Protecting Our Water Environment

Metropolitan Water Reclamation District of Greater Chicago

MONITORING AND RESEARCH DEPARTMENT

REPORT NO. 17-53

ENVIRONMENTAL MONITORING AND RESEARCH DIVISION

2016

ANNUAL REPORT

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ENVIRONMENTAL MONITORING AND RESEARCH DIVISION
2016 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
CDOM	Continuous Dissolved Oxygen Monitoring
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
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

LIST OF ABBREVIATIONS (Continued)

LIFT	Leaders Innovation Forum for Technology
M&O	Maintenance and Operations
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

LIST OF ABBREVIATIONS (Continued)

SOPs	standard operating procedures
SS	suspended solids
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
WE&RF	Water Environment and Reuse Foundation
WET	whole effluent toxicity
WML	Wastewater Microbiology Laboratory
WRP	water reclamation plant
WTPR	Wastewater Treatment Process Research
Zn	zinc

ACKNOWLEDGMENTS

This 2016 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 and Ms. Laura Franklin for their 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

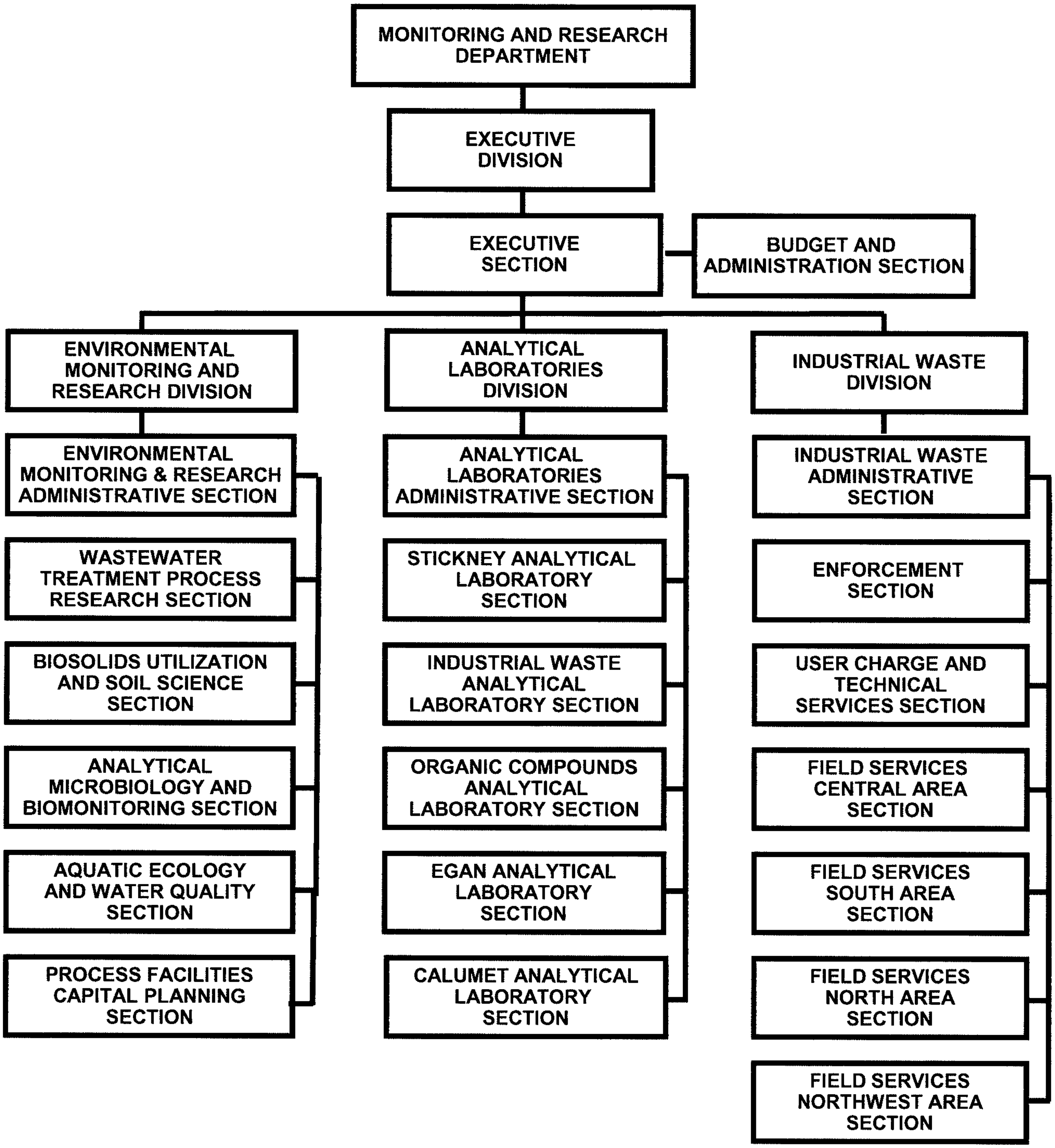
The Environmental Monitoring and Research (EM&R) Division had 86 employees in 2016, and comprises six Sections. These are illustrated in Figure 1 and Appendix I. The six Sections are:

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 and stormwater management 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; stormwater 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: MONITORING AND RESEARCH DEPARTMENT ORGANIZATIONAL CHART FOR 2016



- 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 2016, 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 2016, a total of 2,249 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.

During 2016, 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;

  (a) Water quality monitoring for waterways

  (b) Continuous Dissolved Oxygen monitoring (CDOM)

  (c) WRP monitoring (influent, effluent, and sludge in Excel, MDB, and SAS format)

  (d) TARP groundwater monitoring (primary effluent, and pump back data in MDB, Excel and SAS format)

  (e) Organic compounds monitoring (database in MDB, Excel and SAS format)

- Created many new Visual Basic and SAS functions for routine analysis and to produce tabular and functional graphs. These functions are used to maintain all databases and run all analyses and routines without the need for SAS or SAS IML. Some of these routines are:

(a) Evaluation of Principle Component Analysis (PCA)

(b) Cubic Spline Algorithm for interpolation

(c) Linear and non-linear regressions

(d) Box-Cox Transformations needed for normality and other needs

(e) Matrix and Complex function operations

- Summarized results of the District's Ambient Water Quality Monitoring Program.
- Provided support to production of the annual CDOM Report.
- Provided statistical analysis support 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 mission of the WTPR Section is to provide technical support and perform research in support of the initiatives and goals of District's strategic plan. 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 regulatory required 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.

- 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 2016, 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 cross-training of five laboratory personnel by completing the demonstration of capability, which enables them to perform analyses according to the laboratory standard operating procedures (SOPs) and quality assurance plans (QAPs) on fecal coliform membrane filtration method.

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

- Updated SOPs and QAPs, and implemented Quality Assurance/Chemical Hygiene/Safety 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 2016, the AMB Section laboratories provided microbiological, analytical and technical support to various projects under the EM&R Division program goals. Table 1 shows a summary of the number of analyses provided under each program. The AMB Section laboratories conducted a total of 15,017 microbial analyses. The ABL operations continued in the Trailer Laboratory without any problems or disruption in analyses. The ABL trailer laboratory passed the IDPH site-inspection required for bacteriological testing certification.

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 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.

TABLE 1: TOTAL NUMBER OF ANALYSES PERFORMED BY THE MONITORING AND RESEARCH DEPARTMENT'S ANALYTICAL MICROBIOLOGY LABORATORY IN 2016

Program	Total Coliform/Fecal Coliform/*E. coli*/HPC[1]		Pathogens[2]/ Other[3, 4, 5]
	Total Analysis	Number of Samples	
4652 Liquid Monitoring	5,948	1,393	—[7]
4653 Solids Monitoring	144	83	184[2]
4671 Lake Michigan (Bypass)	48	9	—
4672 Waterways	4,027	448	—
4674 Groundwater	2,203	462	—
4681 Assistance to M&O	28	10	1,700[3]
4682 Assistance to Others	18	6	62[5]
4690 Operation Research	—		655[4, 6]
Total	12,416	2,411	2,601

Note: The values in this table are the total numbers of analyses including actual number of samples and QA/QC.
[1]HPC = Heterotrophic Plate Count.
[2]Enteric virus and *Ascaris* ova (Helminth Ova).
[3]Filamentous bacteria, zooglea, shelled protozoa, and phosphorus-accumulating organisms (PAO).
[4]Coliphage, conductivity, UV transmittance, and turbidity analyses for WERF-UV Project.
[5]Biofilm analyses for ZeeLung™ project and mold and algae assessment for safety support.
[6]Microbial Source Tracking Project analyses and qPCR PAO research.
[7]Not applicable.

- 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.

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 2016

During 2016, 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 from the District's seven WRPs continued in 2016. Analyses of gross alpha and beta, radium 226 and 228, and strontium 90 were conducted on 24-hour composite samples of raw sewage collected annually at all WRPs, and were performed by Environmental, Inc. Midwest Laboratory, Northbrook, Illinois (EIML). The data were presented in the M&R Report No. 17-25.

Biosolids and Plant Odor Monitoring Program. The WTPR and PFCP Sections conducted an Odor Monitoring Program evaluating the characteristics and intensity of odors at the District's facilities. During 2016, WTPR and PFCP, in collaboration with the M&O Department, monitored unit processes at the Stickney and Calumet WRPs as well as solids management areas (SMAs) for odors. Odor conditions were reported to the respective plant managers for the biosolids areas. Table 2 summarizes the results of the 2016 odor monitoring program for the SMAs. The monitoring results were summarized in M&R Report No. 17-42.

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

TABLE 2: 2016 ROUTINE ODOR MONITORING RESULTS OF METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO SOLIDS MANAGEMENT AREAS

Solids Management Area[1]	Departments Participating[2]	Total Number of Observations	Number of Observations Odors were Detected: Very Strong	Strong	Easily Noticeable	Number Non-Detects[3]	Percent Non-Detects
CALSMA	M&R	373	0	1	41	331	89
	M&O	511	0	2	26	483	95
HASMA and LASMA	M&R	608	4	29	99	476	78

[1] CALSMA = Calumet WRP SMA; HASMA = Harlem Avenue SMA; LASMA = Lawndale Avenue SMA (includes Vulcan and Marathon areas).
[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.

hazardous air pollutants (HAPs) if it emits or has the potential to emit ten 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. During 2016, influent samples were collected in January and July. The average influent concentrations and estimated emissions of the HAPs are presented in Table 3 for the three largest District WRPs (Calumet, Terrence J. O'Brien [O'Brien], and Stickney).

According to the results from the BASTE 4 model, all the individual HAP emissions were less than the ten tons/year criterion. Acetaldehyde 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 by the M&O Department as part of the IEPA's Environmental Emissions Reduction Market System.

John E. Egan Water Reclamation Plant Air Quality Permit. As part of the 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 2016, 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 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 metro area under a Controlled Solids Distribution (CSD) Program under a permit issued by the IEPA. The AMB

TABLE 3: INFLUENT CONCENTRATIONS AND ESTIMATED EMISSIONS OF HAZARDOUS AIR POLLUTANT CONCENTRATIONS AT THE CALUMET, STICKNEY, AND TERRENCE J. O'BRIEN WATER RECLAMATION PLANTS IN 2016

Hazardous Air Pollutant	Concentrations (μg/L)[1]			Emissions (tons/year)[2]		
Organic Compound	Stickney	Calumet	O'Brien	Stickney	Calumet	O'Brien
Acetaldehyde	77.30	0.00	0.00	3.92	0.00	0.00
Chloroform	1.58	0.00	1.50	1.20	0.00	0.43
Cresol	2.10	0.00	18.5	0.00	0.00	0.01
Dichloromethane	0.00	1.10	0.00	0.00	0.01	0.00
Methyl ethyl ketone, 2 butanone (MEK)	10.2	0.00	0.00	0.52	0.00	0.00
Propionaldehyde	54.5	0.00	0.00	1.75	0.00	0.00
Styrene	0.00	1.75	0.00	0.00	0.06	0.00
Toluene	4.20	4.00	1.10	2.02	0.03	0.32
Xylene	0.90	0.00	0.00	0.40	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.

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 2016, biosolids analysis under the program included 83 samples for FC analysis and 13 samples for HO and culturable EV analyses.

In 2016, the EM&R Division prepared the following regulatory reports under the biosolids management program:

- The 2016 Biosolids Management Report to the USEPA – Electronic reporting was submitted to USEPA to satisfy the reporting requirements of the Part 503 regulation. A District Report No. 16-05 was also prepared to document the District's 2016 biosolids management.

- Four quarterly reports for the CSD permit were submitted to the IEPA (M&R Department Reports 16-04, 16-16, 16-36, and 16-37). The reports document the biosolids users, project descriptions and locations, and biosolids analyses.

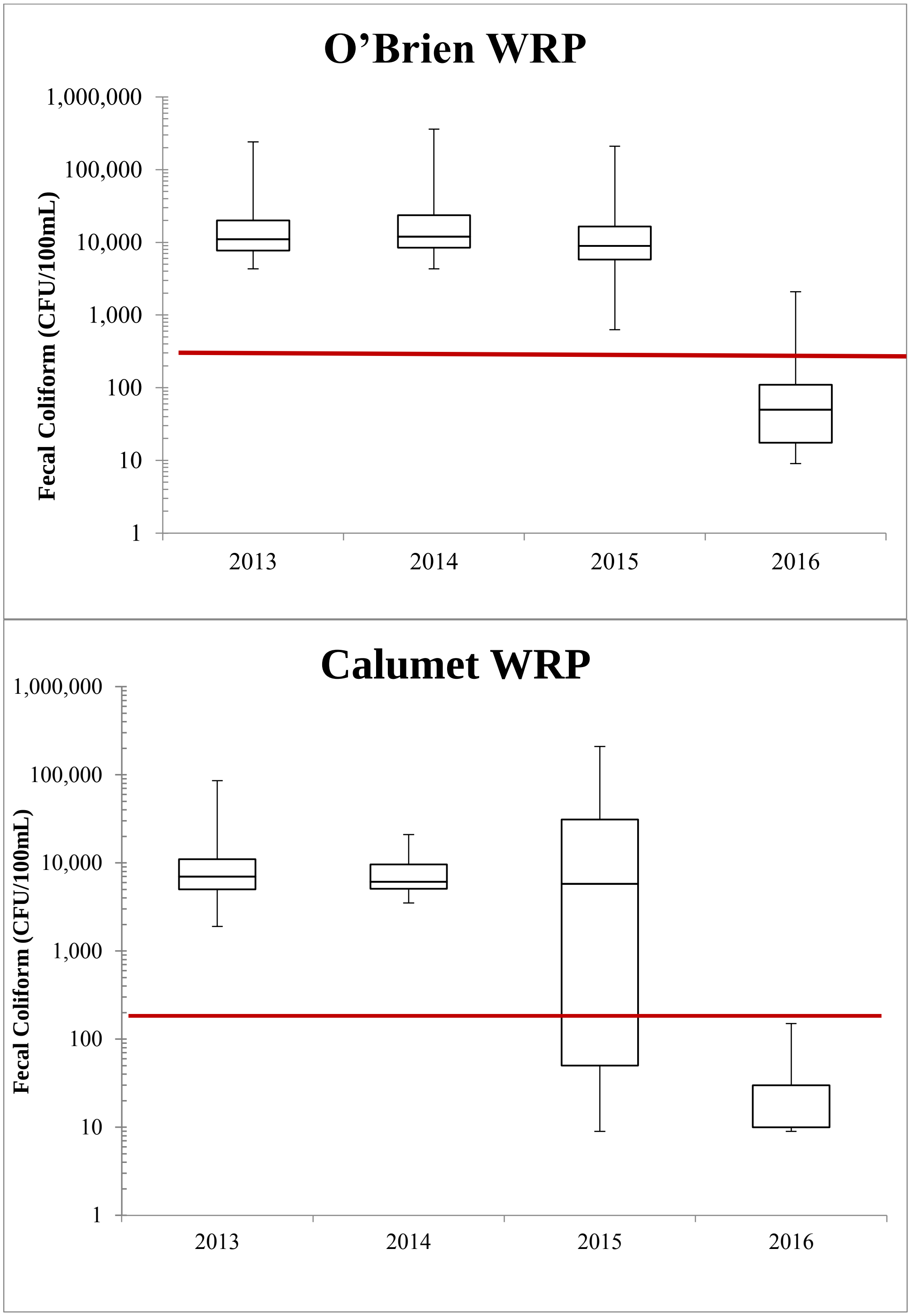
National Pollutant Discharge Elimination System Effluent Monitoring. The AMB Section conducted the following monitoring to satisfy the requirements of the NPDES permits issued to the District WRPs.

- Final Effluent Monitoring – Membrane filtration analysis of FC bacteria was performed to monitor the District's WRP effluents as well as to guide treatment operations. This included the final 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 five WRPs. The ABL performed FC analyses on a total of 1,393 samples from the District's seven WRPs were analyzed by the ABL in 2016. The FC analysis results were reported to the M&O Department.

- Wet Weather Discharge Monitoring - As required in the NPDES permits, microbial monitoring is performed when rain storm events cause excess flow above the treatment capacities of the WRPs. This monitoring support was provided to the John E. Egan (Egan) WRP wet weather excess flow and the Lemont WRP's Wet Weather Treatment facility.

- Disinfection Facility Startup Monitoring - The fecal coliform (FC) and/or *E. coli* (EC) testing of disinfected effluents at the Terrence J. O'Brien (O'Brien) WRP and the Calumet WRP was conducted as a part of the 60-day compliance testing in early 2016. As shown in Figure 2, the fecal coliform levels in the disinfected effluent from the Calumet and O'Brien WRPs have been significantly reduced since disinfection started. As a result of permit required disinfection at these two WRPs, there was a 50 percent increase in liquid process monitoring samples in 2016 compared to 2015.

FIGURE 2: BOX PLOT OF 2013–2016 ANNUAL COLIFORM BACTERIA IN THE TERRENCE J. O'BRIEN AND CALUMET WATER RECLAMATION PLANTS' DISINFECTED FINAL EFFLUENT



Solid line represents the NPDES permit limit (monthly geometric mean of 200 CFU/100 mL).

Thornton Composite Reservoir Odor Monitoring Program. The WTPR and PFCP Sections conducted odor monitoring of the Thornton Composite Reservoir (TCR) in 2016. Data collected as part of this monitoring program included: continuous H_2S readings, daily H_2S and ammonia readings, daily identification of odor intensity/type, daily wind direction and speed, daily surface water elevation in the TCR, daily TARP pumpage, weekly Nasal Ranger (hand-held olfactometry detection to threshold test) test results and the number of verified odor complaints. Every two weeks, the collected data was summarized in a report and submitted to the Executive Director.

Collateral Channel Odor Monitoring. As a response to odor complaints near the Collateral Channel, the WTPR and PFCP Sections conducted odor patrol monitoring starting in June through October of 2016. During each odor patrol, 13 locations surrounding the Collateral Channel were monitored for H_2S, wind speed and direction, air temperature, and identification of odor intensity and character. After each odor patrol, the collected data was summarized and a report submitted to the Executive Director.

Program 2: Waste Monitoring

There is no activity to report under this Program for 2016.

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. 2016-SC-61315) 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 2016 groundwater monitoring data were submitted to the IEPA in the quarterly monitoring reports (M&R Department Report Nos. 16-15, 16-31, 16-42, and 17-12).

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 2016 groundwater monitoring data were submitted to the IEPA in M&R Report Nos. 16-11, 16-27, 16-41, and 17-05.

- 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 2016 groundwater monitoring data were submitted to the IEPA in M&R Report Nos. 16-14, 16-28, 16-40 and 17-08.

- 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 2016 groundwater monitoring data were submitted to the IEPA in M&R Report Nos. 16-13, 16-30, 16-44 and 17-06.

- 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 2016 groundwater monitoring data were submitted to the IEPA in M&R Report Nos. 16-12, 16-29, 16-33 and 17-07.

Tunnel and Reservoir Plan Groundwater Monitoring. The IEPA requires groundwater monitoring and annual reporting for the District's seven TARP systems, which includes the Mainstream, Calumet, Des Plaines, and Upper Des Plaines (UDP) Tunnel Systems, Thornton Composite Reservoir, Thornton Transitional Flood Control Reservoir (TTFCR), and Gloria Alitto Majewski Reservoir (GAMR). After each reservoir fill event resulting from storm events, the TTFCR and GAMR 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 stored in the tunnels and reservoirs. The wells along the tunnels 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 AMBS. A total of 462 samples were collected in 2016 and analyzed for all permit-required analytes, including FC bacteria. The 2015 monitoring data was summarized in 2016 in M&R Report Nos. 16-19, 16-20, 16-21, 16-22, 16-23, 16-24, and submitted to the IEPA.

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. The EM&RD prepared annual monitoring reports for the TCR as required by IEPA. Three reports for this site were prepared during 2016: fourth quarter/annual 2015, first quarter 2016, and second quarter 2016 (M&R Report Nos. 16-32, 16-26, and 16-45, respectively).

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 2016, there was one backflow event to Lake Michigan. During the river backflow, nine water samples collected by the Industrial Waste Division were analyzed for EC and FC.

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 July and November 2016 the AEWQ Section collected fish by electrofishing and seining at seventeen biological monitoring stations in the Des Plaines, Calumet, and Chicago River Systems. In 2016, a total of 5,361 fishes comprised of 41 species were identified, weighed, and measured. The fishes were also examined for parasites and disease. Data from these collections are shown in Table 4.

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.

