MMSD
PARTNERS FOR A CLEANER ENVIRONMENT

2015 Surface Water Quality Annual Summary Report

Freshwater Resources Monitoring Department

Background

The Federal Water Pollution Control Act of 1965, through amendments and revisions, became known as the Clean Water Act of 1977. This act mandates that all states have an Environmental Protection Agency (EPA) approved water quality protection process. In Wisconsin, the legislature has authorized the Department of Natural Resources (WDNR) to formulate and place into effect long-range water resources plans and set water quality standards, or criteria, for a given waterbody according to its highest potential use. In addition, the Southeastern Wisconsin Regional Planning Commission (SEWRPC) helps implement regional water quality plans as part of Section 208 of the Clean Water Act.

In 1979, the Milwaukee Metropolitan Sewerage District (the District) began its surface water quality monitoring program to comply with the Federal Water Pollution Control Act objectives and state water quality standards. The District also began its massive Water Pollution Abatement Program (WPAP) to eliminate bypassing and combined sewer overflows while improving and upgrading the District's two wastewater treatment facilities. As part of the WPAP, the Inline Storage System (ISS) was built and subsequently came online in 1994. At inception, the surface water quality monitoring program consisted of eight monitoring locations on the three major rivers (Milwaukee, Menomonee, and Kinnickinnic) and eleven monitoring locations on Lake Michigan.

Since that time, the District's surface water quality monitoring program has expanded to include greater spatial and temporal coverage. The program currently has 89 unique monitoring locations on 12 different rivers and creeks as well as Lake Michigan (Figure 1). Two boats, the *Pelagos* and the *ORP*, are used to monitor the lake and the Milwaukee Harbor Estuary (lower estuary sites), while vans are used to sample the rivers, creeks, and upper estuary sites.

Introduction

MMSD's surface water quality monitoring program is required under the District's Wisconsin Pollutant Discharge Elimination System (WPDES) permit and the data are submitted annually to the WDNR. Monitoring requirements follow the Surface Water Quality Monitoring Plan (September 2011) and include the survey types listed in Table 1.

In addition to being a permit requirement, other objectives of the surface water quality monitoring program include:

- Monitoring the biological, chemical and physical characteristics of Lake Michigan and local waterways to assess the impact of District watercourse improvement projects, stormwater management rules, and nonpoint pollution prevention programs on water quality.
- Providing physical, chemical and biological data on the quality of water, wastewater and sediments in order to maintain and improve District operations and facilities and to satisfy external customer requests for related project data.
- Supplying water quality data interpretation and reports on environmental monitoring related to District operations and facilities planning.

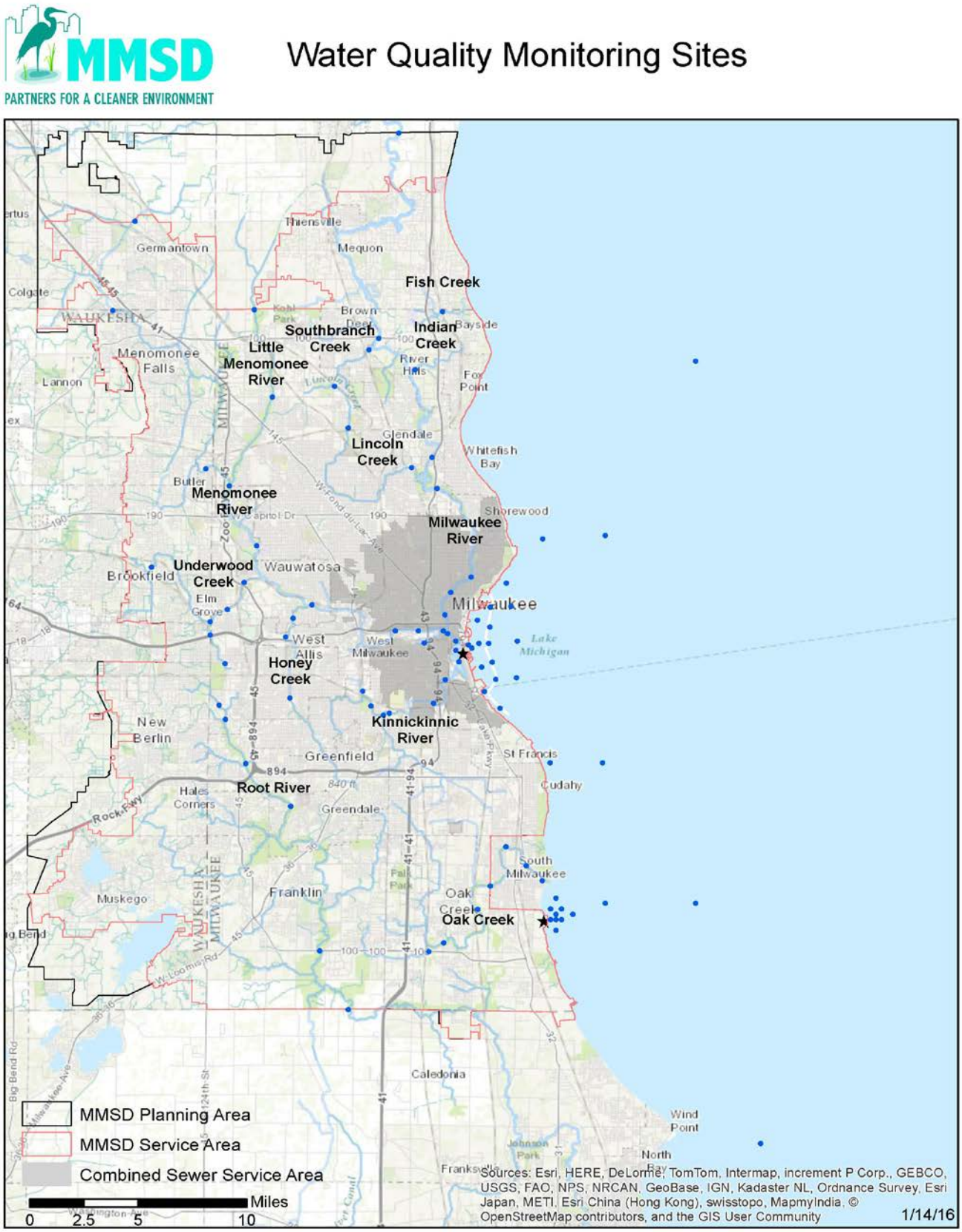


Figure 1: Map of all River, Creek, and Lake Michigan monitoring sites.

- Maintaining a historical water quality database and providing this information to the general public.
- Performing public education and outreach as it relates to the District's mission.

Table 1: Survey types and frequencies.

Survey Type	Number of Scheduled Surveys per Year	Number of Sampling Sites	Year Sampling Commenced
Nearshore	9	13	1979
Outer Harbor	14	16	1979
South Shore	14	9	1979
River	20	27	1980
Little Menomonee River	20	2	2007
Indian Creek	9	1	2002
Southbranch Creek	9	1	1999
Lincoln Creek	9	3	1997
Underwood Creek	9	6	2003
Honey Creek	9	3	2001
Fish Creek	9	1	2002
Oak Creek	9	7	1985
Root River	9	6	1999
CP (dry, wet, CSO)	2 - 4	25	1995

Description of Surveys

Nearshore Survey

The purpose of this effort is to provide a database for the District to assess the impact of MMSD discharges, as well as all other sources of pollution, including stormwater runoff, on nearshore water quality. Some Nearshore survey sampling sites are located a distance from shore to provide data for determining Lake Michigan background levels; these data have been useful in developing some of the District's effluent limitations and permit discharge fees. This survey covers the area of the nearshore environs of Lake Michigan from Fox Point on the north to Wind Point on the south and from the western shore of Lake Michigan to a point ten miles east of the western shore. The total area of the lake covered by this survey is approximately 350 square miles.

Outer Harbor/South Shore Surveys

Water quality data from these two survey types are utilized to evaluate the impact that the Jones Island Water Reclamation Facility (WRF) and the South Shore WRF are having on Lake Michigan. The areas surrounding both of these WRF outfalls are intensively used for recreational boating and fishing.

Sampling sites for these surveys were selected based upon their position relative to the effluent outfalls and the movement of water (or currents) found in the areas. The site identified as OH-02 is the existing outfall for the Jones Island WRF. The site identified as SS-01 is the point of discharge from the South Shore WRF. A major drinking water plant intake (Oak Creek) is located approximately one-mile southeast of SS-01. Water quality in both of these nearshore areas is also affected by the Milwaukee River as well as Oak Creek.

River Survey

Extensive monitoring of the three major river systems within the District's sewer service boundaries provides baseline data for measuring and documenting potential sources of pollution both inside and outside the District boundaries. The River survey helps document the benefits of the Deep Tunnel (ISS), watercourse improvement projects, nonpoint pollution prevention programs, and stormwater management plans. The Milwaukee River is the largest river within the District's service area and is currently recognized by community leaders as an important recreational water resource within the metropolitan area. The headwaters of the Milwaukee River originate in Fond du Lac County near Eden; the river enters the District planning area at Pioneer Road (County Trunk C) after passing through 86% of its drainage area. The main stem of the Milwaukee River totals 43.5 miles, and the Milwaukee River watershed covers 698 square miles. The Menomonee River watershed covers 136 square miles and is nearly 28 miles in length. The Menomonee River originates in a wetland area in the northeast corner of the Village of Germantown. Approximately 90% of the watershed is within the MMSD sewer service area. The Kinnickinnic River is located entirely within Milwaukee County and has a 26 square-mile drainage area. The Kinnickinnic River originates from a storm sewer at S. 60th Street and is 8 miles long. The watershed is highly urbanized and, in contrast to the Milwaukee and Menomonee River basins, the Kinnickinnic watershed is completely serviced by sanitary sewers, i.e., there are no septic systems.

CP Survey

The CP survey, which is fundamentally similar to the River survey, is used to assess the impacts of a combined sewer overflow (CSO) and is sampled up to four times per year, under the following conditions: 1) in the event of a CSO (2 surveys per year required if multiple occurrences); 2) when rainfall equals a minimum of 0.25" basin-wide and there is no CSO (wet CP survey); and 3) when there has been no rain for at least seven days with no CSO (dry CP survey).

Continuous Water Quality Monitoring Stations

In addition to taking discrete (grab) samples, the District maintains 14 continuous water quality monitoring stations, also known as real-time water quality monitoring stations.

A submerged, multi-probe sonde collects in-situ measurements at five minute intervals, 24 hours per day, 365 days per year. Measured parameters include: temperature, specific conductance, dissolved oxygen, turbidity, flow and river level.

Data collected by the monitoring stations are used to document water quality trends, calibrate and verify results of water quality models, assist with watershed planning efforts, and provide water quality information to the communities served by MMSD.

Little Menomonee River Survey

The Little Menomonee River originates in southern Ozaukee County near Freistadt Rd. and flows in a mostly southerly direction for a distance of approximately 10 miles to its confluence with the Menomonee River near Highway 100 and Hampton Avenue. The Little Menomonee River subwatershed encompasses approximately 21.8 square miles, or nearly 16 percent of the Menomonee River watershed.

