Evaluating Beneficial Use: Recreation

F1. Background *(Bacteria)*

Prior to the 2002 Integrated Report (IR), the reporting of recreation use (RU) impairment in Ohio was sporadic. Clean Water Act (CWA) Section 305(b) reports (1998 and earlier) may have included an indication of the potential for RU impairment in various streams, but a comprehensive listing of recreational use impairment was not included. The 2002 IR employed a uniform methodology to examine readily available data on fecal coliform counts. This approach was based on counting the number of exceedances of the secondary contact RU maximum criterion [5,000 colony forming units (cfu)/100 mL fecal coliform or 576 cfu/100 mL *Escherichia coli (E. coli)]*. Any assessment unit with five or more samples over the last five years above these values was listed as having an impaired RU.

The 2004 IR adopted a more statistically robust methodology for assessing the RU attainment of the state's surface waters linked more directly to the applicable water quality standards (WQS). The methodology adopted in 2004 continued to be used through the 2008 IR. The 2008 IR also included a preview of changes anticipated at the time for the 2010 report based on the expectation that the watershed assessment unit (WAU) would change from a larger watershed size (11-digit HUC) to a smaller watershed size (12-digit HUC) and on four anticipated revisions to the water quality standards: 1) dropping the fecal coliform criteria; 2) creation of a tiered set of classes of primary contact recreation waters based on RU intensity; 3) revision of the geometric mean averaging period; and 4) extension of the recreation season. Revisions to the water quality standards pertaining to the RU were adopted on Dec. 15, 2009. The RU assessment method employed in the 2010, 2012, 2014 and 2016 IRs was essentially consistent throughout this time.

A more recent revision to Ohio's water quality standards became effective in January 2016. This revision included updates to the recreational water quality standards to make them consistent with U.S. EPA's November 2012 section 304(a) recommendations. These substantial revisions to Ohio's recreation use WQS included changes to the applicable numeric criteria and a change in the geometric mean averaging period from a seasonal basis to a 90-day period. Furthermore, the tiered set of primary contact recreational use classes adopted in 2010 were collapsed back into a single use as part of these revisions. The revised WQS were approved by U.S. EPA in April 2016. A subsequent revision to Ohio's WQS resulted in the movement of the water quality criteria for the protection of recreational uses from OAC 3745-1-07 to OAC 3745-1-37. The revision that reorganized the content of the WQS became effective in February 2017 and was approved by U.S. EPA in June 2017. The linkage of the assessment methodology to the Ohio WQS is summarized in Table F-1 and detailed in subsequent text.

Table F-1 — Summary of the RU assessment methods.

Bathing Waters		
Indicator	**Criterion (Table 37-2, OAC 3745-1-37)**	**Assessment Method Summary**
E. coli	Geometric mean *E. coli* content* based on samples collected within a 90-day period during the recreation season within a calendar year is 126 cfu/100 mL; statistical threshold value (STV) is 410 cfu/100 mL.	Applied to the four Lake Erie shoreline assessment units and inland lake beaches, exceedance of the geometric mean bathing water criterion or an exceedance of the STV in more than 10 percent of the samples collected during a 90-day period is considered an impairment of the bathing water use, where sufficient data are available**.
Primary Contact and Secondary Contact		
Indicator	**Criterion (Table 37-2, OAC 3745-1-37)**	**Assessment Method Summary**
E. coli	Geometric mean *E. coli* content* based on samples collected within a 90-day period during the recreation season within a calendar year is as follows: Primary Contact Waters 90-day Geometric Mean: 126 cfu/100 mL STV: 410 cfu/100 mL Secondary Contact Waters 90-day Geometric Mean: 1,030 cfu/100 mL STV: 1,030 cfu/100 mL	Applied to streams and inland lake non-beach sites. Data collected within a 90-day period in the recreation season are assessed on a site-by-site basis and compared to the applicable geometric mean and STV *E. coli* criteria whenever sufficient data** are available for the site. Assessment units (AUs) are in full attainment if all sites assessed within the AU meet both the applicable geometric mean and STV criteria and in non-attainment if one or more sites assessed within the AU exceed the applicable geometric mean or STV criteria.

**E. coli* concentrations are expressed in colony forming units (cfu) per 100 milliliters (mL)
** Five or more samples collected within a 90-day period.

F2. Evaluation Method (*Bacteria*)

Lake Erie (Shoreline)

Attainment of the RU designation for the four shoreline Lake Erie assessment units (LEAUs) as delineated in Section D-1 of this report and depicted in Figure D-3 of this report was based upon examination of *E. coli* data from public bathing beaches provided by the Ohio Department of Health (ODH). Routine bacteria monitoring is performed by local health districts, ODH and the Northeast Ohio Regional Sewer District (NEORSD) to monitor bacteria levels at public bathing beaches and advise the public when elevated bacteria are present that represent an increased risk of contracting waterborne illness resulting from exposure to pathogens while recreating in the water. This monitoring takes place at 65 public beaches in Ohio's eight coastal counties. The public can access the ODH Beachguard website to view beach advisory postings and bacteria monitoring data from monitored beaches. The website, available at ***http://publicapps.odh.ohio.gov/BeachGuardPublic/Default.aspx***, is updated daily during the summer recreation season.

Since 2006, beach advisory recommendations have been based upon exceedance of the single sample maximum *E. coli* criterion of 235 cfu/100 mL, consistent with provisions of the 2004 federal Beaches Environmental Assessment and Coastal Health (BEACH) Act rule and the *E. coli* criterion applicable for bathing waters in Ohio's water quality standards. Bacteria data collected by local or state health agencies at public beaches during the recreation season from 2013 through 2017 were included in the analysis. Ohio's water quality standards define the recreation season as May 1 through October 31, though Lake Erie beach monitoring typically is focused between the Memorial Day and Labor Day weekends.

Each of the 22 public beaches that have traditionally been sampled as part of the Lake Erie bathing beach monitoring program (Figure F-1) was individually analyzed to evaluate the percentage of recreation days during which the bathing water beach action value (BAV) of 235 cfu/100 mL was exceeded, since this is the

value used by health departments to post a health advisory at a given beach. The frequency of beach advisory postings is a direct measure of RU impairment, since potential users may be discouraged from utilizing a beach on days when a health advisory is posted or to avoid certain beaches altogether that are prone to frequent advisories. The locations of beaches in Erie and Sandusky Counties are depicted in Figure F-2, while those beaches located in Cuyahoga and Lorain Counties are depicted in Figure F-3.

As of Oct. 1, 2013, there were 169 public access locations in the eight coastal counties along Ohio's Lake Erie coastline. These public access points do not all include a swimming beach, as some are for boat access, fishing access, parks, wildlife viewing areas, etc. The Ohio Department of Natural Resources (ODNR) publishes a *Lake Erie Public Access Guide* available at ***coastal.ohiodnr.gov/gocoast***. This report used data collected from 65 different beaches along the coast as depicted in Figure F-1 through Figure F-3.

The total number of recreation days in a recreation season for each beach was determined by adding the number of days beginning with the first day of sampling and ending with Labor Day, or the date the final sample was collected (whichever was later). The total number of days that a beach exceeded the BAV of 235 cfu/100 mL during the recreation season (as defined above) was tallied. A measured exceedance was assumed to continue until a subsequent sample documented that the BAV was not exceeded. Similarly, a beach was presumed to meet the BAV following a measurement that met the BAV until a subsequent sample was found to exceed the BAV. Sampling frequency varied from year-to-year and from beach-to-beach. A sampling frequency of four times per week was typical, though some beaches were sampled daily while the two beaches in the Lake Erie Islands AU were sampled only once per week.

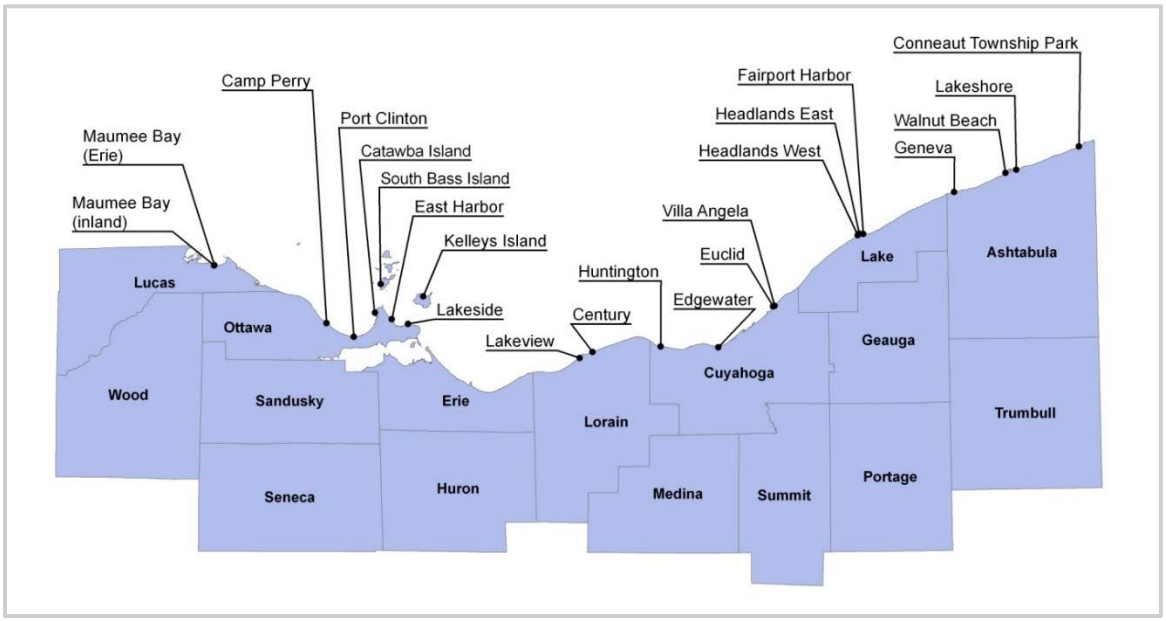

Figure F-1 — Lake Erie public beaches sampled under Ohio's bathing beach monitoring program.

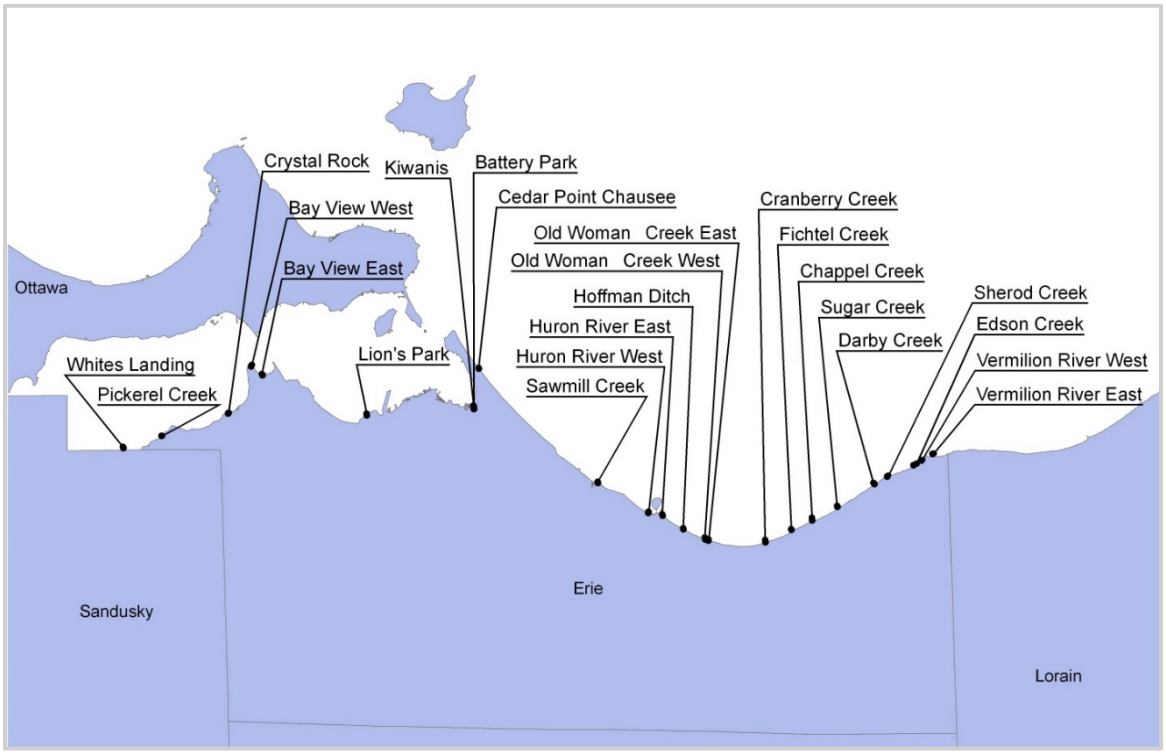

Figure F-2 — Erie and Sandusky County public beaches sampled under Ohio's bathing beach monitoring program.

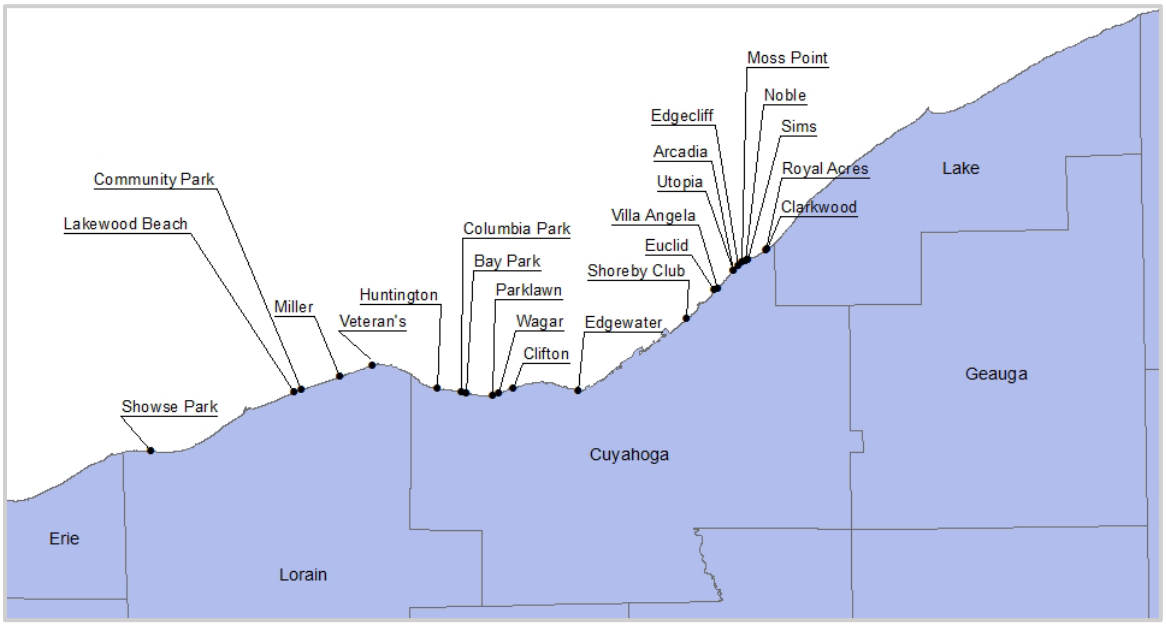

Figure F-3 — Cuyahoga and Lorain County public beaches sampled under Ohio's bathing beach monitoring program.

