Protecting Our Water Environment

Metropolitan Water Reclamation District of Greater Chicago

MONITORING AND RESEARCH DEPARTMENT

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POST-CONSTRUCTION MONITORING REPORT FOR THE CALUMET TUNNEL AND RESERVOIR PLAN SYSTEM

June 2019

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POST-CONSTRUCTION MONITORING REPORT FOR THE CALUMET TUNNEL AND RESERVOIR PLAN SYSTEM

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LIST OF ABBREVIATIONS

Abbreviation	Meaning
130th	130th Street in the Calumet River
170th	170th Street in Thorn Creek
ANOVA	analysis of variance
Ashland	Ashland Avenue in the Little Calumet River South
AWQM	Ambient Water Quality Monitoring
BG	billion gallons
BOD_5	five-day biochemical oxygen demand
Burnham	Burnham Avenue in the Grand Calumet River
C&W	Chicago and Western Indiana Railroad
CAWS	Chicago Area Waterway System
CDOM	continuous DO monitoring
CFU	colony-forming units
Cicero	Cicero Avenue in the Calumet-Sag Channel
CRS	Calumet River System
CSC	Calumet-Sag Channel
CSO	combined sewer overflow
District	Metropolitan Water Reclamation District of Greater Chicago
DO	dissolved oxygen
FC	fecal coliform
GCR	Grand Calumet River
Halsted	Halsted Street in the Little Calumet River
IAC	Illinois Administrative Code
Indiana	Indiana Avenue in the Little Calumet River
L	liter
LCR	Little Calumet River
LCR-S	Little Calumet River South
log	logarithm
M&R	Monitoring and Research
MG	million gallons
mg	milligrams
mL	milliliter
NPDES	National Pollutant Discharge Elimination System
PCMP	Post-Construction Monitoring Plan
QA/QC	quality assurance/quality control
QAPP	Quality Assurance Project Plan
Route 83	Route 83 in the Calumet-Sag Channel
SEPA	Sidestream Elevated Pool Aeration
SOPs	standard operating procedures
TAN	total ammonia nitrogen
TARP	Tunnel and Reservoir Plan

LIST OF ABBREVIATIONS (Continued)

Abbreviation	Meaning
TCR	Thornton Composite Reservoir
TDS	total dissolved solids
TSS	total suspended solids
UMVUE	uniformly minimum variance unbiased estimator
USEPA	United States Environmental Protection Agency
Wentworth	Wentworth Avenue in the Little Calumet River South
WQS	water quality standards
WRP	water reclamation plant

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DISCLAIMER

Mention of proprietary equipment and chemicals in this report does not constitute endorsement by the Metropolitan Water Reclamation District of Greater Chicago.

SUMMARY AND CONCLUSIONS

In 1975 construction began on huge underground tunnels to intercept combined sewer overflow (CSO) discharges and convey them to storage reservoirs. This massive undertaking was in response to growing water quality and flooding problems that came with aging infrastructure and rapid development. Portions of the Calumet tunnel system began operation in 1986, and the entire tunnel system was completed in 2006. The Calumet Tunnel and Reservoir Plan (TARP) System's Thornton Composite Reservoir (TCR) became operational on November 26, 2015, when it took water for the first time, and was fully operational one year after that date. The TCR measures approximately 2,500 by 1,600 feet with a maximum water depth of 292 feet, and has a total capacity of 7.9 billion gallons (BG) (4.8 BG of combined sewerage and 3.1 BG of Thorn Creek floodwater).

The Metropolitan Water Reclamation District of Greater Chicago (District) entered into a Consent Decree on January 6, 2014. This report fulfills one of the Consent Decree requirements to submit a Post-Construction Monitoring Report to analyze water quality data and remaining CSO events following the completion of the TCR.

The District's Monitoring and Research (M&R) Department conducted monitoring in the Calumet River System (CRS) between January 1, 2017, and December 31, 2018, in accordance with the approved Calumet TARP System Post-Construction Monitoring Plan (PCMP). A total of 66 sampling events at nine (9) sampling locations in the Calumet River (1), Grand Calumet River (GCR) (1), Little Calumet River (LCR) (2), Little Calumet River South (LCR-S) (2), Calumet-Sag Channel (CSC) (2), and Thorn Creek (1), were completed during the pre- and post-construction periods. The sampling locations coincided with those used in the existing monthly Ambient Water Quality Monitoring (AWQM) program. Sampling events included monthly AWQM, wet weather without CSOs, wet weather with CSOs, and dry-weather sampling events. A total of 37 sampling events (20 pre- and 17 post-construction) met the criteria for dry-weather conditions, 14 events (six pre- and eight post-construction) met the criteria for wet weather without CSOs, and six events (four pre- and two post-construction) met the criteria for wet weather with CSOs. The criteria for three different weather conditions are defined in the PCMP.

Water quality data collected during dry and wet weather with and without CSOs were compared. The CRS monitoring was also conducted between January 1, 2014, and December 31, 2015, to assess water quality conditions prior to the completion of the TCR. Water quality data from wet- and dry-weather sampling events during these periods were compared using analysis of variance (ANOVA). In addition, monthly AWQM data collected during the post-construction monitoring period were compared to AWQM data collected (a) prior to 1985 (before any portion of the Calumet TARP system was on line); and (b) 2014–2015 (before the TCR went on line) using ANOVA.

The CSO events were drastically reduced in the CRS after the TCR was placed in service. The following conclusions highlight the effectiveness of the Calumet TARP system:

- The 125th Street Pumping Station never discharged during the post-construction monitoring period.

- Two CSO events occurred at a total of three CSO locations in the CRS during the post-construction monitoring period. Both were due to local conditions that restricted the conveyance of storm flows into the TARP drop shaft, not a failure of Calumet TARP system operation. In contrast, there were 19 CSO events at a total of 24 CSO locations during 2014–2015, prior to the completion of the TCR.

- The largest single rain event during the post-construction monitoring period was 4.34 inches and no CSOs occurred.

- The total estimated volume of CSOs during the post-construction monitoring period (6.0 million gallons [MG]) was 99.8 percent lower than the pre-construction monitoring period (3.5 BG).

- After the two post-construction CSO events, total ammonia nitrogen (TAN) and dissolved oxygen (DO) complied with the corresponding water quality standards (WQS) at all monitoring locations. Fecal coliform (FC) concentrations were less than 400 colony-forming units (CFU)/100 milliliters (mL) (used as an estimate of compliance) at Halsted Street in the LCR (Halsted) and Indiana Avenue in the LCR (Indiana), but exceeded 400 CFU/100 mL at the other CRS monitoring locations, both upstream and downstream of CSO discharges. Exceedances of 400 CFU/100 mL were also typical during wet-weather events without CSOs, suggesting nonpoint source contributions.

- During the post-construction monitoring period, water quality at the sampling locations directly downstream of CSO discharges was similar to water quality observed during wet-weather events without CSOs.

- Water quality was generally similar at the sampling locations directly upstream and downstream of CSO discharges during the two post-construction monitoring period CSO events, suggesting that the relatively small volume of CSO discharge did not impact water quality.

- During the post-construction monitoring period, water quality during wet- (with and without CSOs) and dry-weather conditions was generally similar with the following exceptions: (a) geometric mean FC concentrations during wet weather were higher in eight out of nine locations sampled; (b) mean total suspended solids (TSS) concentrations during wet weather were higher in five out of nine locations sampled; and mean total dissolved solids (TDS) concentrations were lower during wet weather in seven out of nine locations sampled.

- Mean TAN, five-day biochemical oxygen demand (BOD_5), FC, and TSS concentrations from monthly AWQM sampling were significantly lower during the post-construction monitoring period compared to historic concentrations for all the locations that were monitored during all three monitoring periods.

- The DO concentrations at the AWQM locations increased significantly in the CRS during both the pre- and post-construction monitoring periods compared to the historic period. Most of the significant DO increases between the pre- and post-construction monitoring periods were observed during sampling events in dry and wet weather with CSOs.

- Overall compliance with DO WQS increased at most continuous DO monitoring (CDOM) locations between pre- and post-construction monitoring periods and was greater than 90 percent at all locations during the post-construction monitoring period.

- Mean TSS concentrations in the pre- and post-monitoring periods were not significantly different at any CRS locations during wet-weather events with or without CSOs.

INTRODUCTION

Background

Chicago and 51 suburbs in the District's service area have combined sewer systems which discharged approximately 100 times a year to area waterways prior to the implementation of TARP. For an average rain event, the pollution load from these CSOs was equivalent to the organic waste loading from a population of four million people (Polls et al., 1998). During the most severe events, it was necessary to reverse the flow in the Chicago Area Waterway System (CAWS) by opening the sluice gates at the controlling works, and discharging stormwater and raw sewage to Lake Michigan. In 1970, in response to this growing water quality and flooding problem, an intergovernmental committee began a study to evaluate a number of different control alternatives. After two years of study, a design that became known as TARP was selected from the over 50 alternative plans considered. Under TARP, huge underground tunnels were excavated beneath the city to intercept CSO discharges in excess of interceptor sewer capacity, and convey them to three large open surface reservoirs for storage. Following a storm, the captured CSOs were then pumped out of the tunnels and reservoirs to water reclamation plants (WRPs) for treatment, and later discharged as WRP effluents to area waterways. Phase I of TARP consisted of tunnel systems that were primarily for pollution control, while Phase II consists of reservoirs primarily for flood control. Construction of the first TARP tunnel began in 1975.

Portions of the Calumet tunnel system began operation in 1986, and the entire tunnel system was completed in 2006. The Calumet TARP System's TCR became operational on November 26, 2015, when it took water for the first time, and was fully operational one year after that date, per Section VI.16.e of the District's Consent Decree. The TCR measures approximately 2,500 by 1,600 feet with a maximum water depth of 292 feet and has a total capacity of 7.9 BG (4.8 BG for combined sewerage and 3.1 BG for Thorn Creek floodwater). The District arranged to provide additional protection by extending its lease of the transitional reservoir (in the West Lobe of the quarry) through 2020. During that time, the community will receive the benefit of 3.1 BG of Thorn Creek floodwater storage provided by the transitional reservoir, in addition to the 7.9 BG of storage in the TCR.

Objectives

One of the requirements of the District's Consent Decree was that a PCMP be developed which included "in stream water quality monitoring relating to applicable water quality standards," and "determination of whether MWRD's [Metropolitan Water Reclamation District of Greater Chicago's] CSOs are in compliance with the then-effective CWRP [Calumet Water Reclamation Plant] NPDES [National Pollutant Discharge Elimination System] Permit, including applicable water quality standards incorporated therein." The District's M&R Department conducted monitoring in the CRS between January 1, 2017, and December 31, 2018, in accordance with the Calumet TARP System PCMP approved by the United States Environmental Protection Agency (USEPA) Region 5 in its October 7, 2016, letter to the District (Appendix A).

The approved PCMP stated that the District would conduct AWQM, CDOM, and wet-weather water quality monitoring during 2017 and 2018 to document water quality under various weather conditions in the CRS following the completion of the Calumet TARP System's TCR. This report contains the following, as outlined in the PCMP:

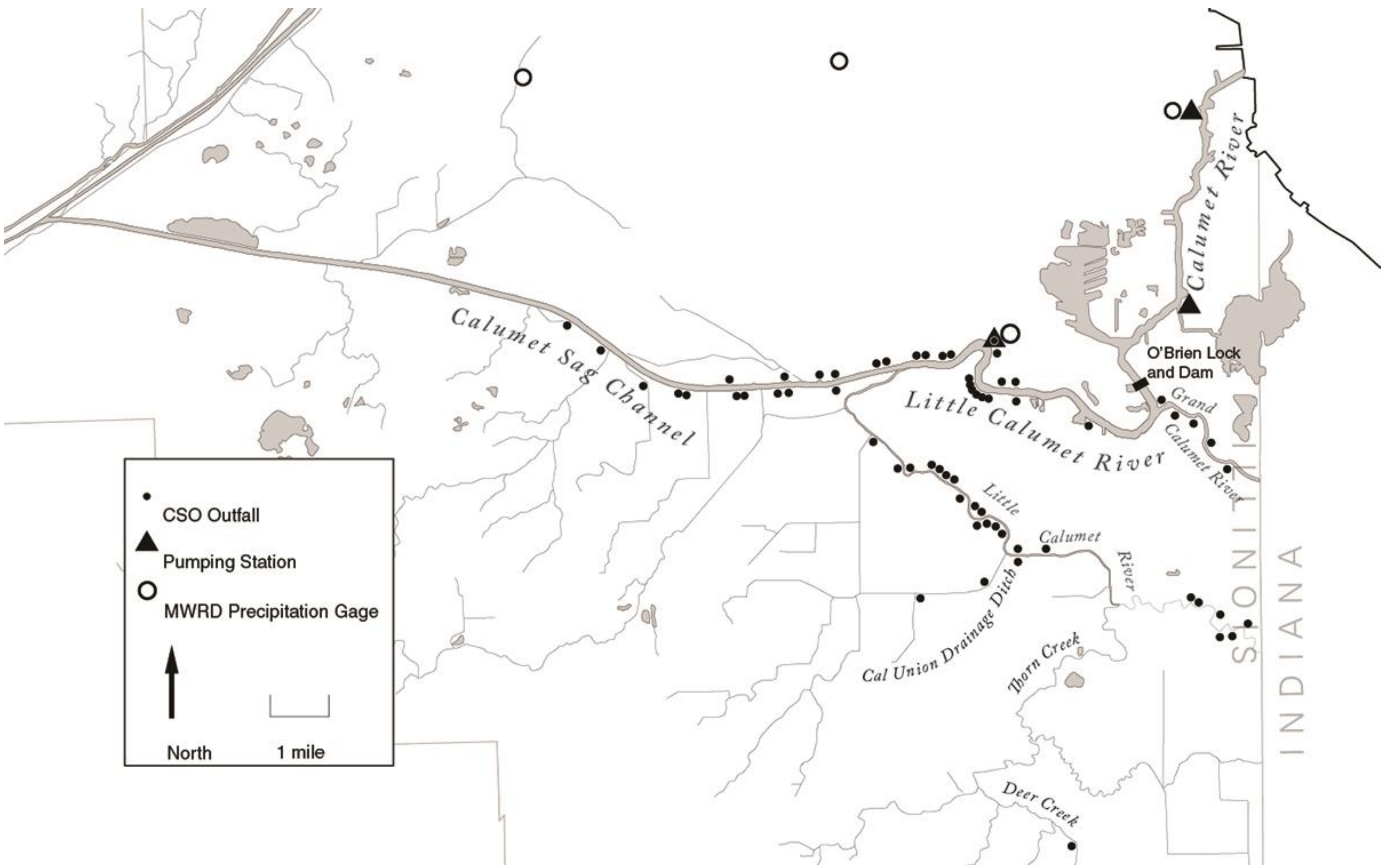
- CSO frequency, duration, and volume data.
- Water quality data generated between January 1, 2017, and December 31, 2018.
- Comparison of the 2017–2018 post-construction monitoring data to applicable WQS for specified parameters.
- Comparison of AWQM data collected during 2017–2018 (following full operation of the TCR) with AWQM data collected during the following periods: (a) prior to 1985 (before any portion of the Calumet TARP system was on line); and (b) 2014–2015 (before the TCR went on line).
- Comparison of 2014–2015 and 2017–2018 data from dry weather, wet weather without CSOs, and wet weather with CSOs.
- Comparison of 2017–2018 data from dry weather, wet weather without CSOs, and wet weather with CSOs.

Study Reach

The CRS is made up of natural and man-made channels as well as natural waterways upstream of the CAWS. The CSC, which is a man-made canal, extends upstream from its junction with the Chicago Sanitary and Ship Canal for 16.2 miles to the LCR. At this point, the waterway becomes the LCR and extends upstream 6.9 miles, ending at the O'Brien Lock and Dam. The Calumet River extends upstream of the O'Brien Lock and Dam to Lake Michigan. The GCR flows from the State of Indiana into the LCR, and the LCR-S flows north into the CSC, also carrying flows from Thorn Creek (Figure 1).

Monitored reaches of the CRS with CSO outfalls include the CSC (16 outfalls), the LCR (16 outfalls, including the 125th Street Pumping Station), the LCR-S (25 outfalls), the GCR (four outfalls), and the Calumet River (three outfalls, including the 122nd and 95th Street Pumping Stations). Appendix B is a detailed list of monitored CSO outfalls, including outfall number, TARP structure number, location, and ownership. Figure 1 displays CSO outfall locations in the CRS.

FIGURE 1: MAP OF CALUMET AREA COMBINED SEWER OVERFLOW OUTFALLS AND PRECIPITATION GAGES



METHODOLOGY

The District followed the approved PCMP (Appendix C) for post-construction monitoring of the Calumet TARP System. The methods are summarized below.

Combined Sewer Overflow Monitoring

The District utilized its approved CSO Representative Monitoring and Reporting Plan for the Calumet area to track the frequency, duration, and volume of individual CSOs within the CRS. In summary, the District has tide gate monitors installed on 51 CSO outfalls. Unmonitored outfalls are assumed to discharge when select monitored ones discharge because of similar invert elevations. Signals are transmitted to the Calumet WRP when the tide gate is open and assumed to be discharging. These signals are verified by WRP staff, and then volume estimates are performed via a conservative method which assumes that all rainfall that falls when a tide gate is open is being discharged to the waterway. These discharge volumes are then compared to two boundary conditions: (a) total area rainfall volume and (b) outfall pipe capacity. The minimum of these three values is used as the final discharge volume. Per the Calumet WRP NPDES permit, all individual CSO discharges resulting from the same storm shall be reported as one CSO event.

Ambient Water Quality Monitoring

Table 1 shows the AWQM stations in the CRS that were used to assess the overall impact of Calumet TARP System completion, along with their station numbers, designated use categories, and Global Positioning System coordinates. A map of these stations is presented in Figure 2. AWQM was conducted on a monthly basis in the CRS on the fourth Monday of each month in accordance with Revision 2.5 of the District's AWQM Quality Assurance Project Plan (QAPP), effective September 1, 2015 (Appendix D).

Wet- and Dry-Weather Monitoring

In addition to the routine monthly monitoring in the AWQM Program, water quality monitoring was conducted during various wet- and dry-weather conditions at each of the nine sampling locations in the CRS. Sampling was done during each of the following conditions during the pre- and post-construction monitoring periods:

1. Dry weather (<0.1 inch precipitation). Dry weather was defined by antecedent dry conditions for two days following a 0.25–0.49 inch event, four days following a 0.50–0.99 inch event, and six days following a >1.0 inch event (from wet-weather limited-use analysis done during the CAWS Use Attainability Analysis).

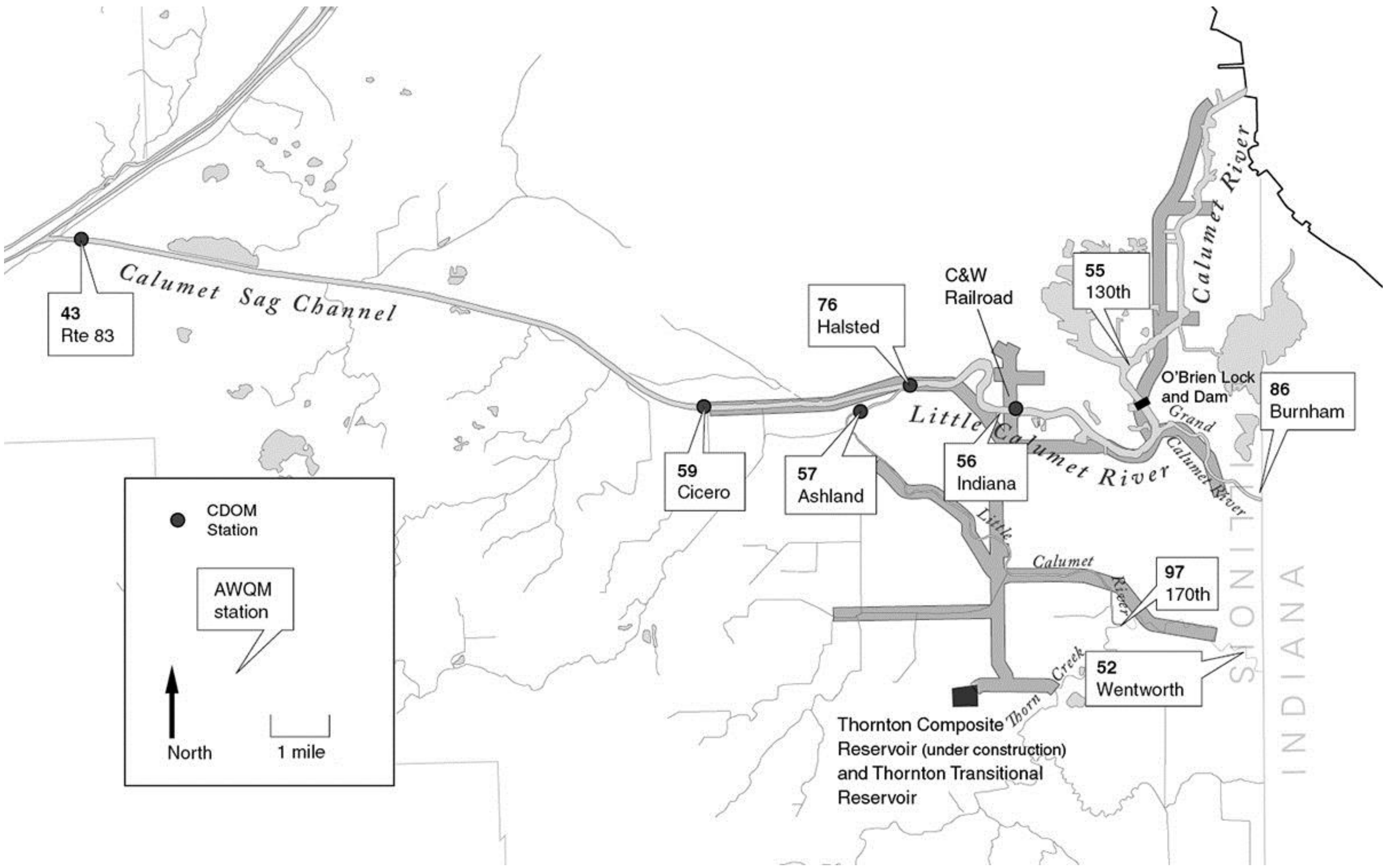
2. Wet weather without CSOs (>0.5 inch precipitation). Water sampling occurred within 12 hours of the end of the rain event.

TABLE 1: AMBIENT WATER QUALITY MONITORING LOCATIONS ASSESSED IN THE CALUMET RIVER SYSTEM

Location	Waterway	Station Number	Designated Use Category	Global Positioning System Coordinates	
				Latitude	Longitude
130th St.	Calumet River	WW_55	CAWS A/Non-Contact	41° 39' 33.48"	-87° 34' 21.66"
Burnham Ave.	Grand Calumet River	WW_86	CAWS A[1]/Incidental Contact	41° 37' 52.75"	-87° 32' 20.76"
Indiana Ave.	Little Calumet River	WW_56	CAWS A/Primary Contact	41° 39' 01.19"	-87° 37' 01.64"
Halsted St.	Little Calumet River	WW_76	CAWS A/Primary Contact	41° 39' 27.05"	-87° 38' 28.13"
Wentworth Ave.	Little Calumet River South	WW_52	General Use	41° 35' 06.34"	-87° 31' 46.89"
Ashland Ave.	Little Calumet River South	WW_57	General Use	41° 39' 06.04"	-87° 39' 38.13"
170th St.	Thorn Creek	WW_97	General Use	41° 35' 11.90"	-87° 34' 32.96"
Cicero Ave.	Calumet-Sag Channel	WW_59	CAWS A/Primary Contact	41° 39' 19.23"	-87° 44' 17.67"
Route 83	Calumet-Sag Channel	WW_43	CAWS A/Primary Contact	41° 41' 46.82"	-87° 56' 10.71"

[1]Chicago Area Waterway System Aquatic Life Use A.

FIGURE 2: AMBIENT WATER QUALITY AND CONTINUOUS DISSOLVED OXYGEN MONITORING STATIONS FOR CALUMET TUNNEL AND RESERVOIR PLAN POST-CONSTRUCTION MONITORING



3. Wet weather with CSOs, to the extent such events occur, including 125th Street Pump Station, if discharging. Water sampling occurred within 12 hours of the end of the rain event.

Average rainfall from the four District rain gages in the Calumet area (Figure 1) was used to determine that the above conditions were met. Table 2 shows the criteria met and conditions (Event Category) for each of the dates sampled during the pre- and post-construction monitoring periods.

The AWQM and wet- and dry-weather sampling locations are representative of water quality in the various waterbody reaches receiving CSO flow. The 130th Street sampling location in the Calumet River (130th) represents "background" upstream conditions, as it is upstream of CSOs with the exception of the 95th Street and 122nd Street Pumping Stations, discharge of which would actually constitute a reversal of flow towards Lake Michigan. Route 83 in the CSC (Route 83) is located at the most downstream location of the CRS, and constitutes well-mixed flow from all of the CSOs that discharge into the system upstream.

In order to assess effects of CSOs on the CRS after the TCR was on line, the following constituents were analyzed: DO, TAN, TSS, TDS, BOD_5, and FC. Applicable WQS used for evaluation are shown in Table 3.

Statistical Analysis of Ambient Water Quality Monitoring and Wet- and Dry-Weather Sampling Data

Water quality data from AWQM and wet- and dry-weather sampling were analyzed for equality of means and standard deviations, using parametric ANOVA. The following statistical comparisons were made using ANOVA:

- AWQM data collected during 2017–2018 (following full operation of the TCR), prior to any portion of the Calumet TARP system coming on line (1974–1985), and 2014–2015 (before the TCR went on line).

- Water quality data collected during 2017–2018 and 2014–2015 during dry weather, wet weather without CSOs, and wet weather with CSOs.

When results were reported as less than the reporting limit, the reporting limit values were used for statistical analyses in this report. Data sets were tested for normality if the sample sizes were greater than or equal to 10 and less than 30 using the Kolmogorov and Smirnov method. If the sample size was greater than or equal to three but less than 10, or equal to or greater than 30, the data distribution was considered normal. Various methods were used to test for equality of variances (F-tests, Bartlett, Cochran, Levene, or Levene-Forsythe), and determination of which method was used was dependent on the number of levels of comparison, sample sizes, and fulfillment of normality assumptions. The test method with the highest resulting p value was reported.

The ANOVA was done using actual data and natural logarithm (log)-transformed ($y = \ln(x)$) data. The results from the log-transformed data are presented in this report for comparison between the historic, pre-, and post-construction periods because the data were log-normal distributed.

TABLE 2: SAMPLE COLLECTION DATES AT CALUMET WATERSHED AMBIENT WATER QUALITY MONITORING STATIONS DURING THORNTON COMPOSITE RESERVOIR PRE- AND POST- CONSTRUCTION MONITORING PERIODS

Pre-Construction Sampling Dates	Category of Event	Post-Construction Sampling Dates	Category of Event
01/29/14[a]	Dry weather	01/23/17[a]	Dry weather
02/24/14 [a]	NA	02/27/17[a]	Dry weather
03/24/14[a]	Dry weather	03/01/17[b]	Wet weather with CSOs
04/15/14	Wet weather without CSOs	03/27/17 [a]	NA
04/28/14[a]	Dry weather	03/31/17[b]	Wet weather with CSOs
05/21/14	Wet weather with CSOs	04/24/17[a]	Dry weather
05/27/14 [a]	NA	05/11/17	Wet weather without CSOs
06/23/14 [a]	NA	05/22/17 [a]	NA
07/01/14	Wet weather with CSOs	06/26/17 [a]	NA
07/22/14	Dry weather	07/31/17[a]	Dry weather
07/28/14[a]	Dry weather	08/28/17[a]	Dry weather
08/05/14	Wet weather without CSOs	09/25/17[a]	Dry weather
08/22/14	Wet weather with CSOs	10/11/17	Wet weather without CSOs
08/25/14 [a]	NA	10/23/17[a]	Wet weather without CSOs
09/29/14[a]	Dry weather	10/25/17	Wet weather without CSOs
10/27/14[a]	Dry weather	11/27/17[a]	Dry weather
11/24/14[a]	Wet weather without CSOs	01/29/18[a]	Dry weather
12/22/14[a]	Dry weather	02/21/18	Wet weather without CSOs
01/26/15[a]	Dry weather	02/26/18[a]	Dry weather
02/23/15[a]	Dry weather	03/26/18[a]	Dry weather
03/23/15[a]	Dry weather	04/23/18[a]	Dry weather
04/10/15	Wet weather without CSOs	05/15/18	Wet weather without CSOs
04/27/15 [a]	NA	05/22/18	Wet weather without CSOs
05/21/15	Dry weather	05/29/18[a]	Dry weather
05/26/15[a]	Dry weather	06/25/18 [a]	NA
06/11/15	Wet weather without CSOs	07/30/18[a]	Dry weather
06/16/15	Wet weather with CSOs	08/27/18[a]	Dry weather
06/22/15[a]	Dry weather	09/24/18[a]	Dry weather
07/17/15	Wet weather without CSOs	10/22/18[a]	Dry weather
07/27/15[a]	Dry weather	11/26/18[a]	Wet weather without CSOs
08/14/15	Dry weather	12/19/18[a]	Dry weather
08/24/15[a]	Dry weather		
09/28/15[a]	Dry weather		
10/26/15[a]	Dry weather		
11/23/15[a]	Dry weather		

NA = Monthly sampling event that did not meet categorical requirements.
[a]Routine monthly sampling event.
[b]Combined sewer overflows occurred, but the 125th Street Pump Station was not activated.

TABLE 3: APPLICABLE WATER QUALITY STANDARDS USED FOR EVALUATION

Water Quality Constituent	Applicable Water Quality Standards (Title 35 Illinois Administrative Code Subtitle C, Chapter 1, Section Number)
Dissolved Oxygen	During March through July, DO shall not be less than 5.0 mg/L at any time; during August through February, it shall not be less than 3.5 mg/L at any time (302.206; 302.405).[1]
Total Ammonia Nitrogen	Not to exceed 15 mg/L; pH- and temperature-based acute and chronic standards (302.212 and 302.412)
Total Suspended Solids	NA
Total Dissolved Solids	NA
Fecal Coliform	During May through October: Geometric mean of five samples within 30 days not to exceed 200 CFU/100 mL; no more than 10% of samples shall exceed 400 CFU/100 mL during any 30-day period (302.209).[2, 3, 4]
Five-day Biochemical Oxygen Demand	NA

NA = No applicable water quality standard.

[1]Minimum DO standard was used for general compliance comparison, while the following applicable seven-day average standards were also used in assessing compliance for CSO events in the post construction period: During March through July, daily mean averaged over seven days shall not be lower than 6.0 mg/L (General Use Waters only), and during August through February, daily minimum averaged over seven days shall not be less than 4.0 mg/L.

[2]For assessment purposes, a limit of 400 CFU/100 mL was used to evaluate compliance.

[3]FC standard does not apply in Incidental Contact or Non-Contact Recreation Waters.

[4]While Primary Contact Recreation Waters are subject to General Use water quality standards for FC, the recreational season is considered March through November according to Effluent Disinfection standards outlined in Illinois Administrative Code Title 35, Sec. 304.224.

Uniformly minimum variance unbiased estimator (UMVUE) for population means were also utilized when log-transformed data were compared because UMVUE variances are lower than other mean estimators.

The actual data without transformation were used to compare various conditions of wet weather with CSOs, wet weather without CSOs, and dry weather during pre- and post-construction monitoring periods, with the exception of FC, in which log-transformed data were used to determine significance.

Data were not used in the ANOVA if variances were less than or equal to 0. This happened when the sample size was one, or all the data values were the same. As a result, some levels were not included in the ANOVA. Data levels were ranked using Tukey's multiple range test, and populations with the same letter are considered not statistically significantly different.

Continuous Dissolved Oxygen Monitoring

The M&R Department also collected hourly DO data from the District's CDOM program for use in assessing waterway compliance and impact of CSOs on the CRS. Table 4 shows the five CDOM locations in the CRS that were assessed to study the impact of Calumet TARP System completion. These stations are also indicated in Figure 2. CDOM stations are located in the LCR, upstream and downstream of the Calumet WRP; the LCR-S, just upstream of the confluence with the LCR; and in the CSC, both immediately downstream of the reach receiving most of the CSO flows, and at the downstream end of the system at Route 83. These station locations allowed comparison of in-stream DO concentrations to applicable WQS in waterway reaches receiving CSO flows.

The CDOM activities were conducted in accordance with Revision 2.1 of the District's CDOM Program QAPP, effective July 1, 2016 (Appendix E). During 2016, the District updated the CDOM standard operating procedures (SOPs), and additional minor updates were made in 2018 (Appendix F). The main changes in 2016 involved: (a) replacing Winkler titrated DO calibrations with one hundred percent saturated air of water calibrations; (b) modifying drift and fouling correction procedures to use calculated DO concentrations at one hundred percent saturated water or air; and (c) calibration of every sonde on the morning of deployment, instead of comparing sonde DO concentrations to Winkler titrated values.

The approved PCMP dictated that if DO concentrations decreased below the WQS following CSO discharges into the CRS, continuous DO data would be included in the Post-Construction Monitoring Report for the period until DO increased above the WQS. If DO did not decrease below the WQS following a CSO discharge, then seven days of continuous DO data was included in the report.

TABLE 4: CONTINUOUS DISSOLVED OXYGEN MONITORING LOCATIONS ASSESSED IN THE CALUMET RIVER SYSTEM

Location	Waterway	Designated Use Category	Global Positioning System Coordinates	
			Latitude	Longitude
C&W Indiana Railroad	Little Calumet River	CAWS A[1]/Primary Contact	41° 39' 01.07"	-87° 36' 42.75"
Halsted Street	Little Calumet River	CAWS A/Primary Contact	41° 39' 25.95"	-87° 38' 27.86"
Ashland Avenue	Little Calumet River South	General Use	41° 39' 06.64"	-87° 39' 37.27"
Cicero Avenue	Calumet-Sag Channel	CAWS A/Primary Contact	41° 39' 20.70"	-87° 44' 18.78"
Route 83	Calumet-Sag Channel	CAWS A/Primary Contact	41° 41' 46.68"	-87° 56' 29.29"

[1]Chicago Area Waterway System Aquatic Life Use A.

RESULTS AND DISCUSSION

All raw data collected in the CRS by the District during the post-construction monitoring period (AWQM as well as various weather condition sampling) are included in Appendix G. The CSO and water quality monitoring results are discussed below.

Combined Sewer Overflow Monitoring

Table 5 reports the date, location, time, duration, and estimated volume of CSOs that occurred during post-construction monitoring. The USEPA and the Illinois Environment Protection Agency were notified by letter of these CSOs (Appendix H). It should be noted that both of the verified CSOs occurred due to local conditions preventing the conveyance of storm flows into the TARP drop shaft, and not a failure of Calumet TARP system operation. A District Engineering Department project to improve TARP connections at CSO locations CDS-45 and C-1 is scheduled to commence in fall 2019.

Two CSO events occurred at a total of three CSO locations (one unverified) in the CRS during post-construction monitoring. In contrast, there were 19 CSO events at a total of 24 CSO locations during 2014–2015, prior to the completion of the TCR. The total estimated volume of CSOs during 2017–2018 (6.0 MG) was 99.8 percent lower than that during 2014–2015 (3.5 BG). The largest single rain event during the post-construction monitoring period was 4.34 inches (October 14 and 15, 2017) and no CSOs occurred. Notably, the 125th Street Pumping Station never discharged during the post-construction monitoring period.

The PCMP outlined a specific protocol to estimate the volume of CSOs that would have occurred in the absence of additional storage that the District had available in the Thornton Transitional Reservoir during 2017–2018. However, this was not necessary because the volume of CSOs captured by the TCR never exceeded 4.8 BG.

Ambient Water Quality Monitoring

Descriptive statistics (minimum, maximum, mean, standard deviation) for the routine monthly Calumet AWQM data during the pre- and post-construction monitoring periods are shown in Tables 6 and 7. Standard deviations were not calculated for constituents with less than three data points.

One objective in the approved PCMP was to statistically compare AWQM data collected (a) during 2017–2018 (following full operation of the TCR); (b) 2014–2015 (before the TCR went on line); and (c) prior to 1985 (before any portion of the Calumet TARP system was on line). Table 8 shows the ANOVA results comparing log-transformed AWQM data for these three time periods. Sampling did not occur at Burnham or 170th Street in Thorn Creek (170th) during 1974–1984, so only two periods were compared for all parameters. Statistically significant differences were mainly observed between the historic sampling period and the pre- and post-construction sampling periods. Mean concentrations from the pre- and post-construction monitoring periods were not statistically different for most parameters.

TABLE 5: DATE, LOCATION, TIME, DURATION, AND ESTIMATED VOLUME OF COMBINED SEWER OVERFLOWS THAT OCCURRED DURING CALUMET TUNNEL AND RESERVOIR PLAN SYSTEM POST-CONSTRUCTION MONITORING PERIOD (2017–2018)

Date	Location	Start Time	Stop Time	Duration	Estimated Volume (gallons)
02/28/2017	C-1	8:30 p.m.	9:04 p.m.	34 minutes	89,570
	CDS-45	6:42 p.m.	7:46 p.m.	1 hour, 4 minutes	865,656
	CDS-45	8:12 p.m.	11:59 p.m.	3 hours, 47 minutes	3,070,374
03/30/2017	CDS-45	2:21 a.m.	4:00 a.m.	1 hour, 39 minutes	1,501,182
	CDS-18*	11:26 a.m.	11:43 a.m.	17 minutes	485,983

*Unable to verify if discharge actually occurred at this location, as it may have ended before it could be investigated.

TABLE 6: SUMMARY OF PRE- AND POST-CONSTRUCTION CALUMET RIVER, LITTLE CALUMET RIVER, AND LITTLE CALUMET RIVER SOUTH MONTHLY AMBIENT WATER QUALITY DATA

Parameter[1]		WW_55 130th St. – Calumet River		WW_56 Indiana Ave. – LCR		WW_76 Halsted St. – LCR		WW_57 Ashland Ave. – LCR-S		WW_52 Wentworth Ave. – LCR-S	
		Pre[2]	Post[3]	Pre	Post	Pre	Post	Pre	Post	Pre	Post
TAN[4] (mg/L)	Minimum	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.14	0.10
	Maximum	0.61	0.50	0.87	0.61	1.66	1.03	0.48	0.51	0.93	0.50
	Mean	0.17	0.23	0.24	0.30	0.57	0.34	0.23	0.29	0.29	0.32
	Std. Dev.	0.13	0.17	0.19	0.19	0.48	0.21	0.10	0.17	0.17	0.15
TSS (mg/L)	Minimum	<4	<4	4	5	4	<4	7	6	6	6
	Maximum	9	7	80	31	33	17	206	135	226	192
	Mean	5	4	20	11	13	8	51	32	46	44
	Std. Dev.	1.4	0.8	17.2	5.9	9.0	3.3	55.1	37.3	49.3	43.9
TDS (ppm)	Minimum	230	182	260	268	412	340	264	434	222	156
	Maximum	436	448	700	560	896	736	1,570	1,234	986	822
	Mean	298	315	440	430	606	536	941	735	603	617
	Std. Dev.	63	88	137	85	157	99	350	258	219	181
BOD_5 (mg/L)	Minimum	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
	Maximum	<2	8	3	3	8	4	9	9	14	8
	Mean	2	3	2	2	3	2	3	3	4	3
	Std. Dev.	0.0	1.5	0.4	0.4	1.9	0.7	1.8	1.7	2.6	1.7

TABLE 6 (Continued): SUMMARY OF PRE- AND POST-CONSTRUCTION LITTLE CALUMET RIVER, AND LITTLE CALUMET RIVER SOUTH MONTHLY AMBIENT WATER QUALITY DATA

Parameter[1]		WW_55 130th St. – Calumet River		WW_56 Indiana Ave. – LCR		WW_76 Halsted St. – LCR		WW_57 Ashland Ave. – LCR-S		WW_52 Wentworth Ave. – LCR-S	
		Pre[2]	Post[3]	Pre	Post	Pre	Post	Pre	Post	Pre	Post
DO	Minimum	6.0	6.8	6.1	4.6	4.7	6.2	4.3	3.9	3.7	2.4
(mg/L)	Maximum	12.0	11.9	14.3	12.2	11.8	11.9	11.5	13.9	12.4	12.6
	Mean	8.8	9.2	9.4	9.4	7.7	8.2	7.4	8.6	6.9	7.5
	Std. Dev.	1.6	1.8	2.1	1.8	1.5	1.2	2.5	2.3	2.6	2.9
FC	Minimum	9	9	9	9	50	<10	60	30	300	210
(CFU/100 mL)	Maximum	1,500	30	5,700	170	39,000	2,900	20,000	9,500	100,000	64,000
	Geomean[5]	20	12	37	19	1,811	114	740	275	2,201	1,156
	Std. Dev.	353	6	1,356	41	10,257	676	4,266	2,315	27,036	13,440

[1]TAN = total ammonia nitrogen; TSS = total suspended solids; TDS = total dissolved solids; BOD_5 = five-day biological oxygen demand; DO = dissolved oxygen; FC = fecal coliform.
[2]Pre-construction monitoring from 2014 through 2015.
[3]Post-construction monitoring from 2017 through 2018.
[4]Reporting limit increased from 0.10 to 0.50 mg/L starting in July 2018.
[5]Geometric mean.

TABLE 7: SUMMARY OF PRE- AND POST-CONSTRUCTION CALUMET-SAG CHANNEL, GRAND CALUMET RIVER, AND THORN CREEK MONTHLY AMBIENT WATER QUALITY DATA

Parameter[1]		WW_59 Cicero Ave. – CSC		WW_43 Route 83 – CSC		WW_86 Burnham Ave. – GCR		WW_97 170th St. – Thorn Cr.	
		Pre[2]	Post[3]	Pre	Post	Pre	Post	Pre	Post
TAN[4] (mg/L)	Minimum	0.20	0.15	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
	Maximum	1.69	1.02	1.04	5.66	4.19	0.93	1.16	0.80
	Mean	0.55	0.38	0.50	0.60	1.10	0.30	0.26	0.29
	Std. Dev.	0.38	0.20	0.26	1.12	1.24	0.22	0.27	0.22
TSS (mg/L)	Minimum	5	6	5	7	<4	4	6	7
	Maximum	111	43	62	39	38	19	181	194
	Mean	26	17	19	17	12	10	40	39
	Std. Dev.	22.3	9.4	12.7	8.2	8.7	4.0	45.3	50.6
TDS (ppm)	Minimum	308	376	308	404	298	330	456	338
	Maximum	892	688	956	846	834	736	1,964	2,780
	Mean	623	569	640	581	664	528	1,289	1,309
	Std. Dev.	161	84	175	106	133	114	525	585
BOD_5 (mg/L)	Minimum	<2	<2	<2	<2	<2	<2	<2	<2
	Maximum	6	21	3	3	16	4	9	11
	Mean	3	3	2	2	4	2	3	3
	Std. Dev.	1.0	4.1	0.4	0.5	3.7	0.5	2.0	2.3
DO (mg/L)	Minimum	4.4	5.5	3.8	4.7	1.3	4.7	2.4	4.6
	Maximum	9.1	10.3	10.1	10.1	13.5	9.7	12.1	11.7
	Mean	6.8	7.8	6.7	7.7	5.7	7.6	7.7	8.7
	Std. Dev.	1.4	1.3	1.6	1.4	3.0	1.4	2.6	2.0

TABLE 7 (Continued): SUMMARY OF PRE- AND POST-CONSTRUCTION CALUMET-SAG CHANNEL, GRAND CALUMET RIVER, AND THORN CREEK MONTHLY AMBIENT WATER QUALITY DATA

Parameter[1]		WW_59 Cicero Ave. – CSC		WW_43 Route 83 – CSC		WW_86 Burnham Ave. – GCR		WW_97 170th St. – Thorn Cr.	
		Pre[2]	Post[3]	Pre	Post	Pre	Post	Pre	Post
FC (CFU/100 mL)	Minimum	20	9	<10	9	20	40	80	80
	Maximum	53,000	860	12,000	2,000	570,000	20,000	84,000	55,000
	Geometric Mean	925	80	174	49	965	457	1,305	721
	Std. Dev.	11,359	270	2,602	445	129,934	4,204	19,147	12,338

[1]TAN = total ammonia nitrogen; TSS = total suspended solids; TDS = total dissolved solids; BOD_5 = five-day biological oxygen demand; DO = dissolved oxygen; FC = fecal coliform.
[2]Pre-construction monitoring from 2014 through 2015.
[3]Post-construction monitoring from 2017 through 2018.
[4]Reporting limit increased from 0.1 to 0.5 mg/L starting in July 2018.
[5]Geometric mean.

TABLE 8: STATISTICAL COMPARISON OF AMBIENT WATER QUALITY MONITORING DATA COLLECTED AT CALUMET RIVER SYSTEM LOCATIONS BETWEEN 1974–1984, 2014–2015, AND 2017–2018

Parameter[1]	Location	Sampling Period	N	Mean[2]	Std. Dev.[3]	p[4]	Rank[5]
TAN[6] (mg/L)	43	1974–1984	142	6.37	4.00	0.000	a
		2014–2015	22	0.51	0.33		b
		2017–2018	23	0.50	0.51		b
	52	1974–1984	114	2.84	2.74	0.000	a
		2014–2015	20	0.28	0.14		b
		2017–2018	22	0.32	0.19		b
	55	1974–1984	121	0.79	0.93	0.000	a
		2014–2015	19	0.16	0.09		b
		2017–2018	20	0.22	0.17		b
	56	1974–1984	108	2.62	2.61	0.000	a
		2014–2015	19	0.23	0.17		b
		2017–2018	23	0.31	0.24		b
	57	1974–1984	112	2.68	3.18	0.000	a
		2014–2015	21	0.23	0.11		b
		2017–2018	23	0.29	0.20		b
	59	1974–1984	128	7.47	4.20	0.000	a
		2014–2015	21	0.54	0.31		b
		2017–2018	23	0.38	0.20		b
	76	1974–1984	113	9.04	5.82	0.000	a
		2014–2015	22	0.56	0.49		b
		2017–2018	23	0.34	0.22		b
	86	2014–2015	21	1.11	1.58	0.003	a
		2017–2018	23	0.30	0.24		b
	97	2017–2018	22	0.29	0.26	0.536	a
		2014–2015	20	0.24	0.19		a
TSS (mg/L)	43	1974–1984	144	40.5	34.3	0.000	a
		2014–2015	22	19.1	12.3		b
		2017–2018	23	16.6	8.0		b
	52	1974–1984	114	55.2	55.8	0.427	a
		2014–2015	20	44.1	37.9		a
		2017–2018	22	43.0	40.7		a
	55	1974–1984	121	19.1	9.7	0.000	a
		2014–2015	19	4.7	1.1		b
		2017–2018	20	4.3	0.7		b
	56	1974–1984	108	27.6	14.2	0.000	a
		2014–2015	19	19.7	14.1		b
		2017–2018	23	11.1	5.2		c

TABLE 8 (Continued): STATISTICAL COMPARISON OF AMBIENT WATER QUALITY MONITORING DATA COLLECTED AT CALUMET RIVER SYSTEM LOCATIONS BETWEEN 1974–1984, 2014–2015, AND 2017–2018

Parameter[1]	Location	Sampling Period	N	Mean[2]	Std. Dev.[3]	p[4]	Rank[5]
TSS (mg/L)	57	1974–1984	112	48.3	65.2	0.296	a
		2014–2015	21	48.7	51.2		a
		2017–2018	23	29.8	29.2		a
	59	1974–1984	128	39.8	28.6	0.000	a
		2014–2015	21	25.3	16.7		b
		2017–2018	23	16.5	8.9		b
	76	1974–1984	113	25.8	15.9	0.000	a
		2014–2015	22	12.5	8.4		b
		2017–2018	23	8.0	3.3		b
	86	2014–2015	21	11.5	7.5	0.788	a
		2017–2018	23	10.0	4.3		a
	97	2014–2015	20	39.8	49.7	0.820	a
		2017–2018	22	35.0	40.6		a
TDS (mg/L)	43	1974–1984	144	603	176	0.600	a
		2014–2015	22	641	192		a
		2017–2018	23	581	107		a
	52	1974–1984	115	642	246	0.746	a
		2014–2015	17	609	270		a
		2017–2018	22	626	257		a
	55	1974–1984	121	387	168	0.060	a
		2014–2015	16	298	60		a
		2017–2018	20	315	91		a
	56	1974–1984	108	443	166	0.978	a
		2014–2015	19	441	142		a
		2017–2018	23	430	89		a
	57	1974–1984	112	830	361	0.221	a
		2014–2015	21	955	457		a
		2017–2018	23	734	251		a
	59	1974–1984	128	609	167	0.679	a
		2014–2015	21	625	179		a
		2017–2018	23	570	91		a
	76	1974–1984	113	599	214	0.503	a
		2014–2015	22	606	156		a
		2017–2018	23	536	103		a
	86	2014–2015	21	666	161	0.002	a
		2017–2018	23	528	118		b

TABLE 8 (Continued): STATISTICAL COMPARISON OF AMBIENT WATER QUALITY MONITORING DATA COLLECTED AT CALUMET RIVER SYSTEM LOCATIONS BETWEEN 1974–1984, 2014–2015, AND 2017–2018

Parameter[1]	Location	Sampling Period	N	Mean[2]	Std. Dev.[3]	p^4	Rank[5]
TDS	97	2014–2015	17	1,308	679	0.998	a
(mg/L)		2017–2018	22	1,333	751		a
BOD_5	43	1974–1984	144	5.68	3.30	0.000	a
(mg/L)		2014–2015	20	2.25	0.41		b
		2017–2018	20	2.30	0.44		b
	52	1974–1984	115	10.34	5.48	0.000	a
		2014–2015	20	3.49	1.73		b
		2017–2018	20	3.11	1.45		b
	55	1974–1984	120	3.65	2.32	0.001	a
		2017–2018	18	2.43	0.95		ab
	56	1974–1984	105	5.23	3.00	0.000	a
		2014–2015	17	2.17	0.35		b
		2017–2018	21	2.24	0.40		b
	57	1974–1984	112	7.11	4.16	0.000	a
		2014–2015	19	2.99	1.35		b
		2017–2018	21	2.84	1.24		b
	59	1974–1984	127	7.14	3.67	0.000	a
		2014–2015	19	2.50	0.79		b
		2017–2018	21	2.75	1.52		b
	76	1974–1984	113	8.42	4.74	0.000	a
		2014–2015	18	2.99	1.39		b
		2017–2018	21	2.33	0.56		b
	86	2014–2015	20	3.73	2.48	0.011	a
		2017–2018	20	2.14	0.38		b
	97	2014–2015	20	3.24	1.57	0.451	a
		2017–2018	19	2.89	1.41		a
DO	43	1974–1984	135	3.31	2.77	0.000	b
(mg/L)		2014–2015	22	6.67	1.69		a
		2017–2018	23	7.71	1.47		a
	52	1974–1984	111	4.84	4.33	0.000	b
		2014–2015	20	6.89	2.61		a
		2017–2018	22	7.61	3.53		a
	55	1974–1984	121	8.72	2.50	0.431	a
		2014–2015	19	8.83	1.59		a
		2017–2018	20	9.23	1.76		a
	56	1974–1984	108	6.05	2.83	0.000	b

TABLE 8 (Continued): STATISTICAL COMPARISON OF AMBIENT WATER QUALITY MONITORING DATA COLLECTED AT CALUMET RIVER SYSTEM LOCATIONS BETWEEN 1974–1984, 2014–2015, AND 2017–2018

Parameter[1]	Location	Sampling Period	N	Mean[2]	Std. Dev.[3]	p[4]	Rank[5]
DO		2014–2015	19	9.44	2.16		a
(mg/L)		2017–2018	23	9.38	2.04		a
	57	1974–1984	110	5.49	3.62	0.000	b
		2014–2015	21	7.35	2.46		a
		2017–2018	23	8.61	2.60		a
	59	1974–1984	125	4.00	4.53	0.000	b
		2014–2015	21	6.83	1.43		a
		2017–2018	23	7.85	1.32		a
	76	1974–1984	108	4.92	3.90	0.000	b
		2014–2015	22	7.68	1.50		a
		2017–2018	23	8.17	1.19		a
	86	2014–2015	21	5.77	3.62	0.003	b
		2017–2018	23	7.56	1.46		a
	97	2014–2015	20	7.79	3.12	0.141	a
		2017–2018	22	8.66	2.13		a
FC	43	1974–1984	137	36,959	241,712	0.000	a
(CFU/100 mL)		2014–2015	22	818	2,511		b
		2017–2018	23	186	498		b
	52	1974–1984	111	152,757	707,068	0.000	a
		2014–2015	20	7,190	16,862		b
		2017–2018	22	2,376	3,778		b
	55	1974–1984	120	318	991	0.000	a
		2014–2015	19	53	102		b
		2017–2018	20	12	4		b
	56	1974–1984	107	5,441	18,264	0.000	a
		2014–2015	19	199	635		b
		2017–2018	23	27	28		b
	57	1974–1984	111	29,374	152,970	0.000	a
		2014–2015	21	1,617	2,722		b
		2017–2018	23	1,062	2,892		b
	59	1974–1984	125	75,410	356,414	0.000	a
		2014–2015	21	4,007	11,549		b
		2017–2018	23	227	488		c
	76	1974–1984	108	360,525	8,805,664	0.000	a
		2014–2015	22	7,369	20,593		b
		2017–2018	23	321	683		c

TABLE 8 (Continued): STATISTICAL COMPARISON OF AMBIENT WATER QUALITY MONITORING DATA COLLECTED AT CALUMET RIVER SYSTEM LOCATIONS BETWEEN 1974–1984, 2014–2015, AND 2017–2018

Parameter[1]	Location	Sampling Period	N	Mean[2]	Std. Dev.[3]	*p*[4]	Rank[5]
FC	86	2014–2015	21	17,897	112,094	0.267	a
(CFU/100 mL)		2017–2018	23	1,760	4,775		a
	97	2014–2015	20	4,368	10,425	0.254	a
		2017–2018	22	2,589	6,629		a

[1]TAN = total ammonia nitrogen; TSS = total suspended solids; TDS = total dissolved solids; BOD_5 = five-day biological oxygen demand; DO = dissolved oxygen; FC = fecal coliform.
[2]Means were calculated using a Uniformly Minimum Variance Unbiased Estimator.
[3]Standard deviation, derived using a Uniformly Minimum Variance Unbiased Estimator.
[4]Significant probability of means being equal (significant if $p \leq 0.05$).
[5]Rank based on Tukey's multiple range test. Populations with the same letters are not significantly different.
[6]Reporting limit increased from 0.1 to 0.5 mg/L starting in July 2018.

Among the parameters monitored, FC concentrations demonstrated the greatest reductions between the pre- and post-construction monitoring periods. The results of ANOVA indicated that geometric mean FC concentrations at Halsted and Cicero Avenue in the CSC (Cicero) were significantly lower during the post-construction monitoring period than in the pre-construction monitoring period. The FC concentration reductions at these locations were due mainly to disinfection during recreational months (March through November) at the Calumet WRP, which began disinfecting its effluent in March 2016. There was also a disinfection trial period during October 2015 through January 2016. Geometric mean FC concentrations were significantly lower at all stations during the pre- and post-construction monitoring periods than in the historic monitoring years.

Post-construction AWQM data had higher mean DO concentrations than pre-construction data at all sampling locations except for Indiana, but they were not statistically significant. The ANOVA results indicated that mean DO concentrations were significantly higher during the pre- and post-construction monitoring periods than in the historic monitoring period at all locations that could be compared. The CDOM data exhibited similar results when comparing pre-construction monitoring to post-construction monitoring, which are described later in this report.

Mean BOD_5 concentrations during the pre- and post-construction monitoring periods were very similar throughout the CRS, ranging from 2–4 milligrams per liter (mg/L). The majority of the BOD_5 measurements were less than the reporting limit of 2 mg/L at all CRS sampling locations, which is reflected in the mean concentrations (not shown). Mean BOD_5 concentrations were significantly lower at all stations during the pre- and post-construction monitoring periods than in the historic monitoring years.

Reductions in mean TSS concentrations were observed at all locations throughout the CRS, when comparing pre- and post-construction monitoring data, but they were only statistically significant at Indiana. Mean TSS concentrations were significantly lower at all stations during the pre- and post-construction monitoring periods than in the historic monitoring years.

During the post-construction monitoring period, mean TDS concentrations decreased at six sampling locations within the CRS (Indiana, Halsted, Ashland, Cicero, Route 83, and Burnham), and increased slightly at three other sampling locations (130th, Wentworth, and 170th) compared to the pre-construction monitoring period, but there were no statistically significant differences except for Burnham. Mean TDS concentrations were an anomaly because statistical analysis showed that concentrations during the pre- and post-construction monitoring periods were not significantly different than the mean concentrations from the historic sampling period at the seven stations that have historic data.

While it appears that mean TAN concentrations actually increased at six of the nine sampling locations when comparing pre- and post-construction monitoring data, this is an artifact resulting from an increased reporting limit (0.10 to 0.50 mg/L) that occurred in July 2018, contributing to relatively higher arithmetic means in the post-construction monitoring period. As described in the Methodology Section of this report, when results were reported as less than the reporting limit, the reporting limit values were used for statistical analyses. Almost all of the TAN concentrations during the last six months of 2018 were lower than the reporting limit of 0.50 mg/L. Mean TAN concentrations were significantly lower at all stations during the pre- and post-construction monitoring periods than in the historic monitoring years. Improvements in nitrification at the Calumet WRP during the 1980s and 1990s likely contributed to the downstream TAN decreases.

Wet- and Dry-Weather Monitoring

Table 2 shows the pre- and post-TCR construction sampling dates in the CRS and their respective categories. A total of 37 sampling events met criteria for dry-weather conditions (20 pre- and 17 post-construction), 14 events (six pre- and eight post-construction) met requirements for wet weather without CSOs, and six events (four pre- and two post-construction) were qualified as wet weather with CSO events. However, the 125th Street Pump Station was not active prior to the two wet-weather sampling events when CSOs occurred in February and March 2017. The 125th Street Pump Station did not discharge during the post-construction monitoring period.

Analysis of Variance Comparing Pre- and Post-Construction Water Quality for Various Weather Categories. Pre- and post-construction monitoring results and *p* values from ANOVA analyses are summarized for each category in Tables 9 through 11. Comparison between the pre- and post-construction wet-weather events with CSOs is somewhat skewed because the criteria for wet weather events with CSOs during the pre-construction monitoring period required the activation of the 125th Street Pump Station. While the 125th Street Pump Station was not activated during the post-construction monitoring period, the approved PCMP required sampling following any CSO events that occurred. Therefore, the two CSO events that occurred in the LCR-S were sampled as wet-weather events with CSOs. Table 12 displays rainfall amounts and CSO activity prior to wet-weather sampling events during the pre- and post-construction monitoring periods.

Overall, geometric mean FC concentrations decreased under all weather conditions during the post-construction monitoring period, especially when comparing with wet-weather events with CSOs in the pre-construction monitoring period. This is not surprising, because only two CSO events occurred at a total of three CSO locations (one unverified) in the CRS during the post-construction monitoring period, and there were 19 CSO events at a total of 24 CSO locations, during 2014–2015.

Geometric mean FC concentrations were significantly lower at Halsted for all three sampling scenarios when comparing post- to pre-construction monitoring data. Disinfection at the Calumet WRP was likely the main contributor to those reductions, because Halsted is only about 0.7 mile downstream of the Calumet WRP outfall. Geometric mean FC concentrations during wet-weather events with CSOs were also significantly reduced at 130th and Indiana, which was expected because there were no CSOs in those reaches during the post-construction monitoring period.

