Harriman Wastewater Treatment Facility Membrane Bioreactor Pilot Study

Final Report 06-08
October 2006

New York State
Energy Research and
Development Authority

The New York State Energy Research and Development Authority (NYSERDA) is a public benefit corporation created in 1975 by the New York State Legislature. NYSERDA's responsibilities include:

- Conducting a multifaceted energy and environmental research and development program to meet New York State's diverse economic needs.
- Administering the **New York Energy $mart**SM program, a Statewide public benefit R&D, energy efficiency, and environmental protection program.
- Making energy more affordable for residential and low-income households.
- Helping industries, schools, hospitals, municipalities, not-for-profits, and the residential sector, including low-income residents, implement energy-efficiency measures.
- Providing objective, credible, and useful energy analysis and planning to guide decisions made by major energy stakeholders in the private and public sectors.
- Managing the Western New York Nuclear Service Center at West Valley, including: (1) overseeing the State's interests and share of costs at the West Valley Demonstration Project, a federal/State radioactive waste clean-up effort, and (2) managing wastes and maintaining facilities at the shut-down State-Licensed Disposal Area.
- Coordinating the State's activities on energy emergencies and nuclear regulatory matters, and monitoring low-level radioactive waste generation and management in the State.
- Financing energy-related projects, reducing costs for ratepayers.

NYSERDA administers the **New York Energy $mart**SM program, which is designed to support certain public benefit programs during the transition to a more competitive electricity market. Some 2,700 projects in 40 programs are funded by a charge on the electricity transmitted and distributed by the State's investor-owned utilities. The **New York Energy $mart**SM program provides energy efficiency services, including those directed at the low-income sector, research and development, and environmental protection activities.

NYSERDA derives its basic research revenues from an assessment on the intrastate sales of New York State's investor-owned electric and gas utilities, and voluntary annual contributions by the New York Power Authority and the Long Island Power Authority. Additional research dollars come from limited corporate funds. Some 400 NYSERDA research projects help the State's businesses and municipalities with their energy and environmental problems. Since 1990, NYSERDA has successfully developed and brought into use more than 170 innovative, energy-efficient, and environmentally beneficial products, processes, and services. These contributions to the State's economic growth and environmental protection are made at a cost of about $.70 per New York resident per year.

Federally funded, the Energy Efficiency Services program is working with more than 540 businesses, schools, and municipalities to identify existing technologies and equipment to reduce their energy costs.

For more information, contact the Communications unit, NYSERDA, 17 Columbia Circle, Albany, New York 12203-6399; toll-free 1-866-NYSERDA, locally (518) 862-1090, ext. 3250; or on the web at www.nyserda.org

Harriman Wastewater Treatment Facility
Membrane Bioreactor Pilot Study
Final Report

Prepared for the

New York State
Energy Research and
Development Authority

Albany, NY
www.nyserda.org

Kathleen O'Connor, P.E.
Project Manager

and

Orange County Department of
Environmental Facilities and Services

Harriman, NY

Edmund A. Fares, P.E.
Commissioner

Prepared by

Camp Dresser & McKee, Inc.
Edison, NJ

Thomas R. Schoettle, P.E., DEE
Project Director

David J. Tanzi, P.E.
Project Manager

Christine Arlotta, P.E.
Project Engineer

NYSERDA
Report 06-08

NYSERDA 8135

October 2006

NOTICE

Abstract

The Orange County Department of Environmental Facilities and Services conducted a 6-month pilot study at the Harriman Wastewater Treatment Plant to establish the feasibility of incorporating membrane bioreactor (MBR) technology as a means of upgrading the treatment capacity of the existing oxidation ditches at the facility. The pilot study, which was cost-shared by the New York State Energy Research and Development Authority (NYSERDA), demonstrated the viability of MBR technology for use at the facility. Data collected during this pilot study were used to estimate the average day treatment capacity that can be provided at the existing site through the use of MBRs. These data were also used to compare the use of MBRs for expansion of the facility with a more conventional treatment technology (step-feed aeration). A computer modeling program (BioWin ™) was used to simulate the two alternatives, estimate the potential to increase the facility's capacity, and predict effluent quality based on existing and future anticipated permit limits.

Based on the necessary improvements required to increase the capacity of the existing oxidation treatment system, planning level capital costs, additional annual operating costs and the present value based on a 20-year life cycle were estimated for each of the two expansion alternatives.

Key Words

MBR, membrane bioreactor, pilot study, conceptual design, biological nutrient removal, NYSERDA, Harriman Wastewater Treatment Plant, Biowin ™

TABLE OF CONTENTS

FIGURES

TABLES

SUMMARY

The Harriman Wastewater Treatment Plant (HWWTP) is a 4.0 million gallon per day (mgd) facility that serves the Orange County Sewer District No.1 and the Moodna Basin Southern Region in Orange County, New York, and is operated by the Orange County Department of Environmental Facilities and Services (OCDEFS). Currently, the HWWTP has two treatment trains, a 2.0 mgd conventional activated sludge (CAS) system constructed in 1974 and a 2.0 mgd oxidation ditch system constructed in 1987. Upgrades (Phase I) completed in 2006 at the HWWTP increased the capacity of the facility to 6.0 mgd through the construction of a new 2.0 mgd CAS system.

Continued residential and commercial growth has prompted the County to plan for additional treatment capacity, above the 6.0 mgd that is now available with the above-mentioned construction (Phase I). Conventional expansion of the facility is constrained by limited land for any new treatment facilities. The existing oxidation ditch system is outdated and nearing the end of its useful life. Since little space is available at the site, future expansion requires acquisition of additional land or the re-use of existing tanks.

Accordingly, the County conducted a pilot study from November 2004 to May 2005, which was cost-shared by the New York State Energy and Research Development Authority (NYSERDA), to establish the feasibility of incorporating membrane bioreactor (MBR) technology as a means of upgrading the existing oxidation ditches and substantially increasing the capacity of the oxidation ditches. The pilot study demonstrated the viability of MBR technology for use at the HWWTP. Data collected during this pilot study was used to estimate the maximum treatment capacity that can be provided within the existing oxidation ditch footprint through the use of MBRs. These data were also used to compare this expansion alternative with a more conventional treatment technology for expansion of the facility. A computer program was used to simulate the two alternatives, estimate the potential to increase the facility's capacity, and predict effluent quality based on existing and anticipated permit limits.

Based on the results of the pilot study, modeling, and conceptual design undertaken as part of the study, it was determined that expansion of the existing facility was feasible by incorporating a MBR treatment system into the existing oxidation ditches. By retrofitting the oxidation ditches with new MBR equipment, upgrading the existing facility headworks and chlorine contact tanks, and performing other ancillary upgrades, the MBR train would have a treatment capacity of 5.0 mgd, an increase of 3.0 mgd compared to the existing oxidation ditch system.

This type of expansion would increase the daily energy use at the facility by 2,200 kwh. (Note: This is a worse case estimate assuming the system will never be gravity operated. The feasibility of this mode of operation must be verified through hydraulic analysis, which was outside the scope of this project. Should gravity operation be feasible, power consumption would decrease by 40 hp.)

As a comparison to incorporating MBR technology, a new conventional activated sludge treatment system (step-feed aeration) was evaluated to replace the oxidation ditches. Under this alternative, the existing oxidation ditches were converted to a suspended growth activated sludge treatment system with diffused aeration and internal recycles necessary to achieve the required effluent limits and a similar 3.0 mgd capacity increase. In addition, this alternative included the construction of new secondary clarifiers and sand filters, as well as upgrades of the existing facility headworks, sand filters, chlorine contact tanks, and other ancillary facilities. This type of expansion would decrease the daily energy use at the facility by 1,029 kwh.

The lower energy requirements of the step-feed system are the result of the inherent inefficiencies of the facility's existing aerators and turbines. These would be replaced by a high-efficiency fine bubble aeration system should the facility be expanded by conventional means. (Note: The ability to increase the capacity of the HWWTP by conventional means is contingent on increasing the depth of the existing oxidation ditches. The feasibility of doing this would have to be verified through structural and geotechnical analyses, which were outside of the scope of this project. Results of such analyses may show that construction of deeper tanks is not feasible or that doing so would be cost prohibitive.)

From an environmental perspective, the MBR system out performed the step-feed system for the majority of effluent parameters modeled. It appears that the MBR system would be capable of producing a high-quality effluent without the use of separate clarifiers or filters, which would be required with the step-feed aeration system. Additionally, based on the results of modeling, the effluent from the MBR system would require less chlorine to disinfect and less coagulant to achieve phosphorus removal than that produced by the step-feed system.

Based on the necessary improvements required to increase the capacity of the existing oxidation treatment system, planning level capital costs, and additional annual operating costs, the present value based on a 20-year life cycle were estimated for each of the two alternatives.

	Planning Level Capital Cost	***Additional Annual Operating Cost***	***Present Value (20-year life cycle)***
Membrane Bioreactor (MBR) Expanded Facility	$24,950,000	$369,100	$29,590,000
Conventional Activated Sludge Expanded Facility	$34,311,000	$167,000	$36,410,000

Both the conceptual MBR and step-feed systems are capable of treating the required average flow while meeting the preliminary future permit limits. However, based on the results of this project, the MBR system expansion option appears to be the most appropriate approach for several reasons including superior effluent quality, reduced chemical requirements, lower capital costs, and fewer constructability issues.

Section 1

PROJECT DESCRIPTION

This report presents the results of the membrane bioreactor (MBR) pilot unit study, modeling and conceptual design of a full-size treatment system at the Harriman Wastewater Treatment Plant (HWWTP) in Harriman, NY, which is operated by the Orange County Department of Environmental Facilities and Services (OCDEFS). Co-funding for the pilot study was provided under a grant from the New York State Energy and Research Development Authority (NYSERDA) under Program Opportunity Notice (PON) #786. OCDEFS provided operational assistance and laboratory analysis during the pilot study.

BACKGROUND

The HWWTP currently consists of two treatment trains – a conventional activated sludge treatment system and an oxidation ditch treatment system. The conventional activated sludge treatment system (Train 2), constructed in 1974, was designed for an average daily flow of 2.0 mgd. The oxidation ditch treatment system (Train 1), constructed in 1987, was also designed for an average daily flow of 2.0 mgd. After demonstrating that the facility could treat flows in excess of 4.0 mgd, the New York State Department of Environmental Conservation (NYSDEC) temporarily increased the facility's permitted capacity to 4.5 mgd. The facility is currently being upgraded (Phase I) with a new, 2.0 mgd conventional activated sludge treatment train (Train 3). Upon construction completion, the design flow rate of the facility will be 6.0 mgd. Continued residential and commercial growth within the sewer district has prompted the County to plan beyond the scope of Phase I for additional wastewater treatment capacity under a second upgrade (Phase II).

The facility serves the Orange County Sewer District No. 1 (OCSD No. 1) and the Moodna Basin Southern Region (MBSR). Member communities in OCSD No. 1 include the Villages of Harriman, Monroe, and Kiryas Joel, and a portion of the Town of Monroe. The Towns of Blooming Grove, Chester, and Woodbury, the Village of Chester, and part of the Town of Monroe are members of the MBSR Joint Sewerage Board. In addition, the facility accepts and processes liquid septage trucked by private haulers.

The existing wastewater treatment facility consists of preliminary, primary, and secondary treatment, followed by disinfection, as well as sludge thickening, and dewatering. Upon entering the facility, raw wastewater is combined with filter backwash water. The flow then passes through a preliminary treatment facility that provides screening and grit removal. The flow is then split between the original 2.0 mgd conventional activated sludge system and the 2.0 mgd oxidation ditch treatment system. In order to achieve a high quality effluent, flow from the conventional activated sludge system and the oxidation ditches is combined and directed to final polishing sand filters. The flow is then conveyed to a chlorine contact tank where chlorine gas and sulfur dioxide gas is added for disinfection and dechlorination. Finally, the flow is discharged through two outfalls (Outfall 001 and 002) to the Ramapo River. The sludge generated from the

HWWTP is thickened by gravity, dewatered by belt filter presses, and composted with the grit. The screenings removed in the preliminary treatment stage are land-filled. The new 2.0 mgd treatment train being constructed at the facility (as part of the Phase I upgrade) will consist of primary settling tanks, aeration tanks, secondary clarifiers, and sand filters. A new chlorine contact tank and chemical storage facility are also being constructed. A new flow distribution box will evenly distribute the influent flow to the three separate treatment trains. The existing treatment trains will continue to operate as described above.

Historical Data Analysis

Operating data from 2002 and 2003 was reviewed to establish design criteria for the project. Table 1-1 presents a summary of the influent wastewater characteristics, based on the available data.

Table 1-1
Influent Wastewater Characteristics

Parameter	***Average Month***	***Maximum Month***	***Maximum Day***
Flow, mgd	4.5	7.1	13.4
Biological Oxygen Demand (BOD), mg/L	135	199	241
Total Suspended Solids (TSS), mg/L	227	509	568
Ammonia (NH_3), mg/L	17.7	21.8	30.0
Temperature, ^oC	17.0	23.0	25.0
pH	7.4	7.7	8.3

The maximum instantaneous flow recorded during the two years was 20.0 mgd. Large amounts of precipitation are typically correlated with increased influent flow; indicating that the plant is influenced by infiltration and inflow. The average influent BOD/TSS ratio is 0.78.

Table 1-2 presents a summary of the effluent wastewater characteristics, based on the available data.

Table 1-2
Effluent Wastewater Characteristics

Parameter	***Average Month***	***Maximum Month***	***Maximum Day***
BOD, mg/L	6.9	16.3	40.4
TSS, mg/L	8.0	20.2	59.0
NH_3, mg/L	2.7	5.7	10.5
TKN, mg/L	4.3	12.9	42.0
UOD, mg/L	29.9	64.2	117
Temperature, ^oC	17	23.6	25.6
pH	7.3	7.7	8.3

The UOD concentration is calculated by: UOD (mg/L) = 4.5 * TKN (mg/L) + 1.5 * BOD5 (mg/L). The effluent wastewater temperature was equal to or greater than the maximum permit limit of 21.1 ^{o}C (70 ^{o}F) for 22.3% of the days in 2002 and 2003.

Solids Inventory. Table 1-3 presents the average mixed liquor suspended solids (MLSS) concentration, solids volume index (SVI), and aerobic solids retention time (SRT) for the three aeration systems. SVI is calculated by dividing the MLSS concentration by the settled sludge volume for each aeration system. SVI values are based on settled sludge volumes after 60 minutes; the standard 30 minute settled sludge volumes were not available.

Table 1-3

Average Solids Summary

Treatment System	*MLSS, mg/L*	*SVI, mL/g*	*SRT, days*
Conventional Aeration Tanks	1,860	95	12.6
Near Oxidation Ditch	1,866	108	27.8
Far Oxidation Ditch	1,490	116	30.4
Average, All Systems	1,729	106	22.4

The SRT for each aeration system was calculated with available MLSS and effluent TSS concentrations and average wasting rates. The SRT is calculated by dividing the mass under air (solids mass in the aeration tank or oxidation ditch) by the sum of the effluent solids load (lb/d) and the aeration solids (MLSS) load (lb/d).

Net Sludge Yield. The average amount of dewatered sludge removed from the facility is 37,000 lb/d (18.5 wet tons/d). The dewatered sludge includes primary sludge and waste activated sludge (WAS) from the three aeration systems. The WAS concentration is approximately twice the concentration of the mixed liquor for each aeration system. With this WAS concentration assumption, the average net sludge yield is 0.52 lb TSS per lb of BOD removed. Table 1-4 presents the average volumes of sludge wasted per day.

Table 1-4

Average Sludge Wasted

Treatment System	*Volume, gpd*
Conventional Aeration Tanks	25,000
Near Oxidation Ditch	20,000
Far Oxidation Ditch	20,000
Total, All Systems	65,000

Power Consumption Summary. Based on the existing equipment at the facility, the load demand of the conventional aeration tanks is 278 kW and it is estimated that they consume 137,500 kWh during maximum month conditions. The monthly power consumption assumes that the aeration blowers and RAS pumps are operating at full power, 24 hours a day. The three blowers (75 hp each), two return activated sludge (RAS) pumps (15 hp each), and three waste activated sludge (WAS) pumps (7.5 hp each) were included in this estimate. Likewise, the load demand of the oxidation ditches is 735 kW and it is estimated that they consume 392,000 kWh during maximum month conditions. The monthly power consumption assumes that the draft tube aerators, aeration blowers, and RAS/WAS pumps are operating at full power, 24 hours a day. The four draft tube aerators (125 hp each), two aeration blowers (100 hp each), and two RAS/WAS pumps (15 hp each) were included in this estimate. Meter readings for individual equipment or processes were not available. The specific power consumption for the facility is 3.56 kWh per thousand gallons (kgal).

EQUIPMENT EVALUATION – MEMBRANE BIOREACTOR

Membrane bioreactors (MBRs) are a variation of the activated sludge process that uses low-pressure size exclusion membranes in place of gravity clarifiers to separate suspended biomass from treated effluent. Two general categories of membranes are used in MBRs – microfiltration (MF) and ultrafiltration (UF). MF membranes are any semi-permeable membrane with pore sizes between 0.1 and 1.0 micrometers (micron, µm) while UF membranes have pore sizes between 0.002 and 0.01 µm. As a result of the small pore sizes, MF membranes act as a nearly complete barrier to the passage of suspended solids, bacteria, and protozoan cysts. Because of their smaller pore sizes, UF membranes are also a barrier to viruses. MF and UF membranes also remove phosphorus and metals in proportion to their content in the solids.

The MBR process is an innovative and rapidly developing technology that offers many potential advantages in comparison to conventional activated sludge treatment processes for wastewater treatment. The major advantages of the MBR system for wastewater treatment are high oxygen utilization, high rate efficiency nutrient removal, small footprint, feed forward control of oxygen demand, modular/retrofit, complete solids removal, and lower sludge production. The major disadvantages of the MBR system for wastewater treatment are membrane fouling, fine screens required, high capital cost, and complex process.

The actual membrane material is the basic building block of the MBR technology and there is a range of commercially available membrane materials and configurations that can be used. The final selection of membrane type and configuration depends on the treatment objective: surface water disposal, irrigation water, plant water, or reuse.

There are two major MBR configurations: external (recirculated) and submerged (integrated). External MBRs use pumps to re-circulate mixed liquor from the aeration tanks through the membranes and back to the aeration tank. The driving force in an external MBR is the pressure differential created by the pumps across the membrane surface. In a submerged membrane, pressure differential is created by gravity or by using pumps to create a vacuum on the permeate (effluent) side of the membrane. First generation submerged MBR designs placed the membranes directly in the aeration tanks. Experience shows that placing the membranes in separate tanks after the aeration tanks can facilitate maintenance. All MBR processes require the use of coarse-bubble aeration under the membranes to scour the membrane surface to reduce fouling. Submerged MBR systems are more economical for large municipal wastewater treatment plants that have limited developable land. The MBR process provides the smallest footprint of any commonly used biological process.

The following submerged MBR manufacturers were evaluated: Aqua-Aerobics Systems/Pall, Enviroquip/Kubota, Ionics/Mitsubishi, USFilter, and Zenon Environmental Systems. A brief description of each system is provided, and Appendix A presents a tabular comparison of the major design features.

Aqua-Aerobics Systems/Pall. The Pall Corporation and Aqua-Aerobics system consists of a bioreactor and a series of phases that promote biological treatment. Separate mixing and aeration devices allow the contents of the reactor to go through alternating aerobic and anoxic periods. Following settling, supernatant from the reactor is transferred from the first barrier to the cloth media filter. Inlet water passes through the 10-μm cloth media. Filtered water is collected in the center tube where it is directed to a supply channel that feeds the external microfiltration membrane system. Flow enters the membrane module where low positive pressure enables the fluid to permeate the membrane, excluding fine particulates down to 0.1 μm in size. Permeate from the membranes is taken directly from the top of the module. The maximum pretreatment fine screen size recommended is 2 mm.

Enviroquip/Kubota. Enviroquip/Kubota's MBR system incorporates flat-plate microfiltration membranes into the process treatment zones to obtain high design flux rates, typically 15 gallons/ft^2/day (gfd). The peak design flux rate can be as high as 35 gfd. The diffuser case houses a coarse-bubble diffuser manifold that distributes air for membrane cleaning. The permeate port at the top of each cartridge is connected to a manifold with a transparent tube. The system can be gravity operated or can use low-suction head permeate pumps to drive the filtration process. The flat-plate membranes can tolerate larger wastewater solids and therefore the maximum pretreatment fine screen size is 3 mm. In addition to the constant coarse-bubbled diffused air to prevent membrane fouling, maintenance cleaning of the membranes is accomplished by relaxing the membranes for one minute during every 10 minutes of operation.

Ionics/Mitsubishi Rayon Corporation. The Ionics/Mitsubishi MBR system uses a biological reaction process with a microfiltration membrane as the final filtration barrier. The system uses hollow fiber membranes in a horizontal configuration and the membranes can be stacked three-high in certain applications. The typical design flux rate is less than 7 gfd and peak flows are accommodated with an equalization tank. Coarse-bubbled diffused air is used to scour the membranes and drive the biological treatment process. A vacuum on the membranes is used to extract the effluent. The maximum pretreatment fine screen size recommended is 2 mm. In lieu of a backwash step, the membranes are allowed to relax for two minutes during every 12 minutes of operation, helping to decrease membrane fouling.

USFilter. The USFilter Immersed MBR system is a single-sludge activated treatment process. The mixing system transports dissolved air and mixed liquor uniformly around and across the microfiltration modules. The membrane modules have been adapted to withstand the rigors of continuous immersion in activated sludge. The typical design flux rate is less than 15 gfd and the peak flux rate can be as high as 30 gfd. The membrane system is placed in an independent tank that draws from aeration tanks. Fluid transfer management is accomplished with a unique “Fluid Renewal System” that provides both fluid transfer, in the form of mixed liquor, and air scour energy, through a two-phase jet. The jet introduces fluid consistently to all membranes in the system by dividing the membrane module into narrow fiber bundles that allow air and fluid to move up and between the individual membrane fibers. This prevents liquid viscosity from increasing and fouling the membrane surface. The maximum pretreatment fine screen size recommended is 2 mm. Membrane maintenance is performed for one minute during every 15 minutes of operation by either backpulsing or relaxing the membranes.

Zenon. Zenon’s MBR system (ZeeWeed® 500) draws water through the membrane fibers in an “outside-in” flow path under a slight vacuum. The ZeeWeed® membrane has been approved by the National Sanitation Foundation (NSF) as an ultrafilter and the outside surface is a highly water-permeable polymeric membrane that can remove biological contaminants, particulates, and colloidal species from water. The typical design flux rate is less than 15 gfd and the peak flux rate can be as high as 25 gfd. The ZeeWeed® 500 membrane module consists of hundreds of membrane fibers oriented vertically between two headers. The shell-less hollow fibers are slightly longer than the distance between the top and bottom headers to allow movement when aerated. The air from coarse bubble diffusers moves through the fibers; scouring and removing solids from the membrane surface. Maintenance cleaning is accomplished by backpulsing and relaxing the membranes every hour. Even with air scouring and backpulsing, the system requires the use of a 2 mm fine screen to avoid stringy material from being caught up on the membrane fibers.

EQUIPMENT EVALUATION – FINE SCREEN

Fine screens used in wastewater applications are typically rotary drum screens, static wedge-wire screens, perforated plate screens, step screens, and band screens. The opening widths range in size from 0.2 to 6 mm and cleaning often occurs with brushes or a water spray system. Rotary drum screens are typically made of stainless steel or nonferrous wire mesh screens with 0.25 to 6.35 mm openings. These screens are appropriate for small plants or where headloss is not an issue. Static wedge-wire screens contain small stainless steel wedge-shaped bars, with openings typically 0.25 to 1.5 mm wide. The static screens can have headlosses up to 7 feet and are typically cleaned 1 to 2 times per day with high pressure hot water, steam, or degreaser. Perforated plate screens are typically attached to a drive chain and the screens are rotated so they can be cleaned. The screens are kept clean by rake bars that extend over the full width of the screen in combination with the screen's installation angle. At the upper turning point, the perforated plates are continuously cleaned by a fast rotating brush. Cleaning is supported by an integrated spray bar and the screenings are discharged into a subsequent wash press. Step screens consist of a separation screen made up of movable and fixed step-like lamellae (thin, flat layers). The moveable lamellae execute a self-cleaning rotary motion over the screening surface according to the countercurrent principle. This eliminates the need for cleaning brushes, scrapers or additional flushing mechanisms. The solid matter is retained by the step-like separation screen. Intermittent operation builds up a screenings mat which performs the principal filtration so that smaller solids are held back. A band screen has openings as small as 2 mm and has an endless band of screening panels through which the water passes, from the outside inwards. Debris collected on the mesh panels is raised to deck level and removed by back washing. Main chains, supported by two sprockets above deck, carry the screening band.

HARRIMAN MBR PILOT UNIT

The operating conditions, system characteristics, and experience in New York State were compared for each of the five manufacturers. Of the systems evaluated, Enviroquip/Kubota was the only manufacturer that had a flat-plate membrane system; instead of a hollow fiber system. The flat plate membranes have the largest pore size of the systems evaluated and the system can treat wastewater effectively to meet effluent permits. The larger pore size allows the system to operate by gravity and reduces the fouling frequency. When specifically compared to hollow fiber membranes, flat plates have a reduced cleaning frequency, do not require back flushing, and can operate by gravity; therefore conceivably requiring less energy to operate.

USFilter already has several large MBRs in operation, has established their system in the marketplace, and data is widely available. Zenon has recently been pilot tested in the State and this current project does not aim to reproduce existing research or data. Although the Ionics/Mitsubishi Rayon MBR system has a unique membrane orientation (horizontal) and has not been pilot tested in New York State; it uses hollow fiber membranes. The Ionics/Mitsubishi Rayon, Aqua-Aerobics/Pall, USFilter, and Zenon MBR systems all require pumps to extract the effluent (permeate) from the system; while the Enviroquip/Kubota MBR system can be operated by gravity. There have been no pilot tests of the Enviroquip/Kubota MBR at municipal wastewater treatment plants in New York State. There is currently a pilot test for a treatment plant that is heavily influenced by industrial activity. Due to the limited extent of that study, it does not appear that there will be a significant data set established or an evaluation report that would include an energy analysis. Additionally, the Enviroquip/Kubota MBR system reports a peak flux that translates into a maximum day flow peaking factor of 2.33; highest of the systems evaluated.

Section 2

PILOT UNIT TESTING PROGRAM AND RESULTS

PILOT STUDY OBJECTIVES

The main objective of the pilot study was to gather data that could be used to assess the feasibility, effectiveness, and cost of implementing a MBR treatment system at the HWWTP. Key considerations included the ability of the MBR pilot unit to meet effluent quality standards and assessment of power consumption. In addition, the pilot study documented the performance of the MBR system under varied conditions including cold and wet-weather flow periods. Another goal of the study was to demonstrate the ability of the MBR process to meet expected future permit limits on ammonia and nitrate. Goals for nitrogen removal were set at less than 2.0 mg/L ammonia and less than 8 to 10 mg/L nitrate. The pilot study was conducted at the HWWTP using an Enviroquip/Kubota MBR pilot unit from the fall of 2004 to the spring of 2005.

Current and Future Discharge Permit Limits

Table 2-1 summarizes the facility's current and potential future NPDES permit effluent limits. These limits are anticipated based on permits being issued in New Jersey watersheds that are downstream of the facility, permits being issued in other New York watersheds, and classification of the Ramapo River.

MBR Pilot Unit Description

The pilot unit used consisted of an anoxic zone and an aerobic/MBR zone. The selected flow range was 0 to 15.0 gpm, with an average flow of 6.0 gpm. The recycle flow was approximately 500% of average daily influent flow, pumped from the anoxic zone into the aerobic/MBR zone with a ½-hp submersible pump. The internal recycle flow was also approximately 500% of the average influent flow, gravity-flow from the MBR zone to the anoxic zone. Fine-bubble diffused aeration was used in the aerobic/MBR zone to provide oxygen for the treatment process. A positive displacement blower was used for the fine-bubble aeration and had a capacity of 40 scfm. A ½-hp submersible pump was used for mixing the aerobic/MBR zone.

Location and Influent Flow. The pilot unit was located next to the existing headworks building at the HWWTP. The influent for the pilot unit was pumped by a constant speed pump installed in the headworks channel. Upstream of this location, the wastewater was screened (coarse screens) and degritted (vortex) in the preliminary treatment facility. This influent also included backwash water from the sand filters. A constant-speed pump was installed in the headworks channel. The flow rate through the pilot unit was controlled with a motorized valve on the effluent pipe. The pilot unit operated by gravity (without the use of permeate pumps) for the majority of the study. The pilot unit influent flow was sent through an integral 3-mm fine screen before entering the anoxic zone.

Table 2-1

Current and Future NPDES Permit Effluent Limits

Effluent Characteristic	***Current Effluent Limits***		***Future Effluent Limits***	
	Outfall 001	***Outfall 002***	***Outfall 001***	***Outfall 002***
Flow Monthly Average, mgd	6.0	2.0	**9.0**	2.0
Biological Oxygen Demand - Monthly Average, mg/L	Monitor	5.0	Monitor	5.0
Biological Oxygen Demand - Daily Maximum, mg/L	5.0	Monitor	5.0	Monitor
Ultimate Oxygen Demand - Monthly Average, mg/L	Monitor	Monitor	Monitor	Monitor
Ultimate Oxygen Demand - Daily Maximum, mg/L	50	55	**45**	55
Total Suspended Solids Monthly Average, Jun – Oct, mg/L	Monitor	Monitor	Monitor	Monitor
Total Suspended Solids Monthly Average, Nov – May, mg/L	30	30	**20**	30
Total Suspended Solids 7-day Average, Nov – May, mg/L	45	45	**30**	45
Total Suspended Solids Daily Maximum, Jun – Oct, mg/L	10	10	10	10
Dissolved Oxygen – Maximum Day, mg/L	7.0	7.0	7.0	7.0
Ammonia Nitrogen - Monthly Average June – October, mg/L	1.3	1.1	**1.2**	1.1
Ammonia Nitrogen - Monthly Average November – May, mg/L	2.2	6.8	2.2	6.8
Total Kjeldahl Nitrogen Monthly Average, mg/L	Monitor	Monitor	Monitor	Monitor
Nitrate Monthly Average, mg/L	N/A	N/A	**10**	**10**
Total Phosphorus Monthly Average, mg/L	N/A	N/A	**0.5**	**0.5**
Temperature - Daily Maximum, ^{o}C	Monitor	21.1	Monitor	21.1
pH (Average Month, Range)	6.5 – 8.5	6.5 – 8.5	6.5 – 8.5	6.5 – 8.5
Fecal Coliform - 30-day Average, No/100 ml	200	200	200	200
Fecal Coliform - 7-day Average, No/100 ml	400	400	400	400
Total Copper - Daily Maximum, lb/d	1.0	1.0	**1.4**	**1.4**
Total Zinc - Daily Maximum, lb/d	8.4	8.4	**12.0**	**12.0**

Anoxic and Aerobic/MBR Zones. Wastewater entered the anoxic zone from the fine screen that was mounted on top of the pilot unit. The anoxic zone contained two pumps; a ½-hp mixing pump and a ½-hp recycle pump. The mixing pump was required in order to maintain an even distribution of solids in the anoxic zone. Wastewater was pumped via a ½-hp submersible pump into the Aerobic/MBR zone at a constant rate from the anoxic zone. A submerged membrane case in the zone contained 75 flat-plate Kubota membranes with a total surface area of 645 square feet. The nominal porosity of the flat-plate membrane was 0.4 μm with an estimated effective porosity of 0.1 μm. A 40 standard cubic feet per minute (SCFM), 2-hp positive displacement blower was integral to the pilot unit and provided process and scour air.

Effluent Flow. Wastewater passing through the membranes exited the pilot unit through a 2-inch diameter pipe. The effluent was discharged into the HWWTP's headworks channel. The flow rate was controlled by a PLC and was continuously monitored and recorded.

INVESTIGATION PROGRAM

Pilot Unit Start-up

The project began with a start-up period to allow the pilot unit to reach steady-state operating conditions and to finalize operating procedures and sample collection methods. During this time, the pilot unit was seeded with MLSS from the HWWTP sludge hopper. Grab samples from the MBR/aerobic zone were collected and tested for MLSS concentration by the operators during start-up. Once the target MLSS concentration of 8,000 mg/L was reached, activated sludge was wasted daily to maintain the target solids retention time (SRT) of 5 days. The recycle flow rate was approximately 500% of influent flow rate.

MBR Process with Varying SRTs

The average daily flow through the pilot unit was set at 6.0 gallons per minute (gpm), which is an average daily flux through the membranes of 14.7 gallons per square foot per day (gfd). The recycle rate was maintained at approximately 30 gpm. The initial SRT of 5 days was maintained with a waste activated sludge (WAS) rate of approximately 600 gallons per day (gpd). Sludge was wasted each day from the anoxic zone. The SRT was increased by decreasing the WAS rate. The WAS rates associated with the 5, 10, 15, and 20 day SRTs were 600, 260, 222, and 165 gpd, respectively. SRT is calculated from a mass balance of solids in the activated sludge system and is defined by the total mass in the system divided by the mass leaving the system. For each SRT, the system was stressed by increasing the flow rate through the pilot unit for 24 hours at the maximum daily flow rate (12.0 gpm). Additionally, the system was stressed by increasing the flow rate through the pilot unit for six hours at the peak hour flow rate (15.0 gpm).

Disinfected Effluent. Effluent samples were disinfected according to Ten States Standards.

Sludge Dewatering. WAS samples were analyzed for sludge settling and dewatering characteristics. The 30-minute settled sludge volume was measured three times per week. Time-to-filter tests were run on sludge samples from the anoxic tank at the end of the SRT testing periods and maximum day flux events.

Data Recording, Lab Analyses, and QA/QC Procedures

A Pilot Unit Operating Protocol and Safety Plan was prepared to provide guidelines for data collection, parameters to be analyzed, and Quality Analysis/Quality Control (QA/QC) procedures. This section provides an overview of the data collection process.

A daily log sheet was created to standardize collection of operating data. Daily monitoring of process parameters helped to maintain operational stability. Operational parameters recorded on a daily basis included flow rates, visual appearance of the two process zones, temperature, dissolved oxygen, and volume of sludge wasted. A sampling program was developed to monitor system operation and evaluate pilot unit performance as related to the pilot study goals. Influent and effluent composite samples were collected five days per week. Grab samples were collected from the anoxic and MBR/aerobic zones as required. Appendix B presents the parameters analyzed for each zone and the typical collection frequency.

Samples collected as part of the sampling program were processed by a combination of the County laboratory and independent certified laboratories. The results obtained were used to monitor system operation and evaluate pilot unit performance. The County laboratory and operation staff provided support throughout pilot unit operation by performing sample analyses and preparing samples for shipment to the independent laboratories. Samples were sent out each weekday to a certified independent laboratory. Orange County Laboratories (OCL) performed the independent laboratory analyses. The protocol for this project was consistent with recommendations made in the Pilot Unit Operating Protocol and Safety Plan.

PROCESS RESULTS AND TREATMENT PERFORMANCE SUMMARY

Investigations

After the pilot unit was delivered and installation was complete, the start-up period commenced. After one month of start-up, the 5-day solids retention time (SRT) testing began. The subsequent SRT testing (10-, 15-, and 20-day) required, on average, three weeks to build up an appropriate level of solids. Table 2-2 presents the general schedule of SRT testing with the average flow rates.

Table 2-2

General Schedule and Flow Rates

Phase	*Start Date*	*End Date*	*Average Flow Rate, gpm*
Start-up	October 22, 2004	November 22, 2004	3.0
5-day SRT	November 23, 2004	December 1, 2004	5.0
10-day SRT	December 2, 2004	January 31, 2005	5.0
15-day SRT	February 1, 2005	April 4, 2005	5.9
20-day SRT	April 5, 2005	May 14, 2005	5.8
5-day SRT, repeat	May 15, 2005	May 27, 2005	5.8

Start-up and General Operation

The pilot unit was delivered and unloaded at the site on September 22, 2004. Complications with the original influent feed and recycle pumps resulted in the need to acquire new pumps. The new pumps were installed on September 28, 2004. The PLC wiring was also not adequate and changes were made in the field by Enviroquip representatives.

Basic system checks and clean water testing were performed October 18 - 20, 2004. The unit was seeded with approximately 2,000 gallons of 3,000 mg/L of MLSS on October 20, 2004 from the main plant sludge hopper. The start-up period ended on November 22, 2004 when the MLSS concentration reached approximately 7,500 mg/L. This MLSS concentration signified a stabilized system.

The 5-day SRT testing began on November 23, 2004 by wasting 600 gallons per day from the pilot unit. Due to the low MLSS concentration and the short SRT, the pilot unit only operated in this mode for one week. After 5 days, the volume of effluent leaving the pilot unit (by gravity) was severely reduced due to membrane fouling thought to be caused by the “young” microorganisms sticking to the membranes. This fouling result was expected; however, running the unit by gravity expedited the timeframe.

The pilot unit was chemically cleaned on December 1, 2004 at the conclusion of the 5-day SRT test and was then set to build up the MLSS concentration in preparation for the 10-day SRT testing. The MBR unit reached the 10-day SRT MLSS concentration goal of approximately 4,900 mg/L on January 5, 2005. Wasting approximately 280 gallons per day, to maintain this SRT, started on January 6, 2005. Peak hour tests were performed on January 11 and January 13, 2005. The maximum day flux testing was performed on January 26 and January 28, 2005 by raising the effluent flow rate to 12 gpm (and the recycle rate to 50 gpm) for a period of 24 hours. During the second max day flux testing, the high transmembrane pressure (TMP) alarm was reached, signifying that the unit may have become fouled. The flux testing was halted and the flow rates were set at the intermediate conditions (effluent: 3.0 gpm, recycle: 20 gpm) to build up solids for the next SRT test phase.

On February 17, 2005 and February 25, 2005 approximately 1,200 gallons of sludge was transferred from the main plant into the MBR unit, increasing the MLSS concentration to 4,652 mg/L. The MLSS concentration measured on February 28, 2005 was 5,942 mg/L and average day flow testing under the 15-day SRT began on March 2, 2005. Sludge dewatering tests were performed on March 17, 2005. Maximum day flow testing was performed on March 21 and March 23, 2005. Peak hour flow testing was performed on March 29 and March 30, 2005.

On April 7, 2005 approximately 1,500 gallons of main plant sludge was added to the pilot unit to jump-start the MLSS concentration for the 20-day SRT testing. The MLSS concentration measured on April 13, 2005 was 4,259 mg/L and the average day testing under the 20-day SRT commenced on April 14, 2005. Peak hour flow testing was performed on May 3 and May 4, 2005. Maximum day flow testing was performed on May 9 and May 11, 2005. Sludge dewatering tests were performed on May 11, 2005. The 20-day SRT testing was completed on May 15, 2005. Starting on May 16, 2005, an additional 5-day SRT testing was performed for nine days. During this time, the unit began to foul only after the flow rate was raised to 12 gpm (maximum day conditions).

Chemical cleaning was performed twice during the pilot study. Overall, the cleaning procedure was not complicated and the pilot unit seemed to respond as expected (low TMPs and no restriction on gravity effluent flow) at the conclusion of cleaning. The unit could not discharge effluent during the 24 hour cleaning procedure. Due to the duration of the pilot study an evaluation of chemical cleaning frequency could not be made. The manufacturer states that typical cleaning frequency for membranes used in a municipal wastewater installation is every 6 months.

Flow and Flux

The average flow set-point through the pilot unit was 5.7 gpm. In accordance with the manufacturer's recommendation, the pilot unit was in a relax-mode for one minute out of every ten. Since no flow exits the unit during this time, the effective flow rate is lower than the set-point; 4.9 gpm. During the maximum day and peak hour flow tests, the flow rate set-point was increased to 12 and 15 gpm, respectively. The recycle flow rate was, on average, 27 gpm. Flux is defined as the amount of fluid that passes through one unit of effective membrane area. The typical units are gallons per square foot per day (gfd). The recommended maximum flux for the Enviroquip/Kubota pilot unit was 33.5 gfd, which corresponds with a flow rate of 15 gpm and the unit effective membrane area of 645 square feet. The average flux for the entire pilot unit study was 11.8 gfd, with a maximum of 24.1 gfd during the peak hour testing.

Transmembrane Pressure

TMP can be an indication of membrane fouling. A high TMP indicates that either the membranes are fouling or they are being stressed (i.e. peak hour or maximum day flow conditions). As expected, TMP spikes are observed during maximum day and peak hour flux testing. The average recorded TMP for the entire pilot study was 0.55 pounds per square inch (psi). The maximum and minimum observed TMPs were 3.5 and -0.20 psi, respectively, which occurred during the 10-day SRT.

Because the pilot unit was generally operated by gravity, high TMPs were not the first indicator of membrane fouling. Lack of flow in the effluent line was the primary indication of fouling. Ignoring the TMP peaks for maximum day and peak hour testing, there appears to be a slight increasing trend under average day conditions after the last chemical cleaning on January 31, 2005. While it is difficult to extract a TMP rise rate from the pilot data, some conclusions can be inferred. Monitoring TMP over long periods of time in a full-scale facility can lead to a prediction of when chemical cleaning should occur to prevent membrane fouling. Operating at the low SRTs (low MLSS concentrations) increased the fouling potential, so the pilot unit was preemptively cleaned at the beginning of the pilot study. The longest period of time that the pilot operated without chemical cleanings was 116 days (approximately four months from February 1, 2005 to the end of the pilot study on May 27, 2005).

Energy

An energy meter was installed on the pilot unit to monitor the amount of energy used by the entire system. The components monitored, as a group, were the fine screen, blower, influent pump, anoxic zone mixing pump, effluent pump, and control panel. The average power used per day was 88 kilowatt-hours (kWh). The average power used based on flow rate through the pilot unit was 15.6 kWh/gpm. The average power used based on volume treated was 0.011 kWh/gal. The average power used based on the mass of BOD removed (BOD_r) was 9.3 kWh/lb BOD_r. These averages exclude pre-SRT days when the average flow rate through the unit was only 2.7 gpm. This data is excluded because the purpose of the pre-SRT operating scenario was solely to build up the solids in the system and is not representative of actual operating conditions. For a majority of the testing phases, there did not appear to be a correlation between operating SRT and power consumption per gpm or lb BOD_r. Additionally, the air required for scouring the membranes was typically more than the air required for process control. If the influent characteristics were different, energy consumption may have varied to compensate for an influent flow with a higher oxygen demand.

Temperature, Dissolved Oxygen, pH, and Alkalinity

Temperature, dissolved oxygen (DO) concentration, pH, and alkalinity were monitored as basic operational and process parameters. The average Aerobic/MBR tank temperature was 14.3 degrees Celsius (^oC), with a low of 10^oC. The coldest influent temperatures were observed in March 2005 during the 15-day SRT testing. In most cases, the temperature in the Aerobic/MBR tank was higher than the temperature of the influent or the anoxic tank. The increase is attributed to the impact of aeration air from the positive displacement blower introduced in the aerobic/MBR tank.

The aerobic/MBR tank target DO concentration was 2.0 mg/L and the minimum airflow rate was 35 standard cubic feet per minute (scfm) for scouring the membranes. The target DO concentration in the anoxic tank was less than 0.2 mg/L. The DO in the aerobic/MBR tank was typically well above the target of 2.0 mg/L; however, scouring the membranes was a priority for the membranes and airflow was not decreased. The influent BOD, TKN, and TSS concentrations observed during the pilot study were less than the anticipated concentrations that were used to size the MBR pilot unit. Therefore, the aerobic/MBR tank and associated air supply was too large for the actual influent concentrations and process demands. The average DO concentration in the anoxic zone was 1.2 mg/L, while the aerobic/MBR tank was 8.1 mg/L. Increasing the MLSS concentration for the 20-day SRT resulted in lower DO concentrations in the anoxic tank (average: 0.86 mg/L).

The average influent and effluent pH results for the pilot study were 7.7 and 7.5, respectively. The average influent and effluent alkalinity concentrations for the pilot study were 210 and 101 mg/L, respectively. Table 2-3 presents the average influent and effluent temperature, DO concentration, pH, and alkalinity results for each of the testing phases. Generally, as the SRT was increased the effluent DO concentration decreased. The other parameters were unaffected by the changing SRT.

Total and Volatile Suspended Solids and Total Dissolved Solids

Total and volatile suspended solids (TSS and VSS) concentrations were monitored to evaluate treatment performance. Table 2-4 presents the average influent and effluent solids concentrations.

Table 2-3

Average Temperature, DO Concentration, pH, and Alkalinity

Phase	***Sample***	***Temperature, °C***	***DO, mg/L***	***pH***	***Alkalinity mg/L***
Pilot Study Average	Influent Composite	14.1	4.7	7.7	210
	Effluent Composite	14.7	8.2	7.5	101
5-day SRT	Influent Composite	16.8	2.3	7.5	172
	Effluent Composite	17.8	8.4	7.7	94
10-day SRT	Influent Composite	12.8	6.4	7.7	202
	Effluent Composite	12.3	9.2	7.5	125
15-day SRT	Influent Composite	11.5	6.3	7.7	201
	Effluent Composite	12.5	8.8	7.5	95
20-day SRT	Influent Composite	15.5	2.9	7.7	224
	Effluent Composite	17.1	7.0	7.4	95
5-day SRT, repeat	Influent Composite	17.2	1.9	7.8	237
	Effluent Composite	18.7	5.8	7.4	92

Table 2-4

Average Total and Volatile Suspended Solids Concentrations

Sample	***TSS, mg/L***	***VSS, mg/L***	***% Volatile***
Influent Composite	274	190	76%
Effluent Composite	<4.0	-	-
Percent Removal	*>98%*		

There was no target effluent TSS concentration established for the pilot study. The facility's permitted effluent TSS daily maximum limit is 10 mg/L. The detection limit for the TSS test was 4.0 mg/L and 91% of the samples were below this value during the pilot study. The average effluent TSS concentration presented in Table 2-6 takes the conservative approach of assuming that the actual TSS concentrations were

4.0 mg/L. Reduction of the TSS concentration was achieved for the purpose of the pilot study and was generally unaffected by the different SRTs and flow rates (maximum day and peak hour). The total dissolved solids (TDS) concentration is a direct measure of the organic and inorganic molecules and ions that are present in true solution in water. The average effluent TDS concentration was 777 mg/L. A high TDS concentration (500 to 1,500 mg/L) can inhibit nitrification; however, this did not appear to affect the pilot unit. It is unclear if a correlation between effluent TDS concentrations and SRT exists because TDS samples during the 5- and 10-day SRT phases were not analyzed.

Mixed Liquor Suspended Solids, Settled Sludge Volume, and Solids Volume Index

Mixed liquor suspended solids (MLSS), settled sludge volume (SSV) and solids volume index (SVI) are commonly measured on the contents of biological aeration tanks at wastewater treatment facilities. MLSS concentration was monitored to calculate the operating SRT. The SSV and the SVI were calculated to give some indication of the sludge settling characteristics. Table 2-5 presents the average MLSS concentrations in the anoxic and aerobic/MBR tanks during each SRT testing phase.

Table 2-5

Average MLSS Concentrations

Phase	*Anoxic MLSS, mg/L*	*Aerobic/MBR MLSS, mg/L*
5-day SRT	NM	4,029
10-day SRT	4,103	4,361
15-day SRT	3,429	4,576
20-day SRT	3,838	3,693
5-day SRT, repeat	1,877	2,009

NM: Not measured

Table 2-6 presents the average SSV and SVI for the aerobic/MBR tank for each SRT testing phase.

Table 2-6

Average Aerobic/MBR SSV and SVI

Phase	*SSV, mL/L*	*SVI, mL/g*
5-day SRT	793	202
10-day SRT	963	225
15-day SRT	968	220
20-day SRT	832	230
5-day SRT, repeat	293	146

The SSV values indicate that the 15-day SRT sludge was the hardest to settle (highest SSV value). The SSV value for the 20-day SRT sludge was expected to be higher than the value obtained for the 10- and 15-day SRT sludge samples because typically older sludge is harder to settle. Higher SVI values can be characteristic of poor settling sludge, and can result in higher effluent TSS concentrations in conventional treatment systems (i.e. settling tanks). There was no correlation between SVI and effluent TSS because the membranes consistently remove solids. Process failure is noted when the system is not discharging a constant flow rate (gravity operation) or when the TMP has reached a certain value (pumped operation).