The exceedance frequency of the bathing water criteria was determined for each beach over a five-year period (2013-2017) on an annual basis. Individual beaches were evaluated for exceedances of both the geometric mean and STV of data collected within 90-day intervals during the recreation season. Results for each individual beach were sorted into the corresponding shoreline LEAU for determining the attainment status of each of the four shoreline LEAUs. The assessment status for each LEAU was based upon whether the frequency of exceedance of the STV was greater than 10 percent for any 90-day period or if the bathing water geometric mean criterion was exceeded within any 90-day period, as described in Table F-2 below.

Table F-2 — Determining assessment status of Lake Erie shoreline AUs.

LEAU Status	Attainment Status of Individual Beaches
Full	Exceedance frequency of the STV is less than 10 percent and the geometric mean is less than 126 cfu/100 ml based on the samples collected within all 90-day intervals during the recreation season for all the beaches in the AU for all years assessed.
Non	Exceedance frequency of the STV is more than 10 percent or the geometric mean is greater than 126 cfu/100 ml based on the samples collected within all 90-day intervals during the recreation season for one or more of the beaches in the AU for one or more of the years assessed.

A 10 percent exceedance frequency was used as the threshold for attainment determination in the last five assessment cycles and has its origins in the WQS applicable at the time as well as Ohio's 1998 *State of the Lake Report* prepared by the Ohio Lake Erie Commission (Ohio LEC 1998). While the stated goal in the *State of the Lake* report for beaches was to have clean beaches all the time (no days under advisement), the report considered having 10 or fewer days under advisement to be excellent (note that 10 days translates to 10 percent of the season based on a 100-day season). The Ohio Lake Erie Commission last published a *State of the Lake Report* (Ohio LEC 2004). That report continued to use these benchmarks in rating the swimmability of Lake Erie beaches along Ohio's 312-mile shoreline. While the 2018 IR continued to track these statistics, which are included in Table F-5 and Table F-6 (pages F-11 through F-13) for individual beaches and further summarized in Table F-7 through Table F-11 (pages F-14 through F-17) and Figure F-5 on page F-16 to provide more detail and allow performance comparisons among individual beaches, the method to determine recreation use status as described above in Table F-2 was revised to reflect the changes to the WQS that became effective in January 2016 (Table F-11).

Rivers and Streams

The 2018 RU impairment list was developed using ambient *E. coli* survey data collected from May 2016 through October 2017 by Ohio EPA as well as from ambient stream data provided by municipal dischargers that were collected at upstream and downstream monitoring stations relative to their primary discharge location as required by their National Pollutant Discharge Elimination System (NPDES) permit and reported in the Surface Water Information Management System (SWIMS) database. *E. coli* data from dischargers, while previously limited in quantity since permits had historically been based on monitoring for fecal coliform, has become more numerous as *E. coli* monitoring has replaced fecal coliform monitoring in most NPDES permits.

Over 2,300 *E. coli* bacteria records were evaluated in this analysis. Data were sorted into their respective 12-digit WAUs and large river assessment units (LRAUs) using a geo-spatial analysis of the latitude/longitude data (and other geographical data if needed) associated with each *E. coli* value. Data within a WAU were further sorted by sampling location and date (calendar year) on which they were collected. Figure F-4 demonstrates the sampling coverage that would be typical for part of a study area. In this case, there are five 12-digit WAUs depicted that drain to one LRAU, the Walhonding River. Each of the five WAUs was sampled in 2010 at one location (depicted by yellow dots) toward the downstream end of the primary tributary in the WAU. Four sampling locations (green dots) are dispersed along the 16-mile stretch of the Walhonding River depicted for an average sampling density of one site per four miles of river length for the Class A primary contact recreation water. Sites were sampled on at least five different occasions over the course the 2010 recreation season, though some sites were sampled more frequently. For example, sample collections on some of the LRAU segments such as the Tuscarawas River and Cuyahoga River in 2017 occurred 10 times. Samples were collected within 90-day sample windows during the recreation season to facilitate data evaluation. RU assessment determinations for rivers and streams

are based on the following two-step process: site-by-site analysis and assessment unit analysis, as described below.

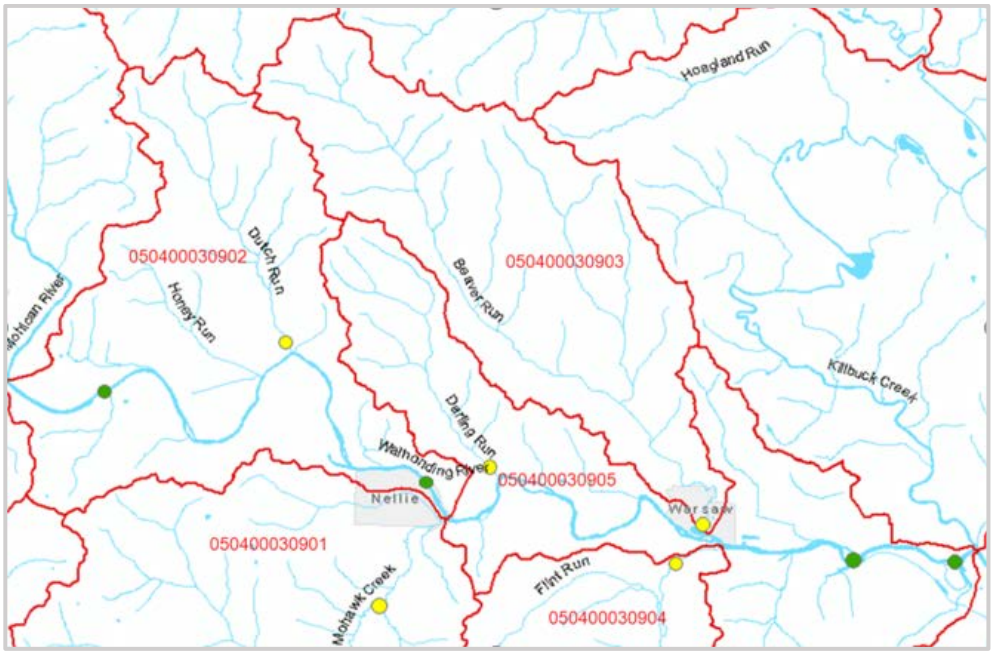

Figure F-4 — Example of bacteria sampling locations, upper Walhonding River study area (2010).

1. Site-by-Site Analysis

E. coli data from each site were compared to the geometric mean *E. coli* criterion and STV. The geometric mean was calculated using the "geomean" function in Microsoft Excel 2016® on a site-by-site basis using the pooled dataset of all *E. coli* data (minimum of five data points required) from the site within a 90-day window during a single recreation season. When data were available for multiple recreation seasons, the data from each season were independently analyzed for each recreation season to determine the 90-day geometric mean for each season. Similarly, comparisons were made of the *E. coli* data to the STV to assess sites where the STV was exceeded in more than 10 percent of the samples collected within a 90-day period. Sites in which either the geometric mean or the STV was exceeded did not fully support the recreation use. Further details are listed as follows:

- Data collected outside of the recreation season as defined in Ohio's WQS (May 1 through October 31) were excluded from the analysis.
- Assessments were only made where there were at least five samples within a 90-day period.
- Certain qualified values, such as sample results that exceeded proper holding time or those that have otherwise been indicated to have significant quality assurance deficiencies, were also excluded from the analysis.
- Values reported as too numerous to count (TNTC) were used in the analysis when it was possible to estimate a value based on the dilutions used and/or the maximum reporting limits.
- Values reported as greater than were also used in the analysis. A geometric mean calculated using one or more greater than or TNTC values in the data set was reported as a greater than geometric mean.
- Values reported as less than values of greater than 50 were excluded since acceptable test methods can detect much lower concentrations when appropriate dilutions are used in the analysis. Values reported as 50 or less were used in the analysis. The value used in statistical analysis was one-half

the reported less than value. A value of one was substituted for computing the geometric mean in any case where a value of less than one was reported. Geometric means cannot be calculated using data sets that contain a value of zero.

- Results from duplicate B were used for calculation of the geometric mean in cases where duplicate sample results were reported, except if the *E. coli* densities of the duplicate samples were more than five times apart from one another, in which case both values were rejected.

2. Assessment Unit Analysis

In the second step of the analysis, the assessment status of the WAU or LRAU was determined based on the attainment status of all the individual sites within the assessment unit and within the assessment period (2013-2017) as described in Table F-3 below.

Table F-3 — Determining assessment status of WAUs and LRAUs.

AU Assessment Status	Attainment Status of Individual Locations
Full (Category 1)	Sufficient data exist to assess at least one location within the WAU (or a minimum of one site for every ~5-7 river miles of a LRAU); the geometric mean criteria and STVs are attained at all assessed sites within the AU
Non (Category 5)	Sufficient data exist to assess at least one location within the WAU (or a minimum of one site for every ~5-7 river miles of a LRAU); the geometric mean or STV is exceeded at one or more assessed sites within the AU
Insufficient Data (Category 3)	No data (category 3) or insufficient data (category 3i) to calculate a geometric mean for any site within the WAU (or for a minimum of one site for every ~5-7 river miles of a LRAU)

Inland Lakes

Inland lakes were assessed in a manner like that described above for the rivers and streams. Inland lake data were analyzed on a site-by-site basis, with each resulting geometric mean value compared to the geometric mean criterion applicable to each site. Lake sampling locations generally included a beach and/or open water sites, with five to 10 samples per location. Inland lakes are considered a component of the AU(s) in which they are geographically located, so sample results from lakes may affect the assessment status of the AU(s) and the index scores for the AU(s).

ODNR, as part of Ohio's Bathing Beach Monitoring Program, monitors *E. coli* levels during the summer at public beaches on lakes located in state parks. While Ohio EPA was unable to establish the level of credibility of these data for use in official listing determinations for this report, a summary of the advisory postings for the 68 beaches monitored in the program is included in Table F-19 on page F-31. Though like the beach monitoring program along Lake Erie, there are several differences. Notably, the sampling frequency is much lower at the inland lake beaches compared to the Lake Erie beaches because of funding disparity. Secondly, because of the large geographic area, beach samples from inland lakes are analyzed by a multitude of consulting laboratories across the state.

RU Attainment Index Score

The RU attainment index score provides a way to compare the relative difference between the *E. coli* concentrations at sites sampled within and between AUs and the RU geometric mean criterion that applies to each of the sampled sites. Those AUs having *E. coli* concentrations that tend to be much greater than the applicable criteria had have the lowest scores, while those AUs having *E. coli* concentrations that attain the applicable criteria, or tend to only slightly exceed the applicable criteria, have the highest scores. An index score was assigned for each site having sufficient data to calculate a geometric mean (five or more samples) by comparing the geometric mean *E. coli* concentration at the site to the applicable geometric mean criterion based on the scale depicted in Table F-4.

Table F-4 — Recreation index score matrix.

Site Geometric Mean	Index Score
Meets criterion	100
Exceeds up to 2x criterion	75
Exceeds more than 2x up to 5x criterion	50
Exceeds more than 5x up to 10x criterion	25
Exceeds more than 10x criterion	0

An average index score is computed for AUs with multiple site index scores based on data from multiple sites and/or recreation seasons. Index scores are reported in Table F-15 on page F-21 for the LRAUs. When only one site index score is available for an AU, that index score is used to represent the assessment unit. The index score for the AU is based upon the same scale as described in Table F-4.

F3. Results (*Bacteria*)

Results for the RU attainment analysis are presented in this section and are based on the methodology outlined in the previous section and available *E. coli* data collected from 65 public beaches along Ohio's Lake Erie 312-mile shoreline (14,721 samples) and at more than 250 locations from Ohio's rivers and streams (2,346 samples) including four of Ohio's largest rivers. Samples used in this analysis were collected from 2013 through 2017 during the recreation season of May 1 through October 31.

F3.1 Lake Erie Public Beaches

Information about water quality conditions at Lake Erie public bathing beaches is summarized in Table F-5 through Table F-11 and Figure F-5. The locations of these beaches are shown in Figure F-1 through Figure F-3. The methodology used for assessing the beaches along Ohio's Lake Erie shoreline was consistent in the 2010, 2012, 2014 and 2016 reports. However, as described in section F2, some modifications to the methods for assessing the Lake Erie beach data were made to accommodate the revisions to the WQS that became effective in January 2016.

Table F-5 contains the seasonal geometric mean *E. coli* levels for 17 public beaches along the coast of Lake Erie's western basin for the past five recreational seasons (2013-2017) while Table F-6 contains the seasonal geometric mean *E. coli* levels for 48 public beaches along the coast of Lake Erie's central basin for the past five recreational seasons (2013-2017).

