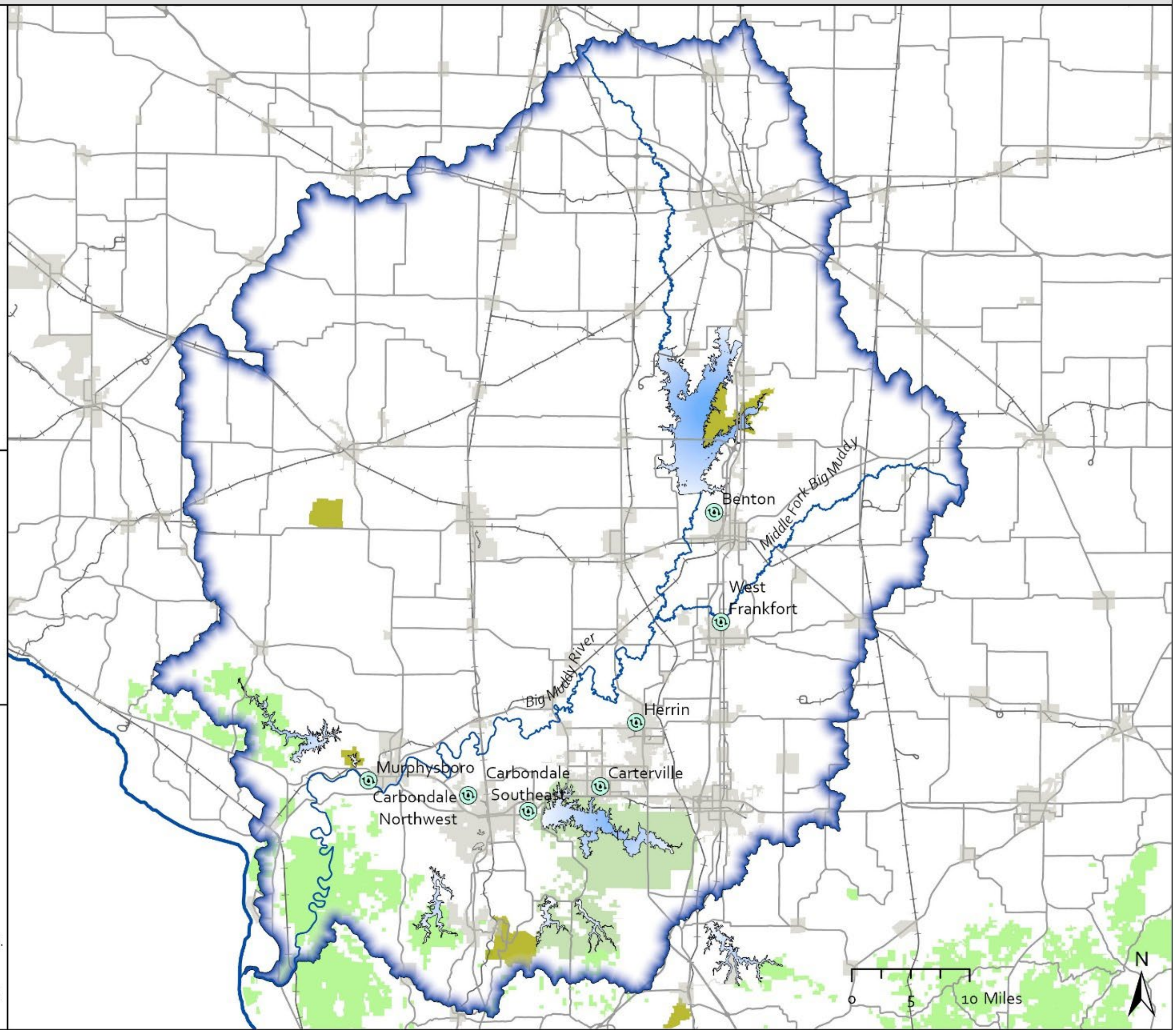
Sampling locations occur at the outfall, upstream, and downstream of the plant. If locations were not sampled before the NARP, new locations were chosen depending on ease and availability of crossings. The graph below and corresponding maps illustrate the locations of all Group sampling locations.