Honey Creek Survey

Honey Creek originates at the S. 43rd Street storm sewer outfall in the City of Greenfield and flows in a northerly direction for approximately 8.8 miles until its confluence with the Menomonee River in the City of Wauwatosa. The Honey Creek subwatershed encompasses 11 square miles. Channel modifications such as deepening, straightening, and lining with concrete have been made to 7.1 miles of Honey Creek. The creek flows under State Fair Park in an enclosed channel that consists of three 10 by 15 foot pipes. The Honey Creek subwatershed has experienced minor flooding problems, but the biggest problem with this creek has been the ecological degradation and habitat loss due to channel modifications.

Indian Creek Survey

Indian Creek is a tributary of the Milwaukee River located in northern Milwaukee County. The creek, 2.6 miles in length, originates in the Village of Bayside and has its confluence with the Milwaukee River just south of Bradley Road in River Hills. Large storms typically cause flooding in this watershed.

Fish Creek Survey

Fish Creek is located along the border between Milwaukee and Ozaukee Counties in the Village of Bayside and the City of Mequon. Fish Creek drains directly into Lake Michigan, approximately 3 miles downstream from the source. Major precipitation events result in rapid surface runoff to Fish Creek, thereby causing a flashy response in the creek, potentially causing flooding in the Village of Bayside.

Southbranch Creek Survey

Southbranch Creek, approximately 1.5 miles long, drains a 3 square mile area before it enters the Milwaukee River. Southbranch Creek originates from a storm sewer outfall located at about N. 58th St. and W. Bradley Rd. and the entire watershed lies in an urban setting. Southbranch Creek has a long history of flooding. In response to this flooding, the District, along with other

Sampling Locations

Little Menomonee, Site 1

Honey Creek, Site 3

Indian Creek, Site 4

Fish Creek, Site 2

concerned parties, implemented a flood management plan. The plan included removing houses from the floodplain as well as the installation of detention basins.

Lincoln Creek Survey

Lincoln Creek is approximately 9 miles in length and drains a 21-square mile watershed. Lincoln Creek originates from a storm sewer outfall on N. 76th St., just north of W. Good Hope Rd. There is a history of having poor water quality and flooding problems due to urbanization within its watershed. In response to these problems, the District, along with other concerned parties, implemented a flood management plan which involved environmental restoration, creation of wetland stormwater detention areas, changes in creek channel morphology, stream bank erosion controls, and improvements in creek bed substrate.

Underwood Creek Survey

Underwood Creek originates in the City of Brookfield and flows approximately 8 miles in a southeasterly direction to its confluence with the Menomonee River. The Underwood Creek subwatershed encompasses approximately 19.8 square miles and includes the Underwood Creek main stem, Dousman Ditch, and the South Branch of Underwood Creek. Much of Underwood Creek flows in a concrete-lined channel. Flooding problems have occurred in the subwatershed and sections of the creek have undergone flood management improvements.

Oak Creek Survey

Oak Creek flows into Lake Michigan about 2 miles north of the MMSD's South Shore WRF. Knowledge of its water quality is helpful in determining impacts to the lake's nearshore zone. When monitoring began on Oak Creek, the area was primarily rural; since then, it has undergone significant development. Continued urbanization will increase the flows that this stream will be required to handle.

Root River Survey

The Root River drains approximately 197 square miles within Milwaukee, Waukesha, Racine, and Kenosha Counties. The watershed includes all, or portions of, 18 communities, and includes five sanitary sewer service areas. The Root River empties into Lake Michigan in the City of Racine. This survey covers the upper 72 square miles of the watershed located within the District's service area.

The MMSD RV *Pelagos*

The MMSD Research Vessel, *Pelagos*, was designed and built specifically for MMSD by Peterson builders, Inc. of Sturgeon Bay, WI in 1989. The *Pelagos* is designed and equipped for taking water column and sediment samples and has on-board computer and laboratory capabilities.

Pelagos stats

Length – 43 feet

Width – 13 feet

Draft – 4 feet

Weight – 30,000 lbs

Cruising speed – 22 knots (25 mph)

Propulsion – twin Caterpillar 300 hp diesel engines

Water Quality Standards

In accordance with the Federal Water Pollution Control Act, eventually known as the Clean Water Act, each state is required to adopt water quality (WQ) standards and a plan of action for applying those standards. Waters are classified into different groups according to what they are or should be used for; these characteristics are then utilized in developing and establishing supportive standards for each classification. Water quality standards for a given body of water are set according to its highest potential use. Standards are used as a measuring stick or qualitative indicator of environmental characteristics of the water body that must be maintained if the water body is to be suitable for its specified use classification. Table 2 lists the WDNR surface water quality standards that are applicable to this report.

Fecal coliform standards are based on a geometric mean of 5 or more samples per month. One to two samples per month are collected at each MMSD monitoring site, but for the purposes of this report, the criteria are used as a benchmark of water quality and potential human health risk.

Table 2: Applicable surface water quality standards.

Variable	Standard	Sampling Site
Fecal Coliform	200 CFU/100 mL[1]	All OH sites except OH 1. All NS sites except NS 28. All SS sites. All FC, SB, RR and OC sites. The Milwaukee River above the North Ave. Dam (RI sites 1, 2, 3, 4, 5). The Menomonee River above HC confluence (RI 36, 16, 21, 22, 32).
	1000 CFU/100 mL[2]	UC, IC, HC, LC, the KK River, the Menomonee River below the confluence with HC (RI Sites 9, 20, 11, 17), the Milwaukee River below the North Ave. Dam (RI sites 6, 7, 8, 15)(OH 1/NS 28), the South Menomonee Canal, and the Burnham Canal (RI site 31).
Total Suspended Solids[3]	12 mg/L	All river and all creek sites within the Milwaukee River basin and the Milwaukee Estuary.
Total Phosphorus[4]	0.007 mg/L	OH sites 6, 8, 12, 13, 14. NS sites 1, 2, 3, 4, 5, 7, 8, 10, 11, 14, 27. All SS sites.
	0.075 mg/L	All creek sites. River sites 36, 16, 21, 33, 34, 35. ML 1 and ML 2.
	0.1 mg/L	River sites, 1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13, 14, 15, 17, 18, 19, 20, 22, 31, 32. OH sites 1, 2, 3, 4, 5, 7, 9, 10, 11, 15. NS sites 12, 13, 28

1 WDNR. Chapter NR 102. Water Quality Standards for Wisconsin Surface Waters. NR 102.04. November, 2010.
2 WDNR. Chapter NR 104. Uses and Designated Standards. NR 104.06. February, 2004.
3 WDNR Recommended Target as part of Milwaukee River Basin TMDL development. CDM Presentation, Stakeholder Workshop 4. October 30,2012. http://www.mmsd.com/-/media/MMSD/Documents/Water%20Quality/tmdl/Slides_MilwBasinTMDLsStakeholderMtg4.pdf
4 WDNR. Chapter NR 102. Water Quality Standards for Wisconsin Surface Waters. NR 102.06. November, 2010.

Methodology

Sample Collection

In order to get an overall assessment of a waterway's health, physical, chemical, and biological variables are analyzed as part of MMSD's surface water quality monitoring program (Table 3). Some variables are captured by sonde in situ (temperature, pH, specific conductance, dissolved oxygen, turbidity, and depth); remaining variables are run in-house by the MMSD Central Laboratory.

The monitoring program addresses, by random design, both dry and wet weather sampling periods. The sampling program is designed to not only capture both wet and dry events, but to be representative of the annual fluctuations in the number of wet and dry events each year. For example, during rainy years, a higher proportion of samples will be collected during rain events.

Sampling frequency varies by survey type. River, Outer Harbor, and South Shore samples are collected twice per month, while Nearshore and creeks are sampled once per month. River sites are sampled year-round; all other survey types are sampled March through November.

Exact sampling depths at any location may vary from year to year depending on lake levels, dam operations, seiches, and precipitation. Generally, three samples are collected at sites greater than four meters deep, i.e., one meter below the surface, one meter above the bottom, and mid-depth. Locations less than four meters deep are generally sampled at either two depths, i.e., one meter below the surface and one meter above the bottom, or one depth, depending on site conditions. Samples are collected from mid-channel, where feasible. Samples for metals testing are collected at mid-depth for sites greater than four meters deep and at the surface for shallower sites.

Field Equipment

Kemmerer sampler

Microbiological sampler

Underwater PAR Sensor

Secchi Disk

Table 3: MMSD's surface water quality monitoring variable list.

Variable	Unit of Measure
1% Light Level	meters
Ammonia Nitrogen	mg/L
Biochemical Oxygen Demand (5 & 20 day)	mg/L
Chloride	mg/L
Chlorophyll *a*	mg/m^3
Depth	meters
Dissolved Oxygen	mg/L
***Escherichia coli* Bacteria**	MPN/100 mL
Fecal Coliform Bacteria	CFU/100 mL
Hardness	mg/L
Nitrate Nitrogen	mg/L
Nitrite Nitrogen	mg/L
Nitrate + Nitrite Nitrogen	mg/L
pH	Std. Units
Soluble Silica	mg/L
Specific Conductance	µS/cm
Temperature	°C
Total Alkalinity	mg/L
Total Arsenic	µg/L
Total Cadmium	µg/L
Total Calcium	mg/L
Total Carbon	mg/L
Total Chromium	µg/L
Total Copper	µg/L
Total Dissolved Organic Carbon	mg/L
Total Inorganic Carbon	mg/L
Total Kjeldahl Nitrogen	mg/L
Total Lead	µg/L
Total Magnesium	mg/L
Total Nickel	µg/L
Total Organic Carbon	mg/L
Total Phosphorus	mg/L
Total Selenium	µg/L
Total Silver	µg/L
Total Solids	mg/L
Total Soluble Phosphorus	mg/L
Total Suspended Solids	mg/L
Total Zinc	µg/L
Turbidity	FNU
Volatile Suspended Solids	mg/L
Water Transparency (Secchi Disk)	meters

Analysis

Wet and dry events were determined using daily mean flow data collected by the USGS and were confirmed using daily precipitation collected by the MMSD. Using the Web-based Hydrograph Analysis Tool (WHAT), the flow data were retrieved and separated into runoff and base flow using the Local Minimum Method[5]. This produced a total flow, direct runoff, and base flow value for each day. The ratio of runoff to total flow was used to determine wet/dry conditions. All days where the total flow was comprised of more than 20% runoff were considered "wet" (Table 4).

[5] Lim, Kyoung Jae, Bernard A. Engel, Zhenxu Tang, Joongdae Choi, Ki-Sung Kim, Suresh Muthukrishnan, and Dibyajyoti Tripathy, 2005. Automated Web GIS Based Hydrograph Analysis Tool, WHAT. Journal of the American Water Resources Association 41(6):1407-1416.

Table 4: Breakdown of wet/dry surveys as determined by WHAT. The one combined sewer overflow that occurred in 2015 (April 10) is included in the number of wet surveys.

