MONITORING AND RESEARCH DEPARTMENT

REPORT NO. 09-64

OPERATING THE SIDESTREAM ELEVATED POOL AERATION STATIONS TO MEET THE PROPOSED WATER QUALITY STANDARDS

November 2009

Metropolitan Water Reclamation District of Greater Chicago
100 East Erie Street Chicago, Illinois 60611-2803 (312) 751-5600

OPERATING THE SIDESTREAM ELEVATED POOL AERATION STATIONS TO MEET THE PROPOSED WATER QUALITY STANDARDS

By

Judith Moran
Research Scientist I

Thomas Minarik
Biologist II

Michael Sopcak
Biologist III

Heng Zhang
Research Scientist III

Samuel Dennison
Biologist IV

Catherine O'Connor
Assistant Director of Monitoring and Research
Environmental Monitoring and Research Division

Thomas C. Granato
Deputy Director of Monitoring and Research

Monitoring and Research Department
Louis Kollias, Director

November 2009

TABLE OF CONTENTS

	Page
LIST OF TABLES	iv
LIST OF FIGURES	vii
ACKNOWLEDGMENTS	ix
DISCLAIMER	ix
INTRODUCTION	1
Sidestream Elevated Pool Aeration Station Background	1
Current and Proposed Illinois Pollution Control Board Dissolved Oxygen Standards	3
OBJECTIVES	5
MATERIALS AND METHODS	6
Study Schedule	6
Pump Operation	6
Monitoring Station Locations	11
Water Quality Monitors	11
RESULTS AND DISCUSSION	14
Event 1—May 1, 2008, to May 21, 2008	14
Dissolved Oxygen Concentrations and Compliance with Proposed Standards	14
Dissolved Oxygen Percent Saturation	16
Dissolved Oxygen Concentrations along the River	16
Factors Affecting Dissolved Oxygen Concentrations in Testing Streams	16

TABLE OF CONTENTS (Continued)

	Page
Event 2—July 10, 2008 to July 31, 2008	19
Dissolved Oxygen Concentrations and Compliance with Proposed Standards	19
Dissolved Oxygen Percent Saturation	19
Dissolved Oxygen Concentrations along the River	21
Factors Affecting Dissolved Oxygen Concentration in Testing Streams	21
Event 3—August 11, 2008 to August 22, 2008	21
Dissolved Oxygen Concentrations and Compliance with Proposed Standards	21
Dissolved Oxygen Percent Saturation	25
Dissolved Oxygen Concentrations along the River	25
Factors Affecting Dissolved Oxygen Concentration in Testing Streams	25
Event 4—September 22, 2008 to October 3, 2008	25
Dissolved Oxygen Concentrations and Compliance with Proposed Standards	25
Dissolved Oxygen Percent Saturation	29
Dissolved Oxygen Concentrations along the River	29
Factors Affecting Dissolved Oxygen Concentrations in Testing Streams	29
Dissolved Oxygen Mass Balance along the Calumet River System	29
Estimated Oxygen Transferred, Energy Used, and Carbon Dioxide, Nitrogen Oxides, and Sulfur Dioxide Emissions due to Energy Consumption	38
Study Summary	40

TABLE OF CONTENTS (Continued)

	Page
CONCLUSIONS	42
REFERENCES	44
APPENDICES	
Dissolved Oxygen Concentrations at Monitoring Stations	AI
Calculation of the Saturation Concentration of Dissolved Oxygen	AII
Daily Flows into the Calumet-Sag Channel	AIII
Precipitation and Estimated Combined Sewer Overflow Volumes	AIV
Sidestream Elevated Pool Aeration Station Pump Data	AV
Calculations for Estimated Oxygen Transfer, Electricity Use, and Carbon Dioxide and Other Emissions	AVI

LIST OF TABLES

Table No.		Page
1	Current and Proposed Dissolved Oxygen Standards	4
2	Study Test Periods	7
3	Sidestream Elevated Pool Aeration Station Pump Number and Capacity	8
4	Pump Schedule for Each Test Period during Study	9
5	Monitoring Station Locations	12
6	Dissolved Oxygen Concentrations in the Calumet-Sag Channel and the Chicago Sanitary and Ship Canal during Event 1 (May 1, 2008, to May 21, 2008)	15
7	Summary of Factors Influencing Dissolved Oxygen in the Calumet-Sag Channel during Event 1	18
8	Dissolved Oxygen Concentrations in the Calumet-Sag Channel and the Chicago Sanitary and Ship Canal during Event 2 (July 10, 2008, to July 31, 2008)	20
9	Summary of Factors Influencing Dissolved Oxygen in the Calumet-Sag Channel during Event 2	23
10	Dissolved Oxygen Concentrations in the Calumet-Sag Channel and the Chicago Sanitary and Ship Canal during Event 3 (August 11, 2008, to August 22, 2008)	24
11	Summary of Factors Influencing Dissolved Oxygen in the Calumet-Sag Channel during Event 3	27
12	Dissolved Oxygen Concentrations in the Calumet-Sag Channel and the Chicago Sanitary and Ship Canal during Event 4 (September 22, 2008, to October 3, 2008)	28
13	Summary of Factors Influencing Dissolved Oxygen in the Calumet-Sag Channel during Event 4	31

LIST OF TABLES (Continued)

Table No.		Page
14	Calculation Results of Dissolved Oxygen Mass in Metric Tons per Day for Events 1 through 4	34
15	Estimated Dissolved Oxygen in Metric Tons per Day Added by Sidestream Elevated Pool Aeration Stations during Events 1 through 4	35
16	Estimated Oxygen Transferred, Electricity Used, and Carbon Dioxide, Nitrogen Oxides, and Sulfur Dioxide Emitted Each Day Due to Operation of Additional Pumps at Sidestream Elevated Pool Aeration Stations 3 and 4 during the Events	39
17	Summary of Events 1 through 4	41
AI-1	Daily Dissolved Oxygen and Temperature Data for the Division Monitoring Station during All Four Events	AI-1
AI-2	Daily Dissolved Oxygen and Temperature Data for the Cicero Avenue Monitoring Station during All Four Events	AI-4
AI-3	Daily Dissolved Oxygen and Temperature Data for the River Mile 311.7 Monitoring Station during All Four Events	AI-7
AI-4	Daily Dissolved Oxygen and Temperature Data for the Southwest Highway Monitoring Station during All Four Events	AI-10
AI-5	Daily Dissolved Oxygen and Temperature Data for the 104th Avenue Monitoring Station during All Four Events	AI-13
AI-6	Daily Dissolved Oxygen and Temperature Data for the Route 83 Calumet-Sag Channel Monitoring Station during All Four Events	AI-16
AI-7	Daily Dissolved Oxygen and Temperature Data for the Route 83 Chicago Sanitary and Ship Canal Monitoring Station during All Four Events	AI-19
AI-8	Daily Dissolved Oxygen and Temperature Data for the Romeoville Monitoring Station during All Four Events	AI-22

LIST OF TABLES (Continued)

Table No.		Page
AI-9	Daily Dissolved Oxygen and Temperature Data for the Lockport Monitoring Station during All Four Events	AI-25
AIII-1	Daily Flow Data into Calumet-Sag Channel	AIII-1
AIV-1	Precipitation and Combined Sewer Overflows during Events 1 through 4	AIV-1
AV-1	Sidestream Elevated Pool Aeration Pump Station Operation during Events 1 through 4	AV-1

LIST OF FIGURES

Figure No.		Page
1	Sidestream Elevated Pool Aeration Station Locations	2
2	Monitoring Station Locations	13
3	Dissolved Oxygen Concentration Data versus River Mile for Event 1	17
4	Dissolved Oxygen Concentration Data versus River Mile for Event 2	22
5	Dissolved Oxygen Concentration Data versus River Mile for Event 3	26
6	Dissolved Oxygen Concentration Data versus River Mile for Event 4	30
7	Dissolved Oxygen Mass in the Calumet River System during Event 1 Average	33
8	Dissolved Oxygen Mass at Monitoring Stations in the Calumet-Sag Channel during Events 1 through 4	37
AI-1	Dissolved Oxygen Concentrations Measured at the Division Street Monitoring Station during Events 1 Through 4	AI-28
AI-2	Dissolved Oxygen Concentrations Measured at the Cicero Avenue Monitoring Station during Events 1 Through 4	AI-29
AI-3	Dissolved Oxygen Concentrations Measured at the River Mile 311.7 Monitoring Station during Events 1 Through 4	AI-30
AI-4	Dissolved Oxygen Concentrations Measured at the Southwest Highway Monitoring Station during Events 1 Through 4	AI-31
AI-5	Dissolved Oxygen Concentrations Measured at the 104th Avenue Monitoring Station during Events 1 Through 4	AI-32
AI-6	Dissolved Oxygen Concentrations Measured at the Route 83 Calumet-Sag Channel Monitoring Station during Events 1 Through 4	AI-33

LIST OF FIGURES (Continued)

Figure No.		Page
AI-7	Dissolved Oxygen Concentrations Measured at the Route 83 Chicago Sanitary and Ship Canal Monitoring Station during Events 1 Through 4	AI-34
AI-8	Dissolved Oxygen Concentrations Measured at the Romeoville Monitoring Station during Events 1 Through 4	AI-35
AI-9	Dissolved Oxygen Concentrations Measured at the Lockport Monitoring Station during Events 1 Through 4	AI-36

ACKNOWLEDGMENTS

Thanks are extended to Mr. David Tang and staff from the Maintenance and Operation Department for their help in operating the SEPA stations according to the experimental plan.

Thanks are also extended to staff from the Industrial Waste Division who deployed and retrieved the water quality monitors during this study.

For data downloading and maintenance of the water quality monitors, thanks are extended to the Aquatic Ecology and Water Quality Section.

Acknowledgment and gratitude are extended to Ms. Laura Franklin for her attention in formatting this report.

DISCLAIMER

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

INTRODUCTION

On October 26, 2007, the Illinois Environmental Protection Agency (IEPA) presented proposed water quality standards (WQS) for the Chicago Area Waterway System (CAWS) to the Illinois Pollution Control Board (IPCB). The dissolved oxygen (DO) standard specified in the proposed standards is significantly more stringent than the current DO standard for the Calumet-Sag Channel (CSC). To understand the impact of this proposed DO standard, Environmental Monitoring and Research Division (EM&R) staff conducted a study to investigate the potential of using the existing Sidestream Elevated Pool Aeration (SEPA) Stations to meet the proposed DO standard. This report presents the results and conclusions of the study.

Sidestream Elevated Pool Aeration Station Background

Water quality monitoring conducted by the Metropolitan Water Reclamation District of Greater Chicago (District) in the 1970's indicated that DO standards could not be met exclusively by improving the water reclamation plant (WRP) effluents and capturing and treating combined sewer overflows (CSOs). In response, SEPA stations were constructed and are operated to improve DO concentrations in the CAWS. There are a total of five SEPA stations, SEPA 1 located on the Calumet River, SEPA 2 on the Little Calumet River (North), SEPAs 3 and 4 located along the CSC and SEPA 5 located at the junction of the CSC and the Chicago Sanitary and Ship Canal (CSSC) as shown in Figure 1. SEPA station operation involves pumping a portion of water from the stream into an elevated pool where the water is then aerated by flowing over multiple cascades that return the aerated water to the stream.

In 2000, the Illinois State Water Survey (ISWS) published a study titled "Effects of Sidestream Elevated Pool Aeration (SEPA) Stations on Instream Dissolved Oxygen." The objectives of this study were to:

1. Determine the actual oxygen (O_2) transfer rate attributable to the waterfalls at the SEPA stations.

2. Determine the actual O_2 transfer rate attributable to the spiral-lift screw pumps at the SEPA stations.

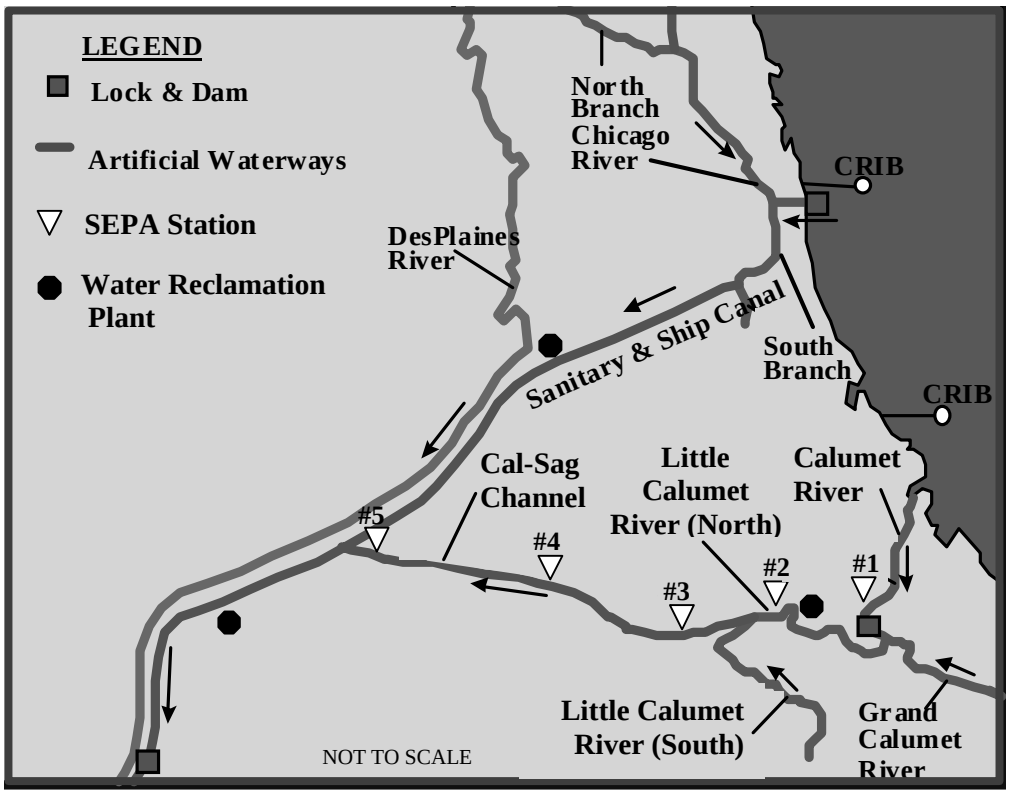
3. Determine the effect of the SEPA stations on the DO levels in the Calumet-Sag Channel.

Pertinent conclusions of the third objective include:

1. SEPA 1 is located in a reach of the waterway which experiences few periods during which DO levels fall below the standards of 5.0 mg/L.

2. SEPA 2 is located in a shallow, open-bay area and its operational efficiency is affected by many meteorological, hydrological and biological problems. The

FIGURE 1: SIDESTREAM ELEVATED POOL AERATION STATION LOCATIONS



data generated during March 16, 1996 through November 19, 1998 indicates that during low-flow warm weather conditions the DO gradually sags from SEPA 1 to SEPA 3 with no detectable influx of DO from SEPA 2.

3. SEPAs 3, 4 and 5 provide DO to the waterway very efficiently, so that the 3.0 mg/L DO standard is met 98.1 percent of the time at SEPA 3 and 96.5 percent of the time at SEPA 4.

The 2000 ISWS study also concluded that mean DO saturation concentrations could be obtained at the outfall of SEPA 3, 4 and 5 for all pump settings, except that the mean outfall DO was only 93% saturated at SEPA 5 when there was only one pump in operation.

Current and Proposed Illinois Pollution Control Board Dissolved Oxygen Standards

The current and proposed IPCB DO standards are shown in Table 1. The proposed standard for the CSC is seasonal with the more stringent standard occurring from March through July.

TABLE 1: CURRENT AND PROPOSED DISSOLVED OXYGEN STANDARDS

Waterway	Current Year-Round	Proposed	
		March–July	August–February
Calumet-Sag Channel	3.0 mg/L	5.0 mg/L	3.5 mg/L anytime, 4.0 mg/L as daily minimum averaged over 7 days
Chicago Sanitary and Ship Canal	4.0 mg/L	3.5 mg/L anytime, 4.0 mg/L as daily minimum averaged over 7 days	3.5 mg/L anytime, 4.0 mg/L as daily minimum averaged over 7 days

OBJECTIVES

The objectives of the current study were to (1) determine whether the existing SEPA stations can be operated to meet the proposed DO standards in the CSC and the CSSC downstream of the junction with the CSC; and (2) if they do, how the SEPA station pump settings should be set to achieve the new standards at minimum cost. The study will also supplement and update the 2000 ISWS study.

This study only tested SEPAs 3, 4 and 5 because SEPA 1 operates upstream of the O'Brien Locks where the waterway is generally in compliance with the proposed DO standards and SEPA 2 has been shown in past studies to provide no influx of DO concentrations between SEPAs 1 and 3. Although these stations were not included in the testing, information on intake DO concentrations and number of pumps operating are included for informational purposes in the results section of this report.

MATERIALS AND METHODS

Study Schedule

The proposed DO standards for the CSC are seasonal. Therefore, the effect of water temperature and DO saturation and the potential influence of discretionary Lake Michigan diversion on stream DO have been taken into account. In order to do this, the tests were conducted at four different times of year as shown in Table 2.

Pump Operation

The five SEPA stations have between two and five pumps depending on the station. The number of pumps located at each station is shown in Table 3 along with pump capacities. According to the 2000 ISWS study, running the maximum number of pumps at SEPAs 3, 4 and 5 would cause turbulence in the channel, potentially interfering with commercial navigation. Due to this potential interference, the practical maximum number of pumps operated during this study were three pumps at SEPAs 3 and 4 and four pumps at SEPA 5.

The current SEPA station operation is governed by DO concentrations at the stations' upstream monitoring stations. For example, if the DO concentration at the monitoring station upstream of SEPA 4 drops below a determined DO set point, a pump or additional pump is activated at SEPA 4 to ensure that DO concentrations within the channel remain greater than the current 3.0 mg/L DO standard in the CSC.

For each of the study events, SEPAs 3 and 4 were operated consistent with current M&O SEPA station operation. However, the procedure was adjusted for Events 1 and 2 to attempt to maintain a DO concentration of 5.0 mg/L in the waterway. New set point DO concentrations at upstream monitoring stations were established and used during these testing events for SEPAs 3 and 4.

During the study, SEPA 5 was to be operated differently than current SEPA station operation. The DO load provided by SEPA 5 benefits the CSSC downstream of the junction with the CSC. DO concentration in this section of the CSSC is greatly influenced by the DO concentration in the CSSC upstream of the junction with the CSC. A pump schedule for SEPA 5 was devised which increased the number of pumps operating throughout each event to determine if SEPA 5 provides any benefit in DO concentration in the CSSC. However, due to unforeseen maintenance needs, SEPA 5 was not operated according to the proposed schedule. Actual SEPA 5 operation is included in the results section of this report.

The pump schedule used for SEPAs 3 and 4 and the proposed schedule for SEPA 5 are shown in Table 4. After a pump was put into service at SEPAs 3 and 4, the pump was operated for a minimum of 48 hours regardless of upstream DO concentration. This duration was selected because during dry weather typical flows in the CSC are about 0.3 foot per second. At this flow, it takes more than 24 hours for water to travel from one SEPA station to the next. After the

TABLE 2: STUDY TEST PERIODS

Event	Description	Dates
1	Spring	5/1/2008–5/21/2008
2	Early Summer	7/10/2008–7/31/2008
3	Summer	8/11/2008–8/22/2008
4	Early Fall	9/22/2008–10/3/2008

TABLE 3: SIDESTREAM ELEVATED POOL AERATION STATION
PUMP NUMBER AND CAPACITY

SEPA Station	No. of Pumps	Capacity per Pump (MGD)
1	4	64.8
2	2	27.8
3	4	81.9
4	4	77.6
5	5	74.4

TABLE 4: PUMP SCHEDULE FOR EACH TEST PERIOD DURING STUDY

Event	SEPA Station[1]	No. of Pumps	Upstream DO (mg/L)	Note
Event 1 (5/1/08–5/21/08)	3, 4	1	6.0	Run for 48 hours even if upstream DO increases
		2	5.6	”
		3	5.3	”
	5	1	—	5/1–5/6
		2	—	5/6–5/11
		3	—	5/11–5/16
		4	—	5/16–5/21
Event 2 (7/10/08–7/31/08)	3, 4	1	6.0	Run for 48 hours even if upstream DO increases
		2	5.6	”
		3	5.3	”
	5	2	—	7/10–7/17
		3	—	7/17–7/24
		4	—	7/24–7/31
Event 3 (8/11/08–8/22/08)	3, 4	1	4.5	Run for 48 hours even if upstream DO increases
		2	4.1	”
		3	3.8	”
	5	2	—	8/11–8/15
		3	—	8/15–8/19
		4	—	8/19–8/22

TABLE 4 (Continued): PUMP SCHEDULE FOR EACH TEST PERIOD DURING STUDY

Event	SEPA Station[1]	No. of Pumps	Upstream DO (mg/L)	Note
Event 4 (9/22/08–10/3/08)	3, 4	1	4.5	Run for 48 hours even if upstream DO increases
		2	4.1	”
		3	3.8	”
	5	1	—	9/22–9/25
		2	—	9/25–9/28
		3	—	9/28–10/1
		4	—	10/1–10/3

[1]SEPA 5 schedule represents the proposed schedule. Actual operation of SEPA 5 is different than proposed schedule due to maintenance needs during the study. Actual SEPA 5 operation can be found in the Results and Discussion.

minimum 48 hours, the number of pumps operating was reduced if the DO concentration at the upstream monitoring station remained above the proper set point.

Monitoring Station Locations

DO monitoring for the study utilized the monitoring stations and data from the Continuous Dissolved Oxygen Monitoring (CDOM) Program already in place by the District. Five monitoring stations from the CDOM Program were used along with four former CDOM Program monitoring stations that were reactivated for the purpose of this study. The names and descriptions for all monitoring stations used in this study are shown in Table 5. Figure 2 is a schematic that depicts the locations of the monitoring and SEPA stations.

Water Quality Monitors

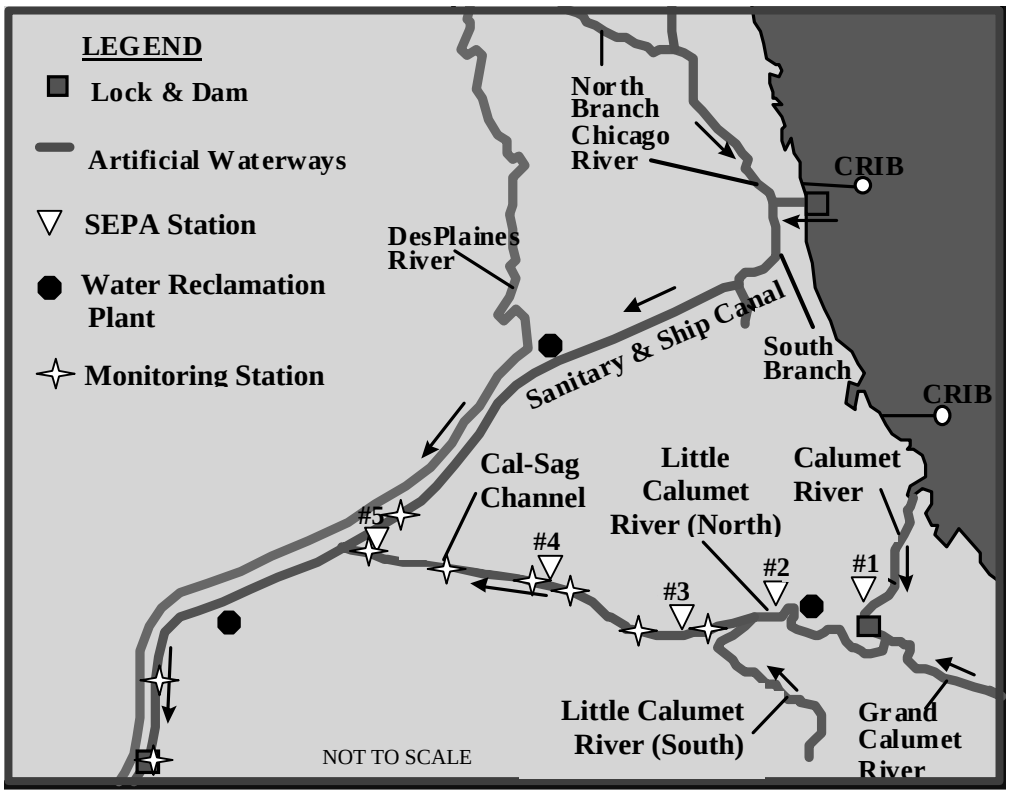
The continuous water quality monitors used for this study are manufactured by YSI Incorporated (YSI). DO, temperature, and conductivity were measured hourly using the YSI Model 6920 or Model 6600 monitor. Data were downloaded weekly and reviewed for quality assurance. Monitors were serviced and data collected in concert with the CDOM Program, using the same data management and review, standard operating procedure, and quality assurance plan. After review of the data, there was an 86 percent data recovery rate.

