Protecting Our Water Environment

Metropolitan Water Reclamation District of Greater Chicago

RESEARCH AND DEVELOPMENT DEPARTMENT

REPORT NO. 08-67

ENVIRONMENTAL MONITORING AND RESEARCH DIVISION

2007

ANNUAL REPORT

DECEMBER 2008

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

2007

ANNUAL REPORT

Research and Development Department
Louis Kollias, Director

December 2008

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ACKNOWLEDGMENTS

This 2007 Annual Report is the result of the efforts of not only the scientists and engineers 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.

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STRUCTURE AND RESPONSIBILITIES OF THE ENVIRONMENTAL MONITORING AND RESEARCH DIVISION

The Environmental Monitoring and Research (EM&R) Division has 65 employees, and is comprised of six Sections. These are illustrated in Figure 1 and Appendix V with a breakdown of the number of employees. The six Sections are:

1. Administrative
2. Wastewater Treatment Process Research
3. Biosolids Utilization and Soil Science
4. Analytical Microbiology and Biomonitoring
5. Aquatic Ecology and Water Quality
6. Radiochemistry

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

- Monitoring the environmental quality of Lake Michigan, area rivers and canals, and the Illinois River to document the effectiveness of the District's wastewater treatment program.

- Assisting in the resolution of sewage treatment and solids disposal operation problems.

- Providing technical assistance to other departments and agencies with respect to issues related to wastewater treatment; combined sewer overflow (CSO) management; waterways management; and solids processing, utilization, and marketing.

- Conducting applied and operations 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. Notably in 2007, the Division began formulating the District's case in the Illinois Pollution Control Board Rulemaking R08-9 Chicago Area Waterways Use Attainability Analysis.

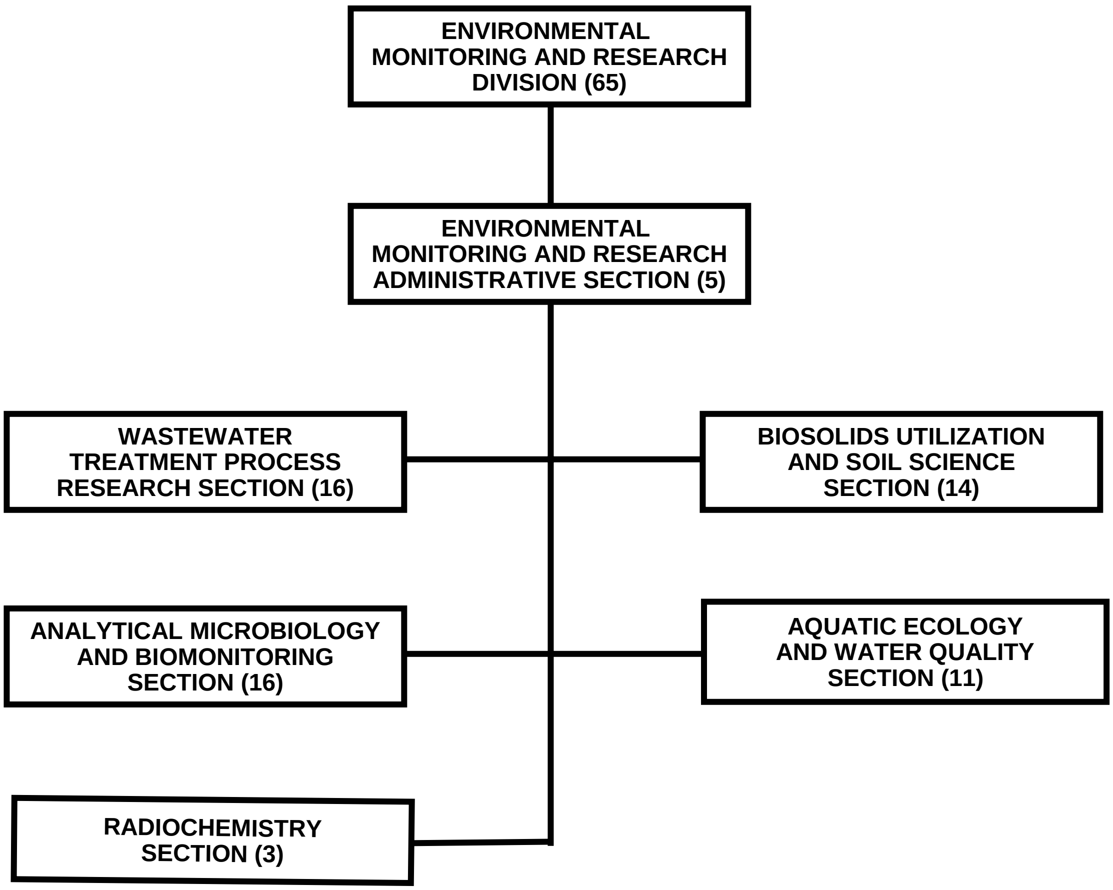
- Generation and transmittal of environmental monitoring reports to regulatory agencies to ensure compliance with requirements of Tunnel and Reservoir

Plan (TARP), water reclamation plant NPDES, and biosolids processing and utilization permits.

- During 2007, the EM&R Division participated in numerous Meetings and Seminars (Appendix I), presented several papers, Power Point presentations, and poster presentations (Appendix II), and also published several papers (Appendix III).

FIGURE 1

ENVIRONMENTAL MONITORING AND RESEARCH DIVISION
ORGANIZATION CHART
(WITH THE NUMBER OF EMPLOYEES)



ADMINISTRATIVE SECTION

ADMINISTRATIVE SECTION

The Administrative Section provides technical guidance, scientific review, and administrative support for the work being carried out by the EM&R Division staff. The Section also organizes a monthly seminar series, open to all District employees, that presents information on areas of interest to the wastewater field. In 2007, 1,892 people attended these seminars. A list of the seminar topics is shown in Appendix IV

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

Experimental Design and Statistical Evaluation Group

The Experimental Design and Statistical Evaluation (EDSE) Group 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. Since 1999, section personnel have been performing these tasks using PC computing media. They also developed programs to interconnect LATEX and Visual Basic Programs with SAS, Access, Excel, Outlook, and Power Point software programs. This computer automation has enabled the section to produce reports, tables, and texts in suitable designs, and to respond to many requests in a shorter period of time.

Statistical and Computing Support. During 2007, a biostatistician provided statistical and computing support to various projects. The following is a description of some highlight activities.

1. Statistical support was provided to the Analytical Microbiology & Biomonitoring Section to study whether fecal coliform (FC) resistance to different antibiotics are the same in all Water Reclamation Plants (WRP), to establish a relation between FC concentration and distance (in miles from the WRPs), and to predict geometric mean of FC concentration in a sampling point on the basis of its distance from a particular WRP.

2. EDSE provided data management support to the Biosolids Utilization and Soil Science Section to produce quarterly reports on the biosolids management areas to meet IEPA permit requirements.

3. Drying site reports were produced for HASMA, LASMA, RASMA, Stony Island, Calumet East, Calumet West, and Hanover Park for the fourth quarter of 2006 and first, second, and third quarter of 2007.

4. Statistical support and consulting was provided to the Biosolids Utilization and Soil Science Section on projects including the USX Demonstration Project, the St. David Coal Refuse Reclamation Project, the bioavailability of phosphorus in biosolids, and the occurrence and fate of dioxin in biosolids.

5. Analysis of the soil organic carbon concentration and carbon sequestration of Lenzburg, Rozetta, and Rapatee soils, following long term biosolids applications was performed.

6. EDSE provided computational support to determine the carbon decay rate in biosolids amended soil by solving for the real roots of a polynomial of degree up to 34.

7. EDSE provided statistical and computer programming support to the Biology Section on the production of the annual Continuous DO Monitoring Reports (Deep-Draft, and Wadeable).
8. Four Ambient Water Quality Monitoring Exceedance Reports were produced by this section for last quarter of 06 and first three quarters of 2007.

Water Quality Data. Each year, the EDSE Group summarizes results of the District's Ambient Water Quality Monitoring program for the Chicago Waterway System. Surface water quality data for 2007 were evaluated regarding compliance with water quality standards set by the Illinois Pollution Control Board (IPCB). In 2007, 67 water quality parameters including dissolved oxygen; temperature; pH; alkalinity (total); chloride; turbidity; total Kjeldahl nitrogen; ammonium nitrogen; un-ionized ammonia; organic nitrogen; nitrite plus nitrate nitrogen; total solids; total suspended solids; volatile suspended solids; total dissolved solids; phenols; sulfate; fats, oils, and greases; total phosphorus; total cyanide; weak acid dissociable cyanide; fluoride; total organic carbon; fecal coliform; escherichia coli; total calcium; total magnesium; hardness; gross alpha radioactivity; gross beta radioactivity; chlorophyll a; benzene; ethylbenzene; toluene; xylene; total silver; total arsenic; total barium; total boron; total cadmium; total copper; total chromium; total hexavalent chromium; total iron; total lead; total nickel; total manganese; total mercury; low level mercury; total zinc; total selenium; soluble calcium; soluble magnesium; soluble silver; soluble arsenic; soluble barium; soluble boron; soluble cadmium; soluble copper; soluble chromium; soluble iron; soluble lead; soluble nickel; soluble manganese; soluble mercury; soluble zinc; and soluble selenium were analyzed and reported.

General Use Water. In 2007, 31 water quality parameters had IPCB General Use standards. Two parameters, benzene and total mercury had IPCB Human Health standards. Twenty-one water quality parameters were in total compliance with the standards in all river systems. They were ammonium nitrogen, phenols, weak acid dissociable cyanide, gross beta radioactivity, benzene, ethylbenzene, toluene, xylene, total silver, total barium, total boron, total manganese, total selenium, soluble arsenic, soluble cadmium, soluble copper, soluble chromium, soluble iron, soluble lead, soluble nickel, and soluble zinc. One parameter, benzene, was in total compliance due to the Human Health Standard in all river systems.

Of the remaining nine parameters, seven parameters (dissolved oxygen, temperature, pH, chloride, sulfate, fluoride, and total hexavalent chromium) had compliance rates greater than 85.0 percent in all River Systems. Total dissolved solids had compliance rates of 89.8, 77.5, and 83.9 percent, respectively, in the Chicago, Calumet, and Des Plaines River Systems. Fecal coliform had the lowest compliance rate in the range of 35.4 to 55.2 percent in all river systems. The compliance rates for total mercury due to Human Health Standard were 81.8, 83.1, and 84.2 percent, respectively, in the Chicago, Calumet, and Des Plaines River Systems.

Secondary Contact Water. Twenty-three water quality parameters measured in the secondary contact waters during 2007 had applicable IPCB standards. Nineteen parameters were in complete compliance with the IPCB standards for the Chicago and the Calumet River Systems in 2007. They were temperature; total dissolved solids; phenols; fats, oils, and greases; total cyanide; fluoride; total silver; total arsenic; total barium; total cadmium; total copper; total hexavalent chromium; total lead; total nickel; total manganese; total mercury; total zinc; total selenium; and soluble iron. The remaining four parameters (dissolved oxygen, pH, un-ionized ammonia, and total iron) had compliance rates greater than 93.0 percent in both river systems.

WASTEWATER TREATMENT PROCESS RESEARCH SECTION

WASTEWATER TREATMENT PROCESS RESEARCH SECTION

The Wastewater Treatment Process Research (WTPR) Section is responsible for conducting basic, applied, and problem-solving research with regard to wastewater and sludge treatment processes currently utilized by the Metropolitan Water Reclamation District of Greater Chicago (District). Technical assistance is provided to the Maintenance and Operations Department (M&O) for solving water reclamation plant (WRP) operating problems. This Section also investigates innovative treatment processes for future use.

The work of the WTPR Section originates from several sources. Current operations may be investigated as the result of a WRP problem, or interest in arriving at new knowledge concerning certain aspects of a waste treatment process. Studies of future operations are concerned with maximizing the efficiency of an existing process at the lowest cost, or the development of new processes. Investigations may take the form of surveys, literature reviews, laboratory bench testing, pilot-plant studies, full-scale testing, special analyses, or a combination or progression of any or all of the above. Plans and specifications are also reviewed at the request of the Engineering Department for the purpose of optimizing process design criteria.

In 2007, the Section was primarily concerned with studies relating to polymer testing, odor monitoring and control, sludge treatment technologies, oxygen transfer efficiency, ammonia (NH_3) loads to the Stickney WRP, and settling and chemical characteristics of combined sewer overflows (CSOs). The Section also participated in the North Side WRP Master Plan and the operation of the Tunnel and Reservoir Plan (TARP) System. Studies conducted in 2007 included application of GPS-X model to simulate the Imhoff tanks at the Stickney WRP, chemical phosphorus (P) removal at the John E. Egan (Egan) WRP, and unsteady flow water quality monitoring for the Chicago Area Waterway System (CAWS). The main projects performed by the Section are summarized below.

Polymer Testing Programs

During 2007, WTPR Section personnel tested polymers for use in dewatering and thickening of various sludge streams and biosolids at District WRPs. The District issues detailed solicitations for submittal of polymers for testing. The polymer selection procedure consisted of testing a prescribed maximum number of polymers from any given vendor. Of the polymers that meet the performance criteria as described in the bid documents, the one with the lowest cost per unit mass of sludge/biosolids is the polymer of choice for purchase.

Polymer Testing Program for the Metropolitan Water Reclamation District of Greater Chicago Centrifuge Complexes. Winter and summer polymer testing was conducted at the Stickney WRP for the selection and purchase of polymers used in the centrifugal dewatering of anaerobically digested biosolids. The testing procedure is performed seasonally at the Stickney WRP because the change in biosolids characteristics during these seasons requires different polymers at this WRP.

Polymer testing was also carried out for post-digestion centrifugal dewatering at the Calumet WRP during May 2007. A total of two polymers were tested with ferric chloride ($FeCl_3$) as a preconditioner.

A summary of the winter and summer tests conducted at the Stickney WRP is presented in Tables II-1 and II-2, respectively. The Calumet WRP test summary is presented in Table II-3.

Polymer Testing Program for Gravity Concentration Tanks at the Calumet Water Reclamation Plant. In October 2007, WTPR staff conducted bench-scale polymer testing at the Lue-Hing Research and Development Complex for the selection and purchase of polymers used in the gravity concentration tanks to thicken the primary and waste-activated sludge at the Calumet WRP.

The polymer selection procedure consisted of testing a maximum of three polymers from any given vendor on a bench-scale test to obtain a capillary suction time (CST) of ten seconds. The polymers that passed the CST test performance criteria were subjected to bench-scale settling tests at a prescribed dose. The polymers were then ranked based on their performance. Of the polymers that met the test criteria, the one with the lowest cost per unit mass of sludge became the polymer of choice for purchase. A summary of the tests conducted during October 2007 for the Calumet WRP gravity concentration tanks is presented in Table II-4.

Polymer Testing Program for Gravity Belt Thickeners at the Hanover Park Water Reclamation Plant. In April 2007, polymer testing was carried out at the Hanover Park WRP for the selection and purchase of polymers used in the gravity belt thickening (GBT) of waste-activated sludge.

The polymer selection procedure consisted of testing a maximum of two polymers from any given vendor on a full-scale GBT to obtain cake solids of 6.0 percent. Of the polymers that met the test performance criteria, the one with the lowest cost per unit mass of sludge became the polymer of choice for purchase. A summary of the tests conducted at the Hanover Park WRP is presented in Table II-5.

Odor Monitoring Programs

As part of the District's continuing odor surveillance program, the EM&R Division conducts odor monitoring at the Harlem Avenue Solids Management Area (HASMA), Vulcan, the Lawndale Avenue Solids Management Area (LASMA), Marathon Solids Drying Area (SDA), and Calumet SDAs. A similar odor monitoring program was initiated in the spring of 2001 at the Stony Island and the Ridgeland Avenue Solids Management Area (RASMA) SDAs. The programs are a part of the National Pollutant Discharge Elimination System (NPDES) permits for the solids management areas. Odor monitoring is also conducted at the Calumet WRP, the Egan WRP, the Stickney WRP, the James C. Kirie (Kirie) WRP, and the North Side WRP.

A similar protocol for monitoring odors is used at each location. Either Research and Development Department (R&D) or M&O personnel visit the monitoring stations at each site on a regular basis. Frequency can range from once per week (as with the Egan WRP), or daily (as with the Kirie WRP), depending on the program. The odor monitoring personnel make subjective observations regarding the character and intensity of odors at each of the stations. The odor intensities are ranked on a scale from 0, no odor, to 5, very strong odor. These data are tabulated monthly.

The objective of the program is to collect and maintain a database of odor levels within and around each WRP and associated solids processing areas. The data are used to study the trends in odor levels associated with WRP operations, and to relate odor levels to changing conditions within the WRP, such as installation of odor control equipment.

Since several residential areas surround the WRPs in the program, the odor monitoring activities also provide early warning of odorous conditions that develop within the WRPs, to allow for corrective action before they become a nuisance to area residents.

The details of the odor surveillance program and odors detected at or near District operations are summarized in R&D Report No. 08-40, "Odor Monitoring Program at Metropolitan Water Reclamation District Facilities during 2007."

Estimation of Emission of Hazardous Air Pollutants

Under Section 112 of Title I of the Clean Air Act, a publicly owned treatment works (POTW) is considered a major source of hazardous air pollutants (HAPs) if it emits or has the potential to emit 10 tons per year or more of any 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 a year and analyzed by the Organic Chemical Analytical Laboratory for 65 of the HAP compounds of concern to POTWs. Estimates of the emissions of these HAPs from the wastewater treatment process units (grit chamber, primary settling tanks, aeration tanks, and secondary settling tanks) are made using the Bay Area Sewage Toxics Emissions (BASTE) computer model developed by CH2M Hill. The average concentration of each HAP detected in the influent sewage was used as input to the model along with the annual running average operating conditions. The physical properties of the individual compounds were taken from the United States Environmental Protection Agency (USEPA) database.

During 2007, influent samples were collected in February and July. The average influent concentrations found are presented in Table II-6 for the three major District WRPs. The estimated emissions of individual HAPs for the three major District WRPs are summarized in Table II-7.

According to the BASTE model, all of the individual HAP emissions were less than the 10 ton/year criterion. Toluene, acetaldehyde, and propionaldehyde were the predominant compounds emitted from the wastewater treatment processes at the Stickney WRP. Toluene and cumene were the predominant compounds emitted from the Calumet WRP liquid stream. The HAP emissions from the North Side WRP were very low, all less than 0.4 ton/yr. The total measured HAP emissions were substantially less than the 25 ton/year threshold at each of the three WRPs. The wastewater treatment process units at the District's WRPs are not a major source of HAPs.

Control, Reduction, and Utilization of Greenhouse Gases in Wastewater Treatment: Methane and Nitrous Oxide

According to a recent USEPA report, wastewater treatment and human sewage are considered major sources of the greenhouse gases, particularly methane (CH_4) and nitrous oxide (N_2O), in the atmosphere. WTPR Section scientists completed a literature review to examine the sources of CH_4 and N_2O in wastewater treatment and collection. An evaluation of control, reduction, and/or utilization of these fugitive gases is also included. This literature review did not include gas emissions from stationary fossil fuel combustion which provides power to the WRPs and facilities or mobile fossil fuel combustion from District vehicles. General wastewater treatment and emerging technologies were examined with emphasis on District processes. The following is an overview of the sources of CH_4 and N_2O in wastewater treatment. The complete literature review is available as R&D Report 07-48, "Control, Reduction, and Utilization of Greenhouse Gases in Wastewater Treatment: Methane and Nitrous Oxide." Also, the WTPR Section plans to sample unit process operations at the Stickney WRP for fugitive CH_4 and N_2O emissions in 2008.

Methane. Methane emissions are largely produced from anaerobic processes. According to the International Panel on Climate Change (IPCC), the only major source of CH_4 at the District is the WRP anaerobic digesters. The main factor in determining the extent of CH_4 production in anaerobic processes is the amount of degradable organic fraction in the wastewater, i.e. CH_4 yield increases with higher biological oxygen demand (BOD). Environmental factors that influence CH_4 production include temperature, pH, retention time, wastewater treatment efficiency, competition between methanogens and sulfate reducing bacteria, and toxicants. Neutral pH and higher temperature promote CH_4 production. Additionally, anaerobic systems are sensitive to oxygen.

Anaerobic conditions can also occur in District collection systems, primary clarifiers, concentration tanks, low-oxygen pockets in aeration basins, drying beds, and facultative lagoons. However, CH_4 release from these sources is considered to be minimal. Methane will also be produced in the pelletizer facility that is currently under construction at the Stickney WRP. Appropriate control technologies, such as regenerative thermal oxidation, are expected to prevent CH_4 release to the atmosphere.

Methane gas is produced by design in District anaerobic digesters. However, processes must be in place to prevent fugitive emissions of CH_4. Currently, the District uses CH_4 for heating and limited flaring. Flaring is the simplest method of converting CH_4 into carbon dioxide, thereby reducing the heat-trapping power of CH_4. However, cogeneration using the energy from CH_4 is the most efficient use of CH_4.

Soluble CH_4 may be present in the secondary effluent and anaerobic digester centrate. Air stripping of aqueous CH_4 can be used to remove CH_4 from effluent. However, the recovered CH_4 gas must be utilized or thermally oxidized to prevent CH_4 emissions.

Methane may also be produced in low-oxygen pockets in aeration basins. Methane production in aeration tanks is often an indicator of poor aeration efficiencies. Reducing rumen protozoa supply to the aeration system may help control CH_4 production. Many methanogens adhere to protozoa, which have been observed to support the methanogenic activity of the attached bacteria; however, this is more relevant with respect to animal waste processing. Additionally, supplying microbial inhibitors will suppress methanogenic activity without compromising removal of BOD and suspended solids (SS).

Nitrous Oxide. In wastewater treatment, collection, and effluent discharge, N_2O production and emission can occur through both incomplete nitrification and denitrification. Understanding the controlling parameters and optimization of nitrification and denitrification should prevent the production of N_2O.

The District nitrifies influent NH_3 during secondary aeration. Nitrification occurs most prevalently in District WRP activated sludge aeration tanks. The wastewater NH_3 concentration, BOD concentration, alkalinity, temperature, and potential for toxic compounds are major issues in the design of biological nitrification processes. Nitrifying bacteria need carbon and P as well as trace elements for cell growth. The growth kinetics of NH_3 oxidation is rate-limited below temperatures of 28°C, and longer solids retention times (SRTs) are needed. Typical design SRT values may range from 10–20 days at 10°C to four to seven days at 20°C. Above 28°C, the relative kinetics of NH_3 and nitrite oxidation change, whereby nitrite will accumulate at lower SRTs.

Additionally, nitrification rates increase up to dissolved oxygen (DO) concentrations of 3–4 mg/L. Larger suspended floc size inhibits nitrification as DO diffusion into the floc is reduced, and nitrifying bacteria within the floc do not receive adequate DO. DO concentrations below 0.50 mg/L greatly inhibit nitrification. Nitrification is also pH-sensitive and rates decline significantly at pH values below 6.8. Compounds that are toxic to nitrifying organisms include solvent organic chemicals, amines, proteins, tannins, phenolic compounds, alcohols, cyanates, ethers, carbonates, benzene, heavy metals, and un-ionized NH_3.

Given the necessary environmental conditions, nitrification and denitrification to produce N_2O can occur in the District collection system (sewers, TARP tunnels and reservoirs, CSOs) and many WRP processes (aeration basin, anaerobic digesters, sludge conditioning and thickening, lagoons, drying beds, and receiving streams). However according to the IPCC, the aeration tanks, anaerobic digesters, and the receiving streams may be considered the major sources of N_2O from nitrification and denitrification. Additionally, low-temperature thermal heating of sludge may result in N_2O emissions if emission controls are not in place.

Beyond process optimization, a number of studies examined intermittent aeration reactor technology with varying periods of oxic and anoxic conditions as a way to achieve maximum nitrogen removal with limited N_2O production. It was observed that most N_2O emissions occurred during the aerobic period when oxygen levels were still low. This is more likely due to nitrifying bacteria producing nitrite under the low DO conditions, where N_2O is an intermediate. Additionally, N_2O can be produced by incomplete nitrification by nitrifiers. In both low DO aerobic and anoxic conditions, higher nitrate concentrations resulted in higher N_2O emissions.

It was observed that N_2O production decreased as pH increased and increased as redox potential increased. However, no significant temperature effects were observed. Finally, filling the reactors under anoxic conditions produced more N_2O than under aerobic conditions. It appeared that anoxic fill could increase N_2O production at the initial stage of the aerobic phase due to the accumulated NH_3 during the anoxic phase.

Nitrifying bacteria genus can also affect the magnitude of N_2O emissions. The N_2O production of *Alcaligenes faecalis*, a typical heterotrophic nitrifier, *Nitrosomonas europea,* a typical autotrophic NH_3 oxidizer, and *Nitrobacter winogradskyi,* a typical nitrite oxidizer, were compared under oxic conditions. *Nitrosomonas europea* produced approximately 280–540 times the N_2O compared to *Nitrobacter winogradskyi* and approximately 20–50 times the N_2O compared to *A. faecalis*. However, due to its heterotrophic nature and potential for dense population, it was suggested that *A. faecalis* can play an important role in N_2O generation under oxic conditions.

Additional Digestion Tests for the Calumet and Egan Water Reclamation Plants

Additional digestion tests are conducted as part of a continuous monitoring program that assesses whether the requirements for vector attraction reduction are met in the biosolids processing at the District WRPs employing Option 2 of Section 503.33(b) of the 40 CFR Part 503 Regulations (Option 2). Option 2 states that vector attraction reduction is demonstrated if after anaerobic digestion of the biosolids, the volatile solids in the biosolids are reduced by less than 17 percent in an additional 40 day bench-scale anaerobic digestion test at a temperature between 30° and 37°C. The additional anaerobic digestion tests in accordance with Option 2 are used as a supplemental monitoring program, in addition to the routine monitoring of anaerobic digestion performance. Option 2 can be used to satisfy the vector attraction reduction requirement for the cases in which 38 percent volatile solids reduction is not achieved in anaerobic digestion in accordance with Option 1 of Section 503.33(b) of the Part 503 Regulations (Option 1).

In 2007, a total of 14 additional anaerobic digestion tests were performed in the WTPR Laboratory for the digester draw from the Calumet WRP. Of the 14 tests conducted in 2007, the additional volatile solids reduction in 13 tests was less than 17 percent, as shown in Table II-8. In one test which was conducted in January 2007, the additional volatile solids reduction was greater than 17 percent. However, volatile solids reduction of 38 percent through plant-scale anaerobic digesters at the Calumet WRP was achieved in January 2007, as shown in Table II-9. Therefore, the combined monitoring results indicated that the requirements for vector attraction reduction for the biosolids generated at the Calumet WRP were met throughout 2007.

Upon the request of M&O, the laboratory-scale additional anaerobic digestion tests in accordance with Option 2 were routinely conducted for the Egan WRP from September to December of 2007. A total of nine tests were performed. Table II-10 presents the tests results from these nine tests along with monthly averages, which are used to access whether the requirements for vector attraction reduction are met. The additional volatile solids reduction in four of the nine tests performed was greater than 17 percent. The average monthly mean test results indicated that additional volatile solids reduction was less than 17 percent in September and November 2007, but was equal or greater than 17 percent in October and December 2007. However, volatile solids reduction of 38 percent through plant-scale anaerobic digesters at the Egan WRP was achieved in October and December 2007, as shown in Table II-11. Therefore, the combined monitoring results indicated that the requirements for vector attraction reduction for the biosolids generated at the Egan WRPs were met in September through December of 2007.

Chemical Phosphorus Removal at the Egan Water Reclamation Plant

The Salt Creek Phosphorus Reduction Demonstration Project was coordinated by EM&RD staff to provide a comprehensive analysis of the impact of P precipitation on the receiving stream, process operations, solids processing, and biosolids quality. This work was conducted at the Egan WRP. The WTPR Section's involvement included monitoring the effectiveness of P removal and documenting the impact of P precipitation on wastewater process operations and on solids processing operations. The target P concentration in the final effluent was 0.5 mg/L of total P (TP). Chemical precipitation of P with $FeCl_3$ was deployed. $FeCl_3$ was added to the mixed liquor (ML) at the end of the aeration tanks and P was removed from the wastewater by precipitating the ferric phosphate particles in the secondary clarifiers.

The Optimal Ferric Chloride Dose Needed to Achieve 0.5 mg/L Total Phosphorus in the Final Effluent. $FeCl_3$ addition commenced on February 7, 2007. The initial $FeCl_3$ dosing rate, which was determined based on the results from the large-scale pilot study conducted for a Water Environment Research Foundation (WERF) project in 2005, was 1.32 gallons per minute (gpm). This dosing rate resulted in an effluent concentration of approximately 0.3 mg/L TP. On April 2, 2007, the $FeCl_3$ dose was lowered to 1.17 gpm. In order to maintain 0.5 mg/L TP in the plant effluent, three dosing rate adjustments with dosing rates ranging from 1.17 gpm to 1.32 gpm were made in 2007 (Figure II-1). The average TP concentration in the final effluent of the Egan WRP from February 7 to December 31, 2007, was 0.353 mg/L, with a range from 0.06–1.77 mg/L. The spike of TP concentrations in the final effluent occurred in the last week of July 2007 because in this period no $FeCl_3$ was added to the north aeration tank during its startup after aeration diffuser pipe repair.

Impact of Ferric Chloride Addition on Liquid Process Operations. Plant performance was not affected by the addition of $FeCl_3$ to the ML. NH_3, SS, and pH in the final effluent of the Egan WRP throughout 2007 remained in the typical ranges for plant final effluent. While parameters used to monitor effective wastewater treatment were not affected by $FeCl_3$ addition, the inorganic solids (IS) content of the ML increased considerably, as expected. During 2007 the additional IS yield due to $FeCl_3$ addition was estimated to be 0.8 lbs IS/lb $FeCl_3$.

The Effect of Ferric Chloride Addition on Solids Processing. Solids processing at the Egan WRP, including GBT operations, anaerobic digestion and centrifuge dewatering were also closely monitored through 2007. GBT operations were not significantly affected by $FeCl_3$ addition. The details of the effect of $FeCl_3$ addition on anaerobic digestion are presented in Table II-12, which shows that volatile solids reduction remained consistent, but alkalinity decreased after $FeCl_3$ addition. Post-digestion centrifuge operations showed lower polymer consumption, higher percent solids in cake, and lower percent solids in centrate after $FeCl_3$ addition (Table II-13).

The details of these monitoring efforts were communicated by memoranda dated September 5, 2007, October 26, 2007, and March 21, 2008, and in an interim report (R&D Report No. 08-38, "Salt Creek Phosphorus Reduction Demonstration Project Interim Report: Comparison of Pre- and Post-Phosphorus Reduction Conditions during 2005–2007 [Revised]"). The final results will be summarized for the entire study in an R&D report to be published in 2009.

Evaluating Two Different Aeration Systems at the Egan Water Reclamation Plant

This project was initiated to compare operational efficiency of two different aeration systems at the Egan WRP. The Egan WRP has two aeration batteries with similar tank configurations. However, the aeration systems in these two batteries are different. The aeration system in the North Aeration Battery (NAB) was replaced with a full floor coverage fine-bubble disc ceramic diffusers a few years ago. The South Aeration Battery (SAB) still has the original spiral roll aeration system using square ceramic diffusers placed on one side of the aeration tank. The two batteries are operated in parallel, which provides an opportunity to conduct a side-by-side evaluation of the performance efficiency. In 2007, the experimental plan for this study was completed and implemented. Field testing, including process oxygen transfer efficiency measurement using the off-gas technique and profile sampling along the aeration tanks for evaluating oxygen uptake rates, nitrification, and DO distribution, was conducted in September through November and was continued into 2008. Valuable field, analytical and operational data were collected and data analysis was performed. A summary report on this study will be completed in 2009.

Pollutants Captured by Tunnel and Reservoir Plan

The EM&RD has been keeping records regarding the removal of SS, both carbonaceous and nitrogenous oxygen-demanding substances, and flow of CSO by the TARP system. The TARP system was built to prevent CSOs from entering Lake Michigan and the CAWS. Calculating the pollution removal gives an indication of how well TARP is protecting the local water environment because the pollutants captured by the TARP system would have otherwise been discharged into the CAWS.

Tables II-14, II-15, and II-16 contain data pertaining to CSO volume captured, TSS, and oxygen-demanding substances removed, respectively, by the TARP systems during the period of 1982 through 2007. As can be seen from these tables, during 2007 the Stickney WRP treated 25.11 billion gallons of CSO captured in the Stickney WRP TARP system, resulting in the removal of 61.06 million pounds of SS and 17.90 million pounds of oxygen-demanding substances (both carbonaceous and nitrogenous). The Calumet WRP treated 19.13 billion gallons of CSO captured in the Calumet WRP TARP system, resulting in the removal of 33.03 million pounds of SS and 19.45 million pounds of oxygen-demanding substances (both carbonaceous and nitrogenous). The Kirie WRP diverted 3.34 billion gallons of CSO into the Kirie TARP system, resulting in the removal of 5.07 million pounds of SS and 6.65 million pounds of oxygen-demanding substances (both carbonaceous and nitrogenous).

Again referring to Tables II-14, II-15, and II-16, it can be seen that since TARP has gone on line a total of 932.66 billion gallons of CSO, 1,822.22 million pounds of SS, and 960.57 million pounds of oxygen-demanding substances (both carbonaceous and nitrogenous) have been removed due to the TARP system which otherwise would have been discharged into the CAWS.

Per Capita Water Consumption and Infiltration and Inflow Concerns at Metropolitan Water Reclamation District of Greater Chicago Water Reclamation Plants

The flow and load characteristics of District WRPs were reviewed to evaluate the potential effects of water conservation in these service areas. Additionally, the North Side WRP service area was closely examined to evaluate whether infiltration and inflow of groundwater into the collection system (I&I) concerns exist.

Water Use Evaluation. The Illinois Recommended Standards for Sewage Works (IRSSW) recommends that for planning purposes, it is reasonable to estimate 100 gallons per capita per day (gpcd) for domestic flow into a WRP. The North Side Master Plan considered 192 gpcd a reasonable value in order to design the WRP for future capacity. Considering this discrepancy, the average yearly flow and load characteristics for each WRP were summarized (Table II-17). For frame of reference, two additional municipalities (Miami, FL, and Denver, CO) are included in Table II-17. In recent years, Denver and Miami have encouraged water conservation through both regulation and public awareness. After employing water conservation policies, Denver showed a 12 percent decrease in flow, Miami showed a 9.6 percent decrease in flow, and both municipalities showed higher concentrations of BOD and SS.

The summarized data indicates that the four smaller capacity District WRPs (Kirie, Egan, Hanover Park, and Lemont) have flows per capita and load characteristics similar to that of Miami and Denver. However, the Stickney, Calumet, and North Side WRPs have much higher flows per capita and more dilute load concentrations (with the exception of Stickney) compared to Miami and Denver. Stickney has high flow per capita (302.3 gpcd) and also has high concentrations of BOD (280.7 mg/L) and TSS (382.7 mg/L), which may be explained by high input of industrial wastewater. The North Side WRP receives an industrial contribution of only 2.5 percent, and Calumet receives an estimated industrial flow of ~6.5 percent.

It is suggested that overconsumption of water may be occurring in the District's three largest service areas leading to the high flows and low concentrations. Water conservation techniques may alleviate these flows and increase the incoming concentrations.

North Side Service Area Evaluation of Water Consumption and Estimation of Infiltration and Inflow of Groundwater into the Collection System. The water consumption within the North Side service area was compared to flow into the North Side WRP to estimate the I&I in the collection system. The flow and load from the three North Side WRP influent interceptors were examined from December 11, 2006, through December 18, 2006. The three interceptors of concern are the North Side Interceptor 1 (NS1), the North Side Interceptor 3 (NS3), and the Howard Street Interceptor (HOW).

On average, NS1, NS3, and HOW contributed 13.9 percent, 61.6 percent, and 24.5 percent, respectively, to the total WRP flow over the study period. Wet weather occurred from December 11, 2006, through December 13, 2006, as reflected through the elevated flows in each interceptor. The total plant flows during these three days were 367, 457, and 344 MGD, respectively. These flows were well above the average wet weather flow for 2001–2005 (285 MGD); the average dry weather flow for 2001–2005 was 232 MGD.

Grab samples from the interceptors were collected approximately every four hours during the study period and analyzed for COD and TSS. Additionally, one daily sample was collected, split, and analyzed for five-day BOD (BOD_5) in parallel with COD. The average flow and load for the North Side WRP influent and the three North Side interceptors during the study period and the average 2004–2005 influent flow and composition for two wastewater treatment plants with similar service populations (Miami, FL, and Denver, CO) are summarized below (Table II-18).