On a seasonal basis, the geometric mean *E. coli* criterion for bathing waters was exceeded at 22 beaches in 2013; 19 beaches in 2014; 16 beaches in 2015; seven beaches in 2016; and three beaches in 2017. The Bay View West and Lakeview beaches were the only beaches documented to exceed the geometric mean criterion on a seasonal basin each of the past five seasons. Not surprisingly, these beaches and others that frequently exceeded the geometric mean criterion on a seasonal basis had among the most days under a swimming advisory during the 2013-2017 reporting period. Highlighted cells in Table F-5 indicate exceedance of the geometric mean criterion on a seasonal basis or exceedance of the BAV more than 10 percent of season. The table also indicates the number of beach advisories for each beach based upon exceedance of the BAV of 235 cfu/100 mL. This is the threshold that triggers the issuance of beach advisories and has been used since 2006. Use of the BAV to post beach advisories complies with the BEACH Act rule (*Water Quality Standards for Coastal and Great Lakes Recreation Waters*, 69 FR 67217, Nov. 16, 2004), which became effective on Dec. 16, 2004.

In Table F-7 through Table F-11, the beaches are arranged alphabetically according to the LEAU in which they are geographically located. The tables indicate the number of days (and the percentage for all years)

when Ohio's Lake Erie public beaches exceeded the BAV compared to the total number of days in the recreation season sampling period.

As depicted in Figure F-5, the frequency during which individual beaches were under a swimming advisory based on elevated bacteria levels above the advisory level for the entire five-year reporting period (2013-2017) ranged from near zero at Battery Park, East Harbor State Park, Lakeside and South Bass Island State Park to nearly 40 percent or more at Bay View West, Edson Creek, Euclid State Park, Lakeshore Park, Lakeview, Maumee Bay State Park (Erie), Sherod, Sims, Veteran's, Villa Angela State Park and White's Landing beaches. Considerable variation in the frequency of advisories was observed between beaches and from season-to-season at many beaches. However, several beaches stand out as consistently good performers over the past several recreation seasons, including Battery Park, Bay Park, Catawba Island, Conneaut, East Harbor State Park, Kelleys Island, Lakeside and South Bass Island State Park, which all had a cumulative exceedance frequency of less than 10 percent on a seasonal basis. These beaches infrequently exceeded 10 days per season under advisement. There were also several beaches that consistently performed poorly with three beaches, including Bay View West, Edson Creek and Lakeview under advisement more than 50 percent of the time during the past five recreation seasons on a cumulative basis. High variation in bacteria levels was also seen between seasons for some beaches. For example, Kiwanis beach was under advisement for 44 days in 2015, but under advisement for just seven days in 2016. Crystal Rock beach was under advisement for just two days in 2016, but under advisement for 20 days in 2017. The annual median number of days under advisement for all beaches by calendar year in this reporting cycle was highest in 2013 at 28 days compared to the rest of the reporting years, which had a median number of days under advisement ranging from 10-23 on an annual basis. The annual average geometric mean *E. coli* level for all beaches by year within this reporting cycle ranged from a low of 50.7 in 2017 to a high of 112.0 in 2014.

In previous IR cycles, impairment of the bathing water RU was determined by pooling data from beaches in each of the three LEAUs and calculating the percentage of days in the recreational season when the *E. coli* criterion was exceeded. A threshold of impairment was set at 10 days per season based on the Ohio Lake Erie Commission's evaluation system (Ohio LEC 1998). This translates to a seasonal exceedance frequency of 10 percent, as the recreation season at Lake Erie's beaches in Ohio typically runs from Memorial Day weekend through Labor Day weekend. Results are shown in Table F-11. As in previous assessment cycles, the 2018 assessment results indicate that the Lake Erie Islands assessment unit would fully support the RU on a seasonal basis while the Western basin and Central basin assessment units would not support the RU. The overall total recreation days in exceedance of the bathing waters criterion on a percentage basis was 19.7 percent in the western basin (15 beaches) and 25.8 percent (48 beaches) in the central basin compared to just 3.9 percent for the Lake Erie Islands (two beaches).

With the revision of Ohio's WQS effective Jan. 4, 2016, the averaging period was revised from a seasonal basis to a 90-day period. Furthermore, the revised WQS specify that the STV is not to be exceeded in more than 10 percent of the samples taken during any 90-day period. As such, the Lake Erie beach data were examined to ensure that all the beaches in each of the Lake Erie shoreline AUs during the reporting cycle of 2013-2017 also attained both the geometric mean and STV on a 90-day basis rather than the seasonal basis as has historically been done. As historically observed at numerous beaches in both the Western basin and Central basin on a seasonal basis, numerous beaches failed to attain the criteria on a 90-day basis as well (Table F-9). In fact, of the 65 total Lake Erie beaches monitored, only 23 attained the geometric mean criteria every year during the reporting cycle on a 90-day averaging period basis, while only three beaches attained both the geometric mean and STV criteria every year throughout the monitoring cycle, including

Battery Park, Lakeside, and East Harbor State Park. Kelleys Island State Park exceeded the 90-day geometric mean criterion in 2016 (geomean = 151.7 cfu/100 ml) and exceeded the STV in 2013, 2014, 2016 and 2017 with exceedance frequencies ranging from 11 percent up to 20 percent within 90-day periods. The beach on South Bass Island experienced no exceedances of the 90-day geometric mean criterion, but exceeded the STV in 2013, having an exceedance rate of 20 percent within a 90-day period. As such, the Lake Erie Islands assessment unit is no longer in support of the recreational use, joining the other three LEAUs in nonsupport status.

Table F-5 — Seasonal geometric mean *E. coli* levels and advisory postings at public Lake Erie shoreline beaches in the western basin (Sandusky Bay and west).

Beach	2013		2014		2015		2016		2017	
	Seasonal geomean	number of days posted	Seasonal geomean	number of days posted	Seasonal geomean	number of days posted	Seasonal geomean	number of days posted	Seasonal geomean	number of days posted
Battery Park	8	5	5	0	11	4	11	4	7	0
Bay View East	168	35	212	57	94	21	51	18	62	11
Bay View West	367	62	205	57	142	42	542	76	210	50
Camp Perry	42	9	155	14	84	26	125	13	76	19
Catawba Island	13	0	22	9	47	11	20	0	9	2
Crystal Rock	38	9	42	10	43	18	25	2	24	20
East Harbor	13	5	13	0	10	5	6	2	7	3
Kelleys Island	63	14	43	6	36	0	63	0	33	4
Kiwanis	145	25	98	20	141	44	67	7	38	10
Lakeside	17	4	15	1	12	7	8	0	9	4
Lion's Park	123	31	97	19	54	12	65	22	40	10
Maumee - Erie	97	35	105	40	167	45	150	39	122	34
Maumee - Inland	47	11	87	15	92	28	95	29	151	37
Pickerel Creek	53	12	36	10	68	24	33	13	29	13
Port Clinton	96	30	28	17	48	32	21	7	38	13
South Bass Island	10	4	6	0	7	2	18	0	15	0
Whites Landing	362	57	158	36	158	45	136	36	71	22

Shaded cells indicate exceedance of the geometric mean criterion on a seasonal basis *(seasonal geomean)* or exceedance of the BAV more than 10 percent of the time during a season. The beach season is defined for this analysis as the time *E. coli* monitoring commences, typically in late May though the end of the Labor Day weekend. The number of days posted is determined by counting the number of days the BAV was exceeded. Days for which no monitoring data were collected are presumed to be in exceedance if the preceding day's bacteria level exceeded the BAV. Unmonitored days are presumed to meet the BAV when preceded by a monitored day that was below the BAV. NS = Not Sampled.

Table F-6 — Seasonal geometric mean *E. coli* levels and advisory postings at public Lake Erie shoreline beaches in the central basin (east of Cedar Point).

	2013		2014		2015		2016		2017	
Beach	Seasonal geomean	number of days posted	Seasonal geomean	number of days posted	Seasonal geomean	number of days posted	Seasonal geomean	number of days posted	Seasonal geomean	number of days posted
Arcadia	141	34	209	34	279	39	53	4	82	28
Bay Park	31	14	40	2	59	13	45	3	20	4
Cedar Point	40	14	25	14	35	8	20	7	35	11
Century	36	15	61	33	110	34	19	10	43	13
Chappel Creek	137	46	160	50	110	27	53	26	62	19
Clarkwood	258	45	106	16	117	22	79	4	113	23
Clifton	67	25	112	28	49	22	34	11	44	6
Columbia Park	60	9	68	11	105	20	41	6	67	13
Community Park	NS	NS	105	41	108	29	23	16	36	9
Conneaut	52	21	32	8	24	3	28	2	17	4
Cranberry	54	34	40	28	39	20	21	4	21	17
Darby	182	40	242	66	86	30	56	16	72	22
Edgecliff	147	20	203	37	288	37	41	8	88	19
Edgewater	58	17	52	17	80	22	36	11	30	7
Edson	207	54	580	78	193	56	151	14	NS	NS
Euclid State Park	231	51	131	32	152	42	81	27	100	30
Fairport Harbor	83	26	77	23	96	28	44	23	58	20
Fichtel Creek	64	32	37	17	34	15	30	4	18	9
Geneva State Park	64	27	43	16	29	3	17	0	17	2
Headlands East	54	29	49	12	53	18	45	16	46	15
Headlands West	56	24	49	12	56	18	45	16	46	16
Hoffman Ditch	87	24	61	26	60	25	32	9	39	17
Huntington	71	26	52	34	68	30	38	15	36	12
Huron River East	72	29	62	18	57	28	64	33	54	16
Huron River West	119	46	102	38	161	28	75	11	106	33
Lakeshore Park	263	55	197	50	228	33	308	38	55	0
Lakeview	473	70	394	78	248	65	264	53	195	38
Lakewood Park	NS	NS	92	33	84	28	21	13	33	19
Miller Beach	45	14	76	23	82	19	32	10	39	15
Moss Point	140	33	200	30	113	21	113	11	27	4
Noble	131	35	296	37	96	25	80	10	45	6
Old Woman East	32	26	28	15	27	15	14	2	16	3

Beach	2013		2014		2015		2016		2017	
	Seasonal geomean	number of days posted	Seasonal geomean	number of days posted	Seasonal geomean	number of days posted	Seasonal geomean	number of days posted	Seasonal geomean	number of days posted
Old Woman West	59	26	72	24	56	24	18	5	26	3
Parklawn	42	9	46	6	47	9	55	9	21	0
Royal Acres	236	46	124	11	104	13	69	6	126	24
Sawmill Creek	72	30	34	17	42	11	24	11	26	12
Sherod Creek	156	41	217	65	89	49	49	19	67	12
Shoreby Club	68	14	77	9	90	14	13	0	23	2
Showse	62	32	73	33	44	24	22	10	28	13
Sims	214	52	328	32	184	32	227	33	91	21
Sugar Creek	180	58	104	52	60	30	46	12	62	13
Utopia	77	22	104	14	235	34	43	2	54	10
Vermilion East	129	39	109	41	65	26	38	16	52	26
Vermilion West	192	45	192	49	143	46	52	9	51	6
Veteran's Beach	116	40	254	51	198	39	53	28	78	27
Villa Angela	231	55	160	40	231	54	122	39	114	39
Wagar	56	14	44	2	65	16	46	9	29	7
Walnut	29	11	32	15	16	14	22	2	10	2

Shaded cells indicate exceedance of the geometric mean criterion on a seasonal basis *(seasonal geomean)* or exceedance of the BAV more than 10 percent of the time during a season. The beach season is defined for this analysis as the time *E. coli* monitoring commences, typically in late May though the end of the Labor Day weekend. The number of days posted is determined by counting the number of days the BAV was exceeded. Days for which no monitoring data were collected are presumed to be in exceedance if the preceding day's bacteria level exceeded the BAV. Unmonitored days are presumed to meet the BAV when preceded by a monitored day that was below the BAV. NS = Not Sampled

Table F-7 — The number of days per season (and the percentage for all years) when Ohio Lake Erie public beaches exceeded the BAV relative to the total number of days in the sampling period, 2013 – 2017, for the central basin shoreline AU.

Beach	2013	2014	2015	2016	2017	All years (%)
Arcadia Beach	34/97	34/97	39/104	4/97	28/98	139/493 (28.2%)
Bay Park Beach	14/98	2/98	13/105	3/98	4/98	36/497 (7.2%)
Century Beach	15/98	33/106	34/113	10/106	13/106	105/529 (19.8%)
Clarkwood Beach	45/97	16/96	22/104	4/97	23/97	110/491 (22.4%)
Clifton Beach	25/98	28/98	22/105	11/98	6/98	92/497 (18.5%)
Columbia Park Beach	9/98	11/98	20/105	6/98	13/96	59/495 (11.9%)
Community Park Beach	NS	41/106	29/113	16/106	9/106	95/431 (22.0%)
Conneaut Township Park	21/98	8/102	3/92	2/76	4/92	38/460 (8.3%)
Edgecliff Beach	20/97	37/97	37/104	8/97	19/97	112/492 (22.7%)
Edgewater State Park	17/104	17/106	22/109	11/104	7/102	74/525 (14.1%)
Euclid State Park	51/104	32/106	42/109	27/104	33/109	185/532 (34.59%)
Fairport Harbor	26/100	23/102	28/112	23/102	20/106	120/522 (23.0%)
Geneva State Park	27/98	16/106	3/92	0/76	2/92	48/464 (10.3%)
Headlands State Park East	29/100	12/102	18/112	16/106	15/106	90/526 (17.1%)
Headlands State Park West	24/100	12/102	18/113	16/106	16/106	86/527 (16.3%)
Huntington Beach	26/116	34/106	30/113	15/106	12/106	117/547 (21.4%)
Lakeshore Park	55/98	50/102	33/92	38/76	0/92	176/460 (38.3%)
Lakewood Beach	NS	33/106	28/113	13/99	19/106	93/424 (21.9%)
Miller Beach	14/98	23/98	19/105	10/99	15/106	81/506 (16.0%)
Moss Point Beach	33/97	30/97	21/104	11/97	4/97	99/492 (20.1%)
Noble Beach	35/97	37/97	25/104	10/97	6/97	113/492 (23.0%)
Parklawn Beach	9/98	6/97	9/105	9/98	0/98	33/496 (6.7%)
Royal Acres Beach	46/97	11/97	13/104	6/97	24/97	100/492 (20.3%)
Shoreby Club Beach	14/97	9/97	14/104	0/97	2/97	39/492 (7.9%)
Sims Beach	52/97	32/97	32/104	33/97	21/97	170/492 (34.6%)
Utopia Beach	22/97	14/97	34/104	2/97	10/98	82/493 (16.6%)
Veteran's Beach	40/98	51/98	39/105	28/99	27/106	185/506 (36.6%)
Villa Angela State Park	55/104	40/106	54/109	39/104	39/110	227/533 (42.6%)
Wagar Beach	14/98	2/98	16/105	9/98	7/92	48/491 (9.8%)
Walnut Beach	11/98	15/102	14/92	2/76	2/92	44/460 (9.6%)

Table F-8 — The number of days per season (and the percentage for all years) when Ohio Lake Erie public beaches exceeded the BAV relative to the total number of days in the sampling period, 2013 – 2017, for the western basin shoreline AU.

