Liquid Processing Facilities Plan

Report

Madison Metropolitan Sewerage District, WI

August 2017

Report for

Madison Metropolitan Sewerage District, Madison, Wisconsin

2016 Liquid Processing Facilities Plan

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EXECUTIVE SUMMARY

ES.01 PROJECT BACKGROUND

The Madison Metropolitan Sewerage District (MMSD or District) has a long history of proactive planning to best serve its customers and the greater Dane County area in a sustainable and fiscally responsible manner. This Liquid Processing Facilities Plan (Facilities Plan) is focused on the future needs and opportunities related to the Nine Springs Wastewater Treatment Plant (NSWWTP) liquid treatment processes. The most recent NSWWTP focused planning studies were developed as noted in the following:

- Tenth Addition Facilities Plan–2003
- 50-Year Master Plan–2009
- Solids Handling Facilities Plan (Eleventh Addition)–2009/2010
- Energy Baseline and Optimization Roadmap Study–2014

The District is a municipal corporation located in Madison, Wisconsin that provides wastewater conveyance and treatment for 43 communities and sanitary districts in the Madison metropolitan area. The MMSD service area includes approximately 182 square miles with a population of approximately 365,000 people. The District's conveyance system includes 94 miles of interceptor sewers, 48 miles of force mains, and 18 pumping stations. All the wastewater collected in the MMSD service area is conveyed to the NSWWTP for treatment and returned to the environment.

This Facilities Plan was prepared for the purpose of developing a plan for liquid processing and treatment at the NSWWTP through the planning year of 2040. The scope of work for the Facilities Plan includes the following:

ES.02 MMSD STRATEGIC GOALS AND OBJECTIVES

While the District has always been committed to providing excellent services at low costs to its ratepayers, the District has more recently established goals that focus on achieving sustainability targets. For example, the District now seeks certification for capital improvement projects to increase the transparency of decisions and to develop the most sustainable solutions for implementation. All decisions and capital improvement projects need consider sustainability objectives based on business case evaluations (including triple bottom line objectives and analyses) to develop the best overall plan for the District and its customers. Specific target areas of the Facilities Plan are described in the following:

1. Peak Capacity Management

   With the construction of Pump Station No. 18 and upgrades to Pump Station No. 11, there is the potential of exceeding the hydraulic capacity of the NSWWTP. In addition, peak flow management constraints within the NSWWTP limit the flexibility and treatment capacity of the plant. The goal of this targeted task is to develop a plan to improve the capacity, resiliency, and flexibility to manage peak flows into the NSWWTP.

   It is noted that the analysis did not include a climate change impact for the District, but it did summarize two recent climate change impact analyses that were completed for the Milwaukee Metropolitan Sewerage District. In general, large wet weather events tended to become larger and more intense, while smaller events tended to become smaller and less frequent, with the average annual rainfall anticipated to remain approximately the same. The climate change scenarios affected the distribution of intensities, rather than the average annual rain amount. The studies predicted a relatively small change in peak sanitary sewer flows of less than 10 percent. Climate change impacts in Madison could be expected to be similar to the Milwaukee study results. With due respect for the uncertainties in the model results, the impacts of climate change in an upper Midwest location like Madison may be a modest variation from the current pattern, rather than a major hydrologic shift.

2. Activated Sludge Facilities

The NSWWTP activated sludge facilities are an exceptionally well operated set of processes within the NSWWTP. However, the majority of the equipment and systems related to these processes were installed in the 1980s and 1990s, and these systems will need to be replaced within the planning horizon of this plan. In addition, the Energy Baseline and Optimization Roadmap Study identified the activated sludge facilities as a primary opportunity to reduce energy consumption at the NSWWTP. The focus of this major planning element was to identify process upgrades and enhancements to reduce energy while meeting current and projected future loading conditions and permit requirements.

3. Headworks Facilities

The headworks facilities include screening and grit removal processes at the head end of the plant, as well as the facilities devoted to receiving trucked-in wastes at the NSWWTP. These facilities were installed as part of the Tenth Addition in about 2005, and generally have required considerably more maintenance and operator attention than was anticipated or should be expected, especially with respect to the screening and hauled waste receiving facilities. The focus of the Headworks Facilities planning is to provide a plan to reduce maintenance, improve operations flexibility and process resiliency, and develop a plan to maximize the use of the existing system while planning for its replacement within the next 10 years.

4. Ultraviolet (UV) Disinfection System

This system is critical to the NSWWTP in terms of meeting its WPDES permit for effluent fecal coliform, as all wastewater that is pumped to the District's two outfall locations is disinfected through this system. The existing UV disinfection system was started-up in 1996 and has been operational for more than 20 years. While the system is still functional, the equipment manufacturer has not supported this equipment for about 20 years, and replacement parts are becoming more difficult to source and/or produce. The focus of this major planning element is to develop a plan to upgrade or replace the system.

5. NSWWTP Electrical Reliability

The NSWWTP includes a significant electrical distribution system with several aging substations and related equipment. Providing safe and reliable power to all NSWWTP processes is critical to maintaining treatment performance and environmental protection. This portion of the planning effort was focused on upgrading and/or replacing unit substations U11, U12, and U13, as well as the Headworks Facilities backup power, east and west blower controls, and the east and west blower switchgear.

6. Asset Management and Condition Assessment

The District is developing a comprehensive asset management plan for all District assets under a different project. However, the process review required for this Facilities Plan was leveraged to provide condition assessments for a large percentage of the assets related to liquid treatment processes at the NSWWTP.

ES.03 APPROACH TO THIS FACILITIES PLANNING PLANNING

This Facilities Plan was developed over the course of approximately 16 months and included significant collaboration between the District and the consultant team, numerous workshops and review meetings, and a series of nine technical memoranda, each devoted to a specific topic and/or area of the NSWWTP planning study. Each of these technical memoranda are included as appendices to the summary facilities planning document. The technical memoranda are outlined below for the reader's information:

Technical Memorandum No. 1–Sustainability Management System (Appendix A)
Technical Memorandum No. 2a–Regulatory Projections (Appendix B)
Technical Memorandum No. 2b–Flow and Loading Projections (Appendix B)
Technical Memorandum No. 3–Condition Assessments (Appendix C)
Technical Memorandum No. 4–Peak Flow Management (Appendix D)
Technical Memorandum No. 5–Biological Nutrient Removal Alternatives Evaluation (Appendix E)
Technical Memorandum No. 6–Headworks and Hauled Waste Receiving (Appendix F)
Technical Memorandum No. 7–Effluent Disinfection (Appendix G)
Technical Memorandum No. 8–Electrical Improvements (Appendix H)

Each major planning element listed included at least one initial meeting between the District and consultant team to discuss direction, elements to include in the analyses, preliminary alternatives, and related information. Following the initial meeting, the consultant team developed a preliminary document that summarized the current issues and concerns, and identified an initial list of technical alternatives that could be evaluated. This document (one for each technical area) was submitted to the District, and one or more workshops were then held to review the background and potential alternatives in detail with District staff. Following the workshops, the technical memoranda identified above were developed and submitted to the District for review. The District provided consolidated comments to the consultant for each technical memorandum, and one or more revisions of each of the technical memoranda were developed to address the District's comments.

ES.04 KEY RESULTS AND RECOMMENDATIONS

Recommendations of capital improvements and related investigations are made throughout the Facilities Plan and within the associated technical memoranda. A summary of the recommended upgrades and modifications for the NSWWTP is summarized by process/major facilities planning area in Table ES.04-1. Also included are the drivers for the recommendations, opinion of capital costs for the improvements, benefits anticipated, potential concerns, and references to the Facilities Planning report sections and technical memoranda to provide more information and background to the interested reader.

Table ES.04-1 Summary of Recommended Capital Improvements

Process or Component	Subcomponent	Main Concern(s) and/or Drivers	Recommended Modifications or Action	Opinion of Capital Cost[a]	Project Phasing (Near, Mid, Future)[b]	Anticipated Benefits	Associated Facilities Plan Section	Associated Technical Memorandum
Overall Peak Flow Management	Hydraulic Upgrades	Improve treatment reliability. Environmental impact from major hydraulic overflow at plant.	Alt. PF10–Construct hydraulic improvement and provide ability to operate in biological contact stabilization mode.	$5,200,000	Near	▪ Improves flexibility and capacity to manage peak flows. ▪ Improves treatment performance at peak flows.	4	TM4
Overall Peak Flow Management	Aggressive I/I Removal	Reduce peak flows.	Alt. PF4–Consider aggressive I/I reduction; consider pilot studies to gauge potential success.	*See Facilities Plan*	TBD	▪ Establish accountability and communications with customer communities. ▪ Potentially reduce flows at the source.	4	TM4
Overall Peak Flow Management	Local Discharge to Nine Springs Creek	Reduce energy use. Infrastructure risk and replacement costs.	Alt. PF9–Begin long-term planning to determine regulatory and political viability.	*See Facilities Plan*	TBD	▪ Reduce energy by eliminating effluent pumping station ▪ Reduce infrastructure risk and replacement costs related to very long and old effluent force main.	4	TM4
						▪		
Headworks and Hauled Waste Receiving	Influent Flow Metering	Operational problems. Screen bypassing.	Alt. IFM5- Relocate existing venturi flow meters to lower elevation	$2,100,000	Near	▪ Allows reuse of the existing flow meters. ▪ Improves screening and screenings handling operations while reducing maintenance. ▪ Reduces likelihood of bypassing the mechanical screens.	5	TM6
Headworks and Hauled Waste Receiving	Screening and Screenings Handling	Reduce maintenance.	Alt. S1–Screen sluiced screenings or Alt. S3–Install new step screens and wash presses	$3,400,000	Mid	▪ Simpler system will reduce maintenance and operator attention.	5	TM6
Headworks and Hauled Waste Receiving	Grit Management	Equipment replacement.	Alt. G1–Replace equipment in the future.	$2,000,000	Mid	▪ Minor benefit; new equipment in the future.	5	TM6
Headworks and Hauled Waste Receiving	Hauled Waste Receiving	Reduce maintenance. Reduce operator attention. Improve revenue.	Alt. 4. HW1–Construction of a drive-through hauled waste receiving station.	$2,900,000	Near	▪ Reduce grit load to screens. ▪ Reduce road icing safety concerns. ▪ Reduce operator attention. ▪ Improve access for haulers as well as accountability and monitoring. ▪ Increase hauled waste revenue.	5	TM6

Process or Component	Subcomponent	Main Concern(s) and/or Drivers	Recommended Modifications or Action	Opinion of Capital Cost[a]	Project Phasing (Near, Mid, Future)[b]	Anticipated Benefits	Associated Facilities Plan Section	Associated Technical Memorandum
Activated Sludge	Clarifier Stress Testing	Cost avoidance.	Conduct clarifier stress testing and hydraulic modeling.	$130,000	Near	▪ Potentially eliminate future need to construct two final clarifiers. ▪ Establish maximum loadings to the final clarifiers.	6	TM5
Activated Sludge	Nitrite Shunt Full-Scale Demonstration	Relatively new process–demonstrate viability.	Convert West Plant No. 3 or 4 to nitrite shunt operations; includes new diffusers, aeration piping, polymer feed, ammonia versus nitrate (AVN) controls, and miscellaneous modifications.	$2,260,000	Mid	▪ Demonstrate full-scale viability before investing in complete upgrade; relatively new process.	6	TM5
Activated Sludge	Nitrite Shunt Full Plant Conversion	Reduce energy use. Future nitrogen removal.	Alt. AS4–Convert remaining plants to nitrite shunt; construct two new final clarifiers.	$17,860,000	Future	▪ Reduce energy use at the activated sludge plant. ▪ Improve nitrogen removal efficiency while not impacting phosphorus removal.	6	TM5
Activated Sludge	Aeration Cross-Connect	Reduce energy use. Cost avoidance.	Construct interconnection aeration piping between east and west plants.	$2,160,000	Mid	▪ Reduce energy use by the aeration systems. ▪ Provide improved redundancy and system reliability. ▪ Avoid the need to replace the east side blowers and switchgear.	6	TM5
Activated Sludge	West Side Blowers	Reduce energy use. Improve reliability.	Replace three west blowers; east side blowers do not need to be replaced if the cross connect is installed.	$6,300,000	Mid and Future	▪ Reduce energy use with more efficient and appropriately sized blowers.	6	TM5
Activated Sludge	Misc. Upgrades	Reduce energy use. Improve reliability.	Miscellaneous upgrades to RAS pumping control and activated sludge process.	$520,000	Mid	▪ Reduce energy use. ▪ Improve reliability and reduce maintenance.	6	TM5
Disinfection	Install New UV System	Improve reliability.	Replace UV system with new UV system in the existing channels.	$3,800,000	Near	▪ Improve disinfection reliability. ▪ Reduce energy use.	7	TM7
Electrical Reliability	East Blower Controls	Improve reliability.	Replace the east side blower control panel and controls.	$390,000	Near	▪ Improve aeration system reliability and control.	8	TM8
Electrical Reliability	East Blower Switchgear	Improve reliability.	Replace the east side blower switchgear (only if new east side blowers are installed).	$1,140,000	Future	▪ Improve electrical reliability and safety.	8	TM8
Electrical Reliability	West Blower Switchgear	Improve reliability.	Replace west switchgear when west blowers are replaced.	$900,000	Future	▪ Improve electrical reliability and safety.	8	TM8
Electrical Reliability	Unit Substation U11, U12, U13	Improve reliability.	Construct one new unit substation and eliminate three unit substations.	$3,100,000	Near	▪ Improve electrical reliability and safety.	8	TM8
Miscellaneous	Primary Tanks 1 and 2 Rehabilitation	Improve reliability.	Rehabilitate Primary Tanks 1 and 2 concrete structure.	$450,000	Near	▪ Improve reliability and structure longevity.	9	TM3
Miscellaneous	54-inch Primary Influent	Improve reliability.	Inspect this sewer; replace or rehabilitate sewer following inspection.	$800,000	Near	▪ Improve reliability. ▪ Avoid potential catastrophic failure.	9	TM3

Process or Component	Subcomponent	Main Concern(s) and/or Drivers	Recommended Modifications or Action	Opinion of Capital Cost[a]	Project Phasing (Near, Mid, Future)[b]	Anticipated Benefits	Associated Facilities Plan Section	Associated Technical Memorandum
Miscellaneous	East-West Plant Flow Metering	Improve operations.	Install new insertion-type flow metering devices within the existing east and west main gravity sewers.	$150,000	Near	▪ Improve operations flow measurement data and reliability.	9	TM5
Miscellaneous	Effluent Force Main Standpipe Revisions	Public perception.	Replace and/or modify the existing standpipe to eliminate treated wastewater from being forced out of the existing standpipe with excessive air.	$100,000	Near	▪ Reduce minor discharge of fully treated water to area around standpipe.	9	TM4
Miscellaneous	PCS Upgrades, Phase II	Improve reliability.	Implement Phase II of the PCS upgrades that were planned in the PCS Facilities Plan (2012).	$1,500,000	Near	▪ Improve aeration system monitoring, reliability, and control.	9	NA[c]
Totals				**$57,160,000**	Varies		10	TM4–TM8

[a]All costs are in 2nd quarter, 2017 dollars.
[b]Near indicates years 2017 to 2022; Mid indicates years 2020 to 2025; Future indicates year 2024 and after. Refer to Table 10.02-1 for more detail.
[c]This project was evaluated in the 2012 PCS Facilities Plan.

A. Peak Flow Management

The main focus of the peak flow management evaluations was to provide the ability to manage the anticipated peak flows without overflowing NSWWTP structures and while continuing to meet effluent permit limits. We recommend the District implement Alternative PF10, which includes hydraulic capacity upgrades to the following facilities at the NSWWTP:

1. Construct bypass channel for west primary clarifiers.
2. Raise west final clarifier influent channel walls by 1 foot and modify channel at roadway crossing to prevent overflows.
3. Construct new effluent structure to control diversion to the lagoons and flow conveyed from the east plant to the disinfection building.
4. Construct upgrades to the east and west activated sludge facilities to provide the ability to operate in a biological contact process mode during high flow events.

We also recommended that the District begin evaluating in more detail potential paths forward related to implementing a local permitted discharge to Nine Springs Creek as a first step towards a potential continuous future discharge to Nine Springs Creek at the District.

The District may also consider initiating an aggressive infiltration/inflow (I/I) reduction pilot study focused on identifying one or more areas with high I/I rates, and then implementing aggressive I/I reduction measures with the goal of quantifying successes and challenges for future additional measures in other areas.

B. Headworks and Hauled Waste Receiving

The main concern with the existing headworks facilities include a requirement to control the screening channel water depth within a very narrow range, which results in continuous screening equipment operation and significant maintenance concerns. In addition, the hauled waste receiving facilities require considerable operator attention and result in high grit loadings to the screening channels. The recommended headworks and hauled waste receiving improvements consist of the following:

1. IFM5–Relocate Venturis to Lower Elevation
2. S1–Screen Sluiced Screenings or S3–Install New Step Screens and Wash Presses
3. G1–Replacement of Grit Classifiers with Grit Washers; Replace Other Equipment (Year 10)
4. HW1–Construction of a Drive-Through Hauled Waste Receiving Station at the Headworks Building

The timing of the execution of the improvements to these facilities may be adjusted to accommodate the condition of the various equipment involved or to combine or separate project elements to fit the needs of the District.

C. Activated Sludge and Nutrient Removal

The existing biological phosphorus removal activated sludge facilities have operated well for many years and continue to serve the near-term needs of the District. The main focus of the facilities planning evaluations was energy efficiency and future upgrades to remove nitrogen. The recommended aeration system capital improvements consist of full-plant implementation of nitrite shunt (Alternative AS4) with high efficiency membrane diffusers, new west blowers and aeration piping cross-connect, and new secondary clarifiers. However, because this process is relatively new and does not have many full-scale operating installations, the District is currently conducting bench-scale pilot testing of the nitrite shunt process. If the bench-scale testing proves to be successful, full-scale pilot testing of nitrite shunt operation is recommended. In addition, final clarifier stress testing is recommended to be conducted to verify clarifier performance and to potentially eliminate the requirement to construct new final clarifiers.

The recommended plan is summarized in the following (assuming successful bench-scale testing):

1. Conduct clarifier stress testing.

2. Implement Nitrite Shunt Full-Scale Demonstration Study-Install new membrane strip diffusers, polymer feed system, and AVN instrumentation and control system in Plant No. 3 or 4 on the west side.

3. If demonstration testing is successful, implement nitrite shunt operations in the remaining activated sludge plants, including membrane strip diffusers, AVN instrumentation, control valves and flow meters, construction of two new final clarifiers (unless stress testing indicates these are not required), and construction of postaeration facilities.

4. Construct aeration system efficiency improvements, including interconnecting the east and west aeration systems and installing new west side blowers. These improvements will likely be phased to coincide with nitrite shunt upgrades noted above. The east side blowers may not require replacement if this cross-connection is put into place.

5. Implement miscellaneous activated sludge system improvements noted during planning, including scum beach icing control, replacement of Plant 2 RAS control valves, and increasing drainage pumping capacity.

6. Improve RAS pump energy efficiency, including new high-efficiency motors for some of the RAS pumps. Alternative improvements include new VFDs or modifying the control of the RAS pumps.

D. Disinfection

The main concern with the existing UV disinfection system is its age. This system was installed in the mid 1990s and is operating beyond the typical useful life for this type of equipment. In addition, the manufacturer of the equipment has not supported this particular system for about 20 years, and replacement parts are becoming more difficult to source or produce. The recommended capital improvements for disinfection include the installation of new UV disinfection equipment within the existing channels (Disinfection Alternative D1 or D2).

E. Electrical Reliability

Electrical improvement alternatives for the NSWWTP included in this facilities planning effort included evaluations related to upgrading or providing the headworks backup power, blower controls, blower medium voltage switchgear, and unit substations U11, U12, and U13. The main goal of these evaluations was to improve systems and overall NSWWTP reliability. The recommended plan consist of the following:

1. No change to the headwork facility backup power situation.
2. Replace the east blower control panel.
3. Replace the east and west blower building switchgear in conjunction with future blower replacements. This may result in no east blower switchgear replacement if the aeration system cross connect is constructed.
4. Construct one new unit substation to replace the existing substations U11, U12, and U13.

F. Miscellaneous Improvements

Miscellaneous improvements were included in the overall scope of the Facility Plan to evaluate upgrades to some of the aging infrastructure. The following improvements are recommended:

1. Rehabilitate primary clarifier tanks 1 and 2–These tanks, which date back to the early 1930s and were part of the First Addition to the NSWWTP, are in need of some concrete restoration.
2. Replace or rehabilitate the 54-inch primary influent pipe from the east primary junction chamber to the east primary clarifiers. The most recent inspection is from 2007 and showed that the pipe had deteriorated. We recommended an additional inspection before proceeding with replacement or rehabilitation.
3. Install flow metering equipment to measure flows to the east and west plants. This will provide improved process monitoring and control.
4. Construct a new, wider effluent force main standpipe to eliminate effluent wastewater from spilling to the ground.

ES.05 IMPACTS ON USER RATES

This facilities plan covers numerous projects over approximately 10 years. The effects on user charges depends on the actual timing and cost of the projects, the CWF interest rate, the growth in district loadings, and the allocation of the annual revenue requirement for capital and annual operating costs over the District's billing parameters. The long time period covered by the projects in this facilities plan further complicates the analysis, and a detailed user charge study is outside the scope of this report. As a general guideline, based on the District's analysis, $1.0 million in debt service equates to $6 to $7 for a typical residential household's annual bill.

Table 10.02-1 shows phasing for the recommended projects in several time periods: Near term (2017-2022), Mid term (2020-2025) and Future (2024+). The costs in Table 10.02-1 are on a 2017 cost basis. Table ES.05-1 summarizes the effects of the proposed projects on the typical residential customer.

Phase	2017 to 2022	2020 to 2025	2024+
Table 10-02-1 Costs	$20,620,000	$12,540,000	$24,000,000
Estimated Cost in Year of Construction	$22,500,000	$14,500,000	$30,400,000
Estimated Annual Debt Service	$1,710,000	$1,100,000	$2,310,000
Residential Rate Impact, per year	$10.50 to $12.00	$6.50 to $7.50	$14.00 to $16.00
Year of Rate Analysis	2020	2022	2025
Estimated Total Annual Residential Charge	$360	$400	$460

Table ES.05-1 Sewer User Charge Impacts

SECTION 1
INTRODUCTION

1.01 BACKGROUND

The Madison Metropolitan Sewerage District (MMSD or District) is a municipal corporation located in Madison, Wisconsin that provides wastewater conveyance and treatment for 43 communities and sanitary districts in the Madison metropolitan area. The MMSD service area includes approximately 182 square miles with a population of approximately 365,000 people. The District's conveyance system includes 94 miles of interceptor sewers, 48 miles of force mains, and 18 pumping stations. All of the wastewater collected in the MMSD service area is conveyed to the Nine Springs Wastewater Treatment Plant (NSWWTP) for treatment and return to the environment.

Liquid treatment at NSWWTP consists of influent flow measurements with venturi meters, fine screening, vortex grit removal, primary clarification, activated sludge secondary treatment using an enhanced biological phosphorus removal (EBPR) process, secondary clarification, ultraviolet disinfection, and effluent pumping. The District has two discharge locations, one at Badfish Creek and another at Badger Mill Creek on the northeast side of Verona. Most of the effluent is pumped to Badfish Creek, with up to 3.6 million gallons per day (mgd) pumped to Badger Mill Creek during normal flow conditions. NSWWTP also has facilities to handle peak flows, including effluent storage for flows that exceed the plant effluent pumping capacity, and an overflow structure to divert flows in excess of the storage volume or disinfection capacity to a storage lagoon. This lagoon can store approximately 40 million gallons prior to overflowing to a channel that discharges to Nine Springs Creek and ultimately to Lake Waubesa.

Solids treatment facilities at NSWWTP consist of primary and waste activated sludge thickening, phosphorus release tanks, acid/methane-phased anaerobic digestion, and digested biosolids gravity belt thickening for liquid biosolids management in the District's Metrogro program. Some of the biosolids can also be centrifuged to produce a dewatered cake material. A struvite harvesting system was incorporated into the plant's digested biosolids dewatering process to recover phosphorus from the biosolids thickening and dewatering recycle streams, as well as from the waste activated sludge prior to digestion.

In this Liquid Processing Facilities Plan (Facilities Plan), the capacity and performance of all liquid treatment processes are evaluated, including peak flow management facilities. Future flows and loadings are projected, and capacity analyses of all liquid process treatment facilities are conducted to assess the impact of future conditions on the existing NSWWTP infrastructure. Recommended improvements related to hydraulic capacity, treatment performance, and electrical components at the facility are presented.

1.02 PROJECT DEFINITION

This Facilities Plan was prepared for the purpose of developing a plan for liquid processing and treatment at the NSWWTP for the next 20 years and beyond. A planning year of 2040 was established for this plan. The scope of work for the Facilities Plan includes the following:

1. Evaluate future loading conditions and regulatory constraints.

2. Conduct condition assessments for structures, equipment, controls, and instrumentation associated with the project. The output from the condition assessments will provide the data needed to populate the District's Asset Management Database being developed in parallel with this Facilities Plan.

3. Evaluate current and future peak flow conditions, as well as potential schemes for managing peak wet weather flows.

4. Evaluate aeration systems for treatment performance, energy efficiency, facility impacts, and costs to meet future process and nutrient removal requirements.

5. Develop an overall plan to meet the future hydraulic requirements of the influent screening, grit removal, and screenings/grit management systems.

6. Develop an overall plan to meet the future hydraulic requirements of the ultraviolet disinfection system.

7. Assess the electrical systems and power reliability for the liquid processing facilities and identify required electrical upgrades.

1.03 CONDITION ASSESSMENTS AND REPLACEMENT COSTS

The District is currently developing an asset management plan under a separate contract with a third party. One of the goals of this Facilities Plan was to establish baseline asset data by conducting Level 2 condition assessments for the major assets and asset groups included within the scope of this planning project. These assessments included the equipment, control panels and electrical distribution equipment, structures, and related infrastructure associated with the NSWWTP headworks, primary clarifiers, activated sludge process, final clarifiers, ultraviolet (UV) disinfection, and hydraulic control elements. The main focus was to capture condition assessment data and estimate the remaining life and replacement costs for these assets. Condition, remaining life, and replacement costs are core elements of compiling the "null-alternative" in each of the evaluated systems. As a result of this effort, the underlying data collected is available for ongoing planning and maintenance tasks. More information related to the assessment process and results is presented in Technical Memorandum No. 3 (Appendix C).

With respect to including equipment replacement costs within the various alternatives evaluated throughout this Facilities Plan and, in particular, with respect to identifying the costs associated with the null alternatives, the null alternative was treated somewhat different depending on the specific alternatives being considered. Sections 4 through 8 of this facilities plan each identify how the null alternative replacement costs were applied.

1.04 SUSTAINABILITY

The District is committed to sustainable performance of infrastructure projects to advance its mission: "to protect public health and the environment by providing exceptional wastewater conveyance, treatment and related services." According to the District's Sustainability Management System (SMS), it strives to be a leader in regulatory compliance, customer service, employee development, and innovation, and continues to work on behalf of the communities it serves to inspire and increase sustainable performance. The District envisions that:

- MMSD will not only enrich the community by improving living conditions for people, plants, and animals, but also educate others so they too can take steps to conserve our resources.
- By changing the way we think about and use water, together we have the power to enhance the quality of life on our planet.
- By making small changes and respecting every drop of water we have today, we can set the tone for a resource-conscious and sustainable community tomorrow.

The District carries this vision into project planning as indicated in the District's SMS infrastructure project sustainability policy statement:

MMSD will use the Envision rating system as a sustainability framework and use the SMS-IP as a tool to manage, measure, and continuously enhance sustainability performance for infrastructure projects.

The District has developed a Sustainability Management System for Infrastructure Project (SMS-IP) that documents sustainability objectives and establishes processes and procedures to facilitate implementation and quality control throughout the planning, design, construction, and operational phases of any given project. Technical Memorandum No. 1 (TM-1) provides the SMS-IP for this planning project. This document identifies the responsible parties for ensuring the sustainability vision aligns with the strategic vision of the District, for ensuring tools align with the mission and vision of the District, for developing project-specific goals and objectives, and for ensuring that sustainability aspects and performance measures are incorporated into the project.

The goal of this Facilities Plan is to find long-term, cost effective solutions that meet the District's sustainability objectives, including flexibility and resilience. In addition, this Facilities Plan establishes the framework for future infrastructure projects to meet the District's sustainability objectives related to capital project delivery.

1.05 PROJECT DOCUMENTATION

This Facilities Plan development has been documented through eight technical memoranda that are attached to this Facilities Plan as appendices. The technical memoranda were developed as independent reports, and submitted as draft documents to the District. The District provided review comments to the consultant team, and each technical memorandum went through one or more revisions prior to approval by the District. The final versions of the technical memorandum are included in the appendices to this Facilities Plan.

The main body of this Facilities Plan summarizes each of the technical memoranda to provide a more concise planning document. The main body includes the results of the analyses and evaluations, and the reader is referred to the appendices if more information and background on the evaluations are required.

1.06 PLANNING AREA

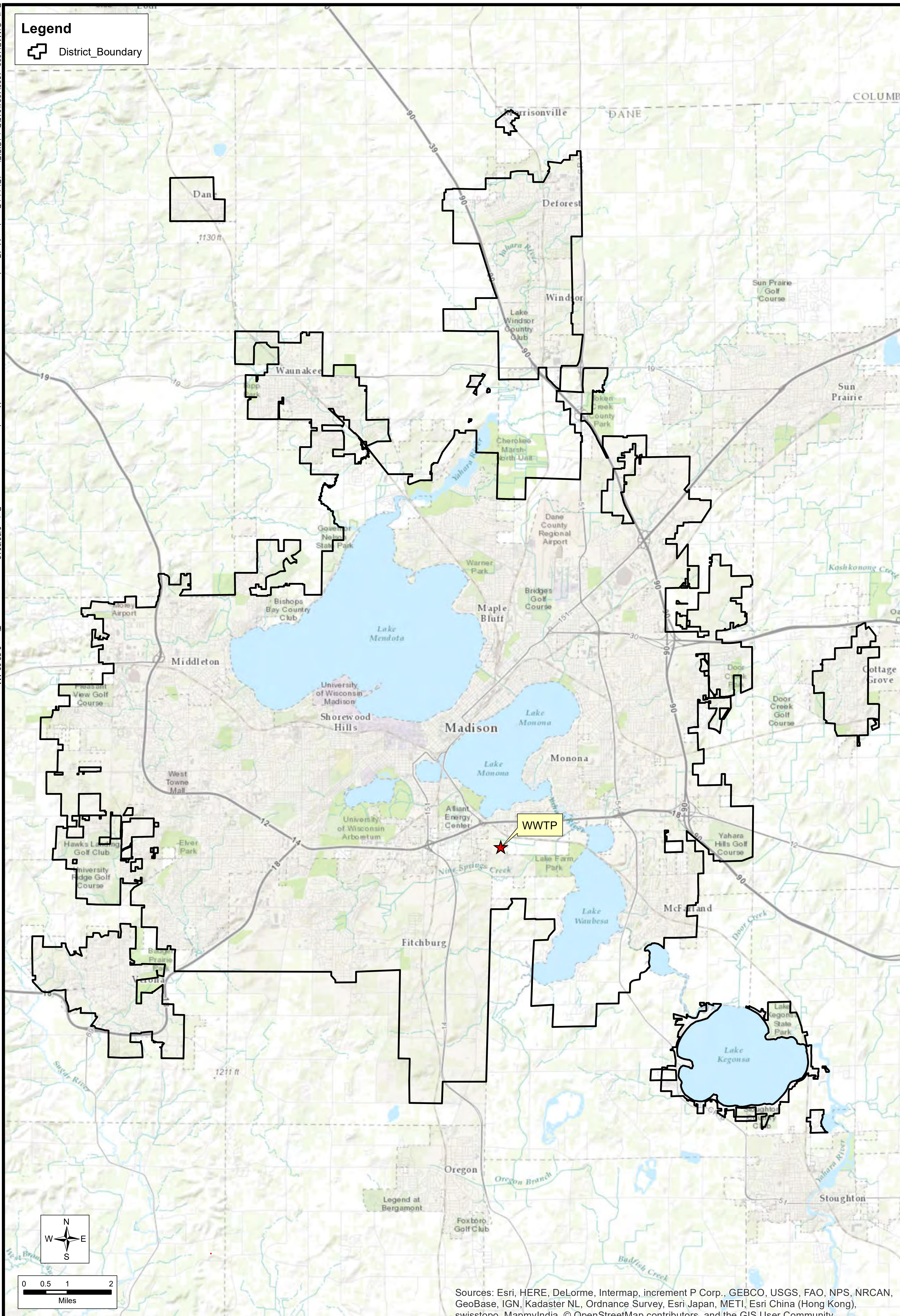
The planning area for this Facilities Plan includes the District's existing service area as indicated in Figure 1.06-1. The service are encompasses approximately 219 square miles in Dane County. The majority of the service area is in the Rock River and Sugar River watersheds, with a small portion in the northwest located in the Wisconsin River Watershed.

1.07 PREVIOUS PLANNING STUDIES

The District completed a Solids Handling Facilities Plan in 2010 that evaluated all of the solids handling processes at the plant and recommended improvements as necessary. The District also completed a 50-Year master Plan in 2009, as well as an Energy Roadmap in 2013. This current Facilities Plan builds on these documents, and the energy efficiency components of this Facilities Plan are the direct result of the 2013 Energy Roadmap document.

1.08 ABBREVIATIONS AND ACRONYMS

A/O	anaerobic/aerobic
ABAC	ammonia based aeration control
AM	adaptive management
AOB	ammonia-oxidizing bacteria
AVN	ammonia versus nitrate
BC	biological contact
BMP	best management practice
BNR	biological nutrient removal
BOD	biochemical oxygen demand
$CBOD_5$	five-day carbonaceous biochemical oxygen demand
CCTV	closed circuit television
CEC	compounds of emerging concerns
CEPT	chemically enhanced primary treatment
CFD	computational fluid dynamics
cfs	cubic feet per second
cfu/100mL	colony-forming units per 100 mL
CHP	combined heat and power
CMOM	Compliance, Management, Operation, and Maintenance
District	Madison Metropolitan Sewerage District
DO	dissolved oxygen
EBPR	enhanced biological phosphorus removal
F&P	Fischer & Porter



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DISTRICT BOUNDARY

2016 LIQUID PROCESSING FACILITIES PLAN
MADISON METROPOLITAN SEWERAGE DISTRICT
DANE COUNTY, WISCONSIN

STRAND ASSOCIATES®

FIGURE 1.06-1
1021.015

Facilities Plan Liquid Processing Facilities Plan
$FeCl_3$ ferric chloride
GHG greenhouse gas
gpm gallons per minute
HBP headworks backup power
HMI human-machine interface
hp horsepower
HVAC heating, ventilation, and air conditioning
I/I infiltration/inflow
IMLR internal mixed liquor recycle
I/O input/output
MATPB Madison Area Transportation Planning Board
MCC motor control center
MG million gallons
MG&E Madison Gas & Electric
mg/L milligrams per liter
mgd million gallons per day
MLR mixed liquor recycle
MLSS mixed liquor suspended solids
MMSD Madison Metropolitan Sewerage District
N_2O nitrous oxide
NH_3-N ammonia nitrogen
NO_2-N nitrate nitrogen
NO_x nitrate + nitrate
NSWWTP Nine Springs Wastewater Treatment Plant
O&M operation and maintenance
PCCP prestressed concrete cylinder pipe
PLC programmable logic controller
PS pump station
PVC polyvinyl chloride
RAS return activated sludge
scfm standard cubic feet per minute
SLR solids loading rates
SMS Sustainability Management System
SMS-IP Sustainability Management System for Infrastructure Project
SPA state point analysis
SSO sanitary sewer overflow
Strand Strand Associates, Inc.®
SUO sewer use ordinance
SVI sludge volume index
TMDL total maximum daily load
TN total nitrogen
TN/L total nitrogen per liter
TSS total suspended solids
UCT University of Cape Town
USEPA United States Environmental Protection Agency

UV	ultraviolet
V	volt
VFD	variable frequency drive
WDNR	Wisconsin Department of Natural Resources
WPDES	Wisconsin Pollutant Discharge Elimination System
WQBEL	water quality based effluent limit
WQT	water quality trading
WWTP	wastewater treatment plant

SECTION 2
REGULATORY REVIEW

This section includes a summary of Technical Memorandum No. 2a (TM-2a, Appendix B), which reviewed the existing and foreseeable future regulatory issues potentially affecting the District's Facilities Plan through the year 2040. A meeting to discuss relevant water quality and regulatory issues was held with the Wisconsin Department of Natural Resources (WDNR) on April 21, 2016. Information from that meeting, the MMSD 50-Year Master Plan, and from our regulatory work with other clients forms the basis for this section.

2.01 CURRENT PERMIT REQUIREMENTS

The MMSD NSWWTP is presently operating under Wisconsin Pollutant Discharge Elimination System (WPDES) Permit No. WI-0024597-08-0 (Appendix B). The permit expiration date was September 30, 2015. Because the permit application for reissuance was submitted more than 180 days prior to the expiration date, MMSD is allowed to operate under the conditions of the expired permit. Relevant permit limits for Badfish Creek and Badger Mill Creek are presented in Tables 2.01-1 and 2.01-2, respectively.

Parameter	Limit Type	Limit and Units	Notes
BOD_5, Total	Monthly Average	19 mg/L	
BOD_5, Total	Monthly Average	7,923 lbs/day	
BOD_5, Total	Weekly Average	20 mg/L	
BOD_5, Total	Weekly Average	8,340 lbs/day	
Suspended Solids, Total	Monthly Average	20 mg/L	
Suspended Solids, Total	Monthly Average	8,340 lbs/day	
Suspended Solids, Total	Weekly Average	23 mg/L	
Suspended Solids, Total	Weekly Average	9,591 lbs/day	
Dissolved Oxygen	Daily Minimum	5.0 mg/L	
pH Field	Daily Maximum	9.0 s.u.	
pH Field	Daily Minimum	6.0 s.u.	
Phosphorus, Total	Monthly Average	1.5 mg/L	
Fecal Coliform	Geometric Mean	400 #/100 ml	Limit applies April 15 to October 15.
Nitrogen, Ammonia, (NH_3-N) Total	Monthly Average	1.8 mg/L	Limit applies May to September.
Nitrogen, Ammonia, (NH_3-N) Total	Monthly Average	4.1 mg/L	Limit applies October to April.
Nitrogen, Ammonia, (NH_3-N) Total	Weekly Average	4.4 mg/L	Limit applies May to September.
Nitrogen, Ammonia, (NH_3-N) Total	Weekly Average	10 mg/L	Limit applies October to April.
Nitrogen, Ammonia, (NH_3-N) Total	Daily Maximum	17 mg/L	Limit applies year-round.
Chloride	Weekly Average	430 mg/L	Target limit.
Chloride	Weekly Average	200,000 lbs/day	
Mercury, Total Recoverable	Daily Maximum	5.7 ng/L	

Table 2.01-1 Relevant WPDES Permit Effluent Limits for Badfish Creek Outfall 001

Parameter	Limit Type	Limit and Units	Notes
BOD_5, Total	Weekly Average	16 mg/L	Limit applies November to April.
BOD_5, Total	Weekly Average	7.0 mg/L	Limit applies May to October.
Suspended Solids, Total	Monthly Average	10 mg/L	Limit applies May to October.
Suspended Solids, Total	Monthly Average	16 mg/L	Limit applies November to April.
Dissolved Oxygen	Daily Minimum	5.0 mg/L	See Section 3.2.2.7 regarding compliance with this limit.
pH Field	Daily Maximum	9.0 s.u.	
pH Field	Daily Minimum	6.0 s.u.	
Phosphorus, Total	Monthly Average	1.5 mg/L	
Fecal Coliform	Geometric Mean	400 #/100 ml	Limit applies May to September
Nitrogen, Ammonia, (NH_3-N) Total	Monthly Average	1.1 mg/L	Limit applies May to September.
Nitrogen, Ammonia, (NH_3-N) Total	Monthly Average	3.8 mg/L	Limit applies October to April.
Nitrogen, Ammonia, (NH_3-N) Total	Weekly Average	2.6 mg/L	Limit applies May to September.
Nitrogen, Ammonia, (NH_3-N) Total	Weekly Average	8.7 mg/L	Limit applies October to April.
Nitrogen, Ammonia, (NH_3-N) Total	Daily Maximum	11 mg/L	Limit applies year-round.
Chloride	Weekly Average	430 mg/L	Target limit.
Chloride	Weekly Average	14,000 lbs/day	Target limit.
Mercury, Total Recoverable	Daily Maximum	5.7 ng/L	

Table 2.01-2 Relevant WPDES Permit Effluent Limits for Badger Mill Creek Outfall 005

2.02 NUTRIENT REGULATIONS

A. Phosphorus

The District's current phosphorus effluent limit is 1.5 mg/L based on an alternative limit for facilities that employ biological phosphorus removal, as provided by NR 217.04(2). The applicable water quality criterion, for MMSD's receiving streams, which would also likely be the water quality based effluent limit (WQBEL), is 0.075 mg/L in accordance with NR 102.06(3)(b). This WQBEL would be expressed as two six-month averages, with a monthly average of three times that value and compliance schedules of up to nine years are provided for meeting these stringent WQBELs.

NR 217.16 has provisions for incorporating less stringent total maximum daily load (TMDL)-based WQBELs into permits in some cases. This is generally allowed for two permit terms but may be extended if significant nonpoint source load reductions are expected to occur. There are also specific requirements for new dischargers to a phosphorus-impaired water in an area with an approved TMDL which may require a corresponding offset by making an equivalent or greater load reduction elsewhere in the TMDL reach.

Additional compliance alternatives are available, including water quality trading (WQT) and watershed adaptive management (AM). WQT is allowed in Wisconsin as NR 217.14 and requires the identification of other potential load reductions in the watershed or TMDL reach, modeling of any proposed best management practices (BMPs), registration of the trades, and installation, verification and maintenance of BMPs. Watershed AM is described in NR 217.18 and allows a wastewater treatment plant (WWTP) to partner with other sources of phosphorus loading to make load reductions elsewhere in its watershed, often including nonpoint source load reductions.

Watershed AM may be used for both phosphorus and total suspended solids (TSS) and essentially extends the phosphorus compliance schedule to 20 years. Interim phosphorus limits of 0.6 and 0.5 mg/L are applied to the outfall in the first and second permit terms of AM, and a 0.5 mg/L is expected to be applied in the third permit term based on the District's communications with WDNR. Receiving stream water quality monitoring is required with this alternative.

The District has already determined, based on cost-effectiveness and triple bottom line considerations, that it will pursue AM for its BFC outfall compliance option. The District is collaborating with multiple partners in the Yahara River watershed on this effort. In 2016 this AM program, called Yahara Watershed Improvement Network (Yahara WINs), is in its fourth year as a pilot project and is transitioning to a full-scale program. MMSD prepared a draft AM Plan and submitted it to WDNR in December 2015. The WDNR indicated the draft AM Plan is approvable and formal AM Plan approval is expected after reissuance of the District's WPDES permit. Because this facilities planning period will coincide with the Yahara WINs AM compliance period (20 years), and the NSWWTP already routinely meets AM interim limits, no additional improvements are necessarily required for the NSWWTP associated with the BFC outfall. However, if MMSD can reduce effluent phosphorus at the NSWWTP at a lower cost than its payments into the Yahara WINs program, the District may consider implementing upgrades at the NSWWTP within the 20-year planning period.

After the WPDES permit is reissued (potentially in late 2017) the District will need to evaluate alternatives for compliance with an expected 0.075 mg/L six-month average and 0.23 mg/L monthly average limit for the BMC outfall. Alternatives may include WQT, AM, tertiary treatment of the BMC return flow, or discontinuing discharge to BMC completely.

B. Total Nitrogen (TN) and Nitrate-Nitrogen

Since around 2000, the United States Environmental Protection Agency (USEPA) has been maintaining the position that states must develop numeric TN criteria or demonstrate that they are not needed. The WDNR's current position and progress on TN is provided in *Wisconsin's Nutrient Reduction Strategy* of November 2013. In 2011 and 2012, water chemistry and biotic data was collected on streams, with laboratory analysis completed in 2012. Statistical analysis and expert review of the data was planned for 2013 and 2014, though it is not clear whether that analysis was ever completed. Based on the WDNR Triennial Standards Review (2015 to 2017) document, development of nitrogen water quality criteria is listed within Category "E," which means that barriers exist to the development of a scientifically based standard. The document indicates that it will address nitrogen standards as resources become available. We expect that TN rule revisions are not likely within 10 years, and possibly not within the planning horizon of this report based on the amount of time it took to adopt phosphorus criteria in Wisconsin. The magnitude of potential future effluent TN limits is unknown at this time, although nearby states have proposed TN effluent goal on the order of 8 to 10 mg/L.

MMSD commissioned a cost evaluation for NSWWTP to meet potential phosphorus and nitrogen limits and used TN limits of 3 and 10 mg/L for that study; the 10 mg/L limits were assumed for scenarios 4 through 6. For this Facilities Plan, a future monthly average TN goal of 10 mg/L will be assumed, although the final recommended plan may not include TN removal to meet this limit.

2.03 ROCK RIVER BASIN TMDL

The Rock River Basin phosphorus and sediment TMDL affects the BFC discharge and would affect any future outfalls in the Yahara River Watershed of the Rock River Basin. The TMDL was approved by the USEPA in 2011.

A. Phosphorus TMDL

MMSD's wasteload allocations for total phosphorus at BFC range from 1,624 to 1,887 pounds per month, which corresponds to effluent concentrations in the range of 0.12 to 0.15 mg/L at the future design flow of 53.6 mgd. The Yahara WINs AM program will be used to meet phosphorus wasteload allocations.

B. Sediment/Total Suspended Solids (TSS) TMDL

MMSD's wasteload allocations for TSS range from 138,120 to 252,980 pounds per month, which corresponds to effluent concentrations in the range of 10 to 19 mg/L at the future design flow of 53.6 mgd. Corresponding TMDL-based weekly average TSS limits will also be included in the reissued permit; these are expected to be approximately 1.3 times higher than the monthly average limits.

MMSD should not need to implement any special provisions at the NSWWTP to meet these TSS wasteload allocations. The Yahara WINs AM program can be used to help meet TSS wasteload allocations if needed.

2.04 OTHER REGULATORY PARAMETERS

In August of 2013 the State of Wisconsin published administrative rule revisions at NR 210 that prohibit sanitary sewer overflows (SSOs) and create a consistent set of factors that will be used to determine when and what enforcement will occur if an SSO occurs. The SSO rule revisions also contain provisions to develop a Compliance, Management, Operation, and Maintenance (CMOM) program and an SSO monitoring and reporting scheme for collection system permittees. The District has been addressing these regulations including implementing projects to reduce infiltration/inflow (I/I) in its collection system and updating its sewer use ordinance (SUO).

The administrative rule revisions also allow the WDNR to approve permit conditions allowing blending during wet weather if a municipality can show that there are no feasible alternatives. The NSWWTP does not currently have provisions for wet weather blending in its WPDES permit. However, there are provisions for storing secondary effluent in the lagoons and for monitoring any overflows from the lagoons to Nine Springs Creek. On rare occasions in the past, some overflow of treatment plant structures has occurred during very high flow events. As part of this facilities planning effort, future wet weather flows are projected and alternatives to reduce I/I and better manage peak flow events at the NSWWTP are evaluated.

2.05 RECREATIONAL STANDARDS

The USEPA released final recommendations on November 26, 2012, for recreational water quality criteria that are designed to protect primary contact recreation and are based on the use of two bacterial indicators of fecal contamination, *E. coli* and enterococci. The WDNR has not yet drafted water quality standards based on these recommendations, but it may do so within the next three to five years.

The USEPA is also working to develop recreational water quality criteria based on coliphage or other organisms as an indicator for the presence of viruses. Research related to how bacteriophages behave in wastewater treatment plants, how they are affected by current disinfection practices, and how their levels compare to those of current indicator organisms is ongoing. The USEPA has indicated that they intend to begin drafting coliphage criteria in late 2017.

Assuming the USEPA finalizes the virus-based criteria in 2018, Wisconsin could adopt associated criteria as early as 2019 and incorporate limits into MMSD's next reissued WPDES permit (i.e., around 2022). If the WDNR and the District believe significant disinfection system modifications are required for compliance with any new effluent limits for viruses, a compliance schedule will likely be included in the reissued WPDES permit.

2.06 THERMAL REGULATIONS

The State of Wisconsin has adopted thermal standard rule revisions in NR 102 and NR 106 of the Wisconsin Administrative Code. MMSD has completed effluent and in-stream temperature monitoring and provided data to the WDNR in its permit application for reissuance, along with a request for Alternative Effluent Limits (AEL) for temperature for BMC, which has been approved. A temperature limit for BFC is not anticipated because of its NR 104 variance status. Should the WDNR include water quality based effluent temperature limits in future reissued permits, the District may have an opportunity to perform a dissipative cooling analysis on one, or both, of the receiving streams to determine if the limits are necessary. Modifications resulting from this Facilities Plan are not expected to have a measurable impact on effluent wastewater temperature, nor will measures to reduce effluent temperature be considered within this plan.

2.07 CHLORIDE REGULATIONS

Wisconsin's chloride standards are included in s. NR 105, and the acute and chronic standards are 757 mg/L and 395 mg/L, respectively. NR 106 includes a variance procedure for facilities that are unable to meet their chloride limits that need to be renewed with each permit application and reviewed and approved by the USEPA.

Chloride concentrations in MMSD effluent continue to increase primarily because of the use of in-home water softeners and I/I containing road deicing salts. MMSD currently has a variance and a 430 mg/L target limit for chloride in its WPDES permit, along with a source reduction program that includes public education and other initiatives. Recently, MMSD has requested winter and summer limits for chloride in its upcoming permit, and WDNR has agreed to include separate winter and summer limits. The limits are anticipated to be 430 mg/L for the months of April through October and 465 mg/L for the months of November through March. In the future, it may be possible for the District to address chloride requirements at least in part through regulatory measures such as changes to water quality standards or by using WQT.

This facilities planning effort will not address chlorides directly, but will consider the potential impact on effluent chlorides from changes to treatment processes.

2.08 AMMONIA REGULATIONS

The current Wisconsin water quality standards for ammonia are based primarily on toxicity to fish. The USEPA developed more stringent ammonia criteria for surface waters that have the ability to support mussels and snails, which are more sensitive to ammonia. The USEPA has adopted these criteria but the schedule for subsequent state implementation is unknown at this time. It appears this initiative could result in more stringent effluent ammonia-nitrogen limits for the NSWWTP outfalls to BFC and BMC within approximately the next five to ten years.

The WWTP currently discharges an average effluent ammonia concentration that is well below permit limits, and District staff do not expect the new criteria and potential lower limits to be a major consideration. This facilities planning effort will consider the more stringent limits if ammonia removal will be impacted by any of the biological treatment alternatives.

2.09 OTHER CURRENT OR UPCOMING WATER QUALITY REGULATIONS

A. Designated Use Changes and Site Specific Criteria

The WDNR is in the process of developing rule revisions related to designated uses and site specific criteria and District staff is involved with the technical advisory committee for this process. These revisions may apply to the District's receiving streams, potentially resulting in more stringent effluent limits for parameters such as dissolved oxygen. It is unclear at this time the overall impact these revisions will have on the District's future permit requirements.

Additionally, the rule revisions should also result in a process for determining site specific criteria for phosphorus or other parameters which may be worth pursuing for BFC and/or BMC if AM is not successful in meeting the 0.075 mg/L water quality criterion.

B. Mercury

Mercury effluent limits are based on wildlife criteria and are set equal to the criterion (1.3 ng/L) in accordance with NR 106.06(6) because the background concentration in Wisconsin surface waters exceeds the wildlife criterion. The District currently has a mercury variance with an alternative effluent limit and has adopted a Mercury Pollutant Minimization Program. The variance may be renewed with each permit application and is subject to approval by the USEPA. The WDNR has not indicated any plans for changing the approach to mercury compliance during this facilities planning period.

C. Pharmaceuticals and Other Compounds of Emerging Concern (CECs)

The WDNR does not currently have rules related to microconstituents like pharmaceuticals or CECs. The District has undertaken initiatives for pollution prevention and source reduction and these efforts may continue to be the best approach for these parameters during the facilities planning period. Approaches like lifestyle changes may be a future focus.

D. Antidegradation Rule Revisions

The WDNR is just beginning a rule revision process related to antidegradation. The intent is to provide a more transparent antidegradation review process that is consistent with federal regulations. These rule revisions could result in more stringent effluent limits in the future, proportional to increases in design flows.

2.10 AIR QUALITY REGULATIONS

Several air quality-related regulations or initiatives may impact MMSD's liquid processing operations. These include state air regulations (covering parameters such as carbon monoxide, nitrogen and sulfur oxides, and volatile organic compound), federal air regulations (which would apply to a major reconstruction project that would increase hazardous air pollutant emissions), and requirements related to greenhouse gas emissions.

The District's Operating Permit requires that the District "follow good engineering practices to minimize emissions of hazardous air pollutants" from treatment operations and requires that all biogas produced from the digesters be combusted to reduce greenhouse gas emissions. Potential changes to air-quality related requirements should be review if a major change to the liquid process is proposed.

2.11 GROUNDWATER DISCHARGE REQUIREMENTS

Groundwater recharge using effluent is being practiced in several locations around the state, particularly in the Wisconsin River Valley and other locations where soils are sandy and thus conducive to infiltration. Typical methods of effluent groundwater recharge are to use seepage cells (also called absorption ponds), which are regulated under NR 206, or injection wells, which would require effluent to meet NR 140 standards. Some potentially favorable groundwater infiltration locations have been identified in Dane County but may not be cost-effective when considering conveyance and additional treatment required compared to the volume recharged.

2.12 EFFLUENT REUSE REQUIREMENTS

Wastewater effluent is being used for industrial noncontact cooling and other noncontact uses in some locations, particularly where fresh water is scarce. Wisconsin currently has no specific standards for the treatment of effluent for use in an industrial facility.

The use of MMSD effluent was considered for the University of Wisconsin West Campus Cogeneration facility in 2002, but was ultimately not pursued because of cost and location concerns. The concept of reusing MMSD effluent for industrial noncontact cooling water could be explored with the largest water users in Dane County who are believed to use fresh water for nonpotable uses. Other potential uses of effluent that were identified in the 50-Year Master Plan include restored wetlands, ethanol production facilities (if sited nearby), sod farms, and large agricultural operations that use fresh water for flushing systems in barns or for other purposes. Residential or commercial landscape watering and crop irrigation were also reviewed. While these uses do not appear sufficiently cost-effective and beneficial at this time, this could change. Depending on the ultimate use, effluent reuse may require treatment to Wisconsin drinking water standards or similar (i.e., California Title 22) standards.

2.13 RECOMMENDED PERMIT LIMITS AND CONSIDERATIONS FOR FACILITIES PLANNING

Strand Associates, Inc.®, on behalf of the District, submitted a facilities planning-level effluent limitations request to the WDNR in May 2016. The WDNR responded to the request in a February 2017 draft memorandum, which was later updated in August 2017, and is included in Technical Memorandum 2a–Regulatory Projections (Appendix B). Based on this memorandum and the information presented above, the following summarizes the planning-level effluent limits and related considerations for this Facilities Plan. Table 2.13-1 and 2.13-2 present the anticipated limits for Outfalls 001 and 005, respectfully.

- Biochemical oxygen demand (BOD) and TSS effluent concentration limits will be essentially the same as existing limits.

- Based on new USEPA water quality criteria, effluent ammonia limits may decrease in the future, but near term effluent ammonia limits will be essentially the same as current limits.

- For the purposes of this Facilities Plan, the plan identifies potential effluent TP concentrations that can be biologically achieved without addition of an external carbon source under different process configurations, as well as with chemical polishing and filtration. The District plans to use AM to comply with effluent phosphorus limits to the BFC outfall. To minimize AM-related costs to the District, effluent TP concentrations would need to be consistently below about 0.26 to 0.28 mg/L under current and near future flows.

- Effluent phosphorus limits at the Badfish Creek outfall will be driven by the District's decision to employ (AM) to comply with effluent phosphorus reduction requirements. The anticipated effluent phosphorus limit (six-month average) is 0.6 mg/L in the next permit, and 0.5 mg/L in the following two permit cycles.

- This Facilities Plan does not develop a plan to meet potential future effluent TP limits (0.075 mg/L) at the BMC discharge. If such low limits are implemented, the District indicated that it may consider discontinuing the discharging to that outfall. If the outfall is maintained, the District could potentially meet these requirements through WQT or AM in the Sugar River watershed.

- There will be no effluent TN limits during this planning period. However, the Facilities Plan evaluations develop scenarios to reduce TN discharges from current levels and perhaps meet a future effluent TN target of approximately 10 mg/L. This value is based on similar limits seen elsewhere in the country and based on a reasonable estimate of what the MMSD WWTP could meet without supplemental carbon addition.

- Emergency discharges to Nine Springs Creek will continue to be allowed with monitoring only, even if the frequency of such discharges increases somewhat as projected in this planning document.

- A "wet weather only," or excess flow, discharge to Nine Springs Creek will need to be completely offset through trading with respect to total phosphorus and TSS loadings. Such a discharge could have a phosphorus limit that is lower than the water quality criterion of 0.075 mg/L according to WDNR correspondence.

- It is assumed that a continuous discharge to Nine Springs Creek will not be allowed without considerable long-term testing, improved treatment, trading to offset phosphorus and TSS loadings, and demonstration of positive triple bottom line factors including energy and carbon footprint reductions, environmental protection, social acceptance, and related factors.

Parameter	Limit Type	Limit and Units	Notes
BOD_5, Total	Monthly Average	19 mg/L	
BOD_5, Total	Monthly Average	7,923 lbs/day	
BOD_5, Total	Weekly Average	20 mg/L	
BOD_5, Total	Weekly Average	8,340 lbs/day	
Suspended Solids, Total	Monthly Average	20 mg/L	
Suspended Solids, Total	Weekly Average	23 mg/L	
Dissolved Oxygen	Daily Minimum	5.0 mg/L	
pH Field	Daily Maximum	9.0 s.u.	
pH Field	Daily Minimum	6.0 s.u.	
Phosphorus, Total	Six-Month Average	0.6 mg/L	Interim limit.
Phosphorus, Total	Monthly Average	0.225 mg/L	Final limit.
Phosphorus, Total	Six-Month Average	0.075 mg/L	Final limit.
Fecal Coliform	Monthly Geometric Mean	400 #/100 ml	Limit applies April 15 to October 15.
Fecal Coliform	Weekly Geometric Mean	780 #/100 ml	Limit applies April 15 to October 15.
Nitrogen, Ammonia, (NH_3-N)	Monthly Average	1.8 mg/L	Limit applies May to September.
Nitrogen, Ammonia, (NH_3-N)	Monthly Average	4.1 mg/L	Limit applies October to April.
Nitrogen, Ammonia, (NH_3-N)	Weekly Average	4.4 mg/L	Limit applies May to September.
Nitrogen, Ammonia, (NH_3-N)	Weekly Average	10 mg/L	Limit applies October to April.
Nitrogen, Ammonia, (NH_3-N)	Daily Maximum	17 mg/L	Limit applies year-round.
Chloride	Weekly Average	430 mg/L	Limit applies April to October.
Chloride	Weekly Average	465 mg/L	Limit applies November to March.
Mercury, Total Recoverable	Daily Maximum	3.4 ng/L	Variance limit.

Table 2.13-1 Anticipated WPDES Permit Effluent Limits for Badfish Creek Outfall 001

Parameter	Limit Type	Limit and Units	Notes
BOD_5, Total	Weekly Average	16 mg/L	Limit applies November to April.
BOD_5, Total	Weekly Average	7.0 mg/L	Limit applies May to October.
Suspended Solids, Total	Monthly Average	10 mg/L	Limit applies May to October.
Suspended Solids, Total	Monthly Average	16 mg/L	Limit applies November to April.
Dissolved Oxygen	Daily Minimum	5.0 mg/L	See Section 3.2.2.7 regarding compliance with this limit.
pH Field	Daily Maximum	9.0 s.u.	
pH Field	Daily Minimum	6.0 s.u.	
Phosphorus, Total	Six-Month Average	0.6 mg/L	Interim limit.
Phosphorus, Total	Monthly Average	0.225 mg/L	Final limit.
Phosphorus, Total	Six-Month Average	0.075 mg/L	Final limit.
Phosphorus, Total	Six-Month Average	2.25 lbs/day	Final limit.
Fecal Coliform	Monthly Geometric Mean	400 #/100 ml	Limit applies May to September
Fecal Coliform	Weekly Geometric Mean	780 #/100 ml	Limit applies May to September
Nitrogen, Ammonia, (NH_3-N)	Monthly Average	1.1 mg/L	Limit applies May to September.
Nitrogen, Ammonia, (NH_3-N)	Monthly Average	3.8 mg/L	Limit applies October to April.
Nitrogen, Ammonia, (NH_3-N)	Weekly Average	2.6 mg/L	Limit applies May to September.
Nitrogen, Ammonia, (NH_3-N)	Weekly Average	8.7 mg/L	Limit applies October to April.
Nitrogen, Ammonia, (NH_3-N)	Daily Maximum	11 mg/L	Limit applies year-round.
Chloride	Weekly Average	430 mg/L	Limit applies April to October.
Chloride	Weekly Average	465 mg/L	Limit applies November to March.
Mercury, Total Recoverable	Daily Maximum	3.4 ng/L	Variance limit.

Table 2.13-2 Anticipated WPDES Permit Effluent Limits for Badger Mill Creek Outfall 005

SECTION 3
WASTELOAD AND FLOW FORECASTS

This section summarizes Technical Memorandum No. 2b (TM-2b, Appendix B) with respect to the existing NSWWTP influent flows and loadings, as well as the projected future influent flows and loadings through the planning year 2040. These projected flows and loadings are used within the future process and peak flow alternatives to evaluate required or recommended upgrades and modifications to the NSWWTP.

3.01 CURRENT FLOWS AND LOADINGS

TM-2b presents an analysis of influent flows and loadings based on historical data. Per capital flows/loads and peaking factors for each constituent were estimated in this analysis for use in the projection of future flow and loadings. Table 3.01-1 below presents a summary of the current average influent flows and loadings and associated per capita values. For reference, the existing service area population is estimated at approximately 370,000.

	Flow (mgd)	**Per Capita Flow (gcd)**
Average Influent Flow[1]	41.3	117
Annual Average Influent Loading[2]	**Load (lbs/day)**	**Per Capita Load (pcd)**
BOD	78,500	0.22
TSS	75,500	0.21
TKN	14,000	0.039
NH_3-N	8,900	0.025
TP	1,869	0.0052

[1] Average of 2006-2015 influent data.
[2] Average of 2011-2015 influent data.

Table 3.01-1 Current Flow and Loadings Summary

3.02 PROJECTED FLOWS AND LOADINGS

Population projections provided by the Madison Area Transportation Planning Board (MATPB) for the MMSD service area were used to estimate future design average flows and loadings to NSWWTP. In TM-2b, design average flows and loadings for the future years of 2020, 2030, and 2040 were developed by multiplying the projected populations in those future years by the average per capita flows and loadings. To estimate future maximum 30-day, maximum 7-day, and maximum day flows, the peaking factors determined using historical data were multiplied by the future design average flows. Summaries of future design flows and future design wasteloads are presented in Tables 3.02-1 and 3.02-2, respectively.

	Peaking Factor	2020	2030	2040
MMSD Population Projection	---	383,904	419,596	455,288
Design Flow Summary				
Average Day (mgd)	---	42.00	47.80	53.60
Maximum 30-day (mgd)	1.32	55.63	63.31	71.00
Maximum 7-day (mgd)	1.72	72.35	82.34	92.34
Maximum Day (mgd)	1.97[1]	82.74	94.17	105.59
Peak Hourly Flow (mgd)	3.36[2]	141	160	180

[1]99.95th percentile highest daily flow used to calculate peaking factor.
[2]Based on modeling results presented in Technical Memorandum No. 4.

Table 3.02-1 Future Design Flow Summary

	Peaking Factor	2020	2030	2040
MMSD Population Projection	—	383,904	419,596	455,288
Design BOD Loading Summary				
Average Day (lbs/day)	—	82,904	90,671	98,438
Maximum 30-day (lbs/day)	1.14	94,167	102,989	111,811
Maximum 7-day (lbs/day)	1.31	108,437	118,597	128,756
Maximum Day (lbs/day)	1.85	153,236	167,592	181,948
Design TSS Loading Summary				
Average Day (lbs/day)	—	79,276	86,703	94,130
Maximum 30-day (lbs/day)	1.17	92,552	101,223	109,894
Maximum 7-day (lbs/day)	1.69	133,964	146,515	159,065
Maximum Day (lbs/day)	3.02	239,700	262,157	284,613
Design TKN Loading Summary				
Average Day (lbs/day)	—	15,019	16,426	17,832
Maximum 30-day (lbs/day)	1.13	16,997	18,567	20,158
Maximum 7-day (lbs/day)	1.18	17,695	19,353	21,010
Maximum Day (lbs/day)	1.46	21,942	23,997	26,052
Design Ammonia-Nitrogen Loading Summary				
Average Day (lbs/day)	–	9,560	10,455	11,350
Maximum 30-day (lbs/day)	1.14	10,929	11,953	12,976
Maximum 7-day (lbs/day)	1.19	11,368	12,433	13,498
Maximum Day (lbs/day)	1.52	14,535	15,896	17,258
Design Total Phosphorus Loading Summary				
Average Day (lbs/day)	—	1,979	2,164	2,349
Maximum 30-day (lbs/day)	1.11	2,204	2,410	2,617
Maximum 7-day (lbs/day)	1.16	2,299	2,514	2,729
Maximum Day (lbs/day)	1.65	3,274	3,580	3,887

Table 3.02-2 Future Design Wasteload Summary

SECTION 4
PEAK FLOW MANAGEMENT

This section includes a summary of the peak flow modeling, in-plant hydraulic analyses, and peak flow management alternatives that were conducted as part of the facility planning for the NSWWTP. In addition, more detailed evaluations of the shortlisted peak flow management alternatives are presented with opinions of probable construction cost and discussion of non-monetary considerations. Additional detail on this evaluation is presented in Technical Memorandum No. 4 (TM-4, Appendix D).

4.01 DESCRIPTION OF EXISTING NSWWTP HYDRAULICS

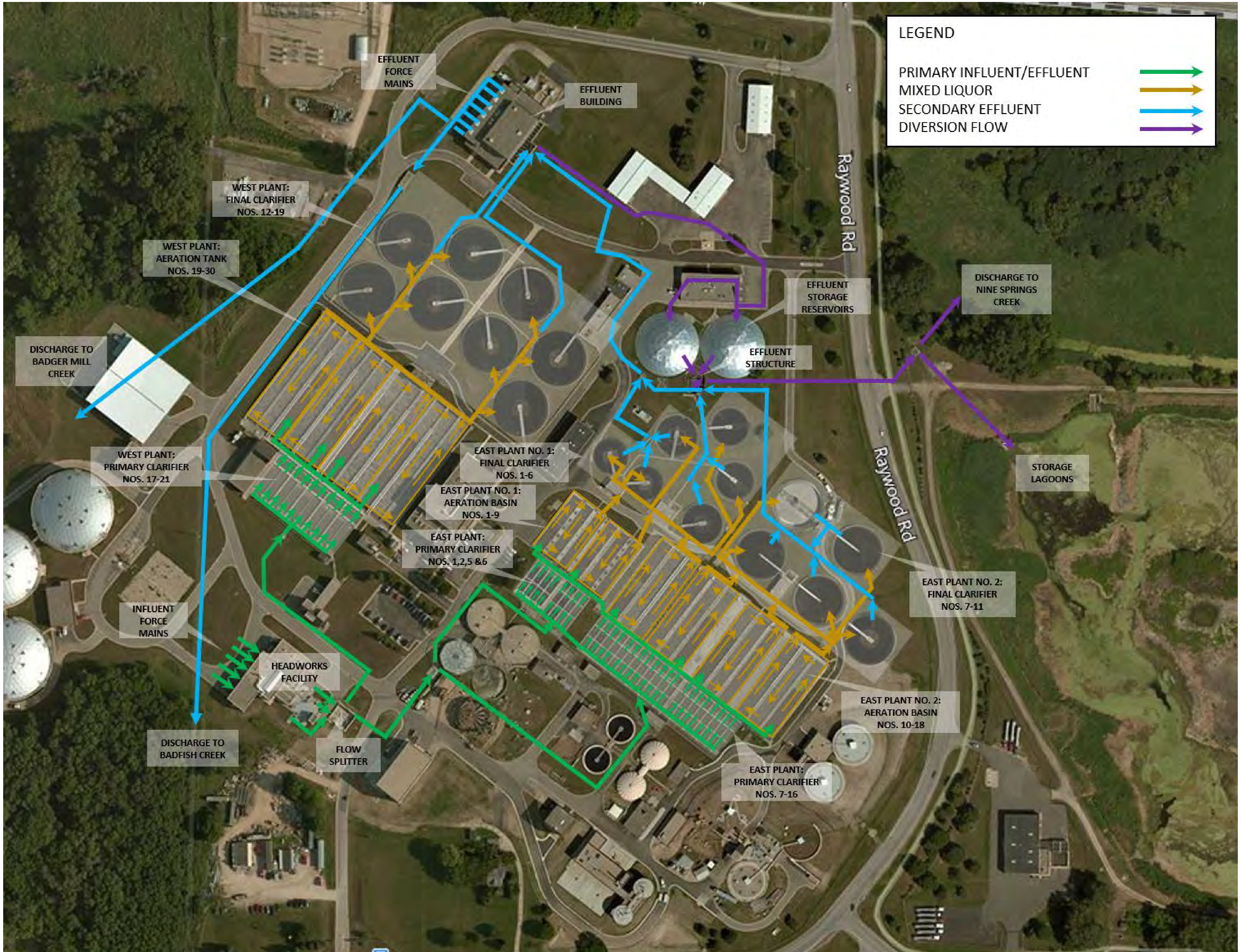
A process flow schematic of NSWWTP is presented in Figure 4.01-1.

Currently, all flows from the MMSD service area are pumped by five major pumping stations and two smaller pumping stations to the NSWWTP for treatment. Pumped flows are discharged at the preliminary treatment building where they receive screening and vortex grit removal. Flow from the preliminary treatment facility is then split between two complexes for primary and secondary treatment (designated herein as the west plant and the east plant) using a splitter structure. Currently, under normal flow conditions, District staff try to achieve a flow split of approximately 55 percent to the west plant and 45 percent to the east plant to efficiently use existing blower capacities. During high flow events, the flow split is changed to send more flow to the east plant because of hydraulic limitations within the west plant, as well as limitations within the lagoon diversion structure within the east plant.

During high flow events, secondary effluent flows greater than the approximate 100 mgd capacity of the UV disinfection facilities are discharged directly to the lagoons. This discharge is hydraulically controlled in the Effluent Structure northwest of the east plant final clarifiers via a fixed-elevation weir within this structure. The Effluent Structure receives flow from East Final Clarifier Nos. 4 through 11, while flow from East Final Clarifier Nos. 1 through 3 discharge to a junction chamber downstream of the Effluent Structure. Secondary effluent from the west plant flows directly to the disinfection building, requiring all forward flow from the west plant to be conveyed through the disinfection channels and into the effluent pump station wet well.

Because of the existing hydraulic layout and connections on the east and west side of the plant, if flow is to be diverted directly to the lagoons without being disinfected, the flow must pass through the east plant or backflow in the east plant secondary effluent piping from the Effluent Building. Based on hydraulic modeling of the plant, the weir elevation in the Effluent Structure is reached when approximately 50 mgd is conveyed from the east plant to the Effluent Building. Therefore, under current conditions, the east plant handles approximately 50 mgd plus any flow to be discharged directly to the lagoons upstream of disinfection. If the plant is operating under an extreme condition in which the water level in the Effluent Building is high enough, secondary effluent from the west plant could backflow to the east plant, allowing west plant flow to be discharged to the lagoons. However, this condition is more likely to result in flooding of the Effluent Building because it would require the water level at the building to be higher than the Effluent Structure overflow elevation.

Any disinfected secondary effluent in excess of the effluent pumping capacity of the plant (about 80 mgd total, 75.5 mgd without the Badger Mill Effluent Pumps in operation) flows to two Effluent Storage Reservoirs. If there continues to be disinfected secondary effluent flow in excess of the effluent pumping capacity after these reservoirs are full, the reservoirs will flow to the Effluent Structure and flow will be combined with any nondisinfected secondary effluent prior to discharge to the lagoons.



NINE SPRINGS WASTEWATER TREATMENT PLANT PROCESS FLOW DIAGRAM

2016 LIQUID PROCESSING FACILITIES PLAN
MADISON METROPOLITAN SEWERAGE DISTRICT

STRAND ASSOCIATES®

FIGURE 4.01-1
1021.015

4.02 PEAK FLOW MODELING

Peak influent flows to the NSWWTP were modeled for current and future conditions for use in evaluating alternatives to manage peak flows. This analysis included an estimated future flow increase of 29 percent, proportional to the 29 percent population projection increase from 2015 to 2040 for the service area.

Based on the peak flow modeling performed, a future peak design flow of 180 mgd was selected for evaluation of hydraulic upgrades that may be required at the NSWWTP through the year 2040. This corresponds to the highest peak instantaneous flow encountered in the future flow modeling and provides a level of service between 50 and 60 years. While the absolute maximum pumping capacity to NSWWTP is greater than 180 mgd (closer to 210 mgd with Pump Station 18 on line), the level of service that would be provided by designing for such extreme events would be in excess of 100 years. Curves showing the recurrence interval for the current and future peak flows are presented in Figure 4.02-1. A detailed approach and description of this modeling is presented in TM-4.

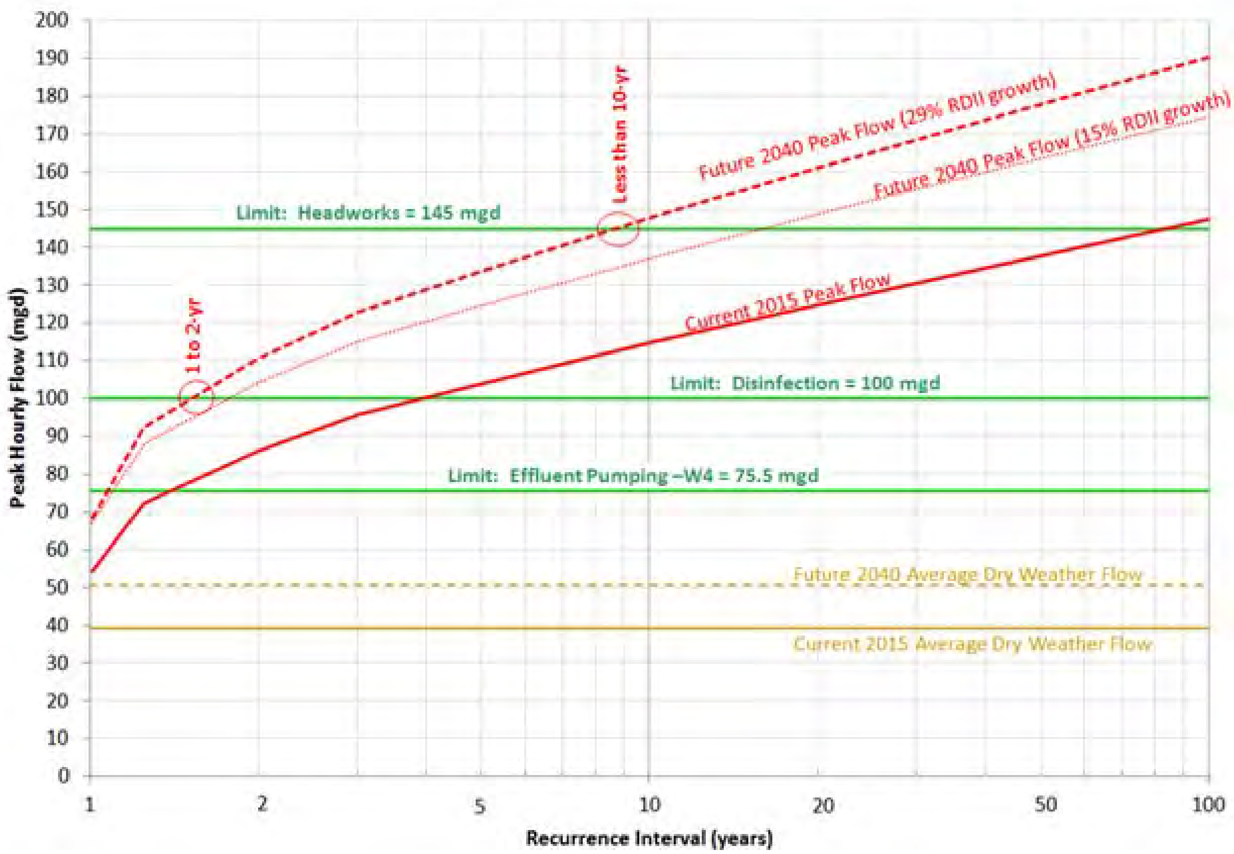


Figure 4.02-1 Future Peak Hourly Flow Frequency and Levels of Service

It is noted that the analysis did not include a climate change impact for the District, but it did summarize two recent climate change impact analyses that were completed for the MMSD. In general, large wet weather events tended to become larger and more intense, while smaller events tended to become smaller and less frequent, with the average annual rainfall anticipated to remain approximately the same.

The climate change scenarios affected the distribution of intensities, rather than the average annual rain amount. The studies predicted a relatively small change in peak sanitary sewer flows of less than 10 percent. Climate change impacts in Madison could be expected to be similar to the Milwaukee study results. With due respect for the uncertainties in the model results, the impacts of climate change in an upper Midwest location like Madison may be a modest variation from the current pattern, rather than a major hydrologic shift.

A hydraulic model of the NSWWTP was developed by Black & Veatch as part of the 10th Addition design. A modified version of this hydraulic model was used in the peak flow analysis for the development of this Facilities Plan to identify hydraulic bottlenecks at the plant and to evaluate potential changes to alleviate these bottlenecks. Modifications made to the model include changes to more accurately portray current plant operation based on discussions with MMSD staff, to better account for situations that may occur during high flow events such as submerged weirs or orifices, and to evaluate peak flow management alternatives.

Based on the current plant hydraulics, flows above about 145 mgd would create hydraulic problems at the screening facilities, and the bypass channel would need to be used. In addition, hydraulic bottlenecks at the west plant primary clarifiers and in the west final clarifier influent channels would create an overflow at the plant site. Diverting flows above approximately 65 mgd to the east plant could be done to avoid these overflows. However, the primary flow splitter to the east and west plants requires manually changing gate positions, which is not an easy or safe procedure and is often required to be completed under poor weather conditions.

Furthermore, the Effluent Structure that controls the diversion to the lagoons is hydraulically controlled by the flow from the east plant to the disinfection building as described earlier, and therefore approximately 50 mgd must be sent to the disinfection building from the east plant prior to a diversion to the lagoons occurring. This means that at the future peak flow of 180 mgd, over 130 mgd must be sent thought the east plant (50 mgd to disinfection and 80 mgd diversion to lagoons). Based on hydraulic modeling analysis, the east plant is not capable of passing flows in excess of approximately 90 mgd with the existing Effluent Structure controlling the water surface elevation downstream of the final clarifiers, and therefore cannot pass the flow required to maintain a maximum of 100 mgd sent to the Effluent Building with the excess 80 mgd sent to the lagoon.

At the future peak flow of 180 mgd without plant improvements, overflows of structures in both the west and east plants would occur and District staff would have a reduced ability to hydraulically control flow splitting throughout the plant.

4.03 PEAK FLOW MANAGEMENT ALTERNATIVES SCREENING

Peak Flow Management Workshop No. 4a (WS 4a) was held on May 9, 2016. The purpose of the workshop was to present the peak flow modeling calibration and results, to identify a range of alternatives that could be used to improve peak flow management, and to conduct preliminary screening on these alternatives. Based on these discussions, the following alternatives were selected to be evaluated further:

- Alternative PF0–No Change (Null Alternative)
- Alternative PF4–Aggressive I/I Removal (high level assessment)
- Alternative PF6–Influent Equalization at NSWWTP

- Alternative PF7–Upgrade NSWWTP Hydraulics
- Alternative PF8–Expand Effluent Pumping Capacity
- Alternative PF9–Upgrade NSWWTP Hydraulics and Increase Nine Springs Creek Discharges
- Alternative PF10–High-Rate Wet Weather Treatment at NSWWTP

4.04 DESCRIPTION OF ALTERNATIVES EVALUATED

This section includes a description of each short-listed peak flow management alternative.

A. Alternative PF0–No Change (Null Alternative)

In this alternative, the null alternative is equivalent to a "do nothing" alternative. Peak flow management at NSWWTP would remain unchanged and there is no investment in additional infrastructure to handle peak flows. As described earlier, the existing plant is not capable of passing the anticipated future peak flows and hydraulic analyses indicate that structure overflows would result from flows over approximately 145 mgd. This would result in untreated or partially treated wastewater overflowing to the NSWWTP site and potentially flooding buildings or flowing off-site and discharging to surface waters.

We note that the null alternative, as defined above, is likely not an acceptable solution to the peak flow management analysis, but it was defined as such at the time of the Peak Flow Management Technical Memorandum development. If an alternative definition of the null alternative were used, such as implementing the minimal improvements to address and eliminate in-plant overflows at the projected peak flow of 180 mgd, the null alternative would have been defined very similar to, if not identically to, Alternative PF7–Upgrade NSWWTP Hydraulics.

B. Alternative PF4–Aggressive I/I Removal

This alternative describes a program to aggressively reduce I/I in MMSD's conveyance system and the community customer systems tributary to MMSD's system. In the past, the District has not taken an aggressive approach to reduce I/I, particularly with its community customers. This is partly because I/I levels have generally been manageable within the District's system and at the NSWWTP, and significant wet weather problems have been rare. However, the peak flow projections developed for this planning project indicate higher peak flows at the NSWWTP, and I/I levels will only be expected to become more significant over time if I/I reduction is not a focus of the District and its community customers. In addition, the District has important energy and sustainability initiatives that support addressing wet weather concerns at the source through I/I reduction rather than building infrastructure to manage increasing levels of wet weather peak flows. This I/I reduction alternative was included to help define the level of effort and high level costs to establish, implement, and administer a program to aggressively reduce I/I.

The vast majority of the sewer infrastructure is in the customer community and private collection systems. Therefore, any program to aggressively reduce I/I will need to include these systems as well as the MMSD's interceptor system. An overall strategy for implementing this alternative is outlined below:

1. Demonstrate initial cost-effectiveness of I/I reduction program relative to other alternatives to manage peak flows.

2. Initiate stakeholder involvement program to gain stakeholder buy-in.

3. Perform I/I evaluation at plant, pump station basin, and sub-basin scales to identify high I/I areas.

4. Identify treatment plant capital and operations and maintenance costs avoided with I/I reduction.

5. Perform conveyance system evaluation to estimate conveyance improvement costs avoided with I/I reduction.

6. Identify risk and cumulative cost of damages of basement backups and SSOs sustained by choosing not to reduce I/I or increase conveyance. (This is the ongoing cost of the "do-nothing" alternative.)

7. Implement a pilot source detection program to identify sources and costs to mitigate sources.

8. Re-evaluate the cost-effectiveness of I/I reduction using the information gathered from Steps 3 to 7.

9. If I/I reduction cost-effectiveness is confirmed, establish I/I reduction targets or allowable peak flow performance standards in conjunction with stakeholders.

10. Implement comprehensive source detection program at all system levels.

11. Conduct pilot program to test rehabilitation technologies and demonstrate effectiveness of I/I reduction efforts.

12. Implement comprehensive I/I reduction program.

13. Measure effectiveness of I/I reduction program as it progresses.

A successful I/I reduction program for MMSD will require a partnership with the MMSD's customer communities because most of the I/I in the system is generated in either the customer community or private systems. There are several approaches that MMSD can take to accomplish I/I reduction:

- Establish performance standards
- Establish design and construction standards for the design and construction of sewers
- Ordinances
- Asset Management
- Financial incentives
- I/I Mitigation Bank

Additional details on an I/I reduction program are presented in Technical Memorandum No. 4.