USGS Station for Flow Data	USGS Station ID	Total Number of Surveys	Number of Wet Surveys	Number of Dry Surveys
Milwaukee River @ Estabrook	04087000	20	13	7
Menomonee River @ 16th St.	04087142	20	13	7
Menomonee River @ 70th St.	04087120	20	13	7
Kinnickinnic River @ 11th St.	04087159	20	13	7
Oak Creek @ 15th Ave.	04087204	9	4	5
Root River @ Grange	04087214	9	4	5
Lincoln Creek @ Sherman Blvd.	040869416	9	3	6
Honey Creek @ Wauwatosa	04087119	9	6	3
Underwood Creek @ Wauwatosa	04087088	9	6	3

All data points that were reported as less than the method detection limit (MDL) by the laboratory were replaced with one-half of the MDL for subsequent analyses. River and creek sites are predominately sampled at the surface only, while lake sites are generally sampled at three depths. All analysis was performed by pooling all depths together where applicable.

Data Verification (Quality Assurance)

After all laboratory analyses have been completed for a survey, Freshwater Resources Monitoring (FRM) staff and Supervisor verify survey results (including quality assurance samples), according to the standard operating procedures. Data will be qualified with a Q flag if a known problem occurred during sample collection or handling, if a partial measure that is greater than 140% of the total, e.g., total soluble phosphorus is greater than 140% of total phosphorus, or if the data are identified as outliers. Data that were Q flagged were not included in this report.

Results and Discussion

Rivers and Creeks

Annual median values for fecal coliform, total phosphorus, and total suspended solids were calculated and mapped for all river and creek sites for 2015 (Figures 2-10). The percent compliance values for meeting that parameter's WQ standard/criterion were also calculated and mapped for 2015 (Figures 2-10).

Fecal Coliform

Fecal coliform bacteria are a group of bacteria that are found in the intestinal tract of warm-blooded animals. Although fecal coliform bacteria are not necessarily harmful, their presence indicates that other pathogenic bacterial, viral, protozoan, or fungal species may be present in the water. Sources of fecal contamination to surface waters include wastewater treatment plant effluent, on-site septic systems, failing infrastructure, domestic and wild animal feces, and stormwater runoff. Restrictions on water bodies (both stream and Lake Michigan) due to fecal contamination lead to decreased recreational usage.

Despite falling under the fecal coliform variance of 1000 CFU/100 mL, many of the downtown estuary locations are meeting the more stringent standard of 200 CFU/100 mL at least half of the time (Figure 2). Estuary sampling sites, however, are influenced by Lake Michigan water traveling upstream. The Milwaukee Harbor Estuary extends up the Milwaukee River to the former North avenue Dam, upstream on the Menomonee River to the former Falk Dam (approximately 38th St.), and upstream to the Kinnickinnic River to approximately Chase Ave. In comparison, sites upstream of the estuary and outside of the CSO area appear to be struggling to meet the fecal standard, even with the fecal coliform variance. Generally speaking, lowest compliance percentages can be found on the Root River, Honey Creek, and the Menomonee River prior to its confluence with Underwood and Honey Creeks. One site on Root River is not meeting its standard at all (0% compliance); another site on Root River, one site on Underwood Creek and two sites on Honey Creek are only meeting the standard 25% of the time. Historically, sites on the Kinnickinnic River have shown poor water quality with regards to fecal coliform values, but six out of eight sites in the Kinnickinnic River watershed are meeting the fecal standard more than 50% of the time. Underwood Creek is split between having sites that are meeting the standard more than half the time and sites that are still struggling to make the 50% compliance mark. Southbranch Creek, Lincoln Creek, and Indian Creek sites are faring slightly better and are meeting their fecal standard over 50% of the time. The most upstream site on Lincoln Creek has 100% compliance with the fecal coliform standard.

Dry weather sampling events show slight improvement in both median fecal coliform values as well as compliance percentages (Figure 3). All downtown locations meet the more stringent 200 CFU/100 mL standard for the dry median and the compliance percentages are also improved. All eight sites in the Kinnickinnic River watershed have dry compliance percentages of 50% or greater. Both the Milwaukee River and the upper Menomonee River show improvement during dry weather. Root River, Honey Creek, the Little Menomonee River and the lower Menomonee River, while showing slight

improvement, are still struggling to meet the fecal standards, even during dry weather. This may indicate another source of fecal coliform that is not related to stormwater runoff but rather a continuous input.

Wet weather sampling events show degraded results for annual medians and compliance percentages for fecal coliform (Figure 4). Out of 57 river and creek sites, only five sites are below the 200 CFU/100 mL standard during wet weather. The mid and lower reaches of the Menomonee River, all sites on Underwood and Honey Creeks, and most sites in the Kinnickinnic watershed have very poor annual wet weather fecal coliform median values along with low percent compliance values. Two sites on the Root River and one site on Oak Creek have 0 % compliance during wet sampling events.

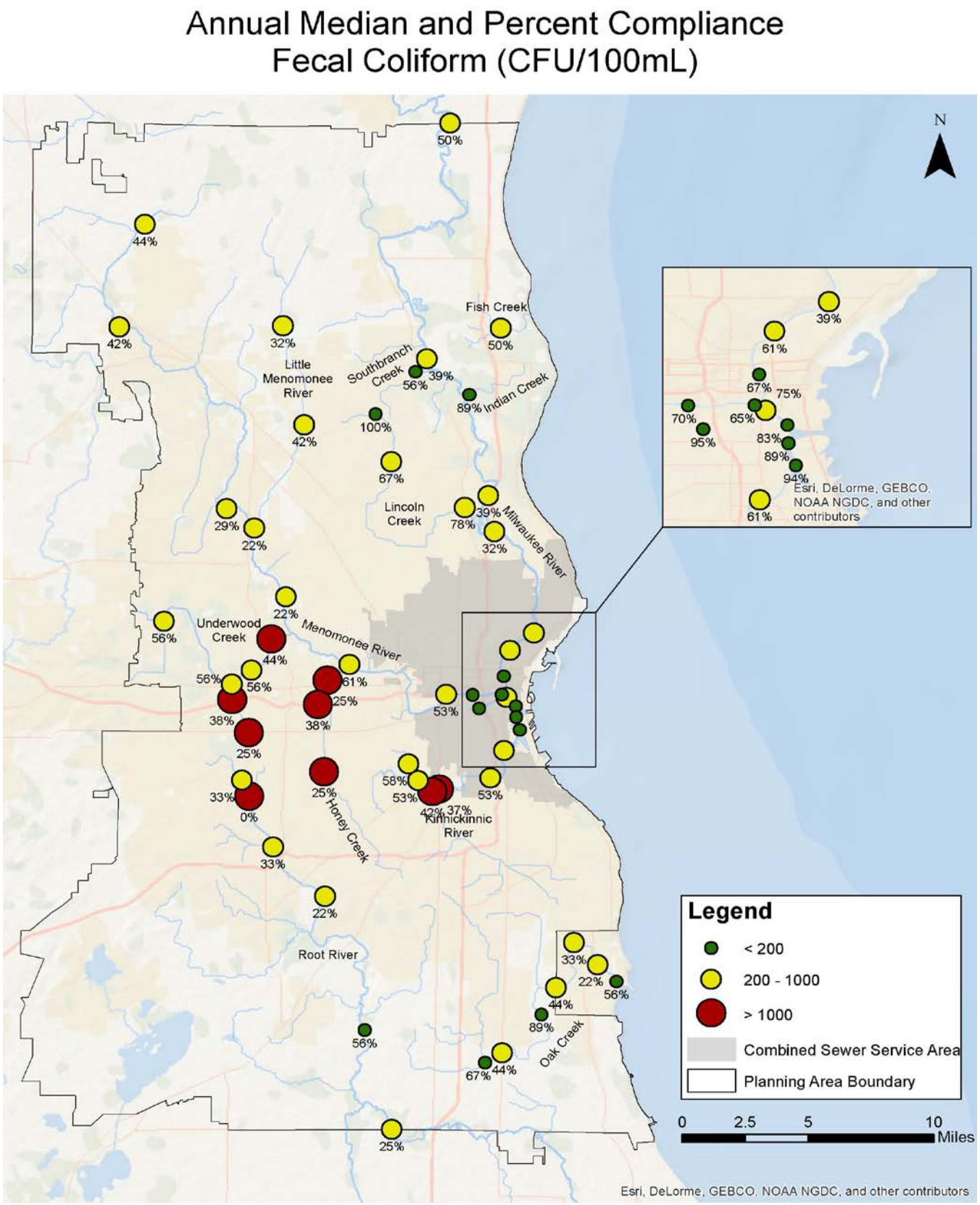


Figure 2: Annual median and percent compliance values for fecal coliform (2015).

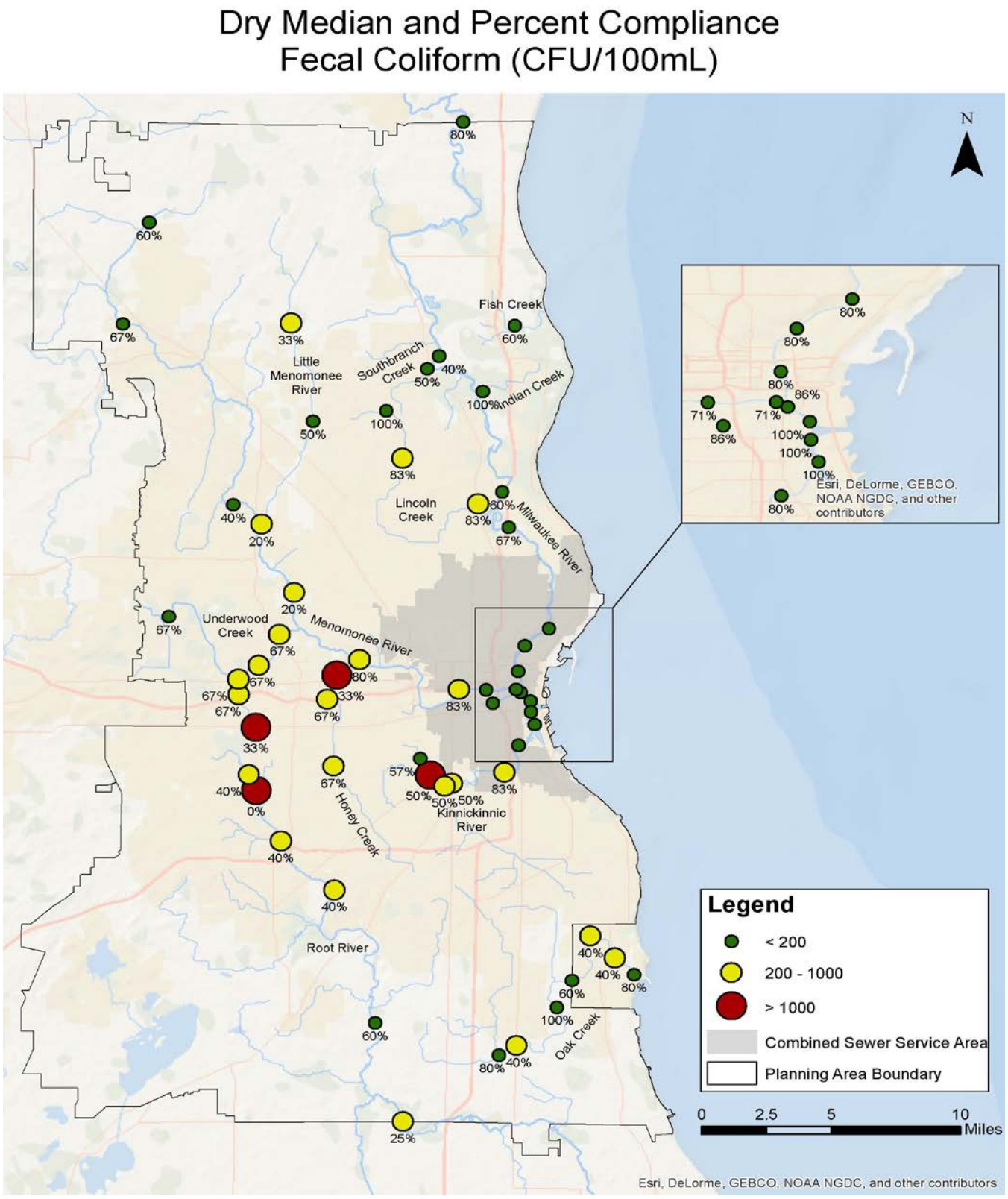


Figure 3: Dry event annual median and percent compliance values for fecal coliform (2015).