FIGURE 3: AMBIENT WATER QUALITY MONITORING SAMPLE STATIONS

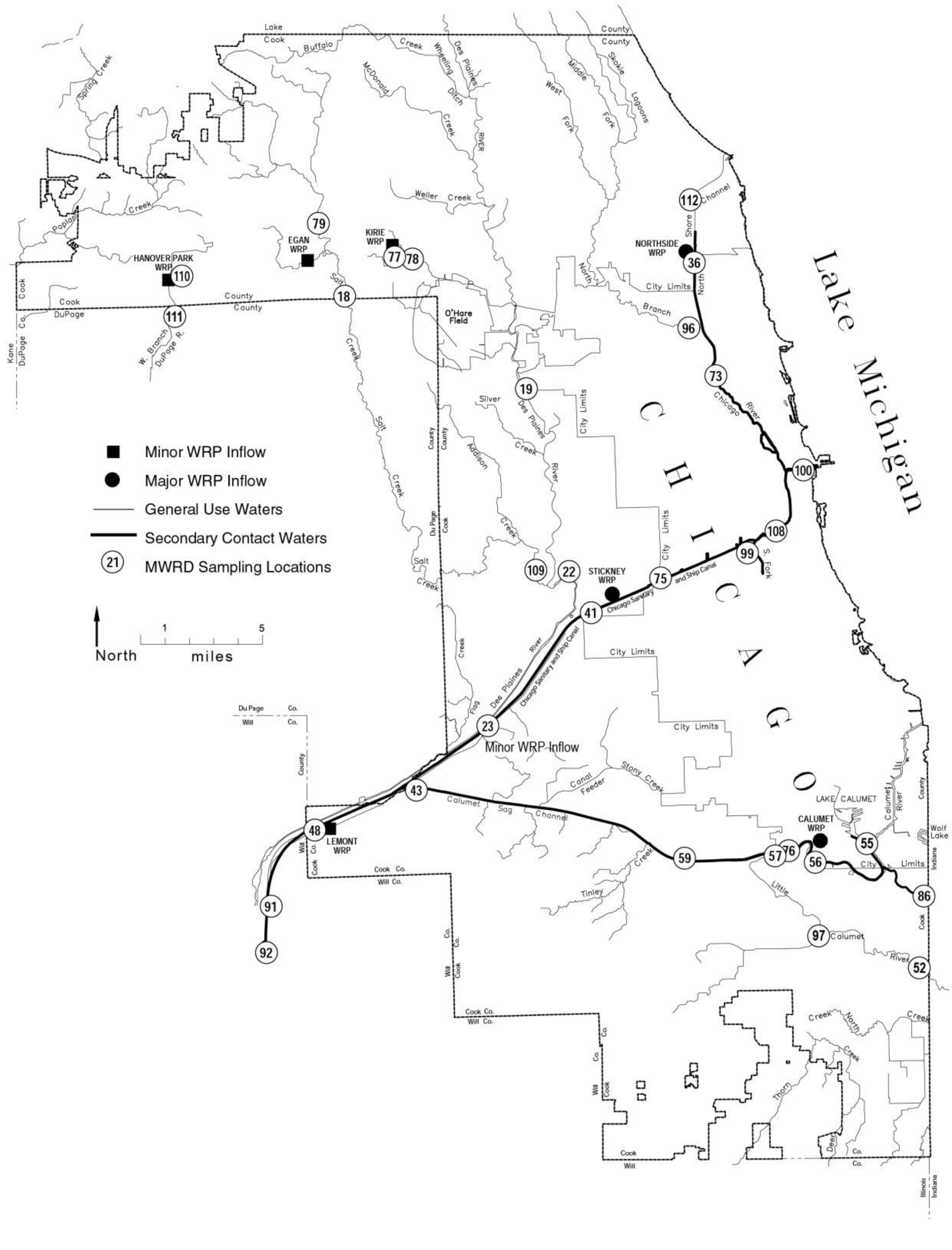
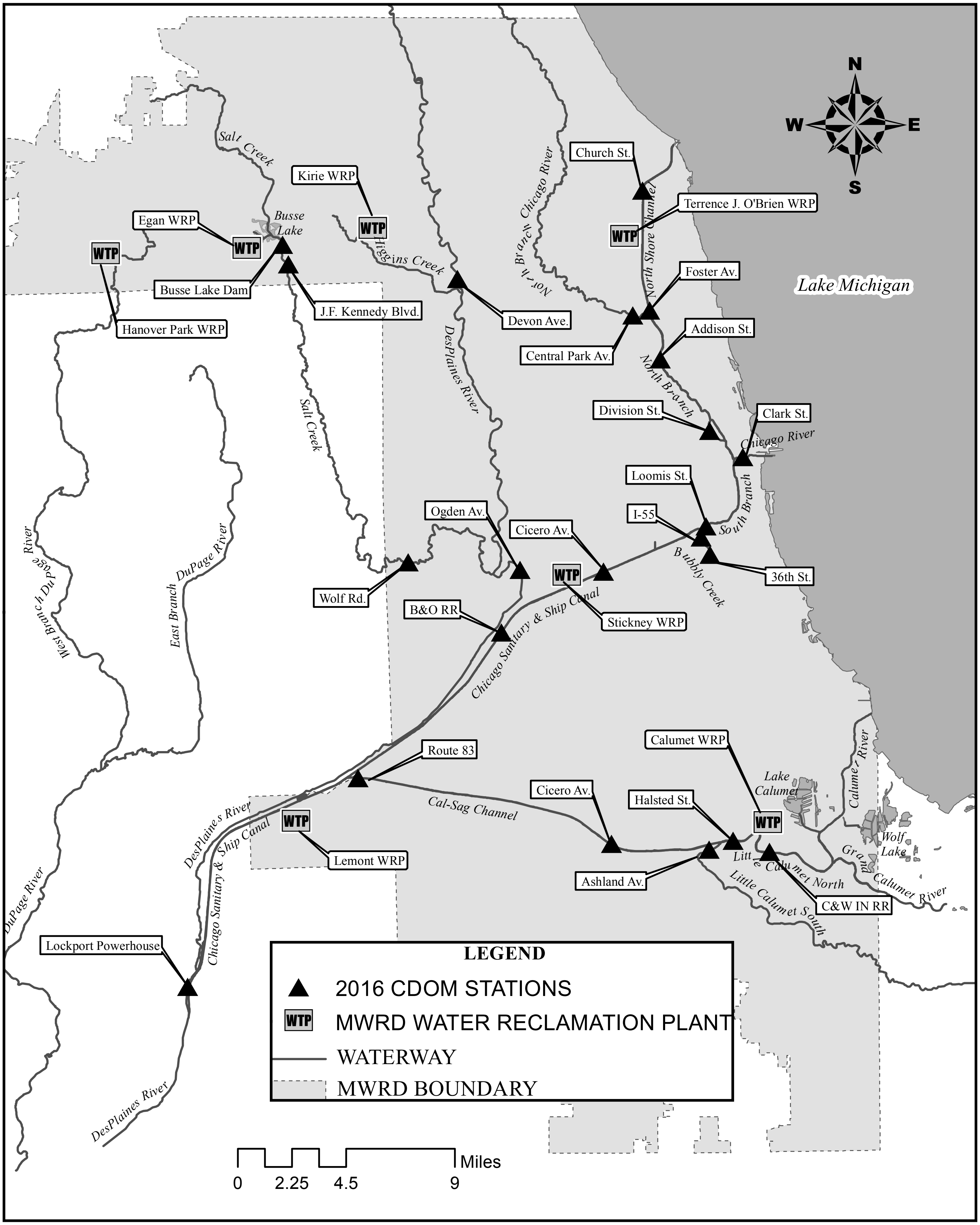


TABLE 4: FISH COLLECTION SUMMARY THE DES PLAINES, CHICAGO, AND CALUMET RIVER SYSTEMS DURING 2016

River System	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	241	2.4	20	6	Green sunfish
Chicago	3,648	745.6	27	10	Gizzard shad
Calumet	1,784	585.5	31	13	Gizzard shad
Total	5,673	1,333.5	41	16	Gizzard shad

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

FIGURE 4: CONTINUOUS DISSOLVED OXYGEN MONITORING SAMPLE STATIONS



The DO results for 2016 are included in M&R Department Report No. 17-38 "Continuous Dissolved Oxygen Monitoring Chicago Area Waterways System During 2016." Continuous DO data are also submitted to the IEPA quarterly in accordance with NPDES permit requirements.

Sensitive Area Assessments. Special Condition 13 of the NPDES permit No. IL0028061 for the Calumet WRP required the District to conduct sensitive area assessments on 13 CSO outfalls. The AEWQ section staff conducted the assessments in the fall of 2015 and prepared a report that demonstrated that each of the CSO outfalls did not discharge to sensitive areas. M&R Report No. 16-17 "Sensitive Area Considerations for Outfalls Designated in National Pollutant Discharge Elimination System Permit Number IL0028061 for the Calumet Water Reclamation Plant" was completed in June 2016 and submitted to the IEPA on June 30, 2016.

Collateral Channel Water Quality Assessment. In late May of 2016, M&R staff were requested to assess potential sources of odor in response to odor complaints near the Collateral Channel. Staff from the AEWQ section performed water quality assessments using water quality meters and probes before and after Maintenance and Operations (M&O) staff opened a tide gate in the Combined Sewer Overflow (CSO) at the north end of the CC (6/17/16). Staff from the AEWQ section also collected water samples from three locations in the Collateral Channel on June 20, 2016. The three sampling stations were located at the northern end, middle, and southern end of the Collateral Channel. Samples were analyzed for nitrogen compounds, dissolved oxygen, cyanide, phenols, suspended solids, volatile suspended solids, various metals, and organic priority pollutants. No elevated chemical concentrations of any of the analyzed constituents were found in water samples. Dissolved oxygen concentrations were low (< 2 mg/L) at all three sampling locations on a few occasions (6/3/16, and 6/30/16), but were > 3 mg/L at all three sampling locations during 6/20/16 and 7/8/16.

Pre-Completion of McCook Phase I Reservoir Wet Weather Monitoring of Chicago and Des Plaines River Systems. Enhanced water quality monitoring was implemented at 15 sampling locations in the northern and southern portions of the Chicago River, and Des Plaines Systems to document baseline conditions for two years preceding the completion of the McCook Phase I 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 first, second and third Mondays of each month, as well as during or after separate 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 is 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 North Branch, Racine Avenue, and Westchester Pump Stations.

Besides the monthly samples, the sampling events completed during 2016 were four wet weather without CSOs, and six wet weather with CSOs. All wet-weather sampling events occurred within 24 hours from the end of each storm event. The results of this monitoring will be included in the reporting under the Chicago and Des Plaines River TARP Systems Pre Construction Monitoring Plan developed per the Consent Decree.

Program 4: Technical Assistance

Drinking Water Monitoring. The Division analyzes drinking water at District facilities on an as-needed basis. During 2016, a total of ten samples were analyzed for bacteria in response to requests from the Stickney and O'Brien WRPs. 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.

John E. Egan Water Reclamation Plant Profile Sampling. A DO and NH_3-N profile evaluation was performed on a quarterly basis 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 2016, 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 operating adequately.

Studies on Enhanced Biological Phosphorus Removal. During 2012, the WTPR Section, together 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 enhanced biological phosphorus removal (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).

In 2016, all four batteries were operating in this configuration at the Stickney WRP and optimization practices continued. An annual average total P (TP) concentration of 0.64 mg/L in the final effluent was achieved in 2016 as shown in Figure 5. One out of twelve months the Stickney WRP TP monthly averages were above the 1 mg/L target. The geometric mean of the final effluent TP concentration in 2016 was 0.45 mg/L.

Monitoring the growth and abundance of PAOs in the anaerobic and aerobic zones of all four batteries continued in 2016. The abundance of PAOs was plotted along with the effluent ortho-P concentrations in each battery, which are shown in Figures 6 through 9.

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-N, and SS NPDES limits, achieving sustainable EBPR performance is difficult. In addition, inconsistent influent organics is often observed. To address these, 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) fermenters were designed in 2016 to help make the EBPR process more stable.

FIGURE 5: STICKNEY WATER RECLAMATION PLANT PRIMARY EFFLUENT AND OUTFALL MONTHLY AVERAGE TOTAL PHOSPHORUS CONCENTRATIONS FOR 2016

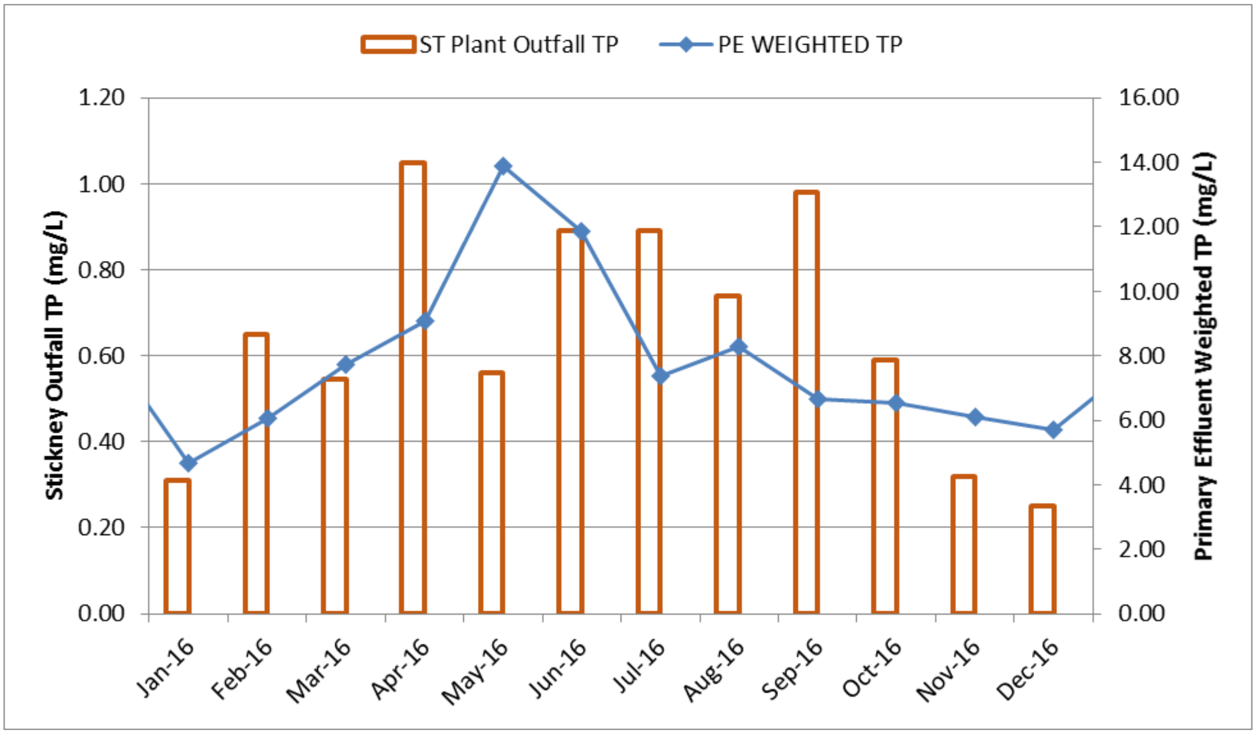


FIGURE 6: PHOSPHORUS-ACCUMULATING ORGANISM ABUNDANCE AND ORTHOPHOSPHATE IN STICKNEY WATER RECLAMATION PLANT BATTERY A EFFLUENT

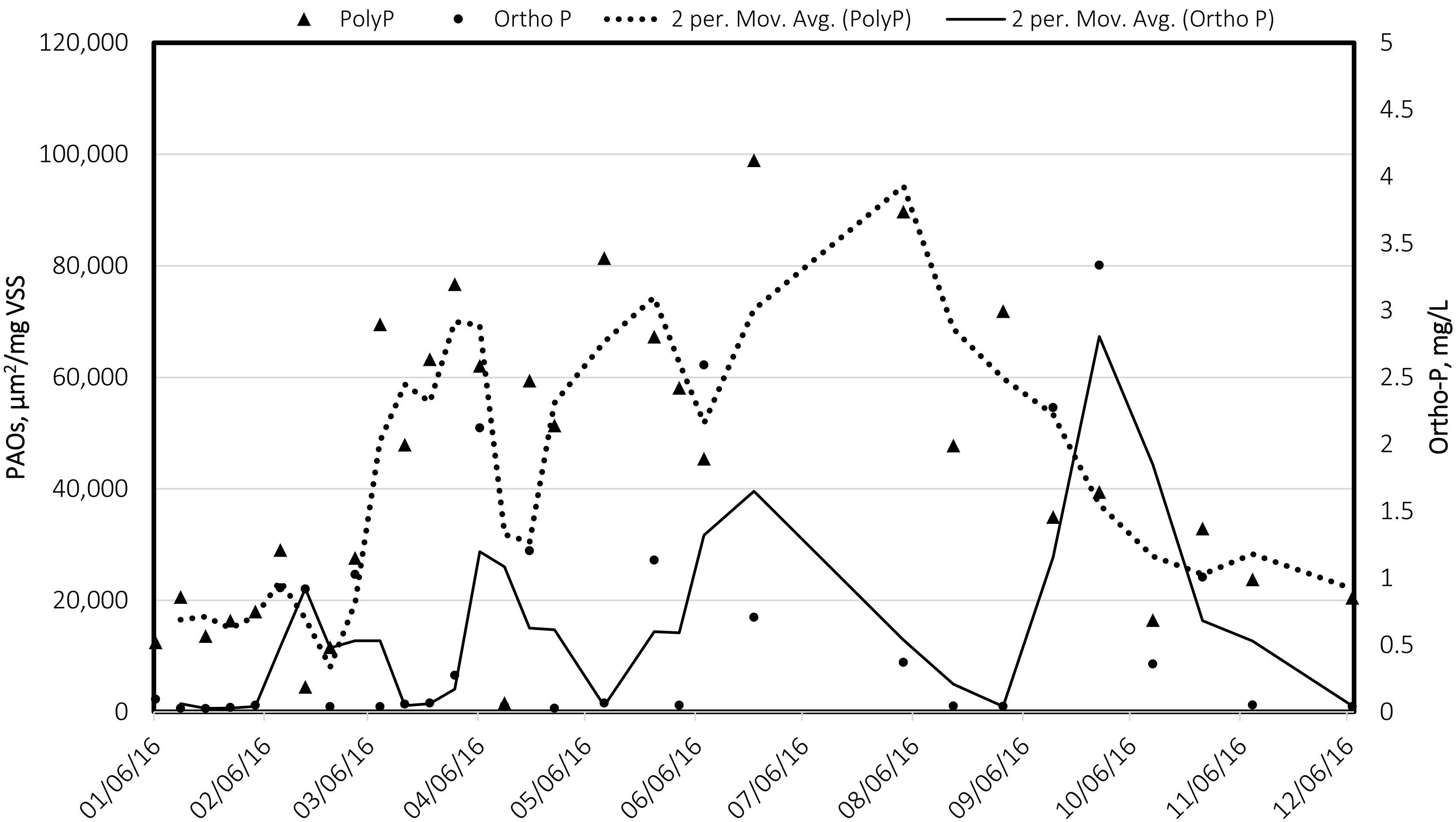


FIGURE 7: PHOSPHORUS-ACCUMULATING ORGANISM ABUNDANCE AND ORTHOPHOSPHATE IN STICKNEY WATER RECLAMATION PLANT BATTERY B EFFLUENT

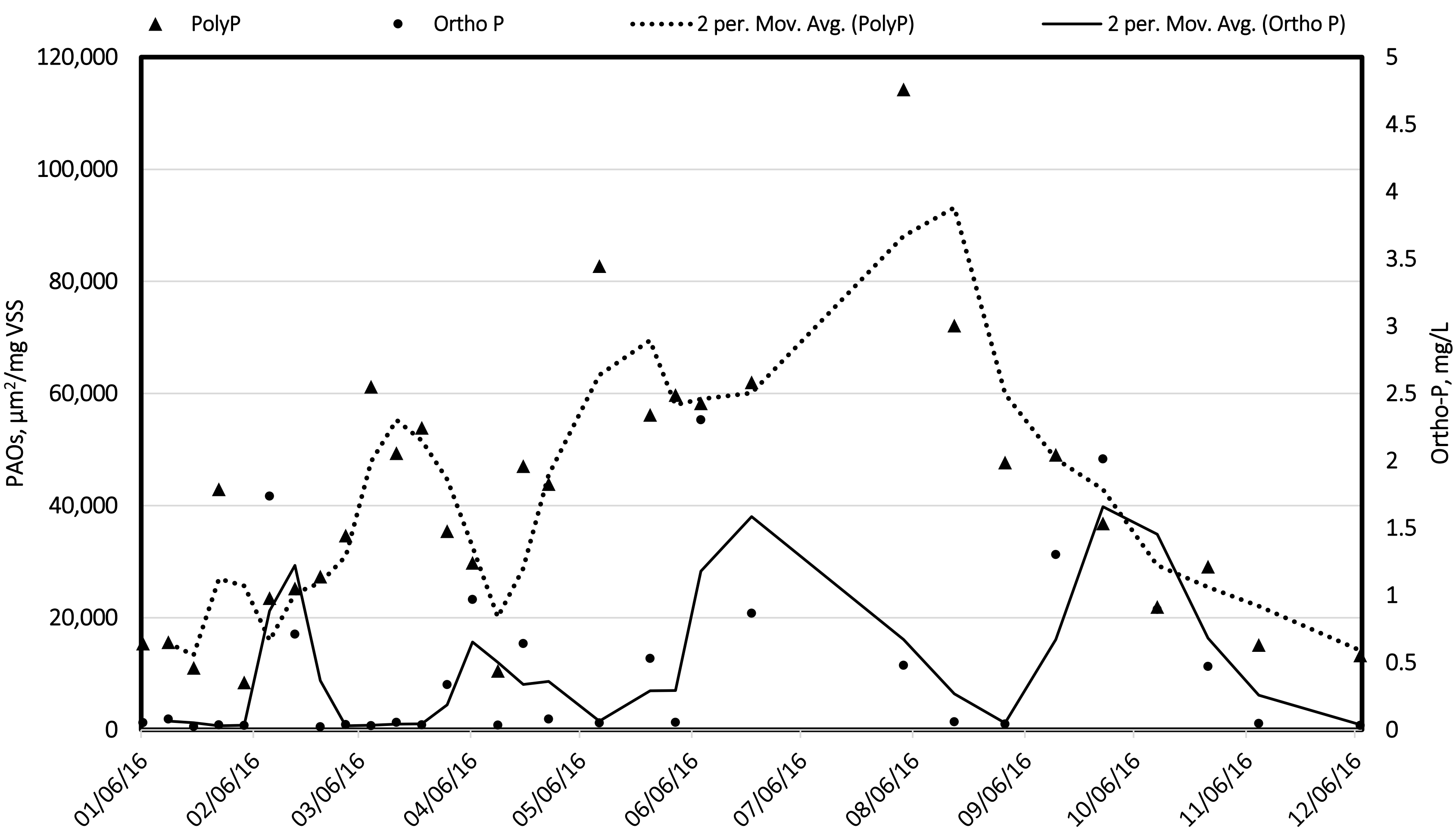


FIGURE 8: PHOSPHORUS-ACCUMULATING ORGANISM ABUNDANCE AND ORTHOPHOSPHATE IN STICKNEY WATER RECLAMATION PLANT BATTERY C EFFLUENT