Dewaterability/Filterability

The time-to-filter (TTF) test provides a quantitative measure of how readily sludge releases water. The results can be used to assist in sludge dewatering processes or to evaluate sludge conditioning aids and dosages. Only five TTF tests were completed during the pilot study (once under 15 day, three times under 20 day, and once under 5 day SRT). The average TTF a 200 mL sludge sample from the pilot unit was 22 seconds. The results for the five TTF tests may indicate that under lower SRTs, the sludge takes longer to filter. However, conclusive results of the TTF tests were not possible due to the limited number of completed tests and the variability of the air flow used to filter (therefore affecting the recorded times).

Yield

Yield computations were based on the mass of TSS per mass of BOD removed (BOD_r). The 10-day TSS and BOD_r averages were used to calculate the yield. The average yield for the pilot study was 0.33 lb/lb. These results are not consistent with the main plant historical net yield of 0.8 lb TSS/lb BOD_r, which was assumed during facilities and pilot study planning. However, the pilot unit was a 'young' mixed liquor system and the conditions were constantly changing. The average yields for the four different operating scenarios (5, 10, 15, and 20 day SRT) were 0.66, 0.32, 0.20, and 0.12 lb/lb, respectively. These averages show an overall trend of decreasing yield with increasing SRT; indicating that sludge production would also decrease with increasing SRT. The lower yield values justified re-seeding the pilot unit several times during the study to boost the MLSS concentration to the next desired level.

Biochemical and Chemical Oxygen Demand

The 5-day biochemical oxygen demand (BOD_5) is the most widely used parameter of organic pollution. The BOD_5 test results can be used to determine the approximate quantity of oxygen that will be required to biologically stabilize the organic matter, to determine the size of wastewater treatment facilities, to measure the efficiency of some treatment processes, and to determine compliance with wastewater discharge permits. The chemical oxygen demand (COD) test is also used to measure the content of organic matter of wastewater. The oxygen equivalent of the organic matter that can be oxidized is measured by using a strong chemical oxidizing agent in an acidic medium. The COD of a waste is, in general, higher than the BOD_5 because more compounds can be chemically oxidized than can be biologically oxidized.

COD and BOD_5 concentrations were measured on influent and effluent composite samples. The average influent and effluent COD concentrations were 500 and 21 mg/L, respectively, which indicate that the process was operating sufficiently to remove the COD (95% removal). The average influent and effluent

BOD_5 concentrations were 200 and 3.4 mg/L, respectively, which also indicate that the process was operating sufficiently to remove the BOD_5 (98% removal). The maximum day and peak hour testing did not have a measurable effect on the effluent COD or BOD_5 concentrations, nor did the different SRTs.

Total and Dissolved Organic Carbon

Other means for measuring the organic matter present in water are the total and dissolved organic carbon (TOC and DOC) tests. The TOC and DOC concentrations were analyzed approximately once a week on the effluent composite samples. The average effluent TOC and DOC concentrations were 6.1 and 5.5 mg/L, respectively. These averages indicate that the majority (90%) of the organic carbon in the effluent was dissolved and therefore not associated with the solids. Maximum day and peak hour flux testing did not affect the effluent TOC and DOC concentrations. These results were expected due to the solids removal efficiency of the membranes.

Nitrogen

Nitrogen removal was important throughout the pilot study. Elements in nitrogen are essential to the growth of protista and plants. The control of algal growths in receiving waters is necessary to protect beneficial uses (i.e. recreational, drinking water sources, etc.). Total nitrogen is comprised of organic nitrogen, ammonia, nitrite, and nitrate. TKN is the sum of the ammonia (NH_3-N) and organic nitrogen. The average influent TKN concentration was 28 mg/L and the average effluent concentration was 2.5 mg/L; resulting in an average removal of 93%. Only a minimal amount of TKN breakthrough was observed during the 20-day SRT maximum day flux testing. The concentration of NH_3-N in the effluent was typically below the effluent permit level goal of 1.1 mg/L. The majority of the influent nitrogen was NH_3-N and organic nitrogen. Table 2-7 presents the average influent and effluent TKN and ammonia concentrations for the different testing phases of the pilot study. Also presented are the percent removal efficiencies.

Table 2-7

Average TKN and Ammonia Concentrations

Phase	*Sample*	*TKN, mg/L*	*Ammonia, mg/L*
Pilot Study Average	Influent Composite	28	18
	Effluent Composite	2.5	1.1
	Percent Removal	*>87%*	*>90%*
5-day SRT	Influent Composite	42	15
	Effluent Composite	<1.0	<1.0
	Percent Removal	*>98%*	*>93%*
10-day SRT	Influent Composite	28	17
	Effluent Composite	1.1	1.1
	Percent Removal	*96%*	*94%*
15-day SRT	Influent Composite	27	16
	Effluent Composite	1.2	<1.0
	Percent Removal	*96%*	*>94%*
20-day SRT	Influent Composite	29	20
	Effluent Composite	1.3	1.2
	Percent Removal	*95%*	*94%*
5-day SRT, repeat	Influent Composite	50	28
	Effluent Composite	1.1	<1.0
	Percent Removal	*98%*	*>97%*

The target DO concentration in the anoxic zone was between zero and 0.2 mg/L because the presence of DO inhibits the enzyme system needed for denitrification. Denitrification was not attained during the pilot study because of high DO concentrations in the anoxic zone (average 1.2 mg/L). Scour air required in the aerobic/MBR zone (to help prevent the membranes from fouling) was higher than the air required for the nitrification process. Therefore, a significant amount of air was transferred to the anoxic zone via the recycle flow. The average DO concentration in the aerobic/MBR zone was 8.1 mg/L. Typically, a DO concentration of 2.0 mg/L is desired for an aerobic zone designed for nitrification. Table 2-8 presents the average influent, aerobic/MBR, anoxic, and effluent nitrate and nitrite concentrations during the entire pilot study period. The average results presented are very typical of each of the SRT testing results.

Table 2-8

Average Nitrate, Nitrite, and Total Nitrogen Concentrations

Sample	*Nitrate, mg/L*	*Nitrite, mg/L*	*Total Nitrogen, mg/L*
Influent Composite	0.21	0.09	18.1
Aerobic/MBR	3.35	0.19	14.1
Anoxic	1.60	0.20	14.0
Effluent Composite	11.3	0.20	12.7
Percent Removal	-	-	*29.8%*

Total nitrogen was calculated by adding the concentrations of TKN, NO_3-N and nitrite (NO_2-N). The average concentration of total nitrogen in the effluent composite samples was 12.7 mg/L and the majority of the nitrogen in the effluent was NO_3-N. Denitrification in the anoxic zone could have reduced the TN concentration significantly.

Phosphorus

Phosphorus is essential to the growth of algae and other biological organisms. The usual forms of phosphorus found in aqueous solutions include orthophosphate, polyphosphate, and organic phosphate. Total phosphorus (TP) and orthophosphate (OP) was measured on the influent and effluent composite samples. The average influent and effluent TP concentrations were 5.8 and 1.7 mg/L as P, respectively which is an average removal efficiency of 68%. The average influent and effluent OP concentrations were 2.5 and 1.4 mg/L as P, respectively which is an average removal efficiency of 35%. Table 2-9 presents the average TP and OP concentrations along with percent removal. There was no phosphorus effluent goal for the pilot study and no correlation appears to exist between phosphorus removal and SRT.

Phosphorus removal was primarily attributed to the low concentration of solids in the effluent and not biological uptake of phosphorus. Enhanced phosphorus removal requires an anaerobic zone in front of the anoxic zone as well as an internal recycle to promote the luxury uptake of phosphorus.

Ultimate Oxygen Demand

The average effluent UOD concentration for the pilot study was 8.2 mg/L. Like the TKN and BOD_5 concentrations, there does not appear to be a correlation between UOD concentration and SRT. Similarly, UOD concentration was generally unaffected by increased fluxes.

Table 2-9

Average Phosphorus Concentrations

Phase	***Sample***	***Total Phosphorus, mg/L as P***	***Orthophosphate, mg/L as P***
Pilot Study Average	Influent Composite	5.8	2.4
	Effluent Composite	1.7	1.4
	Percent Removal	*68%*	*35%*
5-day SRT	Influent Composite	5.7	1.3
	Effluent Composite	1.8	1.5
	Percent Removal	*57%*	*-20%*
10-day SRT	Influent Composite	5.6	2.2
	Effluent Composite	1.3	1.2
	Percent Removal	*76%*	*38%*
15-day SRT	Influent Composite	5.9	1.9
	Effluent Composite	1.6	1.2
	Percent Removal	*70%*	*40%*
20-day SRT	Influent Composite	5.3	2.9
	Effluent Composite	1.6	1.6
	Percent Removal	*70%*	*47%*
5-day SRT, repeat	Influent Composite	9.8	4.9
	Effluent Composite	1.7	1.4
	Percent Removal	*78%*	*56%*

Calcium, Magnesium and Silica

Table 2-10 presents the average influent and effluent calcium and magnesium concentrations. Significant removal of calcium or magnesium was not expected by the pilot unit. Some removal was noticed and could be attributed to either scale formation on the membranes or possibly biological uptake.

Table 2-10

Average Calcium and Magnesium Concentrations

Sample	***Calcium, mg/L***	***Magnesium, mg/L***
Influent Composite	65.8	14.1
Effluent Composite	57.4	13.3
Percent Removals	*5.8%*	*9.0%*

The average silica concentration in the aerobic/MBR zone was 134 mg/L and there was no increasing trend noticed. An increasing trend in silica concentration would have indicated a build up on the membranes.

Fecal and Total Coliform, *Giardia lamblia* and *Cryptosporidium parvum*

Pathogenic organisms found in wastewater may be discharged by humans who are infected with or carriers of a particular disease. The actual number of pathogenic organisms present in wastes and polluted waters are few and difficult to isolate and identify. The Coliform organism is commonly used as an indicator organism when testing water because it is more numerous and more easily tested for. The presence of Coliform organisms is taken as an indication that pathogenic organisms may also be present and the absence of Coliform organisms is taken as an indication that the water is free from disease-producing organisms. Concentrations of fecal and total Coliform results are presented as the "most probable number" per 100 mL (MPN/100 mL). The MPN is not the absolute concentration of organisms that are present but only a statistical estimate of that concentration. Table 2-11 presents the average influent, effluent and disinfected effluent fecal and total Coliform results for the entire pilot study. Disinfection of the effluent samples reduced the fecal and total Coliform counts below detection (5 and 20 MPN/100 mL, respectively).

Table 2-11
Average Fecal and Total Coliform Values

Sample	*Fecal Coliform, MPN/100 mL*	*Total Coliform, MPN/100 mL*
Influent Composite	38,212	420,783
Effluent Composite	38	130
Percent Removals	*99.8%*	*99.9%*
Log Removal	*2-log*	*3-log*
Disinfected Effluent Grab	5	20
Percent Removals	*~100%*	*~100%*

Fecal and total Coliform results during most of the maximum day and peak hour flux testing indicated some breakthrough of Coliform. The highest MPN observed was during a peak hour test: 217 MPN/100 mL. However, it appears that the MBR pilot unit would still meet the fecal Coliform permit limits: 7-day average of 200 MPN/100 mL and 30-day average of 400 MPN/100 mL.

The average influent *Cryptosporidium parvum* and *Giardia lamblia* values were 32 and 554 oocysts/1,000 mL, respectively. *Giardia lamblia* cysts have an average size of 8.8 μm by 12.3 μm and *Cryptosporidium parvum* oocysts have an average diameter of 5 μm. The nominal porosity of the membranes was 0.4 μm so it was expected that no cysts or oocysts would be present in the effluent samples. All effluent samples that were analyzed for *Cryptosporidium parvum* and *Giardia lamblia* were below the detection limits.

Treatment Performance Summary

Overall, the operation of the pilot unit was successful and generally the process performed as expected. The average day flux recommended by the manufacturer (14.7 gfd) was shown to be maintainable by gravity throughout the pilot study. To ensure the desired maximum day and peak hour fluxes, the unit was operated in the pressure mode during these tests. The major factors that influence the flux during gravity operation are hydraulic head available in the system and membrane fouling. Approximately two feet of head was required for gravity operation at the average flux. It is estimated that more than four feet of head was required for gravity operation at the peak hour flux.

The system provided good nitrification capabilities, indicated by the low ammonia (NH_3-N) concentrations in the effluent. Attaining denitrification in the anoxic zone would have lowered the effluent nitrate concentration below the goal of 8 to 10 mg/L. Denitrification was not achieved due to the high DO concentration in the anoxic zone. Because the amount of air required for scouring the membranes can be higher than what is required for process treatment, full scale design may need to incorporate a DO depletion zone. RAS from the membrane zone to the DO depletion zone would precede the anoxic zone.

Like BOD and COD, phosphorus removal was primarily dependent on the amount of solids physically removed by the membranes. The total phosphorus and orthophosphate effluent concentrations were similar throughout the pilot study. Biological phosphorus uptake in the system would have resulted in significantly lower total phosphorus and orthophosphate concentrations in the effluent. Future phosphorus effluent permit limits could be met by incorporating a chemical precipitation processes. The TSS concentration in the effluent composite samples was always below the current permit limit of 10 mg/L. As expected, sludge settling variations and issues within the anoxic or aerobic/MBR zones did not affect the effluent quality of the MBR pilot system.

The effects of maximum day and peak hour flow variations on the pilot unit effluent were minimal. Only small increases in fecal Coliform, total Coliform, and nitrogen were observed. The effluent results indicated that the pilot unit would meet the permit limits. The pilot unit was not operated during the summer months so the expected summer ammonia concentration was not confirmed. However, based on the results during the winter months, it is expected that a system with properly sized zones would meet the effluent limits.

Section 3

MODELING

This section presents the results of computer modeling that was used to compare two conceptual designs for the Phase II expansion of the HWWTP.

MODEL DESCRIPTION

The computer program, BioWin^{TM} can solve a set of process model equations for activated sludge, anaerobic digestion, settling, pH, chemical precipitation, and gas transfer acting upon a uniform set of state variables. The complete model incorporates 45 state variables and 58 processes. With this “one model” approach, it is not required to transfer one model’s output into another model’s input through model interfaces. This significantly reduces the complexity of building full facility models consisting of many different process units within the computer program.

Influent Characteristics

Actual influent wastewater characteristics were used for all of the models developed. Sampling during the pilot study provided supplemental data to the influent variables that the OCDEFS regularly monitors. The influent COD concentration was monitored throughout the pilot study. This parameter was used as the basis for organic material fractions in the BioWin^{TM} influent setup. The advantage of selecting COD as the parameter for quantifying the "strength" of organic material in the influent, as opposed to BOD or TOC, is that it provides a consistent basis for description of the activated sludge process.

BioWin^{TM} requires input for several influent concentrations including: inorganic suspended solids (ISS), COD, TKN, nitrate, TP, magnesium, calcium and alkalinity. The data collected during the pilot study was used for the simulations. Average month concentrations and loads as well as maximum month and day loads were calculated from the pilot study data. In order for the peaking factors to be representative for the entire facility, the daily influent flow rate reported by OCDEFS was used. Table 3-1 presents the maximum month and maximum day peaking factors.

BioWin^{TM} Parameters

Table 3-2 presents the BioWin^{TM} default influent wastewater fractions used to specify the fractional composition of a typical municipal wastewater. Typically, these fractions are not altered unless significant data exists for recalculation. Since the major goal of this evaluation is to compare wastewater process alternatives, the majority of the fractions were not changed. Ammonia removal is a very important design criterion because of the facility’s relatively low permit limits. Specifying the appropriate amount of ammonia in the influent wastewater affects the effluent model predictions as well as the size and operation of the process treatment tanks. The default influent fraction for ammonia with respect to total Kjeldahl nitrogen (TKN) is 0.66 (Fna). During the pilot study, influent wastewater ammonia and TKN concentrations were measured at least once a week.

Table 3-1

Influent Load Peaking Factors

Parameter	*Maximum Month*	*Maximum Day*
Total Suspended Solids (TSS)	1.81	2.81
Volatile Suspended Solids (VSS)	2.05	2.25
Inorganic Suspended Solids (ISS)	1.91	2.93
Chemical Oxygen Demand (COD)	1.37	1.95
Total Kjeldahl Nitrogen (TKN)	2.35	3.32
Nitrate (NO_3)	1.22	2.43
Total Phosphorus (TP)	1.74	3.62
Magnesium (Mg)	1.14	1.16
Calcium (Ca)	1.18	1.34
Dissolved Oxygen (DO)	1.39	2.00
Alkalinity (Alk)	1.03	1.11
Biochemical Oxygen Demand (BOD)	1.09	1.67
Ammonia (NH_3)	1.41	2.51

Table 3-2

BioWin™ Default Influent Wastewater Fractions

Fraction	*BioWin™ Symbol*	*BioWin™ Default Fraction*
Readily biodegradable (including Acetate), gCOD/g total COD	Fbs	0.16
Acetate, gCOD/g readily biodegradable COD	Fac	0.15
Non-colloidal biodegradable, gCOD/g slowly degradable COD	Fxsp	0.75
Unbiodegradable soluble, gCOD/g total COD	Fus	0.05
Unbiodegradable particulate, gCOD/g total COD	Fup	0.13
Ammonia, gNH_3-N/gTKN	Fna	0.66
Particulate organic nitrogen, gN/g Organic N	Fnox	0.50
Soluble unbiodegradable TKN, gN/gTKN	Fnus	0.02
Nitrogen:COD ratio for unbiodegradable part. COD, gN/gCOD	FupN	0.035
Phosphate, gPO4-P/gTP	Fpo4	0.50
Phosphorus:COD ratio, gP/gCOD	FupP	0.011
Non-poly-Phosphorus heterotrophs, gCOD/g total COD	FZbh	1.00E-04
Anoxic methanol utilizers, gCOD/g total COD	FZbm	1.00E-04
Autotrophs, gCOD/g total COD	FZba	1.00E-04
Poly-phosphorus heterotrophic organisms, gCOD/g total COD	FZbp	1.00E-04
Propionic acetogens, gCOD/g total COD	FZbpa	1.00E-04
Acetoclastic methanogens, gCOD/g total COD	FZbam	1.00E-04
H_2-utilizing methanogens, gCOD/g total COD	FZbhm	1.00E-04

The BioWin^{TM} default fraction of 0.66 is twice the fraction calculated from the pilot study data for the maximum month and day conditions. Using the default fraction for these two conditions would result in twice the ammonia concentration in the model influent. In turn, this affects the predicted effluent ammonia concentrations as well as tank sizing for the proposed facility expansions. Therefore, the calculated Fna fractions of 0.29 and 0.32 for maximum month and day, respectively, were used for the simulations.

Model Scenarios

Four scenarios were simulated using BioWin^{TM} for this evaluation:

- Model 1: Existing 4.5-mgd Facility (Trains 1 and 2)
- Model 2: Phase I 6.0-mgd Upgraded Facility (Trains 1, 2 and 3)
- Model 3: Phase II MBR Expanded Facility (Train 1 MBR Expansion, Existing Trains 2 and 3)
- Model 4: Phase II Step-Feed Treatment Expanded Facility (Train 1 Conventional Expansion, Existing Trains 2 and 3)

Both MBR and conventional treatment expansion scenarios are possible for a future Phase II expansion. The MBR scenario (Model 3) provides additional wastewater treatment capacity through the retrofit of the existing oxidation ditch tanks with an MBR process. The increased capacity estimate resulting from a MBR expansion was then used to evaluate the same capacity increase with conventional treatment (Model 4). The models were set-up using existing or conceptual tank dimensions. Several steady-state simulations were performed for each scenario including average month, maximum month, and maximum day conditions as well as influent temperature variations. Figures 3-1 through 3-4, at the end of this section, present the BioWin^{TM} configurations.

MODEL RESULTS

Model 1: Existing 4.5-mgd Facility

Performance of the existing facility was simulated to show that the model results reasonably match the historical effluent concentrations. Treatment trains 1 and 2 were configured within the model with actual tank dimensions, approximate flow split ratios, recycle rates, wasting rates, and solids removal efficiencies. Figure 3-1 presents the Model 1 configuration. The existing facility (Trains 1 and 2) that has a capacity rating of 4.5 mgd was simulated for average month, maximum month, and maximum day influent conditions. Table 3-3 presents the steady-state influent characteristics as well as the source of each value. Model 1 assumed that: 44% of the design average day influent flow (2.0 mgd) is conveyed to the conventional activated sludge (CAS) system (Train 2), sand filter backwash is directed to the head of the facility, and side stream flows from the sludge thickeners and belt filter presses are directed to the Train 2 aeration tank.

Table 3-3
BioWin^{TM} Steady-State Model 1 and 2 Influent Characteristics

Parameter	*Average Month*	*Maximum Month*	*Maximum Day*	*Source*
Flow, mgd	4.7	7.1	13.4	2002-2004 Plant Data
Total Suspended Solids, lb/d	10,106	18,308	28,389	Pilot Study
Volatile Suspended Solids, lb/d	8,049	16,527	18,080	Pilot Study
Inorganic Suspended Solids, lb/d	2,528	4,818	7,416	Calculated
Chemical Oxygen Demand, lb/d	19,396	26,563	37,913	Pilot Study
Total Kjeldahl Nitrogen, lb/d	1,140	2,682	3,779	Pilot Study
Nitrate, lb/d	8.1	9.8	19.6	Pilot Study
Total Phosphorus, lb/d	227	395	820	Pilot Study
Magnesium, lb/d	541	614	627	Pilot Study
Calcium, lb/d	2,602	3,057	3,489	Pilot Study
Dissolved Oxygen, lb/d	188	261	376	Pilot Study
pH	7.7	8	8.6	Pilot Study
Alkalinity, lb/d	8,107	8,805	13,533	Pilot Study
Biological Oxygen Demand, lb/d	7,462	10,513	18,765	Pilot Study
Ammonia, lb/d	707	776	1,205	Pilot Study

The following assumptions were used for Oxidation Ditch system (Train 1): the return activated sludge (RAS) rate was 2.0 mgd (based on the capacity of the existing sludge pumps, per OCDEFS, which is 100% of the average capacity of Train 1) and the MLSS concentration was approximately 1,800 mg/L during average month and 2,400 mg/L during maximum month conditions. The following assumptions were used for CAS system (Train 2): the RAS rate was approximately 50% of the flow rate to the treatment train (based on typical RAS rates for conventional aeration treatment systems) and the MLSS concentration was approximately 1,800 mg/L during average month and 2,900 mg/L during maximum month conditions.

The waste activated sludge (WAS) rate from each of the treatment systems was estimated based on the desired MLSS concentrations listed above. The WAS rate is correlated to either the MLSS or final clarifier underflow suspended solids concentrations in an activated sludge system. For all simulations, the WAS rates required to achieve the target MLSS concentrations remained the same: 0.11 mgd from the oxidation ditches (WAS1) and 0.06 mgd from the CAS system (WAS2). These values are reasonable considering the reported average and maximum month dewatered sludge flow rates: 0.12 and 0.15 mgd, respectively. The model simulations were performed with influent wastewater temperatures of 12.5 and 16.9 degrees Celsius (^{o}C). The lower temperature was chosen because it is less than the minimum recorded influent wastewater temperature (based on 2002 – 2004 data) of 15 ^{o}C.

Table 3-4 presents the model predicted and the actual plant data effluent concentrations, under steady state average month, maximum month, and maximum day conditions. The facility only monitors effluent TSS, ammonia, TKN, BOD, temperature, and pH on a regular basis. Final settling tank (FST) and sand filter performance, in terms of percent removal, were used to help correlate the model response to effluent data. The solids removal percentages for Train 1 FSTs and Train 2 FSTs were 99 and 98 percent, respectively, for all conditions. The solids removal percentage for the sand filters was 80 percent.

Generally, the steady state model effluent output was in agreement with actual effluent concentrations. Perfect correlation between model output and actual effluent data is generally unlikely since even complex mathematical models of the activated sludge process are gross simplifications of real systems. For the purpose of comparing process treatment scenarios, the results from Model 1 indicate that the model is performing adequately. Appendix C presents summary tables for each of the Model 1 simulations.

Model 2: Phase I Upgraded 6.0-mgd Facility

Building on Model 1, the treatment train currently being constructed at the HWWTP was added in BioWin^{TM} (Train 3). Figure 3-2 presents the Model 2 configuration. Design dimensions from the Contract Drawings and/or design report were used. An even flow split between all three trains was applied. The results of this model are an estimate of what can be expected from the Phase I upgraded facility. The Phase I upgraded facility (Trains 1, 2 and 3) was simulated for average, design, and maximum month and maximum day influent conditions. Table 3-3 presented the steady-state influent characteristics. For the design month, an influent flow rate of 6.0 mgd was used along with average month concentrations. Model 2 assumed the following: approximately 33% of the influent flow is conveyed to each of the three treatment trains, sand filter backwash from Trains 1 and 2 is directed to the head of the facility, backwash from Train 3 is directed to the Train 3 primary settling tanks, and sidestream flows from the thickeners and belt filter presses are directed to the Train 3 primary settling tanks.

The following assumptions were used for Oxidation Ditch System (Train 1): the RAS rate was 2.0 mgd and the MLSS concentration was approximately 1,800 mg/L during average month and 2,400 mg/L during maximum month conditions. The following assumptions were used for CAS system (Train 2): the RAS rate was approximately 50% of the flow rate to the treatment train and the MLSS concentration was approximately 1,900 mg/L during average month and 2,300 mg/L during maximum month conditions. The following assumptions were used for CAS system (Train 3): the RAS rate was approximately 60% of the flow rate to the train and the internal recycle (IR) rate was set equal to the average design influent flow.

The WAS rate from each of the treatment systems was estimated based on reasonable MLSS concentrations. For all simulations, the WAS rates required to achieve the target MLSS concentrations remained the same: 0.11 mgd from the oxidation ditches (WAS1) and 0.04 mgd from each of the CAS systems (WAS2 and WAS3). The model simulations were performed with influent wastewater temperatures of 12.5 and 16.9 ^{o}C. The strictest permit limits to attain from a process standpoint, are the summertime and wintertime ammonia concentrations of 1.1 and 2.2 mg/L, respectively.

Table 3-5 presents the results of the Model 2 simulations performed with an influent wastewater temperature of 16.9 ^{o}C. Results include the effluent model concentrations under steady state average, design, and maximum month, and maximum day conditions. Additionally, the permit limits are also presented. The effluent concentrations presented represent the combined effluent from all process treatment trains – predicting what will be discharged from the facility at the completion of the Phase I upgrade. The simulations predict that under current average month conditions, the upgraded facility will meet permit limits. If the facility was to experience maximum month concentrations, the effluent ammonia concentration may rise above the permit limit of 1.1 mg/L. This is primarily due to the fact that the model is predicting that Train 2 does not have enough aeration capacity with respect to ammonia removal under maximum month and maximum day conditions. The existing facility data does not list individual treatment train effluent concentrations; however, the combined effluent ammonia concentration does rise above the permit limit during extreme flow events. Appendix D presents the summary information for Model 2.

Table 3-4

Model 1: Existing 4.5-mgd Facility Steady State Effluent Characteristics – Average Month, Maximum Month, and Maximum Day Conditions

	Average Month			*Maximum Month*			*Maximum Day*			
	Model	***Data (1)***	***% Difference***	***Model***	***Data (2)***	***% Difference***	***Model***	***Data (3)***	***% Difference***	***Permit (4)***
Total Suspended Solids, mg/L	10.7	9.2	15.9%	12.4	25.1	-50.7%	10.4	59	-82.4%	30 (5)
Volatile Suspended Solids, mg/L	7.3			7.8			6.6			NA
Ammonia, mg/L	2.9	2.6	10.0%	4.4	5.7	-22.3%	6.1	10.5	-42.1%	1.1 (6)
Total Kjeldahl Nitrogen, mg/L	5.4	4.3	25.3%	8.6	12.9	-33.3%	10.1	42	-76.0%	Monitor
Nitrate, mg/L	10.0			21.5			11.8			NA
Total Nitrogen, mg/L	15.4			30.1			21.9			NA
Magnesium, mg/L	13.8			10.4			5.6			NA
Calcium, mg/L	66.4			51.6			31.2			NA
Biological Oxygen Demand, mg/L	5.2	7.2	-28.2%	5.7	16.3	-64.8%	5.9	40.4	-85.5%	Monitor
Chemical Oxygen Demand, mg/L	37.8			36.4			29.7			NA
Total Phosphorus, mg/L	1.8			2.7			3.8			NA
Orthophosphate, mg/L	1.6			2.5			3.6			NA
Temperature, deg C	16.9	16.9		16.9			16.9			21.1
Alkalinity, mg/L	123			46			65			NA
pH	6.9	7.3	-5.2%	6.5	7.5	-13.1%	6.7	8.3	-19.4%	6.5 – 8.5 (7)
Inorganic suspended solids, mg/L	3.0			4.1			3.4			NA
Ultimate Oxygen Demand, mg/L	32.0	28.3	43.1%	47.3	64.2	-26.3%	54.2	116.7	-53.5%	50 (8)
Dissolved Oxygen, mg/L	1.9			1.9			1.9			7.0 (9)

Notes:
(1) Actual average month effluent data based on 2002 – 2004 average month values.
(2) Actual maximum month effluent data based on 2002 – 2004 maximum month values.
(3) Actual maximum day effluent data based on 2002 - 2004 maximum day values.
(4) Based on existing permit limits for the facility.
(5) Average month concentration to Outfall 001 or 002 from November through May.
(6) Average month concentration to Outfall 002 from June through October.
(7) Average month range.
(8) Daily maximum concentration to Outfall 001.
(9) Daily maximum concentration.

Table 3-5

Model 2: Phase I Upgraded 6.0-mgd Facility Steady State Effluent Characteristics – Average Month, Design Month, Maximum Month, and Maximum Day Conditions

	Average Month	*Design Month*	*Maximum Month*	*Maximum Day*	*Permit* [(1)]
Total Suspended Solids, mg/L	9.4	10.1	11.1	9.5	30 [(2)]
Volatile Suspended Solids, mg/L	6.4	6.9	7.0	6.0	NA
Ammonia, mg/L	0.75	0.81	1.3	2.5	1.1 [(3)]
Total Kjeldahl Nitrogen, mg/L	3.1	3.3	4.9	6.0	Monitor
Nitrate, mg/L	11.8	11.4	23.1	14.7	NA
Total Nitrogen, mg/L	14.9	14.6	28.0	20.6	NA
Magnesium, mg/L	13.8	13.8	10.4	5.6	NA
Calcium, mg/L	66.4	66.4	51.6	31.2	NA
Biological Oxygen Demand, mg/L	4.1	4.5	4.7	4.6	Monitor
Chemical Oxygen Demand, mg/L	35.9	36.7	34.6	27.8	NA
Total Phosphorus, mg/L	2.1	2.0	3.0	3.9	NA
Orthophosphate, mg/L	1.9	1.8	2.8	3.7	NA
Temperature, deg C	16.9	16.9	16.9	16.9	21.1
Alkalinity, mg/L	110	112	29	42	NA
pH	6.7	6.8	6.2	6.4	6.5 – 8.5 [(4)]
Inorganic suspended solids, mg/L	2.6	2.7	3.7	3.1	NA
Ultimate Oxygen Demand, mg/L	20.3	21.5	29.2	33.7	50 [(5)]
Dissolved Oxygen, mg/L	2.0	2.0	2.0	2.0	7.0 [(6)]

Notes:
(1) Based on existing permit limits for the facility.
(2) Average month concentration to Outfall 001 or 002 from November through May.
(3) Average month concentration to Outfall 002 from June through October.
(4) Average month range.
(5) Daily maximum concentration to Outfall 001.
(6) Daily maximum concentration.

Model 3: Phase II Expanded Facility - MBR

To replace the oxidation ditch treatment train with a MBR system, BioWin™ was used to estimate the potential capacity increase and simulate the effluent characteristics. Building on Model 2, the oxidation ditch treatment train (Train 1) was replaced with a MBR treatment train. Figure 3-3 presents the Model 3 configuration. A dissolved oxygen (DO) depletion zone, anoxic zone, aeration zone, and membrane zone were incorporated into the footprint of the existing oxidation ditches. The volume required for membranes was based on the Enviroquip/Kubota membrane cassettes and space requirements along with the actual dimensions of the oxidation ditches. A DO depletion zone was added so that the DO concentration in the MBR zone did not affect the denitrification capability of the anoxic zone. The Phase II MBR expanded facility was simulated for average month, maximum month, and maximum day influent conditions. The simulations were used to estimate the potential capacity increase and to predict the effluent characteristics if the oxidation ditch system was replaced with a MBR system.

Treatment Capacity Increase. Based on conceptual use of the oxidation ditch volume and dimensions, calculations were performed to estimate the capacity of a MBR system. Volumes for DO depletion and anoxic zones were considered as well as separate membrane zones to keep the membranes isolated from the process aeration zone. Characteristics and sizes of the Enviroquip/Kubota membrane cartridges were also incorporated. Figure 3-5, at the end of this section, presents a layout of the existing oxidation ditches. Placing membranes in Zone 4 of both ditches gives a membrane capacity (average day) of 5.0 mgd.

The volume of the DO depletion, anoxic, and aeration zones were manipulated in the model simulations to determine if the process zones could be configured to produce an effluent quality that meets or exceeds preliminary future permit limits. Model effluent goals of the MBR treatment system included an ammonia concentration of less than 0.5 mg/L, a nitrate (NO_3) concentration of less than 10 mg/L, a BOD concentration of 5.0 mg/L, and a TSS concentration of approximately 4.0 mg/L with an influent wastewater temperature of 12.5 ^{o}C. Because the model does not have a membrane function, the TSS concentration goal was set at the maximum detection limit. This allowed a certain amount of TSS in the effluent that is presumably higher than actual conditions; creating conservative effluent predictions. Effluent quality was evaluated and wasting rates were manipulated for different MBR solids retention time (SRT) simulations.

The proposed conceptual volumes for the MBR treatment zones are: 0.8 million gallons (mgal) Anoxic, 0.65 mgal Aerobic, 0.80 mgal Membranes, and 0.20 mgal DO Depletion. The configuration of the existing oxidation ditches was considered when estimating the volumes and the layout of the process zones is further explained in Section 4. The total volume available for the MBR system in the oxidation ditches would be 2.45 million gallons (not including the secondary clarifiers or decant tank). Further discussion of how the secondary clarifier area may be incorporated into the MBR treatment train is presented in Section 4. The Phase II MBR facility was simulated under average month, maximum month, and maximum day influent conditions. Table 3-6 presents the steady-state influent characteristics used for Phase II models.

Table 3-6
BioWin™ Steady-State Models 3 and 4 (Phase II) Influent Characteristics

Parameter	***Average Month***	***Maximum Month***	***Maximum Day***	***Source***
Flow, mgd	9	13.6	18	N/A
Total Suspended Solids, lb/d	19,351	35,058	54,362	Pilot Study
Volatile Suspended Solids, lb/d	15,412	31,648	34,621	Pilot Study
Inorganic Suspended Solids, lb/d	4,840	9,225	14,201	Calculated
Chemical Oxygen Demand, lb/d	37,142	50,866	72,599	Pilot Study
Total Kjeldahl Nitrogen, lb/d	2,182	5,135	7,236	Pilot Study
Nitrate, lb/d	15.4	18.8	37.6	Pilot Study
Total Phosphorus, lb/d	434	757	1,571	Pilot Study
Magnesium, lb/d	1,036	1,176	1,201	Pilot Study
Calcium, lb/d	4,982	5,855	6,680	Pilot Study
Dissolved Oxygen, lb/d	360	499	721	Pilot Study
pH	7.7	8	8.6	Pilot Study
Alkalinity, lb/d	15,525	16,862	25,914	Pilot Study
Biological Oxygen Demand, lb/d	14,289	20,131	35,933	Pilot Study
Ammonia, lb/d	1,353	1,486	2,308	Pilot Study

The influent concentrations used for Models 3 and 4 are the not the same as concentrations used for Models 1 and 2 because they are based on the load peaking factors. Using load peaking factors to establish influent wastewater parameter concentrations is a more accurate approach to estimating future conditions at the facility. The average month influent flow includes 5.0 mgd to the MBR treatment train (Train 1) and 2.0 mgd to each of the remaining existing treatment trains (Trains 2 and 3). The maximum month influent flow rate of 13.6 mgd is based on the existing maximum month peaking factor of 1.51 (2002 – 2004 operating data). The maximum day influent flow rate includes the maximum day flow of 10.0 mgd to the MBR treatment train and 4.0 mgd to each of the two remaining existing treatment trains (total of 18 mgd).

The following flow split assumptions were used for Model 3 simulations. The MBR treatment train receives approximately 55% of the influent flow and Trains 2 and 3 each receive 50% of the remaining influent flow. For average day conditions, this flow split maintains the design influent flow rates of 2.0 mgd to Trains 2 and 3. Sand filter backwash flow from Train 2 is directed to the head of the facility and backwash flow from Train 3 is directed to the Train 3 primary settling tanks. Sidestream flows from the thickeners and belt filter presses are directed to the Train 1. The following assumptions were used for the MBR System (Train 1): the RAS rate was 300% of the MBR influent flow and the MLSS concentration was varied based on the solids retention time (SRT) evaluations. The following assumptions were used for the CAS system (Train 2): the RAS rate was approximately 50% of the flow rate to the treatment train and the MLSS concentration was approximately 3,000 mg/L during average month conditions. Additionally, an anoxic zone was added to Train 2. The anoxic zone volume was approximately 0.1 million gallons and was sized so that the train could provide an effluent with lower nitrate concentrations. Without this modification, the combined effluent would not meet the nitrate effluent goal (10 mg/L) because Trains 1 and 2 can only decrease the nitrate concentration so low under maximum month conditions. Implementation of this new zone is discussed in Section 4. The same modification is required for the step-feed process. The following assumptions were used for the CAS system (Train 3): the RAS3 rate was approximately 100% of the flow rate to the train and the IR rate was set equal to the average design influent flow of 2.0 mgd.

MBR Solids Retention Time (SRT). Predicted effluent quality was evaluated during BioWin™ simulations for different MBR aerobic solids retention times (SRTs). The steady state model was used to generate effluent results for five different SRTs – 5, 10, 15, 20, and 30 days. Simulations were completed for average month, maximum month, and maximum day conditions.

The primary parameters used to select the operating SRT were the effluent ammonia and nitrate concentrations. The anoxic zone and aeration zone sizes and the return sludge (RAS) flow rate were modified to produce an effluent with a nitrate concentration less than 10 mg/L during the maximum month condition. Furthermore, the MBR process operation was based on meeting the strictest ammonia effluent concentration (1.1 mg/L to Outfall 002 from June through October) during maximum month conditions at the design temperature of 12.5 ^{o}C. The current minimum temperature during the months of June through

October (based on 2002 – 2004 operating data) is 15 ^{o}C. Using a design temperature of 12.5 ^{o}C gives a temperature safety factor of 1.2.

Figure 3-6, at the end of this section, presents the MBR treatment train and combined effluent ammonia concentration results for the different SRT operating scenarios. Figure 3-6 indicates that the effluent ammonia permit limit could be met with a MBR system SRT as low as 10 days; however, designing for a SRT between 10 and 15 days provides a safety factor for potential process upsets and changing influent characteristics. Figure 3-6 can be interpreted to have a point of diminishing returns for ammonia concentration at a SRT of approximately 12 days. Additionally, pilot study results indicated that the MBR should be operated with a MLSS of at least 6,000 mg/L to prevent sticky sludge from fouling the membranes. The MBR manufacturer recommends that the system be operated with a MLSS concentration of at least 8,000 mg/L. With a recycle rate of 300%, the 15 day SRT operating scenario has an average month MLSS concentration of about 9,600 mg/L.

Expected Effluent Characteristics. Table 3-7 presents the model predicted effluent concentrations under average month, maximum month, and maximum day conditions for each of the three treatment trains. This table shows that the MBR (Train 1) produces the highest quality effluent. This is due to the optimization of the zone sizes as well as the membranes ability to remove solids.

Table 3-8 presents the model predicted effluent concentrations under steady state average month, maximum month, and maximum day conditions for the MBR expanded facility. Additionally, the preliminary future permit limits are also presented. The simulations were performed with an influent wastewater temperature of 12.5 ^{o}C and a MBR operating aerobic SRT of 15 days (MLSS concentration of approximately 9,600 mg/L). These simulations predict that under average month and maximum month expanded facility design conditions, the Phase II MBR facility is expected to meet the future preliminary permit limits even with an influent wastewater temperature of 12.5 ^{o}C. Influent wastewater temperature increases will help reduce the effluent ammonia concentration in all cases.

Alum may be used to chemically precipitate phosphorus to meet the future preliminary permit limit of 0.5 mg/L. Table 3-7 shows the predicted phosphorus concentration for each of the treatment trains without chemical addition. These concentrations were used to determine the amount of alum required to meet the phosphorus permit limit. Alum will be added to each train as follows: Train 1 at the MBR/aeration tank, Train 2 at the sand filters, and Train 3 at the sand filters. The amount of alum added to the MBR (Train 1) is based on the predicted phosphorus concentration that will not be removed by the membranes. The amount of alum added to Trains 2 and 3 is based on the predicted phosphorus concentration exiting the FSTs (and therefore entering the sand filters). New sand filters are not expected to be required for this option. The sand filters that currently serve the oxidation ditches will be reallocated for the Train 2 and/or Train 3 aeration systems. An analysis of the loading rates and the effect of alum on the filters will be required during the design process. Appendix E presents the simulation results for Model 3.

Table 3-7

Model 3: Phase II Expanded Facility (MBR)
Individual Treatment Train Steady State Effluent Characteristics
Average Month, Maximum Month, and Maximum Day Conditions

	Average Month	***Maximum Month***	***Maximum Day***
Temperature, ^oC	12.5	12.5	12.5
Train 1 Influent Flow, mgd	5.0	7.5	10.0
Train 2 Influent Flow, mgd	2.0	3.10	4.0
Train 3 Influent Flow, mgd	2.0	3.10	4.0
	Train 1 (MBR, 15 day SRT) - Effluent		
Total Suspended Solids, mg/L	1.9	3.0	4.6
Ammonia, mg/L	0.26	0.28	0.3
Nitrate, mg/L	3.9	8.0	8.7
Nitrite, mg/L	0.0	0.0	0.0
Total Kjeldahl Nitrogen, mg/L	2.1	2.8	2.9
Total Nitrogen, mg/L	6.0	10.8	11.6
Biological Oxygen Demand, mg/L	1.3	1.3	1.6
Total Phosphorus, mg/L [(1)]	0.3	3.0	6.0
Alkalinity, mg/L	133.0	77.0	88.0
Ultimate Oxygen Demand, mg/L	11.3	14.5	15.3
	Train 2 - Effluent		
Total Suspended Solids, mg/L	7.3	8.2	7.5
Ammonia, mg/L	2.4	3.2	5.8
Nitrate, mg/L	4.4	9.2	10.2
Nitrite, mg/L	0.0	0.0	0.0
Total Kjeldahl Nitrogen, mg/L	4.5	6.6	9.1
Total Nitrogen, mg/L	8.9	15.8	19.2
Biological Oxygen Demand, mg/L	4.0	4.2	4.0
Total Phosphorus, mg/L [(1)]	0.6	2.3	2.7
Alkalinity, mg/L	141.0	86.0	107.0
Ultimate Oxygen Demand, mg/L	26.3	35.9	46.9
	Train 3 - Effluent		
Total Suspended Solids, mg/L	3.1	4.4	4.3
Ammonia, mg/L	0.81	1.00	1.1
Nitrate, mg/L	5.2	13.3	14.1
Nitrite, mg/L	0.0	0.0	0.0
Total Kjeldahl Nitrogen, mg/L	2.7	4.0	4.1
Total Nitrogen, mg/L	7.9	17.3	18.3
Biological Oxygen Demand, mg/L	2.0	2.3	2.4
Total Phosphorus, mg/L [(1)]	1.7	2.8	5.1
Alkalinity, mg/L	132.0	63.0	76.0
Ultimate Oxygen Demand, mg/L	15.3	21.3	22.1

Notes:
(1) Total Phosphorus concentration does not account for chemical precipitation using alum. Chemical removal will decrease the effluent TP concentration to 0.5 mg/L to meet the expected permit limit.

Table 3-8

Model 3: Phase II Expanded Facility (MBR)
Combined Effluent Steady State Characteristics
Average Month, Maximum Month, and Maximum Day Conditions

	Average Month	***Maximum Month***	***Maximum Day***	
MBR SRT, days	15	15	15	
Temperature, deg C	12.5	12.5	12.5	
Flow to Train 1 (MBR), mgd	5.0	7.5	10	
Flow to Train 2, mgd	2.0	3.05	4.0	
Flow to Train 3, mgd	2.0	3.05	4.0	
Total Influent Flow, mgd	9.0	13.6	18.0	
Total Effluent Flow, mgd	8.88	13.48	17.90	
Sludge, mgd	0.12	0.12	0.10	
	Combined Effluent			***Permit*** [(1)]
Total Suspended Solids, mg/L	3.0	4.3	5.0	10 [(2)]
Volatile Suspended Solids, mg/L	2.0	2.6	2.8	NA
Ammonia, mg/L	0.73	0.97	1.5	1.1 [(3)]
Total Kjeldahl Nitrogen, mg/L	2.6	3.8	4.3	Monitor
Nitrate, mg/L	4.4	9.6	10.4	10 [(4)]
Nitrite, mg/L	0.0	0.0	0.0	NA
Total Nitrogen, mg/L	7.0	13.4	14.7	NA
Magnesium, mg/L	13.3	10.2	7.6	NA
Calcium, mg/L	65.9	51.6	44.4	NA
Biological Oxygen Demand, mg/L	1.9	2.1	2.2	5 [(5)]
Chemical Oxygen Demand, mg/L	31.8	28.3	31.0	NA
Total Phosphorus, mg/L [(6)]	0.7	2.8	5.2	0.5 [(7)]
Orthophosphate, mg/L	0.7	2.7	5.0	NA
Alkalinity, mg/L	134.0	74.5	88.0	NA
pH	6.8	6.5	6.6	6.5 – 8.5 [(8)]
Inorganic Suspended Solids, mg/L [(9)]	1.0	1.7	2.2	NA
Ultimate Oxygen Demand, mg/L	14.6	20.0	22.8	50 [(10)]
Dissolved Oxygen, mg/L	5.5	4.7	4.0	7.0 [(11)]

Notes:

(1) Based on preliminary permit limits for the Phase II expanded facility (average day flow = 9.0 mgd).
(2) Maximum day concentration from June through October.
(3) Average month concentration to Outfall 002 from June through October.
(4) The preliminary future average month nitrate limit for the facility.
(5) Maximum day concentration to Outfall 001 from June through October.
(6) Total Phosphorus concentration does not account for chemical precipitation using alum. Chemical removal will decrease the effluent TP concentration to 0.5 mg/L to meet the expected permit limit.
(7) Average month concentration to either Outfall.
(8) Average month range to either Outfall.
(9) ISS = TSS - VSS.
(10) UOD = 1.5 * BOD + 4.5 * TKN. Daily maximum concentration to Outfall 001.
(11) Daily maximum concentration to either Outfall.

Model 4: Phase II Expanded Facility – Conventional Treatment

A step-feed biological nutrient removal (BNR) activated sludge process was simulated with BioWin™ as the conventional treatment scenario to expand the facility. Step-feed is a modification of the conventional activated sludge process in which influent wastewater is introduced at several points in the aeration tank to equalize the food to mass (F/M) ratio; thereby lowering the peak oxygen demand. Generally, three or more addition points are used. Flexibility of operation is one of the important features of this process. Anoxic zones provide denitrification capability. Figure 3-4 presents the Model 4 configuration. This is similar to Train 3 (Phase I upgrade) in terms of biological treatment capabilities; however, step-feed systems require a smaller aeration volume in exchange for more complex operations. Building on Model 2, the oxidation ditch treatment train was replaced with a step-feed treatment train. This train consists of a series of four anoxic and aerobic treatment zones within the existing oxidation treatment tanks. This setup requires final settling tanks and sand filters. For comparison purposes, the capacity of this system was based on the results of modeling the MBR treatment train (Model 3).