Beach	2013	2014	2015	2016	2017	All years (%)
Camp Perry	9/84	14/64	26/113	13/106	19/106	81/473 (17.1%)
Catawba Island State Park	0/84	9/106	11/113	0/106	2/104	22/513 (4.3%)
East Harbor State Park	5/84	0/106	5/113	2/106	3/106	15/515 (2.9%)
Lakeside	4/84	1/106	7/113	0/106	4/106	16/515 (3.1%)
Maumee Bay State Park (inland)	11/98	15/98	28/105	29/103	37/98	120/502 (23.9%)
Maumee Bay State Park (Erie)	35/98	40/98	45/105	39/103	34/98	193/502 (38.4%)
Port Clinton	30/84	17/106	32/113	7/106	13/106	99/515 (19.2%)

Table F-9 — The number of days per season (and the percentage for all years) when Ohio Lake Erie public beaches exceeded the BAV relative to the total number of days in the sampling period, 2013 – 2017, for the islands shoreline AU.

Beach	2013	2014	2015	2016	2017	All years (%)
Kelleys Island State Park	14/84	6/106	0/111	10/106	4/106	34/513 (6.6%)
South Bass Island State Park	4/84	0/106	2/113	0/106	0/104	6/513 (1.2%)

Table F-10 — The number of days per season (and the percentage for all years) when Ohio Lake Erie public beaches exceeded the BAV relative to the total number of days in the sampling period, 2013 – 2017, for the Sandusky basin shoreline AU.

Beach	2013	2014	2015	2016	2017	All years (%)
Battery Park	5/98	0/106	4/113	0/106	0/106	9/529 (1.7%)
Bay View East	35/97	57/106	21/113	18/106	11/105	142/528 (26.9%)
Bay View West	62/97	57/106	42/113	76/106	50/106	287/528 (54.4%)
Cedar Point Chausee	14/98	14/106	8/113	7/106	11/106	54/529 (10.2%)
Chappel Creek	46/98	50/106	27/113	26/106	19/106	168/529 (31.8%)
Cranberry Creek	34/98	28/106	20/113	4/106	17/106	103/529 (19.5%)
Crystal Rock	9/98	10/106	18/113	2/106	20/106	59/529 (11.2%)
Darby Creek	40/98	66/106	30/113	16/106	22/106	174/529 (32.9%)
Edson Creek	54/98	78/106	56/113	14/45	NS	202/362 (55.8%)
Fichtel Creek	32/98	17/106	15/113	4/106	9/106	77/529 (14.6%)
Hoffman Ditch	24/98	26/106	25/113	9/106	17/106	101/529 (19.1%)
Huron River East	29/98	18/106	28/113	33/106	16/106	114/529 (21.6%)
Huron River West	46/98	38/106	28/113	11/82	33/106	178/505 (35.2%)
Kiwanis	25/98	20/106	44/113	7/106	10/106	106/529 (20.0%)
Lakeview Beach	70/99	78/106	65/113	53/106	38/106	304/530 (57.4%)
Lion's Park	31/98	19/106	12/113	22/106	10/106	94/529 (17.8%)
Old Woman Creek East	26/98	15/106	15/113	2/106	3/106	61/529 (11.5%)
Old Woman Creek West	26/98	24/106	24/113	5/106	3/106	82/529 (15.5%)
Pickerel Creek	12/98	10/106	24/113	13/106	13/106	72/529 (13.6%)
Sawmill Creek	30/98	17/106	11/113	11/106	12/106	81/529 (15.3%)
Sherod Creek	41/98	65/106	49/113	19/106	12/106	186/529 (35.2%)
Showse Park	32/98	33/106	24/113	10/106	13/105	112/528 (21.2%)
Sugar Creek	58/98	52/106	30/113	12/106	13/106	165/529 (31.2%)
Vermilion River East	39/98	41/106	26/113	16/106	26/106	148/529 (28.0%)
Vermilion River West	45/98	49/106	46/113	9/106	6/106	155/529 (29.3%)
Whites Landing	57/98	36/106	45/113	36/106	22/106	196/529 (37.1%)

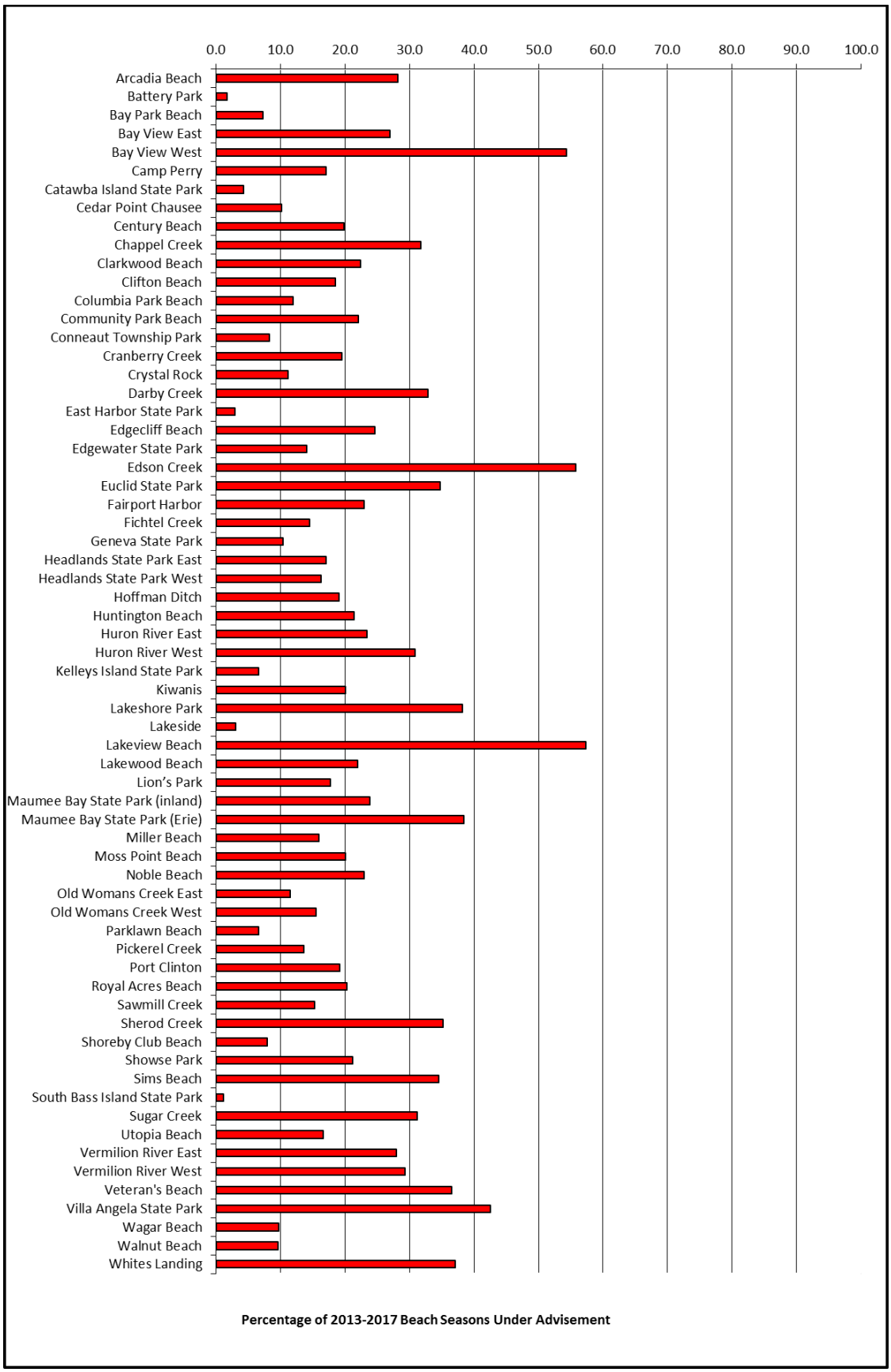

Figure F-5 — Frequency of advisory postings at Ohio's Lake Erie public beaches.

Table F-11 — Aggregated exceedance frequencies at 65 Lake Erie public beaches from 2013-2017 (pooled by Lake Erie shoreline AU to report use support).

	Western Basin	Central Basin	Sandusky Basin	Lake Erie Islands
Number of beaches	7	30	26	2
Total recreation days	3,535	14,857	13,561	1,026
Total days in exceedance	546	3,005	3,426	40
Percentage of days in exceedance	15.4%	20.2%	25.3%	3.9%
Total beach seasons[1]	35	148	129	10
Average # of days *E. coli* BAV exceeded per beach per season[2]	15.6	20.3	26.6	1.0
Number of beaches exceeding 90-d geomean one or more years during reporting cycle[3]	5	22	14	1
Number of beaches exceeding STV within a 90-day period in one or more years during the reporting cycle[3]	5	30	25	2
Attainment status	Does not support	Does not support	Does not Support	Does not Support

[1] The total number of beach seasons in a basin is equal to aggregated sum of the total number of beaches for which monitoring was conducted during each season for the 2013-2017 reporting period.
[2] Calculated by dividing the total days in exceedance in the basin by the total number of beach seasons in the basin.
[3] Used to determine attainment status.

F3.2 Rivers and Streams

Ohio's RU support analysis is based on an examination of *E. coli* data collected from Ohio's rivers, streams and inland lakes during the recreation season. Approximately 2,346 bacteria measurements were evaluated for the 2018 RU support analysis of streams, rivers and inland lakes in Ohio. This is down sharply from the 2016 assessment, in which 18,400 bacteria measurements were used. The primary reason for this decline was the revision of the recreational water quality standards, which now expresses the applicable criteria over a 90-day period rather than the entire recreation season (May 1-October 31) combined with the minimum data requirement of at least five or more samples to make an assessment starting with this reporting cycle. As a result, data from 2013-2015 were not useable for this reporting cycle. Assessments made based on data from 2013-2015, as well as data collected prior to 2013 are all considered historic. Therefore, assessments for this cycle consist of data collected by Ohio EPA in 2016 and 2017 and any discharger data from these years where there were five or more samples collected within a 90-day period. In anticipation of the revisions to the Ohio WQS as described above, Ohio EPA revised its bacteria sampling strategy beginning with the 2016 field season to collect data that would facilitate the recreational assessment of WAUs and LRAUs contained in the 2016 study areas. This transition was successfully executed and repeated in the 2017 field season resulting in data used to support the updates reported in this IR cycle. Data collected in subsequent field seasons will be consistent with this approach to support the recreational assessments for 2020 reporting cycle, which will be based on data collected from 2016 through 2019.

In the 2016 report, approximately 60 percent of the data used came from NPDES dischargers while the remaining 40 percent came from data collected by Ohio EPA. In the 2018 report, relatively little data came from NPDES dischargers. While much of the data collected from NPDES dischargers was useful for RU assessment purposes in previous IR cycles when the WQS were based on a seasonal averaging period, the *E. coli* data collection frequency is generally too dispersed across the recreation season and too infrequent to support its usage in the 2018 IR given the minimum data requirements and the new 90-day averaging

period. In this report, approximately 20 percent of the data are from NPDES dischargers while the remaining 80 percent was generated by Ohio EPA.

Table F-12 provides a summary of Ohio EPA's RU monitoring effort and its translation to use assessment annually for the past seven recreation seasons. Sample collection in the 2016-2017 biennium was down by about one-third compared to the previous biennium.

Table F-12 — Annual Ohio EPA *E. coli* sampling effort and RU assessment (using Ohio EPA data) in Ohio streams, rivers and inland lakes, 2011-2017 recreation seasons.

	2011	2012	2013	2014	2015	2016	2017
Number of samples collected by Ohio EPA	1,674	1,173	1,635	1,423	1,231	926	900
Number of site geometric means computed	276	219	269	222	219	119	137
Number of unique WAUs assessed	130	92	131	121	115	83	73
Number of unique LRAUs assessed	3	5	2	1	0	1	5

The *E. coli* data used in this report collected by Ohio EPA staff was typically collected as part of routine ambient monitoring associated with annual drainage basin surveys conducted around the state. Using the methodology described in Section F2, it was possible to determine the RU attainment status of 164 of the 1,538 (11 percent) WAUs in Ohio based on current data (2016-2017). This figure includes those WAUs in which data were collected between 2016 and 2017, regardless of the category of the AU. Ohio has completed total maximum daily loads (TMDLs) for bacteria in 449 of the 1,538 WAUs in Ohio (29 percent), unchanged from the previous IR cycle. As previously estimated, Ohio's sampling effort will be sufficient to maintain a current assessment status for less than half of the WAU's in Ohio. In fact, the estimate is closer to 40 percent if the sampling effort from 2016 and 2017 becomes representative of future sampling effort.

The overall attainment and impairment rates and the changes between reporting years are summarized in Table F-13. Attainment and impairment rates in Table F-13 are based on the total number of watersheds for which sufficient data were available in the respective reporting cycle and not on the total number of assessment units in the state. For the 170 assessment units having sufficient data available to determine the RU assessment status in 2018, eight percent fully supported the use while 92 percent did not support the use. These results are comparable to the results from previous cycles that consistently show only a relatively small proportion of the state's watersheds demonstrate full support of the RU. Only 15 percent of the individual stream locations sampled by Ohio EPA in 2015 and 2016 were found to attain the applicable recreation criteria.

Table F-13 — Overall differences in the assessment of RU attainment, 2010-2018.

	2010 Report		2012 Report		2014 Report		2016 Report		2018 Report	
	No.	%	No.	%	No.	%	No	%	No	%
Total AUs[a]	1,576	100	1,576	100	1,576	100	1,576	100	1,576	100
Assessed	487	31	588	37	680	43	713	45	170	11
Not Assessed	1,089	69	988	63	896	57	863	55	1,406	89
Supporting Use[b]	65	13	88	15	130	19	73	10	14	8
Not Supporting Use[b]	422	87	500	85	550	81	640	90	156	92

[a] Includes LRAUs.