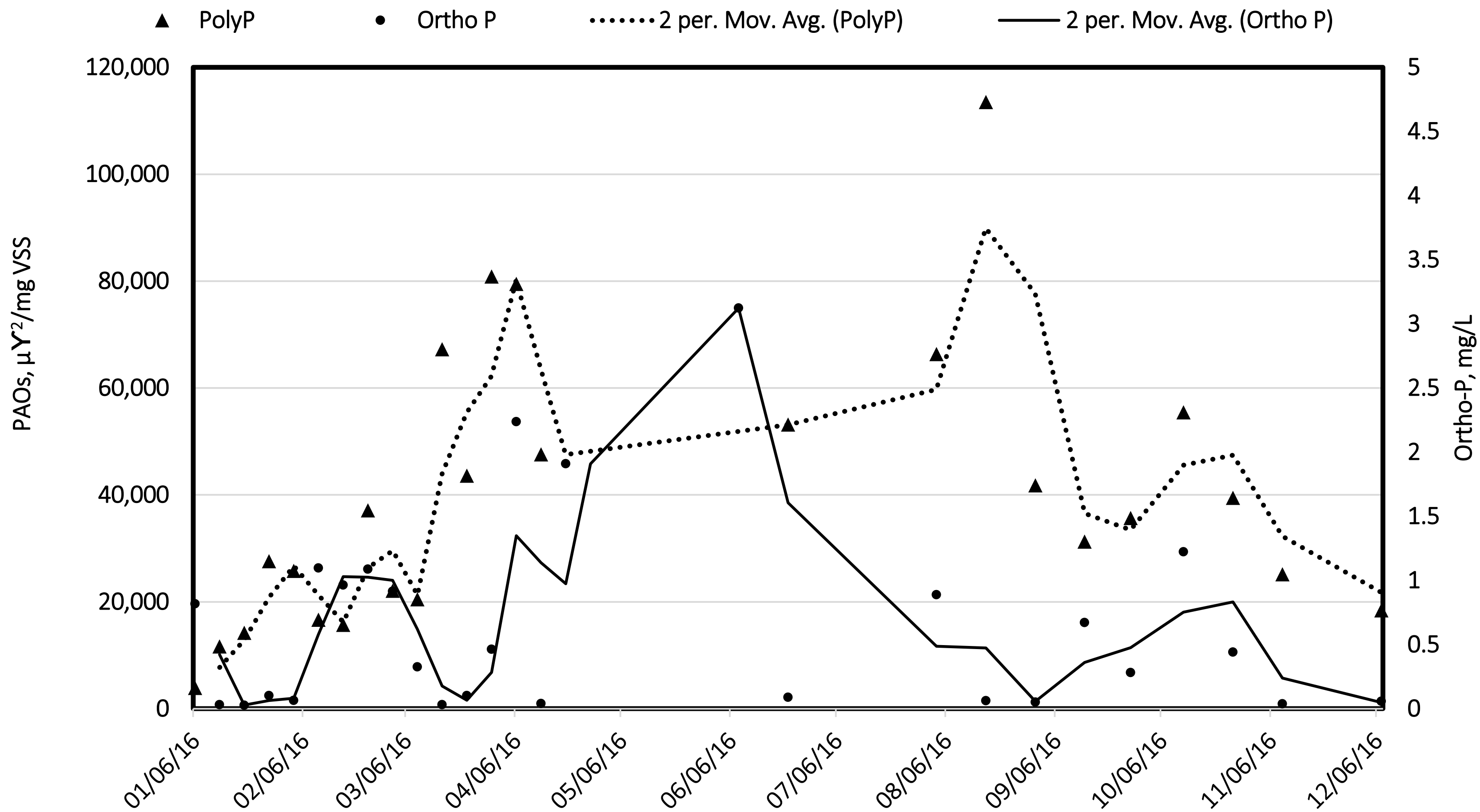
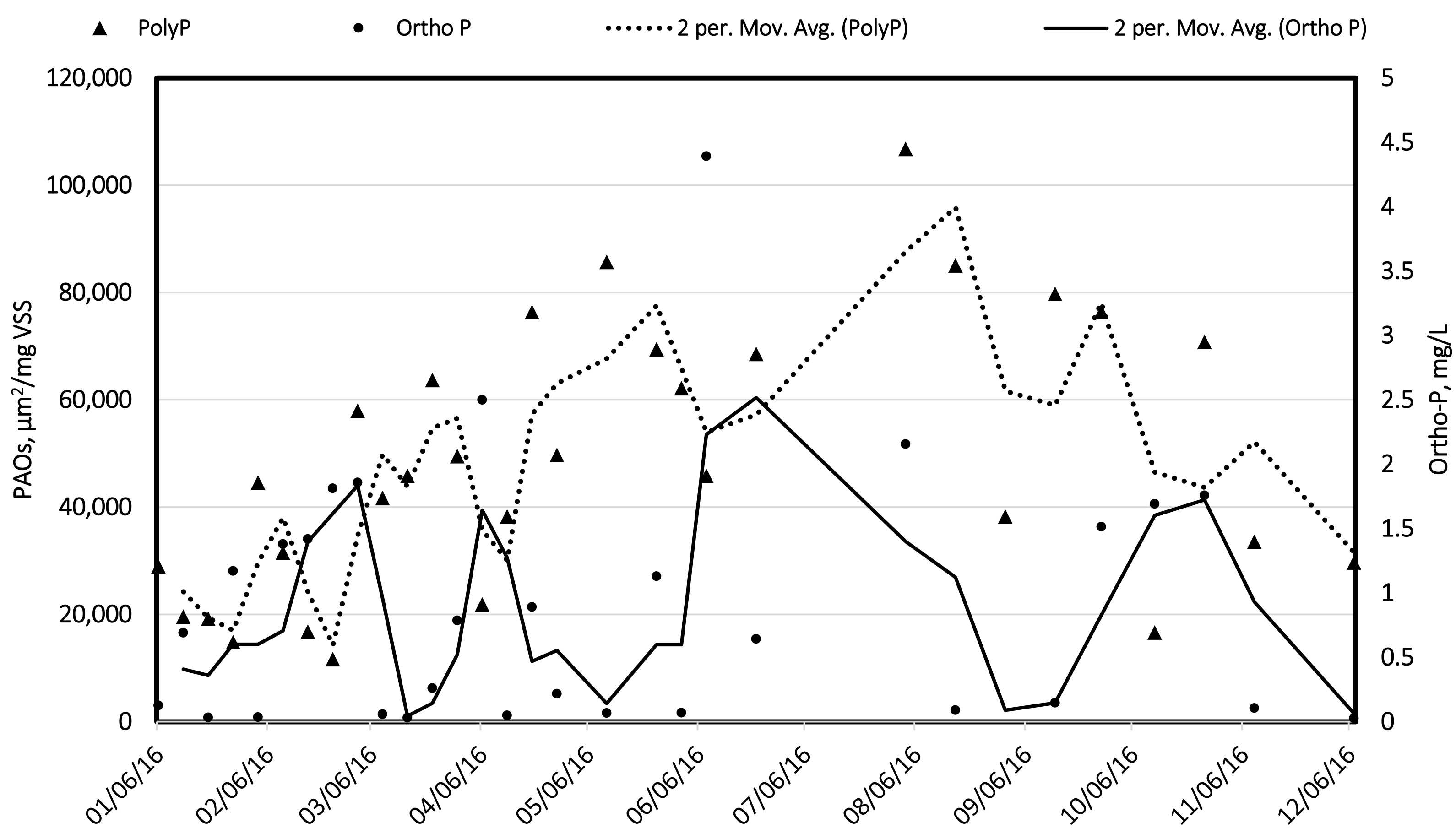


FIGURE 9: PHOSPHORUS-ACCUMULATING ORGANISM ABUNDANCE AND ORTHOPHOSPHATE IN STICKNEY WATER RECLAMATION PLANT BATTERY D EFFLUENT



The construction and implementation of actuation for the first seven valves in all aeration batteries is expected to complete by July 2018, and the conversion of two gravity concentration tanks to primary sludge fermenters is estimated to complete by October 2018. Efforts to acquire an industrial organic carbon supplement are also being investigated. In 2016, 24 high strength organic materials (HSOMs) were tested and 12 of them showed potential to be used as supplemental carbon for the EBPR process. The westernmost channel of Battery D at the Stickney WRP was retrofitted by M&O into a HSOM receiving station including three storage tanks, piping, covers, and pumps to dose the Southwest primary effluent cannel to the south of the battery. The receiving station was ready to receive HSOM by the end of 2016. COD and ortho P analyzers were installed on the Southwest side primary effluents to help with process control in 2016 with the West Side to be installed in 2017.

The Ostara® phosphorus recovery process started up in May 2016 and some positive effects were observed to stabilize the EBPR process. The final effluent TP during Ostara® startup (May – December 2016) averaged 0.67 mg/L, compared to an average final effluent TP of 1.01 mg/L during May – December 2015 without Ostara® in service. Evaluation of the effect of Ostara® on EBPR performance will be continued to 2017. Additionally, a Waste Activated Sludge Stripping to Remove Internal Phosphorus® (WASSTRIP®) process is being constructed to maximize phosphorus recovery. WASSTRIP® is expected to be in operation by December 2017.

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. Prior to further consideration of any of these fermentation options, a similar HSOM screening was conducted for Calumet in order to find a carbon supplement. A full-scale HSOM pilot testing in Battery A was prepared in 2016; all non-instrument materials were ordered and one frac tank was rented to get ready for pilot testing in 2017. The search for HSOMs for the EBPR process at the Calumet WRP will continue in 2017.

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 in the short-term study in 2015. The WTPR reinitiated the study in fall 2016. The three-month study was focused on enhancing conditions for denitrification in the final tanks, reducing RAS return, optimizing mixer operation, and reducing influent flow to test Tank A1 to increase the hydraulic residence time. The results have shown that test Tank A1 did not outperform the control Tank A2, and very low PAOs abundance were observed in Tank A1 during the three-month study. The recommendations from the 2016 study was returning Tank A1 to normal flow, introducing one time per day mixing in the anoxic an anaerobic zones, converting Tank D7 into the AAnO process similar to Stickney WRP, and maintaining as low of a RAS to PE ratio as possible. Testing will continue in 2017.

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 and 2016. 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 the 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. Monitoring of PAOs growth and abundance in both the anaerobic and aerobic zones of the control Tank 4 and in Test Tanks 5 and 6 continued in 2016. Filamentous bacteria counts were also performed on mixed liquor samples.

Monitoring of PAOs growth and abundance in both the anaerobic and aerobic zones of the control Tank 4 and in Test Tanks 5 and 6 continued in 2016. Filamentous bacteria counts were also performed on mixed liquor samples. The microbiological results are shown in Figure 10.

While test results in 2016 indicated that the test tanks were able to meet a TP limit of 1.0 mg/L monthly average during the study period, significant back mixing between the aeration zone and anaerobic zone was observed, which reduced the aeration tank efficiency and the available aeration volume for ammonia removal; this created an environment favorable for filament growth. In the spring of 2016, the plant experienced an extended period of high ammonia in the effluent during wet weather. The EBPR was discontinued by converting all anaerobic zones back to aerobic conditions for ammonia removal during May and June 2016.

In order to maximize the usage of existing aeration tank for P removal and ammonia removal, a swing zone was designed for the two pilot test tanks. First one third of Pass 1 (approximate 11 percent of total aeration tank volume) was operated as an Anaerobic/fermentation zone for P release and to ferment mixed liquor to generate VFAs to enhance P release. The second third of Pass 1 (approximate 11 percent of total aeration tank volume) was operated as a swing zone. The swing zone was operated as either an aerobic zone for an ammonia removal mode or an anaerobic zone for a P removal mode to balance and maximize overall EBPR process and ammonia removal.

In June 2016, the remaining aeration Tanks 1 through 4 were converted to EBPR by converting the first one-third of Pass 1 (or 11 percent of aeration tank volume) to a fermentation/anaerobic zone. Figures 11 and 12 provide a performance comparison between combined effluent from Test Tanks 5 and 6 (with swing zone operation) and combined effluent from Tanks 1 through 4 in terms of P removal and ammonia removal, respectively. Tanks 5 and 6 outperformed Tank 1-4 for P removal. Overall, average Ortho-P concentrations from Tanks 1-4 ranged from 0.1 – 1.66 mg/L with an average of overall 0.54 mg/L while Tanks 5 and 6 ranged from 0.02 – 1.49 mg/L with an average of 0.38 mg/L. Ammonia levels in the effluent from Tank 1-4 (average of 0.37 mg/L) was slightly lower than from Tank 5 and 6 (average of 0.48 mg/L)

In order to further maximize the aeration tank efficiency, two baffle walls were installed in Aeration Tank 6 to provide isolated Anaerobic/fermentation and Swing zones in Pass 1. Figures 13 and 14 provide side-by-side performance comparison between Test Tank 6 (with baffle wall) and Test Tank 5 (without baffle wall) in terms of P removal and ammonia removal, respectively. Both tanks performed well in terms of P removal. The effluent ortho-P level from

FIGURE 10: PHOSPHORUS-ACCUMULATING ORGANISM ABUNDANCE IN JAMES C. KIRIE WATER RECLAMATION PLANT AERATION TANKS 4, 5, AND 6

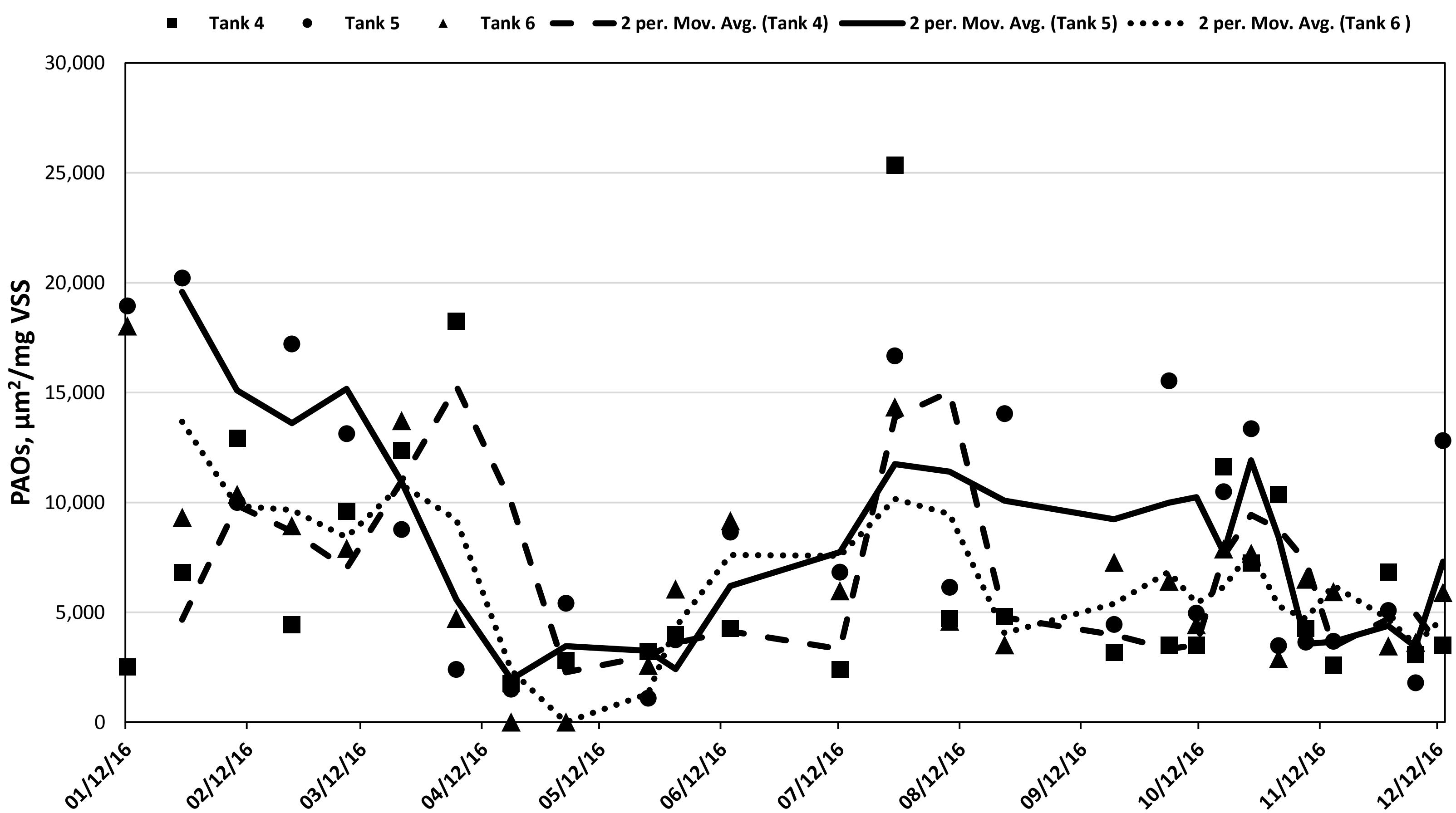
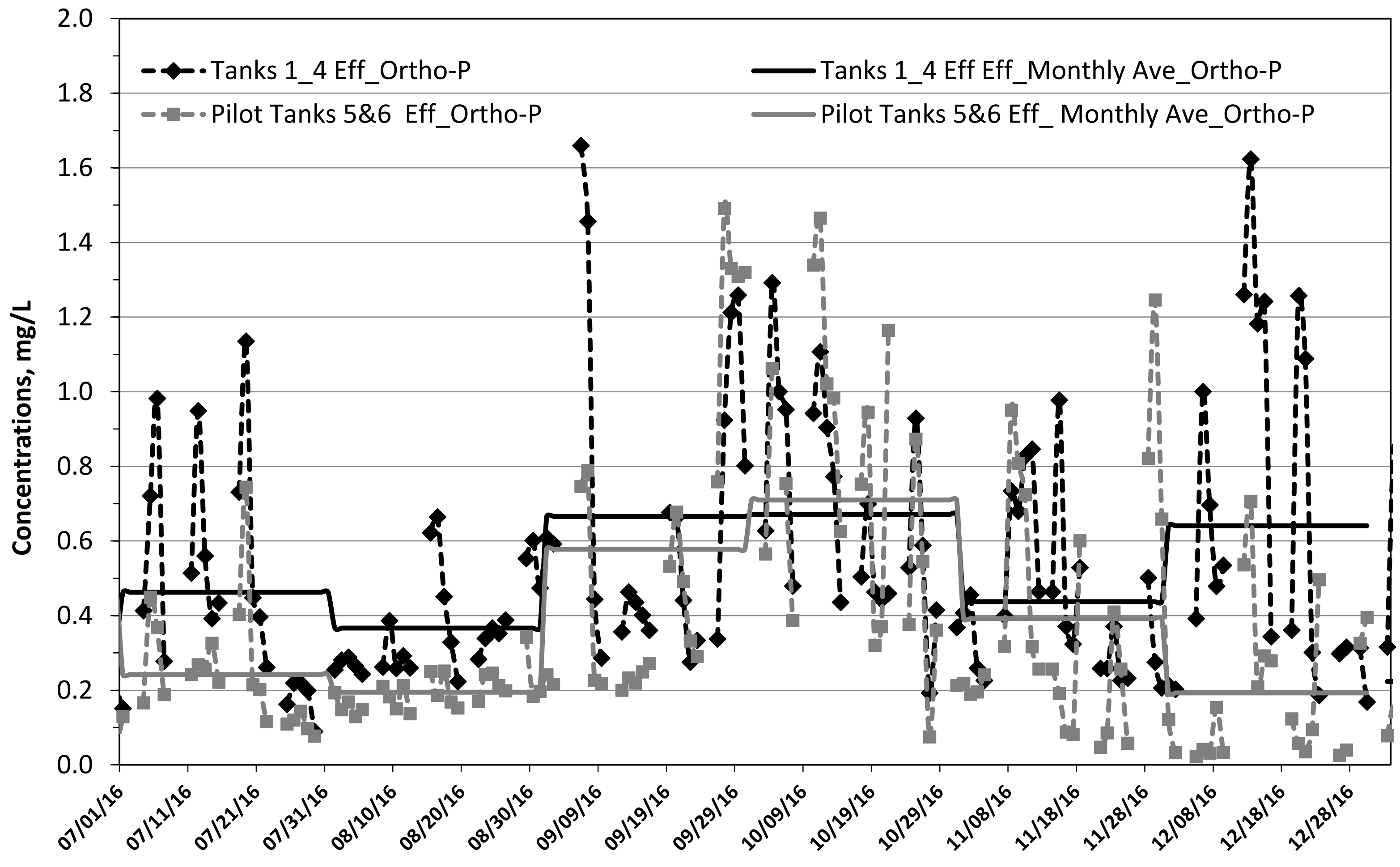
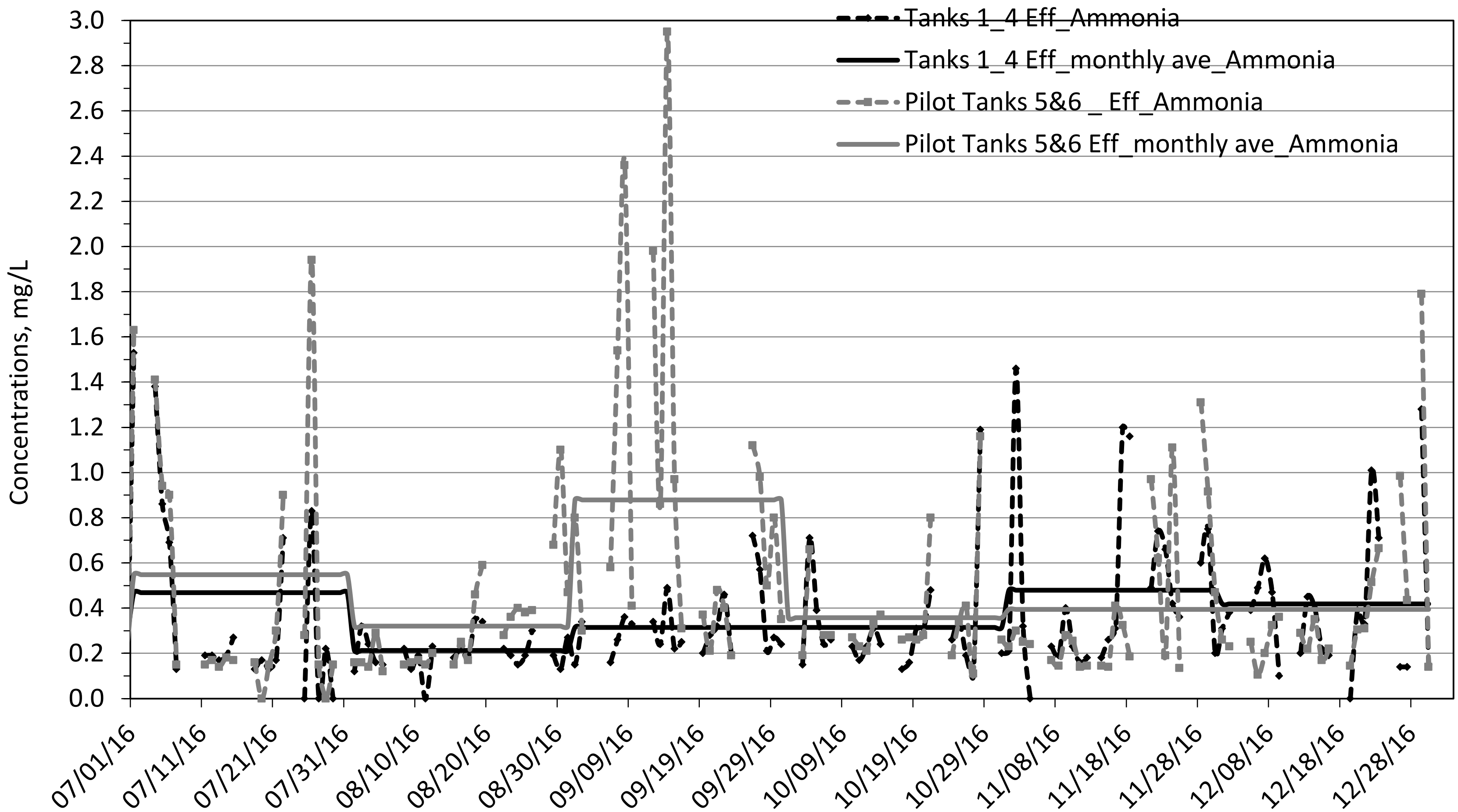


FIGURE 11: COMPARISON OF EFFLUENT ORTHOPHOSPHATE CONCENTRATIONS BETWEEN JAMES C. KIRIE WATER RECLAMATION PLANT AERATION TANKS 1 THROUGH 4 AND TANKS 5 AND 6 WITH SWING-ZONE OPERATION



Note: 9/14/16 - 10/18/16: T6 dissolved oxygen (DO) probe failure, aeration by constant air supply, caused inconsistent DO in T6 aerobic zone, which in turn caused high effluent orthophosphate level in the T6.

