

**EVALUATION OF DISINFECTION ALTERNATIVES AT  
THE ALBANY COUNTY SEWER DISTRICT  
NORTH AND SOUTH PLANTS**

**FINAL REPORT 10-12  
MAY 2009**

NEW YORK STATE  
ENERGY RESEARCH AND  
DEVELOPMENT AUTHORITY

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Final Report

Prepared for the  
**NEW YORK STATE  
ENERGY RESEARCH AND  
DEVELOPMENT AUTHORITY**  
Albany, NY  
[www.nyserda.org](http://www.nyserda.org)

Kathleen O'Connor, P.E.  
Project Manager

Prepared by:  
**MALCOM PIRNIE, INC**

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# 1. Introduction

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## 1.1. Project Background

As part of the “Swimmable Hudson” initiative, the New York State Department of Environmental Conservation (NYS DEC) has undertaken a number of steps to ensure that the quality of the water in the Hudson River is suitable for swimming, including the upgrade of seven wastewater treatment plants (WWTPs) within the Capital District to incorporate disinfection. The Albany County Sewer District (ACSD) is considering upgrade of its North and South Plants to comply with this initiative. The North and South Plants represent over two-thirds of the total design capacity, and consequently potential energy use, of the Capital District WWTPs that will be affected by the “Swimmable Hudson” initiative.

The ACSD is considering the use of either chlorination/dechlorination or ultraviolet (UV) technology to meet their disinfection needs. Chlorination is often one of the most cost-effective methods to disinfect wastewater effluent. However, depending upon the form of chlorine used for disinfection there are a variety of safety and operating challenges that must be considered. Additionally, because of the extremely stringent proposed allowable chlorine residual for ACSD’s effluent, dechlorination will also be required – increasing costs and operating complexity. UV radiation is one of the most environmentally friendly disinfection technologies available. However, the use of UV disinfection has the potential to be extremely energy intensive, particularly if it is improperly designed and operated or used in an inappropriate application.

## 1.2. Project Purpose

The factors that have the greatest effect on the energy use of UV disinfection are flow rate and UV transmittance (UVT) (i.e., the ability for UV light to pass through the water and inactivate the target organism). It is imperative that system design be based on sound data. In the case of the North and South Plants, both of which are served by combined sewers, sufficient sampling must be conducted to fully understand the effect of wet weather flows. Specifically, a thorough understanding of the differences between dry weather operations, wet weather operations without secondary bypass, and wet weather operations with secondary bypass and effluent blending is needed to ensure the most applicable disinfection technology or combination of technologies is selected and is appropriately sized and configured to maximize cost effectiveness and operating flexibility now and in the future.

The purpose of this study was to complete a comprehensive sampling program to clearly establish the operating conditions over which the selected disinfection technology must

operate. The data will be evaluated to identify the most efficient and effective disinfection technology or combination of technologies to meet ACSD's long-term disinfection goals. Recognizing the increased use of UV disinfection and the potential for significant electricity use with the technology, the New York State Energy Research and Development Authority (NYSERDA) co-funded this study under Program Opportunity Notice 1040, with an in-kind contribution from ACSD. The findings of the study should be of significant benefit to ACSD and the other WWTPs affected by the Swimmable Hudson Initiative, as well as other WWTPs throughout the United States that are considering the use of UV disinfection, particularly if the facilities are served by combined sewers.

### **1.3. Description of Facilities**

The Albany County Sewer District owns and operates two wastewater treatment facilities, designated North and South, which provide secondary treatment to the wastewater from eight communities in Albany County. The North Plant, which is located in Menands, is designed to treat an average daily flow of 35 MGD. The South Plant, which is located in the Port of Albany, is designed and permitted for 19 MGD and 29 MGD, respectively. The South Plant treats waste from only the City of Albany, whereas the North Plant treats waste from the Cities of Cohoes, Watervliet and parts of Albany, the Villages of Menands, Green Island and Colonie and parts of the Towns of Guilderland and Colonie. A number of industrial users exist within the service areas of both Plants. However, the majority of wastewater that is discharged by Significant Industrial Users is treated at the North Plant. Some industries are required to pretreat their wastewater prior to discharge.

The North and South Plants have virtually identical process configurations, consisting of preliminary, primary, and secondary treatment. Chlorination facilities were included in the original design for both Plants, but are not used. Preliminary treatment removes solids from the influent wastewater that may clog or damage equipment downstream. During primary treatment, gravity settling removes approximately 25-35 percent of the biochemical oxygen demand (BOD) in the wastewater and 40-60 percent of the suspended solids in the wastewater. Secondary treatment consists of a biological process that removes 85-95 percent of the BOD and settleable solids prior to discharge to the Hudson River. This process generates waste activated sludge that is combined with primary sludge that is then dewatered and incinerated.



## 2. Fundamentals of Wastewater Disinfection

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Disinfection is the destruction or inactivation of disease-causing organisms. The overarching goal of disinfection is to remove or inactivate pathogens to an acceptable level before discharging treated wastewater to the receiving water body. This study evaluates two disinfection alternatives: ultraviolet irradiation and chlorination. The fundamentals of each disinfection technology are discussed in the following sections.

### 2.1. Ultraviolet Disinfection

#### 2.1.1. Fundamentals

Ultraviolet (UV) radiation is defined as that portion of the electromagnetic spectrum between x rays and visible light (i.e., between 40 and 400 nm). UV disinfection transfers electromagnetic energy from a source lamp to the genetic material of the target organism. UV radiation damages the chemical bonds in DNA and RNA, which prevents the pathogen from replicating. The germicidal effect of UV rays for most microorganisms is maximal within the 250 nm to 265 nm range.

Major advantages of UV irradiation include a small process footprint, short contact time, insensitivity to pH and temperature, and flexible dosage control. UV irradiation produces neither toxic disinfection residuals, nor by-products. In addition, UV irradiation does not require onsite chemical storage. However, water quality greatly impacts the effectiveness of UV disinfection and the electricity use associated with UV disinfection can be significant. Additionally, because the lamps contain a small amount of mercury, certain procedures must be followed when handling, replacing, or disposing of lamps.

#### 2.1.2. Ultraviolet Disinfection Technology

The critical components of a UV disinfection system include the UV lamps, the ballasts, the reactor, and the lamp cleaning devices.

UV lamps are a class of gas discharge lamps. The lamps typically used in UV disinfection consist of a quartz tube filled with an inert gas, such as argon, and small quantities of mercury. Ballasts control the power to the UV lamps. Unlike incandescent lamps, gas discharge lamps do not contain a filament. Rather, an electric current flows through the lamp and ionizes the electrons of the gas, and ultraviolet light is produced as a result of electrons returning to a lower energy state. UV lamps lack a phosphorescent coating that is typical of fluorescent lamps. In fluorescent lamps, the phosphorescent coating absorbs the UV wavelengths and converts it into visible light.

Most mercury vapor lamps use an initial high voltage to initiate the electrical arc through the argon and mercury mixture. Argon does not contribute to the spectral output of the lamp, but aids lamp starting. Argon, which has a high ionization potential, is readily excitable. In other words, the energy required to remove an electron from the outermost valence shell of an argon atom is relatively low. When argon atoms with excited electrons collide with mercury atoms, ionization of the mercury atoms occurs. UV radiation is emitted by the ionized mercury atoms as they return to a lower energy state.

Conventional UV lamps include low-pressure, low-output (LPLO), low-pressure high-output (LPHO) and medium-pressure (MP) mercury vapor lamps. The internal mercury vapor pressure dictates the emission spectrum, and the energy output (or intensity) affects the UV dosage that is delivered. Table 2.1, adapted from Dussert (2005), characterizes the physical properties of these three types of UV lamps.

**Table 2.1  
Summary of Physical Characteristics of UV Lamps**

| Type                              | Low Pressure,<br>Low Output | Low Pressure,<br>High Output | Medium Pressure |
|-----------------------------------|-----------------------------|------------------------------|-----------------|
| Hg pressure – atm                 | 0.01                        | 0.01                         | 1-2             |
| Amount of Hg – mg                 | 5-50                        | 35-100                       | 40-400          |
| Operational Temperature (F)       | 100-140                     | 300-400                      | 1,100-1,650     |
| Operational Temperature (C)       | 38-60                       | 150-200                      | 590-900         |
| Emission Spectrum                 | Monochromatic               | Monochromatic                | Polychromatic   |
| Input Power (W)                   | 15-75                       | 150-400                      | 1,000-20,000    |
| UVC <sup>2,3</sup> efficiency (%) | 32-38                       | 30-36                        | 12-16           |
| Output Power <sup>1</sup> (W)     | 4.8-28.5                    | 45-144                       | 120-3,200       |
| Lifetime (hours)                  | 8,000-12,000                | 8,000-15,000                 | 3,000-9,000     |

Notes:

1. The output power was calculated from the input power and the UVC efficiency.
2. The wavelength range of the ultraviolet spectrum includes UVA (long wavelength), UVB (medium wavelength), and UVC (short wavelength) bands.
3. The UVC band is also known as the germicidal wavelength because the germicidal effect of UV rays for most microorganisms is maximal within the 250 nm to 265 nm range.

### 2.1.3. Design Considerations

UV disinfection has been in use for decades, and its performance is well documented. However, because UV disinfection relies on a single piece of equipment (the UV reactor) that is designed by the manufacturer, the design considerations associated with UV disinfection are more typical of those for a large piece of equipment than a treatment process and can generally be broken down into two categories: process suitability and physical constraints.



Process suitability is primarily focused on the ability of UV disinfection to provide sufficient levels of inactivation of the target organism under the proposed conditions of water quality and flow rate to meet the disinfection objectives. Factors that have the greatest effect on process suitability include the UVT of the wastewater, the fouling potential of the wastewater, the UV dose response of the target organism, the initial concentration of the target organism, and the allowable effluent concentration of the target organism.

Physical constraints that are of greatest concern with UV disinfection include available physical space for the UV reactors and control panels, adequate power supply (both primary and backup), adequate power quality (from the grid and as a result of harmonics that may be induced within the treatment plant), and allowable head loss through the system.

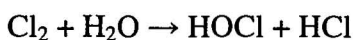
If UV disinfection is feasible, based on an evaluation of process suitability and physical constraints, then the remaining design considerations are focused on selection of the equipment and control strategy that are most suitable for the application. System features that must be considered include whether to use an open-channel or closed vessel system, whether to use a LPLO, LPHO or MP lamp configuration, whether to incorporate lamp intensity control, and the need to include an automatic lamp sleeve cleaning system. For most large scale wastewater applications, open channel configurations using LPHO or MP lamps with lamp intensity control and an automatic sleeve cleaning system are preferred.

## 2.2. Chlorination and Dechlorination

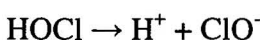
### 2.2.1. Fundamentals

Chlorination is a well-established treatment technology that dates to the early twentieth century. In the United States, chlorine is the most commonly used wastewater disinfectant. The majority of wastewater facilities larger than 1 MGD disinfect wastewater using elemental chlorine in a gaseous or liquid form.

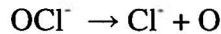
When chlorine is added to water, it reacts to form a pH dependent equilibrium mixture of chlorine, hypochlorous acid and hydrochloric acid:



The cell wall of pathogenic microorganisms is negatively charged. As such, chlorine can migrate through the cell wall. Depending on the pH, hypochlorous acid partly dissociates to hydrogen and hypochlorite ions:



The hypochlorite ion may further dissociate into the chloride ion and oxygen:



Chloride ions destroy microorganisms by destroying cell enzymes once the disinfectant migrates through the cell wall. The replacement of hydrogen atoms by chlorine alters the shape and therefore the function of the enzyme, causing the microorganism to die.

Chlorine residuals can prolong disinfection of the wastewater effluent after the initial treatment. However, chlorine residuals at relatively low levels have proven toxic to aquatic organisms. Chlorine does not readily pass the permeable gill epithelium and destroys the cells of the gills by oxidation, causing an impairment of normal gaseous exchange. In addition, studies have suggested that trihalomethanes, a byproduct of chlorination, may have carcinogenic properties. This is of greater concern in drinking water. However, the presence of disinfection byproducts in source water as a result of upstream wastewater disinfection is drawing greater attention amongst regulators and academia.

Due to the toxicity of residual chlorine to aquatic life and concern over the formation of disinfection byproducts, stringent chlorine residual limits in wastewater effluent are becoming more common, often requiring WWTPs that use chlorine disinfection to also employ dechlorination. Dechlorination is a process by which the chlorine residual is removed from the treated effluent prior to discharge. Although chlorination is often the lowest capital cost process for wastewater disinfection, the addition of a dechlorination process increases the cost and complexity of disinfection. During dechlorination, elemental chlorine ( $\text{Cl}_2$ ), hypochlorous acid ( $\text{HOCl}$ ) or hypochlorite ( $\text{OCl}^-$ ) is converted to the chloride ion ( $\text{Cl}^-$ ). Dechlorination is induced by the addition of a reducing chemical, or in other words, a chemical that releases electrons that are gained by the chlorine.

### **2.2.2. Chlorination Technology**

Chlorine is the most widely used wastewater disinfectant in the U.S., and it kills most bacteria, viruses, and other microorganisms that cause disease. Chlorine is introduced to wastewater in the form of gas, hypochlorites (tablets, solutions, or powder), and other compounds. Commonly used forms of chlorine are gaseous chlorine, sodium hypochlorite solution, calcium hypochlorite, and bromium chloride. A typical chlorine disinfection system includes a chemical receiving and storage area, an injection system, a mixing zone and a contact chamber. The effluent is then discharged to the receiving water. As discussed previously, chlorine residuals can persist in treated wastewater for many hours and the use of dechlorination is becoming more common. Commonly used dechlorinating chemicals are sulfur dioxide, sodium bisulfite, sodium metabisulfite, and activated carbon.



### 2.2.3. Design Considerations

Chemical disinfection has a long history of use, and the key design considerations are well documented and understood. A typical chemical disinfection system consists of a series of integrated components that are readily available from multiple manufacturers and able to be effectively interchanged (e.g., storage tanks, mixing chambers, injection pumps, metering pumps, concrete tanks). Key areas of consideration include selection of chemical(s), design of receiving and storage facilities, design of chemical injection system(s) and controls, and design of system(s) to provide adequate contact time for the necessary reactions to occur. Dependent upon the chemical that is selected, provisions must be incorporated to comply with applicable fire codes and health and safety requirements.

Variables with the greatest influence on the design of a chemical disinfection system include the target organism and its dose-response, the initial concentration of the target organism, the allowable effluent concentration of the organism, the background chlorine demand of the wastewater being treated, the range of anticipated flow rates and the allowable residual chlorine concentration in the final effluent.

### 2.3. Previous Studies

Omerci et al. (2002) investigated the disinfection effectiveness of UV irradiation and free chlorine for naturally occurring particle associated coliform (PAC) and non-particle associated coliform (NPAC) in wastewater. The results of the study indicated that under prolonged contact time chlorine appears to be more effective than UV irradiation for the inactivation of PAC. Contact time appears to be the most important factor in determining the effectiveness of chlorine disinfection of PAC. Contact times shorter than 45 minutes resulted in the survival of PAC regardless of the initial chlorine concentration. Therefore, the chlorine dose alone may not be a good indicator of disinfection effectiveness in wastewater.

Wang et al. (2006) evaluated the reduction of effluent particles and the associated improvement of UV disinfection as a result of pre-chlorination. Pre-chlorination oxidizes organic matter within a particle, which separates a relatively large particle into smaller particles or reduces a relatively small particle to a dissolved state. Pre-chlorination decreases the number and size of particles in the wastewater, thereby increasing the efficiency of the subsequent UV disinfection. The combined chlorination and UV disinfection process demonstrated a higher resistance to particle loading than the UV process alone. In addition, the combined process demonstrated a lower bio-toxicity than a chlorination process of the same disinfection efficiency.

Emerick et al. (1999) evaluated the effect of treatment process type and operation on the formation of particle-associated coliform bacteria and the achievable levels of residual coliform bacteria after high doses of UV light. Treatment systems designed to encourage

biological floc development will have significantly more particle associated coliform bacteria in the effluent. Activated sludge and trickling filter systems have a significantly greater percentage of embedded coliform bacteria than lagoons. Based on studies from activated sludge WWTPs, the percentage of coliform bacteria associated with particles declines exponentially with increased values of the mean cell residence time (MCRT)<sup>1</sup>. This suggests that a relatively small increase in the MCRT could provide a significant improvement in downstream UV disinfection performance.

Das (2001) reported that the range of effective ultraviolet transmittance varies depending on the secondary treatment system. In general, suspended growth treatment processes produce effluent with transmittance varying from 60-65 percent. Fixed film processes range from 50-55 percent transmittance and lagoons from 35-40 percent transmittance. Industries that influence UV transmittance include textile, printing, pulp and paper, food processing, meat and poultry processing, photo developing, and chemical manufacturing.

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<sup>1</sup>The mean cell residence time is the average time that a given unit of cell mass stays in the activated sludge biological reactor.

## 3. Data Collection and Trends

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### 3.1. Overview of Sampling Program

As part of this study, a comprehensive sampling and analysis program was undertaken at the North and South Plants. To maximize the validity and accuracy of the dataset that was developed, Malcolm Pirnie personnel prepared a Sampling and Analysis Plan that established the sampling, laboratory analysis, reporting, and recordkeeping procedures for this study. The plan also defined the roles and responsibilities of ACSD and Malcolm Pirnie personnel. A copy of the Sampling and Analysis Plan is included in Appendix A.

The parameters identified for in-house analysis, all of which are routinely performed by ACSD personnel, include temperature, total suspended solids, chemical oxygen demand, and biological oxygen demand. Additional analyses performed by ACSD personnel for this study included turbidity measurement, UV transmittance measurement and chlorine demand analysis. ACSD personnel performed UV transmittance and turbidity analyses using bench top, direct read equipment. Chlorine demand analyses were performed both in-house at ACSD and also by Envirotest Laboratories. St. Peter's Bender Laboratories conducted all fecal and total coliform analyses.

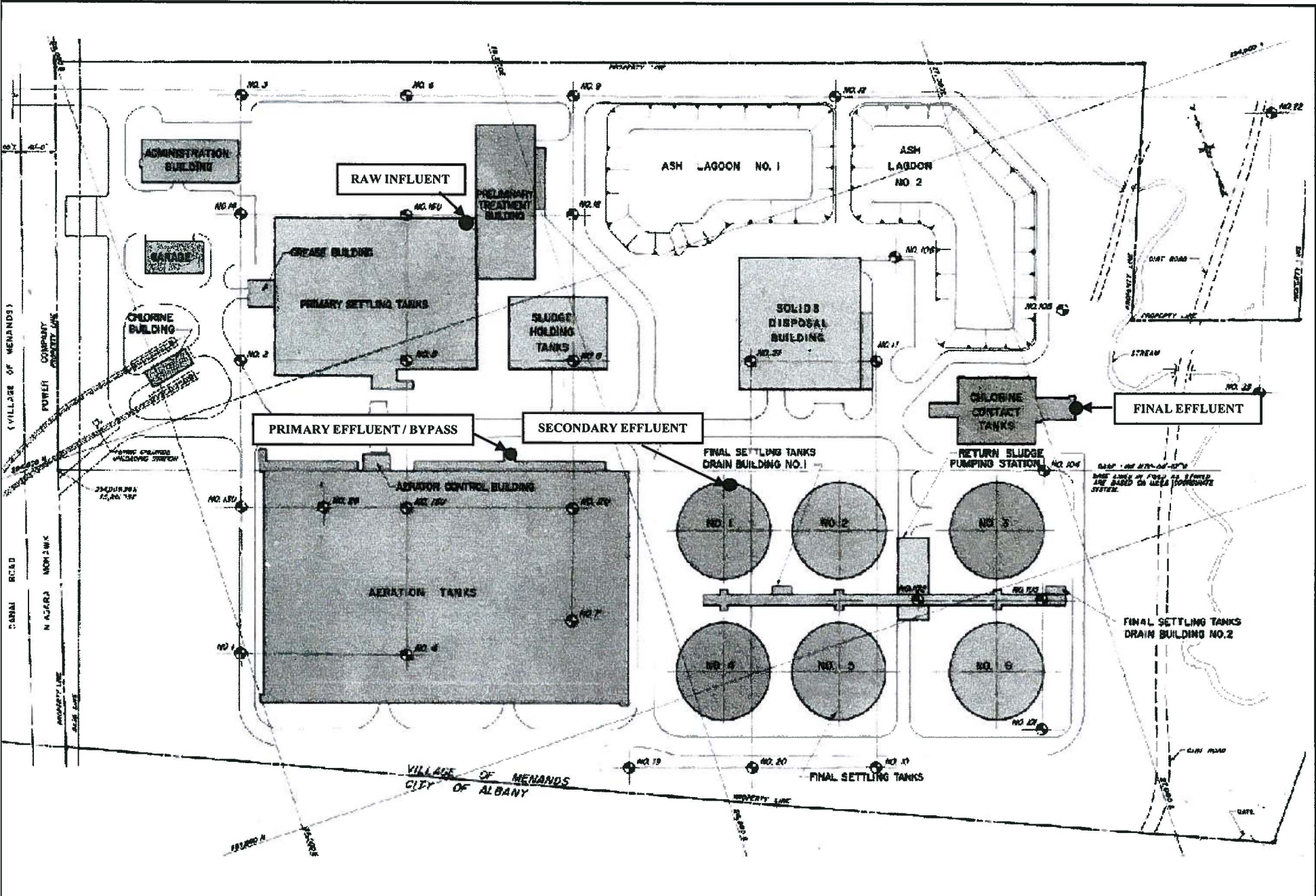
Sampling events were categorized as "dry weather" or "wet weather", defined by pre-determined flow conditions based on historic operating conditions at the North and South Plants. In order to account for bypass conditions, wet weather events were sub-categorized into "wet weather bypass" and "wet weather no-bypass". The category of the sampling event determined the sampling frequencies and locations as outlined in the Sampling and Analysis Plan. Samples were taken of the raw wastewater, the primary effluent, the secondary effluent and the combined discharge (when blended). Figure 3.1 illustrates the sampling locations at the North and South Plants.

ACSD personnel collected grab samples using a swing sampler, which consists of a polyethylene bottle attached to a telescopic pole. A dedicated sampling bottle was used to transfer the sample to sample containers. All analyses were conducted in accordance with appropriate analytical methods and container, preservation, holding time, and transport constraints identified in the sampling plan were met.

### 3.2. Data Acquisition

ACSD personnel conducted sampling during a period of four months from July 2007 to October 2007. ACSD personnel reported the results of all in-house analyses through an electronic spreadsheet e-mailed to Malcolm Pirnie on a monthly basis. St. Peter's Bender Laboratories forwarded all fecal and total coliform results directly to Malcolm Pirnie.









Malcolm Pirnie personnel obtained meteorological data from the “Preliminary Local Climatological Data for Albany” as compiled by the National Weather Service for Albany International Airport. Malcolm Pirnie personnel estimated Hudson River flow through the summation of data available from the USGS Hudson River Gauging Station 01358000 at Green Island, NY and the USGS Mohawk River Gauging Station 01357500 at Cohoes, NY. Prior to 9/30/2006, Gauging Station 01358000 recorded both flow rate and gage height on a daily basis. Since 9/30/2006, only gage height has been recorded on a daily basis. To allow Malcolm Pirnie personnel to estimate flow rate based on reported gage heights, Malcolm Pirnie personnel developed a rating curve (Figure 3.2). The rating curve was developed by fitting historical daily mean flow data and historical gage height data to a polynomial trend line. Flow rates used in this study were obtained by applying real-time gauge heights to this ratings curve.

### **3.3. Data Trends**

A comprehensive sampling program was developed in order to develop clearer relationships between the levels of treatment provided, flow rate, UVT, fecal coliform count, and conventional wastewater parameters. Data trends have been used to establish design criteria for both UV disinfection and chlorine disinfection that account for flow, UVT, and the log inactivation required to meet effluent limits. In addition, monitoring of conventional wastewater parameters in addition to the aforementioned parameters may facilitate sector wide application of the study findings.

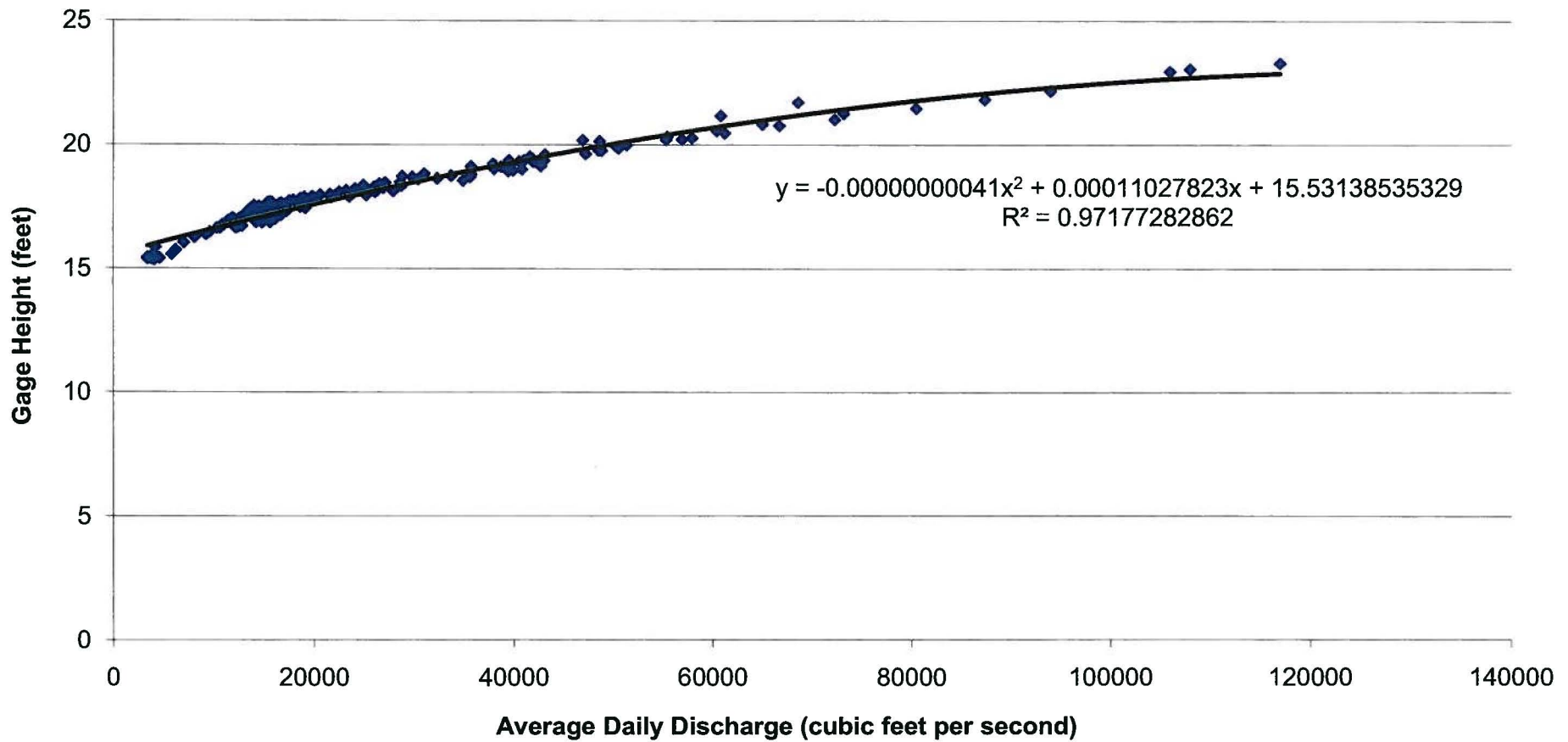
#### **3.3.1. Hudson River Flow Characteristics**

The ACSD North and South Plants are served by combined sewers. Consequently, peak flows at both plants are heavily influenced by stormwater runoff and snowmelt in addition to diurnal variation of wastewater discharge.

In the far upper Hudson drainage basin, the discharge of the Hudson River has relatively modest intrannual variation that is attributable to the climatic conditions of the region. Peak discharge rates occur throughout March and April due to snowmelt. Flow rates decrease from May through August as snowmelt declines and infiltration and evapotranspiration rates increase. As temperatures decrease and the growing season ends, flow rates typically increase from October to December. Throughout the winter months, precipitation is predominantly in the form of snow, thereby reducing the direct influence on river flow rates.