The order of decreasing interceptor flow is as follows: NS1 > HOW ≥ NS3. The North Side WRP appears to be receiving very dilute wastewater. The inceptors' influent flows were examined to see whether excessive I&I was occurring in a particular interceptor system. However, the interceptor concentrations are similar to each other and are very low compared to Miami and Denver (Table II-18). Therefore, either there is very high I&I for all three interceptor systems, or there is very high water consumption in the North Side service area with normal I&I, or a combination of both high water consumption and high I&I.

In order to examine whether high water consumption is a concern, WTPR Section staff contacted the water departments of the city of Chicago and 12 municipalities encompassing the North Side service area and requested monthly pumping rates to consumers for 2001–2005 (Table II-19. The water consumption data were compared to the incoming flow to the North Side WRP to estimate I&I. According to Metcalf and Eddy (2003), 60–90 percent of water consumed is converted to wastewater. I&I was estimated as the difference between the WRP inflow and the water consumed in the WRP service area. The water consumed in the North Side basin, wastewater inflow to the North Side WRP, and estimates of the I&I in the North Side basin collection system are summarized for 2001–2005 (Table II-20).

Regarding the guideline provided by Metcalf & Eddy that 60 percent to 90 percent of the water consumed becomes wastewater, the higher percentages apply to northern states, such as Illinois, during cold weather. Assuming that 75 percent of the water consumed in the North Side service area (255.1 MGD) is converted to wastewater, the I&I contribution to the wastewater flow at the NSWRP can be estimated as 57.5 MGD (42.6 gpcd) (= North Side WRP flow – 0.75 x water consumed). Given the assumption that 75 percent of the water consumed is converted to wastewater, the estimated average I&I of 57.5 MGD for the North Side service area can be considered relatively low.

The average dry and wet weather flows per capita for the North Side WRP for 2001–2005 are 167 and 206 gpcd, respectively. A USEPA infiltration/inflow report defined WRPs with flows per capita much greater than 120 gpcd for dry weather flow as having excessive I&I. The value was set at 275 gpcd for wet weather flow (USEPA, 97-03, 1985). The North Side greatly exceeded the dry weather flow per capita benchmark but was well under the wet weather flow per capita benchmark. However, extraneous unmetered water consumption with negligible I&I could produce the same flow per capita as baseline water consumption with high I&I. Therefore, it is informative to examine the water consumption in the North Side service area.

The north side of Chicago consumes the most water in the North Side service area (77 percent). No community has a water consumed per capita value below the IRSSW benchmark of 100 gpcd. Except for Chicago, Winnetka, Niles, and Glencoe, every municipality is below the flow per capita benchmark of 192 gpcd cited by the North Side Master Plan. However, only Evanston, Wilmette, Northfield, Skokie, and Northbrook are below 150 gpcd. A leaking distribution system in any of these municipalities would increase the water consumption flows. It should also be noted that the flow per capita benchmarks cited above are for wastewater, not water consumed.

If it is assumed that 75 percent of the water consumed is turned into wastewater, only Evanston, Skokie, Wilmette, and Northfield have wastewater flow per capita values below the IRSSW benchmark of 100 gpcd. Except for Winnetka, every municipality is below the wastewater flow per capita benchmark of 192 gpcd cited by the North Side Master Plan. However, Chicago, Niles, and Glencoe have relatively high flows per capita as well (>150 gpcd). As these flows per capita are based on the water consumed, I&I is not considered in the calculations.

Again based on actual wastewater flow, the North Side WRP service area population is generating 187.6 gpcd for 2001–2005; conversely, Miami and Denver are receiving 117.7 gpcd and 87.3 gpcd, respectively, for 2004–2005. If I&I is considered normal and perhaps low (57.5 MGD) for the North Side service area, high water consumption may be the most significant contributor to the dilute wastewaters received at the North Side WRP.

Collection System Bioaugmentation Technology Review

Collection system bioaugmentation is a system that introduces specific blends of microbes into a sewer collection system to achieve specific objectives. WTPR Section scientists reviewed this technology to understand potential benefits to water WRPs. The literature included case studies, white papers, articles, press releases, a grant proposal, patent covers, and a material safety data sheet for a bacterial additive.

The process is intended to enhance the degradation of the organic material in the wastewater before it reaches the treatment plant. Beneficial facultative bacteria are continuously injected into the collection system at strategic locations to cultivate a microbial population capable of enhancing the degradation of organics in the wastewater. The microbes added to the system reportedly develop a biofilm in the collection system that degrades the organics anaerobically. The system used anaerobic digestion because it yields less biomass, thereby the system is less likely to clog the collection system. The surface area available for biofilm development is the area in the pipe wall in which the flow is not turbulent. The biofilm thickness is dependent on water velocity. Sloughing occurs during high flow.

The reported benefits of bioaugmentation are reduced fats, oils and grease concentrations, odors, substrate loading, and solids loading in the collection system and at the treatment plant influent. The product reportedly reduced substrate load and the TSS received at the WRPs by up to 40 percent. The biosolids produced at the WRP was reportedly decreased by as much as 28 percent. The cost savings are expected with reduced energy for aeration and reduced biosolids processing and disposal.

Additional possible benefits of collection system bioaugmentation are collection system odor control, improved effluent quality, nutrient reduction and additional cost savings from lower pumping costs, lower polymer costs, and reduced collection system maintenance. More detailed assessments are needed to verify theses claims.

There are advantages and disadvantages to anaerobic treatment process by the collection system biofilm. The advantages include: lower energy consumption for aeration, lower biomass yield, odor control, fats, oils and grease control. The disadvantages include: methane production, start up time to develop biomass inventory, reaction rates susceptible to low temperatures and toxic substances, and low influent BOD_5.

The Lemont WRP was used to evaluate the potential cost benefit of collection system bioaugmentation. It was chosen because the plant has chronic bulking problems and perhaps bioaugmentation would reduce the fats, oils, and grease in the collection system, therefore reducing the bulking problems.

The 2005 Lemont WRP had an average daily electrical energy usage of 5,850 kWh. The current electrical cost is $0.063/kWh. Assuming half of the electrical energy is for blowers, the daily average electricity usage is 2,925 kWh. The median substrate reduction provided by the vendor was used in this evaluation. The 22 percent reduction in collection system substrate would result in 22 percent less energy needed to power the aeration system. The energy savings would be 644 kWh/day. The cost savings would be $40.57 per day or $14,809 per year.

The median biosolids reduction reported by the vendor was 14 percent. The Lemont WRP generated 309 dry tons of biosolids during 2005. These biosolids are transported by truck for off-site treatment. Given the hauling cost of $37.50 per dry ton, a 14 percent reduction in biosolids would save $25.38 per day or $9,263 per year.

A quotation from a vendor for collection system bioaugmentation microbiological product and services was a discounted rate of $6,000 per month for the Lemont WRP. This cost translates to an annual cost of $72,000. After an undetermined trial period the nondiscounted cost would be $96,000 per year. A comparison of the cost savings versus the expense reveals a net cost of $47,928 per year at the discounted rate.

In summary, the technology appears to have merit. Bioaugmentation has been reported to be cost-effective in soil remediation as well as in oil spill and mine waste remediation. There is a lot of variability in the reported results using the technology in municipal collection systems. Collection system bioaugmentation will not be cost-effective at the Lemont WRP.

Ultraviolet Disinfection of Water Reclamation Plant Effluent

The Master Plan consultants recommended ultraviolet (UV) disinfection for the Stickney, Calumet and North Side WRPs if future NPDES permits require that these plants disinfect their effluent. In anticipation of possible future requirements, in 2006 the EM&RD completed a survey of large WRPs that deploy UV disinfection and conducted sampling at six District WRPs to evaluate whether filtration before UV disinfection would have any benefit.

In 2007, the EM&RD generated UV dose-response data for all seven WRPs. Plant effluent samples were collected three to six times, and the percent UV transmittance (UVT) of each day's sample was measured using a Trojan P254C Photometer. The UV dose response of FC (fecal coliform) in the effluent was determined using Trojan Technologies collimated beam apparatus and the species-specific enumeration method. The sensitivity of the FCs to UV light is measured by varying exposure times to a fixed intensity.

Table II-21 summarizes the UVT data for each WRP. Collectively, the lowest UVT observed was 59 percent at the North Side WRP, and the maximum was 78 percent also from the North Side WRP. The North Side final effluent UVT data was examined with respect to inflow, raw BOD_5, and TSS. As expected, a general trend was observed in which UVT measurements increased with decreasing flow, BOD_5, and TSS. In a previous study the same variability in North Side UVT measurements was observed. UVT data of unfiltered composite samples collected from the North Side WRP final effluent from November 2005 through November 2006 ranged from 66.07 percent to 80.40 percent. These UVT results were reported in a memorandum entitled "Effluent Disinfection Study" dated February 8, 2007. Most UVT measurements in the present study for the other WRPs were within a range of approximately 70–75 percent and were in agreement with the previous study observations.

The minimum, maximum, and geometric mean FC concentrations prior to UV radiation for the seven District WRP effluents are summarized in Table II-22. The highest FC concentrations were observed in the Calumet, Stickney, and North Side WRP final effluents.

The UV dose, FC concentration, and log reduction for each sample are provided in Table II-23. Table II-24 summarizes the approximate dose needed in order to achieve a reduction to 400 colony-forming units (CFU)/100 mL and a 2- and 3-log reduction of FC for each WRP effluent.

Results indicate that in general, a 2-log reduction in FC for each WRP effluent was achieved at a UV dose of 10 mJ/cm^2. A 3-log reduction in FC for each WRP effluent was achieved at a UV dose range of 20–40 mJ/cm^2. However, a 2-log reduction in FC was not observed with Egan WRP secondary effluent even at a dose of 40 mJ/cm^2.

Interestingly, a nutrient removal program using $FeCl_3$ at the Egan WRP coincided with this UV study. $FeCl_3$ or a residual product may be inhibiting UV disinfection of the secondary effluent. As the District is currently considering using $FeCl_3$ for nutrient removal and UV radiation for disinfection at all WRPs, the Egan WRP results may be of concern. A future investigation of both filtered and unfiltered secondary effluent is planned to further evaluate and validate the Egan WRP results. Additionally as a preliminary examination, Stickney effluent samples will be dosed with $FeCl_3$ and undergo the same UV evaluation in order to see if comparable results occur.

Doped Titanium Dioxide Photocatalyst for Wastewater Disinfection

Titanium dioxide (TiO_2) is an attractive photocatalyst for disinfection because of its good photocatalytic activity, chemical stability, low toxicity, and low cost. TiO_2 photocatalyst requires ultraviolet radiation for activation. The high cost and potential hazards of ultraviolet light sources have led to further development of visible light-activated photocatalyst. Researchers at the University of Illinois at Urbana-Champaign, Center of Advanced Materials for Purification of Water Systems (WaterCAMPWS) have developed a nitrogen-doped TiO_2 which is activated by visible light. The photocatalyst reaction time was further improved by co-doping with metal ions. WaterCAMPWS has a pending patent on the product.

The objective of this project was to verify the results reported by WaterCAMPWS and to demonstrate on a bench scale a reduction of *Escherichia coli* in water reclamation plant effluent using their photocatalyst.

A bench trial was performed with three different samples of powdered catalysts. One sample catalyst was produced by University of Illinois at Urbana-Champaign (UIUC) and two were produced at Clark-Atlanta University (CAU).

The tests were conducted in a reactor that consisted of a 1-mL plastic pipette with an inside diameter of 0.328 cm. The light was positioned above the reactor shining down. The area of the catalyst exposed to the light was approximately 0.50 cm^2. The total surface area to total volume ratio of the catalyst in the reactor was 13.92 cm^{-1}. A variable-speed peristaltic pump was used to control the flow of water through the reactor. A 28-watt General Electric fluorescent bulb in a desk lamp was used as the visible light source. The bulb used was equivalent to a

100-watt incandescent bulb in luminous flux. The light output was measured with an LT LX-101 Lux Meter. The output at the bulb was 1,760 lumens.

The Stickney WRP effluent was used as influent to the reactor. The Stickney WRP effluent sample was collected in the morning on the same day as the bench test. The sample was split, with a 50 mL portion kept at 4°C to be used as a control.

Autoclaved Millipore water was used as a blank for all reactors. The blank 100-mL sample was pumped through each reactor. The Stickney WRP effluent was then pumped through each reactor at 13 mL/min. A 50-mL effluent sample was collected from each reactor. The treated effluent and blank samples were analyzed for *E. coli* and total coliform by the Analytical Microbiology and Biomonitoring Section.

The results are shown in Table II-25, in which the control sample analysis for *E. coli* and total coliform can be compared with the results from the trials with the different catalysts. There was a reduction of *E. coli* and total coliform in each of the catalyst trials. All of the blank runs were below the detection limit. The reduction for *E. coli* was 77 percent, 89 percent, and 54 percent for Trails 1, 2, and 3, respectively, and for total coliform was 85 percent, 92 percent, and 60 percent for Trials 1, 2, and 3, respectively. For Trial 4, there was an increase in both *E. coli* and total coliform, which is likely the result of the manner in which the sample was handled. It is likely that greater reductions would have occurred had a greater surface of catalyst been exposed to light.

The metal and nitrogen doped TiO_2 catalyst showed moderate disinfection effect when combined with visible light. However, the small amount of catalyst available and the small size of the apparatus severely limited opportunities to adjust reactor characteristics such as flow rate, catalyst quantity, contact time, and reactor cross-sectional area.

Dynamic Simulation of the Stickney Water Reclamation Plant Used for Imhoff Tank Evaluation

A steady-state model of the Stickney WRP was developed using Hydromantis GPS-X software during the Master Plan Study. This model configuration was upgraded for dynamic simulation by WTPR Section scientists in 2006 to evaluate the effect of taking the Imhoff tanks out of service. For this evaluation, Imhoff tank operations were reconfigured using a combination of a primary clarifier, an anaerobic digester, and a dewatering unit. The original model configured Imhoff operations using a combination of a primary clarifier and a lagoon. For the evaluation in 2006, Imhoff tank operations were isolated from the rest of the plant flow. The results of this effort showed that Imhoff tank effluent would not be severely impacted by taking one battery out of service for construction at the Stickney WRP. In 2007, the Imhoff tank operation process object was incorporated into the model configuration of the entire plant for a complete plant dynamic simulation.

Another modification of the original Stickney WRP model was elimination of the primary clarifiers on the southwest side of the WRP. The steady-state model had problems with the primary clarifier mass balance due to metering problems; the model was adjusted so it more closely represented the Stickney WRP operation. The primary clarifier process interfered with accurate dynamic simulation even though the steady-state model was adequate for its intended purpose in the Stickney WRP Master Plan Study.

Inputs for the dynamic model were 2005 historical plant data. The daily influent concentration and flow data from the Southwest primary clarifier effluent and the Imhoff effluent was used. The daily 2005 Stickney WRP final effluent data was used to compare the model output to the plant data.

The Imhoff tank model developed in 2006 was then combined with the dynamic model of the Stickney WRP. The model input was changed to daily 2005 historical West Side raw influent data. The Southwest primary clarifier effluent data was again used as input since the Southwest primary clarifier mass balance problem was not resolved. The daily SS concentrations of the model output are compared to the daily plant data in Figure II-2. The model output showed some agreement with the plant values. The very high SS concentration data was not predicted by the model. The high SS concentration data occurred during rain events. The model needs further refinement by incorporating data from diurnal sampling during rain events in order to more fully represent plant operations.

In conclusion, the steady-state Stickney WRP model was upgraded for dynamic simulation. Further evaluation and fine-tuning of the Stickney WRP dynamic model is needed.

Unsteady Flow Water Quality Modeling for the Chicago Area Waterway System

An unsteady flow water quality model for the CAWS was developed by Marquette University to simulate various scenarios related to the water quality in the CAWS. The water quality model for the CAWS was built on the platform of Duflow modeling studio. The model was calibrated and verified using part of the 2001 and 2002 hydraulic and water quality monitoring data, respectively, and was delivered to the District in August 2005. In 2007, the model was used to study a number of scenarios related to water quality. Two detailed analysis were performed: (1) an investigation of the impact of discretionary Lake Michigan diversion at three locations, i.e. Wilmette on the North Shore Channel, the Chicago River Controlling Works (CRCW) on the Chicago River and O'Brien Lock and Dam on the Calumet River, on water quality; and (2) a study to understand the impact of operating additional pumps at the Sidestream Elevated Pool Aeration (SEPA) Stations on DO in the Calumet-Sag (Cal-Sag) Channel.

The Impact of Adjusting Discretionary Lake Michigan Diversion. In order to evaluate the impact of discretionary Lake Michigan diversion on the water quality in the CAWS, the original model was modified at its upstream boundaries. A summary of model boundary modifications is shown in Table II-26. The modified model uses the lake inflow data at the corresponding locks as the input data for the upstream boundaries. The inflow from Lake Michigan is quantified in four categories, i.e. Navigation Makeup, Lockage, Leakage, and Discretionary Diversion, at each of the three locks. No navigation makeup or lockage occurs at the Wilmette

Lock. The daily average flow rates at the three locations from July 1 to September 30 of 2001 and 2002 are presented, respectively, in Table II-27. The concentration boundaries at Wilmette in the original model for 2001, which were likely derived from the monitoring data in the channel, were considered not representative of lake water quality. Therefore, the concentration boundaries at Wilmette in 2001 were modified using the corresponding concentration boundaries at CRCW. To maintain hydraulic balance in the model, the downstream (at Romeoville) hydraulic boundary was modified using surface water elevation. The simulation periods were also modified because of the availability of data associated with the modified boundaries. The simulation periods for the modified model are from July 12 to September 29, 2001, and from July 23 to September 23, 2002.

The results of a series of simulations showed that doubling or tripling the lake inflow at Wilmette and redistributing discretionary lake diversion flow from the O'Brien L&D and CRCW would improve the DO concentrations in the NSC upstream of the NSWRP significantly for both 2001 and 2002 simulation periods. The change of DO concentrations elsewhere would be insignificant and on the order of 0.1–0.2 mg/L, on average. For the entire waterway system, it appeared that it would be more beneficial to redistribute the discretionary lake diversion flow from the O'Brien L&D to Wilmette. A detailed description of the simulation results for the redistribution of discretionary Lake Michigan diversion to the CAWS will be provided in a future R&D report.

An Evaluation of the Effectiveness of Sidestream Elevated Pool Aeration to Enhance Dissolved Oxygen in the Calumet-Sag Channel. The CAWS model was also used to evaluate the effectiveness of the SEPA Stations in enhancing oxygen levels in the CAWS.

The baseline computer simulation of the CAWS model results were compared to the simulations with additional SEPA pumps in operation. Baseline simulations represent the model as originally calibrated and validated. The number of pumps that were run in the aeration simulation is two pumps at SEPA Station 2, and three pumps at each of the SEPA Stations 3, 4, and 5. SEPA Station 1, which is upstream of the O'Brien Lock and Dam, was not included in the model. The CAWS model was used to evaluate the Cal-Sag Channel from the Calumet WRP to the Cal-Sag Junction and the Sanitary and Ship Canal from the Cal-Sag Junction to Romeoville.

The results of a series of simulation runs indicate that even with maximum pumping capacity, which includes operating two pumps at SEPA Station 2 and three at SEPA Stations 3, 4, and 5, the instantaneous DO concentration targets of 5.0 mg/L and 3.5 mg/L will not be met one hundred percent of the time on the Cal-Sag Channel. Figures II-3 through II-6 show a comparison of the DO concentration along the waterway for the baseline simulation and the simulation with the maximum number of pumps at the SEPA Stations in operation. The details of this investigation will also be included in a future R&D report.

References

1. Metcalf & Eddy, Inc., Tchobanoglous, G., Burton, F. L., & Stensel, H. D. (2003). *Wastewater Engineering: Treatment and Reuse*. 4th Ed. McGraw-Hill Series in Civil and Environmental Engineering. New Delhi, India: Tata McGraw-Hill.

2. United States Environmental Protection Agency. (1985). *Infiltration/inflow: I/I analysis and project certification*. Washington, DC: U.S. Environmental Protection Agency, Office of Municipal Pollution Control, Municipal Facilities Division.

TABLE II-1: CENTRIFUGE COMPLEX WINTER POLYMER TEST RESULTS AT THE STICKNEY WATER RECLAMATION PLANT—JANUARY 2008

Number of Vendors Involved in Tests	3
Number of Polymers Submitted for Testing	5
Number of Polymers Qualified for Bidding	5
Polymer Selected	Polydyne CE 1142
Polymer Dosage, lbs/dry ton	430.2

TABLE II-2: CENTRIFUGE COMPLEX SUMMER POLYMER TEST RESULTS AT THE STICKNEY WATER RECLAMATION PLANT—SEPTEMBER 2007

Number of Vendors Involved in Tests	5
Number of Polymers Submitted for Testing	8
Number of Polymers Qualified for Bidding	6
Polymer Selected	Polydyne CE 1100
Polymer Dosage, lbs/dry ton	158.0

TABLE II-3: POLYMER TEST RESULTS AT THE CALUMET WATER RECLAMATION PLANT CENTRIFUGE COMPLEX USING FERRIC CHLORIDE AS A PRECONDITIONER—MAY 2007

Number of Vendors Involved in Tests	3
Number of Polymers Submitted for Testing	5
Number of Polymers Qualified for Bidding	2
Polymer Selected	Polydyne CE 1070
Polymer Dosage, lbs/dry ton	94.3

TABLE II-4: POLYMER TEST RESULTS FOR CALUMET WATER RECLAMATION PLANT GRAVITY CONCENTRATION TANKS—OCTOBER 2007

Number of Vendors Involved in Tests	2
Number of Polymers Submitted for Testing	4
Number of Polymers Qualified for Bidding	3
Polymer Selected	Polydyne CE 804
Polymer Dosage, lbs/dry ton	47.29

TABLE II-5: GRAVITY BELT THICKENER POLYMER TEST RESULTS AT THE HANOVER PARK WATER RECLAMATION PLANT—APRIL 2007

Number of Vendors Involved in Tests	6
Number of Polymers Submitted for Testing	11
Number of Polymers Qualified for Bidding	10
Polymer Selected	CE 1067
Polymer Dosage, lbs/dry ton	2.07

TABLE II-6: INFLUENT HAZARDOUS AIR POLLUTANT CONCENTRATIONS AT THE METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO'S MAJOR WATER RECLAMATION PLANTS IN 2007

HAP Organic Compound	Concentrations in µg/L[1]		
	Stickney	Calumet	North Side
Dichloromethane	1.3	3.2	2.8
Chloroform	3.2	3.0	1.9
Benzene	0	0.2	0
Tetrachloroethene	0	0	0
Toluene	15.9	74.6	3.8
Carbon disulfide	0	3.4	0.9
Methyl ethyl ketone	80	5.5	0
Styrene	0	1.8	0
Xylene (total)	3.5	0	0
Cresol (total)	4.2	5.6	0
Acetophenone	0	8.8	0
Cumene	0	62.2	0
2,4-D	0	2.8	0
Acetaldehyde	224.1	0	0
Propionaldehyde	235.3	0	0
Bis(2-ethylhexylphthalate)	0.9	0	0

[1]Average results of the two influent samples collected in February and July 2007.
NF = Not found.

TABLE II-7: HAZARDOUS AIR POLLUTANT EMISSIONS FROM THE METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO'S MAJOR WATER RECLAMATION PLANTS IN 2007[1]

HAP	Emissions in tons/yr		
Organic Compound	Stickney	Calumet	North Side
Dichloromethane	0.2	0	0.1
Chloroform	0.3	0.1	0.1
Benzene	0	0	0
Tetrachloroethene	0	0	0
Toluene	1.4	2.6	0.1
Carbon disulfide	0	0.2	0.1
Methyl ethyl ketone	0.1	0	0
Styrene	0	0	0
Xylene (total)	0.3	0	0
Cresol (total)	0	0	0
Acetophenone	0	0.1	0
Cumene	0	2.3	0
Acetaldehyde	5.9	0	0
Propionaldehyde	9.2	0	0

[1]Emissions estimated using the BASTE model.

TABLE II-8: RESULTS OF ADDITIONAL ANAEROBIC DIGESTION TESTS FOR THE CALUMET WATER RECLAMATION PLANT IN 2007

Test Start	Before Test		After Test*		Volatile Solids Reduction (%)	
Date	TS (%)	%VTS (%)	TS (%)	%VTS (%)	By Equation**	By Mass
1/4/07	2.06	52.74	1.87	47.36	19.4	18.5
2/8/07	2.09	53.14	1.95	48.58	16.7	14.5
3/1/07	1.76	52.86	1.70	50.67	8.4	7.7
4/19/07	2.73	50.32	2.55	47.56	10.5	11.9
5/18/07	2.39	51.27	2.24	47.04	15.6	13.9
5/31/07	2.33	50.35	2.18	47.46	10.9	11.8
6/7/07	2.29	50.54	2.17	46.70	14.3	12.4
7/12/07	2.30	50.16	2.18	46.87	12.3	11.4
8/9/07	2.34	50.11	2.22	45.69	16.2	13.4
8/23/07	2.88	46.78	2.72	43.20	13.5	13.0
9/7/07	2.91	45.88	2.78	42.88	11.4	10.7
10/4/07	2.12	47.09	2.01	44.15	11.2	11.1
11/8/07	2.09	49.67	1.95	46.50	11.9	12.4
12/14/07	1.96	54.03	1.83	52.77	4.9	8.6
May						
Mean	2.36	50.81	2.21	47.25	13.2	12.9
August						
Mean	2.61	48.44	2.47	44.45	14.8	13.2
Yearly						
Mean	2.30	50.35	2.17	46.96	12.7	12.2
Min	1.76	45.88	1.70	42.88	4.9	7.7
Max	2.91	54.03	2.78	52.77	19.4	18.5

*After 40 day of incubation at 35.5°C in bench-scale reactors.
**The Van Kleeck Equation was used in calculations.

TABLE II-9: MONTHLY MEAN VOLATILE SOLIDS REDUCTION THROUGH TWO-STEP ANAEROBIC DIGESTION AT THE CALUMET WATER RECLAMATION PLANT IN 2007

Month	Digester Feed TS (%)	Digester Feed %VTS (%)	Digester Draw TS (%)	Digester Draw %VTS (%)	VS Reduction (%) By Equation*
January	3.99	66.06	2.17	49.57	49.21
February	3.92	70.81	2.08	50.99	56.86
March	4.66	63.08	2.25	50.62	39.81
April	4.34	62.24	2.49	47.91	43.72
May	3.64	62.10	2.52	48.18	43.06
June	4.10	61.37	2.56	48.57	40.14
July	3.54	59.68	2.48	48.17	36.13
August	4.23	53.12	2.48	46.31	23.02
September	3.45	57.64	2.64	44.89	38.66
October	3.61	60.53	2.51	46.25	42.63
November	3.00	68.39	2.14	48.50	55.61
December	3.22	70.06	1.82	52.77	51.96
Yearly					
Mean	3.81	62.9	2.34	48.6	43.4
Min	3.00	53.1	1.82	44.9	23.0
Max	4.66	70.8	2.64	52.8	56.9

*The Van Kleeck Equation was used in calculations. The value in the table for each month is a monthly mean of daily VS reduction values.

TABLE II-10: RESULTS OF ADDITIONAL ANAEROBIC DIGESTION TESTS FOR THE EGAN WATER RECLAMATION PLANT IN 2007

Test Start	Before Test		After Test*		Volatile Solids Reduction (%)	
Date	TS (%)	%VTS (%)	TS (%)	%VTS (%)	By Equation**	By Mass
9/12/07	2.49	56.72	2.30	52.73	14.9	14.1
9/19/07	2.60	56.38	2.41	53.20	12.1	12.7
10/5/07	2.63	56.21	2.41	52.18	15.0	14.9
10/19/07	2.50	57.24	2.28	52.42	**17.7**	16.5
10/25/07	2.43	57.52	2.26	52.52	**18.3**	15.4
11/23/07	1.83	62.01	1.68	58.56	13.4	13.1
11/29/07	2.14	63.21	1.92	58.21	**19.0**	17.2
12/20/07	2.07	65.89	1.86	61.44	**17.5**	16.5
September Mean	2.55	56.55	2.35	52.97	13.5	13.4
October Mean	2.52	56.99	2.32	52.37	17.0	15.6
November Mean	1.98	62.61	1.80	58.38	16.2	15.2

*After 40 day of incubation at 35.5°C in bench-scale reactors.
**The Van Kleeck Equation was used in calculations.

TABLE II-11: RESULTS OF MONTHLY MEAN VALUES OF VOLATILE SOLIDS REDUCTION THROUGH ANAEROBIC DIGESTERS AT THE EGAN WATER RECLAMATION PLANT IN THE SELECTED MONTHS OF 2007

Month	Volatile Solids Reduction through Anaerobic Digesters (%)
September	37.62
October	56.94
November	54.90
December	46.73

TABLE II-12: EFFECTS OF FERRIC CHLORIDE DOSES ON DIGESTER PERFORMANCE

	Digester A				Digester C			
	Background (1/22-2/5/07)		1.32 GPM* (8/1-12/31/07)		Background (1/22-2/5/07)		1.32 GPM* (8/1-12/31/07)	
Parameter	Average	Std. Dev.	Average	Std. Dev.	Average	Std. Dev.	Average	Std. Dev.
Total Feed, MG/day	0.08	0.01	0.10	0.02	0.09	0.01	0.10	0.03
Digester Feed, DT/day	14.91	2.92	20.82	5.41	16.00	2.41	20.88	5.70
Digester Gas Produced X1000 CF	253	11	177	86	343	27	178	86
pH, pH unit	7.45	0.07	7.53	0.15	7.46	0.09	7.59	0.15
Alkalinity, mg/L as $CaCO_3$	5,223	64	4,577	231	4,952	90	4,430	148
Volatile Acids, mg/L	26	8	25	8	31	3	28	9
Temperature, Deg F	97	<1	96	1	96	<1	96	<1
Feed %VS	86	1	80	3	86	1	80	3
Draw %VS	68	1	60	4	68	1	60	4

*$FeCl_3$ was reduced to 1.28 gpm on 10/22/07.

TABLE II-13: EFFECTS OF FERRIC CHLORIDE DOSES ON CENTRIFUGE DEWATERING

Parameter	Background (1/22-2/5/07) Average	Background (1/22-2/5/07) Std. Dev.	1.32 GPM* (8/1-12/31/07) Average	1.32 GPM* (8/1-12/31/07) Std. Dev.	% Change
Sludge Feed, MG/day	0.24	0.15	0.23	0.15	-4
Sludge Feed DT/day	21	13	23	15	10
Polymer Dose lbs/DT	510	134	389	257	-24
Ferric Dose lbs/DT	431	129	288	174	-33
Centrate SS mg/L	2,498	2,451	1,687	1,672	-32
Sludge Cake %TS	24	2	26	2	8

*$FeCl_3$ was reduced to 1.28 gpm on 10/22/07.

TABLE II-14: COMBINED SEWER OVERFLOWS CAPTURED BY THE TUNNEL AND RESERVOIR SYSTEMS DURING THE PERIOD 1982 THROUGH 2007

Date	Stickney[1] Flow (billion gallons)	Calumet[1] Flow (billion gallons)	Kirie[2] Flow (billion gallons)	Total (billion gallons)
1982–1993[3]	206.20	60.20	37.30	303.70
1994	18.74	7.83	1.44	28.01
1995	22.84	9.08	2.60	34.52
1996	21.54	12.02	2.23	35.79
1997	29.10	8.44	1.50	39.04
1998	34.31	13.23	2.69	50.23
1999	27.20	11.77	3.15	42.12
2000	28.55	11.55	2.14	42.24
2001	48.43	16.34	3.24	68.01
2002	41.17	11.15	2.39	54.71
2003	27.22	14.88	1.48	43.58
2004	28.05	15.55	2.67	46.27
2005	21.43	12.95	1.11	35.49
2006	34.52	24.31	2.54	61.37
2007	25.11	19.13	3.34	47.58
Total	614.41	248.43	69.82	932.66

[1]Stickney and Calumet Data were taken from TARP Pumpback reports.
[2]Kirie data were taken from LIMS KRRAW69 Report. CSO capture was calculated by subtracting the average dry weather flow from the average daily flow. The flow data were provided by the Maintenance and Operations Department (Technical Projects).
[3]Data were supplied by Engineering Department.

TABLE II-15: TOTAL SUSPENDED SOLIDS REMOVED THROUGH THE COMBINED SEWER OVERFLOWS CAPTURED BY THE TUNNEL AND RESERVOIR SYSTEMS DURING THE PERIOD 1982 THROUGH 2007

Date	Mainstream (Million Pounds)	Calumet (Million Pounds)	Kirie (Million Pounds)	Total (Million Pounds)
1982–1993[1]	413.20	69.00	25.20	507.40
1994	41.31	12.60	1.90	55.81
1995	67.75	9.93	3.50	81.18
1996	56.57	12.43	3.30	72.30
1997	62.14	14.28	1.88	78.30
1998	107.02	16.00	3.08	126.10
1999	71.69	15.31	6.63	93.63
2000	114.52	18.59	3.95	137.06
2001	88.78	18.53	5.89	113.20
2002	66.85	13.18	4.26	84.29
2003	67.38	23.71	2.43	93.52
2004	62.89	18.55	4.42	85.86
2005	51.14	21.33	1.63	74.10
2006	82.63	33.65	4.03	120.31
2007	61.06	33.03	5.07	99.16
Total	1,414.93	330.12	77.17	1,822.22

[1]Data were supplied by Engineering Department.

TABLE II-16: OXYGEN DEMANDING POLLUTANTS REMOVED[1] THROUGH COMBINED SEWER OVERFLOWS CAPTURED BY THE TUNNEL AND RESERVOIR SYSTEMS DURING THE PERIOD 1982 THROUGH 2007

Date	Mainstream (Million Pounds)	Calumet (Million Pounds)	Kirie (Million Pounds)	Total (Million Pounds)
1982–1993[2]	189.56	59.22	24.68	273.46
1994	15.00	8.46	2.24	25.70
1995	15.77	9.79	3.58	29.14
1996	18.60	12.96	4.14	35.70
1997	26.03	9.16	2.31	37.50
1998	30.86	13.57	4.81	49.24
1999	22.84	13.39	6.36	42.59
2000	35.91	13.61	4.55	54.07
2001	50.67	16.82	5.95	73.44
2002	54.49	12.41	4.71	71.61
2003	36.09	16.56	3.15	55.80
2004	28.22	16.72	5.47	50.41
2005	25.88	19.22	2.14	47.24
2006	37.23	28.12	5.32	70.67
2007	17.90	19.45	6.65	44.00
Total	605.05	269.46	86.06	960.57

[1]CBOD + (Ammonia*4.6), except for Kirie WRP which uses BOD + (Ammonia*4.6). Kirie WRP does not report CBOD.
[2]Data were supplied by Engineering Department.

TABLE II-17: AVERAGE FLOW AND LOAD CHARACTERISTICS OF METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO WATER RECLAMATION PLANTS, 2001–2005

WRP	Flow (MGD)	Flow per Capita (gpcd)	BOD (mg/L)	TSS (mg/L)
Stickney	701.6	302.3	280.7	382.6
Southwest	351.7		410.9	596.6
West	349.9		151.1	186.0
Calumet	245.9	223.0	121.9	145.5
North Side	248.8	184.4	118.2	134.5
Kirie	32.3	119.2	172.6	200.5
Egan	24.3	141.0	198.9	217.6
Hanover Park	8.1	140.9	208.9	218.8
Lemont	2.1	121.3	167.8	206.2
Miami (CDWWT)	117.6	117.6	148.9	201.5
Denver (MWRD)	131	87.3	233.3	237.3

*gpcd = gallons per capita-day.

TABLE II-18: FLOW AND LOAD CHARACTERISTICS OF THE NORTH SIDE WATER RECLAMATION PLANT AND INTERCEPTORS, MIAMI, AND DENVER

Interceptor	Years	Flow (MGD)	COD (mg/L)	TSS (mg/L)	BOD_5 (mg/L)
North Side WRP	December 2006	305.4	—	87	76
NS1	" " "	42.1	201	110	86
NS3	" " "	187.7	195	101	89
HOW	" " "	75.6	244	124	102
Miami	2004–2005	117.6	—	201	148
Denver	2004–2005	131.0	—	237	233

TABLE II-19: WATER CONSUMPTION AND CONSUMPTION PER CAPITA FOR THE NORTH SIDE SERVICE AREA COMMUNITIES (2001–2005)

Municipality	Average Water Consumed (MGD)	Average Water Consumed per Capita (gpcd)*
Chicago (North Side)	197.8	233.2
Evanston	9.2	115.9
Skokie	9.8	130.8
Morton Grove and Golf	3.5	155.3
Glenview	8.9	178.2
Wilmette	3.7	133.0
Kenilworth	0.4	167.0
Winnetka	3.4	274.4
Northfield	1.1	129.0
Northbrook	5.9	143.9
Niles	7.5	241.1
Lincolnwood	2.0	163.9
Glencoe	1.4	203.3

*gpcd = gallons per capita-day.