Expected Capacity and Preliminary Sizing. One of the goals of this evaluation was to compare a conventional treatment process with that of the MBR system. In order to complete this comparison, the capacity of the conventional treatment system was set equal to the MBR system capacity determined by Model 3 (5.0 mgd). Therefore, the Phase II step-feed BNR treatment facility was also simulated in BioWin™ for average month, maximum month, and maximum day influent conditions. Table 3-6 presented the steady-state influent characteristics used for the Phase II models.

The system was simulated to produce similar effluent results as the MBR system. Similar ammonia and nitrate removal were the primary comparison parameters. Matching the solids removal percentage between the MBR and the CAS system is not realistic because the CAS system is limited by the final settling tanks (FSTs) and sand filters. The solids removal in the CAS system is still acceptable for the facility since the average month permitted effluent TSS concentration is 20 mg/L. In order to meet the preliminary future permit limits and maintain the same expanded flow rate as the MBR system for comparison purposes, the step-feed system requires larger treatment zones (0.80 mgal Anoxic, 3.58 Aerobic) than the MBR treatment train. Additionally, the step-feed system requires additional FSTs.

In the step-feed scenario, the aeration volume alone exceeds the available capacity in the existing oxidation ditches. The following flow split assumptions were used for Model 4 simulations: the step-feed treatment train receives approximately 55% of the influent flow and Trains 2 and 3 each receive 50% of the remaining influent flow. For average day conditions, this flow split maintains the design influent flow rates of 2.0 mgd each to Trains 2 and 3. Sand filter backwash flows from Trains 1 and 2 are directed to the head of the facility. Backwash flow from Train 3 is directed to the Train 3 primary settling tanks. Sidestream flows from the thickeners and belt filter presses are directed to the Train 3 primary settling tanks.

The following assumptions were used for the Step-Feed System (Train 1): approximately 33% of the step-feed influent flow was directed to aeration zones 2, 3, and 4, the RAS rate was approximately 50% of the step-feed influent flow, returned to anoxic zone 1, the approximate MLSS concentrations for aeration zones 1, 2, 3, and 4 were 13,000 mg/L, 7,900 mg/L, 5,600 mg/L, and 4,400 mg/L, respectively. The following assumptions were used for the CAS system (Train 2): the RAS rate was approximately 100% of the flow rate to the treatment train and the MLSS concentration was approximately 3,300 mg/L during average month conditions. Additionally an anoxic zone was added to this treatment train. The anoxic zone volume was approximately 0.1 million gallons and was sized so that the train could provide an effluent with lower nitrate concentrations. Without this modification, the combined effluent would not meet the nitrate effluent goal (10 mg/L) because Trains 1 and 2 can only decrease the nitrate concentration so low under maximum month conditions. The same modification is required for the MBR process. The following assumptions were used for the CAS system (Train 3): RAS rate was approximately 100% of the flow rate to the train and the IR rate was set equal to the average design influent flow of 2.0 mgd.

Expected Effluent Characteristics. Table 3-9 presents the predicted effluent concentrations under average month, maximum month, and maximum day conditions for each of the three treatment trains. Table 3-9 shows that the step-feed (Train 1) produces an effluent with similar characteristics as the Train 3 effluent. The predicted effluent characteristics of Trains 2 and 3 in this model are not identical to the predicted effluent characteristics in Model 3 (MBR system) because the side stream flows are directed differently.

Table 3-10 presents the model predicted effluent concentrations, under steady state average month, maximum month, and maximum day conditions for the step-feed expanded facility with an influent wastewater temperature of 12.5 ^{o}C. Additionally, the preliminary future permit limits are also presented. The effluent values presented represent the combined effluent from all three process treatment trains. The step-feed facility operation was based on meeting the strictest ammonia effluent concentration (1.1 mg/L to Outfall 002 during June through October) during average month conditions at the design temperature (12.5 ^{o}C). The current minimum temperature during the months of June through October (based on 2002 – 2004 operating data) is 15 ^{o}C. Using a design temperature of 12.5 ^{o}C gives a temperature safety factor of 1.2.

The model results indicate that under maximum month influent conditions, the conventional facility is expected to meet permit limits even with an influent wastewater temperature of 12.5 ^{o}C. However, the ammonia permit condition only applies during the months of June through October – months that would most likely not see an influent temperature below 15 ^{o}C based on 2002 – 2004 operating data. The predicted average month effluent ammonia concentration at the current average temperature of 16.9 ^{o}C is 0.64 mg/L. Alum may be used to chemically precipitate phosphorus to meet the future preliminary permit limit of 0.5 mg/L. Table 3-9 shows the predicted phosphorus concentration for each of the treatment trains without chemical addition. These concentrations were used to determine the amount of alum required to meet the phosphorus permit limit. Appendix F presents the simulation results for Model 4.

Table 3-9
Model 4: Phase II Expanded Facility (Step-Feed)
Individual Treatment Train Steady State Effluent Characteristics
Average Month, Maximum Month, and Maximum Day Conditions

	Average Month	***Maximum Month***	***Maximum Day***
Temperature, ^{o}C	12.5	12.5	12.5
Train 1 Influent Flow, mgd	5.0	7.5	10.0
Train 2 Influent Flow, mgd	2.0	3.05	4.0
Train 3 Influent Flow, mgd	2.0	3.05	4.0
	Train 1 (Step-Feed) - Effluent		
Total Suspended Solids, mg/L	3.0	5.4	15.0
Ammonia, mg/L	0.63	0.69	0.7
Nitrate, mg/L	2.1	6.8	8.4
Nitrite, mg/L	0.0	0.0	0.0
Total Kjeldahl Nitrogen, mg/L	2.5	3.4	3.9
Total Nitrogen, mg/L	4.6	10.2	12.2
Biological Oxygen Demand, mg/L	1.5	1.7	2.9
Total Phosphorus, mg/L (1)	0.6	4.0	7.6
Alkalinity, mg/L	140.5	82.5	90.5
Ultimate Oxygen Demand, mg/L	13.4	17.9	21.8
	Train 2 - Effluent		
Total Suspended Solids, mg/L	7.4	8.7	10.7
Ammonia, mg/L	1.99	2.85	5.2
Nitrate, mg/L	4.4	9.8	11.0
Nitrite, mg/L	0.0	0.0	0.0
Total Kjeldahl Nitrogen, mg/L	4.2	6.2	8.7
Total Nitrogen, mg/L	8.5	16.0	19.7
Biological Oxygen Demand, mg/L	3.9	4.1	5.0
Total Phosphorus, mg/L (1)	0.5	2.2	2.6
Alkalinity, mg/L	139.5	82.0	101.5
Ultimate Oxygen Demand, mg/L	24.5	34.2	46.4
	Train 3 - Effluent		
Total Suspended Solids, mg/L	4.2	5.2	6.5
Ammonia, mg/L	0.60	0.77	0.9
Nitrate, mg/L	5.9	13.4	14.3
Nitrite, mg/L	0.0	0.0	0.0
Total Kjeldahl Nitrogen, mg/L	2.5	3.7	3.9
Total Nitrogen, mg/L	8.4	17.0	18.2
Biological Oxygen Demand, mg/L	2.0	2.3	2.7
Total Phosphorus, mg/L (1)	1.6	3.0	5.4
Alkalinity, mg/L	128.5	61.5	74.0
Ultimate Oxygen Demand, mg/L	14.4	20.0	21.6

Notes:

(1) Total Phosphorus concentration does not account for chemical precipitation using alum. Chemical removal will decrease the effluent TP concentration to 0.5 mg/L to meet the expected permit limit.

Table 3-10
Model 4: Phase II Expanded Facility (Step-Feed)
Combined Effluent Steady State Characteristics
Average Month, Maximum Month, and Maximum Day Conditions

	Average Month	***Maximum Month***	***Maximum Day***	
Temperature, deg C	12.5	12.5	12.5	
Flow to Train 1 (Step-Feed), mgd	5.0	7.5	10.0	
Flow to Train 2, mgd	2.0	3.05	4.0	
Flow to Train 3, mgd	2.0	3.05	4.0	
Total Influent Flow, mgd	9.0	13.6	18.0	
Total Effluent Flow, mgd	8.87	13.46	17.87	
Sludge, mgd	0.13	0.14	0.13	
	Combined Effluent			***Permit*** [1]
Total Suspended Solids, mg/L	4.0	5.9	12.3	10 [2]
Volatile Suspended Solids, mg/L	2.5	3.4	6.5	NA
Ammonia, mg/L	0.8	1.1	1.6	1.1 [3]
Total Kjeldahl Nitrogen, mg/L	2.7	4.0	4.8	Monitor
Nitrate, mg/L	3.3	8.8	10.2	10 [4]
Nitrite, mg/L	0.0	0.0	0.0	NA
Total Nitrogen, mg/L	6.1	12.8	15.0	NA
Magnesium, mg/L	13.3	10.3	7.8	NA
Calcium, mg/L	65.9	51.6	44.5	NA
Biological Oxygen Demand, mg/L	2.0	2.3	3.3	5 [5]
Chemical Oxygen Demand, mg/L	33.2	29.2	35.9	NA
Total Phosphorus, mg/L [6]	0.8	3.5	6.2	0.5 [7]
Orthophosphate, mg/L	0.7	3.4	5.9	NA
Alkalinity, mg/L	137.5	77.5	89.0	NA
pH	6.7	6.5	6.5	6.5 – 8.5 [8]
Inorganic Suspended Solids, mg/L [9]	1.4	2.5	5.7	NA
Ultimate Oxygen Demand, mg/L	15.3	21.2	26.4	50 [10]
Dissolved Oxygen, mg/L	2.0	2.0	2.0	7.0 [11]

Notes:

(1) Based on preliminary permit limits for the Phase II expanded facility (average day flow = 9.0 mgd).
(2) Maximum day concentration from June through October.
(3) Average month concentration to Outfall 002 from June through October.
(4) The preliminary future average month nitrate limit for the facility.
(5) Maximum day concentration to Outfall 001 from June through October.
(6) Total Phosphorus concentration does not account for chemical precipitation using alum. Chemical removal will decrease the effluent TP concentration to 0.5 mg/L to meet the expected permit limit.
(7) Average month concentration to either Outfall.
(8) Average month range to either Outfall.
(9) ISS = TSS - VSS.
(10) UOD = 1.5 * BOD + 4.5 * TKN. Daily maximum concentration to Outfall 001.
(11) Daily maximum concentration to either Outfall.

Summary

The results of simulating the existing 4.5-mgd facility (Model 1) and the Phase I upgraded 6.0-mgd facility (Model 2) indicated that the BioWin™ models were configured appropriately to perform a conceptual process design comparison. For Model 1, the simulations provided effluent predictions that reasonably matched the existing facility's historical plant data. The effluent predictions from Model 2 indicated that the new Phase I upgraded facility will operate in a manner to meet the existing permit limits.

The results of simulating the Phase II expansion options (Model 3 and 4) provided general process configurations, tank sizes, and process parameters such as recycle rates. Model 3 was used to determine the expanded treatment capacity if a MBR system were to be installed within the existing oxidation ditches. Effluent quality predictions indicated that the 5.0 mgd MBR system along with an alum addition system for phosphorus removal would allow the facility to meet the preliminary future permit limits. The results of Model 4 simulations provided estimates of the tank sizes required if 5.0 mgd were to be treated with the step-feed BNR activated sludge system along with an alum addition system for phosphorus removal. The simulations indicated that this conventional system would not fit within the existing oxidation ditch volume and that additional secondary clarifier and sand filter capacity would also be required.

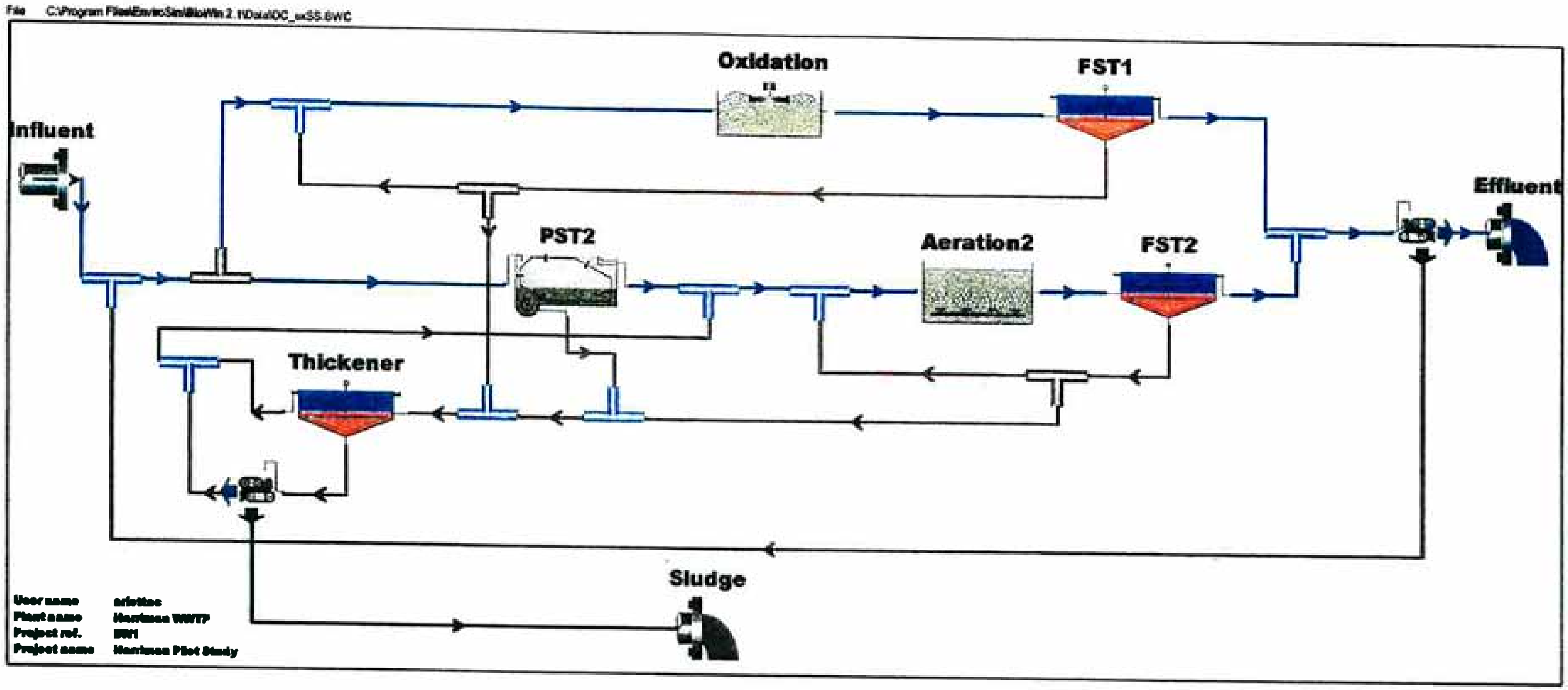


Figure 3-1
BioWin™ Existing 4.5-mgd Facility Model Configuration

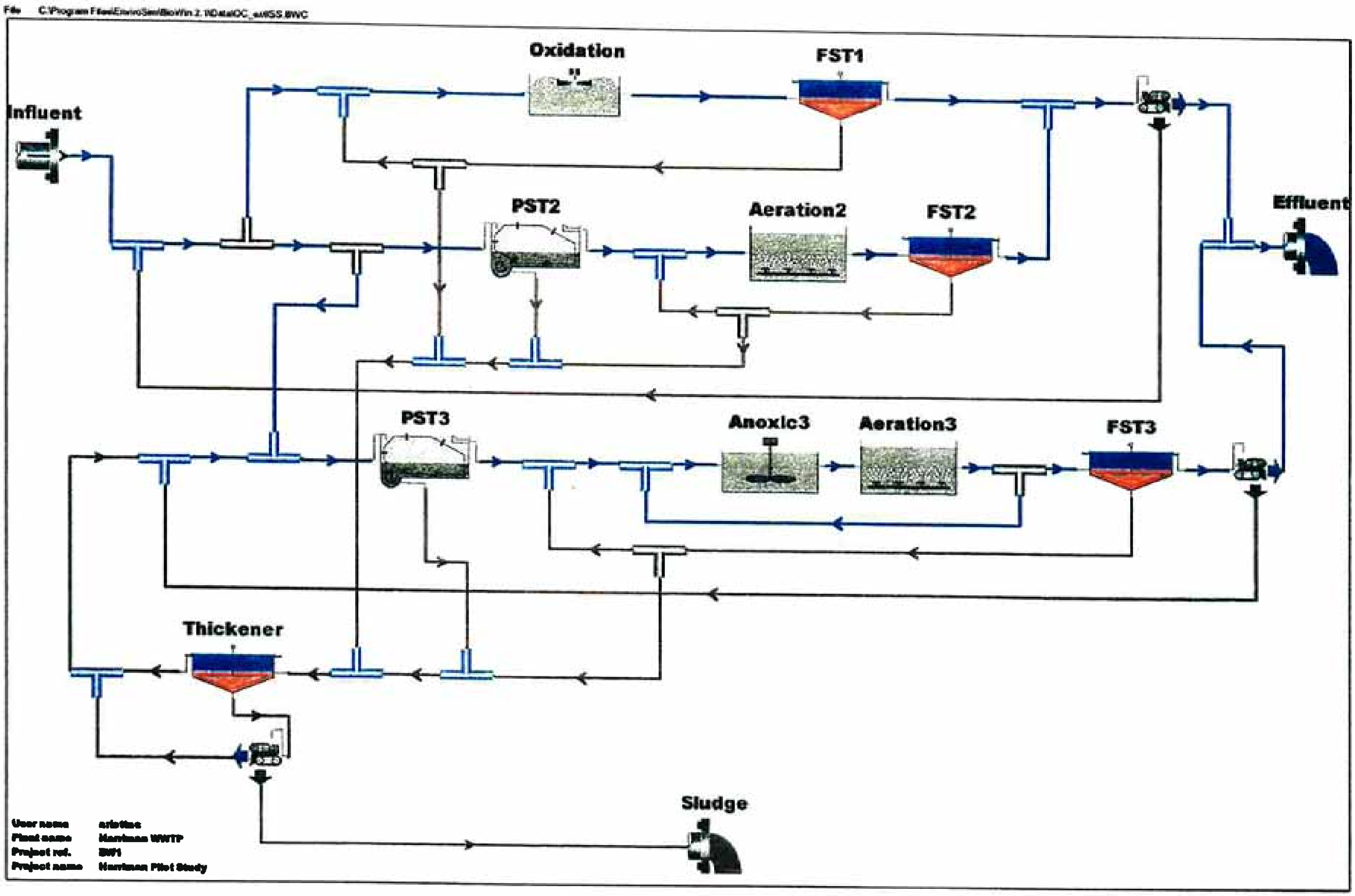


Figure 3-2
BioWin™ Phase I Upgraded 6.0-mgd Facility Model Configuration

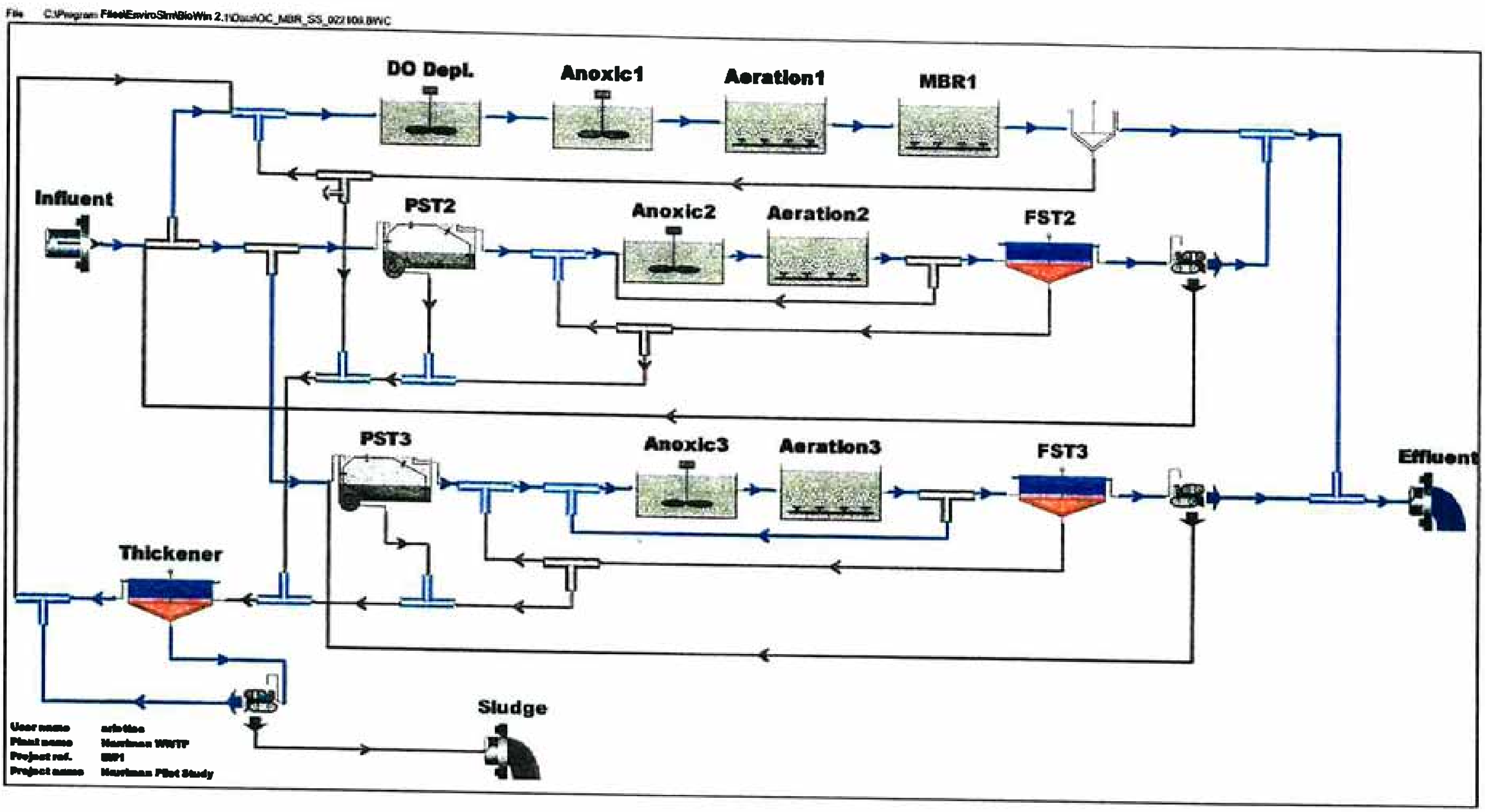


Figure 3-3
BioWin™ Phase II Expanded Facility – MBR Model Configuration

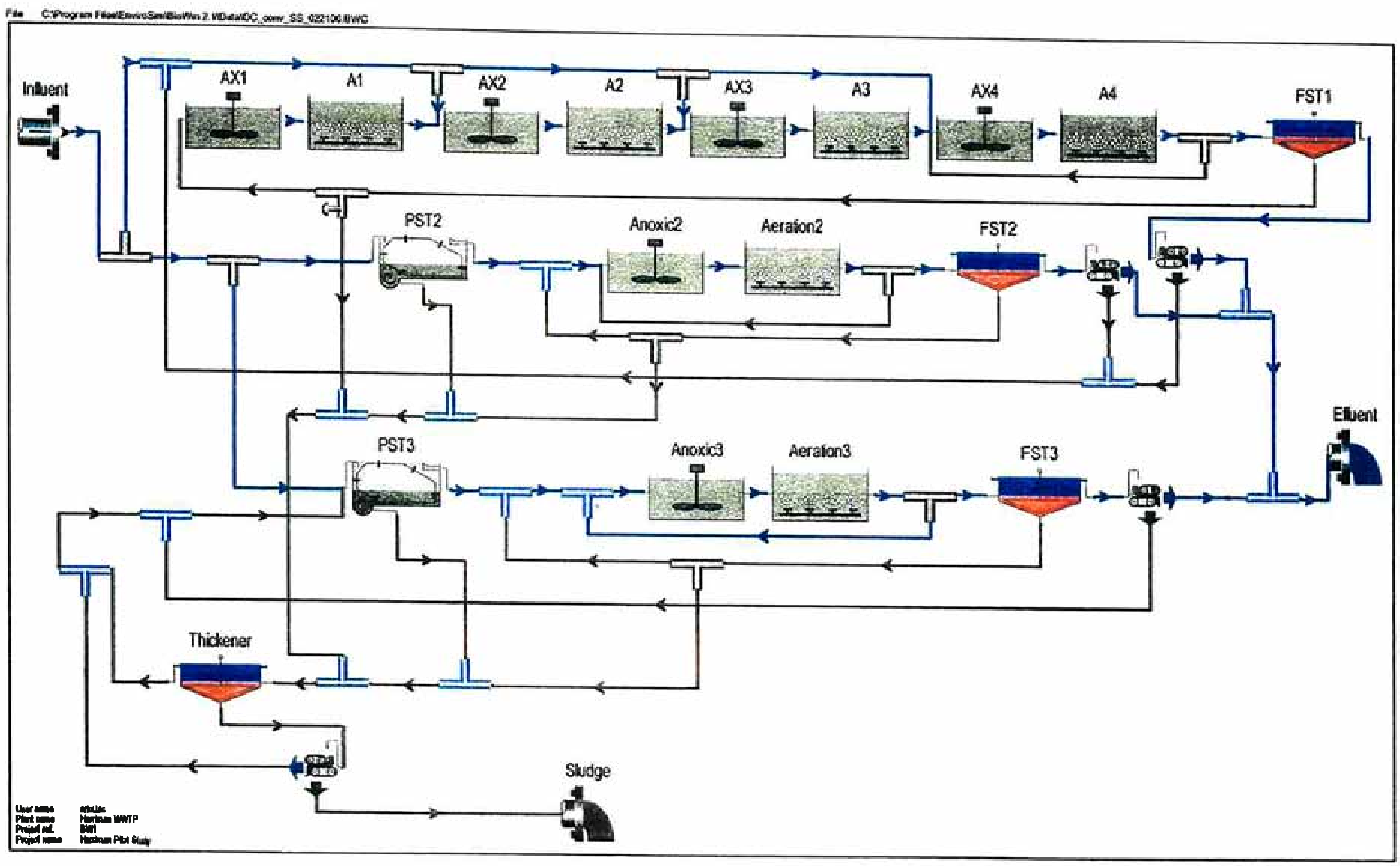
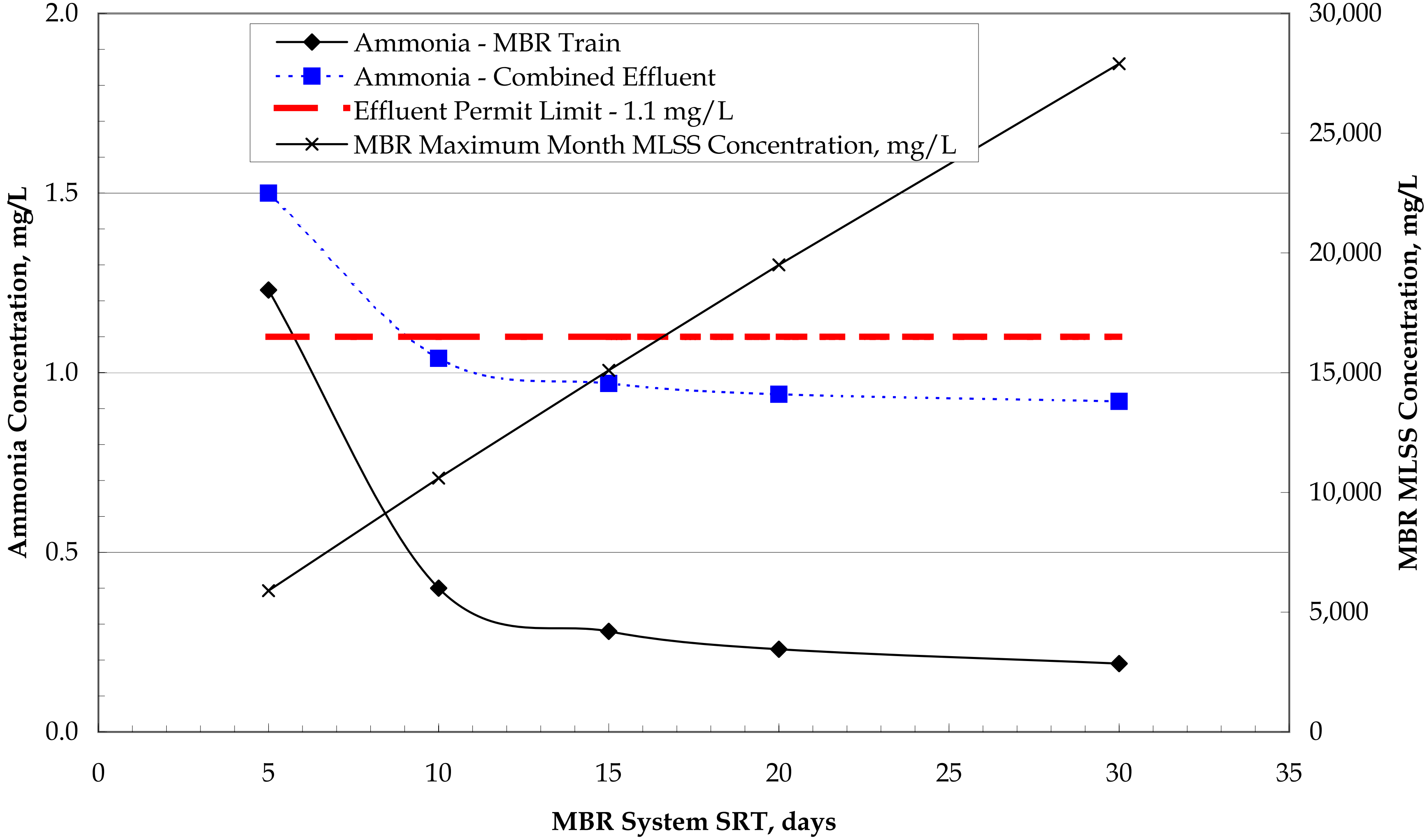


Figure 3-4
BioWin^{TM} Phase II Expanded Facility – Step-Feed Model Configuration

ORANGE COUNTY DEPARTMENT OF ENVIRONMENTAL FACILITIES AND SERVICES

Figure 3-6
MBR Expanded Facility
Predicted Maximum Month Effluent Ammonia Concentrations



Section 4

PHASE II EXPANSION EVALUATION

This section incorporates the results of modeling presented in Section 3 into conceptual design layouts. Further analysis is required before these conceptual ideas can be modified into preliminary designs. This comparison is intended to provide a side by side analysis of two options to expand the facility's treatment capacity.

EXPANDED FACILITY - MBR

A MBR treatment system incorporated into the existing oxidation ditches could increase the average daily treatment capacity to 9.0 mgd. The two existing oxidation ditches (Train 1) have an average daily design capacity of 2.0 mgd and a new MBR treatment train would have a capacity of 5.0 mgd. The new MBR system would include dissolved oxygen (DO) depletion, anoxic, aeration, and membrane zones within the existing oxidation ditch tanks. New aeration and membrane blowers, RAS pumps, anoxic and DO depletions zone mixers, and effluent (permeate) pumps are required for this system. A fine-screen (3-millimeter) incorporated into an upgraded headwork facility would also be required for wastewater entering the MBR train to avoid damaging the membranes with large solids. An alum addition system will be required to meet the anticipated future effluent total phosphorus limit of 0.5 mg/L. Additionally, the capacity of the chlorine contact tanks would need to be increased to accommodate the expanded flow rate.

Layout

The preliminary layout and equipment selection is based on a MBR treatment train average capacity of 5.0 mgd. Wastewater from the upgraded headworks would flow through the existing influent splitter box and then to one of the three treatment trains. Trains 2 and 3 will treat the 2.0 mgd design average flow. Figure 4-1, at the end of this section, presents a conceptual layout of the MBR treatment system incorporated into the existing oxidation ditches. Flow from the existing splitter box would pass through a 3-mm fine screen to remove solids that may damage the membranes. There are two main MBR treatment tanks; one in each of the existing oxidation ditch tanks. Screened and degritted wastewater will enter the MBR system and would be immediately mixed with mixed liquor in the anoxic zones. The volume of each anoxic zone would be approximately 0.40 million gallons (system total of 0.80 million gallons). The contents will be mechanically mixed with mixers that will not add oxygen into the zones. From the anoxic zones, flow will enter the aeration zones. The aeration zones will be kept aerated and mixed by fine bubble diffusers installed in the bottom of the tanks. The volume of each aeration zone is approximately 0.325 million gallons (system total of 0.65 million gallons). Low head, high capacity submerged pumps will convey flow from the aeration zones into the MBR zones. Dimensions of the existing tanks may require pumps in the aeration zones to convey flow to the MBR zones. Several MBR zones (a total of eight) are recommended for maintenance and cleaning flexibility. Providing multiple zones will permit the membranes to be isolated for cleaning or membrane replacement and maximize the firm capacity of the facility when maintenance or chemical cleaning of the membranes is required.

The volume of each of the eight MBR zones will be approximately 0.10 million gallons (total MBR zone volume of 0.80 million gallons). Each MBR zone will contain 15 double stack MBR units (total of 120 double stack units). Coarse bubble diffusers will keep the MBR zones mixed and will provide scour air for the membranes. A channel between the north and south MBR zones in each main tank will be used to convey RAS by gravity to the DO depletion zone at the eastern end of each main tank. Each of the DO depletion zones will be approximately 0.10 million gallons (total volume of 0.20 million gallons). Recycle pumps will convey DO depleted RAS to the anoxic zone at the beginning of the treatment system.

Equipment

The average day flow through the MBR treatment train is 5.0 mgd. The manufacturer's recommended maximum day peaking factor is 2.0, giving a system maximum day capacity of 10 mgd.

Headworks. An upgraded headworks system is required for the entire facility if the treatment capacity is increased in any manner. Additional coarse screens are recommended as well as a new grit removal system. The coarse screens will have the capacity to handle the peak design flow with one unit as standby. A new aerated grit removal system consisting of two parallel tanks will also have capacity to handle the peak design flow. Additionally, a new influent flow meter is recommended. A new flow distribution system may also be required.

Fine Screens. Prior to MBR treatment, the influent flow would pass through a 2 or 3-millimeter (mm) fine screen. Three fine screen units that have a capacity of 5.0 mgd each are recommended for the MBR treatment train. This allows the units to handle the maximum day flow of 10 mgd with one unit as standby.

Anoxic and DO Depletion Zone Mixers. Mixers in the anoxic and DO depletion zones are required to keep the contents mixed. Mixing may be accomplished with paddle units, floating units, or with strategically placed pumps. For this conceptual evaluation, floating units are proposed. Each of the anoxic zones and DO depletion zones will require one 7.5-horsepower (hp) floating mixer.

Process Air Equipment. Based on model simulation results, approximately 11,700 scfm of air is required for process treatment during maximum day conditions. Each of the 120 membrane units requires about 99 scfm of air for scouring for a total of 11,880 scfm. Therefore, the process air will be provided in the MBR zones with the designated scour air blowers. Considering a water depth of 13 feet, the total blower capacity for the coarse bubble diffused air system is 675 hp. Four 250 hp, multi-stage blowers are recommended to provide the maximum demand with one unit as standby. The blowers would be manifold together with Motor actuated valves and air flow meters to provide operational flexibility.

MBR Zone Equipment. Four 15-hp submerged pumps are required to convey flow (influent plus recycle) to the MBR zones. Each pump will have a capacity of 15 mgd giving a total of 60 mgd – the maximum influent flow rate (10 mgd) plus the maximum recycle flow rate (50 mgd: 500 percent of 10 mgd) through the MBR system. The Enviroquip/Kubota EK400 unit was used to determine the size of the MBR zones in the new treatment train as presented in Section 3. This unit is a double stack of membranes that makes better use of the deep oxidation ditches than a single stack unit. The existing side water depth in the oxidation ditches is approximately 13 ft and will remain the same for this option. Approximately 120 of these units are required to treat the average flow of 5.0 mgd at the design influent wastewater temperature of 12.5 ^{o}C. Cold temperatures decrease the membrane flux and must be considered in the design of MBR systems. Approximately 2,700 diffusers are required for all the MBR zones proposed, evenly distributed under the membranes. Low-suction head permeate pumps are required to draw effluent from the membranes. Ten 1.0-mgd (10 hp each) pumps are recommended for the eight MBR basins to provide the maximum capacity of 10 mgd with two pumps as standby.

Return Activated Sludge (RAS) Pumps. Conveying flow from the DO depletion zone to the anoxic zone would be accomplished with non-clog, centrifugal RAS pumps. The MBR system typically requires RAS rates between 200 and 500 percent; therefore the pumps will be provided with variable speed drives. The maximum day flow rate to the MBR system is 10 mgd making the maximum RAS flow rate 50 mgd (500 percent of 10 mgd). The average day flow rate of 5.0 mgd has a typical operating RAS flow rate of 15 mgd (300 percent of 5.0 mgd based on BioWin™ simulations). Five 25-hp RAS pumps that have a capacity of 12.5 mgd each are recommended to provide the maximum RAS flow with one pump as standby.

Train 2 Modifications. Anoxic zones with new mixers and internal recycle pumps will be required for this treatment train to produce an effluent with a lower nitrate concentration. The anoxic zone volume required is approximately 0.1 million gallons. This zone can be created with the installation of a new wall. Without this modification, the combined effluent will not meet the nitrate effluent goal. Similar to Train 3 (currently under construction), 5 hp mixers and pumps will be required. The same modifications are required for the step-feed BNR process.

Chlorine Contact Tank. The capacity of the existing chlorine contact tanks would need to be increased to accommodate the expanded facility flow rate. The existing tank on the east side of the site that serves the existing Trains 1 and 2 has an average capacity of 4.0 mgd. The expanded average capacity of Trains 1 and 2 would be 7.0 mgd after Phase II construction; therefore an additional 3.0 mgd is required. This additional capacity could be provided with the construction of a parallel chlorine contact tank next to the existing tank. To accomplish this, the existing ultraviolet light disinfection building could be demolished since it is no longer used at the facility. The same modifications are required for the step-feed BNR process.

Electrical and Instrumentation and Controls. Upgraded electrical systems will be required to accommodate the power requirements of the new equipment. Further evaluation of the existing electrical system is required prior to final design. Likewise, coordinated instrumentation and controls are required for the new equipment. Similar modifications are required for the step-feed BNR process.

Site Work and Yard Piping. Site work will be required to demolish the existing UV building to allow space for a new chlorine contact tank and for a new fine screen building near the headworks. The major yard piping modifications include new piping from the existing influent splitter box to the new fine screen system and new piping from the MBR system to the chlorine contact tanks.

EXPANDED FACILITY – CONVENTIONAL TREATMENT

As described in Section 2 and modeled in Section 3, a conventional (step-feed BNR) activated sludge treatment system could increase the average day treatment capacity to 9.0 mgd. The new system would have an average day capacity of 5.0 mgd – comparable to the previously discussed MBR treatment system option. The general layout and equipment estimates are based on the assumption that there is physical space for this process at the existing facility. While retrofitting the existing oxidation ditches and creative use of remaining land may provide enough space; serious limitations include maintenaning plant operations during construction, significant excavation requirements, and practicality of this type of construction in the limited space available. The evaluation in this section is provided to demonstrate the components required to conventionally gain the same increase in treatment capacity as the MBR system.

Layout

The preliminary layout and equipment selection is based on an average month step-feed system capacity of 5.0 mgd. Wastewater from the upgraded headworks would flow through the existing influent splitter box and then to one of the three treatment trains. Trains 2 and 3 will each continue to treat an average month flow of 2.0 mgd (design flow rates for these systems). Therefore, the average flow rate to the new step-feed system (Train 1) would be 5.0 mgd (similar to the previously discussed MBR system). Figure 4-2, at the end of this section, presents a conceptual layout of the step-feed BNR treatment system.

The influent to the step-feed system is evenly distributed to anoxic zones 2, 3, and 4. The first anoxic zone is dedicated to denitrifying the RAS from the final settling tanks. Each anoxic zone is followed by an aeration zone. Table 4-1 presents the approximate volumes of each new treatment zone in the step-feed process as well as the total anoxic/aerobic volume required to treat the average month flow of 5.0 mgd. The anoxic zones are mixed with floating mixers that do not add dissolved oxygen. From each anoxic zone, flow enters the aeration zone. The aeration zones are kept aerated and mixed by fine bubble diffusers installed in the bottom of the tanks. Final settling tanks (FSTs) are necessary to settle the activated sludge from the fourth aeration zone. Recycle pumps are used to convey RAS from the final settling tank to the first anoxic zone at the beginning of the treatment system. Sand filters are required to meet the effluent TSS permit limit. Effluent from the FSTs would combine with effluent from Trains 2 and 3.

Table 4-1
Step-Feed System Anoxic/Aeration Volumes

Step-Feed Zones	*Volume per Sub-Train, million gallons*	*Total Volume, million gallons*
Anoxic Zone 1	0.05	0.10
Aeration Zone 1	0.20	0.40
Anoxic Zone 2	0.10	0.20
Aeration Zone 2	0.25	0.50
Anoxic Zone 3	0.25	0.50
Aeration Zone 3	0.35	0.70
Anoxic Zone 4	0.35	0.70
Aeration Zone 4	0.65	1.3
Total	**2.2**	**4.4**

In order to increase the volume of the oxidation ditches to 4.4 million gallons, several major construction activities must occur. The bottom of the decant and integral secondary clarifier tanks must be demolished and excavation for a new bottom that matches the elevation of the oxidation ditches. In addition, the internal walls must also be removed. To further increase the volume, the outside walls must be raised 5.55 feet. Structural and/or geotechnical analyses must be completed prior to finalizing the design for this system to determine the feasibility of performing the structural changes as required. Ultimately these analyses may conclude that the required construction activities are neither practical nor cost effective.

Equipment

Headworks. The headworks upgrades previously discussed, except for the fine screen, are also required for this option since the capacity increase is the same as a MBR expanded facility. Additionally, if the existing oxidation ditches are used for the step-feed process and the wall height can be raised by approximately 5.55 feet, the hydraulic grade line through the treatment train would not allow for gravity flow from the headworks to the aeration tanks. It is estimated that two duty 25 hp pumps will be required (with an additional standby pump) for this option and hydraulic analyses during design are required.

Anoxic Mixers. Mixers in the anoxic zone are required to keep the contents sufficiently mixed for the denitrification process. Similar to the MBR treatment train option, floating units are proposed for the anoxic zones. Each of the eight anoxic zones will require one 5-hp floating mixer.

Process Air Equipment. Based on the model simulation results, approximately 10,100 scfm of air is required for process treatment during maximum day conditions to maintain the desired DO concentration of 2.0 mg/L. To provide this much air, with an estimated water depth of 18.55 feet, the total blower capacity required is approximately 600 hp. Multiple blowers are recommended to provide appropriate quantities of air to each of the eight aeration zones. Supplying four 200-hp multi-stage centrifugal blowers would provide enough capacity and flexibility to meet the above operating conditions with one blower as standby. Air flow meters and motor actuated valves are required to control the amount of air to each aeration zone.

Final Settling Tank Components. Based on an average overflow rate of 300 gpd per square foot of clarifier surface area, approximately 16,700 square feet of clarifier area will be required for this option. There is not enough space at the site to provide traditional circular secondary clarifiers. Rectangular, stacked clarifiers could be incorporated into the site, as shown on Figure 4-2. Typical components of the FST include a scum collection system, overflow weirs, and RAS pumps (discussed separately). It is assumed that these clarifiers would be at least 30 feet deep to accommodate the stacked design.

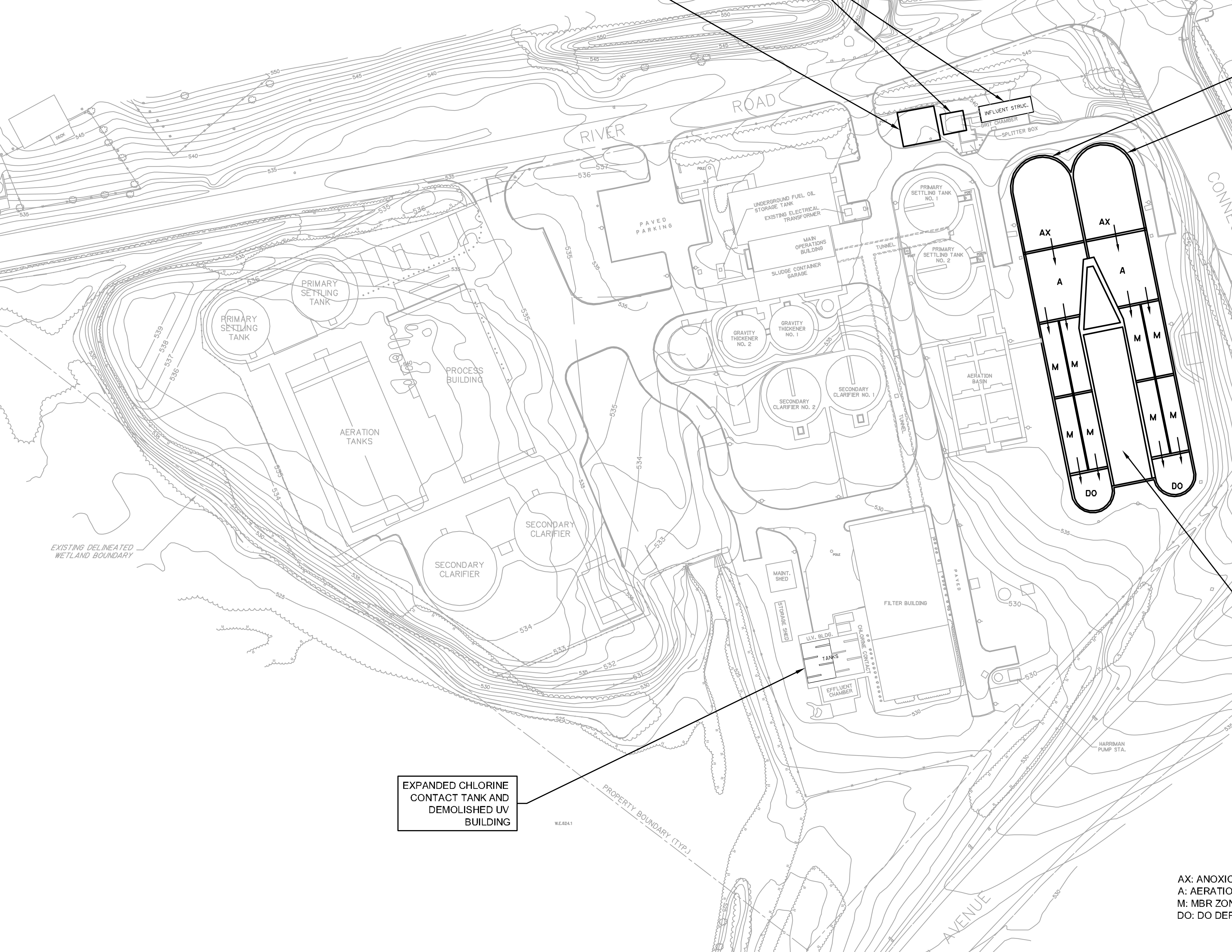
Return Activated Sludge (RAS) Pumps. Conveying return sludge flow from the FST to the anoxic zone would be accomplished with non-clog centrifugal RAS pumps. The step-feed system typically requires RAS rates between 50 and 150 percent; therefore the pumps will be provided with variable speed drives. The maximum month flow rate to the conventional system is 7.4 mgd making the maximum RAS flow rate 11 mgd (150 percent of 7.4 mgd). The average day flow rate of 5.0 mgd has a typical operating RAS flow rate of 2.5 mgd (50 percent of 5.0 mgd). Three 10-hp RAS pumps (with one as standby) that have a capacity of 7.5 mgd each are recommended to provide operating flexibility for the system.

