Metropolitan Water Reclamation District of Greater Chicago

MONITORING AND RESEARCH DEPARTMENT

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ENVIRONMENTAL MONITORING AND RESEARCH DIVISION

2015

ANNUAL REPORT

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Metropolitan Water Reclamation District of Greater Chicago
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ENVIRONMENTAL MONITORING AND RESEARCH DIVISION
2015 ANNUAL REPORT

Monitoring and Research Department
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LIST OF ABBREVIATIONS

AAnO	anoxic, anaerobic, and aerobic zones
ABL	Analytical Bacteriology Laboratory
AEWQ	Aquatic Ecology and Water Quality
AMB	Analytical Microbiology and Biomonitoring
As	arsenic
AWQM	Ambient Water Quality Monitoring
BASTE	Bay Area Sewage Toxics Emission
BMPs	best management practices
BOD_5	five-day biochemical oxygen demand
BU&SS	Biosolids Utilization and Soil Science
CAWS	Chicago Area Waterways System
Cd	cadmium
CIP	Capital Improvement Program
COD	chemical oxygen demand
Combined Plan	dynamic long-term capital plan and Capital Improvement Program
Cr^{+6}	hexavalent chromium
CSD	Controlled Solids Distribution
CSM	Colorado School of Mines
CSO	combined sewer overflow
Cu	copper
District	Metropolitan Water Reclamation District of Greater Chicago
DNA	deoxyribonucleic acid
DO	dissolved oxygen
EBPR	enhanced biological phosphorus removal
EC	*Escherichia coli*
EDSEG	Experimental Design and Statistical Evaluation Group
Egan	John E. Egan
EIML	Environmental, Inc. Midwest Laboratory, Northbrook, Illinois
EM&R	Environmental Monitoring and Research
EQ	exceptional quality
EV	enteric viruses
FC	fecal coliform
GCTs	gravity concentration tanks
H_2S	hydrogen sulfide
HAPs	hazardous air pollutants
HO	helminth ova
HSOW	high-strength organic wastes
IDPH	Illinois Department of Public Health
IEPA	Illinois Environmental Protection Agency
IPCB	Illinois Pollution Control Board
Kirie	James C. Kirie
LC_{50}	lethal dose at the fiftieth percentile
LIFT	Leaders Innovation Forum for Technology
M&O	Maintenance and Operations

LIST OF ABBREVIATIONS (Continued)

M&R	Monitoring and Research
MABR	Membrane-Aerated Biofilm Reactor
MELT	mobile exposure laboratory trailer
MF	membrane filtration
Mg	magnesium
$Mg(OH)_2$	magnesium hydroxide
MGD	million gallons per day
MML	Molecular Microbiology Laboratory
MMO-MUG	orthonitro-phenyl-β-D-galactopyranoside-4-methylumbelliferyl-β-D-glucuronide
MTF	multiple tube fermentation
N	nitrogen
NH_3	ammonia
Ni	nickel
NO_x	nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
NTU	nephelometric turbulence units
O'Brien	Terrence J. O'Brien
OCBs	off-channel bays
ortho-P	orthophosphate
P	phosphorus
PAOs	phosphate-accumulating organisms
Part 503	40 Code of Federal Regulations Part 503 Rule
Pb	lead
pCi	picocuries
PFAA	perfluoroalkyl acids
PFCP	Process Facilities Capital Planning
PFCs	perfluorinated compounds
PFRP	process to further reduce pathogens
PHB	poly-β-hydroxybutyrate
PL	Parasitology Laboratory
Plan	dynamic long-term capital plan
Poly-P	polyphosphate
POTW	publicly owned treatment works
ppmv	parts per million by volume
PS	primary sludge
QAPPs	quality assurance project plans
RAS	return activated sludge
RTTs	reference toxicant tests
SBCR	South Branch Chicago River
SCBNR	shortcut biological nitrogen removal
SMAs	solids management areas
SOPs	standard operating procedures
SS	suspended solids

LIST OF ABBREVIATIONS (Continued)

SVI	sludge volume index
TARP	Tunnel and Reservoir Plan
TC	total coliform
TCR	Thornton Composite Reservoir
TP	total phosphorus
UAA	Use Attainability Analysis
UDP	Upper Des Plaines
USEPA	United States Environmental Protection Agency
VFAs	volatile fatty acids
VL	Virology Laboratory
VSS	volatile suspended solids
WAS	waste activated sludge
WASSTRIP®	Waste Activated Sludge Stripping to Remove Internal Phosphorus®
WEF	Water Environment Federation
WERF	Water Environment Research Foundation
WET	whole effluent toxicity
WML	Wastewater Microbiology Laboratory
WRP	water reclamation plant
WTPR	Wastewater Treatment Process Research
Zn	zinc

ACKNOWLEDGMENTS

This 2015 Annual Report is the result of the efforts of not only the scientists, microbiologist and biologists, who perform the monitoring and research initiatives of the Department, but also the impressive efforts of support staff and other personnel who contribute their valuable time, energy, and know-how to the production of the report. These individuals deserve special recognition and thanks. Special thanks are due to Ms. Marie Biron for her formatting skills, zealous adherence to the Monitoring and Research Department formatting guidelines, responsiveness to turnaround times, and dedication to moving the report forward.

DISCLAIMER

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

STRUCTURE AND RESPONSIBILITIES OF THE ENVIRONMENTAL MONITORING AND RESEARCH DIVISION

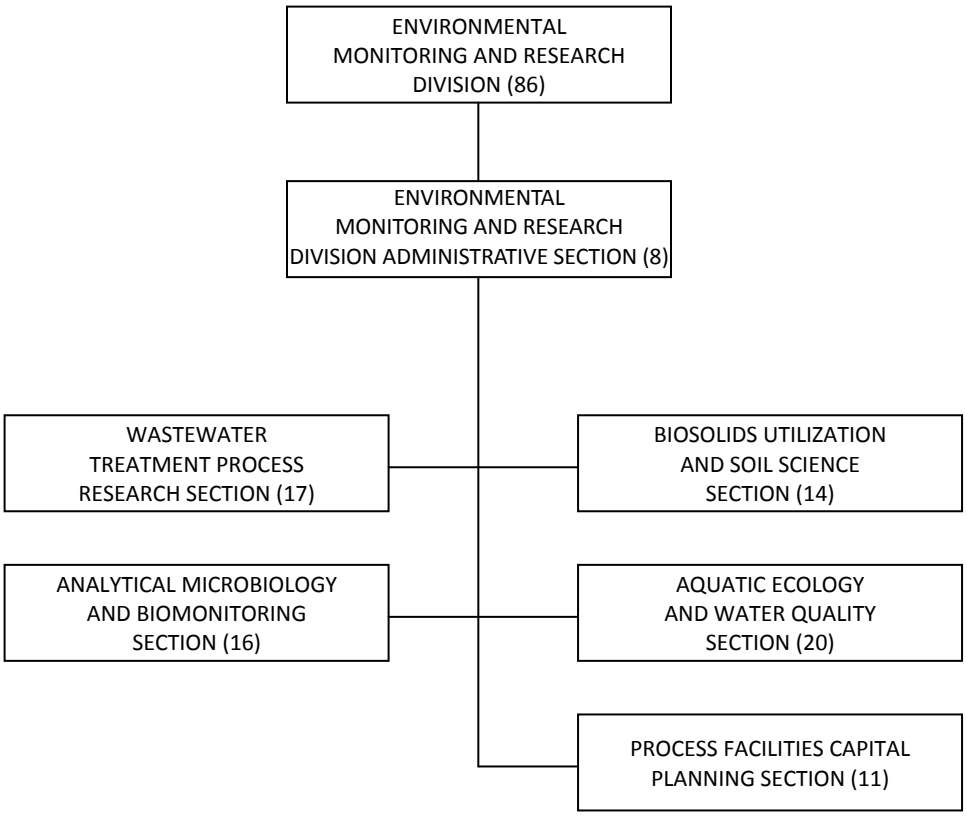
The Environmental Monitoring and Research (EM&R) Division had 86 employees in 2015, and comprises six Sections. These are illustrated in Figure 1 and Appendix I. The six Sections are:

1. Administrative.
2. Wastewater Treatment Process Research (WTPR).
3. Biosolids Utilization and Soil Science (BU&SS).
4. Analytical Microbiology and Biomonitoring (AMB).
5. Aquatic Ecology and Water Quality (AEWQ).
6. Process Facilities Capital Planning (PFCP).

The major areas of focus of the Division were as follows:

- Monitoring the environmental quality of Lake Michigan and area rivers and canals to document the effectiveness of the Metropolitan Water Reclamation District of Greater Chicago's (District's) wastewater treatment operations.
- Assisting in the resolution of sewage treatment and solids management operation problems.
- Providing technical assistance to other departments and agencies on issues related to wastewater treatment; combined sewer overflow (CSO) management; waterways management; and solids processing, utilization, and marketing.
- Conducting operations and applied research to achieve improvement and cost reductions in District wastewater treatment, waterways management, and solids processing and biosolids utilization activities.
- Assessing the impacts of new or proposed regulations on District activities.
- Preparing environmental monitoring reports to regulatory agencies to ensure compliance with requirements of the Tunnel and Reservoir Plan (TARP), water reclamation plant (WRP) National Pollutant Discharge Elimination System (NPDES) permits, biosolids processing and utilization permits, and other operation permits.

FIGURE 1: ENVIRONMENTAL MONITORING AND RESEARCH DIVISION ORGANIZATION CHART



- Identifying the District's capital infrastructure needs, ensuring their alignment with the District's Strategic Plan, and developing a long-term process facilities capital plan.

During 2015, the EM&R Division participated in numerous meetings and seminars (Appendix II), presented several papers, PowerPoint presentations, and poster presentations (Appendix III), and also published several papers (Appendix IV).

OVERVIEW OF SECTIONS OF THE ENVIRONMENTAL MONITORING AND RESEARCH DIVISION

Administrative Section

The Administrative Section provides technical guidance, scientific review, and administrative support for the work done by EM&R Division staff. The Section also organizes a monthly seminar series, open to all District employees and the interested public through prior registration, which presents information on areas of interest to the District operations. In 2015, a total of 2,045 people attended these seminars. A list of the seminar topics is shown in Appendix V.

In addition to the overall administrative and supervisory functions performed by the Administrative Section, the Experimental Design and Statistical Evaluation Group (EDSEG), provided support to the rest of the EM&R Division.

Experimental Design and Statistical Evaluation Group. The EDSEG is responsible for providing assistance in the design of laboratory and full-scale experiments, collection of appropriate data, development of guidelines for data collection methodology, and statistical analyses. Personnel in this Group also develop multistage automation programs to interconnect different software programs such as LATEX, Visual Basic, SAS, Access, Excel, Outlook, and PowerPoint. This computer automation has enabled the Group to format and produce reports, tables, and texts more efficiently.

In 2015, the EDSEG provided statistical and computing support to various projects. The following is a description of some of the activities.

- Database support, evaluation, and maintenance for the various monitoring programs such as Chicago Area Waterways System (CAWS), TARP, dissolved oxygen (DO) monitoring programs.

- Created 30 new functions in SAS and Visual Basic, routines to produce graphics, perform matrix algebra operations and other statistical functions that can be used as substitute for SAS functions such as SAS IML and Graphic software.

- Summarized results of the District's Ambient Water Quality Monitoring (AWQM) Program for the CAWS.

- Provided support to the AEWQ Section on the production of the annual Continuous DO Monitoring Reports (Deep-Draft and Wadeable).

- Provided statistical analysis support to the WTPR Section and other sections in the Division on many research and monitoring projects.

- Provided support to meet requirements under the Freedom of Information Act.

- Prepared numerous statistical analyses and data summaries to respond to Illinois Environmental Protection Agency (IEPA) regulatory issues.

Wastewater Treatment Process Research Section

The WTPR Section's mission is to provide technical support and perform research in light of the District's initiatives and strategic plan goals. The WTPR's role is to:

- Provide technical support to the Maintenance and Operations Department (M&O), Engineering Department, and the Process Facilities Capital Planning Section.

- Conduct applied research on both current treatment processes and new technologies.

- Conduct required regulatory monitoring.

- Review and develop technical information for imminent regulation.

- Solve WRP operating problems and generate new information on wastewater treatment processes.

- Review plans and specifications at the request of Engineering to optimize process design criteria.

- Investigate innovative treatment processes for potential future use .

- Study new technologies to address maximizing the operation and cost efficiencies of existing processes and develop new processes.

Biosolids Utilization and Soil Science Section

The role of the BU&SS Section is the application of science for continuous improvement in the cost effectiveness of the District's biosolids management, TARP groundwater monitoring, and environmental stewardship through:

- Research, technical assistance, and public outreach.

- Contribution to formulation of and compliance with relevant regulations.

- National leadership in biosolids management.

- Assistance on the District's green initiatives.

- Technical assistance on the District's initiative to produce a value-added product by co-composting woodchips with biosolids.

The long-range goals of the BU&SS Section are to:

- Conduct environmental monitoring and reporting to comply with permits and regulations governing the District's biosolids management program and the TARP.

- Conduct applied research aimed at evaluating the benefits and environmental impacts of land application of biosolids and composted biosolids.

- Promote the beneficial, local use of biosolids and composted biosolids by showcasing benefits and performance of using biosolids and composted biosolids and through dissemination of information, demonstrations, public relations, and technical support to users.

- Monitor and review regulations and relevant issues to evaluate the impacts on the District's operations and assist with the development of technically sound regulations.

- Provide technical support on green initiatives relevant to the District's operations.

Analytical Microbiology and Biomonitoring Section

The Analytical Microbiology and Biomonitoring (AMB) Section's mission is to provide on-time, high-quality, cost-effective microbiological monitoring and research services to support the Monitoring and Research (M&R) Department's five program goals. The AMB Section's role is to:

- Conduct microbiological monitoring of liquid and solids for operational control and regulatory reporting requirements and to assess the environmental impacts of District operations.

- Provide monitoring support to various District operations (disinfection, nutrient removal, biosolids and stormwater management) to fulfill regulatory requirements such as meeting the CAWS recreational use attainment.

- Promote employee self-development, education, public awareness, and participation in the District's outreach activities.

The AMB Section has been certified by the Illinois Department of Public Health (IDPH) for the bacterial analysis of water since 1979 and is equipped with the latest technologies and highly knowledgeable professionals and technical staff. The Section is organized into the following five separate laboratories:

1. Analytical Bacteriology Laboratory (ABL).

2. Wastewater Microbiology Laboratory (WML).

3. Parasitology Laboratory (PL).

4. Virology Laboratory (VL).

5. Molecular Microbiology Laboratory (MML).

During 2015, the AMB Section performed the following activities to improve its operations and achieve its goals:

- Maintained its IDPH certification of the ABL, Registry No. 17508, for the examinations of:

    1. Heterotrophic bacteria, heterotrophic plate count.

    2. Total coliform (TC) with *Escherichia coli* (EC) broth verification examination of water from public water supplies and their sources (membrane filtration [MF] and multiple tube fermentation [MTF]).

    3. Fecal coliform (FC) examination of water from public water sources (MF and MTF).

    4. TC and EC examination of samples of water from public water supplies and their sources (minimal medium, orthonitro-phenyl-β-D-galactopyranoside-4-methylumbelliferyl-β-D-glucuronide [MMO-MUG]).

- Ensured laboratory personnel training by completing the demonstration of capability, which enables them to perform analyses according to the laboratory standard operating procedures (SOPs) and quality assurance project plans (QAPPs).

- Monitored the routine operational performance of the laboratory through participation in appropriate performance evaluation and/or inter-laboratory testing programs and provided for corrective actions as necessary.

- Updated SOPs and QAPPs, and implemented Quality Assurance policies and essential applicable Quality Control procedures to assure test validity.

- Increased the number of analyses that can be performed to more efficiently support the District's core monitoring and research programs.

- Fostered a "zero defects" commitment or course of action for all staff. This commitment seeks to produce analytical data and services of the highest quality.

During 2015, the AMB Section laboratories provided microbiological, analytical, and technical support to various projects under the EM&R Division program goals. Figure 2 shows a summary of the number of analyses provided under each program. The AMB Section laboratories conducted a total of 6,142 microbial analyses. The ABL operations moved to the Trailer Laboratory in August without any delay or disruption in analyses. The ABL trailer laboratory passed the IDPH certification for bacteriological analyses.

Aquatic Ecology and Water Quality Section

The mission of the AEWQ Section is to provide scientific and technical support to assess the waterways impacted by the District's wastewater treatment operations. The goals of the section are to:

- Assess the water and sediment quality in waterways in the District's service area and in other waterways impacted by flow from this service area in order to inform policy, guide and assess regulatory developments, and support and improve operations.

- Conduct biological and physical habitat monitoring in order to evaluate the health of waterways and assess changes in waterway conditions over time, especially those associated with District operations.

- Conduct whole effluent toxicity (WET) tests on District effluents in accordance with NPDES permits to monitor and evaluate the final effluents for any adverse effects to aquatic life.

- Perform laboratory chlorophyll analysis on the samples collected at AWQM stations.

- Design and conduct research projects to address potential changes in District operations, such as effluent disinfection and phosphorus (P) removal.

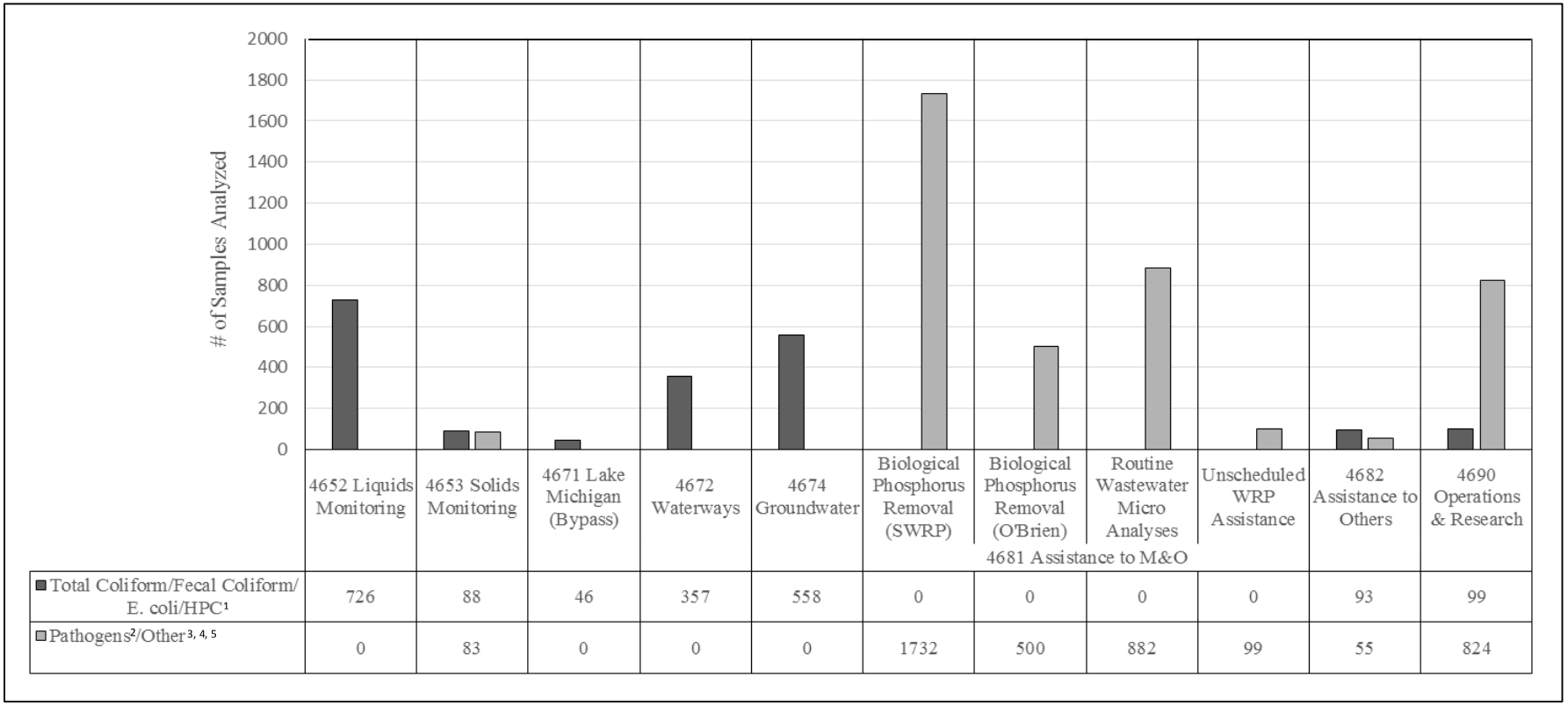
- Design and conduct research projects to explore emerging issues in water quality and treatment.

- Participate in regulatory review of water-quality related standards and documents, including attendance at regulatory hearings and stakeholder meetings relevant to District operations.

- Collaborate with other governmental and non-governmental agencies and academic institutions to develop water quality and aquatic ecology research projects.

- Review plans for stormwater improvement construction projects on small streams and recommend biologically sound implementations.

FIGURE 2: TOTAL NUMBER OF ANALYSES PERFORMED BY THE ANALYTICAL MICROBIOLOGY LABORATORY IN 2015



	4652 Liquids Monitoring	4653 Solids Monitoring	4671 Lake Michigan (Bypass)	4672 Waterways	4674 Groundwater	Biological Phosphorus Removal (SWRP)	Biological Phosphorus Removal (O'Brien)	Routine Wastewater Micro Analyses	Unscheduled WRP Assistance	4682 Assistance to Others	4690 Operations & Research
Total Coliform/Fecal Coliform/ E. coli/HPC[1]	726	88	46	357	558	0	0	0	0	93	99
Pathogens[2]/Other[3, 4, 5]	0	83	0	0	0	1732	500	882	99	55	824

[1]HPC = Heterotrophic Plate Count.

[2]*Salmonella, enteric virus, and Ascaris ova* (Helminth Ova).

[3]Filamentous bacteria, zooglea, shelled protozoa, and phosphorus accumulating organism (PAO).

[4]Coliphage, conductivity, UV transmittance, and turbidity analyses for WERF-UV project, biofilm analyses for Zeelung project, and mold assessment for safety support.

[5]Microbial Source Tracking project analyses and quantitative polymerase chain reaction PAO research.

Process Facilities Capital Planning Section

The mission of the Process Facilities Capital Planning (PFCP) Section is to facilitate the long-term capital planning process to ensure alignment with the District's Strategic Plan by addressing anticipated regulations, District business initiatives and community service level expectations. The goals of the section are to:

- Identify and prioritize areas for research to obtain data for evaluating infrastructure needs and capital projects.
- Utilize data to define and justify capital projects and programs.
- Develop and manage the District Odor Mitigation Strategy, which defines conceptual projects addressing areas of need.
- Develop and manage the District Biosolids Strategy which defines conceptual projects addressing areas of need.
- Assist the M&O Department in addressing technical issues to achieve excellence.

SUMMARY OF ENVIRONMENTAL MONITORING AND RESEARCH DIVISION ACTIVITIES DURING 2015

During 2015, the EM&R Division performed activities under the following five program areas:

Program 1: Operations Monitoring (4650) – Monitor liquid and solids process trains and air quality for operational control and regulatory reporting requirements and compliance.

Program 2: Waste Monitoring (4660) – Monitor and control waste discharged into District's sewage collection system.

Program 3: Environmental Monitoring (4670) – Monitor the environmental impacts of District operations to assess compliance with all regulations and properly assess the impacts of District operations in a cost-efficient manner.

Program 4: Technical Assistance (4680) – Evaluate process control and monitoring information to improve process efficiency, inform design, and support effective regulatory developments.

Program 5: Operations and Applied Research (4690) – Conduct applied and operations research to achieve improvement and cost reductions in District wastewater treatment, waterways management, and solids processing activities.

Program 1: Operations Monitoring

Levels of Radioactivity in Raw and Treated Wastewaters. Radiological monitoring of raw wastewater and final effluent samples from the District's seven WRPs continued in 2015. The Illinois Pollution Control Board (IPCB) has established General Use Water Quality Standards for radioactivity in the waters of Illinois. According to IPCB regulations (Title 35, Chapter 1, Section 302.207), gross beta concentration shall not exceed 100 picocuries (pCi)/L, and the strontium-90 concentration must not exceed 2 pCi/L. The annual average combined concentration of radium-226 and -228 must not exceed 3.75 pCi/L in General Use waters.

The analysis of gross alpha and beta concentrations was conducted on 24-hour composite samples of raw sewage and final effluent collected monthly at all WRPs. The samples were analyzed by Environmental, Inc. Midwest Laboratory, Northbrook, Illinois (EIML). The data will be presented in the 2015 Radiological Annual Report.

Biosolids and Plant Odor Monitoring Program. The WTPR Section conducts an Odor Monitoring Program evaluating the intensity of odors at its facilities. During 2015, WTPR, in collaboration with the M&O Department, monitored unit processes at the Stickney and Calumet WRPs as well as biosolids drying areas for odors. Odor conditions were reported to the

respective plant managers for the biosolids areas. Table 1 summarizes the results of the 2015 odor monitoring program for the biosolids areas. The monitoring results were summarized in M&R numbered report 16-39.

Estimation of Emission of Hazardous Air Pollutants. Part A, Title I, of the Clean Air Act, states that a publicly owned treatment works (POTW) is considered a major source of hazardous air pollutants (HAPs) if it emits or has the potential to emit 10 tons per year or more of any single HAP or 25 tons per year or more of any combination of HAPs. Samples of the influent sewage to each of the District's WRPs are collected twice per year and analyzed for 65 of the HAP compounds of concern to POTWs. Emissions of these HAPs from the wastewater treatment process units (grit chamber, primary settling tanks, aeration tanks, and secondary settling tanks) are estimated using the Bay Area Sewage Toxics Emission (BASTE 4) computer model developed by CH2M. The average concentration of each HAP detected in the influent sewage and the annual running average operating conditions were used as input to the model. The physical properties, such as vapor pressure and molecular weight of the individual compounds, were taken from the United States Environmental Protection Agency (USEPA) database for use in the model as well. During 2015, influent samples were collected in January and August. The average influent concentrations and estimated emissions of the HAPs are presented in Table 2 for the three largest District WRPs (Calumet, Terrence J. O'Brien [O'Brien], and Stickney).

According to the BASTE model, all the individual HAP emissions were less than the ten tons/year criterion. Toluene was the predominant compound emitted from the wastewater treatment processes at the Stickney WRP. Styrene was the predominate compound emitted from the Calumet WRP. Chloroform was the predominant compound emitted from the O'Brien WRP. The total measured HAP emissions were substantially less than the 25 tons/year threshold at each of the three WRPs. Therefore, the wastewater treatment process units at the District's WRPs are not considered major sources of HAPs. Additionally, the annual HAPs report was filed as part of the IEPA's Environmental Emissions Reduction Market System.

John E. Egan Water Reclamation Plant Air Quality Permit. As part of the John E. Egan (Egan) WRP's Federally Enforceable State Operating Permit, monthly hydrogen sulfide (H_2S) monitoring was performed at the facility's compressor room. The monthly permit limit for the digester H_2S is 1,000 parts per million by volume (ppmv). In 2015, there was no permit violation with respect to H_2S concentration in the Egan WRP digester gas.

Monitoring and Reporting for the Biosolids Management Program. The Division conducted the following activities under the District's biosolids management program:

- Biosolids Monitoring Under Process to Further Reduce Pathogens Certification. The District maintains certification of a site-specific process to further reduce pathogens (PFRP) for biosolids processing trains at the Stickney and Calumet WRPs, as awarded by the USEPA. In this certification, the District's air-dried biosolids generated according to a codified operation are designated as Class A according to pathogen standards under the USEPA 40 Code of Federal Regulations Part 503 Rule (Part 503). The monitoring program for this certification includes pathogen analysis of biosolids and

TABLE 1: 2015 ROUTINE ODOR MONITORING RESULTS OF METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO BIOSOLIDS MANAGEMENT AREAS

Solids Management Area[1]	Departments Participating[2]	Total Number of Observations	Number of Observations Odors were Detected			Number Non-Detects[3]	Percent Non-Detects
			Very Strong	Strong	Easily Noticeable		
CALSMA	M&R	239	0	6	56	177	74
	M&O	440	0	0	14	426	97
HASMA and LASMA	M&R	519	2	10	114	393	76
RASMA[4]	M&R	112	0	0	14	98	88
Stony Island SDA	M&R	108	0	0	5	103	95

[1]CALSMA = Calumet WRP SMA; HASMA = Harlem Avenue SMA; LASMA = Lawndale Avenue SMA (includes Vulcan and Marathon areas); RASMA = Ridgeland Avenue SMA.
[2]M&R = Monitoring and Research and M&O = Maintenance and Operations Departments, respectively.
[3]Non-detects are all observations of faint, very faint, or no odor.
[4]RASMA was not used as a biosolids drying site during 2015.