TABLE II-20: MEASURED FLOW, ESTIMATED FLOW, AND INFILTRATION AND INFLOW FOR THE NORTH SIDE WATER RECLAMATION PLANT SERVICE AREA (2001–2005)

Year	NSWRP Flow (MGD)	Water Consumed (MGD)	*Max Wastewater Produced (MGD)*	*Min Wastewater Produced (MGD)*	*Max I&I (MGD)*	*Min I&I (MGD)*
2001	279.9	268.5	*241.6*	*161.1*	*118.8*	*38.2*
2002	249.7	263.0	*236.7*	*157.8*	*91.9*	*13.0*
2003	237.9	253.2	*227.9*	*151.9*	*85.9*	*10.0*
2004	242.6	243.1	*218.8*	*145.9*	*96.7*	*23.8*
2005	234.1	247.7	*222.9*	*148.6*	*85.5*	*11.2*
Avg	248.8	255.1	*229.6*	*153.1*	*95.8*	*19.2*

Note: Values in *italics* are estimated.

TABLE II-21: ULTRAVIOLET TRANSMITTANCE (UVT) OF WATER RECLAMATION PLANT SECONDARY EFFLUENTS AND FINAL EFFLUENTS

WRP	Date	UVT (%)	Average UVT (%)
Stickney	9/6/2007	70.0	72.7
	9/19/2007	74.0	
	9/20/2007	74.0	
Calumet	10/3/2007	70.5	71.0
	10/4/2007	70.0	
	10/10/2007	72.5	
North Side	8/29/2007	76.0	72.8
	8/30/2007	78.0	
	9/5/2007	77.0	
	9/26/2007	59.0	
	9/27/2007	74.0	
Egan	10/24/2007	75.5	75.0
	10/25/2007	73.5	
	10/31/2007	76.0	
Kirie	10/11/2007	74.0	74.7
	10/17/2007	76.5	
	10/18/2007	73.5	
Hanover Park	8/8/2007	68.0	66.8
	8/9/2007	66.0	
	8/15/2007	71.0	
	8/16/2007	72.0	
	8/22/2007	62.0	
	8/23/2007	61.5	
Lemont	11/1/2007	71.0	71.8
	11/7/2007	72.5	
	11/8/2007	72.0	

TABLE II-22: FECAL COLIFORM CONCENTRATIONS FROM METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO WATER RECLAMATION PLANTS

WRP	Fecal Coliform Concentration (CFU/100 mL)		
	Minimum	Maximum	Geometric Mean
Stickney WRP Final Effluent	8,191	44,000	23,326
Calumet WRP Final Effluent	8,018	84,545	17,898
North Side WRP Final Effluent	6,577	71,171	21,254
Egan WRP Secondary Effluent	3,800	8,829	5,667
Kirie WRP Secondary Effluent	3,700	7,928	5,612
Hanover Park WRP Secondary Effluent	5,700	22,000	9,905
Lemont WRP Final Effluent	1,171	28,000	6,578

TABLE II-23: ULTRAVIOLET DOSE-RESPONSE DATA FOR WATER RECLAMATION PLANT SECONDARY EFFLUENT AND FINAL EFFLUENT

WRP	Date	Dose (mJ/cm^2)	Sample A Fecal Coliform Concentration (CFU/100 mL)	Sample B Fecal Coliform Concentration (CFU/100 mL)	Average log (N_0/N)*
Stickney	9/6/2007	0	9,271	8,191	0.00
		10	69	107	2.01
		20	117	143	1.83
		30	11	6	3.04
		40	3	6	3.34
	9/19/2007	0	44,000	41,000	0.00
		10	163	225	2.35
		20	87	117	2.63
		30	120	58	2.71
		40	31	44	3.06
	9/20/2007	0	42,000	28,000	0.00
		10	500	344	1.92
		20	187	200	2.25
		30	117	197	2.35
		40	90	103	2.55
Calumet	10/3/2007	0	84,545	81,818	0.00
		10	180	183	2.66
		20	3	39	3.90
		30	25	29	3.49
		40	20	14	3.69
	10/4/2007	0	8,288	8,018	0.00
		10	123	87	1.90
		20	3	39	2.89
		30	3	8	3.22
		40	6	6	3.15
	10/10/2007	0	8,919	8,018	0.00
		10	123	147	1.80
		20	42	39	2.32
		30	22	14	2.68
		40	20	11	2.75

TABLE II-23 (Continued): ULTRAVIOLET DOSE-RESPONSE DATA FOR WATER RECLAMATION PLANT SECONDARY EFFLUENT AND FINAL EFFLUENT

WRP	Date	Dose (mJ/cm^2)	Sample A Fecal Coliform Concentration (CFU/100 mL)	Sample B Fecal Coliform Concentration (CFU/100 mL)	Average log (N_0/N)*
North Side	8/29/2007	0	39,000	45,000	0.00
		10	187	160	2.38
		20	28	31	3.16
		30	28	25	3.20
		40	9	28	3.43
	8/30/2007	0	11,712	7,651	0.00
		10	500	233	1.44
		20	180	190	1.71
		30	153	167	1.77
		40	127	130	1.87
	9/5/2007	0	7,297	6,577	0.00
		10	110	67	1.91
		20	110	23	2.14
		30	50	22	2.32
		40	3	6	3.24
	9/26/2007	0	72,973	71,171	0.00
		10	314	319	2.36
		20	44	36	3.26
		30	19	14	3.64
		40	17	14	3.68
	9/27/2007	0	24,000	20,000	0.00
		10	143	130	2.21
		20	97	83	2.39
		30	50	31	2.75
		40	3	11	3.58
Egan	10/24/2007	0	5,400	5,300	0.00
		10	680	580	0.93
		20	217	236	1.37
		30	150	133	1.58
		40	133	120	1.63

TABLE II-23 (Continued): ULTRAVIOLET DOSE-RESPONSE DATA FOR WATER RECLAMATION PLANT SECONDARY EFFLUENT AND FINAL EFFLUENT

WRP	Date	Dose (mJ/cm^2)	Sample A Fecal Coliform Concentration (CFU/100 mL)	Sample B Fecal Coliform Concentration (CFU/100 mL)	Average log (N_0/N)*
	10/25/2007	0	8,829	7,838	0.00
		10	1,250	1,040	0.86
		20	333	420	1.35
		30	203	203	1.61
		40	160	123	1.77
	10/31/2007	0	4,400	3,800	0.00
		10	500	560	0.89
		20	140	228	1.36
		30	110	103	1.58
		40	58	69	1.81
Kirie	10/11/2007	0	3,700	3,800	0.00
		10	56	36	1.92
		20	3	11	2.82
		30	6	8	2.74
		40	1	3	3.35
	10/17/2007	0	4,900	7,838	0.00
		10	86	81	1.87
		20	17	14	2.60
		30	3	6	3.19
		40	6	1	3.41
	10/18/2007	0	7,297	7,928	0.00
		10	51	83	2.07
		20	14	9	2.84
		30	11	11	2.83
		40	8	6	3.04
Hanover Park	8/8/2007	0	5,700	6,126	0.00
		10	93	93	1.80
		20	3	14	2.96
		30	6	11	2.85
		40	14	3	2.97

TABLE II-23 (Continued): ULTRAVIOLET DOSE-RESPONSE DATA FOR WATER RECLAMATION PLANT SECONDARY EFFLUENT AND FINAL EFFLUENT

WRP	Date	Dose (mJ/cm^2)	Sample A Fecal Coliform Concentration (CFU/100 mL)	Sample B Fecal Coliform Concentration (CFU/100 mL)	Average log (N_0/N)*
	8/9/2007	0	10,351	8,919	0.00
		10	163	80	1.92
		20	25	19	2.64
		30	11	1	3.46
		40	14	1	3.41
	8/15/2007	0	7,477	6,667	0.00
		10	127	110	1.78
		20	39	33	2.29
		30	6	14	2.89
		40	1	8	3.39
	8/16/2007	0	8,281	5,946	0.00
		10	93	53	2.00
		20	3	9	3.15
		30	6	6	3.10
		40	14	1	3.27
	8/22/2007	0	22,000	17,012	0.00
		10	208	244	1.93
		20	42	36	2.70
		30	11	25	3.06
		40	11	11	3.23
	8/23/2007	0	13,681	22,000	0.00
		10	127	173	2.07
		20	55	47	2.53
		30	14	36	2.89
		40	23	11	3.03
Lemont	11/1/2007	0	1,532	1,171	0.00
		10	25	42	1.62
		20	3	14	2.32
		30	1	1	3.13
		40	1	1	3.13

TABLE II-23 (Continued): ULTRAVIOLET DOSE-RESPONSE DATA FOR WATER RECLAMATION PLANT SECONDARY EFFLUENT AND FINAL EFFLUENT

WRP	Date	Dose (mJ/cm^2)	Sample A Fecal Coliform Concentration (CFU/100 mL)	Sample B Fecal Coliform Concentration (CFU/100 mL)	Average log (N_0/N)*
	11/7/2007	0	9,730	8,288	0.00
		10	90	67	2.06
		20	6	3	3.35
		30	3	8	3.26
		40	1	1	3.95
	11/8/2007	0	20,000	28,000	0.00
		10	64	47	2.63
		20	6	6	3.62
		30	1	1	4.37
		40	1	1	4.37

*N_0 = Initial raw fecal coliform concentration of plant effluent.
N = Fecal coliform concentration upon respective UV dose application to plant effluent.

TABLE II-24: ULTRAVIOLET DOSE NEEDED TO MEET 400 CFU/100 mL AND 2- AND 3-LOG REDUCTION OF FECAL COLIFORM FOR METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO WATER RECLAMATION PLANT SECONDARY EFFLUENTS AND FINAL EFFLUENTS

WRP	Dose Needed to Meet 400 CFU/100 mL (mJ/cm^2)	Maximum Dose Needed to Meet Log Reduction of Fecal Coliform (mJ/cm^2)	
		2-log	3-log
Stickney	8.9	10	40
Calumet	8.1	10	20
North Side	8.6	10	40
Egan	16.1	>40	>40
Kirie	6.0	10	30
Hanover Park	7.5	10	30
Lemont	6.3	10	20

TABLE II-25: RESULTS OF VISIBLE LIGHT DISINFECTION WITH DOPED TITANIUM DIOXIDE PHOTOCATALYST

Photocatalyst	Sample	*E. coli* MPN/100 mL	Total Coliform MPN/100 mL
Raw Sample	WRP Effluent	10,500	72,700
Trial 1 (Ti/Al)	Blank	<1	<1
	WRP Effluent	2,380	11,200
Trial 2 (Ti/Cu)	Blank	<1	<1
	WRP Effluent	1,190	6,130
Trial 3 (Ti/M)	Blank	NA	NA
	WRP Effluent	4,880	29,100
Trial 4 (Control)	Blank	<1	<1
	WRP Effluent	14,100	92,100

TABLE II-26: ORIGINAL AND MODIFIED MODEL BOUNDARY CONDITIONS

<table>
<tr><th>Model Year</th><th>Original</th><th>Modified</th></tr>
<tr><td rowspan="7">2001</td><td colspan="2">Upstream:</td></tr>
<tr><td>Wilmette - 5-minute flow (USGS)</td><td>Daily mean flow from M&O</td></tr>
<tr><td>CRCW - 1-hour water elevation (USGS)</td><td>Daily mean flow from M&O</td></tr>
<tr><td>O'Brien L&D - 1-hour water elevation (USGS)</td><td>Daily mean flow from M&O</td></tr>
<tr><td>Wilmette – concentrations
(in channel monitoring data)
Hourly DO: 0 – 11.6 mg/L
DO_{avg} = 6.39 mg/L; DO_{median} = 7.8 mg/L
BOD_5 = 2.96 mg/L
NH_3-N = 0.09 mg/L
NO_3-N = 0.21 mg/L
TON = 0.41 mg/L
SS = 11.33 mg/L</td><td>Using concentrations at CRCW
(used in the model)
Daily DO: 8 – 11.2 mg/L
DO_{avg} = 9.18 mg/L; DO_{median} = 9 mg/L
BOD_5 = 1.63 mg/L
NH_3-N = 0.04 mg/L
NO_3-N = 0.25 mg/L
TON = 0.38 mg/L
SS = 9.8 mg/L</td></tr>
<tr><td colspan="2">Downstream</td></tr>
<tr><td>Romeoville – 15-minute flow for 7/12 - 9/14/01 (USGS) and 15-minute water elevation for 9/1 – 11/9/01 (USGS)</td><td>15-minute water elevation for 7/12 to 9/30/01 from USGS and model simu-lation results using flow boundary</td></tr>
<tr><td rowspan="6">2002</td><td colspan="2">Upstream:</td></tr>
<tr><td>Wilmette - daily-mean flow (USGS)</td><td>Daily mean flow from M&O</td></tr>
<tr><td>CRCW - 1-hour water elevation (USGS)</td><td>Daily mean flow from M&O</td></tr>
<tr><td>O'Brien L&D - 1-hour water elevation (USGS)</td><td>Daily mean flow from M&O</td></tr>
<tr><td colspan="2">Downstream</td></tr>
<tr><td>Romeoville – 15-minute flow for 5/1 - 8/11/02 (USGS), and 15-minute water elevation for 8/10 - 9/23/02 (USGS)</td><td>15 minutes water elevation for 7/1 - 9/23/01 from USGS and model simu-lation results using flow boundary</td></tr>
</table>

TABLE II-27: LAKE INFLOW IN CUBIC FEET PER SECOND (cfs) AT THREE LOCATIONS DURING THE SUMMERS OF 2001 AND 2002

Parameter	Wilmette		CRCW				O'Brien L&D			
	Leakage	Disc. Div.	Navigation	Lockage	Leakage	Disc. Div.	Navigation	Lockage	Leakage	Disc. Div.
	--- for Period of 7/1/2001 to 9/30/2001 ---									
Mean	0.16	34.89	52.29	21.21	10.10	403.96	76.06	30.32	6.69	283.45
Min	0.00	0.00	0.00	0.99	4.66	0.00	0.00	8.38	0.50	0.00
Max	1.31	50.00	1025.45	37.90	24.68	1330.35	1263.92	58.52	16.18	1275.62
Std. Dev.	0.32	17.45	151.04	6.45	2.69	213.87	206.22	11.86	2.71	187.27
Portion (%)	0.47	**99.53**	10.73	4.35	2.07	**82.85**	19.18	7.65	1.69	**71.48**
Total at each location:										
Mean	35.05		487.56				396.52			
Min	0.00		32.92				32.05			
Max	51.29		1365.95				1331.37			
Std. Dev.	17.51		209.37				236.51			
	--- for Period of 7/1/2002 to 9/30/2002 ---									
Mean	2.36	75.52	24.23	40.09	12.78	386.54	49.38	53.75	8.69	273.70
Min	0.00	0.00	0.00	0.71	8.46	0.00	0.00	13.59	3.55	0.00
Max	3.48	137.44	754.47	56.82	22.26	727.66	1461.17	109.64	16.36	564.92
Std. Dev.	0.70	42.17	103.98	9.19	2.52	185.75	196.31	20.39	2.88	141.32
Portion (%)	3.03	**96.97**	5.23	8.65	2.76	**83.37**	12.81	13.94	2.25	**71.00**
Total at each location:										
Mean	77.88		463.64				385.52			
Min	0.00		38.37				92.88			
Max	140.48		889.17				1611.06			
Std. Dev.	42.63		196.59				212.31			

FIGURE II-1: PHOSPHORUS CONCENTRATIONS IN THE FINAL EFFLUENT OF THE EGAN WATER RECLAMATION PLANT
JANUARY THROUGH DECEMBER 2007

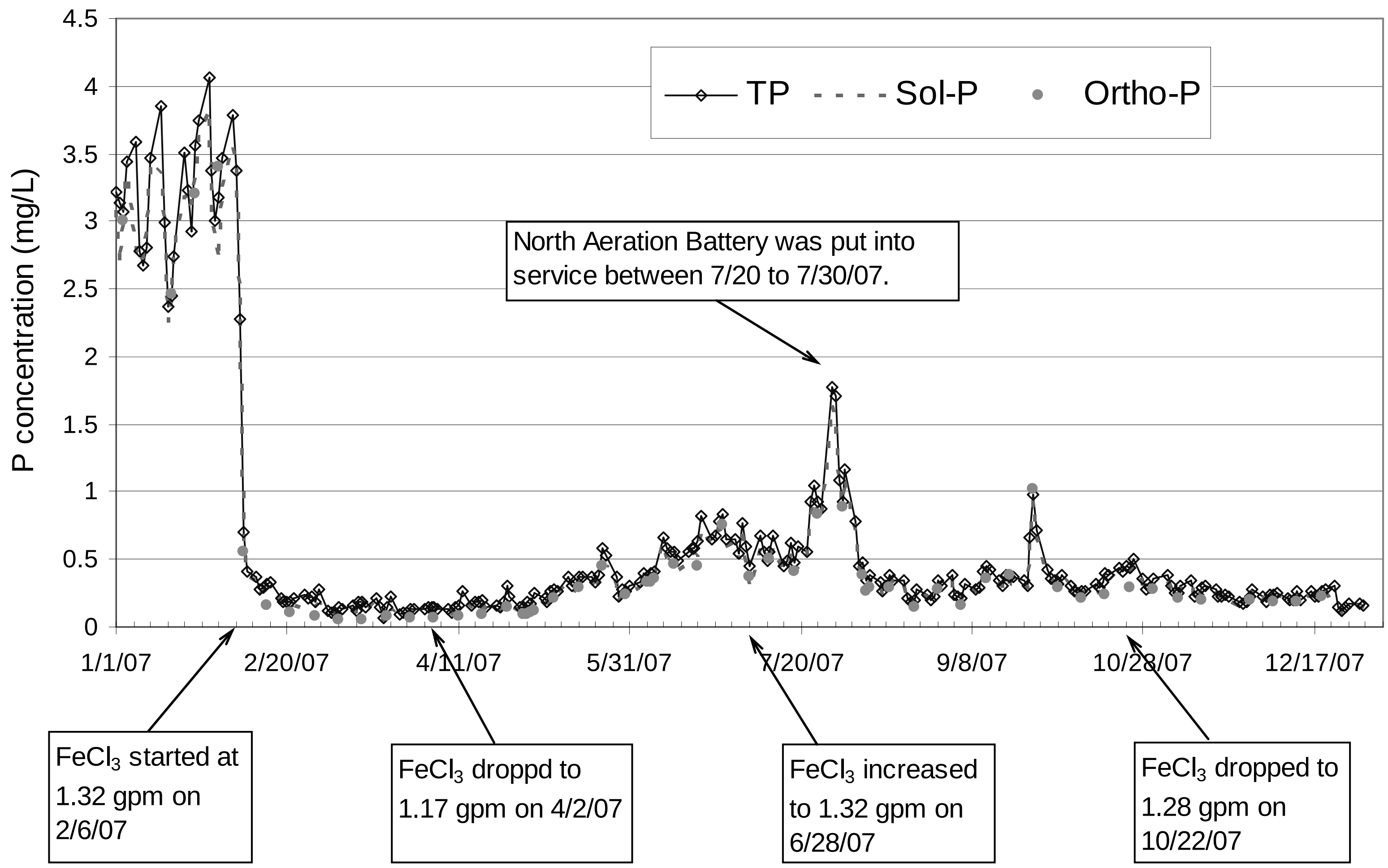


FIGURE II-2: IMHOFF EFFLUENT SUSPENDED SOLIDS, 2005 DAILY PLANT DATA COMPARED TO GPS-X MODEL SIMULATION WITH THREE IMHOFF BATTERIES IN SERVICE

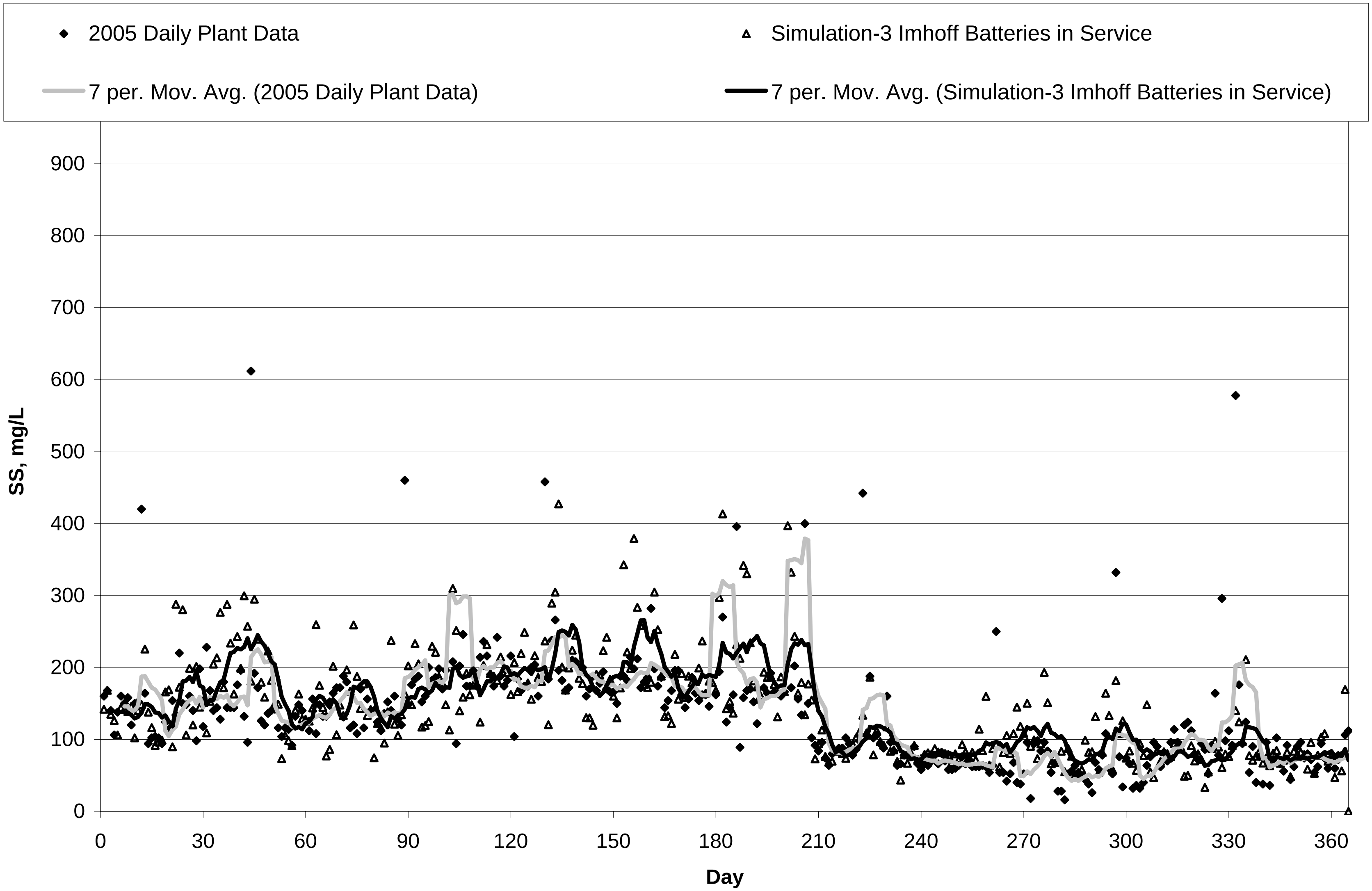


FIGURE II-3: COMPARISON OF DISSOLVED OXYGEN IN THE CHICAGO AREA WATERWAY GIVEN BASELINE AERATION VERSUS ADDITIONAL SIDESTREAM ELEVATED POOL AERATION PUMPS IN SERVICE (7/12–9/14/01)

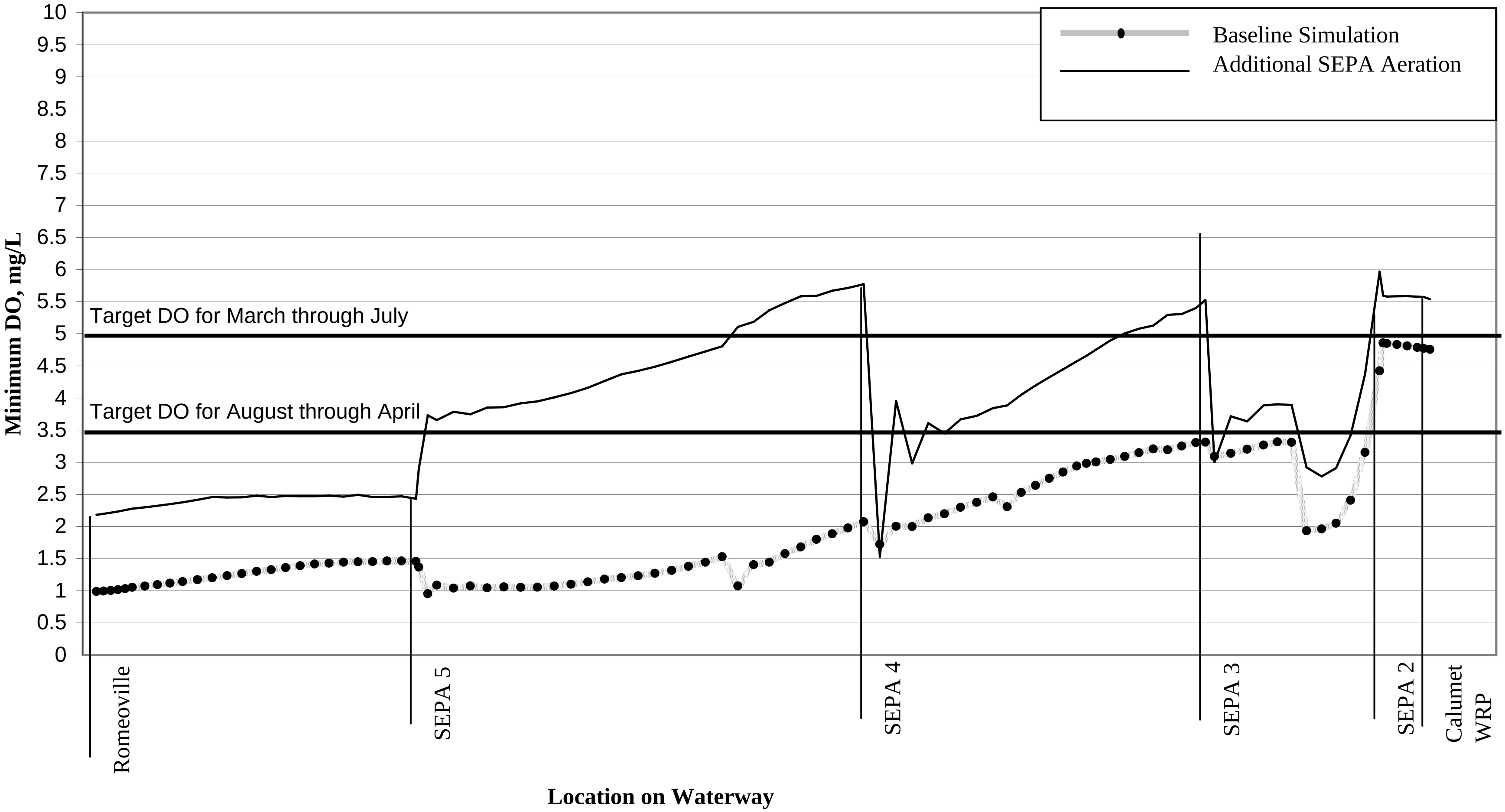


FIGURE II-4: COMPARISON OF DISSOLVED OXYGEN IN THE CHICAGO AREA WATERWAY GIVEN BASELINE AERATION VERSUS ADDITIONAL SIDESTREAM ELEVATED POOL AERATION PUMPS IN SERVICE (9/1–11/9/01)

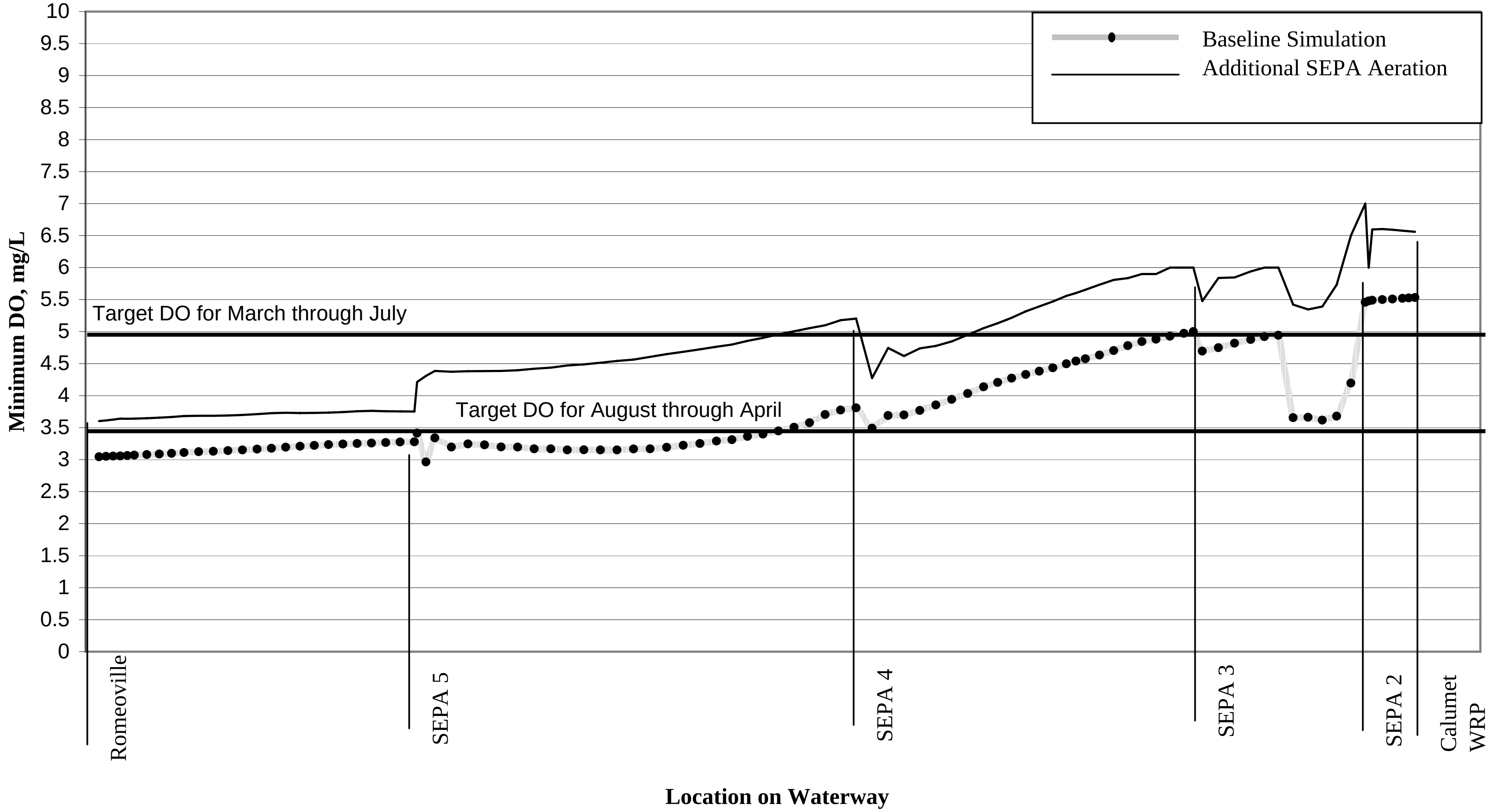


FIGURE II-5: COMPARISON OF DISSOLVED OXYGEN IN THE CHICAGO AREA WATERWAY GIVEN BASELINE AERATION VERSUS ADDITIONAL SIDESTREAM ELEVATED POOL AERATION PUMPS IN SERVICE (5/1–8/11/02)

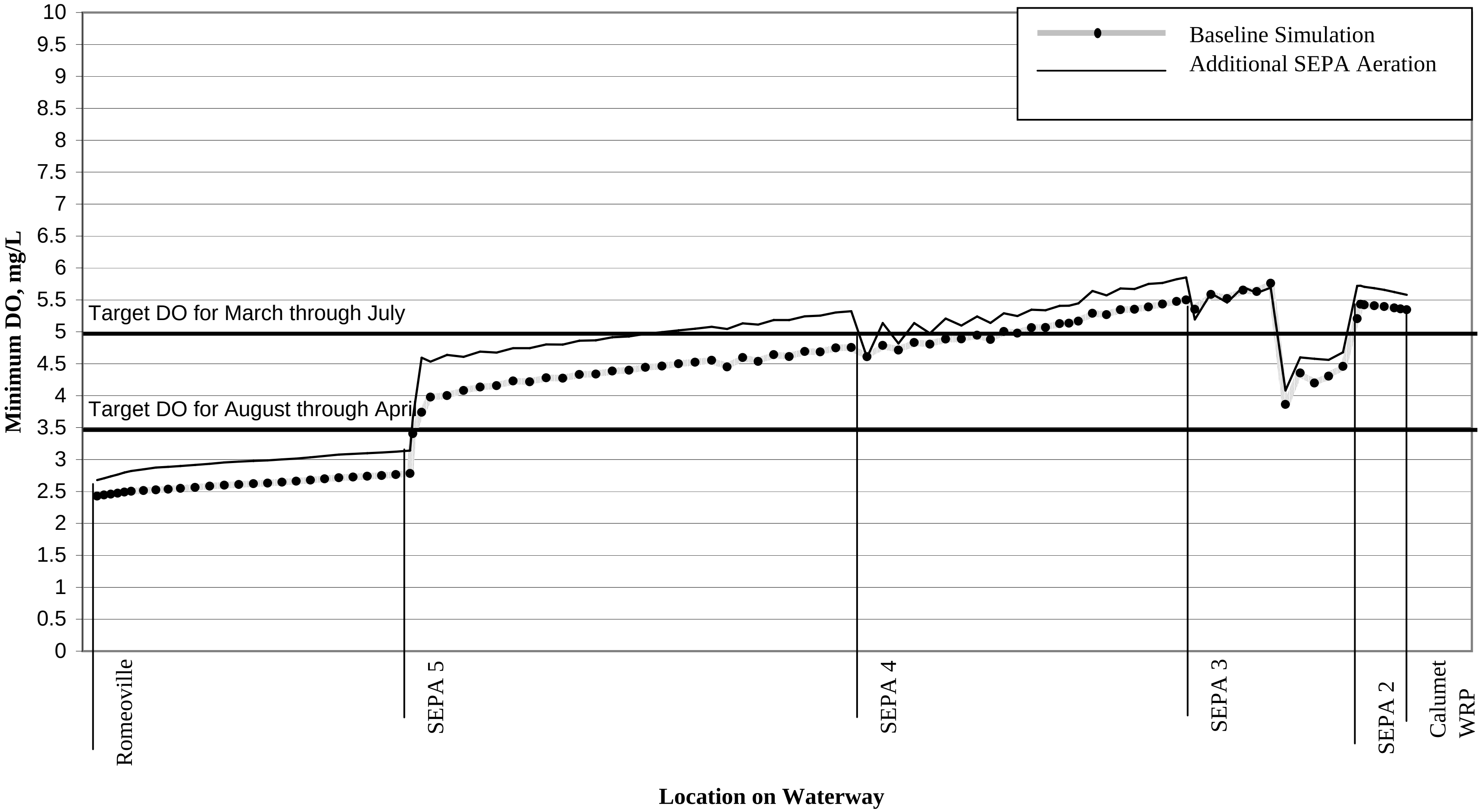
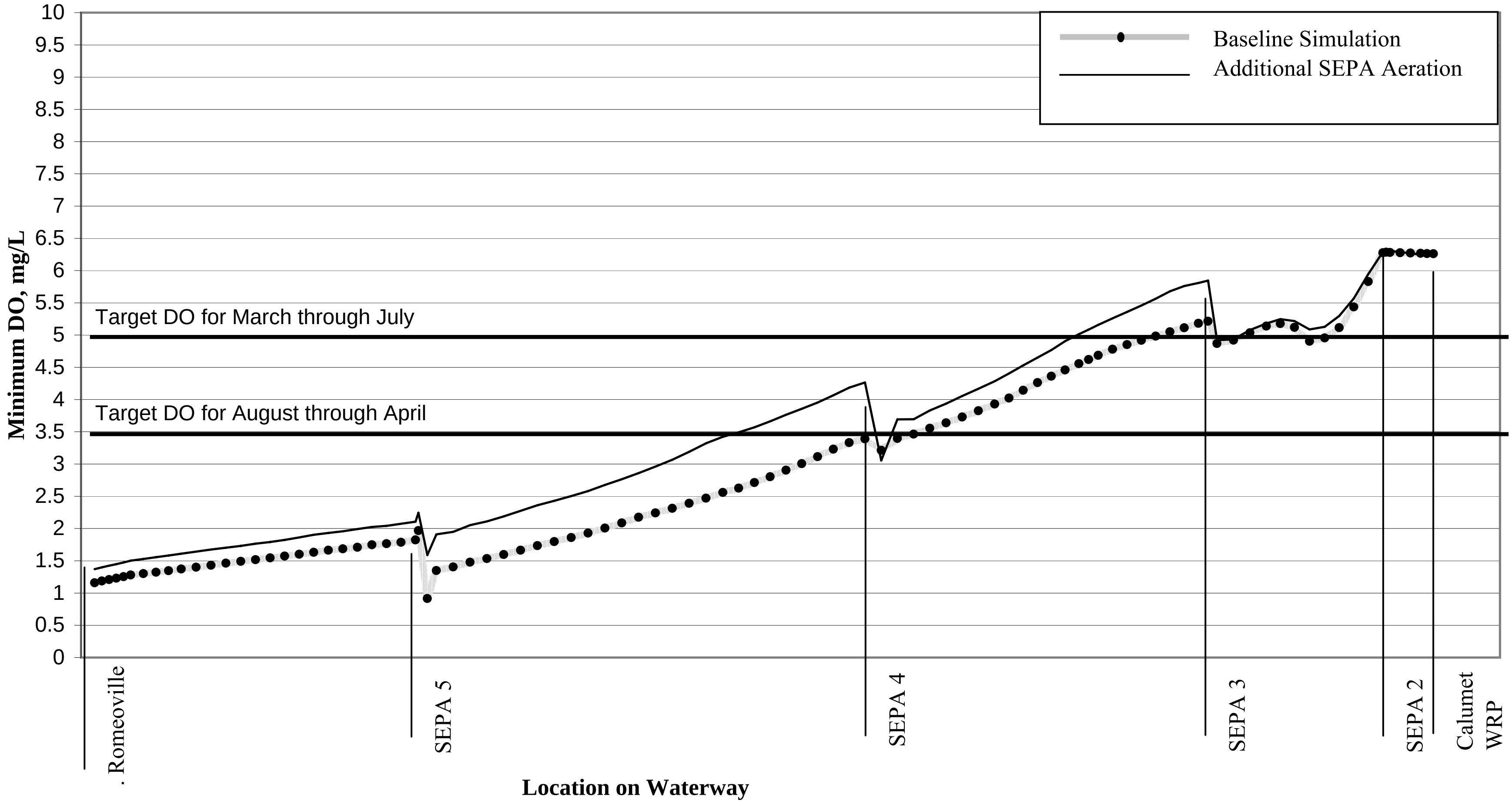


FIGURE II-6: COMPARISON OF DISSOLVED OXYGEN IN THE CHICAGO AREA WATERWAY GIVEN BASELINE AERATION VERSUS ADDITIONAL SIDESTREAM ELEVATED POOL AERATION PUMPS IN SERVICE (8/10–9/23/02)



BIOSOLIDS UTILIZATION AND SOIL SCIENCE SECTION

BIOSOLIDS UTILIZATION AND SOIL SCIENCE SECTION

The Biosolids Utilization and Soil Science Section is responsible for determining, through monitoring and research activities, the environmental impact of the District's biosolids applications on agricultural fields, disturbed and urban lands, and landfill sites. The environmental monitoring component of the program includes the sampling and analysis of biosolids, waters, soils, and plant tissue as required at biosolids land application sites, landfills, and biosolids drying facilities. The results of this monitoring program are reported to the Illinois Environmental Protection Agency (IEPA) and the United States Environmental Protection Agency (USEPA). The research component consists of demonstrations and applied research to support the local marketing of biosolids, address regulatory concerns, and provide technical support for biosolids marketing. The section is responsible for providing technical support for biosolids marketing and oversight of technical aspects of biosolids land application contracts. The section also provides technical support to the native landscape conversions at the District's water reclamation plants (WRPs), and the District's stormwater management program.