C. Alternative PF6–Influent Equalization at NSWWTP (and pass 145 mgd through the NSWWTP)

In this alternative, peak flows up to 145 mgd, the approximate hydraulic capacity of the existing NSWWTP facilities, will be conveyed to the plant. The disinfection and effluent pumping capacities of the plant will remain at 100 mgd and 80 mgd, respectively, and therefore diversions to the lagoon will still occur when these capacities are exceeded. Future peak flows above 145 mgd will be stored in a new influent equalization structure and released to the plant as flows subside following high flow events. This alternative was included in the District's 2017 Capital Improvements Plan Plant Peak Capacity Improvements analysis.
Included in this alternative are the following modifications:

- Construct new influent equalization tank [approximately 10 million gallons (MG)].
- Install a new interceptor to convey peak flows above about 145 mgd to the equalization tank from the splitter structure upstream of the primary clarifiers at NSWWTP.
- Install a drain line from the equalization tank to Pump Station No. 11 and flushing system.
- Alternative Consideration: If the tank were constructed near Pump Station No. 11, flow could be diverted directly to the tank from the pump station.

This alternative (with 10 MG) would not significantly reduce the lagoon overflow frequency or volume to NSC. To provide the same lagoon overflow frequency as existing, approximately 200 to 250 million gallons of equalization volume would be required.

D. Alternative PF7–Upgrade NSWWTP Hydraulics

In this alternative, all wet weather flows are conveyed to and through the NSWWTP in a manner that minimizes plant operational impacts and process overflows and provides the capability to have a more equitable flow split between the west and east plants during peak flow events to better utilize the capacity within the west plant. A goal of this alternative is to improve hydraulics through the plant to allow more flow to be sent to the west plant during peak flow events, better utilizing the existing infrastructure and improving treatment efficiency, while eliminating hydraulic bottlenecks that may lead to overflows of in-plant structures.

In the evaluation of this alternative, the plant hydraulic model was used to evaluate necessary upgrades for wet weather flows up to 180 mgd to be conveyed through secondary treatment at the NSWWTP, with flows above approximately 100 mgd being sent to the lagoons prior to disinfection and effluent pumping. At these peak flows, the hydraulic analysis was completed for approximately 90 mgd sent to both the west plant and the east plant at the primary influent flow splitter structure. This alternative achieves the goals of better utilizing the west plant, better controlling the flow split between the west and east plants, better controlling the flow to the lagoons and the disinfection building, and preventing in-plant overflows.

Included in this alternative are the following modifications to improve plant hydraulics at peak flows:

- Construct bypass channel for west primary clarifiers.
- Raise west final clarifier influent channel walls.
- Construct new lagoon diversion structure to provide flexible flow control to the lagoons and flow conveyed from the east plant to the disinfection building.
- Upgrade lagoon return pump station and force main.

E. Alternative PF8–Double NSWWTP Effluent Pumping Capacity

This alternative would eliminate diversions to the lagoons and Nine Springs Creek by improving plant hydraulics and increasing process capacities so that the 180 mgd peak flow can be disinfected and pumped to the discharges at Badfish Creek and Badger Mill Creek.

It is anticipated that peak flows would be split approximately evenly between the west and east plant in this alternative, and therefore the west plant hydraulic improvements included in Alternative PF7 to allow 90 mgd to be sent through the west plant are also included in this alternative. An additional secondary effluent pipe to convey flow from the east plant to the disinfection building would also be required. In addition, the UV disinfection capacity of the plant would be increased from the current capacity of approximately 100 mgd to the future peak flow of 180 mgd.

This alternative includes larger and/or more effluent pumps and a second force main from NSWWTP to the outfall location at Badfish Creek. A second force main was assumed to be necessary based on the age of the existing piping (approximately 60 years) and a surge analysis conducted on the effluent force main for this planning project.

Included in this alternative are several modifications that are also included in Alternative PF7:

- Construct bypass channel for west primary clarifiers.
- Raise west final clarifier influent channel walls by 1 foot and modify channel at roadway crossing to prevent overflows.
- Construct new effluent structure to control diversions to lagoons and flow conveyed from the east plant to the disinfection building.

Additional modifications for this alternative are as follows:

- Install additional pipe to convey flow from the east plant to the disinfection building.
- Increase UV disinfection capacity to 180 mgd.
- Double effluent pumping capacity and construct new effluent force main.

F. Alternative PF9–Upgrade NSWWTP Hydraulics and Increase Nine Springs Creek Discharge

This alternative is nearly the same as Alternative PF7 except that some flow would be directly discharged to Nine Springs Creek during wet weather/peak flow events in addition to overflows from the lagoons. The current UV disinfection capacity of 100 mgd and effluent pumping capacity of approximately 80 mgd will be maintained in this alternative. Effluent from the disinfection building in excess of the effluent pumping capacity will continue to be conveyed to the Effluent Storage Reservoirs. The flow from these reservoirs will combine with any secondary effluent from the east plant at a new effluent diversion structure as described in Alternative PF7. Peak flows from this structure will be split to two locations: a portion of the flow may be sent to the lagoons and a portion discharged directly to Nine Springs Creek. During peak flow events above the effluent pumping capacity of 80 mgd, but less than about 100 mgd, all diversion flow at this structure will be sent to the lagoons. When flows exceed 100 mgd, the flow in excess of 100 mgd will be sent to a high rate disinfection system located near the diversion structure and discharged directly to Nine Springs Creek. Therefore, during a peak flow event of 180 mgd, approximately 80 mgd would be discharged using the existing effluent pumping system, 80 mgd would be disinfected and discharged to Nine Springs Creek, and 20 mgd would be discharged to the lagoons.

Based on WDNR's draft water quality memorandum received on February 13, 2017, any permitted discharge to Nine Springs Creek would also need to receive tertiary treatment and would need to improve water quality in the phosphorus impaired segment, which would require limits that are less than the water quality criteria. These requirements are based on Nine Springs Creek being listed as impaired for phosphorus and TSS. Therefore, this alternative would also require a new tertiary treatment facility to receive secondary effluent. For planning purposes, these include a new filter influent pumping stations, new deep bed granular media filters, chemical addition facilities, and chemical coagulation facilities.

Included in this alternative are the modifications that are included in Alternative PF7:

- Construct bypass channel for west primary clarifiers.
- Raise west final clarifier influent channel walls by 1 foot and modify channel at roadway crossing to prevent overflows.
- Construct new effluent structure to control diversion to the lagoons and flow conveyed from the east plant to the disinfection building.
- Upgrade lagoon pump station and force main.

Additional modifications for this alternative are as follows:

- Install tertiary treatment facilities for phosphorus removal.
- Install additional effluent piping from the new tertiary treatment facilities to the Nine Springs Creek outfall.

In addition to the regulatory and technical (level of treatment) hurdles that would need to be addressed, public perception of this alternative may be substantially negative. In our experience, new wastewater discharges are not typically well received, especially when the discharge is to recreational use waters that are heavily used by the community. In summary, this alternative is not considered as a viable, constructible alternative within the planning period of this Facilities Plan. However, we believe there is ultimately a significant benefit to establishing a local discharge to Nine Springs Creek, and we recommended the District begin evaluating in more detail potential paths forward related to such a discharge.

G. Alternative PF10–High-Rate Wet Weather Treatment at NSWWTP

This alternative includes the implementation of a biological contact (BC) high-rate treatment process in which mixed liquor or return activated sludge (RAS) is combined with wet weather flows in a small contact chamber. This would occur in Pass 3 of each of the 10 aeration basin trains. The BC process relies on the removal of particulate and colloidal material by biological flocculation in the contact chamber and provides limited soluble substrate uptake. Biological contact has generally been shown to be a cost-effective solution for WWTPs with flow peaking factors up to approximately three to four times the average design flow rate.

Effluent quality from the BC process is expected to achieve less than 15 mg/L of TSS and five-day carbonaceous biochemical oxygen demand ($CBOD_5$) in a well operating clarifier. Daily effluent ammonia nitrogen (NH_3-N) and TP could be higher than conventional secondary treatment depending upon the level of dilution and treatment and would need to be further investigated during preliminary design if this alternative is selected for implementation.

Included in this alternative are the modifications that are included in Alternative PF7:

- Construct bypass channel for west primary clarifiers.
- Raise west final clarifier influent channel walls by 1 foot and modify channel at roadway crossing to prevent overflows.
- Construct new effluent structure to control diversion to the lagoons and flow conveyed from the east plant to the disinfection building.
- Upgrade lagoon return pump station and force main.

Additional modifications for this alternative are as follows:

- New slide gates and control valves with electric actuators at pass 3 of each aeration train.

4.05 PRESENT WORTH ANALYSIS

Table 4.05-1 provides a summary of the opinion of present worth values for the alternatives. A detailed breakdown of present worth costs is included in TM-4.

Since Alternative PF9 was not considered viable within the planning horizon of this Facilities Plan, costs are not included costs for this alternative. We believe inclusion of these costs for Alternative PF9 would only make sense if the long-term (beyond 20 years) costs were included for the other alternatives, and these costs would need to include the costs related to compliance with nutrient regulations in a comprehensive triple bottom line analysis to truly be comparable.

	PF0 Null	PF4 Aggressive I/I[a]	PF6 Influent EQ	PF7 NSWWTP Hydraulic Upgrades	PF8 Effluent Pumping Upgrades	PF10 Biological Contact
Total Opinion of Capital Cost	**$0**	**$4,100,000**	**$65,300,000**	**$4,100,000**	**$71,300,000**	**$ 5,200,000**
Annual O&M	$773,000	$11,000,000 to $16,000,000	$777,000	$ 774,000	$738,000	$782,000
O&M Cost PW	$10,200,000	$80,000,000 to $175,000,000	$10,200,000	$10,200,000	$9,700,000	$10,300,000
Salvage PW	$0	($400,000)	($7,300,000)	($400,000)	($6,500,000)	($400,000)
Total Opinion of Present Worth	**$10,200,000**	**$84,100,000 to $179,100,000**	**$68,200,000**	**$13,900,000**	**$74,500,000**	**$ 15,100,000**

[a]Annual O&M and present worth costs are the total projected program costs for the District, its customers, and private efforts.

Table 4.05-1 Opinion of Present Worth Summary

Alternative PF0–No Change has the lowest capital and long-term present worth costs, based on the fact that no capital improvements would be required within the planning period. It is likely that all of the hydraulic and process structures would continue to operate efficiently under most flow conditions. However, the frequency and severity of peak flows through the plant are anticipated to increase over time, and as these events continue to occur, the potential of a larger process or hydraulic failure increases. In addition, the current split of flow through the plant during high flow events does not provide the optimum use of the existing infrastructure. Therefore, we do not recommend Alternative PF0.

Alternative PF7–Upgrade NSWWTP Hydraulics Only has the next lowest opinion of capital and present worth costs, however it does not consider the process requirements to maintain acceptable clarifier solids loading rates discussed in Section 5–Activated Sludge. To achieve both hydraulic improvement objectives of processing higher flows and process objectives of maintaining acceptable clarifier solids loading rates, Alternative PF10 is required. In addition, this alternative provides hydraulic upgrades that should minimize structure overflows through the plant and optimize the use of both the east and west plant facilities.

4.06 NONMONETARY EVALUATION

Nonmonetary considerations for each alternative were evaluated and are summarized in Table 4.06-1 and 4.06-2. Since Alternative PF10 is not directly comparable to the other peak flow management alternatives because it focuses on improving treatment performance during wet weather events, this alternative is compared to dedicated excess flow treatment scheme such as BioACTIFLO.

Table 4.06-1 Peak Flow Management Alternative Nonmonetary Considerations Summary

Alternative	Benefits	Limitations
Alternative PF0–No Change (Null Alternative)	▪ No changes in plant equipment or processes for staff to become accustomed to.	▪ Does not address hydraulic constraints in the plant that will lead to tank overflows at future peak flows. ▪ Does not improve the level of service of any processes. ▪ Does not improve the level of service with respect to diversion to lagoons and overflow of lagoons to Nine Springs Creek. ▪ Health and safety concerns associated with overflows of untreated wastewater on-site. ▪ Potential to discharge untreated wastewater to the environment as a result of tank overflows running off-site. ▪ Risk of damage to structures and equipment during overflow events. ▪ Legal and regulatory opposition to overflows and operating a plant without adequate capacity. ▪ Negative public perception from lack of action related to plant capacity issues.
Alternative PF4–Aggressive I/I Removal	▪ Addresses peak flow problem at the source so costs for correcting problem are aligned with the source of the problem. ▪ Promotes local responsibility for addressing peak flows at the community customer and property owner level. ▪ Reduces the risk of basement backups (costs, health risks, and emotional stress). ▪ If successful, can reduce or eliminate the costs associated with collection system and treatment plant infrastructure upgrades associated with hydraulic capacity. ▪ Improves system resiliency, if successful. ▪ Potentially reduces energy consumption as a result of reduced pumping. ▪ Could help to promote/improve public perception of MMSD as a good steward of the environment and resources. ▪ Could help to promote customer community/MMSD cooperation.	▪ Long time frame is required for implementation. ▪ Success is difficult to demonstrate in the short-term. ▪ Requires significant cooperation among numerous governmental entities; difficult to coordinate. ▪ There may be resistance from property owners if they are required to undertake private property repairs. ▪ Public perception of MMSD could be negative if benefits of program are not properly communicated or if the program does not meet expectations. ▪ Could create tension between community customers and MMSD if requirements for I/I reduction at community customer level are perceived as onerous. ▪ Successful results and outcomes cannot be assumed, and infrastructure capacity upgrades may, therefore, still be required before I/I reduction success can be demonstrated. ▪ MMSD's overall wet weather peaking factors are relatively low, which equates to lower confidence in achieving desired outcomes.
Alternative PF6–Influent Equalization at NSWWTP and pass 145 MGD through NSWWTP	▪ Provides improved peak flow management, flexibility, and control to operations staff for both short-term and long-term operations. ▪ Reduces extreme peak flow rates through the NSWWTP, which could improve overall treatment performance during extreme wet weather events and eliminate in-plant overflows. ▪ Provides more efficient use of the West Plant facilities, which should improve treatment efficiency during wet weather events. ▪ Low construction risk and low risk of failure; relatively simple to construct. ▪ Does not require significant space at the plant. ▪ Dual-purpose site could become a public recreational asset (e.g., soccer fields)	▪ Does not significantly improve the level of service with respect to diversion to lagoons and overflow of lagoons to Nine Springs Creek. ▪ Potential staff safety and public aesthetics concerns during tank cleaning. ▪ Requires staff to go off-site for maintenance activities. ▪ Tank cleaning will result in solids handling and management requirements; may be able to flush to Pump Station 11. ▪ Repumping of influent wastewater is required (higher energy). ▪ Likely would be constructed on a greenfield site; loss of farmland and the natural setting. May be public concerns regarding siting. ▪ Potential odors following wet weather events. ▪ Discharges to Nine Springs Creek might be permitted differently in the future.
Alternative PF7–Upgrade NSWWTP Hydraulics to Pass 180 mgd	▪ Provides improved peak flow management, flexibility, and control to operations staff for both short-term and long-term operations. ▪ Provides more efficient use of the West Plant facilities, which should improve treatment efficiency during wet weather events. ▪ Low construction risk and low risk of failure; relatively simple to construct. ▪ Does not require additional space at the plant or greenfield development. ▪ Eliminates in-plant overflows, protecting existing equipment and facilities. ▪ Public perception of alternative likely to be positive.	▪ Does not improve the level of service with respect to diversion to lagoons and overflow of lagoons to Nine Springs Creek. ▪ Discharges to Nine Springs Creek might be permitted differently in the future. ▪ Does not meet process objective of maintaining acceptable clarifier solids loading rates at high flows

Alternative	Benefits	Limitations
Alternative PF8–Double NSWWTP Effluent Pumping Capacity and Upgrade Plant Hydraulics to Pass 180 mgd	▪ Provides improved peak flow management, flexibility, and control to operations staff for both short-term and long-term operations. ▪ Provides more efficient use of the West Plant facilities, which should improve treatment efficiency during wet weather events. ▪ Provides full treatment of all flows. ▪ Eliminates lagoon overflow concerns; significantly reduces or eliminates the associated unknown future permit requirements associated with a Nine Springs Creek discharge. ▪ Provides redundant effluent pumping capacity for improved reliability of that critical system. ▪ Provides redundant effluent force main. Allows for more cost-effective maintenance and rehabilitation work. ▪ Maintains discharge flow to Badfish Creek.	▪ Difficult construction of additional large diameter piping to the disinfection building, as well as for the additional effluent pump station and effluent force main through the NSWWTP site. ▪ Requires some additional space at the plant in congested areas. ▪ Requires significant infrastructure investment that would largely be unutilized or underutilized during much of its life. ▪ Construction impacts through environmental corridors and green fields for the force main installation ▪ Potential public perception issues related to construction and traffic impacts. ▪ Potential impacts to Badfish Creek with respect to streambank erosion from higher peak flows; uncertainty if increased flow would be able to be permitted. ▪ Potentially takes the District in a direction away from a potential future local discharge to Nine Springs Creek and the Madison Lakes. ▪ Potentially takes the District in a direction away from decentralized treatment opportunities because of the significant cost to implement. ▪ Does not meet process objective of maintaining acceptable clarifier solids loading rates at high flows.
Alternative PF9–Upgrade NSWWTP Hydraulics to Pass 180 mgd with Increased Nine Springs Creek Discharge Frequency	▪ Eliminates effluent pumping costs, which would enable the District to better meet its energy and efficiency goals. It is noted, however, that any future tertiary treatment on site will likely require the addition of an intermediate pump station. Power use will decrease overall, however. ▪ Eliminates the significant risk associated with a potential failure of the effluent force main to Badfish Creek. ▪ Would provide the ability to meet future low level phosphorus limits if Badfish Creek and Badger Mill Creek discharges continue and adaptive management and/or trading programs are not deemed to be cost-effective. ▪ Directs resources at the District to towards initiating a long-term plan and program to establish a future local discharge to Nine Springs Creek and the Madison Lakes on a continuous basis. It changes the concept of peak flow management and potential long-term discharge locations. ▪ Provides improved peak flow management, flexibility, and control to operations staff for both short-term and long-term operations.	▪ The regulatory viability of a local Nine Springs Creek discharge is unknown at this time. ▪ May require political strategies to change state statues related to a Nine Springs Creek discharge. ▪ Requires significant additional space at the plant. ▪ Would likely require load trading for the relatively small amount of phosphorus and TSS discharged to Nine Springs Creek through the new outfall. ▪ Does not meet process objective of maintaining acceptable clarifier solids loading rates at high flows.
Alternative PF10–High-Rate Treatment at NSWWTP	▪ Low construction impact. Installation of West Primary Clarifier high flow channel to the primary effluent channel significantly less disruptive than alternatives requiring additional tankage and processes. Significantly less large diameter piping required. Less construction will translate into fewer impacts on neighbors from dust, traffic, and noise. ▪ Maximizes investment in existing infrastructure while improving peak flow treatment by using existing tankage and aeration equipment for treatment. ▪ The environmental impacts of new storage or treatment facilities construction are avoided. ▪ Saves NSWWTP space for other uses or future construction. ▪ No chemicals required. ▪ Fast start-up under wet weather conditions. ▪ Simple operations compared to operating a dedicated wet weather treatment plant. ▪ Reduces asset management requirements and maintenance requirements compared to a dedicated wet weather treatment facility. ▪ Proven wet weather treatment system. ▪ Nonproprietary. ▪ Similar or better treatment efficiency anticipated. ▪ Eliminates concerns with permitting a wet weather treatment facility. ▪ Meets both process and hydraulic capacity goals	▪ Does not increase overall NSWWTP wet weather treatment capacity relative to a dedicated excess flow treatment technology; however, the existing plant has adequate hydraulic capacity with the improvements included in this alternative to treat peak flows in existing tankage.

4.07 RECOMMENDED PLAN

Based on the evaluations included herein, the following recommendations are provided with respect to peak flow management for the District and at the NSWWTP:

1. Implement Alternative PF10, which includes the hydraulic capacity upgrades at the NSWWTP included in in Alternative PF7, as well as upgrades to allow the activated sludge process to operate in a biological contact process mode during high flow events. This alternative provides protection against in-plant tank overflows and will provide improved treatment under high flow conditions.

2. Begin evaluating in more detail potential paths forward related to implementing Alternative PF9, which includes initiation of a local permitted discharge to Nine Springs Creek. This alternative would be a first step towards a potential continuous future discharge to Nine Springs Creek at the District, which could significantly reduce energy consumption at the NSWWTP by eliminating the effluent pump station, and would account for a large percentage of the needed energy reduction goals to ultimately attain electrical neutrality at the NSWWTP. Our recommendation is to begin planning with the WDNR for an approximate 5 or 10 mgd tertiary treatment facility that would provide acceptable effluent for discharge to Nine Springs Creek for wet weather events. Added benefits of this alternative include the ability to evaluate low level phosphorus removal over a long term to develop costs for comparison to the adaptive management planning program and to act a first step in establishing a continuous, local discharge to Nine Springs Creek.

3. Consider initiating an aggressive I/I reduction pilot study (Alternative PF4). The study would be focused on identifying one or more areas with high I/I rates, and then implementing aggressive I/I reduction measures with the goal of quantifying successes and challenges for future additional measures in other areas. In addition to the pilot study, The District should consider evaluating a monetized triple bottom line for this alternative to help compare the potential total costs with other alternatives. An aggressive I/I program will require public and private investment, significant coordination and collaboration from multiple communities and entities, and a concentrated long-term effort from the District, and a triple bottom line analysis would help in quantifying the significant social and environmental benefits and costs.

The remaining alternatives were not recommended for the following reasons:

- Alternative PF0 (No Change–Null Alternative) does not address any of the hydraulic concerns that are the focus of this Facilities Plan.
- Alternative PF6 (Influent Equalization) has very high capital and present worth costs, and does not significantly improve overall plant hydraulics and flexibility. In addition, the potential public/aesthetic concerns could result in poor public perception.
- Alternative PF8 (Effluent Pumping Upgrades) has very high capital and present worth costs, and implementation of this alternative could make it more difficult to justify future local discharges to NSC because of the high sunk costs associated with the redundant force main.

SECTION 5
HEADWORKS

This section includes a summary of the influent flow measurement, screening and screenings handling, grit washing, and hauled waste receiving analyses that were conducted as part of the facility planning for the NSWWTP. In addition, detailed evaluations of the shortlisted alternatives are presented with opinions of probable construction cost and discussion of nonmonetary considerations. Additional detail on this evaluation is presented in Technical Memorandum No. 6 (TM-6).

5.01 EXISTING HEADWORKS FACILITIES

A. Description of Existing Facilities

The existing Headworks Facility at the NSWWTP was constructed as part of the 10th Addition project and was brought on-line in approximately 2005. The Headworks Facility is located on the south side of the grounds between the Struvite Harvesting Facility and the Metrogro Storage Tanks. Five force mains from collection system pump stations (PS) enter the west side of the Headworks Facility into the basement Meter Vault Room. Flows are measured using venturi flow meters and sampled. The force mains discharge into a common channel in the Screen Room. Flows are split to pass through up to three center-flow band screens to remove coarse solids from the influent wastewater. After screening, the flows recombine in a channel before being split to flow to the three vortex grit removal tanks. Screened and degritted wastewater then flows to the Flow Splitter Structure where flows are split to the east and west plants. The current capacity of the three screens is estimated at about 140 to 145 mgd. The maximum estimated peak flow that the facilities will be required to process is 180 mgd (Appendix D).

Material removed from the wastewater by the screens is sluiced via the screenings launder trough to the Maci well from which it is pumped to the secondary grit tank, Lisep and Lipactor, for degritting, dewatering, and compacting before being discharged to the haul-off waste container. Grit that accumulates in the Maci well is pumped periodically by the grit pump to the grit snail that dewaters the grit and discharges it to the haul-off waste container.

Grit that is removed from the forward flow in the vortex grit tanks is pumped by the grit pumps to the three grit concentrators/classifiers, which remove some of the organics from the grit and then dewater the grit before discharging it to the haul-off waste container.

The NSWWTP hauled waste receiving facilities are located at the Headworks Facility. The hauled waste facilities includes a covered open trough into which up to two trucks can discharge hauled wastes. The trough discharges into the screening channel just upstream of Screen No. 4. There is no screen or rock removal mechanism in the receiving trough to prevent large objects from discharging to the screening facilities.

B. Summary of Concerns

Flow measurement of the influent wastewater is an important aspect of the Headworks Facility, not only for compliance with regulatory requirements, but because billing of customer communities is based on this metering and process decisions are dependent on accurate flow metering. As such, the flow metering must be reliable and defensible. The existing venturi flow meters meet these requirements, but the meters were installed at an elevation such that the downstream screening channel water level needs to be managed to provide sufficient water depth to maintain meter submergence. This is accomplished by operating the screens to maintain a higher water elevation than intended during design. This results in increased settlement of grit and a greater likelihood of overflow of unscreened wastewater to the bypass channels on either side of the main screening channels. Because all the flows are pumped to the NSWWTP, the influent flow rates can and do change quickly, resulting in a very difficult level control situation upstream of the screens. One screen is always operating on variable speed control to maintain an upstream water level. This control strategy could result in channel overflows, inaccurate metering, or both. Additionally, Screen No. 4 needs to be in service at virtually all times to prevent an undesirable accumulation of grit and rocks in front of this screen resulting from the hauled waste discharge upstream of the screen. The requirement to have Screen No. 4 in constant service leads to excessive wear on this screen in comparison to the other screens.

In addition to the screening channel level control problem, there are a number of issues related to screenings handling with the existing equipment, which are as follows:

1. The trough that conveys the screenings from the screens to the Maci well is relatively flat, resulting in settling of material in the trough. The lack of pitch in the trough also requires constant flow of as much as 100 gallons per minute (gpm) of W4.

2. During higher flows, grit conveyed to the Maci well increases because of the scouring of interceptors and force mains. The increase of grit requires more operator attention to pump grit from the Maci well every 30 to 60 minutes, which is a significant time constraint on the operations staff.

3. Grit captured by the screens settles in the Maci pit and causes excessive wear on the Maci pumps. These pumps are also susceptible to plugging from heavy loads of rags and require very frequent maintenance. In addition, the parts for the Maci pumps are expensive and entail long lead times because of a lack of domestic availability.

4. The need to have a screen run continuously results in continual addition of W4 water to clean the screens. This sends more water to the screenings handling equipment and results in more run time on this equipment than was expected during design.

5. The Lisep and Lipactor screenings handling equipment are susceptible to plugging from heavy grease loads, particularly from hauled waste. The loads require frequent manual cleaning of this equipment.

The grit removal and handling facilities and equipment generally operate well with little attention required. Wear on the cyclone grit concentrators installed on the grit classifiers requires replacement of those units. The nominal capacity of the grit tanks is 50 mgd each, for a total capacity of 150 mgd. Although this capacity is less than the future maximum flow of 180 mgd, it is not recommended to add a fourth grit tank given the infrequency of flow above this nominal capacity of 150 mgd and since the results of exceeding their capacity is simply a reduction in grit removal efficiency for the duration of the high flow event. Hydraulic calculations performed for analysis of the alternatives assumed three grit tanks in service.

The hauled waste facilities receive wastes from about 50 to 60 trucks per day, and in 2015 accepted between 1.6 million and 2.8 million gallons of hauled waste per month. The demand for this service is expected to increase into the future. The hauled waste receiving facilities also have a number of issues that need to be addressed. These issues are detailed in a memorandum prepared by the District and included in TM-6. Some of the main concerns are listed in the following:

1. The existing receiving trough arrangement allows large material including rocks, nuts, bolts, and other objects to enter the influent channels and damage or otherwise hamper operation of the screens and screenings handling equipment.
2. As mentioned above, the location of the discharge pipes from the hauled waste trough necessitate near constant operation of Screen No. 4.
3. The requirement for trucks to back into the discharge trough is not an efficient traffic arrangement. A drive-through arrangement with one-way traffic would be preferred.
4. The slope of the existing unloading area does not allow some trucks to discharge completely.
5. Ice accumulates in the area in the winter, creating slippery conditions.
6. Haulers are on an “honor system” with respect to the volumes they discharge. This system is susceptible to abuse as well as inaccurate and inequitable billing for service.

5.02 INFLUENT FLOW MEASUREMENT ALTERNATIVES IDENTIFICATION AND SCREENING

The Influent Flow Measurement alternatives were discussed during Workshop No. 6. Based on discussion at the workshop and a more detailed hydraulic analysis of the screening channels, the following alternatives were selected to be evaluated further:

- Alternative IFM0–Maintain the Existing Influent Flow Metering Facilities (No Change)
- Alternative IFM1–New Venturi Metering Vaults on NSWWTP Site
- Alternative IFM2–New Influent Parshall Flumes
- Alternative IFM4–Install Venturi Flow Meters at PSs
- Alternative IFM5–Reinstall Venturi Flow Meters at a Lower Elevation

Each of these alternatives are evaluated further in the following sections.

5.03 DESCRIPTION OF INFLUENT FLOW MEASUREMENT ALTERNATIVES

This section includes a description of each of the short-listed influent flow measurement alternatives, including any structural, hydraulic, or operational changes necessary to accommodate the alternative.

A. Alternative IFM0–Maintain the Existing Influent Flow Metering Facilities (No Change)

In the null alternative, the current method of operating the screens to maintain adequate depth in the screening channels to fully submerge the venturis will continue. There are no current capital costs for this alternative since it is feasible to continue operating the existing system as is. Operating costs included in this analyses are the current maintenance costs of the screens. Note that the operation and maintenance

(O&M) costs for the other alternatives are relative to the null alternative, and they include the expected change in maintenance costs and pumping (electrical) costs for the PSs that discharge directly to the NSWWTP for the various alternatives.

B. Alternative IFM 1–New Metering Vaults on NSWWTP Site

In this alternative a new metering vault would be constructed in the open space to the west of the Headworks Building to house the venturis for the force mains from PS Nos. 2, 7, 8, and 18. This structure would be approximately 55 feet long, 25 feet wide, and 25 feet deep. The proximity of the influent force mains to the 54-inch effluent force main will require sheeting along the southwest side of the proposed structure to allow construction. A second structure to the south of the Headworks Building would be constructed to house the force main from PS No. 11. This structure would be approximately 25 feet by 25 feet and 25 feet deep. The intent of this alternative would be to reuse the existing venturis in the new metering vaults. These structures are assumed to be ventilated and include a staircase for entry, similar to the access provided to the east end of the grit pump room, to enable these spaces to be accessed without requiring a confined space entry.

There is space for an additional force main and venturi in the Headworks Building. No provisions are made in this alternative to accommodate this future force main and, as such, flow from this future force main would need to be measured at the pumping station from which it originates.

C. Alternative IFM 2–New Influent Parshall Flumes

The alternative would include construction of a new building structure west of the existing Headworks Building that would house five Parshall flumes with provisions for a sixth. The building housing the flumes would be approximately 50 feet by 55 feet. To maintain 1.5 feet of freeboard at 180 mgd, based on the calculations extended from the hydraulic model, the flumes would be 70 percent submerged at 180 mgd, which is the limit of accuracy for a 4-foot Parshall flume.

The ductile iron force mains would be modified to have the force mains discharge into the flume structure at elevation 15.0 feet for the force mains from PS Nos. 7 and 8, and elevation 21.0 feet for the force mains from PS Nos. 2 and 18. Force main from PS No. 11 would have to be reconfigured slightly to allow it to enter the west end of the flume structure at elevation 25.5 feet.

D. Alternative IFM 4–Install Venturi Flow Meters at Pump Stations

This alternative consists of installing venturi flow meters at individual pump stations to meter flow from each station to NSWWTP.

- A new meter vault at PS No. 2, which is located in Brittingham Park. The vault would be approximately 20 feet long, 16 feet wide, and 12 feet deep. It may be difficult to locate this vault without intruding on the sand volleyball courts in the park.

- A venturi meter for PS No. 3 installed in a manhole adjacent to the PS. The vault would be approximately 20 feet long, 16 feet wide, and 10 feet deep.

- A new meter vault at PS No. 8 adjacent to the north side of the building where the discharge pipe exits the building. The vault would be approximately 20 feet long, 16 feet wide, and 18 feet deep.

- A new meter vault at PS No. 11 adjacent to the east side of the building where the discharge pipe exits the building. The vault would be approximately 20 feet long, 16 feet wide, and 24 feet deep.

- A new meter vault at PS No. 18 on the east side of the building underneath the asphalt access drive where the discharge pipe exits the building. The vault would be approximately 20 feet long, 16 feet wide, and 24 feet deep.

A venturi meter vault could not be constructed at PS No. 7 given the site constraints and that the flows from this PS are conveyed in two force mains. The flows could be measured in a vault on the NSWWTP grounds after the point where the two force mains are combined. This vault would be located to the north of the west final clarifiers and would be approximately 20 feet long, 16 feet wide, and 15 feet deep.

E. Alternative IFM5–Reinstall Venturi Flow Meters at a Lower Elevation

The alternative would involve lowering the elevation at which the influent venturis are installed to allow them to be full at all times, regardless of the water elevation in the screening channels. This would be accomplished by relocating the pipe so that the top of the force main would be below the floor of the screening channels. This would result in the venturis being completely submerged whenever there is flow in the screening channels. A concrete box would be installed for each force main on the east wall of the Meter Vault Room into which the force main would discharge. The influent wastewater would flow up the box and enter the screening channels through the existing 48-inch pipe opening. The existing sluice gates would remain in place to allow isolation of each force main as needed. The Meter Vault Room would likely need to be extended approximately 5 feet to the west to maintain the distance required downstream of the venturis for accurate flow measurement; however, this requirement should be further investigated during the design phase. The pipes and venturis would be installed at approximately floor elevation (pipe centerline elevation 22.75) and a grating platform would be constructed over the pipes, essentially covering the entire room, except for the area of the sump pit in the northeast corner. The samplers would be replaced and relocated on the grating platform. Access stairs or ladders would be installed from the grating level to the floor to provide access to the venturi meters for calibration and maintenance.

The force mains would be removed back to the 45 degree elbows and re-laid to the Headworks Building at the new venturi elevation. A temporary pipe would be installed at the location of the future force main to accept flow from each of the force mains when they are being re-laid at the new elevation. The force main from PS No. 11 is at a higher elevation (centerline 25.5) than the proposed new venturi elevation, which would result in a high point at the transition to the new elevation. For the purposes of this evaluation, an air release valve is assumed to be required. Since this force main is the southernmost in the Meter Vault Room, it may be possible to have the venturi for this force main relocated to the centerline 25.5 elevation without hampering access to the other venturis. Having the venturi at this elevation would require a minimum of 9 inches of water in the screening channels at all times to maintain submergence. This concept should be considered prior to final design to avoid the need for an air release valve in the force main.

5.04 INFLUENT FLOW MEASUREMENT PRESENT WORTH SUMMARY

Table 5.04-1 presents a summary of the costs for each of the Influent Flow Measurement alternatives. Alternative IFM5 has the lowest capital and total present worth opinion of cost, and addresses the issue of screening channel overflow and screen control by providing a much larger variation between the minimum and maximum water level in the screening channels. This alternative also does not require additional space on-site for new metering structures.

	IFM0 No Change	IFM1 New Metering Vaults at NSWWTP	IFM2 New Flumes at NSWWTP	IFM4 New Metering Vaults at PS's	IFM5 Relocate Venturis to Lower Elevation
Total Opinion of Capital Cost	**$0**	**$3,180,000**	**$2,894,000**	**$2,919,000**	**$2,096,000**
Annual O&M	$81,000	$53,000	$86,000	$63,000	$52,000
O&M Cost PW	$1,065,000	$697,000	$1,131,000	$828,000	$684,000
Total Opinion of Present Worth	**$1,065,000**	**$3,877,000**	**$4,025,000**	**$3,747,000**	**$2,780,000**

Table 5.04-1 Influent Flow Measurement Opinion of Present Worth Summary

5.05 INFLUENT FLOW MEASUREMENT NONMONETARY EVALUATION

Nonmonetary considerations for each alternative were evaluated and are summarized in Table 5.05-1.

5.06 INFLUENT SCREENING AND SCREENINGS HANDLING ALTERNATIVES SCREENING

The Influent Screening and Screenings Handling alternatives were discussed during Workshop No. 6. Based on these discussions, none of the preliminary alternatives was excluded from further consideration. Therefore, the following alternatives were selected for further evaluation:

- Alternative S0–Maintain the Existing System (Null Alternative)
- Alternative S1–Install Screen and Wash Press for Sluiced Screenings
- Alternative S2–Install New Band Screens and Dedicated Wash Presses
- Alternative S3–Install Step Screens and Dedicated Wash Presses
- Alternative S4–Install Travelling Rake Screens and Dedicated Wash Presses
- Alternative S5–Install Perforated Plate Screens and Dedicated Wash Presses
- Alternative S6–Install Moving Media Screens and Dedicated Wash Presses
- Alternative S7–Install Chopper Pumps and Wash Presses

Each of these alternatives is further described and evaluated in the following.

5.07 DESCRIPTION OF INFLUENT SCREENING AND SCREENINGS HANDLING ALTERNATIVES EVALUATED

This section includes a description of each of the short-listed influent screening and screenings handling alternatives, including any structural, hydraulic, or operational changes necessary for each alternative.

Table 5.05-1 Influent Flow Measurement Alternative Nonmonetary Considerations Summary

Alternative	Benefits	Limitations
IFM0–Maintain the Existing Influent Flow Metering Facilities (No Change)	▪ No disruption of current operations.	▪ No reduction of grit accumulation in channels without septage receiving improvements. ▪ No improvement to screening operations or reductions in maintenance.
IFM 1–New Metering Vaults on NSWWTP Site	▪ Better influent screen performance, which should reduce pass-through of material and downstream maintenance concerns. ▪ Reduced accumulation of grit in influent channels. ▪ All construction on NSWWTP grounds.	▪ Construction adjacent to effluent force main presents a risk. ▪ Uses areas on-site that may limit construction in those areas in the future.
IFM 2–New Influent Flumes	▪ Better influent screen performance, which should reduce pass-through of material and downstream maintenance concerns. ▪ All construction on NSWWTP grounds.	▪ Construction adjacent to effluent force main presents a risk. ▪ Uses areas on-site that may limit construction in those areas in the future. ▪ Limits access to the Hypochlorite Room and Mechanical Room.
IFM 4–Install Venturi Flow Meters at PS Nos. 2, 3, 4, 7, 8, 11, 18	▪ Better influent screen performance reducing pass-through of material. ▪ Reduced accumulation of grit in influent channels.	▪ Construction at multiple sites including at pump stations and at NSWWTP. ▪ Decentralizes flow metering operations and potentially makes troubleshooting more difficult. ▪ Potential construction impacts to neighboring residences and entities, including noise, vibration, truck traffic, and dust. ▪ Confined space entry requirements at each metering location.
IFM5–Reinstall Venturi Flow Meters at a Lower Elevation	▪ Better influent screen performance, which should reduce pass-through of material and downstream maintenance concerns. ▪ All construction on NSWWTP grounds. ▪ Reuse of existing equipment and facilities.	▪ None.

A. Alternative S0–Maintain the Existing System (Null Alternative)

In this alternative, the existing band screens and screenings handling equipment would be maintained. Replacement of the existing equipment, including the screens, Maci pumps, Lisep, Lipactor, macerator grit pump, and grit snail, and installation of a fourth band screen and Lisep and Lipactor is assumed in Year 10 given the age and condition of the equipment and the need to accommodate the projected maximum flow. This definition of the null alternative is not a "do nothing" alternative, since the existing equipment is replaced at year 10, but rather a "business as usual" alternative utilizing the same screening and screenings handling processes as the existing facilities.

B. Alternative S1–Install Screens and Wash Press for Sluiced Screenings

In this alternative, the existing band screens and sluicing trough would be maintained. The trough would discharge into new channels in which two screens, likely 1/8-inch perforated plate screens to provide the maximum capture of the screened material, would be installed. These screens, which would only be required to handle the volume of sluicing water, would discharge to two screenings wash presses. The washed screenings would discharge directly to the haul-off waste container.

Given the space restrictions and the size of the equipment, specifically the wash presses, it does not appear that there is available space for installation of two screens and wash presses in the Maci pit area. It may be possible, however, to extend the trough to the north and construct concrete channels at floor level under the mezzanine in which the screens could be installed. The wash presses would be installed on top of the channels under the mezzanine and discharge directly into the haul-off waste container. Given District staff comments about the inadequacy of the existing trench drains to handle flows from the grit classifiers, it would be necessary to cut new trench drains into the floor to convey the screened sluicing water back into the screening channels.

C. Alternative S2–Install New Band Screens and Dedicated Wash Presses

In this alternative, new band screens would be installed with dedicated wash presses at each screen. It is necessary to replace the existing screens to use dedicated wash presses because the discharge elevation of the existing screenings is too low to permit installation of a wash press. The wash presses would be positioned on the west side of the screens and would discharge onto a belt conveyor, which would transport the screenings to the haul-off waste container. The ability of the conveyor to reach the container without major modifications to the mezzanine would need to be verified during detailed design.

This alternative would eliminate use of the screenings trough and associated sluicing water, the Maci pumps, the macerator grit pumps, the secondary grit tank, the Lisep and Lipactor, and the grit snail. This alternative also includes cost for installation of a fourth band screen and wash press in Year 10 to accommodate the projected maximum flow.

D. Alternative S3–Install Step Screens and Dedicated Wash Presses

In this alternative new step screens would be installed with dedicated wash presses serving each screen. Significant channel modifications would be required to allow proper flow to the screens and for proper installation of the new screens in the area currently occupied by the existing center-flow band screens.

The wash presses would be positioned on the east side of the screens and would discharge onto a belt conveyor located on the west side of the screens. The conveyor would transport the screenings to the haul-off waste container. The isolation slide gates upstream of the screens would also need to be replaced because of the channel modifications.

This alternative would eliminate use of the screenings trough, the Maci pumps, the macerator grit pumps, the secondary grit tank, the Lisep and Lipactor, and the grit snail. The capacity of the step screens allows the projected maximum flow of 180 mgd to be achieved without installation of a fourth screen.

E. Alternative S4–Install Travelling Rake Screens and Dedicated Wash Presses

This alternative is the same as Alternative S3, except that travelling rake screens would be installed instead of step screens. Travelling rake screens have the advantage of being more robust than step screens and are constructed to sustain impacts from large objects.

This alternative would eliminate use of the screenings trough, the Maci pumps, the macerator grit pumps, the secondary grit tank, the Lisep and Lipactor, and the grit snail.

F. Alternative S5–Install Perforated Plate Screens and Dedicated Wash Presses

This alternative is the same as Alternative S3 except that perforated plate screens would be installed instead of step screens. This alternative would eliminate use of the screenings trough, the Maci pumps, the macerator grit pumps, the secondary grit tank, the Lisep and Lipactor, and the grit snail. This alternative also includes the installation of a fourth screen and wash press in Year 10 to accommodate the projected maximum flow.

G. Alternative S6–Install Moving Media Screens and Dedicated Wash Presses

This alternative is the same as Alternative S3, except that moving media screens would be installed instead of step screens. This alternative would eliminate use of the screenings trough, the Maci pumps, the macerator grit pumps, the secondary grit tank, the Lisep and Lipactor, and the grit snail. This alternative also includes the installation of a fourth screen in Year 10 to accommodate the projected maximum flow.

H. Alternative S7–Install Chopper Pumps and Wash Presses

This alternative involves the use of chopper pumps instead of the Maci pumps. Chopper pumps may be less susceptible to wear and plugging than Maci pumps. Three wash presses would be installed in the mezzanine in place of the existing secondary grit tanks, Lisep equipment, and Lipactors. Each wash press would discharge to the belt conveyor over the haul-off waste container.

This alternative would retain use of the existing band screens, the screenings trough, the Maci pit, macerator grit pumps, and grit snail until this equipment is replaced in 10 years. New band screens (four) and grit pumps would be installed in 10 years, similar to Alterative S2.

5.08 INFLUENT SCREENING AND SCREENINGS HANDLING PRESENT WORTH SUMMARY

The alternatives evaluated herein each provide a minimum influent screening capacity of 180 mgd by or before Year 10. The existing equipment has been in service for about 12 to 13 years, and likely could last another 10 years before it would be absolutely required to be replaced. However, we believe it is in the District's best interest to update the screenings handling equipment before the end of the remaining useful life of the equipment because of the significant and frequent maintenance required on this equipment.

Table 5.08-1 provides an opinion of present worth summary, and more detailed analysis is included in TM-6. Alternative S0 (null alternative) has the lowest opinion of 20-year total present worth, but it is only about 4 percent less than Alternative S3 (new step screens). For the purpose of this Facilities Plan, these costs are considered equal. The null alternative does not resolve any of the operational or maintenance issues related to influent screening. Alternative S3–New Step Screen and Wash Presses would provide an entirely new screening and screenings handling system that would be simpler to maintain over time. This alternative does have a lower “clean screen” screenings capture efficiency but if the screens are allowed to be operated to build “a mat,” the screenings capture efficiency increases to approach that of the band screens.

Alternative S1, which includes replacing the screening sluicing, macerating, and dewatering equipment with two fine screens and screenings washer/compactors, is within 10 percent of the recommended Alternative S3. This alternative could be considered for more detailed evaluation as it continues the use of the most efficient screening equipment (band screens) yet simplifies the screenings handling equipment and processes.

5.09 INFLUENT SCREENING AND SCREENINGS HANDLING NONMONETARY EVALUATION

Nonmonetary considerations for each alternative were evaluated and are summarized in Table 5.09-1.

Table 5.08-1 Screening Opinion of Present Worth Summary

	Null Alternative	Screen Sluiced Screenings	New Band Screens, Wash Presses	New Step Screens, Wash Presses	New Trav. Rake Screens, Wash Presses	New Perf. Plate Screens, Wash Presses	New Moving Media Screens, Wash Presses	Chopper Pumps, Wash Presses
	S0	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**
Total Opinion of Current Capital Cost	---	$1,677,000	$4,145,000	$3,390,000	$3,849,000	$3,590,000	$3,869,000	$1,304,000
Total Opinion of Future Capital Cost	$5,564,000	$4,224,000	$1,713,000	---	---	$1,415,000	$1,169,000	$4,673,000
Annual O&M	$120,000	$96,000	$69,000	$69,000	$69,000	$69,000	$69,000	$104,000
Present Worth								
O&M	$1,578,000	$1,262,000	$907,000	$907,000	$907,000	$907,000	$907,000	$1,368,000
Future Costs	$3,626,000	$2,753,000	$1,116,000	---	---	$473,000	$762,000	$3,045,000
Salvage	($1,182,000)	($897,000)	($363,000)	---	---	($153,000)	($248,000)	($992,000)
Total Opinion of Present Worth	**$4,022,000**	**$4,795,000**	**$5,805,000**	**$4,297,000**	**$4,756,000**	**$ 4,817,000**	**$5,290,000**	**$4,725,000**

Table 5.09-1 Influent Screening and Screenings Handling Alternative Nonmonetary Considerations Summary

Alternative	Benefits	Limitations
S0–Maintain the Existing System (Null Alternative)	▪ Continues use of equipment with remaining useful life (screens, Liseps, Lipactors, Maci pumps, macerator grit pump).	▪ Still has water requirement for sluicing of the screenings. ▪ Continues using equipment that has been problematic and requires frequent attention and maintenance (Liseps, Lipactors, Maci pumps, macerator grit pump, and grit snail).
S1–Install Screens and Wash Press for Sluiced Screenings	▪ Provides improved and simpler screenings handling process with fewer pieces of equipment. ▪ Significantly reduces maintenance required for screenings handling. ▪ Wash presses are less susceptible to plugging with heavy grease loads. ▪ Eliminates the grit snail and associated maintenance. ▪ If one of the two sluicing screens or wash presses is out of service, that does not require any of the main channel screens to be taken out of service.	▪ Still has water requirement for sluicing of the screenings to the new screens. ▪ Replaces equipment that has remaining useful life (Lisep, Lipactors, Maci pumps, and macerator grit pumps). ▪ May create cramped space with channels and equipment under the mezzanine. ▪ Requires a fourth screen to provide 180 mgd.
S2–Install New Band Screens and Dedicated Wash Presses	▪ Provides improved and less complicated screenings handling process with fewer pieces of equipment. ▪ Reduces maintenance required for screenings handling equipment. ▪ Wash presses are less susceptible to plugging with heavy grease loads. ▪ Eliminates water requirement for sluicing of the screenings to the Maci pit. ▪ Least intrusive construction of the screenings alternatives. No changes to screenings channels required.	▪ Conveyor across length of building. ▪ Will require fourth screen for 180 mgd. ▪ Replaces equipment that has remaining useful life (Lisep, Lipactors, Maci pumps, and macerator grit pumps). ▪ Access to slide gates is limited.
S3–Install Step Screens and Dedicated Wash Presses	▪ Provides improved and simpler screenings handling process with fewer pieces of equipment. ▪ Reduces maintenance required for screenings handling. ▪ Wash presses are less susceptible to plugging with heavy grease loads. ▪ Eliminates water requirement for sluicing of the screenings to the Maci pit. ▪ Fourth screen not required for 180 mgd.	▪ Constructability concerns. Significant removal of concrete from channels required to install different style screen. ▪ Step screens are more susceptible to damage from larger objects. ▪ Conveyor across length of building. ▪ Substantial channel modifications required. ▪ Replaces equipment that has remaining useful life (Lisep, Lipactors, Maci pumps, and macerator grit pumps). ▪ Access to slide gates is limited. ▪ Screenings capture is unlikely to be as good as band screens.
S4–Install Travelling Rake Screens and Dedicated Wash Presses	▪ Provides improved and simpler screenings handling process with fewer pieces of equipment. ▪ Reduces maintenance required for screenings handling. ▪ Wash presses are less susceptible to plugging with heavy grease loads. ▪ Eliminates water requirement for sluicing of the screenings to the Maci pit. ▪ Screens are sturdy and better able to handle large objects without damage. ▪ Fourth screen not required for 180 mgd.	▪ Conveyor across length of building. ▪ Substantial channel modifications required. ▪ Replaces equipment that has remaining useful life (Lisep, Lipactors, Maci pumps, and macerator grit pumps). ▪ Screenings capture is unlikely to be as good as band screens.
S5–Install Perforated Plate Screens and Dedicated Wash Presses	▪ Provides improved and less complicated screenings handling process with fewer pieces of equipment. ▪ Improved screenings capture over Alternatives S3 and S4. ▪ Reduces maintenance required for screenings handling. ▪ Wash presses are less susceptible to plugging with heavy grease loads. ▪ Eliminates water requirement for sluicing of the screenings to the Maci pit. ▪ Provides opportunity to design screens for existing hydraulic conditions.	▪ Screenings discharge requires a brush, which is a maintenance item. ▪ Conveyor across length of building. ▪ Substantial channel modifications required. ▪ Will require fourth screen for 180 mgd. ▪ Replaces equipment that has remaining useful life (Lisep, Lipactors, Maci pumps, and macerator grit pumps).
S6–Install Moving Media Screens and Dedicated Wash Presses	▪ Provides improved and simpler screenings handling process with fewer pieces of equipment. ▪ Improved screenings capture over Alternatives S3 and S4. ▪ Reduces maintenance required for screenings handling. ▪ Wash presses are less susceptible to plugging with heavy grease loads. ▪ Eliminates water requirement for sluicing of the screenings to the Maci pit.	▪ Screenings discharge requires a brush, which is a maintenance item. ▪ Conveyor across length of building. ▪ Substantial channel modifications required. ▪ Requires a fourth screen to provide 180 mgd of capacity. ▪ Replaces equipment that has remaining useful life (Lisep, Lipactors, Maci pumps, and macerator grit pumps).
S7–Install Chopper Pumps and Wash Presses	▪ Replaces Maci pumps with pumps better suited to pumping screenings. ▪ Reduced maintenance of screenings handling equipment. ▪ Wash presses are less susceptible to plugging with heavy grease loads.	▪ Proposed solution is not substantially different than the existing system, and may not improve maintenance requirements. ▪ Alternative does not address issues associated with existing screens. ▪ Alternative does not address issues associated with screenings trough. ▪ Operation of grit snail is still required. ▪ Water use is still high. ▪ Replaces equipment that has remaining useful life (Lisep, Lipactors, Maci pumps, and macerator grit pumps).

5.10 GRIT WASHING ALTERNATIVES SCREENING

The Grit Washing alternatives were discussed during Workshop No. 6. Based on this discussion, the following alternatives were selected for further evaluation:

- Alternative G0–No Change (Null Alternative)
- Alternative G1–Replacement of Grit Classifiers with Grit Washers

Each of these alternatives is further described and evaluated below.

5.11 DESCRIPTION OF GRIT WASHING ALTERNATIVES

A. Alternative G0–No Change (Null Alternative)

In this alternative the existing grit system would be unchanged. There would be no initial capital costs and the annual operating costs (the sum of mechanical, operations, and supplies and parts cost categories) would be unchanged from current levels. We have assumed that new grit concentrators, grit tank mechanisms, and grit pumps would be installed in 10 years to replace the existing units, which will be more than 20 years old at that time.

B. Alternative G1–Replacement of Grit Classifiers with Grit Washers

In this alternative the existing grit classifiers would be replaced with grit washers. The grit washers occupy more space than the existing classifiers but there is sufficient room on the mezzanine to install this equipment. This alternative includes the installation of the grit washers in 10 years, which coincides with the approximate end of the useful life of this equipment. The grit tank mechanisms and grit pumps are also assumed to be replaced at this time given their age. Similar to the null alternative for the screening equipment, this is not a “do nothing” alternative, but rather a “business as usual” alternative, assuming the District will continue to manage grit as it does now.

5.12 GRIT WASHING PRESENT WORTH SUMMARY

Table 5.12-1 provides an opinion of present worth summary for the grit handling alternatives. Given that the existing equipment is expected to last for another 10 years, replacement of the equipment in 10 years should be with new state-of-the-art equipment, which includes new grit washers (Alternative G1) in lieu of grit classifiers (Alternative G0–Null Alternative). However, this recommendation is dependent on the screening alternative selected since the mezzanine is not large enough to accommodate three new grit washers without eliminating the existing screening handling equipment on that level.

	G0	G1
Opinion of Capital Cost (Year 0)	$0	$0
Opinion of Capital Cost (Year 10)	$1,893,000	$1,956,000
Annual O&M	$39,000	$40,000
Present Worth		
O&M Cost	$515,000	$526,000
Future Costs	$1,233,000	$1,275,000
Salvage	($402,000)	($415,000)
Total Opinion of Present Worth	**$1,346,000**	**$1,386,000**

Table 5.12-1 Grit Management Opinion of Present Worth Summary

5.13 GRIT WASHING NONMONETARY EVALUATION

Nonmonetary considerations for each alternative were evaluated and are summarized in Table 5.13-1.

Alternative	Benefits	Limitations
G0–No Change (Null Alternative)	▪ Continued use of existing equipment.	▪ Equipment susceptible to wear and breakdowns. ▪ Dewatered grit product not as clean as with grit waters; higher odors.
G1–Replacement of Grit Classifiers with Grit Washers	▪ Cleaner grit product.	▪ Higher W4 demand for grit washing.

Table 5.13-1 Grit Washing Alternative Nonmonetary Considerations Summary

5.14 HAULED WASTE RECEIVING ALTERNATIVES SCREENING

Originally, four alternatives for the hauled waste receiving facility were discussed at Workshop No. 6. However, various concerns were raised, including the desire to maintain the current metering and sampling program, as well as potential public perception and aesthetic concerns with the alternate locations for the facility. For these reasons only the following alternatives were considered for further review:

- Alternative HW0–No Change (Null Alternative)
- Alternative HW1–Construction of a Drive-Through Hauled Waste Receiving Station at the Existing Receiving Location

5.15 DESCRIPTION OF HAULED WASTE RECEIVING ALTERNATIVES EVALUATED

A. Alternative HW0–No Change (Null Alternative)

In this alternative hauled waste receiving facilities and operations would be unchanged. There would be no capital costs for this alternative, and the annual operating costs are unchanged from the existing costs. Similar to the influent follow metering null alternative, this alternative is truly a "do nothing" alternative. However, it also mimics the current operations and hauled waste management facilities, and is a viable 20-year solution with no capital upgrades.

B. Alternative HW1–Construction of a Drive-Through Hauled Waste Receiving Station at the Existing Receiving Location

In this alternative the existing hauled waste receiving area will be widened to allow installation of two mechanical receiving stations equipped with rock traps and screening equipment. Note that the District pilot tested a potential hauled waste receiving system during the summer of 2017, and a summary of the pilot testing results (provided by the District) is included in an appendix to Technical Memorandum No. 6 (Appendix F to this Facilities Plan). The existing trough would be removed and the drive would be extended to allow one-way traffic through the receiving area and to eliminate the need for trucks to back in. The drive would be sloped to allow trucks to be completely emptied. Receiving stations would be installed in an approximately 27- by 53-foot building. Because of the location and size of the building, it is likely that the existing canopy will have to be removed and several pipes will have to be relocated. Additional facilities will need to be added to allow dumping from irregular sources such as barrels, totes, porta-potties, and grease trailers. A proposed preliminary layout for the drive and building is shown in Figure 9, although other layouts should also be considered that may allow the existing canopy to remain in place. An existing stormwater bioswale would be disturbed by construction of the drive that would have to be relocated and likely enlarged to accommodate increased runoff from the increased impervious area. The ventilation system would be designed to incorporate odor control in the future if needed. No costs for an odor control system are included.

Modification of the hauled waste receiving facilities would include incorporation of more security and tracking measures to reduce the potential for unauthorized or inaccurately reported discharges. The measures would include a card or keypad activated entry gate and flow meters on the two receiving stations.

An important consideration of this alternative is the displacement of hauled waste receiving activities during construction. An alternate location for trucks to discharge would need to be identified and any temporary measures, such as a rental receiving station, would need to be put in place prior to the start of construction.

5.16 HAULED WASTE RECEIVING PRESENT WORTH SUMMARY

Table 5.16-1 provides an opinion of present worth summary for the hauled waste receiving alternatives. We recommend implementing Alternative HW1, which includes construction of a drive-through hauled waste receiving station to improve the operations, safety, maintenance, and function of the facility and the downstream headworks processes. The District's hauled waste receiving facilities provide a valuable resource to the community, local industry, and septage haulers. The existing facilities, while functional, require significant attention for operations and maintenance, and winter time traffic is a safety concern with icing roadways and difficult truck maneuvering. In addition, the new system would include an automated card reader system, which will provide improved tracking, billing, and management for the various haulers and for the District.

	HW0	HW1
Total Opinion of Capital Cost	**$0**	**$2,864,000**
Annual O&M	$21,000	$36,000
Present Worth		
O&M Cost	$276,000	$473,000
Salvage	$0	($58,000)
Total Opinion of Present Worth	**$276,000**	**$3,279,000**

Table 5.16-1 Hauled Waste Opinion of Present Worth Summary

5.17 HAULED WASTE RECEIVING NONMONETARY EVALUATION

Nonmonetary considerations for each alternative were evaluated and are summarized in Table 5.17-1.

Alternative	Benefits	Limitations
HW0–No Change (Null Alternative)	▪ No interruption to existing receiving area. ▪ Reuses existing facilities that have remaining useful life.	▪ The numerous issues with hauled waste receiving are not addressed.
HW1–Construction of a Drive-Through Hauled Waste Receiving Station at the Headworks Building	▪ Improved traffic flow. ▪ Improved safety for haulers and operators. ▪ Reduced operator attention regarding unloading operations. ▪ Rocks and larger objects removed prior to screening channels; reduced associated maintenance. ▪ Improved security and tracking. ▪ More accurate and equitable billing for services. ▪ Improved accessibility to haulers.	▪ Hauled waste receiving operations displaced during construction.

Table 5.17-1 Hauled Waste Receiving Alternative Nonmonetary Considerations Summary

5.18 RECOMMENDED PLAN

The recommendations related to the Headworks Facility and hauled waste receiving are a combination of the alternatives presented and discussed above. The timing of the execution of the improvements to these facilities may be adjusted to accommodate the condition of the various equipment involved or to combine or separate project elements to fit the needs of the District.

The recommendations for improvements include:

- IFM5–Relocate Venturis to Lower Elevation
- S1–Screen Sluiced Screenings or S3–Install New Step Screens and Wash Presses
- G1–Replacement of Grit Classifiers with Grit Washers; Replace Other Equipment (Year 10)
- HW1-Construction of a Drive-Through Hauled Waste Receiving Station at the Headworks Building

Lowering the venturis will allow the venturis to remain fully submerged regardless of the water level in the screening channels. Screening Alternative S1 allows continued use of the existing screens and has the least invasive construction requirements of the screenings alternatives. Screening Alternative S3 has the lowest present worth cost of the screenings alternatives that addresses the maintenance and operational issues related to screenings and screenings handling. The grit alternative G1–Replacement of Grit Classifiers with Grit Washers is recommended to be executed when the grit classifiers are at the end of their useful life, which is about 10 years. The HW1 alternative, Construction of a Drive-Through Hauled Waste Receiving Station at the Headworks Building, is also recommended to alleviate the issues with the existing hauled waste receiving operations. Proposed layouts for each of these alternatives are presented in Figures 5.18-1 through 5.

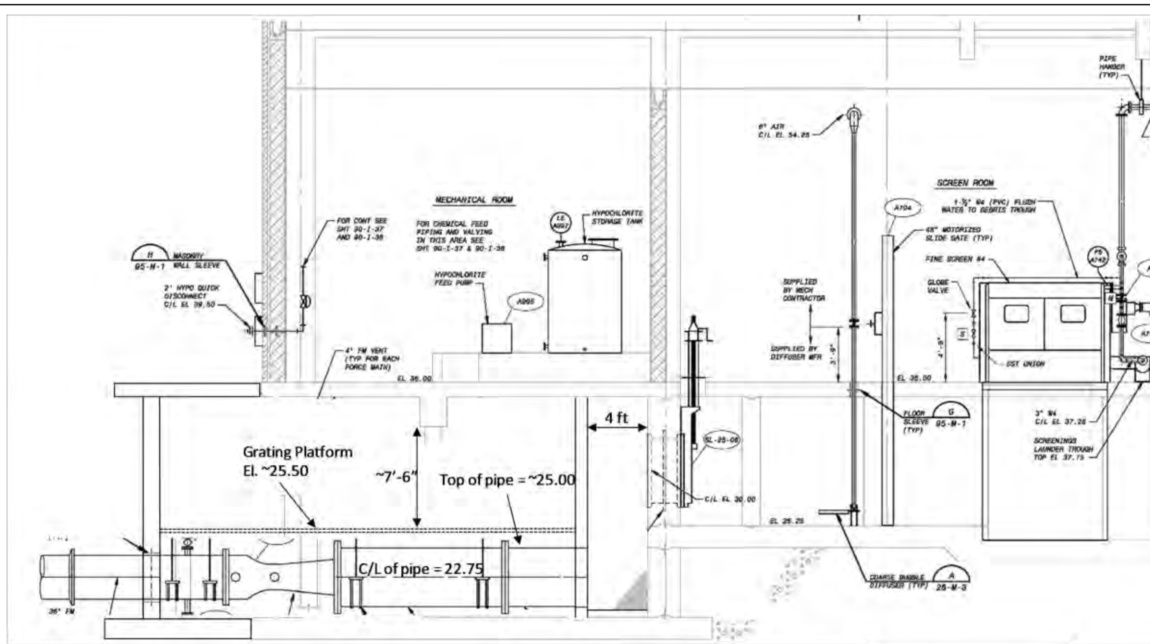


Figure 5.18-1 Alternative IFM5–Section View of Relocated Venturis

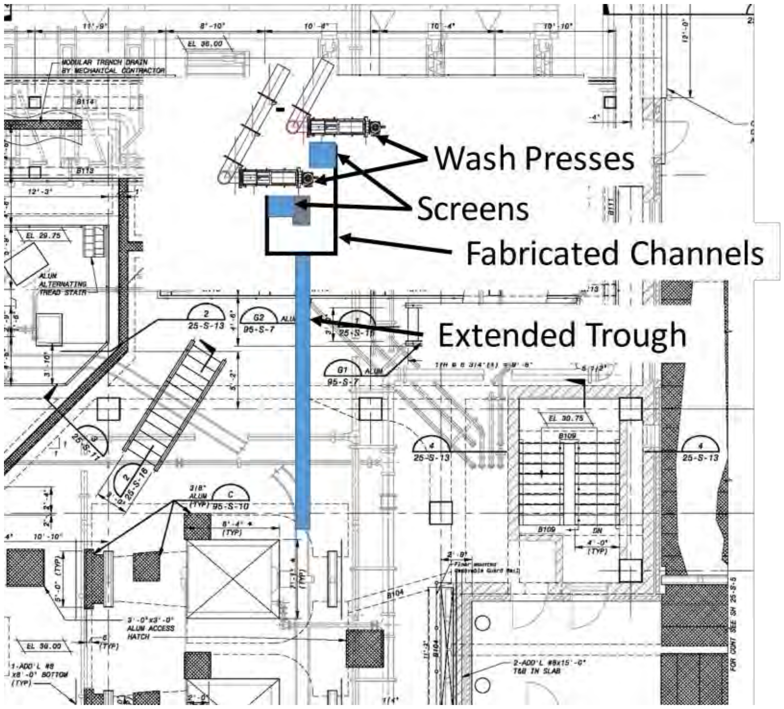


Figure 5.18-2 Alternative S1–Sluiced Screening Preliminary Layout

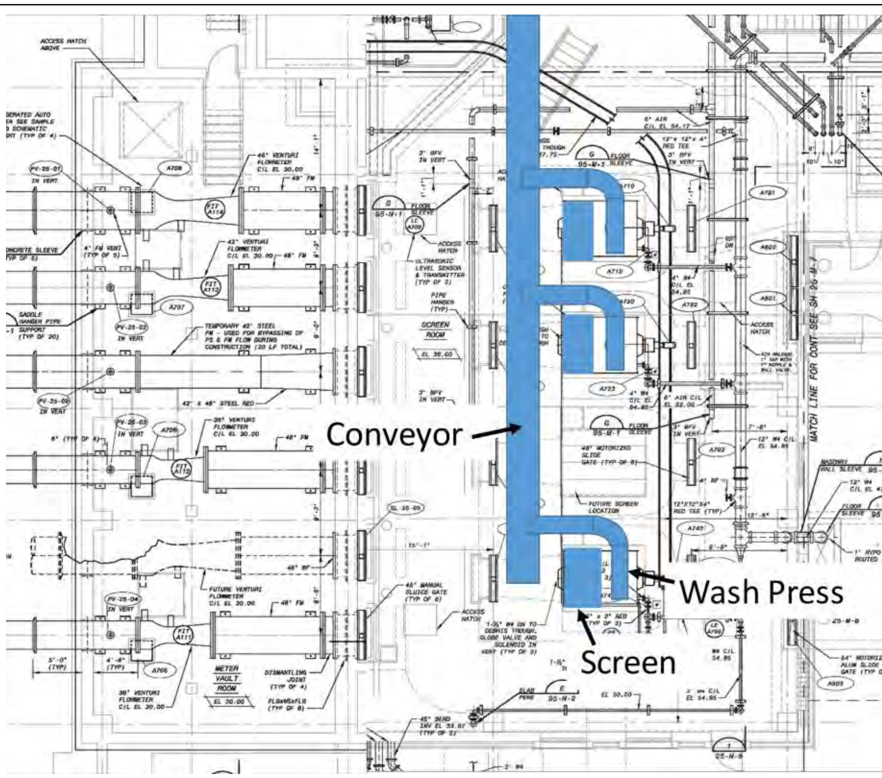


Figure 5.18-3 Alternative S3–Proposed Step Screens and Wash Presses Layout

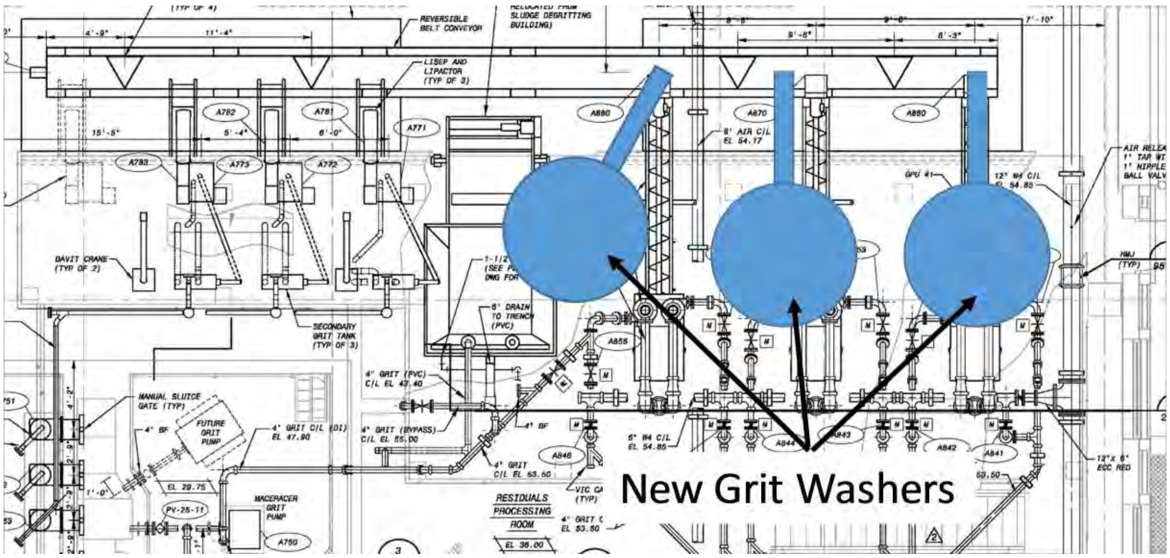


Figure 5.18-4 Alternative G1–Proposed Grit Washer Layout

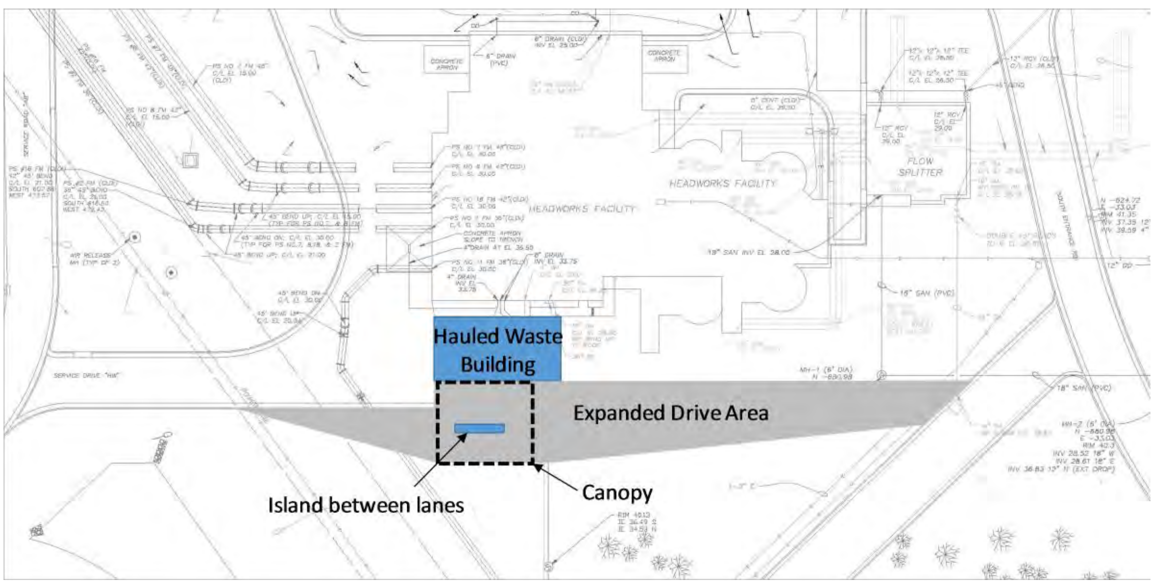


Figure 5.18-5 Alternative HW1–Proposed Hauled Waste Receiving Area Layout

Table 5.18-1 present the Year 0 and Year 10 opinions of probable cost of the recommended alternatives. Because of the significant ongoing concerns with the screening and hauled waste receiving operations, we have assumed the screening and hauled waste receiving improvements would occur in the near future and the grit management improvements would proceed in about 10 years. However, none of these improvements need to happen in the very near future, since all of the equipment likely has another 5 to 10 years of useful life remaining. Therefore, the timing of the project(s) can be tailored to fit the budgetary needs of the District.

Project Element	Opinion of Capital Cost Year 0	Opinion of Capital Cost Year 10
Alternative IFM5–Relocate Venturis to Lower Elevation	$2,096,000	$0
Alternative S1–Screen Sluiced Screenings[a]	$1,667,000	$4,224,000
Alternative S3–New Step Screens and Wash Presses[a]	$3,390,000	$0
Alternative G1–New Grit Washers	$0	$1,956,000
Alternative HW1–Drive-Through Hauled Waste Station	$2,864,000	$0
Totals	$6,627,000 to $8,350,000	$1,956,000 to $6,180,000

[a]These screening alternatives are mutually exclusive. District to select an alternative to implement.

Table 5.18-1 Summary of Capital Costs and Recommended Alternatives

SECTION 6
ACTIVATED SLUDGE

This section includes an evaluation of biological nutrient removal (BNR) alternatives to improve nutrient removal, accommodate influent load growth, and consider how renewal of the existing aeration system components should be coordinated with these improvements. Additional detail on the evaluations included in this section are presented in Technical Memorandum No. 5 (TM-5, Appendix E).

6.01 EXISTING ACTIVATED SLUDGE SYSTEM

A. Process Configuration

The existing NSWWTP activated sludge facilities consist of two complexes. The east complex includes 18 aeration basins configured as six 3-pass aeration train with 11 secondary clarifiers. The west complex includes 12 aeration basins configured as four 3-pass aeration trains with 8 secondary clarifiers. Both complexes operate an EBPR process. A majority of the WWTP, with the exception of two treatment trains in the east complex, use the modified University of Cape Town (UCT) process. This process configuration consists of wastewater entering an anaerobic zone where it is combined with mixed liquor from the downstream anoxic zone. RAS is pumped to the anoxic zone where nitrate is reduced to nitrogen gas before a portion of the mixed liquor is pumped to the upstream anaerobic zone. Flow from the anoxic zone that is not returned continues to the aerated zone for BOD removal and nitrification. The modified UCT configuration improves EBPR performance by maintaining the integrity of the anaerobic zone through the denitrification of the RAS in the anoxic zone prior to entering the anaerobic zone. A flow configuration layout for the modified UCT process is presented in Figure 6.01-1.

Two treatment units in the east complex use the anaerobic/aerobic (A/O) process, which includes an anaerobic zone upstream of an aerated zone and does not have a nitrified mixed liquor recycle.

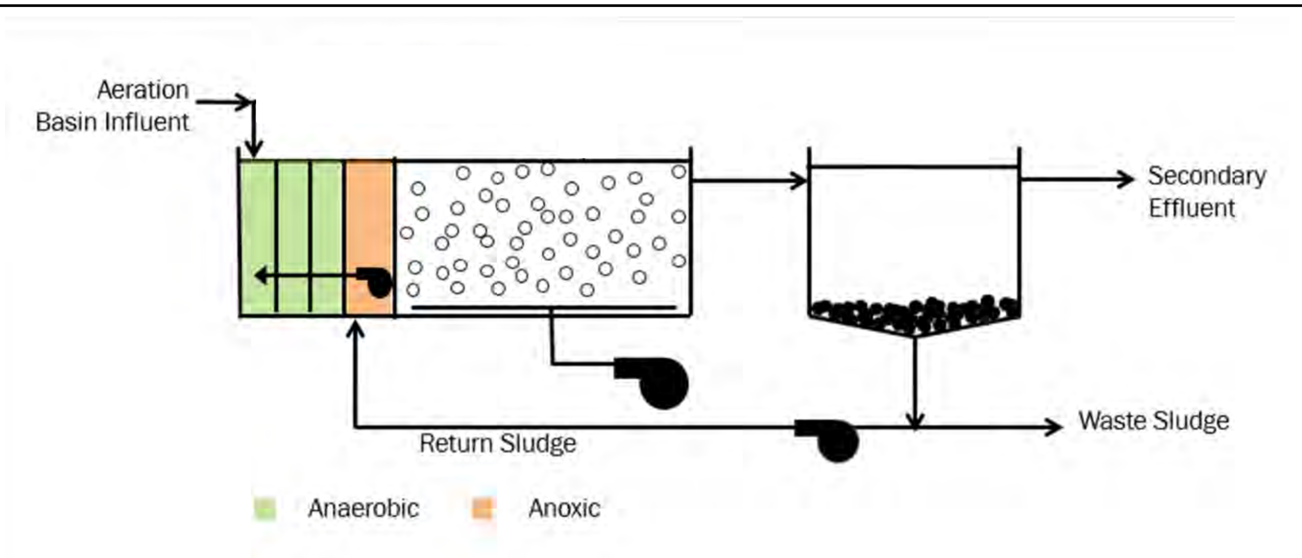


Figure 6.01-1 Modified UCT Flow Configuration

Design criteria of the existing modified UCT process is presented in Table 6.05-1 later in this section.

B. Aeration Blowers

NSWWTP operates two sets of blowers serving the east and west sides of the plant. The two sets of blowers are operated and controlled independently.

There are five east blowers with varying types and capacities, as summarized in Table 6.01-1 below. Approximately 2,500 standard cubic feet per minute (scfm) (roughly 15 percent) of the east aeration air is diverted to channel mixing and agitation air for the headworks.

East Blower No.	Type and Output Control	Capacity	Motor Size
1	Positive displacement; gas engine (biogas)	7,875 cfm @ 600 rpm 9,185 cfm @ 700 rpm 10,500 cfm @ 800 rpm	~ 500 hp @ 800 rpm 160,000 scfm biogas/day
2	Centrifugal Variable inlet vanes	7,000 to 11,500 cfm	600 hp; 4,000 V
3	Centrifugal Variable inlet vanes	7,000 to 11,500 cfm	600 hp; 4,000 V
4	Positive displacement; 2-speed motor	7,760 cfm @ low speed 10,850 cfm @ high speed	375/500 hp; 4,000 V
5	Positive displacement; 2-speed motor	5,840 cfm @ low speed 9,070 cfm @ high speed	325/450 hp; 4,000 V

Table 6.01-1 East Blower Summary

East blower 1 is driven by a gas engine using biogas from the NSWWTP anaerobic digesters and is normally in service to maximize the use of biogas and reduce electrical demands. Blower 1 is approximately 30 years old. During the condition assessment inspectors observed an oil leak and that the blower was running hot, but it is otherwise in acceptable condition. MMSD intends to continue operating this blower for several more years because it is an integral part of its biogas utilization program. Under most operating conditions, either blower 4 (low or high) or blower 5 (low or high) provides the base air demand in parallel with the variable-speed operation of blower 1. The starting and stopping of these blowers is a manual process, as is the selection of the blower high or low speed, but changes to the blower operations are infrequent. Blowers 4 and 5 are nearly 50 years old. Mechanical issues documented by the condition assessment include shaft, supports, and bearing deterioration, vibration of blower 5, and deteriorated condition of electrical distribution system.

The two centrifugal blowers (2 and 3) are approximately 30 years old and are seldom operated.

Three 1,250 horsepower (hp) single-stage centrifugal blowers provide air to activated sludge plants 3 and 4, as summarized in Table 6.01-2. Only one blower is operated at a time and the typical blower output is between 16,000 and 20,000 scfm. Inlet guide vanes on the blower inlet are modulated based on system pressure in the air main. A small quantity of air is diverted from the west blowers for primary channel mixing.

The primary concern with the west blowers is their inability to turn down to match normal diurnal load fluctuations, with aeration basin dissolved oxygen (DO) concentrations rising to 5 mg/L at night. The blowers seldom use the high end of their capacity range, but if loads are very high the blower's motors can overload. To avoid this condition, power monitoring to each blower is used to initiate alarms if the power use rises above 900 kW (~1,200 hp).

East Blower No.	Type and Output Control	Capacity	Motor Size
1	Centrifugal Variable inlet vanes	25,000 cfm	1,250 hp; 4,000 V
2	Centrifugal Variable inlet vanes	25,000 cfm	1,250 hp; 4,000 V
3	Centrifugal Variable inlet vanes	25,000 cfm	1,250 hp; 4,000 V

Table 6.01-2 West Blower Summary

The west blowers were added during the 7th Addition to the NSWWTP in 1986, and are about 31 years old. However, because the plant is able to operate with one of the three blower units, the operating hours are moderate for equipment of this age. Maintenance concerns noted in the conditions assessment include:

- Service support issues leading to prolonged outages and concerns about adequate redundancy.
- Shaft, supports, and bearing deterioration.
- Oil on top of drive and filter smoking (blowers 2 and 3).
- Vibration/oscillation (blower 3).

C. <u>Aeration Diffusers</u>

The aerated zones in the four activated sludge plants currently use 9-inch ceramic fine-pore diffusers and polyvinyl chloride (PVC) air distribution grids that were installed as part of the MMSD 7th Addition to the NSWWTP project in 1986. The east and west plants were constructed in phases, with differing tank depths, ranging from 14.7 to 15.8 feet and with diffuser submergence ranging from 14.7 to 15.8 feet.

Plant staff reported that diffuser grid maintenance issues have been infrequent, but are disruptive to operations when they occur. Maintenance issues have included couplings that loosened and a few cracked pipes that needed to be repaired.

It is difficult to forecast the remaining useful life of the PVC diffuser grid based on industry experience as no WWTPs have operating systems significantly older than NSWWTP's. Materials testing would be required to determine whether the PVC piping has degraded and needs to be replaced to maintain aeration reliability.

D. Aeration Controls

The existing aeration control system for the NSWWTP BNR system uses DO control. DO sensors are located at one-third down the length of Pass 2 and at the end of Pass 3 of the aeration tanks. These sensors measure the bulk fluid DO and the measured value is relayed back to a controller. The controller compares the value to a set point and adjusts the control valves in the air supply piping accordingly. Current DO set points are 1.5 mg/L in Pass 2 and 3.5 mg/L in the Pass 3. The DO concentration in Pass 1 is controlled by the DO measurement in Pass 2 such that if the Pass 2 DO drops below 0.4 mg/L, more air is supplied to Pass 1.

The aeration blowers are controlled on a pressure set point. If more air is required, the valves in the piping system open, which reduces the pressure in the system and calls for blowers to be ramped up or additional units to be brought online. The existing control valves installed in the air supply piping are the same size as the piping. This is a common situation that can lead to poor airflow control. The valve requires an adequate pressure drop to effectively control the airflow, which requires a valve several diameters smaller than the pipe size in aeration systems.

E. Postaeration

NSWWTP WPDES permit includes a minimum effluent DO requirement of 5.0 mg/L. The DO concentration is continuously monitored in the effluent pump wet well and a correlation is used to estimate the DO at the Badfish Creek outfall. Operators are notified when low DO conditions occur.

Under current normal plant operating conditions the minimum effluent DO concentration is achieved through reaeration via weirs, and other cascading flow downstream of the aeration tank. When plant effluent flow rates are high this reaeration is reduced. In general, plant staff have indicated that when two effluent pumps are running they need to increase the Pass 3 DO set point to 2 to 3 mg/L to provide additional DO to meet the minimum effluent DO concentration, and when three pumps are running a Pass 3 DO of 3 to 4 mg/L may be used. Plant operators choose whether these manual DO set point adjustments are warranted as flows increase. The use of elevated Pass 3 DO set points is reportedly infrequent and roughly estimated by plant staff to be on the order of 10 hours per year.

6.02 ACTIVATED SLUDGE BNR ALTERNATIVES SCREENING

Workshop Nos. 5a through 5c were held at the NSWWTP to discuss activated sludge operations, alternatives, and related information. Based on discussion at these workshops, the following BNR alternatives were selected for further evaluation:

- Alternative AS0–Maintain Existing Activated Sludge System (Null Alternative)
- Alternative AS1–Existing Modified University of Cape Town (UCT)
- Alternative AS2–UCT
- Alternative AS3–UCT with Sidestream Deammonification
- Alternative AS4–Main Stream Nitrite Shunt
- Alternative AS5–Chemically Enhanced Primary Treatment (CEPT) with Nitrite Shunt

These alternatives differ in their ability to reduce effluent TN discharges. Alternatives AS0 and AS1, Modified UCT, which also includes the two A/O trains within East Plant No. 1, are capable of achieving current permit limits but does not address reducing effluent TN discharges. In contrast, Alternatives AS2 through AS5 are targeted at achieving current permit discharge limits plus reducing TN discharges. All alternatives include step feed capabilities to route flows greater than 110 mgd to Pass 3 (as described in Section 4) to minimize secondary clarifiers solids loading rates (SLRs) and maximize TSS removal.