An additional location is located further downstream of Murphysboro along the Big Muddy River at the crossing of Town Creek Road. This also represents the most downstream point along with the plan.

Big Muddy NARP	Sample Location			Waterbody/ Receiving Water	NPDES Permit No.
	Site	Latitude	Longitude		
Benton	Outfall 004	38.014167	-88.929722	Sugar Creek	IL0022365
	Upstream	38.03786	-88.956446	Big Muddy River/ Rend Lake Dam Road	
	Downstream	37.993951	-88.976707	Big Muddy River at IL-14	
Carbondale SE Plant	Plant	37.729758	-89.166497	Unnamed Trib to Crab Orchard Creek	IL0027898
	Upstream	37.719364	-89.165767	Crab Orchard Creek	
	Downstream	37.7289	-89.175708	Crab Orchard Creek	
Carbondale NW Plant	Plant	37.746253	-89.242167	Little Crab Orchard Creek	IL0027871
	Upstream	37.767584	-89.22485	Little Crab Orchard Creek	
	Downstream	37.730565	-89.243683	Little Crab Orchard Creek	
Carterville	Outfall	37.774761	-89.074402	Unnamed Trib to Big Muddy River	IL0025178
	Upstream	37.773919	-89.058616	Hurricane Creek*	
	Downstream	37.811227	-89.07181	Hurricane Creek	
Herrin	Outfall	37.835322	-89.05983	Big Muddy River	IL0029165
	Upstream	37.859822	-89.059981	Big Muddy River	
	Downstream	37.817728	-89.129569	Big Muddy River	
Murphysboro	Outfall 001	37.758125	-89.36635	Big Muddy River	IL0023248
	Upstream	37.757953	-89.327439	Big Muddy River	
	Downstream	37.739217	-89.427852	Big Muddy River	
	Downstream	37.758293	-89.366885	Big Muddy River	
West Frankfort	Outfall	37.914333	-88.930844	Middle Fork - Big Muddy River	IL0031704
	Upstream	37.917445	-88.928787	Middle Fork - Big Muddy River	
	Downstream	37.916084	-88.932997	Middle Fork - Big Muddy River	

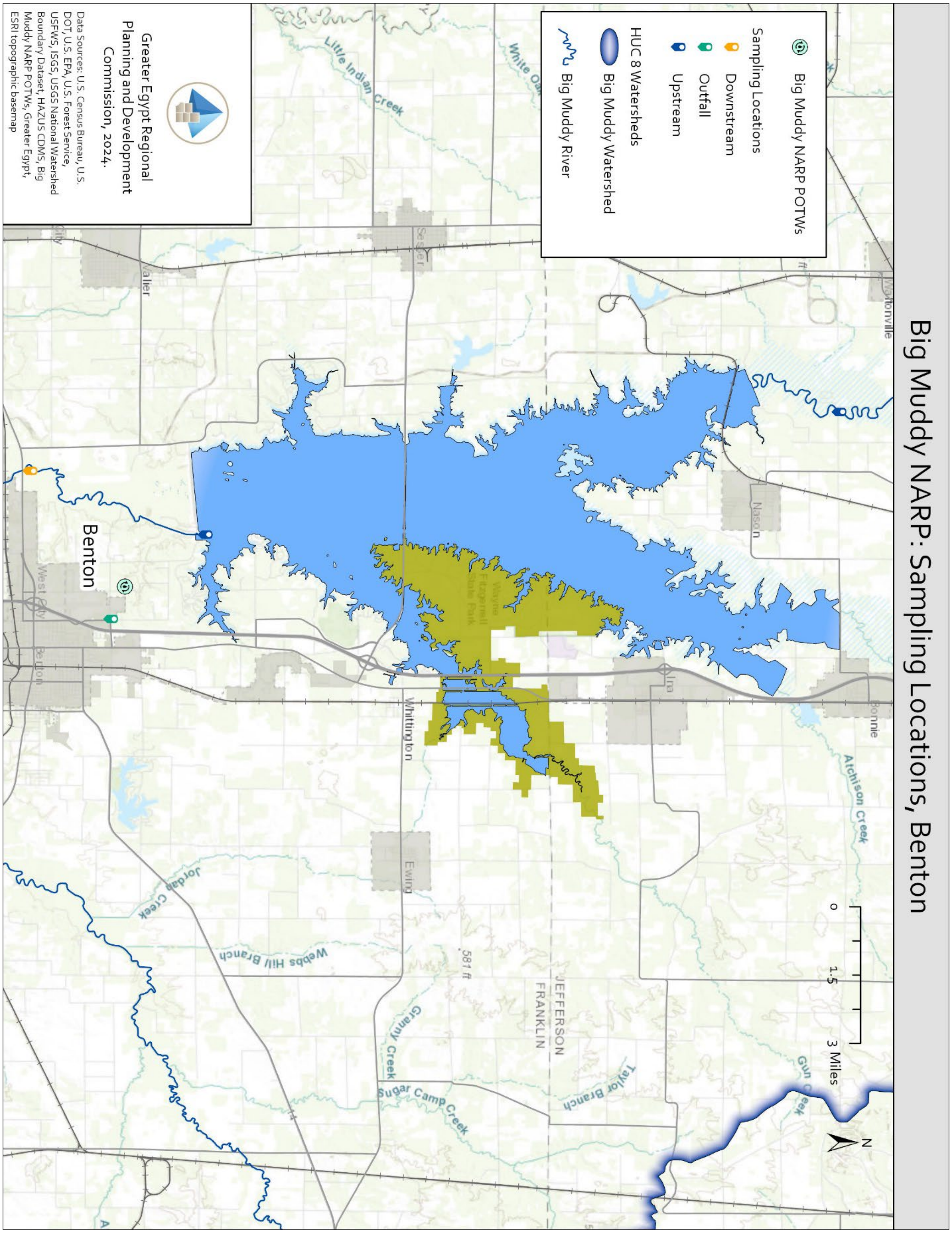
* Denotes location may be seasonally dry