The Mohawk River comprises the largest tributary of the Hudson River. The Mohawk and Hudson River confluence is located at Waterford, north of Troy, NY. In general, the Mohawk River flows are responsive to rainfall levels, whereas the Hudson River flows are subject to the control of sixteen hydroelectric facilities that regulate flow releases.





During periods of relatively low rainfall, the large flows of the Hudson and Mohawk Rivers do not respond to the local precipitation events and continue to fluctuate in a similar pattern to dry-weather periods. However, during a period of large and more regional storm events, flows in the Mohawk River increase in response to the precipitation, whereas the flows in the Hudson River only marginally increase. Therefore, the flow of the Mohawk River is more markedly affected by rainfall than the Hudson River. Also, an incrementally smaller but sustained rainfall more greatly affects river flows than a short, intense rainfall event.

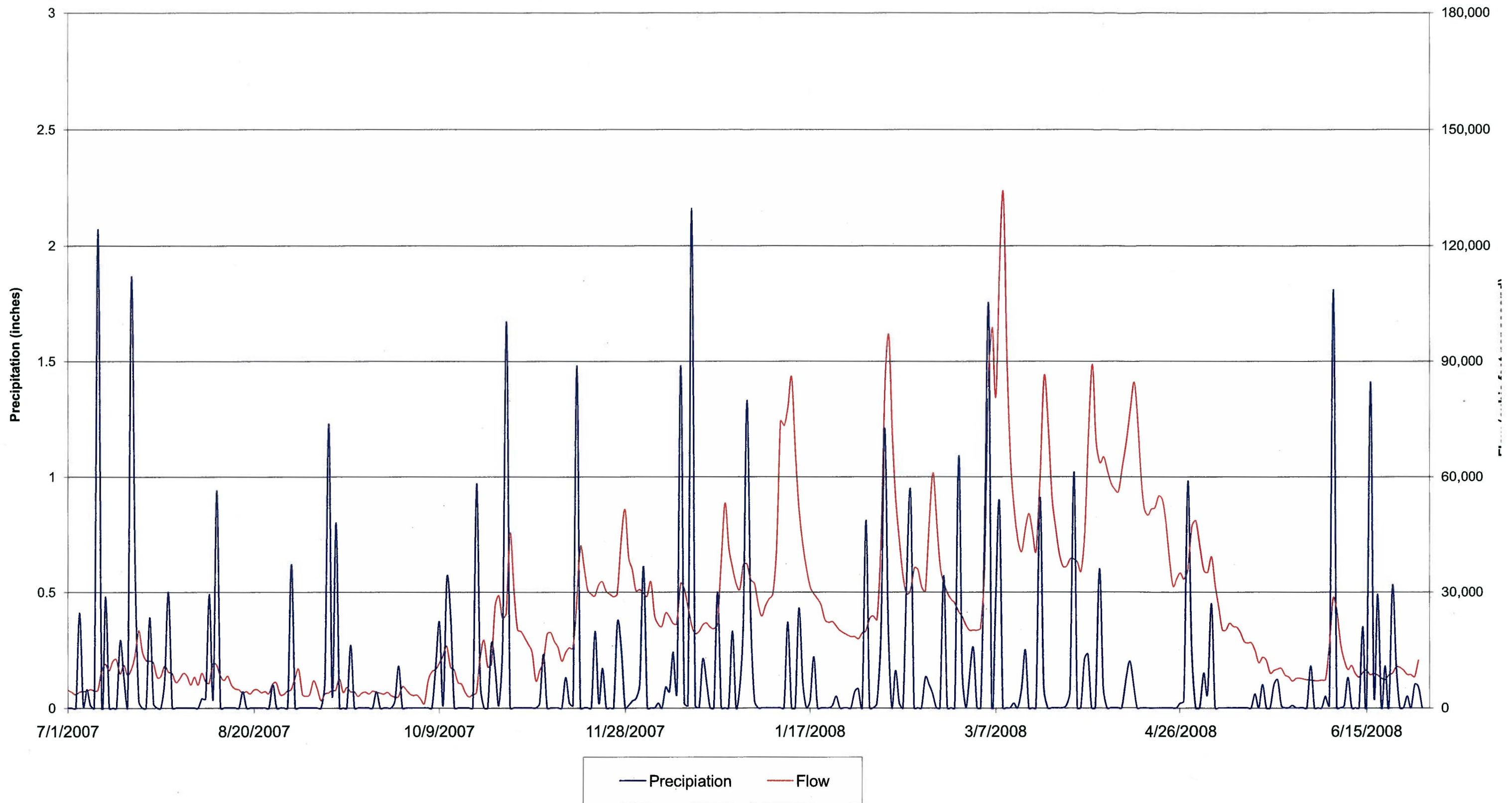
Figure 3.3 illustrates precipitation and Hudson flow rates from July 1, 2007 through June 30, 2008. Snowfall amounts were converted to rainfall through the equivalency of ten inches (10") of snowfall being equal to one inch (1") of rain. South of the Mohawk and Hudson River confluence, the Hudson River base flow is regulated by the upstream hydroelectric facilities' flow releases, whereas the peak Hudson River flows south of the confluence are attributable to Mohawk River contributions, which are responsive to rainfall levels.

Variation in river flow rate impacts the dilution effect of the Hudson River on the discharge from the North and South Plants. Consistent with NYSDEC's Technical & Operational Guidance Series (TOGS) 1.3.1E, chlorine residual is based on the minimum 7 consecutive day flow rate over a 10 year period (7Q10). Fecal coliform discharge requirements are prescribed by TOGS 1.3.1 and are not influenced by flow rate.

### **3.3.2. WWTP Flow Rates**

Flow rate has a significant effect on the performance of a disinfection system. The water quality and flow rates received by the North and South plants vary greatly due to the nature of a combined sewer system. Sufficient capacity and operating flexibility must be incorporated into the design in order to cost-effectively treat the range of expected flow rates. Therefore, it is important that the flow rates be well understood.

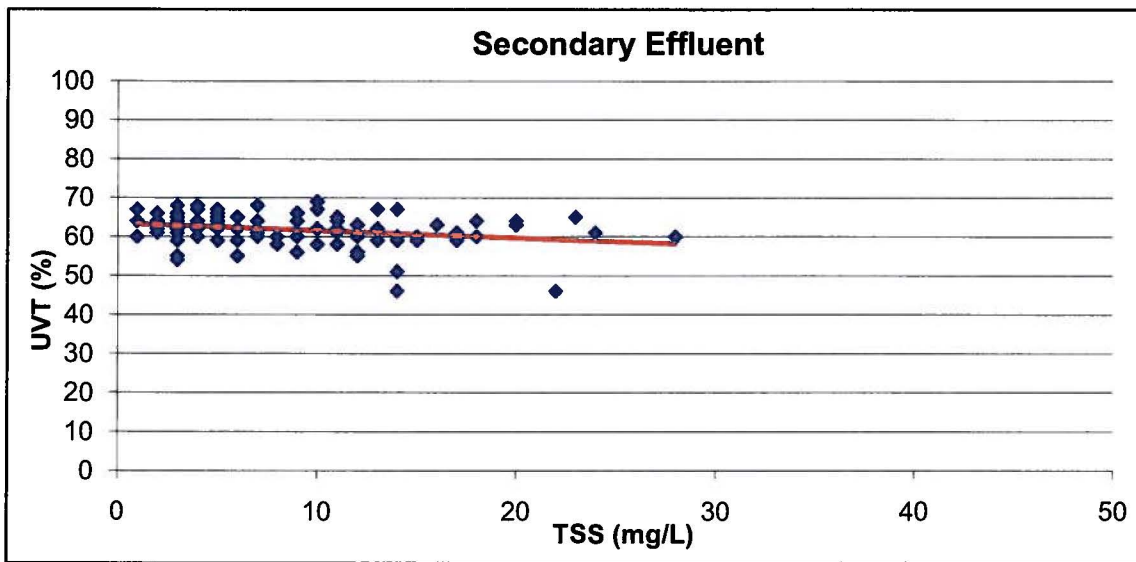
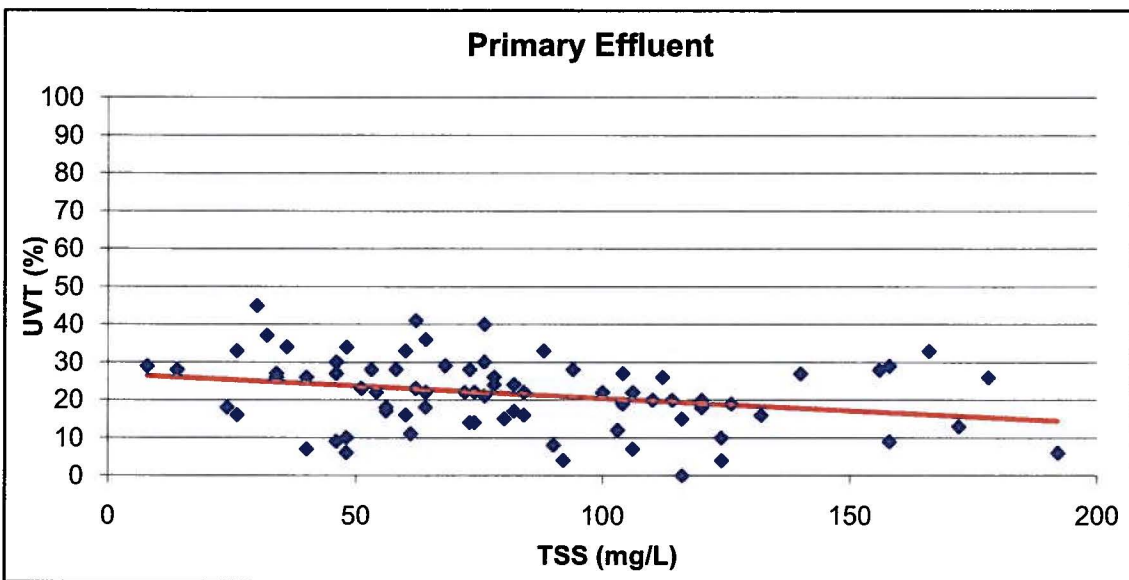
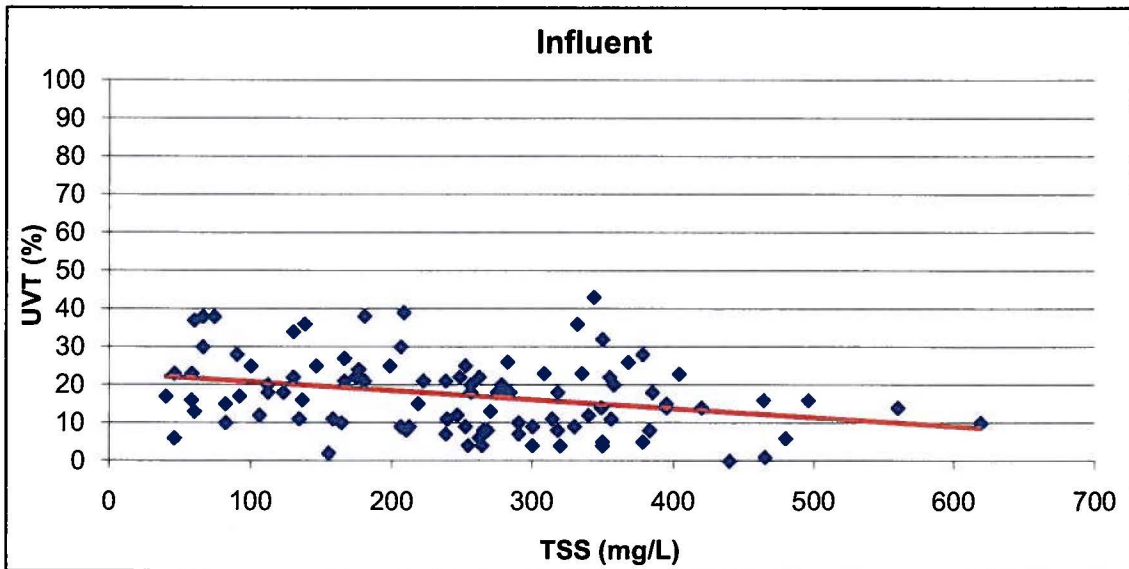
As part of the Albany Pool Combined Sewer Overflow (CSO) Long-Term Control Plan (LTCP) development, a treatment capacity evaluation for the North and South Plants was completed previous to this disinfection alternatives study. Plant influent and operations data were analyzed for the three year period of January 1, 2005 through December 31, 2007. The average daily flow rate, peak day capacity and peak hour capacity for each plant are provided in Table 3.1. The final disinfection capacity requirements are contingent upon the results of river modeling being completed as part of the Long Term Control Plan. The conceptual layouts and costs included in this study are based on the flow rates included in the current SPDES permit for each WWTP (Table 3.1) and do not consider hydraulic limitations within the Plants. Final design criteria and hydraulic constraints must be established during detailed design.



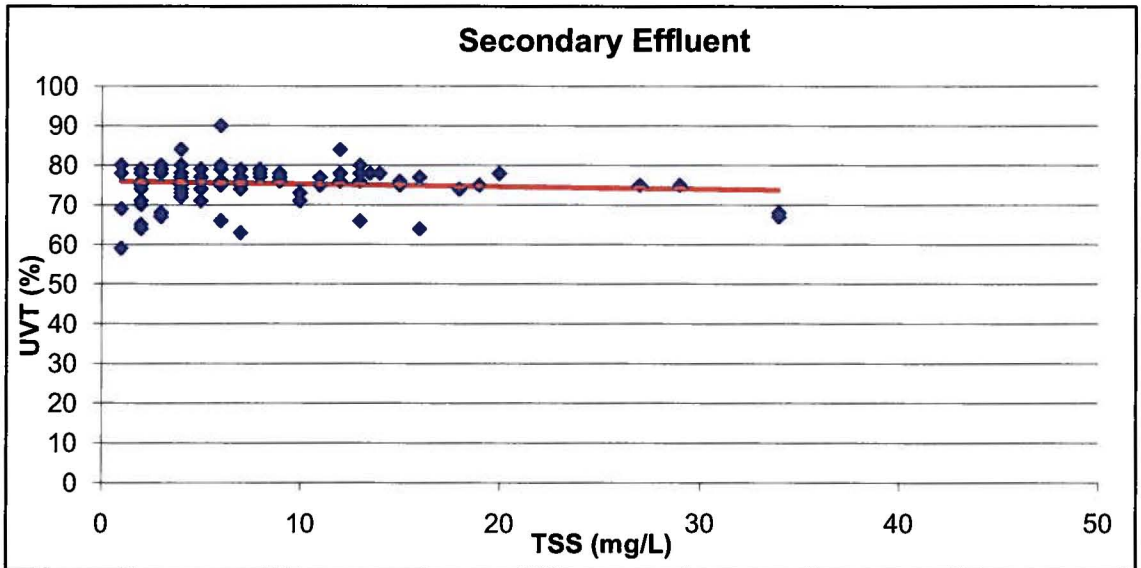
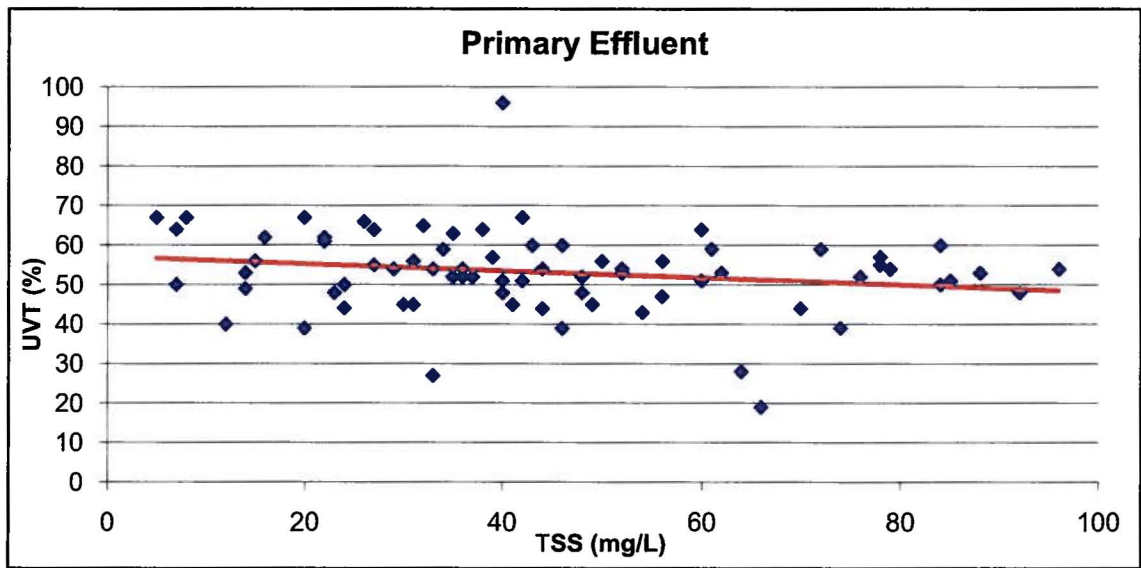
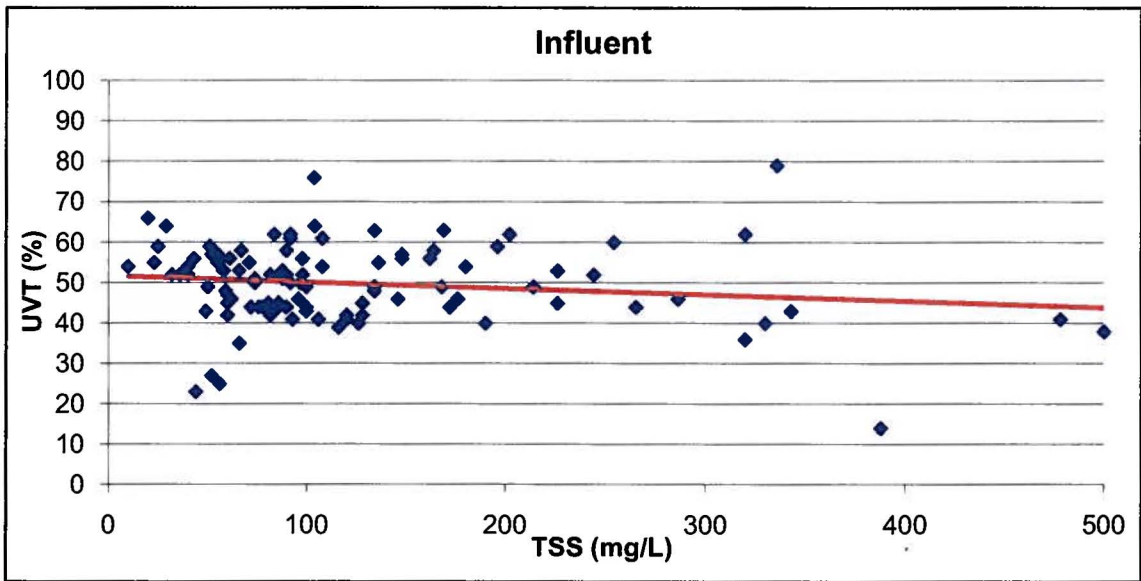
The flow rate was determined for the Hudson River south of the Mohawk River and Hudson River confluence.



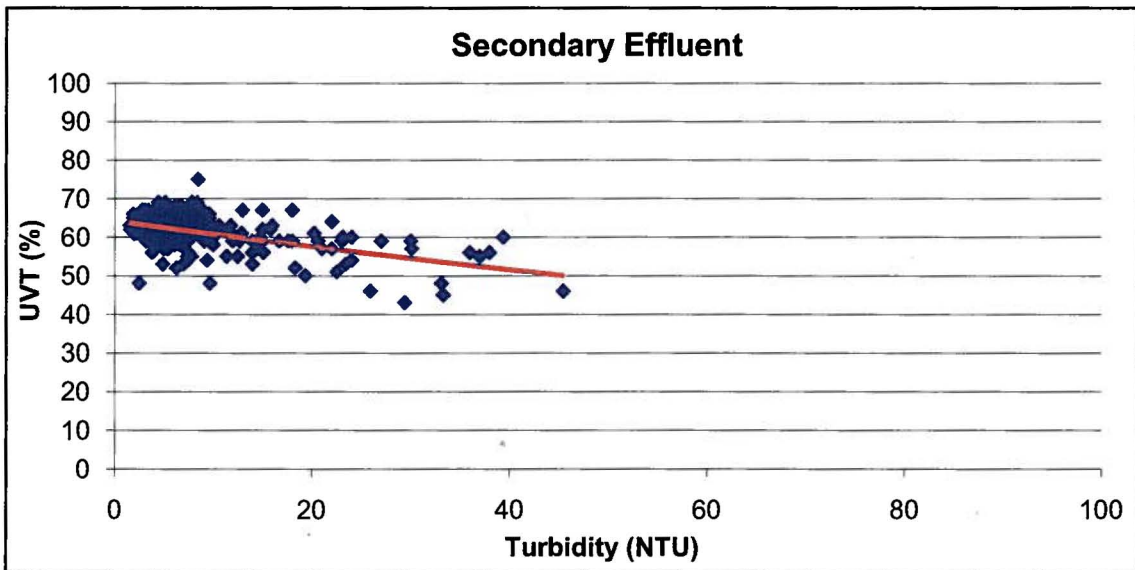
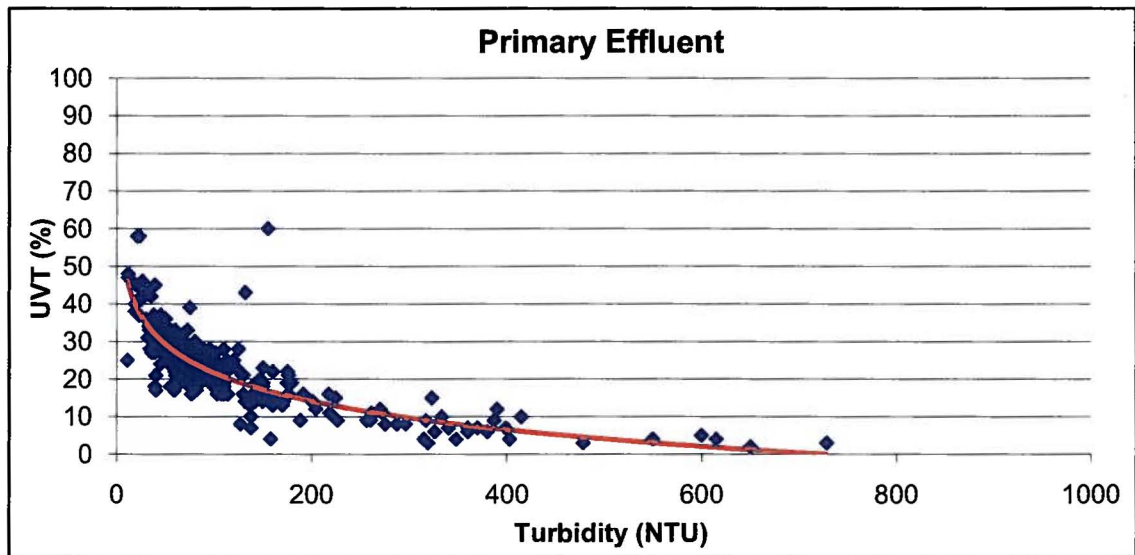
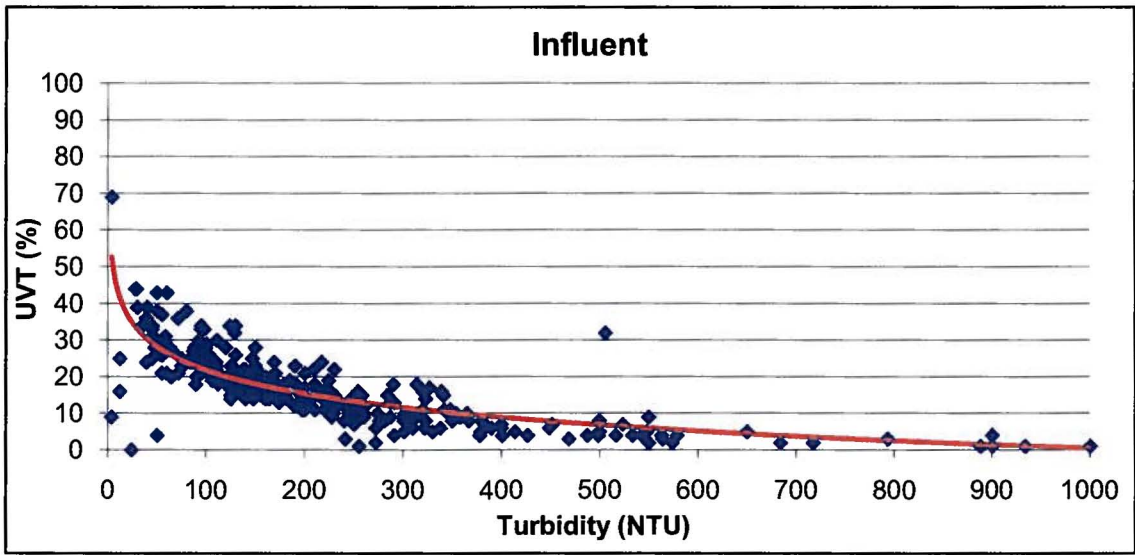
Albany County North Plant