FIGURE 12: COMPARISON OF EFFLUENT AMMONIA CONCENTRATIONS BETWEEN JAMES C. KIRIE WATER RECLAMATION PLANT AERATION TANKS 1 THROUGH 4 AND AERATION TANKS 5 AND 6 WITH SWING-ZONE OPERATION



Note: In early July to early September, DO probe in T6 used for aeration control failed and it gave false high reading, which caused low air supply to T6, and in turn caused high ammonia in T6 effluent.

FIGURE 13: COMPARISON OF EFFLUENT ORTHOPHOSPHATE CONCENTRATIONS BETWEEN JAMES C. KIRIE WATER RECLAMATION PLANT AERATION TANK 6 (WITH BAFFLE WALL) AND AERATION TANK 5 (WITHOUT BAFFLE WALL)

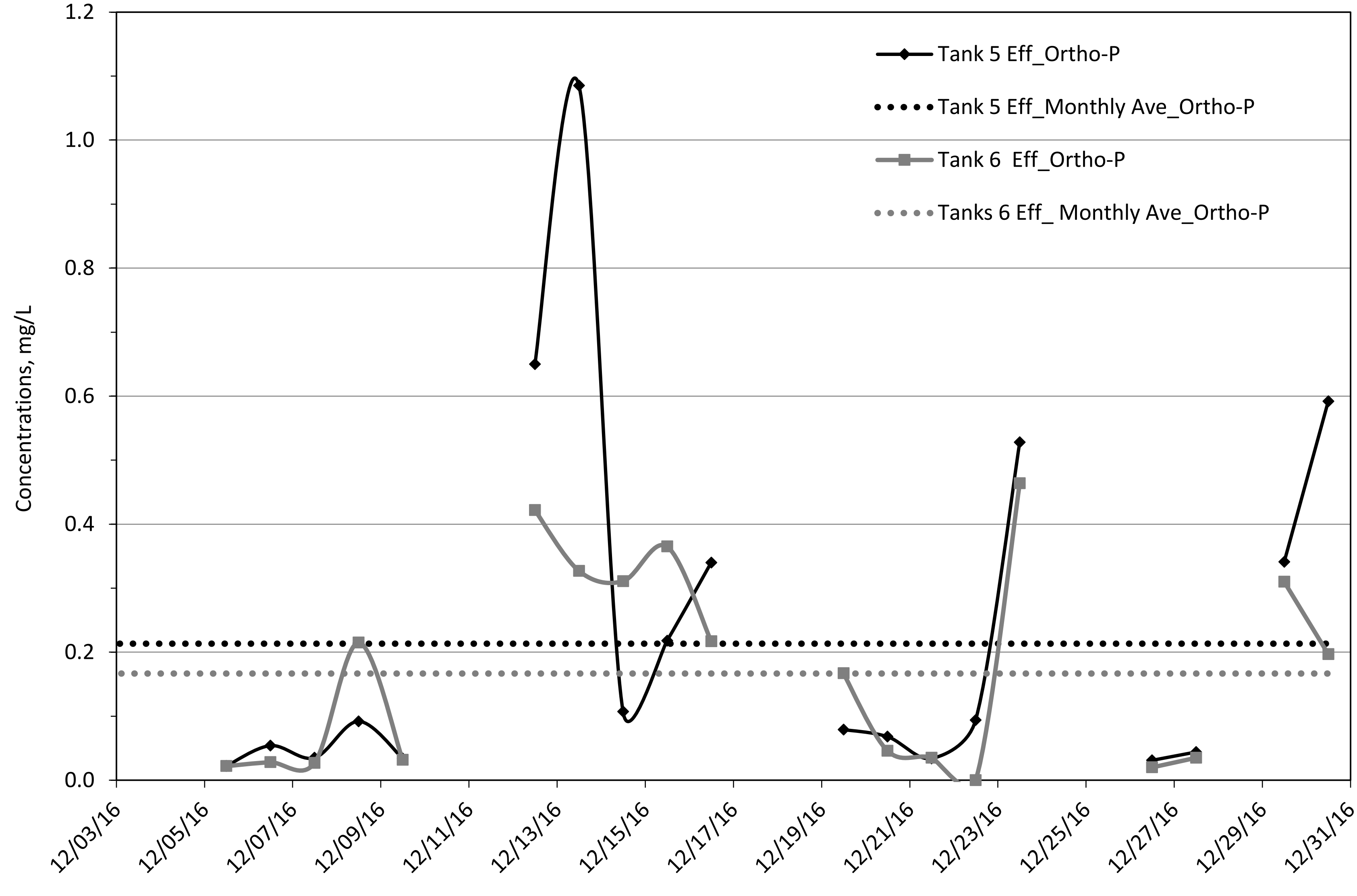
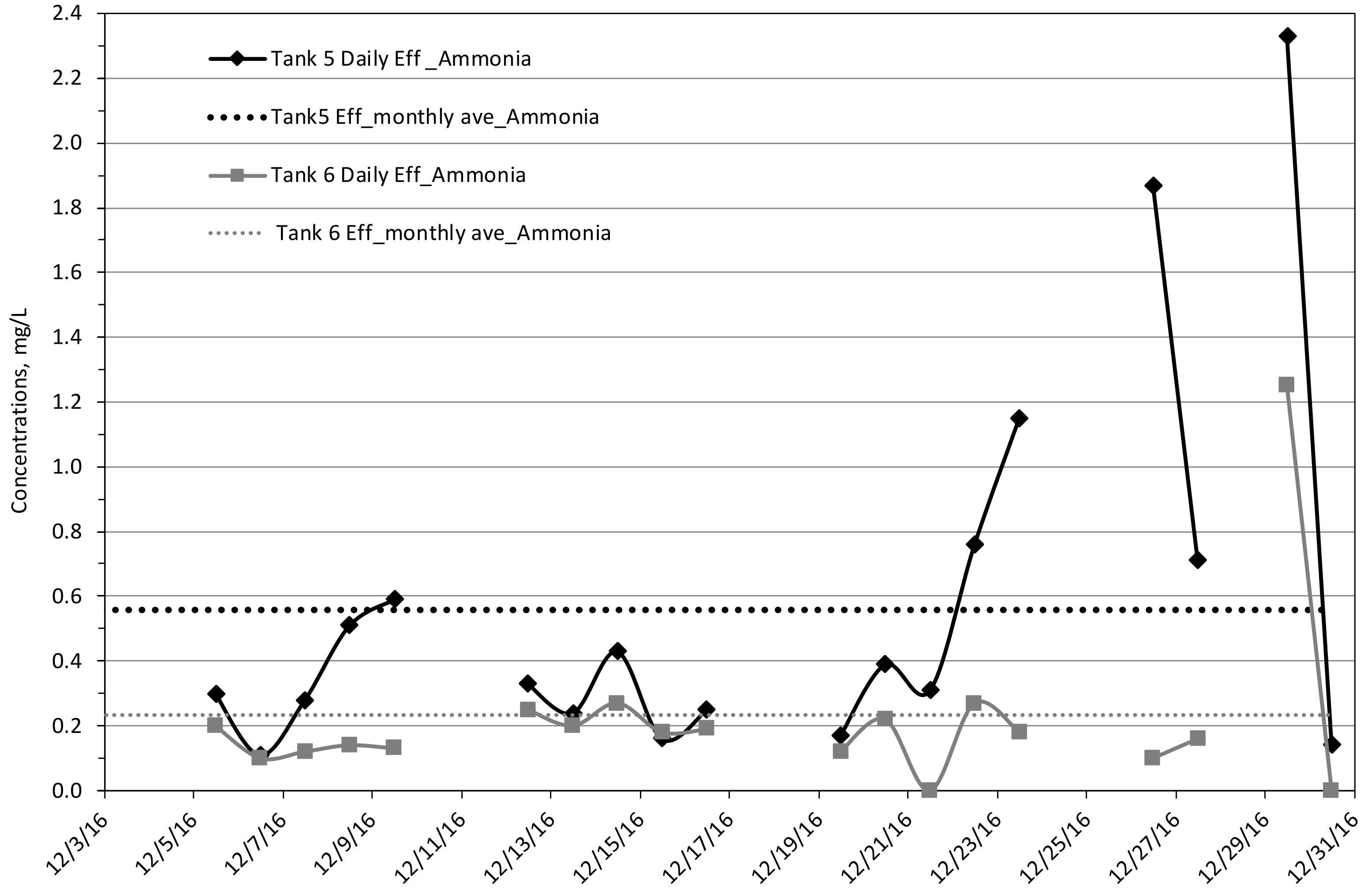


FIGURE 14: COMPARISON OF EFFLUENT AMMONIA CONCENTRATIONS IN JOHN E. EGAN WATER RECLAMATION PLANT AERATION TANK 6 (WITH BAFFLE WALL) AND AERATION TANK 5 (WITHOUT BAFFLE WALL)



Tank 6 ranged from 0.023 – 0.46 mg/L with an average of 0.19 mg/L and was slightly better than Tank 5 with effluent ranging from 0.03 – 1.09 mg/L and an average of 0.21 mg/L. Ammonia removal improved significantly in Tank 6 with the baffle wall. Overall effluent ammonia levels in the Tank 6 ranged from 0.1 – 1.3 mg/L with an average of 0.39 mg/L while effluent ammonia levels in the Tank 5 ranged from 0.1 – 2.3 mg/L with an average of 0.56 mg/L during the comparison period.

Figures 15 and 16 show the Kirie WRP outfall influent and effluent monthly average TP and ammonia levels from year 2013 through 2016. The monthly plant effluent TP level decreased every year since Kirie started implementing EBPR. In the meantime, the effluent ammonia level appeared to increase slightly which is most likely due to the reduced aeration volume. In 2017 we will continue optimize Kirie EBPR and ammonia removal in the two test tanks by providing baffle walls in Aeration Tank 5 and mixers in Tanks 5 and 6. Based on the information gathered from Test Tanks 5 and 6, we will start conceptual design for full plant optimized EBPR implementation

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. Strategy 3 is the focus of the WTPR section.

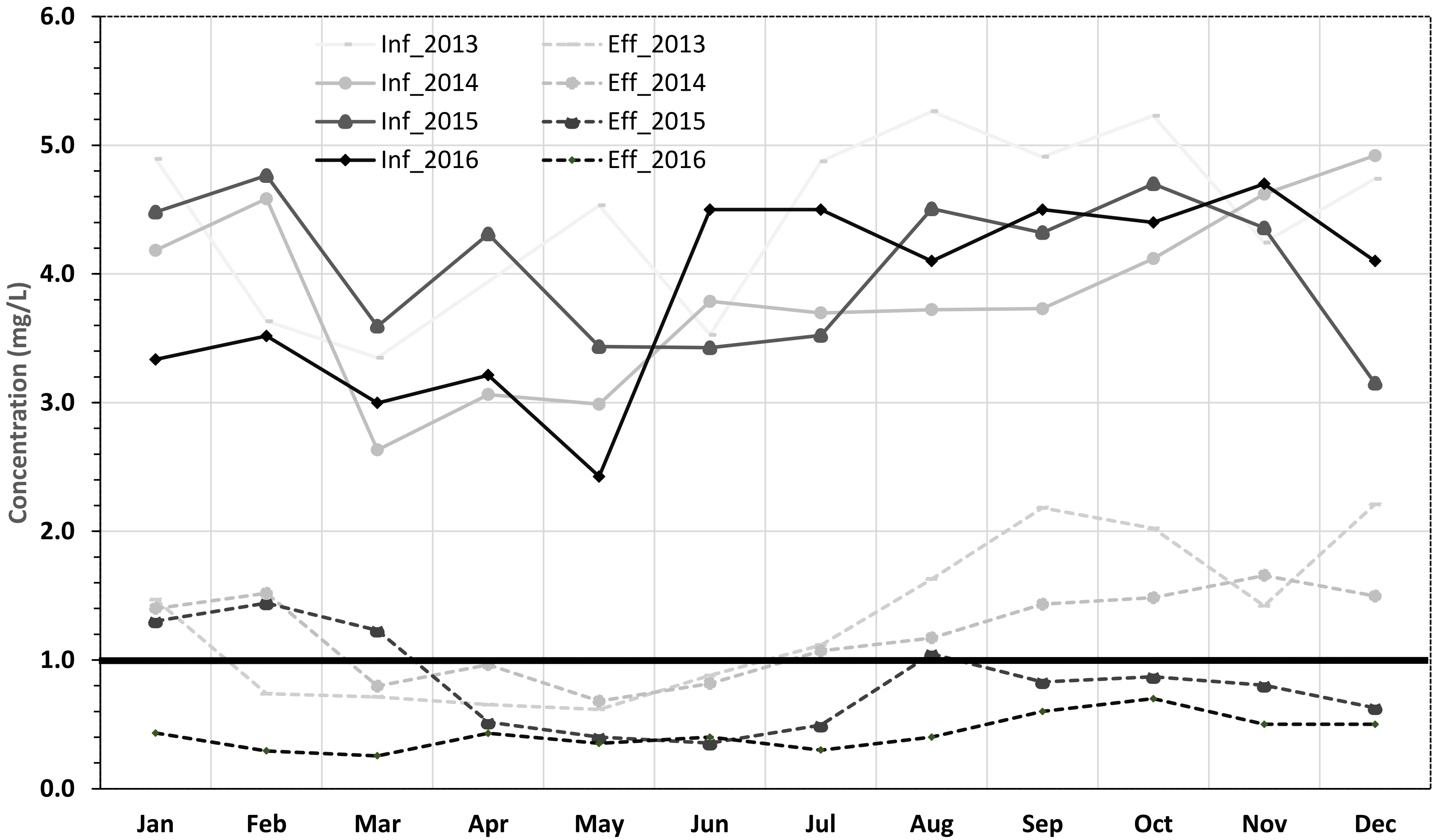
In 2016, WTPR continued laboratory and field tests initiated in 2015 to evaluate the feasibility of EBPR at the O'Brien WRP's based on the existing influent, infrastructure, and treatment capacity. The findings from 2016 agreed with the findings in 2015 and are summarized below.

- Primary effluents from both East (PE_E) and West (PE_W) have ratios of COD:TP and rbCPD:TP above the recommended values for EBPR most of the time. However, many times VFAs are lower than the recommended value for EBPR.

- The RAS contains high level of Nitrate-N and Nitrite-N (NO_x-N) and DO, which is not favorable to the EBPR. The existing RAS conduit does not have sufficient volume for complete denitrification to reduce NO_x and DO prior to entering the aeration tanks.

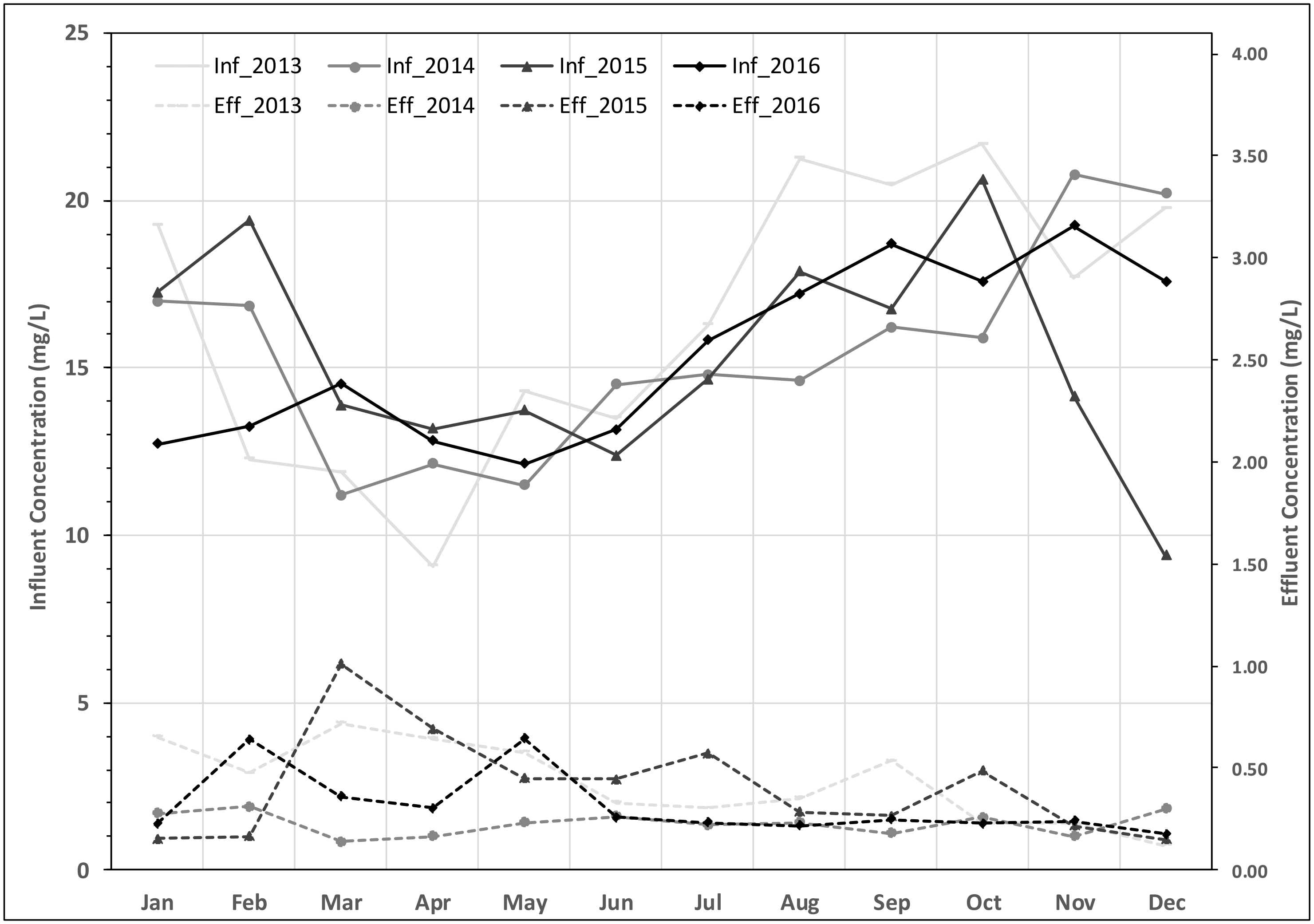
A side by side nitrification performance comparison was conducted for 21 aeration tanks with a middle wall, with aeration tanks C-12 and/or D-5, without middle wall. Results in Tables 5 and 6 indicate that reduced/unequal nitrification rates were observed in about half of the tanks with a middle wall when compared with C-12 and D-5. Dissolved oxygen and ammonia profile sampling results agree with the nitrification rate test results, that is unequal/reduced performance in those tanks. However, the reasons for unbalanced/reduced performance for those aeration tanks is uncertain. It could be due to the following reasons: unequal influent flow split, fouled/broken diffuser plates, unbalanced air flow distribution, and negative impact of the middle wall. The District is planning to obtain consultant services to evaluate various options to improve

FIGURE 15: MONTHLY AVERAGE TOTAL PHOSPHORUS IN JAMES C. KIRIE WATER RECLAMATION PLANT RAW INFLUENT AND OUTFALL EFFLUENT DURING 2013 THROUGH 2016



Note: April 2015, two aeration tanks converted to enhanced biological phosphorus removal (EBPR). June 2016, six aeration tanks (whole plant) converted to EBPR.

FIGURE 16: MONTHLY AVERAGE AMMONIA NITROGEN IN JAMES C. KIRIE WATER RECLAMATION PLANT RAW INFLUENT AND OUTFALL EFFLUENT DURING 2013 THROUGH 2016



Note: April 2015, two aeration tanks converted to enhanced biological phosphorus removal (EBPR). June 2016, six aeration tanks (whole plant) converted to EBPR.