Geometric mean FC concentrations were significantly lower at Ashland and Cicero during dry weather in the post-construction monitoring period, but significantly higher at Ashland and Route 83 under wet weather without CSOs during the post-construction monitoring period, suggesting that there may be significant nonpoint sources of FC in those waterway reaches. Rainfall amounts for wet-weather sampling events without CSOs during the post-construction monitoring period were higher than those in the pre-construction monitoring period (1.25 and 0.7 inches on

TABLE 9: COMPARISON OF WATER QUALITY DATA COLLECTED DURING PRE- AND POST-CONSTRUCTION WET- AND DRY-WEATHER SAMPLING EVENTS AT LOCATIONS IN THE CALUMET RIVER AND LITTLE CALUMET RIVER

Parameter[a]		Event	WW_55 130th St. – Cal. River			WW_56 Indiana Ave. – LCR			WW_76 Halsted St. – LCR		
		Type	1[b]	2[c]	3[d]	1	2	3	1	2	3
TAN[e]	Minimum	Pre[f]	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.26	0.22
(mg/L)		Post[g]	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.10	<0.10
	Maximum	Pre	0.61	0.37	0.19	0.87	0.38	0.55	1.66	1.44	0.87
		Post	<0.50	<0.50	0.30	0.80	<0.50	0.30	1.03	0.50	0.70
	Mean	Pre	0.16	0.20	0.14	0.23	0.18	0.25	0.57	0.60	0.50
		Post	0.29	0.17	0.23	0.30	0.25	0.22	0.37	0.25	0.40
	Std. Dev.	Pre	0.14	0.13	0.04	0.20	0.11	0.20	0.51	0.43	0.27
		Post	0.18	0.14	NA	0.22	0.14	NA	0.22	0.15	NA
	p value[h]		0.16	0.64	0.62	0.14	0.33	0.83	0.12	0.11	0.73
TSS	Minimum	Pre	<4	<4	4	8	4	12	4	5	8
(mg/L)		Post	<4	<4	<4	5	7	11	<4	<4	6
	Maximum	Pre	9	4	12	80	26	14	33	23	16
		Post	6	7	7	31	30	13	17	10	9
	Mean	Pre	5	4	7	23	16	13	14	11	12
		Post	4	6	6	12	11	12	8	7	8
	Std. Dev.	Pre	1.4	0.0	3.6	18.2	8.3	0.8	9.0	6.6	3.4
		Post	0.6	1.4	NA	6.8	7.6	NA	3.8	2.1	NA
	p value		0.19	NC	0.57	0.03	0.27	0.31	0.01	0.21	0.17
TDS	Minimum	Pre	190	250	258	274	358	316	412	472	286
(ppm)		Post	182	202	350	268	262	442	340	370	462
	Maximum	Pre	480	410	328	700	646	428	888	732	462
		Post	446	444	438	558	548	484	736	702	552

TABLE 9 (Continued): COMPARISON OF WATER QUALITY DATA COLLECTED DURING PRE- AND POST-CONSTRUCTION WET- AND DRY-WEATHER SAMPLING EVENTS AT LOCATIONS IN THE CALUMET RIVER AND LITTLE CALUMET RIVER

Parameter[a]		Event Type	WW_55 130th St. – Cal. River 1[b]	2[c]	3[d]	WW_56 Indiana Ave. – LCR 1	2	3	WW_76 Halsted St. – LCR 1	2	3
TDS (ppm)	Mean	Pre	302	334	300	441	474	385	603	590	375
		Post	313	308	394	428	414	463	545	488	507
	Std. Dev.	Pre	79	77	37	143	118	61	161	121	88
		Post	90	86	NA	87	102	NA	108	105	NA
	p value		0.73	0.60	0.12	0.74	0.35	0.20	0.22	0.13	0.17
BOD_5 (mg/L)	Minimum	Pre	<2	<2	<2	<2	<2	<2	<2	<2	3
		Post	<2	<2	<2	<2	<2	<2	<2	<2	<2
	Maximum	Pre	<2	<2	<2	5	4	3	8	5	10
		Post	8	2	<2	3	3	3	4	5	4
	Mean	Pre	<2	<2	<2	2	3	2	3	3	6
		Post	3	2	2	2	2	3	2	3	3
	Std. Dev.	Pre	0.0	0.0	0.0	0.9	0.8	0.5	2.0	1.2	3.1
		Post	1.8	0.0	NA	0.5	0.4	NA	0.7	1.1	NA
	p value		NC	NC	NC	0.62	0.37	0.63	0.16	0.59	0.32
DO (mg/L)	Minimum	Pre	7.3	7.6	6.5	6.1	7.7	5.5	2.9	4.7	3.4
		Post	6.8	7.2	9.1	4.6	7.0	9.9	6.9	6.2	7.0
	Maximum	Pre	11.2	12.0	7.6	12.2	12.7	8.6	11.8	9.3	7.0
		Post	11.9	12.2	11.3	12.2	14.5	10.5	11.9	9.3	8.5
	Mean	Pre	8.9	9.4	7.0	9.3	10.0	7.0	7.5	6.7	4.7
		Post	9.4	8.7	10.2	9.6	9.2	10.2	8.5	7.4	7.8
	Std. Dev.	Pre	1.3	1.9	0.5	1.5	2.1	1.3	1.9	1.9	1.60
		Post	1.9	1.9	NA	1.9	2.6	NA	1.1	1.2	NA
	p value		0.38	0.49	0.01	0.65	0.57	0.03	0.04	0.39	0.07

TABLE 9 (Continued): COMPARISON OF WATER QUALITY DATA COLLECTED DURING PRE- AND POST-CONSTRUCTION WET- AND DRY-WEATHER SAMPLING EVENTS AT LOCATIONS IN THE CALUMET RIVER AND LITTLE CALUMET RIVER

Parameter[a]		Event Type	WW_55 130th St. – Cal. River			WW_56 Indiana Ave. – LCR			WW_76 Halsted St. – LCR		
			1[b]	2[c]	3[d]	1	2	3	1	2	3
FC	Minimum	Pre	9	9	90	9	<10	310	50	2,000	34,000
(CFU/100 mL)		Post	9	9	<10	9	<10	<10	<10	30	60
	Maximum	Pre	110	1,500	500	2,100	90	8,000	83,000	24,000	100,000
		Post	20	91	20	170	530	50	2,900	5,100	70
	Geomean[i]	Pre	13	45	181	35	34	2,148	1,562	7,378	73,811
		Post	11	23	14	16	86	22	120	266	65
	Std. Dev.	Pre	25	600	191	671	31	4,167	20,087	7,756	31,117
		Post	4	27	NA	39	179	NA	773	1,730	NA
	p value[j]		0.35	0.44	0.02	0.13	0.18	0.02	0.00	0.00	0.00

NA = Less than three data points were available, so no standard deviation was calculated.
NC = Not calculated because the variance was zero or there was only one value for one of the levels.
[a]TAN = total ammonia nitrogen; TSS = total suspended solids; TDS = total dissolved solids; BOD_5 = five-day biological oxygen demand; DO = dissolved oxygen; FC = fecal coliform.
[b]Dry-weather event.
[c]Wet-weather event without combined sewer overflows.
[d]Wet-weather event with combined sewer overflows.
[e]Reporting limit increase from 0.10 to 0.50 mg/L staring in July 2018.
[f]Pre-construction monitoring from 2014 through 2015.
[g]Post-construction monitoring from 2017 through 2018.
[h]Significant probability of means not being equal (significant if $p \leq 0.05$).
[i]Geometric mean.
[j]Significant probability of natural logarithm transformed means not being equal (significant if $p \leq 0.05$).

TABLE 10: COMPARISON OF WATER QUALITY DATA COLLECTED DURING PRE- AND POST-CONSTRUCTION WET- AND DRY-WEATHER SAMPLING EVENTS AT LOCATIONS IN THE LITTLE CALUMET RIVER SOUTH AND CALUMET-SAG CHANNEL

Parameter[a]		Event Type	WW_57 Ashland Ave. – LCR-S 1[b]	2[c]	3[d]	WW_52 Wentworth Ave. – LCR-S 1	2	3	WW_59 Cicero Ave. – CSC 1	2	3
TAN[e] (mg/L)	Minimum	Pre[f]	<0.10	<0.10	0.21	0.14	0.12	0.12	0.20	0.27	0.35
		Post[g]	<0.10	<0.10	<0.10	0.10	0.14	0.10	0.15	0.17	0.14
	Maximum	Pre	0.39	0.30	0.33	0.93	0.37	0.31	1.69	1.98	0.73
		Post	0.50	<0.50	0.46	<0.50	<0.50	0.39	1.02	<0.50	0.37
	Mean	Pre	0.22	0.18	0.28	0.28	0.27	0.23	0.60	0.67	0.49
		Post	0.31	0.26	0.28	0.34	0.27	0.25	0.39	0.28	0.26
	Std. Dev.	Pre	0.09	0.08	0.05	0.18	0.11	0.08	0.415	0.65	0.17
		Post	0.17	0.13	NA	0.15	0.12	NA	0.21	0.10	NA
	p value[h]		0.06	0.20	0.99	0.30	0.99	0.90	0.06	0.19	0.19
TSS (mg/L)	Minimum	Pre	7	21	52	6	15	50	5.0	13.0	16
		Post	6	42	204	9	26	45	6	12	95
	Maximum	Pre	168	170	164	226	190	242	56.0	32.0	75
		Post	55	183	239	192	170	316	43	166	179
	Mean	Pre	33	94	128	39	72	114	19.6	18.7	52
		Post	18	103	222	37	63	181	17	42	137
	Std. Dev.	Pre	38.0	62.1	52.7	48.1	73.2	88.1	11.1	7.0	27.7
		Post	13.5	53.2	NA	44.8	45.6	NA	10.4	50.8	NA
	p value		0.15	0.78	0.09	0.91	0.80	0.57	0.40	0.24	0.06
TDS (ppm)	Minimum	Pre	422	644	210	336	274	148	388	476	304
		Post	454	306	240	390	156	262	376	340	268
	Maximum	Pre	1,570	1,222	448	986	672	492	892	764	528
		Post	1,234	840	262	822	482	266	688	616	332

TABLE 10 (Continued): COMPARISON OF WATER QUALITY DATA COLLECTED DURING PRE- AND POST-CONSTRUCTION WET- AND DRY-WEATHER SAMPLING EVENTS AT LOCATIONS IN THE LITTLE CALUMET RIVER SOUTH AND CALUMET-SAG CHANNEL

			WW_57 Ashland Ave. – LCR-S			WW_52 Wentworth Ave. – LCR-S			WW_59 Cicero Ave. – CSC		
Parameter[a]		Event Type	1[b]	2[c]	3[d]	1	2	3	1	2	3
TDS (Continued) (ppm)	Mean	Pre	1,054	826	295	691	454	276	647	599	389
		Post	787	479	251	678	295	264	578	465	300
	Std. Dev.	Pre	276	232	133	161	189	188	156	113	121
		Post	275	177	NA	129	105	NA	86	99	NA
	p value		0.01	0.01	0.68	0.81	0.07	0.92	0.11	0.05	0.41
BOD_5 (mg/L)	Minimum	Pre	<2	3	3	<2	3	3	<2	<2	3
		Post	<2	<2	3	<2	3	4	<2	<2	3
	Maximum	Pre	9	8	7	14	6	4	6	9	4
		Post	4	9	3	5	8	4	21	4	3
	Mean	Pre	3	5	5	3	5	4	2	4	4
		Post	2	5	3	3	5	4	4	3	3
	Std. Dev.	Pre	1.7	2.1	1.7	2.8	1.0	0.5	1.1	2.7	0.6
		Post	0.6	2.2	NA	1.0	1.9	NA	4.9	0.8	NA
	p value		0.48	0.94	NC	0.25	0.92	NC	0.42	0.38	NC
DO (mg/L)	Minimum	Pre	4.7	4.7	4.1	4.6	4.6	5.0	4.4	5.2	4.5
		Post	3.9	6.1	7.5	3.2	4.8	8.1	6.2	5.6	8.4
	Maximum	Pre	11.5	9.0	5.2	12.4	9.9	5.3	9.1	10.0	5.3
		Post	13.5	10.0	8.1	12.6	10.7	8.8	10.3	9.4	8.9
	Mean	Pre	7.4	6.7	4.9	7.1	6.7	5.1	6.8	6.9	5.0
		Post	9.1	7.5	7.8	7.9	7.4	8.5	8.2	7.3	8.7

TABLE 10 (Continued): COMPARISON OF WATER QUALITY DATA COLLECTED DURING PRE- AND POST-CONSTRUCTION WET- AND DRY-WEATHER SAMPLING EVENTS AT LOCATIONS IN THE LITTLE CALUMET RIVER SOUTH AND CALUMET-SAG CHANNEL

Parameter[a]		Event Type	WW_57 Ashland Ave. – LCR-S 1[b]	2[c]	3[d]	WW_52 Wentworth Ave. – LCR-S 1	2	3	WW_59 Cicero Ave. – CSC 1	2	3
DO (Continued)	Std. Dev.	Pre	2.5	1.8	0.5	2.5	2.2	0.2	1.3	1.9	0.4
		Post	2.3	1.5	NA	3.1	1.9	NA	1.1	1.5	NA
	p value		0.05	0.38	0.00	0.37	0.52	0.01	0.00	0.68	0.00
FC (CFU/100 mL)	Minimum	Pre	60	600	7,000	300	780	6,800	20	210	20,000
		Post	30	5,200	4,900	210	270	9,100	9	190	2,000
	Maximum	Pre	20,000	6,900	44,000	100,000	94,000	34,000	7,700	4,700	900,000
		Post	2,700	13,000	7,700	6,800	64,000	9,400	860	5,800	4,800
	Geomean[i]	Pre	498	2,246	19,710	1,550	5,424	17,859	540	1,868	128,969
		Post	165	7,540	6,142	860	7,429	9,249	68	1,699	3,098
	Std. Dev.	Pre	4,614	2,208	17,378	24,683	36,696	11,140	2,431	1,570	426,334
		Post	655	2,634	NA	1,623	20,476	NA	285	1,852	NA
	p value[j]		0.02	0.01	0.15	0.17	0.74	0.13	0.00	0.88	0.07

NA = Fewer than three data points were available, so no standard deviation was calculated.
NC = Not calculated because the variance was zero or there was only one value for one of the levels.
[a]TAN = total ammonia nitrogen; TSS = total suspended solids; TDS = total dissolved solids; BOD_5 = five-day biological oxygen demand; DO = dissolved oxygen; FC = fecal coliform.
[b]Dry-weather event.
[c]Wet-weather event without combined sewer overflows.
[d]Wet-weather event with combined sewer overflows.
[e]Reporting limit increase from 0.10 to 0.50 mg/L starting in July 2018.
[f]Pre-construction monitoring from 2014 through 2015.
[g]Post-construction monitoring from 2017 through 2018.
[h]Significant probability of means not being equal (significant if $p \leq 0.05$).
[i]Geometric mean.
[j]Significant probability of natural logarithm transformed means not being equal (significant if $p \leq 0.05$).

TABLE 11: COMPARISON OF WATER QUALITY DATA COLLECTED DURING PRE- AND POST-CONSTRUCTION WET- AND DRY-WEATHER SAMPLING EVENTS AT LOCATIONS IN THE CALUMET-SAG CHANNEL, GRAND CALUMET RIVER, AND THORN CREEK

Parameter[a]		Event Type	WW_43 Route 83 – CSC 1[b]	WW_43 Route 83 – CSC 2[c]	WW_43 Route 83 – CSC 3[d]	WW_86 Burnham Ave. – GCR 1	WW_86 Burnham Ave. – GCR 2	WW_86 Burnham Ave. – GCR 3	WW_97 170th St. – Thorn Cr. 1	WW_97 170th St. – Thorn Cr. 2	WW_97 170th St. – Thorn Cr. 3
TAN[e] (mg/L)	Minimum	Pre[f]	<0.10	0.33	0.19	<0.10	0.15	0.77	<0.10	0.10	0.14
		Post[g]	<0.10	0.15	0.31	<0.10	<0.10	0.33	<0.10	0.10	<0.10
	Maximum	Pre	1.04	0.93	0.50	4.19	1.44	1.88	1.16	0.94	0.25
		Post	5.70	<0.50	0.14	0.93	0.89	0.97	0.80	0.80	0.38
	Mean	Pre	0.46	0.49	0.34	1.03	0.74	1.19	0.22	0.46	0.19
		Post	0.70	0.29	0.23	0.34	0.28	0.65	0.30	0.38	0.24
	Std. Dev.	Pre	0.25	0.22	0.13	1.30	0.57	0.49	0.25	0.35	0.06
		Post	1.30	0.10	NA	0.23	0.28	NA	0.22	0.24	NA
	p value[h]		0.56	0.07	0.38	0.03	0.11	0.26	0.29	0.61	0.77
TSS (mg/L)	Minimum	Pre	5	10	16	<4	6	6	6	16	78
		Post	7	13	27	4	6	10	7	46	178
	Maximum	Pre	62	42	113	29	13	11	96	203	199
		Post	39	140	181	19	16	19	44	194	252
	Mean	Pre	19	24	80	10	8	9	25	95	140
		Post	15	40	104	10	9	15	18	121	215
	Std. Dev.	Pre	12.9	14.6	45.8	6.9	2.5	2.2	23.1	62.7	53.6
		Post	8.1	42.2	NA	4.0	3.2	NA	11.9	55.9	NA
	p value		0.37	0.36	0.70	0.63	0.50	0.16	0.29	0.43	0.18
TDS (ppm)	Minimum	Pre	380	424	280	548	482	250	570	470	218
		Post	404	316	328	374	330	240	678	270	240
	Maximum	Pre	956	762	402	940	732	402	1,964	1,782	694
		Post	846	584	404	736	614	260	2,780	774	260

TABLE 11 (Continued): COMPARISON OF WATER QUALITY DATA COLLECTED DURING PRE- AND POST-CONSTRUCTION WET- AND DRY-WEATHER SAMPLING EVENTS AT LOCATIONS IN THE CALUMET-SAG CHANNEL, GRAND CALUMET RIVER, AND THORN CREEK

			WW_43			WW_86			WW_97		
		Event	Route 83 – CSC			Burnham Ave. – GCR			170th St. – Thorn Cr.		
Parameter[a]		Type	1[b]	2[c]	3[d]	1	2	3	1	2	3
TDS (Continued)	Mean	Pre	643	588	323	731	639	316	1,498	910	380
		Post	586	449	366	537	445	250	1,512	462	250
	Std. Dev.	Pre	177	126	69	109	112	78	366	515	272
		Post	115	83	NA	112	91	NA	480	186	NA
	p value		0.26	0.03	0.51	0.00	0.01	0.87	0.93	0.12	0.47
BOD_5 (mg/L)	Minimum	Pre	<2	<2	<2	<2	<2	5	<2	3	3
		Post	<2	<2	6	<2	<2	5	<2	3	3
	Maximum	Pre	3	4	8	11	13	9	7	9	5
		Post	3	5	6	<2	10	10	3	11	3
	Mean	Pre	2	3	4	3	6	7	3	6	4
		Post	2	3	6	2	3	8	2	6	3
	Std. Dev.	Pre	0.5	0.8	2.7	2.4	4.0	1.7	1.2	2.5	0.8
		Post	0.5	1.1	NA	0.0	2.8	NA	0.4	2.9	NA
	p value		0.70	0.52	NC	NC	0.15	0.64	0.18	0.82	NC
DO (mg/L)	Minimum	Pre	4.1	4.2	5.0	1.9	0.0	0.0	1.1	5.6	4.7
		Post	6.2	5.7	8.5	5.4	6.1	5.5	4.6	5.5	7.9
	Maximum	Pre	9.0	10.1	6.2	13.5	6.2	1.6	12.1	8.7	5.8
		Post	10.1	8.9	9.5	9.7	9.4	5.8	11.7	10.6	7.9
	Mean	Pre	6.6	6.1	5.7	6.0	4.5	0.9	8.0	6.9	5.2
		Post	8.1	7.0	9.0	7.8	7.1	5.7	8.9	7.7	7.9

TABLE 11 (Continued): COMPARISON OF WATER QUALITY DATA COLLECTED DURING PRE- AND POST-CONSTRUCTION WET- AND DRY-WEATHER SAMPLING EVENTS AT LOCATIONS IN THE CALUMET-SAG CHANNEL, GRAND CALUMET RIVER, AND THORN CREEK

			WW_43			WW_86			WW_97		
		Event	Route 83 – CSC			Burnham Ave. – GCR			170th St. – Thorn Cr.		
Parameter[a]		Type	1[b]	2[c]	3[d]	1	2	3	1	2	3
DO	Std. Dev.	Pre	1.3	2.3	0.5	2.9	2.3	0.7	2.7	1.4	0.5
(Continued)		Post	1.1	1.3	NA	1.3	1.0	NA	2.2	1.7	NA
	p value		0.00	0.37	0.00	0.03	0.03	0.00	0.25	0.35	NC
FC	Minimum	Pre	<10	210	3,700	20	<10	42,000	80	360	3,200
(CFU/100 mL)		Post	9	90	1,400	40	110	34,000	80	600	2,800
	Maximum	Pre	2,600	2,000	68,000	2,500	90	920,000	7,500	84,000	20,000
		Post	780	5,900	1,600	5,400	76,000	74,000	15,000	55,000	18,000
	Geomean[i]	Pre	74	518	22,169	329	6,368	150,366	660	8,452	8,755
		Post	35	2,260	1,497	394	3,521	50,160	515	6,857	7,099
	Std. Dev.	Pre	586	664	28,651	621	31	413,612	1,826	37,166	8,338
		Post	249	1,846	NA	1,644	25,795	NA	3,648	17,781	NA
	p value[j]		0.14	0.04	0.05	0.72	0.65	0.39	0.55	0.82	0.82

NA = Fewer than three data points were available, so no standard deviation was calculated.
NC = Not calculated because the variance was zero or there was only one value for one of the levels.
[a]TAN = total ammonia nitrogen; TSS = total suspended solids; TDS = total dissolved solids; BOD_5 = five-day biological oxygen demand; DO = dissolved oxygen; FC = fecal coliform.
[b]Dry-weather event.
[c]Wet-weather event without combined sewer overflows.
[d]Wet-weather event with combined sewer overflows.
[e]Reporting limit increase from 0.10 to 0.50 mg/L staring in July 2018.
[f]Pre-construction monitoring from 2014 through 2015.
[g]Post-construction monitoring from 2017 through 2018.
[h]Significant probability of means not being equal (significant if $p \leq 0.05$).
[i]Geometric mean.
[j]Significant probability of natural logarithm transformed means not being equal (significant if $p \leq 0.05$).

TABLE 12: SUMMARY OF CALUMET WATERSHED RAINFALL AMOUNTS AND COMBINED SEWER OVERFLOWS FOR WET-WEATHER SAMPLING EVENTS DURING PRE- AND POST-CONSTRUCTION MONITORING

Sampling Date	Rainfall[a] (inches)	Event Type	Number of CSOs[b]
04/15/14	0.56	Wet Weather Without CSOs	0
05/21/14	1.10	Wet Weather With CSOs	13
07/01/14	1.63	Wet Weather With CSOs	17
08/05/14	0.78	Wet Weather Without CSOs	0
08/22/14	2.46	Wet Weather With CSOs	14
04/10/15	0.93	Wet Weather Without CSOs	0
06/11/15	0.54	Wet Weather Without CSOs	0
06/16/15	0.87[c]	Wet Weather With CSOs	21
07/17/15	0.69	Wet Weather Without CSOs	0
03/01/17[d]	1.81	Wet Weather With CSOs	3
03/31/17[d]	2.11	Wet Weather With CSOs	2
05/11/17	0.95	Wet Weather Without CSOs	0
10/11/17	1.44	Wet Weather Without CSOs	0
10/23/17	1.67	Wet Weather Without CSOs	0
10/25/17	0.50	Wet Weather Without CSOs	0
02/21/18	2.75	Wet Weather Without CSOs	0
05/15/18	1.00	Wet Weather Without CSOs	0
05/22/18	0.93	Wet Weather Without CSOs	0
11/26/18	0.73	Wet Weather Without CSOs	0

[a]Rainfall data is the post rain event average of four rain gages in the Metropolitan Water Reclamation District of Greater Chicago's south basin.
[b]Combined sewer overflows.
[c]2.57 inches from 06/11/15–06/15/15 at 125th Street. 0.87 inches from 06/15/15 rain event only.
[d]CSOs occurred, but the 125th Street Pump Station was not active.

average, respectively). This difference could have contributed to the increase in geometric mean FC concentrations at those locations.

With exceptions at 130th and Indiana during wet-weather events without CSOs, mean DO concentrations were higher during the post-construction monitoring period for all three sampling event types, which may be partially due to the fact that there were very few wet-weather events with CSOs during the post-construction monitoring period. In addition, the two CSO events during the post-construction monitoring period occurred within 30 days of each other in February and March, when temperatures are fairly low yielding higher DO concentrations. In contrast, most of the pre-construction wet-weather sampling events took place during spring and summer with higher water temperatures resulting in lower DO concentrations before rain events even occurred.

Mean DO concentrations were significantly higher during the post-construction monitoring period at all sampling locations but 170th, with most of the increases observed during dry weather and wet weather with CSOs. Burnham was the only location that had significantly higher mean DO concentrations for all three sampling scenarios, which is similar to the results of the statistical analysis of the AWQM data. Significant improvements in DO concentrations during post construction dry-weather conditions are likely a result of improvements in the District's operation of Sidestream Elevated Pool Aeration (SEPA) stations and Lake Michigan discretionary diversion. Significant improvements in DO concentrations during wet-weather events with CSOs in the post-construction monitoring period are likely due to the capture of CSOs by the TCR.

Significant changes in mean concentrations of TSS and TDS also occurred when comparing data from pre- and post-construction wet- and dry-weather sampling events with some exceptions. Significantly lower mean TSS concentrations at Halsted and 130th for post-construction sampling events were only found during dry-weather conditions. Post-construction mean TDS concentrations were not significantly different during events with CSOs at any CRS locations. However, mean TDS concentrations were significantly lower at Ashland, Route 83, and Burnham during post-construction sampling during wet-weather events without CSOs and Ashland and Burnham were the only sampling locations with significantly lower mean TDS concentrations during dry weather.

For TAN, despite the reporting limit increase to 0.50 mg/L in July 2018, increases in mean concentrations were not significant. Reductions in mean TAN concentrations were only significant at Burnham during dry weather. Mean BOD_5 concentrations were lower during the post-construction period. However, there were no statistically significant differences at any of the sampling locations or event types.

Comparison of Wet- and Dry-Weather Water Quality During the Post-Construction Monitoring Period. While the low frequency of CSOs during the post-construction monitoring period made statistical comparisons impractical, general water quality comparisons can be made under the various weather conditions using the data presented in Tables 9 through 11. Water quality at sampling locations directly downstream of CSO discharges (Ashland for C-1 and CDS-45 and Indiana for CDS-18 [CSO discharge unverified]) was similar to water quality observed during wet weather events without CSOs. In addition, water quality was generally similar at sampling locations directly upstream and downstream of CSO discharges during the only two CSO events that happened in the post-construction monitoring period, suggesting that the very low volume discharged relative to the receiving water flow had minimal impact on water quality.

Overall, wet-weather events (with and without CSOs) had higher geometric mean FC concentrations than dry-weather events. Geometric mean FC concentrations at Halsted (closest station downstream of the Calumet WRP) were similar during all three weather conditions, due to disinfection at the Calumet WRP. Geometric mean FC concentrations were also similar between the two types of wet-weather events at the rest of the sampling locations, indicating that nonpoint sources of FC were present with or without CSOs. Geometric mean FC was slightly lower during wet weather with CSOs than without CSOs at Ashland (6,142 and 7,540 CFU/100 mL, respectively), the downstream station closest to the CSO discharge at CDS-45 and CDS-1. In addition, during both CSO events, FC concentrations were slightly higher at the upstream sampling location (Wentworth) than downstream of the CSO discharges (Ashland). Following the unverified possible discharge from CDS-18 on March 30, 2017, the FC concentration was 50 CFU/100 mL downstream at Indiana.

Mean DO concentrations were higher at Halsted during dry weather, which is likely a benefit of proximity to SEPA Station 2 and the Calumet WRP effluent. Similarity in DO concentrations between the three sampling event types at the rest of the CRS locations suggests that DO was not heavily influenced by wet-weather events with or without CSOs. The factors that likely had a greater impact on DO concentrations are discussed later in the "Continuous Dissolved Oxygen Monitoring" section of this report.

Mean BOD_5 was five or less for all sampling event types at all locations except Route 83, Burnham, and 170th, which were not in the vicinity of any CSOs. BOD_5 was not reported for the March 1, 2017, sampling event at Route 83, Ashland, 170th, and Cicero, because laboratory quality assurance/quality control (QA/QC) measures failed to meet required criteria. However, during the March 31, 2017, wet weather with CSO sampling event, all BOD_5 concentrations were between <2 to 6 mg/L. BOD_5 was slightly higher upstream than downstream of CSO locations CDS-45 and C-1 (4 and 3 mg/L at Wentworth and Ashland, respectively). Downstream of CDS-18, at Indiana, BOD_5 was 3 mg/L after the possible CSO discharge.

Mean TSS concentrations were slightly higher during wet-weather events with CSOs than without CSOs at all sampling locations except 130th, regardless of their proximity to CSOs. Mean TSS concentrations were lower during dry-weather sampling events at 170th, Wentworth, Ashland, Cicero, and Route 83.

Most sampling locations (Burnham, 170th, Wentworth, Ashland, Cicero, and Route 83) exhibited lower mean TDS concentrations after wet-weather events with CSOs than during any other sampling event type. Dry-weather sampling events showed higher mean TDS concentrations than both types of wet-weather events at all locations except 130th and Indiana.

Mean TAN concentrations were similar between wet- and dry-weather conditions at all sampling locations. During wet weather with CSO events, mean TAN concentrations were very similar upstream and downstream of the CSO discharges at CDS-45 and C-1 (0.25 and 0.28 mg/L at Wentworth and Ashland, respectively). Downstream of CDS-18, TAN was <0.10 mg/L after the possible CSO discharge. Slight variations in TAN concentrations may be due to the increase in reporting limits (described earlier in the Methodology section of this report) that started in July 2018.

Compliance with Water Quality Standards During the Post-Construction Monitoring Period

The TAN WQS were calculated using the applicable pH and temperature based equations and compared to TAN concentrations for all of the AWQM and wet- and dry-weather sampling event data (Title 35 Illinois Administrative Code [IAC] Sections 302.212 and 302.412). As an example, at pH 7 and 10 degrees Celsius during the Early Life Stages Period, the calculated acute and chronic TAN standards would be 22.6 and 5.9 mg/L, respectively. In this case, since the calculated acute standard is above 15 mg/L, the acute standard of 15 mg/L applies. For evaluation purposes, the calculated chronic WQS was compared to each sample concentration since there were insufficient samples to calculate a 30-day average including at least four samples. All the CRS reaches monitored were 100 percent compliant with acute and chronic TAN WQS for CAWS A and General Use Waters. There was also 100 percent compliance with TAN WQS in all CRS reaches during the pre-construction monitoring period.

Table 13 is a summary of FC data that were collected under various conditions during the applicable recreational season in the post-construction monitoring period compared to 400 CFU/100 mL for assessment purposes (a geometric mean of five samples collected within 30 days is required for a true compliance assessment). There are no applicable FC standards for 130th and Burnham, due to the Non-Contact and Incidental Contact Recreational Use Designations on the Calumet River and GCR, respectively. However, data from March through November were summarized at these locations for comparison purposes. The FC WQS in General Use Waters (LCR-S at Wentworth and Ashland, and Thorn Creek at 170th) is applicable from May through October (Title 35 IAC Section 302.209 (a)). While Primary Contact Recreation Waters (LCR at Indiana and Halsted, and CSC at Cicero and Route 83) are subject to General Use WQS for FC, the recreational season is considered March through November according to Effluent Disinfection standards outlined in IAC Title 35, Sec.304.224.

The FC concentrations were below 400 CFU/100 mL one hundred percent of the time at Indiana (WW_56) and Halsted (WW_76) for all three types of sampling events during recreational months. The FC concentrations at Cicero (WW_59) and Route 83 (WW_43) were only below 400 CFU/100 mL one hundred percent of the time during recreational months under dry-weather conditions in the post-construction monitoring period. However, at most stations, FC was above 400 CFU/100 mL most or all of the time during wet weather, irrespective of whether there were CSOs. The FC concentrations at closest stations upstream (Wentworth [WW_52]) and downstream (Ashland [WW_57]) of CDS-45 and C-1 were above 400 CFU/100 mL during both CSO events in the post-construction monitoring period, but these stations were also typically above this threshold during wet-weather events without CSOs and even frequently during dry-weather events. Notably, Cicero (WW_59) and Route 83 (WW_43) were also above 400 CFU/100 mL during both wet-weather with CSO events despite not being in the vicinity of any of the CSOs that discharged. These locations usually exceeded 400 CFU/100 mL during wet-weather events without CSOs as well.

Geometric mean FC was greater than 400 CFU/100 mL at two locations (Wentworth [WW_52 in the LCR-S] and 170th [WW_97 in Thorn Creek]) during recreational months under

TABLE 13: SUMMARY OF WET- AND DRY-WEATHER EVENT FECAL COLIFORM CONCENTRATIONS COLLECTED DURING RECREATIONAL USE MONTHS FOR THE CALUMET RIVER SYSTEM DURING POST-CONSTRUCTION MONITORING OF THORNTON COMPOSITE RESERVOIR

Station ID	Dry-Weather Geometric Mean[2]	Wet-Weather Without CSOs[1] Geometric Mean[2]	Wet-Weather With CSOs Geometric Mean[2]	Dry-Weather Percentage Below 400 CFU/100 mL[3]	Wet-Weather Without CSOs Percentage Below 400 CFU/100 mL[3]	Wet-Weather With CSOs Percentage Below 400 CFU/100 mL[3]
WW_55[4]	12	31	14	NA	NA	NA
WW_86[4]	180	2,270	50,160	NA	NA	NA
WW_56[5]	12	66	22	100	100	100
WW_76[5]	47	175	65	100	100	100
WW_52[6]	853	6,509	9,249	22.2	16.7	0.0
WW_97[6]	530	7,489	7,099	62.5	0.0	0.0
WW_57[6]	75	7,652	6,142	87.5	0.0	0.0
WW_59[5]	29	1,425	3,098	100	14.3	0.0
WW_43[5]	14	2,036	1,497	100	14.3	0.0

[1]Combined sewer overflows.
[2]The reporting limit of 10 CFU/100 mL was used in the calculation of geometric means if concentrations were <10 CFU/100 mL.
[3]For assessment purposes, a limit of 400 CFU/100 mL was used.
[4]No fecal coliform standard; geometric mean calculated using March through November sampling events.
[5]Wet and dry weather data analyzed March through November to correspond with the recreational season in the Chicago Area Waterway System.
[6]Wet and dry weather data analyzed May through October to correspond with the recreational season in General Use Waters.

dry-weather conditions. Thorn Creek receives effluent from the Thorn Creek Basin Sanitary District, while the LCR-S originates in the State of Indiana and receives effluents from WRPs there. There are also CSOs beyond the Illinois state line in the LCR-S that would not be affected by the TCR being online.

In the post-construction monitoring period, mean grab sample DO concentrations at all CRS locations ranged from 5.7 to 10.2 mg/L, as indicated in Tables 9 through 11. Minimum DO concentrations were above the applicable seasonal DO WQS during wet weather with and without CSOs at all locations except Wentworth during a wet-weather event without CSOs. However, minimum DO concentrations were below the applicable seasonal DO WQSs at 170th, Ashland, and Wentworth during dry weather. This suggests that DO compliance issues may be related to low-flow conditions. Grab samples from the AWQM locations provided snapshots of DO concentrations, but continuous DO data from CDOM locations provided a more comprehensive evaluation of compliance with DO standards and is discussed below.

Continuous Dissolved Oxygen Monitoring

The two wet-weather events that resulted in CSOs in February and March 2017 did not cause DO concentrations to drop below any of the applicable DO WQS within seven days of the CSO occurrence at any CDOM location. Figures 3 and 4 show DO graphs at Ashland (CDOM location downstream of verified CSO locations CDS-45 and C-1) for seven days following the two CSO events that occurred in the post construction monitoring period. All of the CRS CDOM data collected within seven days after the wet-weather events that resulted in CSO discharges during the post-construction monitoring period are provided in Appendix I. Tables I-1 through I-4 display DO data from four CDOM stations for seven days following the wet-weather event that resulted in CSO discharges on February 28, 2017. Data from Route 83 were not available following February 28, 2017, because they did not meet QA/QC standards. Tables I-5 through I-9 display DO data from all five CDOM stations for seven days following the wet-weather event that resulted in CSO discharges on March 30, 2017.

All CDOM locations had relatively higher mean DO concentrations during 2017–2018 (Table 14). Increases of 1 mg/L or greater in the minimum DO concentration were seen at Chicago and Western Indiana Railroad (C&W), Ashland, and Cicero when comparing post-construction to pre-construction monitoring periods. Post-construction standard deviations were slightly lower at all of the locations, except Route 83 where it was the same, suggesting that DO concentration distributions were slightly less variable than pre-construction.

Compliance with DO WQS increased during the post-construction monitoring period at all stations except Ashland (Table 14). Overall DO compliance for the post-construction monitoring period was greater than 90 percent at all of the CRS CDOM Stations. Changes in the CDOM SOP described in the Methodology section primarily account for the increase in the number of observations shown in Table 14 during 2017–2018. The SEPA Station 4 was out of service from May 30, 2018, to July 20, 2018, due to electrical issues. Compliance with DO standards at Route 83 would most likely have been higher during 2017–2018 if SEPA Station 4 had been operational during that time. Variation in weather patterns from year to year can also influence DO

FIGURE 3: DISSOLVED OXYGEN CONCENTRATION MEASURED HOURLY AT ASHLAND AVENUE IN THE LITTLE CALUMET RIVER SOUTH, FEBRUARY 28, 2017, THROUGH MARCH 7, 2017

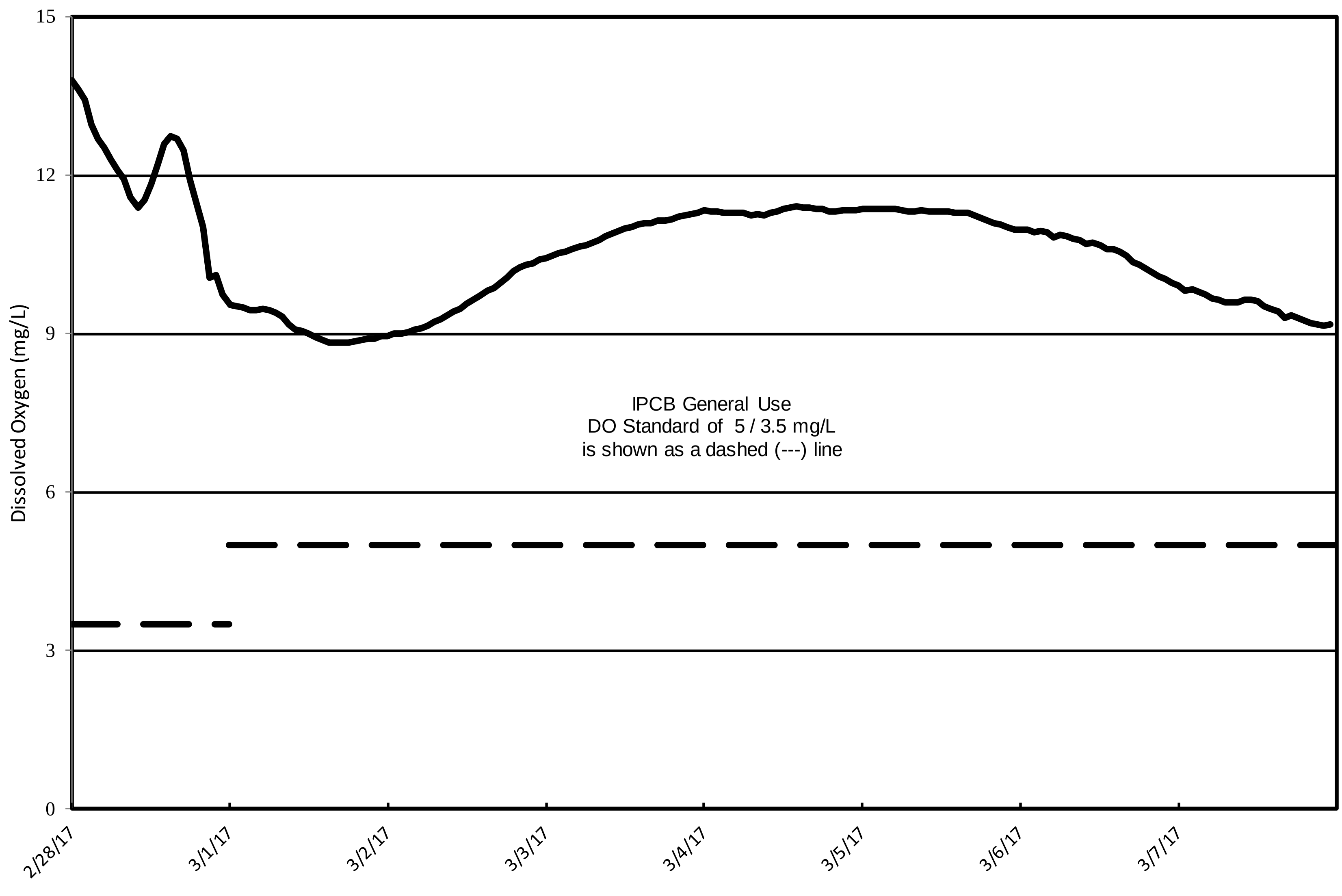


FIGURE 4: DISSOLVED OXYGEN CONCENTRATION MEASURED HOURLY AT ASHLAND AVENUE IN THE LITTLE CALUMET RIVER SOUTH, MARCH 30, 2017, THROUGH APRIL 6, 2017

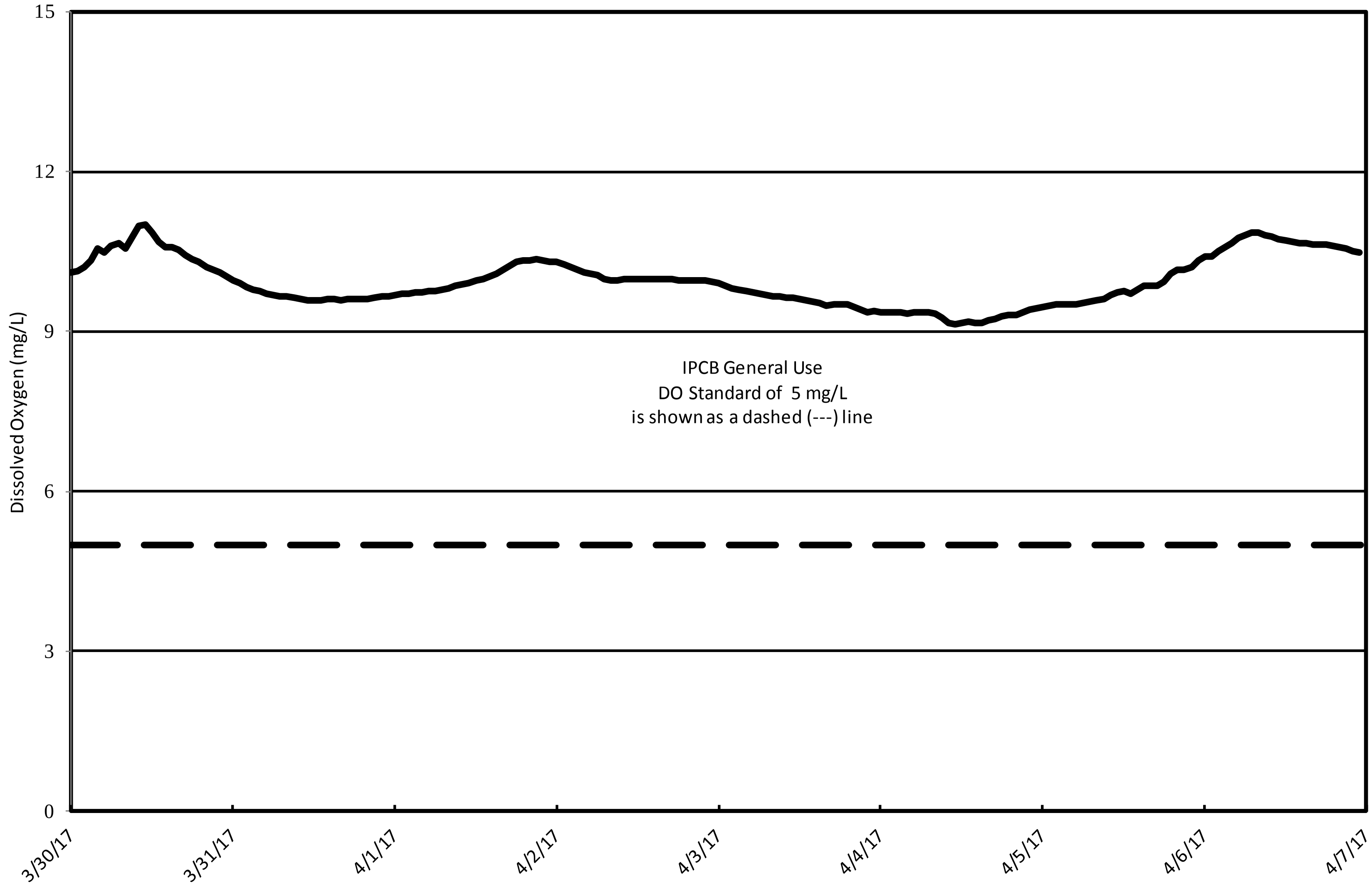


TABLE 14: SUMMARY OF HOURLY DISSOLVED OXYGEN CONCENTRATIONS AT CONTINUOUS DISSOLVED OXYGEN MONITORING STATIONS WITHIN THE CALUMET WATERSHED PRE AND POST CONSTRUCTION OF THORNTON COMPOSITE RESERVOIR

		Little Calumet River		Little Calumet River South	Calumet-Sag Channel	
Parameter	Period	C&W Indiana Railroad	Halsted Street	Ashland Avenue	Cicero Avenue	Route 83
Number of Observations	Pre[1]	13,103	13,577	15,843	14,814	16,628
	Post[2]	17,013	16,509	16,056	16,513	16,989
Minimum DO[3]	Pre	0.2	0.4	0.2	0.2	0.4
	Post	1.3	0.2	1.2	1.4	0.4
Maximum DO	Pre	19.8	22.2	23.2	12.9	14.0
	Post	21.8	15.1	24.0	17.1	15.4
Mean DO	Pre	8.9	6.9	8.6	6.8	6.8
	Post	9.6	8.0	8.9	7.8	7.7
Standard Deviation (mg/L)	Pre	2.7	1.9	3.4	2.0	2.1
	Post	2.5	1.8	3.0	1.9	2.1
Percentage Above DO Standard[4]	Pre	95.2	92.0	94.5	89.0	83.1
	Post	96.5	94.6	94.0	92.8	91.1

[1]Pre construction of Thornton Composite Reservoir, during 2014–2015.
[2]Post construction of Thornton Composite Reservoir, during 2017–2018.
[3]Dissolved oxygen (DO) concentration in milligrams per liter (mg/L).
[4]Illinois Pollution Control Board Chicago Area Waterway System Aquatic Life Use A standard, where DO must be above 5.0 mg/L from March through July and above 3.5 mg/L for the balance of the year.

concentrations. The total precipitation in Chicago during 2017 and 2018 was less than 2014 and 2015 (Table 15), with 2014 exhibiting the highest precipitation.

Another factor that may have influenced DO during the post-construction monitoring period was that the District began to implement a plan to improve Lake Michigan discretionary diversion and instream aeration operations to enhance CAWS DO in 2017. The District agreed to conduct a CAWS DO optimization study during its petition to modify diversion allocation from Lake Michigan. As a result, the District improved operations at O'Brien Lock and Dam and the SEPA stations using supplementary data from additional real-time DO monitoring in the CRS.

TABLE 15: ANNUAL CHICAGO PRECIPITATION DATA DURING PRE- AND POST-CONSTRUCTION MONITORING[1]

Year	Total Precipitation (inches)
2014	52.0
2015	46.0
2017	45.7
2018	44.1

[1]Precipitation data are from measurements made at Chicago's Midway Airport and reported via <www.currentresults.com>.

REFERENCES

Polls, Irwin, Samuel G. Dennison, Salvador J. Sedita, and Cecil Lue-Hing. *Water Quality Improvements in the Chicago and Calumet Waterway Between 1975 and 1993 Associated with the Operation of Water Reclamation Plants, the Tunnel and Reservoir System, and Instream and Sidestream Aeration Stations*. Metropolitan Water Reclamation District of Greater Chicago Research and Development Department Report Number 98–23, September, 1998.

https://www.currentresults.com/Yearly-Weather/USA/IL/Chicago/recent-annual-chicago-temperature-precipitation.php

APPENDIX A

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY LETTER OF APPROVAL FOR CALUMET TUNNEL AND RESERVOIR PLAN SYSTEM POST-CONSTRUCTION MONITORING PLAN

Attn: Ron Hill, Tom Granato
FYI - Good job! D.S.P.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
77 WEST JACKSON BOULEVARD
CHICAGO, IL 60604-3590

OCT 07 2016

REPLY TO THE ATTENTION OF:
WC-15J

CERTIFIED MAIL 7009 1680 0000 7645 8566
RETURN RECEIPT REQUESTED

David St. Pierre
Executive Director
Metropolitan Water Reclamation District
of Greater Chicago
100 East Erie Street
Chicago, Illinois 60611

Re: *U.S. EPA et al. v. Metropolitan Water Reclamation District of Greater Chicago*, Calumet TARP System Post Construction Monitoring Plan

Dear Mr. St. Pierre:

The U.S. Environmental Protection Agency received the September 30, 2016 letter from the Metropolitan Water Reclamation District of Greater Chicago (MWRD) submitting the revised Calumet TARP System Post Construction Monitoring Plan for approval pursuant to Paragraph 35(a) and Section X of the Consent Decree in *U.S. et al. v. Metropolitan Water Reclamation District of Greater Chicago*, Civil Action No. 11-C-8859. EPA has reviewed MWRD's revised Calumet TARP System Post Construction Monitoring Plan and has consulted with the Illinois Environmental Protection Agency regarding the plan, pursuant to Section X of the Consent Decree.

By this letter, EPA approves MWRD's revised Calumet TARP System Post Construction Monitoring Plan pursuant to Section X of the Consent Decree. Pursuant to Paragraph 35(d) of the Consent Decree, MWRD must implement the approved Calumet TARP System Post Construction Monitoring Plan after MWRD has commenced full operation of the Thornton Reservoir in accordance with Paragraph 16(e) of the Consent Decree. If you have any questions, please contact Keith Middleton, of my staff, at (312) 886-6465 or middleton.keith@epa.gov.

Sincerely,

for Tinka G. Hyde
Director, Water Division

cc: Charles Gunnarson, Illinois Environmental Protection Agency
Cathy Banerjee Rojko, United States Department of Justice
Steve Sylvester, Illinois Attorney General's Office

APPENDIX B

CALUMET AND LEMONT WATER RECLAMATION PLANTS' COMBINED SEWER OVERFLOW MONITORING AND REPORTING PLAN

Calumet and Lemont WRPs
NPDES Permit Nos. IL0028061 and IL0028070
CSO Representative Monitoring and Reporting Plan
April 10, 2006
Rev. April 21, 2006
Rev. December 15, 2008
Rev. December 1, 2009
Rev. December 1, 2010
Rev. May 18, 2012
Rev. February 1, 2013
Rev. August 1, 2014
Rev. February 15, 2018

In accordance with Special Conditions (SCs) 13.13 and 14.11 of the Calumet and Lemont National Pollutant Discharge Elimination System (NPDES) Permit Nos. IL0028061 (effective August 1, 2017) and IL0028070 (effective February 1, 2008), the following plan is approved for monitoring the frequency and duration of the discharge from select representative CSO outfalls authorized in the permits for which the Metropolitan Water Reclamation District of Greater Chicago (District) has the ability to monitor through telemetry. These monitored CSO outfalls represent the remaining unmonitored CSO outfalls, so if the monitored outfalls discharge, it is assumed that the associated unmonitored outfalls also discharge.

The 52 CSO outfalls listed below will be monitored as required in SCs 13.13 and 14.11. They include all CSOs for which the District has the ability to monitor through telemetry. This list has been updated to account for multiple outfalls associated with each dropshaft/TARP structure.

The District will document the frequency and duration of CSOs through the outfalls listed below along with an estimate of storm duration and total rainfall for each storm event. Based on this information, the District will estimate CSO volume (MG), BOD5 loading (pounds), and SS loading (pounds) that accounts for all of the CSO outfalls within the District's service area. The District will continue to monitor these designated CSO outfalls at all times unless the telemetry is out of service due to malfunction or routine maintenance. The results of the monitoring will be submitted to the IEPA on a quarterly basis: February 25, May 25, August 25, and November 25.

Receiving Water: Chicago Sanitary & Ship Canal (total 1)

Discharge No.	TARP Structure	Outfall Location	CSO Outfall Owner(s)
002		Lemont WRP	1 - MWRD

Receiving Water: Cal-Sag Channel (total: 9)

Discharge No.	TARP Structure	Outfall Location	CSO Outfall Owner(s)
005/001	*CDS-6*	*California Avenue & Edward Street*	*1 -Blue Island/Posen*
002	CDS-7	Irving Avenue (N)	1 - Blue Island
003	CDS-8	Division Avenue (S)	1 - Blue Island
001/218	*CDS-10*	*Laflin Avenue (N)*	*1 -Calumet Park/Chicago*
158	18E-PS	Pulaski Road PS (Crawford Ave N)	1 - MWRD
157	CDS-2	Central Park Avenue (N)	1 - MWRD
163	CDS-4	Sacramento Avenue (S)	1 - MWRD
156/001	*CDS-5*	*Francisco Avenue (N)*	*1 -MWRD/Blue Island*
154	CDS-11	Throop Street (N)	1 - MWRD

Receiving Water: Little Calumet River (total: 35)

Discharge No.	TARP Structure	Outfall Location	CSO Outfall Owner(s)

002	CDS-53	River Drive (N)	1 - Calumet City
003	CDS-53	Woodview Avenue (N)	1 - Calumet City
004	CDS-55	Greenbay Ave (N)	1 - Calumet City
005	CDS-55	Burnham Avenue (N)	1 - Calumet City
006	CDS-55	Stanley Boulevard (N)	1 - Calumet City
007	CDS-55	Lincoln Avenue (N)	1 - Calumet City
211	CDS-14	130th Street (E)	1 - Chicago
210	CDS-15-5	Indiana Avenue (E)	1 - Chicago
239	CDS-16	Vernon Avenue & East 134th Street	1 - Chicago
241	CDS-12	Stewart Avenue	1 - Chicago
001	CDS-39	Ashland Avenue (S)	1 - Dixmoor
001	CDS-17	Forest Avenue Ext. (S)	1 - Dolton
002	CDS-18	Dorchester Avenue (S)	1 - Dolton
003	CDS-51	Ellis Avenue (N)	1 - Dolton
001	CDS-41	144th Street (W)	1 - Harvey
002	CDS-41	Center Avenue (E)	1 - Harvey
003	CDS-42	Union Street (W)	1 - Harvey
004	CDS-43	Clinton Street (W)	1 - Harvey
005	CDS-43	Illinois Central Railroad (E)	1 - Harvey
006	CDS-45	147th Street (N)	1 - Harvey
007	CDS-45	149th Street (E)	1 - Harvey
002/005	CDS-55	Burnham Avenue (S)	1 - Lansing
004	TARP Outfall	WRP TARP Bypass (W)	1 - MWRD
153	CDS-13	Edbrook Avenue (125th St. PS)	1 - MWRD
001	CDS-45	9th Avenue Extension & 151st Street	1 - Phoenix
002	CDS-15-1	Penn Central & Dearborn Street	1 - Riverdale
003	CDS-15-2	Wabash Street (S)/Ext. State Street	1 - Riverdale
004	CDS-42	Union Avenue P.S. (N)	1 - Riverdale
005	CDS-15-4	Indiana Avenue (W)	1 - Riverdale
N/A	CDS-15-3	Extended State Street	1 - Riverdale
001	CDS-C-1	South Park (N)	1 - South Holland
002	CDS-C-1	South Park (S)	1 - South Holland
003	CDS-48	Chicago & Eastern Railroad Yard	1 - South Holland
004	CDS-45	152nd Street Extension Structure 1	1 - South Holland
N/A	CDS-45	152nd Street Extension Structure 2	1 - South Holland

Receiving Water: Calumet River (total: 3)

Discharge No.	TARP Structure	Outfall Location	CSO Outfall Owner(s)
206	CDS-20	134th & Brainard	1 - Chicago
152	CDS-28	122nd Street PS	1 - MWRD
151	CDS-34	95th Street PS	1 - MWRD

Receiving Water: Grand Calumet River (total: 3)

Discharge No.	TARP Structure	Outfall Location	CSO Outfall Owner(s)
001	CDS-21	Escanaba Avenue	1 - Burnham

002	CDS-22	138th Place Extension (N)	1 - Burnham
003	CDS-23	142nd Street Extension	1 - Burnham

Receiving Water: Calumet Union Drainage Ditch (total: 1)

Discharge No.	TARP Structure	Outfall Location	CSO Outfall Owner
001	CDS-57	Markham PS	1 - Markham

Summary of Monitored CSO Outfalls:

Chicago San & Ship Canal:	1
Cal-Sag Channel	9
Little Calumet River	35
Calumet River	3
Grand Calumet River	3
Cal-Union Drainage Ditch	1
Total CSO Outfalls	52

APPENDIX C

POST-CONSTRUCTION MONITORING PLAN FOR
CALUMET TUNNEL AND RESERVOIR PLAN SYSTEM

Post Construction Monitoring Plan for Calumet TARP System

Background

Portions of the Calumet tunnel system began operation in 1986 and the entire system was completed in 2006. The design storage capacity of the Calumet tunnel system is approximately 630 million gallons. The Thornton Composite Reservoir of the Calumet TARP System measures approximately 2,500 by 1,600 feet with a maximum water depth of 292 feet and has a total capacity of 7.9 billion gallons (4.8 billion gallons for combined sewerage and 3.1 billion gallons for Thorn Creek floodwater). However, the Metropolitan Water Reclamation District of Greater Chicago (MWRD or the District) has arranged to provide additional protection by extending its lease of the transitional reservoir (in the West Lobe of the quarry) through 2020. During that time the community will receive the benefit of 3.1 billion gallons of Thorn Creek floodwater storage provided by the transitional reservoir, in addition to the 7.9 billion gallons of CSO storage in the Thornton Composite Reservoir. This five-year "extra storage period" was made possible because of an agreement between MWRD and the mining company, involving MWRD paying for this extra storage period at a cost of $750,000.00 per year for five years, for a total cost of $3,750,000.00.

The Calumet River System is made up of natural and man-made channels as well as natural waterways upstream of the Chicago Area Waterway System (CAWS). The Cal-Sag Channel extends upstream from its junction with the Chicago Sanitary and Ship Canal for 16.2 miles to the Little Calumet River. At this point, the waterway becomes the Little Calumet River and extends upstream 6.9 miles, ending at the O'Brien Lock and Dam. The Calumet River extends upstream of the O'Brien Lock and Dam to Lake Michigan. The Grand Calumet River flows from the State of Indiana into the Little Calumet River, and the Little Calumet River South, flows north into the Cal-Sag Channel, also carrying flows from Thorn Creek (Figure 1).

Reaches of the Calumet River System with combined sewer overflows (CSOs) include the Cal-Sag Channel (16 outfalls), the Little Calumet River (41 outfalls, including the 125th Street Pumping Station), the Grand Calumet River (4 outfalls), and the Calumet River (3 outfalls, including the 122nd and 95th Street Pumping Stations). Appendix A is a detailed list of CSOs, including outfall number, TARP connection ID, ownership, and monitoring status.

Objectives

One of the requirements of the (MWRD) Consent Decree is that a Post Construction Monitoring Plan (PCMP) shall be developed which includes, "in stream water quality monitoring relating to applicable water quality standards," and "determination of whether MWRD's CSOs are in compliance with the then-effective Calumet Water Reclamation Plant (WRP) National Pollutant Discharge Elimination System (NPDES) Permit, including applicable water quality standards incorporated therein." The District's Maintenance and Operations (M&O) Department will be responsible for tracking the frequency, duration, and volume of CSOs within the Calumet River System and the District's Monitoring and Research Department (M&R) will be responsible for implementing the water quality monitoring component of the PCMP. M&R will conduct monitoring in the Calumet River System in 2017 and 2018 (January 1, 2017 through December 31, 2018), following completion of the Calumet TARP System's Thornton Composite Reservoir. MWRD will compare the 2017 – 2018 post-completion data under wet and dry weather conditions to water quality standards to assess the effectiveness of TARP. In addition, MWRD will compare ambient water quality monitoring data collected prior to 1985, before any portion of the Calumet TARP system was on-line, and 2014 – 2015 monitoring data to post completion ambient water quality data collected in 2017 and 2018, to assess overall improvements due to Calumet TARP.