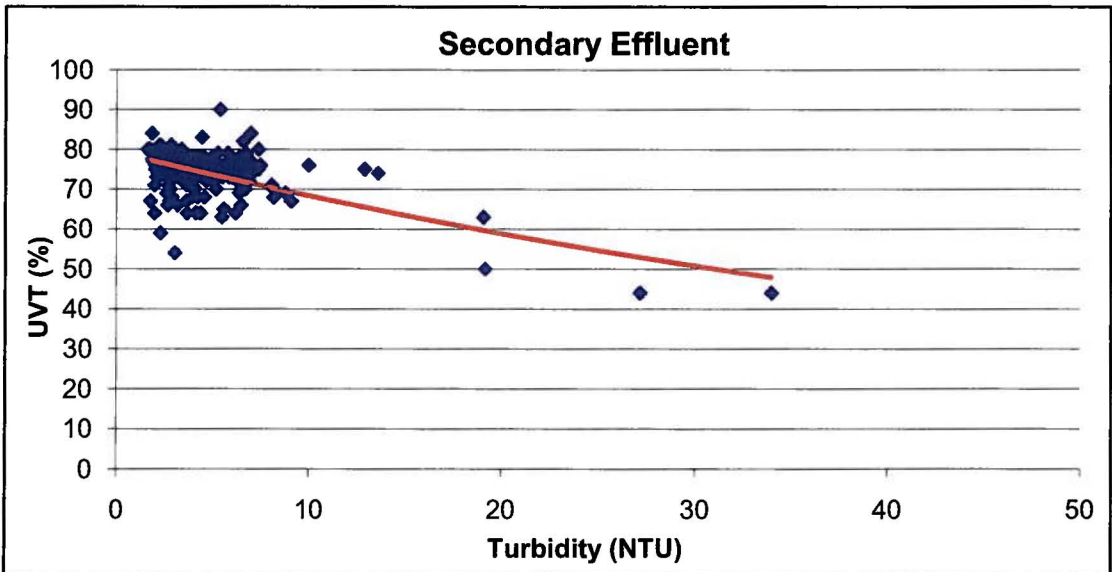
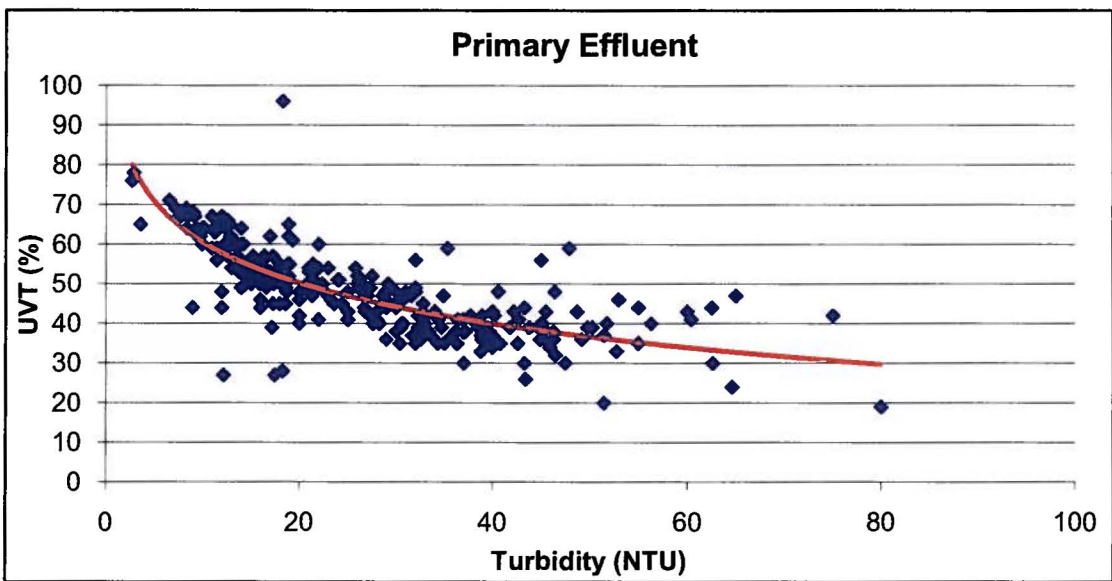
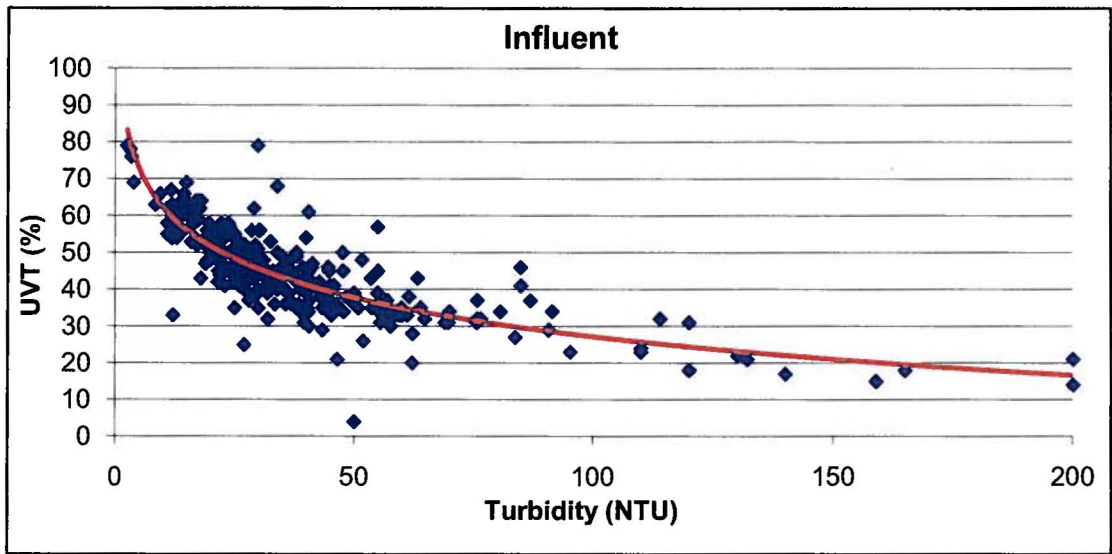
Albany County South Plant



Albany County North Plant

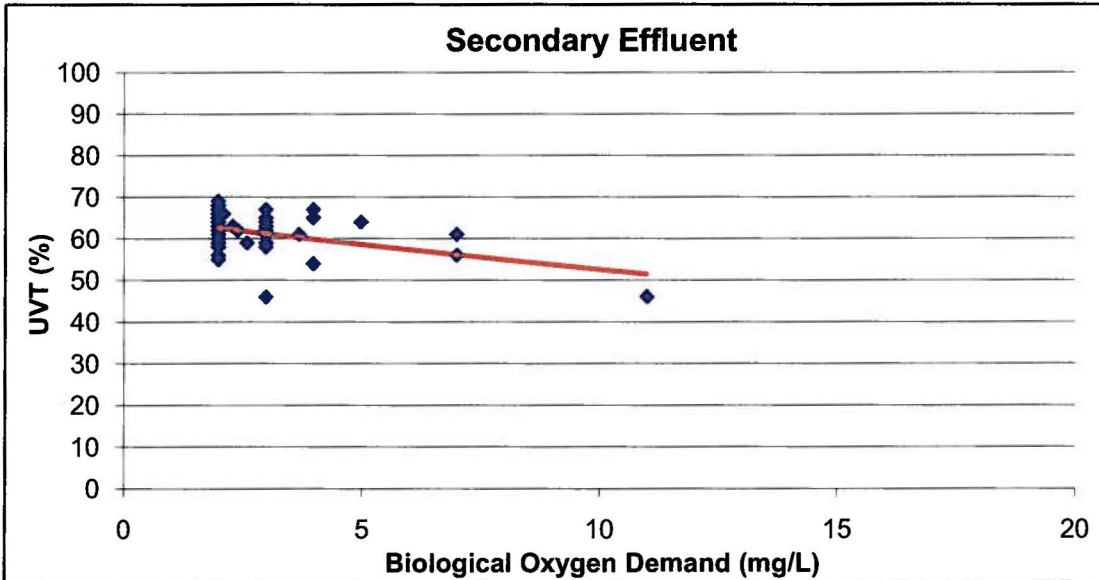
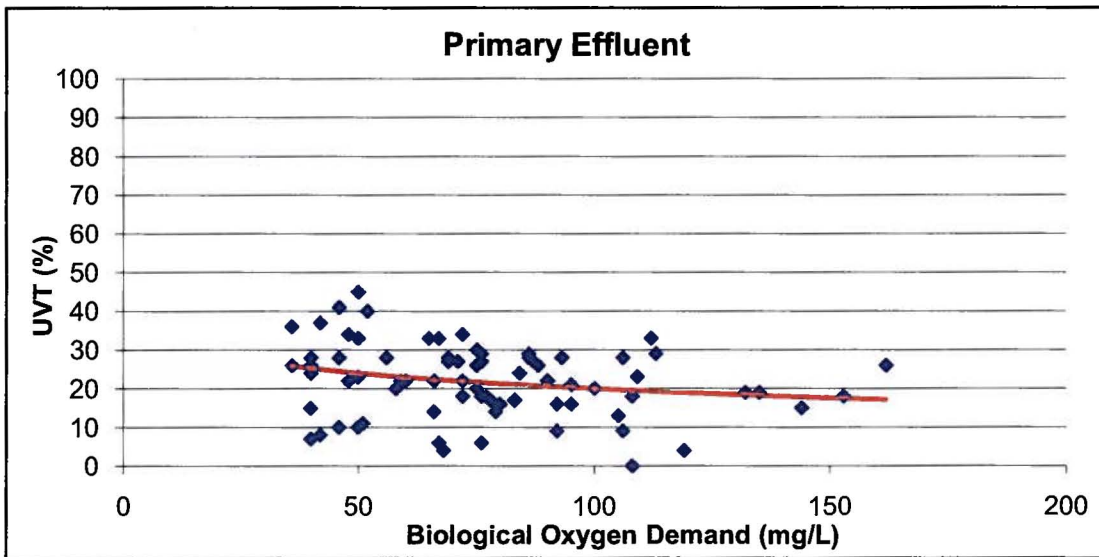
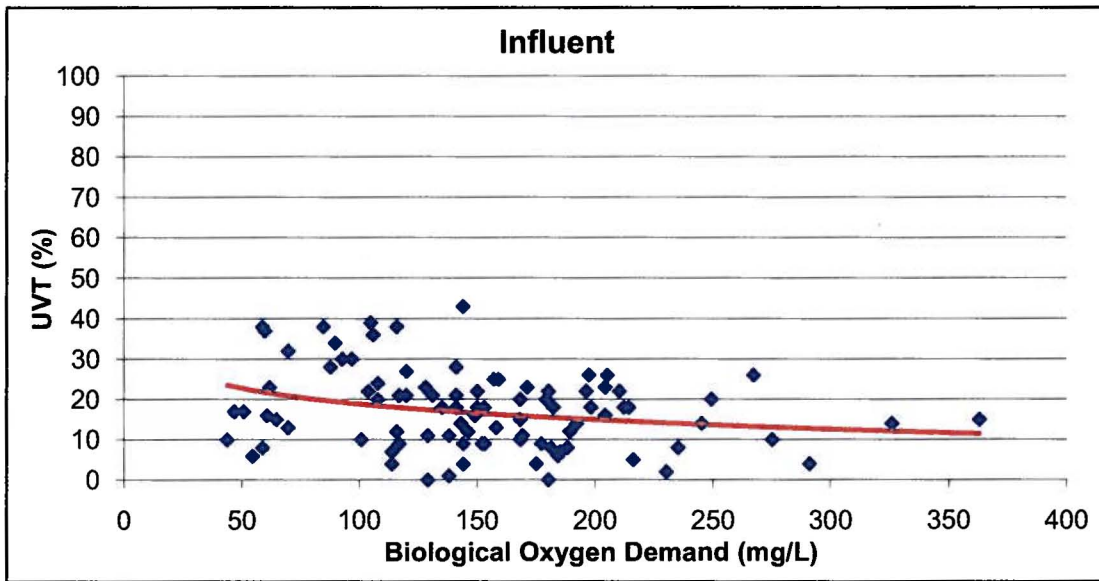


Albany County South Plant



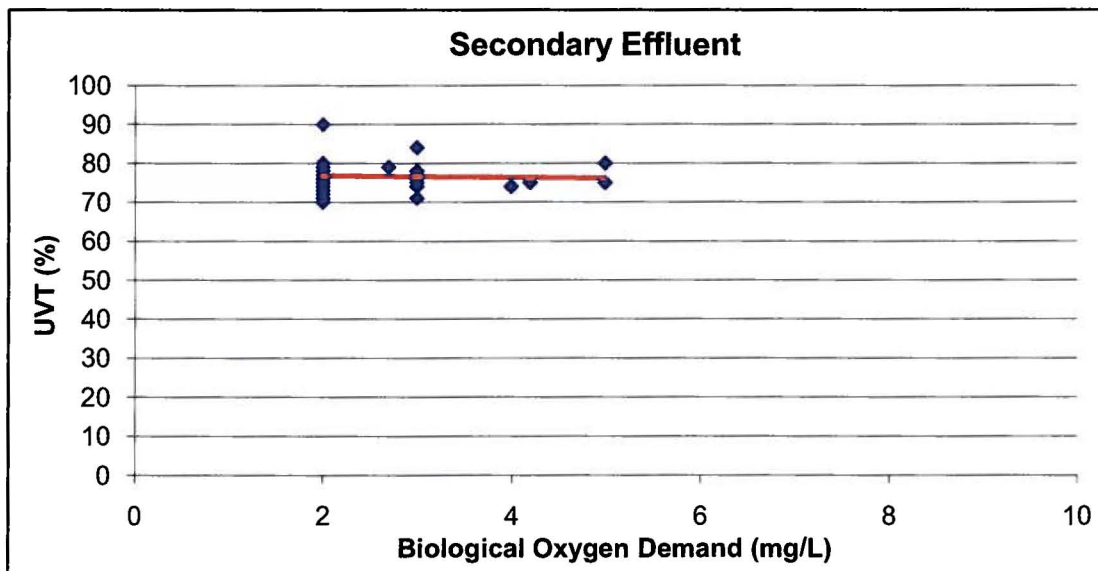
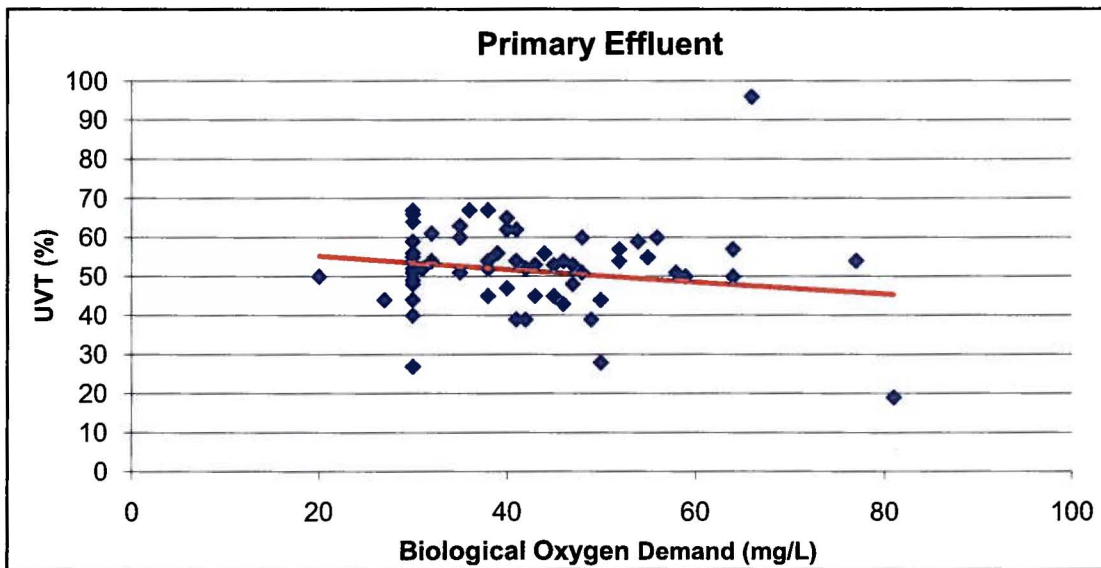
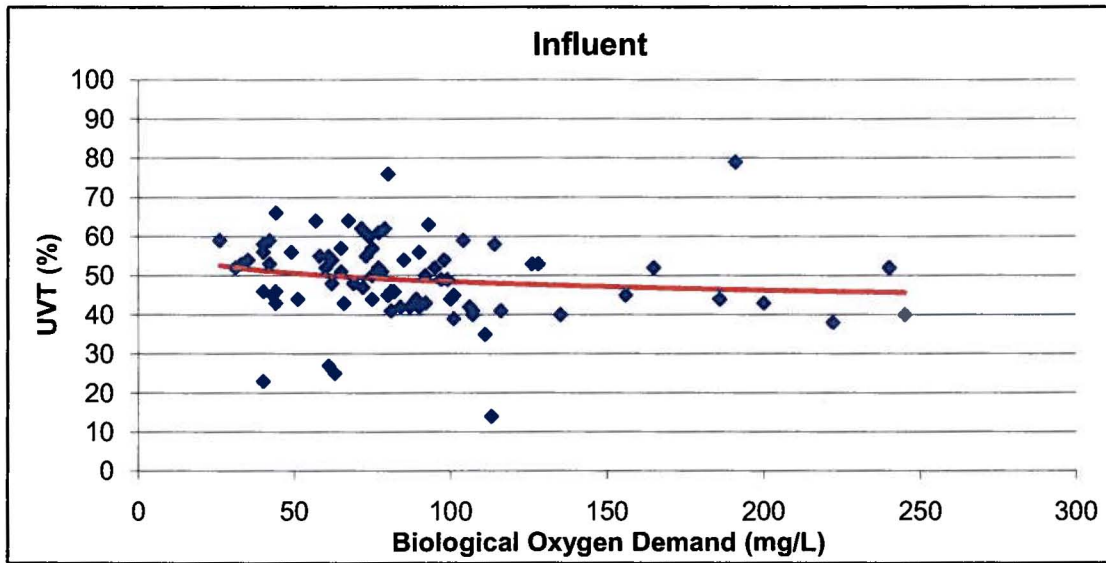


Albany County North Plant

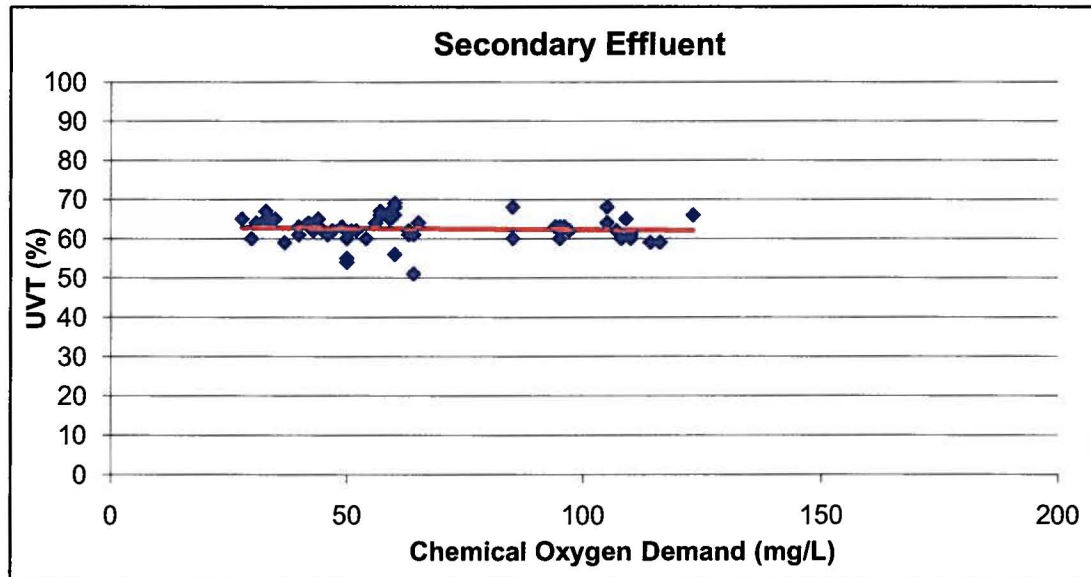
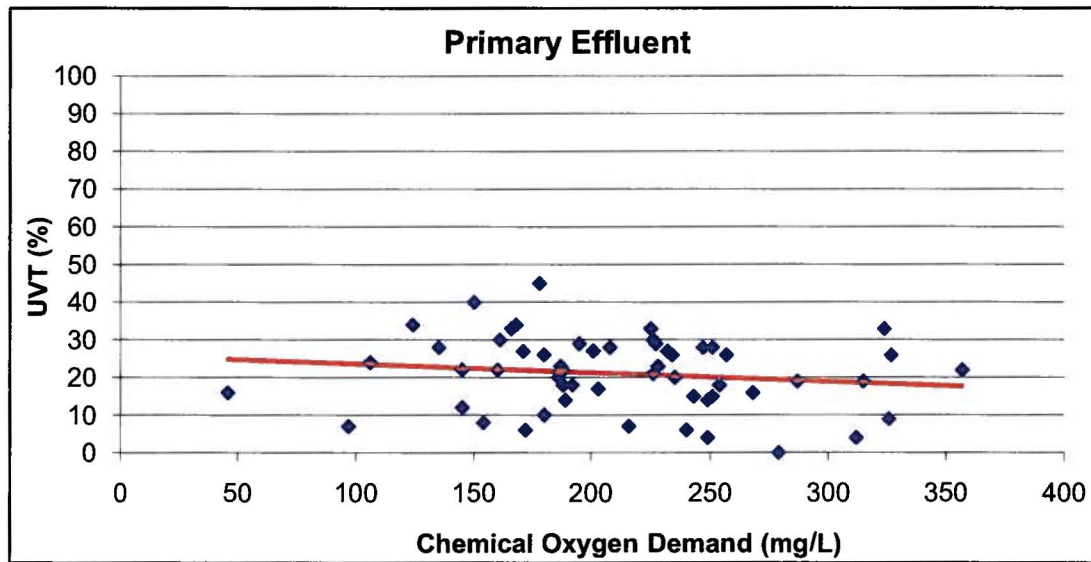
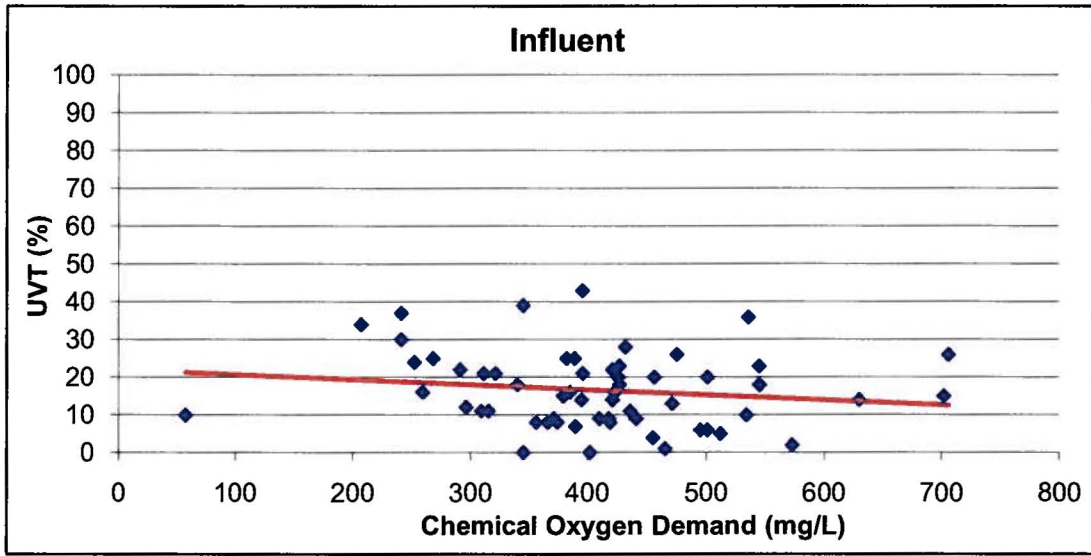




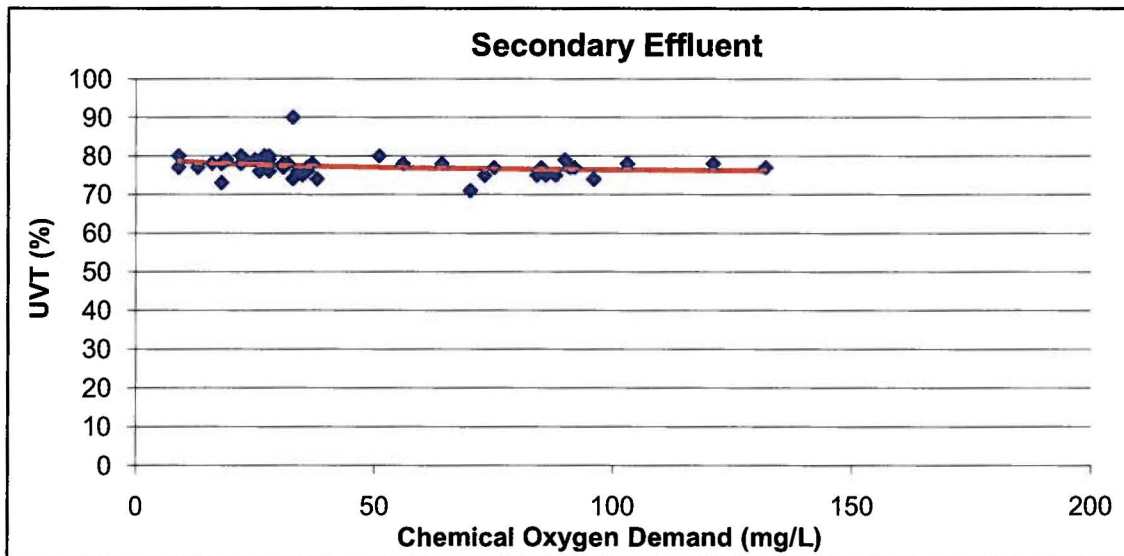
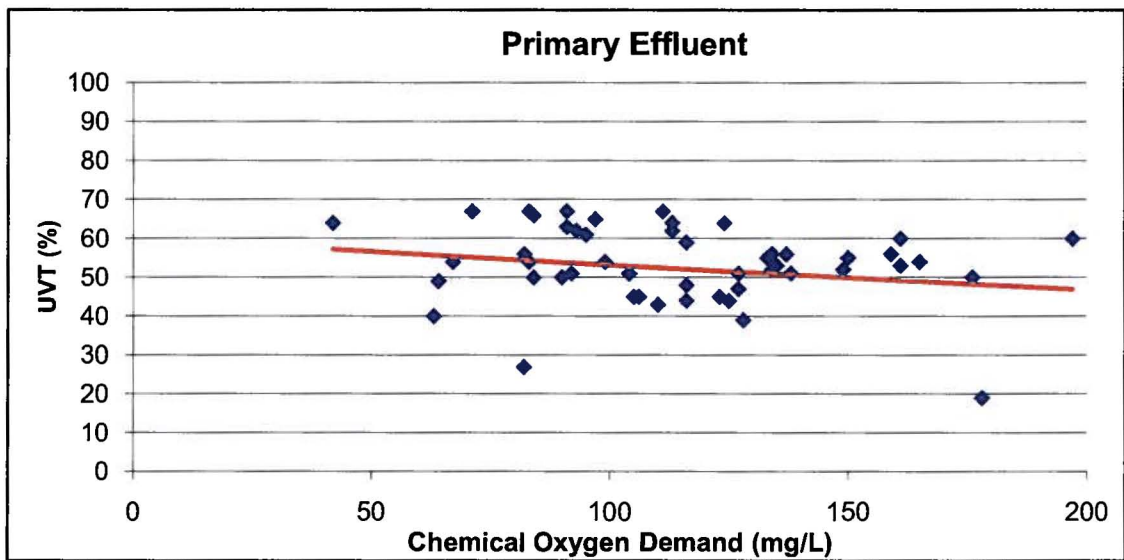
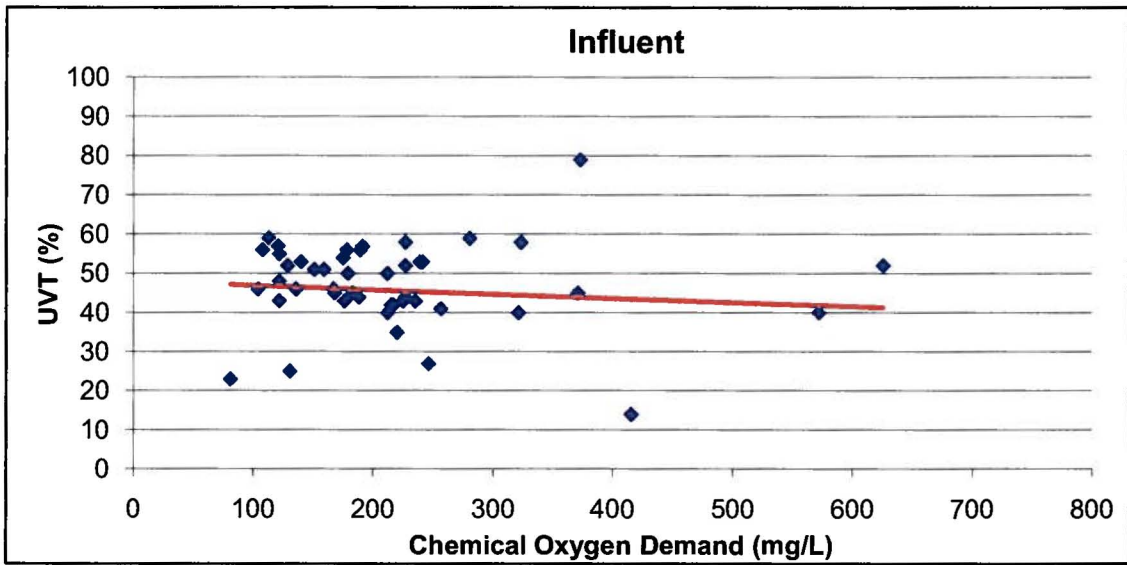
Albany County South Plant

