NORTHEAST OHIO REGIONAL SEWER DISTRICT

2011 Lake Erie Bacteriological Sampling Results at Edgewater, Euclid and Villa Angela Beaches

Prepared by
Water Quality and Industrial Surveillance Division

Introduction

Since 1992, the Northeast Ohio Regional Sewer District (NEORSD) has conducted bacteriological sampling on Lake Erie at Edgewater Beach, Villa Angela Beach, and Euclid Beach in an effort to monitor bacteriological densities at the beaches. In 2005, sampling at Euclid Creek was added to determine the impact the creek may have on the water quality at Villa Angela and Euclid Beaches.

In 2011, the NEORSD continued these sampling efforts by monitoring the *Escherichia coli* (*E. coli*) densities at Edgewater, Villa Angela, and Euclid Beaches and Euclid Creek. The purpose of this sampling was to communicate beach conditions to the public and evaluate water quality standards attainment. In this report, an evaluation of water quality standards attainment will be made from the *E. coli* results from each sample site.

The sampling was completed by NEORSD Level 3 Qualified Data Collectors certified by Ohio Environmental Protection Agency (Ohio EPA) in Chemical Water Quality Assessment, as well as trained personnel, as explained in the NEORSD study plan *2011 Lake Erie Bacteriological Sampling of Edgewater, Euclid and Villa Angela Beaches*, which was approved by Ohio EPA on May 14, 2011. Sample analyses were conducted by NEORSD's Analytical Services division, which is accredited by the National Environmental Laboratory Accreditation Program.

Figure 1 is a map of the sampling locations at Edgewater, Euclid and Villa Angela Beaches and Euclid Creek. Table 1 indicates the sampling sites with respect to location, site or river mile (RM), latitude/longitude and description.

Figure 1. Map of Sampling Sites

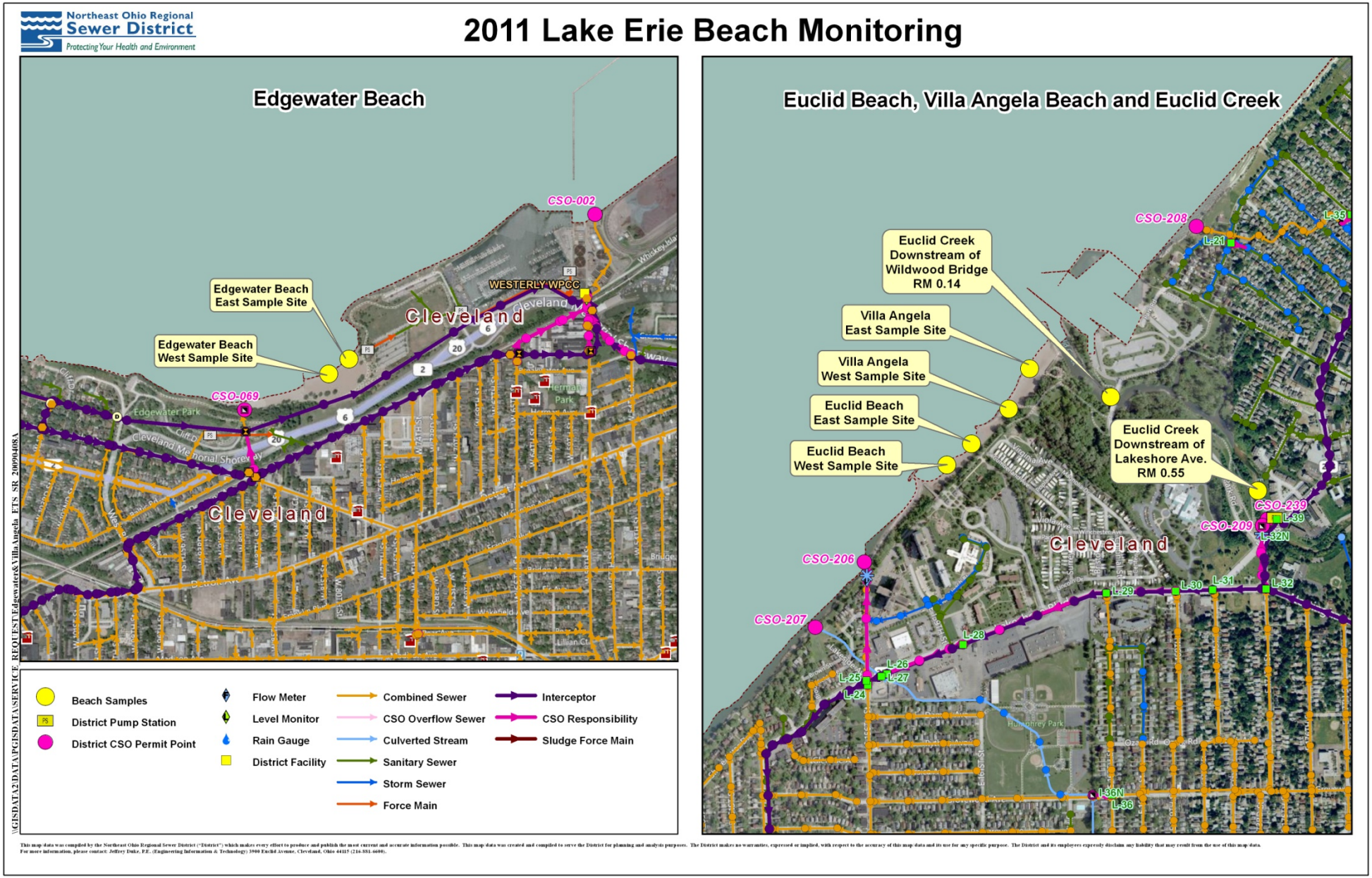


Table 1. List of Lake Erie and Euclid Creek Sampling Sites

Location	Site	Latitude	Longitude	Description	Quadrangle	Purpose
Edgewater Beach	East	N41.4893°	W81.7392°	Eastern half of the beach. In line with the brick stack on the other side of the freeway.	Cleveland South	Public notification of water quality conditions at bathing beaches, determination of water quality standards attainment, evaluation of the impact of point and non-point sources
Edgewater Beach	West	N41.4887°	W81.7404°	Western half of the beach. In line with the large metal pole on the other side of the freeway.	Cleveland South	
Villa Angela Beach	East	N41.5851°	W81.5677°	Eastern half of beach, mid-distance between the 3rd and 4th break walls.	East Cleveland	
Villa Angela Beach	West	N41.5861°	W81.5667°	Western half of beach at the beginning of the 2nd break wall.	East Cleveland	
Euclid Beach	East	N41.5843°	W81.5686°	Eastern half of beach in line with the East side of the pile of stones on the beach.	East Cleveland	
Euclid Beach	West	N41.5838°	W81.5694°	Western half of the beach, between the two break walls, at the second set of stairs.	East Cleveland	
Euclid Creek	RM 0.55	N41.5831°	W81.5594°	Downstream of Lakeshore Boulevard.	East Cleveland	
Euclid Creek	RM 0.14	N41.5854°	W81.5641°	Downstream of Wildwood Bridge.	East Cleveland	

Sampling Methods

Bacteriological sampling was conducted from May 2, 2011 to October 27, 2011. From May 2 through May 12, water samples were collected from each beach site and Euclid Creek RM 0.55 four days a week (Monday through Thursday). Beginning May 16 and lasting through September 9, samples were collected at each beach site and Euclid Creek RM 0.55 seven days a week. From September 12 through October 27, sampling returned to four days a week (Monday through Thursday). Twenty-one (21) samples were not collected during the season due to inclement weather conditions as explained in Table 2. A total of 909 samples were collected from all three of the beaches during 2011. Euclid Creek RM 0.14 was sampled daily, five times a week (Monday through Friday) from June 6 through September 9, excluding July 4 and September 5 (observed holidays). A total of 219 samples were collected from Euclid Creek RMs 0.55 and 0.14 during 2011.

Table 2. 2011 Beach and Creek Samples Not Obtained

Date	Location	Reason
5/16/11	Edgewater Beach East Edgewater Beach West Euclid Beach East Euclid Beach West Villa Angela Beach East Villa Angela Beach West Euclid Creek RM 0.55	Inclement weather; high wave height; high flow
5/17/11	Edgewater Beach East Edgewater Beach West	Inclement weather; high wave height
6/14/11	Euclid Beach East Euclid Beach West Villa Angela Beach East	Inclement weather; high wave height
6/26/11	Euclid Beach East	Inclement weather; high wave height
10/19/11	Euclid Beach West	Inclement weather; high wave height
10/24/11	Edgewater Beach East Edgewater Beach West Euclid Beach East Euclid Beach West Villa Angela Beach East Villa Angela Beach West Euclid Creek RM 0.55	Inadequate staffing

