BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:	)	
	)	
WATER QUALITY STANDARDS AND	)	
EFFLUENT LIMITATIONS FOR THE	)	R08-9
CHICAGO AREA WATERWAY SYSTEM	)	(Rulemaking - Water)
AND THE LOWER DES PLAINES RIVER:	)	
PROPOSED AMENDMENTS TO 35 Ill.	)	
Adm. Code Parts 301, 302, 303 and 304	)	

PRE-FILED TESTIMONY OF STEPHEN F. MCGOWAN

Environmental Assessment of Supplemental Aeration and Flow Augmentation Technologies for Increasing Dissolved Oxygen Concentration in the Chicago Area Waterways

My name is Stephen McGowan and I am a Vice President at Malcolm Pirnie, Inc. I have a Bachelors of Engineering degree in Civil Engineering and a Masters of Engineering degree in Environmental Engineering, both from Manhattan College in Riverdale, New York. I am a licensed Professional Engineer in four states including Illinois and I am also a Board Certified Environmental Engineer (BCEE) with the American Academy of Environmental Engineers. A resume detailing my education and experience is presented in Attachment 1. I am the Project Manager for the study that developed the information in this pre-filed testimony. My testimony today evaluates the environmental impacts, namely air emissions at power generation plants, resulting from the operation of dissolved oxygen (DO) enhancement technologies in sections of the Chicago Area Waterway System (CAWS) (Attachment 2).

I. Introduction and Background

Supplemental aeration is practiced by the Metropolitan Water Reclamation District of Greater Chicago (District) to increase the dissolved oxygen concentration in certain sections of the CAWS. Based upon a Use Attainability Analysis (UAA) study of the CAWS, the Illinois Environmental Protection Agency (IEPA) has proposed new DO water quality standards for the CAWS under this rule-making process.

The District has hired Consoer Townsend Environdyne Engineers, Inc. (CTE) to develop an integrated approach for meeting the proposed DO standards. CTE's study is ongoing and is expected to be completed by mid 2009. Upon the District's request, however, CTE has developed a preliminary cost estimate that will convey to the IPCB the cost implications of achieving the proposed IEPA DO standards for the CAWS at all times.

A map showing the location of the CAWS is presented in Attachment 3. Based on the information provided by CTE, the following are the sections of CAWS considered for supplemental aeration or additional aeration facilities to meet the proposed DO standards at all times.

1. Upper North Shore Channel (UNSC)
2. North Branch of Chicago River (NBCR)
3. South Branch of Chicago River (SBCR)
4. Bubbly Creek (South Fork of SBCR)
5. Chicago Sanitary and Ship Canal (CSSC)
6. Cal-Sag Channel
7. Little Calumet River (North)

II. Locations and Capacities of Flow Augmentation and DO Enhancement Facilities

An updated water quality model of the CAWS, developed by Marquette University, was used to determine the flow augmentation and DO enhancement facilities for the receiving water. Based on the modeling simulations and the historical DO data, the following supplemental aeration was recommended by CTE to meet the proposed IEPA DO standard for the CAWS at all times:

- Eighteen Supplemental Aeration Stations

- Three Flow Augmentation Stations, including;
  - 100 mgd of aerated North Side water reclamation plant effluent for the Upper North Shore Channel
  - 50 mgd of unaerated water from the South Branch of the Chicago River for Bubbly Creek
  - 182.6 mgd of aerated Calumet water reclamation plant effluent for the Little Calumet River
- Existing sidestream elevated pool aeration (SEPA) and diffused air stations operated at full firm capacity

The aeration capacity of each supplemental aeration station or flow augmentation location is presented in Attachment 4. The aeration technology scenarios assume supplemental aeration using only ceramic disc diffusers with an on-shore blower facility to supplement the DO in the waterways. In the case of flow augmentation technology, U-Tube aeration of pumped flow was utilized. Other aeration technologies are under consideration in CTE's ongoing integrated study.

III. Determination of Quantifiable Environmental Impacts

The environmental assessment of supplemental aeration and flow augmentation focuses on energy consumption, which is the largest potential environmental impact for the operation of the DO enhancement technologies in the CAWS. Energy consumption leads to greater electrical demands, resulting in increased air emissions at the coal-based energy generating plants that supply power to run the District facilities. From Attachment 4, CTE estimates that the operation of the DO enhancement technologies will require approximately 74.2 million kWh/yr to achieve the proposed DO standards at all times in the CAWS.

The additional energy requirement for DO enhancement technologies will increase the emissions of criteria pollutants, mercury, and greenhouse gases at the power generating facility.

Mercury (Hg) and the six criteria pollutants: sulfur oxides (SO_x), carbon monoxide (CO), nitrogen oxides (NO_x), particulate matter (PM), ozone (O_3) and lead (Pb), are permitted under the USEPA Clean Air Mercury Rule and Clean Air Act, respectively. For regulatory purposes, sulfur dioxide (SO_2) emissions are reported because they are the indicator of sulfur oxide concentrations in the ambient air. Greenhouse gases, comprised of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluoro-carbons (HFCs), perfluoro-carbons (PFCs) and sulfur hexafluoride (SF_6), are not included in air emission permits, but are of concern on both global and local levels because of their potential to affect global climate changes and global warming. Attachment 5 presents the estimated emission increase at the power generation facility for the most significant of these air pollutants and greenhouse gases.

IV. Comparison of Baseline Conditions and Impact on Future Uses

The implementation of DO enhancement technologies for supplemental aeration will increase the District's energy consumption, resulting in increased air emissions of regulated air pollutants and greenhouse gases at the power generating facility. As described previously, the energy facilities that supply power to run the District facilities are generally coal-based electric generating plants.

Shown in Attachment 6 the total energy required for the operation of the DO enhancement technologies is approximately 74.2 million kWh/yr, which will increase the District's total energy consumption of 550.8 million kWh/yr by 13.5%. The total energy consumption of 550.8 million kWh/yr includes contributions from all District water reclamation plants and pumping facilities.

From the USEPA Greenhouse Gas Equivalencies Calculator, an average household uses 11,965 kWh/yr. Thus, the electricity consumption for DO operation is equivalent to approximately 6,200 households per year. The energy consumption can also be translated to equivalent energy consumption at the Sears Tower, which requires 77 million kWh/yr. The annual energy required for the operation of the DO enhancement technologies is 96% of the annual energy consumption for the Sears Tower.

The increased energy usage for the operation of the DO enhancement technologies will increase the current greenhouse gas emissions of 430,000 tons CO_2 equivalents/yr by 58,000 tons CO_2 equivalents/yr, or 13.5%, at the power generating facility as shown in Attachment 7. Assuming a car emits approximately 6.02 tons of CO_2 equivalents per year (U.S. EPA Greenhouse Gas Equivalencies Calculator), the increase in total greenhouse gas emissions is equivalent to approximately 9,600 additional automobiles added to the road per year. An equivalent 8.9 million trees would be required to absorb that same amount of carbon dioxide emissions. The estimated increase in the most significant permitted air pollutants at the power generating facility are shown in Attachment 8.

The environmental impacts of implementing DO enhancement technologies in the CAWS have been presented in this testimony. Implementing DO enhancement technologies will utilize critical District resources (air, land, water, and financial) that will then become unavailable for future treatment options and alternatives.

Respectfully submitted,

By: Stephen McGowan

Testimony Attachments

1. Resume of Stephen F. McGowan, P.E., BCEE

2. *Environmental Assessment of Plant Effluent Disinfection at the North Side, Calumet, and Stickney Water Reclamation Plants, and Increasing DO in the CAWS*, Malcolm Pirnie, July 2008.

3. Chicago Area Waterways and Water Reclamation Plant Locations

4. Estimated Additional Power Usage for Supplemental Aeration and Flow Augmentation for the CAWS (July 2008)

5. Estimated Emission Loading Increases at Power Generation Facility (tons/yr)

6. Increase of Estimated Annual Energy Usage due to Additional DO Enhancement Operation

7. Increase of Annual Greenhouse Gas Emission Equivalents at the Power Generating Facility due to Additional DO Enhancement Operation

8. Increase of Emissions of Permitted Air Pollutants at the Power Generating Facility due to Additional DO Enhancement Operation

ATTACHMENT 1

Resume of Stephen F. McGowan, P.E., BCEE

Mr. McGowan specializes in water and wastewater process engineering and design. He has extensive experience in municipal and industrial treatment facilities and odor control and has worked at facilities ranging from 0.1 mgd to 1,700 mgd. His work has included pilot and treatability studies for municipal and industrial wastewater treatment, treatment process design, mathematical modeling of treatment processes, and combined sewer overflow projects. He also has experience in construction administration, infiltration/inflow studies, field sampling and pilot studies for odor control, and design of wastewater conveyance and treatment facilities.

DETAILED EXPERIENCE

- **Metropolitan Water Reclamation District of Greater Chicago, Value Engineering Study for the Preliminary Treatment Facilities at the Calumet WRP.** Project Manager for the VE study for the preliminary treatment facilities at the Calumet WRP. The study evaluated the preliminary design of influent conduits, grit removal facilities, primary settling tanks, and effluent conduits for a projected peak flow of 600 mgd. Also provided the lead process engineering review as part of the VE Study.
- **Milwaukee Metropolitan Sanitary Sewerage District, Analysis of Options for Operations and Maintenance of District Facilities and Assistance with Implementation of the Preferred Option.** Project Manager for the evaluation of long term operations and maintenance options for the MMSD's system which includes the Jones Island and South Shore WWTPs, each of which has a maximum rated capacity in excess of 300 mgd, the Metropolitan Interceptor System (MIS), the Inline Storage System (ISS) and other miscellaneous facilities. Provided technical guidance for all aspects of the proposed 10 year operations and maintenance contract including evaluation of current facilities, development of an RFQ, evaluation of SOQs, development of a draft service agreement, development of technical schedules for inclusion in the service agreement, development of an RFP, evaluation of proposals, and negotiations with proposing operations companies.
- **Detroit Water and Sewerage Department: Program Management (P-744) / Detroit MI.** Served as Lead Engineer and Malcolm Pirnie's Project Manager for the Program Management upgrade at the Detroit Water and Sewerage Department's Wastewater Treatment Plant. As part of a team with Wade-Trim and Jacobs Engineering, led all engineering-related tasks for the program, including planning, needs assessments, project scoping (Projects Definition Statement), development of design standards, design management, and engineering assistance during construction. Led a staff of over 15 engineers and 20 subconsultant engineering firms to successfully deliver more than 30 design projects over a four-year period. The project initially included every major treatment process at the 1,700-mgd PS No. 1, upgrade of the 930-mgd

Stephen F. McGowan

Project Role: Project Manager

Title/Firm:
Vice President
Malcolm Pirnie, Inc.

Years of Experience
22

Education
BE Civil Engineering Manhattan College 1984
ME Environmental Engineering Manhattan College 1988

Licenses and Certifications
Professional Engineer
Board Certified Environmental Engineer

Health and Safety Training
Health & Safety Training for Project Management

Professional Training
Anaerobic Treatment of High Strength Wastes
Industrial Wastewater Treatment

Societies
American Water Works Association, AWWA
Water Environment Federation, WEF

Employment History
Malcolm Pirnie, Inc. 1988 to present
O'Brien & Gere Engineers, Inc. 1984 to 1987

secondary treatment process aeration equipment, renovation of seven primary treatment scum buildings, rehabilitation of twelve 110-foot-diameter gravity thickeners, installation of two new 350-mgd intermediate lift pumps, installation of eight new dewatering centrifuges, rehabilitation of ten existing belt filter presses, installation of a 520-dtpd sludge slake pump station, rebuilding of the conveyor and incinerator processes, and installation of a 950-dtpd sludge off-loading.

- **Detroit Water and Sewerage Department (DWSD): Primary Clarifier Design (CS-1311) / Detroit MI.** Served as lead process engineer for the design of two 180-mgd circular clarifiers (250 ft diameter) and 107 mgd of additional raw wastewater pumping capacity. Responsible for managing the preliminary and final Basis of Design Reports for the new clarifiers and pumping. Key elements of the study included detailed analysis of existing influent pumping and primary clarifier facilities, close coordination with WWTP operations and maintenance staff, evaluation of primary clarifier alternatives, development of preliminary cost estimates, development of facility layout drawings, analysis of hydraulic issues and constraints, evaluation of alternatives for providing 107 mgd of additional influent pumping capacity, and final recommendation of a preferred alternative. When completed, this project will increase the firm pumping and primary treatment capacity to 1,700 mgd.
- **Detroit Water and Sewerage Department: Long-Term CSO Control Plan (CS-1158) / Detroit MI.** Conducted extensive investigations, studies, and testing at the City of Detroit's wastewater treatment plant for optimizing the treatment of high wet weather flows. Specific work tasks and responsibilities included the review and analysis of existing data, evaluation of existing sampling procedures, development and calibration of mass balance models for the plant Hydromantic GP3-X dynamic model), development of unit process capacity test protocols, summarizing capacity test results, and preparation of final report with results and recommendations for handling high wet weather flows. Results of these investigations were used to re-rate the primary and secondary capacities to 1,520 mgd and 923 mgd, respectively, and to determine CSO facility sizing in the collection system. Additional responsibilities on the project included estimating efficiencies of proposed CSO treatment facilities, cost estimating, and preliminary facility siting and layout. Results of this work were key elements in the development of DWSD's Long-Term CSO Control Plan.
- **Detroit Water and Sewerage Department (DWSD): Phase III CSO Assistance (CS-1281) / Detroit MI.** On this follow-up project to the DWSD Long-Term CSO Control Plan (CS-1158), Mr. McGowan is the leader of several key work tasks on the DWSD Phase III CSO Assistance project (CS-1281). CS-1281 was initiated in 1997 and is currently ongoing. As a task leader for this project, Mr. McGowan's responsibilities include leading the WWTP Work Group, which addresses WWTP issues related to treatment capacity, coordination with operations and maintenance personnel, individual unit processes, planning, and NPDES permit

compliance. He also leads the Treatment Efficiency Work Group, which assesses treatment efficiency of existing CSO treatment facilities and uses this information for planning future CSO facility planning.

- **Detroit Water and Sewerage Department (DWSD): Conner Creek Pilot CSO Facility (CS-1284) / Detroit MI.** The Conner Creek Basin project was initiated in 1998 and is currently ongoing. The project includes study, design, and construction services phases. Mr. McGowan is the lead process engineer for the design of odor control facilities at the 30-million-gallon Conner Creek CSO Treatment Facility. He has coordinated the evaluation of alternative odor control technologies and provided preliminary design of the proposed alternative. He has also provided process engineering assistance with the evaluation and selection of screens, conveyors, mixers and other process equipment.
- **New York City Department of Environmental Protection: Upgrading of Four Wastewater Treatment Plants / Catskill Region NY.** Operated a 1-gpm pilot plant at the Pine Hill Wastewater Treatment Plant, as part of the New York City watershed protection program. Unit processes included primary clarifiers, rotating biological contractors, final clarifiers, denitrification filters, and alum addition for phosphorus removal. Also responsible for developing process design criteria. Results of the pilot study were used as a basis for design to meet extremely stringent effluent standards for plants in the program.
- **City of Norwalk: Biological Nutrient Removal Demonstration Project / Norwalk CT.** Managed a $1 million biological nutrient removal pilot study at the city's wastewater treatment plant. The study consisted of three 1.5-gpm treatment plants, each with the capability to remove nitrogen and phosphorus to different levels. Each system was optimized and tested for consistent performance. The results of this study will be used to determine nutrient removal alternatives for up to 30 wastewater treatment plants in the State of Connecticut. A key responsibility included development of process design criteria for inclusion in the Facility Planning document. Additional responsibilities include operator training, management of pilot plant operations, data analysis, and report preparation.
- **Puerto Rico Aqueduct and Sewer Authority: Caguas Regional Wastewater Treatment Plant / Caguas PR.** Operated a 1-gpm biological nutrient removal pilot plant at the plant. Responsibilities included full-time operation of the pilot plant, data collection and evaluation, and report preparation. The results of the pilot study were used to develop design criteria for the proposed 15-mgd Caguas-Gurabo Regional Wastewater Treatment Plant. A key responsibility included development of process design criteria for inclusion in the Facility Planning document. This project won the 1991 Honor Award for planning from the American Academy of Environmental Engineers.
- **New York City Department of Environmental Protection: Expansion and Upgrading of the Wards Island Water Pollution Control Plant /**

Bronx NY. Managed a plantwide sampling program at the 285-mgd plant Wards Island WPCP. Sampling consisted of collecting 24-hour composite samples of the wet-stream and solids handling facilities. Analyzed the data to determine influent loadings, unit process treatment efficiency, and effluent quality. Data were also used to develop a mass balance model of the plant to assist in performing a capacity rerating study for the plant.

- **Barceloneta Advisory Council: Wastewater Sampling Studies / Barceloneta PR.** Managed two comprehensive wastewater sampling programs in excess of $0.5 million. Sampling consisted of simultaneous-flow proportional sampling of 11 pharmaceutical industrial wastewater discharges, and also influent and effluent samples at the local regional industrial wastewater treatment plant. Conducted several follow-up tasks using these data to include a reevaluation of the plant's capacity, preparation of an NPDES permit application, and development of a technical support document for approval of a receiving water mixing zone and issuance of a water quality certificate.
- **KMS Group, Inc, Columbia, MD: Wastewater Treatment Plant Expansion.** Analyzed 1.6-mgd wastewater treatment plant for 200,000-gpd upgrade.
- **Pequannock, Lincoln Park, and Fairfield Sewerage Authority: Infiltration/Inflow Study / Lincoln Park NJ.** Performed a desktop analysis of water consumption data, rainfall, and wastewater flows to determine the effect of inflow and infiltration on the plant's performance.

ATTACHMENT 2

Environmental Assessment of Plant Effluent Disinfection at the North Side, Calumet, and Stickney Water Reclamation Plants, and Increasing DO in the CAWS, **Malcolm Pirnie, July 2008.**

Metropolitan Water Reclamation District of Greater Chicago
111 East Erie Street • Chicago, IL 60611

Environmental Assessment of Plant Effluent Disinfection at the North Side, Calumet, and Stickney Water Reclamation Plants, and Increasing DO in the CAWS

July 2008

Report Prepared By:

Malcolm Pirnie, Inc.

1515 East Woodfield Road
Suite 360
Schaumburg, IL 60173
847-517-8114

Contract
07-859-1C

4974003

MALCOLM PIRNIE

Contents

List of Tables

List of Figures

Appendices

1 Introduction

1.1 Background

The Metropolitan Water Reclamation District of Greater Chicago (District) serves the greater Chicago area with its seven water reclamation plants (WRPs), pumping stations, tunnels and other facilities. The District currently does not disinfect the effluent of its three largest facilities (North Side, Calumet, and Stickney WRPs) before discharging to the Chicago Area Waterway System (CAWS). Newly proposed effluent criteria and water quality standards have caused the District to evaluate alternatives for disinfection of plant effluent as well as increasing dissolved oxygen (DO) in some portions of the CAWS.

In 2005, the District retained an independent consultant to conduct a study to determine the most appropriate technology(ies) for disinfection at the District's three largest WRPs, and then to determine the costs of implementing the selected technology(ies). Ultraviolet radiation (UV), ozone, and chlorination followed by dechlorination were evaluated as part of the 2005 study. For purposes of this study, UV disinfection and chlorination/dechlorination will be evaluated for their environmental impacts. UV disinfection is included because it was the highest ranked alternative in the 2005 study. Though chlorination/dechlorination was not ranked high in the report because of concerns related to the formation of disinfection by-products, storage, and transport of large chemical quantities, it is included in this study because it is a commonly used disinfection method for wastewater applications and typically has a lower capital and operating costs.

In a separate study, the District also evaluated increasing the DO in certain portions of the CAWS to meet newly proposed water quality standards relating to sustaining aquatic life. The study evaluated the most feasible technologies and costs of increasing DO at each location. However, the District determined that, based upon the recommendations presented in the study, DO will not meet the proposed water quality standard at some locations in CAWS and alternative strategies must be considered. A supplemental study is currently being conducted by the District to evaluate an integrated water quality strategy for increasing DO in the CAWS.

Implementing new disinfection treatment processes for reducing coliform bacteria and increasing DO levels in the CAWS will require capital-intensive construction activities and ongoing maintenance and operation (M&O). Based on the various studies and to prepare for the rule-making hearings at the Illinois Pollution Control Board (IPCB), the

District is evaluating the costs, benefits and overall environmental impacts of potentially implementing these processes. This report focuses on the potential adverse environmental impacts of implementing each disinfection technology within the study area. The approach considers the environmental impacts of the raw source materials, manufacturing, facility construction, maintenance/operation, and salvage & disposal, and quantifies the most significant impacts from entry into the study area to their disposal within the study area. The benefits, risks, and water quality impacts of implementing these technologies are being addressed by others. Essentially, this report along with work conducted by others will provide the District with the information necessary for an environmental evaluation to select the most sustainable alternative for implementation. This will allow the District to evaluate the environmental benefits (i.e. improved receiving body water quality); impacts (i.e. consumption of energy from coal-fired power plants, land and other resources) of these technologies.

The technical evaluation of DO improvement is ongoing and the required facilities have not been finalized. As such, a comprehensive environmental evaluation of DO improvement technologies is not included in this report. However, based on the information available at this time, a preliminary evaluation of the environmental impacts of DO technologies has been included in this study. The focus of the DO evaluation is on the increase in energy consumption and the resulting air emissions at the power generating facility due to implementation of the DO technologies.

1.2 Scope of Work

The scope of work for this project involved a review of the information collected through literature searches, workshops, previous reports, and equipment manufacturers. This information was utilized to identify the potential environmental impacts, which were then quantified based on the criteria established for the alternatives.

1.3 Project Approach and Goals

The study proceeded through the following main steps:

- **Collection and Review of the Data**

  We reviewed and summarized the design criteria and requirements for each facility. Background information on potential environmental impacts and approaches for evaluating the impacts were also collected and reviewed through a literature search, a brainstorming workshop with the District, and the City of Chicago's *Environmental Action Agenda.* Results were incorporated into the approach.

- **Establish the Baselines**

  We developed the baselines to determine the influence of the District's existing facilities on the environment, which included emissions, discharges and disposals to the natural infrastructure (air, land, water) from existing facilities and operations.

- **Identify and Quantify the Additional Loadings**

  We identified and quantified the additional loadings to air, land, and water infrastructure in the study area that would result from applying either UV or chlorination/dechlorination technology. A weighted ranking matrix was developed to identify the most critical impacts, followed by quantification of the most critical environmental impacts.

- **Compare to the Baseline Conditions**

  We summarized and compared the findings of the additional loadings to the natural infrastructure (where appropriate) in the CAWS ecosystem.

The study's goals are to identify, catalog and systematically determine the potential environmental impacts of implementing the proposed disinfection technologies and provide the District with the required information to support its overall evaluation and determination of the feasibility of implementing these disinfection technologies.

1.4 Study Area

For the purposes of this project, the limits of the study area, as shown in Figure 1-1, coincide with the District's service area that is comprised of seven WRPs covering approximately 883 sq miles and serving over 5.2 million customers. Similar to previous studies carried out by the District, the current evaluation focuses on the overall impacts within its service area. Therefore, the quantification of the environmental impacts of the disinfection technologies is limited to this study area. The study will also qualitatively consider potential impacts that may be outside of the study area; however these impacts will not be evaluated further due to limited data.

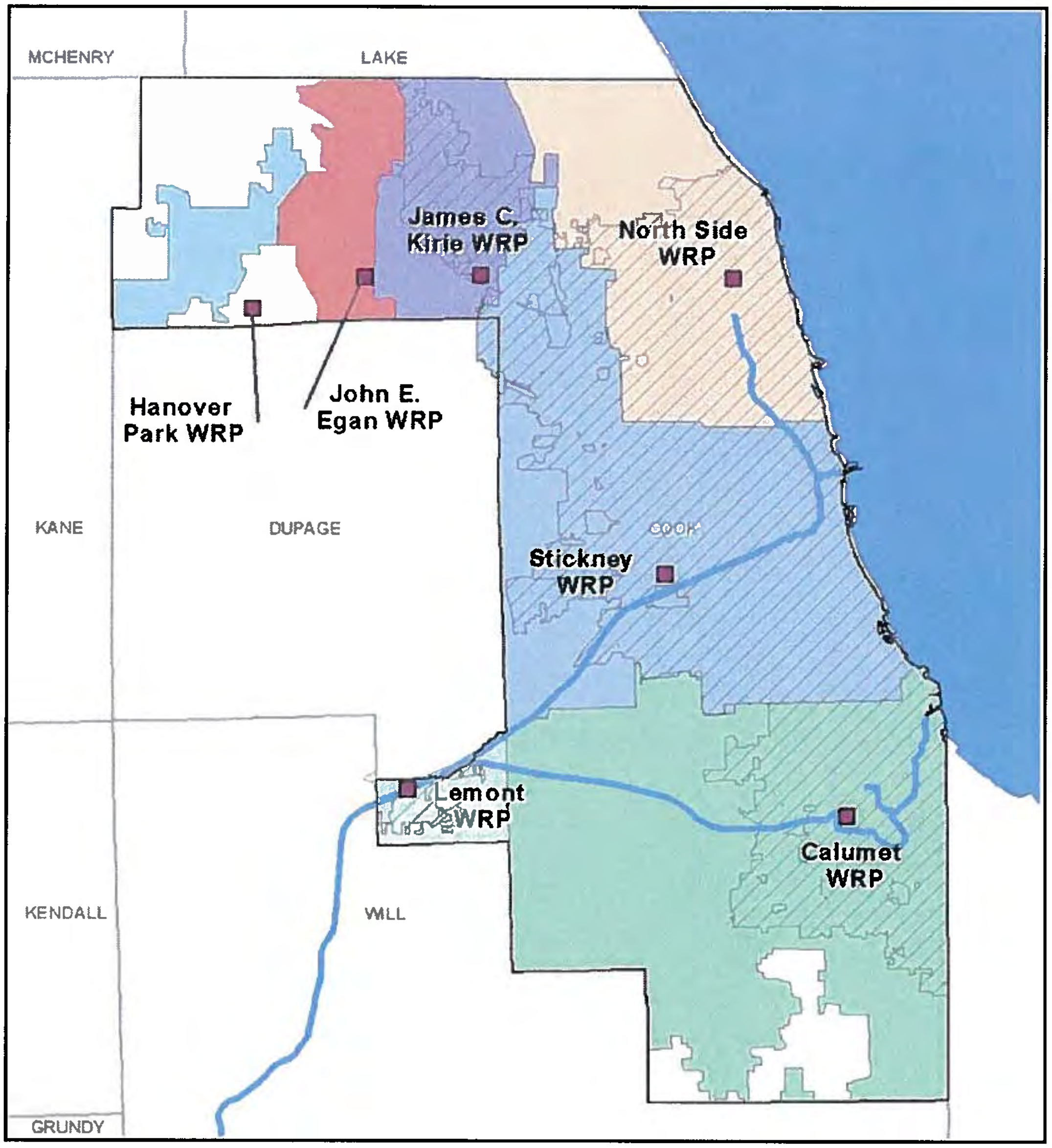


Figure 1-1: District's Service Area

2 Data Collection and Review

2.1 Proposed Facilities Design Criteria

As discussed in Section 1, a 2005 study evaluated many disinfection technologies for the North Side, Calumet, and Stickney WRPs. Two alternatives are considered in this study. The first, UV disinfection, is included because it was the highest ranked alternative in the 2005 study. The second is chlorination followed by dechlorination. This was selected because it is one of the most common technologies utilized in wastewater treatment.

2.1.1 UV System

UV technology is a recognized and well-established alternative for water and wastewater disinfection applications. It is considered effective for the prevention of waterborne pathogen discharges to receiving waters without the formation of any known disinfection by-products. The effectiveness of UV disinfection is, however, sensitive to the effluent stream's water quality, and higher doses are necessary for virus inactivation. Using a power input, the effluent stream is disinfected through the UV system. The UV system is composed of lamps, quartz sleeves, mechanical/chemical cleaning system, ballast, and the power distribution center.

Based on the review of the Consoer Townsend Envirodyne Engineers (CTE) *UV Disinfection Cost Study – North Side Water Reclamation Plant* (January 2008), and from working results of the *Draft Stickney Water Reclamation Plant UV Cost Study* and the *Draft Hydraulic Evaluation Technical Memorandum* (June 2008), the specific design criteria for the UV system at each of the three plants are presented in Table 2-1. These studies were updated from previous reports to reflect an *E. coli* limit of 400 cfu/100 mL. The main design considerations and assumptions for the UV system at the North Side, Calumet, and Stickney plants are as follows:

- Peak hourly flows with redundancy were used to size all equipment.
- Average daily design flows were used to calculate energy and chemical consumption.
- WRPs will disinfect from March through November.
- Medium Pressure-High Intensity (MP-HI) mercury vapor lamps will be used.
- Influent has a minimum UV transmissivity of 65%.
- Minimum UV dose = 40 mW-s/cm^2.
- The design UV lamp life is 5,000 hours.

- MP-HI operating temp = 600 to 900 °C.
- Lamp fouling factor equals 90%.
- Each system consists of a power supply, an electrical system, a reactor, MP-HI lamps, a mechanical and chemical cleaning system, and a control system.
- Cleaning solutions consist of some acidic solution that prevents fouling and are replaced monthly.
- Lamps are enclosed in quartz sleeves.
- Electronic ballast for each lamp is used to control the output.
- System will be enclosed in a building for protection against weather.
- A low lift pumping station is included in the design.

Table 2-1
Proposed UV System Features for the North Side, Calumet, and Stickney WRPs

	North Side	Calumet	Stickney
Average Day/Peak Hour Design Flow, mgd	333/450	319/480	1,250/1,440
E. coli Design Limit, cfu/100 mL	400	400	400
Lamps, Total	1,680	1,680	4,032
Hourly Average Power[1], kW	3,182	2,903	9,225
Average Energy, kWh/day	76,368	69,672	221,400
Average Power, kW/mgd	9.6	9.1	7.4

1. Power includes operation of the equipment only. Design assumes power based on the design average flow rate.

Table 2-2 lists the estimated acreage that would be needed for the UV facility at each plant as communicated by CTE. The estimated land requirement includes the footprint of the UV building, the pump station, a new outfall, and 10-foot buffer around each facility. The new outfall is designed below grade with the assumption that buildings will not be built above it. The proposed maintenance schedule for UV operation is given in Table 2-3.

Table 2-2
UV Acreage at the North Side, Calumet, and Stickney WRPs

	North Side	Calumet[2]	Stickney
UV Land Requirement[1], acres	2.07	1.65	3.72

1. Source: *UV Disinfection Cost Study – North Side Water Reclamation Plant* (CTE. January 2008); the information for Stickney is from working results of the *Draft SWRP UV Cost Study* and the *Draft Hydraulic Evaluation Technical Memorandum* (CTE, June 2008)
2. Land proposed for the UV facilities at Calumet are currently occupied by the existing chlorine contact tanks.

Table 2-3
Proposed UV Maintenance Schedule

Item	Replacement Time	Annual Replacement
Lamps	every year	100%
Ballasts	every 5 years	20%
Quartz Sleeves	every 10 years	10%
Wipers	every 3 years	33%

2.1.2 UV Design Criteria Validation

Table 2-4 provides a review of the revised design criteria in the January 2008 memo (CTE's *UV Disinfection Cost Study – North Side Water Reclamation Plant*) in comparison to the design criteria contained in the August 2005 memo (CTE's *Disinfection Study - Technical Memorandum, TM-1WQ*). Based on Malcolm Pirnie's review of the data, the updated criteria for the proposed UV equipment appears to be consistent with previous work and design criteria developed for similar effluent quality standards at other utilities with an *E. coli* count less than 400 cfu/100 ml in the effluent.

Table 2-4
Proposed UV System Features at the North Side WRP

	UV Disinfection Cost Study, January 2008	Technical Memo (TM-1WQ), 2005 Study
Design Criteria[1]		
Peak Hourly Design Flow, mgd	450	450
Effluent *E. coli*, cfu/100 mL[2]	400	1,030
UV transmittance, %	65	65
UV dose, mW-sec/cm2	40	Not specified
Proposed UV System Details		
UV technology	Medium pressure	Medium pressure
Number of channels	5 (4 duty + 1 standby)	4 (3 duty + 1 standby)
Reactors per channel	1	1
Lamps per reactor	336	288
Lamps (duty/total)	1,344/1,680	864/1,152
Lamp output, kW/lamp	4.0	Not specified
Hourly Maximum Power requirements (duty/total), kW	5,376/6,720	2,765/3,687
Maximum Power Requirements (duty/total), kW/mgd	11.9/14.9	6.1/8.2
No. of lamps/mgd (duty)	3.0	1.9

1. Based on max flow conditions
2. Monthly geometric mean

Table 2-4 reveals that the number of lamps is within the range (2 to 4 lamps/mgd) typically encountered in municipal wastewater disinfection using medium pressure systems. The UV system proposed in the January 2008 report estimates approximately twice the power consumption (11.9 kW/mgd) at peak hour design flow compared to the system in the August 2005 report (6.1 kW/mgd). With all other key design parameters (flow and UVT) equal, the higher power requirement in the January 2008 report is due to the use of the lower *E. coli* value (400 cfu/100 mL), which appears to be reasonable.

2.1.3 Chlorination/Dechlorination Design Criteria

Chlorination is currently one of the most commonly-applied methods for disinfection of waterborne pathogens in wastewater effluent before discharge to receiving waters. Chlorine is recognized for its effectiveness and destroys bacteria, viruses, and protozoa at a relatively low cost. Dechlorination of the excess chlorine prior to discharge is typically required to minimize any harm to aquatic life and for minimizing the formation of disinfection byproducts.

Chlorine is available as a gas, liquid sodium hypochlorite (delivered or generated onsite), or solid calcium hypochlorite. Based on a review of the *Chlorination/Dechlorination Disinfection Cost Study for Stickney, Calumet and North Side Water Reclamation Plants* (CTE, May 2008), the specific design criteria for the chlorination/dechlorination system at each of the three plants are presented in Table 2-5. The main design considerations and assumptions for the chlorination/dechlorination disinfection system at each of the plants are as follows:

- WRPs will use 12.5% sodium hypochlorite (NaOCl) for disinfection and 38% sodium bisulfite ($NaHSO_3$) for dechlorination.
- Dosing rate of chlorine is 6 mg/L as Cl_2; the assumed Cl_2 residual prior to the addition of sodium bisulfite is 2 mg/L.
- Chemicals will be produced off-site and delivered to the plants by tanker trucks; the suppliers are located within 40 miles of each plant.
- Outdoor storage; 14 days of storage provided for all chemicals at average conditions.
- WRPs will disinfect from March through November.
- The expected service life is given below:
  - Steel tank linings, CPVC piping, transfer pumps, feed pumps, mixers and control and instrumentation equipment = 10 years.
  - Steel tanks and Teflon lined chemical piping = 20 years.
  - Building and concrete containment areas = 50 years.
- The design includes the following components:
  - Chemical feed building (for housing the transfer and feed pumps, plus electrical and storage).
  - Low lift pump station.
  - Chemical storage/receiving facilities.
  - Chemical feed facilities.
  - Mixing tank/contact tank.

Table 2-5 summarizes the chlorination/dechlorination specific design criteria for the North Side, Calumet, and Stickney WRPs from CTE's 2008 chlorination/dechlorination cost study for the three plants. Similar to the UV criteria, the chlorination/dechlorination design criteria are based on an *E. coli* limit equal to 400 cfu/100 mL in the effluent.

Table 2-5
Proposed Chlorination/Dechlorination System Features at the North Side, Calumet, and Stickney WRPs

	North Side	Calumet	Stickney
Design Flow, mgd (average day/peak hour)	333/450	319/480	1,250/1,440
E. coli limit, cfu/100 mL	400	400	400
Hourly Average Power[1], kW	24.15	92.06	68.76
Average Energy, kWh/day	580	2,209	1,650
Land Requirement for Chlor/Dechlor, acres[2]	3.1	4.2	9.75

1. Power includes operation of the transfer pumps, feed pumps, and mixers for chlorination/dechlorination. At North Side and Stickney, design assumes one new mixing chamber for each chemical with one mixer each (two total mixers at each plant). At Calumet, design assumes reusing the existing contact tanks and splitting flow such that two mixing chambers are required for each chemical with one mixer each (four total mixers). The additional mixers result in higher energy use at the Calumet WRP.
2. The land requirements at the Calumet WRP include the 2.2 acres occupied by the existing contact tank.

Storage of the chemicals for chlorination/dechlorination poses some potential concern for safety because of the volume of chemical onsite and the frequency of deliveries. The duty storage and the total storage capacities for each WRP, as well as the storage times at peak flow conditions, are given in Table 2-6. To meet the storage requirements at average flow conditions, the frequency of delivery is estimated to be a total of approximately 170 truck loads per week for the three plants. Because rail delivery is not yet available, it is assumed that the deliveries will be made by 4,400-gallon tank trucks for sodium hypochlorite and 4,000-gallon tank trucks for sodium bisulfite. Each storage and day tank will be located outdoors within a concrete spill containment area that is 110% of the total tank volume. Sodium bisulfite solution will be used to contain and neutralize any spilled hypochlorite; the neutralized hypochlorite will be recycled to the head of the plant. Any sodium bisulfite that is spilled will be recycled to the head of the plant.

Table 2-6
Proposed Chlorination/Dechlorination Storage at the North Side, Calumet, and Stickney WRPs

	North Side		Calumet		Stickney	
	Sodium Hypo-chlorite	Sodium Bisulfite	Sodium Hypo-chlorite	Sodium Bisulfite	Sodium Hypo-chlorite	Sodium Bisulfite
Average Daily Dosage, lb/day	16,700	8,100	16,000	7,800	62,550	30,400
Number of tanks	3 (2 duty + 1 standby)	2 (1 duty + 1 standby)	3 (2 duty + 1 standby)	2 (1 duty + 1 standby)	4 (3 duty + 1 standby)	2 (1 duty + 1 standby)
Duty storage capacity, gallons	244,000	28,200	232,000	28,200	892,300	105,500
Total storage capacity, gallons	366,000	56,400	348,000	56,400	1,189,700	211,000
Duty Storage Available at Peak Flow Conditions, days	10.8	10.4	9.7	10.1	12.4	12.4

2.2 Environmental Impact Literature Search

Malcolm Pirnie conducted a literature search in an effort to identify known potential environmental impacts of the various technologies identified above and to gather information that would be relevant to this study. The literature search encompassed scientific journals, conference proceedings, reports, projects, textbooks, and internal Malcolm Pirnie reports from previous projects. The initial searches, which included a combination of descriptors below, did not yield any relevant references specific to UV and chlorination facilities.

- Carbon dioxide
- Energy conservation
- Environmental impact
- Gas emissions
- Nitrogen oxides

- Optimization
- Particulate emissions
- Pollution control
- Sulfur dioxide
- Sustainable
- Wastewater treatment

Subsequently, new searches were conducted with the key words, "Life Cycle Analysis." Although all of the "Life Cycle Analysis" articles covered topics other than the technologies of concern, the information in the references were relevant to the current study. A list of the authors, titles, and publication dates of the reviewed sources is included in Appendix A. To maintain confidentiality, titles or copies of internal Malcolm Pirnie reports from previous projects are not included; however, the findings from these reports are included in the discussion below.

Key findings and common themes from the literature search are described below.

1. Many articles described a side-by-side comparison of two or more alternatives where one alternative was recommended and all others were rejected. Other studies based the analysis on industry benchmarking such that the impacts were benchmarked to an industry standard as a means of comparison. For the current study, each disinfection alternative was compared independently from the other or industry benchmarks. This scenario enables the District to evaluate the impacts of each alternative in comparison to a "no-action" alternative.
2. The environmental impact categories included consumption of energy, land, water and other resources, and emissions to the air, water and land.
3. Impacts were evaluated based on phases; for example, the extraction of raw materials, construction and manufacturing phase, operation phase and final disposal phase.
4. Some examples of environmental impacts and environmental impact categories were presented in each article.
5. The boundaries of the system were defined with respect to geography, time, and concept.
6. Evaluating the environmental impacts has a subjective nature since relative weighting factors must be attributed to each environmental impact category. The weighting factors should reflect the views of the project stakeholders.
7. A unit was defined to assess the environmental impact of a process or system, for example, 100 population equivalents (p.e.).
8. The rankings considered the duration of the environmental impact.

The potential environmental impacts gathered during the literature search were prepared for the December 2007 Environmental Impact Identification Workshop discussion. Many of the themes from the literature search were also incorporated into the study.

2.3 Environmental Impact Identification Workshop

On December 14, 2007, Malcolm Pirnie conducted an Environmental Impact Identification Workshop with the District. The purpose of this workshop was to identify potential environmental impacts from implementation of the disinfection technologies through a brainstorming session. A list of potential environmental impacts and impact categories were compiled and discussed during the workshop. Many potential impacts were considered during the workshop, including impacts during gathering of raw materials, manufacturing, construction, and the maintenance/operation of the facilities. Impacts discussed during the workshop were further analyzed and evaluated as discussed in Section 4 of this report.

2.4 Environmental Action Agenda

In 2005, Mayor Daley revealed the *Chicago Environmental Action Agenda*[1] , which aims to establish environmentally-friendly goals for the operation of the City of Chicago Departments and other agencies. The proposed goals of the Agenda include the following:

- Reduce 6% of City's energy use based on 2000 energy use;
- Reduce 30% of energy at O'Hare Airport;
- Explore renewable energy sources including solar and wind power;
- Strive for zero carbon emissions from the City's energy use;
- Reduce 50% of emissions from City cars and buses based on 2003 emissions;
- Strive for zero-emissions fleet;
- Develop effective idle-reduction strategies for revenue and non-revenue fleets, including policies for enforcement;
- Install 10 million square feet of green space on building rooftops;
- Pursue landscape improvements that decrease the amount of impervious surfaces;

[1] Chicago Mayor Daley's Green Steering Committee (2006). *Environmental Action Agenda: Building the Sustainable City.*

- Incorporate permeable pavement into on-street parking lanes to reduce stormwater runoff;
- Complete construction and commission the McCormick Place Convention Center tunnel system which will cleanly divert stormwater runoff from the roof directly to Lake Michigan, saving the cost of unnecessarily treating millions of gallons of water each year;
- Apply source-separation to reduce waste streams going to the landfill;
- Ensure that all recyclable materials do not enter landfills;
- Reduce the number of large quantity hazardous waste generators;
- Minimize noise exposure at schools experiencing noise levels above 65 decibels Day Night Average Noise Level (DNL).

The goals of this Agenda were considered when developing and screening the environmental impacts for this study.

3 Establishment of the Baselines

To determine impacts of the proposed technologies, it is important to understand the usage of the District's existing infrastructure and equipment as a baseline for the study. The baseline is defined as the facilities and natural infrastructure elements – air, land, and water – currently controlled, accessed, or used by the District to manage loadings (i.e. emissions, discharges, disposals) from existing operations. These baseline data were developed for the current air, land, and water usage by the District at the North Side, Calumet, and Stickney water reclamation plants.

The following data were collected to establish the baseline for the existing District facilities and natural infrastructure. Information on the sources of data, the available documents from each source, and the specific data that were extracted from available documents are listed in Appendix B and summarized below.

- Obtained directly from the District: Information on the existing District facilities including its WRPs, aeration stations, pump stations, reservoirs, biosolids facilities, flow control in its waterways, current treatment processes, equipment, operation methods, and NPDES permits.
- Obtained from the District but also from other governmental agencies such as the US Geological Survey (USGS), Illinois State Water Survey (IL SWS), and from the offices of municipalities in the District service area: Data on the natural infrastructure and its uses including service area maps, CAWS, precipitation, habitat areas of specialized ecosystems, and names and boundaries of communities in the service area.

A summary of the findings from this review is as follows:

- The CAWS is comprised of approximately 76 navigable miles of river and canal infrastructure dedicated to use as drainage, commerce transport, and receiving water for reclamation and sanitation uses.
- Of the 565,312 acres making up its service territory and the surrounding watershed, the District converts 1,831 acres to industrial use, upon which seven water reclamation facilities are located.
- There are 35 reservoirs covering approximately 82,000 acres with 24,000 acre-feet of storage.

- 190,000 dry tons of biosolids are produced each year by the District's wastewater treatment processes.
- 4,400 miles of pipeline are buried underground, often below usable surface land.
- Some 556 million kWh of electricity and 3M therms of natural gas are used annually to process an average of 1.5 billion gallons per day of wastewater from all District facilities.
- The reported 2006 energy usage for the three plants was 384 million kWh ; 60 million kWh for North Side; 79 million kWh for Calumet; and 245 million kWh for Stickney.
- The Chicago area is currently not meeting the National Ambient Air Quality Standards for the criteria pollutants ozone and particulate matter. The District facilities, which are located in the Chicago non-attainment area, are thus regulated by air operating permits for ozone precursors (nitrogen oxides and volatile organic compounds) and particulate matter. These permitted emissions represent the maximum levels of emissions loading for District facilities.

These data were used to identify the air, land, and water assets comprising the environmental system in which the District operates, and the availability of the natural infrastructure to process the emissions and waste streams resulting from the construction and operation of the disinfection facilities. The figures in Appendix C represent a GIS-based depiction of this natural infrastructure baseline. The key data categories are: land use, sewage service areas, watershed, precipitation (additive water) and airshed/air quality.

These key data categories were grouped into three main areas: air, land, and water for the three WRPs, which were used for the baseline comparisons as discussed below. Specific baselines for other components or environmental impacts, such as safety and noise, were not developed because of limited available data and schedule and budget constraints.

3.1 Air Baseline

Air emissions generally come from two sources, those generated at the plant itself (emissions from boilers, gas turbines, waste burner units, ozone systems, etc.), and those from the energy plants that supply power to run the plants. These power plants are generally coal-based electric generating facilities.

The Clean Air Act of 1970 authorized the development of comprehensive federal and state regulations to limit emissions from both stationary (industrial) sources and mobile sources. Included in this act was the creation of the National Ambient Air Quality Standards (NAAQS) for six specific air pollutants. These pollutants were selected as indicators of air quality in the United States, and their standards were established to protect human health and welfare. Commonly referred to as "criteria pollutants," the six air pollutants are as follow: sulfur oxides (SO_x), carbon monoxide (CO), nitrogen oxides (NO_x), particulate matter (PM), ozone (O_3) and lead (Pb). For regulatory purposes, sulfur dioxide (SO_2) emissions are reported because they are the indicator of sulfur oxide concentrations in the ambient air. The District is also subject to the requirements established by IEPA for the ozone precursors (nitrogen oxides (NO_x) and volatile organic material (VOM)) because Cook County has been identified as a non-attainment area for ozone, as mentioned in Section 3.0.

Table 3-1 details each water reclamation plant's 2006 permitted and actual air emissions of the monitored criteria pollutants. Lead is not included because of the unlikelihood of its emission from the WRPs. The existing emissions were provided in the District's Annual 2006 Air Emission Reports. The permitted emissions were retrieved from the IEPA operating permits and represent the maximum levels of emissions loading for each WRP during normal operation.

Table 3-1
2006 Permitted and Reported Emissions of Criteria Pollutants from the North Side, Calumet, and Stickney WRPs

	North Side Emissions[1] (tons/yr)		Calumet Emissions[1] (tons/yr)		Stickney Emissions[2] (tons/yr)		TOTAL EMISSIONS (tons/yr)	
	Permitted	Reported	Permitted	Reported	Permitted	Reported	Permitted	Reported
NO_x	92.61	2.17	68.16	15.39	429.26	36.71	590	54
SO_2	7.16	0.05	51.91	0.73	273.21	7.79	332	9
CO	37.2	1.77	99.76	12.93	137.68	44.91	275	60
PM	6.4	0.16	5.15	1.17	57.01	2.69	69	4
VOM	5.9	0.12	16.02	3.02	325.85	37.22	348	40

1.Federally Enforceable State Operating Permit
2. Title V – Clean Air Act Permit Program (CAAPP) Operating Permit

Additionally, the emissions of the criteria pollutants NO_x and SO_2 resulting from energy consumption can be calculated with emission factors available through the "Emissions & Generation Resource Integrated Database" (eGRID) specifically for Illinois. Thus, the total baseline values for NO_x and SO_2 in Table 3-2 include the 2006 reported emission loadings from the WRPs (Table 3-1) and the emissions at the power generating facility resulting from coal-based energy production. The calculations are included in Appendix D. The overwhelming majority of air emissions are at the power generating facility due to energy production.

The calculated mercury (Hg) emissions (based on eGRID factors) resulting from coal-fired power production are also included in Table 3-2. Even at low levels, the tracking of Hg emissions is important as it is included in the USEPA's "Clean Air Act Amendments of 1990 List of Hazardous Air Pollutants" and in March 2005, USEPA issued the Clean Air Mercury Rule, which is the nation's first rule that regulates mercury emissions from coal-fired power plants.