Train 2 Modifications. Anoxic zones with new mixers and internal recycle pumps will be required for this treatment train to produce an effluent with a lower nitrate concentration. The anoxic zone volume required is approximately 0.1 million gallons. This zone can be created with the installation of a new wall. Without this modification, the combined effluent will not meet the nitrate effluent goal. Similar to Train 3 (currently under construction), 5 hp mixers and pumps will be required. The same modifications are required for the MBR process.

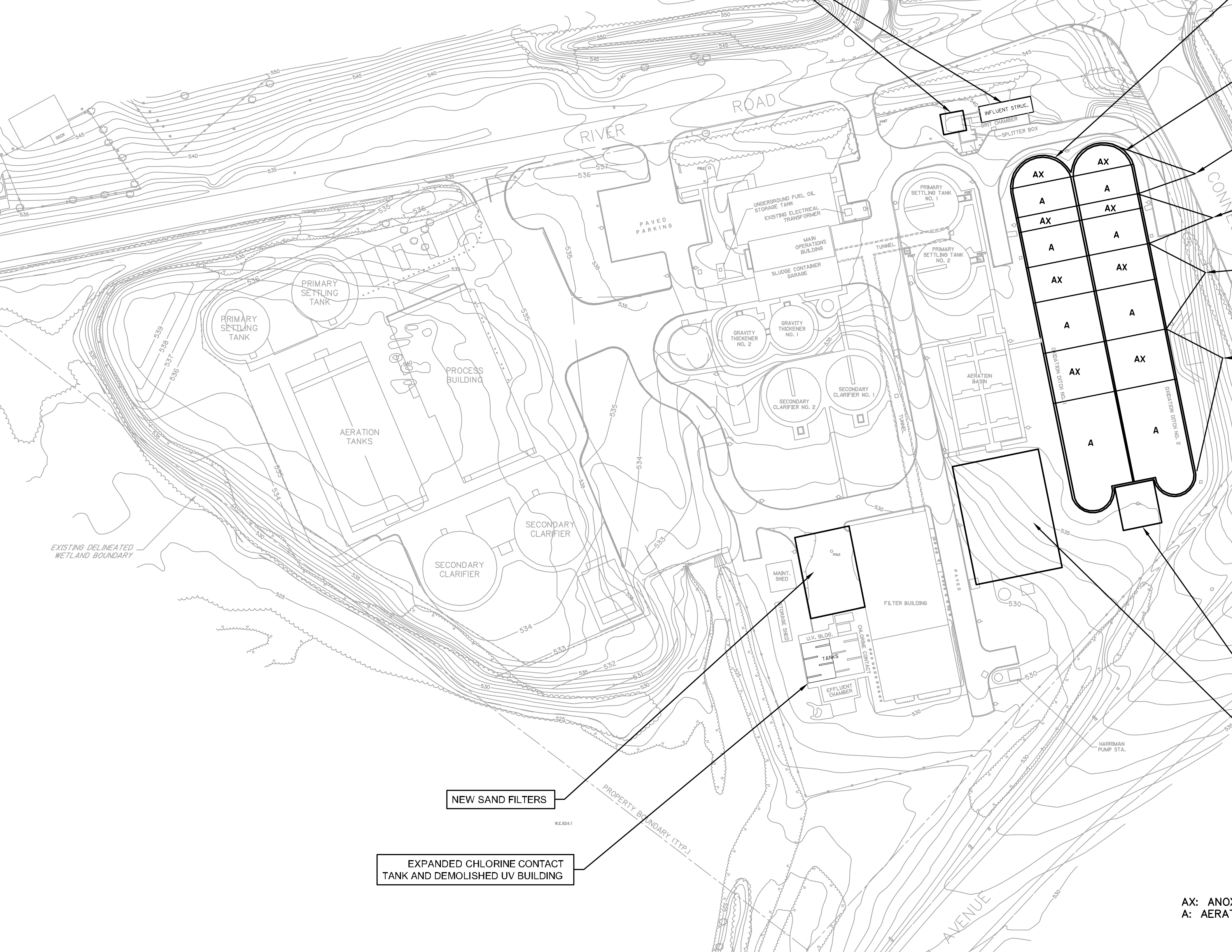
Upgraded and New Sand Filters. Additional sand filter capacity is required to treat the additional 3.0-mgd of flow through the facility. The existing sand filters designed for Trains 1 and 2 have an average capacity of 4.0 mgd. An additional 3.0 mgd of filter capacity is required for the step-feed system. Mechanical upgrades to the existing filters and the addition of two more units could provide the additional required capacity. It is expected that the new sand filters will have a total power requirement of approximately 20 hp (similar to the Train 3 sand filters currently under construction).

Chlorine Contact Tank, Electrical and Instrumentation and Controls. The chlorine contact tank upgrades previously discussed are also required for this option since the capacity increase is the same as a MBR expanded facility. Upgraded electrical systems will be required to accommodate the power requirements of the new equipment. Further evaluation of the existing electrical system is recommended prior to final design. Likewise, coordinated instrumentation and controls are required for new equipment.

Site Work and Yard Piping. Site work will be required for the new stacked secondary clarifier tanks, new sand filters, new equipment building, and to demolish the existing UV building to allow space for a new chlorine contact tank. The major yard piping modifications include new piping from the new step-feed system to the new stacked secondary clarifiers, from the new clarifiers to the existing and new sand filters, as well as additional piping from the sand filters to the new chlorine contact tank.



EXPANDED CHLORINE CONTACT TANK AND DEMOLISHED UV BUILDING
INFLUENT STRUC.
GRIT CHAMBER
SPLITTER BOX
AX
A
M
DO
AX: ANOXIC
A: AERATIO
M: MBR ZON
DO: DO DEF
RIVER ROAD
PAVED PARKING
UNDERGROUND FUEL OIL STORAGE TANK
EXISTING ELECTRICAL TRANSFORMER
MAIN OPERATIONS BUILDING
SLUDGE CONTAINER GARAGE
PRIMARY SETTLING TANK NO. 1
PRIMARY SETTLING TANK NO. 2
TUNNEL
GRAVITY THICKENER NO. 1
GRAVITY THICKENER NO. 2
SECONDARY CLARIFIER NO. 1
SECONDARY CLARIFIER NO. 2
AERATION BASIN
PAVED
FILTER BUILDING
CHLORINE CONTACT
TANKS
U.V. BLDG.
EFFLUENT CHAMBER
MAINT. SHED
STORAGE SHED
HARRIMAN PUMP STA.
PRIMARY SETTLING TANK
PROCESS BUILDING
AERATION TANKS
SECONDARY CLARIFIER
EXISTING DELINEATED WETLAND BOUNDARY
PROPERTY BOUNDARY (TYP.)
AVENUE



NEW SAND FILTERS
EXPANDED CHLORINE CONTACT TANK AND DEMOLISHED UV BUILDING
INFLUENT STRUC.
GRIT CHAMBER
SPLITTER BOX
OXIDATION DITCH NO. 1
OXIDATION DITCH NO. 2
AX
A
PRIMARY SETTLING TANK NO. 1
PRIMARY SETTLING TANK NO. 2
AERATION BASIN
UNDERGROUND FUEL OIL STORAGE TANK
EXISTING ELECTRICAL TRANSFORMER
MAIN OPERATIONS BUILDING
SLUDGE CONTAINER GARAGE
GRAVITY THICKENER NO. 1
GRAVITY THICKENER NO. 2
SECONDARY CLARIFIER NO. 1
SECONDARY CLARIFIER NO. 2
TUNNEL
FILTER BUILDING
CHLORINE CONTACT
TANKS
U.V. BLDG.
EFFLUENT CHAMBER
MAINT. SHED
STORAGE SHED
PAVED
PAVED PARKING
PROCESS BUILDING
AERATION TANKS
PRIMARY SETTLING TANK
SECONDARY CLARIFIER
HARRIMAN PUMP STA.
EXISTING DELINEATED WETLAND BOUNDARY
PROPERTY BOUNDARY (TYP.)
RIVER ROAD
AVENUE
AX: ANOX
A: AERAT

Section 5

SUMMARY AND RECOMMENDATIONS

This section presents the energy, environmental, and economic analyses for the Phase II expansion options.

ENERGY ANALYSIS

The major energy drawing components of the existing oxidation system include aerators, turbines and RAS pumps. The total power draw for the system is 730 hp (aerators: 200 hp, turbines: 500 hp, RAS pumps: 30 hp). The 2.0 mgd (1,389 gpm) oxidation system uses approximately 13,160 kilowatt-hours/day (kWh/d) or 9.47 kWh/gpm total. The power used based on the mass of BOD removed (BOD_r) is 2.42 kWh/BOD_r (actual oxidation ditch effluent BOD loads were not available so this power consumption value is based on the reported effluent BOD values from the existing facility). The following analyses present the estimated changes required for an MBR system expansion and a conventional treatment expansion. The values presented are in terms of the net increase or decrease in power consumption and treatment capacity.

MBR Expanded Facility. The MBR expanded facility is anticipated to increase the total amount of energy used which is not surprising since an increase in treatment capacity will typically result in higher power consumption. This increase will likely be more significant compared to an expansion using conventional technology because of the equipment required and mode operation of the MBR system (however, as discussed later in this section, the MBR facility is expected to out-perform the conventional system on an environmental basis).

The membrane air scour requirements for the MBR system are constant and generally higher than the air required for biological treatment (for the Harriman WWTP), resulting in an average blower horsepower higher than needed for conventional treatment. Conventional treatment can be optimized by decreasing the air during low-flow time periods (i.e. during the night). This is not an option with MBRs because of the air scour requirements. Table 5-1 presents a summary of the MBR system's power requirements; total, average month, and gravity operation of the MBR expanded facility. The total power capacity does not include spare pieces of equipment.

The total net power capacity increase of approximately 325 hp will necessitate electrical modifications to the facility. The capital cost estimates for the new equipment include estimates of required electrical modifications; however, further analysis of the facility's electrical situation is required during the design phase as more extensive modifications may be necessary. The energy demand from the new MBR treatment train assumes that all the new equipment will run at the average month conditions and includes a credit for the decommissioned oxidation ditch aerators, turbines and pumps. The net average month increase of 122 hp equals 2,200 kWh/d. The increased energy used based on the average month capacity of 5.0 mgd (3,472 gpm) is 0.63 kWh/gpm. At a cost of $0.14/kWh, the average month capacity of 5.0 mgd will cost the facility an increase of approximately $0.97/gpm of MBR treated water ($112,000 net increase per year). The average power increase used based on the mass of BOD removed (BOD_r) is 0.28 kWh/lb BOD_r. If there are times when the MBR system can be operated by gravity (sufficient hydraulic head available), the estimated monthly power consumption decreases by 40 hp. A hydraulic analysis of the facility was not performed as part of this project and therefore the more conservative monthly power estimates are used for comparison to the step-feed system.

Table 5-1
MBR Expanded Facility Equipment Power Requirements

Equipment	***Total Capacity, hp***	***Average Month, hp***	***Gravity Operation, hp***
Fine Screen	15	7.5	7.5
Blowers	750	675	675
RAS Pumps	100	50	50
Aeration Pumps	60	30	30
Anoxic Zone Mixers	15	15	15
DO Depletion Zone Mixers	15	15	15
Permeate Pumps	80	40	0
Train 2 Anoxic Mixers	10	10	10
Train 2 Internal Recycle (IR) Pumps	10	10	10
Subtotal	**1,055**	**852**	**842**
Existing Decommissioned Aerators (Credit)	*(200)*	*(200)*	*(200)*
Existing Decommissioned Turbines (Credit)	*(500)*	*(500)*	*(500)*
Existing Decommissioned RAS Pumps (Credit)	*(30)*	*(30)*	*(30)*
Total Net Increase	**325**	**122**	**82**

Step-Feed Expanded Facility. Table 5-2 presents a summary of the power requirements of the new equipment required for the step-feed expanded facility (the technology to which the MBR system was compared for this feasibility study). The air requirement is less than for the MBR expanded facility as a result of the ability to optimize the system during low-flow time periods.

The energy demand from the new step-feed treatment train assumes that all the new equipment will run at the average month conditions and includes a credit for the decommissioned oxidation ditch aerators, turbines and pumps. A new fine bubble aeration system is expected to be far more efficient than the existing oxidation system aerators and turbines and subsequently to utilize less energy than the existing system even though treating more capacity. The net average month decrease of 58 hp equals 1,029 kilowatt-hours/day (kWh/d) saved. The energy saved based on the average month capacity of 5.0 mgd (3,472 gpm) is 0.30 kWh/gpm. At a cost of $0.14/kWh, the average month capacity of 5.0 mgd will save the facility approximately $0.04 per gpm of step-feed treated water (for a net credit of $53,000 per year). The average power reduction used based on the mass of BOD removed (BOD_r) is 0.13 kWh/lb BOD_r.

Table 5-2
Step-Feed Expanded Facility Equipment Power Requirements

Equipment	*Total Capacity, hp*	*Average Month, hp*
Influent Pumps	50	20
Aeration Blowers	600	500
RAS Pumps	20	20
Anoxic Zone Mixers	40	40
Train 2 Anoxic Zone Mixers	10	10
Train 2 IR Pumps	10	10
New Secondary Clarifier Equipment	2.5	2.5
New Sand Filter Equipment	20	20
Subtotal	**773**	**670**
Existing Decommissioned Aerators (Credit)	*(200)*	*(200)*
Existing Decommissioned Turbines (Credit)	*(500)*	*(500)*
Existing Decommissioned RAS Pumps (Credit)	*(30)*	*(30)*
Total Net Increase	**43**	**-58**

Air Scour and Oxygen Transfer Efficiency

The majority of the air required for the MBR treatment train is for membrane air scour. The manufacturer recommends 99 standard cubic feet per minute (SCFM) per unit conceptually proposed for this project (Enviroquip EK400). With 120 units, the constant air required is approximately 11,880 SCFM. Under cold temperatures (most demanding air conditions) and a water depth of 13 ft, this translates into an approximate blower requirement of 675 hp. The estimated air required for biological demands (11,700 SCFM) results in a cold temperature blower requirement of 665 hp. During less demanding conditions (i.e. decreased wastewater flow rate, decreased biological demand, increased water temperature), the air required for biological treatment would be reduced. For conceptual design purposes, the constant blower capacity (675 hp) required for air scour is also enough for the maximum day biological demand. It appears advantageous, for this conceptual design, to combine the aeration volume with the MBR volume so that excess air is not wasted for mixing of separate aeration zones. Separate aerobic/MBR zones are still recommended so that the facility has operational flexibility (i.e. zones can be off-line without taking the entire system or train off-line).

Compared to the step-feed train, the MBR train requires more oxygen because of the air scour as well as the depth of the water. Deeper tanks will require less blower power because the oxygen transfer efficiency (OTE) is higher at deeper depths. The estimated OTE for the MBR system is approximately 10% based on the diffuser submergence of 12.25 ft. Increasing the water depth for the step-feed system (diffuser submergence of 17.8 ft) increases the OTE to approximately 14.6%. This difference is due to the difference in water depths since the two systems were evaluated to provide comparable biological treatment. The increased OTE for the step-feed system results in a maximum day, cold temperature blower power requirement of 585 hp; 90 hp less than the constant blower power required for the MBR system. During average day conditions, it is estimated that only 500 hp of blower capacity will be required for biological treatment to maintain mixing for the step-feed system.

ENVIRONMENTAL ANALYSIS

Environmentally, the MBR system produces a very clean effluent without the use of separate clarifiers or filters. Table 5-3 presents a comparison of the MBR and step-feed trains modeled for the facility.

Table 5-3

Phase II Expanded Facility Train 1 Comparison –
MBR and Step-Feed Maximum Month Steady State Effluent Characteristics

	MBR, 15 day SRT	***Step-Feed***	***Difference***
Total Suspended Solids, mg/L	3.0	5.4	(2.4)
Ammonia, mg/L	0.28	0.69	(0.41)
Nitrate, mg/L	8.0	6.8	1.2
Total Kjeldahl Nitrogen, mg/L	2.8	3.4	(0.6)
Total Nitrogen, mg/L	10.79	10.24	0.5
Biological Oxygen Demand, mg/L	1.34	1.68	(0.34)
Total Phosphorus, mg/L (without chemicals)	3.0	4.0	(1.0)
Alkalinity, mg/L	77.0	82.5	(5.5)
Ultimate Oxygen Demand, mg/L	14.52	17.91	(3.39)

Based on the maximum month effluent characteristics for the two proposed trains, the MBR out-performs the step-feed system for the majority of the effluent parameters. The differences are not extremely large but the effluent from the MBR system would require less chlorine to disinfect and less coagulant to remove phosphorus to the desired level. The potential additional annual chemical costs for the MBR and step-feed expanded facilities are $89,200 and $111,000, respectively (as presented in the Economic Analysis below).

MBR Chemical Cleaning

The manufacturer indicates that typical cleaning frequency for membranes used in a municipal wastewater installation is every six months. Chemical cleaning was performed twice during the six-month pilot study – primarily so that the evaluation of different operating SRTs was not affected by fouled membranes. Chemical cleaning, with a dilute chlorine bleach solution, restores the membranes' capacity for filtration to 'near-new' conditions and can be performed many times over the life of a membrane. It is estimated that for the MBR conceptual design, approximately 985 gallons of 12.5% sodium hypochlorite would be required every six months to clean all the membranes.

Sludge Volume

The two systems evaluated (MBR and step-feed) produce similar quantities of waste sludge, according to the modeling performed. This is reasonable since the two systems were both modeled with an operating SRT of 15 days. The average MLSS concentration in the MBR system was 9,600 mg/L and the weighted average MLSS concentration in the step-feed system was 6,300 mg/L. However, the MBR can be operated at higher MLSS concentrations (higher SRTs) once the process is established. Higher MLSS concentrations will result in lower wasting rates and therefore less sludge processing.

Reduced Pathogen Risk

The MBR system will produce an effluent with significantly fewer pathogen indicators (Coliforms, *Giardia lamblia*, and *Cryptosporidium parvum*) than conventional wastewater treatment (i.e. aeration, clarification and sand filtration). The pilot study indicated average fecal and total Coliform removal of 2- and 3-log, respectively. All effluent samples that were analyzed for *Cryptosporidium parvum* and *Giardia lamblia* during the pilot study were below the detection limits. Due to the lower counts of fecal Coliforms in the MBR effluent, it is expected that the MBR system will require a smaller disinfection dose than a comparable conventional system (i.e. step feed).

ECONOMIC ANALYSIS

MBR Estimated Planning Level Capital and Operating Costs

Estimated costs are presented in February 2006 dollars (Engineering News Record (ENR) Index 7688.9). Present value is a method used to compare different design scenarios. For this analysis, the annual costs for the MBR may be different than other alternatives. Therefore, using a present value enables a common basis comparison in terms of cost.

Capital Cost. Table 5-4 presents a breakdown of the estimated planning level capital costs for the MBR facility. The estimated capital cost to treat the average day flow of 5.0 mgd (net gain of 3.0 mgd) through the MBR treatment train is $4.99 per gallon ($24,950,000/5,000,000 gpd).

Table 5-4

MBR Expanded Facility Planning Level Capital Cost Estimate

Item	***Capital Cost***
Upgraded Headworks	$1,369,000
New Fine Screen Facility	$1,840,000
MBR System	$12,099,000
New Chlorine Contact Tank	$742,000
Sludge Handling Allowance	$1,209,000
Instrumentation & Controls	$605,000
Yard Piping/Site Work	$1,330,000
Subtotal	**$19,194,000**
Contingency, 30 percent	$5,758,000
Capital Cost	**$24,950,000**

Annual and Life Cycle Costs. Table 5-5 presents the planning level annual cost estimate for the MBR facility. Including the net additional power, the estimated annual operating cost is $369,100. These costs are in addition to the existing annual operating costs of the facility.

Table 5-5

MBR Expanded Facility Planning Level Annual Operating Cost Estimate

Item	***Annual Cost***
Additional Average Power	$112,000
Additional Labor	$108,000
Membrane Replacement	$60,000
Additional Average Chemical	$89,100
Additional Annual Operating Cost	**$369,100**

Based on a 20 year life cycle and an interest rate of 4.9 percent, the present value of the estimated annual operating costs is $4,640,000. Combining this cost with the capital cost gives a total present value of $29,590,000. Therefore, the 20-year total present value cost to treat 5.0 mgd (net gain of 3.0 mgd) through the MBR treatment train is $5.92 per gallon ($29,590,000/5,000,000 gpd). The additional annual power cost considers the new equipment required as well as a credit for the decommissioned oxidation ditch equipment. The new equipment is assumed to be operating at average month conditions and the energy cost assumption is $0.14 per kilowatt-hours (kWh). The additional annual labor cost assumes that two new full-time operators will be required, at a rate of $45,000 per year plus 20 percent for benefits. Membrane replacement costs are estimated at one percent of the MBR system capital costs, per manufacturer recommendation for planning purposes. Additional estimated annual chemical costs include the alum required for phosphorus removal.

Step-Feed BNR Estimated Planning Level Capital and Operating Costs

Capital Cost. Table 5-6 presents a breakdown of the estimated planning level capital costs for the step-feed facility. The contingency cost for the step-feed expanded facility is greater than the MBR expanded facility because of the difficulties expected with construction. The stacked clarifiers and new sand filters would be constructed next to existing tanks and would require a significant amount of sheeting and protection. Additionally, geotechnical information is required prior to final design of any additional tanks. The capital cost to treat 5.0 mgd (net gain of 3.0 mgd) through the step-feed treatment train is $6.86 per gallon ($34,311,000/5,000,000 gpd). However, as discussed in Section 4, increasing the water depth for the step-feed option may not be practical for this facility and could be cost prohibitive (on a capital cost basis).

Table 5-6
Step-Feed Expanded Facility Planning Level Capital Cost Estimate

Item	*Capital Cost*
Headworks	$1,490,000
Step-Feed BNR System	$5,914,000
Stacked Final Settling Tanks	$8,580,000
Upgraded and New Sand Filters	$3,309,000
Chlorine Contact Tank	$742,000
Sludge Handling Allowance	$1,209,000
Instrumentation & Controls	$605,000
Yard Piping/Site Work	$1,814,000
Subtotal	**$23,663,000**
Contingency, 45 percent	$10,648,000
Capital Cost	**$34,311,000**

Annual and Life Cycle Costs. Table 5-7 presents the planning level annual cost estimate for the step-feed facility. These costs are in addition to the existing annual operating costs of the facility.

Table 5-7
Step-Feed Expanded Facility Planning Level Annual Operating Cost Estimate

Item	*Annual Cost*
Additional Average Month Power	$-53,000
Additional Labor	$108,000
Additional Chemical	$112,000
Additional Annual Operating Cost	**$167,000**

Based on a 20 year life cycle and an interest rate of 4.9 percent, the present value of the estimated annual costs is $2,099,000. Combining this cost with the capital cost gives a total present value of approximately

$36,410,000. The total 20-year present value cost to treat 5.0 mgd (net gain of 3.0 mgd) through the step-feed treatment train is $7.28 per gallon ($36,410,000/5,000,000 gpd). The additional annual power cost considers the new equipment required as well as a credit for the oxidation ditch equipment that would be decommissioned. The power cost is based on operating the new equipment at the estimated average month capacity and an energy cost of $0.14 per kWh. The additional annual labor cost assumes that two new full-time operators will be required. Additional annual chemical costs are estimates for the expanded facility including the alum required for phosphorus removal.

OTHER ISSUES

Barriers to Technology Acceptance

The largest barrier to acceptance of MBR technology within New York State is the lack of knowledge about the technology. Numerous individuals and organizations will have to be educated before there is acceptance of the technology including the New York State Department of Environmental Conservation (NYSDEC) (which has multiple regional offices in addition to its state office), county health departments, and the New York City Department of Environmental Protection (NYCDEP) (which has jurisdiction over a large upstate watershed). This education process will likely extend the time period for project review and approval, which is difficult for municipalities and developers who are often working on tight schedules. To date, implementation of MBR technology has been limited by the perceived lack of NYSDEC approval of the technology. However, the NYSDEC does not typically "approve" technologies but instead reviews projects based on their stated treatment objectives and sound engineering practices. This misconception seems to be limiting the use of MBRs in New York State. Since there are no operating facilities within the State, some municipalities and engineers are reluctant to consider the new technology because of the perceived regulatory hurdles.

Market Information

There are currently no municipally operated or private MBR wastewater treatment facilities in the New York State that are larger than 100,000 gpd. Several small facilities exist that serve areas like campgrounds. The New York City Regulatory Upgrade Program provided aid to facilities in the watershed to meet the Watershed Regulations' standards that were beyond any provision of federal or State law or enforceable standard. Treatment processes added included phosphorus removal, disinfection, *Giardia lamblia*/*Cryptosporidium* removal, and sand filtration. The Upgrade Program was designed to assist existing West-of-Hudson River facilities to meet the conditions of their respective effluent permits. Equipment that was unreliable, failing or reaching the end of its useful life was eligible for replacement under this program. At the end of 2002, the majority of the contracting and design consultant tasks were completed for the original 102 facilities west of the Hudson River. Upgrades to the facilities responsible for 83.5% of the non-City-owned discharges west of Hudson River were also completed. The Upgrade Program has made improvements to the facilities contributing to the NYC watershed and therefore the majority of the facilities will not require further improvements (per the State in the form of effluent regulations) in the near future. These previous upgrades impact the MBR market in the State because these facilities are essentially “off the table”.

Existing facilities that are not in the NYC watershed should be a focus of the MBR manufacturers. Additionally, any new wastewater treatment facility in the State should also consider the use of MBRs for effective wastewater treatment. The current design of a new wastewater treatment facility for Rockland County incorporates very stringent, owner-imposed effluent limits. These limits are in response to comments by downstream interests including a major drinking water source for the State of New Jersey. While MBRs are not being used at this facility, this advanced facility is incorporating membranes as part of the tertiary treatment train. The treatment abilities of MBRs and membranes could be extremely useful to other facilities facing the same type of downstream constraints as Rockland County.

Technology Advancement

The design, permitting, construction, and startup phases of a WWTP improvement project can take years. A small retrofitted plant (less than 0.1 mgd) could improve the market for MBRs within the State of New York due to the knowledge transfer involved. The pilot study provided some knowledge transfer to interested parties within the State. One of the most important things that could be done to further the MBR technology in the State would be to retrofit a municipal facility on an expedited, funded basis. Funding for a small retrofit plant, as well as some regulatory support to expedite approvals for strategically important reasons, could significantly improve the market for MBRs within the State.

The MBR technology can be further advanced through operation forums presented throughout the different regions within the State. Manufacturers and engineering consultants could work together to provide these forums or workshops to interested parties. Likewise, case studies presented in regional and national industry magazines and conferences could also help to generate interest and advancement of the technology. Further advancements of the membrane air scour requirements could also help the technology become more attractive to wastewater treatment facilities.

RECOMMENDATION

As described in Section 3, the conceptual Phase II MBR and step-feed systems are both capable of treating an average flow of 5.0 mgd while meeting the preliminary future permit limits. The model simulations provided conceptual configurations including tank volumes. The MBR system could be installed at the facility as a phased retrofit project. Further evaluation of the two options for a Phase II expansion included facility layout, cost estimates and an energy analysis. Table 5-8 provides a summary of the two options.

Table 5-8
MBR and Step-Feed System Comparison

	MBR	***Step-Feed***
Average Treatment Capacity, mgd	5.0	5.0
Peak Day Flow Capacity, mgd	10.0	10.0
Total Treatment Tank Volume Required, million gallons	2.45	4.4
Additional Secondary Clarifier Area Required, square feet	0	16,700
Estimated Average Power Change, hp	122	-53
Estimated Capital Cost	$24,950,000	$34,311,000
Estimated Additional Annual Operating Cost	$369,100	$167,000
Estimated Present Worth Value	$29,590,000	$36,410,000

The MBR system estimated present worth value is $6,820,000 less than the step-feed system. Pending structural analyses, phased construction of the MBR system is possible; one of the oxidation ditches could be retrofitted while the other continues to process wastewater. Since the water depth in the tanks would be approximately the same as the existing operation, significant structural alternations may not be required. During the construction, the facility would have an estimated average capacity of approximately 5.0 mgd (50 percent of Train 1, and 100 percent of Trains 2 and 3). After the first MBR system is online, the second ditch could be retrofitted and the facility would have an average treatment capacity of 6.5 mgd (50 of the full Train 1, and 100 percent of Trains 2 and 3). Additionally, the phased retrofit of the oxidation ditches could extend over a number of years thereby making this option more cost effective. Retrofitting one oxidation ditch would increase the facility's average treatment capacity to 7.5 mgd (Train 1 MBR: 2.5 mgd, Train 1 Oxidation Ditch: 1.0 mgd, and 100 percent of Trains 2 and 3).

At the full conceptual average design capacity of 5.0 mgd to the MBR system, the estimated annual increase in operating cost to the OCDEFS is $369,100. This is approximately 2.2 times the increased annual cost to operate a step-feed system with the same capacity. Some annual cost savings may be realized when the MBR facility is first brought online because it may not be necessary to operate all of the MBR units. As the influent flow rate increases, more MBR units can be brought into operation.

Construction of the 5.0 mgd step-feed process would involve increasing the height of the existing oxidation ditch walls. If structural integrity analyses reveal that the existing ditch base slab and walls can not support an additional 5.55 feet of concrete and water, the tanks would need to be demolished to make space for new 20 feet deep tanks. It is estimated that new tanks would cost an additional $10 million. Challenging construction conditions are expected for the new stacked secondary clarifiers and sand filters, as well. Additionally, construction for the new stacked secondary clarifiers and sand filters will significantly decrease the green space at the existing site. During construction, the facility would have an estimated average capacity of only 4.0 mgd (100 percent of Trains 2 and 3) because unlike the MBR expansion, the step-feed expansion could not be phased. The construction period for the step-feed system would most likely be longer compared to the MBR system because of the additional work involved for the secondary clarifier and sand filter tanks. Again, structural and geotechnical analyses are required to asses the construction methods and materials required for this type of construction.

Based on the conceptual designs, cost estimates, and constructability issues, the MBR system has more potential benefits (compared to the step-feed system). On a present worth basis, the MBR system is approximately $6.8 million less than the step-feed system over a 20 year period even considering the higher annual estimated operating cost for this system.

APPENDICIES

Appendix A-1

MBR Manufacturer Comparison

Design Feature	*Aqua-Aerobics/Pall*	*Enviroquip/Kubota*	*Ionics/Mitsubishi*	*USFilter*	*Zenon*
Membrane Type	Hollow Fiber	Flat Plate	Hollow Fiber	Hollow Fiber	Hollow Fiber
Membrane Orientation	Vertical	Vertical	Horizontal	Vertical	Vertical
Membrane Material	PVDF	Chlorinated polyethylene	Polyethylene	PVDF	Composite hollow fiber, PVDF cast over nylon reinforced core
Nominal Pore Size, μm	0.1	0.4	0.4	0.08	0.036
Absolute Pore Size, μm	N/A	0.1	0.5	0.2	0.1
Membrane Location	Membrane Tank	Aeration Tank	Aeration Tank	Membrane Tank	Membrane Tank
Fine Screen Size, mm	N/A	3	2	2	2
Maintenance Cleaning Time and Frequency	1 min/15 min	1 min/10 min	2 min/12 min	1 min/15 min	2 min/60 min
Maintenance Cleaning Method	Backpulse	Relax	Relax	Backpulse or Relax	Backpulse and Relax
Chemical (recovery) Cleaning Frequency	12 times/year	2 to 3 times/year	3 to 4 times/year	3 to 6 times/year	3 to 4 times/year
Chemical (recovery) Cleaning Time	N/R	1 to 2 hours/cassette	N/R	4 to 6 hours/tank	N/R
Chemical (recovery) Cleaning Method	CIP	CIP	CIP	CIP	CIP
Recommended cleaning chemicals	N/R	0.5% NaHOCl or Oxalic Acid	NaOCl 12%	NaOCl or Citric Acid	NaOCl @ 12% w/wcl
Permeate Pumps Required	Low-suction head pumps	Gravity or low-suction head pumps	Low-suction head pumps	Low-suction head pumps	Low-suction head pumps
Mfg. Recommended Solids Retention Time (SRT), days	10 – 20	15	20	10 - 15	10 - 15
Mfg. Recommended Design Flux Rate, gfd	48	10 - 15	5 - 7	10 - 15	10 - 15
Typical Peak Design Flux Rate, gfd (≤ 6 hours)	Requires EQ Tank	35	Requires EQ Tank	30	25
Maximum Peaking Factor	N/A	2.33	N/A	2	1.67
Aeration Cycle	Constant	Constant	Constant	Constant	10 sec On/ 10 sec Off
Expected Membrane Life, months	84	96 - 120	60	96	84
Estimated Energy Consumption (kWh) per 1,000 gal	2.0	2.59	3.05	N/R	N/R
Membrane Replacement Cost (current) per Module	$4,000	$4,500	$8,750	N/R	$2,650
Capital Cost (per mgd)	$1,200,000	N/R	$1,540,000	$1,000,000	N/R
Maximum Operating (TMP), psi	45	3	11.6	7	12
Expected Field Oxygen Transfer Efficiency, %	2	0.5/ft	9	3.3	6.54 @ 32C

N/A: Not applicable, N/R: No response from manufacturer.

Appendix A-2

MBR System Advantages and Disadvantages

Manufacturer	*Advantages*	*Disadvantages*
Aqua-Aerobics/Pall	- Microfiltration - Backpulse not required - Not piloted in NYS - Clean in place	- Hollow fiber membranes - Effluent pumps required
Enviroquip/Kubota	- Flat plate membranes - Gravity Operation - Microfiltration - Backpulse not required - Not piloted in NYS - Clean in place	
Ionics/Mitsubishi Rayon	- Not piloted in NYS - Clean in place	- Hollow fiber membranes - Effluent pumps required - Ultrafiltration - Backpulse required
USFilter	- Not piloted in NYS - Clean in place	- Hollow fiber membranes - Effluent pumps required - Ultrafiltration - Backpulse required
Zenon	- Clean in place	- Hollow fiber membranes - Effluent pumps required - Ultrafiltration - Backpulse required - Recent NYS pilot study completed

Appendix B

Sampling Program

Parameter	***Influent***	***Fine Screened Influent***	***Anoxic Zone***	***MBR/ Aeration Zone***	***Effluent***	***Disinfected Effluent***	***Recycle***
Flow Rate	D				D		D
Temperature and Dissolved Oxygen (DO)	D,T		D,T	D,T	D,T		
pH	3,C		D,T	D,T	3,C	DE	
Ultraviolet Absorption (UV)		2,G			2,C	DE	
Total Dissolved Solids (TDS) [(1)]					1,C		
Total Organic Carbon (TOC)					2,C		
Dissolved Organic Carbon (DOC)				2,G	2,C		
Alkalinity (Alk)	3,C				1,C	DE	
COD	3,C				2,C	DE	1,G
BOD_5	3,C				2,C	DE	
TKN	3,C	3,G			3,C	DE	
NH_3	3,C	3,G	3,G	3,G	2,C	DE	
Nitrate & Nitrite (NO_3 and NO_2)	3,C			3,G	1,C	DE	
Total Phosphorus (TP)	3,C				2,C	DE	
Orthophosphate (OP)	3,C				2,C	DE	
Total Suspended Solids (TSS)	3,C	3,G	1,G	3,G	3,C	DE	3,G
Volatile Suspended Solids (VSS)	1,C	1,G		1,G			1,G
Calcium and Magnesium	1,C					DE	
Silica				1,G			
Fecal and Total Coliform	1,C				1,C	DE	
Giardia lamblia [(1)]	1,C				1,C	DE	
Cryptosporidium [(1)]	1,C				1,C	DE	

Notes: [(1)] Measured approximately once per SRT

Legend

D: Daily

C: 24-hour Composite

G: Grab

T: In Tank

1: One sample per week

2: Two samples per week

3: Three samples per week

DE: Measured when effluent was disinfected

run date:	2/1/06

Model 1: Existing Facility Average Month

Temp: 12.5 deg C — Yellow boxes indicate parameters that may need to be changed in BioWin before running model.

Elements	Flow [mgd]	Total suspended solids [mgTSS/L]	Volatile suspended solids [mgVSS/L]	Total N [mgN/L]	Ammonia N [mgN/L]	Total Kjeldahl Nitrogen [mgN/L]	Nitrate N [mgN/L]	Magnesium [mg/L]	Calcium [mg/L]	Total Carbonaceous BOD [mg/L]	Total COD [mg/L]	Total P [mgP/L]	Soluble PO4-P [mgP/L]	Temperature [deg. C]	Alkalinity [mmol/L]	Dissolved oxygen [mg/L]	pH []	Inorganic S.S. [mgTSS/L]
Influent	4.70	257.47	193.44	29.31	18.04	29.1	0.21	13.8	66.4	243.14	495	5.8	2.9	12.5	4.14	4.8	7.7	64
Influent Mixer	5.90	238.95	177.32	28.32	15.3	26.52	1.8	13.8	66.4	205.57	434.08	5.55	2.6	12.5	3.85	4.21	7.48	60.18
Ox Mixer	5.19	1795.46	1210.17	118.37	10.08	112.86	5.51	13.8	66.4	632.31	1904.25	34.17	2.31	12.5	3.24	3.33	7.39	517.98
Oxidation	5.19	1774.61	1184.94	117.32	0.93	105.33	11.99	13.8	66.4	542.34	1774.17	34.17	1.79	12.5	2.17	1.8	7.18	517.98
RAS1	1.89	4516.48	3015.75	275.79	0.93	263.8	11.99	13.8	66.4	1378.33	4474.32	84.2	1.79	12.5	2.17	1.8	7.18	1318.28
FST1	3.19	57.72	38.54	18.09	0.93	6.1	11.99	13.8	66.4	18.87	83.4	2.84	1.79	12.5	2.17	1.8	7.18	16.85
PST2	2.57	120.87	89.7	24.81	15.3	23.02	1.8	13.8	66.4	148.87	295.36	4.1	2.6	12.5	3.85	4.21	7.48	30.44
Aeration Mixer	3.79	1705.97	1259.45	126.36	13.22	124.03	2.33	13.8	66.4	815.48	1968.94	36.37	2.11	12.5	3.7	3.5	7.19	369.37
Aeration2	3.79	1723.71	1272.73	125.84	9.09	122.71	3.13	13.8	66.4	760.58	1895.77	36.37	1.02	12.5	3.41	2	6.83	369.37
FST2	2.59	25.24	18.63	15.9	9.09	12.77	3.13	13.8	66.4	13.56	55.58	1.54	1.02	12.5	3.41	2	6.83	5.41
RAS2	1.13	5383.92	3975.31	362.76	9.09	359.63	3.13	13.8	66.4	2370.41	5861.39	111.41	1.02	12.5	3.41	2	6.83	1153.72
Sand Filters	4.58	10.9	7.48	15.18	4.58	7.16	8.02	13.8	66.4	5.51	38.33	1.65	1.45	12.5	2.73	1.89	6.9	2.96
Effluent	4.58	10.9	7.48	15.18	4.58	7.16	8.02	13.8	66.4	5.51	38.33	1.65	1.45	12.5	2.73	1.89	6.96	2.96
Thickener	0.04	1479.8	1050.21	93.41	5.71	85.83	7.58	13.8	66.4	597.15	1622.68	27.42	1.65	12.5	2.83	2.21	7.04	379.85
BFP	0.05	112.47	79.82	21.43	5.71	13.85	7.58	13.8	66.4	58.75	165.12	3.61	1.65	12.5	2.83	2.21	6.98	28.87
Sludge	0.12	9325.23	6618.06	506.42	5.71	498.84	7.58	13.8	66.4	3686.37	9985.74	164.06	1.65	12.5	2.83	2.21	7.04	2393.68

	Model	Data	% Difference	Permit	
Flow [mgd]	4.7	4.7	0.0%	6.0	
Total suspended solids [mgTSS/L]	10.9	9.2	18.5%	30	*11/1 - 5/31*
Volatile suspended solids [mgVSS/L]	7.5			NA	
Ammonia N [mgN/L]	4.6	2.6	76.2%	1.1	*outfall 002, 6/1 - 10/31*
Total Kjeldahl Nitrogen [mgN/L]	7.16	4.3	66.5%	monitor	
Nitrate N [mgN/L]	8.0			NA	
Total N [mgN/L]	15.2			NA	
Magnesium [mg/L]	13.8			NA	
Calcium [mg/L]	66.4			NA	
Total Carbonaceous BOD [mg/L]	5.5	7.2	-23.5%	monitor	
Total COD [mg/L]	38.3			NA	
Total P [mgP/L]	1.7			NA	
Soluble PO4-P [mgP/L]	1.5			NA	
Temperature [deg. C]	12.5	16.9		21.1	*outfall 002*
Alkalinity [mmol/L]	2.7			NA	
Dissolved oxygen [mg/L]	1.9	10		7.0	*daily max*
pH []	7.0	7.3	-4.7%	6.5 - 8.5	
Inorganic S.S. [mgTSS/L]	3.0			NA	*outfall 001 daily max,*
UOD, mg/L	40.5	28.3	43.1%	50	*4.5*TKN + 1.5*CBOD*

FST1	98.00%	removal
FST2	99.00%	
Filters	80.00%	removal

Elements	Model	Setpoint	
Influent	4.7		
Oxidation	5.19		
RAS1	2.0	2.0	per OCDEFS: pump runs at capacity
WAS1	0.11	0.11	match
FST1	3.19		
PST2	2.57		
Aeration2	3.79		
RAS2	1.2	1.2	
WAS2	0.07	0.07	match
FST2	2.59		
Effluent	4.58		
Thickener	0.04		
BFP	0.05		
Sludge	0.12	0.12	change BFP output

Model 1: Existing Facility Average Month

Temp:	16.9	deg C	Yellow boxes indicate parameters that may need to be changed in BioWin before running model.

Elements	Flow [mgd]	Total suspended solids [mgTSS/L]	Volatile suspended solids [mgVSS/L]	Total N [mgN/L]	Ammonia N [mgN/L]	Total Kjeldahl Nitrogen [mgN/L]	Nitrate N [mgN/L]	Magnesium [mg/L]	Calcium [mg/L]	Total Carbonaceous BOD [mg/L]	Total COD [mg/L]	Total P [mgP/L]	Soluble PO4-P [mgP/L]	Temperature [deg. C]	Alkalinity [mmol/L]	Dissolved oxygen [mg/L]	pH []	Inorganic S.S. [mgTSS/L]
Influent	4.7	257.47	193.44	29.31	18.04	29.1	0.21	13.8	66.4	243.14	495	5.8	2.9	16.9	4.14	4.8	7.7	64
Influent Mixer	5.9	238.21	176.63	28.32	14.95	26.11	2.21	13.8	66.4	204.84	433.04	5.55	2.63	16.9	3.8	4.21	7.49	60.18
Ox Mixer	5.19	1756.61	1174.12	115.11	9.72	109.07	6.04	13.8	66.4	595.99	1852.33	33.15	2.37	16.9	3.17	3.33	7.39	517.98
Oxidation	5.19	1733.16	1146.49	114.03	0.56	101.28	12.75	13.8	66.4	503.59	1718.78	33.15	1.93	16.9	2.09	1.8	7.18	517.98
RAS1	1.89	4411	2917.88	266.84	0.56	254.1	12.75	13.8	66.4	1279.78	4333.45	81.38	1.93	16.9	2.09	1.8	7.18	1318.28
FST1	3.19	56.37	37.29	18.34	0.56	5.59	12.75	13.8	66.4	17.57	81.53	2.94	1.93	16.9	2.09	1.8	7.18	16.85
PST2	2.57	120.5	89.35	24.84	14.95	22.63	2.21	13.8	66.4	148.49	294.82	4.11	2.63	16.9	3.8	4.21	7.49	30.44
Aeration Mixer	3.79	1678.06	1232.51	124.69	11.94	120.98	3.71	13.8	66.4	786.98	1927.75	35.82	2.15	16.9	3.5	3.5	7.18	369.37
Aeration2	3.79	1694.34	1244.37	124.13	5.7	117.45	6.68	13.8	66.4	730.43	1852.18	35.82	1.09	16.9	2.91	2	6.78	369.37
FST2	2.59	24.81	18.22	16.01	5.7	9.32	6.68	13.8	66.4	12.91	54.64	1.6	1.09	16.9	2.91	2	6.78	5.41
RAS2	1.13	5292.18	3886.73	357.15	5.7	350.47	6.68	13.8	66.4	2276.7	5725.88	109.59	1.09	16.9	2.91	2	6.78	1153.72
Sand Filters	4.58	10.66	7.26	15.43	2.86	5.39	10.03	13.8	66.4	5.17	37.83	1.75	1.55	16.9	2.46	1.89	6.9	2.96
Effluent	4.58	10.66	7.26	15.43	2.86	5.39	10.03	13.8	66.4	5.17	37.83	1.75	1.55	16.9	2.46	1.89	6.92	2.96
Thickener	0.04	1456.08	1027.89	91.78	4.33	82.56	9.22	13.8	66.4	574.19	1589.72	26.92	1.75	16.9	2.61	2.21	7.02	379.85
BFP	0.05	110.66	78.12	21.54	4.33	12.32	9.22	13.8	66.4	56.91	162.48	3.66	1.75	16.9	2.61	2.21	6.99	28.87
Sludge	0.12	9175.73	6477.39	494.8	4.33	485.58	9.22	13.8	66.4	3542.22	9778.81	160.36	1.75	16.9	2.61	2.21	7.02	2393.68

	Model	Data	% Difference	Permit	
Flow [mgd]	4.7	4.7	0.0%	6.0	
Total suspended solids [mgTSS/L]	10.7	9.2	15.9%	30	*11/1 - 5/31*
Volatile suspended solids [mgVSS/L]	7.26			NA	
Ammonia N [mgN/L]	2.86	2.6	10.0%	1.1	*outfall 002, 6/1 - 10/31*
Total Kjeldahl Nitrogen [mgN/L]	5.39	4.3	25.3%	monitor	
Nitrate N [mgN/L]	10.0			NA	
Total N [mgN/L]	15.43			NA	
Magnesium [mg/L]	13.8			NA	
Calcium [mg/L]	66.4			NA	
Total Carbonaceous BOD [mg/L]	5.17	7.2	-28.2%	monitor	
Total COD [mg/L]	37.8			NA	
Total P [mgP/L]	1.75			NA	
Soluble PO4-P [mgP/L]	1.6			NA	
Temperature [deg. C]	16.9	16.9		21.1	*outfall 002*
Alkalinity [mmol/L]	2.5			NA	
Dissolved oxygen [mg/L]	1.9	10		7.0	*daily max*
pH []	6.92	7.3	-5.2%	6.5 - 8.5	
Inorganic S.S. [mgTSS/L]	3.0			NA	*outfall 001 daily max,*
UOD, mg/L	32.0	28.3	13.1%	50	*4.5*TKN + 1.5*CBOD*

Elements	Model	Setpoint	
Influent	4.7		
Oxidation	5.19		
RAS1	2.0	2.0	per OCDEFS: pump runs at capacity
WAS1	0.11	0.11	match
FST1	3.19		
PST2	2.57		
Aeration2	3.79		
RAS2	1.2	1.2	
WAS2	0.07	0.07	match
FST2	2.59		
Effluent	4.58		
Thickener	0.04		
BFP	0.05		
Sludge	0.12	0.12	change BFP output

FST1	98.00%	removal
FST2	99.00%	
Filters	80.00%	removal

run date:	2/1/06

Model 1: Existing Facility Maximum Month

Temp: 12.5 deg C — Yellow boxes indicate parameters that may need to be changed in BioWin before running model.