The District will conduct ambient water quality monitoring, continuous dissolved oxygen monitoring, and wet weather water quality monitoring during 2017 and 2018 to document water quality under various weather conditions in the Calumet River System following the completion of the Calumet TARP System's Thornton Composite Reservoir. By June 30, 2019, a report will be submitted summarizing and analyzing CSO frequency, duration, and volume, as well as water quality data generated during the post construction monitoring period.

As a result of the "extra storage period" described above, for any storms in which the volume of CSOs captured by the Thornton Composite Reservoir exceeds 4.8 billion gallons, MWRD will estimate the volume of CSOs that would have occurred in the absence of the additional storage, during the post construction monitoring period. The District will also estimate the locations of any CSOs that may have resulted without the additional storage using the Calumet TARP System Model. In addition, the District will perform a water quality analysis of those potential CSOs, sampling for 5-day biochemical oxygen demand (BOD_5), total suspended solids (TSS), total dissolved solids (TDS), dissolved oxygen (DO) and fecal coliform, as set forth on pages 6 – 9 of this plan. The results will be included in the final Post Construction Monitoring Report due June 30, 2019.

CSO Monitoring

The MWRD intends to utilize its approved CSO Representative Monitoring and Reporting Plan for the Calumet area to track the frequency, duration, and volume of individual CSOs within the Calumet River System (Appendix B). In summary, the District has tide gate monitors installed on 51 of the 67 total outfalls. Unmonitored outfalls are assumed to discharge when select monitored ones discharge because of similar invert elevations. Signals are transmitted to the Calumet WRP when the tide gate is open and assumed to be discharging. These signals are verified by plant staff and then volume estimates are performed via a conservative method which assumes that all rainfall that falls during the period that a tide gate is open, is being discharged to the waterway. These discharge volumes are then compared to two boundary conditions: (1) total area rainfall volume and (2) outfall pipe capacity. The minimum of these three values is used as the final discharge volume.

Per the Calumet WRP NPDES permit, all individual CSO discharges resulting from the same storm shall be reported as one CSO event. MWRD compiles the above detailed individual CSO information in order to obtain an annual number of CSO events per waterway reach. Appendix C contains an example of the summary CSO report by reach from 2013.

Water Quality Monitoring

Ambient Water Quality Monitoring

Table 1 shows the ambient water quality monitoring (AWQM) stations on the Calumet River System that will be used to assess the overall impact of Calumet TARP System completion. A map of these stations is presented in Figure 1. AWQM will be conducted on a monthly basis in the Calumet River Watershed on the fourth Monday of each month.

Table 1: AWQM locations that will be assessed in Calumet TARP System monitoring

Location	Waterway	Station Number	GPS Coordinates	
Burnham Ave.	Grand Calumet River	86	41° 37' 52.75"	-87° 32' 20.76"
130th St.	Calumet River	55	41° 39' 33.48"	-87° 34' 21.66"
Indiana Ave.	Little Calumet River	56	41° 39' 01.19"	-87° 37' 01.64"
Halsted St.	Little Calumet River	76	41° 39' 27.05"	-87° 38' 28.13"
Ashland Ave.	Little Calumet River, South	57	41° 39' 06.04"	-87° 39' 38.13"
170th St.	Thorn Creek	97	41° 35' 11.90"	-87° 34' 32.96"
Cicero Ave.	Calumet-Sag Channel	59	41° 39' 19.23"	-87° 44' 17.67"
Route 83	Calumet-Sag Channel	43	41° 41' 46.82"	-87° 56' 10.71"
Wentworth Ave.	Little Calumet River, South	52	41° 35' 06.34"	-87° 31' 46.89"

Monitoring activities will be conducted in accordance with Revision 2.5 of the District's Ambient Water Quality Monitoring Quality Assurance Project Plan, effective September 1, 2015. (Appendix D).

In order to assess effects of CSOs on the Calumet River Watershed after the Thornton Composite Reservoir is on-line, the constituents listed in Table 2 will be analyzed. The rationale for inclusion of these constituents is also shown in Table 2.

Table 2: Constituents to be Analyzed in Post Construction Monitoring Plan

Water Quality Constituent (Analytical Method)	Rationale for Inclusion
Dissolved oxygen (SM 4500-O C)	Current designated use impairment in one or more receiving waterbodies
Ammonia (EPA 350.1)	Commonly present in combined sewage
Total Suspended Solids (SM2540 D)	Commonly present in combined sewage
Total Dissolved Solids (SM2530 C)	Current designated use impairment in one or more receiving waterbodies
Fecal Coliform (SM 9222 D) [1]	Current designated use impairment in one or more receiving waterbodies Commonly present in combined sewage
Escherichia coli (USEPA 1603)[2]	Illinois bacterial water quality standard may change to *E. coli* by the post construction monitoring period
Five-day Biochemical Oxygen Demand (SM 5210 B)	Commonly present in combined sewage

[1] MWRD will sample for fecal coliform at each AWQM location for the duration of the sampling period, unless a new *E. coli* state water quality standard replaces the current fecal coliform state water quality standard.

[2]This applies to condition number 3 below, wet weather with CSOs. For condition numbers 1 and 2 below (dry weather and wet weather without CSOs), select samples will be analyzed for *E. coli*, as described on page 8 of this document. If a new *E. coli* state water quality standard replaces the current fecal coliform state water quality standard, *E. coli* will be analyzed for the remainder of samples collected under this plan. In other samples that are not analyzed for *E. coli*, it will be estimated based on empirically established fecal coliform to *E. coli* relationship in the Calumet River System.

Wet Weather Sampling

In addition to the monthly sampling in the AWQM Program, water quality sampling will be conducted during various wet weather conditions at each of the nine sampling locations in the Calumet River System. Constituents listed in Table 2 will be measured during the conditions listed in items 1, 2 and 3 below.

The USEPA CSO Post Construction Compliance Monitoring guidance document (2012) prescribes wet weather sampling to evaluate receiving water impacts under a range of weather conditions. To achieve this, MWRD will capture five events for each of the following conditions during 2017 and 2018:

1. Dry weather (<0.1 inch precipitation). Dry weather will be defined by antecedent dry conditions for 2 days following a 0.25-0.49 inch event, 4 days following a 0.50-0.99 inch event, and 6 days following a >1.0 inch event (from wet weather limited

use analysis done during Chicago Area Waterway System Use Attainability Analysis).

2. Wet weather without CSOs (>0.5 inch precipitation). Water sampling to occur within 12 hours of the end of the rain event.

3. Wet weather with CSOs, to the extent such events occur, including 125th Street Pump Station, if discharging. Water sampling to occur within 12 hours of the end of the rain event or as soon as safe sampling conditions resume. In the Calumet TARP System Final Post Construction Monitoring Report submitted pursuant to Consent Decree Paragraph 36, MWRD will document any instances of delayed sampling, including the reason sampling was delayed, the impacted sampling locations and the amount of the delay.

Average rainfall from the four District rain gages in the Calumet area (Figure 2) will be used to determine that the above conditions have been met.

M&R staff will work closely with M&O staff to predict potential wet weather sampling events. The M&O dispatcher will notify M&R staff when wet weather events are forecast for the Calumet area. M&R staff will consult with M&O staff at Calumet WRP to confirm the above wet weather criteria have been met. As soon as monitoring of a wet weather event is scheduled, lab managers should be notified (see notification flow chart in Figure 3).

Whenever possible, sampling events will be scheduled for weekdays during normal work hours. As the post construction monitoring period progresses, however, if MWRD has not been able to capture enough events for each weather condition, MWRD may need to require overtime for sampling during off-work hours.

The AWQM and wet weather sampling locations are representative of water quality in the various waterbody reaches receiving CSO flow. The 130th Street sampling location on the Calumet River represents "background" upstream conditions, as it is upstream of CSOs with the exception of the 95th Street and 122nd Street Pumping Stations, discharge of which would actually constitute a reversal of flow towards Lake Michigan. The Route 83 station is located at the most downstream location of the Calumet River System and constitutes well mixed flow from all of the CSOs that discharge into the system upstream. Figure 2 displays CSO locations in the Calumet River System.

M&R will also collect hourly DO data from MWRD's Continuous Dissolved Oxygen Monitoring (CDOM) program for use in assessing waterway compliance and impact of CSOs on the Calumet River System.

Table 3 shows the CDOM locations on the Calumet River System that will be used to assess the impact of the Calumet TARP System completion. These stations are also indicated on Figure 1. CDOM stations will be located in the Little Calumet River, upstream and downstream of the Calumet WRP; the Little Calumet River South, just upstream of the confluence with the Little Calumet River; and in the Cal-Sag Channel, both immediately downstream of the reach receiving most of the CSO flows, and at the downstream end of the system at Route 83. These station locations will allow MWRD to compare in-stream DO concentrations to applicable water quality standards in waterway reaches receiving CSO flow. If DO concentrations decrease below the water quality standard following CSO discharges into the Calumet River System, continuous DO data will be included in the Post Construction Monitoring Report for the period until DO increases to above the water quality standard. If DO does not decrease below the water quality standard following CSO discharge, then 7 days of continuous DO data will be included in the report.

Table 3: CDOM locations that will be assessed in Calumet TARP System monitoring

Location	Waterway	GPS Coordinates	
C&W Indiana Railroad	Little Calumet River	41° 39' 01.07"	-87° 36' 42.75"
Halsted St.	Little Calumet River	41° 39' 25.95"	-87° 38' 27.86"
Ashland Ave.	Little Calumet River, South	41° 39' 06.64"	-87° 39' 37.27"
Cicero Ave.	Calumet-Sag Channel	41° 39' 20.70"	-87° 44' 18.78"
Route 83	Calumet-Sag Channel	41° 41' 46.68"	-87° 56' 29.29"

Continuous DO monitoring activities will be conducted in accordance with Revision 2.1 of the District's Continuous Dissolved Oxygen Monitoring Program Quality Assurance Project Plan, effective July 1, 2016 (Appendix E).

Extra Storage Period Sampling and Analysis

After entry of the consent decree, the District successfully negotiated an extension of its agreement with Hanson Material Services, to keep the Thornton Transitional Reservoir (TTR) available to take flood water from Thorn Creek through 2020. Originally, this reservoir was set to be decommissioned once the Thornton Composite Reservoir (TCR) went on-line. One benefit of this new arrangement is that the entire 7.9 BG volume of the TCR will be available for combined sewer overflow storage, instead of the 4.8 BGs required by the consent decree. While this has the potential to further reduce CSOs during extremely wet periods, the additional storage volume is currently only temporary. Therefore, the Calumet TARP post construction monitoring period may not be representative of conditions that will exist after 2020. If, during the monitoring period, there are any events in which the TCR contains more than 4.8 BG of CSO, the District will provide an estimate of the volume and location of CSOs that would have occurred had that additional storage volume not been available (as could be the case after 2020). The District will use the TARP computer models to predict the location and volume of CSOs under that scenario and will also use best efforts to take representative water quality samples (DO, BOD_5, TSS, TDS, fecal coliform, and ammonia) of the CSO that was captured. This will enable the District to form an opinion on what impact the CSO would have had on the waterways, if the TTR had not been available.

In the possible but unlikely scenario that the Thornton Composite Reservoir exceeds a CSO volume over 4.8 billion gallons at any given time during the post construction monitoring period, the District will adhere to the following protocol:

> Sampling Protocol and Reporting: MWRD shall determine an elevation within the Thornton Reservoir that corresponds to 4.8 BG and have the ability to both monitor the water surface elevation of Thornton Reservoir at all times and estimate the volume captured in the Thornton Reservoir. If the total CSO storage volume in Thornton Reservoir exceeds 4.8 BG, MWRD shall record the storage value and time every 15 minutes until the storage volume is less than 4.8 BG. MWRD shall also record the rainfall during the applicable wet weather event at each of its rain gauges in the Calumet system network. MWRD shall include both the rainfall information and the storage value dataset within its final Calumet Post Construction Monitoring Report. MWRD shall take a representative water quality sample from the suction line of the pumps at the Calumet TARP Pump Station within the first two hours of the exceedance of 4.8 BG of CSO storage in Thornton Reservoir. MWRD may also take the sample within 30 minutes prior to CSO storage in the Thornton Reservoir exceeding 4.8 BG. MWRD shall sample enough wastewater to perform pollutant analysis for DO, BOD_5, TSS, TDS, ammonia, and fecal coliform. MWRD shall ensure that all the sampling procedures and the results conform to the requirements in 40 C.F.R. Part 136. MWRD shall report all of the results of any sampling conducted within the TARP shaft in the final Calumet Post Construction Monitoring Report. It is anticipated that sampling at the suction line at the Calumet TARP Pumps set forth above will be sufficient, because the combined stormwater and sanitary sewer flow within this line would be well mixed and the pollutant concentrations relatively consistent.
>
> Hydrologic and Hydraulic Model Evaluation: MWRD shall use its hydrologic and hydraulic model (Metro Flow), developed in part by the University of Illinois, to determine the location and volume of potential CSOs that would have occurred if Thornton Reservoir had allocated only 4.8 BG of total storage for CSO capture. MWRD shall base the Metro Flow model run on the specific storm rainfall data gathered by MWRD from its network of representative rain gauges within the Calumet TARP system during the relevant wet weather event.
>
> Previous Water Quality Comparison: MWRD shall compare the location and the volume of the potential CSOs predicted by its Metro Flow model to the CSO locations and estimated CSO discharge event volumes that occurred in 2014 and 2015 for which sufficient in-stream water quality monitoring exists. The sampling data shall be consistent with the criteria set forth in the wet weather sampling protocol elsewhere in MWRD's Calumet Post-Construction Monitoring Plan. MWRD will utilize the previous in-stream

water quality sampling data from the corresponding 2014 or 2015 sampling event and compare this specific event's sampling results with the applicable water quality standards in the final Calumet Post-Construction Monitoring Report if a specific sampling event from the 2014 or 2015 sampling period has: (1) a CSO discharge duration (minutes) that is similar to Metro Flow's CSO duration for each CSO in the Calumet TARP system; (2) estimated total CSO total volume (gallons) within a range +20% to -10%[1] of the Metro Flow's CSO total volume for each CSO in the Calumet TARP system; and (3) in-stream water quality data collected during the event from a location representative of the affected waterway. MWRD shall only make this comparison if previous sampling data includes sampling results for DO, BOD_5, TSS, TDS, ammonia, and fecal coliform and the applicable water quality standards have not been changed to include different parameters. If a new *E. coli* state water quality standard replaces the current fecal coliform state water quality standard, *E. coli* will be estimated based on the empirically established fecal coliform to *E. coli* relationship in the Calumet River System. To validate the relationship, MWRD will collect and analyze a total of five rounds of *E. coli* samples between 2017 and 2018 from the five identified locations (Indiana (56) and Halsted (76) on the Little Calumet River; Ashland on the Little Calumet River, South (57), Burnham on the Grand Calumet River (86), and Cicero on the Cal-Sag Channel (59)) during wet weather events when there are no CSOs in the Calumet TARP System for a total of 25 *E. coli* samples. MWRD will also collect and analyze one round of *E. coli* samples during dry weather in 2018 from those same locations in the Calumet TARP System for a total of five *E. coli* samples. MWRD will compare the *E. coli* and fecal coliform samples it collects while implementing the PCMP during dry weather and during wet weather without CSOs, with its established fecal coliform to *E. coli* Calumet River system relationship. If the sampling data does not verify the relationship, MWRD will revise the relationship, using the updated Post-Construction Monitoring Plan sampling data. MWRD shall use the applicable sampling period's Continuous Dissolved Oxygen Monitoring (CDOM) data for the receiving waters in the Calumet TARP system, as part of its evaluation of potential water quality impacts from the potential CSOs.

Water Quality Modeling Protocol: If MWRD finds that none of its previous CSO event and corresponding in-stream water quality data collected during the 2014-2015 monitoring are representative of the potential CSO discharges estimated by the Metro Flow model as stated above, MWRD shall evaluate the potential water quality impacts of the potential CSOs through a water quality model analysis. For DO, TSS, fecal coliform, and ammonia, MWRD shall use the existing applicable water quality model (DUFLOW water quality model) to determine the potential CSO(s) in-stream water quality impacts for each of the sampling parameters. Based upon the current applicable bacterial state water quality standard as of the date of the Calumet Post Construction Monitoring Report, it may be necessary to estimate *E. coli* based on empirically established fecal coliform to *E. coli* relationship in the Calumet River System, since *E. coli* is not included in the CAWS DUFLOW model. To validate the relationship, MWRD will collect and analyze a total of five rounds of *E. coli* samples between 2017 and 2018 from the five identified locations

[1] This range is derived from the Water Environment Federation Manual of Practice, "Prevention and Control of Sewer System Overflows" (FD-17) Table 5.2, pg. 209.

(Indiana (56) and Halsted (76) on the Little Calumet River; Ashland on the Little Calumet River, South (57), Burnham on the Grand Calumet River (86), and Cicero on the Cal Sag Channel (59)) during wet weather events when there are no CSOs in the Calumet TARP System for a total of 25 *E. coli* samples. MWRD will also collect and analyze one round of *E. coli* samples during dry weather in 2018 from those same locations in the Calumet TARP System for a total of five *E. coli* samples. MWRD will compare the *E. coli* and fecal coliform samples it collects while implementing the PCMP during dry weather and during wet weather without CSOs, with its established fecal coliform to *E. coli* Calumet River system relationship. If the sampling data does not verify the relationship, MWRD will revise the relationship, using the updated Post-Construction Monitoring Plan sampling data. MWRD shall utilize the CSO locations and volumes from the Metro Flow model along with the sampling results from the Calumet TARP Pump Station as CSO discharge inputs in each of its water quality models. MWRD shall include the water quality modeling results for each of the pollutant parameters in the Calumet Post-Construction Monitoring Report as part of MWRD's evaluation of potential water quality impacts from the potential CSOs.

Deliverables

After it is approved, MWRD will conduct monitoring in accordance with this PCMP and complete such monitoring by December 31, 2018. The Post Construction Monitoring Report for the Thornton TARP System will be submitted to EPA and Illinois EPA by June 30, 2019. The report will detail receiving water impacts and effectiveness of CSO controls and otherwise meet the requirements of Section IX of the Consent Decree.

Reference

United States Environmental Protection Agency. EPA-833-K-11-001. *CSO Post Construction Compliance Monitoring Guidance*. May, 2012.

Figure 1: Ambient Water Quality and Continuous Dissolved Oxygen Monitoring Stations for Thornton TARP Post Construction Monitoring.

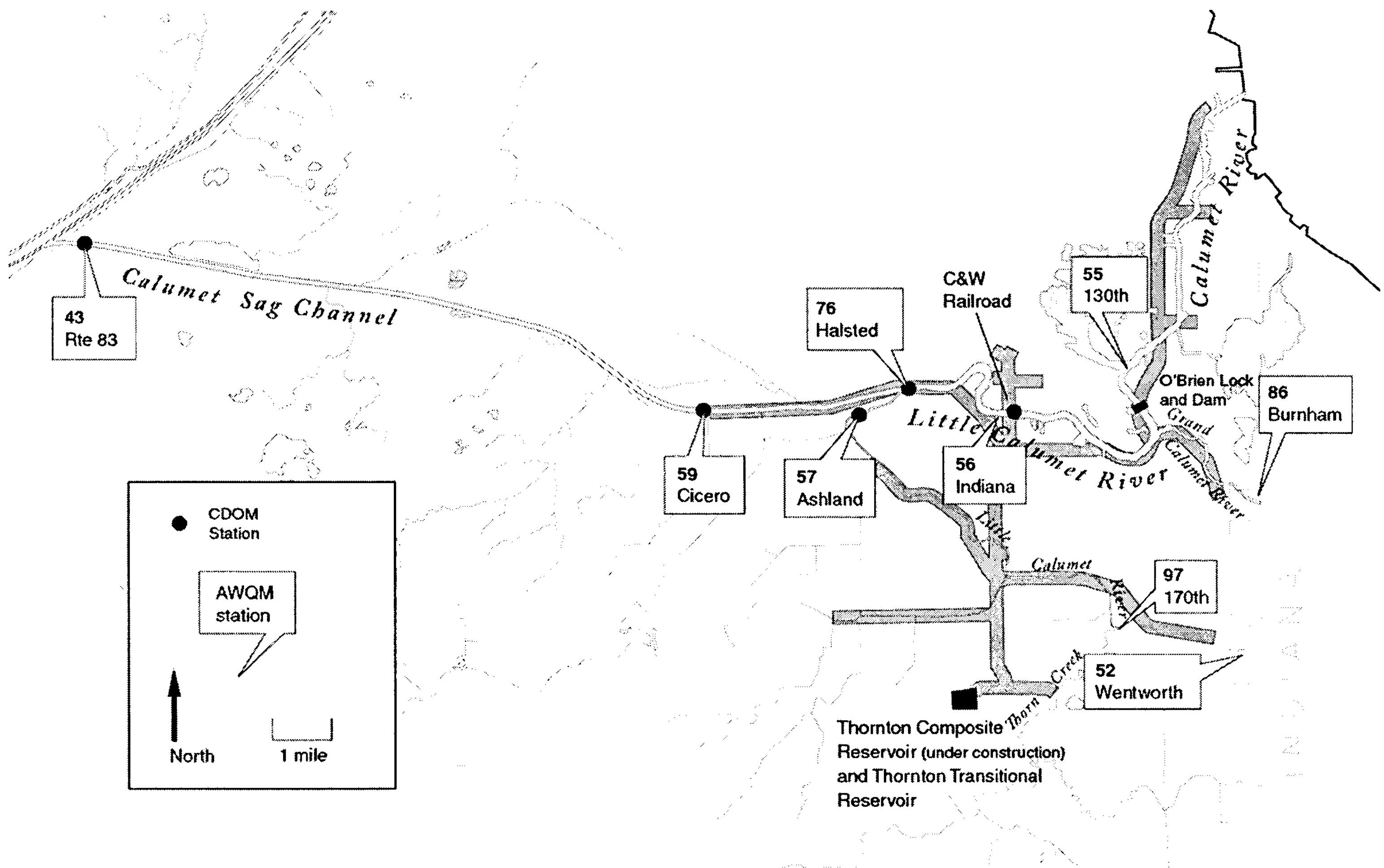


Figure 2: Map of Calumet area Combined Sewer Overflow Outfalls and Precipitation Gages

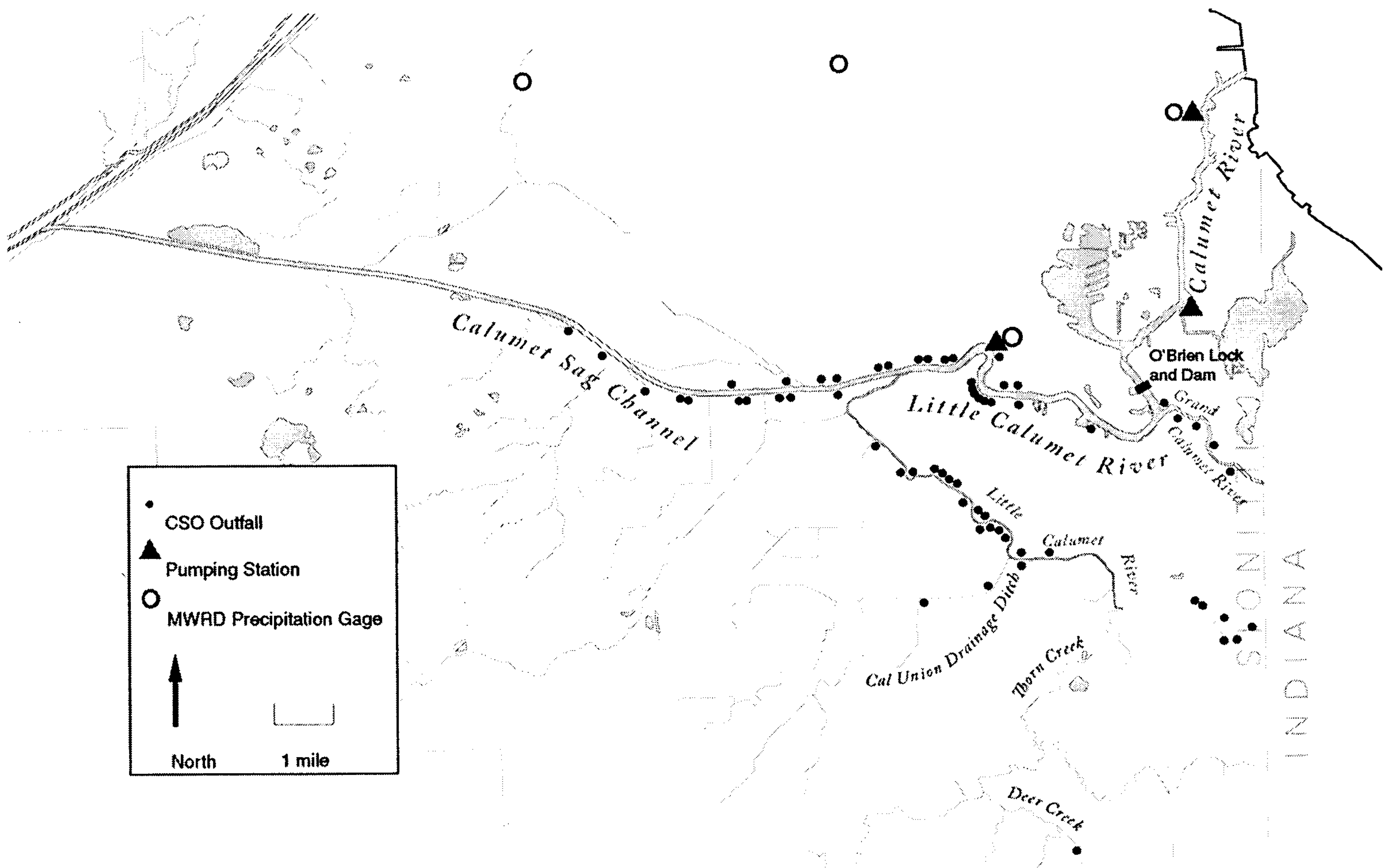
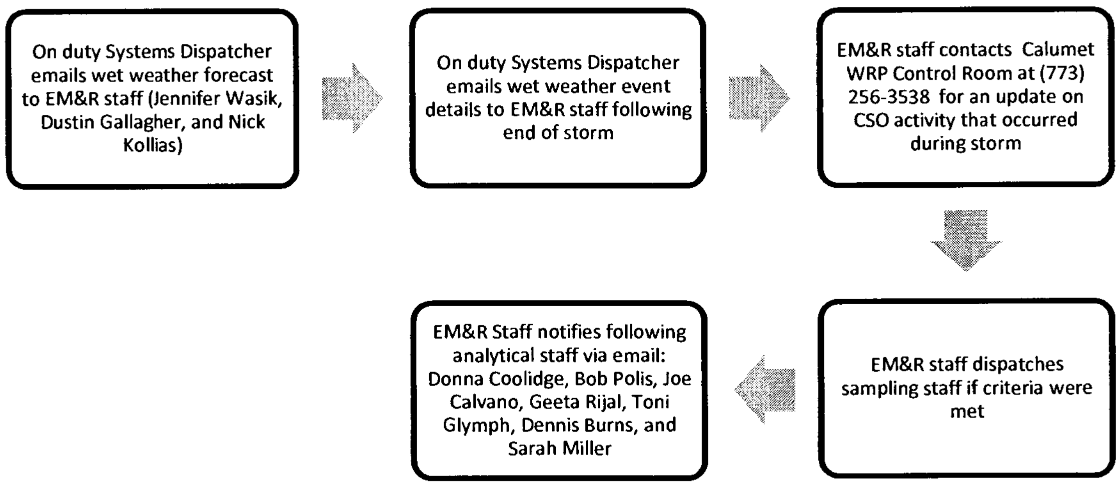


Figure 3: Notification flow chart for Thornton TARP post construction wet weather event sampling



APPENDIX D

AMBIENT WATER QUALITY MONITORING QUALITY ASSURANCE PROJECT PLAN

AMBIENT WATER QUALITY MONITORING
QUALITY ASSURANCE PROJECT PLAN

Revision 2.5
Effective Date: September 1, 2015

Organization: Metropolitan Water Reclamation District of Greater Chicago, Monitoring and Research Department

Address: 100 East Erie Street, Chicago, Illinois 60611-2803

Telephone: (312) 751-5190

GROUP A: PROJECT MANAGEMENT

A1: Approval Sheet:

Date 10/26/15

Thomas C. Granato
Director of Monitoring and Research

Date 10/8/15

Donna Coolidge
Assistant Director of Monitoring and Research
Analytical Laboratories Division

Date 10/8/2015

Heng Zhang
Assistant Director of Monitoring and Research
Environmental Monitoring and Research Division

Date 10/8/2015

John McNamara
Quality Assurance Coordinator
Analytical Laboratories Division

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Page

A3: Distribution List

A copy of this Quality Assurance Project Plan (QAPP) will be distributed to each person signing the approval sheet and each person involved with project tasking identified in Section A4. A copy of this QAPP shall be available on request to any person participating in the project from any of the personnel listed in Section A4. Persons not employed by the Metropolitan Water Reclamation District of Greater Chicago (District) may obtain a copy of this QAPP from the Director of the Monitoring and Research (M&R) Department.

As this document will be updated periodically, the reader is advised to check with the Project Manager for the latest revision if his copy is more than one year old. Revision 2.5 has been prepared following the United States Environmental Protection Agency (USEPA) guidance document EPA QA/R-5 titled "EPA Requirements for Quality Assurance Project Plans," March 2001.

A4: Project/Task Organization

The responsible persons for project management are:

Project Director:
Thomas Granato
Director of Monitoring and Research

Project Manager:
Heng Zhang
Assistant Director of Monitoring and Research
Environmental Monitoring and Research Division

IEPA Project Manager:
Gregg Good
Surface Water Section Manager

Project Coordinator:
Jennifer Wasik
Supervising Aquatic Biologist

Environmental Monitoring Manager:
Nicholas Kollias
Assistant Aquatic Biologist

Stickney Analytical Laboratory Manager:
Joseph Calvano
Supervising Environmental Chemist

Calumet Analytical Laboratory Manager:
Victor Olchowka
Supervising Environmental Chemist

Industrial Waste Analytical Laboratory Manager:
Robert Polis
Supervising Environmental Chemist

Egan Analytical Laboratory Manager:
John Chavich
Supervising Environmental Chemist

Analytical Microbiology Laboratory Manager:
Geeta K. Rijal
Supervising Environmental Microbiologist

Organic Compounds Analytical Laboratory Manager:
Anna Liao
Instrument Chemist IV

Laboratory Information Management System (LIMS) Manager:
Diane Moe
Senior Environmental Chemist

Data Review and Reporting Manager:
Zainul Abedin
Biostatistician

Quality Assurance Officer:
John McNamara
Quality Assurance Coordinator

Illinois Environmental Protection Agency Quality Assurance Officer:
Michelle Rousey
Quality Assurance Officer, Bureau of Water

Figure 1 is the organization chart for the project. Primary lines of communication are shown as dashed lines. However, within the District, communication between any of the project participants may occur and is, in fact, encouraged as questions or issues arise.

The Project Director is responsible for the execution of the entire project. The Project Manager has many responsibilities including planning the scope of the project, execution, and reviewing project reports. The Project Coordinator coordinates project activities, prepares project reports, and completes QAPP revisions. The Quality Assurance (QA) Officer is responsible for oversight of quality control for the project.

The Illinois Environmental Protection Agency (IEPA) Project Manager coordinates the efforts of both agencies to ensure that project data will be usable by the IEPA for assessment of water quality. He is assisted by the IEPA QA Officer, who oversees project activities and project quality control.

The Environmental Monitoring Manager is responsible for the execution of field activities and assists with QAPP revisions. The sampling teams collect and preserve samples, make field measurements, and transport the samples to the District laboratories. Several District laboratories analyze project samples. Participant laboratories include the Stickney Analytical Laboratory (SAL), the Egan Analytical Laboratory (EAL) the Industrial Waste Analytical Laboratory (IWAL), the Calumet Analytical Laboratory (CAL), the Analytical Microbiology Laboratory (AML), the Organic Compounds Analytical Laboratory (OCAL), and the Aquatic Ecology and Water Quality Section (AEWQ). All project data is maintained in the District laboratory information management system (LIMS) database.

The LIMS Manager is responsible for collection of project test results and data verifications for SAL, IWAL, EAL, and CAL data. The Data Review and Reporting Manager maintains the District project database in SAS® software and prepares annual summary reports for the project.

A5: Background

The District routinely collects and analyzes water samples from the District service area waterways. "Waterways" as used in this document will mean natural and modified rivers or streams, and man-made canals. This monitoring has been undertaken by the District to determine water quality on an ongoing basis and establish a historical record. A historical water quality database exists back to project inception in 1970.

The Illinois Pollution Control Board (IPCB) designates District service area waterways based on their recreational and aquatic life use potential. Recreational use designations in these waterways include: General Use, Primary Contact, Incidental Contact, Non-Contact, Non-Recreational, and Secondary Contact. Aquatic Life Uses are General Use, Chicago Area Waterway System (CAWS) Aquatic Life Use A, CAWS Aquatic Life Use B, and Indigenous Aquatic Life Use.

The IPCB has established separate water quality standards to support the designated uses for each waterway. Comprehensive assessments of the water quality data from this project are made annually using all applicable water quality standards established by the IPCB.

The water quality data collected from this project have been used, often in conjunction with data from other monitoring studies, to evaluate the impact of District operations and projects, including the WRPs, the pretreatment program, the flood and pollution control Tunnel and Reservoir Plan, the Sidestream Elevated Pool Aeration Stations, and the Instream Aeration Stations.

The water quality data provide a broad surveillance of significant discharges to the waterways. The data also may have potential use for evaluation of other factors affecting water quality, including intermittent stormwater releases and release of pollutants from bottom sediment in the waterways.

Another goal of this project is to coordinate the waterway monitoring performed by the District with the waterway monitoring performed by the IEPA's Bureau of Water. The District will review key aspects of its program, including sampling locations, sampling frequency, sampling methods, parameters analyzed, and analytical capability, to determine how to best provide water quality data usable by both agencies.

This QAPP will address how to conduct the monitoring of the waterways in a manner that will efficiently utilize available resources and produce water quality data that will meet or exceed the measurement quality objectives for all intended uses of the data.

A6: Project/Task Description

Monitoring is conducted on 13 waterbodies at 28 sampling stations. The total number of river miles monitored is approximately 225. The following rivers, creeks, man-made channels, and a canal are monitored for water quality.

<u>Des Plaines River System</u>

- Higgins Creek
- Salt Creek
- Des Plaines River
- West Branch DuPage River

<u>Chicago River System</u>

- North Branch Chicago River
- North Shore Channel
- Chicago River
- South Branch Chicago River
- South Fork South Branch Chicago River
- Chicago Sanitary and Ship Canal

<u>Calumet River System</u>

- Grand Calumet River
- Little Calumet River
- Calumet-Sag Channel

Figure 2 is a map showing the waterways in the Chicago metropolitan area and the current sampling locations.

A description of the 28 monitoring stations is provided in Tables 1, 2, and 3. Table 1 lists all current and discontinued sampling locations with their station identification number and IPCB use classifications. Table 2 shows the latitude and longitude of each sampling station. Table 3 shows the United States Geological Survey quadrant, township, range, section, and quarter section of each sampling station.

All locations are sampled monthly, except Lockport Powerhouse and Lock (92) which is sampled weekly. Grab samples taken at the surface are collected at each sample location for the analysis of most measured analytes. These water samples are analyzed for a wide range of parameters, including alkalinity, solids, ammonia, nitrate, phosphorus, total or dissolved metals, cyanide, phenol, fecal coliform, organic priority pollutants, nonylphenols, gross alpha radioactivity, and gross beta radioactivity. A special sampling device is used to collect samples at a depth of 3 feet for dissolved oxygen analysis and bacterial analysis. Water temperature and pH are measured onsite at each sampling location. After login, metals samples are transported to EAL for analysis, sulfate and low level mercury samples are transported to CAL, and the rest of the samples are analyzed at SAL.

Following collection, the samples are transported to the Cecil Lue-Hing Research and Development Complex at the Stickney WRP and the OCAL at the John E. Egan WRP for login. After login, metals samples are transported to EAL for analysis, sulfate and low level mercury samples are transported to CAL, and the rest of the samples are analyzed at SAL. The waterways monitoring data are maintained in computer databases. Exceedances of water quality standards are reported quarterly to the Project Coordinator. Annual summary reports are prepared that summarize water quality and compare data upstream and downstream of the District's WRPs.

A7: Quality Objectives and Criteria for Measurement Data

Many analytes measured for this project are present in low concentrations throughout the waterway systems. Analyte concentrations will vary as discharged effluents and stormwater runoffs are introduced into the waterways. All analytes are subject to chemical, biological, and physical processes that will alter their presence in the waterway. It is the intent of this project to employ methods of measurement that will detect and quantify all analytes of interest wherever possible.

Although there are several intended and potential uses of the data, minimum measurement criteria will be established at the lowest analyte concentration required for actual uses of the measurement data. Where no minimum measurement criteria can be identified, the water samples will be analyzed to the lowest concentration readily achievable by District laboratories.

Currently, except for the IPCB water quality standards, there are no other specified minimum measurement criteria for waterways monitoring data. Therefore, this project will use the most restrictive water quality standard applicable to waterways within the District's service area to establish the minimum measurement criteria for each parameter. The minimum measurement criteria will apply for all samples irrespective of the IPCB waterway designation in order to maintain uniform measurement objectives for the project.

The monitored parameters and the established minimum measurement criteria are shown in columns 1 and 3 of Attachment A. Analytes not subject to an IPCB water quality standard will not have specified minimum measurement criteria. The minimum measurement criteria will be adjusted accordingly when IPCB water quality standards are changed or as dictated by other planned uses of the data.

Column 2 of Attachment A gives the Reporting Limits (RLs) for the project, which are established by ALD. RLs are mathematically derived from MDLs. For parameters where RLs are not applicable, such as pH, solids, temperature, and dissolved oxygen, the minimum measurement criteria shown in column 3 of Attachment A are the sensitivities, to be obtained by the measurement method. Sensitivity of a method shall be defined as the difference in concentration that can be distinguished by measurement.

A8: Special Training/Certification

1. Sample collection personnel shall be trained in proper sample collection methods by their supervising Aquatic Biologist.

2. Microbiological analysis shall be performed by analysts who have been certified as competent by the Illinois Department of Public Health (IDPH).

3. Each section of the Analytical Laboratories Division (ALD) has successfully maintained accredited status as certified by the IEPA following the NELAC Institute (TNI) standards.

4. The laboratory contracted to perform radiochemical analyses shall possess National Environmental Laboratory Accreditation Program accreditation and maintain certification for the examination of radiochemical parameters from any state within the United States.

A9: Documents and Records

1. The Project Coordinator and QA Officers for the District and the IEPA shall retain copies of all annual updates and revisions of this QAPP.

2. The Analytical Laboratory Managers and QA Officers for the District and the IEPA shall retain copies of all analytical procedures used for analysis of project samples.

3. The Project Coordinator shall retain copies of all laboratory analytical reports and correspondence with the laboratories.

4. The Project Coordinator shall retain copies of all communications to and from outside agencies and other interested parties.

5. All the records and reports listed above will be retained for 10 years at the Cecil Lue-Hing R&D Complex located at the Stickney WRP.

GROUP B: DATA GENERATION AND ACQUISITION

B1: Sampling Process Design (Experimental Design)

Selection of Sampling Locations. The 28 sampling locations have been previously identified in Tables 1, 2, and 3. Criteria for selecting sampling locations include:

1. Downstream of the point at which major tributaries enter the District's service area.

2. Near the intake control structures where water is diverted into the waterways from Lake Michigan.

3. Upstream and downstream of District facilities, including WRPs, aeration stations, and pumping stations.

4. At the confluence of significant waterway branches.

5. At the Lockport control facility where most flow from the District service area leaves the waterways system.

6. Near the downstream end of a reach designated by the IEPA as a waterbody segment or assessment unit.

Sampling locations must be readily accessible and judged safe for all sampling activities. Bridges over the waterways have provided ideal sampling locations. For locations where bridge access or height will not allow for safe sampling, samples may be collected by boat. Occasionally, if a bridge is under construction or if the sampling schedule required it, water samples that are normally collected by bridge may also be sampled by boat, in accordance with the procedures described in Appendix 1.

The IEPA utilizes water quality data to prepare its annual water quality report as required by Section 305(b) of the Clean Water Act. For this purpose, the IEPA assesses conditions for waterbody segments and has defined these segments for all waters in the state.

Sampling locations may be added or removed from the monitoring network based upon periodic assessments of monitoring needs and resources available.

Sampling Frequency. All 28 sampling locations are monitored monthly, except Lockport Powerhouse and Lock (92), which is sampled weekly. The sampling frequency for each parameter is shown in Attachment B. This schedule provides sampling through seasonal changes and a sufficient number of samples to adequately characterize water quality annually and to identify long-term trends over many years. Monthly sampling may also detect an abrupt degradation of water quality, allowing the opportunity for the District to respond appropriately.

Water quality samples are collected weekly at the Lockport Powerhouse and Lock because this facility controls the release of water from the Chicago Sanitary and Ship Canal, which contains, at that location, the combined flow from the Chicago and Calumet River Systems. The treated wastewater from four District WRPs covering most of the District's service area flows through the Lockport Powerhouse and Lock.

Sampling frequency may be modified temporarily if there is a specific need to acquire additional data.

Selection of Parameters for Monitoring. Parameters selected for analysis are those that have IPCB water quality standards, and other parameters that have been used to characterize instream water quality. Certain parameters may only be analyzed at stations in a particular designated use category waterway. These are identified in Attachment A. Periodically, the parameters monitored are reviewed. A parameter may be dropped from monitoring if the parameter is found to be non-essential for the goals of the project or if the parameter is judged too resource intensive to analyze. If parameters are needed for a monitoring purpose, they will be added to the project.

B2: Sampling Methods

Manual sampling from a bridge or boat is conducted on each Monday of the month. When a Monday is a District paid holiday the sampling will be performed on the following Tuesday. Two person teams, each comprised of Pollution Control Technicians or available trained Aquatic Ecology and Water Quality (AEWQ) Section personnel, perform the sampling under the direction of the supervising Assistant Aquatic Biologist.

The eleven locations on the Des Plaines River System are sampled on the first Monday of each month. The four most northern sampling locations on the Chicago River System are sampled on the second Monday of each month. The remaining six locations on the Chicago River System are sampled on the third Monday of each month. The six sampling locations on the Calumet River System are sampled on the fourth Monday of each month. The Lockport sampling location on the powerhouse forebay catwalk is sampled weekly.

The surface water grab samples are collected using a stainless steel bucket. The bucket is lowered into the waterway from the upstream side of the bridge at the most central location of the waterway. The sampling time is recorded on the sample collection sheet (Appendix 2). The bucket is submerged, filled, and then raised to the top of the bridge. The water temperature and pH are measured immediately from the stainless steel bucket with a calibrated pH/temperature probe and recorded on the sample collection sheet. The contents of the bucket are then discarded and the bucket is lowered and refilled as necessary to provide sample for the individual sample aliquots. A separate water sample is taken for measurement of DO using a special sampling device that prevents aeration of the sample during collection. The sterile sample container for bacterial analysis is filled separately in the waterway to prevent contact of the sample with non-sterile surfaces.

There are exceptions to sampling from bridges. Stephen Street (48) is sampled from the District's Pollution Control Boat in the center of the waterway, since the bridge no longer exists. Water samples are also routinely collected from the boat for safety reasons at Cicero Avenue (75) and Harlem Avenue (41) on the Chicago Sanitary and Ship Canal, Route 83 on the Cal-Sag Channel (43), and Ashland Avenue on the Little Calumet River (57). Occasionally, other stations may also be sampled by boat for logistical reasons, including bridge construction or coordination with other special sampling activities.

The individual sample containers are filled in accordance with the sampling procedures described in Appendix I. The individual containers for sample collection are prepared by the laboratory performing the sample analysis. Chemical preservatives as necessary are placed in the containers by the laboratory of origin before sample collection. Specific information regarding sample containers and chemical preservatives is found in Table 4.

Preprinted adhesive sample labels with unique LIMS identification numbers are placed on each container prior to filling. The sampling team completes the sample collection sheet (Appendix II) in the field as each sample is collected.

B3: Sample Handling and Custody

All sample containers are chilled in an ice-filled cooler immediately after collection and kept in ice during transport to the laboratories except for low level mercury samples.

All water samples are transported to the SAL after collection accompanied by sample collection sheets. The laboratory physically receives the samples from the Industrial Waste Division transporter. An environmental chemist, or a laboratory technician under the direct supervision of a environmental chemist, "receives" the samples into the District's LIMS using a barcode scanner. Each sample is inspected against the laboratory's sample receiving checklist for proper container, proper labeling, sufficient volume, and general appearance. Any missing samples or aliquots are noted on the sample receiving checklist. Sample arrival temperatures are measured using an infrared thermometer calibrated against a NIST traceable certified thermometer ("NIST" is the National Institute of Standards and Technology, United States Department of Commerce), and recorded. Since the time between sampling and arrival at the laboratory is only a few hours, samples may not always reach the 0.1 to 6 degrees C (°C) required for thermal preservation. Samples are acceptable if "evidence of chilling" has begun. Samples that require thermal preservation are refrigerated after sample acceptance in the laboratory. Samples for biological analysis and radiochemical analysis are then routed to the appropriate laboratories at the Cecil Lue-Hing R&D Complex. Samples for organics analysis are transported to the OCAL at the John E. Egan WRP. The remaining samples for inorganic analysis are received by the SAL. Following log-in at the SAL, the samples for metals analyses are transported to the Egan Laboratory, and the aliquot for sulfate and mercury analysis are transported to the CAL within 24 hours by the Maintenance and Operations courier.

Each laboratory receives the samples by logging them into the laboratory logbook and/or laboratory LIMS. Maximum holding times before analysis, as stated in applicable laboratory method standard operating procedures (SOPs), are adhered to. Parameters of particular concern, because of short maximum holding times, include: bacterial analysis (six hours), dissolved oxygen (eight hours), and hexavalent chromium (24 hours).

Copies of the sample collection sheets, along with the sample receiving checklist, are retained by the SAL. The pH and temperature for each field sample are entered into the LIMS by AEWQ Section personnel.

The original sample collection sheets are returned to Environmental Monitoring Manager for review. The Environmental Monitoring Manager is responsible for the execution of field operations and corrective actions for field related quality control problems or other nonconformance issues.

B4: Analytical Methods

The analytical methods shown in Table 5 have been selected to meet the minimum measurement criteria presented in Attachment A. Column 1 of Table 5 gives the analytes to be measured, column 2 shows the method to be used by the laboratory, and column 3 the method reference. Except for chloride, chlorophyll, and nonylphenol, all methods used by the District are USEPA approved methods listed in 40 CFR Parts 136, 141, and 145. Approved USEPA methods are not available for the determination of chlorophyll and nonylphenols.

Table 6 shows laboratory preservation and maximum holding time from the time of sampling for each analyzed parameter. Column 2 of Table 6 gives the laboratory preservation requirements. The maximum holding time for each parameter is given in column 3 of Table 6. Refrigeration of samples that require thermal preservation is maintained at 4°C, but temperatures in the range of 0.1 to 6°C are considered acceptable. Preservation and maximum holding times are in accord with those given in 40 CFR Part 136.

The laboratory where each analysis will be performed is identified in column 2 of Table 7. Column 3 of Table 7 identifies the laboratory method SOP. The analytical method SOPs are incorporated into this QAPP by reference in column 3 of Table 7. SOPs for analytical methods are available from the the responsible Laboratory Manager identified in Section A4.

Attachment A compares the minimum measurement criteria against the reporting limit (RL) achieved by the designated District laboratory. All analytes meet the minimum measurement criteria.

All data collected for this project will be reported to the analyte RL. Test results less than the RL will be reported as either zero or as less than the numerical value of the RL.

B5: Quality Control

Equipment blanks will be used to verify that field samples are free of contamination. Each sampling team will prepare equipment blanks for the appropriate parameters at a sampling location on each day of sampling. The SAL will review the test results. Whenever significant contamination is found, the laboratory will initiate an investigation and implement the necessary corrective actions.

The individuals responsible for verification that proper procedures are followed in matters concerning sampling methods, sample preservation, and sample custody to the delivery of samples to the SAL will be the Environmental Monitoring Manager and his/her supervisor. For more information please see sections B2: Sampling Methods, B3: Sample Handling and Custody, and C1: Assessment and Response Actions. For any quality control or other nonconformance issue, the Environmental Monitoring Manager and his/her supervisor will submit an investigation and corrective action report to the Project Manager, who will send copies to the persons listed on the approval page.

It shall be understood that all measurements, regardless of the sample concentration, must have known and satisfactory accuracy and precision. Because various analytical procedures will be employed for sample analysis, specific criteria for accuracy and precision will not be provided in this document. Rather, satisfactory accuracy and precision shall be considered to be that which is consistent with the USEPA approved methods used to analyze the samples. All measurements must be derived in an environment of an adequate quality control program including statistical process control wherever applicable. The laboratory QAP and laboratory SOPs should be referred to for specific information relating to quality control. Each section of ALD has successfully maintained accredited status as certified by the IEPA following TNI standards.

The individuals responsible for verification that analytical methods and other laboratory procedures are being properly executed are the Laboratory Managers. The Laboratory Managers are also responsible for the reliability of project analytical data. For any quality control or other nonconformance issue that may have affected the reliability of project data, the responsible Laboratory Manager will submit an investigation and corrective action report to the Project Manager, who will send copies to the persons listed on the approval page.

B6: Instrument/Equipment Testing, Inspection, and Maintenance

All instrumentation and equipment used in the laboratory are maintained as required by the manufacturer's manuals and the laboratory SOPs.

Each laboratory is responsible for maintaining an adequate supply of spare parts to perform normal maintenance procedures. The three regional WRPs, at which the participating laboratories are located, maintain storerooms where frequently used supplies and consumables are inventoried. Major laboratory instrumentation is covered by maintenance/service contracts with qualified service representatives. Each laboratory also has an account to purchase any needed parts or consumables not inventoried in the WRP storeroom or in an emergency or other unforeseen situation.

The YSI Model 63 handheld pH/temperature meters used for field measurements (or similar model) are maintained by AEWQ Section. These instruments are calibrated for pH in the laboratory on the first day of the week before use. Calibration records are kept by the AEWQ laboratory. Sample collection personnel sign out a calibrated instrument on the day of sampling and return it on the same day after sampling. The meter operation and calibration are checked when each instrument is returned to the laboratory. The temperature calibration is verified at least annually against a NIST traceable thermometer. The SAL is responsible for stocking spare parts for these meters, performing routine maintenance, and securing service from qualified service representatives as needed.

B7: Instrument Calibration and Frequency

All instrumentation used for testing shall be calibrated each day of use as directed by manufacturer's manuals and laboratory SOPs. General guidelines and requirements regarding calibration of laboratory equipment are contained in the laboratory SOPs. Laboratories that participate in an accreditation program also will comply with the requirements for calibration maintained by the accreditation program.

All instrumentation is uniquely identified by serial number or other means. Wherever possible, NIST traceable standards are used for calibration of instruments. Calibration records are kept each time laboratory instrumentation and equipment are calibrated, and the calibration records and quality control samples are unmistakably identified for each batch of test results.

B8: Inspection/Acceptance of Supplies and Consumables

Supplies and consumables shall be inspected by the laboratories and accepted in accordance with all laboratory procedures and specifications contained in laboratory QAPs or SOPs. The laboratory section supervisors are responsible for verifying that supplies and consumables meet the specifications contained in the method SOPs.

B9: Non-direct Measurements

Non-direct measurements are not required for this project.

B10: Data Management

The District maintains several networked servers. The network may be accessed by personal computers and workstations from any District facility. Computer software used for this project includes a fully networked LIMS and Excel® software and SAS® software on selected workstations. The Thermo LabSystems SMW (SampleManager for Windows) version 10.2.0.0 is customized to incorporate procedures employed at District laboratories. The District LIMS supports numerous features including: barcode usage, prelogging of samples by either the sample submitter or laboratory personnel, label generation, sample login, sample receiving of prelogged samples, sample batching, instrument interfacing, manual data entry, automated calculations, control limit checking for each laboratory control sample, control chart maintenance, NPDES limit checking, industrial waste limit checking, facilitated data handling, and data reporting. The LIMS is utilized by all laboratories participating in this project.

Most chemical analytical data have resided in the District LIMS since 1996. Historical data back to 1970 are stored in Excel® spreadsheet files and SAS® files. Whenever data are manually entered into a software file from hardcopy reports, each number is verified to ensure accuracy of manual entry.

As the waterways are sampled routinely, the samples are prelogged into the District's LIMS. Environmental Monitoring Manager generates sample labels for sample containers before sample collection. The labels contain information including sample location, sample type, and unique sample ID with barcode. Each sample container has a unique sample ID comprised of the sample number and aliquot designation.

The AML, AEWQ, and the OCAL follow documented procedures for sample login, sample acceptance, analysis, and data verification. Test data from the AML and AEWQ are manually entered into LIMS, while OCAL data is automatically uploaded from instrument to LIMS.

Water samples for radiochemical analysis are received and logged in by the SAL. Samples are preserved by AEWQ staff and picked up by the contracted laboratory, who completes a chain of custody form. The analytical results are reviewed and manually entered into LIMS by an Aquatic Biologist.

While the SAL employs the most computerized system for sample tracking and data handling, all participating laboratories follow similar procedures. The analyst assigned to receive the samples in the SAL uses a barcode scanner to log as received the "general chemistry" samples. All samples are checked and any missing sample containers are noted in the sample log. The analyst checks to make certain that sample acceptance criteria, including appropriate sample containers and thermal preservation, are satisfactory.

After the laboratory receives the samples, sub-samples are poured as required. The samples are then distributed to the appropriate analytical sections for analysis. As analyses are completed, the test results are entered into the LIMS generally by data file upload from the laboratory instrument. Test results are reviewed and verified by each analytical section supervisor. Water quality limits are checked for each sampling station for the applicable General Use or Secondary Contact water quality limit. An exceedance of these limits prompts retesting for confirmation. The highest confirmed value is reported.

Retesting for analytes with regulatory limits is only done for a confirmed QC problem in the execution of analysis or if the regulatory limit has been exceeded. No retesting will be performed on the basis of historical limits or multi-day limits without consulting first with the sample submitter for information about any unusual conditions that would corroborate the test results. When such information is not available and a retest is requested, the sample submitter's authorization to conduct the retest should be in writing for documentation purposes. In those instances where retesting is performed for reasons other than a QC failure or to confirm a regulatory limit exceedance, then the highest confirmed value is reported unless otherwise specified above.

As sample analysis in the Analytical Laboratories Division (ALD) Laboratories is completed each month, the approved test data are collected from the LIMS Oracle® database and transferred into an Excel® spreadsheet. To simplify data handling, this spreadsheet is also used to collect field test data (pH and temperature) and test data from the AML (fecal coliform) and the radiochemistry analyses (gross alpha and gross beta radioactivity). The ALD Excel® spreadsheet includes all parameters, except for organics data. Generally, analytical data from any month is expected to be completed and available to data users within 30 days after the end of that month.

The monthly spreadsheet from the ALD laboratories is checked for completeness and atypical test data. This review is performed by the LIMS Manager. When atypical test data are found, they are reported to the appropriate analytical section supervisor for further investigation. If the investigation does not reveal a reason for the atypical data, the section supervisor is requested to reanalyze the sample provided that sufficient sample is available and the maximum holding time has not been exceeded. The retest result is reported as the valid result except when the original test result exceeds a water quality standard. If a water quality standard is exceeded by the original test result, and no error is found that invalidates the original test result, then the highest test result (original or retest) is reported.

Following final approval of ALD laboratory data, the ALD Excel® spreadsheet file is sent to the Biostatistician who creates a file in SAS® (Statistical Analysis Software) from the Excel® data file. A second Excel® file from the Organic Compounds Analytical Laboratory containing the organics test data for BETX is sent to the Biostatistician, and it is also uploaded into SAS®. SAS® is the statistical analysis software used to review and analyze the data.

Currently, the Biostatistician produces a comprehensive water quality report annually.

The annual water quality report presents the following:

1. Annual parameter averages at each sampling location for each of the previous 11 years.

2. Statistical comparison of water quality data upstream and downstream of the District's WRPs.

GROUP C: ASSESSMENT AND OVERSIGHT

C1: Assessment and Response Actions

Random surveillance of a sampling team is conducted by the Environmental Monitoring Manager to verify that water samples are being collected properly and sampling procedures are followed. The results of each surveillance are documented by the Environmental Monitoring Manager. As stated in Section B5, the Environmental Monitoring Manager and his/her supervisor will submit investigation and corrective action reports for all quality control and other nonconformance problems dealing with field procedures to the Project Coordinator with copies to the persons listed on the approval page of this QAPP.

All laboratories maintain internal quality control programs that are described in their quality assurance plans. The ALD Laboratories maintain statistical process control for most analytical procedures. Laboratory assessment activities require investigation and corrective actions for all quality control problems and other nonconformance issues. As stated in Section B5, when the reliability of project data may have been affected by a quality control problem or other nonconformance issue, the responsible Laboratory Manager will submit a copy of the investigation and corrective action report to the Project Coordinator with copies to the persons listed on the approval page of this QAPP.

Also, the responsible Laboratory Manager shall make certain that the project data associated with any quality control or other nonconformance issue is made available to data users with the appropriate data qualification. When data previously released to data users may have been affected by a quality control problem or other nonconformance issue, the Manager shall notify data users of the problem and put in the appropriate data qualifiers in databases used by the District for storage of project data.

The SAL, CAL, EAL, and IWAL participate in two proficiency-testing studies each year. These proficiency studies are the semi-annual Water Pollution Study where data from the fist study is combined with the National Pollutant Discharge Elimination System (NPDES) Discharge Monitoring Report Quality Assurance (DMR-QA) Study. The NPDES DMR-QA Study may be a combined study with one of the Water Pollution Studies. Systematic investigations are conducted for all unacceptable results. The investigation and corrective action reports prepared by the Laboratory Manager and his/her staff are reviewed by the ALD Assistant Director of M&R, by the QA Coordinator, and often by the Director of M&R.

The Organic Compounds Analytical Laboratory participates in two proficiency-testing studies each year and conducts investigations for unacceptable results in a manner similar to that followed by the other ALD Laboratories.

The AML is certified by the IDPH and must successfully pass a biannual on-site audit conducted by the IDPH.

All ALD laboratories as a requirement of their accreditation are audited annually by their Quality Assurance Coordinator and bi-annually by the IEPA.

C2: Reports to Management

The Project Manager and all those on the approval list will receive all investigation and corrective action reports concerning quality control problems and other nonconformance issues from field personnel and participating laboratories.

Project-related systems audits or special data quality assessments are undertaken on a random basis.

GROUP D: DATA VALIDATION AND USABILITY

D1: Data Review, Verification, and Validation

The laboratory data are reviewed and verified as described in Section B10, Data Management. The Biostatistician also reviews the data after it is transferred into the SAS® software. If errors are discovered, the Biostatistician reports them to the Project Coordinator for investigation and resolution.

D2: Verification and Validation Methods

Sample collection records can be verified by the Environmental Monitoring Manager identified in Section A4. Laboratory data shall be verified as necessary by the LIMS Manager identified in Section A4 and the Laboratory Manager of the laboratory that produced the data. All field and laboratory records will be kept for a minimum of five years. Laboratory records that are stored include calibration data, raw data, bench records, and data for quality control samples.

When verification of data results in a change to the project-related data, the Project Manager shall inform data users of the problem and make certain that all databases known to contain the affected data are corrected as necessary.

The person designated as the Project Coordinator (Section A4) has all calculations used for checking applicable IPCB water quality standards. She should be consulted regarding any questions pertaining to compliance with water quality standards and the reporting of data. All data handling and calculations for the water quality report are performed by the Biostatistician using SAS® software and SAS® user programs.

The Project Manager and the QA Officer shall be informed of all situations where data integrity has been found compromised by errors including storage of incorrect data or the corruption of stored data. All responsible persons identified in Section A4 and all known data users shall be informed of data problems when they are discovered and the corrective action taken. The QA Officer shall prepare the disclosure report for distribution.