6.03 DESCRIPTION OF BNR ALTERNATIVES EVALUATED

This section presents descriptions of the short-listed alternatives evaluated, including facility requirements, predicted effluent quality, and changes in operations such as chemical usage or biosolids production. Design flows and loadings and effluent criteria used in this evaluation are presented in Sections 2 and 3, respectively. See TM-5 for more detailed information on the process screening and alternative evaluation.

A. Alternative AS0–Maintain Current Activated Sludge Operation (Null Alternative)

The Null Alternative assumes continued operation of existing modified UCT process with the existing aeration equipment, including blowers and diffusers. Excluding the two A/O trains in East Plant 1, the anaerobic and anoxic zones compose roughly 16 percent and 5 percent of the total aeration basin volume, respectively.

The capacity status of the major components of the existing system is as follows:

- Blower capacity: The forecast future peak airflow for continued use of the modified UCT process under the Null Alternative is within the firm capacity of the existing east and west blower systems, assuming that diffuser air transfer efficiency is maintained at roughly current levels. However, turndown limitations limit the ability of the plant to save energy by minimizing airflow, especially on the west side of the plant.

- Diffuser capacity: The existing diffuser system capacity is sufficient, but the target minimum airflow per diffuser of 1 scfm to minimize diffuser fouling restricts blower turndown.

- Airflow control valves: The existing process airflow control valves appear to be oversized for the projected airflow rates.

- RAS pumps: Based upon rated capacity, the existing RAS pumps have adequate firm capacity for normal load conditions and total capacity for future peak conditions. According to MMSD staff, RAS flow testing is recommended to confirm that the installed RAS pumping capacity matches the rated capacity.

The existing aeration basin sizing and layout are sufficient to meet the target effluent criteria at an aerobic SRT of 9 days. Step feed of peak hour flows is not required to maintain clarifier SLRs below critical levels; however, routing flows to Pass 3 when influent flows exceed 110 mgd is recommended to minimize negative impacts on anaerobic selector/EBPR performance and maximize clarifier TSS removal performance. This alternative assumes that the East Plant 1 two A/O trains are not modified.

Much of the existing equipment associated with the activated sludge system is near or beyond its useful life, including ceramic diffusers, blowers, flow meters, and control valves. The age of this equipment leads to higher risk of failure as well as increased O&M costs for this alternative.

This null alternative is truly a “do nothing” alternative. The viability of this alternative to serve the needs of the District through the year 2040 is questionable, if not doubtful, without significant rehabilitation costs throughout the planning period. However, the null alternative was presented as such to help identify and communicate the potential energy and O&M costs savings that may be realized by replacing the major aeration system components (i.e., Alternative AS1).

B. Alternative AS1–Existing Modified University of Cape Town (UCT) Process

Alternative AS1 includes maintaining the existing modified UCT flow scheme described in Alternative AS0. System improvements under this alternative include the replacement of the existing aeration blowers, replacement of the existing ceramic disc diffusers with EPDM discs, and new aeration control valves and flow meters. This alternative assumes that the East Plant 1 two A/O trains are not modified. The replacement of old and outdated equipment in this alternative reduces O&M costs as well as the risk of equipment failure for equipment that is beyond its useful life.

As long as MMSD continues to operate using the modified UCT, the existing control strategy based on DO measurement can be continued. Alternatively, ammonia based aeration control (ABAC) could be added to provide more control and reduce aeration demands. The aeration savings from adding ammonia inputs to the aeration control system is highly dependent on how low the DO set points are in the DO-only control system. Given the low summer month NH_3-N permit limitations of 2 mg/L, ABAC would provide the greatest benefit during winter conditions when the monthly average NH_3-N limit is 4 mg/L.

C. Alternative AS2–UCT Process

Alternative AS2 modifies the existing plant flow scheme to the UCT process to reduce TN discharges. This is accomplished by adding a mixed liquor recycle (MLR) flow from the last aerobic zone to the first anoxic zone, increasing the size of the existing anoxic zone, and adding a carbon source to reduce annual TN discharges below 10 mg TN/L.

Simulations showed that the UCT system is carbon-limited and therefore methanol addition was included to reduce the nitrate concentration leaving the anoxic zone to 0.5 mg/L, which maintains current EBPR performance. This alternative assumes that the aerated grids in Pass 1 and the first aerated grid (33 percent) of Pass 2 are converted to anoxic zones, simplifying design and construction. In this alternative, the East Plant 1 A/O trains are also converted to the UCT flow scheme.

Plant modifications to incorporate the UCT process configuration include the following:

- New 18,000-gallon methanol storage and metering system to feed methanol to the East and West plant secondary influent channels.
- Convert Pass 1 and the first aerated grid in Pass 2 to anoxic zones by removing the associated aeration grid/system, adding two mixers to each zone, and adding a baffle wall to Pass 2.
- Relocate the existing anoxic recycle pumps to the last anoxic zone and add piping to reconnect to existing recycle piping.
- Add MLR pumping to achieve 300 percent MLR flows at maximum month flows.
- Add three nitrate+nitrite (NO_x) sensors per plant to control methanol feed and MLR flows.
- Relocate the existing Pass 2 DO sensors to farther down the pass.

Aeration control upgrades include relocating the DO sensors is Pass 2 farther downstream at about the midpoint of the last third of the tank. A NO_x sensor is included in the last anoxic zone prior to the aerated zones and is used to pace the methanol addition and MLR to the anoxic zone.

This alternative also includes a new postaeration system with positive-displacement blowers and diffusers to increase effluent DO, especially during high flow conditions, without negatively impacting BNR performance. Biosolids production in this alternative remains essentially the same with UCT as additional solids generated from methanol addition are offset by the longer solids retention time (SRT), which reduces solids production.

D. Alternative AS3–UCT Process with Sidestream Deammonification

Alternative AS3 combines sidestream deammonification with Alternative AS2's UCT configuration in an effort to reduce UCT carbon and energy demands. Deammonification processes convert roughly 50 percent of the sidestream influent NH_3-N to nitrate nitrogen (NO_2-N) using ammonia-oxidizing bacteria (AOB). The resulting NO_2-N and remaining NH_3-N are then converted to nitrogen gas via anammox bacteria without carbon. The key advantage of the deammonification process is that no carbon is needed to convert sidestream ammonia loadings to nitrogen gas.

This alternative assumes that a sidestream deammonification system treating the Ostara effluent is provided to maximize nitrogen removal and minimize methanol needs in the main stream process. Effluent quality for the UCT with sidestream deammonification alternative is similar to Alternative 2, UCT, decreasing the average effluent TN to 14 to 15 mg N/L without methanol addition. If effluent TN is reduced below 10 mg N/L, deammonification reduces average methanol doses by approximately 10 percent.

This alternative also includes a new postaeration system with positive-displacement blowers and diffusers to increase effluent DO without negatively impacting BNR performance.

E. Alternative AS4–Main Stream Nitrite Shunt

Alternative AS4 modifies the existing operations to promote nitrite-shunt in which ammonia is oxidized to nitrite and then reduced to nitrogen gas. Key advantages of this alternative are no carbon addition is needed to meet TN reduction goals and reduced aeration demands. For this evaluation, the A/O flow scheme operated at controlled DO levels was selected. Nitrite shunt pilot testing at MMSD is being conducted to verify the kinetic parameters for detailed design.

Alternative AS4 can reduce average effluent TN discharges below 10 mg N/L without carbon addition and does not negatively impact EBPR performance. The existing aeration tank modifications to implement nitrite shunt consist of the following changes:

- Add ammonia/NO_x sensor to Pass 3B and a DO sensor to Pass 1 for ammonia versus nitrite/nitrate (AVN) control.
- Add a baffle wall between the second and third aeration grids in Pass 3.
- Add a new aeration control valve, meter, and DO sensor to control the aeration airflow in Zone 3C.
- Operationally, route RAS flow to the first anaerobic zone and stop pumping flow from the existing anoxic zone back to the first anaerobic zone.

This alternative also includes two additional 116-foot secondary clarifiers in the West Plant and a polymer addition system for both the East and West plants to address poor sludge quality (SVI) resulting from low DO operation. A new postaeration system with positive-displacement blowers and diffusers to increase effluent DO without negatively impacting BNR performance is also included in this alternative.

One of the major impacts of incorporating a nitrite shunt process is increased process control complexity. This includes AVN control to operate at the optimal point on a TN reduction using ammonia and NO_x sensors. These sensors determine whether aeration in Pass 1, 2, and the first two-thirds of Pass 3 should be increased or decreased to maintain the ammonia and nitrogen oxides (NOX) concentration in Zone 3B at equal levels. The DO in the final aeration zone of Pass 3 must be tightly controlled by a new control valve, airflow meter, and DO sensor to reduce ammonia levels to comply with permit requirements.

F. <u>Alternative AS5–CEPT with Nitrite Shunt</u>

Alternative AS5, CEPT with nitrite shunt, combines Alternative AS4 with CEPT to divert more carbon to the anaerobic digesters for increased biogas/energy production while reducing TN discharges without adding carbon (methanol).

CEPT is implemented by adding ferric chloride ($FeCl_3$) and polymer upstream of the primary clarifiers in locations such as the grit tank influent and effluent channels. The amount of $FeCl_3$ added to promote additional carbon capture must be balanced with maintaining sufficient primary effluent phosphate (PO_4-P) to promote EBPR, which is needed for the existing Ostara struvite recovery process. This alternative assumes that 15 mg/L of $FeCl_3$ is added to reduce primary effluent PO_4-P by 1 mg/L or 35 percent of the Alternative AS4 primary effluent PO_4-P to enhance energy production and still maintain struvite recovery.

It is estimated that CEPT will result in an increase in annual biogas production by roughly 65 scfm or 15 percent. In the near term, use of this additional gas would be limited by the existing engine capacity and heat demands. If a new biogas combined heat and power (CHP) system is installed in the future, this additional gas could be used to increase the CHP output by approximately 260 kW.

Compared to Alternative AS0 and AS1, this alternative would increase biosolids production by approximately 1.1 dry tons per day (DT/d) and reduce struvite production by approximately 0.9 DT/d. Adding 15 mg/L of $FeCl_3$ results in increasing the effluent chloride levels by roughly 10 mg/L, but is not expected to impact UV system operation.

As in Alternative AS4, this alternative also includes two additional 116-foot secondary clarifiers in the West Plant and a polymer addition system for both the East and West plants to offset the decrease in sludge quality resulting from low DO operation. In addition, Alternative AS5 includes a chemical building with $FeCl_3$ storage tank, $FeCl_3$ metering pumps, and polymer feed equipment.

A new postaeration system with positive-displacement blowers and diffusers to increase effluent DO without negatively impacting BNR performance is also included in this alternative.

6.04 AERATION SYSTEM ALTERNATIVE EVALUATION

A. Aeration Diffusers

Table 6.04-1 summarizes the predicted average and peak process airflow requirements and the selected DO profile for each alternative. Ceramic diffusers were not considered for Alternatives AS2 through AS5. In Alternatives AS4 and AS5, diffuser airflows less than 1 scfm/diffuser are desired to maintain low operating DO levels. Lower airflows are also desired in Alternatives AS2 and AS3 to reduce Pass 3C operating DO levels to 1 mg/L to minimize DO recycled in MLR.

Item	AS1: Existing Modified UCT	AS2: UCT	AS3: UCT with Sidestream Deammonification	AS4: Nitrite Shunt	AS5: CEPT with Nitrite Shunt
DO set point (Pass 1/2/3) [a]	0.3/0.8/2.0	-/0.8/2.0	-/0.8/2.0	0.1/0.1/0.1[d]	0.1/0.1/0.1[d]
Existing Ceramic Diffusers (Null Alternative)					
Total average airflow, scfm	34,100	--	--	--	--
Total peak airflow, scfm	62,500	--	--	--	--
Membrane Disc Diffusers [b]					
Total average airflow, scfm	30,700	30,500	29,300	22,300	22,600
Total peak airflow, scfm	55,000	53,900	52,000	58,800	55,700
Membrane Strip Diffusers [c]					
Total average airflow, scfm	28,400	28,200	27,100	20,400	20,600
Total peak airflow, scfm	53,000	51,900	50,100	54,800	51,800

[a]For Alternatives 2–5 the DO in last third of Pass 3 set a 1 mg/L. DO at peak demand set to 0.5 mg/L for all alternatives.
[b]Membrane disc airflow–engineer's estimate.
[c]Membrane strip airflows based on vendor designs received for Alternatives 1 and 4.
[d]Represents average DO in nitrite shunt simulation. Setpoints may vary depending upon bench and pilot scale testing.

Table 6.04-1 BNR Alternatives 2040 Process Aeration Airflow Summary

Alternative AS1 airflow rates with membrane disc and membrane strip diffusers are 10 to 15 percent and 15 to 20 percent lower, respectively, than the existing ceramic diffusers. When comparing membrane disc diffusers, the average and peak airflow requirements for Alternatives AS1 through AS3 are within 5 percent and considered equal for planning purposes. Average airflows for Alternatives AS4 and AS5 decrease by 25 to 30 percent compared to Alternative AS1. Alternative AS4 peak total airflow rates increased by 5 percent while Alternative AS5 total peak airflow rates remained roughly the same as Alternative AS1. Membrane strip diffuser annual and peak airflow rates are 7 percent and 5 percent lower, respectively, than the membrane disc diffusers as a result of higher diffuser standard oxygen transfer efficiency (SOTE).

A diffuser net present worth evaluation was conducted to compare the net present worth of standard and high-efficiency fine-pore diffusers and is summarized in Table 6.04-2. This analysis is intended to evaluate whether the increased equipment cost of high-efficiency diffusers should be included in the alternative's capital cost opinion, and is not intended to be a final diffuser technology recommendation. The net present worth evaluation indicates that under similar fouling assumptions the EPDM disc and membrane strip alternatives have essentially equivalent net present worth.

	Existing Ceramic Diffusers (Null Alternative)	**EPDM Disc**	**Membrane Strip**
Total Opinion of Capital Cost[d,e]	$0	$2,630,000	$3,630000
Present Worth			
Maintenance[g]	$520,000	$550,000	$470,000
Blower Energy [a,f]	$10,400,000	$8,600,000	$7,800,000
Replacement	$0	$1,200,000 [b]	$1,200,000 [c]
Total Opinion of Present Worth	**$11,000,000**	**$12,900,000**	**$13,100,000**

[a]Assumes new high efficiency blowers with turndown constraints relieved.
[b]7-year replacement cycle, $600,000 per cycle (2016 dollars).
[c]15-year replacement cycle, $1,300,000 per cycle (2016 dollars).
[d]Contingency and technical services included
[e]Diffuser vendor quotes (Sanitaire, Aerostrip)
[f]Continued use of the biogas blower no. 1 is assumed, with an energy cost of "zero".
[g]Diffuser maintenance estimated as $21,000/year for EPDM disc and $19,000 per year for membrane strips, covering cleaning and miscellaneous pipe repairs. Blower maintenance is not included in this estimate.

Table 6.04-2 Diffuser Alternative Opinion of Present Worth Summary

The net present worth analysis is dominated by the 20-year blower energy cost which was estimated using the average airflow rates shown in Table 6.04-1, with normal airflow variation. The blower energy estimate is influenced by both the original diffuser efficiency and the rate and degree of fouling. Differences in fouling assumptions can have a significant impact on the comparison between diffuser types in this analysis. Because the net present worth for the EPDM discs and membrane strips are essentially equal if unfouled conditions are assumed, any differences in rate of fouling and average fouling condition will cause the slower-fouling system to be favored over the more fouled diffuser system. If the membrane strips (or one of the other diffuser technologies) can be fairly tested and found to have a fouling advantage, the high-efficiency diffusers would have a lower net present worth than the standard-efficiency diffusers. Because high-efficiency diffusers appear to be at least comparable to the standard-efficiency diffusers, additional capital budget for high-efficiency diffusers appears to be warranted.

B. Aeration Blowers

Although the existing blowers may be reaching the end of their useful life by conventional asset management expectations, the plant has maintained its equipment well and it does not appear that all blower units would need to be replaced concurrently. Instead, new blowers could be phased in over time to gain efficiency from one or two new blowers while the remaining blowers served as standby capacity. The following blower technologies were evaluated based on criteria such as available airflow capacity, energy efficiency, electrical requirements, and issues related to surge conditions:

- Single-Stage Integrally Geared Centrifugal Blowers
- High-Speed Turbo Blowers (Air or Magnetic Bearings)
- Screw Blowers
- Multistage Centrifugal Blowers

Single-stage integrally geared centrifugal blowers are available in sizes that are well matched to the sizes needed for a one-for-one replacement of west and east plant blowers and were used for estimating the capital cost and energy consumption for the BNR alternative present worth analysis in Section 6.07. High speed turbo blowers with magnetic bearings or screw positive displacement blowers are also potentially viable technologies that warrant further consideration during the final design of future blower retrofits.

6.05 BNR ALTERNATIVES DESIGN CRITERIA

Design criteria for each of the BNR alternatives, including operational parameters and chemical usage, are presented in Table 6.05-1. These criteria are used in the treatment performance evaluation simulations presented in Section 6.06 and the present worth analysis presented in Section 6.07.

Table 6.05-1 BNR Alternatives Process Design Criteria

Item	AS0/1 Existing Modified UCT	AS2 UCT	AS3 UCT with Sidestream Deammonification	AS4 Nitrite Shunt	AS5 CEPT with Nitrite Shunt
Influent flow to East plant (average/peak), percent	50/50	50/50	50/50	50/43	50/43
East Aeration Tanks					
Total volume (existing), MG	12.15	12.15	12.15	12.15	12.15
Anaerobic volume, % total	17	17	17	21	21
Anoxic volume, % total	4	28	28	0	0
Aerobic/total SRT, Days	9/11	9/15	9/15	12/15	15/19
Maximum month MLSS, mg/L	2,400	3,600	3,500	3,200	3,200
Mixed liquor return [a], % E. influent	--	300	300	--	--
Anaerobic recycle [a], % E. influent	73	73	73	--	--
East Secondary Clarifiers					
Clarifiers in service, No.	11	11	11	11	11
Pass 3 MLSS at peak hour flow, mg/L	2,400	3,100	3,000	2,750	2,750
RAS, mgd	34	42	42	37	37
Peak hour SLR, lb/ft^2-d	28	38[b]	37[b]	30	30
West Aeration Tanks					
No. of tanks	4	4	4	4	4
Total volume, MG	11.78	11.78	11.78	11.78	11.78
Anaerobic volume, % total	16	16	16	21	21
Anoxic volume, % total	5	28	28	0	0
Aerobic/total SRT, Days	9/10	9/15	9/15	12/15	15/19
Maximum month MLSS, mg/L	2,500	3,600	3,500	3,200	3,200
Mixed liquor return [a] ,% W. influent	--	300	300	--	--
Anaerobic recycle [a], % W. influent	60	60	60	--	--
West Secondary Clarifiers					
Clarifiers in service	8	8	8	10	10
Pass 3 MLSS at peak hour flow, mg/L	2,500	3,100	3,000	2,750	2,750
RAS. ,mgd	34.4	34.4	34.4	34.4	34.4
Peak hour SLR, lb/ft^2-d	25	31 [b]	30[2]	24	24
Additional Annual Requirements					
Methanol, gpd	--	2,250	2,000	0	0
$FeCl_3$, gpd	--	0	0	0	1,000
Polymer, DT/yr				40[c]	125[c]
Biosolids disposal, DT/d	--	0.7	0.5	-2.0	1.1
Struvite production, T/d	--	0	0	0	-0.9
30% $MgCl_2$, T/d	-	0	0	0	-0.17

[a]Mixed liquor return (aerobic to anoxic) and anaerobic recycle (anoxic to anaerobic) capped at 300% and 75% of the plant influent maximum month flow, respectively.
[b]Assumes mixed liquor return is turned off during peak flow events to minimize Pass3 MLSS to clarifiers.
[c]Nitrite shunt polymer addition may also consist of RAS chlorination to minimize costs. Planning O&M costing based upon polymer addition only.

6.06 BNR ALTERNATIVES TREATMENT PERFORMANCE EVALUATION

Treatment performance for each alternative was evaluated, including clarifier loading analysis and whole-plant process modeling using a calibrated NSWWTP BioWin™ model. This evaluation used the Year 2040 projected influent flows and loadings presented in Section 3. For facility evaluation, three loading conditions were considered to define system requirements:

- Condition 1–Maximum month flows and loadings at the minimum month temperature to establish the mixed liquor suspended solids (MLSS) concentration for aeration basin/secondary clarifier sizing and peak aeration demands in latter zones of the aeration tank.

- Condition 2–Maximum month flows and loadings at the maximum month temperature to define the peak aeration system demands.

- Condition 3–Annual average flows, loadings, and temperature to define annual operating conditions.

The design temperatures are based on historical daily effluent temperatures from January 1, 2013, through April 28, 2016 (influent temperatures are not available). For evaluation purposes, the maximum, minimum, and average monthly temperatures of 22, 11, and 15 degrees Celsius (°C), respectively, were selected.

The secondary clarifier capacity was evaluated based upon the maximum allowable SLR capacity as determined using state point analysis (SPA) assuming all clarifiers, RAS pumps, and aeration tanks are in service during peak hour flow conditions. The peak hour flow for process evaluations was defined as the flow associated with a 5-year storm event of 135 mgd. The secondary clarifiers will also need to pass the peak hydraulic flow of 180 mgd. Because there is an inherent uncertainty in defining secondary clarifier capacity using SPA, the calculated maximum allowable SLR was decreased by 20 percent to account for non-ideal settling and thickening in the clarifiers resulting in a lower maximum SLR. It is recommended that the secondary clarifiers be stress-tested with subsequent computational fluid dynamics (CFD) modeling to confirm the secondary clarifiers solids loading rate capacity.

Table 6.06-1 summarizes the secondary clarifier design criteria used in this analysis. The nitrite shunt SVI of 175 mL/g is greater than the UCT-based alternatives as the low operating DO levels will negatively impact sludge quality. The design SVI of 175 mL/g assumes that RAS chlorination and/or polymer is added to control bulking sludge. For the nitrite shunt alternatives, the East Plant RAS pumping capacity was not increased above 37 mgd as higher RAS flows did not increase maximum SLR. Increasing the West plant RAS capacity from 34.4 mgd to 39 mgd could increase the West clarifiers' SLR capacity by 10 percent for both flow schemes, but was not considered for this evaluation. This analysis assumes polymer is added six months per year to reduce SVIs below 175 mL/g to estimate annual chemical requirements. Capital costs assume both RAS chlorination and polymer addition facilities are installed.

	Unit	AS0-AS3 UCT-Based Alternatives	AS4 & AS5 Nitrite Shunt Alternatives
Peak hour flow	mgd	135	135
Design SVI	mL/g	125	175
Clarifier Surface Area [a]			
East Plant	ft^2	73,690	73,690
West Plant	ft^2	84,546	84,546
Return Sludge Flow			
East Plant	mgd	34/42	37
West Plant	mgd	34	34
Maximum Solids Loading Rate			
East Plant	lb/ft^2-d	34/38	30
West Plant	lb/ft^2-d	31	26
Surface Overflow Rate at Peak Hour Flow [b]			
East Plant	gal/ft^2-d	915	915
West Plant	gal/ft^2-d	800	800

[a]Surface area of all existing clarifiers in service.
[b]Assumes peak-hour flow of 135 mgd is split equally between East and West plants

Table 6.06-1 Secondary Clarifier Solids Loading Rate Capacity

This evaluation assumes that each BNR alternative will incorporate biological contact treatment as described in Section 5, which step feeds primary effluent flows in excess of roughly 100 mgd to 110 mgd to Pass 3 of the aeration tanks.

Table 6.06-2 summarizes anticipated effluent ammonia, TP, and TN concentrations for each alternative.

	AS0 Existing Modified UCT	AS1 Existing Modified UCT	AS2 UCT	AS3 UCT with Sidestream Deammonification	AS4 Nitrite Shunt	AS5 CEPT with Nitrite Shunt
Monthly NH_3-N (warm/cold), mg/L	<0.1/0.1	<0.1/0.1	<0.1/0.6[c] 1.6[d]	<0.1/0.6	0.5/1.5	0.5/3.0
Monthly TP, mg/L	0.4	0.4	0.4	0.4	0.3	0.3
Annual TN, mg/L	20	20	15.5 [a]/8 [b]	≈14 [a]/8 [b]	7.5	12
Mature TN reduction technology	NA	NA	Yes	Yes	No	No

[a]No carbon addition, average conditions.
[b]With carbon addition, average conditions.
[c]Steady-state BioWin simulation.
[d]Predicted effluent NH-N_3 for dynamic simulation for comparison with Alternatives AS4 and AS5

Table 6.06-2 BNR Alternatives Predicted Effluent Quality Comparison

6.07 BNR ALTERNATIVES PRESENT WORTH ANALYSIS

Table 6.07-1 provides a summary of the opinion of present worth values for the six alternatives under both existing blower and new blower scenarios. A detailed breakdown of present worth costs is included in Technical Memorandum No. 5b (TM-5b). It is important to note that this alternative comparison includes alternatives with differing levels of service in terms of effluent quality and process risk.

Operating costs in this present worth analysis include energy and chemical use, biosolids production, and struvite operating costs for each alternative as well as a comparison of the annual operating costs of the existing blowers and new blowers with improved efficiency and improved turndown capabilities.

Energy use estimates includes reduced natural gas consumption for engine-driven blowers from improved aeration controls, turndown, and low DO operation (Alternatives AS4 and AS5) as well as increased biogas production from CEPT operation.

Alternatives AS0 and AS1 have the lowest net present worth in this analysis, but these alternatives have higher projected effluent TN concentrations than the other alternatives. The equivalent net present worth for Alternative AS0 and Alternative AS1 with new blowers indicates that the energy upgrades to the blowers, diffusers, and controls included in Alternative AS1 provide sufficient energy savings to balance the estimated capital cost over the 20-year planning period. Similarly, the existing and new blower life-cycle costs for the Alternatives AS2 through AS5 are effectively equal in this analysis However, it should be noted that this blower upgrade scope is focused on energy savings and is limited to one new west blower and two new east blowers. TM-5 and Section 6.09 provide an expanded comparison of blower replacements that includes phased-in east-west cross-connection piping and staged replacement of additional blowers as they reach the end of their useful life.

A major factor in the life-cycle cost analysis is the secondary clarifier addition associated with the nitrite shunt alternatives. If the clarifier tank addition can be deferred or omitted based on stress testing and subsequent computational fluid dynamic modeling of the clarifiers, Alternative AS4 would become approximately equivalent on a new present worth basis with continued use of Modified UCT. Under current SLR assumptions the additional clarifiers would not be required until 2028 based upon current growth projections and assumed clarifier capacity.

6.08 BNR ALTERNATIVES NONMONETARY EVALUATION

Nonmonetary considerations related to process flexibility, operational complexity, chemical use, and technology risk for each alternative were evaluated and are summarized in Table 6.08-1. Other nonmonetary considerations are described in the following.

- Blower Energy: The nitrite shunt alternative significantly reduces blower energy. CEPT enhancement of nitrite shunt further reduces net energy by producing more biogas, but the chemical costs make this approach less financially feasible.

- Non-Blower Energy: The UCT process energy demands are greater than the existing because of addition of the MLR system and additional mixed zones.

- Greenhouse Gas (GHG) Emissions: GHG emissions related to natural gas and electrical consumption vary between BNR alternatives as indicated by energy costs. UCT processes that use methanol as a carbon source incur a significant increase in GHG emissions because methanol is derived from fossil fuels. Some plants have begun to use alternative carbon sources such as glycerin products to reduce this impact. Nitrous oxide (N_2O) emissions associated with nitrogen treatment are relatively small, but their impact can be significant because N_2O has a GHG impact 300 times that of CO_2. Research to better understand and quantify the mechanisms of N_2O emissions is one of the most active research areas related to GHG emissions from wastewater management. In general, field measurements have shown that plants that achieve high levels of nitrogen removal emit less N_2O and most N_2O emissions occur in aerated zones because of air stripping. This area of research should continue to be monitored, especially as data regarding N_2O emissions from nitrite shunt processes become available.

Table 6.07-1 BNR Alternatives Opinion of Present Worth Summary

	Alternative AS0	**Alternative AS1**	**Alternative AS2**	**Alternative AS3**	**Alternative AS4**	**Alternative AS5**
Total Opinion of Capital Cost						
BNR Improvements	$0	$4,100,000	$16,800,000	$21,700,000	$18,500,000	$19,400,000
BNR Improvements and New Blowers	$0	$8,600,000	$21,300,000	$26,200,000	$22,900,000	$23,800,000
Annual O&M						
Existing Blowers	$960,000	$700,000	$2,700,000	$2,500,000	$610,000	$1,600,000
New Blowers	$590,000	$470,000	$2,500,000	$2,200,000	$390,000	$1,300,000
Present Worth						
O&M						
Existing Blowers	$16,500,000	$13,000,000	$48,300,000	$45,700,000	$12,300,000	$30,200,000
New Blowers	$10,300,000	$8,000,000	$43,500,000	$41,500,000	$7,400,000	$25,300,000
Increased biogas production and reduced natural gas	$0	($100,000)[b]	($50,000)	($100,0000)	($80,000)	($300,000)
Total Opinion of Present Worth						
Existing blowers	**$16,500,000**	**$17,000,000**	**$65,100,000**	**$67,300,000**	**$29,900,000**	**$46,700,000**
New blowers	**$10,300,000**	**$16,500,000**	**$64,800,000**	**$67,600,000**	**$29,500,000**	**$46,200,000**
Avoided clarifier tank addition [a]	**N/A**	**N/A**	**N/A**	**N/A**	**$17,800,000**	**$34,500,000**

[a]Net present worth estimate for scenario in which clarifier stress testing finds that clarifier addition is not required prior to the end of the planning period in 2040. This estimate is based on the new blower scenario, but excludes $7,700,000 in clarifier capital costs and $3,900,000 in related contingency and technical services from the base case estimate.

[b]Blower 1 fuel savings related to increased airflow turndown with membrane diffusers.

Table 6.08-1 BNR Alternative Nonmonetary Considerations Summary

Alternative	Benefits	Limitations
ASO: Null alternative	▪ Plant staff familiarity ▪ Performance well proven at NSWWTP ▪ Opportunity to wait for emerging technologies to mature	▪ Does not improve energy efficiency ▪ Does not address risks related to aging equipment
AS1: Existing Modified UCT	▪ Same as Null alternative ▪ Blower turndown with membrane diffusers ▪ New equipment	▪ Uncertainty related to site-specific fouling characteristics of new diffuser technologies
AS2: UCT	▪ Plant staff are familiar with this configuration ▪ Can be designed for flexible operations in nitrite shunt mode	▪ Internal mixed liquor recycle (IMLR) and supplemental carbon add some complexity for operations
AS3: UCT with Sidestream Deammonification	▪ Can be designed for flexible operations in nitrite shunt mode ▪ Reduces supplemental carbon requirements by 10 percent compared to UCT alternative ▪ Takes advantage of shortcut denitrification process to reduce carbon addition ▪ Deammonification is a simple robust process that is automated ▪ Potential to bioaugment mainstream with Anammox biomass	▪ Deammonification systems are patented ▪ Additional process to operate increases complexity ▪ Heating required in sidestream reactor to maintain deammonification activity ▪ Deammonification installations downstream of Ostara process not proven
AS4: Nitrite Shunt	▪ Emerging technology which could set precedence for other utilities to follow ▪ Can be designed for flexible operations in modified UCT mode	▪ Limited installations ▪ The risk of exceeding effluent ammonia limits may be higher than with other alternatives ▪ May require chemical addition for low effluent TP ▪ More complex and potentially more labor required to operate than UCT alternatives—additional nitrogen sensors and accurate aeration control required, as well as potential chemical addition facilities ▪ Reduced sludge volume index (SVI) impact on secondary clarifiers and anticipated polymer feed and RAS chlorination to control settling
AS5: CEPT with Nitrite Shunt	▪ Same as nitrite shunt	▪ Same as nitrite shunt plus the following: ▪ Additional aeration savings not predicted to be significant ▪ CEPT operations add more complexity

6.09 EAST-WEST AERATION SYSTEM CROSS-CONNECTION EVALUATION

Currently the NSWWTP east and west blower complexes supply air to the east and west plants, respectively, and are completely separate systems. During development of the 2014 energy study MMSD staff suggested a possible cross-connection of the east and west aeration systems as a means to reduce energy consumption by using excess west blower capacity within Plants 1 and 2, especially if the transferred flow of air was sufficient to eliminate normal operation of blower 4 or 5. Two cross-connection scenarios were evaluated as part of this Facilities Plan:

- Partial blower cross-connect incorporating the 8-inch-diameter existing pipe to headworks.
- Full capacity east-west cross-connection using new 30-inch-diameter pipe.

After analyzing a partial blower cross-connection using the 8-inch-diameter existing piping, it was determined that this scenario was not feasible because it could not transfer enough air.

A preliminary concept design was developed for a full capacity cross-connection that includes the following components:

- Connection to the west aeration header in the west aeration gallery.

- 30-inch-diameter aeration piping through tunnel between Plant 3 and Plant 4, including insulation to mitigate the safety concern with high-temperature piping near the walkway.

- 30-inch-diameter above-grade piping from Aeration Building 4 to the East Blower building, including overhead pipe supports.

- Connection to east aeration header with valve in blower room.

The existing diffuser submergence is 1 foot greater on the west side than on the east side. In a cross-connected configuration this difference must be throttled so that the airflow from the west does not favor the east aeration tanks. Several options are available to create this balance. For this evaluation it was assumed that an air pressure control valve would be installed between east and west air headers with 1-foot pressure drop. However, other options, such as installing air pressure control valves only on tanks 1 through 6 with a lower diffuser mounting in tanks 7 through 18 when new diffusers are installed, should be considered prior to final design because it results in a more standard diffuser mounting level and reduces energy wasted through the balancing valve.

A benefit of the full-size east-west cross-connection piping is to provide some redundancy between the east and west blower systems. Under the infrequent standby operating condition when the east blowers are supplying air to the west, the aeration control valves would need to be manually adjusted to balance flows and in the east blower discharge pressure would increase from its current setting. With this increased head pressure condition, the east blower airflows are slightly reduced. With four east blowers in service, and under average east blower airflow conditions plus 25 percent for diurnal variation, 26,100 cubic feet per minute (cfm) would be available to supply west aeration. Based on this analysis it appears that the blower capacity in both the east and west facilities is sufficient to provide aeration in either direction.

The cross-connect also provides some energy reduction even with existing blowers by eliminating the need to operate blower 4 or 5 and by operating the west blower in a more efficient condition closer to 100 percent capacity. The energy costs used in the net present worth comparison are based on continued Modified UCT operation with increasing airflow due to growth over the planning period.

A present worth analysis was conducted to compare the installation of a cross-connection between the east and west blowers and the continued operation of separate aeration systems. Table 6.09-1 summarizes the phasing assumptions used for the net present worth analysis. Electrical consumption estimates were based on the "Normal Blower Mode", with increasing airflows over the planning period. The biogas upgrade project and blower 1 decommissioning are assumed to occur around planning year 2025. At this time, under the cross-connected blower scenario all air would be supplied from the west side, using new blowers sized to provide the airflow required by the BNR approach selected for long term operations.

Demolition of the east blower equipment and building is not included in the capital cost estimate. However, the cross-connect scenario analysis assumed maintenance would decrease as the east blowers would not be actively maintained. As such, the east blowers would remain available as a backup only until they are no longer operable due to equipment failures. In other words, if no investments are made to the east blower mechanical and electrical equipment, the ability of the east blowers to serve as a back-up for the west blowers (as described above) could be compromised over time by equipment conditions in the East Blower building, especially if the east blower equipment is idle for extended periods. Conversely, MMSD could choose to make investments to keep the east blowers available for standby service, but these investments would diminish the life cycle cost advantage of the piping cross-connection.

Table 6.09-2 presents the net present worth comparison of the two scenarios. Based on the phasing assumptions in Table 6.09-1, the cross-connected blowers scenario has a lower net present worth because it eliminates east blower replacements and electrical distribution upgrades for the East Blower building and reduces the estimated blower electrical consumption. However, if no investments are made to the east blower mechanical and electrical equipment, the ability of the east blowers to serve as a back-up for the west blowers (as described above) could be compromised over time by equipment conditions in the East Blower building, especially if the east blower equipment is idle for extended periods.

Years	West Blower Average Flow (scfm)	East Blower Average Flow (scfm)	Cross-Connected Blowers		Continued Separate East-West Blowers	
			Normal Blower Mode	Capital Improvements	Normal Blower Mode	Capital Improvements
2020 to 2025	11,300	11,800	• Existing west blower • Blower 1	• East-west piping	• West blower • Blower 1 • Blower 4	• One new west blower • West blower electrical upgrade
2025 to 2030	12,100	12,700	• New west blower	• Two new west blowers • West blower electrical upgrade	• New west blower • New east blower(s)	• Four new east blowers • East blower electrical upgrade
2030 to 2035	12,900	13,400	• New west blower	• Replace remaining west blower	• New west blower • New east blower(s)	• Replace remaining west blowers
2035 to 2040	13,600	14,100	• New west blower	-	• New west blower • New east blower(s)	-

Table 6.09-1 Preliminary Blower Phasing Assumptions for Present Worth Analysis

	Continued Separate East-West Blowers	Cross-Connected Blowers
Total Opinion of Capital Cost[a]	$12,500,000	$9,300,000
Present Worth of O&M	$14,900,000	$13,600,000
Total Opinion of Present Worth	**$27,400,000**	**$22,900,000**

[a]Blower capital cost estimates includes replacement of all existing blowers over the course of the planning period in order to highlight the impact of the cross connection piping on future blower projects.

Table 6.09-2 Blower Cross-Connection Alternatives Opinion of Present Worth Summary

6.10 BLOWER IMPROVEMENT STAGING

Table 6.09-1 presented alternate blower phasing scenarios with and without the proposed aeration cross-connection piping connection. The considerations described in this section were used to develop these proposed blower improvement sequences. Assuming the cross-connection piping alternative is implemented as described in Section 6.09, future blower improvement staging will be focused on the west blower complex.

Both the east and west blower complexes have adequate firm capacity to serve the forecast peak airflow conditions, so peak capacity is not a factor in establishing blower phasing. Similar to the BNR alternatives phasing, blower phasing can be approached through strategic support and phased implementation in conjunction with BNR decision points.

If MMSD chooses to implement blower improvements in a phased program, the west blowers should be given priority for the following reasons:

- The west blowers are limited by turndown and this constraint will limit future savings from either nitrite shunt or high-efficiency diffusers.

- The potential to realize energy savings from improved blower efficiency is higher on the west because it does not have an engine-driven blower.

- Despite being newer and having significant excess capacity, the west blower complex also appears to have the higher risk of prolonged outages that could impact firm blower capacity.

The biggest hurdle to near-term west blower replacement is uncertainty about BNR alternative implementation. Ideally, new blowers would have flexibility to operate over the range of airflows anticipated by potential future scenarios. However, the turndown range implied by this flexibility may be greater than the range of a single blower. As such, some combination of the following approaches could be pursued, bearing in mind that the final design would need to provide firm capacity to meet the projected peak flows with a combination of one large blower and one new blower:

- Installation of a blower model that could be modified via impeller replacement or speed modification in the future.

- Design for a separate channel blower to reduce aeration blower peak air demand.

- Reconfiguration of the blower layout to allow two smaller blowers.

The east blowers are not as limited by turndown and there are multiple redundant units, which mitigates the risk of a major aeration outage. In addition, if the nitrite shunt approach is successful it would allow Plants 1 and 2 to be operated with the engine-driven blower. However, the age and efficiency of the blowers make them candidates for replacement within the next 5 to 10 years.

Deferring the east motor-driven blower replacements will also allow for better coordination with the planned conversion to biogas engine-generators and possible east-west cross-connection piping.

6.11 ENHANCED PHOSPHORUS REDUCTION

Because of MMSD's plan to continue with the Yahara WINs AM approach in the Badfish Creek (Rock River) watershed into the foreseeable future, it is unlikely that a TP limit below 0.5 mg/L (6-month average) would be incorporated into the NSWWTP WPDES permit within the planning period of this Facilities Plan. In addition, if very stringent TP limits were implemented for the Badger Mill Creek discharge location (Sugar River watershed), MMSD may discontinue discharge to Badger Mill Creek altogether, or perhaps seek trading partners to meet future water quality goals. In either case, it was decided that effluent TP limits of less than 0.5 mg/L would not be required to be met within the planning window of this facilities planning project. However, there is a potential that MMSD may want to maintain effluent TP levels in the range of 0.25 to 0.30 mg/L, or lower to maintain (or reduce) costs associated with the Yahara WINs program. As effluent TP loadings increase, the cost to participate in the Yahara WINs program also increases.

MMSD commissioned a recent high-level planning project in 2011 and 2012 (Preliminary Nutrient Removal Cost Estimates, prepared by CH2M Hill) to study the facilities needed to meet a range of monthly effluent TP limits of 0.13 and 0.225 mg/L, annual effluent TP limits of 0.075 mg/L, and monthly TN limits of 3 to 10 mg/L. The purpose of the discussion below is to present a summary of that report and additional comments pertaining to the impacts that low phosphorus limits and effluent filters may have on NSWWTP operations and facilities.

A. Six-Month Average Target Phosphorus of 0.25 to 0.30 mg/L

With respect to the current facilities planning effort, Scenario 1 from the CH2M Technical Memorandum represented the conditions that were most similar to the potential future effluent TP target of 0.25 to 0.30 mg/L on a 6-month average basis. Scenario 1 included a monthly TP limit of 0.225 mg/L, no total nitrogen limit, and existing ammonia limits. The effluent target of 0.11 mg/L TP was selected to achieve the 0.225 mg/L limit reliably. To meet this target effluent concentration, the following facilities were assumed:

- Deep-bed granular media filters.
- Metal salt storage and addition facilities.
- Secondary effluent pump station.
- The filters and pumping facilities were sized to handle 79 mgd, which is approximately the capacity of the existing effluent pump station. This sizing criterion is slightly larger than the 71 mgd peak month flow criterion used for the BNR alternatives presented earlier in this Technical Memorandum, reflecting short-term higher flows to filtration. This maximum capacity may not be required to meet the future effluent TP limit, especially if the limit is a 6-month average limit such as is proposed under the current rules.
- The initial capital cost associated with this alternative was approximately $60 million in 2012 dollars. Annual O&M costs were estimated to be approximately $800,000.

B. Six-Month Average Target Phosphorus of 0.075 mg/L

This scenario represents the potential future effluent phosphorus limit based on water quality criteria for the discharge to Badger Mill Creek, and was presented as Scenario 3 in the CH2M Technical Memorandum:

- A target of 0.05 mg/L TP was selected to achieve the limit reliably.
- This alternative included the processes from Scenario 1, as well as a second feed point for metal salt addition, rapid-mix system, polymer storage and feed facility, flocculation basin, and lamella clarifiers.
- All processes were sized to handle a maximum flow rate of 79 mgd.
- Both the rapid-mix and flocculation systems consisted of four active trains plus a standby train.
- The initial capital cost associated with this alternative was approximately $91 million in 2012 dollars. Annual O&M costs were estimated to be approximately $2.4 million.

C. Chemical Addition for Tertiary Filtration

The addition of filters to meet an effluent TP limit of 0.25 to 0.30 mg/L is not expected to use a significant amount of metal salts. In fact, the previous study indicated that, on an average basis, no metal salts would need to be added. Therefore, operation of new effluent filters to reliably meet a limit in the range of 0.25 to 0.30 mg/L would not be expected to have a significant impact on the existing treatment processes and overall operation of NSWWTP. However, for an effluent TP limit of 0.10 mg/L or lower, the chemical addition required would be significant and could impact existing operations and effluent chloride levels. Waste sludge from such operations has a high concentration of “unused” coagulant. If this unused chemical is recycled back to the plant headworks or primary clarifiers rather than a dedicated solids processing system, it will react with influent ortho-phosphate. Ultimately, depending on actual coagulant doses required, the recycling of coagulant could negatively impact the production of struvite in the Ostara process, which would reduce revenue from the sale of the struvite product. Finally, sludge generation from metal salt addition side reactions would increase biosolids quantities significantly, resulting in higher solids management costs.

If future, low effluent TP limits are required to be met at NSWWTP, a concept that should be explored includes using the high metal salt recycle stream to replace the existing ferric feed to the digesters for hydrogen sulfide control. This could eliminate or reduce the purchase of virgin iron salts added for sulfide control.

6.12 RECOMMENDED PLAN

This section presents recommendations resulting from the study, including further investigations and BNR system issues to be addressed. The proposed approach to BNR and asset renewal is summarized in Table 6.12-1.

A. Secondary Clarifier Stress Testing

Secondary clarifier stress testing and subsequent CFD modeling are recommended to confirm the existing clarifier SLR capacity as each TN reduction alternative has secondary clarifiers SLR at the estimated maximum allowable levels at 2040 critical flow and loading conditions. Stress testing and analysis should be completed as part of the facility improvements predesign to confirm facility requirements. RAS pump hydraulic pumping capacity should also be tested to verify installed capacity meets design data.

B. Pilot Test Nitrite Shunt Operation

If bench-scale testing is successful, full-scale demonstration testing is recommended to further confirm process design criteria, impacts to sludge quality, and operational requirements. The full-scale demonstration test will require one plant to be operated as a nitrite shunt only plant. Converting the existing ceramic diffusers to membrane disc diffusers is required to reduce aeration airflow to the basins and provisions to independently control Zone 3C aeration is needed, or needs to be evaluated in further detail to ensure that combined discharges will meet the plant's WPDES permit. Instrumentation associated with AVN control and Zone 3C DO is also required.

C. Diffuser Grid: PVC Embrittlement Investigation

Theoretically, the existing PVC diffuser grid could be reused and optimized for projected airflow requirements for each aeration zone. However, because the system has already been in operation for 30 years it is likely that the diffuser grid will need to be replaced during the planning period. The timing of this replacement will depend on the likelihood of increasing PVC fractures under normal operation or during future diffuser element plugging or grid modifications.

Bend and tensile testing can be used to determine whether the PVC has become embrittled with age and therefore more prone to failure. The testing results would be compared with a sample of new piping, which may not match the original, but would provide an "order of magnitude" comparison to assess. In addition, materials testing firms could do cross-sectioning and examination to see if any material degradation is evident.

D. Diffuser Grid: Fouling Changes Following Ostara, Cleaning Implications

Previous investigations into ceramic diffuser fouling have implicated mineral deposits, including phosphorus and magnesium. The plant has controlled this fouling by maintaining airflows above a minimum 1 scfm/diffuser rate to move the water/air interface out of the ceramic stone. The Ostara process has reduced the quantity of phosphate and magnesium recycled back to the aeration basins. The reduced phosphate concentrations also decrease the magnesium levels in the aeration basins as EBPR anaerobic phosphate release also releases magnesium into solution as magnesium serves as counter-ion to phosphate so phosphate can cross the cell membrane wall. When MMSD considers future diffuser projects and diffuser types, a small research project that revisits the Waddington (Waddington 1995) findings under current mineral loading rates could improve the accuracy of future diffuser alternatives evaluations. In addition, Sanitaire is now offering liquid cleaning systems that may also provide another means to control ceramic diffuser fouling.

E. RAS Pump Energy Efficiency

The existing RAS pumps are suitable for continued use under the future BNR alternatives. However, there may be opportunities to increase energy efficiency in the RAS system, including modifying the control system to include "most open valve" logic, evaluating variable frequency device (VFD) retrofits, and considering replacement of older motors with higher-efficiency motors.

F. Addressing Other BNR System Maintenance Issues

Plant staff identified other BNR operating issues:

- Scum beach icing control
- Plant 2 RAS control valves
- Drainage pump capacity
- Weir surcharge
- East and west plant flow measurement

Funding to address these issues should be included as capital budgets are established for the facility plan.

Table 6.12-1 NSWWTP BNR Alternatives Phasing Strategy

Item	Approach	Timing	Justifications
BNR strategy	Nitrite shunt bench testing	Ongoing	▪ Evaluate cold weather performance ▪ Improve accuracy of process modeling parameters
	Nitrite shunt full-scale demonstration in one Plant	Following bench testing	▪ Verify cold weather performance ▪ Confirm process modeling parameters ▪ Confirm effluent quality ▪ Gain experience with AVN automated controls
	NSWWTP BioWin validation and design update	Predesign	▪ Validate steady-state model calibration and confirm selected alternative(s) preliminary design evaluations
	Clarifier stress test	Predesign	▪ Determine whether additional aeration tankage will be triggered by growth, especially under increased SVI associated with nitrite shunt ▪ Improve accuracy of BNR alternatives evaluation ▪ Confirm RAS pump hydraulic capacity
	Plant-wide implementation of nitrite shunt	Following demonstration, if successful	▪ Energy reduction ▪ Effluent quality improvement
	Postaeration improvements	Concurrent with plantwide nitrite shunt	▪ Meet effluent DO requirements under high flow conditions
	UCT process improvements	If future permit requires	▪ Implement only if nitrite shunt testing is unsuccessful or permit limits are lower than predicted nitrite shunt effluent quality ▪ Proven TN removal process
Diffusers	PVC condition evaluation	Near term	▪ Informed risk evaluation of continued near-term use of ceramic diffuser system ▪ Accelerate diffuser replacement if evaluation suggests embrittlement or other PVC flaws
	Replace diffusers in one plant with membrane diffusers	Concurrent with nitrite shunt demonstration	▪ Match diffuser density to nitrite shunt process airflow requirements ▪ Designed for expansion if demonstration is unsuccessful ▪ Facilitate low DO conditions and precise DO set points ▪ Life-cycle procurement to optimize diffuser energy performance
	Replace diffusers in remaining plant	Concurrent with plant-wide BNR improvements	▪ Match diffuser density to process airflow requirements based on final BNR configuration
Blowers	Replace two west blowers	Mid term	▪ Reduce failure risk ▪ Reduce energy consumption through improved blower efficiency and reduced turndowns ▪ Blower sizing
	Install east-west cross-connect piping	Mid term	▪ Reduce blower energy consumption by minimizing or eliminating blower 4/5 run time ▪ Provide redundancy between east and west blower systems
	Replace two east blowers[a]	Concurrent with CHP project	▪ Coordinate new blower sizing with ongoing BNR improvements and phase-out of blower 1

[a]East blower replacement not required if cross-connection piping is installed.

SECTION 7
DISINFECTION

This section summarizes the content of Technical Memorandum No. 7 (TM-7) and includes a description of the existing UV disinfection system, discussion and screening of disinfection alternatives, and detailed discussion of the short-listed alternatives with opinions of probable construction cost and nonmonetary considerations.

7.01 EXISTING EFFLUENT DISINFECTION SYSTEM

The existing horizontal UV disinfection system was manufactured by Fischer & Porter (F&P) and was started-up in 1996. Soon after start-up of the UV system, F&P was acquired by Trojan Technologies. After the acquisition, the F&P UV product line was no longer manufactured, nor were replacement parts available from Trojan.

The system consists of 5 channels, 2 banks per channel, and 368 low-pressure UV lamps per bank for a total of 3,680 lamps. Two additional channels were constructed with 1 channel designated for future expansion and the other used as a bypass channel when the UV system is not in use. The nominal capacity of the 5 active UV channels is approximately 100 mgd. Flows above 100 mgd are diverted to the effluent storage lagoons and later recycled back to the NSWWTP for full secondary treatment. Overall, the system has performed well and disinfection permit requirements have been met. However, the system has required more maintenance, parts sourcing, and attention than anticipated. In addition, the system has been in service for more than 20 years and is operating beyond the 15 to 20-year typical life of UV equipment.

7.02 EFFLUENT DISINFECTION ALTERNATIVES SCREENING

Workshop No. 7 was held on October 5, 2016, at the NSWWTP to discuss disinfection operations, alternatives, and related information. The overall concept for several alternatives were presented, including high-level budgetary costs and nonmonetary considerations. Based on discussion at the workshop, the following alternatives were short-listed to be evaluated in greater detail:

- Alternative D0–Maintain Existing System (Null Alternative)
- Alternative D1–UV Disinfection (Trojan Technologies)
- Alternative D2–UV Disinfection (WEDECO-Xylem)
- Alternative D7–Refurbish Existing UV System (IronbrookUV)

All of the alternatives were considered for both 100 mgd and 180 mgd peak flows, and all alternatives were required to meet the current geometric mean fecal coliform limit of 400 colony-forming units per 100 milliliters cfu/100 mL, as well as potential future *E. coli* limits of 126 cfu/100 mL (geometric mean) and 410 cfu/100 mL (statistical threshold value).

7.03 DESCRIPTION OF ALTERNATIVES EVALUATED

This section includes a description of each of the short-listed disinfection alternatives, including any structural or hydraulic modifications necessary to accommodate the disinfection equipment.

A. Alternative D0–Maintain Existing F&P UV System (Null Alternative)

Alternative D0 would maintain the existing UV disinfection system without expanding the system or replacing equipment. Since the equipment is no longer manufactured, parts must be obtained through a third-party vendor. In addition, the control boards are currently supplied by third-party vendors. The ability to maintain a reliable supply of replacement parts and control boards may be limited in the future. This alternative also does not include expanding the system capacity beyond 100 mgd.

The existing system is operating at or beyond the normal useful service life of UV technology. We recommend planning to replace or significantly refurbish the UV system within the next 10 years to avoid a catastrophic system failure, as well as to safeguard against reliance on third-party vendors selling replacement parts for systems that are no longer manufactured. The collective market demand for such parts will reduce over time as the F&P systems installed in the 1990s are taken out of service, and at some point availability of parts will become critical. Therefore, we have assumed that the system will need to be replaced and/or refurbished within 10 years to avoid a significant risk with respect to parts availability and system failure. This definition of the null alternative was applied because we do not believe the existing equipment could operate through the planning horizon without replacement.

B. Alternative D1–UV Disinfection (Trojan Technologies)

Alternative D1 would replace the existing UV system with the Trojan Technologies Signa UV system. Trojan Technologies' design for the 100-mgd system would require 3 channels with 3 UV banks per channel. The lamps for this system are 1,000-watt lamps provided only by Trojan Technologies or its equipment representatives. Trojan offers a 15,000-hour prorated warranty on each lamp. The lamps are 100 percent replaced up to 9,000 hours; the warranty is prorated from 9,000 to 15,000 hours.

The Signa UV system will require the channel bottoms to be lowered by approximately 14 inches because of the longer bulbs and taller overall height of the equipment. Raising the channel walls to provide the additional 14 inches of depth would not be feasible because of the upstream hydraulic control requirements. In addition to the equipment and structural costs to lower the channels, additional costs include new aluminum checker plate to cover the channels.

C. Alternative D2–UV Disinfection (WEDECO-Xylem)

Alternative D2 would replace the existing UV system with the Duron UV system manufactured by WEDECO-Xylem. WEDECO-Xylem's design for the 100-mgd system would require 5 channels with 3 UV banks per channel. The lamps for this system are 600-watt lamps provided by WEDECO and other equipment vendors. WEDECO offers a 14,000 hour prorated warranty on each lamp. The lamps are 100 percent replaced up to 9,000 hours; the warranty is prorated from 9,000 to 14,000 hours.

The Duron banks will fit in the existing channels and only require the channels to be narrowed by approximately 2.25 inches. In addition to the equipment costs, additional costs include new aluminum checker plate to cover the channels and the cost to grout the channel walls.

D. Alternative D7–Refurbish Existing UV System (IronbrookUV)

Alternative D7 includes refurbishing the existing UV system with similar equipment provided by IronbrookUV. The refurbishment would include replacing control boards, ballasts, breakers, transformer, cables, UV intensity monitors, lamps and sleeves, among other items. The lamp racks would also be refurbished. Several F&P systems have been similarly refurbished by IronbrookUV in recent years, including the systems installed at the Glenbard Wastewater Authority in Illinois (16 mgd average, 47 mgd peak) and the San Bernardino facility in California (33 mgd peak capacity). This alternative does not include expanding the system beyond the existing 5 channels, although expanding into the 2 empty channels would bring total system capacity up to approximately 140 mgd.

Costs for equipment upgrades were provided by IronbrookUV and include removal and installation. In addition to the equipment costs, the opinion of probable cost for this alternative also includes replacement of the existing flow control gates with new downward opening weir gates. Confirmation of this style of level control for a refurbished horizontal UV system is pending at this time. If new weir gates are not sufficient for level control, then new weighted effluent gates would be included.

7.04 PRESENT WORTH ANALYSIS

Table 7.04-1 provides a summary of the opinion of present worth values for the four alternatives. A detailed breakdown in present worth costs is included in TM-7. Capital costs for all projects, except for the null alternative (Alternative D0), were assumed to be incurred at the beginning of a 20-year planning period to replace the existing UV system. TM-7 also includes a breakdown of O&M costs associated with each alternative, including the assumptions or data used to develop the O&M costs.

For Alternative D0, it was assumed the system would be replaced in Year 10 of the 20-year planning period. Given the critical nature of the effluent disinfection system to the environmental mission of the District, we do not recommend considering any alternative that does not replace the significant components of the system within the next 10 years. While the system remains functional, the main components have been in operation for 20 years, and we expect the system components to begin failing at a faster rate in the future.

	Alternative D0 Existing F&P	Alternative D1 Trojan	Alternative D2 WEDECO	Alternative D7 IronbrookUV
Total Opinion of Capital Cost	$0	$3,593,000	$3,797,000	$2,153,000
Annual O&M	$70,000-106,000[1]	$52,000	$55,000	$70,000
Present Worth				
O&M	$1,207,000	$684,000	$723,000	$920,000
Replacement	$1,403,000[2]	$0	$0	$0
Salvage	($276,000)[3]			
Total Opinion of Present Worth	**$2,334,000**	**$4,277,000**	**$4,520,000**	**$3,073,000**

[1]$70,000/year is for years 11–20; $106,000 is for years 1–10.
[2]Capital cost for Alt. D7 assumed in year 10, brought back to the present.
[3]Salvage costs assume 50 percent of system life remaining at year 20, which is 10 years after replacement.

Table 7.04-1 Opinion of Present Worth Summary

Alternatives D0 and D7, both of which include the refurbishment of the existing F&P system, have a lower overall present worth cost than the other two alternatives, mainly because of the significantly lower initial and future system installation costs for the Ironbrook UV equipment. The Ironbrook UV upgrades would continue to utilize many of the existing components, which helps reduce costs. The Trojan and WEDECO alternatives have lower annual O&M opinions of cost, which is mainly because of higher energy efficiency and reduced maintenance associated with the significantly fewer bulbs, ballasts, and associated systems.

For the purpose of this planning level evaluation, Alternatives D1 and D2 have approximately equal present worth costs, since the total present worth costs are within 10 percent of each other.

7.05 NONMONETARY EVALUATION

Nonmonetary considerations for each alternative were evaluated and are summarized in Table 7.05-1. While alternatives D0 and D7 have the benefit of familiarity to the District staff, there are numerous limitations with those alternatives that are addressed with Alternatives D1 and D2.

Table 7.05-1 Disinfection Alternative Nonmonetary Considerations Summary

Alternative	Benefits	Limitations
D0–Maintain Existing F&P UV System (Null Alternative)	▪ District staff is familiar with system and equipment.	▪ Since this original equipment is no longer manufactured, replacement parts must be obtained through third-party vendors. ▪ Replacement control boards must be obtained from third-party vendors. ▪ The system is more than 20 years old now and is operating at or beyond its anticipated useful service life. This system will likely require more maintenance and attention over time than a new system would require. ▪ Future availability of replacement parts may be diminished as other F&P installations are replaced. This is a critical consideration and could result in a loss of parts availability over a relatively short period of time, especially if Ironbrook UV would cease operations. ▪ Because of the number of lamps and associated head loss, capacity beyond 140 mgd is not possible without changing the system hydraulics and layout. ▪ Existing flow control gates do not operate properly at high flows because of high water level in the downstream UV effluent channel. ▪ Level control in the UV channels is more critical with horizontal UV lamps, which likely requires the continued use of the weighted level control gates. Continued evaluation of downward opening weir gates should be considered when this system is replaced.
D1–UV Disinfection (Trojan Technologies)	▪ Proven technology developed by a world leader in UV system technology. ▪ Fewest number of lamps of all alternatives. ▪ Fewest number of channels required (3), which would allow the system to be expanded easily to 180 mgd. ▪ System includes both mechanical and chemical cleaning. ▪ Most installations greater than 50 mgd of the short-listed alternatives. ▪ Angled bulb arrangement requires less stringent flow control and provides the ability to replace the weighted gates with downward opening weir gates for level control.	▪ Requires channels to be lowered to accommodate the equipment. ▪ Utilizes 1,000-watt bulbs that must be purchased from Trojan currently; this could change in the future if 1,000-watt bulbs become more common. Guaranteed lamp pricing would need to be established. ▪ Utilizes hydraulic system for sleeve cleaning that adds complexity and potential maintenance issues to system.
D2–UV Disinfection (WEDECO-Xylem)	▪ Proven technology developed by a world leader in UV system technology. ▪ Does not require channels to be lowered; simpler retrofit than Alternative D1. ▪ System includes mechanical cleaning. ▪ Angled bulb arrangement requires less stringent flow control and provides the ability to replace the weighted gates with downward opening weir gates for level control.	▪ None identified.
D7–Refurbish Existing UV System (IronbrookUV)	▪ District staff is familiar with system and equipment.	▪ Future availability of replacement parts may be diminished as other F&P installations are replaced. This is a critical consideration and could result in a loss of parts availability over a relatively short period of time, especially if IronbrookUV would cease operations. ▪ Because of the number of lamps and associated head loss, capacity beyond 140 mgd is not possible without changing the system hydraulics and layout. ▪ Older UV technology. ▪ Minimal energy savings are anticipated. ▪ Existing flow control gates do not operate properly at high flows because of high water level in the downstream UV effluent channel. ▪ Level control in the UV channels is more critical with horizontal UV lamps, which likely requires the continued use of the weighted level control gates. Evaluation of downward opening weir gates or new weighted gates could be considered if this alternative is selected. Capital costs include replacement of the existing weighted gates.

7.06 RECOMMENDED PLAN

The recommended alternative for long-term disinfection at the NSWWTP is Alternative D1 or D2, which include a new UV system using the latest in UV disinfection technology. While these alternatives have a higher present worth than Alternatives D0 and D7, the newer technology offers many advantages as described in the following.

- These systems provide improved electrical efficiency.
- These systems provide improved maintainability.
- These alternatives provide lower risk associated with the older UV technology not being supported throughout the useful service life of the equipment.
- As with any item that is improved over time, having the most recent technology may allow it to be upgraded more readily as the systems continue to improve.

SECTION 8
ELECTRICAL RELIABILITY

This section includes a summary of electrical improvement evaluations that were conducted as part of the facility planning for the NSWWTP. The evaluations include Headworks Facility backup power, east and west blower controls, east and west blower medium-voltage switchgear, existing unit substations (U11, U12, and U13), and indoor versus outdoor substation transformers. A detailed discussion of the short-listed alternatives with opinions of probable construction cost and nonmonetary considerations are summarized herein, and additional detail on these evaluations is presented in Technical Memorandum No. 8 (TM-8, Appendix H).

8.01 EXISTING HEADWORKS FACILITY POWER DISTRIBUTION SYSTEM

The existing Headworks Facility has two 480-volt motor control centers (MCCs), MCC-HF1 and MCC-HF2. Each MCC has a 1,000-amp main circuit breaker and the two MCC busses are interconnected with a 1,000-amp tie circuit breaker. Each MCC houses several motor starters and branch circuit breakers serving the various facility electrical loads. The MCCs are each fed with a 480-volt, 1,000-amp feeder from unit substation U15, which is fed with redundant 4.16-kV power feeds from main switchgear S1. The main unit substation that feeds the main switchgear is fed with redundant 13.8-kV utility power feeds from the Madison Gas & Electric (MG&E) Nine Springs Unit Substation located adjacent to the northwest corner of the NSWWTP. The Nine Springs Unit Substation has an on-site generator able to provide backup power during a regional utility power outage; however, MG&E requires at least two to three hours to bring the generator online.

Over the past 20 years, NSWWTP experienced a single power outage event that resulted in a sustained loss of power at the Headworks Facility. This event occurred on June 14, 2005 and lasted approximately 45 minutes. Continuous operation of the influent screens at the Headworks Facility is critical to NSWWTP operations, and an outage lasting more than 5 minutes during high-flow events would likely cause the influent wastewater channel to flood resulting in unscreened wastewater bypassing the screens. If influent wastewater bypasses the screens, the downstream wastewater treatment processes are subject to potential solids plugging, and the resulting maintenance requirements could be significant. Specific concerns have been noted with the digestion heating system steam injectors, which are susceptible to solids plugging, as well as the potential to impact the District's Class A biosolids product if objectionable materials from screening bypasses are found in the biosolids project.

8.02 HEADWORKS FACILITY BACKUP POWER ALTERNATIVES IDENTIFICATION AND SCREENING

Workshop No. 8 was held on February 6, 2017, at NSWWTP to present a list of electrical alternatives, including alternatives for a backup power supply to the Headworks backup power (HBP), and screen the alternatives down to a shorter list to evaluate in detail. Based on discussion at the workshop, the following alternatives were selected to be evaluated further:

- Alternative HBP No. 0–No Change (Null Alternative)
- Alternative HBP No. 1–Stationary Diesel Generator for Headworks Facility
- Alternative HBP No. 2–Stationary Natural Gas Generator for Headworks Facility

Each of these alternatives are evaluated further in the following sections.

8.03 DESCRIPTION OF HBP ALTERNATIVES

This section includes a detailed evaluation of each short-listed Headworks Facility Backup Power Supply Alternatives.

For all the electrical reliability evaluations included herein, the null alternative was defined as the "do nothing" alternative and assumes the existing equipment will last throughout the planning horizon. While this may not be viable for all of these evaluations (e.g., East Blower Controls), the null alternative was defined as such to maintain consistency within this portion of the facilities plan.

A. Alternative HBP No. 0–No Change (Null Alternative)

Alternative HBP No. 0 would maintain the existing redundant power feeds to the Headworks facility MCCs as the only sources of power to the facility. With only a single power outage recorded over the past 20 years lasting about 45 minutes, the electrical utility and distribution system have proven to be robust and reliable. Electrical distribution system equipment is also routinely inspected and serviced to improve reliability. Electrical distribution equipment at the Headworks Facility and upstream unit substation (U15) is less than 20 years old, and will not need to be replaced for about another 10 years. However, electrical equipment at the main NSWWTP unit substation (H1) and main switchgear (S1), while still functioning properly, was brought online in 1985 and has been in operation for about 32 years. The expected service life for this type of equipment is 30 years, so the equipment should be considered for replacement in the near future.

If the Headworks facility experiences a power outage event, it is likely that wastewater will bypass the mechanical screening equipment. A total loss of power to the Headworks Facility can be caused by a catastrophic event at main unit substation H1, main switchgear S1, or unit substation U15, or due to the configuration of equipment cutting of redundant distribution paths. Based on the current configuration, both MCCs in the Headworks Facility are powered from a single unit substation U15, which would result in the entire facility losing power in U15 were to fail. The District should consider powering the MCCs independently from each of the two incoming power feeds from unit substation U15 so that some equipment would remain energized if only the power feed from substation U15 were to fail.

B. Alternative HBP No. 1–Stationary Diesel Generator for Headworks Facility

Alternative HBP No. 1 would provide a stationary diesel generator dedicated to powering the Headworks Facility during a power outage. This Alternative includes a 300-kW, Tier 3-rated generator, based on a peak recorded electrical demand of approximately 200 kW. A 480-volt, 300-kW generator would be sufficient to power the entire Headworks Facility during a power outage with about 30 percent spare capacity for future electrical loads at the Headworks Facility. The proposed installation location for this generator is the east storage room in Storage Building No. 3 because it has space to accommodate the new generator, and intake/outlet ventilation louvers can be installed in the east and north walls. Minor structural and heating, ventilation, and air conditioning (HVAC) modifications to this building to accommodate the generator and 300-gallon fuel tank are also included in this alternative.

A power transfer control system that automatically transfers the supply of power to the Headworks Facility MCCs from a failed incoming feeder from unit substation U15 to an available U15 feeder, or to the new standby generator is also included in this alternative. This control system includes new electronically controlled circuit breakers and voltage monitors and could be installed as a dedicated control panel or incorporated into the existing programmable logic controller (PLC) control panel in the Headworks Facility.

Opinions of probable construction cost were developed for two scenarios in the alternative. In one scenario, four new circuit breakers are installed and the power feed from the new generator is fed into MCC-HF2 while both power feeds from unit substation U15 remain. In the second option, the new generator is wired directing into a new circuit breaker in the Headworks Facility MCC, which would reduce the number of new circuit breakers but would require one of the redundant power feeds from unit substation U15 to be removed.

C. Alternative HBP No. 2–Stationary Natural Gas Generator for Headworks Facility

Similar to Alternative HBP No. 1, Alternative HBP No. 2 would provide a stationary generator dedicated to powering the Headworks Facility during a power outage. However, a natural gas generator would be installed instead of a diesel generator. Based on the average Headworks Facility electrical loading previously discussed under Alternative HBP No. 1, a 300-kW natural gas generator would also be appropriate to power current and future Headworks facility electrical loads. Natural gas generators require a gas utility line for fuel and do not require any on-site fuel storage.

Maintaining power to the Headworks facility MCCs for this alternative would require the same power transfer control system, MCC voltage monitors, and electrically-controlled MCC circuit breakers previously described under Alternative HBP No. 1. The same generator location and HVAC modifications for the east storage bay in Storage Building No. 3 previously described under Alternative HBP No. 1 are also included in this alternative.

Natural gas piping would need to be extended to the new generator in Storage Building No. 3. Based on recorded natural gas usage by MG&E, there appears to be adequate capacity on the existing gas service line to accommodate a tap to feed a new 300-kW generator. Actual gas service capacity available for the new generator would need to be verified during detailed design.

8.04 HBP ALTERNATIVES COST EVALUATION

Table 8.04-1 presents a summary of the opinion of probable construction costs for each of the Headworks Facility Backup Power alternatives.

There are no upfront costs associated with this Alternative HBP No. 0. However, District staff estimates that it would cost at least $1,000 to clean the process equipment if influent wastewater bypasses the mechanical screens because of a power outage.

The budgetary opinions of probable construction costs for Alternatives HBP No.1 and No. 2 assume that the District would perform all PLC and Human-Machine Interface (HMI) programming updates and does not include estimated fees for engineering design and construction-related services. These two alternatives are presented both with four new circuit breakers (with one accepting the new generator power feed) and with three new circuit breakers. In the three circuit break alternatives, one of the main circuit breakers would be used to accept the new generator power feed.

	Alternative HBP No. 0–No Change (Null Alternative)	Alternative HBP No. 1–Stationary Diesel Generator for Headworks Facility	Alternative HBP No. 2–Stationary Natural Gas Generator for Headworks Facility
Total Opinion of Capital Cost			
Three Breakers	**$0**	**$499,000**	**$643,000**
Four Breakers	**$0**	**$535,000**	**$679,000**

Table 8.04-1 HBP Alternatives Opinion of Probable Construction Cost Summary

8.05 HBP ALTERNATIVES NONMONETARY CONSIDERATIONS

Nonmonetary considerations for each alternative were evaluated and are summarized in Table 8.05-1.

8.06 HBP ALTERNATIVE RECOMMENDATION

The maintenance expense required to clean processes affected by influent wastewater bypassing the mechanical screens is insignificant when compared to the upfront expense required to install a generator, so project costs alone will not justify the installation of a new standby generator. In addition, because of the very infrequent power failures at the headworks, we recommend the null alternative (Alternative HBP No. 0) be continued.

If the District would still like to install a generator to avoid the potential of cleaning process equipment and managing a temporary increase in biosolids debris, we recommend installing a diesel generator at the Headworks Facility (Alternative HBP No. 1). This option not only provides a backup power source for the entire Headworks Facility, but upgrading to electrically-controlled breakers would improve the speed at which power to the Headworks Facility is switched between the two existing feeders from unit substation U15.

- The new electrically-controlled circuit breakers would significantly reduce future electrical outage durations at the Headworks Facility. The electrically-controlled circuit breakers could also be installed by themselves without the generator to eliminate concerns with a single substation U15 power source to both Headworks MCCs (i.e., tie breaker closed) failing and requiring manual transfer to the other U15 power source. This concern could also be eliminated by simply committing to always powering the Headworks Facility MCCs independently from U15 (i.e., tie breaker open).
- The diesel engine generator would be able to supply standby power to the facility during an electric utility outage for about 20 hours before needing to be refueled. Immediate generator operation would not rely on any off-site fuel sources.
- The upfront cost to install a diesel engine generator would be significantly lower than the cost required to install a natural gas engine generator, and would not require any NSWWTP utilities to be modified.

Table 8.05-1 HBP Alternative Nonmonetary Considerations Summary

Alternative	Benefits	Limitations
Alternative HBP No. 0–No Change (Null Alternative)	▪ The Headworks Facility currently has power distribution system redundancy back to the main NSWWTP unit substation, and most of the equipment is operating within its anticipated service life. ▪ There is a limited history of power outages at NSWWTP; only one 45-minute outage over the past 20 years. ▪ The MG&E Nine Springs substation has been upgraded to improve reliability since the previously-recorded, 45-minute outage.	▪ It's possible for the Headworks facility MCC circuit breakers to be configured so that the entire facility would lose power if a single incoming power feed from unit substation U15 fails. ▪ Electrical equipment at the main NSWWTP unit substation H1 and main switchgear S1 has been operating for about 32 years, which is beyond its expected service life of 30 years. ▪ If an outage does occur and the screens are bypassed, there could be a negative impact on downstream processes and the biosolids product.
Alternative HBP No. 1–Stationary Diesel Generator for Headworks Facility	▪ The generator control system would be able to energize the Headworks facility as quickly as 10 seconds after a loss of power on one or both of the MCC incoming power feeds from unit substation U15. ▪ Diesel fuel is stored in a tank underneath the generator, so the fuel source, while limited to 12 to 24 hours before requiring a refill, is not dependent on an off-site source. ▪ No additional utility services (gas, water, etc.) are required for the generator installation.	▪ The generator would require regular maintenance. ▪ Outages lasting longer than 12 to 24 hours, depending on the fuel tank size, would require refueling. ▪ Diesel fuel must be stored on-site, and given that the NSWWTP power distribution system is so reliable, it is likely that most of the fuel would not be used before is degrades and has to be replaced.
Alternative HBP No. 2–Stationary Natural Gas Generator for Headworks Facility	▪ The generator control system would be able to energize the Headworks facility as quickly as 10 seconds after a loss of power on one or both of the MCC incoming power feeders. ▪ No on-site fuel storage or fuel maintenance.	▪ The generator would require regular maintenance. ▪ A natural gas utility service outage would render the generator inoperable. ▪ NSWWTP natural gas utility piping needs to be extended to Storage Building No. 3.

8.07 EXISTING EAST AERATION SYSTEM CONTROL PANEL

There are two blower buildings at the NSWWTP, the East Blower Building (Blower Building 1) and the West Blower Building (Blower Building 2). Each blower building houses several 4.16-kV motor-driven blowers, and the East Blower Building also houses an engine-driven blower.

Controls for the west blowers were upgraded by the District engineering staff about 16 years ago, including PLC control panels and motor control relays in each blower motor starter. Since then, the west blower control systems have operated reliably and, therefore, have not been evaluated for replacement at this time.

The east blower control system, which controls Blower Nos. 2, 3, 4, 5, includes a common control panel using hardwired relay logic and legacy panel-mounted digital controllers. Blower No. 1 is an engine-driven blower that has a separate control panel. The east blower control panel has been in use since the original blowers were installed in the 1960s, and several undocumented modifications and adjustments have been performed over the years to keep the blowers in operation. As a result, the control panel wiring is unorganized and no reliable documentation exists to help District maintenance staff troubleshoot and correct problems that occasionally arise. District staff indicate that problems with this control panel often require several days to diagnose and correct. Since the original controls installation, a newer Allen-Bradley CompactLogix PLC and network switch have been installed, but only to monitor the engine-driven blower (Blower No. 1) temperatures. Replacing the existing east blower control panel with a PLC-based control system similar to what was provided for the west blowers would improve reliability and allow the control system to easily adapt to future blower equipment upgrades.

8.08 EAST AERATION SYSTEM CONTROL PANEL UPGRADE ALTERNATIVES IDENTIFICATION AND SCREENING

Based on discussion at Workshop No. 8, the following alternatives for the east aeration system control panel upgrades (EBC) were selected to be evaluated further:

- Alternative EBC No. 0–No Change (Null Alternative)
- Alternative EBC No. 1–Replace East Blower Control Panel

Each of these alternatives are evaluated further in the following sections.

8.09 DESCRIPTION OF EBC ALTERNATIVES

This section includes a detailed evaluation of each short-listed EBC Alternatives.

A. Alternative EBC No. 0–No Change (Null Alternative)

Alternative EBC No. 0 would leave the existing hardwired control panel for Blower Nos. 2, 3, 4, and 5 in the East Blower Building in operation. The control panel would be replaced during future blower equipment upgrades. The control panel is currently located in the center of the blower room, which is a relatively noisy and dirty environment.

B. Alternative EBC No. 1–Replace East Blower Control Panel

Alternative EBC No. 1 would replace the existing hardwired control panel for Blower Nos. 2, 3, 4, and 5 in the East Blower Building with new dedicated PLC-based control panels for each of these blowers located in Aeration Control Building No. 2. These PLC-based controls include a new remote input/output (I/O) enclosure in the East Blower Building that communicates with the new blower control panel in the Aeration Control Building No. 2 using NSWWTP's recently upgraded fiber optic cabling and would allow most of the existing field wiring to be reused.

The District is currently considering blower equipment upgrades including a change from blowers powered by medium-voltage motors to blowers powered by 480-volt motors. While upgrading the control system prior to the blower equipment upgrades would require the new control panels to be modified slightly to accommodate the new equipment, new PLC-based control panels would easily be able to adapt and interface with any type of upgraded blower equipment.

8.10 EBC ALTERNATIVES COST EVALUATION

Table 8.10-1 presents a summary of the opinion of probable construction costs for each of the EBC Alternatives.

There are no upfront costs associated with Alternative EBC No. 0. However, there will likely be future costs associated with the time and materials required for NSWWTP maintenance staff to troubleshoot and repair blower control panel problems, which are not able to be reliably estimated. The budgetary opinion of probable construction cost for Alternative EBC No.1 assume that the District would perform all PLC and HMI programming updates.

	Alternative EBC No. 0–No Change (Null Alternative)	Alternative EBC No. 1–Replace East Blower Control Panel
Total Opinion of Capital Cost	**$0**	**$390,000**

Table 8.10-1 EBC Alternatives Opinion of Probable Construction Cost Summary

8.11 EBC ALTERNATIVES NONMONETARY CONSIDERATIONS

Nonmonetary considerations for each alternative were evaluated and are summarized in Table 8.11-1.

Table 8.11-1 EBC Alternative Nonmonetary Considerations Summary

Alternative	Benefits	Limitations
Alternative EBC No. 0–No Change (Null Alternative)	▪ None	▪ The existing control panel components are very old, difficult to troubleshoot, and some replacement parts are difficult to find. ▪ Future control panel problems due to aging equipment will likely require several days to troubleshoot and repair. ▪ The existing control panel location in the blower building is not ideal for control equipment because it is a somewhat dirty environment, which can lead to premature equipment failure. The loud noise levels in the East Blower Building also require occupants to wear hearing protection, which complicates maintenance and troubleshooting efforts.
Alternative EBC No. 1–Replace East Blower Control Panel	▪ Replacing aging equipment would reduce the likelihood of control system problems that affect blower operation. ▪ New and well-documented control panels would simplify maintenance and reduce the time required to diagnose and correct problems. ▪ Relocating controls to Aeration Building No. 2 would provide a cleaner and less noisy environment, which would improve equipment longevity and provide a worker-friendly environment for control system maintenance and upgrades. ▪ The new remote I/O enclosure in the East Blower Building would provide a point of local control via a touchscreen OIT and access to all I/O signal wiring. ▪ The new control equipment would match current NSWWTP standards and maintenance staff would have easy access to replacement parts.	▪ Maintenance staff would lose the convenience of having the control panel, blower equipment, and motor starters in the same room. ▪ Control system modifications, while not a significant effort or expense, would be required to interface the new control panel with future blower equipment upgrades.

8.12 EBC ALTERNATIVE RECOMMENDATION

The recommended alternative for the east blower controls replacement is Alternative EBC No. 1. The east blower control panel is very old and replacement parts are hard to locate. In addition, the control panel wiring is undocumented and requires several days to troubleshoot and correct control system problems. Replacing the control system would greatly improve the east blower system reliability and use control equipment consistent with recent NSWWTP control system upgrades.

If the District chooses to upgrade the blowers within the next 5 years, the District could reasonably consider delaying the blower control panel upgrade until the blower equipment is upgraded with the understanding that there is an increased risk for extended control system outages as existing control panel equipment continues to age.

8.13 EXISTING EAST AND WEST BLOWER MEDIUM-VOLTAGE SWITCHGEAR

The East Blower Building and the West Blower Building each house medium-voltage (4.16 kV) switchgear lineups with starters for each blower motor, except for Blower No. 1 in the East Blower Building, which is powered with a digester gas-fueled engine. The East Blower Building has a main switchgear lineup with the main and tie switches and starters for Blowers No. 4 and No. 5, as well as a remote switchgear lineup with starters for Blowers No. 2 and 3. The remote lineup is powered from the main switchgear lineup with redundant power feeds. All motor starters in the West Blower Building switchgear are part of one continuous lineup. The switchgear in both buildings are powered with redundant 4.16-kV power feeds from either side of the main switchgear S1 bus-tie circuit breaker.

Both of the medium-voltage switchgear lineups are regularly inspected and maintained, but are operating beyond their expected service life of 30 years. The East Blower Building’s switchgear was installed in 1963 and the West Blower Building’s switchgear was installed in 1985.

The East Blower Building’s medium-voltage switchgear (S141 & S142) powers the following equipment:

- Blower No. 2: 600 horsepower (HP)
- Blower No. 3: 600 HP
- Blower No. 4: 375/500 HP (two-speed, two-winding motor)
- Blower No. 5: 315/450 HP (two-speed, two winding motor)

The West Blower Building’s medium-voltage switchgear (M51) powers the following equipment:

- Blower No. 1: 1,250 HP
- Blower No. 2: 1,250 HP
- Blower No. 3: 1,250 HP

8.14 EAST AND WEST BLOWERS MEDIUM-VOLTAGE SWITCHGEAR REPLACEMENT ALTERNATIVES IDENTIFICATION AND SCREENING

Based on discussion at Workshop No. 8, the following alternatives for the east and west blower medium-voltage switchgear replacement (BMC) were selected to be evaluated further:

- Alternative BMC No. 0–No Change (Null Alternative)
- Alternative BMC No. 1–Replace East Blower Building Switchgear
- Alternative BMC No. 2–Replace West Blower Building Switchgear

Each of these alternatives are evaluated further in the following sections.

8.15 DESCRIPTION OF BMC ALTERNATIVES

This section includes a detailed evaluation of the East and West Blowers Medium-Voltage Switchgear Replacement Alternatives.

A. Alternative BMC No. 0–No Change (Null Alternative)

Alternative BMC No. 0 would leave both the existing East Blower Building and West Blower Building medium-voltage switchgear in place and powering the blower motors.

The West Blower Building switchgear has been in service for about 32 years and the East Blower Building switchgear has been in service for over 50 years, but have maintained consistent, reliable operation thus far. While there are many examples of switchgear equipment operating for more than 50 years, the expected service life for medium-voltage switchgear is about 30 years. Operating beyond 30 years introduces a greater chance for arc-fault events due to failed insulation, failed switch mechanisms, failed bus hardware, and other potential causes. Operating switchgear beyond its expected service life is possible with proper routine maintenance and testing, but the risk of equipment failure will still increase as equipment ages. Risks can be minimized by reconditioning switchgear with new components, but reconditioning efforts would still not account for the improved reliability and safety that could be provided with modern switchgear.