Elements	Flow [mgd]	Total suspended solids [mgTSS/L]	Volatile suspended solids [mgVSS/L]	Total N [mgN/L]	Ammonia N [mgN/L]	Total Kjeldahl Nitrogen [mgN/L]	Nitrate N [mgN/L]	Magnesium [mg/L]	Calcium [mg/L]	Total Carbonaceous BOD [mg/L]	Total COD [mg/L]	Total P [mgP/L]	Soluble PO4-P [mgP/L]	Temperature [deg. C]	Alkalinity [mmol/L]	Dissolved oxygen [mg/L]	pH []	Inorganic S.S. [mgTSS/L]
Influent	7.1	256.49	175.46	45.47	13.14	45.3	0.17	10.4	51.6	220.54	449	6.7	3.35	12.5	2.98	4.4	8	81
Influent Mixer	8.3	261.64	176.94	45.49	12.4	42.82	2.67	10.4	51.6	203.08	427.19	6.83	3.22	12.5	2.76	4.04	7.65	82.99
Ox Mixer	6.54	2309.88	1429.72	156.3	9.31	146.83	9.48	10.4	51.6	784.18	2230.4	41.71	3.09	12.5	2.07	3.39	7.41	798.39
Oxidation	6.54	2293.35	1407.98	155.2	1.7	129	26.2	10.4	51.6	691.8	2097.22	41.71	2.78	12.5	0.39	1.8	6.48	798.39
RAS1	1.89	7347.03	4510.63	428.82	1.7	402.62	26.2	10.4	51.6	2213.24	6664.96	127.49	2.78	12.5	0.39	1.8	6.48	2557.74
FST1	4.54	66.08	40.57	34.62	1.7	8.41	26.2	10.4	51.6	21.26	84.12	3.9	2.78	12.5	0.39	1.8	6.48	23.01
PST2	3.62	131.9	89.2	37.24	12.4	34.57	2.67	10.4	51.6	146.21	288.55	5.04	3.22	12.5	2.76	4.04	7.65	41.84
Aeration Mixer	5.41	2537.96	1732.04	184.66	13.51	180.6	4.06	10.4	51.6	1100.76	2655.5	50.79	2.81	12.5	2.77	3.37	7.16	697.98
Aeration2	5.41	2555.21	1745.01	184.14	16.03	177.6	6.54	10.4	51.6	1048.36	2585.76	50.79	1.97	12.5	2.84	2	6.78	697.98
FST2	3.61	38.29	26.15	29.08	16.03	22.54	6.54	10.4	51.6	18.13	64.28	2.7	1.97	12.5	2.84	2	6.78	10.46
RAS2	1.73	7605.85	5194.19	495.3	16.03	488.76	6.54	10.4	51.6	3115.71	7645.53	147.3	1.97	12.5	2.84	2	6.78	2077.61
Sand Filters	6.95	12.61	8.02	29.84	8.05	12.35	17.49	10.4	51.6	6.08	36.86	2.64	2.42	12.5	1.47	1.89	6.66	4.09
Effluent	6.95	12.61	8.02	29.84	8.05	12.35	17.49	10.4	51.6	6.08	36.86	2.64	2.42	12.5	1.47	1.89	6.72	4.09
Thickener	0.03	3030.57	1971.44	207.52	8	191.23	16.29	10.4	51.6	1131.94	2999.8	53.38	2.57	12.5	1.54	2.19	6.82	963.88
BFP	0.03	287.9	187.29	46.22	8	29.93	16.29	10.4	51.6	120.35	323.44	7.4	2.57	12.5	1.54	2.19	6.76	91.57
Sludge	0.15	11458.57	7454.01	703.17	8	686.89	16.29	10.4	51.6	4240.47	11224.05	194.68	2.57	12.5	1.54	2.19	6.82	3644.44

	Model	Data	% Difference	Permit	
Flow [mgd]	7.1	7.1	0.0%	6.0	
Total suspended solids [mgTSS/L]	12.6	25.1	-49.8%	30	*11/1 - 5/31*
Volatile suspended solids [mgVSS/L]	8.0			NA	
Ammonia N [mgN/L]	8.05	5.7	41.2%	1.1	*outfall 002, 6/1 - 10/31*
Total Kjeldahl Nitrogen [mgN/L]	12.4	12.9	-4.3%	monitor	
Nitrate N [mgN/L]	17.49			NA	
Total N [mgN/L]	29.8				
Magnesium [mg/L]	10.4			NA	
Calcium [mg/L]	51.6			monitor	
Total Carbonaceous BOD [mg/L]	6.08	16.3	-62.7%	NA	
Total COD [mg/L]	36.9			NA	
Total P [mgP/L]	2.6			NA	
Soluble PO4-P [mgP/L]	2.42			NA	
Temperature [deg. C]	12.5	23.6		21.1	*outfall 002*
Alkalinity [mmol/L]	1.47			NA	
Dissolved oxygen [mg/L]	1.9	13.3		7.0	*daily max*
pH []	6.72	7.5	-10.4%	6.5 - 8.5	
Inorganic S.S. [mgTSS/L]	4.09			NA	*outfall 001 daily max,*
UOD, mg/L	64.7	64.2	0.8%	50	*4.5*TKN + 1.5*CBOD*

Elements	Model	Setpoint	
Influent	7.1		
Oxidation	6.54		
RAS1	2.0	2.0	
WAS1	0.11	0.11	match
FST1	4.54		
PST2	3.62		
Aeration2	5.41		
RAS2	1.8	1.8	
WAS2	0.07	0.07	match
FST2	3.61		
Effluent	6.95		
Thickener	0.03		
BFP	0.03		
Sludge	0.15	0.15	change BFP output

FST1	98.00%	removal
FST2	99.00%	
Filters	80.00%	removal

Model 1: Existing Facility Maximum Month

Temp: 16.9 deg C — Yellow boxes indicate parameters that may need to be changed in BioWin before running model.

Elements	Flow [mgd]	Total suspended solids [mgTSS/L]	Volatile suspended solids [mgVSS/L]	Total N [mgN/L]	Ammonia N [mgN/L]	Total Kjeldahl Nitrogen [mgN/L]	Nitrate N [mgN/L]	Magnesium [mg/L]	Calcium [mg/L]	Total Carbonaceous BOD [mg/L]	Total COD [mg/L]	Total P [mgP/L]	Soluble PO4-P [mgP/L]	Temperature [deg. C]	Alkalinity [mmol/L]	Dissolved oxygen [mg/L]	pH []	Inorganic S.S. [mgTSS/L]
Influent	7.1	256.49	175.46	45.47	13.14	45.3	0.17	10.4	51.6	220.54	449	6.7	3.35	16.9	2.98	4.4	8	81
Influent Mixer	8.3	260.89	176.23	45.46	11.88	42.21	3.25	10.4	51.6	202.32	426.12	6.82	3.23	16.9	2.68	4.04	7.66	82.99
Ox Mixer	6.54	2265.58	1388.54	152.39	8.72	142.16	10.23	10.4	51.6	742.44	2170.9	40.52	3.14	16.9	1.97	3.39	7.4	798.39
Oxidation	6.54	2246.1	1364.05	151.26	0.94	123.85	27.4	10.4	51.6	647.27	2033.75	40.52	2.91	16.9	0.24	1.8	6.29	798.39
RAS1	1.89	7195.65	4369.91	415.34	0.94	387.94	27.4	10.4	51.6	2070.73	6461.78	123.38	2.91	16.9	0.24	1.8	6.29	2557.74
FST1	4.54	64.72	39.3	34.87	0.94	7.46	27.4	10.4	51.6	19.92	82.21	3.99	2.91	16.9	0.24	1.8	6.29	23.01
PST2	3.62	131.52	88.85	37.25	11.88	34	3.25	10.4	51.6	145.82	287.99	5.04	3.23	16.9	2.68	4.04	7.66	41.84
Aeration Mixer	5.41	2508.31	1703.02	182.33	10.82	175.45	6.88	10.4	51.6	1067.65	2610.25	50.26	2.83	16.9	2.38	3.37	7.1	697.98
Aeration2	5.41	2524.58	1715	181.8	8.81	167.75	14.04	10.4	51.6	1013.95	2538.75	50.26	2	16.9	1.78	2	6.58	697.98
FST2	3.61	37.83	25.7	29.17	8.81	15.12	14.04	10.4	51.6	17.4	63.28	2.73	2	16.9	1.78	2	6.58	10.46
RAS2	1.73	7514.66	5104.87	488.08	8.81	474.03	14.04	10.4	51.6	3013.71	7506.19	145.63	2	16.9	1.78	2	6.58	2077.61
Sand Filters	6.95	12.38	7.8	30.08	4.43	8.6	21.48	10.4	51.6	5.73	36.37	2.73	2.51	16.9	0.92	1.89	6.5	4.09
Effluent	6.95	12.38	7.8	30.08	4.43	8.6	21.48	10.4	51.6	5.73	36.37	2.73	2.51	16.9	0.92	1.89	6.52	4.09
Thickener	0.03	2989.88	1933.06	204.16	5.13	184.66	19.5	10.4	51.6	1091.59	2943.03	52.43	2.65	16.9	1.1	2.19	6.68	963.88
BFP	0.03	284.04	183.64	46.12	5.13	26.62	19.5	10.4	51.6	116.42	317.92	7.38	2.65	16.9	1.1	2.19	6.66	91.57
Sludge	0.15	11304.72	7308.89	689.8	5.13	670.3	19.5	10.4	51.6	4088.21	11009.8	190.84	2.65	16.9	1.1	2.19	6.68	3644.44

	Model	Data	% Difference	Permit	
Flow [mgd]	7.1	7.1	0.0%	6.0	
Total suspended solids [mgTSS/L]	12.4	25.1	-50.7%	30	*11/1 - 5/31*
Volatile suspended solids [mgVSS/L]	7.8			NA	
Ammonia N [mgN/L]	4.4	5.7	-22.3%	1.1	*outfall 002, 6/1 - 10/31*
Total Kjeldahl Nitrogen [mgN/L]	8.6	12.9	-33.3%	monitor	
Nitrate N [mgN/L]	21.5			NA	
Total N [mgN/L]	30.1				
Magnesium [mg/L]	10.4			NA	
Calcium [mg/L]	51.6			monitor	
Total Carbonaceous BOD [mg/L]	5.7	16.3	-64.8%	NA	
Total COD [mg/L]	36			NA	
Total P [mgP/L]	2.7			NA	
Soluble PO4-P [mgP/L]	2.51			NA	
Temperature [deg. C]	16.9	23.6		21.1	*outfall 002*
Alkalinity [mmol/L]	0.9			NA	
Dissolved oxygen [mg/L]	1.9	13.3		7.0	*daily max*
pH []	6.5	7.5	-13.1%	6.5 - 8.5	
Inorganic S.S. [mgTSS/L]	4.1			NA	*outfall 001 daily max,*
UOD, mg/L	47.3	64.2	-26.3%	50	*4.5*TKN + 1.5*CBOD*

Elements	Model	Setpoint	
Influent	7.1		
Oxidation	6.54		
RAS1	2.0		
WAS1	0.11		match
FST1	4.54		
PST2	3.62		
Aeration2	5.41		
RAS2	1.8		
WAS2	0.07		match
FST2	3.61		
Effluent	6.95		
Thickener	0.03		
BFP	0.03		
Sludge	0.15		change BFP output

FST1	98.00%	removal
FST2	99.00%	
Filters	80.00%	removal

run date:	2/1/06

Model 1: Existing Facility Maximum Day

Temp: 12.5 deg C — Yellow boxes indicate parameters that may need to be changed in BioWin before running model.

Elements	Flow [mgd]	Total suspended solids [mgTSS/L]	Volatile suspended solids [mgVSS/L]	Total N [mgN/L]	Ammonia N [mgN/L]	Total Kjeldahl Nitrogen [mgN/L]	Nitrate N [mgN/L]	Magnesium [mg/L]	Calcium [mg/L]	Total Carbonaceous BOD [mg/L]	Total COD [mg/L]	Total P [mgP/L]	Soluble PO4-P [mgP/L]	Temperature [deg. C]	Alkalinity [mmol/L]	Dissolved oxygen [mg/L]	pH []	Inorganic S.S. [mgTSS/L]
Influent	13.4	198.5	132.48	33.98	10.82	33.8	0.18	5.6	31.2	166.51	339	7.3	3.65	12.5	2.42	3.4	8.6	66
Influent Mixer	14.6	220.54	146.12	35.11	10.64	34.21	0.9	5.6	31.2	167.04	348.93	7.68	3.64	12.5	2.36	3.28	8.28	72.88
Ox Mixer	10.07	2340.85	1455	151.54	9.52	148.09	3.46	5.6	31.2	857.52	2252.26	44.43	3.71	12.5	2.1	3	7.9	801.04
Oxidation	10.07	2334.22	1442.94	150.63	4.7	136.1	14.52	5.6	31.2	780.75	2141.32	44.43	4	12.5	1	1.8	6.91	801.04
RAS1	1.89	11513.17	7117.08	655.24	4.7	640.72	14.52	5.6	31.2	3844.47	10485.93	203.41	4	12.5	1	1.8	6.91	3951.02
FST1	8.07	58.26	36.01	25.5	4.7	10.98	14.52	5.6	31.2	21.09	72.24	5.01	4	12.5	1	1.8	6.91	19.99
PST2	6.39	110.79	73.4	28.57	10.64	27.67	0.9	5.6	31.2	119.53	234.15	5.67	3.64	12.5	2.36	3.28	8.28	36.61
Aeration Mixer	8.38	2724.26	1859.83	186.91	11.29	185.72	1.19	5.6	31.2	1226.46	2845.28	55.43	3.5	12.5	2.4	2.97	7.39	755.23
Aeration2	8.38	2744.19	1875.87	186.51	13.56	184.6	1.91	5.6	31.2	1183.47	2789.12	55.43	3.04	12.5	2.56	2	6.76	755.23
FST2	6.38	36.04	24.64	21.86	13.56	19.95	1.91	5.6	31.2	18.85	58.04	3.73	3.04	12.5	2.56	2	6.76	9.92
RAS2	1.93	11388.61	7784.99	712.07	13.56	710.16	1.91	5.6	31.2	4900.97	11506.72	220.48	3.04	12.5	2.56	2	6.76	3134.28
Sand Filters	13.25	10.57	6.76	21.74	8.62	12.79	8.95	5.6	31.2	6.26	30.3	3.77	3.58	12.5	1.69	1.89	6.74	3.39
Effluent	13.25	10.57	6.76	21.74	8.62	12.79	8.95	5.6	31.2	6.26	30.3	3.77	3.58	12.5	1.69	1.89	6.8	3.39
Thickener	0.03	4620.04	2995.3	288.51	8.5	280.14	8.37	5.6	31.2	1799.13	4527.71	87.17	3.63	12.5	1.71	2.08	6.91	1480.18
BFP	0.03	438.9	284.55	46.75	8.5	38.38	8.37	5.6	31.2	181.96	461.11	11.57	3.63	12.5	1.72	2.08	6.85	140.62
Sludge	0.15	17468.37	11325.23	1031.41	8.5	1023.04	8.37	5.6	31.2	6768.56	17024.09	319.48	3.63	12.5	1.71	2.08	6.91	5596.55

	Model	Data	% Difference	Permit	
Flow [mgd]	13.4	13.4	0.0%	6.0	
Total suspended solids [mgTSS/L]	10.6	59	-82.1%	30	*11/1 - 5/31*
Volatile suspended solids [mgVSS/L]	6.8			NA	
Ammonia N [mgN/L]	8.62	10.5	-17.9%	1.1	*outfall 002, 6/1 - 10/31*
Total Kjeldahl Nitrogen [mgN/L]	12.8	42	-69.5%	monitor	
Nitrate N [mgN/L]	8.95			NA	
Total N [mgN/L]	21.7				
Magnesium [mg/L]	5.6			NA	
Calcium [mg/L]	31.2			monitor	
Total Carbonaceous BOD [mg/L]	6.26	40.4	-84.5%	NA	
Total COD [mg/L]	30.3			NA	
Total P [mgP/L]	3.8			NA	
Soluble PO4-P [mgP/L]	3.58			NA	
Temperature [deg. C]	12.5	23.6		21.1	*outfall 002*
Alkalinity [mmol/L]	1.69			NA	
Dissolved oxygen [mg/L]	1.9	13.8		7.0	*daily max*
pH []	6.8	8.3	-18.1%	6.5 - 8.5	
Inorganic S.S. [mgTSS/L]	3.39			NA	*outfall 001 daily max,*
UOD, mg/L	66.9	116.7	-42.6%	50	*4.5*TKN + 1.5*CBOD*

Elements	Model	Setpoint	
Influent	13.4		
Oxidation	10.07		
RAS1	2.0		
WAS1	0.11		match
FST1	8.07		
PST2	6.39		
Aeration2	8.38		
RAS2	2.0		
WAS2	0.07		match
FST2	6.38		
Effluent	13.25		
Thickener	0.03		
BFP	0.03		
Sludge	0.15		change BFP output

FST1	98.00%	removal
FST2	99.00%	
Filters	80.00%	removal

Model 1: Existing Facility Maximum Day

Temp:	16.9	deg C	Yellow boxes indicate parameters that may need to be changed in BioWin before running model.

Elements	Flow [mgd]	Total suspended solids [mgTSS/L]	Volatile suspended solids [mgVSS/L]	Total N [mgN/L]	Ammonia N [mgN/L]	Total Kjeldahl Nitrogen [mgN/L]	Nitrate N [mgN/L]	Magnesium [mg/L]	Calcium [mg/L]	Total Carbonaceous BOD [mg/L]	Total COD [mg/L]	Total P [mgP/L]	Soluble PO4-P [mgP/L]	Temperature [deg. C]	Alkalinity [mmol/L]	Dissolved oxygen [mg/L]	pH []	Inorganic S.S. [mgTSS/L]
Influent	13.4	198.5	132.48	33.98	10.82	33.8	0.18	5.6	31.2	166.51	339	7.3	3.65	16.9	2.42	3.4	8.6	66
Influent Mixer	14.6	219.92	145.52	35.07	10.43	33.93	1.14	5.6	31.2	166.39	347.99	7.67	3.65	16.9	2.33	3.28	8.35	72.88
Ox Mixer	10.07	2304.41	1420.74	148.32	8.76	144.02	4.3	5.6	31.2	821.62	2201.93	43.44	3.73	16.9	1.99	3	7.97	801.04
Oxidation	10.07	2295.42	1406.48	147.38	1.56	129.37	18.01	5.6	31.2	742.49	2087.7	43.44	4.09	16.9	0.52	1.8	6.63	801.04
RAS1	1.89	11321.8	6937.26	638.24	1.56	620.23	18.01	5.6	31.2	3656.12	10221.98	198.18	4.09	16.9	0.52	1.8	6.63	3951.02
FST1	8.07	57.29	35.1	25.67	1.56	7.66	18.01	5.6	31.2	20.04	70.77	5.07	4.09	16.9	0.52	1.8	6.63	19.99
PST2	6.39	110.47	73.1	28.56	10.43	27.42	1.14	5.6	31.2	119.2	233.67	5.67	3.65	16.9	2.33	3.28	8.35	36.61
Aeration Mixer	8.38	2683.42	1817.95	184.25	10.71	182.4	1.86	5.6	31.2	1182.03	2775.97	54.65	3.52	16.9	2.31	2.97	7.42	755.23
Aeration2	8.38	2701.94	1832.51	183.82	11.8	179.86	3.96	5.6	31.2	1137.2	2716.9	54.65	3.08	16.9	2.29	2	6.71	755.23
FST2	6.38	35.48	24.07	21.9	11.8	17.95	3.96	5.6	31.2	17.85	56.54	3.75	3.08	16.9	2.29	2	6.71	9.92
RAS2	1.93	11213.25	7605.04	700.65	11.8	696.69	3.96	5.6	31.2	4710.14	11208.75	217.12	3.08	16.9	2.29	2	6.71	3134.28
Sand Filters	13.25	10.39	6.59	21.9	6.08	10.1	11.8	5.6	31.2	5.86	29.72	3.83	3.64	16.9	1.3	1.89	6.67	3.39
Effluent	13.25	10.39	6.59	21.9	6.08	10.1	11.8	5.6	31.2	5.86	29.72	3.83	3.64	16.9	1.3	1.89	6.69	3.39
Thickener	0.03	4561.17	2938.12	283.89	6.24	272.98	10.91	5.6	31.2	1738.83	4439.47	85.77	3.69	16.9	1.37	2.08	6.82	1480.18
BFP	0.03	433.31	279.12	46.46	6.24	35.55	10.91	5.6	31.2	176.07	452.49	11.49	3.69	16.9	1.37	2.08	6.79	140.62
Sludge	0.15	17245.77	11109.03	1013.5	6.24	1002.58	10.91	5.6	31.2	6541.09	16691.16	314.04	3.69	16.9	1.37	2.08	6.82	5596.55

	Model	Data	% Difference	Permit	
Flow [mgd]	13.4	13.4	0.0%	6.0	
Total suspended solids [mgTSS/L]	10.4	59	-82.4%	30	*11/1 - 5/31*
Volatile suspended solids [mgVSS/L]	6.6			NA	
Ammonia N [mgN/L]	6.1	10.5	-42.1%	1.1	*outfall 002, 6/1 - 10/31*
Total Kjeldahl Nitrogen [mgN/L]	10.1	42	-76.0%	monitor	
Nitrate N [mgN/L]	11.8			NA	
Total N [mgN/L]	21.9				
Magnesium [mg/L]	5.6			NA	
Calcium [mg/L]	31.2			monitor	
Total Carbonaceous BOD [mg/L]	5.9	40.4	-85.5%	NA	
Total COD [mg/L]	30			NA	
Total P [mgP/L]	3.8			NA	
Soluble PO4-P [mgP/L]	3.64			NA	
Temperature [deg. C]	16.9	23.6		21.1	*outfall 002*
Alkalinity [mmol/L]	1.3			NA	
Dissolved oxygen [mg/L]	1.9	13.8		7.0	*daily max*
pH []	6.7	8.3	-19.4%	6.5 - 8.5	
Inorganic S.S. [mgTSS/L]	3.4			NA	*outfall 001 daily max,*
UOD, mg/L	54.2	116.7	-53.5%	50	*4.5*TKN + 1.5*CBOD*

Elements	Model	Setpoint	
Influent	13.4		
Oxidation	10.07		
RAS1	2.0		
WAS1	0.11		match
FST1	8.07		
PST2	6.39		
Aeration2	8.38		
RAS2	2.0		
WAS2	0.07		match
FST2	6.38		
Effluent	13.25		
Thickener	0.03		
BFP	0.03		
Sludge	0.15		change BFP output

FST1	98.00%	removal
FST2	99.00%	
Filters	80.00%	removal

run date:	2/1/06

Model 2: Phase I Facility Average Month

Temp: 12.5 deg C — Yellow boxes indicate parameters that may need to be changed in BioWin before running model.

Elements	Flow [mgd]	Total suspended solids [mgTSS/L]	Volatile suspended solids [mgVSS/L]	Total Carbonaceous BOD [mg/L]	Total COD [mg/L]	Ammonia N [mgN/L]	Nitrate N [mgN/L]	Total P [mgP/L]	Soluble PO4-P [mgP/L]	Total Kjeldahl Nitrogen [mgN/L]	Total N [mgN/L]	Inorganic S.S. [mgTSS/L]	Calcium [mg/L]	Magnesium [mg/L]	Temperature [deg. C]	Alkalinity [mmol/L]	pH []	Dissolved oxygen [mg/L]	Liquid volume [Mil. Gal]
Influent	4.7	257.47	193.44	243.14	495	17.75	0.21	5.8	2.9	29.1	29.31	64	66.4	13.8	12.5	4.14	7.7	4.8	0
Oxidation	3.86	1284.1	841.89	354.68	1270.15	0.68	13.2	24.9	2.06	74.89	88.09	392.26	66.4	13.8	12.5	2.08	7.17	2	2.36
FST1	1.86	53.35	34.98	15.88	78.11	0.68	13.2	3.01	2.06	5.51	18.71	16.3	66.4	13.8	12.5	2.08	7.17	2	0.33
RAS1	1.89	2426.52	1590.9	669.16	2376.63	0.68	13.2	45.22	2.06	139.29	152.49	741.23	66.4	13.8	12.5	2.08	7.17	2	0
PST2	1.94	115.02	85.68	146.73	289.38	14.63	2.43	4.03	2.65	22.14	24.58	28.86	66.4	13.8	12.5	3.78	7.46	4.23	0.24
Aeration2	3.1	1905.8	1393.39	787.92	2065.08	4.06	9.12	40.67	1.33	130.56	139.68	419.82	66.4	13.8	12.5	2.64	6.72	2	0.47
FST2	1.9	31.12	22.75	14.58	60.5	4.06	9.12	1.97	1.33	8.04	17.15	6.85	66.4	13.8	12.5	2.64	6.72	2	0.24
RAS2	1.16	4868.99	3559.87	2010.28	5233.6	4.06	9.12	101.86	1.33	324.22	333.34	1072.57	66.4	13.8	12.5	2.64	6.72	2	0
Sand Filters1&2	2.55	12.38	8.47	5.52	39.3	2.39	11.14	1.92	1.69	5.01	16.15	3.39	66.4	13.8	12.5	2.36	6.81	2	0
PST3	2.64	84.84	62.58	107.08	219.22	11.13	4.39	3.58	2.46	17.59	21.98	21.38	66.4	13.8	12.5	3.41	7.18	3.66	0.35
Aeration3	6.1	1495.83	1049.42	480.37	1563.83	0.81	9.93	31.36	1.91	95.91	105.84	378.05	66.4	13.8	12.5	2.33	6.65	2	1.09
FST3	2.6	23.6	16.56	8.58	50.46	0.81	9.93	2.38	1.91	4.07	14.01	5.96	66.4	13.8	12.5	2.33	6.65	2	0.59
RAS3	1.46	4044.52	2837.48	1297.11	4183.73	0.81	9.93	81.53	1.91	254.9	264.83	1022.2	66.4	13.8	12.5	2.33	6.65	2	0
Sand Filters3	2	6.14	4.31	2.99	32.51	0.81	9.93	2.03	1.91	2.99	12.92	1.55	66.4	13.8	12.5	2.33	6.59	2	0
Effluent	4.55	9.64	6.64	4.41	36.32	1.7	10.61	1.97	1.79	4.12	14.73	2.58	66.4	13.8	12.5	2.35	6.76	2	0
Thickener	0.07	844.14	603.11	354.96	971.32	4.17	9.68	15.63	2.04	46.18	55.85	218.42	66.4	13.8	12.5	2.57	6.98	2.47	0.14
BFP	0.03	187.12	133.69	94.26	256.63	4.17	9.68	5.05	2.04	15.3	24.98	48.42	66.4	13.8	12.5	2.57	6.92	2.47	0
Sludge	0.15	7447.25	5320.83	2975.07	8154.05	4.17	9.68	121.96	2.04	356.47	366.15	1927.01	66.4	13.8	12.5	2.57	6.98	2.47	0

	Model	Data	% Difference	Permit	
Flow [mgd]	4.7	4.7	0.0%	6.0	
Total suspended solids [mgTSS/L]	9.64	9.2	4.8%	30	*11/1 - 5/31*
Volatile suspended solids [mgVSS/L]	6.64			NA	
Ammonia N [mgN/L]	1.7	2.6	-34.6%	1.1	*outfall 002, 6/1 - 10/31*
Total Kjeldahl Nitrogen [mgN/L]	4.12	4.3	-4.2%	monitor	
Nitrate N [mgN/L]	10.61			NA	
Total N [mgN/L]	14.73			NA	
Total BOD [mg/L]	4.41	7.2	-38.8%	monitor	
Total COD [mg/L]	36.32			NA	
Total P [mgP/L]	1.97			NA	
Soluble PO4-P [mgP/L]	1.79			NA	
Magnesium [mg/L]	13.8			NA	
Calcium [mg/L]	66.4			monitor	
Temperature [deg. C]	12.5	16.9		21.1	*outfall 002*
Alkalinity [mmol/L]	2.35			NA	
Dissolved oxygen [mg/L]	2	10		7.0	*daily max*
pH []	6.76	7.3	-7.4%	6.5 - 8.5	
Inorganic S.S. [mgTSS/L]	2.58			NA	*outfall 001 daily max,*
UOD, mg/L	25.2	28.3	-11.1%	50	*4.5*TKN + 1.5*CBOD*

Elements	Model	Setpoint	
Influent	4.7		
Oxidation	3.86		
RAS1	2.0		
WAS1	0.11		match
FST1	1.86		
PST2	1.94		
Aeration2	3.1		
RAS2	1.2		
WAS2	0.04		match
FST2	1.9		
PST3	2.64		
Aeration3	6.1		
RAS3	1.5		
IR	2.0		
WAS3	0.04		match
FST3	2.6		
Effluent	4.55		
Thickener	0.07		
BFP	0.03		
Sludge	0.15		change BFP output

FST1	98.00%	removal
FST2	99.00%	removal
FST3	99.00%	removal
Filters	80.00%	removal

Model 2: Phase I Facility Average Month

Temp:	16.9	deg C	Yellow boxes	indicate parameters that may need to be changed in BioWin before running model.

Elements	Flow [mgd]	Total suspended solids [mgTSS/L]	Volatile suspended solids [mgVSS/L]	Total Carbonaceous BOD [mg/L]	Total COD [mg/L]	Ammonia N [mgN/L]	Nitrate N [mgN/L]	Total P [mgP/L]	Soluble PO4-P [mgP/L]	Total Kjeldahl Nitrogen [mgN/L]	Total N [mgN/L]	Inorganic S.S. [mgTSS/L]	Calcium [mg/L]	Magnesium [mg/L]	Temperature [deg. C]	Alkalinity [mmol/L]	pH []	Dissolved oxygen [mg/L]	Liquid volume [Mil. Gal]
Influent	4.7	257.47	193.44	243.14	495	17.75	0.21	5.8	2.9	29.1	29.31	64	66.4	13.8	16.9	4.14	7.7	4.8	0
Oxidation	3.86	1254.41	814.39	326.98	1230.62	0.44	13.82	24.19	2.19	71.99	85.81	392.26	66.4	13.8	16.9	2.02	7.18	2	2.36
FST1	1.86	52.12	33.83	14.69	76.42	0.44	13.82	3.1	2.19	5.15	18.97	16.3	66.4	13.8	16.9	2.02	7.18	2	0.33
RAS1	1.89	2370.42	1538.93	616.85	2301.98	0.44	13.82	43.76	2.19	134.03	147.85	741.23	66.4	13.8	16.9	2.02	7.18	2	0
PST2	1.94	114.78	85.46	146.49	289.03	14.33	2.79	4.05	2.68	21.82	24.62	28.86	66.4	13.8	16.9	3.73	7.46	4.23	0.24
Aeration2	3.1	1865.93	1356.07	748.94	2010.49	1.41	12.03	39.72	1.41	124.59	136.62	419.82	66.4	13.8	16.9	2.24	6.66	2	0.47
FST2	1.9	30.46	22.14	13.84	59.46	1.41	12.03	2.04	1.41	5.31	17.34	6.85	66.4	13.8	16.9	2.24	6.66	2	0.24
RAS2	1.16	4767.14	3464.53	1910.87	5094.36	1.41	12.03	99.29	1.41	313.13	325.16	1072.57	66.4	13.8	16.9	2.24	6.66	2	0
Sand Filters1&2	2.55	12.11	8.21	5.18	38.83	0.93	12.91	2.02	1.8	3.51	16.42	3.39	66.4	13.8	16.9	2.13	6.81	2	0
PST3	2.64	84.35	62.13	106.61	218.54	10.82	4.77	3.61	2.5	17.23	22	21.38	66.4	13.8	16.9	3.35	7.19	3.66	0.35
Aeration3	6.1	1454.61	1011.27	442.31	1509.11	0.51	10.29	30.29	2.01	91.91	102.19	378.05	66.4	13.8	16.9	2.28	6.65	2	1.09
FST3	2.6	22.95	15.95	7.95	49.56	0.51	10.29	2.45	2.01	3.7	13.99	5.96	66.4	13.8	16.9	2.28	6.65	2	0.59
RAS3	1.46	3933.07	2734.33	1194.25	4035.84	0.51	10.29	78.47	2.01	244.6	254.89	1022.2	66.4	13.8	16.9	2.28	6.65	2	0
Sand Filters3	2	5.97	4.15	2.8	32.25	0.51	10.29	2.12	2.01	2.66	12.94	1.55	66.4	13.8	16.9	2.28	6.63	2	0
Effluent	4.55	9.41	6.43	4.14	35.94	0.75	11.76	2.07	1.89	3.14	14.9	2.58	66.4	13.8	16.9	2.19	6.74	2	0
Thickener	0.07	831.92	591.76	343.43	954.9	3.52	10.56	15.39	2.13	44.44	55	218.42	66.4	13.8	16.9	2.46	6.98	2.47	0.14
BFP	0.03	184.41	131.17	91.67	252.94	3.52	10.56	5.07	2.13	14.4	24.96	48.42	66.4	13.8	16.9	2.46	6.95	2.47	0
Sludge	0.15	7339.43	5220.7	2873.63	8009.69	3.52	10.56	119.07	2.13	346.37	356.93	1927.01	66.4	13.8	16.9	2.46	6.98	2.47	0

	Model	Data	% Difference	Permit	
Flow [mgd]	4.7	4.7	0.0%	6.0	
Total suspended solids [mgTSS/L]	9.41	9.2	2.3%	30	*11/1 - 5/31*
Volatile suspended solids [mgVSS/L]	6.43			NA	
Ammonia N [mgN/L]	0.75	2.6	-71.2%	1.1	*outfall 002, 6/1 - 10/31*
Total Kjeldahl Nitrogen [mgN/L]	3.14	4.3	-27.0%	monitor	
Nitrate N [mgN/L]	11.76			NA	
Total N [mgN/L]	14.9			NA	
Total BOD [mg/L]	4.14	7.2	-42.5%	monitor	
Total COD [mg/L]	35.94			NA	
Total P [mgP/L]	2.07			NA	
Soluble PO4-P [mgP/L]	1.89			NA	
Magnesium [mg/L]	13.8			NA	
Calcium [mg/L]	66.4			monitor	
Temperature [deg. C]	16.9	16.9		21.1	*outfall 002*
Alkalinity [mmol/L]	2.19			NA	
Dissolved oxygen [mg/L]	2	10		7.0	*daily max*
pH []	6.74	7.3	-7.7%	6.5 - 8.5	
Inorganic S.S. [mgTSS/L]	2.58			NA	*outfall 001 daily max,*
UOD, mg/L	20.3	28.3	-28.1%	50	*4.5*TKN + 1.5*CBOD*

Elements	Model	Setpoint	
Influent	4.7		
Oxidation	3.86		
RAS1	2.0		
WAS1	0.11		match
FST1	1.86		
PST2	1.94		
Aeration2	3.1		
RAS2	1.2		
WAS2	0.04		match
FST2	1.9		
PST3	2.64		
Aeration3	6.1		
RAS3	1.5		
IR	2.0		
WAS3	0.04		match
FST3	2.6		
Effluent	4.55		
Thickener	0.07		
BFP	0.03		
Sludge	0.15		change BFP output

FST1	98.00%	removal
FST2	99.00%	removal
FST3	99.00%	removal
Filters	80.00%	removal

run date:	2/1/06

Model 2: Phase I Facility Design Month

Temp: 12.5 deg C — Yellow boxes indicate parameters that may need to be changed in BioWin before running model.

Elements	Flow [mgd]	Total suspended solids [mgTSS/L]	Volatile suspended solids [mgVSS/L]	Total Carbonaceous BOD [mg/L]	Total COD [mg/L]	Ammonia N [mgN/L]	Nitrate N [mgN/L]	Total P [mgP/L]	Soluble PO4-P [mgP/L]	Total Kjeldahl Nitrogen [mgN/L]	Total N [mgN/L]	Inorganic S.S. [mgTSS/L]	Calcium [mg/L]	Magnesium [mg/L]	Temperature [deg. C]	Alkalinity [mmol/L]	pH []	Dissolved oxygen [mg/L]	Liquid volume [Mil. Gal]
Influent	6	257.47	193.44	243.14	495	17.75	0.21	5.8	2.9	29.1	29.31	64	66.4	13.8	12.5	4.14	7.7	4.8	0
Oxidation	4.29	1512.66	999.79	436.51	1502.3	0.75	12.86	29.19	1.98	88.82	101.68	453.01	66.4	13.8	12.5	2.11	7.18	2	2.36
FST1	2.29	56.68	37.46	17.53	81.78	0.75	12.86	3	1.98	5.81	18.67	16.97	66.4	13.8	12.5	2.11	7.18	2	0.33
RAS1	1.89	3179.59	2101.53	916.19	3128.63	0.75	12.86	59.18	1.98	183.85	196.71	952.23	66.4	13.8	12.5	2.11	7.18	2	0
PST2	2.37	121.02	90.17	153.78	302.24	15.25	1.94	4.15	2.69	23.09	25.03	30.3	66.4	13.8	12.5	3.85	7.5	4.33	0.24
Aeration2	3.83	2357.5	1727.53	984.06	2553.71	4.74	8.34	50.06	1.28	161.1	169.44	515.12	66.4	13.8	12.5	2.74	6.73	2	0.47
FST2	2.33	38.75	28.4	17.93	68.81	4.74	8.34	2.08	1.28	9.22	17.56	8.47	66.4	13.8	12.5	2.74	6.73	2	0.24
RAS2	1.46	5959.48	4366.99	2484.86	6413.8	4.74	8.34	124.6	1.28	397.04	405.38	1302.17	66.4	13.8	12.5	2.74	6.73	2	0
Sand Filters1&2	3.42	12.87	8.89	5.89	39.95	2.76	10.58	1.87	1.62	5.43	16.01	3.43	66.4	13.8	12.5	2.43	6.82	2	0
PST3	3.04	94.84	70.02	118.79	240.66	12.2	3.51	3.77	2.51	19.23	22.74	23.8	66.4	13.8	12.5	3.54	7.24	3.84	0.35
Aeration3	6.5	1778.51	1254.7	591.43	1863.81	0.9	9.13	37.14	1.87	114.45	123.58	441.66	66.4	13.8	12.5	2.39	6.66	2	1.09
FST3	3	26.68	18.82	9.89	53.79	0.9	9.13	2.39	1.87	4.36	13.5	6.62	66.4	13.8	12.5	2.39	6.66	2	0.59
RAS3	1.46	5282.3	3726.57	1754.57	5483.99	0.9	9.13	106.64	1.87	334.63	343.76	1311.77	66.4	13.8	12.5	2.39	6.66	2	0
Sand Filters3	2.4	6.67	4.71	3.25	33.12	0.9	9.13	2	1.87	3.11	12.24	1.66	66.4	13.8	12.5	2.39	6.6	2	0
Effluent	5.82	10.31	7.16	4.8	37.13	1.99	9.98	1.92	1.72	4.47	14.45	2.7	66.4	13.8	12.5	2.42	6.77	2	0
Thickener	0.05	1518.76	1087.91	631.32	1710.46	4.53	9.11	26.6	2	78.77	87.87	389.64	66.4	13.8	12.5	2.64	7	2.5	0.14
BFP	0.02	360.7	258.38	166.23	448.17	4.53	9.11	7.84	2	23.97	33.08	92.54	66.4	13.8	12.5	2.64	6.94	2.5	0
Sludge	0.18	7975.58	5713.06	3224.48	8748.46	4.53	9.11	131.18	2	384.27	393.38	2046.14	66.4	13.8	12.5	2.64	7	2.5	0

	Model	Data	% Difference	Permit	
Flow [mgd]	6.0	4.7	27.7%	6.0	
Total suspended solids [mgTSS/L]	10.31	9.2	12.1%	30	*11/1 - 5/31*
Volatile suspended solids [mgVSS/L]	7.16			NA	
Ammonia N [mgN/L]	1.99	2.6	-23.5%	1.1	*outfall 002, 6/1 - 10/31*
Total Kjeldahl Nitrogen [mgN/L]	4.47	4.3	4.0%	monitor	
Nitrate N [mgN/L]	9.98			NA	
Total N [mgN/L]	14.45			NA	
Total BOD [mg/L]	4.8	7.2	-33.3%	monitor	
Total COD [mg/L]	37.13			NA	
Total P [mgP/L]	1.92			NA	
Soluble PO4-P [mgP/L]	1.72			NA	
Magnesium [mg/L]	13.8			NA	
Calcium [mg/L]	66.4			monitor	
Temperature [deg. C]	12.5	16.9		21.1	*outfall 002*
Alkalinity [mmol/L]	2.42			NA	
Dissolved oxygen [mg/L]	2	10		7.0	*daily max*
pH []	6.77	7.3	-7.3%	6.5 - 8.5	
Inorganic S.S. [mgTSS/L]	2.7			NA	*outfall 001 daily max,*
UOD, mg/L	27.3	28.3	-3.5%	50	*4.5*TKN + 1.5*CBOD*

Elements	Model	Setpoint	
Influent	6		
Oxidation	4.29		
RAS1	2.0		
WAS1	0.11		match
FST1	2.29		
PST2	2.37		
Aeration2	3.83		
RAS2	1.5		
WAS2	0.04		match
FST2	2.33		
PST3	3.04		
Aeration3	6.5		
RAS3	1.5		
IR	2.0		
WAS3	0.04		match
FST3	3		
Effluent	5.82		
Thickener	0.05		
BFP	0.02		
Sludge	0.18		change BFP output

FST1	98.00%	removal
FST2	99.00%	removal
FST3	99.00%	removal
Filters	80.00%	removal

Model 2: Phase I Facility Design Month

Temp: 16.9 deg C — Yellow boxes indicate parameters that may need to be changed in BioWin before running model.

Elements	Flow [mgd]	Total suspended solids [mgTSS/L]	Volatile suspended solids [mgVSS/L]	Total Carbonaceous BOD [mg/L]	Total COD [mg/L]	Ammonia N [mgN/L]	Nitrate N [mgN/L]	Total P [mgP/L]	Soluble PO4-P [mgP/L]	Total Kjeldahl Nitrogen [mgN/L]	Total N [mgN/L]	Inorganic S.S. [mgTSS/L]	Calcium [mg/L]	Magnesium [mg/L]	Temperature [deg. C]	Alkalinity [mmol/L]	pH []	Dissolved oxygen [mg/L]	Liquid volume [Mil. Gal]
Influent	6	257.47	193.44	243.14	495	17.75	0.21	5.8	2.9	29.1	29.31	64	66.4	13.8	16.9	4.14	7.7	4.8	0
Oxidation	4.29	1477.42	967.12	403.58	1455.32	0.47	13.53	28.33	2.11	85.4	98.92	453.01	66.4	13.8	16.9	2.04	7.18	2	2.36
FST1	2.29	55.36	36.24	16.26	79.97	0.47	13.53	3.09	2.11	5.4	18.93	16.97	66.4	13.8	16.9	2.04	7.18	2	0.33
RAS1	1.89	3105.5	2032.86	847.01	3029.92	0.47	13.53	57.23	2.11	176.98	190.5	952.23	66.4	13.8	16.9	2.04	7.18	2	0
PST2	2.37	120.75	89.91	153.51	301.85	14.96	2.28	4.16	2.71	22.77	25.06	30.3	66.4	13.8	16.9	3.81	7.5	4.33	0.24
Aeration2	3.83	2309.93	1682.93	937.14	2488.33	1.52	11.8	48.92	1.36	153.97	165.78	515.12	66.4	13.8	16.9	2.26	6.66	2	0.47
FST2	2.33	37.97	27.66	17.05	67.58	1.52	11.8	2.14	1.36	5.92	17.72	8.47	66.4	13.8	16.9	2.26	6.66	2	0.24
RAS2	1.46	5839.21	4254.23	2366.43	6248.77	1.52	11.8	121.59	1.36	383.96	395.77	1302.17	66.4	13.8	16.9	2.26	6.66	2	0
Sand Filters1&2	3.42	12.59	8.62	5.54	39.46	1	12.66	1.97	1.73	3.63	16.28	3.43	66.4	13.8	16.9	2.15	6.82	2	0
PST3	3.04	94.28	69.5	118.25	239.89	11.89	3.87	3.78	2.55	18.86	22.73	23.8	66.4	13.8	16.9	3.49	7.25	3.84	0.35
Aeration3	6.5	1729.4	1209.24	546.02	1798.56	0.55	9.51	35.85	1.96	109.7	119.21	441.66	66.4	13.8	16.9	2.34	6.66	2	1.09
FST3	3	25.94	18.14	9.18	52.77	0.55	9.51	2.47	1.96	3.94	13.45	6.62	66.4	13.8	16.9	2.34	6.66	2	0.59
RAS3	1.46	5136.46	3591.54	1619.75	5290.29	0.55	9.51	102.61	1.96	321.25	330.76	1311.77	66.4	13.8	16.9	2.34	6.66	2	0
Sand Filters3	2.4	6.49	4.53	3.05	32.83	0.55	9.51	2.09	1.96	2.73	12.24	1.66	66.4	13.8	16.9	2.34	6.64	2	0
Effluent	5.82	10.07	6.94	4.52	36.73	0.81	11.36	2.02	1.83	3.26	14.62	2.7	66.4	13.8	16.9	2.23	6.75	2	0
Thickener	0.05	1496.76	1067.47	610.53	1680.91	3.76	10.1	26.08	2.09	76.07	86.17	389.64	66.4	13.8	16.9	2.51	6.99	2.5	0.14
BFP	0.02	355.48	253.52	161.26	441.1	3.76	10.1	7.79	2.09	22.74	32.84	92.54	66.4	13.8	16.9	2.51	6.97	2.5	0
Sludge	0.18	7860.06	5605.72	3115.5	8593.57	3.76	10.1	128.09	2.09	373.42	383.52	2046.14	66.4	13.8	16.9	2.51	6.99	2.5	0

	Model	Data	% Difference	Permit	
Flow [mgd]	6.0	4.7	27.7%	6.0	
Total suspended solids [mgTSS/L]	10.07	9.2	9.5%	30	*11/1 - 5/31*
Volatile suspended solids [mgVSS/L]	6.94			NA	
Ammonia N [mgN/L]	0.81	2.6	-68.8%	1.1	*outfall 002, 6/1 - 10/31*
Total Kjeldahl Nitrogen [mgN/L]	3.26	4.3	-24.2%	monitor	
Nitrate N [mgN/L]	11.36			NA	
Total N [mgN/L]	14.62			NA	
Total BOD [mg/L]	4.52	7.2	-37.2%	monitor	
Total COD [mg/L]	36.73			NA	
Total P [mgP/L]	2.02			NA	
Soluble PO4-P [mgP/L]	1.83			NA	
Magnesium [mg/L]	13.8			NA	
Calcium [mg/L]	66.4			monitor	
Temperature [deg. C]	16.9	16.9		21.1	*outfall 002*
Alkalinity [mmol/L]	2.23			NA	
Dissolved oxygen [mg/L]	2	10		7.0	*daily max*
pH []	6.75	7.3	-7.5%	6.5 - 8.5	
Inorganic S.S. [mgTSS/L]	2.7			NA	*outfall 001 daily max,*
UOD, mg/L	21.5	28.3	-24.2%	50	*4.5*TKN + 1.5*CBOD*

Elements	Model	Setpoint	
Influent	6		
Oxidation	4.29		
RAS1	2.0		
WAS1	0.11		match
FST1	2.29		
PST2	2.37		
Aeration2	3.83		
RAS2	1.5		
WAS2	0.04		match
FST2	2.33		
PST3	3.04		
Aeration3	6.5		
RAS3	1.5		
IR	2.0		
WAS3	0.04		match
FST3	3		
Effluent	5.82		
Thickener	0.05		
BFP	0.02		
Sludge	0.18		change BFP output

FST1	98.00%	removal
FST2	99.00%	removal
FST3	99.00%	removal
Filters	80.00%	removal

run date:	2/1/06

Model 2: Phase I Facility Maximum Month

Temp: 12.5 deg C — Yellow boxes indicate parameters that may need to be changed in BioWin before running model.