Table 3-2
Estimated Air Emissions at the Power Generating Facility Due to Energy Production and Total Emissions of Regulated Pollutants

	Emissions at the WRPs	Emissions at the Power Generating Facility Resulting from Energy Utilized at the WRPs[2]			
	2006 Plant Emissions[1] (tons/yr)	North Side (tons/yr)	Calumet (tons/yr)	Stickney (tons/yr)	TOTAL AIR EMISSIONS (tons/yr)
NO_x	54	85	112	348	600
SO_2	9	307	403	1250	1970
Hg	NA	0.001	0.002	0.005	0.008

1. Criteria pollutant emissions from North Side, Calumet, and Stickney as reported in the District's 2006 Annual Air Emission Reports.
2. Estimated energy emissions from coal-based power plants are calculated using energy consumption at the North Side, Calumet, and Stickney plants and eGrid emission factors.

Six gases, commonly referred to as greenhouse gases were also included in the evaluation. These gases comprise of: carbon dioxide (CO_2), methane (CH_4), nitrous oxide

(N_2O), hydrofluoro-carbons (HFCs), perfluoro-carbons (PFCs) and sulfur hexafluoride (SF_6). Even though the District does not have permit limits for these gases, they are of concern on both global and local levels. Greenhouse gases are included in the 2005 Kyoto Protocol because of their potential to affect the global climate changes and global warming. The City of Chicago also has an initiative to reduce greenhouse gas emissions to pre-2005 levels. As such, greenhouse gases are an important consideration in this evaluation. Sources of these gases include combustion, natural gas, landfills, agriculture, and cars.

Table 3-3 presents the estimated emissions at the power generating facility related to each WRP for the most common greenhouse gasses: carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4). The existing emission loading for greenhouse gases were calculated, not measured, from the District's current (2006) electricity consumption and with eGrid emission coefficients specifically for Illinois. The calculations of air emissions are included in Appendix D.

Table 3-3
2006 Estimated Greenhouse Gas Emissions at the Power Generating Facility Due to Energy Production (tons/year)

	North Side	Calumet	Stickney	TOTAL
CO_2	46,800	61,400	190,700	298,900
N_20	0.54	0.71	2.21	3.5
CH_4	0.25	0.32	1.0	1.6
CO_2 equivalents[2]	46,900	61,700	191,400	300,000

1. Estimated energy emissions from coal-based power plants are calculated using energy consumption at the three plants and eGrid emission factors.
2. Carbon dioxide equivalents equal the sum of CO_2, 21*CH_4, and 310*N_20.

The criteria pollutant, mercury, and greenhouse gas emission data presented in this section were used as the baseline to compare the impacts of the additional airshed loadings from the disinfection technologies.

3.2 Land Baseline

The current land usage and allocated land for future projects at each facility are shown in Table 3-4. Data on allocated land was retrieved from the District's Master Plan for each facility. At the North Side plant, 87 acres of the total land area of 97 acres (90%) are currently in use or have been allocated for future use, including land that is currently leased to the Park District, such that they would not be available for future disinfection facilities. At the Calumet plant, 446 acres of the 470 acres (95%) are in use or allocated such that they would not be available for future disinfection facilities. At the Stickney plant, an estimated 404 acres of 570 acres (71%) are currently in use or already allocated for projects such that they would not be available for disinfection development.

The future allocated land includes the following projects:

- North Side: New final clarifiers
- Calumet: High level influent pumping station; New grit facilities/primary settling tanks; Aeration tanks/final settling tanks; and Central boiler facility
- Stickney: Primary clarifiers/pumping stations; Intermediate blower; Digester gas treatment building/digester gas holder, Waste gas burner and control building

Table 3-4
Current and Allocated Land Usage[1]

	North Side	Calumet	Stickney	TOTAL
Total Area (acres)	97	470	570	1137
Estimated Plant Area Currently in Use (acres)[2,3]	63	424	388	875
Estimated Plant Area Allocated for Future Projects (acres)[4]	24	22	16	62
Total Estimated Land Area in Use or Allocated (acres)	87	446	404	937
Percent Used or Allocated Land	90%	95%	71%	82%
Remaining Land[5] (acres)	10	24	166	200

1. Source: MWRDGC M&O Facilities Handbook, 2006, and WRP facility layouts
2. The areas are estimated using layouts of facilities and do not consider any underground structures that are not shown on the layouts.
3. At North Side, the current land in use includes land leased to the Park District.
4. Allocated land is set aside for future projects already identified to meet regulatory requirements and expansion needs as described in the District's Master Plan for each facility.
5. Some portion of the remaining land would be dedicated for disinfection.

The remaining land – 10 acres at North Side, 24 acres at Calumet, and 166 acres at Stickney – could include some area dedicated for disinfection.

3.3 Water Baseline

Water bills were used to estimate the current potable water usage at the North Side WRP. Shown in Table 3-5, the estimated water usage for the North Side plant equaled nearly 3.9 million gallons (MG) in 2007. This reflects an increase of approximately 20% from water usage reported in 2004 (3.2 MG). Water usage for the Stickney and Calumet

WRPs was not provided; thus, water usage was calculated at these WRPs based on flow proportioning.

In addition to the potable water usage, the impervious cover on the three WRPs has an impact on the runoff in the area. Assuming an historical average of 36.4 inches of precipitation per year, the estimated annual runoff from the existing buildings, pavements, and driveways at all three plants is 143 MG, as shown in Table 3-5. Runoff calculations are also included in Appendix D. Water usage and runoff will increase with implementation of disinfection as discussed in Section 4.

Table 3-5
Water Usage and Runoff

	North Side	Calumet	Stickney	Total
Average Daily Design Flow (mgd)[1]	333	319	1,250	1,900
2007 Onsite Water Usage (MG/yr)[2]	3.9	3.7	14.6	22
Estimated Existing Runoff (MG/yr)[3]	11	49	83	143

1. Design flows are from CTE's *Chlorination/Dechlorination Disinfection Cost Study for Stickney, Calumet and North Side Water Reclamation Plants*, May 2008
2. Onsite water usage is based on water bills for North Side, flow-proportioning was applied for Calumet and Stickney since water bills were not available.
3. WRP facility layouts were used to determine runoff areas; assuming an historical average of 36.4 inches of precipitation per year.

4 Additional Loadings and Quantification

As previously mentioned, our approach considered the life of the disinfection facilities and its impact to the environment within the service area from the source of equipment/raw material, through manufacturing, construction, operations, and eventual disposal. The following steps were performed to evaluate the loading potentials:

- Contacted manufacturers of the technologies to collect data on potential impacts related to the raw sources and manufacturing phases. Because of time and scope limitations, only manufacturers of the major disinfection equipment were contacted as part of this phase since these were likely to have the most significant impact during the manufacturing process. Manufacturers of the pumping, building, and other facility equipment/materials were not contacted.
- Developed a matrix to summarize the key impacts and ranked the most critical impacts.
- Identified and quantified the most critical impacts.

The goals of the above steps were to identify how the manufacturing, installation, operation, and disposal of the disinfection equipment would affect the air, land or water.

4.1 UV Manufacturers

Table 4-1 provides a list of the manufacturers/suppliers that were contacted to obtain information on the potential environmental impacts of manufacturing and transporting the proposed UV disinfection systems to the District's WRPs. These were the same suppliers that had been contacted previously during the preliminary design and cost estimation phase of the UV disinfection systems for the North Side and Calumet WRPs.

Table 4-1
UV Disinfection System Manufacturers

Supplier	Initial response	Final response
Trojan Technologies	Positive	Available, in Appendix E
Confidential Supplier	Positive	Confidential
Aquionics	Positive	Manufacturing is in Netherlands; no information will be available.
STS/Quay	None	None

Appendix E contains a copy of the blank questionnaire that was sent to each UV equipment manufacturer. The following information was requested in this questionnaire:

- Types and quantities of raw materials that are used in manufacturing/assembling of a UV disinfection system.
- Source of the raw materials used for manufacturing of the UV equipment.
- Method of shipping the final product to a client.
- Method of disposal of the UV lamps that contain mercury.

From Table 4-1, all but one UV supplier provided a positive initial response. Aquionics, which manufacturers the UV equipment in the Netherlands with global raw source materials, could not provide the requested information. The completed questionnaire from Trojan Technologies is provided in Appendix E; the confidential supplier also completed a questionnaire, but their response is not included in the Appendix. The potential impacts identified by these manufacturers are summarized below.

- **Air impacts from manufacturing**

  The manufacturing plants at Trojan Technologies (Trojan) and a Confidential Supplier use natural gas as a supplemental source of energy. Trojan reports an average of 8,500 m^3/month of natural gas at its manufacturing facility. Trojan also reports using 120,000 lamps, 40,000 ballasts and 70,000 quartz sleeves annually, and average of 3 million kWh/yr of energy. The Confidential Supplier uses an average of 730,000 kWh/yr of energy at their respective manufacturing facilities.

Based on information from Trojan, the assembly of the UV equipment requires 24 kWh of energy per lamp. Shown in Table 4-2, a total of 7,400 lamps per year for the North Side, Calumet, and Stickney plants[2] will consume an estimated 180,000 kWh/yr of energy. Annually, this is equal to 140 tons CO_2 equivalents in greenhouse gas emissions, 0.25 tons of NO_x emissions, 0.90 tons of SO_2 emissions, and 0.01 pounds of Hg emissions.

Table 4-2
Summary of Air Emissions from Energy Consumption during UV Equipment Assembly

Energy Requirement	180,000 kWh/yr
Greenhouse Gases	140 tons CO_2 equivalents/yr
NO_x	0.25 tons/yr
SO_2	0.90 tons/yr
Hg	0.01 pounds/yr

1. Carbon dioxide equivalents equal the sum of CO_2, $21*CH_4$, and $310*N_2O$.

Transportation of the UV equipment contributes additional air emissions. According to Trojan, each reactor weighs approximately 22,000 lbs. The road-based transportation in North America releases carbon dioxide into the atmosphere. Trojan delivers its equipment from its facility near London (ON, Canada), which is approximately 400 miles by road from Chicago. Similarly, the Confidential Supplier is located approximately 460 miles by road from Chicago. The emissions from transportation are quantified in Section 4.6.1.

- **Water impacts from manufacturing**

Water is used at the manufacturing facilities by the employees and during manufacturing and testing of the UV equipment. Trojan uses an average of 2.5 MG/yr of water. Unless it is contaminated, all of the water used in testing of the UV equipment is recycled. At the Confidential Supplier's manufacturing site, less than 100 gallons of contaminated water is generated annually. The contaminated water is disposed of in accordance to environmental regulations. No direct discharges of any waste streams into a water body were reported by either manufacturer.

On average, over 100 gallons of hydraulic oil and glycol coolant are recycled at Trojan's manufacturing site per year. At the Confidential Supplier's manufacturing site, any mercury spills are cleaned up immediately using a

[2] CTE's *UV Disinfection Cost Study – North Side Water Reclamation Plant* (January 2008); the information for Stickney is from working results of the *Draft SWRP UV Cost Study* and the *Draft Hydraulic Evaluation Technical Memorandum* (June 2008)

mercury spill kit; the quantity of mercury spilled at the manufacturing site is typically less than 0.001 pound (0.5 grams) in a year.

- **Land impacts from manufacturing**

  The Trojan manufacturing plant is located on approximately 3 acres of urban land. The Confidential Supplier's manufacturing and storage facility is located in a light industrial park in a rural area.

  At its manufacturing facility, Trojan Technologies generates approximately 40 tons/yr of wood, 60 tons/yr of cardboard, 10 tons/yr of steel and 70 tons/yr of other solid waste. While the wood, cardboard, and steel waste is recycled, the other solid waste is sent to a landfill. Similarly, at the Confidential Supplier manufacturing facility, all recyclable solids such as cardboard, paper, plastic, and metal are recycled. Other trash is disposed in a standard dumpster, with less than one dumpster per week filled at the manufacturing facility. The UV lamps are recycled at the Confidential Supplier's manufacturing facility. Similarly, Trojan reports recycling UV lamps weighing approximately 6 tons/yr.

4.2 Chlorination/Dechlorination Manufacturers

Table 4-3 provides a list of the manufacturers/suppliers that were contacted to obtain information on the potential environmental impacts of manufacturing and transporting the chemicals, equipment, and pumps for the proposed chlorination/dechlorination systems at the District's WRPs. For consistency, the suppliers contacted for chlorination/dechlorination were the same as those contacted during the preliminary design and cost estimation phase.

Table 4-3
Chlorination/Dechlorination Disinfection System Manufacturers

Chemical / Equipment	Supplier	Initial response	Final response
1. Sodium Hypochlorite 2. Sodium Bisulfite	K. A. Steel Chemicals[a]	Positive	Limited[b]
	PVC Chemical[a]	Positive	None
	Hydrite Chemical Company	Positive	Limited[b]
	Olin Chlor Alkali Products	Negative	None
Mixers – Philadelphia Mixer Mills	Winfield Engineering Sales	Positive	None
Piping – Resistoflex kynar lined steel	Corrosion Fluid Products	Positive	Manufacturer will not provide requested information
Dosing Pumps – Bredel hose pumps & Milton Roy diaphragm pumps	Drydon Equipment	Positive	Manufacturer will not provide requested information as it is confidential
Transfer Pumps – ANSI – MAG seal-less magnetic centrifugal pumps	Corrosion Fluid Products	Positive	Manufacturer will not provide requested information
Steel bulk storage and day tanks	Kennedy Tanks	Positive	None

[a] Current supplier for Egan, Kirie, and Hanover Park WRPs
[b] Only name of manufacturing process provided. Other requested information is proprietary and hence not provided.

Appendix E contains a copy of the blank questionnaire that was sent to each chlorination/dechlorination supplier. The following information was requested in this questionnaire:

- Types and quantities of raw materials that are used in manufacturing/assembling of a chlorination/dechlorination disinfection system.
- The method of procurement of raw materials.
- Air/water/land used for manufacturing.
- Air/water/solids waste generated due to manufacturing.

From Table 4-3, all but one chlorination/dechlorination supplier provided a positive initial response with limited information received in the final responses for only the chemicals themselves.

K.A. Steel Chemicals (current sodium hypochlorite supplier for the District) reported that the method used for manufacturing sodium hypochlorite is chemical mixing through a Powell bleach process. In this method, water, caustic, and chlorine gas are mixed together to produce hypochlorite. Although this process does not require electricity specifically for hypochlorite production, the chlorine gas does require electricity during generation and poses a safety risk during handling and storage.

Some hypochlorite suppliers employ the electrolytic process, which uses only salt, water and electricity. In this process, hypochlorite is produced by the electrolysis of a brine solution without the safety risks associated with handling or storing chlorine gas. The chloride ions are oxidized at the anode to form chlorine gas, while sodium hydroxide and hydrogen gas are produced at the cathode. The chlorine that is generated then reacts with the sodium hydroxide to form sodium hypochlorite. It is the general consensus that the electrolytic process is more efficient and cost-effective, yields a purer chemical, and is safer since it does not involve chlorine gas.

On a molar basis, the dosing requirements for sodium bisulfite for dechlorination should be equal to the chlorine residual. The District's current supplier of sodium bisulfite, PVC Chemicals, did not provide any feedback on the manufacturing process or the energy required for chemical manufacturing. However, another manufacturer, Hydrite Chemical Company provided information on the most common procedure for manufacturing sodium bisulfite. In this process, sulfur is oxidized in the presence of air to produce sulfur dioxide, which is cooled and neutralized by caustic soda or soda ash to produce sodium bisulfite.

During the manufacturing of sodium bisulfite, natural gas is used to ignite the sulfur, and some electricity is used for the operation of pumps, mixers and other utilities at the manufacturing facility. A review of the basic chemistry[3] of burning sulfur to make SO_2 shows that once the sulfur is brought to its ignition point at 374°F, its oxidation generates most of the heat during combustion (3,980 BTU/lb) so the natural gas requirement is low. Judging from the other raw materials (caustic soda, water) and equipment (reaction tanks, pumps, etc.), the generation of sodium bisulfite is similar to the Powell bleach process with respect to energy consumption. Thus, energy use is also assumed to be small during the manufacturing of sodium bisulfite and is not quantified in Section 4.6.1. Other quantifiable impacts to the air, land, and water during manufacturing of chlorination/dechlorination are included in section 4.6.

[3] DTE Energy, Energy TechPro™ 2004 (http://energytechpro2.com/Demo-IC/MoreDetail/Combustion_Basics.htm)

4.3 Waste Streams from Manufacturing Facilities

Malcolm Pirnie reviewed the USEPA Toxic Chemical Release Inventory (TRI) (www. epa.gov/triexplorer) to search available data on potential waste streams from the UV and chlorination/dechlorination manufacturing operations. The TRI is a tool used for identifying potential releases of chemicals and other waste streams to the environment during manufacturing. As of November 2006, the TRI database contained over 650 chemical and chemical categories. For each chemical, facilities must report the quantity released to the air, water, land, underground (through injection), or off-site transfer for disposal. Manufacturing facilities (plant, factory or other facility) that meet the following criteria are required to report environmental releases in the TRI:

- Has 10 or more full-time employees, or the equivalent of 20,000 hours per year;
- Manufactures, imports, processes, or uses chemicals in quantities greater than the threshold value – for chlorine, the threshold value is 25,000 pounds; for mercury, the threshold value is 10,000 pounds;
- Releases waste streams in the United States.

A search of releases for the UV manufacturing facilities, suppliers of mercury bulbs, and other UV equipment suppliers yielded no results,, suggesting that these manufacturers did not meet the criteria for reporting to TRI. A search of the chlorine and dechlorination chemical manufacturers resulted in several matches, including Olin Corporation as documented in Appendix F. It should be noted that the reported values include releases from the manufacturing of all chemicals that is generated by the manufacturer, not just chlorine, so these results were not useful in the overall evaluation.

4.4 Matrix of Environmental Impacts

The potential impacts that were identified through the sources detailed above and the brainstorming session with the District were reviewed and categorized into two matrices, one for UV disinfection and another for chlorination/dechlorination. These matrices were used as a screening technique to capture the impacts and provide guidance on the selection of activities for quantification. Each matrix considers the life of the facilities, including source of raw material, manufacturing, facility construction, maintenance/operation, and salvage & disposal for each technology. These are shown as "activities" in the first column of the matrix (Table 4.4 and 4.5).

The environmental impact categories are shown in the first row of each matrix: Energy, Land Use, Labor Burden, Water Quality, Air Quality, Safety/Risk, Transportation, Waste Stream/Hazardous Material, Noise and Dust/Airborne Particles. These categories encompass both the consumption of environmental resources, and the emissions or discharges into the environment. Tables 4-4 and 4-5 summarize what was considered under each impact category for each activity.

Table 4-4 Explanation of UV Impacts and Matrix Components

Environmental Impact - UV	Energy	Land Use	Labor Burden	Water Quality	Air Quality	Safety/ Risk	Transportation	Waste Stream/ Hazardous Material	Noise	Dust/ Airborne Particles
	Coal usage, air emissions	Footprint	Mental/ physical challenges	Sediment, erosion, byproducts	VOC, SOC, toxic gas releases	Potential for leaks, explosions; operational risks	Air emissions from consumption of gas/oil	Chemical and solid waste stream /storage and disposal of hazardous materials	Community nuisance	Dust and particulates
Source										
Construction Materials	Energy for source materials and supplies; mining	Land needed for source materials and supplies; mining	Mental/ physical challenges of gathering source materials and supplies; mining	Sediment from mining; materials and byproducts into water supply	VOC, SOC, toxic air releases during source gathering	Potential for explosions; handling of mercury	Delivery of source materials	Wastes during source material retrieval/mercury	Noise during mining/ excavating of source materials	Dust generated from mining/excavating source materials
Building Equipment and Supplies										
UV Equipment and Supplies										
Manufacturing										
UV Equipment	Energy for assembly	Land needed for warehouses used to assemble equipment and products	Mental/ physical challenges of assembling equipment and handling hazardous material	Mercury or other releases	Air releases during assembly	Risks of assembly; handling mercury	Delivery of equipment and products	Waste during assembly; mercury waste	Noise during assembly	Dust generated from assembling equipment and products
Pumping Station Equipment										
Materials/products to support construction activities										
Power Transmission Line										
Facility Construction										
Building Construction Activities	Energy for building construction; lights	Footprint of building plus construction activity	Mental/physical challenges of facility construction	Introduction of building construction materials or hazardous materials into the water supply	VOC, SOC releases during construction	Falls, chemical leaks and other risks during construction	Concrete deliveries; deliveries during construction; diesel trucks	Waste from construction to landfill; handling of hazardous materials during construction	Noise during construction	Dust during construction activities
Construction waste	Energy for gathering and removing excess lumber, materials, etc.	Footprint of waste during construction		Introduction of pumping station construction materials into the water supply		Risks of handling construction waste; hazardous waste				
Site Work/Stormwater	Energy for grading, fences, lights and other site work	Footprint of site plus construction activity		Stormwater runoff		Hazardous waste exposure due to soil excavation and dewatering				
Pumping Station	Energy for pump station construction and lights	Footprint of pumping station plus construction activity		Introduction of pumping station construction materials into the water supply		Risks during construction				
Maintenance/Operation										
UV Equipment	Energy for operating/ maintaining the UV equipment	Any additional Footprint needed for UV equipment maintenance/ operation	Mental/physical challenges of changing bulbs, maintenance and inspections; potential dermal and airborne exposure to workers related to maintenance and handling of the lamps	Mercury releases; cleaning chemicals in water supplies	VOC, SOC, toxic gas releases	Potential exposure resulting form breakage of the lamps while on line	Traffic to site due to workers, visitors and deliveries	Bulb disposal, mercury and glass, cleaning waste	Noise generated during maintenance and operation	Dust during maintenance and operation
Pumping Equipment	Energy for operating/ maintaining the pumping equipment	Any additional Footprint needed for pump sta. maintenance/ operation	Mental/physical challenges of handling large pumps and pump inspections or maintenance	Chemicals or materials into water supply		Risks of handling equipment/hazardous waste		Waste from pumping equipment		
Analytical Equipment	Energy for operating/ maintaining the analytical equipment	Any additional Footprint needed for analytical equpment maintenance/ operation	Mental/physical challenges of operating, calibrating and maintaining the analytical equipment					Reagents and used laboratory materials		
Building M&O	Energy for operating/ maintaining the building	Any additional Footprint needed for building maintenance/ operation	Mental/physical challenges of maintaining the building	Introduction of chemicals from the building into the water supply				Cleaning activities, worker and construction related debris such as food, paper, trash, cardboard, aluminum, plastic, etc.		
Site M&O	Energy for operating/ maintaining the site	Any additional Footprint needed for site maintenance/ operation	Mental/physical challenges of maintaining the site	Sediment/ chemical runoff from site				Yard waste, chemicals used for the site		
Salvage and Disposal										
UV Equipment	Energy for salvaging and disposing of the equipment	Footprint in landfill	Mental/physical challenges of salvage and disposal	Water quality effects of landfill disposal	VOC, SOC, toxic gas releases during salvage and disposal	Risk of handling mercury and broken bulbs during disposal	Transportation of equipment for salvage and disposal	Waste generated during salvage and disposal	Noise of salvaging and disposal activities	Dust generated during salvaging and disposal of equipment
Building Equipment						Risk of handling hazardous wastes during salvage and disposal				
Electrical Equipment										
Pumping Equipment										

Table 4-5 Explanation of Chlorination/Dechlorination Impacts and Matrix Components

Environmental Impact - Chlorination/Dechlorination	Energy	Land Use	Labor Burden	Water Quality	Air Quality	Safety/ Risk	Transportation	Waste Stream/ Hazardous Material	Noise	Dust/ Airborne Particles
	Coal usage, air emissions	Footprint	Mental/ physical challenges	Sediment, erosion, byproducts	VOC, SOC, toxic gas releases	Potential for leaks, explosions; operational risks	Air emissions from consumption of gas/oil	Chemical and solid waste stream /storage and disposal of hazardous materials	Community nuisance	Dust and particulates
Source										
Construction Materials										
Building Equipment and Supplies	Energy for source materials and supplies; mining	Land needed for source materials and supplies; mining	Mental/ physical challenges of gathering source materials and supplies; mining	Sediment from mining; materials and byproducts into water supply	VOC, SOC, toxic air releases during source gathering	Potential for explosions	Delivery of source materials	Wastes during source material retrieval	Noise during mining/ excavating of source materials	Dust generated from mining/excavating source materials
Chlor/Dechlor Equipment and Supplies										
Manufacturing										
Chlor/Dechlor Chemicals and Equipment	Energy for assembly	Land needed for warehouses used to assemble equipment and products	Mental/ physical challenges of assembling equipment and handling hazardous material	Releases to the water supply	Air releases during assembly	Risks of assembly	Delivery of equipment and products	Waste during assembly	Noise during assembly	Dust generated from assembling equipment and products
Analytical & Monitoring Equipment										
Metering Pumps and Spill Control Equipment										
Pumping Station Equipment										
Materials/products to support construction activities										
Power Transmission Line										
Facility Construction										
Building Construction Activities	Energy for building construction; lights	Footprint of building plus construction activity	Mental/physical challenges of facility construction	Introduction of building construction materials or hazardous materials into the water supply	VOC, SOC releases during construction	Falls, chemical leaks and other risks during construction	Concrete deliveries; deliveries during construction; diesel trucks	Waste from construction to landfill; handling of hazardous materials during construction	Noise during construction	Dust during construction activities
Chlorine Contactor Tanks Construction	Energy for construction; lights	Footprint of contactors plus construction activity								
Construction waste	Energy for gathering and removing excess lumber, materials, etc.	Footprint of waste during construction		Introduction of pumping station construction materials into the water supply		Risks of handling construction waste; hazardous waste				
Site Work/Stormwater	Energy for grading, fences, lights and other site work	Footprint of site plus construction activity		Stormwater runoff		Hazardous waste exposure due to soil excavation and dewatering				
Pumping Station	Energy for pump station construction and lights	Footprint of pumping station plus construction activity		Introduction of pumping station construction materials into the water supply		Risks during construction				
Maintenance/Operation										
Chlor/Dechlor Units and Storage	Energy for operating/maintaining the equipment	Any additional Footprint needed for equipment maintenance/ operation	Mental/physical challenges of changing bulbs, maintenance and inspections; potential dermal and airborne exposure to workers related to maintenance and handling of the equipment	Chemicals or materials into water supply; DBPs	VOC, SOC, toxic gas releases	Potential chemical exposure	Traffic to site due to workers, visitors and deliveries	Chemical disposal, cleaning waste	Noise generated during maintenance and operation	Dust during maintenance and operation
Chlorine Contact Tanks										
Metering Pumps and Spill Control Equipment										
Pumping Equipment	Energy for operating/maintaining the pumping equipment	Any additional Footprint needed for pump sta. maintenance/ operation	Mental/physical challenges of handling large pumps and pump inspections or maintenance			Risks of handling equipment/hazardous waste		Waste from pumping equipment		
Analytical Equipment	Energy for operating/maintaining the analytical equipment	Any additional Footprint needed for analytical equpment maintenance/ operation	Mental/physical challenges of operating, calibrating and maintaining the analytical equipment					Reagents and used laboratory materials		
Building M&O	Energy for operating/maintaining the building	Any additional Footprint needed for building maintenance/ operation	Mental/physical challenges of maintaining the building	Introduction of chemicals from the building into the water supply				Cleaning activities, worker and construction related debris such as food, paper, trash, cardboard, aluminum, plastic, etc.		
Site M&O	Energy for operating/maintaining the site	Any additional Footprint needed for site maintenance/ operation	Mental/physical challenges of maintaining the site	Sediment/ chemical runoff from site				Yard waste, chemicals used for the site		
Salvage and Disposal										
Chlor/Dechlor Equipment	Energy for salvaging and disposing of the equipment	Footprint in landfill	Mental/physical challenges of salvage and disposal	Water quality effects of landfill disposal	VOC, SOC, toxic gas releases during salvage and disposal	Risk of handling chemicals	Transportation of equipment for salvage and disposal	Waste generated during salvage and disposal	Noise of salvaging and disposal activities	Dust generated during salvaging and disposal of equipment
Building Equipment						Risk of handling hazardous wastes during salvage and disposal				
Electrical Equipment										
Pumping Equipment										

Although Energy, Air Quality, Transportation, and Dust/Airborne Particles all generally incorporate aspects of air pollution, listing these categories individually enables tracking of the air pollution impacts from each of these sectors. For example, the Energy impact category includes air emissions during energy production and use (from coal), while Transportation takes into account air pollution due to car emissions. Dust/Airborne Particles consider the chronic response of dust and small, solid particles in the air. In contrast, the Air Quality category includes acute responses from potential VOCs, SOCs and other toxic gas releases.

Exposure to chemicals is included in the Safety/Risk category and not the Waste Stream/Hazardous Material category. The difference between these two impact categories is dependent on the fate. The Waste Stream/Hazardous Material category considers the ending point of a chemical and its potential adverse effect on the environment. For example, a chemical spill poses a safety concern due to exposure, which would be documented under the Safety/Risk category. The potential for the spill to cause a change in pH of the receiving body upon disposal would be documented under the Waste Stream/Hazardous Material category.

As shown in Table 4-6, each category was assigned a relative weighting factor. Categories with a weighting factor of "5" were determined by Malcolm Pirnie and the District to be the most important category with respect to the environmental impact.

Table 4-6
Weighting Factors and Description of the Impact Categories

Impact Category	Weighting Factor (1-5)	Description
Energy	5	Coal usage, air emissions
Land Use	5	Footprint, introduction of impervious material, tree removal, removal of open space
Water Quality	5	Sediment, erosion, byproducts
Air Quality	5	VOCs, SOCs, toxic gas releases (acute response)
Safety/Risk	5	Leaks, explosions, operational risks, chemical exposure, handling of chemicals and mercury (UV only)
Labor Burden	3	Mental/physical challenges
Transportation	3	Emissions from consumption of gas/oil
Waste Stream/Hazardous Material	3	Chemical and solid waste streams/storage and disposal of hazardous materials
Dust/Airborne particles	3	Dust or small, fine, solid particles in the air
Noise	2	Community nuisance

With input from the District, the categories in the matrix were subjectively ranked according to the perceived level of impact, as shown in Table 4-7 and Table 4-8. As mentioned earlier, these matrices were used as a screening technique to prioritize and focus the activities that would be quantified in more detail. The key for the matrix rankings is as follows:

1 - No Impact
2 - Minimal Impact
3 - Some Impact
4 - Significant Impact
5 - Greatest Impact

A ranking of "5" has the greatest environmental impact relative to each of the activities in the matrix, and a ranking of "1" has "no impact." The rankings and weighting factors included input from the District. The value in each cell was determined by the product of the weighting factor for each category and the ranking of each activity. The sum of each cell was then calculated to determine the weighted sum for that particular activity. The highlighted line items in each matrix (Table 4-7 and Table 4-8) are the activities that could potentially pose the greatest overall environmental impact to each category based on the weighted sums and will be further quantified later in this report.

The duration of the environmental impact was considered when assigning the rankings. Activities listed under the "manufacturing" phase consider only the environmental impacts during manufacturing; likewise, the "facility construction" impacts are only applicable when the facilities are under construction. Only direct impacts of the activities were considered. As a result, secondary impacts such as bioaccumulation and soil degradation, which require more detailed evaluations and larger data sets, were not considered in the screening process.

The rankings in both matrices show that even though the operation and maintenance of the facilities over a 20-year period will have the greatest energy requirements (and associated air emissions), the activities during the 3-year construction phase will affect a greater number of environmental impact categories.

Table 4-7 Potential Environmental Impacts of UV Disinfection

Environmental Impact - UV	WEIGHTED SUM	Energy	Land Use	Water Quality	Air Quality	Safety/ Risk	Labor Burden	Transport-ation	Waste Stream/ Hazardous Material	Dust/ Airborne Particles	Noise
weighting factor		5	5	5	5	5	3	3	3	3	2
Source											
Construction Materials	96	2	2	3	3	2	2	3	2	3	3
Building Equipment and Supplies	91	2	2	2	3	2	2	3	2	3	3
UV Equipment and Supplies	107	2	2	2	3	4	2	3	4	3	3
Manufacturing											
UV Equipment	127	3	2	3	5	4	4	3	4	1	3
Pumping Station Equipment	93	3	2	2	2	3	3	3	2	1	3
Materials/products to support construction activities	99	3	2	3	2	3	3	3	3	1	2
Power Transmission Line	93	3	2	2	2	3	3	3	2	1	3
Facility Construction											
UV Building Construction Activities	133	3	4	3	1	4	4	4	3	5	5
Construction waste	108	2	3	3	1	4	3	3	4	3	2
Site Work/Stormwater	117	2	4	5	1	3	3	3	2	4	3
Pumping Station	125	2	5	3	1	4	4	4	2	4	4
Maintenance/Operation											
UV Equipment	117	5	1	1	1	5	5	5	5	1	2
Pumping Equipment	83	4	1	1	1	3	3	3	2	1	3
Analytical Equipment	58	2	1	1	1	2	2	2	2	1	1
Building M&O	95	3	1	2	2	3	3	4	3	2	2
Site M&O	92	2	1	3	2	3	3	3	3	2	2
Salvage and Disposal											
UV Equipment	102	2	3	3	1	4	4	2	3	2	2
Building Equipment	86	2	3	2	1	3	3	2	2	2	2
Electrical Equipment	78	2	2	2	1	3	2	2	2	2	2
Pumping Equipment	70	2	2	2	1	2	2	2	1	2	2

Table 4-8 Potential Environmental Impacts of Chlorination/Dechlorination

Environmental Impact - Chlorination/Dechlorination	WEIGHTED SUM	Energy	Land Use	Water Quality	Air Quality	Safety/ Risk	Labor Burden	Transport-ation	Waste Stream/ Hazardous Material	Dust/ Airborne Particles	Noise
weighting factor		5	5	5	5	5	3	3	3	3	2
Source											
Construction Materials	96	2	2	3	3	2	2	3	2	3	3
Building Equipment and Supplies	91	2	2	2	3	2	2	3	2	3	3
Chlor/Dechlor Equipment and Supplies	91	2	2	2	3	2	2	3	2	3	3
Manufacturing											
Chlor/Dechlor Chemicals and Equipment	102	2	2	3	2	4	3	3	4	1	2
Analytical & Monitoring Equipment	89	2	2	2	2	3	3	3	3	1	2
Metering Pumps and Spill Control Equipment	78	2	2	2	2	2	3	2	2	1	2
Pumping Station Equipment	93	3	2	2	2	3	3	3	2	1	3
Materials/products to support construction activities	99	3	2	3	2	3	3	3	3	1	2
Power Transmission Line	93	3	2	2	2	3	3	3	2	1	3
Facility Construction											
Building Construction Activities	133	3	4	3	1	4	4	4	3	5	5
Chlorine Contactor Tanks Construction	98	2	3	3	1	3	3	3	1	3	4
Construction waste	108	2	3	3	1	4	3	3	4	3	2
Site Work/Stormwater	117	2	4	5	1	3	3	3	2	4	3
Pumping Station	125	2	5	3	1	4	4	4	2	4	4
Maintenance/Operation											
Chlor/Dechlor Units and Storage	96	2	1	1	1	5	3	5	5	1	2
Chlorine Contact Tanks	76	2	1	2	1	3	3	2	3	1	2
Metering Pumps and Spill Control Equipment	70	2	1	1	1	3	3	2	2	1	3
Pumping Equipment	83	4	1	1	1	3	3	3	2	1	3
Analytical Equipment	58	2	1	1	1	2	2	2	2	1	1
Building M&O	95	3	1	2	2	3	3	4	3	2	2
Site M&O	92	2	1	3	2	3	3	3	3	2	2
Salvage and Disposal											
Chlor/Dechlor Equipment	78	2	3	2	1	2	2	2	2	2	2
Building Equipment	86	2	3	2	1	3	3	2	2	2	2
Electrical Equipment	78	2	2	2	1	3	2	2	2	2	2
Pumping Equipment	70	2	2	2	1	2	2	2	1	2	2

4.5 Determination of Quantifiable Impacts

Tables 4-9 and 4-10 summarize the activities with the greatest weighted sums for UV and chlorination/dechlorination as highlighted in Tables 4-7 and 4-8. The categories that can be quantified are marked with a check and will be further evaluated in Section 4.6.

Table 4-9
Quantifiable Potential Environmental Impacts of UV Disinfection

Activity	Impact Category					
	Energy	Land Use	Water Quality	Transpo rtation	Waste Stream/ Hazardous Material	Noise
Manufacturing						
UV Equipment	(1)	(1)	(1),(2)	✓	(1), (2)	(1), (2)
Materials/products to support construction activities	(2)	(1), (2)	(1), (2)	(1)	(1), (2)	(1), (2)
Facility Construction						
UV Building Construction Activities	(2)	✓	(2)	✓	(2)	✓
Construction Waste	(2)	(2)	(2)	✓	(2)	✓
Site Work/Stormwater	(2)	✓	(2)	✓	(2)	✓
Pumping Station	(2)	✓	(2)	✓	(2)	✓
Maintenance/Operation						
UV Equipment	✓	N/A	(2)	✓	✓	✓
Salvage and Disposal						
UV Equipment	(2)	✓	(2)	(2)	✓	(2)

(1) Not quantified - Impact outside the study area
(2) Not quantified - Difficult to quantify because of limited or non-existent data

Table 4-10
Quantifiable Potential Environmental Impacts of Chlorination/Dechlorination

Activity	Impact Category					
	Energy	Land Use	Water Quality	Transpo rtation	Waste Stream/ Hazardous Material	Noise
Manufacturing						
Chlor/Dechlor Chemicals and Equipment	✓	(1)	(1),(2)	✓	✓	(1), (2)
Materials/products to support construction activities	(2)	(2)	(2)	(2)	(2)	(2)
Facility Construction						
Building Construction Activities	(2)	✓	(2)	✓	(2)	✓
Chlorine Contactor Tanks Construction	(2)	✓	(2)	✓	(2)	✓
Construction waste	(2)	(2)	(2)	✓	(2)	✓
Site Work/Stormwater	(2)	✓	(2)	✓	(2)	✓
Pumping Station	(2)	✓	(2)	✓	(2)	✓
Maintenance/Operation						
Chlor/Dechlor Units and Storage	✓	N/A	(2)	✓	✓	✓
Building M&O	(2)	N/A	(2)	✓	(2)	✓

(1) Not quantified - Impact outside the study area
(2) Not quantified - Difficult to quantify because of limited or non-existent data

Certain impacts for a particular activity were excluded because they were either outside the study area or difficult to quantify because of limited or non-existent data, identified by (1) or (2). Any activity under "Source" in Table 4-7 and Table 4-8 was not listed as quantifiable since the collection of raw material typically occurs outside the study area. However, this does not suggest that this activity will not have an impact to the environment. For example, the mining of coal (which is outside the study area) to support the high energy usage for these technologies will significantly affect safety, transportation, depletion of natural resources, dust emissions, and land use of the area that coal is mined, but not the study area.

The maintenance and operation of the pumping station for both UV and Chlorination-Dechlorination is not among the activities with the greatest weighted sum identified in the matrices (Table 4-7 and 4-8). However, because the matrices are only used as a screening tool, after further review of the activities, it was included as one of the activities to be further quantified (in Section 4.6) due to its significant energy consumption and associated air emissions within the study area.

The following impact categories are not quantifiable, but the additional disinfection will adversely affect the environment within the study area as described below:

- Safety/Risk – the plant staff and operators are exposed to greater risk through potential of leaks, large quantities of chemical storage, chemical spills, electric shock, and mercury contact through breakage of UV bulbs. These risks will be most significant during the operation and maintenance of the facilities.
- Labor Burden – the operators will have additional mental and physical challenges with the operation of the disinfection system and the additional mundane and tedious labor requirements associated with extensive bulb replacements or chemical deliveries. From CTE's *UV Disinfection Cost Study – North Side Water Reclamation Plant* (January 2008), the North Side and Calumet WRPs will each require 16 hours per day for UV operation, 80 hours per week for lamp cleaning/inspection, and 16 hours per week for lamp replacement. From CTE's *Chlorination/Dechlorination Disinfection Cost Study for Stickney, Calumet and North Side Water Reclamation Plants* (May 2008) chemical deliveries for sodium hypochlorite and sodium bisulfite will occur a total of approximately 170 times per week for the three plants. Additionally, operation and maintenance of the chlorination/dechlorination system will require 20 hours per day at each facility.
- Dust/Airborne particles – Small particles may become airborne during the construction phase, which will last approximately 3 years. Typically, dust barriers are provided on the site to keep construction dust from leaving the work area.
- Air Quality (VOCs and SOCs) – For each of the technologies, the most likely source of VOCs or SOCs that may be discharged into the atmosphere will be during the manufacturing process of the equipment and building materials, or emissions from cars and semi-trucks. Quantifying the discharges from each of the operations was not practical for this study, but additional VOC/SOC emissions could increase ground level formation of ozone, which leads to smog formation. These emissions can also be carcinogenic if inhaled.
- Disinfection Byproducts – UV disinfection shows no evidence of increased disinfection byproducts at the doses typically applied. With chlorination, microbial inactivation must be balanced with the risks of byproduct formation. On a weight basis, trihalomethanes and haloacetic acids account for the majority of byproducts of chlorination. Disinfection byproducts formation has been addressed in a disinfection risk assessment completed for the District in April

2008.[4] The authors of this study state that the "inventory of DBPs that have the potential to cause adverse health effects is large and highly variable among publicly owned treatment works (POTW) effluents." Further, because the effects of disinfection byproducts are chronic in nature, their health effects are better described through epidemiological or toxicological studies.

The addition of bisulfite for dechlorination may also lead to the formation of disinfection byproducts. From the District's risk assessment, not much is known about the kinetics of reactions between bisulfite and organic combined chlorine. Studies were cited indicating that "some organic chloramines are recalcitrant to S(IV)-based dechlorination and may cause toxicity in dechlorinated wastewater effluent." Additional studies were cited in the risk assessment showing that bisulfite applied for dechlorination "was capable of removing 87% to 98% of residual chlorine, but the remainder, which may exceed regulatory limits [and contribute to disinfection byproduct formation], was very slowly reduced."

In summary, the activities that will be further evaluated and quantified according to its potential impact on the air, land, or water are:

Air

- Energy consumption and associated air emissions during operation of the UV or chlorination/dechlorination equipment and sodium hypochlorite manufacturing;
- Energy consumption and associated air emissions during the operation of the UV or chlorination/dechlorination low lift pumping station;
- Air emissions as a result of the increased traffic from construction, maintenance/operation, and deliveries; and
- Noise associated with the construction and operation of the facilities.

Land

- Land requirements for each facility;
- Modifications to the land during construction such as reduction of open space and additional impervious area;
- Landfill needs for disposal of UV equipment or mercury; and
- Reduction of available space for future expansions.

[4] *Dry and Wet Weather Risk Assessment of Human Health Impacts of Disinfection vs. No Disinfection of the Chicago Area Waterways System (CWS),* Geosyntec Consultants, April 2008.

Water

- Water requirements for facility during construction and operation; and
- Stormwater runoff.

4.6 Quantification of Impacts

4.6.1 Impacts to the Air

UV manufacturing

Sections 4.1 and 4.2 describe the air, water, and land impacts during manufacturing of the disinfection equipment. As reported in Section 4.1, the current UV suppliers are located outside of the study area that is defined in Section 1.4. Although the impacts of UV manufacturing are quantifiable for the global community, the manufacturing practices or land use would not specifically impact the District unless a UV supplier started operations within the study area. Impact to the air due to delivery of the equipment from the study area boundary to each facility is included in the "Transportation" section below.

Chlorination/Dechlorination manufacturing

For chlorination, the method used for hypochlorite manufacturing by the current District supplier is chemical mixing through a Powell bleach process as described in Section 4.2. Only the chlorine gas required for the Powell process requires significant electricity and is currently manufactured outside of the study area. If the chlorine gas is produced at a location outside of the study area, energy consumption is not an impact for hypochlorite manufacturing through the Powell process. However, it is possible that the current supplier may start producing chlorine gas for hypochlorite manufacturing onsite, or may switch to the electrolytic process for hypochlorite production in the future, which also consumes significant amounts of electricity. Alternatively, the District may bid the sodium hypochlorite contract to another supplier (based on a low-bid process) that employs the electrolytic manufacturing approach within the study area. Reasons to switch to an electrolytic process for hypochlorite generation, as presented in Section 4.2, include: a more efficient and cost effective process, purer chemical yield, and increased safety. Thus, the environmental impact of energy use during hypochlorite production is considered.

The electrolytic process that is used by some manufacturers for the production of hypochlorite is similar to onsite generation of hypochlorite. Typically, onsite generation of hypochlorite requires approximately 2.5 kWh/lb as Cl_2 generated from the generation unit, in addition to the smaller demands of the blower for hydrogen dilution and feed system.

Approximately 25 million pounds of chlorine[5] are required to meet the disinfection requirements at the North Side, Calumet, and Stickney plants during the 9-month disinfection period. Assuming 2.5 kWh/lb, an estimated 62 million kWh are consumed annually during manufacturing, which is an increase of 16% from the current energy use of 384 million kWh/yr. Summarized in Table 4-11, annually, this is equal to nearly 48,400 tons CO_2 equivalents in greenhouse gas emissions (includes CO_2, 21 times CH_4 and 310 times N_2O), 90 tons of NO_x emissions, 320 tons of SO_2 emissions, and 3 pounds of Hg emissions. The manufacturing of chlorination chemicals requires significant increase in energy consumption and is the second largest potential environmental impact, following UV operation, which is described in the following section.

Table 4-11
Energy Consumption and Air Emissions from the Power Generating Facility Due to the Manufacturing of Sodium Hypochlorite

	North Side	Calumet	Stickney	Total
Energy Requirement (million kWh/yr)	10.9	10.4	40.7	62
CO_2 (tons/yr)	8,500	8,100	31,600	48,200
CH_4 (tons/yr)	0.04	0.04	0.17	0.3
N_2O (tons/yr)	0.10	0.09	0.37	0.6
NO_x (tons/yr)	15.4	14.8	58	90
SO_2 (tons/yr)	55	53	207	320
Hg (tons/yr)	0.00024	0.00023	0.0009	0.0014

<u>Operation of UV and chlorination equipment and pumping stations</u>

The operation of UV at the three WRPs will also require a significant increase in energy usage and is the largest potential environmental impact of disinfection. For example, to implement only the UV disinfection technology (not including the pump stations) at the North Side, Calumet, and Stickney WRP's, the District would expend an additional 96 million kWh of electricity during 9 months of operation, which is an increase of 25% from the current energy use of 384 million kWh/yr. That additional electricity expenditure would result in greenhouse gas emissions loading of 74,300 tons per year

5. CTE's *Chlorination/Dechlorination Disinfection Cost Study for Stickney, Calumet, and North Side Water Reclamation Plants*, May 2008

from the power generating facility due to UV equipment operation alone. Comparatively, the operation of the chlorination/dechlorination equipment will have a small impact on energy consumption, (equal to an increase of 0.3%). The calculations to determine the estimated energy requirements for the operation of UV and chlorination/dechlorination equipment are included in Appendix D.

A summary of the additional energy requirements and air emissions for the operation of the UV or chlorination/dechlorination equipment are shown below in Tables 4-12 and 4-13. Similarly, a summary of additional energy requirements and air emissions for the operation of the pumping station are shown below in Table 4-14 and 4-15. Described in Section 3, the air emission loadings were calculated from eGRID emission coefficients based on the energy consumption. Emission coefficients are currently available only for the air pollutants that are included in Table 4-13 and Table 4-15.

Table 4-12
Estimated Energy Requirements for UV and Chlorine Disinfection (Equipment Operation Only) at North Side, Calumet, and Stickney WRPs

	North Side	Calumet	Stickney	Total
Average Day Design Flow	333	319	1,250	1902
UV Energy Requirement (Million kWh/yr)	19.9	18.1	57.6	96
Chlorination/Dechlorination Energy Requirement[2] (Million kWh/yr)	0.15	0.57	0.43	1.2

1. The proposed disinfection will be applied March-November.
2. Power includes operation of the transfer pumps, feed pumps, and mixers for chlorination/dechlorination. At North Side and Stickney, design assumes one new mixing chamber for each chemical with one mixer each (two total mixers at each plant). At Calumet, design assumes reusing the existing contact tanks and splitting flow such that two mixing chambers are required for each chemical with one mixer each (four total mixers). The additional mixers result in higher energy use at the Calumet WRP. Source: *Chlorination/Dechlorination Disinfection Cost Study for Stickney, Calumet and North Side Water Reclamation Plants* (CTE, May 2008)

Table 4-13
Estimated Emissions Loading Increase at the Power Generating Facility due to UV and Chlorination (Equipment Operation Only)

		North Side	Calumet	Stickney	TOTAL
Estimated UV Loading Increase (tons/yr)	NO_x	28.2	25.7	82	140
	SO_2	101	92	294	490
	CO_2	15,500	14,100	44,800	74,300
	CH_4	0.08	0.07	0.2	0.4
	N_2O	0.18	0.16	0.5	0.9
	Hg	0.00043	0.00040	0.0013	0.002
Estimated Chlorination/Dechlorination Loading Increase (tons/yr)	NO_x	0.21	0.82	0.61	1.6
	SO_2	0.8	2.9	2.2	5.9
	CO_2	120	450	330	900
	CH_4	0.001	0.0024	0.0018	0.005
	N_2O	0.0014	0.0052	0.0039	0.01
	Hg	0.000003	0.000010	0.000009	0.00003

Table 4-14 presents the energy requirements for the UV and chlorination/dechlorination pump station operation. The total energy represents an increase of approximately 8% from the current energy use of 384 million kWh/yr at the three plants for both UV and chlorination/dechlorination. The corresponding air emissions from the energy requirements are shown in Table 4-15.