Fulton County Environmental Monitoring

The Fulton County Land Reclamation Site is a large tract of land, 6,122.5 hectares (15,264.5 acres), owned by the District in Fulton County, Illinois. Approximately 600 hectares (1,483 acres) were sold through auction in fall 2004. The site is used to recycle biosolids for the purpose of reclaiming mine soil and fertilizing agricultural crops. To satisfy the permit requirements of the IEPA 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 waters, groundwaters, soils, and crops. The Land Reclamation Laboratory is responsible for collecting and analyzing environmental monitoring samples from the Fulton County site. Termination of monitoring soil, crop, and surface and groundwater sites was approved by the IEPA in September 2006; and the coal refuse areas in July 2007.

Summary. No supernatant or biosolids were applied to Fulton County fields during 2007. Supernatant was last applied in 1995 and biosolids were last applied in 2004.

Water monitoring was conducted in the first and second quarters of 2007 and included:

- sampling of 19 lysimeters and three drainage tiles at the St. David coal refuse pile.
- sampling of three lysimeters at the Morgan Mine coal refuse pile quarterly.
- sampling of 10 lysimeters at the United Electric Company (UEC) coal refuse pile quarterly.

Water monitoring also included sampling of the discharges from the Acid-Mine Lake (AML) receiving drainage from the UEC coal refuse in January only. The monitoring data was submitted to the IEPA in monthly reports. Termination of the monitoring of AML was approved by the IEPA in February 2007 under National Pollutant Discharge Elimination System (NPDES) Permit No. IL0063801.

Corn Fertility Experiment on Calcareous Mine Spoil. Since 1973, the District has had 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 management of biosolids and crops.

This is the longest running continuous biosolids research experiment in the country. Data on metal uptake in corn tissues from these plots were used in the risk assessments conducted by the USEPA to develop the 40 CFR Part 503 biosolids regulation, which was promulgated in 1993. All 35 years of soil and plant tissue samples are available in the sample repository at the Fulton County Land Reclamation Laboratory.

The study consists of four treatments of biosolids or commercial fertilizer applied to the plots each year. The amounts of biosolids or commercial fertilizer added annually for each treatment are listed in Table III-1, along with the cumulative totals of biosolids applied per plot through 2007. Table III-2 shows a four-year comparison (2004 to 2007) of soil data from the experimental plots. Table III-3 shows the nutrient and metal concentrations in corn grain for the four treatments. Table III-4 shows the comparison of the corn grain and stover yields for 2005 through 2007.

Phosphorus Studies. As part of the studies that are conducted to address environmental impacts from land application of biosolids phosphorus in 2006, work was done on the Biosolids P Runoff Study located in Field 63 and the Biosolids P Availability Study located in Field 83 at the Fulton County site. Details on this work are presented in the Biosolids P Studies section of this chapter of the report.

Hanover Park Fischer Farm

The Hanover Park Fischer Farm is a 48-hectare (120 acres) tract of land, which utilizes all biosolids generated at the Hanover Park WRP. The farm, located on the south side of the WRP grounds, has seven gently sloping fields, each surrounded by a berm to control surface runoff. Anaerobically digested biosolids are applied by injection from tank trucks. The IEPA operating permit (No. 2002-SC-0672) 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 have been sampled twice monthly since biosolids applications began in 1979. The analytical data for groundwater sampled from these wells were submitted to the IEPA in the quarterly monitoring reports for 2007 (Report Nos. 07-27, 07-53, 07-78, and 08-14).

Groundwater Quality Monitoring at Solids Management Areas

Groundwater quality is monitored at 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% or greater.

Groundwater Quality Monitoring at the John E. Egan Water Reclamation Plant Solids Management Area. In 1986, paved solids drying areas were constructed at the John E. Egan Water Reclamation Plant (WRP) facility. However, since all biosolids generated at the Egan WRP are currently utilized wet as centrifuge cake through the farmland application program, the Egan drying site is no longer being used. The IEPA operating permit (No. 2005-AO-4282) for this drying facility does not require groundwater monitoring unless drying resumes at the site. In October 1986, lysimeters were installed at the John E. Egan WRP for sampling groundwater immediately below the drying site. From June 12, 2003 sampling was discontinued following the IEPA's approval of a request from the District to discontinue monitoring. Hence, the submission of groundwater analytical data in quarterly monitoring reports to the IEPA was not required in 2007.

Groundwater Quality Monitoring at the Calumet Water Reclamation Plant Solids Management Area. The Calumet West and Calumet East SMAs were constructed at the Calumet Water Reclamation Plant (WRP) in 1986 and 1990, respectively. The IEPA operating permit (No. 2005-AO-4281) for these facilities requires groundwater monitoring. Lysimeters installed at both Calumet drying sites are sampled once per month. Analytical data were submitted to the IEPA in the quarterly reports for water samples taken in 2007 from the three lysimeters at the Calumet West SMA (Report Nos. 07-33, 07-55, 07-73, and 08-7) and from the six lysimeters at the Calumet East SMA (Report Nos. 07-32, 07-54, 07-72, and 08-6).

Groundwater Quality Monitoring at Lawndale Avenue Solids Management Area. In 1983, the District began biosolids drying operations on clay surface cells at Lawndale Avenue Solids Management Area (LASMA). These drying surfaces were paved with asphalt in 1984. The IEPA operating permit for this site (No. 2005-AO-4283) requires groundwater monitoring.

Lysimeters and wells installed at LASMA are sampled monthly and quarterly, respectively, as required by the operating permit. The analytical results for lysimeter and well samples collected in 2007 were submitted to the IEPA in quarterly monitoring reports (Report Nos. 07-30, 07-57, 07-75, and 08-30).

In 2005, lysimeters L-3, L-4 and L-5 at LASMA were replaced by L-3N, L-4N, and L-5N, respectively because they were not functioning properly. The old and new lysimeters were monitored simultaneously. In 2007, the monitoring of the old lysimeters was terminated following approval by the IEPA.

Groundwater Quality Monitoring at Ridgeland Avenue Solids Management Area. The solids drying area at Ridgeland Avenue Solids Management Area (RASMA) was originally constructed with a clay surface and drying began in 1987, until the area was paved with asphalt in 1992 and 1993.

The IEPA operating permit for this site (No. 2005-AO-4283) requires groundwater monitoring. Lysimeters installed at RASMA are sampled biweekly, as required by the operating permit. Analytical results for the lysimeter samples collected during 2007 at this site were submitted to the IEPA in quarterly monitoring reports (Report Nos. 07-35, 07-58, 07-76, and 08-10).

In 2005, lysimeter L-4 at RASMA was replaced by L-4N, because it was not functioning properly. The old and new lysimeters were monitored simultaneously. In 2007, the monitoring of the old lysimeter was terminated following approval by the IEPA.

Groundwater Quality Monitoring at Harlem Avenue Solids Management Area. In 1990, the District began biosolids drying operations at Harlem Avenue Solids Management Area (HASMA). The IEPA operating permit for this site (No. 2004-AO-2591) requires biweekly groundwater monitoring. Analytical data for water sampled from the four lysimeters in 2007 were submitted in quarterly reports to the IEPA (Report Nos. 07-34, 07-56, 07-74, and 08-8).

Groundwater Quality Monitoring at the 122nd and Stony Island Solids Management Area. In 1980, drying of biosolids at the SMA located at 122nd Street and Stony Island Avenue was started on clay surface drying cells. The drying cells were paved in 1992. The IEPA operating permit for this drying facility (No. 2005-AO-4283) requires groundwater monitoring. Analytical results for water sampled monthly during 2007 from the four lysimeters at this drying facility were submitted to the IEPA in quarterly monitoring reports (Report Nos. 07-17, 07-59, 07-77, and 08-11).

Biosolids Phosphorus Studies

Land application of biosolids and other soil amendments can cause phosphorus (P) in soils to increase to excessive levels that can potentially contaminate water bodies through surface runoff. Currently, a large portion (over 35 percent) of the District’s biosolids is managed through the farmland application program in which Class B centrifuge cake biosolids are used as fertilizer on area farms. In an effort to minimize P contamination of surface waters, many states are beginning to implement phosphorus-based (P-based) agronomic biosolids application rates in place of the nitrogen-based (N-based) application rates that are currently used. Phosphorus-based application rates are developed based on P content of both the amendments and the soil, and on site characteristics that affect the potential for surface runoff to water bodies. The P-based agronomic biosolids application rates are much lower than the N-based rates. The P-based rates may substantially reduce the viability of land application programs in Illinois, because the low application rates of biosolids could be operationally impractical and unattractive to farmers.

In 2003, the Biosolids Utilization and Soil Science Section began to collaborate with the IEPA to initiate studies to address the potential for environmental impacts associated with application of District biosolids to cropland. Studies were developed to address the following objectives:

1. To determine the bioavailability of P in District biosolids.

2. To estimate the critical biosolids P application rate (environmental impact threshold) to farmland above which the potential for P losses in surface run-off water increases significantly.

3. To evaluate potential for P losses in runoff following recent application of centrifuge cake biosolids and aged air-dried biosolids, which are either surface, applied or incorporated in soil.

4. To evaluate the effectiveness of two lengths of vegetated buffer strips established in the setback zones of land application fields in controlling P runoff. The information obtained from this objective will be used to determine if buffer strips can be used within the required setback zone to allow the land application of biosolids to be continued at N-based rates without the potential for significant P runoff losses from farmland, where soil test P exceeds environmental impact thresholds.

This work includes the following studies:

- Bioavailability of P in District biosolids - Greenhouse Study
- Bioavailability of P in District biosolids - Field Study
- Potential of phosphorus runoff in biosolids amended soils
- Biosolids P runoff field study

Bioavailability of P in District Biosolids – Greenhouse Study. The greenhouse study was started in 2004. The study was designed to evaluate the bioavailability of P in the District's air-dried Class A biosolids and centrifuge cake Class B biosolids, relative to triple superphosphate (TSP) fertilizer P (Objective 1). This study was completed in 2006 and a report is being prepared.

Bioavailability of P in District Biosolids – Field Study. A study was initiated in 2005 at the District's Fulton County site at Field 83, which consists of non-mined soil, to test the bioavailability of biosolids P under field conditions (Objective 1). Before starting the study, the field was cropped for three years without fertilizer P application to deplete the soil to a P deficient level (less than 20 mg P/kg Bray P1 soil test level). This study evaluates crop P uptake in soil amended with two P sources: Class A air-dried biosolids from the Calumet WRP and TSP fertilizer. The experimental layout is a randomized complete block design with four blocks of 10 treatments. The treatments include a control of zero application, sets of four each of TSP and biosolids application established based on the total P loadings associated with biosolids application rates, ranging up to 22.4 Mg/ha (10 dry tons/ac), and a high biosolids rate of 33.6 Mg/ha (15 dry tons/ac). The 10 dry tons/ac rate is equivalent to the average agronomic rate of Class B biosolids utilized in the District's farmland application program. The high biosolids rate of 15 dry tons/ac was used based on the preliminary results from the greenhouse component of the bioavailability study, which indicated that the bioavailability of the biosolids P is much lower than TSP fertilizer P. In November 2005, the treatments (biosolids and TSP fertilizer) were applied to plots 90 feet wide by 120 feet long (0.25 acres) and incorporated into the plow layer (approximately 6 inches). Corn is being planted as the test crop in the spring of 2006, 2007 and 2008, with only the application of supplemental K and N fertilizer, and no additional application of biosolids or TSP treatments. Soil samples are collected at the beginning of each growing season to measure soil P concentration. Crop samples are collected to measure grain and dry matter yields and tissue P concentration.

Bray-1 soil test P and water soluble P increased with P rate. This response was higher for TSP than for biosolids (Figure III-1) and was lower in 2007 than in 2006. The data show P application through biosolids and TSP increases the level of bioavailable P in soil, but the increase in bioavailable P was not reflected in crop yield or P uptake.

Potential for P Runoff in Biosolids Amended Soils. This study was conducted to address Objective 3, to evaluate potential for P losses in runoff following recent applications of centrifuge cake biosolids and aged air-dried biosolids that are either surface applied or incorporated in soil. This study was completed in 2006 and a report of this work is being prepared.

Biosolids P Runoff Field Study. This study was designed to address Objective 3, to evaluate the effectiveness of different lengths of vegetated buffer strips. In 2004, five noncontiguous locations in Field 63 at the Fulton County site were selected as main plots. Each of the main plots was 0.72-ha (1 ac), 122 m (400 ft) long along the slope by 61 m (200 ft) wide, and was split into two subplots 30.5 m (100 ft) wide by 61 m (200 ft) long. The plots were graded lightly to improve surface uniformity such that the slope throughout most of the plots ranged from 3 to 5 percent. A vegetated buffer area was established by planting a mixture of alfalfa (*Medicago sativa* L.) and bromegrass (*Bromus inermis*) on the entire 61-m length of the down-slope portion of the main plots. In each subplot, runoff collection devices were installed at the up-slope end, the middle (30.5 m), and the down-slope end (61 m) of the buffer strip. The typical layout of the main plots is shown in Figure III-2. This setup will allow us to evaluate the effectiveness of two lengths of vegetative buffer strips, 30.5 m and 61 m, in controlling P runoff from the amended portion of the subplots. The current surface water setback in the IEPA Part 391 design criteria for land application of biosolids is 61 m.

In spring 2005, biosolids were applied to the up-slope half of eight of the subplots at two loading rates of 11.25 and 22.5 Mg/ha (5 and 10 dry tons/ac), such that there were four replicates of each amended plot and two unamended control plots. The 22.5 Mg/ha biosolids rate represents the typical N-based application rate of District biosolids. No data were collected in 2007, due to inadequate design of the runoff collection system. The runoff collection system in the plots is being redesigned so that in 2008 and 2009, data will be collected on concentrations of dissolved and particulate P in runoff water, as well as runoff volumes to evaluate mass of P runoff.

Farmland Application of Class B Biosolids Project

A major portion of the District's biosolids is managed through farmland application of Class B centrifuge cake. Farmland application of Class B biosolids is cost-effective to the District and the nutrients in biosolids provide savings in fertilizer costs to the farmers. However, the practice of Class B biosolids application to farmland remains controversial and has been persistently attacked by the environmentalists. Most of the concerns stem from misinformation about the potential human health and environmental risks from pathogens and trace metals in the Class B biosolids applied to farmland. These concerns need to be addressed to protect the viability and sustainability of the District's Class B centrifuge cake biosolids application to farmland program.

In the fall of 2004, the District began a research and demonstration project on farmers' fields in Will and Kankakee Counties to demonstrate the safety of farmland application of Class B centrifuge cake biosolids and to improve the overall public perception and understanding of communities residing in the vicinities of biosolids-amended farmlands. A large proportion of the District's Class B biosolids is currently being applied to farmland in these two counties.

Plots and Treatments. The project was designed to evaluate and compare the impact of various rates of biosolids (0 to 200 percent of conventional agronomic application rate) and commercial N fertilizer (0 to 150 percent of agronomic N application rate) application on soil fertility, corn yield, and subsurface water quality. Plots were established on a 40-acre parcel of clayey soil in the township of Florence in Will County and on a 20-acre parcel of sandy soil in the township of Saint Anne in Kankakee County. Prior to biosolids application, lysimeters were installed at each site for monitoring the impact of biosolids application on subsurface water quality. Details of plot layout, treatments, and location of lysimeters are given in Figure III-3.

Following the conventional practices in each county, the biosolids and fertilizer treatments are applied in the fall at the Will County site and in the spring just before planting at the Kankakee County site each year. The fall application in Will County is done to reduce the amount of field work required in the spring because the heavy textured soils drain slowly, and tend to stay wet for longer periods of time, which may leave only a narrow window for completing the required field work before planting. The treatments are applied similarly each year for the duration of the project. Keeping this in mind, the treatments were applied in fall 2004, 2005, and 2006 at the Will County site and in spring 2005, 2006, and 2007 at the Kankakee County site.

Sampling and Analyses. Details of the sampling schedule and analysis of soil, plant tissues, and water samples are given in Table III-5. Soil sampling was done at both sites prior to application of biosolids and after harvesting corn in the fall. At the Will County site, soil was sampled at four depths (15, 30, 60, and 90-cm depths). At the Kankakee County site, soil was sampled at four depths (15, 30, 60, and 120-cm depths). The soil samples were air-dried, ground, and sieved through a 2-mm sieve and stored in plastic bottles for chemical analysis.

Soil Fertility. The results of soil analysis for the 0- to 6-inch depth for both the Will and Kankakee County plots are presented in Table III-6. In the Will County plots, the inorganic N levels in soil fluctuated, but overall N levels showed increase after biosolids application (Table III-6). In the Kankakee County plots, the data show that most of the applied N was removed from the plow layer (0 to 6 inches), except in the highest rates of biosolids plots in which some accumulation of residual inorganic N was observed in the plow layer. The relatively low levels of residual inorganic N observed in soil compared to the amount of N applied indicate that most of the applied N was utilized by the crop, especially at the Will County site where very little movement of inorganic N is expected below the plow layer (Table III-6).

Nutrients and Trace Metals in Subsurface Water. The mean concentrations of nutrients and trace metals in the subsurface water samples collected from lysimeters in the Will and Kankakee County plots during March through December 2007 are presented in Tables III-7 and III-8, respectively. In the Will County plots, there were no noteworthy trends in TKN, NO_3-N and total P concentrations in lysimeter samples over time (data not shown). The mean NO_3-N in the lysimeter from the biosolids and fertilizer plots were similar and higher than in the control.

Similarly, in the Kankakee County lysimeters, there were no noteworthy trends in TKN, NH_3-N and total P concentrations over time. The mean NO_3-N concentrations ranged from 3.6 to 13.6 mg/L and the highest values were observed in the lysimeters from 30 wet tons/ac biosolids plot (Table III-8).

The mean trace metal concentrations observed for most of the lysimeters at both Will and Kankakee County plots were very low and were either below or close to the detection limits (Tables III-7 and III-8). There was no trend among the plots amended with various rates of fertilizers and biosolids. The data suggest that there was no leaching of trace metals from biosolids-amended soils.

Grain Yield. The corn yield response to application rates of fertilizer N and biosolids in the Will and Kankakee County plots are presented in Figure III-4. For the biosolids treatments, the amount of plant available N was calculated using the conventional formula. At the Will County plots, corn grain yields generally increased with increasing rates of fertilizer N and biosolids (Figure III-4A). The highest corn grain yield in the fertilizer treatments (215 bu/ac) was observed in the 370 lbs/ac N plot, and the highest corn grain yield in the biosolids treatments (226 bu/ac) was observed in the 80 wet ton/ac biosolids plot.

In the Kankakee County plots the corn grain yield generally increased with application of fertilizer N, except in the biosolids plots in which the highest yield was observed in the 10 wet ton/ac biosolids treatment. This was caused by the lack of moisture because the biosolids plots, except the 10 wet ton/ac biosolids treatment, were outside the irrigation pivot range and were not properly irrigated (Figure III-4B).

Carbon Sequestration in Soil Resulting from the Long-Term Application of Biosolids for Land Reclamation. Investigations on the impact of application of biosolids for land reclamation on carbon (C) sequestration in soil was conducted at Fulton County, Illinois, using 41 fields, ranging in size from 3.6 to 66 ha. The fields received biosolids at cumulative loading rates from 455 to 1,654 dry Mg/ha for 8 to 23 years in rotation from 1972 to 2004. The fields were cropped with corn, wheat, and sorghum, and occasionally with soybean and grass or fallowed. The soil organic carbon (SOC) data obtained from routine monitoring and from additional analyses for the period 1972 to 2006 were evaluated. The SOC increased rapidly with the application of biosolids while it fluctuated slightly in fertilizer controls. The peak SOC in the 0 – 15 cm depth of biosolids-amended fields ranged from 4 to 7 percent. In fields where biosolids application ceased for 22 years, SOC was still higher than the initial levels. Over the 34-year period, the mean net soil C sequestration was 1.73 (0.54 – 3.05) Mg C/ha/yr in biosolids-amended fields as compared to -0.07 to 0.17 Mg C/ha/yr in fertilizer controls, demonstrating a high potential of soil C sequestration by the land application of biosolids. Soil C sequestration was significantly correlated with the biosolids application rate (Figure III-5). This relationship can be expressed as: $y = 0.064x - 0.11$, in which y is the annual net soil C sequestration (Mg C/ha/yr) and x is the annual biosolids application in dry weight (Mg/ha/yr).

Technical Support for Biosolids Management

The Biosolids Utilization and Soil Science Section provides technical support for biosolids management to both the Maintenance and Operation (M&O) Department and biosolids users. This ensures full regulatory compliance of these projects and enhances the successful and safe use of the District's biosolids. The Section is also responsible for conducting and communicating the results of applied research on the beneficial use of the District's biosolids. The objectives of this research are to provide information on agronomic and environmental impacts of biosolids and to promote the beneficial use of biosolids. The support the section provides to the biosolids management program consists of the following:

1. Monitoring of air-dried biosolids products for compliance with USEPA and IEPA standards.

2. Collecting samples for internal studies and external requirements.

3. Reporting relevant data and information to contractors, biosolids users, IEPA, and USEPA.

4. Providing oversight support for District contracts for application of Class B centrifuge cake biosolids to farmland.

5. Educating biosolids users to ensure compliance with state and federal regulations governing biosolids use, and to provide technical information related to specific planned uses of biosolids.

6. Documenting biosolids use at major projects to produce case studies to promote future use of biosolids.

7. Initiating and documenting demonstration scale projects using biosolids to increase public acceptance and promote future projects.

8. Providing surveillance and documentation of management practices at local biosolids use projects.

9. Maintaining year-round demonstrations of biosolids as a soil conditioner in the Lue-Hing R&D Complex greenhouse and hosting tours to educate potential biosolids users and promote local marketing.

10. Conducting applied research on agronomic and environmental aspects of biosolids use as a fertilizer, soil conditioner and topsoil substitute.

11. Presenting information at local and national scientific conferences and at meetings with potential biosolids users, promoting the beneficial use of the District's biosolids.

12. Interacting with state and federal regulators to defend the District's biosolids management activities, review and comment on development of new regulations, and obtain permitting or approval for new biosolids projects.

In 2007, the Section provided technical support, in the form of one or more of the activities listed above for several biosolids projects and potential users. Examples of biosolids projects conducted, or supported, by the section in 2007 include:

1. Use of biosolids as a soil conditioner or fertilizer topdressing by 11 schools, 13 park districts and suburban villages, 8 golf courses, 2 athletic clubs, 2 landscaping companies, and 1 District property.

2. Use of biosolids as a topsoil substitute in the final protective layer at various landfills.

3. Maintenance of plots to demonstrate the beneficial use of Class B biosolids on farmland.

4. Collaborate with the University of Florida and Virginia Institute of Marine Sciences on studies of the fate of emerging contaminants in biosolids and biosolids-amended soil.

5. Continue collaborative research with North Shore Country Club to assess the effectiveness of biosolids as a substitute for peat and other soil amendments typically utilized in construction of golf course greens and fairways.

6. Collaborate with University of Illinois to operate research and demonstration plots at various golf courses and recreational fields.

7. Collaborate with the City of Chicago to evaluate and promote the use of biosolids for development of parks and recreational areas in Chicago.

8. Review field information packets for potential application fields under the Class B biosolids to farmland contract. 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. Approval or disqualification of the proposed fields is recommended to the M&O Department.

9. Preparation of biosolids information pamphlets to promote local marketing of biosolids.

10. Marketing of biosolids through attendance and exhibitions at various local conferences, mass mailing of promotional materials and phone calls to school districts and other potential biosolids users.

Technical Support for Native Landscaping

During 2007, the section provided technical support for installation and maintenance of native prairie landscaping at the District's WRPs. The activities included review of contracts prepared by the M&O Department, project-planning meetings with M&O and contractors, herbicide application, and onsite visits to assist in conducting performance evaluation of the native landscaping.

Technical Support for Stormwater Management

During 2007, the section worked with the Engineering and the M&O Departments to evaluate best management practices for stormwater management. The activities include:

1. Collaboration with the Chicago Department of Transportation in monitoring the performance of the Cermak Avenue Streetscape project.

2. Attendance at local seminars and demonstrations.

3. Review and comment on permeable pavement parking lot demonstration project.

TABLE III-1: BIOSOLIDS APPLICATION RATES AT THE CORN FERTILITY EXPERIMENTAL PLOTS AT THE FULTON COUNTY RECLAMATION SITE FOR 2007

Treatment[1]	Biosolids Application Rate (Dry Weight Basis)			
	Annual		Cumulative	
	Mg/ha	tons/acre	Mg/ha	tons/acre
Control	0.0	0.0	0.0	0.0
1/4 Max	16.8	7.5	556	250
1/2 Max	33.6	15.0	1,112	496
Max	67.2	30.0	2,219	991

[1]Control plots receive 336-224-112 kg/ha of N-P-K annually and biosolids amended plots receive 112 kg K/ha annually.

TABLE III-2: MEAN pH, ELECTRICAL CONDUCTIVITY (EC), AND CONCENTRATIONS OF ORGANIC CARBON, NUTRIENTS AND METALS IN SURFACE SOIL[1] FROM THE CORN FERTILITY EXPERIMENTAL PLOTS AT THE FULTON COUNTY RECLAMATION SITE FOR 2004 - 2007

				Organic	0.1N HCl Extracted[3]						Concentrated HNO_3 Extracted							
Plot[2]	Year	pH	EC	Carbon	Zn	Cd	Cu	Cr	Ni	Pb	Zn	Cd	Cu	Cr	Ni	Pb	TKN	Tot-P
			dS/m	%	mg/kg													
Check	2004	6.7	0.68	0.92	113	8.61	45.9	14.4	10.4	21.5	144	8.6	73.8	116	36.5	35.1	1,485	2,611
	2005	7.4	0.36	1.51	200	13.6	79.1	22.4	11.3	28.1	254	12.1	123	174	44.4	54.7	1,728	2,828
	2006	7.3	0.48	1.46	187	13.0	78	22.7	13.7	29.3	253	13.6	126	173	45.6	54.8	1,440	2,468
	2007	6.9	0.31	1.27	74.1	6.8	7.0	0.60	4.2	0.05	270	14.3	123	181	47.5	58.1	1,739	3,026
1/4	2004	7.4	0.23	1.76	251	17.8	106	32.3	15.8	43.1	299	16.4	144	218	47.7	66.1	2,384	4,330
	2005	7.4	0.40	2.39	366	25.1	143	41.7	18.6	46.5	435	24.1	212	306	58.5	96.1	2,465	4,536
	2006	7.2	0.41	2.20	326	22.6	134	40.1	20.1	46.3	422	23.7	212	295	59.0	92.6	2,152	3,936
	2007	6.8	0.31	2.12	115	9.9	7.0	0.50	5.4	0.01	500	26.4	231	336	61.8	106	2,846	4,904
1/2	2004	7.0	0.33	2.59	408	26.9	164	48.7	22.5	52.3	451	24.8	221	321	59.8	98.5	2,327	4,868
	2005	7.1	0.59	2.64	446	28.5	163	44.1	21.7	37.3	486	27.1	248	344	62.9	110	2,945	6,169
	2006	7.0	0.78	2.51	377	23.8	141	39.9	21.8	34.4	465	25.7	243	316	60.9	102	2,825	5,705
	2007	6.7	0.39	2.29	109	8.9	12.6	1.2	6.4	0.30	484	25.9	230	320	62.8	104	2,781	5,583
Max	2004	7.0	0.49	3.73	613	38.1	240	68.7	31.9	56.6	622	34.0	314	430	73.1	133	3,046	5,847
	2005	7.2	0.53	3.48	562	35.9	206	58.8	27.6	49.2	629	35.5	320	446	72.8	140	3,531	7,362
	2006	6.9	0.60	2.77	462	29.4	174	48.9	26.0	44.9	533	29.8	271	366	66.5	116	2,769	5,371
	2007	6.7	0.46	2.96	151	11.9	13.6	0.98	8.0	0.15	663	35.6	315	448	74.1	141	3,668	6,905

[1]Sampling depth = 0-15 cm.
[2]Check = No biosolids application - inorganic fertilizer. 1/4, 1/2, and Max = 16.8, 33.6, and 67.2 Mg/ha/yr biosolids loading rates, respectively.
[3]0.1N HCl extractable metals were done by using a single extraction in 2007 instead of 3 sequential extractions in previous years.

TABLE III-3: MEAN CONCENTRATIONS OF TKN, PHOSPHORUS, AND METALS IN 33P69 HYBRID CORN GRAIN COLLECTED FROM THE CORN FERTILITY EXPERIMENTAL PLOTS AT THE FULTON COUNTY RECLAMATION SITE IN 2007

Analyte[2]	Treatment[1]			
	Control	1/4-Max	1/2-Max	Max
	mg/kg			
TKN	14,742	15,003	16,752	16,737
P	3,071	3,195	3,031	3,068
Zn	24.4	26.9	26.2	27.1
Cd	< 0.02	< 0.02	< 0.02	< 0.02
Cu	1.2	1.3	1.2	1.1
Cr	0.36	0.34	0.30	0.27
Ni	1.0	1.0	0.67	0.59
Pb	0.51	0.41	0.41	0.33
K	4,514	4,473	4,275	4,228
Ca	40.2	38.7	52.0	50.6
Mg	1,317	1,335	1,326	1,279

[1]Control = No biosolids application - inorganic fertilizer. 1/4-Max, 1/2-Max, and Max represent biosolids application rates of 16.8, 33.6, and 67.2 Mg/ha/yr, respectively.
[2]Tissue digested with HNO_3 for metals. TKN = Total Kjeldahl-N.

TABLE III-4: AVERAGE CORN GRAIN AND CORN STOVER YIELDS FOR HYBRID 33P69 GROWN AT THE CORN FERTILITY EXPERIMENTAL PLOTS FROM 2005 TO 2007

		Treatment[1]											
		Control			1/4-Max			1/2-Max			Max		
Harvested Tissue	Unit	2005[2]	2006	2007[3]	2005[2]	2006	2007[3]	2005[2]	2006	2007[3]	2005[2]	2006	2007[3]
Grain	bu/acre	6.8	43	45	9.4	70	36	6.4	84	36	6.8	90	24
	Mg/ha	0.43	2.7	2.8	0.59	4.4	2.2	0.40	5.3	2.3	0.43	5.6	1.5
Stover	tons/acre	1.1	2.2	1.5	0.81	2.6	0.88	0.92	2.9	1.1	1.1	3.3	1.2
	Mg/ha	2.4	5.0	3.4	1.8	5.9	2.0	2.1	6.4	2.4	2.6	7.5	2.7

[1]Control = No biosolids application - inorganic fertilizer. 1/4-Max, 1/2-Max, and Max represent biosolids application rates of approximately 16.8, 33.6, and 67.2 Mg/ha/yr, respectively.
[2]Severe drought year.
[3]Planting repeated twice in 2007 due to severe damage (seed predation) by birds.

TABLE III-5: SAMPLING SCHEDULE AND ANALYSES OF SOIL, PLANT TISSUES, AND SUBSURFACE WATER SAMPLES FOR THE FARMLAND APPLICATION OF CLASS B BIOSOLIDS PROJECTS

Sampling Event*	Sample Type	Parameters Analyzed
1	Deep soil cores	TKN, TP, KCl-ext. (NO_3-N, NH_3-N), Avail. P, Exch. Bases, HNO_3 acid-metals, 2:1 H_2O-ext. (pH, EC, SO_4-S, NH_3-N, NO_3-N), Hg, and OC
2	Shallow soil cores	KCl-ext. (NO_3-N, NH_3-N) and 2:1 H_2O-ext. (NH_3-N, NO_3-N)
3	Leaf tissues	TKN
4	Stover, stalk, and grain tissues	TKN, P, S, and HNO_3 acid-metals
5	Subsurface water	pH, P, EC, TKN, TP, NO_3-N, NO_2-N, NH_3-N, Ca, Na, K, Mg, Fe, Cd, As, Cr, Cu, Ni, Pb, Zn, Mo, Mn, and Co

*Sampling Event 1 first occurred before biosolids application and then repeats every year after crop harvesting; Sampling Event 2 occurs approximately two weeks after planting the corn and repeats every month until the silking stage; Sampling Event 3 occurs approximately one month after planting and repeats every month until the silking stage; Sampling Event 4 occurs at the time of harvesting; Sampling Event 5 occurs every month or after a 1 to 2-inch rainfall event.