TABLE 2: INFLUENT CONCENTRATIONS AND ESTIMATED EMISSIONS OF HAZARDOUS AIR POLLUTANT CONCENTRATIONS AT THE CALUMET, STICKNEY, AND TERRENCE J. O'BRIEN WATER RECLAMATION PLANTS IN 2015

Hazardous Air Pollutant Organic Compound	Concentrations (µg/L)[1]			Emissions (tons/year)[2]		
	Stickney	Calumet	O'Brien	Stickney	Calumet	O'Brien
Acetaldehyde	53.30	0.00	0.00	1.19	0.00	0.00
Acetophenone	0.00	2.33	0.00	0.00	0.00	0.00
Chloroform	1.24	0.00	2.67	0.68	0.00	0.61
Cresol	12.90	0.00	22.33	0.00	0.00	0.01
Cumene	0.00	3.15	0.00	0.00	0.03	0.00
Dichloromethane	0.00	1.01	1.81	0.00	0.01	0.23
Ethylbenzene	0.00	0.00	0.00	0.33	0.00	0.00
Methyl ethyl ketone, 2 butanone (MEK)	0.16	0.00	0.00	0.05	0.00	0.00
Propionaldehyde	20.17	0.00	0.00	0.45	0.00	0.00
Styrene	0.72	7.48	2.78	0.21	0.17	0.31
Toluene	7.20	1.51	2.03	3.18	0.05	0.30
Xylene	0.00	0.00	1.50	1.83	0.00	0.22
Acetaldehyde	53.30	0.00	0.00	1.19	0.00	0.00

[1]Average results of two influent samples collected in January and August 2015.
[2]Emissions estimated using the Bay Area Sewage Toxics Emissions (BASTE) Model.

annual reporting to the USEPA. The PFRP certification was renewed in 2012, and the certification period increased from two years to five years.

- Pathogen monitoring. The District utilizes its exceptional quality (EQ) lagoon-aged, air-dried biosolids in the Chicago metropolitan area under a Controlled Solids Distribution (CSD) Program under a permit issued by the IEPA. The AMB Section laboratories conducted analyses of biosolids for FC bacteria, viable *Ascaris* ova (helminth ova [HO]), and culturable enteric viruses (EV) as required to demonstrate compliance with the Part 503 regulations for Class A pathogen criteria of the EQ standard. During 2015, biosolids analysis under the program included 88 samples for FC analysis and 83 samples (including positive and negative quality controls) for HO and culturable EV analyses.

In 2015, the EM&R Division prepared the following regulatory reports under the biosolids management program:

- The 2014 Biosolids Management Report to the USEPA – This report (Report No. 15-09) was prepared to satisfy the reporting requirements of the Part 503 regulation.

- Four quarterly reports for the CSD permit were submitted to the IEPA (M&R Department Reports 15-01, 15-10, 15-31, and 15-37). The reports document the biosolids users, project descriptions and locations, and biosolids analyses.

National Pollutant Discharge Elimination System Effluent Biomonitoring. The AEWQ and AMB Sections conducted the following monitoring to satisfy the requirements of the NPDES permits issued to the District WRPs.

- Biomonitoring – Under the special conditions of the District WRPs' NPDES permits, the following acute tests were conducted: (1) fish (Fathead minnows) – 96 hour static lethal dose at the fiftieth percentile (LC_{50}) bioassay, and (2) invertebrate (*Ceriodaphnia dubia*) – 48-hour static LC_{50} bioassay, known as the WET test, to monitor and evaluate the District WRPs' effluents for toxicity to aquatic life. One acute WET test on the Egan WRP effluent and one acute WET test on the Lemont WRP effluent were conducted for NPDES permit compliance. No acute toxicity was observed. The acute WET test method and procedures were in accordance with the USEPA's established protocol following an approved SOP and QAPP. For each test performed, ongoing laboratory quality performance was evaluated by performing reference toxicant tests (RTTs) using sodium chloride. All RTTs were performed using the laboratory control water under test conditions identical to NPDES permit required tests. Laboratory staff maintains quality control charts using RTT data from the most recent twenty tests. All twenty RTTs conducted were valid. The Aquatic Ecology Laboratory participated in the Discharge Monitoring Report Quality Assurance Program, established by the USEPA, by conducting toxicity tests of unknown samples. The results were within the acceptable ranges.

- Fecal Coliform Monitoring – Membrane filtration analyses of FC bacteria was conducted to monitor the District's WRP effluents as required by their respective NPDES permits and to guide treatment operations. This included FC bacteria monitoring of the final treated effluent samples from each of the District's seven WRPs one day per week per WRP, and five days per week per WRP during disinfection season (May to October) for three WRPs. The ABL performed FC analyses on a total of 726 samples from the District's seven WRPs. The FC analysis results were reported to the M&O Department. As required in the NPDES permits, additional monitoring is done when rain storm events cause excess flow above the treatment capacities of the WRPs, which result in discharge of untreated and/or wet weather treated effluent to the receiving streams. Microbiological analytical support to the Egan WRP wet weather excess flow, as well as the Lemont WRP's Wet Weather Treatment facility, required FC analyses were provided for nine samples. In anticipation of disinfection at the Calumet WRP, the ABL provided FC and EC testing of treated effluent samples at various times in October, November, and December to ensure that the effluent NPDES permit limits would be met.

- Addressing the USEPA Changes to the Recreational Water Quality Bacteria Criteria Methods – In response to 2012 USEPA changes to the recreational water quality standards to adopt the modified mTEC method for EC bacteria, the AMB Section evaluated the CAWS and final effluent samples by membrane filtration onto two different media: mFC agar (Standard Method, 922D) for FC determination and modified mTEC agar (USEPA Method 1603) for EC growth. The comparison of FC and EC membrane filtration methods were performed on samples collected from 13 CAWS sites and from the O'Brien and Calumet WRPs; data for a total of 173 samples collected for the comparison in 2013 through 2014 were statistically analyzed to determine a relationship between the two methods. The EC and FC data were log-transformed then correlation analysis was performed between the methods for each river system by the O'Brien and Calumet WRPs. The correlation of equality was weak when the river systems and two WRPs were compared to each other. Therefore, the river systems and WRPs were analyzed independently for EC prediction from the FC data. The equation generated from this study (Table 3) can be used if the IEPA moves forward with adoption of the new EC Recreational Water Quality standards.

- In 2015, the final effluent samples were analyzed by three different media – mFC agar for FC determination, and modified mTEC agar and MPN analysis with Quanti-Tray® 2000 (IDEXX Laboratories, Westbrook, Maine) for EC growth. The final disinfected effluent samples were collected from the Egan, Hanover Park, and James C. Kirie (Kirie) WRPs, and secondary treated effluent from O'Brien and Calumet WRPs for comparison. The FC and EC comparison results were shared with the IEPA (Table 4). The FC and EC data comparison will continue in 2016 after the implementation of disinfection systems at the Calumet and O'Brien WRPs is complete. This will ensure that the AMB Section laboratory is adequately staffed and that staff is sufficiently

TABLE 3: ESTABLISHMENT OF FECAL COLIFORM AND ESCHERICHIA COLI RELATIONSHIP (REGRESSION) IN THE CALUMET AND TERRENCE J. O'BRIEN WATER RECLAMATION PLANTS AND RIVERS AND TEST FOR THE EQUALITY OF REGRESSIONS

Source		Regression Estimate			Fit	Test Criteria			
Name	Site	Intercept	Slope	Equation: EC*	RSQ*	DF[1]	DF[2]	F[3]	P[4]
Plant	Calumet	0.213	0.910	1.634*(FC)^0.91	0.889	2	139	2.686	0.072
	O'Brien	0.428	0.866	2.682*(FC)^0.866	0.881	2	139	2.686	
	Both	0.247	0.906	1.767*(FC)^0.906	0.900	2	139	2.686	
River	Calumet	-0.009	0.946	0.98*(FC)^0.946	0.958	2	192	0.919	0.401
	Chicago	-0.065	0.974	0.861*(FC)^0.974	0.968	2	192	0.919	
	Both	-0.047	0.964	0.898*(FC)^0.964	0.964	2	192	0.919	
All	All	-0.068	0.978	0.855*(FC)^0.978	0.971	6	331	2.616	0.017

EC=10^(intercept)(FC)^{slope} (FC and EC data were log-transformed).
[1]Numerator degrees of freedom for testing equality of two regressions.
[2]Denominator degrees of freedom for testing equality of two regressions.
[3]F-Statistics for the test.
[4]Significance probability for testing the hypothesis H_0: all regressions are same.

TABLE 4: ESCHERICHIA COLI AND FECAL COLIFORM DATA FOR THREE DISINFECTED AND TWO NON-DISINFECTED EFFLUENTS OF METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGOWATER RECLAMATION PLANTS

Water Reclamation Plant	Geometric Mean (CFU or MPN/100 mL) FC[1]	EC	EC/FC[2] Ratio	EC Method
Disinfected (Chlorination-Dechlorination)				
John E. Egan WRP	1.00	1.00 13.03	1.00 1.50	[mf]*E. coli* - EPA 1603[3] IDEXX Quanti-Tray, 24h (MPN)
Hanover Park WRP	8.00	8.14 43.77	1.02 1.63	[mf]*E. coli* - EPA 1603 IDEXX Quanti-Tray, 24h (MPN)
James C. Kirie WRP	2.02	1.95 1.49	0.96 22.00	[mf]*E. coli* - EPA 1603 IDEXX Quanti-Tray, 24h (MPN)
Non-Disinfected (Secondary treated effluent[4])				
Terrence J. O'Brien WRP	14,768	11,053	0.74	[mf]*E. coli* - EPA 1603
Calumet WRP	8,287	6,037	0.73	[mf]*E. coli* - EPA 1603

[1]All FC analyses performed by mFC membrane filtration method (Standard Methods 9222D).
[2]EC/FC denotes geometric mean ratio of EC and FC.
[3] [mf] = membrane filtration.
[4]Data collected in 2013-2014.

trained, and will allow the District to further understand the performance goal achievable to meet NPDES compliance.

Program 2: Waste Monitoring

There is no activity to report under this Program for 2015.

Program 3: Environmental Monitoring

Fulton County Environmental Monitoring. The Fulton County Land Reclamation Site consists of 5,568 hectares (13,758 acres) of land the District owns in Fulton County, Illinois. The site was used to recycle biosolids for the purpose of reclaiming mine soil and fertilizing agricultural crops. To satisfy the IEPA permit requirements for operation of the site, the District established an environmental monitoring program to ensure that the land application of biosolids would not adversely affect surface water, groundwater, soils, and crops. The last application of biosolids at the site was done in 2004. As of 2007, all monitoring and reporting for soil, crop, and surface and groundwater at the site was terminated as approved by the IEPA until biosolids application resumes.

On a discretionary basis, samples of soil, plant tissue, groundwater, and surface water from a few locations at the site are collected every two years to add soil and plant tissue samples to the repository and add data to the historical database for the site. The M&O Department staff located at the Fulton County site assists the EM&R Division staff with the sampling. The water samples are analyzed, but soil and plant tissue samples are stored without analysis.

Hanover Park Fischer Farm. The Hanover Park Fischer Farm is a 48-hectare (120 acre) site located on the south side of the Hanover Park WRP, which utilizes all biosolids generated at the WRP. The farm has seven gently sloping fields, each surrounded by a berm to control surface runoff. Anaerobically digested biosolids are applied by subsurface injection. The IEPA operating permit (No. 2012-SC-2255) for the site limits the annual biosolids application rate to 56 dry Mg/ha (25 dry tons/acre). An underground tile drain system collects surface and subsurface drainage, which is returned to the Hanover Park WRP for treatment. Groundwater monitoring is required by the IEPA operating permit. Monitoring wells on the farm are sampled quarterly, except Well No. 7, which is monitored monthly. The 2014 groundwater monitoring data were submitted to the IEPA in the quarterly monitoring reports (M&R Department Report Nos. 15-08, 15-13, 15-29, and 15-42).

Groundwater Quality Monitoring at Solids Management Areas. Groundwater quality is monitored at the solids management areas (SMAs)where paved cells are used for air-drying of lagoon-aged or centrifuge cake biosolids to a solids content of 60 percent or greater. The monitoring frequency for groundwater quality at the SMAs is quarterly. The SMAs include the following six sites:

- John E. Egan WRP Solids Management Area – Currently, biosolids drying is not done on this site. The IEPA operating permit (No. 2015-AO-2196) does

not require groundwater monitoring or reporting unless drying resumes at the site.

- Calumet WRP Solids Management Area – This SMA consists of the Calumet West and East SMAs. The IEPA operating permit (No. 2015-AO-59622) requires quarterly sampling of lysimeters for groundwater monitoring. The 2014 groundwater monitoring data were submitted to the IEPA in report nos. 15-14, 15-18, 15-30,15-39, and 16-07).

- Lawndale Avenue Solids Management Area – The IEPA operating permit for this site (No. 2015-AO-59623) requires quarterly sampling of lysimeters for groundwater monitoring. The 2015 groundwater monitoring data were submitted to the IEPA in report nos. 15-16, 15-27, 15-40 and 16-10.

- Ridgeland Avenue Solids Management Area – Currently, biosolids drying is not done on this site. The IEPA operating permit (No. 2015-AO-59623) does not require groundwater monitoring or reporting unless drying resumes at the site.

- Harlem Avenue Solids Management Area – The IEPA operating permit for this site (No. 2014-AO-58836) requires quarterly sampling of lysimeters for groundwater monitoring. The 2015 groundwater monitoring data were submitted to the IEPA in report nos. 15-15, 15-28, 15-41 and 16-08).

- 122nd and Stony Island Solids Management Area – Currently, biosolids drying is not done on this site. The IEPA operating permit for this site (No. 2015-AO-59623) requires quarterly sampling of lysimeters for groundwater monitoring. The 2015 groundwater monitoring data were submitted to the IEPA in report nos. 15-17, 15-26, 15-38 and 16-09).

Tunnel and Reservoir Plan Groundwater Monitoring. The IEPA requires groundwater monitoring and annual reporting for the District's six TARP systems, which includes the Mainstream, Calumet, Des Plaines, and Upper Des Plaines (UDP) Tunnel Systems, Thornton Transitional Flood Control Reservoir, and Gloria Alitto Majewski Reservoir (Report nos. 15-20, 15-21, 15-22, 15-23, 15-24, and 15-25, respectively). After each reservoir fill event resulting from storm events, the reservoirs are sampled and weekly thereafter, during the period that the stormwater remains in the reservoir. The groundwater monitoring program includes over 150 groundwater wells adjacent to the tunnels and reservoirs to monitor the potential for groundwater contamination through extrusion of combined sewage overflows. The wells are monitored three to six times per year, and all samples for general chemistry are analyzed by the Analytical Laboratories Division, and FC by the Analytical Microbiology Laboratory (AML). A total of 557 samples were collected in 2015 and analyzed for all permit-required analytes, including FC bacteria.

The Thornton Composite Reservoir (TCR) was placed into operation in September 2015. After each TCR fill event resulting from storm events, seven wells surrounding the reservoir were sampled and biweekly thereafter, during the period that the stormwater remains in the

reservoir. The monitoring program for the TCR also includes the reservoir water that is monitored annually. During 2015, there was one fill event and the required sample collection and analyses were done by a contractor. The EM&RD prepared annual monitoring reports for the TCR as required by IEPA.

Lake Michigan Monitoring. Monitoring of the Chicago harbors is conducted when river backflow to Lake Michigan occurs due to heavy rainfall in the Chicagoland area. During the river backflow events, water quality monitoring is conducted to assess the impact of the release of CAWS water to Lake Michigan. In 2015, there was one backflow event to Lake Michigan. During the river backflow, 15 water samples collected by the Industrial Waste Division were analyzed for EC and FC.

Drinking Water Monitoring. The Division analyzes drinking water at District facilities on an as-needed basis. During 2015, a total of five samples were analyzed for bacteria in response to requests from other departments to assess water quality following new pipe construction at the O'Brien WRP, and contamination in a drinking water sink at the Stickney WRP. All samples were examined for the presence of TC and EC, which are indicators of fecal contamination. The Heterotrophic Plate Count was also conducted, which is an indicator of the general bacteriological content of the water. The results were reported together with safety instructions and recommendations where applicable.

Ambient Water Quality Monitoring Program. The AWQM Program includes monthly sampling for water quality analysis, including FC and chlorophyll *a* analyses, at 28 stations on 13 waterways within the District's service area (Figure 3). Analytical results are reported on the District website (mwrd.org). The AWQM Program fulfills NPDES permit waterway monitoring requirements and generates data to be used by the District and provided to the IEPA to assess the waterways in the District service area for attainment of Clean Water Act goals.

The biological monitoring program, which runs in conjunction with the AWQM program, currently consists of fish monitoring. The primary purpose of biological monitoring is to assess the overall health of waterways in the District service area. Between August and October 2015 the AEWQ Section collected fish by electrofishing, mini fyke netting, and seining at ten biological monitoring stations in the Des Plaines River System. In 2015, a total of 471 fishes comprised of 18 species were identified, weighed, and measured. The fishes were also examined for parasites and disease. Data from these collections are shown in Table 5.

Continuous Dissolved Oxygen Monitoring. The AEWQ Section developed a comprehensive continuous DO monitoring program beginning in August 1998 in the Chicago River System and July 2001 in the Calumet River System to evaluate the DO dynamics in deep-draft sections of the CAWS. The DO monitoring in wadeable Chicago area waterways, particularly in the Des Plaines River System, began in July 2005. Figure 4 shows current continuous DO monitoring locations.

The DO results for 2015 are included in M&R Department Report No. 16-33 "Continuous Dissolved Oxygen Monitoring Chicago Area Waterways System During 2015."

FIGURE 3: AMBIENT WATER QUALITY MONITORING SAMPLE STATIONS

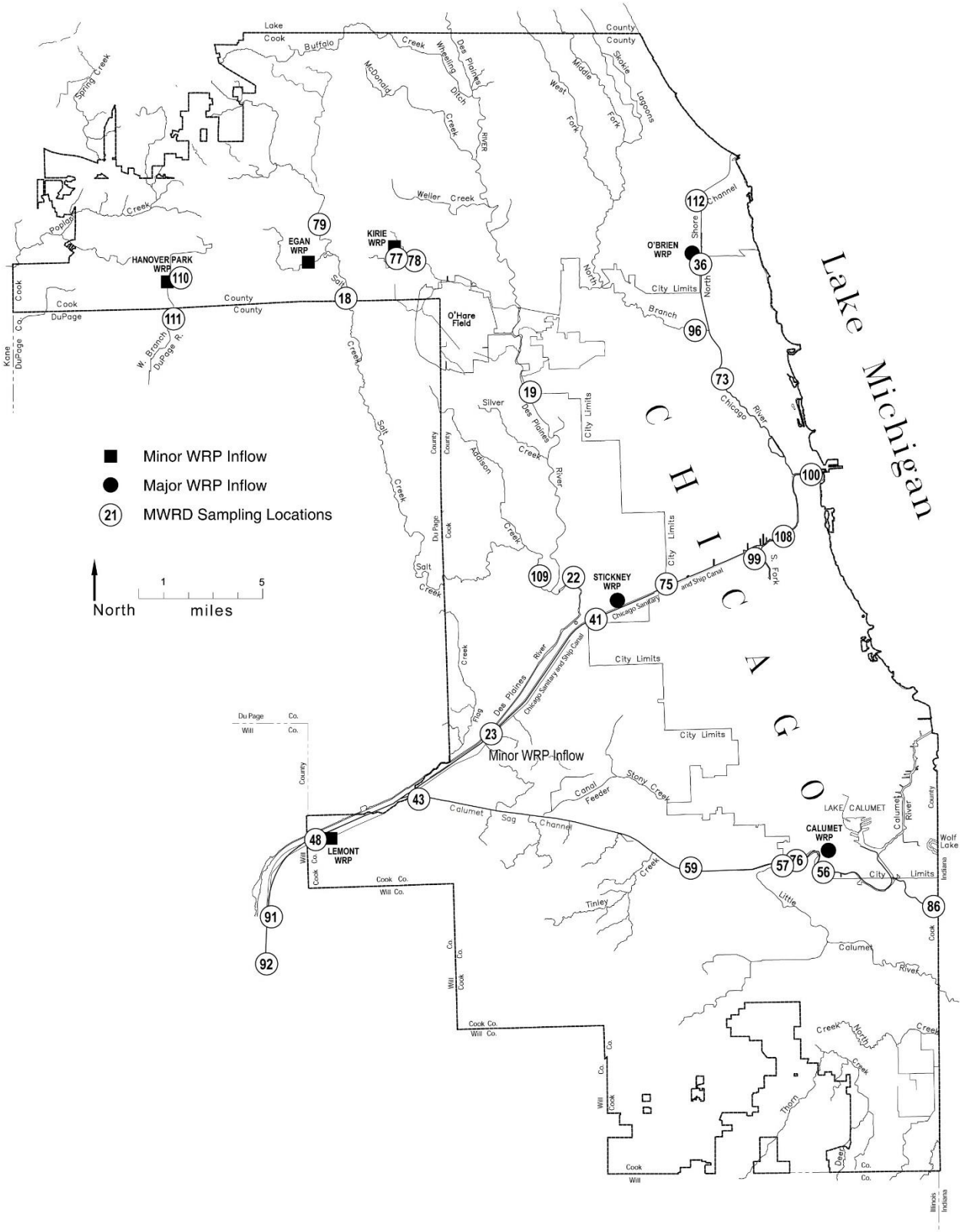
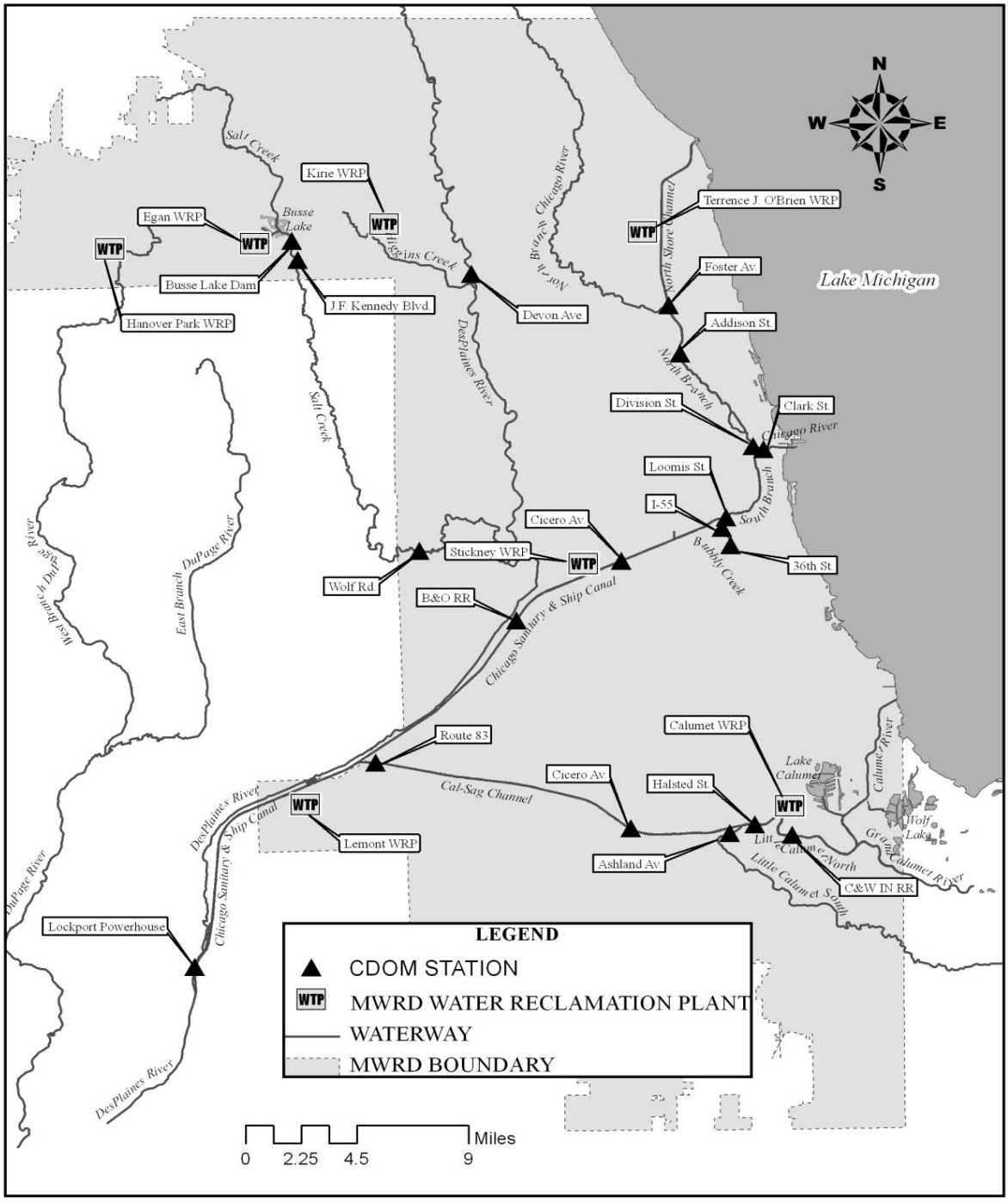


TABLE 5: SUMMARY OF FISH COLLECTION FROM THE DES PLAINES RIVER SYSTEM DURING 2015

Waterway	Number of Fish Collected	Weight of Total Catch (kg)	Number of Fish Species[1]	Number of Game Fish Species[1]	Most Abundant Fish Species
Des Plaines River	124	5.5	14	8	Green sunfish
Higgins Creek	228	0.4	4	2	Fathead minnow
Salt Creek	68	8.0	10	7	Bluegill
West Branch DuPage River	51	8.0	9	4	Green Sunfish
Total	471	21.9	18	10	

[1]Some fish species were collected in more than one waterway.

FIGURE 4: CONTINUOUS DISSOLVED OXYGEN MONITORING SAMPLE STATIONS



Pre-Completion of Thornton Reservoir Wet Weather Monitoring of Calumet River System. Enhanced water quality monitoring was implemented at nine sampling locations in the Calumet River System to document baseline conditions for two years preceding the completion of the Calumet TARP System's Thornton Composite Reservoir. Water samples were analyzed for DO, ammonia (NH_3), total suspended solids (SS), total dissolved solids, FC, and five-day biochemical oxygen demand (BOD_5). Samples were collected on the fourth Monday of each month, as well as during or after separate dry- and wet-weather events.

To evaluate receiving water impacts of TARP under a range of weather conditions the following criteria were used to categorize sampling events:

- Dry weather (<0.1 inch precipitation). Dry weather will be defined by antecedent dry conditions for two days following a 0.25–0.49 inch event, four days following a 0.50–0.99 inch event, and six days following a >1.0 inch event.

- Wet weather (>0.5 inch precipitation) without CSOs.

- Wet weather with CSOs, including the 125th Street Pump Station.

Besides the monthly samples, the sampling events completed during 2015 were two dry weather, three wet weather without CSOs, and one wet weather with CSOs. All wet-weather sampling events occurred within 12 hours from the end of each storm event. The results of this monitoring will be included in the reporting under the Calumet TARP System Post Construction Monitoring Plan developed per the Consent Decree.

Program 4: Technical Assistance

John E. Egan Water Reclamation Plant Profile Sampling. A DO and NH_3-nitrogen (N) profile evaluation was performed quarterly in the North and South Aeration Batteries at the Egan WRP as part of an ongoing support to M&O Department plant operations. Based on the results of this monitoring for 2015, it was determined that NH_3-N was completely removed by 50–80 percent of the tank length for both batteries, and the plant was operated adequately.

John E. Egan Water Reclamation Plant Chlorine Disinfection Process Control Evaluation. In 2013, an investigation was completed of the mainstream disinfection process at the Egan WRP during dry- and wet-weather conditions. The study was undertaken to prevent violations of the Egan WRP NPDES permit for FC. A full-scale study and process evaluation was completed in order to determine the impact of turbidity, SS, and transient conditions on the effectiveness of the disinfection process. The M&R Department provided recommendations for process control improvements. The recommendations included increasing the clear well total residual chlorine from 1 mg/L to above 2 mg/L for the periods that have secondary effluent turbidity at 10 nephelometric turbulence units (NTUs) or greater.

As a follow up, TSS, Turbidity, and FC monitoring of the Egan WRP final effluent was initiated in November 2013 and ended October 2014 to examine long-term correlations between turbidity and SS in the effluent to determine if higher turbidity or SS led to higher FC

concentrations. A weak correlation between TSS and turbidity during both disinfection and non-disinfection periods was observed, which implies that the solids in the final effluent are likely to have large variability in particle size. This variability makes it difficult to use the turbidity measurement as a surrogate for the TSS level. An impact analysis using SAS indicated that both TSS and turbidity levels have an impact on the FC level in the outfall. However, both impacts could not be represented by a linear or nonlinear correlation, which makes it difficult to use the turbidity or TSS level to determine chlorine dosage.

Additional monitoring for particle size distribution, TSS, turbidity, and FC analysis was initiated in November 2015 and will continue in 2016 to accomplish the following:

- If there is an indicator parameter (TSS, turbidity, or particle size distribution) that we can use to represent or predict FC level in the outfall; that is, if the FC levels in the outfall are more impacted by the TSS, turbidity, or a certain particle size range.