Since the original switchgear installations, advancements have been made in switchgear insulating technologies, switch mechanism reliability, and enclosure safety. New arc-resistant switchgear is also available to redirect the massive expansion of gas and molten conductor metal out of ducted passages and away from personnel in front of the switchgear. Photo-sensors and high-speed relays can now be used to quickly detect and clear arc-faults. Draw-out motor controller construction can also be used to improve equipment access and improve safety when maintaining equipment.

In addition to failures resulting from equipment aging, equipment grounding systems must also be considered for regular replacement. It is not uncommon for below-grade ground rods and conductors to corrode beyond the point where it can successfully transmit ground-fault currents.

B. Alternative BMC No. 1–Replace East Blower Building Switchgear

This alternative includes replacing the East Blower Building switchgear with a new switchgear to power the existing blower motors. A switchgear would be installed in the same location as the existing switchgear and existing below-grade, concrete-encased duct bank could be reused to refeed the new switchgear with new medium-voltage cables from main switchgear S1 in the Effluent Building. The existing switchgear configuration allows switchgear replacement on one side of the tie while Blower Nos. 2, 3, and 5 remain energized and replacement on the other side once Blower No. 4 is energized from the new switchgear.

Future blower equipment upgrades could potentially include a change from blowers using medium-voltage motors to blowers using multiple 480-volt motors. If 480-volt blower motors are selected for the upgrade, new 480-volt variable frequency drives or reduced-voltage solid-state starters, and potentially a new unit substation, would have to be installed. As a result, the new medium-voltage motor starters proposed as part of this alternative would no longer be used to power the blowers.

C. Alternative BMC No. 2–Replace West Blower Building Switchgear

This alternative includes replacing the West Blower Building switchgear with new switchgear to power the existing blower motors. Switchgear would be installed in the same location as the existing switchgear and existing below-grade, concrete-encased duct bank could be reused to refeed the new switchgear with new medium-voltage cables from main switchgear S1 in the Effluent Building. The existing switchgear configuration allows switchgear replacement on one side of the tie while Blowers Nos. 2 and 3 remain energized and replacement on the other side once Blower No. 1 is energized from the new switchgear.

Future blower equipment upgrades could potentially include a change from blowers using medium-voltage motors to blowers using multiple 480-volt motors. If 480-volt blower motors are selected for the upgrade, new 480-volt variable frequency drives or reduced-voltage solid-state starters, and potentially a new unit substation, would have to be installed. As a result, the new medium-voltage motor starters proposed as part of this alternative would no longer be used to power the blowers.

8.16 BMC ALTERNATIVES COST EVALUATION

Table 8.16-1 presents a summary of the opinion of probable construction costs for each of the East and West Blowers Medium-Voltage Switchgear Replacement alternatives.

There are no upfront costs associated with Alternative BMC No. 0. There would be future costs associated with the time and materials required for District maintenance staff to troubleshoot and repair switchgear equipment as it fails, which are not able to be reliably estimated. The budgetary opinions of probable construction cost for Alternative BMC No.1 and No. 2 are based on non-fused main and tie switches and draw-out style motor controllers.

	Alternative BMC No. 0–No Change (Null Alternative)	Alternative BMC No. 1–Replace East Blower Building Switchgear	Alternative BMC No. 2–Replace West Blower Building Switchgear
Total Opinion of Capital Cost	**$0**	**$1,136,000**	**$902,000**

Table 8.16-1 BMC Alternatives Opinion of Probable Construction Cost Summary

8.17 BMC ALTERNATIVES NONMONETARY CONSIDERATIONS

Nonmonetary considerations for each alternative were evaluated and are summarized in Table 8.17-1.

Alternative	Benefits	Limitations
Alternative BMC No. 0–No Change (Null Alternative)	▪ If the blowers are eventually replaced with blowers using 480-volt motors, the District would avoid buying new switchgear that could not be reused to power the new 480-volt blower motors.	▪ The switchgear equipment is operating beyond its expected service life and the potential for equipment failures will increase as equipment ages. ▪ Switchgear reliability and safety could be improved if replaced with new equipment using improved operating mechanisms and draw-out motor controller construction. ▪ Newer draw-out style motor starters would improve access to equipment and simplify maintenance.
Alternative BMC No. 1–Replace East Blower Building Switchgear	▪ Switchgear reliability and safety would be improved. ▪ Replacing aging medium-voltage cables would address concerns with the increasing potential for arc-fault events. ▪ Newer draw-out style motor starters would improve access to equipment and simplify maintenance.	▪ If new blower equipment uses 480-volt motors, this new switchgear would need to be replaced with 480-volt VFDs and motor controls
Alternative BMC No. 2–Replace West Blower Building Switchgear	▪ Switchgear reliability and safety would be improved. ▪ Replacing aging medium-voltage cables would address concerns with the increasing potential for arc-fault events. ▪ Newer draw-out style motor starters would improve access to equipment and simplify maintenance.	▪ If new blower equipment uses 480-volt motors, this new switchgear would need to be replaced with 480-volt VFDs and motor controls.

Table 8.17-1 BMC Alternative Nonmonetary Considerations Summary

8.18 BMC ALTERNATIVE RECOMMENDATION

We recommend that the District first decide on what type of future blower equipment will be installed before deciding on which medium-voltage switchgear to replace. If future blower equipment upgrades will also use 4.16-kV motors, then both Alternatives BMC No. 1 and BMC No. 2 should be prioritized in order to upgrade all of the existing blower building switchgear lineups with new switchgear. The existing switchgear and associated medium-voltage conductors are operating beyond their expected service life, and new equipment would address reliability concerns and introduce equipment with enhanced operating and safety features.

8.19 EXISTING UNIT SUBSTATIONS U11, U12, AND U13

Unit substations at the NSWWTP are used to interface with underground 4.16-kV distribution lines powered from main switchgear S1 in the Effluent Building. The unit substation transformers step the distribution system voltage down from 4.16 kV to 480 volts and then distribute 480-volt power to the various motor control centers and distribution panels in each building.

Unit substations U11, U12, and U13 were originally installed in 1984 and brought online in 1985. Outdoor unit substations should be replaced every 25 to 30 years, and these three unit substations have been operating for about 32 years. The unit substation equipment enclosures are significantly corroded, which increases the likelihood of damage to equipment from rain, snow, and rodent intrusion. The District regularly maintains major electrical distribution equipment and also hires a consultant to periodically inspect the equipment every three years. A detailed report of the latest evaluation performed by A.C. Engineering Company, dated May 11, 2015, noted that unit substations U11, U12, and U13 are "very rusted and deteriorated," and recommends that all equipment at these unit substations "be replaced as soon as possible."

Unit substation U11 is located directly west of the West Blower Building and serves two MCCs in the West Blower Building and two MCCs in Storage Building No. 3. The unit is located along a NSWWTP roadway and parking lot and does not have any physical barriers protecting it from vehicle traffic.

Unit substation U12 is located at the northwest corner of the Effluent Building and serves the two MCCs in the Effluent Building and two MCCs in Aeration Control Building No. 4. The unit substation is located in a damp/wet area that is often shaded from sunlight, and as a result, equipment enclosures at this unit substation retain moisture longer than equipment at other unit substations that have more exposure to sunlight.

Unit substation U13 is located directly west of Shop Building No. 1 and serves a disconnect switch at the Service Building, an MCC in Shop Building No. 1, and a fused disconnect switch in Shop Building No. 2. The unit substation is located along a NSWWTP roadway and has four bollards protecting it from vehicle traffic. The load on this unit substation has been significantly reduced since maintenance operations and staff moved to the recently-constructed Maintenance Building. This unit substation is unique to the others in that it has only a single transformer, but a redundant 480-volt power feed is supplied to it from unit substation U2.

Reliable unit substations are critical to maintaining consistent NSWWTP operation. Unit substations U11 and U12 serve critical process buildings with redundant 480-volt feeders, and a critical failure in the 480-volt distribution section of these unit substations would result in an extended power outage to one or more buildings.

8.20 UNIT SUBSTATIONS U11, U12, and U13 REPLACEMENT ALTERNATIVES IDENTIFICATION AND SCREENING

Based on discussion at Workshop No. 8, the following alternatives for the unit substations U11, U12, and U13 replacement were selected to be evaluated further:

- Alternative USUB No. 0–No Change (Null Alternative)
- Alternative USUB No. 2–Replace Unit Substations U11 and U12 with One New Indoor Unit Substation and Eliminate Unit Substation U13
- Alternative USUB No. 3–Replace Unit Substation U12 with One New Indoor Unit Substation and Eliminate Unit Substations U11 and U13

Each of these alternatives are evaluated further in the following sections.

8.21 DESCRIPTION OF USUB ALTERNATIVES

This section includes a detailed evaluation of each short-listed unit substations U11, U12, and U13 Replacement Alternative.

A. Alternative USUB No. 0–No Change (Null Alternative)

Alternative USUB No. 0 would leave existing unit substations U11, U12, and U13 in operation. Unit substation U13 now serves non-critical loads and its electrical load has been significantly reduced since maintenance operations and staff moved to the recently-constructed Maintenance Building. However, unit substations U11 and U12 serve critical processes loads that could significantly affect NSWWTP operation if unit substation equipment fails.

B. Alternative USUB No. 2–Replace Unit Substations U11 and U12 with One New Indoor Unit Substation and Eliminate Unit Substation U13

Alternative USUB No. 2 would replace unit substations U11 and U12 with one new large, indoor unit substation located approximately equidistant from both existing unit substations to serve all of the existing unit substations U11 and U12 electrical loads, except for two MCCs in Storage Building No. 3, which are currently fed from unit substation U11 but could be refed more economically from nearby unit substation U15. Unit substation U13 would be removed entirely and its existing loads would be refed from existing unit substation U2 and a new 480-volt MCC in Shop Building No. 1.

This alternative includes one new large unit substation to feed the existing 480-volt loads currently fed from unit substations U11 and U12. The unit substation would also include additional capacity to serve future equipment associated with NSWWTP process expansion on the west side of the NSWWTP. This substation would be housed in a building with a below-grade cable vault, heating and mechanical cooling, and a new concrete-encased duct bank to reroute fiber optic cabling to the building.

This alternative also includes power meters each 480-volt main circuit, a new 480-volt MCC in the new unit substation building to serve miscellaneous building and HVAC loads, new concrete-encased duct bank from the existing manhole southeast of the Effluent Building to the new substation building, and the replacement of MCCs in Storage Building No. 3 and Shop Building No. 1. Redundant 2,000 kVA transformers with fused, medium-voltage primary switches are assumed in this alternative.

C. Alternative USUB No. 3–Replace Unit Substation U12 with One New Indoor Unit Substation and Eliminate Unit Substations U11 and U13

Alternative USUB No. 3 would replace unit substation U12 with one new indoor unit substation located near the Effluent Building, and unit substations U11 and U13 would be removed entirely. Unit substation U11 loads would be refed from unit substation U14 located in the Metrogro Pump Station. The two MCCs in Storage Building No. 3 that are currently fed from unit substation U11 and would be replaced with one new MCC that could be powered from nearby unit substation U15. Unit substation U13 would be removed entirely and its existing loads would be refed from existing unit substation U2 and a new 480-volt MCC in Shop Building No. 1.

This alternative includes one new unit substation to feed the existing 480-volt loads currently fed from unit substation U12. The unit substation would also include additional capacity to serve potential future equipment associated with NSWWTP process expansion west of the Effluent Building. This substation would be housed in an extension of the existing Effluent Building with a below-grade cable vault and heating and mechanical cooling. New concrete-encased duct bank with new power feeds to the MCCs in the Aeration Control Building No. 4, from U14 to the West Blower Building, and from the existing U12 location to the new U12 location are also provided in this alternative.

This alternative also includes power meters each 480-volt main circuit, a new 480-volt MCC in the new unit substation building to serve miscellaneous building and HVAC loads, and the replacement of MCCs in Storage Building No. 3 and Shop Building No. 1. Redundant 1,500 kVA transformers with fused, medium-voltage primary switches are assumed in this alternative.

This alternative would provide the District with an opportunity to upgrade the existing unit substation U14 480-volt distribution switchboards with draw-out switchgear construction. This switchgear installation is included in the opinion of probable construction cost for this alternative.

8.22 USUB ALTERNATIVES COST EVALUATION

Table 8.22-1 presents a summary of the opinion of probable construction costs for each of Unit Substations U11, U12, and U13 replacement alternatives.

There are no upfront costs associated with Alternative USUB No. 0. There would be future costs associated with the time and materials required for District maintenance staff to troubleshoot and repair unit substation equipment as it fails, which are not able to be reliably estimated.

The budgetary opinions of probable construction cost for Alternative USUB No. 2 and No. 3 are based on the use of indoor, dry-type unit substation transformers. An upfront-cost evaluation associated with the use of indoor, dry-type or outdoor, liquid-filled transformers is included later in this memorandum in alternatives USUB-XFMR No. 1 and USUB-XFMR No. 2. The long-term operating costs of these alternatives would increase because outdoor unit substations are being replaced with a new unit substation building and the additional energy consumed by building electrical and HVAC loads. However, replacing old unit substation equipment and wiring would improve the power distribution system reliability and reduce the likelihood of conductor faults.

The OPCC for Alternative USUB No. 3 also includes the cost to upgrade the 480-volt distribution sections in unit substation U14 to draw-out switchgear construction, including new circuit breakers for all existing loads and the new power feeds to the West Blower Building MCCs. Installing new circuit breakers in the existing unit substation U14 480-volt distribution sections instead of replacing the sections with draw-out switchgear could reduce the OPCC by approximately $90,000.

	Alternative USUB No. 0– No Change (Null Alternative)	Alternative USUB No. 2– Replace Unit Substations U11 and U12 with One New Indoor Unit Substation and Eliminate Unit Substation U13	Alternative USUB No. 3– Replace Unit Substation U12 with One New Indoor Unit Substation and Eliminate Unit Substations U11 and U13
Total Opinion of Capital Cost	**$0**	**$3,227,000**	**$3,136,000**

Table 8.22-1 USUB Alternatives Opinion of Probable Construction Cost Summary

8.23 USUB ALTERNATIVES NONMONETARY CONSIDERATIONS

Nonmonetary considerations for each alternative were evaluated and are summarized in Table 8.23-1.

Table 8.23-1 USUB Alternative Nonmonetary Considerations Summary

Alternative	Benefits	Limitations
Alternative USUB No. 0–No Change (Null Alternative)	▪ None	▪ Unit substation equipment is operating beyond its expected service life and the potential for equipment failure will increase as equipment ages. ▪ Unit substation equipment enclosures are severely rusted, which increases the likelihood of damage to equipment from rain, snow, and rodent intrusion.
Alternative USUB No. 2–Replace Unit Substations U11 and U12 with One New Indoor Unit Substation and Eliminate Unit Substation U13	▪ Replacing aging unit substation equipment would address concerns with the potential for increased equipment failures. ▪ One new unit substation is being installed while three unit substations are being removed, two of which are currently located near roadways/parking lots. ▪ New equipment would be located inside of a building, which helps equipment last longer and provides a safer environment for operating and maintaining the equipment. ▪ Replacing aging medium-voltage cables would address concerns with the increasing potential for arc-fault events.	▪ The only location central to the loads served by the new unit substation impedes on an existing storage lot area and might require earthwork to avoid restricting the drainage swale.
Alternative USUB No. 3–Replace Unit Substation U12 with One New Indoor Unit Substation and Eliminate Unit Substations U11 and U13	▪ Replacing aging unit substation equipment would address concerns with the potential for increased equipment failures. ▪ One new unit substation is being installed while three unit substations are being removed, two of which are currently located near roadways/parking lots. ▪ This alternative takes advantage of spare capacity in existing unit substations U2, U14, and U15 to feed loads currently served by existing unit substations U11 and U13. ▪ New unit substation U12 equipment would be located inside of a building, which helps equipment last longer and provides a safer environment for operating and maintaining the equipment. ▪ Replacing aging medium-voltage cable would address concerns with aging conductor insulation that could lead to future arc-fault events.	▪ Any NSWWTP process expansion to the west would require longer power feeds from unit substation U12 and/or unit substation U14.

8.24 USUB ALTERNATIVES RECOMMENDATION

The recommended unit substations U11, U12, and U13 Replacement alternative is Alternative USUB No. 3. This alternative replaces three existing unit substations with one unit substation and takes advantage of existing electrical capacity in unit substations U2, U14, and U15 to power existing loads currently served by unit substations U11 and U13.

This alternative does require some NSWWTP roadway reconstruction associated with new concrete-encased duct bank conduits that would need to be routed from unit substation U14 to the West Blower Building. However, reusing existing unit substation capacity would reduce the size of the new unit substation building and electrical equipment, which would reduce upfront equipment and installation costs.

8.25 EVALUATION OF INDOOR AND OUTDOOR UNIT SUBSTATION TRANSFORMERS

An evaluation of using indoor dry-type unit transformers versus liquid filled transformers was conducted that corresponds with the unit substation evaluation presented earlier in this section. Dry-type unit substation transformers are commonly used for indoor unit substations instead of liquid-filled transformers because they do not use oil for cooling, which eliminates the need for spill containment, they are non-flammable, and they can be located directly in line with the unit substation medium-voltage and low-voltage switchgear. Liquid-filled transformers are commonly used for outdoor unit substations because they are sealed and use oil-filled heat-sinks to radiate heat. While locating transformers outdoors allows for a smaller unit substation building to be constructed and removes significant heat load from the building, there is a slight increase in risk of damage due to water leaks, corrosion, and rodent intrusion.

8.26 NEW UNIT SUBSTATION TRANSFORMER ALTERNATIVES IDENTIFICATION AND SCREENING

Based on discussion at Workshop No. 8, the following alternatives for the new unit substation transformer were selected to be evaluated further:

- Alternative USUB-XFMR No. 1–Indoor, Dry-Type Unit Substation Transformers
- Alternative USUB-XFMR No. 2–Outdoor, Liquid-Filled Unit Substation Transformers

Each of these alternatives are evaluated further in the following sections.

8.27 DESCRIPTION OF USUB-XFMR ALTERNATIVES

This section includes a detailed evaluation of both short-listed Unit Substation Transformer Alternatives.

A. Alternative USUB-XFMR No. 1–Indoor, Dry-Type Unit Substation Transformers

Alternative USUB-XFMR No. 1 would use indoor, dry-type transformers for the new NSWWTP unit substations previously identified under Alternatives USUB No. 2 and USUB No. 3.

Dry-type unit substation transformers are commonly used for indoor unit substations instead of liquid-filled transformers because they do not require oil spill containment, are non-flammable, and can be located directly in line with the unit substation medium-voltage and low-voltage switchgear. Existing indoor unit substations at the NSWWTP currently use indoor, dry-type transformers and outdoor unit substations use liquid-filled transformers.

Dry-type transformers require less maintenance than liquid-filled transformers, although the additional maintenance required for liquid-filled transformers is relatively minor. Indoor, dry-type transformers require a larger building size to house them and also add a significant heat load inside the building, which increases cooling demand during the summer months but supplements heating equipment during the winter months. Indoor transformers are also difficult to remove and replace relative to how easily outdoor transformers can be accessed and replaced.

B. Alternative USUB-XFMR No. 2–Outdoor, Liquid-Filled Unit Substation Transformers

Alternative USUB-XFMR No. 2 would use outdoor, liquid-filled transformers for the new NSWWTP substations previously identified under Alternatives USUB No. 2 and USUB No. 3.

Liquid-filled transformers are commonly used for outdoor unit substations because they are sealed and use heat-sink fins to radiate heat instead of open ventilation louvers and fans. The sealed construction fully protects the transformer windings from environmental damage. Locating unit substation transformers outdoors allows for a smaller unit substation building to be constructed and provides easier access to the transformers for replacement. Liquid-filled transformers are also slightly more efficient than dry-type transformers.

Liquid-filled transformers require slightly more maintenance than dry-type transformers and introduce a potential fire hazard from the use of cooling/insulating oil, although the risk of fire can be significantly reduced with the use of new less-flammable fluids. Due to the use of cooling/insulating oil, liquid spill containment structures or below-grade geo-synthetic barriers are also required to contain transformer oil leaks.

Locating transformers outdoors also provides a slight increase in risk of damage from water ingress and rodent intrusion, although this type of damage is rarely experienced. However, if paint on an outdoor transformer's enclosure is scratched, the enclosure could begin to rust and increase the likelihood of premature failure.

8.28 USUB-XFMR COST EVALUATION

Table 8.28-1 compares opinions of probable construction costs associated with using indoor versus outdoor transformers for the unit substation alternatives detailed under Alternatives USUB No. 2 and USUB No. 3. There would be additional costs associated with transformer oil containment structures for outdoor transformers, which are not included in Table 8.28-1. Costs for larger air conditioning equipment and a larger unit substation building when using indoor, dry-type unit substation transformers instead of using outdoor, liquid-filled transformers is included, as well as addition conduit and wiring required to use an outdoor transformer.

While indoor transformers would require additional cooling demand inside the unit substation building during the summer months, the heat output from the transformer would supplement heating equipment operating during the winter months. A detailed analysis during project design would need to be performed to accurately determine the actual expected operating times for heating and cooling equipment to determine the potential operating cost savings associated with using indoor or outdoor transformers.

	Alternative USUB-XFMR No. 1–Indoor, Dry-Type Unit Substation Transformers	Alternative USUB-XFMR No. 2–Outdoor, Liquid-Filled Unit Substation Transformers
USUB No. 2: Large Substation		
Equipment Cost	$200,000	$230,000
Additional Conduit and Wire Cost	$0	$57,000
Increased Building Cost for Indoor Transformer	$91,000	$0
USUB No. 3: Substation U12		
Equipment Cost	$170,000	$190,000
Additional Conduit and Wire Cost	$0	$35,000
Increased Building Cost for Indoor Transformer	$89,000	$0

Table 8.28-1 USUB-XFMR Alternative Comparison

8.29 USUB-XFMR ALTERNATIVES RECOMMENDATION

The recommended alternative is Unit Substation Transformer Alternative No. 2 because outdoor, liquid-filled transformers will reduce upfront costs for the unit substation building and HVAC equipment, will operate more efficiently, and will fully-protect the transformer windings from corrosive gasses. Based on the District's consistent maintenance and inspection efforts, it is reasonable to expect that liquid-filled transformers would be properly maintained and could be expected to have a longer operating life than dry-type transformers. The additional transformer maintenance associated with liquid-filled transformers is minor, and transformer failure due to water or rodent ingress is unlikely.

SECTION 9
MISCELLANEOUS MODIFICATIONS

This section presents a summary of additional evaluations and capital upgrades recommended for the NSWWTP that did not fit within the context of the previous evaluations and Facilities Plan sections. Some of these evaluations were developed in the technical memoranda (see Appendices), while others are included herein because of a stated need that was discovered through the various workshops, meetings, and interim deliverables.

Figure 9.01-1 provides a potential location for the metering structures at the plant, as well as other miscellaneous projects highlighted in this section of the Facilities Plan. Table 9.07-1 provides an opinion of probable cost for the structures and related facilities and services.

9.01 EAST-WEST PLANT FLOW METERING

All flows to the NSWWTP are measured using venturi flow meters upstream of the screening facilities. Following screening and grit removal, flows are split between the east and west plants but are not directly measured in terms of flow to each side. In the west plant, there are four magnetic flow meters that measure primary effluent flow into each of the four activated sludge trains. However, because of the location of these flow meters, calibration of the meters is not practical and has not been practiced. These flow meters are mainly used for process control to throttle the primary effluent valves into the activated sludge trains. East plant flows are estimated based on the difference between mixed liquor flows and RAS flows.

Based on the review of the flow data provided by the District for the activated sludge technical memorandum (TM-5, Appendix E), it became clear that the flow metering at the west plant was likely not accurate. This was evidenced by the fact that the flow measures at the west plant were less than the calculated flows to the east plant, even though the main flow splitter structure was set up to divert more flow to the west plant under normal flow conditions. Because of this situation, as well as the importance of accurately measuring flows to each plant for process control purposes, we recommend improving flow metering to both the east and west plants.

If new Parshall flumes are preferred for flow metering, the hydraulic grade line appears to have available head for flow metering downstream of the east-west splitter structure based on the plant hydraulic model (TM-4, Appendix D). New Parshall flumes should accommodate nearly all hydraulic conditions for both the east and west plants without surcharging. On the west plant, assuming an equal flow split to each plant, the new flume should be able to be constructed to avoid surcharging under all anticipated flows up to 90 mgd to the west plant. At the east plant, flows above about 80 mgd to the east plant would likely surcharge the new flume to the east plant. While this is not ideal, the main purpose of the flumes is for process control, and potentially inaccurate flow measurement to one-half of the plant under very rare conditions is not a significant concern. The main drawback of using Parshall flumes is the considerable cost of constructing new concrete structures to house the new flumes. The main pipes serving the east and west plants are fairly deep, and the opinion of construction costs for the new structures and metering equipment is approximately $100,000 to $150,000 for each side, or $200,000 to $300,000 total.

One alternative includes a relatively new in-pipe flow metering technology that would not require construction of significant concrete structures. This technology (e.g., Teledyne ISCO accQpulse™ Velocity Profiler) uses a pressure transducer and measures flow velocity at several locations across the pipe/channel cross section, and can be installed within an existing pipe at a manhole or structure location. This technology provides a ± 2 percent accuracy based on the company’s literature, which is adequate

NINE SPRINGS WASTEWATER TREATMENT PLANT – MISCELLANEOUS MODIFICATIONS

2016 LIQUID PROCESSING FACILITIES PLAN

MADISON METROPOLITAN SEWERAGE DISTRICT

FIGURE 9.01-1

1021.015

for this application. For the purposes of this Facilities Plan, we have assumed that a new access structure would be required in both the east and west plants, which would include a large-diameter manhole. The opinion of cost for this alternative is approximately $50,000 to 75,000 for each side, or approximately $100,000 to $150,000 total. If an existing structure proves suitable for installation of the meters, these costs could potentially be reduced to about $30,000-$40,000 for each metering location, or $60,000 to $80,000 total.

For the purposes of this Facilities Plan, we have included this alternative “in-pipe” metering equipment and have assumed that new structures would be required. A total project budget of $150,000 is recommended. We also recommend the District pilot test the equipment in an accessible pipe to demonstrate accuracy and viability of the technology.

9.02 PRIMARY CLARIFIERS NO. 1 AND NO. 2 REHABILITATION

Primary Clarifiers No. 1 and No. 2 are part of the east plant battery of primary clarifiers and were constructed in the early 1930s as part of the First Addition to the NSWWTP. These tanks have been in service for more than 80 years, and are still in serviceable condition. The structural condition of these tanks was assessed to identify structural deficiencies and develop rehabilitation costs for these tanks to include in the District’s capital plan.

A summary of the condition assessment conducted on these tanks is included in TM-3 (Appendix C) along with photos of the tanks’ noted deficiencies. The opinion of cost to rehabilitate the tank structures is approximately $450,000.

9.03 EAST PRIMARY INFLUENT PIPE REHABILITATION/REPLACEMENT

The east primary influent pipe is a 54-inch pre-stressed concrete cylinder pipe (PCCP). The pipe was installed in about 1975 as part of the 5th addition to the NSWWTP and conveys wastewater approximately 500 feet from Junction Structure No. 2 to the east primary clarifier influent channel. The District previously videotaped the inside of the pipe in 2007, and the video footage was provided to Strand Associates, Inc.® (Strand) for review. The purpose of this review was to develop rehabilitation costs for this pipe to include in the District’s capital plan.

Based on our hydraulic analysis, the existing 54-inch pipe has adequate capacity to accommodate higher future flows, and, therefore, replacement of the pipe to increase hydraulic capacity is not anticipated to be needed within the planning period. The existing pipe will need to be in serviceable condition throughout the planning horizon of this Facilities Plan, and it will require some form of rehabilitation to restore the overall integrity and reliability of the piping. Strand reviewed the closed circuit television (CCTV) video of the sewer conducted by the District in 2007. Detailed notes related to the CCTV review are included in TM3, which is included at Appendix C.

Rehabilitation options focused on trenchless alternatives (vs. conventional “open cut” techniques). This would involve application of a coating that is applied once the system has been thoroughly cleaned. The coatings evaluated included a corrosion-resistant cementitious lining, a polymer-based spray-on lining system, and epoxy coatings. The costs for coating options range from about $300 to $600 per lineal foot and include the necessary preparation work and access chambers for equipment and personnel. Total budgetary costs, including pipe cleaning, bypass pumping, engineering, and contingencies, are in the range of $300,000 to $600,000. Full replacement of the pipe would be expected to be in the range of $500,000 to $800,000.

Prior to developing a final plan to rehabilitate or replace this pipe, we recommend televising the line again to determine whether its condition has deteriorated significantly in the last 10 years. For the purposes of this planning document, we recommend including a budget of $800,000 in the capital plan as a conservative placeholder.

9.04 EFFLUENT PUMPING STATION HYDRAULIC BACKFLOW PROTECTION

There have been at least two occurrences where the effluent pumps failed and the effluent pumping station wet well surcharged. This caused water to leak onto the floor above the wet well. Electrical controls and gear for the effluent pumps are located in the room above the wet well, and there is concern that future occurrences could structurally damage the floor and/or damage the electrical equipment, resulting in a catastrophic failure and the system being out of service for an extended period of time.

The main concern is during peak flow events, when the effluent storage tanks and the wet well are full, and three large effluent pumps are pumping about 76 mgd. Under an emergency shut down condition, the three pumps will stop pumping and the discharge cone valves will close over a 30-second period. During this time, wastewater in the 54-inch force main will reverse flow and flow back through the pumps and into the wet well. Because the storage tanks are typically full, there is not enough hydraulic head to push flow all the way to the effluent storage tanks at the volumetric rate needed. Therefore, the wet well top slab can become pressurized.

This concern was discussed at both the disinfection workshop as well as the electrical reliability workshop. The following alternatives were considered and are discussed further in the following:

- Relocate the electrical controls and gear.
- Construct an overflow from the wet well to the ground.
- Close the cone check valves more quickly.

A. Relocate the Electrical Controls and Gear

Relocating the electrical control and gear would require construction of an addition to the Effluent Building to house the existing electrical controls. Based on the existing area of approximately 25 feet by 84 feet, a building addition of 2,100 square feet would be required. At an approximate cost of $200 per square foot, the addition would be approximately $400,000 plus the cost of relocating the gear. If the electrical equipment is moved, however, a wet well surcharge could still cause structural damage. Based on discussion with District staff at the technical workshops, this alternative was decided to be too expensive and was not considered further.

B. Construct an Overflow from the Wet Well to the Ground

Constructing an overflow from the wet well to the ground outside of the Effluent Building would provide protection of the structure and electrical gear by installing piping to the exterior of the Effluent Building. Effluent forcemain surge modeling indicated that approximately 5,000 gallons of backflow over a 30-second period is anticipated. This represents an average flow rate of 10,000 gpm, with a peak of approximately 24,000 gpm [53.5 cubic feet per second (cfs)]. Because of the relatively small wet well and the considerable complexity of finding a suitable location for the overflow and route to the exterior, multiple pipes may be required rather than one large diameter pipe. In addition, there is a good likelihood that structural and other building modifications will be required because of the location of the wet well and the surrounding process and building elements. Finally, although overflows would be a rare occurrence, the WDNR will need to approve the proposed overflow concept. This option would need to be evaluated in considerable detail during a preliminary design phase to establish actual routing and construction requirements. A minimum budget of about $100,000 should be included, and based on a preliminary review of the structure and potential conflicts, we recommend budgeting $200,000 for this alternative.

C. Close Cone Check Valves More Quickly

If the cone check valves are adjusted to close more rapidly in the event of pump failure, this would reduce the backflow of wastewater into the pumping station wet well. While this may minimize wet well surges, care must be taken not to cause a significant pressure surge in the forcemain and potentially damage the effluent piping through significant negative and positive pressures that would result from a more rapid closing. The existing calculated negative pressures already exceed the nominal specified negative pressure for this pipe. Therefore, we recommend testing of the pipe and additional monitoring of pressures before this alternative is implemented.

The peak flow management recommendations included construction of improvements to better manage the hydraulic profile through the plant, which included the ability to lower the hydraulic grade line through the east plant to divert more volume to the lagoons. This modification will allow the District to better manage the hydraulics through the UV disinfection facilities as well as to the effluent pumping station. The existing wet well has dimensions of about 184 feet long, 10 feet wide, and a total depth of about 17 feet to the bottom of the elevated slab. A weir wall separates the UV disinfection facilities from the wet well, and the top of the weir wall is approximately 13 feet above the floor of the wet well. Given the very long broad crested weir length, the water level over the weir wall would be about 7 inches if the effluent wet well level were at the top of the weir wall at a flow of 80 mgd (122 cfs). The volume available in the wet well under these conditions is in excess of 45,000 gallons before reaching the top slab of the wet well. Therefore, if the hydraulic grade line is maintained at a lower elevation in the effluent wet well under maximum flow conditions, there appears to be ample volume to store the anticipated volume of backflow into the effluent wet well. Based on this analysis, we recommend that a detailed hydraulic analysis be conducted as part of the preliminary design phase of the peak flow management improvements to verify that the proposed overflow structure (with variable weir elevation) will also mitigate the concern with backflow into the effluent pump station wet well under emergency conditions.

9.05 EFFLUENT FORCE MAIN STANDPIPE MODIFICATIONS

The 54-inch effluent force main from the effluent pumping station to the Badfish Creek discharge location includes a standpipe that was installed to provide a positive air release location along the force main route. The standpipe includes about 21 feet of 12-inch ductile iron pipe, with a transition to an additional 20 feet of 16-inch ductile iron pipe. Video footage of one event indicates wastewater is pushed up the standpipe because of large volumes of air within the force main. That is, the standpipe does not overflow, but rather wastewater is forcibly lifted in the standpipe and is expelled with large volumes of air. Force main surge modeling confirmed this understanding and indicates the hydraulic grade line elevation at the standpipe location does not exceed the top of the standpipe (TM-3, Appendix C).

The total potential discharge volume of treated effluent wastewater from the standpipe is not known, nor is the quantity predictable. While the volume of discharge is inconsequential in comparison to the total volumes pumped, and while the wastewater is highly treated and likely does not create an environmental concern, the District wishes to eliminate the surge overflow to the extent practical.

Some of the video footage showed wastewater being discharged more than 10 to 20 feet into the air above the current standpipe. If the standpipe diameter was increased by a factor of 2 or 3 about half way up the standpipe, we believe the wastewater carried with the air would not be expelled from the pipe. For budgetary purposes, we recommend the District include a budget of about $100,000 to conduct more detailed investigations and to replace the approximate 45 feet of standpipe with larger diameter pipe and potentially other modifications.

9.06 PROCESS CONTROL SYSTEM (PCS) PHASE II UPGRADES

The 2012 PCS Facilities Plan was developed to plan the upgrade and replacement of the NSWWTP process control system. The PCS plan is being implemented in two main phases, and Phase I has been completed. Phase II was originally planned to coincide with the upgrades to the east and west blowers, blower controls, and aeration system controls. At the time of the 2012 PCS Facilities Plan development, it was believed that these improvements would be implemented within the next 5 to 7 years (prior to 2020). However, as developed within this current Liquid Processing Facilities Plan, aeration system and blower controls addressed with the PCS Phased II project may not be upgraded until 2024 or later.

The Phase II project will replace the remaining 10 Bristol Babcock distributed control units (DCUs) that were left in place during the Process Control System Upgrade–Phase I. The manufacturer of the DCUs (Bristol Babcock) declared these controllers obsolete as of 2011. Replacement parts for the controllers are no longer available. Configuring the controllers also relies on an operating system that has been obsolete since 2004 (Windows NT). Therefore, the recommendation is to proceed with the PCS Phase II upgrades identified in the 2012 PCS Facilities Plan. District staff and Strand Associates have reviewed the previous facilities plan, and the budget associated with the Phase II project has an opinion of cost of approximately $1,500,000. These upgrades are recommended to be completed as part of the “near term” LPFP upgrade project as provided in Section 10 of this Facilities Plan.

9.07 RECOMMENDATIONS

This section includes a summary of miscellaneous modifications that may be included in future capital projects. Each of the sections provides justification for the various project elements, with a recommendation for implementation and an opinion of cost. These analyses and recommendations are summarized in Table 9.07-1.

Project Element/Description	Alternative to Include in Budget	Recommended Budget	Comments
East-West Flow Metering	In-Pipe Doppler	$150,000	Could potentially be reduced; recommend pilot testing.
Primary Tanks Nos. 1 and 2	Rehabilitate	$450,000	
East Primary Influent Rehab or Replace		$800,000	Recommend reinspecting before deciding on a path forward.
Effluent Pump Station Surge Protection	Do Nothing	$0	Conduct detailed hydraulic analysis of the hydraulic grade-line with the proposed new effluent control structure.
Effluent Force Main Standpipe	Upgrade standpipe and investigate root cause	$100,000	District wishes to eliminate all discharges at the standpipe.
PCS Phase II Upgrades	Implement upgrades	$1,500,000	Planning was completed in 2012 and Phase I was previously implemented.

Table 9.07-1 Miscellaneous Modifications Opinion of Cost Summary

SECTION 10
PROJECT RECOMMENDATIONS AND IMPLEMENTATION

This section summarizes the recommended improvements, presents a proposed implementation schedule, evaluates the impact of the project on the environment, and summarizes the impact of the proposed improvements on sewer user charge rates.

10.01 SUMMARY OF CAPITAL IMPROVEMENT RECOMMENDATIONS

Recommendations for capital improvements and future investigations were made in previous sections of this Facilities Plan and the associated technical memoranda. A summary of the recommended upgrades and modifications for the NSWWTP is summarized by process/major facilities planning area in the following:

A. Peak Flow Management

The main focus of the peak flow management evaluations was to provide the ability to manage the anticipated peak flows without overflowing NSWWTP structures and while continuing to meet effluent permit limits. We recommend the District implement Alternative PF10, which includes hydraulic capacity upgrades to the following facilities at the NSWWTP:

1. Construct bypass channel for west primary clarifiers.
2. Raise west final clarifier influent channel walls by 1 foot and modify channel at roadway crossing to prevent overflows.
3. Construct new effluent structure to control diversion to the lagoons and flow conveyed from the east plant to the disinfection building.
4. Construct upgrades to the east and west activated sludge facilities to provide the ability to operate in a biological contact process mode during high flow events.

We also recommended that the District begin evaluating in more detail potential paths forward related to implementing a local permitted discharge to Nine Springs Creek as a first step towards a potential continuous future discharge to Nine Springs Creek at the District.

The District may also consider initiating an aggressive I/I reduction pilot study focused on identifying one or more areas with high I/I rates, and then implementing aggressive I/I reduction measures with the goal of quantifying successes and challenges for future additional measures in other areas.

B. Headworks and Hauled Waste Receiving

The main concern with the existing headworks facilities include a requirement to control the screening channel water depth within a very narrow range, which results in continuous screening equipment operation and significant maintenance concerns. In addition, the hauled waste receiving facilities require considerable operator attention and result in high grit loadings to the screening channels. The recommended headworks and hauled waste receiving improvements consist of the following:

1. IFM5–Relocate Venturi Flow Meters to Lower Elevation
2. S1–Screen Sluiced Screenings or S3–Install New Step Screens and Wash Presses

3. G1–Replacement of Grit Classifiers with Grit Washers; Replace Other Equipment (Year 10)

4. HW1–Construction of a Drive-Through Hauled Waste Receiving Station at the Headworks Building

The timing of the execution of the improvements to these facilities may be adjusted to accommodate the condition of the various equipment involved or to combine or separate project elements to fit the needs of the District.

C. Activated Sludge and Nutrient Removal

The existing biological phosphorus removal activated sludge facilities have operated well for many years and continue to serve the near-term needs of the District. The main focus of the facilities planning evaluations was energy efficiency and future upgrades to remove nitrogen. The recommended aeration system capital improvements consist of full-plant implementation of nitrite shunt (Alternative AS4) with high efficiency membrane diffusers, new west blowers and aeration piping cross-connect, and new secondary clarifiers. However, because this process is relatively new and does not have many full-scale operating installations, the District is currently conducting bench-scale pilot testing of the nitrite shunt process. If the bench-scale testing proves to be successful, full-scale pilot testing of nitrite shunt operation is recommended. In addition, final clarifier stress testing is recommended to be conducted to verify clarifier performance and to potentially eliminate the requirement to construct new final clarifiers.

The recommended plan is summarized below (assuming successful bench-scale testing):

1. Conduct clarifier stress testing.

2. Implement Nitrite Shunt Full-Scale Demonstration Study-Install new membrane strip diffusers, polymer feed system, and AVN instrumentation and control system in Plant No. 3 or 4 on the west side.

3. If demonstration testing is successful, implement nitrite shunt operations in the remaining activated sludge plants, including membrane strip diffusers, AVN instrumentation, control valves and flow meters, construction of two new final clarifiers (unless stress testing indicates these are not required), and construction of post-aeration facilities.

4. Construct aeration system efficiency improvements, including interconnecting the east and west aeration systems and installing new west side blowers. These improvements will likely be phased to coincide with nitrite shunt upgrades noted above. The east side blowers may not require replacement if this cross-connection is put into place.

5. Implement miscellaneous activated sludge system improvements noted by District staff during planning, including scum beach icing control, replacement of Plant 2 RAS control valves, and increasing drainage pumping capacity.

6. Improve RAS pump energy efficiency, including new high-efficiency motors for some of the RAS pumps. Alternative improvements include new VFDs or modifying the control of the RAS pumps.

D. Disinfection

The main concern with the existing UV disinfection system is its age. This system was installed in the mid 1990s and is operating beyond the typical useful life for this type of equipment. In addition, the manufacturer of the equipment has not supported this particular system for about 20 years, and replacement parts are becoming more difficult to source or produce. The recommended capital improvements for disinfection include the installation of new UV disinfection equipment within the existing channels (Disinfection Alternative D1 or D2).

E. Electrical Reliability

Electrical improvement alternatives for the NSWWTP included in this facilities planning effort consisted of evaluations related to upgrading or providing the headworks backup power, blower controls, blower medium voltage switchgear, and unit substations U11, U12, and U13. The main goal of these evaluations was to improve systems and overall NSWWTP reliability. The recommended plan consist of the following:

1. No change to the headwork facility backup power situation.
2. Replace the east blower control panel.
3. Replace the east and west blower building switchgear in conjunction with future blower replacements. This may result in no east blower switchgear replacement if the aeration system cross connect is constructed.
4. Construct one new unit substation to replace the existing substations U11, U12, and U13.

F. Miscellaneous Improvements

Miscellaneous improvements were included in the overall scope of the facility plan to evaluate upgrades to some of the aging infrastructure. The following improvements are recommended:

1. Rehabilitate primary clarifier Tanks 1 and 2–These tanks date back to the original construction of the NSWWTP and are in need of some concrete restoration.
2. Replace ore rehabilitate the 54-inch primary influent pipe from the east primary junction chamber to the east primary clarifiers. The most recent inspection is from 2007 and showed that the pipe had deteriorated. We recommended an additional inspection before proceeding with replacement or rehabilitation.
3. Install flow metering equipment to measure flows to the east and west plants. This will provide improved process monitoring and control.
4. Conduct further effluent force main standpipe investigations and construct a new, wider effluent force main standpipe to eliminate effluent wastewater from spilling to the ground.
5. Proceed with the PCS Phase II upgrades identified in the 2012 PCS Facilities Plan. This will replace obsolete DCUs and improve overall system control and reliability.

10.02 IMPLEMENTATION PLAN AND SCHEDULE

Since none of the recommended improvements require immediate implementation because of regulatory drivers or because of concerns with imminent failure, the District has flexibility to phase the recommended improvements to best fit its Capital Improvements Plan and future budgets. A preliminary implementation plan for the proposed improvements is presented in Table 10.02-1. This plan is based on discussions with the District and includes three main project phases for near term, mid-term, and longer term construction. All the projects identified are currently scheduled to be completed within about 10 years. However, since there are no immediate regulatory drivers, the District may decide to implement these projects on an alternate schedule.

Table 10.02-1 Recommended Improvements and Phasing

Component	Near Term (2017-2022)	Mid Term (2020-2025)	Future (2024+)
PEAK FLOW			
Alternative PF10–Biological Contact	$5,200,000		
HEADWORKS			
Alternative IFM5–Relocate Venturis to Lower Elevation	$2,100,000		
Alternative S3–New Step Screens and Wash Presses		$3,400,000	
Alternative G1–New Grit Washers			$2,000,000
Alternative HW1–Drive-Through Hauled Waste Station	$2,900,000		
ACTIVATED SLUDGE			
Nitrite Shunt Pilot Test and Polymer Feed System		$2,260,000	
Other BNR System Maintenance Issues		$420,000	
Full Plant Nitrite Shunt			$17,860,000
Aeration Cross-connect Piping		$2,160,000	
Two new west blowers		$4,200,000	
One new west blower			$2,100,000
RAS Pump Energy Efficiency Improvements		$100,000	
Clarifier Stress Testing	$130,000		
DISINFECTION			
Alternative D1/D2–Replace UV Equipment	$3,800,000		
ELECTRICAL			
Alternative EBC No. 1–Replace East Blower Control Panel	$390,000		
Alternative BMC No. 1–Replace East Blower Building Switchgear			$1,140,000
Alternative BMC No. 2–Replace West Blower Building Switchgear			$900,000
Alternative USUB No. 3–Replace Unit Substation U12 with One New Indoor Unit Substation and Eliminate Unit Substations U11 and U13 with Alternative USUB-XFMR No. 2–Outdoor, Liquid-Filled Unit Substation Transformers	$3,100,000		
MISCELLANEOUS			
Primary Tanks 1 and 2 Rehabilitation	$450,000		
54-inch Primary Influent	$800,000		
East-West Plant Flow Metering	$150,000		
Effluent Force Main Standpipe Revisions	$100,000		
PCS Phase II Upgrades	$1,500,000		
TOTALS	**$20,620,000**	**$12,540,000**	**$24,000,000**

Note: All costs are in 2nd quarter 2017 values.

10.03 RESOURCE IMPACT ANALYSES

The recommended improvements will improve effluent quality and the ability of the NSWWTP to manage and treat wastewater in during flow events, resulting in an overall positive impact on the surrounding environment.

A. Water Quality

The recommended improvements improve treatment performance, including nutrient removal and peak flow treatment capacities, as well was electrical and disinfection equipment reliability. These improvements should result in a higher quality effluent and fewer disturbances in treatment during power or equipment related outages and peak flow events.

B. Air Quality

A reduction in energy use associated with the recommended activated sludge improvements is anticipated to have a positive impact on air quality through a reduction in the burning of fossil fuels. As discussed in Section 6, GHG emissions from activated sludge processes is an area of current research, but treatment processes that include nitrogen removal, such as the recommended plan, emit less N_2O than those that do not.

C. Historic and Archeological Sites

All the recommended improvements are located at the existing NSWWTP site. The site has been disturbed in several previous construction projects and no significant historic or archeological sites are known to be present that would be impacted by the recommended improvements.

D. Floodplains and Other Sensitive Environmental Areas

All the recommended improvements are located at the existing NSWWTP site and are outside of the 100-year floodplain. There are no sensitive environmental areas on-site that would be impacted by the recommended improvements. These considerations should be reevaluated if the District choses to pursue a local Nine Springs Creek discharge.

E. Public Health

The recommended plan will improve the treatment capacity, efficiency and reliability of the NSWWTP, which should have a net positive impact on public health.

10.04 PROJECT FUNDING

The District intends to use the Clean Water Fund program to finance future construction projects. The DNR Bureau of Environmental Loans administers the Clean Water Fund program that provides reduced interest rate loans for eligible wastewater projects. The interest rate for eligible projects is 2.38 percent (70 percent of market rate), as of July 1, 2017. The Wisconsin Department of Administration sets the current market interest rate quarterly, and the percent of market rate the Clean Water Fund charges for loans (currently at 70 percent), is set as part of the state budget process. In the next fiscal year, the subsidize interest rate is expected to be 55 percent of the market rate, though this has not been finalized yet. Flows from industrial dischargers and reserve capacity at the treatment plant for flows beyond 10 years from the time of the project completion are not eligible for the low interest rate financing, and the costs associated with facilities to treat these flows would be financed at the market interest rate.

This facilities plan covers numerous projects over approximately 10 years. The effects on user charges depends on the actual timing and cost of the projects, the CWF interest rate, the growth in district loadings, and the allocation of the annual revenue requirement for capital and annual operating costs over the District's billing parameters. The long time period covered by the projects in this facilities plan further complicates the analysis, and a detailed user charge study is outside the scope of this report. As a general guideline, based on the District's analysis, $1.0 million in debt service equates to $6 to $7 for a typical residential household's annual bill.

Table 10.02-1 shows phasing for the recommended projects in several time periods: Near term (2017 to 2022), Mid term (2020 to 2025) and Future (2024+). The costs in Table 10.02-1 are on a 2017 cost basis. Table 10.04-1 summarizes the effects of the proposed projects on the typical residential customer. It includes the following assumptions:

- Annual construction inflation of 3 percent.
- A 4 percent CWF interest rate on project loans, 20 year loans with 19 years of principal payments on each loan.
- $6 to $7 cost to a typical residential households annual bill per $1 million of debt service.
- A 5 percent annual average increase of residential rates including both MMSD and community charges.

The estimated annual residential service charge for MMSD-provided services in 2017 is $170, or $14.20 per month. The estimated annual typical residential charge including both MMSD and local community charges in 2017 is $313. In 2020, the typical residential service charge is estimated to be $360. The cost of the first phase projects is estimated to be $10.50 to $12.00 of the $360 total charge. The second phase projects are estimated to account for $6.50 to $7.50 of a total annual charge of $400 in 2022. The third phase projects are estimated to account for $13 to $15.50 of a total annual charge of $460 in 2025. In total, the projects included in this plan are estimated to account for $14 to $16 of the estimated typical residential charge of $460 in the year 2025.

Phase	2017 to 2022	2020 to 2025	2024+
Table 10-02-1 Costs	$20,620,000	$12,540,000	$24,000,000
Estimated Cost in Year of Construction	$22,500,000	$14,500,000	$30,400,000
Estimated Annual Debt Service	$1,710,000	$1,100,000	$2,310,000
Residential Rate Impact, per year	$10.50 to $12.00	$6.50 to $7.50	$14.00 to $16.00
Year of Rate Analysis	2020	2022	2025
Estimated Total Annual Residential Charge	$360	$400	$460

Table 10.04-1 Sewer User Charge Impacts

Liquid Processing Facilities Plan

Appendices

Madison Metropolitan Sewerage District, WI

August 2017

APPENDIX A–TECHNICAL MEMORANDUM NO. 1
SUSTAINABILITY MANAGEMENT SYSTEM

TECHNICAL MEMORANDUM NO. 1

TO: JEFF KLAWES, MADISON METROPOLITAN SEWERAGE DISTRICT

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DATE: MAY 2, 2016
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RE: 2016 LIQUID PROCESSING FACILITIES PLAN (PLANNING PHASE)
TASK 2 - SUSTAINABILITY MANAGEMENT SYSTEM

INTRODUCTION

The purpose of this technical memorandum is to update the District's Sustainability Management System template specific to the 2016 Liquid Processing Facilities Plan (LPFP). This document is meant to be a living document that will be updated and made more specific at each step of the project development stage.

TECHNICAL MEMORANDUM NO. 1

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PROJECT NAME AND PHASE: 2016 LIQUID PROCESSING FACILITIES PLAN (PLANNING PHASE)

Table 1. Document Control

Authors	Version	Date
MMSD-ch	Draft Template	11/22/13
Strand	First Draft SMS - Planning Phase	5/2/16
Strand	Second Draft - Planning Phase	1/31/17

Section 1 - Madison Metropolitan Sewerage District (MMSD) Sustainability Management System – Infrastructure Projects (SMS-IP) – Introduction and Overview

Overview:

The SMS-IP serves as a tool that enhances sustainable performance of infrastructure projects by documenting sustainability objectives and establishing processes and procedures that facilitate implementation and quality control. It also serves as a repository for documentation that is foundational to standard operating procedures, policies and procedures that are both relevant for sustainability management and are in effect for general operations at the District. The SMS applies to projects that have received the authorization to proceed, with a generally defined scope, type of project, etc. It applies during the initiation phase until the project is officially transferred to operations/commissioned. The SMS-IP is intended as a living document that is continually updated to reflect changes in objectives and procedures. It is intended as a companion document for the project management of infrastructure projects to other documents and procedures that are in place for infrastructure projects.

Procedure:

- The MMSD SMS-IP will be regularly reviewed and updated by the District's Sustainable Infrastructure Manager (SIM) in close coordination with other MMSD staff to ensure its relevance for infrastructure projects.
- Significant updates will be presented to the LPFP Core Team communicated by the MMSD LPFP Project Manager and consulting firm.
- For this project, the MMSD's consultant customized the SMS-IP during the facilities planning phase.

Section 2 - Sustainability Policy Goals and Objectives

Overview:

Infrastructure Project Sustainability Policy

MMSD (or the "District") has a long tradition of working on behalf of the communities it serves. MMSD is an industry leader in regulatory compliance, customer service, employee development and innovation. The mission statement: "To protect public health and the environment by providing exceptional wastewater conveyance, treatment and related services," drives the District's commitment to sustainability. The District envisions that:

- MMSD will not only enrich the community by improving living conditions for people, plants and animals, but also educate others so they too can take steps to conserve our resources.

- By changing the way we think about and use water, together we have the power to enhance the quality of life on our planet.
- By making small changes and respecting every drop of water we have today, we can set the tone for a resource-conscious and sustainable community tomorrow.

Infrastructure project sustainability policy statement:

MMSD will use the Envision rating system as a sustainability framework and use the SMS-IP as a tool to manage, measure and continuously enhance sustainability performance for infrastructure projects.

MMSD leadership and the project team are committed to inspire and increase sustainable performance while holding project team members, consultants and contractors accountable. Through the tools and other project management mechanisms that are identified throughout the document, we establish processes that monitor and continuously improve sustainability performance.

Sustainability Criteria for Infrastructure Projects

MMSD is committed to using the Envision rating system as an infrastructure sustainability framework for its projects. Envision establishes not only a baseline, but outlines a path towards higher performance.

The Envision Credit List on the following page illustrates the criteria that the project will aim to achieve, where applicable.

QUALITY OF LIFE
13 Credits

1 PURPOSE
- QL1.1 Improve Community Quality of Life
- QL1.2 Stimulate Sustainable Growth & Development
- QL1.3 Develop Local Skills and Capabilities

2 WELLBEING
- QL2.1 Enhance Public Health and Safety
- QL2.2 Minimize Noise and Vibration
- QL2.3 Minimize Light Pollution
- QL2.4 Improve Community Mobility and Access
- QL2.5 Encourage Alternative Modes of Transportation
- QL2.6 Improve Site Accessibility, Safety & Wayfinding

3 COMMUNITY
- QL3.1 Preserve Historic and Cultural Resources
- QL3.2 Preserve Views and Local Character
- QL3.3 Enhance Public Space

- QL0.0 Innovate or Exceed Credit Requirements

NATURAL WORLD
15 Credits

1 SITING
- NW1.1 Preserve Prime Habitat
- NW1.2 Protect Wetlands and Surface Water
- NW1.3 Preserve Prime Farmland
- NW1.4 Avoid Adverse Geology
- NW1.5 Preserve Floodplain Functions
- NW1.6 Avoid Unsuitable Development on Steep Slopes
- NW1.7 Preserve Greenfields

2 LAND+WATER
- NW2.1 Manage Stormwater
- NW2.2 Reduce Pesticides and Fertilizer Impacts
- NW2.3 Prevent Surface and Groundwater Contamination

3 BIODIVERSITY
- NW3.1 Preserve Species Biodiversity
- NW3.2 Control Invasive Species
- NW3.3 Restore Disturbed Soils
- NW3.4 Maintain Wetland and Surface Water Functions

- NW0.0 Innovate or Exceed Credit Requirements

LEADERSHIP
10 Credits

1 COLLABORATION
- LD1.1 Provide Effective Leadership & Commitment
- LD1.2 Establish a Sustainability Management System
- LD1.3 Foster Collaboration and Teamwork
- LD1.4 Provide for Stakeholder Involvement

2 MANAGEMENT
- LD2.1 Pursue By-Product Synergy Opportunities
- LD2.2 Improve Infrastructure Integration

3 PLANNING
- LD3.1 Plan for Long-Term Monitoring & Maintenance
- LD3.2 Address Conflicting Regulations and Policies
- LD3.3 Extend Useful Life

- LD0.0 Innovate or Exceed Credit Requirements

CLIMATE AND RISK
8 Credits

1 EMISSIONS
- CR1.1 Reduce Greenhouse Gas Emissions
- CR1.2 Reduce Air Pollutant Emissions

2 RESILIENCE
- CR2.1 Assess Climate Threat
- CR2.2 Avoid Traps and Vulnerabilities
- CR2.3 Prepare for Long-Term Adaptability
- CR2.4 Prepare for Short-Term Hazards
- CR2.5 Manage Heat Island Effects

- CR0.0 Innovate or Exceed Credit Requirements

RESOURCE ALLOCATION
14 Credits

1 MATERIALS
- RA1.1 Reduce Net Embodied Energy
- RA1.2 Support Sustainable Procurement Practices
- RA1.3 Use Recycled Materials
- RA1.4 Use Regional Materials
- RA1.5 Divert Waste from Landfills
- RA1.6 Reduce Excavated Materials Taken Off Site
- RA1.7 Provide for Deconstruction and Recycling

2 ENERGY
- RA2.1 Reduce Energy Consumption
- RA2.2 Use Renewable Energy
- RA2.3 Commission and Monitor Energy Systems

3 WATER
- RA3.1 Protect Fresh Water Availability
- RA3.2 Reduce Potable Water Consumption
- RA3.3 Monitor Water Systems

- RA0.0 Innovate or Exceed Credit Requirements

Procedure:

- The District's leadership is responsible for ensuring that the sustainability vision aligns with the strategic vision of the District as a whole. Any changes that the District's leadership initiates will be communicated with the staff and other stakeholders.
- The SIM is responsible for routinely reviewing the SMS and ensuring that the tools and procedures (including the Envision tool, the Sustainable Action Map [SAM] tool, and the development of Business Cases) align with the mission and vision of the District.
- The SIM is responsible for establishing a review process that is designed to continually improve the tools and mechanisms in place to enhance sustainability performance.
- The PM is responsible for developing project-specific goals and objectives (Section 10). For this project's planning phase, it is anticipated that the PM will have input from the rest of the Project Team including the SIM and the project consultant.
- The PM is responsible for developing and keeping an inventory of sustainability aspects (Table 2) that are considered for each infrastructure project, what decisions are made and actions taken. The Project Team will assist the PM with this inventory during the planning phase of the project. Table 2 will be updated with additional aspects during subsequent design, construction, commissioning and operating phases of the project.
- The PM, with assistance from the Project Team, is responsible for keeping a summary of measurements that correspond to Envision Criteria (actual measurements, e.g., lumen, decibel, pound, percentage, $, etc. - Table 3). Table 3 will be established during the project planning phase and updated during the design and construction phases.
- Project related evaluations, and decisions required to be made by MMSD, will follow a relatively standard engineering planning process as outlined in the *Decision Making and Problem Solving for Liquid Process Facilities Planning Process* memorandum developed by MMSD (Attachment A). Related forms, documents, and procedures used in the decision making process are included in Attachment B (SAM tool) and Attachment C (Business Case procedure example).
- The PM, with assistance from the Project Team, is responsible for ensuring that sustainability aspects, new/changed project elements and performance measures are integrated in the standard project deliverables, in particular the "Facilities Planning Report."

Table 2: Project Sustainability Aspects Considered During Planning Phase) (to be developed further during subsequent project phases)

Overall General		Envision Credit(s) Addressed	Implemented (Y/N)	Engineer Responsible	Status?	Notes
1	Establish project team, leadership and commitment	QL1.3, LD1.1, LD1.3			Open	Foster collaboration and teamwork, develop local skills and capabilities.
2	Establish a sustainability management system	LD1.2			Open	This living document is the SMS. It is intended to be updated through planning and subsequent design and construction phases.
3	Pursue synergies and infrastructure integration	LD2.1, LD2.2			Open	Consider peak flow management strategies upstream of the plant in conjunction with future major collection system needs.
4	Plan for long-term monitoring and maintenance and extend useful life	LD3.1, LD3.3			Open	The LPFP will consider a wide range of options, including the null alternative and will include a life-cycle, Triple Bottom Line analysis for project alternatives.
5	Address conflicting regulations and policies	LD3.2			Open	Opportunities may exist with BFC, BMC, and potential Nine Springs Creek discharges; or related to wet weather flow storage, blending, etc. In addition, upgrades/projects need to consider potential impacts related to air permitting.
6	Reduce net embodied energy and energy consumption; commission and monitor energy systems, reduce greenhouse gas emissions	RA1.1, RA2.1, RA 2.3, CR1.1			Open	Opportunities may exist with energy-efficient activated sludge, aeration systems, and other mechanical systems. Include robust monitoring (e.g., energy monitoring, ammonia-based controls, and more) to increase efficiencies.

7	Use renewable energy	RA2.2			Open	Consider opportunities such as biogas utilization and excess hot water utilization. Solar and wind energy could also be considered, if applicable, or in future phases.
8	Protect fresh water availability	RA3.1			Open	Opportunities related to water balance/watershed issues may exist.
9	Preserve prime habitat, farmland, and greenfields; protect wetlands, surface waters, and floodplain functions; manage stormwater	Various applicable NW credits			Open	Siting of new facilities such as wet weather flow storage, treatment, or disinfection should consider these factors in addition to traditional factors like cost, neighbors and convenience.
10	Provide for resiliency and adaptability; prepare for short-term hazards	CR2.1 - CR2.5			Open	For example, address peak flows and issues related to influent pumping capacity, climate change, etc.
11	Reduce air pollutant emissions	CR1.2			Open	Consider this when planning for biological treatment systems and wet weather flow storage, for example.
12	Prevent surface and groundwater contamination	NW2.3			Open	Threats may exist if the lagoons are disturbed, as portions are a superfund site.

Table 3: Envision Metrics Summary (The items for which applicable baselines are available are included below. This table will be updated during planning and/or as the project proceeds into design and construction phases.)

Envision Criteria	Baseline	Goal for New Measurement	Comments/Applicability
RA2.1 Reduce energy consumption	According to the Envision system, the benchmark involves meeting basic code and regulatory requirements regarding energy consumption. The Envision scoring references "industry norms." The current energy use is close to industry norms according to the Energy Roadmap Study.	Use the energy reduction goals from the Energy Roadmap Study. Reduce liquid treatment facilities operational and maintenance energy by ±15%.	Address during planning and design.
RA2.2 Use renewable energy	According to the Envision system, the benchmark is that renewable energy sources do not exceed 10% of the project's annual anticipated energy consumption. The current renewable energy use will be obtained from the Energy Roadmap Study	Use the renewable energy goals from the Energy Roadmap Study. Note that this facilities plan may recommend eventual elimination of the biogas-fed aeration blower because of age and condition. However, the energy roadmap assumes continued use of biogas for heat and energy production (i.e., versus flaring) and eventual increases in renewable energy use.	Address during planning and design if feasible; however, improvements may need to be deferred to future projects (i.e., new combined heat and power generation equipment using biogas, or new solar, wind or hydro power equipment).

CR1.1 Reduce greenhouse gas (GHG) emissions	According to the Envision system, the benchmark is "no reductions in carbon emissions relative to industry. Follow regulatory requirements only." The baseline is the current GHG emissions from the wastewater treatment plant (WWTP). The Energy Roadmap Study provides some data for the baseline.	Use the energy reduction-related goals above (see RA2.1 and RA2.2) for corresponding GHG emission reductions. GHG emissions from alternative liquid treatment processes may also need to be considered during planning and design (i.e., other than from energy). Reduce liquid treatment facilities GHGs by ±10% compared to the baseline.	Address during planning and design.
CR1.2 Reduce air pollutant emissions	The Envision system benchmark is the air quality required by regulation and compliance with local laws and regulations regarding the control of dust and odors during construction. The baseline is current emissions from the WWTP.	The Envision system suggests focusing on location selection and siting and source reduction during planning. The addition of active controls, monitoring systems` and mitigation measures should be considered at the design stage. The goal will be to substantially improve ambient air quality over previous levels.	Address during planning, design and construction. The six specific pollutants covered by Envision include carbon monoxide, nitrogen oxides, sulfur dioxide, suspended particulate matter smaller than PM-10, ozone and lead. California air quality standards are referenced.

Table 4: Envision Checklist Template

The checklist template, which is in MS Excel format, will be used during planning and design as a guide. A summary sheet is shown in Table 4. The checklist will be saved on the project web site. ISI Members may also find it here: http://www.sustainableinfrastructure.org/

#	Category	Subcategory	Credit	Y	N	NA	Score
1	QUALITY OF LIFE	PURPOSE	QL1.1 Improve Community Quality of Life	0	0	3	0 of 0
2			QL1.2 Stimulate Sustainable Growth and Development	0	0	3	0 of 0
3			QL1.3 Develop Local Skills and Capabilities	0	0	3	0 of 0
4		COMMUNITY	QL2.1 Enhance Public Health and Safety	0	0	1	0 of 0
5			QL2.2 Minimize Noise and Vibration	0	0	1	0 of 0
6			QL2.3 Minimize Light Pollution	0	0	1	0 of 0
7			QL2.4 Improve Community Mobility and Access	0	0	3	0 of 0
8			QL2.5 Encourage Alternative Modes of Transportation	0	0	2	0 of 0
9			QL2.6 Improve Site Accessibility, Safety and Wayfinding	0	0	3	0 of 0
10		WELLBEING	QL3.1 Preserve Historic and Cultural Resources	0	0	2	0 of 0
11			QL3.2 Preserve Views and Local Character	0	0	2	0 of 0
12			QL3.3 Enhance Public Space	0	0	2	0 of 0
			TOTAL	0	0	26	0 of 0
13	LEADERSHIP	COLLABORATION	LD1.1 Provide Effective Leadership and Commitment	0	0	3	0 of 0
14			LD1.2 Establish a Sustainability Management System	0	0	1	0 of 0
15			LD1.3 Foster Collaboration and Teamwork	0	0	3	0 of 0
16			LD1.4 Provide for Stakeholder Involvement	0	0	3	0 of 0
17		MANAGEMENT	LD2.1 Pursue By-product Synergy Opportunities	0	0	1	0 of 0
18			LD2.2 Improve Infrastructure Integration	0	0	3	0 of 0
19		PLANNING	LD3.1 Plan for Long-term Monitoring and Maintenance	0	0	2	0 of 0
20			LD3.2 Address Conflicting Regulations and Policies	0	0	2	0 of 0
21			LD3.3 Extend Useful Life	0	0	1	0 of 0
			TOTAL	0	0	19	0 of 0
22	RESOURCE ALLOCATION	MATERIALS	RA1.1 Reduce Net Embodied Energy	0	0	2	0 of 0
23			RA1.2 Support Sustainable Procurement Practices	0	0	3	0 of 0
24			RA1.3 Use Recycled Materials	0	0	2	0 of 0
25			RA1.4 Use Regional Materials	0	0	2	0 of 0
26			RA1.5 Divert Waste from Landfills	0	0	3	0 of 0
27			RA1.6 Reduce Excavated Materials Taken off Site	0	0	3	0 of 0
28			RA1.7 Provide for Deconstruction and Recycling	0	0	3	0 of 0
29		ENERGY	RA2.1 Reduce Energy Consumption	0	0	3	0 of 0
30			RA2.2 Use Renewable Energy	0	0	2	0 of 0
31			RA2.3 Commission and Monitor Energy Systems	0	0	3	0 of 0
32		WATER	RA3.1 Protect Fresh Water Availability	0	0	7	0 of 0
33			RA3.2 Reduce Potable Water Consumption	0	0	4	0 of 0
34			RA3.3 Monitor Water Systems	0	0	4	0 of 0
			TOTAL	0	0	41	0 of 0
35	NATURAL WORLD	SITING	NW1.1 Preserve Prime Habitat	0	0	5	0 of 0
36			NW1.2 Protect Wetlands and Surface Water	0	0	3	0 of 0
37			NW1.3 Preserve Prime Farmland	0	0	1	0 of 0
38			NW1.4 Avoid Adverse Geology	0	0	3	0 of 0
39			NW1.5 Preserve Floodplain Functions	0	0	6	0 of 0
40			NW1.6 Avoid Unsuitable Development on Steep Slopes	0	0	2	0 of 0
41			NW1.7 Preserve Greenfields	0	0	2	0 of 0
42		LAND & WATER	NW2.1 Manage Stormwater	0	0	2	0 of 0
43			NW2.2 Reduce Pesticide and Fertilizer Impacts	0	0	5	0 of 0
44			NW2.3 Prevent Surface and Groundwater Contamination	0	0	4	0 of 0
45		BIODIVERSITY	NW3.1 Preserve Species Biodiversity	0	0	4	0 of 0
46			NW3.2 Control Invasive Species	0	0	3	0 of 0
47			NW3.3 Restore Disturbed Soils	0	0	2	0 of 0
48			NW3.4 Maintain Wetland and Surface Water Functions	0	0	5	0 of 0
			TOTAL	0	0	47	0 of 0
49	CLIMATE	EMISSION	CR1.1 Reduce Greenhouse Gas Emissions	0	0	2	0 of 0
50			CR1.2 Reduce Air Pollutant Emissions	0	0	2	0 of 0
51		RESILIENCE	CR2.1 Assess Climate Threat	0	0	1	0 of 0
52			CR2.2 Avoid Traps and Vulnerabilities	0	0	2	0 of 0
53			CR2.3 Prepare for Long-term Adaptability	0	0	1	0 of 0
54			CR2.4 Prepare for Short-term Hazards	0	0	2	0 of 0
55			CR2.5 Manage Heat Island Effects	0	0	1	0 of 0
			TOTAL	0	0	11	0 of 0

Section 3 – Planning, Legal, Health and Safety, Emergency Response

Overview:

MMSD infrastructure/capital projects are based on comprehensive planning efforts that ensure that the infrastructure projects meet or exceed the needs of stakeholders, are the most effective use of the District's resources and ensure the continued provision of District services. In addition, MMSD is strongly committed to protecting the health and safety of the public and its workers in all of its activities.

Capital Project Planning

As a public entity, MMSD follows a number of best practices to drive infrastructure project/capital project decisions. Due to the scale and complexity of the projects, the planning typically occurs over several years. The 50-Year Master Plan, which is the overall foundation, included the development of a number of scenarios that were developed using forecasting models and extensive stakeholder participation. The public review for the 50-Year Master Plan included representation from the communities the district serves. MMSD is considering an update to the Master Plan.

Each subsequent planning document may go through several public review cycles first in a conceptual stage and then for budgeting purposes. This includes annual capital improvement plans that establish multi-year forecasts and business cases for capital projects. All plans and the budget are reviewed and ultimately authorized during public hearings by the District's Commission. Commissioners are appointed by the customer communities: five Commissioners are appointed by the Mayor of the City of Madison, three are appointed by an executive council made up of elected officials from District cities and villages, and one is appointed by an executive council made up of town-elected officials.

Current key planning documents are listed in Table 5.

Public Health and Safety

The Envision system has embedded within it numerous regulations that apply to infrastructure projects, for example building code requirements, noise and air quality laws, etc. The rating provides more points for achieving performance above the code/legal requirements.

The District operates under permits issued by the Wisconsin Department of Natural Resources (WDNR) based on federal and state regulations. The purpose of the permits is to ensure that District operations are conducted in a manner that protects public health and the environment. These permits contain numeric limits, monitoring and reporting requirements, compliance schedules and other relevant information. The District currently holds a wastewater permit issued under the Wisconsin Pollutant Discharge Elimination System (WPDES) program and an air permit. The District must also comply with stormwater requirements addressed under a general industrial stormwater WPDES permit issued by the WDNR.

The District has developed a Sewer Use Ordinance to help meet its mission of protecting public health and the environment. The ordinance defines the types of wastes that can be discharged into the sewerage system, imposes requirements on industrial waste dischargers and provides a mechanism for issuing permits to certain users. The ordinance also enables the District to comply with administrative provisions, water quality requirements, pretreatment standards and other discharge criteria which are required or authorized by the State of Wisconsin or Federal Law.

Emergency Response

MMSD has a comprehensive Emergency Response Policy in place that applies to all operational activities as well as work on projects, including infrastructure projects.

Procedure:

- All rules, regulations, policies and procedures that apply at the District will apply to infrastructure projects.
- The PM will communicate applicable rules, regulations, policies, procedures and expectations to staff, consultants and contractors and will keep a log of relevant legal and regulatory documents that are specific to the District (Table 5).
- The PM is responsible for incorporating and monitoring compliance with all applicable laws, regulations, policies and procedures.
- The PM will maintain a log (Table 6) of project-specific authorizations, legal requirements, etc. if they are not included in the Liquid Process Facility Plan.

Table 5: Registry of Applicable Planning/ Legal/Regulatory Documents

Name/Title/Description	Location/Link	Date	Initials[1]
Wisconsin Pollutant Discharge Elimination System (WPDES) Permit	http://www.madsewer.org/Planning/Permits-Ordinances	12/9/2013	CH
Air Permit	http://www.madsewer.org/Portals/0/Planning/PermitsAndOrdinances/air%20permit.pdf	2/19/2014	EH
50-Year Master Plan - 2009	http://www.madsewer.org/Planning/Facility-Plans or M:\Master Planning 2006-2009\Final Report Documents and Files from CD	1/14/2014	CH
2015 Capital Improvement Plan	http://www.madsewer.org/Planning/Budget-Finance	6/8/2015	CH
Emergency Response Manual			
2011 Collection System Facilities Plan Update	M:\Facility Plans\Collection System-2009\Final Report - 2011 Facilities Plan Update	2/19/2014	EH
MMSD Collection System Evaluation – 2009 – by CARPC	"\\engfile01\engr\Facility Plans\Collection System-2009\Collection System Evaluation\MMSD Collection System Evaluation - January 2009.pdf"	2/19/2014	EH
Solids Handling Facilities Plan – 11th Addition - 2010	"M:\Facility Plans\11th Add, 2008-Formerly Solids Handling\Facility Plan\Final_January 2010\Solids Handling Facilities Plan-OCR.pdf"	2/19/2014	EH
Energy Baseline and Optimization Roadmap Study – March 2014	P:\OandM\Energy Study\Final Document	2/19/2014	EH

[1] Initials of the individual who included document in table.

Name/Title/Description	Location/Link	Date	Initials[1]
Space Needs and Planning Study - 2013	"M:\Projects\Active\Nine Springs-Maintenance Facility\Space Needs Study (Planning)\Final Program - Final Report\00-Final MMSD Study Document - Final Edition 6-21-2013.pdf"	2/19/2014	EH

Table 6: Log of Project-Specific Authorizations, Requirements or Conditions (to be completed later in the planning or design phases)

Name/Title/Description	Documentation/Link	Date	Initials
Professional Services Agreement with Strand Associates, Inc.®	M:\Projects\Active\ (Jeff to complete)		JK
Technical Memoranda for 2016 Liquid Processing Facilities Planning	M:\Projects\Active\		JK
DRAFT 2016 Liquid Processing Facilities Plan	M:\Projects\Active\		
DRAFT Design Report for 2016 Liquid Processing Improvements	M:\Projects\Active\TBD		

Section 4 – Authority

Overview:

MMSD has been providing sewerage treatment services for several communities and other entities in Dane County, Wisconsin since 1930. Since that time, MMSD has continuously expanded, upgraded and maintained its infrastructure. There are numerous practices in place that ensure the effective and efficient management of infrastructure projects.

The need for a particular infrastructure project is typically identified in the planning phase. The initial project concept is often developed many years before the project becomes a reality and may undergo iterations in various planning documents. The Capital Improvements Plan is often the last planning document before a project enters the design phase. Because this 2016 Liquid Processing project is more complex, requiring the evaluation of multiple alternatives, a Facilities Plan is being developed by the District and its consultant prior to design.

One of the key practices and documentation approaches used in the design phase is the development of the Design Report, sometimes called the Engineering Report. This report is typically prepared by the consultant and is intended to capture the overall project scope and to document key design decisions. It acts as a guideline for the District's or consultant's development of the Drawings (or Project Plans) and Project Specifications during detailed project design.

After detailed design, the project is typically publicly advertised. Potential contractors review the Contract Documents and provide a bid package which is publicly opened at a time and place listed in the advertisement.

The District maintains a document called “General Conditions” that is incorporated in all construction contracts. In it the terms for different planning and contractual documents, roles and authorities are defined in a legally binding way.

The Drawings and the Project Specifications are part of the Contract Documents which also include the advertisement, bidding instructions, the contractor’s proposal, bonds and the contract or agreement. The entirety of the Contract Documents comprises the legal contract between the contractor and the District that details what the contractor is going to do and how much the contractor is going to charge (the contract amount). Once these documents and negotiations are finalized, they are reviewed and signed by the Chief Engineer and the Director of Engineering.

Once the project has been bid and a contract awarded, the construction phase begins. Key construction phase documentation includes submittals, change orders, and operation and maintenance (O&M) manuals. Submittals are shop drawings, material data, samples and product data submitted by the contractor to the engineer. The primary purpose of the submittal process is for the engineer to verify that products and quantities proposed for installation on the project are correct and conform to requirements of the Drawings and Project Specifications. Submittals may also include test results, construction sequences and proposed means and methods to meet specified requirements. These latter submittals may be of particular use in documenting sustainability practices.

By definition, executed change orders are part of the Contract Documents. A change order is work that is added to or deleted from the original scope of work and that typically alters the original contract amount or the completion date or both. Common causes for change orders include:

- Design errors or omissions
- Changed or unforeseen conditions
- Additional items of work are conceived and requested during construction

O & M manuals are deliverables that describe the operation and maintenance requirements of the project as a whole and of individual systems and pieces of equipment installed as part of the project.

At this point the SMS-IP will be finalized to capture sustainability aspects and activities.

<u>Procedure:</u>

- The PM ensures that responsibilities regarding sustainability aspects and performance are clearly understood and captured in the relevant project management documents.
- The PM, with input from the consultant, will complete the SMS-IP Template (including Table 2) with all relevant information to create a record of all sustainability aspects of the project.
- The PM keeps a listing (Table 7) of delegated tasks and responsibilities regarding sustainability performance which are not included in the other project management documents.
- Critical control points for sustainability aspects are integrated in the overall project management process and recorded in the core documents. The primary documents are the Facilities Plan and this document, as well as the related technical memoranda and SAM evaluations where employed. Some sustainability aspects may also be recorded in other components of the Contract Documents. Construction submittals may be useful to document and quantify sustainable practices performed by the contractor. For instance, the contractor may be required to submit a report detailing the type and amount of materials recycled.

- The PM performs quality control, measurement and verification tasks until the project is fully commissioned.

Table 7: Assigned/Delegated Project-Specific Responsibilities

Activity/Type/Role	Responsibilities	Name	Date
Prepare DRAFT SMS	Strand Associates, Inc.®	RAW/JMC	5/2/2016
Review Draft SMS	MMSD	JK, CH	7/26/20
Revise SMS (Technical Memorandum No. 1)	Strand Associates, Inc.	RAW	1/31/2107

Section 5 – Public Involvement

Overview:

MMSD has worked closely with numerous stakeholders on its infrastructure projects. MMSD's guiding vision to be a good neighbor sets the expectation how MMSD engages with the public. In addition to required public notices and public hearings, depending on the project, MMSD will reach out to the DNR, adjoining property owners, impacted neighborhoods and businesses, as well as public entities to ensure that the project meets and, where possible, exceeds the expectation of the community.

Procedure:

- The PM will ensure that MMSD will comply with all required notices and hearings.
- The PM will determine outreach and involvement methods, initiate meetings, etc. as appropriate to the project and sustainability objectives.
- The PM will keep documentation of feedback and decisions in the project files.

Section 6 – Management Involvement & Review

Overview:

District Leadership is very involved in the initiation of infrastructure projects through the facilities planning, capital planning and budgeting activities. Management also directly participates in the design phase to support decision-making, including decisions affecting sustainability aspects.

Procedure:

- The District will review the SMS-IP periodically. The purpose of the review will be to determine if changes in the guiding policies, strategy or specific goals and objectives are needed.
- District Management will initiate changes to the SMS-IP if changes in the regulatory environment, District policies or strategies require adjustments.
- In general, the procedures outlined in the *Decision Making and Problem Solving for Liquid Process Facilities Plan* memorandum (Attachment A) will be followed to engage management throughout the project.

Section 7 – Glossary

The following Terms, Acronyms, and Abbreviations are defined:

Term/Acronym/Abbreviation	Definition
Design Report	A key project management document that captures the general concepts, design objectives and initial technical specifications and decisions.
Envision	Sustainability performance rating tool for infrastructure projects developed and licensed through the Institute for Sustainable Infrastructure (ISI) http://sustainableinfrastructure.org/index.cfm
GHG	Greenhouse gas
ISI	Institute for Sustainable Infrastructure
LPFP	Liquid Processing Facilities Plan
MMSD	Madison Metropolitan Sewerage District
Null	Do-nothing
O&M	Operation and Maintenance
PM	Project Manager; typically an MMSD Engineer.
Project Plans and Specifications	Key project management documents included in the Contract Documents that capture technical specifications and other project and process requirements for the bidding and contracting process.
QC	Quality Control
SAM	Sustainable Action Map
SIM	Sustainable Infrastructure Manager
SMS-IP	Sustainability Management System - Infrastructure Projects
Sustainability	Meeting current and future needs considering economic, environmental and social costs and benefits.
TBL	Triple Bottom Line
TBL/TPW	Triple-Bottom-Line Total Present Worth
TPW	Total Present Worth
UV	Ultraviolet
WDNR	Wisconsin Department of Natural Resources
WPDES	Wisconsin Pollutant Discharge Elimination System
WWTP	Wastewater Treatment Plant

Section 8 – Project-Specific Goals and Objectives

Project Goals

This project will address peak flow constraints at the Nine Springs WWTP, aeration system condition (capacity, physical condition, process improvements and energy reduction), and Headworks Facility and Ultraviolet (UV) System condition (physical condition and capacity). This plan will also initiate development of a formal asset management plan for the WWTP and will address several unit substations, other power system condition issues, process control system controllers and a number of other Instrumentation and Controls (I&C) components. It is a(n) (implicit) goal of the Liquid Process

Facilities Plan to find long-term, cost-effective solutions. This includes generating and evaluating non-infrastructure solutions and delaying capital investments as long as possible while maintaining the required level of service (null-alternative). The project will attempt to determine the lowest life-cycle cost solutions that meet sustainability objectives, including (in particular) flexibility and resilience. Other project-specific goals and objectives are summarized in the New Initiative Form in Attachment D. Additional detail may be found in Tables 2 and 3, which will be amended as the project proceeds from planning into preliminary design.

Decision Making using Triple-Bottom-Line Evaluations

In general, the following triple-bottom-line (TBL) approach was included in the project scope and serves as the baseline approach to developing the TBL for this facilities planning process.

1. As a team, identify alternatives that could be considered to address a specific need, including the do-nothing ("null") alternative.
2. Pre-screen alternatives that are not well enough established or would not meet the required level of service, in collaboration with MMSD. Use the District's decision making process (Attachment A) to evaluate similar options at a high level to help differentiate alternatives and select the alternatives (typically 3 to 5) that will be moved forward for more detailed analysis. Use of the SAM tool will be a group effort and will generally be facilitated as part of a workshop.
3. Perform twenty-year total present worth (TPW) cost analysis of the do-nothing alternative along with the most viable alternatives following the initial screening. The TPW analysis will include all life-cycle costs such as annual labor, energy, chemicals and supplies.
4. Prepare a narrative on other TBL factors (environmental and social) for the most viable alternatives compared to the null alternative. The narrative will be used in the Business Case to support selection of one alternative over the others, and may be more detailed as needed.

ATTACHMENT A

DECISION MAKING & PROBLEM SOLVING FOR LIQUID PROCESS FACILITIES PLANNING

Decision Making and Problem Solving for Liquid Process Facilities Planning Process DRAFT v.4

Purpose: Clarify and document the process as well as roles and responsibilities in decision making for the planning process.

Background: While it is clear in general, who participates in the process, what their general roles are (for example project manager or subject matter expert), and it is clear, how the process from generating ideas, to analyzing and evaluating various solutions is structured, it would be helpful to identify more specifically who should make what decisions. In addition, this memo will clarify the use of triple-bottom-line tools to aide decision making in this process.