TABLE III-6: MEAN LEVELS OF SOIL FERTILITY PARAMETERS IN SURFACE (0- TO 6-INCH) SOIL LAYER OF THE WILL AND KANKAKEE COUNTY RESEARCH AND DEMONSTRATION FIELDS BEFORE APPLICATION OF BIOSOLIDS AND INORGANIC FERTILIZERS, AND IN THE INDIVIDUAL PLOTS IN 2007 AFTER HARVESTING CORN

	Will County Plots				Kankakee County Plots			
Treatment[1]	pH[2]	EC[2]	Avail. P[3]	Inorg. N[4]	pH[2]	EC[2]	Avail. P[3]	Inorg. N[4]
		dS/m	mg/kg	mg/kg		dS/m	mg/kg	mg/kg
Before[5]	7.1	0.10	14	9.1	6.6	0.04	70	3.4
Control	7.2	0.12	15	5.2	6.5	0.05	76	1.7
BS-1	7.3	0.16	69	16.7	6.7	0.06	76	2.1
BS-2	6.7	0.30	66	18.6	6.2	0.15	103	9.6
BS-3	6.7	0.31	59	23.9	6.5	0.12	98	10.1
BS-4	6.7	0.37	65	23.1	6.1	0.17	105	16.5
BS-5	6.4	0.48	83	45.4	6.1	0.16	152	17.6
F-1	7.1	0.13	20	6.0	6.3	0.09	84	2.4
F-2	6.9	0.14	16	5.2	6.4	0.07	80	2.1
F-3	6.4	0.12	28	9.5	6.3	0.06	80	3.0
F-4	7.3	0.16	16	8.0	6.1	0.08	75	1.9
F-5	7.2	0.16	11	8.2	6.2	0.08	68	3.1
F-6	7.1	0.17	9	8.0	5.9	0.09	57	7.4

[1]Control = no N and recommended rate of P. For Will County plots, BS-1 to BS-5 = 20, 30, 40, 50, and 80 wet tons biosolids per acre; and F-1 to F-6 = 72, 118, 210, 260, 300, and 370 lbs N per acre. For Kankakee County plots, BS-1 to BS-5 = 10, 20, 30, 40 and 60 wet tons biosolids per acre; and F-1 to F-6 = 54, 77, 128, 160, 192, and 238 lbs N per acre. Nitrogen was applied as polymer-coated urea in Will County and as urea in Kankakee County. All plots received K at the recommended agronomic rate.

[2]1:2 (soil:water) ratio.

[3]Bray P1 method.

[4]Sum of KCl-extractable NH_4-N, NO_2-N, and NO_3-N.

[5]Soil samples were collected prior to application of biosolids and fertilizers in November 2004 in Will County and March 2005 in Kankakee County.

TABLE III-7: MEAN CONCENTRATIONS OF NUTRIENTS AND TRACE METALS[1] IN WATER SAMPLES TAKEN FROM THE LYSIMETERS[2] IN WILL COUNTY RESEARCH AND DEMONSTRATION PLOTS FROM MARCH THROUGH DECEMBER 2007

Parameter	Unit	Treatment			
		Control[3]	40 wet tons biosolids/ac[4]	260 lbs N/ac[5]	80 wet tons biosolids/ac[4]
TKN	mg/L	1.73	0.58	0.43	0.67
NH_3-N	"	0.266	0.064	0.029	0.039
NO_3-N[6]	"	21.5	74.3	77.0	66.9
Total P	"	0.11	0.07	0.06	0.07
Hg	µg/L	0.08	0.07	0.06	0.06
As	mg/L	0.015	0.011	0.010	0.011
Ba	"	0.146	0.146	0.145	0.158
Cd	"	0.0006	0.0004	0.0004	0.0005
Cr	"	0.002	0.002	0.002	0.002
Cu	"	0.003	0.002	0.002	0.003
Mn	"	0.051	0.040	0.011	0.020
Mo	"	0.013	0.008	0.011	0.009
Ni	"	0.003	0.002	0.001	0.003
Pb	"	0.007	0.006	0.005	0.007
Sb	"	0.049	0.041	0.039	0.042
Se	"	0.033	0.025	0.021	0.023
Tl	"	0.012	0.012	0.012	0.015
V	"	0.029	0.016	0.016	0.006
Zn	"	0.017	0.015	0.008	0.023

[1]In calculating mean concentrations of trace metals, method detection limits were used in place of non-detectable levels.
[2]Lysimeters were installed at 3.5-ft. depth.
[3]Received no N and recommended agronomic rate of P and K.
[4]Received recommended agronomic rate of K.
[5]Received recommended agronomic rate of P and K. Nitrogen was applied as polymer-coated urea.
[6]Sum of NO_2-N and NO_3-N.

TABLE III-8: MEAN CONCENTRATIONS OF NUTRIENTS AND TRACE METALS[1] IN WATER SAMPLES TAKEN FROM THE LYSIMETERS IN KANKAKEE COUNTY RESEARCH AND DEMONSTRATION PLOTS FROM MARCH THROUGH DECEMBER 2007

		Treatment/Sampling Depth					
		Control[2]		160 lbs N/ac[3]		30 wet tons biosolids/ac[4]	
Parameter	Unit	5 ft	10 ft	5 ft	10 ft	5 ft	10 ft
TKN	mg/L	1.74	0.35	0.51	0.29	0.58	0.38
NH_3-N	"	0.346	0.020	0.025	0.020	0.026	0.023
NO_3-N[5]	"	6.3	3.6	8.8	6.3	13.5	13.6
Total P	"	0.19	0.06	0.08	0.06	0.07	0.24
Hg	µg/L	0.07	0.06	0.07	0.06	0.08	0.10
As	mg/L	0.014	0.010	0.013	0.010	0.013	0.011
Ba	"	0.038	0.048	0.063	0.068	0.097	0.022
Cd	"	0.0006	0.0004	0.0005	0.0004	0.0009	0.0005
Cr	"	0.001	0.001	0.001	0.001	0.001	0.002
Cu	"	0.010	0.002	0.003	0.002	0.003	0.002
Mn	"	0.005	0.004	0.008	0.006	0.035	0.002
Mo	"	0.010	0.002	0.002	0.002	0.002	0.003
Ni	"	0.004	0.002	0.003	0.004	0.008	0.001
Pb	"	0.006	0.004	0.005	0.004	0.005	0.005
Sb	"	0.022	0.012	0.014	0.014	0.018	0.019
Se	"	0.029	0.020	0.025	0.020	0.026	0.023
Tl	"	0.009	0.006	0.008	0.006	0.008	0.008
V	"	0.011	0.007	0.006	0.006	0.006	0.005

TABLE III-8 (Continued): MEAN CONCENTRATIONS OF NUTRIENTS AND TRACE METALS[1] IN WATER SAMPLES TAKEN FROM THE LYSIMETERS IN KANKAKEE COUNTY RESEARCH AND DEMONSTRATION PLOTS FROM MARCH THROUGH DECEMBER 2007

		Treatment/Sampling Depth					
		Control[2]		160 lbs N/ac[3]		30 wet tons biosolids/ac[4]	
Parameter	Unit	5 ft	10 ft	5 ft	10 ft	5 ft	10 ft
Zn	"	0.006	0.012	0.010	0.015	0.022	0.005

[1]In calculating mean concentrations of trace metals, method detection limits were used in place of non-detectable levels.
[2]Received no N and recommended agronomic rate of P and K.
[3]Received recommended agronomic rate of P and K. Nitrogen was applied as urea.
[4]Received recommended agronomic rate of K.
[5]Sum of NO_2-N and NO_3-N.

FIGURE III-1: EFFECT OF PHOSPHORUS FROM BIOSOLIDS AND TRIPLE SUPER-PHOSPHATE (TSP) APPLIED IN FALL 2005 ON CHANGE (RELATIVE TO FALL 2005) IN BRAY-1 P AND WATER EXTRACTABLE P IN SURFACE SOIL IN FALL 2007

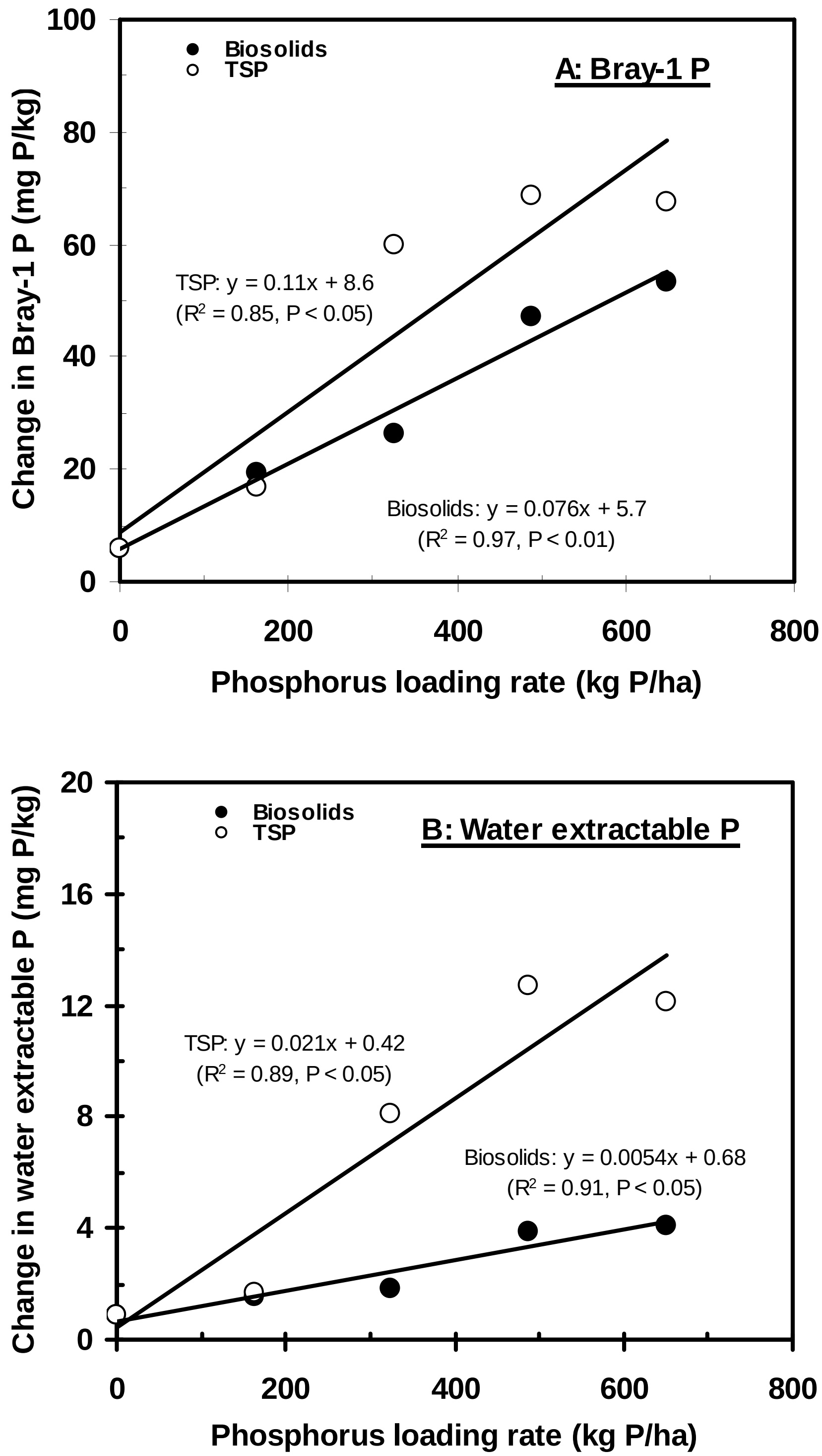


FIGURE III-2: SKETCH OF TYPICAL DESIGN OF MAIN PLOT, SUBPLOT, AND LOCATION OF RUNOFF COLLECTION DEVICES IN THE BIOSOLIDS P RUNOFF FIELD STUDY

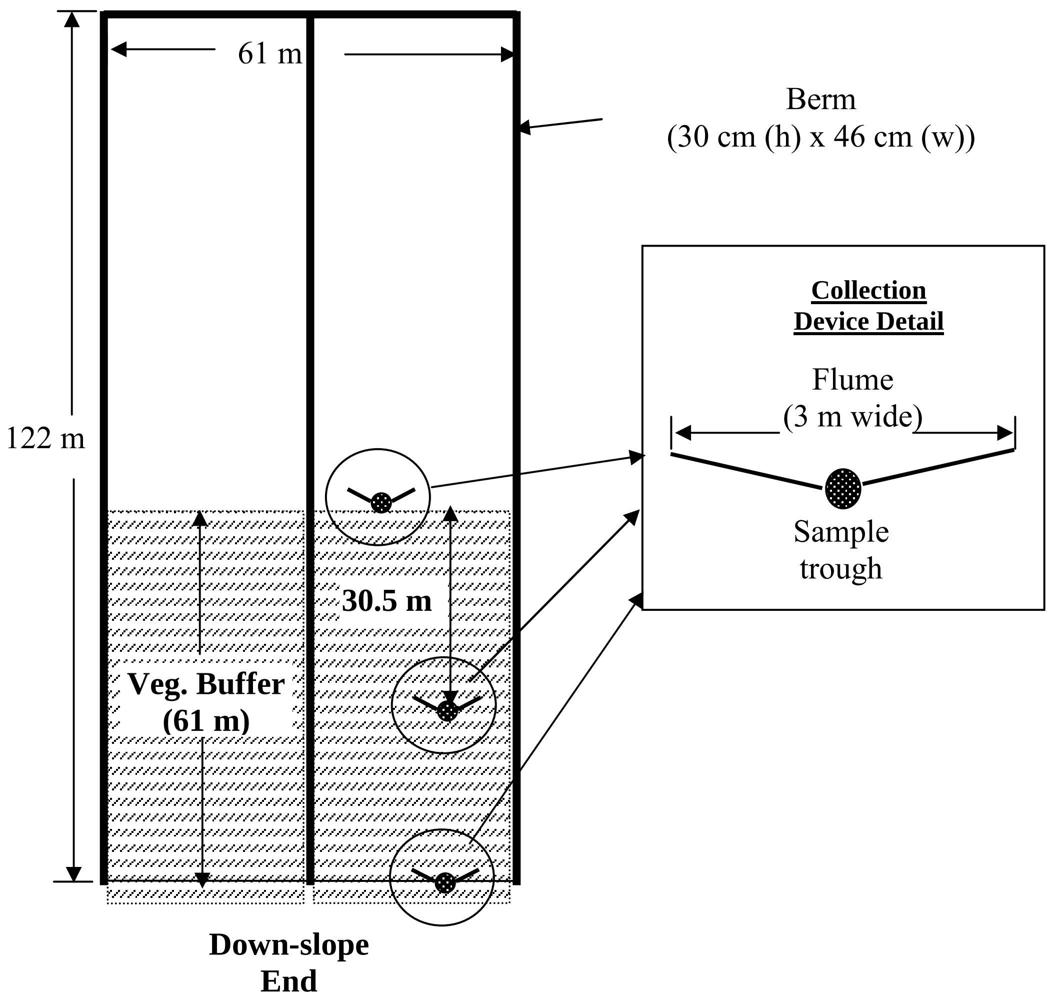
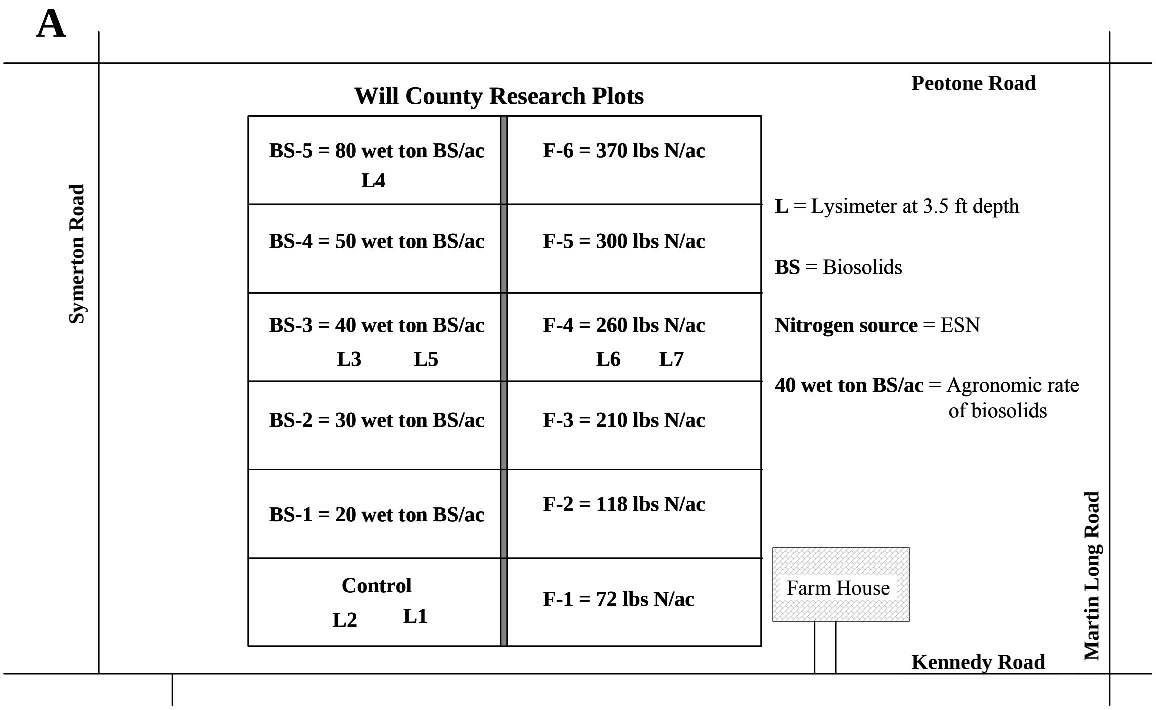


FIGURE III-3: SCHEMATIC OF THE RESEARCH PLOTS LOCATED IN WILL (A) AND KANKAKEE (B) COUNTIES SHOWING THE TREATMENTS AND LOCATIONS OF LYSIMETERS



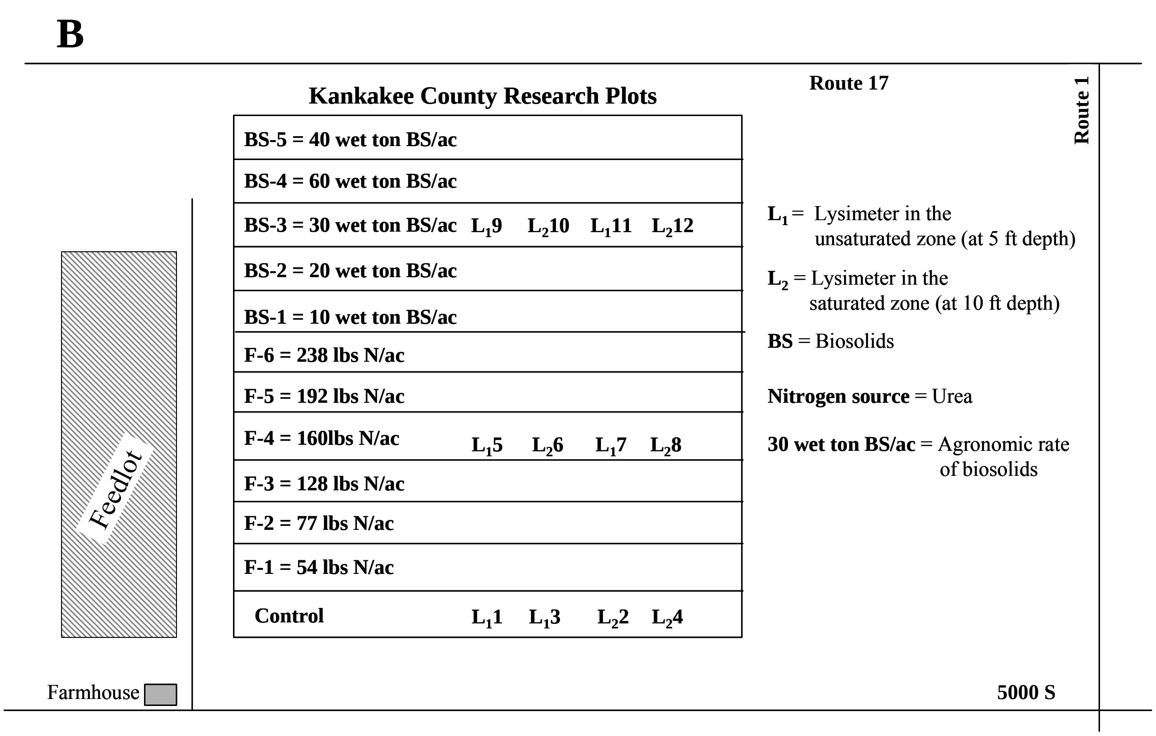


FIGURE III-4: CORN GRAIN YIELD FROM THE RESEARCH AND DEMONSTRATION PLOTS AT THE WILL (A) AND KANKAKEE (B) COUNTY SITES IN 2007

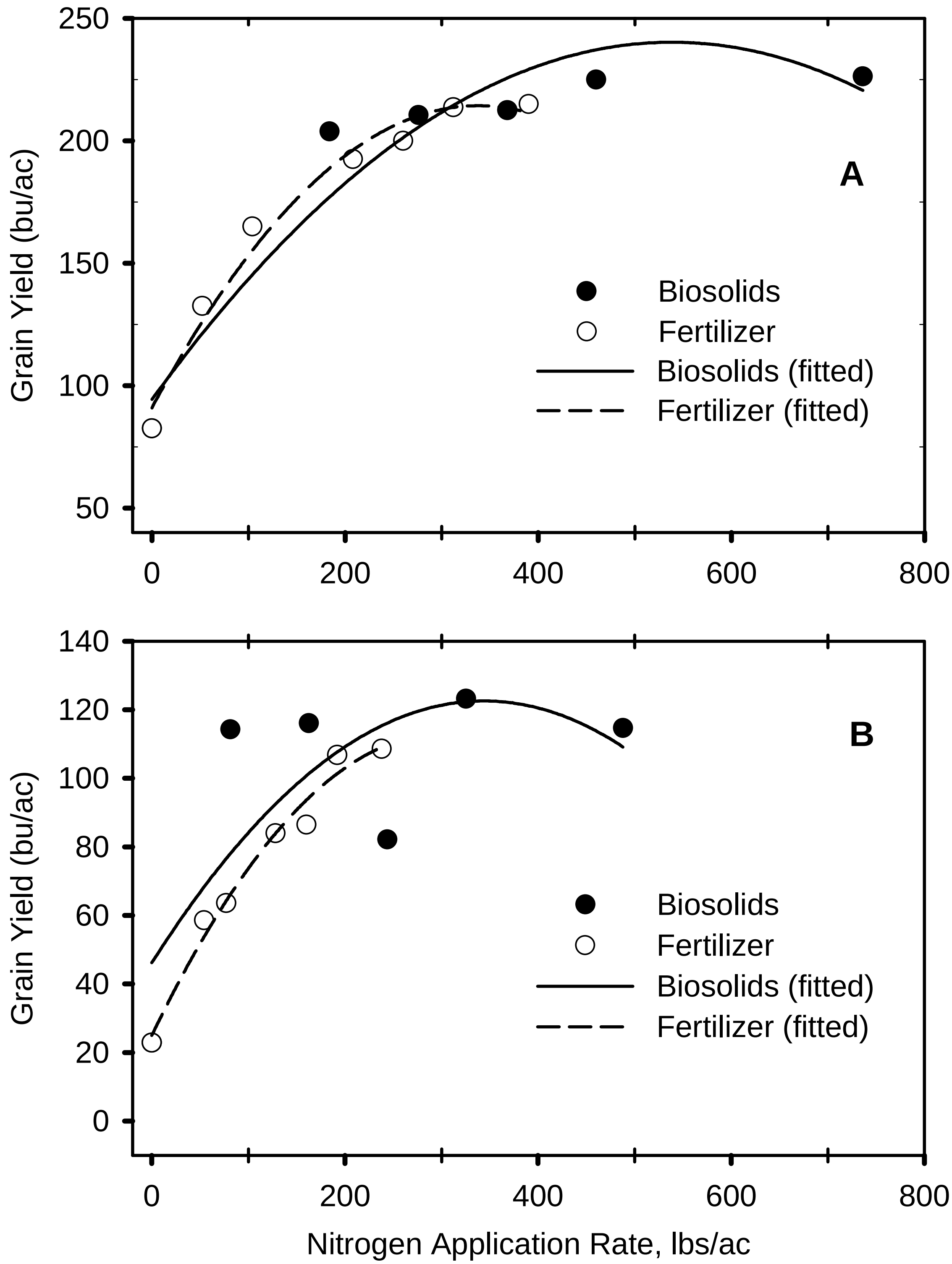
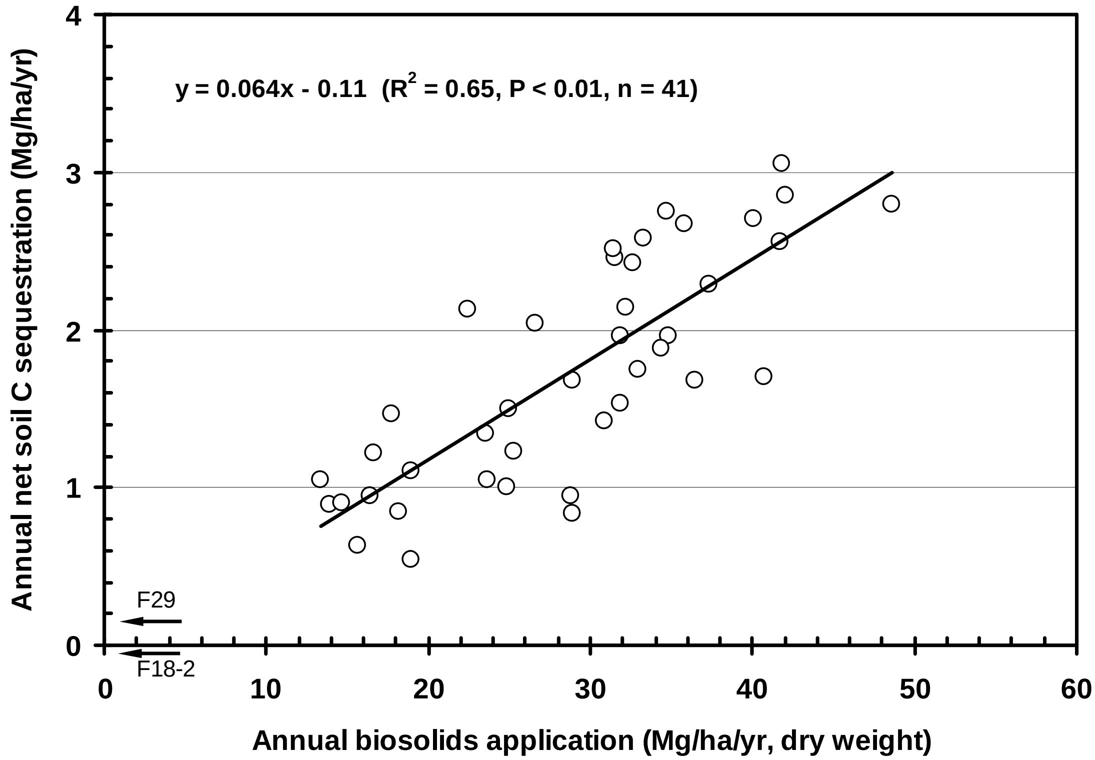


FIGURE III-5: CORRELATION BETWEEN ANNUAL NET SOIL C SEQUESTRATION AND ANNUAL BIOSOLIDS APPLICATION IN FIELDS AT FULTON COUNTY LAND RECLAMATION SITE[1]



[1] The arrows point to the rate of soil C sequestration in fertilizer control fields (F29) and (F18-2).

ANALYTICAL MICROBIOLOGY AND BIOMONITORING SECTION

ANALYTICAL MICROBIOLOGY AND BIOMONITORING SECTION

The Analytical Microbiology and Biomonitoring Section is comprised of four professional and 12 technical personnel who are organized into four groups to perform specific monitoring or research activities. These four groups are:

I. Analytical Microbiology

II. Virology

III. Parasitology

IV. Biomonitoring

Section personnel are often involved in studies of wastewater treatment, biosolids assessment, and environmental monitoring, which require the application of specific microbiological disciplines and expertise. The areas of study in which the Section personnel can be involved during the course of a given year include, but are not limited to:

- Public health risk assessment.
- Ecological risk assessment.
- Water quality monitoring.
- Ecotoxicology and biomonitoring.
- Bioassay (whole effluent toxicity) methodology.
- Microbial processes.
- Enumeration of viral, microbial, and parasitic microorganisms.
- Enumeration of microbial indicators and specific pathogens.
- The microbiology of specific wastewater or biosolids treatment options.
- Epidemiological study of recreational use of the Chicago Area Waterway System (CAWS).
- Illinois Environmental Protection Agency (IEPA) Rulemaking concerning the CAWS water quality standards and effluent disinfection.

- Emerging microconstituents including endocrine disrupters, pharmaceuticals, antibiotic, consumer goods, and personal care products.

Overview of Section Activities

In 2007, personnel in this Section participated in a variety of monitoring and research activities. Listed below are the most important of these activities separated according to the group with the most direct participation.

Analytical Microbiology Group.

a. Water Reclamation Plant (WRP) Quality Control. Monitoring WRP effluents for the presence and density of fecal coliforms (FC) for disinfection control.

b. Chicago Area Waterway System (CAWS). Monitoring District waterways in Cook County upstream and downstream of all District WRPs.

c. Groundwater Monitoring Wells – Tunnel and Reservoir Plan (TARP). Monitoring FC bacteria in groundwater monitoring wells near TARP tunnels as required by Illinois Environmental Protection Agency (IEPA) operational permits.

d. Groundwater Monitoring Wells - Land Reclamation. Monitoring of FC in groundwater monitoring wells around biosolids processing and application handling sites in Cook County.

e. Part 503 Compliance Monitoring. Analysis of Class A and B biosolids for FC.

f. Biosolids Beneficial Use Support. Monitoring bacterial (FC and *Salmonella* spp.) densities in farm soil after application of biosolids.

g. Potable Water Analysis. Monitoring drinking water at District WRPs and other locations.

h. Study of Antibiotic Resistant Bacteria (ARB). Monitoring of ARB in wastewater and the CAWS.

i. Disinfection Study. Bacterial density monitoring at District WRPs. Monitoring for FC and *Escherichia coli* (EC) to evaluate the disinfection technologies - Ultraviolet Light and Titanium Oxide.

j. Research Study. Dry and Wet Weather Risk Assessment of Human Health Impacts of Disinfection vs. No Disinfection of the CAWS. Epidemiological Research Study of Recreational Use of the CAWS.

k. Reviews. Review research reports and the IEPA proposed regulations to determine the impact on District operations.

Virology Group.

a. Part 503 Compliance Monitoring. Analysis of biosolids for enteric viruses.

b. Process Certification for Class A Biosolids. Analysis of biosolids for enteric viruses to demonstrate that the District's codified Process to Further Reduce Pathogens (PFRP) treatment processes consistently produce Class A biosolids as defined in the Part 503 Regulations.

c. Monitoring of Biosolids for Coliphages (Somatic and F-Specific RNA). Research on the use of coliphages as indicators for enteric viruses in biosolids.

d. Biosolids Beneficial Use Support. Monitoring enteric virus densities in farm soil after application of biosolids.

e. Establishment of Molecular Microbiology Laboratory. Polymerase Chain Reaction (PCR) technology capability to meet the future demands for microbial source tracking, pathogen monitoring, and genetic analysis of ARB.

f. Reviews. Review research reports and proposed regulations for any impact on District operations.

Parasitology Group.

a. Part 503 Compliance Monitoring. Analysis of biosolids for viable *Ascaris* ova.

b. Process Certification for Class A Biosolids. Analysis of biosolids for viable *Ascaris* ova to demonstrate that the District's codified PFRP treatment processes consistently produce Class A biosolids as defined in the Part 503 Regulations.

c. Biosolids Beneficial Use Support. Monitoring viable *Ascaris* ova densities in farm soil after application of biosolids.

d. Technical Support to the Wastewater Treatment Process Research Section. Microbiological evaluation to solve operation problems.

e. Reviews. Review research reports and proposed regulations for any impact on District operations.

Biomonitoring Group.

a. Whole Effluent Toxicity (WET) Testing for National Pollutant Discharge Elimination System (NPDES) Permits. Use of fathead minnow (*Pimephales promelas [P. promelas]*) and daphnids *(Ceriodaphnia dubia [C. dubia]*) to assess acute and chronic toxicity of final effluents from District WRPs.

b. The Algal Growth Test (AGT) to assess the Salt Creek nutrient reduction demonstration project at Egan WRP. To assess impacts of Lemont WRP effluent on nutrient load in the Chicago Sanitary and Ship Canal.

c. Reviews. Review research reports and proposed regulations for any impact on District operations.

Analytical Microbiology Group Responsibilities

The Analytical Microbiology Laboratory has been certified by the Illinois Department of Public Health (IDPH) for the bacterial analysis of water since 1979. Monitoring the densities of FC bacteria in WRP effluents was first mandated by NPDES permits in 1972; at present, the Analytical Microbiology Group is responsible for bacterial population density analyses used in WRP effluent monitoring. Monitoring of Chicago's harbors is conducted when river reversals to Lake Michigan occur due to heavy rainfall in the Chicagoland area. In 2007, there was one reversal to Lake Michigan at Wilmette Harbor as a result of the heavy rainfall that day in the north area. Samples were collected and analyzed for FC and EC on August 24, 2007.

The Analytical Microbiology Group conducts microbiological analyses in support of other Section requests. Table IV-1 summarizes the number and types of analyses performed by the Analytical Microbiology Group in 2006-2007. Bacterial analyses for total coliforms (TC), FC, and EC are used by the District as indicators of the sanitary quality of water. Coliform bacteria are identified to species (ID-CONF) using specific biochemical metabolic characteristics. Isolated colonies from culture plates are selected and inoculated to the B-D Crystal ID Systems (BBL™ Crystal™ ID System and BBL Crystal MIND Software V5.02E [Becton, Dickinson and Company, Sparks, Maryland]). The heterotrophic plate count (HPC) is a procedure for estimating the number of viable heterotrophic bacteria in water. The HPC, TC and EC analysis are used to monitor the bacteriological quality of drinking water.

Certification by the Illinois Department of Public Health. The Analytical Microbiology Group is certified by the IDPH, Registry #17508, for the following laboratory examinations:

- HPC for water.
- TC with EC broth verification examination of water from public water supplies and their sources (membrane filtration [MF] and multiple tube fermentation [MTF]).
- FC examination of water from public water sources (MF and MTF).
- 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]).

The Analytical Microbiology Group's facilities, equipment, and procedures were the subject of the biennial on-site evaluation for certification by the IDPH on October 18, 2006, and were found to be in general compliance with the provisions of 18th Edition of *Standard Methods for the Examination of Water and Wastewater* (SM 18th ed.) and the Illinois Rules for Certification and Operation of Environmental Laboratories, Title 77, Part 465. The Group collects and analyzes potable water samples from District facilities as required.

National Pollutant Discharge Elimination System Compliance Monitoring. FC data from disinfected effluents are made available to the Hanover Park, James C. Kirie, and Egan WRPs within 24 hours of sample collections. These data are used as a guide in maintaining proper disinfection at these District WRPs and for reporting compliance with NPDES permit regulations. All District WRPs with NPDES disinfection requirements have a seasonal exemption from November 1 through April 30 of each year and are not subject to any effluent disinfection requirements during this period.

NPDES permits also require additional monitoring when increased flow due to storms exceeds the design maximum treatment capacities of the WRPs. These storms can cause the WRPs to divert a portion of their influent, which is then given minimal treatment before being delivered to the receiving stream. These storm-related excess flow discharges must be monitored for the FC bacteria levels. In 2007, the Analytical Microbiology Group performed four analyses of FC bacteria on four storm-related excess flow discharge events at the Egan WRP service area on August 7, August 19, August 20, and August 24.

Part 503 Compliance Monitoring. In 2007, the Analytical Microbiology Group performed Most Probable Number (MPN) analyses for FC bacteria on 18 samples of biosolids to determine if they met the Class A pathogen requirement of less than 1,000 FC MPN/g (dry weight) specified in the Part 503 Regulations. The results were reported to the Maintenance and Operations (M&O) personnel responsible for the District's Controlled Solids Distribution

Program at the solids management areas. The District has more distribution options for biosolids demonstrated to be Class A than for non-Class A biosolids.

