NUTRIENT ASSESSMENT REDUCTION PLAN

Mauvaise Terre Creek Watershed

Prepared for

City of Jacksonville
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Project MOW5571B

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ACRONYMS AND ABBREVIATIONS

CM	Continuous Monitoring
DM	Discrete Monitoring
DO	Dissolved Oxygen
EPA	Environmental Protection Agency
NARP	Nutrient Assessment Reduction Plan
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
RCPP	Regional Conservation Partnership Program
TCF	The Conservation Fund
TP	Total Phosphorus
WWTP	Wastewater Treatment Plan
WIP	Watershed Implementation Plan
USDA	United States Department of Agriculture
US EPA	United States Environmental Protection Agency

1. INTRODUCTION

The Illinois Environmental Protection Agency (Illinois EPA) has incorporated a special condition requirement to develop a Nutrient Assessment Reduction Plan (NARP) in many Illinois National Pollutant Discharge Elimination System (NPDES) permits for major wastewater water treatment plants (WWTPs) with a design flow of one million gallons per day (MGD). The NARP requirements apply to WWTPs that discharge upstream of water bodies that have a phosphorus-related impairment[1] or are at risk of eutrophication.[2] The purpose of the NARP is to identify phosphorus input reductions and other measures necessary to address phosphorus-related impairments. Illinois EPA recognizes that other measures (such as dam removal, stream restoration, riparian buffers, or constructed wetlands) may be needed to eliminate impairments.

The City of Jacksonville (City) WWTP is located upstream of Mauvaise Terre Creek segment that has been determined by the Illinois EPA to be at "risk of eutrophication." Hence, Illinois EPA incorporated the NARP special condition (Special Condition 23) in the WWTP's NPDES permit. The City hired Geosyntec Consultants, Inc. (Geosyntec) to develop a workplan to identify the scope, schedule, and budget for the work needed to produce the NARP (*Appendix A: City of Jacksonville-NARP Workplan Development,* Geosyntec 2022). The workplan was presented by Geosyntec to Illinois EPA on January 25, 2021, and the agency generally concurred with the workplan.

This report documents the work conducted by Geosyntec in close collaboration with the City and Benton & Associates, Inc. to execute the workplan for NARP. Following this introductory chapter, Chapter 2 provides an overview of the risk of eutrophication, nutrient sources, and other factors impacting water quality and details previous water quality studies. The NARP development process, which included collecting and analyzing data, is described in Chapter 3. Chapter 4 recommends an implementation plan and schedule to address the risk of eutrophication.

The Mauvaise Terre Creek (Creek) drains an area of 166 square miles through Morgan and Scott Counties in west-central Illinois **(Figure 1**). The Creek flows through the Mauvaise Terre Lake in Morgan County, which serves as a secondary drinking water source for Jacksonville and surrounding communities.[3] The Town Brook joins the Creek downstream of Mauvaise Terre Lake. The North Branch Mauvaise Terre Creek merges with the Creek just upstream of the WWTP. The Creek flows 39 miles from east to west to merge into the Illinois River. The study area for the City's NARP is the Mauvaise Terre Creek watershed (Study Area).

Based on the 2022 National Land Cover Database (NLCD), land use in the Study Area is predominantly agriculture (79 percent [%]), with some urban development in and around Jacksonville (**Figure 2**). Most of the soil in the Study Area consists of sand clay loam, which is

[1] A water body with a phosphorus-related impairment is listed by Illinois EPA on the state's 303(d) list as impaired because of the presence of dissolved oxygen or "offensive conditions" (e.g., algae or aquatic plant growth).

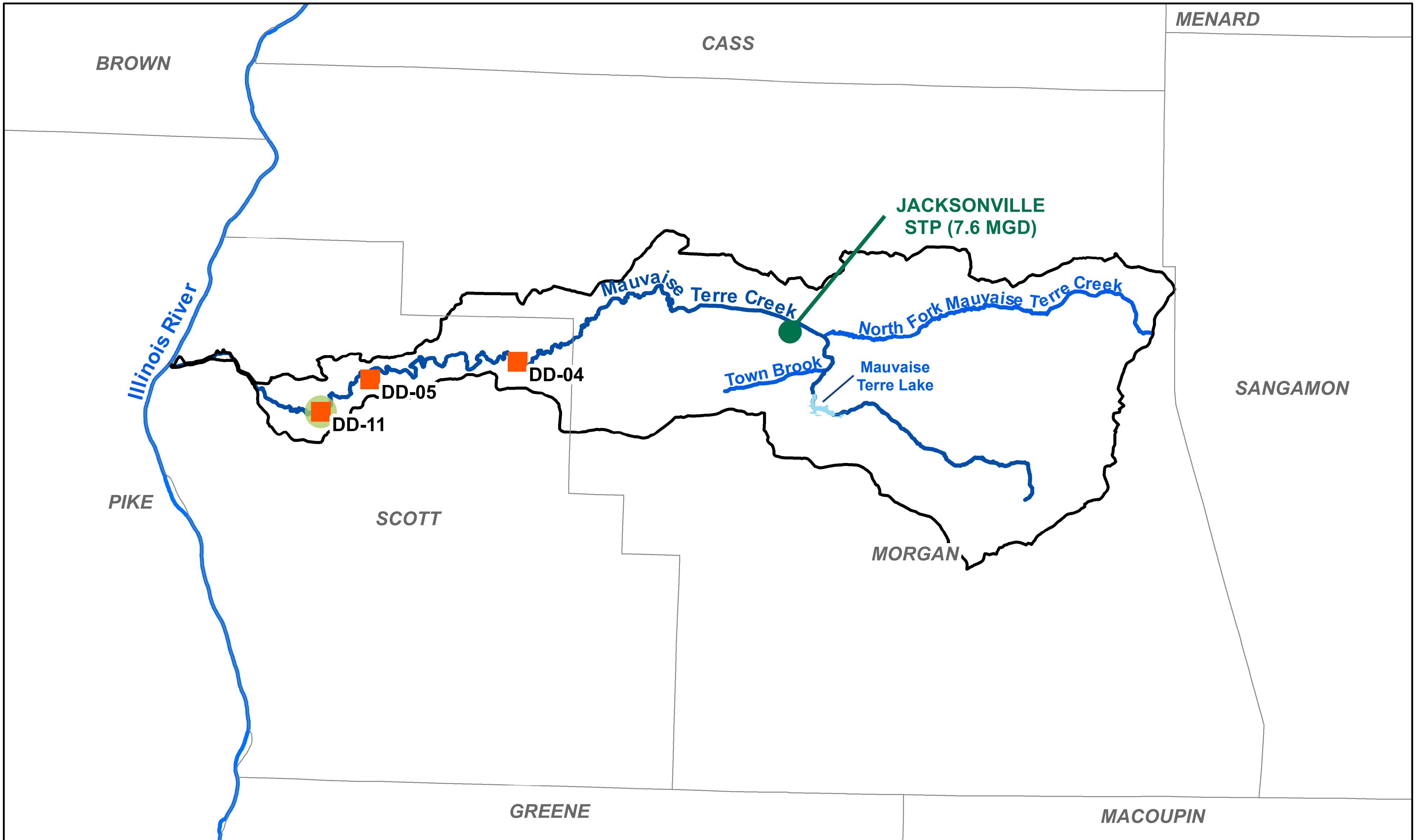
[2] A water body is determined to be at risk at eutrophication if the levels of sestonic chlorophyll-a, pH, and dissolved oxygen are above the thresholds set by Illinois Risk of Eutrophication Committee.

[3] Wells provide the main drinking water supply for the City of Jacksonville.

classified as Hydrologic Soil Group C. This type of soil is poorly drained and has a high runoff potential.

The Study Area has a temperate climate with cold winters and hot summers. The long-term yearly precipitation average for the period of 1970 to 2022 recorded at Jacksonville National Weather Station is 39.5 inches. During this period, the minimum yearly precipitation was recorded in 1989 (25.4 inches), and the maximum yearly precipitation was recorded in 1973 (60 inches). The average monthly temperature between 1970 and 2022 ranged from −3.5 degrees Celsius (°C) to 24 °C (NOAA, 2023).

According to the 2020 United States Census, the total population of Morgan and Scott counties is 37,864 (United States Census Bureau, 2020).



NARP Study Area
Counties
Lakes
Mauvaise Terre Creek
Major Tributaries
IEPA Discrete
IEPA Continuous

N

0 4 Miles

Nutrient Assessment Reduction Plan Study Area

(Lower Illinois River Watershed)
(Illinois)

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(Oak Brook, IL) | September 2023

Figure 1

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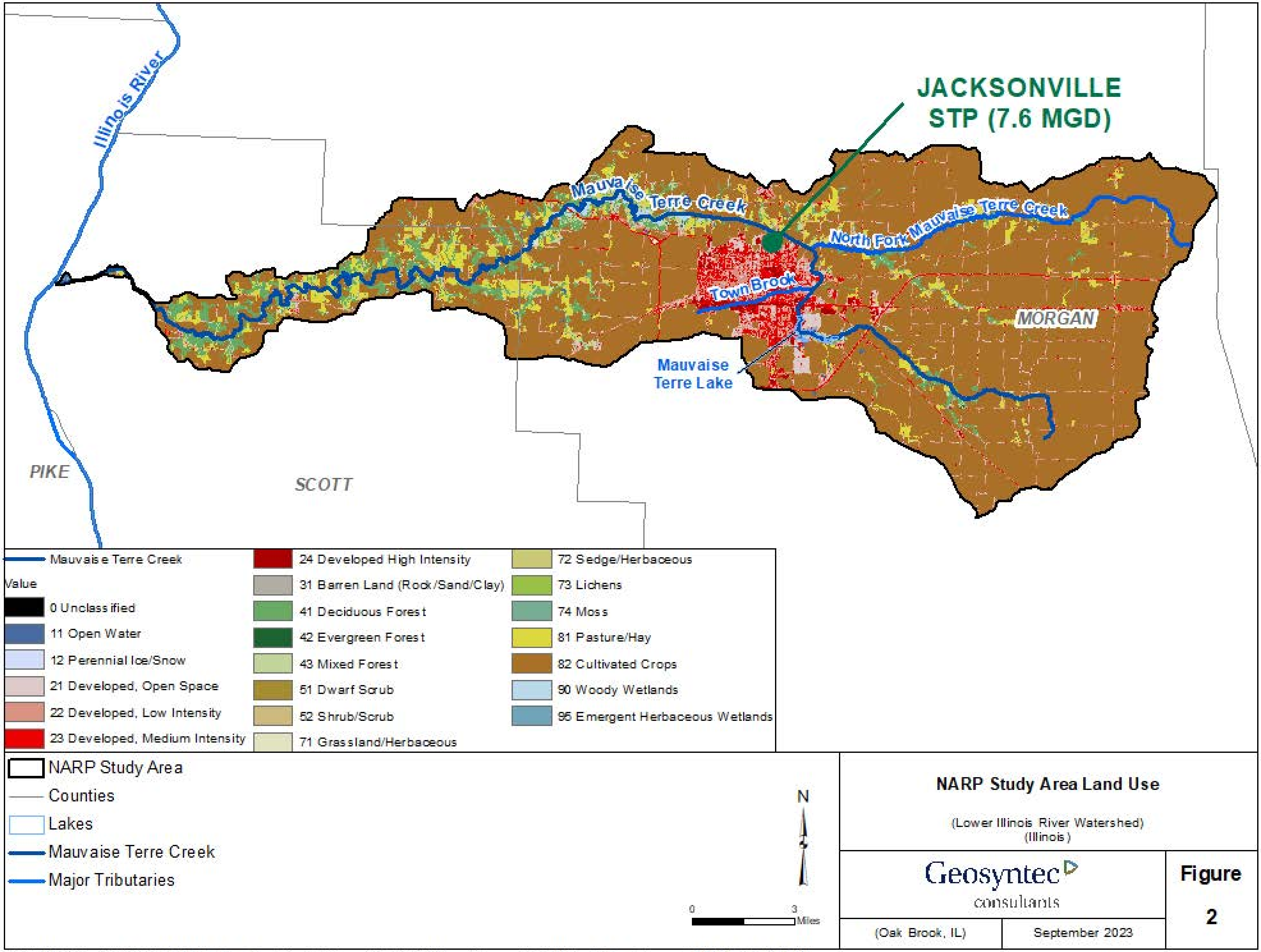

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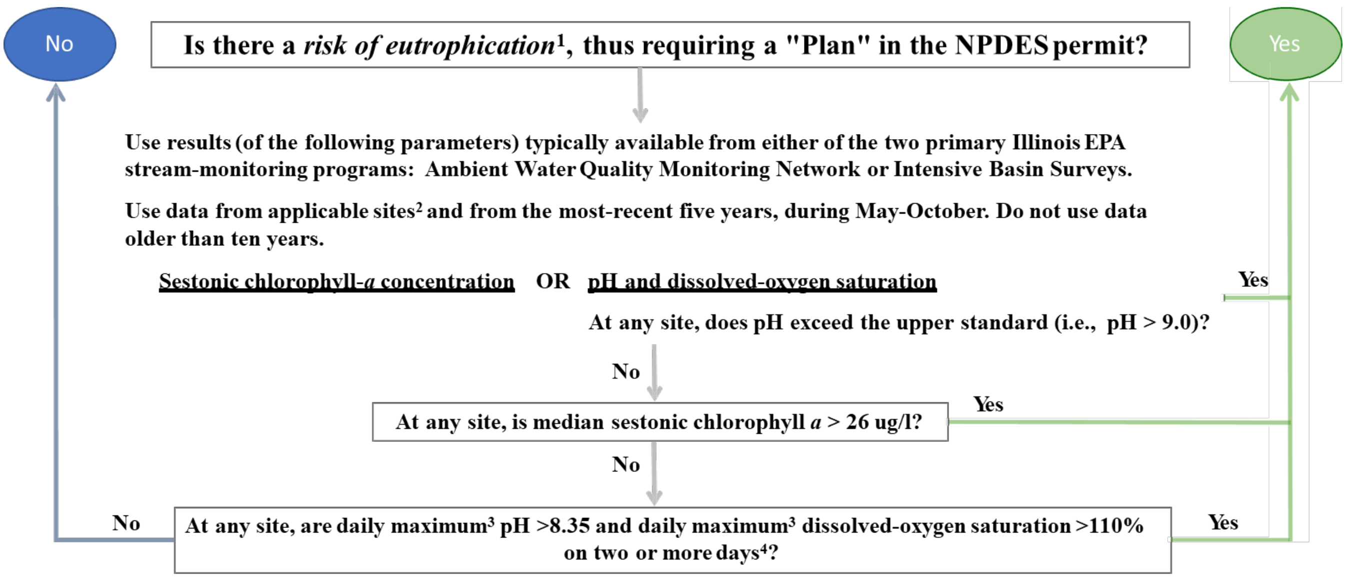
2. WATER QUALITY STATUS

2.1 Risk of Eutrophication Factors

Illinois EPA defines the risk of eutrophication as reasonable suspicion that plant, algal, or cyanobacterial growth is causing or will cause a violation of a water quality standard in a stream segment. The Illinois EPA Risk of Eutrophication Committee developed a simple decision process to assess the risk of eutrophication by using numeric thresholds of chlorophyll-*a*, pH, and dissolved oxygen (DO) saturation **(Figure 3)**. The numeric thresholds for pH, chlorophyll-a, and DO saturation levels were determined by analyzing the relationships between these parameters for data at Illinois EPA sites located throughout the state.



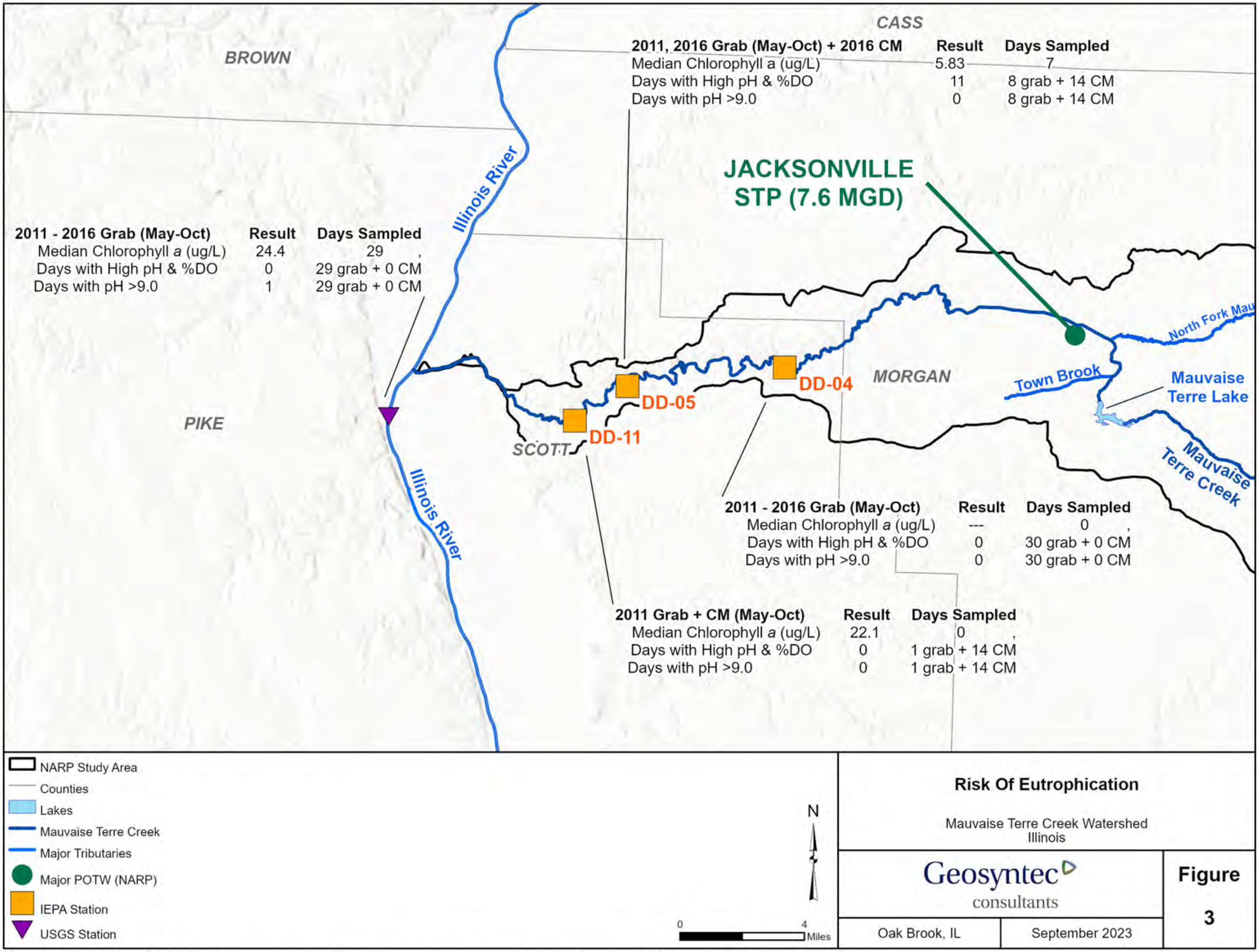
[1] Risk of eutrophication means that there is reasonable suspicion that plant, algal, or cyanobacterial growth is causing or will cause violation of a water-quality standard.

[2] To be determined, case by case.

[3] For one-per-day results, daily maximum is represented by the single result. For many-per-day (i.e., continuously monitored) results, daily maximum is the maximum result in a discrete 24-hour period.

Figure 3: Illinois EPA Procedure for Determining Risk of Eutrophication

Using the above method for determining the risk of eutrophication, Illinois EPA staff analyzed discrete monitoring (DM) and continuous monitoring (CM) data collected from the mainstem Creek in 2011 and 2016. The results of the analysis indicated that Illinois EPA Station DD-05 is at risk of eutrophication; There are 11 days when pH and DO saturation were above their thresholds (**Figure 4)**. The station DD-05 is located approximately 15 miles downstream of the WWTP.



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2.2 Nutrient Sources

The nutrient sources in the NARP Study Area include point-source loading from the WWTP and nonpoint-source (NPS) loading from surface runoff. The NPS loading can be grouped into three major categories:

- Agricultural
- Urban (developed and open space in urban areas)
- Other (forest, rural grassland, surface water, and wetlands)

The annual average phosphorus loading from the WWTP was estimated using the effluent flows and total phosphorus (TP) concentrations from 2013 to 2020. The estimated annual TP loads from the WWTP for 2013 to 2020 are shown graphically in **Figure 5**.

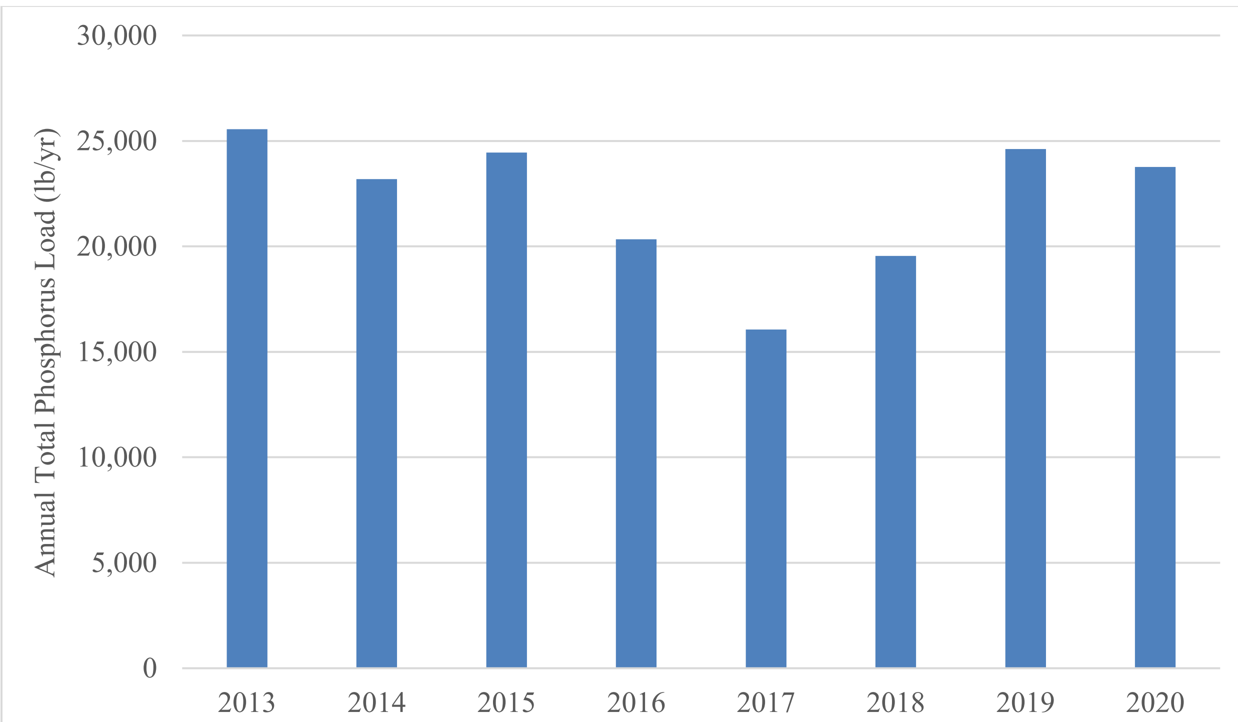


Figure 5: Estimated Annual Total Phosphorus Loading from the Wastewater Treatment Plant

The average annual loading from NPS was estimated using the United States Environmental Protection Agency (US EPA) Pollutant Load Estimation Tool (Tetra Tech 2022) based on the 2011 land cover data from National Land Cover Database (Homer et. al, 2015). The estimated annual average TP load (in pounds per year) and the distribution (by percentage) among the different sources within the Study Area is shown in **Figure 6**. The annual phosphorus load is dominated by agricultural sources (78%), followed by the WWTP effluent discharge (12%), urban (7%), and other (3%) sources. The contribution from CSO area is accounted in the urban area loading. A comparable breakdown is shown in **Figure 7** for the case where TP discharge from the WWTP is capped at 0.5 milligrams per liter (mg/L). In that scenario, the WWTP load contribution is reduced to 5% of the total annual load, and the agricultural load contribution increases to 85%.