- Continue to evaluate if there is any correlation between turbidity and TSS levels; then we can use online instrument turbidity measurements to represent the TSS concentration for control.

- Determine if the TSS or turbidity are more impacted by large or small particles.

Evaluation of Heavy Metal Toxicity Threshold for Nitrification at the Calumet and Stickney Water Reclamation Plants. The District is actively pursuing the goal of energy neutrality. Part of its efforts toward this goal includes using external sources of high-strength organic wastes (HSOWs) for additional biogas production via co-digestion and for fermentation to provide the carbon needed for enhanced biological P removal (EBPR). The impact of heavy metals in these HSOWs on the activated sludge process is critical as inhibition of mainstream biological systems, especially nitrifiers, is a concern. Therefore, a paper study was conducted in 2015 with the goal to establish limits that can be used to formulate the guidance criteria for the acceptance of HSOWs. The study included a literature review of District and non-District studies relevant to metal toxicity, and an evaluation of historical plant-specific data as a first step to developing site-specific heavy metal threshold limits for the Calumet and Stickney WRPs.

Based on a data survey from 239 POTWs by the USEPA, 16 heavy metals are commonly monitored due to their toxicity to the nitrification process in activated sludge and other biological processes such as anaerobic digestion. Inhibition mechanisms, metal toxicity measurement techniques, and dose-response of heavy metals on the nitrification process or on biological treatment systems were reviewed and documented. The heavy metal inhibition limits obtained from the USEPA's local limit guidance, non-District studies, and the single District study showed that there is a wide range of inhibitory limits suggested for each metal and that these concentrations may not be applicable for the site-specific conditions at the Calumet and Stickney WRPs without further refinement through a study.

An analysis of historical data was done by examining the metal and NH_3 concentrations of the Stickney and Calumet WRP plant influent and effluent for 2012–2014. Data on the

concentration of the eight metals monitored at the WRPs were analyzed for two scenarios: one with no heavy metals removal in primary treatment and the other with percent removals of heavy metals in primary treatment. The influent metal concentrations to the aeration tanks were compared to three inhibition threshold values for both scenarios (Table 6).

The number of and percent of daily exceedances for each plant were determined and grouped by year and for the period 2012–2014. Nitrification efficiencies expressed as percent NH_3-N removal were calculated for the three days preceding, the three days following and the days on which the metal concentrations exceeded the inhibitory threshold values to determine the impact on the nitrification process.

At the Stickney WRP, none of the metal concentrations exceeded their respective nitrification toxicity thresholds for cadmium (Cd), lead (Pb), hexavalent chromium (Cr^{+6}), and nickel (Ni), while arsenic (As) and total chromium (Cr Total) marginally exceeded their respective threshold values. However, for both copper (Cu) and zinc (Zn) with no removal in primary treatment, percent exceedance was 90.7 and 99.0, respectively, for the low threshold values and 7.2 and 25.0, respectively, for the high threshold values. Most of the exceedances were for a single metal rather than a combination of metals.

At the Calumet WRP, none of the metal concentrations exceeded their respective nitrification toxicity thresholds for As, Cd, Cr Total, Pb, Ni, and Cr^{+6}. However, for both Cu and Zn with no removal in primary treatment, percent exceedance was 17.9 and 63.5, respectively, for the low threshold values and 0.0 and 2.2, respectively, for the high threshold values. Most of the exceedances were for a single metal rather than a combination of metals.

For both the Stickney and Calumet WRPs, an increase or decrease in nitrification efficiency was calculated in relation to average nitrification removal efficiencies around the metal exceedance days. At the Stickney WRP, there were 193 instances where the total metal concentration exceeded the respective threshold levels during 2012 through 2014; however, none of these exceedances caused a severe impact on the nitrification process. Of these 193 exceedances at the Stickney WRP, only 27 coincided with a 5 percent or more decrease in NH_3-N removal efficiency compared to the average NH_3-N removal efficiencies of the three preceding days. Further, in 24 of the 27 exceedances, nitrification recovered within the next three days without any compromise of the NH_3-N removal efficiency.

At the Calumet WRP, there were 146 instances where the total metal concentration exceeded the respective threshold levels during 2012 through 2014; however, none of these exceedances caused a severe impact on the nitrification process. Of these 146 exceedances at the Calumet WRP, only 12 coincided with a 5 percent or more decrease in NH_3-N removal efficiency compared to the average NH_3-N removal efficiencies of the three preceding days. Further, in 11 of the 12 exceedances, nitrification recovered within the next three days without any compromise of the NH_3-N removal efficiency.

Based on data analysis for both plants, it should be noted that the toxicity thresholds used in the analysis should be considered conservative, since exceedances of these thresholds at both plants generally did not result in inhibition of nitrification. The evaluation in this study indicated the toxicity thresholds reported by the USEPA cannot be applied directly at the Stickney and

TABLE 6: INHIBITION THRESHOLD FOR METALS[1]

Metal	Low	Average	High
	mg/L		
Arsenic (As)[2]	0.1	0.8	1.5
Cadmium (Cd)[3]	1.0	5.2	10
Chromium VI (Cr^{+6})	1.0	5.5	10
Chromium-Tot (Cr)[4]	0.25	1.08	1.9
Copper (Cu)[5]	0.05	0.27	0.48
Lead (Pb)	0.5	—	—
Nickel (Ni)	0.25	0.38	0.5
Zinc (Zn)[6]	0.08	0.29	0.5

[1]Source: (USEPA, 2004) Based on lower range, three values as explained above were determined and used for evaluation.

[2]Inhibition threshold for As for activated sludge process (0.1 mg/L) is lower than nitrification inhibition threshold (1.5 mg/L). Hence, both values and an average thereof, were considered to estimate the number of days that exceeded inhibition threshold.

[3]Inhibition threshold for Cd, for activated sludge process is 1–10 mg/L whereas for nitrification, it is 5.2 mg/L. Hence, all values were considered for evaluation.

[4]Reported inhibition threshold level for Cr is 0.25–1.9 mg/L.

[5] Reported inhibition threshold level for Cu is 0.05–0.48 mg/L.

[6]Inhibition threshold for Zn for nitrification is 0.08–0.5 mg/L and for activated sludge process is 0.3–5 mg/L.

Calumet WRPs. Site-specific toxicity limits may be derived through bench- or pilot-scale tests. However, for the purpose of implementing the HSOW program in the near future, site-specific metal toxicity limits may be estimated with the consideration of both reported thresholds and the results of the data evaluation done in this study.

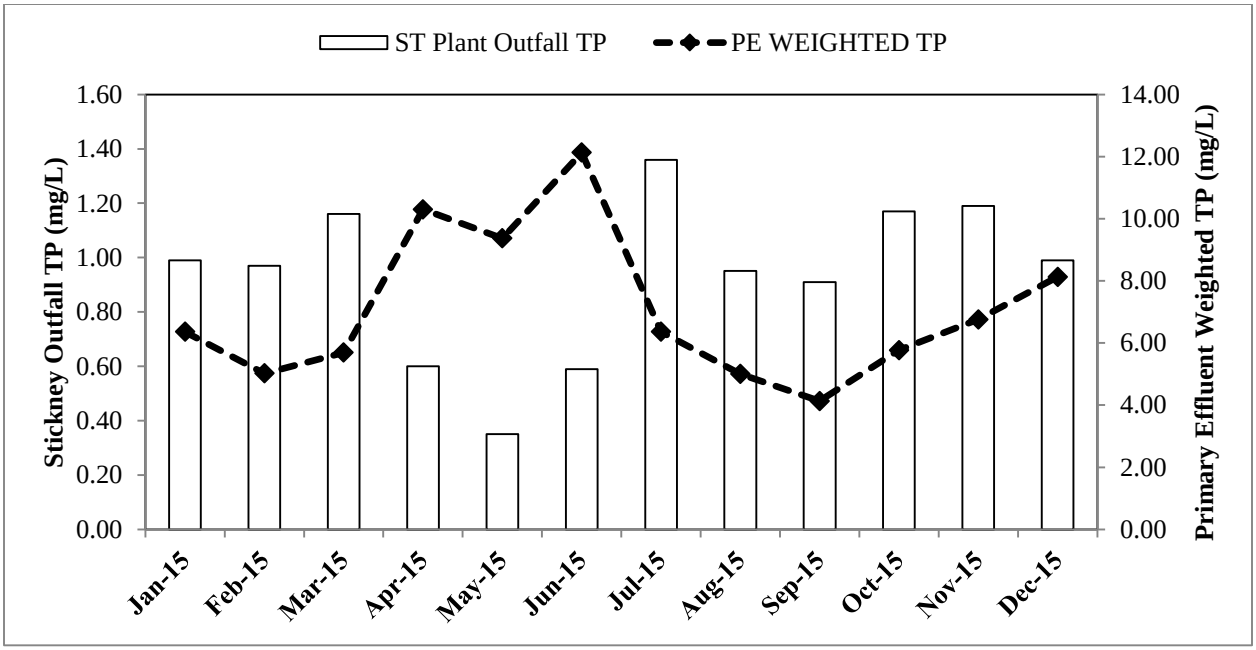
Studies on Enhanced Biological Phosphorus Removal. During 2012, the WTPR Section, in conjunction with the Engineering and M&O Departments, formed a Phosphorus Task Force to assess and implement biological P removal and P recovery at the Calumet, Stickney, O'Brien, and Kirie WRPs. As an initial step, the WTPR Section performed a demonstration of EBPR in one battery at the Stickney WRP and one battery at the Calumet WRP using current plant infrastructure. The process was implemented by creating anoxic, anaerobic, and aerobic zones (AAnO) in the test batteries to facilitate the growth and luxury P uptake of phosphate-accumulating organisms (PAOs).

All four batteries were converted to the EBPR process at the Stickney WRP and optimization practices continued in 2013. An annual average total P (TP) concentration of 0.91 mg/L in the final effluent was achieved in 2015 as shown in Figure 5. However, four out of twelve months the Stickney WRP TP monthly averages were above the 1 mg/L target. The growth of PAOs was monitored in the anaerobic and aerobic zones of all four batteries. The relationship between PHB and Poly-P uptake expressed as the PHB:Poly-P ratio was explored and compared to P removal efficiency in each of the batteries. The comparisons are shown in Figures 6 through 9. Lower PHB:Poly-P ratios appear to correlate well with higher P removal efficiency.

Because the site-specific EBPR process configuration uses the existing infrastructure to minimize capital investment and the plant has to comply with stringent DO, NH_3, and SS NPDES limits, achieving sustainable EBPR performance is difficult. In addition, inconsistent influent organics is often observed. Major infrastructure changes such as adjustments to actuated air valves in the aeration tanks and conversion of gravity concentration tanks (GCTs) to primary sludge (PS) fermentors will be designed and constructed in 2016–2017 to help make the EBPR process more stable. Efforts to acquire an organic carbon supplement is also being investigated. The Ostara® P recovery process will be in operation in 2016 and is expected to stabilize the EBPR process. Additionally, a Waste Activated Sludge Stripping to Remove Internal Phosphorus® (WASSTRIP®) process is being designed to maximize P recovery. WASSTRIP® is expected to be in operation by early 2018.

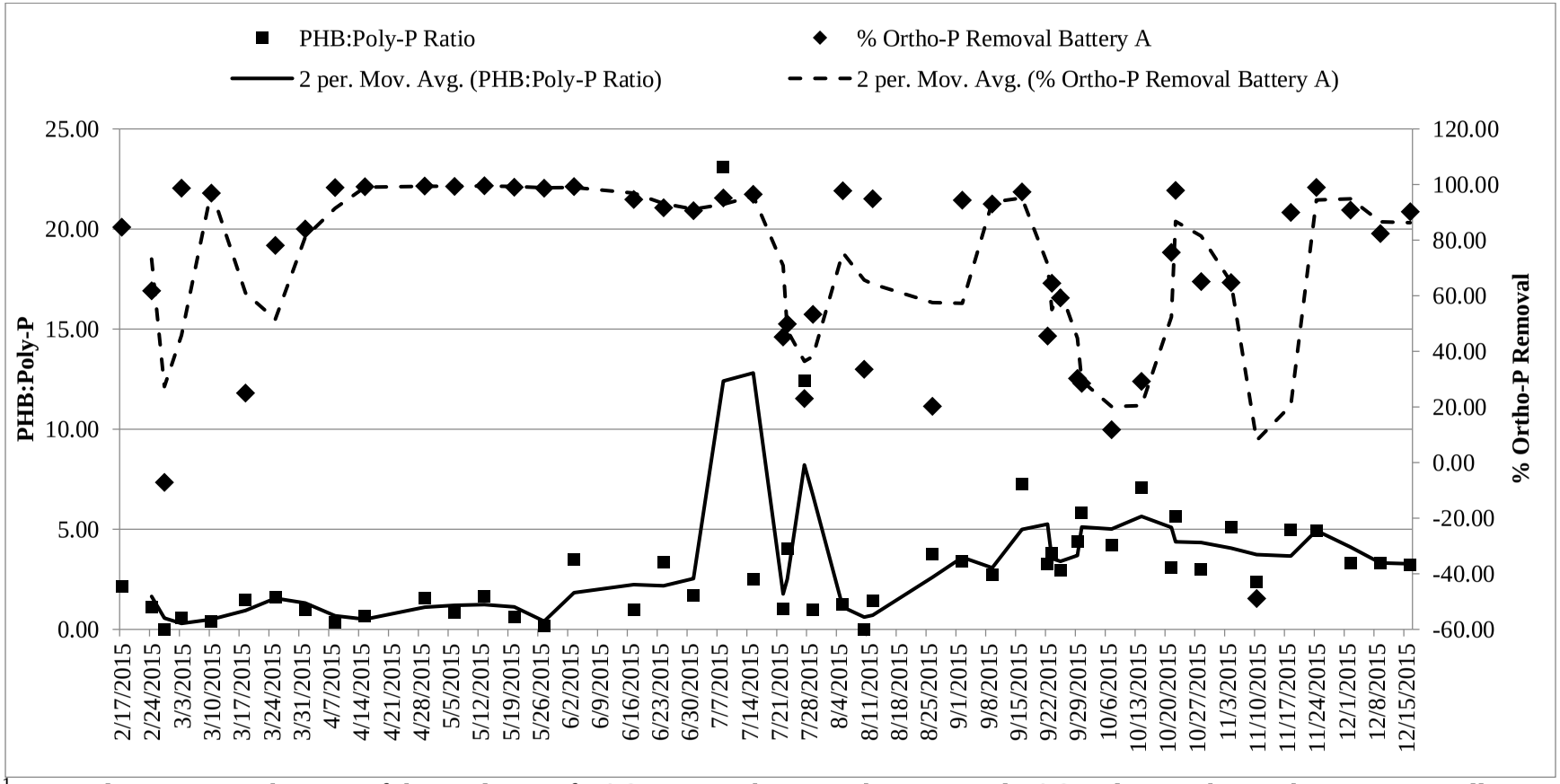
At the Calumet WRP, it was determined that due to a lack of carbon in the plant influent needed to drive the EBPR external carbon source addition is needed for stable EBPR. Based on the success of the full-scale carbon supplement study in late 2014, the WTPR Section and the Task Force worked with industries to find high-strength carbon wastes and developed sludge fermentation options in an effort to meet the carbon needs for sustainable EBPR at the Calumet WRP. The WTPR Section developed criteria to screen potential wastes based on their chemical characteristics, P uptake and release potential, and denitrification potential. Six industrial organic wastes were tested in 2015 with one showing potential to be used as a carbon source for EBPR. The search for HSOWs for the EBPR process at the Calumet WRP will continue in 2016. Pending identification of a promising HSOW, a full-scale study with the selected HSOW will also be conducted in 2016. A similar study is also planned for the Stickney WRP.

FIGURE 5: STICKNEY WATER RECLAMATION PLANT PRIMARY EFFLUENT AND OUTFALL MONTHLY AVERAGE TOTAL PHOSPHORUS CONCENTRATIONS FOR 2015[1]



[1]PE weighted TP is calculated from Southwest and West Side TP concentration and flow.

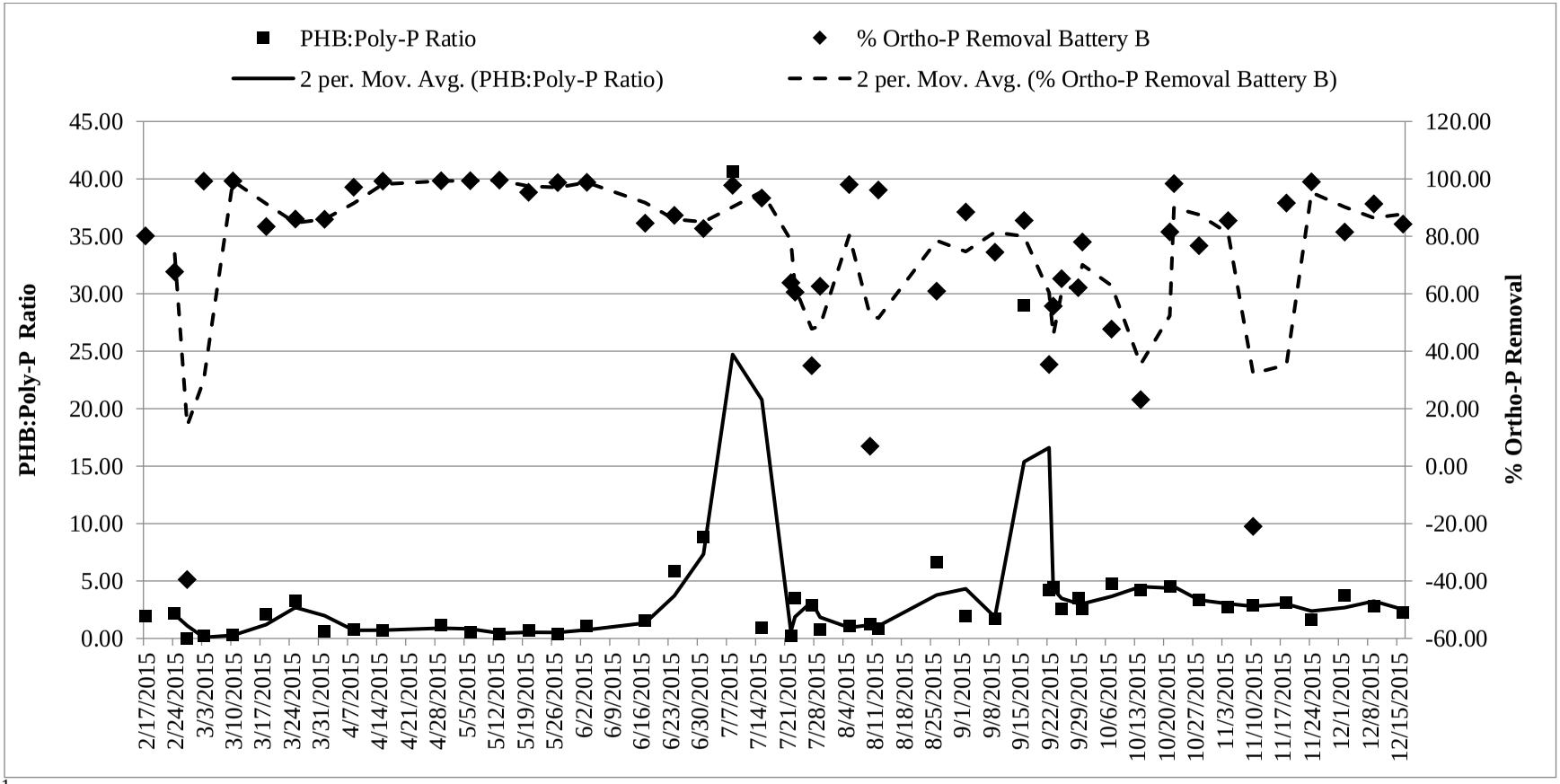
FIGURE 6: COMPARISON OF PHOSPHORUS-ACCUMULATING ORGANISM ABUNDANCE AS POLY-β-HYDROXYBUTYRATE:POLYPHOSPHATE RATIO AND PERCENT ORTHOPHOSPHATE REMOVAL IN STICKNEY WATER RECLAMATION PLANT BATTERY A



[1]PHB:Poly-P Ratio – The ratio of the total area of PAO-PHB in the anaerobic zone and PAO-Poly-P in the aerobic zone per milligram of volatile suspended solids (μm^2/mg VSS) displayed as a moving average.

[2]Percent ortho-P removal calculated using primary effluent (PE) ortho-P and individual battery effluent ortho-P.

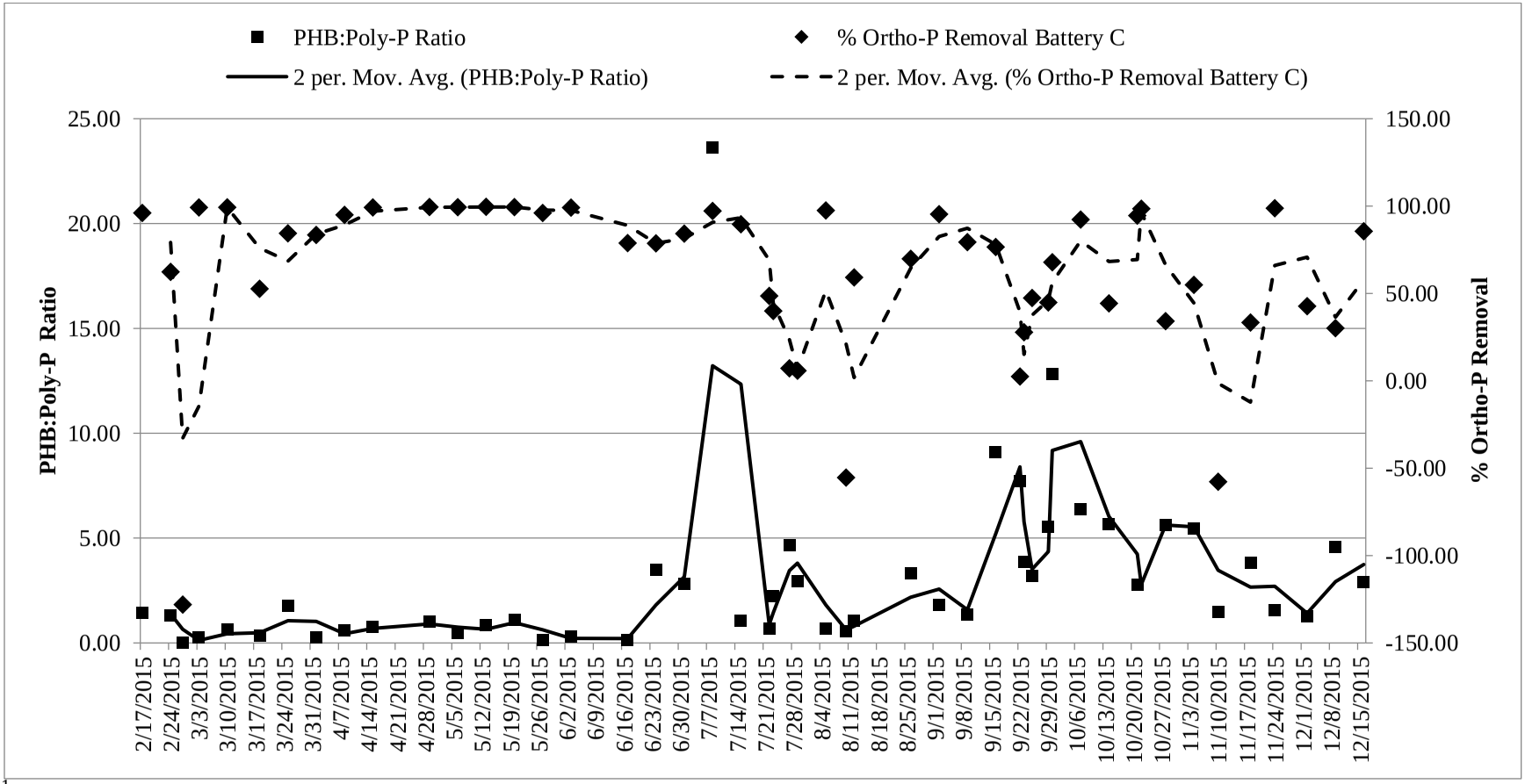
FIGURE 7: COMPARISON OF PHOSPHORUS-ACCUMULATING ORGANISM ABUNDANCE AS POLY-β-HYDROXYBUTYRATE:POLYPHOSPHATE RATIO AND PERCENT ORTHOPHOSPHATE REMOVAL IN STICKNEY WATER RECLAMATION PLANT BATTERY B



[1]PHB:Poly-P Ratio – The ratio of the total area of PAO-PHB in the anaerobic zone and PAO-Poly-P in the aerobic zone per milligram of volatile suspended solids (μm^2/mg VSS) displayed as a moving average.

[2]Percent ortho-P removal calculated using primary effluent (PE) ortho-P and individual battery effluent ortho-P.

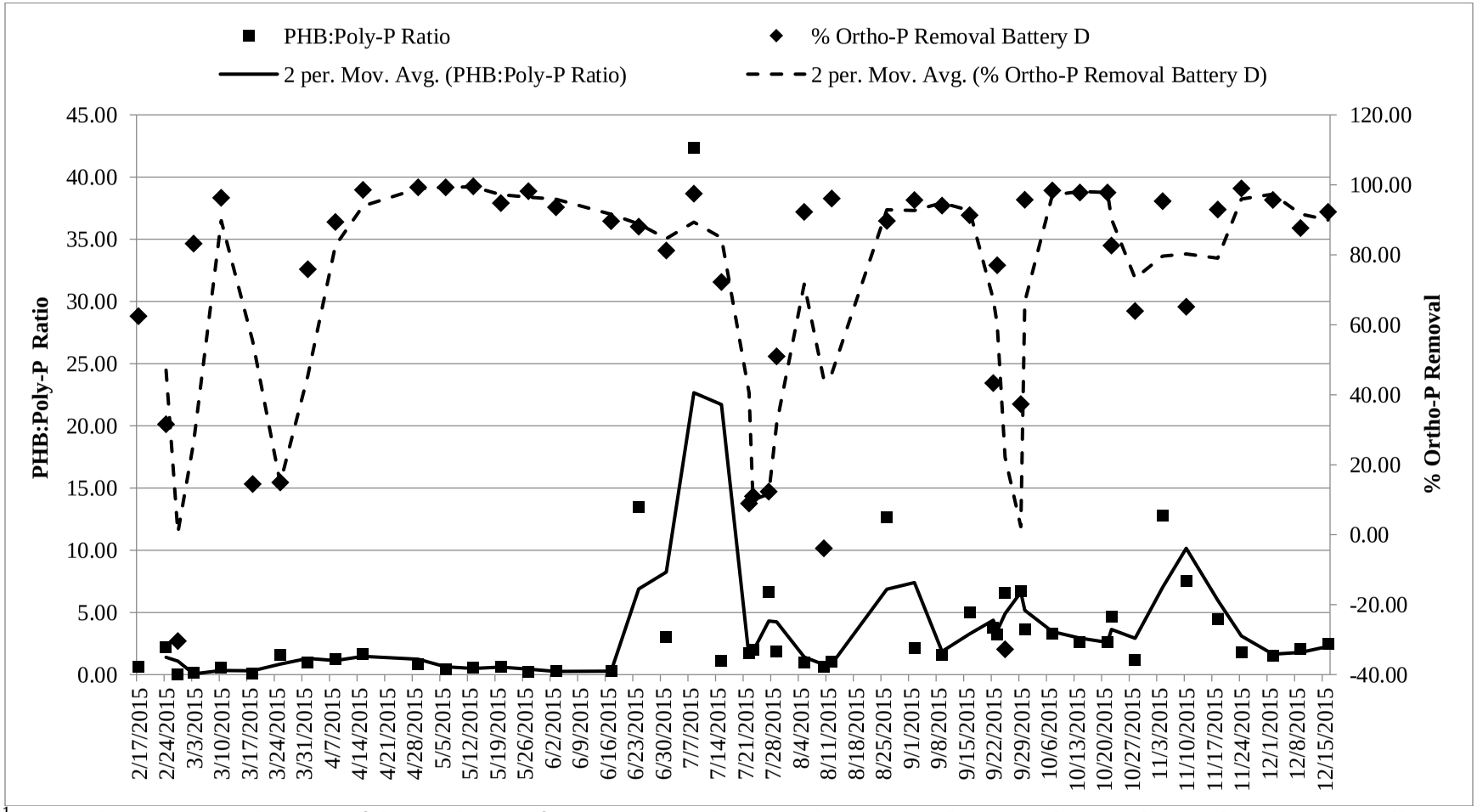
FIGURE 8: COMPARISON OF PHOSPHORUS-ACCUMULATING ORGANISM ABUNDANCE AS POLY-β-HYDROXYBUTYRATE:POLYPHOSPHATE RATIO AND PERCENT ORTHOPHOSPHATE REMOVAL IN STICKNEY WATER RECLAMATION PLANT BATTERY C



[1]PHB:Poly-P Ratio – The ratio of the total area of PAO-PHB in the anaerobic zone and PAO-Poly-P in the aerobic zone per milligram of volatile suspended solids (μm^2/mg VSS) displayed as a moving average.