Big Muddy Nutrient Assessment Reduction Plan: Project Area

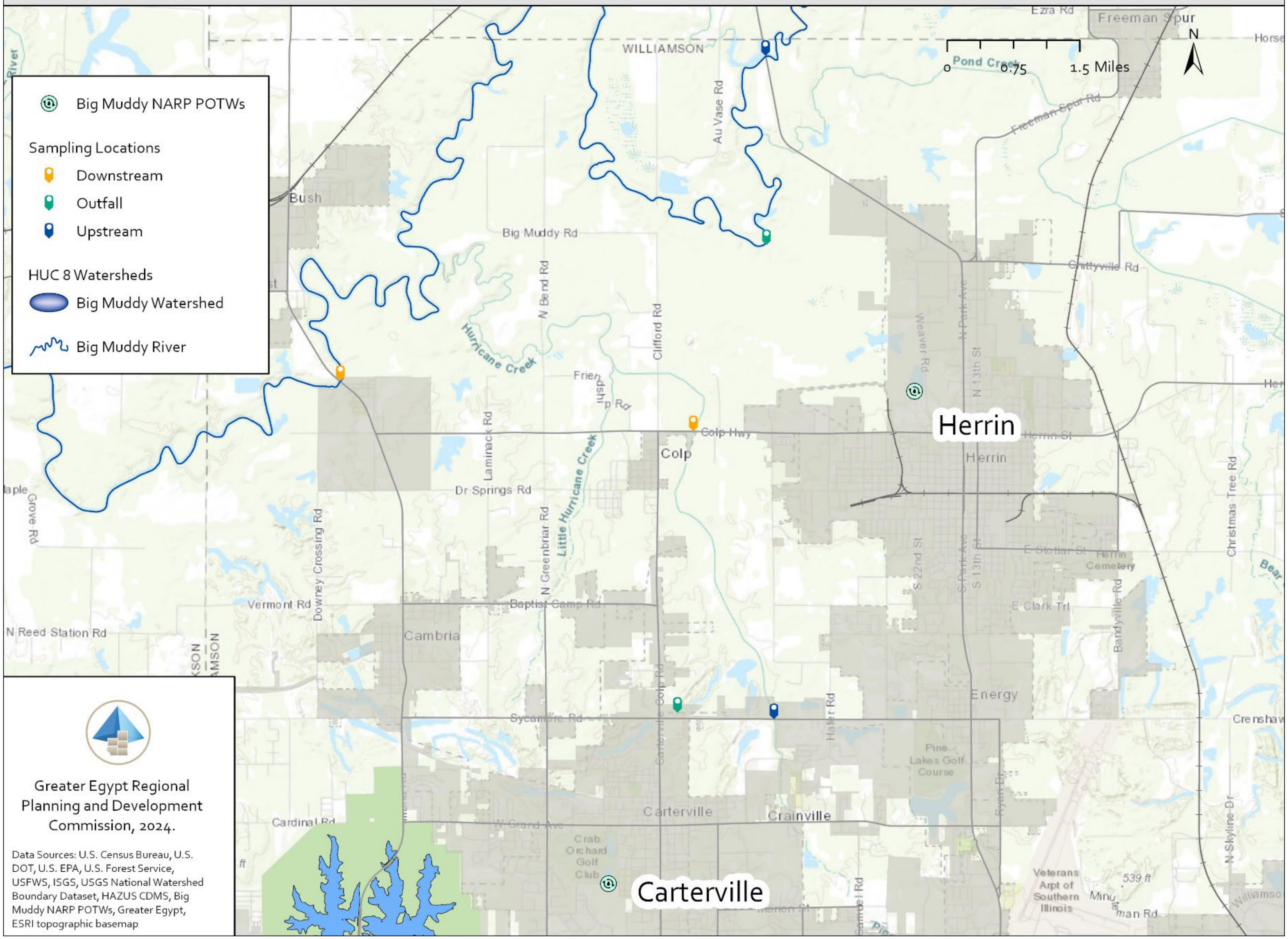