TABLE 5: NITRIFICATION RATE COMPARISON BETWEEN TEST TANKS (SELECTED AERATION TANKS FROM BATTERY A, B, AND C WITH MIDDLE WALL) AND CONTROL TANKS (TANKS C-12 AND D-5 WITHOUT MIDDLE WALL) AT THE TERRENCE J. O'BRIEN WATER RECLAMATION PLANT

Date	Nitrification Rate at 20°C, mg-N/g VSS-hr			
	Test Tanks		Control Tanks	
05/26/2016	A-1E 3.1	A-1W 3.2	C-12 3.9	D-5 3.6
05/12/2016	B-1E 3.0	B-1W 3.1	C-12 3.0	D-5 3.6
04/28/2016	C-1E 4.1	C-1W 2.6	C-12 2.8	D-5 2.4
03/29/2016	A-5E **2.6**	A-5W **0.7**	C-12 **2.7**	D-5 **2.8**
04/14/2016	B-5E **3.1**	B-5W **0.5**	C-12 **3.2**	D-5 **3.7**
02/25/2016	C-5E 3.6	C-5W 2.6	C-12 3.1	D-5 3.7
07/07/2016	A-11E 2.7	A-11W 3.0	C-12 3.2	D-5
06/23/2016	B-11E 3.6	B-11W 4.1	C-12 3.9	D-5 4.3
11-Day Average	C11E **1.8**	C11W 2.7	C12 2.6	D5 2.7
03/17/2016	A-12E 2.8	A-12W **1.4**	C-12 2.7	D-5 3.0
03/10/2016	B-12E 1.8	B-12W **1.4**	C-12 2.4	D-5 3.6

TABLE 6: NITRIFICATION RATE COMPARISON BETWEEN TEST TANKS WITH MIDDLE WALL IN BATTERY C AND CONTROL TANKS (TANK C-12 WITHOUT MIDDLE WALL) AT THE TERRENCE J. O'BRIEN WATER RECLAMATION PLANT

		Nitrification Rate at 20°C, mg-N/gVSS-h		
		Test Tanks		Control Tank
Date	Test Tank	East	West	C12
09/27/2016	C11	**1.4**	2.6	1.9
09/28/2016	C10	2.4	2.4	2.1
10/04/2016	C9	2.3	2.6	2.4
12/02/2016	C8	**0.5**	3.4	2.9
10/05/2016		**0.7**	2.5	2.4
12/01/2016	C7	3.4	3.3	**2.7**
10/11/2016		2.5	2.6	**0.8**
10/12/2016	C6	3.0	3.1	2.6
11/30/2016	C5	2.9	2.4	2.9
10/13/2016		2.0	2.0	2.2
10/18/2016	C4	2.9	3.0	2.6
11/29/2016	C3	2.1	2.0	1.5
10/19/2016		2.8	2.7	2.0
11/18/2016	C2	3.7	2.5	3.5
10/20/2016		3.1	2.8	2.7
11/16/2016	C1	**0.3**	**1.0**	1.9
10/25/2016		**0.0**	1.4	2.5

aeration tank performance through a P removal feasibility study. The contract will be developed in 2017.

Beginning in late July 2016, aeration Battery C at the O’Brien WRP was converted to EBPR by reducing the air supply to the first two aeration drop legs and converting approximate 19 percent of the aeration tank volume to a quasi-anaerobic/anoxic zone. Table 7 shows the side-by-side comparison of effluent monthly average Ortho-P levels between Battery C with the EBPR configuration and Battery B without EBPR configuration. EBPR pilot test Battery C slightly improved P removal efficiency compared to the Control Battery B but could not meet the average of 1.0 mg/L in any month. The following reasons were identified for the poor EBPR performance.

- Influent had a good amount of sCOD but low VFA during the testing period. The test tanks lacked a good anaerobic environment to covert sCOD to VFA and for P release.

- High DO leaving test tanks. The DO at the end of aeration tanks were high, mostly in the range of 5 mg/L or higher. We need to lower DO operated in aeration tank from current 5 mg/L to around 2 mg/L or lower for EBPR. However, this may impact plant ammonia removal, and there is concern of the impact on meeting future DO permit.

- Low MLSS levels in the aeration tank. MLSS in the aeration tanks was around 2,100 mg/L. We were hoping to get MLSS to around 3,000- 3,500 mg/L. However, we will need secondary clarifier improvements with baffle plates before the plant is able to increase the MLSS levels in the aeration tanks. We expect the clarifier baffle installation to be complete in 2019.

In 2017, M&R will continue its nitrification performance survey for all aeration tanks in Battery A, B, and C. We will also continue to try to improve EBPR performance by implementing intermittent aeration in the anaerobic zone to improve anaerobic conditions and try to reduce DO at the end of the aerobic zone as much as possible. All information collected will be fed to the selected consultant for the feasibility study.

Resource Recovery Program Screening for Enhanced Biological Phosphorus Removal. The Resource Recovery Ordinance (RRO) was adopted by the Board of Commissioners in October 2016. Since then, M&R has been actively screening the high strength organic material (HSOM) for EBPR as cited above.

The WTPR Section developed criteria to screen potential wastes based on their chemical characteristics, phosphorus uptake and release potential, and denitrification potential. A series of Resource Recovery Program (RRP) documents have been developed and uploaded to the District website including: Program Description, Organic Materials Delivery Authorization (OMDA), RRO, definitions, and Frequently Asked Questions (FAQ). The program business flow has been developed as well. All District personnel to manage and run the program have been identified and coordinated. In 2016, 24 HSOM were tested, and 12 of them showed potential to be used as supplemental carbon for EBPR process. The Stickney Battery D westernmost channel was

TABLE 7: COMPARISON OF MONTHLY AVERAGE ORTHO-PHOSPHATE LEVELS FROM ENHANCED BIOLOGICAL PHOSPHORUS REMOVAL TEST BATTERY C VERSUS CONTROL BATTERY B AT THE TERRENCE J. O'BRIEN WATER RECLAMATION PLANT

Month	Monthly Average Ortho-P Levels, mg/L				
	Primary Effluent	Control Battery B		Test Battery C	
		Effluent Ortho-P	Ortho-P Removal (%)	Effluent Ortho-P	Ortho-P Removal (%)
August 2016	2.70	1.60	41%	1.90	30%
September 2016	3.10	1.90	39%	1.60	48%
October 2016	3.10	2.00	35%	1.70	45%
November 2016	2.27	1.89	17%	1.28	44%
December 2016	1.70	1.45	15%	1.13	34%

retrofitted by M&O into a HSOM receiving station and is ready to receive HSOM. The Calumet Battery A HSOM receiving frac tank was rented and all non-instrument materials were ordered. Pilot testing in both Stickney and Calumet WRPs will be conducted in 2017.

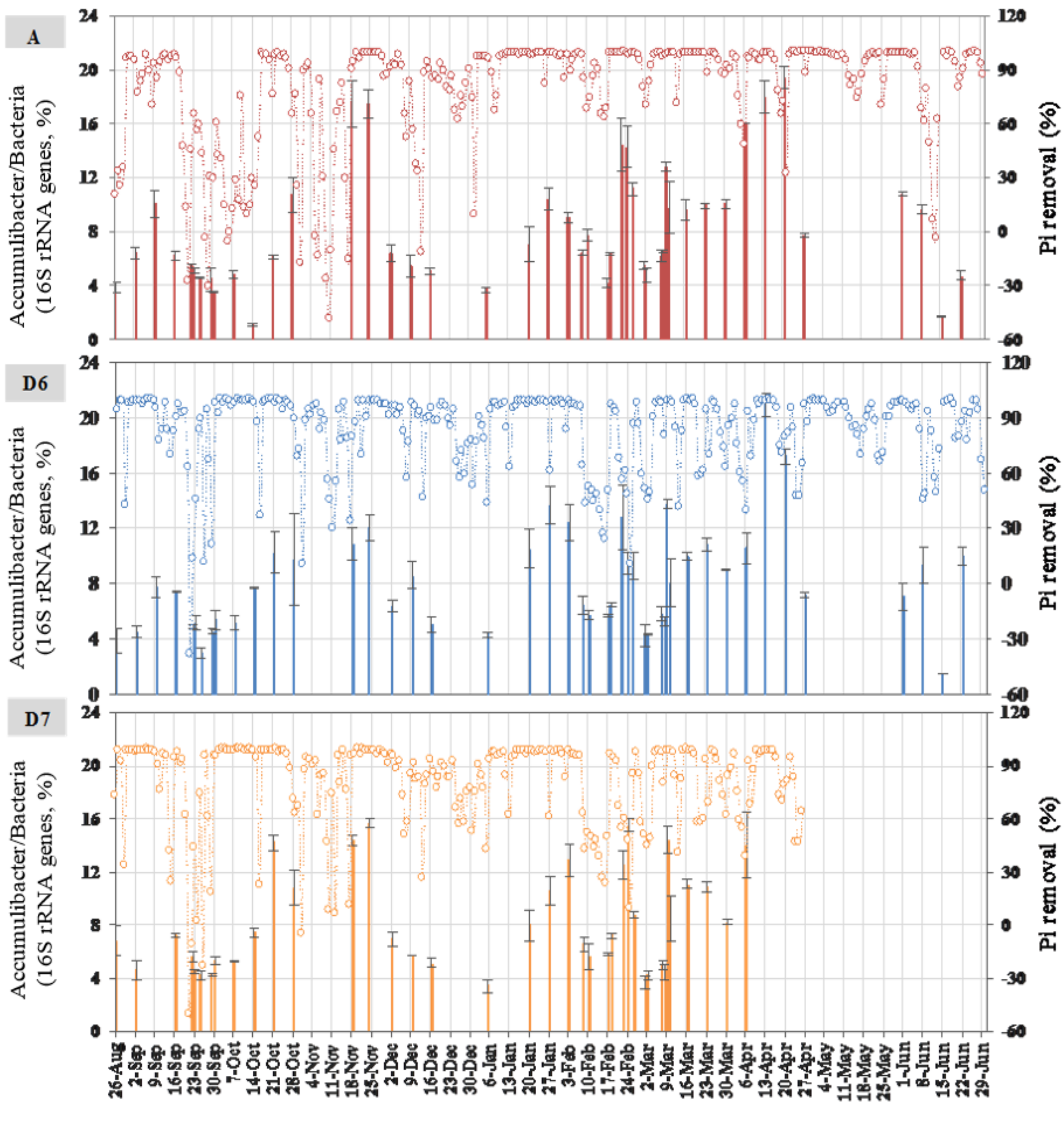
ANITA™ Mox Startup Support. The District completed installation of the ANITA™ Mox sidestream deammonification process from Veolia Water Technologies, Inc. via Kruger at the Egan WRP in August 2016. The process was designed to treat 0.23 mgd of centrate at 1,080 mg/L NH_3-N and provide a guaranteed NH_3-N removal efficiency of greater than 75 percent. The average influent flow during the August to December 2016 start-up period was 44 gpm, with a maximum of 120 gpm in November 2016 (design flow is 160 gpm). Average ammonia removal for the four (4) reactors was 83 percent, which is higher than the design requirements of 75 percent, and average TIN removal was 79 percent, which was also higher than the design requirement of 65 percent. In late December 2016, due to Egan Digester A being out of service for rehabilitation, a reduced influent stream to the ANITA™ Mox process postponed startup until Spring 2017. M&R's role in this startup is to support operations and evaluate monitoring and operating data.

Molecular Methods for Monitoring Biological Nutrient Removal Processes. The M&R Department, in collaboration with the UIUC, completed a molecular microbiology study to characterize and quantify phosphorus accumulating organisms (PAOs) in the Stickney WRP's full-scale EBPR process. The project duration was from August 2015 through August 2016. The results from the study showed the relative abundances of *Candidate Accumulibacter* based on the 16S rRNA genes ranged from 1.05 percent to 22.73 percent, which corresponded to the fluctuation of P removal performance in the Stickney WRP process (Figure 17). The major type of PAOs based on ppk1 gene (polyphosphate kinase gene responsible for polyphosphate accumulation) was Clade IIC followed by Clade IIB. There were no significant differences in PAO abundance observed among different batteries, including tank D7 with the implementation of inline fermentation. The *Accumulibacter* abundances showed low to medium positive correlation to total phosphate in the mixed liquor and MLVSS, and medium negative correlation to wastewater temperature. DAPI staining was demonstrated as a more rapid and reliable way to routinely monitor the PAO populations in full-scale EBPR systems.

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.

The WTPR Section developed screening criteria for accepting the preferred HSOMs for co-digestion. Even after meeting with certain technical and plant and personnel safety based screening criteria, the qualified HSOM suppliers usually cannot provide guidance with respect to their methane (CH_4) generation potential and/or inhibitory or toxicity potential to anaerobic process. Thus, there existed a need to develop additional qualifying tests. The WTPR developed two test procedures, namely, the Biochemical methane Potential (BMP) or specific methane yield (SMY) and Anaerobic toxicity assay (ATA) and adopted them as an integral part of the

FIGURE 17: RELATIVE ABUNDANCE OF ACCUMULIBACTER 16S RIBOSOMAL RIBONUCLEIC ACID GENES TO TOTAL BACTERIAL 16S RIBOSOMAL RIBONUCLEIC ACID GENES (PERCENT) CORRESPONDING TO THE PHOSPHATE REMOVAL PERFORMANCE (PERCENT) IN STICKNEY WATER RECLAMATION PLANT BATTERIES A AND D (TANKS 6 AND 7*) WEEKLY DURING AUGUST TO DECEMBER 2016



*Tank D7 included inline fermentation.

formal screening procedure. These laboratory test procedures are performed on selected HSOMs only on an as-needed basis and validate HSOMs as potential co-digestion feedstocks.

Additionally, it is known that HSOM 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. This testing was performed in summer 2016 to evaluate the effects of mechanical mixing on full-scale digester performance and to test the effects of increased organic and solids loading with and without mixing in Digester No. 5 at the Calumet WRP.

The main objective of the study was to evaluate the performance of Digester No. 5 during higher Organic Loading Rate (OLR) operation and a shorter detention time of 15 days and verify that the mechanical mixing enhances: (1) gas production (total and with respect to VS loading and VS destructed); (2) VS destruction; and (3) solids reduction.

The test results are presented in Table 8, which showed that mechanical mixing energy applied at 0.012 hp/kcft to digester content did not significantly improve either biogas production or impact its quality. It is unclear if this energy level was insufficient to boost gas production. This study results could not determine as to how much mixing energy would be needed for high-rate digester operations. The mixing period had lower volatile solids (VS) destruction than expected, but conversion of destructed VS into a gaseous form was better compared to the non-mixing period. The higher average OLRs from 0.103 to 0.105 lbs/cft-day relative to normal operations at 0.031 lbs/cft-d depressed pH, but supplemental mechanical mixing helped maintain digester buffering capacity. Odor potential did not increase; no process upset occurred, including foaming.

Based on the gas production results alone, additional mechanical mixing is not justified, because it did not significantly improve the gas quantity or the gas quality at higher OLRs and shorter solids retention time (SRT) of just over 15 days. Although not statistically significant, higher absolute gas production and gas production per unit VS destroyed were observed during the mixing period. Therefore, the M&R Department posits that adequate mixing will protect and maintain process performance, increase gas production and also have the benefit of averting possible upset conditions, namely, sour digester conditions and inhibition of methanogens.

Further, the M&R Department suggested that mixers may be modestly and intermittently operated in lieu of continuous operation as far as the energy input is at or about 0.15 hp/1,000 cubic feet and dispersed uniformly throughout the digester volume; all six draft tube mixers, if operational at the Calumet plant, would provide 0.18 hp/1,000 cubic feet of mixing energy and a turnover time of 41 minutes (with one sludge recirculation pump) in Digester No. 5, and thus would be adequate for co-digestion. The suggested SRT is more than 15 days to allow for nearly complete digestion of plant solids and HSOW to help boost the gas production. While applying the lessons from this study to a typical co-digestion application, it should be kept in mind that HSOMs and plant solids digest differently and, hence, the two have different digestion and gas production rates and in turn, different gas yields.

Technical Support to Biosolids Management Program. Technical support is provided to projects under the CSD Program, in which EQ, air-dried biosolids and composted biosolids

TABLE 8: COMPARISON OF OPERATIONAL AND PERFORMANCE DATA BETWEEN THE MIXING AND NON-MIXING PERIODS FOR DIGESTER NUMBER 5 AT THE CALUMET WATER RECLAMATION PLANT DURING THE STUDY PERIOD – JULY 7, 2016, THROUGH NOVEMBER 18, 2016

Parameter	Digester No. 5 (Mixing) 7/7/16 to 9/8/16			Digester No. 5 (Non-Mixing) 9/9/16 to 11/18/16			Significance
	Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev.	Probability $\mu_1 = \mu_2$*
Feed Quantity and Volume							
Daily Feed Volume, gal	64	140,223	20,213	71	139,523	9,562	0.794
% of Total Daily Feed Volume, gal	64	28.71	8.38	71	31.22	11.33	0.149
Daily Feed, DT	64	23.06	5.87	71	21.65	3.72	0.093
Feed Quality							
TS, %	64	3.92	1.00	71	3.67	0.63	0.084
VS, %	64	64.99	4.95	71	70.22	4.11	0.000
OLR[1]							
OLR,[1] lbs/cft-d	64	0.103	0.03	71	0.105	0.02	0.712
Performance Parameters							
Draw TS, %	64	2.87	0.27	71	2.59	0.31	0.000
Draw VS, %	64	55.22	5.70	71	59.39	5.62	0.000
Daily Draw DT	64	16.94	4.71	71	15.21	1.99	0.006
Digester Temperature, °F	64	96.94	0.81	71	96.55	0.75	0.005
pH, pH units	9	7.10	0.10	10	6.98	0.08	0.010
Alkalinity, mg/L as $CaCO_3$	9	2,370	374	10	2,166	289	0.199
Volatile Acids, mg/L	9	8.11	3.62	10	8.80	5.01	0.738
Gas Volume, scf	64	173,391	54,518	71	166,408	38,153	0.387

TABLE 8 (CONTINUED): COMPARISON OF OPERATIONAL AND PERFORMANCE DATA BETWEEN THE MIXING AND NON-MIXING PERIODS FOR DIGESTER NUMBER 5 AT THE CALUMET WATER RECLAMATION PLANT DURING THE STUDY PERIOD – JULY 7, 2016, THROUGH NOVEMBER 18, 2016

Parameter	Digester No. 5 (Mixing) 7/7/16 to 9/8/16			Digester No. 5 (Non-Mixing) 9/9/16 to 11/18/16			Significance Probability $\mu_1 = \mu_2$*
	Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev.	
Detention Time, d	64	15.61	4.05	71	15.32	1.52	0.572
%VS Reduction	63	32.6	14.8	70	38.7	12.8	0.011
%Solids Reduction	57	29.5	14.8	66	30.5	12.3	0.703

*The p-values represent testing the null hypothesis that means are equal for the mixing and non-mixing periods ($H_0 = \mu_1 = \mu_2$). Significance probability <0.05 indicates the values are significantly different.
[1]OLR = Organics loading rate.

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 programs 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 2016 to promote and support the CSD Program include:

  (1) Conducted site visits and meetings and provided technical support on projects where 13,585 dry tons of EQ air-dried biosolids were used as a soil conditioner or topdressing fertilizer. In addition, 1,766 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 the City of Chicago.

  (3) Revision of biosolids marketing brochures and pamphlets.

  (4) Collaboration with the Public Affairs Section to organize and conduct a Sustainability Summit in Chicago jointly hosted by the Chicago Park District. 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.

- Class B Biosolids Farmland Application Program – The activities the BU&SS Section conducted in 2016 to support the program include:

  (1) Reviewed 191 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 25 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 metro area. Biosolids are composted in windrows with wood chips obtained from the City of Chicago. In 2016, 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 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 considered in the evaluation were capital expenditures, polymer and electricity usage, and preventative maintenance requirements. The evaluation determined using the belt filter press technology was the best alternative. However, a final recommendation is on hold pending the outcome of the Calumet Phosphorus Recovery Evaluation, which will be completed in 2018.

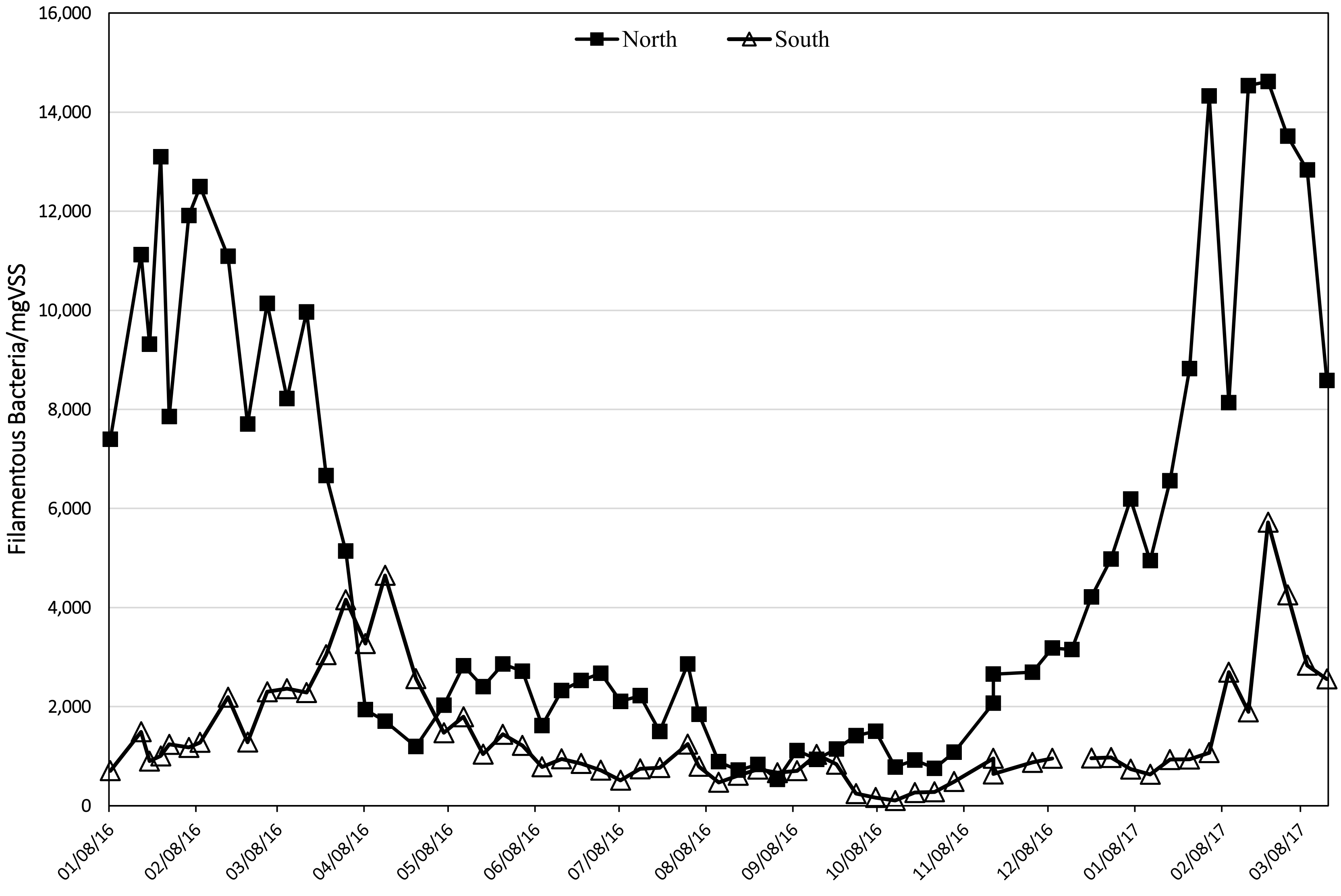
Calumet Water Reclamation Plant Volute Dewater Press Pilot Test. In August 2016, the PFCP Section partnered with Process Wastewater Technologies, LLC to perform a pilot test of a volute dewatering press. The project was initiated due to the successful outcome of a similar pilot at the Stickney WRP and to determine potential suitability of the technology at the Calumet WRP. The pilot test results showed the technology can potentially reduce maintenance and operation requirements and improve process performance. The results of the pilot will be considered in the recommendations of the Calumet WRP dewatering technology evaluation.