Monitoring Bacterial Densities in Farm Soil. In 2007, the Analytical Microbiology Laboratory continued monitoring FC and *Salmonella* spp. densities in farm soil after application of biosolids. A total of 54 samples were analyzed as part of full-scale studies being conducted in Will and Kankakee Counties to demonstrate the benefits and safety of applying Class B centrifuge cake biosolids to farmland. Additional information on this project is in the Biosolids Utilization and Soil Science Section chapter of this report.

Study of Antibiotic Resistant Bacteria in the Chicago Area Waterway System. The District continued the ARB study to survey the CAWS. The purpose of this study is to determine whether ARB present in the final effluents (FE) of the Stickney, Calumet, and North Side WRPs are affecting the number and spatial distribution of ARB in the CAWS. The study will investigate whether secondary sewage treatment at the Stickney, Calumet, and North Side WRPs is adequately reducing the concentration of ARB present in wastewater. The study consists of three objectives to survey the total numbers and percentages of ARB at the following WRP waterway locations:

1) Chicago Sanitary and Ship Canal (CSSC) upstream and downstream of the Stickney WRP (SWRP).

2) The North Shore Channel (NSC) upstream and downstream of the North Side WRP and in the North Branch of the Chicago River (NBCR) downstream of the North Side WRP.

3) The Little Calumet River upstream and downstream of the Calumet WRP (CWRP) and in the Calumet-Sag Channel downstream of the CWRP.

The first objective of this study investigated the impact of SWRP FE. It included the collection and analyses of four sets of water samples from one upstream and four downstream locations in the CSSC and was completed in 2006. The second objective of this study began with sample collections in winter 2006, and the data collection was completed in 2007. It includes the collection and analyses of four sets of water samples, one location upstream of the North Side WRP in the NSC, and four locations downstream of the North Side WRP in the NSC, and the NBCR. The third objective of this study began with sample collections in the winter of 2007 and is still in progress. The study includes the collection and analysis of four sets of samples, one location upstream in the Little Calumet River and four locations downstream of the Calumet WRP in the Calumet-Sag Channel. The data collection will be completed in 2008.

Disinfection Study. In 2007, the District was involved in monitoring bacterial densities to assess the challenges and applicability of its future disinfection needs. Filtered and unfiltered samples of effluent from the seven District WRPs were exposed to an ultraviolet light in laboratory scale experiments. The District performed 280 analyses of the FC content of the District WRP effluents. EC and TC analyses were conducted on WRP effluent samples utilizing titanium oxide and natural light in a laboratory scale experiment to evaluate the disinfection process. The evaluation of disinfection technologies are expected to continue through 2008.

Dry and Wet Weather Risk Assessment of Human Health Impacts of Disinfection vs. No Disinfection of the Chicago Area Waterway System. The District commissioned this study to evaluate the human health impact of continuing the current practice of not disinfecting the FE from the District's Calumet, North Side, and Stickney WRPs versus initiating disinfection of the effluents at these three WRPs. A quantitative microbial risk assessment (QMRA) was conducted by Geosyntec Consultants, based in Chicago, with analytical assistance from world-renowned experts Dr. Charles Gerba at University of Arizona, Dr. Jennifer Clancy of Clancy Environmental Consultants, Dr. James W. Patterson, Patterson Environmental Consultants, Dr. Cecil Lue-Hing, Cecil Lue-Hing & Associates, and Dr. Hendrickson of Hoosier Microbiology Laboratory, Inc. The study was conducted in two phases. Dry weather sampling was conducted between July and September 2005. Wet weather sampling was conducted between June and October 2006.

The microbial risk assessment process was divided into four discrete components: (1) microbial sampling to determine the concentrations of Environmental Protection Agency (EPA)-approved indicator microorganisms (fecal coliform, *E. coli*, enterococci) and representative pathogens (enteric culturable viruses, viable adenovirus, calicivirus, infectious *Cryptosporidium parvum*, viable *Giardia lamblia*, *Salmonella* spp., *Pseudomonas aeruginosa*) typically present in the feces of humans and other warm-blooded animals; (2) analyze the dry and wet weather microbial sampling data; (3) evaluation of disinfection technologies; and (4) assesses the health risk posed from exposure to pathogenic bacteria, viruses, and parasites during incidental contact recreation (fishing, pleasure boating, and canoeing) in the CAWS during dry and wet weather conditions.

The microbial water quality monitoring and risk assessment results from this study indicate that, despite elevated levels of fecal indicator bacteria, the concentrations of actual pathogenic microorganisms in the waterway, representing the spectrum of waterway conditions experienced in a recreational year, are low. Due to low pathogen (*E. coli*, *Salmonella* spp., total enteric viruses, viable adenoviruses, viable *Giardia lamblia,* and infectious *Cryptosporidium parvum)* concentrations in the waterway, there is a low probability of developing gastrointestinal illness for the recreational users in the areas of the CAWS in close proximity to the District's WRP non-disinfected effluents from Stickney, Calumet, and North Side. The results demonstrate that the expected illness rates, both with and without disinfection for each waterway segment, are below the proposed EPA limit of 8 illnesses per 1,000 exposure events for freshwater primary contact recreational use. The pathogen concentrations within the waterway are largely a result of non-WRP derived wet weather inputs. These results conclude that current health risks to CAWS recreators are low, and disinfection of treated wastewater effluent would have little impact on the overall gastrointestinal illness rates.

The final report entitled, "Dry and Wet Weather Risk Assessment of Human Health Impacts of Disinfection vs. No Disinfection of the Chicago Area Waterway System" summarizing the results of this study is posted on the District website (www.mwrd.org) on the Technical Data & Reports page under "Chicago Area Waterway Use Attainability Analysis (UAA)."

Epidemiological Research Study of Recreational Use of the Chicago Area Waterway System. The study known as the Chicago Health, Environmental Exposure and Recreation Study (CHEERS) was initiated to verify the results of the microbial risk assessment study and to ascertain actual health impacts of recreational use of the CAWS. The study is conducted in collaboration with a multidisciplinary team at the University of Illinois at Chicago School of Public Health (Figure IV-1). CHEERS plans to develop a scientific basis for establishing water quality standards on the CAWS by:

1) Determining rates of illness attributable to incidental contact recreation on the CAWS, given current wastewater treatment practices.

2) Describing any observed relationship between measures of water quality and rates of acute illness among those who engage in various forms of secondary contact water recreation. Study participants are followed by phone for the development of acute gastrointestinal, respiratory, eye, and skin conditions.

3) Identifying pathogens responsible for illness among study participants and to explore sources of those pathogens on the CAWS.

The CHEERS has undergone peer review and is being conducted in consultation with national and international experts, including United States Environmental Protection Agency (USEPA) epidemiologists, the Water Environment Research Foundation (WERF), and Center for Disease Control (CDC) personnel. A total of 9,330 participants will be enrolled between 2007 and 2009. The health survey and data collection which commenced in the summer of 2007 resulted in an enrollment of a total of 886 participants for the study by interviewing three groups of people who engage in outdoor recreation: (a) the CAWS group, who engage in incidental contact activities on the CAWS; (b) the general use waters group, who engage in the same activities on local rivers, lagoons, and lakes and do not have a local wastewater treatment facility, and (c) the unexposed group, who engage in outdoor activities such as cycling, jogging, volleyball, softball, and tennis. A study of spatial and temporal variability of water sampling was also performed as part of the CHEERS quality assurance project plan. The CHEERS study will continue through 2009.

Illinois Environmental Protection Agency Rulemaking Concerning the Chicago Area Waterway System Water Quality Standards and Effluent Disinfection. The District participated and supported IEPA concerning the UAA Study, the recreational use potential and protective standards that can be established for the man-made waterways. The drafts and final version of the UAA and the IEPA's proposed regulations were reviewed and commented to determine the impact on District operations. Position statements, questions, comments, and testimonies were drafted to place before the IPCB on the IEPA's proposed "Effluent Bacteria Standard" for the District treatment facilities on the CAWS.

Support to Other Sections. The Analytical Microbiology Group supported a variety of Environmental Monitoring and Research and Industrial Waste Division programs in 2007: effluent analysis, land reclamation and sludge indicator organism densities, District waterway surveys, Lake Michigan monitoring, WRP monitoring, TARP monitoring, research support, industrial waste surveys, the Illinois waterway survey, and other miscellaneous samples. Table IV-2 is a summary of the major programs receiving support from 2006 through 2007, and the number of analyses performed for each program.

Virology Group Activities

In 2007, the Virology Group analyzed 11 biosolids samples for site-specific PFRP equivalency monitoring and for compliance with the Part 503 biosolids regulations. Enteric virus densities in all samples of biosolids produced by the District's codified PFRP processing trains were determined to be below the detectable limit, which is less than one plaque forming unit (PFU) per four grams total solids (dry weight basis). Positive recovery studies were performed on these samples for quality assurance purposes. The mean recovery of spiked viruses was 37.4 percent. Recoveries ranged from 25.1 to 63.4 percent and were dependent upon the sample spiked. Results of these analyses are shown in Table IV-3.

The analytical method used by the District for determining the density of enteric viruses in biosolids was published and approved by the USEPA (Appendix H, EPA/625/R-92/013). The analytical method for enteric viruses involves the elution of viruses from solids, concentration of the eluates, and an assay for plaque forming viruses using BGM-K cells.

Monitoring of Biosolids for Coliphages (F Specific and Somatic). The USEPA coliphage method was modified and adapted in the District to determine coliphage concentrations in Class A and B biosolids. Research is currently being conducted to evaluate the usefulness of coliphages as an indicator for the presence of enteric viruses in biosolids. In 11 samples of biosolids produced by the District's codified process, the concentrations of F Specific Coliphages (FP) were determined to be below the detectable limit (less than one PFU per gram total solids [dry weight basis]). In 8 samples of biosolids produced by the District's codified process, the concentrations of somatic coliphages (SP) were determined to be below the detectable unit (less than one PFU per gram total solids [dry weight basis]). Results of these analyses are shown in Table IV-4.

Data collected to date suggests that FP are a good indicator for predicting the presence or absence of enteric viruses in biosolids.

Monitoring Virus Densities in Farm Soil. In 2007, the Virology Laboratory continued monitoring virus densities in farm soil after application of biosolids. Results of these analyses are shown in Table IV-5. These analyses were conducted as part of full-scale studies set up in Will and Kankakee Counties to demonstrate the benefits and safety of applying Class B centrifuge cake biosolids to farmland. Additional information on this project is in the Biosolids Utilization and Soil Science Section chapter of this report.

Establishment of Molecular Microbiology Laboratory. The District completed its plans to construct a molecular microbiology research laboratory at the Cecil Lue-Hing Research and Development Complex to meet the future demands for microbial source tracking, pathogen monitoring, and genetic analysis of ARB. It is anticipated that the laboratory construction which began in 2007 will be completed in 2009.

Parasitology Group Activities

In 2007, the Parasitology Group analyzed 11 biosolids samples for site-specific PFRP equivalency monitoring and for compliance with the Part 503 biosolids regulations. Viable *Ascaris* ova densities in all samples of biosolids produced by the District's codified PFRP sludge processing trains were determined to be below the detectable limit, which is less than one viable *Ascaris* ovum per four grams of total solids (dry weight basis). Results of these analyses are shown in Table IV-6. Since 1996, when the District began monitoring the levels of FC bacteria (see Analytical Microbiology Group Activities above), enteric viruses (see Virology Group Activities above), and viable *Ascaris* in its dried biosolids product for compliance with the Class A biosolids criteria in the Part 503 biosolids regulations, all biosolids produced by the District's codified PFRP sludge processing trains have been in compliance with the Class A criteria for shipment and use under the District's Controlled Solids Distribution Program.

The analytical method used by the District for enumerating viable *Ascaris* ova in biosolids was published and approved by the USEPA (Appendix I, EPA/625/R-92/013). The *Ascaris* method employs a combination of sieving, flotation, centrifugation, incubation, and microscopic analysis to extract and enumerate viable *Ascaris* ova. *Ascaris* ova are classified as embryonated (viable) or unembryonated (non-viable) by examination under the microscope.

Monitoring Viable *Ascaris* Densities in Farm Soil. In 2007, the Parasitology Laboratory continued monitoring viable *Ascaris* ova in farm soil after application of biosolids. These analyses were conducted as part of full-scale studies set up in Will and Kankakee Counties to demonstrate the benefits and safety of applying Class B centrifuge cake biosolids to farmland. The results of these analyses are shown in Table IV-7. Additional information on this project is in the Biosolids Utilization and Soil Science Section chapter of this report.

Microscopic Image Analysis. The District uses microscopic image analysis (MIA) as an aid to monitor viable *Ascaris* ova in biosolids. The MIA system, mounted on a Nikon Eclipse E600 phase contrast microscope, includes a digital camera with a video image acquisition mode to transmit microscopic images from slide to a computer workstation (Figure IV-2). Digital images are stored and analyzed using the MetaMorph™ imaging software system. The MIA system has proven to be a useful tool for the verification and monitoring of biosolids for Part 503 compliance. For each digital image the following information is automatically stored in a computer file by the imaging software: (1) length of the ovum; (2) width of the ovum; (3) date and time the image was recorded; and (4) sample identification number. A series of digital video images is recorded for each ovum examined when larval movement is observed in order to document viable *Ascaris* ova (Figure IV-3).

Support to Other Sections. Personnel in the Parasitology Group worked cooperatively with the Wastewater Treatment Process Research Section to provide technical assistance in solving operational problems experienced at the Egan WRP. *Microthrix parvicella* (Figure IV-4) was identified as the dominant filamentous bacteria type associated with the sludge bulking and foaming experienced in the north battery of the Egan WRP. Staff attended monthly meetings, conducted microscopic evaluations, and provided input when needed. Staff also provided training to Wastewater Treatment Process Research Section laboratory technicians on protozoa and *Nocardia* spp. enumeration techniques.

Biomonitoring Group Activities

Whole Effluent Toxicity Testing. WET testing is defined as the aggregate toxic effect of an effluent or receiving water as measured with a toxicity test. In WET tests, organisms are exposed to effluent samples for a specific time period. Test treatments consist of different concentrations of effluent. A control treatment (an exposure of the test organisms to dilution water with no effluent added) is used to measure the acceptability of the test by showing the quality of the organisms and the suitability of the dilution water, test conditions, and handling procedures. The organisms used in the Biomonitoring Laboratory (Figure IV-5) are *P. promelas* (fathead minnow) and *C. dubia* (daphnids [water fleas]) (Figure IV-6).

There are two types of WET tests – acute and chronic. Acute tests typically last 48-96 hours, and the objective is to determine the concentration of the effluent that causes organisms to die during a short-term exposure under controlled conditions. The chronic test lasts about 7 days. Chronic tests estimate the effluent concentration that interferes with the normal growth or reproductive potential of test organisms.

National Pollutant Discharge Elimination System Compliance Biomonitoring. In 2007, chronic WET tests with fathead minnow (*P. promelas*) and daphnids (*C. dubia*) were conducted on effluent samples from Hanover Park WRP for NPDES Permit compliance. No chronic toxicity was observed. These data are shown in Table IV-8. A biomonitoring report for Hanover Park WRP (R&D Report No. 07-63) was submitted to IEPA in compliance with the respective NPDES permit.

Discharge Monitoring Report – Quality Assurance Study. The Biomonitoring Laboratory participated in a Discharge Monitoring Report – Quality Assurance (DMR-QA) Study. The WRPs are required to report sample data produced by laboratories that routinely perform analyses for their DMR process. The DMR-QA Study is designed to test the ability of the laboratory staff to conduct the required testing procedures included in the NPDES permits and to test their ability to follow the directions associated with required test methods.

The Algal Growth Test. The District initiated AGT research primarily to study the available biological phosphorus (BP) in the Egan and Lemont WRPs' final effluents and in upstream and downstream locations in conjunction with the planned demonstration project to study river response to phosphorus reduction at the WRPs. Comprehensive water quality monitoring was implemented in Salt Creek in February 2005 in order to assess baseline conditions prior to initiating phosphorus removal by ferric chloride chemical treatment at Egan WRP. The *Selenastrum capricornutum* Printz Algal Assay (EPA-600/9-78-018) determined algal growth potential and nutrient limitation in receiving streams at Egan and Lemont WRPs. By measuring the algal growth potential of water, a differentiation can be made between the total nutrient in the sample (as determined by chemical analysis) and the nutrient forms that are actually available for algal growth.

Eight valid AGTs were conducted to measure BP in effluent samples from the Egan WRP and samples from three monitoring stations on Salt Creek (Busse Reservoir Dam, Kennedy Boulevard, and Thorndale Avenue). Four valid AGTs were conducted on effluent samples from the Lemont WRP and samples from three monitoring stations on the CSSC. Results of AGTs are shown in Tables IV-9 and IV-10.

The results suggest that only a portion of the total phosphorus measured is in a nutrient form that is actually biologically available for algal growth. The results of the AGTs are important in the District's effort to maintain the biotic integrity of the waterways (Salt Creek and CSSC) and the IEPA's effort to develop nutrient standards for the State of Illinois.

TABLE IV-1: ANALYTICAL MICROBIOLOGY GROUP SAMPLES AND ANALYSES 2006 AND 2007

	Analysis or Test Performed[1]								
Year	Samples	TC	FC	SAL	HPC	EC	IQC	ID-CONF	Total
2006	3,140	305	3,195	9	39	491	8210	191	12,440
2007	2,851	102	2,838	7	31	299	8193	135	11,605

[1]TC = Total Coliform; FC = Fecal Coliform; SAL = *Salmonella* spp.; HPC – Heterotrophic Plate Count; EC = *Escherichia coli*; IQC = Internal Quality Control Testing (reported as the number of procedures performed); ID-CONF = Organism Identification using specific multiple biochemical metabolic characteristics.

TABLE IV-2: INDICATOR BACTERIA ANALYSES PERFORMED BY THE ANALYTICAL MICROBIOLOGY GROUP FOR VARIOUS DISTRICT PROGRAMS 2006 THROUGH 2007

Program	Total Coliform		Fecal Coliform		*Escherichia coli*	
	2006	2007	2006	2007	2006	2007
Effluent Analysis	12	12	711	708	-[a]	-
Land Reclamation	-	-	171	175	-	-
Biosolids Indicator Organism Density	-	-	55	49	-	-
District Waterway Surveys	-	-	1065	699	231	220
Industrial Waste Surveys	-	-	6	6	-	-
Research –Support[1]	246	59	364	404	245	39
Lake Michigan Monitoring[2]	-	16	-	8	-	16
Major Treatment Facility Monitoring	-	-	271	201	-	-
Illinois Waterway	-	-	-	-	-	-
TARP	-	-	567	571	-	-
Other[3]	59	25	-	-	15	24
Total	317	112	3,210	2,821	491	299

[a]No samples analyzed.

[1]Includes disinfection study and support to plant operations.

[2]Includes festivals and District bypasses to Lake Michigan.

[3]Includes drinking water.

TABLE IV-3: VIROLOGICAL ANALYSIS OF CLASS A BIOSOLIDS IN 2007[1]

WRP Sample Location	Number Samples Positive/Number Samples Collected	Total Number of Samples that Meet Class A Pathogen Requirement[2]	PFU/4g Dry Wt Range[3,4]	Percent Recovery of Seeded Viruses[5] Range
Calumet				
East and West	0/9	9	<0.8000 - <0.8000	25.7 - 63.4
Stickney				
LASMA[6]	0/1	1	<0.8000	25.1
Vulcan	0/1	1	<0.8004	37.3

[1]Results of analyses performed in the District's Virology Laboratory for site-specific PFRP equivalency monitoring.
[2]Total Culturable Enteric viruses are less than 1 PFU per 4g total dry solids.
[3]Confirmed PFUs/4g.
[4]Failure to detect viruses in solids eluates are recorded as less than (<) the limit of test sensitivity.
[5]Positive recovery controls: percent recovery of 400 PFUs of poliovirus 1 Sabin seeded into a 4g aliquot of sample. A positive recovery control was performed for each sample analyzed.
[6]Lawndale Avenue Solids Management Area.

TABLE IV-4: COLIPHAGE (SOMATIC [SP] AND F SPECIFIC [FP]) ANALYSIS OF CLASS A BIOSOLIDS IN 2007[1]

WRP/Sample Location	Total Solids (TS)[2]	Coliphage MPN/Gram Dry Wt[3,4]	
		SP	FP
Calumet			
East, Cell 3	79.83	<0.1253	<0.1253
East, Cell 2	68.40	<0.1462	<0.1462
East, Cell 4	75.85	<0.1318	<0.1318
West, Cell 1	73.83	<0.1354	<0.1354
West, Cell 5	78.97	<0.1266	<0.1266
West, Cell 2	72.70	520.0000	<0.1376
West. Cell 2	68.40	<0.1462	<0.1462
Stickney			
Vulcan	28.83	690.0000	<0.3469
LASMA[5]	22.22	<0.4500	<0.4500

[1]The coliphages were enumerated according to the USEPA Method 1601: Male-specific (F+) and SP in water by Two-Step Enrichment Procedure (EPA/821-R-01-030). The method was modified to increase the sensitivity of the method for biosolids monitoring.
[2]TS = Percent Total Solids.
[3]Most Probable Number of FP and SP based on dry weight of 1g of as-received biosolids.
[4]Failure to detect coliphages in biosolids is recorded as less than (<) the limit of test sensitivity.
[5]Lawndale Avenue Solids Management Area.

TABLE IV-5: VIROLOGICAL ANALYSIS OF BIOSOLIDS FOR FARMLAND APPLICATION IN 2007[1]

Sample Description	Number Samples Positive/Number Samples Collected	Total Number of Samples that Meet Class A Pathogen Requirement[2]	PFU/4g Dry Wt Range[3,4]	Percent Recovery of Seeded Viruses[5] Range
Kankakee County (Farm Soil)	0/1	1	<0.8000	56.2
HASMA[6]	0/1	1	<0.8000	91.2

[1]Results of analyses performed in the District's Virology Laboratory for site-specific PFRP equivalency monitoring.
[2]Total Culturable Enteric viruses are less than 1 PFU per 4g total dry solids.
[3]Confirmed PFUs/4g.
[4]Failure to detect viruses in solids eluates are recorded as less than (<) the limit of test sensitivity.
[5]Positive recovery controls: percent recovery of 400 PFUs of poliovirus 1 Sabin seeded into a 4g aliquot of sample. A positive recovery control was performed for each sample analyzed.
[6]Harlem Avenue Sludge Management Area.

TABLE IV-6: VIABLE *ASCARIS* OVA ANALYSIS OF CLASS A BIOSOLIDS IN 2007[1,2]

WRP Sample Location	Range of TS[3]	Number of Samples Collected	Total Number of Samples that Meet Class A Pathogen Requirement[4]	Range of Total Viable Ascaris per 4 Gram Dry Weight[5]
Calumet				
East and West	68.40 – 79.83	9	9	<0.0133 – 0.0800
Stickney				
LASMA[6]	22.22	1	1	0.2400
Vulcan	28.83	1	1	0.0800

[1]Test Method for Detecting, Enumerating, and Determining the Viability of *Ascaris* ova in Sludge, Appendix I, Environmental Regulations and Technology, EPA/625/R-92/013, Revised 2003.
[2]United States Environmental Protection Agency, Region V, has approved the practice of analyzing 50g Dry Weight Samples of Biosolids for the determination of *Ascaris* ova densities with every sixth sample being 300g Dry Weight as required in the District's site-specific PFRP compliance monitoring.
[3]TS = Percent Total Solids.
[4]Viable *Ascaris* ova are less than 1 viable *Ascaris* ovum per 4g total dry solids.
[5]Failure to detect viable ova in biosolids is recorded as less than (<) the limit of test sensitivity.
[6]Lawndale Avenue Solids Management Area.

TABLE IV-7: VIABLE *ASCARIS* OVA ANALYSIS OF BIOSOLIDS FOR FARMLAND APPLICATION IN 2007[1, 2]

WRP Sample Location	Sample Source	Range of TS[3]	Total Number of Samples Collected	Range of Total Viable Ascaris per 4 Gram Dry Weight
Class B Biosolids	HASMA[4]	19.57	1	<1.0000
Farm Land Soil	Kankakee County	89.01	1	<1.0000

[1]Farmland Application of Class B Biosolids Project (FLAP).
[2]Test Method for Detecting, Enumerating, and determining the Viability of *Ascaris* Ova in Sludge, Appendix I, Environmental Regulations and Technology, EPA/625/R-92/013, Revised July 2003.
[3]TS=Percent Total Solids.
[4]Harlem Avenue Solids Management Area.

TABLE IV-8: RESULTS OF WHOLE EFFLUENT TOXICITY TEST CONDUCTED ON WATER RECLAMATION PLANT EFFLUENTS FOR NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM PERMIT COMPLIANCE DURING 2007

Effluent Tested	Sample Collection Date(s)	Whole Effluent Toxicity Test[1]		Results[2]
Hanover Park WRP	05/14 - 05/15 05/16 - 05/17 05/18 - 05/19	Chronic *P. promelas*	(Survival)	NTE
			(Growth)	NTE
		Chronic *C. dubia*	(Survival)	NTE
			(Reproduction)	NTE

[1]WET Tests: Chronic *P. promelas* (Survival, Growth) and Chronic *C. dubia* (Survival, Reproduction), EPA 821/R-02/013, (Fourth Edition), 2002.
[2]Results: NTE = no toxic effect.

TABLE IV-9: MEAN RESULTS OF ALGAL GROWTH TESTS CONDUCTED ON EGAN FINAL EFFLUENT AND SAMPLES[1] COLLECTED UPSTREAM AND DOWNSTREAM OF THE EGAN WATER RECLAMATION PLANT OUTFALL - JANUARY 2006 THROUGH FEBRUARY 2007

Sample Location	Total Phosphorus (mg/L)	Ortho-phosphorus (mg/L)	Mean (mg/L)	Biologically Available Phosphorus[2] Range (mg/L)
Busse Dam 1-Mile Upstream	0.065	0.022	0.016	<0.100 - 0.044
Egan Final Effluent	3.459	2.979	1.038	0.821 - 1.207
JFK Blvd 0.7-Miles Downstream of WRP	1.899	1.612	0.551	0.043 - 1.062
Thorndale Ave. 2.4-Miles Downstream of WRP	1.887	1.600	0.451	0.005 - 0.893

[1]Eight valid AGTs were conducted on effluent samples from the Egan WRP and samples from three monitoring stations on Salt Creek (Busse Reservoir Dam, Kennedy Boulevard, and Thorndale Avenue).
[2] Biologically Available Phosphorus (BAP) is calculated as Maximum Standing Crop divided by 430 (Phosphorus Yield Coefficient).

TABLE IV-10: MEAN RESULTS OF ALGAL GROWTH TESTS CONDUCTED ON LEMONT FINAL EFFLUENT AND SAMPLES COLLECTED UPSTREAM AND DOWNSTREAM OF THE LEMONT WATER RECLAMATION PLANT OUTFALL – JANUARY 2006 THROUGH FEBRUARY 2007

Sample Location	Total Phosphorus (mg/L)	Ortho-phosphorus (mg/L)	Mean (mg/P/L)	Biologically Available Phosphorus Range (mg/P/L)
1.9 Miles Upstream	0.740	0.604	0.580	0.293 – 0.811
Lemont Final Effluent	3.133	2.790	0.677	<0.010 – 1.236
Stephen Street 0.1 Miles Downstream	0.830	0.712	0.564	0.254 – 0.787
0.6 Miles Downstream	0.833	0.745	0.644	0.404 – 0.809

[1]Four valid AGTs were conducted on effluent samples from the Lemont WRP and samples from three monitoring stations on the CSSC.
[2]Biologically Available Phosphorus (BAP) is calculated as Maximum Standing Crop divided by 430 (Phosphorus Yield Coefficient).

FIGURE IV-1: CHICAGO HEALTH, ENVIRONMENTAL EXPOSURE AND RECREATION STUDY

CHEERS

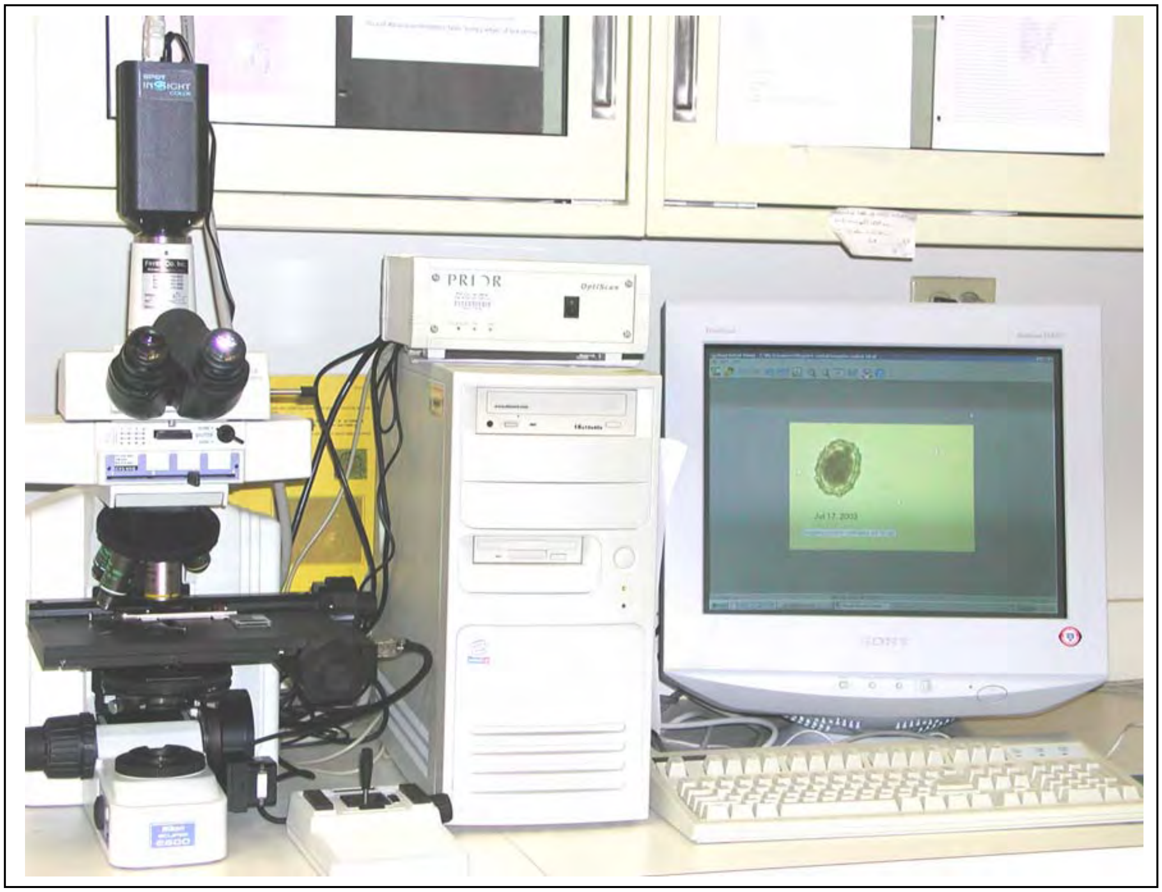
WATER CHICAGO SPORTS

Unexposed recreators

General use recreators

CAWS recreators

FIGURE IV-2: MICROSCOPIC IMAGE ANALYSIS SYSTEM



Nikon E600 Research Phase Contrast Microscope with a Digital Snap Video Camera Transmitting Microscopic Images from Slide to a Computer Workstation with a Metamorph Software Program.

FIGURE IV-3: DIGITAL IMAGES OF *ASCARIS LUMBRICOIDES*

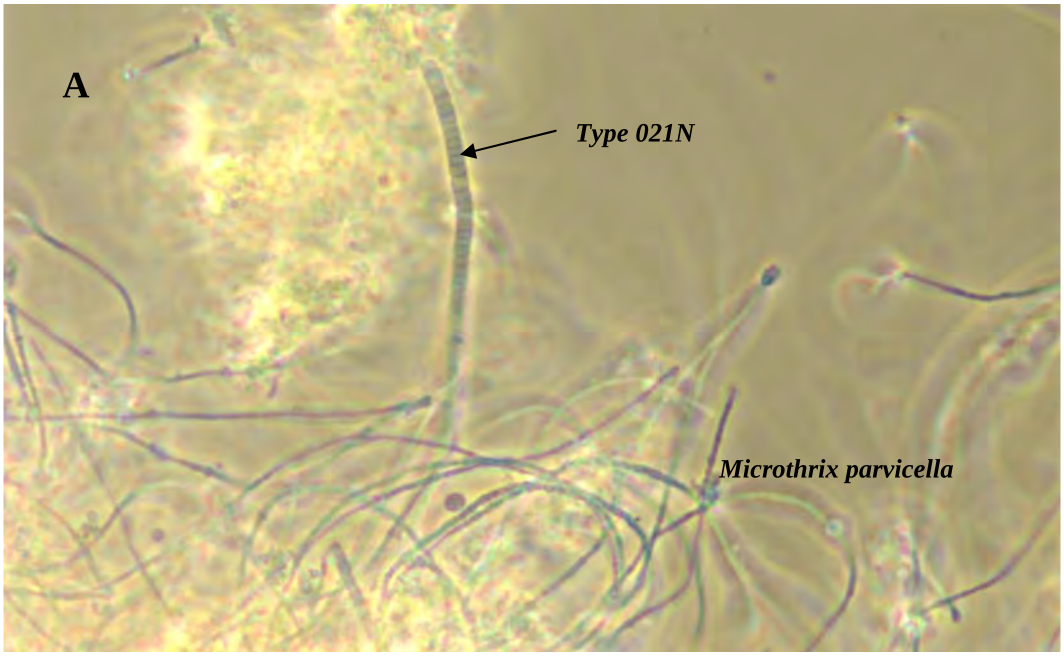
A

B

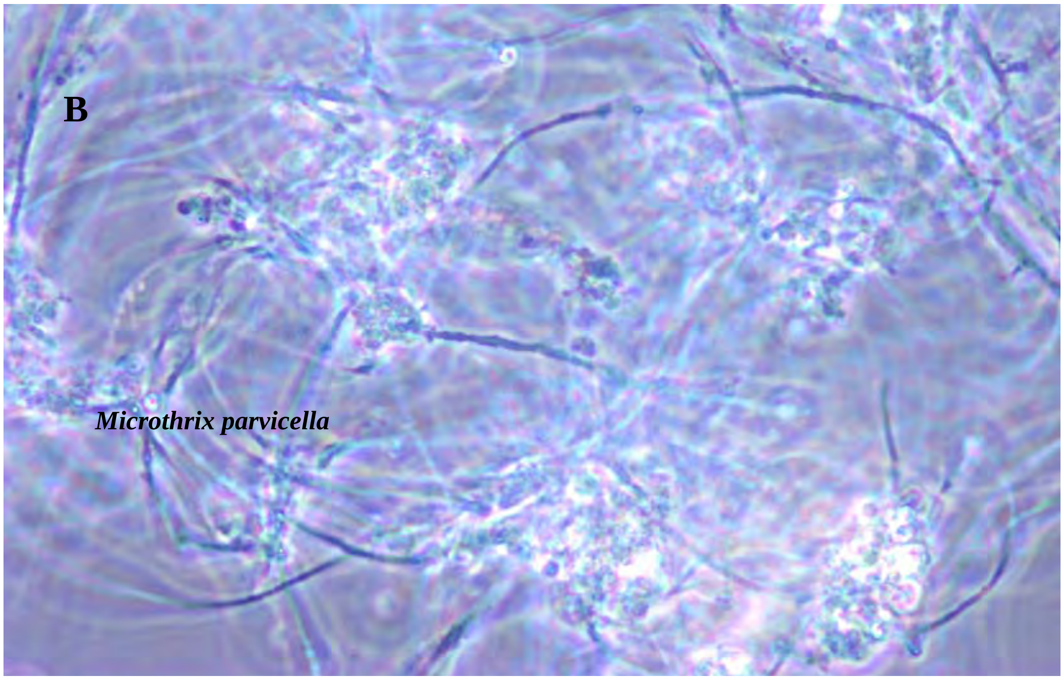
A. Non viable ovum; 67.34 µm long

B. Viable, fertile ovum; 61.61 µm long.

FIGURE IV-4: EGAN WATER RECLAMATION PLANT MIXED LIQUOR AND FOAM SAMPLE

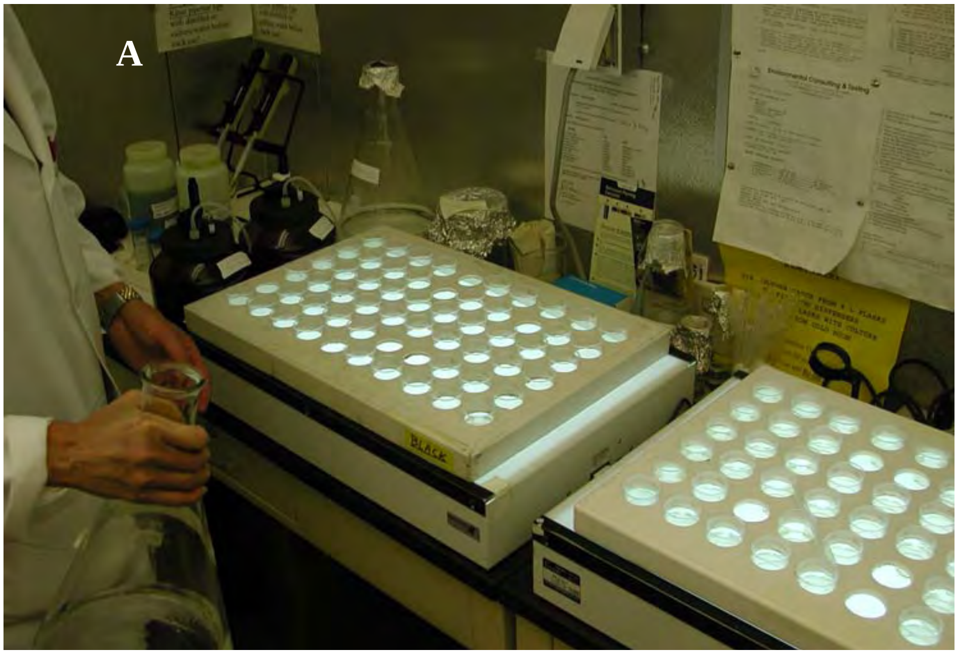


A - Egan Mixed Liquor - *Microthrix parvicella* and filament type 021N – Wet mount, 1000X Oil immersion



B - Egan Foam - *Microthrix parvicella* – Wet mount, 1000X Oil immersion

FIGURE IV-5: BIOMONITORING LABORATORY



A - *Ceriodaphnia dubia* culture trays

B - Fish Culture Lab

FIGURE IV-6: WHOLE EFFLUENT TOXICITY TEST ORGANISMS

Ceriodaphnia dubia (Water Flea)

Pimephales promelas (Fathead Minnow)

AQUATIC ECOLOGY AND WATER QUALITY SECTION

AQUATIC ECOLOGY AND WATER QUALITY SECTION

The Aquatic Ecology and Water Quality Section is primarily responsible for assessing the water and sediment quality in both shallow water (wadeable) and deep-draft waterways in the District's service area. The biological monitoring program, which runs in conjunction with the Ambient Water Quality Monitoring (AWQM) Program, includes chlorophyll monitoring, the study of the benthic invertebrate and fish communities, characterization of the physical habitat, and assessment of sediment toxicity and sediment chemistry. The primary objective of the monitoring program is to provide scientific data to the District and the Illinois Environmental Protection Agency (IEPA) regarding the biological condition of the Chicago Waterway System (CWS). The IEPA uses the data to assess the biological integrity, physical habitat, and sediment quality in waterways in the District's service area. These assessments are summarized in the IEPA's Integrated Water Quality Report and Section 303 (d) Lists. Results are used by IEPA to prepare a list of impaired waters through the 303 (d) listing process.