D3: Reconciliation with User Requirements

The QAPP shall govern the operation of the project at all times. Each responsible person shall adhere to the procedural requirements of the QAPP and ensure that subordinate personnel do likewise.

This QAPP shall be reviewed annually by the Project Coordinator to ensure that the project will achieve all intended purposes. The annual review shall address every aspect of the program including:

1. The adequacy and location of sampling stations.
2. The adequacy of sampling frequency at each location.
3. Sampling procedures.
4. The appropriateness of parameters monitored.
5. Changes in data quality objectives and minimum measurement criteria.
6. Whether the data obtained met minimum measurement criteria.
7. Analytical procedures.
8. The quarterly violations reports and the annual project report.
9. Corrective actions taken during the previous year for field and laboratory operations.
10. Coordination of the project with the IEPA.
11. Review of other user requirements and recommendations.

The project will be modified as directed by the Project Director. The Project Manager shall be responsible for the implementation of changes to the project and shall document the effective date of all changes made.

It is expected that from time to time, ongoing and perhaps unexpected changes will need to be made to the project. Changes or deviations in the operation of the project shall not be made without authorization by the Project Director. The need of a change in project operation should be conveyed by the appropriate responsible person to the Project Coordinator. Data users and other interested persons may also suggest changes to the project to the Project Coordinator.

The Project Coordinator shall evaluate the need for the change, consult with other responsible persons as appropriate, and make a recommendation to the Project Director for approval. The Project Coordinator shall, in a timely manner, inform the appropriate project personnel of approved changes in project operation.

Following approval, a memorandum documenting each authorized change shall be prepared by the Project Coordinator and distributed to those on the approval list, as well as the other Assistant Directors of the M&R Department. Approved changes shall be considered an amendment to the QAPP and shall be incorporated into the QAPP when it is updated.

The Project Coordinator will prepare a QAPP update if major changes have taken place.

REFERENCES

"1999 Annual Summary Report, Water Quality Within the Waterways System of the Metropolitan Water Reclamation District of Greater Chicago," Report No. 01-12, Metropolitan Water Reclamation District of Greater Chicago, October 2001.

Environmental Protection Agency, "Guidelines Establishing Test Procedures for the Analysis of Pollutants," Code of Federal Regulations, Volume 40, Part 136, March 26, 2007.

Standard Methods for the Examination of Water and Wastewater, Prepared and published jointly by the American Public Health Association, the American Water Works Association, and the Water Environment Federation, Washington, DC, 20th ed., 1998.

State of Illinois Rules and Regulations, Title 35: Environmental Protection, Subtitle C: Water Pollution, Chapter I: Pollution Control Board, August 1, 2015.

FIGURE 1: AMBIENT WATER QUALITY MONITORING PROJECT ORGANIZATION CHART

```
|-- Project Director ---------------------------------- O
|        (Planning, decision making, and ultimate execution    |
|        of project)                                            |
|                                                  IEPA Project Manager
|                                                    (IEPA coordination)
O--- Project Manager                                          |
|      |   (Project planning, execution, and                  |
|      |   reporting)                              IEPA QA Officer
|      |                                            (IEPA oversight, QA/QC)
|      |                                                      |
O----O-- QA Officer ---------------------------------------O
|      |    | (Project QA/QC)
|      |    |
O----O---O- Project Coordinator
   |   |        |     (Project coordination and reporting)
   |   |        |
   |   |    O-O--- Environmental Monitoring  Manager
   |   |    |             (Execution of field activities)
   |   |    |                           |
   |   |    |               Sampling Teams
   |   |    |               |    (Sample collection and preservation, field measurements
   |   |    |               |    and transport of samples)
   |   |    |               |
   |  O---O------ Laboratories
   |        |             Stickney Analytical Laboratory
   |        |             Industrial Waste Analytical Laboratory
   |        |             Calumet Analytical Laboratory
   |        |             Egan Analytical Laboratory
   |        |             Analytical Microbiology Laboratory
   |        |             Organic Compounds Analytical Laboratory
   |        |             Aquatic Ecology and Water Quality Section
   |        |                 (Analysis, data verification, and data storage of LIMS)
   |        |               |
```

(*continued on next page*)

FIGURE 1 (Continued): AMBIENT WATER QUALITY MONITORING PROJECT ORGANIZATION CHART

```
         |  |                |                      |
(to Project Manager)

    |     (to Project Coordinator)
    |         |
    |         |        (to Laboratories)
    |         |                        |
    |         |                        |
    |        O---- LIMS Manager
    |         |         (Excel® spreadsheet, data review and exceedance reporting)
    |         |                                   |
    |         |                                   |
    O----- O---------- Data Review and Reporting Manager
                            (SAS® database, data review, compliance comparison, and annual reports)
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FIGURE 2: AMBIENT WATER QUALITY MONITORING PROGRAM
WATERWAY SAMPLE STATIONS

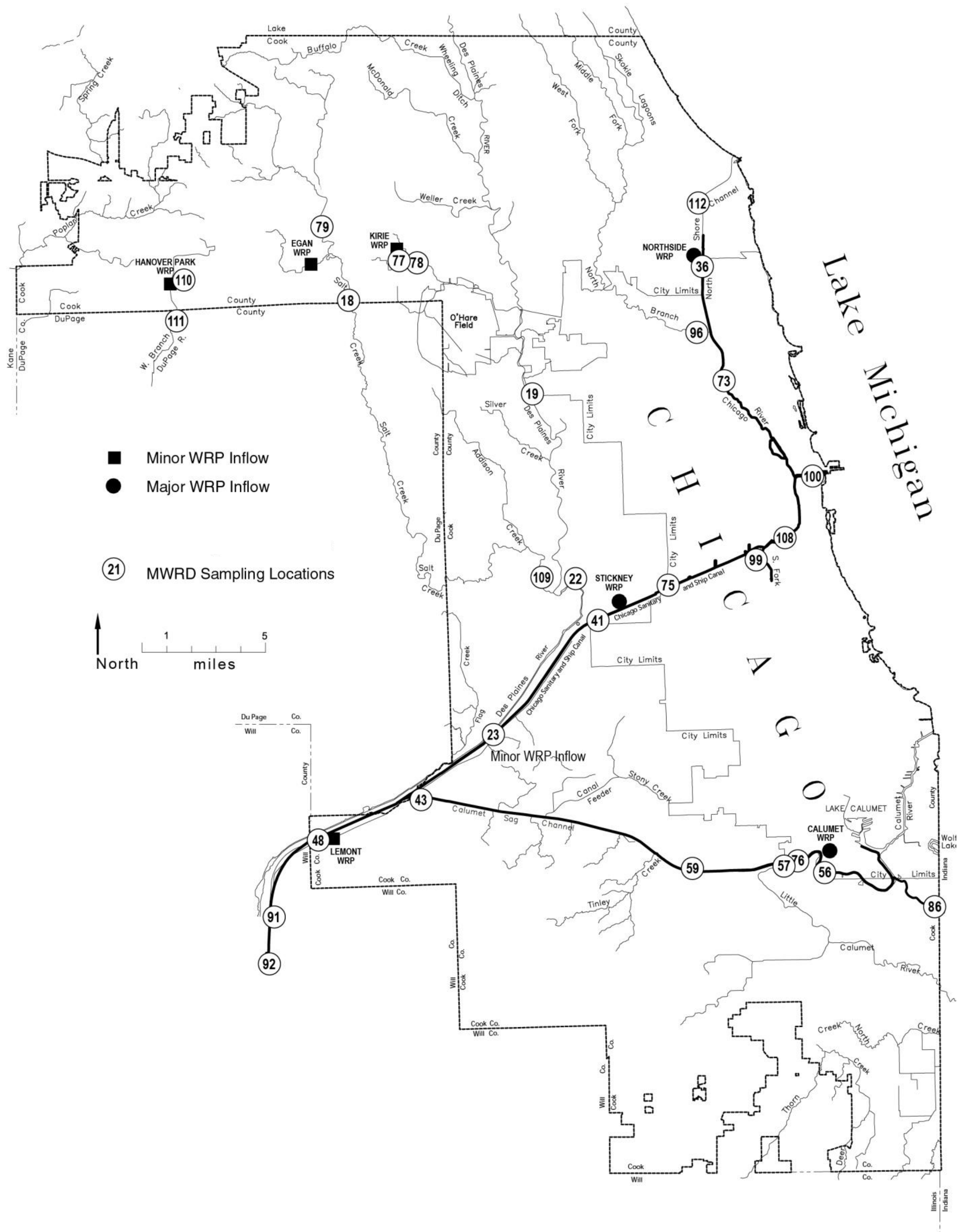

TABLE 1: SAMPLING LOCATIONS

Station	Location	IEPA Classification
	Chicago River System	
106	Dundee Road, West Fork North Branch of Chicago River	General Use
103	Golf Road, West Fork North Branch of Chicago River	General Use
31	Lake-Cook Road, Middle Fork North Branch of Chicago River	General Use
104	Glenview Road, Middle Fork North Branch of Chicago River	General Use
32	Lake-Cook Road, Skokie River	General Use
105	Frontage Road, Skokie River	General Use
34	Dempster Street, North Branch of Chicago River	General Use
96	Albany Avenue, North Branch of Chicago River*	General Use
35	Central Street, North Shore Channel	General Use
112	Dempster Street, North Shore Channel*	General Use
102	Oakton Street, North Shore Channel	General Use
36	Touhy Avenue, North Shore Channel*	CAWS A/PC
101	Foster Avenue, North Shore Channel	CAWS A/PC
37	Wilson Avenue, North Branch of Chicago River	CAWS A/PC
73	Diversey Parkway, North Branch of Chicago River*	CAWS A/PC
46	Grand Avenue, North Branch of Chicago River	CAWS A/PC
74	Lake Shore Drive, Chicago River	General Use
100	Wells Street, Chicago River*	General Use
39	Madison Street, South Branch of Chicago River	CAWS A/PC
108	Loomis Street, South Branch of Chicago River*	CAWS A/PC
99	Archer Avenue, South Fork South Branch of Chicago River*	IAL/SC
40	Damen Avenue, Chicago Sanitary and Ship Canal	CAWS B/ICR
75	Cicero Avenue, Chicago Sanitary and Ship Canal*	CAWS B/ICR
41	Harlem Avenue, Chicago Sanitary and Ship Canal*	CAWS B/ICR
42	Route 83, Chicago Sanitary and Ship Canal	CAWS B/ICR
48	Stephen Street, Chicago Sanitary and Ship Canal*	CAWS B/NR
92	Lockport Powerhouse Forebay*	CAWS B/NR
	Calumet River System	
49	Ewing Avenue, Calumet River	CAWS A/NCR
50	Wolf Lake, Burnham Avenue	General Use
55	130th Street, Calumet River	CAWS A/ICR
86	Burnham Avenue, Grand Calumet River*	CAWS A/ICR

TABLE 1 (Continued): SAMPLING LOCATIONS

Station	Location	IEPA Classification
	Calumet Waterway System (Continued)	
56	Indiana Avenue, Little Calumet River*	CAWS A/PC
76	Halsted Street, Little Calumet River*	CAWS A/PC
52	Wentworth Avenue, Little Calumet River	General Use
54	Joe Orr Road, Thorn Creek	General Use
97	170th Street, Thorn Creek	General Use
57	Ashland, Little Calumet River*	General Use
58	Ashland Avenue, Calumet-Sag Channel	CAWS A/PC
59	Cicero Avenue, Calumet-Sag Channel*	CAWS A/PC
43	Route 83, Calumet-Sag Channel*	CAWS A/PC
	Des Plaines River System	
12	Lake-Cook Road, Buffalo Creek	General Use
13	Lake-Cook Road, Des Plaines River	General Use
17	Oakton Street, Des Plaines River	General Use
19	Belmont Avenue, Des Plaines River*	General Use
20	Roosevelt Road, Des Plaines River	General Use
22	Ogden Avenue, Des Plaines River*	General Use
23	Willow Springs Road, Des Plaines River*	General Use
29	Stephen Street, Des Plaines River	General Use
91	Material Service Road, Des Plaines River*	General Use
110	Springinsguth Road, West Branch of DuPage River*	General Use
89	Walnut Lane, West Branch of DuPage River	General Use
111	Arlington Drive, West Branch of DuPage River*	General Use
79	Higgins Road, Salt Creek*	General Use
80	Arlington Heights Road, Salt Creek	General Use
18	Devon Avenue, Salt Creek*	General Use
24	Wolf Road, Salt Creek	General Use
109	Brookfield Avenue, Salt Creek*	General Use
77	Elmhurst Road, Higgins Creek*	General Use
78	Wille Road, Higgins Creek*	General Use
	Fox River	
90	Route 19, Poplar Creek	General Use

*Current sampling location as of September, 2015
PC=Primary Contact
ICR = Incidental Contact Recreation
NCR = Non-Contact Recreation
NR = Non-Recreational
SC=Secondary Contact
IAL = Indigenous Aquatic Life

TABLE 2: LATITUDE AND LONGITUDE OF CURRENT SAMPLING LOCATIONS

Station	Description	North Latitude	West Longitude
96	North Branch Chicago River @ Albany Ave.	41° 58.475'	87° 42.375'
112	North Shore Channel @ Dempster St.	42° 02.460'	87° 42.583'
36	North Shore Channel @ Touhy Ave.	42° 00.690'	87° 42.600'
73	North Branch Chicago River @ Diversey Ave.	41° 55.920'	87° 40.940'
100	Chicago River Main Stem @ Wells St.	41° 53.259'	87° 38.045'
108	South Branch Chicago River @ Loomis St.	41° 50.752'	87° 39.642'
99	South Fork, South Branch Chicago River @ Archer Ave.	41° 50.331'	87° 39.849'
75	Chicago Sanitary & Ship Canal @ Cicero Ave.	41° 49.169'	87° 44.616'
41	Chicago Sanitary & Ship Canal @ Harlem Ave.	41° 48.263'	87° 48.104'
48	Chicago Sanitary & Ship Canal @ Stephen St.	41° 40.750'	88° 00.683'
92	Chicago Sanitary & Ship Canal @ Lockport Powerhouse Forebay	41° 34.256'	88° 04.704'
86	Grand Calumet River @ Burnham Ave.	41° 37.870'	87° 32.352'
56	Little Calumet River @ Indiana Ave.	41° 39.136'	87° 35.828'
76	Little Calumet River @ Halsted St.	41° 39.440'	87° 38.476'
57	Little Calumet River @ Ashland Ave.	41° 39.099'	87° 39.633'
59	Calumet-Sag Channel @ Cicero Ave.	41° 39.282'	87° 44.284'
43	Calumet-Sag Channel @ Route 83	41° 41.790'	87° 56.480'
19	Des Plaines @ Belmont Ave.	41° 56.236'	87° 50.975'
22	Des Plaines River @ Ogden Ave.	41° 49.256'	87° 48.654'
23	Des Plaines River @ Willow Springs Rd.	41° 44.135'	87° 52.901'
91	Des Plaines River @ Material Service Rd.	41° 35.794'	88° 04.112'
110	West Branch DuPage River @ Springinsguth Rd.	42° 00.495'	88° 07.142'
111	West Branch DuPage River @ Arlington Drive	41° 58.500'	88° 08.316'
79	Salt Creek @ Higgins Rd.	42° 01.880'	88° 00.679'
18	Salt Creek @ Devon Ave.	41° 59.546'	87° 59.924'
109	Salt Creek @ Brookfield Ave.	41° 49.370'	87° 50.494'
77	Higgins Creek @ Elmhurst Rd.	42° 01.287'	87° 56.436'
78	Higgins Creek @ Wille Rd.	42° 01.120'	87° 56.201'

TABLE 3: QUADRANT, TOWNSHIP, AND RANGE OF CURRENT SAMPLING LOCATIONS

Station	Description	Quadrant	TWP	Range	Sec.	¼ Sec
96	North Branch Chicago River @ Albany Ave.	Chicago Loop	40N	13E	12	SW
112	North Shore Channel @ Dempster St.	Evanston	41N	13E	14	SE
36	North Shore Channel @ Touhy Ave.	Evanston	42N	13E	26	SE
73	North Branch Chicago River @ Diversey Ave.	Chicago Loop	40N	14E	30	SW
100	Chicago River Main Stem @ Wells St.	Chicago Loop	39N	14E	9	SW
108	South Branch Chicago River @ Loomis St.	Englewood	39N	14E	28	NW
99	South Fork, South Branch Chicago River @ Archer Ave.	Englewood	39N	14E	29	SW
75	Chicago Sanitary & Ship Canal @ Cicero Ave.	Englewood	38N	13E	3	NW
41	Chicago Sanitary & Ship Canal @ Harlem Ave.	Berwyn	38N	12E	7	NW
48	Chicago Sanitary & Ship Canal @ Stephen St.	Romeoville	37N	11E	20	NW
92	Chicago Sanitary & Ship Canal @ Lockport Powerhouse	Joliet	36N	10E	27	SW
86	Grand Calumet River @ Burnham Ave.	Lake Calumet	36N	15E	5	SW
56	Little Calumet River @ Indiana Ave.	Lake Calumet	37N	14E	34	SW
76	Little Calumet River @ Halsted St.	Blue Island	37N	14E	33	NW
57	Little Calumet River @ Ashland Ave.	Blue Island	37N	14E	32	SW
59	Calumet-Sag Channel @ Cicero Ave.	Blue Island	37N	13E	34	NW
43	Calumet-Sag Channel @ Route 83	Calumet-Sag Bridge	37N	11E	14	SE
19	Des Plaines @ Belmont Ave.	River Forest	40N	12E	22	SE
22	Des Plaines River @ Ogden Ave.	Berwyn	38N	12E	1	NE
23	Des Plaines River @ Willow Springs Rd.	Calumet-Sag Bridge	38N	12E	33	SW
91	Des Plaines River @ Material Service Rd.	Joliet	36N	10E	22	SW
110	West Branch DuPage River @ Springinsguth Rd.	Streamwood	41N	10E	26	SW
111	West Branch DuPage River Arlington Drive	West Chicago	40N	10E	6	SE
79	Salt Creek @ Higgins Rd.	Palatine	41N	11E	20	NW
18	Salt Creek @ Devon Ave.	Elmhurst	41N	11E	33	SW
109	Salt Creek @ Brookfield Ave.	Berwyn	39N	12E	35	SW
77	Higgins Creek @ Elmhurst Rd.	Arlington Hts.	41N	11E	25	NW
78	Higgins Creek @ Wille Rd.	Arlington Hts.	41N	11E	25	NW

TABLE 4: SAMPLE CONTAINERS AND FIELD PRESERVATION

Parameter	Container and Field Preservation
1. Dissolved oxygen	300 mL glass stoppered bottle, sample is fixed immediately after collection with manganous sulfate solution, alkali-iodide solution and sulfuric acid. Chill the fixed sample with ice and protect from light. See Appendix AI page AI-5 for the detailed procedure.
2. Fecal coliform	125 mL square polypropylene bottle, sterilized and sealed with 0.45 mL of 15% disodium salt of EDTA adjusted to pH of 6.5, and 0.15 mL of 10% sodium thiosulfate. Chill sample with ice. See Appendix I page AI-4 and AI-5 for the correct procedure.
3. General chemistry[1] (see footnote for parameters)	1 gallon polyethylene bottle. Chill sample with ice.
4. Metals, total	250 mL polyethylene bottle with 2.5 mL conc. HNO_3 to adjust pH<2. Chill sample with ice.
5. Metals, dissolved	900 mL certified clean polyethylene bottle. Chill sample with ice. (Sample filtered in laboratory with 0.45 μm membrane filter into a 250 mL certified clean polyethylene bottle and acidified with 1 mL of conc. HNO_3.)
6. Mercury (total and low level)	4 – 40 mL vials, each with 200μL BrCl. Do not put sample on ice.
7. Cyanide, total and chlorine amenable	½ gallon plastic bottle with 5 mL 10% NaOH to adjust pH>12. Chill sample with ice.
8. Phenol	1 quart glass bottle with 2 mL of conc. H_2SO_4 to adjust pH<2. Chill sample with ice.
9. n-Hexane extractable materials	2-1 quart glass bottles. Chill sample with ice.
10. Alkalinity, chloride	250 mL polyethylene bottle. Chill sample with ice.
11. Sulfate	250 mL polyethylene bottle. Chill sample with ice.

TABLE 4 (Continued): SAMPLE CONTAINERS AND FIELD PRESERVATION

Parameter	Container and Field Preservation
12. Total Phosphorus, Total Kjeldahl Nitrogen	250 mL polyethylene bottle with 0.3 mL of sulfuric acid to acidify sample. Chill sample with ice.
13. Fluoride	250 mL polyethylene bottle. Chill sample with ice.
14. Ammonia, NO_2+NO_3	250 mL polyethylene bottle, preserved with 0.3 mL of sulfuric acid upon collection.
14. Carbon, total organic	500 mL wide-mouth glass bottle with 1 mL H_2SO_4 to adjust pH<2. Chill sample with ice.
15. Radiochemistry	1 liter polyethylene bottle.
16. Chlorophyll	1 liter HDPE Nalgene amber, wide-mouth bottle with 1 mg powdered $MgCO_3$. Chill sample with ice.
17. Volatile organics, BETX (benzene, ethyl benzene, toluene, and xylenes)	Three 40-mL vials with Teflon-lined septum screw caps, each with 25 mg ascorbic acid, filled to top with minimal overflow and no air bubbles. Chill sample with ice.
18. Base/neutral and acid extractable compounds, pesticides, PCBs, OPPs and nonylphenols[2]	1 gallon glass with 0.7 mL of 50% sodium thiosulfate solution. Chill sample with ice.

[1]General chemistry parameters include total dissolved solids, total suspended solids
[2]Nonylphenol analyzed from same container as OPPs.

TABLE 5: ANALYTICAL METHODS

Parameter	Method	Method Reference
Dissolved oxygen	Titration	SM 4500-O C
Temperature	Electrode	SM 2550 B
pH	Electrode	SM 4500-H^+ B
Ammonia nitrogen	Colorimetric	EPA 350.1
Ammonia nitrogen, un-ionized[1]	Calculation	
Nitrate and nitrite nitrogen	Colorimetric	EPA 353.2 R.2.0
Kjeldahl nitrogen	Colorimetric	EPA 351.2 R.2.0
Phosphorus, total	Colorimetric	EPA 365.4
Sulfate	Colorimetric	EPA 375.2
Total dissolved solids	Gravimetric	SM 2540 C
Suspended solids	Gravimetric	SM 2540 D
Volatile suspended solids	Gravimetric	SM 2540 E
Alkalinity	Titration	SM 2320 B
Chloride	Potentiometric	SM 4500-Cl D
Fluoride	Potentiometric	SM 4500 F-C
Organic carbon, total	UV-Oxidation	SM 5310 C
Phenol	Colorimetric	EPA 420.2
Cyanide, total	Colorimetric	EPA Kelada-01
Cyanide, chlorine amenable	Colorimetric	SM 4500-CN G
Barium, total	ICP	EPA 200.7, SM 3120 B
Boron, total	ICP	
Calcium, total	ICP	EPA 200.7, SM 3120 B
Chromium, trivalent[2]	ICP	EPA 200.7, SM 3120 B
Chromium, hexavalent	Colorimetric	SM 3500-Cr B
Magnesium, total	ICP	EPA 200.7, SM 3120 B
Manganese, total	ICP	EPA 200.7, SM 3120 B
Mercury, low-level, total; General Use	Cold vapor AFS	EPA 1631 E
Selenium, total	ICP	EPA 200.7, SM 3120 B
Silver, total	ICP	EPA 200.7, SM 3120 B
Arsenic, dissolved	ICP	SM 3030 B, SM 3120 B
Cadmium, dissolved	ICP	SM 3030 B, SM 3120 B
Chromium, dissolved	ICP	SM 3030 B, SM 3120 B
Copper, dissolved	ICP	SM 3030 B, SM 3120 B
Iron, dissolved	ICP	SM 3030 B, SM 3120 B
Lead, dissolved	ICP	SM 3030 B, SM 3120 B
Nickel, dissolved	ICP	SM 3030 B, SM 3120 B
Silver, dissolved	ICP	SM 3030 B, SM 3120 B
Zinc, dissolved	ICP	SM 3030 B, SM 3120 B
Fecal coliform	Membrane	SM 9222 D

TABLE 5 (Continued): ANALYTICAL METHODS

Parameter	Method	Method Reference
n-Hexane extractable materials	Gravimetric	EPA 1664, Rev. A
Gross alpha radioactivity	Gas proportional	SM 7110
Gross beta radioactivity	Gas proportional	SM 7110
Chlorophyll	Colorimetric	SM 10200 H
BETX (Benzene, ethyl Benzene, toluene, xylenes)	Purge and trap GC/MS	EPA 624
Organic Priority Pollutants		
Volatile organic compounds	Purge and trap GC/MS	EPA 624
Base/neutral and acid extractable compounds	GC/MS	EPA 625
Pesticides	GC/ECD	EPA 608
PCBs	GC/ECD	EPA 608
Nonylphenols	GC/MS	GCMS004[3]

[1]Calculated from pH, temperature, and ammonia nitrogen.
[2]Trivalent chromium measured as total chromium.
[3]USEPA Region V Method, Revision 1 dated June 6, 2003.

TABLE 6: LABORATORY PRESERVATION AND MAXIMUM HOLDING TIME

Parameter	Laboratory Preservation[1,2]	Maximum Holding Time
Dissolved oxygen (Fixed)	Refrigerate	8 hours
Temperature	NA	0.25 hours
pH	NA	0.25 hours
Ammonia nitrogen	(a) Refrigerate, (b) with H_2SO_4 to pH<2	24 hours, 28 days
Ammonia nitrogen, Un-ionized[3]	NA	NA
Nitrate and nitrite nitrogen	(a) Refrigerate, (b) with H_2SO_4 to pH<2	24 hours, 28 days
Nitrite	Refrigerate	48 hours
Kjeldahl nitrogen	(a) Refrigerate, (b) with H_2SO_4 to pH<2	24 hours, 28 days
Phosphorus, total	(a) Refrigerate, (b) with H_2SO_4 to pH<2	24 hours, 28 days
Sulfate	Refrigerate	28 days
Total dissolved solids	Refrigerate	7 days
Suspended solids	Refrigerate	7 days
Volatile suspended solids	Refrigerate	7 days
Turbidity	Refrigerate, store in dark	48 hours
Alkalinity	Refrigerate	14 days
Chloride	None required	28 days
Fluoride	None required	28 days
Organic carbon, total	Refrigerate, H_2SO_4 to pH<2	28 days
Phenol	Refrigerate, H_2SO_4 to pH<2	28 days
Cyanide, total	Refrigerate, NaOH to pH>12	14 days
Cyanide, chlorine amenable	Refrigerate, NaOH to pH>12	14 days
Chromium, hexavalent	Refrigerate	24 hours
Metals, total (excluding mercury)	HNO_3 to pH<2	6 months
Mercury, low-level, total	BrCl	90 days
Metals, dissolved (excluding mercury)	Filter, HNO_3 to pH<2	6 months
Fecal coliform	Refrigerate	6 hours

TABLE 6 (Continued): LABORATORY PRESERVATION AND MAXIMUM HOLDING TIME

Parameter	Laboratory Preservation[1,2]	Maximum Holding Time
n-Hexane extractable materials	Refrigerate, H_2SO_4 to pH<2	28 days
Gross alpha radioactivity	HNO_3 to pH<2	None
Gross beta radioactivity	HNO_3 to pH<2	None
Chlorophyll	Refrigerate	30 days
BETX (Benzene, ethyl benzene, toluene, xylenes)	Refrigerate	7 days
Organic priority pollutants	Refrigerate	7 days
Nonylphenols	Refrigerate	7 days

NA = Not applicable.
[1]All samples stored in ice after collection and in transport to laboratory except for low-level mercury.
[2]Refrigeration at 4ºC.
[3]Calculated from pH, temperature, and ammonia nitrogen.

TABLE 7: RESPONSIBLE LABORATORIES AND METHOD STANDARD OPERATING PROCEDURE IDENTIFICATION

Parameter	Laboratory	Method SOP ID
Dissolved oxygen (Fixed)	Industrial Waste	IW-DO-WINKLER
Temperature	Field measurement	M90 Oper. Instr.
pH	Field measurement	M90 Oper. Instr.
Ammonia nitrogen	Stickney	ST-NH3
Ammonia nitrogen, un-ionized[1]	Calculation	NA
Nitrate and nitrite nitrogen	Stickney	ST-NO3/NO2
Kjeldahl nitrogen	Stickney	ST-TKN
Phosphorus, total	Stickney	ST-TP
Sulfate	Calumet	CaSO4
Total dissolved solids	Stickney	ST-TDS
Suspended solids	Stickney	ST-TSS/VSS
Volatile suspended solids	Stickney	ST-TSS/VSS
Alkalinity	Stickney	ST-Alk
Chloride	Stickney	ST-Cl
Fluoride	Stickney	ST-F
Organic carbon, total	Industrial Waste	IW-TOC
Phenol	Industrial Waste	IW-PHENOL-A
Cyanide, total	Industrial Waste	IW-CN-AUTO
Cyanide, chlorine amenable	Industrial Waste	IW-CN-AMEN
Chromium, hexavalent	Industrial Waste	IW-CR6
Metals, total and dissolved (except mercury)	Egan	ICP-SOP V. 1.13
Mercury, low-level, total	Calumet	CaLLHg
Fecal coliform	Microbiology	
n-Hexane extractable materials	Industrial Waste	IW-FOG-SPE
Gross alpha radioactivity	Contracted Lab	A/B.TSD
Gross beta radioactivity	Contracted Lab	A/B.TSD
Chlorophyll	Aquatic Ecology	
Benzene, ethyl benzene, toluene, xylenes	Organic Compounds Analytical	SOPEPA624
Organic priority pollutants	Organic Compounds Analytical	SOPEPA624[2] SOPEPA625[3] SOPEPA608[4]
Nonylphenols	Organic Compounds Analytical	GCMS004[5]

[1]Calculated from pH, temperature and ammonia nitrogen.
[2]Volatile organic compounds.
[3]Base/neutral and acid extractable compounds.
[4]Pesticides and PCBs.
[5]USEPA Region V Method, Revision 1 dated June 6, 2003.

AMBIENT WATER QUALITY MONITORING PROJECT
QUALITY ASSURANCE PROJECT PLAN

APPENDIX I

SAMPLING PROCEDURES

WATERWAY SAMPLING

Sampling Procedures

1) Before sample collection day, scrub the stainless steel sampling bucket, stirrers, and DO sampling device with a solution of non-interfering residue-free critical cleaning liquid detergent and water. Rinse with de-ionized water.

2) Samples should be collected from the upstream side of the bridge.

3) Samples may be collected from the District's Pollution Control (PC) boats if approved by an Aquatic Biologist, when circumstances deem necessary. Boat sampling should not be performed in areas where sediment could be disturbed. When sampling from a District PC boat, the following steps should be followed:

   a. Ensure the PC boat is in the correct location and the engines/motors are in idle.

   b. Communicate with the Patrol Boat Operator to ensure it is safe to collect the sample.

   c. Collect the sample from the side of the PC boat, away from the propellers and exhaust.

4) Take the samples from a representative location - the center of the river at the deepest point. DO NOT SAMPLE FROM THE BANK OF THE WATERWAY.

5) If boat traffic is encountered when sampling from a navigable body of water, delay sampling until the unnatural turbulence caused by the vessel's wake subsides. Indicate in the "Remarks" section of the sample collection sheet that sampling was interrupted due to a passing vessel.

6) Upon arrival at each prescribed sampling location, the following steps should be followed:

   a. Collect samples routinely collected from pail. See Section A.

   b. Collect DO and bacterial samples with modified DO sampler. See Section B.

   c. When required, collect equipment blanks from pail. See Section C.

d. When required, collect organics samples from pail. See Section D.

6. Complete the sample collection sheet as appropriate at each sampling location.

   a. Sample collection date.

   b. Sampler's name(s).

   c. Weather conditions during sampling (Example: Clear, Cloudy, Rain, Snow, Air Temperature, if possible).

   d. Type of aliquots obtained.

   e. Time aliquots were obtained.

   f. Sample pH as obtained with the handheld meter.

   g. Sample temperature as obtained with the handheld meter.

   h. Sample storage temperature.

   i. In the "Remarks" column, describe visual observation of sample (Clear, Semi-Clear, Lt. Sed., etc.), indicate if there was any passing boat traffic and any unusual observations of the waterway quality, such as oil, discoloration, or debris. Also provide the LIMS number.

   j. At the bottom of the collection sheet, a space is available for additional remarks.

7. Upon completion of the sampling assignment, immediately transport the samples to the laboratory for analysis.

8. Upon relinquishing the samples to the laboratory analyst record the following pertinent information on the sample collection sheet to complete chain-of-custody requirements (<u>Appendix II</u>).

   a. Signature of transporter.

   b. Signature of the person who relinquished the sample.

   c. Signature of the laboratory analytical staff member who received the sample.

   d. Time sample relinquished.

Section A: Routine Samples Collected in Pail

1. Properly identify (label) each sample container and arrange in order specified on sample trays.

2. Lower the clean stainless steel bucket into the river/stream water. Retrieve the bucket and immediately obtain a pH and temperature reading with the handheld meter.

3. Empty the bucket, lower and retrieve it two more times rinsing thoroughly to acclimate it to the waterway.

4. When sampling during precipitation events (rain or snow), cover the sample bucket at all times with the lid provided, except when the bucket is being raised or lowered from the bridge.

5. Whenever the sampling bucket is being raised or lowered from the bridge, give special attention to insure there is no contact with the bridge structure. If there is contact, discard the sample and start over. Also, make sure that the rope does not come in contact with the ground. Place the rope into the gray, plastic container.

6. Only after acclimating the sampling bucket three times should the actual sample be obtained. After the sample is obtained, stir the sample with the stirring rod 5x in one direction and then 5x in the other direction. Pour it into the individual sample aliquot bottles filling the aliquot bottles half way from right to left. Then stir the sample water in the bucket with the same procedure as above to ensure a homogeneous distribution of suspended solids and finish filling the bottles from left to right.

7. Samples to be collected and order in trays:

    a. General chemistry sample: 1-gallon (wide-mouth plastic) container.

    b. Alkalinity, chloride sample: plastic 250 mL container, fill to shoulder.

    c. Cyanide sample: fill the plastic half-gallon container (containing 5 mL of 10% NaOH preservative) to shoulder.

    d. Phenol sample: fill the glass sample bottle to the shoulder; exercise <u>CAUTION</u> as bottle contains 2 mL sulfuric acid as a preservative. Do not breathe the vapors that may be emitted by the sulfuric acid preservative.

e. Radiochemistry sample: fill 1 liter plastic bottle to shoulder. Do not overfill.

f. Dissolved metals sample: fill a 900 mL certified clean, plastic bottle.

g. Total organic carbon: fill a 500-mL glass bottle.

h. Trace metals sample: fill 8 oz. plastic bottle. Leave approximately l/4-inch air space at top of bottle. NOTE: The bottle contains 2 mL of nitric acid. (Overfilling may cause a loss of preservative.)

i. Sulfate: fill a 250 mL square plastic bottle.

j. Total Phosphorus, Total Kjeldahl Nitrogen: fill a 250 mL plastic bottle to the shoulder; exercise CAUTION as bottle contains 0.3 mL sulfuric acid as a preservative. Do not breathe the vapors that may be emitted by the sulfuric acid preservative

k. Fluoride: fill a 250 mL plastic bottle to the shoulder.

l. Ammonia, NO_2+NO_3: fill a 250 mL polyethylene bottle to the shoulder; exercise CAUTION as bottle contains 0.3 mL sulfuric acid as a preservative. Do not breathe the vapors that may be emitted by the sulfuric acid preservative.

m. Chlorophyll: fill an opaque, brown 1-liter bottle (obtained from Room LE213). Leave approximately 1/2-inch air space at top of bottle.

n. n-Hexane extractable materials sample: fill two glass quart jars.

8. After all the sample aliquots have been poured-off, rinse the sample bucket and stirring rod with de-ionized water.

9. Place each sample aliquot into the 72-quart thermal ice chest filled from 1/3 to 1/2 full of ice cubes. Insure the sample bottles are surrounded in ice.

Section B: Dissolved Oxygen and Bacterial Samples

The DO sample and bacterial sample are collected at the same time using a DO sampler that has been modified to hold the bacterial sample container. The DO and bacterial samples are collected as follows:

1. The bacterial container is a sterilized 4 oz. plastic bottle with foil covered plastic screw cap. The DO container is a 300-mL glass bottle.

2. Do not open bacterial bottle until sampling, and replace foil covered plastic cap as soon as possible.

3. Care should be taken not to touch the neck or the mouth of the bacterial bottle, or the inside of the plastic cap to prevent contamination of the sample.

4. Insert bacterial bottle into the compartment attached to the outside of the DO sampling can making sure not to allow the top of the bottle to touch any part of the sample can.

5. Place a 300-mL DO glass bottle into the special DO sampling device.

6. Slowly lower the DO sampling device with the bacterial bottle and DO bottle into the waterway to the depth of approximately 3 feet from the surface taking care to prevent turbulence and the formation of air bubbles while filling.

7. Raise the sampling device when all the air bubbles have stopped rising.

8. Remove the bacterial bottle from the DO sampling device.

9. Obtain a second bacterial bottle, label, and then remove the foil-covered cap without removing the foil from the cap.

10. Care should be taken not to touch the neck or the mouth of the bottle, or the inside of the plastic cap to prevent contamination of the sample.

11. Pour the aliquot obtained with the DO sampling device into the second bacterial bottle. Fill the bottle approximately 80 percent full. DO NOT OVERFILL.

12. Close the bottle with the foil-covered cap and place the sample into the cooler on ice

13. Return the bacterial bottle used to collect the sample to the Microbiology Laboratory.

14. Place the sample into the cooler on ice.

15. Remove the DO bottle. Replace the glass stopper and pour off excess water at the top of the bottle.

15. Remove the glass stopper and add 1 mL of manganous sulfate (use Reagent Dispenser #1). Then, add 1-mL potassium hydroxide – potassium iodide solution (alkali-iodide-azide reagent) (use Reagent Dispenser #2). NOTE:

The tips of the Reagent Dispensers, #1 and #2, should be at the surface of the liquid in the DO bottle when the reagents are added. Add reagents slowly, allowing them to run down the inside of the bottle neck, to avoid introducing air into the sample. This prevents the introduction of extraneous oxygen into the sample.

16. Replace the glass stopper on the DO bottle carefully to exclude air bubbles.

17. Rinse the bottle with river water or fresh water, if available.

18. Mix the sample by inverting the bottle several times until dissolution is complete. NOTE: The initial precipitate, manganous hydroxide, combines with the DO in the sample to form manganic hydroxide, a brown precipitate. Place the bottle in an area protected from direct sunlight while precipitate is settling.

19. When the precipitate settles approximately half way in the sample, add 1-ml sulfuric acid (Reagent #3), by removing the glass stopper on the sample bottle and placing the tip of the Reagent Dispenser #3 in the inside neck of the bottle above the level of the sample. This allows the acid to run down the inside of bottleneck, and mix with the sample. Once again, this eliminates the introduction of extraneous oxygen into the sample.

20. Replace the glass stopper on the DO bottle.

21. Rinse the bottle with river water or fresh water if it is available.

22. Mix the sample by inverting bottle several times.

23. Place sample into cooler on ice. (Protect from sunlight.)

24. Complete appropriate entries on sample collection sheet.

Section C: Equipment Blanks. If sampling is occurring at one of the following stations, then equipment blanks must be obtained: WW_78, WW_23, WW_110, WW_36, WW_108, WW_41, and WW_57. Equipment blanks are collected as follows:

1. Properly identify (label) each sample container and arrange in order specified on sample trays.

2. Fill the stainless steel bucket two-thirds full with reagent water obtained from the laboratory.

3. Proceed with the filling of the sample containers as is done in Section A, steps g through i, refilling the bucket as necessary to fill all sample containers.

4. Complete sample collection sheet as appropriate.

Section D: Organics Samples. Organic priority pollutants (OPP), nonylphenol, and BETX (benzene, ethylbenzene, and total xylenes) samples are collected as follows:

1. The amber colored glass containers provided by the OCAL must be used for BETX and OPP/nonylphenols samples. These containers contain a preservative and should not be rinsed prior to filling.

2. OPP/nonylphenol samples require one (1) gallon bottle and three (3) vials per sampling location.

3. BETX samples require three (3) vials per sampling location.

4. Each sampling team will transport a clearly marked, "Trip Blank" sample, consisting of two (2) amber vials filled with Milli-Q de-ionized water, with the other organic samples collected during the sampling trip.

5. Obtain a water sample in the stainless steel pail and fill sample containers.

6. When filling the containers care should be taken to minimize air bubbles in the sample container. Gallons and vials are to be filled to the top with minimal overflow. A slight bulge of water at the neck of the container caused by surface tension should be evident at the time the cap is tightened to insure elimination of excess air.

7. Place samples into cooler on ice.

8. Complete sample collection sheet as appropriate.

9. After transport to the laboratory, store the samples in the laboratory cooler for later transportation to the Organic Compounds Analytical Laboratory by the night transporter.

Section E: Low Level Mercury Samples. Low level Mercury (LLHg) samples and field blanks are collected as follows:

1. Obtain the labeled LLHg sampling kit provided by CAL. The sampling kit contains four pairs of clean gloves, four 40 mL sample vials, two empty 40 mL field blank vials, and three 40 mL field blank vials filled with reagent water.

2. Do not expose the sample to anything that may contain significant amounts of mercury. Potential contamination sources: Sampling

equipment, bailers, sampling tubing (including peristaltic pump tubing), gloves, clothing, bottles, exhaled breath from mercury amalgam fillings, precipitation, dirt, dust and airborne vapor.

3. Collect LLHg samples according to the following procedure:

   a. Obtain a water sample in the stainless steel pail.

   b. Sampler #1: Put on clean gloves and sufficient protective clothing to ensure dust and debris is not transferred from the person to the sample.

   c. Sampler #2: Put on clean gloves and sufficient protective clothing to ensure dust and debris is not transferred from the person to the sample. Do not touch anything that may contaminant your gloves.

   d. Sampler #1: Set up sampling equipment, open cooler, remove double bagged bottle kit from cooler and its bubble pack bag, open outer bag and hold it open so sampler #2 can reach inside.

   e. Sampler #2: Do not touch the outer bag. Open the inner bag, remove one 40 mL vial from the bag, remove the cap and fill with water sample to the top, screw cap onto vial and return filled vial to the innermost bag. There is no need to rinse the bottle or add a preservative. Repeat until 4 vials have been filled from the same sampling point. Close the zip-lock seal most of the way, squeeze the inner bag to expel most of the air, complete the seal, push the inner bag inside the outer bag.

   f. Sampler #1: Close the outer bag zip-lock seal most of the way, squeeze the bag to expel most of the air, complete the seal. Place the double-bagged bottle kit in the bubble pack bag, remove the adhesive strip cover and seal the bubble bag closed. Place the kit in the cooler. NOTE: LLHg samples should not be placed on ice.

4. Collect LLHg field blanks according to following procedure:

   a. Sampler #1: Put on clean gloves and sufficient protective clothing to ensure dust and debris is not transferred from the person to the sample.

   b. Sampler #2: Put on clean gloves and sufficient protective clothing to ensure dust and debris is not transferred from the person to the sample. Do not touch anything that may contaminant your gloves.

c. Sampler #1: Open cooler, remove double bagged kit labeled field blank bottle kit from cooler and its bubble pack bag, apply client label to the outer zip-lock bag, open outer bag and hold it open so the clean hands person can reach inside.

d. Sampler #2: Do not touch the outer bag. Open the inner bag, remove one full 40 mL vial from the bag, and one empty 40 mL vial, remove the caps and pour the reagent water from one vial into the other under the same conditions to which regular samples were exposed, screw caps onto vials and return filled vial to the innermost bag discard the empty vial. There is no need to rinse the bottle or add a preservative. Repeat until 2 vials have been filled. There is an extra filled reagent water vial in case a spill occurs, discard if not needed. Close the zip-lock seal most of the way, squeeze the inner bag to expel most of the air, complete the seal, push the inner bag inside the outer bag.

e. Sampler #1: Close the outer bag zip-lock seal most of the way, squeeze the bag to expel most of the air, complete the seal. Place the double-bagged bottle kit in the bubble pack bag, remove the adhesive strip cover and seal the bubble bag closed. Place the kit in the cooler. NOTE: LLHg field blanks should not be placed on ice.

5. Complete Sample collection sheet as appropriate.

Materials Required for Sampling

1. Labels - Electronically generated adhesive backed labels with identifying LIMS barcode.

2. Bottles (per station, note: an equipment blank will require an additional set of sample containers a through l).

   a. Gallon (polyethylene) – General chemistry.

   b. 250-mL rectangular (polyethylene) – Alkalinity, chloride.

   c. 1/2 Gallon (polyethylene) – Cyanide.

   d. Quart (glass) – Phenol.

e. Quart (polyethylene) – Radiochemistry.

f. 900 mL (polyethylene – certified clean) – Dissolved metals.

g. 500-mL (glass) – Total organic carbon.

h. 8 oz. (polyethylene) – Trace metals (total).

i. 250-mL rectangular (polyethylene) – Sulfate.

j. Two quarts (glass) – n-Hexane extractable materials (2).

k. 250-mL rectangular (polyethylene) – Ammonia, NO2 + NO3, Fluoride.

l. 250-mL rectangular (polyethylene) - Total Phosphorus, Total Kjeldahl Nitrogen

m. Mercury Kit (General Use waters only; see Appendix I, Section E).

n. 1 liter brown, opaque (plastic) – Chlorophyll.

o. Two 4 oz. (polypropylene w/foil covered stopper) – Fecal coliform.

p. 300 mL (narrow-mouth glass w/ ground glass stopper) – Dissolved oxygen.

q. Three 40-mL vials (amber colored glass) – BETX.

r. Three 40-mL vials (amber colored glass); and 1 gallon (glass) – Organic priority pollutants and nonylphenols, .

3. Sampling Devices.

a. 13 quart stainless steel bucket and lid.

b. Stainless steel DO sampling device equipped with a lid and a fill tube that extends into the glass 300 mL DO sample bottle stopping just below the bottom. This device is designed to bleed sample into the bottle through the tube and the bottle is filled to overflowing inside the device to prevent turbulence and the formation of air bubbles while filling. Attached to this device is a stainless steel holder for a bacti-bottle.

c. Portable handheld electronic pH and temperature meter.

d. Sufficient length of 3/8-inch nylon rope (approximately 100 feet).

4. Miscellaneous.

a. Waterway Field Collection Sheet, for locations to be sampled.

b. 72-quart ice chests as needed.

c. Ice.

d. DO reagents.

e. Gray plastic container for storage of sampling rope during sampling events.

f. Wood tray to hold sample bottles with each compartment labeled with name of the sample bottle in the order the aliquot will be poured off.

g. Stainless steel stirring rod.

h. Two carboys of reagent water provided by the SAL.

Safety

1. DO NOT park District vehicle on a bridge. Attempt off-road parking, if possible.

2. Use rotating lights on the vehicle when stopped.

3. When parking on the road, use safety cone markers.

5. Wear red warning vests and life vests when bridge sampling.

6. Wear life vests when boat sampling.

5. Wear gloves and eye protection when handling DO reagents. Do not allow reagents to come into contact with each other outside of the DO bottle since they are extremely reactive.

6. When sampling during winter months, do not attempt to sample if the waterway is frozen. Do not walk on the ice. Indicate the circumstances on the sample collection sheet.

AMBIENT WATER QUALITY MONITORING PROJECT
QUALITY ASSURANCE PROJECT PLAN

APPENDIX II

SAMPLE COLLECTION SHEET

#1 **WEEK 1**

Des Plaines River Watershed

DATE COLLECTED: ____________ COLLECTED BY: ____________ WEATHER: ____________

DATA CODE	LOCATION	TIME	TEMPERATURE	GEN. CHEM. (gallon)	F.O.G. (glass quart x2)	ALK / CL (250mL rect.)	CYN. (1/2 gallon)	PHEN. (glass quart)	T.M. (8oz cylinder preserved x2)	SOL. T.M. (900mL)	BAC'T (4oz w/ foil x2)	D.O. (300mL w/ glass stopper)	RAD. (quart)	TOC (500mL glass)	PRIORTIY POLL. (amber gallon O-NP, 40mL vials x3 BETX)	SO4 (250mL rectangular)	CHLOROPHYLL, a (1L opaque brown)	LACHAT (250mL rect., 250mL preserved rect.)	pH	REMARKS
77	Higgins Creek, Upstream O'Hare WRP at Elmhurst Road										MST				BETA O-NP/OPP				6.5-9.0	LIMS#
78	Higgins Creek, Downstream, O'Hare WRP. At Wille Road										MST				BETA O-NP/OPP				6.5-9.0	LIMS#
	EQUIPMENT BLANK																			LIMS#
19	Des Plaines River at Belmont Ave.										MST				BETA O-NP/OPP				6.5-9.0	LIMS #
																			6.5-9.0	LIMS #
																			6.5-9.0	LIMS #

STORED AT 4°C YES ______ NO ______ IN CUSTODY OF ____________ METER # ____________

TRANSPORTED BY: ____________ VEHICLE # ____________

RELINQUISHED BY: ____________ DATE: ________ TIME: ________

RECEIVED BY LABORATORY: ____________ DATE: ________ TIME: ________

RELINQUISHED BY SAL LAB: ____________ RECEIVED BY CAL LAB: ____________

ATTACHMENT A: LABORATORY REPORTING LIMITS AND ILLINOIS POLLUTION CONTROL BOARD MINIMUM MEASUREMENT CRITERIA

Parameter	Reporting Limit (RL)	Minimum Measurement Criteria
Dissolved oxygen	NA	0.1 mg/L[1]
Temperature	NA	0.1 degree C[1]
pH	NA	0.1 pH unit[1]
Ammonia nitrogen	0.1 mg/L	15.0 mg/L
Ammonia nitrogen, un-ionized[2]	NA	0.1 mg/L[3]
Nitrate and nitrite nitrogen	0.15 mg/L	No standard
Kjeldahl nitrogen	1 mg/L	No standard
Phosphorus, total	0.2 mg/L	No standard
Sulfate	5 mg/L	500 mg/L
Total dissolved solids	60 mg/L	No standard
Suspended solids	4 mg/L	No standard
Volatile suspended solids	NA	No standard
Alkalinity	10 mg/L	No standard
Chloride	10 mg/L	500 mg/L
Fluoride	0.1 mg/L	15 mg/L[4]
Organic carbon, total	1 mg/L	No standard
Phenol	0.005 mg/L	0.1 mg/L
Cyanide, total	0.005 mg/L	0.1 mg/L[3]
Cyanide, chlorine amenable	0.001 mg/L	0.022 mg/L
Arsenic, total	0.05 mg/L	0.36 mg/L[3]
Barium, total	0.004 mg/L	5.0 mg/L[3]
Boron, total	0.05 mg/L	40.1 mg/L[5]
Calcium, total	1 mg/L	No standard
Chromium, trivalent[6]	0.005 mg/L	1.0 mg/L[3]
Chromium, hexavalent	6 µg/L	0.016 mg/L
Magnesium, total	1 mg/L	No standard

ATTACHMENT A: (Continued): LABORATORY REPORTING LIMITS AND ILLINOIS POLLUTION CONTROL BOARD MINIMUM MEASUREMENT CRITERIA

Parameter	Reporting Limit (RL)	Minimum Measurement Criteria
Manganese, total	0.001 mg/L	1.0 mg/L[3]
Mercury, total	0.0002 mg/L	0.0005 mg/L[3]
Mercury, low level, total	0.0005 µg/L	0.012 µg/L[7]
Selenium, total	0.005 mg/L	1.0 mg/L
Silver, total	0.001 mg/L	0.005 mg/L
Arsenic, dissolved	0.02 mg/L	340 µg/L
Cadmium, dissolved	0.001 mg/L	19.5 µg/L[4]
Chromium, dissolved	0.005 mg/L	968 µg/L[4]
Copper, dissolved	0.005 mg/L	27.3 µg/L[4]
Iron, dissolved	0.1 mg/L	0.5 mg/L[3]
Lead, dissolved	0.02 mg/L	160 µg/L[4]
Mercury, dissolved	0.0002 mg/L	1.2 µg/L
Nickel, dissolved	0.005 mg/L	148 µg/L[4]
Silver, dissolved	0.001 mg/L	11.4 µg/L[4,8]
Zinc, dissolved	0.01 mg/L	215 µg/L[4]
Fecal coliform	10 cfu/100 mL	200 cfu/100 mL[5]
n-Hexane extractable materials	3 mg/L	15 mg/L[3]
Gross alpha radioactivity	3 pCi/L[9]	No standard
Gross beta radioactivity	4 pCi/L[9]	100 pCi/L[5]
Chlorophyll	1 µg/L	No standard
Benzene	2 µg/L	310 µg/L
Ethyl benzene	2 µg/L	150 µg/L
Toluene	2 µg/L	2,000 µg/L

ATTACHMENT A: (Continued): LABORATORY REPORTING LIMITS AND ILLINOIS POLLUTION CONTROL BOARD MINIMUM MEASUREMENT CRITERIA

Parameter	Reporting Limit (RL)	Minimum Measurement Criteria
Xylenes	3 µg/L	920 µg/L
Organic priority pollutants[10]	Variable[11]	No standards
Nonylphenols	5 µg/L	No standard

NA = Not applicable.
[1]Required sensitivity.
[2]Calculated from pH, temperature, and ammonia nitrogen. Significant figures for pH, temperature, and ammonia nitrogen allow calculation to 0.01 mg/L.
[3]Indigenous Aquatic Life Use water quality standard only.
[4]Calculated standard based on a minimum water hardness of 200 mg/L as $CaCO_3$.
[5]General Use water quality standard only.
[6]Trivalent chromium measured as total chromium.
[7]Human Health Standard.
[8]CAWS A and B Aquatic Life Use water quality standard only.
[9]RL varies with total solids concentration of the sample
[10]Organic priority pollutants are identified in 40 CFR Part 122, Appendix D, Table II as amended.
[11]The RLs will be provided in the data report.

ATTACHMENT B: SAMPLING FREQUENCY

Station	Description	General Sampling[1]	n-Hexane Extractable Materials	Radio-Activity	BETX[2]	OPPs	Nonyl-phenols
96	Albany Avenue, North Branch Chicago River	Monthly 2nd Mon.		Monthly 2nd Mon.	Bi-monthly	Semi-annually	
112	Dempster Street, North Shore Channel	Monthly 2nd Mon.	Monthly 2nd Mon.	Monthly 2nd Mon.	Bi-monthly	Semi-annually	Quarterly
36	Touhy Avenue, North Shore Channel	Monthly 2nd Mon.	Monthly 2nd Mon.	Monthly 2nd Mon.	Bi-monthly	Semi-annually	Quarterly
73	Diversey Parkway, North Branch Chicago River	Monthly 2nd Mon.	Monthly 2nd Mon.		Bi-monthly	Semi-annually	
100	Wells Street, Chicago River	Monthly 3rd Mon.		Monthly 3rd Mon.	Bimonthl y	Semi-annually	
108	Loomis Street, South Branch Chicago River	Monthly 3rd Mon.	Monthly 3rd Mon.		Bi-monthly	Semi-annually	
99	Archer Avenue, South Fork South Branch Chicago River	Monthly 3rd Mon.	Monthly 3rd Mon.		Bi-monthly	Semi-annually	
75	Cicero Avenue, Chicago Sanitary & Ship Canal	Monthly 3rd Mon.	Monthly 3rd Mon.	Monthly 3rd Mon.	Bi-monthly	Semi-annually	Bimonthly
41	Harlem Avenue, Chicago Sanitary & Ship Canal	Monthly 3rd Mon.	Monthly 3rd Mon.	Monthly 3rd Mon.	Bi-monthly	Semi-annually	Bimonthly
48	Stephen Street, Chicago Sanitary & Ship Canal	Monthly 3rd Mon.	Monthly 3rd Mon.		Bi-monthly	Semi-annually	Quarterly
92	Lockport Powerhouse Chicago Sanitary & Ship Canal	Weekly Every Mon.	Monthly 3rd Mon.	Monthly 3rd Mon.	Bi-monthly	Semi-annually	Bimonthly

ATTACHMENT B (Continued): SAMPLING FREQUENCY

Station	Description	General Sampling[1]	n-Hexane Extractable Materials	Radio-Activity	BETX[2]	OPPs	Nonyl-phenols
86	Burnham Avenue, Grand Calumet River	Monthly 4th Mon.	Monthly 4th Mon.	Monthly 4th Mon.	Bi-monthly	Semi-annually	
56	Indiana Avenue, Little Calumet River	Monthly 4th Mon.	Monthly 4th Mon.	Monthly 4th Mon.	Bi-monthly	Semi-annually	Quarterly
76	Halsted Street, Little Calumet River	Monthly 4th Mon.	Monthly 4th Mon.	Monthly 4th Mon.	Bi-monthly	Semi-annually	Quarterly
57	Ashland Avenue, Little Calumet River	Monthly 4th Mon.		Monthly 4th Mon.	Bi-monthly	Semi-annually	
59	Cicero Avenue, Calumet-Sag Channel	Monthly 4th Mon.	Monthly 4th Mon.		Bi-monthly	Semi-annually	Quarterly
43	Route 83, Calumet-Sag Channel	Monthly 4th Mon.	Monthly 4th Mon.		Bi-monthly	Semi-annually	
19	Belmont Avenue, Des Plaines River	Monthly 1st Mon.		Monthly 1st Mon.	Bi-monthly	Semi-annually	
22	Ogden Avenue, Des Plaines River	Monthly 1st Mon.		Monthly 1st Mon.	Bi-monthly	Semi-annually	Quarterly
23	Willow Springs Road, Des Plaines River	Monthly 1st Mon.		Monthly 1st Mon.	Bi-monthly	Semi-annually	
91	Material Service Road, Des Plaines River	Monthly 1st Mon.		Monthly 1st Mon.	Bi-monthly	Semi-annually	
110	Springinsguth Road, West Branch DuPage River	Monthly 1st Mon.		Monthly 1st Mon.	Bi-monthly	Semi-annually	

ATTACHMENT B (Continued): SAMPLING FREQUENCY

Station	Description	General Sampling[1]	n-Hexane Extractable Materials	Radio-Activity	BETX[2]	OPPs	Nonyl-phenols
111	Arlington Drive, West Branch DuPage River	Monthly 1st Mon.		Monthly 1st Mon.	Bi-monthly	Semi-annually	Quarterly
79	Higgins Road, Salt Creek	Monthly 1st Mon.		Monthly 1st Mon.	Bi-monthly	Semi-annually	Quarterly
18	Devon Avenue, Salt Creek	Monthly 1st Mon.		Monthly 1st Mon.	Bi-monthly	Semi-annually	
109	Brookfield Avenue, Salt Creek	Monthly 1st Mon.		Monthly 1st Mon.	Bi-monthly	Semi-annually	
77	Elmhurst Road, Higgins Creek	Monthly 1st Mon.		Monthly 1st Mon.	Bi-monthly	Semi-annually	Bimonthly
78	Wille Road, Higgins Creek	Monthly 1st Mon.		Monthly 1st Mon.	Bi-monthly	Semi-annually	Bimonthly

[1]The parameters included in the general sampling performed monthly include temperature, pH, dissolved oxygen, fecal coliform, total metals, soluble metals, hexavalent chromium, ammonia nitrogen, combined nitrate and nitrite nitrogen, Kjeldahl nitrogen, total phosphorus, total cyanide, cyanide amenable to chlorination, phenol, alkalinity, chloride, fluoride, turbidity, total dissolved solids, total suspended solids, total organic carbon, and chlorophyll. General sampling excluded oil and grease, radioactivity, *E.coli*, BETX, priority organics, and nonylphenol.
[2]BETX is the sum of benzene, ethyl benzene, toluene, and xylenes.

APPENDIX E

CONTINUOUS DISSOLVED OXYGEN MONITORING
QUALITY ASSURANCE PROJECT PLAN

CONTINUOUS DISSOLVED OXYGEN MONITORING QUALITY ASSURANCE PROJECT PLAN

Revision 2.1

Effective Date: July 1, 2016

Organization: Metropolitan Water Reclamation District of Greater Chicago
Department of Monitoring and Research

Address: 100 East Erie Street
Chicago, Illinois 60611-2803

Telephone: (312) 751-5190

GROUP A: PROJECT MANAGEMENT

A1: Approval Sheet:

______________________________ Date 3/31/16
Thomas Granato
Director of Monitoring and Research

______________________________ Date 3-28-16
Thomas Minarik
Senior Aquatic Biologist
Monitoring and Research

______________________________ Date 3/28/16
John McNamara
Quality Assurance Coordinator
Monitoring and Research

A2: TABLE OF CONTENTS

A3: Distribution List

A copy of this Quality Assurance Project Plan (QAPP) will be distributed to each person signing the approval sheet and each person involved with project tasking identified in Section A4. A copy of this QAPP shall be available on request to any person participating in the project from any of the personnel listed in Section A4. Persons not employed by the Metropolitan Water Reclamation District of Greater Chicago (District) may obtain a copy of this QAPP from the District website under the "M&R Data and Reports" section.

As this document will be updated periodically, the reader is advised to check with the Network Coordinator for the latest revision if the version is more than one-year old. Revision 2.1 has been prepared following the United States Environmental Protection Agency guidance document EPA QA/R-5 titled "EPA Requirements for Quality Assurance Project Plans," March 2001.

A4: Project/Task Organization

The responsible persons for project management are:

Project Director:
Thomas Granato
Director of Monitoring and Research

Project Manager:
Thomas Minarik
Senior Aquatic Biologist

Network Coordinator:
Jennifer Wasik
Supervising Aquatic Biologist

Field Operations Manager:
Nick Kollias
Assistant Aquatic Biologist

Quality Assurance Officer:
John McNamara
Quality Assurance Coordinator

Figure 1 is the organization chart for the project. Primary lines of communication are shown as dashed lines. However, within the District, communication between any of the project participants may occur and is in fact encouraged as questions or issues arise.

Overall, project planning, including the selection of monitoring locations, is performed jointly by the Project Director, the Project Manager, and the Network

Coordinator. The Project Director is responsible for project staffing, funding, and the proper execution of the entire project. The Network Coordinator oversees the execution of routine project activities, resolves major deviations from procedures, assists in the final review of project reports and the QAPP.

The Project Manager coordinates day-to-day project activities, resolves minor deviations from procedures and ordinary quality control problems, supervises the data review, statistical analysis, management of the project database, preparation of project reports, and prepares and updates the QAPP.

The Field Operations Manager is responsible for the execution of field activities. A field team deploys the monitors, collects and preserves samples, makes field measurements, and transports the retrieved monitors and collected samples to the Aquatic Ecology and Water Quality Section. These activities are primarily done by boat, but certain monitoring stations require a land-based team. Two days each week are scheduled to retrieve and deploy the monitors at various monitoring stations.

The Aquatic Ecology and Water Quality Section maintains and calibrates the water quality monitors, downloads collected data from the monitors, and assists in the cross-sectional dissolved oxygen (DO) profiling performed at each monitoring location each spring, summer and fall. The Project Manager oversees the fabrication, installation, and maintenance of the protective housing needed for field deployment of the water quality monitors. An aquatic biologist (biologist) oversees field deployment and retrieval of the water quality monitors, reviews monitoring data for abnormalities, prepares time series plots of DO data, and directs the laboratory's quality control program.

The Quality Assurance (QA) Officer is responsible for oversight of quality control for the project and reviewing the QAPP.

A5: Problem Definition/Background

The Chicago Area Waterway System (CAWS) was designed in the 19^{th} century to convey Chicago's sewage and stormwater away from Lake Michigan, Chicago's primary source of drinking water. This was accomplished by the construction of the Chicago Sanitary and Ship Canal (CSSC) and the reversal of the flow in the Chicago River and South Branch Chicago River. Instead of flowing into Lake Michigan, the Chicago River and South Branch Chicago River now flow into the CSSC. The CSSC collects the area's treated sewage effluents and stormwater runoff and carries it into the Des Plaines River at the canal juncture south of Lockport. Major waterways in the CAWS include the North Shore Channel, the Chicago River, the North and South Branches of the Chicago River, the CSSC, Calumet River, Grand Calumet River, Little Calumet River, and the Calumet-Sag Channel. The District service area, including the CAWS is shown in Figure 2.

The data from this project will be used in conjunction with other District projects to determine overall water quality of the waterway system. These other projects include the Ambient Water Quality Monitoring project, which analyzes inorganic and organic parameters at 28 monitoring locations, and a biological survey project that assesses biological health by monitoring the diversity of biological species and their abundance at various locations in the waterway system.

The continuous DO monitoring data from the CAWS are also provided to the Illinois Environmental Protection Agency (IEPA) on a quarterly basis, as required by the District's National Pollutant Discharge Elimination System (NPDES) permits for the O'Brien and Calumet Water Reclamation Plants (WRPs).

A6: Project/Task Description

Currently, DO and water temperature is monitored at 19 locations in nine Chicago area waterways. The monitored waterways include the following rivers, man-made channels, and canals:

Chicago Waterway System
- North Shore Channel
- North Branch Chicago River
- South Branch Chicago River
- Bubbly Creek (South Fork South Branch Chicago River)
- Chicago Sanitary and Ship Canal

Calumet Waterway System
- Little Calumet River
- Calumet-Sag Channel

Des Plaines Waterway System
- Des Plaines River
- Salt Creek

The CDOM program was initiated at 20 locations during the summer of 1998. These monitoring locations were concentrated on the North Shore Channel, the North Branch Chicago River, the Chicago River, the South Branch Chicago River, Bubbly Creek, the CSSC, and the Calumet-Sag Channel. The monitoring location on the Des Plaines River at Jefferson Street, Joliet, and the location on the Chicago River at the Chicago River Lock and Michigan Avenue were added in 2000. An additional 11 monitoring locations were added in 2001. These included additional locations on the Calumet-Sag Channel and locations on the Grand Calumet River, the Little Calumet River, and the Calumet River. An additional Bubbly Creek monitoring location at 36th Street was added in 2002. During 2004 a monitoring location was added at Foster Avenue on the North Shore Channel. During 2005 an additional 11 monitoring locations were added. These locations monitor Salt Creek and additional reaches of the Des Plaines River, Grand Calumet River, Little Calumet River, and North Branch Chicago River. During 2011, the CDOM program was reassessed and reduced to a total of 18 stations, 13 in the deep draft and five in wadeable locations. In 2014 the deep draft location at Cicero Avenue on the Calumet-Sag Channel was reactivated.

Descriptions of all monitoring locations, both active and inactive, are provided in Tables 1, 2, and 3. Table 1 lists all monitoring locations and service history. Table 2 shows the latitude and longitude of each monitoring location. Table 3 gives the IPCB waterway classification and IPCB DO water quality standard at each monitoring location. Figure 2 is a map showing the active monitoring locations.

The locations of the monitoring stations are reviewed at least annually. Monitoring location changes may occur over time for logistical or safety reasons, or to respond to different monitoring objectives that may arise.

A7: Quality Objectives and Criteria for Measurement Data

Measurement data must be accurate enough to determine compliance with the applicable IPCB DO water quality standards. The DO standards are stated to tenths of a milligram per liter (mg/L). Therefore, measurements of DO should be accurate to ± 0.1 mg/L.

The IPCB water quality standards for temperature specify the maximum allowable water temperature and maximum allowable temperature rises resulting from, for example, the discharge of heated effluents. These standards are stated in degrees Fahrenheit (°F), or to tenths of degrees Celsius (°C) following conversion of the standard from degrees F to degrees C. While these standards are presently not a primary concern of this project, temperature measurements to ± 0.5°C or less are necessary to ensure the accuracy of the recorded DO measurements, as these measurements are affected by temperature.

A8: Special Training/Certification

The tasking of the project has been assigned to personnel with appropriate job classifications. Project personnel are trained on the job to perform their assigned technical activities. No additional special training or certifications are required for the project.

A9: Documents and Records

Project Data and Reports

The Network Coordinator maintains the following project records and reports:

1. Monitoring data are stored in a custom designed Microsoft® SQL Server 2014 database. The DO database is backed up weekly.

2. Field observations performed during monitor retrieval and deployment are stored electronically in an Excel® spreadsheet.

3. Laboratory calibration and maintenance records are stored electronically in an Excel® spreadsheet.

4. Seasonal cross-sectional DO surveys at each monitoring station are stored electronically in an Excel® spreadsheet.

5. Statistical summary tables and graphs depicting hourly data are prepared weekly with Excel® software.

<u>Other Reports and Communications</u>

1. The Network Coordinator shall retain copies of all correspondence related to the transmittal of project data to the IEPA and retain electronic copies of data transmittals.

2. The Project Manager and Network Coordinator shall retain copies of annual M&R reports pertaining to continuous DO monitoring.

3. The Network Coordinator and QA Officer shall retain copies of all annual updates and revisions of this QAPP.

4. The Network Coordinator shall retain copies of all sampling procedures and analytical procedures used for collection and analysis of project samples.

5. The Network Coordinator and Project Manager shall retain copies of all laboratory analytical reports and correspondence with other laboratories.

6. The Project Manager and Network Coordinator shall retain copies of all management reports pertinent to continuous DO monitoring.

7. The Project Manager and Network Coordinator shall retain copies of all communications pertinent to continuous DO monitoring to and from outside agencies and other interested parties.

All of the records and reports listed above will be retained for a minimum of ten years at the Cecil Lue-Hing Research and Development Complex located at the Stickney WRP.

GROUP B: DATA GENERATION AND ACQUISITION

B1: Sampling Process Design (Experimental Design)

Selection of Monitoring Locations

Forty-eight locations have been selected for DO monitoring in the Chicago area waterways (Table 1) since the inception of this project. Of these, 19 are currently actively monitored. The criteria used to select these locations were:

1. A history of low DO levels,

2. Above and below the confluence of major waterways,

3. Proximity to an artificial aeration station,

2. Above and below the major WRPs,

5. Below pumping stations, such as the North Branch and Racine Avenue, and below discretionary Lake Michigan diversion locations,

6. Proximity to ambient biological monitoring locations.

To ensure the suitability of a sampling location, cross-sectional DO profiles are made at each site to verify the uniformity of DO concentrations. Uniform cross-sectional DO at a monitoring location is necessary to ensure that representative DO measurements could be obtained from a single DO monitor. Cross-sectional DO profiles are routinely repeated three times each year (spring, summer, and fall) at each monitoring location to verify that cross-sectional uniformity of DO concentrations has been maintained.

Monitoring locations may be added or removed from the monitoring network based upon periodic assessments of monitoring needs and available resources. Table 1 shows the monitoring history of monitoring locations used for this project.

Measurement Frequency

The DO concentration at any point in a waterway is subject to many influences. Measurements taken at infrequent intervals, such as weekly or even daily, may be insufficient to adequately characterize fluctuations that may occur during wet weather events or diurnal fluctuations that may occur in wadeable waterways. Previous monitoring has shown that hourly measurements will record these changes and allow for a more comprehensive understanding of DO behavior in the Chicago area waterways. After CDOM has been conducted for a suitable amount of time at a given station, it may not be necessary to continue such intensive monitoring until conditions change in that waterway due to operational upgrades, completion of reservoirs, or changes in lake diversion amounts, for instance.

Parameters Measured and Information Monitored

When DO measurements are taken, it is important to record water temperature since the DO saturation concentration will increase as temperature decreases. Specific conductivity is also measured at continuous monitoring locations. Available information related to lake water diversions, precipitation, and recorded CSOs into the waterways, is also used to interpret the collected DO data.

B2: Sampling Methods

The water quality monitors used for this project are programmed to record DO, specific conductivity, and temperature measurements at hourly intervals. The alkaline batteries used by the monitors (AA or C cells) generally allow field deployment a period of at least three weeks. The monitors are exchanged in prescheduled batches, on Tuesdays and Wednesdays. Rarely, usually because of inclement weather, monitors may be in the field for extended periods during which they will continue to collect measurement data until the batteries are exhausted. In one instance, monitors were found to be operational after having been under ice for two months.

The monitors are secured in eight-inch stainless steel pipes to protect them from marine vessels, debris, and vandalism. The monitors are typically deployed inside a 12- to 15-foot pipe vertically mounted on the side of a suitable bridge abutment, dolphin, or seawall. The monitors are generally positioned two to three feet below the water surface. These pipes have numerous two-inch openings in the pipe wall to allow water to flow freely through the housing and around the monitor, thereby ensuring accurate water quality measurements.

B3: Sample Handling and Custody

The newly prepared and calibrated monitors are transported to the monitoring stations in coolers that contain enough tap water to saturate the air inside the cooler with humidity. The monitors that are retrieved from the waterway are placed in the same coolers for transport back to the laboratory. When the monitors arrive in the Aquatic Ecology and Water Quality Section Laboratory, they are suspended vertically in a water-filled tank referred to as the "receiving tank."

When a monitor is deployed at a sampling location, a calibrated hand-held DO meter is used to measure DO and temperature in situ just prior to deployment at the same depth and location. The results are recorded on the field data sheet.

B4: Analytical Methods

Each DO monitor utilizes a DO probe, conductivity probe, and a thermistor to measure water temperature. The DO probes utilize optical DO sensors. The optical DO sensor measures the lifetime of the luminescence, which is inversely proportional to the amount of oxygen present. The DO probe calibration is performed with a single point adjustment to 100 percent DO saturation. The conductivity sensor measures the voltage drop between the electrodes and converts it to specific conductance. Temperature is measured with a thermistor that changes in proportion to resistance with temperature variation.

For this project, the water in the monitor storage tank is used as the reference sample for monitor performance evaluations. The DO of the storage tank water is determined using the Winkler method as given in Standard Methods, Method 4500-O C, "Azide Modification" (Standard Methods, 2005). The monitors used for the project automatically compensate for temperature-induced changes. The use of monitors to obtain in situ DO measurements eliminates errors associated with sample handling and storage when grab samples are collected for wet chemistry DO analysis.

Independent DO readings are taken with a calibrated DO meter at each monitoring location when freshly calibrated monitors are deployed for corroborating DO analysis in the laboratory.

B5: Quality Control

Daily performance checks of the DO probes are made while the monitors are maintained in a ready state in the laboratory prior to field deployment.

Monitors are recalibrated whenever the monitor DO is not within ± 0.2 mg/L of the Winkler DO measurement of the storage tank water.

The automatic collection of DO and temperature data does not lend itself to the use of quality control measures that would normally be employed in the laboratory analysis of samples. Therefore, great care is exercised in the calibration of monitors and verification that each monitor has maintained its calibration after deployment.

To verify that data collected by each monitor is accurate, the following quality control measures are employed:

1. Verification of the accuracy of each monitor after retrieval against a 100 percent DO saturation check.

2. Checking the last field DO measurement made by each monitor against a calibrated handheld portable DO meter reading taken in the waterway next to the deployed monitor.

If acceptance criteria for these measurement verifications are not met, the data collected by that monitor may be rejected. Sections B10 and D1 detail these verification procedures.

B6: Instrument Testing, Inspection, and Maintenance

In addition to the monitors that are at all times deployed at the active monitoring sites, a number of monitors are kept in controlled storage in the laboratory after being prepared for deployment the following week. Other monitors that are not deployed, or are not being prepared for deployment, are available to replace those monitors that require servicing that cannot be performed in the laboratory.

The monitors are maintained as required by the manufacturer's manuals and the laboratory SOPs (Vick, 2016; YSI, 2011; Manta, 2015). Inventoried parts and supplies include batteries, o-rings, wiper assemblies, calibration standards for the conductivity sensors, and temperature/conductivity sensors.

When the monitors are returned to the laboratory, the field data is downloaded (see Section B10), and the monitors are cleaned of surface debris. The monitor probes are cleaned and inspected for damage with a 5-40 power microscope.

The thermistor in each monitor is checked annually against a certified thermometer traceable to a National Institute of Standards and Technology (NIST) standard. When the error of the thermistor exceeds 0.5°C, the temperature/conductivity sensor is changed. If the temperature measurement is still beyond the acceptance range, the monitor is returned to the manufacturer for service.

B7: Instrument Calibration and Frequency

Monitors awaiting field deployment are stored in the Aquatic Ecology and Water Quality Section Laboratory in water-filled, stainless steel holding tanks. While suspended vertically in these tanks, each DO sensor is checked at least once daily, Monday through Friday, against the Winkler DO measurement of the water in the holding tank. A monitor is recalibrated to 100 percent DO saturation whenever the sensor DO is more than $\pm$ 0.2 mg/L from the Winkler DO.

Monitors that are scheduled for deployment are checked twice on the day before deployment. On the day of scheduled deployment the DO sensor is calibrated to 100 percent DO saturation.

B8: Inspection/Acceptance of Supplies and Consumables

Supplies and consumables shall be inspected by a technician in the Aquatic Ecology and Water Quality Section and accepted only if they satisfy all specifications for the intended use.

B9: Non-direct Measurements

Non-direct measurements are not required for this project.

B10: Data Management

Every three weeks the 19 deployed water quality monitors are exchanged with cleaned and newly calibrated monitors. The retrieved monitors are brought back to the Aquatic Ecology and Water Quality Laboratory and placed in the receiving tank. The following morning, each monitor is checked for accuracy by verification to a 100 percent DO saturation check. While still in the receiving tank, the DO, temperature, and conductivity data collected during the deployed period are downloaded from each monitor data logger into the project Microsoft® SQL Server 2014 database by a laboratory technician. The DO measurements are corrected for initial error and instrument drift using the observed errors from the 100 percent DO saturation calibration taken on the morning of deployment and the 100 percent DO saturation check taken the morning after retrieval (Wagner, 2006). Sensor drift is assumed to be linear over deployment period, and the DO correction is calculated for each hourly measurement.

A biologist prepares a hard copy of the hourly DO data recorded at each monitoring station in service during the past deployment and a summary of the temperature and specific conductivity. A biologist reviews the hourly DO data and summarized temperature and specific conductivity data for inconsistent measurements and highlights them for later review by a second biologist.

A biologist then transfers the hourly DO values for all monitoring stations from the Microsoft® SQL Server 2014 database into an Excel® application using Access®. A statistical summary table of the week's data is then prepared for the monitoring stations in each waterway system. The summary table prepared for a monitoring station lists the number of DO measurements, the mean, the minimum recorded DO, the maximum recorded DO, and the percent of DO measurements above the applicable DO water quality standard (Appendix I). A biologist also prepares a graph of the hourly DO measurements for each monitoring station (Appendix II).

Following each storm event, the Maintenance and Operations Department (M&O) prepares a storm report that details the rainfall amount, pumping station overflows, and back flows to Lake Michigan. The storm report is available to laboratory staff via Microsoft Outlook®.

M&O personnel also compile the daily flow information for Lake Michigan discretionary diversion. The discretionary diversion data is transmitted to the Aquatic Ecology and Water Quality Section on a monthly basis.

A biologist assesses the total rainfall recorded at rain gauges throughout the District's service area in order to determine whether a storm event occurred in a specific geographic area during the monitoring period. Overflows at the North Branch, Racine Avenue, and 125th Street Pumping Stations are evaluated by a biologist to interpret the impact at monitoring stations on the North Branch of the Chicago River, CSSC (above the Stickney WRP outfall), and the Little Calumet River, respectively. A biologist reviews the daily discretionary diversion flows at the Wilmette Pumping Station, Chicago River Controlling Works, and O'Brien Lock to determine the effects at monitoring stations on the North Shore Channel (above the North Side WRP outfall), South Branch Chicago River, and the Little Calumet River, respectively.

Then a biologist reviews and verifies the field DO data following the guidance provided in the IEPAs Standard Operating Procedure for Continuous Monitoring of Water Quality (IEPA, 2014). The criteria used to review and validate the DO data are stated in Section D1. The biologist also considers the rain and flow information as well as best professional judgment when verifying the DO data. All DO data that fail the review criteria and are considered to be erroneous are marked as data lost in the database. Following the data review process, the biologist revises the weekly DO summary tables and DO hourly plots as necessary.

GROUP C: ASSESSMENT AND OVERSIGHT

C1: Assessment and Response Actions

Routine assessments are not used in this project.

C2: Reports to Management

The Project Manager and all those on the approval list will receive from the Network Coordinator all investigation and corrective action reports concerning quality control problems and other non-conformance issues from field personnel and participating laboratories.

Project related systems audits or special data quality assessments are not undertaken.

GROUP D: DATA VALIDATION AND USABILITY

D1: Data Review, Verification, and Validation

A biologist reviews and verifies the field DO data. The field data from any water quality monitor may be rejected following review of these quality control checks:

1. Accuracy of Retrieved Monitors

   The monitor in the laboratory receiving holding tank is given a post calibration check to 100 percent DO saturation. A difference of more than 0.4 mg/L is used as a rejection criterion for the batch of field collected data. This check is done to evaluate inaccuracies due to calibration drift.

2. Comparison of Monitor DO Measurement with Meter Measurement

   A DO meter reading is taken in close proximity to the protective enclosure during the exchange of monitors by a calibrated handheld DO meter. The DO measured from the meter is compared with the last DO measurement of the retrieved monitor. The relative percent difference is calculated and if it is greater than 20 percent and the absolute magnitude is greater than 0.3 mg/L, this will alert the biologist of a possible problem and may result in the rejection of the entire batch of field data. If evidence suggests that there were conditions in the waterway at the time of the meter measurement that can explain a difference greater than 20 percent, the reviewers may accept the data. This check is done to evaluate total inaccuracies attributed to fouling drift and calibration drift.

Additional review of the field data is necessary to verify continuous monitoring data. Situations can arise where portions of a batch of data may need to be rejected if, for example, the equipment malfunctioned in the middle of a deployment, the monitor experienced a period of time out of the water due to a draw down or vandalism, or the monitor recorded momentary spikes in the data. The reviewers will use best professional judgement, the rain data, diversion data, and CSO data to help make these decisions. An electronic file is kept to record all deployment dates and justifications for lost data.

D2: Verification and Validation Methods

The Project Manager and the QA Officer shall be informed of all situations where data integrity has been found compromised by errors, including storage of incorrect data or the corruption of stored data. All responsible persons identified in Section A4, and all known data users shall be informed of data problems when they are discovered and the corrective action taken. The QA Officer shall prepare the disclosure report for distribution.

D3: Reconciliation with User Requirements

The QAPP shall govern the operation of the project at all times. Each responsible person listed in Section A4 shall adhere to the procedural requirements of the QAPP and ensure that subordinate personnel do likewise.

This QAPP shall be reviewed annually to ensure that the project will achieve all intended purposes. All the responsible persons listed in Section A4 shall participate in the review of the QAPP. The annual review shall address every aspect of the program including:

1. The accuracy of the information contained in the QAPP and incorporation of changes made since its completion.
2. The adequacy and location of monitoring stations.
3. The adequacy of measurement frequency at each location.
4. Sampling procedures.
5. Analytical procedures.
6. The appropriateness of parameters monitored.
7. Changes in data quality objectives and minimum measurement criteria.
8. Whether the data obtained met minimum measurement criteria.
9. Corrective actions taken during the previous year for field and laboratory operations.
10. The adequacy of quality control procedures.
11. All interim reports and annual project report.
12. Review of other user requirements and recommendations.

The project will be modified as directed by the Project Director. The Project Manager shall be responsible for the implementation of changes to the project and shall document the effective date of all changes made.

It is expected that, from time to time, ongoing and perhaps unexpected changes will need to be made to the project. Significant changes or deviations in the operation of the project shall not be made without authorization by the Project Director. The need for a change in project operation should be conveyed to the Network Coordinator. Data users and other interested persons may also suggest changes to the project to the Network Coordinator.

The Network Coordinator shall evaluate the need for the change, consult with the Project Manager and others as appropriate, and make a recommendation to the Project Director for approval. The Network Coordinator shall, in a timely manner, inform the appropriate project personnel of approved changes in project operation.

Following approval, a memorandum documenting each authorized change shall be prepared by the Network Coordinator and distributed to all the responsible persons listed in Section A4. Approved changes shall be considered an amendment to the QAPP and shall be incorporated into the QAPP when it is updated.

Following the annual QAPP review, the Project Manager will prepare an updated version of the QAPP with the assistance of the QA Officer.

REFERENCES

Illinois Environmental Protection Agency, Bureau of Water. Document Control number 202. Standard Operating Procedure for Continuous Monitoring of Water Quality. Revision No. 1. June 26, 2014.

Manta 2, Sub 2, and Sub 3, Water Quality Multiprobe Manual, Eureka Water Probes, February, 2015.

Standard Methods for the Examination of Water and Wastewater, Prepared and published jointly by the American Public Health Association, the American Water Works Association and the Water Environment Federation, Washington, D.C., 21st edition, 2005.

Vick, J.A., Laboratory Servicing Procedures for Continuous Dissolved Oxygen Monitors, Environmental Monitoring and Research Division Laboratory, MWRDGC, July 1, 2016.

Wagner, R.J., R.W. Boulger Jr., C.J. Oblinger, and B.A. Smith. 2006. Guidelines and Standard Operating Procedures for Continuous Water-Quality Monitors: Station Operation, Record Computation, and Data Reporting. Techniques and Methods 1-D3. United States Geological Survey. Reston, VA.

YSI Incorporated, Environmental Monitoring Systems Operations Manual, Revision H, November, 2011.

FIGURE 1: CONTINUOUS DISSOLVED OXYGEN MONITORING
PROJECT ORGANIZATION CHART