Native Prairie Landscaping. During 2016, the Division provided technical support for maintenance of the conventional and native prairie landscaping at the District’s facilities. In addition, the Division also provided support to the maintenance of the Meany Employee Garden at the Stickney WRP.

Wastewater Microbiology Monitoring. In 2016, the AMBS continued the microscopic examination of mixed liquor samples from the District’s WRPs to help characterize changes in microbial communities associated with operations performance and assessment of process stability to provide early warning of process upset such as appearance of excess filamentous bacteria in mixed liquor. In 2016, microbiological analyses were conducted on samples collected from the Egan, Stickney, Calumet and O’Brien WRPs. Egan WRP samples were analyzed weekly. All other WRPs were monitored on an as needed basis. The filamentous bacteria-type *Microthrix parvicella* was dominant in the aeration tanks at the Egan WRP and was present in the highest abundance in the North Battery (Figure 18). Elevated levels of filamentous bacteria *Microthrix parvicella* were observed in the Egan North Battery during the winter months, because colder temperatures and a low food:microorganism ratio provided optimum conditions for its growth. These elevated levels caused bulking conditions in the North Battery. The microscopic assessment results were summarized and transmitted to the M&O Department.

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

FIGURE 18: ABUNDANCE OF FILAMENTOUS BACTERIA IN THE JOHN E. EGAN WATER RECLAMATION PLANT NORTH AND SOUTH BATTERIES



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.

- 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. This is an on-going process that will continue to generate standalone odor control projects at various locations.

Calumet Water Reclamation Plant Odor Control Evaluation. The PFCP Section acquired a “real time” odor monitoring system to improve odor monitoring at the Calumet WRP. The system uses “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 historian to determine if odor complaints were caused by the plant. Installation of the OdoWatch dispersion modeling system was completed in 2016. The system is currently being tested to verify the odor measurements.

Hanover Park Water Reclamation Plant Odor Control Evaluation. In 2016, the EM&R Division in conjunction with the M&O Department completed a triple bottom line analysis evaluating odor control technologies for The Coarse Screen Building, Gravity Belt Thickening (GBT) Area, and the Pre-treatment Building at the Hanover Park WRP. Based on this analysis, a bio-trickling filter was recommended to address the odors from the GBT Area and Pretreatment Building and a carbon adsorption system was recommended for the Coarse Screen Building.

Stickney Water Reclamation Plant Waste Activated Sludge Stripping to Remove Internal Phosphorus® Odor Evaluation. The old concentration tanks located near the SW Coarse Screen Building are being converted to WASSTRIP process tanks. This area was identified for evaluation because of the odors anticipated with this new process. Along with the SW Coarse Screen Building, these tanks are in close proximity to other odorous locations including the Sludge Screen Building and TARP overhead weirs, which were previously treated with an ozone system. The ozone system was decommissioned a number of years ago because of suspect performance. Recommissioning this unit was investigated, but because of the cost to put it back in service, its expensive maintenance and its suspect performance, it was determined to evaluate other odor control technologies.

In 2016, odor data along with air flow requirements were determined for the WASSTRIP process tanks, SW Coarse Screen Building, TARP overhead weirs, and Sludge Screen Building.

An evaluation of a number of different odor control technologies resulted in the selection of a biofilter to address the odors from these locations. A biofilter will address the multiple odorous compounds identified at these locations and has relatively low maintenance. The conceptual design was delegated to the Engineering Department in 2017.

Stickney Water Reclamation Plant Post Digestion Centrifuge Building Odor Evaluation. The Post Digestion Centrifuge Building (Post Building) was identified by plant staff as a location of high odors. This building was previously evaluated for odor control by the Illinois Institute of Technology (IIT) in 2010. Conclusions from the IIT evaluation along with additional odor and airflow data collected by M&R personnel in 2016 were used to determine the most appropriate odor control technology.

A major obstacle in this project was isolating the odors within the building to limit the amount of air requiring treatment. The primary conveyors along with the drop locations from the primary to the secondary conveyors, the secondary to the inclined conveyors, and the inclined conveyors into the hoppers were determined to be the areas of the highest odor release. These locations, along with the polymer and sulfuric acid tank vent stacks, will have air collected and conveyed to a new biofilter. A biofilter was selected because of its ability to address the odor compounds in the building and its low maintenance requirement. The Post Building conceptual design was handed over to the Engineering Department for detailed design in 2017.

Kirie Water Reclamation Plant Odor Evaluation. An evaluation was started in 2016 to determine the best odor control technology for the headworks and airlifts at the Kirie WRP, which were identified by WRP staff as areas needing odor control. Odor and airflow data was collected at a number of locations at the headworks of the plant, including the coarse screen exhaust, pump room exhaust, and the discharge piping vent. Some conceptual design work was also completed in 2016. Exhaust air from Airlifts 1-4 were treated by a now decommissioned ozone system while Airlifts 5-6 are treated by an effective carbon adsorption system. The Calumet WRP has a similar carbon adsorption unit installed at the plant's Junction Chamber, which was determined to not be the best technology for treating odors in that area, but is an appropriate size for treating air from Airlifts 1-4 at the Kirie WRP. As a result, the carbon adsorption unit at the Calumet WRP Junction Chamber will be moved to the Kirie WRP to treat the air from Airlifts 1-4. The remaining odor control recommendations and conceptual designs for the Kirie WRP will be finalized and combined with conceptual designs resulting from the EBPR evaluation. This combined conceptual design is expected to be completed in 2018.

Long Term Capital Planning. In 2016, the PFCP Section and other interdepartmental workgroups finalized the annual update of the dynamic long-term capital plan (Plan) for the District focusing on the 5 to 20 year timeframe. The Plan was updated using deliverables completed by the Regulatory, District Initiative, Budget and Finance, and Cost Estimating workgroups along with the Districts Biosolids and Odor Master Plans. The updated Plan was approved in August 2016. The Plan will continue to be updated on an annual basis, so that it 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 2016:

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

- 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.

- 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 nitrogen and phosphorus 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 ammonia 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.

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

Support to Other Agencies. The AMBS staff supported the Regulatory Review/Water Quality Standards for Bacteria/Coliphages/Algal Toxins effort. The goal is to explore through proactive, resourceful, reliable, and prudent understanding of USEPA's Coliphage as an alternate indicator organism for the Biosolids microbial quality assessment. The section provided in-kind support to WE&RF, USEPA, IEPA and NACWA organization by sharing valuable data on coliphages to promote the District's active leadership in federal water quality rulemaking.

Program 5: Operations and Applied Research

Membrane-Aerated Biofilm Reactor (ZeeLung™) Pilot Test. Following the year-long pilot study of the membrane aerated biofilm reactor (MABR), the PFCP worked with the technology provider to develop a conceptual design for full scale implementation of the MABR technology at both the O'Brien and Hanover Park WRPs, with the goal to intensify nitrification so that anaerobic zones for biological phosphorus removal can be created within the existing aeration tanks in order to achieve an effluent total phosphorus concentration of 1.0 mg/L while maintaining full nitrification. Planning level cost estimates for two other traditional methods for removing phosphorus were developed for the Hanover Park WRP and compared to the cost estimate for implementing MABR. Full scale implementation of the MABR process appears to be a viable option for the Hanover Park WRP, but a more detailed evaluation will be completed as part of the Phosphorus Removal Feasibility Study for the Hanover Park WRP (16-RFP-21).

Evaluation of Co-Fermentation of High Strength Organic Wastes with Primary Sludge as a Source of Volatile Fatty Acids. The efficiency and success of EBPR depend on the type and amount of available organic carbon in the form of volatile fatty acids (VFAs). The amount of readily biodegradable organic carbon in raw sewage is typically lower than the amount required for effective EBPR. Internal VFA source generation such as PS fermentation is often more cost effective compared to external carbon sources. However, fermentation of PS cannot meet the needed carbon as the previous study conducted at the District in 2013 showed that fermentation of PS produced an average VFA concentration of 357 mg/L (with a range of <5 to 1,461 mg/L), having an average yield of VFA/TS of 0.043. The results suggested that the expected VFA production over 4 to 5 days of fermentation time may be ~200 mg/L from PS fermentation alone compared to the need of >1,000 mg/L (1,667 lbs/day compared to the need of 9,560 to 19,120 lbs/d considering the range of VFA:TP from 2:1 to 4:1 for the WASSTRIP® process alone). A similar study conducted from May 2 – 19, 2016 showed an average VFA concentration of 1,438 mg/L at a HRT/SRT of 4.1 days. Both of these results clearly indicate that the carbon requirement cannot be achieved through PS fermentation alone.

A laboratory-scale study was conducted from May 23, 2016, through November 25, 2016 to evaluate co-fermentation of available external HSOMs with municipal primary treatment sludge as a cost effective option. Primary treatment sludge and three different HSOMs were evaluated based on the following objectives: i) to evaluate the viability of the concept of co-fermentation of HSOMs with Stickney PS; ii) to evaluate the effects of SRT, temperature, and mixing energy on VFA yield; and iii) to determine how the laboratory-scale test results and the experience from other studies can be used to develop design criteria for full-scale application of the co-fermentation process at the Stickney WRP.

Three HSOMs tested were: i) OSM-3; a biofuel based waste (5/23/16 to 7/6/16; to measure VFA production); ii) Pullman Industries (Pullman) FOG sludge from DAF treatment (7/14 to 10/6/16; to evaluate impact of SRT, temperature, and mixing energy variables); and iii) Goose Island Brewery yeast concentrate (10/11 to 11/28/16 to measure VFA production at optimum variables determined from Pullman tests).

The study confirmed that co-fermentation of HSOM with PS appears to be a viable concept and may be implemented in full-scale operation to meet the carbon demand. However, VFA production is more likely to be unstable and inconsistent depending upon variations in characteristics of the HSOMs and process operation. Also, it was learned that all HSOMs may not produce desirable VFAs and hence, sources need careful screening. Both Pullman DAF FOG sludge and Goose Island Brewery yeast concentrate showed promise to fulfill the needed carbon demand for the WASSTRIP® process.

The key design parameters developed from the experiments included: i) SRT = <5 days; ii) moderate mixing; iii) temperature at 20°C; and iv) the need for elutriation of VFA from fermenting solids. The key process control parameters from experiments were identified as: i) SRT; ii) gentle mixing; iii) pH of 4.8 to 6.0 which is desirable for acid formers and discourage methanogens (pH 6.3 to 7.8); and iv) organic ratio of HSOM/PS.

Enhanced Biological Nutrient Removal Sludge Dewatering Data Analysis. Poor dewatering of anaerobically digested sludge after implementation of EBPR process has been observed at the District and at other facilities. However, it was unclear whether EBPR has any impact on sludge dewatering and the mechanism through which EBPR might affect this performance. The limited guidance available from a literature review is either insufficient or inconclusive; additionally, there is no apparent consensus on the impact and its mechanism, and no implementable operational guidance exists. Therefore, the objective of this study was to use operation data to determine if poor performance could be linked to EBPR at the Stickney WRP.

Three periods were selected for comparison; pre-, transitional-, and post-EBPR periods, which are defined as January 1, 2010 to October 30, 2011; May 7, 2012 to April 11, 2013; and January 1 – December 31, 2014, respectively. The pre- and post-EBPR periods were compared based on percent phosphorus removal, polymer consumption, solids capture, and percent cake solids. Table 9 presents the significance test results from the comparison of each similar parameter's mean and variance between two periods. Both periods indicated significant difference at an alpha value of 0.05 between the two periods for every single parameter; the ranking denoted by the letters "A" and "B" indicate relatively higher and lower values, respectively.

The statistical testing also included evaluation to determine which parameter had an impact on polymer dose, polymer consumption, cake solids, and solids capture. The results of the hexpanded statistical testing are presented in Table 10. The positive rate of change suggests that the value of dependent parameter will increase if an independent parameter value increases, and the negative rate of change suggests that the value of dependent parameter will decrease if an independent parameter value increases. The significant impact is denoted in bold letters as positive impact in the "Impact" column of Table 10. The percent P-removal in liquid stream positively impacted solids capture and negatively impacted polymer consumption (gal/d) in the pre-EBPR period. Additionally, the decrease in polymer consumption (gal/d) correlated with decreased P-removal. During the post-EBPR period, percent P-removal positively impacted polymer dose and cake solids.

The post-EBPR period had statistically lower cake solids and solids capture and statistically higher polymer dosage. The higher percent P-removal during the post-EBPR period was directly related to higher polymer dosage (Table 9). Due to these results and to better understand the mechanism of deterioration in dewatering performance due to the implementation of EBPR, the District is participating in a WE&RF study to accomplish this.

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

TABLE 9: COMPARISON OF SELECT PARAMETERS RELATED TO PHOSPHORUS REMOVAL AND SLUDGE DEWATERING BETWEEN PRE- AND POST-ENHANCED BIOLOGICAL PHOSPHORUS REMOVAL PERIODS

Parameter Name	Unit	Period Name	Basic Statistics N	Mean	STD	Rank[1]
Influent Phosphorus Load	lbs/day	Post	360	111,907	109,951	A
		Pre	658	60,267	78,333	B
Effluent Phosphorus Load	lbs/day	Pre	667	6,244	3,327	A
		Post	329	5,336	4,339	B
Phosphorus Removal	%	Post	326	92	7	A
		Pre	657	84	11	B
Centrifuge Feed	dry tons/d	Pre	629	297	120	A
		Post	341	156	71	B
Centrifuge Cake Production	dry tons/d	Pre	629	282	114	A
		Post	342	146	71	B
Polymer Consumption	gal/day	Pre	629	17,668	6,624	A
		Post	342	9,618	4,262	B
Polymer Dosage	lbs/dry ton/d	Post	342	568	283	A
		Pre	629	524	159	B
Cake	%TS	Pre	629	25	2	A
		Post	342	24	3	B
Solids Capture	%	Pre	629	95	3	A
		Post	341	92	7	B
Polymer Consumption	lbs/day	Pre	629	139,568	51,584	A
		Post	342	73,555	32,527	B

[1]Rank is determined by Tukey's Studentized range method.

TABLE 10: STATISTICAL EVALUATION OF RELATIONSHIPS BETWEEN DEPENDENT AND INDEPENDENT VARIABLES OF SELECT PARAMETERS RELATED TO PHOSPHORUS REMOVAL AND SLUDGE DEWATERING BETWEEN PRE- AND POST-ENHANCED BIOLOGICAL PHOSPHORUS REMOVAL PERIODS

Parameter[1]			Basic Statistics				Test	
Dep	Indep	Period	N	T[2]	P[3]	P[4]	H_0: P[3] = P[4]	Impact
X6	**X3**	**Pre**	**622**	**334**	**0.537**	**0.463**	**0.009**	**X6 is negatively impacted by X3**
X6	X3	Post	306	144	0.471	0.529	0.145	No impact of X3 on X6
X7	X3	Pre	622	294	0.473	0.527	0.054	No impact of X3 on X7
X7	**X3**	**Post**	**306**	**139**	**0.454**	**0.546**	**0.023**	**X7 is positively impacted by X3**
X8	X3	Pre	622	299	0.481	0.519	0.173	No impact of X3 on X8
X8	**X3**	**Post**	**306**	**133**	**0.435**	**0.565**	**0.001**	**X8 is positively impacted by X3**
X9	**X3**	**Pre**	**622**	**293**	**0.471**	**0.529**	**0.041**	**X9 is positively impacted by X3**
X9	X3	Post	305	143	0.469	0.531	0.123	No impact of X3 on X9

[1]X3, X6, X7, X8, and X9 = P removal (%), polymer consumption (gal/day), polymer dosage (lbs/dry ton/day), cake solids (%), and solids capture (%), respectively; Dep. and Indep. indicate dependent and independent variable, respectively.
[2]Total number of negative rate of change.
[3]Probability of negative rate of change.
[4]Probability of positive rate of change.

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 Stage One for EBPR and High Rate Activated Sludge to Remove Carbon and Phosphorus, and Stage Two for Deammonification for Ammonia and TN Removal.

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

The M&R Department is working with Northwestern University to conduct a bench scale study at the O'Brien WRP to evaluate options 1 and 3. Bench scale testing units for both High Rate Activated Sludge (HRAS)-P and Deammonification reactors (as shown in Figure 19) were set up and started in May 2016. The M&R Department has been and will be working closely with the university to optimize the testing process.

Currently, the HRAS-P process demonstrated potential for efficient biological-P and COD removal and minimal nitrification at low solids retention times (3-4 days). We predict that continued improvements in operational techniques, aeration control, and selective solids retention techniques will allow for a more stable performance from the reactor. Subsequent to these improvements, the plan will then be to transit from the proof of concept stage of HRAS-P reactor testing to the process optimization stage. HRAS-P performance at lower HRTs and SRTs will be tested in 2017, and a carbon mass balance will be conducted to evaluate carbon harvesting through this process.

For the deammonification process, integrated fixed-film activated sludge (IFAS) and suspended growth (SG) reactors were started in May 2016 as well and have been operated in parallel for unusually dilute mainstream conditions (approximately 20 mg N/L total nitrogen in primary effluent) at the O'Brien WRP. The IFAS reactor biofilms achieved efficient anammox biomass and activity retention throughout, while the SG reactor, without any selective anammox retention mechanisms in place, lost greater than 60 percent anammox biomass and greater than 80 percent maximum anammox activity potential within 3-4 months. In 2017, a selective solids retention technique will be developed for the SG reactor to retain anammox biomass.

A multi-departmental task force has been formed to evaluate and conduct the plant level studies for Options 2 and 4.

Aeration Tanks 3 and 4 in Stickney WRP Battery D were selected to implement Option 4 – ammonia based aeration control. All probes and instruments for the pilot tests were purchased and installed by Stickney M&O, and the control algorithm was developed by M&R. Pilot testing started in June 2016, and we plan to run multiple control scenarios to evaluate proper DO and ammonia set points for optimum air saving without compromising the EBPR and nitrification performance. However, due to multiple ammonia probe failures, no information has been generated from this evaluation. M&R will work with Stickney M&O to continue the pilot test throughout 2017.

FIGURE 19: BENCH SCALE SHORT-CUT BIOLOGICAL NUTRIENT NUTTRIENT REMOVAL SETUP AT THE O'BRIEN WATER RECLAMATION PLANT FOR TESTING HIGH RATE ACTIVATED SLUDGE -PHOSPHORUS REMOVAL PLUS DEAMMONIFICATION

The Egan North aeration battery has been selected for Option 2. M&R completed the conceptual design for the pilot study in 2015. The Engineering Department is working on the detailed design, and they expect to complete preliminary design in 2017. Equipment procurement and construction for the pilot test facility are expected to start in 2018.

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 grain yield and stover dry matter for 2016 are shown in Table 11.

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 cover crops were planted in six fields using an interseeder and through aerial seeding. The collection of data for calibration of paired fields for BMP testing were continued in six fields, where flow meters and runoff samplers were installed. During 2016, collaborators on the project included staff of the Departments of Biological and Environmental Engineering and Crop Science of University of Illinois, and an agricultural consulting firm.

TABLE 11: GRAIN YIELD AND STOVER DRY MATTER OF CORN GROWN IN 2016 AT THE BIOSOLIDS LONG-TERM EXPERIMENT AT FULTON COUNTY SITE

Treatment	Grain Yield	Stover Dry Matter
	Mg/ha	
Chemical fertilizer 300-100-100 (N-P-K) kg/ha/yr (Control 1)	12.3	6.2
Compost 33 Mg/ha/yr (Control 2)	12.3	7.1
Aged biosolids 33 Mg/ha/yr	12.4	6.2
Unaged biosolids 25 Mg/ha/yr	11.6	6.7
Aged biosolids 165 Mg/ha thereafter 3/4 chemical fertilizer rate	14.3	7.9
Aged biosolids 330 Mg/ha thereafter 1/2 chemical fertilizer rate	13.7	8.2
Aged biosolids 495 Mg/ha thereafter 1/4 chemical fertilizer rate	12.8	8.0
Compost 165 Mg/ha thereafter 3/4 chemical fertilizer rate	12.7	8.3

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 (Figure 20).

Two different waste streams were evaluated simultaneously. The first is the Supernatant from sludge gravity concentration tanks at O'Brien WRP. The second stream is the centrate from the post-digestion centrifuges at the Stickney WRP. For three months the RAB systems were operated at semi-continuous basis with 7-day of hydraulic retention time (HRT). For two months, the HRT was reduced to 4.6 days, then reduced again to 1.3 days for another two months.

The Stickney Centrate feeding operation was started with HRT=7 days using the same procedures as those in the O'Brien Supernatant. After 4-5 weeks of operation, however, the biofilm of the 3-ft RAB system collapsed, the biofilm in the 6-ft RAB was also significantly inhibited although it did not collapse. It was hypothesized that some compounds in the Stickney Centrate (for example, ammonia or trace organics) may cause this growth inhibition, although the exact mechanism is still unknown. To solve this problem, the HRT of the RAB reactors were extended to 14 days. The algal growth in those reactors slowly recovered. However, these reactors despite having high nutrient concentrations did not produce much biomass yield in comparison to the reactors running on O'Brien Supernatant. It is possible that under a continuous flow operation, the algae population may grow accustomed to the inhibitory constituents in the Stickney centrate and the system would function well. However, since the Stickney centrate required trucking samples to the O'Brien WRP on a weekly basis, the Stickney centrate feeding operation was eventually suspended. Therefore, results in this report focus on the O'Brien supernatant feed source. In general, results showed that 6-ft RAB system was much more efficient in nutrients removal as compared to 3-ft RABs. As seen on Figure 21, the longer (7-day and 4.6-day) HRT's, had nearly consistently achieved complete removal (> 80 percent) of P from the Supernatant. While complete removal is positive, however, rate of removal was slow and the HRT of 7 days is too long.

Results for the 1.3-day HRT demonstrated that the P is being reduced from about 6-8 mg/l to about 3-4 mg/l (approximately 50 percent removal). This demonstrates that the RAB reactor can function effectively with HRT of < 4 days. These results indicated that longer HRTs are needed for complete (> 80 percent) removal of P or we may have to increase the height of the RAB system further to improve efficiency of nutrient removal and consequently reduce HRTs to less than 1 day. In all cases, the removal of P with the RAB out-performed the Control Pond (Figure 21). This demonstrates that the RAB technology can more rapidly uptake P compared to conventional raceway pond technology.