Table 4-14
Pumping Station Operation Energy Requirements for UV and Chlorination/Dechlorination

	North Side	Calumet	Stickney	TOTAL
UV Pump Station Energy Requirement (Million kWh/yr)	2.3	2.1	26.5	30.9
Chlorination/Dechlorination Pump Station Energy Requirement (Million kWh/yr)	2.3	2.3	27.5	32.1

Table 4-15
Estimated Emissions Loading Increase at the Power Generating Facility Due to Pumping Station Operation

		North Side	Calumet	Stickney	TOTAL
Estimated UV Loading Increase (tons/yr)	NO_x	3.3	2.9	38	44
	SO_2	11.9	10.5	135	157
	CO_2	1,820	1,600	21,000	24,000
	CH_4	0.01	0.01	0.11	0.1
	N_2O	0.02	0.02	0.24	0.3
	Hg	0.000051	0.000045	0.00058	0.0007
Estimated Chlorination/Dechlorination Loading Increase (tons/yr)	NO_x	3.3	3.2	39	46
	SO_2	11.9	11.6	140	164
	CO_2	1,820	1,780	21,400	25,000
	CH_4	0.01	0.01	0.11	0.1
	N_2O	0.02	0.02	0.25	0.3
	Hg	0.000051	0.000050	0.0006	0.0007

Transportation

Facility construction and maintenance/operation will require transportation of materials and people by gasoline-based cars and trucks, which will increase the emissions loadings to the air. The following transportation is expected during the construction and maintenance/operation phases.

- Delivery of concrete and materials, and workers' transportation during construction for 3 years (52 weeks per year, 5 days per week and 8 hours per day).
- Delivery of UV bulbs, delivery of chemicals, and workers' transportation during maintenance and operation for 20 years (52 weeks per year, 7 days per week and 24 hours per day).
- Delivery of the disinfection equipment during installation.

Transportation emissions from employee commuting are assumed to occur over the entire year, including the three months of the year when the disinfection equipment is not in service. For chlorination/dechlorination, based on the volume of chemicals used per day and truck capacity, there will be an estimated total of 170 deliveries per week for chemical delivery alone at the three plants in the 9-month disinfection period.

According to the USEPA Office of Transportation and Air Quality, several components are included in vehicle emissions such as hydrocarbons, carbon monoxide, nitrous oxides, and carbon dioxide. However, the largest contributor to vehicle emissions is carbon dioxide; every gallon of gasoline or diesel that is burned produces approximately 20 pounds of CO_2. Table 4-16 presents the estimated annual carbon dioxide emissions from transport of materials and equipment, idling of vehicles, and employee commuting during construction and maintenance/operation of the disinfection facilities.

In the 3 years of construction and 20 years of maintenance/operation, transportation would result in the total release of 6,800 tons of CO_2 for UV, and 15,200 tons of CO_2 for chlorination/dechlorination. Detailed calculations are included in Appendix D.

Table 4-16
Annual CO_2 Emissions During 3-Year Construction and 20-Year O&M Phases

	UV (tons CO_2/yr)	Chlor/Dechlor (tons CO_2/yr)
Construction	450	480
Maintenance/Operation	270	690

<u>Noise</u>

Noise can be generated by both stationary sources, such as mechanical and construction equipment, and by mobile sources, such as cars and delivery trucks. The potential impact of noise is dependent on the sound level given in decibels, frequency of the noise source, spatial relationship between the source of the noise and the receptors, time of day, and the existing noises at the receptors. The lower threshold of hearing is at 10-15 dB, talking is at 70 dB, and the threshold of pain is at 140 dB. The decibel levels of typical construction equipment are presented in Table 4-17.

Table 4-17
Noise from Construction Equipment

Equipment	Sound levels, decibels
Pneumatic chip hammer	103-113
Jackhammer	102-111
Concrete joint cutter	99-102
Portable saw	88-102
Stud welder	101
Bulldozer	93-96
Earth tamper	90-96
Crane[1]	90-96
Hammer	87-95
Earthmover[2]	87-94
Front-end loader	86-94
Backhoe	84-93

1. Noise of crane lifting a load is 96 decibels; at rest, the crane noise may be less than 80 decibels
2. Noise of earthmover is 94 decibels at 10 feet; noise is 82 decibels at 70 feet
3. The Center to Protect Workers' Rights

Permissible noise limits are set by OSHA and by city noise ordinances. As shown in Table 4-18, OSHA sets limits on sound level dependent on the duration of exposure.

Table 4-18
Permissible Noise Exposure

Duration per day, hours	Sound level, decibels
8	90
6	92
4	95
3	97
2	100
1.5	102
1	105
0.5	110
0.25	115

1. Source: OSHA

The City of Chicago's Noise Ordinance provides guidance on acceptable sound levels and when the noise limits are to be enforced. However, it does not apply "to any construction, demolition or repair work of an emergency nature or to work on public improvements authorized by a governmental body or agency." Briefly, the Chicago Noise Ordinance states that the limit on mechanical stationary sources is 55 dBa at a distance of 100 feet or more between the hours of 8pm-8am. In a residential area, noise disturbances caused by "loading, unloading, opening, closing or other handling of boxes, crates, containers, building materials, garbage cans, dumpsters or similar objects" is not allowed between the hours of 10pm-7am. Except in manufacturing districts, earthshaking vibrations are prohibited beyond the boundaries of the work site between the hours of 8pm-8am.

Because the construction of the disinfection facilities would be a public improvement project that is authorized by a governmental body, it is exempt from the Chicago Noise Ordinance. However, the noise-producing activities during construction and operation such as the equipment operations and handling of delivery containers or dumpsters during operation will impact the noise levels within the surrounding area.

4.6.2 Impacts to the Land

Additional land requirements

The land use requirements for UV and Chlorination disinfection facilities are shown in Table 4-19. The estimated land requirement includes the footprint of the disinfection building or chlorine contact tanks, the pumping station, a new outfall, and 10-foot buffer around each facility. The new outfall is designed below grade with the assumption that no buildings will be built above.

Table 4-19
Land Requirements for Disinfection Technologies at the WRPs

	North Side	Calumet	Stickney	TOTAL
UV Land Requirement[1] (acres)	2.1	1.7	3.7	7.5
Chlorination/Dechlorination Land Requirement[2,3] (acres)	3.1	4.2	9.8	17.1

1. Source: *Draft UV Disinfection Cost Study – North Side Water Reclamation Plant* (CTE, January 2008); working results of the *Draft Stickney Water Reclamation Plant UV Cost Study* and the *Hydraulic Evaluation Technical Memorandum* (CTE, June 2008)
2. The land requirement for Chlorination/Dechlorination at Calumet includes 2.2 acres of the existing contact tanks.
3. Source: *Chlorination/Dechlorination Disinfection Cost Study for Stickney, Calumet and North Side Water Reclamation Plants* (CTE, May 2008).

Modifications to land usage

Installation of the equipment will require the conversion of green space to impervious areas for buildings, roadways and driveways. This conversion will reduce infiltration for recharge of the groundwater. Table 4-20 presents the area that will be converted from green space to impervious areas at each facility with UV disinfection, including the pumping station based site plans of the proposed facilities. At the Calumet plant, where chlorine tanks are existing, installation of the proposed UV equipment and removal of the chlorine contact tanks results in a negative increase in impervious area (-0.8 acres). The negative value indicates that the greenspace at this facility will increase with the installation of UV.

Table 4-20
Conversion of Green Space for UV Disinfection

	North Side	Calumet	Stickney	TOTAL
New building/ pavement/ driveways (sq. ft.)	68,000	30,000	180,000	280,000
Removal of existing building/ pavement/ driveways (sq. ft.)	0	66,000	0	66,000
Increase in Impervious Area (acres)	1.6	-0.8	4.1	4.8

The increase in impervious area from facilities, pumping station, roadways, and driveways required for chlorination/dechlorination is presented in Table 4-21 based on site plans of the proposed facility. Chlorination/dechlorination will not require the removal of existing facilities or pavement.

Table 4-21
Conversion of Green Space for Chlorination/Dechlorination

	North Side	Calumet	Stickney	TOTAL
New building/ pavement/ driveways (sq. ft.)	133,000	88,000	350,000	570,000
Removal of existing building/ pavement/ driveways (sq. ft.)	0	0	0	0
Increase in Impervious Area (acres)	3.1	2.0	8.1	13.1

Landfill needs

After removal of the recyclable pieces and compression, the remaining equipment is estimated to occupy 10%-20% of its original volume upon disposal. Table 4-22 presents the dimensions of the proposed UV equipment at the North Side, Calumet, and Stickney plants. This table also presents the landfill volume requirements as 10% or 20% of the equipment volume. Upon disposal, the remaining UV equipment will require an estimated 1500-3000 cubic feet of volume at the landfill.

Table 4-22
Approximate Size of the Proposed UV Equipment and Estimated Required Volume at the Landfill

	Proposed UV Equipment Dimensions				Size at Disposal	
	Length (ft)	Width (ft)	Depth (ft)	Total Volume (cubic feet)	10% of Total Volume (cubic feet)	20% of Total Volume (cubic feet)
North Side	41	9	14	5,100	500	1,000
Calumet	41	9	14	5,100	500	1,000
Stickney	41	9	14	5,100	500	1,000
TOTAL					1,500	3,000

For UV disinfection, and estimated 1,680 blubs at North Side, 1,680 bulbs at Calumet, and 4,032 bulbs at Stickney will be replaced every year. Based on information from supplier, each bulb contains approximately 150 mg of mercury. Thus, the mercury waste stream from the UV disinfection technology is approximately 2.4 lb/year. Illinois law considers mercury as a hazardous waste and is subject to the Universal Waste Rule under state regulations. As such, the mercury must be recycled and is not permitted to be disposed into a landfill. Thus, mercury disposal would not have an impact on the landfill resources of the study area.

4.6.3 Impacts to the Water

Water requirements for the equipment

UV and Chlorination disinfection do not have significant water usage requirements or inputs into their respective systems. Therefore, implementation of these technologies at either of the WRPs would not significantly increase the District's water usage and was not evaluated further for potential impacts.

Stormwater runoff

The increase in impervious area shown in Table 4-20 and Table 4-21 will introduce additional stormwater runoff, which may affect water quality in the receiving stream. Based on 30-year historical data, Chicago receives an average of 36.4 inches of precipitation per year. Shown in Table 4-23, the installation of UV disinfection has the potential to increase the total stormwater runoff by 5 MG per year, which is an increase of 3% from the existing total runoff. Similarly chlorination/dechlorination has the potential to increase the total stormwater runoff by 13 MG per year, which is an increase of 9% from the existing total runoff.

Table 4-23
Estimated Increase of Runoff from Impervious Area

		North Side	Calumet	Stickney	TOTAL
UV	Increase in Impervious Area (acres)	1.56	-0.83	4.11	4.84
	Increase in Runoff per year (MG)	1.54	-0.82	4.06	4.79
	Percent Difference from Current Runoff	14%	-1.7%	4.9%	3.3%
Chlorination/ Dechlorination	Increase in Impervious Area (acres)	3.05	2.02	8.05	13.12
	Increase in Runoff per year (MG)	3.02	2.00	7.95	13.0
	Percent Difference from Current Runoff	27.8%	4.0%	9.6%	9.1%

4.6.4 Summary of Impacts

In summary, these activities impacting the air, land, and water were quantified for both UV and chlorination/dechlorination to assess their impacts on the environment. The most significant impacts are as follows:

Ultraviolet Radiation

- Increase the District's electricity use by an average of 126 million kWh/yr from operation of the UV equipment and operation of the low lift pumping station.
- Result in emissions of 99,000 tons of carbon dioxide equivalents of greenhouse gases per year from transportation and at the power generating facility due to operation of the UV equipment, and operation of the low lift pumping station.
- Result in emissions of 180 tons of NO_x per year; 650 tons of SO_2 per year; 6 pounds Hg per year at the power generating facility due to operation of the UV equipment and operation of the low lift pumping station.
- Require 7.5 acres of District land to be converted to an industrial plant from current or allocated uses; this land will not be available for future expansions (5 acres will become impervious area).
- Require 1,500-3,000 cubic feet at the landfill upon disposal the end of its useful life.
- Increase stormwater runoff volume by 5 MG per year.

Chlorination-Dechlorination

- Increase the District's electricity use by an average of 95 million kWh/yr from operation of the chlorination/dechlorination pumps and mixers, operation of the low lift pumping station, and manufacturing of sodium hypochlorite.
- Result in emissions of 75,000 tons of carbon dioxide equivalents of greenhouse gases per year from transportation and at the power generating facility due to operation of the chlorination/dechlorination pumps and mixers, operation of the low lift pumping station, and manufacturing of sodium hypochlorite.
- Result in total emissions of 140 tons of NO_x per year; 490 tons of SO_2 per year; 4 pounds Hg per year at the power generating facility due to operation of the chlorination/dechlorination pumps and mixers, operation of the low lift pumping station, and manufacturing of sodium hypochlorite.
- Require 17 acres of District land to be converted to an industrial plant from current uses; this land will not be available for future expansions (13 acres will become impervious).
- Increase stormwater runoff volume by 13 MG per year.

5 Comparison to Baseline Conditions and Impact on Future Uses

The overall impacts of the disinfection options (UV or chlorination/dechlorination) on future air or land uses were evaluated. Because of the relatively low impact of several parameters and the limitations with the baseline data, the comparisons made in this section are limited to the District's energy usage, air emissions at the power generation plant resulting from energy use, air emissions from transportation, and land usage.

The energy requirements for implementing disinfection will require additional electricity originating from coal-powered plants. As shown in Table 5-1, the annual total energy required for the operation of the UV disinfection equipment and pumping station will increase the District's current usage at the three plants of 384 million kWh/yr by approximately 126 million kWh/yr, or 33%. From the USEPA Greenhouse Gas Equivalencies Calculator, an average household uses 11,965 kWh/yr. Thus, the electricity consumption for operation of the UV and low lift pumping station is equivalent to approximately 10,600 households. For chlorination/dechlorination, the total energy requirements for manufacturing of the sodium hypochlorite, operation of the pumps/mixers, and operation of the low lift pumping station will increase the District's current usage District's current usage at the three plants of 384 million kWh/yr by approximately 95 million kWh/yr, or 25%. This is equivalent to the electricity use of approximately 8,000 households.

The annual energy use can also be translated in terms of equivalent energy consumption at the Sears Tower, which requires 77 million kWh/yr. The annual energy required for the operation of the UV equipment and pumping station is 67% more than the annual energy consumption for the Sears Tower. Similarly the annual energy requirements for operation of the chlorination/dechlorination pumps and mixers, operation of the low lift pumping station, and manufacturing of sodium hypochlorite are 24% more than the annual energy consumption for the Sears Tower.

Table 5-1
Annual Electricity Equivalents

	UV[1]	Chlorination/ Dechlorination[2]
District's Current Energy Consumption at North Side, Calumet, and Stickney WRPs (kWh/yr)[3]	384 million	
Energy Increase (kWh/yr)	126 million	95 million
Percent Increase from Current	33%	25%
No. of Equivalent Households[4]	10,600	8,000
Disinfection Energy Use Relative to Sears Tower Energy Use[5]	164%	124%

1. UV includes equipment operation and low lift pumping station operation only.
2. Chlorination/Dechlorination includes operation of the pumps/mixers, operation of the low lift pumping station, and manufacturing of sodium hypochlorite.
3. 2006 energy consumption as reported in the District's "2008 Budget Book Info Final, All Divisions" (January, 2008).
4. 11,965 kWh/household per year provided by USEPA, http://www.epa.gov/cleanenergy/energy-resources/calculator.html
5. Assume 77 Million kWh/year needed to run the Sears Tower. Source: http://securitysolutions.com/fire_life_safety/security_modernizing_legend/

The increased energy usage for the UV equipment and pumping equipment and associated transportation at the three plants will increase the greenhouse gas emissions by 98,970 tons CO_2 equivalents/yr (98,700+270), or 33%, as shown in Table 5-2. Transportation emissions will result in an increase in greenhouse gas emissions of less than 0.5%; the remaining emissions will be at the power generating facility. Assuming 6.02 tons per car, the increase in total greenhouse gas emissions is equivalent to over 16,400 additional automobiles added to the road per year (based on the USEPA Greenhouse Gas Equivalencies Calculator). An equivalent 15.2 million trees would be required to absorb that same amount of carbon dioxide emissions.

For the chlorination/dechlorination equipment, pumping station, sodium hypochlorite manufacturing, and transportation at the three plants, the greenhouse gas emissions will increase current greenhouse gas emissions by 74,990 tons CO_2 equivalents/yr (74,300 + 690), or 25%, which is equivalent to approximately 12,500 automobiles added to the road per year. An equivalent of approximately 11.5 million trees will be required to absorb that same amount of carbon dioxide emissions. Transportation emissions will result in an increase in greenhouse gas emissions of less than 1.0%, with the remaining emissions occurring at the power generating facility.

Table 5-2
Annual Greenhouse Gas Emission Equivalents from Transportation and at the Power Generating Facility Due to Energy Consumption

	UV	Chlorination/ Dechlorination
Current CO_2 Emissions at the Power Generating Facility due to Energy Use at the Three Plants (tons CO_2 /yr)[1]	299,000	
CO_2 Emissions Increase at the Power Generating Facility (tons CO_2 /yr)	98,300	74,000
CO_2 Emissions Increase from Transportation (tons CO_2 /yr)[2]	270	690
Equivalent No. of Trees for CO_2 absorption (trees/yr)[3]	15.2 million	11.5 million
Percent Increase of CO_2 Emissions	33%	25%
Current GHG Emissions at the Power Generating Facility due to Energy Use at the Three Plants (tons CO_2 equivalents/yr)[4]	300,000	
GHG Emissions Increase at the Power Generating Facility (tons CO_2 equivalents/yr)	98,700	74,300
GHG Emissions Increase from Transportation (tons CO_2 equivalents/yr)	270	690
Equivalent No. of Cars Added to the Road (cars/yr)[5]	16,400	12,500
Percent Increase	33%	25%

1. Calculated based on energy consumption and eGrid emission factors.
2. Transportation emissions for only the associated manufacturing/operation of the facility are included.
3. A single tree absorbs 13lb CO_2 per year. Coder, R.D. (October 1996). *Identified Benefits of Community Trees and Forests.*
4. Carbon dioxide equivalents of ghg are presented - 21*CH4; 310*N20.
5. 6.02 tons CO2equivalents/car per year provided by USEPA, http://www.epa.gov/cleanenergy/energy-resources/calculator.html

Emissions from UV and chlorination/dechlorination will decrease the air capacity that might otherwise be available for other economic or developmental uses in the future. The current and estimated increase in the major permitted air pollutants are shown are shown in Table 5-3. The increase in criteria pollutants and mercury emissions are from energy production at the power generating facility.

Table 5-3
Annual Additional Air Emissions of Regulated Air Pollutants at the Power Generating Facility

	Current Total Emissions (tons/yr)[1]	Additional Air Emissions at Power Generating Facility (tons/yr)		Percent Change From Current Emissions	
		UV	Chlorination	UV	Chlorination
NO_x	600	180	140	30%	23%
SO_2	1970	650	490	33%	25%
Hg	0.008	0.003	0.002	33%	25%

1. Summation of emissions reported in the District's 2006 Annual Air Emission Reports and emissions at the power plant due to energy use.

The UV and chlorination facilities will also decrease the available land or reduce landfill space that might otherwise be available for other economic or developmental uses in the future. The current used/allocated land, remaining land, and percent increase in land use if the disinfection and pumping facilities are installed are shown in Table 5-4.

Table 5-4
Land Increase from the Disinfection and Pumping Facilities

	Currently Used or Allocated Land (acres)[1,2,3,4]	Remaining Land (acres)	Additional Land Required for Disinfection (acres)		Percent Change From Current/Allocated Land Use	
			UV	Chlorination	UV	Chlorination
North Side	87	10	2.1	3.1	2.4%	3.6%
Calumet	446	24	1.7	4.2	0.4%	0.9%
Stickney	404	166	3.7	9.8	0.9%	5.9%
TOTAL	937	200	7.5	17.1	0.8%	1.8%

1. Source: MWRDGC M&O Facilities Handbook, 2006, and WRP facility layouts.
2. The areas are estimated using layouts of facilities and do not consider any underground structures that are not shown on the layouts.
3. At North Side, the current land in use includes land leased to the Park District.
4. Allocated land is set aside for future projects already identified to meet regulatory requirements and expansion needs as described in the District's Master Plan for each facility.

As described in this study, the environmental impacts of implementing disinfection technologies at the North Side, Calumet, and Stickney plants are not consistent with the goals of the Chicago *Environmental Action Agenda.* Presented in Section 2.4, the *Environmental Action Agenda* advocates environmentally-friendly policies in the City's departments and other agencies to strengthen Chicago's economy and improve the quality of life. It is the intention of the Mayor to continue efforts that inform and engage the residents and employees of Chicago "to make sure that Green remains routine over time." Therefore, when selecting the appropriate technology, one must also be mindful of aligning with the goals of the City's agenda and other agencies that strengthen Chicago's economy and improve the quality of life for current and future residents. It should also be noted that implementing disinfection technologies will utilize critical District resources (air, land, water, and financial) that will then become unavailable for future treatment options and alternatives.

6 Environmental Assessment of Increasing DO in the CAWS

6.1 Introduction and Background

Supplemental aeration is practiced by the Metropolitan Water Reclamation District of Greater Chicago (District) to increase the dissolved oxygen concentration in certain sections of the Chicago Area Waterway System. Currently, under existing Illinois Pollution Control Board (IPCB) Secondary Contact water quality regulations, certain sections of CAWS are required to maintain a minimum DO of either 3mg/l or 4 mg/l at all times; and for the sections classified as General Use waters, a minimum DO of 5 mg/L is required at all times. The Clean Water Act requires that States periodically review the uses of waterways to determine if changes to the existing water quality standards are needed to support a change in use. Based upon a Use Attainability Analysis (UAA) study of the CAWS, the Illinois Environmental Protection Agency (IEPA) has proposed new DO water quality standards for the CAWS under the rule-making process.

The District has hired Consoer Townsend Environdyne Engineers, Inc. (CTE) to develop an integrated approach for meeting the proposed DO standards. CTE's study is ongoing and is expected to be completed by mid 2009. Upon the District's request, however, CTE has developed a preliminary cost estimate that will convey to the IPCB the cost implications of achieving the proposed IEPA DO standards for the CAWS at all times.

A map showing the location of the CAWS is presented in Figure 6-1. Based on the information provided by CTE, the following are the sections of CAWS considered for supplemental aeration or additional aeration facilities to meet the proposed DO standards at all times.

1. Upper North Shore Channel (UNSC)
2. North Branch of Chicago River (NBCR)
3. South Branch of Chicago River (SBCR)
4. Bubbly Creek (South Fork of SBCR)
5. Chicago Sanitary and Ship Canal (CSSC)
6. Cal-Sag Channel
7. Little Calumet River (North)

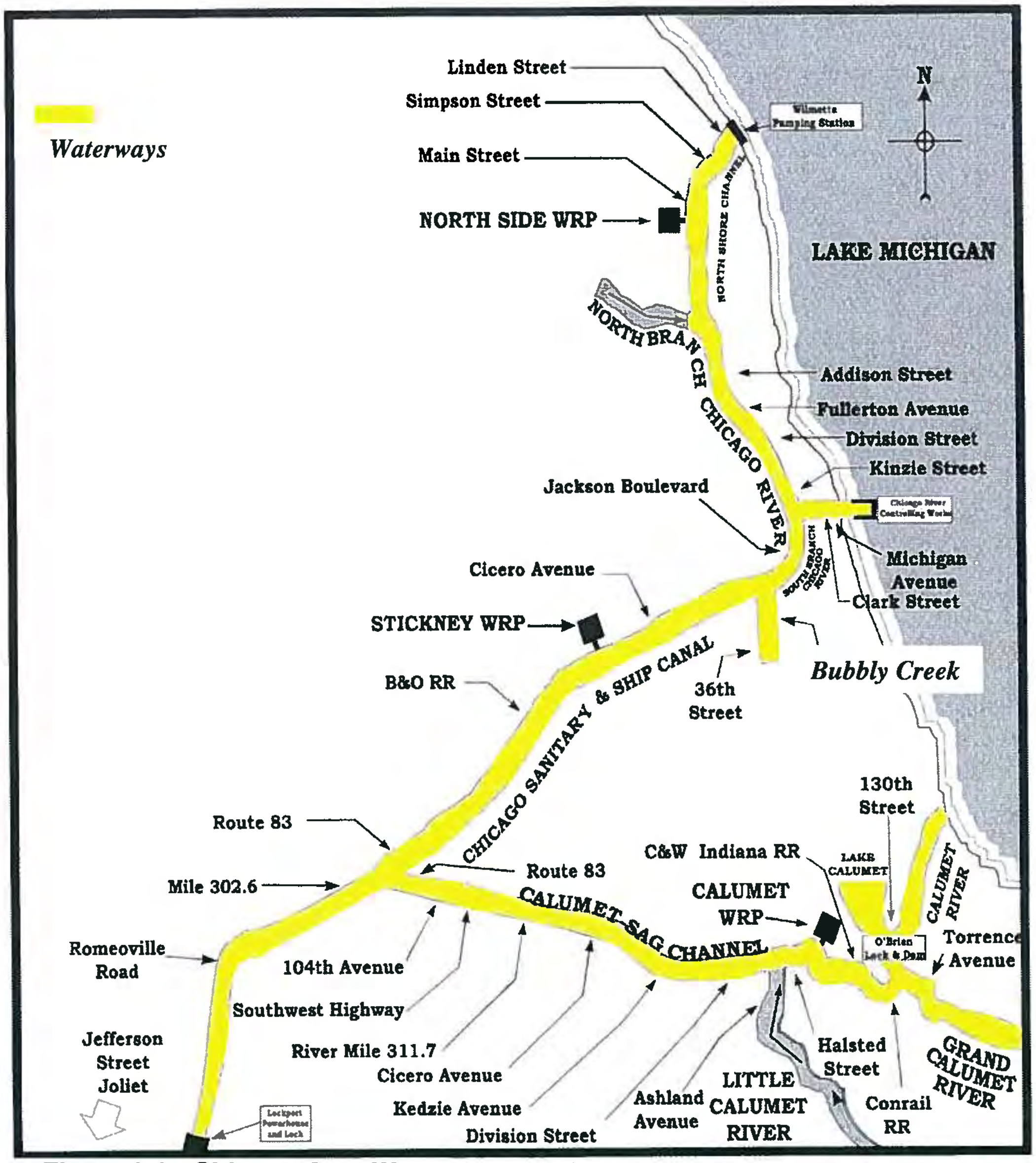


Figure 6-1: Chicago Area Waterways and Water Reclamation Plant Locations

6.2 Locations and Capacities of Flow Augmentation and DO Enhancement Facilities

An updated water quality model of the CAWS, developed by Marquette University, was used to determine the flow augmentation and DO enhancement facilities for the receiving water. Based on the modeling simulations and the historical DO data, the following supplemental aeration was recommended by CTE to meet the proposed IEPA DO standard for the CAWS at all times:

- Eighteen Supplemental Aeration Stations
- Three Flow Augmentation Stations, including;
  - 100 mgd of aerated North Side water reclamation plant effluent for the Upper North Shore Channel
  - 50 mgd of unaerated water from the South Branch of the Chicago River for Bubbly Creek
  - 182.6 mgd of aerated Calumet water reclamation plant effluent for the Little Calumet River
- Existing sidestream elevated pool aeration (SEPA) and diffused air stations operated at full firm capacity

The aeration capacity of each supplemental aeration station or flow augmentation location developed by CTE is presented in Table 6-1. The aeration technology scenarios assume supplemental aeration using only ceramic disc diffusers with an on-shore blower facility to supplement the DO in the waterways. In the case of flow augmentation technology, U-Tube aeration of pumped flow was utilized. Other aeration technologies are under consideration in CTE's ongoing integrated study.

Table 6-1
Estimated Additional Power Usage for Supplemental Aeration and Flow Augmentation of CAWS (July 2008)

Supplemental Aeration Station Location	Aeration Capacity (grams per second, g/s)	Hourly Operating Power † (kW)	Annual Energy Usage† (kW-hr/yr)
UNSC[1]	18	765	2,511,415
UNSC #1	80	1,000	3,285,000
UNSC #2	80	1,000	3,285,000
UNSC #3	80	1,000	3,285,000
North Branch	80	1,000	3,285,000
South Branch #1	80	1,000	3,285,000
South Branch #2	80	1,000	3,285,000
South Branch #3	80	1,000	3,285,000
Bubbly Creek #1	80	1,000	3,285,000
Bubbly Creek #2	80	1,000	3,285,000
Bubbly Creek #3	80	1,000	3,285,000
Bubbly Creek[2]	N/A	372	1,222,743
CSSC #1	80	1,000	3,285,000
CSSC #2	80	1,000	3,285,000
CSSC #3	80	1,000	3,285,000
CSSC #4	80	1,000	3,285,000
CSSC #5	80	1,000	3,285,000
Little Calumet River (North)	80	1,000	3,285,000
Cal-Sag Station #1	70	875	2,874,375
Cal-Sag Station #2	80	1,000	3,285,000
Little Calumet[3]	33	1,846	6,063,401
SEPA Station No. 3[4]	N/A	560	1,839,600
SEPA Station No. 4[4]	N/A	560	1,839,600
SEPA Station No. 5[4]	N/A	612	2,010,420
		Total	74,206,554

† Energy usage taken from TM-4WQ, pgs. B-9 and C-9 for the 80 gps station, TM-5WQ, pgs. 5-16, G-2, and G-3 for UNSC, and TM-6WQ, pgs. 6-17 and I-2 for Bubbly Creek. Assumes operating at full firm capacity for 1 month, half capacity for 7 months, and non-operational 4 months each year.

Energy usage is for additional operation required to meet 100% compliance with proposed DO standards.
1. Includes a 18 g/s U-Tube aerator and a 100 mgd firm capacity pump station and forcemain for flow augmentation and aeration.
2. Includes one 50 mgd firm capacity pump station and forcemain.
3. Includes a 33 gps U-Tube aerator and a 182.6 mgd firm capacity pump station and forcemain.
4. Power usage for SEPA pumps provided by MWRDGC.

6.3 Determination of Quantifiable Environmental Impacts

The environmental assessment of supplemental aeration and flow augmentation focuses on energy consumption, which is the largest potential environmental impact for the operation of the DO enhancement technologies in the CAWS. Energy consumption leads to greater electrical demands, resulting in increased air emissions at the coal-based energy generating plants that supply power to run the District facilities. From Table 6-1, CTE estimates that the operation of the DO enhancement technologies will require approximately 74.2 million kWh/yr to achieve the proposed DO standards at all times in the CAWS.

The additional energy requirement for DO enhancement technologies will increase the emissions of criteria pollutants, mercury, and greenhouse gases at the power generating facility. Mercury (Hg) and the six criteria pollutants: sulfur oxides (SO_x), carbon monoxide (CO), nitrogen oxides (NO_x), particulate matter (PM), ozone (O_3) and lead (Pb), are permitted under the USEPA Clean Air Mercury Rule and Clean Air Act, respectively. For regulatory purposes, sulfur dioxide (SO_2) emissions are reported because they are the indicator of sulfur oxide concentrations in the ambient air. Greenhouse gases, comprised of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluoro-carbons (HFCs), perfluoro-carbons (PFCs) and sulfur hexafluoride (SF_6), are not included in air emission permits, but are of concern on both global and local levels because of their potential to affect global climate changes and global warming. Table 6-2 presents the estimated emission increase at the power generation facility for the most significant of these air pollutants and greenhouse gases.

Table 6-2
Estimated Emission Loading Increases at Power Generation Facility Due to Energy Consumption (tons/yr)

NO_x	105
SO_2	378
CO_2	57,700
CH_4	0.30
N_2O	0.70
Hg	0.0016

1. The air emissions resulting from energy consumption were calculated based on energy requirements and emission coefficients from the "Emissions & Generation Resource Integrated Database" (eGRID) specifically for Illinois.

6.4 Comparison of Baseline Conditions and Impact on Future Uses

The implementation of DO technologies for supplemental aeration will increase the District's energy consumption, resulting in increased air emissions of regulated air pollutants and greenhouse gases at the power generating facility. As described previously, the energy facilities that supply power to run the District facilities are generally coal-based electric generating plants.

As shown in Table 6-3, the total energy required for the operation of the DO technologies is approximately 74.2 million kWh/yr, which will increase the District's total energy consumption of 550.8 million kWh/yr by 13.5%. The total energy consumption of 550.8 million kWh/yr includes contributions from all District water reclamation plants and pumping facilities. In comparison, the evaluation of the environmental impacts of disinfection compared the increase in energy due to disinfection relative to current energy consumption only at the North Side, Calumet, and Stickney plants.

From the USEPA Greenhouse Gas Equivalencies Calculator, an average household uses 11,965 kWh/yr. Thus, the electricity consumption for DO operation is equivalent to approximately 6,200 households per year. The energy consumption can also be translated to equivalent energy consumption at the Sears Tower, which requires 77 million kWh/yr. The energy required for the operation of the DO technologies is 96% of the annual energy consumption for the Sears Tower.

Table 6-3
Increase of Estimated Annual Energy Usage due to Additional DO Enhancement Operation

District's Current Energy Consumption (kWh/yr)[1]	550.8 million
Energy Increase (kWh/yr)	74.2 million
Percent Energy Increase from Current	13.5%
No. of Equivalent Households[2]	6,200
DO Energy Use Relative to Sears Tower Energy Use[3]	96%

1. Energy consumption as reported in Table 8 of the District's "2008 Budget Book Info Final, All Divisions" (January 2008).
2. 11,965 kWh/household per year provided by USEPA, http://www.epa.gov/cleanenergy/energy-resources/calculator.html
3. Assume energy consumption is 77 Million kWh/year for the Sears Tower. Source: http://securitysolutions.com/fire_life_safety/security_modernizing_legend/

The increased energy usage for the operation of the DO technologies will increase the current greenhouse gas emissions of 430,000 tons CO_2 equivalents/yr by 58,000 tons CO_2 equivalents/yr, or 13.5%, at the power generating facility as shown in Table 6-4. Assuming a car emits approximately 6.02 tons of CO_2 equivalents per year (U.S. EPA Greenhouse Gas Equivalencies Calculator), the increase in total greenhouse gas emissions is equivalent to approximately 9,600 additional automobiles added to the road per year. An equivalent 8.9 million trees would be required to absorb that same amount of carbon dioxide emissions.

Table 6-4
Increase of Annual Greenhouse Gas Emission Equivalents at the Power Generating Facility due to Additional DO Enhancement Operation

Current CO_2 Emissions (tons CO_2 /yr)[1]	428,500
CO_2 Emissions Increase (tons CO_2 /yr)	57,700
Equivalent No. of Trees for CO_2 absorption (trees/yr)[2]	8.9 million
Percent Increase of CO_2 Emissions from Current	13.5%
Current GHG Emissions (tons CO_2 equivalents/yr)[3]	430,000
GHG Emissions Increase (tons CO_2 equivalents/yr)	58,000
Equivalent No. of Cars Added to the Road (cars/yr)[4]	9,600
Percent Increase of GHG Emissions from Current	13.5%

1. Calculated based on energy consumption and eGrid emission factors. Energy consumption as reported in Table 8 of the District's "2008 Budget Book Info Final, All Divisions" (January 2008).
2. A single tree absorbs 13lb CO_2 per year. Coder, R.D. (October 1996). *Identified Benefits of Community Trees and Forests.*
3. Carbon dioxide equivalents of ghg equal the sum of CO_2, 21*CH_4, and 310*N_20.
4. 6.02 tons CO2equivalents/car per year provided by USEPA, http://www.epa.gov/cleanenergy/energy-resources/calculator.html

The estimated increase in the most significant permitted air pollutants at the power generating facility are shown in Table 6-5. Emissions at the power generating facility from operation of the DO technologies will decrease the air capacity that might otherwise be available for other economic or developmental uses in the future.

Table 6-5
Increase of Emissions of Permitted Air Pollutants at the Power Generating Facility due to Additional DO Enhancement Operation

	Current Air Emissions[1] (tons/yr)	Additional Air Emissions at Power Generating Facilities Due to DO Energy Consumption (tons/yr)	Percent Change from Current Emissions
NO_x	850	105	12.4%
SO_2	2840	378	13.3%
Hg	0.012	0.00162	13.5%

1. Summation of emissions reported in the District's 2006 Annual Air Emission Reports and emissions at the power generating facility due to energy use.

As described in this study, the environmental impacts of implementing DO enhancement technologies in the CAWS are not consistent with the goals of the Chicago *Environmental Action Agenda*. Presented in Section 2.4, the *Environmental Action Agenda* advocates environmentally-friendly policies in the City's departments and other agencies to strengthen Chicago's economy and improve the quality of life. It is the intention of the Mayor to continue efforts that inform and engage the residents and employees of Chicago "to make sure that Green remains routine over time." Therefore, when selecting the appropriate technology, one must also be mindful of aligning with the goals of the City's agenda and other agencies that strengthen Chicago's economy and improve the quality of life for current and future residents. It should also be noted that implementing DO enhancement technologies will utilize critical District resources (air, land, water, and financial) that will then become unavailable for future treatment options and alternatives.

APPENDIX A

Environmental Impact Literature Search

Table A-1. Environmental Impact Literature Search

Author	Title	Publication Year
Beavis, P. and Lundie, S.	Integrated environmental assessment of tertiary and residuals treatment - LCA in the wastewater industry	2003
Houillon, G. and Jolliet, O.	Life cycle assessment of processes for the treatment of wastewater urban sludge: Energy and global warming analysis	2005
Kenway, S. et al.	Triple Bottom Line Reporting of Sustainable Water Utility Performance (AwwaRF)	2007
Little, A.	Total Cost Assessment Methodology: Internal Managerial Decision Tool	1999
Lyons, E. et al.	Life Cycle Assessment of Three Water Supply Systems: Importation, Reclamation and Desalination	Not yet published
Machado, A. et al.	Life cycle assessment of wastewater treatment options for small and decentralized communities	2007
Mitchell, C. et al.	Costing for Sustainable Outcomes in Urban Water Systems.	2007
Munoz, I. et al.	Life cycle assessment of a coupled solar photocatalytic-biological process for wastewater treatment	2006
Narayan, R.	Drivers & rationale for use of biobased materials based on life cycle assessment (LCA)	2004
Rebitzer, G., Hunkeler, D. and Jolliet, O.	The Economic Pillar of Sustainability: Methodology and Application to Wastewater Treatment	2003
Schenck, R.	LCA for Mere Mortals: A Primer on Environmental Life Cycle Assessment	2000
San Francisco Public Utilities Commission (SFPUC)	SFPUC Sustainability Plan: Sustainability Baseline Assessment FY05/06	2007
San Francisco Public Utilities Commission (SFPUC)	SFPUC Sustainability Plan: Sustainability Indicators and Best Practices	2006
Stroemberg, L. and Paulsen, J.	LCA Application to Russian Conditions	2002
Tarantini, M.; Ferri, F.	A Life Cycle Assessment Study of the Environmental Sustainability of Domestic Water Saving Techniques	2003

Power/Energy impact (websites)

- http://www.powerscorecard.org/elec_env.cfm
- http://www.eia.doe.gov/fuelcoal.html
- http://www.ucsusa.org/clean_energy/fossil_fuels/offmen-how-coal-works.html

Manufacturing discharges (websites)

- http://www.epa.gov/enviro/
- http://www.epa.gov/tri/
- http://www.epa.gov/tri/tridata/index.htm
- http://www.epa.gov/enviro/html/multisystem_query_java.html

Industry benchmarking (websites)

- http://www.globalreporting.org/Home
- http://www.ib-net.org/
- http://www.water.org.uk/
- http://www.awwa.org/Resources/utilitymanage.cfm?ItemNumber=3766&navItemNumber=1587

APPENDIX B

Documents for Establishment of Baselines

Table B-1. Existing infrastructure – information from MWRDGC

Source	Medium	Document Received	Data
MWRDGC	1. Personal meeting 2. Telephone request	M&O Facility Handbook (2006)	1. Service area maps 2. Locations in municipalities 3. Current Water Reclamation Plants (WRPs) infrastructure and processes and equipment capacities and descriptions 4. Solid Processing Areas – locations and dimensions 5. Pumping Stations – locations and capacities 6. Reservoirs – locations, volumes, and pump capacities 7. Aeration Stations – locations and pump capacities 8. Chicago River Controlling Works / Wilmette Gate / O'Brien Controlling Works – locations, equipment, pumps information 9. NPDES permit limits for WRPs 10. Chicago Area Waterways map and details
		Air Emission Reports (2004, 2005, 2006)	1. Annual carbon emissions to air from WRPs 2. Annual permitted emissions to air from WRPs 3. Natural gas and digester gas usage in WRPs
		Annual Budgets (2006, 2007, 2008)	1. Annual energy consumption – electricity usage 2. Annual energy consumption – natural gas usage 3. Annual energy consumption – gasoline/diesel 4. Man-hours for maintenance management 5. Total annual maintenance and operation costs
		Miscellaneous data sheets	1. Total annual electricity consumption and costs (2003-2006) 2. Total annual gas usage and costs (2004-2006)
		Monthly Plant Operating Data reports (2005)	1. Total and average annual air usage 2. Annual energy usage only for WRPs
	3. MWRDGC website – Engineering Dept.	Our Community and Flooding (1998)	1. List of watersheds in Chicago Metropolitan area 2. Areas of watersheds
	4. MWRDGC website	Service area information	1. List of municipalities and townships totally or partially within MWRDGC service area

Table B-2. Existing infrastructure – other information sources

Source	Medium	Document Received	Data
Illinois State Water Survey (IL SWS)	SWS Internet database	2000 – 2006 daily precipitation data	1. Total annual precipitation in Cook County 2. Average annual precipitation in Cook County 3. 7-year total precipitation in Cook County 4. 7-year average precipitation in Cook County
USGS	USGS Internet database	Watershed cataloging units information	1. Watershed delineation and maps for Cataloging Units for Chicago River and Des Plaines River 2. Watershed areas for Chicago and Des Plaines rivers
		National water-use data files	1. Watershed water use and budget for Chicago and Des Plaines river watersheds, e.g., total ground-water/surface water withdrawals, fresh/saline water withdrawals, total water reclaimed in WRPs, total consumption and conveyance losses in the watershed
Municipalities in MWRDGC service area	1. Official websites on Internet 2. Telephone request	CAFRs for: 1. Village of Hanover Park 2. Village of LaGrange 3. Village of Lemont 4. Skokie Park District 5. Village of Glencoe 6. Village of Palos Park 7. Village of Arlington Heights 8. Village of Orland Park 9. Village of Bartlett	1. Median Household Income 2. Per Capita personal income 3. Municipal bond ratings 4. Outstanding Debt 5. Assessed property values 6. Unemployment rates 7. Property tax revenues collected 8. Property tax revenue levied