[2]Percent ortho-P removal calculated using primary effluent (PE) ortho-P and individual battery effluent ortho-P.

FIGURE 9: COMPARISON OF PHOSPHORUS-ACCUMULATING ORGANISM ABUNDANCE AS POLY-β-HYDROXYBUTYRATE:POLYPHOSPHATE RATIO AND PERCENT ORTHOPHOSPHATE REMOVAL IN STICKNEY WATER RECLAMATION PLANT BATTERY D



[1]PHB:Poly-P Ratio – The ratio of the total area of PAO-PHB in the anaerobic zone and PAO-Poly-P in the aerobic zone per milligram of volatile suspended solids (μm^2/mg VSS) displayed as a moving average.

[2]Percent Ortho-P removal calculated using primary effluent (PE) ortho-P and individual battery effluent ortho-P.

The M&R Department has also undertaken a project at the Hanover Park WRP to evaluate EBPR potential and energy savings. The WTPR Section initiated an EBPR pilot study of the AAnO process at the Hanover Park WRP using a converted aeration tank (A1). Tank A1 was modified to include baffles to separate three zones within pass 1 of A1. The first two zones also have mechanical mixers to provide unaerated environments. However, EBPR was unsuccessful during the 45-day preliminary study in the fall of 2015. The results of the preliminary study were evaluated and recommendations were made in an effort to optimize the EBPR process at HPWRP by enhancing conditions for denitrification in final tanks, reducing RAS return, and reducing influent flow to Tank A1 to increase the hydraulic residence time. Testing will continue in 2016.

The WTPR Section and the P Task Force also began to examine EBPR at the James C. Kirie WRP in 2014 and continued in 2015. Two aeration tanks (5 and 6) in Battery A and their associated clarifiers (5 and 6) were isolated for pilot testing by installing stop logs in RAS and mixed liquor channels and providing dedicated RAS pumps. Actuated air control valves were installed in 2015 to evaluate intermittent air mixing. A quasi fermentation/anaerobic/anoxic zone was generated at the beginning of the first pass in each pilot test tank using this intermittent aeration. The growth of PAOs was monitored in both the anaerobic and aerobic zones of the control Tank 4 and in Test Tanks 5 and 6. Filamentous bacteria counts were also performed on mixed liquor samples. The microbiological results are shown in Table 7. The average PAO abundance was higher in Test Tanks 5 and 6 when compared to Control Tank 4.

While test results shown in Figure 10 indicated that the test tanks with the current EBPR configuration were able to meet a TP limit of 1.0 mg/L monthly average during the study period, significant back mixing from aeration zone to anaerobic zone was observed, which reduced the aeration tank efficiency and created an environment favorable for filament growth. Baffle walls will be added in 2016 to prevent back mixing and promote inline mixed liquor fermentation. The task force is planning to convert the entire Kirie Battery A to EBPR in 2016. However, if case EBPR is not stable, some of infrastructure changes are planned including installation of mechanical mixers, additional baffles, and pumps for EBPR optimization.

At the O'Brien WRP, the following three P removal/recovery strategies are being investigated: (1) Reduction of P loading to the WRP through source control; (2) Using algae for P removal and recovery from the liquid stream, and (3) Implementing EBPR for P removal from the liquid stream by modifying and adding to the existing infrastructure.

Beginning in July 2015, the M&R Department conducted laboratory and field tests to evaluate the feasibility of EBPR at the O'Brien WRP based on the existing influent, infrastructure, and treatment capacity. Preliminary findings are summarized below.

- Primary effluents from both East (PE_E) and West (PE_W) have sufficient COD and rbCOD for EBPR most of the time. However, VFAs many times are lower than the recommended value for EBPR (Figures 10 through 13).

- Average RAS nitrate-N and nitrite-N (NO_x) concentrations in Batteries A, B, and C and Battery D were 2.2 mg/L and 2.8 mg/L, respectively. Average RAS

TABLE 7: COMPARISON OF PHOSPHORUS-ACCUMULATING ORGANISMS IN THE ANAEROBIC ZONE, AEROBIC ZONE, AND FILAMENTOUS BACTERIA IN THE CONTROL AND TEST TANKS AT THE JAMES C. KIRIE WATER RECLAMATION PLANT

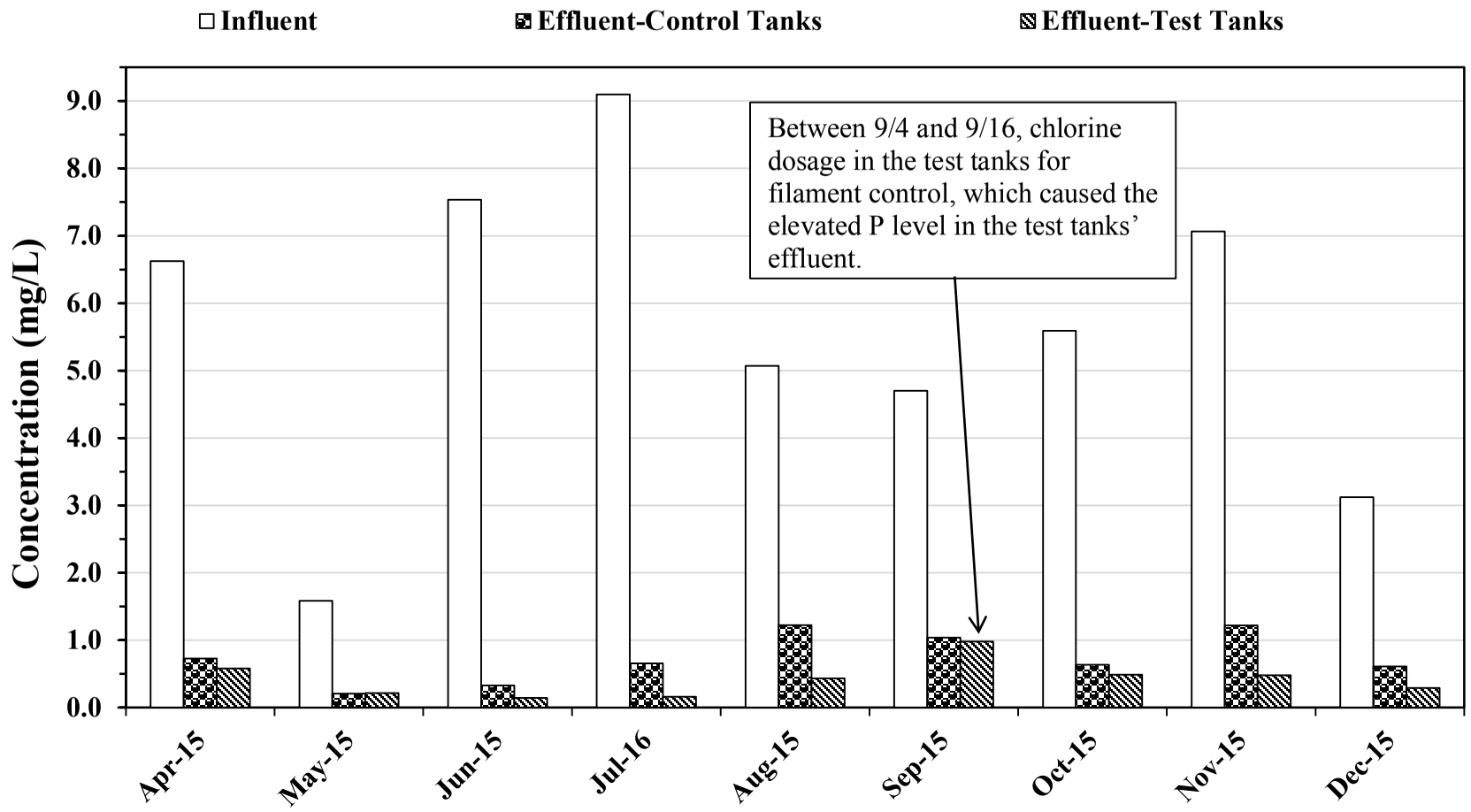
	Control Tank 4			Test Tank 5			Test Tank 6		
Sample Date	PAO-PHB[1] $\mu m^2/mgVSS^3$ (10^3)	PAO-PolyP[2] $\mu m^2/mgVSS^3$ (10^3)	FB Count/ $mgVSS^4$	PAO-PHB[1] $\mu m^2/mgVSS^3$ (10^3)	PAO-PolyP[2] $\mu m^2/mgVSS^3$ (10^3)	FB Count/ $mgVSS^4$	PAO-PHB[1] $\mu m^2/mgVSS^3$ (10^3)	PAO-PolyP[2] $\mu m^2/mgVSS^3$ (10^3)	FB Count/ $mgVSS^5$
4/7/2015	45.1	3.9	1139	63.4	4.7	798	18.9	5.5	736
4/21/2015	38.5	11.3	590	53.6	6.9	404	58.0	7.7	415
5/5/2015	51.9	1.4	1349	37.7	4.6	831	34.1	9.6	488
5/20/2015	7.0	1.9	1677	17.7	5.4	851	13.7	5.5	729
6/2/2015	7.4	2.3	1734	9.8	31.7	1157	5.8	56.9	1071
6/16/2015	54.9	3.5	1112	45.3	8.9	628	--[5]	4.3	503
6/30/2015	26.3	6.5	1645	46.7	11.5	1518	22.3	42.9	1170
7/14/2015	29.9	7.3	715	91.4	27.5	959	14.7	22.7	1279
7/28/2015	11.1	4.9	--[6]	19.3	50.5	--	43.5	15.9	--
8/11/2015	35.8	4.3	--	93.3	13.6	--	97.5	10.3	--
8/25/2015	84.7	1.9	2060	54.0	3.3	2361	15.3	7.4	1851
9/8/2015	38.1	8.9	1113	12.5	7.9	1911	118.3	38.4	1624
9/15/2015	43.1	4.0	806	226.4	5.5	780	31.1	4.5	789
9/22/2015	33.2	3.8	460	30.2	4.5	708	36.6	2.4	639
10/6/2015	53.1	13.6	830	25.7	8.3	1086	20.4	19.4	1065
10/20/2015	27.9	11.2	507	81.9	11.0	807	71.3	17.4	845
11/3/2015	42.7	7.0	935	79.7	16.8	1416	78.8	8.0	1304

TABLE 7 (continued): COMPARISON OF PHOSPHORUS ACCUMULATING ORGANISMS IN THE ANAEROBIC ZONE, AEROBIC ZONE, AND FILAMENTOUS BACTERIA IN THE CONTROL AND TEST TANKS AT THE JAMES C. KIRIE WATER RECLAMATION PLANT

Sample Date	Control Tank 4			Test Tank 5			Test Tank 6		
	PAO-PHB[1] $\mu m^2/mgVSS^3$ (10^3)	PAO-PolyP[2] $\mu m^2/mgVSS^3$ (10^3)	FB Count/ $mgVSS^4$	PAO-PHB[1] $\mu m^2/mgVSS^3$ (10^3)	PAO-PolyP[2] $\mu m^2/mgVSS^3$ (10^3)	FB Count/ $mgVSS^4$	PAO-PHB[1] $\mu m^2/mgVSS^3$ (10^3)	PAO-PolyP[2] $\mu m^2/mgVSS^3$ (10^3)	FB Count/ $mgVSS^4$
11/17/2015	23.4	7.1	824	42.8	7.9	741	29.8	11.9	1281
12/1/2015	17.2	7.2	946	36.4	3.3	447	14.8	5.8	791
12/15/2015	93.1	2.0	901	51.1	9.9	1839	48.6	10.3	1361
Average	38.2	5.7	1075	55.9	12.1	1069	40.6	15.3	997

[1]PHB – Poly-β-hydroxybutyrate –Sudan Black staining procedure.
[2]PolyP – Polyphosphate granules – stained using the Neisser staining procedure.
[3]$\mu m^2/mgVSS$ – The abundance of phosphorus accumulating microorganisms (PAO) expressed as total area per milligram of volatile suspended solids.
[4]FB= Filamentous Bacteria
[5]Count/mgVSS – Total filamentous bacteria expressed as total count/mgVSS. Filamentous bacteria Type 021N was dominant in the Kirie WRP.
[6]-- = No sample

FIGURE 10: JAMES C. KIRIE WATER RECLAMATION PLANT ENHANCED BIOLOGICAL PHOSPHORUS REMOVAL PILOT STUDY – MONTHLY AVERAGE TOTAL PHOSPHORUS LEVEL IN INFLUENT AND EFFLUENT



Note: The pilot study started in April 2015. The data shown on the chart is based on the average of grab samples taken by the M&R Department on a weekly basis.

FIGURE 11: RATIO OF CHEMICAL OXYGEN DEMAND TO TOTAL PHOSPHORUS IN TERRENCE J. O'BRIEN WATER RECLAMATION PLANT RAW EFFLUENT

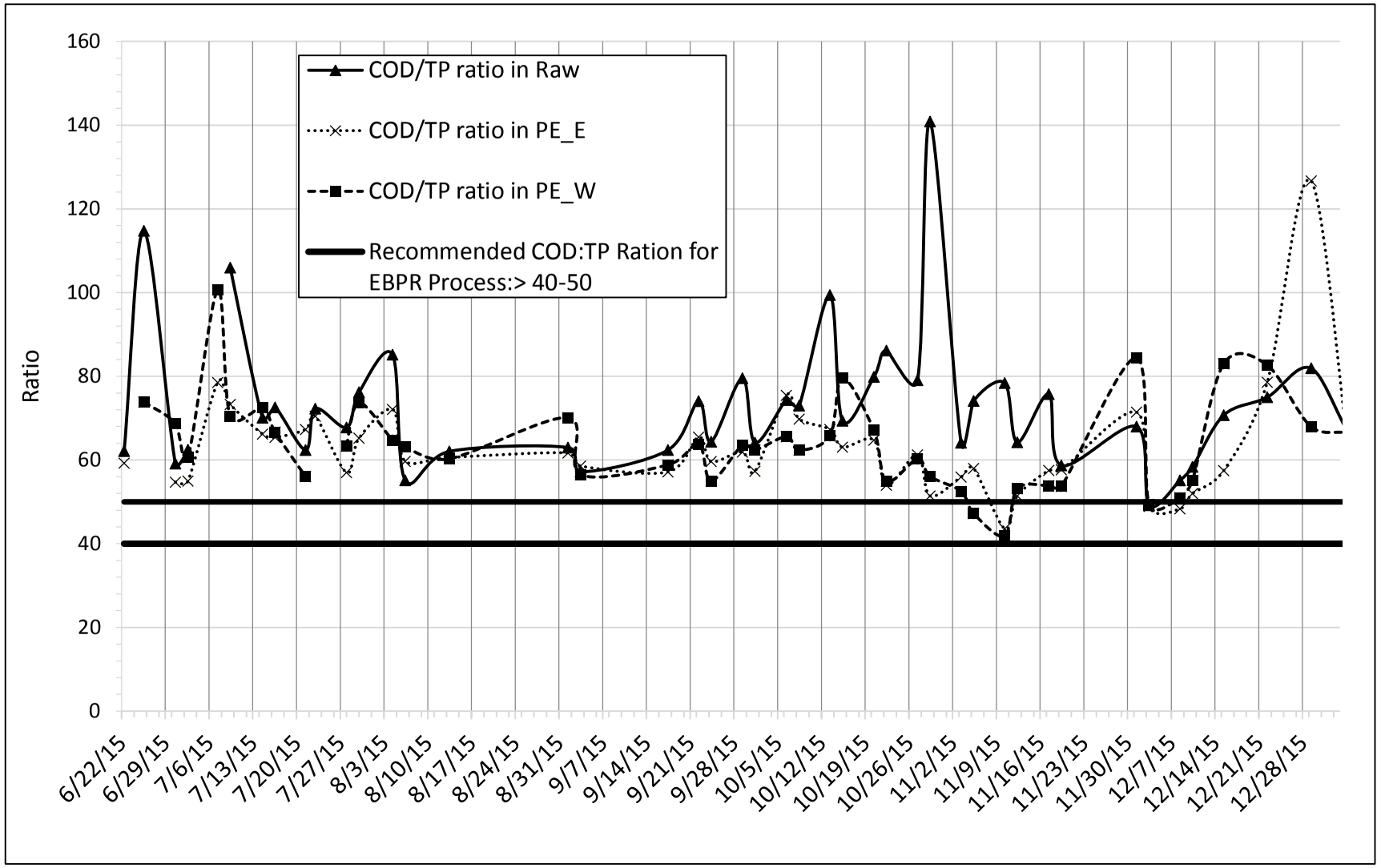
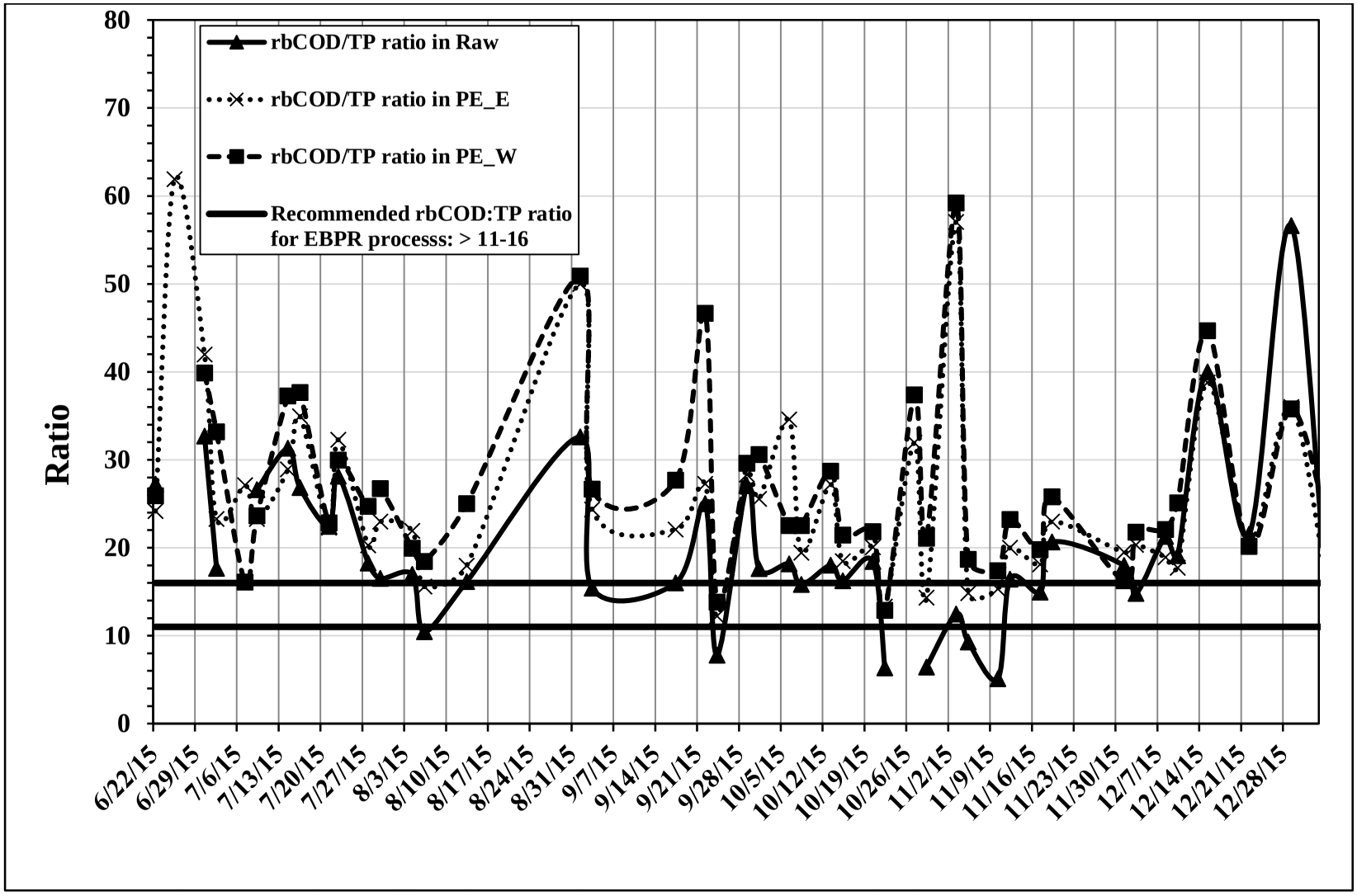
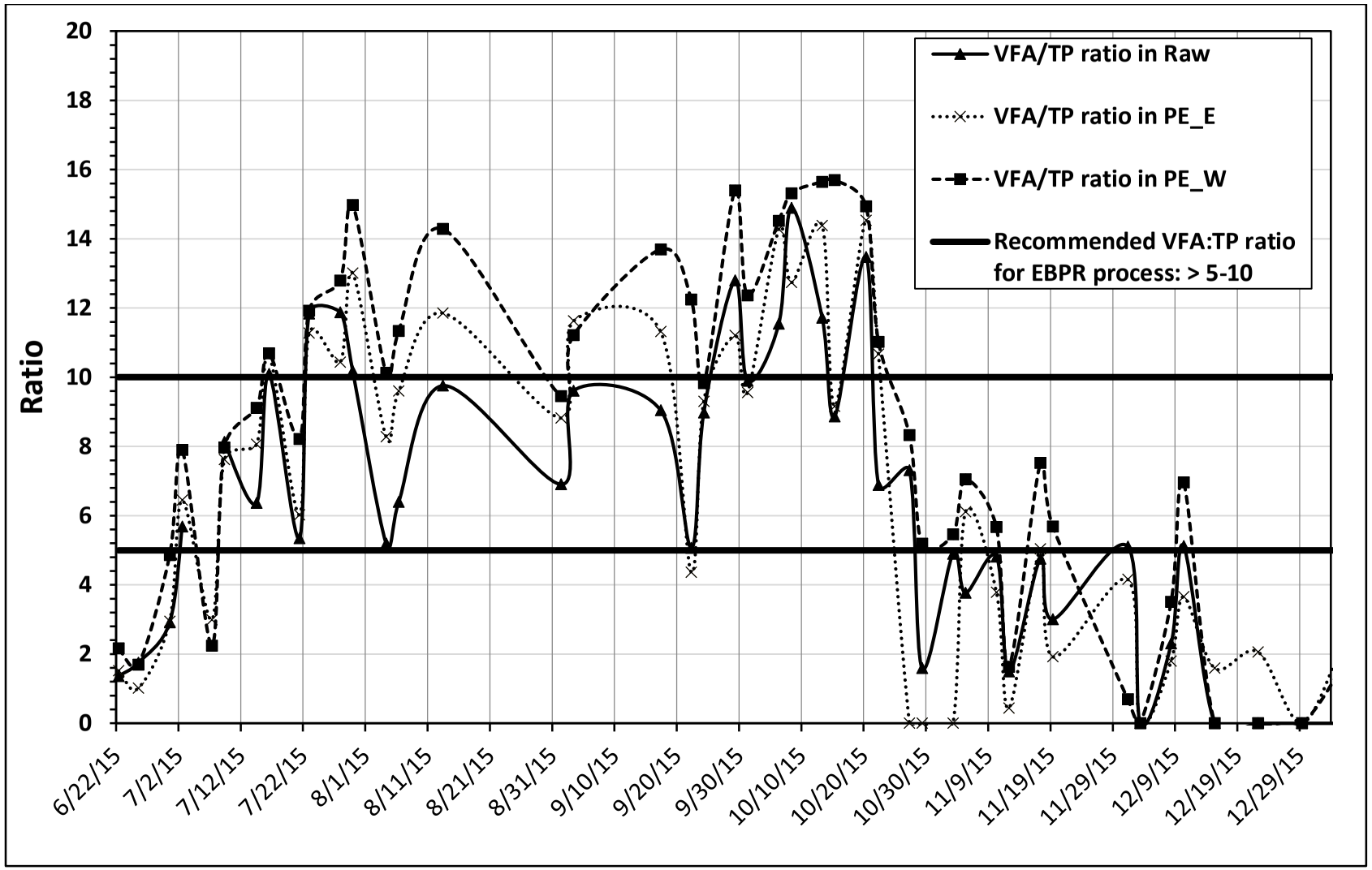


FIGURE 12: RATIO OF READILY BIODEGRADABLE CHEMICAL OXYGEN DEMAND TO TOTAL PHOSPHORUS IN TERRENCE J. O'BRIEN WATER RECLAMATION PLANT RAW INFLUENT AND PRIMARY EFFLUENT



Note: PE_E and PE_W = Primary effluent in east and west O'Brien WRP, respectively.

FIGURE 13: RATIO OF VOLATILE FATTY ACIDS TO TOTAL PHOSPHORUS IN TERRENCE J. O'BRIEN WATER RECLAMATION PLANT RAW INFLUENT AND PRIMARY EFFLUENT



Note: PE_E and PE_W = Primary effluent in east and west O'Brien WRP, respectively.

DO concentrations in Batteries A, B, and C, and Battery D were 0.6 mg/L and 4.9 mg/L, respectively (Figures 14 and 15).

- Reduced nitrification rates and NH_3 removal performance were observed in Tank C11, an aeration tank with a middle wall, compared to tanks C12 and D4, aeration tanks without a middle wall, due to the uneven air distribution between the C11 east train and C11 west train (C11_E and C11_W) (Figures 16 through 19 and Table 8).

The testing will conclude in summer 2016.

Stickney Water Reclamation Plant Waste Activated Sludge Stripping to Remove Internal Phosphorus. With the implementation of the EBPR process in all batteries at the Stickney WRP, there are expected to be increased concentrations of TP and magnesium (Mg) in the waste activated sludge (WAS) stream. As part of the plan to install Ostara® reactors at the plant for P recovery, WASSTRIP® process is being planned that can strip off the P and Mg in the WAS which can subsequently be recovered through struvite precipitation in the Ostara® reactors. This WASSTRIP® process is based on holding WAS quiescently under anaerobic conditions with available, readily-degradable carbon to promote orthophosphate (ortho-P) release from the PAO biomass. Mg cations carry the ortho-P across the PAO cell walls. An advantage of WASSTRIP® is that the extraction from the WAS stream will reduce ortho-P and Mg concentrations in the digester feed sludge, reduce the potential for struvite formation in the digesters, and reduce the amount of Mg addition needed for the Ostara® reactor. Therefore, the WASSTRIP® process is an integral part of the Ostara® P recovery system.

Currently, there are 10 old unused gravity concentration tanks at the Stickney plant. To best utilize tankage, these 10 old GCTs will be repurposed; two allocated PS fermentation to provide the carbon needed for the WASSTRIP® process, four for WAS thickening to maximize the hydraulic time in the WASSTRIP® process, and four as WASSTRIP® reactors. To inform this design configuration, laboratory-scale tests were performed to understand the effect of WAS thickening levels and the amount of PS fermentate needed maximize ortho-P release. The procedure used for WASSTRIP® bench-scale tests was based on a procedure provided by Ostara. PS was collected, thickened, and fermented for 96 hours on ten separate days to supplement the carbon for each experiment. Phase I examined the effect of different carbon additions to a uniform thickened WAS (TWAS), i.e. WAS settled for 70 minutes. Phase II examined different TWASs with a uniform carbon addition, i.e. WAS settled for 70 and 120 minutes. Phase I consisted of 11 experiments on four different days using varying amounts and concentrations of PS fermentate in order to understand the carbon needed to achieve approximately 30 percent ortho-P release of initial TP in TWAS. Phase II consisted of ten experiments on six different days. No polymers or other dewatering aids were used in the WAS settling.

The following are some of the important conclusions drawn from the study:

- PS fermentation for 96 hours produced average VFA and soluble chemical oxygen demand (sol-COD) concentrations of 1,967 mg/L and 4,391 mg/L, respectively. The average carbon yield relative to the initial volatile solids concentration of the PS was 0.39 for sol-COD and 0.19 for VFA.