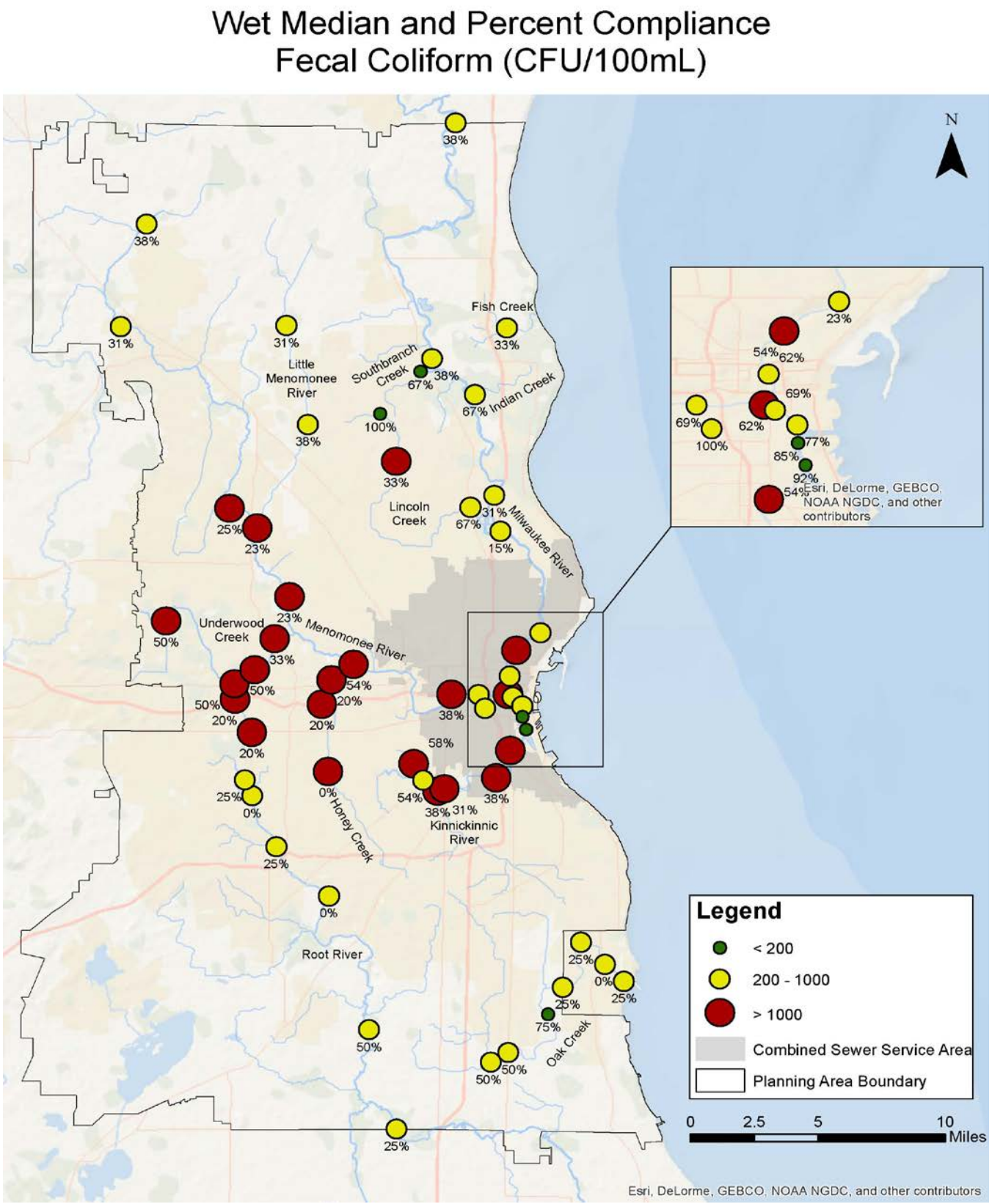


Figure 4: Wet event annual median and percent compliance values for fecal coliform (2015).

Total Phosphorus

Phosphorus as phosphate is one of the major nutrients required for plant growth. Excess phosphorus can lead to eutrophication of a water body, resulting in algal blooms, hypoxia, and fish kills. Phosphorus attaches to soil particles, thus entering the water body during storm runoff events. Sources of phosphorus include fertilizers, manure, organic wastes in sewage, and industrial effluent.

Median values for most sites on Oak Creek, as well as the downstream reaches of Underwood Creek, are below the WQ standard of 0.075 mg/L (Figure 5), although the sites are only achieving this goal 56 to 78% of the time. The upstream reach of the Menomonee River has one site meeting the standard, but again, it is only meeting this goal 50% of the time. Wilson Park Creek, just prior to entering the KK River, is also meeting the standard, but only 68% of the time. The Milwaukee River has high phosphorus values throughout the watershed. The downtown sampling locations have the best compliance records and are meeting the standard 100% of the time, but this may be due to the influence of Lake Michigan water. Sites on Southbranch, Indian, and Lincoln Creeks, as well as most of the Milwaukee River, all have elevated total phosphorus median values. In the Menomonee River watershed, four sites have elevated total phosphorus median values along with two sites in the Kinnickinnic River watershed. Four sites along the upstream portion of the Root River are not meeting their total phosphorus standard. Two sites, one on Lincoln Creek and one on Root River, are not meeting their total phosphorus standard at all (0% compliance).

Dry weather sampling data (Figure 6) show improvement for some sites, while other sites show a decrease in compliance. The downtown estuary sites show improved compliance as does Oak Creek, with several sites in complete compliance, while the data for Underwood Creek and most sites in the Kinnickinnic watershed show a decrease in percent compliance. Some sites on Root River improved, while others did not. Most sites on the upper and middle portions of the Menomonee River decreased in percent compliance. For dry weather sampling events, the number of sites achieving 0% compliance increased from two sites to seven sites, indicating that there may be factors leading to elevated phosphorus values other than precipitation.

During wet weather, only four sampling sites are meeting the standard for total phosphorus (Figure 7). One of the four sites is on Lincoln Creek, and interestingly, the two sites downstream both have 0% compliance during wet weather. Out of 57 sites, 19 have compliance percentages greater than 50% during wet weather. There is a well-known positive relationship between discharge and total phosphorus which would imply that wet weather events should decrease compliance percentages (as compared to dry events). In the case where compliance actually increases with wet weather, the volume of stormwater runoff may outweigh the ambient phosphorus concentration, thereby causing a dilution effect at these 19 sites. Four sites have 0% compliance during wet weather events; one is on Root River while the other three sites are all on tributaries to the Milwaukee River.

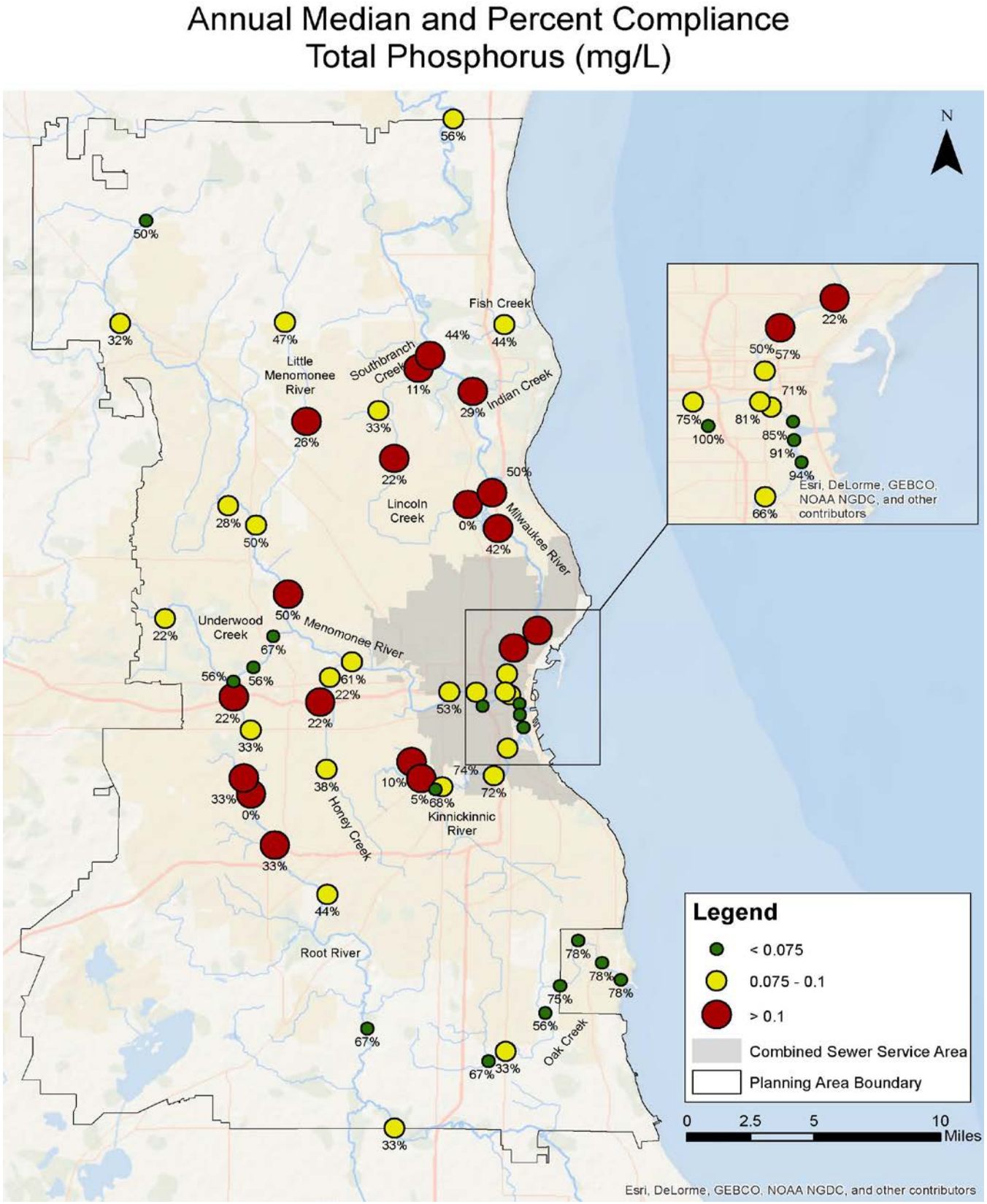


Figure 5: Annual median and percent compliance values for total phosphorus (2015).