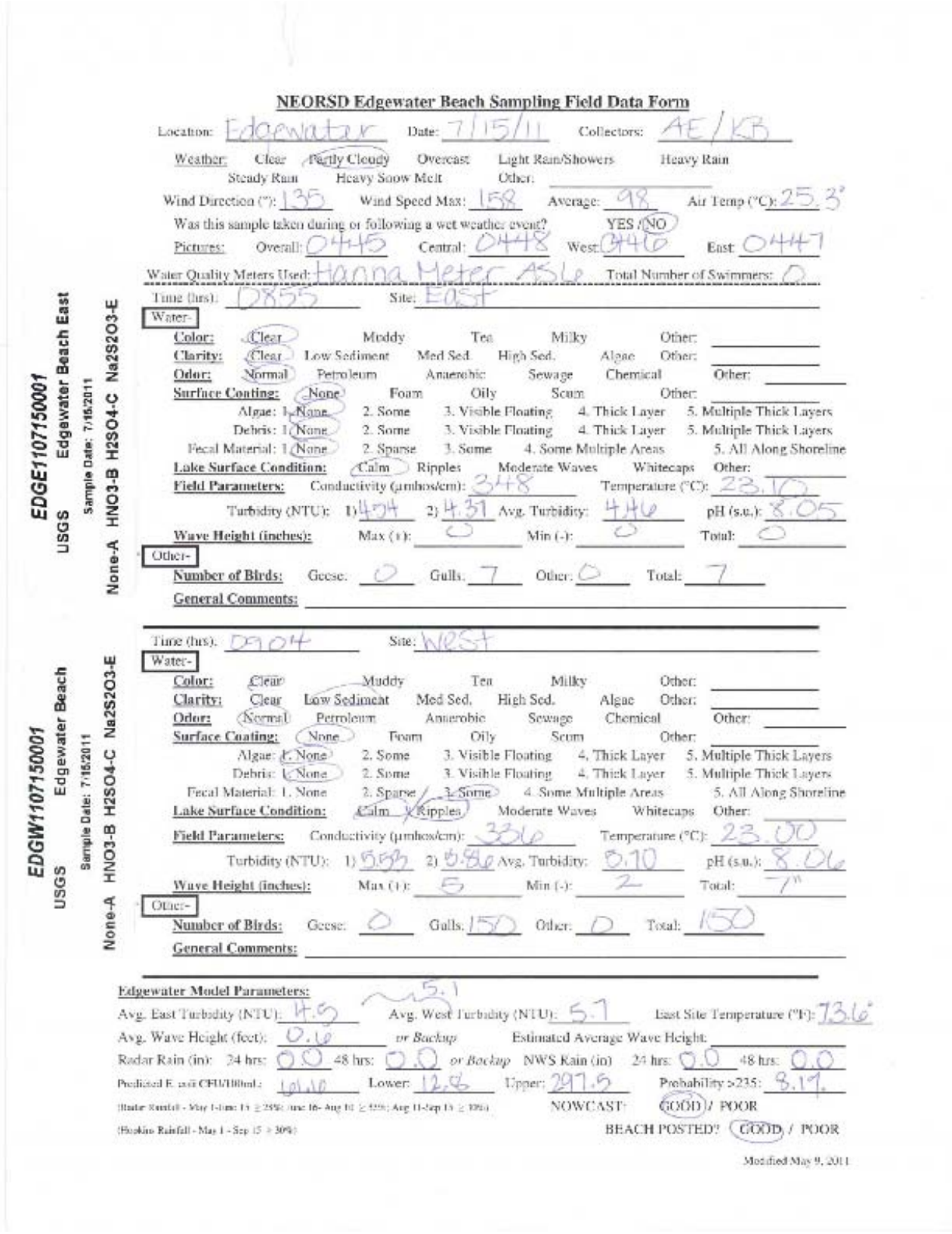
Field analysis included the use of a Hanna HI 98129, YSI 600XL Sonde or Extech EC500 Exstik II pH/Conductivity meter to measure pH, water temperature, and conductivity. Additionally, the Hach 2100P Portable Turbidimeter, Thermo Orion AQUAfast AQ4500 Turbidimeter, or LaMotte 2020*e* Portable Turbidimeter was used to obtain field turbidity measurements. All water samples and field parameters were collected as specified in the most current NEORSD Beach Sampling Standard Operating Procedure (*SOP-EA016-06*), *The Ohio Department of Health Ohio Bathing Beach Monitoring Program Quality Assurance Project Plan, April 2009*, (effective dates of 9/29/08-9/28/11) and the *Manual of Ohio EPA Surveillance Methods and Quality Assurance Practices* (2009).

Bacteriological grab samples were collected in 2-liter sterilized polypropylene containers. Additional grab samples for water chemistry were obtained at Edgewater Beach East, Villa Angela Beach East, Euclid Beach East and Euclid Creek RM 0.55. The

grab samples were collected in 4-liter polyethylene cubitainers, 473-mL plastic bottles field preserved with H_2SO_4 and 250mL amber glass jars field preserved with H_2SO_4. Samples at each location were collected approximately 6-12 inches below the surface, in water that was approximately three feet deep. At the time of sample collection, field parameters were measured and field observations and water conditions were documented at each beach site. All data that was collected was recorded on an NEORSD Beach Sampling Field Data Form (Figure 2). All samples were placed in a cooler with ice and stored in a locked NEORSD vehicle until the samples were transferred to NEORSD's Analytical Services sample receiving with a Chain of Custody. All Beach Sampling Field Data Forms, Chains of Custody and Certificates of Analysis are available upon request from the Water Quality and Industrial Surveillance division, and the Analytical Services division.

The quality assurance and quality control of bacteriological water sample collections included field duplicates that were collected at a frequency not less than 10% of the total samples collected. Since field blanks are not required by method 1603 or by the National Environmental Laboratory Accreditation Conference (NELAC) for bacteria analysis, no bacteriological field blanks were collected during the study. Analytical Services has procedures in place which are required by NELAC to demonstrate that the sample containers are clean and sterile.

The quality assurance and quality control of water chemistry samples from each of the beach East sites and Euclid Creek RM 0.55 included duplicate collection at a randomly selected site at a frequency not less than 10% of the total samples collected. Additionally, field blanks were collected at a frequency not less than 5% of the total samples collected. It appears that possible contamination of the water chemistry field blanks occurred during the sampling period, resulting in the qualification or rejection of some data (Table 3). It is unknown how some of the field blanks may have become contaminated. As a result, where there was possible contamination for a particular parameter in the field blank resulting in the rejection or reduced confidence of sample data, that same parameter was omitted from the field sample results and not included when analyzing the data.



NEORSD Edgewater Beach Sampling Field Data Form

Location: Edgewater Date: 7/15/11 Collectors: AE/KB

Weather: Clear Partly Cloudy Overcast Light Rain/Showers Heavy Rain
Steady Rain Heavy Snow Melt Other:

Wind Direction (°): 135 Wind Speed Max: 15.8 Average: 9.8 Air Temp (°C): 25.3

Was this sample taken during or following a wet weather event? YES / NO

Pictures: Overall: 0445 Central: 0448 West: 0446 East: 0447

Water Quality Meters Used: Hanna Meter ASL Total Number of Swimmers: 0

EDGE1107150001 USGS Edgewater Beach East Sample Date: 7/15/2011 None-A HNO3-B H2SO4-C Na2S2O3-E

Time (hrs): 0855 Site: East

Water-

Color: Clear Muddy Tea Milky Other:
Clarity: Clear Low Sediment Med Sed. High Sed. Algae Other:
Odor: Normal Petroleum Anaerobic Sewage Chemical Other:
Surface Coating: None Foam Oily Scum Other:
Algae: 1. None 2. Some 3. Visible Floating 4. Thick Layer 5. Multiple Thick Layers
Debris: 1. None 2. Some 3. Visible Floating 4. Thick Layer 5. Multiple Thick Layers
Fecal Material: 1. None 2. Sparse 3. Some 4. Some Multiple Areas 5. All Along Shoreline
Lake Surface Condition: Calm Ripples Moderate Waves Whitecaps Other:
Field Parameters: Conductivity (µmhos/cm): 348 Temperature (°C): 23.10
Turbidity (NTU): 1) 4.04 2) 4.31 Avg. Turbidity: 4.16 pH (s.u.): 8.05
Wave Height (inches): Max (+): 0 Min (-): 0 Total: 0

Other-

Number of Birds: Geese: 0 Gulls: 7 Other: 0 Total: 7
General Comments:

EDGW1107150001 USGS Edgewater Beach Sample Date: 7/15/2011 None-A HNO3-B H2SO4-C Na2S2O3-E

Time (hrs): 0904 Site: WEST

Water-

Color: Clear Muddy Tea Milky Other:
Clarity: Clear Low Sediment Med Sed. High Sed. Algae Other:
Odor: Normal Petroleum Anaerobic Sewage Chemical Other:
Surface Coating: None Foam Oily Scum Other:
Algae: 1. None 2. Some 3. Visible Floating 4. Thick Layer 5. Multiple Thick Layers
Debris: 1. None 2. Some 3. Visible Floating 4. Thick Layer 5. Multiple Thick Layers
Fecal Material: 1. None 2. Sparse 3. Some 4. Some Multiple Areas 5. All Along Shoreline
Lake Surface Condition: Calm Ripples Moderate Waves Whitecaps Other:
Field Parameters: Conductivity (µmhos/cm): 336 Temperature (°C): 23.00
Turbidity (NTU): 1) 5.93 2) 5.86 Avg. Turbidity: 5.90 pH (s.u.): 8.06
Wave Height (inches): Max (+): 5 Min (-): 2 Total: 7"

Other-

Number of Birds: Geese: 0 Gulls: 150 Other: 0 Total: 150
General Comments:

Edgewater Model Parameters:

Avg. East Turbidity (NTU): 4.5 Avg. West Turbidity (NTU): 5.7 (5.1) East Site Temperature (°F): 73.6

Avg. Wave Height (feet): 0.16 or Backup Estimated Average Wave Height:

Radar Rain (in): 24 hrs: 0.0 48 hrs: 0.0 or Backup NWS Rain (in) 24 hrs: 0.0 48 hrs: 0.0

Predicted E. coli CFU/100mL: 60.0 Lower: 12.8 Upper: 297.5 Probability >235: 8.19

(Radar Rainfall - May 1-June 15 ≥ 25%; June 16- Aug 31 ≥ 50%; Aug 11-Sept 15 ≥ 30%)

NOWCAST: GOOD / POOR

(Hoskin Rainfall - May 1 - Sep 15 > 30%)

BEACH POSTED? GOOD / POOR

Modified May 9, 2011

Figure 2. Example of the NEORSD Beach Sampling Field Data Form

Table 3. Possible Field Blank Contamination

Site	Date	Parameter	Field Blank Value (mg/L)	Sample Value (mg/L)	Parameter MDL (mg/L)	Parameter PQL (mg/L)
Edgewater Beach East	5/5/2011	Total Dissolved Solids	22	184	1	2
	5/5/2011	Ammonia	0.024	0.043	0.002	0.01
	6/1/2011	Ammonia	j0.008	0.02	0.002	0.01
	6/8/2011	Total phosphorus	0.055	0.037	0.001	0.01
	6/8/2011	Ammonia	j0.009	0.0765	0.002	0.01
Euclid Beach East	5/10/2011	Ammonia	0.134	0.137	0.002	0.01
	5/10/2011	Total phosphorus	j0.005	0.026	0.001	0.01
	5/11/2011	Ammonia	0.1	0.069	0.002	0.01
Villa Angela Beach East	5/25/2011	Total Dissolved Solids	30	180	1	2
	5/25/2011	Total phosphorus	0.052	0.0325	0.001	0.01
	6/23/2011	Ammonia	0.092	0.081	0.002	0.01
	6/23/2011	Total phosphorus	j0.006	0.0405	0.001	0.01
Euclid Creek RM 0.55	5/5/2011	Ammonia	j0.007	0.023	0.002	0.01
	5/5/2011	Total phosphorus	j0.006	0.038	0.001	0.01
	5/17/2011	Total Suspended Solids	10.8	7.25	0.5	1
	5/17/2011	Ammonia	j0.006	0.033	0.002	0.01
	5/17/2011	Total phosphorus	0.018	0.058	0.001	0.01
	6/29/2011	Ammonia	j0.008	0.0245	0.002	0.01
	6/29/2011	Total Suspended Solids	j0.7	4.95	0.5	1

MDL= Minimum Detection Limit

PQL= Practical Quantitation Limit

j= >MDL but <PQL

The sample duplicate results (for bacteria and water chemistry) were compared to the sample results (for bacteria and water chemistry) using relative percent difference (RPD) (Formula 1).