FIGURE 14: DISSOLVED OXYGEN AND NITRATE PLUS NITRITE NITROGEN CONCENTRATIONS IN BATTERY D RETURN ACTIVATED SLUDGE FROM THE TERRENCE J. O'BRIEN WATER RECLAMATION PLANT

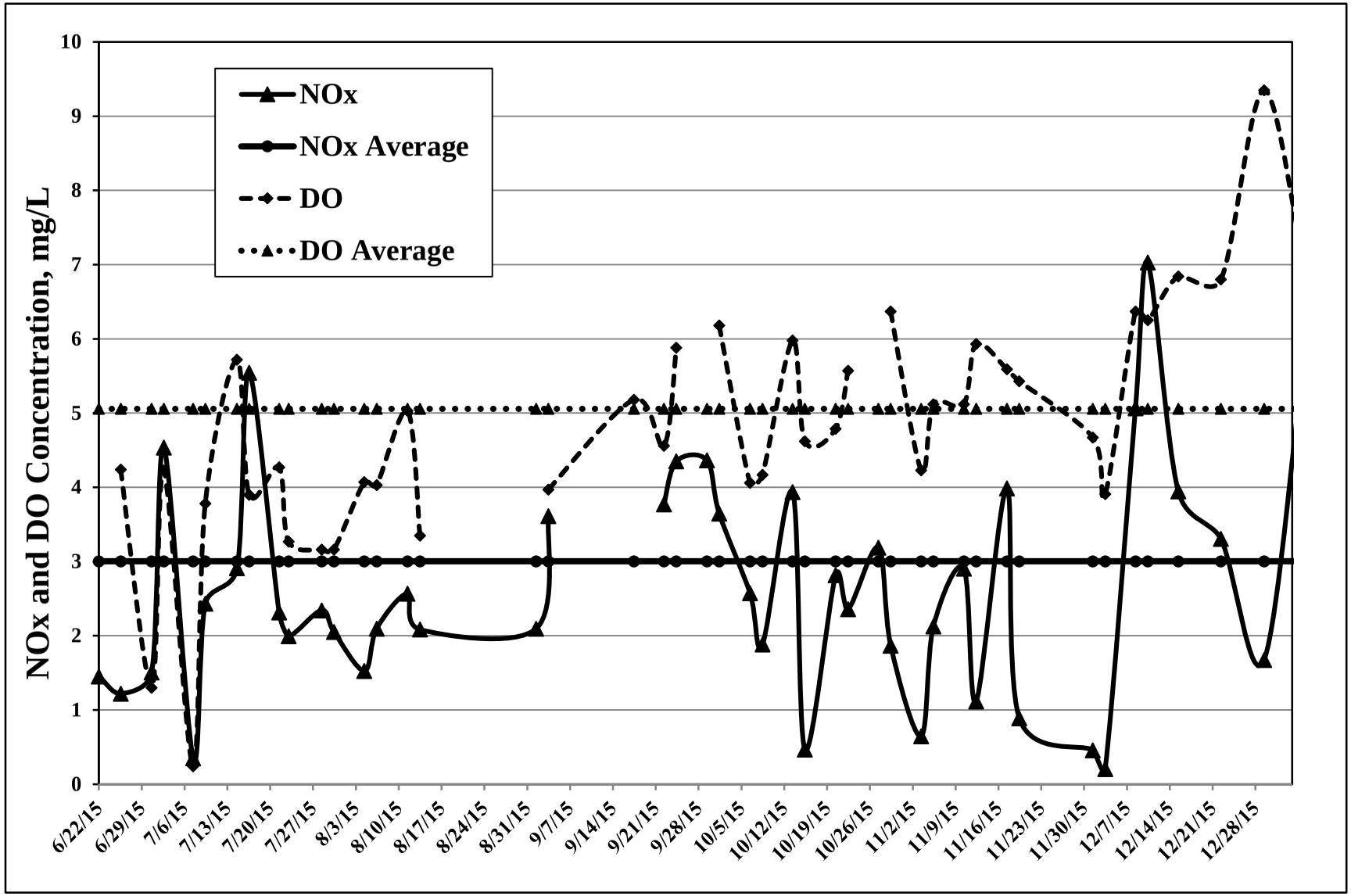


FIGURE 15: DISSOLVED OXYGEN AND NITRATE PLUS NITRITE NITROGEN CONCENTRATIONS IN BATTERY A, B, AND C RETURN ACTIVATED SLUDGE FROM THE TERRENCE J. O'BRIEN WATER RECLAMATION PLANT

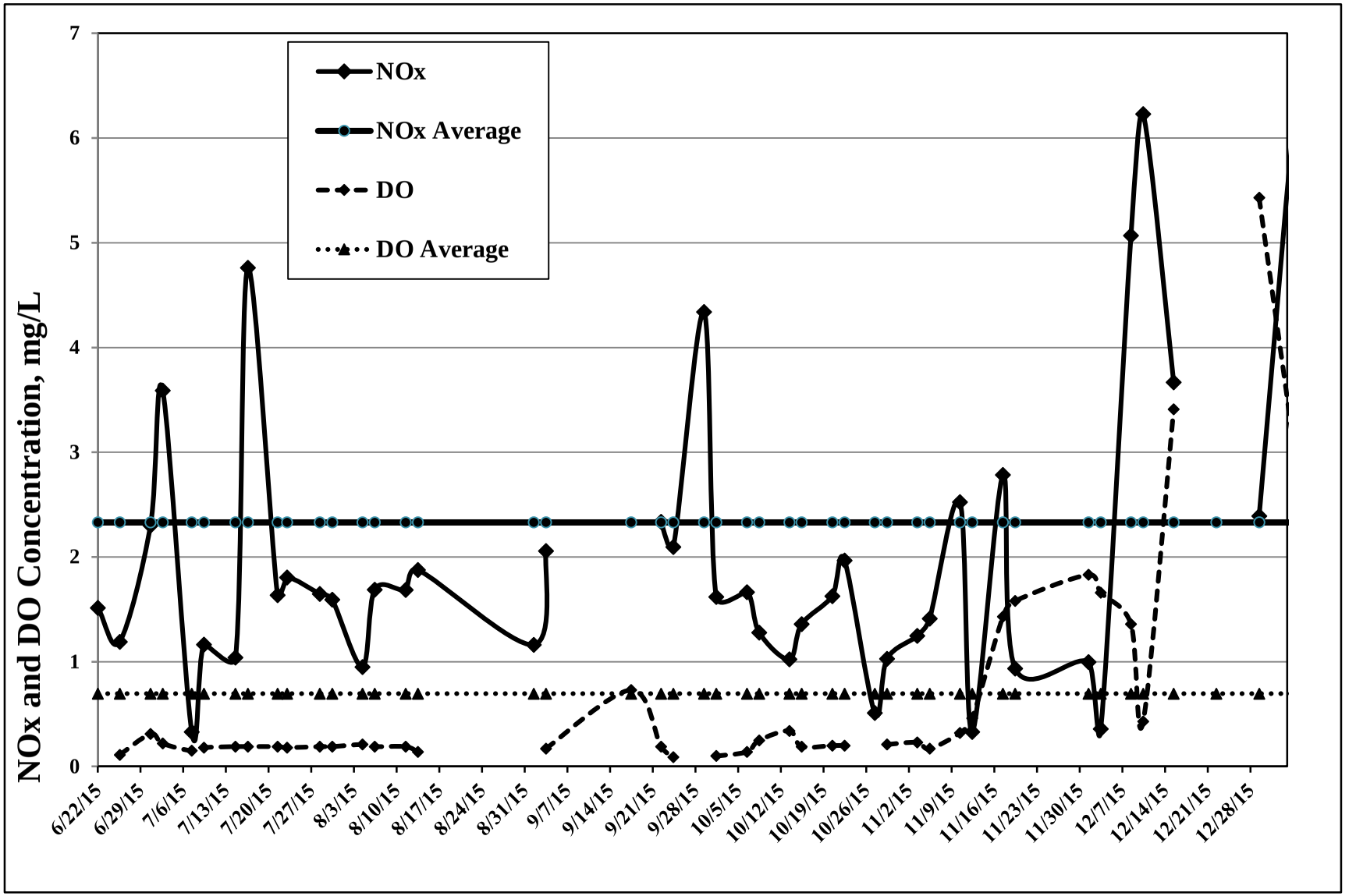
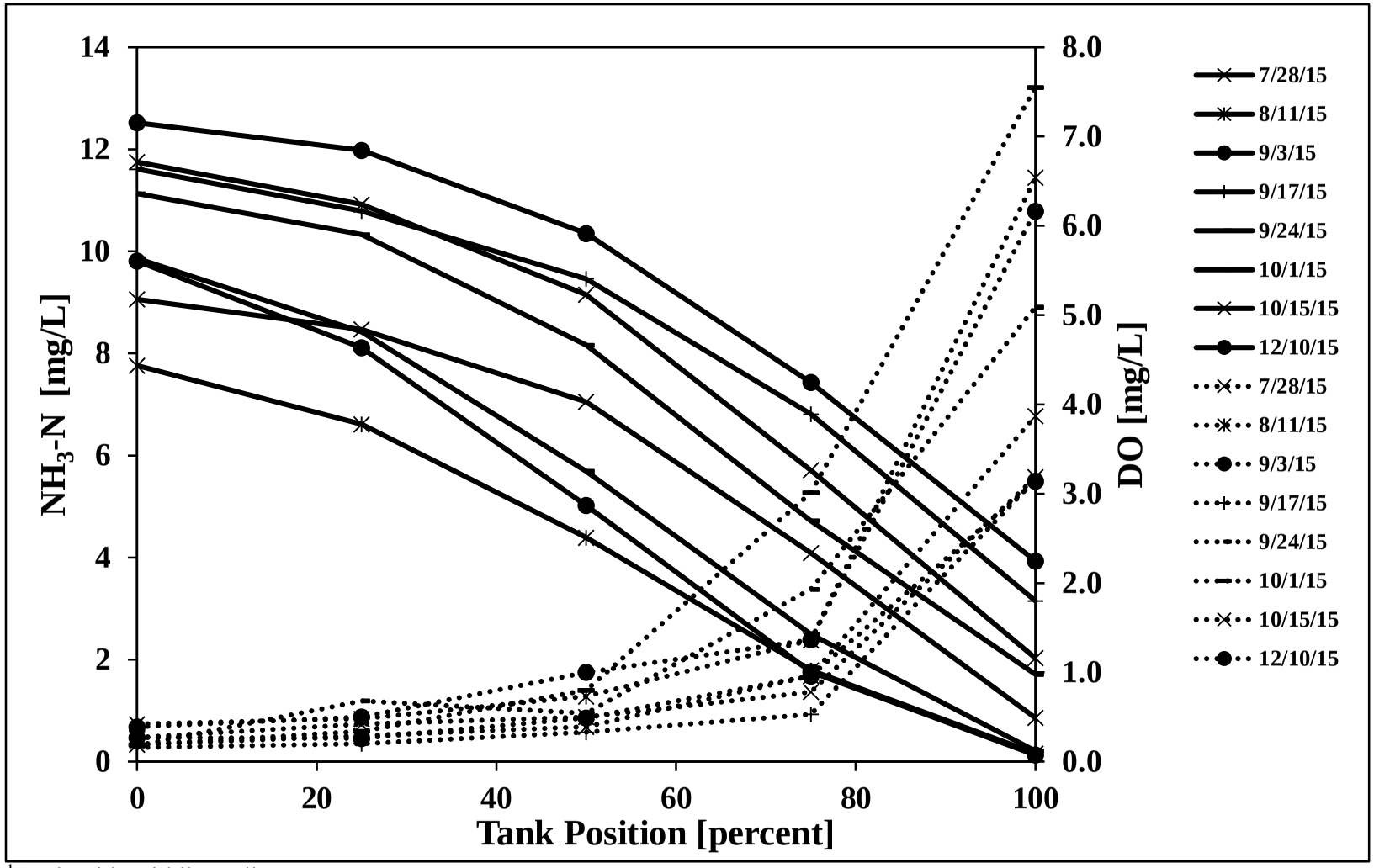
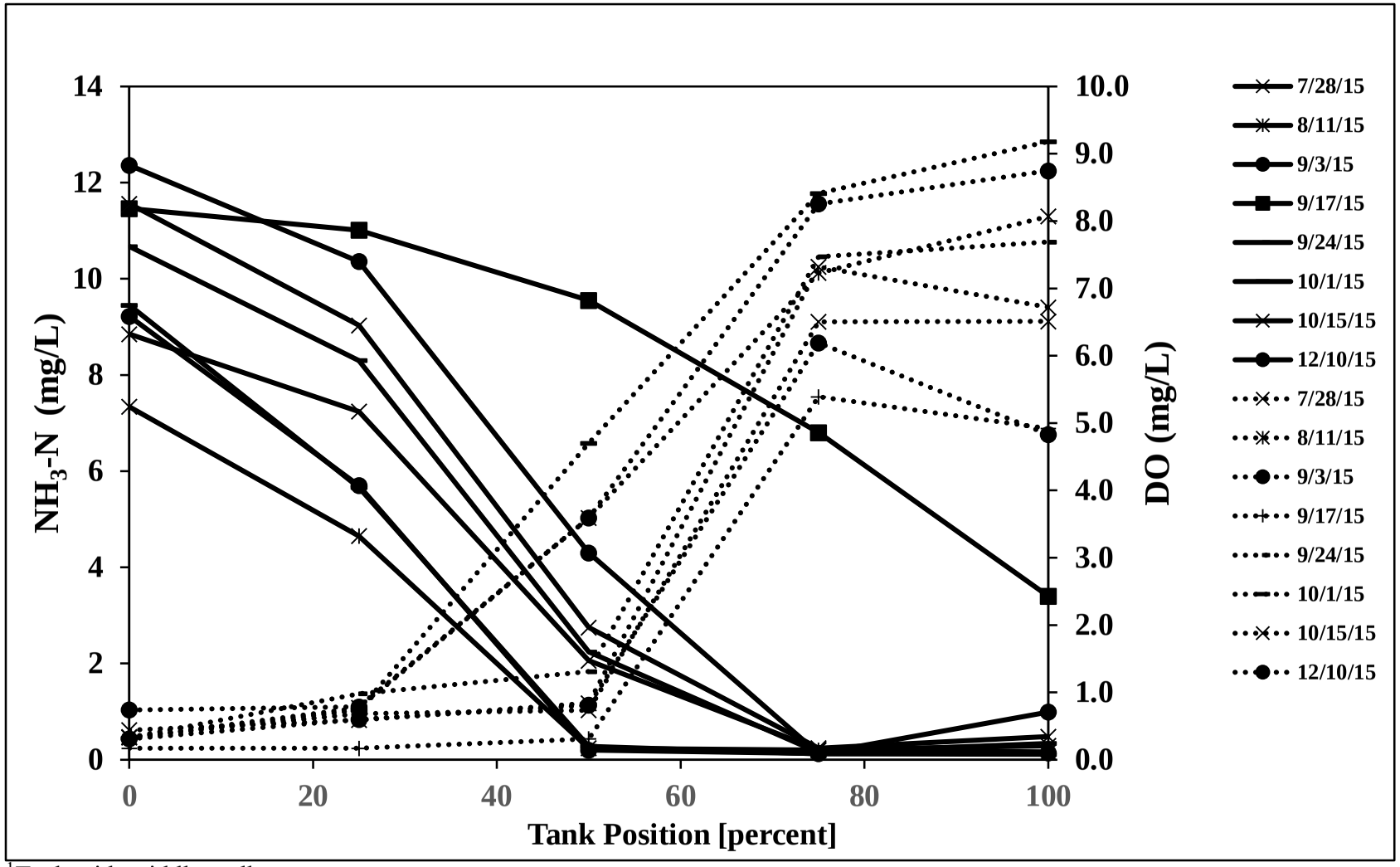


FIGURE 16: AMMONIA AND DISSOLVED OXYGEN CONCENTRATION PROFILES IN TERRENCE J. O'BRIEN WATER RECLAMATION PLANT TANK C-11E[1]



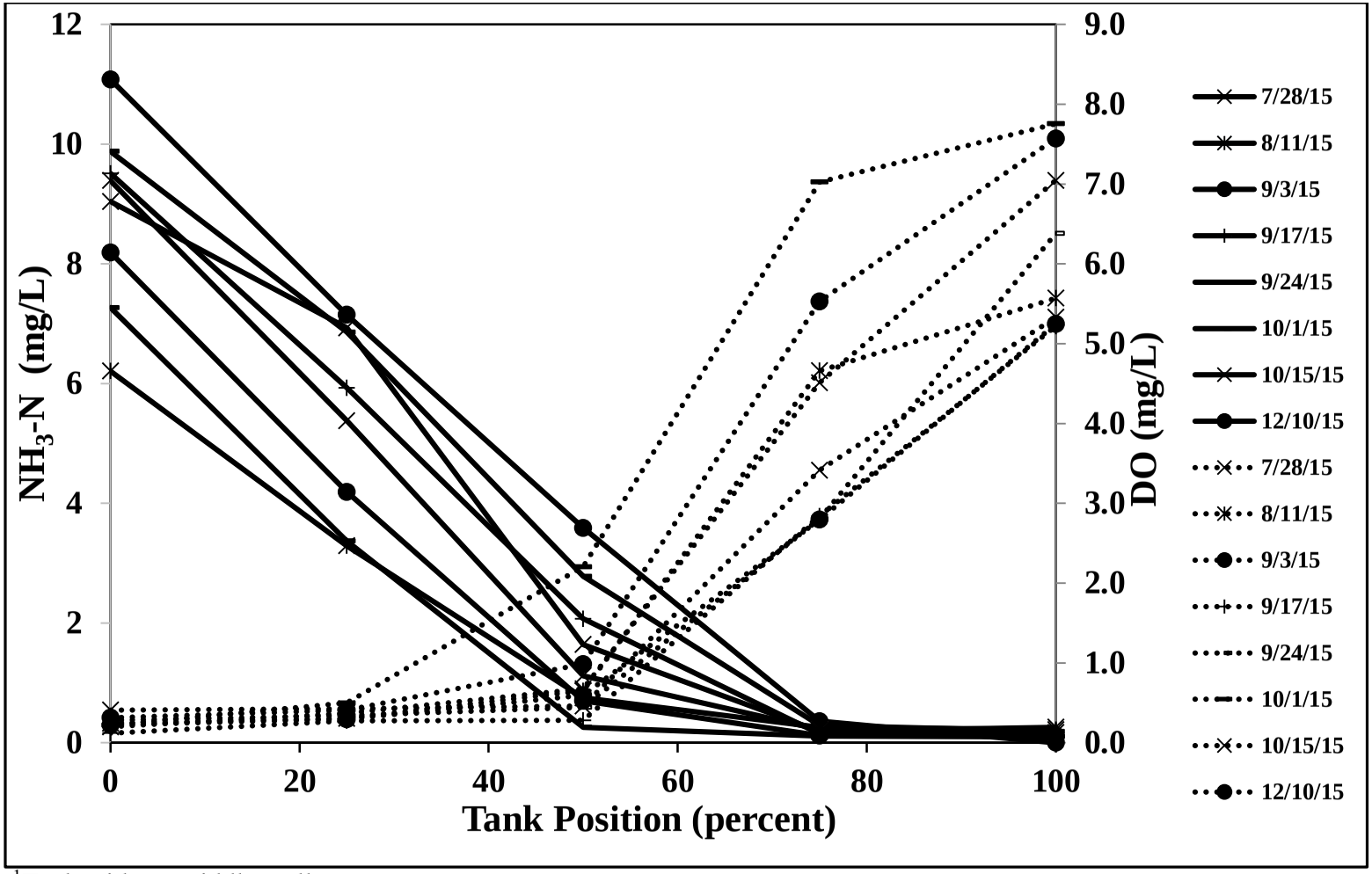
[1]Tank with middle wall.

FIGURE 17: AMMONIA AND DISSOLVED OXYGEN CONCENTRATION PROFILES IN TERRENCE J. O'BRIEN WATER RECLAMATION PLANT TANK C-11W[1]



[1]Tank with middle wall.

FIGURE 18: AMMONIA AND DISSOLVED OXYGEN CONCENTRATION PROFILES IN TERRENCE J. O'BRIEN WATER RECLAMATION PLANT TANK C-12[1]



[1]Tank without middle wall.

FIGURE 19: AMMONIA AND DISSOLVED OXYGEN CONCENTRATION PROFILES IN TERRENCE J. O'BRIEN WATER RECLAMATION PLANT TANK D-5

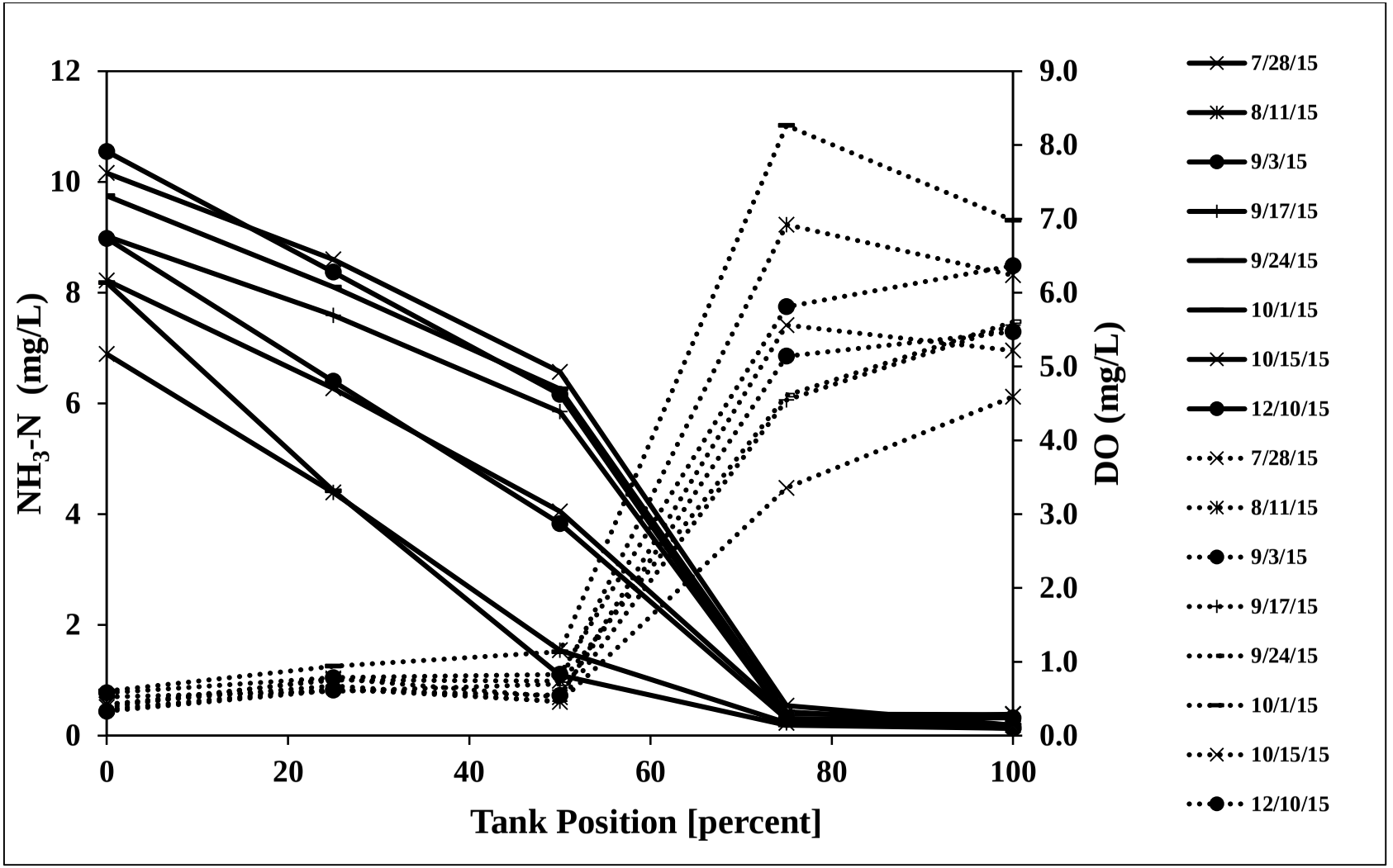


TABLE 8: TERRENCE J. O'BRIEN WATER RECLAMATION PLANT NITRIFICATION RATE TEST RESULTS FOR AERATION TANKS

Test Date	Nitrification Rate @ 20°C, mg-N/g VSS-h			
	C11E	C11W	C12	D5
07/28/15	1.20	2.93	2.35	ND
08/11/15	2.89	2.65	2.22	2.87
09/17/15	0.33	2.43	2.05	2.71
09/24/15	1.55	2.32	2.25	2.50
10/01/15	2.71	2.51	2.29	2.09
10/15/15	1.30	3.02	2.65	2.58
12/10/15	4.01	3.30	3.36	3.25
01/21/16	1.61	3.44	2.74	2.32
02/11/16	0.01	3.12	2.32	2.15
Average	1.73	2.69	2.42	2.55

ND=No Data

- The WASSTRIP® experiments, regardless of different WAS thickness or carbon additions, could not reliably and consistently achieve the overall released ortho-P concentrations to meet the minimum bench mark concentration of 75 mg/L needed by the Ostara® reactors. The average and maximum ortho-P concentration observed was 58.8 mg/L and 75 mg/L, respectively. The percent ortho-P release ranged from 14.3 to 31.7 with an average of 21.5 for all treatments (compared to a 30 percent goal), which is lower than observed from the WASSTRIP® experiments at other plants. Only two of 21 tests had a greater than 30 percent ortho-P release (31.2 percent and 31.7 percent) and the remaining 19 tests had a range of ortho-P release from 14.3 percent to 26.2 percent.

- Average soluable Mg (sol-Mg) release ranged from 34.28 mg/L to 39.20 mg/L over six hours. An average molar ratio of sol-Mg to ortho-P release was 1.29 over one hour and reached 0.86 at six hours, compared to a literature value of 0.3.

- An ideal mass ratio of the VFA to TP in TWAS to achieve a 30 percent ortho-P concentration is estimated to be between 4 to 6 (as VFA) for optimum ortho-P release which is higher than Ostara's experience of a 2:1 carbon to released ortho-P ratio and in-line or slightly above literature suggested value of a 4:1 mass ratio in terms of acetate to the anticipated mass of ortho-P.

- The maximum percent ortho-P release increased from 17.4 percent to 23.8 percent with increase in TWAS SS concentration from 13,760 mg/L to 15,880 mg/L and decreased from 23.8 percent to 17.2 percent with further increase in TWAS SS concentration from 16,280 mg/L to 18,800 mg/L. Maximum ortho-P percent release and concentration for 70-minute WAS settling time were 23.1 percent and 63.4 mg/L compared to 22.6 percent and 68.2 mg/L for 120-minute WAS settling time.

- Thickening WAS to about 1.58 percent (takes about 70 minutes) would reduce the flow of TWAS to the WASSTRIP reactors to approximately 6.6 MGD, which would allow for an HRT of 4.9 hours in the WASSTRIP reactors. Thickening WAS to about 1.58 percent (taking about 70 minutes) is beneficial for Ortho-P release. Further thickening of WAS does not provide additional benefit unless TWAS contains TP higher than 2.7 percent.

- Higher TP in the TWAS closer to 4–5 percent is needed to maximize ortho-P release; however, the percent TP in TWAS tested ranged from 2.06 percent to 2.72 percent with an average of 2.39 percent which handicapped ortho-P release.

- This study confirmed that the chosen distribution of ten tanks is the most preferred configuration for the ten repurposed GCTs. The use of a polymer to enhance thickening of an entire average WAS flow of 12.6 MGD in the four thickening tanks is warranted, especially as the flows vary. Estimated ortho-P

load to the Ostara process under average conditions is 3,110 lb/day. This ortho-P load could potentially be increased by allowing for fermentation to occur elsewhere in the plant and for four tanks to be used for thickening and six tanks for the WASSTRIP® reaction.

Molecular Methods for Monitoring Biological Nutrient Removal Processes. The AMB Section provided sampling and analytical support to several EBPR projects. The MML provided molecular microbiological support to the Stickney EBPR project. The population of PAOs was monitored by molecular method to evaluate the use of molecular tools for monitoring the District's EBPR process. The 16S rRNA based quantitative polymerase chain reaction (qPCR) was tested to establish a baseline number of PAO DNA copies for all four batteries at the Stickney WRP. A total of 77 samples were processed for DNA extraction, and qPCR was performed using *Accumulibacter* specific 16S probes. The number of DNA copies per mg volatile suspended solids (VSS) was calculated from a standard curve generated using synthetic standard PAO-16S. PAO abundance was compared in the aerobic and anaerobic zones of each battery. There was no significant difference found between PAO abundance in aerobic and anaerobic zones. A comparison of the PAO abundance by two different methods and ortho-P (mg/L) values for all 4 batteries are shown in Table 9 and Figure 20.

The AMB staff provided sampling support to Northwestern University's joint partnership with the University of Oklahoma on the Global Water Microbiome Consortium on global water microbiome studies. Under this consortium on municipal wastewater microbiome research, the AMB staff coordinated sampling from the four north side WRPs to determine the temporal dynamics of functionally divergent taxonomic groups of organisms (i.e. bacteria, archaea, fungi, protists) in wastewater systems, and the mechanisms controlling their dynamics.

Co-digestion of High-Strength Organic Wastes. As part of the initiatives to achieve the District's goal of energy neutrality, the Engineering Department in partnership with the M&R and M&O Departments has been actively pursuing additional biogas production through co-digestion and effective biogas utilization. The WTPR investigated the feasibility of co-digestion at the Calumet and Stickney WRPs. This began with determination of unused digester capacity that may be utilized for co-digestion.

In order to efficiently evaluate numerous HSOWs, spreadsheet models for both the Calumet and Stickney WRPs were developed using 2012 plant operations data. Unused digester capacity was estimated at 1,350,000 gal/day for Stickney WRP and 500,000 gal/day for Calumet WRP. Plant operations improvement, regulatory requirements, and HSOW characteristics were considered in the model assumptions. For example, both models assumed that performance of thickening operations would be improved to 5.50 percent TS (within practical pumping range) from approximately 3.74 percent TS, a minimum detention time required to meet the Procedure to Significantly Reduce Pathogens (40 CFR 503.32b3) would be maintained at 20 days as opposed to the typical required 15 days (the time requirement is temperature dependent), HSOW would contain no fats, oils or grease, and a total digester feed flow from post-thickening operations would be around 2,400,000 gpd at the Stickney WRP and 640,000 gpd at the Calumet WRP. All of the above assumptions can be practiced without much difficulty under existing infrastructure with some improvements.