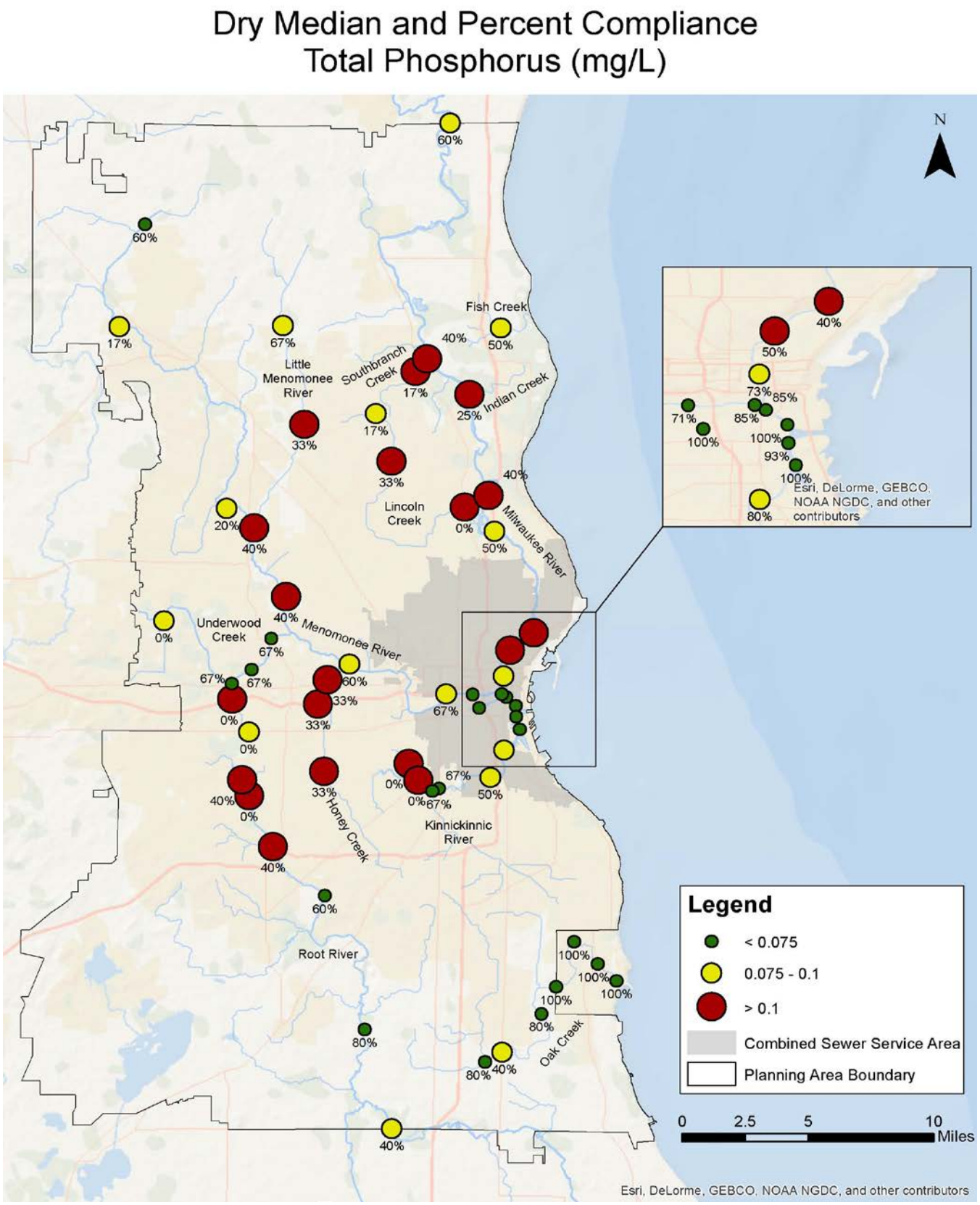


Figure 6: Dry event annual median and percent compliance values for total phosphorus (2015).

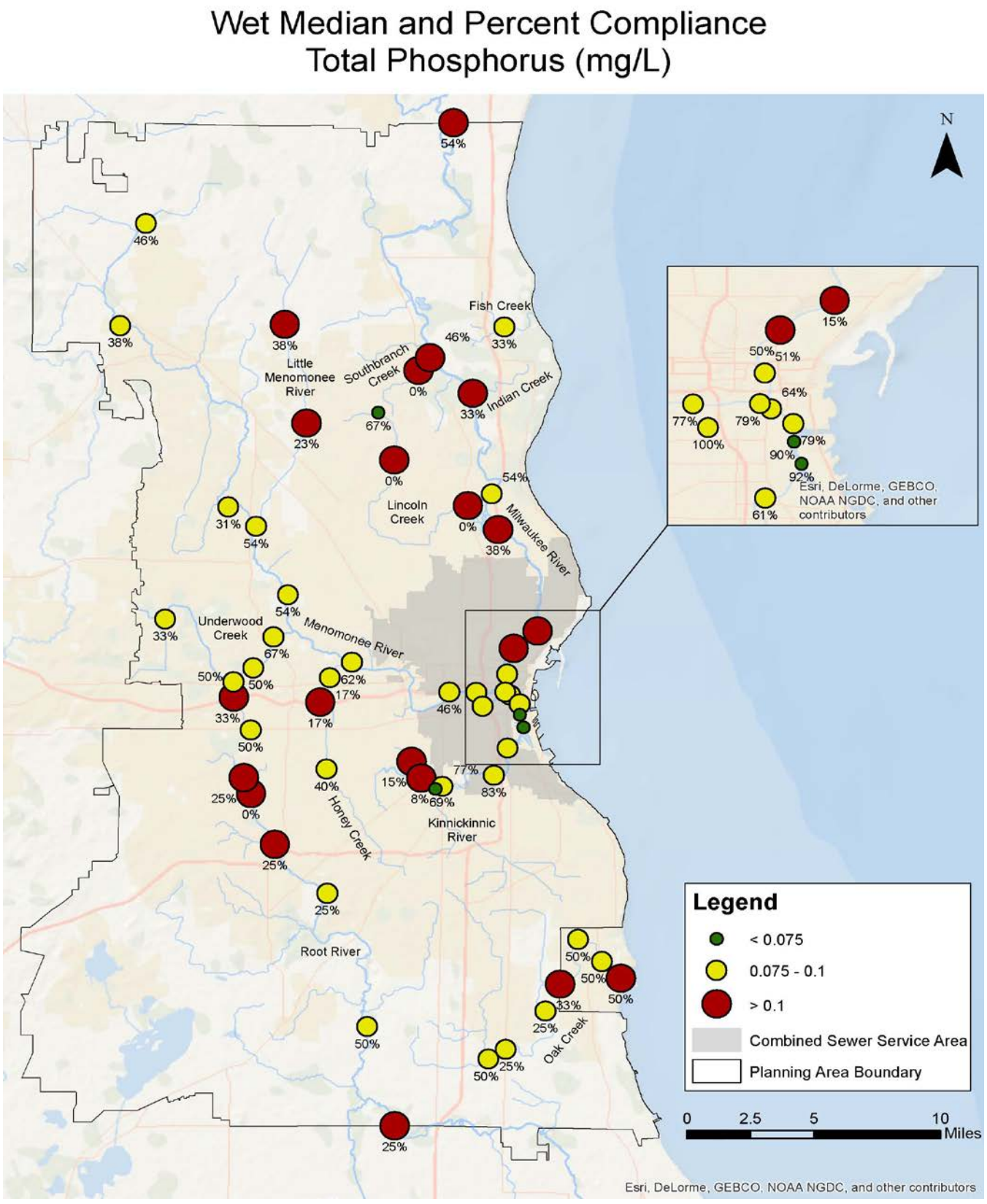


Figure 7: Wet event annual median and percent compliance values for total phosphorus (2015).

Total Suspended Solids

Total suspended solids are any solid particles, organic or inorganic, that will not pass through a filter. Point sources of suspended solids include sanitary wastewater and industrial wastewater, while non-point sources include streambank erosion, agricultural runoff and construction site runoff. Bottom feeders, such as carp, can also increase the amount of sediment found in the water column. When solids are washed into a stream during a storm event, nutrients, bacteria, pesticides, metals and toxins adsorb onto the solids and also get carried into the receiving stream. As suspended solids increase, water quality and habitat quality decrease. High levels of suspended solids can increase the temperature of a stream due to sunlight (heat) absorption by the suspended particles. Warmer stream temperatures hold less dissolved oxygen which is detrimental to aquatic organisms. Since less sunlight reaches aquatic plants when suspended solids values are high, there is also a simultaneous decrease in photosynthesis, resulting in even less available dissolved oxygen. Excessive sediment can clog the gills of fish, smother fish eggs, and make it more difficult for fish and other organisms, including aquatic birds, to find food. Aquatic insect habitat quality is decreased when excessive solids degrade the substrate. From a human standpoint, drinking water facilities have a more difficult time cleaning the water when solids are high which results in poorer settling and disinfection of the water.

Out of 57 sampling sites, all but 10 sites are meeting the recommended TMDL standard of 12 mg/L for total suspended solids (Figure 8). Sites with median values greater than 12 mg/L are scattered throughout the lower Milwaukee River, Root River, Oak Creek, and Menomonee River watersheds. Five of the 10 sites are located along the Milwaukee River. Sampling sites with a median value of less than 12 mg/L are widely varied in their compliance percentages, from 56% to 100%. Urban areas have sites with a high percentage of compliance as well as sites with a medium percentage of compliance. Rural sites show a similar variety of compliance percentages. Sampling sites with a median value greater than 12 mg/L generally have a low compliance percentage, with values ranging from 17% to 50% compliance.

Dry weather sampling events reveal data that are below the recommended criterion of 12 mg/L for suspended solids with only three sites having median values that exceed this criterion (Figure 9). This reflects an increase in compliance percentages for dry weather sampling, with most sites at 67% compliance or greater and 15 of the sites achieving 100% compliance.