APPENDIX C

GIS Figures of the Natural Infrastructure Baseline

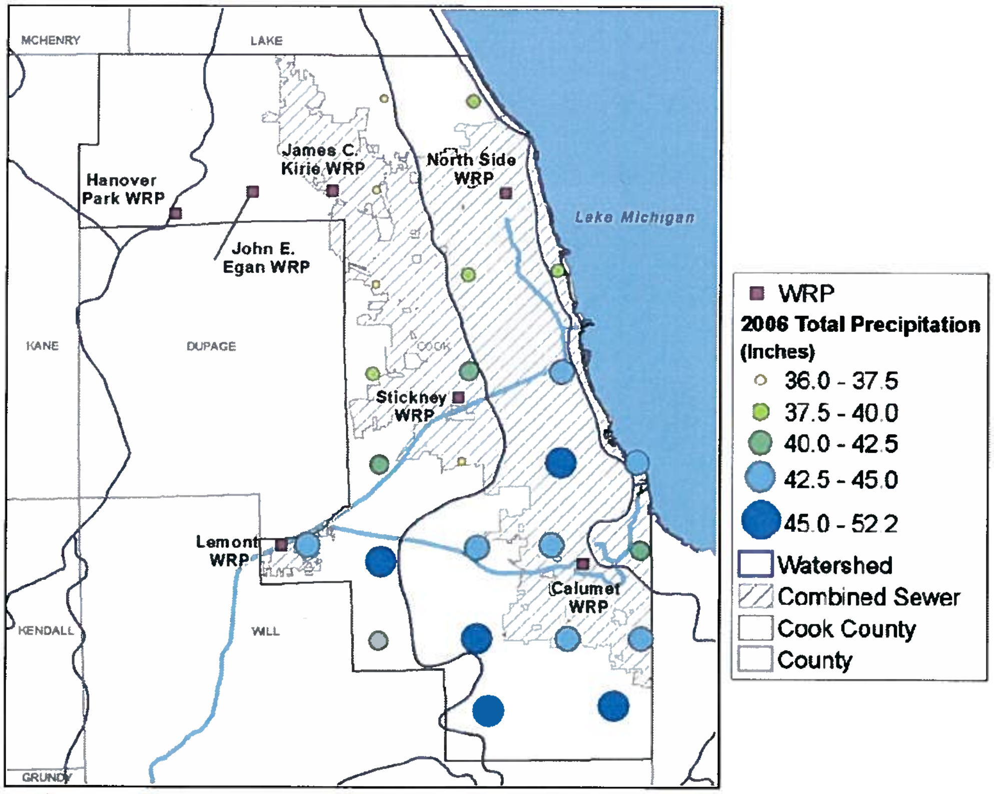


Figure C-1. 2006 Average Precipitation

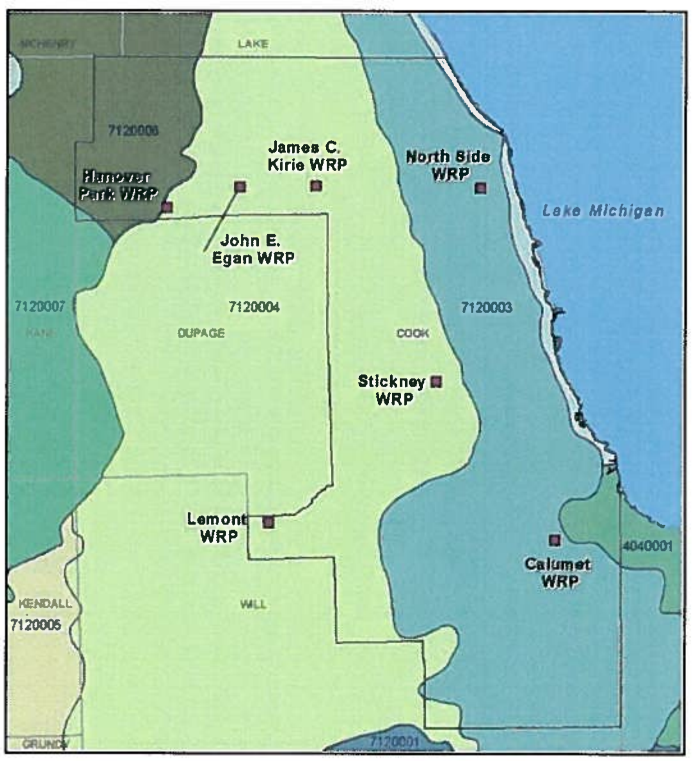


Figure C-2. Watersheds

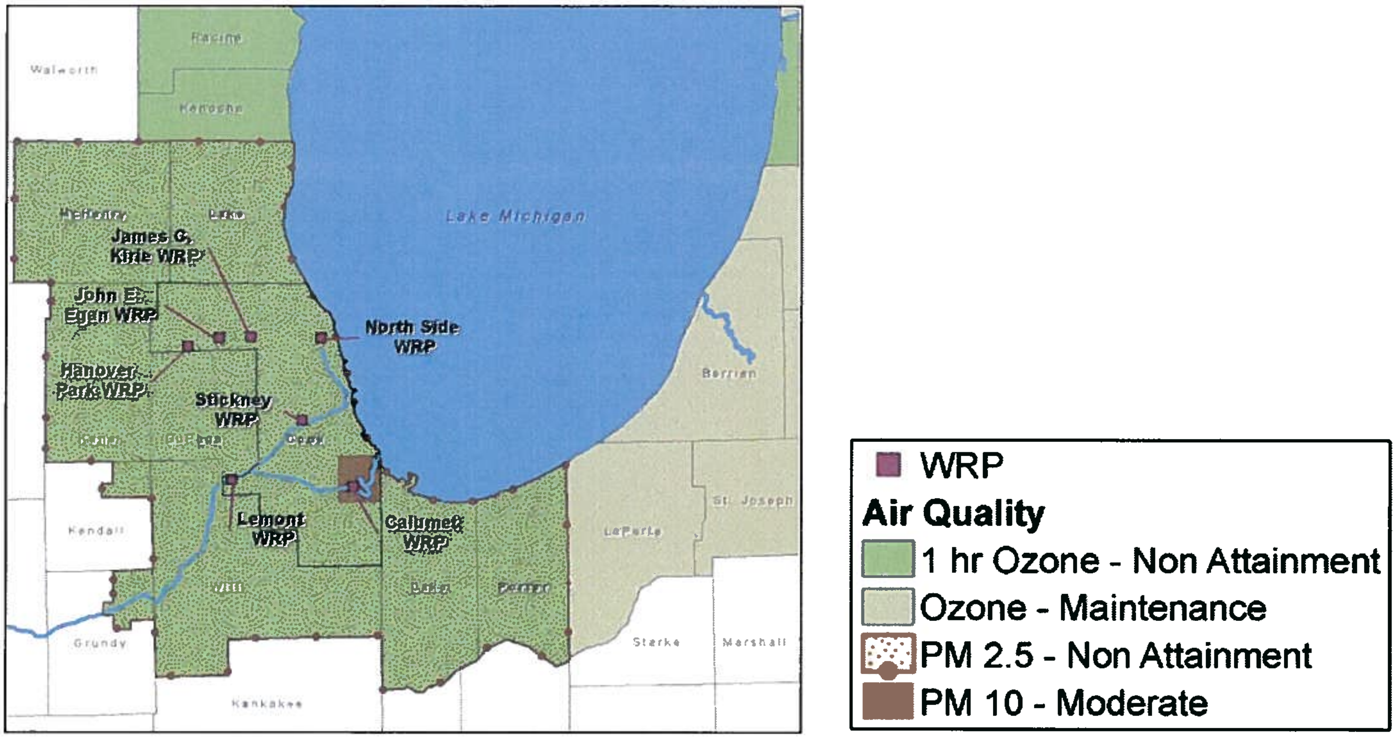


Figure C-3. Regional Air Quality

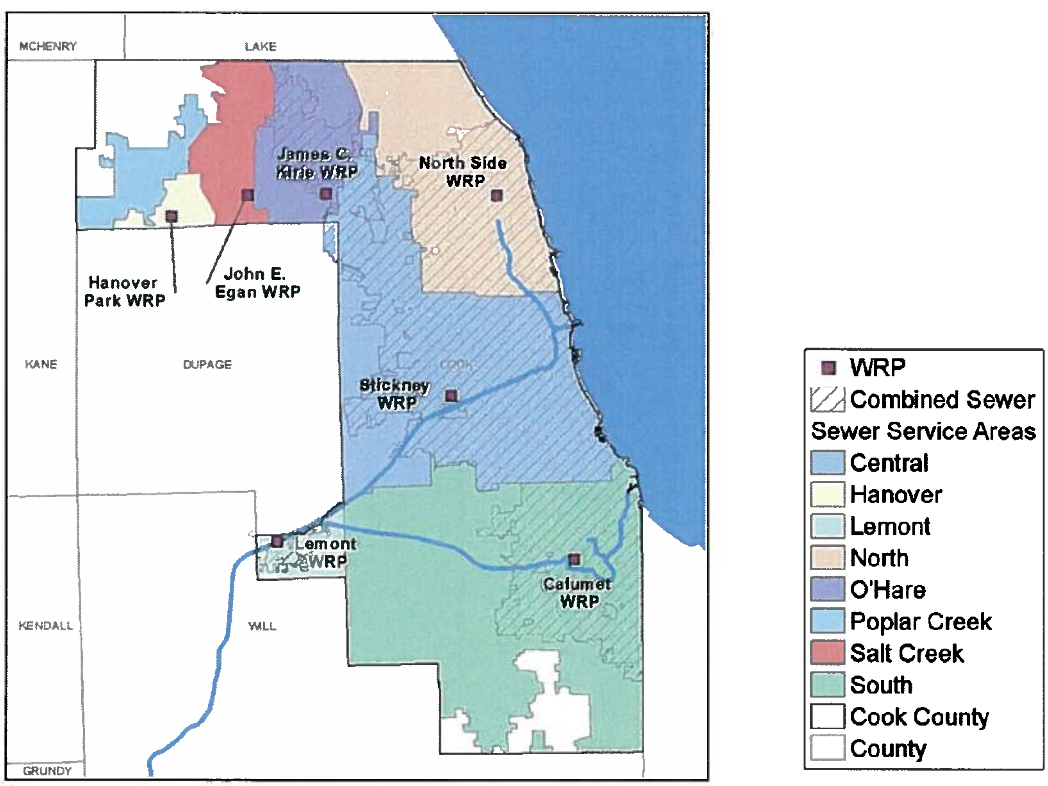


Figure C-4. Sewer Service Areas

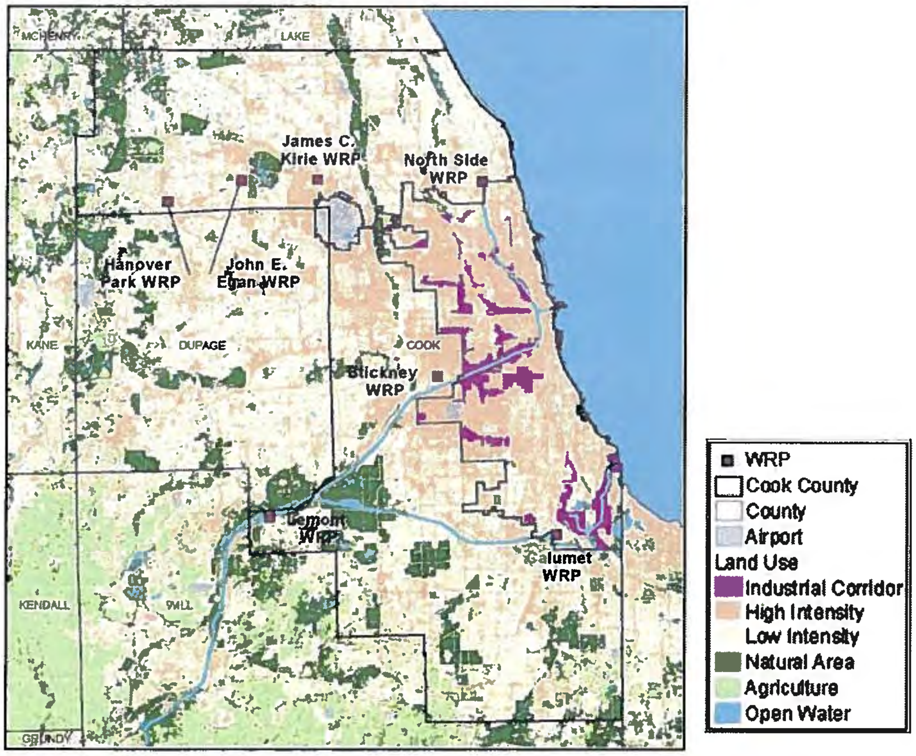


Figure C-5. Land Use

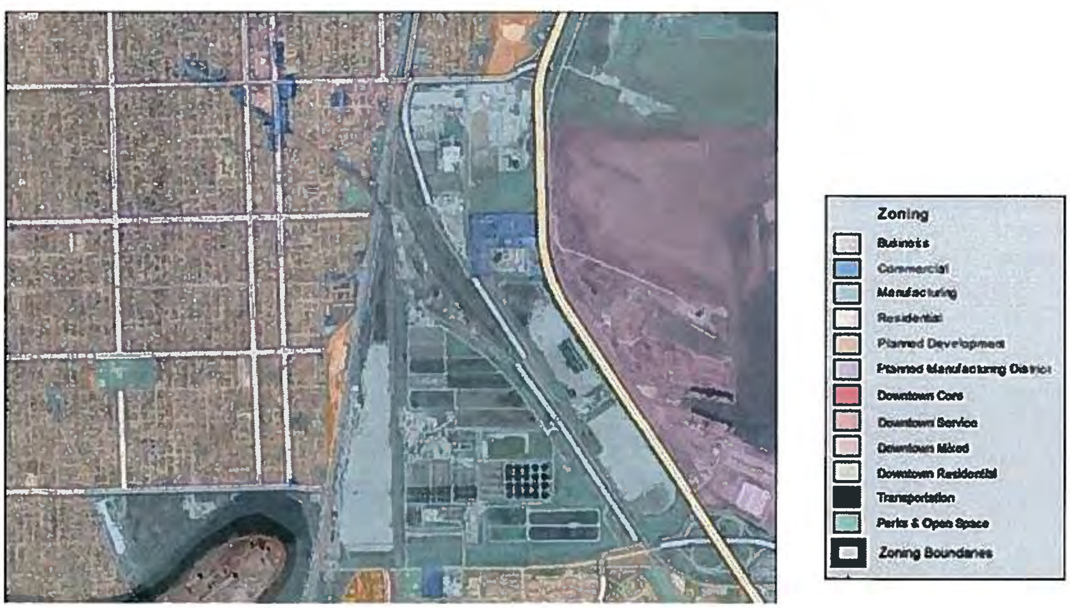


Figure C-6. Calumet WRP Zoning

APPENDIX D

Calculations of Air Emissions, Equivalents, Land Use, and Runoff

Emission Coefficients (Source: eGRID 2006)

Pollutant	Electricity Coefficient	Units
CO2	1,556	lbs/MWH
CH4	0.0082	lbs/MWH
N2O	0.0180	lbs/MWH
NOx	2.8410	lbs/MWH
SO2	10.1990	lbs/MWH
Hg	4.37E-05	lbs/MWH

2006 Reported	NorthSide	Calumet	Stickney	Total 3 Plants	Total District
NOx	2.17	15.39	36.71	54.27	67.804265
SO2	0.05	0.73	7.79	8.57	31.022165

2006 Energy Use and Emissions from 2008 Budget	Northside	Calumet	Stickney	Energy Emission Subtotal - 3 plants	**Total Emissions - 3 plants**	District Energy Emissions Subtotal	**Total Emissions - District**
2006 Energy Use (kWh)	60,120,815	78,974,014	245,085,418	384,180,247	**384,180,247**	550,795,508	**550,795,508**
CO2 tons	46,774	61,442	190,676	298,892	**298,892**	428,519	**428,519**
CO2 Equiv tons	46,947	61,669	191,381	299,997	**299,997**	430,103	**430,103**
CH4 tons	0.25	0.32	1.00	1.6	**1.6**	2.26	**2.26**
N2O tons	0.54	0.71	2.21	3.5	**3.5**	4.96	**4.96**
NOx	85.40	112.18	348.14	545.7	**600.0**	782.41	**850.21**
SO2	306.59	402.73	1,249.81	1,959.1	**1,967.7**	2,808.78	**2,839.80**
Hg tons	0.0013	0.0017	0.0054	0.0084	**0.0084**	0.012	**0.012**

	Rate of Energy Use (kW)				Energy Use (kWh/yr)[1]			
Source	CTE Reports				Manufacturer	Calculation		
	Average Day Flows (MGD)	Chemical Dose (lb/day)	Equipment Operation	Pump Station Operation	Manufacturing (outside of study area)	Equipment Operation	Pump Station Operation	Total in Study Area
UV								
North Side	333	-	3,182	375	40,320	19,855,680	2,340,000	22,195,680
Calumet	305	-	2,903	331	40,320	18,114,720	2,065,440	20,180,160
Stickney	1,250	-	9,225	4,240	96,768	57,564,000	26,457,600	84,021,600
Total	1,888	-	15,310	4,946	177,408	95,534,400	30,863,040	126,397,440
%increase from total at 3 plants					0.0%	24.9%	8.0%	33%

	Rate of Energy Use (kW)				Energy Use (kWh/yr)[1]			
Source	CTE Reports				Calculation			
	Average Day Flows (MGD)	Chemical Dose (lb/day)	Equipment Operation	Pump Station Operation	Chemical Manufacturing[2]	Equipment Operation	Pump Station Operation	Total in Study Area
Ch/Dechlor								
North Side	333	16,700	24.15	375	10,855,000	150,696	2,340,000	13,345,696
Calumet	319	16,000	92.06	365	10,400,000	574,454	2,277,600	13,252,054
Stickney	1,250	62,550	68.76	4,402	40,657,500	429,062	27,468,480	68,555,042
Total	1,902	95,250	185	5,142	61,912,500	1,154,213	32,086,080	95,152,793
%increase from total at 3 plants					16.1%	0.3%	8.4%	24.8%

DO	
Total, 100% Scenario (kWh/yr)	74,206,554

1. Disinfection is applied 24 hours a day for 9 months; from CTE report, DO is applied 24 hours per day for 8 months.
2. Assume 2.5 kwh/lb Cl2 generated; sodium bisulfite generation consumes very little energy

DO - 100 %

	North Side	Calumet	Stickney	TOTAL
NO_x				105.41
SO_2				378.42
CO_2				57732.70
CH_4				0.30
N_2O				0.67
Hg				1.62E-03

Estimated Emissions Loading Increases

Manufacturing		North Side	Calumet	Stickney	TOTAL
Estimated UV Loading Increase (tons/yr)	NO_x	0.06	0.06	0.14	**0.25**
	SO_2	0.21	0.21	0.49	**0.90**
	CO_2	31.37	31.37	75.29	**138.02**
	CH_4	0.00	0.00	0.00	**0.00**
	N_2O	0.00	0.00	0.00	**0.00**
	Hg	0.00000088	0.00000088	0.00000211	**0.00000388**
Estimated Chlorination Loading Increase (tons/yr)	NO_x	15.42	14.77	57.75	**87.95**
	SO_2	55.36	53.03	207.33	**315.72**
	CO_2	8445.19	8091.20	31631.54	**48167.93**
	CH_4	0.04	0.04	0.17	**0.25**
	N_2O	0.10	0.09	0.37	**0.56**
	Hg	0.00024	0.00023	0.00089	**0.00135**

Equipment Operation		North Side	Calumet	Stickney	TOTAL
Estimated UV Loading Increase (tons/yr)	NO_x	28.20	25.73	81.77	**135.71**
	SO_2	101.25	92.38	293.55	**487.18**
	CO_2	15447.72	14093.25	44784.79	**74325.76**
	CH_4	0.08	0.07	0.24	**0.39**
	N_2O	0.18	0.16	0.52	**0.86**
	Hg	0.000434	0.000396	0.001258	**0.002087**
Estimated Chlorination Loading Increase (tons/yr)	NO_x	0.21	0.82	0.61	**1.64**
	SO_2	0.77	2.93	2.19	**5.89**
	CO_2	117.24	446.93	333.81	**897.98**
	CH_4	0.001	0.0024	0.0018	**0.005**
	N_2O	0.0014	0.0052	0.0039	**0.01**
	Hg	0.00000329	0.00001255	0.00000938	**0.00002522**

Pump Station Operation		North Side	Calumet	Stickney	TOTAL
Estimated UV Loading Increase (tons/yr)	NO_x	3.32	2.93	37.58	**43.84**
	SO_2	11.93	10.53	134.92	**157.39**
	CO_2	1820.52	1606.91	20584.01	**24011.45**
	CH_4	0.01	0.01	0.11	**0.13**
	N_2O	0.02	0.02	0.24	**0.28**
	Hg	0.000051	0.000045	0.000578	**0.000674**
Estimated Chlorination Loading Increase (tons/yr)	NO_x	3.32	3.24	39.02	**45.58**
	SO_2	11.93	11.61	140.08	**163.62**
	CO_2	1820.52	1771.97	21370.48	**24962.97**
	CH_4	0.01	0.01	0.11	**0.13**
	N_2O	0.02	0.02	0.25	**0.29**
	Hg	0.000051	0.000050	0.000600	**0.000701**

Total Emissions of Greenhouse Gases and Criteria Pollutants from Energy Use

		NOx	SO2	CO2	CO2 equi	CH4	N2O	Hg	
UV	Manufacturing	0.00	0.00	0	0	0.00	0.00	0.00000000	Not in study area
	Transportation	-	-	269	269	-	-	-	
	Equipment	135.71	487.18	74,326	74,601	0.39	0.86	0.00208743	
	Pump Station	43.84	157.39	24,011	24,100	0.13	0.28	0.00067436	
	Total	**179.55**	**644.56**	**98605.73**	**98969.26**	**0.52**	**1.14**	**0.00276178**	
Chlor/Declor	Manufacturing	87.95	315.72	48,168	48,346	0.25	0.56	0.00135279	
	Transportation	-	-	691	691	-	-	-	
	Equipment	1.64	5.89	898	901	0.00	0.01	0.00002522	
	Pump Station	45.58	163.62	24,963	25,055	0.13	0.29	0.00070108	
	Total	**135.16**	**485.23**	**74719.55**	**74993.22**	**0.39**	**0.86**	**0.00207909**	
DO	100%	105.41	378.42	57732.70	57946.12	0.30	0.67	0.00162141	

Annual Electricity Equivalents of UV and Chlorination Energy Use

	UV			Chlor/Dechlor				DO - 100%			
	Energy Increase (kWh/yr)	No. of Equivalent Households[1]	Equivalent no. of days to light the Sears Tower[2]		Energy Increase (kWh/yr)	No. of Equivalent Households[1]	Equivalent no. of days to light the Sears Tower2		Energy Increase (kWh/yr)	No. of Equivalent Households[1]	Equivalent no. of days to light the Sears Tower2
North Side (Equip+PS+Man)	22,195,680	1,855	105	North Side	13,345,696	1,115	63				
Calumet (Equip+PS+Man)	20,180,160	1,687	96	Calumet	13,252,054	1,108	63				
Stickney (Equip+PS+Man)	84,021,600	7,022	398	Stickney	68,555,042	5,730	325				
TOTAL	**126,397,440**	**10,564**	**599**	**TOTAL**	**95,152,793**	**7,953**	**451**	**TOTAL**	**74,206,554**	**6,202**	**352**
Baseline - current use	384,180,247	-	-	Baseline - current use	384,180,247	-	-	Baseline - current use	550,795,508	-	-
Percent increase	32.9%	-	-	Percent increase	24.8%	-	-	Percent increase	13.5%	-	-

1 Assume 11,965 kWh/household per year provided by USEPA, http://www.epa.gov/cleanenergy/energy-resources/calculator.htm

2 Assume 77 Million kWh/year needed to run the Sears Tower. Source: http://securitysolutions.com/fire_life_safety/security_modernizing_legend/

3 Manufacturing of UV is outside of the study area

Annual Greenhouse Gas Emission Equivalents of UV and Chlorination

	UV				Chlor/Dechlor					DO - 100%				
	CO2 Emissions (tons CO2 equivalents/yr)	Total GHG Emissions (tons CO2 equivalents/yr)[1]	Equivalent No. of Cars Added to the Road (cars/yr)[2]	Equivalent No. of Trees for CO2 absorption (trees/yr)[3]		CO2 Emissions (tons CO2 equivalents/yr)	Total GHG Emissions (tons CO2 equivalents/yr)[1]	Equivalent No. of Cars Added to the Road (cars/yr)[2]	Equivalent No. of Trees for CO2 absorption (trees/yr)[3]		CO2 Emissions (tons CO2 equivalents/yr)	Total GHG Emissions (tons CO2 equivalents/yr)[1]	Equivalent No. of Cars Added to the Road (cars/yr)[2]	Equivalent No. of Trees for CO2 absorption (trees/yr)[3]
North Side	17,268	17,332	2,879	2,656,652	North Side	1,938	1,945	323	298,117					
Calumet	15,700	15,758	2,618	2,415,410	Calumet	2,219	2,227	370	341,369					
Stickney	65,369	65,610	10,899	10,056,739	Stickney	21,704	21,785	3,619	3,339,121					
Transportation[4]	269	269	45	41,311	Trasportation	691	691	115	106,259					
Manufacturing5	0	0	0	0	Manufacturing	48,168	48,346	8,031	7,410,450					
TOTAL	**98,606**	**98,969**	**16,440**	**15,170,112**	**TOTAL**	**74,720**	**74,993**	**12,457**	**11,495,316**	**TOTAL**	**57,733**	**57,946**	9,626	8,881,954
Baseline - current use		299,997	-	-	Baseline - current use		299,997	-	-	Baseline - current use		430,103	-	-
Percent increase		33.0%	-	-	Percent increase		25.0%	-	-	Percent increase		13.5%	-	-

1 Carbon dioxide equivalents are equal to CO2+ 21*CH4+ 310*N20.

2 6.02 tons CO2equivalents/car per year provided by USEPA, http://www.epa.gov/cleanenergy/energy-resources/calculator.htm

3 A single tree absorbs 13lb CO2 per year. Coder, R.D. (October 1996). Identified Benefits of Community Trees and Forests.

5 Manufacturing of UV is outside of the study area

Annual Criteria Pollutant Emissions of UV and Chlorination

	NOx			SO2			Hg		
	UV	Chlor	DO-100%	UV	Chlor	DO-100%	UV	Chlor	DO-100%
Total	**180**	**135**	**105.41**	**645**	**485**	**378.42**	**0.00276**	**0.00208**	**0.00162**
Baseline - current use	600	600	850	1,968	1,968	2,840	0.0084	0.0084	0.0120
Percent increase	29.9%	22.5%	12.4%	32.8%	24.7%	13.3%	32.9%	24.8%	13.5%

Transportation CO2 Emissions

Construction

Duration = 3 years, 52 weeks/year, 5 days/week, 8 hours/day

Concrete Delivery

NS UV	Cal UV	Stickney UV	UV Total	C/D Total	NS C/D	Cal C/D	Stickney C/D	
8358	6363	23099	37,820	59,979	15381	8258	36340	cubic yards, from CTE memos

	UV	C/D	
Volume concrete in each truck =	8	8	cubic yards (from Tom L.)
Number of Concrete Trucks, total =	4,727	7,497	trucks in 3 years
Miles per truck =	30	30	miles, per truck (assumed)
Miles, total =	141,824	224,920	miles, total in 3 years
Average speed =	40	40	miles per hour (assumed)
Total Driving Time =	3,546	5,623	hours, total in 3 years
Idling time per truck =	1.5	1.5	hours (from Tom L., includes time to clean truck)
Total idling time	7,091	11,246	total hours in 3 years
Duration of emissions, total =	**10,637**	**16,869**	hours, total in 3 years
CO2 driving	226918.008	359871.237	pounds CO2
CO2 idling	85094.2531	134951.714	pounds CO2
Total CO2	156.006131	247.411475	tons CO2

Material Deliveries

	UV	C/D	
Number of Delivery Trucks =	3	3	per week (estimated), each plant
Total Delivery Trucks =	468	468	trucks in 3 years
Miles per truck =	30	30	miles, per truck (assumed)
Miles, total=	14,040	14,040	miles, total in 3 years
Weight per truck =	200	200	metric tons
Average speed =	40	40	miles per hour (assumed)
Total Driving Time =	351	351	hours, total in 3 years
Unloading time =	1	1	hour, each (assumed)
Total unloading	468	468	total hours in 3 years
Duration of emissions, total =	**819**	**819**	hours, total in 3 years
CO2 driving	2042314.56	2042314.56	pounds CO2 Climate Trust: Total Miles x met tons x 0.00033
Co2 unloading	5616	5616	pounds CO2
Total Co2	1023.96528	1023.96528	tons CO2

Workers' transportation

	UV	C/D	
Number of people =	50	50	workers per week (assumed)
People per car=	1	1	people per car, (assumed)
Total cars =	50	50	cars per week
total commute per car =	66	66	minutes per round-trip commute per car (US Census Bureau)
Total Driving Time =	**8,580**	**8,580**	hours, total in 3 years Assume 1/2 driving and 1/2 idling
CO2 driving	274560	274560	pounds @40mph
CO2 idling	51480	51480	pounds
Total	163.02	163.02	tons

Medium car emissions calculations based on 1.1 pounds of carbon dioxide emissions per mile[1]
SUV/4 wheel drive carbon dioxide emissions based on 1.57 pounds per mile[1]

[1] Source: Sightline Institute

Assume - 1.6 pounds of CO2 emissions per mile

Every gallon of fuel that is burned produces about 20 pounds of CO_2.
The Climate Trust

O&M/Salvage

Duration = 20 years, 7 days a week, 24 hours a day = 174,720 hours

Workers' transportation

Number of people* =	35	30	workers per day (CTE) *number of operators nassumed for UV at Stickney
People per car=	1	1	cars per day (assumed)
Total cars =	35	30	cars, total per day
Total commute =	66	66	minutes per round-trip commute per car (US Census Bureau)
Total Driving Time =	**280,280**	**240,240**	hours, total in 20 years
CO2 driving	8968960	7687680	pounds @40mph
CO2 idling	1681680	1441440	pounds
Total	5325.32	4564.56	tons
	4484.48		

UV Bulb or other Delivery

Number of Delivery Trucks =	1.5	-	per week (estimated), 3 plants
Total Delivery Trucks =	1560	-	trucks in 20 years
Miles per truck =	30	-	miles, per truck (assumed)
Miles, total=	46,800	-	miles, total in 20 years
Weight per truck	1		metric tons, assumed
Average speed =	40	-	miles per hour (assumed)
Total Driving Time =	1170	-	hours, total in 20 years
Unloading time =	3	-	hour, each (assumed), 3 plants
Total unloading time	4680	-	total hours in 20 years
Duration of emissions, total =	**5850**	-	hours, total in 20 years
CO2 driving	34038.576		pounds CO2 Climate Trust: Total Miles x met tons x 0.00033
CO2 idling	56160		pounds CO2
Total CO2	45.099288		tons CO2

Chemical Delivery

Number of Delivery Trucks =	-	171.2	per week (estimated), 3 plants
Total Delivery Trucks =	-	127166.775	trucks in 20 years
Miles per truck =	-	70	miles, per truck (assumed)
Miles, total=	-	8,901,674	miles, total in 20 years
Average speed =	-	40	miles per hour (assumed)
Total Driving Time =	-	222541.856	hours, total in 20 years
Unloading time =	-	1	hour, each (assumed)
Total unloading time	-	127166.775	total hours in 20 years
Duration of emissions, total =	-	**349708.631**	hours, total in 20 years
CO2 driving	-	16972127.6	pounds CO2
CO2 idling	-	1526001.3	pounds CO2
Total CO2	-	9249.06444	tons CO2

Total CO2

	UV	C-D	**UV**	**C-D**
	Tons	Tons	**tons per year**	
Constructic	1343	1434	**448**	**478**
O&M	5370	13814	**269**	**691**

Truck delivery of Sodium Hypochlorite		
Total NaClO used per day:	95,250 gallon	CTE Chlor/Dechlor Report, May 2008
Volume of tank truck:	4,400 gallon/truck	The Chlorination/Dechlorination Handbook, by Gerald F. Connell, 2002
No. of truck per day	21.6	
per wk:	151.5	
Truck delivery of Sodium Bisulfite		
Total NaHSO3 used per day:	11,230 gallon	CTE Chlor/Dechlor Report, May 2008
Volume of tank truck:	4,000 gallon/truck	The Chlorination/Dechlorination Handbook, by Gerald F. Connell, 2002
No. of truck per day	2.8	
per wk:	19.7	

	Chlorine	Bisulfite	
Gallons per day	95,250	11,230	gal/day
Truck Volume	4,400	4,000	gallons
Truck Distance	70	70	miles, round trip
Number of trucks =	22	3	per day
Number of trucks =	5,628	730	per year, 9 months
Miles per year =	393,989	51,095	
Pounds per day	95,250	46,300	
Number of trucks per day	22	3	
Pounds per truck	4,400	16,492	
Metric tons per truck	2.00	7.48	
CO2	260	126	met tons of CO2 per year
	286	139	tons per year
	5,710	2,776	tons for 20 years

From the Climate Trust:

To determine the amount of CO_2 emitted as a result of shipping by heavy-duty truck, the calculator multiplies the amount shipped (metric tons) by the number of miles it was shipped. It then multiplies the product by the emissions factor for heavy-duty truck shipping, 0.00033 metric tons CO_2 per metric ton-mile transported. This emissions factor was calculated as follows:

According to the U.S. EPA, the amount of CO_2 emitted in 2005 as a result of heavy-duty trucking was 385.8 teragrams of CO_2, or 385,800,000 metric tons of CO_2.[xii] According to the U.S. Department of Transportation's Bureau of Transportation Statistics, that amount was transported by heavy-duty truck a total of 1,293.3 billion short ton-miles in 2005.[xiii] To convert this figure into metric ton-miles, multiply it by 0.907 (1 short ton = 0.907 metric tons), which equals 1,173.02 billion metric ton-miles. Finally, to determine the emissions factor perform the following calculation:

385,800,000 metric tons CO_2 / 1,173,020,000,000 metric ton-miles = 0.00033 metric tons of CO_2 per metric ton-mile.

Land Use:

Facility	Service Area (Square miles)	Total Land Area (acres)	Approximate Plant Land Area Used (acres)[2]		Approximate Additional Land Area Use in Future[2,3] (acres)	Used or Allocated (acres)	Percent Used or Allocated	Remaining Land (acres)
North Side	143	97	63		24	87	90%	10
Calumet	305	470	424	(Process, D	22	446	95%	24
Stickney	260	570	388		16	404	71%	166
TOTAL	708	1137	875		62	937	82%	200

Approximate current land area where runoff may occur (acres)
11
50
84
145

1. Source: MWRDGC M&O Facilities Handbook, 2006, and WRP facility layouts
2. The areas are estimated using layouts of facilities and do not consider any underground structures that are not shown on the layouts.
3. Based on layouts from respective Master Plans for the facilities.

RUNOFF

Assume rainfall per year (inches) = 36.4

Current Runoff

	Existing building/pavement/driveways[1]	Runoff per year		
	acres	cubic feet	gallons	MG
North Side	11	1,453,452	10,872,577	10.9
Calumet	50	6,606,600	49,420,803	49.4
Stickney	84	11,099,088	83,026,950	83.0
Total	145	19,159,140	**143,320,330**	143.3

1. Source: MWRDGC M&O Facilities Handbook, 2006, and WRP facility layouts

UV Runoff Increase

	New building/pavement/driveways	Removal of exisiting buildling/pavement/driveways	Total new land use		Runoff per year			
	sqaure feet	square feet	square feet	acres	cubic feet	gallons	MG	%Difference from Current
North Side	67,991	0	67,991	1.56	206,241	1,542,787	1.54	14.2%
Calumet	30,159	66,306	-36,147	-0.83	-109,647	-820,218	-0.82	-1.7%
Stickney	179,122	0	179,122	4.11	543,337	4,064,447	4.06	4.9%
Total	**277,272**	**66,306**	**210,966**	4.84	**639,931**	**4,787,016**	4.79	3.3%

Chlor/Dechlor Runoff

	New building/pavement/driveways	Removal of exisiting buildling/pavement/driveways	Total new land use		Runoff per year			
	sqaure feet	square feet	square feet	acres	cubic feet	gallons	MG	%Difference from Current
North Side	133,042	0	133,042	3.05	403,562	3,018,851	3.019	27.8%
Calumet	88,084	0	88,084	2.02	267,189	1,998,713	1.999	4.0%
Stickney	350,498	0	350,498	8.05	1,063,176	7,953,113	7.953	9.6%
Total	571,624	0	**571,624**	13.12	**1,733,927**	**12,970,677**	12.971	9.1%

e tanks are existing

APPENDIX E

Information from Manufacturers

Questionnaire for UV disinfection equipment manufacturers

Company name: Trojan Technologies
Contact person: Allan Gates
Phone: 519-457-3400 Fax: 519-457-3030

Major raw materials: (names and quantities per year)
Lamps – 120,000 per year
Ballasts – 40,000 per year
Quartz Sleeves – 70,000 per year

Chemicals: None

Other: Purchases of stainless steel weldments (>1,000)

Source / transportation of raw materials:
North America – truck
Europe – sea, air
Asia – sea, air

Units produced per year: (avg number): 20,000 units/yr

Manhours: (per year): 60,000 direct lbr hrs/yr

Average energy consumption: 240,000 kWh/mth

Direct use of natural infrastructure:
Airshed information: (if available, or quantity of air used)
na

Water used/affected (avg/mth): 800 m^3/mth

Land use for production/storage: (area, and type of land – urban, rural, etc.)
12,000 m^2 urban

Carbon source used (type and quantity, avg/mth): (natural gas, coal, oil, etc.)
Natural gas, 8,500 m^3/mth

Transportation (shipping) methods for product:

Transport truck
Sea container
Air

Waste streams:

Waste	Disposal method	Total waste, quantity (also, any permit information)

Liquid Hydraulic oil and glycol coolant	Recycle	400 L/yr
Solid Wood Cardboard Steel Waste	 Recycle Recycle Recycle Landfill	 40 MT/yr 50 MT/yr 10 MT/yr 60 MT/yr
Emissions to air	na	na

Disposal of UV lamps:

Recycle: 5,000 kg/yr

Questionnaire for UV disinfection equipment manufacturers

Company name:
Contact person:
Phone: Fax:

Major raw materials: (names and quantities per year)
Lamps:

Equipment:

Chemicals:

Other:

Source / transportation of raw materials:

Units produced per year: (avg number)

Manhours: (per year)

Average energy consumption: kWh or kW

Direct use of natural infrastructure:
Airshed information: (if available, or quantity of air used)

Water used/affected:

Land use for production/storage: (area, and type of land – urban, rural, etc.)

Carbon source used (type and quantity): (natural gas, coal, oil, etc.)

Transportation (shipping) methods for product:

Waste streams:

Waste	Disposal method	Total waste, quantity (also, any permit information)
Liquid		
Solid		
Emissions to air		

Disposal of UV lamps:

Project: METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO (MWRDGC)
Economic and Environmental Assessment of Water Quality Improvement in the CAWS

QUESTIONNAIRE FOR MANUFACTURERS/SUPPLIERS OF: Chlorination+dechlorination equipments and chemicals for disinfection of wastewater treatment plant effluent.

Company name:
Contact person:
Phone:
Fax:

Please fill-in the following information to the best of your knowledge. All the required information pertains to YOUR manufacturing/assembling site only. (and NOT the plant where it will be implemented.)

Production of 1-ton of SODIUM HYPOCHLORITE (15%)

Raw materials (name)	Raw materials (quantity to produce 1-ton sodium hypochlorite (15%)	Manufacturing location	Approx. transportation distance to your manufacturing plant	Safety concerns in manufacturing
1.				
2.				
3.				
4.				
5.				

Production of 1-ton of SODIUM BISULFITE (suggest strength of solution)

Raw materials (name)	Raw materials (quantity to produce 1-ton sodium bisulfite (suggest strength of solution)	Manufacturing location	Approx. transportation distance to your manufacturing plant	Safety concerns in manufacturing
1.				
2.				
3.				
4.				
5.				

Manufacturing of analytical & monitoring equipment, metering pumps, mixers, storage tanks*

Raw materials (name of raw material or equipment)	Raw materials (quantity) (see note below)	Approx. transportation distance (your source to **your** plant)	For manufacturing or assembling			
			Electricity used (KWH, or other units)	Water used	Air used	Labor used, man-hrs
1.						
2.						
3.						
4.						

5.						

* Since we do not have the design yet, please give your best numbers based on disinfection of 100MGD secondary effluent from a typical wastewater treatment plant, to get the E. Coli. count down to 400 from 200,000 cfu/100ml.

Waste Generation at your site:

Waste	Total waste, quantity (also, any permit information)	Disposal method
Liquid		
Solid		
Emissions to air		

Typical service life of major equipment used in disinfection process at site of application:

Equipment name	Typical service life

Any recycle program for the equipment used in disinfection and supportive facilities:

APPENDIX F

Waste Streams from Manufacturing Facilities

Summary of Releases from Chlorine Generation Industry (2005 data)

Facility Name: Olin Corp
Location: New York
SIC: 2812 (Alkalines and Chlorine) and 2819 (Industrial Organic Chemicals, NEC)

Releases to Air:

	Fugitive	Point
Chlorine	6.8 lbs	1560 lbs
Hydrochloric Acid	5 lbs	851 lbs

No other reported releases

Facility Name: Pioneer Americas LLC
Location: Louisiana
SIC: 2812 (Alkalines and Chlorine)

Releases to Air:

	Fugitive	Point	
Chlorine	271.8 lbs	84.8 lbs	
Mercury	730.5 lbs	48 lbs	used as a manufacturing aid

Releases to Streams or Water Bodies:	Mississippi River
Chlorine	0.05 lbs

Off-Site Transfers	RCRA Landfill	Metals Recovery	Other Landfills
Mercury	621.43 lbs	164 lbs	0.03 lbs

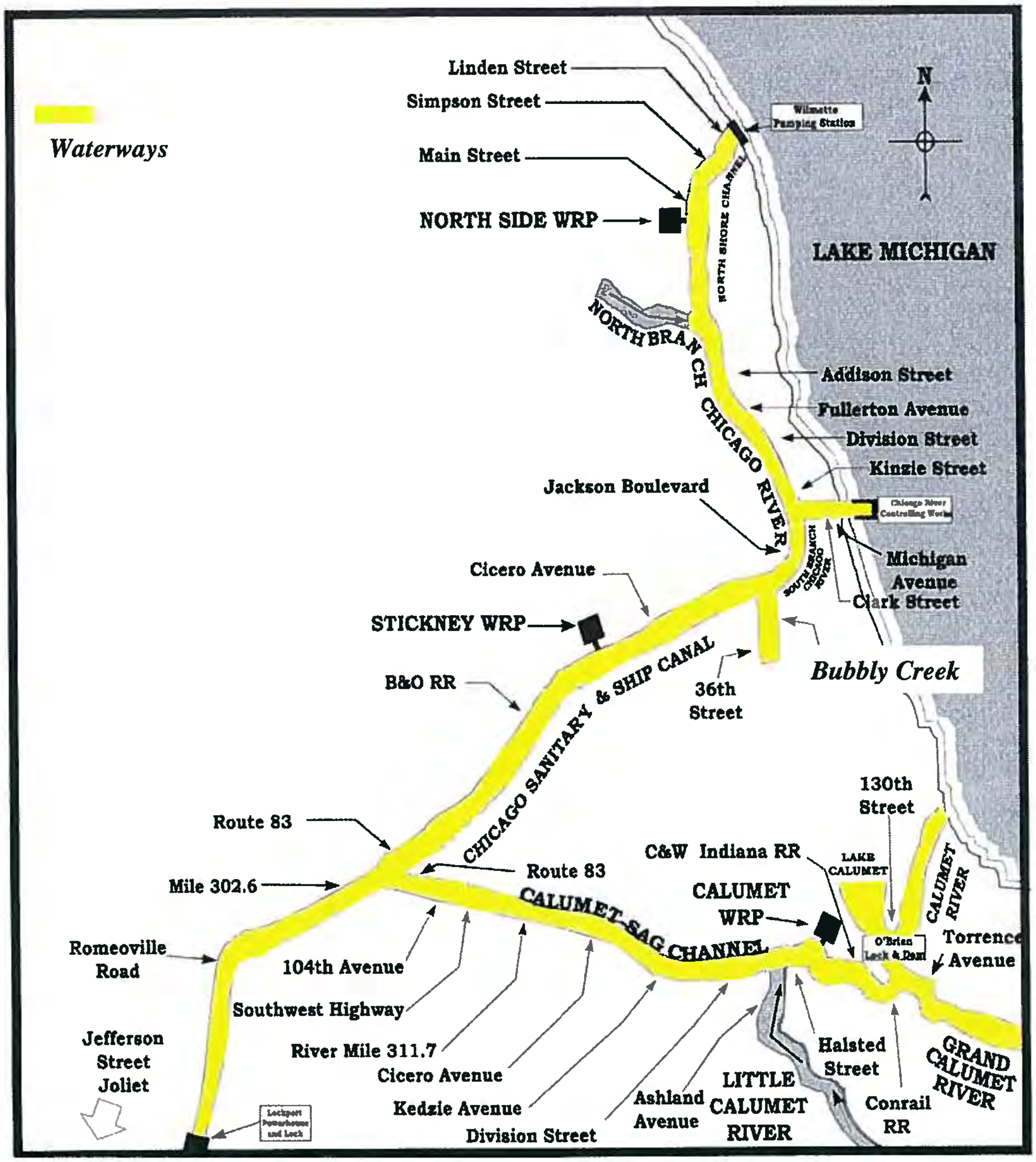
No other reported releases
Have an air scrubber for removing chlorine and mercury emissions from stack.
Conduct onsite metals recovery for mercury

Facility Name: Arch Chemicals
Location: Tennessee
SIC: 2819 (Industrial Organic Chemicals, NEC)

Releases to Air:

	Fugitive	Point
Chlorine	5.0 lbs	90525 lbs

No other reported releases
Have an air scrubber for removing chlorine emissions from stack.



Attachment 3. Chicago Area Waterways and Water Reclamation Plant Locations

Attachment 4 Estimated Additional Power Usage for Supplemental Aeration and Flow Augmentation for the CAWS (July 2008)			
Supplemental Aeration Station Location	Aeration Capacity (grams per second, g/s)	Hourly Operating Power † (kW)	Annual Energy Usage† (kW-hr/yr)
UNSC[1]	18	765	2,511,415
UNSC #1	80	1,000	3,285,000
UNSC #2	80	1,000	3,285,000
UNSC #3	80	1,000	3,285,000
North Branch	80	1,000	3,285,000
South Branch #1	80	1,000	3,285,000
South Branch #2	80	1,000	3,285,000
South Branch #3	80	1,000	3,285,000
Bubbly Creek #1	80	1,000	3,285,000
Bubbly Creek #2	80	1,000	3,285,000
Bubbly Creek #3	80	1,000	3,285,000
Bubbly Creek[2]	N/A	372	1,222,743
CSSC #1	80	1,000	3,285,000
CSSC #2	80	1,000	3,285,000
CSSC #3	80	1,000	3,285,000
CSSC #4	80	1,000	3,285,000
CSSC #5	80	1,000	3,285,000
Little Calumet (North)	80	1,000	3,285,000
Cal-Sag Station #1	70	875	2,874,375
Cal-Sag Station #2	80	1,000	3,285,000
Little Calumet[3]	33	1,846	6,063,401
SEPA Station No. 3[4]	N/A	560	1,839,600
SEPA Station No. 4[4]	N/A	560	1,839,600
SEPA Station No. 5[4]	N/A	612	2,010,420
		Total	74,206,554

† Energy usage taken from TM-4WQ, pgs. B-5 and C-5 for the 30 gps stations and pgs. B-9 and C-9 for the 80 gps station, TM-5WQ, pgs. 5-16, G-2, and G-3 for UNSC, and TM-6WQ, pgs. 6-17 and I-2 for † Energy usage taken from TM-4WQ, pgs. B-9 and C-9 for the 80 gps station, TM-5WQ, pgs. 5-16, G-2, and G-3 for UNSC, and TM-6WQ, pgs. 6-17 and I-2 for Bubbly Creek.

Assumes operating at full firm capacity for 1 month, half capacity for 7 months, and non-operational 4 months each year.

Energy usage is for additional operation required to meet 100% compliance with proposed DO standards.

1. Includes a 18 g/s U-Tube aerator and a 100 mgd firm capacity pump station and forcemain for flow augmentation and aeration.
2. Includes one 50 mgd firm capacity pump station and forcemain.
3. Includes a 33 gps U-Tube aerator and a 182.6 mgd firm capacity pump station and forcemain.
4. Power usage for SEPA pumps provided by MWRDGC.

Attachment 5 Estimated Emission Loading Increases at Power Generation Facility (tons/yr)	
NO_x	105
SO_2	378
CO_2	57,700
CH_4	0.30
N_2O	0.70
Hg	0.0016

1. The air emissions resulting from energy consumption were calculated based on energy requirements and emission coefficients from the "Emissions & Generation Resource Integrated Database" (eGRID) specifically for Illinois.

Attachment 6 Increase of Estimated Annual Energy Usage due to Additional DO Enhancement Operation	
District's Current Energy Consumption (kWh/yr)[1]	550.8 million
Energy Increase (kWh/yr)	74.2 million
Percent Energy Increase from Current	13.5%
No. of Equivalent Households[2]	6,200
DO Energy Use Relative to Sears Tower Energy Use[3]	96%

1. Energy consumption as reported in Table 8 of the District's "2008 Budget Book Info Final, All Divisions" (January 2008).
2. 11,965 kWh/household per year provided by USEPA, http://www.epa.gov/cleanenergy/energy-resources/calculator.html
3. Assume energy consumption is 77 Million kWh/year for the Sears Tower. Source: http://securitysolutions.com/fire_life_safety/security_modernizing_legend/

Attachment 7 Increase of Annual Greenhouse Gas Emission Equivalents at the Power Generating Facility due to Additional DO Enhancement Operation	
Current CO_2 Emissions (tons CO_2 /yr)[1]	428,500
CO_2 Emissions Increase (tons CO_2 /yr)	57,700
Equivalent No. of Trees for CO_2 absorption (trees/yr)[2]	8.9 million
Percent Increase of CO_2 Emissions from Current	13.5%
Current GHG Emissions (tons CO_2 equivalents/yr)[3]	430,000
GHG Emissions Increase (tons CO_2 equivalents/yr)	58,000
Equivalent No. of Cars Added to the Road (cars/yr)[4]	9,600
Percent Increase of GHG Emissions from Current	13.5%

1. Calculated based on energy consumption and eGrid emission factors. Energy consumption as reported in Table 8 of the District's "2008 Budget Book Info Final, All Divisions" (January 2008).
2. A single tree absorbs 13lb CO_2 per year. Coder, R.D. (October 1996). *Identified Benefits of Community Trees and Forests.*
3. Carbon dioxide equivalents of ghg equal the sum of CO_2, 21*CH_4, and 310*N_20.
4. 6.02 tons CO2equivalents/car per year provided by USEPA, http://www.epa.gov/cleanenergy/energy-resources/calculator.html

Attachment 8 Increase of Emissions of Permitted Air Pollutants at the Power Generating Facility due to Additional DO Enhancement Operation			
	Current Air Emissions[1] (tons/yr)	Additional Air Emissions at Power Generating Facilities Due to DO Energy Consumption (tons/yr)	Percent Change from Current Emissions
NO_x	850	105	12.4%
SO_2	2840	378	13.3%
Hg	0.012	0.00162	13.5%

1. Summation of emissions reported in the District's 2006 Annual Air Emission Reports and emissions at the power generating facility due to energy use.

BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:	)	
	)	
WATER QUALITY STANDARDS AND	)	
EFFLUENT LIMITATIONS FOR THE	)	R08-9
CHICAGO AREA WATERWAY SYSTEM	)	(Rulemaking - Water)
AND THE LOWER DES PLAINES RIVER:	)	
PROPOSED AMENDMENTS TO 35 Ill.	)	
Adm. Code Parts 301, 302, 303 and 304	)	

PRE-FILED TESTIMONY OF STEPHEN F. MCGOWAN

Environmental Assessment of Plant Effluent Disinfection at the North Side, Calumet, and Stickney Water Reclamation Plants

My name is Stephen McGowan and I am a Vice President at Malcolm Pirnie, Inc. I have a Bachelors of Engineering degree in Civil Engineering and a Masters of Engineering degree in Environmental Engineering, both from Manhattan College in Riverdale, New York. I am a licensed Professional Engineer in four states including Illinois and I am also a Board Certified Environmental Engineer (BCEE) with the American Academy of Environmental Engineers. I am the Project Manager for the study that developed the information in this pre-filed testimony. A resume detailing my education and experience is presented in Attachment 1.

I. Introduction and Background

My testimony evaluates the overall environmental impacts of potentially implementing disinfection at the North Side, Calumet and Stickney water reclamation plants. The Metropolitan Water Reclamation District of Greater Chicago (District) currently does not disinfect the effluent of these three largest plants before discharging to the Chicago Area Waterway System (CAWS). The effluent criteria and water quality standards proposed by the Illinois Environmental

Protection Agency in this rulemaking have caused the District to evaluate alternatives for disinfection of the effluent from the plants.

This testimony describes the study we conducted to evaluate the environmental and energy impacts of two disinfection alternatives: ultraviolet radiation (UV) and chlorination followed by dechlorination (Attachment 2). These technologies were selected because UV disinfection was the highest ranked alternative in a separate study by the District (*Technical Memorandum 1WQ: Disinfection Study*" prepared by CTE, August 2005), and chlorination/dechlorination is a commonly used disinfection method for wastewater applications. Our study focused on the potential adverse environmental impacts of implementing either disinfection technology within the study area, including manufacturing, facility construction, maintenance/operation, and disposal. Our study then quantified the most significant impacts from entry into the study area to their disposal within the study area.

For the purposes of this project, the limits of the study area coincide with the District's service area that is comprised of seven water reclamation plants covering approximately 883 square miles and serving over 5.2 million customers. The current evaluation focuses on the overall impacts within the District's service area. Therefore, the quantification of the disinfection technologies' environmental impacts is limited to this study area.

II. Proposed Technologies

Based on the review of the Consoer Townsend Envirodyne Engineers (CTE) *UV Disinfection Cost Study – North Side Water Reclamation Plant* (January 2008), and from working results of the *Draft Stickney Water Reclamation Plant UV Cost Study* and the *Draft Hydraulic Evaluation Technical Memorandum* (CTE, June 2008), the specific design criteria for the UV system at each of the three plants are presented in Attachment 3. The main design considerations and assumptions for the UV system at the North Side, Calumet, and Stickney plants are as follows:

- Each system consists of a power supply, an electrical system, a reactor, medium pressure-high intensity lamps, a mechanical and chemical cleaning system, and a control system.
- The system will be enclosed in a building for protection against weather.
- A low lift pump station is included in the design.
- The plants will disinfect from March through November.