TABLE 9: COMPARISON OF THE PHOSPHORUS ACCUMULATING ORGANISM ABUNDANCE BY TWO METHODS, MOLECULAR AND MICROSCOPIC STAINING, AND PHOSPHORUS REMOVAL IN THE STICKNEY WATER RECLAMATION PLANT ACTIVATED SLUDGE SAMPLES[1]

	Battery A (Aerobic Zone)			Battery B (Aerobic Zone)			Battery C (Aerobic Zone)			Battery D (Aerobic Zone)		
Sample Date	PAO (DNA)[2] copy #/mg VSS (10^8)	Ortho-P mg/L @ FE[3]	Ortho-P Removal[4] (%)	PAO (DNA) copy #/mg VSS (10^8)	Ortho-P mg/L @ FE	Ortho-P Removal (%)	PAO (DNA) copy #/mg VSS (10^8)	Ortho-P mg/L @ FE	Ortho-P Removal (%)	PAO (DNA) copy #/mg VSS (10^8)	Ortho-P mg/L @ FE	Ortho-P Removal (%)
10/28/15	1.95	0.845	65	1.88	0.563	77	1.54	1.594	34	2.19	0.873	64
11/4/15	2.50	1.111	65	2.67	0.458	85	1.66	1.421	55	1.67	0.147	95
11/10/15	1.29	5.093	-49	1.72	4.138	-21	1.27	5.396	-57	1.13	1.192	65
11/18/15	0.11	0.216	90	0.21	0.181	92	0.16	1.433	33	0.22	0.152	93
11/24/15	0.21	0.025	99	0.19	0.025	99	0.15	0.03	99	0.24	0.025	99
12/2/15	0.22	0.204	91	0.19	0.411	81	0.19	1.272	43	0.15	0.096	96
12/9/15	0.13	0.614	82	0.11	0.303	91	0.11	2.432	30	0.16	0.43	88
12/16/15	0.13	0.228	90	0.13	0.367	84	0.16	0.336	86	0.08	0.18	92
Average Copy#/mgVSS	0.82	1.042	73	0.89	0.806	76	0.65	1.739	47	0.73	0.387	86
Average PAO-PolyP μm^2 /mgVSS[5]	0.00028			0.00031			0.00028			0.00045		

[1]Number of samples = 32.

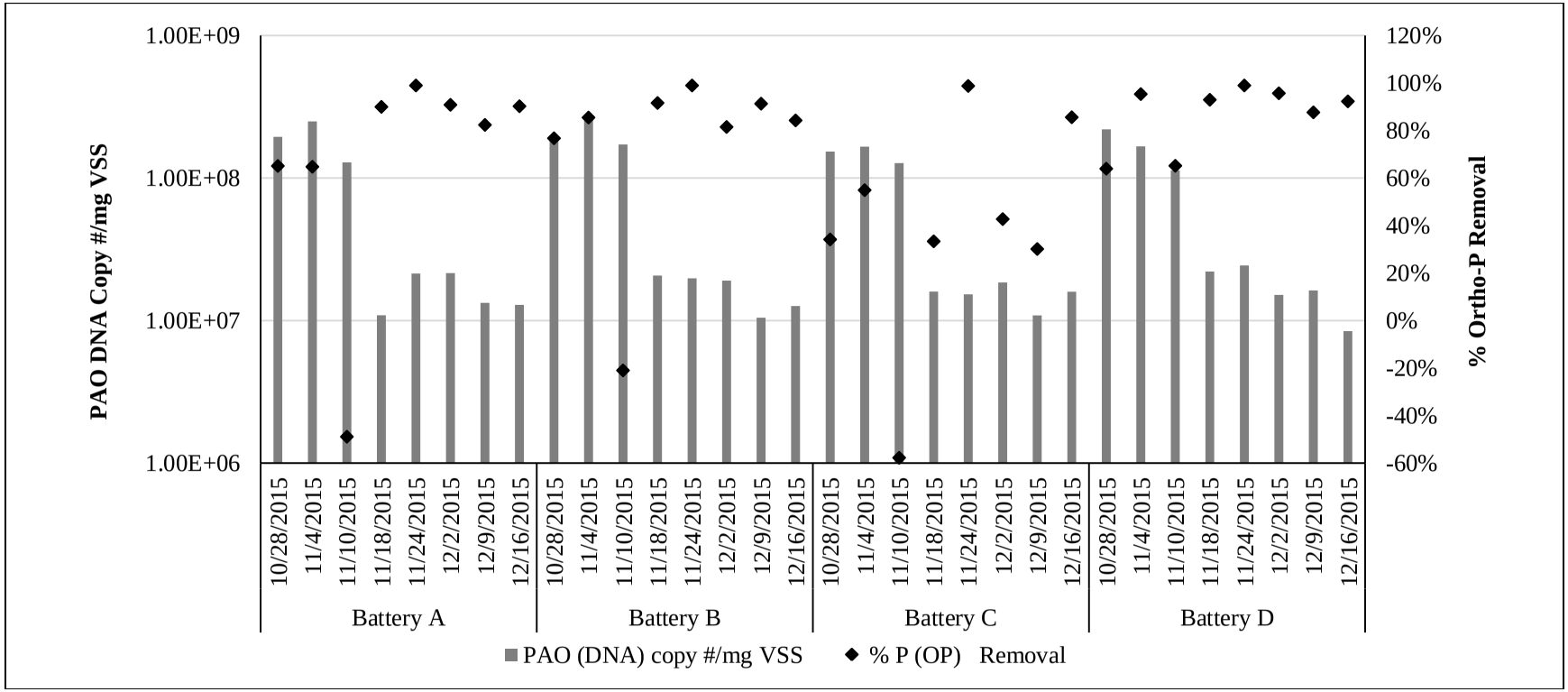
[2]Deoxyribonucleic Acid.

[3]Final Effluent from each battery.

[4]Phosphorus removal (%) calculated using Ortho-P (mg/L) from final effluent of each battery and Ortho-P (mg/L) from Influent Primary effluent (PE). Analyses performed by ALD Laboratory.

[5]Average PAO-PolyP abundance (10^8) determined using traditional microscopy and the Neisser staining method.

FIGURE 20: COMPARISON OF PHOSPHORUS ACCUMULATING ORGANISM ABUNDANCE BY QUANTITATIVE POLYMERASE CHAIN REACTION METHOD[1] AND PHOSPHORUS REMOVAL IN THE STICKNEY WATER RECLAMATION PLANT'S FOUR BATTERIES[2]



[1]*Candidatus Accumulibacter* 16s rRNA gene probe was selected for quantitative Polymerase Chain Reaction (qPCR) analysis.[*]

[*]He, Shaomei, Daniel L. Gall, and Katherine D. McMahon. "'Candidatus Accumulibacter' population structure in enhanced biological phosphorus removal sludges as revealed by polyphosphate kinase genes." *Applied and environmental microbiology* 73.18 (2007): 5865–5874.

[2]Battery D autoclaved sample on 12/26/15 showed only 0.0025 x 10^8 copy # PAO DNA/mg VSS (Inactive cells). Phosphorus removal (%) calculated using Ortho-P(mg/L) from final effluent of each battery and OrthoP (mg/L) from primary effluent (PE). On 11/10/15 all batteries except battery D had higher Ortho-P value in Final Effluent than in the Influent (Primary effluent).

The WTPR Section developed criteria for accepting the preferred HSOWs for co-digestion. This included chemical characteristics and developing a test method, biochemical methane production (BMP), to help screen HSOWs based on their ability to produce the biogas.

Literature data and experiences of other utilities with respect to a few chosen waste streams may not provide sufficient information on critical operating performance parameters to evaluate suitability on HSOW at District plants. Therefore, the WTPR Section conducted laboratory-scale experiments to evaluate co-digestion of an HSOW. The experience from the laboratory-scale study and developed protocols may be useful if further testing is needed beyond the above screening protocol.

Finally, it is known that HSOW co-digestion would increase the organic loading and total solids concentration in the digesters, and it is suggested that such operating conditions require proper mixing of the contents. However, it is necessary to understand the true potential and the role of mixing during co-digestion operating conditions. In order to evaluate the effects of mechanical mixing on full-scale digester performance, a work plan was prepared in 2015 to test increased organic and solids loading with and without mixing in one digester at the Calumet WRP. This testing will be performed in summer 2016.

Technical Support to Biosolids Management Program. Technical support is provided to projects under the CSD Program, in which EQ biosolids, air-dried biosolids, and composted biosolids are used in the Chicago metropolitan area, and to the Class B Biosolids Farmland Application Program. The technical support is provided to help biosolids users maximize the benefits they receive from the program and to ensure that the District and the users comply with applicable regulations and permits. The Division also conducts extensive marketing activities to promote the use of biosolids and composted biosolids under the CSD Program.

- CSD Program – The activities conducted in 2015 to promote and support the CSD Program include:

    1. Conducted site visits and meetings and provided technical support on projects where 15,360 dry tons of EQ air-dried biosolids were used as a soil conditioner or topdressing fertilizer. In addition, 2,261 dry tons of composted biosolids were used as soil amendments for varying landscaping projects.

    2. Collaboration with the Chicago Park District, to promote the use of biosolids for development of parks and recreational areas in Chicago.

    3. Revision of biosolids marketing brochures and pamphlets.

    4. Collaboration with the Public Affairs Section to organize and conduct a Sustainability Summit in Hinsdale jointly hosted by the Village of Hinsdale Park and Recreation Services. Attendees learned about the District's green initiatives,

sustainable practices, regulations pertaining to land application of biosolids, benefits of using biosolids for topdressing turf, and interacted with biosolids users.

5. Performed survey of CSD users to understand user perspectives on the biosolids program and identify areas for improvement.

- Class B Biosolids Farmland Application Program – The activities the BU&SS Section conducted in 2015 to support the program include:

    1. Reviewed 187 field information packets for potential application fields under the Class B Biosolids Farmland Application Program. This includes reviewing the field location, buffers established for surface water, roads and dwellings, contacts made with neighbors and public officials, and soil pH and liming requirement, if any. Approval or disqualification notice for the proposed fields is submitted to the M&O Department.

    2. Conducted 30 field inspections and meetings with individuals, community groups, and public officials to answer questions and address concerns regarding the use of biosolids.

- Biosolids Composting. The District started the biosolids composting initiative in 2011. The main goal of this initiative is to produce a value-added and odor-free biosolids product for distribution in the Chicago metropolitan area. Biosolids are composted in windrows with wood chips obtained from the city of Chicago. In 2015, the EM&R staff monitored temperature in the windrows and advised M&O Department staff to manage the windrows as needed to comply with the time and temperature requirement to produce a Class A product. Samples of the final product were collected and analyzed.

Calumet Water Reclamation Plant Final Biosolids Processing Technologies Evaluation. A task force was formed to evaluate technologies to improve the final biosolids processing at the Calumet WRP. The task force included members from the M&O, Engineering, Procurement and Materials Management, Finance, and M&R Departments. The major items that were studied include:

- Reduce/eliminate odors due to current biosolids drying and handling procedures.

- Create readily available end-use products that are not dependent on weather conditions.

- Optimize operational land requirement.

- Increase utilization within Cook County.

- Ensure financial/environmental sustainability of the program.

The task force recommended composting using the GORE® Cover Composting as the best alternative biosolids management technology in order to meet the EQ biosolids requirements and produce a high quality composted biosolids product. The composting system is in design and is anticipated to be operational in 2018.

Calumet Water Reclamation Plant Dewatering Technology Evaluation. The PFCP Section performed a comprehensive evaluation of viable dewatering technologies to recommend a conceptual strategy to improve the biosolids dewatering process at the WRP and meet the feedstock requirements for covered composting**.** The major items being considered in the evaluation include capital expenditures, polymer and electricity usage, and preventative maintenance requirements. A recommendation will be provided in the first quarter of 2016.

Evaluation of Permeable Pavement at the Stickney Water Reclamation Plant. In this project, the District is evaluating porous pavement technology for stormwater management in the Chicago metropolitan area. Three different permeable pavements (paver stone, concrete, and asphalt) were established on driving areas and parking slots on the general parking lot at the Stickney WRP. The permeability of the pavements measured in 2015 is shown in Table 10. Permeability of different surfaces varied and was in the order of asphalt > concrete > paver stone and was generally lower in the driving area than in the parking area. Vacuum cleaning of permeable pavements was conducted in May 2014, which helped in improving the permeability of all surfaces as compared to the values measured in 2013; however, in 2015 the infiltration rate declined as compared to previous year. Periodic site visits during periods of rainfall indicated no visible standing water or runoff on any of the permeable lots during all monitoring seasons. Standing water and runoff were observed in the impermeable control lot. There were significant amounts of weeds growing in the paver stone lot between the pavers, which need to be removed.

Streetscape and Sustainable Design Program. The District is conducting a collaborative project with the Chicago Department of Transportation and the United States Geological Survey for evaluating various green infrastructure BMPs to reduce stormwater and pollutant loads to the collection systems. Construction of the BMPs was completed in fall 2012, which consisted of permeable pavers, planter boxes, and bioswales. Immediately after construction of the BMPs, the permeability of pavers and soil in the planter boxes and bioswales was measured. Permeability of permeable pavers at different sites measured during 2015 is shown in Table 11. Permeability declined with time; however, when pavers were cleaned, the permeability of pavers increased significantly. Permeability of bioswales is presented in Table 12. Permeability in the center of bioswales was higher than near curb cut, probably due to higher sediment deposition close to the curb cut. Permeability of bioswales at both locations declined with time. Permeability in both pavers and bioswales has declined as compared to previous years. In general, the data showed that greater than 95 percent of the runoff generated was captured by the BMPs, and this exceeded the project goal of capturing 80 percent of the runoff generated during an average two-year storm. The final report on this project will be prepared in 2016.

Native Prairie Landscaping. During 2015, the Division provided technical support for maintenance of the conventional and native prairie landscaping at the District's facilities. In

TABLE 10: PERMEABILITY OF PERMEABLE SURFACES AT THE STICKNEY WATER RECLAMATION PLANT PARKING LOT IN 2015, SEVEN YEARS AFTER INSTALLATION

Area	Paver Stone	Concrete	Asphalt
	Permeability (inch/sec)		
Driving Area	0.10 ± 0.01	0.18 ± 0.01	0.23 ± 0.01
Parking Slot	0.25 ± 0.02	0.328 ± 0.02	0.33 ± 0.02

TABLE 11: CHANGES IN AVERAGE PERCOLATION RATE OF PERMEABLE PAVEMENTS IN THE STREETSCAPE CORRIDOR WITH TIME

Test Done/Pavers Cleaning	Juarez Academy	Blue Island North	Blue Island-South
	---------- Percolation (inch/hr) ----------		
October 2012	9.0 ± 1.2	18.2 ± 3.4	20.1 ± 2.2
June 2013	3.9 ± 0.9	4.1 ± 1.8	8.3 ± 1.9
Paver Cleaned (July 2013)[1]	No	Yes	Yes
August 2013	2.7 ± 0.6	44.7 ± 6.9	169.5 ± 22.4
May 2014	2.4 ± 0.6	21.0 ± 6.0	63.0 ± 14.4
Pavers Cleaned (July 2014)[1]	No	Yes	Yes
August 2014	2.4 ± 0.6	43.2 ± 10.8	140.4 ± 22.2
May 2015	1.9 ± 0.9	2.35 ± 0.79	2.63 ± 1.0
Pavers Cleaned (May 2015)[2]	No	Yes	Yes
June2 015	1.6 ± 0.5	20.6 ± 11.8	7.17 ± 4.3

[1]Manual pavers cleaning with pressurized air, all fill aggregate removed and replaced with new aggregate.
[2]Mechanical cleaning conducted utilizing a vacuum truck and rotary wet brushing, only 1/2 inch aggregate removed and replaced with new aggregate.

TABLE 12: CHANGES IN AVERAGE PERCOLATION RATE OF SOIL IN THE BIOSWALE AND PLANTER BOXES IN THE STREETSCAPE PROJECT CORRIDOR WITH TIME

Test Done	Bioswale		Planter Boxes	
	Near Curb-Cut	Center	Without Curb-Cut	With Curb-Cut
	Percolation			
October 2012	11.4 ± 3.7	61.2 ± 18.3	65.9 ± 15.2	60.5 ± 14.9
June 2013	9.2 ± 3.2	55.3 ± 15.4	62.7 ± 13.5	45.9 ± 10.6
August 2013	7.5 ± 3.6	50.4 ± 11.8	55.6 ± 12.1	43.4 ± 8.9
May 2014	5.5 ± 2.3	20.6 ± 7.2	52.4 ± 10.5	35.8 ± 9.6
August 2014	5.2 ± 2.1	18.4 ± 7.1	48.6 ± 9.2	30.5 ± 8.8
May 2015	3.3 ± 1.4	10.5 ± 5.6	39.7 ± 8.7	20.9 ± 7.4
June 2015	3.1 ± 1.6	8.6 ± 4.7	35.7 ± 7.4	18.9 ± 6.6

addition, the Division also provided support to the maintenance of the Meany Employee Garden at the Stickney WRP.

Wastewater Microbiology Monitoring. In 2015, the AMB Section continued the microscopic examination of mixed liquor samples from the District's WRPs to determine the relative abundance of protozoan and metazoan species; filamentous bacteria; and to characterize the health of the biological floc. The microscopic results help guide the treatment process with information to address treatment system operation and/or upsets. The microscopic assessment results were summarized and transmitted to the M&O Department.

Hanover Park and Kirie WRP samples were collected on an as-needed basis. Egan WRP mixed liquor was monitored weekly. The sludge volume index (SVI), a measure of the sludge settleability, was associated with the abundance of the filamentous bacteria *Microthrix parvicella* at the Egan and Hanover Park WRPs (Figure 21). The filamentous bacteria counts and SVI values at the Egan WRP North and South Batteries are shown in Figure 22. The filamentous bacteria Type 021N was dominant at the Kirie WRP, with filament counts exceeding 3,000/mg VSS, which was above the baseline average filamentous bacteria count for Kirie WRP (Figure 23).

Stickney Water Reclamation Plant Southwest Scum Process Evaluation. The PFCP Section completed the Southwest Scum Evaluation and drafted a Technical Memorandum summarizing the findings and recommending several improvements. The four major components of the southwest scum system identified and analyzed include: (1) scum skimmers, (2) scum piping, (3) scum concentration building, and (4) overall PST area. The operational and maintenance recommendations include a team approach and a sense of asset ownership, increased communication between staff, a holistic approach to asset operation and maintenance, and implementation of the standard operating procedures that were drafted as part of this evaluation. Some of the capital improvements include replacement of the scum skimmer pull chains with the original design pull arms, replacement of leaking scum bucket bushings, replacement of scum piping isolation valve on scum line No. 4, automation of the scum removal system, and replacement of the horizontal screws in the scum concentration building. The evaluation and implementation of recommendations resulted in an increase in scum removal to historical rates (Figure 24).

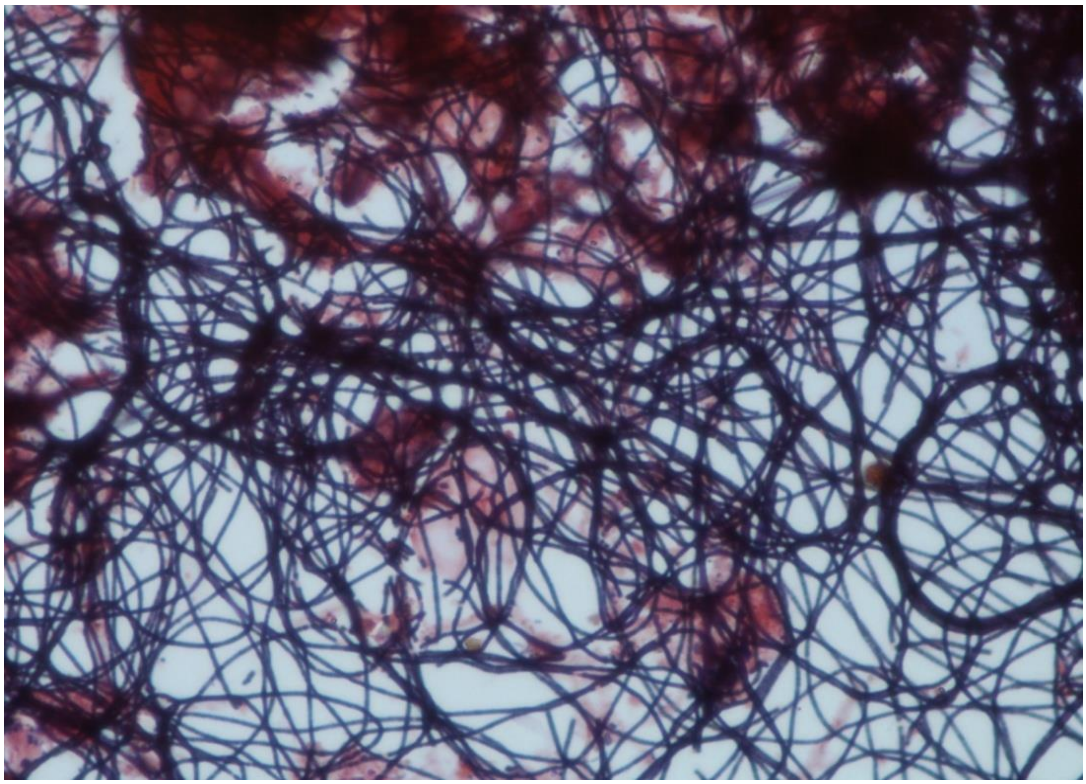
Odor Master Plan. In 2014, the PFCP Section started the development of a District-wide Odor Master Plan.

The goals of the Odor Master Plan include:

- Review existing odor control technologies and procedures employed at the District for effectiveness and cost efficiency.

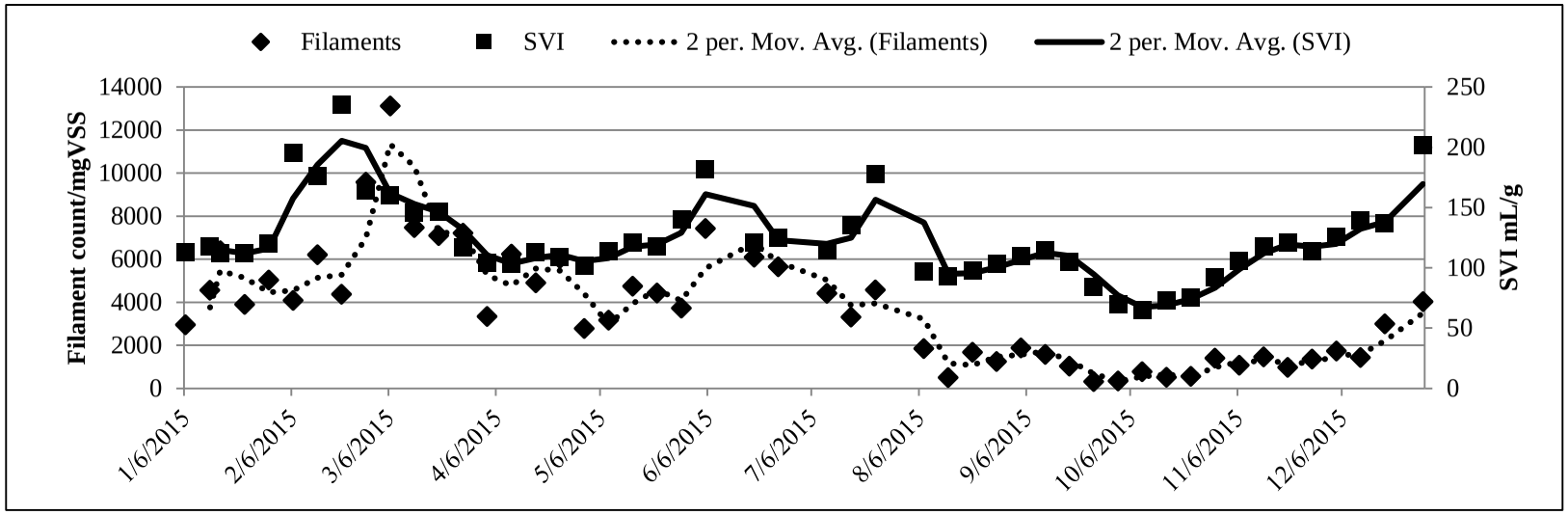
- Provide guidelines to supplement the current monitoring program to identify and prioritize odorous "hot spots" and to identify technologies available for collecting and testing samples.