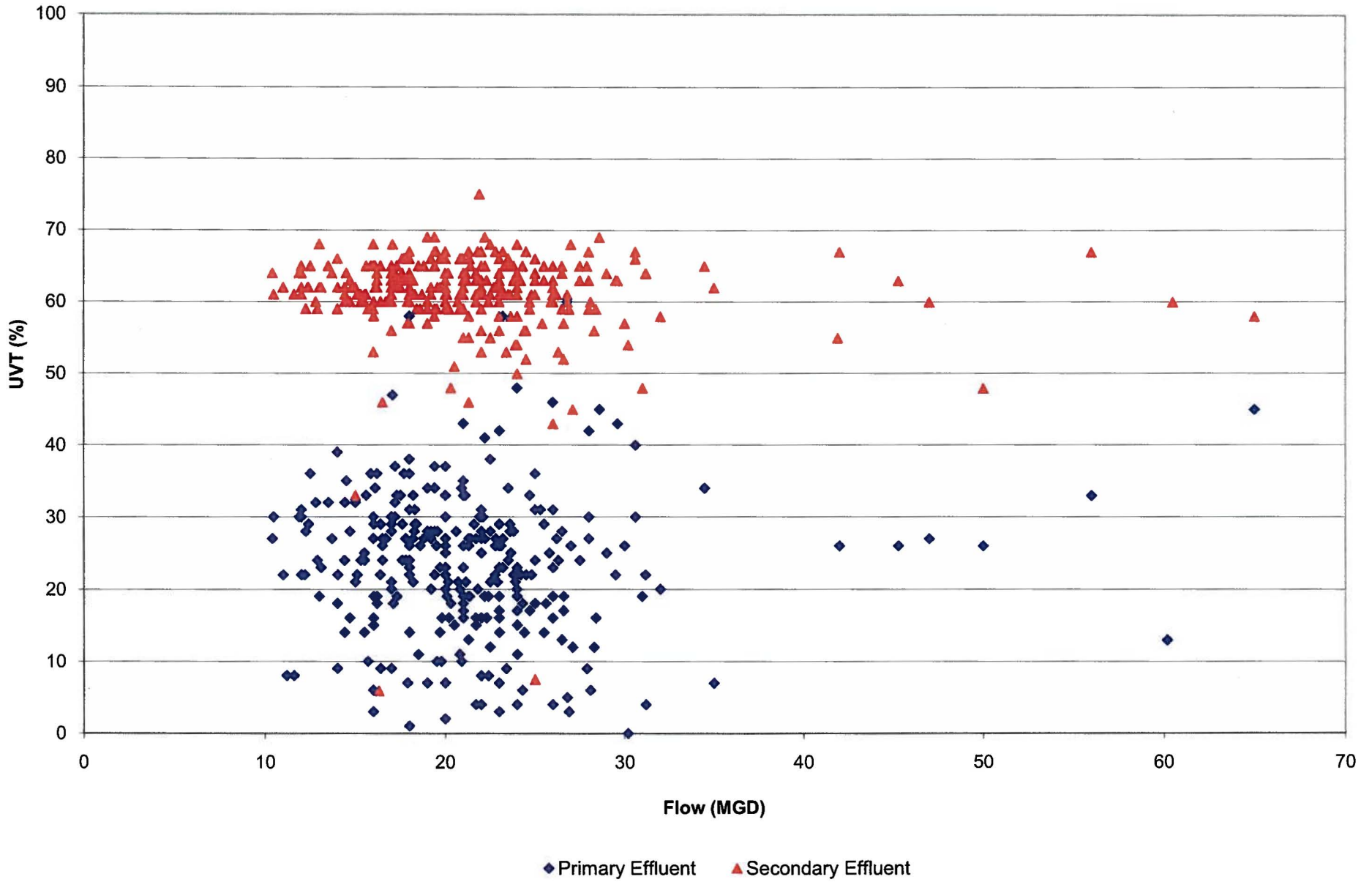


Albany County North Plant

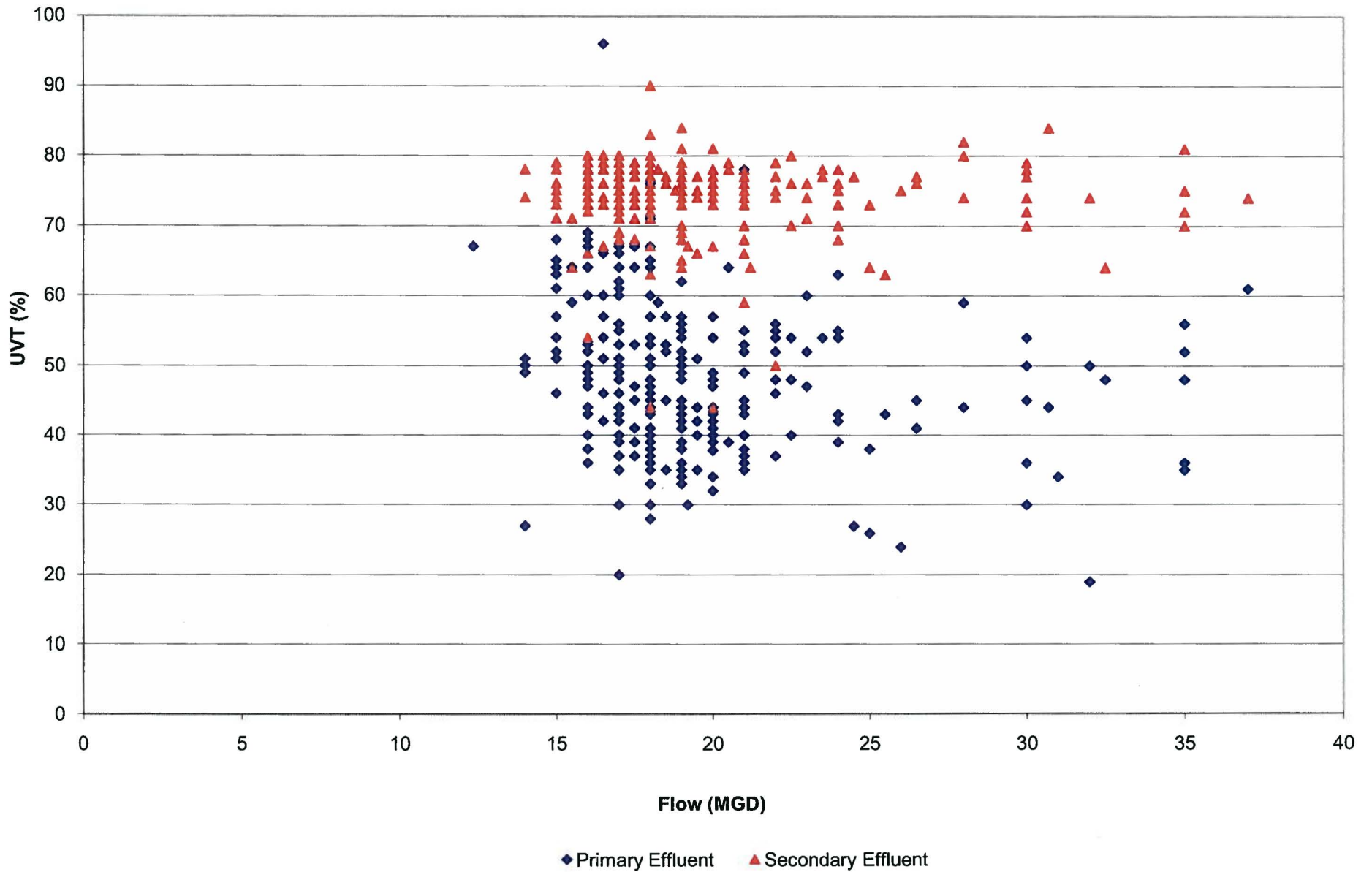


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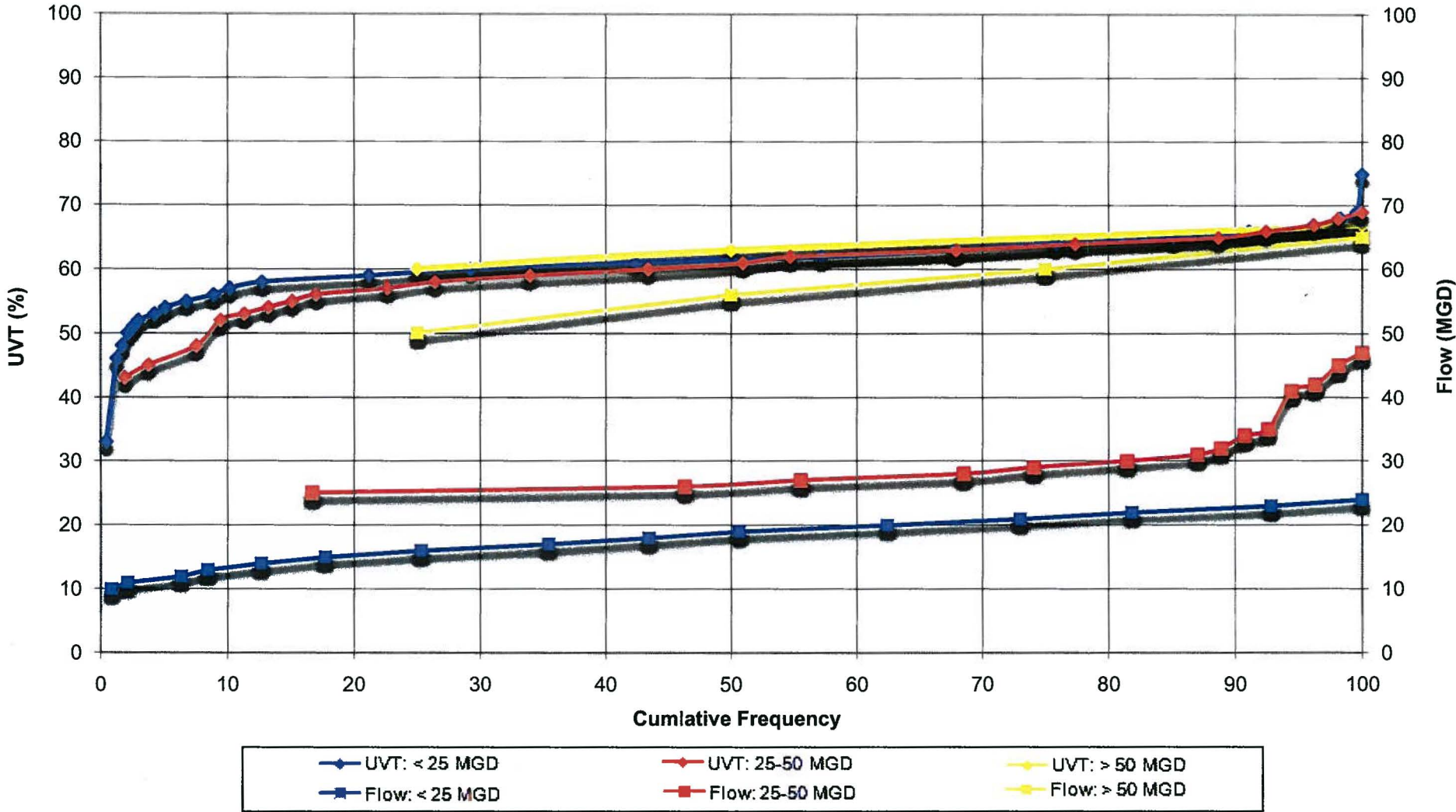




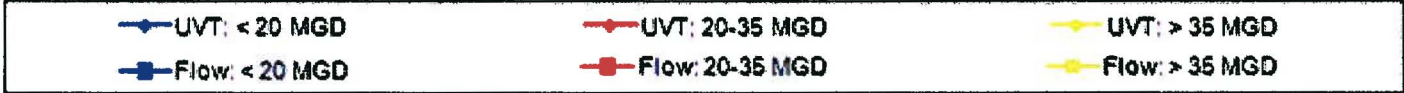
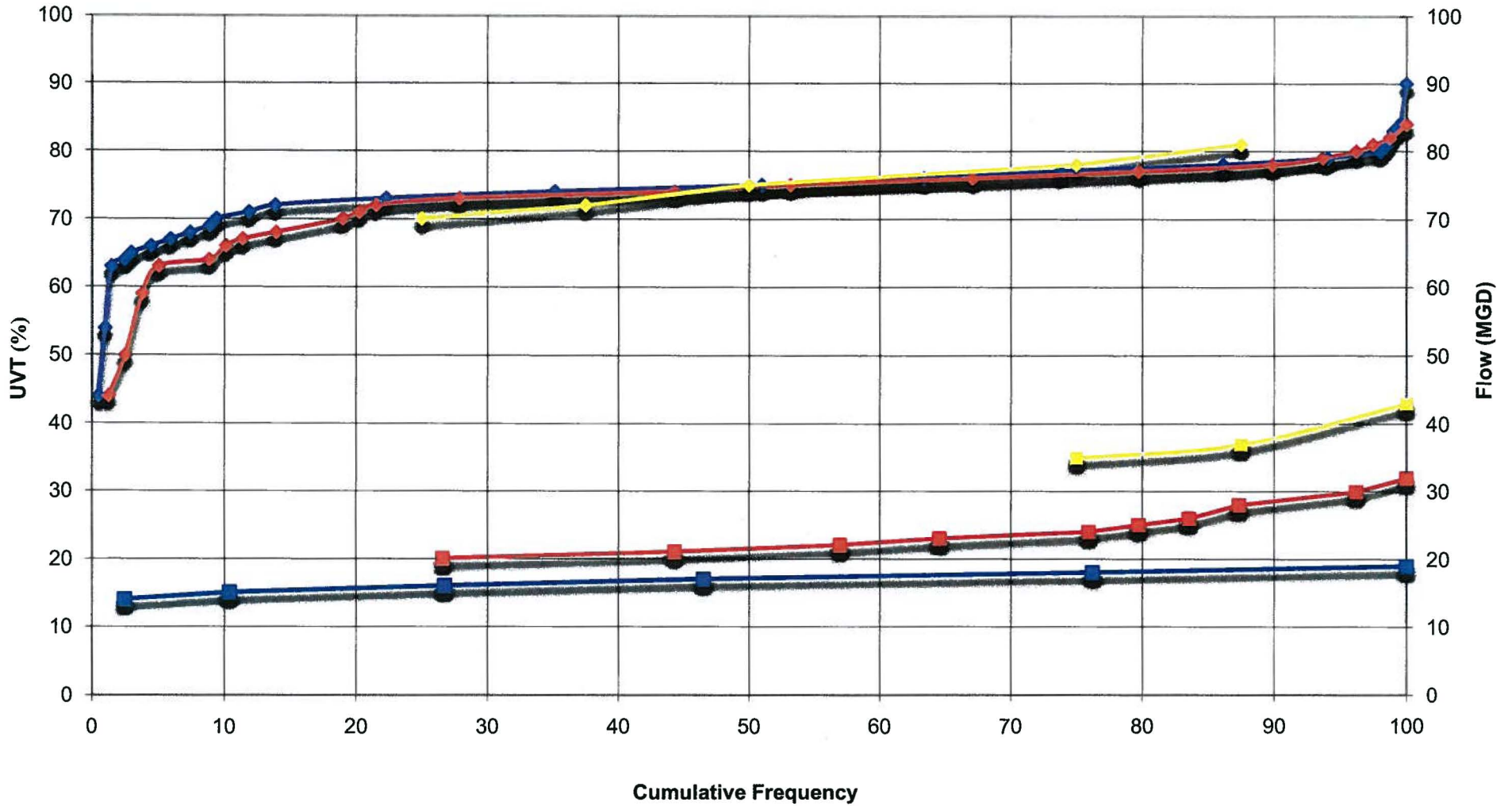




### Secondary Effluent



### Secondary Effluent



Overall, coliform results varied from expected trends. Specifically, this study anticipated very low fecal coliform counts during periods of high stormwater contribution, thereby allowing a lower UV dose to be used to achieve the same effluent limit. However, fecal coliform and influent flow did not demonstrate a clear inverse relationship. Fecal coliform counts varied across dry, wet weather no bypass, and wet weather bypass flow conditions.



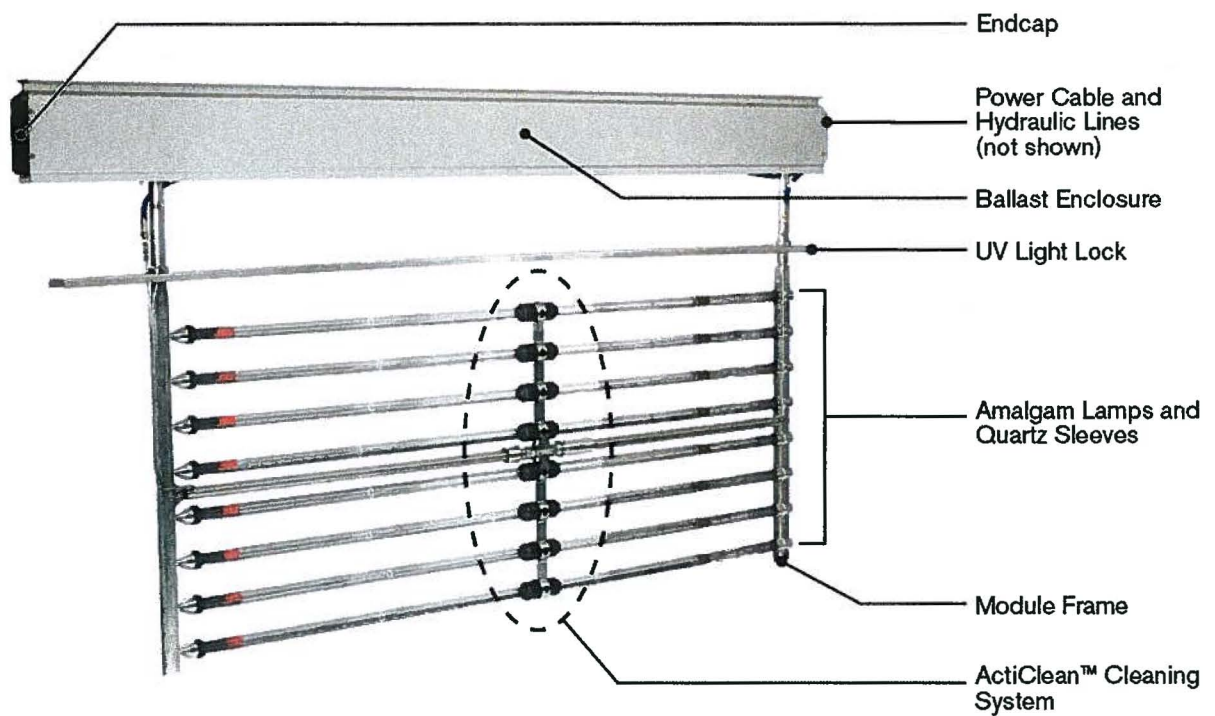
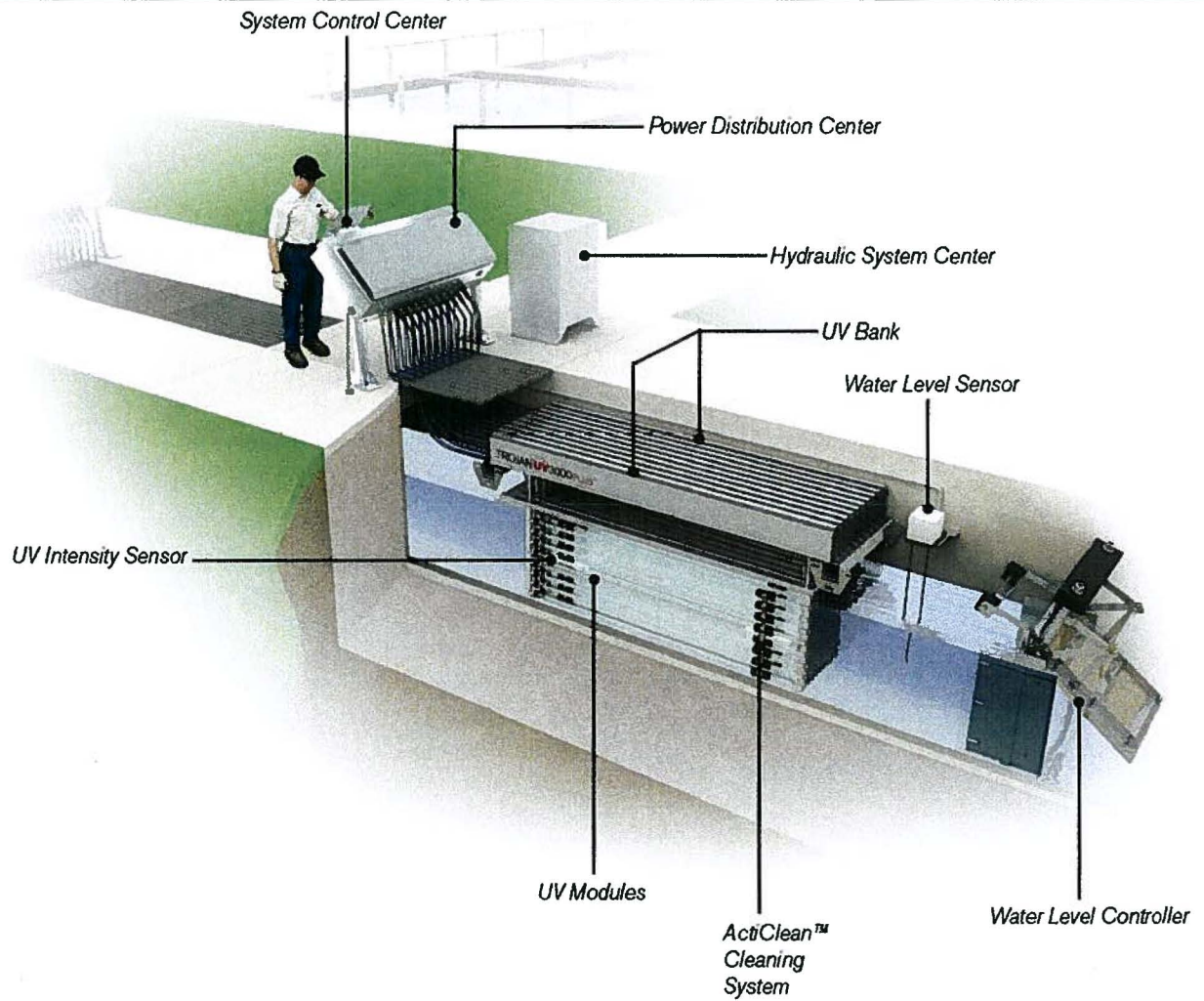
## 4. Evaluation of Disinfection Technologies

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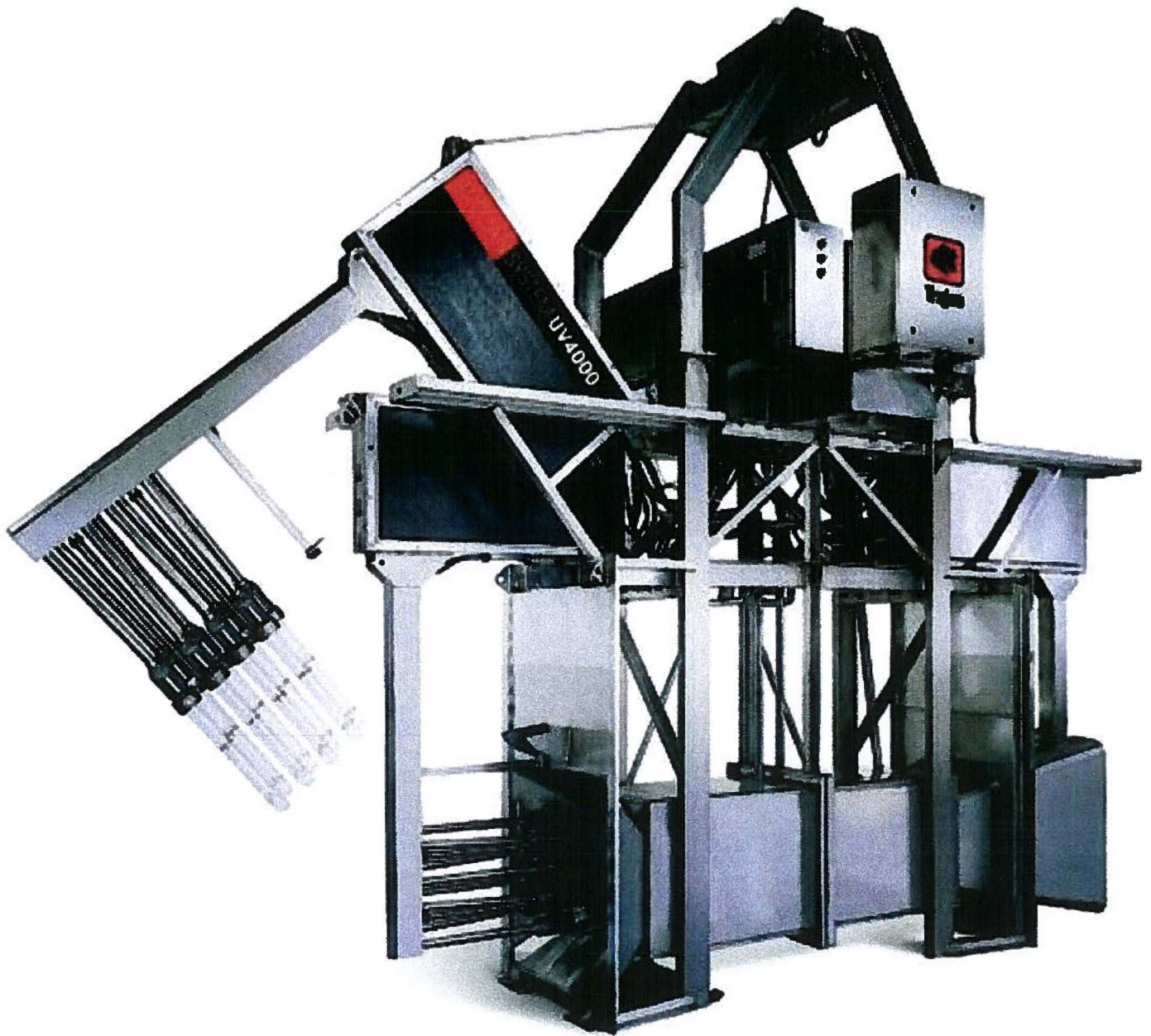
### 4.1. Design Criteria

Under the most recently proposed State Pollutant Discharge Elimination System (SPDES) permits for the ACSO North and South Plants, seasonal effluent disinfection will be required from May 1<sup>st</sup> through October 31<sup>st</sup> of each year. The proposed disinfection limit is a 30-day geometric mean of less than 200 fecal coliform count per 100 milliliters and a 7 day geometric mean of less than 400 fecal coliform count per 100 milliliters. If chlorination is selected for effluent disinfection, a maximum effluent residual chlorine of 2.0 mg/l is currently being proposed, likely requiring dechlorination to also be used.