The biological portion of the AWQM Program, as it currently exists, began in 2001 and is conducted from June through September at 59 stations on the CWS (Figure V-1). Fifteen of the 59 sampling stations are assessed annually, with the remaining 44 stations assessed once every four years.

Additional water and sediment quality monitoring is conducted outside of the District's service area in the lower Des Plaines River and the Illinois River. Special water quality surveys are also conducted to provide technical assistance for the Maintenance and Operations (M&O) and Engineering Departments.

Fish Monitoring 2007

During June through October of 2007, fish were collected by electrofishing and seining at 25 biological monitoring stations on the CWS, plus at three Sidestream Elevated Pool Aeration (SEPA) Stations (Numbers 3, 4, and 5). In 2007, 5,725 fish composed of 47 species and 3 hybrid species were identified, weighed, and measured for length. The fish were also examined for parasites and disease.

Data from these collections are shown in Table V-1 for the deep-draft waterways and in Table V-2 for the wadeable waterways. The most abundant species in the deep-draft waterways included gizzard shad, emerald shiners, carp, bluntnose minnows, pumpkinseed sunfish, rock bass and largemouth bass. In the wadeable waterways, gizzard shad, carp, fathead minnows, green sunfish, spotfin shiners, white suckers, mosquito fish, and bluegills were the most abundant.

Chlorophyll Monitoring 2007

As a photosynthetic component of all algae cells, the determination of chlorophyll *a* is an accepted way of quantifying algal biomass in lakes and streams. Chlorophyll *a* values are of interest to regulatory agencies since it is also widely accepted that high algae concentrations may indicate nutrient impairment. The IEPA is cooperating with other state and local agencies to promulgate regional water quality criteria for nutrients and possibly chlorophyll. In light of this consideration, the District began monitoring chlorophyll on a monthly basis in August 2001 as part of the AWQM Program. Results from 2007 are shown in Table V-3. The highest mean values of chlorophyll *a* were 101 μg/L at Burnham Avenue on the Grand Calumet River, 39 μg/L at Higgins Road on Salt Creek, and 23 μg/L at both Lake-Cook Road on Buffalo Creek and at Lake Street on the West Branch of the DuPage River.

Illinois Waterway Monitoring

In 1984, the R&D Department established a long-term water and sediment monitoring program along the Illinois Waterway from the Lockport Lock to the Peoria Lock, a distance of approximately 133 miles. The purpose of the monitoring program is to assess the chemical and microbiological quality of the water and to characterize the chemical quality of the sediments.

In 2007, water samples were collected during May, August, and October from each of the 49 sampling stations (Figures V-2 and V-3). During October, sediment samples were collected at 14 selected stations. Data for these sampling events were compiled in R&D Report No. 08-61 entitled, "Water and Sediment Quality Along the Illinois Waterway from the Lockport Lock to the Peoria Lock During 2007."

Salt Creek Nutrient Reduction Demonstration Project

Baseline chemical and biological monitoring began in 2005 and continued throughout 2006 in advance of a demonstration project to lower total phosphorus in effluent from the John E. Egan (Egan) WRP. Total phosphorus reduction to approximately 0.5 mg/L was achieved through ferric chloride addition throughout 2007 and 2008, and impacts on water quality in Salt Creek were monitored. Water samples collected from one station upstream of the Egan WRP (Busse Lake Dam) and two stations downstream (J. F. Kennedy Boulevard and Thorndale Avenue) were analyzed for 16 relevant water quality constituents, including chlorophyll *a*. These samples were collected twice per month during April through November, once per month in January through March and December, and for four sequential days following rain events, which occurred in April, May, June, and August of 2007. Biological monitoring, including fish and macroinvertebrate collections, and a physical habitat assessment, were performed once at each station during 2007, along with sediment chemistry analysis. R&D Report 08-38R entitled, "Salt Creek Phosphorus Reduction Demonstration Project Interim Report: Comparison of Pre- and Post-Phosphorus Reduction Conditions During 2005 - 2007," includes all background monitoring data that was collected during 2005 and 2006 and data for 2007, which was the first post-phosphorus reduction. Results showed that there was no apparent stream response to lower phosphorus concentration during 2007.

Continuous Monitoring of Dissolved Oxygen

In order to gain a better understanding of the oxygen dynamics in deep-draft sections of the CWS, the EM&R Division developed a comprehensive continuous dissolved oxygen (DO) monitoring program beginning in August 1998 in the Chicago River System, July 2001 in the Calumet River System, and in the Des Plaines River System in July 2005.

Dissolved oxygen was measured hourly using remote (in-situ) water quality monitors deployed in protective stainless steel housing enclosures. As shown in Figure V-1, in the Chicago River System the monitors were located at 14 stations on the North Shore Channel, North Branch of the Chicago River, Chicago River, South Branch of the Chicago River, Bubbly Creek, and the Chicago Sanitary and Ship Canal. In the Calumet River System, the monitors were located at nine stations on the Calumet River, Grand Calumet River, Little Calumet River, and the Calumet-Sag Channel. Nine stations were located in the Des Plaines River System on the Des Plaines River and Salt Creek.

The DO results for 2007 can be found in the reports entitled, "Continuous Dissolved Oxygen Monitoring in the Deep-Draft Chicago Waterway System During 2007" (R&D Report No. 08-39) and "Continuous Dissolved Oxygen Monitoring in Chicago Area Wadeable Streams During 2007" (R&D Report No. 08-59).

North Shore Channel Endocrine Disruptor Study with United States Environmental Protection Agency

This study focused on pharmaceuticals and personal care products (PPCP's), hormones, and alkylyphenol ethoxylates (APE's) in the North Shore Channel (NSC). The United States Environmental Protection Agency's (USEPA) Great Lakes National Program Office (GLNPO) and USEPA, Region 5, developed this study as a supplement to the Office of Water's national study to determine the concentrations of PPCP's in fish. It is a collaborative partnership between the GLNPO, Region 5, the Chicago Regional Laboratory (CRL), the Office of Water, the Office of Research and Development, the United States Geological Survey, the United States Department of Agriculture, St. Cloud State University, the Illinois Department of Natural Resources, and the District. The four main objectives of the supplemental study are: (1) to determine if there is reproductive impairment in resident fish, (2) estimate whole fish and fillet concentrations of PPCP's, APE's, and hormones, (3) estimate effluent and stream concentrations of PPCP's, APE's, and hormones, and (4) document seasonal differences in concentrations of these compounds in effluent, stream, and fish.

Sampling was conducted in the fall of 2006 and spring of 2007. In the fall, samples were collected from the NSWRP effluent, the NSC, and a reference sample from Lake Michigan. In the spring, samples were collected from the NSWRP effluent, the NSC, and a reference sample from Braidwood Lake. Effluent samples were collected by the District and stream and reference samples were collected by Region 5. Effluent samples were collected 19 times from 9/14/06 to 10/24/06 and 21 times from 2/26/07 to 4/23/07. Stream samples were collected six times from

9/19/06 to 10/24/06 and six times from 3/2/07 to 4/23/07. Fish samples were collected on 9/26/06 and 3/28/07 from the NSC and from the specific reference site on 9/27/06 and 3/29/07.

Reproductive impairment was assessed by examining fish gonads for evidence of intersex, analyzing male fish blood for the presence of vitellogenin (vtg), and examining the livers for abnormalities. Analysis was conducted by Dr. Heiko Schoenfuss from St. Cloud State University. Summary findings for the fall collection showing the fish sex and occurrence of vtg are shown in Table V-4 and summary findings for the spring collection are shown in Table V-5. The histological analysis of the liver and gonads did not reveal any patterns between males and females or between vitellogenic males and those without plasma vtg for the fall samples. All female largemouth bass contained all stages of oogenesis in their ovaries, while all male largemouth bass exhibited all stages of spermatogenesis from the fall sample. One trend observed in the fall collection was the greater abundance of connective tissue in the testis of male largemouth bass collected in the NSC. Ovatestis were not observed in any of the fish collected in the fall and spring collections. In the spring collection common carp were collected along with largemouth bass. Most of the female fish collected in the spring had high concentrations of plasma vtg which should be expected in gravid females at the beginning of the spawning season. Only one male largemouth bass was collected from the NSC, making it difficult to make comparisons, but it should be noted that the vtg concentration was an order of magnitude higher than all of the male largemouth bass vtg concentrations from Braidwood Lake. Carp collected from Braidwood Lake had vtg concentrations comparable to males collected from the NSC. Males at the Braidwood site were generally in an earlier spermatogenic stage than males from the NSC. Histological analysis of all testis and livers in males and females of both species from the spring collection did not reveal any gross abnormalities.

TABLE V-1: FISH COLLECTED FROM DEEP-DRAFT WATERWAYS DURING 2007

Station No.	Location	Number of Fish Collected	Weight (kg) of Total Catch	Number of Fish Species	Number of Game Fish Species	Most Abundant Fish Species
		North Shore Channel				
36	Touhy Avenue	387	84.8	14	9	Gizzard shad
		North Branch Chicago River				
46	Grand Avenue	117	36.0	13	5	Gizzard shad
		Chicago Sanitary and Ship Canal				
75	Cicero Avenue	280	23.7	13	7	Pumpkinseed
41	Harlem Avenue	282	142.3	12	5	Pumpkinseed
92	16th St., Lockport	64	9.3	6	3	Gizzard shad
		Calumet River				
SEPA 1	Torrence Avenue	543	64.6	15	6	Bluntnose minnow
55	130th Street	233	100.7	15	6	Largemouth bass
		Little Calumet River				
49	Ewing Avenue	102	10.5	5	2	Rock bass
76	Halsted Street	281	150.7	21	10	Carp
		Calumet-Sag Channel				
58	Ashland Avenue	131	175.7	12	5	Gizzard shad
SEPA 3	Western Avenue	407	94.0	14	5	Emerald shiner
59	Cicero Avenue	297	59.1	12	7	Gizzard shad
SEPA 4	Harlem Avenue	417	97.7	14	6	Emerald shiner
43	Route 83	261	19.3	9	3	Gizzard shad
SEPA 5	Junction CSSC/ Calumet-Sag Channel	394	18.2	17	9	Gizzard shad

TABLE V-2: FISH COLLECTED FROM WADEABLE WATERWAYS DURING 2007

Station No.	Location	Number of Fish Collected	Weight (g) of Total Catch	Number of Fish Species	Number of Game Fish Species	Most Abundant Fish Species
		North Branch Chicago River (Shallow Portion)				
96	Albany Avenue	14	75.1	4	1	White sucker
		Higgins Creek				
78	Wille Road	465	2,117.1	5	1	Fathead minnow
		Des Plaines River				
13	Lake-Cook Road	146	901.1	6	3	Green sunfish
22	Ogden Avenue	71	1,233.5	13	7	Mosquitofish and Bluegill
91	Material Services Rd.	38	6,821.7	10	4	Green sunfish
		Salt Creek				
	Busse Dam	258	2,473.2	10	6	Spotfin shiner
	JFK Boulevard	39	765	7	6	Green sunfish
18	Devon Avenue	20	394.9	4	3	Green sunfish
	Thorndale Avenue	31	2,813.7	6	3	Green sunfish
		West Branch DuPage River				
64	Lake Street	59	2,506	7	4	Green sunfish
		Little Calumet River				
52	Wentworth Avenue	16	4,640	6	1	Gizzard shad
57	Ashland Avenue	135	41,149.9	13	6	Gizzard shad
		Grand Calumet River				
86	Burnham Avenue	18	11,937.6	5	2	Carp
		Thorn Creek				
54	Joe Orr Road	42	4,609.0	5	2	Green sunfish
97	170th Street	12	8,654.1	5	3	Carp, Green sunfish
		Wolf Lake Drain				
50	Burnham Avenue	9	72.7	6	5	Green sunfish

TABLE V-3: MEAN AND RANGE OF CHLOROPHYLL *a* VALUES FROM CHICAGO AREA WATERWAYS DURING 2007

Station No.	Location	Number of Samples	Mean (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Standard Deviation (µg/L)
	West Fork North Branch Chicago River					
106	Dundee Road	4	6	4	8	2
103	Golf Road	11	12	4	22	7
	Middle Fork North Branch Chicago River					
31	Lake-Cook Road	10	8	2	17	4
	Skokie River					
32	Lake-Cook Road	10	9	3	20	6
105	Frontage Road	11	18	3	55	14
	North Branch Chicago River (Wadeable Portion)					
104	Glenview Road	11	12	1	39	12
34	Dempster Street	10	9	2	32	9
96	Albany Avenue	11	9	2	31	9
	North Shore Channel					
35	Central Street	10	8	1	22	9
102	Oakton Street	12	16	1	102	29
36	Touhy Avenue	12	1	1	2	<1
101	Foster Avenue	12	1	<1	2	1
	North Branch Chicago River (Deep-Draft Portion)					
37	Wilson Avenue	12	3	<1	7	2
73	Diversey Avenue	12	2	1	7	2
46	Grand Avenue	11	5	2	13	4
	Chicago River					
74	Lake Shore Drive	11	2	1	6	2
100	Wells Street	11	2	1	6	2

TABLE V-3 (Continued): MEAN AND RANGE OF CHLOROPHYLL *a* VALUES FROM CHICAGO AREA WATERWAYS DURING 2007

Station No.	Location	Number of Samples	Mean (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Standard Deviation (µg/L)
	South Branch Chicago River					
39	Madison Street	11	4	1	12	4
108	Loomis Street	12	4	1	11	3
	Bubbly Creek (South Fork South Branch Chicago River)					
99	Archer Avenue	11	7	<1	22	8
	Chicago Sanitary and Ship Canal					
40	Damen Avenue	12	5	1	14	4
75	Cicero Avenue	12	5	1	16	4
41	Harlem Avenue	12	3	1	7	2
42	Route 83	11	5	1	18	5
48	Stephen Street	11	6	2	19	5
92	Lockport	50	6	1	19	4
	Calumet River					
49	Ewing Avenue	10	1	1	2	<1
55	130th Street	10	4	1	14	4
	Wolf Lake					
50	Burnham Avenue	11	6	2	14	3
	Grand Calumet River					
86	Burnham Avenue	10	101	4	691	212
	Little Calumet River (Deep-Draft Portion)					
56	Indiana Avenue	9	14	3	40	11
76	Halsted Street	11	7	<1	41	12
	Thorn Creek					
54	Joe Orr Road	10	3	1	8	2
97	170th Street	11	9	3	26	7

TABLE V-3 (Continued): MEAN AND RANGE OF CHLOROPHYLL *a* VALUES FROM CHICAGO AREA WATERWAYS DURING 2007

Station No.	Location	Number of Samples	Mean (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Standard Deviation (µg/L)
	Little Calumet River (Wadeable Portion)					
52	Wentworth Avenue	11	13	1	82	23
57	Ashland Avenue	11	7	2	24	7
	Calumet-Sag Channel					
58	Ashland Avenue	11	7	1	39	11
59	Cicero Avenue	11	8	1	43	12
43	Route 83	11	7	1	29	8
	Buffalo Creek					
12	Lake-Cook Road	9	23	9	35	9
	Higgins Creek					
77	Elmhurst Road	4	15	8	28	9
78	Wille Road	11	4	1	10	3
	Des Plaines River					
13	Lake-Cook Road	12	14	3	71	19
17	Oakton Street	11	12	1	58	16
19	Belmont Avenue	11	6	1	16	5
20	Roosevelt Road	11	7	1	18	6
22	Ogden Avenue	11	6	1	16	5
23	Willow Springs Road	11	5	1	13	4
29	Stephen Street	10	9	3	18	5
91	Material Service Road	10	12	3	27	9
	Salt Creek					
79	Higgins Road	10	39	6	85	26
80	Arlington Heights Road	12	14	3	31	10
18	Devon Avenue	12	14	4	31	10
24	Wolf Road	11	7	1	22	7
109	Brookfield Avenue	10	7	1	23	7

TABLE V-3 (Continued): MEAN AND RANGE OF CHLOROPHYLL *a* VALUES FROM CHICAGO AREA WATERWAYS DURING 2007

Station No.	Location	Number of Samples	Mean (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Standard Deviation (µg/L)
			West Branch DuPage River			
110	Springinsguth Road	9	21	2	53	19
89	Walnut Lane	12	7	2	34	9
64	Lake Street	11	23	4	42	11
			Poplar Creek			
90	Route 19	11	11	1	31	10

TABLE V-4: SUMMARY OF FISH SEX AND OCCURRENCE OF VITELLOGENIN DETECTED IN FALL COLLECTION

	North Shore Channel	Lake Michigan Outer Harbor
Immature fish (w/vtg)	4 (0%)	0
Male fish (w/vtg)	5 (60%)	4 (0%)
Female fish (w/vtg)	3 (100%)	5 (100%)

TABLE V-5: SUMMARY OF FISH SEX, WEIGHT, AND VITELLOGENIN CONCENTRATION DETECTED IN SPRING COLLECTION

	Largemouth Bass				Common Carp			
	North Shore Channel		Braidwood		North Shore Channel		Braidwood	
	Male	Female	Male	Female	Male	Female	Male	Female
Sample size	1	8	8	4	9	5	11	2
Weight (g)	1050	949±64	998±110	941±114	3176±466	3518±779	2222±207	1889±874
VTG (µg/ml)	3.3	7±1.8	0.08±0.05	9.3±5.1	38±17	38900±9334	29±12	48350±31950

FIGURE V-1: AMBIENT WATER QUALITY MONITORING AND CONTINUOUS DISSOLVED OXYGEN MONITORING SAMPLE STATIONS

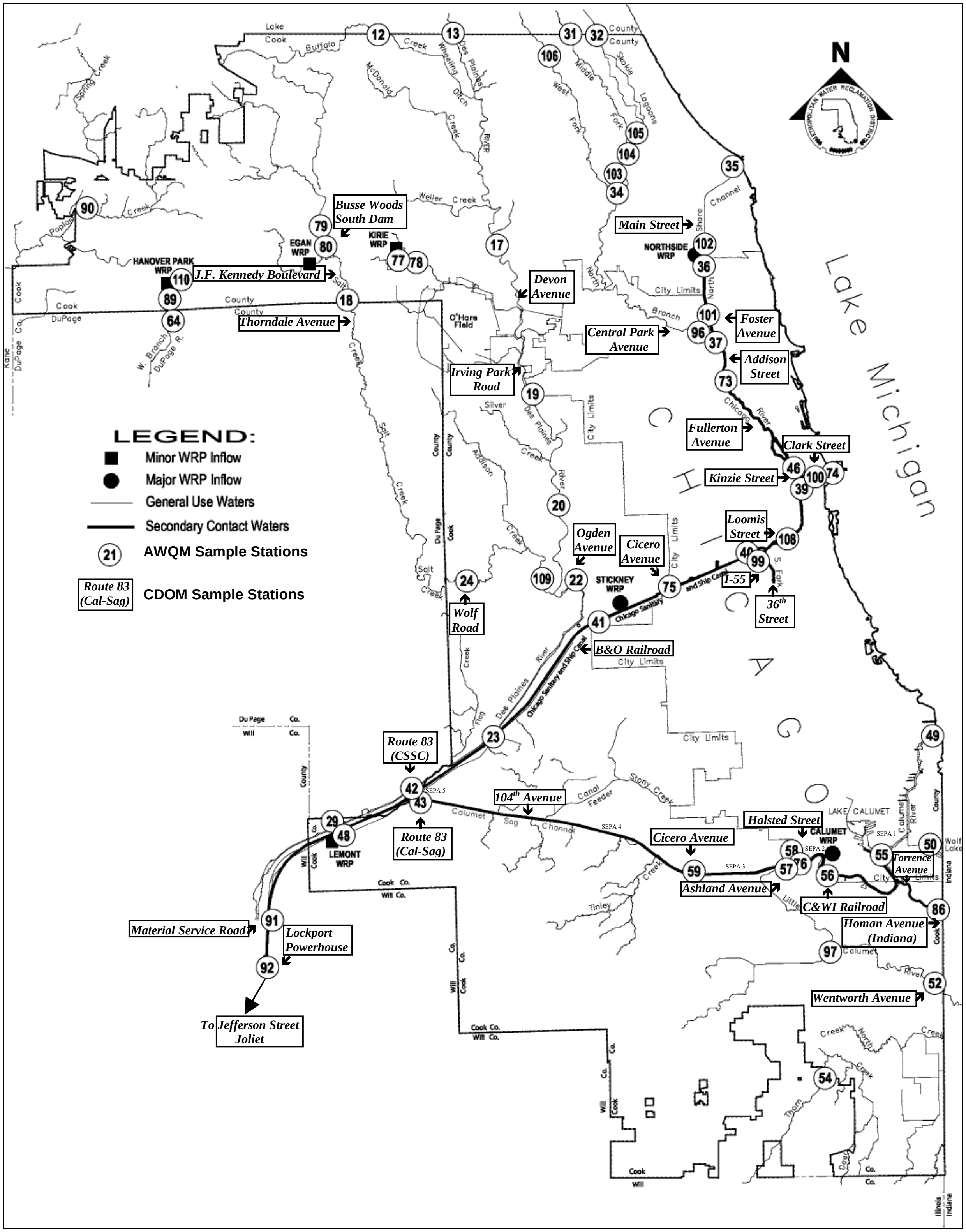


FIGURE V-2: MAP OF THE ILLINOIS WATERWAY FROM LOCKPORT TO MARSEILLES SHOWING SAMPLING STATIONS 1 TO 21

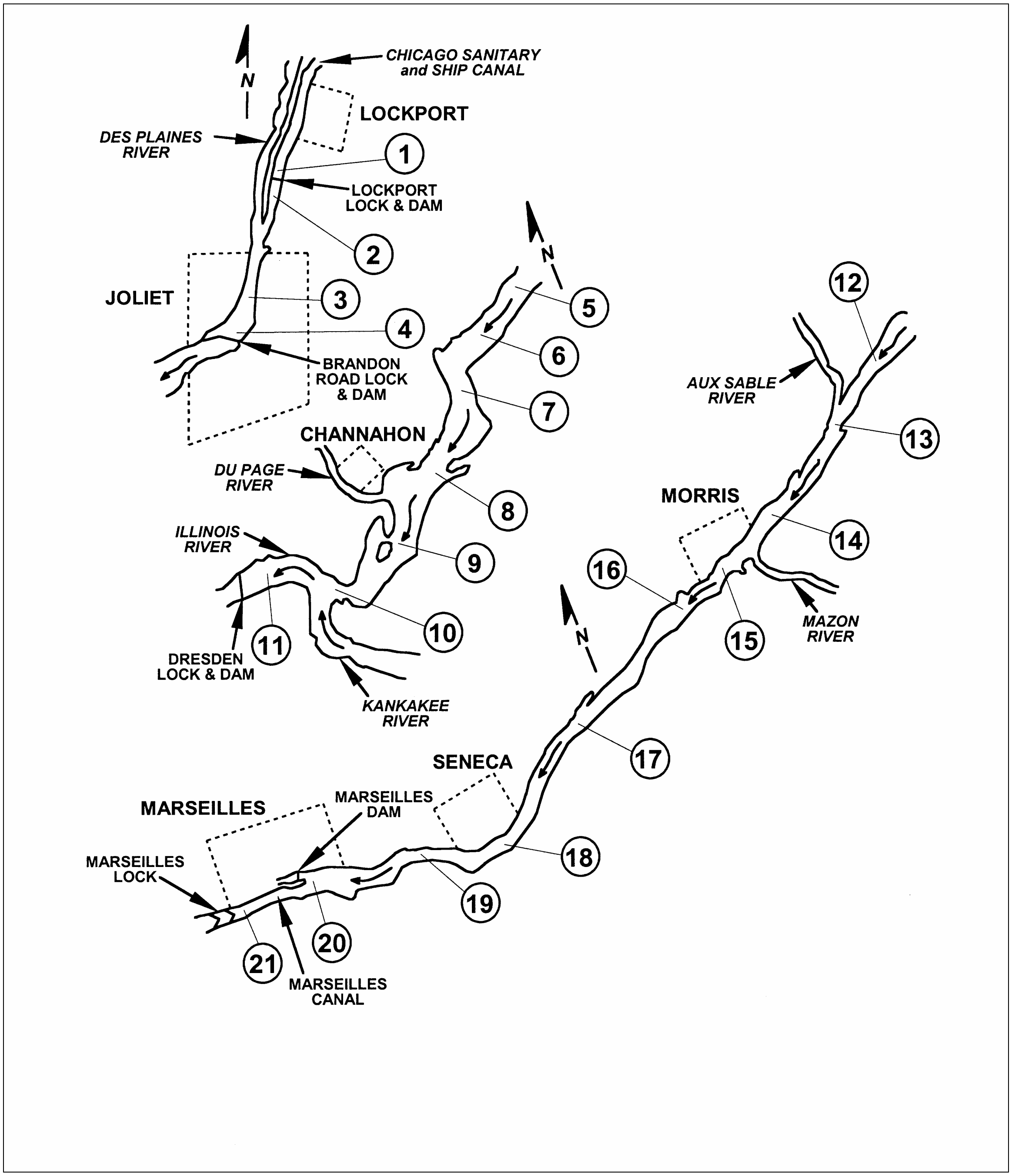
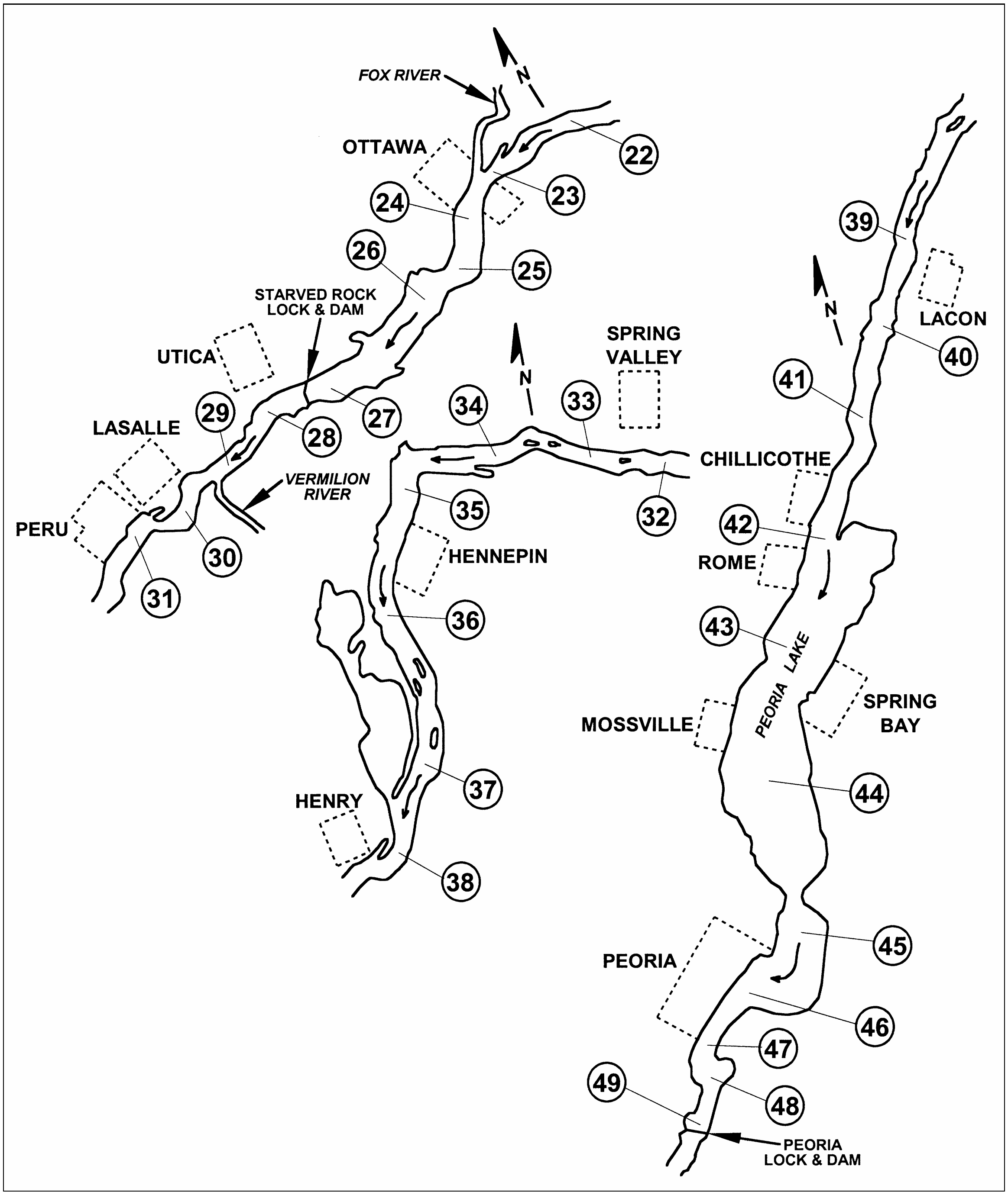


FIGURE V-3: MAP OF THE ILLINOIS WATERWAY FROM OTTAWA TO PEORIA SHOWING SAMPLING STATIONS 22 TO 49



RADIOCHEMISTRY SECTION

RADIOCHEMISTRY SECTION

The Radiochemistry Section is responsible for the radiological monitoring of waters, wastewaters, sludges, and biosolids, and the maintenance of radiation safety at the District. It also performs special tasks involving the use of ionizing radiation and radioisotopes.

The section also maintains a radioactive material license issued to the District by the Illinois Emergency Management Agency, Division of Nuclear Safety (IEMA-DNS), assuring that the activities involving use of radioactive material are conducted according to the license conditions and regulations.

The Radiochemistry Laboratory is certified by the IEMA-DNS and is approved for the examination of gross alpha/beta, tritium, and photon emitting radionuclides in public water supplies.

The laboratory participates in the Environmental Resource Associates (ERA) RadChem Proficiency Testing (PT) water study as required by the IEMA-DNS for maintaining laboratory certification. The section also participates in the ERA's MRad Multi-Media Radiochemistry PT Soil Study. This involvement contributes to the state of the profession and further validates the analysis performed by the laboratory.

The radiological monitoring of raw and treated wastewaters from the District's WRPs was initiated in 1967 as the State of Illinois Sanitary Water Board developed effluent criteria (Technical Release 20-22, April 1, 1967). Although the present NPDES permits from the IEPA do not include limits for radioactivity in the District's effluents, monitoring has continued into 2007 since there are radioactivity parameters in the water quality standards for the General Use waters.

Since 1978, the section has conducted radiological monitoring of biosolids from both the LASMA and HASMA solids drying sites. Beginning in 1993, the solids survey was expanded to include raw sludge and digested biosolids from District WRPs and air-dried biosolids ready for final use at all of the Stickney and Calumet solids management areas.

The Radiochemistry Section participates in the ambient water quality monitoring program of the Chicago Waterway System (CWS). The radiological monitoring of area waterways under the jurisdiction of the District includes the Calumet, Chicago, and Des Plaines River systems.

Radiation Safety

The Radiochemistry Section continues to maintain a radiation safety program for the District. The program includes:

- maintaining the IEMA-DNS radioactive material license;

- managing low-level radioactive waste;
- monitoring personnel for radiation exposure;
- testing the operation of radiation survey meters;
- surveying of the Radiochemistry Laboratory work areas for radiation;
- leak testing the radioactive sealed sources; and
- maintaining a physical inventory of licensed radioactive materials.

The District possesses a radioactive material license from the IEMA-DNS. The radiation protection program is conducted in accordance with the license conditions and regulatory requirements of IEMA-DNS.

The Illinois Low-Level Radioactive Waste Management Act requires all generators and brokers of low-level radioactive waste (LLRW) in Illinois to file an annual survey form with the IEMA-DNS. In 2007, the relevant forms were received from the IEMA-DNS, completed, and returned to the IEMA-DNS.

The monitoring of District employees for radiation exposure was carried out using dosimeter badges and finger ring dosimeters. The dosimeters are worn by laboratory personnel, and users of moisture/density gauges. A total of 252 dosimeters were analyzed in 2007. No District employee was exposed to an overdose of radiation.

The operational checks of radiation survey meters were carried out on the day radioactive materials were used or at least once a month. A record was maintained for the operational checks of radiation survey instruments.

The Radiochemistry Laboratory is regularly surveyed for radiation contamination. A total of 120 wipe tests were performed in 2007. No contamination was found in any work area.

As per IEMA-DNS regulations, radioactive sealed sources are tested for leakage or contamination at intervals not to exceed six months. All of the radioactive sealed sources used by the District personnel were tested for leakage twice in 2007.

Nickel-63 sources constitute a part of the electron capture detectors of gas chromatographs used by the R&D Department. Leak tests were performed on six detectors from three gas chromatographs in 2007. No leaks were discovered in any detectors used by the District.

Two leak tests each were performed in 2007 on the APD2000 CW Detector, and an XRF Paint Analyzer, owned by the Safety Section of General Administration. The APD2000 CW detector is equipped with a nickel-63 sealed source and the XRF Paint Analyzer is equipped with a Cobalt-57 sealed source. No leaks were discovered in the detectors.

Leak tests were also performed on four Troxler surface moisture/density gauges used by the Construction Division of the Engineering Department. A total of 16 leak tests were performed in 2007. No leaks were discovered in any of these gauges.

A physical inventory of the radioactive sealed sources possessed by the District was carried out twice in the year 2007. A record of this inventory was maintained as per license requirements.

Certification by the Illinois Emergency Management Agency, Division of Nuclear Safety

The Radiochemistry Laboratory was certified by the Illinois Department of Nuclear Safety, now the IEMA-DNS, on October 2, 2001 and has maintained its certification status. The laboratory is approved for the examination of gross alpha/beta, tritium, and photon emitting radionuclides in public water supplies.