Formula 1

$$RPD = \left(\frac{|X-Y|}{(X+Y)/2} \right) * 100$$

X= concentration of analyte in the primary sample
Y= concentration of the analyte in the duplicate sample

After an RPD was calculated, any result greater than 40% was investigated to determine the reason for the discrepancy. A total of 26 potential water chemistry discrepancies were found among all of the beach sites and the two Euclid Creek sites. There were twenty-four (24) times when the parameter values of the sample and sample duplicate were less than ten times their respective practical quantitation limits (PQL), which are considered very low concentrations. Differences in very low concentrations can lead to high RPD values; therefore, these results were still included in analysis of the data. The only remaining discrepancy, for ammonia, had sample results and paired duplicates that were both greater than ten times their PQLs (Table 4). Since ammonia had an RPD greater than 40%, the results were not included when analyzing the data.

Table 4. Unexplained Water Quality Discrepancies

Beach	Site	Date Collected	Parameter	Units	Sample Result	Duplicate Result	RPD Value %
Euclid Beach	East	6/7/2011	Ammonia	mg/L	0.101	0.171	51.5

Beach Results and Discussion

The *E. coli* results from each beach site were compared to the Ohio water quality standards to determine recreation use attainment. The three beaches are designated as Bathing Waters for the Protection of Recreation Use (Ohio EPA, 2010). The Bathing Waters criteria include an *E. coli* criterion not to exceed a single sample maximum of 235 colony-forming units per 100 milliliters (cfu/100mL) in more than ten percent of the samples taken during any thirty-day period and a seasonal geometric mean criterion of 126 cfu/100mL. The criteria are only in effect during the recreation season, which is defined as, “the period from May first to October thirty-first” (Ohio EPA, 2010).

Water chemistry samples were collected from the east sites at each beach and Euclid Creek RM 0.55 from May 1 through August 26. The water chemistry samples were analyzed for alkalinity, ammonia, nitrate+nitrite, sulfate, total dissolved solids, total

organic carbon, total suspended solids, total phosphorus, chlorophyll *a*, chloride and/or ortho-phosphorus. The purpose of this sampling was to determine if a correlation existed between one or more of the above mentioned chemical parameters and *E. coli* that could be used for future modeling at the beaches. It was determined by NEORSD's Analytical Services division that no significant correlations existed, therefore, the collection of water chemistry samples did not continue past August 26 (Note: This data will be presented in a Great Lakes Restoration Initiative (GLRI) grant report to be written by Analytical Services). However, the results collected may be used in the future when the Ohio EPA develops water quality standards for nutrients. Additionally, the data may help in determining the overall impact of nutrients on Lake Erie.

Edgewater Beach

During the recreation season, 155 bacteriological samples were collected at Edgewater Beach East, and another 155 bacteriological samples were collected at Edgewater Beach West, corresponding to a total of 154 thirty-day periods[1] for each site. The 155 bacteriological samples included extra samples that were collected from the East and West sites between July 19-20 and August 15-17. These samples were collected due to Combined Sewer Overflow (CSO) 069, which discharged on July 17 and August 15 and were included in the comparison of the Edgewater Beach bacteriological results to the Ohio water quality standards. The extra samples were collected due to the CSOs' close proximity to Edgewater Beach, which is discussed later in this report.

At Edgewater Beach East, 12 thirty-day periods (7.8%) were in attainment of the single sample maximum (SSM) criterion, while 142 thirty-day periods (92.2%) exceeded the criterion (Figure 3). At Edgewater Beach West, two thirty-day periods (1.3%) were in attainment of the SSM criterion, while 152 thirty-day periods (98.7%) exceeded the criterion (Figure 4). Although there were multiple exceedances of the SSM criterion, both sites were in attainment of the seasonal geometric mean (SGM) criterion (Figure 9).

[1] Based on not less than two (2) samples collected within a thirty-day period.

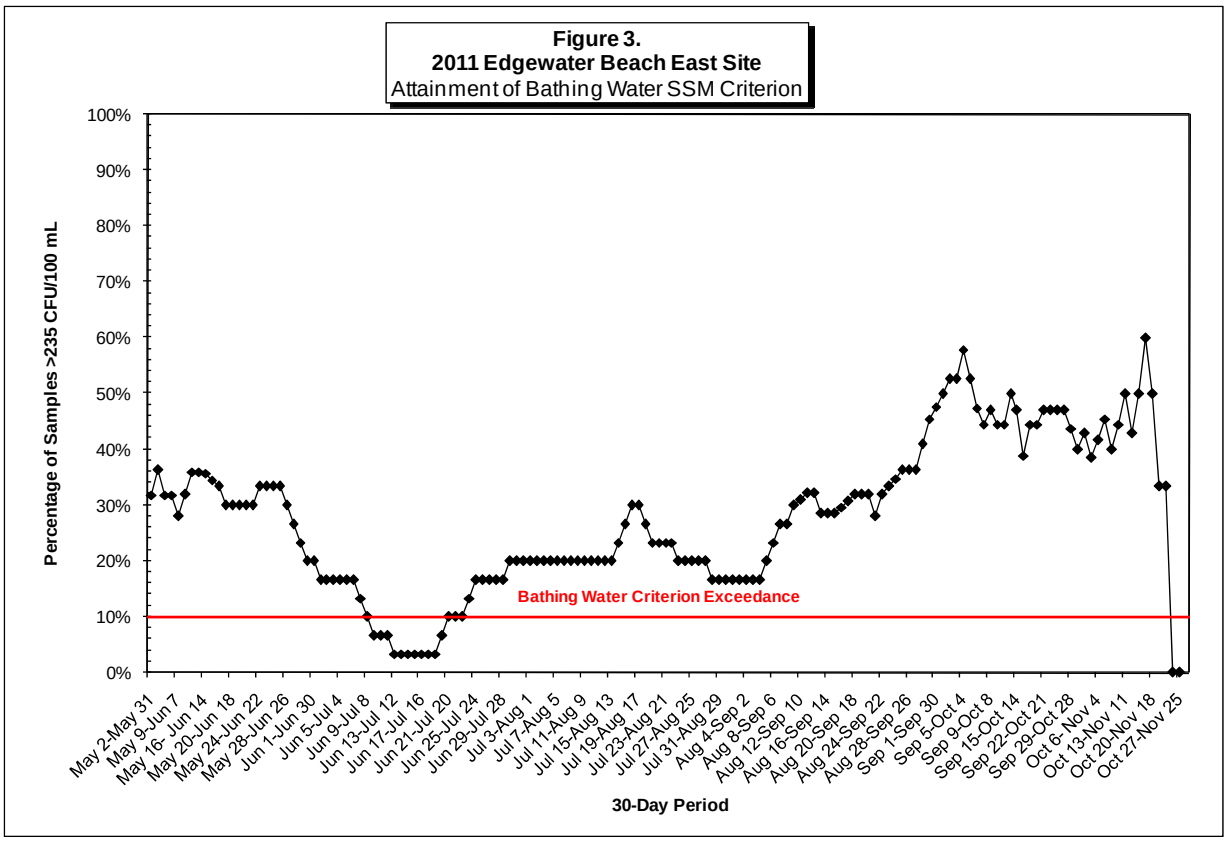


Figure 3.
2011 Edgewater Beach East Site
Attainment of Bathing Water SSM Criterion
Percentage of Samples >235 CFU/100 mL
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Bathing Water Criterion Exceedance
May 2-May 31
May 9-Jun 7
May 16- Jun 14
May 20-Jun 18
May 24-Jun 22
May 28-Jun 26
Jun 1-Jun 30
Jun 5-Jul 4
Jun 9-Jul 8
Jun 13-Jul 12
Jun 17-Jul 16
Jun 21-Jul 20
Jun 25-Jul 24
Jun 29-Jul 28
Jul 3-Aug 1
Jul 7-Aug 5
Jul 11-Aug 9
Jul 15-Aug 13
Jul 19-Aug 17
Jul 23-Aug 21
Jul 27-Aug 25
Jul 31-Aug 29
Aug 4-Sep 2
Aug 8-Sep 6
Aug 12-Sep 10
Aug 16-Sep 14
Aug 20-Sep 18
Aug 24-Sep 22
Aug 28-Sep 26
Sep 1-Sep 30
Sep 5-Oct 4
Sep 9-Oct 8
Sep 15-Oct 14
Sep 22-Oct 21
Sep 29-Oct 28
Oct 6- Nov 4
Oct 13-Nov 11
Oct 20-Nov 18
Oct 27-Nov 25
30-Day Period