TABLE 5: MONITORING STATION LOCATIONS

Monitoring Station	Description of Monitoring Station
Division Street[1]	0.4 mile upstream of SEPA 3
Cicero Avenue	3.1 miles downstream of SEPA 3, 3.3 miles upstream of SEPA 4
River Mile 311.7[1] (RM 311.7)	6.4 miles downstream of SEPA 3, 0.1 mile upstream of SEPA 4
Southwest Highway[1]	0.8 mile downstream of SEPA 4
104th Avenue	4.6 miles downstream of SEPA 4, 3.1 miles upstream of SEPA 5
Route 83 CSC[2] (RT 83 CSC)	CSC, 0.3 miles upstream of SEPA 5
Route 83 CSSC[3] (RT 83 CSSC)	CSSC, 1.2 miles upstream of junction with CSC, 1.1 miles upstream of SEPA 5
Romeoville[1]	6.3 miles downstream of junction with CSC on CSSC
Lockport Powerhouse	12.4 miles downstream of junction with CSC on the CSSC

[1]Reactivated monitoring site.
[2]Calumet-Sag Channel.
[3]Chicago Sanitary and Ship Canal.

FIGURE 2: MONITORING STATION LOCATIONS



RESULTS AND DISCUSSION

Graphs of the hourly DO concentrations measured at each of the monitoring stations during four Events can be found in Figures AI-1 through AI-9 of Appendix AI. The hourly DO concentration data were also summarized as a daily minimum, maximum, and mean. This daily DO data can be found in Tables AI-1 through AI-9 of Appendix AI.

The daily flow data is provided in Table AIII-1 of Appendix AIII. The precipitation data was obtained from District gauges 10, 11, and 12 and CSO information from the District's M&O Department. Precipitation and CSO data are provided in Table AIV-1 of Appendix AIV. SEPA station pump operation data are provided in Table AV-1 of Appendix AV.

Event 1—May 1, 2008, to May 21, 2008

Dissolved Oxygen Concentrations and Compliance with Proposed Standards. The minimum, maximum, and mean DO concentrations and the percent of DO values in compliance with the proposed standard at each monitoring location during Event 1 are shown in Table 6. Stream DO concentrations at four of the nine monitoring stations did not meet the proposed "anytime" standard 100 percent of the time. These stations were Division Street, Cicero Avenue, River Mile 311.7 and RT 83 CSSC.

The DO concentrations measured at the Division Street monitoring station met the proposed 5.0 mg/L standard approximately 69.4 percent of the time. The Division Street monitoring station is located upstream of SEPA 3. A possible way of improving DO concentrations at this location is to provide supplemental DO upstream of this location. One alternative of achieving this is through the use of discretionary diversion from Lake Michigan, which typically has higher DO concentrations. However, during Event 1, there was no discretionary diversion from Lake Michigan. Further investigation into possible causes for low DO compliance at this monitoring station and potential ways of improving the DO at this location was beyond the scope of this study.

The DO concentrations measured at both the Cicero Avenue and River Mile 311.7 monitoring stations met the proposed 5.0 mg/L standard approximately 98.6 percent of the time. These monitoring stations are located downstream of SEPA 3, which had two pumps operating for the duration of Event 1. It was possible that the use of three pumps, the maximum practical number of pumps that can be used, might have resulted in 100 percent compliance with the proposed standard during this test period.

The DO concentrations measured at the RT 83 CSSC monitoring station met the proposed 3.5 mg/L standard approximately 98.4 percent of the time. This station is located upstream of SEPA 5 on the CSSC. The DO concentration at this location is dependent on upstream water quality of the CSSC which receives flows from the Chicago River System, effluents from

TABLE 6: DISSOLVED OXYGEN CONCENTRATIONS IN THE CALUMET-SAG CHANNEL AND THE CHICAGO SANITARY AND SHIP CANAL DURING EVENT 1 (MAY 1, 2008, TO MAY 21, 2008)

Monitoring Station Location	Waterway	Proposed IPCB DO Standard (mg/L)	No. of DO Values	DO Concentration[1] (mg/L)			Percent DO Values Above Standard	Average Percent DO Saturation[2]
				Min.	Max.	Mean		
Division St.	Calumet-Sag Channel	5.0	504	3.3	7.6	5.4	69.4	53.1
Cicero Ave.	Calumet-Sag Channel	5.0	504	4.6	8.4	6.5	98.6	64.6
River Mile 311.7	Calumet-Sag Channel	5.0	504	4.7	8.5	6.6	98.6	64.4
Southwest Hwy.	Calumet-Sag Channel	5.0	503	5.3	9.4	7.1	100.0	70.2
104th Ave.	Calumet-Sag Channel	5.0	504	5.6	8.5	7.0	100.0	69.0
Route 83	Calumet-Sag Channel	5.0	504	5.5	8.0	6.7	100.0	65.8
Route 83	Chicago Sanitary and Ship Canal	3.5	504	2.5	7.3	5.5	98.4	58.3
Romeoville Rd.	Chicago Sanitary and Ship Canal	3.5	504	4.4	7.2	5.7	100.0	58.5
Lockport	Chicago Sanitary and Ship Canal	3.5	231	5.0	6.6	5.9	100.0	62.9

[1]Dissolved oxygen was measured hourly using a YSI Model 6920 or Model 6600 continuous water quality monitor.
[2]Average of daily mean percent saturations during event.

the Stickney WRP and North Side WRP, storm runoff and CSOs. DO concentrations at this location are not affected by SEPA station operation.

During Event 1, the DO concentrations measured at the monitoring stations on the CSSC complied with the proposed standard of 4.0 mg/L as a daily minimum averaged over 7 days. The monitoring stations on the CSC were not required to meet this 4.0 mg/L standard at the time of Event 1.

Dissolved Oxygen Percent Saturation. DO saturation concentration in water is significantly affected by the water's temperature. As the water temperature increases, the amount of O_2 that can be dissolved in the water decreases. To account for this, DO concentration is often referred to in terms of percent saturation, where the DO saturation concentration is the amount of O_2 that will dissolve in water at a certain temperature and pressure.

An average DO percent saturation was calculated for each monitoring station. The calculation was done by dividing the daily average DO concentration measured at the monitoring station by the daily DO saturation concentration calculated for that monitoring station. The DO saturation concentration was calculated by the Weiss equation (Weiss, 1970) using the daily average temperature measured at the monitoring station and assuming an atmospheric pressure of 1 atm. A daily DO percent saturation was calculated and averaged to obtain an Event average for each monitoring station. The Weiss equation is provided in Appendix AII.

Table 6 includes the average DO percent saturation at each of the monitoring stations for Event 1. The overall average DO percent saturation and water temperature of the nine monitoring stations during Event 1 were approximately 63 percent and 15°C, respectively.

Dissolved Oxygen Concentrations along the River. Figure 3 shows the DO data spatially by river mile. In this figure, the Lockport Powerhouse, which is located at the U.S. Army Corps of Engineer's (the Corps) River Mile 291, is shown as 0 and SEPA 1, which is at the Corps' river Mile 328.1 is shown as 37.1 miles upstream of the Lockport Powerhouse. Figure 3 also includes the event average SEPA station effluent DO concentrations, which were assumed to be equal to the DO saturation concentration. The DO saturation concentrations were calculated by the Weiss equation (Weiss, 1970) at the temperature measured at the upstream monitoring station and 1 atm pressure. The DO data collected at the RT 83 CSSC monitoring station is not included for clarity as this monitoring station is located upstream of SEPA 5 on the CSSC.

Factors Affecting Dissolved Oxygen Concentrations in Testing Streams. Factors that can affect the DO concentration were collected for the Event 1 time period. A summary of these factors is shown in Table 7. There was a significant rain event which occurred on 5/11/08. This resulted in CSO on 5/11 and 5/12/08 and increased flow into the CSC during this time. The rain and resulting CSO and flows did not appear to affect the DO concentrations along the CSC. However, they may have affected the DO concentration at the RT 83 CSSC monitoring station on the CSSC upstream of SEPA 5, where almost a 3 mg/L drop in DO concentrations was observed on 5/12/08.

FIGURE 3: DISSOLVED OXYGEN CONCENTRATION DATA VERSUS RIVER MILE FOR EVENT 1

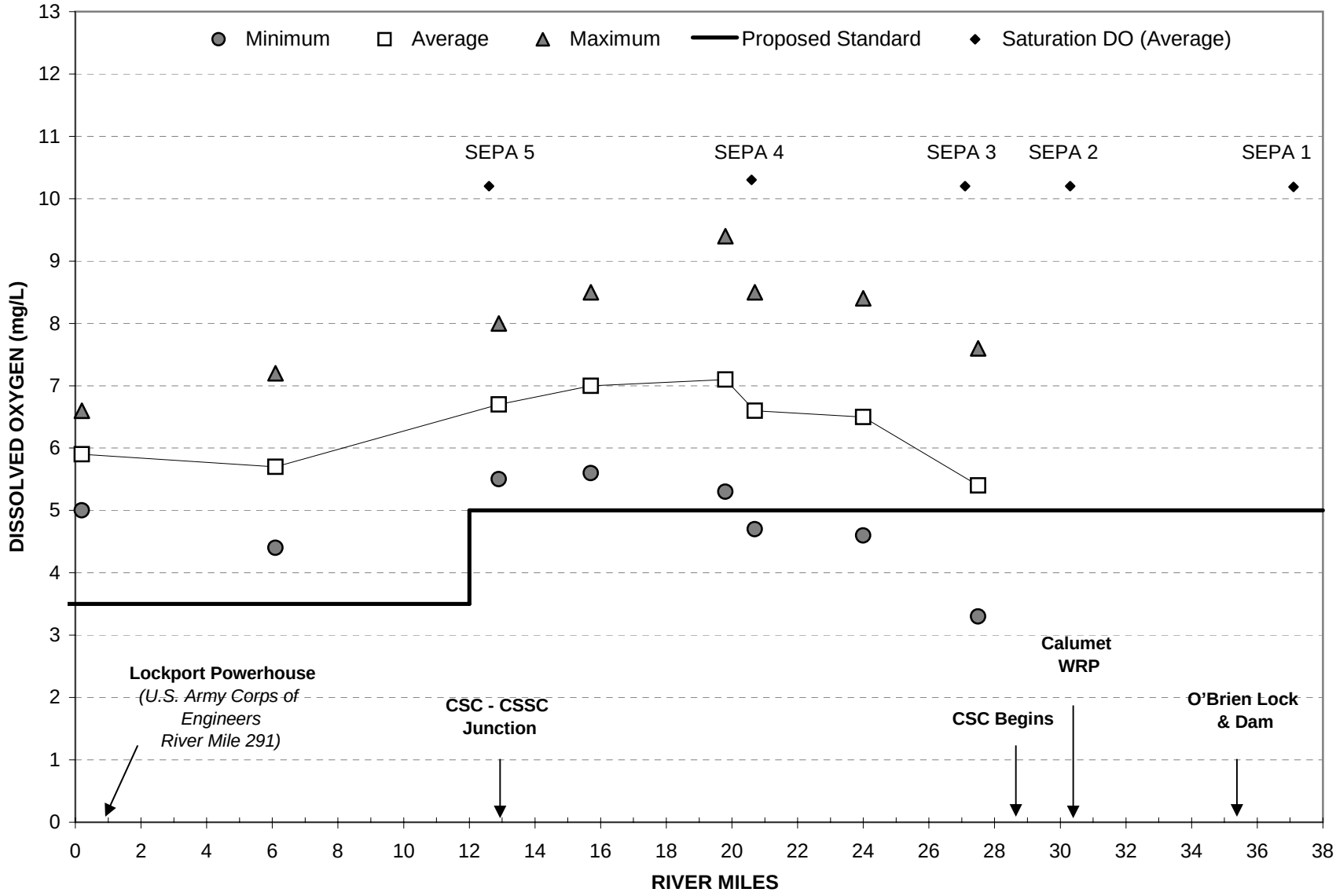


TABLE 7: SUMMARY OF FACTORS INFLUENCING DISSOLVED OXYGEN IN THE CALUMET-SAG CHANNEL DURING EVENT 1

Factors	Min.	Max.	Mean	Event Total	Notes
Flow into CSC[1] (MGD)	289	1,176	507	10,640 (MG)	—
Lake Inflow[2] (MGD)	13	148	26	544 (MG)	No discretionary diversion
Daily Rainfall[3] (inches)	0	1.95	0.14	3.03	—
CSO[4] (MG)				86	Occurred on two days during event (5/11 and 5/12/08)
Temperature (°C)	12	16	15	—	—
SEPA 1 Pumps (#)	0	1	—	—	1 pump operating for 17 out of 21 days
SEPA 2 Pumps (#)	1	1	—	—	1 pump operating for duration of event
SEPA 3 Pumps (#)	2	2	—	—	2 pumps operating for duration of event
SEPA 4 Pumps (#)	0	3	—	—	3 pumps operating for 16 out of 21 days
SEPA 5 Pumps (#)	1	1	—	—	1 pump operating for duration of event

[1]All flow entering the CSC including flow from Lake Michigan.
[2]All flow from Lake Michigan: navigational make-up, lockages, leakage and discretionary.
[3]Equal to the largest rainfall recorded by one of three rain gauges.
[4]Estimated discharged volume.

Event 2—July 10, 2008 to July 31, 2008

Dissolved Oxygen Concentrations and Compliance with Proposed Standards. The minimum, maximum, and mean DO concentrations measured at each monitoring station during Event 2 are shown in Table 8 along with the applicable proposed standard and percent of DO values above that standard. None of the monitoring stations met the proposed standard 100 percent of the time.

The DO concentrations measured at the Division Street monitoring station met the proposed "anytime" standard approximately 80.5 percent of the time. As previously discussed under Event 1, availability of discretionary diversion could improve DO concentrations at this location. During Event 2, there was an average of 284 MGD discretionary diversion and an 11 percent increase in compliance with the proposed standard compared to 69.4 percent compliance observed during Event 1 when there was no discretionary diversion.

The DO concentrations measured at the monitoring stations located on the CSC between SEPAs 3 and 5 met the proposed "anytime" standard of 5.0 mg/L between 79.1 and 99.6 percent of the time with the majority of DO concentrations less than the standards occurring between 7/20 and 7/23/08 following a rain event. During this time, three pumps, the practical maximum, were operating at both SEPAs 3 and 4. Therefore no additional aeration capacity was available during this time to improve DO concentrations downstream of these SEPA stations.

The DO concentrations measured at the RT 83 CSSC monitoring station upstream of SEPA 5 and at the Romeoville Road and Lockport monitoring stations downstream of SEPA 5 met the proposed "anytime" standard of 3.5 mg/L 86.0, 91.7, and 90.5 percent of the time during Event 2, respectively. The majority of DO concentrations were below the standard between 7/20 and 7/23/08 following a rain event and during which only two pumps were operating at SEPA 5 due to maintenance problems with the other pumps. It is unknown whether the use of an additional pump would have resulted in DO concentrations above the proposed standard 100 percent of the time at the monitoring stations downstream of SEPA 5 since DO concentrations are also dependent on the upstream CSSC water quality. However, a comparison of the monitoring stations upstream and downstream of SEPA 5 on the CSSC show an increase downstream of SEPA 5 which is likely due to the DO added by SEPA 5 and the relatively high DO concentrations in the water from the CSC. DO concentrations measured at the RT 83 CSSC monitoring station upstream of SEPA 5 on the CSSC can not be improved by existing SEPA stations.

Compliance with the proposed standard of 4.0 mg/L as a daily minimum averaged over 7 days was quite low for DO measured in the CSSC during Event 2. DO concentrations measured at the RT 83 CSSC, Romeoville and Lockport monitoring stations met this standard approximately 22, 44, and 19 percent of the time, respectively. Compliance at these monitoring stations was low because of the influence of the upstream CSSC water quality. DO measured on the CSC were not required to meet the 4.0 mg/L daily minimum standard during the time of Event 2.

Dissolved Oxygen Percent Saturation. As previously discussed under Event 1, DO concentration is often presented as percent saturation because there is a temperature and pressure

TABLE 8: DISSOLVED OXYGEN CONCENTRATIONS IN THE CALUMET-SAG CHANNEL AND THE CHICAGO SANITARY AND SHIP CANAL DURING EVENT 2 (JULY 10, 2008, TO JULY 31, 2008)

Monitoring Station Location	Waterway	Proposed IPCB Standard (mg/L)	Number of DO Values	DO Concentration[1] (mg/L)			Percent DO Values Above Standard	Average DO Percent Saturation[2]
				Min.	Max.	Mean		
Division St.	Calumet-Sag Channel	5.0	528	3.2	8.6	5.6	80.5	67.3
Cicero Ave.	Calumet-Sag Channel	5.0	527	3.7	9.3	6.6	93.7	79.2
River Mile 311.7	Calumet-Sag Channel	5.0	528	4.2	10.8	7.0	93.9	83.7
Southwest Hwy.	Calumet-Sag Channel	5.0	528	4.2	10.2	6.6	95.3	79.6
104th Ave.	Calumet-Sag Channel	5.0	491	4.8	9.8	6.9	99.6	83.1
Route 83	Calumet-Sag Channel	5.0	374	4.1	8.5	6.2	79.1	76.4
Route 83	Chicago Sanitary and Ship Canal	3.5	336	2.0	6.7	4.6	86.0	57.2
Romeoville Rd.	Chicago Sanitary and Ship Canal	3.5	528	2.9	6.4	4.6	91.7	57.3
Lockport	Chicago Sanitary and Ship Canal	3.5	528	2.9	8.8	4.6	90.5	57.2

[1]Dissolved oxygen was measured hourly using a YSI model 6920 or model 6600 continuous water quality monitor.
[2]Average of daily mean percent saturations during event.

dependent saturation limit on the amount of O_2 that can be dissolved in water. A daily DO percent saturation at each monitoring station was calculated by dividing the daily average DO concentration by the DO saturation concentration, where the DO saturation concentration was calculated by the Weiss equation (Weiss, 1970) using the upstream temperature and an atmospheric pressure of 1 atm. The daily DO percent saturation was averaged to get an Event average for each monitoring station, which is shown in Table 8. During Event 2, the overall average DO percent saturation and water temperature of the nine monitoring stations were approximately 71 percent and 26°C, respectively. The Weiss equation is provided in Appendix AII.

Dissolved Oxygen Concentrations along the River. Figure 4 shows the DO data spatially. On the x-axis of the figure, the Lockport Powerhouse, located at the Corps' River Mile 291, is shown at 0 and SEPA 1, located at the Corps' River Mile 328.1 is shown at 37.1 miles upstream. Figure 4 also includes the estimated event average DO concentration of the flow exiting the SEPA stations, which was assumed to be equal to the DO saturation concentration. The DO saturation concentration at the SEPA stations was calculated by the Weiss equation using the upstream temperature and 1 atm pressure. Data for the RT 83 CSSC monitoring station was not included for clarity as it is upstream of SEPA 5 on the CSSC.

The daily maximum DO concentrations measured at the monitoring stations were higher than the calculated DO saturation concentrations. Temperature at the time of measurement was not the reason for these high values. The maximum daily measurements all occurred in the afternoon, between 1:00 and 8:00 PM, which may indicate the presence of algal growth. However, the exact cause of these apparently super-saturated DO concentrations is unknown.

Factors Affecting Dissolved Oxygen Concentration in Testing Streams. Factors that can affect DO concentrations were collected for Event 2 and a summary is shown in Table 9. There was a significant rain event from 7/19 through 7/21/08, which caused increased flows in the CSC and CSSC and CSO events in the CSSC. The rain event appears to have affected the DO concentrations in both the CSC and CSSC; the lowest DO concentrations during Event 2 were observed directly following this event. There were no reported CSO occurrences in the CSC as a result of this rain event. However, the CSC does receive flow from other river systems such as the Little and Grand Calumet Rivers upstream of the SEPA and monitoring stations. It is possible that there were CSOs or other runoff in these streams which could have caused the DO drops in the CSC and CSSC during this time.

Event 3—August 11, 2008 to August 22, 2008

Dissolved Oxygen Concentrations and Compliance with Proposed Standards. The minimum, maximum, and mean DO data collected during Event 3 are shown in Table 10 along with the proposed standard for each monitoring location and the percent of DO values above that standard. DO concentrations measured at eight of the nine monitoring stations met the proposed "anytime" standard of 3.5 mg/L 100 percent of the time. Data were not available for the 104th Avenue monitoring station for Event 3.

FIGURE 4: DISSOLVED OXYGEN CONCENTRATION DATA VERSUS RIVER MILE FOR EVENT 2

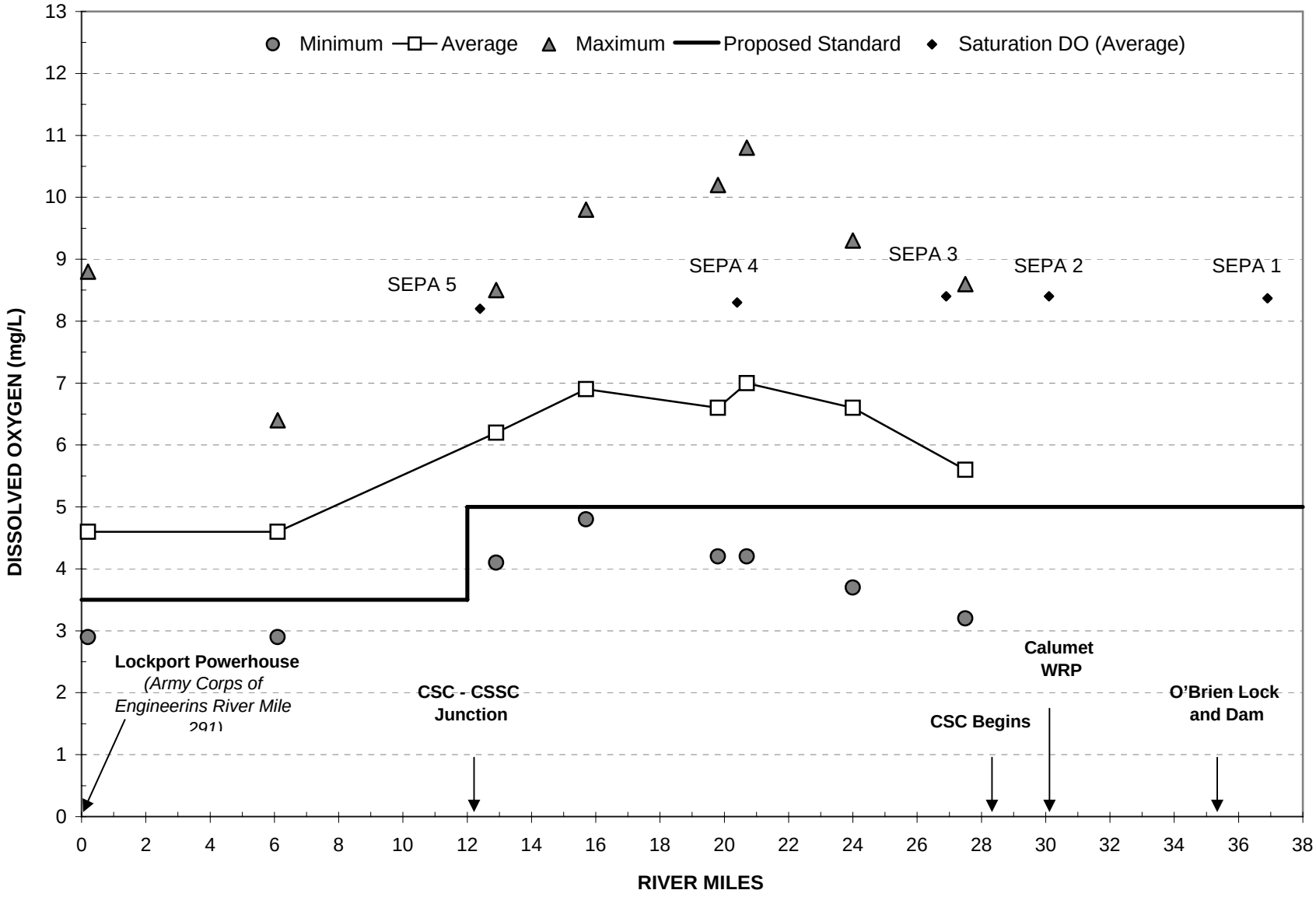


TABLE 9: SUMMARY OF FACTORS INFLUENCING DISSOLVED OXYGEN IN THE CALUMET-SAG CHANNEL DURING EVENT 2

Factors	Min.	Max.	Mean	Event Total	Notes
Flow into CSC[1] (MGD)	281	814	579	12,742 (MG)	—
Lake Inflow[2] (MGD)	34	476	280	6,167 (MG)	5,209 MG of discretionary diversion
Daily Rainfall[3] (inches)	0	1.35	0.14	3.14	—
CSO[4] (MG)	0	0	0	0	No CSO directly into CSC
Temperature (°C)	23.6	25.9	24.7	—	—
SEPA 1 Pumps (#)	0	1	—	—	1 pump operating for 15 out of 22 days
SEPA 2 Pumps (#)	1	1	—	—	1 pump operating for duration of event
SEPA 3 Pumps (#)	2	3	—	—	3 pumps operating for 18 out of 22 days
SEPA 4 Pumps (#)	2	3	—	—	3 pumps operating for 7 out of 22 days
SEPA 5 Pumps (#)	2	3	—	—	3 pump operating for 4 out of 22 days

[1]Includes all flow from rivers entering the CSC and flow from Lake Michigan. Does not include flow from creeks or small streams.
[2]All flow from Lake Michigan: navigational make-up, lockages, leakage and discretionary.
[3]Equal to the largest rainfall recorded by one of three rain gauges.
[4]Estimated discharged volume.