```
|---Project Director
|    (Planning, decision making, staffing, and
|          ultimate execution of project)
|
O----Project Manager
|   | (Project planning,, execution, and reporting,
|   |  troubleshoot database issues, QAPP preparation,
                 and supervise data review)
|   |
O----O---QA Officer
|   |   | (Project QA/QC, review of QAPP)
|   |   |
O----O---O- Network Coordinator
    |  |  | (Coordination of project activities, review
    |  |  |                 of M&R reports, review of monitoring data,
    |  |  |                 review of QAPP, provide data to IEPA)
    |  |  |
    |  O--O-- Field Operations Manager
    |  |  |    (Execution of field activities by field team)
    |  |  |          |
    |  |  |     Field Team
    |  |  |     | (Monitor deployment, field measurements, and
    |  |  |     |  transport of monitors and samples)
    |  |  |
    |  O--O—-
    O------O-- AEWQ Laboratory Technicians and Biologists
                                   (Analysis of DO water samples, calibrate DO
                                   sensors, clean and maintain water quality
                                   monitors, download data from monitors,
                                   conduct cross-sectional DO surveys, review of monitoring
                                   data, preparation of statistical summaries and DO graphs,
                                   and collection of auxiliary information.)
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FIGURE 2: CURRENTLY ACTIVE CONTINUOUS DISSOLVED OXYGEN MONITORING STATIONS

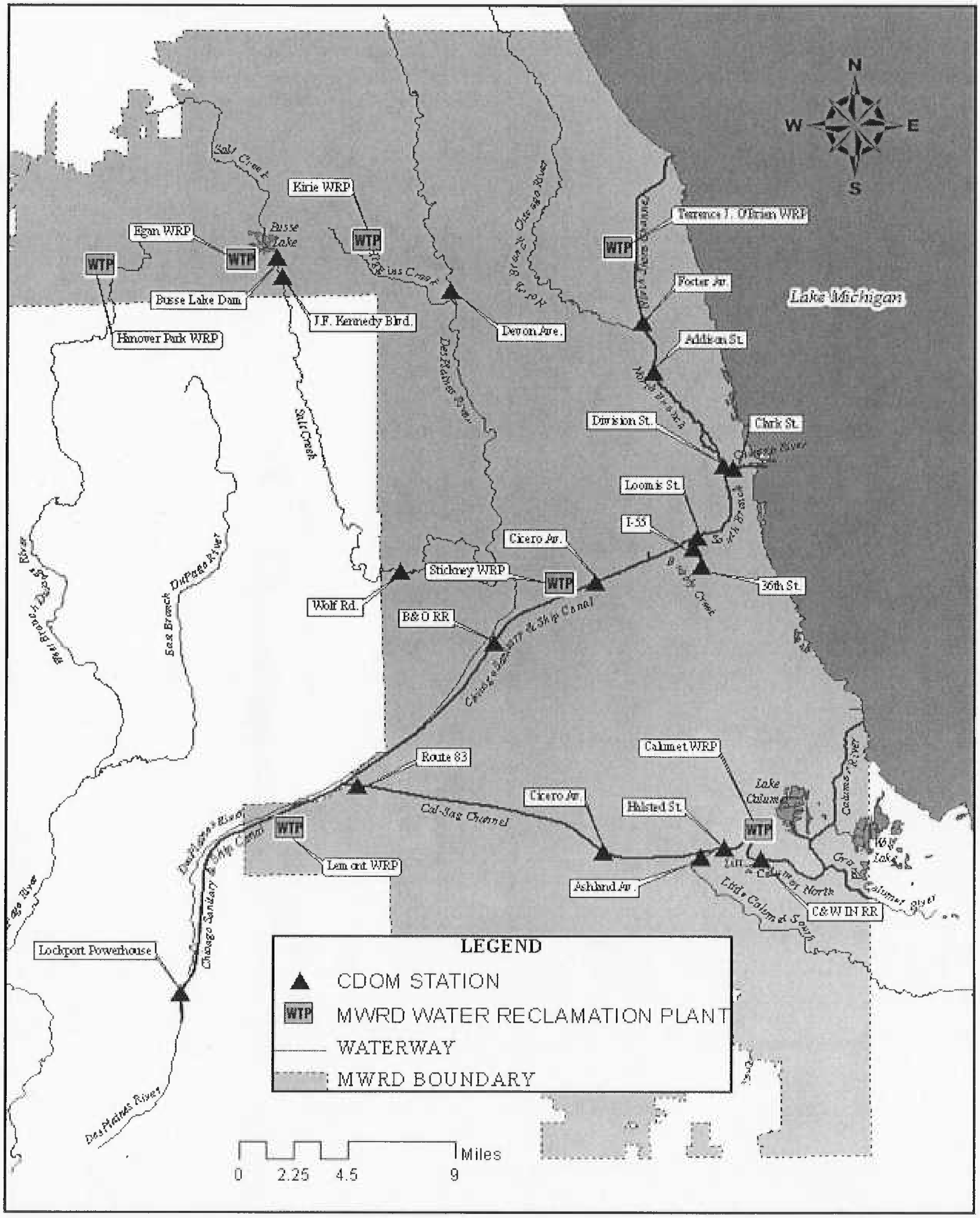


TABLE 1: SAMPLING HISTORY AT EACH MONITORING LOCATION

Loc. ID	Continuous DO Monitoring Location	Time Period DO Measured Hourly at Location	Status
1	Linden St., North Shore Channel	August 1998 - March 2004	Inactive
2	Simpson St., North Shore Channel	August 1998 - March 2004	Inactive
3	Main St., North Shore Channel	August 1998 - Dec. 2010	Inactive
4	Devon Ave., North Shore Channel	August 1998 - January 2001	Inactive
57	Foster Ave., North Shore Channel	August 2004 – Present	Active
66	Central Park Ave., North Branch Chicago River	July 2005 – April 2013	Inactive
5	Lawrence Ave., North Branch Chicago River	August 1998 - January 2001	Inactive
6	Addison St., North Branch Chicago River	August 1998 – Present	Active
7	Fullerton Ave., North Branch Chicago River	August 1998 - Dec. 2010	Inactive
8	Division St., North Branch Chicago River	August 1998 – March 2004, June 2013 – Present	Active
9	Kinzie St., North Branch Chicago River	August 1998 – June 2013	Inactive
21	Chicago River Controlling Works, Chicago River	March 2000 - March 2004	Inactive
22	Michigan Ave., Chicago River	March 2000 - March 2004	Inactive
10	Clark St., Chicago River	August 1998 – Dec. 2010, May 2012 – Present	Active
11	Jackson Blvd., South Branch Chicago River	August 1998 - March 2004	Inactive
12	Loomis St., South Branch Chicago River	August 1998 - January 2001, April 2003 – Present	Active
49	36th St., Bubbly Creek	June 2002 – Present	Active
13	I-55, Bubbly Creek	August 1998 - January 2001 April 2002 – Present	Active
14	Cicero Ave., Chicago Sanitary & Ship Canal	August 1998 – Present	Active
15	B&O Central RR, Chicago Sanitary & Ship Canal	August 1998 – Present	Active
16	Route 83, Chicago Sanitary & Ship Canal	August 1998 - Dec. 2010	Inactive
17	River Mile 302.6, Chicago Sanitary & Ship Canal	August 1998 - March 2004	Inactive
18	Romeoville Rd., Chicago Sanitary & Ship Canal	August 1998 - March 2004	Inactive
19	Lockport Powerhouse, Chgo. Sanitary & Ship Canal	August 1998 – Present	Active
58	Devon Ave., Des Plaines River	October 2005 – Dec. 2010, May 2011 – Present	Active
62	Irving Park Rd., Des Plaines River	July 2005 – May 2011	Inactive
63	Ogden Ave., Des Plaines River	July 2005 - Dec. 2010	Inactive
64	Material Service Rd., Des Plaines River	October 2005 - Dec. 2010	Inactive
23	Jefferson St., Des Plaines River	March 2000 - Dec. 2010	Inactive
31	130th St., Calumet River	July 2001 - March 2004	Inactive
67	Hohman Ave., Grand Calumet River	July 2005 - April 2008	Inactive
32	Torrence Ave., Grand Calumet River	July 2001 - Dec. 2010	Inactive
33	Conrail RR, Little Calumet River	July 2001 - March 2004	Inactive
34	C&W Indiana RR, Little Calumet River	July 2001 - Present	Active
35	Halsted St., Little Calumet River	July 2001 - Present	Active
65	Wentworth Ave., Little Calumet River	July 2005 - Dec. 2010	Inactive
36	Ashland Ave., Little Calumet River	July 2001 - Present	Active
37	Division St., Calumet-Sag Channel	July 2001 - March 2004	Inactive
38	Kedzie Ave., Calumet-Sag Channel	July 2001 - March 2004	Inactive
39	Cicero Ave., Calumet-Sag Channel	July 2001 – Dec. 2010, March 2014 – Present	Active

TABLE 1 (Continued): SAMPLING HISTORY AT EACH MONITORING LOCATION

Loc. ID	Continuous DO Monitoring Location	Time Period DO Measured Hourly at Location	Status
40	River Mile 311.7, Calumet-Sag Channel	July 2001 - November 2004	Inactive
41	Southwest Hwy., Calumet-Sag Channel	July 2001 - March 2004	Inactive
42	104th Ave., Calumet-Sag Channel	July 2001 - October 2010	Inactive
20	Route 83, Calumet-Sag Channel	August 1998 - Present	Active
68	Busse Woods Main Dam, Salt Creek	October 2005 - Present	Active
59	J. F. Kennedy Blvd., Salt Creek	July 2005 - Present	Active
60	Thorndale Ave., Salt Creek	July 2005 - March 2009	Inactive
61	Wolf Rd., Salt Creek	July 2005 - Present	Active

TABLE 2: LATITUDE AND LONGITUDE OF MONITORING LOCATIONS

Loc. ID	Continuous DO Monitoring Location	Latitude	Longitude
1	Linden St., North Shore Channel	42° 04.390'	87° 41.140'
2	Simpson St., North Shore Channel	42° 03.350'	87° 42.400'
3	Main St., North Shore Channel	42° 02.010'	87° 42.570'
4	Devon Ave., North Shore Channel	41° 59.820'	87° 42.610'
57	Foster Ave., North Shore Channel	41° 58.5660'	87° 42.2860'
66	Central Park Ave., North Branch Chicago River	41° 58.3790'	87° 42.0882'
5	Lawrence Ave., North Branch Chicago River	41° 58.100'	87° 42.020'
6	Addison St., North Branch Chicago River	41° 56.790'	87° 41.720'
7	Fullerton Ave., North Branch Chicago River	41° 55.520'	87° 40.450'
8	Division St., North Branch Chicago River	41° 54.210'	87° 39.430'
9	Kinzie St., North Branch Chicago River	41° 53.440'	87° 38.330'
21	Chicago River Lock, Chicago River	41° 53.280'	87° 36.580'
22	Michigan Ave., Chicago River	41° 53.340'	87° 37.370'
10	Clark St., Chicago River	41° 53.241'	87° 37.893'
11	Jackson Blvd., South Branch Chicago River	41° 53.911'	87° 38.135'
12	Loomis St., South Branch Chicago River	41° 50.747'	87° 39.662'
49	36th St., South Fork South Branch Chicago River	41° 49.071'	87° 39.437'
13	I-55, South Fork South Branch Chicago River	41° 50.648'	87° 39.878'
14	Cicero Ave., Chicago Sanitary & Ship Canal	41° 49.169'	87° 44.616'
15	B&O RR Bridge, Chicago Sanitary & Ship Canal	41° 46.990'	87° 49.540'
16	Route 83, Chicago Sanitary & Ship Canal	41° 42.420'	87° 55.750'
17	River Mile 302.6, Chicago Sanitary & Ship Canal	41° 41.240'	87° 58.470'
18	Romeoville Rd., Chicago Sanitary & Ship Canal	41° 38.450'	88° 03.549'
19	Lockport Powerhouse, Chicago Sanitary & Ship Canal	41° 34.277'	88° 04.711'
58	Devon Ave., Des Plaines River	41° 59.7633'	87° 51.5629'
62	Irving Park Rd., Des Plaines River	41° 57.1905'	87° 51.2461'
63	Ogden Ave., Des Plaines River	41° 49.2501'	87° 48.6311'
64	Material Service Rd., Des Plaines River	41° 35.7913'	88° 04.1275'
23	Jefferson St., Des Plaines River	41° 31.489'	88° 05.155'
31	130th St., Calumet River	41° 39.619'	87° 34.195'
67	Hohman Ave., Grand Calumet River	41° 37.4546'	87° 31.0777'
32	Torrence Ave., Grand Calumet River	41° 38.652'	87° 33.542'
33	Conrail RR, Little Calumet River	41° 38.345'	87° 33.955'
34	C&W Indiana Harbor Belt RR, Little Calumet River	41° 39.026'	87° 36.695'
35	Halsted St., Little Calumet River	41° 39.431'	87° 38.450'
65	Wentworth Ave., Little Calumet River	41° 35.1058'	87° 31.7625'
36	Ashland Ave., Little Calumet River	41° 39.110'	87° 39.625'
37	Division St., Calumet-Sag Channel	41° 39.160'	87° 40.250'
38	Kedzie Ave., Calumet-Sag Channel	41° 39.120'	87° 41.920'
39	Cicero Ave., Calumet-Sag Channel	41° 39.345'	87° 44.313'
40	River Mile 311.7, Calumet-Sag Channel	41° 40.626'	87° 47.532'
41	Southwest Hwy., Calumet-Sag Channel	41° 40.812'	87° 48.642'

TABLE 2 (Continued): LATITUDE AND LONGITUDE OF MONITORING LOCATIONS

Loc. ID	Continuous DO Monitoring Location	Latitude	Longitude
42	104th Ave., Calumet-Sag Channel	41° 41.352'	87° 53.052'
20	Route 83, Calumet-Sag Channel	41° 41.810'	87° 56.480'
68	Busse Woods Main Dam, Salt Creek	42° 01.0089'	88° 00.0289'
59	J. F. Kennedy Blvd., Salt Creek	42° 00.3152'	87° 59.7498'
60	Thorndale Ave., Salt Creek	41° 59.0307'	87° 59.4212'
61	Wolf Rd., Salt Creek	41° 49.5759'	87° 54.0781'

TABLE 3: ILLINOIS POLLUTION CONTROL BOARD USE CLASSIFICATION AND DISSOLVED OXYGEN STANDARD AT EACH MONITORING LOCATION

Loc. ID	Continuous DO Monitoring Location	IPCB Classification	DO Standard
1	Linden St., North Shore Channel	CAWS ALU A	3.5-5.0[1]
2	Simpson St., North Shore Channel	CAWS ALU A	3.5-5.0[1]
3	Main St., North Shore Channel	CAWS ALU A	3.5-5.0[1]
4	Devon Ave., North Shore Channel	CAWS ALU A	3.5-5.0[1]
57	Foster Ave., North Shore Channel	CAWS ALU A	3.5-5.0[1]
66	Central Park Ave., North Branch Chicago River	General Use	3.5-6.0[2]
5	Lawrence Ave., North Branch Chicago River	CAWS ALU A	3.5-5.0[1]
6	Addison St., North Branch Chicago River	CAWS ALU A	3.5-5.0[1]
7	Fullerton Ave., North Branch Chicago River	CAWS ALU A	3.5-5.0[1]
8	Division St., North Branch Chicago River	CAWS ALU A	3.5-5.0[1]
9	Kinzie St., North Branch Chicago River	CAWS ALU A	3.5-5.0[1]
21	Chicago River Lock, Chicago River	General Use	3.5-6.0[2]
22	Michigan Ave., Chicago River	General Use	3.5-6.0[2]
10	Clark St., Chicago River	General Use	3.5-6.0[2]
11	Jackson Blvd., South Branch Chicago River	CAWS ALU A	3.5-5.0[1]
12	Loomis St., South Branch Chicago River	CAWS ALU A	3.5-5.0[1]
49	36th St., South Fork South Branch Chicago River	Indigenous ALU	4.0
13	I-55, South Fork South Branch Chicago River	Indigenous ALU	4.0
14	Cicero Ave., Chicago Sanitary & Ship Canal	CAWS ALU B	3.5-4.0[3]
15	B&O RR, Chicago Sanitary & Ship Canal	CAWS ALU B	3.5-4.0[3]
16	Route 83, Chicago Sanitary & Ship Canal	CAWS ALU B	3.5-4.0[3]
17	River Mile 302.6, Chicago Sanitary & Ship Canal	CAWS ALU B	3.5-4.0[3]
18	Romeoville Rd., Chicago Sanitary & Ship Canal	CAWS ALU B	3.5-4.0[3]
19	Lockport Powerhouse, Chicago Sanitary & Ship Canal	CAWS ALU B	3.5-4.0[3]
58	Devon Ave., Des Plaines River	General Use	3.5-6.0[2]
62	Irving Park Rd., Des Plaines River	General Use	3.5-6.0[2]
63	Ogden Ave., Des Plaines River	General Use	3.5-6.0[2]
64	Material Service Rd., Des Plaines River	General Use	3.5-6.0[2]
23	Jefferson St., Des Plaines River	CAWS ALU B	3.5-4.0[3]
31	130th St., Calumet River	CAWS ALU A	3.5-5.0[1]
67	Hohman Ave., Grand Calumet River	CAWS ALU A	3.5-5.0[1]
32	Torrence Ave., Grand Calumet River	CAWS ALU A	3.5-5.0[1]
33	Conrail RR, Little Calumet River	CAWS ALU A	3.5-5.0[1]
34	C&W Indiana Harbor Belt RR, Little Calumet River	CAWS ALU A	3.5-5.0[1]
35	Halsted St., Little Calumet River	CAWS ALU A	3.5-5.0[1]
65	Wentworth Ave., Little Calumet River	General Use	3.5-6.0[2]
36	Ashland Ave., Little Calumet River	General Use	3.5-6.0[2]
37	Division St., Calumet-Sag Channel	CAWS ALU A	3.5-5.0[1]
38	Kedzie Ave., Calumet-Sag Channel	CAWS ALU A	3.5-5.0[1]
39	Cicero Ave., Calumet-Sag Channel	CAWS ALU A	3.5-5.0[1]

TABLE 3 (Continued): ILLINOIS POLLUTION CONTROL BOARD USE CLASSIFICATION AND DISSOLVED OXYGEN STANDARD AT EACH MONITORING LOCATION

Loc. ID	Continuous DO Monitoring Location	IPCB Classification	DO Standard
40	River Mile 311.7, Calumet-Sag Channel	CAWS ALU A	3.5-5.0[1]
41	Southwest Hwy., Calumet-Sag Channel	CAWS ALU A	3.5-5.0[1]
42	104th Ave., Calumet-Sag Channel	CAWS ALU A	3.5-5.0[1]
20	Route 83, Calumet-Sag Channel	CAWS ALU A	3.5-5.0[1]
68	Busse Woods Main Dam, Salt Creek	General Use	3.5-6.0[2]
59	J. F. Kennedy Blvd., Salt Creek	General Use	3.5-6.0[2]
60	Thorndale Ave., Salt Creek	General Use	3.5-6.0[2]
61	Wolf Rd., Salt Creek	General Use	3.5-6.0[2]

[1]The Chicago Area Waterway System Aquatic Life Use A (CAWS ALU A) waters require that during the period of March through July, DO shall not be less than 5.0 mg/L at any time, and that during the period of August through February, DO shall not be less than 4.0 mg/L as a daily minimum averaged over seven days, or less than 3.5 mg/L at any time.

[2]The General Use Standard requires that during the period of March through July, DO shall not be less than 5.0 mg/L at any time, or less than 6.0 mg/L as a daily mean averaged over seven days, and that during the period of August through February, DO shall not be less than 3.5 mg/L at any time, or less than 4.0 mg/L as a daily minimum averaged over seven days, or less than 5.5 mg/l as a daily mean averaged over 30 days.

[3]The Chicago Area Waterway System Aquatic Life Use B (CAWS ALU B) waters require that DO shall not be less than 4.0 mg/L as a daily minimum averaged over seven days, or less than 3.5 mg/L at any time.

CONTINUOUS DISSOLVED OXYGEN MONITORING
QUALITY ASSURANCE PROJECT PLAN

APPENDIX I

EXAMPLE OF A WEEKLY DISSOLVED OXYGEN SUMMARY TABLE

TABLE AI-1: DISSOLVED OXYGEN VALUES IN THE NORTH SHORE CHANNEL, NORTH BRANCH CHICAGO RIVER, AND CHICAGO RIVER DURING THE PERIOD FEBRUARY 26, 2015 THROUGH MARCH 5, 2015[1]

Monitor Location	Waterway	IPCB Standard	Number of DO Values	DO Concentration (mg/L)			Percent of DO Values Above Standard
				Min	Max	Mean	
Foster Avenue	North Shore Channel	3.5/5.0	168	6.5	8.3	7.7	100
Addison Street	North Branch Chicago River	3.5/5.0	169	5.6	8.0	7.2	100
Division Street	North Branch Chicago River	3.5/5.0	169	6.1	9.1	7.2	100
Clark Street	Chicago River	3.5/5.0	168	8.9	13.1	11.6	100

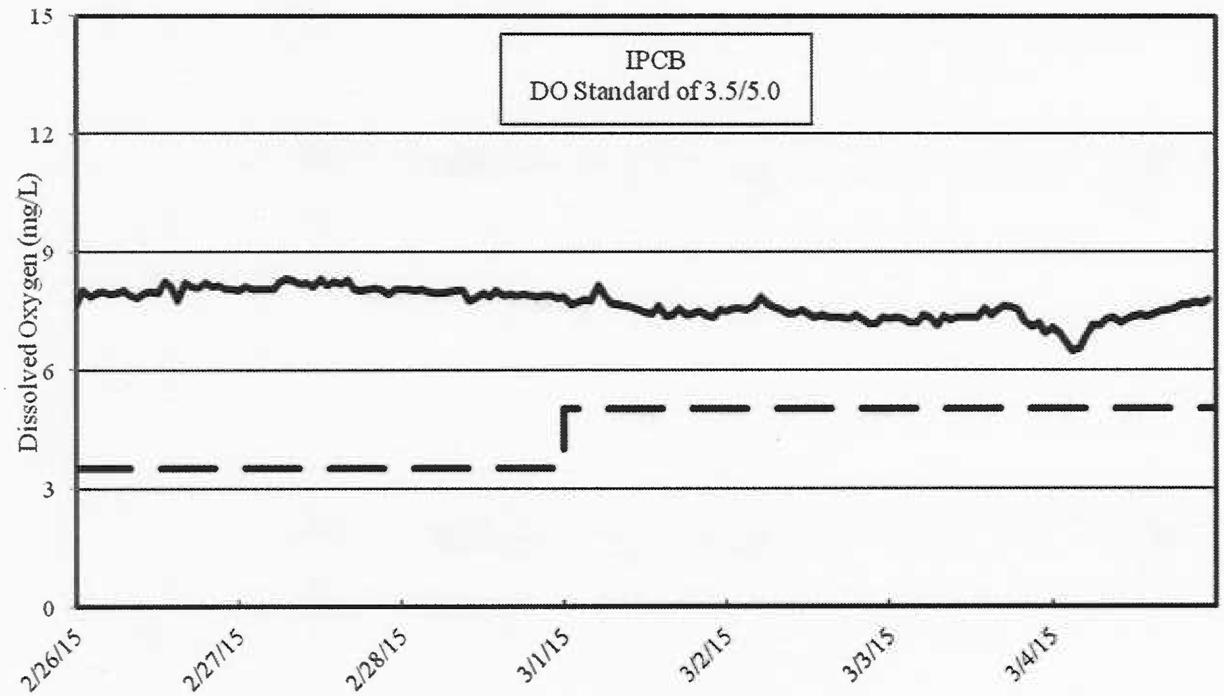
[1]Parameter was measured hourly using a YSI or Eureka brand continuous water quality monitor.

CONTINUOUS DISSOLVED OXYGEN MONITORING
QUALITY ASSURANCE PROJECT PLAN

APPENDIX II

EXAMPLE OF AN HOURLY DISSOLVED OXYGEN PLOT

FIGURE AII-1: DISSOLVED OXYGEN CONCENTRATION MEASURED HOURLY AT FOSTER AVENUE IN NORTH SHORE CHANNEL, FEBRUARY 26, 2015 THROUGH MARCH 4, 2015



APPENDIX F

STANDARD OPERATING PROCEDURE FOR LABORATORY SERVICING PROCEDURES FOR CONTINUOUS DISSOLVED OXYGEN MONITORS

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

Environmental Monitoring and Research Division Laboratory
Stickney Water Reclamation Plant
Cecil Lue-Hing Research and Development Complex
6001 West Pershing Road
Cicero, Illinois 60804

STANDARD OPERATING PROCEDURE

LABORATORY SERVICING PROCEDURES FOR CONTINUOUS DISSOLVED OXYGEN MONITORS

Prepared by:	Thomas Minarik	Date	4/26/18
Reviewed by:	Justin Vick	Date	5/2/18
Reviewed by:	Dustin Gallagher	Date	4/27/18
Approved by:		Date	5/8/18

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1.0 Scope and Application

1.1 This method is adapted from in-situ dissolved oxygen (DO) monitoring techniques used to evaluate the reaeration efficiency of sidestream pool aeration stations (Butts, 1998), from U.S. Geological Survey guidelines and standard procedures for continuous water-quality monitors (USGS, 2000), and from the Illinois Environmental Protection Agency standard operating procedure for continuous monitoring of water quality (IEPA, 2014).

1.2 This method can be used to "continuously" determine DO levels in any waterway at any commonly used measurement interval.

1.3 This method determines DO at an accuracy of the greater of ±0.1 mg/L or 1% of the reading. Resolution is 0.01 mg/L.

2.0 Summary of Method

2.1 In-situ water quality monitors (monitors or sondes) are deployed for three-week intervals at monitoring locations throughout Chicago area waterways as part of the continuous DO monitoring (CDOM) program. DO measurements are made hourly at all monitoring locations. The monitors utilize Luminescent DO (LDO) probes, which use a luminescent membrane that is quenched by oxygen to determine oxygen concentration. DO readings are automatically corrected for water temperature and specific conductivity by inputs from on-board probes. DO, specific conductivity, water temperature, and time and date values are logged hourly to a file in non-volatile memory in each monitor.

2.2 In the laboratory, data collected by each monitor is downloaded to a specially configured SQL Server database with a Microsoft Access® interface. Corrections for DO probe drift over the deployment period are made by comparing DO readings logged by the monitors with 100% DO saturation before and after deployment. Corrections are made by a linear algorithm built into the Access® program.

2.3 Hourly DO values are output from the SQL Server database through a Microsoft Access® interface to a Microsoft Excel Visual Basic® application to provide summary statistics and hourly plots for each monitoring location.

3.0 Definitions

3.1 Sonde- An instrument probe that automatically transmits or stores information about its surroundings underground, under water, in the atmosphere, etc.

4.0 Interferences

4.1 LDO probes are subject to fouling from waterway contaminants and biological growths. Routine cleaning and maintenance of the DO probe between deployments will keep fouling to a minimum and help to ensure measurement accuracy.

4.2 Accuracy may decrease as the time of field deployment increases due to instrument drift from the initial DO calibration.

5.0 Health and Safety Warning

5.1 The following chemicals used in this method have the potential to be toxic or hazardous:

a. Conductivity calibrator solution
b. pH 7 and pH 10 buffer solutions
c. Liqui-Nox® cleaning liquid detergent

The appropriate Material Safety Data Sheets are available in Room LE-209, and can also be viewed online at:

http://hq.msdsonline.com/mwrdchi3495/Search/Default.aspx

5.2 Always keep work areas clean and organized.

5.3 All chemical and reagent containers must be labeled with their contents and hazard information.

5.4 Lab appropriate clothing (closed toe shoes, full length pants), lab coat, protective eyewear, and chemically resistant gloves must be worn when handling hazardous or toxic chemicals or reagents.

5.5 Cracked, chipped, or broken glassware must be placed in broken glass disposal containers. Puncture-resistant gloves must be worn when disposing of broken glass.

5.6 Note the location of all laboratory safety equipment before analyses are begun.

6.0 Equipment and Supplies

a. YSI Multiparameter Water Quality Monitors (Figure 1), models 6600, 6600V2, 6920V2, each equipped with YSI 6150 Luminescent DO and YSI 6560 Conductivity/Temperature probes
b. YSI Model 6150, and YSI Model 6560 water quality probes
c. YSI 6570 sonde maintenance kit
d. YSI 6155 Luminescent DO membrane kit
e. O-rings (number 110, 017, 018, 118, and 229)
f. YSI 6067X calibration cables
g. Eureka Manta2 or Manta+ sonde each equipped with a temperature, conductivity and optical dissolved oxygen sensors
h. Eureka 15 and 35 meter field cables
i. Eureka Amphibian2 Data Display with GPS and Bluetooth
j. Eureka Manta2 sonde equipped with temperature, conductivity, optical dissolved oxygen, pH, and depth sensors. These ***instruments*** are used for real time profiling.
k. "AA-cell", "C-cell" and "D-cell" alkaline batteries
l. Liqui-Nox® non-phosphate laboratory detergent
m. 1/2-inch diameter conductivity cell cleaning brush
n. 3-inch diameter tapered bottle brush.
o. NIST traceable thermometer, reads –8° to 32°C with 0.1° readability
p. YSI Model 30 Salinity-Conductivity-Temperature meter with ±0.5% accuracy at full scale and 0.1 μS/cm resolution.
q. HACH HQ30d and HQ40d portable meters with IntelliCAL LDO probe, rugged (LDO10115).
r. HACH LDO sensor replacement kit for (LDO101)

7.0 Reagents and Standards

a. Conductivity Standard Solution, 1000 μS/cm
b. pH 4 Standard Solution
c. pH 7 Standard Solution
d. pH10 Standard Solution

8.0 Sample Collection, Preservation, and Storage

8.1 DO monitors are stored in the "Receiving Tank" upon return from field monitoring locations.

8.2 DO monitors being readied for deployment are stored in one of two (North or East) "Holding Tanks."

9.0 Quality Control

9.1 The DO probes on each monitor are checked the day before field deployment. If a DO probe is out of range, another sonde must be set up as described in section 10.8 of this document. DO probe calibration is checked when the monitors are returned to the laboratory after field deployment.

9.2 DO is measured by a calibrated portable HACH DO meter in each holding tank and the receiving tank in the morning of every workday. Sondes set up for deployment will be checked against the holding tank measured DO in the afternoon of the same day. Monitors with DO values that differ by more than 0.3 mg/L from holding tank DO values are calibrated using the appropriate 100% DO saturation method. Before calibrating a sonde, check all sondes in that tank so that you can recognize a trend possibly caused by a bad tank DO measurement, a contaminated holding tank, or sudden change in barometric pressure before you begin calibrating instruments. One can check hourly local barometric pressure at the following website (there is a shortcut on the sonde computer):

http://w1.weather.gov/obhistory/KMDW.html

If the barometric pressure has recently had a significant change, you may need to wait until the next reading for the sonde to be equilibrated to the change. If there hasn't been an abrupt barometric pressure change, verify the measured tank DO by taking another measurement with the portable HACH DO meter. The last thing to check is if the water in the tank is dirty or contaminated (algae or a biofilm of some type, particulates from the vents in the water, etc.). Visually inspect the tank using a flashlight. If the tank is dirty, lightly wash each sonde and place them in another holding tank, then wash the dirty holding tank. DO readings for each tank are recorded on the log sheet and stored electronically in the appropriate Holding Tank Log Sheet form (Appendix I).

9.3 After retrieval of a deployed sonde, a 100% DO saturation check is done and corrections are made to the data as a control for calibration drift over the deployment period.

9.4 Temperature is checked in each holding tank and in the receiving tank using a digital NIST traceable thermometer in the morning and afternoon of every workday. Temperature readings for each tank are recorded on the log sheet and stored electronically in the appropriate Holding Tank Log Sheet form (Appendix I). Sonde temperature probes differing more than ± 0.5°C from the digital NIST thermometer reading are to be replaced.

9.5 Specific conductivity is measured once per week in each holding tank and in the receiving tank using a portable conductivity meter. The portable conductivity meter is given a calibration check with 1000 μS/cm conductivity standard solution at 25°C before each use. The 1000 μS/cm conductivity standard solution is to be refreshed weekly. Specific conductivity readings for each tank are recorded on the log sheet and stored electronically in the appropriate Holding Tank Log Sheet form (Appendix I).

10.0 Procedures

10.1 Monitor System Setup

10.1.1 Set sonde to report Date (m/d/y), Time (hh:mm:ss), Temp (°C), Specific Conductivity (μS/cm), DO (mg/L), and Battery volts. YSI instruments will need to have "Auto Sleep RS232" enabled in the "Advanced" menu and "Wait for DO" in the "Advanced-Sensor" menu disabled.

10.1.2 Monitors are set to log readings at one-hour intervals in the laboratory holding tanks and during field deployments.

10.2 Seasonal Adjustments to Monitor Operation

10.2.1 For weeks between April 1 and October 31, when setting up a sonde for deployment the batteries must be replaced when the sonde battery voltage reading indicates the voltage is less than 10.0 for YSI sondes and 8.0 for Eureka sondes. Between November 1 and March 31, sondes are to be deployed with a full set of new batteries that have been checked using a voltage meter. Exact dates for winter battery voltage limits may vary depending on temperature trending and will be subject to professional staff discretion.

10.2.2 In-house sonde clocks will be changed to Central Standard Time or Central Daylight Time the Friday previous to the official time change. Sondes in the field during the time change will have their clock adjusted as they are recovered.

10.3 DO Calibration

10.3.1 Each morning the portable HACH DO meter must be calibrated to 100% DO saturation following the manufacturer's instructions and documented on the log sheet.

10.3.2 If after checking all the sondes in a holding tank (and ruling out a trend caused by a bad tank DO measurement, tank contamination, or sudden change in barometric pressure) there are sonde DO values which are greater than +/-0.3 mg/L from the measured tank DO, these will need to be recalibrated for DO. Refer to the respective sonde manual for 100% DO saturation calibration procedure.

10.3.3 Each sonde set up for deployment is calibrated to 100% DO saturation on the morning of the deployment date. Refer to the respective sonde manual for 100% DO saturation calibration procedure.

10.6 Specific Conductivity Calibration

10.6.1 Conductivity probes are checked weekly, and calibrated as needed to the specific conductance of the holding tanks, as measured by a YSI Model 30 S-C-T meter. If the sonde measured conductivity is greater than +/- 0.8% from the meter measured conductivity, the sonde conductivity probe is calibrated. Refer to the respective sonde manual for conductivity calibration procedures.

10.6.2 The YSI Model 30 S-C-T meter is given a calibration check weekly using 1000 μS/cm Conductivity Standard Solution. If the meter measured conductivity is greater than +/- 0.5% of 1,000, the meter is calibrated. Before calibrating, check the calibration standard expiration date and order replacement reagent if within two months of expiration or if the standard is less than 1/3 full. Refer to YSI Model 30 Handheld Salinity, Conductivity, and Temperature System Operations Manual, May 1998 for meter calibration procedures.

10.7 Problem Sondes

10.7.1 If after performing normal troubleshooting a sonde will still not operate correctly, consult a biologist.

10.7.2 If the biologist decides to send the sonde back to the manufacturer for repair, the assigned technician will prepare the appropriate paperwork (noting the serial numbers of the sonde and attached probes), prepare the sonde (remove batteries, install calibration cup with 100mL water, wrap sonde in bubble wrap), and box the sonde for shipping. The technician will save a copy of the paperwork in the appropriate folder at the following destination:

\\hawk\M&R\120_EM&R_Division\126_Aquatic_Ecology\126_Lab_Techs\CDOM\Sondes\Repair

The technician will also create a record in the appropriate repair log. While sondes are at the manufacturer for repair, the repair paperwork is saved in the *sondes currently at manufacturer for repair* folder.