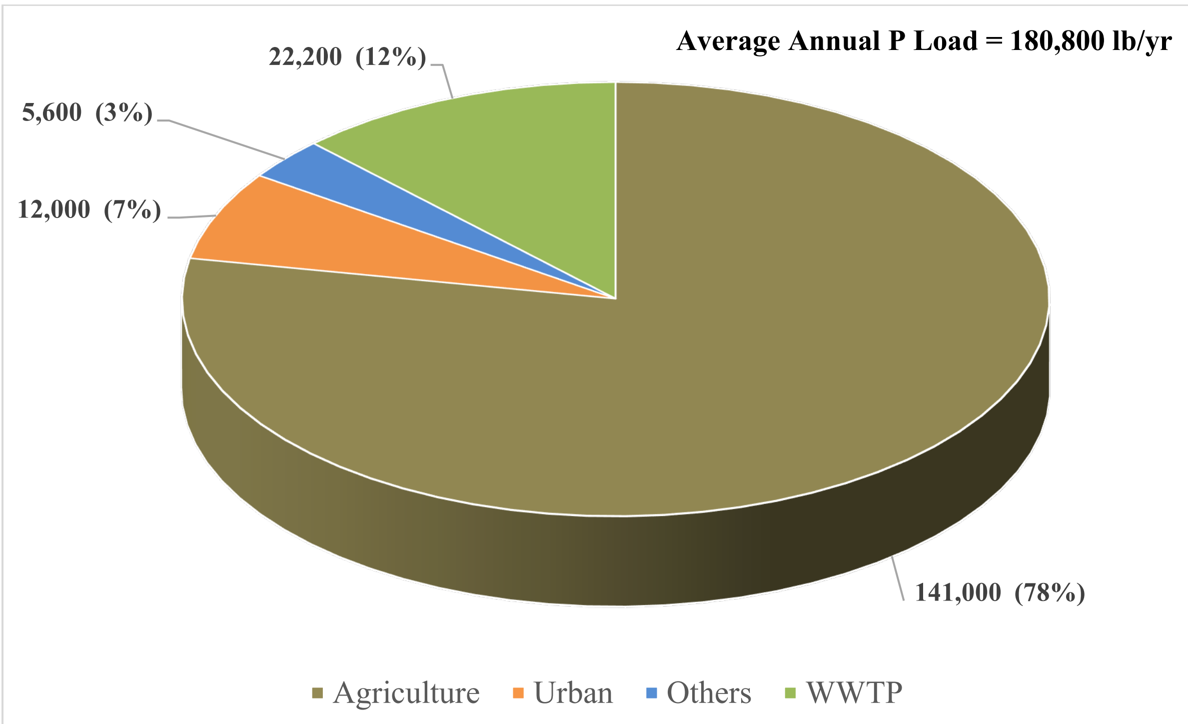


Figure 6: Estimated Average Annual Total Phosphorus Load to Study Area

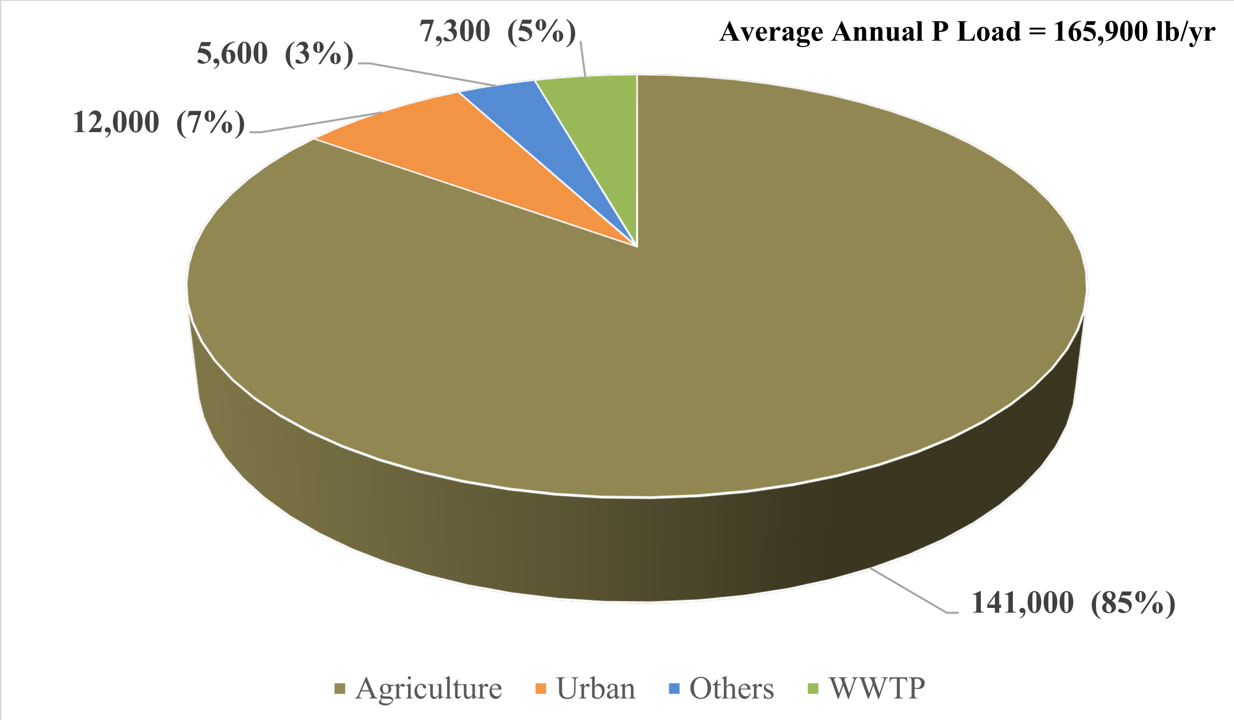


Figure 7: Estimated Annual Average Total Phosphorus Load to Study Area Assuming Total Phosphorus Concentration from the Wastewater Treatment Plant is Capped at 0.5 milligrams per liter

2.3 Water Quality Studies

The following sections describe the previous studies in the watershed by Illinois EPA, the City, and other stakeholders.

2.3.1 Mauvaise Terre Creek TMDL 2010

Section 303(d) of the Clean Water Act and US EPA's Water Quality Planning and Management regulations require states to develop total maximum daily loads (TMDLs) for water bodies that do not meet designated uses. In 2010, Illinois EPA commissioned the *Mauvaise Terre Creek Watershed TMDL* report (LimnoTech, Inc. 2011). Within the watershed, the Mauvaise Terre Lake (Lake) has been listed by Illinois EPA as impaired for aquatic life due to DO and TP (Illinois EPA 2022). Potential sources of phosphorus to the Lake include bottom sediments, golf courses, and agricultural land. The reported TP concentrations in the Lake were higher in the deeper portions, which suggests sediment resuspension as a source of TP.

A steady-state water quality model of the Lake was developed using the BATHTUB framework for the TMDL. The model results indicated that phosphorus load into the Lake is from external (18%) and internal (82%) sources. The TP target for the Lake is 0.05 mg/L, the Illinois General Use Water Quality Standard for lakes (Illinois Administrative Code Title 35, Section 302.205). Because of elevated internal phosphorus flux from the sediments, the initial results of the

BATHTUB model indicated that the TP water quality criterion would not be met by reducing the external loading. The TMDL recommended addressing the external loading sources before addressing internal loading sources from lake sediment. The TMDL states that the internal phosphorus flux is anticipated to diminish with a future reduction in external loads. A model scenario, assuming an internal phosphorus flux of zero and reduced external loading, was run to simulate this future condition. The results of this scenario indicated that the instream TP target would be met with a roughly 57% reduction in external loading.

2.3.2 Lake Mauvaise Terre Watershed Implementation Plan

The *Lake Mauvaise Terre Watershed Implementation Plan* (WIP) was prepared by the American Farmland Trust & Northwater Consulting (American Farmland Trust and Northwater Consulting 2014). The WIP recommends upland agricultural practices and structures for reducing sediment and phosphorus loading into the Lake. The plan builds upon the 2011 TMDL reports and provides a detailed analysis of watershed conditions, including impairments, causes and sources, best management practices (BMPs) and management strategies, pollutant loading quantities, and load reductions.

The plan identified erosion from upland cropped soils as a major contributor of phosphorus loading to the lake. A pollution loading model based on the SWAMM framework (Northwater Consulting 2023) was developed to estimate TP loading resulting from direct runoff, observed gully erosion, and streambank erosion. The supporting model results were reviewed against the TMDL estimated loads and used to calculate load reduction resulting from potential BMPs. BMPs were assessed on a site-specific and basin-wide scale. The model estimated that implementation of the recommended practices would reduce annual pollutant loads delivered to the Lake by 15,650 pounds for nitrogen, 4,131 pounds for phosphorus, and 1,733 tons for sediment. The WIP estimated that a 57% reduction in nitrogen and a 57% reduction in phosphorus is needed to meet the TMDL water quality targets. Results indicated that, even if all BMPs were implemented, the target reductions would not be met. However, the model estimated that conversion of cropland to native grasses on 2,799 acres would achieve a 56% load reduction. The combination of both cropland conversion and implementation of all of the proposed BMPs was estimated to achieve an overall reduction in phosphorus of 88%.

The WIP Addendum prepared by the American Farmland Trust & Northwater Consulting (2015) evaluated streambank erosion for the Creek and an unnamed tributary in the watershed and their contribution to sediment in the Lake and explored the potential benefit and feasibility of a low-flow dam structure in the Lake. Sediment and nutrient loading were estimated using the US EPA Region 5 Load Reduction Model (US EPA 2023). Overall, the streams were found to be mostly unstable and will continue to contribute sediment and nutrients as they seek equilibrium. The results suggest that stream bank erosion from the two tributaries contributes 12% of the total sediment load to the Lake, with the rest from upland sheet and rill erosion in agricultural areas. The study also assessed the use of instream and riparian BMPs to reduce sediment and nutrient loading. The WIP addendum recommended upland treatment within the agricultural areas for sediment management. The WIP addendum also recommended the construction of low-flow, in-lake sediment dams to reduce the sediment loading into the Lake. The City evaluated the feasibility of the construction of the low-flow/in-lake sediment dam and found it to be infeasible because of permitting and regulatory requirements (Benton and Associates and Northwater Consulting, 2023).

2.3.3 Lake Mauvaise Terre Nutrient Reduction Initiative: Plan Implementation and Construction

In 2015, funding was obtained to implement and construct practices detailed in the WIP, including over 24,000 feet of water-and-sediment-control basins, over 19 acres of grassed waterways, 420 acres of cover crop, 17 grade-control structures, over 2,000 feet of low-gradient surface drains, two sediment basins, one pond, and one livestock waste treatment system. The implemented projects were estimated to result in annual load reductions of 4,534 pounds of phosphorus, 16,674 pounds of nitrogen, and 2,274 pounds of sediment.

3. NARP DEVELOPMENT PROCESS

3.1 Data Acquisition

Geosyntec and City staff conducted water quality monitoring from July to September 2022. The goal of the NARP monitoring effort was to characterize nutrients, chlorophyll-*a,* and dissolved oxygen levels in the Creek during critical summer conditions (i.e., low flow, high water temperatures, and high biological productivity). The location of the monitoring station is shown in **Figure 8**. An example photo for the Creek at station CJ-3 is shown in **Figure 9**. The monitoring consisted of continuous and discrete data collection, which is described below.

3.1.1 Continuous Monitoring

Four CM water quality sites were installed on the Creek. Two sites were installed upstream of the WWTP outfall, and two sites were installed downstream. One of the upstream sites was located upstream of the Creek confluence with North Fork Mauvaise Terre Creek (station CJ-1), while the other was located directly below the North Fork confluence (station CJ-3). The two sites downstream of the WWTP were located at Poor Farm Road (station CJ-4) and Exeter Bluffs Road (station CJ-5).

YSI/Xylem EXO3 sondes were used to monitor DO, water temperature, pH, and conductivity at four sites. Streamflow was measured at station CJ-3 with the use of an ISCO 2150 flowmeter. **Table 1** identifies the CM sites and parameters monitored at each site.

Table 1: Continuous Monitoring Sites and Parameters

Station Name	Latitude	Longitude	Water Temperature	Dissolved Oxygen	pH	Specific Conductivity	Streamflow
CJ-1	39.74	-90.21	Yes	Yes	Yes	Yes	No
CJ -3	39.75	-90.22	Yes	Yes	Yes	Yes	Yes
CJ -4	39.76	-90.27	Yes	Yes	Yes	Yes	No
CJ -5	39.72	-90.50	Yes	Yes	Yes	Yes	No

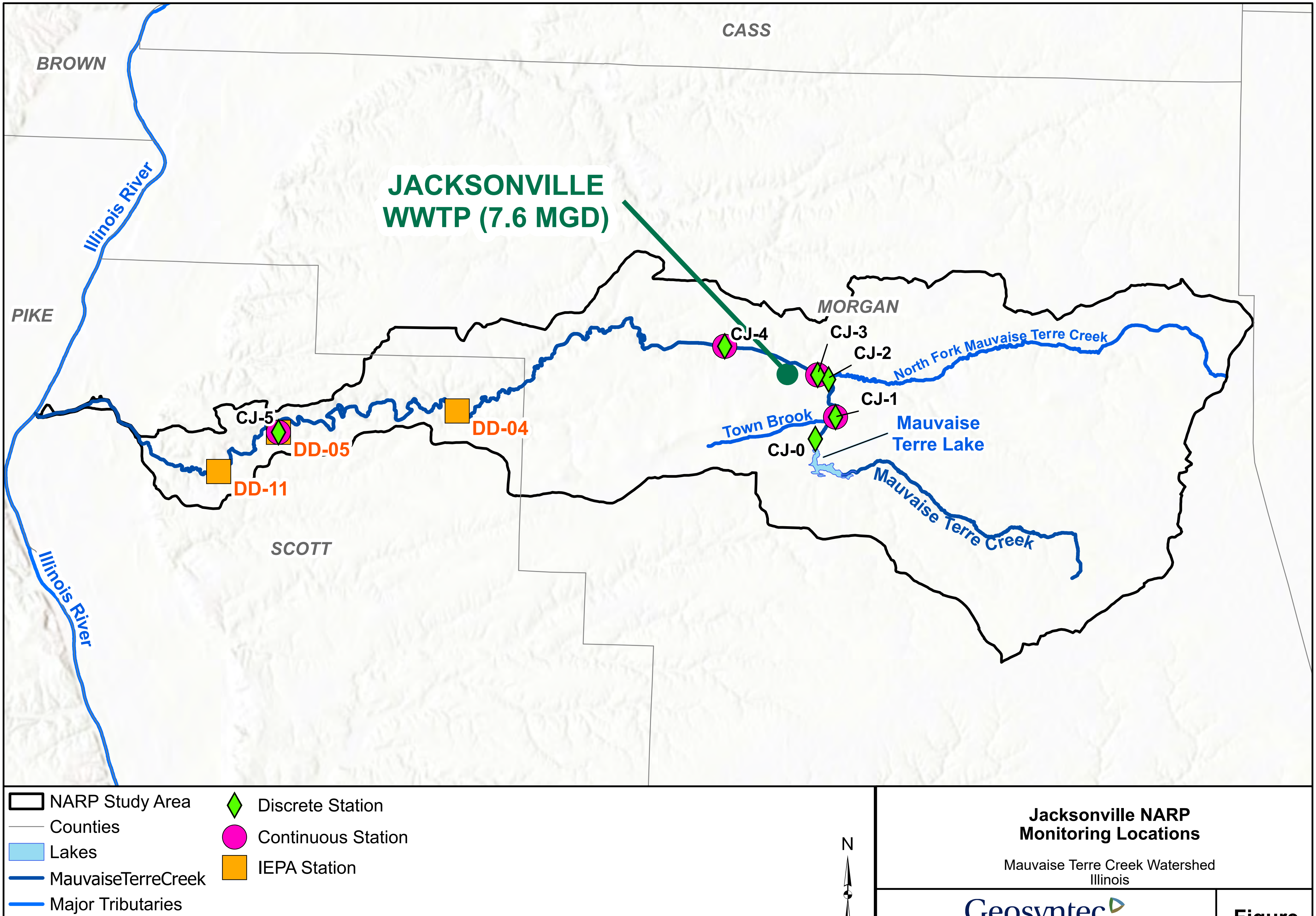
3.1.2 Discrete Monitoring

The City staff collected a total of seven grab samples at six DM sites on the Creek every two weeks from July to September 2022. The discrete water quality samples consisted of five (5) vertical samples (surface to near bottom) equally spaced across the channel. Water from each vertical sample was composited and split using a clean churn splitter and allocated to new laboratory-prepared sample bottles. A known volume of field-filtered sestonic chlorophyll-*a* was also collected, and benthic chlorophyll-*a* was collected once per month at station CJ-5 when possible. Collected samples were delivered to a qualified laboratory for analysis. **Table 2** lists the parameters measured at each DM station.

Table 2: Discrete Monitoring Sites and Parameters

Parameters	CJ-0	CJ-1	CJ-2	CJ-3	CJ-4	CJ-5
Nitrate plus Nitrite	Yes	Yes	Yes	Yes	Yes	Yes
TKN	Yes	Yes	Yes	Yes	Yes	Yes
Ammonia	Yes	Yes	Yes	Yes	Yes	Yes
Total Phosphorus	Yes	Yes	Yes	Yes	Yes	Yes
DRP^	Yes	Yes	Yes	Yes	Yes	Yes
$CBOD_5$	Yes	Yes	Yes	Yes	Yes	Yes
Sestonic Chlorophyll-*a*	Yes	Yes	Yes	Yes	Yes	Yes
Benthic Chlorophyll-*a*	Yes	**No**	**No**	Yes	Yes	Yes
Water Temperature*	Yes	Yes	Yes	Yes	Yes	Yes
Dissolved Oxygen*	Yes	Yes	Yes	Yes	Yes	Yes
Specific Conductance*	Yes	Yes	Yes	Yes	Yes	Yes
pH*	Yes	Yes	Yes	Yes	Yes	Yes

Notes:
^ Field filtration is required.
* Measurements are field measurements.
$CBOD_5$: five-day carbonaceous biochemical oxygen demand
DRP: dissolved reactive phosphorus
TKN: total Kjeldahl nitrogen



Jacksonville NARP Monitoring Locations

Mauvaise Terre Creek Watershed
Illinois

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Oak Brook, IL | December 2023

Figure 8

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Figure 9: Photo of Sampling Site CJ-5 (July 13, 2022)

3.2 Data Analysis

Geosyntec analyzed the results of data monitoring to assess the linkage of instream TP with algae and DO. The results of the data analysis were presented to Illinois EPA on a conference call on January 3, 2023. The slides from the meeting with the Illinois EPA staff are included in *Appendix B: Jacksonville NARP Data Analysis*. The results of the data analysis are described below.

The measured flows during the monitoring period at station CJ-3 (located just upstream of WWTP) for the period of July 15 to September 30, 2022, range from 2 to 498 cubic feet per second (cfs) (

Figure 10). During the same period, the WWTP effluent daily average flow ranged from 0.7 to 9.2 cfs (0.4 to 5.9 MGD).

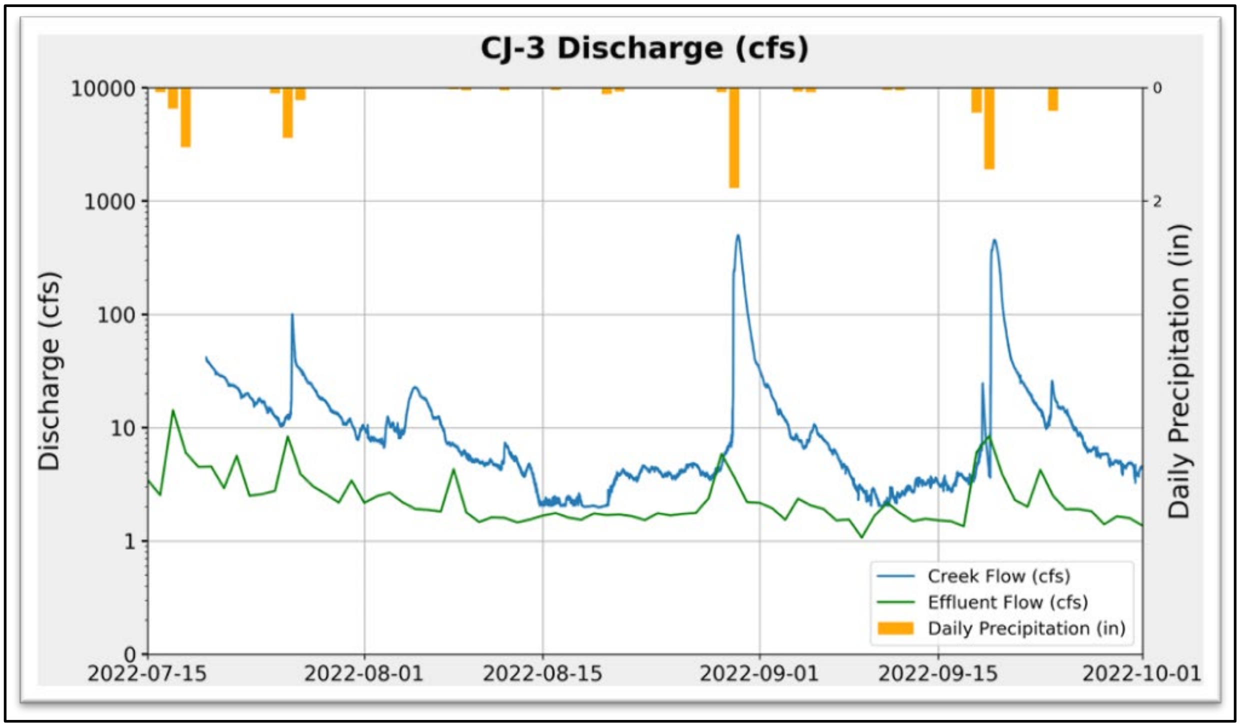

Figure 10: Comparison of Flow at Station CJ-3 and the Wastewater Treatment Plant for the Period of July to September 2022

The range of measured data TP, sestonic chlorophyll-*a*, benthic alga, DO and DO saturation, are presented in **Table 3. Figure 11** shows the longitudinal box plots[4] for measured TP, sestonic chlorophyll-*a*, DO, DO saturation, and pH along the main stem of the Creek. **Figure 11** shows that TP values are elevated at station CJ-4 due to phosphorus loading from the City WWTP. Instream sestonic chlorophyll-*a* is moderately elevated at station CJ-0 (10 to 50 micrograms per liter [µg/L]), located just downstream of Mauvaise Terre Lake, and decreases downstream. The higher chlorophyll-*a* levels (greater than 30 µg/L) at downstream sites (CJ-4 and CJ-5) in mid-September were due to the flushing of algae from the Lake (*Appendix B: Jacksonville Data Analysis*). The measured DO was below the Illinois state water quality standards at all sites except the most downstream station, CJ-5. The low DO values in the Creek are driven by the flow from the Lake, as shown by the lowest DO values at station CJ-1. The measured DO was undersaturated at all sites except for a brief period at the most downstream station, CJ-5.

[4] Whiskers represent the minimum and maximum values, the edges of the box represent the 25th and 75th percentile values, and the central lines represents the median values. Text on top of each box shows the numbers of samples available.

Table 3: Summary of Monitoring Results

Site	TP[1] (mg/L)	Sestonic Chlorophyll-*a*[1] (µg/L)	Benthic Algae[1] (mg/m^2)	pH[2]	DO[2] (mg/L)	DOsat[2] (percent)
CJ-0	0.1 - 0.3	6.9 - 46.0	-	-	-	-
CJ-1	0.1 - 0.2	2.3 - 44.0	-	7.2 - 8.7	2.5 - 9.0	35 - 110
CJ-2	0.1 - 0.2	0.5 - 69.0	-	-	-	-
CJ-3	0.1 - 0.3	0.5 - 30.0	-	7.3 - 8.1	3.0 - 8.3	25 - 90
CJ-4	0.3 - 2.4	0.5 - 29.0	-	7.0 - 7.8	0.5 - 7.8	6 - 95
CJ-5	0.2 - 0.6	0.5 - 38.0	1.3 - 4.2	7.3 - 8.4	5.4 - 10.7	65 - 136

[1] Discrete data
[2] Continuous data
µg/L: micrograms per liter
DO: dissolved oxygen
DOsat: dissolved oxygen saturation
mg/L: milligrams per liter
mg/m^2: milligrams per square meter

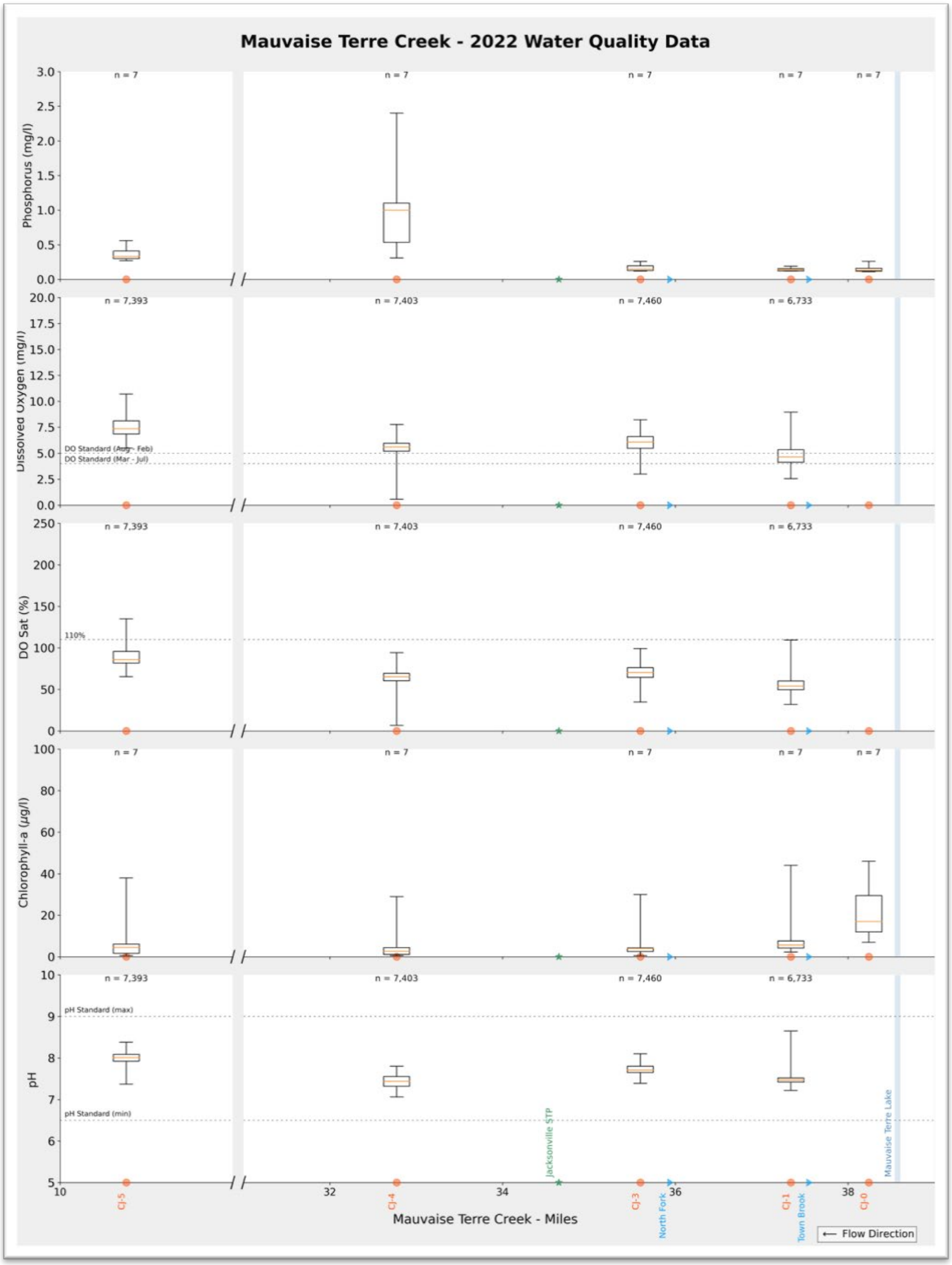

Figure 11: Longitudinal Plot of Water Quality Data along the Mauvaise Terre Creek

Geosyntec applied the risk-of-eutrophication method (**Figure 3**) to the data collected at the CM sites, and the results for each station are summarized in **Table 4**. Station CJ-5 was the only station determined to be at risk of eutrophication based on the analysis.

Figure 12 shows the timeseries of measured DO, DO saturation, pH, and chlorophyll-*a* at Station CJ-5. The measured DO at this location is always above the water quality standard for DO. The number of continuous days with measurements above pH and DO saturation thresholds is four days. This was discussed with Illinois EPA on a conference call on January 3, 2023, and the agency staff agreed that the risk of eutrophication is minimal based on the data analysis. The measured sestonic chlorophyll-*a* at this station is below 10 µg/L, except for the one high measurement in September 2023. Similarly, the measured benthic algae levels are relatively low (1.3 to 4.2 milligrams per square meter [mg/m^2]). This indicates that the risk-of-eutrophication determination might not be related to algal levels and, consequently, instream TP.