TABLE 10: DISSOLVED OXYGEN CONCENTRATIONS IN THE CALUMET-SAG CHANNEL AND THE CHICAGO SANITARY AND SHIP CANAL DURING EVENT 3 (AUGUST 11, 2008, TO AUGUST 22, 2008)

Monitoring Station Location	Waterway	Proposed IPCB Standard (mg/L)	Number of DO Values	DO Concentration[1] (mg/L)			Percent DO Values Above Standard	Average DO Percent Saturation[2]
				Min.	Max.	Mean		
Division St.	Calumet-Sag Channel	3.5	288	5.0	7.6	5.9	100.0	70.7
Cicero Ave.	Calumet-Sag Channel	3.5	288	5.2	7.2	6.1	100.0	73.2
River Mile 311.7	Calumet-Sag Channel	3.5	288	5.2	7.6	6.3	100.0	71.7
Southwest Hwy.	Calumet-Sag Channel	3.5	288	4.7	7.5	5.9	100.0	70.6
104th Ave.	Calumet-Sag Channel	3.5	0	ND	ND	ND	ND	ND
Route 83	Calumet-Sag Channel	3.5	288	4.8	7.0	5.8	100.0	69.4
Route 83	Chicago Sanitary and Ship Canal	3.5	52	4.1	5.0	4.7	100.0	59.8
Romeoville Rd.	Chicago Sanitary and Ship Canal	3.5	250	4.0	6.1	4.9	100.0	60
Lockport	Chicago Sanitary and Ship Canal	3.5	118	3.6	7.0	5.6	100.0	72.1

[1]Dissolved oxygen was measured hourly using a YSI model 6920 or model 6600 continuous water quality monitor.
[2]Average of daily mean percent saturations during event.

During this event, DO concentrations in both the CSC and the CSSC had to also meet the proposed standard of 4.0 mg/L as a daily minimum averaged over seven days. The DO concentrations measured at six of the nine monitoring stations met this standard. Sufficient data were not available for the RT 83 CSSC and Lockport monitoring stations to determine compliance with the seven day average standard. However, the three days of DO concentration data collected at the RT 83 CSSC monitoring station all had a daily minimum greater than 4.0 mg/L, and five out of the six days of DO concentration data collected at the Lockport monitoring station had a daily minimum greater than 4.0 mg/L. There was no DO concentration data available for the 104th Avenue monitoring station during this Event.

Dissolved Oxygen Percent Saturation. DO concentration is often presented as percent saturation, which is dependent on temperature and pressure. The average DO percent saturation achieved at each of the monitoring stations during Event 3 is shown in Table 10. The average DO percent saturation was calculated by dividing the daily average DO concentration at each monitoring station by the daily DO saturation concentration calculated for that monitoring station. The DO saturation concentrations were calculated by the Weiss equation (Weiss, 1970) using the temperature measured at the monitoring station and an atmospheric pressure of 1 atm. The overall Event average DO percent saturation and water temperature of the nine monitoring stations were 68 percent and 24°C, respectively. The Weiss equation is provided in Appendix AII.

Dissolved Oxygen Concentrations along the River. Figure 5 shows the DO data spatially by river mile. The Lockport Powerhouse, located at the Corps' River Mile 291 is shown on the x-axis at 0 and SEPA 1, located at the Corps' River Mile 328.1, is shown 37.1 miles upstream. Figure 5 also includes the estimated event average DO concentrations of the SEPA station effluents, which were assumed to be equal to the DO saturation concentration. The SEPA Station DO saturation concentration was calculated using the Weiss equation at the daily average upstream temperature and 1 atm. DO data collected for the RT 83 CSSC monitoring station were not included for clarity as it is upstream of SEPA 5 on the CSSC.

Factors Affecting Dissolved Oxygen Concentration in Testing Streams. Factors that can affect DO concentrations were obtained for the Event 3 time period. A summary of these factors for the CSC is shown in Table 11. There was minimal rainfall, no CSO occurrences, and significant discretionary diversion during this Event.

Event 4—September 22, 2008 to October 3, 2008

Dissolved Oxygen Concentrations and Compliance with Proposed Standards. The minimum, maximum, and mean DO concentration data collected during Event 4 for each monitoring station is shown in Table 12 along with the applicable proposed standard and the percent of DO values above that standard. All DO concentrations measured at nine monitoring stations met the proposed "anytime" standard of 3.5 mg/L 100 percent of the time.

FIGURE 5: DISSOLVED OXYGEN CONCENTRATION DATA VERSUS RIVER MILE FOR EVENT 3

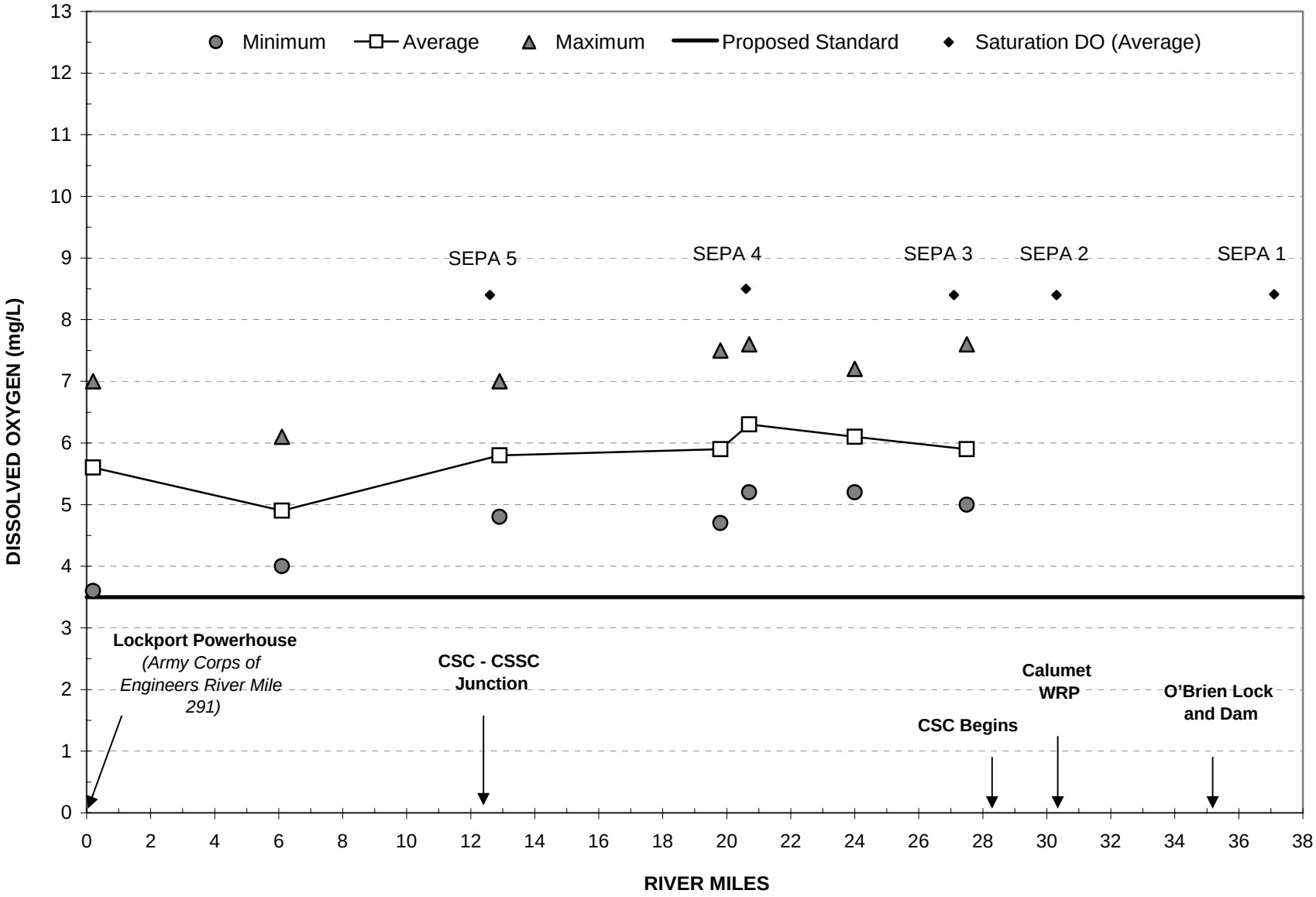


TABLE 11: SUMMARY OF FACTORS INFLUENCING DISSOLVED OXYGEN IN THE CALUMET-SAG CHANNEL DURING EVENT 3

Parameter	Min.	Max.	Mean	Event Total	Notes
Flow into CSC[1] (MGD)	423	765	640	7,682 (MG)	—
Lake Inflow[2] (MGD)	215	499	419	5,026 (MG)	4,596 MG of discretionary diversion
Daily Rainfall[3] (inches)	0	0.05	0.01	0.09	—
CSO[4] (MG)	0	0	0	0	No CSO directly into CSC
Temperature (°C)	23.3	24.6	23.9	—	—
SEPA 1 Pumps (#)	0	1	—	—	1 pump operating for 2 out of 12 days
SEPA 2 Pumps (#)	1	1	—	—	1 pump operating for duration of event
SEPA 3 Pumps (#)	2	2	—	—	2 pumps operating for duration of event
SEPA 4 Pumps (#)	2	2	—	—	2 pumps operating for duration of event
SEPA 5 Pumps (#)	2	3	—	—	3 pump operating for 5 out of 22 days

[1]All flow entering the CSC including flow from Lake Michigan.
[2]All flow from Lake Michigan: navigational make-up, lockages, leakage and discretionary.
[3]Equal to the largest rainfall recorded by one of three rain gauges.
[4]Estimated discharged volume.

TABLE 12: DISSOLVED OXYGEN CONCENTRATIONS IN THE CALUMET-SAG CHANNEL AND THE CHICAGO SANITARY AND SHIP CANAL DURING EVENT 4 (SEPTEMBER 22, 2008, TO OCTOBER 3, 2008)

Monitoring Station Location	Waterway	Proposed IPCB Standard (mg/L)	Number of DO Values	DO Concentration[1] (mg/L)			Percent DO Values Above Standard	Average DO Percent Saturation[2]
				Min.	Max.	Mean		
Division St.	Calumet-Sag Channel	3.5	288	4.3	6.1	5.2	100.0	57.6
Cicero Ave.	Calumet-Sag Channel	3.5	288	3.6	6.0	5.1	100.0	57.1
River Mile 311.7	Calumet-Sag Channel	3.5	288	4.2	6.1	5.2	100.0	58.1
Southwest Hwy.	Calumet-Sag Channel	3.5	288	6.0	6.3	5.0	100.0	55.0
104th Ave.	Calumet-Sag Channel	3.5	61	5.4	6.4	6.0	100.0	63.1
Route 83	Calumet-Sag Channel	3.5	120	4.8	6.1	5.3	100.0	57.4
Route 83	Chicago Sanitary and Ship Canal	3.5	62	5.8	6.2	6.0	100.0	66.5
Romeoville Rd.	Chicago Sanitary and Ship Canal	3.5	288	4.4	6.1	5.3	100.0	59.9
Lockport	Chicago Sanitary and Ship Canal	3.5	288	4.3	6.0	5.3	100.0	62.9

[1]Dissolved oxygen was measured hourly using a YSI model 6920 or model 6600 continuous water quality monitor.
[2]Average of daily mean percent saturations during event.

DO concentrations measured at all the monitoring stations also had to meet the proposed standard of 4.0 mg/L as a daily minimum averaged over seven days. DO concentrations measured at six of the nine monitoring stations met the 4.0 mg/L standard. Sufficient DO concentration data was not available to determine compliance with the 4.0 mg/L proposed standard for the 104th Avenue, RT 83 CSC and RT 83 CSSC monitoring stations. For the 104th Avenue and RT 83 CSSC monitoring stations, there was three days of DO concentration data available, and all three days had daily minimums greater than 4.0 mg/L. For the RT 83 CSC monitoring station, there was six days of DO concentration data available, and the daily minimum was greater than 4.0 mg/L on all of these days. Based on the data available, it is most likely that the proposed standard of 4.0 mg/L as a daily minimum averaged over seven days would have been met at all the monitoring stations during Event 4.

Dissolved Oxygen Percent Saturation. The average percent saturation of DO at each of the monitoring stations during Event 4 is listed in Table 12. The percent saturation was calculated by dividing the daily average DO concentration at each monitoring station by the calculated DO saturation concentration at that monitoring station. The DO saturation concentration was calculated using the Weiss equation (Weiss, 1970) at the measured temperature and an atmospheric pressure of 1 atm. The overall Event average percent saturation and water temperature of the nine monitoring stations were 60 percent and 20°C, respectively. The Weiss equation is provided in Appendix AII.

Dissolved Oxygen Concentrations along the River. Figure 6 shows the DO data spatially by river mile. The Lockport Powerhouse, located at the Corps' River Mile 291 is shown on the x-axis at 0 and SEPA 1, located at the Corps' River Mile 328.1, is shown 37.1 miles upstream. Figure 6 also shows the estimated DO concentrations leaving the SEPA stations, assumed to be equal to the saturation concentration, which was calculated using the Weiss equation, upstream temperature and 1 atm pressure. DO data for the RT 83 CSSC monitoring station were not included for clarity as it is located upstream of SEPA 5 on the CSSC.

Factors Affecting Dissolved Oxygen Concentrations in Testing Streams. Factors that can affect the DO concentrations were collected for the Event 4 time period. A summary of these factors for the CSC is provided in Table 13. There was minimal rainfall, no CSO occurrences, and significant discretionary Lake Michigan diversion. In addition, unlike the other Events, no pumps were operated at SEPA 3 due to maintenance requirements at the station.

Dissolved Oxygen Mass Balance along the Calumet River System

A simple DO mass calculation was performed for the Calumet River System. For each Event, three mass balances were conducted: an Event average, a wet weather and a dry weather mass balance. Three mass balances were completed for Events 1 and 2 where there were distinct wet and dry weather periods. Only one mass balance, the Event average, was completed for Events 3 and 4, which can be considered dry weather mass balances as there was little precipitation during these Events.

FIGURE 6: DISSOLVED OXYGEN CONCENTRATION DATA VERSUS RIVER MILE FOR EVENT 4

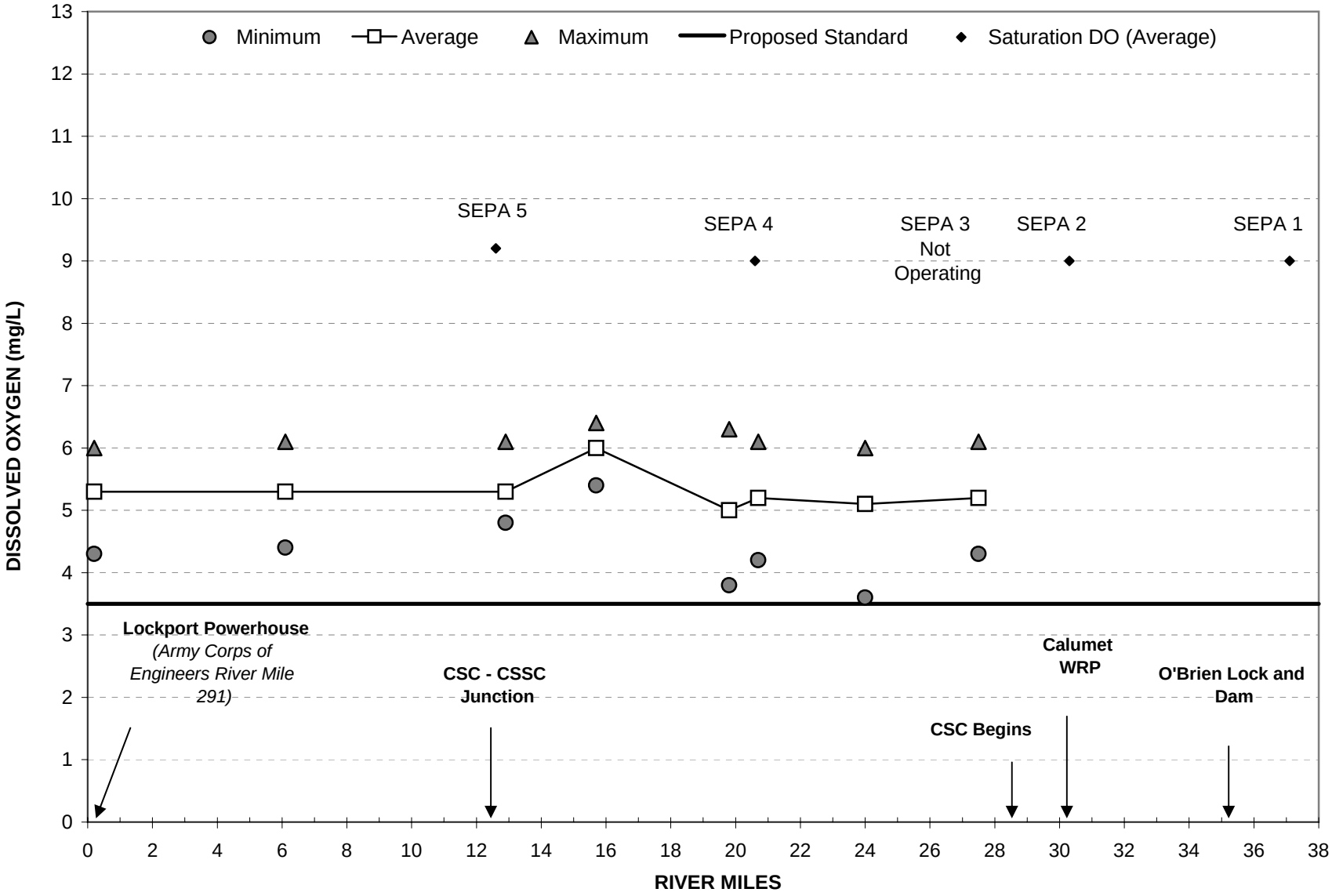


TABLE 13: SUMMARY OF FACTORS INFLUENCING DISSOLVED OXYGEN IN THE CALUMET-SAG CHANNEL DURING EVENT 4

Factors	Min.	Max.	Mean	Event Total	Notes
Flow into CSC[1] (MGD)	672	1,106	876	10,511 (MG)	—
Lake Inflow[2] (MGD)	81	616	292	3,499 (MG)	3,288 MG of discretionary diversion
Daily Rainfall[3] (inches)	0	0.06	0.01	0.06	—
CSO[4] (MG)	0	0	0	0	No CSO directly into CSC
Temperature (°C)	18.1	21.4	20.4	—	—
SEPA 1 Pumps (#)	1	1	—	—	1 pump operating for duration of event
SEPA 2 Pumps (#)	1	1	—	—	1 pump operating for duration of event
SEPA 3 Pumps (#)	0	0	—	—	Station offline for maintenance
SEPA 4 Pumps (#)	2	3	—	—	3 pumps operating for 11 out of 12 days
SEPA 5 Pumps (#)	3	3	—	—	3 pump operating for duration of event

[1]All flow entering the CSC including flow from Lake Michigan.
[2]All flow from Lake Michigan: navigational make-up, lockages, leakage and discretionary.
[3]Equal to the largest rainfall recorded by one of three rain gauges.
[4]Estimated discharged volume.

The DO mass was calculated using the following equation:

$$DO_M \text{ (ton/day)} = [DO_C \text{ (mg/L)} \times 8.34 \times Q \text{ (MGD)}] \div 2200 \text{ lbs/ton}$$

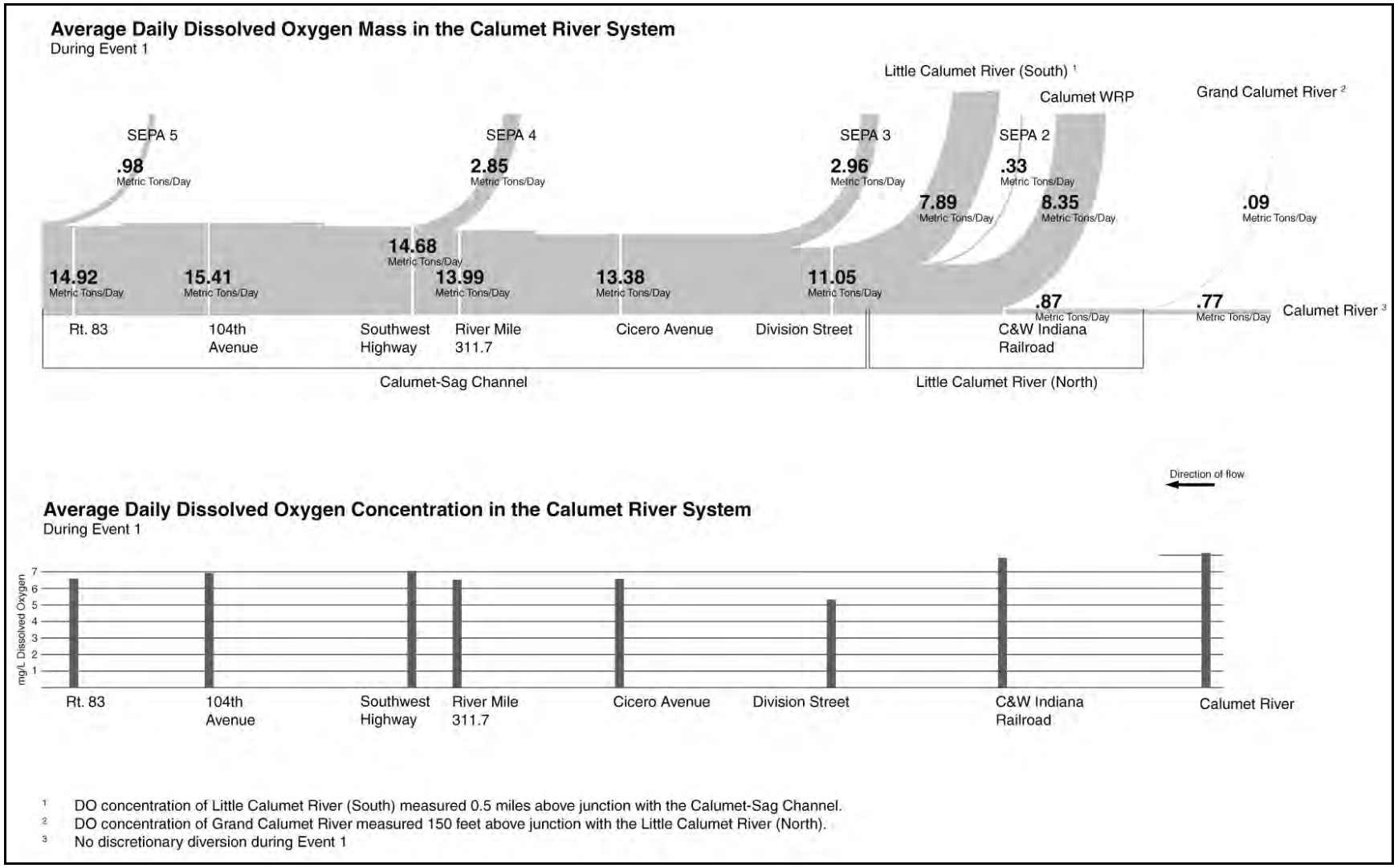
where DO_M is the DO mass in metric tons per day; DO_C is the average DO concentration measured at a particular location; 8.34 is a unit conversion factor; and Q is the estimated flow at that location. The DO concentrations used in the calculation were from monitoring stations utilized in this study and the Torrence Avenue, C&W Indiana Railroad and Ashland Avenue monitoring stations from the CDOM program, which are located on the Grand Calumet River, the Little Calumet River (North), and the Little Calumet River (South), respectively. The flow data used were those shown in Table AIII-1 of Appendix AIII. In addition to the rivers and WRP, there are also a few creeks that flow into the CSC. Additional flow data for these minor creek flows were obtained and used in the DO mass calculations. Flow data for the Midlothian and Tinley Creeks were obtained from USGS flow gauges and the Midlothian Creek flow was multiplied by factors provided in Technical Report #18 (Marquette, 2006) to obtain estimated flows for four other creeks: Navajo, Stony East, Mill and Stony West Creeks. The DO mass was calculated for each day using daily average DO concentration and flow data. These daily values were then averaged to obtain an Event, dry weather and wet weather average.