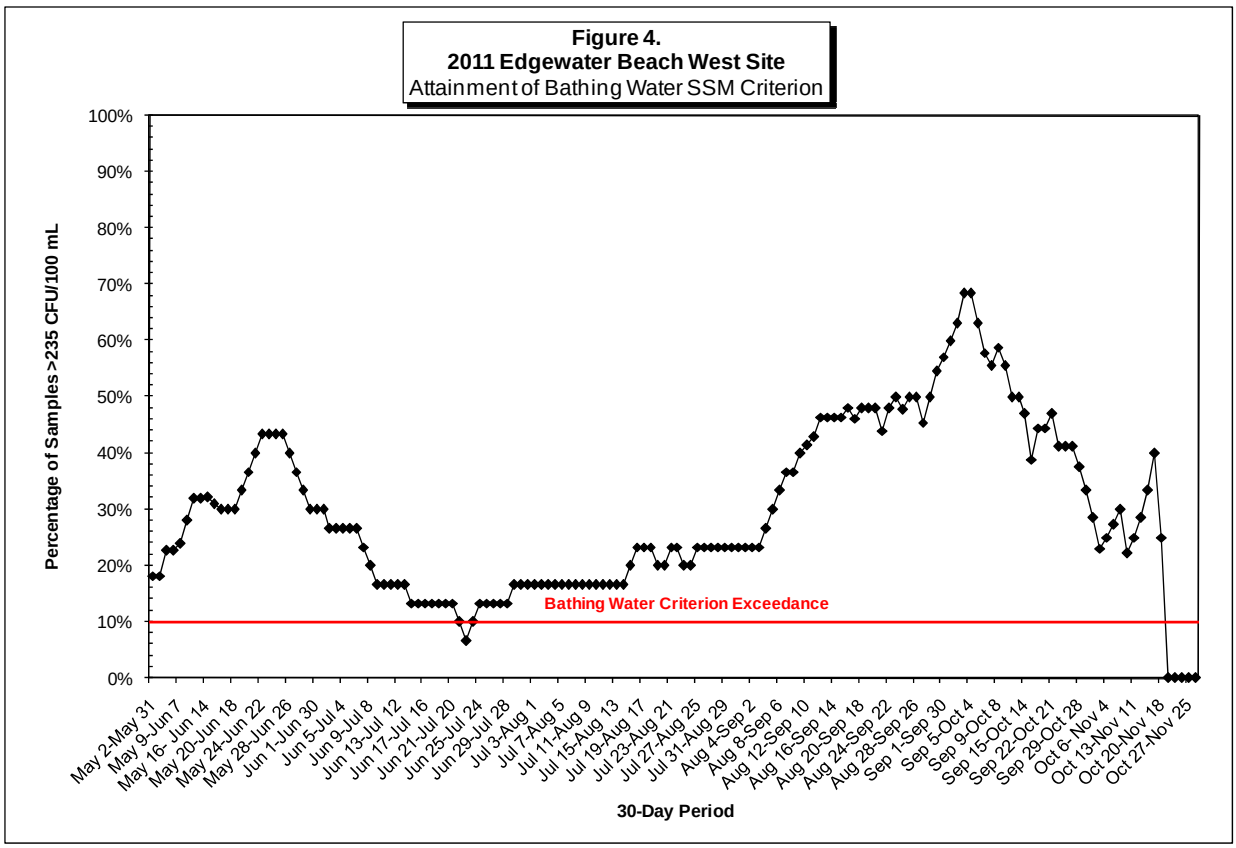


Figure 4.
2011 Edgewater Beach West Site
Attainment of Bathing Water SSM Criterion
Percentage of Samples >235 CFU/100 mL
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Bathing Water Criterion Exceedance
May 2-May 31
May 9-Jun 7
May 16- Jun 14
May 20-Jun 18
May 24-Jun 22
May 28-Jun 26
Jun 1-Jun 30
Jun 5-Jul 4
Jun 9-Jul 8
Jun 13-Jul 12
Jun 17-Jul 16
Jun 21-Jul 20
Jun 25-Jul 24
Jun 29-Jul 28
Jul 3-Aug 1
Jul 7-Aug 5
Jul 11-Aug 9
Jul 15-Aug 13
Jul 19-Aug 17
Jul 23-Aug 21
Jul 27-Aug 25
Jul 31-Aug 29
Aug 4-Sep 2
Aug 8-Sep 6
Aug 12-Sep 10
Aug 16-Sep 14
Aug 20-Sep 18
Aug 24-Sep 22
Aug 28-Sep 26
Sep 1-Sep 30
Sep 5-Oct 4
Sep 9-Oct 8
Sep 15-Oct 14
Sep 22-Oct 21
Sep 29-Oct 28
Oct 6- Nov 4
Oct 13-Nov 11
Oct 20-Nov 18
Oct 27-Nov 25
30-Day Period

A possible explanation for the exceedances of the SSM criterion is wet weather. NEORSD defines wet weather as greater than 0.10 inches of rain but less than 0.25 inches, samples collected that day and the following day were considered wet weather samples; for greater than 0.25 inches, the samples collected that day and the following two days were considered wet weather samples. Sixty-one percent of the recreation season at Edgewater Beach was considered wet weather[2]. Wet weather events may contribute to elevated bacteria levels by causing discharges from CSOs, storm sewer runoff and urban runoff to enter Lake Erie.

Three NEORSD CSOs in the vicinity of Edgewater Beach are monitored daily by NEORSD's Sewer System Maintenance and Operation (SSMO) department. These CSOs discharged to Lake Erie a total of 42 times during the recreation season and may have had an effect on *E. coli* densities at the sampling sites (Table 5). Because CSO 069 is located approximately 0.2 miles west of the Edgewater Beach sampling sites, in accordance with NEORSD's Emergency Response Plan 2.2.4 (Edgewater Overflow), additional samples were collected at the East and West sites during the afternoon on July 19 and 20 and August 15 and 17. Although all of these CSOs are in close proximity to the beach, it is unknown if these overflow events had a direct effect on the water quality at Edgewater Beach. Other sources of contamination to the beach water may include avian waste and contaminated beach sand.

Table 5. Number of Monitored NEORSD CSO Overflows during 2011 Recreation Season

CSO	Location	Number of Overflows	Beach/Creek Potentially Affected
069	Upper Edgewater Beach	2	Edgewater
071	Harborview Drive and West 117th Street	9	Edgewater
002	NEORSD Westerly Water Pollution Control Center from the Combined Sewer Overflow Treatment Facility	31	Edgewater
001	Storm overflow at Easterly Wastewater Treatment Plant	42	Euclid Beach, Villa Angela
206	North end of East 156th Street at Lake Erie	15	Euclid Beach, Villa Angela
242	East 142nd Street and Lakeshore Boulevard	24	Euclid Beach, Villa Angela
239	Lakeshore Boulevard at Euclid Creek	73	Euclid Beach, Villa Angela, Euclid Creek

[2] Rainfall data obtained from NEORSD's Division Avenue Pump Station Rain Gauge. For days when this rain gauge did not record rainfall, rainfall data was obtained from accuweather.com

In the study, "Evaluation of Avian Waste and Bird Counts as Predicators of *Escherichia coli* Contamination at Door County, Wisconsin Beaches" by Kleinheinz, McDermott, & Chomeau (2006), researchers counted avian waste along 13 beaches in Wisconsin three times a week. The purpose was to evaluate avian *E. coli* density in beach water. Results indicated that at 30% of the beaches, the number of birds was positively correlated with *E. coli* densities in beach water. Therefore, if the relationship between the number of birds observed and *E. coli* densities at Door County beaches holds true, then in the Cleveland area, bird feces may be a contributing factor to increased *E. coli* densities in the water at Edgewater Beach and the high number of SSM criterion exceedances. When examining the number of birds at the three beaches, Edgewater Beach had the highest average number of birds during sampling of all the beaches (Table 6).

Table 6. 2011 Estimated Bird Counts

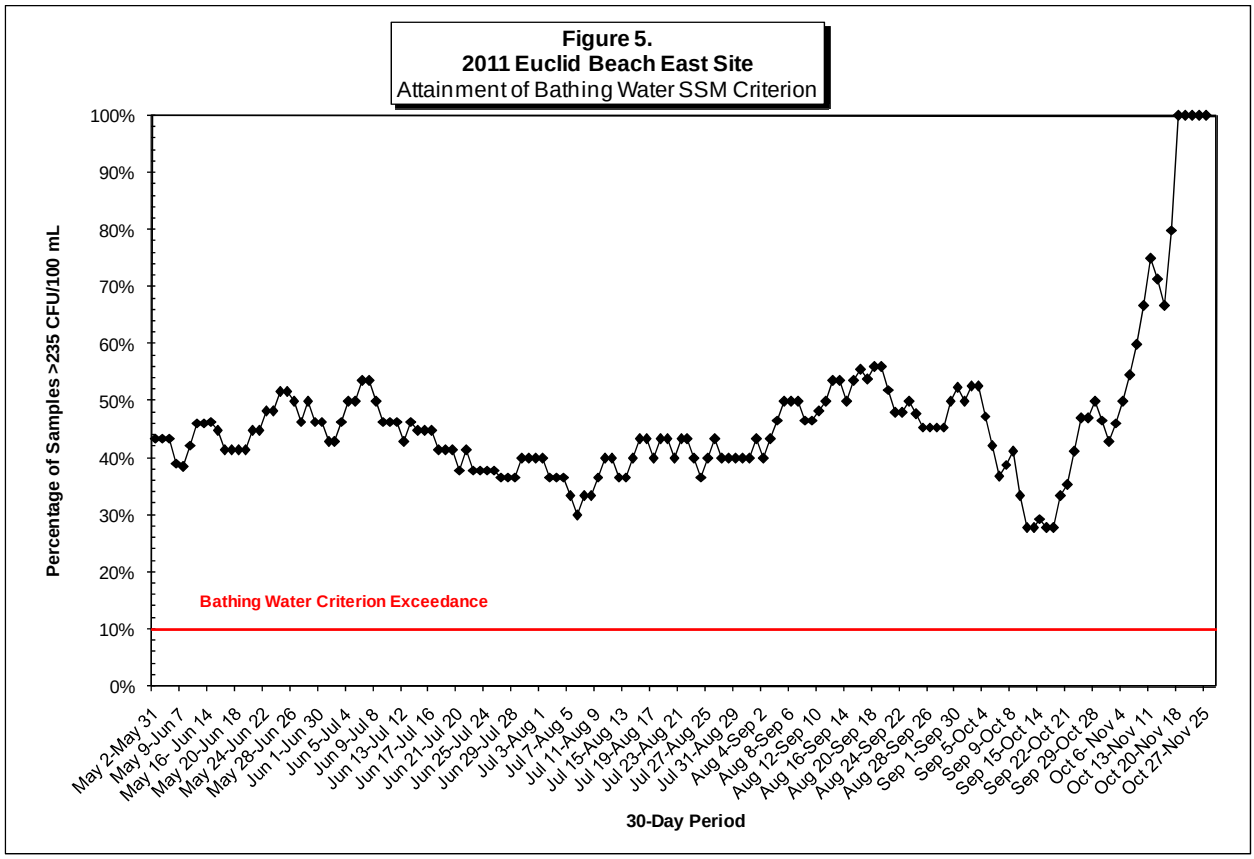
Beach	Site	Average Number of Birds
Edgewater	East	26
	West	81
Euclid	East	15
	West	21
Villa Angela	East	28
	West	10

Beach sand may also have an impact on *E. coli* densities in the water. In the study, "Foreshore Sand as a Source of Escherichia coli in Nearshore Water of a Lake Michigan Beach" by Whitman and Nevers (2003), researchers discovered that *E. coli* concentrations in sand and water were significantly correlated, with the highest concentration being found in foreshore sand[3], followed by those in submerged sediment and water of increasing depth. The study also stated that foreshore beach sand is an important non-point source of *E. coli* to lake water because it is capable of supporting high density bacteria for sustained periods, independent of lake, human, or animal input. If this is also the case in the Cleveland area, then beach sand may be contributing to the high *E. coli* densities at Edgewater Beach. Wave action must be taken into account, though, as it may influence the early colonization and distribution of *E. coli* in beach sand and the subsequent release of sand or sediment-borne *E. coli* in lake water (Ischii, Hansen, Hicks & Sadowsky, 2007).

[3] The area of a shore that lies between the average high tide mark and the average low tide mark.