Elements	Flow [mgd]	Total suspended solids [mgTSS/L]	Volatile suspended solids [mgVSS/L]	Total Carbonaceous BOD [mg/L]	Total COD [mg/L]	Ammonia N [mgN/L]	Nitrate N [mgN/L]	Total P [mgP/L]	Soluble PO4-P [mgP/L]	Total Kjeldahl Nitrogen [mgN/L]	Total N [mgN/L]	Inorganic S.S. [mgTSS/L]	Calcium [mg/L]	Magnesium [mg/L]	Temperature [deg. C]	Alkalinity [mmol/L]	pH []	Dissolved oxygen [mg/L]	Liquid volume [Mil. Gal]
Influent	7.1	256.49	175.46	220.54	449	13.14	0.17	6.7	3.35	45.3	45.47	81	51.6	10.4	12.5	2.98	8	4.4	0
Oxidation	4.66	1722.4	1031.25	466.24	1544.8	1.2	27.81	31.37	3.07	94.34	122.16	628.59	51.6	10.4	12.5	0.23	6.25	2	2.36
FST1	2.66	60.38	36.15	17.55	77.53	1.2	27.81	4.06	3.07	7.36	35.17	22.04	51.6	10.4	12.5	0.23	6.25	2	0.33
RAS1	1.89	3929.88	2352.92	1062.18	3493.63	1.2	27.81	67.65	3.07	209.87	237.68	1434.21	51.6	10.4	12.5	0.23	6.25	2	0
PST2	2.74	124.67	84.58	143.58	281.69	11.9	3.29	4.94	3.25	33.62	36.91	39.52	51.6	10.4	12.5	2.68	7.62	4.05	0.24
Aeration2	4.5	2713.02	1838.68	1056.16	2713.16	7.89	15.79	54.4	2.19	178.32	194.11	751.7	51.6	10.4	12.5	1.59	6.51	2	0.47
FST2	2.7	45.24	30.66	19.39	69.83	7.89	15.79	3.06	2.19	14.27	30.06	12.53	51.6	10.4	12.5	1.59	6.51	2	0.24
RAS2	1.76	6709.97	4547.51	2609.47	6673.46	7.89	15.79	131.31	2.19	424.11	439.9	1859.13	51.6	10.4	12.5	1.59	6.51	2	0
Sand Filters1&2	4.15	13.6	8.61	5.9	37.26	4.57	21.75	2.87	2.63	8.64	30.39	4.45	51.6	10.4	12.5	0.91	6.41	2	0
PST3	3.4	102.4	68.83	114.94	232.06	9.89	6.42	4.61	3.15	28.02	34.44	32.47	51.6	10.4	12.5	2.33	7.21	3.67	0.35
Aeration3	7.16	2141.22	1381.89	655.55	2046.84	1.15	19.61	41.75	2.72	127.99	147.59	668.42	51.6	10.4	12.5	0.82	6.2	2	1.09
FST3	3.36	32.89	21.23	11.09	55	1.15	19.61	3.32	2.72	5.93	25.54	10.27	51.6	10.4	12.5	0.82	6.2	2	0.59
RAS3	1.76	6073.03	3919.38	1857.4	5761.42	1.15	19.61	113.43	2.72	355.61	375.22	1895.79	51.6	10.4	12.5	0.82	6.2	2	0
Sand Filters3	2.76	8.01	5.17	3.49	31.49	1.15	19.61	2.86	2.72	4.49	24.09	2.5	51.6	10.4	12.5	0.82	6.15	2	0
Effluent	6.91	11.37	7.24	4.94	34.96	3.21	20.9	2.87	2.66	6.98	27.88	3.67	51.6	10.4	12.5	0.88	6.35	2	0
Thickener	0.04	2258.2	1474.62	852.64	2293.44	4.59	19.07	38.89	2.9	144.8	163.87	726.97	51.6	10.4	12.5	1.08	6.65	2.45	0.14
BFP	0.02	429.06	280.18	178.39	477.14	4.59	19.07	9.74	2.9	35.61	54.67	138.13	51.6	10.4	12.5	1.08	6.59	2.45	0
Sludge	0.19	8987.65	5869	3333.23	8975.63	4.59	19.07	146.14	2.9	546.51	565.58	2893.36	51.6	10.4	12.5	1.08	6.65	2.45	0

	Model	Data	% Difference	Permit	
Flow [mgd]	7.1	7.1	0.0%	6.0	
Total suspended solids [mgTSS/L]	11.37	25.1	-54.7%	30	*11/1 - 5/31*
Volatile suspended solids [mgVSS/L]	7.24			NA	
Ammonia N [mgN/L]	3.21	5.7	-43.7%	1.1	*outfall 002, 6/1 - 10/31*
Total Kjeldahl Nitrogen [mgN/L]	6.98	12.9	-45.9%	monitor	
Nitrate N [mgN/L]	20.9			NA	
Total N [mgN/L]	27.88			NA	
Total Carbonaceous BOD [mg/L]	4.94			monitor	
Total COD [mg/L]	34.96			NA	
Total P [mgP/L]	2.87	16.3		NA	
Soluble PO4-P [mgP/L]	2.66			NA	
Magnesium [mg/L]	10.4			NA	
Calcium [mg/L]	51.6			monitor	
Temperature [deg. C]	12.5	23.6		21.1	*outfall 002*
Alkalinity [mmol/L]	0.88			NA	
Dissolved oxygen [mg/L]	2	13.3		7.0	*daily max*
pH []	6.35	7.5	-15.3%	6.5 - 8.5	
Inorganic S.S. [mgTSS/L]	3.67			NA	*outfall 001 daily max,*
UOD, mg/L	38.8	64.2	-39.5%	50	*4.5*TKN + 1.5*CBOD*

Elements	Model	Setpoint	
Influent	7.1		
Oxidation	4.66		
RAS1	2.0		
WAS1	0.11		match
FST1	2.66		
PST2	2.74		
Aeration2	4.5		
RAS2	1.8		
WAS2	0.04		match
FST2	2.7		
PST3	3.4		
Aeration3	7.16		
RAS3	1.8		
IR	2.0		
WAS3	0.04		match
FST3	3.36		
Effluent	6.91		
Thickener	0.04		
BFP	0.02		
Sludge	0.19		change BFP output

FST1	98.00%	removal
FST2	99.00%	removal
FST3	99.00%	removal
Filters	80.00%	removal

Model 2: Phase I Facility Maximum Month

Temp: 16.9 deg C | Yellow boxes indicate parameters that may need to be changed in BioWin before running model.

Elements	Flow [mgd]	Total suspended solids [mgTSS/L]	Volatile suspended solids [mgVSS/L]	Total Carbonaceous BOD [mg/L]	Total COD [mg/L]	Ammonia N [mgN/L]	Nitrate N [mgN/L]	Total P [mgP/L]	Soluble PO4-P [mgP/L]	Total Kjeldahl Nitrogen [mgN/L]	Total N [mgN/L]	Inorganic S.S. [mgTSS/L]	Calcium [mg/L]	Magnesium [mg/L]	Temperature [deg. C]	Alkalinity [mmol/L]	pH []	Dissolved oxygen [mg/L]	Liquid volume [Mil. Gal]
Influent	7.1	256.49	175.46	220.54	449	13.14	0.17	6.7	3.35	45.3	45.47	81	51.6	10.4	16.9	2.98	8	4.4	0
Oxidation	4.66	1686.16	997.65	432.32	1496.46	0.82	28.61	30.47	3.2	90.59	119.2	628.59	51.6	10.4	16.9	0.14	6.05	2	2.36
FST1	2.66	59.11	34.98	16.33	75.79	0.82	28.61	4.16	3.2	6.81	35.42	22.04	51.6	10.4	16.9	0.14	6.05	2	0.33
RAS1	1.89	3847.21	2276.28	984.83	3383.4	0.82	28.61	65.43	3.2	201.86	230.48	1434.21	51.6	10.4	16.9	0.14	6.05	2	0
PST2	2.74	124.41	84.34	143.32	281.32	11.47	3.77	4.94	3.26	33.15	36.92	39.52	51.6	10.4	16.9	2.61	7.63	4.05	0.24
Aeration2	4.5	2670.09	1798.28	1011.68	2653.59	2.43	21.55	53.38	2.26	168.97	190.52	751.7	51.6	10.4	16.9	0.79	6.22	2	0.47
FST2	2.7	44.52	29.99	18.54	68.69	2.43	21.55	3.11	2.26	8.64	30.18	12.53	51.6	10.4	16.9	0.79	6.22	2	0.24
RAS2	1.76	6603.77	4447.57	2499.64	6526.36	2.43	21.55	128.7	2.26	409.18	430.73	1859.13	51.6	10.4	16.9	0.79	6.22	2	0
Sand Filters1&2	4.15	13.34	8.37	5.58	36.81	1.63	25.06	2.96	2.72	5.59	30.65	4.45	51.6	10.4	16.9	0.46	6.17	2	0
PST3	3.4	101.83	68.3	114.38	231.27	9.44	6.93	4.62	3.17	27.5	34.43	32.47	51.6	10.4	16.9	2.26	7.22	3.67	0.35
Aeration3	7.16	2087.23	1331.91	605.54	1975.13	0.68	20.13	40.3	2.8	122.55	142.69	668.42	51.6	10.4	16.9	0.74	6.18	2	1.09
FST3	3.36	32.06	20.46	10.29	53.85	0.68	20.13	3.38	2.8	5.33	25.47	10.27	51.6	10.4	16.9	0.74	6.18	2	0.59
RAS3	1.76	5919.9	3777.62	1715.61	5558.1	0.68	20.13	109.16	2.8	341.16	361.29	1895.79	51.6	10.4	16.9	0.74	6.18	2	0
Sand Filters3	2.76	7.81	4.98	3.27	31.18	0.68	20.13	2.94	2.8	3.95	24.08	2.5	51.6	10.4	16.9	0.74	6.15	2	0
Effluent	6.91	11.14	7.02	4.66	34.56	1.25	23.09	2.95	2.76	4.94	28.03	3.67	51.6	10.4	16.9	0.58	6.18	2	0
Thickener	0.04	2229.3	1447.76	825.06	2254.6	3.37	20.54	38.18	2.99	140.91	161.45	726.97	51.6	10.4	16.9	0.89	6.58	2.45	0.14
BFP	0.02	423.57	275.07	173.11	469.71	3.37	20.54	9.67	2.99	33.84	54.38	138.13	51.6	10.4	16.9	0.89	6.55	2.45	0
Sludge	0.19	8872.63	5762.07	3223.57	8821.22	3.37	20.54	143.04	2.99	534.81	555.36	2893.36	51.6	10.4	16.9	0.89	6.58	2.45	0

	Model	Data	% Difference	Permit	
Flow [mgd]	7.1	7.1	0.0%	6.0	
Total suspended solids [mgTSS/L]	11.14	25.1	-55.6%	30	*11/1 - 5/31*
Volatile suspended solids [mgVSS/L]	7.02			NA	
Ammonia N [mgN/L]	1.25	5.7	-78.1%	1.1	*outfall 002, 6/1 - 10/31*
Total Kjeldahl Nitrogen [mgN/L]	4.94	12.9	-61.7%	monitor	
Nitrate N [mgN/L]	23.09			NA	
Total N [mgN/L]	28.03			NA	
Total Carbonaceous BOD [mg/L]	4.66			monitor	
Total COD [mg/L]	34.56			NA	
Total P [mgP/L]	2.95	16.3		NA	
Soluble PO4-P [mgP/L]	2.76			NA	
Magnesium [mg/L]	10.4			NA	
Calcium [mg/L]	51.6			monitor	
Temperature [deg. C]	16.9	16.9		21.1	*outfall 002*
Alkalinity [mmol/L]	0.58			NA	
Dissolved oxygen [mg/L]	2	13.3		7.0	*daily max*
pH []	6.18	7.5	-17.6%	6.5 - 8.5	
Inorganic S.S. [mgTSS/L]	3.67			NA	*outfall 001 daily max,*
UOD, mg/L	29.2	64.2	-54.5%	50	*4.5*TKN + 1.5*CBOD*

Elements	Model	Setpoint	
Influent	7.1		
Oxidation	4.66		
RAS1	2.0		
WAS1	0.11		match
FST1	2.66		
PST2	2.74		
Aeration2	4.5		
RAS2	1.8		
WAS2	0.04		match
FST2	2.7		
PST3	3.4		
Aeration3	7.16		
RAS3	1.8		
IR	2.0		
WAS3	0.04		match
FST3	3.36		
Effluent	6.91		
Thickener	0.04		
BFP	0.02		
Sludge	0.19		change BFP output

FST1	98.00%	removal
FST2	99.00%	removal
FST3	99.00%	removal
Filters	80.00%	removal

run date:	2/1/06

Model 2: Phase I Facility Maximum Day

Temp: 12.5 deg C — Yellow boxes indicate parameters that may need to be changed in BioWin before running model.

Elements	Flow [mgd]	Total suspended solids [mgTSS/L]	Volatile suspended solids [mgVSS/L]	Total Carbonaceous BOD [mg/L]	Total COD [mg/L]	Ammonia N [mgN/L]	Nitrate N [mgN/L]	Total P [mgP/L]	Soluble PO4-P [mgP/L]	Total Kjeldahl Nitrogen [mgN/L]	Total N [mgN/L]	Inorganic S.S. [mgTSS/L]	Calcium [mg/L]	Magnesium [mg/L]	Temperature [deg. C]	Alkalinity [mmol/L]	pH []	Dissolved oxygen [mg/L]	Liquid volume [Mil. Gal]
Influent	13.4	198.5	132.48	166.51	339	10.82	0.18	7.3	3.65	33.8	33.98	66	31.2	5.6	12.5	2.42	8.6	3.4	0
Oxidation	6.76	1852.29	1114.62	559.52	1659.34	1.83	18.48	35.29	4.26	103.1	121.58	668.55	31.2	5.6	12.5	0.5	6.61	2	2.36
FST1	4.76	52.62	31.67	17.27	65.55	1.83	18.48	5.14	4.26	7.47	25.96	18.99	31.2	5.6	12.5	0.5	6.61	2	0.33
RAS1	1.89	6132.06	3689.98	1849.06	5449.52	1.83	18.48	106.99	4.26	330.5	348.98	2213.24	31.2	5.6	12.5	0.5	6.61	2	0
PST2	4.84	104.06	69.04	116.82	227.63	10.58	1.03	5.56	3.66	27.2	28.22	34.51	31.2	5.6	12.5	2.35	8.25	3.28	0.24
Aeration2	6.8	2935.66	1981.16	1195.98	2920.19	14.04	2.52	59.61	3.2	196.97	199.49	824.11	31.2	5.6	12.5	2.55	6.74	2	0.47
FST2	4.8	41.6	28.07	19.14	61.2	14.04	2.52	4	3.2	20.12	22.64	11.68	31.2	5.6	12.5	2.55	6.74	2	0.24
RAS2	1.96	9876.95	6665.55	4018.58	9777.35	14.04	2.52	192.98	3.2	621.15	623.67	2772.69	31.2	5.6	12.5	2.55	6.74	2	0
Sand Filters1&2	8.35	10.77	6.83	5.57	29.56	7.96	10.47	3.92	3.73	11.76	22.23	3.5	31.2	5.6	12.5	1.53	6.66	2	0
PST3	5.5	94.85	62.55	102.87	204.38	9.57	2.41	5.38	3.65	24.71	27.12	31.2	31.2	5.6	12.5	2.18	7.6	3.13	0.35
Aeration3	9.46	2479.23	1600.58	826.2	2358.35	1.79	12.8	49.15	3.54	148.95	161.75	771.77	31.2	5.6	12.5	0.93	6.27	2	1.09
FST3	5.46	33.88	21.87	12.4	50.52	1.79	12.8	4.16	3.54	6.43	19.23	10.55	31.2	5.6	12.5	0.93	6.27	2	0.59
RAS3	1.96	9151.27	5908.03	3046.6	8655.16	1.79	12.8	171.89	3.54	537.8	550.61	2848.72	31.2	5.6	12.5	0.93	6.27	2	0
Sand Filters3	4.86	7.61	4.91	3.66	25.73	1.79	12.8	3.68	3.54	4.9	17.7	2.37	31.2	5.6	12.5	0.93	6.21	2	0
Effluent	13.21	9.61	6.13	4.87	28.15	5.69	11.33	3.83	3.66	9.24	20.57	3.09	31.2	5.6	12.5	1.31	6.55	2	0
Thickener	0.04	3401.34	2198.15	1306.14	3377.42	5.76	11	65.28	3.83	207.62	218.62	1115.6	31.2	5.6	12.5	1.32	6.79	2.29	0.14
BFP	0.02	646.26	417.65	262.21	675.32	5.76	11	15.51	3.83	47.86	58.86	211.96	31.2	5.6	12.5	1.32	6.73	2.29	0
Sludge	0.19	13537.34	8748.64	5146.79	13318.46	5.76	11	248.41	3.83	795.38	806.38	4440.1	31.2	5.6	12.5	1.32	6.79	2.29	0

	Model	Data	% Difference	Permit	
Flow [mgd]	13.4	13.4	0.0%	6.0	
Total suspended solids [mgTSS/L]	9.61	59	-83.7%	30	*11/1 - 5/31*
Volatile suspended solids [mgVSS/L]	6.13			NA	
Ammonia N [mgN/L]	5.69	10.5	-45.8%	1.1	*outfall 002, 6/1 - 10/31*
Total Kjeldahl Nitrogen [mgN/L]	9.24	42	-78.0%	monitor	
Nitrate N [mgN/L]	11.33			NA	
Total N [mgN/L]	20.57			NA	
Total Carbonaceous BOD [mg/L]	4.87			monitor	
Total COD [mg/L]	28.15			NA	
Total P [mgP/L]	3.83	40.4		NA	
Soluble PO4-P [mgP/L]	3.66			NA	
Magnesium [mg/L]	5.6			NA	
Calcium [mg/L]	31.2			monitor	
Temperature [deg. C]	12.5	23.6		21.1	*outfall 002*
Alkalinity [mmol/L]	1.31			NA	
Dissolved oxygen [mg/L]	2	13.8		7.0	*daily max*
pH []	6.55	8.3	-21.1%	6.5 - 8.5	
Inorganic S.S. [mgTSS/L]	3.09			NA	*outfall 001 daily max,*
UOD, mg/L	48.9	116.7	-58.1%	50	*4.5*TKN + 1.5*CBOD*

Elements	Model	Setpoint	
Influent	13.4		
Oxidation	6.76		
RAS1	2.0		
WAS1	0.11		match
FST1	4.76		
PST2	4.84		
Aeration2	6.8		
RAS2	2.0		
WAS2	0.04		match
FST2	4.8		
PST3	5.5		
Aeration3	9.46		
RAS3	2.0		
IR	2.0		
WAS3	0.04		match
FST3	5.46		
Effluent	13.21		
Thickener	0.04		
BFP	0.02		
Sludge	0.19		change BFP output

FST1	98.00%	removal
FST2	99.00%	removal
FST3	99.00%	removal
Filters	80.00%	removal

Model 2: Phase I Facility Maximum Day

Temp: 16.9 deg C — Yellow boxes indicate parameters that may need to be changed in BioWin before running model.

Elements	Flow [mgd]	Total suspended solids [mgTSS/L]	Volatile suspended solids [mgVSS/L]	Total Carbonaceous BOD [mg/L]	Total COD [mg/L]	Ammonia N [mgN/L]	Nitrate N [mgN/L]	Total P [mgP/L]	Soluble PO4-P [mgP/L]	Total Kjeldahl Nitrogen [mgN/L]	Total N [mgN/L]	Inorganic S.S. [mgTSS/L]	Calcium [mg/L]	Magnesium [mg/L]	Temperature [deg. C]	Alkalinity [mmol/L]	pH []	Dissolved oxygen [mg/L]	Liquid volume [Mil. Gal]
Influent	13.4	198.5	132.48	166.51	339	10.82	0.18	7.3	3.65	33.8	33.98	66	31.2	5.6	16.9	2.42	8.6	3.4	0
Oxidation	6.76	1816.44	1081.25	525.38	1610.99	0.91	19.75	34.37	4.36	98.85	118.6	668.55	31.2	5.6	16.9	0.34	6.45	2	2.36
FST1	4.76	51.61	30.72	16.23	64.09	0.91	19.75	5.22	4.36	6.4	26.15	18.99	31.2	5.6	16.9	0.34	6.45	2	0.33
RAS1	1.89	6013.38	3579.5	1736.18	5289.66	0.91	19.75	103.71	4.36	318.71	338.46	2213.24	31.2	5.6	16.9	0.34	6.45	2	0
PST2	4.84	103.88	68.87	116.63	227.37	10.21	1.42	5.56	3.66	26.8	28.22	34.51	31.2	5.6	16.9	2.29	8.32	3.28	0.24
Aeration2	6.8	2911.77	1957.54	1164.57	2882.72	5.98	10.76	59.17	3.22	186.95	197.71	824.11	31.2	5.6	16.9	1.38	6.48	2	0.47
FST2	4.8	41.26	27.74	18.52	60.41	5.98	10.76	4.01	3.22	11.89	22.65	11.68	31.2	5.6	16.9	1.38	6.48	2	0.24
RAS2	1.96	9796.55	6586.1	3913.34	9651.91	5.98	10.76	191.46	3.22	606.83	617.59	2772.69	31.2	5.6	16.9	1.38	6.48	2	0
Sand Filters1&2	8.35	10.62	6.68	5.29	29.17	3.45	15.24	3.98	3.79	7.14	22.38	3.5	31.2	5.6	16.9	0.87	6.45	2	0
PST3	5.5	94.36	62.09	102.37	203.68	9.13	2.88	5.38	3.66	24.2	27.08	31.2	31.2	5.6	16.9	2.11	7.68	3.13	0.35
Aeration3	9.46	2420.82	1546.41	771.26	2280.38	0.89	13.72	47.55	3.6	142.72	156.44	771.77	31.2	5.6	16.9	0.8	6.22	2	1.09
FST3	5.46	33.08	21.13	11.61	49.4	0.89	13.72	4.2	3.6	5.4	19.13	10.55	31.2	5.6	16.9	0.8	6.22	2	0.59
RAS3	1.96	8935.67	5708.06	2843.93	8367.51	0.89	13.72	165.84	3.6	517.36	531.08	2848.72	31.2	5.6	16.9	0.8	6.22	2	0
Sand Filters3	4.86	7.43	4.75	3.45	25.43	0.89	13.72	3.74	3.6	3.93	17.65	2.37	31.2	5.6	16.9	0.8	6.19	2	0
Effluent	13.21	9.45	5.97	4.61	27.79	2.51	14.68	3.89	3.72	5.96	20.64	3.09	31.2	5.6	16.9	0.84	6.37	2	0
Thickener	0.04	3364.01	2163.18	1269.04	3326.23	3.82	13.12	64.32	3.89	202.31	215.43	1115.6	31.2	5.6	16.9	1.03	6.69	2.29	0.14
BFP	0.02	639.16	411	255.11	665.52	3.82	13.12	15.37	3.89	45.24	58.36	211.96	31.2	5.6	16.9	1.03	6.67	2.29	0
Sludge	0.19	13388.77	8609.44	4999.32	13115.03	3.82	13.12	244.42	3.89	780.18	793.3	4440.1	31.2	5.6	16.9	1.03	6.69	2.29	0

	Model	Data	% Difference	Permit	
Flow [mgd]	13.4	13.4	0.0%	6.0	
Total suspended solids [mgTSS/L]	9.45	59	-84.0%	30	*11/1 - 5/31*
Volatile suspended solids [mgVSS/L]	5.97			NA	
Ammonia N [mgN/L]	2.51	10.5	-76.1%	1.1	*outfall 002, 6/1 - 10/31*
Total Kjeldahl Nitrogen [mgN/L]	5.96	42	-85.8%	monitor	
Nitrate N [mgN/L]	14.68			NA	
Total N [mgN/L]	20.64			NA	
Total Carbonaceous BOD [mg/L]	4.61			monitor	
Total COD [mg/L]	27.79			NA	
Total P [mgP/L]	3.89	40.4		NA	
Soluble PO4-P [mgP/L]	3.72			NA	
Magnesium [mg/L]	5.6			NA	
Calcium [mg/L]	31.2			monitor	
Temperature [deg. C]	16.9	23.6		21.1	*outfall 002*
Alkalinity [mmol/L]	0.84			NA	
Dissolved oxygen [mg/L]	2	13.8		7.0	*daily max*
pH []	6.37	8.3	-23.3%	6.5 - 8.5	
Inorganic S.S. [mgTSS/L]	3.09			NA	*outfall 001 daily max,*
UOD, mg/L	33.7	116.7	-71.1%	50	*4.5*TKN + 1.5*CBOD*

Elements	Model	Setpoint	
Influent	13.4		
Oxidation	6.76		
RAS1	2.0		
WAS1	0.11		match
FST1	4.76		
PST2	4.84		
Aeration2	6.8		
RAS2	2.0		
WAS2	0.04		match
FST2	4.8		
PST3	5.5		
Aeration3	9.46		
RAS3	2.0		
IR	2.0		
WAS3	0.04		match
FST3	5.46		
Effluent	13.21		
Thickener	0.04		
BFP	0.02		
Sludge	0.19		change BFP output

FST1	98.00%	removal
FST2	99.00%	removal
FST3	99.00%	removal
Filters	80.00%	removal

run date: 2/23/06

Model 3: Phase II MBR Facility Average Month Several MBR SRT Runs: 5, 10, 15, 20, 30 days

Yellow boxes indicate parameters that may need to be changed in BioWin before running model.

#1

MLSS 3,700 mg/L SRT 5.0 days

Elements	Flow [mgd]	Total suspended solids [mgTSS/L]	Volatile suspended solids [mgVSS/L]	Total COD [mg/L]	Total Carbonaceous BOD [mg/L]	Ammonia N [mgN/L]	Nitrate N [mgN/L]	Total Kjeldahl Nitrogen [mgN/L]	Total N [mgN/L]	Total P [mgP/L]	Soluble PO4-P [mgP/L]	Temperature [deg. C]	Alkalinity [mmol/L]	pH []	Dissolved oxygen [mg/L]	Magnesium [mg/L]	Calcium [mg/L]	Liquid volume [Mil. Gal]
Influent	9	257.47	193.44	495	243.14	18.04	0.21	29.1	29.31	5.8	2.9	12.5	4.14	7.7	4.8	13.8	66	0
DO Depl.	19.74	3768.09	2435.16	3640.16	1104.63	4.58	1.37	211.69	213.07	101.84	0.24	12.5	3.18	6.85	0.07	13.33	65.87	0.2
Anoxic1	19.74	3748.47	2428.4	3635.67	1096.06	5.78	0.01	211.69	211.7	101.84	7.9	12.5	3.35	6.83	0	15.07	66.35	0.8
Aeration1	19.74	3749.07	2418.82	3609.27	1084.96	3.26	1.54	210.04	211.58	101.84	2.21	12.5	3.07	6.77	2	13.77	65.99	0.65
MBR1	19.74	3741.98	2407.48	3588.33	1073.38	1.17	3.11	208.44	211.54	101.84	0.08	12.5	2.81	6.8	8.28	13.27	65.85	0.8
Membranes1	4.89	0.76	0.49	29.35	1.44	1.17	3.11	2.9	6	0.1	0.08	12.5	2.81	6.74	8.28	13.27	65.85	0
RAS1	14.63	4973.81	3200.01	4760.16	1426.33	1.17	3.11	276.11	279.22	135.33	0.08	12.5	2.81	6.8	8.28	13.27	65.85	0
PST2	2.35	96.07	72.1	284.85	150.42	16.47	0.62	23.32	23.94	3.77	2.64	12.5	4.01	7.51	4.52	13.77	65.99	0.24
Anoxic2	6.32	2966.81	2124.44	3151.24	1159.84	7.96	0.02	196.82	196.84	94.54	4.25	12.5	3.51	6.91	0	14.32	66.14	0.1
Aeration2	6.32	2957.31	2107.3	3108.86	1136.51	2.35	4.35	192.23	196.57	94.54	0.32	12.5	2.82	6.74	2	13.46	65.91	0.41
FST2	2.32	27.53	19.62	56.15	11.8	2.35	4.35	5.8	10.15	1.2	0.32	12.5	2.82	6.74	2	13.46	65.91	0.24
RAS2	1.97	6357.61	4530.25	6651.82	2441.86	2.35	4.35	408.59	412.94	202.86	0.32	12.5	2.82	6.74	2	13.46	65.91	0
Sand Filters2	1.32	7.25	5.17	35.02	4.01	2.35	4.35	4.51	8.86	0.55	0.32	12.5	2.82	6.68	2	13.46	65.91	0
PST3	3.19	83.47	62.33	242.05	124.18	13.55	1.47	19.79	21.25	3.5	2.45	12.5	3.75	7.28	4.05	13.75	65.99	0.36
Anoxic3	7.15	2044.43	1427.94	2136.21	662.49	6.55	0.04	132.82	132.86	47.88	2.22	12.5	3.4	6.88	0	13.81	66	0.14
Aeration3	7.15	2025.85	1407.53	2089.89	634.51	0.81	5.16	127.39	132.54	47.88	1.64	12.5	2.64	6.7	2	13.7	65.97	1.09
FST3	3.15	16.56	11.51	43.36	6.17	0.81	5.16	3.57	8.72	2.01	1.64	12.5	2.64	6.7	2	13.7	65.97	0.69
RAS3	1.96	5189.78	3605.77	5312.48	1623.93	0.81	5.16	322.36	327.51	120.1	1.64	12.5	2.64	6.7	2	13.7	65.97	0
Sand Filters3	2.55	3.07	2.13	29.62	1.95	0.81	5.16	2.74	7.89	1.71	1.64	12.5	2.64	6.64	2	13.7	65.97	0
Effluent	8.76	2.41	1.67	30.29	1.98	1.24	3.89	3.09	6.98	0.64	0.57	12.5	2.76	6.76	5.51	13.42	65.9	0
Thickener	0.05	2348.14	1618.15	2505.27	877.28	3.62	3.09	116.09	119.18	52.77	0.71	12.5	2.98	6.86	6.33	13.42	65.9	0.14
BFP	0.06	175.5	120.94	233.84	81.33	3.62	3.09	13.99	17.08	4.6	0.71	12.5	2.98	6.8	6.33	13.42	65.9	0
Sludge	0.24	8730.89	6016.61	9178.22	3215.6	3.62	3.09	416.04	419.13	194.28	0.71	12.5	2.98	6.86	6.33	13.42	65.9	0

Check	Permit	Combined Effluent	?
TSS	20	2.41	OK
Ammonia	1.1	1.24	NO
TKN	NA	3.09	OK
CBOD	NA	1.98	OK
UOD	45	16.9	OK
NO3	10	3.89	OK
Flow	8.8	mgd	

Zones	mgal		
DO Depl.	0.200		
Anoxic	0.800		
Aeration	0.650		
Membranes	0.800		
Total Vol Req'd	2.450		
Total Vol Avail.	2.450		
Vol. check:	OK		
MBR:	99.995%	removal	(enter manually)
FSTs:	99.50%	removal	(enter manually)
Filters:	85.00%	removal	(enter manually)
SRT MBR:	5.0	days	
MBR MLSS:	3,749	mg/L	

Elements	Model	Setpoint
Influent	9	
DO Depl.	19.74	
Anoxic1	19.74	
Aeration1	19.74	
MBR1	19.74	
Membranes1	4.89	
RAS1	14.63	
WAS1	0.22	
PST2	2.35	
Aeration2	6.32	
FST2	2.32	
RAS2	2.00	2.00
IR	2.00	2.00
WAS2	0.03	0.03
PST3	3.19	
Anoxic3	7.15	
Aeration3	7.15	
FST3	3.15	
RAS3	2.00	2.00
IR	2.00	2.00
WAS3	0.04	0.04
Effluent	8.76	

Elements	Model	Setpoint
Thickener	0.05	
Thickener Underflow	0.30	0.3
BFP	0.06	
Sludge	0.24	0.24
Sidestream	0.11	

Model 3: Phase II MBR Facility Average Month

#2

MLSS 6,700 mg/L SRT 10.0 days

Elements	Flow [mgd]	Total suspended solids [mgTSS/L]	Volatile suspended solids [mgVSS/L]	Total COD [mg/L]	Total Carbonaceous BOD [mg/L]	Ammonia N [mgN/L]	Nitrate N [mgN/L]	Total Kjeldahl Nitrogen [mgN/L]	Total N [mgN/L]	Total P [mgP/L]	Soluble PO4-P [mgP/L]	Temperature [deg. C]	Alkalinity [mmol/L]	pH []	Dissolved oxygen [mg/L]	Magnesium [mg/L]	Calcium [mg/L]	Liquid volume [Mil. Gal]
Influent	9	257.47	193.44	495	243.14	18.04	0.21	29.1	29.31	5.8	2.9	12.5	4.14	7.7	4.8	13.8	66	0
DO Depl.	19.82	6779.34	4131.93	6177.04	1446.43	4.02	1.52	349.27	350.8	201.54	0.41	12.5	3.11	6.84	0.05	13.27	65.85	0.2
Anoxic1	19.82	6755.5	4123.78	6171.93	1436.63	5.37	0.01	349.27	349.28	201.54	9.72	12.5	3.31	6.82	0	15.39	66.44	0.8
Aeration1	19.82	6755.54	4112.21	6142.67	1424.43	2.13	2.3	346.84	349.15	201.54	3.16	12.5	2.92	6.75	2	13.87	66.02	0.65
MBR1	19.82	6748.08	4099.06	6119.28	1410.93	0.38	3.71	345.4	349.11	201.54	0.15	12.5	2.69	6.78	8.18	13.15	65.82	0.8
Membranes1	4.97	1.35	0.82	30.94	1.31	0.38	3.71	2.15	5.86	0.19	0.15	12.5	2.69	6.72	8.18	13.15	65.82	0
RAS1	14.74	9005.84	5470.52	8156.72	1882.66	0.38	3.71	460.26	463.97	268.92	0.15	12.5	2.69	6.78	8.18	13.15	65.82	0
PST2	2.35	96.07	72.1	284.85	150.42	16.47	0.62	23.32	23.94	3.77	2.64	12.5	4.01	7.51	4.52	13.77	65.99	0.24
Anoxic2	6.32	2966.81	2124.44	3151.24	1159.84	7.96	0.02	196.82	196.84	94.54	4.25	12.5	3.51	6.91	0	14.32	66.14	0.1
Aeration2	6.32	2957.31	2107.3	3108.86	1136.51	2.35	4.35	192.23	196.57	94.54	0.32	12.5	2.82	6.74	2	13.46	65.91	0.41
FST2	2.32	27.53	19.62	56.15	11.8	2.35	4.35	5.8	10.15	1.2	0.32	12.5	2.82	6.74	2	13.46	65.91	0.24
RAS2	1.97	6357.61	4530.25	6651.82	2441.86	2.35	4.35	408.59	412.94	202.86	0.32	12.5	2.82	6.74	2	13.46	65.91	0
Sand Filters2	1.32	7.25	5.17	35.02	4.01	2.35	4.35	4.51	8.86	0.55	0.32	12.5	2.82	6.68	2	13.46	65.91	0
PST3	3.19	83.47	62.33	242.05	124.18	13.55	1.47	19.79	21.25	3.5	2.45	12.5	3.75	7.28	4.05	13.75	65.99	0.36
Anoxic3	7.15	2044.43	1427.94	2136.21	662.49	6.55	0.04	132.82	132.86	47.88	2.22	12.5	3.4	6.88	0	13.81	66	0.14
Aeration3	7.15	2025.85	1407.53	2089.89	634.51	0.81	5.16	127.39	132.54	47.88	1.64	12.5	2.64	6.7	2	13.7	65.97	1.09
FST3	3.15	16.56	11.51	43.36	6.17	0.81	5.16	3.57	8.72	2.01	1.64	12.5	2.64	6.7	2	13.7	65.97	0.69
RAS3	1.96	5189.78	3605.77	5312.48	1623.93	0.81	5.16	322.36	327.51	120.1	1.64	12.5	2.64	6.7	2	13.7	65.97	0
Sand Filters3	2.55	3.07	2.13	29.62	1.95	0.81	5.16	2.74	7.89	1.71	1.64	12.5	2.64	6.64	2	13.7	65.97	0
Effluent	8.84	2.73	1.85	31.17	1.9	0.8	4.22	2.67	6.89	0.68	0.6	12.5	2.7	6.75	5.47	13.36	65.88	0
Thickener	0.04	2800.82	1890.57	2940.01	962.16	4.4	3.36	131.92	135.29	65.8	1.03	12.5	3	6.88	5.37	13.44	65.9	0.14
BFP	0.04	250.01	168.76	317.88	107.97	4.4	3.36	17.89	21.26	6.81	1.03	12.5	3	6.82	5.37	13.44	65.9	0
Sludge	0.16	12437.98	8395.69	12846.63	4189.34	4.4	3.36	562.74	566.1	288.67	1.03	12.5	3	6.88	5.37	13.44	65.9	0

Check	Permit	Combined Effluent	?
TSS	20	2.73	OK
Ammonia	1.1	0.8	OK
TKN	NA	2.67	OK
CBOD	NA	1.9	OK
UOD	45	14.9	OK
NO3	10	4.22	OK
Flow	8.8	mgd	

Zones	mgal		
DO Depl.	0.200		
Anoxic	0.800		
Aeration	0.650		
Membranes	0.800		
Total Vol Req'd	2.450		
Total Vol Avail.	2.450		
Vol. check:	OK		
MBR:	99.995%	removal	(enter manually)
FSTs:	99.50%	removal	(enter manually)
Filters:	85.00%	removal	(enter manually)
SRT MBR:	10.0	days	
MBR MLSS:	6,748	mg/L	

Elements	Model	Setpoint
Influent	9	
DO Depl.	19.82	
Anoxic1	19.82	
Aeration1	19.82	
MBR1	19.82	
Membranes1	4.97	
RAS1	14.74	
WAS1	0.11	
PST2	2.35	
Aeration2	6.32	
FST2	2.32	
RAS2	2.00	2.00
IR	2.00	2.00
WAS2	0.03	0.025
PST3	3.19	
Anoxic3	7.15	
Aeration3	7.15	
FST3	3.15	
RAS3	2.00	2.00
IR	2.00	2.00
WAS3	0.04	0.035
Effluent	8.84	

Elements	Model	Setpoint
Thickener	0.04	
Thickener Underflow	0.20	0.2
BFP	0.04	
Sludge	0.16	0.16
Sidestream	0.08	

Model 3: Phase II MBR Facility Average Month

#3

MLSS 9,600 mg/L **SRT** 15.0 days

Elements	Flow [mgd]	Total suspended solids [mgTSS/L]	Volatile suspended solids [mgVSS/L]	Total COD [mg/L]	Total Carbonaceous BOD [mg/L]	Ammonia N [mgN/L]	Nitrate N [mgN/L]	Total Kjeldahl Nitrogen [mgN/L]	Total N [mgN/L]	Total P [mgP/L]	Soluble PO4-P [mgP/L]	Temperature [deg. C]	Alkalinity [mmol/L]	pH []	Dissolved oxygen [mg/L]	Magnesium [mg/L]	Calcium [mg/L]	Liquid volume [Mil. Gal]
Influent	9	257.47	193.44	495	243.14	18.04	0.21	29.1	29.31	5.8	2.9	12.5	4.14	7.7	4.8	13.8	66	0
DO Depl.	19.86	9629.84	5676.45	8498.97	1624.41	3.94	1.57	471.87	473.44	298.05	0.56	12.5	3.1	6.83	0.05	13.26	65.85	0.2
Anoxic1	19.86	9603.94	5667.62	8493.58	1614.15	5.36	0.01	471.86	471.88	298.05	10.66	12.5	3.3	6.82	0	15.56	66.48	0.8
Aeration1	19.86	9603.56	5655.25	8462.95	1601.26	1.8	2.66	469.07	471.73	298.05	3.88	12.5	2.86	6.74	2	13.98	66.05	0.65
MBR1	19.86	9596.24	5641.21	8438.39	1586.83	0.26	3.93	467.76	471.69	298.05	0.24	12.5	2.66	6.78	8.13	13.11	65.81	0.8
Membranes1	5.01	1.9	1.12	32.09	1.29	0.26	3.93	2.07	6	0.3	0.24	12.5	2.66	6.72	8.13	13.11	65.81	0
RAS1	14.78	12832.79	7543.84	11274.18	2121.69	0.26	3.93	624.85	628.79	398.5	0.24	12.5	2.66	6.78	8.13	13.11	65.81	0
PST2	2.35	96.07	72.1	284.85	150.42	16.47	0.62	23.32	23.94	3.77	2.64	12.5	4.01	7.51	4.52	13.77	65.99	0.24
Anoxic2	6.32	2966.81	2124.44	3151.24	1159.84	7.96	0.02	196.82	196.84	94.54	4.25	12.5	3.51	6.91	0	14.32	66.14	0.1
Aeration2	6.32	2957.31	2107.3	3108.86	1136.51	2.35	4.35	192.23	196.57	94.54	0.32	12.5	2.82	6.74	2	13.46	65.91	0.41
FST2	2.32	27.53	19.62	56.15	11.8	2.35	4.35	5.8	10.15	1.2	0.32	12.5	2.82	6.74	2	13.46	65.91	0.24
RAS2	1.97	6357.61	4530.25	6651.82	2441.86	2.35	4.35	408.59	412.94	202.86	0.32	12.5	2.82	6.74	2	13.46	65.91	0
Sand Filters2	1.32	7.25	5.17	35.02	4.01	2.35	4.35	4.51	8.86	0.55	0.32	12.5	2.82	6.68	2	13.46	65.91	0
PST3	3.19	83.47	62.33	242.05	124.18	13.55	1.47	19.79	21.25	3.5	2.45	12.5	3.75	7.28	4.05	13.75	65.99	0.36
Anoxic3	7.15	2044.43	1427.94	2136.21	662.49	6.55	0.04	132.82	132.86	47.88	2.22	12.5	3.4	6.88	0	13.81	66	0.14
Aeration3	7.15	2025.85	1407.53	2089.89	634.51	0.81	5.16	127.39	132.54	47.88	1.64	12.5	2.64	6.7	2	13.7	65.97	1.09
FST3	3.15	16.56	11.51	43.36	6.17	0.81	5.16	3.57	8.72	2.01	1.64	12.5	2.64	6.7	2	13.7	65.97	0.69
RAS3	1.96	5189.78	3605.77	5312.48	1623.93	0.81	5.16	322.36	327.51	120.1	1.64	12.5	2.64	6.7	2	13.7	65.97	0
Sand Filters3	2.55	3.07	2.13	29.62	1.95	0.81	5.16	2.74	7.89	1.71	1.64	12.5	2.64	6.64	2	13.7	65.97	0
Effluent	8.88	3.03	2.01	31.81	1.88	0.73	4.35	2.62	6.97	0.74	0.65	12.5	2.68	6.75	5.46	13.33	65.87	0
Thickener	0.06	1674.8	1118.92	1774.45	562.33	5.08	3.38	80.37	83.74	40.53	1.22	12.5	3.04	6.9	4.85	13.47	65.91	0.14
BFP	0.02	486.94	325.32	563.26	183.65	5.08	3.38	28.7	32.08	12.65	1.22	12.5	3.04	6.84	4.85	13.47	65.91	0
Sludge	0.12	16150.14	10789.76	16534.05	5176.85	5.08	3.38	709.97	713.35	380.36	1.22	12.5	3.04	6.9	4.85	13.47	65.91	0

Check	Permit	Combined Effluent	?
TSS	20	3.03	OK
Ammonia	1.1	0.7	OK
TKN	NA	2.62	OK
CBOD	NA	1.88	OK
UOD	45	14.6	OK
NO3	10	4.35	OK
Flow	8.9	mgd	

Zones	mgal		
DO Depl.	0.200		
Anoxic	0.800		
Aeration	0.650		
Membranes	0.800		
Total Vol Req'd	2.450		
Total Vol Avail.	2.450		
Vol. check:	OK		
MBR:	99.995%	removal	(enter manually)
FSTs:	99.50%	removal	(enter manually)
Filters:	85.00%	removal	(enter manually)
SRT MBR:	15.0	days	
MBR MLSS:	9,596	mg/L	

Elements	Model	Setpoint
Influent	9	
DO Depl.	19.86	
Anoxic1	19.86	
Aeration1	19.86	
MBR1	19.86	
Membranes1	5.01	
RAS1	14.78	
WAS1	0.07	
PST2	2.35	
Aeration2	6.32	
FST2	2.32	
RAS2	2.00	2.00
IR	2.00	2.00
WAS2	0.03	0.03
PST3	3.19	
Anoxic3	7.15	
Aeration3	7.15	
FST3	3.15	
RAS3	2.00	2.00
IR	2.00	2.00
WAS3	0.04	0.04
Effluent	8.88	

Elements	Model	Setpoint
Thickener	0.06	
Thickener Underflow	0.14	0.14
BFP	0.02	
Sludge	0.12	0.12
Sidestream	0.08	

Model 3: Phase II MBR Facility Average Month

#4

MLSS	12,400	mg/L	SRT	20.0	days

Elements	Flow [mgd]	Total suspended solids [mgTSS/L]	Volatile suspended solids [mgVSS/L]	Total COD [mg/L]	Total Carbonaceous BOD [mg/L]	Ammonia N [mgN/L]	Nitrate N [mgN/L]	Total Kjeldahl Nitrogen [mgN/L]	Total N [mgN/L]	Total P [mgP/L]	Soluble PO4-P [mgP/L]	Temperature [deg. C]	Alkalinity [mmol/L]	pH []	Dissolved oxygen [mg/L]	Magnesium [mg/L]	Calcium [mg/L]	Liquid volume [Mil. Gal]
Influent	9	257.47	193.44	495	243.14	18.04	0.21	29.1	29.31	5.8	2.9	12.5	4.14	7.7	4.8	13.8	66	0
DO Depl.	19.86	12408.81	7159.27	10733.63	1733.96	3.92	1.6	588.24	589.83	388.7	0.71	12.5	3.09	6.83	0.05	13.27	65.85	0.2
Anoxic1	19.86	12381.62	7150.02	10728.05	1723.42	5.38	0.01	588.23	588.25	388.7	11.34	12.5	3.3	6.82	0	15.69	66.52	0.8
Aeration1	19.86	12380.88	7137.18	10696.61	1710.1	1.62	2.86	585.23	588.1	388.7	4.49	12.5	2.83	6.73	2	14.1	66.08	0.65
MBR1	19.86	12373.8	7122.61	10671.35	1695.09	0.21	4.06	584	588.06	388.7	0.36	12.5	2.64	6.77	8.11	13.11	65.81	0.8
Membranes1	5.01	2.45	1.41	33.02	1.28	0.21	4.06	2.06	6.12	0.44	0.36	12.5	2.64	6.71	8.11	13.11	65.81	0
RAS1	14.8	16547.16	9524.88	14260.08	2266.47	0.21	4.06	780.31	784.37	519.67	0.36	12.5	2.64	6.77	8.11	13.11	65.81	0
PST2	2.35	96.07	72.1	284.85	150.42	16.47	0.62	23.32	23.94	3.77	2.64	12.5	4.01	7.51	4.52	13.77	65.99	0.24
Anoxic2	6.32	2966.81	2124.44	3151.24	1159.84	7.96	0.02	196.82	196.84	94.54	4.25	12.5	3.51	6.91	0	14.32	66.14	0.1
Aeration2	6.32	2957.31	2107.3	3108.86	1136.51	2.35	4.35	192.23	196.57	94.54	0.32	12.5	2.82	6.74	2	13.46	65.91	0.41
FST2	2.32	27.53	19.62	56.15	11.8	2.35	4.35	5.8	10.15	1.2	0.32	12.5	2.82	6.74	2	13.46	65.91	0.24
RAS2	1.97	6357.61	4530.25	6651.82	2441.86	2.35	4.35	408.59	412.94	202.86	0.32	12.5	2.82	6.74	2	13.46	65.91	0
Sand Filters2	1.32	7.25	5.17	35.02	4.01	2.35	4.35	4.51	8.86	0.55	0.32	12.5	2.82	6.68	2	13.46	65.91	0
PST3	3.19	83.47	62.33	242.05	124.18	13.55	1.47	19.79	21.25	3.5	2.45	12.5	3.75	7.28	4.05	13.75	65.99	0.36
Anoxic3	7.15	2044.43	1427.94	2136.21	662.49	6.55	0.04	132.82	132.86	47.88	2.22	12.5	3.4	6.88	0	13.81	66	0.14
Aeration3	7.15	2025.85	1407.53	2089.89	634.51	0.81	5.16	127.39	132.54	47.88	1.64	12.5	2.64	6.7	2	13.7	65.97	1.09
FST3	3.15	16.56	11.51	43.36	6.17	0.81	5.16	3.57	8.72	2.01	1.64	12.5	2.64	6.7	2	13.7	65.97	0.69
RAS3	1.96	5189.78	3605.77	5312.48	1623.93	0.81	5.16	322.36	327.51	120.1	1.64	12.5	2.64	6.7	2	13.7	65.97	0
Sand Filters3	2.55	3.07	2.13	29.62	1.95	0.81	5.16	2.74	7.89	1.71	1.64	12.5	2.64	6.64	2	13.7	65.97	0
Effluent	8.88	3.34	2.18	32.34	1.88	0.7	4.42	2.62	7.04	0.82	0.72	12.5	2.67	6.75	5.45	13.33	65.87	0
Thickener	0.04	2336.46	1551.71	2442.01	753.22	5.54	3.36	107.95	111.31	56.25	1.35	12.5	3.08	6.91	4.52	13.51	65.92	0.14
BFP	0.02	478.73	317.94	556.4	179.08	5.54	3.36	28.53	31.89	12.6	1.35	12.5	3.08	6.85	4.52	13.51	65.92	0
Sludge	0.12	15877.86	10544.95	16186.62	4938.24	5.54	3.36	686.92	690.27	374.46	1.35	12.5	3.08	6.91	4.52	13.51	65.92	0