A visual representation of the Event 1 Average DO mass and DO concentration results is shown in Figure 7. The DO mass calculated for each monitoring station was based on the average daily DO concentration and flow at that monitoring station and is not representative of any location other than that monitoring station. The Division Street DO mass does not equal the sum of all upstream DO mass due to the possibility of DO demand between locations. There is also some distance between the Division Street monitoring station and actual locations where upstream DO concentrations were measured. Along the Calumet-Sag Channel, the upstream monitoring station DO mass and the estimated SEPA station DO load do not necessarily add up to the downstream monitoring station DO mass. This can be due to a number of reasons, including the presence of a DO demand and the possibility that the downstream monitoring station is located where mixing of the SEPA DO saturated side stream and the main channel flow is not complete. Also, the DO load supplied by the SEPA stations was estimated based on the DO concentration measured at the upstream monitoring station, and it was assumed that the DO concentration leaving the SEPA station is at saturation. The actual DO load can be less than estimated if concentrations leaving the SEPA stations are less than saturated, or if DO concentrations entering the SEPA stations are higher due to dispersion of high DO concentrated water upstream of the SEPA station effluent.

The results of the DO calculations for various locations for all four events are provided in Table 14. Table 15 contains the estimated DO loads added to the system by the SEPA stations. Based on the DO mass calculations, the following observations were made of the rivers and the WRP feeding the CSC:

1. The Calumet River can be a large source of DO mass if there is discretionary diversion from Lake Michigan. During Event 1, when there was no discretionary diversion, the average DO mass in the Calumet River was 0.77 metric

FIGURE 7: DISSOLVED OXYGEN MASS IN THE CALUMET RIVER SYSTEM DURING EVENT 1 AVERAGE



1 DO concentration of Little Calumet River (South) measured 0.5 miles above junction with the Calumet-Sag Channel.
2 DO concentration of Grand Calumet River measured 150 feet above junction with the Little Calumet River (North).
3 No discretionary diversion during Event 1

TABLE 14: CALCULATION RESULTS OF DISSOLVED OXYGEN MASS IN METRIC TONS PER DAY FOR EVENTS 1 THROUGH 4

Location	Description	Event 1			Event 2			Event 3	Event 4
		Avg.	Dry	Wet	Avg.	Dry	Wet	Avg./Dry	Avg./Dry
Calumet River	Flow from Lake Michigan and Lake Calumet; Controlled by the O'Brien Lock and Dam	0.77	0.61	1.22	ND	ND	ND	11.21	ND
Grand Calumet River	Flow from Indiana; Upstream of Little Calumet River (North)	0.09	0.07	0.13	ND	ND	ND	0.04	ND
C&W Indiana RR	CDOM Monitoring Station on Little Calumet River (North); Upstream of Calumet WRP	0.87	0.69	1.35	7.22	8.82	4.90	11.24	5.10
Calumet WRP	Located on Little Calumet River (North); Upstream of SEPA 2	8.35	7.48	12.04	5.91	5.08	7.10	5.03	3.78
Little Calumet (South)	Flow from South Holland	7.89	2.68	14.40	0.76	0.35	1.35	0.57	3.78
Division St	Monitoring Station Upstream of SEPA 3; Downstream of CSC-Little Calumet Junction	11.05	8.44	22.10	12.20	12.40	11.90	14.29	16.73
Cicero Ave.	Located on CSC; Downstream of SEPA 3	13.38	10.41	26.02	14.31	14.39	14.19	14.76	16.69
RM 311.7	Located on CSC; Upstream of SEPA 4	13.99	10.68	28.05	15.00	15.25	14.65	15.11	17.02
Southwest Hwy	Located on CSC; Downstream of SEPA 4	14.68	11.60	27.65	14.22	14.31	14.09	14.27	16.10
104th Avenue	Located on CSC; Downstream of SEPA 4	15.41	11.68	31.30	14.85	14.48	15.47	ND	ND
RT 83 CSC	Located on CSC: Upstream of SEPA 5	14.92	11.17	30.86	14.12	14.39	13.52	14.08	16.41

ND: No data available for event period.

TABLE 15: ESTIMATED DISSOLVED OXYGEN IN METRIC TONS PER DAY ADDED BY SIDESTREAM ELEVATED POOL AERATION STATIONS DURING EVENTS 1 THROUGH 4

Location	Description	Event 1			Event 2			Event 3	Event 4
		Avg.	Dry	Wet	Avg.	Dry	Wet	Avg./Dry	Avg./Dry
SEPA 2	Located on Little Calumet River (North); Upstream of Little Calumet River and CSC junction	0.33	0.32	0.36	0.15	0.16	0.14	0.25	0.30
SEPA 3	Located on CSC	2.96	3.02	2.71	2.41	2.33	2.53	1.53	0.00
SEPA 4	Located on CSC	2.85	2.81	3.08	1.05	0.80	1.43	1.28	3.22
SEPA 5	Located on the CSC	1.23	1.23	1.05	2.10	2.10	2.10	2.13	3.34

tons per day (ton/day) compared to 11.21 ton/day during Event 3 when there was about 4,596 MG of discretionary diversion.

2. The Grand Calumet River did not appear to be a significant source of DO mass due to low flow, which ranged on average from 2.4 to 16.6 MGD.

3. The Calumet WRP was a significant source of DO mass. The average DO mass in the Calumet WRP effluent during an Event ranged from 3.78 to 8.35 ton/day.

4. The Little Calumet River (South) was only a significant source of DO during the Event 1 wet weather when flows were significantly higher than during the other Events. The average DO mass in the Little Calumet River (South) ranged from 0.35 to 3.78 ton/day not including the Event 1 wet weather or Event 1 average.

Figure 8 shows the DO mass at the monitoring stations in the CSC during all four Events. In general, the results for the CSC locations were relatively similar (within ±2 ton/day) except for the Event 1 wet weather, Event 1 dry weather and the Event 4 results. During Event 1 wet weather, the mass of DO in some locations was more than double those calculated for the other events. The reason for the larger DO mass during Event 1 wet weather was the higher DO concentrations and significantly larger flows, up to 550 MGD more, than other Events. During Event 1 dry weather, the mass of DO in the CSC was the lowest. This was the result of the lowest flows occurring during this time. The DO mass calculated for Event 4 was slightly higher than the other events, except for Event 1 wet weather, due to an increase in flow during this time. The flow during Event 4 was about 72 MGD less than during Event 1 wet weather, but Event 4 experienced much lower DO concentrations than Event 1 wet weather.

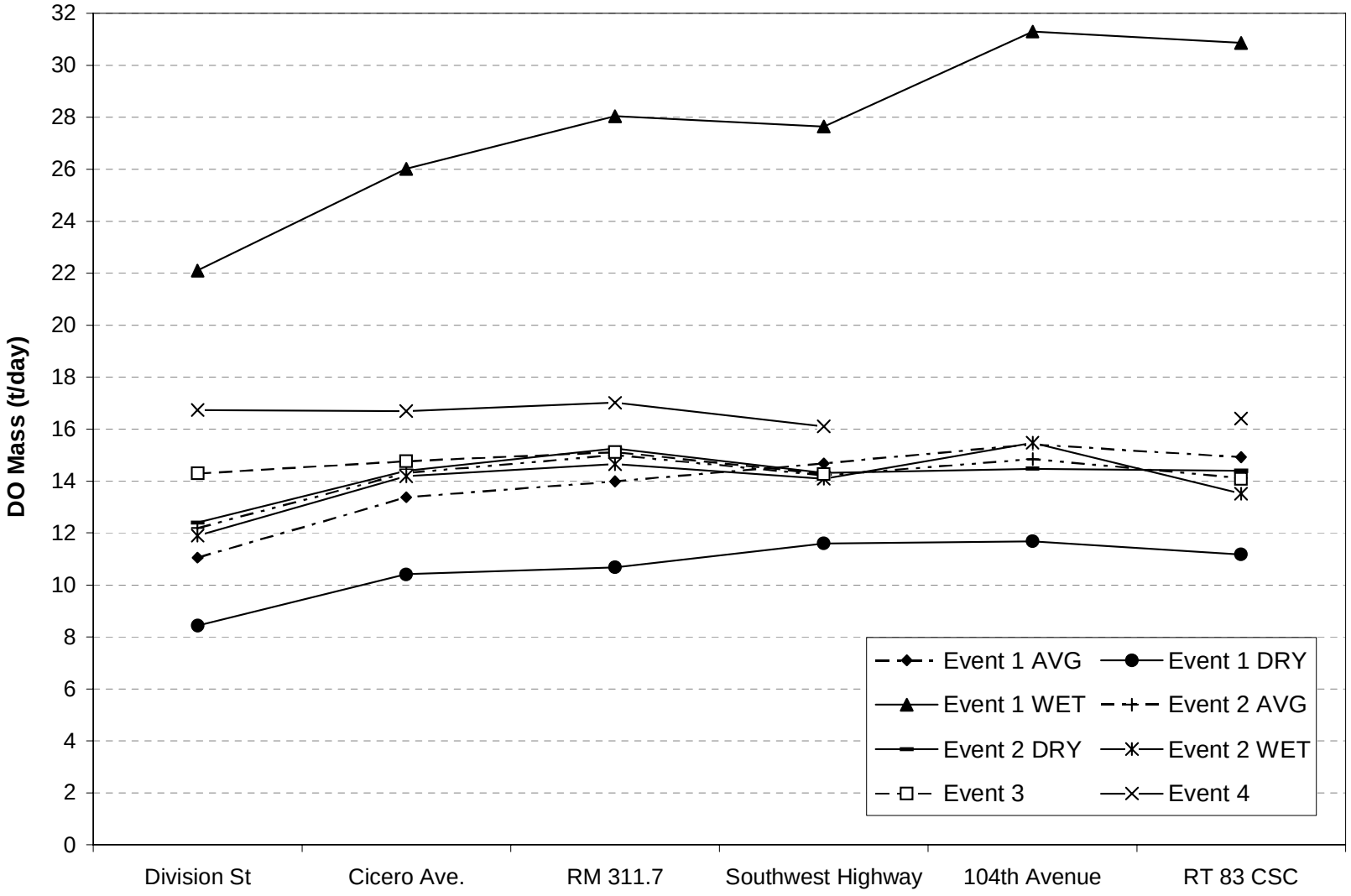
When examining the Event wet weather, dry weather and average DO mass at the monitoring stations down the CSC, the following was observed:

1. In general, the DO mass increased from the Division Street to the Cicero Avenue monitoring stations, which shows that SEPA 3, located between these two stations, had a positive effect on DO in the CSC. This increase ranged from 0.5 to 3.9 ton/day, except for Event 4 when there was a 0.04 ton/day decrease.

2. The DO mass continued to increase from the Cicero Avenue to RM 311.7 monitoring stations. This increased ranged from 0.46 to 2.03 ton/day.

3. The DO mass generally decreased from the RM 311.7 to the Southwest Highway monitoring stations. This decrease ranged from 0.4 to 0.94 ton/day, except for the Event 1 average and dry weather when there was a 0.69 and 0.92 ton/day increase, respectively. The decrease in DO mass did not correspond to the estimated amount of DO added by SEPA 4, which is located between these two monitoring stations. It is possible that the location of the monitoring station is in an area where the mixing of DO-saturated flow from SEPA 4

FIGURE 8: DISSOLVED OXYGEN MASS AT MONITORING STATIONS IN THE CALUMET-SAG CHANNEL DURING EVENTS 1 THROUGH 4



and the main channel flow is not complete. In addition, it was observed that for Event 1 average and dry weather, where an increase in DO mass was observed between RM 311.7 and the Southwest Highway monitoring stations, the average ratio of SEPA sidstream flow to the main channel flow was 0.44 and 0.53, respectively, while the average ratio ranged from 0.17 to 0.35 for the remaining events, during which a decrease in DO mass was observed. It is possible that low SEPA 4 sidestream flow may contribute to the incomplete mixing at the location of the Southwest Highway monitoring station.

4. The DO mass generally increased between the Southwest Highway and 104th Avenue monitoring stations. This increase ranged from 0.08 to 3.65 ton/day. This increase was likely due to better mixing of the SEPA 4 effluent and the main channel flow further downstream of SEPA 4.

5. DO mass decreased between the 104th Avenue and RT 83 CSC monitoring stations. This decrease ranged from 0.09 to 1.95 ton/day. This decrease is likely due to DO consumption and minimal surface reaeration.

Estimated Oxygen Transferred, Energy Used, and Carbon Dioxide, Nitrogen Oxides, and Sulfur Dioxide Emissions due to Energy Consumption

Typically, operation of the SEPA stations requires the use of one pump at each station to meet current DO standards. To meet the proposed standards 100 percent of the time in the CSC, the number of pumps in operation will increase. Operating additional pumps requires more energy, and there is an economic and environmental cost associated with this energy use.

For each Event, the number of additional pumps operated at SEPAs 3 and 4 was determined using one pump in operation at each SEPA station as a basis. Each pump operating in addition to the one pump was considered an additional pump, with the exception of Event 4. During Event 4, no pumps were operated at SEPA 3 due to required maintenance. To account for this, three pumps were operated at SEPA 4. Only one pump was considered an additional pump for this Event as it was assumed that one of the pumps operated at SEPA 4 was to account for no pumps operating at SEPA 3. The amount of O_2 transferred by the additional pumps, the energy used and the estimated carbon dioxide (CO_2), nitrogen oxides (NO_X), and sulfur dioxide (SO_2) produced were determined for each Event and are shown in Table 16.

The amount of O_2 transferred was calculated daily using the daily average DO concentrations measured upstream of the SEPA station; the DO concentration of the SEPA station effluent which was assumed to be the DO saturation concentration at the upstream temperature and 1 atm pressure; and the flow rate through the SEPA station. The electricity usage was determined based on the pumps' power requirements. The CO_2, NO_X, and SO_2 produced were calculated based on the Environmental Disclosure of the District's electricity supplier. Examples of these calculations can be found in Appendix AVI.

TABLE 16: ESTIMATED OXYGEN TRANSFERRED, ELECTRICITY USED, AND CARBON DIOXIDE, NITROGEN OXIDES, AND SULFUR DIOXIDE EMITTED EACH DAY DUE TO OPERATION OF ADDITIONAL PUMPS AT SIDESTREAM ELEVATED POOL AERATION STATIONS 3 AND 4 DURING THE EVENTS

Additional Pumps Operated at SEPAs 3 and 4	Estimated O_2 Transferred metric ton/day	Electricity Usage		Estimated Emissions[2]		
		MWh/day	No. of Homes per Day Electricity Can Power[1]	CO_2 metric ton/day	NO_X metric ton/day	SO_2 metric ton/day
Event 1: 3 Additional Pumps	3.6	21.5	717	11.9	0.019	0.069
Event 2: 4 Additional Pumps	2.6	28.6	953	15.8	0.026	0.091
Event 3: 2 Additional Pumps	1.4	14.3	477	7.9	0.013	0.046
Event 4: 1 Additional Pump	1.1	7.2	240	4.0	0.007	0.023

[1]Based on national average household energy use of 11,000 kWh per year as reported by the United States Department of Energy's Energy Information Administration in the 2005 Residential Energy Consumption Survey.
[2]Based on the Environmental Disclosure of Integrys Energy Services, Inc.

In general, as the number of pumps operating increased, the amount of O_2 transferred, electricity used and emissions increased. However, when comparing Event 1 and Event 2, Event 2 used more pumps resulting in greater electricity use and emissions, yet there was less O_2 transfer. This is due to water temperature and its effect on DO. The water temperature during Event 2 was approximately 11°C warmer than during Event 1. As temperature increases, the amount of O_2 that can dissolve into water decreases therefore, making it more difficult for O_2 to dissolve in water and essentially decreasing the efficiency of the SEPA stations.

Study Summary

Table 17 provides a summary of all four Events for comparison purposes.

The proposed "anytime" standard of 3.5 mg/L was met 100 percent of the time in the CSC during Events 3 and 4, while the proposed "anytime" standard of 5.0 mg/L was not met 100 percent of the time during Events 1 and 2.

Comparing Events 1 and 2, when the proposed 5.0 mg/L "anytime" standard applied, there was less compliance during Event 2 than Event 1. However, during Event 2 a higher DO percent saturation was achieved, a greater amount of water was diverted from Lake Michigan, no CSO was discharged directly into the CSC, and a greater number of pumps were in operation at the SEPA stations. The major difference between the Events 1 and 2 was the change in water temperature. The average water temperature during Event 2 was 11°C higher than Event 1, which makes O_2 transfer much less efficient at the SEPA stations and compliance with the proposed DO standards more difficult using the existing SEPA stations.

TABLE 17: SUMMARY OF EVENTS 1 THROUGH 4

Parameter	Event 1 (5/1–5/21)	Event 2 (7/22–7/31)	Event 3 (8/11–8/22)	Event 4 (9/22–10/3)
Proposed "Anytime" Standard (mg/L)	5.0	5.0	3.5	3.5
Average Percent DO Values Above Proposed "Anytime" Standard (%)	96	90	100	100
Average DO Percent Saturation (%)	63	71	68	60
Average Temperature (°C)	15	26	25	20
Average Flow into CSC (MGD)	507	579	640	876
Average Lake Michigan Diversion (MGD)	26	280	419	292
Total Rainfall (inches)	3.03	3.14	0.09	0.06
CSO directly into CSC	Yes	No	No	No
Average O_2 Added by SEPAs 3 and 4 (metric ton/day)	5.8	3.5	2.8	3.2
Total Additional Pumps Operated at SEPAs 3 and 4 to Meet Proposed Standards	3	4	2	1
Avg. O_2 Transferred by Additional Pumps (metric tons/day)	3.6	2.6	1.4	1.1
Electricity Used by Additional Pumps (MWh/day)	21.5	28.6	14.3	7.2
CO_2 Produced by Additional Pumps (metric tons/day)	11.9	15.8	7.9	4.0

CONCLUSIONS

The study was conducted to determine whether or not SEPA station operation would allow the CSC to meet the more stringent water quality standards that were proposed by IEPA to the Illinois Pollution Control Board on October 26, 2007. Four Events were chosen at various times between the spring and fall of 2008 to study the effects of SEPA operation on meeting the proposed standards.

The conclusions of the study on SEPA station operation to meet proposed water quality standards are:

1. Of the four Events, the proposed "anytime" standards were not met 100 percent of the time during Events 1 and 2 when the more stringent proposed standard of 5.0 mg/L would be applicable for the CSC. The proposed standard of 4.0 mg/L as a daily minimum averaged over seven days was not met at monitoring stations located on the CSSC during Event 2. The lowest percent compliance with all proposed standards was observed during Event 2 of the study.

2. This study, specifically Event 2, demonstrated that in certain situations, the operation of existing SEPA stations alone will not provide enough supplemental DO so that the proposed standards are met 100 percent of the time. During part of Event 2, the maximum practical number of pumps were in operation at SEPAs 3 and 4 and DO values at monitoring stations downstream of these stations were still below the proposed standards.

3. Factors that can affect DO concentrations were collected for the CSC and CSSC. These factors included river and WRP effluent flows into the CSC, CSO events, precipitation and temperature. Temperature greatly affects the amount of DO that SEPA stations can transfer to the water and ultimately impacts SEPA efficiency. It was also observed that the majority of DO values less than the proposed standards at monitoring stations between SEPAs 3 and 5 occurred during or immediately following a significant rain event.

4. Operating pumps at the SEPA stations requires a significant amount of electricity and this electricity consumption has an associated economic and environmental cost. For each additional pump operated at SEPAs 3 and 4 for one day, 7.2 MWh of electricity is used and 4.0 metric tons of CO_2 is emitted due to the additional energy consumption. The amount of DO transferred by pumps operated in addition to the typical one pump at SEPAs 3 and 4 ranged between 1.1 and 3.6 metric tons per day. Increasing the number of pumps in operation will not necessarily result in greater O_2 transfer, as was shown in the comparison of Events 1 and 2, in which increasing temperature resulted in essentially a decrease in SEPA station efficiency.

5. A simple DO mass calculation was conducted for the Calumet River System including the CSC. The most significant sources of DO entering the CSC were the Calumet WRP effluent and the Calumet River during use of discretionary diversion. An increase in O_2 concentration was observed between the Division Street and Cicero Avenue monitoring stations as expected due to the operation of SEPA 3. However, an increase in DO concentration was not detected immediately downstream of SEPA 4 at the Southwest Highway monitoring station. This is possibly due to the monitoring station being located where mixing of the DO-saturated flow from SEPA 4 and the main channel flow is not complete, particularly when the ratio of SEPA 4 sidestream flow to the main channel flow is small. There may be are other factors that can cause undetectable DO mass increase immediately downstream of SEPA 4; therefore, further study would be required to determine the actual cause.

REFERENCES

1. Illinois State Water Survey. "Effects of Sidestream Elevated Pool Aeration (SEPA) Stations on Instream Dissolved Oxygen." 2000.

2. Energy Information Administration, United States Department of Energy. "2005 Residential Energy Consumption Survey." 2005.

3. Integrys Energy Services Inc. "Environmental Disclosure." 2008.

4. Institute for Urban Environmental Risk Management Marquette University. Technical Report #18. "Calibration of a Model for Simulation of Water Quality During Unsteady Flow in the Chicago Waterway System and Application to Evaluate Use Attainability Analysis Remedial Actions." February, 2006.

5. Weiss, R.F. "The solubility of nitrogen, oxygen and argon in water and seawater." Deep-Sea Research. Pergamon Press. Vol. 17, pp. 721 to 735. 1970.

6. USGS. Quality of Water Branch Technical Memorandum No. 81.11 (Subject: Water Quality—New tables of dissolved oxygen saturation values). May 8, 1981.