Table 4: Risk of Eutrophication Results at Continuous Monitoring Sites

Site	Median Chlorophyll-*a* (No. of Samples)	Days with pH > 9	Days with High pH and DO Saturation (Total Number of Days)	Risk of Eutrophication
CJ-1	5.6 (7)	0	0	No
CJ-3	4.0 (7)	0	0	No
CJ-4	2.7 (7)	0	0	No
CJ-5	4.5 (7)	0	4	Yes

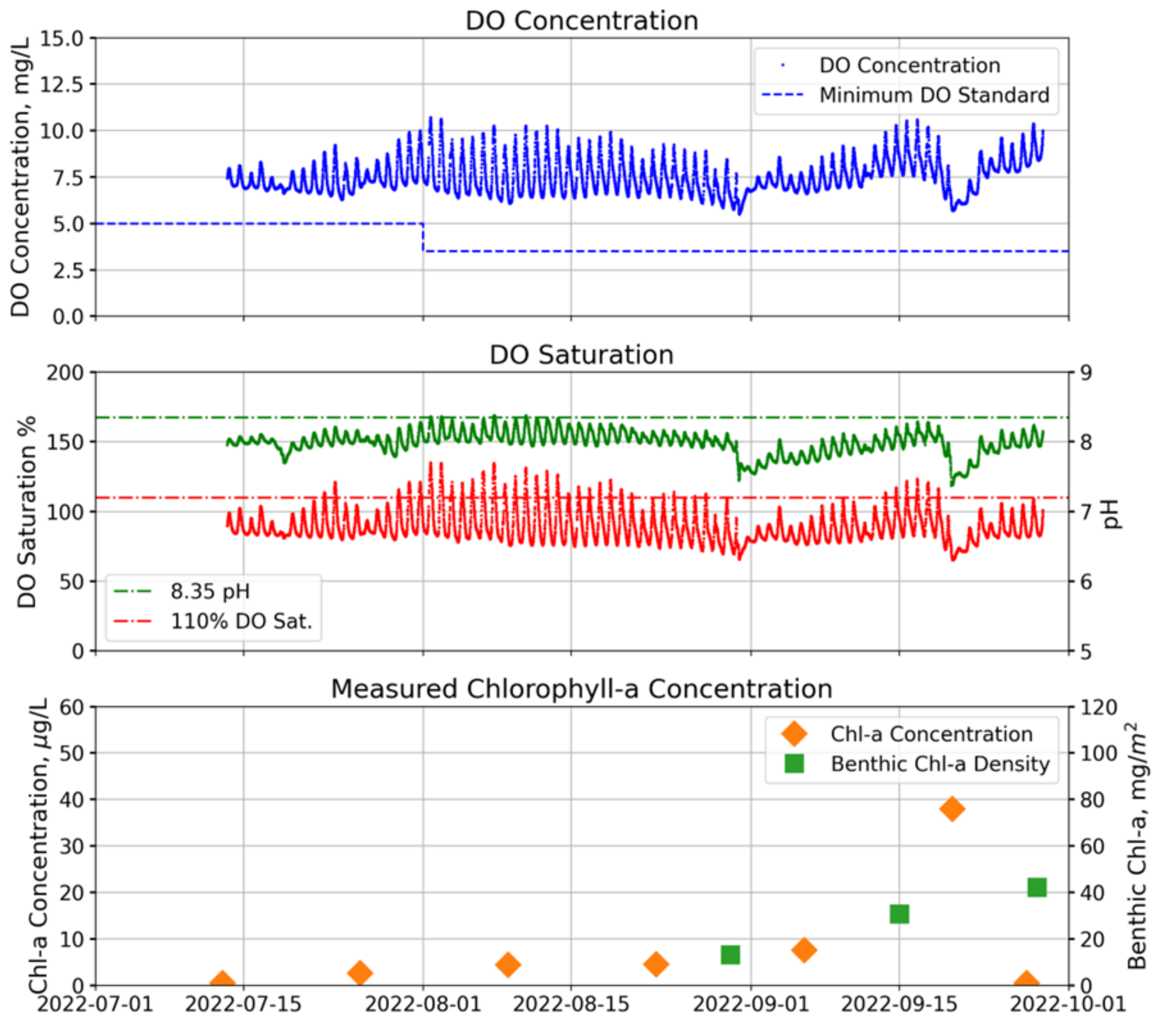

Figure 12: Water Quality Data Collected at Sampling Site CJ-5

3.3 Mass Balance Analysis

Geosyntec conducted a mass balance analysis to assess the impact of reducing the WWTP TP concentrations on the instream TP levels downstream of the WWTP.

The 2022 existing condition was first assessed to confirm that the mass balance analysis could predict the trends in TP concentration downstream of the WWTP. Instream monitoring data for station CJ-3 (flow and discrete TP samples) was used as input for the upstream boundary condition. The mass balance was performed using the WWTP monitoring data (daily flow and discrete monthly TP samples) to estimate the downstream TP concentrations. These estimated TP concentrations were then compared to the measured TP concentrations at station CJ-4 (**Figure 13**). The estimated downstream TP concentrations based on the mass balance match reasonably well with measured downstream TP concentrations at station CJ-4. The overprediction of TP concentration in August could be due to higher variability in the WWTP TP concentrations during August because of increased loading from an industrial source in August.

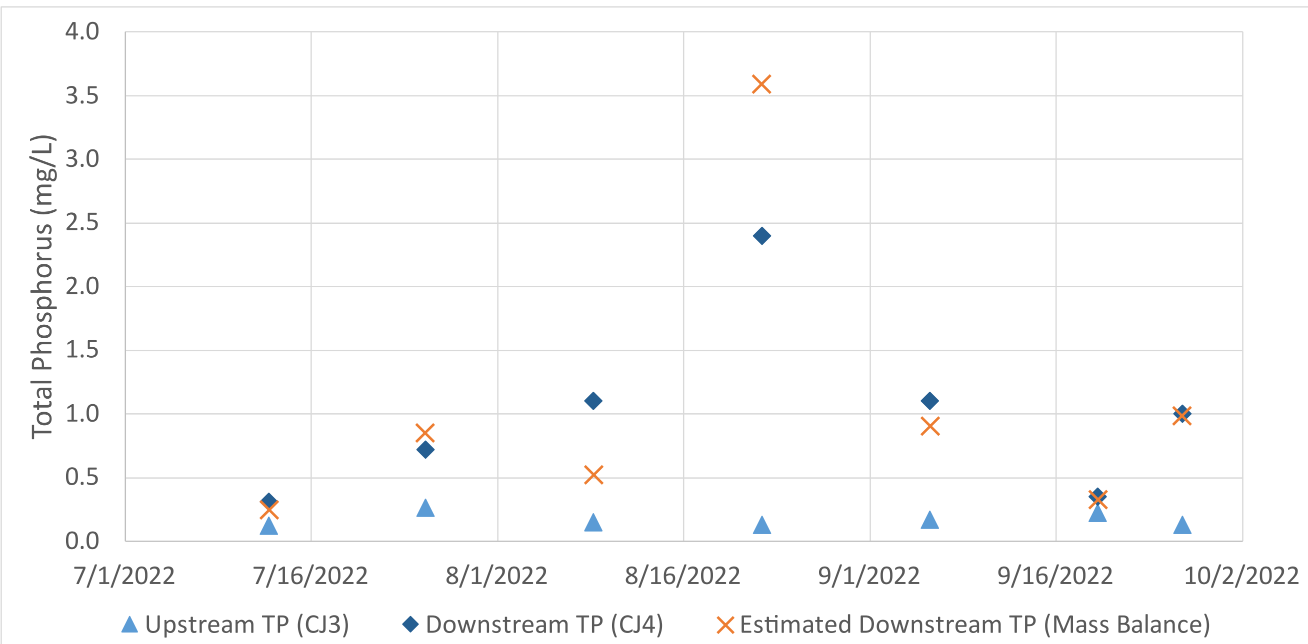

Figure 13: Comparison of Estimated TP Concentration Downstream of the WWTP with Measured Values at Station CJ-4

The estimated TP concentrations were then used as the baseline for comparison to future scenarios. The mass balance was applied to simulate future scenarios where the WWTP TP concentration was set to 0.5 mg/L and 0.1 mg/L, keeping the upstream inputs and WWTP flow similar to the baseline. **Figure 14** shows the comparison of estimated concentration for the baseline and two future scenarios with WWTP TP effluent concentration set to 0.5 mg/L and 0. 1 mg/L. The results of the mass balance calculations show that reducing the WWTP effluent TP concentration to 0.5

mg/L from the baseline condition will significantly reduce the instream TP levels downstream of the WWTP. Further reduction of WWTP TP effluent concentration to 0.1 mg/L would not have a significant impact on downstream TP levels in the Creek.

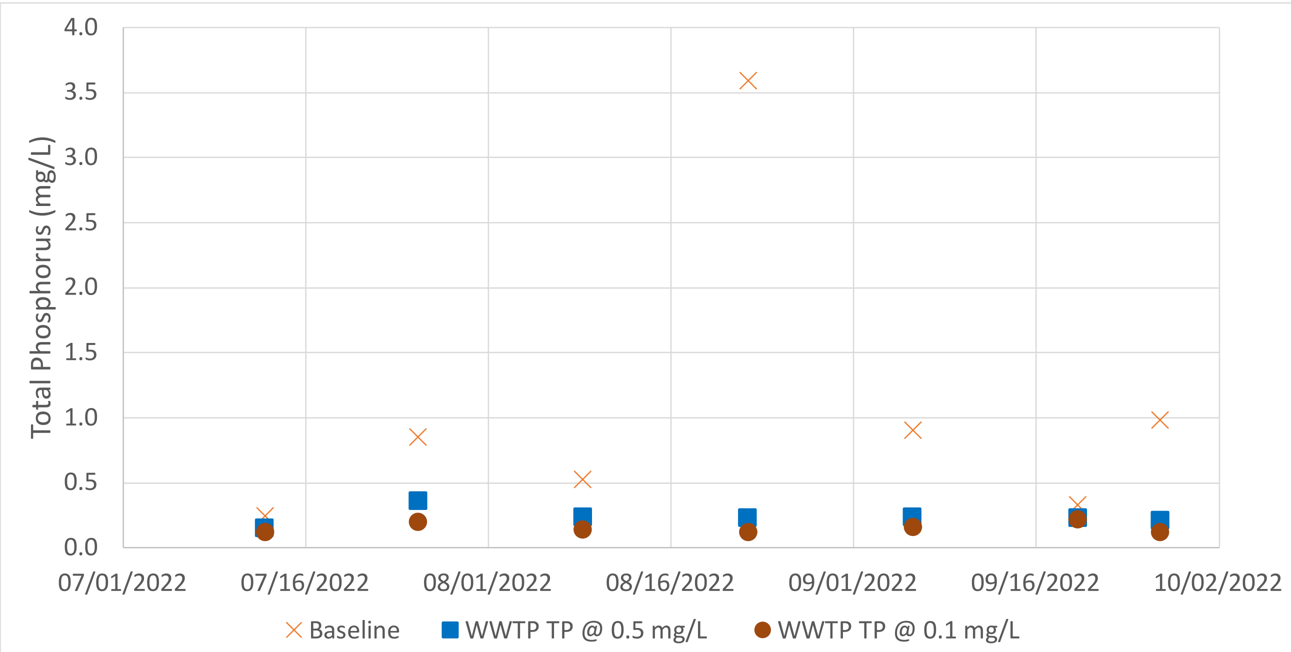

Figure 14: Comparison of Estimated Total Phosphorus Concentrations Downstream of the Wastewater Treatment Plant for the Baseline and Future Scenarios

3.4 Key Findings from Analysis

The key findings from the data and mass balance analysis are summarized below.

3.4.1 Key Takeaway #1: Total phosphorus reductions beyond 0.5 mg/L at the wastewater treatment plant have minimal impact on water quality.

The mass balance analysis results (**Figure 14)** show that reduction of TP effluent concentrations beyond 0.5 mg/L will not significantly impact the downstream instream TP levels. The WWTP TP loading constitutes approximately 12% of the annual average TP loading to the Creek under the existing condition. Reduction of the WWTP effluent TP concentration to 0.5 mg/L would result in a reduction of approximately 40% in the WWTP TP load but would not substantially impact the total loading to the Creek (**Figure 7**).

3.4.2 Key Takeaway #2: Reductions in agricultural loads are required to significantly reduce the loading from Mauvaise Terre Creek.

Agriculture contributes more than 80% of the annual TP loading to the Creek in the watershed (**Figure 5**). Therefore, a reduction in agricultural loading is required to significantly reduce loading into the Creek.

3.4.3 Key Takeaway #3: Reduction in high algae load from Mauvaise Terre Lake is required to reduce the high algae levels in Mauvaise Terre Creek.

The Mauvaise Terre Lake shows elevated levels of sestonic chlorophyll-*a*, which are flushed down the Creek. Therefore, a reduction in algae levels from the Lake is required to address the high levels in the Creek.

4. IMPLEMENTATION PLAN AND SCHEDULE

The work completed for the NARP focused on identifying management actions to eliminate DO and nuisance algae impairments. This section presents the recommended management actions for addressing the risk of eutrophication in the Study Area. Recommended actions fall under the following categories:

- WWTP upgrade
- Actions to reduce NPS loading
- Actions to reduce loading from Mauvaise Terre Lake
- Monitoring studies

The recommended actions include shorter-term actions that can be implemented prior to 2035 and longer-term priorities for implementation after 2035. An implementation schedule with realistic milestones has been developed to allow the City and other watershed stakeholders to pursue and utilize funds more effectively. The pre-and post-2035 recommended actions, along with key stakeholders and potential funding sources, are summarized in **Table 5** and described in detail below.

Table 5: Implementation Plan and Schedule for the Jacksonville NARP

Category	Pre-2035	Post-2035	Key Stakeholders	Potential Funding Sources
Wastewater Treatment Plant (WWTP) Upgrades	Meet a 0.5 milligram per liter (mg/L) total phosphorus (TP) effluent limit (12-month rolling geometric mean, calculated monthly) by December 31, 2035	Monitor the impact of 0.5 mg/L effluent on attainment of mainstem DO swings and algal growth	City of Jacksonville (City); Illinois Environmental Protection Agency (Illinois EPA)	City of Jacksonville (City) State Revolving Fund
Actions to Address Non-Point Source Loading	Collaborate with the American Farmland Trust and Morgan County Soil and Water Conservation District to support the implementation of best management practices (BMPs) if grant funding is available	Continue to support the implementation of identified projects if grant funding is available	City; American Farmland Trust; Illinois Farm Bureau; Natural Resources Conservation Service (NRCS); The Conservation Fund; Morgan County SWCD; Illinois Department of Agriculture (IDOA); NRCS	American Farmland Trust; Illinois EPA Section 319; NRCS
	Explore opportunities to engage in implementation programs like the Regional Conservation Partnership Program (RCPP)			
	Continue to implement recommendations of the Combined Sewer Overflow (CSO) Operation and Maintenance (O&M) Plan, pollution prevention plan (PPP)	Continue to implement recommendations of CSO O&M Plan, PPP	City	City Capital Budget
	Continue communal practices in relation to seasonal street sweeping and leaf litter pickup	Encourage a targeted leaf collection program.		
	Evaluate opportunities for implementation of BMPs such as pretreatment devices, retention basins, and filtration BMPs			

Category	Pre-2035	Post-2035	Key Stakeholders	Potential Funding Sources
Action to Reduce Mauvaise Terre Creek Loading	Assess and identify funding mechanisms for the implementation of Watershed Implementation Plan (WIP, American Farmland Trust and Northwater Consulting, 2015) recommendations for stream stabilization, grade-control structure, filter strips, and livestock	Implement projects if funding is available	City; American Farmland Trust; Illinois Farm Bureau; Illinois EPA; Morgan County Soil and Water Conservation District (SWCD); Landowners; Illinois Department of Agriculture (IDOA); NRCS	Illinois EPA Section 319; City Capital Budget Private Funds
	Evaluate additional options to reduce sediment loading to the Lake	Implement feasible options to reduce sediment loading to the Lake		
Monitoring Studies		Implement monitoring program, assess the impact of WWTP upgrades	City; Illinois EPA	City Capital Budget; Illinois EPA Section 604(b)
	Monitoring to meet the National Pollutant Discharge Elimination System (NPDES) permit requirements for WWTP and CSO	Continue monitoring		City Capital Budget

4.1 Wastewater Treatment Plant Upgrade

The NPDES permit for the City's WWTP requires meeting a TP effluent limit of 0.5 mg/L by December 2035 (12-month rolling average, calculated monthly) with the use of biological nutrient removal (BNR), incorporating nitrogen removal. The City is currently planning to upgrade the WWTP to a BNR facility with anaerobic and anoxic tanks, along with chemical polishing

Phased construction of WWTP upgrades is focused on meeting new phosphorus treatment standards, safety, and resiliency. Phase 1 is under construction and includes installation of a new headworks and an electrical building. Phase 2 is scheduled to begin construction in 2026 and includes installation of new generators, a SCADA system, a new sludge dewatering, treatment, and storage system and a new chemical phosphorus removal system. Phase 3 includes rehabilitation of the existing aeration system, final clarifiers rehabilitation, and RAS/WAS pump station rehabilitation along with a new biological phosphorous treatment system, featuring new anaerobic tanks, and anoxic selectors. All work will take place at the existing wastewater treatment plant on and adjacent to existing equipment and infrastructure. The estimated cost of the upgrade is approximately $40 million.

4.1.1 Stakeholder Engagement

The stakeholders for the WWTP upgrade include the City, its ratepayers, and Illinois EPA. It will be important to communicate information about needed upgrades with these stakeholders to help ensure that the required upgrades get funded.

4.1.2 Potential Funding Sources

The Illinois EPA has provided planning approval of $30 million through Illinois' Water Pollution Control Loan Program for Phase 2 and Phase 3 of WWTP upgrades (Illinois EPA, 2023).

4.2 Actions to Reduce Non-Point Source Loading

The NPS loading to the Creek includes agriculture and urban sources.

Agriculture contributes more than 80% of the TP load into the Creek. Therefore, it is essential to reduce phosphorus loading from agriculture to the Creek. This would warrant a select group of BMPs more conducive to capturing water in a rural field setting. Engaging agricultural communities in collaborative efforts to reduce NPS pollution is a strategy that has been widely adopted to aid in-stream water quality improvements. Although attribution and quantification remain challenging, field-level research documents the benefit of implementing in-field, edge-of-field, and structural practices to decrease field runoff.

Recommended practices to reduce agricultural loading include traditional practices such as improved nutrient management, cover crops, grassed waterways, riparian buffers, filter strips, and innovative practices such as iron sand filters and agricultural runoff treatment systems (ARTS).

The urban sources of loading into the Creek include direct runoff, sanitary sewer overflows, and combined sewer overflows (CSOs). The City has developed three separate plans required by the Illinois EPA to reduce pollutant loading from CSOs into the Creek. These plans include the Plan of Study for CSO Assessment (CDM Smith, 2005), Stormwater Pollution Prevention Plan (Benton & Associates, 2018), and CSO Long Term Control Plan (Benton & Associates, 2008) The City would continue to implement the recommendations of these plans to control urban sources.

Additional programmatic recommendations for the reduction of phosphorus loading for the City's consideration include the following:

- Evaluate opportunities for implementation of BMPs that reduce phosphorus, such as pretreatment devices, retention basins, and filtration BMPs
- Continue communal practices in relation to seasonal street sweeping and leaf litter pickup. The City's Street Sweeping program runs year-round with higher volumes during the spring and fall. The City also performs leaf and brush pickup at a minimum two months per year in the spring and fall and then runs short programs at different times in the summer.
- Continue to promote the construction, retrofitting and maintenance of stormwater detention facilities consistent with the WIP

4.2.1 Stakeholder Engagement

The City may explore opportunities for engaging the agricultural community in the application of these recommended practices. This could be done through the Illinois Farm Bureau, the American Farmland Trust, county farm bureaus, and the Morgan County Soil and Water Conservation District, and The Conservation Fund. The City would engage with these organizations periodically to discuss TP reduction efforts from NPS and potential collaboration on grants.

The City could work with the agricultural community to identify farm practitioners for pilot demonstration projects. Innovative technologies (e.g., iron sand filters, ARTS) can be merged with traditional practices (e.g., cover crop, no-till). After the initial projects, the City could further investigate opportunities for adoption of BMPs and strategic alliances with the agricultural community to shore up marginal lands, switching them from limited agricultural returns to areas of beneficial nutrient capture while investigating the means to programmatically fund the design and construction of the needed facilities to reduce agricultural loading. The above strategy would tie in well with the goals of the Illinois Nutrient Loss Reduction Strategy (Illinois EPA et al., 2015).

Farmers make decisions to implement conservation practices based on multiple considerations, including bottom-line cost, land tenure, soil productivity, and peer norms, beliefs, and attitudes. Access to information can also affect how these decisions are made. Programs to increase conservation adoption should consider how all these factors come together to affect land management decisions and associated practices. Financial assistance has traditionally been offered to incentivize farmers to change their work practices or try something new. Recent research suggests that additional tactics that can successfully address NPS agricultural runoff include working in localized, smaller watersheds, aligning cost-share incentives to target the highest contributors, and promoting adoption of conservation systems (e.g., by adopting a graduated cost-share rate that supports multi-practice adoption). A targeted and tailored outreach and engagement strategy is equally important.

4.2.2 Potential Funding Sources

Potential funding sources for agriculture-related implementation practices are primarily from the United States Department of Agriculture (USDA) through the Natural Resources Conservation Service (NRCS) and Farm Service Agency (FSA). The USDA has programs that include the: Agricultural Conservation Easement Program, Conservation Reserve Program, Conservation Stewardship Program, Environmental Quality Incentives Program, and the Regional Conservation Partnership Program (RCPP). The United States Department of Environmental Protection (US EPA) sponsors the Wetland Program Development Grant program.

The Agricultural Conservation Easement Program offers technical and financial assistance to help farmers, ranchers and forest landowners to protect the agricultural viability and conservation values by limiting nonagricultural uses which negatively affect agricultural uses and conservation values. This program helps protect, conserve and restore eligible grazing land and wetlands on eligible land.

The Conservation Reserve Program contracts with agricultural producers to protect (i.e. not farm) environmentally sensitive agricultural land creating conservation benefits by providing rental payments and cost-share assistance. Participants establish long-term, approved grasses or trees to control soil erosion and improve water quality.

The Conservation Stewardship Program offers technical and financial assistance to help agricultural and forest producers improve their conservation efforts to the next level. The program compensates producers who agree to increase their level of conservation by adopting additional conservation activities and maintaining their baseline level of conservation.

The Environmental Quality Incentives Program provides technical and financial assistance to producers to address natural resource concerns and improve water quality, conserve ground and surface water, increased soil health and reduce soil erosion and sedimentation, and mitigated against climate change.

The Regional Conservation Partnership Program is a partner-driven approach to conservation that funds natural resource solutions on agricultural land. In collaboration with project partners. Classic projects are implemented using NRCS contracts and easements with producers and communities, With Grant projects, the partner works with agricultural producers to develop new conservation structures and approaches that are not available under the Classic program.

The Wetland Program Development Grant provides grants to conduct projects that promote the coordination, research, training, demonstrations, surveys and studies relating to the causes, effects, extent, prevention, reduction and elimination of water pollution through wetland management, enhancement, and restoration.

4.2.3 Local Assistance

The Morgan County Soil and Water Conservation District (MCSWCD) offers agricultural producers one-on-one help and financial assistance to plan and implement conservation practices. The nutrient and soil conservation goals of the MCSWCD are to: 1) assist land users with sheet, rill, and gully erosion in constructing projects that reduce soil loss, protect water quality, and reduce flooding, and 2) provide incentives to eligible land users for drainage water management projects that minimize the transport of nutrients to surface water and groundwater. MCSWCD is an expert on many of the above funding sources.

The Conservation Fund (TCF) and its partners are offering financial assistance to farmers in Illinois to implement conservation practices that promote soil health, production diversity, and healthy waters and habits through the Regional Conservation Partnership Program. The initiative is called the Illinois Working Lands, Water & Wildlife Conservation Partnership (TCF 2023). 32 of the 60 eligible practices under the program would reduce the phosphorus loading to the Creek.

4.3 Actions to Reduce Mauvaise Terre Lake Loading

Mauvaise Terre Lake is a significant source of phosphorus and algae into the Creek. The 2010 TMDL reported that loadings of TP from lake bottom sediments constitute more than 80% of the TP loading into the Lake. This TP bound with lake bottom sediments is resuspended during periods of high flow. The City undertook dredging of the Mauvaise Terre Lake in 2014, removing approximately 550,000 cubic yards of sediment. The dredging project cost was approximately $3.4 million. The dredging has significantly reduced internal phosphorus loading to the Lake. The reported TP concentrations from May to October 2023 at station CJ-0 (located just downstream of the Lake) range from 0.1 to 0.3 µg/L.

The City has worked with the American Farmland Trust and Illinois EPA to implement 200 individual treatment practices at an estimated cost of $700,000. The City may evaluate additional measures to reduce sediment loading to the Lake.

4.3.1 Stakeholders

The stakeholders in the effort to reduce Mauvaise Terre Lake loading include the City, American Farmland Trust, and Illinois EPA.

4.3.2 Potential Funding Sources

The potential funding sources include Illinois EPA Section 319 grants and the American Farmland Trust.

4.4 Monitoring Studies

The City will undertake the following monitoring studies to track the progress of implemented action items for the NARP.

4.4.1 Monitoring to Support NPDES Permitting

The City will continue to undertake monitoring to meet the requirements of the WWTP's NPDES permit.

4.4.2 Post-2035 Monitoring Study

The City will consider conducting a monitoring study after 2035. The monitoring could be conducted using the approach followed for the 2022 monitoring. The results of the study could be used to assess the impact of implemented management actions.

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Appendix A

City of Jacksonville
NARP Workplan Development

Geosyntec consultants

Workplan for Development of a NARP for the City of Jacksonville Wastewater Treatment Plant

January 25, 2021

Nutrient Assessment Reduction Plan (NARP) Requirement and Study Area

Geosyntec consultants

NARP Background

- NARP provides permittees the flexibility to establish the appropriate nutrient-related criteria for the receiving water
  - US EPA ecoregion criteria are too conservative and based on little data
  - Illinois' Nutrient Science Advisory Committee criteria are unsupportable (but referenced in the NARP permit language)
- NARP presumes that there are cost-effective means to address the phosphorus-related impairments
  - Does not identify what a permittee can do if point and nonpoint source reductions and other measures needed to eliminate the impairment are not cost-effective or unaffordable

When is a NARP Required?