Wet weather seemingly affects some rivers and creeks more than others, with all sites on Oak Creek having median suspended solids values that exceed the criterion (Figure 10). The Milwaukee and Menomonee Rivers also seem to be impacted by wet weather. Sites along the Root River, Honey Creek, Underwood Creek, the Little Menomonee River, and all creeks tributary to the Milwaukee seem to fare relatively well during wet weather. This indicates that the elevated suspended solids values on the Milwaukee River are originating from the Milwaukee River mainstem as opposed to inputs from tributaries and are likely from agricultural sources

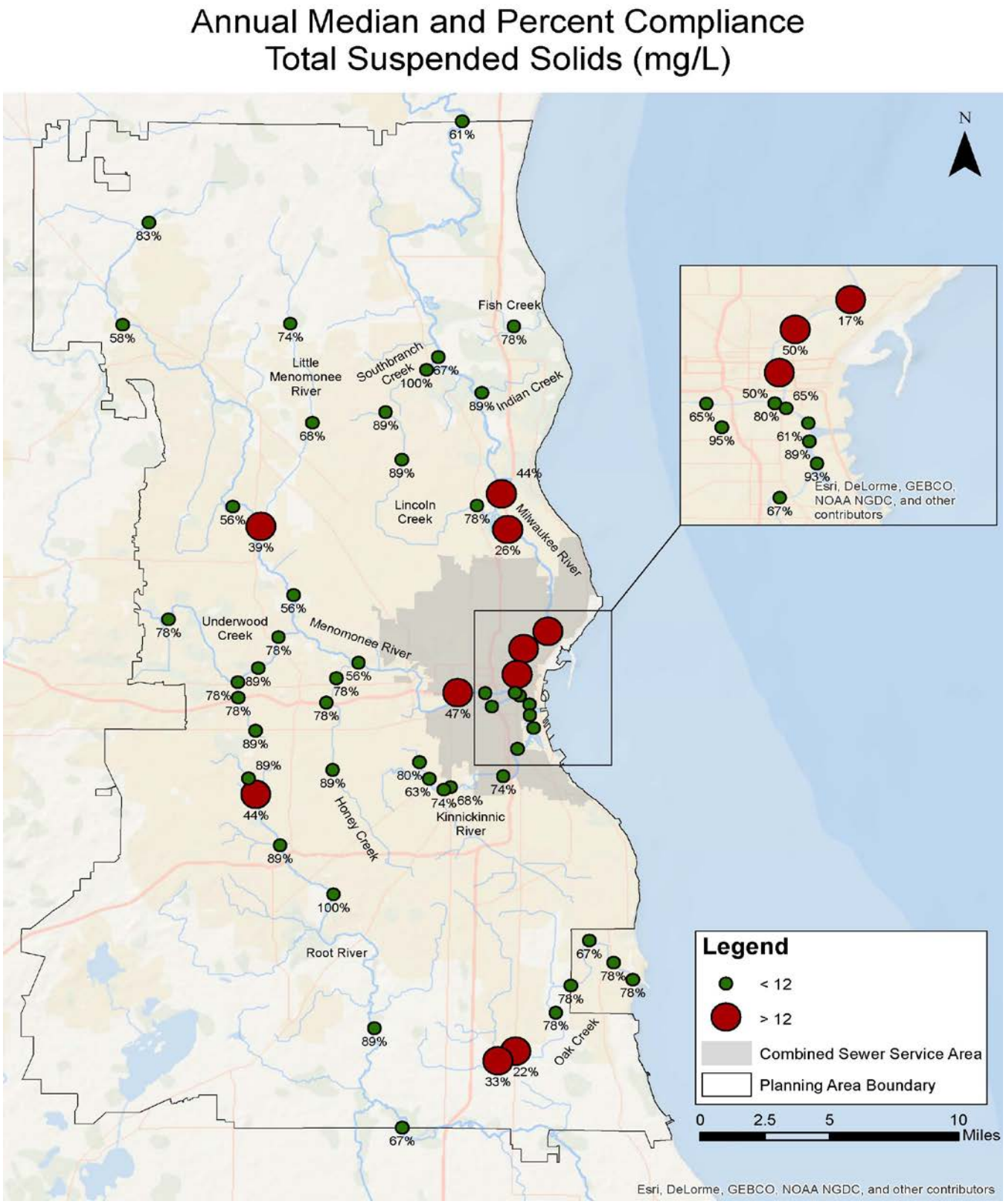


Figure 8: Annual median and percent compliance values for total suspended solids (2015).

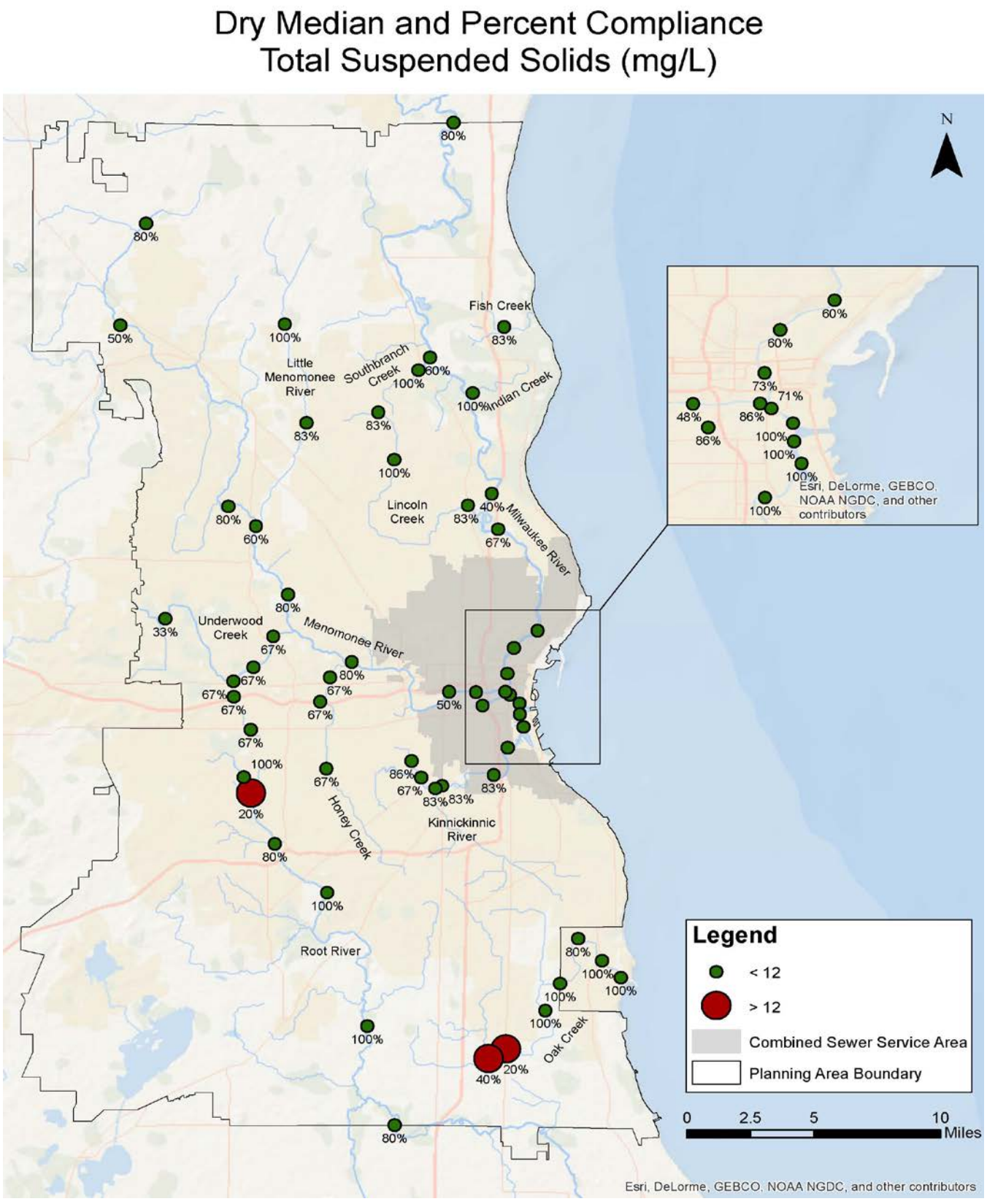


Figure 9: Dry event annual median and percent compliance values for total suspended solids (2015).

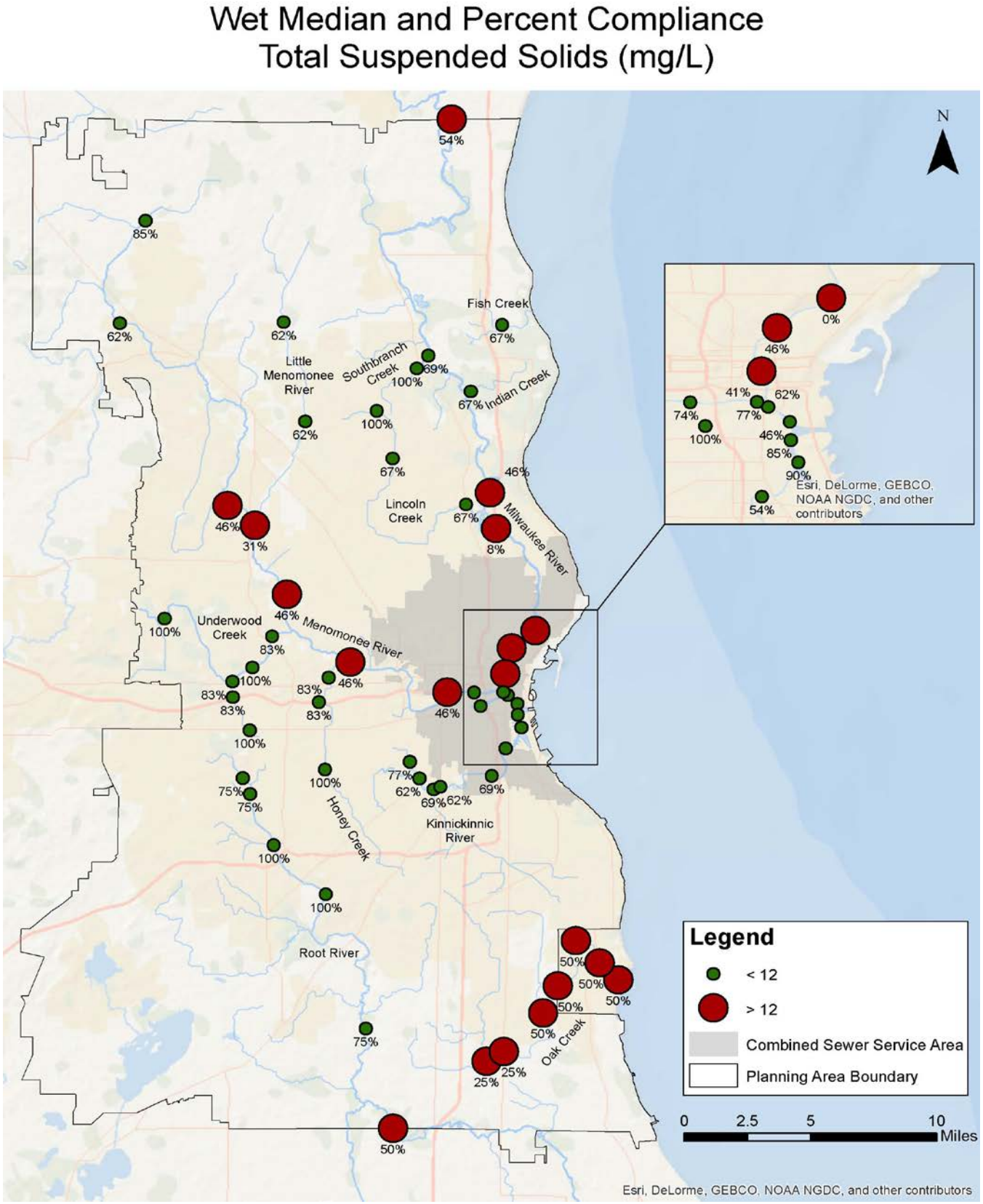
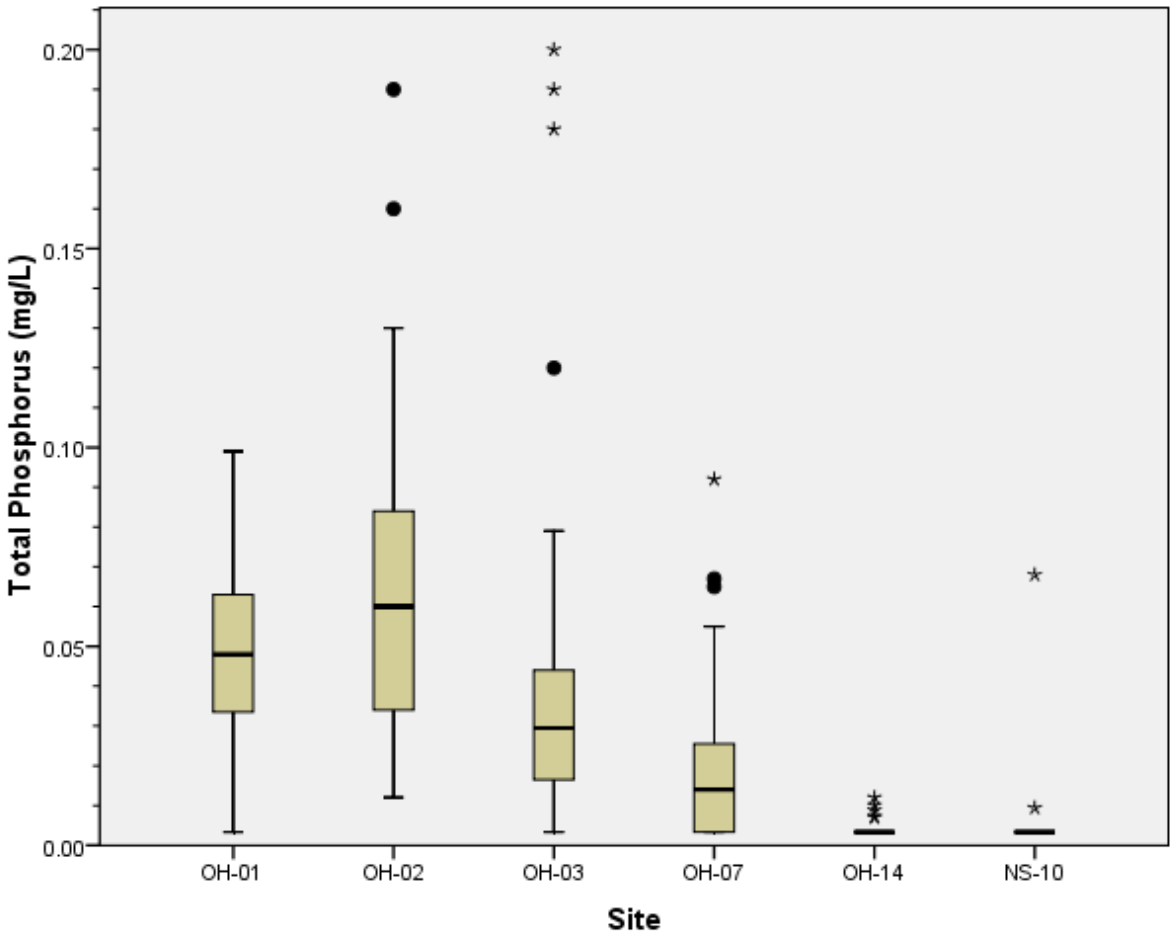