FIGURE 21: FILAMENTOUS BACTERIA *MICROTHRIX PARVICELLA* OBSERVED IN THE JOHN E. EGAN AND HANOVER PARK WATER RECLAMATION PLANTS

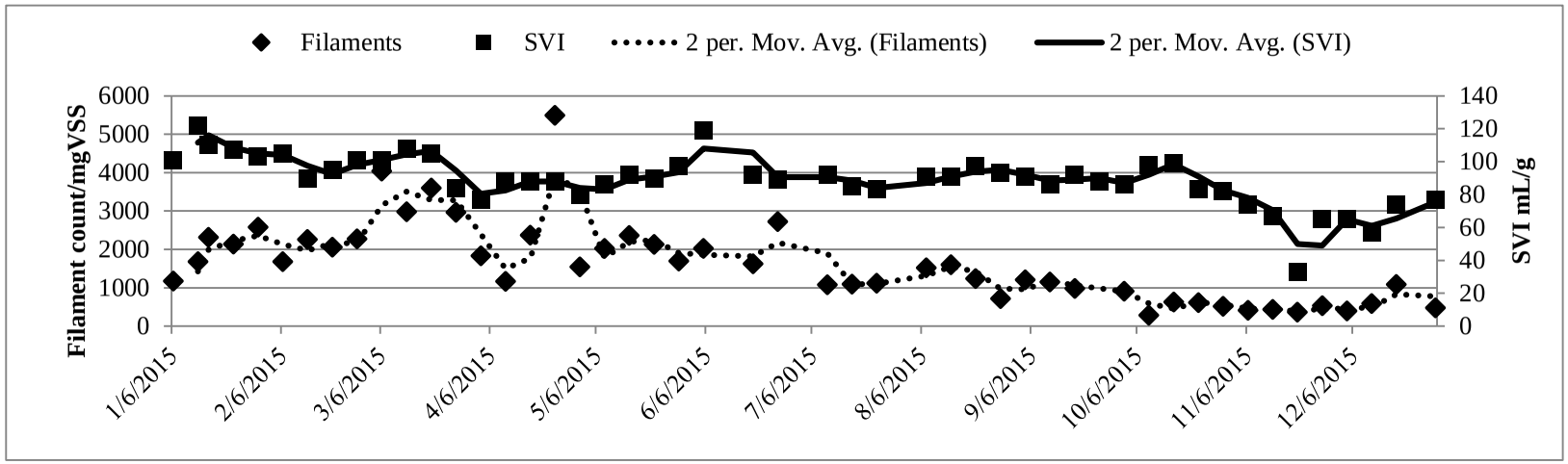


Gram positive filamentous bacteria observed under 100x oil immersion Brightfield microscope

FIGURE 22: COMPARISON OF THE FILAMENTOUS BACTERIA COUNTS AND SLUDGE VOLUME INDEX IN THE NORTH AND SOUTH BATTERIES OF THE JOHN E. EGAN WATER RECLAMATION PLANT

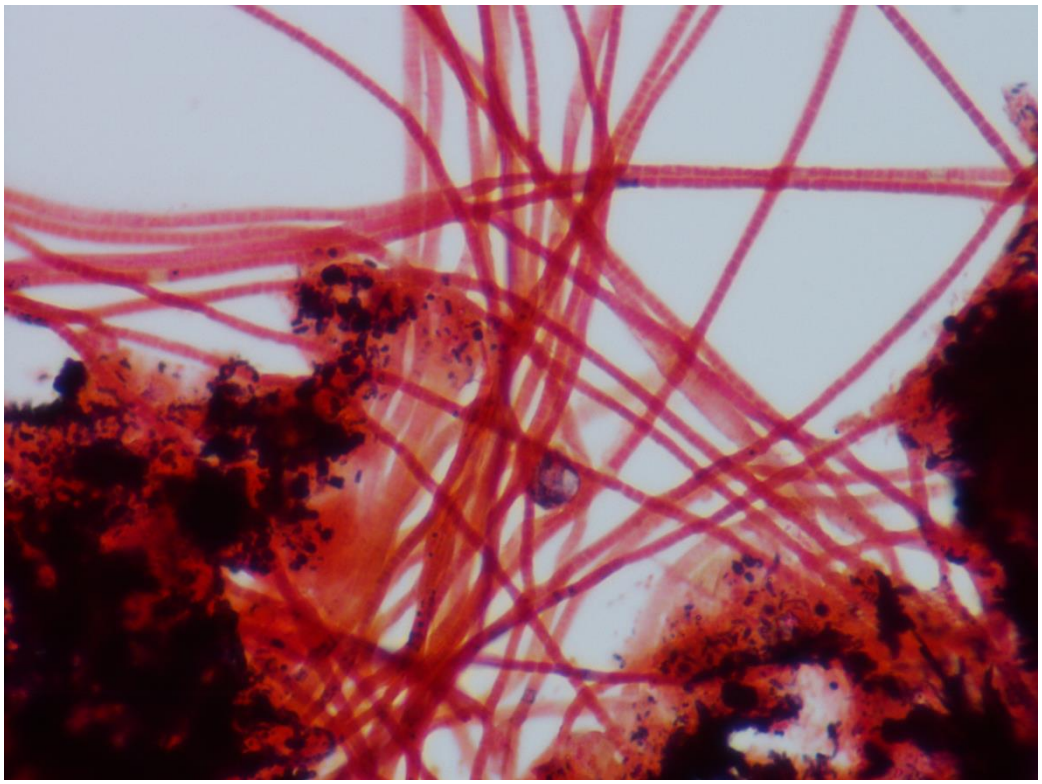


(A) North Battery – Dominant filament *Microthrix parvicella*



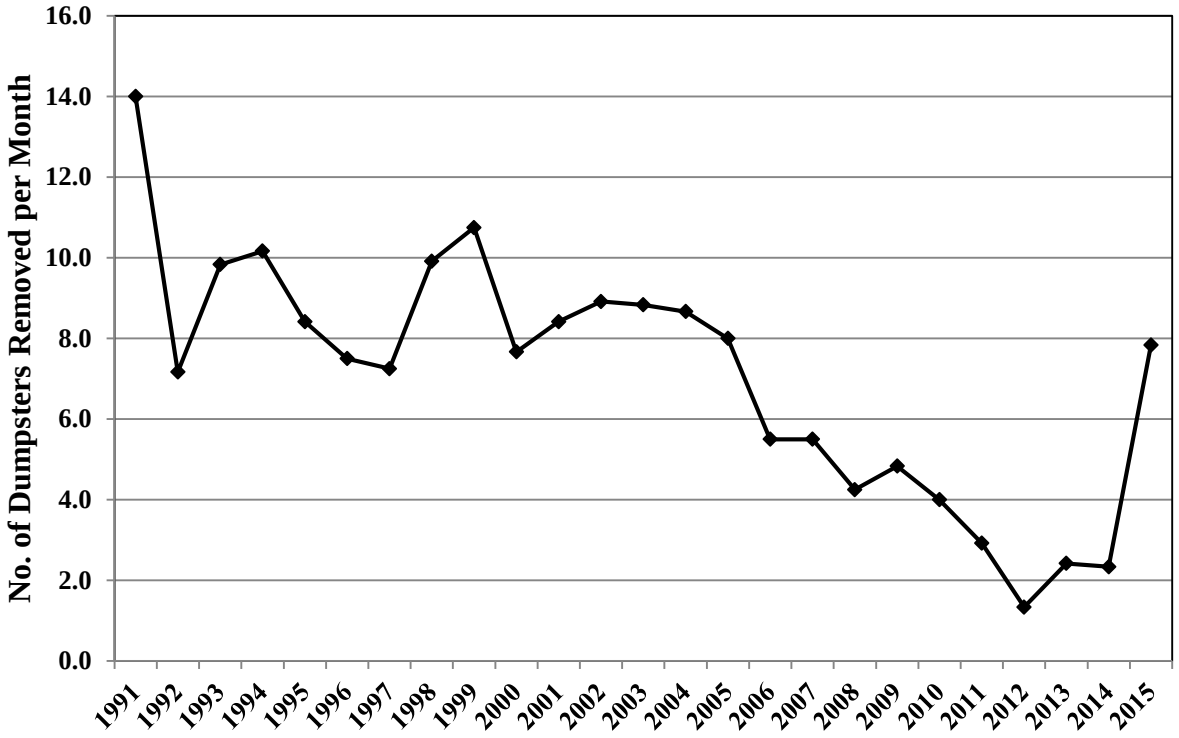
(B) South Battery – Dominant filament Types 0041 and 0675

FIGURE 23: FILAMENTOUS BACTERIA TYPE O21N OBSERVED IN THE JAMES C. KIRIE WATER RECLAMATION PLANT



Gram negative filamentous bacteria observed under 100x oil immersion Brightfield Microscope

FIGURE 24: SCUM REMOVAL AT SOUTHWEST PORTION OF THE STICKNEY WATER RECLAMATION PLANT



- Provide a menu of mitigation options to address different odorous compounds and treated air flows.

- Provide recommendations on dispersion modeling that will be used to assist with the identification and prioritization of odors as well as provide support for the design of odor mitigation projects.

- Identify potential improvements in the District's current community relations program with respect to odor.

Significant sources of odors will be prioritized and addressed at the WRPs, collection systems, pump stations, and the solids processing facilities.

Calumet Water Reclamation Plant Odor Control Evaluation. This evaluation was initiated in 2014 as an early deliverable of the Odor Master Plan. The EM&R Division, in conjunction with the Engineering and M&O Departments, formed an evaluation team to identify options to effectively treat the odorous areas at the Calumet WRP headworks, aerated grit facility, and sludge concentration building. These locations were identified as the most odorous areas of the plant by reviewing data collected under the existing Odor Monitoring Program. The sludge concentration building was excluded from this evaluation due to anticipated process changes in the building, and will be evaluated under a separate project.

Baseline data were collected from both the liquid and air streams in the junction chamber, screen building, and aerated grit facility to identify odorous compounds and the concentrations of these compounds. This information, along with a comparison air flow of 12 air changes per hour, was used to compare different odor control technologies. A long list of options was identified for these areas which were narrowed down to a short list by the evaluation team. Utilizing a bio-trickling filter with the existing carbon adsorption system, increase the dosing at the existing sodium hypochlorite dosing station, and installing a high-speed exhaust fan at the junction chamber are the short list of options identified for the headworks of the plant. Modifying existing ductwork and covering and treating the effluent channel and weirs with a carbon adsorption system were identified as the short list options for the aerated grit facility.

The evaluation was completed and presented to the Executive Team in September of 2015. The odor control technology recommended for the Junction Chamber is a bio-trickling filter which will be more effective than the existing carbon adsorption system. For the Aerated Grit Building, HVAC modifications were recommended to better utilize the existing high-speed exhaust fans. The carbon adsorption system from the Junction Chamber will be relocated to a location with lower odor. The plant will increase the use of the existing sodium hypochlorite dosing system to address odors at the junction chamber until the new bio-trickling filter is installed.

The PFCP Section initiated the process of acquiring a "real time" odor monitoring system to improve odor monitoring at the Calumet WRP. The system will use "electronic noses," calibrated to plant-specific odor compounds coupled with a calibrated dispersion model and a weather station to produce "real time" odor plumes originating from the plant. These odor plumes can be used by plant personnel to: (1) identify odorous areas in the plant, (2) initiate

corrective actions to prevent odors from reaching the surrounding communities, and (3) utilize the system's history to determine if odor complaints were caused by the plant. Installation of the OdoWatch dispersion modeling system was started in late 2015. A project was initiated under a Job Order Contract to install all the supports, electrical connections, and foundations needed to mount the electronic noses (eNoses, SulfNose), and weather station associated with the system. The installation, training, and model verification will be completed in 2016.

Hanover Park Water Reclamation Plant Odor Control Evaluation. The Hanover Park WRP was identified as the next location to receive an odor evaluation based on the close proximity of the plant to the surrounding community, including an elementary school just outside the fence line. The Coarse Screen Building, Gravity Belt Thickening (GBT) Area, and the Pre-treatment Building were identified by plant personnel as areas in need of odor control.

Odor data was collected from these areas and the required amount of air to be treated was calculated. Data was collected at the GBT area when the existing ozone system was running and when it was turned off. Analysis of this data showed that the ozone system had no effect on eliminating the odorous compounds in the air stream. The odor data collected at the identified areas was used to size different odor control technologies for comparison. The long list of odor control technologies will be scored using a triple bottom line analysis based on categories and scoring percentages agreed upon by the evaluation team that includes staff from M&R and M&O WRP staff. Odor control technologies will be selected in 2016 along with the detailed design of the odor control system.

Thornton Composite Reservoir Odor Modeling. After the TCR was placed in service in September 2015, significant odor emissions occurred following fill events which led to odor complaints from the surrounding communities. As part of the effort to address odor emissions, dispersion modeling was performed on the TCR to help predict the effect of odors on the surrounding communities. Both liquid stream and air stream odor data were collected from the reservoir. These data along with five years of hourly weather data from the Lansing Municipal Airport was used to develop the dispersion model. Three different scenarios were used in the model: (1) Full Reservoir Scenario – the model will assume the reservoir is at full design capacity, (2) Mid-Level Reservoir Scenario – the model will assume the reservoir is approximately half full, and (3) Low-Level Reservoir Scenario – the model will assume the reservoir has a low water level with an assumed amount of debris accumulated at the base of the reservoir. Graphic outputs of each of the three scenarios modeled will include two isopleth maps, one reflecting the maximum 1-hour odor strength and another reflecting the frequency of impacts over a predetermined nuisance threshold. All maps will be overlaid on aerial photographs of the reservoir. In addition to predicting the effect on surrounding communities, these dispersion models can be used in the future to assist in the design and optimization of odor mitigation strategies developed for the TCR.

Long Term Capital Planning. In 2015, the PFCP Section and other interdepartmental workgroups finalized the first iteration of a dynamic long-term capital plan (Plan) for the District focusing on the 5 to 20 year timeframe. The Plan was developed using deliverables completed by the Regulatory, District Initiative, Community, Budget and Finance, and Supporting Information workgroups in 2014. The combination of the Plan and CIP (Combined Plan) were approved in early 2015. The next steps for the Long Term Capital Planning project include annual updates of

the Combined Plan, so that the Combined Plan remains dynamic in response to changing conditions. All information regarding the Plan such as meeting minutes and deliverables are available on the District's intranet.

Regulatory Review. The Division conducts reviews and provides technical support in response to imminent regulations that can potentially affect District operations. Some of these reviews are requested by professional affiliations or organizations. Some of the technical support is provided to the Law Department regarding various legal challenges and lawsuits. The following reviews were conducted in 2015:

- Reviewed documents and provided data in support of the IPCB Rulemaking concerning the CAWS use attainability analysis.

- Reviewed and commented on documents related to District and third–party NPDES permit appeals for the O'Brien, Calumet, and Stickney WRPs.

- Provided testimony and answers to the Illinois Department of Natural Resources and third-party intervener questions concerning the District's petition for modification of Lake Michigan discretionary diversion allocation.

- Provided technical review of expert witness reports, supplied data and information to the District's expert witness, and helped the Law Department provide the technical basis for legal arguments in the citizen's suit against the District.

- Attended workgroup meetings and reviewed on draft revision of "Offensive Conditions" water quality standard regarding algae.

- Participated in the development of IEPA's Illinois Nutrient Loss Reduction Strategy and resulting workgroups. The Strategy established statewide goals and a strategy for reducing N and P discharge from the state as part of a national effort to reduce the Gulf of Mexico hypoxic zone.

- Attended stakeholder and workgroup meetings on development of NH_3 effluent limits based on most recent USEPA criteria.

- Provided data and analysis to support CAWS Chloride Reduction Initiative Workgroup and Water Quality Committee.

- Provided data and review of the national water quality criteria for bacteria.

- Reviewed documents and provided data in support of the IPCB Rulemaking concerning the CAWS UAA.

- Worked with the Law Department to review state and federal biosolids regulations and developed language for Illinois legislative changes to recognize the federal EQ biosolids designation.

Program 5: Operations and Applied Research

Membrane-Aerated Biofilm Reactor (ZeeLung™) Pilot Test. In collaboration with GE water, an innovative membrane-aerated biofilm reactor (MABR) technology was studied at the O'Brien WRP to evaluate its potential with respect to EBPR process. Using this system the nitrification capacity in the existing aeration tanks is expected to increase, thus permitting the creation of an anaerobic zone for EBPR without adding costly new infrastructure. Laboratory studies have demonstrated that this technology has the added benefit of improving total suspended solids (TSS) and NH_3 removal rates during periods of stress (peak flow and cold weather conditions), while reducing the energy required for aeration by up to 30 percent relative to the current conventional activated sludge mode of operation. A year-long pilot study was conducted at the O'Brien WRP using a single MABR cassette placed in a side-stream configuration on Battery D to evaluate the performance of such system under plant conditions with actual NH_3 loading. The WML staff collected samples and conducted microscopic analysis to identify dominant microorganisms growing on the ZeeLung cartridge. Chronomids and bristle worms were observed growing on the ZeeLung cartridge. Microscopic observation reports were submitted to M&O and WTPR. The results of this evaluation showed promising results in terms of removing NH_3 under optimized operation within the cassette. The PFCP section will evaluate the economic and technical merit of this technology, then a full scale test might be performed at the Hanover Park WRP in 2016.

Mainstream Shortcut Biological Nitrogen Removal. M&R completed a technology review regarding mainstream shortcut biological N removal (SCBNR) to reduce aeration energy in the mainstream treatment process and promote total N removal. Four process options have been identified for further research to evaluate feasibility and potential energy savings, two at the laboratory and two at the plant pilot level.

Option 1: Anaerobic + Nitritation/Denitritation through Modulating Aeration + Integrated Fixed-Film Activated Sludge + Reaeration.

Option 2: Step-Feed SCBNR Activated Sludge Process.

Option 3: Two Stage Process with 1st Stage for EBPR and High Rate Activated Sludge to Remove Carbon and Phosphorus and 2nd Stage for Deammonification for Ammonia and TN Removal.

Option 4: Reducing Energy Consumption through Ammonia Based Aeration Control.

In 2015, the District entered into a 3-year agreement with a university to conduct a bench scale study at the O'Brien WRP to evaluate options 1 and 3. Testing will start in 2016.

A multi-departmental task force has been formed to evaluate and conduct the plant level studies. Stickney WRP Battery D Aeration Tanks 3 and 4 have been selected for Option 4. All probes and instruments for the pilot tests have been purchased and installed by Stickney M&O, and the control algorithm has been developed by M&R. Pilot testing will start in May 2016 to evaluate reduction in cost of aeration through various control scenarios.

The Egan North aeration battery has been selected for Option 2. M&R has completed the conceptual design for the pilot study. The Engineering Department will begin design in 2016. Equipment procurement and construction for the pilot test will start in 2017 with testing to begin in spring 2018.

The testing results from both bench scale and pilot scale will be used to evaluate the next steps for full scale implementation.

Corn Fertility Experiment at the Fulton County Site. Since 1973, the District has been conducting a corn fertility experiment on calcareous mine spoil at the Fulton County site. The purpose of this experiment is to evaluate the effect of long-term applications of anaerobically digested biosolids on crop yields, crop chemical composition, and mine spoil chemical composition. The experiment was designed to simulate biosolids application to fields at the site at agronomic and reclamation rates and to provide information that can be used for managing land application of biosolids for crop production. In 2010, these plots were abandoned and new plots were established in 2011.

The new long-term biosolids experimental plots were established in Field 83, which is on unmined land. The experiment was designed to obtain more information compared to the information received from the abandoned plots. The experiment will evaluate the effect of unaged biosolids to support the Farmland Application Program and the effect of aged, air-dried biosolids to support the CSD Program. The experiment is also aimed at collecting data to evaluate biosolids P management practices to address future state regulations that may stipulate P-based agronomic rates of biosolids. The experiment includes a chemical fertilizer treatment, annual application of two types of biosolids (Class B centrifuge-dewatered biosolids and Class A air-dried biosolids) at agronomic rate, one time application of biosolids at three high (reclamation) rates, and annual applications of vegetative compost at agronomic and reclamation rates. Therefore, there are eight treatments (one chemical fertilizer control, two compost references, two types of biosolids for annual agronomic rates, and three treatments of biosolids for land reclamation application) in this experiment. The corn yield, stover dry matter and grain nutrient and trace element analyses for 2015 are shown in Table 13.

Plant Uptake of Perfluorinated Compounds in Biosolids-Amended Soil. The occurrence of perfluorinated compounds (PFCs) in biosolids and the potential risk of transport of these compounds through the food chain are emerging concerns that have to be addressed to ensure public acceptance and long-term sustainability of biosolids application to farmlands. The District collaborated with the USEPA Region 5 and the Colorado School of Mines (CSM) to generate data on the uptake of PFCs by plants grown in biosolids-amended soils for an evaluation of exposure risks to humans. As a part of this collaboration, the District conducted a three-year field study that consisted of plots amended with four rates of biosolids application each year, including control plots that received only the recommended rate of commercial fertilizers. All plots were planted with corn and four vegetable crops, i.e., tomatoes, zucchini, carrots, and lettuce. The soil and plant tissue samples were collected at the time of crop maturity and shipped to CSM for analysis of PFCs. Due to shortage of funds, only a small number of samples were analyzed. The District established a contract with CSM to analyze more plant tissue samples from the field study to generate a dataset to adequately evaluate the uptake of PFCs by the vegetable crops grown in biosolids-amended soils. The results of this study indicate

TABLE 13: GRAIN YIELD, STOVER DRY MATTER, AND ANALYSIS OF NUTRIENT AND TRACE METAL CONCENTRATIONS IN GRAIN OF CORN GROWN AT THE BIOSOLIDS LONG-TERM EXPERIMENT AT THE FULTON COUNTY SITE IN 2015

Treatment	Grain yield	Stover dry matter	Total N	Total P	Zn	Cd	Cu	Cr	Ni	Pb	K	Ca	Mg
	Mg/ha		mg/kg										
Chemical fertilizer 220-50-50 (N-P-K) kg/ha/yr (Control 1)	6.15	3.33	13452	2803	23.3	0.068	3.24	0.26	0.80	1.17	3972	155	1106
Compost 33 Mg/ha/yr (Control 2)	6.05	2.47	10969	2585	23.6	0.084	2.84	0.28	0.46	1.09	4105	153	1123
Aged biosolids 33 Mg/ha/yr	6.52	3.78	11286	2491	23.6	0.086	2.75	0.31	0.57	1.24	4008	163	1134
Unaged biosolids 25 Mg/ha/yr	6.07	3.52	12161	2788	25.8	0.101	2.99	0.27	0.53	1.04	4253	169	1187
Aged biosolids 165 Mg/ha in 2013 thereafter 3/4 chemical fertilizer rate	7.94	5.25	12729	2696	24.9	0.101	2.74	0.30	0.58	1.18	3925	161	1136
Aged biosolids 330 Mg/ha in 2013 thereafter 1/2 chemical fertilizer rate	7.78	4.88	12164	2575	24.3	0.096	2.86	0.31	0.53	1.44	4068	163	1109
Aged biosolids 495 Mg/ha in 2013 thereafter 1/4 chemical fertilizer rate	7.25	4.02	11984	2629	25.1	0.103	2.66	0.31	0.50	1.25	3814	159	1167
Compost 165 Mg/ha in 2013 thereafter 3/4 chemical fertilizer rate	6.07	2.84	12707	2706	24.1	0.056	2.57	0.26	0.48	1.06	4030	155	1184

that the potential for bioaccumulation of perfluoroalkyl acids (PFAAs) in vegetable crops grown in biosolids-amended soils under field conditions is low, and depends on the crop and the PFAA. A final report summarizing the results was prepared in 2015 (Uptake of Perfluoroalkyl Acids into Edible Crops Grown in Biosolids-Amended Soil, M&R Department Report No. 15-44).

Nutrient Loss Reduction Research at the Fulton County Site. Nutrient loss from agricultural fields is the primary source of N and P enrichment in lakes, rivers, and coastal waters of the United States, and is attributed as the main contributor to nutrient loading in the Mississippi River Basin and hypoxia in the Gulf of Mexico. Reduction in N and P loss from agricultural fields can lead to significant reduction in Illinois N and P load to the Mississippi River. To contribute to Illinois statewide Nutrient Loss Reduction Strategy that is aimed to reduce nutrient loading to the Gulf of Mexico and address local quality, the District initiated a multi-year nutrient loss reduction research project at the Fulton County site. In 2014, the five-year work plan for the research project was prepared. The overall goal of the project is to work in collaboration with the agricultural sector to test and develop BMPs that can be adopted by farmers in Illinois. The work plan includes the development and demonstration of the effectiveness of several BMPs such as cover cropping, riparian vegetation buffer restoration, runoff irrigation, and bioreactor for nutrient loss reduction from agricultural fields. The rye cover crop was established in a corn field using an interseeder. The cover crop nutrient uptake will be determined in the spring of 2016. The equipment for continuous measurement of field runoff and nutrient loss was installed in a pair of fields, and data reporting will commence in 2016. During 2015, collaborators on the project included staff of the Department of Biological and Environmental Engineering of University of Illinois, and an agricultural consulting firm.

Phosphorus Removal Using Phycoremediation. In 2013, the EM&R Division, in collaboration with the Engineering Department, evaluated many technologies for phycoremediation using algae for nutrient removal from wastewater treatment streams. A collaborative research project between the District and Iowa State University was developed to design and construct a greenhouse for testing a pilot-scale revolving algal biofilm (RAB) system for nutrient removal and recovery at the O'Brien WRP. The main goal of this project is to evaluate the removal efficiencies of N and P by pilot-scale RAB treatment systems. Two wastewater streams have been evaluated; supernatant from the activated sludge gravity thickening tank at the O'Brien WRP (O'Brien Supernatant) and centrate from centrifuge-dewatering of the anaerobically digested sludge at the Stickney WRP (Stickney Centrate).

The project began at the O'Brien greenhouse facility in September 2015 when the algal reactors were installed and initial culture was started. From September to November 2015, the research was focused on the establishment of the algal biofilm on the RAB system. From late November to December 2015, the project was focused on improvements and modifications of the greenhouse facility such as the installation of wastewater pumping system for O'Brien Supernatant, arrangement for delivering Stickney Centrate to the O'Brien greenhouse facility, and development of standard practices for operating the algal reactors. The nutrient removal data were not collected during this period because steady state operation of the reactors was not achieved.

Microbial Source Tracking Study of the Chicago Area Waterway System. A collaborative research project with Argonne National Laboratory (Argonne) was initiated to

track the microbial sources in the CAWS as the District begins disinfecting to comply with the new primary contact use designated effluent bacteria limitations. The goal of the study is to understand the microbial community and their sources in the CAWS in response to the changes in FC levels in the final effluents due to WRP disinfection and frequency of CSO discharges due to TARP reservoir completion during the study period. The seven-year (2013–2019) research project is defined by three phases of facility improvements in the Calumet and Chicago River Systems. Disinfection facility construction at the Calumet and O'Brien WRPs (Chicago River System) are scheduled for completion in 2015. At both WRPs, disinfection will begin in the 2016 disinfection season, which is March through November. In the Calumet River System, the Thornton Composite Reservoir portion of the TARP, serving the south side of Chicago and south suburbs of Cook County, is scheduled for completion in 2015. In the Chicago River system, the McCook Reservoir is being constructed in two stages and Stage 1 is scheduled for completion in 2017. Therefore, the three phases of the project are defined as:

1. Phase I – Pre-disinfection and pre-TARP reservoir completion, in both Calumet and Chicago River Systems (2013–2015).

2. Phase II – Post-disinfection and pre-TARP reservoir completion, in the Chicago River Systems (2016–2017).

3. Phase III – Post-disinfection and post-TARP reservoir completion, in the Calumet River System (2016–2019) and in the Chicago River Systems (2018–2019).

On August 12, 2015, M&R Department staff attended a Metagenomic Analysis Workshop and laboratory tour at Argonne National Laboratory. The Argonne project leaders and staff on the Microbial Source Tracking project provided an overview of microbiome molecular tools on what they are and how they are being used for microbial source tracking.

Argonne completed the third year of monitoring in November 2015. This period covered the pre-disinfection baseline, with samples collected during dry and wet events during the recreational season between March and November. Argonne has analyzed 1,156 samples from the Ambient Water Quality Monitoring stations in 2013, 2014, and 2015, plus several samples of specific identified sources such as fish, beaches, mixed liquor, and wildlife, to add to the CAWS microbiome database. This study is building unprecedented genomic datasets on Chicago river systems. Data analysis is ongoing for all samples analyzed to date. Argonne expects the results to be summarized in a draft interim report in 2016.

South Branch Chicago River Slip Study. This study will determine which slips in the South Branch Chicago River (SBCR) have the most abundant aquatic life and why, and then determine if and how less productive slips could be modified to be more favorable to fish. The slips are off-channel bays (OCBs) that provide needed refuge for fish in the SBCR. The CAWS has a limited number of OCBs and the SBCR slips are some of the largest OCBs in the system. The SBCR slips of interest are Mason's Slip, Stetson's Slip, and Arnold's Slip.

During 2015, each slip was assessed individually for fish abundance and health, and water quality. The slips were sampled for fish three times, using a boat mounted pulse direct

current electrofisher. A summary of the fish data is presented in Table 14. Cross-sectional DO measurements were conducted in the slips at select transects in June, August, and October. Cross-sectional data and the analysis of all data collected for this study will be included in a District report in 2016.

Hydraulic and Process Modeling at the Calumet Water Reclamation Plant. Through the Request for Proposal process, the PFCP Section implemented a contract for the hydraulic and process modeling for the Calumet WRP. The District has an existing process model for the Calumet WRP, but the model is outdated and requires significant updates. There is no whole plant hydraulic model for the Calumet WRP, or any of the other District WRPs. The objective of this project is to help the District to establish a practice of developing, maintaining and updating whole plant process and hydraulic models for each WRP and to use these models for capital planning, feasibility studies, and engineering evaluations. The Calumet WRP was selected as the first for whole plant hydraulic and process modeling, because of several upcoming initiatives at that plant such as implementation of nutrient removal and the significant plant upgrades since the last process model was developed for the plant in 2005.

The scope of the work includes advising on the development of the models, providing recommendations for the hydraulic modeling software, collecting plant operating and infrastructure data, developing and calibrating/validating the models, providing training on the software, and establishing procedures for model maintenance and updates. The consultant completed the first two tasks in 2015 and will complete the majority of the work by December 2016.

Effect of Treatment Plant Upgrades on Endocrine-Active Compounds Biological Recovery in an Effluent-Dominated Aquatic Ecosystem. In collaboration with St. Cloud State University, University of St. Thomas, and the College of Wooster, as part of a National Science Foundation grant, the AEWQ Section is committed to provide data, sample collection, and mobile laboratory experiment support for a four-year period from 2014 through 2017. The goal of this research is to assess how the effluent disinfection being implemented at the O'Brien and Calumet WRPs will reduce the overall load of endocrine-active compounds in the effluent and if there will be a biological effect on the native fish populations.

In 2015, the AEWQ section collected monthly water samples from eight sampling sites, collected wild sunfish from four sites in the spring, exposed caged bluegill sunfish to ambient water for 14 days at six locations in the spring and conducted on-site mobile laboratory exposure experiments at the Calumet and O'Brien WRPs in the spring and fall. The monthly water samples were analyzed for select compounds with known endocrine activity and used for bioassay based estimation of estrogenic and androgenic activity. The wild and caged sunfish were assessed for their health and reproductive potential.

The mobile laboratory experiments involved the use of a mobile exposure laboratory trailer (MELT) that was set up with a flow-through design to expose male fathead minnows to various concentrations of the final effluent. The MELT is used to evaluate the relationship between a water source and observed endocrine disruption and the compounds that may be responsible. After seven days of continuous exposure, the male fathead minnows were analyzed for various biological endpoints to identify any biological effects from exposure to WRP

TABLE 14: SAMPLING TIME, NUMBER, WEIGHT, AND NUMBER OF SPECIES FOR FISH COLLECTED FROM SLIPS IN THE SOUTH BRANCH CHICAGO RIVER DURING 2015

	Sampling Time (seconds)	Number of Fish	Weight (kg)	Number of Species		Most Abundant Species
				Total	Game	
Mason's Slip	4,210	710	31.9	20	10	Gizzard shad, bluegill, bluntnose minnow
Stetson's Slip	11,460	1,609	134.4	21	9	Gizzard shad, green sunfish, bluegill
Arnold's Slip	6,392	786	129.2	18	7	Golden shiner, bluntnose minnow, bluegill
Total	22,062	3,105	295.5	29	12	Gizzard shad, bluegill, bluntnose minnow

effluents. The 2015 results will be put in a report that will include the two years pre-disinfection (2014 and 2015) and the two years post-disinfection (2016–2017).

Research Collaboration. The Division staff participated in the following collaborative research activities:

- Water Environment Research Foundation (WERF) Research Projects – The Division staff served on project sub-committees and provided technical review of the research projects and regulatory documents. This included attendance at meetings, evaluation of project proposals, and a final report.

- Water Environment Federation (WEF) and WERF Leaders Innovation Forum for Technology (LIFT) – Division staff served on working groups for different technical areas. This included attendance at meetings and sharing information and collaborating with other utilities.

- National Association of Clean Water Agencies – Division staff participated as an advisory member of the National Association of Clean Water Agencies' Recreational Criteria Workgroup that conducted review of the USEPA's efforts to develop new recreational water quality criteria.