10.7.3 When a repaired sonde is received from the manufacturer, the assigned technician will check all of the sonde settings described in section 10.1 of this document. The sonde will be placed on a red peg and monitored for three days to make sure the sonde is operating correctly. The technician will update any new hardware serial numbers in the Monitor Serial Numbers spreadsheet in the following folder:

\\hawk\M&R\120_EM&R_Division\126_Aquatic_Ecology\126_Lab_Techs\CDOM\Sondes

The technician will then move the electronic copy of the paperwork from the *sondes currently at manufacturer for repair* folder to the appropriate sonde folder, and update the repair log with the date received, repair performed, and any other pertinent information.

10.8 Field Deployment-Monitor Setup

10.8.1 Data collected during each monitor deployment is logged to a separate file in monitor memory. Refer to sonde manuals for log file creation and startup. Each file will have the sonde number, six digit date and site name with an underscore between each of these, such that 01_010101_Busse would be sonde number one deployed January First, 2001 to Busse Woods. YSI instruments only allow 8 characters such that the same file would have only the date with a single digit year, 01_01011.

10.8.2 A monitor should not be deployed to a station if it has been deployed to that same station within the previous two deployments. This is done to avoid potential instrument bias at a given location. Refer to the Sonde Site Log electronic form (Appendix II) to determine monitor deployment history. If there is no other alternative, use the instrument that has not been to the intended station in the longest amount of time.

10.8.3 To be eligible for deployment, DO readings logged by a monitor over the preceding 24 hours must be stable and within ±0.3 mg/L of the current measured DO reading in the holding tank where it is stored.

10.8.4 Refer to respective manuals for log file creation and initiation procedures.

10.8.5 Record the identification number of the monitor deployed at each field location and the date deployed on the Monitor Deployment Data log sheet (Appendix III).

10.8.6 Allow the monitors to log DO readings overnight in the holding tanks.

10.8.7 On the day of deployment, calibrate the sonde to 100% DO saturation according to the respective manual (references 15.3 and 15.4). Record the measured 100% DO saturation value from the sonde and the calculated 100% DO saturation value from the current barometric pressure reading and the result provided through the USGS solubility tables (water.usgs.gov/software/DOTABLES/) on the Monitor Deployment Data log sheet (Appendix III).

10.8.8 Label each monitor with the station name where it is to be deployed. A metal tag with the station name is affixed to the monitor bail as indicated in Figure 1.

10.8.9 Install a 1-1/8-inch diameter white rubber cap over the YSI sonde connector cap to protect it from damage.

Place the monitors to be deployed into a designated sonde cooler along with a sonde cleaning brush for transport to the waterway monitoring locations. Add approximately one-half gallon of tap water to the cooler. In a bucket, make sure there are the following items in good working condition: keys, HACH DO meter, and field observation sheet (Appendix III). In a second bucket, make sure there is the 8 inch diameter, weighted, chimney-cleaning brush, with attached 35 foot rope.

10.9 Post-Deployment Monitor Service

10.9.1 After deployment, monitors are temporarily stored in the "Receiving" holding tank in laboratory LE-208. The monitor continues to log readings while in the tank.

10.9.2 Verify the sonde number and site tags correspond for the deployment and that the sonde readings show the expected change (temperature, DO and specific conductivity will read differently in the transport cooler) at the retrieval time indicated on the deployment/retrieval field sheet.

10.9.3 Use a stream of compressed air to remove moisture around the sonde bulkhead connector. Check the time and date of the most recent reading to verify the sonde is currently reading. If the monitor is not currently logging because of insufficient battery power, replace the batteries and confirm the battery voltage.

10.9.4 Conduct a 100% DO saturation check for each retrieved sonde. Record the measured 100% DO saturation value from the sonde and the calculated 100% DO saturation value from the current barometric pressure reading and the result provided through the USGS solubility tables (water.usgs.gov/software/DOTABLES/) on the Monitor Deployment Data log sheet (Appendix III). Next, the technician assigned to sondes will download these retrieved sondes as described in 11.1 Data Download. In the event there is only one technician covering sondes, they are expected to download the data and then maintain the sondes.

10.9.5 Prepare a cleaning solution by adding 50-75 milliliters Liqui-Nox® laboratory detergent to 2 gallons hot (50-60°C) tap water in a 2.5-gallon stainless steel bucket or plugged sink.

10.9.6 Remove the station name label from the monitor bail.

10.9.7 Remove the white rubber cap from the YSI sonde connector and place it in the detergent solution.

10.9.8 Scrub the monitor body with detergent solution using a 3-inch diameter bottle brush or a sponge. Remove all biological growth and silt from the exterior surfaces of the monitor.

10.9.9 Remove the probe guard from the monitor and allow it to soak in the detergent solution.

10.9.10 Place the monitor in the bucket or sink with the probes facing up. Use a 1/2-inch diameter round brush to clean the electrodes and exterior surfaces of the conductivity cell.

10.9.11 Clean the exterior of the DO probe, probe bulkhead, and the probe port plugs with detergent solution using a 1/2-inch diameter round brush and cotton swabs.

10.9.12 Clean the DO probe cap by rinsing it with deionized water and gently blotting it with a non-abrasive cloth.

10.9.13 Clean the exterior and interior of the probe guard and rubber protective cap with a 3-inch diameter bottle brush and detergent solution. Reinstall the probe guard.

10.9.14 Rinse the exterior of the monitor and probe guard with 50-60°C tap water to remove all detergent residue.

10.9.15 Use paper towels to remove residual water from the exterior of the monitor. A compressed air blowgun supplying 25-35 pounds per square inch of pressure is used to remove moisture from the sonde bulkhead connector and battery compartment lid of the monitor.

10.9.16 Remove batteries from the monitor. Examine the battery compartment wells for signs of water leakage. If water has leaked into the battery compartment, use a compressed air blowgun with a 12-inch extension tip to remove visible water from the battery compartments with the monitor inverted. Place the blowgun tip as far as possible into each battery compartment while compressed air is being dispensed. Allow the battery compartment to air-dry overnight with the cover off. Discard batteries exposed to water.

10.9.17 Remove both battery compartment cover o-rings. Clean o-rings thoroughly with Kimwipes® and inspect them for cuts or stretching. Use Kimwipes® and tapered-tip cotton swabs to remove silt and grit deposits from o-ring grooves in the monitor and battery compartment cover. Battery compartment o-ring mating surfaces must be thoroughly cleaned of all contamination. Clean the monitor battery compartment cover recess, battery compartment cover screw inserts, and battery compartment cover attachment screw threads by wiping with Kimwipes® and tapered-tip cotton swabs. Remove the sonde connector cap and extract the o-ring at the top of the cap with a fine-pointed probe or forceps. Wipe this o-ring clean with a Kimwipe®. Clean the o-ring groove and threads on the cap with a tapered-tip cotton swab. Sonde connector cap threads should be free of all grit, which may require use of more than one cotton swab during cleaning. Clean the threads on the sonde connector with a 2-inch by 4-inch flat nylon-bristle brush and wipe the non-threaded portion of the sonde connector with a Kimwipe®. Clean the interior surfaces of the sonde connector and connector contact pins with a tapered-tip cotton swab. Use compressed air to remove residual moisture, dust, and lint from the battery compartment cover, sonde connector, and sonde connector cap.

10.9.18 Lubricate sonde bulkhead cap o-rings and battery compartment o-rings (do not lubricate the flat battery compartment gasket on YSI model 6600) with a very light film of silicone grease. Do not use an excess of silicone grease because it makes the monitor more difficult to clean. Re-install o-rings (2) on the battery compartment cover and sonde bulkhead cap. Place battery compartment cover and sonde bulkhead cap on a clean surface.

10.9.19 Test each battery individually with a load-type battery tester. The battery tester load-selector switch should be set to the “Alkaline” or “Heavy” battery load setting. Discard batteries that test in the “Replace” range of the meter. Use a compressed air blowgun with a 12-inch extension tip to clean both battery compartments. Clean batteries with compressed air before installing them.

10.9.20 Battery compartment cover, and sonde bulkhead cap should be lightly seated against the o-ring seals using a torque wrench.

10.9.21 After servicing, replace monitors in the water-filled stainless steel holding tanks. Match the number written on the sonde with the numbered pegs and place them in an opening in the holding tank cover. Monitors are always stored with probe guards installed.

10.10 Daily Inspection and Maintenance

10.10.1 The first activity of the day is to calibrate the portable HACH DO meter as described in 10.3.

10.10.2 Measure the DO using the portable HACH DO meter on all holding tanks each morning. Watch for abrupt changes in dissolved oxygen concentration. These are likely caused by either a bad tank DO measurement, a contaminated holding tank, or sudden change in barometric pressure. One can check hourly local barometric pressure at the following website:

http://w1.weather.gov/obhistory/KMDW.html.

There is also a shortcut on the sonde computer. If the barometric pressure has recently had a significant increase, then the DO concentration should increase due to higher pressure. Conversely, if the barometric pressure drops, the dissolved oxygen concentration in the tanks should also go down. The last thing to check for is dirty or contaminated water in the tank (possibly algal growth, a biofilm and/or particulates from the ceiling vents in the water). Visually inspect the tank using a flashlight. If the tank is dirty, lightly wash each sonde and place them in another holding tank, and then wash the dirty holding tank as described in the next section 10.11 - Holding Tank Inspection and Maintenance. Record holding tank DO and water temperature readings on the "Monitor Holding Tank DO, Temperature, and Conductivity" log sheet (Appendix I).

10.10.3 View the current log file. Note the DO, holding tank DO, DO gain, specific conductivity, and the current version of monitor operating system software. These values are to be entered into a new Daily Sonde Readings (Appendix IV) file each day. Non deployment DO calibration is to be noted in the calibration dates column with a log of these dates with a log of calibration dates in an attached note for each cell in this column.

10.10.4 Reset internal clock for monitors that are more than five minutes different than actual time.

10.11 Holding Tank Inspection and Maintenance

10.11.1 When filled with water, holding tanks must remain within the yellow-lined area painted on the floor.

10.11.2 Holding tanks are inspected each workday morning for correct water level, leaks in the drain valve, circulator pump function, and water clarity.

10.11.3 Holding tanks are cleaned on a rotating schedule, with each tank being cleaned once every 4 weeks. The receiving tank is cleaned weekly after monitor recovery has been completed. Holding tanks must be cleaned immediately if water turbidity increases, biological growth appears on the interior walls, or a film is present on the water surface. If there is a contamination, be sure to wash and rinse the sondes from the contaminated tank before transferring them to another tank.

10.11.4 Place the cleaned sondes in the other holding tank when a tank is scheduled to be cleaned. If sufficient openings are not available in the other tanks, store the monitors with calibration cups installed. Calibration cups should contain 5-10 milliliters of tap water when they are placed on the monitor.

10.11.5 Remove the small circulator pump and plywood cover and drain the tank into a floor drain or sink with a hose or submersible pump. Do not attempt to move the tank while it is full of water. When less than six inches of water remains in the tank, utilize the floor jack to slightly elevate one side of the tank to assist with draining it. The tank should remain in this position until cleaning has been completed. Clean the tank and circulator pump with concentrated Liqui-Nox® laboratory detergent and a bottle brush. Rinse detergent solution from the interior of the tank with hot tap water from a hose-mounted spray attachment. Rinse water should flow into the floor drain. Close the drain valve, remove the floor jack, and replace the tank in position within its yellow-lined area.

10.11.6 Refill the holding tank with tap water that is near room temperature.

10.11.7 Place a 20-gallon per minute submersible pump on the bottom of the tank. Plug the pump into a GFCI protected outlet and allow it to discharge vertically in the tank for 4-5 hours.

10.11.8 Remove the pump and reinstall the holding tank cover. Replace the monitors in their assigned spaces by placing wooden dowel rods through the suspension bails.

10.11.9 Replace the small circulator pump in the tank and plug it into a GFCI protected outlet.

10.11.10 Wait until the next day to measure the DO on the newly cleaned tank.

11.0 Data Download, Review, and Verification

11.1 Data Download

11.1.1 Check the retrieved sonde for accuracy by reading in 100% saturated DO. Note this reading in the appropriate box in the Monitor Deployment Data spreadsheet.

11.1.2 Refer to the Monitor Deployment Data form (Appendix III) completed during the week that the monitors were deployed to determine the field location that corresponds to the identification number on the monitor.

11.1.3 Connect the monitor to a PC and download the deployment file to the Recently Downloaded files folder in the YSIDB folder. For YSI files- add second digit to year and station name to file. Copy this file to the YSIDB folder. Change Eureka files to txt file format by changing .csv to .txt in the file name.

11.1.4 Change the file name to download.txt

11.1.5 Open the Access® "ysidb.mdb" database program located on the server

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11.1.6 When the "MWRDGC Continuous Monitoring Data Management" screen appears, click on "Update Database" to access the "Continuous Monitor Exchange" form (Appendix V, Figure 1).

11.1.7 Click on the pull-down "Station" menu and select the name of the location where the monitor was deployed.

11.1.8 Press the Tab key to move to the "Date" field and enter the date the monitor was deployed.

11.1.9 Press the Tab key to move to the "Time" field and enter the time the monitor was deployed.

11.1.10 Press the Tab key to move to the "Measured DO" field and enter the field meter DO value.

11.1.11 Click on the pull-down "Deployed on" menu under the "Monitor Recovered" heading and select the deployment date and time of the monitor being downloaded. Verify that the "Monitor Number" field displays the identification number of the monitor being downloaded.

11.1.12 Under the "Monitor Deployed" heading, click on "Monitor Number" and enter the identification number of the monitor that is currently deployed in the field at the listed station.

11.1.13 Click the box next to "Recover data from text file" at the bottom of the "Continuous Monitor Exchange" form.

11.1.14 Click on the "Download Data" button.

11.1.15 Click on the "OK" button when asked if the data are ready in a file named download.txt in the ysidb folder.

11.1.16 When the transfer is complete click on the "Yes" button. If problems were encountered during the download, click "No" to begin again or "Cancel" to abort the download.

11.1.17 Click on the "Apply Corrections" button at the bottom of the "Continuous Monitor Exchange" form. The "Data Corrections Points" screen will appear, displaying values for date, time, (Check) DO and Sonde DO readings that were entered into the database previously (Appendix V, Figure 2). Click in the "Date/Time column of the top-most "In-Tank" row. Enter the deployment date, a space, deployment time, (Check) DO and Sonde DO readings from the pre deployment 100% DO saturation calibration (Appendix V, Figure 3). Click in the "Date/Time column of the bottom-most "In-Tank" row. Enter the correction date and time, separated by a space, (Check) DO and monitor DO readings from the post deployment 100% DO saturation check (Appendix V, Figure 3). Click in the boxes at the end of top-most and bottom-most rows to place check marks in them (Appendix V, Figure 3).

11.1.18 Click on the "Save" button at the bottom of the "Data Corrections Points" form (Appendix V, Figure 3) to correct the field readings for instrument drift. Close the "Data Corrections Points" form.

11.1.19 Click on "View Data" button and review the "doCorr" values column. All data between the date/time limits entered in Section 10.11.16 should display "Yes" in the "InRange" column (Appendix V, Figure 4). In addition, verify that specific-conductivity (specCond) displayed a sharp increase after the reported time of deployment and a sharp decrease after the reported time of retrieval (Appendix V, Figure 5). If these specific-conductivity increases or decreases occurred earlier or later than reported, adjust the deployment or retrieval times in the "Data Corrections Points" form as needed and if there are calculated values for "doCorr" for times when the sonde was not "InRange", delete those values.

11.2 Report Creation (Biologist)

11.2.1 Open the Access® database program and select "Reports (Date Range)" from the menu in the "Continuous Monitoring Data Management" window.

11.2.2 Select the week of retrieval from the Week Retrieved drop-down menu.

11.2.3 Click on "Select Stations for Printing" and select stations to be included in the report by clicking in the box next to the station name. Close the selection window.

11.2.4 Click on "Weekly Summary Table" to create the DO summary statistics pages.

11.2.5 Click on "Weekly Statistical Summary" to create DO, specific conductivity, and temperature statistical pages for the chosen sites.

11.2.6 Select DO at the parameter dropdown box.

11.2.7 Click on "Time Series" to create the line drawings for each monitoring location for selected DO parameter.

11.2.8 Double-click on "Field DO at Monitor Installation Sites." Enter retrieval week to create field DO file.

11.2.9 Click on "Pre- and Post-Tank DO" and enter deployment week to create receiving tank DO file.

11.3 Data Review and Evaluation (Biologist)

11.3.1 Examine the minimum, maximum, and mean DO values in the summary tables for an appropriate pattern moving downstream in the waterways.

11.3.2 Review the line drawings for an appropriate pattern moving downstream in the waterways.

11.3.3 Calibration drift is determined from a post 100% DO saturation check. If this value is determined to be greater than 0.4mg/L the instrument will have failed this test and the data will be marked data lost.

11.3.4 Compare the field probe DO value measured in the field at the end of the monitoring period before sonde retrieval with the DO value recorded by the retrieved monitor at the end of the field monitoring period. The relative percent difference (RPD) is calculated and if it is greater than 20% and the absolute magnitude of this difference is >0.3 mg/L, then some or all of the data will be rejected for this deployment period. Biologists will use best professional judgement to determine whether conditions in the waterway are likely to have caused the sudden change in DO.

11.3.5 Review rainfall and discretionary diversion data to verify events that may have affected the DO at any station during the monitoring period. If a very unusual pattern of recorded DO values cannot be explained by any rainfall, discretionary diversion, or other known unusual event, this is sufficient reason to consider deleting the data set for the entire monitoring period.

11.3.6 Remove any data in which the sonde appears to not have been in the river from the beginning to the end of a DO monitor deployment period. This usually involves deleting one outlying value.

11.3.7 Make final decisions as to the accuracy of the data and make any necessary corrections to the database, creating new DO summary tables and graphs when necessary.

12.0 Cross-Sectional DO Measurements

12.1 Cross-sectional DO measurements are performed during May, August, and October at all active continuous DO monitoring locations.

12.2 Assigned cross sectional technicians are expected to arrive at the scheduled time, conduct a check of the profiling sondes, and head into the field within 30 minutes of arrival. The sondes must be calibrated to 100% DO saturation and have the depth calibrated, if needed.

12.3 A monitor with DO, specific conductivity/temperature, and depth sensors is used to make the measurements. DO readings are displayed on a handheld display unit which is connected to the monitor by a field cable.

12.4 Two sondes should be taken in the field to perform DO cross sections. One sonde will be chosen to be the primary sonde for use before departing from the laboratory. The second sonde serves as a back-up monitor in case there are issues that interfere with the ability to use the primary sonde. All pre DO cross section checks and calibrations should be done for both sondes. Post DO cross section checks will only be required for the sonde that is used.

12.5 The specific conductivity/temperature probes on sondes that are to be used for DO cross sections should be checked and, if necessary, calibrated the work day preceding the scheduled cross sectional by the technicians scheduled to perform the cross section analysis

12.6 On the day of scheduled DO cross sections, the cross section sondes are to be calibrated with the appropriate 100% DO saturation method as described in 10.8.7. The calibration and calibration check data are to be recorded near the bottom of the corresponding cross section field data sheet in the "Pre Cross Section" table (Appendix VI).

12.7 Sondes are to be checked for depth by lowering the sonde to the bottom of a holding tank where the sonde is standing vertically on the bottom of the tank. The sonde depth reading will then be compared to a measurement taken with a yard stick. If the difference is greater than or equal to 0.1 feet, the sonde should be calibrated for depth with the appropriate calibration method. All depth calibration and calibration check data will also be recorded in the "Pre Cross Section" table (Appendix VI).

12.8 After DO cross sections are completed and the crew has returned to the lab, a post cross section check is to be completed for DO and depth. The methods for post cross section calibration check for depth are the same as 12.7. If the post check for depth is greater than 0.1 feet, a biologist should be notified. A post check for DO is performed by conducting a 100% DO saturation check the same as 10.9.4. If a post check DO difference is greater than 0.4 mg/L, a biologist should be notified. Post DO cross section calibration check and calibration data will be recorded in the "Post Cross Section" table at the bottom of the corresponding field data sheet (Appendix VI).

12.9 Cross-sectional DO measurements are taken from highway bridges at Busse Woods Dam,, Wolf Road (Salt Creek), Devon Avenue (Des Plaines River), Foster Avenue (North Shore Channel), Church Street (North Shore Channel), and Ashland Avenue (Little Calumet River). Cross-sectional DO measurements are taken from the catwalk upstream of the head race at Lockport Powerhouse.

Cross-sectional DO measurements are taken from a boat at the remaining monitoring locations.

12.10 Cross-sectional DO measurements are conducted in the center of the waterway and at the left and right side of the flow. As the side analyses are to be representative of the flow on that side, the technician must avoid sampling in debris or in areas which are too shallow.

12.11 At each point on the bank-to-bank transect, a maximum of four DO measurements are recorded near the bottom of the waterway, one-half the total depth of the waterway, three feet below the surface, and within one foot of the surface where possible. If the maximum depth is below 8' there is no mid depth reading required. If maximum depth is less than 4' no mid depth or 3' reading required. If maximum depth is equal to or less than 1' only bottom reading is required.

12.12 DO measurements are recorded on the "Cross-Sectional DO Data Sheets" form (Appendix VI).

12.13 Data collected and notes are to be entered to the corresponding spreadsheet in the cross sectional DO at Monitor Installations folder at:

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12.14 A second technician verifies that all of the data for the cross sectional analysis is entered correctly and then notifies a biologist via email that the cross sectional data review is complete.

13.0 Waste Management

13.1 All solution wastes may be flushed down a drain with cold tap water.

13.2 Use large quantities of cold tap water and pour slowly when flushing acids and bases down a drain.

14.0 References

14.1 Butts, T. A., Bergerhouse, T. R., "Sidestream Elevated Pool Aeration (SEPA) Station Reaeration Efficiency Evaluation Using Continuous In-Situ Dissolved Oxygen Monitoring," Prepared for the Metropolitan Water Reclamation District of Greater Chicago by the Illinois State Water Survey, Chemistry Division, March 1998.

14.2 Wagner, R. J., Mattraw, H. C., Ritz, G. F., Smith, B. A., "Guidelines and Standard Procedures for Continuous Water-Quality Monitors: Site Selection, Field Operation, Calibration, Record Computation and Reporting," U.S. Geological Survey, Water Resources Investigations Report 00-4252, 2000.

14.3 YSI, Inc., "6-Series Environmental Monitoring Systems Operations Manual," (EMSOM), Revision A, November 2011.

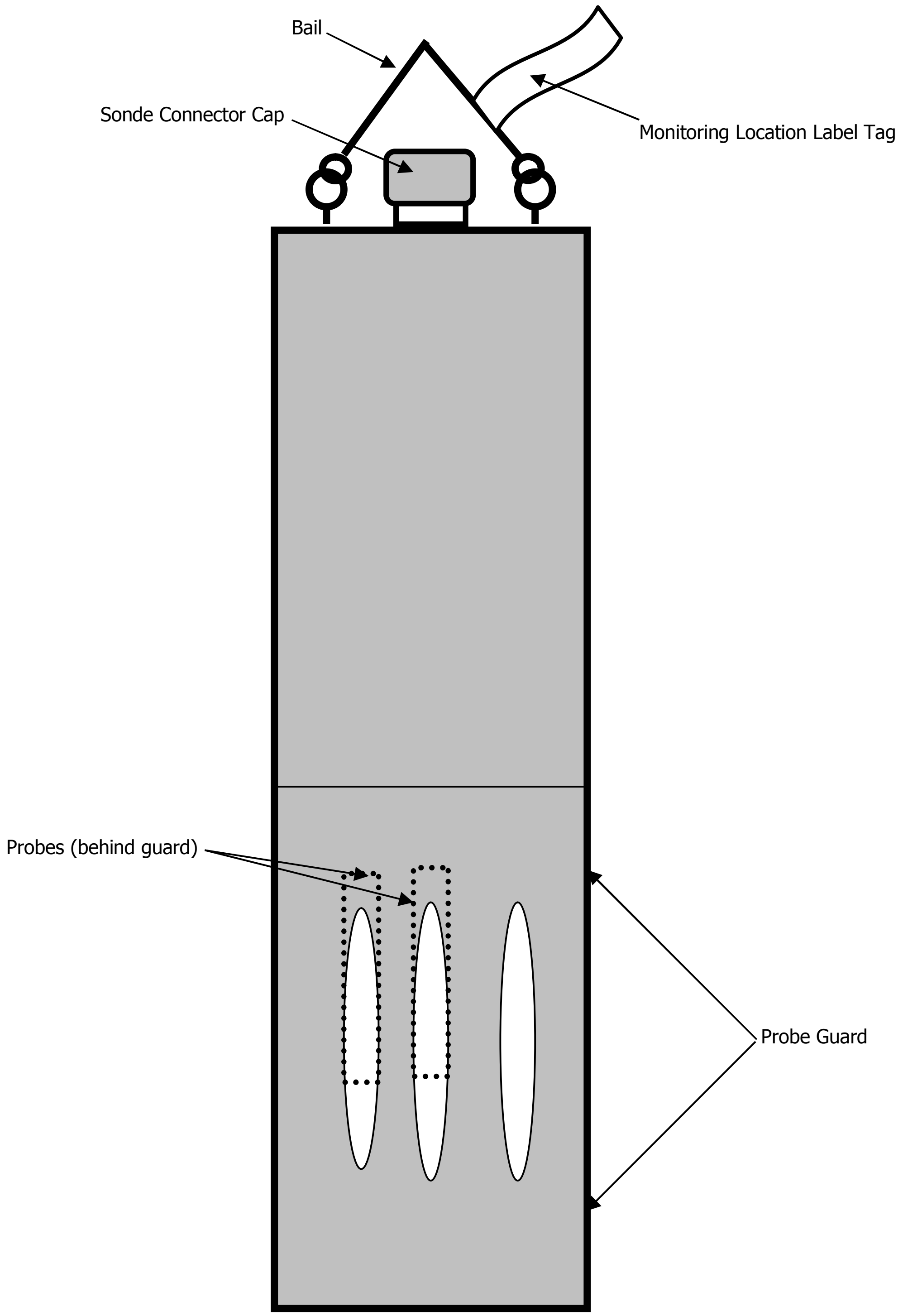
14.4 Eureka "Manta 2, Sub2 and Sub3 Water-Quality Multiprobe Manual", February 20, 2015.

14.5 American Public Health Association, "Standard Methods for the Examination of Water and Wastewater," 20th Edition, 1998.

14.6 Illinois Environmental Protection Agency Bureau of Water, "Standard Operating Procedure for Continuous Monitoring of Water Quality", IEPA BOW SOP014-01-0114, Revision 1, June 2014.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 1: WATER QUALITY MONITOR (TYPICAL)



APPENDIX I

HOLDING TANK LOG

Monitor Holding Tank DO, Temperature, and Conductivity - North Tank

NORTH

Date	Time	DO	Water Temp.	Time	DO	Water Temp.	Specific Cond.
/ /							
/ /							
/ /							
/ /							
/ /							
/ /							
/ /							
/ /							
/ /							
/ /							
/ /							
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/ /							
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/ /							

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APPENDIX II

SONDE-SITE LOG

Deployment date	Clark St.	Division St.	Addison St.	Foster Ave.

APPENDIX III

MONITOR DEPLOYMENT DATA LOG SHEET AND FIELD SHEET

Monitor Deployment / Retrieval Data

04/02/18 - 04/25/18

					PRE-deployment				POST-retrieval				
Location	Deployed Monitor #	Deployment / Retrieval Date and Time		Field Meter DO	Specific Cond.	Sonde Temp.	Calculated 100% DO saturation	Sonde DO in 100% DO saturation after calibration	Retrieved Monitor #	Specific Cond.	Sonde Temp.	Calculated 100% DO saturation day after recovery	Sonde DO in 100% DO saturation day after recovery

Week A / Tuesday / Land Run

Ready time:________ BP(mmHg):________ date/time: BP(mmHg):________ date/time:

Week A / Wednesday / Boat Run

Ready time:________ BP(mmHg):________ date/time: BP(mmHg):________ date/time:

Downloading completed by: ________

Corrections reviewed by: ________

Sonde Deployment and Retrieval - Field Observations
01/01/18 - 01/24/18

Location	Recovery Date	Time Sonde Recovered	Tube Cleaned	Temp (C)	Hach DO*	Observations (Water discoloration, debris accumulations in sonde housing or on sonde, damage to installations)
Church St. (NSC)			Y/N			
Clark St (CR)			Y/N			
Division St. (NBCR)			Y/N			
Addison St. (NBCR)			Y/N			
Foster Ave. (NSC)			Y/N			

Weather: Sunny Cloudy Rain Snow

Floatables: None Light Medium Heavy

Logjam near sonde housing yes no

Personnel:

*** Do not exchange sonde if unable to record DO with HACH meter**
Please empty sonde cooler when done

Rev. 01/2/18 \\hawk\M&R\120_EM&R_Division\126_Aquatic_Ecology\126_Lab_Techs\CDOM\Sondes\Weekly Information forms\Monitor and Field Data\2018\Week_A_Template_2018

APPENDIX IV

DAILY SONDE READINGS

Tank Value	North	East
DO (mg/L)		
Temp (°C)		

Barometric Pressure

Sonde #	Temp (°C)	Cond.	Sonde DO	Battery Voltage	DO Gain*(0.7-1.7)	Tank	Tank DO	Disparity	firm-ware version	Calibration Dates	New ODO Membrane
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											
21											
22											
23											
24											
25											
26											
27											
33											
34											
35											
36											
37											
38											
39											
40											
48											
50											
57											
61											
81											
82											
83											
84											
85											

APPENDIX V

CDOM DATABASE SCREENSHOTS

FIGURE 1:

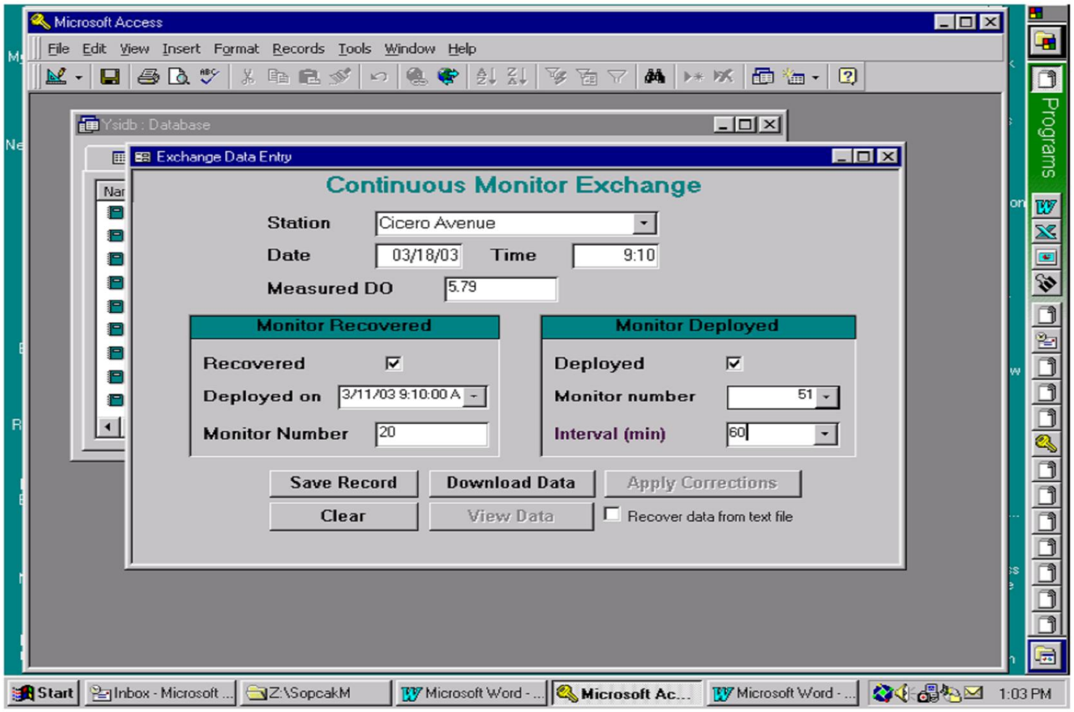

Microsoft Access
File Edit View Insert Format Records Tools Window Help
Ysidb : Database
Exchange Data Entry
Continuous Monitor Exchange
Station
Cicero Avenue
Date
03/18/03
Time
9:10
Measured DO
5.79
Monitor Recovered
Recovered
Deployed on
3/11/03 9:10:00 A
Monitor Number
20
Monitor Deployed
Deployed
Monitor number
51
Interval (min)
60
Save Record
Download Data
Apply Corrections
Clear
View Data
Recover data from text file
Start
Inbox - Microsoft ...
Z:\SopcakM
Microsoft Word - ...
Microsoft Ac...
Microsoft Word - ...
1:03 PM
Programs

FIGURE 2:

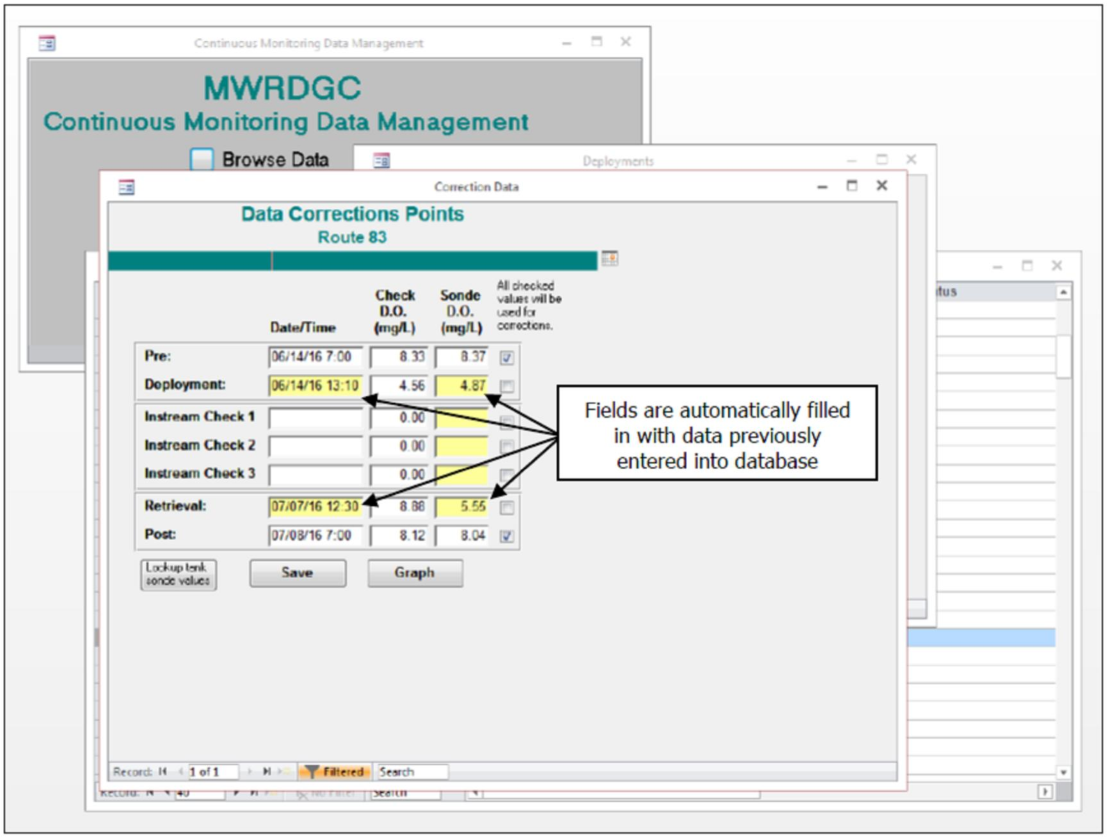

Continuous Monitoring Data Management
MWRDGC
Continuous Monitoring Data Management
Browse Data
Deployments
Correction Data
Data Corrections Points
Route 83
Date/Time
Check D.O. (mg/L)
Sonde D.O. (mg/L)
All checked values will be used for corrections.
Pre:
06/14/16 7:00
8.33
8.37
Deployment:
06/14/16 13:10
4.56
4.87
Instream Check 1
0.00
Instream Check 2
0.00
Instream Check 3
0.00
Retrieval:
07/07/16 12:30
8.88
5.55
Post:
07/08/16 7:00
8.12
8.04
Lookup tank sonde values
Save
Graph
Fields are automatically filled in with data previously entered into database
Record: 1 of 1
Filtered
Search

FIGURE 3:

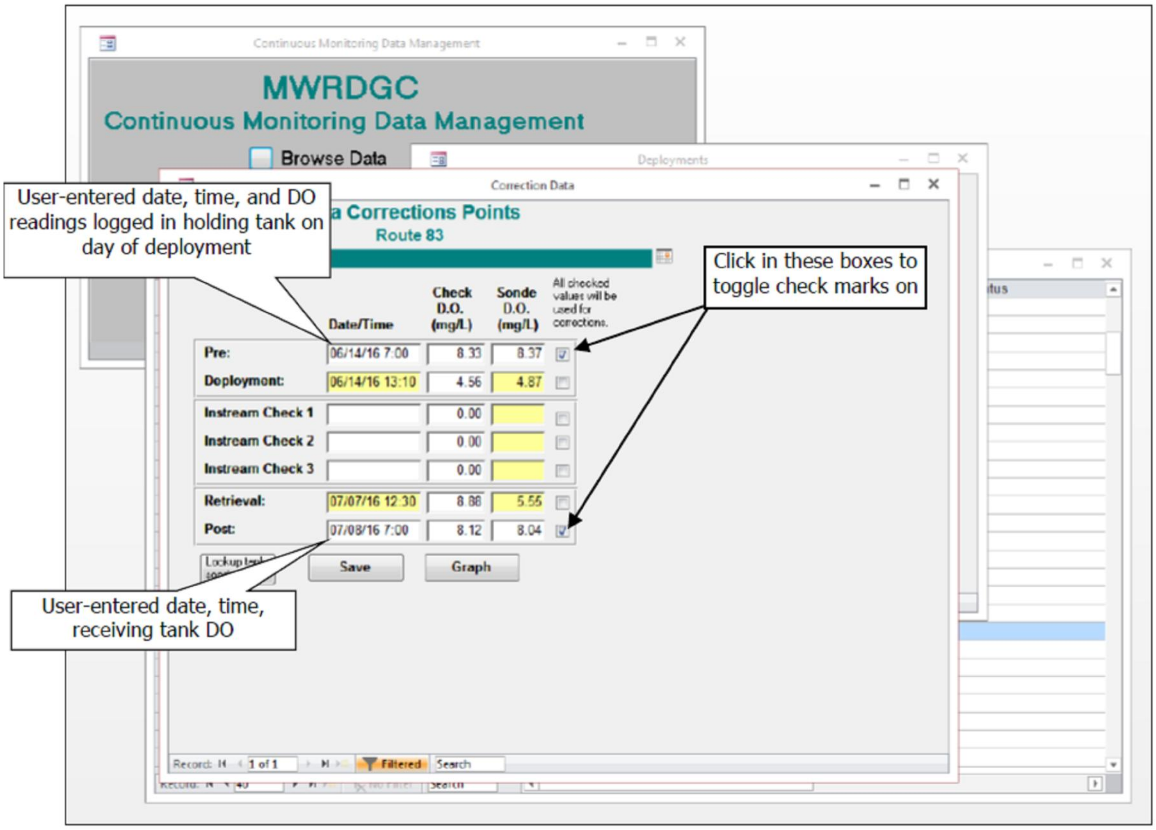

MWRDGC
Continuous Monitoring Data Management
Browse Data
Correction Data
a Corrections Points
Route 83
User-entered date, time, and DO readings logged in holding tank on day of deployment
Click in these boxes to toggle check marks on
Date/Time
Check D.O. (mg/L)
Sonde D.O. (mg/L)
All checked values will be used for corrections.
Pre: 06/14/16 7:00 8.33 8.37
Deployment: 06/14/16 13:10 4.56 4.87
Instream Check 1 0.00
Instream Check 2 0.00
Instream Check 3 0.00
Retrieval: 07/07/16 12:30 8.88 5.55
Post: 07/08/16 7:00 8.12 8.04
Save
Graph
User-entered date, time, receiving tank DO

FIGURE 4:

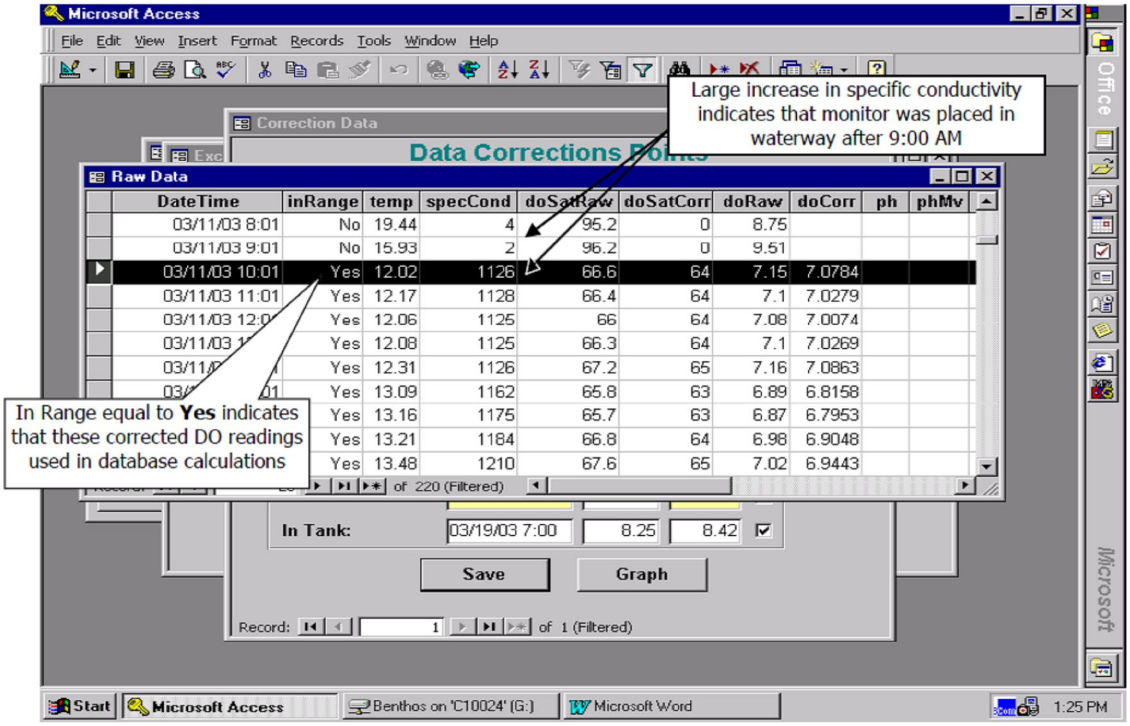
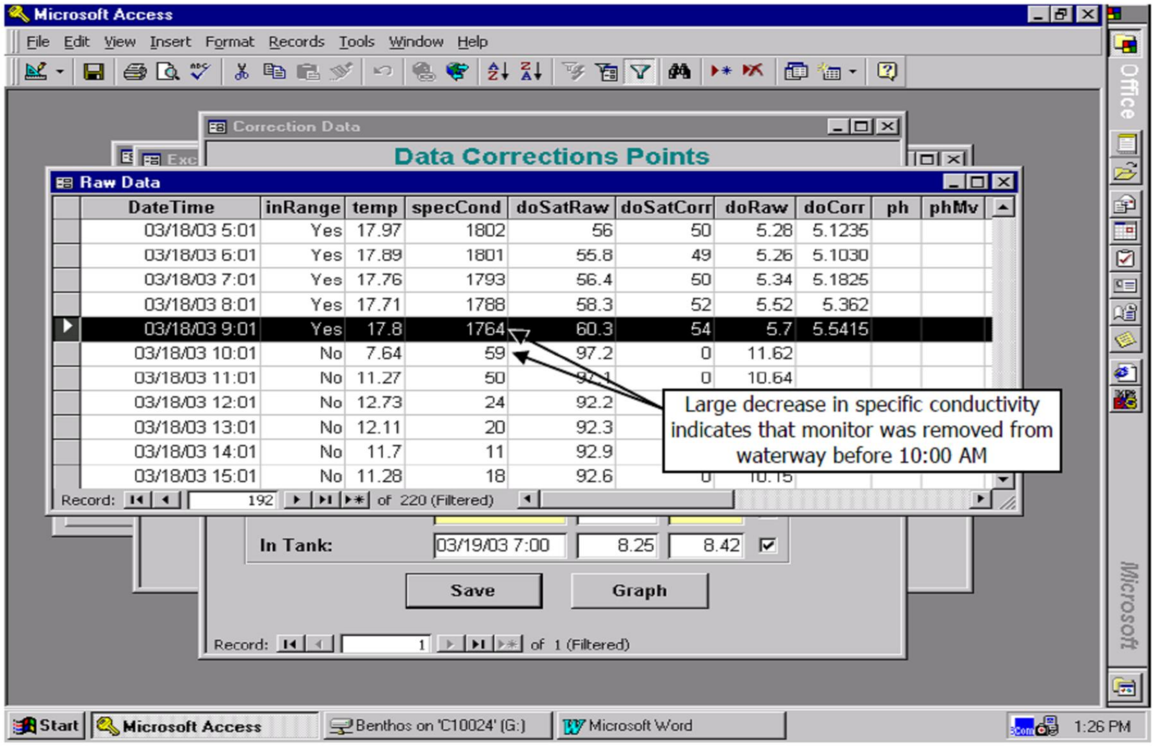

Large increase in specific conductivity indicates that monitor was placed in waterway after 9:00 AM
In Range equal to **Yes** indicates that these corrected DO readings used in database calculations
Microsoft Access
Correction Data
Data Corrections Points
Raw Data
DateTime
inRange
temp
specCond
doSatRaw
doSatCorr
doRaw
doCorr
ph
phMv
03/11/03 8:01
03/11/03 9:01
03/11/03 10:01
03/11/03 11:01
of 220 (Filtered)
In Tank:
03/19/03 7:00
8.25
8.42
Save
Graph
Record:
of 1 (Filtered)
Start
Microsoft Access
Benthos on 'C10024' (G:)
Microsoft Word
1:25 PM

FIGURE 5:


Microsoft Access
File Edit View Insert Format Records Tools Window Help
Correction Data
Data Corrections Points
Raw Data
DateTime inRange temp specCond doSatRaw doSatCorr doRaw doCorr ph phMv
03/18/03 5:01 Yes 17.97 1802 56 50 5.28 5.1235
03/18/03 6:01 Yes 17.89 1801 55.8 49 5.26 5.1030
03/18/03 7:01 Yes 17.76 1793 56.4 50 5.34 5.1825
03/18/03 8:01 Yes 17.71 1788 58.3 52 5.52 5.362
03/18/03 9:01 Yes 17.8 1764 60.3 54 5.7 5.5415
03/18/03 10:01 No 7.64 59 97.2 0 11.62
03/18/03 11:01 No 11.27 50 0 10.64
03/18/03 12:01 No 12.73 24 92.2
03/18/03 13:01 No 12.11 20 92.3
03/18/03 14:01 No 11.7 11 92.9
03/18/03 15:01 No 11.28 18 92.6
Large decrease in specific conductivity indicates that monitor was removed from waterway before 10:00 AM
Record: 192 of 220 (Filtered)
In Tank: 03/19/03 7:00 8.25 8.42
Save
Graph
Record: 1 of 1 (Filtered)
Start
Microsoft Access
Benthos on 'C10024' (G:)
Microsoft Word
1:26 PM

APPENDIX VI

CROSS SECTION SUMMARY

Cross-Sectional Dissolved Oxygen readings for the North-Boat Water Quality Monitor Installation Sites

Station / Date	Sampling Depth	Left* Side of Channel	Center* of Channel Sonde DO	Right* Side of Channel Sonde DO	Statistics
Clark St. (CR)	Surface				Mean
Date:	3 Feet				#DIV/0!
	Mid-Depth				Std. Dev.
	Bottom				#DIV/0!
Time:	Depth (ft)				
Division St. (NBCR)	Surface				Mean
Date:	3 Feet				#DIV/0!
	Mid-Depth				Std. Dev.
	Bottom				#DIV/0!
Time:	Depth (ft)				
Addison St. (NBCR)	Surface				Mean
Date:	3 Feet				#DIV/0!
	Mid-Depth				Std. Dev.
	Bottom				#DIV/0!
Time:	Depth (ft)				

***Facing upstream**

Avoid stirring benthic sediment when measuring DO at waterway bottom.
If sediment is stirred move to an adjacent location.
Record sampling start and end time
Calibrate sonde for depth each day
Calibrate the depth when there is a difference of 0.1 feet or greater
Manta depth correction factor (add to sonde depth) without the weight is 0.20, and with the weight is 0.25 (for sonde tank depth and total depth in the field)
Record depth at each location on the transect
≤1 ft Only a Bottom reading is needed
<4 ft Surface and Bottom readings are needed
≥4 ft to <8 ft, Surface, 3 ft, Bottom readings are needed
≥8 ft Surface, 3 ft, Mid-Depth, Bottom readings are needed

Cross-Sectional Dissolved Oxygen readings for the North-Boat Water Quality Monitor Installation Sites

Note unusual environmental conditions (heavy rain, CSO overflows, strong wind, strong current, passage of barges, or large pleasure craft)

Pre Cross-Section

Date / Time	Sonde #	BP (mmHg)	Sp. Cond. (µs/cm)	Temp. (°C)	Calculated DO	Sonde DO

Sonde #	Sonde Depth *	Tank Depth (ft)	Depth after Calibration *

* Add Manta Depth Correction Factor (0.2' or 0.25')

Battery Volts

Post Cross-Section

Date / Time	Sonde #	BP (mmHg)	Sp. Cond. (µs/cm)	Temp. (°C)	Calculated DO	Sonde DO

Sonde #	Sonde Depth	Tank Depth (ft)

Field Crew initials: Data entered by:

APPENDIX G

WATER QUALITY DATA FROM MONTHLY, WET-WEATHER, AND DRY-WEATHER SAMPLING EVENTS FROM POST-CONSTRUCTION MONITORING AT CALUMET WATERSHED LOCATIONS

TABLE G-1: WATER QUALITY DATA FROM MONTHLY, WET-WEATHER, AND DRY WEATHER SAMPLING EVENTS FROM POST CONSTRUCTION MONITORING AT CALUMET WATERSHED LOCATIONS

Collection Date	Sampling Point	Dissolved Oxygen (mg/L)	Total Ammonia Nitrogen (mg/L)	Total Suspended Solids (mg/L)	Total Dissolved Solids (ppm)	5-Day Biochemical Oxygen Demand (mg/L)	Fecal Coliform (CFU/100 mL)
01/23/2017	WW_86	8.2	0.29	13	702	NA	1,600
01/23/2017	WW_56	4.6	0.57	31	558	NA	30
01/23/2017	WW_76	8.2	0.32	7	694	NA	1,500
01/23/2017	WW_57	10.2	0.21	47	566	NA	780
01/23/2017	WW_59	8.8	0.26	43	648	NA	830
01/23/2017	WW_43	9.2	0.19	39	548	NA	650
02/27/2017	WW_52	10.1	0.26	14	670	NA	560
02/27/2017	WW_97	11.6	0.22	9	1,584	NA	470
02/27/2017	WW_55	11.3	0.37	4	324	NA	<10
02/27/2017	WW_86	9.4	0.93	13	634	NA	1,900
02/27/2017	WW_56	11.1	0.50	14	442	<2	20
02/27/2017	WW_76	9.0	0.45	7	582	3	2,900
02/27/2017	WW_57	12.0	0.31	9	1,176	<2	30
02/27/2017	WW_59	9.0	0.49	15	668	<2	550
02/27/2017	WW_43	7.5	5.66	12	734	<2	160
03/01/2017	WW_86	5.8	0.97	19	304	10	74,000
03/01/2017	WW_55	11.3	0.30	<4	350	<2	20
03/01/2017	WW_56	9.9	0.33	13	442	<2	<10
03/01/2017	WW_57	8.1	0.46	239	262	NA	7,700
03/01/2017	WW_76	7.0	0.70	6	552	4	60
03/01/2017	WW_97	7.9	0.38	252	260	NA	18,000
03/01/2017	WW_59	8.9	0.37	179	268	NA	2,000
03/01/2017	WW_43	8.5	0.31	181	404	NA	1,400

TABLE G-1 (Continued): WATER QUALITY DATA FROM MONTHLY, WET-WEATHER, AND DRY WEATHER SAMPLING EVENTS FROM POST CONSTRUCTION MONITORING AT CALUMET WATERSHED LOCATIONS

Collection Date	Sampling Point	Dissolved Oxygen (mg/L)	Total Ammonia Nitrogen (mg/L)	Total Suspended Solids (mg/L)	Total Dissolved Solids (ppm)	5-Day Biochemical Oxygen Demand (mg/L)	Fecal Coliform (CFU/100 mL)
03/01/2017	WW_52	8.1	0.39	45	266	4	9,400
03/27/2017	WW_52	8.0	0.13	110	426	4	1,400
03/27/2017	WW_97	7.9	<0.10	82	554	3	510
03/27/2017	WW_55	8.9	<0.10	<4	376	<2	<10
03/27/2017	WW_86	7.1	0.13	15	524	<2	770
03/27/2017	WW_56	11.1	<0.10	12	516	<2	<10
03/27/2017	WW_76	8.3	0.11	7	532	<2	40
03/27/2017	WW_57	9.2	0.13	120	552	3	1,800
03/27/2017	WW_59	8.5	0.17	24	584	<2	150
03/27/2017	WW_43	8.0	0.48	20	646	<2	140
03/31/2017	WW_86	5.5	0.33	10	350	5	34,000
03/31/2017	WW_55	9.1	<0.10	7	438	<2	<10
03/31/2017	WW_56	10.5	<0.10	11	484	3	50
03/31/2017	WW_57	7.5	<0.10	204	240	3	4,900
03/31/2017	WW_76	8.5	<0.10	9	462	<2	70
03/31/2017	WW_97	7.9	<0.10	178	240	3	2,800
03/31/2017	WW_59	8.4	0.14	95	332	3	4,800
03/31/2017	WW_43	9.5	0.14	27	328	6	1,600
03/31/2017	WW_52	8.8	0.10	316	262	4	9,100
04/24/2017	WW_52	7.9	0.14	40	658	<2	210
04/24/2017	WW_97	8.0	<0.10	8	1,364	NA	80
04/24/2017	WW_55	7.8	<0.10	4	446	8	<10
04/24/2017	WW_86	8.2	0.54	13	578	<2	80

TABLE G-1 (Continued): WATER QUALITY DATA FROM MONTHLY, WET-WEATHER, AND DRY WEATHER SAMPLING EVENTS FROM POST CONSTRUCTION MONITORING AT CALUMET WATERSHED LOCATIONS

Collection Date	Sampling Point	Dissolved Oxygen (mg/L)	Total Ammonia Nitrogen (mg/L)	Total Suspended Solids (mg/L)	Total Dissolved Solids (ppm)	5-Day Biochemical Oxygen Demand (mg/L)	Fecal Coliform (CFU/100 mL)
04/24/2017	WW_56	10.4	<0.10	10	548	<2	<10
04/24/2017	WW_76	9.4	0.15	17	564	4	60
04/24/2017	WW_57	8.4	<0.10	17	982	<2	140
04/24/2017	WW_59	8.1	0.19	17	600	<2	20
04/24/2017	WW_43	8.9	0.10	17	646	3	<10
05/11/2017	WW_86	7.7	<0.10	10	614	3	1,700
05/11/2017	WW_55	8.8	0.15	7	444	<2	<10
05/11/2017	WW_56	14.5	<0.10	30	544	NA	20
05/11/2017	WW_57	7.1	0.28	162	390	NA	9,500
05/11/2017	WW_76	8.6	0.24	9	548	5	140
05/11/2017	WW_97	7.7	0.26	189	312	NA	6,900
05/11/2017	WW_59	8.4	0.20	31	504	NA	1,100
05/11/2017	WW_43	8.0	0.25	33	484	NA	4,700
05/11/2017	WW_52	7.3	0.23	69	296	NA	11,000
05/22/2017	WW_52	6.6	0.18	42	648	<2	340
05/22/2017	WW_97	7.1	<0.10	18	984	<2	140
05/22/2017	WW_55	8.2	<0.10	5	448	<2	<10
05/22/2017	WW_86	7.1	<0.10	6	660	<2	230
05/22/2017	WW_56	8.3	0.10	10	560	<2	9
05/22/2017	WW_76	6.2	0.36	6	570	<2	70
05/22/2017	WW_57	6.4	0.26	22	708	<2	270
05/22/2017	WW_59	6.2	0.56	13	618	<2	150
05/22/2017	WW_43	5.8	0.48	35	646	NA	30

TABLE G-1 (Continued): WATER QUALITY DATA FROM MONTHLY, WET-WEATHER, AND DRY WEATHER SAMPLING EVENTS FROM POST CONSTRUCTION MONITORING AT CALUMET WATERSHED LOCATIONS

Collection Date	Sampling Point	Dissolved Oxygen (mg/L)	Total Ammonia Nitrogen (mg/L)	Total Suspended Solids (mg/L)	Total Dissolved Solids (ppm)	5-Day Biochemical Oxygen Demand (mg/L)	Fecal Coliform (CFU/100 mL)
06/26/2017	WW_52	2.4	0.23	6	730	<2	570
06/26/2017	WW_97	7.3	<0.10	17	1,714	<2	320
06/26/2017	WW_55	7.4	<0.10	4	310	<2	<10
06/26/2017	WW_86	4.7	0.13	15	498	<2	100
06/26/2017	WW_56	7.8	0.19	11	400	<2	30
06/26/2017	WW_76	7.3	0.31	9	478	<2	60
06/26/2017	WW_57	4.4	0.10	24	754	6	90
06/26/2017	WW_59	5.9	0.50	13	514	<2	9
06/26/2017	WW_43	6.2	0.64	18	598	<2	30
07/31/2017	WW_52	6.2	0.10	25	700	<2	1,700
07/31/2017	WW_97	7.1	<0.10	14	1,454	<2	320
07/31/2017	WW_55	7.5	<0.10	4	264	<2	9
07/31/2017	WW_86	6.7	<0.10	15	498	<2	130
07/31/2017	WW_56	8.9	0.21	10	364	<2	9
07/31/2017	WW_76	8.7	0.20	6	476	<2	130
07/31/2017	WW_57	7.6	<0.10	12	628	4	410
07/31/2017	WW_59	7.3	0.15	10	444	<2	40
07/31/2017	WW_43	9.0	0.10	9	494	<2	<10
08/28/2017	WW_52	4.9	0.24	14	750	<2	1,400
08/28/2017	WW_97	6.8	<0.10	33	1,444	<2	540
08/28/2017	WW_55	7.6	<0.10	6	220	<2	20
08/28/2017	WW_86	5.4	<0.10	7	374	<2	100
08/28/2017	WW_56	8.3	<0.10	11	314	<2	9

TABLE G-1 (Continued): WATER QUALITY DATA FROM MONTHLY, WET-WEATHER, AND DRY WEATHER SAMPLING EVENTS FROM POST CONSTRUCTION MONITORING AT CALUMET WATERSHED LOCATIONS