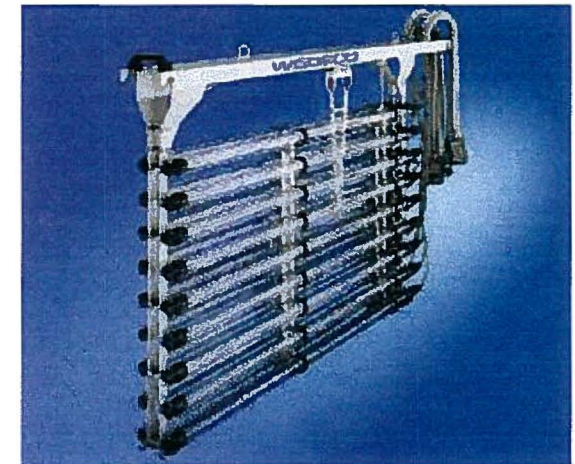
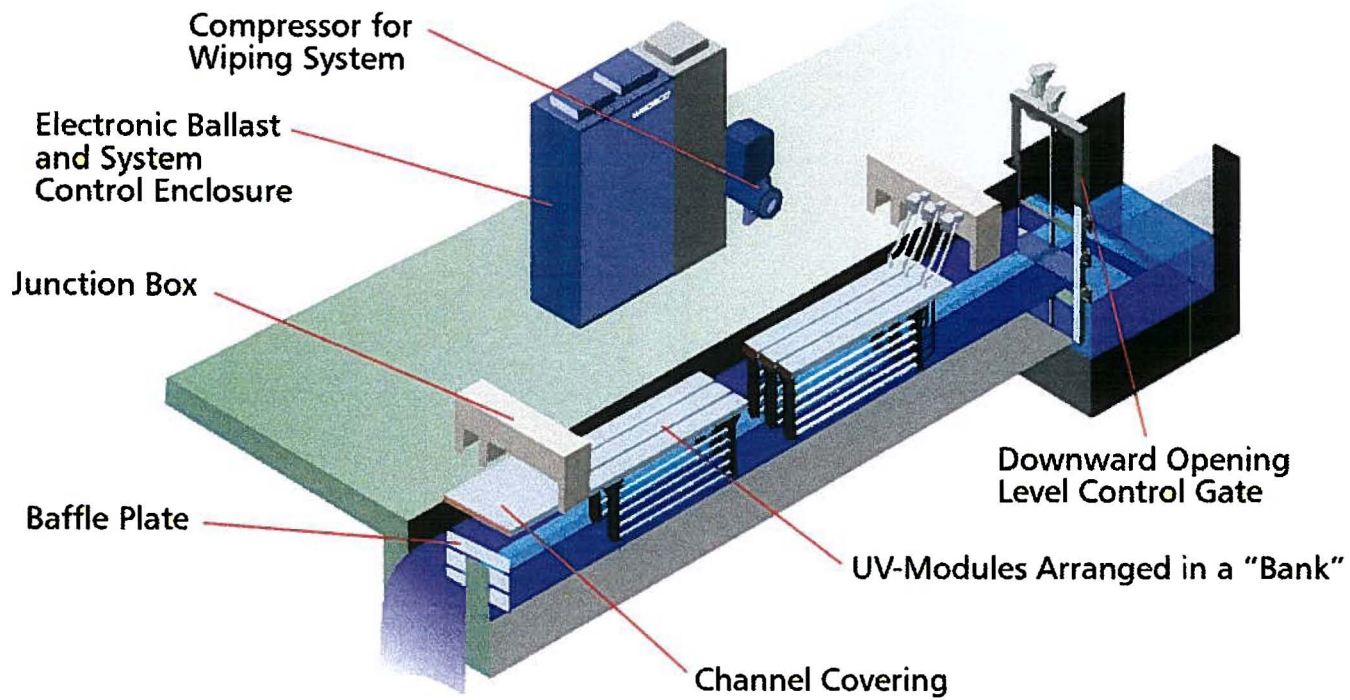
The design flow rate information was obtained from an existing capacity review completed in June 2008 as part of the Albany Pool CSO Long Term Control Plan. The sodium hypochlorite dosage is based on guidance provided in Recommended Standards for Wastewater Facilities (Ten State Standards) for activated sludge facilities. The sodium bisulfite dosage is based on the stoichiometric dosage of sodium bisulfite needed to react with 2 mg/l of residual chlorine, accounting for some inefficiencies in the reaction. The UVT data are based on measurements taken as part of this study from July 2007 through October 2007. The design criteria used for this evaluation are summarized in Table 4.1. It should be noted that the final design criteria are dependent upon the requirements established in the final SPDES permit, which may be affected by the recommendations outlined in the Albany Pool LTCP and by the manner in which other WWTPs within the Albany Pool elect to handle effluent disinfection. Criteria should be thoughtfully established during detailed design.





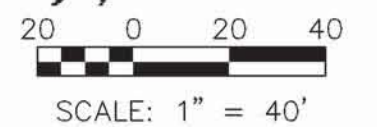
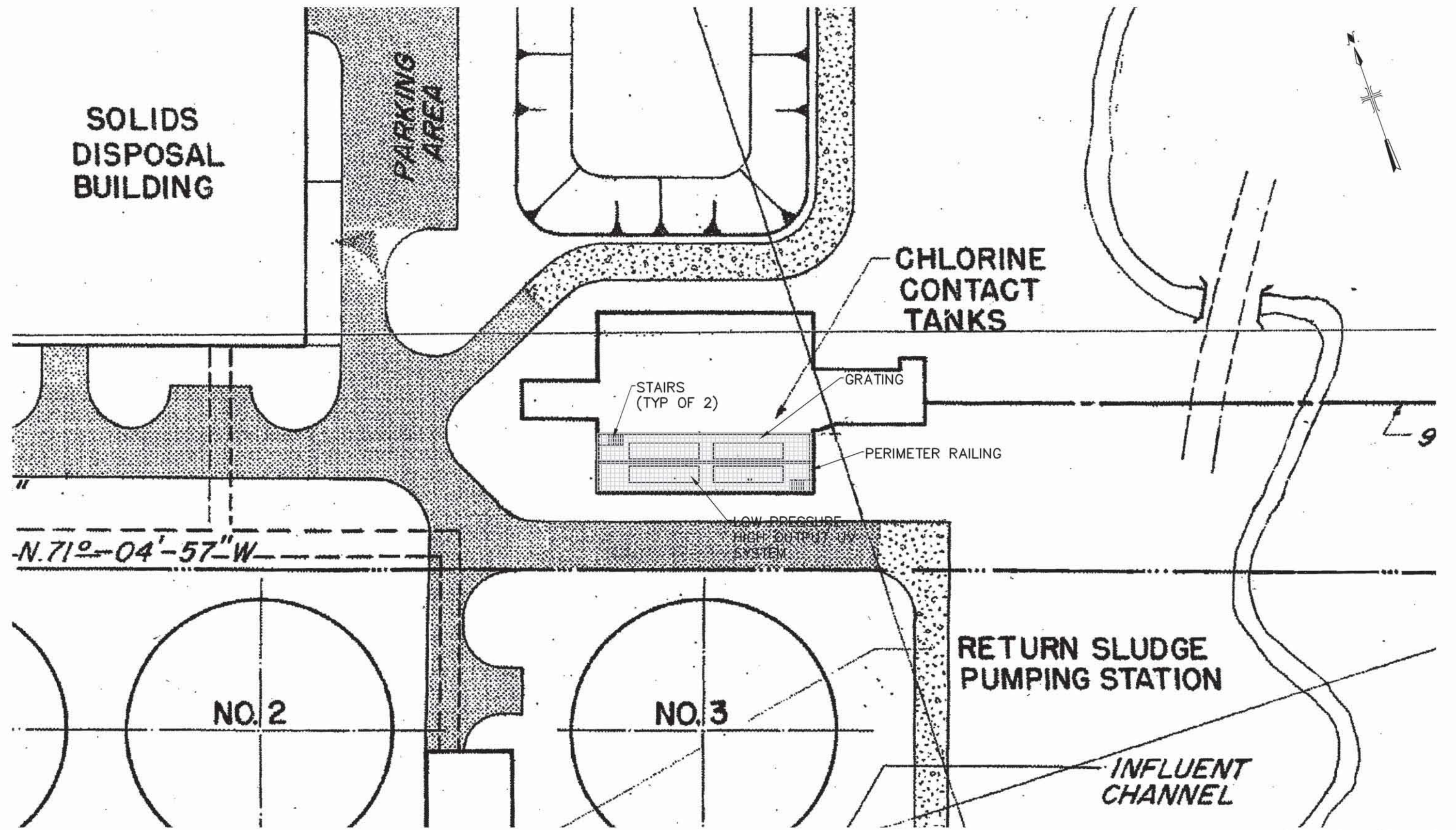








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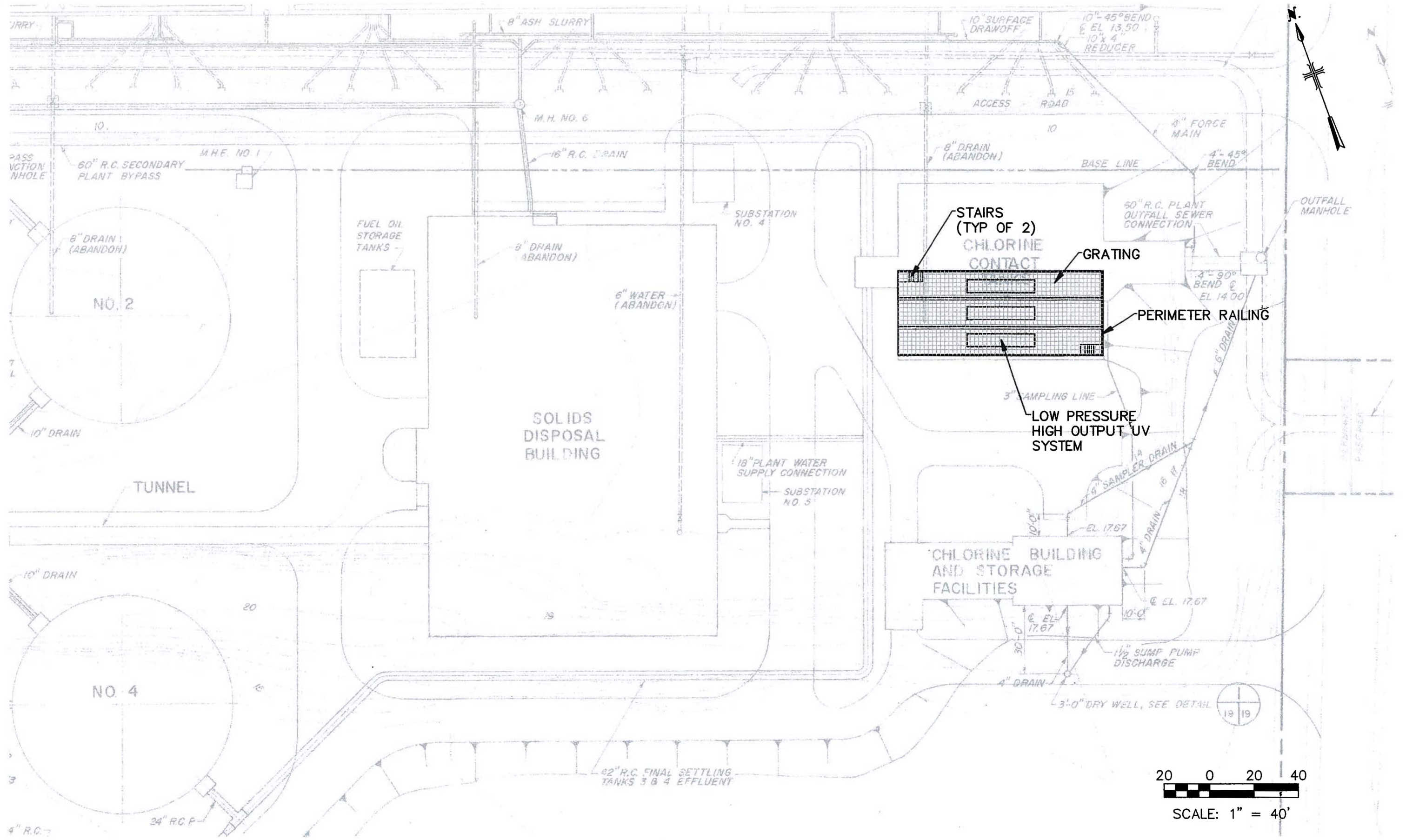
NYSERDA/ALBANY COUNTY SEWER DISTRICT  
EVALUATION OF DISINFECTION ALTERNATIVES

ALBANY COUNTY SEWER DISTRICT NORTH PLANT  
SITE PLAN  
SCALE: 1"=40'

MALCOLM PIRNIE, INC.  
MAY 2009  
FIGURE 4-4



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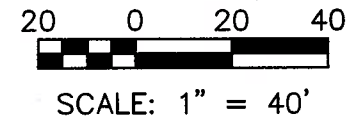
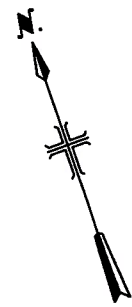
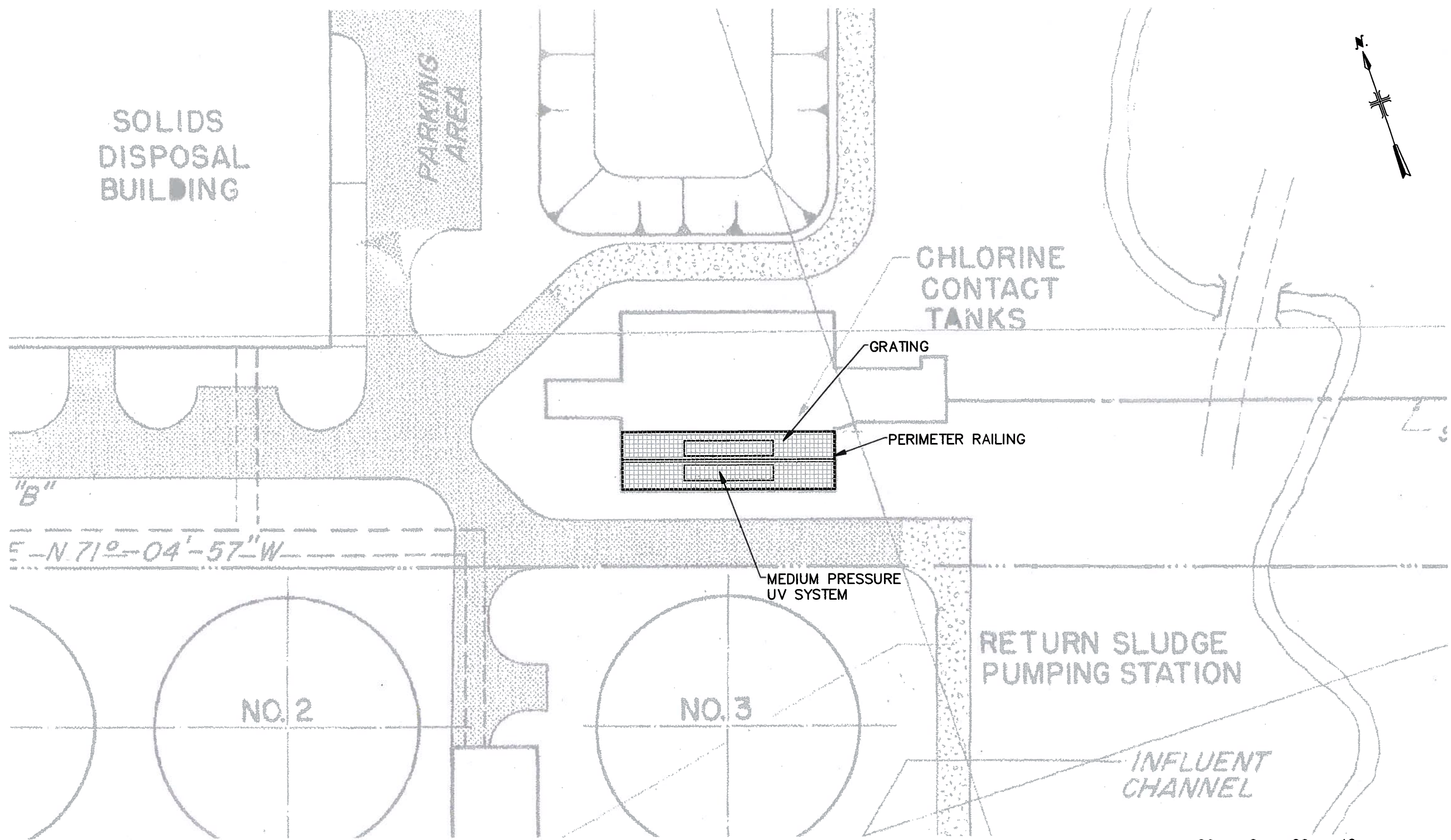
NYSDA/ALBANY COUNTY SEWER DISTRICT  
 EVALUATION OF DISINFECTION ALTERNATIVES

ALBANY COUNTY SEWER DISTRICT SOUTH PLANT  
 SITE PLAN  
 SCALE: 1"=40'

MALCOLM PIRNIE, INC.  
 MAY 2009  
 FIGURE 4-5



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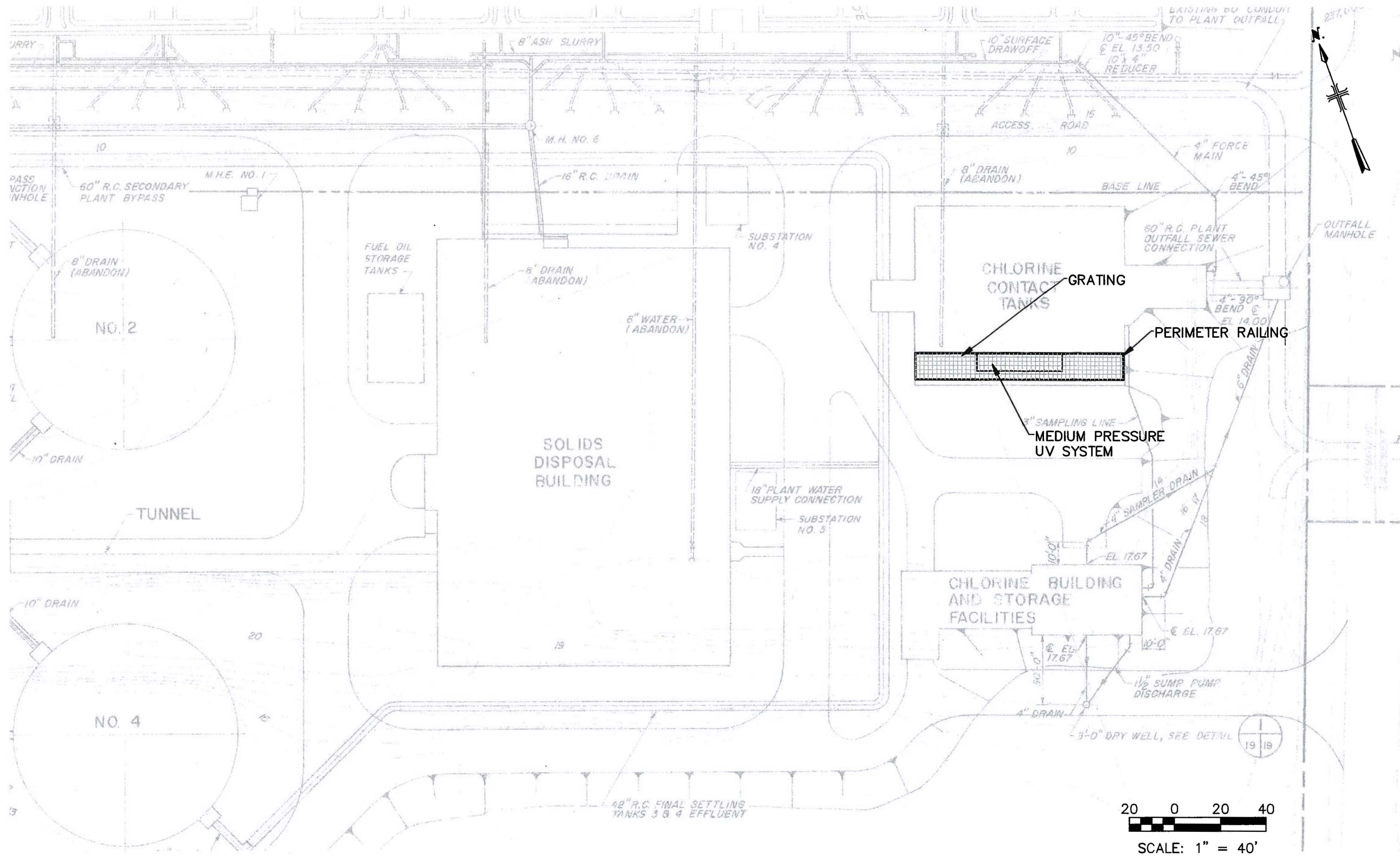
NYSDA/ALBANY COUNTY SEWER DISTRICT  
EVALUATION OF DISINFECTION ALTERNATIVES

ALBANY COUNTY SEWER DISTRICT NORTH PLANT  
SITE PLAN  
SCALE: 1"=40'

MALCOLM PIRNIE, INC.  
MAY 2009  
FIGURE 4-6



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**MALCOLM  
PIRNIE**

NYSERDA/ALBANY COUNTY SEWER DISTRICT  
EVALUATION OF DISINFECTION ALTERNATIVES

ALBANY COUNTY SEWER DISTRICT SOUTH PLANT  
SITE PLAN  
SCALE: 1"=40'

MALCOLM PIRNIE, INC.  
MAY 2009  
FIGURE 4-7

respectively. The electricity cost analysis and detailed operations and maintenance cost estimates are included in Appendix C.

The estimated annual operating costs for the North and South Plants using MP technology are \$215,441 and \$240,628, respectively. The estimated annual operating costs for the North and South Plants using LPHO technology are \$132,667 and \$100,755, respectively.

#### 4.2.3.3. Life Cycle Cost

The Life Cycle Costs for UV disinfection using MP and LPHO technologies are summarized in Table 4.2. The life cycle costs shown were calculated as the Estimate of Probable Construction Cost plus the year one annual operations and maintenance costs multiplied by a 20-year system life.

**Table 4.2  
Summary of Life Cycle Costs for Ultraviolet Radiation Disinfection**

| Plant/Scenario     | Estimate of Probable Construction Cost | Year 1 Operations and Maintenance Costs | 20-Year Life-Cycle Costs |
|--------------------|--|---|--------------------------|
| North Plant – MP   | \$5,014,000                            | \$215,441                               | \$9,322,828              |
| North Plant – LPHO | \$5,650,000                            | \$132,667                               | \$8,303,350              |
| South Plant – MP   | \$3,260,000                            | \$240,628                               | \$8,072,553              |
| South Plant - LPHO | \$3,896,000                            | \$100,755                               | \$5,911,105              |

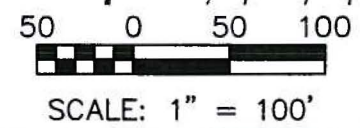
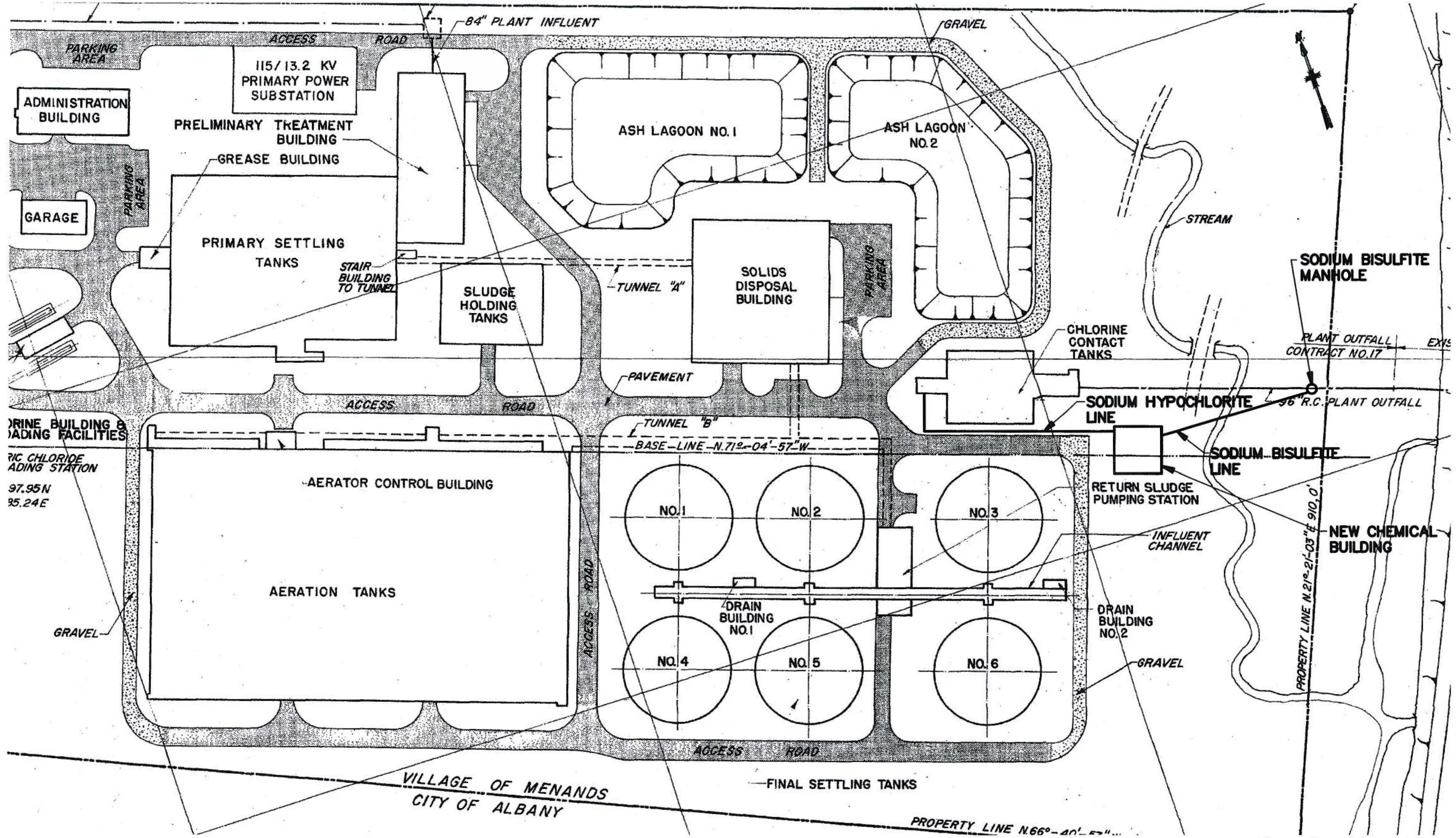
### 4.3. Chlorine Disinfection

#### 4.3.1. General

As discussed in Section 2.2, chlorine is the most widely used wastewater disinfectant in the United States, and it kills many bacteria, viruses, and other microorganisms that cause disease. Commonly used forms of chlorine are gaseous chlorine, sodium hypochlorite solution, calcium hypochlorite, and bromium chloride. Chemical disinfection has a long history of use, and the key design considerations are well documented and understood. Variables with the greatest influence on the design of a chemical disinfection system include the target organism and its dose-response, the initial concentration of the target organism, the allowable effluent concentration of the organism, the background chlorine demand of the wastewater being treated, the range of anticipated flow rates and the allowable residual chlorine concentration in the final effluent.

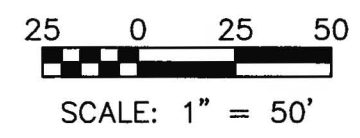
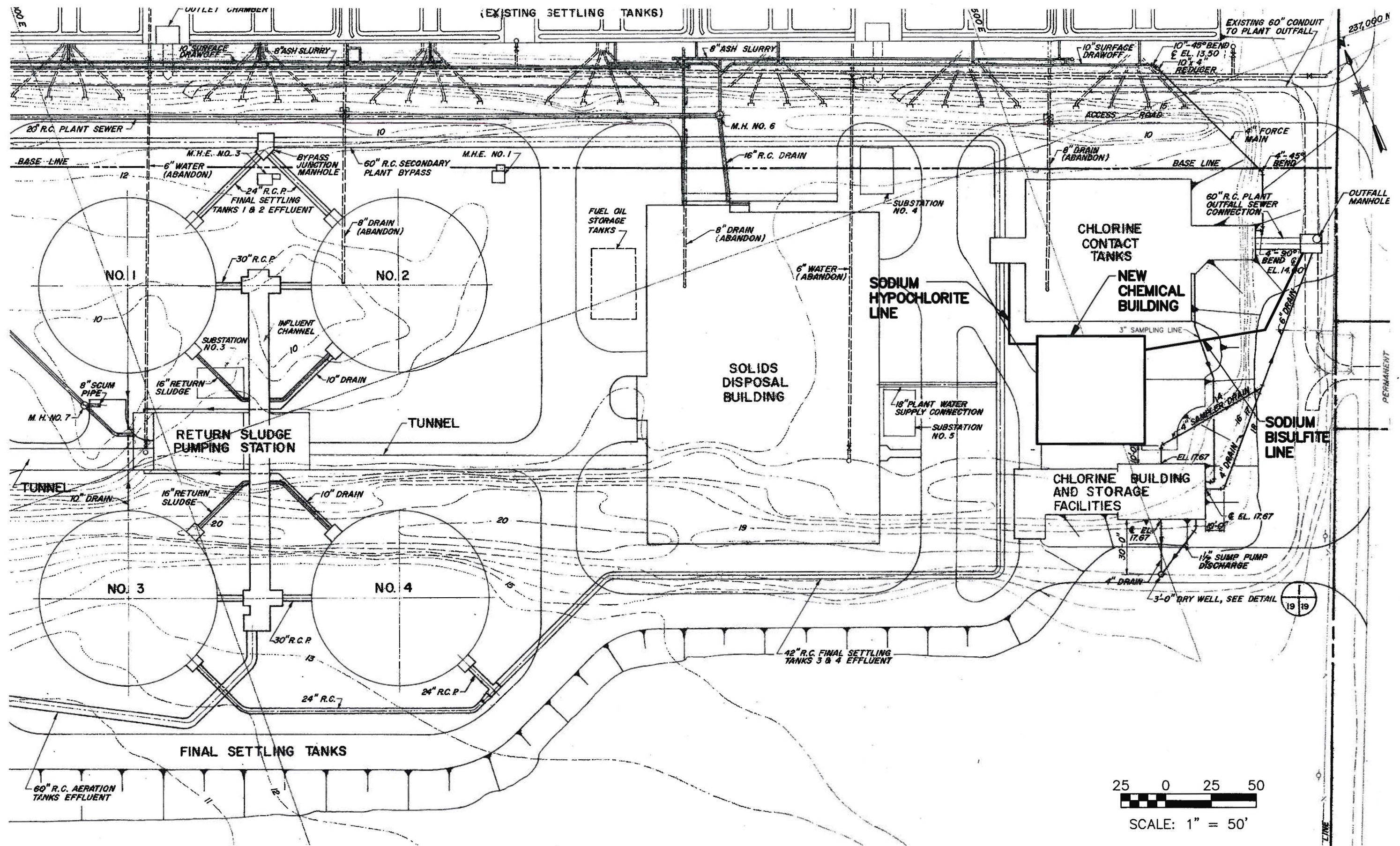


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NYSDA/ALBANY COUNTY SEWER DISTRICT  
 EVALUATION OF DISINFECTION ALTERNATIVES

ALBANY COUNTY SEWER DISTRICT SOUTH PLANT  
 SITE PLAN  
 SCALE: 1"=50'

MALCOLM PIRNIE, INC.  
 MAY 2009  
 FIGURE 4-9



The stoichiometric dosage of sodium bisulfite to react with 1.0 mg/L of chlorine is 1.47 mg/L but due to inefficiencies in the reaction process 1.65 mg/L of sodium bisulfite per 1.0 mg/L of chlorine has been used for the design dosage. Assuming the effluent will have an average chlorine concentration of 2 mg/L following the required contact time, the system will be sized using an average dosage of sodium bisulfite of 3.3 mg/L.