Based on the review of the *Chlorination/Dechlorination Disinfection Cost Study for Stickney, Calumet and North Side Water Reclamation Plants* (CTE, May 2008), the specific design criteria for the chlorination/dechlorination system at each of the three plants are presented in Attachment 4. The main design considerations and assumptions for the chlorination/dechlorination disinfection system at each of the plants are as follows:

- The plants will use 12.5% sodium hypochlorite for disinfection and 38% sodium bisulfite for dechlorination.
- Chemicals will be produced off-site and delivered to the plants by tanker trucks; the suppliers are located within 40 miles of each plant.
- Chemicals will be stored outdoors, but transfer pumps, feed pumps, electrical, controls, and storage will be within a temperature controlled building.
- A low lift pump station is included in the design.
- The plants will disinfect from March through November.

III. Baseline Development

To determine impacts of the proposed technologies, it is important to understand the usage of the District's existing infrastructure and equipment as a baseline for the study. The baseline is defined as the facilities and natural infrastructure elements – air, land, and water –

currently controlled, accessed, or used by the District to manage loadings (i.e. emissions, discharges, disposals) from existing operations. These baseline data were developed for the current air, land, and water usage by the District at the North Side, Calumet, and Stickney water reclamation plants.

Air emissions generally come from two sources, those generated at the plant itself (emissions from boilers, gas turbines, excess digester gas flares, ozone systems, etc.), and those from the energy plants that supply power to run the plants. These power plants are generally coal-based electric generating facilities.

Mercury (Hg) and the six criteria pollutants: sulfur oxides (SO_x), carbon monoxide (CO), nitrogen oxides (NO_x), particulate matter (PM), ozone (O_3) and lead (Pb), are permitted under the USEPA Clean Air Mercury Rule and Clean Air Act, respectively. For regulatory purposes, sulfur dioxide (SO_2) emissions are reported because they are the indicator of sulfur oxide concentrations in the ambient air. Greenhouse gases, comprised of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluoro-carbons (HFCs), perfluoro-carbons (PFCs) and sulfur hexafluoride (SF_6), are not included in air emission permits, but are of concern on both global and local levels because of their potential to affect global climate changes and global warming.

Air emissions of the most significant criteria pollutants, greenhouse gases, and mercury are summarized in <u>Attachment 5</u>. The emissions include criteria pollutants from the three plants as reported in the District's 2006 Annual Air Emission Reports, and estimated air emissions at the power generating facility due to energy production. The estimated emissions from energy production were calculated with emission factors available through the "Emissions & Generation Resource Integrated Database" (eGRID) specifically for Illinois

The current land usage and allocated land for future projects at each facility are shown in Attachment 6. An estimated 90% of the total area at the North Side plant, 95% of the total area at Calumet, and 71% of the total area at Stickney are currently in use or allocated for future projects. The remaining land – 10 acres at North Side, 24 acres at Calumet, and 166 acres at Stickney – could include some area dedicated for disinfection.

Attachment 7 shows the 2007 estimated water usage at each facility. In addition to the potable water usage, the impervious cover on the three plants has an impact on the runoff in the area. Assuming an historical average of 36.4 inches of precipitation per year, the estimated annual runoff from the existing and allocated buildings, pavements, and driveways at all three plants is 143 MG, as shown in Attachment 7. Water usage and runoff will increase with implementation of disinfection as discussed later.

IV. Determination of Quantifiable Environmental Impacts

The potential environmental impacts were identified through professional experience, literature reviews, input from manufacturers, and brainstorming sessions. The impacts considered for both UV and chlorination/dechlorination included the source of raw material, manufacturing, facility construction, maintenance/operation, and salvage & disposal for each technology. The impacts were then ranked and prioritized based on their potential to affect the environment. Based on this analysis, activities were identified as those with the most potential to affect the air, land, and water within the study area.

Activities that impact the air include: (1) Energy consumption and associated air emissions during operation of the UV or chlorination/dechlorination equipment and sodium hypochlorite manufacturing; (2) Energy consumption and associated air emissions during the operation of the UV or chlorination/dechlorination low lift pumping station; (3) Air emissions as a result of the increased traffic from construction, maintenance/operation, and deliveries; and (4) Noise associated with the construction and operation of the facilities.

Activities that impact the land include: (1) Land requirements for each facility; (2) Modifications to the land during construction such as reduction of open space and additional impervious area; (3) Landfill needs for disposal of UV equipment or mercury; and (4) Reduction of available space for future expansions.

Activities that impact the water include: (1) Water requirements for facility during construction and operation; and (2) Stormwater runoff.

These activities impacting the air, land, and water were quantified for both UV and chlorination/dechlorination to assess their impacts on the environment. The most significant impacts are as follows:

Ultraviolet Radiation will:

- Increase the District's electricity use by an average of 126 million kWh/yr from operation of the UV equipment and operation of the low lift pumping station.
- Result in emissions of 99,000 tons of carbon dioxide equivalents of greenhouse gases per year from transportation and at the power generating facility due to operation of the UV equipment, and operation of the low lift pumping station.
- Result in emissions of 180 tons of NO_x per year; 650 tons of SO_2 per year; 6 pounds Hg per year at the power generating facility due to operation of the UV equipment and operation of the low lift pumping station.
- Require 7.5 acres of District land to be converted to an industrial plant from current or allocated uses; this land will not be available for future expansions (5 acres will become impervious area).
- Require 1,500-3,000 cubic feet at the landfill upon disposal at the end of its useful life.
- Increase stormwater runoff volume by 5 MG per year.

Chlorination-Dechlorination will:

- Increase the District's electricity use by an average of 95 million kWh/yr from operation of the chlorination/dechlorination pumps and mixers, operation of the low lift pumping station, and manufacturing of sodium hypochlorite.
- Result in emissions of 75,000 tons of carbon dioxide equivalents of greenhouse gases per year from transportation and at the power generating facility due to operation of the chlorination/dechlorination pumps and mixers, operation of the low lift pumping station, and manufacturing of sodium hypochlorite.
- Result in total emissions of 140 tons of NO_x per year; 490 tons of SO_2 per year; 4 pounds Hg per year at the power generating facility due to operation of the chlorination/dechlorination pumps and mixers, operation of the low lift pumping station, and manufacturing of sodium hypochlorite.
- Require 17 acres of District land to be converted to an industrial plant from current uses; this land will not be available for future expansions (13 acres will become impervious).
- Increase stormwater runoff volume by 13 MG per year.

V. Comparison to Baseline Conditions and Impact on Future Uses

Based upon our evaluation of environmental impacts of the disinfection options (UV or chlorination/dechlorination) to baseline conditions, the comparisons are presented for the District's energy usage, air emissions at the power generating facility due to energy use, air emissions from transportation, and land usage.

The energy consumption for implementing disinfection will require additional electricity originating from a coal-powered generating facility. As shown in Attachment 8, the annual total energy required for the operation of the UV disinfection equipment and pumping station will increase the District's current usage at the three plants of 384 million kWh/yr by approximately 126 million kWh/yr, or 33%. From the USEPA Greenhouse Gas Equivalencies Calculator, an average household uses 11,965 kWh/yr. Thus, the electricity consumption for operation of the UV and low lift pumping station is equivalent to approximately 10,600 households. For chlorination/dechlorination, the total energy requirements for manufacturing of sodium hypochlorite, operation of the pumps/mixers, and operation of the low lift pumping station will increase the District's current usage by approximately 95 million kWh/yr, or 25%. This is equivalent to the electricity use of approximately 8,000 households.

The annual energy use can also be translated in terms of equivalent energy consumption at the Sears Tower, which requires 77 million kWh/yr. The annual energy required for the operation of the UV equipment and pumping station is 67% more than the annual energy consumption for the Sears Tower. Similarly the annual energy requirements for operation of the chlorination/dechlorination pumps and mixers, operation of the low lift pumping station, and manufacturing of sodium hypochlorite are 24% more than the annual energy consumption for the Sears Tower.

The increased energy usage for the UV equipment, pumping equipment, and associated transportation at the three plants will increase the greenhouse gas emissions by 98,970 tons CO_2 equivalents/yr (98,700 + 270), or 33%, as shown in Attachment 9. Transportation emissions will result in an increase in greenhouse gas emissions of less than 0.5%; the remaining emissions will be at the power generating facility. Assuming 6.02 tons per car, the increase in total greenhouse gas emissions is equivalent to over 16,400 additional automobiles added to the road per year (based on the USEPA Greenhouse Gas Equivalencies Calculator). An equivalent 15.2 million trees would be required to absorb that same amount of carbon dioxide emissions.

For the chlorination/dechlorination equipment, pumping station, sodium hypochlorite manufacturing, and associated transportation at the three plants, the greenhouse gas emissions will increase by 74,990 tons CO_2 equivalents/yr (74,300+690), or 25%, which is equivalent to approximately 12,500 automobiles added to the road per year. An equivalent of approximately 11.5 million trees will be required to absorb that same amount of carbon dioxide emissions.

Transportation emissions will result in an increase in greenhouse gas emissions of less than 1.0%, with the remaining emissions occurring at the power generating facility.

Emissions from UV and chlorination/dechlorination will decrease the air shed capacity that might otherwise be available for other economic or developmental uses in the future. The current and estimated increase in the major permitted air pollutants are shown in Attachment 10. The increase in criteria pollutants and mercury emissions are from energy production at the power generation plant.

The UV and chlorination/dechlorination facilities will also decrease the available land or reduce landfill space that might otherwise be available for other economic or developmental uses in the future. The current used/allocated land, remaining land, and percent increase in land use if the disinfection and pumping facilities are installed are shown in Attachment 11.

The environmental impacts of implementing disinfection technologies at the North Side, Calumet, and Stickney plants have been presented in this testimony. Implementing disinfection technologies will utilize critical District resources (air, land, water, and financial) that will then become unavailable for future treatment options and alternatives.

Respectfully submitted,

By: *Stephen McGowan*

Testimony Attachments

1. Resume of Stephen F. McGowan, P.E., BCEE
2. *Environmental Assessment of Plant Effluent Disinfection at the North Side, Calumet, and Stickney Water Reclamation Plants, and Increasing DO in the CAWS*, Malcolm Pirnie, July 2008.
3. UV Design Criteria for the North Side, Calumet, and Stickney Plants
4. Chlorination/Dechlorination Design Criteria for the North Side, Calumet, and Stickney Plants
5. Total Air Emissions of Criteria Pollutants, Greenhouse Gases, and Mercury
6. Current and Allocated Land Usage
7. Water Usage and Runoff
8. Annual Electricity Equivalents
9. Annual Greenhouse Gas Emission Equivalents from Transportation and at the Power Generating Facility Due to Energy Consumption
10. Annual Additional Air Emissions of Regulated Air Pollutants at the Power Generating Facility
11. Land Increase

ATTACHMENT 1

Resume of Stephen F. McGowan, P.E., BCEE

Mr. McGowan specializes in water and wastewater process engineering and design. He has extensive experience in municipal and industrial treatment facilities and odor control and has worked at facilities ranging from 0.1 mgd to 1,700 mgd. His work has included pilot and treatability studies for municipal and industrial wastewater treatment, treatment process design, mathematical modeling of treatment processes, and combined sewer overflow projects. He also has experience in construction administration, infiltration/inflow studies, field sampling and pilot studies for odor control, and design of wastewater conveyance and treatment facilities.

Detailed Experience

- **Metropolitan Water Reclamation District of Greater Chicago, Value Engineering Study for the Preliminary Treatment Facilities at the Calumet WRP.** Project Manager for the VE study for the preliminary treatment facilities at the Calumet WRP. The study evaluated the preliminary design of influent conduits, grit removal facilities, primary settling tanks, and effluent conduits for a projected peak flow of 600 mgd. Also provided the lead process engineering review as part of the VE Study.
- **Milwaukee Metropolitan Sanitary Sewerage District, Analysis of Options for Operations and Maintenance of District Facilities and Assistance with Implementation of the Preferred Option.** Project Manager for the evaluation of long term operations and maintenance options for the MMSD's system which includes the Jones Island and South Shore WWTPs, each of which has a maximum rated capacity in excess of 300 mgd, the Metropolitan Interceptor System (MIS), the Inline Storage System (ISS) and other miscellaneous facilities. Provided technical guidance for all aspects of the proposed 10 year operations and maintenance contract including evaluation of current facilities, development of an RFQ, evaluation of SOQs, development of a draft service agreement, development of technical schedules for inclusion in the service agreement, development of an RFP, evaluation of proposals, and negotiations with proposing operations companies.
- **Detroit Water and Sewerage Department: Program Management (P-744) / Detroit MI.** Served as Lead Engineer and Malcolm Pirnie's Project Manager for the Program Management upgrade at the Detroit Water and Sewerage Department's Wastewater Treatment Plant. As part of a team with Wade-Trim and Jacobs Engineering, led all engineering-related tasks for the program, including planning, needs assessments, project scoping (Projects Definition Statement), development of design standards, design management, and engineering assistance during construction. Led a staff of over 15 engineers and 20 subconsultant engineering firms to successfully deliver more than 30 design projects over a four-year period. The project initially included every major treatment process at the 1,700-mgd PS No. 1, upgrade of the 930-mgd

Stephen F. McGowan

Project Role: Project Manager

Title/Firm:
Vice President
Malcolm Pirnie, Inc.

Years of Experience
22

Education
BE Civil Engineering Manhattan College 1984
ME Environmental Engineering Manhattan College 1988

Licenses and Certifications
Professional Engineer
Board Certified Environmental Engineer

Health and Safety Training
Health & Safety Training for Project Management

Professional Training
Anaerobic Treatment of High Strength Wastes
Industrial Wastewater Treatment

Societies
American Water Works Association, AWWA
Water Environment Federation, WEF

Employment History
Malcolm Pirnie, Inc. 1988 to present
O'Brien & Gere Engineers, Inc. 1984 to 1987

secondary treatment process aeration equipment, renovation of seven primary treatment scum buildings, rehabilitation of twelve 110-foot-diameter gravity thickeners, installation of two new 350-mgd intermediate lift pumps, installation of eight new dewatering centrifuges, rehabilitation of ten existing belt filter presses, installation of a 520-dtpd sludge slake pump station, rebuilding of the conveyor and incinerator processes, and installation of a 950-dtpd sludge off-loading.

- **Detroit Water and Sewerage Department (DWSD): Primary Clarifier Design (CS-1311) / Detroit MI.** Served as lead process engineer for the design of two 180-mgd circular clarifiers (250 ft diameter) and 107 mgd of additional raw wastewater pumping capacity. Responsible for managing the preliminary and final Basis of Design Reports for the new clarifiers and pumping. Key elements of the study included detailed analysis of existing influent pumping and primary clarifier facilities, close coordination with WWTP operations and maintenance staff, evaluation of primary clarifier alternatives, development of preliminary cost estimates, development of facility layout drawings, analysis of hydraulic issues and constraints, evaluation of alternatives for providing 107 mgd of additional influent pumping capacity, and final recommendation of a preferred alternative. When completed, this project will increase the firm pumping and primary treatment capacity to 1,700 mgd.
- **Detroit Water and Sewerage Department: Long-Term CSO Control Plan (CS-1158) / Detroit MI.** Conducted extensive investigations, studies, and testing at the City of Detroit's wastewater treatment plant for optimizing the treatment of high wet weather flows. Specific work tasks and responsibilities included the review and analysis of existing data, evaluation of existing sampling procedures, development and calibration of mass balance models for the plant Hydromantic GP3-X dynamic model), development of unit process capacity test protocols, summarizing capacity test results, and preparation of final report with results and recommendations for handling high wet weather flows. Results of these investigations were used to re-rate the primary and secondary capacities to 1,520 mgd and 923 mgd, respectively, and to determine CSO facility sizing in the collection system. Additional responsibilities on the project included estimating efficiencies of proposed CSO treatment facilities, cost estimating, and preliminary facility siting and layout. Results of this work were key elements in the development of DWSD's Long-Term CSO Control Plan.
- **Detroit Water and Sewerage Department (DWSD): Phase III CSO Assistance (CS-1281) / Detroit MI.** On this follow-up project to the DWSD Long-Term CSO Control Plan (CS-1158), Mr. McGowan is the leader of several key work tasks on the DWSD Phase III CSO Assistance project (CS-1281). CS-1281 was initiated in 1997 and is currently ongoing. As a task leader for this project, Mr. McGowan's responsibilities include leading the WWTP Work Group, which addresses WWTP issues related to treatment capacity, coordination with operations and maintenance personnel, individual unit processes, planning, and NPDES permit

compliance. He also leads the Treatment Efficiency Work Group, which assesses treatment efficiency of existing CSO treatment facilities and uses this information for planning future CSO facility planning.

- **Detroit Water and Sewerage Department (DWSD): Conner Creek Pilot CSO Facility (CS-1284) / Detroit MI.** The Conner Creek Basin project was initiated in 1998 and is currently ongoing. The project includes study, design, and construction services phases. Mr. McGowan is the lead process engineer for the design of odor control facilities at the 30-million-gallon Conner Creek CSO Treatment Facility. He has coordinated the evaluation of alternative odor control technologies and provided preliminary design of the proposed alternative. He has also provided process engineering assistance with the evaluation and selection of screens, conveyors, mixers and other process equipment.
- **New York City Department of Environmental Protection: Upgrading of Four Wastewater Treatment Plants / Catskill Region NY.** Operated a 1-gpm pilot plant at the Pine Hill Wastewater Treatment Plant, as part of the New York City watershed protection program. Unit processes included primary clarifiers, rotating biological contractors, final clarifiers, denitrification filters, and alum addition for phosphorus removal. Also responsible for developing process design criteria. Results of the pilot study were used as a basis for design to meet extremely stringent effluent standards for plants in the program.
- **City of Norwalk: Biological Nutrient Removal Demonstration Project / Norwalk CT.** Managed a $1 million biological nutrient removal pilot study at the city's wastewater treatment plant. The study consisted of three 1.5-gpm treatment plants, each with the capability to remove nitrogen and phosphorus to different levels. Each system was optimized and tested for consistent performance. The results of this study will be used to determine nutrient removal alternatives for up to 30 wastewater treatment plants in the State of Connecticut. A key responsibility included development of process design criteria for inclusion in the Facility Planning document. Additional responsibilities include operator training, management of pilot plant operations, data analysis, and report preparation.
- **Puerto Rico Aqueduct and Sewer Authority: Caguas Regional Wastewater Treatment Plant / Caguas PR.** Operated a 1-gpm biological nutrient removal pilot plant at the plant. Responsibilities included full-time operation of the pilot plant, data collection and evaluation, and report preparation. The results of the pilot study were used to develop design criteria for the proposed 15-mgd Caguas-Gurabo Regional Wastewater Treatment Plant. A key responsibility included development of process design criteria for inclusion in the Facility Planning document. This project won the 1991 Honor Award for planning from the American Academy of Environmental Engineers.
- **New York City Department of Environmental Protection: Expansion and Upgrading of the Wards Island Water Pollution Control Plant /**

Bronx NY. Managed a plantwide sampling program at the 285-mgd plant Wards Island WPCP. Sampling consisted of collecting 24-hour composite samples of the wet-stream and solids handling facilities. Analyzed the data to determine influent loadings, unit process treatment efficiency, and effluent quality. Data were also used to develop a mass balance model of the plant to assist in performing a capacity rerating study for the plant.

- **Barceloneta Advisory Council: Wastewater Sampling Studies / Barceloneta PR.** Managed two comprehensive wastewater sampling programs in excess of $0.5 million. Sampling consisted of simultaneous-flow proportional sampling of 11 pharmaceutical industrial wastewater discharges, and also influent and effluent samples at the local regional industrial wastewater treatment plant. Conducted several follow-up tasks using these data to include a reevaluation of the plant's capacity, preparation of an NPDES permit application, and development of a technical support document for approval of a receiving water mixing zone and issuance of a water quality certificate.
- **KMS Group, Inc, Columbia, MD: Wastewater Treatment Plant Expansion.** Analyzed 1.6-mgd wastewater treatment plant for 200,000-gpd upgrade.
- **Pequannock, Lincoln Park, and Fairfield Sewerage Authority: Infiltration/Inflow Study / Lincoln Park NJ.** Performed a desktop analysis of water consumption data, rainfall, and wastewater flows to determine the effect of inflow and infiltration on the plant's performance.

ATTACHMENT 2

Environmental Assessment of Plant Effluent Disinfection at the North Side, Calumet, and Stickney Water Reclamation Plants, and Increasing DO in the CAWS, **Malcolm Pirnie, July 2008.**

Metropolitan Water Reclamation District of Greater Chicago
111 East Erie Street • Chicago, IL 60611

Environmental Assessment of Plant Effluent Disinfection at the North Side, Calumet, and Stickney Water Reclamation Plants, and Increasing DO in the CAWS

July 2008

Report Prepared By:

Malcolm Pirnie, Inc.
1515 East Woodfield Road
Suite 360
Schaumburg, IL 60173
847-517-8114

Contract
07-859-1C

4974003

MALCOLM PIRNIE

Contents

List of Tables

List of Figures

Appendices

1 Introduction

1.1 Background

The Metropolitan Water Reclamation District of Greater Chicago (District) serves the greater Chicago area with its seven water reclamation plants (WRPs), pumping stations, tunnels and other facilities. The District currently does not disinfect the effluent of its three largest facilities (North Side, Calumet, and Stickney WRPs) before discharging to the Chicago Area Waterway System (CAWS). Newly proposed effluent criteria and water quality standards have caused the District to evaluate alternatives for disinfection of plant effluent as well as increasing dissolved oxygen (DO) in some portions of the CAWS.

In 2005, the District retained an independent consultant to conduct a study to determine the most appropriate technology(ies) for disinfection at the District's three largest WRPs, and then to determine the costs of implementing the selected technology(ies). Ultraviolet radiation (UV), ozone, and chlorination followed by dechlorination were evaluated as part of the 2005 study. For purposes of this study, UV disinfection and chlorination/dechlorination will be evaluated for their environmental impacts. UV disinfection is included because it was the highest ranked alternative in the 2005 study. Though chlorination/dechlorination was not ranked high in the report because of concerns related to the formation of disinfection by-products, storage, and transport of large chemical quantities, it is included in this study because it is a commonly used disinfection method for wastewater applications and typically has a lower capital and operating costs.

In a separate study, the District also evaluated increasing the DO in certain portions of the CAWS to meet newly proposed water quality standards relating to sustaining aquatic life. The study evaluated the most feasible technologies and costs of increasing DO at each location. However, the District determined that, based upon the recommendations presented in the study, DO will not meet the proposed water quality standard at some locations in CAWS and alternative strategies must be considered. A supplemental study is currently being conducted by the District to evaluate an integrated water quality strategy for increasing DO in the CAWS.

Implementing new disinfection treatment processes for reducing coliform bacteria and increasing DO levels in the CAWS will require capital-intensive construction activities and ongoing maintenance and operation (M&O). Based on the various studies and to prepare for the rule-making hearings at the Illinois Pollution Control Board (IPCB), the

District is evaluating the costs, benefits and overall environmental impacts of potentially implementing these processes. This report focuses on the potential adverse environmental impacts of implementing each disinfection technology within the study area. The approach considers the environmental impacts of the raw source materials, manufacturing, facility construction, maintenance/operation, and salvage & disposal, and quantifies the most significant impacts from entry into the study area to their disposal within the study area. The benefits, risks, and water quality impacts of implementing these technologies are being addressed by others. Essentially, this report along with work conducted by others will provide the District with the information necessary for an environmental evaluation to select the most sustainable alternative for implementation. This will allow the District to evaluate the environmental benefits (i.e. improved receiving body water quality); impacts (i.e. consumption of energy from coal-fired power plants, land and other resources) of these technologies.

The technical evaluation of DO improvement is ongoing and the required facilities have not been finalized. As such, a comprehensive environmental evaluation of DO improvement technologies is not included in this report. However, based on the information available at this time, a preliminary evaluation of the environmental impacts of DO technologies has been included in this study. The focus of the DO evaluation is on the increase in energy consumption and the resulting air emissions at the power generating facility due to implementation of the DO technologies.

1.2 Scope of Work

The scope of work for this project involved a review of the information collected through literature searches, workshops, previous reports, and equipment manufacturers. This information was utilized to identify the potential environmental impacts, which were then quantified based on the criteria established for the alternatives.

1.3 Project Approach and Goals

The study proceeded through the following main steps:

- **Collection and Review of the Data**

  We reviewed and summarized the design criteria and requirements for each facility. Background information on potential environmental impacts and approaches for evaluating the impacts were also collected and reviewed through a literature search, a brainstorming workshop with the District, and the City of Chicago's *Environmental Action Agenda*. Results were incorporated into the approach.

- **Establish the Baselines**

  We developed the baselines to determine the influence of the District's existing facilities on the environment, which included emissions, discharges and disposals to the natural infrastructure (air, land, water) from existing facilities and operations.

- **Identify and Quantify the Additional Loadings**

  We identified and quantified the additional loadings to air, land, and water infrastructure in the study area that would result from applying either UV or chlorination/dechlorination technology. A weighted ranking matrix was developed to identify the most critical impacts, followed by quantification of the most critical environmental impacts.

- **Compare to the Baseline Conditions**

  We summarized and compared the findings of the additional loadings to the natural infrastructure (where appropriate) in the CAWS ecosystem.

The study's goals are to identify, catalog and systematically determine the potential environmental impacts of implementing the proposed disinfection technologies and provide the District with the required information to support its overall evaluation and determination of the feasibility of implementing these disinfection technologies.

1.4 Study Area

For the purposes of this project, the limits of the study area, as shown in Figure 1-1, coincide with the District's service area that is comprised of seven WRPs covering approximately 883 sq miles and serving over 5.2 million customers. Similar to previous studies carried out by the District, the current evaluation focuses on the overall impacts within its service area. Therefore, the quantification of the environmental impacts of the disinfection technologies is limited to this study area. The study will also qualitatively consider potential impacts that may be outside of the study area; however these impacts will not be evaluated further due to limited data.

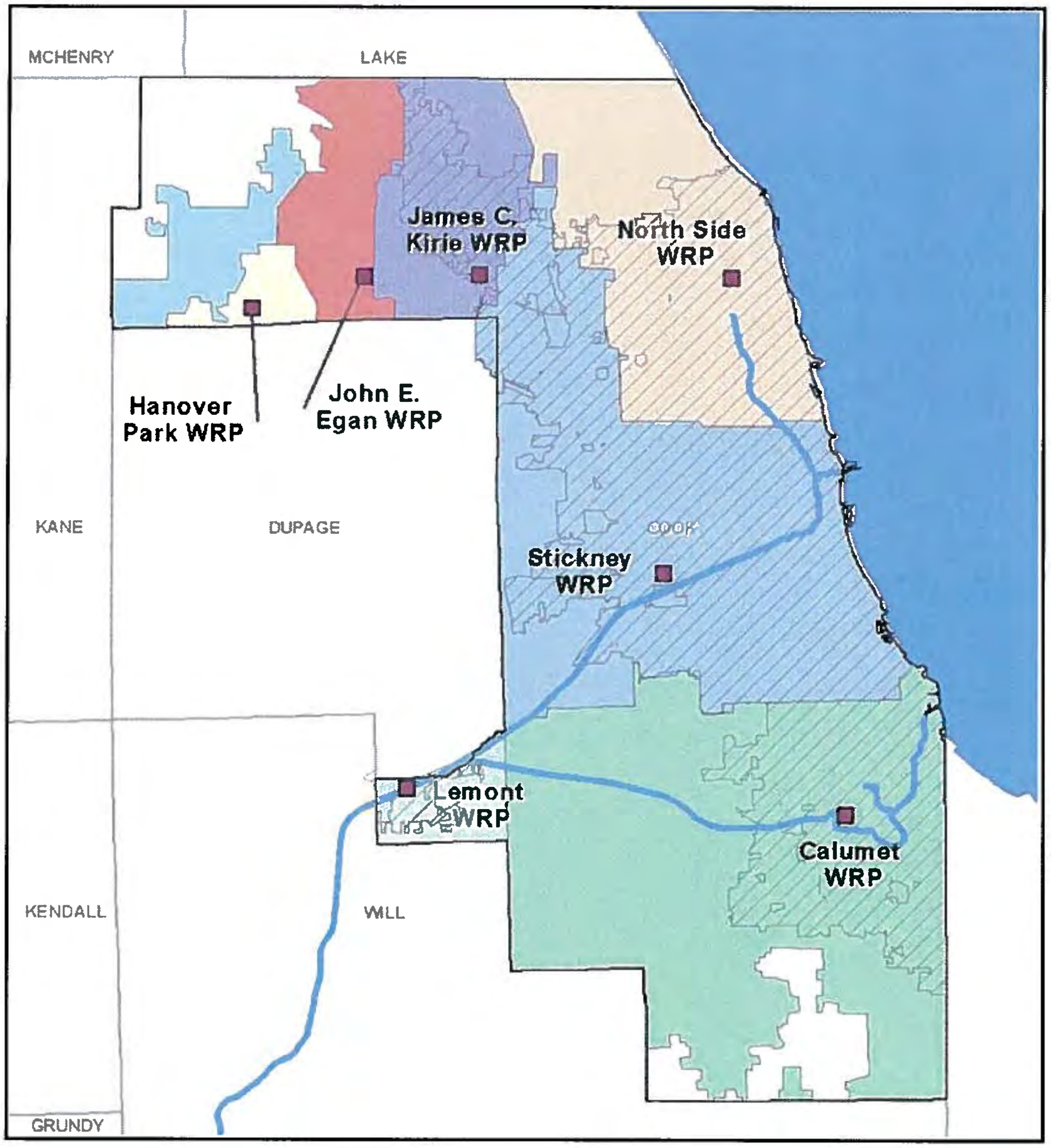


Figure 1-1: District's Service Area

2 Data Collection and Review

2.1 Proposed Facilities Design Criteria

As discussed in Section 1, a 2005 study evaluated many disinfection technologies for the North Side, Calumet, and Stickney WRPs. Two alternatives are considered in this study. The first, UV disinfection, is included because it was the highest ranked alternative in the 2005 study. The second is chlorination followed by dechlorination. This was selected because it is one of the most common technologies utilized in wastewater treatment.

2.1.1 UV System

UV technology is a recognized and well-established alternative for water and wastewater disinfection applications. It is considered effective for the prevention of waterborne pathogen discharges to receiving waters without the formation of any known disinfection by-products. The effectiveness of UV disinfection is, however, sensitive to the effluent stream's water quality, and higher doses are necessary for virus inactivation. Using a power input, the effluent stream is disinfected through the UV system. The UV system is composed of lamps, quartz sleeves, mechanical/chemical cleaning system, ballast, and the power distribution center.

Based on the review of the Consoer Townsend Envirodyne Engineers (CTE) *UV Disinfection Cost Study – North Side Water Reclamation Plant* (January 2008), and from working results of the *Draft Stickney Water Reclamation Plant UV Cost Study* and the *Draft Hydraulic Evaluation Technical Memorandum* (June 2008), the specific design criteria for the UV system at each of the three plants are presented in Table 2-1. These studies were updated from previous reports to reflect an *E. coli* limit of 400 cfu/100 mL. The main design considerations and assumptions for the UV system at the North Side, Calumet, and Stickney plants are as follows:

- Peak hourly flows with redundancy were used to size all equipment.
- Average daily design flows were used to calculate energy and chemical consumption.
- WRPs will disinfect from March through November.
- Medium Pressure-High Intensity (MP-HI) mercury vapor lamps will be used.
- Influent has a minimum UV transmissivity of 65%.
- Minimum UV dose = 40 mW-s/cm^2.
- The design UV lamp life is 5,000 hours.

- MP-HI operating temp = 600 to 900 °C.
- Lamp fouling factor equals 90%.
- Each system consists of a power supply, an electrical system, a reactor, MP-HI lamps, a mechanical and chemical cleaning system, and a control system.
- Cleaning solutions consist of some acidic solution that prevents fouling and are replaced monthly.
- Lamps are enclosed in quartz sleeves.
- Electronic ballast for each lamp is used to control the output.
- System will be enclosed in a building for protection against weather.
- A low lift pumping station is included in the design.

Table 2-1
Proposed UV System Features for the North Side, Calumet, and Stickney WRPs

	North Side	Calumet	Stickney
Average Day/Peak Hour Design Flow, mgd	333/450	319/480	1,250/1,440
E. coli Design Limit, cfu/100 mL	400	400	400
Lamps, Total	1,680	1,680	4,032
Hourly Average Power[1], kW	3,182	2,903	9,225
Average Energy, kWh/day	76,368	69,672	221,400
Average Power, kW/mgd	9.6	9.1	7.4

1. Power includes operation of the equipment only. Design assumes power based on the design average flow rate.

Table 2-2 lists the estimated acreage that would be needed for the UV facility at each plant as communicated by CTE. The estimated land requirement includes the footprint of the UV building, the pump station, a new outfall, and 10-foot buffer around each facility. The new outfall is designed below grade with the assumption that buildings will not be built above it. The proposed maintenance schedule for UV operation is given in Table 2-3.

Table 2-2
UV Acreage at the North Side, Calumet, and Stickney WRPs

	North Side	Calumet[2]	Stickney
UV Land Requirement[1], acres	2.07	1.65	3.72

1. Source: *UV Disinfection Cost Study – North Side Water Reclamation Plant* (CTE. January 2008); the information for Stickney is from working results of the *Draft SWRP UV Cost Study* and the *Draft Hydraulic Evaluation Technical Memorandum* (CTE, June 2008)
2. Land proposed for the UV facilities at Calumet are currently occupied by the existing chlorine contact tanks.

Table 2-3
Proposed UV Maintenance Schedule

Item	Replacement Time	Annual Replacement
Lamps	every year	100%
Ballasts	every 5 years	20%
Quartz Sleeves	every 10 years	10%
Wipers	every 3 years	33%

2.1.2 UV Design Criteria Validation

Table 2-4 provides a review of the revised design criteria in the January 2008 memo (CTE's *UV Disinfection Cost Study – North Side Water Reclamation Plant*) in comparison to the design criteria contained in the August 2005 memo (CTE's *Disinfection Study - Technical Memorandum, TM-1WQ*). Based on Malcolm Pirnie's review of the data, the updated criteria for the proposed UV equipment appears to be consistent with previous work and design criteria developed for similar effluent quality standards at other utilities with an *E. coli* count less than 400 cfu/100 ml in the effluent.

Table 2-4
Proposed UV System Features at the North Side WRP

	UV Disinfection Cost Study, January 2008	Technical Memo (TM-1WQ), 2005 Study
Design Criteria[1]		
Peak Hourly Design Flow, mgd	450	450
Effluent *E. coli*, cfu/100 mL[2]	400	1,030
UV transmittance, %	65	65
UV dose, mW-sec/cm2	40	Not specified
Proposed UV System Details		
UV technology	Medium pressure	Medium pressure
Number of channels	5 (4 duty + 1 standby)	4 (3 duty + 1 standby)
Reactors per channel	1	1
Lamps per reactor	336	288
Lamps (duty/total)	1,344/1,680	864/1,152
Lamp output, kW/lamp	4.0	Not specified
Hourly Maximum Power requirements (duty/total), kW	5,376/6,720	2,765/3,687
Maximum Power Requirements (duty/total), kW/mgd	11.9/14.9	6.1/8.2
No. of lamps/mgd (duty)	3.0	1.9

1. Based on max flow conditions
2. Monthly geometric mean

Table 2-4 reveals that the number of lamps is within the range (2 to 4 lamps/mgd) typically encountered in municipal wastewater disinfection using medium pressure systems. The UV system proposed in the January 2008 report estimates approximately twice the power consumption (11.9 kW/mgd) at peak hour design flow compared to the system in the August 2005 report (6.1 kW/mgd). With all other key design parameters (flow and UVT) equal, the higher power requirement in the January 2008 report is due to the use of the lower *E. coli* value (400 cfu/100 mL), which appears to be reasonable.

2.1.3 Chlorination/Dechlorination Design Criteria

Chlorination is currently one of the most commonly-applied methods for disinfection of waterborne pathogens in wastewater effluent before discharge to receiving waters. Chlorine is recognized for its effectiveness and destroys bacteria, viruses, and protozoa at a relatively low cost. Dechlorination of the excess chlorine prior to discharge is typically required to minimize any harm to aquatic life and for minimizing the formation of disinfection byproducts.

Chlorine is available as a gas, liquid sodium hypochlorite (delivered or generated onsite), or solid calcium hypochlorite. Based on a review of the *Chlorination/Dechlorination Disinfection Cost Study for Stickney, Calumet and North Side Water Reclamation Plants* (CTE, May 2008), the specific design criteria for the chlorination/dechlorination system at each of the three plants are presented in Table 2-5. The main design considerations and assumptions for the chlorination/dechlorination disinfection system at each of the plants are as follows:

- WRPs will use 12.5% sodium hypochlorite (NaOCl) for disinfection and 38% sodium bisulfite ($NaHSO_3$) for dechlorination.
- Dosing rate of chlorine is 6 mg/L as Cl_2; the assumed Cl_2 residual prior to the addition of sodium bisulfite is 2 mg/L.
- Chemicals will be produced off-site and delivered to the plants by tanker trucks; the suppliers are located within 40 miles of each plant.
- Outdoor storage; 14 days of storage provided for all chemicals at average conditions.
- WRPs will disinfect from March through November.
- The expected service life is given below:
  - Steel tank linings, CPVC piping, transfer pumps, feed pumps, mixers and control and instrumentation equipment = 10 years.
  - Steel tanks and Teflon lined chemical piping = 20 years.
  - Building and concrete containment areas = 50 years.
- The design includes the following components:
  - Chemical feed building (for housing the transfer and feed pumps, plus electrical and storage).
  - Low lift pump station.
  - Chemical storage/receiving facilities.
  - Chemical feed facilities.
  - Mixing tank/contact tank.

Table 2-5 summarizes the chlorination/dechlorination specific design criteria for the North Side, Calumet, and Stickney WRPs from CTE's 2008 chlorination/dechlorination cost study for the three plants. Similar to the UV criteria, the chlorination/dechlorination design criteria are based on an *E. coli* limit equal to 400 cfu/100 mL in the effluent.

Table 2-5
Proposed Chlorination/Dechlorination System Features at the North Side, Calumet, and Stickney WRPs

	North Side	Calumet	Stickney
Design Flow, mgd (average day/peak hour)	333/450	319/480	1,250/1,440
E. coli limit, cfu/100 mL	400	400	400
Hourly Average Power[1], kW	24.15	92.06	68.76
Average Energy, kWh/day	580	2,209	1,650
Land Requirement for Chlor/Dechlor, acres[2]	3.1	4.2	9.75

1. Power includes operation of the transfer pumps, feed pumps, and mixers for chlorination/dechlorination. At North Side and Stickney, design assumes one new mixing chamber for each chemical with one mixer each (two total mixers at each plant). At Calumet, design assumes reusing the existing contact tanks and splitting flow such that two mixing chambers are required for each chemical with one mixer each (four total mixers). The additional mixers result in higher energy use at the Calumet WRP.
2. The land requirements at the Calumet WRP include the 2.2 acres occupied by the existing contact tank.

Storage of the chemicals for chlorination/dechlorination poses some potential concern for safety because of the volume of chemical onsite and the frequency of deliveries. The duty storage and the total storage capacities for each WRP, as well as the storage times at peak flow conditions, are given in Table 2-6. To meet the storage requirements at average flow conditions, the frequency of delivery is estimated to be a total of approximately 170 truck loads per week for the three plants. Because rail delivery is not yet available, it is assumed that the deliveries will be made by 4,400-gallon tank trucks for sodium hypochlorite and 4,000-gallon tank trucks for sodium bisulfite. Each storage and day tank will be located outdoors within a concrete spill containment area that is 110% of the total tank volume. Sodium bisulfite solution will be used to contain and neutralize any spilled hypochlorite; the neutralized hypochlorite will be recycled to the head of the plant. Any sodium bisulfite that is spilled will be recycled to the head of the plant.

Table 2-6
Proposed Chlorination/Dechlorination Storage at the North Side, Calumet, and Stickney WRPs

	North Side		Calumet		Stickney	
	Sodium Hypo-chlorite	Sodium Bisulfite	Sodium Hypo-chlorite	Sodium Bisulfite	Sodium Hypo-chlorite	Sodium Bisulfite
Average Daily Dosage, lb/day	16,700	8,100	16,000	7,800	62,550	30,400
Number of tanks	3 (2 duty + 1 standby)	2 (1 duty + 1 standby)	3 (2 duty + 1 standby)	2 (1 duty + 1 standby)	4 (3 duty + 1 standby)	2 (1 duty + 1 standby)
Duty storage capacity, gallons	244,000	28,200	232,000	28,200	892,300	105,500
Total storage capacity, gallons	366,000	56,400	348,000	56,400	1,189,700	211,000
Duty Storage Available at Peak Flow Conditions, days	10.8	10.4	9.7	10.1	12.4	12.4

2.2 Environmental Impact Literature Search

Malcolm Pirnie conducted a literature search in an effort to identify known potential environmental impacts of the various technologies identified above and to gather information that would be relevant to this study. The literature search encompassed scientific journals, conference proceedings, reports, projects, textbooks, and internal Malcolm Pirnie reports from previous projects. The initial searches, which included a combination of descriptors below, did not yield any relevant references specific to UV and chlorination facilities.

- Carbon dioxide
- Energy conservation
- Environmental impact
- Gas emissions
- Nitrogen oxides

- Optimization
- Particulate emissions
- Pollution control
- Sulfur dioxide
- Sustainable
- Wastewater treatment

Subsequently, new searches were conducted with the key words, "Life Cycle Analysis." Although all of the "Life Cycle Analysis" articles covered topics other than the technologies of concern, the information in the references were relevant to the current study. A list of the authors, titles, and publication dates of the reviewed sources is included in Appendix A. To maintain confidentiality, titles or copies of internal Malcolm Pirnie reports from previous projects are not included; however, the findings from these reports are included in the discussion below.

Key findings and common themes from the literature search are described below.

1. Many articles described a side-by-side comparison of two or more alternatives where one alternative was recommended and all others were rejected. Other studies based the analysis on industry benchmarking such that the impacts were benchmarked to an industry standard as a means of comparison. For the current study, each disinfection alternative was compared independently from the other or industry benchmarks. This scenario enables the District to evaluate the impacts of each alternative in comparison to a "no-action" alternative.
2. The environmental impact categories included consumption of energy, land, water and other resources, and emissions to the air, water and land.
3. Impacts were evaluated based on phases; for example, the extraction of raw materials, construction and manufacturing phase, operation phase and final disposal phase.
4. Some examples of environmental impacts and environmental impact categories were presented in each article.
5. The boundaries of the system were defined with respect to geography, time, and concept.
6. Evaluating the environmental impacts has a subjective nature since relative weighting factors must be attributed to each environmental impact category. The weighting factors should reflect the views of the project stakeholders.
7. A unit was defined to assess the environmental impact of a process or system, for example, 100 population equivalents (p.e.).
8. The rankings considered the duration of the environmental impact.

The potential environmental impacts gathered during the literature search were prepared for the December 2007 Environmental Impact Identification Workshop discussion. Many of the themes from the literature search were also incorporated into the study.

2.3 Environmental Impact Identification Workshop

On December 14, 2007, Malcolm Pirnie conducted an Environmental Impact Identification Workshop with the District. The purpose of this workshop was to identify potential environmental impacts from implementation of the disinfection technologies through a brainstorming session. A list of potential environmental impacts and impact categories were compiled and discussed during the workshop. Many potential impacts were considered during the workshop, including impacts during gathering of raw materials, manufacturing, construction, and the maintenance/operation of the facilities. Impacts discussed during the workshop were further analyzed and evaluated as discussed in Section 4 of this report.

2.4 Environmental Action Agenda

In 2005, Mayor Daley revealed the *Chicago Environmental Action Agenda*[1] , which aims to establish environmentally-friendly goals for the operation of the City of Chicago Departments and other agencies. The proposed goals of the Agenda include the following:

- Reduce 6% of City's energy use based on 2000 energy use;
- Reduce 30% of energy at O'Hare Airport;
- Explore renewable energy sources including solar and wind power;
- Strive for zero carbon emissions from the City's energy use;
- Reduce 50% of emissions from City cars and buses based on 2003 emissions;
- Strive for zero-emissions fleet;
- Develop effective idle-reduction strategies for revenue and non-revenue fleets, including policies for enforcement;
- Install 10 million square feet of green space on building rooftops;
- Pursue landscape improvements that decrease the amount of impervious surfaces;

[1] Chicago Mayor Daley's Green Steering Committee (2006). *Environmental Action Agenda: Building the Sustainable City.*

- Incorporate permeable pavement into on-street parking lanes to reduce stormwater runoff;
- Complete construction and commission the McCormick Place Convention Center tunnel system which will cleanly divert stormwater runoff from the roof directly to Lake Michigan, saving the cost of unnecessarily treating millions of gallons of water each year;
- Apply source-separation to reduce waste streams going to the landfill;
- Ensure that all recyclable materials do not enter landfills;
- Reduce the number of large quantity hazardous waste generators;
- Minimize noise exposure at schools experiencing noise levels above 65 decibels Day Night Average Noise Level (DNL).

The goals of this Agenda were considered when developing and screening the environmental impacts for this study.

3 Establishment of the Baselines

To determine impacts of the proposed technologies, it is important to understand the usage of the District's existing infrastructure and equipment as a baseline for the study. The baseline is defined as the facilities and natural infrastructure elements – air, land, and water – currently controlled, accessed, or used by the District to manage loadings (i.e. emissions, discharges, disposals) from existing operations. These baseline data were developed for the current air, land, and water usage by the District at the North Side, Calumet, and Stickney water reclamation plants.

The following data were collected to establish the baseline for the existing District facilities and natural infrastructure. Information on the sources of data, the available documents from each source, and the specific data that were extracted from available documents are listed in Appendix B and summarized below.

- Obtained directly from the District: Information on the existing District facilities including its WRPs, aeration stations, pump stations, reservoirs, biosolids facilities, flow control in its waterways, current treatment processes, equipment, operation methods, and NPDES permits.
- Obtained from the District but also from other governmental agencies such as the US Geological Survey (USGS), Illinois State Water Survey (IL SWS), and from the offices of municipalities in the District service area: Data on the natural infrastructure and its uses including service area maps, CAWS, precipitation, habitat areas of specialized ecosystems, and names and boundaries of communities in the service area.

A summary of the findings from this review is as follows:

- The CAWS is comprised of approximately 76 navigable miles of river and canal infrastructure dedicated to use as drainage, commerce transport, and receiving water for reclamation and sanitation uses.
- Of the 565,312 acres making up its service territory and the surrounding watershed, the District converts 1,831 acres to industrial use, upon which seven water reclamation facilities are located.
- There are 35 reservoirs covering approximately 82,000 acres with 24,000 acre-feet of storage.

- 190,000 dry tons of biosolids are produced each year by the District's wastewater treatment processes.
- 4,400 miles of pipeline are buried underground, often below usable surface land.
- Some 556 million kWh of electricity and 3M therms of natural gas are used annually to process an average of 1.5 billion gallons per day of wastewater from all District facilities.
- The reported 2006 energy usage for the three plants was 384 million kWh ; 60 million kWh for North Side; 79 million kWh for Calumet; and 245 million kWh for Stickney.
- The Chicago area is currently not meeting the National Ambient Air Quality Standards for the criteria pollutants ozone and particulate matter. The District facilities, which are located in the Chicago non-attainment area, are thus regulated by air operating permits for ozone precursors (nitrogen oxides and volatile organic compounds) and particulate matter. These permitted emissions represent the maximum levels of emissions loading for District facilities.

These data were used to identify the air, land, and water assets comprising the environmental system in which the District operates, and the availability of the natural infrastructure to process the emissions and waste streams resulting from the construction and operation of the disinfection facilities. The figures in Appendix C represent a GIS-based depiction of this natural infrastructure baseline. The key data categories are: land use, sewage service areas, watershed, precipitation (additive water) and airshed/air quality.

These key data categories were grouped into three main areas: air, land, and water for the three WRPs, which were used for the baseline comparisons as discussed below. Specific baselines for other components or environmental impacts, such as safety and noise, were not developed because of limited available data and schedule and budget constraints.

3.1 Air Baseline

Air emissions generally come from two sources, those generated at the plant itself (emissions from boilers, gas turbines, waste burner units, ozone systems, etc.), and those from the energy plants that supply power to run the plants. These power plants are generally coal-based electric generating facilities.