Proposed Approach:

In general, the LPFP follows a relatively standard Engineering planning process with the following steps:

#	*PROCESS STEP*	*ACTIVITIES*
1.	Define/specify the problem (the null alternative)	The consultant provides a detailed assessment/analysis of the current situation/process/facility.
2.	Identify potential solutions	The consultant provides initial solutions to the problem (worksheet/summary description). What will it take ?
3.	Work shop to review the problems and solutions, generate additional solutions	All Subject Matter Experts (SMEs) potentially most Directors and Chief Engineer and Director; Core Team

4.	Evaluate solutions through initial screen and SAM	Consultant provides initial screening and SAM; these are reviewed and input provided.
5.	Select options for detailed analysis	Based on screening and input, Core team reviews and chooses options for further evaluation. Some of the other options that are promising but not affordable or timely, may be included in other planning efforts.
6.	Tech memo that analyzes and assesses the most promising solutions as well as the null alternative and includes a triple-bottom-line analysis that does not monetize social or environmental factors that require a specific monetization approach.	Consultant performs analysis and compiles tech memo draft. SMEs review tech memo draft and provide comments/questions.
7.	Pre-review meeting to arrive at decision to provide direction to consultant	Core team reviews SME comments and questions; involves SME as required; makes recommendation as to position of the District.
8.	Review the tech memo in review meeting.	Core team meets with consultant provides direction.
9.	Finalize the tech memo	Consultant finalizes the tech memo.
10.	Liquid Process Facility Plan	Consultant writes LPFP; SMEs review, provide input; core team compiles, reviews, finalizes direction to consultant.
11..	CIP/Other Planning integration	Solutions are grouped in three groups: · Urgent and affordable options go into the CIP. · Promising but non-urgent and/or not affordable options are considered for further planning efforts. · Any remaining options are eliminated from further consideration.

The proposed approach establishes a Core Team that will make the major decisions to provide direction to the consultant.

At various times throughout the process, the PM will initiate ad-hoc meetings with various SME's and/or the consultant to clarify and resolve technical issues, work plan items, etc.

The SAM is a qualitative triple-bottom-line assessment tool. It will be used to screen potential solutions.

The Triple Bottom Line analysis will use monetary values where available and will conduct a qualitative assessment in other areas. It will be used for a smaller set of solutions as well as the "null-alternative" to help in decision-making as to the identification and, in particular the timing of solutions that are urgent and affordable.

Roles & Responsibilities

PM – Manages project process and makes related decisions; monitors progress on deliverables; identifies issues & initiates review meetings; etc. The PM makes all day-to-day decisions.
Subject Matter Expert – Provides input on potential solutions; reviews and comments on technical issues; verifies assumptions; provides information and data as required.
Core Team – Reviews all materials; reviews SME comments and questions; makes final decisions on technical matters as needed; determines "position of District" and provides direction to consultant. If no agreement can be reached, the CED will decide.
Consultant – Provides subject matter expertise; conducts analysis; identifies solutions; makes recommendations; writes the tech memos and Liquid Process Facility Plan.

PM
Jeff Klawes

Subject Matter Experts
Aaron Dose – Operations
Alan Grooms – Operations/Process/Permit
Bruce Borelli — Engineering
Claudia Haack – Sustainable Infrastructure/Asset Management
Dave Taylor – Adaptive Management/Regulatory/Permit
Dave Lundey – Electrical
Erik Rehr - Maintenance
Hank Richardson - Asset Management
Jeff Klawes – Scope/Engineering
John Bembinster – Electrical
Kathy Lake—Adaptive Management/Regulatory/Permit
Matt Seib – Operations/Process/Permit
Matt Allen - Operations/Process
Michael Mucha – Strategy/Sustainability
Mike Simon – Scope/Planning/CIP/Collection System/Electrical
Paul Nehm – Operations/Process/Maintenance/Permit
Todd Gebert – CIP/Collection System

Core Team
Jeff Klawes
Michael Mucha
Mike Simon
Bruce Borelli
Paul Nehm
Claudia Haack
Alan Grooms

ATTACHMENT B
SAM INFORMATION

S.A.M.

Sustainable Action Map

Leadership Required
Manageable Risks
Value Delivered

Name: ______________________ Decision: ______________________________

Healthy Environment	Strong Community		Vital Economy
Natural: *How does it impact environmental health?*	**Individual:** How does it directly impact the well-being of people?	**Community:** *How does it impact relationships, effective government, socal justice, and overall livability?*	**Economy:** *How does it impact the local economy and at what long and short term costs?*
S:	S:	S:	S:
W:	W:	W:	W:
O:	O:	O:	O:
T:	T:	T:	T:

SWOT: S=Strengths W=Weaknesses O=Opportunities T=Threats

Madison Metropolitan Sewerage District

Instructions for Sustainable Action Map

THE FRAMEWORK

Four Needs: Satisfy four distinct healthy community needs to assure a balanced/sustainable outcome: Natural, Individual, Community and Economy.

S.W.O.T.: For any given action there are Strengths, Weaknesses, Opportunities, and Threats.

Traffic Signal: Red, Yellow, Green: This dimension provides an indicator for how well a particular action satisfies a healthy community need. If green, the action provides value, or contributes in a positive way. If yellow, there are manageable risks. If red, there may be fatal flaws that need attention.

STEPS FOR USING THE FORM

Step 1: Identifying

Clearly identify the topic.

Identify a clear topic, policy, or issue you would like to evaluate. Be specific, because this will help focus your discussion on the action most important to you. Write the action on the top of the form as a statement (e.g. "Building a three-lane roadway cross-section on Main Street," or "Removing glass from the recycling stream").

Step 2: Brainstorming

Complete the framework on the form (get as many ideas as possible).

Brainstorm Strengths, Weaknesses, Opportunities, and Threats in each of the Four Needs categories. Start by asking the question,"So how does what we are proposing impact the economy?" Remember, impact can be good or bad.

Strengths and Weaknesses are things internal to your organization that you have direct control over.

Opportunities and Threats are things outside your control, and you must respond to proactively.

Encourage the flow of ideas. Sometimes there will be overlap. Start in one category that may lead to factors in other categories. Discuss those factors together and put them on the map at the same time so the team can begin to see the relationships and competing factors.

Step 3: Distilling

Refine your brainstorming list to key issues.

After brainstorming all the ideas, begin selecting what you believe to be the ***most important*** Strengths and Opportunities and the ***most concerning*** Weaknesses and Threats. For any issue, there should not be more than a few for each of the Four Needs categories.

Step 4: Evaluating

Determine how balanced your solution is.

Step back and look it over your prioritized list. What is it telling you? If a Need category has many Strengths and Opportunities, it is likely a **green light**. If it has some Strengths, but also some Weaknesses and Threats you feel you can overcome, it is likely a **yellow light**. If there are some significant Weaknesses or Threats that you have not figured out a way to overcome, it is likely a **red light**. One significant Weakness by itself may warrant a red light.

Step 5: Problem Solving

Find a balanced solution (all Need categories have a green or yellow rating).

Focus the group's attention to the key issues that create red lights. Ask the question, "What can we do differently to turn this red light into a yellow or green light?" Some of those answers may take time to formulate. Create an assignment list for more research and agree to get back together to discuss the solutions.

Step 6: Move Forward

Clarify accountability for action that moves the topic forward.

Once all your research is completed and you have a balanced solution, get commitments. Decide who must do what, by when to move the item forward. Pay attention to the specific actions necessary to overcome risks in the yellow lights and innovative actions that turns red lights into yellow/green lights.

Last Revised: July 30, 2014
The original instructions and S.A.M. form reside in the Employee Handbook.

ATTACHMENT C

BUSINESS CASE EXAMPLES

Business Case Summary
Project ID: A04
9/17/2014

Plant Energy Projects


Project Proposer/Champion: Paul Nehm

Project Purpose:
The purpose of this project is to address projects that were identified during the Energy Study that is being finalized in the first quarter of 2014.

Project History and Status:
Brown and Caldwell/Strand Associates performed an energy study whose purpose was to provide a roadmap that the District can follow to achieve energy independence. This includes ways to further reduce energy usage, ways to more efficiently use digester gas, and ways to produce additional energy. Many of the projects were associated with the aeration system – these have generally been included in a separate project. Others involve the hot water system for heating and cooling processes and buildings. The most significant project would be the acceptance of high strength waste with subsequent digestion in the District's anaerobic digesters.

Options:
At this time the full scope and timing of this project is yet to be determined. We expect that further project evaluation will include:

1. A survey of potential sources of high strength waste
2. An evaluation of the potential of food scraps as a feed source for the digesters
3. An evaluation of the capacity of the existing digesters
4. A determination of the need for additional digesters
5. An evaluation of the additional amount of gas that could be produced
6. An evaluation of replacements for the existing gas-driven engines
7. A review of how waste heat might be used

Alternatives
All alternatives will require that adequate treatment processes are available to meet the requirements of the District's discharge permit and that all gas generated in the digesters is used efficiently.

Key Risks and Issues
As the project is further defined, additional risks and issues may surface. At this time the key risks and issues are:

1. Sources of high strength waste may not be reliable. The District should not make capital expenditures unless adequate and reliable long-term feed sources are available and guaranteed.

2. Use of all excess heat may not be possible. The heat may need to be dissipated in the effluent or the air.

Economic Analysis
Without a study to define the issues included in this project, it is difficult to determine costs. After further project definition, a better estimate will be made. The costs shown in the Financial Summary below are the best estimates available at this time.

Recommended Option:
Beginning later in 2014, a pilot project, developed in conjunction with the University of Wisconsin, will investigate the effects of food waste on the District's anaerobic digesters. In 2015, a preliminary survey of sources of high strength waste will be conducted. If possible sources are identified, full-scale testing of those materials in the District's anaerobic digesters could occur. The District will identify possible projects in 2016 based on the results of the survey and full-scale tests. Facility planning would start in 2017.

Project Schedule:

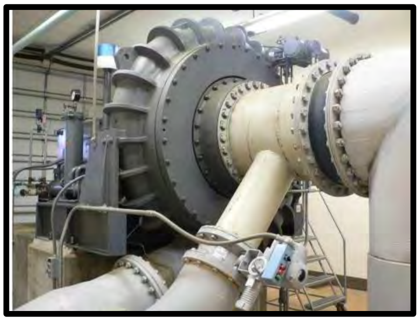
	Start Date	Completion Date
Facility Planning	Summer 2017	Summer 2018
Design	Summer 2018	Summer 2019
Construction	Summer 2019	Summer 2021

Financial Summary:
The costs included are for planning purposes only and provide a cost allocation or "placeholder" for the project within the Capital Improvements Plan. Costs will be redefined as the project scope is better defined and as decisions and project estimates are made. At this time, the total project allocation included in the plan is estimated at $10.1 million (2014$). The Capital Improvements Plan reflects this amount modified by an inflation factor. Planning/ budgetary numbers will be updated as new estimates are provided.

Return to TOC

Business Case Summary
Project ID: A05a & A05b
9/17/2014

Plant Aeration System Projects



Project Proposer/Champion: Paul Nehm

Project Purpose:
The purpose of this project is to address issues related to inefficiencies, replacement, and operations and maintenance of the secondary treatment system aeration-related equipment. This includes all blowers, diffusers, control systems, electrical systems, dissolved oxygen probes, and transmitters. At this time it does not appear that renewal of the District's discharge permit in 2015 will require modifications to the secondary treatment system.

Project History and Status:
The fine bubble diffusers in the District's aeration tanks were installed during the Seventh and Ninth Additions to the Nine Springs Wastewater Treatment Plant in the 1980s and 1990s. Since their installation, all diffusers have been cleaned using muriatic acid every three to four years. Some of the original diffusers have been replaced, while others have been in service for close to thirty years. If nitrogen removal is required in the future, the aeration tanks will need to be reconfigured again and changes will need to be made to the diffuser pattern.

The three blowers in the West Blower Building were installed in the mid-1980s as part of the Seventh Addition to the treatment plant. The operating blower at its minimum capacity supplies more air to the aeration tanks than is needed. Recently one of these blowers failed on vibration. Various parts of the blower were disassembled and inspected by the manufacturer's technician. The bearings on the inlet guide vanes were replaced. Similar future maintenance is expected on the other two blowers.

There are five blowers in the East Blower Building. One of the blowers is powered by an engine that uses digester gas as its fuel. Two of the blowers are variable speed blowers that were installed in the Seventh Addition in the mid-1980s. The other two blowers are two speed blowers that were installed as part of the Fourth Addition in the early 1960s. One of these blowers and its motor were overhauled in 2013. The second blower and its motor are scheduled to be overhauled in 2014.

The switchgear for the blowers in the East Blower Building should be assessed and may need replacement, or at a minimum refurbishment, due to its age. The control panels in both blower buildings will need to be upgraded to the standards of the Process Control System Upgrade project. The dissolved oxygen probes, installed during the Ninth Addition to the plant, need evaluation with any change in the aeration system.

Options:
At this time, the full scope and timing of the project is not fully defined, but we expect that project evaluation will include:

1. A calculation of the amount of aeration capacity needed to meet the discharge permit
2. A determination of the number and spacing of diffusers in the aeration tanks
3. A determination of blower sizing for each side of the treatment plant
4. A review of the reliability and capacity of the existing blowers
5. A review of the types and efficiency of replacement blowers

6. A review of the blower control panels and power supplies
7. A review of dissolved oxygen probes

Alternatives
All alternatives will require that adequate treatment processes are available to meet the requirements of the District's discharge permit.

Key Risks and Issues
As the project is further defined, additional risks and issues may surface. At this time, the key risks and issues are:
1. Many of the blowers are near the time at which they will need major overhauls. Most major work is being delayed so it can be determined if use of those blowers will continue or if they will be replaced. There is potential for failure of one or more of them before that decision can be made.
2. Periodically, failure of some of the diffuser piping has occurred. Such failure will probably continue before the diffusers are replaced.
3. The control panels for the blower could fail before they are upgraded.
4. The dissolved oxygen probes are near the end of their expected life.

Economic Analysis
Without a study to define the issues to be included in this project, it is difficult to provide a good cost estimate. After the project is defined in 2015, a better estimate can be made. The costs shown in the Financial Summary below are the best estimates available at this time.

Recommended Option:
Without further definition of the project, recommended options cannot be made.

Project Schedule:

	Start Date	Completion Date
*Facility Planning	Early 2015	Early 2016
Design	Spring 2016	Early 2017
Construction	Spring 2017	Summer 2019

*Please note that the facility planning effort for this project (Project A05b) has been included in Project A05a, Plant Aeration and Peak Capacity Facilities Plan. That planning effort will also include planning related to Project A07, Plant Peak Capacity Improvements, as well as planning related to Project A10, UV System Replacement/ Rehab.

Financial Summary:
The costs included are for planning purposes only and provide a cost allocation or "placeholder" for the project within the Capital Improvements Plan. Costs will be redefined as the project scope is better defined and as decisions and better project estimates are made. At this time, the total project cost for the Plant Aeration System Projects is estimated to be $8,025,000 (2014$). Costs for the Plant Aeration and Peak Capacity Facilities Plan are estimated at $500,000.

ATTACHMENT D
NEW INITIATIVE FORM

Madison Metropolitan Sewerage District

New Initiative Proposal

INITIATIVE: 2016 Liquid Processing Facilities Plan

LEADER: Mike Simon/Jeff Klawes SPONSOR: Mike Simon

DESCRIPTION: (What does success look like? What do you want to achieve? (Result/ Outcome/ Deliverable).

The District has some known needs that were identified in the Master Plan (2008), re-assessed in the 2011 asset management planning effort, and most recently recognized through CIP business cases that Operations developed. This initiative involves hiring a consultant to help the District investigate and develop a facilities plan for portions of the Nine Springs Wastewater Treatment Plant that will address peak capacity constraints, aeration system condition (capacity, physical condition, process improvements, and energy reduction), and Headworks Facility and UV System condition (physical condition and capacity). This plan will also initiate development of a formal asset management plan for the treatment plant (a counter-part to the Collection Systems Facility Plan). As a part of this process, the plan will also address several unit substations, other power system condition issues, replacement of the remaining Bristol Babcock process control system controllers, and a number of other I&C components.

WHY IS THIS IMPORTANT? (What is driving the need for this initiative?):

The Wisconsin Department of Natural Resources requires facilities planning prior to design of any new or replacement facilities. The facilities plan will develop options and business cases for any new or replacement facilities, and will better define a scope and schedule for moving forward. The plan will investigate important needs such as ensuring that the plant is not overwhelmed by the potential to pump more to the plant than can be processed. The District's Energy Study also recommended improvements in the District's aeration system to reduce energy use – significant reductions in energy are possible by improving aeration system efficiency.

In alignment with the District's goal to manage its infrastructure to meet customer expectations at the lowest cost of ownership and following the recently completed sustainable infrastructure framework, the facilities plan will serve as one of the foundations for the plant asset management plan. It will include an assessment of condition and remaining life for key liquid process assets, and provide direction on maintenance as well as capital strategies through the business cases.

SMART GOAL STATEMENT: (Specific-Measurable-Attainable-Relevant-Timeline):

Hire and retain the services of an engineering consultant by the end of year 2015 to conduct a facilities plan during 2016. Complete an approvable facilities plan by the end of 2016. Gain approval of the facilities plan from the District's Commission and Wisconsin DNR by early 2017 and move forward with related design thereafter.

The following are the primary goals of the facilities plan:

The primary objective of the Facilities Plan is to review and evaluate the capacity and condition of the following key areas, seek and investigate alternatives, and recommend the best alternative based on required levels of service, feasibility, risk management, life cycle costs, and triple bottom line factors:

- Identify and address means to improve total plant hydraulic capacity and capture or prevent any overflows during high flow events.
- Identify and address issues related to energy inefficiencies and ways to improve energy efficiency in the secondary system.
- Review remaining asset life and related energy savings potential for the secondary treatment system including blowers, diffusers, return and waste activated sludge pumping systems, control systems, electrical systems, dissolved oxygen probes, transmitters, and control valves. This should include review of alternative control system instrumentation, such as ORP probes and ammonia probes.
- Consider nitrogen removal options, such as nitrate recycle or concurrent nitrification/denitrification, its impact on biological phosphorus removal, and potential future regulatory nutrient limitations in alternative evaluations.
- The potential need for future total or partial effluent filtration should be considered in the hydraulic and treatment analyses. That is, alternative solutions must allow for the possibility of effluent filtration at some point in the future.

- Identify and address issues related to the District's Headworks Facility including screening, grit removal, and septage receiving areas. Investigate and recommend backup power options for the facility (Headworks Facility only).
- Identify and address issues related to the hydraulic and treatment capacity of the effluent ultraviolet disinfection system.
- Establish baseline asset data including age, condition, remaining life, replacement value for major assets and asset groups (as agreed with owner) evaluated in a format that can be easily updated.

ACTION PLAN EVENT SEQUENCE: (What are the major steps, who will be involved, when will it be done? Will there be follow ups with Executive Team?):

1. Hire and retain the services of an engineering consultant by the end of year 2015. Members from Planning, Engineering, and Operations have been developing a Request for Proposal (RFP) to solicit consulting services. The present schedule is to send this to consultants by late September to early October. Proposals would be due about a month later. A selection committee (makeup to be determined) will reduce the number of candidate firms/teams for interviews to four or less. Following interviews, the selection committee will select one firm to recommend to the District's Commission. The intent is to have the firm approved in December and a contract in place by late 2015 to early 2016.
2. Conduct a facilities plan during 2016 completing an approvable facilities plan by the end of 2016. The facilities plan would again involve members from Planning, Operations, and Engineering. Occasionally, others within the organization may become involved.
3. Gain approval of the facilities plan from the District's Commission and Wisconsin DNR by early 2017 and move forward with related design thereafter.
4. Periodic project updates will be provided to the District's Commission, the Executive Team, and District employees (Plant meetings or other form of communication).

ADDITIONAL INFORMATION: (Helpful background information or resources to learn more):

Additional information will be provided from time to time. At this time, the request for proposal is under development and the scope resembles information found in the following business cases of the District's Draft Capital Improvements Plan 2016:

A03 – Plant Aeration and Peak Capacity Facilities Plan (please note the name change to 2016 Liquid Processing Facilities Plan)

A07 – Plant Aeration Systems Projects

A08 – Plant Unit Substation Improvements

A09 – Plant Peak Capacity Improvements

A10 – Headworks Improvements

A11 – Ultraviolet Disinfection System Replacement

The Draft Capital Improvements Plan can be found on the District's website at http://www.madsewer.org/Planning/Budget-Finance. It's located on the right-hand side of the page. Further details can also be obtained from the individuals listed below.

WHO TO CONTACT WITH QUESTIONS OR COMMENTS:

INITIATIVE LEADER'S NAME:

1. **Mike Simon during RFP development (thru hiring of consultant)**
   EMAIL: mikes@madsewer.org EXTENSION: 268
2. **Jeff Klawes – project manager during planning process**
   EMAIL: jeffk@madsewer.org EXTENSION: 238

OPERATIONS/PROCESS RELATED QUESTIONS:

Alan Grooms EXTENSION: 253
Steve Reusser EXTENSION: 263 (until Steve's retirement)
Paul Nehm EXTENSION: 252

ASSET MANAGEMENT RELATED QUESTIONS:

Claudia Haack EXTENSION: 297

STATUS: Active

APPENDIX B
TECHNICAL MEMORANDUM NOS. 2A AND 2B

TECHNICAL MEMORANDUM NO. 2A–REGULATORY PROJECTIONS

Technical Memorandum No. 2a for the

Madison Metropolitan Sewerage District, Madison, Wisconsin

Regulatory Projections
2016 Liquid Processing Facilities Plan

Prepared by:

STRAND ASSOCIATES, INC.®
910 West Wingra Drive
Madison, WI 53715
www.strand.com

August 2016
Revised May 2017

STRAND ASSOCIATES®

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APPENDIX C–DNR MEMORANDA

INTRODUCTION

This Technical Memorandum includes a review of existing and foreseeable future regulatory issues potentially affecting Madison Metropolitan Sewerage District's (MMSD or the District) Liquid Processing Facilities Plan (LPFP) through the year 2040. This review is conducted for various potential alternatives, such as continued use of treatment at Nine Springs Wastewater Treatment Plant (NSWWTP) with discharge to existing Badfish Creek (BFC) Outfall 001 and Badger Mill Creek (BMC) Outfall 005, an increased discharge to Badger Mill Creek, continued emergency lagoon overflows to Nine Springs Creek (NSC) and Lake Waubesa, increased wet weather discharges to NSC, and a continuous discharge to NSC. The regulations are discussed in the approximate order of importance for this planning effort. A meeting to discuss relevant water quality and regulatory issues was held with the Wisconsin Department of Natural Resources (WDNR) on April 21, 2016. Information from that meeting, the MMSD 50-Year Master Plan, the Wisconsin Section Central States Water Environment Association Government Affairs Committee, and from our regulatory work with other clients forms the basis for this memorandum.

The MMSD NSWWTP is presently operating under Wisconsin Pollutant Discharge Elimination System (WPDES) Permit No. WI-0024597-08-0, which is included as Appendix A. The permit expiration date was September 30, 2015. Because the permit application for reissuance was submitted more than 180 days prior to the expiration date, MMSD is allowed to operate under the conditions of the expired permit. Relevant permit limits for BFC and BMC are presented in Tables 1 and 2, respectively.

Parameter	Limit Type	Limit and Units	Notes
BOD_5, Total	Monthly Average	19 mg/L	
BOD_5, Total	Monthly Average	7,923 lbs/day	
BOD_5, Total	Weekly Average	20 mg/L	
BOD_5, Total	Weekly Average	8,340 lbs/day	
Suspended Solids, Total	Monthly Average	20 mg/L	
Suspended Solids, Total	Monthly Average	8,340 lbs/day	
Suspended Solids, Total	Weekly Average	23 mg/L	
Suspended Solids, Total	Weekly Average	9,591 lbs/day	
Dissolved Oxygen	Daily Minimum	5.0 mg/L	
pH Field	Daily Maximum	9.0 s.u.	
pH Field	Daily Minimum	6.0 s.u.	
Phosphorus, Total	Monthly Average	1.5 mg/L	
Fecal Coliform	Geometric Mean	400 #/100 ml	Limit applies April 15 to October 15.
Nitrogen, Ammonia, (NH_3-N) Total	Monthly Average	1.8 mg/L	Limit applies May to September.
Nitrogen, Ammonia, (NH_3-N) Total	Monthly Average	4.1 mg/L	Limit applies October to April.
Nitrogen, Ammonia, (NH_3-N) Total	Weekly Average	4.4 mg/L	Limit applies May to September.
Nitrogen, Ammonia, (NH_3-N) Total	Weekly Average	10 mg/L	Limit applies October to April.
Nitrogen, Ammonia, (NH_3-N) Total	Daily Maximum	17 mg/L	Limit applies year-round.
Chloride	Weekly Average	430 mg/L	Target limit.
Chloride	Weekly Average	200,000 lbs/day	
Mercury, Total Recoverable	Daily Maximum	5.7 ng/L	

Table 1 Relevant WPDES Permit Effluent Limits for BFC Outfall 001

Parameter	Limit Type	Limit and Units	Notes
BOD_5, Total	Weekly Average	16 mg/L	Limit applies November to April.
BOD_5, Total	Weekly Average	7.0 mg/L	Limit applies May to October.
Suspended Solids, Total	Monthly Average	10 mg/L	Limit applies May to October.
Suspended Solids, Total	Monthly Average	16 mg/L	Limit applies November to April.
Dissolved Oxygen	Daily Minimum	5.0 mg/L	See Section 3.2.2.7 regarding compliance with this limit.
pH Field	Daily Maximum	9.0 s.u.	
pH Field	Daily Minimum	6.0 s.u.	
Phosphorus, Total	Monthly Average	1.5 mg/L	
Fecal Coliform	Geometric Mean	400 #/100 ml	Limit applies May to September
Nitrogen, Ammonia, (NH_3-N) Total	Monthly Average	1.1 mg/L	Limit applies May to September.
Nitrogen, Ammonia, (NH_3-N) Total	Monthly Average	3.8 mg/L	Limit applies October to April.
Nitrogen, Ammonia, (NH_3-N) Total	Weekly Average	2.6 mg/L	Limit applies May to September.
Nitrogen, Ammonia, (NH_3-N) Total	Weekly Average	8.7 mg/L	Limit applies October to April.
Nitrogen, Ammonia, (NH_3-N) Total	Daily Maximum	11 mg/L	Limit applies year-round.
Chloride	Weekly Average	430 mg/L	Target limit.
Chloride	Weekly Average	14,000 lbs/day	Target limit.
Mercury, Total Recoverable	Daily Maximum	5.7 ng/L	

Table 2 Relevant WPDES Permit Effluent Limits for BMC Outfall 005

NUTRIENT REGULATIONS

A. Phosphorus

The District's current phosphorus effluent limit is 1.5 mg/L based on an alternative limit for facilities that employ biological phosphorus removal, as provided by NR 217.04(2). Revised rules for phosphorus became effective in 2010 after the District's WPDES permit was reissued. The applicable water quality criterion for MMSD's receiving streams is 0.075 mg/L in accordance with NR 102.06(3)(b). Implementation considerations, including effluent limit calculations and compliance options, are included in NR 217. Associated WDNR guidance documents and information can be found on the WDNR's internet site at the following location: http://dnr.wi.gov/topic/surfacewater/phosphorus.html. Relevant points for the District's LPFP are outlined below.

1. The NR 217.13 water quality-based effluent limit (WQBEL) for phosphorus would be equal to the water quality criterion (0.075 milligrams per liter [mg/L]) if there is insufficient receiving stream flow to provide dilution or if upstream phosphorus concentrations are above the criterion. For the District's receiving streams, one or both of these factors would likely be true.

2. Some relief is provided for WQBELs that are less than 0.3 mg/L. In the District's case, the 0.075 mg/L WQBEL would be expressed as an annual average per NR 217.14(2) (in practice, two six-month averaging periods are used instead of an annual average in permits) and the monthly average limit would be three times that value or 0.23 mg/L.

3. There are specific requirements for new dischargers, particularly for new dischargers to streams that are impaired for phosphorus. Any new discharge to a phosphorus-impaired water in the Rock River Basin, where a total maximum daily load (TMDL) for phosphorus and sediment has been approved by the United States Environmental Protection Agency (USEPA), may need to have a corresponding offset by making equivalent or greater load reductions elsewhere in the TMDL reach.

4. NR 217.16 has provisions for incorporating less stringent TMDL-based WQBELs into permits in some cases. This is generally allowed for two permit terms but may be extended if significant nonpoint source load reductions are expected to occur. If the TMDL WQBEL is more stringent than the NR 217.13 WQBEL, it is incorporated into the permit.

5. Compliance schedules of up to nine years are provided for meeting stringent WQBELs.

6. Compliance options include two watershed-based options.

   a. Water quality trading (WQT) is a compliance option that is allowed by the Clean Water Act (CWA) for compliance with almost any effluent limit. It is allowed in Wisconsin as indicated by a note in NR 217.14: "*In accordance with s. 283.84, Stats., the department may approve the use of phosphorus trading as a means for a point source to achieve compliance with the water quality based effluent limitation, including a TMDL based limitation. The trade shall be incorporated into the terms of the WPDES permit for the point source and must be approved by the department prior to implementation.*" WQT would require identification of other potential load reductions in the watershed or TMDL reach; modeling of any proposed best management practices (BMPs); registration of the trades; and installation, verification, and maintenance of BMPs.

   b. Watershed adaptive management (AM) is a compliance option that is described in NR 217.18. With adaptive management, a wastewater treatment plant (WWTP) partners with other sources of phosphorus loading to make load reductions elsewhere in its watershed. These often include nonpoint source load reductions since they are typically less costly than point source load reductions to achieve low phosphorus levels. To qualify, a WWTP needs to have a stringent limit (below 0.4 mg/L monthly average) and show that more than half of the phosphorus loading in the receiving stream at the WWTP outfall is from nonpoint sources or show that the receiving stream cannot meet water quality criteria without control of nonpoint sources. Watershed adaptive management may be used for both phosphorus and total suspended solids (TSS) and essentially extends the phosphorus compliance schedule to 20 years. Interim phosphorus limits of 0.6 and 0.5 mg/L are applied to the outfall in the first and second permit terms of AM, respectively, and a 0.5 mg/L limit is expected to be applied in the third permit term based on the District's communications with WDNR. Receiving stream water quality monitoring is required with this alternative.

7. USEPA recently approved the state multi-discharger variance related to phosphorus compliance. However, the variance is not be available to permittees in Dane County, which include the District.

The District has already determined, based on cost-effectiveness and triple bottom line considerations, that it will use AM for its BFC outfall compliance option. The District is collaborating with multiple partners in the Yahara River watershed on this effort. In 2016 this AM program, called Yahara Watershed Improvement Network (Yahara WINs), completed its four-year pilot project and is transitioning to a full-scale program. MMSD prepared a draft AM Plan and submitted it to WDNR in December 2015. The WDNR indicated the draft AM Plan is approvable and formal AM Plan approval is expected after reissuance of the District's WPDES permit. Additional information, including the draft AM Plan, is provided on the District's internet site: http://www.madsewer.org/Programs-Initiatives/Yahara-WINs.

At the April 21, 2016 meeting between the District and WDNR, WDNR staff indicated they do not expect any changes to phosphorus regulations or compliance approaches within this facilities planning period.

Because this facilities planning period will coincide with the Yahara WINs AM compliance period (20 years), and the NSWWTP already routinely meets AM interim limits, no additional improvements are necessarily required for the NSWWTP associated with the BFC outfall. Reduction of effluent phosphorus at the NSWWTP, through liquid process systems upgrades, could potentially result in lower payments by MMSD to the Yahara WINs program. Conversely, liquid process system upgrades that increase effluent phosphorus could potentially increase MMSD payments. After the WPDES permit is reissued (potentially in early 2017), the District will need to evaluate alternatives for compliance with an expected 0.075 mg/L six-month average and 0.23 mg/L monthly average limit for the BMC outfall. Alternatives that have been discussed preliminarily include WQT, AM, tertiary treatment of the BMC return flow to meet the limits, or site-specific criteria development for the BMC. In addition, the District began discharging to the BMC in the 1990s as a means of replacing the discharge flow associated with the decommissioning of the Verona WWTP and as a means to return approximately the same flow to the Sugar River watershed as is pumped to the NSWWTP from that watershed for treatment. This District was (and is) not required to discharge to BMC, and therefore, if the limits at the BMC discharge become too stringent and costly to meet, an additional option that could be considered by the District would be the elimination or significant reduction of this discharge.

B. Total Nitrogen (TN) and Nitrate-Nitrogen

Since around 2000, the USEPA has been maintaining the position that States must develop numeric TN criteria or demonstrate that they are not needed. The WDNR's current position and progress on TN is provided in *Wisconsin's Nutrient Reduction Strategy* of November 2013, located on the WDNR internet site at the following link: http://dnr.wi.gov/topic/SurfaceWater/nutrient/combined_draft.pdf. Studies conducted prior to promulgating phosphorus criteria indicated Wisconsin's surface waters are phosphorus-limited with respect to algal production, meaning phosphorus is the nutrient that needs to be controlled for water quality to improve. Chapter 10 of *Wisconsin's Nutrient Reduction Strategy* indicates that additional data was collected on high nitrogen-low phosphorus streams in Wisconsin. In 2011 and 2012, water chemistry and biotic data was collected on the selected streams, with laboratory analysis completed in 2012. Statistical analysis and expert review of the data was planned for 2013 and 2014. The WDNR's 2015 to 2017 Triennial Standards Review document indicates that TN continues to be a high priority but that the WDNR does not believe sufficient data is available to calculate scientifically sound water quality standards. WDNR intends to continue to review data and address TN as resources become available. If criteria are found to be required, Wisconsin's process for administrative rule revisions will follow.

TN load reduction goals or effluent limits could also be developed in response to Gulf of Mexico hypoxia or as a result of new studies related to aquatic toxicity.

We expect that TN rule revisions could be promulgated within about five years, or longer, based on the amount of time it took to adopt phosphorus criteria in Wisconsin. The magnitude of potential future effluent TN limits is unknown at this time, although some levels that have been discussed in other nearby states and nationwide are summarized below.

1. Iowa, Illinois, and other states in the region have proposed TN effluent goals on the order of 8 to 10 mg/L. Numeric limits or goals in this range have been included in some Illinois WWTP permits to meet antidegradation rules for WWTPs with expanded capacities. These limits or goals can often be met using biological nitrogen removal without a supplemental carbon source.

2. The Natural Resources Defense Council (NRDC) has petitioned the USEPA to revise the definition of secondary treatment to include nutrient removal. The NRDC has recommended effluent standards on the order of 3 mg/L for TN. The petition was ultimately rejected by USEPA. Limits this low typically require a supplemental carbon source and a tertiary treatment process, and therefore, can result in a significantly higher carbon footprint than the 8 to 10 mg/L limits.

3. The drinking water and Wisconsin groundwater standard for nitrate-nitrogen is 10 mg/L. In other states in the region there are some WWTPs that discharge to surface waters that have been given 10 mg/L effluent nitrate limits. In Wisconsin, effluent dischargers to groundwater (i.e., via seepage cells) are typically given 10 mg/L total nitrogen limits. The drinking water standard for nitrite-nitrogen is 1 mg/L.

MMSD commissioned a cost evaluation for NSWWTP to meet potential phosphorus and nitrogen limits and used TN limits of 3 and 10 mg/L for that study; the 10 mg/L limits were assumed for Scenarios 4 through 6. For this facilities plan, a future monthly average TN goal of 10 mg/L will be assumed, although the final recommended plan may not include TN removal to meet this limit. Technical Memorandum No. 5 (TM5) will evaluate plant upgrades that could be employed to achieve a TN limit of 10 mg/L, as well as alternatives that will reduce TN loadings from current levels but may not necessarily meet an effluent TN goal of 10 mg/L.

ROCK RIVER BASIN TMDL

The Rock River Basin phosphorus and sediment TMDL affects the BFC discharge and would affect any future outfalls in the Yahara River Watershed of the Rock River Basin. The TMDL was approved by the USEPA in 2011 and can be found on the WDNR internet site at the following location: http://dnr.wi.gov/topic/TMDLs/RockRiver/FinalRockRiverTMDLReportWithTables.pdf .

A. Phosphorus TMDL

MMSD's wasteload allocations for phosphorus at BFC are shown in Table 3. Corresponding required effluent concentrations at current, current design, and future design flows are also shown.

Month	TMDL Wasteload Allocation (lb/month)	Monthly Average Effluent Limit (lb/day)	Corresponding Effluent Concentration at 41 mgd (mg/L)	Corresponding Effluent Concentration at 50 mgd (mg/L)	Corresponding Effluent Concentration at 53.6 mgd (mg/L)
January	1,875	60	0.18	0.15	0.14
February	1,887	67	0.20	0.16	0.15
March	1,816	59	0.17	0.14	0.13
April	1,797	60	0.18	0.14	0.13
May	1,760	57	0.17	0.14	0.13
June	1,836	61	0.18	0.15	0.14
July	1,741	56	0.16	0.13	0.13
August	1,677	54	0.16	0.13	0.12
September	1,624	54	0.16	0.13	0.12
October	1,717	55	0.16	0.13	0.12
November	1,804	60	0.18	0.14	0.13
December	1,863	60	0.18	0.14	0.13

Table 3 TMDL-Based Total Phosphorus Effluent Limitations and Concentrations

The Yahara WINs AM program will be used to meet phosphorus wasteload allocations as discussed in the Nutrient Regulations section. TM5 will provide a cursory review of the costs of AM compared to the cost of NSWWTP upgrades to meet the TMDL-based effluent phosphorus limits under current and future conditions.

B. Sediment/TSS TMDL

MMSD's wasteload allocations for TSS are shown in Table 4, along with corresponding required monthly average effluent concentrations at various flows. Corresponding TMDL-based weekly average TSS limits will also be included in the reissued permit; these are expected to be approximately 1.3 times higher than the monthly average limits. This expectation is based on 2013 WDNR guidance including an assumption that the coefficient of variability (CV) of the effluent data is 0.6. The CV assumption should be reviewed by WDNR or the District during the permit reissuance process.

Month	TMDL Wasteload Allocation (lb/month)	Monthly Average Effluent Limit (lb/day)[1]	Corresponding Effluent Concentration at 41 mgd (mg/L)	Corresponding Effluent Concentration at 50 mgd (mg/L)	Corresponding Effluent Concentration at 53.6 mgd (mg/L)
January	212,580	6,857	20	16	15
February	237,020	8,465	25	20	19
March	252,900	8,158	24	20	18
April	252,980	8,433	25	20	19
May	252,900	8,158	24	20	18
June	252,980	8,433	25	20	19
July	252,900	8,158	24	20	18
August	219,360	7,076	21	17	16
September	138,120	4,604	13	11	10
October	222,600	7,181	21	17	16
November	252,980	8,433	25	20	19
December	222,360	7,173	21	17	16

[1]: Weekly average limits of approximately 1.3x the monthly average limits are anticipated, too.

Table 4 TMDL-Based TSS Effluent Limitations and Concentrations

MMSD should not need to implement any special provisions at the NSWWTP to meet these TSS wasteload allocations. The Yahara WINs AM program can be used to help meet TSS wasteload allocations if needed.

WET WEATHER-RELATED REGULATIONS

In August 2013, the State of Wisconsin published administrative rule revisions at NR 210 concerning sanitary sewer overflows (SSO) to make Wisconsin regulations more consistent with requirements of the USEPA's regulatory approach regarding SSOs. The rule revisions were also in response to a letter from USEPA highlighting areas where Wisconsin regulations did not comply with the CWA. The revisions specifically prohibit SSOs and create a consistent set of factors that will be used to determine when and what enforcement will occur if an SSO occurs. The SSO rule revisions also contain provisions to develop a Compliance, Management, Operation, and Maintenance (CMOM) program and an SSO monitoring and reporting scheme for collection system permittees. The development of a CMOM program by August 1, 2016 is required for MMSD, its customer communities, and all owners/operators of collection systems in Wisconsin.

The District has been addressing these regulations including implementing projects to reduce infiltration/inflow (I/I) in its collection system. The District also recently updated its sewer use ordinance (SUO, available here: http://www.madsewer.org/Portals/0/Planning/PermitsAndOrdinances/SEWER%20USE%20ORDINANCE_electronic_2015.pdf) that requires customer communities to address excessive I/I, which is defined in the SUO.

The administrative rule revisions also clarify the WDNR's requirements for blending and bypassing at a WWTP and create a process whereby the WDNR may approve permit conditions that allow blending during wet weather. In general, the permittee has to show that excessive flow may damage the WWTP and that there are no feasible alternatives to blending. The no-feasible-alternatives analysis may consider technical achievability, costs, risks to the public, and other factors. The portion of flow that is routed around biological treatment must be recombined with the biologically treated effluent, and the combined flow must meet permit limits (including disinfection if required by the permit) prior to discharge. The NSWWTP does not currently have provisions for wet weather blending in its WPDES permit. However, there are provisions for storing secondary effluent in the lagoons and for monitoring any overflows from the lagoons to NSC.

Also noteworthy is NR 210.12(4), which indicates the WDNR may allow blending "*if the permittee operates sewage treatment facilities approved by the department that provide a separate sewage treatment process or processes solely for excess flow or that provide a sewage treatment process as an alternative to a biological treatment process and complies with all other requirements*" of the section. This subsection indicates a satellite wet weather treatment facility may be permitted by WDNR if all other blending conditions are met.

Unscheduled bypassing at a WWTP is allowed only if it is unavoidable and other conditions are met. Scheduled bypassing for construction or normal maintenance must be authorized by the WDNR in advance in writing. On rare occasions in the past, some overflow of WWTP structures has occurred during very high flow events. As part of this facilities planning effort (Technical Memorandum No. 4 [TM4]), future wet weather flows will be projected and alternatives to better manage peak flow events at the NSWWTP will be evaluated. In addition, as part of TM4, the potential costs, benefits, and related information will be developed for an aggressive I/I reduction program within the District-owned system and customer communities' systems.

RECREATIONAL STANDARDS

The USEPA released final recommendations on November 26, 2012, for recreational water quality criteria. The 2012 recommended criteria are based on the use of two bacterial indicators of fecal contamination, *E. coli* and enterococci. The new criteria are designed to protect primary contact recreation, including swimming and other activities where a high degree of bodily contact with the water, immersion, and ingestion are likely. The recommended criteria are shown in Table 5.

CRITERIA ELEMENTS	Recommendation 1 Estimated Illness Rate 36/1,000		Recommendation 2 Estimated Illness Rate 32/1,000	
Indicator	GM (cfu/100 mL)	STV (cfu/100 mL)	GM (cfu/100 mL)	STV (cfu/100 mL)
Enterococci (marine & fresh)	35	130	30	110
E. coli (fresh)	126	410	100	320

Table 5 USEPA 2012 Recommended Water Quality Criteria

A geometric mean (GM) and statistical threshold value (STV) are recommended for the bacteria samples. The STV approximates the 90th percentile of the water quality distribution and is intended to be a value that should not be exceeded by more than 10 percent of the samples taken. The GM and STV are recommended to be determined over a 30-day interval. These recommendations are not regulations but are intended to be used by states to set water quality standards. The WDNR has not yet drafted water quality standards based on these recommendations, but it may do so within the next three to five years. Also, as a result of WDNR Rule Package 4, weekly effluent fecal coliform limits are being included in recent WPDES permits in addition to monthly limits, with weekly limits in the range of 656 CFU/100 mL to 780 cfu/100 mL geometric mean.

The USEPA is also working to develop recreational water quality criteria based on coliphage or other organisms as an indicator for the presence of viruses. According to a November 2014 memorandum from the National Association of Clean Water Agencies (NACWA), NACWA encouraged the USEPA to work closely with the Water Environment Research Foundation (WERF) to conduct studies of how bacteriophages behave in WWTPs, how they are affected by current disinfection practices, and how their levels compare to those of current indicator organisms like fecal coliform and *E. coli*. NACWA, WERF, and the Water Environment Federation (WEF) are coordinating efforts on this issue and have identified areas that need additional research. NACWA also indicated that viruses are generally harder to disinfect than bacteria. However, with little available data, it is difficult to predict the extent of any changes that might be required to existing disinfection practices to meet the new criteria. WEF hosted a recent webinar based listening session on coliphage in which USEPA reported it intends to begin drafting coliphage criteria in late 2017.

Assuming the USEPA finalizes the virus-based criteria in 2018, Wisconsin could adopt associated criteria as early as 2019 and incorporate limits into MMSD’s next reissued WPDES permit (i.e., around 2022). If the WDNR and the District believe significant disinfection system modifications are required for compliance with any new effluent limits for viruses, a compliance schedule will likely be included in the reissued WPDES permit.

Disinfection using ultraviolet (UV) has been shown to be effective at inactivating viruses. However, these potential regulatory changes will be considered for the disinfection portion of this LPFP in Technical Memorandum No. 7.

THERMAL REGULATIONS

The State of Wisconsin adopted thermal standard rule revisions in NR 102 and NR 106 of the Wisconsin Administrative Code. The rules have an effective date of October 1, 2010. Chapter NR 102 was revised to create water quality standards for heat in surface waters. Chapter NR 106 was revised to include procedures to implement the thermal standards into WPDES permits issued to point sources discharging to surface waters. WDNR stated during rule revision development that it did not expect the thermal standards to have a significant impact on existing publicly owned treatment works (POTWs) except in unusual situations or where there is a high temperature industrial discharge to the POTW. BFC is classified as an effluent ditch near the discharge and MMSD will only need to show the maximum day (acute) temperature criteria are met in that segment. MMSD has completed effluent and in-stream temperature monitoring and provided data to the WDNR. Should the WDNR include any effluent temperature limits in the reissued permit, the District will have the opportunity to perform a dissipative cooling analysis on one or both of the receiving streams to determine if the limits are necessary. Other options could include an alternative effluent limit, a site-specific ambient temperature value (for BMC), or a site-specific criterion for temperature. It is also conceivable, although unlikely, that effluent cooling could be required. Modifications resulting from this LPFP are not expected to have a measurable impact on effluent wastewater temperature, nor will measures to reduce effluent temperature be considered within this plan.

CHLORIDE REGULATIONS

Chloride may be toxic to aquatic life if concentrations are high enough. Wisconsin's chloride standards are included in s. NR 105, and the acute and chronic standards are 757 mg/L and 395 mg/L, respectively. Effluent limits are determined using NR 106 and may be higher than the standards because of dilution with the receiving water. In service areas where ion exchange water softening is employed, it is often not possible for WWTPs to meet chloride effluent limits, so NR 106 includes a variance procedure. Variances need to be renewed with each permit application and reviewed and approved by the USEPA.

Chloride concentrations in MMSD effluent continue to increase primarily because of the use of in-home water softeners. Average influent wastewater flows to the NSWWTP have remained relatively constant over the past several years even with increasing population, and this has been attributed to a reduction in water use, as well as, potentially, improvements in I/I removal. Lower flows may result in higher chloride concentrations. Chloride levels are also increasing in the raw water supply because of salts used for pavement deicing, and I/I containing deicing salts can also contribute to higher effluent chloride concentrations. MMSD currently has a variance and a 430 mg/L target limit for chloride in its WPDES permit and a requirement to establish and maintain a source reduction program. MMSD commissioned a chloride treatment study in 2014-2015 that concluded it would not be feasible to treat the effluent to remove chloride. MMSD provides public education on optimizing water softener salt usage and leads or participates in other source reduction initiatives. As an example, MMSD is considering working with the City of Madison on a sustainability initiative that could pave the way for other raw water sources or softening methods for Madison's water supply. The District is also considering strengthening the SUO with respect to chloride discharges, including the potential to include chloride as a billing parameter, improving training requirements, and requiring municipalities to develop chloride reduction strategies. In the future, it may be possible for the District to address chloride requirements at least in part through regulatory measures such as changes to water quality standards or by using WQT.

This facilities planning effort will not address chlorides directly, but will consider the potential impact on effluent chlorides from changes to treatment processes. For example, if metal chloride salts are considered for phosphorus removal, the impact on the effluent chloride levels will need to be identified.

AMMONIA REGULATIONS

The current Wisconsin water quality standards for ammonia are based primarily on toxicity to fish. The USEPA developed more stringent ammonia criteria for surface waters that have the ability to support mussels and snails, which are more sensitive to ammonia. This could include BFC or BMC, although these receiving waters may be too small to support such populations. The USEPA released its draft mussel- and snail-based ammonia criteria in 2009 and public comments were received. The USEPA adopted these criteria, but the schedule for subsequent state implementation is unknown at this time. It appears this initiative could result in more stringent effluent ammonia-nitrogen limits for the NSWWTP outfalls to BFC and BMC within approximately the next five to ten years.

The WWTP currently discharges average effluent ammonia concentrations that are well below permit limits, and District staff do not expect the new criteria and potential lower limits to be a major consideration. This facilities planning effort will consider the more stringent limits if nitrification capacity will be reduced with any of the biological treatment alternatives. In addition, with one or more of the activated sludge alternatives (TM5), higher in-situ ammonia levels are desired to improve biological population dynamics under low dissolved oxygen conditions. For such scenarios, ammonia polishing may need to be integrated into the process to meet potential future ammonia limits.

OTHER CURRENT OR UPCOMING WATER QUALITY REGULATIONS

A. Designated Use Changes and Site Specific Criteria

The WDNR is in the process of developing rule revisions related to designated uses and site-specific criteria. The WDNR indicated that this effort will not, at least immediately, change the classification of variance streams that are included in NR 104. Therefore, portions of BFC will remain limited aquatic life or limited forage fish for the near-term. A portion of BMC is currently classified as limited forage fish in NR 104 as well. Based on the preliminary documents provided by the WDNR, BMC will have a natural community designation of cool-warm transitional. BMC will have a natural community designation of cool-cold transitional. The Sugar River (of which BMC is a tributary) is identified as both cold and cool-cold transitional. It appears NSC could be classified as a warm stream. Dissolved oxygen effluent limits could become more stringent for one or more of the outfalls in the more distant future, potentially requiring additional post-aeration or other measures. It is unclear at this time whether other effluent limits will change significantly.

The rule revisions should also result in a process for determining site specific criteria for phosphorus or other parameters. A site specific phosphorus criterion may be pursued for either BFC or BMC. For example, a site specific criterion for BFC may be worth pursuing in the distant future if adaptive management is not successful in meeting the 0.075 mg/L water quality criterion. The District has been collecting fish and other biological and chemical data from BFC which should be helpful in making a case for a sitespecific criterion. This may be a plausible approach for BMC as well.

B. Mercury

Mercury effluent limits are based on Great Lakes wildlife criteria and are set equal to the criterion (1.3 ng/L) in accordance with NR 106.06(6) because the background concentration in Wisconsin surface waters exceeds the wildlife criterion. This criterion is more stringent than the human health criterion, and the applicability may be worth reviewing with WDNR since the NSWWTP does not discharge to the Great Lakes. The District currently has a mercury variance with an alternative effluent limit. Similar to the chloride variance, the mercury variance focuses on source minimization. The District has a Mercury Pollutant Minimization Program including local limits for mercury in the SUO, and it submits annual status reports to the WDNR. The variance may be renewed with each permit application and is subject to approval by the USEPA. The WDNR has not indicated any plans for changing the approach to mercury compliance during this facilities planning period. However, it is noted that some tertiary treatment processes may reduce the effluent mercury concentrations.

C. Pharmaceuticals and Other Compounds of Emerging Concern (CECs)

The WDNR does not currently have rules related to microconstituents like pharmaceuticals or CECs. Pollution prevention and source reduction may continue to be the best approach for these parameters during the facilities planning period. The District's SUO requires customer communities to take reasonable steps to minimize the discharge of pharmaceuticals to the sewerage system. In 2007, MMSD cosponsored a pharmaceutical take-back program to reduce the chance that these compounds will end up in the wastewater. This program evolved into the MedDrop program in the Dane County area. The District continues to partner with Safe Communities on the MedDrop program. In addition, the District focuses pollution prevention on reducing other intentional discharges of pharmaceuticals and personal care products including such discharges from hospitals, clinics, and other care facilities These approaches are only partially effective since many pharmaceuticals are excreted in human waste. Approaches like lifestyle changes may be a future focus.

D. Antidegradation Rule Revisions

The WDNR is just beginning a rule revision process related to antidegradation. The intent is to provide a more transparent antidegradation review process that is consistent with federal regulations. The federal regulations include three tiers, with Tier 1 applying to all waters and Tiers 2 and 3 intended to protect waters that are higher quality than current standards. Related revisions are expected to Wisconsin Administrative Code chapters NR 102, NR 106, NR 205, NR 207, and NR 217. These rule revisions could result in more stringent effluent limits in the future, proportional to increases in design flows.

E. Whole Effluent Toxicity (WET) Testing

WDNR Rule Packages released in 2016 included the potential that a single WET test failure can result in a WPDES permit effluent limit for toxicity. The WDNR's WET Program Guidance Document was revised in November 2016 to incorporate methods for evaluating test results, determining if reasonable potential exists to exceed a toxicity effluent limit, and other guidelines associated with the NR 106 2016 rule revisions.

AIR QUALITY REGULATIONS

The following air quality-related regulations or initiatives have been identified that may impact MMSD's liquid processing operations.

1. State air regulations (NR 404, NR 405, NR 406, NR 407, NR 429, NR 438, NR 439, and NR 445): These regulations could impact multiple areas of MMSD's operations including emissions from unit processes. Typical focus is on parameters such as carbon monoxide, nitrogen and sulfur oxides, and volatile organic compounds. These regulations may require additional permitting, sampling, covering of tanks, stack testing, or other measures in the future. Emissions from the current treatment processes, mainly volatile organic compounds originating from the plant influent, are permitted through the Operation Permit issued in January 2016 by the WDNR. According to the Operation Permit, the facility is "required to follow good engineering practices to minimize emissions of hazardous air pollutants" from treatment operations."

2. Federal air regulations (Maximum Achievable Control Technology Standards): These regulations would primarily apply to new WWTP projects, or major reconstruction projects, that are over a certain size. Currently, a major source is defined as one that emits more than 10 tons a year of a hazardous air pollutant (HAP) or more than 25 tons per year of a combination of HAPs. The facility is currently permitted as a synthetic minor source "SM80" such that the potential to emit is at least 80 percent but less than 100 percent of major source thresholds. This should be reviewed if a major change to the liquid process is proposed.

3. Greenhouse gas emissions and climate change: The District's Operation Permit requires that all biogas produced from the digesters be combusted in some manner to reduce greenhouse gas emissions. Again, this is an area that should be reviewed if major changes to the biological treatment or other liquid processing systems are proposed.

GROUNDWATER DISCHARGE REQUIREMENTS

Groundwater recharge using effluent is being practiced in several locations around the state, particularly in the Wisconsin River Valley and other locations where soils are sandy and are thus conducive to infiltration. A typical method of effluent groundwater recharge is to use seepage cells (also called absorption ponds), which are regulated under NR 206. Current effluent limitations for discharge to absorption ponds include:

Biochemical Oxygen Demand (BOD)	50 mg/L
TN	10 mg/L
Total Dissolved Solids	500 mg/L
Chloride	250 mg/L

Groundwater monitoring is usually required for absorption ponds and the relevant groundwater standards at the design management zone boundary (250 feet from the seepage cell boundary) or at the property line would apply. These are contained in NR 140. The groundwater preventive action limit (PAL) for chloride is 125 mg/L and the enforcement standard (ES) is 250 mg/L; this may be a limiting factor for recharge of NSWWTP effluent unless a variance could be obtained.

Favorable groundwater infiltration locations were explored as part of the Madison Gas and Electric (MGE) West Campus Cogeneration facility environmental impact review. Four sites were identified in west and south Madison with the projected ability to recharge 120 million gallons per year of stormwater. A large, potentially favorable, infiltration site has also been identified in Fitchburg through a University of Wisconsin practicum. These and other potential sites would need to be reviewed from the perspective of wastewater quality to determine whether they would be effective for effluent infiltration and cost-effective when considering conveyance and other costs compared to volume recharged.

The use of injection wells is another method of groundwater infiltration. Federal drinking water regulations include five types of injection well permits. Effluent would need to meet NR 140 standards before injection, unless it could be shown that the aquifer receiving the effluent was nonpotable and isolated from water supply aquifers.

Depending on the location of groundwater absorption ponds, infiltration galleries, or injection wells, it may be necessary to provide additional treatment to remove additional pathogens or microconstituents from the effluent prior to recharge. The upper sandstone aquifer in the Madison area is no longer widely used for human consumption, and recharge of this aquifer could help provide restoration of local springs and wetlands. However, the lower water supply aquifer is not protected everywhere in Dane County because the shale layer below the sandstone aquifer is discontinuous in some locations, and some community water supply wells are open to both the upper and lower sandstone. Therefore, infiltration sites would need to be carefully selected if higher levels of treatment are not provided.

EFFLUENT REUSE REQUIREMENTS

Wastewater effluent is being used for industrial noncontact cooling and other noncontact uses in some locations, particularly where fresh water is scarce. An example in Wisconsin is the Heart of the Valley WWTP in Kaukauna where highly treated effluent is being used by a nearby power plant for cooling. Wisconsin currently has no specific standards for the treatment of effluent for use in an industrial facility.

In 2002, MGE briefly explored the use of MMSD effluent for cooling at its new West Campus Cogeneration facility. A discussion is contained in the MGE-University of Wisconsin (UW) West Campus Cogeneration Facility Final Environmental Impact Statement (MGE 2003). The use of effluent would have offset MGE's 2.75 mgd proposed full build-out water withdrawal from Lake Mendota. The cost for additional disinfection and filtration to remove protozoans, and a pipeline to convey effluent to the Cogeneration Facility, was determined to be approximately $9.5 million at that time. There were also concerns from the UW regarding use of the effluent in a residential and campus setting for a facility of the size being considered, so the concept was not pursued further.

It may be possible for effluent to be reused for noncontact industrial cooling water. The concept could be initially explored with the largest water users in Dane County, who are believed to use fresh water for nonpotable uses. Some of the potential users identified in the 50-Year Master Plan follow.

- MGE Blount Street or other location
- UW Physical Plant
- Lycon Corporation
- Wingra Stone

The current MMSD permit contains provisions related to use of effluent on the Nine Springs Golf Course in Fitchburg as a demonstration project. This type of discharge would be regulated primarily under s. NR 206. Hydraulic loading rates and load and rest cycles are determined on a case-by-case basis and generally depend on the soil type. Likewise, TN and fecal coliform limits are determined on a case-by-case basis. Groundwater monitoring is often required for these systems, particularly when significant pretreatment is not provided. Groundwater standards for chloride (125 mg/L PAL and 250 mg/L ES) may be of greatest concern for MMSD's effluent.

Other potential uses of effluent that were identified in the 50-Year Master Plan include restored wetlands, ethanol production facilities (if sited nearby), sod farms, and large agricultural operations that use fresh water for flushing systems in barns or for other purposes. Residential or commercial landscape watering and crop irrigation were also reviewed. While these uses do not appear sufficiently cost-effective and beneficial at this time, this could change. For example, highly treated effluent could become a commodity for irrigation or cooling during dry weather periods, and effluent reuse in general could become feasible in some cases when considering the triple bottom line.

Depending on the ultimate use, effluent reuse may require treatment to Wisconsin drinking water standards or similar (i.e., California Title 22) standards. Drinking water standards would include parameters and levels similar to those listed previously for groundwater discharge. Title 22 standards for irrigation onto parks and food crops include a turbidity of 2 nephalometric turbidity units (NTU) and a median of 2.2 total coliforms per 100 mL, requiring advanced filtration, among other requirements.

RECOMMENDED PERMIT LIMITS AND CONSIDERATIONS FOR FACILITIES PLANNING

Strand Associates, Inc.®, on behalf of the District, submitted a facilities planning-level effluent limitations request to the WDNR in May 2016 (Appendix B). The WDNR responded to the request in a February 2017 memorandum (Appendix C). Based on this memorandum and the information presented above, the following summarizes the planning-level effluent limits for this Liquid Process Facilities Plan.

1. BOD and TSS effluent concentration limits will be marginally lower based on mass loading limits.

2. Based on new USEPA water quality criteria, effluent ammonia limits will decrease to approximately the following for BFC and to somewhat lower levels for BMC (these were not provided by WDNR but were assumed for planning purposes based on information from the Illinois Environmental Protection Agency:

    a. 1 mg/L monthly average in summer
    b. 2 mg/L weekly average in summer
    c. 2 mg/L monthly average in winter
    d. 4 mg/L weekly average in winter

3. Effluent phosphorus limits will be approximately as summarized in the summary notes from the May 24, 2016 workshop. The anticipated interim effluent phosphorus limit (six-month average) through the year 2035 is anticipated to be 0.6 mg/L in the next permit and 0.5 mg/L in the following permits.

4. For the purposes of this LPFP, the plan identifies potential effluent total phosphorus (TP) concentrations that can be biologically achieved without addition of an external carbon source under different process configurations, as well as with chemical polishing and filtration. The District plans to use AM to comply with effluent phosphorus limits to the BFC outfall. To minimize AM-related costs to the District, effluent TP concentrations would need to be consistently below about 0.26 to 0.28 mg/L under current and near future flows.

5. This LPFP does not develop a plan to meet potential future effluent TP limits (0.075 mg/L) at the BMC discharge. If such low limits are implemented, the District indicated that it may cease discharging to that outfall. If the outfall is maintained, the District could potentially meet these requirements through WQT or AM in the Sugar River watershed.

6. There will be no effluent TN limits during this planning period. However, the LPFP evaluations will include developing scenarios to reduce TN discharges from current levels and perhaps meet a future effluent TN target of approximately 10 mg/L. This value is based on similar limits seen elsewhere in the country and based on a reasonable estimate of what the MMSD WWTP could meet without supplemental carbon addition.

7. Emergency discharges to NSC will continue to be allowed with monitoring only, even if the frequency of such discharges increases somewhat as projected in this planning effort.

8. A "wet weather only," or excess flow, discharge to NSC will need to be completely offset through trading with respect to total phosphorus and TSS loadings. Such a discharge could have a phosphorus limit that is lower than the water quality criterion of 0.075 mg/L, according to WDNR correspondence.

9. It is assumed that a continuous discharge to NSC will not be allowed without considerable long-term testing, improved treatment, trading to offset phosphorus and TSS loadings, and demonstration of positive triple bottom line factors.

APPENDIX A

CURRENT WPDES PERMIT

State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES

WISCONSIN DEPT. OF NATURAL RESOURCES

Jim Doyle, Governor
Matthew J. Frank, Secretary
Lloyd L. Eagan, Regional Director

South Central Region Headquarters
3911 Fish Hatchery Road
Fitchburg, WI 53711-5397
Telephone (608) 275-3266
FAX (608) 275-3338
TTY Access via relay - 711

October 28, 2010

Mr. Jon Schellpfeffer
Chief Eng. & Director
1610 Moorland Road
Madison, WI 53713

SUBJECT: Typographical Error(s) in WPDES Permit No. WI-0024597-08-0

Dear Permittee:

A typographical error in WPDES Permit No. WI-0024597-08-0 issued to MADISON METROPOLITAN SEWERAGE DISTRICT on September 30, 2010 has been discovered.

The chloride target limit effective dates in sections 3.2.1, 3.2.2 and in the first and last Required Action boxes in section 6.2 were listed incorrectly as 6/30/14, 6/30/14, 6/30/14 and 9/30/14, respectively. Because reissuance of this permit was delayed by 18 months, these due dates were extended to 9/30/15, as originally intended.

The attached page(s), namely 6, 9 and 20, replace(s) pages 6, 9 and 20 of the original permit issued on September 30, 2010. Please replace the original page(s) with the attached corrected page(s) in all copies of the permit which you retain in your records. All discharges from this facility and actions or reports relating thereto shall be in accordance with the terms and conditions of the original permit as amended by this letter.

The WPDES permit program has been approved by the Administrator of the U.S. Environmental Protection Agency pursuant to Section 402(b) of the Federal Water Pollution Control Act Amendments of 1972 (33 U.S. C. Section 1342(b)). Therefore, the permit is subject to enforcement under ss. 283.89 and 283.91, Stats. and Section 309 of the Federal Act (33 U.S.C. Section 1319).

To challenge this decision, s. 283.63, Stats., and ch. NR 203, Wis. Adm. Code require that you file a verified petition for review with the Secretary of the Department of Natural Resources within 60 days of the date of this decision. This notice is provided pursuant to s. 227.48, Stats.

Sincerely,

Robert Liska

Robert Liska
Wastewater Specialist

cc: Permit File – Region & Central Office
Robert Liska - SCR
U.S. Fish and Wildlife Service (Electronic Copy via Email)
EPA – Region V (Electronic Copy via Email)

State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES

Jim Doyle, Governor
Matthew J. Frank, Secretary
Lloyd L. Eagan, Regional Director

South Central Region Headquarters
3911 Fish Hatchery Road
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Mr. Jon Schellpfeffer
Chief Eng. & Director
MADISON METROPOLITAN SEWERAGE DISTRICT
1610 Moorland Road
Madison, WI 53713

SUBJECT: WPDES Permit Reissuance No. WI-0024597-08-0
Madison Metropolitan Sewerage District WWTF, 1610 Moorland Road

Dear Mr. Schellpfeffer:

Your Wisconsin Pollutant Discharge Elimination System (WPDES) Permit is enclosed. The conditions of the enclosed permit reissuance were determined using the permit application, information from your WPDES permit file, other information available to the Department, comments received during the public notice period, and applicable Wisconsin Administrative Codes. All discharges from this facility and actions or reports relating thereto shall be in accordance with the terms and conditions of the enclosed permit.

This enclosed permit requires you to submit monitoring results to the Department on a periodic basis. Blank copies of the appropriate monitoring forms and instructions for completing them will be mailed to you under separate cover. Any forms you are submitting electronically will be updated and available on the web.

The WPDES permit program has been approved by the Administrator of the U.S. Environmental Protection Agency pursuant to Section 402(b) of the Federal Water Pollution Control Act Amendments of 1972 (33 U.S.C. Section 1342 (b)). The terms and conditions of the enclosed permit are accordingly subject to enforcement under ss. 283.89 and 283.91, Stats., and Section 309 of the Federal Act (33 U.S.C. Section 1319).

The Department has the authority under chs. 160 and 283, Stats., to establish effluent limitations, monitoring requirements, and other permit conditions for discharges to groundwater and surface waters of the State. The Department also has the authority to issue, reissue, modify, suspend, or revoke WPDES permits under ch. 283, Stats.

The enclosed permit contains water quality-based effluent limitations that are necessary to ensure the water quality standards for the Yahara River and Sugar River are met. You may apply for a variance from the water quality standard used to derive the limitations pursuant to s. 283.15, Stats., by submitting an application to the Director of the Bureau of Watershed Management, P.O. Box 7921, Madison, Wisconsin 53707 within 60 days of the date the permit was issued (see "Date Permit Signed/Issued" after the signature on the front page of the enclosed permit). Subchapter III of ch. NR 200, Wis. Adm. Code, specifies the procedures that must be followed and the information that must be included when submitting an application for a variance.

To challenge the reasonableness of or necessity for any term or condition of the enclosed permit, s. 283.63, Stats., and ch. NR 203, Wis. Adm. Code, require that you file a verified petition for review with the Secretary of the Department of Natural Resources within 60 days of the date the permit was issued (see "Date Permit Signed/Issued" after the signature on the front page of the enclosed permit). For permit-related decisions that are not reviewable pursuant to s. 283.63, Stats., it may be possible for permittees or other persons to obtain an administrative review pursuant to s. 227.42, Stats., and s. NR 2.05(5), Wis. Adm. Code, or a judicial review pursuant to s. 227.52, Stats. If you choose to pursue one of these options, you should know that Wisconsin Statutes and Administrative Code establish time periods within which requests to review Department decisions must be filed.

Sincerely,

Kenneth Johnson
South Central Region Water Leader

Dated: 9/30/2010

cc: Legal Permit File
Cyndi Barr, WT/3
U.S. Fish and Wildlife Service (Electronic Copy via Email)
Robert Liska
EPA – Region V (Electronic Copy via Email)

WPDES PERMIT

STATE OF WISCONSIN
DEPARTMENT OF NATURAL RESOURCES

PERMIT TO DISCHARGE UNDER THE WISCONSIN POLLUTANT DISCHARGE ELIMINATION SYSTEM

MADISON METROPOLITAN SEWERAGE DISTRICT

is permitted, under the authority of Chapter 283, Wisconsin Statutes, to discharge from a facility located at

1610 Moorland Road, Madison,WI

to

BADFISH CREEK, FROM OUTFALL 001, AND GROUNDWATER OF THE YAHARA RIVER AND LAKE MONONA WATERSHED, FROM OUTFALL 008, BOTH IN THE LOWER ROCK RIVER BASIN AND TO BADGER MILL CREEK, FROM OUTFALL 005, INTHE SUGAR-PECATONICA RIVER BASIN, ALL IN DANE COUNTY

in accordance with the effluent limitations, monitoring requirements and other conditions set forth in this permit.

The permittee shall not discharge after the date of expiration. If the permittee wishes to continue to discharge after this expiration date an application shall be filed for reissuance of this permit, according to Chapter NR 200, Wis. Adm. Code, at least 180 days prior to the expiration date given below.

State of Wisconsin Department of Natural Resources
For the Secretary

By ______________________
Kenneth Johnson
South Central Region Water Leader

9/30/2010
Date Permit Signed/Issued

PERMIT TERM: EFFECTIVE DATE - October 01, 2010 **EXPIRATION DATE - September 30, 2015**

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1 Influent Requirements

1.1 Sampling Point(s)

Sampling Point Designation	
Sampling Point Number	**Sampling Point Location, WasteType/Sample Contents and Treatment Description (as applicable)**
701	Influent to the wastewater treatment plant.

1.2 Monitoring Requirements

The permittee shall comply with the following monitoring requirements.

1.2.1 Sampling Point 701 - INFLUENT TO PLANT

Monitoring Requirements and Limitations					
Parameter	**Limit Type**	**Limit and Units**	**Sample Frequency**	**Sample Type**	**Notes**
Flow Rate		MGD	Continuous	Continuous	
BOD_5, Total		mg/L	Daily	24-Hr Flow Prop Comp	
Suspended Solids, Total		mg/L	Daily	24-Hr Flow Prop Comp	
Cadmium, Total Recoverable		µg/L	Monthly	24-Hr Flow Prop Comp	
Chromium, Total Recoverable		µg/L	Monthly	24-Hr Flow Prop Comp	
Copper, Total Recoverable		µg/L	Monthly	24-Hr Flow Prop Comp	
Lead, Total Recoverable		µg/L	Monthly	24-Hr Flow Prop Comp	
Nickel, Total Recoverable		µg/L	Monthly	24-Hr Flow Prop Comp	
Zinc, Total Recoverable		µg/L	Monthly	24-Hr Flow Prop Comp	
Mercury, Total Recoverable		ng/L	Monthly	24-Hr Flow Prop Comp	

1.2.1.1 Total Metals Analyses

Measurements of total metals and total recoverable metals shall be considered as equivalent.

1.2.1.2 Sample Analysis

Samples shall be analyzed using a method which provides adequate sensitivity so that results can be quantified, unless not possible using the most sensitive approved method.

1.2.1.3 Mercury Monitoring

The permittee shall collect and analyze all mercury samples according to the data quality requirements of ss. NR 106.145(9) and (10), Wisconsin Administrative Code. The limit of quantitation (LOQ) used for the effluent and field blank shall be less than 1.3 ng/L, unless the samples are quantified at levels above 1.3 ng/L. The permittee shall collect at least one mercury field blank for each set of mercury samples (a set of samples may include combinations of intake, influent, effluent or other samples all collected on the same day). The permittee shall report results of samples and field blanks to the Department on Discharge Monitoring Reports.

2 In-Plant Requirements

2.1 Sampling Point(s)

Sampling Point Designation	
Sampling Point Number	**Sampling Point Location, WasteType/Sample Contents and Treatment Description (as applicable)**
111	In plant mercury monitoring - collect a mercury field blank at the Effluent Building using the Clean Hands/Dirty Hands sample collection procedure excerpted from EPA Method 1669.
112	Wet weather diversion structure to Nine Springs Creek tributary.

2.2 Monitoring Requirements and Limitations

The permittee shall comply with the following monitoring requirements and limitations.

2.2.1 Sampling Point 111 - In plant mercury monitoring

Monitoring Requirements and Limitations					
Parameter	**Limit Type**	**Limit and Units**	**Sample Frequency**	**Sample Type**	**Notes**
Mercury, Total Recoverable		ng/L	Monthly	Blank	

2.2.1.1 Mercury Monitoring

The permittee shall collect and analyze all mercury samples according to the data quality requirements of ss. NR 106.145(9) and (10), Wisconsin Administrative Code. The limit of quantitation (LOQ) used for the effluent and field blank shall be less than 1.3 ng/L, unless the samples are quantified at levels above 1.3 ng/L. The permittee shall collect at least one mercury field blank for each set of mercury samples (a set of samples may include combinations of intake, influent, effluent or other samples all collected on the same day). The permittee shall report results of samples and field blanks to the Department on Discharge Monitoring Reports.

2.2.2 Sampling Point 112 - Diversion structure

Monitoring Requirements and Limitations					
Parameter	**Limit Type**	**Limit and Units**	**Sample Frequency**	**Sample Type**	**Notes**
Volume		MGD	Per Occurrence	Estimated	
Fecal Coliform		#/100 ml	Per Occurrence	Grab	

2.2.2.1

During wet weather high flow conditions, when necessary to maintain the proper function of the wastewater treatment facility, the permittee may operate in-plant diversion facilities that have been designed and constructed for that purpose. In-plant diversion shall only be used by the permittee when there are high wet weather wastewater flows to the treatment facility and when such alternative operations are necessary to supplement effluent pumping capacity.

2.2.2.2

The use of these facilities is authorized on the condition that the permittee shall: 1) implement a program of management, operation, and maintenance of the sanitary sewage collection system that is designed to effectively reduce, to the maximum extent practicable, the entry of wet weather flows into the sewerage system and, 2) implement diversion option 4 as described in the February 8, 2005 Effluent Diversion Evaluation Report and as approved by the Department.

3 Surface Water Requirements

3.1 Sampling Point(s)

Sampling Point Designation	
Sampling Point Number	Sampling Point Location, WasteType/Sample Contents and Treatment Description (as applicable)
001	Disinfected effluent sample point at Effluent Building - Nine Springs Wastewater Treatment Plant; effluent discharged to Badfish Creek.
005	Same sample point as 001; effluent discharged to Badger Mill Creek.

3.2 Monitoring Requirements and Effluent Limitations

The permittee shall comply with the following monitoring requirements and limitations.

3.2.1 Sampling Point (Outfall) 001 - EFFL/BADFISH CREEK

Monitoring Requirements and Effluent Limitations					
Parameter	Limit Type	Limit and Units	Sample Frequency	Sample Type	Notes
Flow Rate		MGD	Continuous	Continuous	
BOD_5, Total	Monthly Avg	19 mg/L	Daily	24-Hr Comp	
BOD_5, Total	Weekly Avg	20 mg/L	Daily	24-Hr Comp	
Suspended Solids, Total	Monthly Avg	20 mg/L	Daily	24-Hr Comp	
Suspended Solids, Total	Weekly Avg	23 mg/L	Daily	24-Hr Comp	
Dissolved Oxygen	Daily Min	5.0 mg/L	Daily	Grab	
pH Field	Daily Max	9.0 su	Daily	Grab	
pH Field	Daily Min	6.0 su	Daily	Grab	
Phosphorus, Total	Monthly Avg	1.5 mg/L	Daily	24-Hr Comp	
Fecal Coliform	Geometric Mean	400 #/100 ml	2/Week	Grab	Limit applies April 15 - October 15.
Nitrogen, Ammonia (NH_3-N) Total	Monthly Avg	1.8 mg/L	Daily	24-Hr Comp	Limit applies May - September.
Nitrogen, Ammonia (NH_3-N) Total	Daily Max	17 mg/L	Daily	24-Hr Comp	Limit applies year-round.
Nitrogen, Ammonia (NH_3-N) Total	Weekly Avg	4.4 mg/L	Daily	24-Hr Comp	Limit applies May - September.
Nitrogen, Ammonia (NH_3-N) Total	Monthly Avg	4.1 mg/L	Daily	24-Hr Comp	Limit applies October - April.
Nitrogen, Ammonia (NH_3-N) Total	Weekly Avg	10 mg/L	Daily	24-Hr Comp	Limit applies October - April.
Acute WET		rTUa	Quarterly	24-Hr Comp	Sample during the quarters specified in section 3.2.1.5 .

Monitoring Requirements and Effluent Limitations					
Parameter	**Limit Type**	**Limit and Units**	**Sample Frequency**	**Sample Type**	**Notes**
Chronic WET		rTU$_c$	Quarterly	24-Hr Comp	Sample during the quarters specified in section 3.2.1.5 .
Cadmium, Total Recoverable		µg/L	Monthly	24-Hr Comp	
Chromium, Total Recoverable		µg/L	Monthly	24-Hr Comp	
Copper, Total Recoverable		µg/L	Monthly	24-Hr Comp	
Lead, Total Recoverable		µg/L	Monthly	24-Hr Comp	
Nickel, Total Recoverable		µg/L	Monthly	24-Hr Comp	
Zinc, Total Recoverable		µg/L	Monthly	24-Hr Comp	
Mercury, Total Recoverable	Daily Max	5.7 ng/L	Monthly	Grab	
BOD_5, Total	Monthly Avg	7,923 lbs/day	Daily	Calculated	
BOD_5, Total	Weekly Avg	8,340 lbs/day	Daily	Calculated	
Suspended Solids, Total	Monthly Avg	8,340 lbs/day	Daily	Calculated	
Suspended Solids, Total	Weekly Avg	9,591 lbs/day	Daily	Calculated	
Chloride	Weekly Avg	481 mg/L	Weekly	24-Hr Comp	"This interim limit applies until 09/30/2015 when the target value of 430 mg/L becomes effective as the target limit. (See section 6.2)
Chloride	Weekly Avg	200,000 lbs/day	Weekly	Calculated	

3.2.1.1 Total Metals Analyses

Measurements of total metals and total recoverable metals shall be considered as equivalent.

3.2.1.2 Sample Analysis

Samples shall be analyzed using a method which provides adequate sensitivity so that results can be quantified, unless not possible using the most sensitive approved method.

3.2.1.3 Mercury Monitoring

The permittee shall collect and analyze all mercury samples according to the data quality requirements of ss. NR 106.145(9) and (10), Wisconsin Administrative Code. The limit of quantitation (LOQ) used for the effluent and field blank shall be less than 1.3 ng/L, unless the samples are quantified at levels above 1.3 ng/L. The permittee shall collect at least one mercury field blank for each set of mercury samples (a set of samples may include combinations of intake, influent, effluent or other samples all collected on the same day). The permittee shall report results of samples and field blanks to the Department on Discharge Monitoring Reports.

3.2.1.4 Non-Wet Weather and Alternative Wet Weather Mass Limit

This parameter (chloride) has a mass limit based on weather conditions. The applicable non-wet weather mass limit is 200,000 pounds/day. The applicable wet weather mass limit is 260,000 pounds/day. Report the applicable mass limit on the Discharge Monitoring Report form in the variable limit column. See Standard Requirements for "Applicability of Alternative Wet Weather Mass Limitations" and "Appropriate Formulas for Effluent Calculations".

3.2.1.5 Whole Effluent Toxicity (WET) Testing

Primary Control Water: Control water shall be standard laboratory control water which has a hardness of +/- 10 % of the hardness of: 1) the Yahara River above the confluence with Badfish Creek. Different control water may be used if prior approval has been given by the Department.

Instream Waste Concentration (IWC): 93%

Dilution series: At least five effluent concentrations and dual controls must be included in each test.

- **Acute:** 100, 50, 25, 12.5, 6.25% and any additional selected by the permittee.
- **Chronic:** 100, 30, 10, 3, 1% (if the IWC ≤30%) or 100, 75, 50, 25, 12.5% (if the IWC >30%) and any additional selected by the permittee.

WET Testing Frequency: Tests are required during the following quarters.

- **Acute: Jan – Mar 2011; April – June 2012; Oct – Dec 2013; July – Sep 2014; Jan – Mar 2015**
- **Chronic: Jan – Mar and April – June 2011; April – June and July – Sep 2012; July – Sep and Oct – Dec 2013; July – Sep and Oct – Dec 2014; Jan – Mar and April – June 2015**

Reporting: The permittee shall report test results on the Discharge Monitoring Report form, and also complete the "Whole Effluent Toxicity Test Report Form" (Section 6, "*State of Wisconsin Aquatic Life Toxicity Testing Methods Manual, 2nd Edition*"), for each test. The original, complete, signed version of the Whole Effluent Toxicity Test Report Form shall be sent to the Biomonitoring Coordinator, Bureau of Watershed Management, 101 S. Webster St., P.O. Box 7921, Madison, WI 53707-7921, within 45 days of test completion. The original Discharge Monitoring Report (DMR) form and one copy shall be sent to the contact and location provided on the DMR by the required deadline.

Determination of Positive Results: An acute toxicity test shall be considered positive if the Toxic Unit - Acute (TU_a) is greater than 1.0 for either species. The TU_a shall be calculated as follows: If $LC_{50} \geq 100$, then $TU_a = 1.0$. If LC_{50} is < 100, then $TU_a = 100 \div LC_{50}$. A chronic toxicity test shall be considered positive if the Relative Toxic Unit - Chronic (rTU_c) is greater than 1.0 for either species. The rTU_c shall be calculated as follows: If $IC_{25} \geq IWC$, then $rTU_c = 1.0$. If $IC_{25} < IWC$, then $rTU_c = IWC \div IC_{25}$.

Additional Testing Requirements: Within 90 days of a test which showed positive results, the permittee shall submit the results of at least 2 retests to the Biomonitoring Coordinator on "Whole Effluent Toxicity Test Report Forms". The 90 day reporting period shall begin the day after the test which showed a positive result. The retests shall be completed using the same species and test methods specified for the original test (see the Standard Requirements section herein).

3.2.1.6 Chloride Variance – Implement Source Reduction Measures

This permit contains a variance to the water quality-based effluent limit (WQBEL) for chloride granted in accordance with s. NR 106.83(2), Wis. Adm. Code. As conditions of this variance the permittee shall (a) maintain effluent quality at or below the interim effluent limitation specified in the table above, (b) implement the chloride source reduction measures specified below, and (c) perform the actions listed in the compliance schedule. (See the Schedules of Compliance section herein.):

1. Identify sources of chloride to the sewer system.

2. Require significant industrial and commercial contributors to evaluate their chloride discharges and make recommendations for significantly reducing them, with the results of that evaluation being the basis for potential restrictions of chloride discharges.

3. Educate homeowners on the impact of chloride from residential softeners, discuss options available for increasing softener salt efficiency, and request voluntary reductions.

4. Recommend residential softener tune–ups on a voluntary basis.

5. Request voluntary support from local water softening businesses in the efforts described in subds. 2. and 3.

6. Educate licensed installers and self–installers of softeners on providing optional hard water for outside faucets for residences.

3.2.1.7 Compliance with Dissolved Oxygen Limit

D.O. values of 4.5 mg/L or greater, as measured at sample point 001, will be deemed as compliant by the Department for outfall 001based on the results of a previous study by the permittee sent to the Department on 8/18/1999 and approved 9/22/1999. This study documented that the minimum D.O. gain across the Badfish Creek aerator was 0.5 mg/L.

3.2.1.8 Watershed-Based Trading to Meet Future Rock River TMDL Phosphorus Requirements

The District may implement watershed-based trading approaches to meet future phosphorus reduction goals that may be required under a Total Maximum Daily Load for the Rock River Basin to the extent that such trading is authorized under state statutes and approved by the Department.

3.2.2 Sampling Point (Outfall) 005 - EFFL/BADGER MILL CREEK

Monitoring Requirements and Effluent Limitations					
Parameter	**Limit Type**	**Limit and Units**	**Sample Frequency**	**Sample Type**	**Notes**
Flow Rate		MGD	Continuous	Continuous	
BOD_5, Total	Weekly Avg	16 mg/L	Daily	24-Hr Comp	Limit applies November - April.
BOD_5, Total	Weekly Avg	7.0 mg/L	Daily	24-Hr Comp	Limit applies May - October.
Suspended Solids, Total	Monthly Avg	10 mg/L	Daily	24-Hr Comp	Limit applies May - October.
Suspended Solids, Total	Monthly Avg	16 mg/L	Daily	24-Hr Comp	Limit applies November - April.
Dissolved Oxygen	Daily Min	5.0 mg/L	Daily	Grab	See section 3.2.2.7 regarding compliance with this limit.