### **Storage**

The storage facility requirements for sodium bisulfite are similar to those for sodium hypochlorite. Fiberglass reinforced storage tanks should be used for storage of sodium bisulfite with a minimum of two tanks to assure uninterrupted service if one tank is out of service for repair or maintenance. The solution is stable at atmospheric conditions, thus long term storage in excess of 30 days presents no problems; therefore, the tanks should be sized for a minimum of 30 days of storage. The minimum size should also be sufficient to receive a full tanker truck load (approximately 4,000 gallons) in order to obtain the best pricing for the chemical. Based on the above criteria, the storage for this conceptual design has been sized for a full tanker truck load, plus an allowance for some reserve capacity. Storage volumes and days of storage are summarized in Table 4.5 for average and peak days.



#### 4.4. Findings for ACSD North and South Plant

For both the North and South Plants, chemical disinfection has a lower capital cost than UV disinfection. Similarly, for both Plants, MP UV disinfection has a lower capital cost than LPHO UV disinfection. However, over the 20-year estimated life of these facilities, no single disinfection alternative provides the lowest life-cycle cost at both Plants.

For the North Plant, if the chlorine dosage rates recommended in Ten States for activated sludge plants are used, UV disinfection using LPHO technology provides the lowest life-cycle cost. However, because of high chemical costs, if the disinfection objectives are able to be achieved using a chemical dose approximately 20-25 percent lower than that recommended in Ten States (i.e., 6 mg/l sodium hypochlorite and 2.5 mg/l sodium bisulfite), then the life-cycle cost of chemical disinfection is approximately \$1,358,000 less than UV disinfection using LPHO technology. Based on the very low effluent chlorine demand measured during this study, it is probable that the lower chemical dosage rates can be successfully used by ACSD. In addition, if chemical disinfection is used only at the North Plant, or if the Rensselaer County Sewer District elects to use UV disinfection, it is possible that the NYSDEC could recalculate less stringent chlorine residual requirements, making chemical disinfection even more cost-effective.

For the South Plant, UV disinfection using LPHO lamp technology has a life-cycle cost nearly \$956,000 less than the next closest alternative (chemical disinfection at reduced dosage rates).

If ACSD wishes to standardize a single method of disinfection for both the North and South Plants, chemical disinfection at the reduced dosage rates has a combined estimated life-cycle cost for both Plants of \$13,812,370. UV disinfection using LPHO lamp technology has a combined estimated life-cycle cost for both Plants of \$14,214,455, or approximately 3 percent more over the life of the system.

Capital cost, first year operations and maintenance costs, and life-cycle costs for the alternatives considered in this study are presented in Table 4.7.

**Table 4.7  
Summary of Costs**

| Scenario                      | Opinion of Probable Cost |                     | 20-Year Life Cycle |
|-------------------------------|--------------------------|---------------------|--------------------|
|                               | Capital Cost             | First Year O&M Cost |                    |
| North – Chlor/Dechlor (6/2.5) | \$2,137,000              | \$240,411           | \$6,945,225        |
| North – LPHO                  | \$5,650,000              | \$132,667           | \$8,303,350        |
| North – Chlor/Dechlor (8/3)   | \$2,137,000              | \$317,935           | \$8,495,700        |
| North – MP                    | \$5,014,000              | \$215,441           | \$9,322,828        |
| South – LPHO                  | \$3,896,000              | \$100,755           | \$5,911,105        |
| South – Chlor/Dechlor (6/2.5) | \$2,118,000              | \$237,457           | \$6,867,145        |
| South – MP                    | \$3,260,000              | \$240,628           | \$8,072,553        |
| South – Chlor/Dechlor (8/3)   | \$2,118,000              | \$314,063           | \$8,399,260        |

## 5. Applicability of Findings to Other WWTPs

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### 5.1. Swimmable Hudson Initiative

In 2004, New York State set a new goal of making Hudson River water quality suitable for swimming from its source in the Adirondacks to New York City. To achieve that goal, water quality improvements – namely a reduction in bacteria and floatables – are needed. Implementation of seasonal effluent disinfection at wastewater treatment plants, control of combined sewer overflows, management of stormwater runoff from construction sites and urbanized areas, and continued improvements in boat sanitary waste pump-out facilities are the key areas being targeted by NYSDEC. Seasonal effluent disinfection is expected to provide the greatest water quality improvement. In all, the NYSDEC evaluated over 500 wastewater treatment plants that are located within the Hudson River drainage basin considering such aspects as current disinfection practices, discharge volume and distance from the Hudson River main stem. Through this evaluation, the NYSDEC determined seasonal effluent disinfection should be implemented at 21 additional municipal and 23 additional industrial/private wastewater treatment plants (Mitchell, 2008). Figure 5.1 provides the locations of WWTPs affected by the Swimmable Hudson Initiative.

A summary by design capacity of the WWTPs targeted for effluent disinfection is provided below:

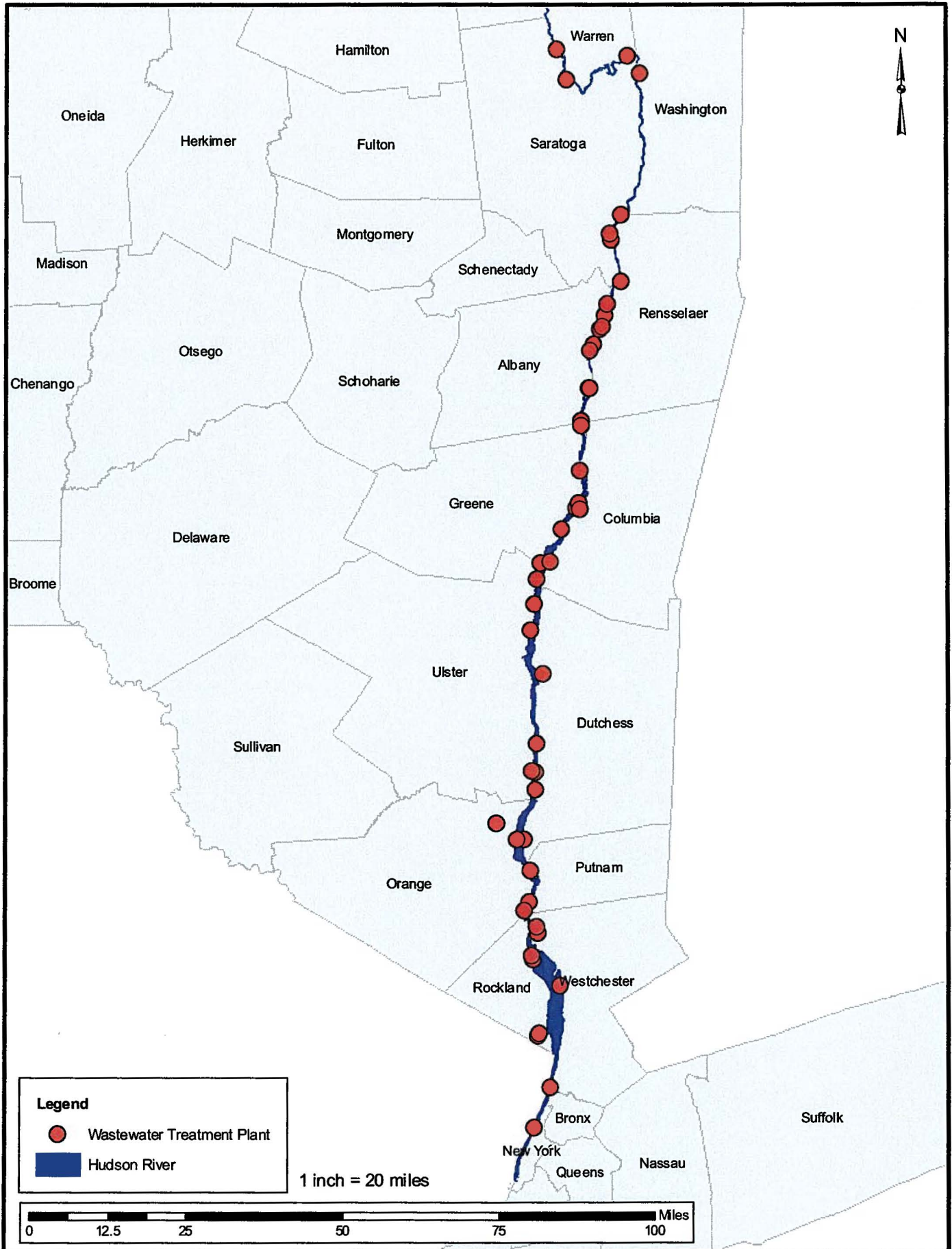
- Less than 1 MGD – 20 WWTPs
- 1 to 5 MGD – 9 WWTPs
- 5 to 10 MGD – 6 WWTPs
- Greater than 10 MGD – 9 WWTPs

### 5.2. Relevant Findings

#### 5.2.1. UVT and Fecal Coliform Counts for WWTPs with Combined Sewers

As discussed in Section 3, fecal coliform results varied from expected trends. This study anticipated low fecal coliform counts during periods of high stormwater contribution, thereby allowing a lower UV dose to be used to achieve the same effluent limit. However, although the dataset obtained during this study was limited, fecal coliform count and effluent flow rate did not demonstrate a clear inverse relationship. Fecal





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coliform counts varied across dry, wet weather no bypass, and wet weather bypass flow conditions.

Similarly, it was anticipated that during peak flows (bypass events) the larger contribution of stormwater would cause UVT to stabilize at higher flow rates. UVT values during monitored bypass events at the South Plant remained fairly stable, with an average UVT of 68 percent compared to the average throughout the study period of 74 percent. UVT values during monitored bypass events at the North Plant were observed to generally decline as flow rates increased, with an average UVT of 58 percent compared to the average throughout the study period of 66 percent. Figure 5.2 illustrates UVT versus flow rate at the North and South Plants during monitored bypass events.

Based on the findings of this study, fecal coliform counts do not decrease significantly during periods of significant stormwater contribution. As such, to achieve the same level of disinfection, the same UV dose must be delivered. This fact, when combined with the apparent potential for low UVT during peak periods of flow, requires that the UV system be conservatively sized (when compared to the average operating conditions) to ensure that disinfection objectives can be effectively met over the range of targeted flow conditions. However, the findings emphasize the importance of clearly understanding the range of operating conditions and incorporating sufficient operating flexibility into the design of UV systems to achieve disinfection objectives during the worst case scenario while maintaining efficient operations during average operating conditions.

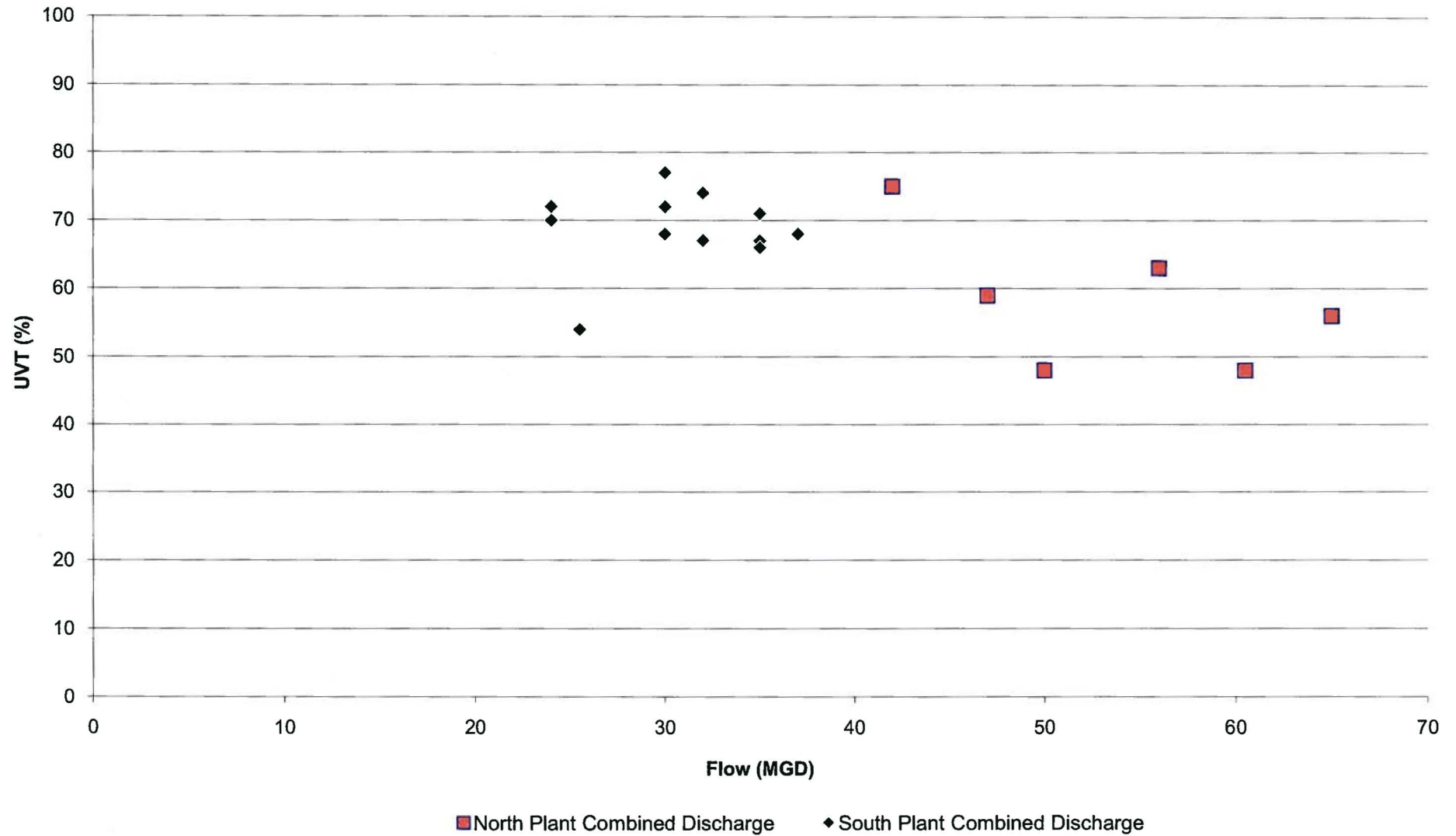
**5.2.2. Influence of Industrial Discharges on UVT**

The treatment processes employed at the North and South Plants are nearly identical and the majority of wastewater that is treated by both facilities is domestic in nature. However, because of a number of industrial users that discharge to the North Plant, certain influent characteristics are significantly different from those at the South Plant. Similarly, treatment performance at the North Plant has a greater effect on the secondary effluent UVT than it does as the South Plant. Table 5.1 summarizes the average influent characteristics for selected parameters monitored during the study period at both the North and South Plant.

**Table 5.1  
Summary of Average Influent Characteristics During Study Period**

| Plant | Flow (MGD) | UVT (%) | Temperature (Degrees C) | pH (SU) | Turbidity (NTU) | COD (mg/l) | BOD (mg/l) | TSS (mg/l) |
|-------|------------|---------|-------------------------|---------|-----------------|------------|------------|------------|
| North | 21.4       | 17      | 23.4                    | 7.1     | 227             | 407        | 151        | 249        |
| South | 19.5       | 45      | 21.5                    | 7.0     | 30              | 218        | 88         | 121        |

### Bypass Event





At the onset of the study, based on visual observations that had historically been made at the North Plant influent, sampling was conducted at one of the industrial user's facilities to correlate discharges from that facility with influent characteristics at the Plant. UVT and turbidity were measured at the discharge from the industrial facility on eleven separate dates throughout the study period. However, based on the results, it does not appear that the sampled industry is a significant factor in the UVT and turbidity of the influent at the WWTP. On the dates when industrial samples were collected, the average UVT at the Plant influent was 23 percent versus an average UVT of 60 percent at the point of discharge from the industrial user's facility. Similarly, the average turbidity at the Plant influent was 165 NTU whereas the average turbidity at the industrial discharge was 30 NTU.

The relatively higher turbidity and lower UVT observed at the North Plant when compared to the South Plant is likely due to industrial contributions. A co-product of the paper industry, lignin sulfonate, is a strong UV absorbent used during equipment validation testing for drinking water UV disinfection applications. It is possible that process wastewater from paper making or cardboard making facilities could contain lignin sulfonate or related products that could significantly affect UVT. Similarly, iron is a noted UV absorbent. Accordingly, industrial discharges with high concentrations of iron or significant groundwater infiltration containing elevated concentrations of iron may contribute to a low UVT.

In some instances, on-site treatment or pretreatment of industrial discharges that significantly influence the overall UVT of the wastewater at a WWTP may be a cost effective method of reducing electrical consumption associated with UV disinfection. In the case of the North and South Plants, the average flow rate from January 2005 through December 2007 was less than 2 percent different. However, because of a measured difference of 8 percent in average UVT (66 percent versus 74 percent), nearly 150,000 kWh of additional electricity will be consumed to meet seasonal disinfection objectives at the North Plant when compared to the South Plant. For the MP systems considered, this equates to only about a 10 percent increase in electricity use. For the LPHO systems considered, this equates to greater than a 35 percent increase in electricity use. Before ruling out UV disinfection due to low UVT, WWTPs should consider if increased control or elimination of specific discharges or flow contributors within their service area offers a viable and economically attractive method of improving the technical feasibility of UV disinfection. In the case of the North Plant, it is unlikely that the costs of additional industrial pretreatment are warranted. Most likely energy savings associated with UV disinfection at the Plant would be offset by increased energy usage by the industrial users.

### 5.2.3. Chlorine Demand for Activated Sludge Facilities

Ten States recommends a chlorine dose of 8 mg/l for activated sludge facilities and 6 mg/l for nitrified effluent. However, that dosage is driven by the typical chlorine demand of secondary treated wastewater. To meet disinfection objectives, it is generally agreed that a residual of 1 mg/l of chlorine should be present following 15 minutes of contact time. For the North and South Plants, the chlorine demand during the study period was extremely low (less than 1 mg/l after 15 minutes). Although it is necessary to design the system in accordance with Ten States, understanding the actual chlorine demand reinforces the need to incorporate sufficient operating flexibility to allow the system to be operated in a manner that more closely aligns with actual conditions.

Based on the results of the study, in the case of the North and South Plants, because of the very low chlorine demand of the effluent, it appears conceivable that disinfection objectives can be achieved with relatively lower dosages of chlorine, significantly reducing the chemical costs. Understanding the actual chlorine demand (as opposed to literature values) allows a more accurate estimate of chemical costs to be developed, thereby improving the validity of the life-cycle analyses used in alternative selection.

### 5.2.4. Estimating Electricity Costs

For many alternatives evaluations within the water and wastewater sector, estimating electricity costs using the preceding year's average electricity pricing (cents per kilowatt hour) provides a reasonable measure of the expected electricity costs for the alternative being considered. This is true because many types of equipment and processes used at water and wastewater facilities have similar electricity usage patterns to the treatment facility as a whole and the alternatives being considered typically represent only a small portion of the overall electrical load at the plant. However, for alternatives that have a relatively larger electricity use, operate only intermittently or seasonally, or have widely varying electrical demand, it is important that demand costs and consumption costs are adequately considered and that seasonal or daily variations in electric pricing are taken into account. Whether conducting life-cycle cost analyses for comparison of alternatives or estimating electricity savings to calculate return on investment or simple payback for a proposed energy efficiency measure, failing to accurately account for demand charges and seasonal price variation could result in incorrect conclusions.

As summarized in Section 4.2.3.2, because of the seasonal nature of the proposed UV disinfection facilities at the ACSD's North and South Plants and the typical electricity usage patterns of UV disinfection technology, it was imperative that the electricity cost analyses be sufficiently in-depth to account for seasonal cost variation and the influence of electricity demand costs on the overall average unit rate of electricity. Had these items been ignored and the electricity analyses based solely on the average unit electricity rates for 2008, the annual electricity costs associated with the UV disinfection alternatives would have been underestimated by 15-35 percent.



## 5.2.5. Screening Criteria for Other Affected WWTPs

### 5.2.5.1. Energy, Economic and Environmental Considerations

The use of chlorine gas or chlorine compounds remains the predominant method of wastewater disinfection. However, because of increased safety requirements imposed on the use of chlorine gas and increased public health concerns related to disinfection byproducts that arise from the use of chlorine-based disinfection, UV disinfection is gaining in popularity and is seeing widespread use in both the water and wastewater sector. UV disinfection is an effective disinfectant and produces no identified harmful byproducts. However, because UV disinfection relies on the generation and transfer of ultraviolet light to inactivate target organisms, it can be a fairly energy intensive process. To the contrary, chlorine-based disinfection has historically been considered a low electricity use process. However, this perspective is based on the actual connected electrical load associated with a chemical disinfection system and does not consider the energy use associated with manufacturer of the treatment chemicals.

Sodium hypochlorite is manufactured through an energy intensive electrochemical process. Sodium bisulfite is produced by the absorption of sulfur dioxide into soda ash. Both require energy to manufacture, purify, store, ship and apply the chemical. A 2002 study prepared by SBW Consulting, Inc. for Pacific Gas and Electric entitled, "Energy Benchmarking Secondary Wastewater Treatment and Ultraviolet Disinfection Processes at Various Municipal Wastewater Treatment Facilities", looked at the electricity use associated with the production of chemicals for disinfection. Based on that study, the energy required to produce sodium hypochlorite is approximately 2.5 kWh per pound of sodium hypochlorite. Secondary energy consumption associated with handling, shipping and transport of sodium hypochlorite was not included and, due to the complexity in quantifying energy content, the energy associated with production of sodium bisulfite was not calculated.

Table 5.2 summarizes the electricity use associated with production of sodium hypochlorite for the North and South Plants based on seasonal disinfection using dosages of 8 mg/l and 6 mg/l, an average flow rate of 23.5 MGD, and a unit electricity consumption of 2.5 kWh/pound of sodium hypochlorite. For illustrative purposes, that electricity consumption is compared to the electricity consumption for LPHO and MP UV disinfection. However, it is important to note that this comparison is not entirely valid as it does not include the energy use associated with the manufacture, handling and shipping of the UV lamps and equipment. However, it does illustrate the complexity of assessing cradle-to-grave energy use and illustrates the need for any type of proposed greenhouse gas or carbon tax to not be based solely on energy consumption at the point of use, but rather the overall energy consumption associated with manufacture, use and disposal of products, which will then, in turn, be reflected in the costs of the product.



**Table 5.2  
Summary of Electricity Consumption for Various Disinfection Technologies**

| Plant      | Sodium Hypochlorite at 8 mg/l | Sodium Hypochlorite at 6 mg/l | LPHO UV Disinfection | MP UV Disinfection |
|------------|-------------------------------|-------------------------------|----------------------|--------------------|
| North WWTP | 761,100 kWh/yr                | 570,900 kWh/yr                | 377,400 kWh/yr       | 1,309,800 kWh/yr   |
| South WWTP | 761,100 kWh/yr                | 570,900 kWh/yr                | 244,200 kWh/yr       | 1,198,800 kWh/yr   |

**5.2.5.2. UV Disinfection Considerations**

While implementation of the UVT monitoring program by ACSD personnel did not allow significant reduction in the sizing of the UV disinfection system, it did enable a more accurate estimate of average operating conditions, and consequently a more accurate estimate of electricity use could be developed. It also provided a clearer understanding of the range of operating conditions that must be met, allowing the engineer and the equipment manufacturer to work together to develop the most efficient system design for the proposed application.

The flow rate and UVT of the wastewater that is being treated, the level of redundancy that is incorporated into the system design and the required dose have the greatest influence on overall equipment sizing and capital cost. It is important to understand the electrical requirements of the proposed UV system to determine if sufficient capacity is available in the existing primary and backup electrical systems and, if not, to ensure that the costs for electrical upgrades are included in the estimated capital cost.

Factors that have the most influence on the energy efficiency and cost effectiveness of the operations include:

- Lamp technology
- Number of channels
- Number of banks of lamps
- Need for an automated sleeve cleaning system
- Need for an on-line UVT meter
- Turndown capabilities of the ballasts

### **5.2.5.3. Chlorine Disinfection Considerations**

Like the UVT monitoring program, the chlorine demand monitoring program completed at the ACSD North and South Plants did not enable a reduction in the size or capital cost of the chemical disinfection systems. In large part, this was due to the inherent conservativeness of the design guidance included in Ten States. However, as was the case with the UVT monitoring, the chlorine demand monitoring program did provide a more accurate estimate of actual chlorine demand which provided a clearer understanding of the range of operating conditions that must be met and the actual operating costs that can be expected. The single most important consideration to enable cost-effective use of chemical disinfection is to incorporate sufficient operating flexibility (primarily in the control logic and pumping rate adjustment) to allow the operating set points to be easily adjusted in response to actual operating conditions once the design is complete and the system is constructed.

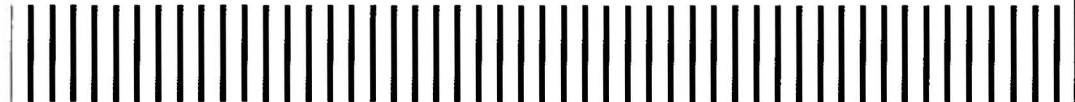


**New York State Energy Research and Development  
Authority**  
Evaluation of Disinfection Alternatives at the Albany County  
Sewer District North and South Plants

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# **Appendix A**

## **Sampling and Analysis Plan**





**New York State Energy Research and Development Authority**  
17 Columbia Circle • Albany, NY 12203-6399

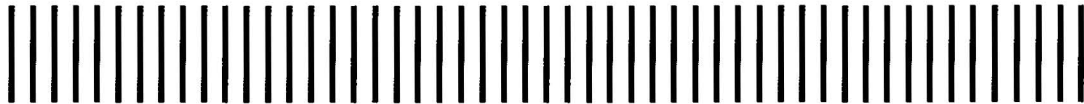


**Albany County Sewer District**  
P.O. Box 4187 • Albany, NY 12204

# **Evaluating Disinfection Alternatives at the Albany County Sewer District's North and South Plants**

## **Sampling and Analysis Plan**

June 2007



Report Prepared By:

**Malcolm Pirnie, Inc.**

43 British American Boulevard  
Latham, NY 12110  
(518) 782-2100

2255081



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# 1. Project Overview

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As part of Governor Pataki’s “Swimmable Hudson” initiative, the New York State Department of Environmental Conservation has undertaken a number of steps to ensure that the quality of the water in the Hudson River is suitable for swimming. The Albany County Sewer District (ACSD) is planning to upgrade its North and South Plants to ensure the most appropriate disinfection technology to comply with the initiative.