PHOSPHORUS RELATED IMPAIRMENT

Listed on 303(d) list for:

- Dissolved oxygen
- Offensive condition (algae and/or aquatic plant growth)

RISK OF EUTROPHICATION

Information that plant, algal, or cyanobacterial growth is causing or will cause violations of water quality standards

- pH
- Dissolved oxygen
- Chlorophyll-a

OTHER

Permit can be re-opened if

- Phosphorus related impairment
- Risk of eutrophication

Risk of Eutrophication Criteria

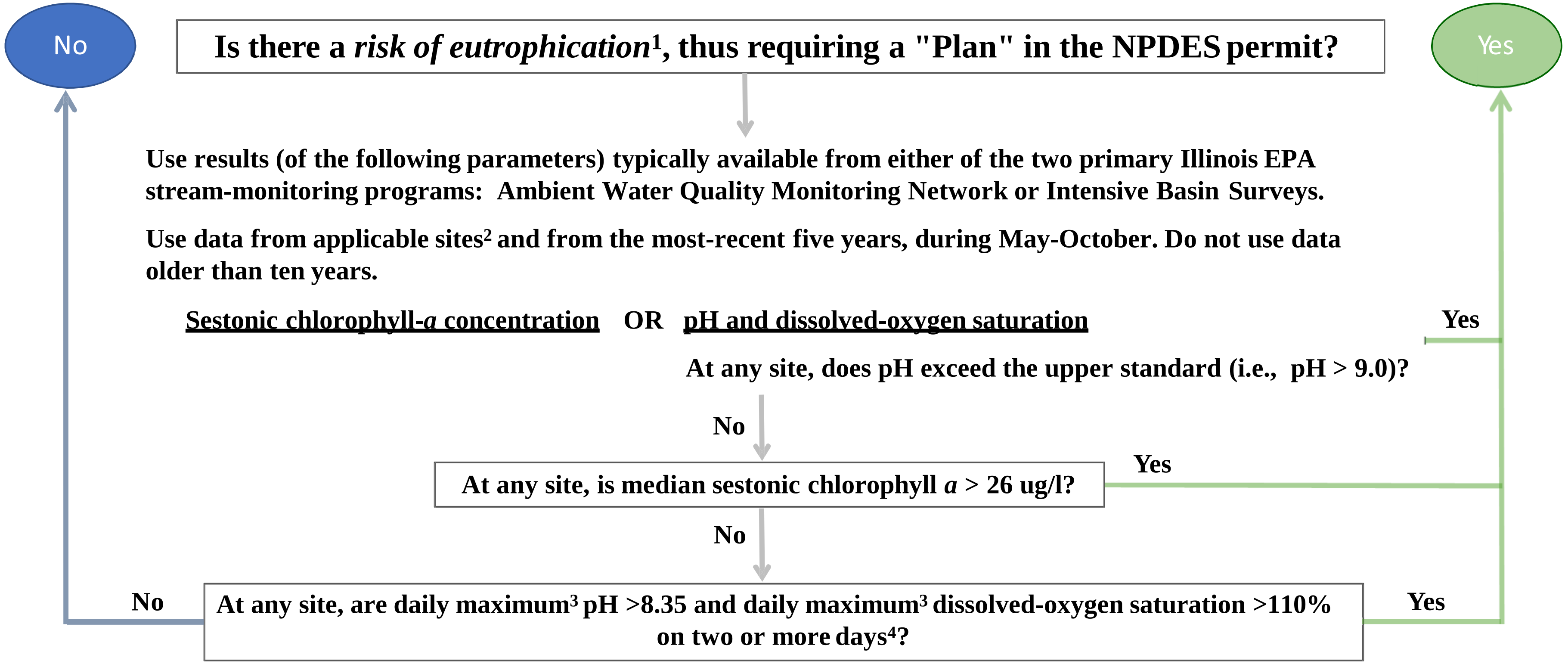
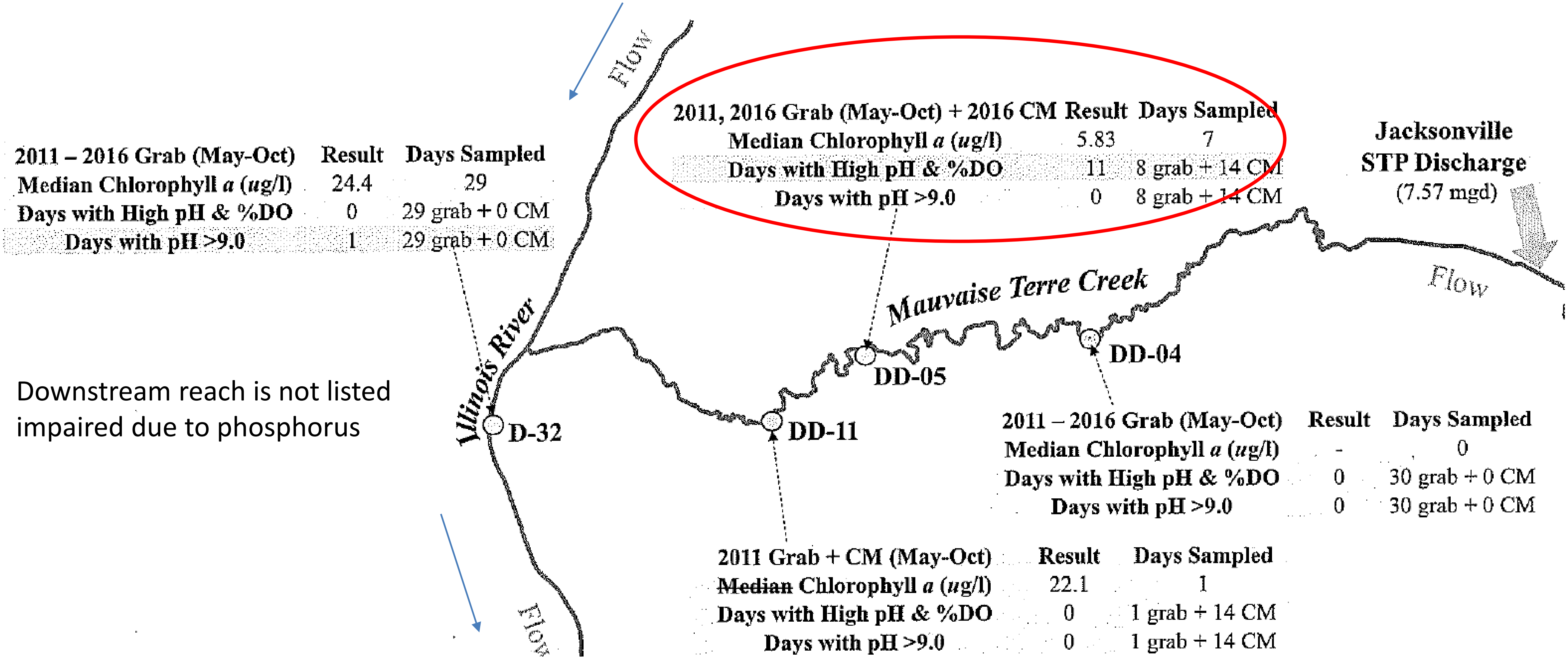


Figure 5 : Illinois EPA Procedure for Determining Risk of Eutrophication

[1] *Risk of eutrophication* means reasonable suspicion that plant, algal, or cyanobacterial growth is causing or will cause violation of a water-quality standard.
[2] To be determined, case by case.
[3] For one-per-day results, "*daily maximum*" is represented by the single result. For many-per-day (i.e., continuously monitored) results, "*daily maximum*" is the maximum result in a discrete 24-hour period.
[4] For many-per-day (i.e., continuously monitored) results, a "*day*" means a discrete 24-hour period.

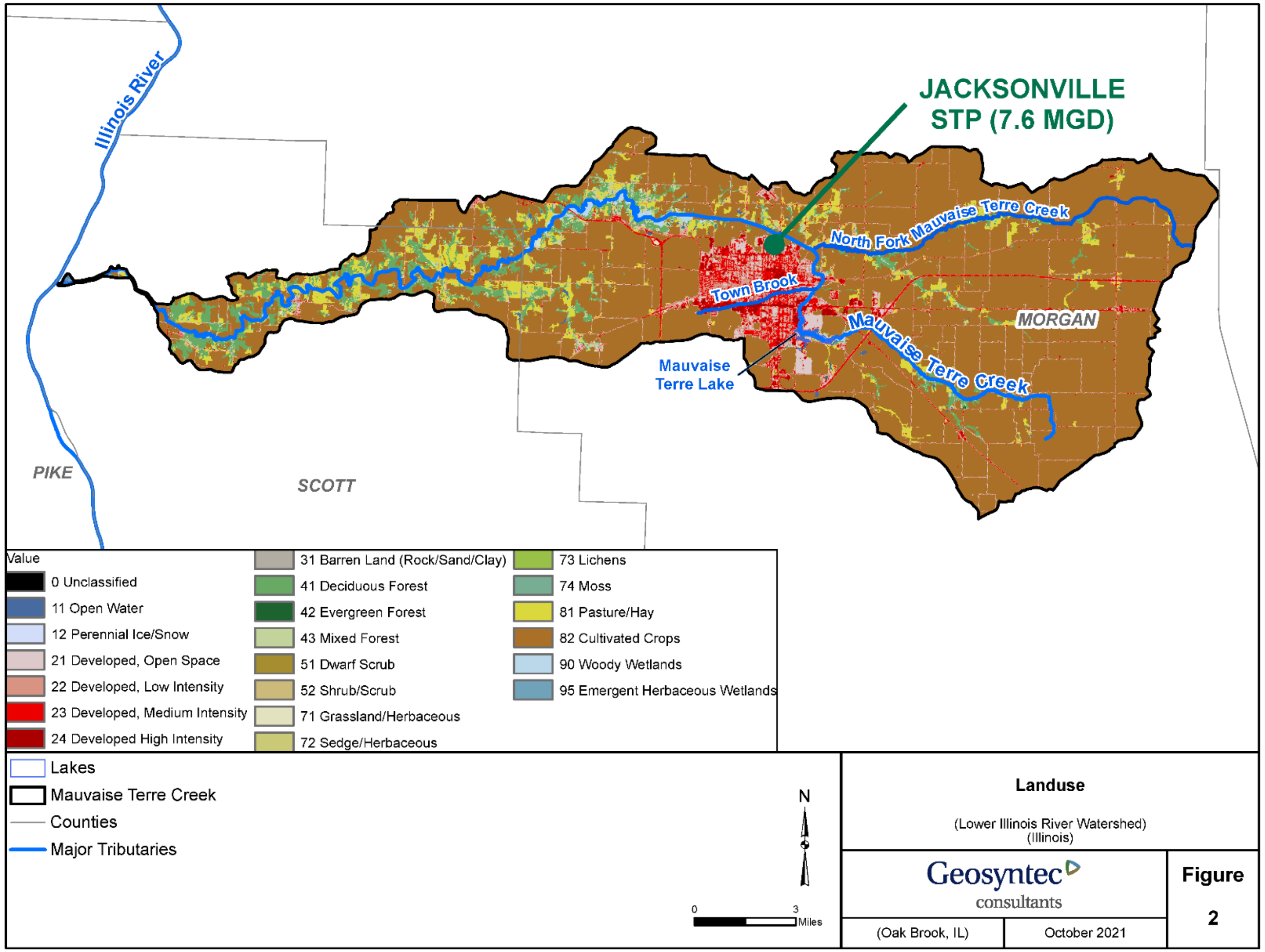
Risk of Eutrophication – Illinois EPA



Downstream reach is not listed impaired due to phosphorus

Jacksonville NARP Geographic Boundaries

- Illinois River drainage area upstream of confluence with Mauvaise Terre Creek 26,000 sq. mile
- Mauvaise Terree Creek watershed 167 sq. miles
- NARP for Jacksonville WWTP should focus on Mauvaise Teree Creek watershed



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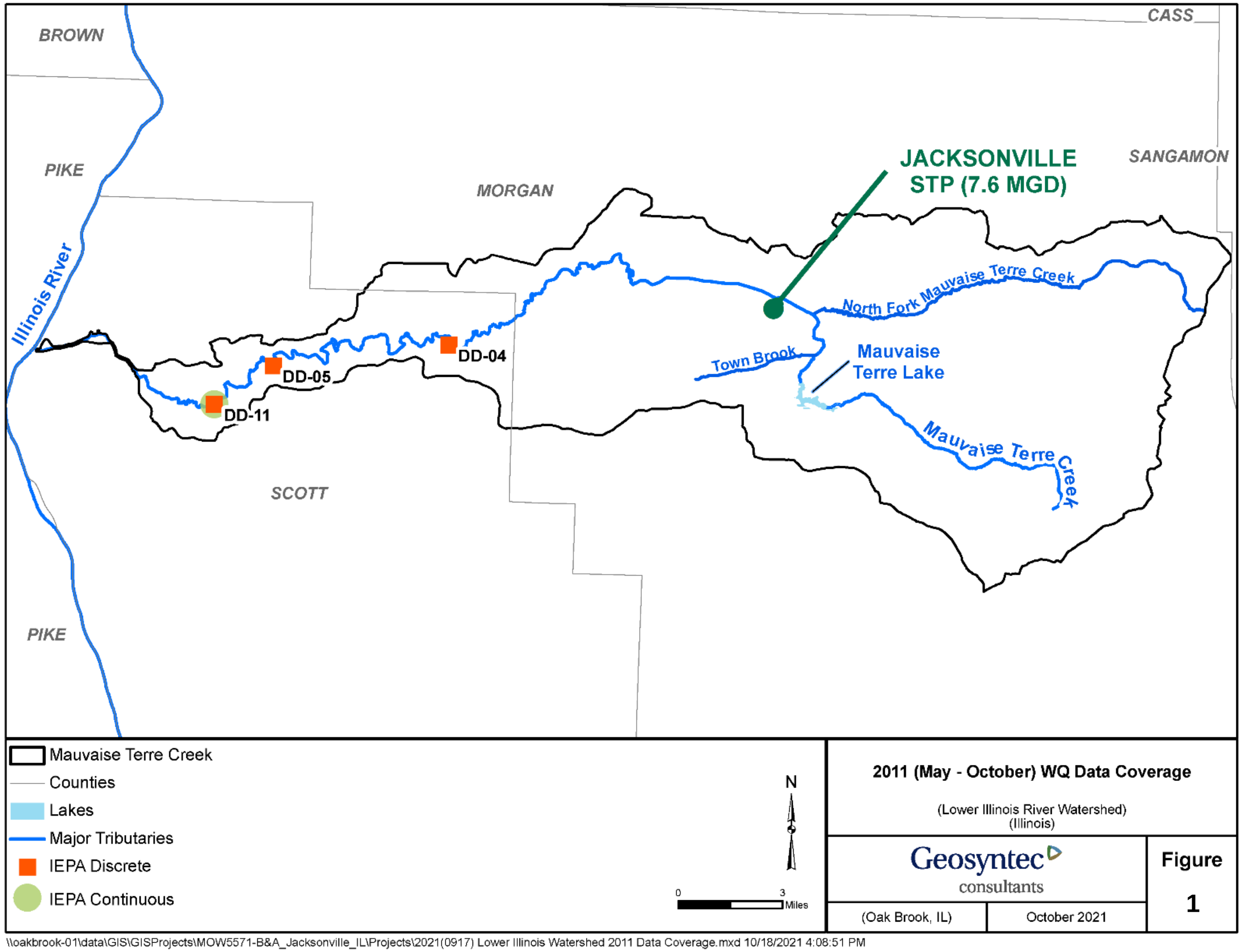
Instream Data Review

Instream Data Review

- Data coverage
  - 2011
    - Three discrete and one continuous station
  - 2016
    - Two discrete and one continuous station
  - Focus the analysis on May-Oct (growing season for algae)

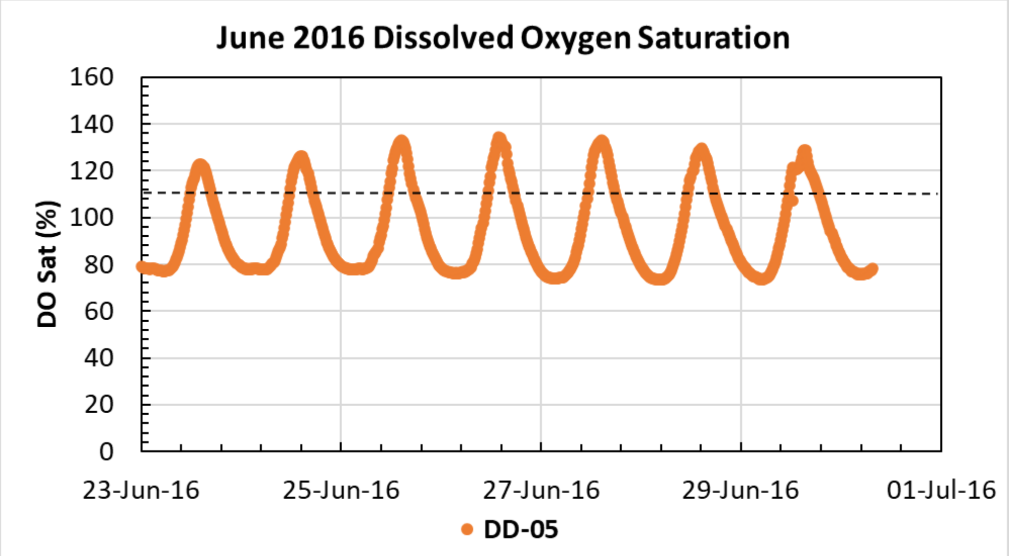


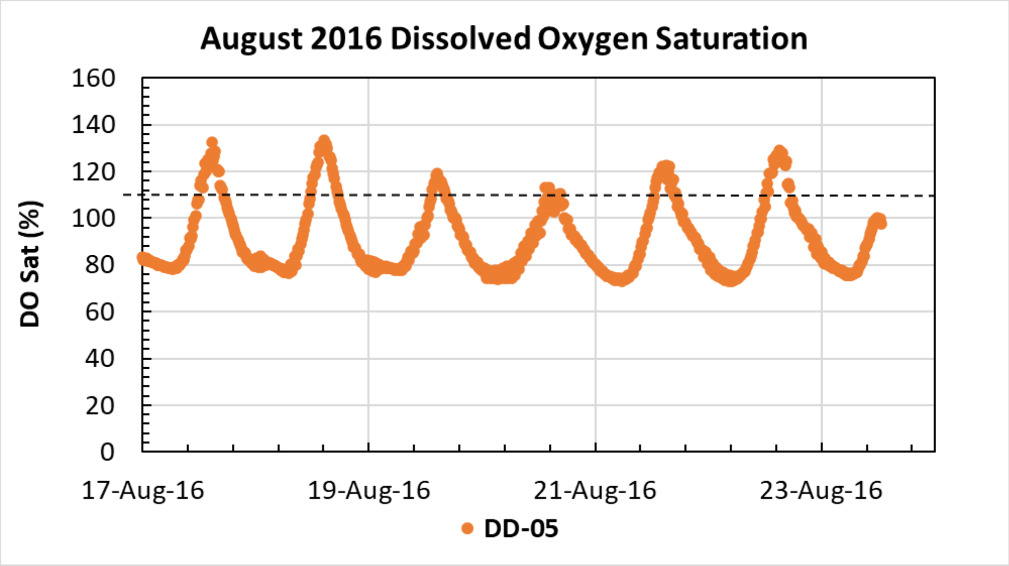
Summary of Instream Data Review

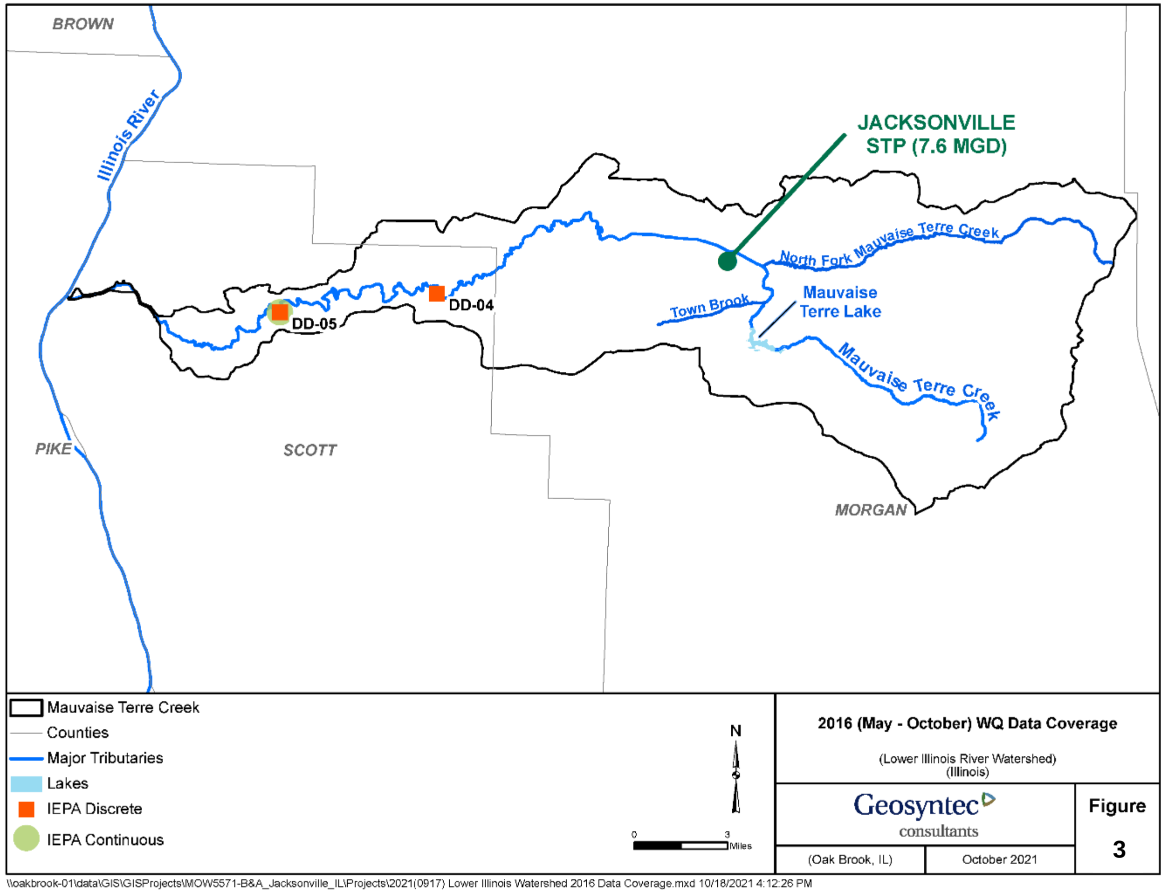
- Water quality parameters
  - Sestonic chlorophyll-a: 5 to 25 ug/L
  - Dissolved oxygen (DO): > 4 mg/L (IL WQ standard)
  - DO saturation: > 110% for several days
  - Total phosphorus: 0.25 to 1.75 mg/L

- Instream DO impairment is potentially driven by benthic algae (not measured by Illinois EPA)

Example of DO Impairment







NARP Workplan

Geosyntec consultants

Recommended NAR{ Steps for Jacksonville STP

Phase 1 : Conduct Data Monitoring and Analysis

↓

Phase 2 : Develop Modeling Tools

↓

Phase 3 : Evaluate Watershed Management Scenarios

↓

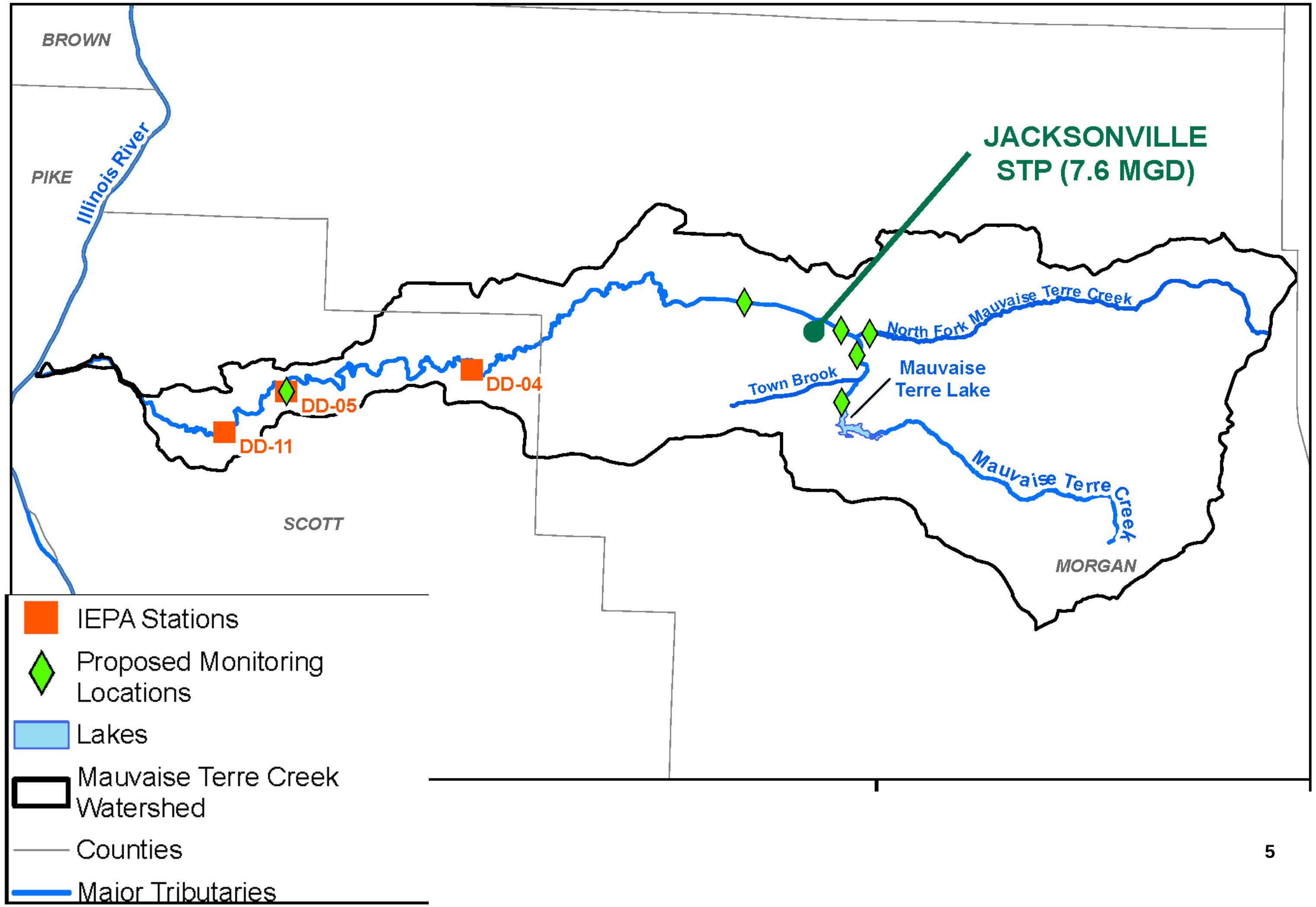
Phase 4 : Write Implementation Plan and Schedule