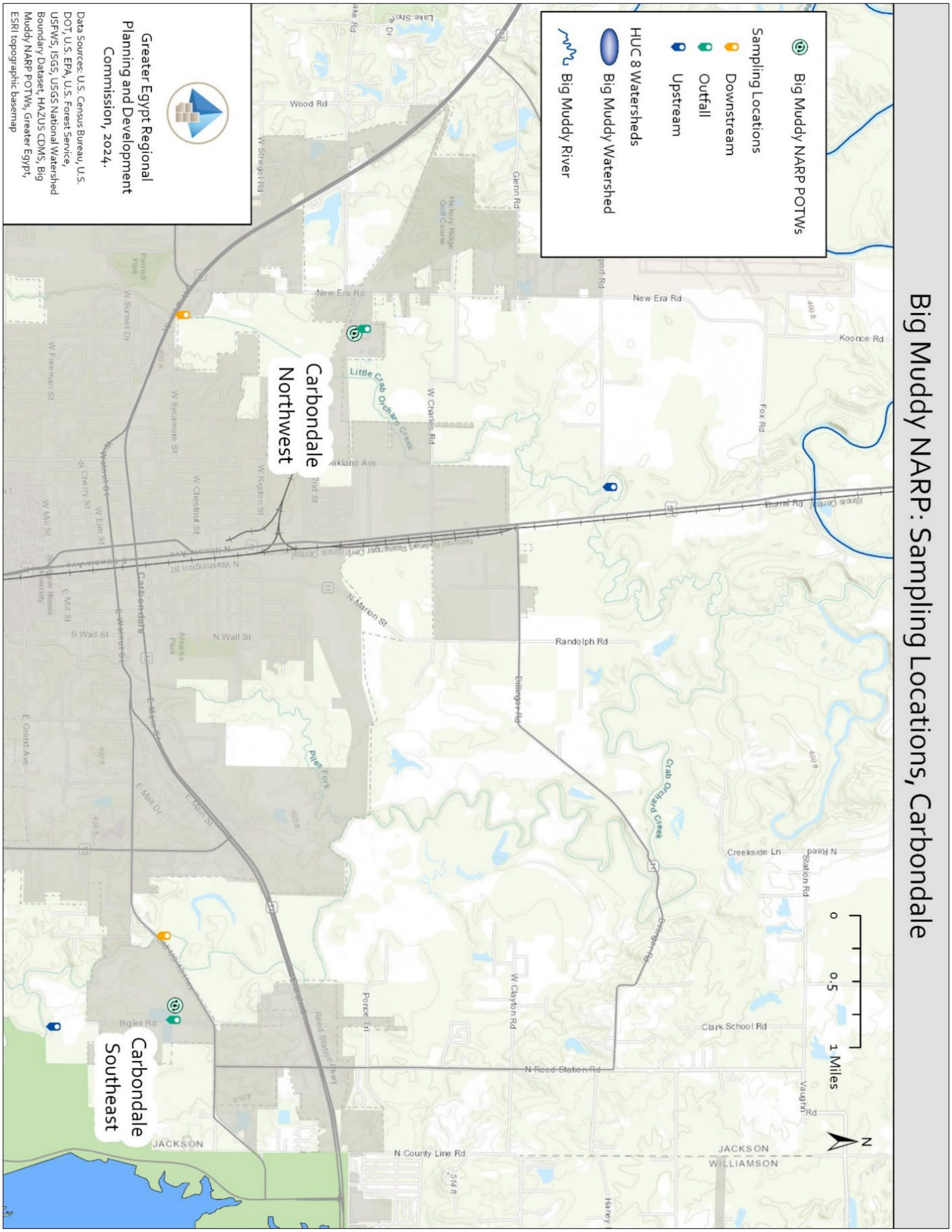
Greater Egypt Regional Planning and Development Commission, 2023.