Euclid Beach

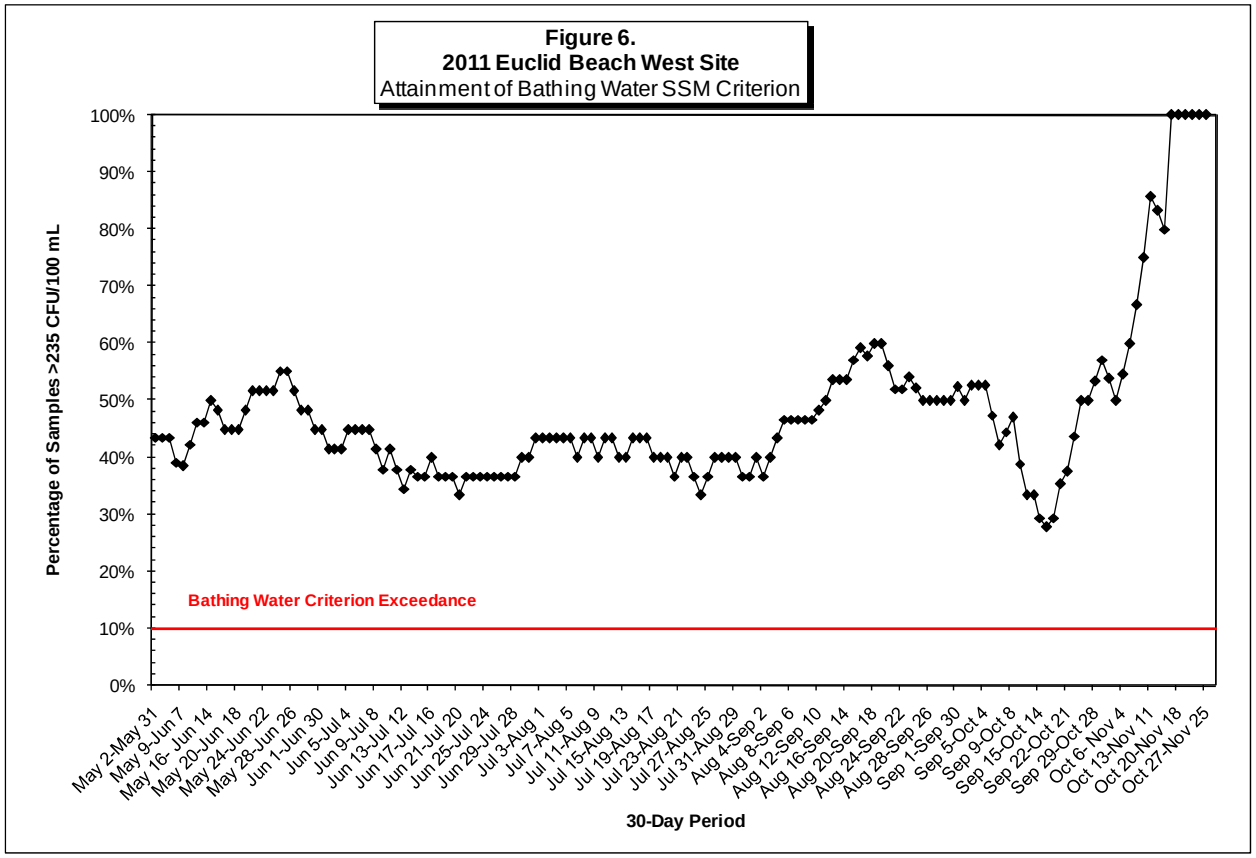
During the recreation season, 149 bacteriological samples were collected at each Euclid Beach site, corresponding to 148 thirty-day periods. At both the East and West sites, all thirty-day periods (100%) exceeded the SSM criterion (Figures 5 and 6) and neither site was in attainment of the SGM criterion (Figure 9).



A possible explanation for the exceedances of the SSM criterion and SGM criterion is wet weather. Wet weather may cause CSOs, storm sewer runoff, and urban runoff that might contain elevated *E. coli* densities to enter the lake. Sixty-four percent of the recreation season at Euclid and Villa Angela Beaches was considered wet weather[4]. Four NEORSD CSOs in the vicinity of Euclid and Villa Angela Beach are monitored daily by NEORSD's SSMO department. These CSOs discharged a total of 154 times during the recreation season and may have had an effect on *E. coli* densities at the sampling sites (Table 5). Also, CSO 207, at East 156th Street and Lakeshore Boulevard, and CSO 208, north of Neff Road and East Park Drive, which are not monitored by the SSMO department, may have overflowed during the recreation season. Although these CSOs are in close proximity to the beaches, it is unknown if these

[4] Rainfall data obtained from NEORSD's Easterly Wastewater Treatment Plant Rain Gauge. For days when this rain gauge did not record rainfall, rainfall data was obtained from accuweather.com

overflow events had an impact on the water quality at Euclid Beach. Aside from CSOs, other sources of contamination to beach water may include avian waste and beach sand.



Additionally, on July 18, the Euclid Creek Pump Station (ECPS) lost power for approximately 11 hours, discharging 680,000 gallons of combined sewage to Euclid Creek, which empties into Lake Erie approximately 400 yards east of Euclid Beach (refer to report titled "*Response to Overflow from Euclid Creek Pump Station, July 19, 2011*" on September 13, 2011). Bacteriological samples were obtained at sites north of the breakwaters near Villa Angela and Euclid Beaches on July 19 and 20, and afternoon samples were collected on July 20 at Euclid Beach East and West. This additional sampling was performed to determine any impacts the discharge event may have had on the water quality in Lake Erie. The extra afternoon bacteriological samples were included in the comparison of the Euclid Beach bacteriological results to the Ohio water quality standards. This discharge event may have contributed to Euclid Beach failing to meet the SSM and SGM criteria. The bacteriological results from the ECPS event indicated more impaired water quality on July 19, with significantly lower bacteriological results obtained on July 20 (Table 7).

Table 7. Euclid Creek Pump Station Overflow Event *E. coli* Results

	7/19/2011	7/20/11 (Morning)	7/20/11 (Afternoon)	7/21/2011
Site	cfu/100 mL			
Villa Angela Beach East	240	55	40	720
Villa Angela Beach West	225	30	53	1,470
Euclid Beach East	116	53	60	1,000
Euclid Beach West	1,950	37	40	600
Euclid Creek RM 0.55	16,660	2,250	--	1,200
Euclid Creek RM 0.14	29,600	3,450	--	920 EC

EC – estimated count

Similar to Edgewater Beach, bird waste may also play a role in *E. coli* densities at Euclid Beach. The bird community at Euclid Beach (Table 6) may contribute to avian fecal contamination in the water and thus a potential increase in bacteriological density in beach water. The same can be said of beach sand, which has the potential to contaminate beach water.

Villa Angela Beach

During the recreation season, 150 bacteriological samples were collected at Villa Angela Beach East, corresponding to 149 thirty-day periods. At this site, all thirty-day periods (100%) exceeded the SSM criterion (Figure 7). At Villa Angela Beach West, a total of 151 samples were collected, corresponding to 150 thirty-day periods. At the West site, all thirty-day periods (100%) exceeded SSM criterion (Figure 8). Villa Angela West was in attainment of the SGM criterion, but the East site was not (Figure 9).

Figure 7.
2011 Villa Angela Beach East Site
Attainment of Bathing Water SSM Criterion