Participation in the Environmental Resource Associates Proficiency Testing Program

The Radiochemistry Section participated in the ERA RadChem PT water study and the MRad Multi-Media Radiochemistry PT soil study, along with other certified laboratories. The participation in the RadChem PT water study is an IEMA-DNS requirement to maintain laboratory certification.

During 2007, the Radiochemistry Section analyzed three water samples for gross alpha, gross beta, barium-133, cobalt-60, cesium-134, cesium-137, zinc-65 and tritium radioactivity. The section also analyzed two soil samples for actinium-228, bismuth-212, bismuth-214, cesium-134. cesium-137, cobalt-60, lead-212, lead-214, potassium-40 and zinc-65. The analytical results were reported to the ERA. Acceptable results were obtained on all the samples.

Levels of Radioactivity in Raw and Treated Wastewaters

Radiological monitoring of raw wastewaters and final effluents from the District's seven WRPs continued in 2007. Data from the monitoring serves as a measure of present-day radioactivity levels in comparison to levels in past years. The IPCB has established General Use water quality standards for radioactivity in the waters of Illinois. According to IPCB regulations, (Title 35, Chapter 1, Section 302.207) gross beta concentration shall not exceed 100 pCi/L, and the strontium-90 concentration must not exceed 2 pCi/L. The annual average radium-226 and 228 combined concentration must not exceed 3.75 pCi/L in General Use waters. There are no IPCB or USEPA radioactivity standards for raw sewage or final effluents. However, the District uses the IPCB General Use waters limits for gross beta concentration as the standard for monitoring effluents.

The radioactivity analysis was conducted on 24-hour composite samples of raw sewage and final effluent. The samples were processed using USEPA, Environmental Monitoring and

Support Laboratory procedures, March 1979, and counted for gross alpha and gross beta radioactivity on a Tennelec LB5100 alpha/beta gas proportional counter. The gas proportional counter was calibrated for alpha efficiency using thorium-230, and for beta efficiency using cesium-137 standards obtained from North American Scientific, California.

Table VI-1 presents the 2007 yearly averages of gross alpha radioactivity for the raw sewage and final effluent from the District's seven WRPs. Slightly elevated levels of radioactivity in Lemont raw sewage have been observed since 1989. This is because the Village of Lemont began utilizing a water treatment process to remove radium from their water supply and discharged the backwash water into the Lemont WRP. However, this backwash from the Lemont drinking water system does not pose a threat to the District's compliance status.

Table VI-2 presents the 2007 yearly averages for gross beta radioactivity in raw sewage and final effluent from the District's seven WRPs.

Levels of Radioactivity in Sludge and Biosolids

In 1993, the Radiochemistry Section revised and expanded its radiological monitoring program of District sludges in response to the increased emphasis on monitoring biosolids quality brought about by adoption of the USEPA's Part 503 Sewage Sludge Regulations. Although there are no standards for radioactivity in these regulations, it was felt that the District should expand its database on the radiological characteristics of its sludge and biosolids.

During 2007, sludge or biosolids samples were collected monthly at all WRPs. Biosolids samples were also collected monthly from the seven solids drying sites of the District from May through September.

Sludge and biosolids samples were processed according to the Standard Methods (20th Edition, 1998) procedures, and counted for gross alpha and gross beta radioactivity using a Tennelec LB5100 alpha/beta counting system. The instrument was calibrated with a thorium-230 standard for gross alpha, and a cesium-137 standard for gross beta radioactivity determinations. The results, in pCi/g of dry weight (DW), were averaged and tabulated in Tables VI-3 and VI-4.

Table VI-3 presents the gross alpha and gross beta radioactivity data of the District's sewage sludge and biosolids.

Table VI-4 presents the gross alpha and gross beta radioactivity data for air-dried biosolids from the District's solids management areas.

Sludge and biosolids samples were also processed for the determination of gamma-emitting radionuclides. The samples were dried on hot plates, ground and passed through a 30-mesh sieve. The samples were packed in three-ounce canisters and sealed with a vinyl electrical tape to avoid loss of the gaseous progeny of uranium and thorium. The samples were stored for at least 30-days for radium-radon to reach equilibrium before counting. The samples were analyzed by a gamma spectroscopy system equipped with a high-purity germanium detector and Genie-2000 spectroscopy software analysis package from Canberra Industries.

Eleven specific radionuclides, with a potential for reconcentration in sludge, were analyzed. Only three of these elements were detected at measurable levels. The radium-226 activity concentration was calculated from the 186 keV photopeak, cesium-137 radioactivity concentration was calculated from the 661.6 keV photopeak, and potassium-40 radioactivity from the 1461 keV photopeak. Two of these three radionuclides, radium-226 and potassium-40, are of natural origin. The third radionuclide, cesium-137, is man-made and may have arisen from fallout of nuclear weapons testing in the middle of the 20th century.

Table VI-5 presents the potassium-40, radium-226, and cesium-137 concentrations in the District's sewage sludge and biosolids.

Table VI-6 presents the potassium-40, radium-226, and cesium-137 concentrations in air-dried biosolids from the District's solids management areas.

Radiological Monitoring of the Chicago Waterway System

Radiological monitoring is a part of the overall monitoring program of the water quality within the District's waterways. Radiological monitoring involves the determination of gross alpha and gross beta radioactivity of samples collected from the waterways. The program includes the Calumet, Chicago, and Des Plaines River systems comprising 170 miles (273.6 km) of waterways. There were sixteen sampling locations on the Chicago River system, nine on the Calumet River system, and twenty on the Des Plaines River system. Each location was sampled once per month.

The waterways samples were processed using USEPA, Environmental Monitoring and Support Laboratory procedures, March 1979, and the gross alpha and gross beta radioactivity was counted using a Tennelec LB5100 gas proportional counter.

Table VI-7 presents the 2007 average values for gross alpha and gross beta radioactivity for the CWS at each of the 45 sampling locations. The concentrations of radioactivity in all samples analyzed were well within the USEPA Drinking Water Standards of 15 pCi/L for gross alpha (excluding radon and uranium), and 50 pCi/L (screening level) for gross beta particle activity minus the naturally occurring potassium-40 beta particle activity.

TABLE VI–1: AVERAGE GROSS ALPHA RADIOACTIVITY IN RAW AND TREATED WASTEWATER FROM DISTRICT WATER RECLAMATION PLANTS – 2007

WRP Type of Sample	Gross Alpha Radioactivity (pCi/L)
<u>Stickney</u>	
Raw (West Side)	<5.1
Raw (Southwest)	<7.2
Secondary – Final Effluent	<5.2
<u>Calumet</u>	
Raw	<5.5
Secondary – Final Effluent	<5.1
<u>North Side</u>	
Raw	<5.0
Secondary – Final Effluent	<4.9
<u>Hanover Park</u>	
Raw	<5.0
Tertiary – Final Effluent	<5.0
<u>John E. Egan</u>	
Raw	<5.4
Tertiary – Final Effluent	<5.2
<u>Lemont</u>	
Raw	15.2
Secondary – Final Effluent	<10.8
<u>James C. Kirie</u>	
Raw	<5.6
Tertiary – Final Effluent	<5.6

< = Less than the lower limit of detection.

TABLE VI–2: AVERAGE GROSS BETA RADIOACTIVITY IN RAW AND TREATED WASTEWATER FROM DISTRICT WATER RECLAMATION PLANTS - 2007

WRP Type of Sample	Gross Beta Radioactivity (pCi/L)
Stickney	
Raw (West Side)	11.4
Raw (Southwest)	22.7
Secondary – Final Effluent	8.4
Calumet	
Raw	9.8
Secondary – Final Effluent	6.9
North Side	
Raw	9.0
Secondary – Final Effluent	6.5
Hanover Park	
Raw	9.8
Tertiary – Final Effluent	9.2
John E. Egan	
Raw	11.4
Tertiary – Final Effluent	8.7
Lemont	
Raw	26.3
Secondary – Final Effluent	20.0
James C. Kirie	
Raw	13.0
Tertiary – Final Effluent	11.1

TABLE VI–3: GROSS ALPHA AND GROSS BETA RADIOACTIVITY OF WATER RECLAMATION PLANT SLUDGES AND BIOSOLIDS - 2007

WRP Type of Sample	No. of Samples	Gross Alpha (pCi/g DW)			Gross Beta (pCi/g DW)		
		Average	Minimum	Maximum	Average	Minimum	Maximum
Calumet Digester Draw	12	11.5	8.9	14.7	25.5	20.5	30.6
John E. Egan Digester Draw	12	9.3	6.4	11.5	18.2	15.9	21.6
Lemont[1] Activated Sludge	12	76.8	47.5	124.3	64.8	41.9	91.6
Hanover Park Digester Draw	12	7.0	5.5	9.4	13.0	10.2	20.4
James C. Kirie[1] Activated Sludge	12	6.8	4.9	8.0	14.6	9.5	20.1
North Side[1] Activated Sludge	12	7.0	5.9	8.7	14.4	9.1	19.5
Stickney Digester Draw	12	9.9	7.7	11.9	26.1	20.2	30.2

[1]No digesters at this WRP.

TABLE VI–4: GROSS ALPHA AND GROSS BETA RADIOACTIVITY IN DISTRICT AIR-DRIED BIOSOLIDS - 2007

Sample Location	No. of Samples	Gross Alpha (pCi/g DW) Average	Gross Alpha (pCi/g DW) Minimum	Gross Alpha (pCi/g DW) Maximum	Gross Beta (pCi/g DW) Average	Gross Beta (pCi/g DW) Minimum	Gross Beta (pCi/g DW) Maximum
LASMA	5	13.9	10.9	18.1	24.2	22.7	25.8
Calumet East	5	13.5	9.1	20.0	23.2	15.1	28.8
Calumet West	3	14.0	10.6	16.8	30.4	29.9	30.8
HASMA	5	12.8	11.3	14.7	24.0	21.5	25.2
Marathon	5	14.4	8.5	17.5	25.2	21.2	28.0
Stony Island	5	10.8	7.3	13.5	25.1	22.1	28.0
Vulcan	4	12.8	7.6	15.4	23.1	21.4	23.0

TABLE VI–5: CONCENTRATION OF GAMMA-EMITTING RADIONUCLIDES IN WATER RECLAMATION PLANT SLUDGES AND BIOSOLIDS – 2007

Sample Location WRP	No. of Samples	Potassium-40 (pCi/g DW)			Radium-226 (pCi/g DW)			Cesium-137 (pCi/g DW)		
		Average	Min.	Max.	Average	Min.	Max.	Average	Min.	Max.
Calumet	3	10.5	9.3	11.6	4.3	3.7	4.9	0.05	0.04	0.05
John E. Egan	3	7.6	6.6	8.6	3.9	3.4	4.5	ND	ND	ND
Hanover Park	3	4.6	4.2	5.3	4.0	3.4	4.4	ND	ND	ND
Stickney	3	11.7	10.2	13.7	3.4	3.1	3.6	0.06	0.05	0.06
Lemont	3	7.3	6.4	8.7	52.4	42.9	60.5	ND	ND	ND

ND – Not Detected

TABLE VI–6: CONCENTRATION OF GAMMA-EMITTING RADIONUCLIDES IN DISTRICT AIR-DRIED BIOSOLIDS – 2007

Sample Location	No. of Samples	Potassium-40 (pCi/g DW)			Radium-226 (pCi/g DW)			Cesium-137 (pCi/g DW)		
		Average	Min.	Max.	Average	Min.	Max.	Average	Min.	Max.
Calumet East	5	8.8	4.8	13.1	4.4	3.5	4.8	0.04	ND	0.07
Calumet West	3	17.5	16.6	17.8	3.6	3.4	3.7	0.04	0.03	0.04
Stony Island	5	8.7	8.1	10.2	3.9	3.3	4.2	0.06	0.05	0.08
HASMA	5	8.6	7.8	9.3	3.7	3.5	4.0	0.06	0.05	0.08
LASMA	5	10.7	9.5	11.5	3.4	3.2	3.7	0.05	0.03	0.06
Marathon	5	11.1	9.3	15.0	3.4	2.8	3.8	0.06	ND	0.07
Vulcan	4	9.4	9.0	10.0	3.6	3.3	3.7	0.06	0.06	0.07

ND – Not Detected

TABLE VI–7: AVERAGE GROSS ALPHA AND GROSS BETA RADIOACTIVITY FOR THE CHICAGO WATERWAY SYSTEM - 2007

Location	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
Lake-Cook Rd., Des Plaines River	<5.2	8.9
Oakton Street, Des Plaines River	<5.3	8.4
Belmont Ave., Des Plaines River	<5.3	9.8
Roosevelt Road, Des Plaines River	<5.4	9.7
Ogden Avenue, Des Plaines River	<5.5	9.3
Willow Springs Rd., Des Plaines River	<5.2	8.0
Stephen Street, Des Plaines River	<5.2	9.5
Material Service Rd., Des Plaines River	<5.1	9.9
Lake-Cook Rd., Buffalo Creek	<5.7	8.2
Elmhurst Rd., Higgins Creek	<5.2	7.0
Wille Rd., Higgins Creek	<5.3	11.8
Higgins Rd., Salt Creek	<5.4	7.5
Arlington Heights Rd., Salt Creek	<5.2	9.1
Devon Ave., Salt Creek	<5.2	9.4
Wolf Rd., Salt Creek	<5.4	9.3
Brookfield Ave., Salt Creek	<5.4	8.9
Route 19, Popular Creek	<5.2	6.3
Springinsguth Rd., W. Br. Dupage River	<6.1	7.4
Walnut Lane, W. Br. Dupage River	<4.8	9.4

TABLE VI-7: (Continued) AVERAGE GROSS ALPHA AND GROSS BETA RADIOACTIVITY FOR THE CHICAGO WATERWAY SYSTEM - 2007

Location	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
Lake St., W. Br. Dupage River	<4.8	9.3
Central St., N. Shore Channel	<3.8	4.9
Oakton St., N. Shore Channel	<4.3	5.9
Touhy Avenue, N. Shore Channel	<5.3	7.7
Dundee Rd., W. Fork N. Branch, Chicago River	<11.7	<12.0
Golf Rd., W. Fork N. Branch, Chicago River	<7.1	9.7
Lake-Cook Rd., Middle Fork, N. Branch, Chicago River	<5.2	6.7
Glenview Rd., Middle Fork, N. Branch, Chicago River	<5.4	7.2
Lake-Cook Rd., Skokie River	<5.3	5.9
Frontage Rd., Skokie River	<5.1	8.2
Dempster St., N. Br., Chicago River	<6.6	<9.0
Albany Ave., N. Br., Chicago River	<6.0	<8.2
Lake Shore Dr., Chicago River	<4.3	<4.7
Wells St., Chicago River	<4.3	5.2
Cicero Ave., Chicago Sanitary & Ship Canal	<5.4	7.4
Harlem Ave., Chicago Sanitary & Ship Canal	<6.1	9.4
Lockport, Chicago Sanitary and Ship Canal	<4.9	8.0
Ewing Ave., Calumet River	<4.1	5.4
130th St., Calumet River	<4.7	7.2
Burnham Ave., Wolf Lake	<4.2	7.0

TABLE VI-7: (Continued) AVERAGE GROSS ALPHA AND GROSS BETA RADIOACTIVITY FOR THE CHICAGO WATERWAY SYSTEM – 2007

Location	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
Indiana Ave., Little Calumet River	<5.1	7.8
Halsted St., Little Calumet River	<5.3	8.7
Wentworth Ave., Little Calumet River	<5.6	10.6
Ashland Ave., Little Calumet River	<5.4	9.5
Joe Orr Road, Thorn Creek	<7.3	8.9
170th St., Thorn Creek	<6.3	10.7

< = Less than the lower limit of detection.

APPENDIX I

APPENDIX I

MEETINGS AND SEMINARS 2007
ENVIRONMENTAL MONITORING & RESEARCH DIVISION

1. Illinois Water Environment Association, Government Affairs in Water Pollution Control Seminar, Lisle, Illinois, *January 2007*.

2. Mid-America Horticultural Trade Show, Chicago, Illinois, *January 2007*.

3. Midwest Water Analysts Association, Winter Expo 2007, Kenosha, Wisconsin, *January 2007*.

4. United States Department of Agriculture, Regional Research Committee W-1170 Annual Meeting, Savannah, Georgia, *January 2007*.

5. United States Environmental Protection Agency, 2007 Midwest Surface Water Monitoring and Standards (SWiMS) Workshop, Chicago, Illinois, *January 2007*.

6. United States Environmental Protection Agency, Aquatic Nuisance Species Barrier Panel Meeting (and follow-up committee meetings throughout the year), Chicago, Illinois, *January 2007*.

7. United States Environmental Protection Agency, Regional Technical Assistance Group, Nutrient Workgroup Meeting, Chicago, Illinois, *January 2007*.

8. United States Fish and Wildlife Service, Hines Emerald Dragonfly Critical Habitat Planning Meeting (and follow-up committee meetings throughout the year), Romeoville, Illinois, *January 2007*.

9. DuPage River, Salt Creek Watershed Workgroup Annual Meeting (and follow-up committee meetings throughout the year), Elmhurst, Illinois, *February 2007*.

10. Illinois Chapter of American Fisheries Society, Annual Meeting, Findlay, Illinois, *February 2007*.

11. Illinois River, Coordinating Council Meeting, Aurora, Illinois, *February 2007*.

12. United States Department of Agriculture, Fourth Greenhouse Gas Conference: Positioning Agriculture and Forestry to Meet the Challenges of Climate Change, Baltimore, Maryland, *February 2007*.

13. University of Illinois, WaterCAMPWS Advisory Board Meeting, Urbana, Illinois, *February 2007*.

MEETINGS AND SEMINARS 2007
ENVIRONMENTAL MONITORING & RESEARCH DIVISION

14. Water Environment Research Foundation, Specialty Conference Disinfection 2007, Pittsburg, Pennsylvania, *February 2007.*

15. Illinois Environmental Protection Agency, Use Attainability Analysis Stakeholder's Meeting (and follow-up committee meetings throughout the year), Chicago, Illinois, *March 2007*.

16. Illinois Pollution Control Board, Total Dissolved Solids Sulfate Hearing, Springfield, Illinois, *March 2007*.

17. Illinois Water Environment Association, 28th Annual Conference (and follow-up committee meetings throughout the year), Bloomington, Illinois, *March 2007*.

18. National Association of Clean Water Agencies, 2007 Water and Wastewater Leadership Center, Chapel Hill, North Carolina, *March 2007*.

19. Water Environment Federation and International Water Association, Specialty Conference, Nutrient Removal 2007, Conference, Baltimore, Maryland, *March 2007*

20. City of Chicago, Department of Environment, Bubbly Creek Active Sediment Capping Committee Meeting (and follow-up committee meetings throughout the year), Chicago, Illinois, *April 2007*.

21. City of Chicago, Earth Day Celebration, Chicago, Illinois, *April 2007*.

22. Illinois Water Environment Association, Young Professional Summit, Chicago, Illinois, *April 2007*.

23. Water Environment Federation, Joint Residuals and Biosolids Specialty Conference, Denver, Colorado, *April 2007.*

24. American Society for Microbiology, 107th General Meeting, Toronto, Ontario, Canada, *May 2007*.

25. Illinois Association of Wastewater Agencies, Technical Committee Meeting and Workshop on Constructed Wetlands for Nutrient Abatement, Utica, Illinois, *May 2007*.

26. Illinois River Coordinating Council Meeting, Springfield, Illinois, *May 2007*.

27. Industrial Water, Waste, and Sewage Group Meeting, Chicago, Illinois, *May 2007*.

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MEETINGS AND SEMINARS 2007
ENVIRONMENTAL MONITORING & RESEARCH DIVISION

28. Air and Waste Management Association, 100th Annual Conference, Pittsburg, Pennsylvania, *June 2007*.

29. American Water Resources Association, Emerging Contaminants of Concern Conference, Vail, Colorado, *June 2007*.

30. Calumet Government Working Group Meeting (and follow-up committee meetings throughout the year), Chicago, Illinois, *June 2007*.

31. Midwest Water Analysts Association, 2007 Spring Meeting, Milwaukee, Wisconsin, *June 2007*.

32. United States Environmental Protection Agency, Epidemiology Study Briefing, Washington, D. C., *June 2007*.

33. Water Environment Federation, TMDL Conference, Seattle, Washington, *June 2007*.

34. Water Environment Federation and International Water Association, Moving Forward, Wastewater Biosolids Sustainability: Technical, Managerial, and Public Synergy Conference, Moncton, New Brunswick, Canada, *June 2007*.

35. Greater DuPage Chapter, Wild Ones, Native Plants, Natural Landscapes, 27th National Wild Ones Conference, Naperville, Illinois, *July 2007*.

36. International Union of Soil Science, 18th World Congress of Soil Science, Philadelphia, Pennsylvania, *July 2007*.

37. National Association of Clean Water Agencies, 2007 Summer Conference, Cleveland, Ohio, *July 2007*.

38. PRZ Sports Turf Seminar, Joliet, Illinois, *July 2007*.

39. Water Environment Federation, Compounds of Emerging Concern Conference, Providence, Rhode Island, *July 2007*.

40. Illinois Chapter of American Fisheries Society, Mussel Identification Workshop, Monticello, Illinois, *August 2007*.

41. Illinois Water Environment Association, Illinois State Fair Booth Volunteer, Springfield, Illinois, *August 2007*.

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MEETINGS AND SEMINARS 2007
ENVIRONMENTAL MONITORING & RESEARCH DIVISION

42. Chemical Industry Council of Illinois, Greenhouse Gas Emissions Seminar, Willow Springs, Illinois, *September 2007.*

43. International Water Association, 14th International Symposium on Health Related Water Microbiology, Tokyo, Japan, *September 2007*.

44. Illinois Environmental Protection Agency, 2007 Governor's Conference on Management of the Illinois River System, Peoria, Illinois, *October 2007*.

45. Illinois Environmental Protection Agency, CFAR Nutrient Standards Update, Springfield, Illinois, *October 2007*.

46. Keep America Playing, National Sports Field Management Seminar, Bourbonnais, Illinois, *October 2007*.

47. Midwest Water Analysts Association, 2007 Fall Meeting, Gurnee, Illinois, *October 2007*.

48. National Association of Clean Water Agencies, 2007 Pretreatment Conference, New Orleans, Louisiana, *October 2007*.

49. Water Environment Association of Ontario, Biosolids Management Beyond 2010, Burlington, Ontario, Canada, *October 2007*.

50. Water Environmental Federation, 80th Annual Technical Exhibition and Conference, San Diego, California, *October 2007*.

51. Air and Waste Management Association, Midwest Chapter, Air Quality Management Conference, Oak Brook, Illinois, *November 2007*.

52. Illinois Chapter of American Fisheries Society, Fish Passage on Midwestern Streams Conference, Naperville, Illinois, *November 2007*.

53. Illinois Sports Turf Managers Association, Illinois Professional Turf Conference, St. Charles, Illinois, *November 2007*.

54. Society of Environmental Toxicology and Chemistry, North America, 28th Meeting, Milwaukee, Wisconsin, *November 2007*.

55. Soil Science Society of America, Annual Meeting, New Orleans, Louisiana, *November 2007*.

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MEETINGS AND SEMINARS 2007
ENVIRONMENTAL MONITORING & RESEARCH DIVISION

56. United States Geological Survey, Streamgage Meeting, Upper Mississippi River Basin States Cooperator's Roundtable for the United States Geological Survey Cooperative Water Program, Dubuque, Iowa, *November 2007*.

57. Water Environment Research Foundation, Issue Area Team Member Meeting on Pathogen Challenge, Alexandria, Virginia, *November 2007*.

58. Chicago Metropolitan Agency for Planning, Symposium on Climate Change, Chicago, Illinois, *December 2007*.

59. Illinois Water Environmental Association, Meeting on Tiered Aquatic Life Use Standards, Downers Grove Sanitary District, Downer's Grove, Illinois, *December 2007*.

APPENDIX II

APPENDIX II

PRESENTATIONS 2007
ENVIRONMENTAL MONITORING & RESEARCH DIVISION

1. "Triclosan and Triclocarban: Uses, Effectiveness, Do We Know the Fate?" Presented at the Illinois Water Environment Association, Government Affairs in Water Pollution Control Seminar, Lisle, Illinois, by C. O'Connor. *January 2007*. PP

2. "Biosolids: CO_2 Source or Sink." Presented at the United States Department of Agriculture, Fourth Greenhouse Gas Conference, Baltimore, Maryland, by G. Tian, T. C. Granato, and A. E. Cox. *February 2007*. PP

3. "Survey of Large Ultraviolet Disinfection Installations." Presented at the Water Environment Research Foundation, Specialty Conference Disinfection 2007, Pittsburg, Pennsylvania, by D. Bernstein, J. S. Jain, and C. O'Connor. *February 2007*. B

4. "Computer Simulation Development of the Stickney Water Reclamation Plant Imhoff Tank Process." Presented at the Illinois Water Environment Association, 28th Annual Conference, Bloomington, Illinois, by D. Bernstein, D. MacDonald, and J. S. Jain. *March 2007*. PP

5. "Plant Availability of Phosphorus in Biosolids-amended Soil." Presented at the Illinois Water Environment Association, 28th Annual Conference, Bloomington, Illinois, by A. E. Cox, K. Kumar, G. Tian, T. C. Granato, G. A. O'Connor, H. A. Elliott, and J. Hutton. *March 2007*. PP

6. "Potential for Phosphorus Runoff and its Control in Biosolids-amended Soil." Presented at the Illinois Water Environment Association, 28th Annual Conference, Bloomington, Illinois, by K. Kumar, G. Tian, A. E. Cox, T. C. Granato, G. A. O'Connor, H. A. Elliott, and J. Hutton. *March 2007*. PP

7. "Sewage Treatment by Metropolitan Water Reclamation District of Greater Chicago." Presented at the Illinois Water Environment Association, 28th Annual Conference, Bloomington, Illinois, by G. K. Rijal. *March 2007*. PP

8. "Antibiotic Resistant Bacteria in Wastewater Processed by the Metropolitan Water Reclamation District of Greater Chicago System." Presented at the American Society for Microbiology, 107th General Meeting, Toronto, Ontario, Canada, by G. K. Rijal. *May 2007*. PS

9. "Environmental Issues in the United States: Past, Present, Projections into the Future." Presented at the Industrial Water, Waste, and Sewage Group Meeting, Chicago, Illinois, by C. O'Connor. *May 2007*. PP

APPENDIX II

PRESENTATIONS 2007
ENVIRONMENTAL MONITORING & RESEARCH DIVISION

10. "An Information Briefing, Metropolitan Water Reclamation District Studies Update." Presented at the United States Environmental Protection Agency, Epidemiology Study Briefing, Washington, D. C., by G. K. Rijal. *June 2007.* PP

11. "Thornton Transitional Reservoir Water Quality and Safety." Presented at the Thornton Quarry, Chicago, Illinois, by R. Gore and G. K. Rijal. *June 2007.* PP

12. "Antibiotic Resistant Bacteria in Wastewater Processed by the Metropolitan Water Reclamation District of Greater Chicago System." Presented at the International Water Association, 14^{th} International Symposium on Health Related Water Microbiology, Tokyo, Japan, by G. K. Rijal. *September 2007.* PS

13. "Beneficial Use of Biosolids on Urban Land in Metropolitan Chicago." Presented at the Water Environment Association of Ontario, Biosolids Management Beyond 2010, Burlington, Ontario, Canada, by L. S. Hundal. *October 2007.* PP

14. "Fecal Coliform Reactivation and Regrowth Experience at the Chicago's Stickney and Calumet Water Reclamation Plants: Operational and Process Perspectives." Presented at the Water Environment Federation, 80^{th} Annual Technical Exhibition and Conference, San Diego, California, by G. K. Rijal, C. Lue-Hing, T. C. Granato, D. Lordi, K. Patel, and R. Gore. *October 2007.* PP

15. "Agronomic and Environmental Liability of Phosphorus in Biosolids Applied to Farmland." Presented at the Soil Science Society of America, Annual Meeting, New Orleans, Louisiana, by G. Tian, A. E. Cox, T. C. Granato, G. A. O'Connor, and H. A. Elliott. *November 2007.* PP

16. "Beneficial Use of Biosolids in the Chicago Metro Area." Presented at the Chicago State University, Biology Department Seminar Series, Chicago, Illinois, by A. E. Cox, *November 2007.* PP

17. "Chicago Area Waterways Use Attainability Analysis Public Health Studies." Presented at the Water Environment Research Foundation, Issue Area Team Member Meeting on Pathogen Challenge, Alexandria, Virginia, by G. K. Rijal. *November 2007.* PP

18. "Response of Turf and Agronomic Crops to Ni." Presented at the Soil Science Society of America, Annual Meeting, New Orleans, Louisiana, by P. V. Lindo, T. C. Granato, and A. E. Cox. *November 2007.* PS

APPENDIX II

PRESENTATIONS 2007
ENVIRONMENTAL MONITORING & RESEARCH DIVISION

19. "What's the Scoop on Chicago Poop? Local Communities Benefit from It!" Presented at the American Chemical Society, Joliet Chapter Seminar Series, Joliet, Illinois, by L. S. Hundal. *November 2007*. PP

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*P = Available as a paper
B = Available as both a paper and PowerPoint Presentation
PP = Available as PowerPoint Presentation
PS = Poster Presentation

APPENDIX III

APPENDIX III

PAPERS PUBLISHED 2007
ENVIRONMENTAL MONITORING & RESEARCH DIVISION

1. Granato, T. C., A. Khalique, A. Cox, and R. I. Pietz, "Assessment of Radioactivity in Chicago Biosolids and its Transfer to Soil and Crops from Long Term Application." *Water Practice, 1: 1-11, 2007*.

2. Rijal, G. K., J. T. Zmuda, R. Gore, Z. Abedin, T. Granato, L. Kollias, and R. Lanyon, "Antibiotic Resistant Bacteria in Wastewater Processed by the Metropolitan Water Reclamation District of Greater Chicago System." Proceedings of the International Water Association, 14^{th} International Symposium on Health Related Water Microbiology, Tokyo, Japan and *Water, Science, and Technology, Tokyo, Japan*, *2007.*

APPENDIX IV

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO
RESEARCH AND DEVELOPMENT DEPARTMENT 2007 SEMINAR SERIES

Date	Subject
January 26, 2007	***Nutrient Farming and Traditional Removal: An Economic Comparison*** Dr. Donald Hey, The Wetlands Initiative, Chicago, IL
February 23, 2007	***Watershed-Wide Distribution of Escherichia Coli: Implications for Meeting Water Quality Standards*** Dr. Richard Whitman, United States Geological Survey, Porter, IN
March 30, 2007	***Fundamental and Practical Studies on Enhanced Biological Phosphorus Removal (EBPR): Identifying the Polyphosphate Accumulating Organisms and Achieving Very Low Effluent Phosphorus Concentrations*** Dr. Daniel Noguera, University of Wisconsin, Madison, WI
April 27, 2007	***Toward Understanding Dynamic Microbial Responses to Chemical Stress: Elucidating Biomarkers for Use in Upset Early Warning Systems*** Dr. Nancy Love, Virginia Tech, Blacksburg, VA
May 18, 2007	***Development of an Integrated Water Quality Strategy for the Chicago Area Waterways*** Dr. David R. Zenz, CTE/AECOM Engineers, Chicago, IL
June 29, 2007	***Antibiotic Resistant Bacteria in Wastewater Processed by the Metropolitan Water Reclamation District of Greater Chicago System*** Dr. Geeta Rijal, Microbiologist, Research and Development Department, Metropolitan Water Reclamation District of Greater Chicago (District), Cicero, IL
July 27, 2007	***Greenhouse Gases to Greenbacks – Carbon Sequestration and Nutrient Management*** Dr. Prakasam Tata, Tata Consulting International, Naperville, IL
August 24, 2007	***Risk Assessment for Recreational Use of the Chicago Area Waterways*** Drs. Chriso Petropoulou and Keith Tolson, Geosyntec Consulting, Inc., Chicago, IL
September 28, 2007	***USEPA's Part 503 Regulations: Using Historical Developments as a Guide to Address Future Rulemaking*** Dr. Cecil Lue-Hing, Cecil Lue-Hing and Associates, Burr Ridge, IL
October 26, 2007	***Impact of Water on Sustainability: Nexus to the Economy, Energy, and the Environment*** Dr. Mark Shannon, University of Illinois (WATER CAMPQS), Urbana, IL
November 16, 2007	***An Update on the Implementation of the Stickney, Calumet, and North Side Water Reclamation Plant's Master Plans*** Mr. Thomas Kunetz, Assistant Chief Engineer, Engineering Department, District, Chicago, IL
December 7, 2007	***Metropolitan Water Reclamation District of Greater Chicago's New Heat Drying Facility for Biosolids*** Mr. Steve Waters, Veolia Water North America, Evanston, IL

RESERVATIONS REQUIRED (at least 24 hours in advance)
CONTACT: Dr. Thomas C. Granato, Assistant Director of Research and Development, EM&R Division, (708) 588-4264 or (708) 588-4059
LOCATION: Stickney Water Reclamation Plant, Lue-Hing Research and Development Complex, 6001 West Pershing Road, Cicero, IL 60804
TIME: 10:00 A.M. (Picture ID required for plant entry)
(Note: These seminars are eligible for Professional Development Credits/CEUs)

APPENDIX V

Environmental Monitoring and Research Division

Section 121
Administrative Section

Granato, Thomas, Assistant Director of R&D
Messina, Deborah, Secretary

O'Connor, Catherine, Research Scientist 4
Urlacher, Nancy, Administrative Assistant

Abedin, Zainul, Biostatistician

Section 122
Wastewater Treatment Process Research

Jain, Jain, Research Scientist 3
Lordi, David, Research Scientist 3
Franklin, Laura, Prin. Office Support
Patel, Kamlesh, Research Scientist 2
Zhang, Heng, Research Scientist 2
Bernstein, Doris, Research Scientist 1
Kozak, Joseph, Research Scientist 1
MacDonald, Dale, Research Scientist 1
Oskouie, Ali, Research Scientist 1
Haizel, Anthony, Lab Tech 2
Reddy, Thota, Lab Tech 2
Bodnar, Robert, Lab Tech 1
Byrnes, Marc, Lab Tech 1
Kowalski, Shawn, Lab Tech 1
Pierson, Rodney, Lab Tech 1
Swies, Christopher, Lab Tech 1

Section 123
Biosolids Utilization and Soil Science

Cox, Albert, Soil Scientist 3
Yarn, Sabina, Prin. Office Support
Hundal, Lakhwinder, Soil Scientist 2
Tian, Guanglong, Soil Scientist 2
Lindo, Pauline, Soil Scientist 1
Kumar, Kuldip, Soil Scientist 1
Dennison, Odona, Sanitary Chemist 1
Patel, Minaxi, Sanitary Chemist 1
Mackoff, Ilyse, Lab Tech 2
Tate, Tiffany, Lab Tech 2
Adams, Richard, Lab Tech 1
Burke, Michael, Lab Tech 1
Holic, Lawrence, Lab Assistant
Lukina, Erna, Lab Assistant

Section 124
Analytical Microbiology and Biomonitoring

Rijal, Geeta, Microbiologist 4
Griffith, Rhonda, Prin. Office Support
Glymph, Auralene, Microbiologist 3
Gore, Richard, Microbiologist 2
Yamanaka, Jon, Biologist 1
Billett, George, Lab Tech 2
Jackowski, Kathleen, Lab Tech 2
Maka, Andrea, Lab Tech 2
Rahman, Shafiq, Lab Tech 2
Shukla, Hemangini, Lab Tech 2
Hussaini, Syed, Lab Tech 1
Kaehn, James, Lab Tech 1
Mangkorn, Damrong, Lab Tech 1
Roberts, David, Lab Tech 1
Bukala, Anthony, Lab Assistant
Latimore, Thomas, Lab Assistant

Section 126
Aquatic Ecology and Water Quality

Dennison, Sam, Biologist 4
Scrima, Joan, Prin. Office Support
Sopcak, Michael, Biologist 3
Wasik, Jennifer, Biologist 2
Minarik, Thomas, Biologist 1
Gallagher, Dustin, Lab Tech 2
Joyce, Colleen, Lab Tech 2
Schackart, Richard, Lab Tech 2
Vick, Justin, Lab Tech 2
Lansiri, Panu, Lab Tech 1
Whitington, Angel, Lab Tech 1

Section 128
Radiochemistry

Khalique, Abdul, Radiation Chemist
Abdussalam, Tasneem, San Chemist 1
Robinson, Harold, Lab Tech 1

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