Instream Water Quality Monitoring Data

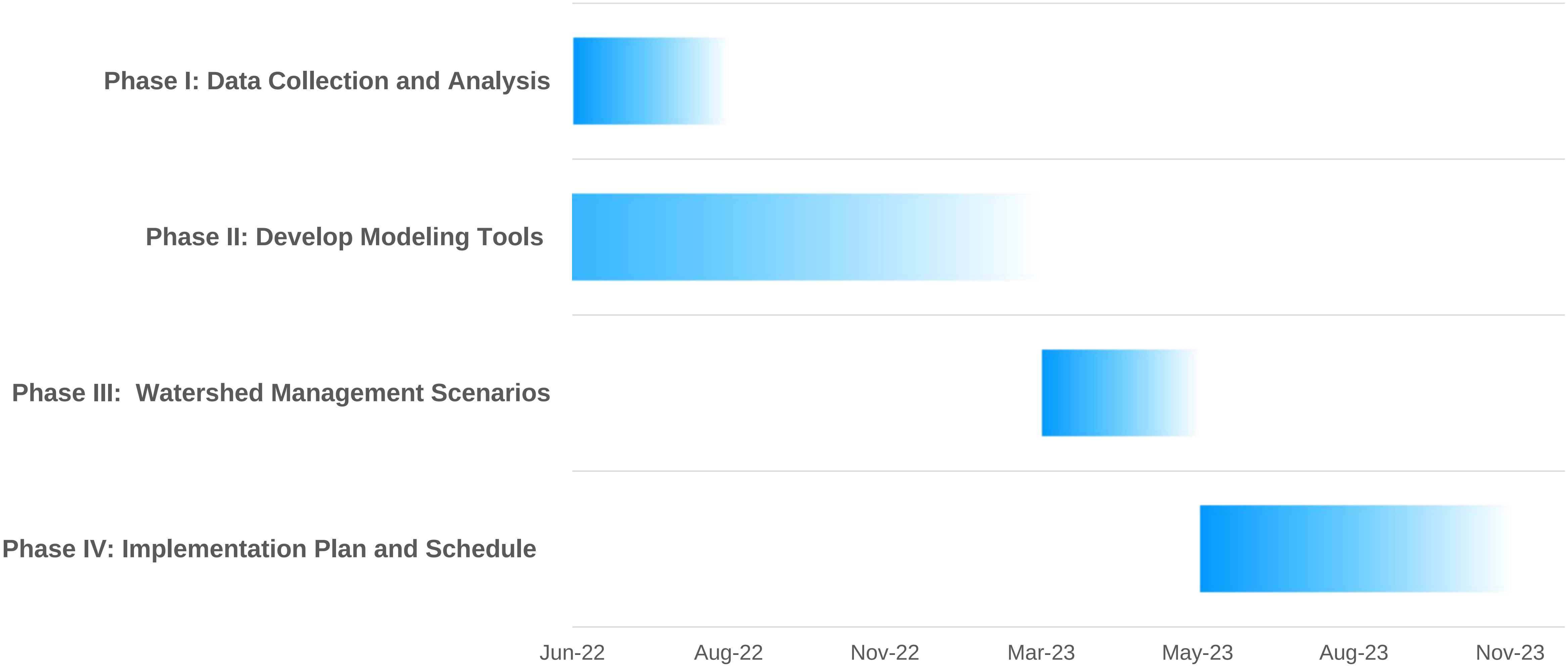
- Recommended time period – 3 months
- Discrete water quality data – Sample every two weeks
  - CBOD, nutrients, and sestonic chlorophyll-a
  - 6 locations
- Benthic algae
  - Sample monthly at 2 locations
- Continuous water quality monitoring
  - Dissolved oxygen, pH, temperature
  - 4 locations
- Flow monitoring at one location

Recommended Monitoring Locations

- Proposed monitoring locations
  - Downstream of lake
    - Previously reported source of phosphorus
  - After confluence with Town Brook
  - Prior to North Fork confluence
    - To capture individual boundary loads
  - Upstream and downstream of WWTP
  - Illinois EPA station DD-05
    - Downstream conditions to capture temporal changes



Proposed Schedule for meeting current deadline of Dec 2023



- Questions?

Appendix B

Jacksonville NARP Data Analysis

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Jacksonville NARP Data Analysis

March 9, 2023

Agenda

- Background and Objectives
- 2022 Data Review & Analysis
  - Continuous Data
  - Discrete Data
- Summary & Conclusions

Background and Objectives

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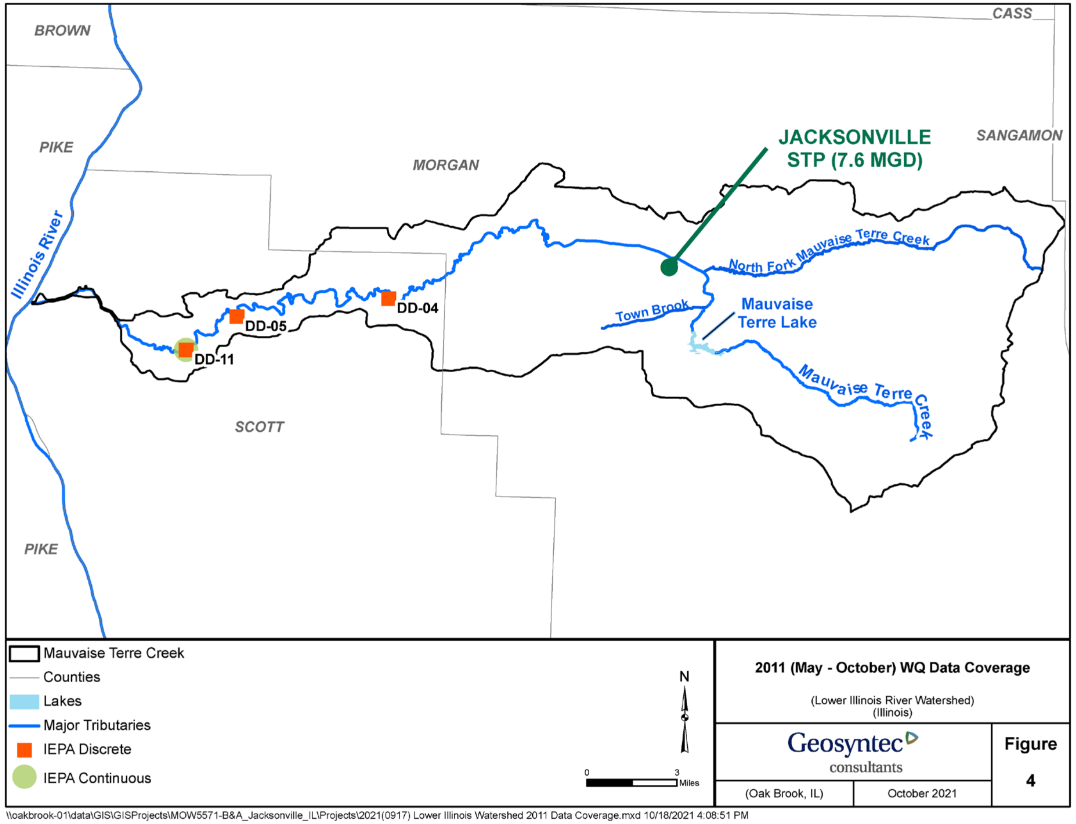
Background

- Jacksonville STP 7.6 MGD facility discharge to Mauvaise Terre Creek
  - Risk of Eutrophication (ROE) at DD-05
- Review new data analysis with Illinois EPA
- Gain concurrence from Illinois EPA
  - Risk of eutrophication is not currently driven by Jacksonville STP
  - Recommended Next Steps on NARP



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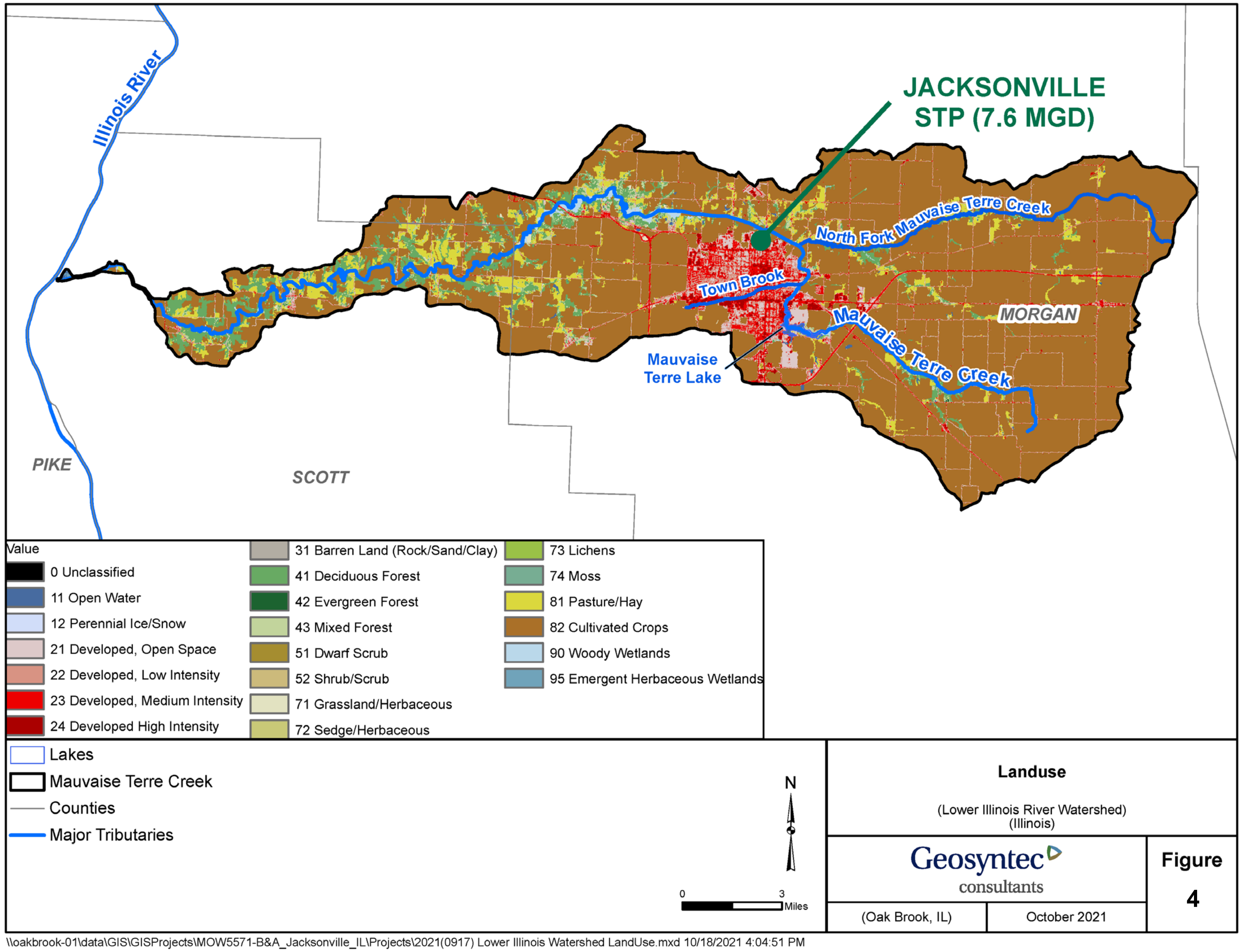
Background

- Landuse
  - Agricultural landuse dominates
- Slope
  - Low Average Slope
  - S = 0.001
- Other Impairments
  - Mauvaise Terre Lake impaired for Phosphorus



2022 Data Review & Analysis

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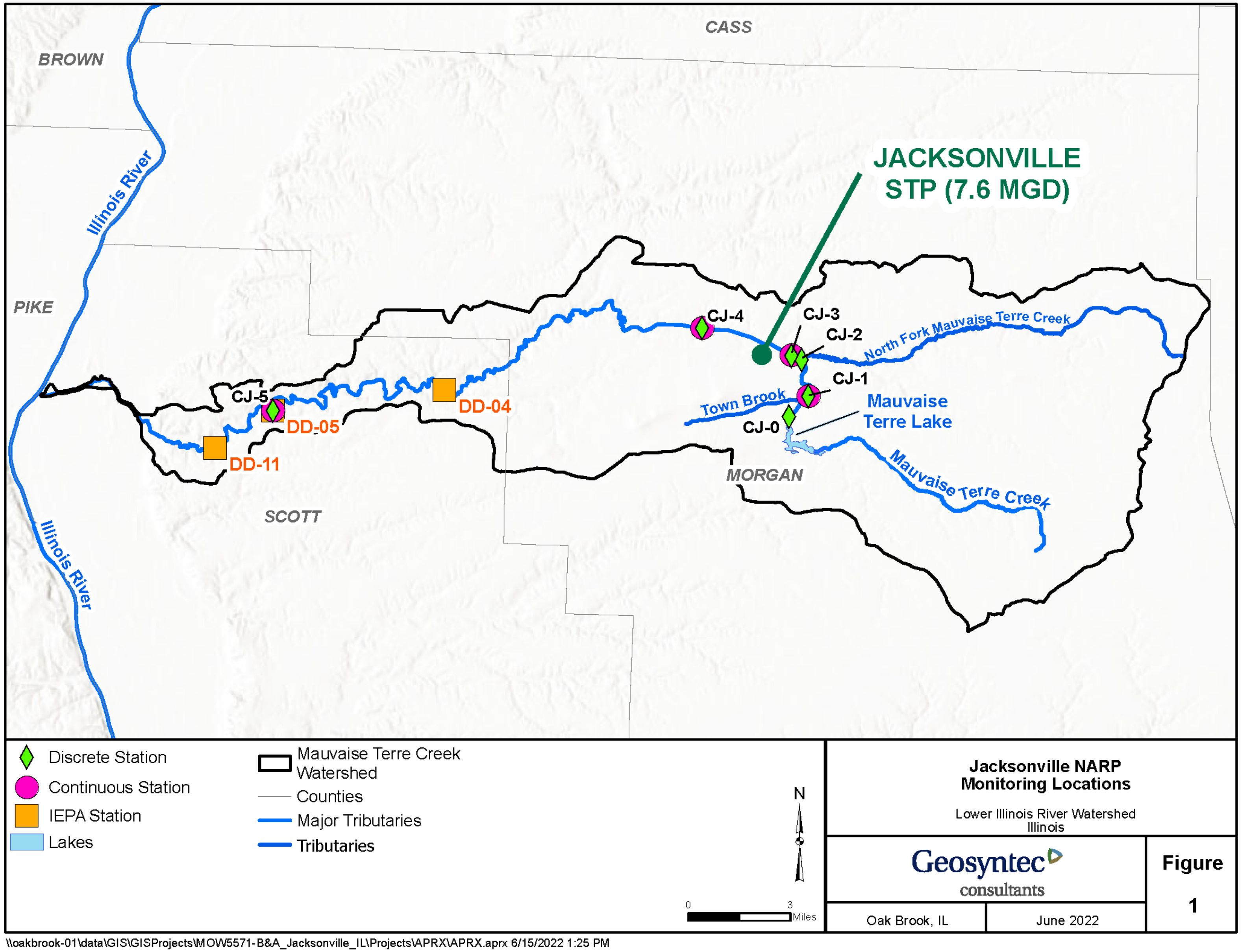
2022 Monitoring Locations

- Monitoring Locations
  - 4 Continuous
  - 6 Discrete
- Continuous Parameters
  - Temperature, DO, pH, specific conductivity
- Discrete Parameters
  - Nutrient Suite, Chlorophyll-a
  - Benthic Chl-a (as needed)



Monitoring Data Review

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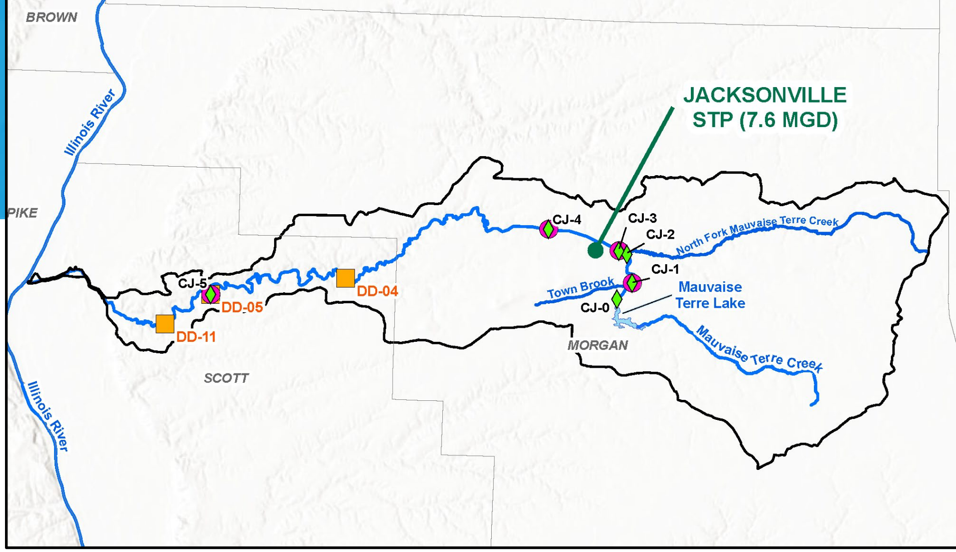
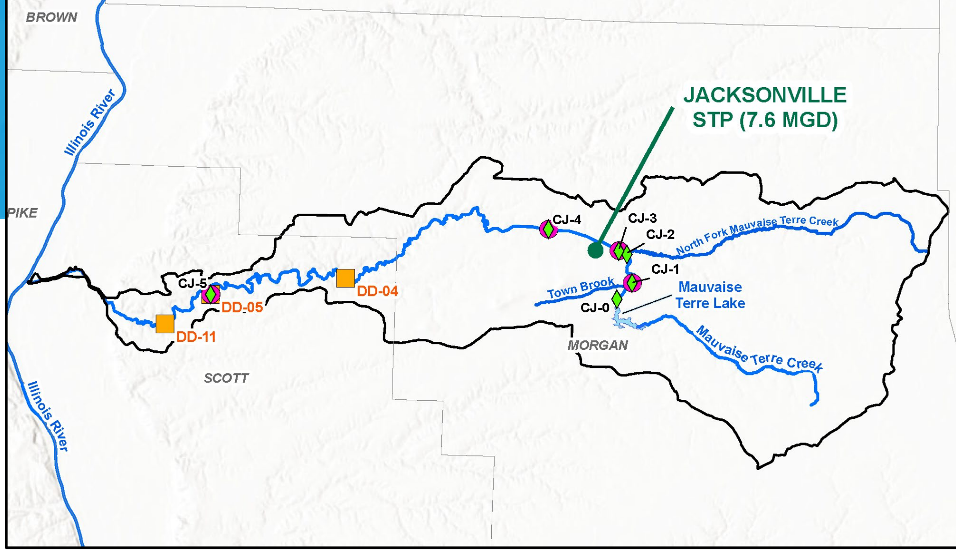
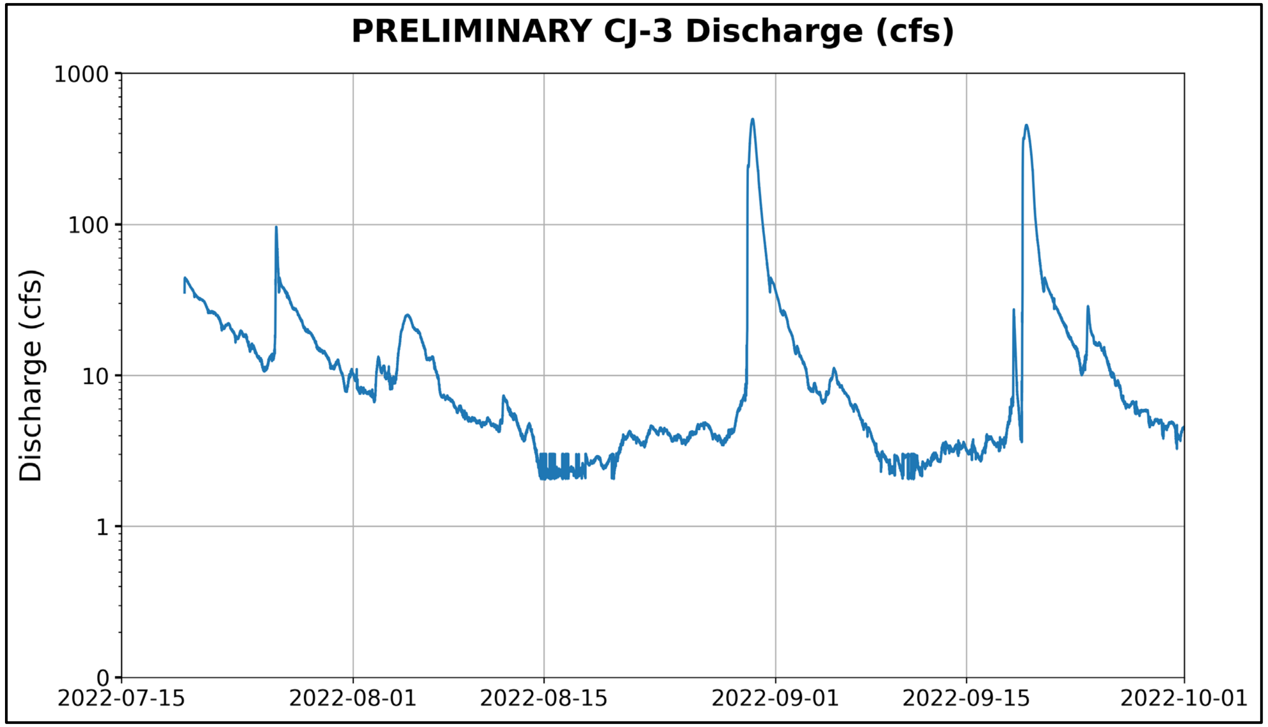
CJ-0 – D/S of Mauvaise Terre Lake