[b] Note: The percentage of AUs reported as supporting the RU and not supporting the RU are based on the total AUs that were assessed (e.g., 187 in the 2018 analysis).

RU Attainment Index Score

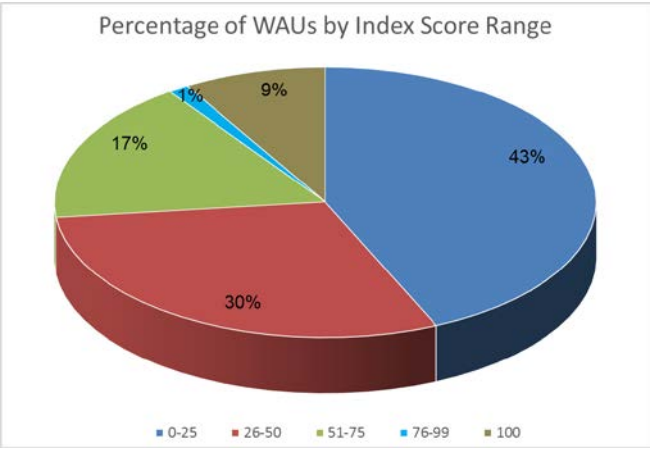

Figure F-6 — Histogram of RU index scores for Ohio's WAUs

Since assessment units can often be composed of monitoring sites having a range of *E. coli* geometric means and the range of impairment can be wide between assessment units, an RU index was developed to provide some differentiation between those assessment units composed of monitoring sites that greatly exceed the criteria versus those where exceedances are comparably low. The index scores also serve as a useful tool in the TMDL prioritization process (see Section J for more details). Index scores were only assigned to those assessment units for which sufficient *E. coli* monitoring data were available to assess the RU support as described in Section F2. Index scores range from 0-100 depending on the magnitude of exceedance of the site(s) from the applicable criterion within the AU. An index score of 100 indicates that all sites sampled within the AU fully attained the applicable geometric mean *E. coli* criterion, while lower scores indicate a progressively greater average level of exceedance from the criteria for monitored sites within the AU. Figure F-6 summarizes the index scores for the WAUs. The median WAU index score for the 2016 reporting cycle slipped to 63, slightly lower than the median WAU index score of 70 for the 2014 reporting cycle and very similar to the medians of 63 and 65 for the 2012 and 2010 reporting cycles, respectively. This underscores the observation that most sites assessed fail to meet the geometric mean by a significant margin, as opposed to narrowly missing the mark.

The RU attainment status of Ohio's 1,538 WAUs is summarized in Table F-14. This table differs slightly from the summary presented in Table F-13 as this table accounts for those watersheds for which TMDLs have been completed and placed into category 4A and it also includes historic categorizations carried over from previous reporting cycles. WAUs attaining the recreational WQS appear to have leveled off at around 10 percent while WAUs for which a TMDL has been completed have also held steady at just under 30 percent. WAUs not supporting the recreation use, and in need of a TMDL, increased to 50 percent. The number of WAUs that have never been assessed for recreational use attainment fell to just 12 percent. Bacteria data collected in support of the past five IR cycles clearly shows that the swimmable goal of the CWA is largely unsupported across Ohio with very little improvement evident in the data. Because of the ubiquitous nature of the problem, a statewide TMDL followed by more intense and substantial focus on implementation activities in cooperation with local partners to identify and address bacteria loading sources could be a logical option in moving more of the WAUs toward attainment goals. This should be coupled with continued monitoring to measure success.

Table F-14 — Summary assessment status of the RU in Ohio's WAUs by Assessment Cycle[1].

Assessment Category	Number of Assessment Units Categorized					Percentage of Assessment Units Categorized				
	2010	2012	2014	2016	2018	2010	2012	2014	2016	2018
1	59	103	141	153	141	4%	7%	9%	10%	9%
3	888	673	511	252	182	58%	44%	33%	16%	12%
4	266	341	425	449	449	17%	22%	28%	29%	29%
5	325	421	461	685	766	21%	27%	30%	45%	50%
Total	1,538	1,538	1,538	1,538	1,538	100%	100%	100%	100%	100%

In addition to Ohio's 1,538 WAUs, there are also 23 large rivers in Ohio, eight of which are further divided into two or more subdivisions for a total of 38 large river assessment units. Large river assessment units have drainage areas greater than 500 square miles and comprise, in total, 1,236 river miles in the state. The large river assessment units were analyzed independently of the WAUs through which they flow and LRAU data were not included in WAU assessments. Table F-15 summarizes the results of the analysis of *E. coli* data for the large river assessment units and the resulting RU support determinations and index scores. Sufficient data were available to determine the use support status for just six of the 38 LRAUs (16 percent) in the 2018 reporting cycle. While this appears to be less compared to the 2016 cycle (17 of 38 LRAUs or 45 percent) and the 2014 cycle (16 of 38 LRAUs or 42 percent), the assessments for this cycle are based on data collected over a two-year period, compared to five years for the 2014 and 2016 cycle. Projecting the 2016-2017 sampling effort over a five-year period would result in 15 of 38 LRAUs assessed or 39 percent, which would be similar to the two previous report cycles.

The six LRAU subdivisions evaluated in this cycle had an average spatial sampling frequency ranging from 1.8 to 7.5 stream miles. All six of the LRAUs evaluated in this cycle failed to support the recreation use. However, two of the lower Tuscarawas River segments came close, with one scoring a 94 and another having an index score of 82. It should be noted that the Huron River mainstem, although not an LRAU, was also documented to fully support the recreation use.

[1] See Section J for assessment category descriptions.

Table F-15 — Summary assessment status of the RU in Ohio's LRAUs.

LRAU	Length (miles)	Number Sampling Stations	Avg Length per station (miles)	Index Score	Assess. Category	Last Assess.
Auglaize River – Ottawa River to the mouth	12.86	0	n/a	n/a	1h	2012
Blanchard River – Dukes Run to the mouth	35.65	0	n/a	n/a	3	2005
Cuyahoga River – Brandywine Creek to the mouth	25.34	14	1.8	48	4Ax	2017
Grand River – Mill Creek to the mouth	41.28	0	n/a	n/a	4Ah	2004
Great Miami River – Tawawa Creek to Mad River	48.93	0	n/a	n/a	5h	2009
Great Miami River- Mad River to Fourmile Creek	43.10	0	n/a	n/a	5h	2010
Great Miami River – Fourmile Creek to the mouth	38.38	0	n/a	n/a	5h	2010
Hocking River – Scott Creek to Margaret Creek	32.58	0	n/a	n/a	5h	2004
Hocking River – Margaret Creek to the mouth	36.38	0	n/a	n/a	5h	2004
Licking River	23.21	0	n/a	n/a	5h	2008
Little Miami River – Caesar Creek to O'Bannon Cr.	26.92	0	n/a	n/a	4Ah	2007
Little Miami River – O'Bannon Creek to the mouth	24.00	0	n/a	n/a	4Ah	2007
Mad River – Donnels Creek to the mouth	18.38	0	n/a	n/a	5h	2003
Mahoning River – Eagle Cr. to Pennsylvania border	35.39	0	n/a	n/a	5h	2013
Maumee River – Indiana state border to Tiffin R.	42.11	0	n/a	n/a	5h	2012
Maumee River – Tiffin River to Beaver Creek	34.44	0	n/a	n/a	5h	2012
Maumee River – Beaver Creek to Maumee Bay	31.32	0	n/a	n/a	5h	2012
Mohican River	27.58	0	n/a	n/a	5h	2007
Muskingum River – Walhonding River to Licking R.	34.94	0	n/a	n/a	5h	2006
Muskingum River – Licking River to Meigs Creek	46.78	0	n/a	n/a	5h	2006
Muskingum River – Meigs Creek to the mouth	29.42	0	n/a	n/a	5h	2006
Paint Creek – Paint Creek Lake dam to the mouth	39.17	0	n/a	n/a	5h	2006
Raccoon Creek – Little Raccoon Creek to the mouth	37.55	5	7.5	40	5	2016
Sandusky River – Tymochtee Creek to Wolf Creek	43.00	0	n/a	n/a	4Ah	2009
Sandusky River – Wolf Creek to Sandusky Bay	22.73	0	n/a	n/a	4Ah	2009
Scioto River – Little Scioto River to Olentangy River	32.70	0	n/a	n/a	3i	2009
Scioto River – Olentangy River to Big Darby Creek	31.42	0	n/a	n/a	5h	2011
Scioto River – Big Darby Creek to Paint Creek	37.30	0	a/n	n/a	5h	2011
Scioto River – Paint Creek to Sunfish Creek	36.68	0	n/a	n/a	1h	2011
Scioto River – Sunfish Creek to mouth	26.82	0	n/a	n/a	3	2011
Stillwater River – Greenville Creek to the mouth	32.38	0	n/a	n/a	5h	2013
Tiffin River – Brush Creek to the mouth	19.67	0	n/a	n/a	5h	2013
Tuscarawas River – Chippewa Creek to Sandy Cr.	30.12	6	5.0	54	5	2017
Tuscarawas River – Sandy Creek to Stillwater Cr.	26.05	7	3.7	82	5	2017
Tuscarawas River – Stillwater Creek to mouth	47.05	9	5.2	94	5	2017
Walhonding River	23.19	0	n/a	n/a	1h	2010
Whitewater River – Indiana border to the mouth	8.26	3	2.8	58	5	2017
Wills Creek – Salt Fork to the mouth	44.06	0	n/a	n/a	5h	2014
Legend						
Last assessed in:	2017-2013		2012-2008		2007-2003	
Number LRAU Segments	10		16		12	
Percent LRAU Segments	26%		42%		32%	

F3.3 Inland Lakes

Data availability for inland lakes is relatively limited compared to that for streams and rivers. A total of 424 samples were collected from 50 different lakes in the period 2013-2017. Lakes were typically sampled at an open water location (L-1), with some larger lakes sampled at multiple open water locations (L-2, L-3). Samples were also collected at beach locations for those lakes having a swimming beach. Samples were also sometimes collected at other locations of interest, such as boat ramps, marinas and water supply intakes. The revision of the recreational WQS that became effective on Jan. 4, 2016, revised the averaging period from seasonal to 90 days. As a result, *E. coli* monitoring has largely been dropped as part of the routine inland lakes sampling by Ohio EPA because the collection of five samples within the 90-day window is not compatible with the primary mission of inland lake sampling, which is assessment of the trophic condition of the lake. Ohio EPA's sampling of inland lakes normally occurs monthly during the warmer months of the year. ODNR maintains a sampling program at state park beaches described later in this section. Additional details on the inland lakes sampling program can be found on Ohio EPA's webpage at: ***epa.ohio.gov/dsw/inland_lakes/index.aspx***.

Table F-18 summarizes the *E. coli* data collected at inland lakes at selected sample locations. These data were not included as part of the assessment of the WAUs since sufficient sample collections did not occur within the 90-day averaging period, but they are reported to provide some indication of the performance at individual lakes. As in the past, geometric means were generally found to be very low both at open water locations and at beach or other locations sampled. Based on the geometric means, the inland lakes sampled in 2013-2017 were below the geometric mean of 126 cfu/100 mL at all locations sampled, although it is notable that bacteria levels were observed to occasionally spike above the 235 *E. coli*/100 mL water single sample criterion typically used as the threshold for posting a swimming advisory at a beach.

Table F-16 — Summary assessment status of the RU for inland lakes, 2013-2017.

Lake		Sample Location	Sample Year	Number of Samples	Geometric Mean	Maximum Value
Alum Creek	L-1	Open Water	2013	5	11	20
		Open Water	2014	5	24	60
	L-2	Open Water	2014	4	40	290
Amann Reservoir		Open Water	2016	5	12	30
Amicks Reservoir		Open Water	2016	5	10	10
Archbold Reservoir #3		Open Water	2013	5	3	6
		Open Water	2014	5	4	16
Atwood Lake	L-1	Open Water	2016	5	7	32
	L-2	Open Water	2016	3	1	2
	L-3	Open Water	2016	3	3	8
	L-4	Open Water	2016	4	10	740*
Barberton Reservoir	L-1	Open Water	2016	4	4	11
	L-2	Open Water	2016	4	3	6
	L-3	Open Water	2016	4	6	20
	L-4	Open Water	2016	4	124	360
Barton Lake		Open Water	2013	5	2	3
		Open Water	2014	5	5	130
Bucyrus Reservoir #4		Open Water	2016	5	10	10
Cambridge Reservoir		Open Water	2014	5	13	40
		Open Water	2015	4	7	5
Clendening Reservoir		Open Water	2013	5	10	10
Coe Lake		Open Water	2014	4	23	91
		Open Water	2015	4	14	72
Cutler Lake		Open Water	2017	5	11	20

Lake		Sample Location	Sample Year	Number of Samples	Geometric Mean	Maximum Value
Delaware Lake		Open Water	2016	5	30	560*
Delta Reservoir		Open Water	2015	5	2	2
Delphos Reservoir		Open Water	2014	5	2	8
		Open Water	2015	4	2	15
Evans Lake		Water Intake	2013	4	11	50
Findley Lake		Open Water	2013	4	4	14
		Beach	2013	4	18	120
Forked Run Lake		Open Water	2015	7	16	50
		Open Water	2016	5	18	50
Hoover Reservoir	L-1	Open Water	2013	4	32	500*
		Open Water	2014	5	23	200
	L-3	Open Water	2014	4	34	450*
Jackson Lake		Boat Ramp	2016	3	25	40
		Open Water	2016	2	205	300
Lake Alma		Boat Ramp	2016	3	62	180
		Open Water	2016	2	10	10
Lake Hamilton		Water Intake	2013	3	8	69
Lake Hope		Open Water	2016	5	12	30
Lake Rupert		Boat Ramp	2016	3	10	10
		Open Water	2016	2	10	40
Lake Waynoka		Open Water	2016	4	4	11
		Beach	2016	4	10	43
Leesville Lake	L-1	Open Water	2016	5	1	4
	L-2	Open Water	2016	5	1	2
	L-3	Open Water	2016	4	1	3
McKelvey Lake		Water Intake	2013	4	9	28
McKarns Lake		Open Water	2013	5	2	3
		Open Water	2014	5	2	2
Meander Reservoir		Water Intake	2013	5	6	15
Mosquito Creek Reservoir	L-1	Open Water	2013	4	9	30
		Open Water	2014	3	4	21
	L-2	Open Water	2013	4	4	5
		Open Water	2014	5	4	21
	L-3	Open Water	2013	4	5	10
		Open Water	2014	4	4	10
	Dam	Open Water	2013	3	83	230
		Open Water	2014	4	23	190
Nettle Lake		Open Water	2013	5	3	8
		Open Water	2014	5	5	10
New Concord Reservoir		Open Water	2014	5	12	30
		Open Water	2015	5	8	10
Norwalk Reservoir		Open Water	2016	3	7	20
Piedmont Reservoir		Open Water	2013	6	10	10
		Essex Bay	2013	5	14	30
Salt Fork Lake	L-1	Open Water	2014	6	22	100
		Open Water	2015	5	31	350
	L-2	Open Water	2014	6	10	10
		Open Water	2015	5	11	20
Senecaville Lake		Open Water	2014	6	13	50
		Open Water	2015	4	26	40
Stonelick Reservoir		Open Water	2013	5	28	5,820*