- Lake Michigan Total Maximum Daily Load for Illinois Beaches, USEPA Region 5, and the IEPA.

- Testing and Refinement of the Trace Organics Screening Tool – The AEWQ section collaborated on a WERF project (CEC6R12) that is examining trace organic compounds and tools that can be used to support assessments of risk from these compounds to the aquatic community. The District's Egan WRP and its receiving water (Salt Creek) were one of three sites chosen to apply these screening tools. AEWQ provided WRP and waterway data, and assisted with a week-long field sampling event in 2014. Additional data and information were provided in 2015. A final WERF report was published in summer of 2016 (Report Number CEC6R12).

Outreach Activities

The EM&R Division staff continued outreach support activities to promote public awareness and acceptance of District operations. The staff attended and presented at the local and national meetings and provided support to the following activities.

- Wastewater Microbiology Hands-On Workshop. As a member of the WEF program, staff presented at the WEF Technical Exhibition and Conference (WEFTEC), sharing knowledge on wastewater microbes in an interactive on-site workshop session. The workshop presented real-life examples covering several different aspects of wastewater process control.

- A full-day WEFTEC workshop titled "Fate, Indicators, and Assays: New Developments in Pathogens" was hosted by professionals in the AMB Section Laboratory.

- Laboratory tours are conducted as part of the District's tours and are also conducted, upon request, for any person or group interested in learning about the EM&R Division's laboratory operations. A total of 20 tours were conducted in 2015.

- The AMB staff supported the internship program for college students by providing a unique, hands-on learning opportunity in the District's Analytical Microbiology Laboratory monitoring and research program. The internship program is a learning opportunity for students who want to develop essential career skills in environmental microbiology.

- Division staff supported public affairs outreach events, such as meeting with high school students and describing the role microbes in the wastewater treatment process. The AMB staff assisted a high school student with a science fair research project by providing resources and technical assistance on three methods of drinking water disinfection. Professional staff also participated in the WBEZ Curious City Live radio event, providing video information on microorganisms in wastewater treatment.

- In 2015, the AEWQ Section provided seven tours of the Chicago Area Waterway System on the M&R Department research and monitoring vessel to various groups, including area legislators.

- AEWQ Section staff participated in 13 local parades with the District float.

- The AMB laboratory provided in-kind support to a WERF project titled "Design and Validation Protocol for UV Disinfection Systems Used in Municipal Wastewater Treatment and Reuse Applications" (ENER16T15). As part of the support, FC, EC, F-specific (RNA) coliphage, ultraviolet transmittance percentage, conductivity, and turbidity analyses were performed on O'Brien WRP secondary treated final effluent samples. Staff also participated in the technical review of the WERF project, "Next Generation Tools for Assessing Death and Decay of Critical Wastewater Bacteria."

APPENDIX AI
ENVIRONMENTAL MONITORING AND RESEARCH DIVISION EMPLOYEES 2015

Environmental Monitoring and Research Division

Heng Zhang, Assistant Director of M&R (121[8])

Marie Biron, Administrative Specialist

Albert E. Cox, Environmental Monitoring and Research Division Manager; Zainul Abedin, Biostatistician; Edward Podczerwinski, Managing Civil Engineer; Paramasivam Srinivasan, Senior Environmental Research Scientist; Kathleen A. Quinlan, Senior Administrative Specialist; Cynthia Colvin, Administrative Specialist

Wastewater Treatment Process Research (122 [17])

Joseph Kozak, Supervising Environmental Research Scientist

Laura Franklin, Administrative Specialist

Senior Environmental Research Scientist

Ali Oskouie

Kamlesh Patel

Fenghua Yang

Associate Environmental Research Scientist

Weizhe An

Doris Bernstein

Dale MacDonald

Dongqi Qin

Laboratory Technician II's

Thota Reddy

Vacant

Laboratory Technician I's

Robert Bodnar

Marc Byrnes

Shawn Kowalski

Harold Robinson

Edgar Rojas Herbas

Luke Toonen

Biosolids Utilization & Soil Science (123 [14])

Lakhwinder Hundal, Supervising Environmental Soil Scientist

Coleen Maurovich, Administrative Specialist

Senior Environmental Soil Scientist

Kuldip Kumar

Guanglong Tian

Associate Environmental Soil Scientist

Dominic Brose

Pauline Lindo

Olawale Oladeji

Assistant Environmental Chemist

Minaxi Patel

Laboratory Technician II's

Upendra Patel

Tiffany Tate

Laboratory Technician I's

Maricela Sabido

Field and Laboratory Technicians

Jacob Baylor

Jeffrey Simpson

Laboratory Assistant

Andrew Scott

Analytical Microbiology & Biomonitoring (124 [16])

Geeta Rijal, Supervising Environmental Microbiologist

Vacant, Administrative Specialist

Senior Environmental Microbiologist

Auralene Glymph-Martin

Associate Environmental Microbiologist

Kaylyn Patterson

Vacant

Assistant Environmental Microbiologist

Hemangini Shukla

Laboratory Technician II's

Kathleen Jackowski

James Kaehn

Andrea Maka

Sunita Reddy

Laboratory Technician I's

Meera Advani

Jeffrey Kowar

Brandon Reynolds

James Southworth IV

Laboratory Assistants

Petronela Paul

Reginald Rembert

Aquatic Ecology and Water Quality (126 [20])

Jennifer Wasik, Supervising Aquatic Biologist

Senior Aquatic Biologist

Thomas Minarik

Associate Aquatic Biologist

Dustin Gallagher

Justin Vick

Assistant Aquatic Biologist

Nick Kollias

Laboratory Technician II's

Shawn Kowalski

Angel Whitington

Vacant

Vacant

Laboratory Technician I's

Matthew Bryan

Rolinda Dominguez

Patrol Boat Operator

Kazimier Iwasyk

John Jacob

Vacant

Pollution Control Technician II

Ryan Kirkland

James Rivera

Pollution Control Technician I

Janis Dickerson

Patricia Sandrik

David Zintak

Vacant

Capital Planning (129 [11])

Principal Civil Engineer

Jonathan Grabowy

Senior Civil Engineer

Matthew McGregor

Daniel Salabaj

Senior Environmental Research Scientist

Judith Moran-Andrews

Senior Electrical Engineer

Mohammed Nator

Senior Mechanical Engineer

Brent Bedell

Associate Civil Engineer

Peter O'Brien

Gyanshyam Patel

Associate Electrical Engineer

Predrag Ungureanu

Associate Environmental Research Scientist

Avanti Kavathekar

Associate Mechanical Engineer

Jonathan Villegas

APPENDIX AII
MEETINGS AND SEMINARS 2015, ENVIRONMENTAL MONITORING AND RESEARCH DIVISION

MEETINGS AND SEMINARS 2014, ENVIRONMENTAL MONITORING AND RESEARCH DIVISION

January 2015

Illinois Water Environment Association Government Affairs Conference, Burr Ridge, Illinois.

Illinois Water Environment Association and the Illinois Section of the Central States Water Environment Association, 2015 Government Affairs in Water Pollution Control Conference, Burr Ridge, Illinois.

Midwest Water Analysts Association 2015 Winter Exposition, Kenosha, Wisconsin.

Chicago Area Waterway System Chloride Stakeholder Workgroup Meeting, Stickney, Illinois.

Illinois Association of Wastewater Agencies Quarterly Technical Committee Meeting (and follow-up meetings throughout the year), Starved Rock, Illinois.

Calumet Area Industrial Commission, Alsip, Illinois.

Industrial Water, Waste, and Sewage Group Meeting (and follow-up meetings throughout the year), Chicago, Illinois.

February 2015

Illinois Water Environment Association 36th Annual Conference and Exposition 2015, Champaign, Illinois.

Partnership for River Restoration and Science in the Upper Midwest 2015 Upper Midwest Stream Restoration Symposium, Dubuque, Iowa.

Gasvoda and Associates, Latest Evolution in Flow Monitoring and Technologies Seminar, Calumet City, Illinois.

March 2015

Society for Ecological Restoration Midwest Great Lakes Chapter Annual Meeting, Glencoe, Illinois.

WERF Challenge Group, Linking Receiving Water Impacts to Sources Meeting, Westminster, Colorado.

52nd Annual Meeting of the Illinois Chapter of the American Fisheries Society, Grafton, Illinois.

Fox River Study Group Monthly Meeting – March-November, Oswego, Illinois.

MEETINGS AND SEMINARS 2015, ENVIRONMENTAL MONITORING AND RESEARCH DIVISION (Continued)

DuPage River Salt Creek Workgroup Bi-monthly Meetings, Lombard, Illinois.

Illinois Section of the American Water Works Association and Illinois Water Environment Association, WaterCon 2015, Joint Conference and Expo, Springfield, Illinois.

OSHA Safety Day Conference, Maintaining Safe Work Environments, Dixon, Illinois.

NELAC Institute, TNI National Environmental Monitoring Conference, Chicago, Illinois.

United States Environmental Protection Agency, Advanced Environmental Crimes Investigation Training Program (and follow-up meetings throughout the year), Glynco, Georgia.

Pipeline Safety, Arlington Heights, Illinois.

April 2015

Illinois Association of Water Pollution Control Operators Annual Conference 2015, Springfield, Illinois.

Agilent LC/MS Seminar, Schaumburg, Illinois.

May 2015

Illinois Environmental Protection Agency, Illinois Bacteria Water Quality Standards Stakeholder Meeting, Springfield, Illinois.

University of North Carolina Water Microbiology Conference 2015, Chapel Hill, North Carolina.

American Society for Microbiology General Meeting, New Orleans, Louisiana.

Water Environment Federation Technical Exhibition and Conference, Chicago, Illinois.

Argonne National Laboratory's Discussing Immunology and the Microbiome at Microbiology 2015 Virtual Event, Stickney Water Reclamation Plant, Cicero, Illinois.

Society for Freshwater Science Annual Meeting, Milwaukee, Wisconsin.

Central States Water Environment Association, Inc. 88th Annual Meeting, Oakbrook Terrace, Illinois.

Midwest Water Analysts Association, Spring Meeting, River Restoration Projects, Milwaukee, Wisconsin.

Horizon Technology Seminar, Schaumburg, Illinois.

National Association of Clean Water Agencies, Annual Pretreatment and Pollution Prevention Workshop, Greenville, South Carolina.

American Management Association, Mastering Excel Pivot Tables, Chicago, Illinois.

June 2015

Asian Carp Technical and Policy Workgroup Meeting, Chicago, Illinois.

WEF/IWA Residuals and Biosolids Conference 2015: The Next Generation of Science, Technology, and Management, Washington, DC.

USDA W-3170 Committee Meeting, Beltsville, Maryland.

Water Environment Federation Seminar, "Making Scents Out of Wastewater Odors: A Step-By-Step Guide to Managing Your Odor Problems," Washington, D.C.

Water and Energy 2015: Opportunities for Energy and Resource Recovery in Changing World, Washington, DC.

Hazardous Materials Emergency Response Training Briefing, Chicago, Illinois.

JPK Group, Business Forecasting and Innovation Forum, Chicago, Illinois.

July 2015

Ammonia Water Quality Standards Stakeholders Workgroup held by IEPA, Springfield, Illinois.

Urban Flood Management through No Adverse Impact and Green Infrastructure workshop held by Resilient Chicago, Chicago, Illinois.

Rights-of-Way as Habitat Working Group Meeting held by Energy Resources Center, University of Illinois Chicago, Chicago, Illinois.

National Association of Clean Water Agencies Summer Conference, Providence, Rhode Island.

NEMC, Chicago, Illinois.

Technical Writing Seminar, Illinois Institute of Technology, Chicago, Illinois.

MEETINGS AND SEMINARS 2015, ENVIRONMENTAL MONITORING AND RESEARCH DIVISION (Continued)

August 2015

Illinois Nutrient Loss Reduction Strategy Stakeholder Meeting, Champaign, Illinois.

Webinars: Revisiting Organic Agriculture Webinar Series (August 4, September 1, October 6, and November 3) ASA Webinar Series.

Water Environment and Research Foundation Intensification of Resource Recovery (IR^2) Forum, Manhattan College, New York.

Deskins Quickdry Filter System Site Visit, Casey, Illinois.

September 2015

Water Quality Standards Regulatory Revisions Final Rule Informational Webinar, Stickney Water Reclamation Plant, Cicero, Illinois.

Laboratory Fraud: Why Should I Worry…What Could Happen? Webinar, Stickney Water Reclamation Plant, Cicero, Illinois.

Nutrient Monitoring Council Meeting, Springfield, Illinois.

Northwest Biosolids Management Association's 28th Annual Biosolids Management Conference; Biofest 2015: Walk the Talk, Campbell's Conference Center, Chelan, Washington.

2015 Illinois Water Environment Association Nutrient Removal and Recovery Workshop, Addison, Illinois.

WEFTEC, Annual Conference, Chicago, Illinois.

WEFTEC, Laboratory Workshop, Chicago, Illinois.

Cook County Department of Homeland Security and Emergency Management (and follow-up meetings throughout the year) HAZMATIIQ Federal Resources, LaGrange, Illinois.

Illinois Water Environment Association, the Illinois Association of Wastewater Agencies, and the Illinois Association of Water Pollution control Operators Joint 2015 Nutrient Removal and Recovery Workshop, Addison, Illinois.

October 2015

Pryor Seminars – Leadership, Team-building and Coaching Skills for Managers and Supervisors, Elk Grove Village, Illinois.

MEETINGS AND SEMINARS 2015, ENVIRONMENTAL MONITORING AND RESEARCH DIVISION (Continued)

Illinois Nutrient Loss Reduction Strategy Policy Workgroup Meeting, Champaign, Illinois.

2015 Stakeholder Webinar on the Environmental Protection Agency's Development of Ambient Water Quality Criteria for Coliphage – A Viral Indicator, Stickney Water Reclamation Plant, Cicero, Illinois.

IEPA Ammonia Water Quality Standards Implementation Committee Meeting, Springfield, Illinois.

15th Biennial Governor's Conference on the Management of the Illinois River System, Peoria, Illinois.

Illinois Section of the American Water Works Association Annual Regulatory Update Meeting, Elgin, Illinois.

Hydraulic Engineering for Professionals, Madison, Wisconsin.

Water Environment Federation, Technical Exhibition and Conference 2015, Chicago, Illinois.

Illinois Water Conference 2015, Urbana, Illinois.

Workshops at Urbana-Champaign Sanitary District and Glenbard Wastewater Authority, Urbana, Illinois.

AirPrex Pilot Site Visit, Fox River Water Reclamation District, South Elgin.

LEAD Leadership Development Program, Lake Forest Graduate School of Management, Willow Springs, Illinois.

iPACS (internet POTW Administrative and Compliance System) Annual User Group Conference, Brunswick, New Jersey.

Northern/Central Illinois Pipeline Association, 2015 Pipeline Safety Meeting for Emergency Responders and Public Officials, Alsip, Illinois.

November 2015

Michigan Department of Environmental Quality Linking Fecal Bacteria in Rivers to Environmental Factors and Sources Webinar, Stickney Water Reclamation Plant, Cicero, Illinois.

United States Environmental Protection Agency, National Science Foundation and Water Environment Research Foundation Collaborative Workshop on Bio-Contaminated Wastewater, Alexandria, Virginia.

MEETINGS AND SEMINARS 2015, ENVIRONMENTAL MONITORING AND RESEARCH DIVISION (Continued)

Midwest Water Analysts Association, Fall Tour, The Plant, Chicago, Illinois.

Synergy in Science, ASA/CSSA/SSSA/ESA 2015 Joint Annual Meeting, Minneapolis, Minnesota.

University of Wisconsin Project Management Training, Stickney, Illinois.

Midwest Water Analysts Association, 2014 Fall Meeting, Racine, Wisconsin.

Project Management Training, University of Wisconsin, Stickney Water Reclamation Plant, Cicero, Illinois.

Trace Metals Analysis Productivity Seminar, Schaumburg, Illinois.

The Government Finance Officers Association of the United States and Canada, Budgeting Best Practices in the Field of Finance, Chicago, Illinois.

December 2015

Pryor Seminars – Managing Multiple Priorities, Projects and Deadlines, Elmhurst, Illinois.

Nutrient Monitoring Council Meeting, Urbana, Illinois.

Chicago Wilderness Priority Species Workshop, Chicago, Illinois.

Nutrient Management and Edge of Field Conference, Memphis, Tennessee.

Illinois Institute of Technology School of Applied Technology, Advanced Excel and Pivot Table Training, Chicago, Illinois.

APPENDIX AIII
PRESENTATIONS 2015, ENVIRONMENTAL MONITORING AND RESEARCH DIVISION

PRESENTATIONS 2015, ENVIRONMENTAL MONITORING AND RESEARCH DIVISION

January 2015

"Microbiological Monitoring of Biological Nutrient Removal Systems." Presented at the Midwest Water Analysts Association 2015 Exposition, Kenosha, Wisconsin, by A. Glymph-Martin. PP

"Enhanced Biological Phosphorus Removal and Recovery at the MWRD's Stickney WRP: Startup, Transition, and Progress." Presented at the Illinois Water Environment Association Government Affairs Conference, by J.A. Kozak., Y. Lefler, D. Qin, and B. Garelli. PP

"Technical Re-evaluation of Local Limits for Industrial Discharges in the Metropolitan Water Reclamation District of Greater Chicago (District) Service Area," Presented at the January, 2015, M&R Seminar, Stickney Water Reclamation Plant, Cicero, Illinois, by Kuldip Kumar. PP

February 2015

"Microbiological Innovations for Wastewater Process Control." Presented at the Illinois Water Environment Association Annual Conference and Exposition 2015, Champaign, Illinois, by A. Glymph-Martin. PP

"Biosolids Beneficial Reuse Programs: SWOT and PEST Evaluations to Ensure Sustainability." Presented at the 2015 IWEA 36th Annual Conference, Champaign, Illinois, by O. O. Oladeji, D. Brose, K. Kumar, L. Hundal, D. Collins, and T. C. Granato. PP

"Biosolids Planning at the Metropolitan Water Reclamation District of Greater Chicago." Presented at the 2015 IWEA 36th Annual Conference, Champaign, Illinois, by M. McGregor. PP

"MWRDGC Contracting Experience: John E. Egan ANITA™ Mox." Presented at WEF/WERF 2015 LIFT Forum Webinar: Contracting Experience with New Technologies, by J. A. Kozak. PP

March 2015

"Updates on the User Attainability Analysis for the Chicago Waterway System." Presented at the March 27, 2015, M&R Seminar, Stickney Water Reclamation Plant, Cicero, Illinois, by J. Wasik. PP

April 2015

"Development of a Wastewater Microbiology Program at the Metropolitan Water Reclamation District of Greater Chicago." Presented at the Illinois Association of Water Pollution Control Operators Annual Conference 2015, Springfield, Illinois, by A. Glymph-Martin. PP

"Opportunities and Challenges at the Metropolitan Water Reclamation District of Greater Chicago." Presented at the UIUC Agricultural & Biological Engineering Department Spring Seminar, by K. Patel. PP

"Phosphorus Testing, Investigation, Capture and Recovery." Presented at the Central States Water Environment Association, Laboratory Pre-treatment Seminar, Geneva, Illinois, by T. Liston. PP

May 2015

"Scientific Basis for Defining Microbiological Health of Chicago River System." Presented at the Water Institute at University of North Carolina Conference: Where Science Meets Policy, Chapel Hill, North Carolina, by G. K. Rijal. PP

"Developing a Long Term Capital Improvement Plan and Vetting Capital Improvement Projects Using an Organization-wide, Transparent and Objective Approach." Presented at the May 29, 2015, M&R Seminar, Stickney Water Reclamation Plant, Cicero, Illinois, by E. Podczerwinski and J. Grabowy. PP

"Pretreatment Staff Turnover: Handling Retirement and Hiring." Presented at the 2015 National Association of Clean Water Agencies Annual Pretreatment and Pollution Prevention Workshop, Greensville South Carolina, by M. Joseph. PP

"Multi-Jurisdictional Agreements: Pretreatment Program and Obligations and Responsibilities." Presented at the 2015 National Association of Clean Water Agencies Annual Pretreatment and Pollution Prevention Workshop, Greensville South Carolina, by M. Goldrich. PP

June 2015

"Uptake of Trace Metals in Vegetables Grown in Exceptional Quality Biosolids Amended Soil." Presented at the USDA W-3170 Committee Annual Meeting, Beltsville, Maryland, by L. Hundal. PP

July 2015

"Challenges to Achieving Stable Performance in a Site-Specific EBPR Configuration (AAnO) at the Stickney Water Reclamation Plant," Presented at the WEF/WERF/CWEA/BACWA Nutrient Symposium 2015, San Jose, California, by H. Zhang; J.A. Kozak; D. Qin; Y. Lefler; B. Garelli; R. Dring; J. Cummings; C. O'Connor and G. Rohloff. PP

PRESENTATIONS 2015, ENVIRONMENTAL MONITORING AND RESEARCH DIVISION (Continued)

August 2015

September 2015

"Maximizing the Potential of Your Mesophilic Anaerobic Digesters – Operating Procedures and Practical Concerns," Presented at the 88th Annual Water Environment Federation Technical Exhibition and Conference Digestion Workshop #16, Chicago, Illinois, by H. Zhang. PP

"Activated Sludge and Biological Nutrient Removal Process Control: Hands-On in the Real World." Presented at the 88th Annual Water Environment Federation Technical Exhibition and Conference Activated Sludge Workshop #20, Schaumburg, Illinois, by A. Glymph-Martin. PP

"Total Culturable Virus Monitoring at the Metropolitan Water Reclamation District of Greater Chicago." Presented at the 88th Annual Water Environment Federation Technical Exhibition and Conference Pathogen Workshop #24, Stickney Water Reclamation Plant, Cicero, Illinois, by G. Rijal. PP

"A Framework to Prioritize Trace Organics for Human and Eco-Toxicity Studies." Presented at NBMA's 28th Annual Biosolids Management Conference; Biofest 2015: Walk The Talk, Campbell's Conference Center, Chelan, Washington, by K. Kumar. PP

"Recovering Resources: Transforming Water." Presented at NBMA's 28th Annual Biosolids Management Conference; Biofest 2015: Walk The Talk, Campbell's Conference Center, Chelan, Washington, by K. Kumar. PP

October 2015

"Developing a Long Term Capital Plan." Presented at October 14, 2015 Marquette Environmental Engineering Seminar Series, Marquette, University, Milwaukee, WI, by J. Grabowy. PP

November 2015

"The Metropolitan Water Reclamation District of Greater Chicago's Perspective on Bio-Contaminated Wastewater." Presented at the United States Environmental Protection Agency, National Science Foundation and Water Environment Research Foundation Collaborative Workshop on Bio-Contaminated Wastewater, Alexandria, Virginia, by G. Rijal. PP

"Trace Metals in Vegetables Grown in Soil Amended with Exceptional Quality Biosolids." Presented at the Synergy in Science, ASA/CSSA/SSSA/ESA 2015 Joint Annual Meeting, Minneapolis, Minnesota, by K. Kumar, L. Hundal, A. Cox, H. Zhang and T. C. Granato. PP

"Nitrogen Phytoavailability of Composted Biosolids." Presented at the Synergy in Science, ASA/CSSA/SSSA/ESA 2015 Joint Annual Meeting, Minneapolis, Minnesota, by O. O. Oladeji, G. Tian, P. Lindo, L. Hundal, A. Cox, H. Zhang, and T. C. Granato. PP

"Stagnation of Soil Organic Carbon Equilibrium in the United States Midwest and Transcendence by Biosolids." Presented at the American Society of Agronomy Annual Conference, Minneapolis, Minnesota, by G. Tian and C. Y. Chiu. PP

"Industrial Waste Ordinances and the District's Regulatory Authority Update." Presented at the DePaul University Student Symposium, Chicago, Illinois, by G. Yarnick. PP

December 2015

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* PP = Available as PowerPoint Presentation.

APPENDIX AIV
PAPERS PUBLISHED 2014, ENVIRONMENTAL MONITORING
AND RESEARCH DIVISION

PAPERS PUBLISHED 2015, ENVIRONMENTAL MONITORING AND RESEARCH DIVISION

Barber L., J. Loyo-Rosales, C. Rice, T. Minarik, and A. Oskouie."Endocrine Disrupting Alkylphenolic Chemicals and Other Contaminants in Wastewater Treatment Plant Effluents, Urban Streams, and Fish in the Great Lakes and Upper Mississippi River Regions." *Science of the Total Environment*, 517 (2015) 195–206.

Tian G., C. Y. Chiu, A. J. Franzluebbers, O. O. Olawale, T. C. Granato, and A. E. Cox. "Biosolids amendment dramatically increases sequestration of crop residue-carbon in agricultural soils in western Illinois." *Applied Soil Ecology*, 85: 86–93.

Zhang, H., J.A. Kozak, D. Qin, Y. Lefler, B. Garelli, R. Dring, J. Cummings, C. O'Connor, and G. Rohloff. "Challenges to Achieving Stable Performance in a Site-Specific EBPR Configuration (AAnO) at the Stickney Water Reclamation Plant," Proceedings of WEF Nutrient Symposium 2015, San Jose, California, July 26–28, 2015.

APPENDIX AV
MONITORING AND RESEARCH DEPARTMENT 2015 SEMINARS

APPENDIX AV
METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO
MONITORING AND RESEARCH DEPARTMENT 2015 SEMINAR SERIES

January 30, 2015	***Technical Re-evaluation of Local Limits for Industrial Discharges in the Metropolitan Water Reclamation District of Greater Chicago (District) Service Area,*** Dr. Kuldip Kumar, Senior Environmental Soil Scientist, District, Chicago, Illinois
February 27, 2015	***Wastewater Worker Safety – Addressing Concerns on Ebola in Wastewater,*** Dr. Matthew J. Arduino, Team Lead, Center for Disease Control Ebola Response Environmental Infection Control Team, Atlanta, Georgia
March 27, 2015	***Updates on the User Attainability Analysis for the Chicago Waterway System,*** Ms. Margaret Conway, Principal Attorney, Law Department and Ms. Jennifer Wasik, Supervising Aquatic Biologist, Monitoring and Research Department, District, Chicago, Illinois
April 24, 2015	***Algal-sludge Granules: An Innovative Wastewater Treatment and Energy Recovery Process,*** Dr. Chul Park, Associate Professor, Department of Civil and Environmental Engineering, University of Massachusetts, Amherst, Massachusetts
May 29, 2015	***Developing a Long Term Capital Improvement Plan and Vetting Capital Improvement Projects Using an Organization-wide, Transparent and Objective Approach,*** Mr. Edward Podczerwinski, Managing Civil Engineer and Mr. Jonathan Grabowy, Principal Civil Engineer, Monitoring and Research Department, District, Chicago, Illinois
June 26, 2015	***Development of the Illinois Nutrient Loss Reduction Strategy,*** Mr. Sanjay Sofat, Manager of the Division of Water Pollution Control, Illinois Environmental Protection Agency, Springfield, Illinois
July 31, 2015	***Recent Progress in Development of Mainstream Deammonification - A Potential Low Energy Option for Nitrogen Removal,*** Dr. George Wells, Assistant Professor, Department of Civil and Environmental Engineering, Northwestern University, Evanston, Illinois
August 28, 2015	***Green Infrastructure Program at DC Water,*** Ms. Bethany Bezak, Green Infrastructure Manager, DC Clean Rivers Project, District of Columbia Water and Sewer Authority, Washington, DC
September 25, 2015	***Waste Activated Sludge Stripping to Remove Internal Phosphorus (WASSTRIP®) Application at Clean Water Services,*** Mr. Peter Schauer, Principal Process Engineer, Clean Water Services, Hillsboro, Oregon
October 30, 2015	***The MWRD's Perspective on Co-Digestion and Biogas Utilization,*** Mr. Thomas Kunetz, Assistant Director of Engineering, Engineering Department, District, Chicago, Illinois
November 20, 2015	***Investigation of Antibiotic-Resistant Genes in Reclaimed Water,*** Professor Amy Pruden, Department of Civil and Environmental Engineering & Associate Dean for Interdisciplinary Graduate Education, Virginia Tech, Blacksburg, Virginia
December 18, 2015	***Development and Utilization of a Customized Model for Evaluating Performance of the Calumet, Mainstream and Des Plaines Tunnel and Reservoir Plan Systems,*** Mr. Patrick Jensen, PE, Associate Civil Engineer and Ms. Ann Gray, Associate Civil Engineer, Collection Facilities/TARP, Engineering Department, District, Chicago, Illinois

RESERVATIONS REQUIRED (at least 24 hours in advance); PICTURE ID REQUIRED FOR PLANT ENTRY
CONTACT: Dr. Heng Zhang, Assistant Director of Monitoring and Research, EM&R Division, (708) 588-4264 or (708) 588-4059
LOCATION: Stickney Water Reclamation Plant, Lue-Hing R&D Complex, 6001 West Pershing Road, Cicero, IL 60804; TIME: 1:30 P.M.
NOTE: These seminars are eligible for Professional Development Credits/CEUs