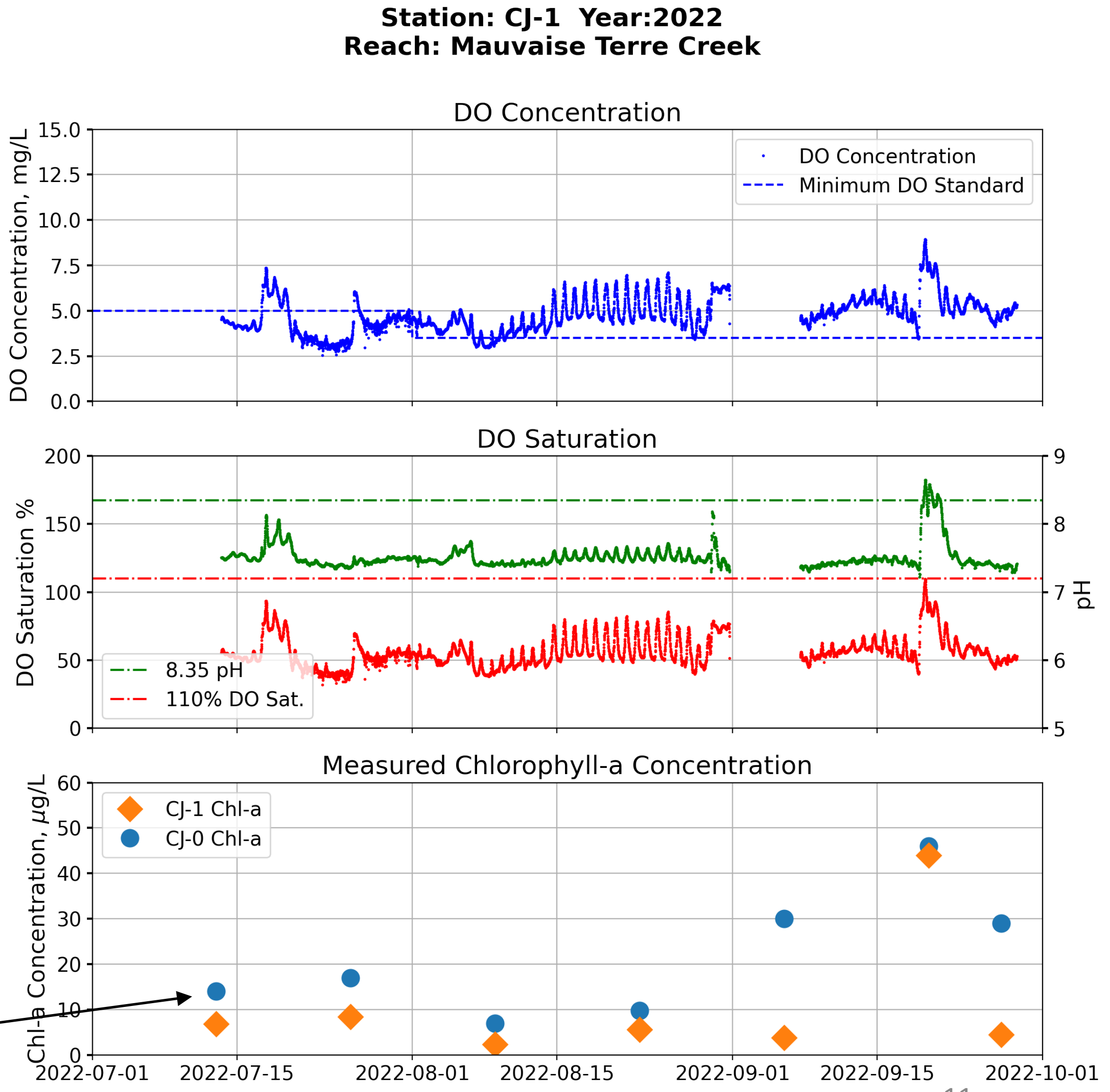


CJ-1 – D/S of Town Brook



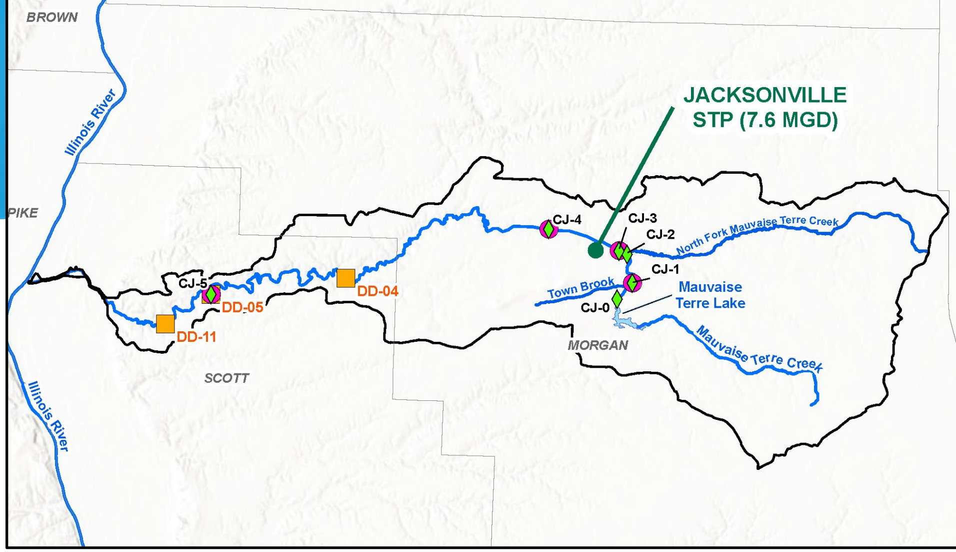
CJ-1 Data Analysis



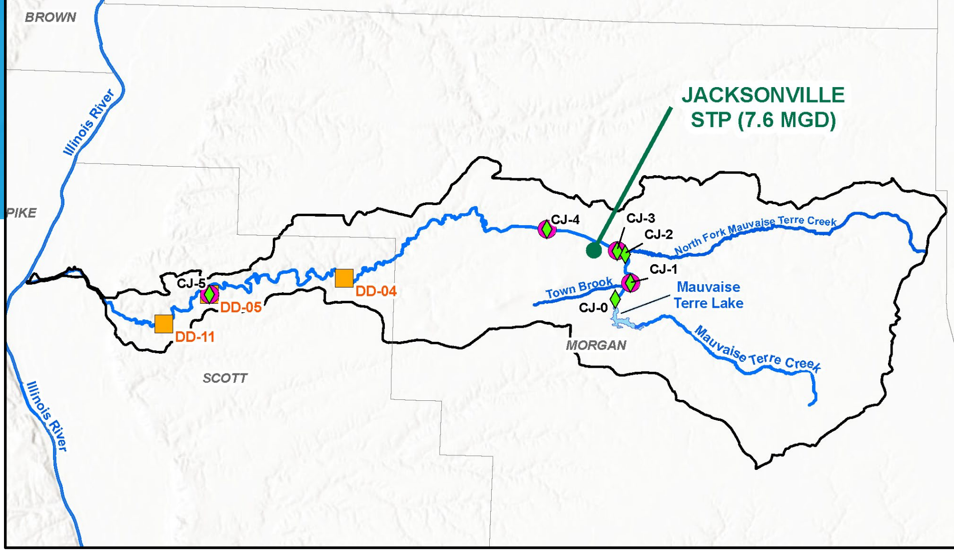


High Chl-a input from Mauvaise Terre Lake

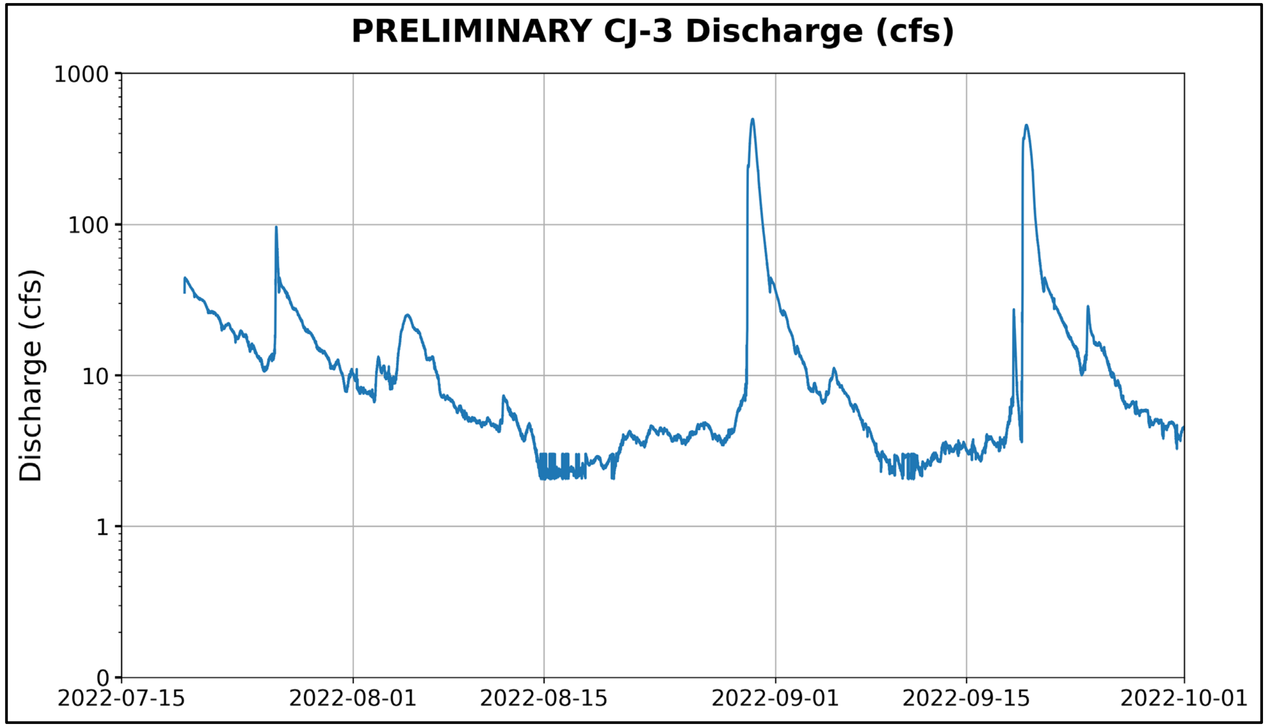
CJ-2 – North Fork

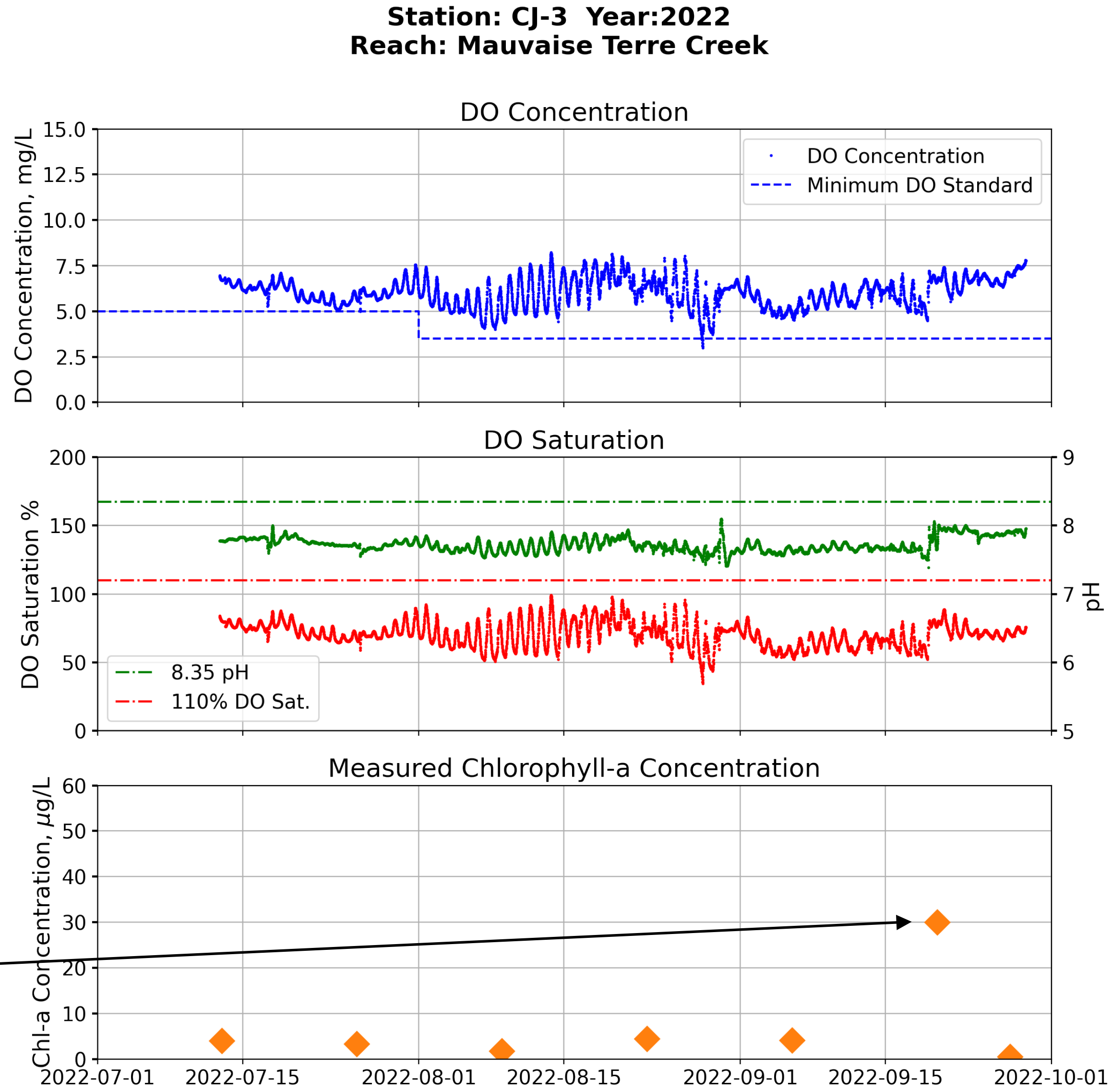


CJ-3 – D/S North Fork



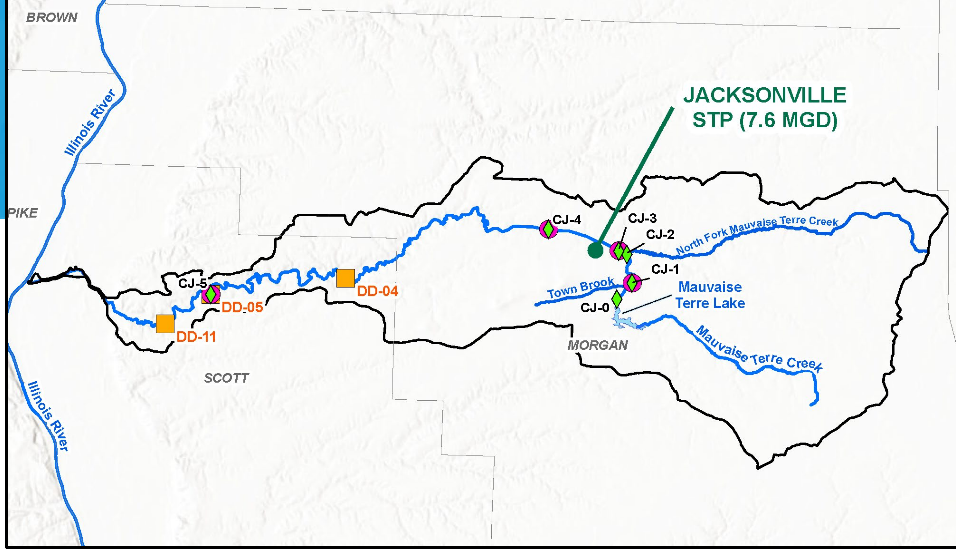
CJ-3 Data Analysis



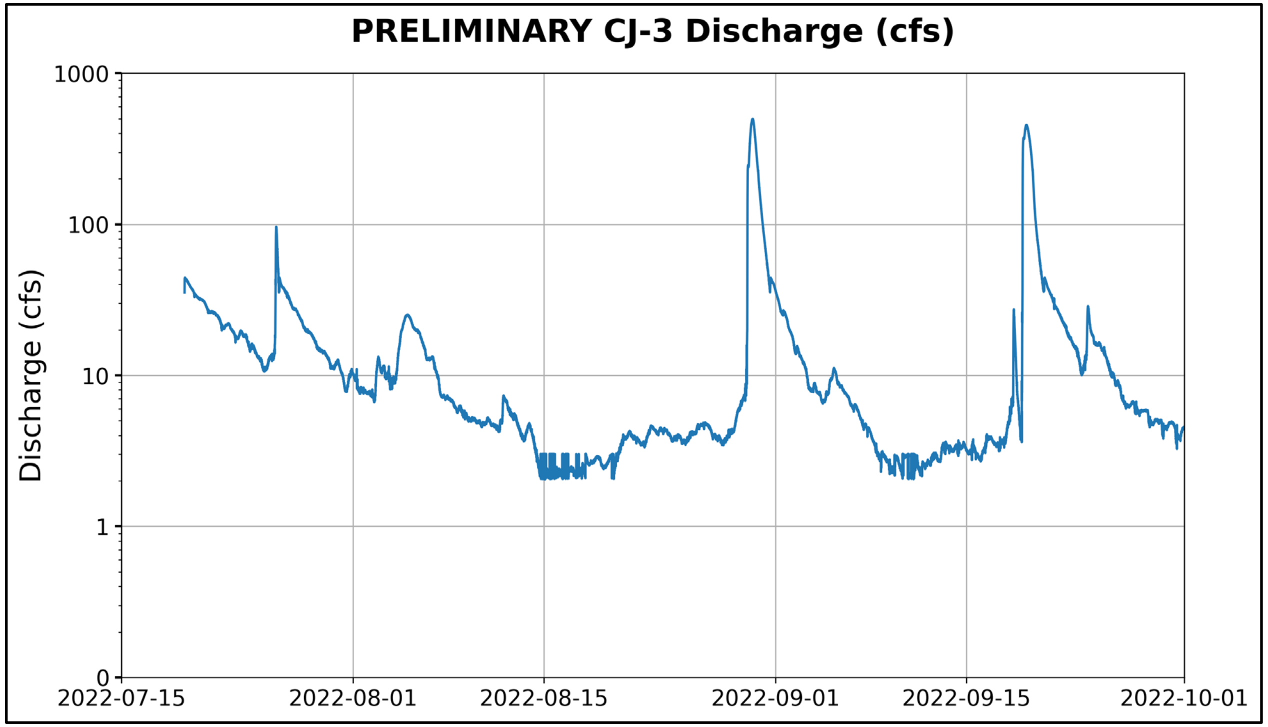


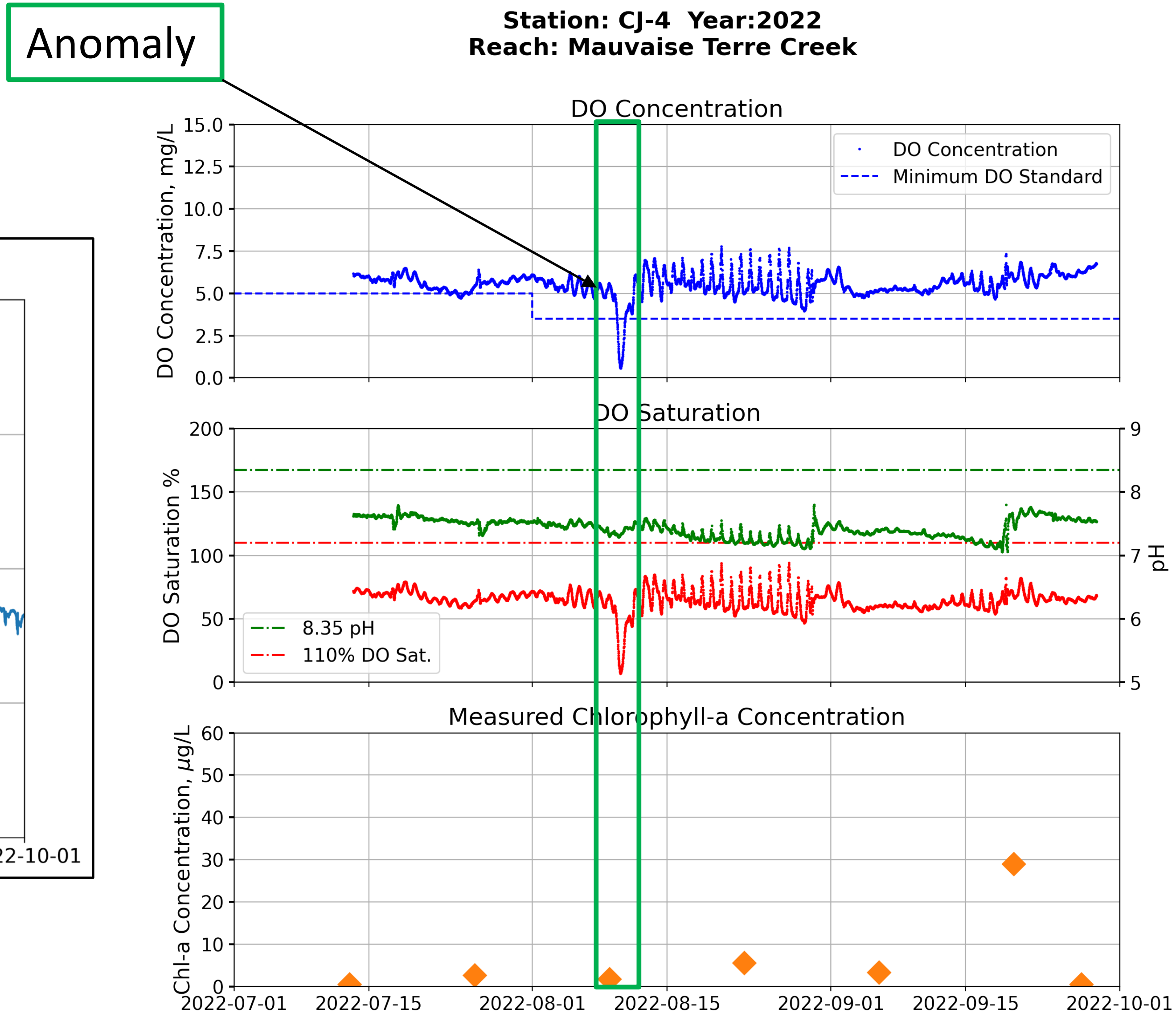
Peak Chl-a in September from Mauvaise Terre Lake advected downstream

CJ-4 – D/S Jacksonville STP

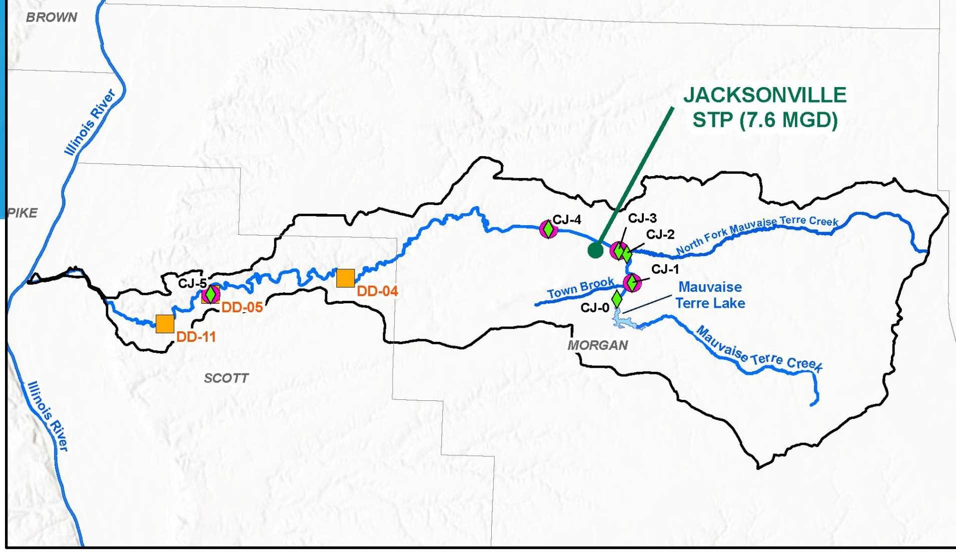


CJ-4 Data Analysis



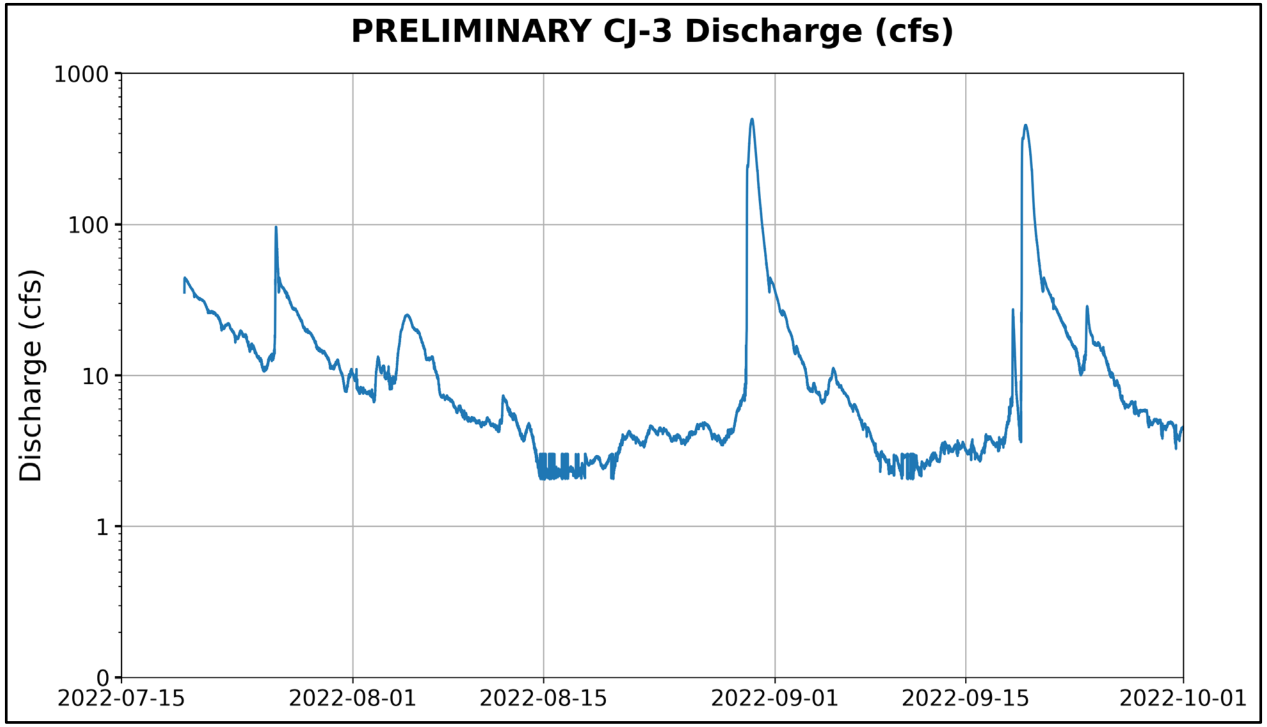


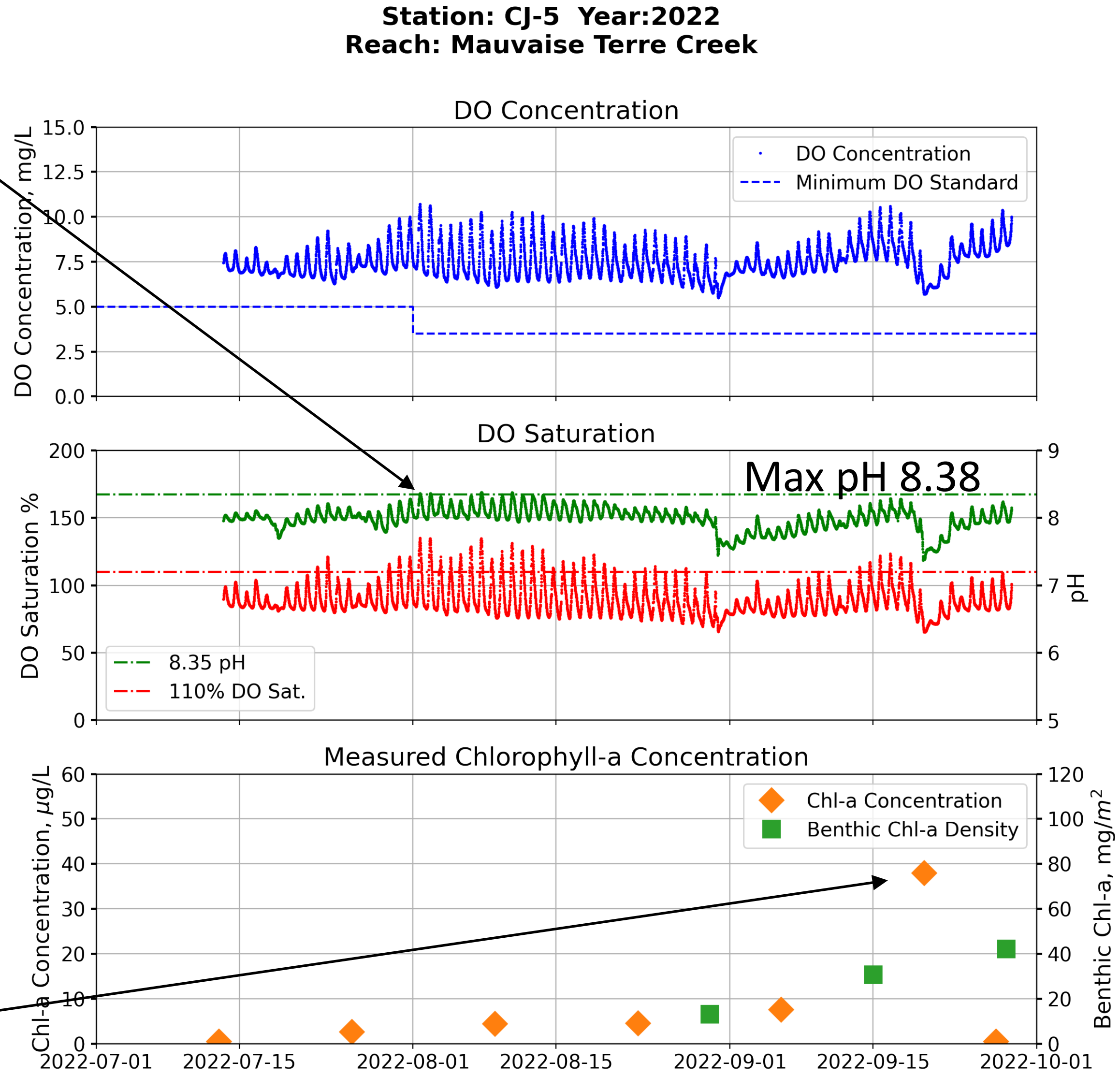
CJ-5 – Most D/S Site



CJ-5 Data Analysis

Risk of Eutrophication:
pH > 8.35 & DOsat > 110%





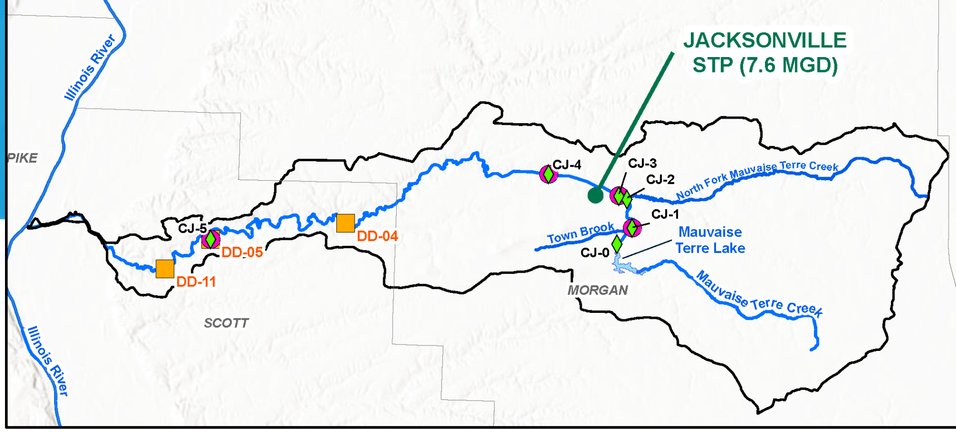
Relatively low sestonic Chl-a and benthic algae concentration except for September peak