Check	Permit	Combined Effluent	?
TSS	20	3.34	OK
Ammonia	1.1	0.7	OK
TKN	NA	2.62	OK
CBOD	NA	1.88	OK
UOD	45	14.6	OK
NO3	10	4.42	OK
Flow	8.9	mgd	

Zones	mgal		
DO Depl.	0.200		
Anoxic	0.800		
Aeration	0.650		
Membranes	0.800		
Total Vol Req'd	2.450		
Total Vol Avail.	2.450		
Vol. check:	OK		
MBR:	99.995%	removal	(enter manually)
FSTs:	99.50%	removal	(enter manually)
Filters:	85.00%	removal	(enter manually)
SRT MBR:	20.0	days	
MBR MLSS:	12,374	mg/L	

Elements	Model	Setpoint
Influent	9	
DO Depl.	19.86	
Anoxic1	19.86	
Aeration1	19.86	
MBR1	19.86	
Membranes1	5.01	
RAS1	14.8	
WAS1	0.05	
PST2	2.35	
Aeration2	6.32	
FST2	2.32	
RAS2	2.00	2.00
IR	2.00	2.00
WAS2	0.03	0.03
PST3	3.19	
Anoxic3	7.15	
Aeration3	7.15	
FST3	3.15	
RAS3	2.00	2.00
IR	2.00	2.00
WAS3	0.04	0.04
Effluent	8.88	

Elements	Model	Setpoint
Thickener	0.04	
Thickener Underflow	0.14	0.14
BFP	0.02	
Sludge	0.12	0.12
Sidestream	0.06	

Model 3: Phase II MBR Facility Average Month

#5

MLSS	17,800	mg/L	SRT	30.0	days

Elements	Flow [mgd]	Total suspended solids [mgTSS/L]	Volatile suspended solids [mgVSS/L]	Total COD [mg/L]	Total Carbonaceous BOD [mg/L]	Ammonia N [mgN/L]	Nitrate N [mgN/L]	Total Kjeldahl Nitrogen [mgN/L]	Total N [mgN/L]	Total P [mgP/L]	Soluble PO4-P [mgP/L]	Temperature [deg. C]	Alkalinity [mmol/L]	pH []	Dissolved oxygen [mg/L]	Magnesium [mg/L]	Calcium [mg/L]	Liquid volume [Mil. Gal]
Influent	9	257.47	193.44	495	243.14	18.04	0.21	29.1	29.31	5.8	2.9	12.5	4.14	7.7	4.8	13.8	66	0
DO Depl.	19.92	17857.12	10057.44	15107.86	1865.15	3.9	1.63	814.05	815.68	542.52	1.08	12.5	3.08	6.83	0.04	13.33	65.87	0.2
Anoxic1	19.92	17828.47	10047.77	15102.03	1854.31	5.41	0.01	814.05	814.06	542.52	12.3	12.5	3.3	6.81	0	15.89	66.57	0.8
Aeration1	19.92	17827.19	10034.43	15069.79	1840.52	1.45	3.09	810.81	813.9	542.52	5.48	12.5	2.8	6.72	2	14.3	66.14	0.65
MBR1	19.92	17820.51	10019.27	15043.75	1824.87	0.17	4.2	809.66	813.86	542.52	0.75	12.5	2.62	6.77	8.08	13.17	65.83	0.8
Membranes1	5.07	3.5	1.97	34.42	1.27	0.17	4.2	2.09	6.29	0.85	0.75	12.5	2.62	6.71	8.08	13.17	65.83	0
RAS1	14.82	23902.89	13438.98	20167.65	2447.41	0.17	4.2	1085.35	1089.55	727.44	0.75	12.5	2.62	6.77	8.08	13.17	65.83	0
PST2	2.35	96.07	72.1	284.85	150.42	16.47	0.62	23.32	23.94	3.77	2.64	12.5	4.01	7.51	4.52	13.77	65.99	0.24
Anoxic2	6.32	2966.81	2124.44	3151.24	1159.84	7.96	0.02	196.82	196.84	94.54	4.25	12.5	3.51	6.91	0	14.32	66.14	0.1
Aeration2	6.32	2957.31	2107.3	3108.86	1136.51	2.35	4.35	192.23	196.57	94.54	0.32	12.5	2.82	6.74	2	13.46	65.91	0.41
FST2	2.32	27.53	19.62	56.15	11.8	2.35	4.35	5.8	10.15	1.2	0.32	12.5	2.82	6.74	2	13.46	65.91	0.24
RAS2	1.97	6357.61	4530.25	6651.82	2441.86	2.35	4.35	408.59	412.94	202.86	0.32	12.5	2.82	6.74	2	13.46	65.91	0
Sand Filters2	1.32	7.25	5.17	35.02	4.01	2.35	4.35	4.51	8.86	0.55	0.32	12.5	2.82	6.68	2	13.46	65.91	0
PST3	3.19	83.47	62.33	242.05	124.18	13.55	1.47	19.79	21.25	3.5	2.45	12.5	3.75	7.28	4.05	13.75	65.99	0.36
Anoxic3	7.15	2044.43	1427.94	2136.21	662.49	6.55	0.04	132.82	132.86	47.88	2.22	12.5	3.4	6.88	0	13.81	66	0.14
Aeration3	7.15	2025.85	1407.53	2089.89	634.51	0.81	5.16	127.39	132.54	47.88	1.64	12.5	2.64	6.7	2	13.7	65.97	1.09
FST3	3.15	16.56	11.51	43.36	6.17	0.81	5.16	3.57	8.72	2.01	1.64	12.5	2.64	6.7	2	13.7	65.97	0.69
RAS3	1.96	5189.78	3605.77	5312.48	1623.93	0.81	5.16	322.36	327.51	120.1	1.64	12.5	2.64	6.7	2	13.7	65.97	0
Sand Filters3	2.55	3.07	2.13	29.62	1.95	0.81	5.16	2.74	7.89	1.71	1.64	12.5	2.64	6.64	2	13.7	65.97	0
Effluent	8.94	3.93	2.49	33.14	1.87	0.67	4.49	2.63	7.13	1.05	0.94	12.5	2.66	6.74	5.45	13.36	65.88	0
Thickener	0.08	1160.61	766.47	1248.35	380.54	6.12	3.31	57.4	60.71	28.13	1.54	12.5	3.12	6.92	4.12	13.57	65.94	0.14
BFP	0.02	468.4	309.33	548.52	174.12	6.12	3.31	28.37	31.68	12.27	1.54	12.5	3.12	6.86	4.12	13.57	65.94	0
Sludge	0.06	31070.45	20519.16	31487.53	9299.8	6.12	3.31	1311.65	1314.96	713.32	1.54	12.5	3.12	6.92	4.12	13.57	65.94	0

Check	Permit	Combined Effluent	?
TSS	20	3.93	OK
Ammonia	1.1	0.67	OK
TKN	NA	2.63	OK
CBOD	NA	1.87	OK
UOD	45	14.6	OK
NO3	10	4.49	OK
Flow	8.9	mgd	

Zones	mgal		
DO Depl.	0.200		
Anoxic	0.800		
Aeration	0.650		
Membranes	0.800		
Total Vol Req'd	2.450		
Total Vol Avail.	2.450		
Vol. check:	OK		
MBR:	99.995%	removal	(enter manually)
FSTs:	99.50%	removal	(enter manually)
Filters:	85.00%	removal	(enter manually)
SRT MBR:	30.0	days	
MBR MLSS:	17,821	mg/L	

Elements	Model	Setpoint
Influent	9	
DO Depl.	19.92	
Anoxic1	19.92	
Aeration1	19.92	
MBR1	19.92	
Membranes1	5.07	
RAS1	14.82	
WAS1	0.03	
PST2	2.35	
Aeration2	6.32	
FST2	2.32	
RAS2	2.00	2.00
IR	2.00	2.00
WAS2	0.03	0.03
PST3	3.19	
Anoxic3	7.15	
Aeration3	7.15	
FST3	3.15	
RAS3	2.00	2.00
IR	2.00	2.00
WAS3	0.04	0.04
Effluent	8.94	

Elements	Model	Setpoint
Thickener	0.08	
Thickener Underflow	0.08	0.11
BFP	0.02	
Sludge	0.06	0.08
Sidestream	0.1	

run date:	2/23/06

Model 3: Phase II MBR Facility Maximum Month — Several MBR SRT Runs: 5, 10, 15, 20, 30 days

Yellow boxes indicate parameters that may need to be changed in BioWin before running model.

#1

MLSS 5,900 mg/L **SRT** 5.0 days

Elements	Flow [mgd]	Total suspended solids [mgTSS/L]	Volatile suspended solids [mgVSS/L]	Total COD [mg/L]	Total Carbonaceous BOD [mg/L]	Ammonia N [mgN/L]	Nitrate N [mgN/L]	Total Kjeldahl Nitrogen [mgN/L]	Total N [mgN/L]	Total P [mgP/L]	Soluble PO4-P [mgP/L]	Temperature [deg. C]	Alkalinity [mmol/L]	pH []	Dissolved oxygen [mg/L]	Magnesium [mg/L]	Calcium [mg/L]	Liquid volume [Mil. Gal]
Influent	13.6	256.1	175.07	448	220.05	13.14	0.17	45.3	45.47	6.7	3.35	12.5	2.98	8	4.4	10.4	51.6	0
DO Depl.	29.87	5875.45	3377.68	5031.17	1500.38	4.67	4.17	300.18	304.35	136.1	1.99	12.5	2.16	6.73	0.05	10.11	51.52	0.2
Anoxic1	29.87	5865.22	3370.21	5019.13	1490.86	7.29	0.04	300.18	300.22	136.1	3.71	12.5	2.63	6.83	0	10.48	51.62	0.8
Aeration1	29.87	5858.79	3361.57	5000.24	1481.47	4.12	3.58	296.52	300.1	136.1	2.77	12.5	2.15	6.64	2	10.26	51.56	0.65
MBR1	29.87	5850.62	3351.15	4981.77	1470.79	1.23	7.13	292.93	300.06	136.1	1.85	12.5	1.69	6.57	6.82	10.03	51.5	0.8
Membranes1	7.43	1.18	0.67	25.4	1.39	1.23	7.13	3.87	11	1.88	1.85	12.5	1.69	6.51	6.82	10.03	51.5	0
RAS1	22.22	7788.65	4461.23	6623.92	1957.63	1.23	7.13	388.7	395.83	180.57	1.85	12.5	1.69	6.57	6.82	10.03	51.5	0
PST2	3.32	98.65	67.4	265.69	140.77	12.46	0.79	33.5	34.29	4.58	3.27	12.5	2.89	7.71	4.24	10.39	51.6	0.24
Anoxic2	7.3	3959.45	2646.04	3908.24	1457.15	10.22	0.05	253.24	253.29	89.15	2.9	12.5	2.85	7	0	10.45	51.61	0.1
Aeration2	7.3	3943.36	2627.42	3865.14	1432.37	3.2	9.18	243.79	252.98	89.15	2.16	12.5	1.72	6.54	2	10.32	51.58	0.41
FST2	3.3	31.67	21.1	55.15	12.68	3.2	9.18	8.01	17.19	2.86	2.16	12.5	1.72	6.54	2	10.32	51.58	0.24
RAS2	1.97	10397.38	6927.66	10151.35	3774.75	3.2	9.18	632.82	642.01	231.52	2.16	12.5	1.72	6.54	2	10.32	51.58	0
Sand Filters2	2.3	8.18	5.45	32.27	4.16	3.2	9.18	6.59	15.78	2.34	2.16	12.5	1.72	6.48	2	10.32	51.58	0
PST3	4.26	91.53	62.29	238.17	123.23	10.85	2.54	29.72	32.26	4.44	3.19	12.5	2.66	7.36	3.92	10.39	51.6	0.36
Anoxic3	8.23	2876.7	1875.02	2779.43	900.07	8.02	3.09	180.51	183.6	55.21	2.68	12.5	2.49	6.94	0.01	10.4	51.6	0.14
Aeration3	8.23	2852.54	1849.75	2730.42	869.63	1	13.29	169.93	183.23	55.21	2.73	12.5	1.26	6.39	2	10.4	51.6	1.09
FST3	4.23	21.01	13.63	43.75	7.38	1	13.29	4.93	18.23	3.11	2.73	12.5	1.26	6.39	2	10.4	51.6	0.69
RAS3	1.96	8834.62	5728.87	8406.48	2691.29	1	13.29	518.52	531.82	165.27	2.73	12.5	1.26	6.39	2	10.4	51.6	0
Sand Filters3	3.63	4.41	2.86	27.99	2.32	1	13.29	3.97	17.26	2.81	2.73	12.5	1.26	6.33	2	10.4	51.6	0
Effluent	13.36	3.26	2.09	27.29	2.12	1.5	9.16	4.36	13.52	2.21	2.14	12.5	1.58	6.52	4.68	10.18	51.54	0
Thickener	0.05	3598.71	2239.67	3441.85	1200.73	3.21	6.95	209.42	216.37	72.03	2.21	12.5	1.84	6.66	5.47	10.15	51.53	0.14
BFP	0.05	316.4	196.91	345.03	120.9	3.21	6.95	25.56	32.51	8.35	2.21	12.5	1.84	6.6	5.47	10.15	51.53	0
Sludge	0.24	13117.48	8163.72	12422.67	4332.27	3.21	6.95	742.62	749.57	256.71	2.21	12.5	1.84	6.66	5.47	10.15	51.53	0

Check	Permit	Combined Effluent	?
TSS	20	3.26	OK
Ammonia	1.1	1.5	NO
TKN	NA	4.36	OK
CBOD	NA	2.12	OK
UOD	45	22.8	OK
NO3	10	9.16	OK
Flow	13.4	mgd	

Zones	mgal		
DO Depl.	0.200		
Anoxic	0.800		
Aeration	0.650		
Membranes	0.800		
Total Vol Req'd	2.450		
Total Vol Avail.	2.450		
Vol. check:	OK		
MBR:	99.995%	removal	(enter manually)
FSTs:	99.50%	removal	(enter manually)
Filters:	82.00%	removal	(enter manually)
SRT MBR:	5.0	days	
MBR MLSS:	5,851	mg/L	

Elements	Model	Setpoint
Influent	13.6	
DO Depl.	29.87	
Anoxic1	29.87	
Aeration1	29.87	
MBR1	29.87	
Membranes1	7.43	
RAS1	22.22	
WAS1	0.22	
PST2	3.32	
Aeration2	7.3	
FST2	3.3	
RAS2	2.00	2.00
IR	2.00	2.00
WAS2	0.03	0.025
PST3	4.26	
Anoxic3	8.23	
Aeration3	8.23	
FST3	4.23	
RAS3	2.00	2.00
IR	2.00	2.00
WAS3	0.04	0.035
Effluent	13.36	

Elements	Model	Setpoint
Thickener	0.05	
Thickener Underflow	0.30	0.30
BFP	0.05	
Sludge	0.24	0.24
Sidestream	0.1	

Model 3: Phase II MBR Facility Maximum Month

#2

MLSS 10,600 mg/L **SRT** 10.0 days

Elements	Flow [mgd]	Total suspended solids [mgTSS/L]	Volatile suspended solids [mgVSS/L]	Total COD [mg/L]	Total Carbonaceous BOD [mg/L]	Ammonia N [mgN/L]	Nitrate N [mgN/L]	Total Kjeldahl Nitrogen [mgN/L]	Total N [mgN/L]	Total P [mgP/L]	Soluble PO4-P [mgP/L]	Temperature [deg. C]	Alkalinity [mmol/L]	pH []	Dissolved oxygen [mg/L]	Magnesium [mg/L]	Calcium [mg/L]	Liquid volume [Mil. Gal]
Influent	13.6	256.1	175.07	448	220.05	13.14	0.17	45.3	45.47	6.7	3.35	12.5	2.98	8	4.4	10.4	51.6	0
DO Depl.	29.95	10618.54	5693.6	8500.7	1925.73	4.23	4.38	485.98	490.36	238.57	2.47	12.5	2.1	6.72	0.04	10.12	51.52	0.2
Anoxic1	29.95	10605.32	5684.71	8488.05	1915.41	6.97	0.04	485.98	486.02	238.57	5.07	12.5	2.59	6.83	0	10.68	51.68	0.8
Aeration1	29.95	10598.03	5674.49	8466.58	1904.71	2.55	4.83	481.06	485.89	238.57	3.7	12.5	1.94	6.59	2	10.35	51.59	0.65
MBR1	29.95	10588.43	5662.11	8445.35	1892.07	0.4	7.78	478.06	485.84	238.57	2.44	12.5	1.57	6.53	6.8	10.03	51.5	0.8
Membranes1	7.51	2.11	1.13	26.37	1.34	0.4	7.78	2.92	10.7	2.49	2.44	12.5	1.57	6.47	6.8	10.03	51.5	0
RAS1	22.33	14133.62	7557.88	11264.73	2525.25	0.4	7.78	637.18	644.96	317.63	2.44	12.5	1.57	6.53	6.8	10.03	51.5	0
PST2	3.32	98.65	67.4	265.69	140.77	12.46	0.79	33.5	34.29	4.58	3.27	12.5	2.89	7.71	4.24	10.39	51.6	0.24
Anoxic2	7.3	3959.45	2646.04	3908.24	1457.15	10.22	0.05	253.24	253.29	89.15	2.9	12.5	2.85	7	0	10.45	51.61	0.1
Aeration2	7.3	3943.36	2627.42	3865.14	1432.37	3.2	9.18	243.79	252.98	89.15	2.16	12.5	1.72	6.54	2	10.32	51.58	0.41
FST2	3.3	31.67	21.1	55.15	12.68	3.2	9.18	8.01	17.19	2.86	2.16	12.5	1.72	6.54	2	10.32	51.58	0.24
RAS2	1.97	10397.38	6927.66	10151.35	3774.75	3.2	9.18	632.82	642.01	231.52	2.16	12.5	1.72	6.54	2	10.32	51.58	0
Sand Filters2	2.3	8.18	5.45	32.27	4.16	3.2	9.18	6.59	15.78	2.34	2.16	12.5	1.72	6.48	2	10.32	51.58	0
PST3	4.26	91.53	62.29	238.17	123.23	10.85	2.54	29.72	32.26	4.44	3.19	12.5	2.66	7.36	3.92	10.39	51.6	0.36
Anoxic3	8.23	2876.7	1875.02	2779.43	900.07	8.02	3.09	180.51	183.6	55.21	2.68	12.5	2.49	6.94	0.01	10.4	51.6	0.14
Aeration3	8.23	2852.54	1849.75	2730.42	869.63	1	13.29	169.93	183.23	55.21	2.73	12.5	1.26	6.39	2	10.4	51.6	1.09
FST3	4.23	21.01	13.63	43.75	7.38	1	13.29	4.93	18.23	3.11	2.73	12.5	1.26	6.39	2	10.4	51.6	0.69
RAS3	1.96	8834.62	5728.87	8406.48	2691.29	1	13.29	518.52	531.82	165.27	2.73	12.5	1.26	6.39	2	10.4	51.6	0
Sand Filters3	3.63	4.41	2.86	27.99	2.32	1	13.29	3.97	17.26	2.81	2.73	12.5	1.26	6.33	2	10.4	51.6	0
Effluent	13.44	3.77	2.33	27.82	2.09	1.04	9.51	3.83	13.34	2.55	2.47	12.5	1.51	6.5	4.68	10.18	51.54	0
Thickener	0.03	5847.54	3548.52	5459.24	1769.56	3.78	7.17	326.27	333.44	113.18	2.66	12.5	1.86	6.7	4.81	10.21	51.55	0.14
BFP	0.04	375.07	227.6	403.77	136.25	3.78	7.17	29.64	36.8	9.75	2.66	12.5	1.86	6.64	4.81	10.21	51.55	0
Sludge	0.16	18659.54	11323.34	17294.96	5593.42	3.78	7.17	1020.74	1027.91	355.31	2.66	12.5	1.86	6.7	4.81	10.21	51.55	0

Check	Permit	Combined Effluent	?
TSS	20	3.77	OK
Ammonia	1.1	1.04	OK
TKN	NA	3.83	OK
CBOD	NA	2.09	OK
UOD	45	20.4	OK
NO3	10	9.51	OK
Flow	13.4	mgd	

Zones	mgal		
DO Depl.	0.200		
Swing	0.800		
Aeration	0.650		
Membranes	0.800		
Total Vol Req'd	2.450		
Total Vol Avail.	2.450		
Vol. check:	OK		
MBR:	99.995%	removal	(enter manually)
FSTs:	99.50%	removal	(enter manually)
Filters:	82.00%	removal	(enter manually)
SRT MBR:	10.0	days	
MBR MLSS:	10,598	mg/L	

Elements	Model	Setpoint
Influent	13.6	
DO Depl.	29.95	
Anoxic1	29.95	
Aeration1	29.95	
MBR1	29.95	
Membranes1	7.51	
RAS1	22.33	
WAS1	0.11	
PST2	3.32	
Aeration2	7.3	
FST2	3.3	
RAS2	2.00	2.00
IR	2.00	2.00
WAS2	0.03	0.025
PST3	4.26	
Anoxic3	8.23	
Aeration3	8.23	
FST3	4.23	
RAS3	2.00	2.00
IR	2.00	2.00
WAS3	0.04	0.035
Effluent	13.44	

Elements	Model	Setpoint
Thickener	0.03	
Thickener Underflow	0.21	0.21
BFP	0.04	
Sludge	0.16	0.16
Sidestream	0.07	

Model 3: Phase II MBR Facility Maximum Month

#3

MLSS	15,100	mg/L	SRT	15.0	days

Elements	Flow [mgd]	Total suspended solids [mgTSS/L]	Volatile suspended solids [mgVSS/L]	Total COD [mg/L]	Total Carbonaceous BOD [mg/L]	Ammonia N [mgN/L]	Nitrate N [mgN/L]	Total Kjeldahl Nitrogen [mgN/L]	Total N [mgN/L]	Total P [mgP/L]	Soluble PO4-P [mgP/L]	Temperature [deg. C]	Alkalinity [mmol/L]	pH []	Dissolved oxygen [mg/L]	Magnesium [mg/L]	Calcium [mg/L]	Liquid volume [Mil. Gal]
Influent	13.6	256.1	175.07	448	220.05	13.14	0.17	45.3	45.47	6.7	3.35	12.5	2.98	8	4.4	10.4	51.6	0
DO Depl.	29.99	15125.58	7809.64	11687.77	2139.25	4.22	4.44	652.31	656.75	318.32	2.85	12.5	2.08	6.72	0.03	10.16	51.53	0.2
Anoxic1	29.99	15110.94	7800.16	11674.93	2128.55	7	0.05	652.31	652.36	318.32	5.93	12.5	2.59	6.82	0	10.83	51.72	0.8
Aeration1	29.99	15103.29	7789.22	11652.19	2117.2	2.06	5.36	646.86	652.22	318.32	4.34	12.5	1.86	6.57	2	10.45	51.61	0.65
MBR1	29.99	15093.03	7775.92	11629.64	2103.64	0.28	8.01	644.16	652.17	318.32	2.91	12.5	1.54	6.52	6.79	10.08	51.51	0.8
Membranes1	7.55	3	1.54	27.26	1.34	0.28	8.01	2.78	10.79	2.98	2.91	12.5	1.54	6.46	6.79	10.08	51.51	0
RAS1	22.37	20173.34	10393.29	15535.78	2811.41	0.28	8.01	860.09	868.1	424.49	2.91	12.5	1.54	6.52	6.79	10.08	51.51	0
PST2	3.32	98.65	67.4	265.69	140.77	12.46	0.79	33.5	34.29	4.58	3.27	12.5	2.89	7.71	4.24	10.39	51.6	0.24
Anoxic2	7.3	3959.45	2646.04	3908.24	1457.15	10.22	0.05	253.24	253.29	89.15	2.9	12.5	2.85	7	0	10.45	51.61	0.1
Aeration2	7.3	3943.36	2627.42	3865.14	1432.37	3.2	9.18	243.79	252.98	89.15	2.16	12.5	1.72	6.54	2	10.32	51.58	0.41
FST2	3.3	31.67	21.1	55.15	12.68	3.2	9.18	8.01	17.19	2.86	2.16	12.5	1.72	6.54	2	10.32	51.58	0.24
RAS2	1.97	10397.38	6927.66	10151.35	3774.75	3.2	9.18	632.82	642.01	231.51	2.16	12.5	1.72	6.54	2	10.32	51.58	0
Sand Filters2	2.3	8.18	5.45	32.27	4.16	3.2	9.18	6.59	15.78	2.34	2.16	12.5	1.72	6.48	2	10.32	51.58	0
PST3	4.26	91.53	62.29	238.17	123.23	10.85	2.54	29.72	32.26	4.44	3.19	12.5	2.66	7.36	3.92	10.39	51.6	0.36
Anoxic3	8.23	2876.7	1875.02	2779.43	900.07	8.02	3.09	180.51	183.6	55.21	2.68	12.5	2.49	6.94	0.01	10.4	51.6	0.14
Aeration3	8.23	2852.54	1849.75	2730.42	869.63	1	13.29	169.93	183.23	55.21	2.73	12.5	1.26	6.39	2	10.4	51.6	1.09
FST3	4.23	21.01	13.63	43.75	7.38	1	13.29	4.93	18.23	3.11	2.73	12.5	1.26	6.39	2	10.4	51.6	0.69
RAS3	1.96	8834.62	5728.87	8406.48	2691.29	1	13.29	518.52	531.82	165.27	2.73	12.5	1.26	6.39	2	10.4	51.6	0
Sand Filters3	3.63	4.41	2.86	27.99	2.32	1.0	13.29	3.97	17.26	2.81	2.73	12.5	1.26	6.33	2	10.4	51.6	0
Effluent	13.48	4.26	2.56	28.31	2.09	0.97	9.63	3.75	13.38	2.82	2.74	12.5	1.49	6.49	4.69	10.2	51.55	0
Thickener	0.05	3029.97	1817.34	2836.48	887.99	4.37	7.14	172.16	179.3	57.88	2.88	12.5	1.9	6.73	4.43	10.27	51.56	0.14
BFP	0.02	729.67	437.64	731.35	235.66	4.37	7.14	49.41	56.55	16.13	2.88	12.5	1.9	6.67	4.43	10.27	51.56	0
Sludge	0.12	24200.59	14515.22	22210.83	6891.64	4.37	7.14	1301.86	1308.99	442.18	2.88	12.5	1.9	6.73	4.43	10.27	51.56	0

Check	Permit	Combined Effluent	?
TSS	20	4.26	OK
Ammonia	1.1	0.97	OK
TKN	NA	3.75	OK
CBOD	NA	2.09	OK
UOD	45	20.0	OK
NO3	10	9.63	OK
Flow	13.5	mgd	

Zones	mgal		
DO Depl.	0.200		
Swing	0.800		
Aeration	0.650		
Membranes	0.800		
Total Vol Req'd	2.450		
Total Vol Avail.	2.450		
Vol. check:	OK		
MBR:	99.995%	removal	(enter manually)
FSTs:	99.50%	removal	(enter manually)
Filters:	82.00%	removal	(enter manually)
SRT MBR:	15.0	days	
MBR MLSS:	15,103	mg/L	

Elements	Model	Setpoint
Influent	13.6	
DO Depl.	29.99	
Anoxic1	29.99	
Aeration1	29.99	
MBR1	29.99	
Membranes1	7.55	
RAS1	22.37	
WAS1	0.07	
PST2	3.32	
Aeration2	7.3	
FST2	3.3	
RAS2	2.00	2.00
IR	2.00	2.00
WAS2	0.03	0.025
PST3	4.26	
Anoxic3	8.23	
Aeration3	8.23	
FST3	4.23	
RAS3	2.00	2.00
IR	2.00	2.00
WAS3	0.04	0.035
Effluent	13.48	

Elements	Model	Setpoint
Thickener	0.05	
Thickener Underflow	0.14	0.14
BFP	0.02	
Sludge	0.12	0.12
Sidestream	0.07	

Model 3: Phase II MBR Facility Maximum Month

#4

MLSS 19,500 mg/L SRT 20.0 days

Elements	Flow [mgd]	Total suspended solids [mgTSS/L]	Volatile suspended solids [mgVSS/L]	Total COD [mg/L]	Total Carbonaceous BOD [mg/L]	Ammonia N [mgN/L]	Nitrate N [mgN/L]	Total Kjeldahl Nitrogen [mgN/L]	Total N [mgN/L]	Total P [mgP/L]	Soluble PO4-P [mgP/L]	Temperature [deg. C]	Alkalinity [mmol/L]	pH []	Dissolved oxygen [mg/L]	Magnesium [mg/L]	Calcium [mg/L]	Liquid volume [Mil. Gal]
Influent	13.6	256.1	175.07	448	220.05	13.14	0.17	45.3	45.47	6.7	3.35	12.5	2.98	8	4.4	10.4	51.6	0
DO Depl.	30.03	19543.62	9852.2	14771.1	2269.09	4.23	4.47	811.26	815.74	385.63	3.13	12.5	2.08	6.72	0.03	10.2	51.54	0.2
Anoxic1	30.03	19528.16	9842.39	14758.16	2258.18	7.04	0.05	811.26	811.31	385.63	6.49	12.5	2.59	6.82	0	10.93	51.75	0.8
Aeration1	30.03	19520.29	9831.04	14734.68	2246.44	1.82	5.64	805.53	811.17	385.63	4.78	12.5	1.81	6.56	2	10.52	51.63	0.65
MBR1	30.03	19509.64	9817.2	14711.37	2232.34	0.23	8.13	802.98	811.12	385.63	3.26	12.5	1.52	6.52	6.78	10.12	51.52	0.8
Membranes1	7.59	3.86	1.94	28.05	1.35	0.23	8.13	2.75	10.88	3.34	3.26	12.5	1.52	6.46	6.78	10.12	51.52	0
RAS1	22.39	26111.36	13139.17	19680.93	2987.41	0.23	8.13	1073.82	1081.95	515.02	3.26	12.5	1.52	6.52	6.78	10.12	51.52	0
PST2	3.32	98.65	67.4	265.69	140.77	12.46	0.79	33.5	34.29	4.58	3.27	12.5	2.89	7.71	4.24	10.39	51.6	0.24
Anoxic2	7.3	3959.45	2646.04	3908.24	1457.15	10.22	0.05	253.24	253.29	89.15	2.9	12.5	2.85	7	0	10.45	51.61	0.1
Aeration2	7.3	3943.36	2627.42	3865.14	1432.37	3.2	9.18	243.79	252.98	89.15	2.16	12.5	1.72	6.54	2	10.32	51.58	0.41
FST2	3.3	31.67	21.1	55.15	12.68	3.2	9.18	8.01	17.19	2.86	2.16	12.5	1.72	6.54	2	10.32	51.58	0.24
RAS2	1.97	10397.38	6927.66	10151.35	3774.75	3.2	9.18	632.82	642.01	231.52	2.16	12.5	1.72	6.54	2	10.32	51.58	0
Sand Filters2	2.3	8.18	5.45	32.27	4.16	3.2	9.18	6.59	15.78	2.34	2.16	12.5	1.72	6.48	2	10.32	51.58	0
PST3	4.26	91.53	62.29	238.17	123.23	10.85	2.54	29.72	32.26	4.44	3.19	12.5	2.66	7.36	3.92	10.39	51.6	0.36
Anoxic3	8.23	2876.7	1875.02	2779.43	900.07	8.02	3.09	180.51	183.6	55.21	2.68	12.5	2.49	6.94	0.01	10.4	51.6	0.14
Aeration3	8.23	2852.54	1849.75	2730.42	869.63	1	13.29	169.93	183.23	55.21	2.73	12.5	1.26	6.39	2	10.4	51.6	1.09
FST3	4.23	21.01	13.63	43.75	7.38	1	13.29	4.93	18.23	3.11	2.73	12.5	1.26	6.39	2	10.4	51.6	0.69
RAS3	1.96	8834.62	5728.87	8406.48	2691.29	1	13.29	518.52	531.82	165.27	2.73	12.5	1.26	6.39	2	10.4	51.6	0
Sand Filters3	3.63	4.41	2.86	27.99	2.32	1	13.29	3.97	17.26	2.81	2.73	12.5	1.26	6.33	2	10.4	51.6	0
Effluent	13.52	4.74	2.78	28.75	2.09	0.94	9.7	3.73	13.42	3.03	2.93	12.5	1.48	6.49	4.69	10.23	51.55	0
Thickener	0.07	2080.06	1239.39	1961.49	603.31	4.79	7.08	121.28	128.36	39.41	2.98	12.5	1.93	6.75	4.18	10.3	51.57	0.14
BFP	0.02	716.84	427.13	720.36	228.67	4.79	7.08	49.19	56.27	15.54	2.98	12.5	1.93	6.69	4.18	10.3	51.57	0
Sludge	0.08	35663.02	21249.61	32536.94	9832.75	4.79	7.08	1897.28	1904.36	627.55	2.98	12.5	1.93	6.75	4.18	10.3	51.57	0

Check	Permit	Combined Effluent	?
TSS	20	4.74	OK
Ammonia	1.1	0.94	OK
TKN	NA	3.73	OK
CBOD	NA	2.09	OK
UOD	45	19.9	OK
NO3	10	9.7	OK
Flow	13.5	mgd	

Zones	mgal		
DO Depl.	0.200		
Swing	0.800		
Aeration	0.650		
Membranes	0.800		
Total Vol Req'd	2.450		
Total Vol Avail.	2.450		
Vol. check:	OK		
MBR:	99.995%	removal	(enter manually)
FSTs:	99.50%	removal	(enter manually)
Filters:	82.00%	removal	(enter manually)
SRT MBR:	20.0	days	
MBR MLSS:	19,520	mg/L	

Elements	Model	Setpoint
Influent	13.6	
DO Depl.	30.03	
Anoxic1	30.03	
Aeration1	30.03	
MBR1	30.03	
Membranes1	7.59	
RAS1	22.39	
WAS1	0.05	
PST2	3.32	
Aeration2	7.3	
FST2	3.3	
RAS2	2.00	2.00
IR	2.00	2.00
WAS2	0.03	0.025
PST3	4.26	
Anoxic3	8.23	
Aeration3	8.23	
FST3	4.23	
RAS3	2.00	2.00
IR	2.00	2.00
WAS3	0.04	0.035
Effluent	13.52	

Elements	Model	Setpoint
Thickener	0.07	
Thickener Underflow	0.11	0.11
BFP	0.02	
Sludge	0.08	0.08
Sidestream	0.09	

Model 3: Phase II MBR Facility Maximum Month

#5

MLSS	27,900	mg/L	SRT	30.0	days

Elements	Flow [mgd]	Total suspended solids [mgTSS/L]	Volatile suspended solids [mgVSS/L]	Total COD [mg/L]	Total Carbonaceous BOD [mg/L]	Ammonia N [mgN/L]	Nitrate N [mgN/L]	Total Kjeldahl Nitrogen [mgN/L]	Total N [mgN/L]	Total P [mgP/L]	Soluble PO4-P [mgP/L]	Temperature [deg. C]	Alkalinity [mmol/L]	pH []	Dissolved oxygen [mg/L]	Magnesium [mg/L]	Calcium [mg/L]	Liquid volume [Mil. Gal]
Influent	13.6	256.1	175.07	448	220.05	13.14	0.17	45.3	45.47	6.7	3.35	12.5	2.98	8	4.4	10.4	51.6	0
DO Depl.	30.05	27946.18	13696.1	20582.66	2414.53	4.25	4.51	1108.23	1112.74	498.93	3.48	12.5	2.07	6.72	0.03	10.25	51.56	0.2
Anoxic1	30.05	27929.81	13685.94	20569.61	2403.39	7.08	0.05	1108.23	1108.28	498.93	7.16	12.5	2.58	6.82	0	11.06	51.78	0.8
Aeration1	30.05	27921.7	13674.12	20545.29	2391.2	1.59	5.92	1102.21	1108.13	498.93	5.32	12.5	1.77	6.54	2	10.61	51.66	0.65
MBR1	30.05	27910.62	13659.7	20521.15	2376.51	0.19	8.27	1099.81	1108.08	498.93	3.7	12.5	1.5	6.51	6.76	10.19	51.54	0.8
Membranes1	7.61	5.51	2.7	29.43	1.35	0.19	8.27	2.75	11.01	3.8	3.7	12.5	1.5	6.45	6.76	10.19	51.54	0
RAS1	22.41	37379.96	18294.08	27474.82	3182.49	0.19	8.27	1472.09	1480.36	666.95	3.7	12.5	1.5	6.51	6.76	10.19	51.54	0
PST2	3.32	98.65	67.4	265.69	140.77	12.46	0.79	33.5	34.29	4.58	3.27	12.5	2.89	7.71	4.24	10.39	51.6	0.24
Anoxic2	7.3	3959.45	2646.04	3908.24	1457.15	10.22	0.05	253.24	253.29	89.15	2.9	12.5	2.85	7	0	10.45	51.61	0.1
Aeration2	7.3	3943.36	2627.42	3865.14	1432.37	3.2	9.18	243.79	252.98	89.15	2.16	12.5	1.72	6.54	2	10.32	51.58	0.41
FST2	3.3	31.67	21.1	55.15	12.68	3.2	9.18	8.01	17.19	2.86	2.16	12.5	1.72	6.54	2	10.32	51.58	0.24
RAS2	1.97	10397.38	6927.66	10151.35	3774.75	3.2	9.18	632.82	642.01	231.51	2.16	12.5	1.72	6.54	2	10.32	51.58	0
Sand Filters2	2.3	8.18	5.45	32.27	4.16	3.2	9.18	6.59	15.78	2.34	2.16	12.5	1.72	6.48	2	10.32	51.58	0
PST3	4.26	91.53	62.29	238.17	123.23	10.85	2.54	29.72	32.26	4.44	3.19	12.5	2.66	7.36	3.92	10.39	51.6	0.36
Anoxic3	8.23	2876.7	1875.02	2779.43	900.07	8.02	3.09	180.51	183.6	55.21	2.68	12.5	2.49	6.94	0.01	10.4	51.6	0.14
Aeration3	8.23	2852.54	1849.75	2730.42	869.63	1	13.29	169.93	183.23	55.21	2.73	12.5	1.26	6.39	2	10.4	51.6	1.09
FST3	4.23	21.01	13.63	43.75	7.38	1	13.29	4.93	18.23	3.11	2.73	12.5	1.26	6.39	2	10.4	51.6	0.69
RAS3	1.96	8834.62	5728.87	8406.48	2691.29	1	13.29	518.52	531.82	165.27	2.73	12.5	1.26	6.39	2	10.4	51.6	0
Sand Filters3	3.63	4.41	2.86	27.99	2.32	1	13.29	3.97	17.26	2.81	2.73	12.5	1.26	6.33	2	10.4	51.6	0
Effluent	13.54	5.67	3.21	29.53	2.09	0.92	9.77	3.73	13.5	3.28	3.18	12.5	1.47	6.49	4.68	10.26	51.56	0
Thickener	0.07	1969.63	1165.62	1856.66	557.96	5.3	6.99	115.44	122.43	35.84	3.05	12.5	1.97	6.77	3.88	10.33	51.58	0.14
BFP	0.02	701.29	415.02	707.82	221.3	5.3	6.99	48.99	55.99	14.72	3.05	12.5	1.98	6.71	3.88	10.33	51.58	0
Sludge	0.06	46518.94	27529.77	42208.77	12382.89	5.3	6.99	2449.36	2456.35	777.38	3.05	12.5	1.97	6.77	3.88	10.33	51.58	0

Check	Permit	Combined Effluent	?
TSS	20	5.67	OK
Ammonia	1.1	0.92	OK
TKN	NA	3.73	OK
CBOD	NA	2.09	OK
UOD	45	19.9	OK
NO3	10	9.77	OK
Flow	13.5	mgd	

Zones	mgal		
DO Depl.	0.200		
Swing	0.800		
Aeration	0.650		
Membranes	0.800		
Total Vol Req'd	2.450		
Total Vol Avail.	2.450		
Vol. check:	OK		
MBR:	99.995%	removal	(enter manually)
FSTs:	99.25%	removal	(enter manually)
Filters:	82.00%	removal	(enter manually)
SRT MBR:	30.0	days	
MBR MLSS:	27,922	mg/L	

Elements	Model	Setpoint
Influent	13.6	
DO Depl.	30.05	
Anoxic1	30.05	
Aeration1	30.05	
MBR1	30.05	
Membranes1	7.61	
RAS1	22.41	
WAS1	0.03	
PST2	3.32	
Aeration2	7.3	
FST2	3.3	
RAS2	2.00	2.00
IR	2.00	2.00
WAS2	0.03	0.025
PST3	4.26	
Anoxic3	8.23	
Aeration3	8.23	
FST3	4.23	
RAS3	2.00	2.00
IR	2.00	2.00
WAS3	0.04	0.035
Effluent	13.54	

Elements	Model	Setpoint
Thickener	0.07	
Thickener Underflow	0.09	0.09
BFP	0.02	
Sludge	0.06	0.06
Sidestream	0.09	

run date: 2/23/06

Model 3: Phase II MBR Facility Maximum Day MBR SRT : 15 days

Yellow boxes indicate parameters that may need to be changed in BioWin before running model.

#1

MLSS 23,000 mg/L SRT 15.0 days

Elements	Flow [mgd]	Total suspended solids [mgTSS/L]	Volatile suspended solids [mgVSS/L]	Total COD [mg/L]	Total Carbonaceous BOD [mg/L]	Ammonia N [mgN/L]	Nitrate N [mgN/L]	Total Kjeldahl Nitrogen [mgN/L]	Total N [mgN/L]	Total P [mgP/L]	Soluble PO4-P [mgP/L]	Temperature [deg. C]	Alkalinity [mmol/L]	pH []	Dissolved oxygen [mg/L]	Magnesium [mg/L]	Calcium [mg/L]	Liquid volume [Mil. Gal]
Influent	18	284.17	189.14	484	237.73	15.42	0.25	48.2	48.45	10.5	5.25	12.5	3.46	8.6	4.8	8	44.5	0
DO Depl.	39.72	23025.53	11431.69	17091.6	3158.03	5	4.41	952.35	956.76	529.1	5.59	12.5	2.43	6.8	0.02	7.65	44.4	0.2
Anoxic1	39.72	23008.1	11421.46	17078.81	3146.66	7.87	0.04	952.35	952.4	529.1	9.97	12.5	2.93	6.88	0	8.6	44.66	0.8
Aeration1	39.72	23000.41	11409.37	17053.14	3134.14	2.22	5.97	946.27	952.24	529.1	7.9	12.5	2.1	6.62	2	8.07	44.52	0.65
MBR1	39.72	22989.87	11394.44	17027.77	3118.93	0.26	8.71	943.46	952.17	529.1	5.87	12.5	1.76	6.56	5.49	7.53	44.37	0.8
Membranes1	10.02	4.56	2.26	30.7	1.57	0.26	8.71	2.87	11.58	5.98	5.87	12.5	1.76	6.5	5.49	7.53	44.37	0
RAS1	29.63	30743.73	15237.48	22761.57	4170.54	0.26	8.71	1260.76	1269.47	705.57	5.87	12.5	1.76	6.56	5.49	7.53	44.37	0
PST2	4.26	111.34	74.05	291.47	154.67	14.91	0.77	36.66	37.43	7.21	5.1	12.5	3.39	8.36	4.65	7.97	44.49	0.24
Anoxic2	8.23	5171.64	3348.81	4941.42	1918.16	14.05	0.03	320.09	320.13	190.98	6.84	12.5	3.44	7.19	0	8.46	44.63	0.1
Aeration2	8.23	5158.81	3326.36	4887.1	1888.17	5.75	10.15	309.61	319.76	190.98	2.39	12.5	2.14	6.64	2	7.42	44.34	0.41
FST2	4.23	37.99	24.49	62.41	15.19	5.75	10.15	10.86	21.01	3.78	2.39	12.5	2.14	6.64	2	7.42	44.34	0.24
RAS2	1.97	15992.42	10311.77	15094.18	5850.65	5.75	10.15	941.63	951.78	587.02	2.39	12.5	2.14	6.64	2	7.42	44.34	0
Sand Filters2	3.23	7.46	4.81	33.65	4.02	5.75	10.15	9.08	19.23	2.67	2.39	12.5	2.14	6.58	2	7.42	44.34	0
PST3	5.28	107.14	71.04	269.28	139.95	13.36	2.28	33.44	35.72	7.12	5.09	12.5	3.18	7.8	4.35	7.97	44.49	0.36
Anoxic3	9.25	3676.03	2364.37	3497.33	1186.55	10.51	1.47	227.4	228.87	72.62	4.74	12.5	3.1	7.14	0.01	7.97	44.49	0.14
Aeration3	9.25	3647.07	2333.91	3438.14	1150.22	1.14	14.14	214.29	228.43	72.62	5.04	12.5	1.52	6.47	2	7.97	44.49	1.09
FST3	5.25	25.18	16.12	49.24	8.94	1.14	14.14	5.34	19.48	5.51	5.04	12.5	1.52	6.47	2	7.97	44.49	0.69
RAS3	1.96	13154.19	8417.91	12333.69	4145.98	1.14	14.14	762.76	776.9	248.76	5.04	12.5	1.52	6.47	2	7.97	44.49	0
Sand Filters3	4.65	4.26	2.73	29.67	2.35	1.14	14.14	4.13	18.27	5.12	5.04	12.5	1.52	6.41	2	7.97	44.49	0
Effluent	17.9	5.01	2.84	30.96	2.21	1.5	10.38	4.32	14.7	5.16	5.03	12.5	1.76	6.55	3.95	7.62	44.4	0
Thickener	0.06	3804.98	2209.02	3437.28	1085.74	5.52	7.63	204.18	211.82	89.61	5.02	12.5	2.24	6.82	4.08	7.73	44.43	0.14
BFP	0.03	724.66	420.71	711.59	232.74	5.52	7.63	48.47	56.11	21.13	5.02	12.5	2.24	6.76	4.08	7.73	44.43	0
Sludge	0.1	43262.49	25116.45	38352.15	12012.26	5.52	7.63	2198.77	2206.41	966.85	5.02	12.5	2.24	6.82	4.08	7.73	44.43	0

Check	Permit	Combined Effluent	?
TSS	20	5.01	OK
Ammonia	1.1	1.5	NO
TKN	NA	4.32	OK
CBOD	NA	2.21	OK
UOD	45	22.8	OK
NO3	10	10.38	NO
Flow	17.9	mgd	

Zones	mgal		
DO Depl.	0.200		
Anoxic	0.800		
Aeration	0.650		
Membranes	0.800		
Total Vol Req'd	2.450		
Total Vol Avail.	2.450		
Vol. check:	OK		
MBR:	99.995%	removal	(enter manually)
FSTs:	99.50%	removal	(enter manually)
Filters:	82.00%	removal	(enter manually)
SRT MBR:	15.0	days	
MBR MLSS:	22,990	mg/L	

Elements	Model	Setpoint
Influent	18	
DO Depl.	39.72	
Anoxic1	39.72	
Aeration1	39.72	
MBR1	39.72	
Membranes1	10.02	
RAS1	29.7	
WAS1	0.07	
PST2	4.26	
Aeration2	8.23	
FST2	4.23	
RAS2	2.00	2.00
IR	2.00	2.00
WAS2	0.03	0.025
PST3	5.28	
Anoxic3	9.25	
Aeration3	9.25	
FST3	5.25	
RAS3	2.00	2.00
IR	2.00	2.00
WAS3	0.04	0.035
Effluent	0.06	

Elements	Model	Setpoint
Thickener	0.06	
Thickener Underflow	0.14	0.14
BFP	0.03	
Sludge	0.10	0.1
Sidestream	0.09	

run date:	2/21/06

Model 4: Phase II Conv. Facility Average Month

Temp: 12.5 deg C — Yellow boxes indicate parameters that may need to be changed in BioWin before running model.