Collection Date	Sampling Point	Dissolved Oxygen (mg/L)	Total Ammonia Nitrogen (mg/L)	Total Suspended Solids (mg/L)	Total Dissolved Solids (ppm)	5-Day Biochemical Oxygen Demand (mg/L)	Fecal Coliform (CFU/100 mL)
08/28/2017	WW_76	7.8	0.27	10	404	<2	20
08/28/2017	WW_57	8.6	0.24	12	500	<2	40
08/28/2017	WW_59	6.8	0.33	16	502	<2	20
08/28/2017	WW_43	7.2	0.12	20	430	3	<10
09/25/2017	WW_52	5.4	0.43	41	764	<2	2,000
09/25/2017	WW_97	6.5	<0.10	33	2,780	<2	730
09/25/2017	WW_55	7.8	<0.10	<4	182	5	<10
09/25/2017	WW_86	6.0	0.14	12	374	<2	300
09/25/2017	WW_56	8.1	<0.10	6	268	<2	9
09/25/2017	WW_76	8.3	<0.10	8	340	<2	20
09/25/2017	WW_57	8.8	0.11	14	454	<2	40
09/25/2017	WW_59	7.1	0.20	6	376	<2	9
09/25/2017	WW_43	6.6	0.14	10	404	<2	<10
10/11/2017	WW_86	6.3	0.20	7	388	<2	6,000
10/11/2017	WW_55	7.2	<0.10	5	202	<2	40
10/11/2017	WW_56	7.1	0.15	9	262	<2	310
10/11/2017	WW_57	6.3	0.36	52	504	4	13,000
10/11/2017	WW_76	6.6	0.49	10	370	<2	360
10/11/2017	WW_97	6.7	0.80	109	678	6	12,000
10/11/2017	WW_59	6.3	0.30	23	428	<2	3,100
10/11/2017	WW_43	5.7	0.31	19	362	<2	3,100
10/11/2017	WW_52	6.1	0.14	37	212	3	20,000
10/23/2017	WW_52	7.1	0.29	68	156	6	64,000

TABLE G-1 (Continued): WATER QUALITY DATA FROM MONTHLY, WET-WEATHER, AND DRY WEATHER SAMPLING EVENTS FROM POST CONSTRUCTION MONITORING AT CALUMET WATERSHED LOCATIONS

Collection Date	Sampling Point	Dissolved Oxygen (mg/L)	Total Ammonia Nitrogen (mg/L)	Total Suspended Solids (mg/L)	Total Dissolved Solids (ppm)	5-Day Biochemical Oxygen Demand (mg/L)	Fecal Coliform (CFU/100 mL)
10/23/2017	WW_97	7.4	0.60	162	472	7	20,000
10/23/2017	WW_55	7.9	<0.10	7	232	<2	30
10/23/2017	WW_86	7.0	0.18	7	390	<2	1,500
10/23/2017	WW_56	7.0	0.31	8	338	<2	140
10/23/2017	WW_76	6.2	0.17	9	394	<2	390
10/23/2017	WW_57	7.4	<0.10	135	434	4	9,500
10/23/2017	WW_59	6.5	0.25	26	406	<2	710
10/23/2017	WW_43	5.9	0.28	23	466	<2	2,000
10/25/2017	WW_86	6.8	0.11	6	450	<2	1,400
10/25/2017	WW_55	7.8	<0.10	4	250	<2	40
10/25/2017	WW_56	7.4	0.37	10	344	<2	220
10/25/2017	WW_57	7.5	0.13	56	318	<2	7,200
10/25/2017	WW_76	7.1	0.14	8	426	<2	200
10/25/2017	WW_97	6.9	0.10	46	326	3	3,100
10/25/2017	WW_59	7.0	0.17	37	340	3	4,000
10/25/2017	WW_43	7.1	0.15	26	316	3	3,900
10/25/2017	WW_52	7.7	0.14	38	282	3	10,000
11/27/2017	WW_52	9.9	0.18	18	590	<2	1,300
11/27/2017	WW_97	10.1	0.10	10	1,098	<2	1,400
11/27/2017	WW_55	10.7	0.10	<4	306	<2	<10
11/27/2017	WW_86	8.9	<0.10	5	736	<2	2,100
11/27/2017	WW_56	9.7	0.19	5	448	<2	50
11/27/2017	WW_76	8.2	0.19	4	524	<2	90

TABLE G-1 (Continued): WATER QUALITY DATA FROM MONTHLY, WET-WEATHER, AND DRY WEATHER SAMPLING EVENTS FROM POST CONSTRUCTION MONITORING AT CALUMET WATERSHED LOCATIONS

Collection Date	Sampling Point	Dissolved Oxygen (mg/L)	Total Ammonia Nitrogen (mg/L)	Total Suspended Solids (mg/L)	Total Dissolved Solids (ppm)	5-Day Biochemical Oxygen Demand (mg/L)	Fecal Coliform (CFU/100 mL)
11/27/2017	WW_57	9.0	0.12	11	814	<2	510
11/27/2017	WW_59	7.7	0.20	7	588	<2	110
11/27/2017	WW_43	7.5	0.20	8	542	<2	50
01/29/2018	WW_52	10.1	0.48	17	448	<2	2,000
01/29/2018	WW_97	9.9	0.38	14	1,552	<2	760
01/29/2018	WW_55	11.7	0.15	<4	266	<2	<10
01/29/2018	WW_86	8.1	0.32	8	456	<2	1,500
01/29/2018	WW_56	10.5	0.35	8	392	<2	<10
01/29/2018	WW_76	7.8	1.03	6	660	3	1,100
01/29/2018	WW_57	9.5	0.51	11	1,226	<2	930
01/29/2018	WW_59	8.2	1.02	13	688	<2	270
01/29/2018	WW_43	8.4	0.84	7	846	<2	99
02/21/2018	WW_86	6.5	0.89	16	390	10	76,000
02/21/2018	WW_55	12.2	0.17	7	362	<2	9
02/21/2018	WW_56	10.7	0.25	9	548	<2	530
02/21/2018	WW_57	9.4	0.19	183	306	5	6,800
02/21/2018	WW_76	9.3	0.14	<4	702	<2	5,100
02/21/2018	WW_97	9.8	0.17	107	270	3	3,700
02/21/2018	WW_59	9.4	0.21	166	360	4	5,800
02/21/2018	WW_43	8.9	0.23	140	438	5	4,700
02/21/2018	WW_52	9.6	0.21	170	222	4	20,000
02/26/2018	WW_52	9.9	0.28	58	390	4	790
02/26/2018	WW_97	10.4	0.80	44	678	3	15,000

TABLE G-1 (Continued): WATER QUALITY DATA FROM MONTHLY, WET-WEATHER, AND DRY WEATHER SAMPLING EVENTS FROM POST CONSTRUCTION MONITORING AT CALUMET WATERSHED LOCATIONS

Collection Date	Sampling Point	Dissolved Oxygen (mg/L)	Total Ammonia Nitrogen (mg/L)	Total Suspended Solids (mg/L)	Total Dissolved Solids (ppm)	5-Day Biochemical Oxygen Demand (mg/L)	Fecal Coliform (CFU/100 mL)
02/26/2018	WW_55	11.1	0.20	4	380	<2	9
02/26/2018	WW_86	7.8	0.29	8	622	<2	4,500
02/26/2018	WW_56	8.7	0.61	16	522	3	170
02/26/2018	WW_76	7.5	0.34	4	736	<2	470
02/26/2018	WW_57	9.8	0.41	55	560	3	2,700
02/26/2018	WW_59	8.5	0.32	32	646	<2	860
02/26/2018	WW_43	8.9	0.27	22	620	3	510
03/26/2018	WW_52	12.6	0.10	9	774	3	430
03/26/2018	WW_97	11.6	<0.10	9	1,538	<2	90
03/26/2018	WW_55	11.2	0.21	<4	436	<2	<10
03/26/2018	WW_86	9.6	0.16	8	474	<2	2,500
03/26/2018	WW_56	11.4	0.14	8	472	<2	<10
03/26/2018	WW_76	8.6	0.20	5	508	<2	100
03/26/2018	WW_57	13.9	0.15	6	876	<2	110
03/26/2018	WW_59	8.4	0.31	20	586	<2	<10
03/26/2018	WW_43	8.8	0.40	8	646	3	9
04/23/2018	WW_52	9.7	0.16	23	694	<2	450
04/23/2018	WW_97	10.4	0.13	12	1,208	<2	200
04/23/2018	WW_55	11.0	0.12	<4	430	<2	20
04/23/2018	WW_86	9.7	0.20	8	476	<2	70
04/23/2018	WW_56	9.7	0.18	9	500	<2	<10
04/23/2018	WW_76	8.0	0.37	7	652	<2	20
04/23/2018	WW_57	8.2	0.15	17	916	<2	180

TABLE G-1 (Continued): WATER QUALITY DATA FROM MONTHLY, WET-WEATHER, AND DRY WEATHER SAMPLING EVENTS FROM POST CONSTRUCTION MONITORING AT CALUMET WATERSHED LOCATIONS

Collection Date	Sampling Point	Dissolved Oxygen (mg/L)	Total Ammonia Nitrogen (mg/L)	Total Suspended Solids (mg/L)	Total Dissolved Solids (ppm)	5-Day Biochemical Oxygen Demand (mg/L)	Fecal Coliform (CFU/100 mL)
04/23/2018	WW_59	8.5	0.42	10	656	<2	30
04/23/2018	WW_43	8.1	0.43	12	720	<2	9
05/15/2018	WW_86	7.0	<0.10	8	488	<2	6,600
05/15/2018	WW_55	7.5	<0.10	7	372	<2	91
05/15/2018	WW_56	8.7	0.19	9	442	<2	100
05/15/2018	WW_57	6.1	0.25	85	420	3	5,300
05/15/2018	WW_76	6.3	0.17	5	482	<2	210
05/15/2018	WW_97	5.5	0.23	98	526	7	7,800
05/15/2018	WW_59	6.1	0.30	21	490	<2	2,500
05/15/2018	WW_43	6.3	0.27	49	440	3	2,400
05/15/2018	WW_52	4.8	0.33	26	394	5	270
05/22/2018	WW_86	6.1	0.16	10	512	<2	110
05/22/2018	WW_55	7.3	<0.10	6	358	<2	20
05/22/2018	WW_56	7.9	<0.10	7	460	<2	<10
05/22/2018	WW_57	6.3	0.30	42	840	5	5,200
05/22/2018	WW_76	6.6	0.18	6	472	3	30
05/22/2018	WW_97	6.8	0.31	60	774	4	600
05/22/2018	WW_59	5.6	0.30	18	578	3	2,600
05/22/2018	WW_43	5.7	0.33	14	504	3	5,900
05/22/2018	WW_52	6.0	0.29	50	482	3	2,000
05/29/2018	WW_52	3.4	0.40	16	818	3	600
05/29/2018	WW_97	4.6	0.21	30	1,780	3	360
05/29/2018	WW_55	6.8	<0.10	<4	412	<2	<10

TABLE G-1 (Continued): WATER QUALITY DATA FROM MONTHLY, WET-WEATHER, AND DRY WEATHER SAMPLING EVENTS FROM POST CONSTRUCTION MONITORING AT CALUMET WATERSHED LOCATIONS

Collection Date	Sampling Point	Dissolved Oxygen (mg/L)	Total Ammonia Nitrogen (mg/L)	Total Suspended Solids (mg/L)	Total Dissolved Solids (ppm)	5-Day Biochemical Oxygen Demand (mg/L)	Fecal Coliform (CFU/100 mL)
05/29/2018	WW_86	6.6	<0.10	19	662	<2	99
05/29/2018	WW_56	12.2	0.10	11	480	3	<10
05/29/2018	WW_76	11.9	0.14	12	586	4	<10
05/29/2018	WW_57	3.9	0.36	27	1,234	<2	80
05/29/2018	WW_59	9.9	0.16	13	644	4	<10
05/29/2018	WW_43	9.2	<0.10	17	636	3	9
06/25/2018	WW_52	5.4	0.33	114	426	5	1,300
06/25/2018	WW_97	7.0	0.15	90	540	3	1,200
06/25/2018	WW_86	6.6	0.20	15	616	3	220
06/25/2018	WW_56	8.2	0.15	9	430	<2	40
06/25/2018	WW_76	6.5	0.20	9	586	<2	80
06/25/2018	WW_57	6.0	0.21	23	456	<2	930
06/25/2018	WW_59	5.5	0.30	13	540	<2	140
06/25/2018	WW_43	4.7	0.30	14	454	<2	240
07/30/2018	WW_52	5.6	<0.50	31	720	<2	870
07/30/2018	WW_97	8.9	<0.50	7	1,882	<2	380
07/30/2018	WW_55	7.6	<0.50	<4	240	<2	9
07/30/2018	WW_86	6.5	<0.50	6	472	<2	340
07/30/2018	WW_56	10.4	<0.50	5	386	<2	9
07/30/2018	WW_76	9.7	<0.50	5	522	<2	40
07/30/2018	WW_57	11.0	<0.50	9	576	3	40
07/30/2018	WW_59	10.3	<0.50	8	538	21	50
07/30/2018	WW_43	10.1	<0.50	10	550	<2	9

TABLE G-1 (Continued): WATER QUALITY DATA FROM MONTHLY, WET-WEATHER, AND DRY WEATHER SAMPLING EVENTS FROM POST CONSTRUCTION MONITORING AT CALUMET WATERSHED LOCATIONS

Collection Date	Sampling Point	Dissolved Oxygen (mg/L)	Total Ammonia Nitrogen (mg/L)	Total Suspended Solids (mg/L)	Total Dissolved Solids (ppm)	5-Day Biochemical Oxygen Demand (mg/L)	Fecal Coliform (CFU/100 mL)
08/27/2018	WW_52	3.2	<0.50	30	762	<2	550
08/27/2018	WW_97	6.5	<0.50	31	1,542	<2	690
08/27/2018	WW_86	6.9	<0.50	8	606	<2	110
08/27/2018	WW_56	9.8	<0.50	11	390	3	<10
08/27/2018	WW_76	8.1	<0.50	11	498	3	70
08/27/2018	WW_57	6.7	<0.50	24	1,088	3	390
08/27/2018	WW_59	7.7	<0.50	10	524	3	40
08/27/2018	WW_43	6.2	<0.50	23	496	3	30
09/24/2018	WW_52	5.3	<0.50	31	748	5	370
09/24/2018	WW_97	8.8	<0.50	9	1,840	<2	350
09/24/2018	WW_55	8.2	<0.50	5	196	<2	20
09/24/2018	WW_86	6.7	<0.50	9	418	<2	70
09/24/2018	WW_56	7.5	<0.50	17	294	<2	30
09/24/2018	WW_76	6.9	<0.50	14	416	<2	60
09/24/2018	WW_57	7.2	<0.50	10	488	<2	40
09/24/2018	WW_59	6.2	<0.50	20	498	<2	40
09/24/2018	WW_43	6.6	<0.50	14	470	<2	<10
10/22/2018	WW_52	9.3	<0.50	192	822	NA	6,800
10/22/2018	WW_97	10.3	<0.50	11	1,652	NA	220
10/22/2018	WW_55	9.0	<0.50	<4	262	NA	<10
10/22/2018	WW_86	8.0	<0.50	4	464	NA	40
10/22/2018	WW_56	9.2	<0.50	22	402	NA	<10
10/22/2018	WW_76	8.4	<0.50	11	476	NA	110

TABLE G-1 (Continued): WATER QUALITY DATA FROM MONTHLY, WET-WEATHER, AND DRY WEATHER SAMPLING EVENTS FROM POST CONSTRUCTION MONITORING AT CALUMET WATERSHED LOCATIONS

Collection Date	Sampling Point	Dissolved Oxygen (mg/L)	Total Ammonia Nitrogen (mg/L)	Total Suspended Solids (mg/L)	Total Dissolved Solids (ppm)	5-Day Biochemical Oxygen Demand (mg/L)	Fecal Coliform (CFU/100 mL)
10/22/2018	WW_57	8.1	<0.50	14	554	NA	30
10/22/2018	WW_59	7.4	<0.50	33	592	NA	110
10/22/2018	WW_43	7.7	<0.50	22	586	NA	40
11/26/2018	WW_52	10.7	<0.50	48	312	8	6,100
11/26/2018	WW_97	10.6	0.55	194	338	11	55,000
11/26/2018	WW_55	11.0	<0.50	<4	246	<2	<10
11/26/2018	WW_86	9.4	<0.50	10	330	4	20,000
11/26/2018	WW_56	10.6	<0.50	9	370	3	30
11/26/2018	WW_76	8.3	<0.50	7	506	<2	200
11/26/2018	WW_57	10.0	<0.50	109	620	9	6,600
11/26/2018	WW_59	9.2	<0.50	12	616	<2	190
11/26/2018	WW_43	8.5	<0.50	13	584	<2	90
12/19/2018	WW_52	12.0	<0.50	20	564	3	1,100
12/19/2018	WW_97	11.7	<0.50	11	798	3	2,500
12/19/2018	WW_55	11.9	<0.50	<4	324	<2	<10
12/19/2018	WW_86	9.4	<0.50	6	584	<2	5,400
12/19/2018	WW_56	12.0	<0.50	5	488	3	40
12/19/2018	WW_76	8.5	<0.50	<4	624	<2	890
12/19/2018	WW_57	11.0	<0.50	14	744	<2	590
12/19/2018	WW_59	8.8	<0.50	8	620	3	350
12/19/2018	WW_43	8.1	<0.50	11	594	<2	780

APPENDIX H

LETTERS TO THE ILLINOIS ENVIRONMENTAL PROTECTION AGENCY AND UNITED STATES ENVIRONMENTAL PROTECTION AGENCY FOR NOTIFICATION OF COMBINED SEWER OVERFLOWS

Metropolitan Water Reclamation District of Greater Chicago

100 EAST ERIE STREET CHICAGO, ILLINOIS 60611-3154 312.751.5600

David St. Pierre
Executive Director

312.751.7900 f: 312.751.7926
david.stpierre@mwrd.org

April 28, 2017

Jay Patel, Field Operations Section
Illinois Environmental Protection Agency (IEPA)
Division of Water Pollution Control
Des Plaines Regional Office
9511 West Harrison Street
Des Plaines, IL 60016

Elizabeth Wallace
Thomas Shepherd
Assistant Attorney General
Environmental Bureau
Illinois Attorney General's Office
69 West Washington, Suite 1800
Chicago, IL 60602

Roger Callaway, Compliance Assurance Section
Illinois Environmental Protection Agency (IEPA)
Division of Water Pollution Control
1021 North Grand Avenue East
Post Office Box 19276
Springfield, IL 62794

Subject: Metropolitan Water Reclamation District of Greater Chicago (District)
National Pollutant Discharge Elimination System (NPDES) Permits
Consent Decree (Civil Action No. 11 C 8859) – Notice of Combined Sewer Overflow
February 28, 2017

On February 28, 2017, a combined sewer overflow occurred at C-1 and CDS-45 on the Little Cal Leg of the Calumet TARP System as a result of an average rainfall in the south area in the amount of 1.81 inches, with locally heavier rainfall. The Illinois State Water Survey gage 22, located near Harvey, Illinois recorded 3.32 inches in a six-hour period.

The details of these discharges are as follows:

Location	Overflow Date & Start Time	Overflow Date & Stop Time	Duration	Estimated Volume of Discharge (Gallons)
C-1	2/28/17 @ 8:30 pm	2/28/17 @ 9:04 pm	34 min	89,570
CDS-45	2/28/17 @ 6:42 pm	2/28/17 @ 7:46 pm	1 hr 4 min	865,656
	2/28/17 @ 8:12 pm	2/28/17 @ 11:59 pm	3 hrs 47 min	3,070,374

At both C-1 and CDS-45, the TARP south connecting structure is upstream of the interceptor connecting structure. In order to prevent dry weather flow (DWF) from going to TARP, a flume was created that was designed to take DWF through the TARP connecting structure to the interceptor. During severe storms, it is possible for some of the flumed flow to go to the CSO outfall when the interceptor is full, rather than into TARP. When this occurred in August 2016, an attempt was made to rectify this situation by adding weir boards just upstream of the tide gates at both C-1 and CDS-45 in an effort to force flow back to the TARP connection. The boards that were added at each location in 2016 to increase the weir elevation were proven to be of insufficient height to prevent an overflow during a major rain event such as that which occurred on February 28, 2017.

As the original modification did not prevent further overflows, the District is now investigating whether this flow can be rerouted to prevent a reoccurrence.

Condition VIII.28.f of the Consent Decree (Calumet TARP System Performance Criteria) states that *"For each precipitation event, no CSO Outfall in the Calumet TARP System shall discharge until conditions described in subparagraphs (a) through (e) preceding this subparagraph are achieved"*. These conditions for this storm are documented below:

a. *All flows that enter the Calumet TARP tunnels and Thornton Composite Reservoir are conveyed to the Calumet WRP for full treatment in accordance with the then current Calumet NPDES Permit, including the bypass provisions in that permit; provided however, that, when the Cal Sag Tunnel is full, flow may leave the Calumet TARP Tunnels through Outfall No. 158 on the Calumet 18EA branch tunnel without first being conveyed to the Calumet WRP for full treatment as described in Appendix A. Notwithstanding the above, Outfall No. 158 remains subject to the terms of the then current Calumet NPDES Permit.*

   All flows that entered into the Calumet TARP System received full treatment; the flows that discharged through C-1 and CDS-45 were unable to enter the system due to local volume/hydraulic restrictions. There were no discharges through Outfall No. 158 nor were there any plant bypasses through 002 or 003.

b. *During all precipitation events, MWRD shall accept and provide full treatment of the Maximum Practical Flow at the Calumet WRP;*

   The Calumet WRP provided full treatment for the maximum practical flow that could be pumped to the plant at any given time. At the start of the storm, the flow at the plant was 197 MGD. As the flow to the wet well increased, the pumping rate was also increased until a maximum flow rate of 474 MGD was achieved. Flow into the wet well decreased after 4 am on March 1, 2017; TARP pumps were not put into service until 2:20 pm to accommodate a leakage test on the seal water line. See item d. below.

c. *Treatment at the Calumet WRP and capture of combined sewage in the Calumet TARP System is maximized at all times, consistent with the TARP Operational Plan approved by Illinois EPA and in accordance with the then current Calumet NPDES Permit (at the time the proposed Operational Plan is submitted to Illinois EPA for approval, MWRD must provide a copy of the proposed plan to the United States);*

   The availability of the dewatering pumps at the TARP Pump Station is currently limited due to the planned replacement of the TARP pumps in the East Pump House and the recent replacement and ongoing testing of the new pumps in the West Pump House, under Contract No. 06-212-3M, Calumet TARP Pump Station Improvements. The West Pump House is currently in service and consists of three 72 MGD pumps; however, a maximum of two pumps can be used at any time because the discharge pipe is not large enough to accept flow from three pumps, limiting the flow to ~ 144 MGD. In addition, the ability to pump from the West Pump House has been and continues to be affected by constraints imposed due to construction under this project. The recently replaced pumps are undergoing the 120-day testing period, which may necessitate one or more pumps being taken out of service as issues arise. This testing period began on January 9, 2017, and is scheduled for completion on May 9, 2017. This testing period may be extended in order to ensure proper installation and operation. Pumping from TARP cannot start until capacity is available in the wet well after sufficient dewatering of the interceptor system. The current NPDES permit for the Calumet WRP does not require the submittal of the TARP Operational Plan. The District has reached out to the Illinois EPA for direction regarding this requirement.

   Also, as stated in item b. above, a leakage test was scheduled on the seal water line on March 1, 2017. The television inspection was required due to a water leak in the pump house. As a result, the TARP pumps were not started when the plant flow decreased below the maximum flow rate at approximately 4 am, because the system needed to be isolated and locked out by 7 am to accommodate the test. West Pump No. 2 was put into service subsequent to the inspection at 2:20 pm. West Pump No. 3 was not available due to vibration issues which were being investigated by the contractor. An attempt was made to start West Pump No. 1 which kicked out due to vibration issues. West Pump No. 1 was able to be put in service at 7 am on March 3, 2017.

d. *During all times when the Calumet TARP tunnels or Thornton Composite Reservoir contain combined sewage in excess of any Retained Amount, MWRD shall pump combined sewage from the Calumet TARP Pump Station at the Maximum Practical Pumping Rate subject to the Maximum Practical Flow capable of receiving full treatment at the Calumet WRP;*

At the start of the storm on February 28, 2017 at 5:15 pm, the TARP tunnels had an available capacity of 74.8% (627 MG total) while the reservoir had an available capacity of 99.2% (7,900 MG total); therefore, the amount in the reservoir (0.8%) was less than the Retained Maximum Amount (5.6%). The dewatering of the TARP System started on March 1, 2017 at 2:20 pm when there was 28.2% capacity in the tunnel and 78.6% capacity in the reservoir and has been ongoing as a result of subsequent storms.

e. *All Calumet TARP drop shaft control structures (inlet sluice gates) must be maintained in the 100 percent Equivalent Open position to receive maximum flow into the Calumet TARP tunnels and Thornton Composite Reservoir until the Thornton Composite Reservoir is Full or Transient Events would occur if the sluice gates remained in the 100 Percent Equivalent Open position.*

All sluice gates were maintained in the 100% equivalent open position throughout the duration of the storm. No gates were closed in anticipation of a transient event nor did a transient event occur. All gates were operable throughout.

The CSOs did not occur as a result of failure to achieve the conditions above or to operate the TARP System in a manner that was consistent with the Operating Plan, but rather occurred as a result of local conditions preventing the conveyance of storm flows into the TARP dropshaft.

Section XII. Reporting Requirement Certification, Paragraph 48:

I certify under penalty of law that this document and its attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fines and imprisonment for knowing violations.

Sincerely,

David St. Pierre /

David St. Pierre

JPM:BAP:SO'C
c: Dean Maraldo, Chief, EPA – Chicago
Regional Counsel, EPA – Chicago
Chief, Environmental Enforcement Section, U.S. DOJ – Washington, D.C.
Granato/Hill/O'Connor/Garelli/Serafino/Conway

Protecting Our Water Environment

Metropolitan Water Reclamation District of Greater Chicago

100 EAST ERIE STREET CHICAGO, ILLINOIS 60611-3154 312.751.5600

David St. Pierre
Executive Director

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April 28, 2017

Mr. Dean Maraldo, Chief
Water Enforcement and Compliance Assurance Branch
Water Division
United States Environmental Protection Agency (USEPA)
Region 5
77 W. Jackson Blvd.
Chicago, IL 60604

Chief, Environmental Enforcement
Section
Environmental and Natural Resources
Division
US Department of Justice (USDOJ)
Box 7611 Ben Franklin Station
Washington. D.C. 20044-7611
Re: DOJ No. 90-5-1-1-07679

Regional Counsel
USEPA, Region 5
Division of Water Pollution Control
77 W. Jackson Blvd.
Chicago, IL 60604

Subject: Metropolitan Water Reclamation District of Greater Chicago (District)
National Pollutant Discharge Elimination System (NPDES) Permits
Consent Decree (Civil Action No. 11 C 8859) – Notice of Combined Sewer Overflow
February 28, 2017

On February 28, 2017, a combined sewer overflow occurred at C-1 and CDS-45 on the Little Cal Leg of the Calumet TARP System as a result of an average rainfall in the south area in the amount of 1.81 inches, with locally heavier rainfall. The Illinois State Water Survey gage 22, located near Harvey, Illinois recorded 3.32 inches in a six-hour period.

The details of these discharges are as follows:

Location	Overflow Date & Start Time	Overflow Date & Stop Time	Duration	Estimated Volume of Discharge (Gallons)
C-1	2/28/17 @ 8:30 pm	2/28/17 @ 9:04 pm	34 min	89,570
CDS-45	2/28/17 @ 6:42 pm	2/28/17 @ 7:46 pm	1 hr 4 min	865,656
	2/28/17 @ 8:12 pm	2/28/17 @ 11:59 pm	3 hrs 47 min	3,070,374

At both C-1 and CDS-45, the TARP south connecting structure is upstream of the interceptor connecting structure. In order to prevent dry weather flow (DWF) from going to TARP, a flume was created that was designed to take DWF through the TARP connecting structure to the interceptor. During severe storms, it is possible for some of the flumed flow to go to the CSO outfall when the interceptor is full, rather than into TARP. When this occurred in August 2016, an attempt was made to rectify this situation by adding weir boards just upstream of the tide gates at both C-1 and CDS-45 in an effort to force flow back to the TARP connection. The boards that were added at each location in 2016 to increase the weir elevation were proven to be of insufficient height to prevent an overflow during a major rain event such as that which occurred on February 28, 2017.

As the original modification did not prevent further overflows, the District is now investigating whether this flow can be rerouted to prevent a reoccurrence.

Condition VIII.28.f of the Consent Decree (Calumet TARP System Performance Criteria) states that *"For each precipitation event, no CSO Outfall in the Calumet TARP System shall discharge until conditions described in subparagraphs (a) through (e) preceding this subparagraph are achieved"*. These conditions for this storm are documented below:

a. *All flows that enter the Calumet TARP tunnels and Thornton Composite Reservoir are conveyed to the Calumet WRP for full treatment in accordance with the then current Calumet NPDES Permit, including the bypass provisions in that permit; provided however, that, when the Cal Sag Tunnel is full, flow may leave the Calumet TARP Tunnels through Outfall No. 158 on the Calumet 18EA branch tunnel without first being conveyed to the Calumet WRP for full treatment as described in Appendix A. Notwithstanding the above, Outfall No. 158 remains subject to the terms of the then current Calumet NPDES Permit.*

   All flows that entered into the Calumet TARP System received full treatment; the flows that discharged through C-1 and CDS-45 were unable to enter the system due to local volume/hydraulic restrictions. There were no discharges through Outfall No. 158 nor were there any plant bypasses through 002 or 003.

b. *During all precipitation events, MWRD shall accept and provide full treatment of the Maximum Practical Flow at the Calumet WRP;*

   The Calumet WRP provided full treatment for the maximum practical flow that could be pumped to the plant at any given time. At the start of the storm, the flow at the plant was 197 MGD. As the flow to the wet well increased, the pumping rate was also increased until a maximum flow rate of 474 MGD was achieved. Flow into the wet well decreased after 4 am on March 1, 2017; TARP pumps were not put into service until 2:20 pm to accommodate a leakage test on the seal water line. See item d. below.

c. *Treatment at the Calumet WRP and capture of combined sewage in the Calumet TARP System is maximized at all times, consistent with the TARP Operational Plan approved by Illinois EPA and in accordance with the then current Calumet NPDES Permit (at the time the proposed Operational Plan is submitted to Illinois EPA for approval, MWRD must provide a copy of the proposed plan to the United States);*

   The availability of the dewatering pumps at the TARP Pump Station is currently limited due to the planned replacement of the TARP pumps in the East Pump House and the recent replacement and ongoing testing of the new pumps in the West Pump House, under Contract No. 06-212-3M, Calumet TARP Pump Station Improvements. The West Pump House is currently in service and consists of three 72 MGD pumps; however, a maximum of two pumps can be used at any time because the discharge pipe is not large enough to accept flow from three pumps, limiting the flow to ~ 144 MGD. In addition, the ability to pump from the West Pump House has been and continues to be affected by constraints imposed due to construction under this project. The recently replaced pumps are undergoing the 120-day testing period, which may necessitate one or more pumps being taken out of service as issues arise. This testing period began on January 9, 2017, and is scheduled for completion on May 9, 2017. This testing period may be extended in order to ensure proper installation and operation. Pumping from TARP cannot start until capacity is available in the wet well after sufficient dewatering of the interceptor system. The current NPDES permit for the Calumet WRP does not require the submittal of the TARP Operational Plan. The District has reached out to the Illinois EPA for direction regarding this requirement.

   Also, as stated in item b. above, a leakage test was scheduled on the seal water line on March 1, 2017. The television inspection was required due to a water leak in the pump house. As a result, the

TARP pumps were not started when the plant flow decreased below the maximum flow rate at approximately 4 am, because the system needed to be isolated and locked out by 7 am to accommodate the test. West Pump No. 2 was put into service subsequent to the inspection at 2:20 pm. West Pump No. 3 was not available due to vibration issues which were being investigated by the contractor. An attempt was made to start West Pump No. 1 which kicked out due to vibration issues. West Pump No. 1 was able to be put in service at 7 am on March 3, 2017.

d. *During all times when the Calumet TARP tunnels or Thornton Composite Reservoir contain combined sewage in excess of any Retained Amount, MWRD shall pump combined sewage from the Calumet TARP Pump Station at the Maximum Practical Pumping Rate subject to the Maximum Practical Flow capable of receiving full treatment at the Calumet WRP;*

At the start of the storm on February 28, 2017 at 5:15 pm, the TARP tunnels had an available capacity of 74.8% (627 MG total) while the reservoir had an available capacity of 99.2% (7,900 MG total); therefore, the amount in the reservoir (0.8%) was less than the Retained Maximum Amount (5.6%). The dewatering of the TARP System started on March 1, 2017 at 2:20 pm when there was 28.2% capacity in the tunnel and 78.6% capacity in the reservoir and has been ongoing as a result of subsequent storms.

e. *All Calumet TARP drop shaft control structures (inlet sluice gates) must be maintained in the 100 percent Equivalent Open position to receive maximum flow into the Calumet TARP tunnels and Thornton Composite Reservoir until the Thornton Composite Reservoir is Full or Transient Events would occur if the sluice gates remained in the 100 Percent Equivalent Open position.*

All sluice gates were maintained in the 100% equivalent open position throughout the duration of the storm. No gates were closed in anticipation of a transient event nor did a transient event occur. All gates were operable throughout.

The CSOs did not occur as a result of failure to achieve the conditions above or to operate the TARP System in a manner that was consistent with the Operating Plan, but rather occurred as a result of local conditions preventing the conveyance of storm flows into the TARP dropshaft.

Section XII. Reporting Requirement Certification, Paragraph 48:

I certify under penalty of law that this document and its attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fines and imprisonment for knowing violations.

Sincerely,

David St. Pierre /sp

David St. Pierre

JPM:BAP:SO'C
c: Roger Callaway, IEPA – Springfield
Jay Patel, IEPA – Des Plaines
Elizabeth Wallace and Thomas Shepherd, Illinois Attorney General's Office - Chicago
Granato/Hill/O'Connor/Garelli/Serafino/Conway

Protecting Our Water Environment

Metropolitan Water Reclamation District of Greater Chicago

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May 24, 2017

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Elizabeth Wallace
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Chicago, IL 60602

Roger Callaway, Compliance Assurance Section
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Division of Water Pollution Control
1021 North Grand Avenue East
Post Office Box 19276
Springfield, IL 62794

Subject: Metropolitan Water Reclamation District of Greater Chicago (District)
National Pollutant Discharge Elimination System (NPDES) Permits
Consent Decree (Civil Action No. 11 C 8859) – Notice of Combined Sewer Overflow
March 30, 2017

On March 30, 2017, a combined sewer overflow occurred at CDS-45 on the Little Cal Leg and may have occurred at CDS-18 on the 140th Street Leg of the Calumet TARP System as a result of an average rainfall in the south area in the amount of 2.13 inches.

The details of these discharges are as follows:

Location	Overflow Date & Start Time	Overflow Date & Stop Time	Duration	Estimated Volume of Discharge (Gallons)
CDS-45	3/30/17 @ 2:21 am	3/30/17 @ 4:00 am	1 hr 39 min	1,501,182
CDS-18	3/30/17 @ 11:26 am	3/30/17 @ 11:43 am	17 min	485,983

At CDS-45, the TARP south connecting structure is upstream of the interceptor connecting structure. In order to prevent dry weather flow (DWF) from going to TARP, a flume was created that was designed to take DWF through the TARP connecting structure to the interceptor. During severe storms, it is possible for some of the flumed flow to go to the CSO outfall when the interceptor is full, rather than into TARP. When this occurred in August 2016, an attempt was made to rectify this situation by adding weir boards just upstream of the tide gates at CDS-45 in an effort to force flow back to the TARP connection. The boards that were added at this location in 2016 to increase the weir elevation were proven to be of insufficient height to prevent an overflow during a major rain event such as that which occurred on March 30, 2017.

As the original modification did not prevent further overflows, the District is now investigating whether this flow at CDS-45 can be rerouted to prevent a reoccurrence.

The District was unable to verify if a discharge occurred at CDS-18, as, if it occurred, it was short-lived and ended before it could be investigated. Also, there were no known conditions that existed during the storm which may have resulted in the overflow, as the TARP elevations were low, the sluice gates were open, and the design configuration/hydraulics at this location would not prevent flow from entering TARP. The functionality of the tide gate and the proximity switch were verified about one week prior to, and again after, the incident. The sluice gate was also inspected to verify the gate's position and operability following the event.

Condition VIII.28.f of the Consent Decree (Calumet TARP System Performance Criteria) states that *"For each precipitation event, no CSO Outfall in the Calumet TARP System shall discharge until conditions described in subparagraphs (a) through (e) preceding this subparagraph are achieved"*. These conditions for this storm are documented below:

a. *All flows that enter the Calumet TARP tunnels and Thornton Composite Reservoir are conveyed to the Calumet WRP for full treatment in accordance with the then current Calumet NPDES Permit, including the bypass provisions in that permit; provided however, that, when the Cal Sag Tunnel is full, flow may leave the Calumet TARP Tunnels through Outfall No. 158 on the Calumet 18EA branch tunnel without first being conveyed to the Calumet WRP for full treatment as described in Appendix A. Notwithstanding the above, Outfall No. 158 remains subject to the terms of the then current Calumet NPDES Permit.*

   All flows that entered into the Calumet TARP System received full treatment; the flow that discharged from CDS-45 was unable to enter the system due to local volume/hydraulic restrictions. The District has been unable to verify that there was an actual discharge through CDS-18 or determine why it may have occurred.

b. *During all precipitation events, MWRD shall accept and provide full treatment of the Maximum Practical Flow at the Calumet WRP;*

   The Calumet WRP provided full treatment for the maximum practical flow that could be pumped to the plant at any given time. At the start of the storm, the flow at the plant was 353 MGD. TARP pumps were already in operation (71 and 72 MGD, respectively) at this time, as dewatering from previous rain events was ongoing. As the flow to the wet well increased, the pumping rate through the plant was also increased until a maximum flow rate of 480 MGD was achieved. The flow pumped at the plant was maintained between 430 MGD and 480 MGD throughout the duration of the storm and beyond.

c. *Treatment at the Calumet WRP and capture of combined sewage in the Calumet TARP System is maximized at all times, consistent with the TARP Operational Plan approved by Illinois EPA and in accordance with the then current Calumet NPDES Permit (at the time the proposed Operational Plan is submitted to Illinois EPA for approval, MWRD must provide a copy of the proposed plan to the United States);*

   The availability of the dewatering pumps at the TARP Pump Station is currently limited due to the planned replacement of the TARP pumps in the East Pump House and the recent replacement and ongoing testing of the new pumps in the West Pump House, under Contract No. 06-212-3M, Calumet TARP Pump Station Improvements. The West Pump House is currently in service and consists of three 72 MGD pumps; however, a maximum of two pumps can be used at any time because the discharge pipe is not large enough to accept flow from three pumps, limiting the flow to ~ 144 MGD. In addition, the ability to pump from the West Pump House has been and continues to be affected by constraints imposed due to construction under this project. However, two pumps at the West Pump House were available throughout the duration of this storm and both pumps were utilized as capacity in the wet well became available, after sufficient dewatering of the interceptor system.

The current NPDES permit for the Calumet WRP does not require the submittal of the TARP Operational Plan. As previously reported, the District has reached out to the Illinois EPA for direction regarding this requirement.

d. *During all times when the Calumet TARP tunnels or Thornton Composite Reservoir contain combined sewage in excess of any Retained Amount, MWRD shall pump combined sewage from the Calumet TARP Pump Station at the Maximum Practical Pumping Rate subject to the Maximum Practical Flow capable of receiving full treatment at the Calumet WRP;*

At the start of the storm on March 30, 2017 at 6:55 pm, the TARP tunnels had an available capacity of 60% (627 MG total) while the reservoir had an available capacity of 96.2% (7,900 MG total); therefore, the amount in the reservoir (3.8%) was less than the Retained Maximum Amount (5.6%). The dewatering of the TARP System had been ongoing at the start of the storm and continued as a result of subsequent storms.

e. *All Calumet TARP drop shaft control structures (inlet sluice gates) must be maintained in the 100 percent Equivalent Open position to receive maximum flow into the Calumet TARP tunnels and Thornton Composite Reservoir until the Thornton Composite Reservoir is Full or Transient Events would occur if the sluice gates remained in the 100 Percent Equivalent Open position.*

All sluice gates were maintained in the 100% equivalent open position throughout the duration of the storm. No gates were closed in anticipation of a transient event nor did a transient event occur. All gates were operable throughout.

The CSO at CDS-45 did not occur as a result of failure to achieve the conditions above or to operate the TARP System in a manner that was consistent with the Operating Plan, but rather occurred as a result of local conditions preventing the conveyance of storm flows into the TARP dropshaft. As noted above, the District has been unable to determine if and why there was a discharge at CDS-18.

Section XII. Reporting Requirement Certification, Paragraph 48:

I certify under penalty of law that this document and its attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fines and imprisonment for knowing violations.

Sincerely,

David St. Pierre

JPM:BAP:SO'C
c: Dean Maraldo, Chief, EPA – Chicago
Regional Counsel, EPA – Chicago
Chief, Environmental Enforcement Section, U.S. DOJ – Washington, D.C.
Podczerwinski/Morakalis/O'Connor/Conway

Protecting Our Water Environment

Metropolitan Water Reclamation District of Greater Chicago
100 EAST ERIE STREET CHICAGO, ILLINOIS 60611-3154 312.751.5600

David St. Pierre
Executive Director

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david.stpierre@mwrd.org

May 24, 2017

Mr. Dean Maraldo, Chief
Water Enforcement and Compliance Assurance Branch
Water Division
United States Environmental Protection Agency (USEPA)
Region 5
77 W. Jackson Blvd.
Chicago, IL 60604

Chief, Environmental Enforcement Section
Environmental and Natural Resources Division
US Department of Justice (USDOJ)
Box 7611 Ben Franklin Station
Washington. D.C. 20044-7611
Re: DOJ No. 90-5-1-1-07679

Regional Counsel
USEPA, Region 5
Division of Water Pollution Control
77 W. Jackson Blvd.
Chicago, IL 60604

Subject: Metropolitan Water Reclamation District of Greater Chicago (District)
National Pollutant Discharge Elimination System (NPDES) Permits
Consent Decree (Civil Action No. 11 C 8859) – Notice of Combined Sewer Overflow
March 30, 2017

On March 30, 2017, a combined sewer overflow occurred at CDS-45 on the Little Cal Leg and may have occurred at CDS-18 on the 140th Street Leg of the Calumet TARP System as a result of an average rainfall in the south area in the amount of 2.13 inches.

The details of these discharges are as follows:

Location	Overflow Date & Start Time	Overflow Date & Stop Time	Duration	Estimated Volume of Discharge (Gallons)
CDS-45	3/30/17 @ 2:21 am	3/30/17 @ 4:00 am	1 hr 39 min	1,501,182
CDS-18	3/30/17 @ 11:26 am	3/30/17 @ 11:43 am	17 min	485,983

At CDS-45, the TARP south connecting structure is upstream of the interceptor connecting structure. In order to prevent dry weather flow (DWF) from going to TARP, a flume was created that was designed to take DWF through the TARP connecting structure to the interceptor. During severe storms, it is possible for some of the flumed flow to go to the CSO outfall when the interceptor is full, rather than into TARP. When this occurred in August 2016, an attempt was made to rectify this situation by adding weir boards just upstream of the tide gates at CDS-45 in an effort to force flow back to the TARP connection. The boards that were added at this location in 2016 to increase the weir elevation were proven to be of insufficient height to prevent an overflow during a major rain event such as that which occurred on March 30, 2017.

As the original modification did not prevent further overflows, the District is now investigating whether this flow at CDS-45 can be rerouted to prevent a reoccurrence.

The District was unable to verify if a discharge occurred at CDS-18, as, if it occurred, it was short-lived and ended before it could be investigated. Also, there were no known conditions that existed during the storm which may have resulted in the overflow, as the TARP elevations were low, the sluice gates were open, and the design configuration/hydraulics at this location would not prevent flow from entering TARP. The functionality of the tide gate and the proximity switch were verified about one week prior to, and again after, the incident. The sluice gate was also inspected to verify the gate's position and operability following the event.

Condition VIII.28.f of the Consent Decree (Calumet TARP System Performance Criteria) states that *"For each precipitation event, no CSO Outfall in the Calumet TARP System shall discharge until conditions described in subparagraphs (a) through (e) preceding this subparagraph are achieved"*. These conditions for this storm are documented below:

a. *All flows that enter the Calumet TARP tunnels and Thornton Composite Reservoir are conveyed to the Calumet WRP for full treatment in accordance with the then current Calumet NPDES Permit, including the bypass provisions in that permit; provided however, that, when the Cal Sag Tunnel is full, flow may leave the Calumet TARP Tunnels through Outfall No. 158 on the Calumet 18EA branch tunnel without first being conveyed to the Calumet WRP for full treatment as described in Appendix A. Notwithstanding the above, Outfall No. 158 remains subject to the terms of the then current Calumet NPDES Permit.*

   All flows that entered into the Calumet TARP System received full treatment; the flow that discharged from CDS-45 was unable to enter the system due to local volume/hydraulic restrictions. The District has been unable to verify that there was an actual discharge through CDS-18 or determine why it may have occurred.

b. *During all precipitation events, MWRD shall accept and provide full treatment of the Maximum Practical Flow at the Calumet WRP;*

   The Calumet WRP provided full treatment for the maximum practical flow that could be pumped to the plant at any given time. At the start of the storm, the flow at the plant was 353 MGD. TARP pumps were already in operation (71 and 72 MGD, respectively) at this time, as dewatering from previous rain events was ongoing. As the flow to the wet well increased, the pumping rate through the plant was also increased until a maximum flow rate of 480 MGD was achieved. The flow pumped at the plant was maintained between 430 MGD and 480 MGD throughout the duration of the storm and beyond.

c. *Treatment at the Calumet WRP and capture of combined sewage in the Calumet TARP System is maximized at all times, consistent with the TARP Operational Plan approved by Illinois EPA and in accordance with the then current Calumet NPDES Permit (at the time the proposed Operational Plan is submitted to Illinois EPA for approval, MWRD must provide a copy of the proposed plan to the United States);*

   The availability of the dewatering pumps at the TARP Pump Station is currently limited due to the planned replacement of the TARP pumps in the East Pump House and the recent replacement and ongoing testing of the new pumps in the West Pump House, under Contract No. 06-212-3M, Calumet TARP Pump Station Improvements. The West Pump House is currently in service and consists of three 72 MGD pumps; however, a maximum of two pumps can be used at any time because the discharge pipe is not large enough to accept flow from three pumps, limiting the flow to ~ 144 MGD. In addition, the ability to pump from the West Pump House has been and continues to be affected by constraints imposed due to construction under this project. However, two pumps at the West Pump House were available throughout the duration of this storm and both pumps were utilized as capacity in the wet well became available, after sufficient dewatering of the interceptor system.

The current NPDES permit for the Calumet WRP does not require the submittal of the TARP Operational Plan. As previously reported, the District has reached out to the Illinois EPA for direction regarding this requirement.

d. *During all times when the Calumet TARP tunnels or Thornton Composite Reservoir contain combined sewage in excess of any Retained Amount, MWRD shall pump combined sewage from the Calumet TARP Pump Station at the Maximum Practical Pumping Rate subject to the Maximum Practical Flow capable of receiving full treatment at the Calumet WRP;*

   At the start of the storm on March 30, 2017 at 6:55 pm, the TARP tunnels had an available capacity of 60% (627 MG total) while the reservoir had an available capacity of 96.2% (7,900 MG total); therefore, the amount in the reservoir (3.8%) was less than the Retained Maximum Amount (5.6%). The dewatering of the TARP System had been ongoing at the start of the storm and continued as a result of subsequent storms.

e. *All Calumet TARP drop shaft control structures (inlet sluice gates) must be maintained in the 100 percent Equivalent Open position to receive maximum flow into the Calumet TARP tunnels and Thornton Composite Reservoir until the Thornton Composite Reservoir is Full or Transient Events would occur if the sluice gates remained in the 100 Percent Equivalent Open position.*

   All sluice gates were maintained in the 100% equivalent open position throughout the duration of the storm. No gates were closed in anticipation of a transient event nor did a transient event occur. All gates were operable throughout.

The CSO at CDS-45 did not occur as a result of failure to achieve the conditions above or to operate the TARP System in a manner that was consistent with the Operating Plan, but rather occurred as a result of local conditions preventing the conveyance of storm flows into the TARP dropshaft. As noted above, the District has been unable to determine if and why there was a discharge at CDS-18.

Section XII. Reporting Requirement Certification, Paragraph 48:

I certify under penalty of law that this document and its attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fines and imprisonment for knowing violations.

Sincerely,

David St. Pierre

JPM:BAP:SO'C

c: Roger Callaway, IEPA – Springfield
Jay Patel, IEPA – Des Plaines
Elizabeth Wallace and Thomas Shepherd, Illinois Attorney General's Office - Chicago
Podczerwinski/Morakalis/O'Connor/Conway

APPENDIX I

HOURLY CONTINUOUS DISSOLVED OXYGEN MONITORING DATA COLLECTED AFTER COMBINED SEWER OVERFLOWS DURING POST-CONSTRUCTION MONITORING

TABLE I-1: DISSOLVED OXYGEN CONCENTRATION MEASURED HOURLY AT CHICAGO AND WESTERN INDIANA RAILROAD IN THE LITTLE CALUMET RIVER, FEBRUARY 28, 2017, THROUGH MARCH 7, 2017

Date and Time	Dissolved Oxygen (mg/L)	Date and Time	Dissolved Oxygen (mg/L)
02/28/2017 00:00	13.0	03/01/2017 13:00	12.3
02/28/2017 01:00	12.8	03/01/2017 14:00	12.4
02/28/2017 02:00	12.8	03/01/2017 15:00	12.4
02/28/2017 03:00	12.7	03/01/2017 16:00	12.4
02/28/2017 04:00	12.4	03/01/2017 17:00	12.4
02/28/2017 05:00	12.4	03/01/2017 18:00	12.3
02/28/2017 06:00	12.5	03/01/2017 19:00	12.2
02/28/2017 07:00	12.5	03/01/2017 20:00	11.9
02/28/2017 08:00	12.6	03/01/2017 21:00	11.9
02/28/2017 09:00	12.6	03/01/2017 22:00	11.7
02/28/2017 10:00	12.7	03/01/2017 23:00	11.8
02/28/2017 11:00	12.8	03/02/2017 00:00	11.3
02/28/2017 12:00	12.8	03/02/2017 01:00	11.6
02/28/2017 13:00	13.0	03/02/2017 02:00	11.5
02/28/2017 14:00	13.0	03/02/2017 03:00	11.4
02/28/2017 15:00	13.2	03/02/2017 04:00	11.3
02/28/2017 16:00	13.2	03/02/2017 05:00	11.3
02/28/2017 17:00	13.2	03/02/2017 06:00	11.2
02/28/2017 18:00	13.0	03/02/2017 07:00	11.2
02/28/2017 19:00	13.1	03/02/2017 08:00	11.5
02/28/2017 20:00	12.6	03/02/2017 09:00	11.2
02/28/2017 21:00	12.6	03/02/2017 10:00	11.1
02/28/2017 22:00	12.2	03/02/2017 11:00	11.1
02/28/2017 23:00	12.0	03/02/2017 12:00	11.2
03/01/2017 00:00	12.3	03/02/2017 13:00	11.4
03/01/2017 01:00	11.9	03/02/2017 14:00	11.2
03/01/2017 02:00	11.4	03/02/2017 15:00	11.2
03/01/2017 03:00	11.7	03/02/2017 16:00	11.2
03/01/2017 04:00	11.8	03/02/2017 17:00	11.5
03/01/2017 05:00	11.6	03/02/2017 18:00	11.2
03/01/2017 06:00	11.8	03/02/2017 19:00	11.0
03/01/2017 07:00	11.7	03/02/2017 20:00	11.0
03/01/2017 08:00	12.1	03/02/2017 21:00	11.0
03/01/2017 09:00	12.0	03/02/2017 22:00	10.8
03/01/2017 10:00	12.0	03/02/2017 23:00	10.8
03/01/2017 11:00	12.2	03/03/2017 00:00	11.0
03/01/2017 12:00	12.3	03/03/2017 01:00	10.9

TABLE I-1 (Continued): DISSOLVED OXYGEN CONCENTRATION MEASURED HOURLY AT CHICAGO AND WESTERN INDIANA RAILROAD IN THE LITTLE CALUMET RIVER, FEBRUARY 28, 2017, THROUGH MARCH 7, 2017

Date and Time	Dissolved Oxygen (mg/L)	Date and Time	Dissolved Oxygen (mg/L)
03/03/2017 02:00	10.8	03/04/2017 15:00	10.4
03/03/2017 03:00	10.8	03/04/2017 16:00	10.6
03/03/2017 04:00	10.6	03/04/2017 17:00	10.5
03/03/2017 05:00	10.7	03/04/2017 18:00	10.2
03/03/2017 06:00	10.4	03/04/2017 19:00	10.3
03/03/2017 07:00	10.5	03/04/2017 20:00	10.1
03/03/2017 08:00	10.6	03/04/2017 21:00	9.9
03/03/2017 09:00	10.5	03/04/2017 22:00	9.9
03/03/2017 10:00	10.3	03/04/2017 23:00	9.9
03/03/2017 11:00	10.4	03/05/2017 00:00	9.9
03/03/2017 12:00	10.2	03/05/2017 01:00	9.9
03/03/2017 13:00	10.2	03/05/2017 02:00	9.9
03/03/2017 14:00	10.3	03/05/2017 03:00	9.9
03/03/2017 15:00	10.4	03/05/2017 04:00	9.9
03/03/2017 16:00	10.6	03/05/2017 05:00	9.9
03/03/2017 17:00	10.6	03/05/2017 06:00	9.9
03/03/2017 18:00	9.7	03/05/2017 07:00	9.9
03/03/2017 19:00	10.2	03/05/2017 08:00	9.9
03/03/2017 20:00	9.9	03/05/2017 09:00	10.0
03/03/2017 21:00	9.8	03/05/2017 10:00	10.1
03/03/2017 22:00	9.8	03/05/2017 11:00	10.1
03/03/2017 23:00	9.8	03/05/2017 12:00	10.1
03/04/2017 00:00	10.1	03/05/2017 13:00	10.3
03/04/2017 01:00	9.8	03/05/2017 14:00	10.3
03/04/2017 02:00	10.1	03/05/2017 15:00	10.2
03/04/2017 03:00	10.1	03/05/2017 16:00	10.1
03/04/2017 04:00	9.8	03/05/2017 17:00	10.2
03/04/2017 05:00	9.9	03/05/2017 18:00	10.4
03/04/2017 06:00	10.1	03/05/2017 19:00	10.4
03/04/2017 07:00	10.0	03/05/2017 20:00	10.5
03/04/2017 08:00	10.0	03/05/2017 21:00	10.4
03/04/2017 09:00	9.9	03/05/2017 22:00	10.3
03/04/2017 10:00	9.9	03/05/2017 23:00	10.3
03/04/2017 11:00	9.8	03/06/2017 00:00	10.4
03/04/2017 12:00	9.9	03/06/2017 01:00	10.5
03/04/2017 13:00	10.2	03/06/2017 02:00	10.5
03/04/2017 14:00	10.4	03/06/2017 03:00	10.3

TABLE I-1 (Continued): DISSOLVED OXYGEN CONCENTRATION MEASURED HOURLY AT CHICAGO AND WESTERN INDIANA RAILROAD IN THE LITTLE CALUMET RIVER, FEBRUARY 28, 2017, THROUGH MARCH 7, 2017

Date and Time	Dissolved Oxygen (mg/L)	Date and Time	Dissolved Oxygen (mg/L)
03/06/2017 04:00	10.4	03/07/2017 02:00	10.9
03/06/2017 05:00	10.4	03/07/2017 03:00	10.8
03/06/2017 06:00	10.5	03/07/2017 04:00	10.7
03/06/2017 07:00	10.7	03/07/2017 05:00	10.7
03/06/2017 08:00	10.6	03/07/2017 06:00	10.7
03/06/2017 09:00	10.6	03/07/2017 07:00	10.6
03/06/2017 10:00	10.7	03/07/2017 08:00	10.6
03/06/2017 11:00	10.8	03/07/2017 09:00	10.8
03/06/2017 12:00	10.8	03/07/2017 10:00	10.9
03/06/2017 13:00	11.0	03/07/2017 11:00	11.0
03/06/2017 14:00	11.0	03/07/2017 12:01	11.1
03/06/2017 15:00	11.1	03/07/2017 13:01	11.0
03/06/2017 16:00	11.2	03/07/2017 14:01	10.8
03/06/2017 17:00	11.2	03/07/2017 15:01	11.0
03/06/2017 18:00	11.2	03/07/2017 16:01	11.1
03/06/2017 19:00	11.2	03/07/2017 17:01	10.9
03/06/2017 20:00	11.1	03/07/2017 18:01	10.9
03/06/2017 21:00	11.0	03/07/2017 19:01	10.7
03/06/2017 22:00	11.0	03/07/2017 20:01	10.7
03/06/2017 23:00	10.9	03/07/2017 21:01	10.7
03/07/2017 00:00	10.9	03/07/2017 22:01	10.6
03/07/2017 01:00	10.8	03/07/2017 23:01	10.4

TABLE I-2: DISSOLVED OXYGEN CONCENTRATION MEASURED HOURLY AT HALSTED STREET IN THE LITTLE CALUMET RIVER, FEBRUARY 28, 2017, THROUGH MARCH 7, 2017

Date and Time	Dissolved Oxygen (mg/L)	Date and Time	Dissolved Oxygen (mg/L)
02/28/2017 00:01	9.6	03/01/2017 13:01	7.6
02/28/2017 01:01	9.8	03/01/2017 14:01	7.6
02/28/2017 02:01	9.7	03/01/2017 15:01	7.7
02/28/2017 03:01	9.8	03/01/2017 16:01	7.6
02/28/2017 04:01	9.5	03/01/2017 17:01	8.0
02/28/2017 05:01	9.8	03/01/2017 18:01	8.1
02/28/2017 06:01	9.7	03/01/2017 19:01	8.3
02/28/2017 07:01	9.6	03/01/2017 20:01	8.2
02/28/2017 08:01	9.7	03/01/2017 21:01	8.4
02/28/2017 09:01	9.7	03/01/2017 22:01	8.5
02/28/2017 10:01	9.6	03/01/2017 23:01	8.7
02/28/2017 11:01	9.7	03/02/2017 00:01	8.8
02/28/2017 12:01	9.6	03/02/2017 01:01	8.8
02/28/2017 13:01	9.7	03/02/2017 02:01	8.9
02/28/2017 14:01	9.6	03/02/2017 03:01	9.0
02/28/2017 15:01	9.9	03/02/2017 04:01	9.0
02/28/2017 16:01	9.5	03/02/2017 05:01	9.1
02/28/2017 17:01	9.5	03/02/2017 06:01	9.2
02/28/2017 18:01	9.5	03/02/2017 07:01	9.2
02/28/2017 19:01	9.6	03/02/2017 08:01	9.3
02/28/2017 20:01	9.9	03/02/2017 09:01	9.6
02/28/2017 21:01	10.0	03/02/2017 10:01	9.6
02/28/2017 22:01	10.1	03/02/2017 11:01	9.7
02/28/2017 23:01	10.0	03/02/2017 12:01	9.7
03/01/2017 00:01	9.7	03/02/2017 13:01	9.8
03/01/2017 01:01	9.7	03/02/2017 14:01	9.9
03/01/2017 02:01	9.7	03/02/2017 15:01	10.0
03/01/2017 03:01	9.9	03/02/2017 16:01	10.2
03/01/2017 04:01	9.9	03/02/2017 17:01	10.2
03/01/2017 05:01	9.9	03/02/2017 18:01	10.3
03/01/2017 06:01	9.9	03/02/2017 19:01	10.4
03/01/2017 07:01	9.9	03/02/2017 20:01	10.5
03/01/2017 08:01	9.8	03/02/2017 21:01	10.5
03/01/2017 09:01	8.8	03/02/2017 22:01	10.5
03/01/2017 10:01	8.2	03/02/2017 23:01	10.4
03/01/2017 11:01	7.7	03/03/2017 00:01	10.4
03/01/2017 12:01	7.6	03/03/2017 01:01	10.4

TABLE I-2 (Continued): DISSOLVED OXYGEN CONCENTRATION MEASURED HOURLY AT HALSTED STREET IN THE LITTLE CALUMET RIVER, FEBRUARY 28, 2017, THROUGH MARCH 7, 2017