APPENDIX AI: DISSOLVED OXYGEN CONCENTRATIONS AT MONITORING STATIONS

TABLE AI-1: DAILY DISSOLVED OXYGEN AND TEMPERATURE DATA FOR THE DIVISION MONITORING STATION DURING ALL FOUR EVENTS

Date	Dissolved O_2 (mg/L) Minimum	Maximum	Mean	Temperature (°C) Mean
		Event 1		
5/1/2008	5.51	7.41	6.40	12.1
5/2/2008	4.91	6.39	5.63	13.8
5/3/2008	4.39	5.69	5.09	14.4
5/4/2008	4.28	5.83	5.02	13.7
5/5/2008	4.51	5.86	5.22	14.3
5/6/2008	3.85	5.87	4.62	15.5
5/7/2008	3.34	4.59	3.91	16.2
5/8/2008	3.67	5.29	4.22	15.5
5/9/2008	3.41	5.12	4.18	14.7
5/10/2008	3.72	5.37	4.44	14.5
5/11/2008	4.08	7.65	5.84	13.7
5/12/2008	5.68	7.02	6.16	12.5
5/13/2008	5.36	6.62	6.18	13.6
5/14/2008	5.07	6.56	5.89	14.7
5/15/2008	5.48	6.01	5.83	14.2
5/16/2008	5.59	6.42	5.98	14.0
5/17/2008	5.85	6.46	6.15	15.2
5/18/2008	5.45	6.20	5.88	15.5
5/19/2008	4.69	5.69	5.17	15.0
5/20/2008	5.11	6.96	5.77	14.9
5/21/2008	5.46	7.01	6.26	15.1
		Event 2		
7/10/2008	5.11	8.46	6.66	23.9
7/11/2008	4.41	7.17	5.80	23.1
7/12/2008	4.36	7.03	5.81	23.7
7/13/2008	4.88	6.54	5.71	23.1
7/14/2008	5.08	8.58	6.00	23.3
7/15/2008	4.67	6.61	5.70	23.7
7/16/2008	4.72	6.91	5.61	24.3
7/17/2008	4.66	8.06	6.09	25.1
7/18/2008	4.66	6.82	5.43	25.2
7/19/2008	3.87	5.60	4.59	24.5
7/20/2008	3.19	4.53	3.91	23.7
7/21/2008	3.84	6.28	4.65	24.1

TABLE AI-1 (Continued): DAILY DISSOLVED OXYGEN AND TEMPERATURE DATA FOR THE DIVISION MONITORING STATION DURING ALL FOUR EVENTS

Date	Dissolved O_2 (mg/L)			Temperature (°C)
	Minimum	Maximum	Mean	Mean
7/22/2008	4.18	5.82	4.95	24.0
7/23/2008	4.66	6.76	5.52	24.0
7/24/2008	5.50	7.61	6.22	24.2
7/25/2008	5.14	6.90	5.97	24.2
7/26/2008	5.33	7.23	6.16	24.6
7/27/2008	5.29	6.43	5.92	24.3
7/28/2008	4.72	6.19	5.49	24.4
7/29/2008	5.01	6.62	5.81	24.8
7/30/2008	5.02	6.80	5.90	24.9
7/31/2008	5.23	6.40	5.86	24.9
Event 3				
8/11/2008	5.21	6.53	5.68	23.4
8/12/2008	5.20	6.20	5.67	23.6
8/13/2008	5.00	6.31	5.55	23.6
8/14/2008	5.35	6.40	5.76	23.6
8/15/2008	5.52	6.81	6.02	23.7
8/16/2008	5.64	6.50	5.90	23.7
8/17/2008	5.21	6.64	5.91	23.8
8/18/2008	5.40	6.58	5.99	24.0
8/19/2008	5.36	6.79	6.02	24.2
8/20/2008	5.30	7.57	6.22	24.4
8/21/2008	5.89	7.16	6.34	24.3
8/22/2008	5.44	7.21	6.20	24.4
Event 4				
9/22/2008	4.56	5.16	4.77	20.5
9/23/2008	4.28	5.18	4.69	20.7
9/24/2008	4.34	6.10	4.90	21.0
9/25/2008	4.27	5.48	4.93	21.3
9/26/2008	4.29	5.75	4.96	21.2
9/27/2008	4.64	6.12	5.32	21.2
9/28/2008	5.05	5.97	5.43	21.1
9/29/2008	4.90	5.61	5.27	20.7
9/30/2008	4.82	5.88	5.37	20.2
10/1/2008	5.28	5.83	5.54	19.3

TABLE AI-1 (Continued): DAILY DISSOLVED OXYGEN AND TEMPERATURE DATA FOR THE DIVISION MONITORING STATION DURING ALL FOUR EVENTS

Date	Dissolved O_2 (mg/L)			Temperature (°C)
	Minimum	Maximum	Mean	Mean
10/2/2008	5.20	5.89	5.50	18.7
10/3/2008	5.24	5.79	5.55	18.5

TABLE AI-2: DAILY DISSOLVED OXYGEN AND TEMERATURE DATA FOR THE CICERO AVENUE MONITORING STATION DURING ALL FOUR EVENTS

Date	Dissolved O_2 (mg/L) Minimum	Maximum	Mean	Temperature (°C) Mean
		Event 1		
5/1/2008	7.16	8.41	7.62	12.5
5/2/2008	6.54	7.89	7.43	13.8
5/3/2008	6.08	7.09	6.52	14.8
5/4/2008	5.66	6.47	6.06	14.7
5/5/2008	5.59	7.06	6.16	15.0
5/6/2008	5.52	6.83	6.30	15.8
5/7/2008	5.41	6.73	5.92	16.6
5/8/2008	5.17	5.86	5.55	16.1
5/9/2008	4.56	5.59	5.14	15.2
5/10/2008	5.23	6.71	6.07	14.9
5/11/2008	5.93	7.41	6.68	13.9
5/12/2008	6.61	7.17	6.81	12.9
5/13/2008	6.98	7.41	7.21	13.4
5/14/2008	6.28	7.43	6.91	14.6
5/15/2008	6.45	7.14	6.86	14.5
5/16/2008	6.13	7.29	6.77	14.2
5/17/2008	6.66	7.44	7.01	15.2
5/18/2008	6.18	7.45	6.78	15.6
5/19/2008	5.99	7.25	6.59	15.5
5/20/2008	5.62	6.52	6.14	15.2
5/21/2008	6.05	7.82	6.86	15.1
		Event 2		
7/10/2008	6.24	8.47	7.47	24.2
7/11/2008	5.99	8.23	6.93	23.9
7/12/2008	5.40	7.10	6.33	23.9
7/13/2008	5.42	7.96	6.77	23.7
7/14/2008	5.70	8.58	6.74	23.4
7/15/2008	5.80	9.27	6.93	24.2
7/16/2008	5.44	8.15	6.97	24.6
7/17/2008	5.62	8.04	6.93	25.2
7/18/2008	6.27	7.74	7.04	25.7
7/19/2008	4.83	6.35	5.39	25.2
7/20/2008	3.71	5.18	4.56	24.2
7/21/2008	4.72	5.85	5.13	24.3
7/22/2008	5.23	6.59	5.86	24.4

TABLE AI-2 (Continued): DAILY DISSOLVED OXYGEN AND TEMERATURE DATA FOR THE CICERO AVENUE MONITORING STATION DURING ALL FOUR EVENTS

Date	Dissolved O_2 (mg/L) Minimum	Maximum	Mean	Temperature (°C) Mean
7/23/2008	5.28	7.45	6.18	24.2
7/24/2008	5.76	7.74	6.56	24.2
7/25/2008	6.62	8.06	7.08	24.6
7/26/2008	6.31	7.84	6.98	24.9
7/27/2008	6.00	7.71	6.62	24.7
7/28/2008	5.68	6.86	6.37	24.7
7/29/2008	5.89	7.25	6.50	25.0
7/30/2008	5.91	8.91	7.33	25.3
7/31/2008	7.54	8.72	8.06	25.1
Event 3				
8/11/2008	5.49	5.95	5.70	22.9
8/12/2008	5.43	6.16	5.82	23.3
8/13/2008	5.22	6.05	5.76	23.6
8/14/2008	5.34	6.17	5.83	23.9
8/15/2008	5.48	6.65	6.01	24.0
8/16/2008	5.91	6.38	6.17	24.0
8/17/2008	5.98	6.55	6.27	24.1
8/18/2008	5.82	6.76	6.27	24.2
8/19/2008	5.87	7.04	6.31	24.4
8/20/2008	5.88	7.09	6.41	24.8
8/21/2008	6.36	7.00	6.61	24.5
8/22/2008	6.14	7.17	6.46	24.6
Event 4				
9/22/2008	4.73	5.08	4.89	20.8
9/23/2008	4.88	5.59	5.18	21.1
9/24/2008	4.69	5.04	4.86	21.2
9/25/2008	4.54	5.45	4.96	21.5
9/26/2008	4.63	4.98	4.83	21.4
9/27/2008	4.93	5.58	5.24	21.4
9/28/2008	3.59	5.58	5.07	21.4
9/29/2008	4.36	5.18	4.95	20.8
9/30/2008	4.65	5.12	4.84	20.3
10/1/2008	4.78	5.89	5.35	19.4
10/2/2008	5.22	5.95	5.61	18.7

TABLE AI-2 (Continued): DAILY DISSOLVED OXYGEN AND TEMERATURE DATA FOR THE CICERO AVENUE MONITORING STATION DURING ALL FOUR EVENTS

Date	Dissolved O_2 (mg/L)			Temperature (°C)
	Minimum	Maximum	Mean	Mean
10/3/2008	5.49	5.98	5.71	18.4
10/3/2008	5.49	5.98	5.71	18.4
10/3/2008	5.49	5.98	5.71	18.4

TABLE AI-3: DAILY DISSOLVED OXYGEN AND TEMERATURE DATA FOR THE RIVER MILE 311.7 MONITORING STATION DURING ALL FOUR EVENTS

Date	Dissolved O_2 (mg/L) Minimum	Maximum	Mean	Temperature (°C) Mean
		Event 1		
5/1/2008	6.93	7.40	7.23	10.7
5/2/2008	7.00	7.68	7.31	11.9
5/3/2008	6.18	7.18	6.81	12.8
5/4/2008	6.09	7.31	6.55	13.3
5/5/2008	5.79	6.72	6.13	14.1
5/6/2008	5.12	6.84	6.01	14.7
5/7/2008	5.77	6.40	6.17	15.7
5/8/2008	5.49	5.92	5.71	16.3
5/9/2008	4.75	5.54	5.13	15.7
5/10/2008	5.04	5.48	5.28	15.1
5/11/2008	5.67	7.90	6.92	13.9
5/12/2008	6.44	7.06	6.75	13.0
5/13/2008	6.81	7.40	7.19	13.3
5/14/2008	6.80	7.12	6.95	14.2
5/15/2008	6.69	7.01	6.84	13.8
5/16/2008	6.57	6.98	6.75	14.0
5/17/2008	6.83	7.33	7.03	14.5
5/18/2008	6.89	7.39	7.07	15.1
5/19/2008	6.64	7.73	7.17	15.0
5/20/2008	6.55	7.49	7.04	14.9
5/21/2008	6.32	8.51	6.73	15.3
		Event 2		
7/10/2008	7.57	9.68	8.73	24.3
7/11/2008	6.26	8.47	7.31	24.0
7/12/2008	6.13	7.78	7.24	24.0
7/13/2008	5.88	8.14	6.93	23.9
7/14/2008	6.45	10.08	8.22	23.7
7/15/2008	6.85	10.11	7.95	24.2
7/16/2008	6.73	10.75	8.41	25.0
7/17/2008	6.41	9.65	7.95	25.5
7/18/2008	6.15	8.86	7.75	25.8
7/19/2008	5.05	7.05	5.96	25.6
7/20/2008	4.48	5.95	5.02	24.8
7/21/2008	4.22	5.33	4.71	24.5

TABLE AI-3 (Continued): DAILY DISSOLVED OXYGEN AND TEMERATURE DATA FOR THE RIVER MILE 311.7 MONITORING STATION DURING ALL FOUR EVENTS

Date	Dissolved O_2 (mg/L)			Temperature (°C)
	Minimum	Maximum	Mean	Mean
7/22/2008	4.87	6.79	5.65	24.5
7/23/2008	5.91	7.46	6.55	24.4
7/24/2008	5.92	7.91	6.81	24.5
7/25/2008	6.53	8.83	7.43	24.8
7/26/2008	6.37	7.47	6.98	25.2
7/27/2008	6.33	7.50	6.75	25.1
7/28/2008	6.00	7.22	6.51	25.2
7/29/2008	5.89	7.00	6.44	25.3
7/30/2008	6.18	8.00	6.76	25.6
7/31/2008	6.51	7.54	6.94	25.6
Event 3				
8/11/2008	5.43	6.73	5.84	23.2
8/12/2008	5.51	6.41	5.83	23.5
8/13/2008	5.29	6.70	6.04	23.3
8/14/2008	5.23	6.45	5.90	23.0
8/15/2008	5.53	6.61	5.98	23.0
8/16/2008	5.90	7.01	6.35	23.2
8/17/2008	5.61	6.97	6.34	23.3
8/18/2008	6.04	7.07	6.48	23.4
8/19/2008	6.18	7.20	6.63	23.6
8/20/2008	6.23	7.63	6.68	24.2
8/21/2008	6.30	7.26	6.76	24.5
8/22/2008	5.92	7.59	6.48	24.5
Event 4				
9/22/2008	4.63	5.18	4.98	20.9
9/23/2008	4.81	6.02	5.38	21.2
9/24/2008	4.63	5.45	5.03	21.3
9/25/2008	4.41	5.83	5.02	21.5
9/26/2008	4.23	5.35	4.76	21.5
9/27/2008	4.58	5.90	5.15	21.3
9/28/2008	5.00	5.66	5.28	21.3
9/29/2008	4.89	5.27	5.04	20.7
9/30/2008	4.67	5.49	5.00	20.1
10/1/2008	4.73	5.94	5.37	19.3

TABLE AI-3 (Continued): DAILY DISSOLVED OXYGEN AND TEMERATURE DATA FOR THE RIVER MILE 311.7 MONITORING STATION DURING ALL FOUR EVENTS

Date	Dissolved O_2 (mg/L)			Temperature (°C)
	Minimum	Maximum	Mean	Mean
10/2/2008	5.62	6.14	5.84	18.5
10/3/2008	5.67	6.00	5.82	18.3

TABLE AI-4: DAILY DISSOLVED OXYGEN AND TEMERATURE DATA FOR THE SOUTHWEST HIGHWAY MONITORING STATION DURING ALL FOUR EVENTS

Date	Dissolved O_2 (mg/L) Minimum	Maximum	Mean	Temperature (°C) Mean
		Event 1		
5/1/2008	7.30	9.36	7.97	12.3
5/2/2008	6.75	8.77	7.56	13.3
5/3/2008	6.29	7.80	7.12	14.1
5/4/2008	6.54	7.89	7.25	14.7
5/5/2008	6.58	8.25	7.34	15.8
5/6/2008	6.10	8.06	6.94	16.3
5/7/2008	6.05	7.21	6.64	16.3
5/8/2008	5.51	6.87	6.06	15.9
5/9/2008	5.43	8.48	7.12	15.5
5/10/2008	5.87	7.35	6.84	15.0
5/11/2008	5.27	7.81	6.82	13.5
5/12/2008	6.37	7.35	6.78	12.5
5/13/2008	6.35	6.96	6.61	12.9
5/14/2008	6.14	7.53	6.92	14.2
5/15/2008	6.56	7.61	6.99	14.3
5/16/2008	6.36	7.87	6.93	14.6
5/17/2008	6.13	7.77	6.94	15.1
5/18/2008	6.78	8.60	7.50	15.5
5/19/2008	6.71	8.01	7.36	15.5
5/20/2008	7.26	8.54	7.72	15.6
5/21/2008	7.36	9.04	8.06	15.2
		Event 2		
7/10/2008	6.32	9.01	7.57	24.3
7/11/2008	5.38	7.88	6.45	24.4
7/12/2008	5.83	7.60	6.56	24.4
7/13/2008	5.17	8.25	6.48	24.0
7/14/2008	5.87	8.85	7.22	23.9
7/15/2008	6.41	9.32	7.31	24.3
7/16/2008	6.26	9.73	7.45	25.1
7/17/2008	5.70	9.66	7.45	25.5
7/18/2008	5.79	10.17	7.51	26.0
7/19/2008	5.11	7.78	6.09	25.7
7/20/2008	4.60	6.34	5.31	25.1
7/21/2008	4.19	6.38	5.11	24.7
7/22/2008	5.24	7.27	6.09	24.6

TABLE AI-4 (Continued): DAILY DISSOLVED OXYGEN AND TEMERATURE DATA FOR THE SOUTHWEST HIGHWAY MONITORING STATION DURING ALL FOUR EVENTS

Date	Dissolved O_2 (mg/L)			Temperature (°C)
	Minimum	Maximum	Mean	Mean
7/23/2008	6.47	7.39	6.80	24.3
7/24/2008	6.09	7.73	6.78	24.3
7/25/2008	6.39	7.97	6.95	24.7
7/26/2008	5.77	8.10	6.67	25.0
7/27/2008	6.05	7.96	6.76	24.9
7/28/2008	5.08	7.63	6.19	25.1
7/29/2008	4.82	6.50	5.58	25.1
7/30/2008	4.87	7.45	6.02	25.7
7/31/2008	5.41	6.74	6.18	25.8
Event 3				
8/11/2008	5.38	6.35	5.75	23.2
8/12/2008	5.26	5.89	5.62	23.6
8/13/2008	5.17	6.51	5.79	23.7
8/14/2008	5.30	6.41	5.81	23.8
8/15/2008	4.80	7.47	6.03	23.9
8/16/2008	5.16	7.00	5.93	24.0
8/17/2008	5.31	6.23	5.78	24.2
8/18/2008	4.73	6.80	5.78	24.4
8/19/2008	5.56	6.59	6.19	24.6
8/20/2008	5.79	6.85	6.25	24.7
8/21/2008	5.57	6.46	6.05	24.6
8/22/2008	5.10	7.54	5.92	24.7
Event 4				
9/22/2008	4.13	4.83	4.42	20.9
9/23/2008	4.10	5.32	4.57	21.2
9/24/2008	4.02	4.99	4.48	21.2
9/25/2008	3.83	5.86	4.77	21.3
9/26/2008	4.10	5.38	4.70	21.2
9/27/2008	4.17	5.80	4.83	21.0
9/28/2008	4.75	5.39	5.06	21.0
9/29/2008	4.52	5.09	4.72	20.5
9/30/2008	4.33	5.54	4.99	19.8
10/1/2008	4.70	6.15	5.44	19.0

TABLE AI-4 (Continued): DAILY DISSOLVED OXYGEN AND TEMERATURE DATA FOR THE SOUTHWEST HIGHWAY MONITORING STATION DURING ALL FOUR EVENTS

Date	Dissolved O_2 (mg/L)			Temperature (°C)
	Minimum	Maximum	Mean	Mean
10/2/2008	5.41	6.33	5.92	18.4
10/3/2008	5.21	6.07	5.69	18.1

TABLE AI-5: DAILY DISSOLVED OXYGEN AND TEMERATURE DATA FOR THE 104TH AVENUE MONITORING STATION DURING ALL FOUR EVENTS[1]

Date	Dissolved O_2 (mg/L) Minimum	Maximum	Mean	Temperature (°C) Mean
		Event 1		
5/1/2008	6.84	7.63	7.30	12.7
5/2/2008	7.47	8.23	7.80	13.3
5/3/2008	6.90	7.50	7.21	13.8
5/4/2008	6.71	7.41	7.00	14.0
5/5/2008	6.49	7.15	6.78	15.1
5/6/2008	6.48	7.21	6.85	16.1
5/7/2008	5.91	6.93	6.39	16.7
5/8/2008	6.03	6.69	6.37	16.3
5/9/2008	5.78	6.23	6.05	16.1
5/10/2008	5.56	7.01	6.11	15.8
5/11/2008	6.31	7.70	7.11	14.1
5/12/2008	6.70	7.48	7.05	13.0
5/13/2008	6.72	7.14	6.92	13.6
5/14/2008	6.78	7.13	6.98	14.3
5/15/2008	6.84	7.24	7.06	14.3
5/16/2008	6.85	7.31	7.10	14.4
5/17/2008	6.87	7.40	7.13	15.3
5/18/2008	6.77	7.12	6.96	15.4
5/19/2008	6.89	7.70	7.39	15.4
5/20/2008	6.95	7.45	7.17	15.5
5/21/2008	6.84	8.54	7.71	15.6
		Event 2		
7/10/2008	7.73	9.28	8.29	24.0
7/11/2008	6.24	7.45	6.71	23.7
7/12/2008	5.84	6.89	6.32	24.0
7/13/2008	5.72	7.04	6.37	23.6
7/14/2008	5.28	7.41	6.42	23.6
7/15/2008	6.97	8.20	7.43	23.9
7/16/2008	6.47	8.87	7.64	24.7
7/17/2008	7.77	9.79	8.74	25.6
7/18/2008	7.93	9.81	8.92	25.9
7/19/2008	6.11	8.99	7.55	25.7
7/20/2008	6.02	7.34	6.47	25.1
7/21/2008	5.51	6.76	6.24	24.9

TABLE AI-5 (Continued): DAILY DISSOLVED OXYGEN AND TEMERATURE DATA FOR THE 104TH AVENUE MONITORING STATION DURING ALL FOUR EVENTS[1]

Date	Dissolved O_2 (mg/L) Minimum	Maximum	Mean	Temperature (°C) Mean
7/22/2008	5.28	6.38	5.84	24.6
7/23/2008	5.55	7.54	6.37	24.5
7/24/2008	5.94	7.60	6.74	24.5
7/25/2008	5.89	7.70	6.77	24.6
7/26/2008	6.14	7.85	6.93	25.3
7/27/2008	5.71	7.33	6.52	25.2
7/28/2008	5.34	7.51	6.44	25.4
7/29/2008	5.47	6.78	6.11	25.6
7/30/2008	4.85	6.08	5.38	25.5
7/31/2008	—	—	—	—
Event 3				
8/11/2008	—	—	—	—
8/12/2008	—	—	—	—
8/13/2008	—	—	—	—
8/14/2008	—	—	—	—
8/15/2008	—	—	—	—
8/16/2008	—	—	—	—
8/17/2008	—	—	—	—
8/18/2008	—	—	—	—
8/19/2008	—	—	—	—
8/20/2008	—	—	—	—
8/21/2008	—	—	—	—
8/22/2008	—	—	—	—
Event 4				
9/22/2008	—	—	—	—
9/23/2008	—	—	—	—
9/24/2008	—	—	—	—
9/25/2008	—	—	—	—
9/26/2008	—	—	—	—
9/27/2008	—	—	—	—
9/28/2008	—	—	—	—
9/29/2008	—	—	—	—
9/30/2008	—	—	—	—
10/1/2008	5.43	5.73	5.57	19.1

TABLE AI-5 (Continued): DAILY DISSOLVED OXYGEN AND TEMERATURE DATA FOR THE 104TH AVENUE MONITORING STATION DURING ALL FOUR EVENTS[1]

Date	Dissolved O_2 (mg/L)			Temperature (°C)
	Minimum	Maximum	Mean	Mean
10/2/2008	5.71	6.37	6.06	18.5
10/3/2008	5.82	6.25	6.04	18.2

[1]Data not available for Event 3 and most of Event 4.

TABLE AI-6: DAILY DISSOLVED OXYGEN AND TEMERATURE DATA FOR THE ROUTE 83 CALUMET-SAG CHANNEL MONITORING STATION DURING ALL FOUR EVENTS[1]

Date	Dissolved O_2 (mg/L)			Temperature (°C)
	Minimum	Maximum	Mean	Mean
Event 1				
5/1/2008	5.94	7.00	6.36	12.1
5/2/2008	6.63	7.89	7.43	12.5
5/3/2008	7.08	7.97	7.66	12.7
5/4/2008	7.04	7.73	7.36	12.9
5/5/2008	7.00	7.49	7.20	13.9
5/6/2008	6.64	7.53	7.02	15.0
5/7/2008	6.06	7.57	6.63	16.4
5/8/2008	5.81	6.72	6.29	16.2
5/9/2008	5.68	6.73	6.19	16.1
5/10/2008	5.47	6.27	5.87	15.9
5/11/2008	5.67	7.72	7.13	14.3
5/12/2008	6.54	7.76	7.10	12.8
5/13/2008	6.53	6.86	6.69	13.6
5/14/2008	6.18	6.80	6.52	14.1
5/15/2008	5.98	6.43	6.22	14.2
5/16/2008	6.29	6.71	6.45	14.5
5/17/2008	6.24	7.07	6.54	15.4
5/18/2008	5.92	6.55	6.30	15.5
5/19/2008	5.78	6.51	6.24	15.3
5/20/2008	6.36	7.05	6.69	15.5
5/21/2008	5.71	7.53	6.67	15.9
Event 2				
7/10/2008	—	—	—	—
7/11/2008	—	—	—	—
7/12/2008	—	—	—	—
7/13/2008	—	—	—	—
7/14/2008	—	—	—	—
7/15/2008	—	—	—	—
7/16/2008	6.41	7.86	7.11	25.4
7/17/2008	6.63	7.72	6.98	26.1
7/18/2008	6.97	8.36	7.63	26.5
7/19/2008	6.10	7.61	6.91	26.2
7/20/2008	4.25	6.00	4.86	25.5
7/21/2008	4.29	5.51	4.78	25.4

TABLE AI-6 (Continued): DAILY DISSOLVED OXYGEN AND TEMERATURE DATA FOR THE ROUTE 83 CALUMET-SAG CHANNEL MONITORING STATION DURING ALL FOUR EVENTS[1]

Date	Dissolved O_2 (mg/L)			Temperature (°C)
	Minimum	Maximum	Mean	Mean
7/22/2008	4.11	5.40	4.73	25.1
7/23/2008	4.49	6.17	5.28	24.9
7/24/2008	6.14	7.52	6.53	24.8
7/25/2008	5.96	7.37	6.50	24.9
7/26/2008	6.35	8.31	7.02	25.4
7/27/2008	6.10	8.04	6.99	25.5
7/28/2008	5.61	8.46	6.81	25.8
7/29/2008	5.70	7.11	6.25	25.9
7/30/2008	4.64	7.06	5.61	26.0
7/31/2008	4.46	6.43	5.58	26.2
Event 3				
8/11/2008	5.04	5.60	5.29	23.7
8/12/2008	4.85	5.58	5.20	23.6
8/13/2008	4.90	6.00	5.49	23.6
8/14/2008	5.29	6.29	5.73	23.7
8/15/2008	5.52	7.01	6.06	23.8
8/16/2008	5.73	6.81	6.19	23.9
8/17/2008	5.67	6.75	6.15	24.2
8/18/2008	5.22	6.39	5.85	24.4
8/19/2008	5.52	6.12	5.81	24.5
8/20/2008	5.58	6.68	6.02	24.6
8/21/2008	5.71	6.78	6.25	24.5
8/22/2008	5.18	6.37	5.73	24.9
Event 4				
9/22/2008	4.77	4.99	4.88	20.8
9/23/2008	4.78	5.16	4.93	21.1
9/24/2008	4.97	5.09	5.02	21.2
9/25/2008	—	—	—	—
9/26/2008	—	—	—	—
9/27/2008	—	—	—	—
9/28/2008	—	—	—	—
9/29/2008	—	—	—	—
9/30/2008	—	—	—	—

TABLE AI-6 (Continued): DAILY DISSOLVED OXYGEN AND TEMERATURE DATA FOR THE ROUTE 83 CALUMET-SAG CHANNEL MONITORING STATION DURING ALL FOUR EVENTS[1]

Date	Dissolved O_2 (mg/L)			Temperature (°C)
	Minimum	Maximum	Mean	Mean
10/1/2008	5.22	5.55	5.43	18.3
10/2/2008	5.15	5.92	5.53	17.7
10/3/2008	5.67	6.12	5.91	17.2

[1]Note: Data not available for Event 2 (7/10 to 7/15) and Event 4 (9/25 to 9/30).