Monitoring Requirements and Effluent Limitations					
Parameter	**Limit Type**	**Limit and Units**	**Sample Frequency**	**Sample Type**	**Notes**
pH Field	Daily Max	9.0 su	Daily	Grab	
pH Field	Daily Min	6.0 su	Daily	Grab	
Phosphorus, Total	Monthly Avg	1.5 mg/L	Daily	24-Hr Comp	
Fecal Coliform	Geometric Mean	400 #/100 ml	2/Week	Grab	Limit applies May - September.
Nitrogen, Ammonia (NH_3-N) Total	Weekly Avg	8.7 mg/L	Daily	24-Hr Comp	Limit applies October - April.
Nitrogen, Ammonia (NH_3-N) Total	Weekly Avg	2.6 mg/L	Daily	24-Hr Comp	Limit applies May - September.
Nitrogen, Ammonia (NH_3-N) Total	Monthly Avg	3.8 mg/L	Daily	24-Hr Comp	Limit applies October - April.
Nitrogen, Ammonia (NH_3-N) Total	Daily Max	11 mg/L	Daily	24-Hr Comp	Limit applies year-round.
Nitrogen, Ammonia (NH_3-N) Total	Monthly Avg	1.1 mg/L	Daily	24-Hr Comp	Limit applies May - September.
Acute WET		rTUa	Quarterly	24-Hr Comp	Sample during the quarters specified in section 3.2.2.5 .
Chronic WET		rTU_c	Quarterly	24-Hr Comp	Sample during the quarters specified in section 3.2.2.5 .
Chloride	Weekly Avg	481 mg/L	Daily	24-Hr Comp	This interim limit applies until 09/30/2015 when the target value of 430 mg/L becomes effective as the target limit. (See section 6.2)
Chloride	Weekly Avg	14,000 lbs/day	Daily	24-Hr Comp	
Mercury, Total Recoverable	Daily Max	5.7 ng/L	Daily	Grab	

3.2.2.1 Total Metals Analyses

Measurements of total metals and total recoverable metals shall be considered as equivalent.

3.2.2.2 Sample Analysis

Samples shall be analyzed using a method which provides adequate sensitivity so that results can be quantified, unless not possible using the most sensitive approved method.

3.2.2.3 Mercury Monitoring

The permittee shall collect and analyze all mercury samples according to the data quality requirements of ss. NR 106.145(9) and (10), Wisconsin Administrative Code. The limit of quantitation (LOQ) used for the effluent and field blank shall be less than 1.3 ng/L, unless the samples are quantified at levels above 1.3 ng/L. The permittee shall collect at least one mercury field blank for each set of mercury samples (a set of samples may include combinations of intake, influent, effluent or other samples all collected on the same day). The permittee shall report results of samples and field blanks to the Department on Discharge Monitoring Reports.

3.2.2.4 Non-Wet Weather and Alternative Wet Weather Mass Limit

This parameter (chloride) has a mass limit based on weather conditions. The applicable non-wet weather mass limit is 14,000 pounds/day. The applicable wet weather mass limit is not applicable to this outfall because all effluent is pumped, with a maximum pump rate of 3.6 MGD. Report the applicable mass limit on the Discharge Monitoring Report form in the variable limit column. See Standard Requirements for "Applicability of Alternative Wet Weather Mass Limitations" and "Appropriate Formulas for Effluent Calculations".

3.2.2.5 Whole Effluent Toxicity (WET) Testing

Primary Control Water: Control water shall be standard laboratory control water which has a hardness of +/- 10 % of the hardness of: 1) the Sugar River above the confluence with Badger Mill Creek, for Outfall 005. Different control water may be used if prior approval has been given by the Department.

Instream Waste Concentration (IWC): 97%

Dilution series: At least five effluent concentrations and dual controls must be included in each test.

- **Acute:** 100, 50, 25, 12.5, 6.25% and any additional selected by the permittee.
- **Chronic:** 100, 30, 10, 3, 1% (if the IWC ≤30%) or 100, 75, 50, 25, 12.5% (if the IWC >30%) and any additional selected by the permittee.

WET Testing Frequency: Tests are required during the following quarters.

- **Acute: Jan – Mar 2011; April – June 2012; Oct – Dec 2013; July – Sep 2014; Jan – Mar 2015**
- **Chronic: Jan – Mar and April – June 2011; April – June and July – Sep 2012; July – Sep and Oct – Dec 2013; July – Sep and Oct – Dec 2014; Jan – Mar and April – June 2015**

Reporting: The permittee shall report test results on the Discharge Monitoring Report form, and also complete the "Whole Effluent Toxicity Test Report Form" (Section 6, "*State of Wisconsin Aquatic Life Toxicity Testing Methods Manual, 2nd Edition*"), for each test. The original, complete, signed version of the Whole Effluent Toxicity Test Report Form shall be sent to the Biomonitoring Coordinator, Bureau of Watershed Management, 101 S. Webster St., P.O. Box 7921, Madison, WI 53707-7921, within 45 days of test completion. The original Discharge Monitoring Report (DMR) form and one copy shall be sent to the contact and location provided on the DMR by the required deadline.

Determination of Positive Results: An acute toxicity test shall be considered positive if the Toxic Unit - Acute (TU_a) is greater than 1.0 for either species. The TU_a shall be calculated as follows: If $LC_{50} \geq 100$, then $TU_a = 1.0$. If LC_{50} is < 100, then $TU_a = 100 \div LC_{50}$. A chronic toxicity test shall be considered positive if the Relative Toxic Unit - Chronic (rTU_c) is greater than 1.0 for either species. The rTU_c shall be calculated as follows: If $IC_{25} \geq IWC$, then $rTU_c = 1.0$. If $IC_{25} < IWC$, then $rTU_c = IWC \div IC_{25}$.

Additional Testing Requirements: Within 90 days of a test which showed positive results, the permittee shall submit the results of at least 2 retests to the Biomonitoring Coordinator on "Whole Effluent Toxicity Test Report Forms". The 90 day reporting period shall begin the day after the test which showed a positive result. The retests shall be completed using the same species and test methods specified for the original test (see the Standard Requirements section herein).

3.2.2.6 Chloride Variance – Implement Source Reduction Measures

This permit contains a variance to the water quality-based effluent limit (WQBEL) for chloride granted in accordance with s. NR 106.83(2), Wis. Adm. Code. As conditions of this variance the permittee shall (a) maintain effluent quality at or below the interim effluent limitation specified in the table above, (b) implement the chloride source reduction measures specified for Outfall 001, and (c) perform the actions listed in the compliance schedule. (See the Schedules of Compliance section herein.)

3.2.2.7 Compliance with Dissolved Oxygen Limit

D.O. values of 3.8 mg/L or greater, as measured at sample point 001, will be deemed as compliant by the Department for outfall 005 based on the results of a previous study by the permittee sent to the Department on 8/18/1999 and approved 9/22/1999. This study documented that the minimum D.O. gain across the Badger Mill Creek aerator was 1.2 mg/L.

4 Land Treatment Requirements

4.1 Sampling Point(s)

Sampling Point Designation	
Sampling Point Number	**Sampling Point Location, Waste Description/Sample Contents and Treatment Description (as applicable)**
008	Demonstration project - spray irrigation of final effluent on golf course.

4.2 Monitoring Requirements and Limitations

The permittee shall comply with the following monitoring requirements and limitations:

4.2.1 Sampling Point (Outfall) 008 - Golf Course Spray Irrigation, Spray Irrigation

Monitoring Requirements and Limitations					
Parameter	**Limit Type**	**Limit and Units**	**Sample Frequency**	**Sample Type**	**Notes**
Flow Rate		gal	Daily	Total Daily	
Hydraulic Application Rate	Monthly Avg	10,000 gal/ac/day	Monthly	Calculated	
BOD_5, Total	Monthly Avg	16 mg/L	Monthly	24-Hr Flow Prop Comp	Use sample result from outfall 001.
Suspended Solids, Total		mg/L	Monthly	24-Hr Flow Prop Comp	Use sample result from outfall 001.
pH Field		su	Monthly	Grab	Use sample result from outfall 001.
Nitrogen, Total Kjeldahl		mg/L	Monthly	24-Hr Flow Prop Comp	Use sample result from outfall 001.
Nitrogen, Ammonia (NH_3-N) Total		mg/L	Monthly	24-Hr Flow Prop Comp	Use sample result from outfall 001.
Nitrogen, Organic Total		mg/L	Monthly	Calculated	Use sample result from outfall 001.
Nitrogen, Nitrite + Nitrate Total		mg/L	Monthly	24-Hr Flow Prop Comp	Use sample result from outfall 001.
Nitrogen, Total		mg/L	Monthly	Calculated	Use sample result from outfall 001.
Chloride		mg/L	Monthly	24-Hr Flow Prop Comp	Use sample result from outfall 001.

Monitoring Requirements and Limitations					
Parameter	**Limit Type**	**Limit and Units**	**Sample Frequency**	**Sample Type**	**Notes**
Solids, Total Dissolved		mg/L	Monthly	24-Hr Flow Prop Comp	Use sample result from outfall 001.
Nitrogen, Max Applied On Any Zone		lbs/ac/yr	Annual	Total Annual	
Fecal Coliform	Geometric Mean	400 #/100 ml	2/Week	Grab	Use sample result from outfall 001.
Phosphorus, Total		mg/L	Daily	24-Hr Flow Prop Comp	Use sample result from outfall 001.

Daily Log – Monitoring Requirements and Limitations

All discharge and monitoring activity shall be documented on log sheets. Originals of the log sheets shall be kept by the permittee as described under "Records Retention" in the Standard Requirements section, and if requested, made available to the Department.

Parameters	Limit	Units	Sample Frequency	Sample Type
Zone or Location Being Sprayed	-	Number	As Needed	Log
Acres Being Sprayed	-	Acres	As Needed	Log
Start to End Time	-	Date, Hour	As Needed	Log
Wastewater Loading Volume	-	Gallons	As Needed	Log
Wastewater Loading Volume	-	Gallons/Acre	As Needed	Calculated
Visual Observations	-	-	As Needed	Log

Annual Report – Monitoring Requirements and Limitations

The Annual Report is due by January 31st of each year for the previous calendar year.

Parameters	Limit	Units	Sample Frequency	Sample Type
Total Volume Applied Per Zone	-	Gallons	Annual	Total Annual
Total Volume Applied Per Zone	-	Gallons/Acre	Annual	Total Annual
Total Nitrogen Applied per Zone	-	Pounds/Acre/Year	Annual	Calculated
Soil Analysis	-	-	Annual	Composite

Annual Report – Monitoring Requirements and Limitations The Annual Report is due by January 31st of each year for the previous calendar year.				
Parameters	**Limit**	**Units**	**Sample Frequency**	**Sample Type**
Fertilizer Used	-	Pounds/Acre/Year	Annual	Total Annual

Note: Inches/load cycle = gallons/acre/load cycle divided by 27,154.

4.2.1.1 Monthly Avg Flow – LT Calculation

The monthly average discharge flow for Land Treatment systems is calculated by dividing the total wastewater volume discharged for the month by the total number of days in the month.

4.2.1.2 Spray Irrigation Site - Soil Analysis

The soil at each spray irrigation site shall be tested annually for nitrate-nitrogen, available phosphorus, available potassium and pH.

4.2.1.3 Additional Demonstration Irrigation Project Requirements at Outfall 008

Irrigation may be conducted at Outfall 008 under the following conditions:

1. **Prior Approval Necessary for Equipment or Operational Changes:** The District shall provide written notice to the department in advance of substantive changes to equipment or operating procedures at this outfall. The written notice shall provide information on the proposed changes.
2. **Application of Effluent:** Effluent shall only be applied by direct irrigation and may not be applied during times of the day when the golf course is open for golfing or during times when wind conditions may be expected to cause significant drift.
3. **Irrigation Season:** Effluent may only be applied during the period of April 15th through October 15th.
4. **Irrigation Ponds:** Effluent storage in irrigation ponds shall only be done according to a department-approved management plan.
5. **Soil Samples:** A routine soil sample shall be collected from each spray field according to current UW Soils Dept. methods, and tested for the purpose of obtaining plant available nutrients and for making fertilizer and liming recommendations for the cover crop being grown.
6. **Golf Course Signage:** Adequate signage shall be placed in each area where effluent is used, advising the public that the test plot is being irrigated using non-potable treated effluent and that all golfers or other persons using the areas should practice good personal hygiene and hand washing before eating, drinking or smoking.

4.2.1.4 Additional Demonstration Irrigation Projects at Other Sites

The District may conduct other effluent reuse demonstration projects subject to prior review and approval by DNR and to terms/conditions specified by DNR.

5 Land Application Requirements

In order for biosolids to be land applied it must at a minimum, meet all of the following criteria: the ceiling concentration limits for metals established in this permit; Class B pathogen requirements established in this permit; and one of the vector control requirements specified in this permit.

The permittee may publicly distribute biosolids if it meets the exceptional quality (EQ) criteria specified in s. NR 204.03(19). These criteria require EQ biosolids to meet the following: the high quality metal concentration limits; Class A process requirements for pathogens as well as either a fecal coliform limit of less than 1000 MPN/g TS or a *Salmonella* limit of less than 3 MPN/4g TS; and one of the process requirements for vector attraction reduction. If the biosolids do not meet the exceptional quality criteria specified in s. NR 204.03(19), the permitttee may not publicly distribute the biosolids, but the biosolids may be land applied if the minimum criteria specified in this section are met.

5.1 Sampling Point(s)

The discharge(s) shall be limited to land application of the waste type(s) designated for the listed sampling point(s) on Department approved land spreading sites or by hauling to another facility.

Sampling Point Designation	
Sampling Point Number	**Sampling Point Location, WasteType/Sample Contents and Treatment Description (as applicable)**
002	Anaerobically digested, gravity belt thickened liquid sludge. Monitoring shall apply only when this outfall is active.
009	Sequencing batch temperature phased anaerobically digested liquid sludge. Notify the Department when this outfall becomes active.
010	Sequencing batch temperature phased anaerobically digested, centrifuged cake sludge. Notify the Department when this outfall becomes active.

5.2 Monitoring Requirements and Limitations

The permittee shall comply with the following monitoring requirements and limitations.

5.2.1 Sampling Points (Outfalls) 002, 009 and 010

Monitoring Requirements and Limitations					
Parameter	**Limit Type**	**Limit and Units**	**Sample Frequency**	**Sample Type**	**Notes**
Solids, Total		Percent	1/ 2 Months	Composite	
Arsenic Dry Wt	High Quality	41 mg/kg	1/ 2 Months	Composite	Sample 010 annually.
Arsenic Dry Wt	Ceiling	75 mg/kg	1/ 2 Months	Composite	
Cadmium Dry Wt	High Quality	39 mg/kg	1/ 2 Months	Composite	Sample 010 annually.
Cadmium Dry Wt	Ceiling	85 mg/kg	1/ 2 Months	Composite	
Copper Dry Wt	High Quality	1,500 mg/kg	1/ 2 Months	Composite	Sample 010 annually.
Copper Dry Wt	Ceiling	4,300 mg/kg	1/ 2 Months	Composite	
Lead Dry Wt	High Quality	300 mg/kg	1/ 2 Months	Composite	Sample 010 annually.
Lead Dry Wt	Ceiling	840 mg/kg	1/ 2 Months	Composite	
Mercury Dry Wt	High Quality	17 mg/kg	1/ 2 Months	Composite	Sample 010 annually.

Monitoring Requirements and Limitations					
Parameter	**Limit Type**	**Limit and Units**	**Sample Frequency**	**Sample Type**	**Notes**
Mercury Dry Wt	Ceiling	57 mg/kg	1/ 2 Months	Composite	
Molybdenum Dry Wt	Ceiling	75 mg/kg	1/ 2 Months	Composite	Sample 010 annually.
Nickel Dry Wt	High Quality	420 mg/kg	1/ 2 Months	Composite	Sample 010 annually.
Nickel Dry Wt	Ceiling	420 mg/kg	1/ 2 Months	Composite	
Selenium Dry Wt	Ceiling	100 mg/kg	1/ 2 Months	Composite	Sample 010 annually.
Selenium Dry Wt	High Quality	100 mg/kg	1/ 2 Months	Composite	
Zinc Dry Wt	High Quality	2,800 mg/kg	1/ 2 Months	Composite	Sample 010 annually.
Zinc Dry Wt	Ceiling	7,500 mg/kg	1/ 2 Months	Composite	Sample 010 annually.
Nitrogen, Total Kjeldahl		Percent	1/ 2 Months	Composite	Sample 010 annually.
Nitrogen, Ammonium (NH_4-N) Total		Percent	1/ 2 Months	Composite	Sample 010 annually.
Phosphorus, Total		Percent	1/ 2 Months	Composite	Sample 010 annually.
Potassium, Total Recoverable		Percent	1/ 2 Months	Composite	Sample 010 annually.
Municipal Sludge Priority Pollutant Scan			Once	Composite	As specified in ch. NR 215.03 (1-4), Wis. Adm. Code. Sample Outfall 002 only, in 2013.

Other Sludge Requirements	
Sludge Requirements	**Sample Frequency**
List 3 Requirements – Pathogen Control: The requirements in List 3 shall be met prior to land application of sludge.	**Sample 002 or 009 Bimonthly. Sample 010 Annually.**
List 4 Requirements – Vector Attraction Reduction: The vector attraction reduction shall be satisfied prior to, or at the time of land application as specified in List 4.	**Sample 002 or 009 Bimonthly. Sample 010 Annually.**

5.2.1.1 Exception to Bimonthly Sludge Sample Frequency

Where bimonthly sludge sampling is required, the requirement for the January – February period is hereby waived. To compensate, a sixth sample shall be collected and reported during any of the other bimonthly report periods.

5.2.1.2 List 2 Analysis

If the monitoring frequency for List 2 parameters is more frequent than "Annual" then the sludge may be analyzed for the List 2 parameters just prior to each land application season rather than at the more frequent interval specified.

5.2.1.3 Changes in Feed Sludge Characteristics

If a change in feed sludge characteristics, treatment process, or operational procedures occurs which may result in a significant shift in sludge characteristics, the permittee shall reanalyze the sludge for List 1, 2, 3 and 4 parameters each time such change occurs.

5.2.1.4 Multiple Sludge Sample Points (Outfalls)

If there are multiple sludge sample points (outfalls), but the sludges are not subject to different sludge treatment processes, then a separate List 2 analysis shall be conducted for each sludge type which is land applied, just prior to land application, and the application rate shall be calculated for each sludge type. In this case, List 1, 3, and 4 and PCBs need only be analyzed on a single sludge type, at the specified frequency. If there are multiple sludge sample points (outfalls), due to multiple treatment processes, List 1, 2, 3 and 4 and PCBs shall be analyzed for each sludge type at the specified frequency.

5.2.1.5 Sludge Which Exceeds the High Quality Limit

Cumulative pollutant loading records shall be kept for all bulk land application of sludge which does not meet the high quality limit for any parameter. This requirement applies for the entire calendar year in which any exceedance of Table 3 of s. NR 204.07(5)(c), is experienced. Such loading records shall be kept for all List 1 parameters for each site land applied in that calendar year. The formula to be used for calculating cumulative loading is as follows:

[(Pollutant concentration (mg/kg) x dry tons applied/ac) ÷ 500] + previous loading (lbs/acre) = cumulative lbs pollutant per acre

When a site reaches 90% of the allowable cumulative loading for any metal established in Table 2 of s. NR 204.07(5)(b), the Department shall be so notified through letter or in the comment section of the annual land application report (3400-55).

5.2.1.6 Sludge Analysis for PCBs

The permittee shall analyze the sludge for Total PCBs one time during **2013**. The results shall be reported as "PCB Total Dry Wt". Either congener-specific analysis or Aroclor analysis shall be used to determine the PCB concentration. The permittee may determine whether Aroclor or congener specific analysis is performed. Analyses shall be performed in accordance with Table EM in s. NR 219.04, Wis. Adm. Code and the conditions specified in Standard Requirements of this permit. PCB results shall be submitted by January 31, following the specified year of analysis.

5.2.1.7 Lists 1, 2, 3, and 4

List 1 **TOTAL SOLIDS AND METALS** See the Monitoring Requirements and Limitations table above for monitoring frequency and limitations for the List 1 parameters
Solids, Total (percent)
Arsenic, mg/kg (dry weight)
Cadmium, mg/kg (dry weight)
Copper, mg/kg (dry weight)
Lead, mg/kg (dry weight)
Mercury, mg/kg (dry weight)
Molybdenum, mg/kg (dry weight)
Nickel, mg/kg (dry weight)
Selenium, mg/kg (dry weight)
Zinc, mg/kg (dry weight)

List 2 **NUTRIENTS** See the Monitoring Requirements and Limitations table above for monitoring frequency for the List 2 parameters
Solids, Total (percent)
Nitrogen Total Kjeldahl (percent)
Nitrogen Ammonium (NH4-N) Total (percent)
Phosphorus Total as P (percent)
Phosphorus, Water Extractable (as percent of Total P)
Potassium Total Recoverable (percent)

List 3

PATHOGEN CONTROL FOR CLASS A SLUDGE

The permittee shall implement pathogen control as listed in List 3. The Department shall be notified of the pathogen control utilized and shall be notified when the permittee decides to utilize alternative pathogen control.

The following requirements shall be met prior to land application of sludge.

Parameter	Unit	Limit
Fecal Coliform*	MPN/g TS	1,000
	OR	
Salmonella	MPN/4g TS	3
AND, ONE OF THE FOLLOWING PROCESS OPTIONS		
Temp/Time based on % Solids	Alkaline Treatment	
Prior test for Enteric Virus/Viable Helminth Ova	Post test for Enteric Virus/Viable Helminth Ova	
Composting	Heat Drying	
Heat Treatment	Thermophilic Aerobic Digestion	
Beta Ray Irradiation	Gamma Ray Irradiation	
Pasteurization	PFRP Equivalent Process	

* For Class A sludge, each sampling event shall satisfy the numerical standards specified above.

List 3

PATHOGEN CONTROL FOR CLASS B SLUDGE

The permittee shall implement pathogen control as listed in List 3. The Department shall be notified of the pathogen control utilized and shall be notified when the permittee decides to utilize alternative pathogen control.

The following requirements shall be met prior to land application of sludge.

Parameter	Unit	Limit
Fecal Coliform*	MPN/gTS or CFU/gTS	2,000,000
OR, ONE OF THE FOLLOWING PROCESS OPTIONS		
Aerobic Digestion	Air Drying	
Anaerobic Digestion	Composting	
Alkaline Stabilization	PSRP Equivalent Process	

* The Fecal Coliform limit shall be reported as the geometric mean of 7 discrete samples on a dry weight basis.

List 4
VECTOR ATTRACTION REDUCTION

The permittee shall implement any one of the vector attraction reduction options specified in List 4. The Department shall be notified of the option utilized and shall be notified when the permittee decides to utilize an alternative option.

One of the following shall be satisfied prior to, or at the time of land application as specified in List 4.

Option	Limit	Where/When it Shall be Met
Volatile Solids Reduction	≥38%	Across the process
Specific Oxygen Uptake Rate	≤1.5 mg O_2/hr/g TS	On aerobic stabilized sludge
Anaerobic bench-scale test	<17 % VS reduction	On anaerobic digested sludge
Aerobic bench-scale test	<15 % VS reduction	On aerobic digested sludge
Aerobic Process	>14 days, Temp >40°C and Avg. Temp > 45°C	On composted sludge
pH adjustment	>12 S.U. (for 2 hours) and >11.5 (for an additional 22 hours)	During the process
Drying without primary solids	>75 % TS	When applied or bagged
Drying with primary solids	>90 % TS	When applied or bagged
Equivalent Process	Approved by the Department	Varies with process
Injection	-	When applied
Incorporation	-	Within 6 hours of application

5.2.1.8 Daily Land Application Log

Daily Land Application Log

Discharge Monitoring Requirements and Limitations

The permittee shall maintain a daily land application log for biosolids land applied each day when land application occurs. The following minimum records must be kept, in addition to all analytical results for the biosolids land applied. The log book records shall form the basis for the annual land application report requirements.

NOTE: The Department considers the information maintained in the District's Metrogro Database as satisfying this requirement.

Parameters	Units	Sample Frequency
DNR Site Number(s)	Number	Daily as used
Outfall number applied	Number	Daily as used
Acres applied	Acres	Daily as used
Amount applied	As appropriate * /day	Daily as used
Application rate per acre	unit */acre	Daily as used
Nitrogen applied per acre	lb/acre	Daily as used
Method of Application	Injection, Incorporation, or surface applied	Daily as used

*gallons, cubic yards, dry US Tons or dry Metric Tons

6 Schedules of Compliance

6.1 Mercury Pollutant Minimization Program

The permittee shall implement or continue a pollutant minimization program whenever, after the first 24 months of mercury monitoring, a mercury effluent limitation is necessary under the procedure in s. NR 106.145(2), Wis. Adm. Code.

Required Action	Date Due
Implement the Mercury Pollutant Minimization Program: The permittee shall implement the PMP as submitted or as amended by agreement of the permittee and the Department.	
Submit Annual Status Reports: The permittee shall submit to the Department an annual status report on the progress of the PMP as required by s. NR 106.145(7), Wis. Adm. Code. Submittal of each annual status report is required by March 31, annually. Note: If the permittee wishes to apply for an alternative mercury effluent limitation, that application is due with the application for permit reissuance by 6 months prior to permit expiration. The permittee should submit or reference the PMP plan as updated by the Annual Status Report or more recent developments as part of that application.	

6.2 Chloride Target Value

As a condition of the variance to the water quality based effluent limitation(s) for chloride granted in accordance with s. NR 106.83(2), Wis. Adm. Code, the permittee shall perform the following actions.

Required Action	Date Due
Annual Chloride Progress Report: Submit an annual progress report, that shall indicate which chloride source reduction measures have been implemented. The report shall also include a calculated annual mass discharge of chloride based on chloride sampling and flow data. After the first progress report is submitted, the permittee may submit a written request to the department to waive further annual progress reports. If after evaluating the progress of the source reduction measures, the department decides to accommodate the request, the department shall notify the permittee in writing that the subsequent annual reports are waived. The Final Chloride Report cannot be waived and shall be submitted by the Date Due. Note that the interim limitation of 481 mg/L remains enforceable until 9/30/2015, when the target value of 430 mg/L becomes effective. The first annual chloride progress report is to be submitted by the Date Due.	06/30/2011
Annual Chloride Progress Report #2: Submit a chloride progress report.	06/30/2012
Annual Chloride Progress Report #3: Submit a chloride progress report.	06/30/2013
Annual Chloride Progress Report #4: Submit a chloride progress report.	06/30/2014
Final Chloride Report: Submit a final report documenting the success in meeting the chloride target value of 430 mg/L, as well as the anticipated future reduction in chloride sources and chloride effluent concentrations. This report shall also include proposed target values and source reduction measures for negotiations with the department if the permittee intends to seek a renewed chloride variance per s. NR 106.83, Wis. Adm. Code, for the reissued permit. Note that the target value is the benchmark for evaluating the effectiveness of the chloride source reduction measures, but is not an enforceable limitation until the last day of this permit, 09/30/2015.	06/30/2015

7 Standard Requirements

NR 205, Wisconsin Administrative Code: The conditions in ss. NR 205.07(1) and NR 205.07(2), Wis. Adm. Code, are included by reference in this permit. The permittee shall comply with all of these requirements. Some of these requirements are outlined in the Standard Requirements section of this permit. Requirements not specifically outlined in the Standard Requirement section of this permit can be found in ss. NR 205.07(1) and NR 205.07(2).

7.1 Reporting and Monitoring Requirements

7.1.1 Monitoring Results

Monitoring results obtained during the previous month shall be summarized and reported on a Department Wastewater Discharge Monitoring Report. The report may require reporting of any or all of the information specified below under 'Recording of Results'. This report is to be returned to the Department no later than the date indicated on the form. When submitting a paper Discharge Monitoring Report form, the original and one copy of the Wastewater Discharge Monitoring Report Form shall be submitted to the return address printed on the form. A copy of the Wastewater Discharge Monitoring Report Form or an electronic file of the report shall be retained by the permittee.

All Wastewater Discharge Monitoring Reports submitted to the Department should be submitted using the electronic Discharge Monitoring Report system. Permittees who may be unable to submit Wastewater Discharge Monitoring Reports electronically may request approval to submit paper DMRs upon demonstration that electronic reporting is not feasible or practicable.

If the permittee monitors any pollutant more frequently than required by this permit, the results of such monitoring shall be included on the Wastewater Discharge Monitoring Report.

The permittee shall comply with all limits for each parameter regardless of monitoring frequency. For example, monthly, weekly, and/or daily limits shall be met even with monthly monitoring. The permittee may monitor more frequently than required for any parameter.

An Electronic Discharge Monitoring Report Certification sheet shall be signed and submitted with each electronic Discharge Monitoring Report submittal. This certification sheet, which is not part of the electronic report form, shall be signed by a principal executive officer, a ranking elected official or other duly authorized representative and shall be mailed to the Department at the time of submittal of the electronic Discharge Monitoring Report. The certification sheet certifies that the electronic report form is true, accurate and complete. Paper reports shall be signed by a principal executive officer, a ranking elected official, or other duly authorized representative.

7.1.2 Sampling and Testing Procedures

Sampling and laboratory testing procedures shall be performed in accordance with Chapters NR 218 and NR 219, Wis. Adm. Code and shall be performed by a laboratory certified or registered in accordance with the requirements of ch. NR 149, Wis. Adm. Code. Groundwater sample collection and analysis shall be performed in accordance with ch. NR 140, Wis. Adm. Code. The analytical methodologies used shall enable the laboratory to quantitate all substances for which monitoring is required at levels below the effluent limitation. If the required level cannot be met by any of the methods available in NR 219, Wis. Adm. Code, then the method with the lowest limit of detection shall be selected. Additional test procedures may be specified in this permit.

7.1.3 Pretreatment Sampling Requirements

Sampling for pretreatment parameters (cadmium, chromium, copper, lead, nickel, zinc, and mercury) shall be done during a day each month when industrial discharges are occurring at normal to maximum levels. The sampling of the influent and effluent for these parameters shall be coordinated. All 24 hour composite samples shall be flow proportional.

7.1.4 Recording of Results

The permittee shall maintain records which provide the following information for each effluent measurement or sample taken:

- the date, exact place, method and time of sampling or measurements;
- the individual who performed the sampling or measurements;
- the date the analysis was performed;
- the individual who performed the analysis;
- the analytical techniques or methods used; and
- the results of the analysis.

7.1.5 Reporting of Monitoring Results

The permittee shall use the following conventions when reporting effluent monitoring results:

- Pollutant concentrations less than the limit of detection shall be reported as < (less than) the value of the limit of detection. For example, if a substance is not detected at a detection limit of 0.1 mg/L, report the pollutant concentration as < 0.1 mg/L.

- Pollutant concentrations equal to or greater than the limit of detection, but less than the limit of quantitation, shall be reported and the limit of quantitation shall be specified.

- For the purposes of reporting a calculated result, average or a mass discharge value, the permittee may substitute a 0 (zero) for any pollutant concentration that is less than the limit of detection. However, if the effluent limitation is less than the limit of detection, the department may substitute a value other than zero for results less than the limit of detection, after considering the number of monitoring results that are greater than the limit of detection and if warranted when applying appropriate statistical techniques.

7.1.6 Compliance Maintenance Annual Reports

Compliance Maintenance Annual Reports (CMAR) shall be completed using information obtained over each calendar year regarding the wastewater conveyance and treatment system. The CMAR shall be submitted by the permittee in accordance with ch. NR 208, Wis. Adm. Code, by June 30, each year on an electronic report form provided by the Department.

In the case of a publicly owned treatment works, a resolution shall be passed by the governing body and submitted as part of the CMAR, verifying its review of the report and providing responses as required. Private owners of wastewater treatment works are not required to pass a resolution; but they must provide an Owner Statement and responses as required, as part of the CMAR submittal.

A separate CMAR certification document, that is not part of the electronic report form, shall be mailed to the Department at the time of electronic submittal of the CMAR. The CMAR certification shall be signed and submitted by an authorized representative of the permittee. The certification shall be submitted by mail. The certification shall verify the electronic report is complete, accurate and contains information from the owner's treatment works.

7.1.7 Records Retention

The permittee shall retain records of all monitoring information, including all calibration and maintenance records and all original strip chart recordings for continuous monitoring instrumentation, copies of all reports required by the permit, and records of all data used to complete the application for the permit for a period of at least 3 years from the date of the sample, measurement, report or application. All pertinent sludge information, including permit application information and other documents specified in this permit or s. NR 204.06(9), Wis. Adm. Code shall be retained for a minimum of 5 years.

7.1.8 Other Information

Where the permittee becomes aware that it failed to submit any relevant facts in a permit application or submitted incorrect information in a permit application or in any report to the Department, it shall promptly submit such facts or correct information to the Department.

7.2 System Operating Requirements

7.2.1 Noncompliance Notification

- The permittee shall report the following types of noncompliance by a telephone call to the Department's regional office within 24 hours after becoming aware of the noncompliance:
    - any noncompliance which may endanger health or the environment;
    - any violation of an effluent limitation resulting from an unanticipated bypass;
    - any violation of an effluent limitation resulting from an upset; and
    - any violation of a maximum discharge limitation for any of the pollutants listed by the Department in the permit, either for effluent or sludge.
- A written report describing the noncompliance shall also be submitted to the Department's regional office within 5 days after the permittee becomes aware of the noncompliance. On a case-by-case basis, the Department may waive the requirement for submittal of a written report within 5 days and instruct the permittee to submit the written report with the next regularly scheduled monitoring report. In either case, the written report shall contain a description of the noncompliance and its cause; the period of noncompliance, including exact dates and times; the steps taken or planned to reduce, eliminate and prevent reoccurrence of the noncompliance; and if the noncompliance has not been corrected, the length of time it is expected to continue.

NOTE: Section 292.11(2)(a), Wisconsin Statutes, requires any person who possesses or controls a hazardous substance or who causes the discharge of a hazardous substance to notify the Department of Natural Resources **immediately** of any discharge not authorized by the permit. The discharge of a hazardous substance that is not authorized by this permit or that violates this permit may be a hazardous substance spill. To report a hazardous substance spill, call DNR's 24-hour HOTLINE at **1-800-943-0003**

7.2.2 Flow Meters

Flow meters shall be calibrated annually, as per s. NR 218.06, Wis. Adm. Code.

7.2.3 Raw Grit and Screenings

All raw grit and screenings shall be disposed of at a properly licensed solid waste facility or picked up by a licensed waste hauler. If the facility or hauler are located in Wisconsin, then they shall be licensed under chs. NR 500-536, Wis. Adm. Code.

7.2.4 Sludge Management

All sludge management activities shall be conducted in compliance with ch. NR 204 "Domestic Sewage Sludge Management", Wis. Adm. Code.

7.2.5 Prohibited Wastes

Under no circumstances may the introduction of wastes prohibited by s. NR 211.10, Wis. Adm. Code, be allowed into the waste treatment system. Prohibited wastes include those:

- which create a fire or explosion hazard in the treatment work;
- which will cause corrosive structural damage to the treatment work;
- solid or viscous substances in amounts which cause obstructions to the flow in sewers or interference with the proper operation of the treatment work;
- wastewaters at a flow rate or pollutant loading which are excessive over relatively short time periods so as to cause a loss of treatment efficiency; and
- changes in discharge volume or composition from contributing industries which overload the treatment works or cause a loss of treatment efficiency.

7.2.6 Unscheduled Bypassing

Any unscheduled bypass or overflow of wastewater at the treatment works or from the collection system is prohibited, and the Department may take enforcement action against a permittee for such occurrences under s. 283.89, Wis. Stats., unless:

- The bypass was unavoidable to prevent loss of life, personal injury, or severe property damage;
- There were no feasible alternatives to the bypass, such as the use of auxiliary treatment facilities, retention of untreated wastes, or maintenance during normal periods of equipment downtime. This condition is not satisfied if adequate back-up equipment should have been installed in the exercise of reasonable engineering judgment to prevent a bypass which occurred during normal periods of equipment downtime or preventive maintenance; and
- The permittee notified the Department as required in this Section.

Whenever there is an unscheduled bypass or overflow occurrence at the treatment works or from the collection system, the permittee shall notify the Department within 24 hours of initiation of the bypass or overflow occurrence by telephoning the wastewater staff in the regional office as soon as reasonably possible (FAX, email or voice mail, if staff are unavailable).

In addition, the permittee shall within 5 days of conclusion of the bypass or overflow occurrence report the following information to the Department in writing:

- Reason the bypass or overflow occurred, or explanation of other contributing circumstances that resulted in the overflow event. If the overflow or bypass is associated with wet weather, provide data on the amount and duration of the rainfall or snow melt for each separate event.
- Date the bypass or overflow occurred.
- Location where the bypass or overflow occurred.
- Duration of the bypass or overflow and estimated wastewater volume discharged.
- Steps taken or the proposed corrective action planned to prevent similar future occurrences.
- Any other information the permittee believes is relevant.

7.2.7 Scheduled Bypassing

Any construction or normal maintenance which results in a bypass of wastewater from a treatment system is prohibited unless authorized by the Department in writing. If the Department determines that there is significant public interest in the proposed action, the Department may schedule a public hearing or notice a proposal to approve the bypass. Each request shall specify the following minimum information:

- proposed date of bypass;
- estimated duration of the bypass;

- estimated volume of the bypass;
- alternatives to bypassing; and
- measures to mitigate environmental harm caused by the bypass.

7.2.8 Proper Operation and Maintenance

The permittee shall at all times properly operate and maintain all facilities and systems of treatment and control which are installed or used by the permittee to achieve compliance with the conditions of this permit. The wastewater treatment facility shall be under the direct supervision of a state certified operator as required in s. NR 108.06(2), Wis. Adm. Code. Proper operation and maintenance includes effective performance, adequate funding, adequate operator staffing and training as required in ch. NR 114, Wis. Adm. Code, and adequate laboratory and process controls, including appropriate quality assurance procedures. This provision requires the operation of back-up or auxiliary facilities or similar systems only when necessary to achieve compliance with the conditions of the permit.

7.3 Surface Water Requirements

7.3.1 Permittee-Determined Limit of Quantitation Incorporated into this Permit

For pollutants with water quality-based effluent limits below the Limit of Quantitation (LOQ) in this permit, the LOQ calculated by the permittee and reported on the Discharge Monitoring Reports (DMRs) is incorporated by reference into this permit. The LOQ shall be reported on the DMRs, shall be the lowest quantifiable level practicable, and shall be no greater than the minimum level (ML) specified in or approved under 40 CFR Part 136 for the pollutant at the time this permit was issued, unless this permit specifies a higher LOQ.

7.3.2 Appropriate Formulas for Effluent Calculations

The permittee shall use the following formulas for calculating effluent results to determine compliance with average limits and mass limits:

Weekly/Monthly average concentration = the sum of all daily results for that week/month, divided by the number of results during that time period.

Weekly Average Mass Discharge (lbs/day): Daily mass = daily concentration (mg/L) x daily flow (MGD) x 8.34, then average the daily mass values for the week.

Monthly Average Mass Discharge (lbs/day): Daily mass = daily concentration (mg/L) x daily flow (MGD) x 8.34, then average the daily mass values for the month.

7.3.3 Visible Foam or Floating Solids

There shall be no discharge of floating solids or visible foam in other than trace amounts.

7.3.4 Percent Removal

During any 30 consecutive days, the average effluent concentrations of BOD_5 and of total suspended solids shall not exceed 15% of the average influent concentrations, respectively. This requirement does not apply to removal of total suspended solids if the permittee operates a lagoon system and has received a variance for suspended solids granted under NR 210.07(2), Wis. Adm. Code.

7.3.5 Fecal Coliforms

The limit for fecal coliforms shall be expressed as a monthly geometric mean.

7.3.6 Seasonal Disinfection

Disinfection shall be provided from May 1 through September 30 of each year for the Badger Mill Creek Outfall (005) and from April 15 through October 15 of each year for the Badfish Creek Outfall (001). Monitoring requirements and the limitation for fecal coliforms apply only during the period in which disinfection is required. Whenever chlorine is used for disinfection or other uses, the limitations and monitoring requirements for residual chlorine shall apply. A dechlorination process shall be in operation whenever chlorine is used.

7.3.7 Whole Effluent Toxicity (WET) Monitoring Requirements

In order to determine the potential impact of the discharge on aquatic organisms, static-renewal toxicity tests shall be performed on the effluent in accordance with the procedures specified in the *"State of Wisconsin Aquatic Life Toxicity Testing Methods Manual, 2nd Edition" (PUB-WT-797,* November 2004) as required by NR 219.04, Table A, Wis. Adm. Code). All of the WET tests required in this permit, including any required retests, shall be conducted on the *Ceriodaphnia dubia* and fathead minnow species. Receiving water samples shall not be collected from any point in contact with the permittee's mixing zone and every attempt shall be made to avoid contact with any other discharge's mixing zone.

7.3.8 Whole Effluent Toxicity (WET) Identification and Reduction

Within 60 days of a retest which showed positive results, the permittee shall submit a written report to the Biomonitoring Coordinator, Bureau of Watershed Management, 101 S. Webster St., PO Box 7921, Madison, WI 53707-7921, which details the following:

- A description of actions the permittee has taken or will take to remove toxicity and to prevent the recurrence of toxicity;

- A description of toxicity reduction evaluation (TRE) investigations that have been or will be done to identify potential sources of toxicity, including some or all of the following actions:

  (a) Evaluate the performance of the treatment system to identify deficiencies contributing to effluent toxicity (e.g., operational problems, chemical additives, incomplete treatment)
  (b) Identify the compound(s) causing toxicity
  (c) Trace the compound(s) causing toxicity to their sources (e.g., industrial, commercial, domestic)
  (d) Evaluate, select, and implement methods or technologies to control effluent toxicity (e.g., in-plant or pretreatment controls, source reduction or removal)

- Where corrective actions including a TRE have not been completed, an expeditious schedule under which corrective actions will be implemented;

- If no actions have been taken, the reason for not taking action.

The permittee may also request approval from the Department to postpone additional retests in order to investigate the source(s) of toxicity. Postponed retests must be completed after toxicity is believed to have been removed.

7.3.9 Whole Effluent Toxicity (WET) and Chloride Source Reduction Measures

Acute whole effluent toxicity testing requirements and acute whole effluent toxicity limitations may be held in abeyance by the department until chloride source reduction actions are completed, according to s. NR 106.89, Wis. Adm. Code, if either:

- the permittee can demonstrate to the satisfaction of the department that the effluent concentration of chloride exceeds 2,500 mg/L, or
- the permittee can demonstrate to the satisfaction of the department that the effluent concentration of chloride is less than 2,500 mg/L, but in excess of the calculated acute water quality-based effluent limitation, and additional data are submitted which demonstrate that chloride is the sole source of acute toxicity.

Chronic whole effluent toxicity testing requirements and chronic whole effluent toxicity limitations may be held in abeyance by the department until chloride source reduction actions are completed, according to s. NR 106.89, Wis. Adm. Code, if either:

- the permittee can demonstrate to the satisfaction of the department that the effluent concentration of chloride exceeds 2 times the calculated chronic water quality-based effluent limitation, or
- the permittee can demonstrate to the satisfaction of the department that the effluent concentration of chloride is less than 2 times the calculated chronic water quality-based effluent limitation, but in excess of the calculated chronic water quality-based effluent limitation, and additional data are submitted which demonstrate that chloride is the sole source of chronic toxicity.

Following the completion of chloride source reduction activities, the department shall evaluate the need for whole effluent toxicity monitoring and limitations.

7.4 Pretreatment Program Requirements

The permittee is required to operate an industrial pretreatment program as described in the program initially approved by the Department of Natural Resources including any subsequent program modifications approved by the Department, and including commitments to program implementation activities provided in the permittee's annual pretreatment program report, and that complies with the requirements set forth in 40 CFR Part 403 and ch. NR 211, Wis. Adm. Code. To ensure that the program is operated in accordance with these requirements, the following general conditions and requirements are hereby established:

7.4.1 Inventories

The permittee shall implement methods to maintain a current inventory of the general character and volume of wastewater that industrial users discharge to the treatment works and shall provide an updated industrial user listing annually and report any changes in the listing to the Department by March 31 of each year as part of the annual pretreatment program report required herein.

7.4.2 Regulation of Industrial Users

7.4.2.1 Limitations for Industrial Users:

The permittee shall develop, maintain, enforce and revise as necessary local limits to implement the general and specific prohibitions of the state and federal General Pretreatment Regulations.

7.4.2.2 Control Documents for Industrial Users (IUs)

The permittee shall control the discharge from each significant industrial user through individual discharge permits as required by s. NR 211.235, Wis. Adm. Code and in accordance with the approved pretreatment program procedures and the permittee's sewer use ordinance. The discharge permits shall be modified in a timely manner during the stated term of the discharge permits according to the sewer use ordinance as conditions warrant. The discharge permits shall include at a minimum the elements found in s. NR 211.235(1), Wis. Adm. Code and references to the approved pretreatment program procedures and the sewer use ordinance.

The permittee shall provide a copy of all newly issued, reissued, or modified discharge permits to the Department.

7.4.2.3 Review of Industrial User Reports, Inspections and Compliance Monitoring

The permittee shall require the submission of, receive, and review self-monitoring reports and other notices from industrial users in accordance with the approved pretreatment program procedures. The permittee shall randomly sample and analyze industrial user discharges and conduct surveillance activities to determine independent of information supplied by the industrial users, whether the industrial users are in compliance with pretreatment standards and requirements. The inspections and monitoring shall also be conducted to maintain accurate knowledge of local industrial processes, including changes in the discharge, pretreatment equipment operation, spill prevention control plans, slug control plans, and implementation of solvent management plans.

At least one time per year the permittee shall inspect and sample the discharge from each significant industrial user, or more frequently if so specified in the permittee's approved pretreatment program. At least once every 2 years the permittee shall evaluate whether each significant industrial user needs a slug control plan. If a slug control plan is needed, the plan shall contain at a minimum the elements specified in s. NR 211.235(4)(b), Wis. Adm. Code.

7.4.2.4 Enforcement and Industrial User Compliance Evaluation & Violation Reports

The permittee shall enforce the industrial pretreatment requirements including the industrial user discharge limitations of the permittee's sewer use ordinance. The permittee shall investigate instances of noncompliance by collecting and analyzing samples and collecting other information with sufficient care to produce evidence admissible in enforcement proceedings or in judicial actions. Investigation and response to instances of noncompliance shall be in accordance with the permittee's sewer use ordinance and approved Enforcement Response Plan.

The permittee shall make a semiannual report on forms provided or approved by the Department. The semiannual report shall include an analysis of industrial user significant noncompliance (i.e. the Industrial User Compliance Evaluation, also known as the SNC Analysis) as outlined in s.NR 211.23(1)(j), Wis. Adm. Code, and a summary of the permittee's response to all industrial noncompliance (i.e. the Industrial User Violation Report). The Industrial User Compliance Evaluation Report shall include monitoring results received from industrial users pursuant to s. NR 211.15(1)-(5), Wis. Adm. Code. The Industrial User Violation Report shall include copies of all notices of noncompliance, notices of violation and other enforcement correspondence sent by the permittee to industrial users, together with the industrial user's response. The Industrial User Compliance Evaluation and Violation Reports for the period January through June shall be provided to the Department by September 30 of each year and for the period July through December shall be provided to the Department by March 31 of the succeeding year, unless alternate submittal dates are approved.

7.4.2.5 Publication of Violations

The permittee shall publish a list of industrial users that have significantly violated the municipal sewer use ordinance during the calendar year, in the largest daily newspaper in the area by March 31 of the following year pursuant to s. NR 211.23(1)(j), Wis. Adm. Code. A copy of the newspaper publication shall be provided as part of the annual pretreatment report specified herein.

7.4.2.6 Multijurisdictional Agreements

The permittee shall establish agreements with all contributing jurisdictions as necessary to ensure compliance with pretreatment standards and requirements by all industrial users discharging to the permittee's wastewater treatment system. Any such agreement shall identify who will be responsible for maintaining the industrial user inventory, issuance of industrial user control mechanisms, inspections and sampling, pretreatment program implementation, and enforcement.

7.4.3 Annual Pretreatment Program Report

The permittee shall evaluate the pretreatment program, and submit the Pretreatment Program Report to the Department on forms provided or approved by the Department by March 31 annually, unless an alternate submittal date is approved. The report shall include a brief summary of the work performed during the preceding calendar year, including the numbers of discharge permits issued and in effect, pollution prevention activities, number of inspections and monitoring surveys conducted, budget and personnel assigned to the program, a general discussion of program progress in meeting the objectives of the permittee's pretreatment program together with summary comments and recommendations.

7.4.4 Pretreatment Program Modifications

- Future Modifications: The permittee shall within one year of any revisions to federal or state General Pretreatment Regulations submit an application to the Department in duplicate to modify and update its approved pretreatment program to incorporate such regulatory changes as applicable to the permittee. Additionally, the Department or the permittee may request an application for program modification at any time where necessary to improve program effectiveness based on program experience to date.

- Modifications Subject to Department Approval: The permittee shall submit all proposed pretreatment program modifications to the Department for determination of significance and opportunity for comment in accordance with the requirements and conditions of s. NR 211.27, Wis. Adm. Code. Any substantial proposed program modification shall be subject to Department public noticing and formal approval prior to implementation. A substantial program modification includes, but is not limited to, changes in enabling legal authority to administer and enforce pretreatment conditions and requirements; significant changes in program administrative or operational procedures; significant reductions in monitoring frequencies; significant reductions in program resources including personnel commitments, equipment, and funding levels; changes (including any relaxation) in the local limitations for substances enforced and applied to users of the sewerage treatment works; changes in treatment works sludge disposal or management practices which impact the pretreatment program; or program modifications which increase pollutant loadings to the treatment works. The Department shall use the procedures outlined in s. NR 211.30, Wis. Adm. Code for review and approval/denial of proposed pretreatment program modifications. The permittee shall comply with local public participation requirements when implementing the pretreatment program.

7.4.5 Program Resources

The permittee shall have sufficient resources and qualified personnel to carry out the pretreatment program responsibilities as listed in ss. NR 211.22 and NR 211.23, Wis. Adm. Code.

7.5 Land Treatment (Land Disposal) Requirements

7.5.1 Application of NR 140 to Substances Discharged

This permit does not authorize the permittee to discharge any substance in a concentration which would cause an applicable groundwater standard of ch. NR 140, Wis. Adm. Code, to be exceeded. The Department may seek a response under NR 140 if the permittee's discharge causes exceedance of an applicable groundwater standard for any substance, including substances not specifically limited or monitored under this permit

7.5.2 Appropriate Formulas for Nitrogen

Total Nitrogen = Total Kjeldahl Nitrogen (mg/L) + [NO_2 + NO_3] Nitrogen (mg/L)

Organic Nitrogen (mg/L) = Total Kjeldahl Nitrogen (mg/L) - Ammonia Nitrogen (mg/L)

7.5.3 Toxic or Hazardous Pollutants

The discharge of toxic or hazardous pollutants to land treatment systems is prohibited unless the applicant can demonstrate and the department determines that the discharge of such pollutants will be in such small quantities that no detrimental effect on groundwater or surface water will result pursuant to s. NR 206.07(2)(c), Wis. Adm. Code. The criteria used shall include but not be limited to the toxicity of the pollutant, capacity of the soil to remove the pollutant, degradability, usual or potential presence of the pollutant in the existing environment, method of application and all other relevant factors.

7.5.4 Industrial Waste - Pretreatment Requirements

Industrial waste discharges tributary to municipal land treatment systems shall be in compliance with the applicable pretreatment standards under ch. NR 211 Wis. Adm. Code pursuant to s. NR 206.07(2)(e), Wis. Adm. Code.

7.5.5 Overflow

Discharge to a land treatment system shall be limited so that the discharge and any precipitation which falls within the boundary of the disposal system during such discharge does not overflow the boundary of the system unless the WPDES permit authorizes collection and discharge of runoff to surface water pursuant to s. NR 206.07(2)(g), Wis. Adm. Code.

7.5.6 Management Plan Requirements

All land treatment systems shall be operated in accordance with an approved management plan. The management plan shall conform to the requirements of s. NR 110.25(3m), Wis. Adm. Code, per s. NR 206.07(2)(h), Wis. Adm. Code

7.5.7 Monthly Average Hydraulic Application Rate

Determine the monthly average hydraulic application rate (in gal/acre/day) for each outfall by calculating the total gallons of wastewater applied onto the site for the month, dividing that total by the number of wetted acres loaded during the month, and then dividing this resulting value by the number of days in the month. Enter this calculated monthly average value on the Discharge Monitoring Report form in the box for the last day of the month, in the "Hydraulic Application Rate" column.

7.5.8 Nitrogen Loading Requirements for Spray Irrigation

The annual total pounds of nitrogen applied to the irrigation acreage shall be restricted to the annual nitrogen needs of the cover crop as specified in the irrigation annual report table. The Department may approve an alternate nitrogen loading limit in the management plan, pursuant to s. NR 206.06, Wis. Adm. Code.

7.5.9 Runoff

Discharge shall be limited to prevent any runoff of effluent from the spray irrigation site. Wastewater may not be sprayed during any rainfall event that causes runoff from the site, pursuant to s. NR 206.08(2)(b)1,Wis. Adm. Code.

7.5.10 Ponding

The volume of discharge to a spray irrigation system shall be limited to prevent ponding, except for temporary conditions following rainfall events, pursuant to s. NR 206.08(2)(b)2, Wis. Adm. Code.

7.5.11 Frozen Ground

Spray irrigation onto frozen ground is prohibited, pursuant to s. NR 110.255(2)(a)2, Wis. Adm. Code.

7.5.12 Land Treatment Annual Report

Annual Land Treatment Reports are due by January 31st of each year for the previous calendar year.

7.6 Land Application Requirements

7.6.1 Sludge Management Program Standards And Requirements Based Upon Federally Promulgated Regulations

In the event that new federal sludge standards or regulations are promulgated, the permittee shall comply with the new sludge requirements by the dates established in the regulations, if required by federal law, even if the permit has not yet been modified to incorporate the new federal regulations.

7.6.2 General Sludge Management Information

The General Sludge Management Form 3400-48 shall be completed and submitted prior to any significant sludge management changes.

7.6.3 Sludge Samples

All sludge samples shall be collected at a point and in a manner which will yield sample results which are representative of the sludge being tested, and collected at the time which is appropriate for the specific test.

7.6.4 Land Application Characteristic Report

Each report shall consist of a Characteristic Form 3400-49 and Lab Report, unless approval for not submitting the lab reports has been given. Both reports shall be submitted by January 31 following each year of analysis.

The permittee shall use the following convention when reporting sludge monitoring results: Pollutant concentrations less than the limit of detection shall be reported as < (less than) the value of the limit of detection. For example, if a substance is not detected at a detection limit of 1.0 mg/kg, report the pollutant concentration as < 1.0 mg/kg.

All results shall be reported on a dry weight basis.

7.6.5 Calculation of Water Extractable Phosphorus

The permittee shall use the following formula to calculate and report Water Extractable Phosphorus:
Water Extractable Phosphorus (% of Total P) =
[Water Extractable Phosphorus (mg/kg, dry wt) ÷ Total Phosphorus (mg/kg, dry wt)] x 100

7.6.6 Monitoring and Calculating PCB Concentrations in Sludge

When sludge analysis for "PCB, Total Dry Wt" is required by this permit, the PCB concentration in the sludge shall be determined as follows.

Either congener-specific analysis or Aroclor analysis shall be used to determine the PCB concentration. The permittee may determine whether Aroclor or congener specific analysis is performed. Analyses shall be performed in accordance with the following provisions and Table EM in s. NR 219.04, Wis. Adm. Code.

- EPA Method 1668 may be used to test for all PCB congeners. If this method is employed, all PCB congeners shall be delineated. Non-detects shall be treated as zero. The values that are between the limit of detection and the limit of quantitation shall be used when calculating the total value of all congeners. All results shall be added together and the total PCB concentration by dry weight reported. **Note:** It is recognized that a number of the congeners will co-elute with others, so there will not be 209 results to sum.

- EPA Method 8082A shall be used for PCB-Aroclor analysis and may be used for congener specific analysis as well. If congener specific analysis is performed using Method 8082A, the list of congeners tested shall include at least congener numbers 5, 18, 31, 44, 52, 66, 87, 101, 110, 138, 141, 151, 153, 170, 180, 183, 187, and 206 plus any other additional congeners which might be reasonably expected to occur in the particular sample. For either type of analysis, the sample shall be extracted using the Soxhlet extraction (EPA Method 3540C) (or the Soxhlet Dean-Stark modification) or the pressurized fluid extraction (EPA Method 3545A). If Aroclor analysis is performed using Method 8082A, clean up steps of the extract shall be performed as necessary to remove interference and to achieve as close to a limit of detection of 0.11 mg/kg as possible. Reporting protocol, consistent with s. NR 106.07(6)(e), should be as follows: If all Aroclors are less than the LOD, then the Total PCB Dry Wt result should be reported as less than the highest LOD. If a single Aroclor is detected then that is what should be reported for the Total PCB result. If multiple Aroclors are detected, they should be summed and reported as Total PCBs. If congener specific analysis is done using Method 8082A, clean up steps of the extract shall be performed as necessary to remove interference and to achieve as close to a limit of detection of 0.003 mg/kg as possible for each congener. If the aforementioned limits of detection cannot be achieved after using the appropriate clean up techniques, a reporting limit that is achievable for the Aroclors or each congener for the sample shall be determined. This reporting limit shall be reported and qualified indicating the presence of an interference. The lab conducting the analysis shall perform as many of the following methods as necessary to remove interference:

3620C – Florisil	3611B - Alumina
3640A - Gel Permeation	3660B - Sulfur Clean Up (using copper shot instead of powder)
3630C - Silica Gel	3665A - Sulfuric Acid Clean Up

7.6.7 Land Application Report

Land Application Report Form 3400-55 shall be submitted by January 31, following each year non-exceptional quality sludge is land applied. Non-exceptional quality sludge is defined in s. NR 204.07(4), Wis. Adm. Code.

7.6.8 Other Methods of Disposal or Distribution Report

The permittee shall submit Report Form 3400-52 by January 31, following each year sludge is hauled, landfilled, incinerated, or when exceptional quality sludge is distributed or land applied.

7.6.9 Approval to Land Apply

Bulk non-exceptional quality sludge as defined in s. NR 204.07(4), Wis. Adm. Code, may not be applied to land without a written approval letter or Form 3400-122 from the Department unless the Permittee has obtained permission from the Department to self approve sites in accordance with s. NR 204.06 (6), Wis. Adm. Code. Analysis of sludge characteristics is required prior to land application. Application on frozen or snow covered ground is restricted to the extent specified in s. NR 204.07(3) (l), Wis. Adm. Code.

7.6.10 Soil Analysis Requirements

Each site requested for approval for land application must have the soil tested prior to use. Each approved site used for land application must subsequently be soil tested such that there is at least one valid soil test in the four years prior to land application. All soil sampling and submittal of information to the testing laboratory shall be done in accordance with UW Extension Bulletin A-2100. The testing shall be done by the UW Soils Lab in Madison or Marshfield, WI or at a lab approved by UW. The test results including the crop recommendations shall be submitted to the DNR contact listed for this permit, as they are available. Application rates shall be determined based on the crop nitrogen recommendations and with consideration for other sources of nitrogen applied to the site.

7.6.11 Land Application Site Evaluation

For non-exceptional quality sludge, as defined in s. NR 204.07(4), Wis. Adm. Code, a Land Application Site Request Form 3400-053 shall be submitted to the Department for the proposed land application site. The Department will evaluate the proposed site for acceptability and will either approve or deny use of the proposed site. The permittee may obtain permission to approve their own sites in accordance with s. NR 204.06(6), Wis. Adm. Code.

7.6.12 Class A Sludge: Fecal Coliform Density Requirement

If fecal coliform density is used to demonstrate compliance with Class A requirements, the fecal coliform density, which must be < 1000 MPN/g TS as required in s. NR 204.07, Wis. Adm. Code, shall be satisfied immediately after the treatment process is completed. If the material is bagged or distributed at that time, no re-testing is required. If the material is bagged, distributed or land applied at a later time, the sludge shall be re-tested and this requirement satisfied at that time also, to ensure that regrowth of bacteria has not occurred. See Municipal Wastewater Sludge Guidance Memo #3 (Fecal Coliform Monitoring - Sampling and Analytical Procedures).

7.6.13 Class A Sludge: Salmonella Density Requirements

If salmonella density is used to demonstrate compliance with Class A requirements, the salmonella density, which must be < 3 MPN/4 g TS as required in s. NR 204.07, Wis. Adm. Code, shall be satisfied immediately after the treatment process is completed. If the material is bagged or distributed at that time, no re-testing is required. If the material is bagged, distributed or land applied at a later time, the sludge shall be re-tested and this requirement satisfied at that time also, to ensure that regrowth of bacteria has not occurred.

7.6.14 Class B Sludge: Fecal Coliform Limitation

Compliance with the fecal coliform limitation for Class B sludge shall be demonstrated by calculating the geometric mean of at least 7 separate samples. (Note that a Total Solids analysis must be done on each sample). The geometric mean shall be less than 2,000,000 MPN or CFU/g TS. Calculation of the geometric mean can be done using one of the following 2 methods.

Method 1:
Geometric Mean = $(X_1 \times X_2 \times X_3 \ldots \times X_n)^{1/n}$
Where X = Coliform Density value of the sludge sample, and where n = number of samples (at least 7)

Method 2:
Geometric Mean = antilog$[(X_1 + X_2 + X_3 \ldots + X_n) \div n]$
Where X = $\log_{10}$ of Coliform Density value of the sludge sample, and where n = number of samples (at least 7)
Example for Method 2

Sample Number	Coliform Density of Sludge Sample	$\log_{10}$
1	6.0×10^5	5.78
2	4.2×10^6	6.62
3	1.6×10^6	6.20
4	9.0×10^5	5.95
5	4.0×10^5	5.60
6	1.0×10^6	6.00
7	5.1×10^5	5.71

The geometric mean for the seven samples is determined by averaging the $\log_{10}$ values of the coliform density and taking the antilog of that value.
$(5.78 + 6.62 + 6.20 + 5.95 + 5.60 + 6.00 + 5.71) \div 7 = 5.98$
The antilog of 5.98 = 9.5×10^5

7.6.15 Vector Control: Volatile Solids Reduction

The mass of volatile solids in the sludge shall be reduced by a minimum of 38% between the time the sludge enters the digestion process and the time it either exits the digester or a storage facility. For calculation of volatile solids reduction, the permittee shall use the Van Kleeck equation or one of the other methods described in "Determination of Volatile Solids Reduction in Digestion" by J.B. Farrell, which is Appendix C of EPA's *Control of Pathogens in Municipal Wastewater Sludge* (EPA/625/R-92/013). The Van Kleeck equation is:

$$VSR\% = \frac{VS_{IN} - VS_{OUT}}{VS_{IN} - (VS_{OUT} \times VS_{IN})} \times 100$$

Where: VS_{IN} = Volatile Solids in Feed Sludge (g VS/g TS)

VS_{OUT} = Volatile Solids in Final Sludge (g VS/g TS)

VSR% = Volatile Solids Reduction, (Percent)

7.6.16 Class B Sludge - Vector Control: Incorporation

Class B sludge shall be incorporated within 6 hours of surface application, or as approved by the Department.

8 Summary of Reports Due

FOR INFORMATIONAL PURPOSES ONLY

Description	Date	Page
Mercury Pollutant Minimization Program -Implement the Mercury Pollutant Minimization Program	See Permit	21
Mercury Pollutant Minimization Program -Submit Annual Status Reports	See Permit	21
Chloride Target Value -Annual Chloride Progress Report	June 30, 2011	21
Chloride Target Value -Annual Chloride Progress Report #2	June 30, 2012	21
Chloride Target Value -Annual Chloride Progress Report #3	June 30, 2013	21
Chloride Target Value -Annual Chloride Progress Report #4	June 30, 2014	21
Chloride Target Value -Final Chloride Report	June 30, 2015	21
Compliance Maintenance Annual Reports (CMAR)	by June 30, each year	22
Industrial User Compliance Evaluation and Violation Reports	Semiannual	28
Pretreatment Program Report	Annually	29
General Sludge Management Form 3400-48	prior to any significant sludge management changes	31
Characteristic Form 3400-49 and Lab Report	by January 31 following each year of analysis	31
Land Application Report Form 3400-55	by January 31, following each year non-exceptional quality sludge is land applied	32
Report Form 3400-52	by January 31, following each year sludge is hauled, landfilled, incinerated, or when exceptional quality sludge is distributed or land applied	32
Annual Land Treatment Reports	by January 31st of each year for the previous calendar year	31
Wastewater Discharge Monitoring Report	no later than the date indicated on the form	21

Report forms shall be submitted to the address printed on the report form. Any facility plans or plans and specifications for municipal, industrial, industrial pretreatment and non industrial wastewater systems shall be submitted to the Bureau of Watershed Management, P.O. Box 7921, Madison, WI 53707-7921. All other submittals required by this permit shall be submitted to:
Mr. Robert Liska, South Central Region, 3911 Fish Hatchery Road, Fitchburg, WI 53711-5397

APPENDIX B

REQUEST FOR FACILITIES PLANNING LIMITS

STRAND ASSOCIATES®

Strand Associates, Inc.®
910 West Wingra Drive
Madison, WI 53715
(P) 608-251-4843
(F) 608-251-8655

May 27, 2016

Mr. Barton T. Chapman, P.E.
Wastewater Section Chief
Wisconsin Department of Natural Resources
Bureau of Water Quality
PO Box 7921
Madison, WI 53707-7921

Re: Madison Metropolitan Sewerage District–Facilities Planning Limits Request
WPDES Permit No. WI-0024597-08-0

Dear Mr. Chapman:

The Madison Metropolitan Sewerage District (District) has engaged Strand Associates, Inc.® (Strand) to conduct a Facilities Planning effort for evaluating the liquid processing facilities at the Nine Springs Wastewater Treatment Plant (NSWWTP) through the planning year of 2040. Strand and District staff met with you and others from the Department on April 21 to provide an overview of this planning effort and begin conversations with the Department on regulatory and related issues that need to be considered as the facilities planning process moves forward.

One of the areas that we briefly discussed at the April 21 meeting was the need to begin to understand potential effluent limitations that could be associated with various management strategies being considered as part of the facilities planning effort. You noted that we could make a Facilities Planning Limits Request to the Department once we were further along in the planning process. We are now at that point where such a request makes sense.

On behalf of the District, Strand is submitting this request for effluent discharge limits for the NSWWTP in Dane County, Wisconsin. Year 2040 design flows have been projected by the Capital Area Regional Planning Commission, and an increase in design average flow from the current 50 million gallons per day (mgd) to 53.6 mgd is projected. The District is hereby requesting projected effluent limits and use designations for discharging to surface water at the District's two existing outfall locations: Badfish Creek (Outfall 001) and Badger Mill Creek (Outfall 005). For purposes of a thorough alternatives analysis, the District is also requesting projected effluent limits and use designations for a potential new outfall to Nine Springs Creek.

All wastewater is pumped from NSWWTP to the two existing discharge locations. Constraints in the effluent force main to the Badfish Creek discharge location (001) will likely continue to limit future maximum flows to approximately 78 mgd. The discharge to the Badger Mill Creek discharge location (005) began in the 1990s in an effort to return approximately the same flow to the Sugar River watershed as was being pumped from that watershed to the NSWWTP for treatment. Outfall 005 is not used when the NSWWTP is receiving peak flows if there are concerns with flooding in Badger Mill Creek. The future Badger Mill Creek discharge flow rates could range significantly depending on the future anticipated limits at that discharge location. The District is not required to discharge at that location. Therefore, if future limits are too restrictive, one option that the District could consider is to

JMC:pll\S:\MAD\1000--1099\1021\015\Wrd\Task 2 - Regulatory and Loads\RequestforLimits 052616.doc discontinue using that discharge location altogether. Based on these future scenarios, effluent permit limits are requested for the Outfalls 001 and 005 for the following conditions:

		Design Average Flow (mgd)			Design Maximum Day and Hourly Flow (mgd)[a]		
Number Outfalls	**Scenario**	**Total**	**Badfish Creek (001)**	**Badger Mill Creek (005)**	**Total**	**Badfish Creek (001)**	**Badger Mill Creek (005)**
2	Same Outfall Capacities	53.6	50.0	3.6	81.6	78	3.6
2	Expand 005	53.6	48.6	5.0	84.0	78	6.0
1	Discontinue 005	53.6	53.6	NA	78.0	78	NA

[a]Because all flow is pumped to the outfalls, the maximum day flow equals max hourly flow.

We understand the Department will be updating the tiered aquatic life uses and biological criteria, which may include new designated uses (DUs) with revised criteria in some cases. Therefore, we are requesting, to the extent practical, that a preliminary determination of the future DUs be provided for Badfish Creek and Badger Mill Creek at the District's outfall 001 and 005, respectively, along with any information that would indicate changes in future effluent limits related to the changing DUs.

In addition, as part of the facilities planning project, the District is conducting wet weather flow modeling to help assess future peak flow management strategies. Currently, effluent flow from the plant is limited to 75 to 80 mgd because of effluent pumping and force main restrictions. Capacity expansions to existing outfalls would be extremely expensive. Flows up to 75 to 80 mgd receive full treatment and are pumped to the two discharge locations. Flows above 75 to 80 mgd up to about 100 mgd receive full treatment, but are stored first in two effluent tanks. If flows continue to exceed the effluent pump station capacity, the tanks overflow to the large storage lagoons located east of the SWWWTP. Flows above 100 mgd still receive secondary treatment and are discharged to the lagoons without being disinfected. In summary, all flows to the effluent storage tanks and lagoons have received full secondary treatment, except that flows above about 100 mgd are not disinfected. When flows subside, the stored wastewater from the lagoons is brought back to the NSWWTP for full biological treatment and disinfection before being pumped to Outfalls 001 and 005. However, if the capacity of the lagoons is exceeded (about 50 million gallons), there is an overflow structure from the lagoons to Nine Springs Creek (discharge location is 89°21'9.353"W, 43°2'10.478"N; see enclosed United States Geological Survey map).

As you may be aware, the District voluntarily put these lagoons into service for effluent storage to help the District manage effluent flows and to reduce discharges to Nine Springs Creek as part of a 2005 project. Since then, the lagoons have only overflowed to Nine Springs Creek during one extreme event in June 2008. However, modeling of future (2040) wet weather events indicates that, depending on the assumed future wet weather flows, the lagoons may discharge to Nine Springs Creek on a more frequent basis. The following table provides a range of predicted overflow frequencies and volumes that could occur, along with the current predicted frequency of overflows.

Condition	Predicted Lagoon Overflow Occurrence Frequency	Predicted Maximum Volume Per Overflow[a]
Current Conditions	~Once per 10 years	~50 million gallons
Future Condition (Similar Peak Factors to Existing)	~Once per 4 years	~250 million gallons
Future Conditions (Reduce Peak Factors by 10% Through Aggressive I/I Reduction)	~Once per 5 years	~200 million gallons

[a]Average/typical overflows would be expected to be about 50 percent of this volume.

To assist the District in planning for the future wet weather management challenges, we are requesting that the Department consider such discharges to Nine Springs Creek and provide guidance as to the discharge requirements and/or limits that could be expected for such infrequent discharges from the lagoons. In addition to these intermittent, infrequent discharges, the District would like to understand what treatment requirements might be needed to discharge flow at this location on a more frequent basis for the following two conditions.

1. Intermittently during and following wet weather events that exceed a NSWWTP flow of 80 mgd at an assumed flow rate of approximately 10 to 40 mgd (a wet weather flow treatment process could be used to meet secondary or better effluent limits, and lagoon storage would be employed for flows above these rates).

2. Continuously at a relatively low flow rate similar to Badger Mill Creek. The goals of such discharges would be to alleviate the significant effluent flow restrictions that currently exist for Outfalls 001 and 005, and to reduce the high power consumption and carbon footprint associated with pumping effluent flow to the two existing outfalls, and to thereby help the District along its path to net zero electrical energy use.

We note that the background surface water quality during wet weather is very different than dry weather. This fact, along with considerations related to advances in wastewater treatment, as well as sustainability considerations (e.g. carbon footprint and water balance issues) can hopefully help frame further discussions with the Department related to identifying viable options.

We want to stress that the above request is being made for the purpose of helping us do a thorough evaluation of different flow management strategies in the context of a broad facilities planning study. We appreciate in advance time spent by the Department in fulfilling this request. Since we are proceeding with facilities planning at this time, we are hopeful that guidance can be provided within the next few weeks. Please call us at 608.251.4843 if you have any questions or concerns about this request. If a meeting is desired to discuss this request, please contact Strand or Dave Taylor at the District.

Sincerely,

STRAND ASSOCIATES, INC.

Jane M. Carlson, P.E., ENV SP
Senior Associate

Randall A. Wirtz, Ph.D., P.E., ENV SP
Senior Associate

c: Dave Taylor, Madison Metropolitan Sewerage District
Jeff Klawes, Madison Metropolitan Sewerage District

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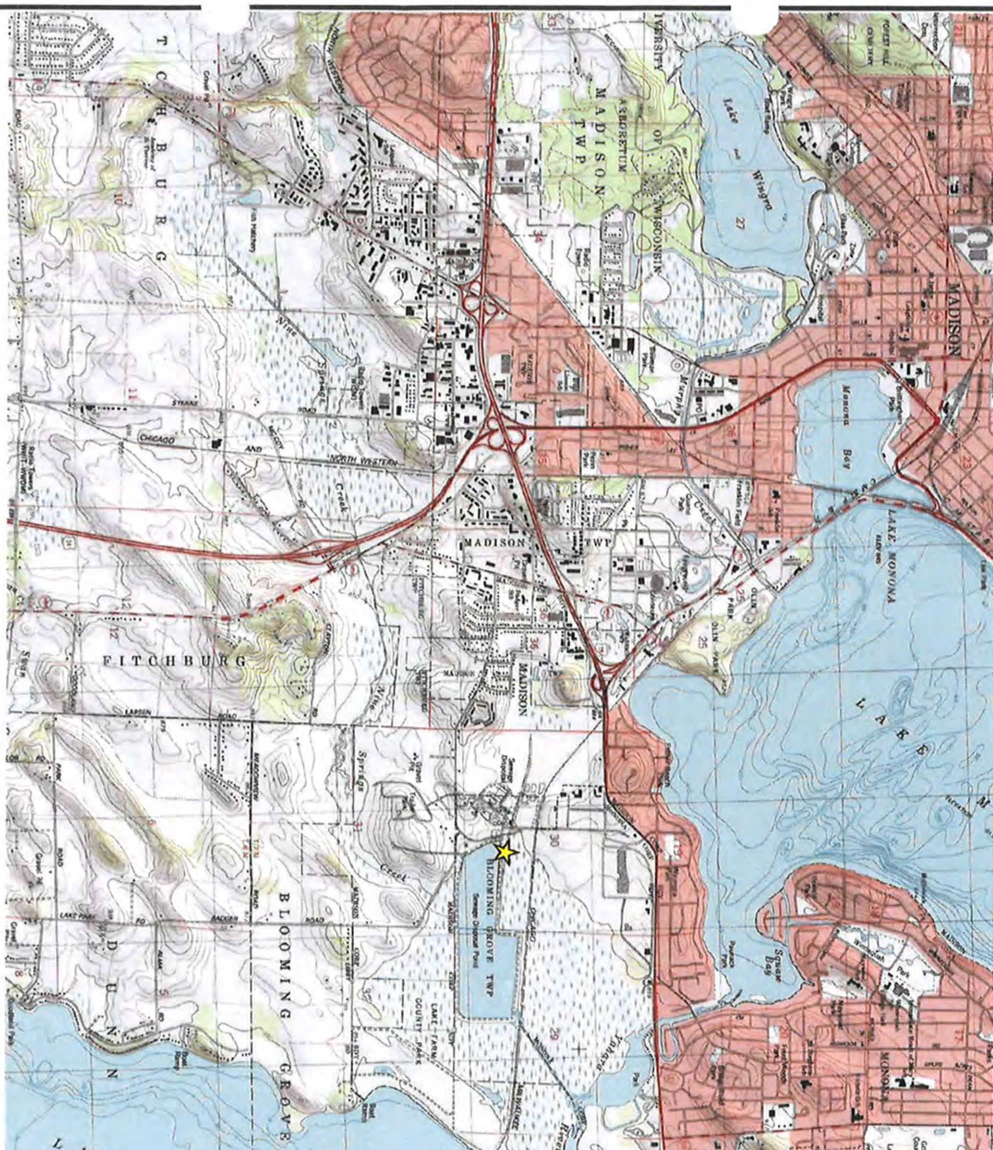

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STRAND ASSOCIATES®

USGS MAP SHOWING DISCHARGE LOCATION TO NINE SPRINGS CREEK
2016 LIQUID PROCESSING FACILITIES PLAN
MADISON METROPOLITAN SEWERAGE DISTRICT
MADISON, WISCONSIN

APPENDIX C

DNR MEMORANDA

WDNR MEMORANDUM
ON WATER QUALITY BASED EFFLUENT LIMITS
FOR PERMIT REISSUANCE

State of Wisconsin

CORRESPONDENCE/MEMORANDUM

DATE: May 19, 2017 FILE REF: 3200

TO: Phillip Spranger – SCR/Fitchburg

FROM: Adrian Stocks – WY/3 Diane Figiel for AS.

SUBJECT: Water Quality-Based Effluent Limitations for the Madison Metropolitan Sewerage District WPDES Permit No. WI-0024597

This is in response to your request for an evaluation of the need for water quality-based effluent limitations using Chapters NR 102, 104, 105, 106, 207, 210 and 217 of the Wisconsin Administrative Code (where applicable), for the discharge from the Madison Metropolitan Sewerage District (MMSD) (Nine Springs Wastewater Treatment Plant) in Dane County. This municipal wastewater treatment facility (WWTF) discharges through two different outfalls. Outfall 001 discharges to Badfish Creek located in the Lower Badfish Creek Watershed (LR-07) in the Lower Rock River Basin. This outfall is included in the Rock River TMDL as approved by EPA. Outfall 005 discharges to Badger Mill Creek which is the Upper Sugar River Watershed (SP-15) in the Sugar-Pecatonica River Basin. The evaluation of the permit recommendations is discussed in more detail in the attached report.

No changes are recommended in the permit limitations for Dissolved Oxygen, Ammonia, or pH. Based on our review, the following recommendations are made on a chemical-specific basis:

Outfall 001

Parameter	Daily Maximum	Daily Minimum	Weekly Average	Monthly Average	Six Month Average	Footnotes
$CBOD_5$			20 mg/L 8340 lbs/day	19 mg/L 7923 lbs/day		8
TSS			23 mg/L	20 mg/L		1
DO		5.0 mg/L				
pH	9.0 s.u.	6.0 s.u.				
Fecal Coliforms (April 15-Oct 15)			**780#/100 mL Geometric Mean**	400#/100 mL Geometric Mean		5
Chloride (Nov-Mar) (April-Oct)			 465 mg/L 430 mg/L			3
Phosphorus Interim Final				 0.225 mg/L	 0.6 mg/L 0.075 mg/L	1,4
Ammonia Nitrogen (May-Sept) (Oct-April)	 17 mg/L 17 mg/L		 4.4 mg/L 10 mg/L	 1.8 mg/L 4.1 mg/L		
Mercury	3.4 ng/L					2,3
Copper						2,6
Cadmium						2,6
Chromium						2,6

Parameter	Daily Maximum	Daily Minimum	Weekly Average	Monthly Average	Six Month Average	Footnotes
Lead						2,6
Nickel						2,6
Zinc						2,6

Outfall 005

Parameter	Daily Maximum	Daily Minimum	Weekly Average	Monthly Average	Six Month Average	Footnotes
$CBOD_5$ (Nov-April) (May-Oct)			16 mg/L 7 mg/L	**16 mg/L** **7 mg/L**		5,8
TSS (Nov-April) (May-Oct)			**27 mg/L** **17 mg/L**	16 mg/L 10 mg/L		5
DO		5.0 mg/L				
pH	9.0 s.u.	6.0 s.u.				
Fecal Coliforms (May-Sept)			**780#/100 mL Geometric mean**	400#/100 mL Geometric mean		5
Chloride (Nov-Mar) (April-Oct)			465 mg/L 430 mg/L			3
Phosphorus Interim Final				0.225 mg/L, 2.25 lbs/day	0.6 mg/L 0.075 mg/L	9
Ammonia Nitrogen (May-Sept) (Oct-April)	11 mg/L 11 mg/L		2.6 mg/L 8.7 mg/L	1.1 mg/L 3.8 mg/L		
Mercury	3.4 ng/L					2,3
Thermal						7

1. In addition to these limits, additional phosphorus and TSS mass limitations in attachment #1 are required in accordance with the wasteload allocations specified in the Rock River TMDL
   - Monthly average Total Phosphorus mass limits are required as listed in the table on page 18.
   - Monthly and weekly average TSS mass limits are required as listed in the table on page 21.
2. Measurement in the "total recoverable" form is acceptable.
3. The current permit has a variance limit which requires EPA approval at each permit reissuance. In the absence of a variance, water quality based effluent limits consistent with ss. NR 106.07(2)(a) and (9) and s. NR 106.88(c) and as well as a mass limits based on the annual average design flow would be included in the permit. For chlorine the concneration limit would be 395 mg/L and for mercury 1.3 ng/L for both outfalls.
4. The final WQBEL for phosphorus based on s. NR 217.13 is 0.225 mg/L as a monthly average and 0.075 mg/L as a six month average. MMSD is currently in the process of evaluating adaptive management as the option to achieve compliance with this limit. Along with the TMDL mass limits, interim limits consistent with this approach as outlined in s. NR 217.18(3)(e) would be included in the permit in place of the final WQBEL. If the receiving water is not meeting the

water quality criteria after two permit terms the final WQBEL based on s. NR 217.13 may be included in the permit.

5. Additional limitations needed to comply with s. NR 106.07 Expression of limits requirements are listed in bold
6. Monitoring only
7. Limits apply for the months of January, October, November, and December and are listed on page 24. The permittee is currently conducting an AEL (Alternative Effluent Limit) Study to reevaluate this temperature review. This study will be addressed in a separate report.
8. CBOD limits are recommended in the reissued permit in place of the current BOD limits.
9. In addition to the concentration limits for phosphorus, a mass limit based on the effluent flow rate would need to be included in the permit due to the fact that the Sugar River is listed as impaired for phosphorus pursuant to s. NR 207.14(1)(a).

Along with the chemical-specific recommendations mentioned above, the need for acute and chronic whole effluent toxicity (WET) monitoring and limits has also been evaluated for the discharge from MMSD. Following the guidance provided in the Department's November 1, 2016 *Whole Effluent Toxicity Program Guidance Document - Revision #11*, **annual acute WET testing is recommended and chronic WET testing is recommended two times a year for both outfalls** in the reissued permit. Tests should be done in rotating quarters, in order to collect seasonal information about this discharge. WET testing shall continue after the permit expiration date (until the permit is reissued).

Sampling WET concurrently with any chemical-specific toxic substances is recommended. Chronic testing shall be performed using a dilution series of 100%, 75%, 50%, 25% & 12.5%. The Instream Waste Concentration at both Outfall 001 and 005 to assess chronic test results is 100%. The primary control and dilution water used in WET tests conducted on Outfalls 001 and 005 shall be a grab sample collected from the receiving water location, upstream/out of the influence of the mixing zone and any other known discharge.

Please consult the attached report for details regarding the above recommendations. If there are any questions or comments, please contact Rachel Fritz at (608) 266-2675 or Diane Figiel at (608) 264-6274 or Diane.Figiel@wisconsin.gov

Attachments (2) – Narrative & Map

PREPARED BY: Rachel Fritz, Wastewater Engineer – WY/3

APPROVED BY: Diane Figiel date: 5/19/17
Diane Figiel, PE,
Water Resources Engineer

cc: Amy Garbe, Basin Engineer – SCR/Waukesha
Jake Zimmerman, Basin Engineer – SCR/Fitchburg
Tim Ryan, Regional Wastewater Supervisor – SCR/Fitchburg

Attachment #1

Water Quality-Based Effluent Limitations for
Madison Metropolitan Sewerage District
(Nine Springs Wastewater Treatment Plant)

WPDES Permit No. WI-0024597

Prepared by: Rachel Fritz

PART 1 – BACKGROUND INFORMATION

Facility Description:

The Nine Springs Wastewater Treatment Plant is located at 1610 Moorland Road, Madison, Wisconsin. Preliminary treatment is performed by fine screening of inorganic solids and separation of grit in vortex grit tanks. The inorganic solids and grit are hauled to the Dane County Landfill for disposal. The wastewater receives primary and advanced secondary treatment. Sludge from the primary settling tanks is thickened in two gravity thickener tanks. The advanced secondary treatment system is composed of aeration tanks with selectors and clarifiers. Phosphorus removal is accomplished biologically in this process. Following final clarification, the treated water is disinfected using ultraviolet disinfection on a seasonal basis from April 15 to October 15. Treated effluent is discharged to two receiving streams - Badfish Creek and Badger Mill Creek.