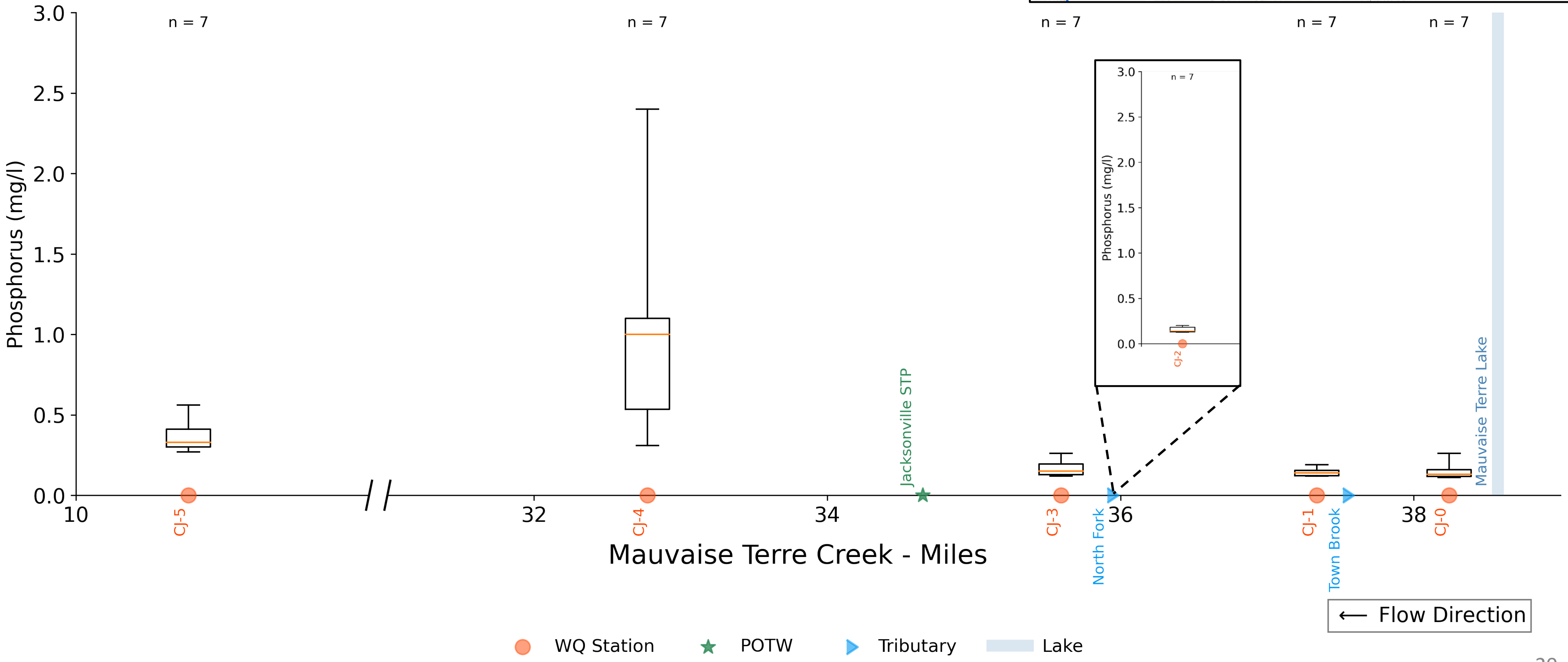
Discrete Data Review

Geosyntec consultants

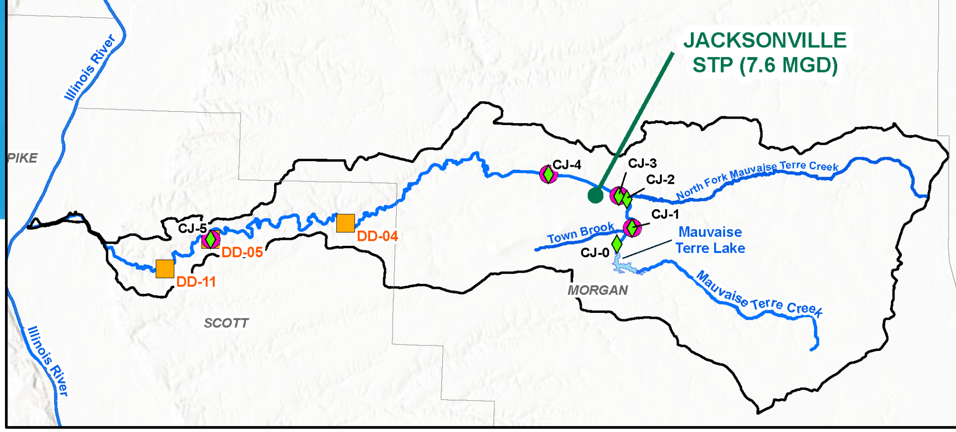
Total Phosphorus

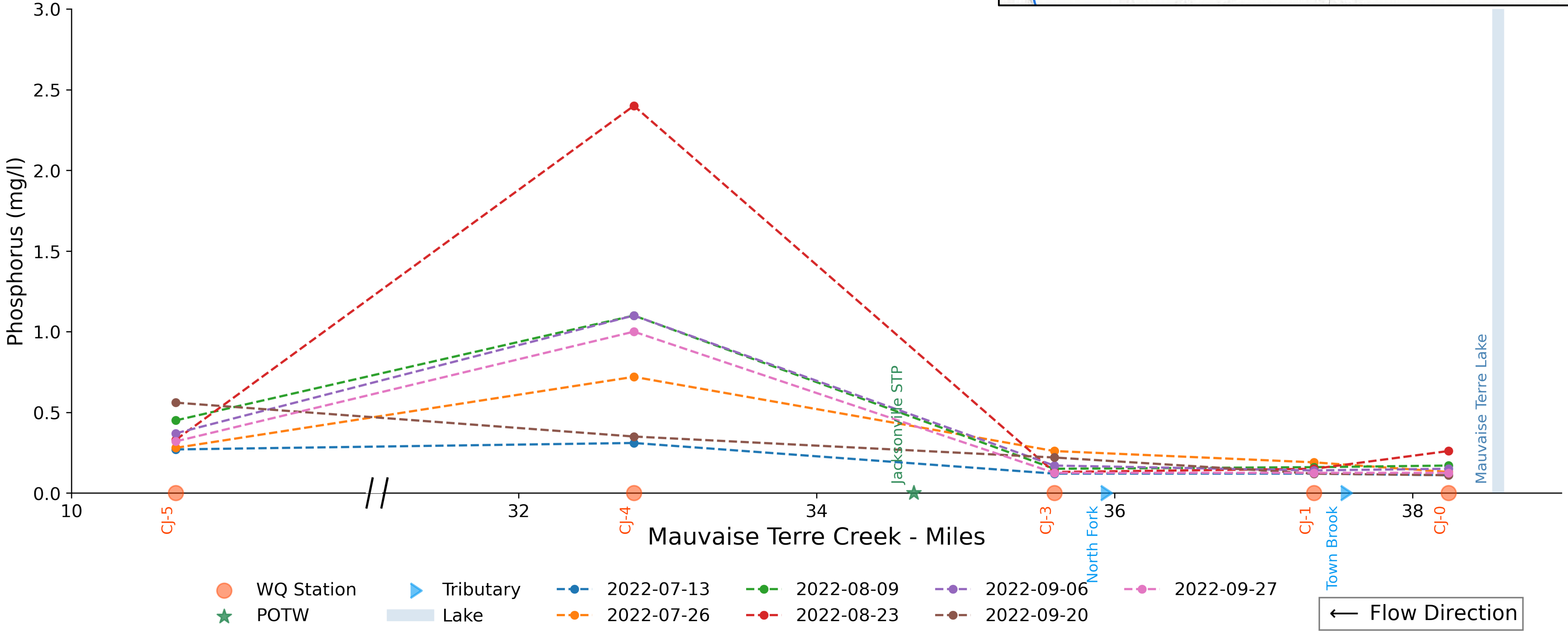
Increase in TP downstream of Jacksonville STP