Lake	Sample Location	Sample Year	Number of Samples	Geometric Mean	Maximum Value
Summit Lake	Open Water	2013	7	33	96
Timber Ridge Lake	Open Water	2017	5	10	10
Tappan Lake	Open Water	2013	5	11	20
	Beach	2013	4	24	80
Tycoon Lake	Boat Ramp	2016	3	10	10
Van Wert Reservoir #2	Open Water	2014	5	2	5
	Open Water	2015	4	7	140
Veto Lake	Open Water	2015	3	15	70
		2016	5	21	110
Veto Lake-Plum Run Arm	Open Water	2015	8	59	2,500*
Wallace Lake	Open Water	2014	4	33	110
	Open Water	2015	2	30	37
Waynoka Lake	Open Water	2015	5	6	28
	Beach	2015	3	18	44
Wellington Reservoir	Boat Ramp	2013	4	14	49
	Open Water	2013	5	2	6
Wills Creek Reservoir	Open Water	2014	5	25	100
	Open Water	2015	3	37	130
Winton Lake	Campground	2013	5	40	326
	Campground	2014	5	43	1,120*
Woodsfield Reservoir	Open Water	2016	5	25	200

*Value exceeds the STV of 235 cfu/100mL.
**Value exceeds the geometric mean bathing water criterion of 126 cfu/100mL.

ODNR's Division of Parks and Recreation also conducts routine bacteria sampling of public bathing beaches at inland state park beaches pursuant to Ohio Revised Code sections 1541.032 and 3701.18. Advisory signs are posted whenever notified by the director of the Ohio Department of Health that the bacteria levels in the waters tested present a possible health risk to swimmers. Advisory postings are recommended whenever the *E. coli* density of a water sample exceeds the bathing water BAV of 235 cfu/100 mL. Sampling frequency at the inland state park beaches is generally once every two weeks. This sampling frequency is much less intense compared to sampling frequency at many of the Lake Erie beaches, which typically occurs at a frequency of four or more days per week.

Table F-17 summarizes the advisory postings from 2013 through 2017 at 51 of the state's inland state park beaches. Beaches at which more than 10 percent of the samples collected over a recreation season exceeded the BAV of 235 cfu/100 mL are highlighted. The inland lake data from ODNR are presented in the IR for informational purposes and not for official use support determinations since the level of data credibility was indeterminate at the publication of this report. Its inclusion here is intended to notify readers of the existence of this sampling program for these popular recreational resources in Ohio and to provide some information as to the relative amount of data and relative water quality conditions with respect to bacteria indicators. Should Ohio EPA affirm the data as Level 3 credible data in the future, it will be considered in the process for making official use support determinations.

Table F-17 — Swimming advisory postings at Ohio's inland lake public beaches (2013-2017).

Park	Beach	County	2013[a]	2014[a]	2015[a]	2016[a]	2017[a]	Total[a]
Alum Creek	Main	Delaware	2/10	3/10	2/9	2/10	3/11	12/50
	Camp	Delaware	0/9	2/10	1/8	0/8	0/8	3/43
Atwood Lake		Carroll	--	--	--	17/44	3/28	20/82
Barkcamp		Belmont	1/8	0/8	0/12	0/9	0/7	1/44
Blue Rock		Muskingum	0/8	2/10	2/10	4/10	0/7	8/45
Buck Creek	Main	Clark	8/51	0/8	1/9	2/9	0/8	11/85
	Camp	Clark	0/5	0/9	0/8	0/7	0/8	0/37
Buckeye Lake	Crystal Beach	Fairfield	3/8	10/15	3/4	0/1	5/7	21/35
	Fairfield Beach	Fairfield	0/8	8/14	3/4	--	2/7	13/33
	Brooks Park	Fairfield	8/12	8/14	3/3	--	--	19/29
Burr Oak	Main	Athens	0/9	0/7	1/10	0/9	0/8	1/43
	Lodge	Athens	--	--	0/4	0/2	--	0/6
Caesar Creek	North	Warren	0/7	0/8	3/11	1/9	0/8	4/43
	South	Warren	6/10	3/9	1/11	3/9	4/10	17/49
Charles Mill Lake		Ashland	--	--	--	0/1	7/23	7/24
Cowan Lake	Main (S)	Clinton	0/7	0/8	2/11	0/7	0/8	4/42
	Camp (N)	Clinton	0/7	1/9	1/10	0/7	0/8	2/41
Deer Creek		Pickaway	0/8	0/8	0/10	0/7	5/10	5/41
Delaware		Delaware	0/6	2/7	3/9	4/10	3/10	6/36
Dillon		Muskingum	4/10	5/12	6/11	1/9	4/10	20/52
East Fork	Main	Clermont	0/14	0/7	0/16	0/15	2/16	2/68
	Camp	Clermont	0/14	0/10	0/16	0/15	--	0/55
Findlay		Lorain	0/6	0/8	0/9	0/8	0/5	0/36
Forked Run		Meigs	0/8	0/7	2/12	1/7	1/7	4/41
Grand Lake St. Marys	Main East	Auglaize	1/7	2/10	2/9	3/9	0/9	8/44
	Main West	Auglaize	4/8	4/11	3/11	2/9	0/9	13/48
	Camp	Auglaize	1/7	3/10	1/9	4/11	3/10	12/47
	Windy Point	Auglaize	2/8	1/9	4/10	2/8	2/9	11/44
Guilford Lake	Main	Columbiana	1/7	1/8	0/7	0/6	0/8	2/36
	Camp	Columbiana	0/7	1/8	0/7	0/6	1/8	2/36
Harrison Lake		Fulton	0/3	1/9	1/10	2/9	1/8	5/39
Hueston Woods		Preble	1/12	2/13	1/9	0/8	0/8	4/50
Indian Lake	Fox Island	Logan	0/7	0/3	0/9	2/10	1/9	3/38
	Camp	Logan	0/7	0/3	1/9	0/8	2/9	3/36
	Oldfield	Logan	1/8	0/3	1/9	0/8	0/8	2/36
Jackson Lake		Jackson	1/6	1/9	2/10	2/8	1/8	7/41
Jefferson Lake		Jefferson	0/6	1/9	1/8	0/8	0/8	2/39
Kiser Lake		Champaign	0/7	2/8	2/9	1/9	1/8	6/41
Lake Alma	#1-West	Vinton	0/7	1/9	0/6	0/8	0/8	1/38
Lake Hope		Vinton	2/8	0/7	0/8	0/8	1/8	3/39
Lake Logan		Hocking	0/8	1/11	0/8	0/7	3/11	4/45
Lake Loramie		Shelby	2/10	1/7	5/12	3/11	1/10	12/50
Lake Milton		Mahoning	0/5	2/11	0/8	1/9	0/6	3/39
Lake White		Pike	0/7	0/7	--	--	--	0/14
Madison Lake		Madison	1/7	1/9	6/12	5/11	5/10	18/49
Mosquito		Trumbull	3/8	0/7	3/9	2/7	0/8	8/39
Munroe Falls		Summit	--	--	--	0/10	--	0/10
Paint Creek		Ross	0/7	1/8	0/8	1/9	1/8	3/40
Pike Lake		Pike	1/8	--	2/7	3/9	7/11	13/35
Pleasant Hill		Richland	--	--	--	0/1	0/24	0/25

Park	Beach	County	2013[a]	2014[a]	2015[a]	2016[a]	2017[a]	Total[a]
Portage Lakes	Main	Summit	0/8	0/8	1/9	2/10	0/8	3/43
	Camp	Summit	0/8	0/8	1/ 4	--	--	1/20
Punderson		Geauga	0/1	0/5	0/7	0/8	1/8	1/29
Pymatuning	Main	Ashtabula	2/9	--	0/7	1/6	1/9	4/31
	Camp	Ashtabula	0/8	--	1/7	0/6	0/9	1/30
	Cabins	Ashtabula	0/8	--	0/6	0/6	0/9	0/29
Rocky Fork	North Shore	Highland	0/7	0/8	1/8	1/9	0/8	2/40
	South Shore	Highland	0/7	1/9	1/8	1/9	1/9	4/42
Salt Fork	Main	Guernsey	0/8	1/9	0/8	0/9	1/9	2/43
	Camp	Guernsey	0/8	0/8	0/8	0/9	0/8	0/41
	Cabins	Guernsey	0/8	0/8	0/8	0/9	--	0/33
Scioto Trail		Ross	0/6	6/11	1/8	0/7	1/8	8/40
Seneca Lake		Noble	--	--	--	14/45	5/25	19/70
Shawnee	Turkey Cr Lodge	Scioto	0/6	2/9	1/9	0/7	0/9	3/39
	Roosevelt-Camp	Scioto	1/6	--	0/6	2/8	0/9	3/29
Silver Creek		Summit	--	--	--	1/10	--	1/10
Stonelick		Clermont	0/14	0/8	0/16	0/15	5/18	5/71
Strouds Run		Athens	0/8	0/7	2/10	0/8	0/7	2/40
Tappan Lake		Harrison	--	--	--	16/46	3/25	19/71
Tar Hollow	Main	Ross	0/6	1/9	2/9	0/7	0/8	3/39
	Camp	Ross	2/9	0/9	1/8	1/8	0/8	4/42
West Branch	Main	Portage	1/5	2/12	0/8	0/9	1/9	4/43
	Camp	Portage	--	2/11	0/8	0/9	0/8	2/36
Wolf Run		Noble	0/8	0/7	0/8	1/8	0/7	1/38
	Total Advisory Postings[a]		**59**	**85**	**81**	**108**	**88**	**421/ 3,062**

[a] Indicates the number of advisories posted, based on a measured *E. coli* density exceeding 235 cfu/100 mL, followed by the number of samples collected.

Beaches at inland state park lakes are tested for bacteria less frequently compared to those beaches along Lake Erie. Sampling was most frequent at Seneca Lake (2016-2017), Atwood Lake (2016-2017) and Tappan Lake (2016-2017). Even at these beaches, the sampling frequency is roughly only half as intense as that of many Lake Erie beaches (Table F-7).

The sample results in Table F-17 indicate that at most inland lake beaches, the BAV of 235 cfu/100mL is not frequently exceeded, resulting in fewer postings compared to some of the beaches along Lake Erie. There were 46 inland lake beaches where the overall exceedance frequency was less than 10 percent for the five-year reporting period. Overall, the frequency of exceedances for all the inland lake beaches during the five-year reporting period was 13.8 percent, slightly higher than the 12.4 percent rate reported in the 2011-2015 cycle, which in turn was slightly higher than the 10.5 percent reported in the 2008-2012 reporting period. There were 28 inland lake beaches where the aggregated exceedance frequency was more than 10 percent. The highest aggregated exceedance frequency of 66 percent was found at the Brooks Park beach at Buckeye Lake followed closely by Buckeye Lake's Crystal Beach at 60 percent. Thirteen beaches exceeded the BAV 25 percent or more of the time over the five-year reporting period total: Buckeye Lake's Brooks Park, Fairfield and Crystal beaches; Caesar Creek Lake (south beach); Charles Mill Lake; Dillon Reservoir; Grand Lake St. Marys' camp, Windy Point and main beaches (west); Madison Lake; Pike Lake; Seneca Lake; and Tappan Lake.

Sample results at some inland lake beaches indicated a need for posting an advisory much more frequently during certain years. For example, five of 18 (28 percent) of the samples collected at Stonelick Lake exceeded the BAV in 2017 while none of the 15 samples exceeded the BAV in 2016 at Stonelick Lake. More frequent sampling, particularly at beaches where previous sampling data indicates an increased likelihood of exceeding the recreation criteria, should be considered by beach managers so that the public can be adequately informed of actual water quality conditions at the time of their visit. Sampling results at other lakes appear remarkably consistent, such as Alum Creek Lake's main beach, where from 2013-2017 the annual exceedance rate of the BAV ranged from 20 to 30 percent per year or Findlay Lake, where no exceedances were observed during annual sampling over the past five years.

F.4 Recreation Assessment for Algae in Western Lake Erie

F.4.1 Background

A healthy Lake Erie is a vital component of Ohio's economic and ecological health. Funding under the Great Lakes Restoration Initiative (GLRI) and other sources has led to the availability of new data and opportunities to expand assessment and reporting of water quality conditions in Lake Erie. These combined data sets, along with advances in the use of satellite imagery to detect, quantify and track algal blooms, have allowed Ohio to include in this report the first phase of a method to assess the open waters of Lake Erie for impairment caused by algae.

This section outlines a framework for assessing and listing impairment in Lake Erie, including:

- Assessment Unit (AU) definitions/boundaries;
- data availability relative to the AUs, including quantity, type and source of data generated; and
- an assessment method for impairment caused by algae for the western basin units.

Regarding data availability, it is important to keep in mind that Ohio's credible data law (ORC 6111.50 to 6111.56) requires Level 3 credible data for impairment assessments and decisions. However, Ohio EPA cannot compel data collectors to apply for Level 3 status. Thus, while many parties may be collecting data in Lake Erie, much of it is not currently useable in IR assessments. Data requirements and the credible data law are also discussed in Section D3 of this report.