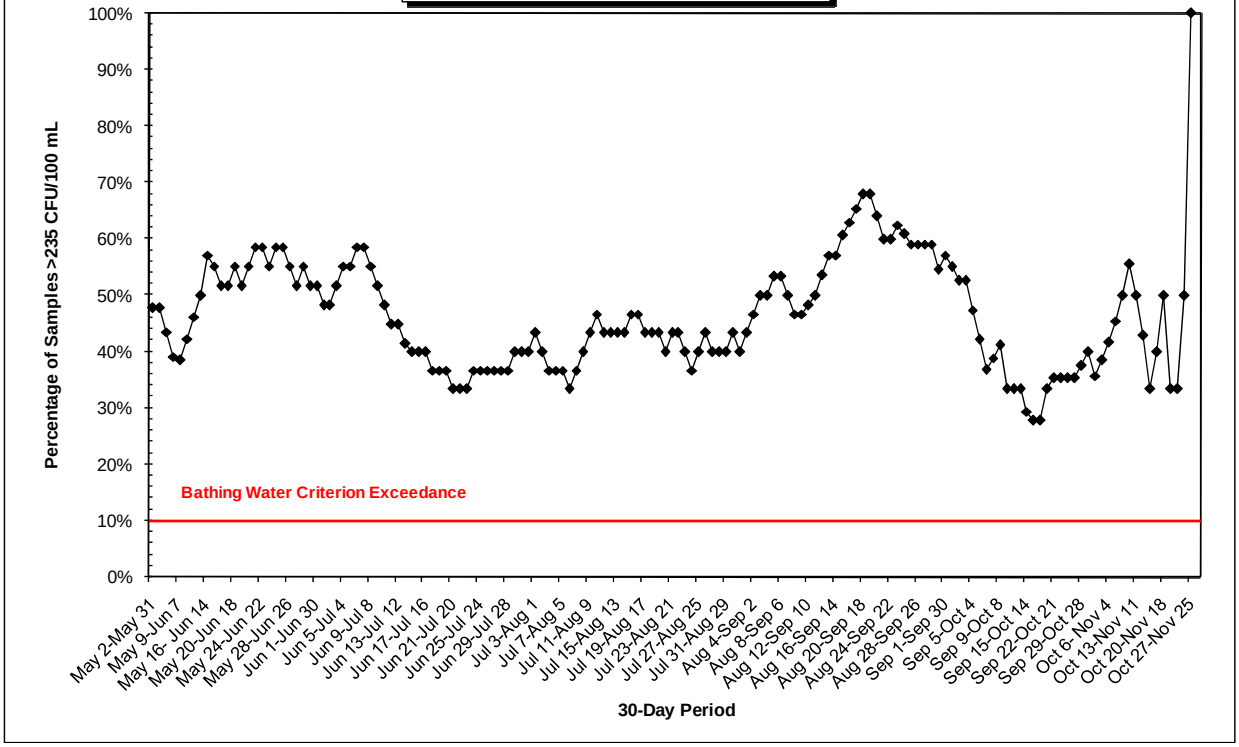
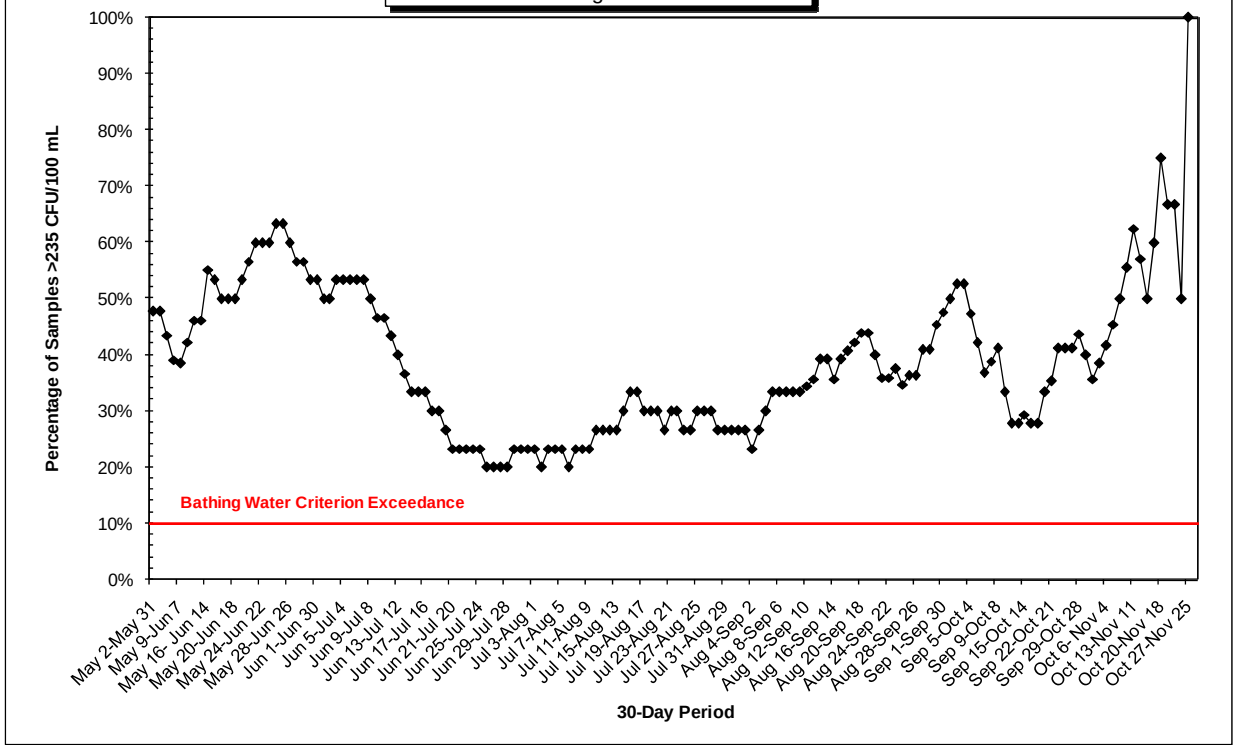
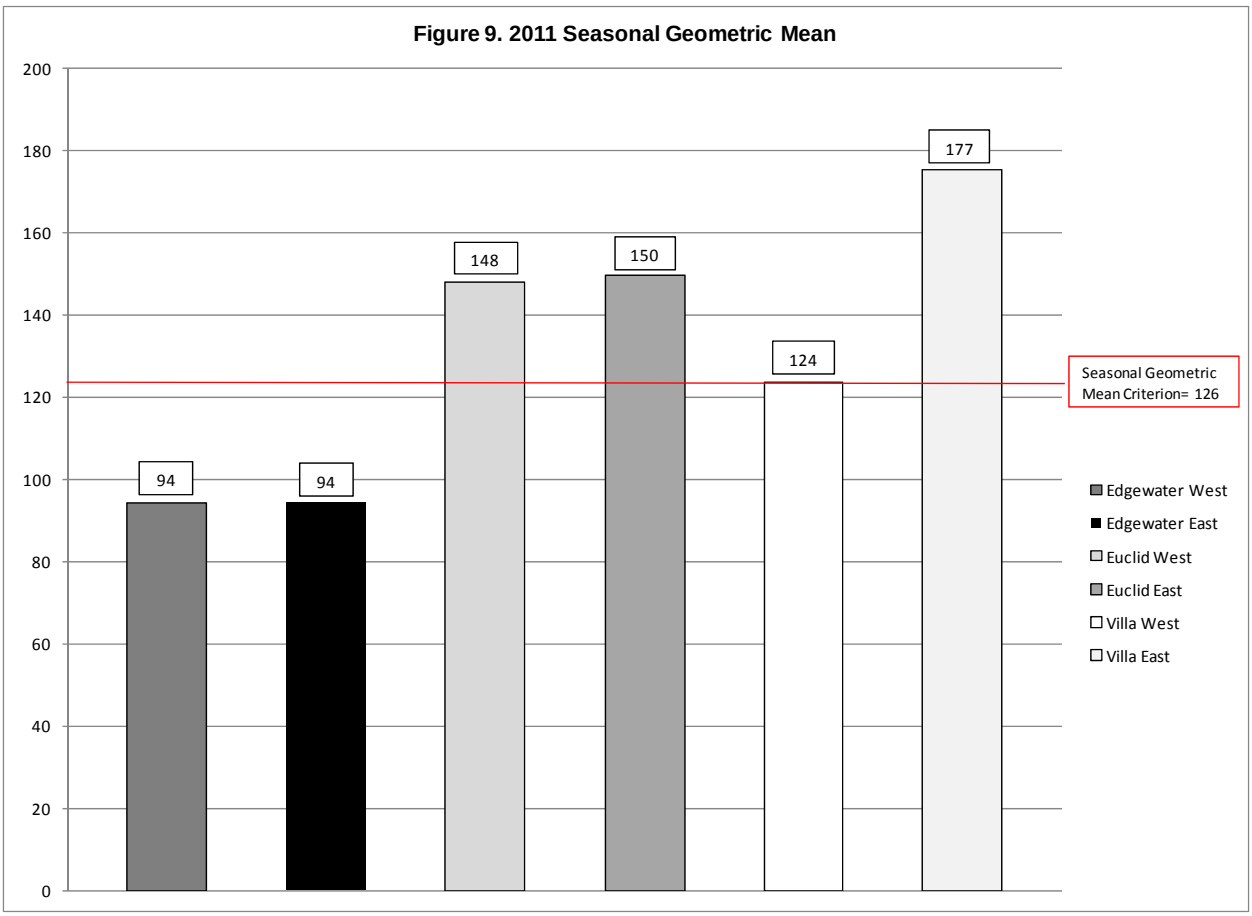


Figure 8.
2011 Villa Angela Beach West Site
Attainment of Bathing Water SSM Criterion



A possible explanation for the exceedances of the SSM criterion at both sites and SGM criterion at the East Site could be wet weather. Wet weather may cause CSOs, storm sewer runoff, and urban runoff to enter the lake that may contain elevated *E. coli* densities. As previously mentioned, there are four monitored NEORSD CSOs in the vicinity of Villa Angela and Euclid Beach that discharged a total of 154 times during the recreation season. Although these CSOs are in close proximity to the beach, it is unknown if the overflow events had an impact on the water quality at Villa Angela Beach. Additionally, the ECPS discharge event that occurred on July 18 may have also contributed to the SSM and SGM criteria exceedances, since Euclid Creek is located adjacent to Villa Angela Beach East (Table 5).

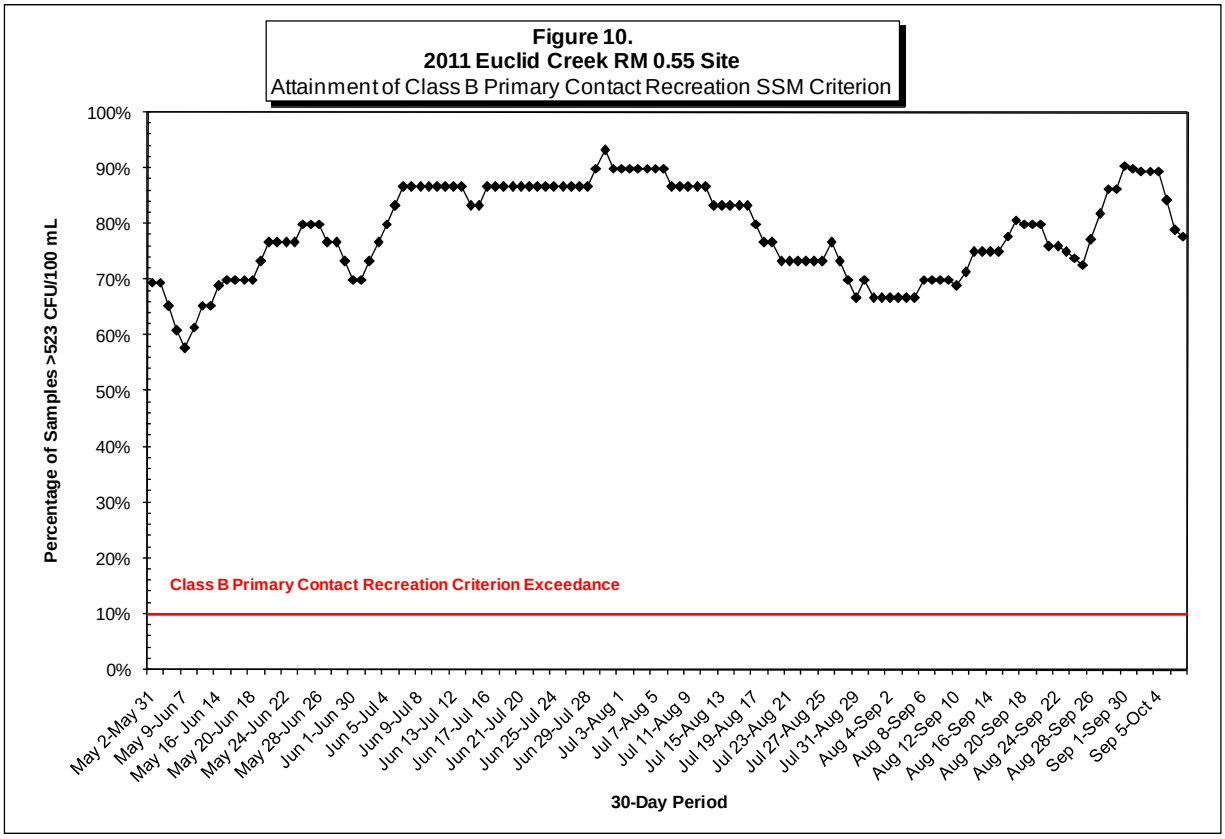
The average number of birds on Villa Angela Beach was 28 and 10 for the East and West sites, respectively, during the sampling season (Table 6). Similar to Edgewater and Euclid Beaches, bird waste may be contributing to the elevated *E. coli* densities observed, as well as beach sand, which has the potential to contaminate beach water.



Euclid Creek Results and Discussion

The *E. coli* results from both creek sites were compared to the Ohio water quality standards to determine recreation use attainment. Euclid Creek is designated as Class B Primary Contact Recreation for the Protection of Recreation Use (Ohio EPA, 2010). The Class B Primary Contact Recreation criteria includes an *E. coli* criterion not to exceed a single sample maximum of 523 cfu/100mL in more than ten percent of the samples taken during any thirty-day period, and a seasonal geometric mean criterion of 161 cfu/100mL. The criteria are only in effect during the recreation season (Ohio EPA, 2010).