The Clean Air Act of 1970 authorized the development of comprehensive federal and state regulations to limit emissions from both stationary (industrial) sources and mobile sources. Included in this act was the creation of the National Ambient Air Quality Standards (NAAQS) for six specific air pollutants. These pollutants were selected as indicators of air quality in the United States, and their standards were established to protect human health and welfare. Commonly referred to as "criteria pollutants," the six air pollutants are as follow: sulfur oxides (SO_x), carbon monoxide (CO), nitrogen oxides (NO_x), particulate matter (PM), ozone (O_3) and lead (Pb). For regulatory purposes, sulfur dioxide (SO_2) emissions are reported because they are the indicator of sulfur oxide concentrations in the ambient air. The District is also subject to the requirements established by IEPA for the ozone precursors (nitrogen oxides (NO_x) and volatile organic material (VOM)) because Cook County has been identified as a non-attainment area for ozone, as mentioned in Section 3.0.

Table 3-1 details each water reclamation plant's 2006 permitted and actual air emissions of the monitored criteria pollutants. Lead is not included because of the unlikelihood of its emission from the WRPs. The existing emissions were provided in the District's Annual 2006 Air Emission Reports. The permitted emissions were retrieved from the IEPA operating permits and represent the maximum levels of emissions loading for each WRP during normal operation.

Table 3-1
2006 Permitted and Reported Emissions of Criteria Pollutants from the North Side, Calumet, and Stickney WRPs

	North Side Emissions[1] (tons/yr)		Calumet Emissions[1] (tons/yr)		Stickney Emissions[2] (tons/yr)		TOTAL EMISSIONS (tons/yr)	
	Permitted	Reported	Permitted	Reported	Permitted	Reported	Permitted	Reported
NO_x	92.61	2.17	68.16	15.39	429.26	36.71	590	54
SO_2	7.16	0.05	51.91	0.73	273.21	7.79	332	9
CO	37.2	1.77	99.76	12.93	137.68	44.91	275	60
PM	6.4	0.16	5.15	1.17	57.01	2.69	69	4
VOM	5.9	0.12	16.02	3.02	325.85	37.22	348	40

1.Federally Enforceable State Operating Permit
2. Title V – Clean Air Act Permit Program (CAAPP) Operating Permit

Additionally, the emissions of the criteria pollutants NO_x and SO_2 resulting from energy consumption can be calculated with emission factors available through the "Emissions & Generation Resource Integrated Database" (eGRID) specifically for Illinois. Thus, the total baseline values for NO_x and SO_2 in Table 3-2 include the 2006 reported emission loadings from the WRPs (Table 3-1) and the emissions at the power generating facility resulting from coal-based energy production. The calculations are included in Appendix D. The overwhelming majority of air emissions are at the power generating facility due to energy production.

The calculated mercury (Hg) emissions (based on eGRID factors) resulting from coal-fired power production are also included in Table 3-2. Even at low levels, the tracking of Hg emissions is important as it is included in the USEPA's "Clean Air Act Amendments of 1990 List of Hazardous Air Pollutants" and in March 2005, USEPA issued the Clean Air Mercury Rule, which is the nation's first rule that regulates mercury emissions from coal-fired power plants.

Table 3-2
Estimated Air Emissions at the Power Generating Facility Due to Energy Production and Total Emissions of Regulated Pollutants

	Emissions at the WRPs	Emissions at the Power Generating Facility Resulting from Energy Utilized at the WRPs[2]			
	2006 Plant Emissions[1] (tons/yr)	North Side (tons/yr)	Calumet (tons/yr)	Stickney (tons/yr)	TOTAL AIR EMISSIONS (tons/yr)
NO_x	54	85	112	348	600
SO_2	9	307	403	1250	1970
Hg	NA	0.001	0.002	0.005	0.008

1. Criteria pollutant emissions from North Side, Calumet, and Stickney as reported in the District's 2006 Annual Air Emission Reports.
2. Estimated energy emissions from coal-based power plants are calculated using energy consumption at the North Side, Calumet, and Stickney plants and eGrid emission factors.

Six gases, commonly referred to as greenhouse gases were also included in the evaluation. These gases comprise of: carbon dioxide (CO_2), methane (CH_4), nitrous oxide

(N_2O), hydrofluoro-carbons (HFCs), perfluoro-carbons (PFCs) and sulfur hexafluoride (SF_6). Even though the District does not have permit limits for these gases, they are of concern on both global and local levels. Greenhouse gases are included in the 2005 Kyoto Protocol because of their potential to affect the global climate changes and global warming. The City of Chicago also has an initiative to reduce greenhouse gas emissions to pre-2005 levels. As such, greenhouse gases are an important consideration in this evaluation. Sources of these gases include combustion, natural gas, landfills, agriculture, and cars.

Table 3-3 presents the estimated emissions at the power generating facility related to each WRP for the most common greenhouse gasses: carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4). The existing emission loading for greenhouse gases were calculated, not measured, from the District's current (2006) electricity consumption and with eGrid emission coefficients specifically for Illinois. The calculations of air emissions are included in Appendix D.

Table 3-3
2006 Estimated Greenhouse Gas Emissions at the Power Generating Facility Due to Energy Production (tons/year)

	North Side	Calumet	Stickney	TOTAL
CO_2	46,800	61,400	190,700	298,900
N_20	0.54	0.71	2.21	3.5
CH_4	0.25	0.32	1.0	1.6
CO_2 equivalents[2]	46,900	61,700	191,400	300,000

1. Estimated energy emissions from coal-based power plants are calculated using energy consumption at the three plants and eGrid emission factors.
2. Carbon dioxide equivalents equal the sum of CO_2, $21*CH_4$, and $310*N_20$.

The criteria pollutant, mercury, and greenhouse gas emission data presented in this section were used as the baseline to compare the impacts of the additional airshed loadings from the disinfection technologies.

3.2 Land Baseline

The current land usage and allocated land for future projects at each facility are shown in Table 3-4. Data on allocated land was retrieved from the District's Master Plan for each facility. At the North Side plant, 87 acres of the total land area of 97 acres (90%) are currently in use or have been allocated for future use, including land that is currently leased to the Park District, such that they would not be available for future disinfection facilities. At the Calumet plant, 446 acres of the 470 acres (95%) are in use or allocated such that they would not be available for future disinfection facilities. At the Stickney plant, an estimated 404 acres of 570 acres (71%) are currently in use or already allocated for projects such that they would not be available for disinfection development.

The future allocated land includes the following projects:

- North Side: New final clarifiers
- Calumet: High level influent pumping station; New grit facilities/primary settling tanks; Aeration tanks/final settling tanks; and Central boiler facility
- Stickney: Primary clarifiers/pumping stations; Intermediate blower; Digester gas treatment building/digester gas holder, Waste gas burner and control building

Table 3-4
Current and Allocated Land Usage[1]

	North Side	Calumet	Stickney	TOTAL
Total Area (acres)	97	470	570	1137
Estimated Plant Area Currently in Use (acres)[2,3]	63	424	388	875
Estimated Plant Area Allocated for Future Projects (acres)[4]	24	22	16	62
Total Estimated Land Area in Use or Allocated (acres)	87	446	404	937
Percent Used or Allocated Land	90%	95%	71%	82%
Remaining Land[5] (acres)	10	24	166	200

1. Source: MWRDGC M&O Facilities Handbook, 2006, and WRP facility layouts
2. The areas are estimated using layouts of facilities and do not consider any underground structures that are not shown on the layouts.
3. At North Side, the current land in use includes land leased to the Park District.
4. Allocated land is set aside for future projects already identified to meet regulatory requirements and expansion needs as described in the District's Master Plan for each facility.
5. Some portion of the remaining land would be dedicated for disinfection.

The remaining land – 10 acres at North Side, 24 acres at Calumet, and 166 acres at Stickney – could include some area dedicated for disinfection.

3.3 Water Baseline

Water bills were used to estimate the current potable water usage at the North Side WRP. Shown in Table 3-5, the estimated water usage for the North Side plant equaled nearly 3.9 million gallons (MG) in 2007. This reflects an increase of approximately 20% from water usage reported in 2004 (3.2 MG). Water usage for the Stickney and Calumet

WRPs was not provided; thus, water usage was calculated at these WRPs based on flow proportioning.

In addition to the potable water usage, the impervious cover on the three WRPs has an impact on the runoff in the area. Assuming an historical average of 36.4 inches of precipitation per year, the estimated annual runoff from the existing buildings, pavements, and driveways at all three plants is 143 MG, as shown in Table 3-5. Runoff calculations are also included in Appendix D. Water usage and runoff will increase with implementation of disinfection as discussed in Section 4.

Table 3-5
Water Usage and Runoff

	North Side	Calumet	Stickney	Total
Average Daily Design Flow (mgd)[1]	333	319	1,250	1,900
2007 Onsite Water Usage (MG/yr)[2]	3.9	3.7	14.6	22
Estimated Existing Runoff (MG/yr)[3]	11	49	83	143

1. Design flows are from CTE's *Chlorination/Dechlorination Disinfection Cost Study for Stickney, Calumet and North Side Water Reclamation Plants*, May 2008
2. Onsite water usage is based on water bills for North Side, flow-proportioning was applied for Calumet and Stickney since water bills were not available.
3. WRP facility layouts were used to determine runoff areas; assuming an historical average of 36.4 inches of precipitation per year.

4 Additional Loadings and Quantification

As previously mentioned, our approach considered the life of the disinfection facilities and its impact to the environment within the service area from the source of equipment/raw material, through manufacturing, construction, operations, and eventual disposal. The following steps were performed to evaluate the loading potentials:

- Contacted manufacturers of the technologies to collect data on potential impacts related to the raw sources and manufacturing phases. Because of time and scope limitations, only manufacturers of the major disinfection equipment were contacted as part of this phase since these were likely to have the most significant impact during the manufacturing process. Manufacturers of the pumping, building, and other facility equipment/materials were not contacted.
- Developed a matrix to summarize the key impacts and ranked the most critical impacts.
- Identified and quantified the most critical impacts.

The goals of the above steps were to identify how the manufacturing, installation, operation, and disposal of the disinfection equipment would affect the air, land or water.

4.1 UV Manufacturers

Table 4-1 provides a list of the manufacturers/suppliers that were contacted to obtain information on the potential environmental impacts of manufacturing and transporting the proposed UV disinfection systems to the District's WRPs. These were the same suppliers that had been contacted previously during the preliminary design and cost estimation phase of the UV disinfection systems for the North Side and Calumet WRPs.

Table 4-1
UV Disinfection System Manufacturers

Supplier	Initial response	Final response
Trojan Technologies	Positive	Available, in Appendix E
Confidential Supplier	Positive	Confidential
Aquionics	Positive	Manufacturing is in Netherlands; no information will be available.
STS/Quay	None	None

Appendix E contains a copy of the blank questionnaire that was sent to each UV equipment manufacturer. The following information was requested in this questionnaire:

- Types and quantities of raw materials that are used in manufacturing/assembling of a UV disinfection system.
- Source of the raw materials used for manufacturing of the UV equipment.
- Method of shipping the final product to a client.
- Method of disposal of the UV lamps that contain mercury.

From Table 4-1, all but one UV supplier provided a positive initial response. Aquionics, which manufacturers the UV equipment in the Netherlands with global raw source materials, could not provide the requested information. The completed questionnaire from Trojan Technologies is provided in Appendix E; the confidential supplier also completed a questionnaire, but their response is not included in the Appendix. The potential impacts identified by these manufacturers are summarized below.

- **Air impacts from manufacturing**

  The manufacturing plants at Trojan Technologies (Trojan) and a Confidential Supplier use natural gas as a supplemental source of energy. Trojan reports an average of 8,500 m^3/month of natural gas at its manufacturing facility. Trojan also reports using 120,000 lamps, 40,000 ballasts and 70,000 quartz sleeves annually, and average of 3 million kWh/yr of energy. The Confidential Supplier uses an average of 730,000 kWh/yr of energy at their respective manufacturing facilities.

Based on information from Trojan, the assembly of the UV equipment requires 24 kWh of energy per lamp. Shown in Table 4-2, a total of 7,400 lamps per year for the North Side, Calumet, and Stickney plants[2] will consume an estimated 180,000 kWh/yr of energy. Annually, this is equal to 140 tons CO_2 equivalents in greenhouse gas emissions, 0.25 tons of NO_x emissions, 0.90 tons of SO_2 emissions, and 0.01 pounds of Hg emissions.

Table 4-2
Summary of Air Emissions from Energy Consumption during UV Equipment Assembly

Energy Requirement	180,000 kWh/yr
Greenhouse Gases	140 tons CO_2 equivalents/yr
NO_x	0.25 tons/yr
SO_2	0.90 tons/yr
Hg	0.01 pounds/yr

1. Carbon dioxide equivalents equal the sum of CO_2, $21*CH_4$, and $310*N_20$.

Transportation of the UV equipment contributes additional air emissions. According to Trojan, each reactor weighs approximately 22,000 lbs. The road-based transportation in North America releases carbon dioxide into the atmosphere. Trojan delivers its equipment from its facility near London (ON, Canada), which is approximately 400 miles by road from Chicago. Similarly, the Confidential Supplier is located approximately 460 miles by road from Chicago. The emissions from transportation are quantified in Section 4.6.1.

- **Water impacts from manufacturing**

Water is used at the manufacturing facilities by the employees and during manufacturing and testing of the UV equipment. Trojan uses an average of 2.5 MG/yr of water. Unless it is contaminated, all of the water used in testing of the UV equipment is recycled. At the Confidential Supplier's manufacturing site, less than 100 gallons of contaminated water is generated annually. The contaminated water is disposed of in accordance to environmental regulations. No direct discharges of any waste streams into a water body were reported by either manufacturer.

On average, over 100 gallons of hydraulic oil and glycol coolant are recycled at Trojan's manufacturing site per year. At the Confidential Supplier's manufacturing site, any mercury spills are cleaned up immediately using a

[2] CTE's *UV Disinfection Cost Study – North Side Water Reclamation Plant* (January 2008); the information for Stickney is from working results of the *Draft SWRP UV Cost Study* and the *Draft Hydraulic Evaluation Technical Memorandum* (June 2008)

mercury spill kit; the quantity of mercury spilled at the manufacturing site is typically less than 0.001 pound (0.5 grams) in a year.

- **Land impacts from manufacturing**

  The Trojan manufacturing plant is located on approximately 3 acres of urban land. The Confidential Supplier's manufacturing and storage facility is located in a light industrial park in a rural area.

  At its manufacturing facility, Trojan Technologies generates approximately 40 tons/yr of wood, 60 tons/yr of cardboard, 10 tons/yr of steel and 70 tons/yr of other solid waste. While the wood, cardboard, and steel waste is recycled, the other solid waste is sent to a landfill. Similarly, at the Confidential Supplier manufacturing facility, all recyclable solids such as cardboard, paper, plastic, and metal are recycled. Other trash is disposed in a standard dumpster, with less than one dumpster per week filled at the manufacturing facility. The UV lamps are recycled at the Confidential Supplier's manufacturing facility. Similarly, Trojan reports recycling UV lamps weighing approximately 6 tons/yr.

4.2 Chlorination/Dechlorination Manufacturers

Table 4-3 provides a list of the manufacturers/suppliers that were contacted to obtain information on the potential environmental impacts of manufacturing and transporting the chemicals, equipment, and pumps for the proposed chlorination/dechlorination systems at the District's WRPs. For consistency, the suppliers contacted for chlorination/dechlorination were the same as those contacted during the preliminary design and cost estimation phase.

Table 4-3
Chlorination/Dechlorination Disinfection System Manufacturers

Chemical / Equipment	Supplier	Initial response	Final response
1. Sodium Hypochlorite 2. Sodium Bisulfite	K. A. Steel Chemicals[a]	Positive	Limited[b]
	PVC Chemical[a]	Positive	None
	Hydrite Chemical Company	Positive	Limited[b]
	Olin Chlor Alkali Products	Negative	None
Mixers – Philadelphia Mixer Mills	Winfield Engineering Sales	Positive	None
Piping – Resistoflex kynar lined steel	Corrosion Fluid Products	Positive	Manufacturer will not provide requested information
Dosing Pumps – Bredel hose pumps & Milton Roy diaphragm pumps	Drydon Equipment	Positive	Manufacturer will not provide requested information as it is confidential
Transfer Pumps – ANSI – MAG seal-less magnetic centrifugal pumps	Corrosion Fluid Products	Positive	Manufacturer will not provide requested information
Steel bulk storage and day tanks	Kennedy Tanks	Positive	None

[a] Current supplier for Egan, Kirie, and Hanover Park WRPs
[b] Only name of manufacturing process provided. Other requested information is proprietary and hence not provided.

Appendix E contains a copy of the blank questionnaire that was sent to each chlorination/dechlorination supplier. The following information was requested in this questionnaire:

- Types and quantities of raw materials that are used in manufacturing/assembling of a chlorination/dechlorination disinfection system.
- The method of procurement of raw materials.
- Air/water/land used for manufacturing.
- Air/water/solids waste generated due to manufacturing.

From Table 4-3, all but one chlorination/dechlorination supplier provided a positive initial response with limited information received in the final responses for only the chemicals themselves.

K.A. Steel Chemicals (current sodium hypochlorite supplier for the District) reported that the method used for manufacturing sodium hypochlorite is chemical mixing through a Powell bleach process. In this method, water, caustic, and chlorine gas are mixed together to produce hypochlorite. Although this process does not require electricity specifically for hypochlorite production, the chlorine gas does require electricity during generation and poses a safety risk during handling and storage.

Some hypochlorite suppliers employ the electrolytic process, which uses only salt, water and electricity. In this process, hypochlorite is produced by the electrolysis of a brine solution without the safety risks associated with handling or storing chlorine gas. The chloride ions are oxidized at the anode to form chlorine gas, while sodium hydroxide and hydrogen gas are produced at the cathode. The chlorine that is generated then reacts with the sodium hydroxide to form sodium hypochlorite. It is the general consensus that the electrolytic process is more efficient and cost-effective, yields a purer chemical, and is safer since it does not involve chlorine gas.

On a molar basis, the dosing requirements for sodium bisulfite for dechlorination should be equal to the chlorine residual. The District's current supplier of sodium bisulfite, PVC Chemicals, did not provide any feedback on the manufacturing process or the energy required for chemical manufacturing. However, another manufacturer, Hydrite Chemical Company provided information on the most common procedure for manufacturing sodium bisulfite. In this process, sulfur is oxidized in the presence of air to produce sulfur dioxide, which is cooled and neutralized by caustic soda or soda ash to produce sodium bisulfite.

During the manufacturing of sodium bisulfite, natural gas is used to ignite the sulfur, and some electricity is used for the operation of pumps, mixers and other utilities at the manufacturing facility. A review of the basic chemistry[3] of burning sulfur to make SO_2 shows that once the sulfur is brought to its ignition point at 374°F, its oxidation generates most of the heat during combustion (3,980 BTU/lb) so the natural gas requirement is low. Judging from the other raw materials (caustic soda, water) and equipment (reaction tanks, pumps, etc.), the generation of sodium bisulfite is similar to the Powell bleach process with respect to energy consumption. Thus, energy use is also assumed to be small during the manufacturing of sodium bisulfite and is not quantified in Section 4.6.1. Other quantifiable impacts to the air, land, and water during manufacturing of chlorination/dechlorination are included in section 4.6.

[3] DTE Energy, Energy TechPro™ 2004 (http://energytechpro2.com/Demo-IC/MoreDetail/Combustion_Basics.htm)

4.3 Waste Streams from Manufacturing Facilities

Malcolm Pirnie reviewed the USEPA Toxic Chemical Release Inventory (TRI) (www.epa.gov/triexplorer) to search available data on potential waste streams from the UV and chlorination/dechlorination manufacturing operations. The TRI is a tool used for identifying potential releases of chemicals and other waste streams to the environment during manufacturing. As of November 2006, the TRI database contained over 650 chemical and chemical categories. For each chemical, facilities must report the quantity released to the air, water, land, underground (through injection), or off-site transfer for disposal. Manufacturing facilities (plant, factory or other facility) that meet the following criteria are required to report environmental releases in the TRI:

- Has 10 or more full-time employees, or the equivalent of 20,000 hours per year;
- Manufactures, imports, processes, or uses chemicals in quantities greater than the threshold value – for chlorine, the threshold value is 25,000 pounds; for mercury, the threshold value is 10,000 pounds;
- Releases waste streams in the United States.

A search of releases for the UV manufacturing facilities, suppliers of mercury bulbs, and other UV equipment suppliers yielded no results,, suggesting that these manufacturers did not meet the criteria for reporting to TRI. A search of the chlorine and dechlorination chemical manufacturers resulted in several matches, including Olin Corporation as documented in Appendix F. It should be noted that the reported values include releases from the manufacturing of all chemicals that is generated by the manufacturer, not just chlorine, so these results were not useful in the overall evaluation.

4.4 Matrix of Environmental Impacts

The potential impacts that were identified through the sources detailed above and the brainstorming session with the District were reviewed and categorized into two matrices, one for UV disinfection and another for chlorination/dechlorination. These matrices were used as a screening technique to capture the impacts and provide guidance on the selection of activities for quantification. Each matrix considers the life of the facilities, including source of raw material, manufacturing, facility construction, maintenance/operation, and salvage & disposal for each technology. These are shown as "activities" in the first column of the matrix (Table 4.4 and 4.5).

The environmental impact categories are shown in the first row of each matrix: Energy, Land Use, Labor Burden, Water Quality, Air Quality, Safety/Risk, Transportation, Waste Stream/Hazardous Material, Noise and Dust/Airborne Particles. These categories encompass both the consumption of environmental resources, and the emissions or discharges into the environment. Tables 4-4 and 4-5 summarize what was considered under each impact category for each activity.

Table 4-4 Explanation of UV Impacts and Matrix Components

Environmental Impact - UV	Energy	Land Use	Labor Burden	Water Quality	Air Quality	Safety/ Risk	Transportation	Waste Stream/ Hazardous Material	Noise	Dust/ Airborne Particles
	Coal usage, air emissions	Footprint	Mental/ physical challenges	Sediment, erosion, byproducts	VOC, SOC, toxic gas releases	Potential for leaks, explosions; operational risks	Air emissions from consumption of gas/oil	Chemical and solid waste stream /storage and disposal of hazardous materials	Community nuisance	Dust and particulates
Source										
Construction Materials	Energy for source materials and supplies; mining	Land needed for source materials and supplies; mining	Mental/ physical challenges of gathering source materials and supplies; mining	Sediment from mining; materials and byproducts into water supply	VOC, SOC, toxic air releases during source gathering	Potential for explosions; handling of mercury	Delivery of source materials	Wastes during source material retrieval/mercury	Noise during mining/ excavating of source materials	Dust generated from mining/excavating source materials
Building Equipment and Supplies										
UV Equipment and Supplies										
Manufacturing										
UV Equipment	Energy for assembly	Land needed for warehouses used to assemble equipment and products	Mental/ physical challenges of assembling equipment and handling hazardous material	Mercury or other releases	Air releases during assembly	Risks of assembly; handling mercury	Delivery of equipment and products	Waste during assembly; mercury waste	Noise during assembly	Dust generated from assembling equipment and products
Pumping Station Equipment										
Materials/products to support construction activities										
Power Transmission Line										
Facility Construction										
Building Construction Activities	Energy for building construction; lights	Footprint of building plus construction activity	Mental/physical challenges of facility construction	Introduction of building construction materials or hazardous materials into the water supply	VOC, SOC releases during construction	Falls, chemical leaks and other risks during construction	Concrete deliveries; deliveries during construction; diesel trucks	Waste from construction to landfill; handling of hazardous materials during construction	Noise during construction	Dust during construction activities
Construction waste	Energy for gathering and removing excess lumber, materials, etc.	Footprint of waste during construction		Introduction of pumping station construction materials into the water supply		Risks of handling construction waste; hazardous waste				
Site Work/Stormwater	Energy for grading, fences, lights and other site work	Footprint of site plus construction activity		Stormwater runoff		Hazardous waste exposure due to soil excavation and dewatering				
Pumping Station	Energy for pump station construction and lights	Footprint of pumping station plus construction activity		Introduction of pumping station construction materials into the water supply		Risks during construction				
Maintenance/Operation										
UV Equipment	Energy for operating/ maintaining the UV equipment	Any additional Footprint needed for UV equipment maintenance/ operation	Mental/physical challenges of changing bulbs, maintenance and inspections; potential dermal and airborne exposure to workers related to maintenance and handling of the lamps	Mercury releases; cleaning chemicals in water supplies	VOC, SOC, toxic gas releases	Potential exposure resulting form breakage of the lamps while on line	Traffic to site due to workers, visitors and deliveries	Bulb disposal, mercury and glass, cleaning waste	Noise generated during maintenance and operation	Dust during maintenance and operation
Pumping Equipment	Energy for operating/ maintaining the pumping equipment	Any additional Footprint needed for pump sta. maintenance/ operation	Mental/physical challenges of handling large pumps and pump inspections or maintenance	Chemicals or materials into water supply		Risks of handling equipment/hazardous waste		Waste from pumping equipment		
Analytical Equipment	Energy for operating/ maintaining the analytical equipment	Any additional Footprint needed for analytical equpment maintenance/ operation	Mental/physical challenges of operating, calibrating and maintaining the analytical equipment					Reagents and used laboratory materials		
Building M&O	Energy for operating/ maintaining the building	Any additional Footprint needed for building maintenance/ operation	Mental/physical challenges of maintaining the building	Introduction of chemicals from the building into the water supply				Cleaning activities, worker and construction related debris such as food, paper, trash, cardboard, aluminum, plastic, etc.		
Site M&O	Energy for operating/ maintaining the site	Any additional Footprint needed for site maintenance/ operation	Mental/physical challenges of maintaining the site	Sediment/ chemical runoff from site				Yard waste, chemicals used for the site		
Salvage and Disposal										
UV Equipment	Energy for salvaging and disposing of the equipment	Footprint in landfill	Mental/physical challenges of salvage and disposal	Water quality effects of landfill disposal	VOC, SOC, toxic gas releases during salvage and disposal	Risk of handling mercury and broken bulbs during disposal Risk of handling hazardous wastes during salvage and disposal	Transportation of equipment for salvage and disposal	Waste generated during salvage and disposal	Noise of salvaging and disposal activities	Dust generated during salvaging and disposal of equipment
Building Equipment										
Electrical Equipment										
Pumping Equipment										

Table 4-5 Explanation of Chlorination/Dechlorination Impacts and Matrix Components

Environmental Impact - Chlorination/Dechlorination	Energy	Land Use	Labor Burden	Water Quality	Air Quality	Safety/ Risk	Transportation	Waste Stream/ Hazardous Material	Noise	Dust/ Airborne Particles
	Coal usage, air emissions	Footprint	Mental/ physical challenges	Sediment, erosion, byproducts	VOC, SOC, toxic gas releases	Potential for leaks, explosions; operational risks	Air emissions from consumption of gas/oil	Chemical and solid waste stream /storage and disposal of hazardous materials	Community nuisance	Dust and particulates
Source										
Construction Materials	Energy for source materials and supplies; mining	Land needed for source materials and supplies; mining	Mental/ physical challenges of gathering source materials and supplies; mining	Sediment from mining; materials and byproducts into water supply	VOC, SOC, toxic air releases during source gathering	Potential for explosions	Delivery of source materials	Wastes during source material retrieval	Noise during mining/ excavating of source materials	Dust generated from mining/excavating source materials
Building Equipment and Supplies										
Chlor/Dechlor Equipment and Supplies										
Manufacturing										
Chlor/Dechlor Chemicals and Equipment	Energy for assembly	Land needed for warehouses used to assemble equipment and products	Mental/ physical challenges of assembling equipment and handling hazardous material	Releases to the water supply	Air releases during assembly	Risks of assembly	Delivery of equipment and products	Waste during assembly	Noise during assembly	Dust generated from assembling equipment and products
Analytical & Monitoring Equipment										
Metering Pumps and Spill Control Equipment										
Pumping Station Equipment										
Materials/products to support construction activities										
Power Transmission Line										
Facility Construction										
Building Construction Activities	Energy for building construction; lights	Footprint of building plus construction activity	Mental/physical challenges of facility construction	Introduction of building construction materials or hazardous materials into the water supply	VOC, SOC releases during construction	Falls, chemical leaks and other risks during construction	Concrete deliveries; deliveries during construction; diesel trucks	Waste from construction to landfill; handling of hazardous materials during construction	Noise during construction	Dust during construction activities
Chlorine Contactor Tanks Construction	Energy for construction; lights	Footprint of contactors plus construction activity								
Construction waste	Energy for gathering and removing excess lumber, materials, etc.	Footprint of waste during construction		Introduction of pumping station construction materials into the water supply		Risks of handling construction waste; hazardous waste				
Site Work/Stormwater	Energy for grading, fences, lights and other site work	Footprint of site plus construction activity		Stormwater runoff		Hazardous waste exposure due to soil excavation and dewatering				
Pumping Station	Energy for pump station construction and lights	Footprint of pumping station plus construction activity		Introduction of pumping station construction materials into the water supply		Risks during construction				
Maintenance/Operation										
Chlor/Dechlor Units and Storage	Energy for operating/maintaining the equipment	Any additional Footprint needed for equipment maintenance/ operation	Mental/physical challenges of changing bulbs, maintenance and inspections; potential dermal and airborne exposure to workers related to maintenance and handling of the equipment	Chemicals or materials into water supply; DBPs	VOC, SOC, toxic gas releases	Potential chemical exposure	Traffic to site due to workers, visitors and deliveries	Chemical disposal, cleaning waste	Noise generated during maintenance and operation	Dust during maintenance and operation
Chlorine Contact Tanks										
Metering Pumps and Spill Control Equipment										
Pumping Equipment	Energy for operating/maintaining the pumping equipment	Any additional Footprint needed for pump sta. maintenance/ operation	Mental/physical challenges of handling large pumps and pump inspections or maintenance			Risks of handling equipment/hazardous waste		Waste from pumping equipment		
Analytical Equipment	Energy for operating/maintaining the analytical equipment	Any additional Footprint needed for analytical equpment maintenance/ operation	Mental/physical challenges of operating, calibrating and maintaining the analytical equipment					Reagents and used laboratory materials		
Building M&O	Energy for operating/maintaining the building	Any additional Footprint needed for building maintenance/ operation	Mental/physical challenges of maintaining the building	Introduction of chemicals from the building into the water supply				Cleaning activities, worker and construction related debris such as food, paper, trash, cardboard, aluminum, plastic, etc.		
Site M&O	Energy for operating/maintaining the site	Any additional Footprint needed for site maintenance/ operation	Mental/physical challenges of maintaining the site	Sediment/ chemical runoff from site				Yard waste, chemicals used for the site		
Salvage and Disposal										
Chlor/Dechlor Equipment	Energy for salvaging and disposing of the equipment	Footprint in landfill	Mental/physical challenges of salvage and disposal	Water quality effects of landfill disposal	VOC, SOC, toxic gas releases during salvage and disposal	Risk of handling chemicals	Transportation of equipment for salvage and disposal	Waste generated during salvage and disposal	Noise of salvaging and disposal activities	Dust generated during salvaging and disposal of equipment
Building Equipment						Risk of handling hazardous wastes during salvage and disposal				
Electrical Equipment										
Pumping Equipment										

Although Energy, Air Quality, Transportation, and Dust/Airborne Particles all generally incorporate aspects of air pollution, listing these categories individually enables tracking of the air pollution impacts from each of these sectors. For example, the Energy impact category includes air emissions during energy production and use (from coal), while Transportation takes into account air pollution due to car emissions. Dust/Airborne Particles consider the chronic response of dust and small, solid particles in the air. In contrast, the Air Quality category includes acute responses from potential VOCs, SOCs and other toxic gas releases.

Exposure to chemicals is included in the Safety/Risk category and not the Waste Stream/Hazardous Material category. The difference between these two impact categories is dependent on the fate. The Waste Stream/Hazardous Material category considers the ending point of a chemical and its potential adverse effect on the environment. For example, a chemical spill poses a safety concern due to exposure, which would be documented under the Safety/Risk category. The potential for the spill to cause a change in pH of the receiving body upon disposal would be documented under the Waste Stream/Hazardous Material category.

As shown in Table 4-6, each category was assigned a relative weighting factor. Categories with a weighting factor of "5" were determined by Malcolm Pirnie and the District to be the most important category with respect to the environmental impact.

Table 4-6
Weighting Factors and Description of the Impact Categories

Impact Category	Weighting Factor (1-5)	Description
Energy	5	Coal usage, air emissions
Land Use	5	Footprint, introduction of impervious material, tree removal, removal of open space
Water Quality	5	Sediment, erosion, byproducts
Air Quality	5	VOCs, SOCs, toxic gas releases (acute response)
Safety/Risk	5	Leaks, explosions, operational risks, chemical exposure, handling of chemicals and mercury (UV only)
Labor Burden	3	Mental/physical challenges
Transportation	3	Emissions from consumption of gas/oil
Waste Stream/Hazardous Material	3	Chemical and solid waste streams/storage and disposal of hazardous materials
Dust/Airborne particles	3	Dust or small, fine, solid particles in the air
Noise	2	Community nuisance

With input from the District, the categories in the matrix were subjectively ranked according to the perceived level of impact, as shown in Table 4-7 and Table 4-8. As mentioned earlier, these matrices were used as a screening technique to prioritize and focus the activities that would be quantified in more detail. The key for the matrix rankings is as follows:

1 - No Impact
2 - Minimal Impact
3 - Some Impact
4 - Significant Impact
5 - Greatest Impact

A ranking of "5" has the greatest environmental impact relative to each of the activities in the matrix, and a ranking of "1" has "no impact." The rankings and weighting factors included input from the District. The value in each cell was determined by the product of the weighting factor for each category and the ranking of each activity. The sum of each cell was then calculated to determine the weighted sum for that particular activity. The highlighted line items in each matrix (Table 4-7 and Table 4-8) are the activities that could potentially pose the greatest overall environmental impact to each category based on the weighted sums and will be further quantified later in this report.

The duration of the environmental impact was considered when assigning the rankings. Activities listed under the "manufacturing" phase consider only the environmental impacts during manufacturing; likewise, the "facility construction" impacts are only applicable when the facilities are under construction. Only direct impacts of the activities were considered. As a result, secondary impacts such as bioaccumulation and soil degradation, which require more detailed evaluations and larger data sets, were not considered in the screening process.

The rankings in both matrices show that even though the operation and maintenance of the facilities over a 20-year period will have the greatest energy requirements (and associated air emissions), the activities during the 3-year construction phase will affect a greater number of environmental impact categories.

Table 4-7 Potential Environmental Impacts of UV Disinfection

Environmental Impact - UV	WEIGHTED SUM	Energy	Land Use	Water Quality	Air Quality	Safety/ Risk	Labor Burden	Transport-ation	Waste Stream/ Hazardous Material	Dust/ Airborne Particles	Noise
weighting factor		5	5	5	5	5	3	3	3	3	2
Source											
Construction Materials	96	2	2	3	3	2	2	3	2	3	3
Building Equipment and Supplies	91	2	2	2	3	2	2	3	2	3	3
UV Equipment and Supplies	107	2	2	2	3	4	2	3	4	3	3
Manufacturing											
UV Equipment	127	3	2	3	5	4	4	3	4	1	3
Pumping Station Equipment	93	3	2	2	2	3	3	3	2	1	3
Materials/products to support construction activities	99	3	2	3	2	3	3	3	3	1	2
Power Transmission Line	93	3	2	2	2	3	3	3	2	1	3
Facility Construction											
UV Building Construction Activities	133	3	4	3	1	4	4	4	3	5	5
Construction waste	108	2	3	3	1	4	3	3	4	3	2
Site Work/Stormwater	117	2	4	5	1	3	3	3	2	4	3
Pumping Station	125	2	5	3	1	4	4	4	2	4	4
Maintenance/Operation											
UV Equipment	117	5	1	1	1	5	5	5	5	1	2
Pumping Equipment	83	4	1	1	1	3	3	3	2	1	3
Analytical Equipment	58	2	1	1	1	2	2	2	2	1	1
Building M&O	95	3	1	2	2	3	3	4	3	2	2
Site M&O	92	2	1	3	2	3	3	3	3	2	2
Salvage and Disposal											
UV Equipment	102	2	3	3	1	4	4	2	3	2	2
Building Equipment	86	2	3	2	1	3	3	2	2	2	2
Electrical Equipment	78	2	2	2	1	3	2	2	2	2	2
Pumping Equipment	70	2	2	2	1	2	2	2	1	2	2

Table 4-8 Potential Environmental Impacts of Chlorination/Dechlorination

Environmental Impact - Chlorination/Dechlorination	WEIGHTED SUM	Energy	Land Use	Water Quality	Air Quality	Safety/ Risk	Labor Burden	Transport-ation	Waste Stream/ Hazardous Material	Dust/ Airborne Particles	Noise
weighting factor		5	5	5	5	5	3	3	3	3	2
Source											
Construction Materials	96	2	2	3	3	2	2	3	2	3	3
Building Equipment and Supplies	91	2	2	2	3	2	2	3	2	3	3
Chlor/Dechlor Equipment and Supplies	91	2	2	2	3	2	2	3	2	3	3
Manufacturing											
Chlor/Dechlor Chemicals and Equipment	102	2	2	3	2	4	3	3	4	1	2
Analytical & Monitoring Equipment	89	2	2	2	2	3	3	3	3	1	2
Metering Pumps and Spill Control Equipment	78	2	2	2	2	2	3	2	2	1	2
Pumping Station Equipment	93	3	2	2	2	3	3	3	2	1	3
Materials/products to support construction activities	99	3	2	3	2	3	3	3	3	1	2
Power Transmission Line	93	3	2	2	2	3	3	3	2	1	3
Facility Construction											
Building Construction Activities	133	3	4	3	1	4	4	4	3	5	5
Chlorine Contactor Tanks Construction	98	2	3	3	1	3	3	3	1	3	4
Construction waste	108	2	3	3	1	4	3	3	4	3	2
Site Work/Stormwater	117	2	4	5	1	3	3	3	2	4	3
Pumping Station	125	2	5	3	1	4	4	4	2	4	4
Maintenance/Operation											
Chlor/Dechlor Units and Storage	96	2	1	1	1	5	3	5	5	1	2
Chlorine Contact Tanks	76	2	1	2	1	3	3	2	3	1	2
Metering Pumps and Spill Control Equipment	70	2	1	1	1	3	3	2	2	1	3
Pumping Equipment	83	4	1	1	1	3	3	3	2	1	3
Analytical Equipment	58	2	1	1	1	2	2	2	2	1	1
Building M&O	95	3	1	2	2	3	3	4	3	2	2
Site M&O	92	2	1	3	2	3	3	3	3	2	2
Salvage and Disposal											
Chlor/Dechlor Equipment	78	2	3	2	1	2	2	2	2	2	2
Building Equipment	86	2	3	2	1	3	3	2	2	2	2
Electrical Equipment	78	2	2	2	1	3	2	2	2	2	2
Pumping Equipment	70	2	2	2	1	2	2	2	1	2	2

4.5 Determination of Quantifiable Impacts

Tables 4-9 and 4-10 summarize the activities with the greatest weighted sums for UV and chlorination/dechlorination as highlighted in Tables 4-7 and 4-8. The categories that can be quantified are marked with a check and will be further evaluated in Section 4.6.

Table 4-9
Quantifiable Potential Environmental Impacts of UV Disinfection

Activity	Impact Category					
	Energy	Land Use	Water Quality	Transpo rtation	Waste Stream/ Hazardous Material	Noise
Manufacturing						
UV Equipment	(1)	(1)	(1),(2)	✓	(1), (2)	(1), (2)
Materials/products to support construction activities	(2)	(1), (2)	(1), (2)	(1)	(1), (2)	(1), (2)
Facility Construction						
UV Building Construction Activities	(2)	✓	(2)	✓	(2)	✓
Construction Waste	(2)	(2)	(2)	✓	(2)	✓
Site Work/Stormwater	(2)	✓	(2)	✓	(2)	✓
Pumping Station	(2)	✓	(2)	✓	(2)	✓
Maintenance/Operation						
UV Equipment	✓	N/A	(2)	✓	✓	✓
Salvage and Disposal						
UV Equipment	(2)	✓	(2)	(2)	✓	(2)

(1) Not quantified - Impact outside the study area
(2) Not quantified - Difficult to quantify because of limited or non-existent data

Table 4-10
Quantifiable Potential Environmental Impacts of Chlorination/Dechlorination

Activity	Impact Category					
	Energy	Land Use	Water Quality	Transportation	Waste Stream/ Hazardous Material	Noise
Manufacturing						
Chlor/Dechlor Chemicals and Equipment	✓	(1)	(1),(2)	✓	✓	(1), (2)
Materials/products to support construction activities	(2)	(2)	(2)	(2)	(2)	(2)
Facility Construction						
Building Construction Activities	(2)	✓	(2)	✓	(2)	✓
Chlorine Contactor Tanks Construction	(2)	✓	(2)	✓	(2)	✓
Construction waste	(2)	(2)	(2)	✓	(2)	✓
Site Work/Stormwater	(2)	✓	(2)	✓	(2)	✓
Pumping Station	(2)	✓	(2)	✓	(2)	✓
Maintenance/Operation						
Chlor/Dechlor Units and Storage	✓	N/A	(2)	✓	✓	✓
Building M&O	(2)	N/A	(2)	✓	(2)	✓

(1) Not quantified - Impact outside the study area
(2) Not quantified - Difficult to quantify because of limited or non-existent data

Certain impacts for a particular activity were excluded because they were either outside the study area or difficult to quantify because of limited or non-existent data, identified by (1) or (2). Any activity under "Source" in Table 4-7 and Table 4-8 was not listed as quantifiable since the collection of raw material typically occurs outside the study area. However, this does not suggest that this activity will not have an impact to the environment. For example, the mining of coal (which is outside the study area) to support the high energy usage for these technologies will significantly affect safety, transportation, depletion of natural resources, dust emissions, and land use of the area that coal is mined, but not the study area.

The maintenance and operation of the pumping station for both UV and Chlorination-Dechlorination is not among the activities with the greatest weighted sum identified in the matrices (Table 4-7 and 4-8). However, because the matrices are only used as a screening tool, after further review of the activities, it was included as one of the activities to be further quantified (in Section 4.6) due to its significant energy consumption and associated air emissions within the study area.

The following impact categories are not quantifiable, but the additional disinfection will adversely affect the environment within the study area as described below:

- Safety/Risk – the plant staff and operators are exposed to greater risk through potential of leaks, large quantities of chemical storage, chemical spills, electric shock, and mercury contact through breakage of UV bulbs. These risks will be most significant during the operation and maintenance of the facilities.
- Labor Burden – the operators will have additional mental and physical challenges with the operation of the disinfection system and the additional mundane and tedious labor requirements associated with extensive bulb replacements or chemical deliveries. From CTE's *UV Disinfection Cost Study – North Side Water Reclamation Plant* (January 2008), the North Side and Calumet WRPs will each require 16 hours per day for UV operation, 80 hours per week for lamp cleaning/inspection, and 16 hours per week for lamp replacement. From CTE's *Chlorination/Dechlorination Disinfection Cost Study for Stickney, Calumet and North Side Water Reclamation Plants* (May 2008) chemical deliveries for sodium hypochlorite and sodium bisulfite will occur a total of approximately 170 times per week for the three plants. Additionally, operation and maintenance of the chlorination/dechlorination system will require 20 hours per day at each facility.
- Dust/Airborne particles – Small particles may become airborne during the construction phase, which will last approximately 3 years. Typically, dust barriers are provided on the site to keep construction dust from leaving the work area.
- Air Quality (VOCs and SOCs) – For each of the technologies, the most likely source of VOCs or SOCs that may be discharged into the atmosphere will be during the manufacturing process of the equipment and building materials, or emissions from cars and semi-trucks. Quantifying the discharges from each of the operations was not practical for this study, but additional VOC/SOC emissions could increase ground level formation of ozone, which leads to smog formation. These emissions can also be carcinogenic if inhaled.
- Disinfection Byproducts – UV disinfection shows no evidence of increased disinfection byproducts at the doses typically applied. With chlorination, microbial inactivation must be balanced with the risks of byproduct formation. On a weight basis, trihalomethanes and haloacetic acids account for the majority of byproducts of chlorination. Disinfection byproducts formation has been addressed in a disinfection risk assessment completed for the District in April

2008.[4] The authors of this study state that the "inventory of DBPs that have the potential to cause adverse health effects is large and highly variable among publicly owned treatment works (POTW) effluents." Further, because the effects of disinfection byproducts are chronic in nature, their health effects are better described through epidemiological or toxicological studies.

The addition of bisulfite for dechlorination may also lead to the formation of disinfection byproducts. From the District's risk assessment, not much is known about the kinetics of reactions between bisulfite and organic combined chlorine. Studies were cited indicating that "some organic chloramines are recalcitrant to S(IV)-based dechlorination and may cause toxicity in dechlorinated wastewater effluent." Additional studies were cited in the risk assessment showing that bisulfite applied for dechlorination "was capable of removing 87% to 98% of residual chlorine, but the remainder, which may exceed regulatory limits [and contribute to disinfection byproduct formation], was very slowly reduced."

In summary, the activities that will be further evaluated and quantified according to its potential impact on the air, land, or water are:

<u>Air</u>

- Energy consumption and associated air emissions during operation of the UV or chlorination/dechlorination equipment and sodium hypochlorite manufacturing;
- Energy consumption and associated air emissions during the operation of the UV or chlorination/dechlorination low lift pumping station;
- Air emissions as a result of the increased traffic from construction, maintenance/operation, and deliveries; and
- Noise associated with the construction and operation of the facilities.

<u>Land</u>

- Land requirements for each facility;
- Modifications to the land during construction such as reduction of open space and additional impervious area;
- Landfill needs for disposal of UV equipment or mercury; and
- Reduction of available space for future expansions.

[4] *Dry and Wet Weather Risk Assessment of Human Health Impacts of Disinfection vs. No Disinfection of the Chicago Area Waterways System (CWS),* Geosyntec Consultants, April 2008.

Water

- Water requirements for facility during construction and operation; and
- Stormwater runoff.

4.6 Quantification of Impacts

4.6.1 Impacts to the Air

UV manufacturing

Sections 4.1 and 4.2 describe the air, water, and land impacts during manufacturing of the disinfection equipment. As reported in Section 4.1, the current UV suppliers are located outside of the study area that is defined in Section 1.4. Although the impacts of UV manufacturing are quantifiable for the global community, the manufacturing practices or land use would not specifically impact the District unless a UV supplier started operations within the study area. Impact to the air due to delivery of the equipment from the study area boundary to each facility is included in the "Transportation" section below.

Chlorination/Dechlorination manufacturing

For chlorination, the method used for hypochlorite manufacturing by the current District supplier is chemical mixing through a Powell bleach process as described in Section 4.2. Only the chlorine gas required for the Powell process requires significant electricity and is currently manufactured outside of the study area. If the chlorine gas is produced at a location outside of the study area, energy consumption is not an impact for hypochlorite manufacturing through the Powell process. However, it is possible that the current supplier may start producing chlorine gas for hypochlorite manufacturing onsite, or may switch to the electrolytic process for hypochlorite production in the future, which also consumes significant amounts of electricity. Alternatively, the District may bid the sodium hypochlorite contract to another supplier (based on a low-bid process) that employs the electrolytic manufacturing approach within the study area. Reasons to switch to an electrolytic process for hypochlorite generation, as presented in Section 4.2, include: a more efficient and cost effective process, purer chemical yield, and increased safety. Thus, the environmental impact of energy use during hypochlorite production is considered.

The electrolytic process that is used by some manufacturers for the production of hypochlorite is similar to onsite generation of hypochlorite. Typically, onsite generation of hypochlorite requires approximately 2.5 kWh/lb as Cl_2 generated from the generation unit, in addition to the smaller demands of the blower for hydrogen dilution and feed system.

Approximately 25 million pounds of chlorine[5] are required to meet the disinfection requirements at the North Side, Calumet, and Stickney plants during the 9-month disinfection period. Assuming 2.5 kWh/lb, an estimated 62 million kWh are consumed annually during manufacturing, which is an increase of 16% from the current energy use of 384 million kWh/yr. Summarized in Table 4-11, annually, this is equal to nearly 48,400 tons CO_2 equivalents in greenhouse gas emissions (includes CO_2, 21 times CH_4 and 310 times N_2O), 90 tons of NO_x emissions, 320 tons of SO_2 emissions, and 3 pounds of Hg emissions. The manufacturing of chlorination chemicals requires significant increase in energy consumption and is the second largest potential environmental impact, following UV operation, which is described in the following section.

Table 4-11
Energy Consumption and Air Emissions from the Power Generating Facility Due to the Manufacturing of Sodium Hypochlorite

	North Side	Calumet	Stickney	Total
Energy Requirement (million kWh/yr)	10.9	10.4	40.7	62
CO_2 (tons/yr)	8,500	8,100	31,600	48,200
CH_4 (tons/yr)	0.04	0.04	0.17	0.3
N_2O (tons/yr)	0.10	0.09	0.37	0.6
NO_x (tons/yr)	15.4	14.8	58	90
SO_2 (tons/yr)	55	53	207	320
Hg (tons/yr)	0.00024	0.00023	0.0009	0.0014

Operation of UV and chlorination equipment and pumping stations

The operation of UV at the three WRPs will also require a significant increase in energy usage and is the largest potential environmental impact of disinfection. For example, to implement only the UV disinfection technology (not including the pump stations) at the North Side, Calumet, and Stickney WRP's, the District would expend an additional 96 million kWh of electricity during 9 months of operation, which is an increase of 25% from the current energy use of 384 million kWh/yr. That additional electricity expenditure would result in greenhouse gas emissions loading of 74,300 tons per year

5. CTE's *Chlorination/Dechlorination Disinfection Cost Study for Stickney, Calumet, and North Side Water Reclamation Plants*, May 2008

from the power generating facility due to UV equipment operation alone. Comparatively, the operation of the chlorination/dechlorination equipment will have a small impact on energy consumption, (equal to an increase of 0.3%). The calculations to determine the estimated energy requirements for the operation of UV and chlorination/dechlorination equipment are included in Appendix D.