TABLE AI-7: DAILY DISSOLVED OXYGEN AND TEMERATURE DATA FOR THE ROUTE 83 CHICAGO SANITARY AND SHIP CANAL MONITORING STATION DURING ALL FOUR EVENTS[1]

Date	Dissolved O_2 (mg/L)			Temperature (°C)
	Minimum	Maximum	Mean	Mean
Event 1				
5/1/2008	4.13	5.96	5.12	17.0
5/2/2008	4.36	5.72	5.20	18.2
5/3/2008	4.71	5.48	5.12	18.5
5/4/2008	4.23	5.05	4.79	18.1
5/5/2008	5.00	5.73	5.37	18.0
5/6/2008	5.49	6.36	5.79	18.3
5/7/2008	4.27	6.31	5.54	19.7
5/8/2008	4.42	5.55	5.09	19.9
5/9/2008	3.78	5.35	4.59	18.7
5/10/2008	4.32	5.83	4.89	18.3
5/11/2008	5.01	6.17	5.58	18.1
5/12/2008	2.49	5.49	4.11	16.0
5/13/2008	4.39	7.18	5.92	15.0
5/14/2008	5.65	7.21	6.65	15.3
5/15/2008	6.34	7.07	6.70	15.5
5/16/2008	6.77	7.32	7.01	15.5
5/17/2008	5.55	7.08	6.29	17.2
5/18/2008	5.47	6.23	5.94	18.5
5/19/2008	5.26	6.27	5.65	19.3
5/20/2008	4.95	5.84	5.56	18.9
5/21/2008	3.48	5.99	5.37	19.2
Event 2				
7/10/2008	—	—	—	—
7/11/2008	—	—	—	—
7/12/2008	—	—	—	—
7/13/2008	—	—	—	—
7/14/2008	—	—	—	—
7/15/2008	—	—	—	—
7/16/2008	3.87	5.16	4.51	26.4
7/17/2008	4.21	5.81	5.07	26.7
7/18/2008	4.50	6.24	5.17	27.5
7/19/2008	4.47	6.54	5.32	26.9
7/20/2008	2.82	4.86	3.80	26.7
7/21/2008	2.58	3.62	3.14	25.0

TABLE AI-7 (Continued): DAILY DISSOLVED OXYGEN AND TEMERATURE DATA FOR THE ROUTE 83 CHICAGO SANITARY AND SHIP CANAL MONITORING STATION DURING ALL FOUR EVENTS[1]

Date	Dissolved O_2 (mg/L)			Temperature (°C)
	Minimum	Maximum	Mean	Mean
7/22/2008	1.96	4.50	3.26	25.0
7/23/2008	3.56	5.31	4.43	24.8
7/24/2008	4.20	5.09	4.58	25.3
7/25/2008	4.04	5.01	4.41	25.9
7/26/2008	4.12	5.11	4.63	26.1
7/27/2008	4.54	5.44	4.90	26.0
7/28/2008	4.44	6.23	5.24	25.9
7/29/2008	4.97	6.74	5.64	26.9
7/30/2008	3.99	5.61	4.99	26.7
7/31/2008	—	—	—	—
Event 3				
8/11/2008	—	—	—	—
8/12/2008	—	—	—	—
8/13/2008	—	—	—	—
8/14/2008	—	—	—	—
8/15/2008	—	—	—	—
8/16/2008	—	—	—	—
8/17/2008	—	—	—	—
8/18/2008	—	—	—	—
8/19/2008	—	—	—	—
8/20/2008	4.64	4.79	4.70	27.8
8/21/2008	4.55	5.03	4.82	27.5
8/22/2008	4.13	4.99	4.55	27.8
Event 4				
9/22/2008	—	—	—	—
9/23/2008	—	—	—	—
9/24/2008	—	—	—	—
9/25/2008	—	—	—	—
9/26/2008	—	—	—	—
9/27/2008	—	—	—	—
9/28/2008	—	—	—	—
9/29/2008	—	—	—	—
9/30/2008	—	—	—	—

TABLE AI-7 (Continued): DAILY DISSOLVED OXYGEN AND TEMERATURE DATA FOR THE ROUTE 83 CHICAGO SANITARY AND SHIP CANAL MONITORING STATION DURING ALL FOUR EVENTS[1]

Date	Dissolved O_2 (mg/L)			Temperature (°C)
	Minimum	Maximum	Mean	Mean
10/1/2008	5.96	6.18	6.07	20.7
10/2/2008	5.88	6.08	5.96	20.4
10/3/2008	5.83	6.00	5.94	20.0

[1]Data not available for Event 2 (7/10 to 7/15), Event 3 (8/11 to 8/19) and Event 4 (9/22 to 9/30).

TABLE AI-8: DAILY DISSOLVED OXYGEN AND TEMERATURE DATA FOR THE ROMEOVILLE MONITORING STATION DURING ALL FOUR EVENTS[1]

Date	Dissolved O_2 (mg/L) Minimum	Maximum	Mean	Temperature (°C) Mean
		Event 1		
5/1/2008	4.42	5.69	5.46	14.8
5/2/2008	5.10	5.96	5.55	15.7
5/3/2008	5.33	5.84	5.61	16.5
5/4/2008	4.67	5.76	5.09	16.6
5/5/2008	4.35	4.97	4.66	17.0
5/6/2008	4.63	5.32	5.06	17.3
5/7/2008	5.29	5.68	5.50	17.7
5/8/2008	5.15	5.75	5.49	18.7
5/9/2008	4.90	5.49	5.24	18.4
5/10/2008	4.91	5.27	5.02	18.0
5/11/2008	5.20	6.63	6.02	16.9
5/12/2008	5.91	6.55	6.34	14.9
5/13/2008	5.68	6.65	6.22	14.8
5/14/2008	6.61	7.19	6.83	14.8
5/15/2008	6.38	6.80	6.56	15.0
5/16/2008	5.86	6.41	6.11	15.4
5/17/2008	6.33	6.59	6.48	15.8
5/18/2008	5.52	6.46	6.08	16.7
5/19/2008	5.30	5.86	5.61	17.6
5/20/2008	5.11	5.40	5.27	18.3
5/21/2008	5.08	5.66	5.29	18.0
		Event 2		
7/10/2008	4.09	5.81	4.94	26.0
7/11/2008	3.92	4.99	4.29	26.0
7/12/2008	3.73	4.37	4.13	25.7
7/13/2008	3.49	4.61	3.99	25.9
7/14/2008	3.40	4.57	4.03	25.1
7/15/2008	3.63	4.84	4.18	24.8
7/16/2008	4.17	5.18	4.72	25.3
7/17/2008	3.94	5.94	5.05	28.7
7/18/2008	4.70	5.90	5.27	28.4
7/19/2008	5.04	6.01	5.57	26.9
7/20/2008	3.90	4.90	4.29	26.7
7/21/2008	3.07	3.94	3.52	26.0
7/22/2008	2.91	3.61	3.24	25.2

TABLE AI-8 (Continued): DAILY DISSOLVED OXYGEN AND TEMERATURE DATA FOR THE ROMEOVILLE MONITORING STATION DURING ALL FOUR EVENTS[1]

Date	Dissolved O_2 (mg/L)			Temperature (°C)
	Minimum	Maximum	Mean	Mean
7/23/2008	3.07	4.02	3.56	24.9
7/24/2008	3.64	4.71	4.29	25.0
7/25/2008	4.72	5.28	5.02	25.3
7/26/2008	4.91	5.48	5.16	26.0
7/27/2008	4.77	5.42	5.11	26.0
7/28/2008	4.66	5.66	5.18	26.0
7/29/2008	5.48	6.38	5.91	26.4
7/30/2008	4.83	5.78	5.40	26.7
7/31/2008	4.29	5.05	4.76	27.0
Event 3				
8/11/2008	4.30	4.67	4.47	25.1
8/12/2008	4.38	4.75	4.56	25.3
8/13/2008	4.51	4.93	4.69	25.2
8/14/2008	4.45	5.03	4.78	25.4
8/15/2008	4.38	5.80	4.86	27.2
8/16/2008	4.95	6.14	5.27	26.3
8/17/2008	4.82	5.97	5.27	26.1
8/18/2008	4.51	5.60	5.08	26.3
8/19/2008	4.60	5.30	4.91	26.4
8/20/2008	4.02	5.01	4.69	26.6
8/21/2008	4.16	5.04	4.75	26.7
8/22/2008	—	—	—	—
Event 4				
9/22/2008	4.76	5.07	4.95	22.0
9/23/2008	4.36	4.80	4.57	22.7
9/24/2008	4.35	4.74	4.53	22.8
9/25/2008	4.60	5.09	4.81	22.5
9/26/2008	4.85	5.31	5.05	22.5
9/27/2008	5.28	5.65	5.44	22.4
9/28/2008	5.41	5.71	5.56	22.0
9/29/2008	5.62	5.97	5.76	21.2
9/30/2008	5.63	6.04	5.76	20.8
10/1/2008	5.21	5.66	5.36	20.2

TABLE AI-8 (Continued): DAILY DISSOLVED OXYGEN AND TEMERATURE DATA FOR THE ROMEOVILLE MONITORING STATION DURING ALL FOUR EVENTS[1]

Date	Dissolved O_2 (mg/L)			Temperature (°C)
	Minimum	Maximum	Mean	Mean
10/2/2008	5.46	5.84	5.70	19.7
10/3/2008	5.76	6.05	5.88	19.4

[1]Data not available for 8/22/08.

TABLE AI-9: DAILY DISSOLVED OXYGEN AND TEMERATURE DATA FOR THE LOCKPORT MONITORING STATION DURING ALL FOUR EVENTS[1]

Date	Dissolved O_2 (mg/L)			Temperature (°C)
	Minimum	Maximum	Mean	Mean
Event 1				
5/1/2008	—	—	—	—
5/2/2008	—	—	—	—
5/3/2008	—	—	—	—
5/4/2008	—	—	—	—
5/5/2008	—	—	—	—
5/6/2008	—	—	—	—
5/7/2008	—	—	—	—
5/8/2008	—	—	—	—
5/9/2008	—	—	—	—
5/10/2008	—	—	—	—
5/11/2008	—	—	—	—
5/12/2008	5.79	6.02	5.90	17.1
5/13/2008	5.33	6.16	5.74	16.2
5/14/2008	5.75	6.58	6.24	16.3
5/15/2008	6.07	6.42	6.30	16.1
5/16/2008	5.92	6.37	6.24	16.6
5/17/2008	5.85	6.52	6.27	17.7
5/18/2008	6.07	6.42	6.25	19.1
5/19/2008	5.27	6.04	5.72	19.2
5/20/2008	5.26	5.81	5.51	19.3
5/21/2008	5.05	5.80	5.31	22.3
Event 2				
7/10/2008	4.81	5.74	5.24	29.6
7/11/2008	3.94	4.96	4.38	28.3
7/12/2008	3.65	4.09	3.89	28.5
7/13/2008	3.05	3.85	3.50	28.8
7/14/2008	2.90	5.09	4.04	27.7
7/15/2008	3.67	5.74	4.48	29.8
7/16/2008	4.36	6.79	5.13	28.8
7/17/2008	4.55	8.77	5.85	29.4
7/18/2008	4.27	7.72	5.41	31.3
7/19/2008	3.45	5.99	4.39	31.1
7/20/2008	3.09	5.13	4.12	28.5
7/21/2008	2.98	4.40	3.40	29.1

TABLE AI-9 (Continued): DAILY DISSOLVED OXYGEN AND TEMERATURE DATA FOR THE LOCKPORT MONITORING STATION DURING ALL FOUR EVENTS[1]

Date	Dissolved O_2 (mg/L)			Temperature (°C)
	Minimum	Maximum	Mean	Mean
7/22/2008	3.48	3.74	3.58	28.6
7/23/2008	2.88	4.05	3.44	28.0
7/24/2008	3.62	4.80	4.11	28.0
7/25/2008	4.25	5.50	4.74	28.4
7/26/2008	4.58	5.55	4.85	28.8
7/27/2008	4.30	4.88	4.62	29.9
7/28/2008	4.26	5.59	4.84	30.1
7/29/2008	4.75	6.45	5.57	29.4
7/30/2008	5.25	6.40	5.65	30.1
7/31/2008	4.77	5.44	5.10	30.5
Event 3				
8/11/2008	3.55	4.10	3.85	27.9
8/12/2008	—	—	—	—
8/13/2008	—	—	—	—
8/14/2008	—	—	—	—
8/15/2008	—	—	—	—
8/16/2008	—	—	—	—
8/17/2008	—	—	—	—
8/18/2008	6.04	6.59	6.38	28.9
8/19/2008	5.47	6.96	5.93	30.1
8/20/2008	5.28	6.49	5.69	30.4
8/21/2008	5.15	6.04	5.55	29.9
8/22/2008	4.94	5.93	5.39	30.0
Event 4				
9/22/2008	4.89	5.46	5.22	24.0
9/23/2008	4.46	4.87	4.74	24.5
9/24/2008	4.31	4.57	4.46	25.1
9/25/2008	4.36	4.95	4.62	25.4
9/26/2008	4.62	5.11	4.87	25.7
9/27/2008	4.93	5.46	5.19	25.3
9/28/2008	5.28	5.60	5.42	24.7
9/29/2008	5.41	5.77	5.58	24.0
9/30/2008	5.67	5.87	5.80	23.3
10/1/2008	5.49	5.99	5.66	23.1

TABLE AI-9 (Continued): DAILY DISSOLVED OXYGEN AND TEMERATURE DATA FOR THE LOCKPORT MONITORING STATION DURING ALL FOUR EVENTS[1]

Date	Dissolved O_2 (mg/L)			Temperature (°C)
	Minimum	Maximum	Mean	Mean
10/2/2008	5.43	5.97	5.68	23.3
10/3/2008	5.73	5.95	5.86	22.6

[1]Data not available for Event 1 (5/1 to 5/11) and Event 3 (8/12 to 8/17).

FIGURE AI-1: DISSOLVED OXYGEN CONCENTRATIONS MEASURED AT THE DIVISION STREET MONITORING STATION DURING EVENTS 1 THROUGH 4

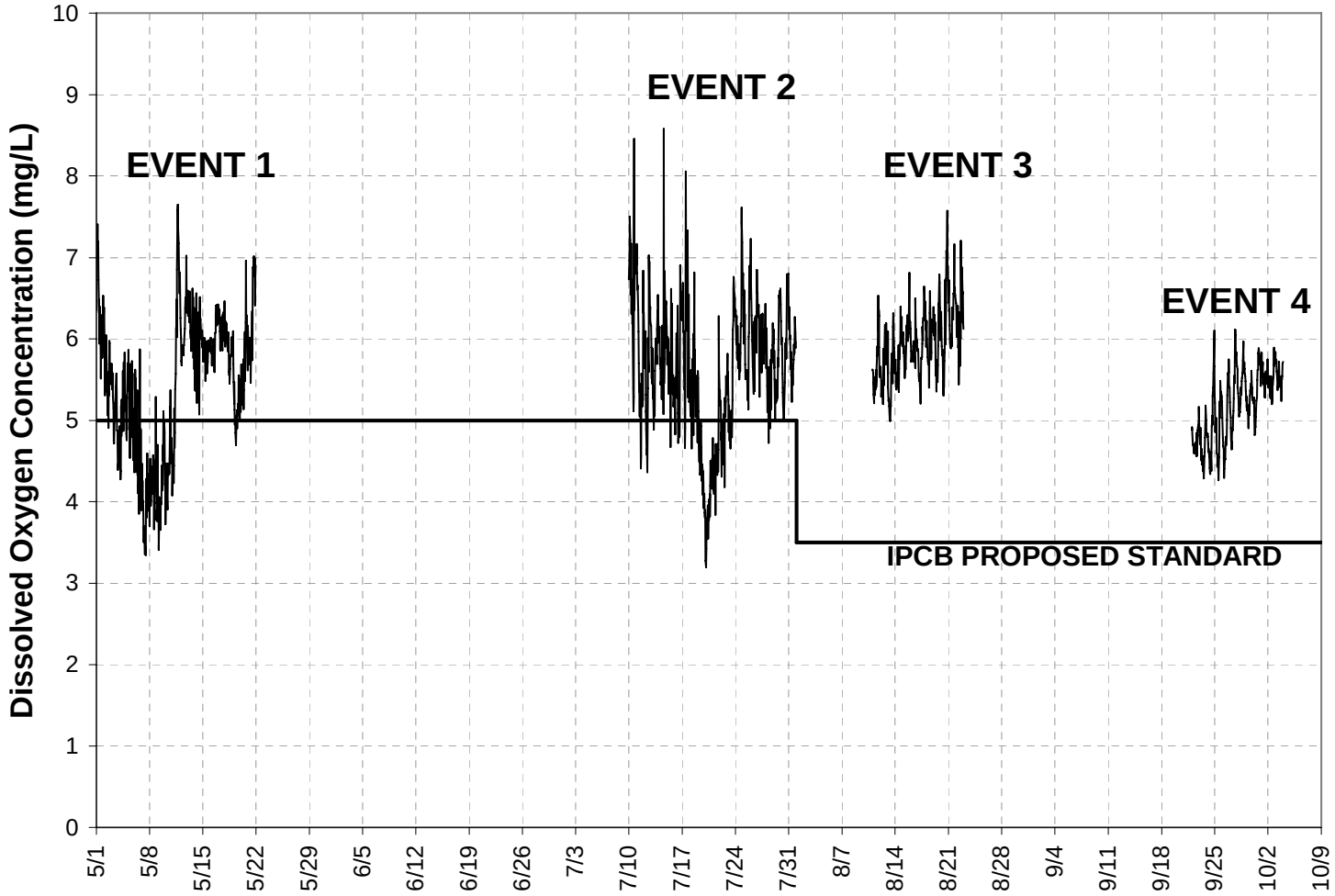


FIGURE AI-2: DISSOLVED OXYGEN CONCENTRATIONS MEASURED AT THE CICERO AVENUE MONITORING STATION DURING EVENTS 1 THROUGH 4

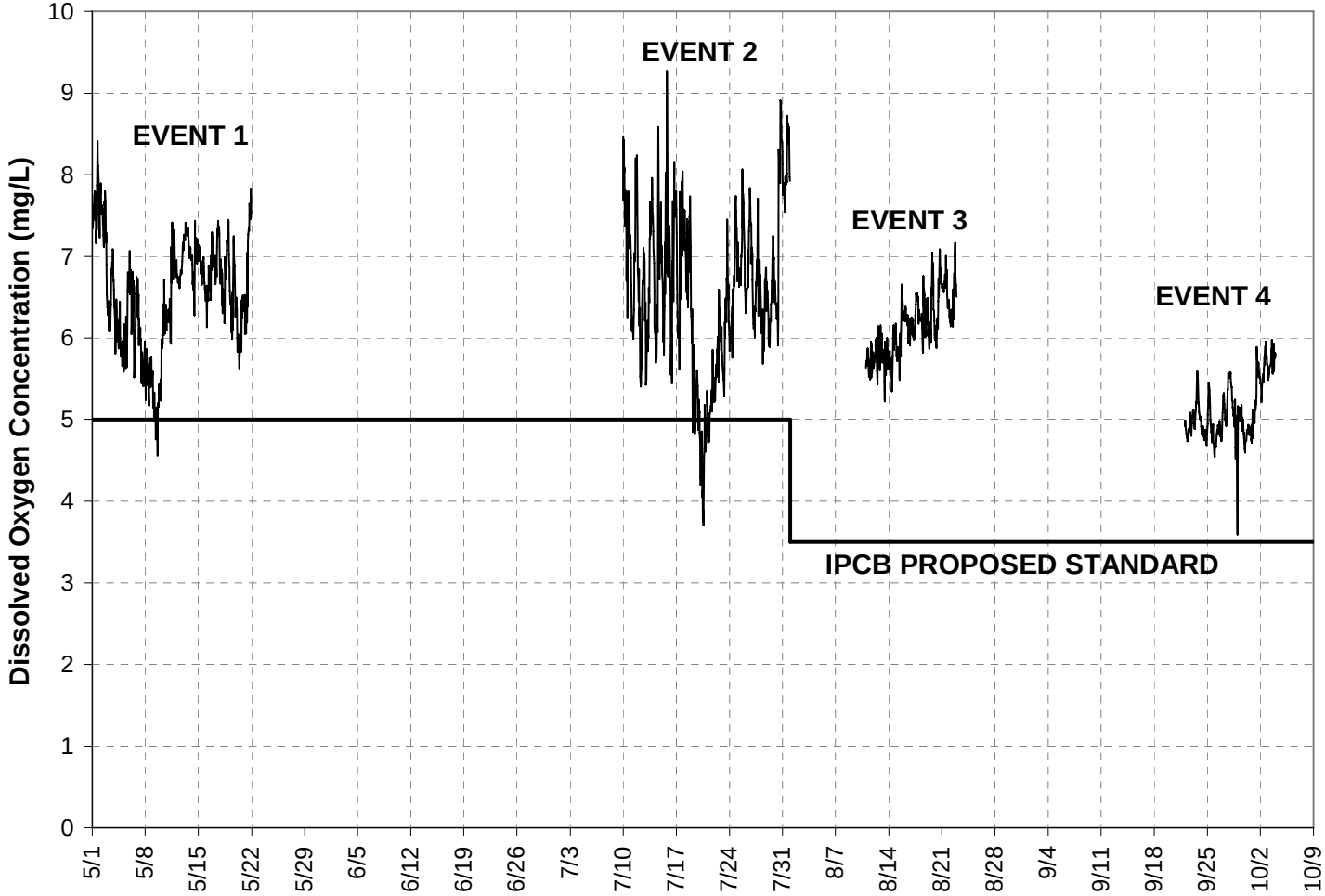


FIGURE AI-3: DISSOLVED OXYGEN CONCENTRATIONS MEASURED AT
THE RIVER MILE 311.7 MONITORING STATION DURING EVENTS 1 THROUGH 4

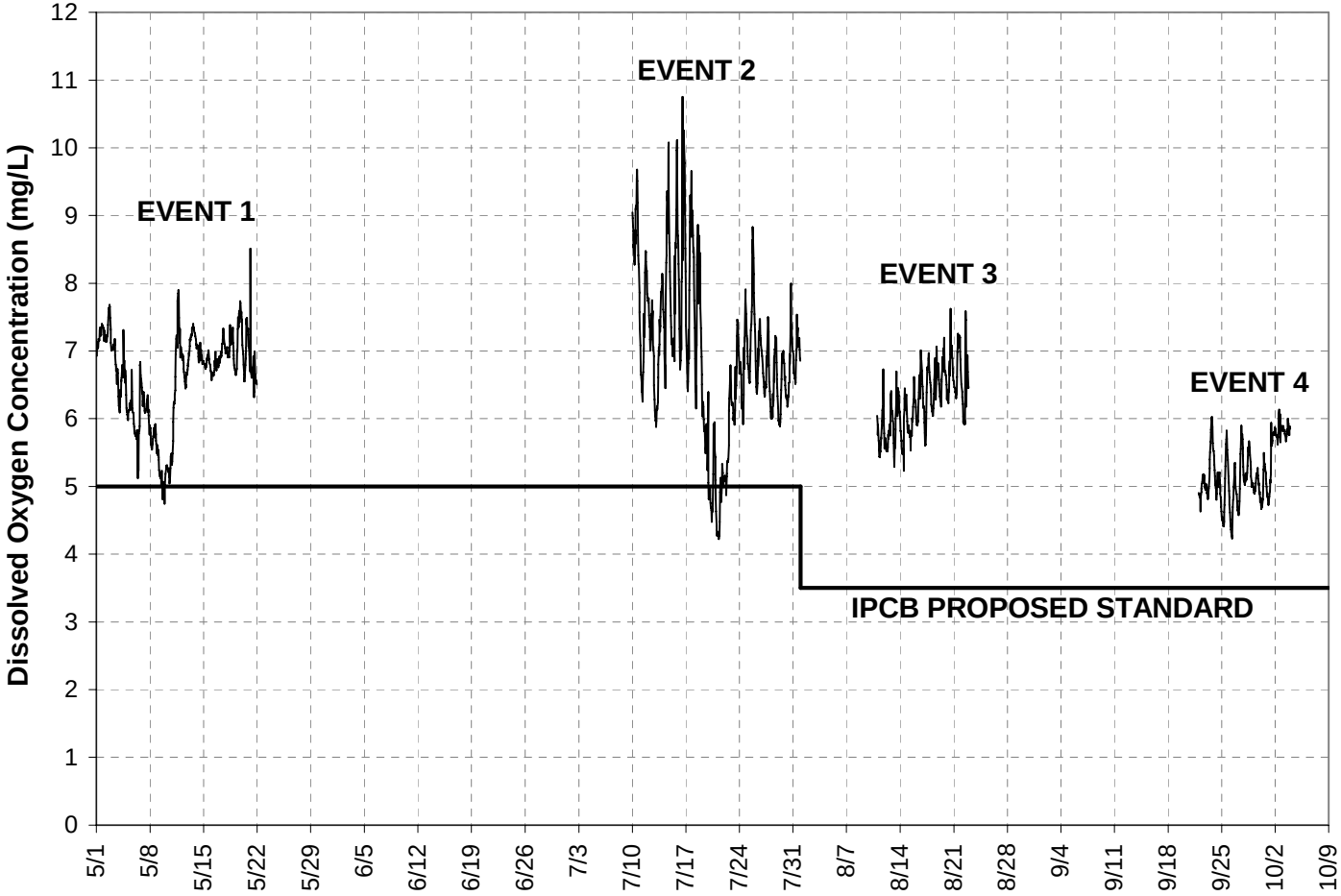


FIGURE AI-4: DISSOLVED OXYGEN CONCENTRATIONS MEASURED AT THE SOUTHWEST HIGHWAY MONITORING STATION DURING EVENTS 1 THROUGH 4