The ACSD is considering the use of ultraviolet (UV) technology to meet their disinfection needs. UV is one of the most environmentally friendly disinfection technologies available. However, the use of UV disinfection has the potential to be extremely energy intensive, particularly if it is improperly designed and operated or used in an inappropriate application.

The factors that have the greatest effect on the energy use for UV disinfection are UV transmittance (i.e., the ability for UV light to pass through the water and inactivate the target organism) and flow rate. It is imperative that system design be based on sound data. In the case of the North and South Plants, both of which are served by combined sewers, sufficient sampling must be conducted to fully understand the effect of wet weather flows. Specifically, a thorough understanding of the differences between dry weather operations, wet weather operations without WWTP bypass, and wet weather operations with WWTP bypass and effluent blending is needed to ensure the most applicable disinfection technology is selected and is appropriately sized and configured to maximize energy efficiency.

An extensive sampling program at the ACSD’s North and South Plants is proposed as part of this project to assist ACSD in the selection and conceptual sizing of their disinfection system. This Sampling and Analysis Plan is being prepared to define roles and responsibilities and to ensure consistency in the sampling, laboratory analysis, reporting, and recordkeeping procedures, ensuring the data are of the highest quality and integrity.

## 2. Quality Assurance Objectives

---

Sampling data will be used to develop an accurate representation of the wastewater characteristics and to determine design criteria for the disinfection system at the North and South Plants.

Samples will be collected at the influent, primary effluent, secondary effluent, and combined discharge (when blended) at both the North Plant and the South Plant.

Potential sources of error include sampling error associated with the inherent variability in physical conditions during sampling, and measurement error associated with sample collection techniques and/or analytical procedures. To ensure that the data collected during the investigation are of sufficient quality, all analytical work shall be conducted using the appropriate analytical methods listed in Table 2-1. ACSD's current quality control procedures are appropriate for this study and have been modified as-needed to accommodate additional analyses and activities that will be used for this project.

**Table 2-1.**  
**Summary of Analytical Methods, Container, Preservation, and Holding Time Requirements**

| Parameter            | Analysis                       | Container          | Preservation   | Holding Time | Lab                    |
|----------------------|--------------------------------|--------------------|--|--------------|------------------------|
| COD                  | EPA 410.1                      | 100 mL, P/G        | Cool, 4°C  | 28 days      | ACSD                   |
| BOD                  | EPA 405.1                      | 1000 mL, P/G       | Cool, 4°C  | 48 hrs       | ACSD                   |
| TSS                  | EPA 160.2                      | 500 mL, P/G        | Cool, 4°C  | 7 days       | ACSD                   |
| UVT                  | Trojan P254C                   | 100 mL, P/G        | Cool, 4°C  | 48 hrs       | ACSD                   |
| Turbidity            | Lamotte 2020                   | 100 mL, P/G        | Cool, 4°C  | 48 hrs       | ACSD                   |
| Chlorine Demand      | SM 2350B, 20 <sup>TH</sup> Ed. | 1000 mL, G         | Cool, 4°C  | 24 hrs       | ACSD                   |
| Total/Fecal Coliform | SM 9222D, 19 <sup>th</sup> Ed. | 125 mL, P, sterile | Cool, 4°C<br>Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> | 6 hrs        | St. Peter's Bender Lab |

Source: "Schedule of Services." Lancaster Laboratories.

Notes:

COD – Chemical Oxygen Demand

BOD<sub>5</sub> – 5-day Biochemical Oxygen Demand

TSS – Total suspended Solids

UVT – Ultraviolet Transmittance



## 3. Description of Sampling

---

### 3.1. Sample Handling

ACSD already collects samples and analyzes them for a number of the parameters included in this study. Additional parameters that have been included for this study include UVT, turbidity, fecal coliform, total coliform, and chlorine demand. UVT and turbidity will be measured by ACSD personnel using benchtop, direct read equipment. Chlorine demand will be analyzed by ACSD personnel using Method 2350B, coliform analyses will be conducted by St. Peter's Bender Laboratories (St. Peter's), with sample delivery by ACSD personnel. St. Peter's will provide sterile sample bottles for use during this study. Malcolm Pirnie has provided additional 100 mL plastic bottles to supplement ACSD's current supply. All other bottleware will be provided by ACSD as part of their normal sampling program. Container closures will be screw-on type and made of inert materials. Sample containers should be cleaned and prepared by the laboratory performing the analysis.

In general, all samples collected will be identified with a sample label. A label will be attached to each bottle and each sample will be identified with a unique sample number. For samples that are being collected as part of the ACSD's normal sampling program, current labeling procedures and documentation procedures shall be followed with supplemental recordkeeping as identified in this plan.

Immediately following sample collection, each sample container will be marked with a weather-proof pen with the following information:

- Sample Code (i.e. 1\_NdwRRaw1). Table 3-1 provides a list of acronyms for clarification of coding.
- Date/Time.
- Requested Analysis.
- Preservative, if used.
- Sampler's Initials.

The sample code will indicate the event number, plant location (N for North Plant), event type (dwR for Dry Weather Routine), the sample station (Raw for Raw Wastewater), and the shift number.

In the field, each sample will be checked for proper labeling. All coliform samples will be recorded and tracked under strict chain-of-custody protocols. The samples will then

be packed into coolers with ice and delivered to the laboratory by ACS D personnel. A chain-of-custody form will be completed for each cooler. The form will be signed and dated by the person who collected the samples, the person the samples were relinquished to for transport to the laboratory, and the laboratory sample controller/custodian who receives the samples. A sample chain-of-custody form is included in Appendix A. St. Peter's will provide chain-of-custody forms for all samples to be analyzed by their lab.

## **3.2. Sampling Procedures**

### **3.2.1. Sampling Equipment**

- Weather-proof pen
- Sampling stick with bottle attachment and sampling bottle
- Certified, pre-cleaned sample containers
- Preservatives (as appropriate)
- Latex gloves (disposable)
- Neoprene gloves (as appropriate)

### **3.2.2. Sampling Procedures**

The sampling bottle shall be submerged with its opening facing upstream, making sure to avoid any floating or submerged debris. If the wastewater is not directly reachable, the sample shall be collected with the help of a sampling stick. For locations that require the use of the sampling stick, a dedicated sampling bottle shall be used for each location. These bottles will be provided by Malcolm Pirnie along with the sampling sticks. The dedicated sampling bottle will be used to transfer water to the sample containers. Disposable gloves will be worn by the sampling personnel and shall be changed for each location.

Collection procedures for wastewater samples are:

1. Submerge a sampling bottle (or sampling stick with attached bottle) with minimal surface disturbance.
2. Allow the bottle to fill slowly and continuously.
3. Retrieve the sampling bottle from the surface water with minimal disturbance.
4. Remove the cap from the sample container and slightly tilt the mouth of the container below the sampling bottle edge.
5. Empty the sampling bottle slowly, allowing the sample stream to flow gently down the side of the container with minimal entry turbulence.

Samples will be preserved as outlined in Table 2-1.

If the exterior of sample containers become grossly contaminated during sample collection due to highly turbid wastewater, the exterior of the containers will be washed

with soapy water and rinsed with de-ionized water after the containers have been capped and before placing the samples in the cooler for shipment.

### 3.3. Sampling collection and frequency

The frequency of sampling for the routine monitoring events and expanded monitoring events are identified below. In all instances, if ACSD already includes sampling and analysis for a given parameter at the locations and under the conditions required, these samples may be used (example: composite sample of raw wastewater for BOD, COD, and TSS).

#### 3.3.1. Routine Sampling

Frequency: 1 per **shift**. Collect grab samples for:

- pH
- Temperature
- Turbidity
- UV Transmittance
- Chlorine Demand

Frequency: 1 per **event**. Collect grab samples for:

- COD
- BOD<sub>5</sub>
- TSS

#### 3.3.2. Expanded Sampling

Frequency: 1 per **event**. Collect grab samples for:

- pH
- Temperature
- Turbidity
- UV Transmittance
- Chlorine Demand
- COD
- BOD<sub>5</sub>
- TSS
- Total/Fecal coliform (where required).

***Note: Due to laboratory scheduling and holding time constraints, fecal coliform and total coliform samples can be collected only during the period from 7 am to 3 pm, Monday through Friday and must be delivered to St. Peter's by 4:00 pm.***



### 3.4. Dry Weather Sampling

The dry weather condition is defined as follows:

| Shift No. | Time                | North Plant<br>Dry Weather Flow | South Plant<br>Dry Weather Flow |
|-----------|---------------------|---------------------------------|---------------------------------|
| 1         | 12:00 am to 8:00 am | < 17 MGD                        | < 16 MGD                        |
| 2         | 8:00 am to 4:00 pm  | < 24 MGD                        | < 19 MGD                        |
| 3         | 4:00 pm to 12:00 am | < 22 MGD                        | < 19 MGD                        |

#### 3.4.1. Dry Weather Routine Sampling

There will be a total of 12 sampling events under dry weather conditions at each plant. Once the dry weather flow condition is identified, write the date, time sampled, and weather conditions (i.e. sunny, cloudy, rain) on the Inspection Form Check List (attached under Appendix B). Write the number assigned to the sampling event on the sampling bottles and fill out the information on the sample labels.

Sampling locations for the North and South Plants are shown on Figures 3-1 and 3-2, respectively. Detailed sampling locations for each sampling event are described below.

##### Sampling Locations:

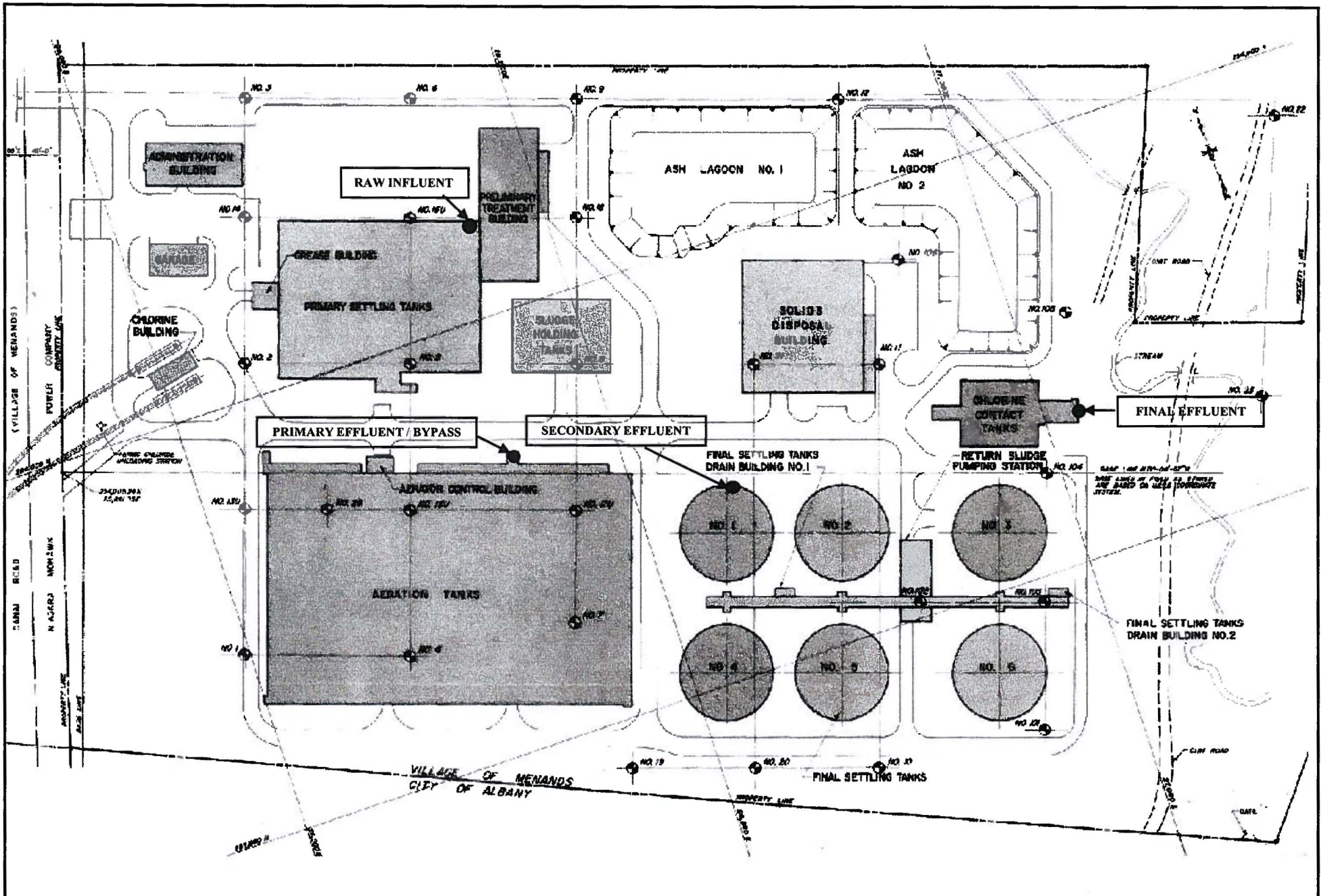
- Raw Wastewater (grab samples out of the influent sampler line of the composite sampler)
- Secondary Effluent (grab samples from the Clarifier No. 1 outlet channel)

#### 3.4.2. Dry Weather Expanded Sampling

There will be a total of 3 sampling events for this condition. Once the dry weather flow condition is identified, write the date, time sampled, and weather conditions (i.e. sunny, cloudy, rain) on the Inspection Form Check List (attached under Appendix B). Write the number assigned to the sampling event on the sampling bottles and fill out the information on the sample labels.

##### Sampling Locations:

- Raw Wastewater (grab samples out of the influent sampler line of the composite sampler)
- Primary Effluent (grab samples out of the effluent distribution channel); no coliform sample
- Secondary Effluent (grab samples from the Clarifier No. 1 outlet channel)









### 3.5. Wet Weather with No Bypass Sampling

The wet weather condition is defined as follows:

| Shift No. | Time                | North Plant<br>Wet Weather Flow | South Plant<br>Wet Weather Flow |
|-----------|---------------------|---------------------------------|---------------------------------|
| 1         | 12:00 am to 8:00 am | 30 to 40 MGD                    | 25 to 35 MGD                    |
| 2         | 8:00 am to 4:00 pm  | 30 to 40 MGD                    | 25 to 35 MGD                    |
| 3         | 4:00 pm to 12:00 am | 30 to 40 MGD                    | 25 to 35 MGD                    |

#### 3.5.1. Wet Weather – No Bypass Routine Sampling

There will be a total of 7 sampling events for this condition. Once the wet weather, no bypass flow condition is identified, write date, time sampled, and weather conditions (i.e. sunny, cloudy, rain) on the Inspection Form Check List (attached under Appendix B). Write the number assigned to the sampling event on the sampling bottles and fill out the information on the sample labels.

**Sampling Locations:**

- Raw Wastewater (grab samples out of the influent sampler line of the composite sampler)
- Secondary Effluent (grab samples from the Clarifier No. 1 outlet channel)

#### 3.5.2. Wet Weather- No Bypass Expanded Sampling

There will be a total of 3 sampling events for this condition. Once the wet weather, no bypass flow condition is identified, write the date, time sampled, and weather conditions (i.e. sunny, cloudy, rain) on the Inspection Form Check List (attached under Appendix B). Write the number assigned to the sampling event on the sampling bottles and fill out the information on the sample labels.

**Sampling Locations:**

- Raw Wastewater (grab samples out of the influent sampler line of the composite sampler)
- Primary Effluent (grab samples out of the effluent distribution channel); no coliform sample
- Secondary Effluent (grab samples from the Clarifier No. 1 outlet channel)

### 3.6. Wet Weather with Bypass and Effluent Blending Sampling

The wet weather with bypass condition is defined as follows:

| Shift No. | Time                | North Plant<br>Wet Weather with<br>Bypass Flow | South Plant<br>Wet Weather with<br>Bypass Flow |
|-----------|---------------------|--|--|
| 1         | 12:00 am to 8:00 am | >50 MGD  | >35 MGD  |
| 2         | 8:00 am to 4:00 pm  | >50 MGD  | >35 MGD  |
| 3         | 4:00 pm to 12:00 am | >50 MGD  | >35 MGD  |

#### 3.6.1. Wet Weather – Bypass Routine Sampling

There will be a total of 2 sampling events for this condition. Once the wet weather, bypass flow condition is identified, write the date, time sampled, and weather conditions (i.e. sunny, cloudy, rain) on the Inspection Form Check List (attached under Appendix B). Write the number assigned to the sampling event on the sampling bottles and fill out the information on the sample labels.

##### Sampling Locations:

- Raw Wastewater (grab samples out of the influent sampler line of the composite sampler)
- Primary Effluent (grab samples out of the effluent distribution channel)
- Secondary Effluent (grab samples from the Clarifier No. 1 outlet channel)
- Combined Discharge (grab samples from outfall channel where bypass and secondary effluent are blended)

#### 3.6.2. Wet Weather- Bypass Expanded Sampling

There will be a total of 3 sampling events for this condition. Once the wet weather, bypass flow condition is identified, write the date, time sampled, and weather conditions (i.e. sunny, cloudy, rain) on the Inspection Form Check List (attached under Appendix B). Write the number assigned to the sampling event on the sampling bottles and fill out the information on the sample labels.

##### Sampling Locations:

- Raw Wastewater (grab samples out of the influent sampler line of the composite sampler)
- Primary Effluent (grab samples out of the effluent distribution channel)
- Secondary Effluent (grab samples from the Clarifier No. 1 outlet channel)
- Combined Discharge (grab samples from outfall channel where bypass and secondary effluent are blended)

A summary of the proposed sampling regime and the specific parameters that will be analyzed for is given in Table 3-2.



## 4. Reporting and Recordkeeping

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ACSD lab will report analytical results of pH, temperature, turbidity, chlorine demand, UV transmittance, COD, BOD<sub>5</sub>, and TSS on the Lab Worksheet for Disinfection Study (attached in Appendix C and provided electronically). Should ACSD determine it is more practical to simply modify the existing Lab Worksheet to include fields for the additional parameters being analyzed as part of this disinfection study that shall be considered acceptable. It is anticipated that ACSD will initially record results manually following existing protocols and using the modified/supplemental Daily Lab Worksheet. These data will then be entered electronically into the appropriate spreadsheets.

St. Peter's Bender lab will report analytical results of fecal coliform and total coliform to ACSD, for subsequent entry into the appropriate electronic spreadsheets.

ACSD personnel will insert the information from the lab reports and from the SCADA system for each plant into the Inspection Forms (attached under Appendix D and provided electronically):

- Routine - Dry Weather, Sampling Events 1 through 12
- Expanded - Dry Weather, Sampling Events 1 through 3
- Routine - Wet Weather, No Bypass, Sampling Events 1 through 7
- Expanded - Wet Weather, No-Bypass, Sampling Events 1 through 3
- Routine - Wet Weather, Bypass, Sampling Events 1 and 2
- Expanded - Wet Weather, Bypass, Sampling Events 1 through 3

Malcolm Pirnie will assist as needed and will assess the data to identify any potential anomalies or data entry errors. If needed, Malcolm Pirnie will work with ACSD to review sampling and analytical quality control documents to determine the cause of questionable data and will work with ACSD to modify protocols to minimize the likelihood of reoccurrence. Additionally, Malcolm Pirnie will assess the results to confirm the necessary data are being gathered. As appropriate, the procedures identified herein may be modified to provide the highest quality results.

Following each sampling event, unless it is more practical to do so on a weekly or biweekly basis, ACSD will provide the following information to Malcolm Pirnie:

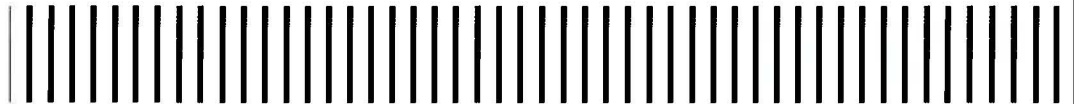
- Complete Inspection Form
- Daily Lab Worksheet
- St. Peter's Bender analytical report.

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Evaluation of Disinfection Alternatives at the Albany County  
Sewer District North and South Plants

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**Appendix B**

**Opinion of Probable Construction  
Costs**

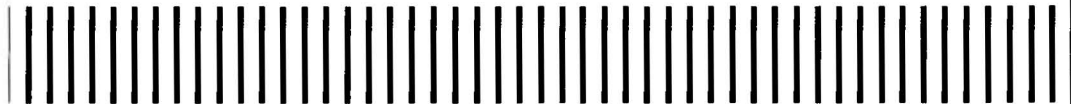


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**Evaluation of Disinfection Alternatives at the Albany County  
Sewer District North and South Plants**

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- Chlorination & Dechlorination at North Wastewater Treatment Plant
- Chlorination & Dechlorination at South Wastewater Treatment Plant
- Low Pressure High Output UV Disinfection South Wastewater Treatment Plant
- Medium Pressure UV Disinfection North Wastewater Treatment Plant
- Low Pressure High Output UV Disinfection North Wastewater Treatment Plant
- Medium UV Disinfection South Wastewater Treatment Plant
- Opinion of Probable Life Cycle Cost







**Albany County Sewer District  
Chlorination & Dechlorination at North Wastewater Treatment Plant  
Opinion of Probable Construction Costs**

| DESCRIPTION                               | QTY.       | UNIT       | UNIT COST  | SUBTOTAL OF ITEMS  | General Conditions | Contractor OH & Profit | Escalation       | Construction Contingency | 2008 CONSTRUCTION COST TOTAL |
|---|------------|------------|------------|--------------------|--------------------|------------------------|------------------|--------------------------|------------------------------|
|   |            |            |            |                    | 8%                 | 15%                    | 7%               | 10%                      |                              |
| FRP Storage Tanks (Hypochlorite)          | 3          | EA         | \$27,000   | \$81,000           | \$6,480            | \$13,122               | \$7,042          | \$10,764                 | \$118,409                    |
| FRP Storage Tanks (Bisulfite)             | 2          | EA         | \$18,000   | \$36,000           | \$2,880            | \$5,832                | \$3,130          | \$4,784                  | \$52,626                     |
| Feed Pumps (Hypochlorite)                 | 3          | EA         | \$16,000   | \$48,000           | \$3,840            | \$7,776                | \$4,173          | \$6,379                  | \$70,168                     |
| Feed Pumps (Bisulfite)                    | 3          | EA         | \$10,300   | \$30,900           | \$2,472            | \$5,006                | \$2,686          | \$4,106                  | \$45,171                     |
| North Plant Building                      | 2500       | SF         | \$300      | \$750,000          | \$60,000           | \$121,500              | \$65,205         | \$99,671                 | \$1,096,376                  |
| North Plant Injector (Bisulfite)          | 1          | EA         | \$10,000   | \$10,000           | \$800              | \$1,620                | \$869            | \$1,329                  | \$14,618                     |
| Site Work                                 | 1          | LS         | \$75,000   | \$75,000           | \$6,000            | \$12,150               | \$6,521          | \$9,967                  | \$109,638                    |
| Building Plumbing, HVAC, Sprinklers, etc. | 1          | LS         | \$330,000  | \$330,000          | \$26,400           | \$53,460               | \$28,690         | \$43,855                 | \$482,405                    |
| Containment and Health & Safety           | 1          | LS         | \$75,000   | \$75,000           | \$6,000            | \$12,150               | \$6,521          | \$9,967                  | \$109,638                    |
| Electrical Work                           | 1          | LS         | \$19,725   | \$19,725           | \$1,578            | \$3,195                | \$1,715          | \$2,621                  | \$28,835                     |
| Bisulfite Line                            | 1          | LS         | \$2,000    | \$2,000            | \$160              | \$324                  | \$174            | \$266                    | \$2,924                      |
| Hypochlorite Line                         | 1          | LS         | \$4,000    | \$4,000            | \$320              | \$648                  | \$348            | \$532                    | \$5,847                      |
|   |            |            |            |                    |                    |                        |                  |                          |                              |
|   |            |            |            |                    |                    |                        |                  |                          |                              |
| <b>TOTALS</b>                             | <b>N/A</b> | <b>N/A</b> | <b>N/A</b> | <b>\$1,462,000</b> | <b>\$117,000</b>   | <b>\$237,000</b>       | <b>\$127,000</b> | <b>\$388,600</b>         | <b>\$2,137,000</b>           |

**OPINION OF PROBABLE CONSTRUCTION COST (Point Estimate) \$2,137,000**

**OPINION OF PROBABLE CONSTRUCTION COST (Range Estimate - Low (-25%)) \$1,600,000**

**OPINION OF PROBABLE CONSTRUCTION COST (Range Estimate - High (+40%)) \$2,990,000**

- The following assumptions and reference were used to develop the opinion of probable cost:
1. Estimates are consistent with an AACE Class 4 construction cost estimate which are typically accurate to -25% to +40%.
  2. All unit costs are in 2008 dollars.
  3. Construction costs include General Conditions (8%) & Contractor Overhead and Profit (15%).
  4. Escalation covers inflation between Opinion of Probable Costs and estimated midpoint of construction in 2010.



**Albany County Sewer District  
Chlorination & Dechlorination at South Wastewater Treatment Plant  
Opinion of Probable Construction Costs**

| DESCRIPTION                               | QTY.       | UNIT       | UNIT COST  | SUBTOTAL OF ITEMS  | General Conditions | Contractor OH & Profit | Escalation       | Construction Contingency | 2008 CONSTRUCTION COST TOTAL |
|---|------------|------------|------------|--------------------|--------------------|------------------------|------------------|--------------------------|------------------------------|
|   |            |            |            |                    | 8%                 | 15%                    | 7%               | 10%                      |                              |
| FRP Storage Tanks (Hypochlorite)          | 3          | EA         | \$27,000   | \$81,000           | \$6,480            | \$13,122               | \$7,042          | \$10,764                 | \$118,409                    |
| FRP Storage Tanks (Bisulfite)             | 2          | EA         | \$18,000   | \$36,000           | \$2,880            | \$5,832                | \$3,130          | \$4,784                  | \$52,626                     |
| Feed Pumps (Hypochlorite)                 | 3          | EA         | \$16,000   | \$48,000           | \$3,840            | \$7,776                | \$4,173          | \$6,379                  | \$70,168                     |
| Feed Pumps (Bisulfite)                    | 3          | EA         | \$10,300   | \$30,900           | \$2,472            | \$5,006                | \$2,686          | \$4,106                  | \$45,171                     |
| North Plant Building                      | 2500       | SF         | \$300      | \$750,000          | \$60,000           | \$121,500              | \$65,205         | \$99,671                 | \$1,096,376                  |
| Site Work                                 | 1          | LS         | \$75,000   | \$75,000           | \$6,000            | \$12,150               | \$6,521          | \$9,967                  | \$109,638                    |
| Building Plumbing, HVAC, Sprinklers, etc. | 1          | LS         | \$330,000  | \$330,000          | \$26,400           | \$53,460               | \$28,690         | \$43,855                 | \$482,405                    |
| Containment and Health & Safety           | 1          | LS         | \$75,000   | \$75,000           | \$6,000            | \$12,150               | \$6,521          | \$9,967                  | \$109,638                    |
| Electrical Work                           | 1          | LS         | \$19,725   | \$19,725           | \$1,578            | \$3,195                | \$1,715          | \$2,621                  | \$28,835                     |
| Bisulfite Line                            | 1          | LS         | \$2,000    | \$2,000            | \$160              | \$324                  | \$174            | \$266                    | \$2,924                      |
| Hypochlorite Line                         | 1          | LS         | \$1,250    | \$1,250            | \$100              | \$203                  | \$109            | \$166                    | \$1,827                      |
|   |            |            |            |                    |                    |                        |                  |                          |                              |
|   |            |            |            |                    |                    |                        |                  |                          |                              |
|   |            |            |            |                    |                    |                        |                  |                          |                              |
| <b>TOTALS</b>                             | <b>N/A</b> | <b>N/A</b> | <b>N/A</b> | <b>\$1,449,000</b> | <b>\$116,000</b>   | <b>\$235,000</b>       | <b>\$126,000</b> | <b>\$385,200</b>         | <b>\$2,118,000</b>           |

**OPINION OF PROBABLE CONSTRUCTION COST (Point Estimate) \$2,118,000**

**OPINION OF PROBABLE CONSTRUCTION COST (Range Estimate - Low (-25%)) \$1,590,000**

**OPINION OF PROBABLE CONSTRUCTION COST (Range Estimate - High (+40%)) \$2,970,000**

The following assumptions and reference were used to develop the opinion of probable cost:

1. Estimates are consistent with an AACE Class 4 construction cost estimate which are typically accurate to -25% to +40%.
2. All unit costs are in 2008 dollars.
3. Construction costs include General Conditions (8%) & Contractor Overhead and Profit (15%).
4. Escalation covers inflation between Opinion of Probable Costs and estimated midpoint of construction in 2010.