Waste activated sludge (WAS) from the secondary treatment system is thickened using Dissolved Air Floatation (DAF) and sent to phosphorus release tanks prior to being thickened on gravity belt thickeners. The thickened primary sludge and thickened WAS are fed to an acid-phase anaerobic digester process. Following this process the sludge is further anaerobically digested at mesophilic temperatures. Most of the digested biosolids (85%) are then thickened by gravity belt thickeners and temporarily stored in Metrogro Storage Tanks before being recycled through land application on agricultural land. A smaller portion (15%) of the mesophilicly digested biosolids is further digested at thermophilic temperatures to meet EPA time/temperature requirements for Class A Biosolids. These biosolids are then dewatered on a centrifuge. The resulting cake biosolids can be managed alone or mixed with amendments such as sand and sawdust to produce a soil-like material.

Phosphorus in the form of struvite is harvested from waste streams using the Ostara process.

Effluent sampling is performed upstream of the flow split to the separate outfalls; therefore, all data is the same for both outfalls.

Attachment #2 is a USGS topographic map of the area showing the approximate location of the outfalls.

Existing Permit Limitations: The current permit, which expired on September 30, 2015, includes the following effluent limitations.

Outfall 001

Parameter	Daily Maximum	Daily Minimum	Weekly Average	Monthly Average	Monthly Geometric Mean	Footnotes
Flow Rate						1
BOD_5			20 mg/L 8340 lbs/day	19 mg/L 7923 lbs/day		5
TSS			23 mg/L 9591 lbs/day	20 mg/L 8340 lbs/day		5
Dissolved Oxygen		5.0 mg/L				5
pH	9.0 s.u.	6.0 s.u.				5
Fecal Coliforms (April 15-Oct 15)					400#/100 mL	4
Ammonia Nitrogen (May-Sept) (Oct-April)	 17 mg/L 17 mg/L		 4.4 mg/L 10 mg/L	 1.8 mg/L 4.1 mg/L		
Phosphorus				1.5 mg/L		
Chloride			481 mg/L 200,000 lbs/day			2
Mercury	5.7 ng/L					3
Copper						1
Cadmium						1
Chromium						1
Lead						1
Nickel						1
Zinc						1
WET						1

Outfall 005

Parameter	Daily Maximum	Daily Minimum	Weekly Average	Monthly Average	Monthly Geometric Mean	Footnotes
Flow Rate						1
BOD_5 (Nov-April) (May-Oct)			16 mg/L 7 mg/L			5
TSS (Nov-April) (May-Oct)			16 mg/L 10 mg/L			5
DO		5.0 mg/L				5
pH	9.0 s.u.	6.0 s.u.				5
Fecal Coliforms (May-Sept)					400#/100 mL	

Ammonia Nitrogen (May-Sept) (Oct-April)	 11 mg/L 11 mg/L		 2.6 mg/L 8.7 mg/L	 1.1 mg/L 3.8 mg/L		
Phosphorus				1.5 mg/L		
Chloride			481 mg/L 14000 lbs/day			2
Mercury	5.7 ng/L					3
WET						1

Footnotes:

1. Monitoring only
2. This interim limit applied until 09/30/2015 when the target value of 430 mg/L became effective as the target limit.
3. This is a variance limit for mercury.
4. The fecal coliform limit at Outfall 001 is effective from April 15 – Oct 15 to protect human and animal health pursuant to s. NR 210.06(c).
5. These limitations are not being evaluated as part of this review. Because the reference effluent flow rates and receiving water characteristics have not changed, limitations for these water quality characteristics do not need to be re-evaluated at this time.

Receiving Water Information for Outfall 001:

- Name: Badfish Creek
- Classification:
  Limited aquatic life (marginal) – at the point of discharge
  Limited forage fish community - Approximately five miles down-stream after the Oregon Branch,
  Warm water sport fish community - Approximately four additional miles down-stream after the CTH "A" bridge

  Non-public water supply applies for all of the above classifications.
- Low Flow: The following 7-Q_{10} and 7-Q_2 values are from USGS for Station LR57, where Outfall 001 is located. The Harmonic Mean has been estimated as recommended in *State of Wisconsin Water Quality Rules Implementation Plan* (Publ. WT-511-98)
  7-Q_{10} = 0 cfs (cubic feet per second)
  7-Q_2 = 0 cfs
  90-Q_{10} = 0 cfs
  Harmonic Mean Flow = 0 cfs
- Hardness = 350 ppm. This value represents the mean of data from previous limits memo
- % of Flow used to calculate limits: N/A where receiving water low flows are equal to zero.
- Source of background concentration data: Background concentrations are not included since they don't impact the calculated WQBEL when the receiving water low flows are equal to zero.
- Multiple dischargers: Not applicable
- Impaired water status: Badfish Creek is listed as impaired for PCBs at the point of discharge. Approximately 21 miles downstream of the discharge, the Yahara River is listed as impaired for Phosphorus and TSS. A TMDL has been approved for the entire Rock River Basin for Phosphorus and TSS.

Receiving Water Information for Outfall 005:

- Name: Badger Mill Creek
- Classification:
  Limited forage fish community at the point of discharge
  Coldwater community - Approximately four miles downstream at STH 69 (category 5 for ammonia limits)
  Non-public water supply applies for both of the above classifications.
- Low Flow: The following $7\text{-}Q_{10}$ and $7\text{-}Q_2$ values are from USGS for Station S9, where Outfall 005 is located. The Harmonic Mean has been estimated as recommended in *State of Wisconsin Water Quality Rules Implementation Plan* (Publ. WT-511-98)
  $7\text{-}Q_{10}$ = <0.01 cfs (cubic feet per second)
  $7\text{-}Q_2$ = 0.02 cfs
  $90\text{-}Q_{10}$ = 0.017 cfs
  Harmonic Mean Flow = 0 cfs
- Hardness = 330 mg/L as $CaCO_3$. This value represents the historic average from WET monitoring results.
- % of Flow used to calculate limits: 25% 6
- Source of background concentration data: Background concentrations are not included since they don't impact the calculated WQBEL when the receiving water low flows approach zero
- Multiple dischargers: Not applicable
- Impaired water status: Approximately 14 miles downstream of the discharge, the Sugar River is listed as impaired for Phosphorus.

Effluent Information:

- Design Flow Rate(s): The design effluent flow rates for each outfall are given below in MGD (million gallons per day). For reference, the actual average flows from 1/1/2011 to 6/30/2016 are also given.

Design Effluent Flow Rates (MGD)		
	Outfall 001	**Outfall 005**
Annual Average	50	3.6
Peak Daily	65	3.6
Peak Weekly	62.5	3.6
Peak Monthly	57.5	3.6
Actual Average Flow	37	3.4

- Hardness = 365 mg/L as $CaCO_3$. This value represents the geometric mean of data from 9/24/2014 to 10/14/2014 from effluent monitoring reported in the permit reissuance application.
- Acute dilution factor used: Not applicable – this facility does not have an approved Zone of Initial Dilution (ZID).
- Effluent characterization: This facility is categorized as a major municipal discharger so the permit application required effluent sample analyses for all of the "priority pollutants" except for the Dioxins and Furans, plus Chloride and Hardness. The permit-required monitoring for Cd, Cr, Cu, Pb, Ni, Hg and Zn from January 1, 2011 to June 30, 2016 is used in this evaluation.

Effluent sampling is performed upstream of the flow split to the separate outfalls; therefore, all data is the same for both outfalls.

	Chloride mg/L	Cadmium µg/L	Chromium (+3) µg/L	Copper µg/L	Mercury ng/L	Nickel µg/L	Zinc µg/L
1-day P_{99}	489	0.196	1.55	47.6	3.42	3.91	69.1
4-day P_{99}	446	0.108	0.871	25.8	2.25	2.27	59.6
30-day P_{99}	423	0.045	0.364	13.5	1.62	1.21	54.0
Mean	408	0.0145	0.0967	8.45	1.32	0.760	51.1
Std	35	0.073	0.71	9.9	0.63	0.86	6.8
Sample size	1621	67	66	66	67	67	67
# of no detects	0	44	49	0	1	21	0
Range	245-581	0.05-0.310	0.6-2.70	4.11-82.8	0.2-3.54	0.8-3.69	33.5-66.6

Sample Date	Lead µg/L
08/10/2011	1.43
05/08/2012	2.93
02/04/2014	1.12
03/03/2015	1.39
11/03/2015	1.39
# of no detects	61
Mean*	0.125

*When data was reported as not detected a value of zero was used to calculate the mean

1,1 dichloroethane was also detected at 0.15 µg/L, however the department does not have sufficient data to calculate a secondary value limitation for this substance.

Effluent data for substances for which a single sample was analyzed is shown in the tables in Part 2 below, in the column titled "MEAN EFFL. CONC." Parameters where the substance was not detected at an adequate level of detection are not included in the tables below.

- Water Source: the Cities of Fitchburg, Madison, Middleton, Monona and Verona; the Villages of Cottage Grove, Dane, DeForest, Maple Bluff, McFarland, Shorewood Hills and Waunakee; and sanitary and utility districts and other areas in the Towns of Blooming Grove, Burke, Dunn, Madison, Middleton, Pleasant Springs, Verona, Vienna, Westport and Windsor
- Additives: none

PART 2 – WATER QUALITY-BASED EFFLUENT LIMITATIONS FOR TOXIC SUBSTANCES – EXCEPT AMMONIA NITROGEN

In general, permit limits for toxic substances are recommended whenever any of the following occur:

1. The maximum effluent concentration exceeds the calculated limit (s. NR 106.05(3), Wis. Adm. Code)

2. If 11 or more detected results are available in the effluent, the upper 99th percentile (or P_{99}) value exceeds the comparable calculated limit (s. NR 106.05(4), Wis. Adm. Code)
3. If fewer than 11 detected results are available, the mean effluent concentration exceeds 1/5 of the calculated limit (s. NR 106.05(6), Wis. Adm. Code)

The following tables list the water quality-based effluent limitations for this discharge along with the results of effluent sampling for all of the detected substances. All concentrations are expressed in term of micrograms per Liter (µg/L), except for hardness and chloride (mg/L) and mercury (ng/L).

Daily Maximum Limits based on Acute Toxicity Criteria (ATC)

RECEIVING WATER FLOW = 0 cfs, ($1\text{-}Q_{10}$ (estimated as 80% of $7\text{-}Q_{10}$)).

Outfall 001							
SUBSTANCE	REF. HARD.* mg/L	ATC	MAX. EFFL. LIMIT	1/5 OF EFFL. LIMIT	MEAN EFFL. CONC.	1-day P_{99}	1-day MAX. CONC.
Cadmium	365	127	127			0.196	0.310
Chromium (+3)	301	4450	4450			1.55	2.70
Copper	365	52.6	52.6			47.6	82.8
Lead	356	365	365	72.9	0.125		
Mercury (ng/L)		830	830			3.42	3.54
Nickel	268	1080	1080			3.91	3.69
Zinc	333	345	345			69.1	66.6
Cyanide		22.4	22.4	4.48	0.013		
Chloride (mg/L)		757	757			489	581

RECEIVING WATER FLOW = 0 cfs, ($1\text{-}Q_{10}$ (estimated as 80% of $7\text{-}Q_{10}$)).

Outfall 005							
SUBSTANCE	REF. HARD.* mg/L	ATC	MAX. EFFL. LIMIT	1/5 OF EFFL. LIMIT	MEAN EFFL. CONC.	1-day P_{99}	1-day MAX. CONC.
Cadmium	365	45.5	45.5			0.196	0.310
Chromium (+3)	301	4450	4450			1.55	2.70
Copper	365	52.6	52.6			47.6	82.8
Lead	356	365	365	72.9	0.125		
Mercury (ng/L)		830	830			3.42	3.54
Nickel	268	1080	1080			3.91	3.69
Zinc	333	345	345			69.1	66.6
Cyanide		22.4	22.4	4.48	0.013		
Chloride (mg/L)		757	757			489	581

* The indicated hardness may differ from the effluent hardness because the effluent hardness exceeded the maximum range in ch. NR 105 over which the acute criteria are applicable. In that case, the maximum of the range is used to calculate the criterion.

* * Per the changes to s. NR 106.07(3), Wis. Adm. Code, effective 09/01/2016 consideration of ambient concentrations and 1Q10 flow rates yields a more restrictive limit than the 2 x ATC method of limit calculation.

Weekly Average Limits based on Chronic Toxicity Criteria (CTC)

RECEIVING WATER FLOW = 0 cfs (¼ of the 7-Q_{10})

Outfall 001							
SUBSTANCE	REF. HARD.* mg/L	CTC	MEAN BACK-GRD.	WEEKLY AVE. LIMIT	1/5 OF EFFL. LIMIT	MEAN EFFL. CONC.	4-day P_{99}
Cadmium	175	3.82		3.82			0.108
Chromium (+3)	301	326		326			0.871
Copper	350	30.2		30.2			25.8
Lead	350	94.0		94.0	18.8	0.125	
Mercury (ng/L)		440		440			2.25
Nickel	268	120		120			2.27
Zinc	333	345		345			59.6
Cyanide		5.22		5.22	1.04	0.013	
Chloride (mg/L)		395		395			446

RECEIVING WATER FLOW = 0 cfs (¼ of the 7-Q_{10})

Outfall 005							
SUBSTANCE	REF. HARD.* mg/L	CTC	MEAN BACK-GRD.	WEEKLY AVE. LIMIT	1/5 OF EFFL. LIMIT	MEAN EFFL. CONC.	4-day P_{99}
Cadmium	175	3.82		3.82			0.108
Chromium (+3)	301	326		326			0.871
Copper	330	28.8		28.8			25.8
Lead	330	88.8		88.8	18.8	0.125	
Mercury (ng/L)		440		440			2.25
Nickel	268	120		120			2.27
Zinc	330	342		342			59.6
Cyanide		5.22		5.22	1.04	0.013	
Chloride (mg/L)		395		395			446

* The indicated hardness may differ from the receiving water hardness because the receiving water hardness exceeded the maximum range in ch. NR 105 over which the chronic criteria are applicable. In that case, the maximum of the range is used to calculate the criterion.

Monthly Average Limits based on Wildlife Criteria (WC)

RECEIVING WATER FLOW = 0 cfs (¼ of the 90-Q_{10})

Outfall 001						
SUBSTANCE	WC	MEAN BACK-GRD.	MO'LY AVE. LIMIT	1/5 OF EFFL. LIMIT	MEAN EFFL. CONC.	30-day P_{99}
Mercury (ng/L)	1.30		1.30			1.62

RECEIVING WATER FLOW = 0.0043 cfs (¼ of the 90-Q_{10})

Outfall 005						
SUBSTANCE	WC	MEAN BACK-GRD.	MO'LY AVE. LIMIT	1/5 OF EFFL. LIMIT	MEAN EFFL. CONC.	30-day P_{99}
Mercury (ng/L)	1.30		1.30			1.62

Monthly Average Limits based on Human Threshold Criteria (HTC)

RECEIVING WATER FLOW = 0 cfs (¼ of the Harmonic Mean)

Outfall 001						
SUBSTANCE	HTC	MEAN BACK-GRD.	MO'LY AVE. LIMIT	1/5 OF EFFL. LIMIT	MEAN EFFL. CONC.	30-day P_{99}
Antimony	1120		1120	224	0.39	
Cadmium	880		880			0.045
Chromium (+3)	8400000		8400000			0.400
Lead	2240		2240	448	0.125	
Mercury (ng/L)	336		336			1.60
Nickel	110000		110000			1.20
Cyanide	28000		28000	5600	0.013	

RECEIVING WATER FLOW = 0 cfs (¼ of the Harmonic Mean)

Outfall 005						
SUBSTANCE	HTC	MEAN BACK-GRD.	MO'LY AVE. LIMIT	1/5 OF EFFL. LIMIT	MEAN EFFL. CONC.	30-day P_{99}
Antimony	373		373	74.6	0.39	
Cadmium	370		370			0.045
Chromium (+3)	3820000		3820000			0.400
Lead	140		140	28	0.125	
Mercury (ng/L)	1.50		1.50			1.62
Nickel	43000		43000			1.20
Cyanide	9300		9300	1860	0.013	

Monthly Average Limits based on Human Cancer Criteria (HCC)

RECEIVING WATER FLOW = 0 cfs (¼ of the Harmonic Mean)

Outfall 001					
SUBSTANCE	HCC	MEAN BACK-GRD.	MO'LY AVE. LIMIT	1/5 OF EFFL. LIMIT	MEAN EFFL. CONC.
Dichlorobromomethane	11200		11200	2240	0.31
1,4-Dichlorobenzene	2940		2940	588	0.19

RECEIVING WATER FLOW = 0.0 cfs (¼ of the Harmonic Mean)

Outfall 005					
SUBSTANCE	HCC	MEAN BACK-GRD.	MO'LY AVE. LIMIT	1/5 OF EFFL. LIMIT	MEAN EFFL. CONC.
Dichlorobromomethane	1960		1960	392	0.31
1,4-Dichlorobenzene	163		163	32.6	0.19

In addition to evaluating the need for limits for each individual substance for which HCC exist, s. NR 106.06(8) requires the evaluation of the cumulative cancer risk. That risk is considered additive, as represented in the table below. If the sum of the effluent concentration divided by the calculated limit is greater than 1.0, effluent limits for all substances that were detected may be considered. That sum is less than 1.0 as shown.

Outfall 001			
DETECTED CARCINOGEN	HCC-BASED EFFLUENT LIMIT	MEAN EFFLUENT CONC.	EFFLUENT CONC. ÷ LIMIT
Dichlorobromomethane	2240	0.31	0.00014
1,4-Dichlorobenzene	588	0.19	0.00032
TOTAL (must be < 1.0) =			0.00046

Outfall 005			
DETECTED CARCINOGEN	HCC-BASED EFFLUENT LIMIT	MEAN EFFLUENT CONC.	EFFLUENT CONC. ÷ LIMIT
Dichlorobromomethane	392	0.31	0.00079
1,4-Dichlorobenzene	32.6	0.19	0.0058
TOTAL (must be < 1.0) =			0.0066

Conclusions and Recommendations: Based on a comparison of the effluent data and calculated effluent limitations, effluent limitations are apparently needed for chloride and mercury at both outfalls.

Mercury – The water quality-based effluent limit for total recoverable mercury is set equal to the most stringent criterion of 1.3 ng/L because the background concentration in the receiving water and similar inland streams is known to exceed 1.3 ng/L.

The previous permit included an alternative effluent limitation for mercury, and included a daily maximum interim limit of 5.7 ng/L for both outfalls. A review of data from the January 2011 through September 2016 indicates the 30 day P_{99} is 1.6 ng/L, which is above the Wildlife Criterion of 1.3 ng/L. Therefore, **a mercury effluent limit is recommended for Outfalls 001 and 005.**

Section NR 106.145(4) allows for eligibility for an alternative mercury effluent limitation if the permittee submits an application for a variance, which includes the submittal of a pollutant minimization plan. MMSD has submitted this application. Section NR 106.145(5) specifies that an alternative limitation shall equal the 1-day P_{99} of the effluent data, and shall be expressed as a daily maximum concentration. The 1-day P_{99} value is 3.4 ng/L. Therefore, **an alternative mercury limitation of 3.4 ng/L, daily maximum, is recommended for both Outfalls 001 aud 005.**

Chloride – Because the 4-day P_{99} exceeds the calculated weekly average WQBEL, an effluent limit is needed in accordance with s. NR 106.05(4)(b) Wis. Adm. Code.

However, Subchapter VII of ch. NR 106 provides for a variance from water quality standards for this substance, and MMSD has requested such a variance. That variance may be granted subject to the following conditions:

1) The permit shall include an "Interim" limitation intended to prevent an increase in the discharge of Chlorides;
2) The permit shall specify "Source Reduction Measures" to be implemented during the course of the permit term, with periodic progress reports; and
3) The permit shall include a "Target Limit" or "Target Value" to gage the effectiveness of the Source Reduction Measures, and progress toward the water quality-based effluent limitations.

MMSD's current permit includes an alternative interim limit of 481 mg/l, weekly average, and a compliance schedule for source reduction of chlorides. The target limit of 430 mg/L went into effect on 9/30/2015. MMSD has reapplied for a variance to the water quality based limit for chloride in conformance with ch. NR 106.83(2)(b). The application of an interim alternative limit assumes agreement between the DNR and the permittee on a compliance schedule for chloride source reduction, and on imposition of a target value or limit.

Interim Limit for Chloride: Section NR 106.82(9) defines a "Weekly average interim limitation" as either the 4-day P_{99} concentration or 105% of the highest weekly average concentration of the representative data.

Typically, the same calculated interim limit is applied year-round. However, chloride concentrations at publicly owned treatment works tend to be highly variable, with the greatest variability occurring during months where salt is applied to roads to protect public safety. Under various conditions, the road salt can enter the sanitary sewer system and increase the concentration (and mass) of chloride to the POTW. The seasonal chloride effluent data is summarized below:

Effluent Chloride Concentrations (mg/L)			
	Nov-Mar	April-Oct	Annual
1-day P_{99}	510	459	489
4-day P_{99}	**465**	**426**	**446**
30-day P_{99}	437	406	423
Min	292	245	
Max	581	475	
Mean	422	395	408

The chloride concentrations in the winter are significantly higher than those in the summer. In this case, separate interim limits for November to May and April to October are recommended. Interim limits equal to the 4-day P_{99} value of **465 mg/L for November through March and 430 mg/L for April through October are recommended.**

A target limit and permit language for Source Reduction Measures are not recommended as part of this evaluation. These should follow contact with MMSD. Though it should be understood that if the department and MMSD are unable to reach agreement on all the terms of a chloride variance, the calculated limits described earlier should be included in the permit, in accordance with s. NR 106.83(3).

Chloride monitoring recommendations: Four samples per month (on consecutive days) are recommended. This allows for averaging of the results to compare with the interim limit, and also allows the use of the average in determining future interim limits, and degree of success with chloride reduction measures.

In the absence of a variance, MMSD would be subject to the water quality-based effluent limit of 400 mg/l as a weekly average; the weekly average mass limit of 165,000 lbs/day for 001 (395 mg/L x 50 MGD x 8.34) and 11,900 lbs/day for 005 (395 mg/L x 3.6 MGD x 8.34); and alternative wet weather mass limits.

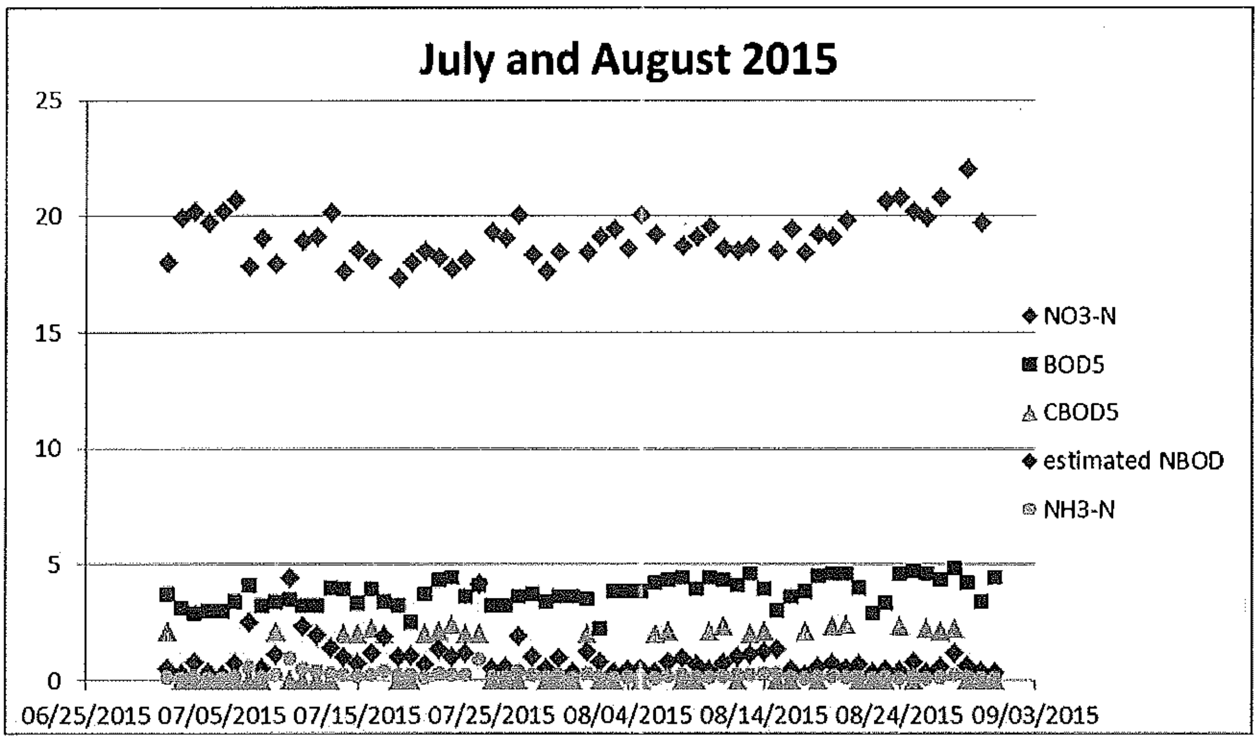
PART 3 – WATER QUALITY-BASED EFFLUENT LIMITATIONS FOR CARBONACEOUS BIOLOGICAL OXYGEN DEMAND (CBOD)

Permits for POTWs typically contain limits for BOD_5 but $CBOD_5$ limits can be used instead in some cases. Differences may occur between $CBOD_5$ and BOD_5 if nitrification occurs during the 5-day BOD test, because the biological oxidation of nitrogenous materials would give the impression of errors in the standard 5-day BOD test. A plant that is nitrifying during the 5-day test period may be generating high BOD_5 concentrations that are, at least partially, due to Nitrogenous BOD (NBOD) in the effluent, so the plant's actual removal of BOD_5 (treatment as evidenced by $CBOD_5$) would be greater than shown by the data. NBOD is not commonly removed by processes associated with BOD treatment, because it represents oxygen demand associated with the conversion of organic and ammonia nitrogen to nitrate nitrogen.

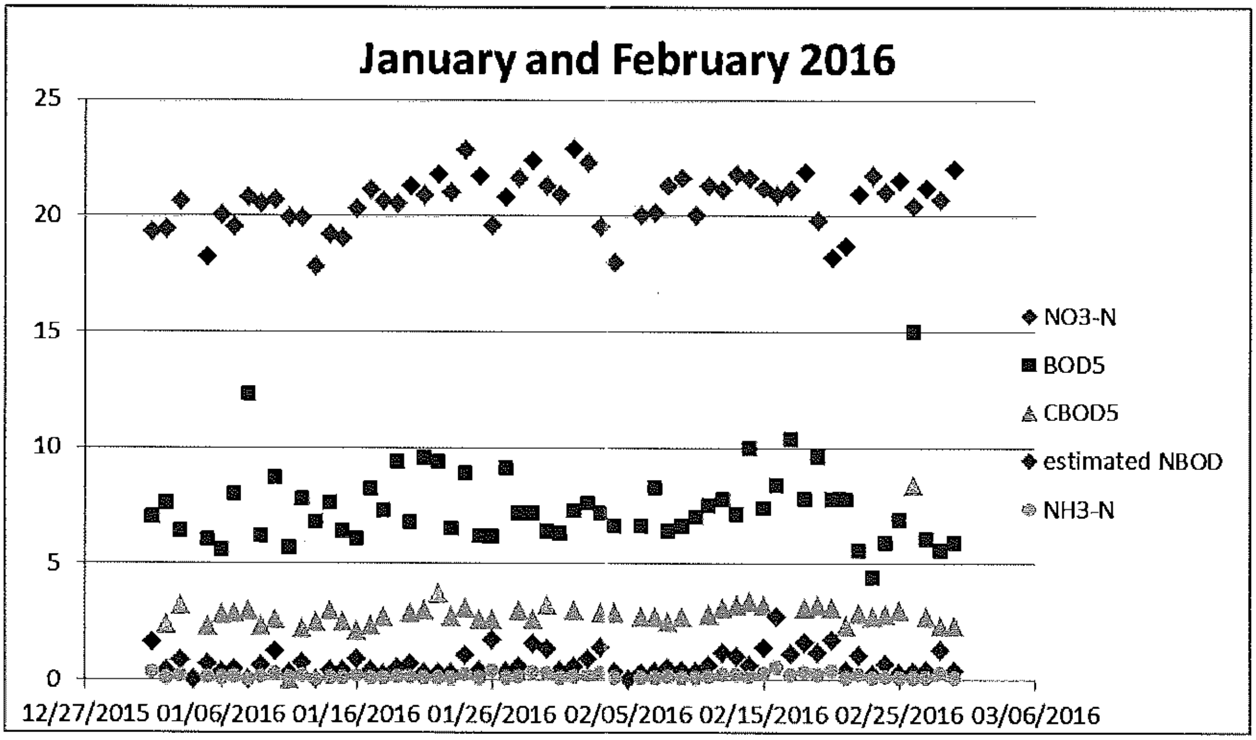
A $CBOD_5$ limit may be deemed appropriate if it can be demonstrated that nitrification occurring during the first 5 days of BOD testing accounts for the difference between $CBOD_5$ and BOD_5 results.

MMSD has requested the department evaluate the potential for $CBOD_5$ limits in place of their current BOD_5 limits. They have submitted 121 samples of paired effluent data for BOD_5, $CBOD_5$, NH3-N, and NO3-N taken between 7/1/2015 and 2/29/2016.

To determine if nitrification is taking place during the 5-day BOD test period, procedures detailed in the 1994 guidance document *Calculating $CBOD_5$ limits* were followed. An "ultimate NBOD" value was estimated as 4.57 times the effluent NH_3-N. This is the estimated value that should account for the difference between $CBOD_5$ and BOD_5 results if nitrification is taking place during the test period. The calculated NBOD value was added to that day's $CBOD_5$ value and the sum was compared to that day's BOD_5 result. A summary of the data is shown below:



Attachment #1



	$CBOD_5$ (mg/L)	Ultimate NBOD estimate (mg/L)	$CBOD_5$ + NBOD (mg/L)	BOD_5 (mg/L)
1-day P_{99}	6.8	3.5	7.9	13
4-day P_{99}	3.9	1.9	4.7	8.7
30-day P_{99}	2.5	1.2	3.1	6.6
Mean	1.8	0.8	2.4	5.6
Std	1.3	0.7	1.5	2.3
Min	0	0	0	2.2
Max	8.4	4.4	8.8	15

The results of this comparison should fall into one of the following categories, after which the recommended course of action is indicated:

1) **If the sum of $CBOD_5$ and the calculated NBOD is consistently equal or close to BOD_5 values,** complete nitrification is taking place in the 5-day test. In this case, the $CBOD_5$ limit may be set equal to the BOD_5 limit calculated using the WLA model or the 26-Pound Method.

2) **If the sum of $CBOD_5$ and the calculated NBOD is consistently greater than the BOD_5 value,** partial nitrification is taking place during the 5-day test. Some of the effluent ammonia is translating into $NBOD_5$. As in the first case, the $CBOD_5$ limit may be set equal to the BOD_5 limit calculated using the WLA model or the 26-Pound Method.

3) **If $CBOD_5$ is equal (or nearly equal) to BOD_5,** nitrification is not taking place, because there is little or no $NBOD_5$ present. $CBOD_5$ limitations are not appropriate for this discharger.

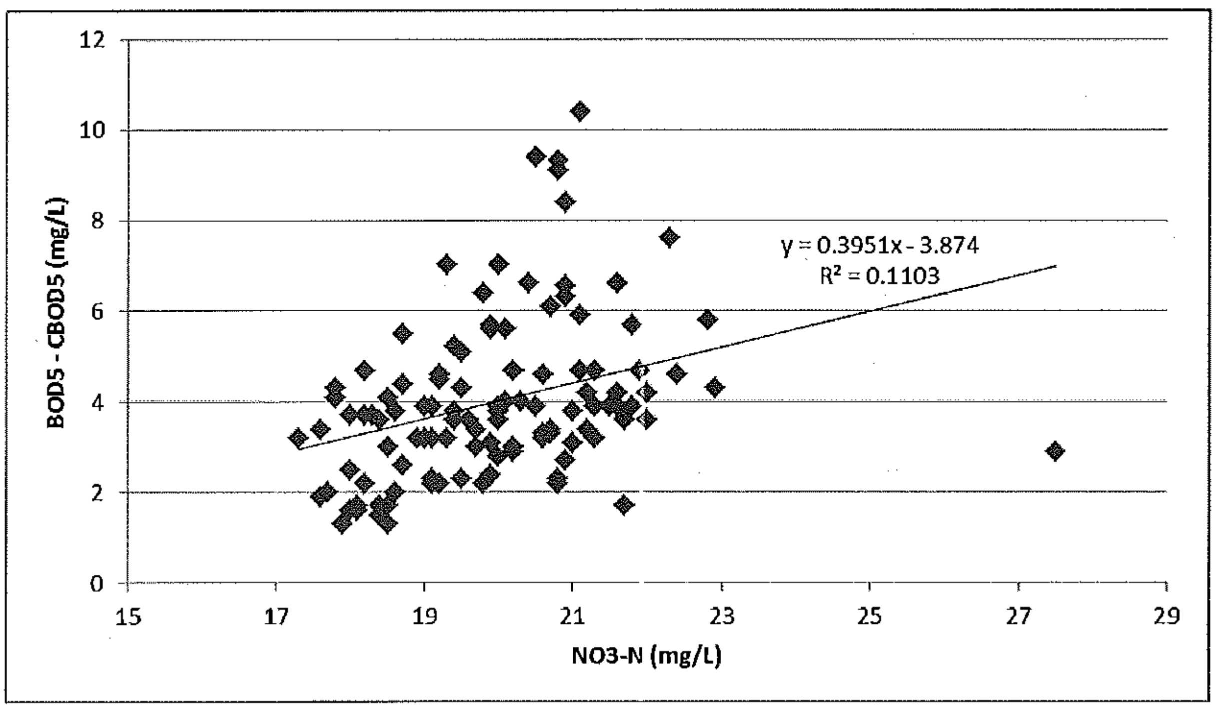
4) **If the sum of $CBOD_5$ and the calculated NBOD is consistently less than the BOD_5 values,** the test is inconclusive.

The sum of $CBOD_5$ and the calculated NBOD data is approximately half of the BOD_5 values. Therefore the data falls into category 4). Here, the difference between $CBOD_5$ and BOD_5 is greater than the amount normally associated with NBOD. Two possible explanations are considered:

(a) It is possible that the CBOD test itself is causing some form of toxic reaction, something in addition to or even beyond the effects estimated as a result of nitrification. Instead of (or in addition to) nitrification, some other reaction may be taking place.

(b) It is possible that nitrification may be occurring even faster than expected. If $NBOD_5$ is low, it may be because the nitrogen has already been converted from ammonia into nitrates and/or nitrites. If nitrate/nitrite levels are high and can be associated with the difference not explained by ammonia/$NBOD_5$, then nitrification is occurring and the recommendations given above in 1) or 2) can be used here, namely setting the $CBOD_5$ limit equal to the BOD_5 limit.

As shown in the graphs above, the effluent nitrate levels are very high and estimated NBOD is very low. The average ratio of NO_3-N to NH_3-N is 167:1, suggesting that a large amount of nitrification has already taken place. Also, the graph below shows a positive correlation between the nitrate concentration and the unaccounted for oxygen demand ($BOD_5 - CBOD_5$):



These pieces of evidence together strongly support option (b). The large difference between $CBOD_5$ and BOD_5 is most likely due to nitrification. **$CBOD_5$ limits set equal to the current BOD_5 limits are recommended in the reissued permit.**

PART 4 – WATER QUALITY-BASED EFFLUENT LIMITATIONS FOR AMMONIA NITROGEN

Monthly and weekly average limits are not re-evaluated because there have been no changes in the effluent and receiving water flows. The current daily ammonia limits were based on an effluent pH of 7.8 as a 99^{th} upper percentile value from the previous permit term . A total of 2,002 results were reported during the most recent permit term, and none of the values were above 7.8.

Potential chauges to daily maximum Ammonia Nitrogen effluent limitations:
Updates to subchapter IV of ch. NR 106, Wis. Adm. Code (effective September 1, 2016) outline the option for the Department to implement use of the $1\text{-}Q_{10}$ receiving water low flow in order to calculate daily maximum ammonia nitrogen limits if it is determined that the previous method of acute ammonia limit calculation (2×ATC) is not sufficiently protective of the fish and aquatic life. If such a determination is able to be made, the outcome of these changes could range from limits being reduced by 50 % from the previous method of calculation to no change from the 2004 method of calculation if sufficient dilution is available. The 2×ATC approach limits are considered to be the "ceiling" due to antidegradation provisions in ch. NR 207, Wis. Adm. Code.

The calculated daily maximum ammonia nitrogen effluent limits using the mass balance approach with the $1\text{-}Q_{10}$ (estimated as 80 % of $7\text{-}Q_{10}$) and the 2×ATC approach are shown below.

Summary of Calculated Daily Maximum Ammonia Nitrogen Effluent Limitations, in mg/L

	Outfall 001		Outfall 005	
Month	May - Sept	Oct - April	May - Sept	Oct - April
2×ATC	34	34	24	24
$1\text{-}Q_{10}$	17	17	12	12
Current limit	17	17	11	11

As shown in the table, the daily maximum ammonia nitrogen limits calculated using the $1\text{-}Q_{10}$ are more restrictive than the limits calculated using the 2 × ATC approach.. However the current daily maximum limits are still more restrictive. **No changes are recommended in any of the permit limits for ammonia.**

PART 5 –PHOSPHORUS

Technology Based Limits (TBL) – Phosphorus
Wisconsin Administrative Code, ch. NR 217, requires municipal wastewater treatment facilities that discharge greater than 150 pounds of Total Phosphorus per month to comply with a Monthly Average limit of 1.0 mg/L, or an approved Alternative Concentration limit. The MMSD currently has an existing technology based alternative limit of 1.5 mg/L based on biological phosphorus removal. The alternative limit is no longer applicable because the current effluent quality is well below 1.0 mg/L. An interim limit based on current effluent quality along with a more stringent water quality based limit should be included in the permit in place of this limit.

Water Quality based Effluent Limits (WQBEL)
Revisions to administrative rules regulating phosphorus took effect on December 1, 2010. These rule revisions include additions to ch. NR 102 (s. NR 102.06), which establish phosphorus standards for surface waters. Revisions to ch. NR 217 (s. NR 217, Subchapter III) establish procedures for determining water quality based effluent limits for phosphorus, based on the applicable standards in ch. NR 102.

Outfall 001
Phosphorus criteria in s. NR 102.06 do not apply to limited aquatic life waters [s. NR 102.06 (6) (d)]. These waters were not included in the USGS/WDNR stream and river studies and, therefore, the Department lacked the technical basis to determine and propose applicable criteria. At some time in the future, the Department may adopt phosphorus criteria based on new studies focusing on limited aquatic life waters. The guidance suggests that during the interim, water quality based effluent limitations should be based on the criteria and flow conditions for the next stream segment downstream. The discharge location of the wastewater from MMSD is classified as limited aquatic life downstream from the point of discharge downstream approximately 4 miles until the classification changes to LFF past the Oregon Branch. Typically discharges which fall under the Rock River TMDL don't receive phosphorus limits under NR 217.13 because the wasteload allocations were designed to be protective of impaired receiving waters. However, Badfish Creek was not listed as impaired until after the TMDL was approved. Therefore the TMDL is not protective of the LFF portion of Badfish Creek and water quality based limits must be considered for this stream segment.

Section NR 102.06(3)(a) specifically names reaches of rivers for which a phosphorus criterion of 0.1 mg/l applies. For other stream segments that are not specified in s. NR 102.06(3)(a), s. NR 102.06(3)(b) specifies a phosphorus criterion of 0.075 mg/l. The phosphorus criterion of 0.075 mg/l applies for Badfish Creek.

The conservation of mass equation is described in s. NR 217.13 (2)(a) for phosphorus water quality based effluent limitations (WQBELs).:

Limitation = [(WQC)(Qs+(1-f)Qe) – (Qs-fQe)(Cs)]/Qe

Where:
WQC = 0.075 mg/l for Badfish Creek.
Qs = 100% of the 7Q2 of 77.5 cfs.

Cs = background concentration of phosphorus in the receiving water pursuant to s. NR 217.13(2)(d)
Qe = effluent flow rate = 55 MGD = 102.2 cfs
f = the fraction of effluent withdrawn from the receiving water = 0

Section NR 217.13(2)(d), Wis. Adm. Code, specifies that the background phosphorus concentration used in the limit calculation formula shall equal the median of at least four samples collected during the months of May through October, and that all samples collected during a 28 day period shall be considered as a single sample and the average of these concentrations used to determine a median. Averaging begins at date of the first sample in the range of May through October.

The following data were considered in estimating the background phosphorus concentration:

SWIMS ID	133044	10012601	543226
Station Name	Yahara River at U.S. Hwy 51	Badfish Creek - Casey Road	Yahara River at Sth 59 Near Fulton WI
Waterbody	Yahara River	Badfish Creek	Yahara River
Sample Count	6	6	20
First Sample	10/21/2008	10/18/2006	05/01/2000
Last Sample	09/15/2009	09/18/2007	09/18/2007
Mean	0.0782	0.3043	0.2192
Median	0.0765	0.2935	0.2075
NR 217 Median	0.077	0.285	0.209

Substituting a background concentration above criteria into the limit calculation equation above would result in a calculated limit that is less than the applicable criterion of 0.075 mg/L. However, s. NR 217.13(7), Wis. Adm. Code, specifies that "if the water quality-based effluent limitation calculated pursuant to the procedures in this section is less than the phosphorus criterion specified in s. NR 102.06, Wis. Adm. Code, for the water body, the effluent limit shall be set equal to the criterion."

Limit Expression

Because the calculated WQBEL is less than or equal to 0.3 mg/L, the effluent limit of 0.075 mg/L may be expressed as a six month average. If a concentration limitation expressed as a six month average is included in the permit, a monthly average concentration limitation of 0.225 mg/L, equal to three times the WQBEL calculated under s. NR 217.13 shall also be included in the permit. The six month average should be averaged during the months of May – October and November – April.

TMDL Limits – Phosphorus

The Department has developed a TMDL for the Upper and Lower Rock River Basins. The US EPA approved the Rock River TMDL on September 28, 2011. The document, along with the referenced appendices can be found at:
http://dnr.wi.gov/topic/TMDLs/RockRiver/Final_Rock_River_TMDL_Report_with_Tables.pdf

The monthly average total phosphorus (Total P) effluent limits in lbs/day are calculated based on the monthly phosphorus wasteload allocation (WLA) given in pounds per month as suggested in the *TMDL Development and Implementation Guidance: Integrating the WPDES and Impaired Waters Programs* dated April 15, 2013. The WLA for this facility is found in the *Total Maximum Daily Loads for Total*

Phosphorus and Total Suspended Solids in the Rock River Basin report dated July 2011. The limits are equivalent to concentrations ranging from 0.129 mg/L to 0.161 mg/L at the facility design flow of 50 MGD. **Monthly average mass effluent limits in accordance with the following table are recommended for this discharge.**

Total Phosphorus Effluent Limitations

Month	Monthly Total P WLA[1] (lbs/month)	Days Per Month	Monthly Ave Total P Effluent Limit[2] (lbs/day)
Jan	1874.87	31	**60.48**
Feb	1886.69	28	**67.38**
March	1816.15	31	**58.59**
April	1796.94	30	**59.90**
May	1759.56	31	**56.76**
June	1835.71	30	**61.19**
July	1741.16	31	**56.17**
Aug	1676.93	31	**54.09**
Sept	1623.92	30	**54.13**
Oct	1717.37	31	**55.40**
Nov	1804.09	30	**60.14**
Dec	1863.48	31	**60.11**

Footnotes:

1- Rock River TMDL Appendix P. Monthly Total Phosphorus Allocations by Wastewater Treatment Facility (p. 147)

2- monthly average Total P effluent limit (lbs/day) = monthly Total P WLA (lbs/month) ÷ days per month

Outfall 005

Section NR 102.06(3)(a) specifically names reaches of rivers for which a phosphorus criterion of 0.1 mg/l applies. For other stream segments that are not specified in s. NR 102.06(3)(a), s. NR 102.06(3)(b) specifies a phosphorus criterion of 0.075 mg/l. The phosphorus criterion of 0.075 mg/l applies for Badger Mill Creek.

The conservation of mass equation is described in s. NR 217.13 (2)(a) for phosphorus water quality based effluent limitations (WQBELs).:

$$\text{Limitation} = [(WQC)(Qs+(1-f)Qe) - (Qs-fQe)(Cs)]/Qe$$

Where:
WQC = 0.075 mg/l for Badger Mill Creek.
Qs = 100% of the 7Q2 of <0.01 cfs.
Cs = background concentration of phosphorus in the receiving water pursuant to s. NR 217.13(2)(d)
Qe = effluent flow rate = 3.6 MGD = 6.69 cfs
f = 0, the fraction of effluent withdrawn from the receiving water

A review of all available in stream total phosphorus data stored in the Surface Water Integrated Monitoring System database from 5/9/2000 to 10/02/2000 indicates the median background total phosphorus concentration in Badger Mill Creek at Verona Station #133212 is 0.2158 mg/L, downstream from the point of discharge to Badger Mill Creek.

Other nearby monitoring stations also have phosphorus concentrations exceeding criteria. At SWIMS Station #133417 on the Sugar River before confluence with Badger Mill Creek, total phosphorus concentration is 0.0885 mg/L. At SWIMS Station #133416 on the Sugar River downstream of the confluence with Badger Mill Creek, total phosphorus concentration is 0.1159 mg/L.

The following data were considered in estimating the background phosphorus concentration:

SWIMS ID	133212	133417	133416
Station Name	Badger Mill Creek at Verona Stp.Rd Bruce St	Sugar River at Valley Road	Sugar River at Sth 69 Dwnstm Bridge
Waterbody	Badger Mill Creek	Sugar River	Sugar River
Sample Count	10	10	10
First Sample	05/09/2000	05/09/2000	05/09/2000
Last Sample	10/02/2000	10/02/2000	10/02/2000
Mean	0.2158 mg/L	0.0885 mg/L	0.1159 mg/L
Median	0.2025 mg/L	0.0755 mg/L	0.103 mg/L
NR 217 Median	0.221 mg/L	0.081 mg/L	0.109 mg/L

Substituting a median value of 0.2025 mg/L into the limit calculation equation above would result in a calculated limit that is less than the applicable criterion of 0.075 mg/L. However, s. NR 217.13(7), Wis. Adm. Code, specifies that "if the water quality-based effluent limitation calculated pursuant to the procedures in this section is less than the phosphorus criterion specified in s. NR 102.06, Wis. Adm. Code, for the water body, the effluent limit shall be set equal to the criterion."

Limit Expression

Because the calculated WQBEL is less than or equal to 0.3 mg/L, the effluent limit of 0.075 mg/L may be expressed as a six month average. If a concentration limitation expressed as a six month average is included in the permit, a monthly average concentration limitation of 0.225 mg/L, equal to three times the WQBEL calculated under s. NR 217.13 shall also be included in the permit. The six month average should be averaged during the months of May – October and November – April.

Mass Limits

The downstream receiving water, the Sugar River is listed as impaired for phosphorus, therefore a mass limit is also required, pursuant to s. NR 217.14(1)(a), Wis. Adm. Code. **This final mass limit shall be 0.075 mg/L × 8.34 × 3.6 MGD = 2.25 lbs/day.**

Effluent Data

The following table summarizes effluent total phosphorus monitoring data from January 2011 through June 2016. The data suggest that a compliance schedule will be necessary in order for the facility to meet the given limits at both Outfalls 001 and 005.

Attachment #1

	Phosphorus mg/L
1-day P_{99}	0.73
4-day P_{99}	0.48
30-day P_{99}	0.35
Mean	0.29
Std	0.13
Sample size	1989
Range	0.08 to 1.27

<u>Interim Limits – Outfalls 001 and 005</u>

An interim limit is required per s. NR 217.17 when a compliance schedule is needed in the permit to meet the WQBEL. The interim limit should reflect a concentration that the facility is able to meet without investing in additional "temporary" treatment, but also should prevent backsliding from current conditions.

With its permit application, Madison Met has indicated that they are pursuing watershed adaptive management as a means to comply with the phosphorus limitations for Outfall 001. Since this is the first permit term in which MMSD is implementing an adaptive management plan, a 6-month average phosphorus limit of 0.6 mg/L should be included in the permit pursuant s. NR 217.18(3) (e) 2, Wis. Adm. Code, An effluent limit not to exceed 1.0 mg/L of total phosphorus expressed as a monthly average shall also be included in the permit. The department may allow the permittee a compliance schedule that may not exceed five years if necessary to meet this interim limitation."

Therefore **it is recommended that the interim limits for Outfalls 001 and 005 be set equal to 0.6 mg/L as a 6-month average and 1.0 mg/L as a monthly average for permit reissuance along with requirements for optimization of phosphorus removal.**

PART 6 –TOTAL SUSPENDED SOLIDS (TSS)

<u>Outfall 001</u>

TMDL Limits – TSS

The Rock River TMDL also has wasteload allocations (WLA) for total suspended solids (TSS). For a municipal facility the limits for TSS must be expressed as weekly and monthly averages. The current permit includes a monthly average limit of 20 mg/L and a weekly average limit of 23 mg/L which equates to 8340 lbs/day monthly and 9591 lbs/day weekly at the facilities design flow of 50 MGD.

Monthly average and weekly average mass effluent limitations should be included in the permit according to the table below, along with the currently imposed concentration limit. For reference, the mass limits shown are equivalent to concentrations ranging from 11 – 20 mg/L as a monthly average and 18 – 34 mg/L as a weekly average.

Attachment #1

Total Suspended Solids WLA- Outfall 001

Month	Monthly TSS WLA[1] (tons/month)	Days Per Month	Monthly Ave TSS Effluent Limit from WLA[2] (lbs/day)	Weekly Ave TSS Effluent Limit from WLA[3] (lbs/day)	Recommended Monthly Ave TSS Effluent Limit (lbs/day)	Recommended Weekly Ave TSS Effluent Limit (lbs/day)
Jan	106	31	6860	11500	**6860**	**9591**
Feb	119	28	8470	14100	**8340**	**9591**
March	126	31	8160	13600	**8160**	**9591**
April	126	30	8430	14100	**8340**	**9591**
May	126	31	8160	13600	**8160**	**9591**
June	126	30	8430	14100	**8340**	**9591**
July	126	31	8160	13600	**8160**	**9591**
Aug	110	31	7080	11800	**7080**	**9591**
Sept	69.1	30	4600	7690	**4600**	**7690**
Oct	111	31	7180	12000	**7180**	**9591**
Nov	126	30	8430	14100	**8340**	**9591**
Dec	111	31	7170	12000	**7170**	**9591**

Footnotes:

1- Rock River TMDL Appendix Q. Monthly Total Suspended Solids Allocations by Wastewater Treatment Facility (p. 149)

2- Monthly average TSS effluent limit (lbs/day) = maximum monthly TSS WLA (tons/month) ÷ days per month x 2,000 lbs/ton

3- Weekly average effluent limit (lbs/day) = monthly average limit (lbs/day) x multiplier

The current permit contains monthly and weekly average mass limitations for TSS of 8340 lbs/day and 9591 lbs/day respectively. In months where the TMDL is less restrictive than the current mass limits, the current mass limits apply unless the facility is able to make a successful demonstration of need for the higher limits.

The multiplier used in the weekly average limit calculation was determined according to implementation guidance. A coefficient of variation was calculated, based on TSS mass monitoring data, to be 0.31. This value, along with monitoring frequency, is used to select the multiplier. Monitoring for TSS is specified as daily in the current permit. Based on these two variables, Table 5-3 of EPA's Technical Support Document for Water Quality-based Toxics Control (EPA/505/2-90-001) is used to select the multiplier of 1.67. **If there is a change in monitoring frequency from daily, the stated limits should be re-evaluated.**

Limits based on a WLA should be given in a permit regardless of reasonable potential. However, for informational purposes, the following table lists the statistics for Total Suspended Solids discharge from January 2011 through June 2016.

Attachment #1

	TSS (mg/L)	**TSS (lbs/day)**
1-day P_{99}	8.60	2728
4-day P_{99}	6.35	1988
30-day P_{99}	5.15	1596
Mean	4.55	1398
Std	1.36	440
Sample Size	1989	1989
Range	0.9-20	0-6227

Outfall 005

No changes are recommended to TSS limits at Outfall 005.

PART 7 –THERMAL

New surface water quality standards for temperature took effect on October 1, 2010. These new regulations are detailed in Chapter NR 102 (Subchapter II – Water Quality Standards for Temperature) and NR 106 (Subchapter V – Effluent Limitations for Temperature) of the Wisconsin Administrative Code.

Outfall 001

The daily maximum effluent temperature limitation shall be 86 °F for discharges to surface waters classified as Limited Aquatic Life according to s. NR 104.02(3)(b)1, except for those classified as wastewater effluent channels and wetlands regulated under ch. NR 103 [s. NR 106.55(2), Wis. Adm. Code] which have effluent temperature limitations of 120 °F. This outfall is classified as a wastewater effluent channel so the applicable daily maximum effluent temperature limitation is 120 °F.

Reasonable Potential

Based on the available discharge temperature data from October 2012 through December 2013 and shown below, the maximum daily effluent temperature reported was 71°F; therefore, no reasonable potential for exceeding the daily maximum limit exists, and **no limits are recommeuded.**

Attachment #1

Badfish Creek (001)				
Month	Representative Highest Monthly Effluent Temperature		**Calculated Effluent Limit**	
	Weekly Maximum (°F)	Daily Maximum (°F)	**Weekly Average Effluent Limitation** (°F)	**Daily Maximum Effluent Limitation** (°F)
JAN	56	57	-	120
FEB	54	55	-	120
MAR	54	55	-	120
APR	55	58	-	120
MAY	61	63	-	120
JUN	65	65	-	120
JUL	69	70	-	120
AUG	70	71	-	120
SEP	70	71	-	120
OCT	68	69	-	120
NOV	63	64	-	120
DEC	58	60	-	120

Outfall 005

Daily maximum and weekly average temperature criteria are available for the 12 different months of the year for Limited Forage Fish streams.

In accordance with s. NR 106.53(2)(b), the highest daily maximum flow rate for a calendar month is used to determine the acute (daily maximum) effluent limitation. In accordance with s. NR 106.53(2)(c), the highest 7-day rolling average flow rate for a calendar month is used to determine the sub-lethal (weekly average) effluent limitation. These values were based off of actual flow reported from September 2009 to March 2016.

The tables below summarize the maximum temperatures reported during monitoring from October 2012 to December 2013. Comparing the representative highest effluent temperature to the calculated effluent limits determines the reasonable potential of exceeding the effluent limits. The months in which limitations are recommended are highlighted. The complete thermal tables used for the calculations are attached.

Based on available discharge temperature data, **there is reasonable potential to exceed temperature limits in the months of January, October, November, and December. Limits are recommended for these months.**

Attachment #1

Badger Mill Creek (005)				
	Representative Highest Monthly Effluent Temperature		**Calculated Effluent Limit**	
Month	Weekly Maximum (°F)	Daily Maximum (°F)	**Weekly Average Effluent Limitation** (°F)	**Daily Maximum Effluent Limitation** (°F)
JAN	**56**	57	**54**	**78**
FEB	54	55	**54**	**79**
MAR	54	55	**57**	**80**
APR	55	58	**63**	**81**
MAY	61	63	**70**	**84**
JUN	65	65	**77**	**85**
JUL	69	70	**81**	**86**
AUG	70	71	**79**	**86**
SEP	70	71	**73**	**85**
OCT	**68**	69	63	**83**
NOV	**63**	64	**54**	**80**
DEC	**61**	62	**54**	**79**

**Temperature data from 08/12/13 to 08/16/13 and from 10/28/13 to 10/31/13 was excluded because effluent was not discharged at outfall 005 for maintenance reasous.

The following general options are available for a facility to explore potential relief from the temperature limits:

- Effluent monitoring data: Verification or additional effluent monitoring (flow and/or temperature) may be appropriate if there were questions on the representativeness of the current effluent data.
- Dissipative cooling demonstration: Effluent limitations based on sub-lethal criteria may be adjusted based on the potential for heat dissipation from municipal treatment plants (s. NR 106.59(4))
- Alternative Effluent Limitation: Permittees may request an alternative effluent limit for temperature (AEL) under ch. NR 106 Subchapter VI, Wis. Adm. Code, to demonstrate that the default effluent limitations for temperature determined under Subchapter V are more stringent than necessary to protect fish and aquatic life.
- A variance to the water quality standard: This is typically considered to be the least preferable and most complex option as it requires the evaluation of the other alternatives.

These options are explained in additional detail in the August 15, 2013 Department *Guidance for Implementation of Wisconsin's Thermal Water Quality Standards* http://dnr.wi.gov/topic/surfacewater/documents/ThermalGuidance2edition8152013.pdf

The permittee is currently conducting an AEL (Alternative Effluent Limit) Study for Outfall 005 to reevaluate this temperature review. This study will be addressed in a separate report.

PART 8 – WHOLE EFFLUENT TOXICITY (WET)

WET testing is used to measure, predict, and control the discharge of toxic materials that may be harmful to aquatic life. In WET tests, organisms are exposed to a series of effluent concentrations for a given time and effects are recorded. The following evaluation is based on procedures in the Department's WET Program Guidance Document (revision #11, dated November 1, 2016).

- Acute tests predict the concentration that causes lethality of aquatic organisms during a 48 to 96-hour exposure. In order to assure that a discharge is not acutely toxic to organisms in the receiving water, WET tests must produce a statistically valid LC_{50} (Lethal Concentration to 50% of the test organisms) greater than 100% effluent.

- Chronic tests predict the concentration that interferes with the growth or reproduction of test organisms during a seven-day exposure. In order to assure that a discharge is not chronically toxic to organisms in the receiving water, WET tests must produce a statistically valid IC_{25} (Inhibition Concentration) greater than the instream waste concentration (IWC). The IWC is an estimate of the proportion of effluent to total volume of water (receiving water + effluent). The IWC of 100% shown in the WET Checklist summary below was calculated according to the following equation, as specified in s. NR 106.03(6):

$$IWC\ (\text{as }\%) = Q_e \div \{(1 - f)Q_e + Q_s\} \times 100$$

Where:

Q_e = annual average flow = 77.5 cfs for 001 and 5.6 cfs for 005
f = fraction of the Q_e withdrawn from the receiving water = 0
Q_s = ¼ of the 7-Q_{10} = 0 cfs ÷ 4 = 0 cfs

- According to the *State of Wisconsin Aquatic Life Toxicity Testing Methods Manual* (s. NR 219.04, Table A, Wis. Adm. Code), a synthetic (standard) laboratory water may be used as the dilution water and primary control in acute WET tests, unless the use of different dilution water is approved by the Department prior to use. The primary control water must be specified in the WPDES permit.

- According to the *State of Wisconsin Aquatic Life Toxicity Testing Methods Manual* (s. NR 219.04, Table A, Wis. Adm. Code), receiving water must be used as the dilution water and primary control in chronic WET tests, unless the use of different dilution water is approved by the Department prior to use. The dilution water used in WET tests conducted on Outfalls 001 and 005 shall be a grab sample collected from the receiving water location, upstream/out of the influence of the mixing zone and any other known discharge. The specific receiving water location must be specified in the WPDES permit.

- Shown below is a tabulation of all available WET data for Outfalls 001 and 005. Efforts are made to insure that decisions about WET monitoring and limits are made based on representative data. Data which is not believed to be representative of the discharge is not included in reasonable potential calculations. The table below differentiates between tests used and not used when making WET determinations.

Attachment #1

WET Data History

Outfall 001									
Date Test Initiated	Acute Results LC$_{50}$ % (% survival in 100% effluent)				Chronic Results IC$_{25}$ %				
	C. dubia	Fathead minnow	Pass or Fail?	Used in RP?	*C. dubia*	Fathead Minnow	Pass or Fail?	Use in RP?	Footnotes or Comments
7/20/2010					>100	>100	Pass	Y	
3/22/2011	>100	>100	Pass	Y				N	1
4/5/2011					>100	>100	Pass	Y	2
5/17/2011					>100	>100	Pass	Y	
6/26/2012	>100	>100	Pass	Y	>100	>100	Pass	Y	
8/21/2012					>100	>100	Pass	Y	
8/20/2013					82.1	100	Pass	N	1
9/24/2013					>100		Pass	Y	2,3
9/24/2013					>100	>100	Pass	Y	2
10/08/2013					>100		Pass	Y	2,3
10/08/2013					>100	>100	Pass	Y	2
12/10/2013	>100	>100	Pass	Y	>100	>100	Pass	Y	
8/05/2014	>100	>100	Pass	Y			Pass	Y	
9/23/2014					>100	>100	Pass	Y	2
9/23/2014					>100		Pass	Y	3
11/18/2014					>100	>100	Pass	Y	
3/03/2015	>100	>100	Pass	Y	>100	>100	Pass	Y	
6/16/2015					>100	>100	Pass	Y	

Footnotes:

1) *Qualified or Inconclusive Data.* QA concerns were noted during testing which calls into question the reliability of the test results. A retest was requested.
2) *Retest.* Shows the results from a retest in response to the request for a retest from the previous chronic WET testing attempt.
3) *Effluent treated with UV light before use.*

Attachment #1

Outfall 005									
Date Test Initiated	Acute Results LC$_{50}$ % (% survival in 100% effluent)				Chronic Results IC$_{25}$ %				
	C. dubia	Fathead minnow	Pass or Fail?	Used in RP?	*C. dubia*	Fathead Minnow	Pass or Fail?	Use in RP?	Footnotes or Comments
8/12/2010					>100	>100	Pass	Y	
3/03/2011	>100	>100	Pass	Y	>100	>100	Pass	Y	
6/09/2011					>100	>100	Pass	Y	
6/19/2012	>100	>100	Pass	Y	>100	>100	Pass	Y	
9/11/2012					>100	>100	Pass	Y	
9/10/2013					<12.5	>100	Pass	N	1
11/05/2013	>100	>100	Pass	Y		>100	Pass	Y	2
11/12/2013					>100	>100	Pass	Y	3
11/19/2013					>100	>100	Pass	Y	3
12/03/2013					>100	>100	Pass	Y	
10/21/2014	>100	>100	Pass	Y	>100	>100	Pass	Y	4
10/21/2014					98.5	>100	Pass	N	5
11/04/2014					>100	>100	Pass	Y	
3/17/2015	>100	>100	Pass	Y	>100	>100	Pass	Y	
4/21/2015							Fail	N	1
5/05/2015					>100	>100	Pass	Y	

Footnotes:

1) *Qualified or Inconclusive Data.* QA concerns were noted during testing which calls into question the reliability of the test results.
2) *Retest of Fathead Minnow Only. C. dubia* test was terminated due to excessive organism mortality in the control solutions.
3) *Retest to substitute for 9/10/2013 test.*
4) *Effluent was treated with UV light before use*
5) *Parallel test with UV treated effluent for the same day used instead because of pathogen issues*

- WET reasonable potential is determined by multiplying the highest toxicity value that has been measured in the effluent by a safety factor, in order to predict the likelihood (95% probability) of toxicity occurring in the effluent above the applicable WET limit. The safety factor used in the equation changes based on the number of toxicity detects in the dataset. The fewer detects present, the higher the safety factor, because there is more uncertainty surrounding the predicted value. WET limits must be given, according to s. NR 106.08(6), Wis. Adm. Code, whenever the applicable Reasonable Potential equation results in a value greater than 1.0.

  According to s. NR 106.08(6)(d), TUa effluent values are equal to zero whenever toxicity is not detected (i.e. when the LC50. IC25 or IC 50 ≥ 100%.)

Acute Reasonable Potential = 0 < 1.0, reasonable potential is not shown and a limit is not required.

Chronic Reasonable Potential = 0 < 1.0, reasonable potential is not shown and a limit is not required

The WET Checklist was developed to help DNR staff make recommendations regarding WET limits, monitoring, and other permit conditions. The Checklist steps the user through a series of questions that evaluate the potential for effluent toxicity. The Checklist indicates whether acute and chronic WET limits are needed, based on requirements specified in s. NR 106.08, Wis. Adm. Code, and recommends monitoring frequencies based on points accumulated during the Checklist analysis. As toxicity potential increases, more points accumulate and more monitoring is recommended to insure that toxicity is not occurring. The completed WET Checklist recommendations for this permittee are summarized in the table below. Staff recommendations, based on the WET Checklist and best professional judgment, are provided below the summary table. For guidance related to RP and the WET Checklist, see Chapter 1.3 of the WET Guidance Document: http://dnr.wi.gov/topic/wastewater/WETguidance.html.

WET Checklist Summary

	Outfall 001	
	Acute	**Chronic**
AMZ/IWC	Not Applicable. **0 Points**	IWC = 100 %. **15 Points**
Historical Data	All passed, RPF=0 **0 Points**	All passed, RPF=0 **0 Points**
Effluent Variability	No violations or upsets, consistent WWTF operations **0 Points**	Same as Acute. **0 Points**
Receiving Water Classification	< 4 mi from FFAL Variance Water **5 Points**	Same as Acute. **5 Points**
Chemical-Specific Data	Limits for ammonia based on ATC; Cd, Cr, Pb, Hg, Ni, Zn, Cn, Chloride detected. Additional: Chloroform, Antimony, Dichlorobromomethane, 1,4-Dichlorobenzene **10 Points**	Limits for Chloride and ammonia based on CTC; Cd, Cr, Pb, Hg, Ni, Zn, Cn detected. Additional: Chloroform, Antimony, Dichlorobromomethane, 1,4-Dichlorobenzene **11 Points**
Additives	0 Biocides and 0 Water Quality Conditioners added. SorbX-100 Used: No **0 Points**	None **0 Points**

Attachment #1

Discharge Category	45 Industrial Contributors. Including food processing, dairy operations, meat packing, and waste from other activities **15 Points**	Same as Acute. **15 Points**
Wastewater Treatment	Secondary Treatment **0 Points**	Same as Acute. **0 Points**
Downstream Impacts	No impacts known **0 Points**	Same as Acute. **0 Points**
Total Checklist Points:	**30 Points**	**46 Points**
Recommended Monitoring Frequency (from Checklist):	1x yearly	2x yearly
Limit Required?	No	No
TRE Recommended? (from Checklist)	No	No

Outfall 005		
	Acute	**Chronic**
AMZ/IWC	Not Applicable. **0 Points**	IWC = 100 %. **15 Points**
Historical Data	All passed, RPF = 0. **0 Points**	All passed, RP = 0. **0 Points**
Effluent Variability	No violations or upsets, consistent WWTF operations **0 Points**	Same as Acute. **0 Points**
Receiving Water Classification	Limited Forage Fish community **5 Points**	Same as Acute. **5 Points**
Chemical-Specific Data	Limits for ammonia based on ATC; Cd, Cr, Pb, Hg, Ni, Zn, Cn, Chloride detected. Additional: Chloroform, Antimony, Dichlorobromomethane, 1,4-Dichlorobenzene **10 Points**	Limits for Chloride and ammonia based on CTC; Cd, Cr, Pb, Hg, Ni, Zn, Cn detected. Additional: Chloroform, Antimony, Dichlorobromomethane, 1,4-Dichlorobenzene **11 Points**

Additives	0 Biocides and 0 Water Quality Conditioners added. SorbX-100 Used: No **0 Points**	Same as Acute. **0 Points**
Discharge Category	45 Industrial Contributors. Including food processing, dairy operations, meat packing, waste from other activities **15 Points**	Same as Acute. **15 Points**
Wastewater Treatment	Secondary Treatment **0 Points**	Same as Acute. **0 Points**
Downstream Impacts	No impacts known **0 Points**	Same as Acute. **0 Points**
Total Checklist Points:	**30 Points**	**46 Points**
Recommended Monitoring Frequency (from Checklist):	1x yearly	2x yearly
Limit Required?	No	No
TRE Recommended?	No	No

- Following the guidance provided in the Department's WET Program Guidance Document (revision #11, dated November 1, 2016), based upon the point totals generated by the WET Checklist, other information given above, and Chapter 1.3 of the WET Guidance Document, **annual acute WET testing and 2x yearly chronic WET testing is recommended for both outfalls** in the reissued permit. Tests should be done in rotating quarters, in order to collect seasonal information about this discharge. WET testing shall continue after the permit expiration date (until the permit is reissued).

- A minimum of annual acute and chronic monitoring is recommended at each outfall because MMSD is a major municipal discharger with a design flow in excess of 1.0 MGD. Federal regulations at 40 CFR Part 122.21(j) requires at least 4 acute and chronic WET tests with each permit application on samples collected since the previous reissuance.

PART 9 – EXPRESSION OF LIMITS

Revisions to ch. NR 106 align Wisconsin's water quality-based effluent limitations with 40 CFR 122.45(d), which requires WPDES permits contain the following limits, whenever practicable and necessary to protect water quality:

- Weekly average and monthly average limitations for publically owned treatment works (POTWs), and
- Daily maximum and monthly average limitations for all other discharges.

MMSD is POTW, and is therefore subject to weekly average and monthly average limitations whenever limitations are determined to be necessary.

This evaluation provides additional limitations necessary to comply with the expression of limits in s. NR 106.07. Pollutants already compliant with s. NR 106.07 or that have an approved impracticability demonstration, are excluded from this evaluation including water-quality based effluent limitations for phosphorus, temperature, and pH, among other parameters.

Additional limitations needed to comply with s. NR 106.07 Expression of limits:

Parameter	Weekly Average	Monthly Average	Multiplication Factor (CV)	Assumed Monitoring Frequency (n)
Outfall 001				
Fecal Coliform	780#/100 mL		1.95	8
Outfall 005				
Fecal Coliform	780#/100 mL		1.95	8
TSS May-Oct Nov-April	17 mg/L 27 mg/L		1.67	30
$CBOD_5$ May-Oct Nov-April		7 mg/L 16 mg/L		

Method for calculation:

The methods for calculating limitations for municipal POTWs to conform to 40 CFR 122.45(d) are specified in s. NR 106.07(3), and are as follows:

1. Whenever a daily maximum limitation is determined necessary to protect water quality, a weekly and monthly average limitation shall also be included in the permit and set equal to the daily maximum limit unless a more restrictive limit is already determined necessary to protect water quality.
2. Whenever a weekly average limitation is determined necessary to protect water quality, a monthly average limitation shall also be included in the permit and set equal to the weekly average limit unless a more restrictive limit is already determined necessary to protect water quality.
3. Whenever a monthly average limitation is determined necessary to protect water quality, a weekly average limit shall be calculated using the following procedure and included in the permit unless a more restrictive limit is already determined necessary to protect water quality:

   Weekly Average Limitation = (Monthly Average Limitation x MF)

   Where:

   MF= Multiplication factor as defined in Table 1

   CV= coefficient of variation (CV) as calculated in s. NR 106.07(5m)

   n= the number of samples per month required in the permit

Attachment #1

s. NR 106.07 (3) (e) 4. Table 1 — For Fecal Coliform at Outfalls 001 and 005

CV	n=1	n=2	n=3	n=4	n=8	n=12	n=16	n=20	n=24	n=30
0.6	1.00	1.31	1.51	1.64	1.95	2.12	2.23	2.30	2.36	2.43

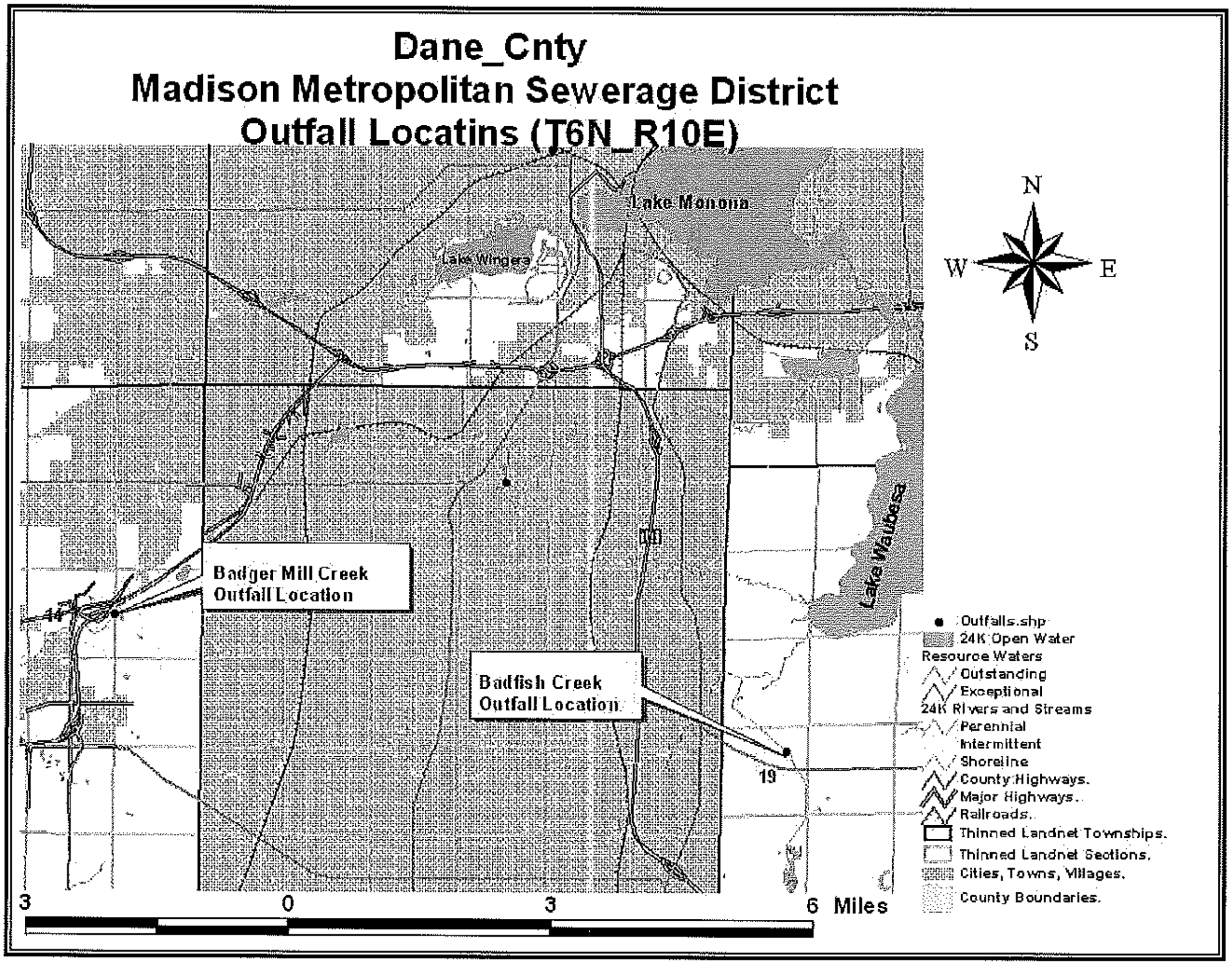
For TSS at Outfall 005

CV	n=1	n=2	n=3	n=4	n=8	n=12	n=16	n=20	n=24	n=30
0.3	1.00	1.19	1.29	1.36	1.49	1.56	1.60	1.63	1.65	1.67

Note: This methodology is based on the *Technical Support Document for Water Quality-based Toxics Control* (March 1991). PB91-127415.

Attachment #2

Site Map



Attachment #3

Temperature limits for receiving waters with unidirectional flow

(calculation using default ambient temperature data)

Facility:	MMSD - Badger Mill Creek	**Data Range**		**7Q10 or 4B3:**	0 cfs
Outfall(s):	005	**Start:**	01/01/12	**Dilution:**	25%
Date Prepared:		**End:**	04/30/16	**f:**	0
Design Flow (Qe):	3.6 mgd			**Stream type:**	Limited forage fish community
Region:	SC			**Qs:Qe ratio:**	0.0 :1
				Calculation Needed?	YES

Month	Water Quality Criteria			Receiving Water Flow Rate (Qs)	Representative Highest Effluent Flow Rate (Qe)		Representative Highest Monthly Effluent Temperature		99th Percentile of Representative Data		**Calculated Effluent Limits**	
	Ta (default)	Sub-Lethal WQC	Acute WQC		7-day Rolling Ave (Qesl)	Daily Max Flow Rate (Qea)	Weekly Ave	Daily Max	Weekly Ave	Daily Max*	**Weekly Ave Limit**	**Daily Max Limit**
	(°F)	(°F)	(°F)	(cfs)	(mgd)	(mgd)	(°F)	(°F)	(°F)	(°F)	(°F)	(°F)
JAN	37	54	78	0.00	3.497	3.500	**56**	57	**56**	58	54	78
FEB	39	54	79	0.00	3.190	3.190	54	55	54	55	54	79
MAR	43	57	80	0.00	3.571	3.580	54	55	54	55	57	80
APR	50	63	81	0.00	3.560	3.580	55	58	55	57	63	81
MAY	59	70	84	0.00	3.569	3.590	61	63	61	64	70	84
JUN	64	77	85	0.00	3.586	3.590	65	65	65	68	77	85
JUL	69	81	86	0.00	3.581	3.590	69	70	69	72	81	86
AUG	68	79	86	0.00	3.591	3.680	70	71	70	66	79	86
SEP	63	73	85	0.00	3.597	3.660	70	71	70	72	73	85
OCT	55	63	83	0.00	3.584	3.590	**68**	69	**68**	68	63	83
NOV	46	54	80	0.00	3.579	3.590	**63**	64	**63**	NA	54	80
DEC	40	54	79	0.00	3.517	3.520	**61**	62	**59**	NA	54	79

*NA - Indicates that there are greater than 100 daily maximum values, therefore 99th percentile would be a value less than the recorded daily maximum.

**Temperature data from 08/12/13 to 08/16/13 and from 10/28/13 to 10/31/13 was excluded because effluent was not discharged at outfall 005 for maintenance reasons.

WDNR MEMORANDUM
ON WATER QUALITY BASED EFFLUENT LIMITATIONS
FOR THE MADISON METROPOLITAN SEWERAGE DISTRICT
FOR FACILITY PLANNING PURPOSES

State of Wisconsin

CORRESPONDENCE/MEMORANDUM

DATE: DRAFT FILE REF: 3200

TO: Steve Smith – WY/3

FROM: Adrian Stocks – WY/3

SUBJECT: Water Quality-Based Effluent Limitations for the Madison Metropolitan Sewerage District for Facility Planning Purposes WPDES Permit No. WI-0024597

This is in response to your request for an evaluation of the need for water quality-based effluent limitations for facility planning purposes using Chapters NR 102, 104, 105, 106, 207, 210 and 217 of the Wisconsin Administrative Code (where applicable), for the discharge from the Madison Metropolitan Sewerage District (MMSD) (Nine Springs Wastewater Treatment Plant) in Dane County. This municipal WWTF currently discharges effluent through two different outfalls.

- Outfall 001 discharges to Badfish Creek located in the Lower Badfish Creek Watershed (LR-07) in the Lower Rock River Basin. This outfall is included in the Rock River Total Maximum Daily Load (TMDL) as approved by EPA.
- Outfall 005 discharges to Badger Mill Creek which is the Upper Sugar River Watershed (SP-15) in the Sugar-Pecatonica River Basin.

Three possible design scenarios were submitted by MMSD:

	Number of Outfalls	Description	Design Average Flow (MGD)		
			Total	Badfish Creek (001)	Badger Mill Creek (005)
Scenario 1	2	Same Outfall Capacities	53.6	50	3.6
Scenario 2	2	Expand 005	53.6	48.6	5.0
Scenario 3	1	Discontinue 005	53.6	53.6	-

The facility planning request also included an option for a discharge to Nine Springs Creek which flows into Upper Mud Lake and then into Lake Waubesa. This would be a new discharge of phosphorus according to the definition in s. NR 217.11(3). Nine Springs Creek is listed as impaired for Phosphorus so the requirements of s. NR 217.13(8) for new discharges of phosphorus to impaired waters would apply. Nine Springs Creek is included as part of the Rock River TMDL for phosphorus and TSS; however, this new discharge did not receive a wasteload allocation (WLA) as part of the TMDL, nor is there reserve capacity. Therefore, the new discharge to Nine Springs Creek would have to discharge zero phosphorus and zero TSS. It could be possible to offset the discharge by implementing a trade which would need to be approved by the Department and implemented prior to discharge. A compliance schedule for this discharge would not be allowed per s. NR 217.17(4). Additionally, Section 281.47, Wis. State Statute would apply to a discharge at this location because it flows to Lake Waubesa. This statute states that tertiary treatment would be required at this outfall.

This evaluation specifically addresses the so-called "conventional pollutants" as well as ammonia, phosphorus, the need for disinfection and temperature. The recommendations are discussed in more detail in the attached report. Effluent limits for toxic substances (other than ammonia) and WET testing requirements were not re-evaluated in this report as they are not expected to change as part of the facility planning efforts.

Based on our review, the following recommendations are made on a chemical-specific basis for each outfall:

Outfall 001 Badfish Creek – for all three proposed scenarios (Qe = 50 MGD, 48.6 MGD or 53.6 MGD)

Parameter	Daily Maximum	Daily Minimum	Weekly Average	Monthly Average	Six-Month Average	Footnotes
BOD_5			20 mg/L 8340 lbs/day	19 mg/L 7923 lbs/day		1
TSS			23 mg/L	20 mg/L		2
Dissolved Oxygen		5.0 mg/L				1
pH	6.0 s.u.	9.0 s.u.				
Fecal Coliforms April 15-Oct 15			**780/#100 ml** Geometric mean	400/#100 ml Geometric mean		3
Ammonia Nitrogen May-Sept Oct-April	 17 mg/L 13 mg/L		 4.4 mg/L 10 mg/L	 1.8 mg/L 4.1 mg/L		8,9
Phosphorus Interim Final				 1.0 mg/L 0.225 mg/L	 0.6 mg/L 0.075 mg/L	2,5
Chloride			400 mg/L			4
Mercury				1.3 ngL		4

Outfall 005 Badger Mill Creek – for scenarios 1 and 2 (Qe = 3.6 MGD or 5.0 MGD)

Parameter	Daily Maximum	Daily Minimum	Weekly Average	Monthly Average	Six-Month Average	Footnotes
BOD_5 May-Oct Nov-April			 7.0 mg/L 16 mg/L	 7.0 mg/L 16 mg/L		1
TSS May-Sept Oct-April			 10 mg/L 16 mg/L	 10 mg/L 16 mg/L		1
Dissolved Oxygen		5.0 mg/L				1
pH	6.0 s.u.	9.0 s.u.				
Fecal Coliforms May 1 – Sept 30			**780/#100 ml** Geometric mean	400/#100 ml Geometric mean		3
Ammonia Nitrogen May-Sept Oct-April	 11 mg/L 11 mg/L		 2.6 mg/L 8.7 mg/L	 1.1 mg/L 3.8 mg/L		8,9
Phosphorus Interim Final				 1.0 mg/L 0.225 mg/L	 0.6 mg/L 0.075 mg/L	6
Temperature						7
Chloride			400 mg/L			4
Mercury				1.3 ng/L		4

Footnotes:

1. The BOD, dissolved oxygen and TSS limits were established based on protection of the immediate receiving water as well as the downstream receiving water. Given the proposed minor

changes to the effluent flow rates, continuation of these limits is considered to be appropriate under the current designated use.