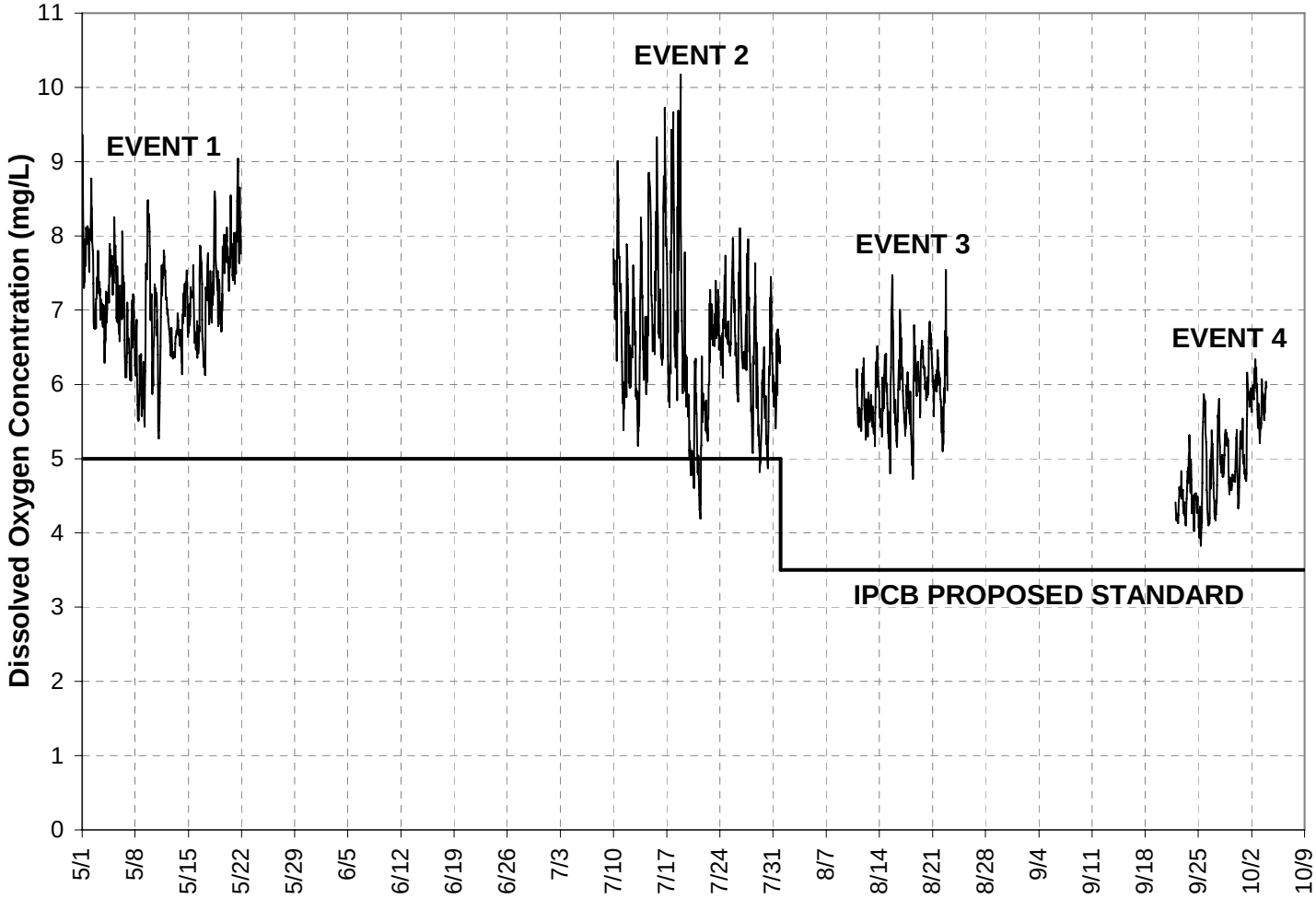


FIGURE AI-5: DISSOLVED OXYGEN CONCENTRATIONS MEASURED AT THE 104TH AVENUE MONITORING STATION DURING EVENTS 1 THROUGH 4

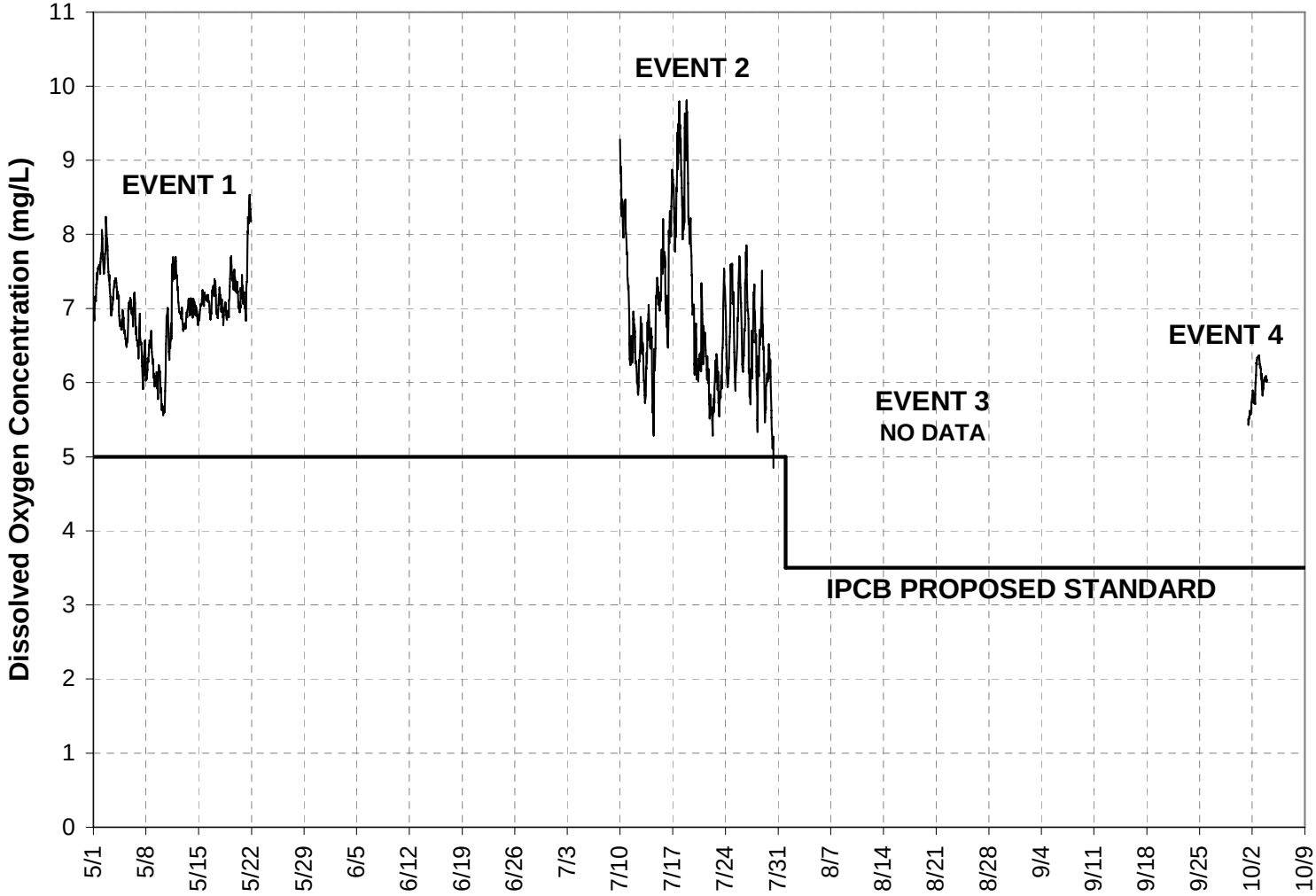


FIGURE AI-6: DISSOLVED OXYGEN CONCENTRATIONS MEASURED AT THE ROUTE 83 CALUMET-SAG CHANNEL MONITORING STATION DURING EVENTS 1 THROUGH 4

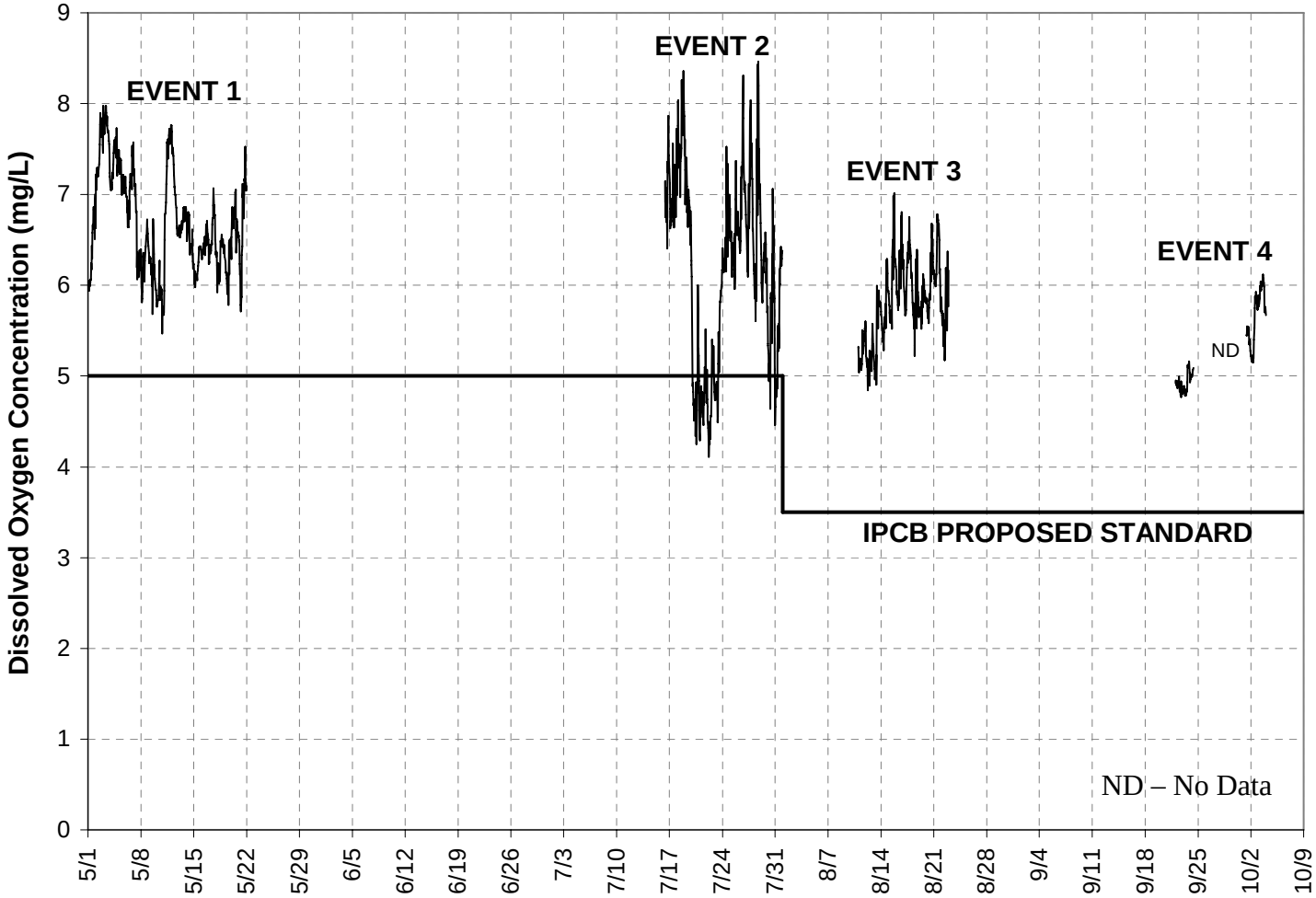


FIGURE AI-7: DISSOLVED OXYGEN CONCENTRATIONS MEASURED AT THE ROUTE 83 CHICAGO SANITARY AND SHIP CANAL MONITORING STATION DURING EVENTS 1 THROUGH 4

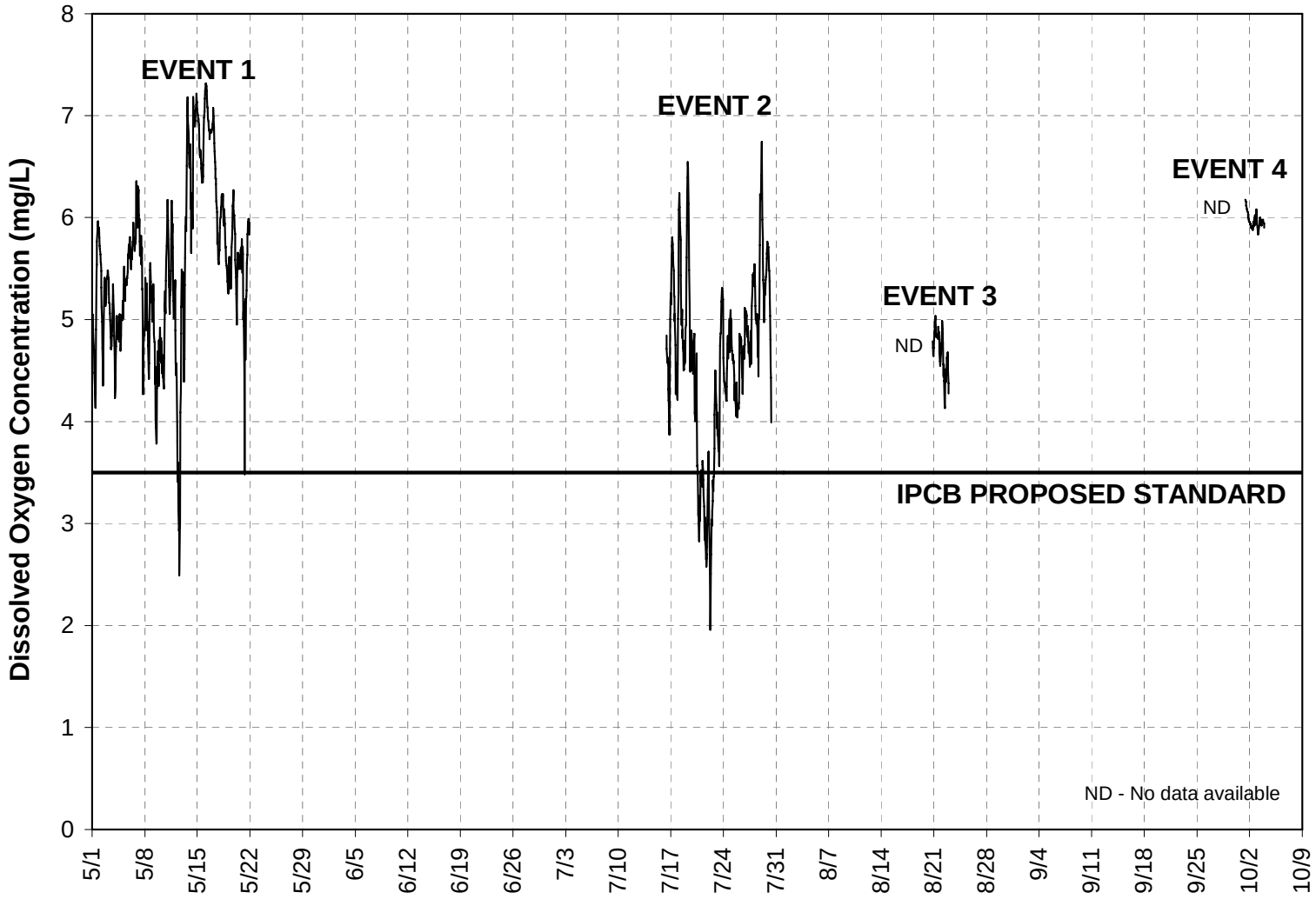


FIGURE AI-8: DISSOLVED OXYGEN CONCENTRATIONS MEASURED AT THE ROMEOVILLE MONITORING STATION DURING EVENTS 1 THROUGH 4

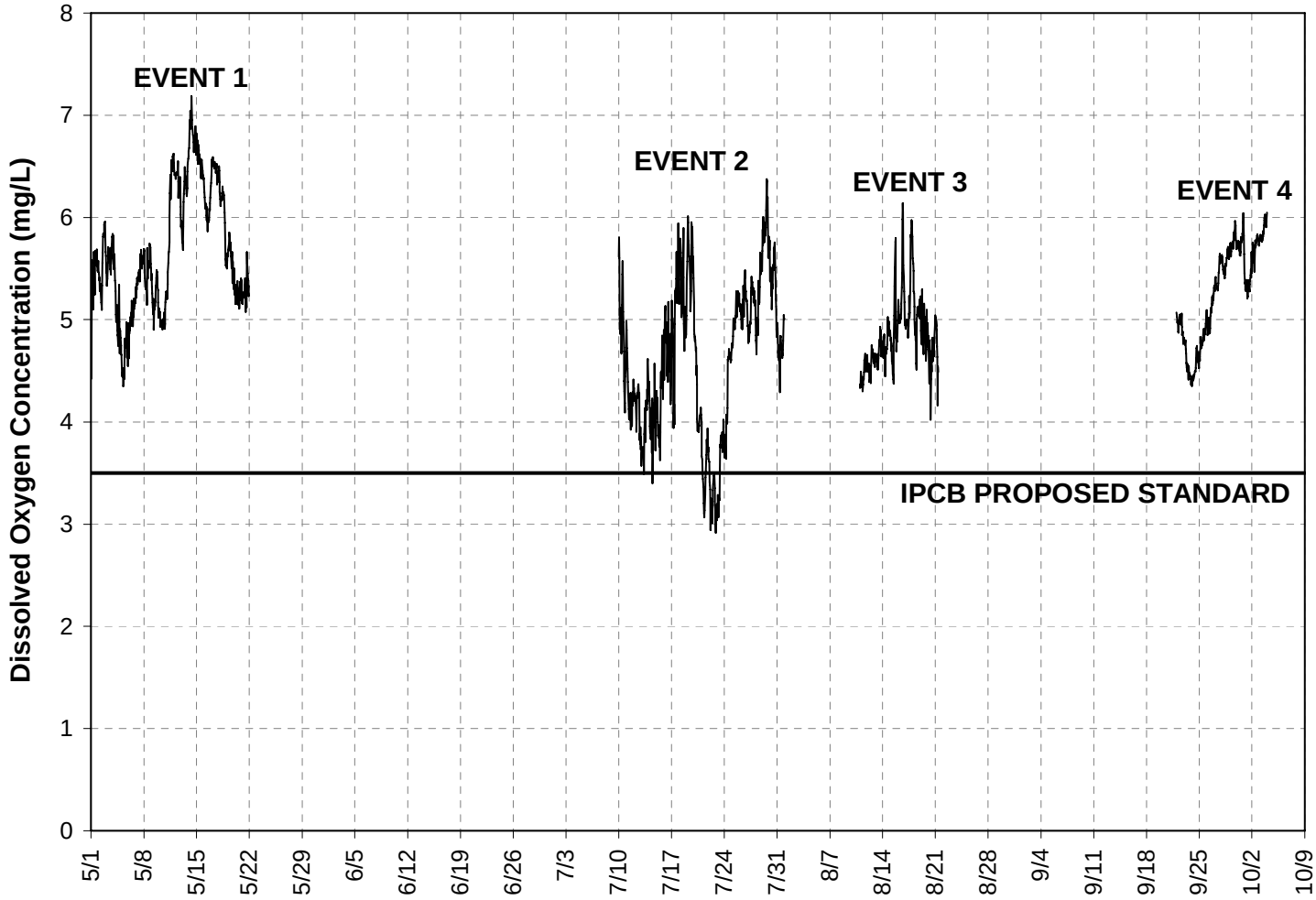
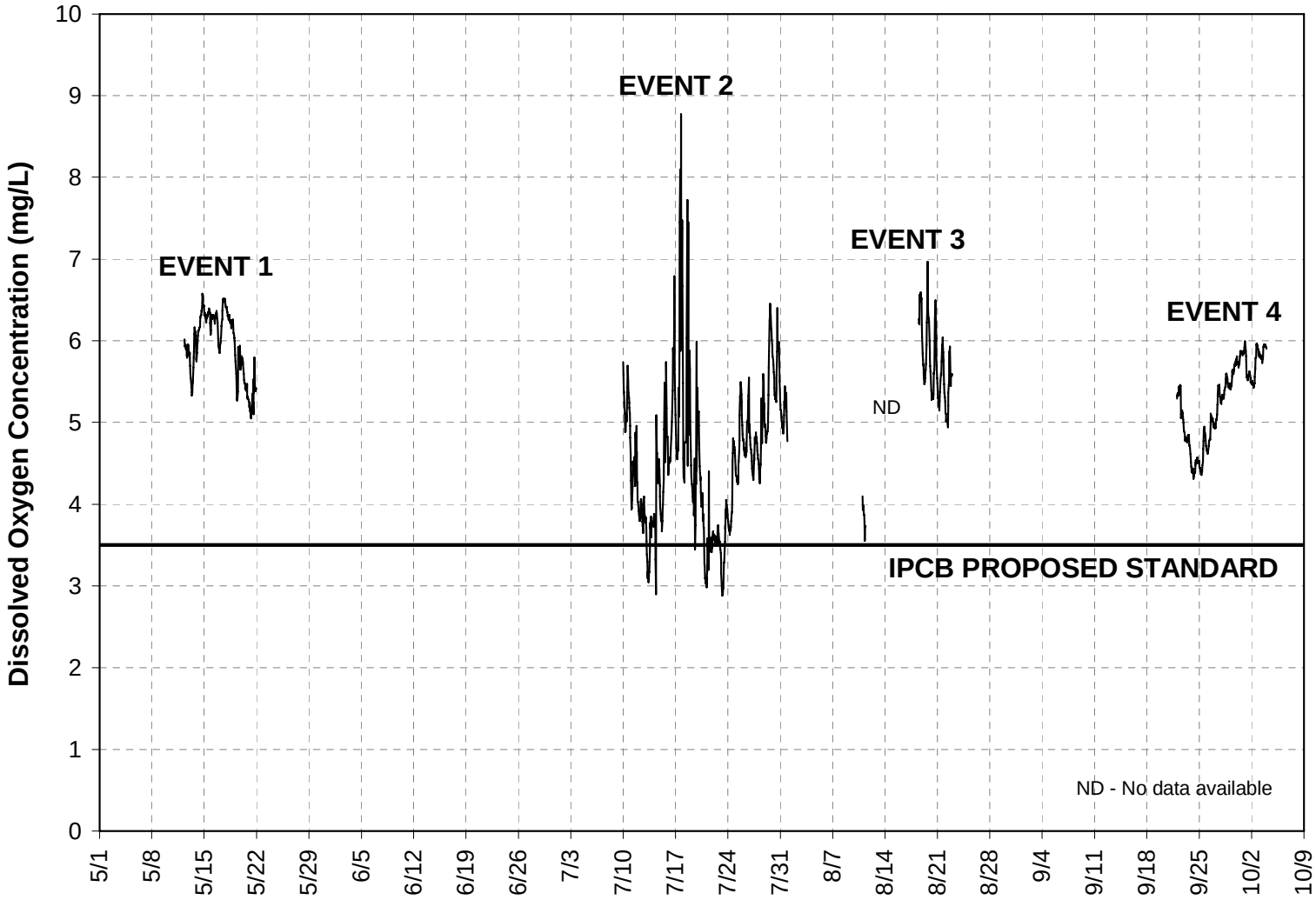


FIGURE AI-9: DISSOLVED OXYGEN CONCENTRATIONS MEASURED AT THE LOCKPORT MONITORING STATION DURING EVENTS 1 THROUGH 4



APPENDIX AII: CALCULATION OF THE SATURATION CONCENTRATION OF DISSOLVED OXYGEN

CALCULATION OF THE SATURATION CONCENTRATION OF DISSOLVED OXYGEN

The dissolved oxygen saturation concentrations were calculated for the monitoring stations and the SEPA stations using the following equation by Weiss (Weiss, 1970):

$$\ln DO = Al + A2 \times 100/T + A3 \times \ln[T/100] + A4 \times T/100$$

Where:

DO = DO saturation concentration (mL/L)
T = temperature in degrees Kelvin (273.15 + °C)
A1 = -173.4292
A2 = 249.6339
A3 = 143.3483
A4 = -21.8492

The DO saturation concentration results were then multiplied by 1.4276 to convert to units of mg/L. To simplify the calculation of the DO saturation concentration, salinity was assumed to be negligible and atmospheric pressure was assumed to be 1 atm. There are tables and variations of the above equation that account for salinity and pressure however they are not included in this report.