Date and Time	Dissolved Oxygen (mg/L)	Date and Time	Dissolved Oxygen (mg/L)
03/03/2017 02:01	10.4	03/04/2017 15:01	9.2
03/03/2017 03:01	10.4	03/04/2017 16:01	9.1
03/03/2017 04:01	10.3	03/04/2017 17:01	9.2
03/03/2017 05:01	10.3	03/04/2017 18:01	9.2
03/03/2017 06:01	10.2	03/04/2017 19:01	9.3
03/03/2017 07:01	10.1	03/04/2017 20:01	9.4
03/03/2017 08:01	10.0	03/04/2017 21:01	9.3
03/03/2017 09:01	10.0	03/04/2017 22:01	9.4
03/03/2017 10:01	9.9	03/04/2017 23:01	9.5
03/03/2017 11:01	10.0	03/05/2017 00:01	9.5
03/03/2017 12:01	10.0	03/05/2017 01:01	9.4
03/03/2017 13:01	9.9	03/05/2017 02:01	9.3
03/03/2017 14:01	9.9	03/05/2017 03:01	9.4
03/03/2017 15:01	10.1	03/05/2017 04:01	9.4
03/03/2017 16:01	10.0	03/05/2017 05:01	9.4
03/03/2017 17:01	10.0	03/05/2017 06:01	9.4
03/03/2017 18:01	10.0	03/05/2017 07:01	9.2
03/03/2017 19:01	10.0	03/05/2017 08:01	9.3
03/03/2017 20:01	9.8	03/05/2017 09:01	9.3
03/03/2017 21:01	9.8	03/05/2017 10:01	9.3
03/03/2017 22:01	9.8	03/05/2017 11:01	9.2
03/03/2017 23:01	9.8	03/05/2017 12:01	9.1
03/04/2017 00:01	9.8	03/05/2017 13:01	8.8
03/04/2017 01:01	9.7	03/05/2017 14:01	9.5
03/04/2017 02:01	9.3	03/05/2017 15:01	9.0
03/04/2017 03:01	9.5	03/05/2017 16:01	9.2
03/04/2017 04:01	9.6	03/05/2017 17:01	9.0
03/04/2017 05:01	9.3	03/05/2017 18:01	9.0
03/04/2017 06:01	9.3	03/05/2017 19:01	9.1
03/04/2017 07:01	9.4	03/05/2017 20:01	9.1
03/04/2017 08:01	9.4	03/05/2017 21:01	8.9
03/04/2017 09:01	9.3	03/05/2017 22:01	9.1
03/04/2017 10:01	9.3	03/05/2017 23:01	9.2
03/04/2017 11:01	9.1	03/06/2017 00:01	9.1
03/04/2017 12:01	9.2	03/06/2017 01:01	9.1
03/04/2017 13:01	9.1	03/06/2017 02:01	9.1
03/04/2017 14:01	9.2	03/06/2017 03:01	8.8

TABLE I-2 (Continued): DISSOLVED OXYGEN CONCENTRATION MEASURED HOURLY AT HALSTED STREET IN THE LITTLE CALUMET RIVER, FEBRUARY 28, 2017, THROUGH MARCH 7, 2017

Date and Time	Dissolved Oxygen (mg/L)	Date and Time	Dissolved Oxygen (mg/L)
03/06/2017 04:01	9.1	03/07/2017 02:01	8.9
03/06/2017 05:01	9.2	03/07/2017 03:01	8.9
03/06/2017 06:01	9.2	03/07/2017 04:01	8.9
03/06/2017 07:01	9.2	03/07/2017 05:01	8.7
03/06/2017 08:01	9.1	03/07/2017 06:01	8.7
03/06/2017 09:01	9.2	03/07/2017 07:01	8.7
03/06/2017 10:01	9.3	03/07/2017 08:01	8.6
03/06/2017 11:01	9.2	03/07/2017 09:01	8.9
03/06/2017 12:01	9.1	03/07/2017 10:01	8.8
03/06/2017 13:01	9.0	03/07/2017 11:01	9.3
03/06/2017 14:01	9.0	03/07/2017 12:01	9.0
03/06/2017 15:01	8.9	03/07/2017 13:01	9.0
03/06/2017 16:01	8.8	03/07/2017 14:01	8.9
03/06/2017 17:01	8.6	03/07/2017 15:01	9.1
03/06/2017 18:01	8.5	03/07/2017 16:01	9.0
03/06/2017 19:01	8.7	03/07/2017 17:01	8.9
03/06/2017 20:01	8.8	03/07/2017 18:01	9.0
03/06/2017 21:01	8.8	03/07/2017 19:01	8.9
03/06/2017 22:01	8.9	03/07/2017 20:01	8.6
03/06/2017 23:01	8.9	03/07/2017 21:01	8.4
03/07/2017 00:01	8.9	03/07/2017 22:01	8.6
03/07/2017 01:01	9.0	03/07/2017 23:01	8.5

TABLE I-3: DISSOLVED OXYGEN CONCENTRATION MEASURED HOURLY AT ASHLAND AVENUE IN LITTLE CALUMET RIVER SOUTH, FEBRUARY 28, 2017, THROUGH MARCH 7, 2017

Date and Time	Dissolved Oxygen (mg/L)	Date and Time	Dissolved Oxygen (mg/L)
02/28/2017 00:01	13.8	03/01/2017 13:01	8.9
02/28/2017 01:01	13.6	03/01/2017 14:01	8.9
02/28/2017 02:01	13.4	03/01/2017 15:01	8.8
02/28/2017 03:01	13.0	03/01/2017 16:01	8.8
02/28/2017 04:01	12.7	03/01/2017 17:01	8.8
02/28/2017 05:01	12.5	03/01/2017 18:01	8.8
02/28/2017 06:01	12.3	03/01/2017 19:01	8.9
02/28/2017 07:01	12.1	03/01/2017 20:01	8.9
02/28/2017 08:01	11.9	03/01/2017 21:01	8.9
02/28/2017 09:01	11.6	03/01/2017 22:01	8.9
02/28/2017 10:01	11.4	03/01/2017 23:01	8.9
02/28/2017 11:01	11.5	03/02/2017 00:01	9.0
02/28/2017 12:01	11.8	03/02/2017 01:01	9.0
02/28/2017 13:01	12.2	03/02/2017 02:01	9.0
02/28/2017 14:01	12.6	03/02/2017 03:01	9.0
02/28/2017 15:01	12.7	03/02/2017 04:01	9.1
02/28/2017 16:01	12.7	03/02/2017 05:01	9.1
02/28/2017 17:01	12.5	03/02/2017 06:01	9.1
02/28/2017 18:01	11.9	03/02/2017 07:01	9.2
02/28/2017 19:01	11.5	03/02/2017 08:01	9.3
02/28/2017 20:01	11.0	03/02/2017 09:01	9.4
02/28/2017 21:01	10.1	03/02/2017 10:01	9.4
02/28/2017 22:01	10.1	03/02/2017 11:01	9.5
02/28/2017 23:01	9.7	03/02/2017 12:01	9.6
03/01/2017 00:01	9.6	03/02/2017 13:01	9.6
03/01/2017 01:01	9.5	03/02/2017 14:01	9.7
03/01/2017 02:01	9.5	03/02/2017 15:01	9.8
03/01/2017 03:01	9.4	03/02/2017 16:01	9.9
03/01/2017 04:01	9.4	03/02/2017 17:01	10.0
03/01/2017 05:01	9.5	03/02/2017 18:01	10.1
03/01/2017 06:01	9.4	03/02/2017 19:01	10.2
03/01/2017 07:01	9.4	03/02/2017 20:01	10.3
03/01/2017 08:01	9.3	03/02/2017 21:01	10.3
03/01/2017 09:01	9.2	03/02/2017 22:01	10.3
03/01/2017 10:01	9.1	03/02/2017 23:01	10.4
03/01/2017 11:01	9.0	03/03/2017 00:01	10.4
03/01/2017 12:01	9.0	03/03/2017 01:01	10.5

TABLE I-3 (Continued): DISSOLVED OXYGEN CONCENTRATION MEASURED HOURLY AT ASHLAND AVENUE IN LITTLE CALUMET RIVER SOUTH, FEBRUARY 28, 2017, THROUGH MARCH 7, 2017

Date and Time	Dissolved Oxygen (mg/L)	Date and Time	Dissolved Oxygen (mg/L)
03/03/2017 02:01	10.5	03/04/2017 15:01	11.4
03/03/2017 03:01	10.6	03/04/2017 16:01	11.4
03/03/2017 04:01	10.6	03/04/2017 17:01	11.4
03/03/2017 05:01	10.6	03/04/2017 18:01	11.4
03/03/2017 06:01	10.7	03/04/2017 19:01	11.3
03/03/2017 07:01	10.7	03/04/2017 20:01	11.3
03/03/2017 08:01	10.8	03/04/2017 21:01	11.3
03/03/2017 09:01	10.8	03/04/2017 22:01	11.3
03/03/2017 10:01	10.9	03/04/2017 23:01	11.3
03/03/2017 11:01	10.9	03/05/2017 00:01	11.4
03/03/2017 12:01	11.0	03/05/2017 01:01	11.4
03/03/2017 13:01	11.0	03/05/2017 02:01	11.4
03/03/2017 14:01	11.1	03/05/2017 03:01	11.4
03/03/2017 15:01	11.1	03/05/2017 04:01	11.4
03/03/2017 16:01	11.1	03/05/2017 05:01	11.4
03/03/2017 17:01	11.1	03/05/2017 06:01	11.3
03/03/2017 18:01	11.2	03/05/2017 07:01	11.3
03/03/2017 19:01	11.2	03/05/2017 08:01	11.3
03/03/2017 20:01	11.2	03/05/2017 09:01	11.3
03/03/2017 21:01	11.2	03/05/2017 10:01	11.3
03/03/2017 22:01	11.3	03/05/2017 11:01	11.3
03/03/2017 23:01	11.3	03/05/2017 12:01	11.3
03/04/2017 00:01	11.3	03/05/2017 13:01	11.3
03/04/2017 01:01	11.3	03/05/2017 14:01	11.3
03/04/2017 02:01	11.3	03/05/2017 15:01	11.3
03/04/2017 03:01	11.3	03/05/2017 16:01	11.3
03/04/2017 04:01	11.3	03/05/2017 17:01	11.3
03/04/2017 05:01	11.3	03/05/2017 18:01	11.2
03/04/2017 06:01	11.3	03/05/2017 19:01	11.1
03/04/2017 07:01	11.3	03/05/2017 20:01	11.1
03/04/2017 08:01	11.3	03/05/2017 21:01	11.1
03/04/2017 09:01	11.3	03/05/2017 22:01	11.0
03/04/2017 10:01	11.3	03/05/2017 23:01	11.0
03/04/2017 11:01	11.3	03/06/2017 00:01	11.0
03/04/2017 12:01	11.4	03/06/2017 01:01	11.0
03/04/2017 13:01	11.4	03/06/2017 02:01	10.9
03/04/2017 14:01	11.4	03/06/2017 03:01	11.0

TABLE I-3 (Continued): DISSOLVED OXYGEN CONCENTRATION MEASURED HOURLY AT ASHLAND AVENUE IN LITTLE CALUMET RIVER SOUTH, FEBRUARY 28, 2017, THROUGH MARCH 7, 2017

Date and Time	Dissolved Oxygen (mg/L)	Date and Time	Dissolved Oxygen (mg/L)
03/06/2017 04:01	10.9	03/07/2017 02:01	9.8
03/06/2017 05:01	10.8	03/07/2017 03:01	9.8
03/06/2017 06:01	10.9	03/07/2017 04:01	9.8
03/06/2017 07:01	10.8	03/07/2017 05:01	9.7
03/06/2017 08:01	10.8	03/07/2017 06:01	9.6
03/06/2017 09:01	10.8	03/07/2017 07:01	9.6
03/06/2017 10:01	10.7	03/07/2017 08:01	9.6
03/06/2017 11:01	10.7	03/07/2017 09:01	9.6
03/06/2017 12:01	10.7	03/07/2017 10:01	9.6
03/06/2017 13:01	10.6	03/07/2017 11:01	9.6
03/06/2017 14:01	10.6	03/07/2017 12:01	9.6
03/06/2017 15:01	10.6	03/07/2017 13:01	9.5
03/06/2017 16:01	10.5	03/07/2017 14:01	9.5
03/06/2017 17:01	10.4	03/07/2017 15:01	9.4
03/06/2017 18:01	10.3	03/07/2017 16:01	9.3
03/06/2017 19:01	10.2	03/07/2017 17:01	9.4
03/06/2017 20:01	10.2	03/07/2017 18:01	9.3
03/06/2017 21:01	10.1	03/07/2017 19:01	9.3
03/06/2017 22:01	10.0	03/07/2017 20:01	9.2
03/06/2017 23:01	10.0	03/07/2017 21:01	9.2
03/07/2017 00:01	9.9	03/07/2017 22:01	9.2
03/07/2017 01:01	9.8	03/07/2017 23:01	9.2

TABLE I-4: DISSOLVED OXYGEN CONCENTRATION MEASURED HOURLY AT CICERO AVENUE IN THE CALUMET-SAG CHANNEL, FEBRUARY 28, 2017, THROUGH MARCH 7, 2017

Date and Time	Dissolved Oxygen (mg/L)	Date and Time	Dissolved Oxygen (mg/L)
02/28/2017 00:01	9.2	03/01/2017 13:01	9.2
02/28/2017 01:01	9.3	03/01/2017 14:01	9.3
02/28/2017 02:01	9.1	03/01/2017 15:01	9.3
02/28/2017 03:01	9.1	03/01/2017 16:01	9.3
02/28/2017 04:01	9.0	03/01/2017 17:01	9.2
02/28/2017 05:01	9.0	03/01/2017 18:01	9.1
02/28/2017 06:01	9.0	03/01/2017 19:01	8.9
02/28/2017 07:01	9.0	03/01/2017 20:01	8.8
02/28/2017 08:01	9.1	03/01/2017 21:01	8.7
02/28/2017 09:01	9.1	03/01/2017 22:01	8.7
02/28/2017 10:01	9.1	03/01/2017 23:01	8.6
02/28/2017 11:01	9.3	03/02/2017 00:01	8.5
02/28/2017 12:01	9.3	03/02/2017 01:01	8.4
02/28/2017 13:01	9.4	03/02/2017 02:01	8.4
02/28/2017 14:01	9.4	03/02/2017 03:01	8.4
02/28/2017 15:01	9.4	03/02/2017 04:01	8.4
02/28/2017 16:01	9.3	03/02/2017 05:01	8.4
02/28/2017 17:01	9.3	03/02/2017 06:01	8.5
02/28/2017 18:01	9.3	03/02/2017 07:01	8.5
02/28/2017 19:01	9.5	03/02/2017 08:01	8.6
02/28/2017 20:01	9.5	03/02/2017 09:01	8.6
02/28/2017 21:01	9.7	03/02/2017 10:01	8.7
02/28/2017 22:01	10.0	03/02/2017 11:01	8.7
02/28/2017 23:01	10.0	03/02/2017 12:01	8.8
03/01/2017 00:01	10.1	03/02/2017 13:01	8.9
03/01/2017 01:01	10.0	03/02/2017 14:01	8.9
03/01/2017 02:01	9.8	03/02/2017 15:01	9.0
03/01/2017 03:01	9.9	03/02/2017 16:01	9.1
03/01/2017 04:01	10.0	03/02/2017 17:01	9.2
03/01/2017 05:01	10.0	03/02/2017 18:01	9.3
03/01/2017 06:01	9.5	03/02/2017 19:01	9.3
03/01/2017 07:01	9.0	03/02/2017 20:01	9.4
03/01/2017 08:01	8.9	03/02/2017 21:01	9.5
03/01/2017 09:01	8.9	03/02/2017 22:01	9.6
03/01/2017 10:01	9.0	03/02/2017 23:01	9.7
03/01/2017 11:01	9.1	03/03/2017 00:01	9.8
03/01/2017 12:01	9.2	03/03/2017 01:01	9.9

TABLE I-4 (Continued): DISSOLVED OXYGEN CONCENTRATION MEASURED HOURLY AT CICERO AVENUE IN THE CALUMET-SAG CHANNEL, FEBRUARY 28, 2017, THROUGH MARCH 7, 2017

Date and Time	Dissolved Oxygen (mg/L)	Date and Time	Dissolved Oxygen (mg/L)
03/03/2017 02:01	10.0	03/04/2017 15:01	10.4
03/03/2017 03:01	10.1	03/04/2017 16:01	10.3
03/03/2017 04:01	10.2	03/04/2017 17:01	10.2
03/03/2017 05:01	10.2	03/04/2017 18:01	10.2
03/03/2017 06:01	10.1	03/04/2017 19:01	10.2
03/03/2017 07:01	10.2	03/04/2017 20:01	10.1
03/03/2017 08:01	10.2	03/04/2017 21:01	10.0
03/03/2017 09:01	10.2	03/04/2017 22:01	9.9
03/03/2017 10:01	10.2	03/04/2017 23:01	9.8
03/03/2017 11:01	10.2	03/05/2017 00:01	9.8
03/03/2017 12:01	10.2	03/05/2017 01:01	9.6
03/03/2017 13:01	10.2	03/05/2017 02:01	9.7
03/03/2017 14:01	10.3	03/05/2017 03:01	9.6
03/03/2017 15:01	10.3	03/05/2017 04:01	9.6
03/03/2017 16:01	10.2	03/05/2017 05:01	9.6
03/03/2017 17:01	10.2	03/05/2017 06:01	9.5
03/03/2017 18:01	10.2	03/05/2017 07:01	9.5
03/03/2017 19:01	10.2	03/05/2017 08:01	9.5
03/03/2017 20:01	10.1	03/05/2017 09:01	9.4
03/03/2017 21:01	10.1	03/05/2017 10:01	9.5
03/03/2017 22:01	10.1	03/05/2017 11:01	9.5
03/03/2017 23:01	10.1	03/05/2017 12:01	9.5
03/04/2017 00:01	10.2	03/05/2017 13:01	9.5
03/04/2017 01:01	10.1	03/05/2017 14:01	9.5
03/04/2017 02:01	10.1	03/05/2017 15:01	9.5
03/04/2017 03:01	10.0	03/05/2017 16:01	9.6
03/04/2017 04:01	10.2	03/05/2017 17:01	9.6
03/04/2017 05:01	10.2	03/05/2017 18:01	9.7
03/04/2017 06:01	10.2	03/05/2017 19:01	9.8
03/04/2017 07:01	10.2	03/05/2017 20:01	9.6
03/04/2017 08:01	10.3	03/05/2017 21:01	9.7
03/04/2017 09:01	10.2	03/05/2017 22:01	9.7
03/04/2017 10:01	10.3	03/05/2017 23:01	9.6
03/04/2017 11:01	10.4	03/06/2017 00:01	9.6
03/04/2017 12:01	10.4	03/06/2017 01:01	9.6
03/04/2017 13:01	10.3	03/06/2017 02:01	9.5
03/04/2017 14:01	10.3	03/06/2017 03:01	9.4

TABLE I-4 (Continued): DISSOLVED OXYGEN CONCENTRATION MEASURED HOURLY AT CICERO AVENUE IN THE CALUMET-SAG CHANNEL, FEBRUARY 28, 2017, THROUGH MARCH 7, 2017

Date and Time	Dissolved Oxygen (mg/L)	Date and Time	Dissolved Oxygen (mg/L)
03/06/2017 04:01	9.5	03/07/2017 02:01	8.9
03/06/2017 05:01	9.5	03/07/2017 03:01	9.0
03/06/2017 06:01	9.5	03/07/2017 04:01	8.8
03/06/2017 07:01	9.5	03/07/2017 05:01	8.8
03/06/2017 08:01	9.4	03/07/2017 06:01	8.6
03/06/2017 09:01	9.4	03/07/2017 07:01	8.5
03/06/2017 10:01	9.3	03/07/2017 08:01	8.5
03/06/2017 11:01	9.2	03/07/2017 09:01	8.6
03/06/2017 12:01	9.2	03/07/2017 10:01	8.7
03/06/2017 13:01	9.1	03/07/2017 11:01	8.8
03/06/2017 14:01	9.1	03/07/2017 12:01	8.6
03/06/2017 15:01	9.1	03/07/2017 13:01	8.7
03/06/2017 16:01	9.0	03/07/2017 14:01	8.8
03/06/2017 17:01	9.0	03/07/2017 15:01	8.8
03/06/2017 18:01	9.0	03/07/2017 16:01	8.7
03/06/2017 19:01	9.1	03/07/2017 17:01	8.8
03/06/2017 20:01	9.1	03/07/2017 18:01	8.9
03/06/2017 21:01	9.2	03/07/2017 19:01	8.8
03/06/2017 22:01	9.2	03/07/2017 20:01	8.8
03/06/2017 23:01	9.2	03/07/2017 21:01	8.9
03/07/2017 00:01	9.1	03/07/2017 22:01	9.0
03/07/2017 01:01	9.0	03/07/2017 23:01	8.9

TABLE I-5: DISSOLVED OXYGEN CONCENTRATION MEASURED HOURLY AT CHICAGO AND WESTERN INDIANA RAILROAD IN THE LITTLE CALUMET RIVER, MARCH 30, 2017, THROUGH APRIL 6, 2017

Date and Time	Dissolved Oxygen (mg/L)	Date and Time	Dissolved Oxygen (mg/L)
03/30/2017 00:00	11.7	03/31/2017 13:00	10.9
03/30/2017 01:00	11.5	03/31/2017 14:00	11.0
03/30/2017 02:00	11.6	03/31/2017 15:00	10.9
03/30/2017 03:00	11.4	03/31/2017 16:00	11.0
03/30/2017 04:00	11.4	03/31/2017 17:00	10.9
03/30/2017 05:00	11.1	03/31/2017 18:00	10.8
03/30/2017 06:00	10.9	03/31/2017 19:00	10.7
03/30/2017 07:00	10.9	03/31/2017 20:00	10.5
03/30/2017 08:00	10.9	03/31/2017 21:00	10.4
03/30/2017 09:00	10.9	03/31/2017 22:00	10.1
03/30/2017 10:00	11.4	03/31/2017 23:00	10.0
03/30/2017 11:00	11.5	04/01/2017 00:00	10.0
03/30/2017 12:00	11.4	04/01/2017 01:00	10.0
03/30/2017 13:00	11.3	04/01/2017 02:00	9.7
03/30/2017 14:00	11.1	04/01/2017 03:00	9.9
03/30/2017 15:00	11.3	04/01/2017 04:00	9.9
03/30/2017 16:00	11.0	04/01/2017 05:00	9.8
03/30/2017 17:00	11.4	04/01/2017 06:00	10.0
03/30/2017 18:00	11.2	04/01/2017 07:00	10.5
03/30/2017 19:00	11.3	04/01/2017 08:00	10.1
03/30/2017 20:00	11.4	04/01/2017 09:00	10.4
03/30/2017 21:00	11.2	04/01/2017 10:00	10.2
03/30/2017 22:00	11.0	04/01/2017 11:00	10.7
03/30/2017 23:00	11.0	04/01/2017 12:00	10.5
03/31/2017 00:00	10.8	04/01/2017 13:00	10.9
03/31/2017 01:00	10.9	04/01/2017 14:00	10.7
03/31/2017 02:00	10.9	04/01/2017 15:00	10.7
03/31/2017 03:00	10.9	04/01/2017 16:00	10.7
03/31/2017 04:00	10.8	04/01/2017 17:00	10.5
03/31/2017 05:00	10.9	04/01/2017 18:00	10.4
03/31/2017 06:00	10.7	04/01/2017 19:00	10.1
03/31/2017 07:00	10.9	04/01/2017 20:00	10.3
03/31/2017 08:00	10.8	04/01/2017 21:00	10.2
03/31/2017 09:00	10.9	04/01/2017 22:00	10.1
03/31/2017 10:00	10.9	04/01/2017 23:00	9.9
03/31/2017 11:00	10.9	04/02/2017 00:00	9.8
03/31/2017 12:00	10.9	04/02/2017 01:00	9.7

TABLE I-5 (Continued): DISSOLVED OXYGEN CONCENTRATION MEASURED HOURLY AT CHICAGO AND WESTERN INDIANA RAILROAD IN THE LITTLE CALUMET RIVER, MARCH 30, 2017, THROUGH APRIL 6, 2017

Date and Time	Dissolved Oxygen (mg/L)	Date and Time	Dissolved Oxygen (mg/L)
04/02/2017 02:00	9.6	04/03/2017 15:00	9.3
04/02/2017 03:00	9.7	04/03/2017 16:00	9.6
04/02/2017 04:00	10.1	04/03/2017 17:00	9.1
04/02/2017 05:00	9.7	04/03/2017 18:00	9.2
04/02/2017 06:00	9.5	04/03/2017 19:00	9.6
04/02/2017 07:00	9.5	04/03/2017 20:00	9.3
04/02/2017 08:00	9.6	04/03/2017 21:00	9.0
04/02/2017 09:00	9.4	04/03/2017 22:00	8.7
04/02/2017 10:00	9.5	04/03/2017 23:00	9.3
04/02/2017 11:00	9.5	04/04/2017 00:00	9.2
04/02/2017 12:00	9.8	04/04/2017 01:00	9.1
04/02/2017 13:00	9.6	04/04/2017 02:00	9.1
04/02/2017 14:00	9.7	04/04/2017 03:00	9.1
04/02/2017 15:00	9.8	04/04/2017 04:00	9.2
04/02/2017 16:00	10.1	04/04/2017 05:00	9.2
04/02/2017 17:00	9.4	04/04/2017 06:00	9.0
04/02/2017 18:00	9.8	04/04/2017 07:00	9.2
04/02/2017 19:00	9.7	04/04/2017 08:00	9.1
04/02/2017 20:00	9.5	04/04/2017 09:00	8.9
04/02/2017 21:00	9.5	04/04/2017 10:00	9.5
04/02/2017 22:00	9.6	04/04/2017 11:00	9.1
04/02/2017 23:00	9.3	04/04/2017 12:00	9.5
04/03/2017 00:00	9.3	04/04/2017 13:00	9.0
04/03/2017 01:00	9.3	04/04/2017 14:00	9.8
04/03/2017 02:00	8.9	04/04/2017 15:00	9.1
04/03/2017 03:00	9.4	04/04/2017 16:00	8.6
04/03/2017 04:00	9.3	04/04/2017 17:00	9.0
04/03/2017 05:00	9.3	04/04/2017 18:00	10.4
04/03/2017 06:00	9.3	04/04/2017 19:00	9.8
04/03/2017 07:00	9.4	04/04/2017 20:00	9.5
04/03/2017 08:00	9.3	04/04/2017 21:00	9.3
04/03/2017 09:00	9.1	04/04/2017 22:00	9.3
04/03/2017 10:00	9.0	04/04/2017 23:00	9.3
04/03/2017 11:00	9.1	04/05/2017 00:00	9.6
04/03/2017 12:00	9.4	04/05/2017 01:00	10.0
04/03/2017 13:00	9.2	04/05/2017 02:00	9.6
04/03/2017 14:00	9.1	04/05/2017 03:00	9.3

TABLE I-5 (Continued): DISSOLVED OXYGEN CONCENTRATION MEASURED HOURLY AT CHICAGO AND WESTERN INDIANA RAILROAD IN THE LITTLE CALUMET RIVER, MARCH 30, 2017, THROUGH APRIL 6, 2017

Date and Time	Dissolved Oxygen (mg/L)	Date and Time	Dissolved Oxygen (mg/L)
04/05/2017 04:00	9.6	04/06/2017 02:00	9.8
04/05/2017 05:00	9.5	04/06/2017 03:00	10.0
04/05/2017 06:00	9.7	04/06/2017 04:00	9.9
04/05/2017 07:00	9.3	04/06/2017 05:00	9.8
04/05/2017 08:00	9.2	04/06/2017 06:00	9.9
04/05/2017 09:00	9.5	04/06/2017 07:00	9.9
04/05/2017 10:00	9.6	04/06/2017 08:00	10.0
04/05/2017 11:00	9.9	04/06/2017 09:00	9.9
04/05/2017 12:00	9.7	04/06/2017 10:00	10.2
04/05/2017 13:00	10.7	04/06/2017 11:00	10.3
04/05/2017 14:00	10.0	04/06/2017 12:00	10.5
04/05/2017 15:00	9.8	04/06/2017 13:00	10.5
04/05/2017 16:00	9.8	04/06/2017 14:00	10.6
04/05/2017 17:00	9.8	04/06/2017 15:00	10.6
04/05/2017 18:00	10.0	04/06/2017 16:00	11.0
04/05/2017 19:00	10.1	04/06/2017 17:00	10.4
04/05/2017 20:00	9.9	04/06/2017 18:00	10.7
04/05/2017 21:00	10.0	04/06/2017 19:00	10.7
04/05/2017 22:00	9.9	04/06/2017 20:00	10.4
04/05/2017 23:00	9.9	04/06/2017 21:00	10.5
04/06/2017 00:00	9.9	04/06/2017 22:00	10.3
04/06/2017 01:00	10.0	04/06/2017 23:00	10.3

TABLE I-6: DISSOLVED OXYGEN CONCENTRATION MEASURED HOURLY AT HALSTED STREET IN THE LITTLE CALUMET RIVER, MARCH 30, 2017, THROUGH APRIL 6, 2017

Date and Time	Dissolved Oxygen (mg/L)	Date and Time	Dissolved Oxygen (mg/L)
03/30/2017 00:00	9.1	03/31/2017 13:00	9.4
03/30/2017 01:00	9.2	03/31/2017 14:00	9.5
03/30/2017 02:00	9.4	03/31/2017 15:00	9.6
03/30/2017 03:00	9.6	03/31/2017 16:00	9.7
03/30/2017 04:00	9.7	03/31/2017 17:00	9.9
03/30/2017 05:00	9.6	03/31/2017 18:00	10.0
03/30/2017 06:00	9.1	03/31/2017 19:00	10.0
03/30/2017 07:00	9.6	03/31/2017 20:00	10.0
03/30/2017 08:00	9.5	03/31/2017 21:00	10.0
03/30/2017 09:00	9.7	03/31/2017 22:00	10.0
03/30/2017 10:00	9.6	03/31/2017 23:00	9.9
03/30/2017 11:00	9.5	04/01/2017 00:00	9.8
03/30/2017 12:00	9.7	04/01/2017 01:00	9.9
03/30/2017 13:00	9.5	04/01/2017 02:00	9.8
03/30/2017 14:00	9.6	04/01/2017 03:00	9.8
03/30/2017 15:00	9.5	04/01/2017 04:00	9.8
03/30/2017 16:00	9.2	04/01/2017 05:00	9.8
03/30/2017 17:00	8.9	04/01/2017 06:00	9.8
03/30/2017 18:00	8.9	04/01/2017 07:00	9.8
03/30/2017 19:00	9.0	04/01/2017 08:00	9.8
03/30/2017 20:00	8.6	04/01/2017 09:00	9.9
03/30/2017 21:00	8.3	04/01/2017 10:00	9.9
03/30/2017 22:00	8.1	04/01/2017 11:00	10.0
03/30/2017 23:00	8.1	04/01/2017 12:00	9.9
03/31/2017 00:00	8.1	04/01/2017 13:00	9.9
03/31/2017 01:00	8.1	04/01/2017 14:00	10.0
03/31/2017 02:00	8.2	04/01/2017 15:00	10.0
03/31/2017 03:00	8.3	04/01/2017 16:00	10.0
03/31/2017 04:00	8.4	04/01/2017 17:00	10.0
03/31/2017 05:00	8.5	04/01/2017 18:00	10.0
03/31/2017 06:00	8.6	04/01/2017 19:00	10.0
03/31/2017 07:00	8.6	04/01/2017 20:00	10.0
03/31/2017 08:00	8.8	04/01/2017 21:00	9.7
03/31/2017 09:00	8.9	04/01/2017 22:00	9.8
03/31/2017 10:00	9.0	04/01/2017 23:00	9.8
03/31/2017 11:00	9.2	04/02/2017 00:00	9.7
03/31/2017 12:00	9.3	04/02/2017 01:00	9.5

TABLE I-6 (Continued): DISSOLVED OXYGEN CONCENTRATION MEASURED HOURLY AT HALSTED STREET IN THE LITTLE CALUMET RIVER, MARCH 30, 2017, THROUGH APRIL 6, 2017

Date and Time	Dissolved Oxygen (mg/L)	Date and Time	Dissolved Oxygen (mg/L)
04/02/2017 02:00	9.3	04/03/2017 15:00	8.6
04/02/2017 03:00	9.3	04/03/2017 16:00	8.5
04/02/2017 04:00	9.2	04/03/2017 17:00	8.6
04/02/2017 05:00	9.1	04/03/2017 18:00	8.5
04/02/2017 06:00	9.0	04/03/2017 19:00	8.6
04/02/2017 07:00	8.9	04/03/2017 20:00	8.4
04/02/2017 08:00	8.9	04/03/2017 21:00	8.4
04/02/2017 09:00	8.8	04/03/2017 22:00	8.2
04/02/2017 10:00	8.9	04/03/2017 23:00	8.3
04/02/2017 11:00	8.9	04/04/2017 00:00	8.2
04/02/2017 12:00	9.0	04/04/2017 01:00	8.1
04/02/2017 13:00	9.2	04/04/2017 02:00	8.0
04/02/2017 14:00	9.2	04/04/2017 03:00	7.9
04/02/2017 15:00	9.1	04/04/2017 04:00	7.9
04/02/2017 16:00	9.2	04/04/2017 05:00	7.8
04/02/2017 17:00	9.3	04/04/2017 06:00	7.8
04/02/2017 18:00	9.3	04/04/2017 07:00	7.9
04/02/2017 19:00	9.2	04/04/2017 08:00	8.0
04/02/2017 20:00	9.3	04/04/2017 09:00	8.0
04/02/2017 21:00	9.2	04/04/2017 10:00	8.1
04/02/2017 22:00	9.2	04/04/2017 11:00	8.0
04/02/2017 23:00	9.1	04/04/2017 12:00	8.3
04/03/2017 00:00	9.0	04/04/2017 13:00	8.2
04/03/2017 01:00	8.9	04/04/2017 14:00	8.2
04/03/2017 02:00	8.9	04/04/2017 15:00	8.2
04/03/2017 03:00	8.8	04/04/2017 16:00	8.3
04/03/2017 04:00	8.8	04/04/2017 17:00	8.5
04/03/2017 05:00	8.7	04/04/2017 18:00	8.5
04/03/2017 06:00	8.7	04/04/2017 19:00	8.3
04/03/2017 07:00	8.6	04/04/2017 20:00	8.3
04/03/2017 08:00	8.5	04/04/2017 21:00	8.2
04/03/2017 09:00	8.4	04/04/2017 22:00	8.2
04/03/2017 10:00	8.4	04/04/2017 23:00	8.2
04/03/2017 11:00	8.4	04/05/2017 00:00	8.1
04/03/2017 12:00	8.4	04/05/2017 01:00	8.1
04/03/2017 13:00	8.4	04/05/2017 02:00	8.1
04/03/2017 14:00	8.4	04/05/2017 03:00	8.1

TABLE I-6 (Continued): DISSOLVED OXYGEN CONCENTRATION MEASURED HOURLY AT HALSTED STREET IN THE LITTLE CALUMET RIVER, MARCH 30, 2017, THROUGH APRIL 6, 2017

Date and Time	Dissolved Oxygen (mg/L)	Date and Time	Dissolved Oxygen (mg/L)
04/05/2017 04:00	8.1	04/06/2017 02:00	9.1
04/05/2017 05:00	8.0	04/06/2017 03:00	9.2
04/05/2017 06:00	8.1	04/06/2017 04:00	8.9
04/05/2017 07:00	8.2	04/06/2017 05:00	8.4
04/05/2017 08:00	8.3	04/06/2017 06:00	8.8
04/05/2017 09:00	8.5	04/06/2017 07:00	8.9
04/05/2017 10:00	8.5	04/06/2017 08:00	8.7
04/05/2017 11:00	8.7	04/06/2017 09:00	8.8
04/05/2017 12:00	8.7	04/06/2017 10:00	8.8
04/05/2017 13:00	8.8	04/06/2017 11:00	8.7
04/05/2017 14:00	8.7	04/06/2017 12:00	8.8
04/05/2017 15:00	8.7	04/06/2017 13:00	8.9
04/05/2017 16:00	8.7	04/06/2017 14:00	9.1
04/05/2017 17:00	8.6	04/06/2017 15:00	9.3
04/05/2017 18:00	8.8	04/06/2017 16:00	9.5
04/05/2017 19:00	8.9	04/06/2017 17:00	9.6
04/05/2017 20:00	8.8	04/06/2017 18:00	9.6
04/05/2017 21:00	8.8	04/06/2017 19:00	9.7
04/05/2017 22:00	8.9	04/06/2017 20:00	9.8
04/05/2017 23:00	9.1	04/06/2017 21:00	9.8
04/06/2017 00:00	8.9	04/06/2017 22:00	9.8
04/06/2017 01:00	9.0	04/06/2017 23:00	9.9

TABLE I-7: DISSOLVED OXYGEN CONCENTRATION MEASURED HOURLY AT ASHLAND AVENUE IN LITTLE CALUMET RIVER SOUTH, MARCH 30, 2017, THROUGH APRIL 6, 2017

Date and Time	Dissolved Oxygen (mg/L)	Date and Time	Dissolved Oxygen (mg/L)
03/30/2017 00:00	10.1	03/31/2017 14:01	9.6
03/30/2017 01:00	10.1	03/31/2017 15:01	9.6
03/30/2017 02:00	10.2	03/31/2017 16:01	9.6
03/30/2017 03:00	10.3	03/31/2017 17:01	9.6
03/30/2017 04:00	10.6	03/31/2017 18:01	9.6
03/30/2017 05:00	10.5	03/31/2017 19:01	9.6
03/30/2017 06:00	10.6	03/31/2017 20:01	9.6
03/30/2017 07:00	10.7	03/31/2017 21:01	9.6
03/30/2017 08:00	10.6	03/31/2017 22:01	9.7
03/30/2017 10:00	11.0	03/31/2017 23:01	9.7
03/30/2017 11:01	11.0	04/01/2017 00:01	9.7
03/30/2017 12:01	10.9	04/01/2017 01:01	9.7
03/30/2017 13:01	10.7	04/01/2017 02:01	9.7
03/30/2017 14:01	10.6	04/01/2017 03:01	9.7
03/30/2017 15:01	10.6	04/01/2017 04:01	9.7
03/30/2017 16:01	10.5	04/01/2017 05:01	9.8
03/30/2017 17:00	10.4	04/01/2017 06:01	9.8
03/30/2017 18:01	10.4	04/01/2017 07:01	9.8
03/30/2017 19:01	10.3	04/01/2017 08:01	9.8
03/30/2017 20:01	10.2	04/01/2017 09:01	9.9
03/30/2017 21:01	10.2	04/01/2017 10:01	9.9
03/30/2017 22:01	10.1	04/01/2017 11:01	9.9
03/30/2017 23:01	10.0	04/01/2017 12:01	10.0
03/31/2017 00:01	10.0	04/01/2017 13:00	10.0
03/31/2017 01:01	9.9	04/01/2017 14:01	10.0
03/31/2017 02:01	9.8	04/01/2017 15:00	10.1
03/31/2017 03:01	9.8	04/01/2017 16:01	10.2
03/31/2017 04:01	9.8	04/01/2017 17:01	10.2
03/31/2017 05:01	9.7	04/01/2017 18:01	10.3
03/31/2017 06:01	9.7	04/01/2017 19:01	10.3
03/31/2017 07:01	9.7	04/01/2017 20:01	10.3
03/31/2017 08:01	9.7	04/01/2017 21:01	10.4
03/31/2017 09:01	9.6	04/01/2017 22:01	10.3
03/31/2017 10:01	9.6	04/01/2017 23:01	10.3
03/31/2017 11:01	9.6	04/02/2017 00:01	10.3
03/31/2017 12:01	9.6	04/02/2017 01:01	10.3
03/31/2017 13:01	9.6	04/02/2017 02:01	10.2

TABLE I-7 (Continued): DISSOLVED OXYGEN CONCENTRATION MEASURED HOURLY AT ASHLAND AVENUE IN LITTLE CALUMET RIVER SOUTH, MARCH 30, 2017, THROUGH APRIL 6, 2017

Date and Time	Dissolved Oxygen (mg/L)	Date and Time	Dissolved Oxygen (mg/L)
04/02/2017 03:01	10.2	04/03/2017 16:01	9.5
04/02/2017 04:01	10.1	04/03/2017 17:01	9.5
04/02/2017 05:01	10.1	04/03/2017 18:01	9.5
04/02/2017 06:01	10.1	04/03/2017 19:01	9.5
04/02/2017 07:01	10.0	04/03/2017 20:01	9.5
04/02/2017 08:01	10.0	04/03/2017 21:01	9.4
04/02/2017 09:01	10.0	04/03/2017 22:01	9.4
04/02/2017 10:01	10.0	04/03/2017 23:01	9.4
04/02/2017 11:01	10.0	04/04/2017 00:01	9.4
04/02/2017 12:01	10.0	04/04/2017 01:01	9.4
04/02/2017 13:01	10.0	04/04/2017 02:01	9.4
04/02/2017 14:01	10.0	04/04/2017 03:01	9.4
04/02/2017 15:01	10.0	04/04/2017 04:01	9.3
04/02/2017 16:01	10.0	04/04/2017 05:01	9.4
04/02/2017 17:01	10.0	04/04/2017 06:01	9.4
04/02/2017 18:01	10.0	04/04/2017 07:01	9.4
04/02/2017 19:01	10.0	04/04/2017 08:01	9.3
04/02/2017 20:01	10.0	04/04/2017 09:01	9.3
04/02/2017 21:01	10.0	04/04/2017 10:01	9.2
04/02/2017 22:01	10.0	04/04/2017 11:01	9.1
04/02/2017 23:01	9.9	04/04/2017 12:01	9.2
04/03/2017 00:01	9.9	04/04/2017 13:01	9.2
04/03/2017 01:01	9.9	04/04/2017 14:01	9.2
04/03/2017 02:01	9.8	04/04/2017 15:01	9.2
04/03/2017 03:01	9.8	04/04/2017 16:01	9.2
04/03/2017 04:01	9.8	04/04/2017 17:01	9.2
04/03/2017 05:01	9.7	04/04/2017 18:01	9.3
04/03/2017 06:01	9.7	04/04/2017 19:01	9.3
04/03/2017 07:01	9.7	04/04/2017 20:01	9.3
04/03/2017 08:01	9.7	04/04/2017 21:01	9.4
04/03/2017 09:01	9.7	04/04/2017 22:01	9.4
04/03/2017 10:01	9.6	04/04/2017 23:01	9.4
04/03/2017 11:01	9.6	04/05/2017 00:01	9.5
04/03/2017 12:01	9.6	04/05/2017 01:01	9.5
04/03/2017 13:01	9.6	04/05/2017 02:01	9.5
04/03/2017 14:01	9.6	04/05/2017 03:01	9.5
04/03/2017 15:01	9.5	04/05/2017 04:01	9.5

TABLE I-7 (Continued): DISSOLVED OXYGEN CONCENTRATION MEASURED HOURLY AT ASHLAND AVENUE IN LITTLE CALUMET RIVER SOUTH, MARCH 30, 2017, THROUGH APRIL 6, 2017

Date and Time	Dissolved Oxygen (mg/L)	Date and Time	Dissolved Oxygen (mg/L)
04/05/2017 05:01	9.5	04/06/2017 03:01	10.6
04/05/2017 06:01	9.5	04/06/2017 04:01	10.7
04/05/2017 07:01	9.6	04/06/2017 05:01	10.8
04/05/2017 08:01	9.6	04/06/2017 06:01	10.8
04/05/2017 09:01	9.6	04/06/2017 07:01	10.9
04/05/2017 10:01	9.7	04/06/2017 08:01	10.9
04/05/2017 11:01	9.7	04/06/2017 09:01	10.8
04/05/2017 12:01	9.8	04/06/2017 10:01	10.8
04/05/2017 13:01	9.7	04/06/2017 11:01	10.7
04/05/2017 14:01	9.8	04/06/2017 12:01	10.7
04/05/2017 15:01	9.9	04/06/2017 13:01	10.7
04/05/2017 16:01	9.9	04/06/2017 14:01	10.7
04/05/2017 17:01	9.9	04/06/2017 15:01	10.7
04/05/2017 18:01	9.9	04/06/2017 16:01	10.6
04/05/2017 19:01	10.1	04/06/2017 17:01	10.6
04/05/2017 20:01	10.2	04/06/2017 18:01	10.6
04/05/2017 21:01	10.2	04/06/2017 19:01	10.6
04/05/2017 22:01	10.2	04/06/2017 20:01	10.6
04/05/2017 23:01	10.3	04/06/2017 21:01	10.6
04/06/2017 00:01	10.4	04/06/2017 22:01	10.5
04/06/2017 01:01	10.4	04/06/2017 23:01	10.5
04/06/2017 02:01	10.5		

TABLE I-8: DISSOLVED OXYGEN CONCENTRATION MEASURED HOURLY AT CICERO AVENUE IN THE CALUMET-SAG CHANNEL, MARCH 30, 2017, THROUGH APRIL 6, 2017

Date and Time	Dissolved Oxygen (mg/L)	Date and Time	Dissolved Oxygen (mg/L)
03/30/2017 00:00	9.4	03/31/2017 13:00	8.8
03/30/2017 01:00	9.4	03/31/2017 14:00	8.9
03/30/2017 02:00	9.3	03/31/2017 15:00	8.9
03/30/2017 03:00	9.3	03/31/2017 16:00	8.9
03/30/2017 04:00	9.4	03/31/2017 17:00	8.9
03/30/2017 05:00	9.3	03/31/2017 18:00	9.0
03/30/2017 06:00	9.3	03/31/2017 19:00	9.0
03/30/2017 07:00	9.5	03/31/2017 20:00	9.1
03/30/2017 08:00	9.5	03/31/2017 21:00	9.1
03/30/2017 09:00	9.4	03/31/2017 22:00	9.2
03/30/2017 10:00	9.3	03/31/2017 23:00	9.2
03/30/2017 11:00	9.4	04/01/2017 00:00	9.2
03/30/2017 12:00	9.4	04/01/2017 01:00	9.3
03/30/2017 13:00	9.5	04/01/2017 02:00	9.3
03/30/2017 14:00	9.8	04/01/2017 03:00	9.3
03/30/2017 15:00	10.0	04/01/2017 04:00	9.4
03/30/2017 16:00	10.2	04/01/2017 05:00	9.4
03/30/2017 17:00	10.2	04/01/2017 06:00	9.4
03/30/2017 18:00	10.2	04/01/2017 07:00	9.4
03/30/2017 19:00	10.2	04/01/2017 08:00	9.4
03/30/2017 20:00	10.1	04/01/2017 09:00	9.4
03/30/2017 21:00	10.0	04/01/2017 10:00	9.4
03/30/2017 22:00	9.9	04/01/2017 11:00	9.4
03/30/2017 23:00	9.9	04/01/2017 12:00	9.4
03/31/2017 00:00	9.8	04/01/2017 13:00	9.4
03/31/2017 01:00	9.8	04/01/2017 14:00	9.4
03/31/2017 02:00	9.7	04/01/2017 15:00	9.4
03/31/2017 03:00	9.5	04/01/2017 16:00	9.4
03/31/2017 04:00	9.4	04/01/2017 17:00	9.4
03/31/2017 05:00	9.2	04/01/2017 18:00	9.4
03/31/2017 06:00	9.0	04/01/2017 19:00	9.4
03/31/2017 07:00	8.9	04/01/2017 20:00	9.4
03/31/2017 08:00	8.8	04/01/2017 21:00	9.4
03/31/2017 09:00	8.7	04/01/2017 22:00	9.5
03/31/2017 10:00	8.7	04/01/2017 23:00	9.5
03/31/2017 11:00	8.7	04/02/2017 00:00	9.5
03/31/2017 12:00	8.8	04/02/2017 01:00	9.5

TABLE I-8 (Continued): DISSOLVED OXYGEN CONCENTRATION MEASURED HOURLY AT CICERO AVENUE IN THE CALUMET-SAG CHANNEL, MARCH 30, 2017, THROUGH APRIL 6, 2017

Date and Time	Dissolved Oxygen (mg/L)	Date and Time	Dissolved Oxygen (mg/L)
04/02/2017 02:00	9.6	04/03/2017 15:00	8.5
04/02/2017 03:00	9.6	04/03/2017 16:00	8.4
04/02/2017 04:00	9.6	04/03/2017 17:00	8.5
04/02/2017 05:00	9.6	04/03/2017 18:00	8.4
04/02/2017 06:00	9.6	04/03/2017 19:00	8.5
04/02/2017 07:00	9.6	04/03/2017 20:00	8.5
04/02/2017 08:00	9.5	04/03/2017 21:00	8.4
04/02/2017 09:00	9.5	04/03/2017 22:00	8.4
04/02/2017 10:00	9.5	04/03/2017 23:00	8.3
04/02/2017 11:00	9.4	04/04/2017 00:00	8.3
04/02/2017 12:00	9.3	04/04/2017 01:00	8.3
04/02/2017 13:00	9.3	04/04/2017 02:00	8.3
04/02/2017 14:00	9.2	04/04/2017 03:00	8.2
04/02/2017 15:00	9.1	04/04/2017 04:00	8.2
04/02/2017 16:00	9.1	04/04/2017 05:00	8.1
04/02/2017 17:00	8.9	04/04/2017 06:00	8.1
04/02/2017 18:00	8.9	04/04/2017 07:00	8.2
04/02/2017 19:00	8.9	04/04/2017 08:00	8.2
04/02/2017 20:00	8.8	04/04/2017 09:00	8.1
04/02/2017 21:00	8.8	04/04/2017 10:00	8.1
04/02/2017 22:00	8.8	04/04/2017 11:00	8.0
04/02/2017 23:00	8.8	04/04/2017 12:00	8.0
04/03/2017 00:00	8.8	04/04/2017 13:00	8.0
04/03/2017 01:00	8.7	04/04/2017 14:00	7.9
04/03/2017 02:00	8.8	04/04/2017 15:00	7.9
04/03/2017 03:00	8.8	04/04/2017 16:00	7.9
04/03/2017 04:00	8.9	04/04/2017 17:00	7.9
04/03/2017 05:00	8.9	04/04/2017 18:00	7.8
04/03/2017 06:00	8.8	04/04/2017 19:00	7.8
04/03/2017 07:00	8.8	04/04/2017 20:00	7.8
04/03/2017 08:00	8.8	04/04/2017 21:00	7.8
04/03/2017 09:00	8.8	04/04/2017 22:00	7.8
04/03/2017 10:00	8.8	04/04/2017 23:00	7.8
04/03/2017 11:00	8.7	04/05/2017 00:00	7.8
04/03/2017 12:00	8.7	04/05/2017 01:00	7.8
04/03/2017 13:00	8.6	04/05/2017 02:00	7.8
04/03/2017 14:00	8.5	04/05/2017 03:00	7.9

TABLE I-8 (Continued): DISSOLVED OXYGEN CONCENTRATION MEASURED HOURLY AT CICERO AVENUE IN THE CALUMET-SAG CHANNEL, MARCH 30, 2017, THROUGH APRIL 6, 2017

Date and Time	Dissolved Oxygen (mg/L)	Date and Time	Dissolved Oxygen (mg/L)
04/05/2017 04:00	7.9	04/06/2017 02:00	8.9
04/05/2017 05:00	7.9	04/06/2017 03:00	9.0
04/05/2017 06:00	8.0	04/06/2017 04:00	9.1
04/05/2017 07:00	8.0	04/06/2017 05:00	9.3
04/05/2017 08:00	8.1	04/06/2017 06:00	9.4
04/05/2017 09:00	8.2	04/06/2017 07:00	9.5
04/05/2017 10:00	8.2	04/06/2017 08:00	9.5
04/05/2017 11:00	8.3	04/06/2017 09:00	9.7
04/05/2017 12:00	8.3	04/06/2017 10:00	9.8
04/05/2017 13:00	8.3	04/06/2017 11:00	9.9
04/05/2017 14:00	8.3	04/06/2017 12:00	10.0
04/05/2017 15:00	8.3	04/06/2017 13:00	10.2
04/05/2017 16:00	8.2	04/06/2017 14:00	10.2
04/05/2017 17:00	8.2	04/06/2017 15:00	10.1
04/05/2017 18:00	8.3	04/06/2017 16:00	9.9
04/05/2017 19:00	8.3	04/06/2017 17:00	9.8
04/05/2017 20:00	8.4	04/06/2017 18:00	9.7
04/05/2017 21:00	8.4	04/06/2017 19:00	9.6
04/05/2017 22:00	8.5	04/06/2017 20:00	9.5
04/05/2017 23:00	8.6	04/06/2017 21:00	9.5
04/06/2017 00:00	8.6	04/06/2017 22:00	9.5
04/06/2017 01:00	8.8	04/06/2017 23:00	9.6

TABLE I-9: DISSOLVED OXYGEN CONCENTRATION MEASURED HOURLY AT ROUTE 83 IN THE CALUMET-SAG CHANNEL, MARCH 30, 2017, THROUGH APRIL 6, 2017

Date and Time	Dissolved Oxygen (mg/L)	Date and Time	Dissolved Oxygen (mg/L)
03/30/2017 00:00	8.6	03/31/2017 13:00	9.7
03/30/2017 01:00	8.7	03/31/2017 14:00	9.7
03/30/2017 02:00	8.8	03/31/2017 15:00	9.6
03/30/2017 03:00	8.9	03/31/2017 16:00	9.5
03/30/2017 04:00	9.1	03/31/2017 17:00	9.4
03/30/2017 05:00	9.1	03/31/2017 18:00	9.3
03/30/2017 06:00	9.3	03/31/2017 19:00	9.2
03/30/2017 07:00	9.3	03/31/2017 20:00	9.2
03/30/2017 08:00	9.4	03/31/2017 21:00	9.1
03/30/2017 09:00	9.5	03/31/2017 22:00	9.1
03/30/2017 10:00	9.6	03/31/2017 23:00	9.1
03/30/2017 11:00	9.8	04/01/2017 00:00	9.1
03/30/2017 12:00	9.9	04/01/2017 01:00	9.1
03/30/2017 13:00	10.0	04/01/2017 02:00	9.1
03/30/2017 14:00	10.1	04/01/2017 03:00	9.1
03/30/2017 15:00	10.2	04/01/2017 04:00	9.2
03/30/2017 16:00	10.2	04/01/2017 05:00	9.2
03/30/2017 17:00	10.2	04/01/2017 06:00	9.2
03/30/2017 18:00	10.1	04/01/2017 07:00	9.2
03/30/2017 19:00	10.1	04/01/2017 08:00	9.2
03/30/2017 20:00	10.1	04/01/2017 09:00	9.3
03/30/2017 21:00	10.0	04/01/2017 10:00	9.3
03/30/2017 22:00	9.9	04/01/2017 11:00	9.3
03/30/2017 23:00	9.9	04/01/2017 12:00	9.4
03/31/2017 00:00	9.8	04/01/2017 13:00	9.4
03/31/2017 01:00	9.8	04/01/2017 14:00	9.4
03/31/2017 02:00	9.9	04/01/2017 15:00	9.4
03/31/2017 03:00	10.0	04/01/2017 16:00	9.3
03/31/2017 04:00	10.0	04/01/2017 17:00	9.3
03/31/2017 05:00	10.0	04/01/2017 18:00	9.3
03/31/2017 06:00	10.0	04/01/2017 19:00	9.3
03/31/2017 07:00	10.0	04/01/2017 20:00	9.3
03/31/2017 08:00	9.9	04/01/2017 21:00	9.3
03/31/2017 09:00	9.9	04/01/2017 22:00	9.3
03/31/2017 10:00	9.8	04/01/2017 23:00	9.2
03/31/2017 11:00	9.8	04/02/2017 00:00	9.2
03/31/2017 12:00	9.8	04/02/2017 01:00	9.2

TABLE I-9 (Continued): DISSOLVED OXYGEN CONCENTRATION MEASURED HOURLY AT ROUTE 83 IN THE CALUMET-SAG CHANNEL, MARCH 30, 2017, THROUGH APRIL 6, 2017

Date and Time	Dissolved Oxygen (mg/L)	Date and Time	Dissolved Oxygen (mg/L)
04/02/2017 02:00	9.2	04/03/2017 15:00	8.8
04/02/2017 03:00	9.2	04/03/2017 16:00	8.8
04/02/2017 04:00	9.2	04/03/2017 17:00	8.8
04/02/2017 05:00	9.2	04/03/2017 18:00	8.7
04/02/2017 06:00	9.2	04/03/2017 19:00	8.6
04/02/2017 07:00	9.1	04/03/2017 20:00	8.5
04/02/2017 08:00	9.1	04/03/2017 21:00	8.5
04/02/2017 09:00	9.2	04/03/2017 22:00	8.4
04/02/2017 10:00	9.2	04/03/2017 23:00	8.4
04/02/2017 11:00	9.3	04/04/2017 00:00	8.4
04/02/2017 12:00	9.3	04/04/2017 01:00	8.4
04/02/2017 13:00	9.3	04/04/2017 02:00	8.3
04/02/2017 14:00	9.2	04/04/2017 03:00	8.4
04/02/2017 15:00	9.3	04/04/2017 04:00	8.4
04/02/2017 16:00	9.3	04/04/2017 05:00	8.5
04/02/2017 17:00	9.2	04/04/2017 06:00	8.4
04/02/2017 18:00	9.2	04/04/2017 07:00	8.5
04/02/2017 19:00	9.2	04/04/2017 08:00	8.5
04/02/2017 20:00	9.2	04/04/2017 09:00	8.5
04/02/2017 21:00	9.2	04/04/2017 10:00	8.6
04/02/2017 22:00	9.2	04/04/2017 11:00	8.6
04/02/2017 23:00	9.2	04/04/2017 12:00	8.6
04/03/2017 00:00	9.2	04/04/2017 13:00	8.7
04/03/2017 01:00	9.2	04/04/2017 14:00	8.7
04/03/2017 02:00	9.2	04/04/2017 15:00	8.7
04/03/2017 03:00	9.2	04/04/2017 16:00	8.6
04/03/2017 04:00	9.1	04/04/2017 17:00	8.5
04/03/2017 05:00	9.1	04/04/2017 18:00	8.5
04/03/2017 06:00	9.0	04/04/2017 19:00	8.4
04/03/2017 07:00	9.0	04/04/2017 20:00	8.3
04/03/2017 08:00	9.0	04/04/2017 21:00	8.2
04/03/2017 09:00	8.9	04/04/2017 22:00	8.2
04/03/2017 10:00	8.9	04/04/2017 23:00	8.2
04/03/2017 11:00	8.9	04/05/2017 00:00	8.2
04/03/2017 12:00	8.9	04/05/2017 01:00	8.2
04/03/2017 13:00	8.9	04/05/2017 02:00	8.2
04/03/2017 14:00	8.9	04/05/2017 03:00	8.2

TABLE I-9 (Continued): DISSOLVED OXYGEN CONCENTRATION MEASURED HOURLY AT ROUTE 83 IN THE CALUMET-SAG CHANNEL, MARCH 30, 2017, THROUGH APRIL 6, 2017

Date and Time	Dissolved Oxygen (mg/L)	Date and Time	Dissolved Oxygen (mg/L)
04/05/2017 04:00	8.1	04/06/2017 02:00	9.0
04/05/2017 05:00	8.2	04/06/2017 03:00	9.0
04/05/2017 06:00	8.2	04/06/2017 04:00	9.1
04/05/2017 07:00	8.2	04/06/2017 05:00	9.2
04/05/2017 08:00	8.2	04/06/2017 06:00	9.3
04/05/2017 09:00	8.3	04/06/2017 07:00	9.4
04/05/2017 10:00	8.3	04/06/2017 08:00	9.5
04/05/2017 11:00	8.4	04/06/2017 09:00	9.6
04/05/2017 12:00	8.4	04/06/2017 10:00	9.7
04/05/2017 13:00	8.5	04/06/2017 11:00	9.8
04/05/2017 14:00	8.5	04/06/2017 12:00	9.9
04/05/2017 15:00	8.5	04/06/2017 13:00	9.9
04/05/2017 16:00	8.5	04/06/2017 14:00	9.9
04/05/2017 17:00	8.5	04/06/2017 15:00	10.0
04/05/2017 18:00	8.6	04/06/2017 16:00	10.0
04/05/2017 19:00	8.6	04/06/2017 17:00	10.0
04/05/2017 20:00	8.6	04/06/2017 18:00	10.0
04/05/2017 21:00	8.7	04/06/2017 19:00	10.0
04/05/2017 22:00	8.7	04/06/2017 20:00	10.0
04/05/2017 23:00	8.8	04/06/2017 21:00	10.0
04/06/2017 00:00	8.9	04/06/2017 22:00	10.0
04/06/2017 01:00	8.9	04/06/2017 23:00	10.0