Data Sources: U.S. Census Bureau, U.S. DOT, U.S. EPA, U.S. Forest Service, USFWS, ISGS, USGS National Watershed Boundary Dataset, HAZUS CDMS

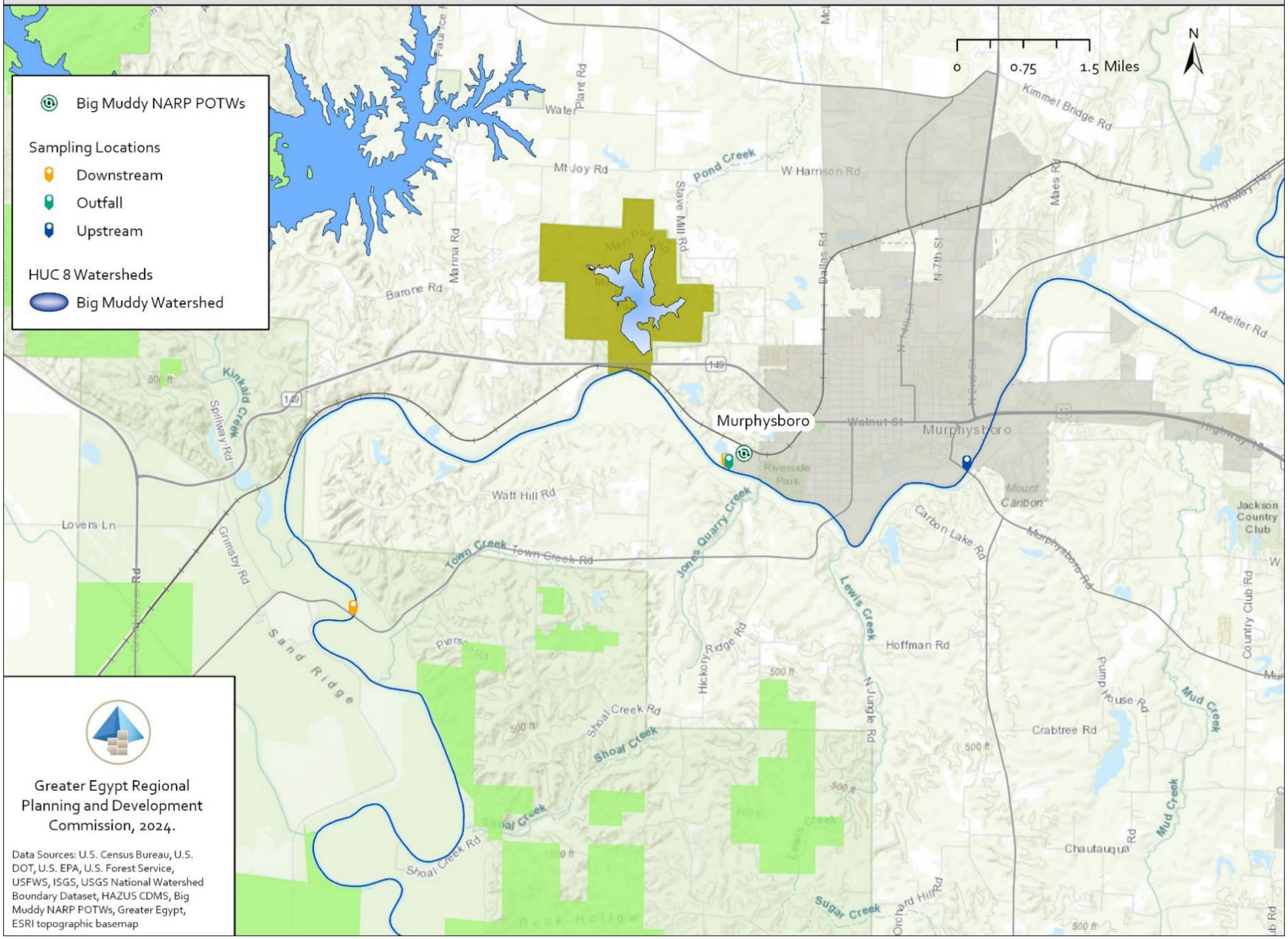

Big Muddy NARP: Sampling Locations, Benton
Big Muddy NARP POTWs
Sampling Locations
Downstream
Outfall
Upstream
HUC 8 Watersheds
Big Muddy Watershed
Big Muddy River
Greater Egypt Regional Planning and Development Commission, 2024.
Data Sources: U.S. Census Bureau, U.S. DOT, U.S. EPA, U.S. Forest Service, USFWS, ISGS, USGS National Watershed Boundary Dataset, HAZUS CDMS, Big Muddy NARP POTWs, Greater Egypt, ESRI topographic basemap
0
1.5
3 Miles
N
Benton
Whittington
Ewing
Ina
Bonnie
Nason
Sesser
Little Indian Creek
Atchison Creek
Jordan Creek
Webbs Hill Branch
Granny Creek
Sugar Camp Creek
Taylor Branch
JEFFERSON
FRANKLIN
581 ft