During the recreation season at Euclid Creek RM 0.55, 151 bacteriological samples were collected at RM 0.55. This corresponds to a total of 150 thirty-day periods. At Euclid Creek RM 0.14, 68 bacteriological samples were collected, corresponding to a total of 67 thirty-day periods. At both creek sites, all thirty-day periods (100%) exceeded the SSM criterion (Figures 10 and 11). Additionally, both sites exceeded the SGM criterion (Figure 12).



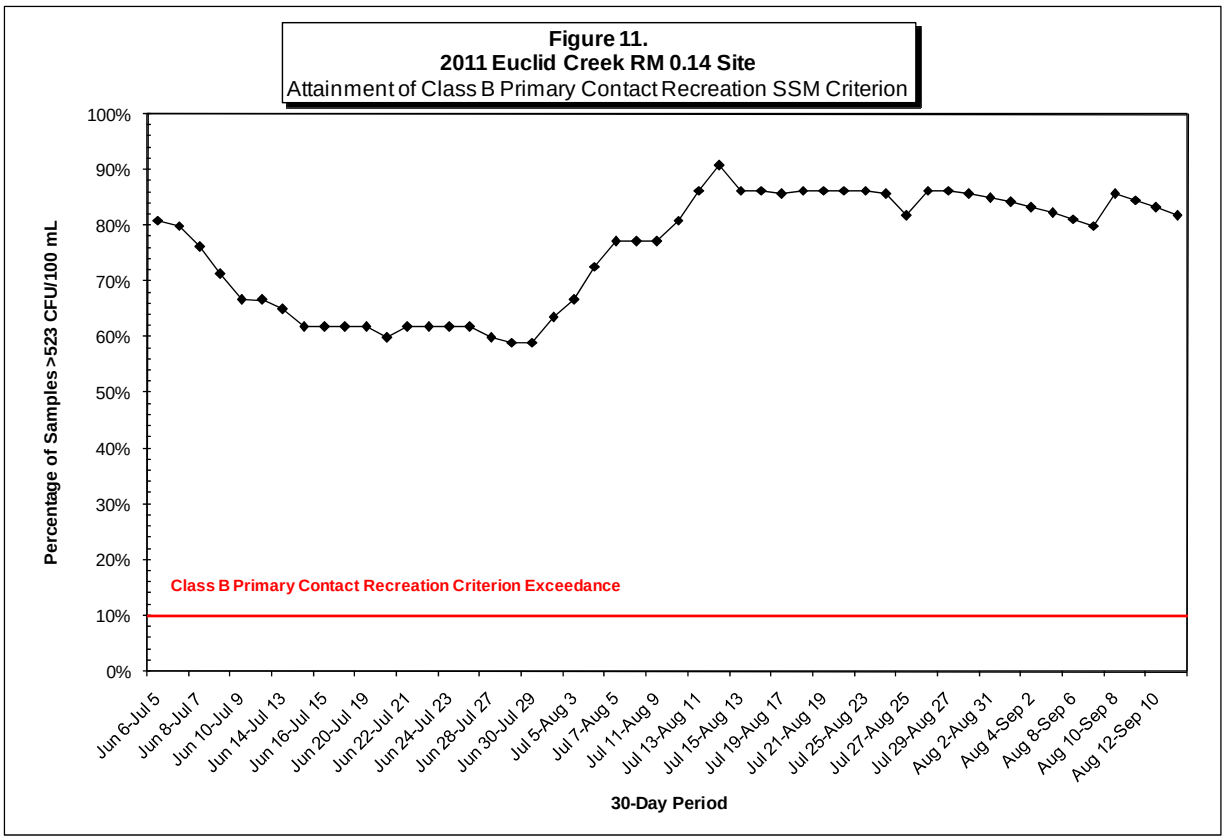
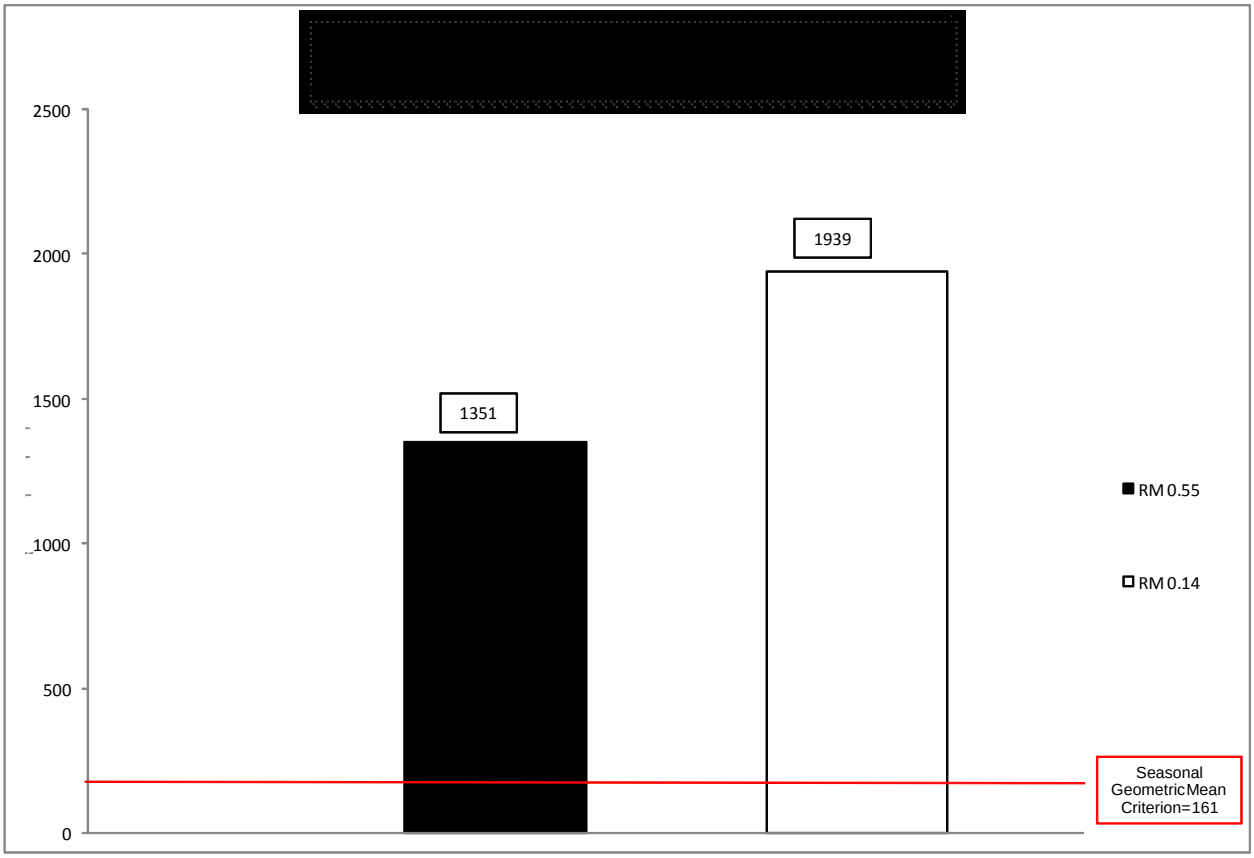


Figure 11.
2011 Euclid Creek RM 0.14 Site
Attainment of Class B Primary Contact Recreation SSM Criterion
Percentage of Samples >523 CFU/100 mL
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Class B Primary Contact Recreation Criterion Exceedance
Jun 6-Jul 5
Jun 8-Jul 7
Jun 10-Jul 9
Jun 14-Jul 13
Jun 16-Jul 15
Jun 20-Jul 19
Jun 22-Jul 21
Jun 24-Jul 23
Jun 28-Jul 27
Jun 30-Jul 29
Jul 5-Aug 3
Jul 7-Aug 5
Jul 11-Aug 9
Jul 13-Aug 11
Jul 15-Aug 13
Jul 19-Aug 17
Jul 21-Aug 19
Jul 25-Aug 23
Jul 27-Aug 25
Jul 29-Aug 27
Aug 2-Aug 31
Aug 4-Sep 2
Aug 8-Sep 6
Aug 10-Sep 8
Aug 12-Sep 10
30-Day Period


2500
2000
1500
1000
500
0
1351
1939
RM 0.55
RM 0.14
Seasonal Geometric Mean Criterion=161

A possible explanation for the exceedances of the SSM and SGM criterion could be wet weather. Looking at wet weather occurrences in 2011, 64% of the recreation season at Euclid Creek was considered wet weather[5]. Wet weather may cause CSO overflows, storm sewer runoff, and urban runoff to enter the creek that may contain elevated *E. coli* densities. As previously mentioned, CSO 239 overflowed 73 times to Euclid Creek during the recreation season. Also, CSO 210, located under the Saint Clair Avenue Bridge, and CSO 209, located just north of Lakeshore Boulevard, which are not monitored by the SSMO department, may have also overflowed during the recreation season. Although these CSOs discharge to Euclid Creek, it is unknown if the overflow events had an impact on the water quality in Euclid Creek.

It is likely that the ECPS discharge event had an impact on the water quality at the two Euclid Creek sites. The ECPS is located 100 yards upstream of Euclid Creek RM 0.55; therefore, the discharge of 680,000 gallons of combined sewage on July 18 most likely contributed to the SSM and SGM exceedances at both sites (Table 7).