F.4.2 Rationale and Evaluation Method

Defining AUs

In the past several IR cycles, Ohio EPA has evaluated Lake Erie using three AUs that cover the shallow waters along Ohio's coast: western basin; central basin; and Lake Erie Islands as measured from the shoreline to 100 meters lakeward; as well as the area within a 500-yard radius of active public drinking water supply intake structures. For 2018, Ohio EPA has refined these AUs to follow the topography (bathymetry) of the lake (100 meters lakeward is now recommended as a three-meter depth contour) and add the open water areas (Ohio waters beyond the three-meter depth). Due to the Maumee River, Detroit area and Sandusky River influences, there is tremendous variability across the western and Sandusky basins and segregating the shoreline waters into individual units will provide more refined assessments. The Sandusky Bay open water area of Lake Erie is also differentiated to capture the unique characteristics of the transitional waters between the western and central basins as influenced by the Sandusky Bay and lake circulation patterns.

Under this framework, Lake Erie AUs have increased from three (western, island and central shorelines) to seven units (Table F-18 and Figure F-7). This will allow assessments to be conducted on individual areas of more uniform characteristics so the targets for attaining the use designations can be set at the most

appropriate levels for the given area. In addition, the public water supply intakes can now be included in the AU where they are physically located, rather than associated with nearest shoreline AU.

Table F-18 describes the proposed AUs and the identifying codes assigned to them (tied to the HUC codes for the lake); Figure F-7 depicts the AU boundaries on Lake Erie.

Table F-18 — Proposed Ohio Lake Erie AUs.

AU Code	AU Name	Description
041202000201	Western Basin Shoreline (W1)	Lake Erie shoreline from the MI/OH state line to the west side of Catawba Island at depths ≤3m, including Maumee Bay
041202000301	Western Basin Open Waters (W2)	Lake Erie open water from the MI/OH state line to a line between the Marblehead Lighthouse and Pelee Point at depths >3m (U.S. waters only)
041202000100	Islands Shoreline (I1)	Lake Erie island shorelines from the west side of Catawba Island to the Marblehead Lighthouse at depths ≤3m and including, but not limited to the following Islands; West Sister, Bass and Kelleys
041202000202	Sandusky Basin Shoreline (S1)	Lake Erie shoreline from the Marblehead Lighthouse to the Black River at depths ≤3m, including Sandusky Bay
041202000302	Sandusky Basin Open Waters (S2)	Lake Erie open water from a line between the Marblehead Lighthouse and Pelee Point to the Lorain Ridge at depths >3m (U.S. waters only)
041202000203	Central Basin Shoreline (C1)	Lake Erie shoreline from the Black River to the OH/PA state line at depths ≤3m
041202000303	Central Basin Open Waters (C2)	Lake Erie open water from the Lorain Ridge to the OH/PA state line at depths >3m (U.S. waters only)

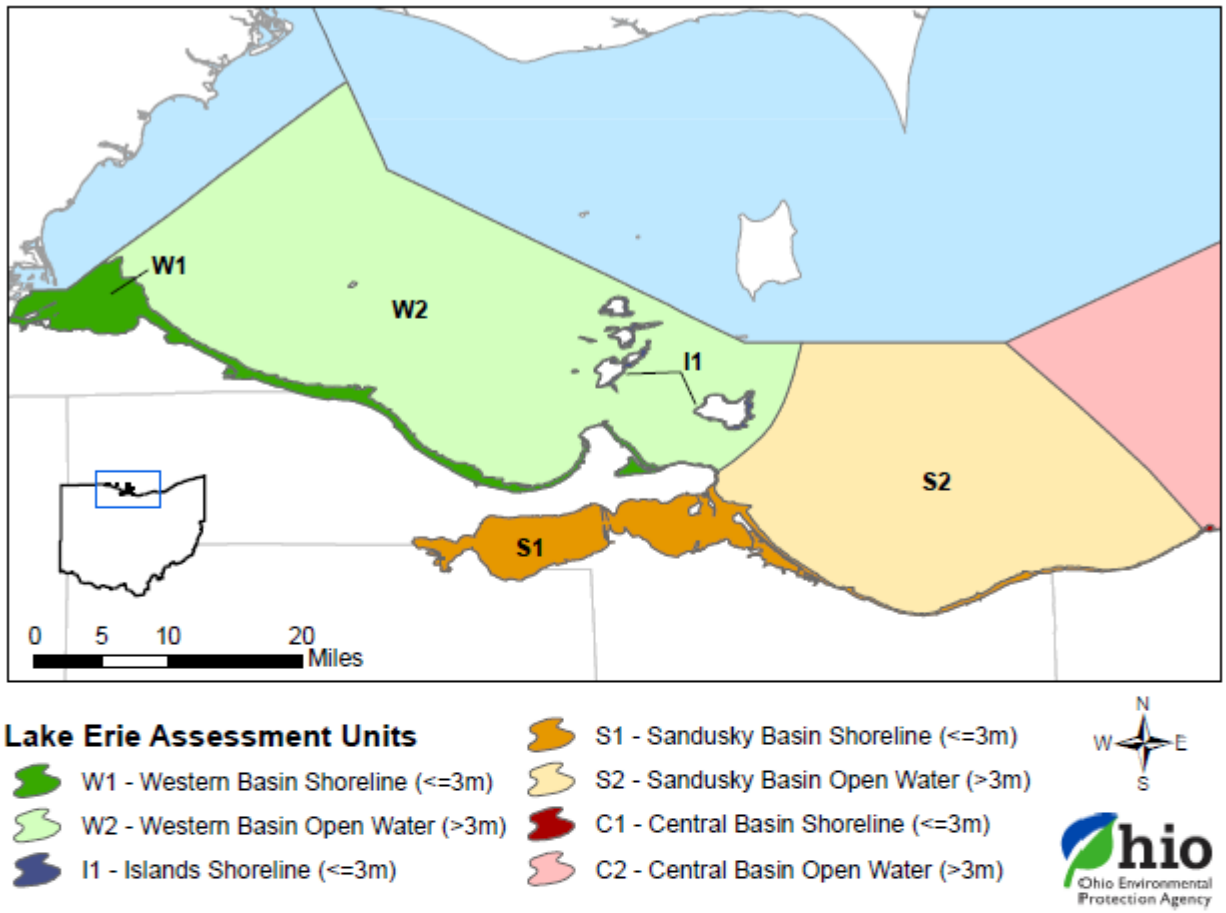

Figure F-7 — New Ohio Lake Erie AUs

Identifying Data Sources

As specified in the Ohio credible data law 2003 (ORC 6111.50 to 6111.56), Ohio EPA is limited to data accepted as Level 3 when making attainment determinations for Ohio waters. Data types may be applicable only for specific beneficial uses or AU types (for example, shoreline versus offshore AUs). Ohio EPA has determined that the Northeast Ohio Regional Sewer District (NEORSD) data through 2016 is Level 3 credible data, and the National Oceanic and Atmospheric Administration (NOAA) satellite information has been reviewed to ensure that it meets the Level 3 credible data requirements. Ohio EPA will continue evaluating protocols and data from U.S. EPA, NOAA, U.S. Geological Survey, the Ohio State University, Bowling Green State University and the University of Toledo to ensure more Level 3 data is available for future assessments.

Through the efforts of Great Lakes Water Quality Agreement (GLWQA) Annex 4 workgroups and Ohio EPA staff, a list of data collectors in the western basin was compiled, along with information related to the sample collection and analysis. Figure F-8 illustrates the locations of all the known routine data collection sites in the western basin. The charter boat captain sites are from the original study plan for illustrative purposes and may not include all the sites sampled over the last five years.

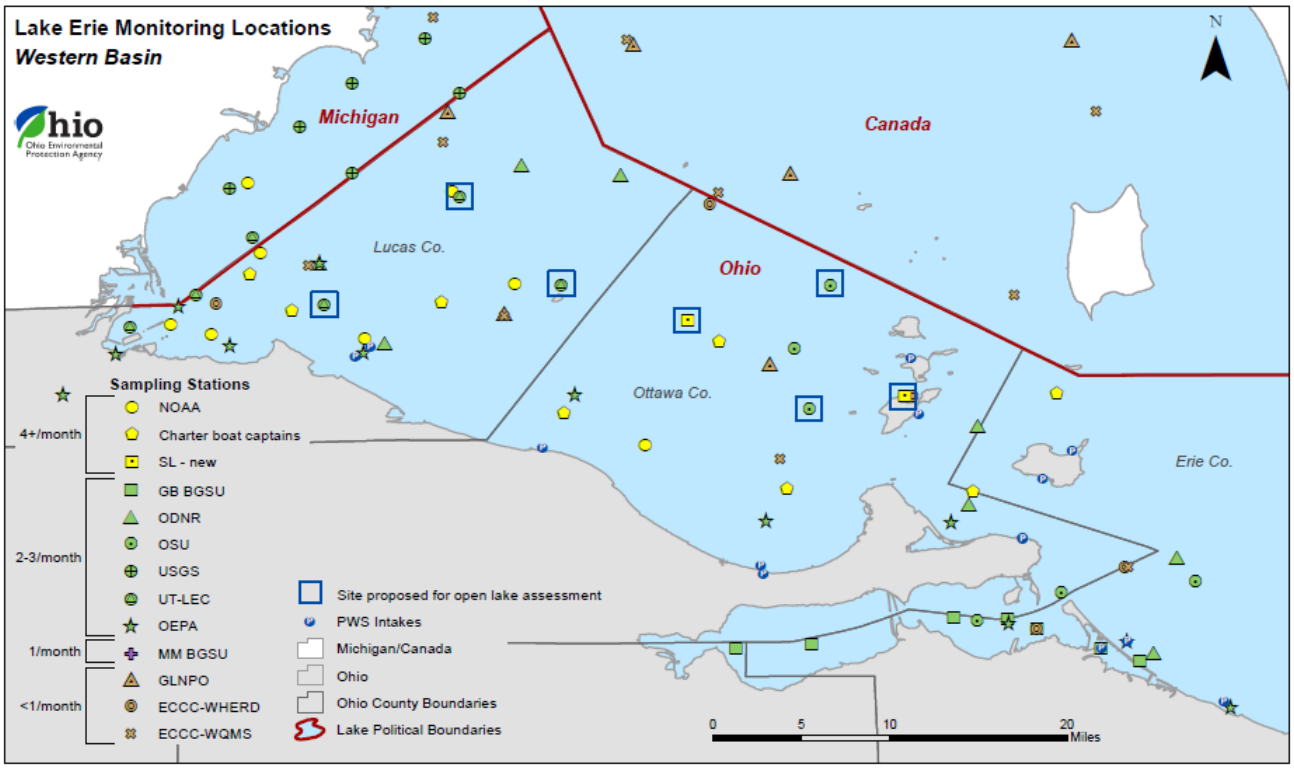

Figure F-8 — Monitoring locations in the western basin of Lake Erie in 2017.

Table F-19 presents a summary of the data available that is currently eligible for use by Ohio EPA to determine attainment, data that Ohio EPA could more easily accept as Level 3 credible data (some federal agencies are exempt from portions of the credible data requirements), as well as limitations to the use of the data in a reasonable assessment of a large water body such as Lake Erie where algal blooms shift and change significantly over a season.

Table F-19 — Data collected in Ohio waters of Lake Erie that is credible level 3 or could likely be approved as level 3 with review and coordination.

Agency/ Collector	Geographic Location	Start/ End Date	Sampling Frequency	Parameters analyzed	Basin	Limitations/Notes	Eligible for IR use?
U.S. EPA	Offshore/near shore — 9 sites in central basin; only 3-7 in OH waters	1983-present	Spring, Summer	Phytoplankton, zooplankton, nutrients, chlorophyll, water quality parameters	Central	2 samples/ year unless intense survey year	potential
U.S. EPA	Offshore/near shore — 3 sites in western basin OH waters	1983-present	Spring, Summer	Phytoplankton, zooplankton, nutrients, chlorophyll, water quality parameters	West	2 samples/ year unless intense survey year	potential
NOAA	All Lake Erie	2002-present	clear days	cyanobacterial chlorophyll	All		yes (2012 forward)
ODNR-Sandusky	South of Middle Sister	May - Sept	bi-weekly	Chl-A, Species, Phosphorus	West	only P data is confirmed level 3	yes for P, rest potential
ODNR-Sandusky	Toledo Water Intake	May - Sept	bi-weekly	Chl-A, Species, Phosphorus	West	only P data is confirmed level 3	yes for P, rest potential
ODNR-DOW Sandusky	Western basin Offshore	May-Sept	Bi-weekly	Phytoplankton, Zooplankton, Chlorophyll, DO/Temperature profile, Phosphorus	West	only P data is confirmed level 3	yes for P, rest potential
ODNR-DOW Sandusky	Western basin Nearshore	May-Sept	Bi-weekly	Phytoplankton, Zooplankton, Chlorophyll, DO/Temperature profile, Phosphorus	West	only P data is confirmed level 3	yes for P, rest potential
NOAA GLERL	Toledo Shipping Channel	2012-present	weekly June - October	biovolume, taxa, picoplankton, chla, PC, toxins, nutrients, phys-chem, DNA	West		potential
NOAA GLERL	Western basin Offshore	2012-present	weekly June - October	biovolume, taxa, picoplankton, chla, PC, toxins, nutrients, phys-chem, DNA	West		potential
NOAA GLERL	Maumee Bay	2012-present	weekly June - October	biovolume, taxa, picoplankton, chla, PC, toxins, nutrients, phys-chem, DNA	West	in bay	potential
NOAA GLERL	Mouth of Maumee River	2016-present	weekly June - October	biovolume, taxa, picoplankton, chla, PC, toxins, nutrients, phys-chem, DNA	West	in bay, just started 2016	potential
NOAA GLERL	Toledo Water Intake	2014-present	weekly June - October	biovolume, taxa, picoplankton, chla, PC, toxins, nutrients, phys-chem, DNA	West	started 2014	potential