For saturation concentrations calculated for the monitoring stations, the average daily temperature measured at the station was used in the above equation. For the saturation concentrations calculated for the SEPA stations, the average daily temperature measured at the monitoring station upstream of the SEPA station was used in the above equation.

APPENDIX AIII: DAILY FLOWS INTO THE CALUMET-SAG CHANNEL

TABLE AIII-1: DAILY FLOW DATA INTO CALUMET-SAG CHANNEL

Date	Little Calumet South[1] (cfs)	(mgd)	Grand Calumet[2] (cfs)	(mgd)	O'Brien L&D[3] (cfs)	(mgd)	Calumet WRP[4] (cfs)	(mgd)
				Event 1				
5/1/2008	138	89	4	3	36	23	367	237
5/2/2008	195	126	8	5	46	30	413	267
5/3/2008	279	180	2	2	43	28	472	305
5/4/2008	206	133	2	1	40	26	340	220
5/5/2008	145	94	4	3	23	15	371	240
5/6/2008	118	76	4	3	22	14	345	223
5/7/2008	222	144	9	6	25	16	484	313
5/8/2008	255	165	5	3	21	13	483	312
5/9/2008	149	96	4	2	34	22	316	204
5/10/2008	111	72	4	3	41	26	292	189
5/11/2008	632	409	25	16	229	148	668	432
5/12/2008	1,090	705	11	7	20	13	698	451
5/13/2008	591	382	7	4	26	17	625	404
5/14/2008	359	232	4	2	28	18	610	394
5/15/2008	254	164	6	4	29	19	572	370
5/16/2008	194	125	5	3	29	19	667	431
5/17/2008	155	100	2	2	42	27	640	414
5/18/2008	152	98	5	3	24	16	518	335
5/19/2008	117	76	2	2	34	22	364	235
5/20/2008	106	69	3	2	24	16	340	220
5/21/2008	93	60	5	3	26	17	356	230
				Event 2				
7/10/2008	55	36	24	15	139	90	410	265
7/11/2008	147	95	34	22	383	247	472	305
7/12/2008	109	70	28	18	248	160	436	282
7/13/2008	77	50	24	15	321	207	353	228
7/14/2008	45	29	21	14	370	239	275	178
7/15/2008	36	23	22	14	340	219	275	178
7/16/2008	30	19	24	15	545	352	278	180
7/17/2008	27	17	22	14	160	104	308	199
7/18/2008	26	17	22	14	64	42	323	209
7/19/2008	229	148	54	35	53	34	571	369
7/20/2008	256	165	41	27	265	171	571	369
7/21/2008	127	82	29	19	556	360	546	353

TABLE AIII-1 (Continued): DAILY FLOW DATA INTO CALUMET-SAG CHANNEL

Date	Little Calumet South[1] (cfs)	Little Calumet South[1] (mgd)	Grand Calumet[2] (cfs)	Grand Calumet[2] (mgd)	O'Brien L&D[3] (cfs)	O'Brien L&D[3] (mgd)	Calumet WRP[4] (cfs)	Calumet WRP[4] (mgd)
7/22/2008	73	47	29	19	330	213	418	270
7/23/2008	49	32	24	16	561	363	326	211
7/24/2008	39	25	21	13	736	476	308	199
7/25/2008	33	21	19	12	707	457	289	187
7/26/2008	31	20	18	12	708	458	295	191
7/27/2008	29	19	18	12	370	239	271	175
7/28/2008	27	17	18	12	680	439	266	172
7/29/2008	35	23	19	12	720	465	277	179
7/30/2008	37	24	18	11	708	457	350	226
7/31/2008	57	37	36	23	581	375	415	268
Event 3								
8/11/2008	102	66	6	4	667	431	408	264
8/12/2008	69	45	5	3	571	369	277	179
8/13/2008	56	36	4	3	753	487	323	209
8/14/2008	57	37	5	3	772	499	266	172
8/15/2008	56	36	5	3	737	476	283	183
8/16/2008	38	25	4	3	725	469	302	195
8/17/2008	29	19	3	2	725	469	282	182
8/18/2008	25	16	2	1	747	483	257	166
8/19/2008	25	16	3	2	577	373	278	180
8/20/2008	30	19	3	2	571	369	285	184
8/21/2008	30	19	2	1	599	387	268	173
8/22/2008	24	16	1	0	333	215	297	192
Event 4								
9/22/2008	532	344	ND	ND	570	369	610	394
9/23/2008	455	294	ND	ND	504	326	552	357
9/24/2008	401	259	ND	ND	384	248	532	344
9/25/2008	334	216	ND	ND	347	224	631	408
9/26/2008	272	176	ND	ND	401	259	623	403
9/27/2008	218	141	ND	ND	635	410	623	403
9/28/2008	148	96	ND	ND	654	423	647	418
9/29/2008	118	76	ND	ND	578	374	647	418
9/30/2008	98	63	ND	ND	954	616	636	411
10/1/2008	68	44	ND	ND	373	241	599	387

TABLE AIII-1 (Continued): DAILY FLOW DATA INTO CALUMET-SAG CHANNEL

Date	Little Calumet South[1]		Grand Calumet[2]		O'Brien L&D[3]		Calumet WRP[4]	
	(cfs)	(mgd)	(cfs)	(mgd)	(cfs)	(mgd)	(cfs)	(mgd)
10/2/2008	80	52	ND	ND	339	219	631	408
10/3/2008	104	67	ND	ND	364	235	ND	390

ND: No data.
[1]South Holland, IL USGS Station Number 05536290.
[2]Hammond, IN USGS Station Number 05536357.
[3]District M&O Data.
[4]Monthly Plant Operating Report.

APPENDIX AIV: PRECIPITATION AND ESTIMATED COMBINED SEWER OVERFLOW VOLUMES

TABLE AIV-1: PRECIPITATION AND COMBINED SEWER OVERFLOWS DURING EVENTS 1 THROUGH 4

Date	Precipitation (in)[1]			Combined Sewer Overflow (MG)[2]	
	Gauge 10	Gauge 11	Gauge 12	CSC	CSSC
Event 1					
5/1/2008	0.00	0.00	0.00	0	0
5/2/2008	0.42	0.33	0.20	0	0.008
5/3/2008	0.00	0.05	0.00	0	0
5/4/2008	0.00	0.00	0.00	0	0
5/5/2008	0.00	0.00	0.00	0	0
5/6/2008	0.00	0.00	0.00	0	0
5/7/2008	0.56	0.29	0.50	0	0.096
5/8/2008	0.00	0.00	0.00	0	0
5/9/2008	0.00	0.00	0.00	0	0
5/10/2008	0.00	0.00	0.00	0	0
5/11/2008	1.55	1.95	1.05	84.6	1,159
5/12/2008	0.00	0.00	0.00	1.08	0
5/13/2008	0.12	0.05	0.14	0	0
5/14/2008	0.09	0.02	0.01	0	0
5/15/2008	0.00	0.00	0.00	0	0
5/16/2008	0.28	0.17	0.10	0	0
5/17/2008	0.00	0.00	0.00	0	0
5/18/2008	0.00	0.00	0.00	0	0
5/19/2008	0.01	0.00	0.01	0	0
5/20/2008	0.00	0.00	0.00	0	0
5/21/2008	0.00	0.00	0.00	0	0
Event 2					
7/10/2008	0.41	Out	0.48	0	0
7/11/2008	0.01	0.00	Out	0	0
7/12/2008	0.42	0.28	Out	0	87.5
7/13/2008	0.00	Out	0.00	0	0
7/14/2008	0.00	Out	0.00	0	0
7/15/2008	0.00	Out	0.00	0	0
7/16/2008	0.00	Out	0.00	0	0
7/17/2008	0.00	Out	0.00	0	0
7/18/2008	0.00	Out	0.00	0	0
7/19/2008	1.35	Out	0.89	0	261
7/20/2008	0.31	Out	0.20	0	1,442

TABLE AIV-1 (Continued): PRECIPITATION AND COMBINED SEWER OVERFLOWS DURING EVENTS 1 THROUGH 4

Date	Precipitation (in)[1]			Combined Sewer Overflow (MG)[2]	
	Gauge 10	Gauge 11	Gauge 12	CSC	CSSC
7/21/2008	0.12	Out	0.11	0	0
7/22/2008	0.00	Out	0.00	0	0
7/23/2008	0.00	Out	0.00	0	0
7/24/2008	0.00	Out	0.00	0	0
7/25/2008	0.00	Out	0.00	0	0
7/26/2008	0.00	Out	0.00	0	0
7/27/2008	0.00	Out	0.00	0	0
7/28/2008	0.00	Out	0.00	0	0
7/29/2008	0.28	0.01	0.26	0	0
7/30/2008	0.13	0.00	0.05	0	0
7/31/2008	0.11	0.12	0.62	0	0
Event 3					
8/11/2008	0.00	0.00	0.00	0	0
8/12/2008	0.00	0.00	0.00	0	0
8/13/2008	0.04	0.00	0.00	0	0
8/14/2008	0.05	0.00	0.00	0	0
8/15/2008	0.00	0.00	0.00	0	0
8/16/2008	0.00	0.00	0.00	0	0
8/17/2008	0.00	0.00	0.00	0	0
8/18/2008	0.00	0.00	0.00	0	0
8/19/2008	0.00	0.00	0.00	0	0
8/20/2008	0.00	0.00	0.00	0	0
8/21/2008	0.00	0.00	0.00	0	0
8/22/2008	0.00	0.00	0.00	0	0
Event 4					
9/22/2008	Out	0.00	0.00	0	0
9/23/2008	Out	0.00	0.00	0	0
9/24/2008	Out	0.00	0.00	0	0
9/25/2008	Out	0.00	0.00	0	0
9/26/2008	Out	0.00	0.00	0	0
9/27/2008	Out	0.00	0.00	0	0
9/28/2008	Out	0.00	0.00	0	0
9/29/2008	Out	0.05	0.06	0	0

TABLE AIV-1 (Continued): PRECIPITATION AND COMBINED SEWER OVERFLOWS DURING EVENTS 1 THROUGH 4

Date	Precipitation (in)[1]			Combined Sewer Overflow (MG)[2]	
	Gauge 10	Gauge 11	Gauge 12	CSC	CSSC
9/30/2008	Out	0.00	0.00	0	0.639
10/1/2008	Out	0.00	0.00	0	0
10/2/2008	Out	0.00	0.00	0	0
10/3/2008	Out	0.01	0.00	0	0

[1]From District rain gauges.
[2]From District M&O.

APPENDIX AV: SIDESTREAM ELEVATED POOL AERATION STATION PUMP DATA

TABLE AV-1: SIDESTREAM ELEVATED POOL AERATION PUMP STATION OPERATION
DURING EVENTS 1 THROUGH 4

Date	SEPA 1			SEPA 2			SEPA 3			SEPA 4			SEPA 5		
	No. Pumps[1]	Flow MGD	DO[2] (mg/L)	No. Pumps	Flow MGD	DO (mg/L)	No. Pumps	Flow MGD	DO (mg/L)	No. Pumps	Flow MGD	DO (mg/L)	No. Pumps	Flow MGD	DO (mg/L)
Event 1															
5/1/08	1	64.8	5.7	1	27.8	7.8	2	163.8	7.5	2	155.2	6.2	1	74.4	5.3
5/2/08	1	64.8	5.7	1	27.8	7.8	2	163.8	6.3	1	77.6	6.9	1	74.4	6
5/3/08	1	64.8	—	1	27.8	—	2	163.8	—	1	77.6	—	1	74.4	—
5/4/08	1	64.8	—	1	27.8	—	2	163.8	—	1	77.6	—	1	74.4	—
5/5/08	1	64.8	5.9	1	27.8	7	2	163.8	6.2	3	232.8	5.6	1	74.4	5.6
5/6/08	1	64.8	8.4	1	27.8	6.8	2	163.8	5.5	3	232.8	5.6	1	74.4	5.7
5/7/08	1	64.8	6.4	1	27.8	7.8	2	163.8	5.2	3	232.8	6.2	1	74.4	6.2
5/8/08	1	64.8	5.6	1	27.8	6.9	2	163.8	5.2	3	232.8	5.7	1	74.4	5.5
5/9/08	0	0	0	1	27.8	6.5	2	163.8	5.2	3	232.8	6.8	1	74.4	5
5/10/08	0	0	—	1	27.8	—	2	163.8	—	3	232.8	—	1	74.4	—
5/11/08	0	0	—	1	27.8	—	2	163.8	—	3	232.8	—	1	74.4	—
5/12/08	0	0	0	1	27.8	7.6	2	163.8	6.9	3	232.8	6.5	1	74.4	5
5/13/08	1	64.8	8.5	1	27.8	7.1	2	163.8	7	0	0	0	1	74.4	5.5
5/14/08	1	64.8	8.4	1	27.8	6.1	2	163.8	6.8	3	232.8	6.7	1	74.4	5.9
5/15/08	1	64.8	8	1	27.8	6.9	2	163.8	6.1	3	232.8	6.9	1	74.4	5
5/16/08	1	64.8	7.7	1	27.8	6.1	2	163.8	6.1	3	232.8	6.6	1	74.4	5.6
5/17/08	1	64.8	—	1	27.8	—	2	163.8	—	3	232.8	—	1	74.4	—
5/18/08	1	64.8	—	1	27.8	—	2	163.8	—	3	232.8	—	1	74.4	—
5/19/08	1	64.8	8	1	27.8	6.4	2	163.8	5.7	3	232.8	6.7	1	74.4	5.3
5/20/08	1	64.8	8.5	1	27.8	7.6	2	163.8	6.3	3	232.8	6.5	1	74.4	5.5
5/21/08	1	64.8	8.2	1	27.8	7.6	2	163.8	6.9	3	232.8	6.4	1	74.4	4.9

TABLE AV-1 (Continued): SIDESTREAM ELEVATED POOL AERATION PUMP STATION OPERATION DURING EVENTS 1 THROUGH 4

Date	SEPA 1			SEPA 2			SEPA 3			SEPA 4			SEPA 5		
	No. Pumps[1]	Flow MGD	DO[2] (mg/L)	No. Pumps	Flow MGD	DO (mg/L)	No. Pumps	Flow MGD	DO (mg/L)	No. Pumps	Flow MGD	DO (mg/L)	No. Pumps	Flow MGD	DO (mg/L)
Event 2															
7/10/08	1	64.8	5.1	1	27.8	8.2	2	163.8	6.5	2	155.2	8.3	2	148.8	5.2
7/11/08	1	64.8	5.2	1	27.8	6.4	2	163.8	5.7	2	155.2	7	2	148.8	5.8
7/12/08	1	64.8	—	1	27.8	—	2	163.8	—	2	155.2	—	2	148.8	—
7/13/08	1	64.8	—	1	27.8	—	2	163.8	—	2	155.2	—	2	148.8	—
7/14/08	1	64.8	5	1	27.8	5.5	3	245.7	5.4	2	155.2	7.4	2	148.8	5.2
7/15/08	1	64.8	8.6	1	27.8	6.3	3	245.7	5.8	2	155.2	7.2	2	148.8	6
7/16/08	1	64.8	8.4	1	27.8	6.7	3	245.7	6	2	155.2	7.5	2	148.8	7.5
7/17/08	1	64.8	8.7	1	27.8	6.7	3	245.7	6.2	2	155.2	7.5	2	148.8	7.5
7/18/08	1	64.8	8.7	1	27.8	6.1	3	245.7	6	2	155.2	7.1	2	148.8	7.6
7/19/08	1	64.8	—	1	27.8	—	3	245.7	—	2	155.2	—	2	148.8	—
7/20/08	1	64.8	—	1	27.8	—	3	245.7	—	2	155.2	—	2	148.8	—
7/21/08	1	64.8	8.7	1	27.8	5.3	3	245.7	5	3	232.8	5.5	2	148.8	5.8
7/22/08	1	64.8	8.7	1	27.8	5.9	3	245.7	5.1	3	232.8	6.2	2	148.8	5.4
7/23/08	1	64.8	8.7	1	27.8	6.3	3	245.7	5.3	3	232.8	7	2	148.8	5.8
7/24/08	0	0	0	1	27.8	7	3	245.7	5.4	3	232.8	6.8	2	148.8	6.9
7/25/08	0	0	0	1	27.8	6.7	3	245.7	5.7	3	232.8	7.1	2	148.8	7.1
7/26/08	0	0	—	1	27.8	—	3	245.7	—	3	232.8	—	2	148.8	—
7/27/08	0	0	—	1	27.8	—	3	245.7	—	3	232.8	—	2	148.8	—
7/28/08	0	0	0	1	27.8	6.3	3	245.7	5.4	2	155.2	6.5	3	223.2	7.2
7/29/08	1	64.8	8.2	1	27.8	7.3	3	245.7	6.6	2	155.2	6.6	3	223.2	5.4
7/30/08	0	0	0	1	27.8	7.3	3	245.7	6.5	2	155.2	5.7	3	223.2	5.2
7/31/08	0	0	7.4	1	27.8	5.6	3	245.7	6.3	2	155.2	5.9	3	223.2	5

TABLE AV-1 (Continued): SIDESTREAM ELEVATED POOL AERATION PUMP STATION OPERATION DURING EVENTS 1 THROUGH 4

Date	SEPA 1			SEPA 2			SEPA 3			SEPA 4			SEPA 5		
	No. Pumps[1]	Flow MGD	DO[2] (mg/L)	No. Pumps	Flow MGD	DO (mg/L)	No. Pumps	Flow MGD	DO (mg/L)	No. Pumps	Flow MGD	DO (mg/L)	No. Pumps	Flow MGD	DO (mg/L)
Event 3															
8/11/08	0	0	0	1	27.8	4.8	2	163.8	5.5	2	155.2	4.8	2	148.8	5.1
8/12/08	0	0	0	1	27.8	6.1	2	163.8	5.6	2	155.2	5.7	2	148.8	5.7
8/13/08	0	0	0	1	27.8	5.9	2	163.8	5.4	2	155.2	5.9	2	148.8	6.1
8/14/08	0	0	0	1	27.8	5.5	2	163.8	5.4	2	155.2	5.9	2	148.8	5.1
8/15/08	0	0	0	1	27.8	5.6	2	163.8	5.4	2	155.2	6.1	2	148.8	6.2
8/16/08	0	0	—	1	27.8	—	2	163.8	—	2	155.2	—	2	148.8	—
8/17/08	0	0	—	1	27.8	—	2	163.8	—	2	155.2	—	2	148.8	—
8/18/08	0	0	0	1	27.8	5.8	2	163.8	5.7	2	155.2	5.9	3	223.2	5.8
8/19/08	0	0	0	1	27.8	6.1	2	163.8	5.7	2	155.2	6.1	3	223.2	5.4
8/20/08	0	0	0	1	27.8	0	2	163.8	5.8	2	155.2	6.4	3	223.2	5.1
8/21/08	1	64.8	8.9	1	27.8	6.2	2	163.8	5.1	2	155.2	6.3	3	223.2	5.4
8/22/08	1	64.8	8.8	1	27.8	6.2	2	163.8	4.3	2	155.2	6	3	223.2	5.8
Event 4															
9/22/08	1	64.8	4.9	1	27.8	5.7	0	0	—	2	155.2	4.7	3	223.2	4.9
9/23/08	1	64.8	5	1	27.8	5.5	0	0	—	3	232.8	5.2	3	223.2	5
9/24/08	1	64.8	4.6	1	27.8	5.5	0	0	—	3	232.8	4.7	3	223.2	4.2
9/25/08	1	64.8	5	1	27.8	5.9	0	0	—	3	232.8	4.7	3	223.2	5.7
9/26/08	1	64.8	5.6	1	27.8	6.8	0	0	—	3	232.8	4.4	3	223.2	4.9
9/27/08	1	64.8	—	1	27.8	—	0	0	—	3	232.8	—	3	223.2	—
9/28/08	1	64.8	—	1	27.8	—	0	0	—	3	232.8	—	3	223.2	—
9/29/08	1	64.8	7	1	27.8	5.7	0	0	—	3	232.8	4.8	3	223.2	5.6

TABLE AV-1 (Continued): SIDESTREAM ELEVATED POOL AERATION PUMP STATION OPERATION DURING EVENTS 1 THROUGH 4

Date	SEPA 1			SEPA 2			SEPA 3			SEPA 4			SEPA 5		
	No. Pumps[1]	Flow MGD	DO[2] (mg/L)	No. Pumps	Flow MGD	DO (mg/L)	No. Pumps	Flow MGD	DO (mg/L)	No. Pumps	Flow MGD	DO (mg/L)	No. Pumps	Flow MGD	DO (mg/L)
9/30/08	1	64.8	7.6	1	27.8	5.9	0	0	—	3	232.8	5.2	3	223.2	5.3
10/1/08	1	64.8	7.5	1	27.8	6.4	0	0	—	3	232.8	5.7	3	223.2	5.6
10/2/08	1	64.8	7.9	1	27.8	7	0	0	—	3	232.8	5.8	3	223.2	5.7
10/3/08	1	64.8	7.8	1	27.8	7.2	0	0	—	3	232.8	5.9	3	223.2	6.3
39724	1	64.8	8.9	1	27.8	8.2	3	245.7	7.5	3	232.8	8.3	3	223.2	7.6

[1]The number of pumps in operation was changed at 7 AM on the weekdays. Pumps operating on Friday were kept operating through the weekend.

[2]The DO was measured at the SEPA station before the pumps using a DO probe. Measurements were taken at 7 AM and are not representative of the whole day.

APPENDIX AVI: CALCULATIONS FOR ESTIMATED OXYGEN TRANSFER, ELECTRICITY USE, AND CARBON DIOXIDE AND OTHER EMISSIONS

CALCULATIONS FOR ESTIMATED OXYGEN TRANSFER, ELECTRICITY USE, AND CARBON DIOXIDE AND OTHER EMISSIONS

Oxygen Transfer

The amount of oxygen transferred to the water by the SEPA stations was calculated using the following equation:

$$O_2 \text{ (lb/day)} = [DO_S \text{ (mg/L)} - DO_O \text{ (mg/L)}] \times 8.34 \text{ (lbs/gal)} \times Q \text{ (mgd)}$$

where DO_S is the DO concentration of the water leaving the SEPA station, assumed to be equal to the DO saturation concentration at the temperature measured at the upstream monitoring station and 1 atm; DO_O is the DO concentration measured at the monitoring station upstream of the SEPA station; and Q is equal to the flow of water going through the SEPA station. The O_2 transferred was calculated daily and the daily values averaged to get the Event average.

Electricity Usage

The estimated amount of electricity used by the SEPA station pumps was calculated based on the power requirements of the screw pumps at the SEPA stations as shown in the following sample calculations:

Electricity Used by One (1) Pump at SEPA 3

Power (motor) = 400 hp = 298.4 kW
Energy Use per Hour= 298.4 kWh/hr
Energy Use per Day = 7,161.6 kWh/day = 7.2 MWh/day

The energy used per day was compared to the average energy use per home. According to the 2005 Residential Energy Consumption Survey conducted by the Energy Information Administration of the United States Department of Energy, one (1) household uses approximately 11 MWh (11,000 kWh) per year, or about 30 kWh per day.

Number of Homes Powered by Energy Used by One (1) Pump at SEPA 3

Energy Use per Day = 7,200 kWh/day
Average Daily Energy Use per Household = 30 kWh/day
Number of Households Powered by 7,200 kWh/day = 240 homes/day

Carbon Dioxide and Other Emissions

The amount of carbon dioxide (CO_2), nitrogen oxides (NO_X) and sulfur dioxide (SO_2) emitted due to the generation of 1 MWh of electricity is estimated to be about 1,219.04, 1.99 and 7.02 lbs, respectively, according to the Environmental Disclosure of Integrys Energy Services Inc., the electricity supplier of the District.

Emissions from Electricity Use of One (1) Pump at SEPA 3

Energy Use per Day = 7,200 kWh/day = 7.2 MWh/day

CO_2 Emitted per MWh = 1,219.04 lbs = 554.11 kg

CO_2 Emitted per Day = 3,989.59 kg = 4.0 metric tons/day

NO_x Emitted per Day = 0.007 metric tons/day

SO_2 Emitted per Day = 0.023 metric tons/day