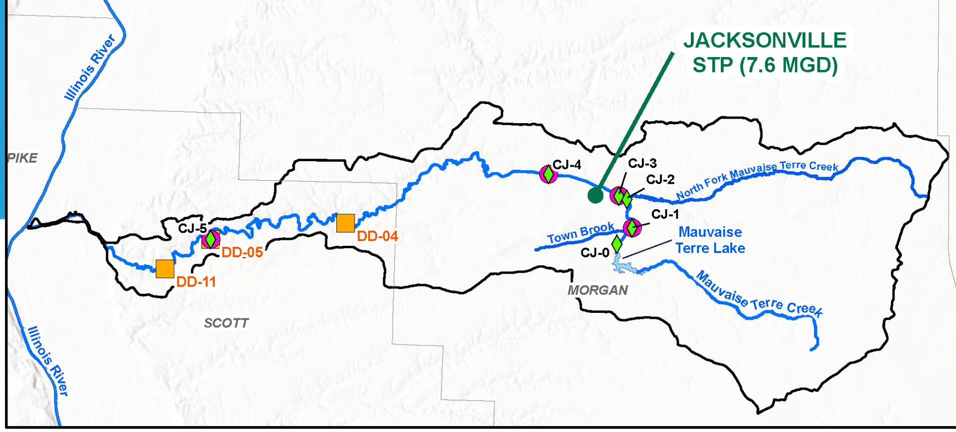


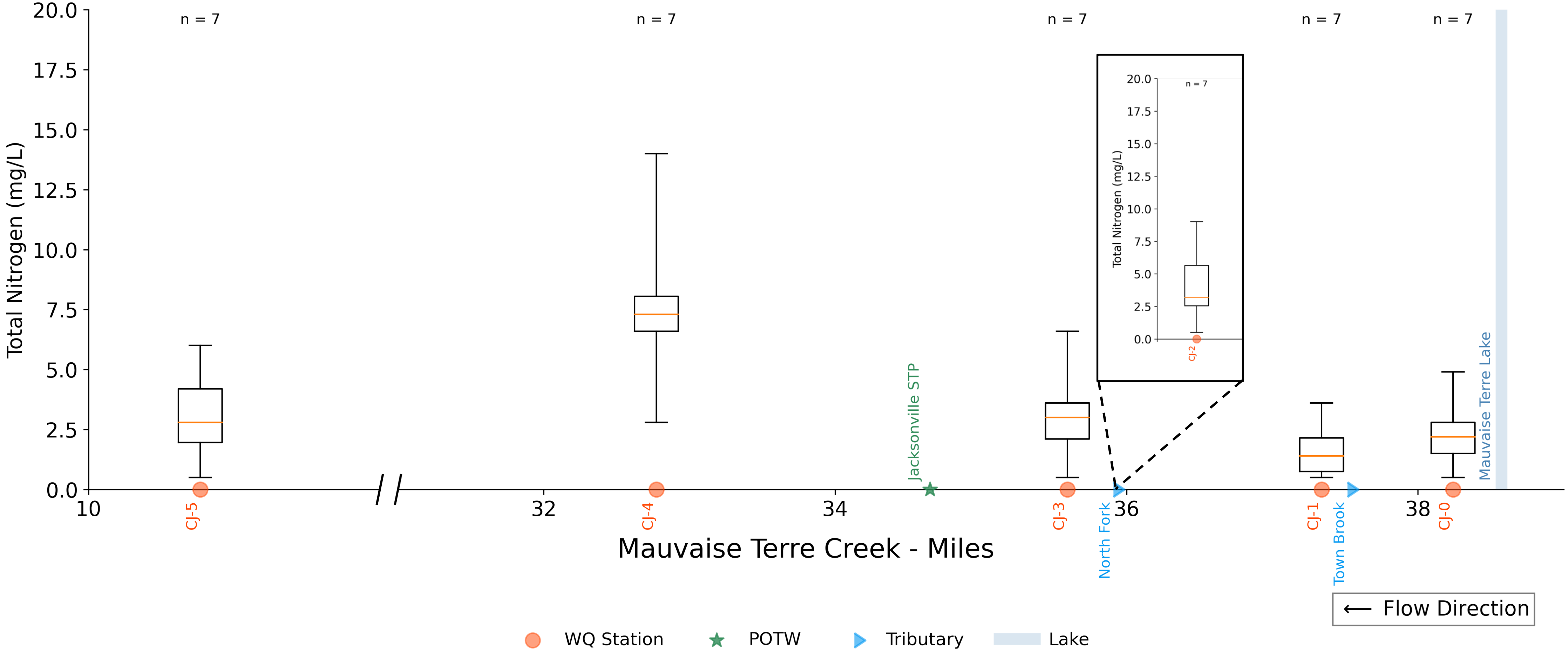
Total Phosphorus - Events



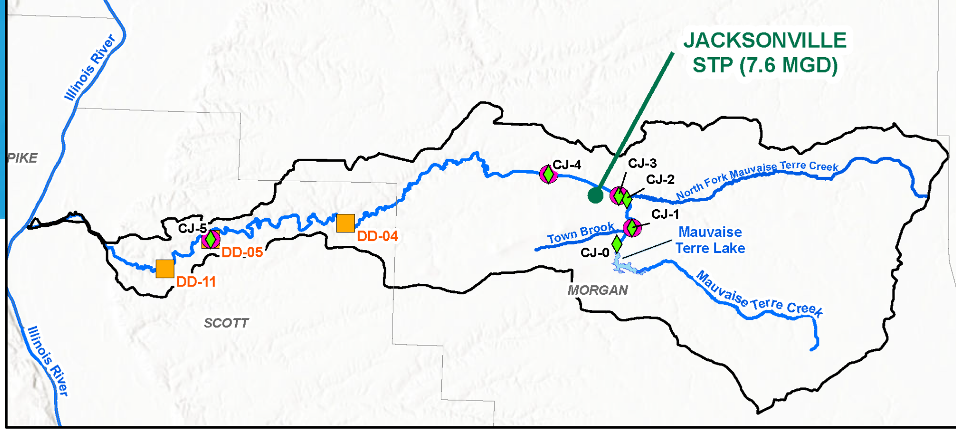


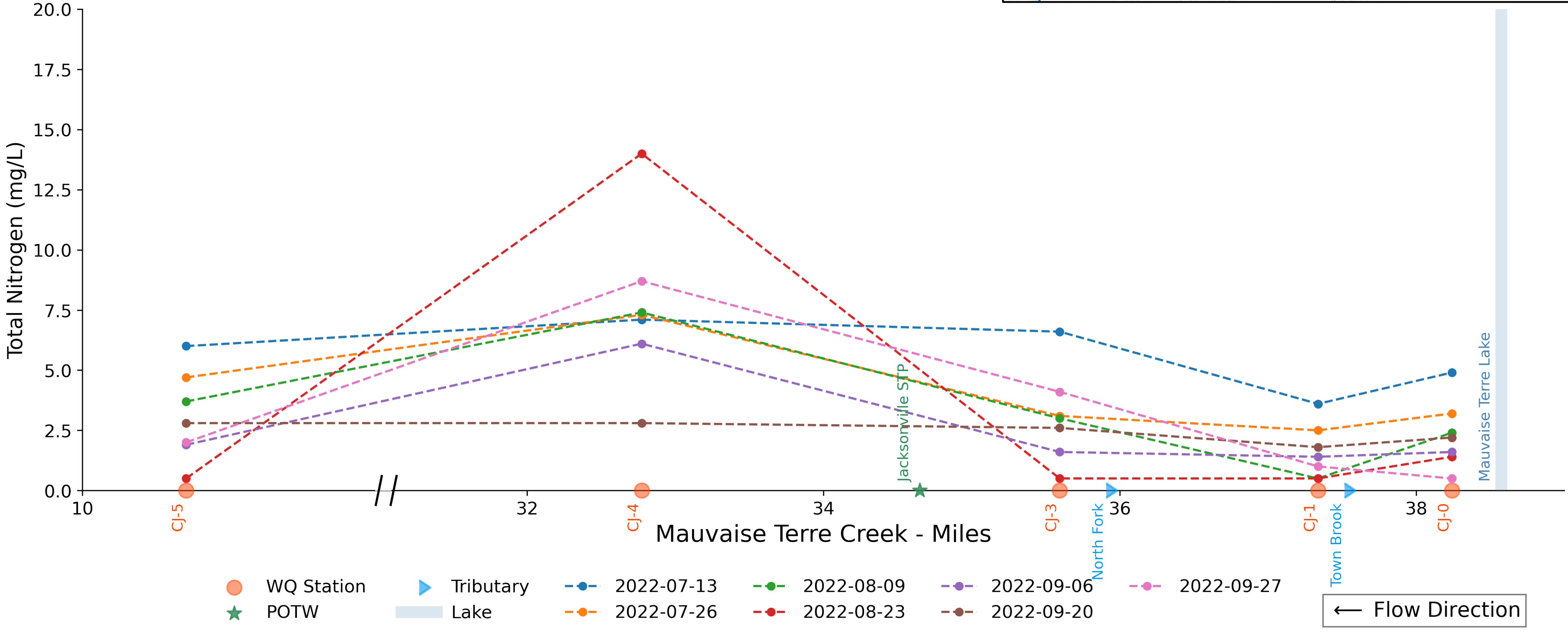
Total Nitrogen



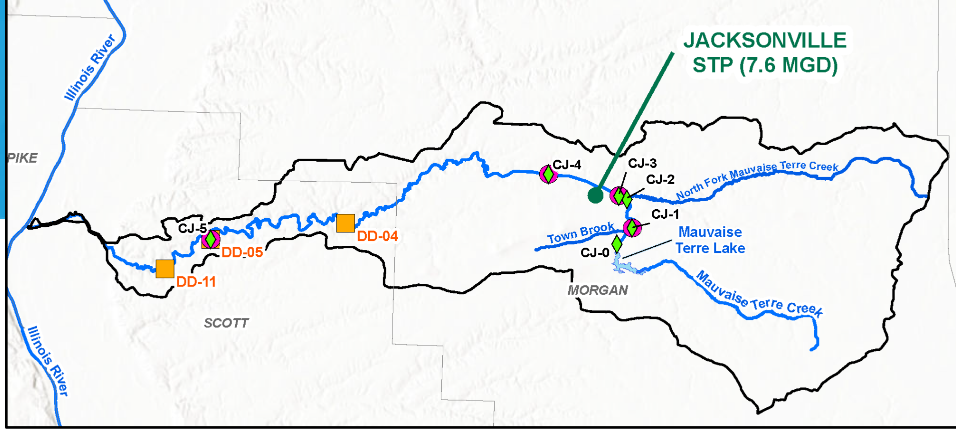


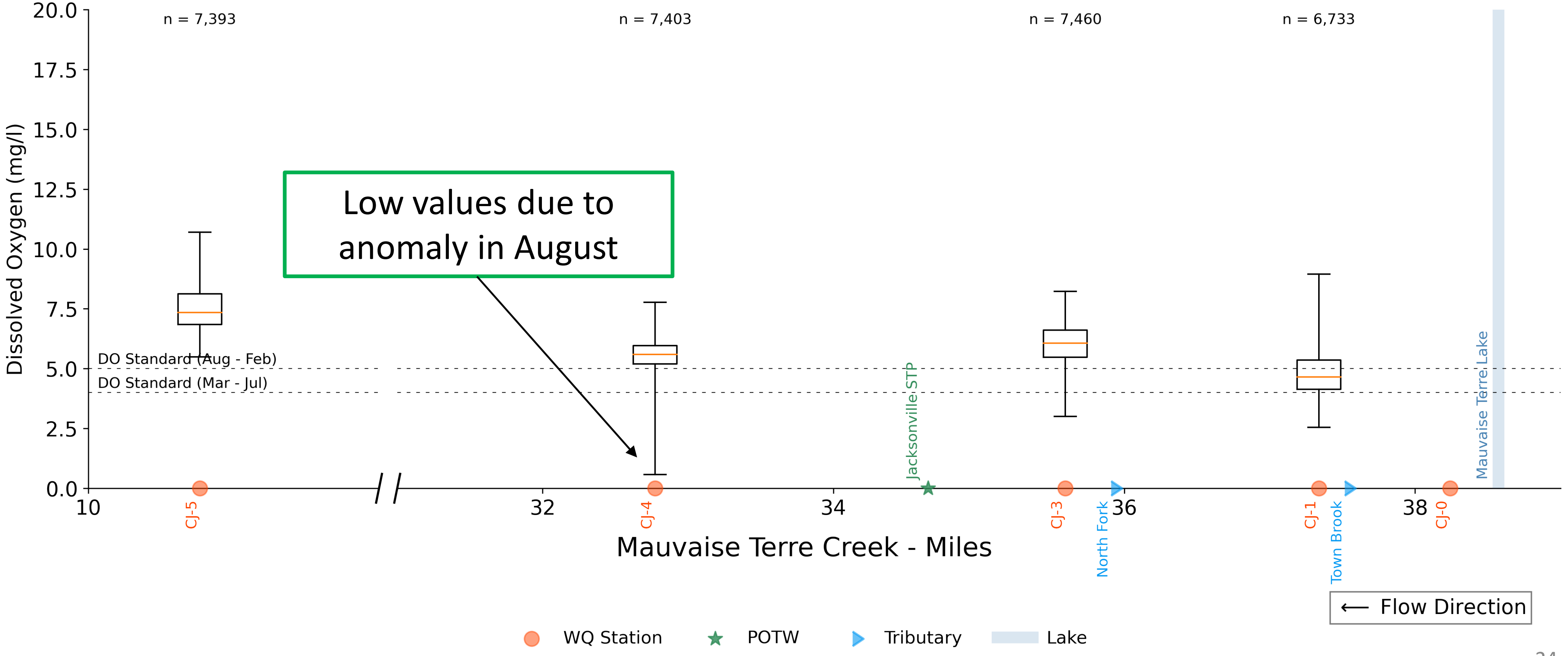
Total Nitrogen - Events



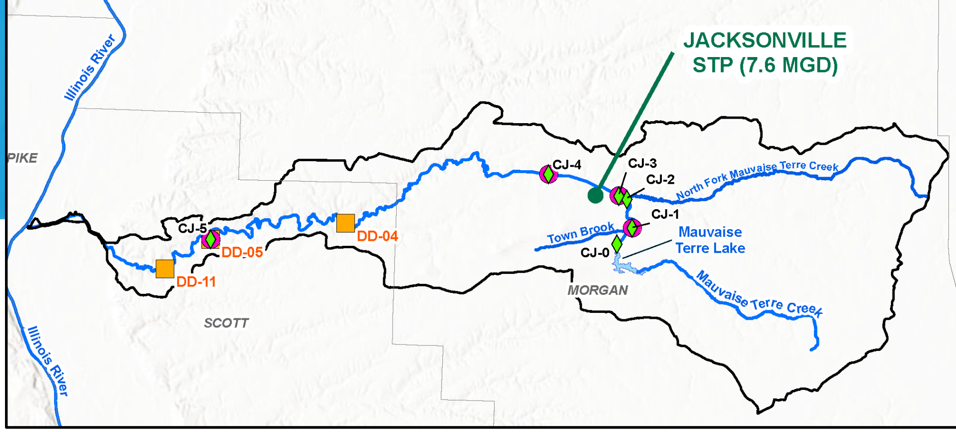


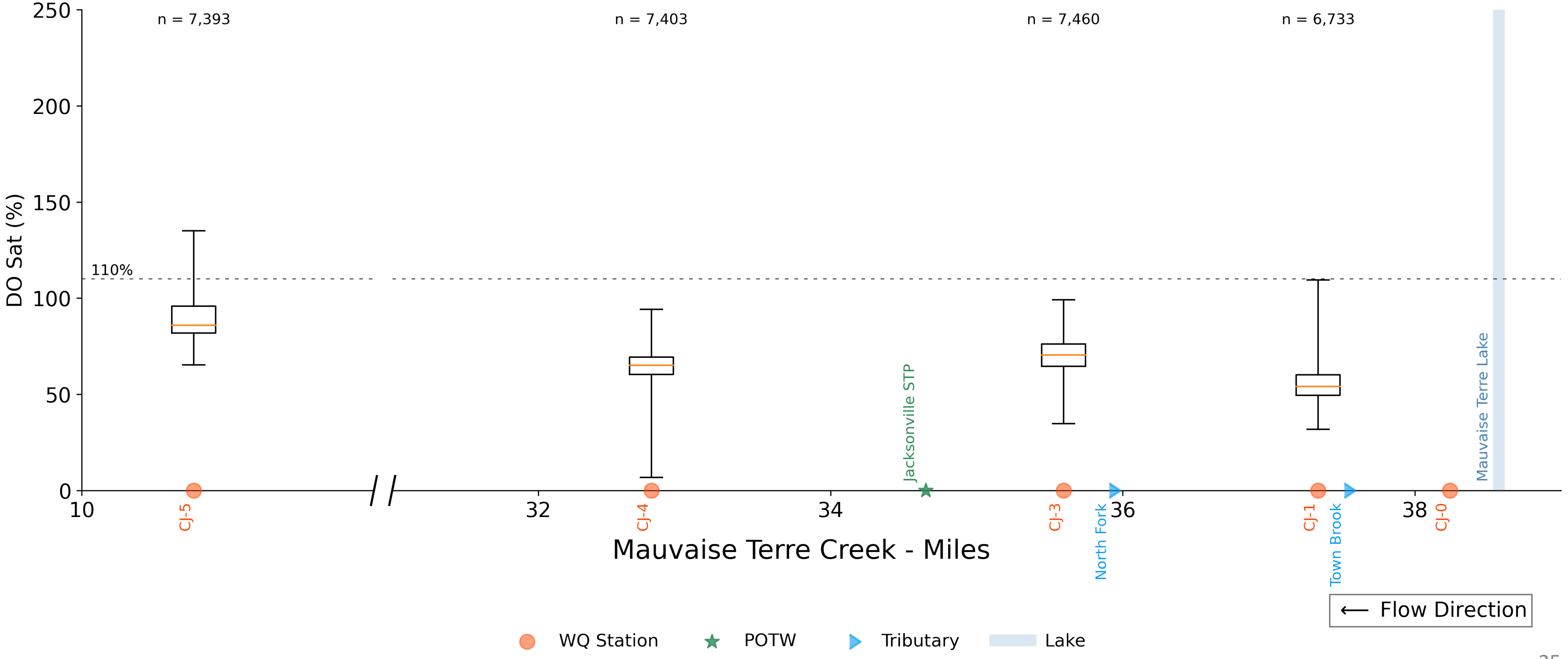
Dissolved Oxygen



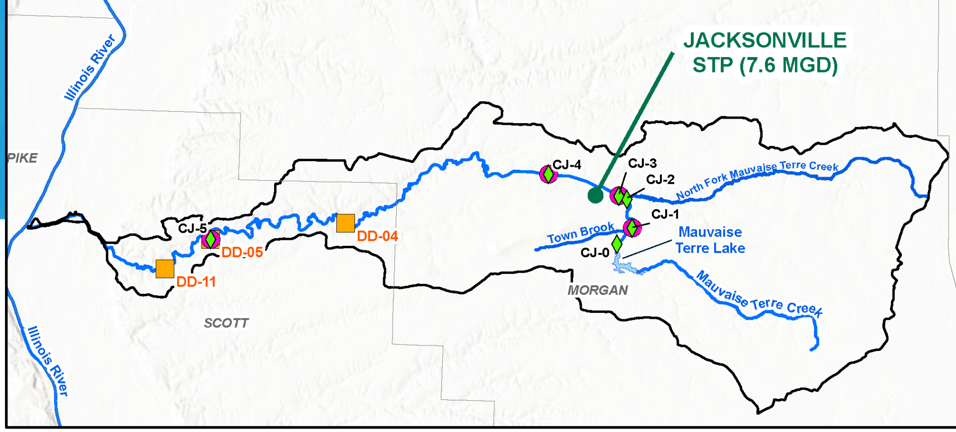


DO Saturation

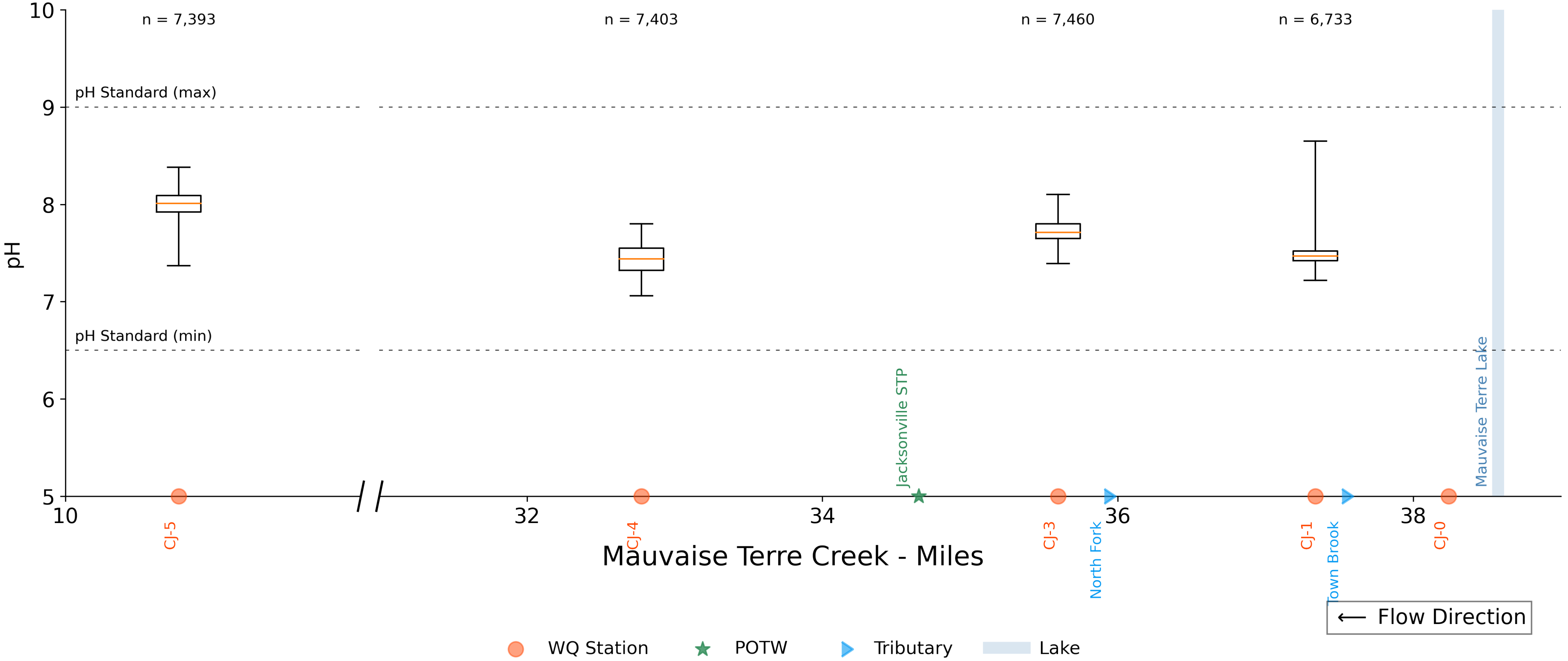




pH

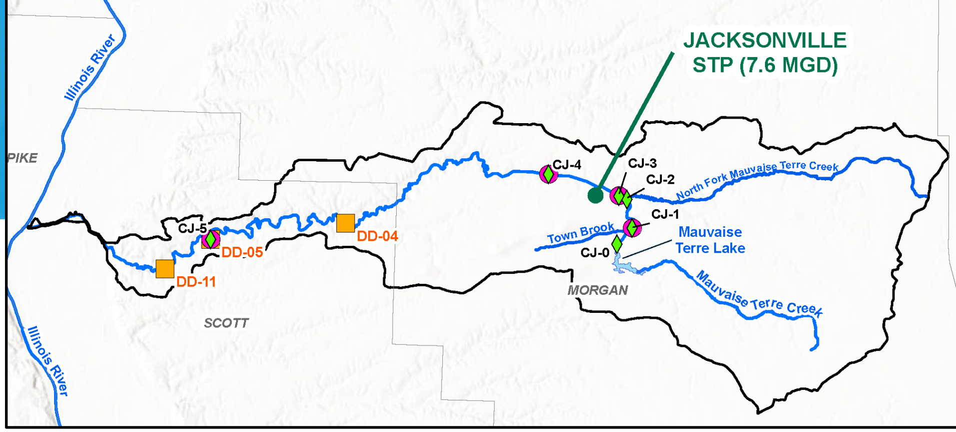


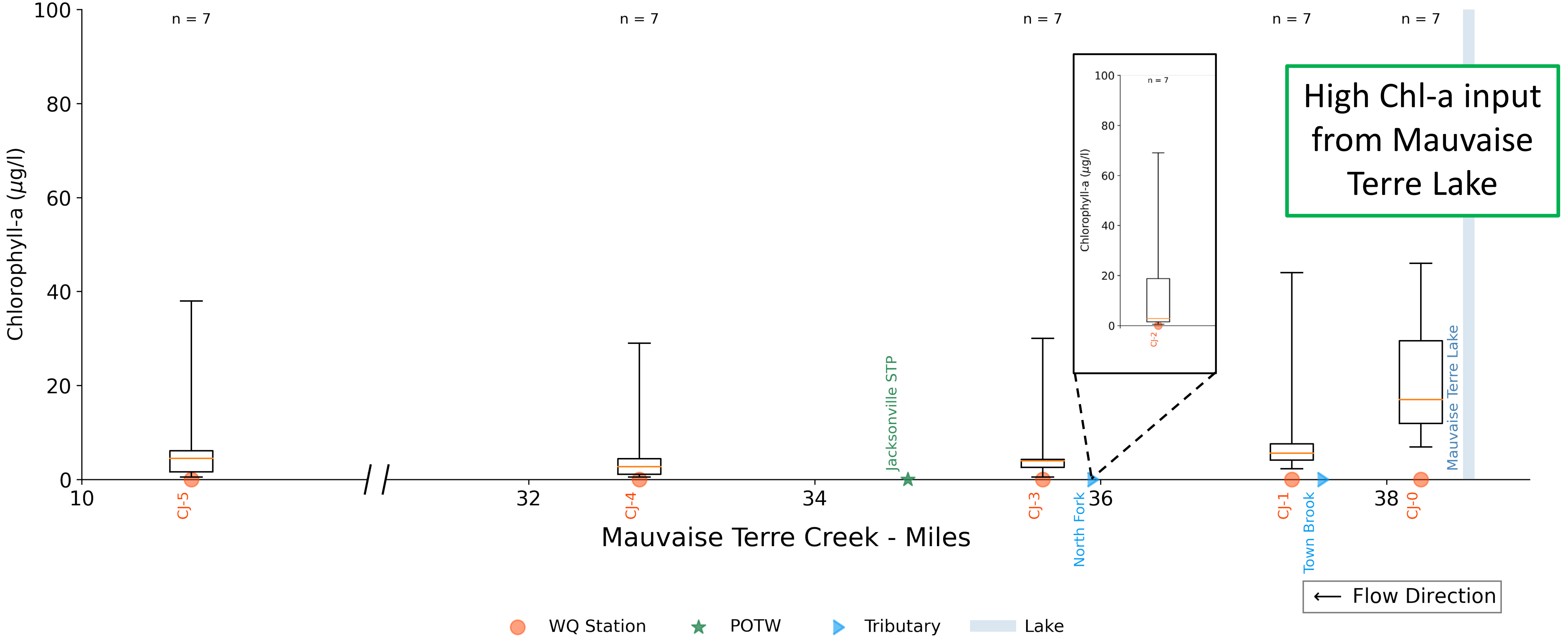
JACKSONVILLE
STP (7.6 MGD)
Illinois River
PIKE
CJ-4
CJ-3
CJ-2
CJ-1
CJ-0
CJ-5
North Fork Mauvaise Terre Creek
Town Brook
Mauvaise
Terre Lake
DD-04
DD-05
DD-11
MORGAN
SCOTT
Mauvaise Terre Creek
Illinois River



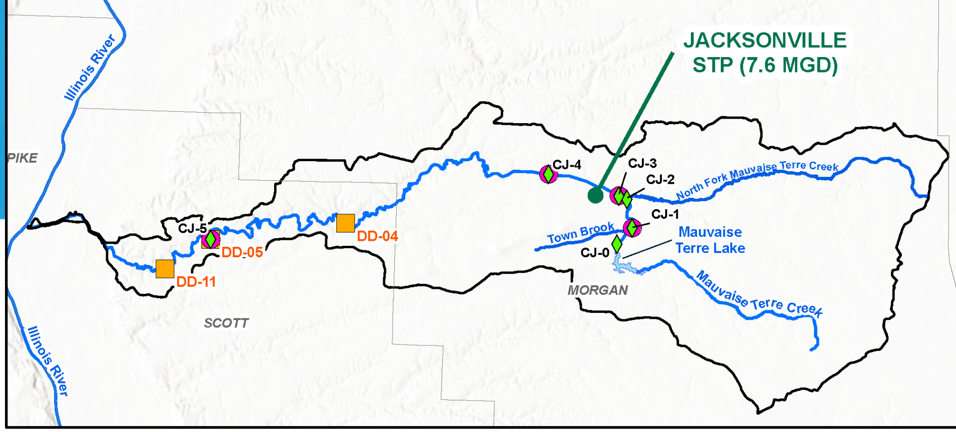
n = 7,393
n = 7,403
n = 7,460
n = 6,733
pH Standard (max)
pH Standard (min)
pH
10
9
8
7
6
5
10
32
34
36
38
Jacksonville STP
Mauvaise Terre Lake
CJ-5
CJ-4
CJ-3
North Fork
CJ-1
Town Brook
CJ-0
Mauvaise Terre Creek - Miles
← Flow Direction
WQ Station
POTW
Tributary
Lake

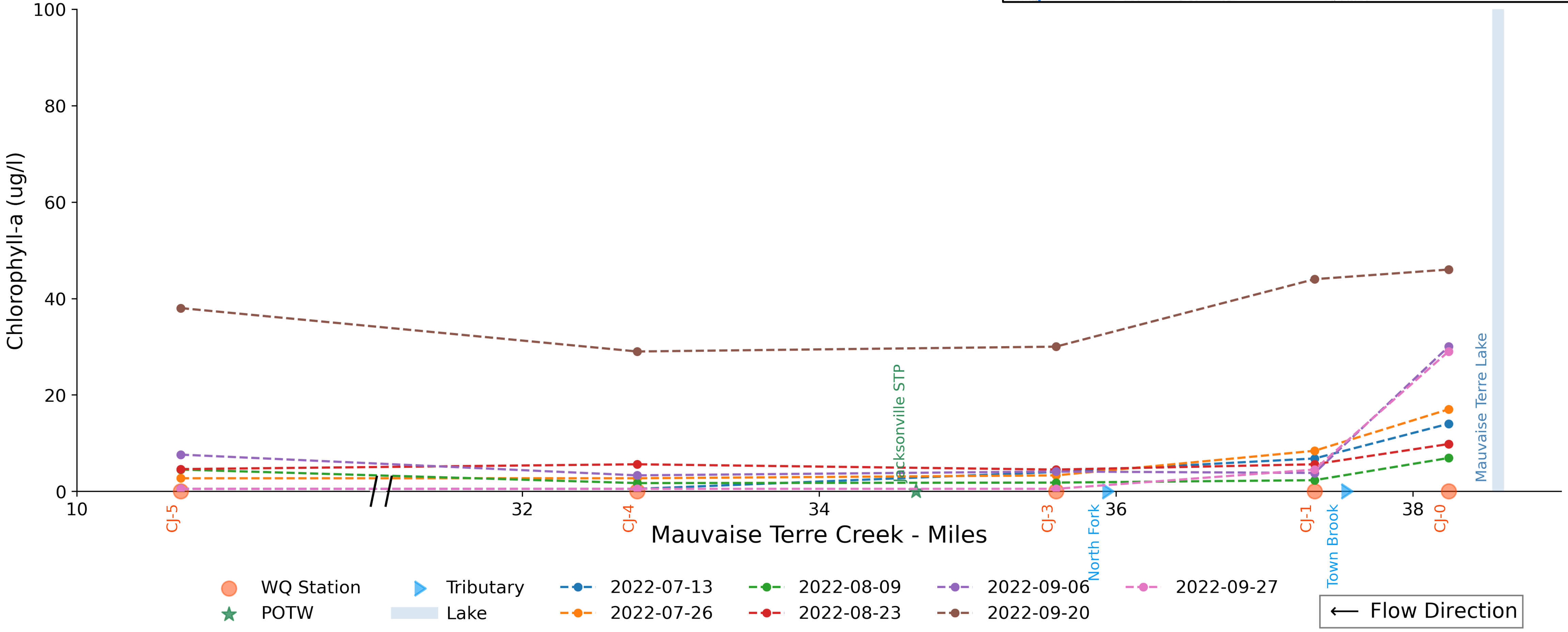
Chlorophyll-a



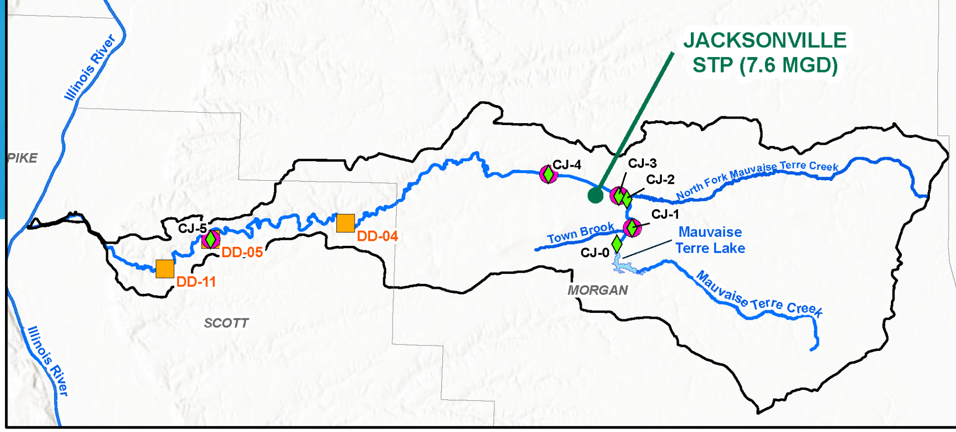


Chlorophyll-a - Events

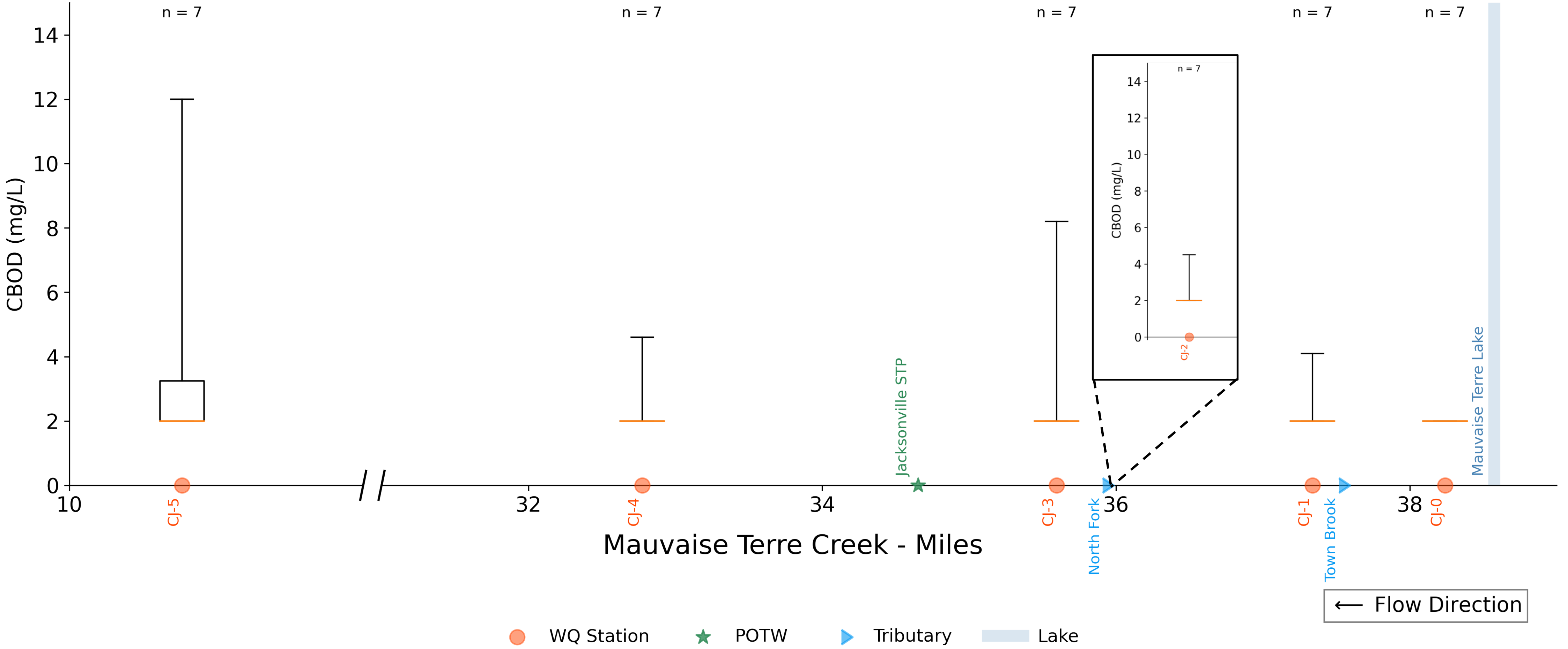




CBOD

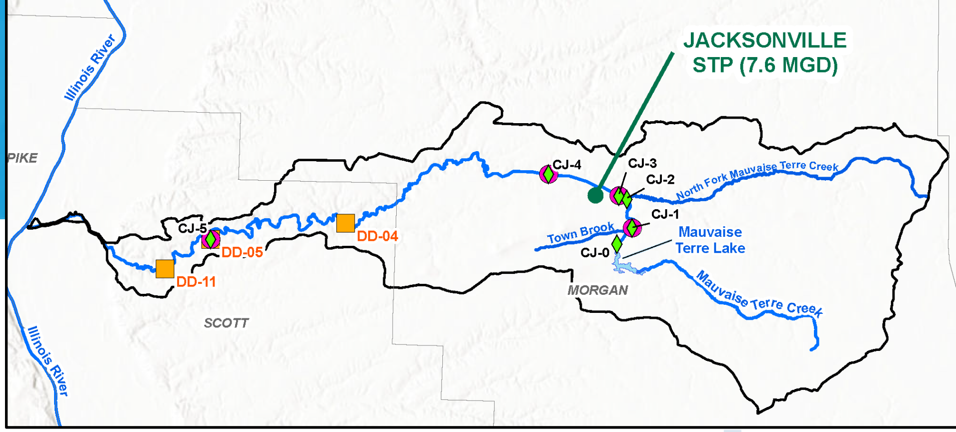


JACKSONVILLE STP (7.6 MGD)
Illinois River
PIKE
CJ-4
CJ-3
CJ-2
CJ-1
CJ-0
CJ-5
North Fork Mauvaise Terre Creek
Town Brook
Mauvaise Terre Lake
Mauvaise Terre Creek
DD-04
DD-05
DD-11
MORGAN
SCOTT
Illinois River

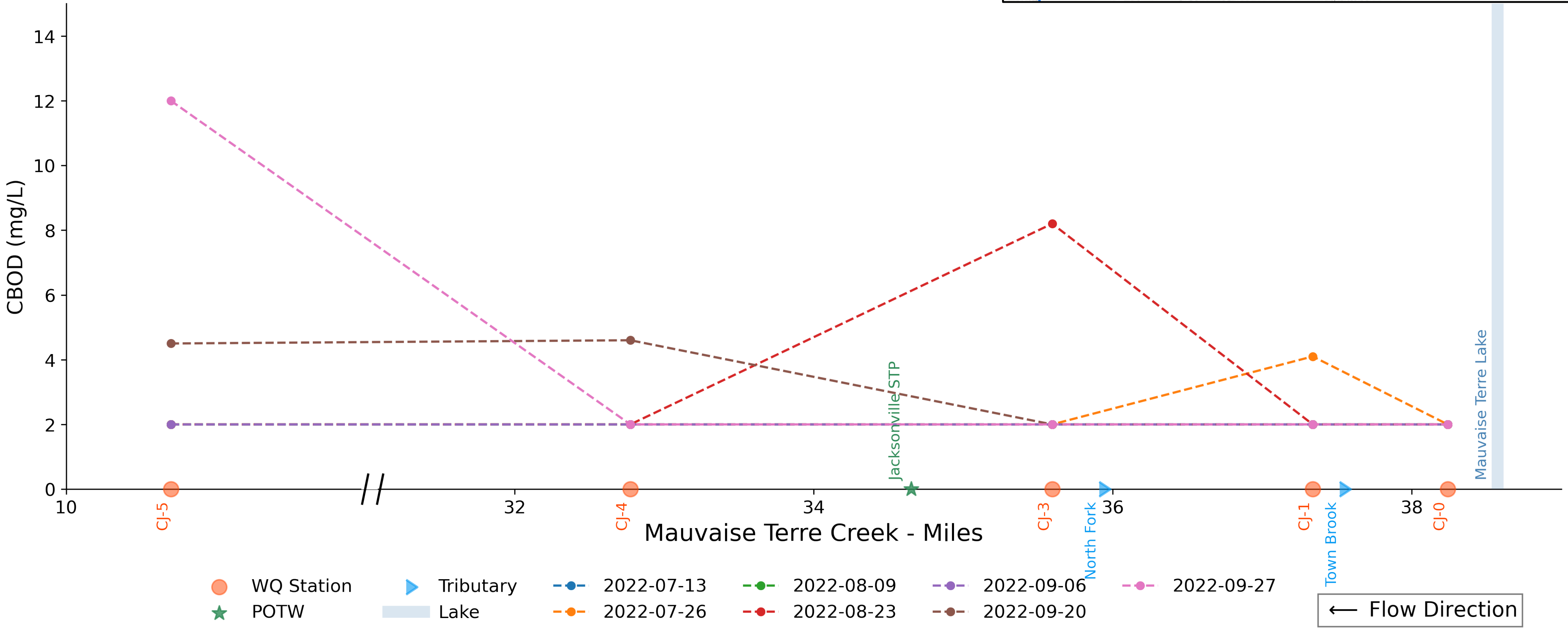


n = 7
n = 7
n = 7
n = 7
n = 7
CBOD (mg/L)
14
12
10
8
6
4
2
0
10
32
34
36
38
CJ-5
CJ-4
CJ-3
CJ-1
CJ-0
Jacksonville STP
North Fork
Town Brook
Mauvaise Terre Lake
n = 7
CJ-2
Mauvaise Terre Creek - Miles
← Flow Direction
WQ Station
POTW
Tributary
Lake

CBOD - Events



JACKSONVILLE STP (7.6 MGD)
Illinois River
PIKE
CJ-4
CJ-3
CJ-2
CJ-1
CJ-0
CJ-5
North Fork Mauvaise Terre Creek
Town Brook
Mauvaise Terre Lake
Mauvaise Terre Creek
DD-04
DD-05
DD-11
MORGAN
SCOTT



CBOD (mg/L)
14
12
10
8
6
4
2
0
10
32
34
36
38
CJ-5
CJ-4
CJ-3
CJ-1
CJ-0
Jacksonville STP
North Fork
Town Brook
Mauvaise Terre Lake
Mauvaise Terre Creek - Miles
WQ Station
POTW
Tributary
Lake
2022-07-13
2022-07-26
2022-08-09
2022-08-23
2022-09-06
2022-09-20
2022-09-27
⟵ Flow Direction

Summary and Discussion

Geosyntec consultants

Summary

- Risk of Eutrophication Downstream at CJ-5 (DD-05)
  - pH > 8.35 & DOsat > 110% for ≥ 2 days
  - Impetus for NARP Special Condition

- High Chl-a input from Mauvaise Terre Lake

- Photorespiration at CJ-5
  - Low Sestonic Chlorophyll-a
  - Benthic Chlorophyll levels not correlated to DO swings

Conclusion & Recommendation

- Conclusion
  - Jacksonville STP Phosphorus does not currently drive risk of eutrophication

- Recommended NARP Path forward
  - No modeling required
  - TP reduction to 0.5 mg/L will provide ample water quality improvement
    - Include recommendation for additional monitoring after achieving TP 0.5 mg/L
  - Continued efforts on the Mauvaise Terre Lake Watershed project will further reduce algal levels in the creek
  - With Illinois EPA's concurrence, complete the NARP with a Monitoring & Data Analysis Report

Questions?

Geosyntec consultants