The RAB technology is superior in performance to conventional algal raceway ponds in terms of land area requirements. The removal capacity of a 6-ft. RAB at 1.3 days HRT is about 7 times greater than an algal raceway pond on a per footprint basis (Figure 22). The RAB technology is also superior in performance to conventional algal raceway ponds in terms of

FIGURE 20: REVOLVING ALGAL BIOFILM SYSTEM SHOWING (A) SCHEMATICS OF DESIGN; (B) SCHEMATICS WITH SERPENTINE CONFIGURATION OF ATTACHMENT BELT; (C) PILOT SCALE SET-UP FOR TREATING WASTEWATER AT THE TERRENCE J. O'BRIEN WATER RECLAMATION PLANT

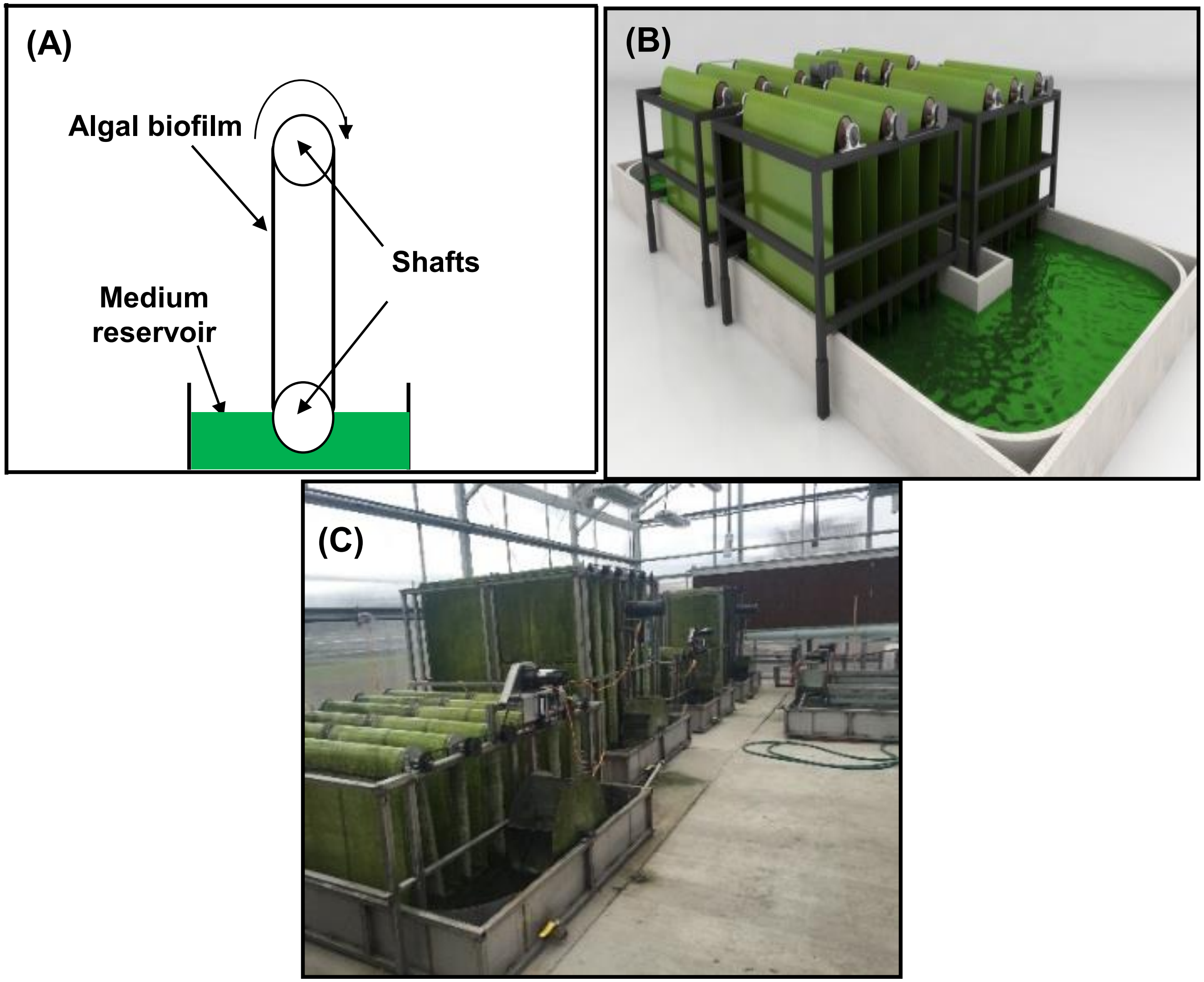
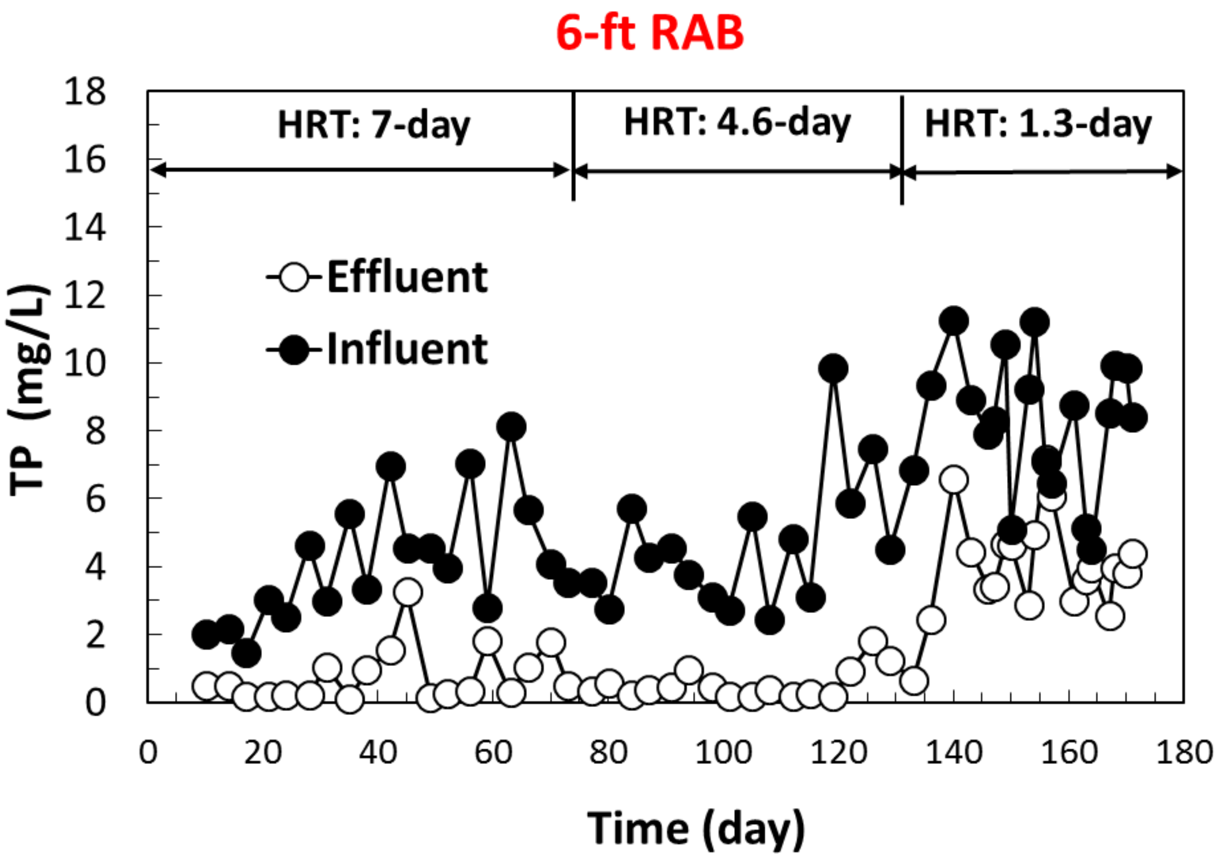


FIGURE 21: TOTAL PHOSPHORUS IN INFLUENT VERSUS EFFLUENT RESULTS FOR TERRENCE J. O'BRIEN WATER RECLAMATION PLANT SUPERNATANT DURING TEST OF THE 6-FOOT REVOLVING ALGAL BIOFILM SYSTEM



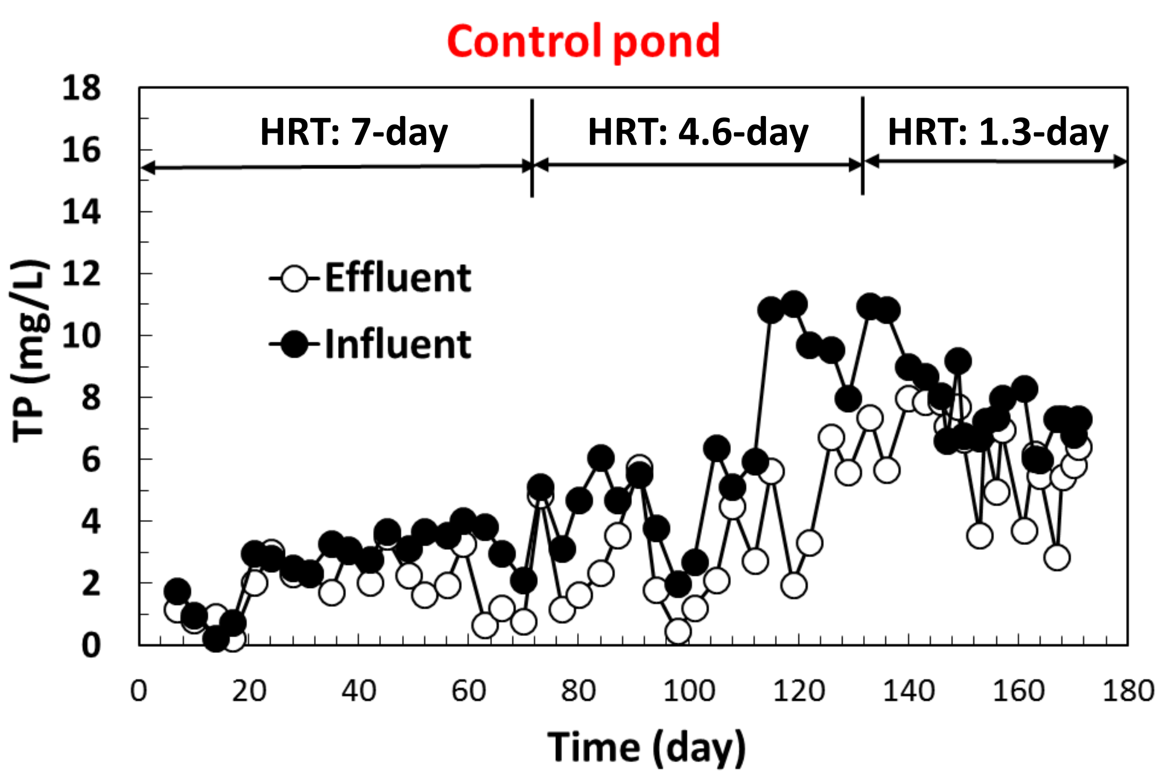
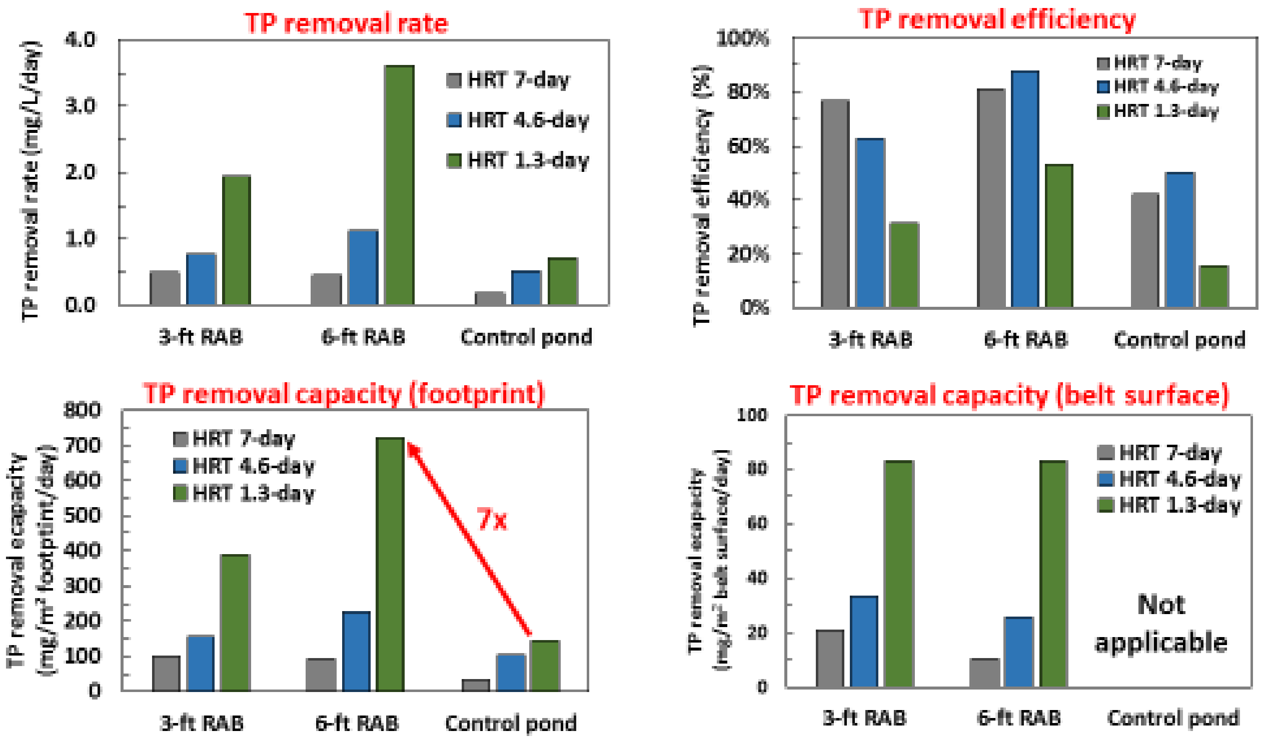


FIGURE 22: PERFORMANCE OF 3-FEET. AND 6-FEET. REVOLVING ALGAL BIOFILM VS. CONTROL POND FOR TOTAL PHOSPHORUS REMOVAL



harvesting the biomass. The biomass removed from the 6-ft RAB was approximately 18 percent dry solids (see Figure 23). In contrast, the suspended algae growth in an algal raceway pond is typically less than 0.5 percent dry solids. This also represents a giant leap forward, in that far less energy will be required to take the harvested algae from the RAB system to a marketable feedstock, than will be required to dewater raceway pond suspended algae.

Development of a Scalable, Flow-Through Algae Wastewater Treatment System for Sustainable Nutrient Removal at the O'Brien Water Reclamation Plant. The District is collaborating with Illinois Sustainable Technology Center (ISTC) at the University of Illinois to develop a scalable algal wastewater treatment system for enhanced nutrient removal and the potential for beneficial reuse of algal biomass. The project started in September, 2016 and during 2016 statement of work and project scope was developed. ISTC conducted preliminary tests on a bench-scale reactor to test LED lighting.

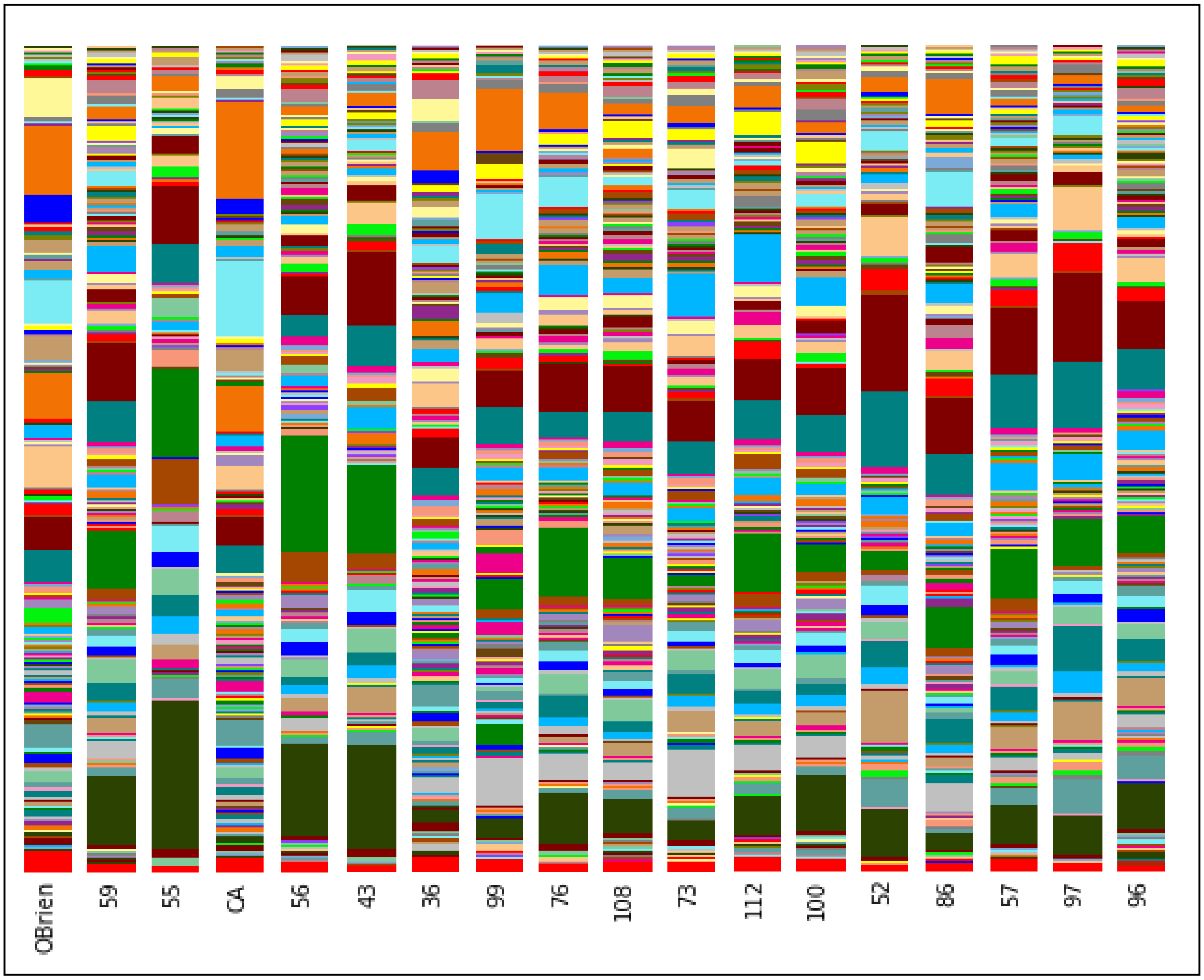
Parjana Project - Testing of Groundwater Recharge Product. This project falls under the District's stormwater management program using green infrastructure, which is defined as the range of stormwater control measures that use plant/soil systems, permeable pavement, stormwater harvest and reuse, or native landscaping to store, infiltrate, and/or evapotranspirate stormwater and reduce flows to sewer systems or to surface waters. Parjana Distribution, LLC ("Parjana") submitted a proposal to Chicago Park District (CPD) and the District to install a passive flood control system using its Energy-passive Groundwater Recharge Product (EGRP) at Mount Greenwood Park, Chicago. The technology claims to infiltrate rain water into the soil quickly and thus generate less runoff. The Project aims to reduce flooding at Mount Greenwood Park and reduce the amount of stormwater reaching the District's interceptors and treatment plants, thereby providing additional capacity for the collection and treatment of sewage in the region. During 2016 design of the project was completed and plan for monitoring was developed.

Microbial Source Tracking Study of the Chicago Area Waterway System. The M&R Department, in collaboration with scientists from the U.S. Department of Energy's Argonne National Laboratory (Argonne), continued its fourth year of a seven-year Microbiome project, which began in 2013 to obtain information on the microbial sources in the CAWS that can be used to guide decisions on evaluating the impact of disinfection activities and TARP reservoir operations on CAWS water quality. In 2016, the study published the Phase I interim report[1]. The Phase I interim report show that the microbial communities in the CAWS were significantly different based on sampling location and sampling medium; however, they were stable between years and monthly sampling events. The CAWS prior to disinfection period show a complex microbial community, with >20,000 species of bacteria found in the water and sediment (Figure 24. A published article on *Polynucleobacter*, a freshwater bacteria in the CAWS, provides the

[1] Phase I Interim Report for Chicago Area Waterways System Microbiome Research December 2013-December 2015, Draft Report By Argonne National Laboratory, July 18, 2016. http://pepportal.mwrd.local:50100/irj/portal/anonymous/ArgMicrobiome

FIGURE 23: ALGAE HARVESTED FROM REVOLVING ALGAL BIOFILM SYSTEM

FIGURE 24: RELATIVE MICROORGANISM ABUNDANCE (TAXONOMIC CHARACTERIZATION) SHOWING MICROBIAL DIVERSITY OF CHICAGO AREA WATERWAYS SAMPLING SITES[1] WITH EACH COLOR REPRESENTING A UNIQUE GROUP OF MICROBES



[1] Sampling site description:

O'Brien: O'Brien WRP Treated Effluent; 59: Cal-Sag Channel at Cicero Avenue; 55: Calumet River at 130th Street; CA: Calumet WRP Treated Effluent; 56: Little Calumet River at Indiana Avenue; 43: Cal-Sag-Channel at Route 83; 36: North Shore Channel at Touhy Avenue; 99: South Fork South Branch Chicago River at Archer Avenue; 76: Little Calumet River at Halsted Street; 108: South Branch Chicago River at Loomis Street; 73: North Branch Chicago River at Diversey Avenue; 112: North Shore Channel at Dempster Street; 100: Chicago River Downtown Main Stem at Wells Street; 52: Little Calumet River at Wentworth Avenue; 86: Grand Calumet River at Burnham Avenue; 57: Little Calumet River at Ashland Avenue; 97: Thorn Creek at 170th Street; 96: North Branch Chicago River at Albany Avenue.

information on ecological health (Sangwan et al., 2016[2]). To determine the likely sources of CAWS microbes, the SourceTracker 2.0 analysis was performed on samples collected during 2013-2015 using a customized database comprising sediment, outfall, sewage, Lake Michigan water, and fish samples and 50,000 samples from the Argonne's Earth Microbiome Project. The total CAWS bacteria potentially originated from secondary treated effluent samples, but also from other sources, including animals such as pigeon, domestic cat, rabbit, dog, common carp, rat, goose, brown trout, and sunfish. The diversity varied by season as expected, but was relatively stable year to year. The preliminary report findings found no significant difference in microbial community structure between wet and dry sampling events. Mapping genes against *E. coli* supported amplicon show evidence for a low abundance of this species, including a very low abundance of *E. coli* associated virulence markers.