A summary of the additional energy requirements and air emissions for the operation of the UV or chlorination/dechlorination equipment are shown below in Tables 4-12 and 4-13. Similarly, a summary of additional energy requirements and air emissions for the operation of the pumping station are shown below in Table 4-14 and 4-15. Described in Section 3, the air emission loadings were calculated from eGRID emission coefficients based on the energy consumption. Emission coefficients are currently available only for the air pollutants that are included in Table 4-13 and Table 4-15.

Table 4-12
Estimated Energy Requirements for UV and Chlorine Disinfection (Equipment Operation Only) at North Side, Calumet, and Stickney WRPs

	North Side	Calumet	Stickney	Total
Average Day Design Flow	333	319	1,250	1902
UV Energy Requirement (Million kWh/yr)	19.9	18.1	57.6	96
Chlorination/Dechlorination Energy Requirement[2] (Million kWh/yr)	0.15	0.57	0.43	1.2

1. The proposed disinfection will be applied March-November.
2. Power includes operation of the transfer pumps, feed pumps, and mixers for chlorination/dechlorination. At North Side and Stickney, design assumes one new mixing chamber for each chemical with one mixer each (two total mixers at each plant). At Calumet, design assumes reusing the existing contact tanks and splitting flow such that two mixing chambers are required for each chemical with one mixer each (four total mixers). The additional mixers result in higher energy use at the Calumet WRP. Source: *Chlorination/Dechlorination Disinfection Cost Study for Stickney, Calumet and North Side Water Reclamation Plants* (CTE, May 2008)

Table 4-13
Estimated Emissions Loading Increase at the Power Generating Facility due to UV and Chlorination (Equipment Operation Only)

		North Side	Calumet	Stickney	TOTAL
Estimated UV Loading Increase (tons/yr)	NO_x	28.2	25.7	82	140
	SO_2	101	92	294	490
	CO_2	15,500	14,100	44,800	74,300
	CH_4	0.08	0.07	0.2	0.4
	N_2O	0.18	0.16	0.5	0.9
	Hg	0.00043	0.00040	0.0013	0.002
Estimated Chlorination/Dechlorination Loading Increase (tons/yr)	NO_x	0.21	0.82	0.61	1.6
	SO_2	0.8	2.9	2.2	5.9
	CO_2	120	450	330	900
	CH_4	0.001	0.0024	0.0018	0.005
	N_2O	0.0014	0.0052	0.0039	0.01
	Hg	0.000003	0.000010	0.000009	0.00003

Table 4-14 presents the energy requirements for the UV and chlorination/dechlorination pump station operation. The total energy represents an increase of approximately 8% from the current energy use of 384 million kWh/yr at the three plants for both UV and chlorination/dechlorination. The corresponding air emissions from the energy requirements are shown in Table 4-15.

Table 4-14
Pumping Station Operation Energy Requirements for UV and Chlorination/Dechlorination

	North Side	Calumet	Stickney	TOTAL
UV Pump Station Energy Requirement (Million kWh/yr)	2.3	2.1	26.5	30.9
Chlorination/Dechlorination Pump Station Energy Requirement (Million kWh/yr)	2.3	2.3	27.5	32.1

Table 4-15
Estimated Emissions Loading Increase at the Power Generating Facility Due to Pumping Station Operation

		North Side	Calumet	Stickney	TOTAL
Estimated UV Loading Increase (tons/yr)	NO_x	3.3	2.9	38	44
	SO_2	11.9	10.5	135	157
	CO_2	1,820	1,600	21,000	24,000
	CH_4	0.01	0.01	0.11	0.1
	N_2O	0.02	0.02	0.24	0.3
	Hg	0.000051	0.000045	0.00058	0.0007
Estimated Chlorination/Dechlorination Loading Increase (tons/yr)	NO_x	3.3	3.2	39	46
	SO_2	11.9	11.6	140	164
	CO_2	1,820	1,780	21,400	25,000
	CH_4	0.01	0.01	0.11	0.1
	N_2O	0.02	0.02	0.25	0.3
	Hg	0.000051	0.000050	0.0006	0.0007

Transportation

Facility construction and maintenance/operation will require transportation of materials and people by gasoline-based cars and trucks, which will increase the emissions loadings to the air. The following transportation is expected during the construction and maintenance/operation phases.

- Delivery of concrete and materials, and workers' transportation during construction for 3 years (52 weeks per year, 5 days per week and 8 hours per day).
- Delivery of UV bulbs, delivery of chemicals, and workers' transportation during maintenance and operation for 20 years (52 weeks per year, 7 days per week and 24 hours per day).
- Delivery of the disinfection equipment during installation.

Transportation emissions from employee commuting are assumed to occur over the entire year, including the three months of the year when the disinfection equipment is not in service. For chlorination/dechlorination, based on the volume of chemicals used per day and truck capacity, there will be an estimated total of 170 deliveries per week for chemical delivery alone at the three plants in the 9-month disinfection period.

According to the USEPA Office of Transportation and Air Quality, several components are included in vehicle emissions such as hydrocarbons, carbon monoxide, nitrous oxides, and carbon dioxide. However, the largest contributor to vehicle emissions is carbon dioxide; every gallon of gasoline or diesel that is burned produces approximately 20 pounds of CO_2. Table 4-16 presents the estimated annual carbon dioxide emissions from transport of materials and equipment, idling of vehicles, and employee commuting during construction and maintenance/operation of the disinfection facilities.

In the 3 years of construction and 20 years of maintenance/operation, transportation would result in the total release of 6,800 tons of CO_2 for UV, and 15,200 tons of CO_2 for chlorination/dechlorination. Detailed calculations are included in Appendix D.

Table 4-16
Annual CO_2 Emissions During 3-Year Construction and 20-Year O&M Phases

	UV (tons CO_2/yr)	Chlor/Dechlor (tons CO_2/yr)
Construction	450	480
Maintenance/Operation	270	690

Noise

Noise can be generated by both stationary sources, such as mechanical and construction equipment, and by mobile sources, such as cars and delivery trucks. The potential impact of noise is dependent on the sound level given in decibels, frequency of the noise source, spatial relationship between the source of the noise and the receptors, time of day, and the existing noises at the receptors. The lower threshold of hearing is at 10-15 dB, talking is at 70 dB, and the threshold of pain is at 140 dB. The decibel levels of typical construction equipment are presented in Table 4-17.

Table 4-17
Noise from Construction Equipment

Equipment	Sound levels, decibels
Pneumatic chip hammer	103-113
Jackhammer	102-111
Concrete joint cutter	99-102
Portable saw	88-102
Stud welder	101
Bulldozer	93-96
Earth tamper	90-96
Crane[1]	90-96
Hammer	87-95
Earthmover[2]	87-94
Front-end loader	86-94
Backhoe	84-93

1. Noise of crane lifting a load is 96 decibels; at rest, the crane noise may be less than 80 decibels
2. Noise of earthmover is 94 decibels at 10 feet; noise is 82 decibels at 70 feet
3. The Center to Protect Workers' Rights

Permissible noise limits are set by OSHA and by city noise ordinances. As shown in Table 4-18, OSHA sets limits on sound level dependent on the duration of exposure.

Table 4-18
Permissible Noise Exposure

Duration per day, hours	Sound level, decibels
8	90
6	92
4	95
3	97
2	100
1.5	102
1	105
0.5	110
0.25	115

1. Source: OSHA

The City of Chicago's Noise Ordinance provides guidance on acceptable sound levels and when the noise limits are to be enforced. However, it does not apply "to any construction, demolition or repair work of an emergency nature or to work on public improvements authorized by a governmental body or agency." Briefly, the Chicago Noise Ordinance states that the limit on mechanical stationary sources is 55 dBa at a distance of 100 feet or more between the hours of 8pm-8am. In a residential area, noise disturbances caused by "loading, unloading, opening, closing or other handling of boxes, crates, containers, building materials, garbage cans, dumpsters or similar objects" is not allowed between the hours of 10pm-7am. Except in manufacturing districts, earthshaking vibrations are prohibited beyond the boundaries of the work site between the hours of 8pm-8am.

Because the construction of the disinfection facilities would be a public improvement project that is authorized by a governmental body, it is exempt from the Chicago Noise Ordinance. However, the noise-producing activities during construction and operation such as the equipment operations and handling of delivery containers or dumpsters during operation will impact the noise levels within the surrounding area.

4.6.2 Impacts to the Land

<u>Additional land requirements</u>

The land use requirements for UV and Chlorination disinfection facilities are shown in Table 4-19. The estimated land requirement includes the footprint of the disinfection building or chlorine contact tanks, the pumping station, a new outfall, and 10-foot buffer around each facility. The new outfall is designed below grade with the assumption that no buildings will be built above.

Table 4-19
Land Requirements for Disinfection Technologies at the WRPs

	North Side	Calumet	Stickney	TOTAL
UV Land Requirement[1] (acres)	2.1	1.7	3.7	7.5
Chlorination/Dechlorination Land Requirement[2,3] (acres)	3.1	4.2	9.8	17.1

1. Source: *Draft UV Disinfection Cost Study – North Side Water Reclamation Plant* (CTE, January 2008); working results of the *Draft Stickney Water Reclamation Plant UV Cost Study* and the *Hydraulic Evaluation Technical Memorandum* (CTE, June 2008)
2. The land requirement for Chlorination/Dechlorination at Calumet includes 2.2 acres of the existing contact tanks.
3. Source: *Chlorination/Dechlorination Disinfection Cost Study for Stickney, Calumet and North Side Water Reclamation Plants* (CTE, May 2008).

Modifications to land usage

Installation of the equipment will require the conversion of green space to impervious areas for buildings, roadways and driveways. This conversion will reduce infiltration for recharge of the groundwater. Table 4-20 presents the area that will be converted from green space to impervious areas at each facility with UV disinfection, including the pumping station based site plans of the proposed facilities. At the Calumet plant, where chlorine tanks are existing, installation of the proposed UV equipment and removal of the chlorine contact tanks results in a negative increase in impervious area (-0.8 acres). The negative value indicates that the greenspace at this facility will increase with the installation of UV.

Table 4-20
Conversion of Green Space for UV Disinfection

	North Side	Calumet	Stickney	TOTAL
New building/ pavement/ driveways (sq. ft.)	68,000	30,000	180,000	280,000
Removal of existing building/ pavement/ driveways (sq. ft.)	0	66,000	0	66,000
Increase in Impervious Area (acres)	1.6	-0.8	4.1	4.8

The increase in impervious area from facilities, pumping station, roadways, and driveways required for chlorination/dechlorination is presented in Table 4-21 based on site plans of the proposed facility. Chlorination/dechlorination will not require the removal of existing facilities or pavement.

Table 4-21
Conversion of Green Space for Chlorination/Dechlorination

	North Side	Calumet	Stickney	TOTAL
New building/ pavement/ driveways (sq. ft.)	133,000	88,000	350,000	570,000
Removal of existing building/ pavement/ driveways (sq. ft.)	0	0	0	0
Increase in Impervious Area (acres)	3.1	2.0	8.1	13.1

Landfill needs

After removal of the recyclable pieces and compression, the remaining equipment is estimated to occupy 10%-20% of its original volume upon disposal. Table 4-22 presents the dimensions of the proposed UV equipment at the North Side, Calumet, and Stickney plants. This table also presents the landfill volume requirements as 10% or 20% of the equipment volume. Upon disposal, the remaining UV equipment will require an estimated 1500-3000 cubic feet of volume at the landfill.

Table 4-22
Approximate Size of the Proposed UV Equipment and Estimated Required Volume at the Landfill

	Proposed UV Equipment Dimensions				Size at Disposal	
	Length (ft)	Width (ft)	Depth (ft)	Total Volume (cubic feet)	10% of Total Volume (cubic feet)	20% of Total Volume (cubic feet)
North Side	41	9	14	5,100	500	1,000
Calumet	41	9	14	5,100	500	1,000
Stickney	41	9	14	5,100	500	1,000
TOTAL					1,500	3,000

For UV disinfection, and estimated 1,680 blubs at North Side, 1,680 bulbs at Calumet, and 4,032 bulbs at Stickney will be replaced every year. Based on information from supplier, each bulb contains approximately 150 mg of mercury. Thus, the mercury waste stream from the UV disinfection technology is approximately 2.4 lb/year. Illinois law considers mercury as a hazardous waste and is subject to the Universal Waste Rule under state regulations. As such, the mercury must be recycled and is not permitted to be disposed into a landfill. Thus, mercury disposal would not have an impact on the landfill resources of the study area.

4.6.3 Impacts to the Water

Water requirements for the equipment
UV and Chlorination disinfection do not have significant water usage requirements or inputs into their respective systems. Therefore, implementation of these technologies at either of the WRPs would not significantly increase the District's water usage and was not evaluated further for potential impacts.

Stormwater runoff
The increase in impervious area shown in Table 4-20 and Table 4-21 will introduce additional stormwater runoff, which may affect water quality in the receiving stream. Based on 30-year historical data, Chicago receives an average of 36.4 inches of precipitation per year. Shown in Table 4-23, the installation of UV disinfection has the potential to increase the total stormwater runoff by 5 MG per year, which is an increase of 3% from the existing total runoff. Similarly chlorination/dechlorination has the potential to increase the total stormwater runoff by 13 MG per year, which is an increase of 9% from the existing total runoff.

Table 4-23
Estimated Increase of Runoff from Impervious Area

		North Side	Calumet	Stickney	TOTAL
UV	Increase in Impervious Area (acres)	1.56	-0.83	4.11	4.84
	Increase in Runoff per year (MG)	1.54	-0.82	4.06	4.79
	Percent Difference from Current Runoff	14%	-1.7%	4.9%	3.3%
Chlorination/ Dechlorination	Increase in Impervious Area (acres)	3.05	2.02	8.05	13.12
	Increase in Runoff per year (MG)	3.02	2.00	7.95	13.0
	Percent Difference from Current Runoff	27.8%	4.0%	9.6%	9.1%

4.6.4 Summary of Impacts

In summary, these activities impacting the air, land, and water were quantified for both UV and chlorination/dechlorination to assess their impacts on the environment. The most significant impacts are as follows:

Ultraviolet Radiation

- Increase the District's electricity use by an average of 126 million kWh/yr from operation of the UV equipment and operation of the low lift pumping station.
- Result in emissions of 99,000 tons of carbon dioxide equivalents of greenhouse gases per year from transportation and at the power generating facility due to operation of the UV equipment, and operation of the low lift pumping station.
- Result in emissions of 180 tons of NO_x per year; 650 tons of SO_2 per year; 6 pounds Hg per year at the power generating facility due to operation of the UV equipment and operation of the low lift pumping station.
- Require 7.5 acres of District land to be converted to an industrial plant from current or allocated uses; this land will not be available for future expansions (5 acres will become impervious area).
- Require 1,500-3,000 cubic feet at the landfill upon disposal the end of its useful life.
- Increase stormwater runoff volume by 5 MG per year.

Chlorination-Dechlorination

- Increase the District's electricity use by an average of 95 million kWh/yr from operation of the chlorination/dechlorination pumps and mixers, operation of the low lift pumping station, and manufacturing of sodium hypochlorite.
- Result in emissions of 75,000 tons of carbon dioxide equivalents of greenhouse gases per year from transportation and at the power generating facility due to operation of the chlorination/dechlorination pumps and mixers, operation of the low lift pumping station, and manufacturing of sodium hypochlorite.
- Result in total emissions of 140 tons of NO_x per year; 490 tons of SO_2 per year; 4 pounds Hg per year at the power generating facility due to operation of the chlorination/dechlorination pumps and mixers, operation of the low lift pumping station, and manufacturing of sodium hypochlorite.
- Require 17 acres of District land to be converted to an industrial plant from current uses; this land will not be available for future expansions (13 acres will become impervious).
- Increase stormwater runoff volume by 13 MG per year.

5 Comparison to Baseline Conditions and Impact on Future Uses

The overall impacts of the disinfection options (UV or chlorination/dechlorination) on future air or land uses were evaluated. Because of the relatively low impact of several parameters and the limitations with the baseline data, the comparisons made in this section are limited to the District's energy usage, air emissions at the power generation plant resulting from energy use, air emissions from transportation, and land usage.

The energy requirements for implementing disinfection will require additional electricity originating from coal-powered plants. As shown in Table 5-1, the annual total energy required for the operation of the UV disinfection equipment and pumping station will increase the District's current usage at the three plants of 384 million kWh/yr by approximately 126 million kWh/yr, or 33%. From the USEPA Greenhouse Gas Equivalencies Calculator, an average household uses 11,965 kWh/yr. Thus, the electricity consumption for operation of the UV and low lift pumping station is equivalent to approximately 10,600 households. For chlorination/dechlorination, the total energy requirements for manufacturing of the sodium hypochlorite, operation of the pumps/mixers, and operation of the low lift pumping station will increase the District's current usage District's current usage at the three plants of 384 million kWh/yr by approximately 95 million kWh/yr, or 25%. This is equivalent to the electricity use of approximately 8,000 households.

The annual energy use can also be translated in terms of equivalent energy consumption at the Sears Tower, which requires 77 million kWh/yr. The annual energy required for the operation of the UV equipment and pumping station is 67% more than the annual energy consumption for the Sears Tower. Similarly the annual energy requirements for operation of the chlorination/dechlorination pumps and mixers, operation of the low lift pumping station, and manufacturing of sodium hypochlorite are 24% more than the annual energy consumption for the Sears Tower.

Table 5-1
Annual Electricity Equivalents

	UV[1]	Chlorination/ Dechlorination[2]
District's Current Energy Consumption at North Side, Calumet, and Stickney WRPs (kWh/yr)[3]	384 million	
Energy Increase (kWh/yr)	126 million	95 million
Percent Increase from Current	33%	25%
No. of Equivalent Households[4]	10,600	8,000
Disinfection Energy Use Relative to Sears Tower Energy Use[5]	164%	124%

1. UV includes equipment operation and low lift pumping station operation only.
2. Chlorination/Dechlorination includes operation of the pumps/mixers, operation of the low lift pumping station, and manufacturing of sodium hypochlorite.
3. 2006 energy consumption as reported in the District's "2008 Budget Book Info Final, All Divisions" (January, 2008).
4. 11,965 kWh/household per year provided by USEPA, http://www.epa.gov/cleanenergy/energy-resources/calculator.html
5. Assume 77 Million kWh/year needed to run the Sears Tower. Source: http://securitysolutions.com/fire_life_safety/security_modernizing_legend/

The increased energy usage for the UV equipment and pumping equipment and associated transportation at the three plants will increase the greenhouse gas emissions by 98,970 tons CO_2 equivalents/yr (98,700+270), or 33%, as shown in Table 5-2. Transportation emissions will result in an increase in greenhouse gas emissions of less than 0.5%; the remaining emissions will be at the power generating facility. Assuming 6.02 tons per car, the increase in total greenhouse gas emissions is equivalent to over 16,400 additional automobiles added to the road per year (based on the USEPA Greenhouse Gas Equivalencies Calculator). An equivalent 15.2 million trees would be required to absorb that same amount of carbon dioxide emissions.

For the chlorination/dechlorination equipment, pumping station, sodium hypochlorite manufacturing, and transportation at the three plants, the greenhouse gas emissions will increase current greenhouse gas emissions by 74,990 tons CO_2 equivalents/yr (74,300 + 690), or 25%, which is equivalent to approximately 12,500 automobiles added to the road per year. An equivalent of approximately 11.5 million trees will be required to absorb that same amount of carbon dioxide emissions. Transportation emissions will result in an increase in greenhouse gas emissions of less than 1.0%, with the remaining emissions occurring at the power generating facility.

Table 5-2
Annual Greenhouse Gas Emission Equivalents from Transportation and at the Power Generating Facility Due to Energy Consumption

	UV	Chlorination/ Dechlorination
Current CO_2 Emissions at the Power Generating Facility due to Energy Use at the Three Plants (tons CO_2 /yr)[1]	299,000	
CO_2 Emissions Increase at the Power Generating Facility (tons CO_2 /yr)	98,300	74,000
CO_2 Emissions Increase from Transportation (tons CO_2 /yr)[2]	270	690
Equivalent No. of Trees for CO_2 absorption (trees/yr)[3]	15.2 million	11.5 million
Percent Increase of CO_2 Emissions	33%	25%
Current GHG Emissions at the Power Generating Facility due to Energy Use at the Three Plants (tons CO_2 equivalents/yr)[4]	300,000	
GHG Emissions Increase at the Power Generating Facility (tons CO_2 equivalents/yr)	98,700	74,300
GHG Emissions Increase from Transportation (tons CO_2 equivalents/yr)	270	690
Equivalent No. of Cars Added to the Road (cars/yr)[5]	16,400	12,500
Percent Increase	33%	25%

1. Calculated based on energy consumption and eGrid emission factors.
2. Transportation emissions for only the associated manufacturing/operation of the facility are included.
3. A single tree absorbs 13lb CO_2 per year. Coder, R.D. (October 1996). *Identified Benefits of Community Trees and Forests.*
4. Carbon dioxide equivalents of ghg are presented - 21*CH4; 310*N20.
5. 6.02 tons CO2equivalents/car per year provided by USEPA, http://www.epa.gov/cleanenergy/energy-resources/calculator.html

Emissions from UV and chlorination/dechlorination will decrease the air capacity that might otherwise be available for other economic or developmental uses in the future. The current and estimated increase in the major permitted air pollutants are shown are shown in Table 5-3. The increase in criteria pollutants and mercury emissions are from energy production at the power generating facility.

Table 5-3
Annual Additional Air Emissions of Regulated Air Pollutants at the Power Generating Facility

	Current Total Emissions (tons/yr)[1]	Additional Air Emissions at Power Generating Facility (tons/yr)		Percent Change From Current Emissions	
		UV	Chlorination	UV	Chlorination
NO_x	600	180	140	30%	23%
SO_2	1970	650	490	33%	25%
Hg	0.008	0.003	0.002	33%	25%

1. Summation of emissions reported in the District's 2006 Annual Air Emission Reports and emissions at the power plant due to energy use.

The UV and chlorination facilities will also decrease the available land or reduce landfill space that might otherwise be available for other economic or developmental uses in the future. The current used/allocated land, remaining land, and percent increase in land use if the disinfection and pumping facilities are installed are shown in Table 5-4.

Table 5-4
Land Increase from the Disinfection and Pumping Facilities

	Currently Used or Allocated Land (acres)[1,2,3,4]	Remaining Land (acres)	Additional Land Required for Disinfection (acres)		Percent Change From Current/Allocated Land Use	
			UV	Chlorination	UV	Chlorination
North Side	87	10	2.1	3.1	2.4%	3.6%
Calumet	446	24	1.7	4.2	0.4%	0.9%
Stickney	404	166	3.7	9.8	0.9%	5.9%
TOTAL	937	200	7.5	17.1	0.8%	1.8%

1. Source: MWRDGC M&O Facilities Handbook, 2006, and WRP facility layouts.
2. The areas are estimated using layouts of facilities and do not consider any underground structures that are not shown on the layouts.
3. At North Side, the current land in use includes land leased to the Park District.
4. Allocated land is set aside for future projects already identified to meet regulatory requirements and expansion needs as described in the District's Master Plan for each facility.

As described in this study, the environmental impacts of implementing disinfection technologies at the North Side, Calumet, and Stickney plants are not consistent with the goals of the Chicago *Environmental Action Agenda.* Presented in Section 2.4, the *Environmental Action Agenda* advocates environmentally-friendly policies in the City's departments and other agencies to strengthen Chicago's economy and improve the quality of life. It is the intention of the Mayor to continue efforts that inform and engage the residents and employees of Chicago "to make sure that Green remains routine over time." Therefore, when selecting the appropriate technology, one must also be mindful of aligning with the goals of the City's agenda and other agencies that strengthen Chicago's economy and improve the quality of life for current and future residents. It should also be noted that implementing disinfection technologies will utilize critical District resources (air, land, water, and financial) that will then become unavailable for future treatment options and alternatives.

6 Environmental Assessment of Increasing DO in the CAWS

6.1 Introduction and Background

Supplemental aeration is practiced by the Metropolitan Water Reclamation District of Greater Chicago (District) to increase the dissolved oxygen concentration in certain sections of the Chicago Area Waterway System. Currently, under existing Illinois Pollution Control Board (IPCB) Secondary Contact water quality regulations, certain sections of CAWS are required to maintain a minimum DO of either 3mg/l or 4 mg/l at all times; and for the sections classified as General Use waters, a minimum DO of 5 mg/L is required at all times. The Clean Water Act requires that States periodically review the uses of waterways to determine if changes to the existing water quality standards are needed to support a change in use. Based upon a Use Attainability Analysis (UAA) study of the CAWS, the Illinois Environmental Protection Agency (IEPA) has proposed new DO water quality standards for the CAWS under the rule-making process.

The District has hired Consoer Townsend Environdyne Engineers, Inc. (CTE) to develop an integrated approach for meeting the proposed DO standards. CTE's study is ongoing and is expected to be completed by mid 2009. Upon the District's request, however, CTE has developed a preliminary cost estimate that will convey to the IPCB the cost implications of achieving the proposed IEPA DO standards for the CAWS at all times.

A map showing the location of the CAWS is presented in Figure 6-1. Based on the information provided by CTE, the following are the sections of CAWS considered for supplemental aeration or additional aeration facilities to meet the proposed DO standards at all times.

1. Upper North Shore Channel (UNSC)
2. North Branch of Chicago River (NBCR)
3. South Branch of Chicago River (SBCR)
4. Bubbly Creek (South Fork of SBCR)
5. Chicago Sanitary and Ship Canal (CSSC)
6. Cal-Sag Channel
7. Little Calumet River (North)

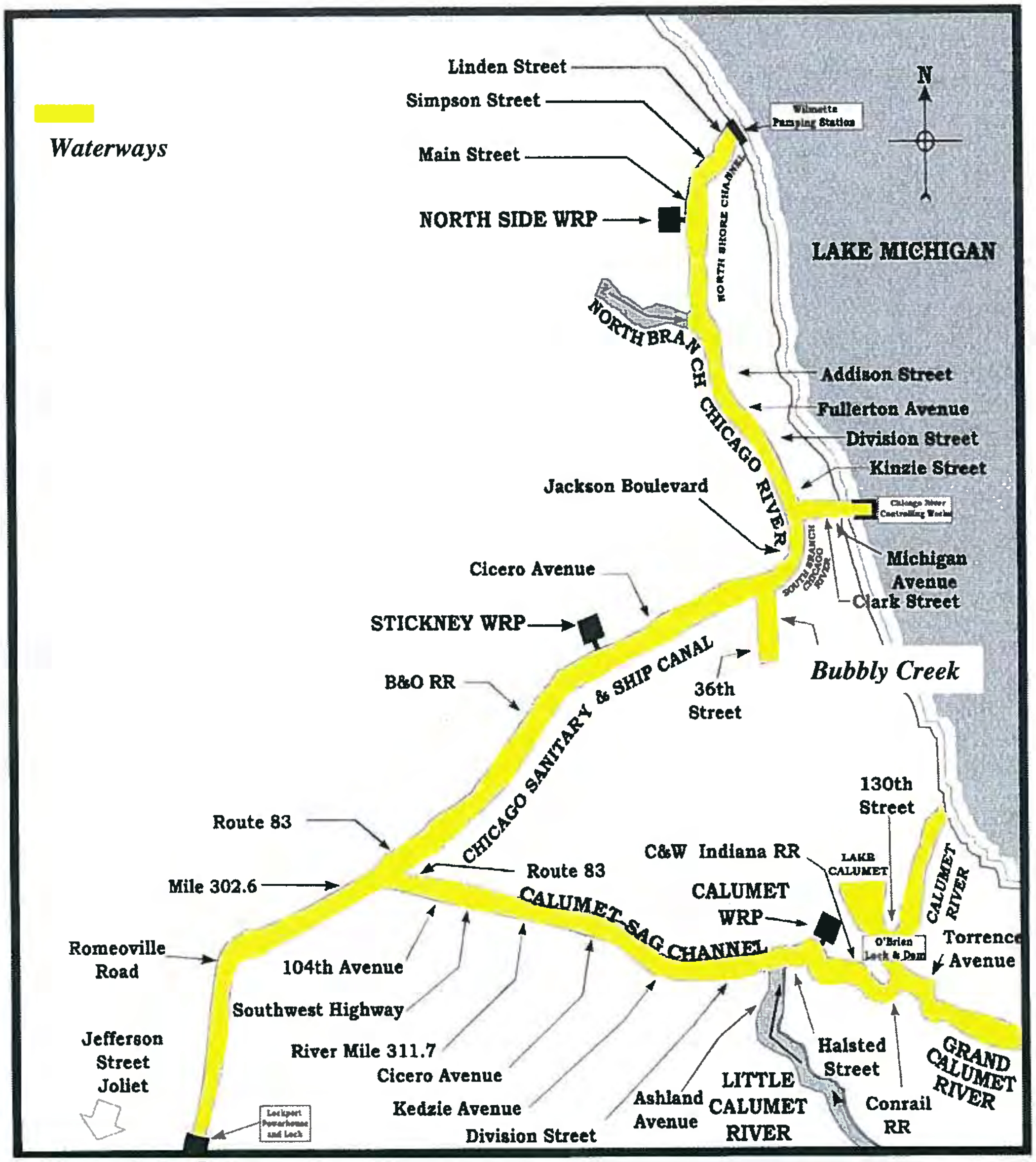


Figure 6-1: Chicago Area Waterways and Water Reclamation Plant Locations

6.2 Locations and Capacities of Flow Augmentation and DO Enhancement Facilities

An updated water quality model of the CAWS, developed by Marquette University, was used to determine the flow augmentation and DO enhancement facilities for the receiving water. Based on the modeling simulations and the historical DO data, the following supplemental aeration was recommended by CTE to meet the proposed IEPA DO standard for the CAWS at all times:

- Eighteen Supplemental Aeration Stations
- Three Flow Augmentation Stations, including;
  - 100 mgd of aerated North Side water reclamation plant effluent for the Upper North Shore Channel
  - 50 mgd of unaerated water from the South Branch of the Chicago River for Bubbly Creek
  - 182.6 mgd of aerated Calumet water reclamation plant effluent for the Little Calumet River
- Existing sidestream elevated pool aeration (SEPA) and diffused air stations operated at full firm capacity

The aeration capacity of each supplemental aeration station or flow augmentation location developed by CTE is presented in Table 6-1. The aeration technology scenarios assume supplemental aeration using only ceramic disc diffusers with an on-shore blower facility to supplement the DO in the waterways. In the case of flow augmentation technology, U-Tube aeration of pumped flow was utilized. Other aeration technologies are under consideration in CTE's ongoing integrated study.

Table 6-1
Estimated Additional Power Usage for Supplemental Aeration and Flow Augmentation of CAWS (July 2008)

Supplemental Aeration Station Location	Aeration Capacity (grams per second, g/s)	Hourly Operating Power † (kW)	Annual Energy Usage† (kW-hr/yr)
UNSC[1]	18	765	2,511,415
UNSC #1	80	1,000	3,285,000
UNSC #2	80	1,000	3,285,000
UNSC #3	80	1,000	3,285,000
North Branch	80	1,000	3,285,000
South Branch #1	80	1,000	3,285,000
South Branch #2	80	1,000	3,285,000
South Branch #3	80	1,000	3,285,000
Bubbly Creek #1	80	1,000	3,285,000
Bubbly Creek #2	80	1,000	3,285,000
Bubbly Creek #3	80	1,000	3,285,000
Bubbly Creek[2]	N/A	372	1,222,743
CSSC #1	80	1,000	3,285,000
CSSC #2	80	1,000	3,285,000
CSSC #3	80	1,000	3,285,000
CSSC #4	80	1,000	3,285,000
CSSC #5	80	1,000	3,285,000
Little Calumet River (North)	80	1,000	3,285,000
Cal-Sag Station #1	70	875	2,874,375
Cal-Sag Station #2	80	1,000	3,285,000
Little Calumet[3]	33	1,846	6,063,401
SEPA Station No. 3[4]	N/A	560	1,839,600
SEPA Station No. 4[4]	N/A	560	1,839,600
SEPA Station No. 5[4]	N/A	612	2,010,420
		Total	74,206,554

† Energy usage taken from TM-4WQ, pgs. B-9 and C-9 for the 80 gps station, TM-5WQ, pgs. 5-16, G-2, and G-3 for UNSC, and TM-6WQ, pgs. 6-17 and I-2 for Bubbly Creek. Assumes operating at full firm capacity for 1 month, half capacity for 7 months, and non-operational 4 months each year.

Energy usage is for additional operation required to meet 100% compliance with proposed DO standards.
1. Includes a 18 g/s U-Tube aerator and a 100 mgd firm capacity pump station and forcemain for flow augmentation and aeration.
2. Includes one 50 mgd firm capacity pump station and forcemain.
3. Includes a 33 gps U-Tube aerator and a 182.6 mgd firm capacity pump station and forcemain.
4. Power usage for SEPA pumps provided by MWRDGC.

6.3 Determination of Quantifiable Environmental Impacts

The environmental assessment of supplemental aeration and flow augmentation focuses on energy consumption, which is the largest potential environmental impact for the operation of the DO enhancement technologies in the CAWS. Energy consumption leads to greater electrical demands, resulting in increased air emissions at the coal-based energy generating plants that supply power to run the District facilities. From Table 6-1, CTE estimates that the operation of the DO enhancement technologies will require approximately 74.2 million kWh/yr to achieve the proposed DO standards at all times in the CAWS.

The additional energy requirement for DO enhancement technologies will increase the emissions of criteria pollutants, mercury, and greenhouse gases at the power generating facility. Mercury (Hg) and the six criteria pollutants: sulfur oxides (SO_x), carbon monoxide (CO), nitrogen oxides (NO_x), particulate matter (PM), ozone (O_3) and lead (Pb), are permitted under the USEPA Clean Air Mercury Rule and Clean Air Act, respectively. For regulatory purposes, sulfur dioxide (SO_2) emissions are reported because they are the indicator of sulfur oxide concentrations in the ambient air. Greenhouse gases, comprised of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluoro-carbons (HFCs), perfluoro-carbons (PFCs) and sulfur hexafluoride (SF_6), are not included in air emission permits, but are of concern on both global and local levels because of their potential to affect global climate changes and global warming. Table 6-2 presents the estimated emission increase at the power generation facility for the most significant of these air pollutants and greenhouse gases.

Table 6-2
Estimated Emission Loading Increases at Power Generation Facility Due to Energy Consumption (tons/yr)

NO_x	105
SO_2	378
CO_2	57,700
CH_4	0.30
N_2O	0.70
Hg	0.0016

1. The air emissions resulting from energy consumption were calculated based on energy requirements and emission coefficients from the "Emissions & Generation Resource Integrated Database" (eGRID) specifically for Illinois.

6.4 Comparison of Baseline Conditions and Impact on Future Uses

The implementation of DO technologies for supplemental aeration will increase the District's energy consumption, resulting in increased air emissions of regulated air pollutants and greenhouse gases at the power generating facility. As described previously, the energy facilities that supply power to run the District facilities are generally coal-based electric generating plants.

As shown in Table 6-3, the total energy required for the operation of the DO technologies is approximately 74.2 million kWh/yr, which will increase the District's total energy consumption of 550.8 million kWh/yr by 13.5%. The total energy consumption of 550.8 million kWh/yr includes contributions from all District water reclamation plants and pumping facilities. In comparison, the evaluation of the environmental impacts of disinfection compared the increase in energy due to disinfection relative to current energy consumption only at the North Side, Calumet, and Stickney plants.

From the USEPA Greenhouse Gas Equivalencies Calculator, an average household uses 11,965 kWh/yr. Thus, the electricity consumption for DO operation is equivalent to approximately 6,200 households per year. The energy consumption can also be translated to equivalent energy consumption at the Sears Tower, which requires 77 million kWh/yr. The energy required for the operation of the DO technologies is 96% of the annual energy consumption for the Sears Tower.

Table 6-3
Increase of Estimated Annual Energy Usage due to Additional DO Enhancement Operation

District's Current Energy Consumption (kWh/yr)[1]	550.8 million
Energy Increase (kWh/yr)	74.2 million
Percent Energy Increase from Current	13.5%
No. of Equivalent Households[2]	6,200
DO Energy Use Relative to Sears Tower Energy Use[3]	96%

1. Energy consumption as reported in Table 8 of the District's "2008 Budget Book Info Final, All Divisions" (January 2008).
2. 11,965 kWh/household per year provided by USEPA, http://www.epa.gov/cleanenergy/energy-resources/calculator.html
3. Assume energy consumption is 77 Million kWh/year for the Sears Tower. Source: http://securitysolutions.com/fire_life_safety/security_modernizing_legend/

The increased energy usage for the operation of the DO technologies will increase the current greenhouse gas emissions of 430,000 tons CO_2 equivalents/yr by 58,000 tons CO_2 equivalents/yr, or 13.5%, at the power generating facility as shown in Table 6-4. Assuming a car emits approximately 6.02 tons of CO_2 equivalents per year (U.S. EPA Greenhouse Gas Equivalencies Calculator), the increase in total greenhouse gas emissions is equivalent to approximately 9,600 additional automobiles added to the road per year. An equivalent 8.9 million trees would be required to absorb that same amount of carbon dioxide emissions.

Table 6-4
Increase of Annual Greenhouse Gas Emission Equivalents at the Power Generating Facility due to Additional DO Enhancement Operation

Current CO_2 Emissions (tons CO_2 /yr)[1]	428,500
CO_2 Emissions Increase (tons CO_2 /yr)	57,700
Equivalent No. of Trees for CO_2 absorption (trees/yr)[2]	8.9 million
Percent Increase of CO_2 Emissions from Current	13.5%
Current GHG Emissions (tons CO_2 equivalents/yr)[3]	430,000
GHG Emissions Increase (tons CO_2 equivalents/yr)	58,000
Equivalent No. of Cars Added to the Road (cars/yr)[4]	9,600
Percent Increase of GHG Emissions from Current	13.5%

1. Calculated based on energy consumption and eGrid emission factors. Energy consumption as reported in Table 8 of the District's "2008 Budget Book Info Final, All Divisions" (January 2008).
2. A single tree absorbs 13lb CO_2 per year. Coder, R.D. (October 1996). *Identified Benefits of Community Trees and Forests.*
3. Carbon dioxide equivalents of ghg equal the sum of CO_2, 21*CH_4, and 310*N_20.
4. 6.02 tons CO2equivalents/car per year provided by USEPA, http://www.epa.gov/cleanenergy/energy-resources/calculator.html

The estimated increase in the most significant permitted air pollutants at the power generating facility are shown in Table 6-5. Emissions at the power generating facility from operation of the DO technologies will decrease the air capacity that might otherwise be available for other economic or developmental uses in the future.

Table 6-5
Increase of Emissions of Permitted Air Pollutants at the Power Generating Facility due to Additional DO Enhancement Operation

	Current Air Emissions[1] (tons/yr)	Additional Air Emissions at Power Generating Facilities Due to DO Energy Consumption (tons/yr)	Percent Change from Current Emissions
NO_x	850	105	12.4%
SO_2	2840	378	13.3%
Hg	0.012	0.00162	13.5%

1. Summation of emissions reported in the District's 2006 Annual Air Emission Reports and emissions at the power generating facility due to energy use.

As described in this study, the environmental impacts of implementing DO enhancement technologies in the CAWS are not consistent with the goals of the Chicago *Environmental Action Agenda.* Presented in Section 2.4, the *Environmental Action Agenda* advocates environmentally-friendly policies in the City's departments and other agencies to strengthen Chicago's economy and improve the quality of life. It is the intention of the Mayor to continue efforts that inform and engage the residents and employees of Chicago "to make sure that Green remains routine over time." Therefore, when selecting the appropriate technology, one must also be mindful of aligning with the goals of the City's agenda and other agencies that strengthen Chicago's economy and improve the quality of life for current and future residents. It should also be noted that implementing DO enhancement technologies will utilize critical District resources (air, land, water, and financial) that will then become unavailable for future treatment options and alternatives.

APPENDIX A

Environmental Impact Literature Search

Table A-1. Environmental Impact Literature Search

Author	Title	Publication Year
Beavis, P. and Lundie, S.	Integrated environmental assessment of tertiary and residuals treatment - LCA in the wastewater industry	2003
Houillon, G. and Jolliet, O.	Life cycle assessment of processes for the treatment of wastewater urban sludge: Energy and global warming analysis	2005
Kenway, S. et al.	Triple Bottom Line Reporting of Sustainable Water Utility Performance (AwwaRF)	2007
Little, A.	Total Cost Assessment Methodology: Internal Managerial Decision Tool	1999
Lyons, E. et al.	Life Cycle Assessment of Three Water Supply Systems: Importation, Reclamation and Desalination	Not yet published
Machado, A. et al.	Life cycle assessment of wastewater treatment options for small and decentralized communities	2007
Mitchell, C. et al.	Costing for Sustainable Outcomes in Urban Water Systems.	2007
Munoz, I. et al.	Life cycle assessment of a coupled solar photocatalytic-biological process for wastewater treatment	2006
Narayan, R.	Drivers & rationale for use of biobased materials based on life cycle assessment (LCA)	2004
Rebitzer, G., Hunkeler, D. and Jolliet, O.	The Economic Pillar of Sustainability: Methodology and Application to Wastewater Treatment	2003
Schenck, R.	LCA for Mere Mortals: A Primer on Environmental Life Cycle Assessment	2000
San Francisco Public Utilities Commission (SFPUC)	SFPUC Sustainability Plan: Sustainability Baseline Assessment FY05/06	2007
San Francisco Public Utilities Commission (SFPUC)	SFPUC Sustainability Plan: Sustainability Indicators and Best Practices	2006
Stroemberg, L. and Paulsen, J.	LCA Application to Russian Conditions	2002
Tarantini, M.; Ferri, F.	A Life Cycle Assessment Study of the Environmental Sustainability of Domestic Water Saving Techniques	2003

Power/Energy impact (websites)

- http://www.powerscorecard.org/elec_env.cfm
- http://www.eia.doe.gov/fuelcoal.html
- http://www.ucsusa.org/clean_energy/fossil_fuels/offmen-how-coal-works.html

Manufacturing discharges (websites)

- http://www.epa.gov/enviro/
- http://www.epa.gov/tri/
- http://www.epa.gov/tri/tridata/index.htm
- http://www.epa.gov/enviro/html/multisystem_query_java.html

Industry benchmarking (websites)

- http://www.globalreporting.org/Home
- http://www.ib-net.org/
- http://www.water.org.uk/
- http://www.awwa.org/Resources/utilitymanage.cfm?ItemNumber=3766&navItemNumber=1587

APPENDIX B

Documents for Establishment of Baselines

Table B-1. Existing infrastructure – information from MWRDGC

Source	Medium	Document Received	Data
MWRDGC	1. Personal meeting 2. Telephone request	M&O Facility Handbook (2006)	1. Service area maps 2. Locations in municipalities 3. Current Water Reclamation Plants (WRPs) infrastructure and processes and equipment capacities and descriptions 4. Solid Processing Areas – locations and dimensions 5. Pumping Stations – locations and capacities 6. Reservoirs – locations, volumes, and pump capacities 7. Aeration Stations – locations and pump capacities 8. Chicago River Controlling Works / Wilmette Gate / O'Brien Controlling Works – locations, equipment, pumps information 9. NPDES permit limits for WRPs 10. Chicago Area Waterways map and details
		Air Emission Reports (2004, 2005, 2006)	1. Annual carbon emissions to air from WRPs 2. Annual permitted emissions to air from WRPs 3. Natural gas and digester gas usage in WRPs
		Annual Budgets (2006, 2007, 2008)	1. Annual energy consumption – electricity usage 2. Annual energy consumption – natural gas usage 3. Annual energy consumption – gasoline/diesel 4. Man-hours for maintenance management 5. Total annual maintenance and operation costs
		Miscellaneous data sheets	1. Total annual electricity consumption and costs (2003-2006) 2. Total annual gas usage and costs (2004-2006)
		Monthly Plant Operating Data reports (2005)	1. Total and average annual air usage 2. Annual energy usage only for WRPs
	3. MWRDGC website – Engineering Dept.	Our Community and Flooding (1998)	1. List of watersheds in Chicago Metropolitan area 2. Areas of watersheds
	4. MWRDGC website	Service area information	1. List of municipalities and townships totally or partially within MWRDGC service area

Table B-2. Existing infrastructure – other information sources

Source	Medium	Document Received	Data
Illinois State Water Survey (IL SWS)	SWS Internet database	2000 – 2006 daily precipitation data	1. Total annual precipitation in Cook County 2. Average annual precipitation in Cook County 3. 7-year total precipitation in Cook County 4. 7-year average precipitation in Cook County
USGS	USGS Internet database	Watershed cataloging units information	1. Watershed delineation and maps for Cataloging Units for Chicago River and Des Plaines River 2. Watershed areas for Chicago and Des Plaines rivers
		National water-use data files	1. Watershed water use and budget for Chicago and Des Plaines river watersheds, e.g., total ground-water/surface water withdrawals, fresh/saline water withdrawals, total water reclaimed in WRPs, total consumption and conveyance losses in the watershed
Municipalities in MWRDGC service area	1. Official websites on Internet 2. Telephone request	CAFRs for: 1. Village of Hanover Park 2. Village of LaGrange 3. Village of Lemont 4. Skokie Park District 5. Village of Glencoe 6. Village of Palos Park 7. Village of Arlington Heights 8. Village of Orland Park 9. Village of Bartlett	1. Median Household Income 2. Per Capita personal income 3. Municipal bond ratings 4. Outstanding Debt 5. Assessed property values 6. Unemployment rates 7. Property tax revenues collected 8. Property tax revenue levied