Elements	Flow [mgd]	Total suspended solids [mgTSS/L]	Volatile suspended solids [mgVSS/L]	Total COD [mg/L]	Total Carbonaceous BOD [mg/L]	Ammonia N [mgN/L]	Nitrate N [mgN/L]	Total Kjeldahl Nitrogen [mgN/L]	Total N [mgN/L]	Total P [mgP/L]	Soluble PO4-P [mgP/L]	Temperature [deg. C]	Alkalinity [mmol/L]	pH []	Dissolved oxygen [mg/L]	Magnesium [mg/L]	Calcium [mg/L]	Liquid volume [Mil. Gal]
Influent	9.0	257.47	193.44	495	243.14	18.04	0.21	29.1	29.31	5.8	2.9	12.5	4.14	7.7	4.8	13.8	66	0
InfluentSplit 1-2,3	4.0	257.47	193.44	495	243.14	18.04	0.21	29.1	29.31	5.8	2.9	12.5	4.14	7.69	4.8	13.8	66	0
AX1	3.24	13463.62	7832.75	11731.65	2018.26	1.69	0.03	644.64	644.67	409.09	6.04	12.5	3.03	6.7	0	14.4	66.17	0.1
A1	3.24	13427.63	7785.97	11652.01	1970.35	0.15	2.48	641.7	644.18	409.09	0.22	12.5	2.72	6.69	2	12.85	65.74	0.4
AX2	5.57	7893.89	4607.21	6928.18	1201.74	6.64	0.01	382.68	382.69	239.98	11.2	12.5	3.37	6.84	0	15.55	66.48	0.2
A2	5.57	7887.41	4584.08	6875.9	1175.96	0.98	4.44	377.96	382.4	239.98	1.89	12.5	2.66	6.69	2	13.4	65.89	0.5
AX3	7.91	5614.5	3282.91	4947.7	863.66	5.42	0.03	273.13	273.16	170.65	9.89	12.5	3.29	6.79	0	15.31	66.42	0.5
A3	7.91	5611.4	3265.21	4907.27	844.57	1.03	3.21	269.73	272.94	170.65	1.74	12.5	2.76	6.7	2	13.43	65.9	0.7
AX4	13.55	4374.7	2555.25	3854.13	673.02	3.46	0.05	212.68	212.74	132.9	4.78	12.5	3.16	6.76	0	14.16	66.1	0.7
A4	13.55	4368.12	2540.8	3824.39	657.55	0.63	2.13	210.44	212.57	132.9	0.53	12.5	2.81	6.71	2	13.17	65.83	1.3
RAS1	3.24	13482.58	7842.41	11739.86	2027.32	0.63	2.13	644.68	646.81	409.09	0.53	12.5	2.81	6.71	2	13.17	65.83	0
FST1	6.93	16.13	9.38	44.9	3.51	0.63	2.13	3.1	5.22	1.0	0.53	12.5	2.81	6.71	2	13.17	65.83	1.75
Sand Filters1	5.53	3.03	1.76	33.52	1.54	0.63	2.13	2.47	4.6	0.62	0.53	12.5	2.81	6.65	2	13.17	65.83	0
Inf Flow Split2-3	2.0	257.47	193.44	495	243.14	18.04	0.21	29.1	29.31	5.8	2.9	12.5	4.14	7.69	4.8	13.8	66	0
PST2	1.97	130.69	98.19	342.62	179.34	18.04	0.21	25.96	26.17	4.37	2.9	12.5	4.14	7.69	4.8	13.8	66	0.24
Anoxic2	5.94	3387.54	2366.24	3515.31	1238.76	7.76	0.02	215.54	215.57	102.57	4.89	12.5	3.49	6.9	0	14.46	66.18	0.1
Aeration2	5.94	3376.26	2346.03	3467.7	1212.83	1.99	4.36	210.9	215.27	102.57	0.3	12.5	2.79	6.74	2	13.44	65.9	0.41
RAS2	1.97	6621.41	4600.96	6774.2	2377.39	1.99	4.36	410.07	414.44	200.88	0.3	12.5	2.79	6.74	2	13.44	65.9	0
FST2	1.94	34.27	23.81	62.54	13.52	1.99	4.36	5.79	10.15	1.34	0.3	12.5	2.79	6.74	2	13.44	65.9	0.24
Sand Filters2	1.34	7.44	5.17	35.2	3.89	1.99	4.36	4.15	8.51	0.52	0.3	12.5	2.79	6.68	2	13.44	65.9	0
PST3	2.63	89.2	65.11	250.24	126.73	13.84	1.55	20.49	22.03	3.84	2.54	12.5	3.76	7.3	4.13	13.75	65.99	1.32
Anoxic3	5.6	2434.24	1633.49	2444.14	641.08	6.93	0.04	149.51	149.55	69.38	3.26	12.5	3.43	6.9	0	14.02	66.06	0.14
Aeration3	5.6	2413.36	1608.78	2391.82	609.66	0.6	5.9	143.29	149.19	69.38	1.47	12.5	2.57	6.69	2	13.6	65.95	1.09
RAS3	1.97	5521.88	3680.97	5438.1	1393.75	0.6	5.9	324.91	330.81	156.85	1.47	12.5	2.57	6.69	2	13.6	65.95	0
FST3	2.6	21.35	14.23	47.71	6.31	0.6	5.9	3.54	9.44	2.07	1.47	12.5	2.57	6.69	2	13.6	65.95	0.69
Sand Filters3	2.0	4.16	2.78	30.87	1.97	0.6	5.9	2.54	8.44	1.59	1.47	12.5	2.57	6.63	2	13.6	65.95	0
Effuent	8.87	3.95	2.51	33.18	1.99	0.83	3.32	2.74	6.06	0.83	0.71	12.5	2.75	6.71	2	13.31	65.86	0
Thickener	0.03	3626.85	2377.52	3701.22	1096.83	5.75	2.69	164.37	167.06	88.79	1.35	12.5	3.13	6.88	2.79	13.48	65.91	0.14
BFP	0.03	310.56	203.58	383.85	123.92	5.75	2.69	21.66	24.35	8.84	1.35	12.5	3.14	6.83	2.79	13.48	65.91	0
Sludge	0.13	14261.87	9349.14	14339.74	4216.89	5.75	2.69	622.05	624.74	345.21	1.35	12.5	3.13	6.88	2.79	13.48	65.91	0

Check	Permit	Combined Effluent	?
TSS	20	3.95	OK
Ammonia	1.1	0.83	OK
TKN	NA	2.74	OK
CBOD	NA	1.99	OK
UOD	45	15.3	OK
NO3	10	3.32	OK
Flow	8.9	mgd	

Zones	mgal
AX1	0.100
A1	0.400
AX2	0.200
A2	0.500
AX3	0.500
A3	0.700
AX4	0.700
A4	1.300
FST1	1.750
Total Aer. Vol Req'd	4.400
Total Vol Avail.	3.080
Vol. check:	NO

FSTs:	99.50%	removal	(enter manually)
Filters:	85.00%	removal	(enter manually)
Step-Feed SRT	15	days	(enter manually)

Elements	Model	Setpoint	Elements	Model	Setpoint
Influent	9.0		PST2	2.0	
AX1	3.24		Aeration2	5.94	
A1	3.24		IR	2.00	2.0
AX2	5.57		RAS2	2.00	2.0
A2	5.57		WAS2	0.03	0.03
AX3	7.91		FST2	1.94	
A3	7.91		PST3	2.63	
AX4	13.55		Anoxic3	5.6	
A4	13.55		Aeration3	5.6	
IR	3.31	3.31	IR	1.00	1.0
RAS1	3.24		RAS3	2.00	2.0
WAS1	0.07		WAS3	0.03	0.03
FST1	6.93		FST3	2.60	
			Effuent	8.87	
			Thickener	0.03	
			Thickener Underflow	0.16	0.16
			BFP	0.03	
			Sludge	0.13	0.13

Model 4: Phase II Conv. Facility Average Month | Temp: 16.9 deg C | Yellow boxes indicate parameters that may need to be changed in BioWin before running model.

Elements	Flow [mgd]	Total suspended solids [mgTSS/L]	Volatile suspended solids [mgVSS/L]	Total COD [mg/L]	Total Carbonaceous BOD [mg/L]	Ammonia N [mgN/L]	Nitrate N [mgN/L]	Total Kjeldahl Nitrogen [mgN/L]	Total N [mgN/L]	Total P [mgP/L]	Soluble PO4-P [mgP/L]	Temperature [deg. C]	Alkalinity [mmol/L]	pH []	Dissolved oxygen [mg/L]	Magnesium [mg/L]	Calcium [mg/L]	Liquid volume [Mil. Gal]
Influent	9	257.47	193.44	495	243.14	18.04	0.21	29.1	29.31	5.8	2.9	16.9	4.14	7.7	4.8	13.8	66	0
InfluentSplit 1-2,3	4.0	257.47	193.44	495	243.14	18.04	0.21	29.1	29.31	5.8	2.9	16.9	4.14	7.69	4.8	13.8	66	0
AX1	3.24	13298.26	7673.97	11504.21	1864.64	1.5	0.03	629.02	629.05	408.08	6.21	16.9	3.01	6.7	0	14.42	66.17	0.1
A1	3.24	13262.75	7627.56	11425.53	1817.06	0.12	2.53	626.04	628.56	408.08	0.23	16.9	2.71	6.7	2	12.83	65.73	0.4
AX2	5.57	7797.34	4514.73	6796.14	1112.28	6.56	0.01	373.49	373.5	239.4	11.38	16.9	3.36	6.84	0	15.58	66.49	0.2
A2	5.57	7790.85	4491.3	6743.14	1086.18	0.66	4.65	368.55	373.21	239.4	1.91	16.9	2.62	6.69	2	13.38	65.89	0.5
AX3	7.91	5546.08	3217.14	4853.51	800.02	5.14	0.03	266.44	266.47	170.23	9.9	16.9	3.27	6.79	0	15.3	66.41	0.5
A3	7.91	5542.8	3199.2	4812.67	780.7	0.66	3.3	262.95	266.25	170.23	1.73	16.9	2.72	6.7	2	13.41	65.89	0.7
AX4	13.55	4321.24	2503.96	3780.71	623.41	3.16	0.05	207.42	207.47	132.58	4.87	16.9	3.14	6.76	0	14.17	66.1	0.7
A4	13.55	4314.64	2489.37	3750.67	607.78	0.41	2.08	205.22	207.3	132.58	0.54	16.9	2.8	6.72	2	13.16	65.82	1.3
RAS1	3.24	13317.52	7683.67	11512.27	1873.72	0.41	2.08	629.06	631.14	408.08	0.54	16.9	2.8	6.72	2	13.16	65.82	0
FST1	6.93	15.94	9.2	44.65	3.31	0.41	2.08	2.84	4.92	1.03	0.54	16.9	2.8	6.72	2	13.16	65.82	1.75
Sand Filters1	5.53	3	1.73	33.5	1.49	0.41	2.08	2.23	4.31	0.64	0.54	16.9	2.8	6.69	2	13.16	65.82	0
Inf Flow Split2-3	2.0	257.47	193.44	495	243.14	18.04	0.21	29.1	29.31	5.8	2.9	16.9	4.14	7.69	4.8	13.8	66	0
PST2	1.97	130.69	98.19	342.62	179.34	18.04	0.21	25.96	26.17	4.37	2.9	16.9	4.14	7.69	4.8	13.8	66	0.24
Anoxic2	5.94	3307.5	2288.94	3403	1162.85	7.06	0.02	207.72	207.74	102	4.7	16.9	3.44	6.9	0	14.4	66.17	0.1
Aeration2	5.94	3295.01	2267.92	3354.66	1136.31	0.95	4.8	202.64	207.43	102	0.32	16.9	2.68	6.73	2	13.42	65.9	0.41
RAS2	1.97	6462.07	4447.79	6552.65	2227.39	0.95	4.8	394.87	399.67	199.72	0.32	16.9	2.68	6.73	2	13.42	65.9	0
FST2	1.94	33.44	23.02	61.24	12.69	0.95	4.8	4.66	9.46	1.35	0.32	16.9	2.68	6.73	2	13.42	65.9	0.24
Sand Filters2	1.34	7.26	5	34.8	3.67	0.95	4.8	3.07	7.87	0.55	0.32	16.9	2.68	6.71	2	13.42	65.9	0
PST3	2.63	88.9	64.83	249.83	126.45	13.79	1.58	20.41	21.98	3.84	2.55	16.9	3.76	7.31	4.13	13.75	65.99	1.32
Anoxic3	5.6	2378.95	1581.31	2369.37	589.68	6.81	0.04	144.3	144.34	68.51	3.33	16.9	3.42	6.9	0	14.02	66.06	0.14
Aeration3	5.6	2357.48	1555.99	2316.24	557.72	0.41	6.03	137.95	143.98	68.51	1.51	16.9	2.54	6.69	2	13.59	65.94	1.09
RAS3	1.97	5394.02	3560.17	5265.18	1274.92	0.41	6.03	312.94	318.97	154.82	1.51	16.9	2.54	6.69	2	13.59	65.94	0
FST3	2.6	20.86	13.77	47.03	5.83	0.41	6.03	3.3	9.32	2.1	1.51	16.9	2.54	6.69	2	13.59	65.94	0.69
Sand Filters3	2	4.07	2.68	30.72	1.86	0.41	6.03	2.33	8.36	1.62	1.51	16.9	2.54	6.67	2	13.59	65.94	0
Effuent	8.87	3.88	2.44	33.07	1.91	0.49	3.38	2.38	5.76	0.84	0.73	16.9	2.72	6.71	2	13.3	65.86	0
Thickener	0.03	3587.72	2340.05	3647.4	1060.34	5.47	2.77	160.49	163.25	88.47	1.36	16.9	3.11	6.89	2.79	13.47	65.91	0.14
BFP	0.03	307.21	200.38	379.22	120.78	5.47	2.77	21.06	23.82	8.82	1.36	16.9	3.11	6.87	2.79	13.47	65.91	0
Sludge	0.13	14108.15	9201.89	14128.27	4073.48	5.47	2.77	607.63	610.4	343.89	1.36	16.9	3.11	6.89	2.79	13.47	65.91	0

Check	Permit	Combined Effluent	?
TSS	20	3.88	OK
Ammonia	1.1	0.49	OK
TKN	NA	2.38	OK
CBOD	NA	1.91	OK
UOD	45	13.6	OK
NO3	10	3.38	OK
Flow	8.9	mgd	

Zones	mgal
AX1	0.100
A1	0.400
AX2	0.200
A2	0.500
AX3	0.500
A3	0.700
AX4	0.700
A4	1.300
FST1	1.750
Total Aer. Vol Req'd	4.400
Total Vol Avail.	3.080
Vol. check:	NO

FSTs:	99.50%	removal	(enter manually)
Filters:	85.00%	removal	(enter manually)
Step-Feed SRT	15	days	(enter manually)

Elements	Model	Setpoint	Elements	Model	Setpoint
Influent	9.0		PST2	2.0	
AX1	3.24		Aeration2	5.94	
A1	3.24		IR	2.00	2.0
AX2	5.57		RAS2	2.00	2.0
A2	5.57		WAS2	0.03	0.03
AX3	7.91		FST2	1.94	
A3	7.91		PST3	2.63	
AX4	13.55		Anoxic3	5.6	
A4	13.55		Aeration3	5.6	
IR	3.31	3.31	IR	1.00	1.0
RAS1	3.24		RAS3	2.00	2.0
WAS1	0.07		WAS3	0.03	0.03
FST1	6.93		FST3	2.60	
			Effuent	8.87	
			Thickener	0.03	
			Thickener Underflow	0.16	0.16
			BFP	0.03	
			Sludge	0.13	0.13

run date:	2/21/06

Model 4: Phase II Conv. Facility Maximum Month

Temp: 12.5 deg C — Yellow boxes indicate parameters that may need to be changed in BioWin before running model.

Elements	Flow [mgd]	Total suspended solids [mgTSS/L]	Volatile suspended solids [mgVSS/L]	Total COD [mg/L]	Total Carbonaceous BOD [mg/L]	Ammonia N [mgN/L]	Nitrate N [mgN/L]	Total Kjeldahl Nitrogen [mgN/L]	Total N [mgN/L]	Total P [mgP/L]	Soluble PO4-P [mgP/L]	Temperature [deg. C]	Alkalinity [mmol/L]	pH []	Dissolved oxygen [mg/L]	Magnesium [mg/L]	Calcium [mg/L]	Liquid volume [Mil. Gal]
Influent	13.6	256.1	175.07	448	220.05	13.14	0.17	45.3	45.47	6.7	3.35	12.5	2.98	8	4.4	10.4	51.6	0
InfluentSplit 1-2,3	6.05	256.1	175.07	448	220.05	13.14	0.17	45.3	45.47	6.7	3.35	12.5	2.98	7.99	4.4	10.4	51.6	0
AX1	4.93	19186.14	9859.03	14756.88	2453.39	1.78	3.67	812.88	816.55	304.74	4.07	12.5	1.95	6.55	0.01	10.32	51.58	0.1
A1	4.93	19142.58	9814.82	14686.6	2409.24	0.14	8.21	807.83	816.04	304.74	4.54	12.5	1.48	6.43	2	10.21	51.55	0.4
AX2	8.11	11731.17	6035.93	9055.23	1514.64	7.52	0.03	505.73	505.76	187.73	5.75	12.5	2.6	6.83	0	10.68	51.68	0.2
A2	8.11	11713.15	6015.21	9013.05	1490.74	0.99	8.44	497.04	505.47	187.73	4.8	12.5	1.54	6.46	2	10.42	51.61	0.5
AX3	11.29	8479.94	4367.73	6560.14	1102.23	6.79	0.06	367.64	367.69	136.66	5.58	12.5	2.56	6.79	0	10.68	51.68	0.5
A3	11.29	8466.33	4351.53	6527.79	1084.57	1.2	6.72	360.76	367.48	136.66	4.6	12.5	1.69	6.5	2	10.43	51.61	0.7
AX4	19.48	6657.22	3429.45	5152.51	866.9	4.11	2.46	288.07	290.54	108.06	4.17	12.5	2.21	6.67	0.01	10.4	51.6	0.7
A4	19.48	6644.36	3415.36	5128.1	852.4	0.69	6.82	283.54	290.36	108.06	3.92	12.5	1.65	6.49	2	10.3	51.57	1.3
RAS1	4.93	19193.45	9865.9	14767.6	2460.44	0.69	6.82	813.02	819.84	304.74	3.92	12.5	1.65	6.49	2	10.3	51.57	0
FST1	9.48	25.37	13.04	43.77	4.24	0.69	6.82	4.27	11.08	4.31	3.92	12.5	1.65	6.49	2	10.3	51.57	1.75
Sand Filters1	8.08	5.36	2.75	28.4	1.68	0.69	6.82	3.42	10.24	4	3.92	12.5	1.65	6.43	2	10.3	51.57	0
Inf Flow Split2-3	3.03	256.1	175.07	448	220.05	13.14	0.17	45.3	45.47	6.7	3.35	12.5	2.98	7.99	4.4	10.4	51.6	0
PST2	3	129.33	88.41	309.36	162.01	13.14	0.17	37.05	37.22	5.04	3.35	12.5	2.98	7.99	4.4	10.4	51.6	0.24
Anoxic2	6.97	4635.36	2993.24	4428.12	1593.38	10.39	0.04	282.04	282.08	108.88	3.22	12.5	2.86	7.01	0	10.51	51.63	0.1
Aeration2	6.97	4616.81	2971	4378.95	1565.38	2.85	9.83	271.91	281.74	108.88	1.95	12.5	1.64	6.52	2	10.24	51.56	0.41
RAS2	1.97	11416.15	7346.5	10792.1	3869.02	2.85	9.83	663.95	673.78	266.37	1.95	12.5	1.64	6.52	2	10.24	51.56	0
FST2	2.97	38.63	24.86	60.8	14.28	2.85	9.83	7.94	17.77	2.84	1.95	12.5	1.64	6.52	2	10.24	51.56	0.24
Sand Filters2	2.37	8.71	5.61	32.59	4.14	2.85	9.83	6.22	16.04	2.15	1.95	12.5	1.64	6.46	2	10.24	51.56	0
PST3	3.64	96.92	64.45	244.94	125.29	11.01	2.4	30.34	32.74	4.62	3.28	12.5	2.68	7.41	3.99	10.4	51.6	1.32
Anoxic3	6.61	3153.65	1991.47	2956.41	851.51	8.71	1.97	189.66	191.63	58.38	2.8	12.5	2.61	7	0.01	10.4	51.6	0.14
Aeration3	6.61	3125.38	1962.24	2901.51	817.3	0.77	13.36	177.86	191.22	58.38	2.92	12.5	1.23	6.38	2	10.4	51.6	1.09
RAS3	1.97	8724.85	5477.81	8057.36	2279.94	0.77	13.36	490.43	503.79	157.76	2.92	12.5	1.23	6.38	2	10.4	51.6	0
FST3	3.61	24.28	15.24	46.1	7.26	0.77	13.36	4.74	18.1	3.35	2.92	12.5	1.23	6.38	2	10.4	51.6	0.69
Sand Filters3	3.01	5.24	3.29	28.56	2.29	0.77	13.36	3.68	17.04	3.01	2.92	12.5	1.23	6.32	2	10.4	51.6	0
Effuent	13.46	5.92	3.38	29.17	2.25	1.09	8.81	3.97	12.78	3.45	3.35	12.5	1.55	6.47	2	10.32	51.58	0
Thickener	0.03	5686.62	3368.87	5207.85	1548.72	4.67	6.49	308.9	315.4	93.36	3.3	12.5	1.96	6.72	2.71	10.34	51.58	0.14
BFP	0.02	701.05	415.32	700.37	218.12	4.67	6.49	47.79	54.28	14.4	3.3	12.5	1.96	6.66	2.71	10.34	51.58	0
Sludge	0.14	19929.83	11806.83	18085.24	5350.08	4.67	6.49	1054.87	1061.36	318.93	3.3	12.5	1.96	6.72	2.71	10.34	51.58	0

Check	Permit	Combined Effluent	?
TSS	20	5.92	OK
Ammonia	1.1	1.09	OK
TKN	NA	3.97	OK
CBOD	NA	2.25	OK
UOD	45	21.2	OK
NO3	10	8.81	OK
Flow	13.5	mgd	

Zones	mgal
AX1	0.100
A1	0.400
AX2	0.200
A2	0.500
AX3	0.500
A3	0.700
AX4	0.700
A4	1.300
FST1	1.750
Total Aer. Vol Req'd	4.400
Total Vol Avail.	3.080
Vol. check:	NO

FSTs:	99.50%	removal	(enter manually)
Filters:	82.00%	removal	(enter manually)
Step-Feed SRT	15	days	(enter manually)

Elements	Model	Setpoint	Elements	Model	Setpoint
Influent	13.6		PST2	3.0	
AX1	4.93		Aeration2	6.97	
A1	4.93		IR	2.00	2.0
AX2	8.11		RAS2	2.00	2.0
A2	8.11		WAS2	0.03	0.025
AX3	11.29		FST2	2.97	
A3	11.29		PST3	3.64	
AX4	19.48		Anoxic3	6.61	
A4	19.48		Aeration3	6.61	
IR	5.0	5.0	IR	1.00	1.0
RAS1	4.93		RAS3	2.00	2.0
WAS1	0.06		WAS3	0.03	0.03
FST1	9.48		FST3	3.61	
			Effuent	13.46	
			Thickener	0.03	
			Thickener Underflow	0.15	0.15
			BFP	0.02	
			Sludge	0.14	0.014

Model 4: Phase II Conv. Facility Maximum Month

Temp:	16.9	deg C	Yellow boxes indicate parameters that may need to be changed in BioWin before running model.

Elements	Flow [mgd]	Total suspended solids [mgTSS/L]	Volatile suspended solids [mgVSS/L]	Total COD [mg/L]	Total Carbonaceous BOD [mg/L]	Ammonia N [mgN/L]	Nitrate N [mgN/L]	Total Kjeldahl Nitrogen [mgN/L]	Total N [mgN/L]	Total P [mgP/L]	Soluble PO4-P [mgP/L]	Temperature [deg. C]	Alkalinity [mmol/L]	pH []	Dissolved oxygen [mg/L]	Magnesium [mg/L]	Calcium [mg/L]	Liquid volume [Mil. Gal]
Influent	13.6	256.1	175.07	448	220.05	13.14	0.17	45.3	45.47	6.7	3.35	16.9	2.98	8	4.4	10.4	51.6	0
InfluentSplit 1-2,3	6.05	256.1	175.07	448	220.05	13.14	0.17	45.3	45.47	6.7	3.35	16.9	2.98	7.99	4.4	10.4	51.6	0
AX1	4.93	18917.27	9658.67	14469.66	2218.1	1.58	3.68	792.88	796.56	267.83	4.38	16.9	1.93	6.56	0.01	10.38	51.59	0.1
A1	4.93	18872.02	9613.59	14398.31	2173.11	0.11	8.22	787.82	796.04	267.83	5.29	16.9	1.47	6.44	2	10.36	51.59	0.4
AX2	8.11	11565.37	5911.22	8879.65	1371.58	7.6	0.02	493.51	493.53	165.3	5.6	16.9	2.59	6.83	0	10.61	51.66	0.2
A2	8.11	11547.21	5891.15	8834.95	1345.61	0.68	8.77	484.45	493.22	165.3	5.13	16.9	1.49	6.46	2	10.47	51.62	0.5
AX3	11.29	8365.37	4281.33	6433.03	999.36	6.14	0.57	358.46	359.03	120.56	4.6	16.9	2.48	6.8	0	10.46	51.62	0.5
A3	11.29	8349.33	4264.03	6402.17	981.51	0.7	7.13	351.67	358.8	120.56	4.44	16.9	1.62	6.5	2	10.39	51.6	0.7
AX4	19.48	6565.21	3360.67	5053.69	785.98	3.75	2.62	280.94	283.56	95.49	4.18	16.9	2.17	6.68	0.01	10.39	51.6	0.7
A4	19.48	6551.33	3346.06	5028.54	770.99	0.45	6.9	276.47	283.38	95.49	4.24	16.9	1.62	6.5	2	10.37	51.59	1.3
RAS1	4.93	18924.74	9665.71	14480.59	2225.3	0.45	6.9	793.05	799.95	267.83	4.24	16.9	1.62	6.5	2	10.37	51.59	0
FST1	9.48	25.02	12.78	43.09	3.92	0.45	6.9	4.01	10.91	4.59	4.24	16.9	1.62	6.5	2	10.37	51.59	1.75
Sand Filters1	8.08	5.28	2.7	28.01	1.6	0.45	6.9	3.18	10.09	4.32	4.24	16.9	1.62	6.47	2	10.37	51.59	0
Inf Flow Split2-3	3.03	256.1	175.07	448	220.05	13.14	0.17	45.3	45.47	6.7	3.35	16.9	2.98	7.99	4.4	10.4	51.6	0
PST2	3	129.33	88.41	309.36	162.01	13.14	0.17	37.05	37.22	5.04	3.35	16.9	2.98	7.99	4.4	10.4	51.6	0.24
Anoxic2	6.97	4495.46	2885.42	4271.37	1488.18	9.49	0.04	270.75	270.8	91.14	2.95	16.9	2.79	7.01	0	10.44	51.61	0.1
Aeration2	6.97	4474.61	2862.24	4221.53	1459.49	1.18	10.68	259.76	270.44	91.14	2.48	16.9	1.46	6.48	2	10.34	51.58	0.41
RAS2	1.97	11064.51	7077.57	10403.1	3607.27	1.18	10.68	636.43	647.11	221.73	2.48	16.9	1.46	6.48	2	10.34	51.58	0
FST2	2.97	37.44	23.95	59.31	13.33	1.18	10.68	6.13	16.81	3.22	2.48	16.9	1.46	6.48	2	10.34	51.58	0.24
Sand Filters2	2.37	8.44	5.4	32.11	3.88	1.18	10.68	4.48	15.16	2.64	2.48	16.9	1.46	6.46	2	10.34	51.58	0
PST3	3.64	96.56	64.15	244.5	124.97	10.96	2.44	30.25	32.69	4.61	3.29	16.9	2.67	7.43	3.99	10.4	51.6	1.32
Anoxic3	6.61	3079.22	1923.12	2858.29	783.01	8.6	1.96	182.75	184.72	55.98	2.82	16.9	2.6	7.02	0.01	10.4	51.6	0.14
Aeration3	6.61	3049.92	1892.95	2802.24	748.01	0.5	13.57	170.73	184.3	55.98	2.98	16.9	1.19	6.38	2	10.4	51.6	1.09
RAS3	1.97	8514.18	5284.36	7780.3	2086.54	0.5	13.57	471.08	484.65	150.93	2.98	16.9	1.19	6.38	2	10.4	51.6	0
FST3	3.61	23.7	14.71	45.29	6.71	0.5	13.57	4.39	17.95	3.39	2.98	16.9	1.19	6.38	2	10.4	51.6	0.69
Sand Filters3	3.01	5.11	3.17	28.36	2.16	0.5	13.57	3.37	16.93	3.07	2.98	16.9	1.19	6.36	2	10.4	51.6	0
Effuent	13.46	5.8	3.28	28.81	2.13	0.59	9.06	3.45	12.51	3.74	3.65	16.9	1.5	6.47	2	10.37	51.59	0
Thickener	0.03	5616.02	3313.35	5128.02	1488.63	4.3	6.68	303.09	309.77	85.54	3.5	16.9	1.92	6.72	2.71	10.38	51.59	0.14
BFP	0.02	692.36	408.48	690.41	210.71	4.3	6.68	46.74	53.42	13.62	3.5	16.9	1.92	6.7	2.71	10.38	51.59	0
Sludge	0.14	19682.71	11612.46	17806.09	5139.6	4.3	6.68	1035.46	1042.14	291.03	3.5	16.9	1.92	6.72	2.71	10.38	51.59	0

Check	Permit	Combined Effluent	?
TSS	20	5.8	OK
Ammonia	1.1	0.59	OK
TKN	NA	3.45	OK
CBOD	NA	2.13	OK
UOD	45	18.7	OK
NO3	10	9.06	OK
Flow	13.5	mgd	

Zones	mgal
AX1	0.100
A1	0.400
AX2	0.200
A2	0.500
AX3	0.500
A3	0.700
AX4	0.700
A4	1.300
FST1	1.750
Total Aer. Vol Req'd	4.400
Total Vol Avail.	3.080
Vol. check:	NO

FSTs:	99.50%	removal	(enter manually)
Filters:	82.00%	removal	(enter manually)
Step-Feed SRT	15	days	(enter manually)

Elements	Model	Setpoint	Elements	Model	Setpoint
Influent	13.6		PST2	3.0	
AX1	4.93		Aeration2	6.97	
A1	4.93		IR	2.00	2.0
AX2	8.11		RAS2	2.00	2.0
A2	8.11		WAS2	0.03	0.025
AX3	11.29		FST2	2.97	
A3	11.29		PST3	3.64	
AX4	19.48		Anoxic3	6.61	
A4	19.48		Aeration3	6.61	
IR	5.0	5.0	IR	1.00	1.0
RAS1	4.93		RAS3	2.00	2.0
WAS1	0.06		WAS3	0.03	0.03
FST1	9.48		FST3	3.61	
			Effuent	13.46	
			Thickener	0.03	
			Thickener Underflow	0.15	0.15
			BFP	0.02	
			Sludge	0.14	0.014

run date:	2/20/06

Model 4: Phase II Conv. Facility Maximum Day

Temp: 12.5 deg C — Yellow boxes indicate parameters that may need to be changed in BioWin before running model.

Elements	Flow [mgd]	Total suspended solids [mgTSS/L]	Volatile suspended solids [mgVSS/L]	Total COD [mg/L]	Total Carbonaceous BOD [mg/L]	Ammonia N [mgN/L]	Nitrate N [mgN/L]	Total Kjeldahl Nitrogen [mgN/L]	Total N [mgN/L]	Total P [mgP/L]	Soluble PO4-P [mgP/L]	Temperature [deg. C]	Alkalinity [mmol/L]	pH []	Dissolved oxygen [mg/L]	Magnesium [mg/L]	Calcium [mg/L]	Liquid volume [Mil. Gal]
Influent	18	284.17	189.14	484	237.73	15.42	0.25	48.2	48.45	10.5	5.25	12.5	3.46	8.6	4.8	8	44.5	0
InfluentSplit 1-2,3	8.01	284.17	189.14	484	237.73	15.42	0.25	48.2	48.45	10.5	5.25	12.5	3.46	8.59	4.8	8	44.5	0
AX1	4.94	31327.02	15618.95	23347.38	3973.91	2.17	3.2	1290.67	1293.88	500.87	7.78	12.5	2.28	6.6	0	7.93	44.48	0.1
A1	4.94	31255.57	15546.67	23231.79	3901.57	0.14	9.82	1283.21	1293.03	500.87	9.24	12.5	1.6	6.46	2	7.83	44.45	0.4
AX2	8.94	17414.74	8691.72	13022.5	2225.24	10.51	0.01	728.7	728.71	281.7	12.16	12.5	3.08	6.96	0	8.94	44.76	0.2
A2	8.94	17393.32	8664.83	12963.28	2192.23	1.14	11.35	716.97	728.32	281.7	10.09	12.5	1.61	6.47	2	8.35	44.6	0.5
AX3	12.93	12120.33	6055.61	9074.35	1558.29	7.93	1.01	508.75	509.76	198.03	8.68	12.5	2.86	6.87	0	8.25	44.57	0.5
A3	12.93	12102.31	6034.79	9037.63	1536.89	1.18	8.84	500.65	509.49	198.03	7.99	12.5	1.81	6.53	2	7.99	44.5	0.7
AX4	21.93	9318.36	4656.96	6983.8	1201.55	5.04	3.06	390.97	394.03	153.86	7.42	12.5	2.51	6.75	0.01	7.98	44.49	0.7
A4	21.93	9302.15	4639.33	6953.44	1183.49	0.73	8.36	385.45	393.8	153.86	7.38	12.5	1.81	6.53	2	7.89	44.47	1.3
RAS1	4.94	31338.75	15629.8	23363.84	3984.75	0.73	8.36	1290.82	1299.18	500.87	7.38	12.5	1.81	6.53	2	7.89	44.47	0
FST1	11.93	66	32.92	75.39	9.41	0.73	8.36	5.98	14.34	8.4	7.38	12.5	1.81	6.53	2	7.89	44.47	1.75
Sand Filters1	10.53	14.96	7.46	37.37	2.92	0.73	8.36	3.88	12.24	7.62	7.38	12.5	1.81	6.47	2	7.89	44.47	0
Inf Flow Split2-3	4	284.17	189.14	484	237.73	15.42	0.25	48.2	48.45	10.5	5.25	12.5	3.46	8.59	4.8	8	44.5	0
PST2	3.97	143.16	95.29	333.85	174.87	15.42	0.25	39.75	40	7.89	5.25	12.5	3.46	8.59	4.8	8	44.5	0.24
Anoxic2	7.95	6051.68	3799.76	5615.49	2116.34	14.24	0.03	357.94	357.97	218.21	7.47	12.5	3.45	7.2	0	8.57	44.66	0.1
Aeration2	7.95	6036.31	3772.99	5553.52	2082.45	5.18	11.02	346.53	357.55	218.21	2.26	12.5	2.03	6.62	2	7.33	44.32	0.41
RAS2	1.97	17865.53	11166.82	16384.31	6160.84	5.18	11.02	1009.84	1020.85	641.42	2.26	12.5	2.03	6.62	2	7.33	44.32	0
FST2	3.95	45.47	28.42	68.33	16.97	5.18	11.02	10.6	21.62	3.88	2.26	12.5	2.03	6.62	2	7.33	44.32	0.24
Sand Filters2	3.35	10.72	6.7	36.52	5	5.18	11.02	8.65	19.67	2.64	2.26	12.5	2.03	6.56	2	7.33	44.32	0
PST3	4.62	111.95	72.53	274.86	141.39	13.45	2.13	33.92	36.05	7.33	5.25	12.5	3.19	7.89	4.42	8	44.5	1.32
Anoxic3	7.59	3978.53	2455.25	3644.41	1107.54	11.63	0.07	233.94	234.01	79.18	5.21	12.5	3.26	7.19	0	8.04	44.51	0.14
Aeration3	7.59	3947.56	2422.37	3577.15	1066.97	0.87	14.3	219.21	233.52	79.18	5.23	12.5	1.48	6.46	2	7.97	44.49	1.09
RAS3	1.97	12944.85	7943.43	11671.56	3496.64	0.87	14.3	710.8	725.1	247.73	5.23	12.5	1.48	6.46	2	7.97	44.49	0
FST3	4.59	28.34	17.39	51.22	8.61	0.87	14.3	5.08	19.38	5.76	5.23	12.5	1.48	6.46	2	7.97	44.49	0.69
Sand Filters3	3.99	6.52	4	31.59	2.72	0.87	14.3	3.89	18.19	5.35	5.23	12.5	1.48	6.4	2	7.97	44.49	0
Effuent	17.87	12.28	6.54	35.92	3.26	1.59	10.18	4.78	14.96	6.18	5.94	12.5	1.78	6.53	2	7.8	44.45	0
Thickener	0.03	7914.66	4569.37	7045.06	2143.56	6.02	7.31	409.24	416.55	156.59	5.57	12.5	2.3	6.82	2.88	7.86	44.46	0.14
BFP	0.02	1025.08	591.81	977.87	308.75	6.02	7.31	64.15	71.46	25.13	5.57	12.5	2.3	6.77	2.88	7.86	44.46	0
Sludge	0.13	31383.18	18118.45	27712.18	8393.63	6.02	7.31	1584.76	1592.07	604.39	5.57	12.5	2.3	6.82	2.88	7.86	44.46	0

Check	Permit	Combined Effluent	?
TSS	20	12.28	OK
Ammonia	1.1	1.59	NO
TKN	NA	4.78	OK
CBOD	NA	3.26	OK
UOD	45	26.4	OK
NO3	10	10.18	NO
Flow	17.9	mgd	

Zones	mgal
AX1	0.100
A1	0.400
AX2	0.200
A2	0.500
AX3	0.500
A3	0.700
AX4	0.700
A4	1.300
FST1	1.750
Total Aer. Vol Req'd	4.400
Total Vol Avail.	3.080
Vol. check:	NO

FSTs:	99.50%	removal	(enter manually)
Filters:	80.00%	removal	(enter manually)
Step-Feed SRT	15	days	(enter manually)

Elements	Model	Setpoint	Elements	Model	Setpoint
Influent	18.0		PST2	4.0	
AX1	4.94		Aeration2	7.95	
A1	4.94		IR	2.0	2.0
AX2	8.94		RAS2	2.0	2.0
A2	8.94		WAS2	0.02	0.025
AX3	12.93		FST2	3.95	
A3	12.93		PST3	4.62	
AX4	21.93		Anoxic3	7.59	
A4	21.93		Aeration3	7.59	
IR	5.00	5.0	IR	1.00	1.0
RAS1	4.94		RAS3	2.00	2.0
WAS1	0.06		WAS3	0.03	0.03
FST1	11.93		FST3	4.59	
			Effuent	17.87	
			Thickener	0.03	
			Thickener Underflow	0.14	0.14
			BFP	0.02	
			Sludge	0.13	0.13

Model 4: Phase II Conv. Facility Maximum Day Temp: 16.9 deg C — Yellow boxes indicate parameters that may need to be changed in BioWin before running model.

Elements	Flow [mgd]	Total suspended solids [mgTSS/L]	Volatile suspended solids [mgVSS/L]	Total COD [mg/L]	Total Carbonaceous BOD [mg/L]	Ammonia N [mgN/L]	Nitrate N [mgN/L]	Total Kjeldahl Nitrogen [mgN/L]	Total N [mgN/L]	Total P [mgP/L]	Soluble PO4-P [mgP/L]	Temperature [deg. C]	Alkalinity [mmol/L]	pH []	Dissolved oxygen [mg/L]	Magnesium [mg/L]	Calcium [mg/L]	Liquid volume [Mil. Gal]
Influent	18	284.17	189.14	484	237.73	15.42	0.25	48.2	48.45	10.5	5.25	16.9	3.46	8.6	4.8	8	44.5	0
InfluentSplit 1-2,3	8.01	284.17	189.14	484	237.73	15.42	0.25	48.2	48.45	10.5	5.25	16.9	3.46	8.59	4.8	8	44.5	0
AX1	4.94	30901.53	15226.4	22785.22	3589.36	1.91	3.14	1251.51	1254.65	487.89	7.83	16.9	2.26	6.61	0	7.92	44.48	0.1
A1	4.94	30829.77	15154.04	22670.16	3516.93	0.11	9.66	1244.15	1253.81	487.89	9.28	16.9	1.6	6.47	2	7.81	44.45	0.4
AX2	8.94	17178.12	8473.87	12711.65	2012.31	10.46	0.01	706.97	706.98	274.51	12.41	16.9	3.07	6.97	0	8.98	44.77	0.2
A2	8.94	17156.69	8446.8	12651.33	1978.64	0.73	11.69	694.9	706.58	274.51	10.26	16.9	1.55	6.47	2	8.36	44.6	0.5
AX3	12.93	11956.39	5904.55	8858.11	1410.3	7.57	1.15	493.38	494.53	193.04	8.79	16.9	2.82	6.89	0	8.26	44.57	0.5
A3	12.93	11938.05	5883.32	8820.79	1388.5	0.72	9.09	485.17	494.26	193.04	8.06	16.9	1.75	6.53	2	7.99	44.5	0.7
AX4	21.93	9192.39	4540.79	6817.44	1087.74	4.67	3.14	379.07	382.21	150.05	7.48	16.9	2.48	6.75	0.01	7.98	44.49	0.7
A4	21.93	9175.9	4522.84	6786.6	1069.37	0.47	8.34	373.64	381.98	150.05	7.43	16.9	1.79	6.53	2	7.88	44.47	1.3
RAS1	4.94	30913.39	15237.35	22801.79	3600.3	0.47	8.34	1251.67	1260.02	487.89	7.43	16.9	1.79	6.53	2	7.88	44.47	0
FST1	11.93	65.11	32.09	74.18	8.59	0.47	8.34	5.63	13.97	8.45	7.43	16.9	1.79	6.53	2	7.88	44.47	1.75
Sand Filters1	10.53	14.75	7.27	37.08	2.73	0.47	8.34	3.6	11.94	7.66	7.43	16.9	1.79	6.51	2	7.88	44.47	0
Inf Flow Split2-3	4	284.17	189.14	484	237.73	15.42	0.25	48.2	48.45	10.5	5.25	16.9	3.46	8.59	4.8	8	44.5	0
PST2	3.97	143.16	95.29	333.85	174.87	15.42	0.25	39.75	40	7.89	5.25	16.9	3.46	8.59	4.8	8	44.5	0.24
Anoxic2	7.95	5853.91	3669.57	5424.08	1988.65	12.45	0.03	344.11	344.14	178.78	6.6	16.9	3.32	7.22	0	8.36	44.6	0.1
Aeration2	7.95	5834.29	3641.85	5362.25	1954.08	1.56	12.99	330.72	343.71	178.78	3.31	16.9	1.63	6.53	2	7.55	44.38	0.41
RAS2	1.97	17267.62	10778.71	15818.84	5781.04	1.56	12.99	970.22	983.21	522.63	3.31	16.9	1.63	6.53	2	7.55	44.38	0
FST2	3.95	43.95	27.43	66.57	15.93	1.56	12.99	6.84	19.84	4.64	3.31	16.9	1.63	6.53	2	7.55	44.38	0.24
Sand Filters2	3.35	10.36	6.47	35.85	4.69	1.56	12.99	4.96	17.96	3.63	3.31	16.9	1.63	6.51	2	7.55	44.38	0
PST3	4.62	111.53	72.16	274.33	141.03	13.4	2.18	33.83	36	7.32	5.26	16.9	3.18	8.01	4.42	8	44.5	1.32
Anoxic3	7.59	3882.77	2366.96	3517.88	1021.25	11.55	0.06	225.12	225.19	76.27	5.25	16.9	3.25	7.22	0	8.04	44.51	0.14
Aeration3	7.59	3850.68	2333.05	3449.11	979.65	0.55	14.59	210.09	224.69	76.27	5.3	16.9	1.43	6.46	2	7.97	44.49	1.09
RAS3	1.97	12627.18	7650.55	11251.79	3210.34	0.55	14.59	681.69	696.29	238.03	5.3	16.9	1.43	6.46	2	7.97	44.49	0
FST3	4.59	27.64	16.75	50.26	7.96	0.55	14.59	4.66	19.26	5.81	5.3	16.9	1.43	6.46	2	7.97	44.49	0.69
Sand Filters3	3.99	6.36	3.85	31.34	2.55	0.55	14.59	3.52	18.11	5.42	5.3	16.9	1.43	6.44	2	7.97	44.49	0
Effuent	17.87	12.06	6.36	35.57	3.06	0.69	10.61	3.83	14.45	6.41	6.19	16.9	1.68	6.52	2	7.84	44.46	0
Thickener	0.03	7814.8	4484.96	6923.66	2060.86	5.36	7.64	400.33	407.98	148.88	5.76	16.9	2.23	6.83	2.88	7.89	44.47	0.14
BFP	0.02	1012.11	580.86	962.07	298.02	5.36	7.64	62.4	70.04	24.29	5.76	16.9	2.23	6.81	2.88	7.89	44.47	0
Sludge	0.13	30986.23	17783.17	27230.12	8065.5	5.36	7.64	1551.41	1559.05	573.26	5.76	16.9	2.23	6.83	2.88	7.89	44.47	0

Check	Permit	Combined Effluent	?
TSS	20	12.06	OK
Ammonia	1.1	0.69	OK
TKN	NA	3.83	OK
CBOD	NA	3.06	OK
UOD	45	21.8	OK
NO3	10	10.61	NO
Flow	17.9	mgd	

Zones	mgal
AX1	0.100
A1	0.400
AX2	0.200
A2	0.500
AX3	0.500
A3	0.700
AX4	0.700
A4	1.300
FST1	1.750
Total Aer. Vol Req'd	4.400
Total Vol Avail.	3.080
Vol. check:	NO

FSTs:	99.50%	removal	(enter manually)
Filters:	85.00%	removal	(enter manually)
Step-Feed SRT	15	days	(enter manually)

Elements	Model	Setpoint
Influent	18.0	
AX1	4.94	
A1	4.94	
AX2	8.94	
A2	8.94	
AX3	12.93	
A3	12.93	
AX4	21.93	
A4	21.93	
IR	5.00	5.00
RAS1	4.94	
WAS1	0.06	
FST1	11.93	

Elements	Model	Setpoint
PST2	4.0	
Aeration2	7.95	
IR	2.0	2.0
RAS2	2.0	2.0
WAS2	0.02	0.025
FST2	3.95	
PST3	4.62	
Anoxic3	7.59	
Aeration3	7.59	
IR	1.00	1.0
RAS3	2.00	2.0
WAS3	0.03	0.03
FST3	4.59	
Effuent	17.87	
Thickener	0.03	
Thickener Underflow	0.14	0.14
BFP	0.02	
Sludge	0.13	0.13

For information on other
NYSERDA reports, contact:

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

toll free: 1 (866) NYSERDA
local: (518) 862-1090
fax: (518) 862-1091

info@nyserda.org
www.nyserda.org

Harriman Wastewater Treatment Facility Membrane Bioreactor Pilot Study

Final Report 06-08

State of New York
George E. Pataki, Governor

New York State Energy Research and Development Authority
Vincent A. DeIorio, Esq., Chairman
Peter R. Smith, President, and Chief Executive Officer

HARRIMAN WASTEWATER TREATMENT FACILITY MEMBRANE BIOREACTOR PILOT STUDY

NYSERDA Final Report 06-08