A peer review process was initiated by the M&R Department for this study in 2016. A Peer Review Team (Team) of scientific experts organized by Water Environment and Reuse Foundation (WE&RF) (formerly Water Environment Research Foundation) is conducting the review of the CAWS Microbiome study plan and the Phase I research study interim report. The Team is composed of scientists from academia/research institutes, the USEPA, and utilities. The scope of the peer review includes three phases: The first phase review in 2016, which was completed in December 2016, provided input into the study design, work plan, and Quality Assurance Plan (QAP), and comments on the first phase interim draft report. The second review will be held in 2017, and the final review in 2019.

Hydraulic and Process Modeling at the Calumet Water Reclamation Plant. The PFCP Section completed the development of whole plant hydraulic and process models for the Calumet WRP. The whole plant hydraulic model was developed using Visual Hydraulics, a commercially available software. The hydraulic model includes calibrated and validated full plant and critical path models that generate output for developing a hydraulic profile of the plant. The whole plant process model was developed using the GPS-X (version 6.5) software. The calibrated and validated process model was utilized to evaluate several scenarios for phosphorus and nitrogen removal, side-steam phosphorus removal/recovery, and pump-back from the Thornton Reservoir. A small number of staff from both the M&R and Engineering Departments received training on the models, so that District staff can maintain, update and utilize the models in the future. The whole plant process models will be utilized for capital planning, feasibility studies and engineering evaluations. Technical Memorandums were generated to document this work. Results from this work will also be presented in the February 2017 M&R Department Seminar Series.

Phosphorus Removal Evaluation at the Calumet Water Reclamation Plant. Work was started on a technology evaluation to determine the best alternative for meeting a future total phosphorus effluent limit of 1.0 mg/L. Alternatives being considered include chemical phosphorus removal, biological phosphorus removal and a combination of the two. A number of

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[2] Sangwan, N, Zarraonaindia, I, Hampton, Jarrad T, Ssegane, Herbert, Eshoo, T.W, Rijal, G, Negri, M.C, and Gilbert, J.A. 2016. Differential functional constraints cause strain level endemism in *Polynucleobacter* populations mSystems May 2016, 1 (3) e00003-16; DOI: 10.1128/mSystems.00003-Research Article | Ecological and Evolutionary Science

chemicals were evaluated for both chemical removal and carbon addition to support biological removal. A modified triple bottom line evaluation matrix was developed and alternatives selected for evaluation. Final evaluation results with recommendations will be completed in 2017.

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 to the native fish populations.

In 2016, 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 effluents. The 2016 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 and Reuse Foundation (WE&RF) 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 WE&RF 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. Staff also participated on NACWA Water Quality Committee.

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

- The AEWQ section provided assistance to the USEPA and its consultant Environmental Resources Management Inc. for water, sediment, fish, and benthic invertebrate sampling on the Chicago Sanitary and Ship Canal below the Stickney WRP outfall. This work was part of a national study to assess the presence of Siloxanes in the wastewater treatment train and the receiving waters as well as in sediments and the biota.

- The AEWQ section is providing in-kind pre- and post-biological monitoring of a series of floating wetland installed by Urban Rivers on the North Branch Canal near the eastern portion of Goose Island in Chicago. This support will help quantify the impact these islands have on the biota of this portion of the river. Floating island installation is an internationally accepted method of adding habitat to very urbanized waterways and treating stormwater in retention ponds.

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.

- The Division supported the District’s internship program for college students by providing a unique, hands-on learning opportunity on various projects and programs in the Division.

- 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.

- Laboratory Tours. 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. Individual and group tours were provided in 2016 with a total of 47 tours.

- Waterway Tours. In 2016, the AEWQ Section provided eight 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 12 local parades with the District float.

The Division staff collaborated with various organizations through committees and projects such as WE&RF, NACWA, IAWA, Department of Energy, Argonne National Laboratory, Universities, IEPA, USEPA, IDPH, and American Academy of Environmental Engineers and Scientist to learn, contribute and provide leadership activities in the wastewater treatment, CAWS, and the water environment.

APPENDIX I
ENVIRONMENTAL MONITORING AND RESEARCH DIVISION EMPLOYEES 2016

APPENDIX I – ENVIRONMENTAL MONITORING AND RESEARCH DIVISION EMPLOYEES
2016 (As of December 2016)

Environmental Monitoring and Research Administrative Section (Section 121)

Assistant Director of M&R	Zhang, Heng
Administrative Specialist	Biron, Marie
Environmental Monitoring and Research Manager	Cox, Albert
Biostatistician	Abedin, Zainul
Managing Civil Engineering	Grabowy, Jonathan
Senior Environmental Research Scientist	Srinivasan, Paramasivam
Senior Administrative Specialist	Quinlan, Kathleen
Administrative Specialist	Venuso, Valerie

Waste Water Treatment Process Research Section (Section 122)

Supervising Environmental Research Scientist	Kozak, Joseph
Administrative Specialist	Franklin, Laura
Senior Environmental Research Scientist	Oskouie, Ali
Senior Environmental Research Scientist	Patel, Kamlesh
Senior Environmental Research Scientist	Yang, Fenghua
Associate Environmental Research Scientist	Swanson, Robert
Associate Environmental Research Scientist	MacDonald, Dale
Associate Environmental Research Scientist	Qin, Dongqi
Associate Environmental Research Scientist	An, Weizhe
Senior Environmental Research Technician	Vacant
Laboratory Technician II	Reddy, Thota
Laboratory Technician II	Bodnar, Robert
Laboratory Technician I	Vacant
Laboratory Technician I	Byrnes, Marc
Laboratory Technician I	Robinson, Harold
Laboratory Technician I	Rojas-Herbas, Edgar
Environmental Research Technician	Rachel Ryan

Biosolids Utilization and Soil Science Section (Section 123)

Supervising Environmental Soil Scientist	Guanglong Tian
Administrative Specialist	Maurovich, Coleen
Senior Environmental Soil Scientist	Kumar, Kuldip
Senior Environmental Soil Scientist	Vacant
Associate Environmental Soil Scientist	Brose, Dominic
Associate Environmental Soil Scientist	Lindo, Pauline
Associate Environmental Soil Scientist	Oladeji, Olawale
Assistant Environmental Chemist	Patel, Minaxi
Laboratory Technician II	Tate, Tiffany
Laboratory Technician I	Sabido, Maricela
Laboratory Assistant	Scott, Andrew
Environmental Research Technician	Baylor, Jacob
Environmental Research Technician	Dreger, Daniel
Environmental Research Technician	Vacant

Analytical Microbiology and Biomonitoring Section (Section 124)

Supervising Environmental Microbiologist	Rijal, Geeta
Administrative Specialist	Vacant
Senior Environmental Microbiologist	Glymph, Auralene
Associate Environmental Microbiologist	Patterson, Kaylyn

Analytical Microbiology and Biomonitoring Section (Section 124) (Continued)

Assistant Environmental Microbiologist	Shukla, Hemangini
Senior Laboratory Technician	Kaehn, James
Laboratory Technician II	Jackowski, Kathleen
Laboratory Technician II	Maka, Andrea
Laboratory Technician II	Southworth IV, James
Laboratory Technician I	Vacant
Laboratory Technician I	Advani, Meera
Laboratory Technician I	Kowar, Jeffrey
Laboratory Technician I	Reynolds, Brandon
Laboratory Assistant	Paul, Petronela
Laboratory Assistant	Rembert, Reginald

Aquatic Ecology and Water Quality Section (Section 126)

Supervising Aquatic Biologist	Wasik, Jennifer
Senior Aquatic Biologist	Minarik, Thomas
Associate Aquatic Biologist	Gallagher, Dustin
Associate Aquatic Biologist	Vick, Justin
Assistant Aquatic Biologist	Kollias, Nick
Laboratory Technician II	Whitington, Angel
Laboratory Technician II	Kowalski, Shawn
Laboratory Technician I	Bryan, Matthew
Laboratory Technician I	Dominguez, Rolinda
Environmental Research Technician	Collin Hinz
Patrol Boat Operator	Iwasyk, Kazimier
Patrol Boat Operator	Jacob, John
Pollution Control Technician II	Kirkland, Ryan
Pollution Control Technician II	Rivera, James
Pollution Control Technician I	Dickerson, Janis
Pollution Control Technician I	Lahori, John
Pollution Control Technician I	Sandrik, Patty
Pollution Control Technician I	Zintak, David
Senior Environmental Research Technician	Vacant

Process Facilities Capital Planning Section (Section 129)

Principal Civil Engineer	McGregor, Matthew
Senior Civil Engineer	Vacant
Senior Civil Engineer	Salabaj, Daniel
Associate Civil Engineer	O'Brien, Peter
Associate Civil Engineer	Patel, Ghanshyam
Senior Electrical Engineer	Nator, Mohammed
Associate Electrical Engineer	Ungureanu, Predrag
Senior Environmental Research Scientist	Moran-Andrews, Judy
Associate Environmental Research Scientist	Kavathekar, Avanti
Senior Mechanical Engineer	Bedell, Brent
Senior Mechanical Engineer	Andruszkiewicz, Edward J
Associate Mechanical Engineer	Villegas, Jonathan
Associate Electrical Engineer	Eatman, Nathan
Associate Civil Engineer (Facilities Manager)	Kedl, George
Associate Mechanical Engineer	Stanek, Kinga
Associate Mechanical Engineer	Conrath Andrea

APPENDIX II
MEETINGS AND SEMINARS 2016, ENVIRONMENTAL MONITORING AND RESEARCH DIVISION

APPENDIX II

MEETINGS, SEMINARS, WEBINARS, AND TRAINING – 2016

January 2016

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

Illinois Association of Wastewater Agencies Quarterly Technical Committees Meeting, Starved Rock, Illinois.

2016 Midwest Fish and Wildlife Conference, Grand Rapids, Michigan.

Water Equipment and Policy monthly teleconference for "Reducing chloride discharges to area waterways: a menu of options for policymakers."

February 2016

Partnership for River Restoration and Science in the Upper Midwest 2015 Upper Midwest Stream Restoration Symposium- Milwaukee, Wisconsin.

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

Chicago Area Waterway System Chloride Initiative Water Quality Committee meeting, teleconference.

Illinois Water Environment Association/Industrial Water, Waste & Sewage Group Industrial Pretreatment Dinner, Oakbrook, Illinois.

Gasvoda & Associates, Inc Advances in Open Channel Flow and Parameter Monitoring Calumet City, Illinois.

Illinois Water Environment Association – Annual Conference 2016 Champaign, Illinois.

March 2016

Midwest Society of Environmental Toxicology and Chemistry Annual Meeting, Madison, Wisconsin.

Nutrient Monitoring Council Meetings- Springfield, Illinois.

Industrial Water, Waste & Sewage Group, Hofbrauhaus Chicago Brewery, Rosemont, Illinois.

Oak Lawn Emergency Management Agency Train Derailment 2016, Oak Lawn, Illinois.

Pipeline Safety Program, Response Exercise for Pipelines, Arlington Heights/Oak Lawn, Illinois.

April 2016

Water Environment Federation Residuals and Biosolids Conference, Wisconsin Center, Milwaukee, Wisconsin.

Introduction to Proper Aseptic Techniques and Cleanroom Behavior. Webinar, Stickney Water reclamation Plant, Cicero, Illinois.

Chicago Area Waterway System Chloride Initiative Workgroup meeting. Joliet, Illinois.

May 2016

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.

Illinois Environmental Protection Agency Ammonia standards implementation workgroup meeting. Springfield, Illinois.

Chi_Cal Rivers Fund Partners Meeting. Chicago, Illinois.

National Association of Clean Water Agencies Water Quality Committee meeting teleconference (quarterly).

National Association of Clean Water Agencies, National Pretreatment & Pollution Prevention Workshop & Training, Long Beach, California.

Industrial Water, Waste & Sewage Group, Jardine Water Plant Tour/Dinner, Chicago, Illinois.

June 2016

W3170 United States Drug Administration Committee Annual Meeting, The Ohio State University, Columbus, Ohio.

Illinois Environmental Protection Agency Nutrient Science Advisory Committee Update teleconference.

APPENDIX II

MEETINGS, SEMINARS, WEBINARS, AND TRAINING – 2016 (Continued)

July 2016

Water Environment Federation\Illinois Water Association Nutrient Removal and Recovery 2016, Denver, Colorado.

Illinois River Coordinating Council Meeting, Chicago, Illinois.

August 2016

Intelligent Water Systems Knowledge Development Forum 2016, Orlando, Florida.

Lower Des Plaines Workgroup Meetings, Romeoville and Joliet, Illinois.

September 2016

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

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

Laboratory Fraud: Why Should I Worry, What Could Happen? Part 2. Webinar, Stickney Water Reclamation Plant, Cicero, Illinois.

Effects of Environmental Contaminants on Microbiology in Wastewater Treatment Systems. American Chemical Society, Education Night. Chicago, Illinois.

Science Works, Museum of Science and Industry, Chicago, Illinois.

Water Environment Federation Technical Exhibition and Conference 2016. New Orleans, Louisiana.

Anaerobic Treatment of High-Strength Industrial and Agricultural Wastes, Marquette University, Milwaukee, Wisconsin.

Metropolitan Planning Council Roundtable Transforming Chicago's Great Rivers. Chicago Illinois.

United States Geological Survey Water Quality Cooperators Meeting. Urbana, Illinois.

The 4th Annual Sustainability Summit "Recovering Resources to Become Utility of the Future", Chicago, Illinois.

Algae and Wastewater Treatment Forum, Phoenix, Arizona.

Environmental Protection Agency's Development of Ambient Water Quality Criteria for Coliphage – a Viral Indicator, webinar, Stickney Water Reclamation Plant, Cicero, Illinois

Fox River Study Group Annual Meeting – October 27, Batavia, Illinois.

2016 Illinois Water Conference, October 26-27, Champaign-Urbana, Illinois.

October 2016

EnfoTech/iPACS Pretreatment Management System User Group Conference, North Brunswick, New Jersey.

Northern Illinois Pipeline Association, Pipeline Safety for Emergency Responders Alsip, Illinois.

November 2016

American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America International Annual Meeting "Resilience Emerging from Scarcity and Abundance", Phoenix, Arizona.

Making Transition from Staff to Supervisor. Fred Pryor Seminars. Chicago, Illinois.

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.

30th Annual Illinois Governor's Sustainability Awards Ceremony, November 1, Chicago, Illinois.

Industrial Water, Waste & Sewage Group, Erie Café, Chicago, Illinois.

APPENDIX II

MEETINGS, SEMINARS, WEBINARS, AND TRAINING – 2016 (Continued)

December 2016

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

Chicago Wilderness Healthy Waters Workgroup Meeting, Chicago, Illinois.

Chicago Area Water System Chloride Initiative Workgroup meeting. Des Plaines, Illinois.

APPENDIX III
PRESENTATIONS 2016, ENVIRONMENTAL MONITORING AND RESEARCH DIVISION

APPENDIX III

PRESENTATIONS – 2016

January 2016

“Biosolids Update.” Presented at the 2016 MWAA Winter Expo, Kenosha, Wisconsin, by D. Brose. PP.

February 2016

“Biosolids: A Key Ingredient to Urban Sustainability.” Presented at the 2016 IWEA 37th Annual Conference, Champaign, Illinois, by D. Brose. PP.

“Overview of the District’s Illinois Waterway Monitoring Program.” Presented at the February M&R Seminar Series, Stickney, IL, by Thomas Minarik, Jr. PP.

March 2016

“Microorganisms Monitoring and Research at the Metropolitan Water Reclamation District of Greater Chicago,” Presented at the Northwestern University, Illinois, by Geeta Rijal. PP.

April 2016

“Carbon Management Strategies for Metropolitan Water Reclamation of Greater Chicago’s Calumet Water Reclamation Plant”, Water Environment Federation 2016 Residuals and Biosolids Conference, Milwaukee, Wisconsin, by Heng Zhang.PP

“Fate, Exposure, and Bioavailability of Microconstituents in Biosolids”, Water Environment Federation 2016 Residuals and Biosolids Conference, Milwaukee, Wisconsin , by K. Kumar, L. Hundal, A. Cox, H. Zhang, D. Collins, and T. C. Granato. PP.

May 2016

“Chicago Area Waterway System Microbiome Research – Revealing Microbial Community Diversity and Abundance,” 2016 Water Microbiology Conference in Chapel Hill, North Carolina, Geeta Rijal. PP.

July 2016

“Overview of District nutrient recovery efforts to date.” Presented at the Nutrient Monitoring Council Meeting, Springfield, IL by Justin Vick. PP.

“A Summary of Illinois Waterway Study Findings” presented at the Illinois River Coordinating Council Meeting, Chicago, IL, by Dustin Gallagher. PP.

APPENDIX III

PRESENTATIONS – 2016 (Continued)

August 2016

"Turning Towards the River," presented at the Bridgehouse Museum Lunch Seminar Series, Chicago, IL, by Jennifer Wasik. Lecture.

September 2016

"The Effects of Environmental Contaminants on Microorganisms in the Wastewater Treatment Process", American Chemical Society. Loyola University by A. Glymph-Martin. PP.

October 2016

"Benefits of Biosolids/Composted Biosolids." Presented at the 4th Annual Sustainability Summit: Recovering Resources to Become Utility of the Future, Chicago, Illinois by K. Kumar. PP.

"MWRD's Sustainable Biosolids/Composted Biosolids Utilization Program in Chicagoland." Presented at the 4th Annual Sustainability Summit: Recovering Resources to Become Utility of the Future, Chicago, Illinois by G. Tian, O. Oladeji, D. Brose, P. indo, D. Collins, and A. Laban. PP.

"Utilizing Algae Based Technologies for Nutrient Removal & Recovery: Opportunities & Challenges of Phycoremediation." Presented at Algae for Wastewater Treatment Forum, Phoenix, Arizona by K. Kumar and T. Kunetz. PP.

December 2016

"Chicago Area Waterway System Chloride Initiative." Presented at the December M&R Seminar Series by Jennifer Wasik. PP.

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* PP = Available as PowerPoint Presentation

APPENDIX IV
PAPERS PUBLISHED 2016, ENVIRONMENTAL MONITORING AND RESEARCH DIVISION

APPENDIX IV

PAPERS PUBLISHED IN 2016

Kumar, K., and L.S. Hundal. 2016. Soil in The City: Sustaianbly Improving Urban Soils. J. Environ. Qual., Special Section “Soil in The City”, 45: 2-8.

Basta, N.T., D.M. Busalacchi, L.S. Hundal, K. Kumar, R.P. Dick, R.P. Lanno, J. Carlson, A.E. Cox, and T.C. Granato. 2016. Restoring ecosystem function in degraded urban soil using biosolids, biosolids blend, and compost. J. Environ. Qual. 45:74–83.

Brose, D.A., L.S. Hundal, O.O. Oladeji, K. Kumar, T.C. Granato, A. Cox, and Z. Abedin. 2016. Greening a steel mill slag brownfield with biosolids and sediments: A case study. J. Environ. Qual. 45:53–61.

Kumar, K., J.A. Kozak, L. Hundal, A. Cox, H. Zhang, and T.C. Granato. 2016. *In-situ infiltration performance of different permeable pavements in an employee used parking lot: A four-year study*. Journal of Environmental Management. 167, 8-14.

APPENDIX V
MONITORING AND RESEARCH DEPARTMENT 2016 SEMINARS

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO
MONITORING AND RESEARCH DEPARTMENT 2016 SEMINAR SERIES

January 22, 2016	***Point Source/Nonpoint Source Collaboration on Nutrient Loss Reduction with the Concept of Environmental Utility,*** Mr. Steve John, Executive Director, Agricultural Watershed Institute, Decatur, Illinois
February 26, 2016	***Overview of the MWRDGC's Illinois Waterway Monitoring Program,*** Mr. Thomas Minarik, Senior Aquatic Biologist, Monitoring and Research Department (M&R), MWRDGC, Chicago, Illinois
March 18, 2016	***Innovative Solutions to Corrosion and Odor Problems in Municipal Sewer Networks,*** Professor Zhiguo Yuan, Director of Advanced Water Management Centre, the University of Queensland, Brisbane, Australia
April 29, 2016	***Anaerobic Digestion – Microbial Fundamental and Future Resource Management Potential,*** Professor Wen-Tso Liu, Department of Civil and Environmental Engineering, University of Illinois at Urbana-Champaign, Illinois
May 20, 2016	***Trace Levels of Heavy Metals and Organic Pollutants in Edible Parts of Crops Grown in Exceptional Quality Biosolids Amended Soils: Human Health Risk Assessment,*** Dr. Kuldip Kumar, Senior Environmental Soil Scientist, M&R Department, MWRDGC, Chicago, Illinois
June 24, 2016	***New Advances in Process Control and Modeling for WRRFs,*** Professor Peter Vanrolleghem, Laval University, Quebec City, Canada
July 29, 2016	***Point Source Odor Control Technologies - Design, Operation and Maintenance***, Mr. Richard Pole, Vice President, Odor Services Leader, Hazen and Sawyer, New York; Consultant to the MWRDGC Odor Control Strategy
August 26, 2016	***Microbes of the Chicago Area Waterway Systems (CAWS),*** Dr. Cristina Negri, Principal Agronomist/Environmental Engineer, Energy Systems Division, Argonne National Laboratory; Dr. Jack Gilbert, Professor in Department of Surgery, the University of Chicago, Microbial Ecologist, Group Leader, Biosciences Division, Argonne National Laboratory
September 30, 2016	***Asset Management Program at the Milwaukee Metropolitan Sewerage District*****,** Mr. Gregory Hottinger, Asset Management Program Director, Milwaukee Metropolitan Sewerage District, Milwaukee, Wisconsin
October 28, 2016	***Biosolids Composting and Utilization at the Metropolitan Water Reclamation District of Greater Chicago,*** Mr. Daniel Collins, Managing Civil Engineer, M&O Department; Dr. Lakhwinder Hundal, Supervising Environmental Soil Scientist, M&R Department, MWRDGC, Chicago, Illinois
November 18, 2016	***Biological Phosphorus Removal at the Cedar Creek Wastewater Treatment Plant,*** Ms. Heather Phillips, Wastewater Operations Manager, Public Works, City of Olathe, Kansas
December 16, 2016	***The Chicago Area Water System (CAWS) Chloride Initiative,*** Mr. Antonio Quintanilla, Assistant Director of Maintenance and Operations, M&O Department, MWRDGC, 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: 10:30 A.M.
NOTE: These seminars are eligible for Professional Development Credits/CEUs