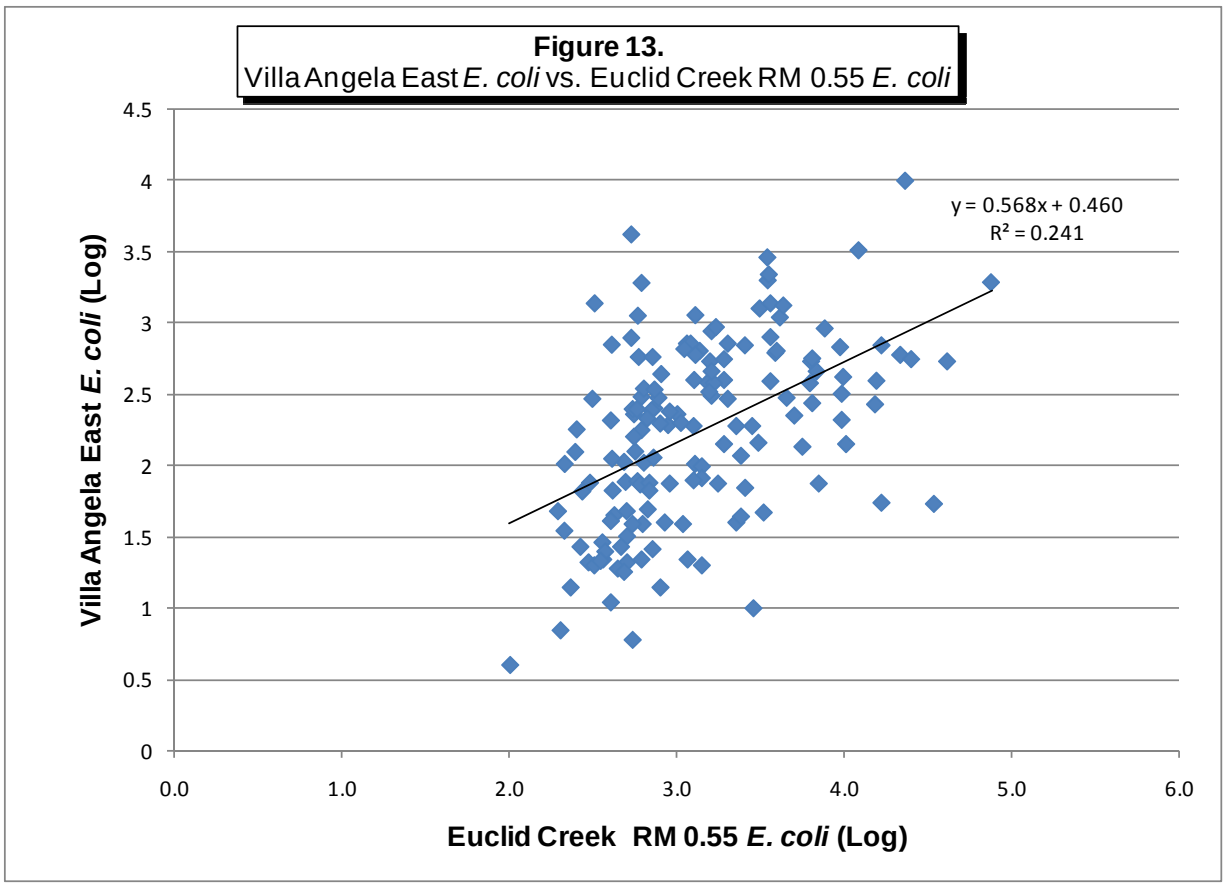
Dry weather flow to Euclid Creek may also have an effect on *E. coli* densities at RMs 0.55 and 0.14. Investigations by WQIS personnel on Euclid Creek in 2005, 2006 and 2007 revealed eight storm sewer outfalls in the cities of Cleveland and Euclid that had continuously elevated densities of *E. coli* entering the creek during dry weather. In 2010, WQIS personnel and the City of Euclid verified that two outfalls are no longer a source of bacteriological contamination to the creek. The remaining six storm sewer outfalls as well as CSOs outside of the NEORSD service area and sanitary sewer overflows may still be impacting the water quality at the Euclid Creek sampling sites.

Impact of Euclid Creek on Villa Angela Beach

Due to its close proximity, *E. coli* densities measured in Euclid Creek may be impacting the sampling sites on Villa Angela and Euclid Beaches (Figure 12). In the report titled "Interaction and Influence of Two Creeks on *Escherichia coli* Concentrations of Nearby Beaches: Exploration of Predictability and Mechanisms" (Nevers, Whitman & Frick, 2007), it was discovered that *E. coli* contamination in creeks had the greatest effect on *E. coli* densities at surrounding beaches. The transportation of *E. coli* from the creeks to the beaches was significantly influenced by wind speed and direction, currents, wave height and shoreline orientation. Thus, bacteria that enter Euclid Creek may flow downstream and into Lake Erie. Once there, prevailing winds and currents may direct the bacteria toward Euclid and Villa Angela Beaches and the sampling locations. Thus, *E. coli* densities in Euclid Creek may impact *E. coli* densities, and attainment of the recreation criteria, at Euclid and Villa Angela Beaches. Figure 13 shows the correlation between bacteriological densities at Villa Angela Beach East and Euclid Creek RM 0.55.

[5] Rainfall data obtained from NEORSD's South Euclid Rain Gauge.

Figure 12. Orientation of Euclid Creek and Villa Angela Beach



Conclusions

Edgewater, Villa Angela and Euclid Beaches

In 2011, beach sampling sites exceeded the SSM criterion 100% of the time, except for Edgewater Beach East (92.2%) and West (98.7%) (Table 8). Attainment of the criterion varied from 7.8% at Edgewater East and 1.3% at Edgewater West to 0% at all other beach sampling sites. The only sites in attainment of the SGM criterion were Edgewater Beach East and West, and Villa Angela Beach West (Table 9). It is evident from these results that the beaches were impacted by bacteriological contamination.

Table 8. 2011 Beach Results of Single Sample Maximum Criterion

Beach	Site	# Thirty-day periods	# Thirty-day periods in attainment of criterion	% Attainment	# Thirty-day periods in exceedance of criterion	% Exceedance
Edgewater	East	154	12	7.8%	142	92.2%
	West	154	2	1.3%	152	98.7%
Euclid	East	148	0	0%	148	100%
	West	148	0	0%	148	100%
Villa Angela	East	149	0	0%	149	100%
	West	150	0	0%	150	100%

Table 9. 2011 Beach Results of Seasonal Geometric Mean Criterion

Beach	Site	SGM (cfu/100mL)	Attainment of Criterion (YES/NO)
Edgewater	East	98	YES
	West	97	YES
Euclid	East	149	NO
	West	148	NO
Villa Angela	East	174	NO
	West	123	YES

The Euclid Creek sampling sites exceeded the SSM criterion 100% of the time, with no attainment at either site (Table 10). Additionally, both sites exceeded the SGM criterion in 2011 (Table 11).

Table 10. 2011 Creek Results of Single Sample Maximum Criterion

Creek	Site	# Thirty-day periods	# Thirty-day periods in attainment of criterion	% Attainment	# Thirty-day periods in exceedance of criterion	% Exceedance
Euclid Creek	0.55	150	0	0%	150	100%
	0.14	67	0	0%	67	100%

Table 11. 2011 Creek Results of Seasonal Geometric Mean Criterion

Creek	Site	SGM (cfu/100mL)	Attainment of Criterion (YES/NO)
Euclid Creek	RM 0.55	1351	NO
	RM 0.14	1939	NO

When comparing the 2011 beach data to the 2010 data, a greater percentage of thirty-day periods exceeded the SSM criterion at the beaches in 2011 than 2010. Only one out of six sites exceeded the SSM criterion 100% of the time in 2010 (Table 12), while four of the six sites exceeded the SSM criterion 100% of the time in 2011 (Table 8). The results of the SGM criterion at the beaches were different in 2010 and 2011, with one site exceeding the SGM criterion in 2010 and three sites exceeding the SGM in 2011 (Tables 9 and 13). The differences between 2011 and 2010 may be attributed to seasonal variability (i.e., rainfall, wind speed, wind direction, wave height, and number of CSO discharge events, etc.) from year to year.

Especially true was the difference in wet weather between 2011 and 2010. For Edgewater, 61% of the season was considered wet weather in 2011 versus 16% in 2010. For Euclid and Villa Angela Beaches, 64% of the season was considered wet weather in 2011 versus 22% in 2010. Increased rainfall may cause CSO discharge events, stormwater runoff, urban runoff and other pollutant loads. These potential sources that

could enter Lake Erie may contain elevated bacteriological densities. Since 2011 had a higher percentage of wet weather days than 2010, the increased rainfall amount (and subsequent effects) may have been an important factor contributing to the increased thirty-day SSM exceedances and the failure of three beach sites to attain the SGM criterion in 2011.

Table 12. 2010 Beach Results of Single Sample Maximum Criterion

Beach	Site	# Thirty-day periods	# Thirty-day periods in attainment of criterion	% Attainment	# Thirty-day periods in exceedance of criterion	% Exceedance
Edgewater	East	149	40	26.8%	109	73.2%
	West	149	49	32.9%	100	67.1%
Euclid	East	145	14	9.7%	131	90.3%
	West	146	8	5.5%	138	94.5%
Villa Angela	East	148	0	0%	148	100%
	West	147	14	9.5%	133	90.5%

Table 13. 2010 Beach Results of Seasonal Geometric Mean Criterion

Beach	Site	SGM (cfu/100mL)	Attainment of Criterion (YES/NO)
Edgewater	East	56	YES
	West	46	YES
Euclid	East	110	YES
	West	100	YES
Villa Angela	East	128	NO
	West	89	YES

Euclid Creek

The 2011 Euclid Creek data was identical to the 2010 data, as both sites exceeded the SSM criterion 100% of the time and both sites exceeded the SGM criterion (Tables 10 & 14; Tables 11 & 15). Euclid Creek RM 0.55 had a greater number of sampling days, and thus thirty-day periods in 2011, but RM 0.14 had less sampling days (and thus less thirty-day periods) in 2011. Additionally, both Euclid Creek sites had a higher SGM in 2011 than 2010. This difference may be attributed to seasonal variability (i.e., rainfall, wind speed, wind direction, number of CSO discharge events, etc.) from year to year.

Table 14. 2010 Creek Results of Single Sample Maximum Criterion

Creek	Site	# Thirty-day periods	# Thirty-day periods in attainment of criterion	% Attainment	# Thirty-day periods in exceedance of criterion	% Exceedance
Euclid Creek	0.55	71	0	0%	71	100%
	0.14	71	0	0%	71	100%

Table 15. 2010 Creek Results of Seasonal Geometric Mean Criterion

Creek	Site	SGM (cfu/100mL)	Attainment of Criterion (YES/NO)
Euclid Creek	RM 0.55	1047	NO
	RM 0.14	1288	NO

Elevated *E. coli* densities continue to be observed at the Edgewater, Villa Angela, and Euclid Beaches as well as Euclid Creek. Many factors, such as CSOs, sanitary sewer overflows, storm sewer and urban runoff, beach sand, and avian waste may be contributing to the elevated *E. coli* densities observed. Further monitoring at the beaches and creek will continue to characterize and help to identify the issues that may be impacting these sites.

In 2011, the NEORSD entered into a consent decree with the United States Environmental Protection Agency, Ohio Environmental Protection Agency, Department of Justice, and the Ohio Attorney General's Office to reduce the volume of raw sewage that discharges into the environment during rain events. This 25-year CSO control program will help control the number of CSO overflows, and thus bacteria, into Lake Erie and Euclid Creek. Bacteriological sampling results from 2010 and 2011 will serve as baseline data for this program, as new CSO controls are implemented in the coming years. It is anticipated that the water quality at the beaches and Euclid Creek will improve as these CSO controls come online which will help NEORSD to better identify other possible sources and causes of the elevated *E. coli* densities at the beaches.

Acknowledgements

Field activities and report review completed by the following, except where otherwise noted:

Kelly Boreman
Jonathan Brauer
Amy Erzen
Kristina Granlund
Seth Hothem
Ron Maichle
Cole Musial
Andrea Nagy
Jill Novak, Author
Francisco Rivera
Tom Zablotny

Analytical Services Division – Completed analysis for all water chemistry and bacteriological sampling.

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