Agency/ Collector	Geographic Location	Start/ End Date	Sampling Frequency	Parameters analyzed	Basin	Limitations/Notes	Eligible for IR use?
NOAA GLERL	West Sister Island	2014-present	weekly June - October	biovolume, taxa, picoplankton, chla, PC, toxins, nutrients, phys-chem, DNA	West	started 2014	potential
NOAA GLERL	Southeastern Western Basin	2015-present	weekly June - October	biovolume, taxa, picoplankton, chla, PC, toxins, nutrients, phys-chem, DNA	West	started 2015	potential
NEORSD	Lake Erie - Cleveland area 8 sites	2012-present	1/mo May-July 2/mo Aug-Oct	nutrients, chla, microcystin, alkalinity, TSS and field parameters	Central	mostly along shore, one site 7 miles out	yes through 2016
Ohio EPA	Maumee Bay near Woodtick Peninsula	2012-present	phytoplankton 3/yr, chemistry/field 2x/month	nutrients, for more see list in footnote (1)	West	in bay	yes
Ohio EPA	Maumee Bay near State Park	2013-present	phytoplankton 3/yr, chemistry/field 2x/month	nutrients, for more see list in footnote (1)	West	in bay	yes
Ohio EPA	Lake Erie near Toledo Lighthouse	2011-present	phytoplankton 3/yr, chemistry/field 2x/month	nutrients, for more see list in footnote (1)	West	close to shore	yes
Ohio EPA	Lake Erie between Toledo/Oregon WTP Intakes	2015-present	phytoplankton 3/yr, chemistry/field 2x/month	nutrients, for more see list in footnote (1)	West	close to shore	yes
Ohio EPA	Lake Erie near West Sister Island	2011-2015	phytoplankton 3/yr, chemistry/field 2x/month	nutrients, for more see list in footnote (1)	West	data no longer being collected	yes
Ohio EPA	Lake Erie near Middle Sister Island	2013-2015	phytoplankton 3/yr, chemistry/field 2x/month	nutrients, for more see list in footnote (1)	West	data no longer being collected	yes
Ohio EPA	Lake Erie near Middle Bass Island	2011-2015	phytoplankton 3/yr, chemistry/field 2x/month	nutrients, for more see list in footnote (1)	West	data no longer being collected	yes
Ohio EPA	Lake Erie North of Port Clinton	2014-present	phytoplankton 3/yr, chemistry/field 2x/month	nutrients, for more see list in footnote (1)	West	close to shore	yes
Ohio EPA	Lake Erie near Lake Side	2016-present	phytoplankton 3/yr, chemistry/field 2x/month	nutrients, for more see list in footnote (1)	West	very close to shore, data started 2016	yes
Ohio EPA	Lake Erie Near Crane Reef	2016-present	phytoplankton 3/yr, chemistry/field 2x/month	nutrients, for more see list in footnote (1)	West	data started 2016	yes
Ohio EPA	Sandusky Bay near Johnsons Island	2010-present	phytoplankton 3/yr, chemistry/field monthly	nutrients, for more see list in footnote (1)	SB	in bay	yes
Ohio EPA	Lake Erie near Cedar Point	2011-2015	phytoplankton 3/yr, chemistry/field monthly	nutrients, for more see list in footnote (1)	SB	close to shore, no longer being collected	yes

Agency/ Collector	Geographic Location	Start/ End Date	Sampling Frequency	Parameters analyzed	Basin	Limitations/Notes	Eligible for IR use?
Ohio EPA	Lake Erie near City of Sandusky WTP Intake	2016-present	phytoplankton 3/yr, chemistry/field 2x/month	nutrients, for more see list in footnote (1)	SB	very close to shore, data started 2016	yes
Ohio EPA	Lake Erie near City of Huron WPT Intake	2016-present	phytoplankton 3/yr, chemistry/field 2x/month	nutrients, for more see list in footnote (1)	SB	in shoreline area, data started 2016	yes
Ohio EPA	Lake Erie near Huron	2011-2015	phytoplankton 3/yr, chemistry/field 2x/month	nutrients, for more see list in footnote (1)	SB	close to shore, no longer being collected	yes
Ohio EPA	Lake Erie near City of Vermilion WTP Intake	2016-present	phytoplankton 3/yr, chemistry/field 2x/month	nutrients, for more see list in footnote (1)	SB	in shoreline area, data started 2016	yes
Ohio EPA	Lake Erie near Lorain	2011-present	phytoplankton 3/yr, chemistry/field 2x/month	nutrients, for more see list in footnote (1)	SB	close to shore	yes
Ohio EPA	Lake Erie near Rocky River	2010-present	phytoplankton 3/yr, chemistry/field monthly	nutrients, for more see list in footnote (1)	Central	close to shore	yes
Ohio EPA	Lake Erie near Wildwood	2010-present	phytoplankton 3/yr, chemistry/field monthly	nutrients, for more see list in footnote (1)	Central	close to shore	yes
Ohio EPA	Lake Erie near Fairport	2011-present	phytoplankton 3/yr, chemistry/field monthly	nutrients, for more see list in footnote (1)	Central	close to shore	yes
Ohio EPA	Lake Erie near Geneva	2011-present	phytoplankton 3/yr, chemistry/field monthly	nutrients, for more see list in footnote (1)	Central	close to shore	yes
Ohio EPA	Lake Erie near Conneaut	2010-present	phytoplankton 3/yr, chemistry/field monthly	nutrients, for more see list in footnote (1)	Central	close to shore	Yes

(1) Ohio EPA Parameters: Alkalinity, Bicarbonate, Carbonate, Chloride, Sulfate, Solids, TDS, TSS, Ammonia, Nitrite, Nitrate-Nitrite, Kjeldahl, Total, Phosphorus Total, Orthophosphate, Chlorophyll a, Microcystins, Field Parameters (water depth, secchi depth, pH, dissolved oxygen, temperature, fluorescence, conductivity and specific conductance), phytoplankton as noted.

NOTES: Ohio EPA Fish and Mayfly sites were not included since no chemistry or phytoplankton samples are typically collected there. That information can be found in the study plan at: ***epa.ohio.gov/Portals/35/lakeerie/2017_Erie_Study_Plan.pdf***.
Ohio EPA transects for dissolved oxygen and other field parameters are not included in the table. These are collected in the central basin at various depths and locations to assist in defining/tracking the hypoxic zone - but do not include nutrients, chlorophyll or cyanotoxins.

Establishing Expectations: Targets for Lake Erie Algal Blooms

A common means to estimate algal productivity and trophic status is to measure the photosynthetic pigment chlorophyll a in a filtered water sample. The importance of phosphorus as the limiting nutrient that feeds algal blooms is also recognized. Ohio does not have numeric criteria for these constituents in Lake Erie and no federal criteria have been established to date. Also, the GLQWA Annex 4 committees and workgroups recognized that measuring nutrient levels in the open waters of the lake may not be the best way to track success in reducing algal blooms. Ohio water quality standards (OAC 3745-1-04) do contain narrative requirements that all surface waters be:

> *"(D) Free from substances entering the waters as result of human activity in concentrations that are toxic or harmful to human, animal or aquatic life or are rapidly lethal in the mixing zone. (E) Free from nutrients entering the water as a result of human activity in concentrations that create nuisance growths of aquatic weeds and algae."*

Ohio EPA requested input from representatives from the Ohio State University Sea Grant College Program, University of Toledo, Bowling Green State University and NOAA to identify metrics that would provide a scientifically relevant determination of impairment. The request stated that the metrics needed to provide a reasonable, objective assessment method for the western basin open water using targets that will meet the goals established by the GLWQA Annex 4 committee and provide assurance that the WQS are met.

The foundation of the first phase of Ohio's assessment method for algae is an evaluation of the western basin algal bloom pattern over time, such as that conducted by NOAA in 2012 (Stumpf, 2012). Data sets from the MODIS (or Moderate Resolution Imaging Spectroradiometer) satellite (2012 to 2017) were used for this first assessment. The GLWQA Annex 4 committee set goals for phosphorus loadings to the lake at levels that are expected to produce a bloom no greater than those that occurred in 2004 or 2012. The extent of algal bloom coverage considered acceptable, or attaining the recreation use designation, should be no greater than that in 2004 or 2012. In addition, the algae (cyanobacteria) cell count level in the bloom should be no greater than 20,000 cells/mL. When cyanobacteria capable of producing cyanotoxins, especially *Microcystis*, exceed concentrations of 20,000 cells/ml, there is a higher likelihood that cyanotoxins will be present at detectable concentrations. The relationship between the presence of *Microcystis* blooms and elevated microcystins concentrations has been well documented in the Lake Erie western basin. This density (20,000 cells/mL) corresponds to the nominal floor used by NOAA to analyze satellite images with a comfortable degree of certainty (Wynne and Stumpf, 2015).

To account for the way that algal blooms shift in time and space in a large water body like the western basin, the method developed is as follows:

- In each 10-day frame, an exceedance means that a bloom with greater than 20,000 cells/mL covers (is present in) more than 30 percent of the western basin open water unit area
- If more than three 10-day frames have an exceedance in one year (July-Oct.), then that year exceeds the goal (is above the threshold target of the 2004 and 2012 blooms under Annex 4 of the GLWQA)
- Because of the year-to-year variation, if any two or more years in a rolling six-year window exceeds the goal (is above the threshold target of the 2004 and 2012 blooms under Annex 4 of the GLWQA) then the unit is impaired

Within each 10-day frame, an average percent coverage by a bloom at 20,000 cell/mL or greater was calculated for the western basin open water assessment unit (W2 in Figure F-7). In the western basin, blooms typically begin developing by July 22 and peak between August 10 and September 18 (Wynne and Stumpf, 2015). The 10-day time frames used in the assessment method are:

July 1 – July 10	Aug. 30 – Sept. 8
July 11 – July 20	Sept. 9 – Sept. 18
July 21 – July 30	Sept. 19 – Sept. 28
July 31 – Aug 9	Sept. 29 – Oct. 8
Aug. 10 – Aug. 19	Oct. 9 – Oct. 18
Aug. 20 – Aug. 29	Oct. 19 – Oct. 31

The threshold of 30 percent coverage is based on an examination of the bloom coverage in Lake Erie's western basin since 2002 and which blooms were considered to meet the Annex 4 target severity index (the Target Bloom in Figure F-9). Severity Index (SI) is the measure of the peak bloom biomass over a 30-day period (in each year, whichever 30-days captured/represents the most biomass in that year). As illustrated in Figure F-9, bloom severity meets the target in 2004 and very nearly in 2012. In those years the bloom was not considered to significantly impede the recreational use of the water and the extent of coverage did not exceed 30 percent of the western basin open water AU in more than three 10-day frames (fewer than three exceeded).

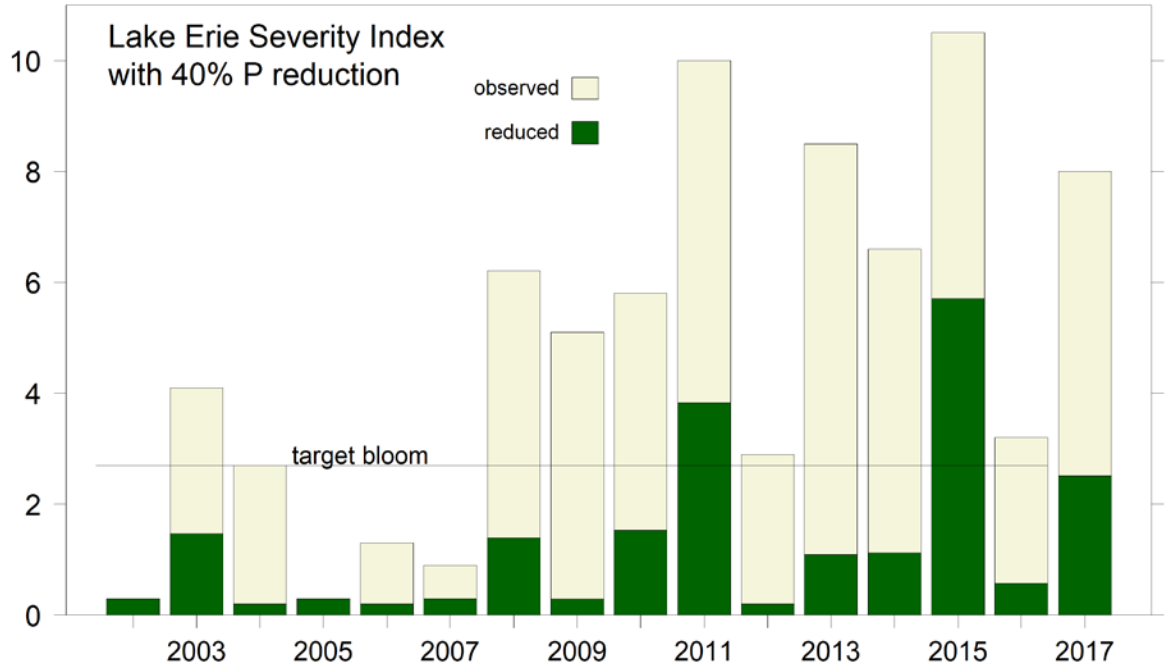

Figure F-9 — Bloom severity observed and projected (with 40 percent TP reduction) since 2002. Courtesy of Dr. Rick Stumpf, NOAA National Centers for Coastal Ocean Science.

F.4.3 Results

Table F-20 shows the end results of the analysis, using the MODIS satellite data 2012-2017 and including the full six-year window in the assessment. Some years do not include all 12 of the 10-day frames because of extended cloud cover or other interferences with the satellite images. The western basin open waters are considered impaired since the last five years all exceeded the thresholds outlined above (more than three 10-day frames exceeded within the year).

Table F-20 — The number of 10-day time frames exceeding the 30 percent coverage threshold (with 20,000 cells/mL or greater) in the western basin open water unit for each year beginning in 2012.

	≥30% coverage at ≥20,000 cell/mL	
Year	10-day frames exceeding	total frames
2012	2	12
2013	10	11
2014	6	12
2015	9	11
2016	5	10
2017	7	11

Since the island shoreline assessment units are contained within the western basin open water unit shape file that was used to conduct the analysis, the island shoreline unit is also considered impaired. As people are more likely to come into direct contact with the water and algae along the shoreline than in the open water, Ohio EPA is also including the western basin shoreline unit on the impaired waters list. This is based on proximity to the open waters that are clearly impaired, and the expectation that, reviewing the patterns of blooms over the past six years, the shoreline area would be just as impacted by the blooms as the open water.

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