Figure 10: Wet event annual median and percent compliance values for total suspended solids (2015).

Lake Michigan

Three parameters, total phosphorus, fecal coliform, and total suspended solids, were analyzed for select Lake Michigan sampling sites (Figures 11 – 15). Annual medians were calculated for select Outer Harbor (OH) and Nearshore (NS) sites and plotted from west to east (shoreline to open-lake) with the addition of the Jones Island WRF (OH-02) outfall. For comparison, OH-01, OH-02, OH-03, and OH-07 are inside the break wall. OH-07 is 0.9 miles and OH-14 is over 2 miles from the mouth of the Milwaukee River (OH-01), and NS-10, used as a water quality reference site, is over 9 miles from shore.

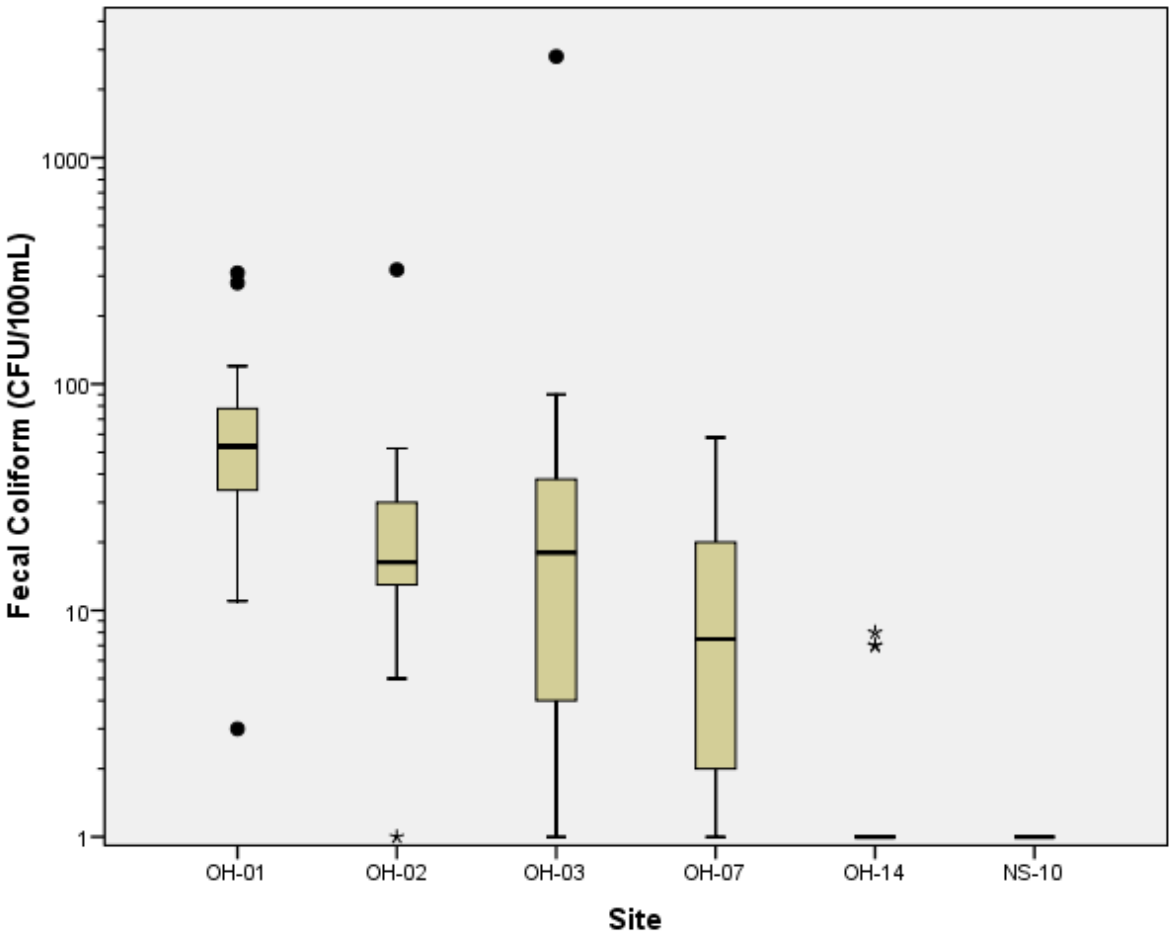
The boxplots in Figure 11 illustrate decreasing total phosphorus concentrations as the sites move farther away from shore. Results from within the harbor breakwater (OH- 01, -02, -03, and -07) are well below the water quality standard of 0.1 mg/L and are generally reflective of the influence of the Milwaukee River, while two sites outside of the breakwater, OH-14 and NS-10, are below the open-lake phosphorus standard of 0.007 mg/L. This shows the relatively low impact the river is having on open water sites with respect to phosphorus.



Median	0.048	0.06	0.0295	0.014	0.00335	0.00335

Figure 11: 2015 boxplots for total phosphorus concentrations for select harbor and open-lake sites. Median values for 2015 are shown below each site.

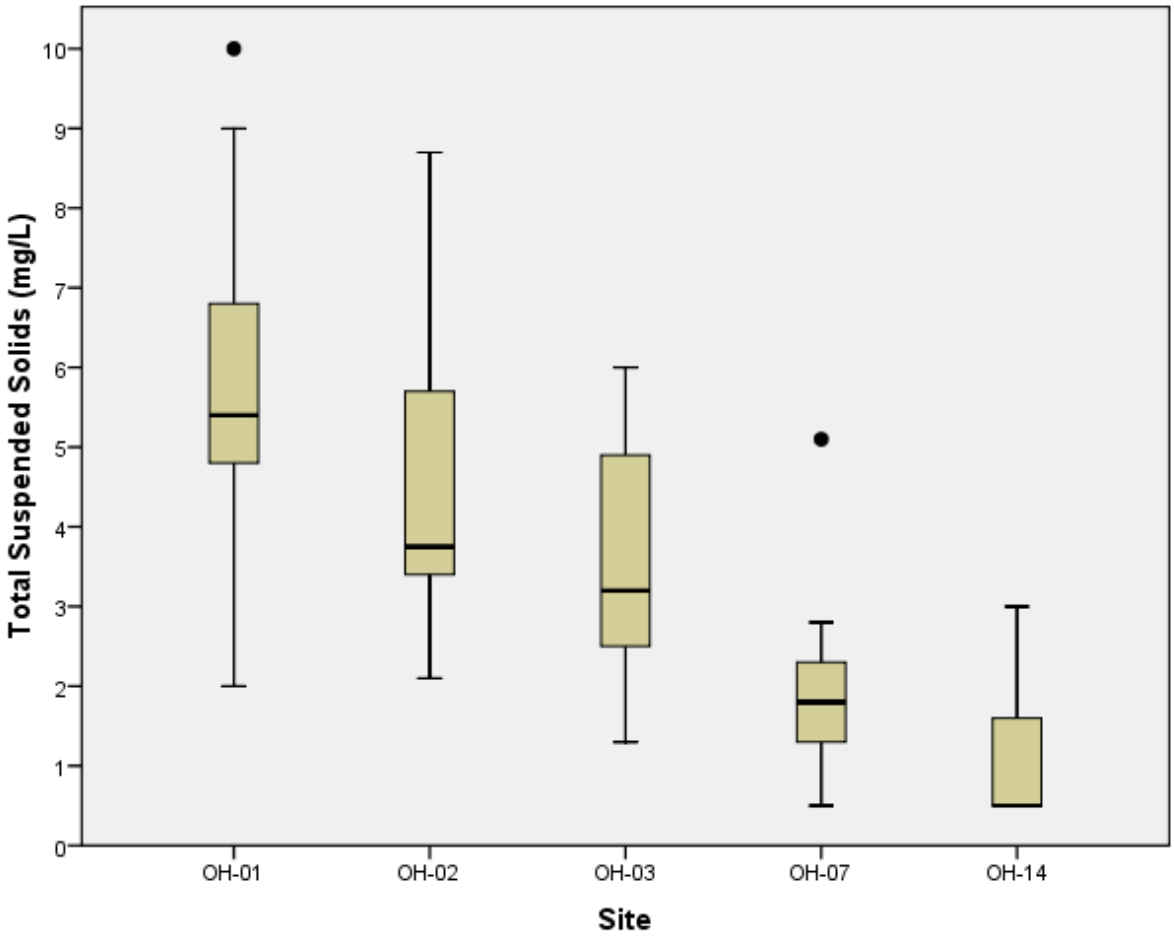
Similarly, fecal coliform bacterial levels decrease moving away from the mouth of the river (Figure 12). Once outside of the breakwater, fecal coliform drops down below the laboratory method detection limit (MDL) of 2 CFU/100 mL. Values from OH-02 are less than the values from the mouth of the Milwaukee River (OH-01) and similar to values from OH-03. Median values from 2015 are all below the fecal coliform water quality standard of 200 CFU/100 mL.