**Albany County Sewer District  
Low Pressure High Output UV Disinfection South Wastewater Treatment Plant  
Opinion of Probable Construction Costs**

| DESCRIPTION                           | QTY.       | UNIT       | UNIT COST   | SUBTOTAL OF ITEMS  | General Conditions | Contractor OH & Profit | Escalation       | Construction Contingency | 2008 CONSTRUCTION COST TOTAL |
|---------------------------------------|------------|------------|-------------|--------------------|--------------------|------------------------|------------------|--------------------------|------------------------------|
|                                       |            |            |             |                    | 8%                 | 15%                    | 7%               | 10%                      |                              |
| Modification of Chlorine Contact Tank | 1          | LS         | \$120,000   | \$120,000          | \$9,600            | \$19,440               | \$10,433         | \$15,947                 | \$175,420                    |
| UV equipment                          | 1          | LS         | \$2,300,000 | \$2,300,000        | \$184,000          | \$372,600              | \$199,962        | \$305,656                | \$3,362,218                  |
| Electrical Work                       | 1          | LS         | \$225,000   | \$225,000          | \$18,000           | \$36,450               | \$19,562         | \$29,901                 | \$328,913                    |
| Site Work                             | 1          | LS         | \$20,000    | \$20,000           | \$1,600            | \$3,240                | \$1,739          | \$2,658                  | \$29,237                     |
|                                       |            |            |             |                    |                    |                        |                  |                          |                              |
| <b>TOTALS</b>                         | <b>N/A</b> | <b>N/A</b> | <b>N/A</b>  | <b>\$2,665,000</b> | <b>\$213,000</b>   | <b>\$432,000</b>       | <b>\$232,000</b> | <b>\$708,400</b>         | <b>\$3,896,000</b>           |

**OPINION OF PROBABLE CONSTRUCTION COST (Point Estimate) \$3,896,000**

**OPINION OF PROBABLE CONSTRUCTION COST (Range Estimate - Low (-25%)) \$2,920,000**

**OPINION OF PROBABLE CONSTRUCTION COST (Range Estimate - High (+40%)) \$5,450,000**

The following assumptions and reference were used to develop the opinion of probable cost:

1. Estimates are consistent with an AACE Class 4 construction cost estimate which are typically accurate to -25% to +40%.
2. All unit costs are in 2008 dollars.
3. Construction costs include General Conditions (8%) & Contractor Overhead and Profit (15%).
4. Escalation covers inflation between Opinion of Probable Costs and estimated midpoint of construction in 2010.





**Albany County Sewer District  
Medium Pressure UV Disinfection North Wastewater Treatment Plant  
Opinion of Probable Construction Costs**

| DESCRIPTION                           | QTY.       | UNIT       | UNIT COST   | SUBTOTAL OF ITEMS  | General Conditions | Contractor OH & Profit | Escalation       | Construction Contingency | 2008 CONSTRUCTION COST TOTAL |
|---------------------------------------|------------|------------|-------------|--------------------|--------------------|------------------------|------------------|--------------------------|------------------------------|
|                                       |            |            |             |                    | 8%                 | 15%                    | 7%               | 10%                      |                              |
| Modification of Chlorine Contact Tank | 1          | LS         | \$160,000   | \$160,000          | \$12,800           | \$25,920               | \$13,910         | \$21,263                 | \$233,893                    |
| UV equipment                          | 1          | LS         | \$3,000,000 | \$3,000,000        | \$240,000          | \$486,000              | \$260,820        | \$398,682                | \$4,385,502                  |
| Electrical Work                       | 1          | LS         | \$250,000   | \$250,000          | \$20,000           | \$40,500               | \$21,735         | \$33,224                 | \$365,459                    |
| Site Work                             | 1          | LS         | \$20,000    | \$20,000           | \$1,600            | \$3,240                | \$1,739          | \$2,658                  | \$29,237                     |
|                                       |            |            |             |                    |                    |                        |                  |                          |                              |
|                                       |            |            |             |                    |                    |                        |                  |                          |                              |
| <b>TOTALS</b>                         | <b>N/A</b> | <b>N/A</b> | <b>N/A</b>  | <b>\$3,430,000</b> | <b>\$274,000</b>   | <b>\$556,000</b>       | <b>\$298,000</b> | <b>\$911,600</b>         | <b>\$5,014,000</b>           |

|   |                    |
|---|--------------------|
| <b>OPINION OF PROBABLE CONSTRUCTION COST<br/>(Point Estimate)</b>               | <b>\$5,014,000</b> |
| <b>OPINION OF PROBABLE CONSTRUCTION COST<br/>(Range Estimate - Low (-25%))</b>  | <b>\$3,760,000</b> |
| <b>OPINION OF PROBABLE CONSTRUCTION COST<br/>(Range Estimate - High (+40%))</b> | <b>\$7,020,000</b> |

The following assumptions and reference were used to develop the opinion of probable cost:

1. Estimates are consistent with an AACE Class 4 construction cost estimate which are typically accurate to -25% to +40%.
2. All unit costs are in 2008 dollars.
3. Construction costs include General Conditions (8%) & Contractor Overhead and Profit (15%).
4. Escalation covers inflation between Opinion of Probable Costs and estimated midpoint of construction in 2010.



**Albany County Sewer District  
Low Pressure High Output UV Disinfection North Wastewater Treatment Plant  
Opinion of Probable Construction Costs**

| DESCRIPTION                           | QTY.       | UNIT       | UNIT COST   | SUBTOTAL OF ITEMS  | General Conditions | Contractor OH & Profit | Escalation       | Construction Contingency | 2008 CONSTRUCTION COST TOTAL |
|---------------------------------------|------------|------------|-------------|--------------------|--------------------|------------------------|------------------|--------------------------|------------------------------|
|                                       |            |            |             |                    | 8%                 | 15%                    | 7%               | 10%                      |                              |
| Modification of Chlorine Contact Tank | 1          | LS         | \$120,000   | \$120,000          | \$9,600            | \$19,440               | \$10,433         | \$15,947                 | \$175,420                    |
| UV equipment                          | 1          | LS         | \$3,500,000 | \$3,500,000        | \$280,000          | \$567,000              | \$304,290        | \$465,129                | \$5,116,419                  |
| Electrical Work                       | 1          | LS         | \$225,000   | \$225,000          | \$18,000           | \$36,450               | \$19,562         | \$29,901                 | \$328,913                    |
| Site Work                             | 1          | LS         | \$20,000    | \$20,000           | \$1,600            | \$3,240                | \$1,739          | \$2,658                  | \$29,237                     |
|                                       |            |            |             | \$0                | \$0                | \$0                    | \$0              | \$0                      | \$0                          |
|                                       |            |            |             | \$0                | \$0                | \$0                    | \$0              | \$0                      | \$0                          |
| <b>TOTALS</b>                         | <b>N/A</b> | <b>N/A</b> | <b>N/A</b>  | <b>\$3,865,000</b> | <b>\$309,000</b>   | <b>\$626,000</b>       | <b>\$336,000</b> | <b>\$1,027,200</b>       | <b>\$5,650,000</b>           |

**OPINION OF PROBABLE CONSTRUCTION COST (Point Estimate)** **\$5,650,000**

**OPINION OF PROBABLE CONSTRUCTION COST (Range Estimate - Low (-25%))** **\$4,240,000**

**OPINION OF PROBABLE CONSTRUCTION COST (Range Estimate - High (+40%))** **\$7,910,000**

The following assumptions and reference were used to develop the opinion of probable cost:

1. Estimates are consistent with an AACE Class 4 construction cost estimate which are typically accurate to -25% to +40%.
2. All unit costs are in 2008 dollars.
3. Construction costs include General Conditions (8%) & Contractor Overhead and Profit (15%).
4. Escalation covers inflation between Opinion of Probable Costs and estimated midpoint of construction in 2010.



**Albany County Sewer District  
Medium UV Disinfection South Wastewater Treatment Plant  
Opinion of Probable Construction Costs**

| DESCRIPTION                           | QTY.       | UNIT       | UNIT COST   | SUBTOTAL OF ITEMS  | General Conditions | Contractor OH & Profit | Escalation       | Construction Contingency | 2008 CONSTRUCTION COST TOTAL |
|---------------------------------------|------------|------------|-------------|--------------------|--------------------|------------------------|------------------|--------------------------|------------------------------|
|                                       |            |            |             |                    | 8%                 | 15%                    | 7%               | 10%                      |                              |
| Modification of Chlorine Contact Tank | 1          | LS         | \$160,000   | \$160,000          | \$12,800           | \$25,920               | \$13,910         | \$21,263                 | \$233,893                    |
| UV equipment                          | 1          | LS         | \$1,800,000 | \$1,800,000        | \$144,000          | \$291,600              | \$156,492        | \$239,209                | \$2,631,301                  |
| Electrical Work                       | 1          | LS         | \$250,000   | \$250,000          | \$20,000           | \$40,500               | \$21,735         | \$33,224                 | \$365,459                    |
| Site Work                             | 1          | LS         | \$20,000    | \$20,000           | \$1,600            | \$3,240                | \$1,739          | \$2,658                  | \$29,237                     |
|                                       |            |            |             | \$0                | \$0                | \$0                    | \$0              | \$0                      | \$0                          |
|                                       |            |            |             | \$0                | \$0                | \$0                    | \$0              | \$0                      | \$0                          |
| <b>TOTALS</b>                         | <b>N/A</b> | <b>N/A</b> | <b>N/A</b>  | <b>\$2,230,000</b> | <b>\$178,000</b>   | <b>\$361,000</b>       | <b>\$194,000</b> | <b>\$592,600</b>         | <b>\$3,260,000</b>           |

**OPINION OF PROBABLE CONSTRUCTION COST (Point Estimate) \$3,260,000**

**OPINION OF PROBABLE CONSTRUCTION COST (Range Estimate - Low (-25%)) \$2,450,000**

**OPINION OF PROBABLE CONSTRUCTION COST (Range Estimate - High (+40%)) \$4,560,000**

The following assumptions and reference were used to develop the opinion of probable cost:

1. Estimates are consistent with an AACE Class 4 construction cost estimate which are typically accurate to -25% to +40%.
2. All unit costs are in 2008 dollars.
3. Construction costs include General Conditions (8%) & Contractor Overhead and Profit (15%).
4. Escalation covers inflation between Opinion of Probable Costs and estimated midpoint of construction in 2010.



| Scenario   | Opinion of Probable Cost |                     | 20-Year Life Cycle <sup>1</sup> |
|--|--------------------------|---------------------|---------------------------------|
|  | Capital Cost             | First Year O&M Cost |                                 |
| North Plant - Chlor/Dechlor (6/2.5) <sup>3</sup> | \$2,137,000              | \$240,411           | \$6,945,225                     |
| North Plant - LPHO                               | \$5,650,000              | \$132,667           | \$8,303,350                     |
| North Plant - Chlor/Dechlor (8/3) <sup>2</sup>   | \$2,137,000              | \$317,935           | \$8,495,700                     |
| North Plant - MP                                 | \$5,014,000              | \$215,441           | \$9,322,828                     |
| South Plant - LPHO                               | \$3,896,000              | \$100,755           | \$5,911,105                     |
| South Plant - Chlor/Dechlor (6/2.5) <sup>3</sup> | \$2,118,000              | \$237,457           | \$6,867,145                     |
| South Plant - MP                                 | \$3,260,000              | \$240,628           | \$8,072,553                     |
| South Plant - Chlor/Dechlor (8/3) <sup>2</sup>   | \$2,118,000              | \$314,063           | \$8,399,260                     |

<sup>1</sup> Calculated simply as capital cost plus current operations and maintenance cost multiplied by 20-year system life.

<sup>2</sup> Based on chlorine dose of 8 mg/l and sodium bisulfite dose of 3.3 mg/l.

<sup>3</sup> Based on chlorine dose of 6 mg/l and sodium bisulfite dose of 2.5 mg/l.

## **Appendix C**

# **Opinion of Probable O&M Costs and Electricity Cost Analysis**

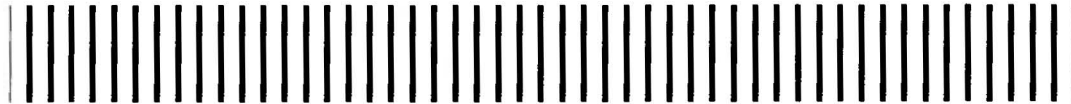


**New York State Energy Research and Development  
Authority**

**Evaluation of Disinfection Alternatives at the Albany County  
Sewer District North and South Plants**

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- Opinion of Probable Equipment and Electricity Costs
- Opinion of Probable Electricity Costs North Plant
- Opinion of Probable Electricity Costs South Plant
- Opinion of Probable Chemical Costs





### Rates

|   |                        |
|---|------------------------|
| Labor rate                                  | \$35.00 per hour       |
| Average Elec Rate North - MP <sup>1</sup>   | \$0.139 per kWh        |
| Average Elec Rate North - LPHO <sup>1</sup> | \$0.139 per kWh        |
| Average Elec Rate South - MP <sup>1</sup>   | \$0.176 per kWh        |
| Average Elec Rate South - LPHO <sup>1</sup> | \$0.203 per kWh        |
| LPHO Lamp cost                              | \$260.00 per lamp      |
| MP Lamp Cost                                | \$290.00 per lamp      |
| Ballast cost                                | \$1,750.00 per ballast |
| Sleeve cost                                 | \$180.00 per sleeve    |
| Wiper cost                                  | \$12.00 per wiper      |
| Chemical cost                               | \$50.00 per gallon     |

### Run time/Life Expectancy

|                 |         |  |
|-----------------|---------|--|
| Operating hours | 4,440   | Based on May 1 to October 31 Operation |
| LPHO Lamp life  | 12,000  | hours                                  |
| MP Lamp Life    | 6,000   | hours                                  |
| Ballast life    | 43,800  | hours                                  |
| Sleeve life     | 175,200 | hours                                  |
| Wiper life      | 30,000  | strokes                                |

### Labor Effort

|                         |     |               |
|-------------------------|-----|---------------|
| Labor to change lamp    | 0.5 | hours/lamp    |
| Labor to change ballast | 4   | hours/ballast |
| Labor to replace sleeve | 1   | hours/sleeve  |
| Labor to change wiper   | 0.2 | hours/wiper   |

| Operating Characteristics             | North Plant      |                  | South Plant      |                  |
|---------------------------------------|------------------|------------------|------------------|------------------|
|                                       | LPHO             | MP               | LPHO             | MP               |
| Maximum power                         | 450              | 1540             | 280              | 900              |
| Average power                         | 85               | 295              | 55               | 270              |
| Total number of lamps                 | 1792             | 480              | 1104             | 280              |
| Lamps replaced per year               | 125              | 68               | 80               | 62               |
| Number of ballasts in service         | 169              | 46               | 108              | 42               |
| Ballasts replaced per year            | 5                | 1                | 3                | 1                |
| Number of quartz sleeves              | 1792             | 480              | 1104             | 280              |
| Number replaced per year <sup>2</sup> | 47               | 13               | 29               | 8                |
| Number of wipers/gaskets <sup>3</sup> | 7168             | 1920             | 4416             | 1120             |
| Number replaced per year <sup>4</sup> | 1354             | 368              | 867              | 336              |
| Electricity Use (kWh)                 | 377,400          | 1,309,800        | 244,200          | 1,198,800        |
| Electricity Cost                      | \$52,459         | \$182,062        | \$49,573         | \$210,989        |
| Labor (hours)                         | 400              | 126              | 255              | 111              |
| Labor Cost                            | \$14,014         | \$4,408          | \$8,939          | \$3,886          |
| Consumables Cost                      | \$66,195         | \$28,971         | \$42,244         | \$25,753         |
| <b>TOTAL ANNUAL O&amp;M</b>           | <b>\$132,667</b> | <b>\$215,441</b> | <b>\$100,755</b> | <b>\$240,628</b> |

<sup>1</sup> Average rate is calculated using the actual rates for May through October 2008, monthly demand estimated as 80% of maximum power, and estimated electricity consumption using average power.

<sup>2</sup> Based on accidental breakage of 1% of lamps replaced each year plus yearly average based on sleeve life.

<sup>3</sup> Based on 4 wipers/gaskets per lamp.

<sup>4</sup> Based on replacement of those on active lamps each year.



**Albany County Sewer District  
Opinion of Probable Electricity Costs  
North Plant**

**Medium Pressure**

| Month        | Average KW | Days in Month | Peak KW Est | kWh Est          | Demand Cost | RKVA Cost | SBC Cost | kWh Delivery | kWh Purchase | Cost                |
|--------------|------------|---------------|-------------|------------------|-------------|-----------|----------|--------------|--------------|---------------------|
| January      | 0          | 0             | 0           | 0                | \$6.22      | \$1.02    | \$0.00   | \$0.00       | \$0.10       | \$0.00              |
| February     | 0          | 0             | 0           | 0                | \$6.23      | \$1.00    | \$0.00   | \$0.00       | \$0.09       | \$0.00              |
| March        | 0          | 0             | 0           | 0                | \$6.22      | \$1.02    | \$0.00   | \$0.00       | \$0.10       | \$0.00              |
| April        | 0          | 0             | 0           | 0                | \$6.23      | \$1.02    | \$0.00   | \$0.00       | \$0.11       | \$0.00              |
| May          | 295        | 31            | 1232        | 219480           | \$6.23      | \$1.02    | \$0.00   | \$0.00       | \$0.13       | \$37,411.68         |
| June         | 295        | 30            | 1232        | 212400           | \$5.98      | \$1.02    | \$0.00   | \$0.00       | \$0.12       | \$34,078.29         |
| July         | 295        | 31            | 1232        | 219480           | \$6.23      | \$1.02    | \$0.00   | \$0.00       | \$0.11       | \$33,790.02         |
| August       | 295        | 31            | 1232        | 219480           | \$6.23      | \$1.02    | \$0.00   | \$0.00       | \$0.08       | \$25,769.99         |
| September    | 295        | 30            | 1232        | 212400           | \$6.23      | \$1.02    | \$0.00   | \$0.00       | \$0.08       | \$25,567.85         |
| October      | 295        | 31            | 1232        | 219480           | \$6.23      | \$1.02    | \$0.00   | \$0.00       | \$0.07       | \$23,983.34         |
| November     | 0          | 0             | 0           | 0                | \$6.24      | \$1.02    | \$0.00   | \$0.00       | \$0.07       | \$0.00              |
| December     | 0          | 0             | 0           | 0                | \$5.87      | \$1.02    | \$0.00   | \$0.00       | \$0.07       | \$0.00              |
| <b>TOTAL</b> |            |               | <b>7392</b> | <b>1,302,720</b> |             |           |          |              |              | <b>\$180,601.17</b> |

\$0.139 /kWh

**Low Pressure High Output**

| Month        | Average KW | Days in Month | Peak KW Est | kWh Est        | Demand Cost | RKVA Cost | SBC Cost | kWh Delivery | kWh Purchase | Cost               |
|--------------|------------|---------------|-------------|----------------|-------------|-----------|----------|--------------|--------------|--------------------|
| January      | 0          | 0             | 0           | 0              | \$6.22      | \$1.02    | \$0.00   | \$0.00       | \$0.10       | \$0.00             |
| February     | 0          | 0             | 0           | 0              | \$6.23      | \$1.00    | \$0.00   | \$0.00       | \$0.09       | \$0.00             |
| March        | 0          | 0             | 0           | 0              | \$6.22      | \$1.02    | \$0.00   | \$0.00       | \$0.10       | \$0.00             |
| April        | 0          | 0             | 0           | 0              | \$6.23      | \$1.02    | \$0.00   | \$0.00       | \$0.11       | \$0.00             |
| May          | 85         | 31            | 360         | 63240          | \$6.23      | \$1.02    | \$0.00   | \$0.00       | \$0.13       | \$10,811.64        |
| June         | 85         | 30            | 360         | 61200          | \$5.98      | \$1.02    | \$0.00   | \$0.00       | \$0.12       | \$9,849.92         |
| July         | 85         | 31            | 360         | 63240          | \$6.23      | \$1.02    | \$0.00   | \$0.00       | \$0.11       | \$9,768.11         |
| August       | 85         | 31            | 360         | 63240          | \$6.23      | \$1.02    | \$0.00   | \$0.00       | \$0.08       | \$7,457.25         |
| September    | 85         | 30            | 360         | 61200          | \$6.23      | \$1.02    | \$0.00   | \$0.00       | \$0.08       | \$7,399.01         |
| October      | 85         | 31            | 360         | 63240          | \$6.23      | \$1.02    | \$0.00   | \$0.00       | \$0.07       | \$6,942.46         |
| November     | 0          | 0             | 0           | 0              | \$6.24      | \$1.02    | \$0.00   | \$0.00       | \$0.07       | \$0.00             |
| December     | 0          | 0             | 0           | 0              | \$5.87      | \$1.02    | \$0.00   | \$0.00       | \$0.07       | \$0.00             |
| <b>TOTAL</b> |            |               | <b>2160</b> | <b>375,360</b> |             |           |          |              |              | <b>\$52,228.39</b> |

\$0.139 /kWh

**Albany County Sewer District  
Opinion of Probable Electricity Costs  
South Plant**

**Medium Pressure**

| Month        | Average KW | Days in Month | Peak KW Est | kWh Est          | Demand Cost | RKVA Cost | SBC Cost | kWh Delivery | kWh Purchase | Cost                |
|--------------|------------|---------------|-------------|------------------|-------------|-----------|----------|--------------|--------------|---------------------|
| January      | 0          | 0             | 0           | 0                | \$14.42     | \$0.85    | \$0.00   | \$0.01       | \$0.11       | \$0.00              |
| February     | 0          | 0             | 0           | 0                | \$14.20     | \$0.85    | \$0.00   | \$0.01       | \$0.10       | \$0.00              |
| March        | 0          | 0             | 0           | 0                | \$14.20     | \$0.85    | \$0.00   | \$0.01       | \$0.10       | \$0.00              |
| April        | 0          | 0             | 0           | 0                | \$14.20     | \$0.85    | \$0.00   | \$0.01       | \$0.11       | \$0.00              |
| May          | 269        | 31            | 720         | 200136           | \$14.20     | \$0.85    | \$0.00   | \$0.01       | \$0.14       | \$42,133.64         |
| June         | 269        | 30            | 720         | 193680           | \$14.20     | \$0.85    | \$0.00   | \$0.02       | \$0.13       | \$38,264.44         |
| July         | 269        | 31            | 720         | 200136           | \$14.20     | \$0.85    | \$0.00   | \$0.02       | \$0.12       | \$38,782.31         |
| August       | 269        | 31            | 720         | 200136           | \$14.20     | \$0.85    | \$0.00   | \$0.02       | \$0.09       | \$31,070.65         |
| September    | 269        | 30            | 720         | 193680           | \$14.20     | \$0.85    | \$0.00   | \$0.01       | \$0.09       | \$30,830.42         |
| October      | 269        | 31            | 720         | 200136           | \$14.20     | \$0.85    | \$0.00   | \$0.01       | \$0.08       | \$27,836.82         |
| November     | 0          | 0             | 0           | 0                | \$14.20     | \$0.85    | \$0.00   | \$0.01       | \$0.08       | \$0.00              |
| December     | 0          | 0             | 0           | 0                | \$14.20     | \$0.85    | \$0.00   | \$0.01       | \$0.07       | \$0.00              |
| <b>TOTAL</b> |            |               |             | <b>1,187,904</b> |             |           |          |              |              | <b>\$208,918.28</b> |

\$0.176 /kWh

**Low Pressure High Output**

| Month        | Average KW | Days in Month | Peak KW Est | kWh Est        | Demand Cost | RKVA Cost | SBC Cost | kWh Delivery | kWh Purchase | Cost               |
|--------------|------------|---------------|-------------|----------------|-------------|-----------|----------|--------------|--------------|--------------------|
| January      | 0          | 0             | 0           | 0              | \$14.42     | \$0.85    | \$0.00   | \$0.01       | \$0.11       | \$0.00             |
| February     | 0          | 0             | 0           | 0              | \$14.20     | \$0.85    | \$0.00   | \$0.01       | \$0.10       | \$0.00             |
| March        | 0          | 0             | 0           | 0              | \$14.20     | \$0.85    | \$0.00   | \$0.01       | \$0.10       | \$0.00             |
| April        | 0          | 0             | 0           | 0              | \$14.20     | \$0.85    | \$0.00   | \$0.01       | \$0.11       | \$0.00             |
| May          | 55         | 31            | 224         | 40920          | \$14.20     | \$0.85    | \$0.00   | \$0.01       | \$0.14       | \$9,714.08         |
| June         | 55         | 30            | 224         | 39600          | \$14.20     | \$0.85    | \$0.00   | \$0.02       | \$0.13       | \$8,922.98         |
| July         | 55         | 31            | 224         | 40920          | \$14.20     | \$0.85    | \$0.00   | \$0.02       | \$0.12       | \$9,028.87         |
| August       | 55         | 31            | 224         | 40920          | \$14.20     | \$0.85    | \$0.00   | \$0.02       | \$0.09       | \$7,452.13         |
| September    | 55         | 30            | 224         | 39600          | \$14.20     | \$0.85    | \$0.00   | \$0.01       | \$0.09       | \$7,403.02         |
| October      | 55         | 31            | 224         | 40920          | \$14.20     | \$0.85    | \$0.00   | \$0.01       | \$0.08       | \$6,790.94         |
| November     | 0          | 0             | 0           | 0              | \$14.20     | \$0.85    | \$0.00   | \$0.01       | \$0.08       | \$0.00             |
| December     | 0          | 0             | 0           | 0              | \$14.20     | \$0.85    | \$0.00   | \$0.01       | \$0.07       | \$0.00             |
| <b>TOTAL</b> |            |               |             | <b>242,880</b> |             |           |          |              |              | <b>\$49,312.02</b> |

\$0.203 /kWh



**Albany County Sewer District  
Opinion of Probable Chemical Costs**

| North Plant   |                                |
|---|--------------------------------|
| Hypo  | 1345 gpd                       |
|   | \$1.20 per gal                 |
|   | \$1,614 per day                |
|   | 180 days of operation per year |
|   | \$290,520 per year             |
| Bisulfite   | 145 gpd                        |
|   | \$0.75 per gal                 |
|   | \$109 per day                  |
|   | 180 days of operation per year |
|   | \$19,575 per year              |
| other costs<br>5% of mechanical<br>costs (\$84,000) | \$4,200 per year               |
| Labor   | 4 hr/wk                        |
|   | 26 wks                         |
|   | \$35 per hour                  |
|   | \$3,640 per year               |
| <b>TOTAL</b>  | <b>\$317,935</b>               |

| South Plant   |                                |
|---|--------------------------------|
| Hypo  | 1328 gpd                       |
|   | \$1.20 per gal                 |
|   | \$1,594 per day                |
|   | 180 days of operation per year |
|   | \$286,848 per year             |
| Bisulfite   | 145 gpd                        |
|   | \$0.75 per gal                 |
|   | \$109 per day                  |
|   | 180 days of operation per year |
|   | \$19,575 per year              |
| other costs<br>5% of mechanical<br>costs (\$80,000) | \$4,000 per year               |
| Labor   | 4 hr/wk                        |
|   | 26 wks                         |
|   | \$35 per hour                  |
|   | \$3,640 per year               |
| <b>TOTAL</b>  | <b>\$314,063</b>               |

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fax: (518) 862-1091

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# **EVALUATION OF DISINFECTION ALTERNATIVES AT THE ALBANY COUNTY SEWER DISTRICT NORTH AND SOUTH PLANTS**

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**FINAL REPORT 10-12**

**STATE OF NEW YORK**

**DAVID A. PATERSON, GOVERNOR**

**NEW YORK STATE ENERGY RESEARCH AND DEVELOPMENT AUTHORITY**

**VINCENT A. DEIORIO, ESQ., CHAIRMAN**

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