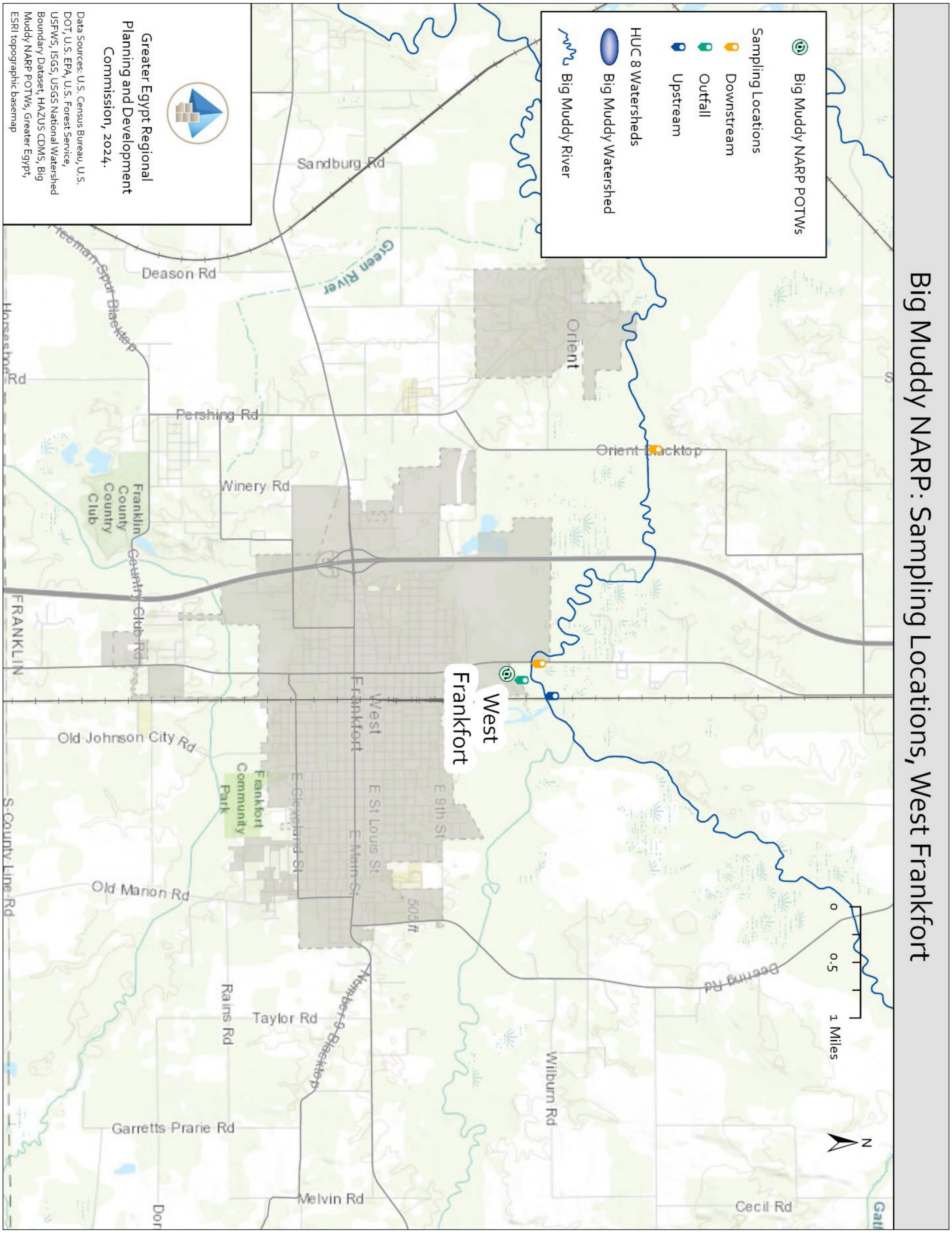
Big Muddy NARP: Sampling Locations, Carterville and Herrin




Big Muddy NARP: Sampling Locations, Carbondale
Big Muddy NARP POTWs
Sampling Locations
Downstream
Outfall
Upstream
HUC 8 Watersheds
Big Muddy Watershed
Big Muddy River
Greater Egypt Regional Planning and Development Commission, 2024.
Data Sources: U.S. Census Bureau, U.S. DOT, U.S. EPA, U.S. Forest Service, USFWS, ISGS, USGS National Watershed Boundary Dataset, HAZUS CDMS, Big Muddy NARP POTWs, Greater Egypt, ESRI topographic basemap
Carbondale Northwest
Carbondale Southeast
0
0.5
1 Miles
N
JACKSON
WILLIAMSON
Crab Orchard Creek
Little Crab Orchard Creek
Piles Fork
New Era Rd
Koonce Rd
Randolph Rd
Clark School Rd
N Reed Station Rd
N County Line Rd
Creekside Ln
Wood Rd
Glenn Rd
Bigler Rd

Big Muddy NARP: Sampling Locations, Murphysboro




Big Muddy NARP: Sampling Locations, West Frankfort
Big Muddy NARP POTWs
Sampling Locations
Downstream
Outfall
Upstream
HUC 8 Watersheds
Big Muddy Watershed
Big Muddy River
Greater Egypt Regional Planning and Development Commission, 2024.
Data Sources: U.S. Census Bureau, U.S. DOT, U.S. EPA, U.S. Forest Service, USFWS, ISGS, USGS National Watershed Boundary Dataset, HAZUS CDMS, Big Muddy NARP POTWs, Greater Egypt, ESRI topographic basemap
0
0.5
1 Miles
N
West Frankfort
Orient
Orient Blacktop
Sandburg Rd
Deason Rd
Green River
Pershing Rd
Winery Rd
Franklin County Country Club
Country Club Rd
FRANKLIN
Old Johnson City Rd
Frankfort Community Park
Old Marion Rd
S County Line Rd
Rains Rd
Taylor Rd
Garretts Prarie Rd
Melvin Rd
Wilburn Rd
Deering Rd
Cecil Rd
E 9th St
E St Louis St
E Main St
E Cleveland St
505ft