APPENDIX C

GIS Figures of the Natural Infrastructure Baseline

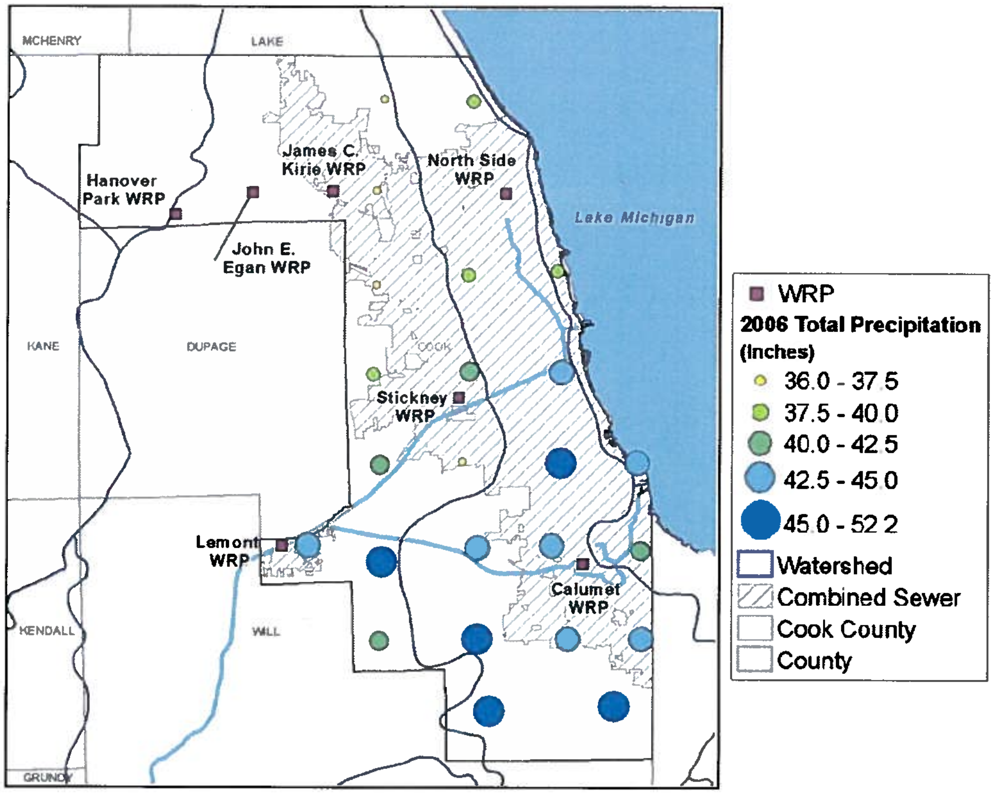


Figure C-1. 2006 Average Precipitation

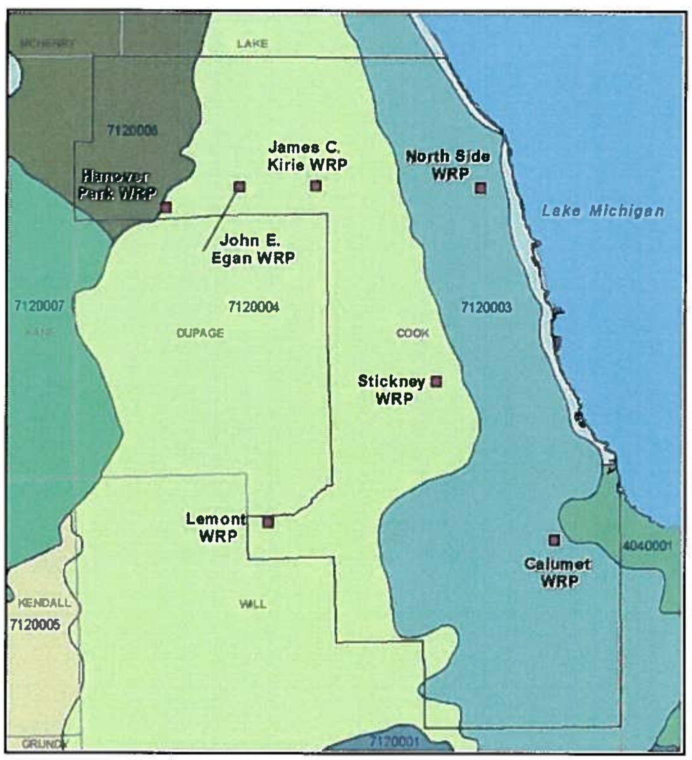


Figure C-2. Watersheds

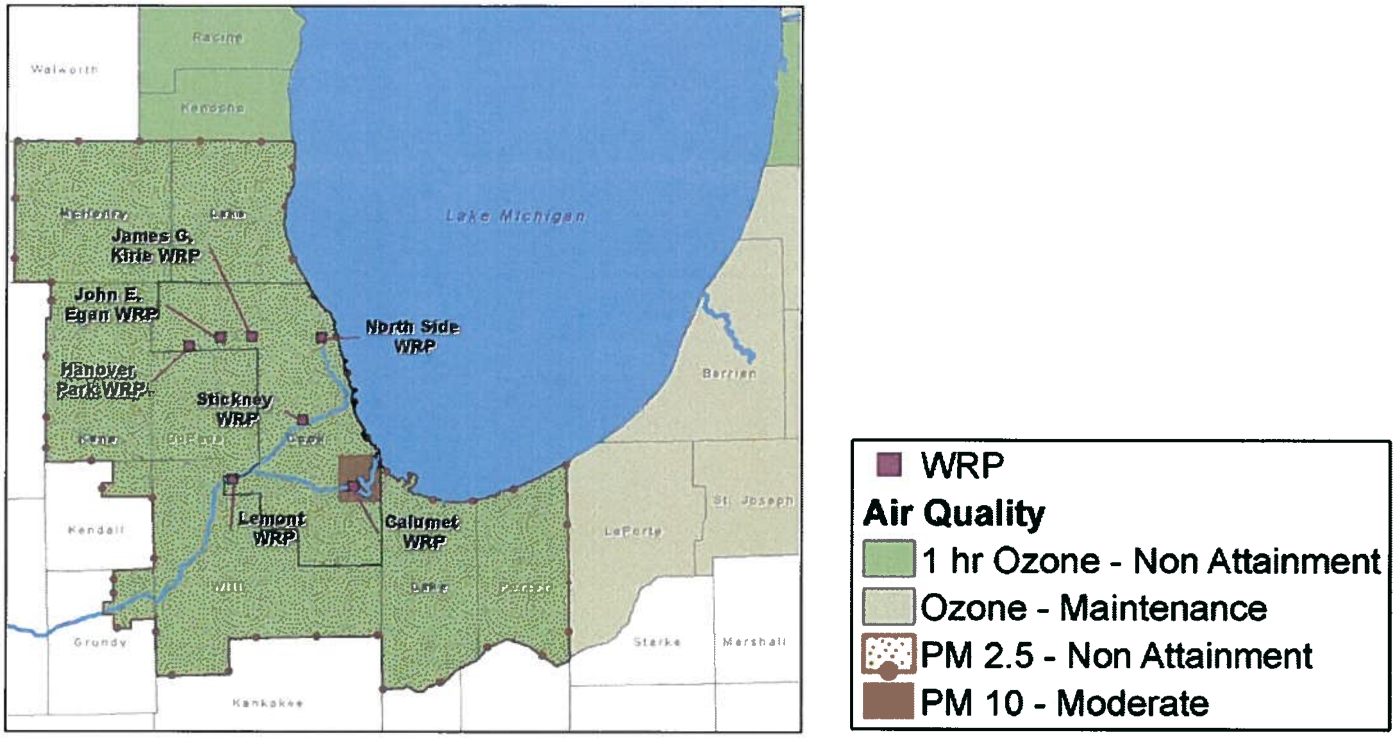


Figure C-3. Regional Air Quality

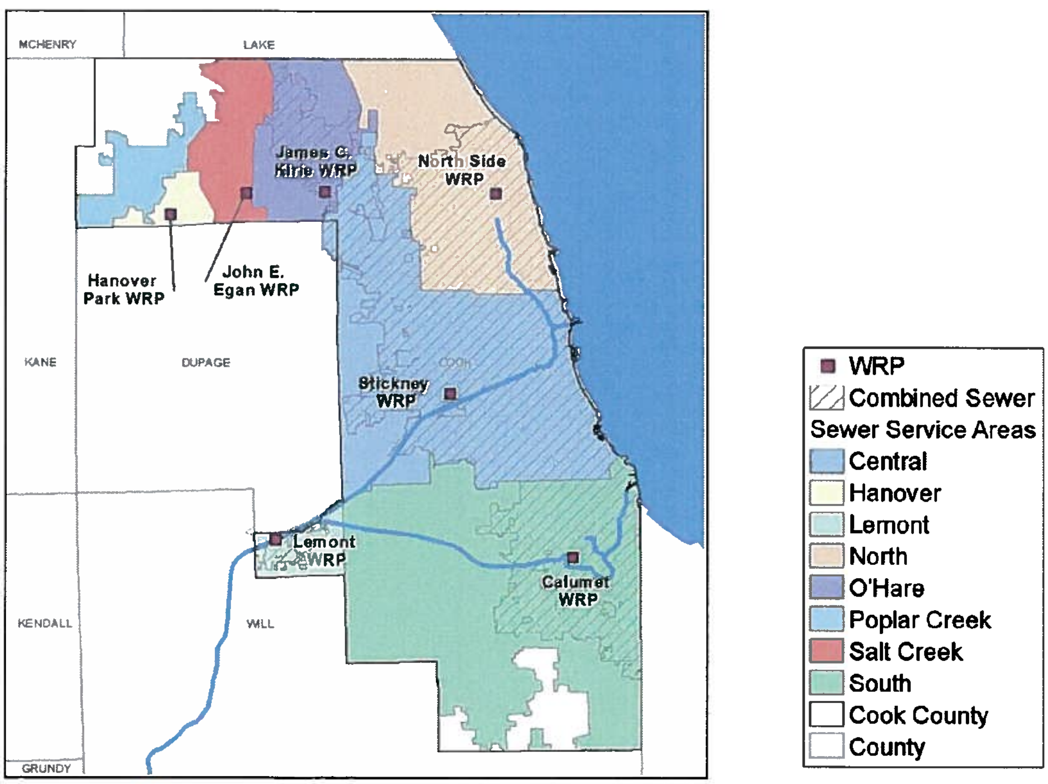


Figure C-4. Sewer Service Areas

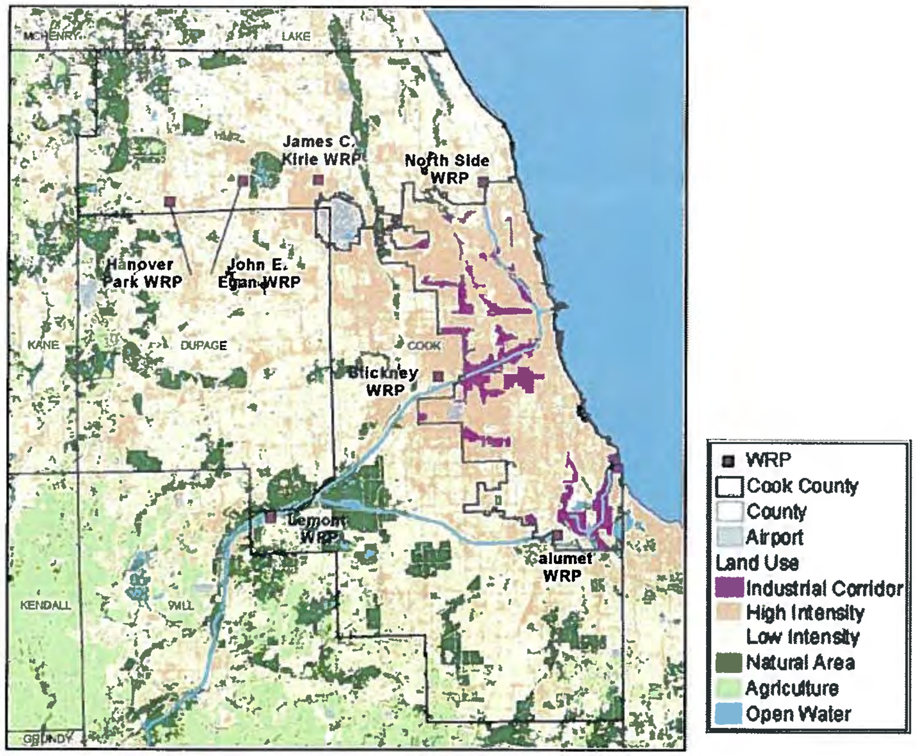


Figure C-5. Land Use

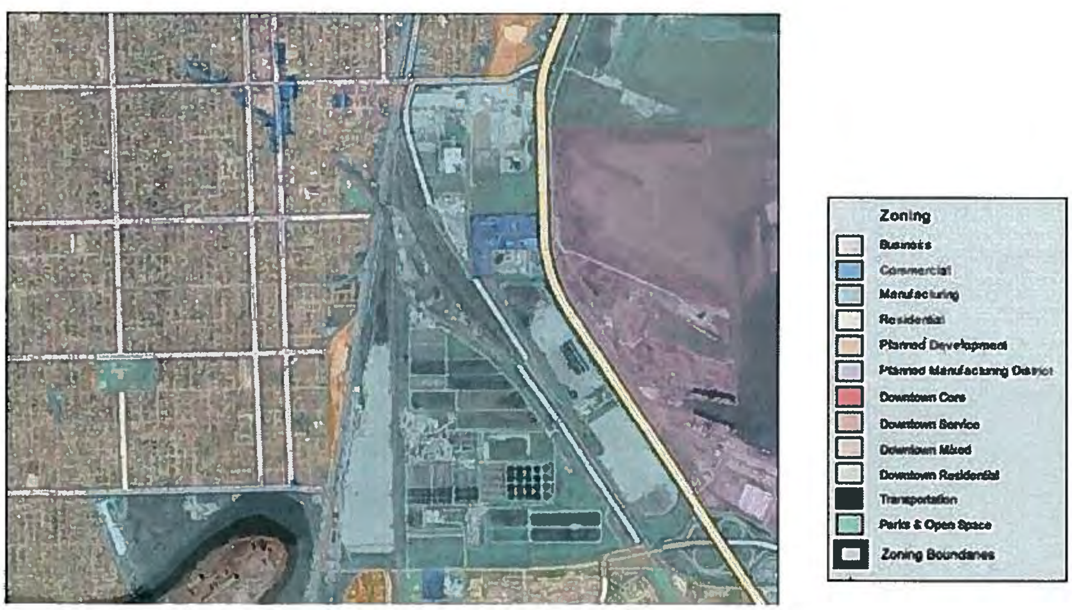


Figure C-6. Calumet WRP Zoning

APPENDIX D

Calculations of Air Emissions, Equivalents, Land Use, and Runoff

Emission Coefficients (Source: eGRID 2006)

Pollutant	Electricity Coefficient	Units
CO2	1,556	lbs/MWH
CH4	0.0082	lbs/MWH
N2O	0.0180	lbs/MWH
NOx	2.8410	lbs/MWH
SO2	10.1990	lbs/MWH
Hg	4.37E-05	lbs/MWH

2006 Reported	NorthSide	Calumet	Stickney	Total 3 Plants	Total District
NOx	2.17	15.39	36.71	54.27	67.804265
SO2	0.05	0.73	7.79	8.57	31.022165

2006 Energy Use and Emissions from 2008 Budget	Northside	Calumet	Stickney	Energy Emission Subtotal - 3 plants	**Total Emissions - 3 plants**	District Energy Emissions Subtotal	**Total Emissions - District**
2006 Energy Use (kWh)	60,120,815	78,974,014	245,085,418	384,180,247	**384,180,247**	550,795,508	**550,795,508**
CO2 tons	46,774	61,442	190,676	298,892	**298,892**	428,519	**428,519**
CO2 Equiv tons	46,947	61,669	191,381	299,997	**299,997**	430,103	**430,103**
CH4 tons	0.25	0.32	1.00	1.6	**1.6**	2.26	**2.26**
N2O tons	0.54	0.71	2.21	3.5	**3.5**	4.96	**4.96**
NOx	85.40	112.18	348.14	545.7	**600.0**	782.41	**850.21**
SO2	306.59	402.73	1,249.81	1,959.1	**1,967.7**	2,808.78	**2,839.80**
Hg tons	0.0013	0.0017	0.0054	0.0084	**0.0084**	0.012	**0.012**

	Rate of Energy Use (kW)				Energy Use (kWh/yr)[1]			
Source	CTE Reports				Manufacturer	Calculation		
	Average Day Flows (MGD)	Chemical Dose (lb/day)	Equipment Operation	Pump Station Operation	Manufacturing (outside of study area)	Equipment Operation	Pump Station Operation	Total in Study Area
UV								
North Side	333	-	3,182	375	40,320	19,855,680	2,340,000	22,195,680
Calumet	305	-	2,903	331	40,320	18,114,720	2,065,440	20,180,160
Stickney	1,250	-	9,225	4,240	96,768	57,564,000	26,457,600	84,021,600
Total	1,888	-	15,310	4,946	177,408	95,534,400	30,863,040	126,397,440
%increase from total at 3 plants					0.0%	24.9%	8.0%	33%

	Rate of Energy Use (kW)				Energy Use (kWh/yr)[1]			
Source	CTE Reports				Calculation			
	Average Day Flows (MGD)	Chemical Dose (lb/day)	Equipment Operation	Pump Station Operation	Chemical Manufacturing[2]	Equipment Operation	Pump Station Operation	Total in Study Area
Ch/Dechlor								
North Side	333	16,700	24.15	375	10,855,000	150,696	2,340,000	13,345,696
Calumet	319	16,000	92.06	365	10,400,000	574,454	2,277,600	13,252,054
Stickney	1,250	62,550	68.76	4,402	40,657,500	429,062	27,468,480	68,555,042
Total	1,902	95,250	185	5,142	61,912,500	1,154,213	32,086,080	95,152,793
%increase from total at 3 plants					16.1%	0.3%	8.4%	24.8%
DO								
Total, 100% Scenario (kWh/yr)					74,206,554			

1. Disinfection is applied 24 hours a day for 9 months; from CTE report, DO is applied 24 hours per day for 8 months.
2. Assume 2.5 kwh/lb Cl2 generated; sodium bisulfite generation consumes very little energy

DO - 100 %

	North Side	Calumet	Stickney	TOTAL
NO_x				105.41
SO_2				378.42
CO_2				57732.70
CH_4				0.30
N_2O				0.67
Hg				1.62E-03

Estimated Emissions Loading Increases

Manufacturing		North Side	Calumet	Stickney	TOTAL
Estimated UV Loading Increase (tons/yr)	NO_x	0.06	0.06	0.14	**0.25**
	SO_2	0.21	0.21	0.49	**0.90**
	CO_2	31.37	31.37	75.29	**138.02**
	CH_4	0.00	0.00	0.00	**0.00**
	N_2O	0.00	0.00	0.00	**0.00**
	Hg	0.00000088	0.00000088	0.00000211	**0.00000388**
Estimated Chlorination Loading Increase (tons/yr)	NO_x	15.42	14.77	57.75	**87.95**
	SO_2	55.36	53.03	207.33	**315.72**
	CO_2	8445.19	8091.20	31631.54	**48167.93**
	CH_4	0.04	0.04	0.17	**0.25**
	N_2O	0.10	0.09	0.37	**0.56**
	Hg	0.00024	0.00023	0.00089	**0.00135**

Equipment Operation		North Side	Calumet	Stickney	TOTAL
Estimated UV Loading Increase (tons/yr)	NO_x	28.20	25.73	81.77	**135.71**
	SO_2	101.25	92.38	293.55	**487.18**
	CO_2	15447.72	14093.25	44784.79	**74325.76**
	CH_4	0.08	0.07	0.24	**0.39**
	N_2O	0.18	0.16	0.52	**0.86**
	Hg	0.000434	0.000396	0.001258	**0.002087**
Estimated Chlorination Loading Increase (tons/yr)	NO_x	0.21	0.82	0.61	**1.64**
	SO_2	0.77	2.93	2.19	**5.89**
	CO_2	117.24	446.93	333.81	**897.98**
	CH_4	0.001	0.0024	0.0018	**0.005**
	N_2O	0.0014	0.0052	0.0039	**0.01**
	Hg	0.00000329	0.00001255	0.00000938	**0.00002522**

Pump Station Operation		North Side	Calumet	Stickney	TOTAL
Estimated UV Loading Increase (tons/yr)	NO_x	3.32	2.93	37.58	**43.84**
	SO_2	11.93	10.53	134.92	**157.39**
	CO_2	1820.52	1606.91	20584.01	**24011.45**
	CH_4	0.01	0.01	0.11	**0.13**
	N_2O	0.02	0.02	0.24	**0.28**
	Hg	0.000051	0.000045	0.000578	**0.000674**
Estimated Chlorination Loading Increase (tons/yr)	NO_x	3.32	3.24	39.02	**45.58**
	SO_2	11.93	11.61	140.08	**163.62**
	CO_2	1820.52	1771.97	21370.48	**24962.97**
	CH_4	0.01	0.01	0.11	**0.13**
	N_2O	0.02	0.02	0.25	**0.29**
	Hg	0.000051	0.000050	0.000600	**0.000701**

Total Emissions of Greenhouse Gases and Criteria Pollutants from Energy Use

		NOx	SO2	CO2	CO2 equi	CH4	N2O	Hg	
UV	Manufacturing	0.00	0.00	0	0	0.00	0.00	0.00000000	Not in study area
	Transportation	-	-	269	269	-	-	-	
	Equipment	135.71	487.18	74,326	74,601	0.39	0.86	0.00208743	
	Pump Station	43.84	157.39	24,011	24,100	0.13	0.28	0.00067436	
	Total	**179.55**	**644.56**	**98605.73**	**98969.26**	**0.52**	**1.14**	**0.00276178**	
Chlor/Declor	Manufacturing	87.95	315.72	48,168	48,346	0.25	0.56	0.00135279	
	Transportation	-	-	691	691	-	-	-	
	Equipment	1.64	5.89	898	901	0.00	0.01	0.00002522	
	Pump Station	45.58	163.62	24,963	25,055	0.13	0.29	0.00070108	
	Total	**135.16**	**485.23**	**74719.55**	**74993.22**	**0.39**	**0.86**	**0.00207909**	
DO	100%	105.41	378.42	57732.70	57946.12	0.30	0.67	0.00162141	

Annual Electricity Equivalents of UV and Chlorination Energy Use

	UV			Chlor/Dechlor				DO - 100%			
	Energy Increase (kWh/yr)	No. of Equivalent Households[1]	Equivalent no. of days to light the Sears Tower[2]		Energy Increase (kWh/yr)	No. of Equivalent Households[1]	Equivalent no. of days to light the Sears Tower2		Energy Increase (kWh/yr)	No. of Equivalent Households[1]	Equivalent no. of days to light the Sears Tower2
North Side (Equip+PS+Man)	22,195,680	1,855	105	North Side	13,345,696	1,115	63				
Calumet (Equip+PS+Man)	20,180,160	1,687	96	Calumet	13,252,054	1,108	63				
Stickney (Equip+PS+Man)	84,021,600	7,022	398	Stickney	68,555,042	5,730	325				
TOTAL	**126,397,440**	**10,564**	**599**	**TOTAL**	**95,152,793**	**7,953**	**451**	**TOTAL**	**74,206,554**	**6,202**	**352**
Baseline - current use	384,180,247	-	-	Baseline - current use	384,180,247	-	-	Baseline - current use	550,795,508	-	-
Percent increase	32.9%	-	-	Percent increase	24.8%	-	-	Percent increase	13.5%	-	-

1 Assume 11,965 kWh/household per year provided by USEPA, http://www.epa.gov/cleanenergy/energy-resources/calculator.htm
2 Assume 77 Million kWh/year needed to run the Sears Tower. Source: http://securitysolutions.com/fire_life_safety/security_modernizing_legend/
3 Manufacturing of UV is outside of the study area

Annual Greenhouse Gas Emission Equivalents of UV and Chlorination

	UV				Chlor/Dechlor					DO - 100%				
	CO2 Emissions (tons CO2 equivalents/yr)	Total GHG Emissions (tons CO2 equivalents/yr)[1]	Equivalent No. of Cars Added to the Road (cars/yr)[2]	Equivalent No. of Trees for CO2 absorption (trees/yr)[3]		CO2 Emissions (tons CO2 equivalents/yr)	Total GHG Emissions (tons CO2 equivalents/yr)[1]	Equivalent No. of Cars Added to the Road (cars/yr)[2]	Equivalent No. of Trees for CO2 absorption (trees/yr)[3]		CO2 Emissions (tons CO2 equivalents/yr)	Total GHG Emissions (tons CO2 equivalents/yr)[1]	Equivalent No. of Cars Added to the Road (cars/yr)[2]	Equivalent No. of Trees for CO2 absorption (trees/yr)[3]
North Side	17,268	17,332	2,879	2,656,652	North Side	1,938	1,945	323	298,117					
Calumet	15,700	15,758	2,618	2,415,410	Calumet	2,219	2,227	370	341,369					
Stickney	65,369	65,610	10,899	10,056,739	Stickney	21,704	21,785	3,619	3,339,121					
Transportation[4]	269	269	45	41,311	Trasportation	691	691	115	106,259					
Manufacturing5	0	0	0	0	Manufacturing	48,168	48,346	8,031	7,410,450					
TOTAL	**98,606**	**98,969**	**16,440**	**15,170,112**	**TOTAL**	**74,720**	**74,993**	**12,457**	**11,495,316**	**TOTAL**	**57,733**	57,946	9,626	8,881,954
Baseline - current use		299,997	-	-	Baseline - current use		299,997	-	-	Baseline - current use		430,103	-	-
Percent increase		33.0%	-	-	Percent increase		25.0%	-	-	Percent increase		13.5%	-	-

1 Carbon dioxide equivalents are equal to CO2+ 21*CH4+ 310*N20.
2 6.02 tons CO2equivalents/car per year provided by USEPA, http://www.epa.gov/cleanenergy/energy-resources/calculator.htm
3 A single tree absorbs 13lb CO2 per year. Coder, R.D. (October 1996). Identified Benefits of Community Trees and Forests.
5 Manufacturing of UV is outside of the study area

Annual Criteria Pollutant Emissions of UV and Chlorination

	NOx			SO2			Hg		
	UV	Chlor	DO-100%	UV	Chlor	DO-100%	UV	Chlor	DO-100%
Total	**180**	**135**	**105.41**	**645**	**485**	**378.42**	**0.00276**	**0.00208**	**0.00162**
Baseline - current use	600	600	850	1,968	1,968	2,840	0.0084	0.0084	0.0120
Percent increase	29.9%	22.5%	12.4%	32.8%	24.7%	13.3%	32.9%	24.8%	13.5%

Transportation CO2 Emissions

Construction

Duration = 3 years, 52 weeks/year, 5 days/week, 8 hours/day

Concrete Delivery

NS UV	Cal UV	Stickney UV	UV Total	C/D Total	NS C/D	Cal C/D	Stickney C/D	
8358	6363	23099	37,820	59,979	15381	8258	36340	cubic yards, from CTE memos

	UV	C/D	
Volume concrete in each truck =	8	8	cubic yards (from Tom L.)
Number of Concrete Trucks, total =	4,727	7,497	trucks in 3 years
Miles per truck =	30	30	miles, per truck (assumed)
Miles, total =	141,824	224,920	miles, total in 3 years
Average speed =	40	40	miles per hour (assumed)
Total Driving Time =	3,546	5,623	hours, total in 3 years
Idling time per truck =	1.5	1.5	hours (from Tom L., includes time to clean truck)
Total idling time	7,091	11,246	total hours in 3 years
Duration of emissions, total =	**10,637**	**16,869**	hours, total in 3 years
CO2 driving	226918.008	359871.237	pounds CO2
CO2 idling	85094.2531	134951.714	pounds CO2
Total CO2	156.006131	247.411475	tons CO2

Material Deliveries

	UV	C/D	
Number of Delivery Trucks =	3	3	per week (estimated), each plant
Total Delivery Trucks =	468	468	trucks in 3 years
Miles per truck =	30	30	miles, per truck (assumed)
Miles, total=	14,040	14,040	miles, total in 3 years
Weight per truck =	200	200	metric tons
Average speed =	40	40	miles per hour (assumed)
Total Driving Time =	351	351	hours, total in 3 years
Unloading time =	1	1	hour, each (assumed)
Total unloading	468	468	total hours in 3 years
Duration of emissions, total =	**819**	**819**	hours, total in 3 years
CO2 driving	2042314.56	2042314.56	pounds CO2 Climate Trust: Total Miles x met tons x 0.00033
Co2 unloading	5616	5616	pounds CO2
Total Co2	1023.96528	1023.96528	tons CO2

Workers' transportation

	UV	C/D	
Number of people =	50	50	workers per week (assumed)
People per car=	1	1	people per car, (assumed)
Total cars =	50	50	cars per week
total commute per car =	66	66	minutes per round-trip commute per car (US Census Bureau)
Total Driving Time =	**8,580**	**8,580**	hours, total in 3 years Assume 1/2 driving and 1/2 idling
CO2 driving	274560	274560	pounds @40mph
CO2 idling	51480	51480	pounds
Total	163.02	163.02	tons

Medium car emissions calculations based on 1.1 pounds of carbon dioxide emissions per mile[1]
SUV/4 wheel drive carbon dioxide emissions based on 1.57 pounds per mile[1]

[1] Source: Sightline Institute

Assume - 1.6 pounds of CO2 emissions per mile

Every gallon of fuel that is burned produces about 20 pounds of CO_2.
The Climate Trust

O&M/Salvage

Duration = 20 years, 7 days a week, 24 hours a day = 174,720 hours

Workers' transportation

Number of people* =	35	30	workers per day (CTE) *number of operators nassumed for UV at Stickney
People per car=	1	1	cars per day (assumed)
Total cars =	35	30	cars, total per day
Total commute =	66	66	minutes per round-trip commute per car (US Census Bureau)
Total Driving Time =	**280,280**	**240,240**	hours, total in 20 years
CO2 driving	8968960	7687680	pounds @40mph
CO2 idling	1681680	1441440	pounds
Total	5325.32	4564.56	tons
	4484.48		

UV Bulb or other Delivery

Number of Delivery Trucks =	1.5	-	per week (estimated), 3 plants
Total Delivery Trucks =	1560	-	trucks in 20 years
Miles per truck =	30	-	miles, per truck (assumed)
Miles, total=	46,800	-	miles, total in 20 years
Weight per truck	1		metric tons, assumed
Average speed =	40	-	miles per hour (assumed)
Total Driving Time =	1170	-	hours, total in 20 years
Unloading time =	3	-	hour, each (assumed), 3 plants
Total unloading time	4680	-	total hours in 20 years
Duration of emissions, total =	**5850**	-	hours, total in 20 years
CO2 driving	34038.576		pounds CO2 Climate Trust: Total Miles x met tons x 0.00033
CO2 idling	56160		pounds CO2
Total CO2	45.099288		tons CO2

Chemical Delivery

Number of Delivery Trucks =	-	171.2	per week (estimated), 3 plants
Total Delivery Trucks =	-	127166.775	trucks in 20 years
Miles per truck =	-	70	miles, per truck (assumed)
Miles, total=	-	8,901,674	miles, total in 20 years
Average speed =	-	40	miles per hour (assumed)
Total Driving Time =	-	222541.856	hours, total in 20 years
Unloading time =	-	1	hour, each (assumed)
Total unloading time	-	127166.775	total hours in 20 years
Duration of emissions, total =	-	**349708.631**	hours, total in 20 years
CO2 driving	-	16972127.6	pounds CO2
CO2 idling	-	1526001.3	pounds CO2
Total CO2	-	9249.06444	tons CO2

Total CO2

	UV	C-D	**UV**	**C-D**
	Tons	Tons	**tons per year**	
Constructic	1343	1434	**448**	**478**
O&M	5370	13814	**269**	**691**

Truck delivery of Sodium Hypochlorite			
Total NaClO used per day:	95,250 gallon		CTE Chlor/Dechlor Report, May 2008
			The Chlorination/Dechlorination Handbook, by Gerald F. Connell, 2002
Volume of tank truck:	4,400 gallon/truck		
No. of truck per day	21.6		
per wk:	151.5		
Truck delivery of Sodium Bisulfite			
Total NaHSO3 used per day:	11,230 gallon		CTE Chlor/Dechlor Report, May 2008
			The Chlorination/Dechlorination Handbook, by Gerald F. Connell, 2002
Volume of tank truck:	4,000 gallon/truck		
No. of truck per day	2.8		
per wk:	19.7		

	Chlorine	Bisulfite	
Gallons per day	95,250	11,230	gal/day
Truck Volume	4,400	4,000	gallons
Truck Distance	70	70	miles, round trip
Number of trucks =	22	3	per day
Number of trucks =	5,628	730	per year, 9 months
Miles per year =	393,989	51,095	
Pounds per day	95,250	46,300	
Number of trucks per day	22	3	
Pounds per truck	4,400	16,492	
Metric tons per truck	2.00	7.48	
CO2	260	126	met tons of CO2 per year
	286	139	tons per year
	5,710	2,776	tons for 20 years

From the Climate Trust:

To determine the amount of CO_2 emitted as a result of shipping by heavy-duty truck, the calculator multiplies the amount shipped (metric tons) by the number of miles it was shipped. It then multiplies the product by the emissions factor for heavy-duty truck shipping, 0.00033 metric tons CO_2 per metric ton-mile transported. This emissions factor was calculated as follows:
According to the U.S. EPA, the amount of CO_2 emitted in 2005 as a result of heavy-duty trucking was 385.8 teragrams of CO_2, or 385,800,000 metric tons of CO_2.[xii] According to the U.S. Department of Transportation's Bureau of Transportation Statistics, that amount was transported by heavy-duty truck a total of 1,293.3 billion short ton-miles in 2005.[xiii] To convert this figure into metric ton-miles, multiply it by 0.907 (1 short ton = 0.907 metric tons), which equals 1,173.02 billion metric ton-miles. Finally, to determine the emissions factor perform the following calculation:

385,800,000 metric tons CO_2 / 1,173,020,000,000 metric ton-miles = 0.00033 metric tons of CO_2 per metric ton-mile.

Land Use:

Facility	Service Area (Square miles)	Total Land Area (acres)	Approximate Plant Land Area Used (acres)[2]		Approximate Additional Land Area Use in Future[2,3] (acres)	Used or Allocated (acres)	Percent Used or Allocated	Remaining Land (acres)
North Side	143	97	63		24	87	90%	10
Calumet	305	470	424	(Process, D	22	446	95%	24
Stickney	260	570	388		16	404	71%	166
TOTAL	708	1137	875		62	937	82%	200

Approximate current land area where runoff may occur (acres)
11
50
84
145

1. Source: MWRDGC M&O Facilities Handbook, 2006, and WRP facility layouts
2. The areas are estimated using layouts of facilities and do not consider any underground structures that are not shown on the layouts.
3. Based on layouts from respective Master Plans for the facilities.

RUNOFF

Assume rainfall per year (inches) = 36.4

Current Runoff

	Existing building/pavement/driveways[1]	Runoff per year		
	acres	cubic feet	gallons	MG
North Side	11	1,453,452	10,872,577	10.9
Calumet	50	6,606,600	49,420,803	49.4
Stickney	84	11,099,088	83,026,950	83.0
Total	145	19,159,140	**143,320,330**	143.3

1. Source: MWRDGC M&O Facilities Handbook, 2006, and WRP facility layouts

UV Runoff Increase

	New building/pavement/driveways	Removal of exisiting buildling/pavement/driveways	Total new land use		Runoff per year			
	sqaure feet	square feet	square feet	acres	cubic feet	gallons	MG	%Difference from Current
North Side	67,991	0	67,991	1.56	206,241	1,542,787	1.54	14.2%
Calumet	30,159	66,306	-36,147	-0.83	-109,647	-820,218	-0.82	-1.7%
Stickney	179,122	0	179,122	4.11	543,337	4,064,447	4.06	4.9%
Total	**277,272**	**66,306**	**210,966**	4.84	**639,931**	**4,787,016**	4.79	3.3%

Chlor/Dechlor Runoff

	New building/pavement/driveways	Removal of exisiting buildling/pavement/driveways	Total new land use		Runoff per year			
	sqaure feet	square feet	square feet	acres	cubic feet	gallons	MG	%Difference from Current
North Side	133,042	0	133,042	3.05	403,562	3,018,851	3.019	27.8%
Calumet	88,084	0	88,084	2.02	267,189	1,998,713	1.999	4.0%
Stickney	350,498	0	350,498	8.05	1,063,176	7,953,113	7.953	9.6%
Total	571,624	0	**571,624**	13.12	**1,733,927**	**12,970,677**	12.971	9.1%

e tanks are existing

APPENDIX E

Information from Manufacturers

Questionnaire for UV disinfection equipment manufacturers

Company name: Trojan Technologies
Contact person: Allan Gates
Phone: 519-457-3400 Fax: 519-457-3030

Major raw materials: (names and quantities per year)
Lamps – 120,000 per year
Ballasts – 40,000 per year
Quartz Sleeves – 70,000 per year

Chemicals: None

Other: Purchases of stainless steel weldments (>1,000)

Source / transportation of raw materials:
North America – truck
Europe – sea, air
Asia – sea, air

Units produced per year: (avg number): 20,000 units/yr

Manhours: (per year): 60,000 direct lbr hrs/yr

Average energy consumption: 240,000 kWh/mth

Direct use of natural infrastructure:
Airshed information: (if available, or quantity of air used)
na

Water used/affected (avg/mth): 800 m^3/mth

Land use for production/storage: (area, and type of land – urban, rural, etc.)
12,000 m^2 urban

Carbon source used (type and quantity, avg/mth): (natural gas, coal, oil, etc.)
Natural gas, 8,500 m^3/mth

Transportation (shipping) methods for product:

Transport truck
Sea container
Air

Waste streams:

Waste	Disposal method	Total waste, quantity (also, any permit information)

Liquid Hydraulic oil and glycol coolant	Recycle	400 L/yr
Solid Wood Cardboard Steel Waste	 Recycle Recycle Recycle Landfill	 40 MT/yr 50 MT/yr 10 MT/yr 60 MT/yr
Emissions to air	na	na

Disposal of UV lamps:

Recycle: 5,000 kg/yr

Questionnaire for UV disinfection equipment manufacturers

Company name:
Contact person:
Phone: Fax:

Major raw materials: (names and quantities per year)
Lamps:

Equipment:

Chemicals:

Other:

Source / transportation of raw materials:

Units produced per year: (avg number)

Manhours: (per year)

Average energy consumption: kWh or kW

Direct use of natural infrastructure:
Airshed information: (if available, or quantity of air used)

Water used/affected:

Land use for production/storage: (area, and type of land – urban, rural, etc.)

Carbon source used (type and quantity): (natural gas, coal, oil, etc.)

Transportation (shipping) methods for product:

Waste streams:

Waste	Disposal method	Total waste, quantity (also, any permit information)
Liquid		
Solid		
Emissions to air		

Disposal of UV lamps:

Project: METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO (MWRDGC)
Economic and Environmental Assessment of Water Quality Improvement in the CAWS

QUESTIONNAIRE FOR MANUFACTURERS/SUPPLIERS OF: Chlorination+dechlorination equipments and chemicals for disinfection of wastewater treatment plant effluent.

Company name:
Contact person:
Phone:
Fax:

Please fill-in the following information to the best of your knowledge. <u>All the required information pertains to YOUR manufacturing/assembling site only. (and NOT the plant where it will be implemented.)</u>

Production of 1-ton of SODIUM HYPOCHLORITE (15%)

Raw materials (name)	Raw materials (quantity to produce 1-ton sodium hypochlorite (15%)	Manufacturing location	Approx. transportation distance to your manufacturing plant	Safety concerns in manufacturing
1.				
2.				
3.				
4.				
5.				

Production of 1-ton of SODIUM BISULFITE (suggest strength of solution)

Raw materials (name)	Raw materials (quantity to produce 1-ton sodium bisulfite (suggest strength of solution)	Manufacturing location	Approx. transportation distance to your manufacturing plant	Safety concerns in manufacturing
1.				
2.				
3.				
4.				
5.				

Manufacturing of analytical & monitoring equipment, metering pumps, mixers, storage tanks*

Raw materials (name of raw material or equipment)	Raw materials (quantity) (see note below)	Approx. transportation distance (your source to **your** plant)	For manufacturing or assembling			
			Electricity used (KWH, or other units)	Water used	Air used	Labor used, man-hrs
1.						
2.						
3.						
4.						

5.						

* Since we do not have the design yet, please give your best numbers based on disinfection of 100MGD secondary effluent from a typical wastewater treatment plant, to get the E. Coli. count down to 400 from 200,000 cfu/100ml.

Waste Generation at your site:

Waste	Total waste, quantity (also, any permit information)	Disposal method
Liquid		
Solid		
Emissions to air		

Typical service life of major equipment used in disinfection process at site of application:

Equipment name	Typical service life

Any recycle program for the equipment used in disinfection and supportive facilities:

APPENDIX F

Waste Streams from Manufacturing Facilities

Summary of Releases from Chlorine Generation Industry (2005 data)

Facility Name: Olin Corp
Location: New York
SIC: 2812 (Alkalines and Chlorine) and 2819 (Industrial Organic Chemicals, NEC)

Releases to Air:

	Fugitive	Point
Chlorine	6.8 lbs	1560 lbs
Hydrochloric Acid	5 lbs	851 lbs

No other reported releases

Facility Name: Pioneer Americas LLC
Location: Louisiana
SIC: 2812 (Alkalines and Chlorine)

Releases to Air:

	Fugitive	Point	
Chlorine	271.8 lbs	84.8 lbs	
Mercury	730.5 lbs	48 lbs	used as a manufacturing aid

Releases to Streams or Water Bodies:	Mississippi River
Chlorine	0.05 lbs

Off-Site Transfers	RCRA Landfill	Metals Recovery	Other Landfills
Mercury	621.43 lbs	164 lbs	0.03 lbs

No other reported releases
Have an air scrubber for removing chlorine and mercury emissions from stack.
Conduct onsite metals recovery for mercury

Facility Name: Arch Chemicals
Location: Tennessee
SIC: 2819 (Industrial Organic Chemicals, NEC)

Releases to Air:

	Fugitive	Point
Chlorine	5.0 lbs	90525 lbs

No other reported releases
Have an air scrubber for removing chlorine emissions from stack.

Attachment 3 UV Design Criteria for the North Side, Calumet, and Stickney Plants			
	North Side	Calumet	Stickney
Average Day/Peak Hour Design Flow, mgd	333/450	319/480	1250/1440
E. coli Design Limit, cfu/100 mL	400	400	400
Lamps, Total	1,680	1,680	4,032
Hourly Average Power[2], kW	3,182	2,903	9,225
Average Energy, kWh/day	76,368	69,672	221,400
UV Land Requirement[3], acres	2.07	1.65	3.72

1. Source: *UV Disinfection Cost Study – North Side Water Reclamation Plant* (CTE. January 2008); the information for Stickney is from working results of the *Draft SWRP UV Cost Study* and the *Draft Hydraulic Evaluation Technical Memorandum* (CTE, June 2008)
2. Power includes operation of the equipment only.
3. Land proposed for the UV facilities at Calumet are currently occupied by the existing chlorine contact tanks.

Attachment 4 Chlorination/Dechlorination Design Criteria for the North Side, Calumet, and Stickney Plants			
	North Side	Calumet	Stickney
Average Day/Peak Hour Design Flow, mgd	333/450	319/480	1,250/1,440
E. coli limit, cfu/100 mL	400	400	400
Average Daily Sodium Hypochlorite Dosage, lb/day	16,700	16,000	62,550
Average Daily Sodium Bisulfite Dosage, lb/day	8,100	7,800	30,400
Hourly Average Power[2], kW	24.15	92.06	68.76
Average Energy, kWh/day	580	2,209	1,650
Land Requirement for Chlor-Dechlor, acres[3]	3.1	4.2	9.75

1. Source: *Chlorination/Dechlorination Disinfection Cost Study for Stickney, Calumet and North Side Water Reclamation Plants* (CTE, May 2008).
2. Power includes operation of the transfer pumps, feed pumps, and mixers for chlorination/dechlorination. At North Side and Stickney, design assumes one new mixing chamber for each chemical with one mixer each (two total mixers at each plant). At Calumet, design assumes reusing the existing contact tanks and splitting flow such that two mixing chambers are required for each chemical with one mixer each (four total mixers). The additional mixers result in higher energy use at the Calumet WRP.
3. The land requirements for chlorination/dechlorination at the Calumet plant include the 2.2 acres occupied by the existing contact tank.

Attachment 5

Total Air Emissions of Criteria Pollutants, Greenhouse Gases, and Mercury

	Emissions at the plants	Emissions at the Power Generating Facility Resulting from Energy Utilized at the Plants[2]			
	2006 Plant Emissions[1] (tons/yr)	North Side (tons/yr)	Calumet (tons/yr)	Stickney (tons/yr)	TOTAL AIR EMISSIONS (tons/yr)
NO_x	54	85	112	348	600
SO_2	9	307	403	1,250	1,970
Hg	NA	0.001	0.002	0.005	0.008
CO_2 (tons/yr)	NA	46,800	61,400	190,700	298,900
N_20 (tons/yr)	NA	0.54	0.71	2.21	3.5
CH_4 (tons/yr)	NA	0.25	0.32	1.0	1.6
CO_2 equivalents[3]	NA	46,900	61,700	191,400	300,000

1. Criteria pollutant emissions from North Side, Calumet, and Stickney as reported in the District's 2006 Annual Air Emission Reports.
2. Estimated energy emissions from coal-based power plants are calculated using energy consumption at the North Side, Calumet, and Stickney plants and eGrid emission factors.
3. Carbon dioxide equivalents equal the sum of CO_2, $21*CH_4$, and $310*N_20$.

Attachment 6

Current and Allocated Land Usage[1]

	North Side	Calumet	Stickney	TOTAL
Total Area (acres)	97	470	570	1,137
Estimated Plant Area Currently in Use (acres)[2,3]	63	424	388	875
Estimated Plant Area Allocated for Future Projects (acres)[4]	24	22	16	62
Total Estimated Land Area in Use or Allocated (acres)	87	446	404	937
Percent Used or Allocated Land	90%	95%	71%	82%
Remaining Land[5] (acres)	10	24	166	200

1. Source: MWRDGC M&O Facilities Handbook, 2006, and facility layouts.
2. The areas are estimated using layouts of facilities and do not consider any underground structures that are not shown on the layouts.
3. At North Side, the current land in use includes land leased to the Park District.
4. Allocated land is set aside for future projects already identified to meet regulatory requirements and expansion needs as described in the District's Master Plan for each facility.
5. Some portion of the remaining land would be dedicated for disinfection.

Attachment 7

Water Usage and Runoff

	North Side	Calumet	Stickney	Total
Average Daily Design Flow (mgd)[1]	333	319	1,250	1,900
2007 Onsite Water Usage (MG/yr)[2]	3.9	3.7	14.6	22
Estimated Existing Runoff (MG/yr)[3]	11	49	83	143

1. Design flows are from CTE's disinfection cost studies.
2. Onsite water usage is based on water bills for North Side, flow-proportioning was applied for Calumet and Stickney since water bills were not available.
3. Facility layouts were used to determine runoff areas; assume an historical average of 36.4 inches of precipitation per year.

Attachment 8 Annual Electricity Equivalents		
	UV	Chlorination/ Dechlorination
District's Current Energy Consumption at North Side, Calumet, and Stickney plants (kWh/yr)1	384 million	
Energy Increase (kWh/yr)	126 million	95 million
Percent Increase from Current	33%	25%
No. of Equivalent Households[2]	10,600	8,000
Disinfection Energy Use Relative to Sears Tower Energy Use[3]	164%	124%

1. 2006 energy consumption as reported in the District's "2008 Budget Book Info Final, All Divisions" (January, 2008).
2. 11,965 kWh/household per year provided by USEPA, http://www.epa.gov/cleanenergy/energy-resources/calculator.html
3. Assume energy consumption is 77 Million kWh/year for the Sears Tower. Source: http://securitysolutions.com/fire_life_safety/security_modernizing_legend/

Attachment 9 Annual Greenhouse Gas Emission Equivalents from Transportation and at the Power Generating Facility Due to Energy Consumption		
	UV	Chlorination/ Dechlorination
Current CO_2 Emissions at the Power Generating Facility due to Energy Use at the Three Plants (tons CO_2 /yr)[1]	299,000	
CO_2 Emissions Increase at the Power Generating Facility (tons CO_2 /yr)	98,300	74,000
CO_2 Emissions Increase from Transportation (tons CO_2 /yr)[2]	270	690
Equivalent No. of Trees for CO_2 absorption (trees/yr)[3]	15.2 million	11.5 million
Percent Increase of CO_2 Emissions	33%	25%
Current GHG Emissions at the Power Generating Facility due to Energy Use at the Three Plants (tons CO_2 equivalents/yr)[4]	300,000	
GHG Emissions Increase at the Power Generating Facility (tons CO_2 equivalents/yr)	98,700	74,300
GHG Emissions Increase from Transportation (tons CO_2 equivalents/yr)	270	690
Equivalent No. of Cars Added to the Road (cars/yr)[5]	16,400	12,500
Percent Increase	33%	25%

1. Calculated based on energy consumption and eGrid emission factors. District energy consumption from Table 8 of "2008 Budget Book Info Final, All Divisions (January 16, 2008)" provided by the District.
2. Transportation emissions for only the associated manufacturing/operation of the facility are included.
3. A single tree absorbs 13lb CO_2 per year. Coder, R.D. (October 1996). *Identified Benefits of Community Trees and Forests.*
4. Carbon dioxide equivalents equal the sum of CO_2, 21*CH_4, and 310*N_20.
5. 6.02 tons CO2equivalents/car per year provided by USEPA, http://www.epa.gov/cleanenergy/energy-resources/calculator.html

Attachment 10 Annual Additional Air Emissions of Regulated Air Pollutants at the Power Generating Facility					
	Current Total Emissions (tons/yr)[1]	Additional Air Emissions at Power Generating Facility (tons/yr)		Percent Change From Current Emissions	
		UV	Chlorination	UV	Chlorination
NO_x	600	180	140	30%	23%
SO_2	1970	650	490	33%	25%
Hg	0.008	0.003	0.002	33%	25%

1. Summation of emissions reported in the District's 2006 Annual Air Emission Reports for the North Side, Calumet, and Stickney plants, and emissions at the power plant due to energy use.

Attachment 11 Land Increase						
	Currently Used or Allocated Land (acres)[1,2,3,4]	Remaining Land (acres)	Additional Land Required for Disinfection[5] (acres)		Percent Change From Current/Allocated Land Use	
			UV	Chlorination	UV	Chlorination
North Side	87	10	2.1	3.1	2.4%	3.6%
Calumet	446	24	1.7	4.2	0.4%	0.9%
Stickney	404	166	3.7	9.8	0.9%	5.9%
TOTAL	937	200	7.5	17.1	0.8%	1.8%

1. Source: MWRDGC M&O Facilities Handbook, 2006, and facility layouts.
2. The areas are estimated using layouts of facilities and do not consider any underground structures that are not shown on the layouts.
3. At North Side, the current land in use includes land leased to the Park District.
4. Allocated land is set aside for future projects already identified to meet regulatory requirements and expansion needs as described in the District's Master Plan for each facility.
5. Source: *Draft UV Disinfection Cost Study – North Side Water Reclamation Plant* (CTE, January 2008); working results of the *Draft Stickney Water Reclamation Plant UV Cost Study* and the *Hydraulic Evaluation Technical Memorandum* (CTE, June 2008); *Chlorination/Dechlorination Disinfection Cost Study for Stickney, Calumet and North Side Water Reclamation Plants* (CTE, May 2008).