Median	53	16.5	18	7.5	1	1

Figure 12: 2015 boxplots for fecal coliform for select harbor and open-lake sites plotted on a log scale. Median values for 2015 are shown below each site.

Total suspended solids values are shown in Figure 13, displaying decreasing values as the sites move away from shore. Site NS-10 is not included in this figure because this parameter is not collected on nearshore surveys.

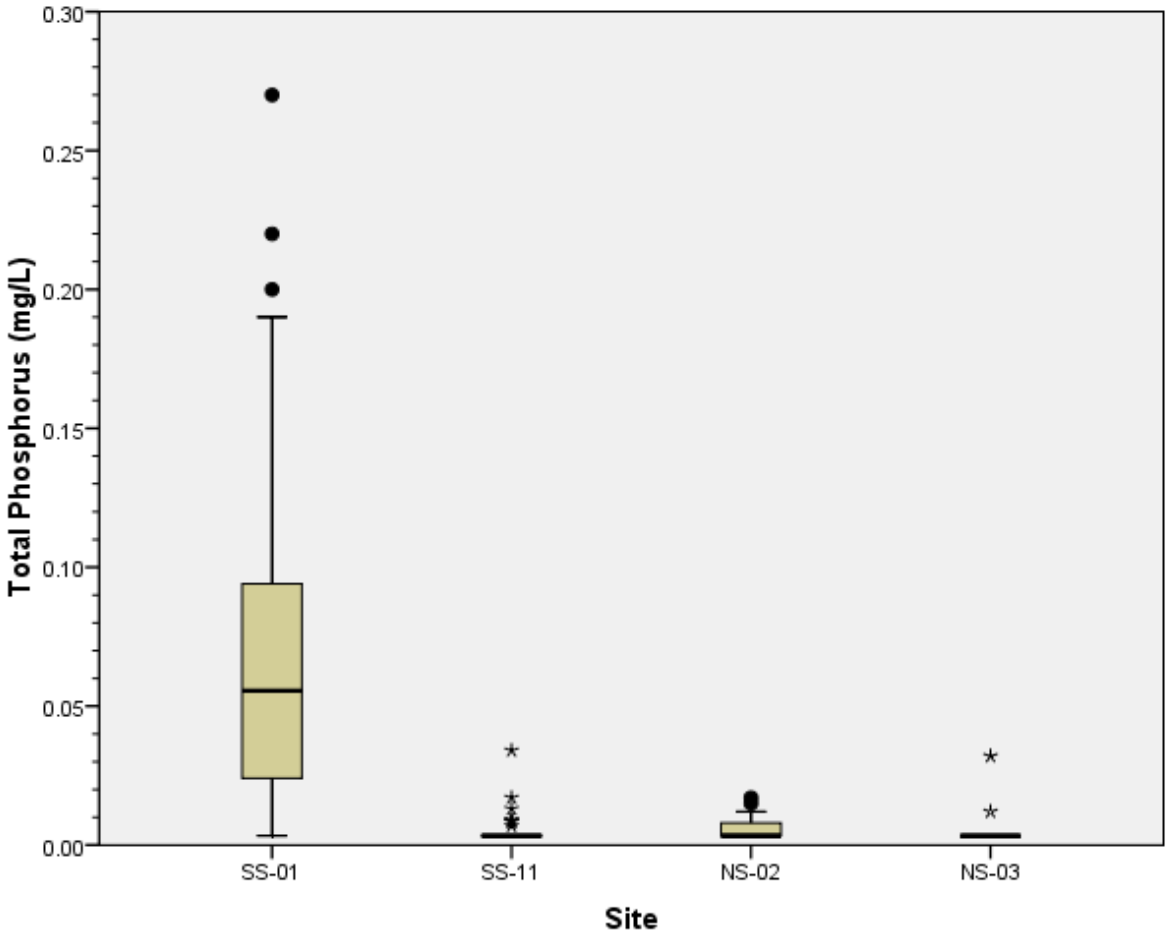


Median	5.4	3.75	3.2	1.8	0.5

Figure 13: 2015 boxplots for total suspended solids for select harbor and open-lake sites. Median values for 2015 are shown below each site.

Annual medians were also calculated for select South Shore (SS) and Nearshore (NS) sites and plotted in a west to east direction (shoreline towards open-lake) with the addition of the South Shore WRF (SS-01) outfall. Without the constraints of a breakwater, the open-lake total phosphorus standard of .007 mg/L applies to all South Shore sampling sites. The distance from the SS-01 to NS-02 is over 2 miles, and NS-03 is nearly 7 miles offshore.

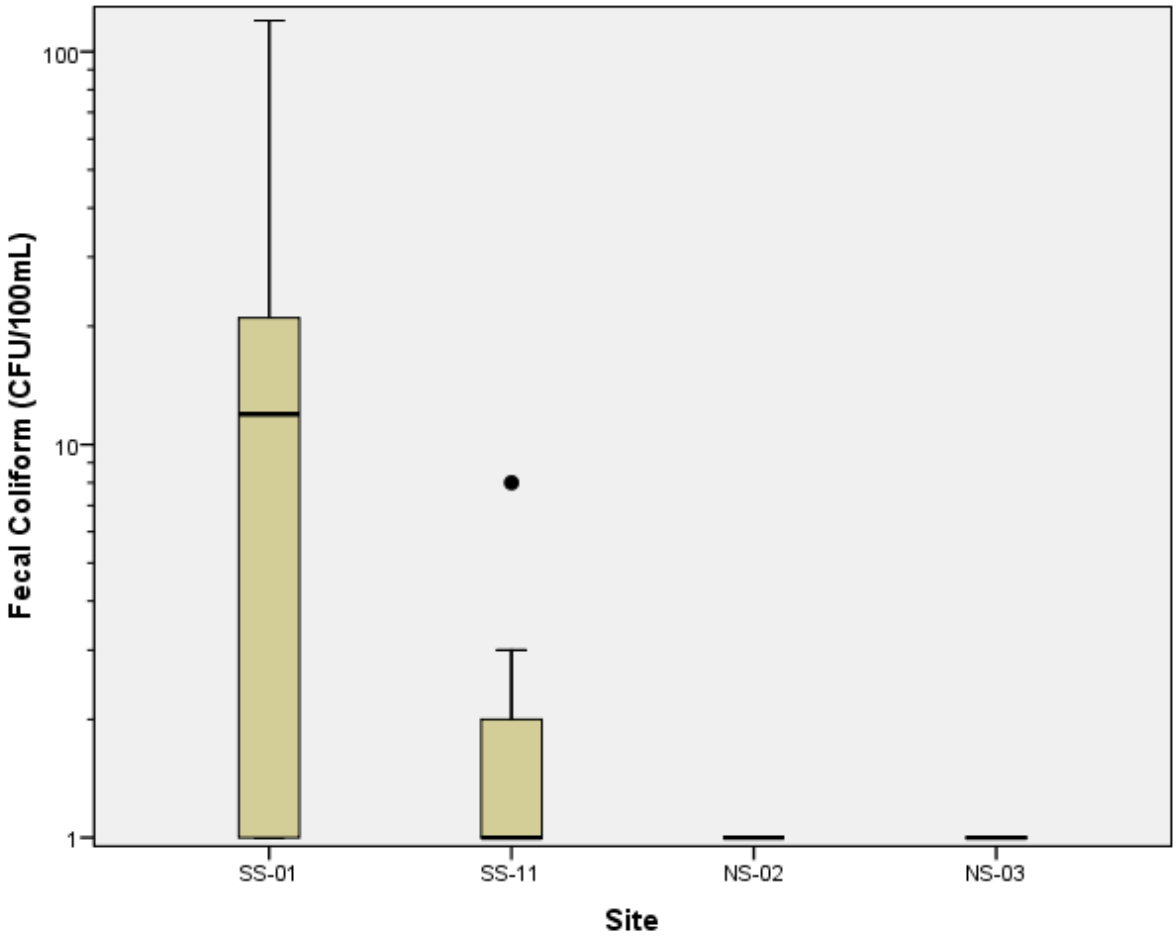
With the exception of the outfall (SS-01), 2015 median values for total phosphorus are very low and are in 100% compliance with the standard (Figure 14). This shows very little impact from the outfall on the surrounding water quality.



Median	0.0555	0.00335	0.00335	0.00335

Figure 14: 2015 boxplots for total phosphorus for select South Shore and open-lake sites. Median values for 2015 are shown below each site.

Fecal coliforms are nearly non-detectable in the water surrounding the South Shore WRF (Figure 15). The 2015 median value for the outfall (SS-01) is very low and the sites away from shore are all below the MDL. All detections at SS-11 are less than 10 CFU/100mL.



Median	12	1	1	1

Figure 15: 2015 boxplots for fecal coliforms for select South Shore and open-lake sites. Median values for 2015 are shown below each site.

Conclusion

This report is designed to summarize approximately 67,000 data points that were collected by the Freshwater Resources Monitoring Department in 2015. Some variables of interest were highlighted in this report, but additional data or analysis can be provided upon request.

The data generated by the District's surface water quality monitoring program have been utilized extensively in-house as well as by other agencies, organizations, and individual citizens. The District's historical database has allowed other public agencies to make informed, defensible decisions regarding Milwaukee's valuable surface water resources. Examples of uses of this data include the MMSD 2020 Facilities Plan (developed by multi-agency and citizen stakeholder committees) and the Regional Water Quality Management Plan (required under the Clean Water Act). This type of long-term, comprehensive information has provided a valuable service to the community by eliminating the need for smaller, more expensive piecemeal projects that would be required each time a specific need for information arises.

Through water quality monitoring, the District has been able to document beneficial changes to the local aquatic environment. Continued tracking of water quality, along with stream restoration activities, will help ensure a healthy aquatic environment and will help retain the beneficial uses of Lake Michigan and Milwaukee-area waterways for the public.

The District's comprehensive surface water quality monitoring program reflects the District's commitment to the improvement and preservation of the community's surface water resources and it should be continued for use in future water resource decisions for the Milwaukee metropolitan area.