2. Additional mass limitations for phosphorus and TSS in attachment #1 are required in accordance with the wasteload allocations specified in the Rock River TMDL
   - Monthly average total Phosphorus mass limits are required as listed in the table on pg.14.
   - Monthly and weekly average TSS mass limits are required as listed in the table on pg. 5.
3. Additional limitations needed to comply with s. NR 106.07 expression of limits requirements are listed in bold.
4. The current permit has a variance limit which requires EPA approval at each permit reissuance. In the absence of a variance, concentration limits consistent with s. NR 106.88(c) and ss. NR 106.07(2)(a) and (9) would be included in the permit as well as chloride mass limits based on the annual average design flow.
5. The final WQBEL for phosphorus based on s. NR 217.13 is 0.225 mg/L as a monthly average and 0.075 mg/L as a six month average. MMSD is currently in the process of evaluating adaptive management as the option to achieve compliance with this limit. Along with the TMDL mass limits, interim limits consistent with this approach as outlined in s. NR 217.18(3)(e) would be included in the permit in place of the final WQBEL. If the receiving water is not meeting the water quality criteria after three permit terms, the final WQBEL based on s. NR 217.13 may be included in the permit.
6. In addition to the concentration limits for phosphorus, a mass limit based on the chosen design flow rate would need to be included in the permit due to the fact that the Sugar River is listed as impaired for phosphorus pursuant to s. NR 207.14(1)(a).
7. See attached report regarding potential weekly average temperature limitations. The permittee is currently conducting an AEL (Alternative Effluent Limit) Study to reevaluate this temperature review. This study will be addressed in a separate report.
8. The ammonia monthly and weekly average limits calculated in this evaluation are less restrictive than the current permit limits. Pursuant to ss. NR 207.04(1) and (2), the facility must demonstrate the need for a higher effluent limit in order to be allowed an increase in the permit limit. Without this demonstration, the limits listed above will apply.
9. EPA has revised their aquatic life criteria for ammonia https://www.epa.gov/wqc/aquatic-life-criteria-ammonia. At some time in the future, the Department will likely be making revisions to our administrative codes to promulgate criteria consistent with the EPA criteria. It is unknown when this will occur or how this will impact the effluent limits in the future as implementation factors that have not yet been determined may significantly impact the results. This is not currently a priority on the department work plan.

Antidegradation needs to be considered for all new or increased discharges of phosphorus consistent with ch. NR 217. Since this is an existing discharge, the test for antidegradation is whether any of the effluent limitations is an increased discharge as defined in ch. NR 207. “Increased discharge” means any change in concentration, level or loading of a substance which would exceed an effluent limitation specified in a current WPDES permit. With the exception of ammonia, none of the effluent limitations outlined above, or in the attachment which addresses the proposed stream reclassification, would constitute an increased discharge as defined in ch. NR 207 as they are equal to or less than the existing permit limitations or are the first-time imposition of the limit.

MMSD also requested a preliminary determination of the potential new designated uses for Badfish Creek and Badger Mill Creek along with resulting changes to effluent limits. Based on natural community modeling and fish data near Outfalls 001 and 005, Badfish Creek would likely be re-classified as a Warm Water Sport Fish Community (WWSF). Badger Mill Creek would likely be re-classified from Outfall 005 to Lincoln St. as WWSF and from Lincoln Street to the confluence with the Sugar River as a Cold Water Community (CW) (category 5 for ammonia criteria). More details about this preliminary determination and resulting limits can be found in attachment #3.

The reclassification of these receiving waters would require revisions to ch. NR 104 as the classification is currently listed in this code. This code revision is not part of the Use Designation Review currently in progress and is not part of the department current work plan. Workload priorities, such as these, are established using the triennial standards review process http://dnr.wi.gov/topic/surfacewater/tsr.html.

Please consult the attached report for details regarding the above recommendations. If there are any questions or comments regarding the development of limitations designed to protect surface water quality, please contact Rachel Fritz at (608) 266-2675 Rachel.Fritz@wisconsin.gov or Diane Figiel at (608) 264-6274 Diane.Figiel@wisconsin.gov.

Attachments (3) – Narrative, Map and Potential Stream Reclassification

PREPARED BY: Rachel Fritz, Wastewater Engineer – WY/3

APPROVED BY: ______________________________ date: ______________
Diane Figiel, PE,
Water Resources Engineer

cc: Amy Garbe, Basin Engineer – SCR/Waukesha
Jake Zimmerman, Basin Engineer – SCR/Fitchburg
Tim Ryan, Regional Wastewater Supervisor – SCR/Fitchburg

Attachment #1

Water Quality-Based Effluent Limitations for

Madison Metropolitan Sewerage District

(Nine Springs Wastewater Treatment Plant)

WPDES Permit No. WI-0024597

Prepared by: Rachel Fritz

PART 1 – BACKGROUND INFORMATION

The Nine Springs Wastewater Treatment Plant is located at 1610 Moorland Road, Madison, Wisconsin. Preliminary treatment is performed by fine screening of inorganic solids and separation of grit in vortex grit tanks. The inorganic solids and grit are hauled to the Dane County Landfill for disposal. The wastewater receives primary and advanced secondary treatment. Sludge from the primary settling tanks is thickened in two gravity thickener tanks. The advanced secondary treatment system is composed of aeration tanks with selectors and clarifiers. Phosphorus removal is accomplished biologically in this process. Following final clarification, the treated water is disinfected using ultraviolet disinfection on a seasonal basis. Treated effluent is discharged to two receiving streams - Badfish Creek and Badger Mill Creek.

Waste activated sludge (WAS) from the secondary treatment system is thickened using Dissolved Air Floatation (DAF) and sent to phosphorus release tanks prior to being thickened on gravity belt thickeners. The thickened primary sludge and thickened WAS are fed to an acid-phase anaerobic digester process. Following this process the sludge is further anaerobically digested at mesophilic temperatures. Most of the digested biosolids (85%) are then thickened by gravity belt thickeners and temporarily stored in Metrogro Storage Tanks before being recycled through land application on agricultural land. A smaller portion (15%) of the mesophilicly digested biosolids is further digested at thermophilic temperatures to meet EPA time/temperature requirements for Class A Biosolids. These biosolids are then dewatered on a centrifuge. The resulting cake biosolids can be managed alone or mixed with amendments such as sand and sawdust to produce a soil-like material.

Phosphorus in the form of struvite is harvested from waste streams using the Ostara process.

Effluent sampling is performed upstream of the flow split to the separate outfalls; therefore, all data is the same for both outfalls.

Attachment #2 is a map of the area showing the approximate location of Outfalls 001 and 005.

Existing Permit Limitations: The current permit, which expired on September 30, 2015, includes the following effluent limitations.

Attachment #1

Outfall 001 - Badfish Creek - Effluent flow rate = 50 MGD

Parameter	Daily Maximum	Daily Minimum	Weekly Average	Monthly Average	Monthly Geometric Mean	Footnotes
Flow Rate						1
BOD_5			20 mg/L 8340 lbs/day	19 mg/L 7923 lbs/day		
TSS			23 mg/L 9591 lbs/day	20 mg/L 8340 lbs/day		
Dissolved Oxygen		5.0 mg/L				
pH	9.0 s.u	6.0 s.u				
Fecal Coliforms April 15-Oct 15					400#/100 mL	4
Ammonia Nitrogen May-Sept Oct-April	 17 mg/L 17 mg/L		 4.4 mg/L 10 mg/L	 1.8 mg/L 4.1 mg/L		
Phosphorus				1.5 mg/L		
Chloride			481 mg/L 200,000 lbs/day			2
Mercury	5.7 ng/L					3
Cadmium						1
Chromium						1
Copper						1
Lead						1
Nickel						1
Zinc						1
WET						1

Outfall 005 - Badger Mill Creek - Effluent flow rate = 3.6 MGD

Parameter	Daily Maximum	Daily Minimum	Weekly Average	Monthly Average	Monthly Geometric Mean	Footnotes
Flow Rate						1
BOD_5 Nov-April May-Oct			 16 mg/L 7.0 mg/L			
TSS Nov-April May-Oct				 16 mg/L 10 mg/L		
DO		5.0 mg/L				
pH	9.0 s.u	6.0 s.u				
Fecal Coliforms May1 – Sept 30					400#/100 mL	4

Ammonia Nitrogen May-Sept Oct-April	 11 mg/L 11 mg/L		 2.6 mg/L 8.7 mg/L	 1.1 mg/L 3.8 mg/L		
Phosphorus				1.5 mg/L		
Chloride			481 mg/L 14,000 lbs./day			2
Mercury	5.7 ng/L					3
WET						1

Footnotes:

1. Monitoring only
2. This interim limit applied until 09/30/2015 when the target value of 430 mg/L became effective as the target limit.
3. This is a variance limit for mercury.
4. The fecal coliform limit is effective from April 15 – Oct 15 to protect human and animal health pursuant to s. NR 210.06(c).

Receiving Water Information for Outfall 001:

- Name: Badfish Creek
- Current Classification:
  Limited aquatic life (marginal) – at the point of discharge
  Limited forage fish community - Approximately five miles down-stream after the Oregon Branch,
  Warm water sport fish community - Approximately four additional miles down-stream after the CTH "A" bridge
  Non-public water supply applies for all of the above classifications. See Attachment #3 for potential reclassification information
- Low Flow: The following 7-Q_{10} and 7-Q_2 values are from USGS for Station LR57, where Outfall 001 is located. The Harmonic Mean has been estimated as recommended in *State of Wisconsin Water Quality Rules Implementation Plan* (Publ. WT-511-98)
  7-Q_{10} = 0 cfs (cubic feet per second)
  7-Q_2 = 0 cfs
- % of Flow used to calculate limits: N/A where receiving water low flows are equal to zero.
- Source of background concentration data: Background concentrations are not included since they don't impact the calculated WQBEL when the receiving water low flows are equal to zero.
- Multiple dischargers: Not applicable
- Impaired water status: Badfish Creek is listed as impaired for PCBs at the point of discharge. Approximately 21 miles downstream of the discharge, the Yahara River is listed as impaired for Phosphorus and TSS. A TMDL has been approved for the entire Rock River Basin for Phosphorus and TSS.

Receiving Water Information for Outfall 005:

- Name: Badger Mill Creek
- Current Classification:
  Limited forage fish community at the point of discharge
  Coldwater community - Approximately four miles downstream at STH 69 (category 5 for ammonia limits)

Non-public water supply applies for both of the above classifications. See Attachment #3 for potential reclassification information

- Flow: The following 7-Q_{10} and 7-Q_2 values are from USGS for Station S9, where Outfall 005 is located. The Harmonic Mean has been estimated as recommended in *State of Wisconsin Water Quality Rules Implementation Plan* (Publ. WT-511-98)
  7-Q_{10} = <0.01 cfs (cubic feet per second)
  7-Q_2 = 0.02 cfs
- % of Flow used to calculate limits: 25%
- Source of background concentration data: Background data for calculating effluent limitations for Ammonia Nitrogen are described later.
- Multiple dischargers: Approximately 18 miles downstream the Village of Belleville discharges to the Sugar River. This does not impact the effluent limitations in this recommendation as the mixing zones will not overlap.
- Impaired water status: Approximately 14 miles downstream of the discharge, the Sugar River is listed as impaired for Phosphorus.

Effluent Information for both Outfalls:
The recent request for facility planning limits listed the following design flows. The current permit design flows are also listed in the table below in MGD.

All effluent flow rates in MGD	Annual Average		Peak Daily		Peak Weekly		Peak Monthly	
	Badfish Creek (001)	Badger Mill Creek (005)	Badfish Creek (001)	Badger Mill Creek (005)	Badfish Creek (001)	Badger Mill Creek (005)	Badfish Creek (001)	Badger Mill Creek (005)
Current Permit	50	3.6	65	3.6	62.5	3.6	57.5	3.6
Scenario 1	50	3.6	78	3.6				
Scenario 2	48.6	5.0	78	6.0				
Scenario 3	53.6	-	78	-				

PART 2 – CONVENTIONAL POLLUTANTS

The current BOD_5, dissolved oxygen and TSS limits were established based on protection of the immediate receiving water as well as the downstream receiving water. Given the proposed minor changes to the effluent flow rates, continuation of these limits are considered to be appropriate under the current designated use. The option for CBOD limits in place of the current BOD limits is currently being considered by the department and will be addressed in the WQBEL memo for the next permit reissuance. Additional TSS limits are needed at Outfall 001 due to implementation of the Rock River TMDL.

TOTAL SUSPENDED SOLIDS (TSS) AT OUTFALL 001

Badfish Creek is under the Rock River TMDL which has waste load allocations (WLA) for TSS. These limits are expressed in monthly and weekly averages and will remain the same regardless of effluent flow rate or stream classification.

Attachment #1

TSS Limits for Outfall 001				
Month	**Monthly TSS WLA[1] (tons/month)**	**Days Per Month**	**Monthly Ave TSS Effluent Limit[2] (lbs/day)**	**Weekly Ave TSS Effluent Limit[3] (lbs/day)**
Jan	106	31	**6860**	**11500**
Feb	119	28	**8470**	**14100**
March	126	31	**8160**	**13600**
April	126	30	**8430**	**14100**
May	126	31	**8160**	**13600**
June	126	30	**8430**	**14100**
July	126	31	**8160**	**13600**
Aug	110	31	**7080**	**11800**
Sept	69.1	30	**4600**	**7690**
Oct	111	31	**7180**	**12000**
Nov	126	30	**8430**	**14100**
Dec	111	31	**7170**	**12000**

Footnotes:
1- Rock River TMDL Appendix Q. Monthly Total Suspended Solids Allocations by Wastewater Treatment Facility (p. 149)
2- Monthly average TSS effluent limit (lbs/day) = maximum monthly TSS WLA (tons/month) ÷ days per month x 2,000 lbs/ton
3- Weekly average effluent limit (lbs/day) = monthly average limit (lbs/day) x multiplier

The following BOD_5 and TSS data was reported on the DMRs for MMSD from January 2011 to June 2016. The data was identical for both outfalls.

	BOD_5 mg/L	TSS mg/L
1-day P_{99}	10.78	8.60
4-day P_{99}	7.41	6.35
30-day P_{99}	5.67	5.15
Mean	4.81	4.55
Std	1.88	1.36
Sample size	1984	1989
Range	0-27	0-20

PART 3 – WATER QUALITY-BASED EFFLUENT LIMITATIONS FOR AMMONIA NITROGEN

Daily Maximum Limits based on Acute Toxicity Criteria (ATC):
Daily maximum limitations are based on acute toxicity criteria, which are a function of the effluent pH and the receiving water classification. The acute toxicity criterion (ATC) for ammonia is calculated using the following equation.

$$\text{ATC in mg/L} = [A \div (1 + 10^{(7.204 - pH)})] + [B \div (1 + 10^{(pH - 7.204)})]$$

Where:

A = 0.411 and B = 58.4 for a Limited Forage Fishery
A = 0.633 and B = 90.0 for Limited Aquatic Life
A = 0.411 and B = 58.4 for a Warmwater Sport fishery, and
A = 0.275 and B = 39.0 for a Coldwater Category 1 fishery, and
pH (su) = that characteristic of the effluent.

The effluent pH data for the past three years was examined as part of this evaluation. A total of 1093 sample results were reported from January 2014 through December 2016. The maximum reported value was 7.8 su (Standard pH Units). The one-day P_{99}, calculated in accordance with s. NR 106.05(5), is 7.63 su. And the mean plus the standard deviation multiplied by a factor of 2.33, an estimate of the upper ninety ninth percentile for a normally distributed dataset, is 7.25 su. A value of 7.8 is believed to represent the maximum reasonably expected pH, and therefore most appropriate for determining daily maximum limitations for ammonia nitrogen. Substituting a value of 7.8 into the equation above yields the ATC values and ammonia limits for each outfall as included in the tables following an explanation of the chronic limits on pages 9-10.

Acute Limits based on 1-Q_{10}

Previously daily maximum limits for toxic substances were calculated as two times the ATC. However, changes to ch. NR 106, Wis. Adm. Code (September 1, 2016) require the Department to calculate acute limitations using the same mass balance equation as used for other limits along with the 1-Q_{10} receiving water low flow in order to determine if more restrictive effluent limitations are needed to protect the receiving stream from discharges which may cause or contribute to an exceedance of the acute water quality standards.

$$\text{Limitation} = \frac{(WQC)\,(Qs + (1-f)Qe) - (Qs - fQe)\,(Cs)}{Qe}$$

Where:

WQC =Acute toxicity criterion or secondary acute value according to ch. NR 105
Qs = average minimum 1-day flow which occurs once in 10 years (1-day Q10)
if the 1-day Q10 flow data is not available = 80% of the average minimum 7-day flow which occurs once in 10 years (7-day Q10).
Qe = Effluent flow (in units of volume per unit time) as specified in s. NR 106.06(4)(d)
f = Fraction of the effluent flow that is withdrawn from the receiving water, and
Cs = Background concentration of the substance (in units of mass per unit volume) as specified in s. NR 106.06(4)(e).

Considering the background stream temperature, ammonia nitrogen concentration, and 1-Q_{10} low flows (estimated as 80% of 7-Q_{10}), the calculated daily maximum ammonia nitrogen effluent limits are below the current 2×ATC limit, as shown in the tables following an explanation of the chronic limits.

Weekly Average & Monthly Average Limits based on Chronic Toxicity Criteria (CTC):
The ammonia limit calculation also warrants evaluation of weekly and monthly average limits based on chronic toxicity criteria for ammonia, since those limits relate to the assimilative capacity of the receiving water. Ammonia limits were last calculated in January 2009. At that time, default stream pH and temperatures were used to calculate limits. At this time, though, more specific information is available for both parameters which warrant a re-calculation of weekly and monthly average limits. New default temperature data are available for relatively small warmwater streams as part of the state's new thermal standards; the new default ambient stream temperatures are contained in Table 2 of ch. NR 102. The new ambient values are used in conjunction with the effluent and river low flows to re-calculate limits using the procedure in s. NR 106.32. Effluent limits are recalculated for ammonia based on the proposed design criteria.

Weekly average and monthly average limits for Ammonia Nitrogen are based on chronic toxicity criteria. The 30-day chronic toxicity criterion (CTC) for ammonia in waters classified for Limited Aquatic Life is calculated by the following equation.

$$CTC = E \times \{[0.0676 \div (1 + 10^{(7.688 - pH)})] + [2.912 \div (1 + 10^{(pH - 7.688)})]\} \times C$$

Where:

pH = the pH (su) of the receiving water,
E = 1.0,
$C = 8.09 \times 10^{(0.028 \times (25 - T))}$
T = the temperature of the receiving (ºC)

The 30-day chronic toxicity criterion (CTC) for ammonia in waters classified as a Limited Forage Fishery is calculated by the following equation.

$$CTC = E \times \{[0.0676 \div (1 + 10^{(7.688 - pH)})] + [2.912 \div (1 + 10^{(pH - 7.688)})]\} \times C$$

Where:

pH = the pH (su) of the receiving water,
E = 1.0,
C = the minimum of 3.09 or $3.73 \times 10^{(0.028 \times (25 - T))}$ – (Early Life Stages Present), or
$C = 3.73 \times 10^{(0.028 \times (25 - T))}$ – (Early Life Stages Absent), and
T = the temperature (ºC) of the receiving water – (Early Life Stages Present), or
T = the maximum of the actual temperature (ºC) and 7 - (Early Life Stages Absent)

The 30-day chronic toxicity criterion (CTC) for ammonia in waters classified as a Warmwater sport fishery is calculated by the following equation.

$$CTC = E \times \{[0.0676 \div (1 + 10^{(7.688 - pH)})] + [2.912 \div (1 + 10^{(pH - 7.688)})]\} \times C$$

Where:

pH = the pH (su) of the receiving water,
E = 0.854,
C = the minimum of 2.85 or $1.45 \times 10^{(0.028 \times (25 - T))}$ – (Early Life Stages Present), or
$C = 1.45 \times 10^{(0.028 \times (25 - T))}$ – (Early Life Stages Absent), and
T = the temperature (ºC) of the receiving water – (Early Life Stages Present), or
T = the maximum of the actual temperature (ºC) and 7 - (Early Life Stages Absent)

The 30-day chronic toxicity criterion (CTC) for ammonia in waters classified for a Coldwater fishery is calculated by the following equation.

$$CTC = E \times \{[0.0676 \div (1 + 10^{(7.688 - pH)})] + [2.912 \div (1 + 10^{(pH - 7.688)})]\} \times C$$

Where:

pH = the pH (su) of the receiving water,
E = 0.854,
C = the minimum of 2.85 or $1.45 \times 10^{(0.028 \times (25 - T))}$,
T = the temperature (ºC) of the receiving water

The 4-Day criterion is simply equal to the 30-Day criterion multiplied by 2.5. The 4-day criteria are used in a mass-balance equation with the $7\text{-}Q_{10}$ ($4\text{-}Q_3$, if available) to derive weekly average limitations. And the 30-day criteria are used with the $30\text{-}Q_5$ (estimated as 85% of the $7\text{-}Q_2$ if the $30\text{-}Q_5$ is not available) to derive monthly average limitations. The stream flow value is further adjusted to temperature. 100% of the flow is used if the Temperature ≥ 16 ºC. Only 25% of the flow is used if the Temperature < 11 ºC. And 50% of the flow is used if the Temperature ≥ 11 ºC but < 16 ºC.

The rules provide a mechanism for less stringent weekly average and monthly average effluent limitations when early life stages (ELS) of critical organisms are absent from the receiving water. This applies only when the water temperature is less than 14.5 ºC, during the winter and spring months. Burbot, an early spawning species, are not believed to be present in Badger Mill Creek, based on conversations with local fisheries biologists. With a stream classification of LFF "ELS Absent" criteria apply from October through April, and "ELS Present" criteria will apply from May through September. For Badfish Creek which is classified as LAL, there is only one set of criteria and there is no applicable distinction based on ELS.

Since minimal ambient data is available, the "default" basin assumed values are used for Temperature, pH and background ammonia concentrations, shown in the table below, with the resulting criteria and effluent limitations.

Attachment #1

Badfish Creek (001) (*Qe = 50 MGD, 48.6 MGD or 53.6 MGD)		**LAL** **At point of discharge**		**LFF** **Approx. 5 miles downstream**		**WWSF** **Approx. 9 miles from outfall**	
		May-Sept.	**Oct.-April**	**May-Sept.**	**Oct.-April**	**May-Sept.**	**Oct.-April**
Effluent Information:	Flow (MGD)	*	*	*	*	*	*
	Flow (cfs)	*	*	*	*	*	*
	Maximum pH	7.8	7.8	7.8	7.8	7.8	7.8
Background Information:	1-Q_{10} (cfs)	0	0	0.16	0.16	4.56	4.56
	7-Q_{10} (cfs)	0	0	0.2	0.2	5.7	5.7
	7-Q_2 (cfs)	0	0	0.37	0.37	10.54	10.54
	Ammonia (mg/L)	-	-	0.07	0.17	0.07	0.17
	Temperature (°C)	23	3	23	3	23	3
	pH (su)	7.8	7.8	8.21	7.97	8.21	7.97
	% of Flow used	NA	NA	100	100	100	100
	Reference Weekly Flow (cfs)	0	0	0.2	0.2	5.7	5.7
	Reference Monthly Flow (cfs)	0	0	0.3145	0.3145	8.959	8.959
Criteria mg/L:	Acute (at effluent pH)	18.71	18.71	12.14	12.14	12.14	12.14
	4-Day Chronic						
	Early Life Stages Present			5.60	8.06	2.55	6.35
	Early Life Stages Absent	30.08	109.22	7.69	31.06	2.55	10.31
	30-Day Chronic						
	Early Life Stages Present			2.24	3.22	1.02	2.54
	Early Life Stages Absent	12.03	43.69	3.08	12.42	1.02	4.12
Effluent Limits mg/L:	Daily Maximum	18.71	18.71	**12.2**	**12.2**	**13.2**	**13.2**
	Weekly Average						
	Early Life Stages Present			**5.62**	8.08	**2.74**	6.8
	Early Life Stages Absent	**30.08**	**109.22**	7.71	**31.14**		**11**
	Monthly Average						
	Early Life Stages Present			**2.25**	3.24	**1.13**	2.8
	Early Life Stages Absent	**12.03**	**43.69**	3.09	**12.47**		**4.6**
Downstream After Decay mg/L	Daily Maximum	18.71	18.71	**16.7**	**13.1**	18.7	14.9
	Weekly Average	30.08	109.22	7.7	33.3	**4.8**	**12.4**
	Monthly Average	12.03	43.69	3.1	13.3	**2.0**	**5.2**

Attachment #2

Badger Mill Creek (005) (*Qe = 3.6 MGD, and 5.0 MGD)		**LFF At point of discharge**		**WWSF (CW Class 5) Approx. 4 miles from outfall**	
		May-Sept.	**Oct.-April**	**May-Sept.**	**Oct.-April**
Effluent Information:	Flow (MGD)	*	*	*	*
	Flow (cfs)	*	*	*	*
	Maximum pH	7.8	7.8	7.8	7.8
Background Information:	$1\text{-}Q_{10}$ (cfs)	0	0	0.14	0.14
	$7\text{-}Q_{10}$ (cfs)	0	0	0.18	0.18
	$7\text{-}Q_2$ (cfs)	0.02	0.02	0.58	0.58
	Ammonia (mg/L)	0.07	0.17	0.07	0.17
	Temperature (°C)	23	3	23	3
	pH (su)	7.8	7.8	8.21	7.97
	% of Flow used	100	25	100	100
	Reference Weekly Flow (cfs)	0	0	0.18	0.18
	Reference Monthly Flow (cfs)	0.017	0.00425	0.493	0.493
Criteria mg/L:	Acute (at effluent pH)	12.14	12.14	12.14	12.14
	4-Day Chronic				
	Early Life Stages Present	10.10	10.10	2.55	6.35
	Early Life Stages Absent	13.87	38.91	2.55	10.31
	30-Day Chronic				
	Early Life Stages Present	4.04	4.04	1.02	2.54
	Early Life Stages Absent	5.55	15.56	1.02	4.12
Effluent Limits mg/L:	Daily Maximum	12.14	12.14	12.4	12.4
	Weekly Average				
	Early Life Stages Present	**10.10**	10.10	**2.6**	6.5
	Early Life Stages Absent	13.87	**38.91**		**10.6**
	Monthly Average				
	Early Life Stages Present	**4.05**	4.04	**1.1**	2.7
	Early Life Stages Absent	5.56	**15.58**		**4.4**
Downstream After Decay mg/L	Daily Maximum	12.14	12.14	**12.1**	**12.1**
	Weekly Average	10.10	38.91	**3.3**	**11.2**
	Monthly Average	4.05	15.58	**1.4**	**4.6**

Effluent limits do not change based on design scenario because the base flow is much lower than the effluent flow, so the minimal change results in the same limit after rounding.

Evaluation of downstream impacts, in-stream decay of ammonia: The more restrictive calculated limits should be used in order to protect at the point of discharge and downstream uses. Where the calculated limits are more restrictive based on downstream uses, ammonia decay can be considered to determine if these more restrictive limits are needed or if the ammonia will decay before it reaches the point of the classification change.

Ammonia decay rates are dependent on temperature with in-stream nitrification essentially non-existent in the winter. In-stream decay is expected so a first order decay model will be used. Based on the available literature, a decay rate of 0.25 day^{-1} at 20°C has been suggested as a default rate. A temperature correction factor of θ = 1.08 is ($k_{t} = k_{20}\ \theta^{(T-20)}$).

$$N_{Limit} = \left(\frac{N_{down}}{EXP(-k_t T)} \right)$$

Where:

N_{Limit} = Ammonia limit needed to protect downstream use (mg/L)
N_{down} = Ammonia limit calculated based on downstream classification and flow (mg/L)
$-k_t$ = Ammonia decay rate at background stream temperature (day^{-1})
T = Travel time from outfall to downstream use (day)

The velocity of receiving water is assumed to be 5 miles per day and the approximate distance from the point of discharge to the classification change is shown in the above tables.

Conclusions and Recommendations:
In summary, after rounding to two significant figures, the following effluent limitations for Ammonia Nitrogen are recommended for MMSD. No mass limitations are recommended in accordance with s. NR 106.32(5).

When the current permit limits are more restrictive than the newly calculated limits, pursuant to ss. NR 207.04(1) and (2) the facility must demonstrate the need for a higher effluent limit in order to be allowed an increase in the permit limit. Without this demonstration, the current weekly and monthly average limits will apply. These are listed in the table below.

Badfish Creek Outfall 001	Current Permit Limits mg/L		Calculated Limits mg/L		Recommended Limits mg/L	
	May-Sept.	Oct.-April	May-Sept.	Oct.-April	May-Sept.	Oct.-April
Daily Maximum	**17**	17	16.7	**13.1**	17	13
Weekly Average	**4.4**	**10**	4.8	12.4	4.4	10
Monthly Average	**1.8**	**4.1**	2.0	5.2	1.8	4.1

Badger Mill Creek Outfall 005	Current Permit Limits mg/L		Calculated Limits mg/L		Recommended Limits mg/L	
	May-Sept.	Oct.-April	May-Sept.	Oct.-April	May-Sept.	Oct.-April
Daily Maximum	**11**	**11**	12.1	12.1	11	11
Weekly Average	**2.6**	**8.7**	3.3	11.2	2.6	8.7
Monthly Average	**1.1**	**3.8**	1.4	4.6	1.1	3.8

The following table evaluates the statistics based upon ammonia data reported from January 2011 to June 2016 for informational purposes.

	Ammonia mg/L Oct.-April	Ammonia mg/L May-Sept.
1-day P_{99}	2.34	1.30

4-day P_{99}	1.30	0.70
30-day P_{99}	0.59	0.36
Mean*	0.31	0.23
Std	0.52	0.27
Sample size	1173	817.00
Range	0-7.22	0-4.16

PART 4 – WATER QUALITY-BASED EFFLUENT LIMITATIONS FOR TOXIC SUBSTANCES – EXCEPT AMMONIA NITROGEN

Neither the proposed design flows nor the predicted stream classification changes are expected to trigger any new limits for toxic substances. The only WQBELs for toxic substances in the current permit are variance limits for chloride and mercury. MMSD will be able to apply for the same variances which must be approved by EPA at each permit reissuance. Given the low flows of the receiving waters are nearly zero, the WQBELs will be the same regardless of the effluent flow rate. In addition, the criteria for these substances are the same for the proposed stream classifications for Badfish Creek and Badger Mill Creek, so the limits for these parameters would not change as a result of a stream reclassification.

Mercury – The most stringent water quality-based effluent limit for total recoverable mercury is based on the wildlife criterion. The limit is set equal to the criterion of 1.3 ng/L because the receiving water flow upstream of the discharge is zero. The 30-day P_{99} of the effluent data is 1.6 ng/L, which is greater than the limit therefore, **a limit is recommended for mercury.**

In the absence of a variance, a limit of 1.3 ng/L as a monthly average would apply. If a variance is granted and approved by US Environmental Protection Agency, in accordance with s. NR 106.145(5), Wis. Adm. Code, an alternative limit for mercury would be set equal to the upper 99th percentile of daily concentrations, or 1-day P_{99}, and would be expressed as a daily maximum. Accordingly, if a variance is granted, the alternative mercury limit would be **3.4 ng/L, daily maximum**. In conjunction with an alternative limit, the proposed permit shall also include a pollutant minimization program in accordance with s. NR 106.145(6), Wis. Adm. Code.

Chloride – Weekly average calculated limitations of 400 mg/L (395, rounded) and respective mass limits are apparently needed, in accordance with s. NR 106.05(4)(b), because the upper ninety-ninth percentile of the 4-day concentration (the 4-day P_{99}) exceeds the calculated limit. The respective mass limits based on s. NR 106.07(2) for each design scenario are listed in the table below:

Chloride Mass Limit (lbs./day)		
	Badfish Creek (001)	Badger Mill Creek (005)
Scenario 1	165,000	11,900
Scenario 2	160,000	16,500
Scenario 3	177,000	-

Alternative wet weather mass limits would also be required based on the projected maximum weekly average flow rate which would need to be provided by the facility.

Subchapter VII of ch. NR 106 provides for a variance from water quality standards for this substance, and MMSD currently has such a variance. That variance is subject to EPA approval and may be granted subject to the following conditions:

1) The permit shall include an "Interim" limitation intended to prevent an increase in the discharge of Chlorides;
2) The permit shall include a pollutant minimization program in accordance with s. NR 106.145(6), Wis. Adm. Code which specifies "Source Reduction Measures" to be implemented during the course of the permit term, with periodic progress reports; and
3) The permit shall include a "Target Limit" or "Target Value" to gage the effectiveness of the Source Reduction Measures, and progress toward the water quality-based effluent limitations.

Interim Limit for Chloride: Section NR 106.82(9) defines a "Weekly average interim limitation" as either the 4-Day P_{99} concentration or 105% of the highest weekly average concentration of the representative data. The interim limit for the next permit issuance is currently under discussion and will be addressed in the WQBEL memo for the next permit reissuance.

In the absence of a variance, a limit of 400 mg/L as a weekly average would apply in addition to the mass limits according to the table on page 12.

PART 5 –PHOSPHORUS

Technology Based Limits (TBL) – Phosphorus

Wisconsin Administrative Code, ch. NR 217, requires municipal wastewater treatment facilities that discharge greater than 150 pounds of Total Phosphorus per month to comply with a Monthly Average limit of 1.0 mg/L, or an approved Alternative Concentration limit. MMSD currently has an existing technology based alternative limit of 1.5 mg/L based on biological phosphorus removal. The alternative limit is no longer applicable because the current effluent quality is well below 1.0 mg/L. An interim limit based on current effluent quality along with a more stringent water quality based limit based on the Rock River TMDL will be included in reissued permits in place of this limit.

Water Quality based Effluent Limits (WQBEL)

Revisions to administrative rules regulating phosphorus took effect on December 1, 2010. These rule revisions include additions to ch. NR 102 (s. NR 102.06), which establish phosphorus standards for surface waters. Revisions to ch. NR 217 (s. NR 217, Subchapter III) establish procedures for determining water quality based effluent limits for phosphorus, based on the applicable standards in ch. NR 102.

Badfish Creek Outfall 001

Water Quality Limits

Phosphorus criteria in s. NR 102.06 do not apply to limited aquatic life waters [s. NR 102.06 (6) (d)]. These waters were not included in the USGS/WDNR stream and river studies and, therefore, the Department lacked the technical basis to determine and propose applicable criteria. At some time in the future, the Department may adopt phosphorus criteria based on new studies focusing on limited aquatic life waters. The guidance suggests that during the interim, water quality based effluent limitations should be based on the criteria and flow conditions for the next stream segment downstream. The discharge location of the wastewater from MMSD is classified as limited aquatic life downstream from the point of discharge downstream approximately 4 miles until the classification changes to LFF past the Oregon Branch. Typically discharges which fall under the Rock River TMDL don't receive phosphorus limits under NR 217.13 because the wasteload allocations were designed to be protective of impaired receiving waters. However, Badfish Creek was not listed as impaired until after the TMDL was approved. Therefore the TMDL is not protective of the LFF portion of Badfish Creek and water quality based limits must be considered for this stream segment.

Section NR 102.06(3)(a) specifically names reaches of rivers for which a phosphorus criterion of 0.1 mg/l applies. For other stream segments that are not specified in s. NR 102.06(3)(a), s. NR 102.06(3)(b) specifies a phosphorus criterion of 0.075 mg/l. The phosphorus criterion of 0.075 mg/l applies for Badfish Creek.

The conservation of mass equation is described in s. NR 217.13 (2)(a) for phosphorus water quality based effluent limitations (WQBELs).:

Limitation = [(WQC)(Qs+(1-f)Qe) – (Qs-fQe)(Cs)]/Qe

Where:
WQC = 0.075 mg/l for Badfish Creek.
Qs = 100% of the 7Q2 of 77.5 cfs.
Cs = background concentration of phosphorus in the receiving water pursuant to s. NR 217.13(2)(d)
Qe = effluent flow rate
f = the fraction of effluent withdrawn from the receiving water = 0

Section NR 217.13(2)(d), Wis. Adm. Code, specifies that the background phosphorus concentration used in the limit calculation formula shall equal the median of at least four samples collected during the months of May through October, and that all samples collected during a 28 day period shall be considered as a single sample and the average of these concentrations used to determine a median. Averaging begins at date of the first sample in the range of May through October.

The following data were considered in estimating the background phosphorus concentration:

SWIMS ID	133044	10012601	543226
Station Name	Yahara River at U.S. Hwy 51	Badfish Creek - Casey Road	Yahara River at Sth 59 Near Fulton WI
Waterbody	Yahara River	Badfish Creek	Yahara River
Sample Count	6	6	20
First Sample	10/21/2008	10/18/2006	05/01/2000
Last Sample	09/15/2009	09/18/2007	09/18/2007
Mean	0.0782	0.3043	0.2192
Median	0.0765	0.2935	0.2075
NR 217 Median	0.077	0.285	0.209

Substituting a background concentration above criteria into the limit calculation equation above would result in a calculated limit that is less than the applicable criterion of 0.075 mg/L. However, s. NR 217.13(7), Wis. Adm. Code, specifies that "if the water quality-based effluent limitation calculated pursuant to the procedures in this section is less than the phosphorus criterion specified in s. NR 102.06, Wis. Adm. Code, for the water body, the effluent limit shall be set equal to the criterion."

Limit Expression
Because the calculated WQBEL is less than or equal to 0.3 mg/L, the effluent limit of 0.075 mg/L may be expressed as a six month average. If a concentration limitation expressed as a six month average is included in the permit, a monthly average concentration limitation of 0.225 mg/L, equal to three times the WQBEL calculated under s. NR 217.13 shall also be included in the permit. The six month average should be averaged during the months of May – October and November – April.

TMDL Limits – Phosphorus
The Department also has developed a TMDL for the Upper and Lower Rock River Basins. The US EPA approved the Rock River TMDL on September 28, 2011. The document, along with the referenced appendices can be found at:
http://dnr.wi.gov/topic/TMDLs/RockRiver/Final_Rock_River_TMDL_Report_with_Tables.pdf
Section NR 217.16, Wis. Adm. Code, states that the Department may include a TMDL-derived water quality based effluent limit (WQBEL) for phosphorus in addition to, or in lieu of, a s. NR 217.13 WQBEL in a WPDES permit. Because the Rock River Basin TMDL was developed to protect and improve the water quality of phosphorus impaired waters within the basin and MMSD discharges to a receiving water classified as a limited aquatic life water which then flows

The monthly average total phosphorus (Total P) effluent limits in lbs/day are calculated based on the monthly phosphorus wasteload allocation (WLA) given in pounds per month as suggested in the *TMDL Development and Implementation Guidance: Integrating the WPDES and Impaired Waters Programs* dated April 15, 2013. The WLA for this facility is found in the *Total Maximum Daily Loads for Total Phosphorus and Total Suspended Solids in the Rock River Basin* report dated July 2011. For reference, the limits are equivalent to the concentrations listed below at each design flow:

Design Option	**Equivalent Concentration (mg/L)**	
	Min	**Max**
Scenario 1 (50 MGD)	0.129	0.161
Scenario 2 (48.6 MGD)	0.133	0.166
Scenario 3 (53.6 MGD)	0.121	0.151

*These concentrations are not effluent limits; they are only for reference.

Monthly average mass effluent limits in accordance with the following table are recommended for this discharge.

Total Phosphorus Effluent Limitations

Month	**Monthly Total P WLA[1] (lbs/month)**	**Days Per Month**	**Monthly Ave Total P Effluent Limit[2] (lbs/day)**
Jan	1874.87	31	**60.48**
Feb	1886.69	28	**67.38**

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March	1816.15	31	**58.59**
April	1796.94	30	**59.90**
May	1759.56	31	**56.76**
June	1835.71	30	**61.19**
July	1741.16	31	**56.17**
Aug	1676.93	31	**54.09**
Sept	1623.92	30	**54.13**
Oct	1717.37	31	**55.40**
Nov	1804.09	30	**60.14**
Dec	1863.48	31	**60.11**

Footnotes:

1- Rock River TMDL Appendix P. Monthly Total Phosphorus Allocations by Wastewater Treatment Facility (p. 147)

2- Monthly average Total P effluent limit (lbs/day) = monthly Total P WLA (lbs/month) ÷ days per month

Badger Mill Creek Outfall 005

Section NR 102.06(3)(a) specifically names reaches of rivers for which a phosphorus criterion of 0.1 mg/l applies. For other stream segments that are not specified in s. NR 102.06(3)(a), s. NR 102.06(3)(b) specifies a phosphorus criterion of 0.075 mg/l. The phosphorus criterion of 0.075 mg/l applies for Badger Mill Creek.

The limit calculation formula is described in s. NR 217.13 (2)(a) for phosphorus water quality based effluent limitations (WQBELs).:

Limitation = [(WQC)(Qs+(1-f)Qe) – (Qs-fQe)(Cs)]/Qe

Where:

WQC = 0.075 mg/l for Badger Mill Creek.
Qs =0.0 cfs, 100% of the 7Q2 of 0 cfs.
Cs = background concentration of phosphorus in the receiving water pursuant to s. NR 217.13(2)(d)
Qe =3.6 or 5.0 effluent flow rate (in MGD)
f =0, the fraction of effluent withdrawn from the receiving water

Because there is no dilution at the location of the outfall, the effluent limit will be set equal to criteria. Phosphorus limits will be 0.075 mg/l for any possible design flow or stream classification.

Reasonable potential determination:

Since the 30-day P_{99} of reported effluent total phosphorus data is above the calculated WQBEL, **the discharge has reasonable potential to cause or contribute to an exceedance of the water quality criterion.** Therefore, **a water quality-based effluent limit is recommended.**

Limit Expression:

According to s. NR 217.14(2), the water quality based effluent limit may be expressed as a six-month average, and a monthly average limit equal to three times the six month average, or 0.225 mg/L. Since the discharge is to a surface water that has a phosphorus impairment, a mass limit is also required, pursuant to

s. NR 217.14, Wis. Adm. Code. **This final mass limit shall be 2.3 lbs/day for a 3.6 MGD design flow or 3.1 lbs/day for a 5.0 MGD design flow** (0.075 mg/L × 8.34 × eff. flow MGD).

Interim Limit for 001 and 005

The calculated WQBEL's for total phosphorus at Outfalls 001 and 005 are recommended with an extended compliance schedule. In order to make the reductions necessary to meet the total phosphorus effluent limits, MMSD has decided to pursue the watershed adaptive management compliance option as described in s. NR 217.18, Wis. Adm. Code.

Madison Met has selected Adaptive Management as a compliance option for Outfall 001. According to s. NR 217.18(3) (e) 2, Wis. Adm. Code, "In the first permit reissuance term following approval by the department under sub. (2), the initial interim effluent limitation shall be no higher than 0.6 mg/L of total phosphorus expressed as a six-month average. An effluent limit not to exceed 1.0 mg/L of total phosphorus expressed as a monthly average shall also be included in the permit. The department may allow the permittee a compliance schedule that may not exceed five years if necessary to meet this interim limitation." **Therefore interim limits of 0.6 mg/L as a six-month average and 1.0 mg/L as a monthly average are recommended for both outfalls.**

An evaluation of effluent total phosphorus data from January 2011 through June 2016 is shown in the table below for informational purposes.

Effluent Data Total Phosphorus, mg/L	
1-day P_{99}	0.73
4-day P_{99}	0.48
30-day P_{99}	0.35
Mean	0.29
Std	0.13
Sample size	1989
Range	0.08 to 1.27

PART 6 –THERMAL

New surface water quality standards for temperature took effect on October 1, 2010. These new regulations are detailed in chs. NR 102 (Subchapter II – Water Quality Standards for Temperature) and NR 106 (Subchapter V – Effluent Limitations for Temperature) of the Wisconsin Administrative Code. Daily maximum and weekly average temperature criteria are available for the 12 different months of the year depending on the receiving water classification.

In accordance with s. NR 106.53(2)(b), the highest daily maximum flow rate for a calendar month is used to determine the acute (daily maximum) effluent limitation. In accordance with s. NR 106.53(2)(c), the highest 7-day rolling average flow rate for a calendar month is used to determine the sub-lethal (weekly average) effluent limitation. These values were based off of actual flow reported from September 2009 to March 2016.

The table below summarizes the maximum temperatures reported during monitoring from October 2012 to December 2013. Comparing the representative highest effluent temperature to the calculated effluent limits determines the reasonable potential of exceeding the effluent limits. The months in which limitations are recommended are highlighted.

The daily maximum effluent temperature limitation shall be 86 °F for discharges to surface waters classified as Limited Aquatic Life according to s. NR 104.02(3)(b)1, except for those classified as wastewater effluent channels and wetlands regulated under ch. NR 103 [s. NR 106.55(2), Wis. Adm. Code]. Due to the fact that Badfish Creek is currently classified in ch. NR 104 as a wastewater effluent channel the applicable limit is 120° F year- round.

Badfish Creek (001)						
	Representative Highest Monthly Effluent Temperature		Current Classification (LAL)		Predicted Classification (WWSF)	
			Calculated Effluent Limit			
Month	Weekly Maximum (°F)	Daily Maximum (°F)	**Weekly Average Effluent Limitation** (°F)	**Daily Maximum Effluent Limitation** (°F)	**Weekly Average Effluent Limitation** (°F)	**Daily Maximum Effluent Limitation** (°F)
JAN	56	57	**-**	**120**	**49**	**76**
FEB	54	55	**-**	**120**	**50**	**76**
MAR	54	55	**-**	**120**	**52**	**77**
APR	55	58	**-**	**120**	**55**	**79**
MAY	61	63	**-**	**120**	**65**	**82**
JUN	65	65	**-**	**120**	**76**	**84**
JUL	69	70	**-**	**120**	**81**	**85**
AUG	70	71	**-**	**120**	**81**	**84**
SEP	70	71	**-**	**120**	**73**	**82**
OCT	68	69	**-**	**120**	**61**	**80**
NOV	63	64	**-**	**120**	**49**	**77**
DEC	58	60	**-**	**120**	**49**	**76**

Based on the available discharge temperature data, dated October 2012 through December 2013 and shown below, the maximum daily effluent temperature reported was 71°F; therefore, no reasonable potential for exceeding the daily maximum limit exists, and **no limits are recommended for Outfall 001**. Given the fact that the effluent temperature is much lower than this limit along with the fact that the effluent travels for 5 miles before the classification changes to limited forage fish, it has been determined that limitations are not needed to protect the downstream waterbody.

Limits for the predicted stream reclassification are also included for informational purposes. Current effluent temperature data shows a need for limits October through March. If Badfish Creek is reclassified, the need for temperature limits will be evaluated based on the most recent effluent temperature data.

Attachment #2

Badger Mill Creek (005)								
	Representative Highest Monthly Effluent Temperature*		Current Classification (LFF)		Predicted Classification (WWSF Section) Calculated Effluent Limit		Predicted Classification (downstream CW section)	
Month	Weekly Maximum (°F)	Daily Maximum (°F)	**Weekly Average Effluent Limitation** (°F)	**Daily Maximum Effluent Limitation** (°F)	**Weekly Average Effluent Limitation** (°F)	**Daily Maximum Effluent Limitation** (°F)	**Weekly Average Effluent Limitation** (°F)	**Daily Maximum Effluent Limitation** (°F)
JAN	56	57	**54**	**78**	**49**	**76**	**47**	**68**
FEB	54	55	**54**	**79**	**50**	**76**	**47**	**68**
MAR	54	55	**57**	**80**	**52**	**77**	**51**	**69**
APR	55	58	**63**	**81**	**55**	**79**	**57**	**70**
MAY	61	63	**70**	**84**	**65**	**82**	**63**	**72**
JUN	65	65	**77**	**85**	**76**	**84**	**67**	**72**
JUL	69	70	**81**	**86**	**81**	**85**	**67**	**73**
AUG	70	71	**79**	**86**	**81**	**84**	**65**	**73**
SEP	70	71	**73**	**85**	**73**	**82**	**60**	**72****
OCT	68	69	**63**	**83**	**61**	**80**	**53**	**70**
NOV	63	64	**54**	**80**	**49**	**77**	**48**	**69**
DEC	61	62	**54**	**79**	**49**	**76**	**47**	**69**

*Effluent data from August and October 2013 was not included in this evaluation because there was no discharge to Badger Mill Creek during these months due to maintenance activities.
**This limit is triggered based on the calculated 99[th] percentile of the representative data which is 72 °F.

Based on the available discharge temperature data, dated October 2012 to December 2013 and shown above, **reasonable potential to exceed thermal limits exists for all possible scenarios for Outfall 005. Therefore, thermal limits are recommended.** Limits for predicted stream classifications are also included for informational purposes. The need for these limits would be evaluated based on the most recent effluent temperature data if the stream segments are reclassified.

The facility is currently conducting an AEL (Alternative Effluent Limit) Study for Outfall 005 to reevaluate this temperature review. This study will be addressed in a separate report.

If Badfish Creek is reclassified, the following general options are available for a facility to explore potential relief from the temperature limits at Outfall 001:

- Effluent monitoring data: Verification or additional effluent monitoring (flow and/or temperature) may be appropriate if there were questions on the representativeness of the current effluent data.
- Dissipative cooling demonstration: Effluent limitations based on sub-lethal criteria may be adjusted based on the potential for heat dissipation from municipal treatment plants (s. NR 106.59(4))
- Alternative Effluent Limitation: Permittees may request an alternative effluent limit for temperature (AEL) under ch. NR 106 Subchapter VI, Wis. Adm. Code, to demonstrate that the

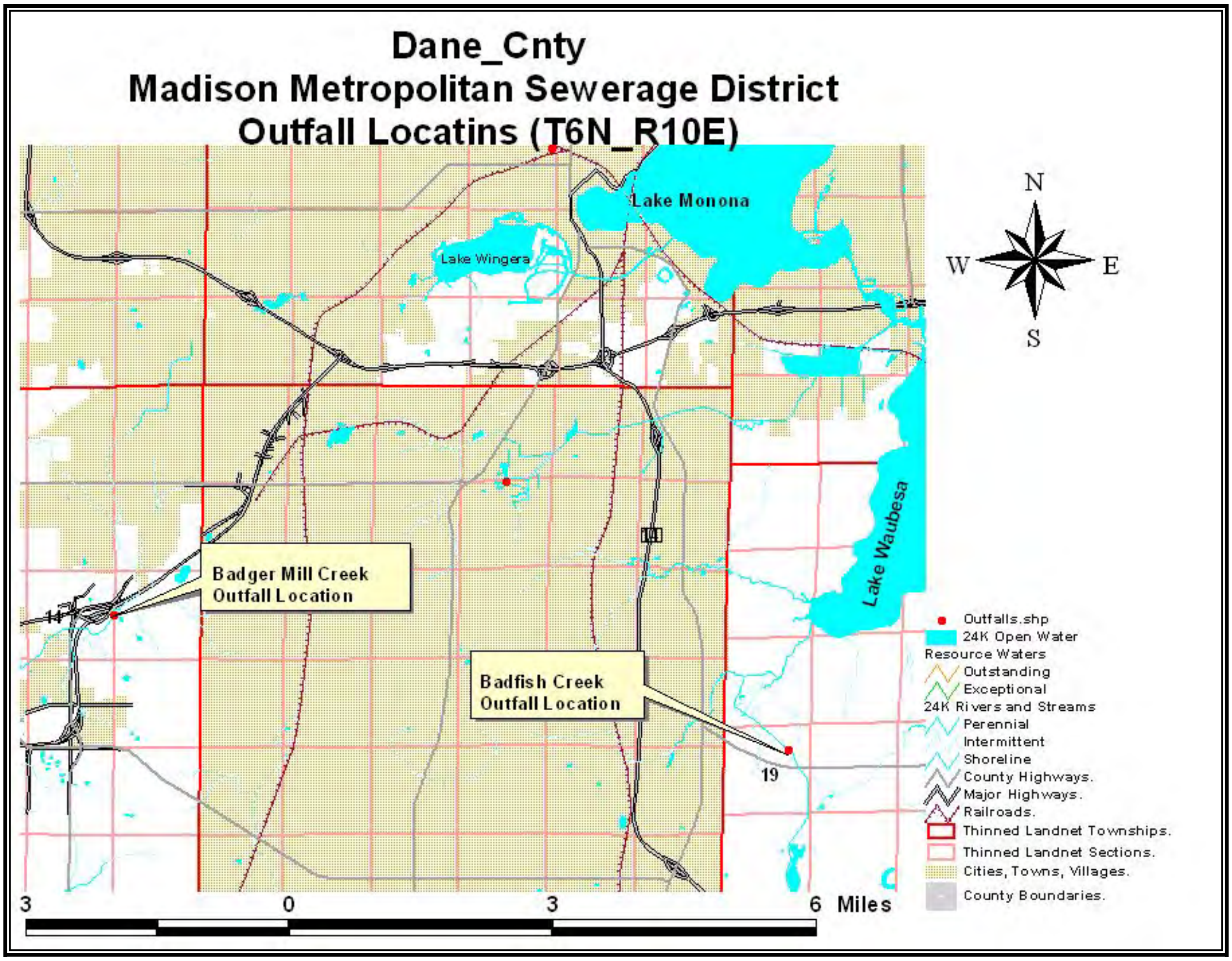
default effluent limitations for temperature determined under Subchapter V are more stringent than necessary to protect fish and aquatic life.

- A variance to the water quality standard: This is typically considered to be the least preferable and most complex option as it requires the evaluation of the other alternatives.

These options are explained in additional detail in the August 15, 2013 Department *Guidance for Implementation of Wisconsin's Thermal Water Quality Standards* http://dnr.wi.gov/topic/surfacewater/documents/ThermalGuidance2edition8152013.pdf

Attachment #2

SITE MAP



POTENTIAL REVISED CLASSIFICATION PRELIMINARY DETERMINATION

MMSD also requested a preliminary determination of the potential new designated uses for Badfish Creek and Badger Mill Creek along with resulting changes to effluent limits. Based on natural community modeling and fish data near Outfalls 001 and 005, Badfish Creek would likely be re-classified as a Warm Water Sport Fish Community (WWSF). Badger Mill Creek would likely be re-classified from Outfall 005 to Lincoln St. as WWSF and from Lincoln Street to the confluence with the Sugar River as a Cold Water Community (CW) (category 5 for ammonia criteria). More details about this preliminary determination and resulting limits can be found in attachment #3.

The reclassification of these receiving waters would require revisions to ch. NR 104 as the classification is currently listed in this code. This code revision is not part of the Use Designation Review currently in progress and is not part of the department's current work plan. Workload priorities, such as these, are established using the triennial standards review process http://dnr.wi.gov/topic/surfacewater/tsr.html.

Badfish Creek

Badfish Creek is currently listed as a Limited Aquatic Life community in NR 104, Wis. Adm. Code. The classification could potentially be revised based on the biological community present in the receiving water however this would require a revision to ch. NR 104.

In 2014 and 2016, fish surveys were conducted at three sites on Badfish Creek. For all intents and purposes, it is modeled to be a cool-warm main stem. Highly variable numbers of brown trout were found each year of the fish survey. These are likely coming from a tributary to Badfish Creek known as the Rutland Branch which is stocked with brown trout. Although Badfish Creek can support brown trout, the numbers present vary greatly and there are no other coldwater indicator species present. Our biologist therefore believes that **its appropriate natural community is cool-warm**. This equates to the water quality standards for **WWSF**.

Badger Mill Creek

Badger Mill Creek is a tributary to the Sugar River. The stream is considered intermittent upstream of the MMSD outfall and effluent dominated from the outfall to the Lincoln Street footbridge. A set of springs near this point cause the stream to exhibit cold water community characteristics. Downstream from Lincoln St., the MMSD effluent composes about half of the stream flow.

Currently, the segment from Bruce St. to Hwy. 69 is classified as LFF (limited forage fishery). The rest of Badger Mill Creek does not have a classification and had defaulted to LFF for effluent limit calculation purposes.

In 1998, sampling by the department and MMSD staff showed the presence of cold and cool water species in the stream. Fisheries surveys were also completed at 5 stations on the Creek in September of 2005. All stations showed the presence of multiple year classes of trout. Therefore the department proposed to reclassify the segment downstream of Lincoln St. as Coldwater-B stream.

If Badger Mill Creek were to be reclassified, it would likely be classified as **cool-warm main stem from Outfall 005 to Lincoln St. and cool-cold main stem from Lincoln St. to the confluence with the Sugar River.** This equates to the water quality standards for **WWSF (Warm-Water Sport Fish Community) and CW (Cold Water Community)** respectively.

However, all of Badger Mill Creek is currently classified as a Class II Trout water by fisheries. However, the water quality biologist does not believe that the segment above Lincoln St. is suitable habitat for trout reproduction. Considering this, the intent is to work with fisheries to label the segment from Outfall 005 to Lincoln St. a Class III Trout water instead of a Class II Trout water. This will allow the Water Evaluation Section to use best professional judgment and classify this segment as WWSF instead of CW. For the purposes of ammonia criteria, the receiving water is considered to be coldwater, category 5 regardless of whether it is Class II or Class III.

POTENTIAL CHANGES TO EFFLUENT LIMITATIONS

The limits for BOD, TSS, ammonia nitrogen, and temperature would change as a result of a reclassification of the receiving water. The other limitations including pH, fecal coliform, phosphorus chloride and mercury, would remain unchanged due to the fact that the water quality criteria are the same for both the current and proposed classifications. Potential revisions to the temperature limits were addressed in the previous temperature section.

BIOLOGICAL OXYGEN DEMAND (BOD_5) AND DISSOLVED OXYGEN (for WWSF and CW)

In establishing BOD_5 (5-day Biochemical Oxygen Demand) limitations, the primary intent is to prevent a lowering of dissolved oxygen levels in the receiving water below water quality standards as specified in ss. NR 102.04(4)(a) and (b). The 26-lb method is the most frequently used approach for calculating BOD_5 limits when resources are not available to develop a detailed water quality model. This simplified model was developed in the 1970's by the Wisconsin Committee on Water Pollution on the Fox, Wisconsin, Oconto, and Flambeau Rivers. Further studies throughout the 1970's proved this model to be relatively accurate. The model has since then been used by the Department on many occasions when resources are not available to perform a site-specific model. The "26" value stems from the following equation:

$$\frac{26\ {}^{\text{lbs}}/_{\text{day}}}{{}^{\text{ft}^3}/_{\text{sec}}} * \frac{1\,\text{day}}{86{,}400\,\text{sec}} * \frac{454{,}000\,\text{mg}}{\text{lbs}} * \frac{1\,\text{ft}^3}{28.32\,\text{L}} = 4.8 = 2.4 * 2\ {}^{\text{mg}}/_{\text{L}}$$

The 4.8 has been calculated by taking 2.4 which is the number one receives when converting 26 lbs of BOD/day/cfs into mg/L, multiplied by 2.0 which is the change in the DO level. A typical background DO level for Wisconsin waters is 7 mg/L, so a 2 mg/L decrease is allowed in order to meet the 5 mg/L standard for warm water streams. The above relationship is temperature dependent and an appropriate temperature correction factor is applied. The 26-lb method is based on a typical 24°C summer value for warm water streams. Adjustments for temperature are made using the following equation:

$$k_t = k_{24}\left(0.967^{(T-24)}\right)$$

Where k_{24} = 26 lbs of BOD/day/cfs

Calculations based on Full Assimilative Capacity at 7Q10 Conditions:

$$Limitation(mg/L) = 2.4\left(DO_{stream} - DO_{std}\right)\left(\frac{\left({}_{7}Q_{10} + Q_{eff}\right)}{Q_{eff}}\right)\left(0.967^{(T-24)}\right)$$

Where:
Q_{eff} = effluent design flow
DO_{stream} = background dissolved oxygen = 7 mg/L
DO_{std} = dissolved oxygen criteria from s. NR 102.04(4) = 5 mg/L
${}_{7}Q_{10}$ = 0 cfs for Badfish Creek and <0.01 cfs for Badger Mill Creek
T = Receiving water temperature from s. NR 102.25 = 25ºC May-Oct and 3ºC Nov-April

Badfish Creek			
BOD_5 (and TSS) Effluent Limitations (26 LB Method)		**May-Sept.**	**Oct.-April**
Background Information:	$7\text{-}Q_{10}$ (cfs)	0	0
	River Temperature (°C)	21	3
Dissolved Oxygen mg/L:	Effluent	7	7
	Background	7	7
	Mix DO	7	7
	Criteria	5	5
Weekly Ave BOD_5 Effluent Limitations	Concentration Limits (mg/L)	5.3	10.4
	Mass (lbs./d)	N/A	N/A

Badger Mill Creek			
BOD_5 (and TSS) Effluent Limitations (26 LB Method)		**May-Sept.**	**Oct.-April**
Background Information:	$7\text{-}Q_{10}$ (cfs)	0	0
	River Temperature (°C)	21	1
Dissolved Oxygen mg/L:	Effluent	7	7
	Background	7	7
	Mix DO	7	7
	Criteria	5	5
Weekly Ave BOD_5 Effluent Limitations	Concentration Limits (mg/L)	5.3	10.4
	Mass (lbs./d)	N/A	N/A

Weekly average concentration limits of 5.3 mg/L summer and 10 mg/L winter would be included in the permit for both outfalls if the classifications were to change. These limits would apply regardless of effluent flow rate given the fact that the upstream receiving water low flow is equal to zero. These are the minimum concentration limits given to a facility and would also be the same regardless of whether the receiving water is considered to be a Class II or Class III Trout water.

Mass limits would not be required as these are the minimum concentration limits given to a facility. In addition a dissolved oxygen limit of 7.0 mg/L is recommended for both outfalls based on this calculation.

TOTAL SUSPENDED SOLIDS (TSS)

The TSS limitations are primarily given to maintain or improve water clarity and are not water quality based. Typically suspended solids limitations are established as the same concentration as the BOD_5 limitations. TSS limits for Badger Mill Creek are recommended equal to the BOD_5 limits.

Badfish Creek is under the Rock River TMDL which has waste load allocations (WLA) for TSS. These mass limits are expressed in monthly and weekly averages and will remain the same regardless of effluent flow rate or stream classification.

AMMONIA NITROGEN – BADFISH CREEK

Badfish Creek (001) (*Qe = 50 MGD, 48.6 MGD or 53.6 MGD)		**WWSF At point of discharge**	
		May-Sept.	**Oct.-April**
Effluent Information:	Flow (MGD)	*	*
	Flow (cfs)	*	*
	Maximum pH	7.8	7.8
Background Information:	1-Q_{10} (cfs)	0	0
	7-Q_{10} (cfs)	0	0
	7-Q_2 (cfs)	0	0
	Ammonia (mg/L)	0.07	0.17
	Temperature (°C)	23	3
	pH (su)	7.8	7.8
	% of Flow used	N/A	N/A
	Reference Weekly Flow (cfs)	0	0
	Reference Monthly Flow (cfs)	0	0
Criteria mg/L:	Acute (at effluent pH)	12.14	12.14
	4-Day Chronic		
	Early Life Stages Present	4.60	7.96
	Early Life Stages Absent	4.60	12.92
	30-Day Chronic		
	Early Life Stages Present	1.84	3.18
	Early Life Stages Absent	11.84	3.18
Effluent Limits mg/L:	Daily Maximum	**12.14**	**12.14**
	Weekly Average		
	Early Life Stages Present	4.60	7.96
	Early Life Stages Absent		**12.92**
	Monthly Average		
	Early Life Stages Present	1.84	3.18
	Early Life Stages Absent		**5.17**

Badfish Creek Outfall 001	Current Classification mg/L		Calculated Limits mg/L		Recommended Limits mg/L	
	May-Sept.	Oct.-April	May-Sept.	Oct.-April	May-Sept.	Oct.-April
Daily Maximum	17	13	12.14	12.14	12	12
Weekly Average	4.4	10	4.60	12.92	4.4	10
Monthly Average	1.8	4.1	1.84	5.17	1.8	4.1

The limits are the same regardless of effluent flow rate. The daily maximum limits would be reduced as a result of a classification change, however the weekly and monthly average limits would remain the same unless the facility is able to make a demonstration for an increased discharge pursuant to ch.NR 207.

AMMONIA NITROGEN – BADGER MILL CREEK

Badger Mill Creek (005) (*Qe = 3.6 MGD, and 5.0 MGD)		**WWSF (CW Class 5) At the point of discharge**	
		May-Sept.	**Oct.-April**
Effluent Information:	Flow (MGD)	*	*
	Flow (cfs)	*	*
	Maximum pH	7.8	7.8
Background Information:	$7\text{-}Q_{10}$ (cfs)	0.18	0.18
	$7\text{-}Q_2$ (cfs)	0.58	0.58
	Ammonia (mg/L)	0.07	0.17
	Temperature (°C)	23	3
	pH (su)	8.21	7.97
	% of Flow used	100	25
	Reference Weekly Flow (cfs)	0.18	0.045
	Reference Monthly Flow (cfs)	0.49	0.12
Criteria mg/L:	Acute (at effluent pH)	12.14	12.14
	4-Day Chronic		
	Early Life Stages Present	2.55	6.35
	Early Life Stages Absent	2.55	10.31
	30-Day Chronic		
	Early Life Stages Present	1.02	2.54
	Early Life Stages Absent	1.02	4.12
Effluent Limits mg/L:	Daily Maximum	**12.14**	**12.14**
	Weekly Average		
	Early Life Stages Present	**2.63**	6.40
	Early Life Stages Absent		**10.39**
	Monthly Average		
	Early Life Stages Present	**1.11**	2.59
	Early Life Stages Absent		**4.21**

Attachment #3

Badger Mill Creek Outfall 005	Current Classification mg/L		Calculated Limits mg/L		Recommended Limits mg/L	
	May-Sept.	Oct.-April	May-Sept.	Oct.-April	May-Sept.	Oct.-April
Daily Maximum	11	11	12.14	12.14	11	11
Weekly Average	2.6	8.7	2.63	10.39	2.6	8.7
Monthly Average	1.1	2.6	1.11	4.21	1.1	2.6

The limits are the same regardless of effluent flow rate. As a result of a classification change all of the limits would remain the same unless the facility is able to make a demonstration for an increased discharge pursuant to ch.NR 207.

TECHNICAL MEMORANDUM NO. 2B–FLOW AND LOADING PROJECTIONS

Technical Memorandum No. 2b for the

Madison Metropolitan Sewerage District, Madison, Wisconsin

Flow and Wasteload Forecasts
2016 Liquid Processing Facilities Plan

Prepared by:

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STRAND ASSOCIATES®

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APPENDIX

APPENDIX–CARPC POPULATION AND PRELIMINARY RAW WASTEWATER PROJECTIONS

This memorandum documents the existing Nine Springs Wastewater Treatment Plant (NSWWTP) influent flows and loadings, as well as the projected future influent flows and loadings for the 2016 Liquid Processing Facilities Plan (LPFP) through the planning year 2040. These projected flows and loadings are used within the future process and peak flow alternatives to evaluate required or recommended upgrades and modifications to the NSWWTP.

SERVICE AREA

The Madison Metropolitan Sewerage District (MMSD or District) provides wastewater conveyance and treatment services to the majority of residents in Dane County, Wisconsin. The service area (Figure 1) includes the 12 cities and villages, as well as 25 town and sanitary districts in Dane County (Table 1).

Cities	Villages	Towns and Sanitary Districts
Fitchburg	Cottage Grove	Blooming Grove
Madison	Dane	Blooming Grove–Waunona SD No. 2
Middleton	DeForest	Blooming Grove No. 10
Monona	Maple Bluff	Dunn No. 1, 3, and 4
Verona	McFarland	Dunn–Kegonsa Sanitary District
	Shorewood Hills	Madison
	Waunakee	Middleton No. 5
		Pleasant Springs No. 1
		Verona No. 1
		Vienna No. 1 and 2
		Westport–Cherokee
		Westport No. 1, 2, 3, and 4
		Windsor No. 1, 2, and 3
		Windsor–Hidden Springs
		Windsor–Lake Windsor
		Windsor–Morrisonville
		Windsor–Oak Springs

Table 1 MMSD Customer Communities

POPULATION PROJECTIONS

As a part of this 2016 LPFP, the Capital Area Regional Planning Commission (CARPC) developed population and preliminary raw wastewater flow projections through the year 2040 (refer to the Appendix). CARPC's official population projections, which are based on the Department of Administration's (DOA's) population data, includes a year 2040 service population of 437,777, which is approximately 86,000 more than the population in 2010 based on DOA Census Data. This amounts to a total population increase of about 24 percent over 30 years, or about 0.7 percent annually.

CARPC also considers population projections developed by the Madison Area Transportation Planning Board (MATPB), which are used to assist with planning transportation corridors in the same general area served by MMSD. The MATPB Transportation Analysis Zones (TAZ) population projections derived for the MMSD service area are about 4 percent higher than the DOA-based projections, with an estimated population of about 455,288 in year 2040. These projections are shown in Figure 2. For the purpose of this technical memorandum and the 2016 LPFP, the TAZ population projections will be used. These represent a 29 percent increase from 2010 populations.

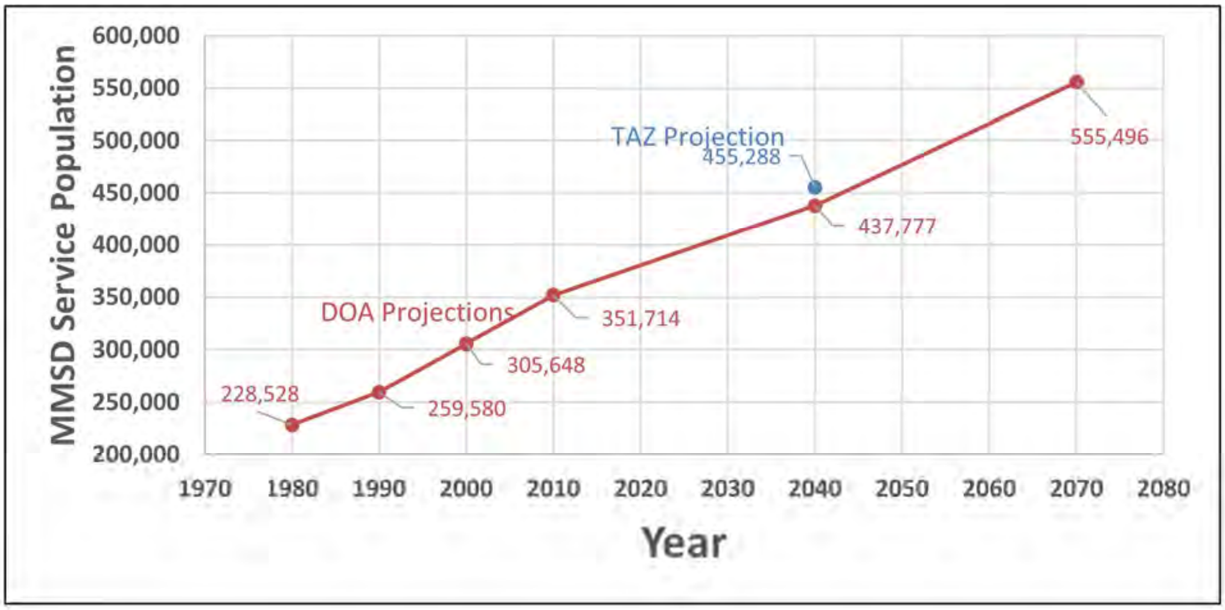

Figure 2 Population Projections for the MMSD Service Area

As part of the District's 50-Year Master Plan, the District met with the City of Sun Prairie, the City of Stoughton, and the Village of Oregon to determine the potential of those communities discharging wastewater to the District in the foreseeable future. Based on that effort, all three of these communities indicated they plan to continue operating independent wastewater treatment facilities, and the population projections included herein have assumed this will remain the status quo through the year 2040 at a minimum.

EXISTING INFLUENT FLOWS AND LOADINGS

A. Influent Flows

Influent flows and loadings to the NSWWTP consist of raw wastewater delivered from the District's service area via five force mains, as well as trucked-in wastes consisting of septage, holding tank, landfill leachate and other wastes. Trucked-in wastes are a very small percentage of the flows and loadings to the plant (less than 1 percent), and will be addressed in Technical Memorandum No. 6. Those flows and loadings are not included in this section.

Historical average influent flows have generally increased over time, though over recent years there has been a noticeable levelling or flattening of annual average flows. Figure 3 shows a graphical representation of the annual average flows to NSWWTP for the past 80 years. The data demonstrates that, while the service population has consistently increased since about 1980 (see Figure 2), average flows have actually flattened or even decreased, especially over the past 10 to 15 years (except for 2008, which experience a significant amount of wet weather). This reduction in flow increases is likely the result of water use reductions and water saving appliances. Recent dry weather, such as the drought of 2012, may also be a factor. Table 2 shows the trends in "per capita" wastewater flows, which further demonstrates the reduction in water use. Per capita wastewater flows have decreased from nearly 140 gpcd in the year 2000 to less than 110 gpcd in recent years. It is noted that the per capita flow values include industrial wastewater discharges, which were not subtracted because industrial flow volumes and loadings were not provided by the District and are not readily available.

Year	Average Flow (mgd)	Estimated Per Capita Flow (gpcd)
2000	42.1	138
2001	41.8	135
2002	40.1	128
2003	38.6	121
2004	41.9	129
2005	39.4	120
2006	41.2	124
2007	42.9	127
2008	47.3	138
2009	43.5	125
2010	43.0	122
2011	40.4	114
2012	36.6	103
2013	40.9	114
2014	38.6	106
2015	38.2	104
Average (2000-2015)	**41.0**	**122**
Average (2006-2015)	**41.3**	**117**

Table 2 Per Capita Flows (gpcd)

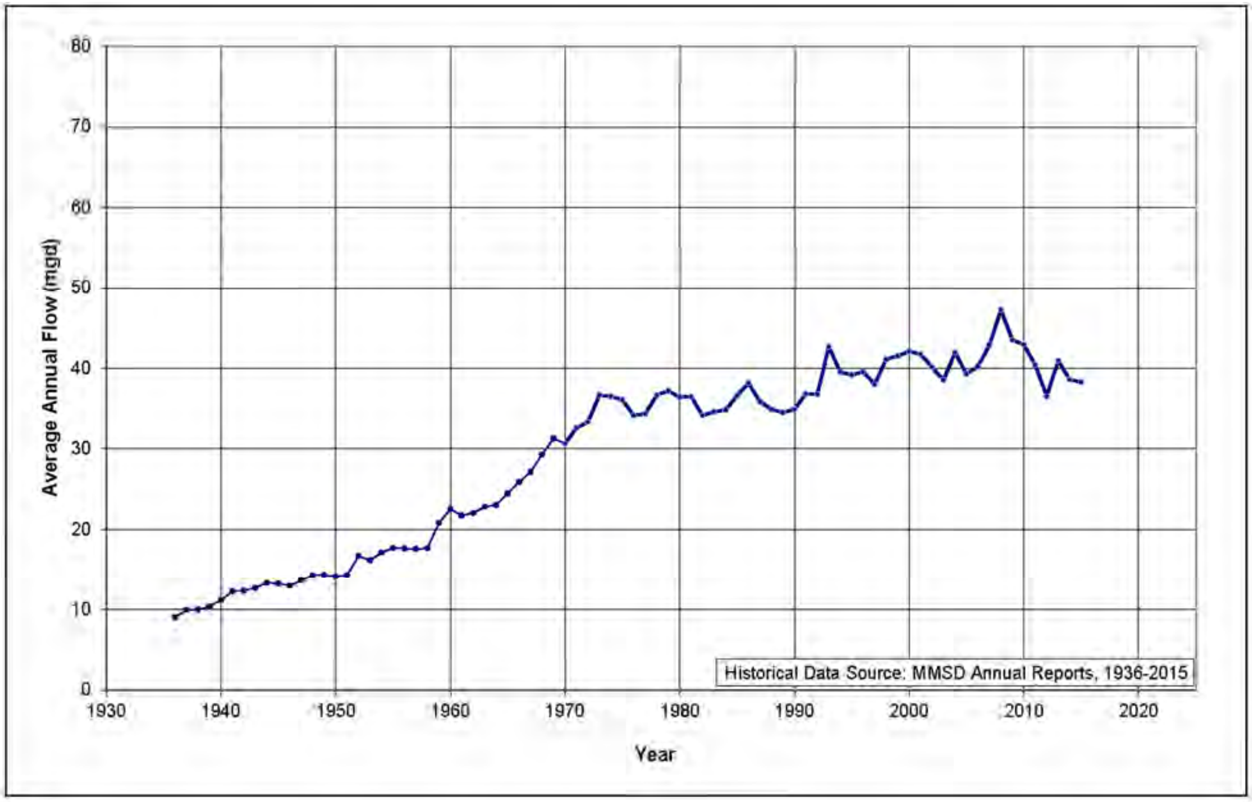

Figure 3 NSWWTP Average Annual Influent Flows

Table 3 presents an analysis of NSWWTP influent flow data from 2011 through 2015. Average monthly flows during this time have ranged from 34 mgd to nearly 49 mgd, with an average of about 39 mgd over the 5-year span. Using NSWWTP data, the maximum month flow over this time period was 48.7 mgd, and the maximum 30-day period was slightly higher at about 51.6 mgd. The maximum 7-day and maximum day peak flows are also shown in Table 3. In general, the peaking factors observed at the NSWWTP are relatively modest compared to many similar wastewater treatment facilities and service areas. This and the additional analysis provided in TM No. 4 indicates infiltration and inflow (I/I) is not "excessive" by regulatory agency standards.

	2011	2012	2013	2014	2015	Overall (2011-2015)
January	39.37	36.24	36.78	35.77	34.76	
February	41.34	37.12	38.72	37.0X3	34.53	
March	45.13	38.56	40.25	38.53	35.88	
April	44.17	37.55	47.82	40.18	38.66	
May	42.87	38.74	43.56	38.96	39.76	
June	41.52	36.4	48.65	43.23	39.41	
July	40.38	36.99	45.68	41.18	38.63	
August	39.25	36.05	40.04	38.37	38.05	
September	38.6	35.71	38.63	39.44	40.24	
October	36.97	37.09	37.42	38.23	38.46	
November	38.21	35.14	37.65	37.06	39.39	
December	37.53	34.09	36.03	35.26	41.03	
Average	40.45	36.64	40.94	38.6	38.23	38.98
Maximum Month	45.13	38.74	48.65	43.23	41.03	48.65
Max. Month Peak Factor	1.12	1.06	1.19	1.12	1.07	1.25
Maximum 30-day Period (PF)						51.61 (1.32)
Maximum 7-day Period (PF)						67.15 (1.72)
Maximum Day[a] (PF)						95.47 (2.45)
Maximum Day[b] (PF)						76.64 (1.97)

PF = Peaking factor (applied to average flow).
[a]Occurred June 26, 2013. Next highest daily flows were 74.8 mgd on June 27, 2013, and 71.29 mgd on June 25, 2013.
[b]Based on a statistical analysis, the 99.95th percentile maximum day flow is 76.64 mgd. Statistically, this flow would be expected to be exceeded less than 1 day during the 5-year period. This flow and peaking factor will be used for future projections.

Table 3 Existing Influent Average and Peak Flows (mgd)

B. Influent Loadings

Summaries of the influent wastewater loadings for 5-day biochemical oxygen demand (BOD), total suspended solids (TSS), total Kjeldahl nitrogen (TKN), ammonia-nitrogen (NH_3-N), and total phosphorus (TP) are shown in Tables 4 through 8, respectively. Evaluation of the trends in loading data indicate the following:

§ BOD loadings increased consistently through 2007 to about 85,000 lbs/day, and since then have actually decreased on an average basis by more than 5,000 lbs/day (~6 percent).

§ TSS loadings experienced a significant upward trend through 2004, with a significant increase in 2004 of 10,000 lbs/day and then a decrease in 2005 by approximately 14,000 lbs/day to a relatively consistent average loading of about 80,000 lbs/day. Since then, influent loadings have actually decreased on average to about 75,000 lbs/day, with an annual average low of 73,000 lbs/day in 2015.

§ Total phosphorus loadings were relatively flat at about 2,100 lbs/day through about 2009, and then decreased by about 200 to 300 lbs/day (10 to 15 percent) through 2012. This could possibly be the result of the phosphorus ban in detergents, which took effect in July 2015. Over the last three years, the TP loadings have increased consistently, though not to the pre-2010 levels. The ratio of TP to BOD and to TSS has remained fairly consistent since 2000, with a slight decrease in TP:BOD ratio over that time span.

§ TKN and ammonia have shown a consistent increase throughout this time period and through the present time. Both TKN and ammonia have increased by approximately 40 percent since 2000, while the service population has only increased by about 20 percent over this same time period.

§ The ratio of TKN to both BOD and TSS has consistently increased since 2000, with an overall increase of about 31 percent for both TKN:BOD and TKN:TSS.

§ The ratio of ammonia-nitrogen to TKN has remained fairly constant and has ranged between 60 to 65 percent throughout this time.

Given that the District's service population has increased over this time period, it is reasonable to assume residential loadings of all wasteload parameters have increased approximately in proportion to the population increase, which is about 20 percent, since it seems unlikely that the District's service population has collectively changed caloric intake over this time period. It is possible that more people are composting waste food rather than discharging it through a garbage disposal, but there is no data that we could find that supports any correlation with reduced BOD, TSS, and TP loadings. Complicating the evaluation is the significant increase in nitrogen loadings to the plant, which have increased at a rate of twice the population growth. We have compiled a list of potential explanations for the wasteload anomalies noted above. This memorandum does not attempt to define the specific cause of the decreased wastewater loadings further, but we have suggested some possible actions to better determine the cause:

1. It is possible that industrial loadings of BOD, TSS, and TP have decreased, while discharges of TKN and ammonia have increased. As stated previously, industrial wastewater information was not available to us because the District does not routinely directly monitor the industries. However, we are generally familiar with the industrial dischargers in the MMSD service area, and we are aware that wastewater loadings from these facilities may have decreased because of shutdowns and load reductions through alternate disposal means. Kraft-Heinz (Oscar Mayer), for example, has decreased production and wastewater loadings during this time period and ultimately plans to discontinue operations in Madison altogether in the near future. A detailed investigation of industrial loadings throughout this time period would need to be conducted to determine whether the NSWWTP influent loading observations are a function of changing industrial loadings. We recommend conducting such a study as part of preliminary design prior to any significant upgrades to the activated sludge facilities at the NSWWTP. Further note: Assuming the industrial loading decrease theory explains the decrease in BOD, TSS, and TP loadings, one would further need to assume that these same industrial discharges did not have significant TKN or ammonia concentrations.

2. Loadings of all particulate parameters could show a reduction through solids sedimentation in the collection system, which could result from the lower flows observed throughout this time period. However, if the phenomenon was strictly a physical settling of the particulate fractions, during periods of high flows the loadings would be expected to increase more significantly than has been observed, and overall annual loadings would not be expected to decrease. The data do not show significantly higher peaking factors during the wetter years (2008, 2013) compared to drier years.

3. BOD and TSS reduction could be the result of the observed reduction of wastewater flows during this time period, which would increase the residence time of wastewater in the District's sanitary sewer collection system and could result in partial biological treatment within the sewers and a reduction in BOD and TSS. If this phenomenon is actually occurring, the main reductions would be observed for BOD and TSS, whereas nitrogen and TP loadings would be less impacted, which at least partially matches the observations herein. However, if this were the case, loadings should be higher in the wetter years when sewer detention times are lower, and such a trend is not apparent.

4. The potential of influent sampling inaccuracies following the Tenth Addition construction could explain part of the observed loading decreases. We are not sure when the revised sampling equipment was installed and operational as part of this major plant upgrade. However, loadings of all parameters (except for TKN) decreased from 2004 to 2005, albeit at differing rates, following a consistent increase in loadings for all parameters the previous two or more years. This is not a conclusive argument, and we are not suggesting the influent loading data is inaccurate. However, to rule this potential out, it may be advisable to determine the date of the change-over from the old to the new samplers and sampling protocol. If the date matches the observations herein, a sampling plan could be conducted to determine if there is a reasonable chance that the existing sampling is not representative, or perhaps that the previous setup was not representative.

Year	Population	BOD Loads (lbs/day)				Per Capita Load (pcd)	BOD Peak Factors		
		Average	Max 30-day	Max 7-day	Max Day		Max 30-day	Max 7-day	Max Day
2000	305,648	75,671	79,884	86,069	106,704	0.25	1.06	1.14	1.41
2001	310,255	74,966	79,822	90,712	113,287	0.24	1.06	1.21	1.51
2002	314,861	74,889	82,338	90,997	110,193	0.24	1.10	1.22	1.47
2003	319,468	78,212	84,074	94,415	131,686	0.24	1.07	1.21	1.68
2004	324,074	82,465	101,302	94,993	114,589	0.25	1.23	1.15	1.39
2005	328,681	81,123	89,478	109,440	117,708	0.25	1.10	1.35	1.45
2006	333,288	84,119	92,392	102,067	121,531	0.25	1.10	1.21	1.44
2007	337,894	85,131	93,400	108,578	144,939	0.25	1.10	1.28	1.70
2008	342,501	82,650	87,400	92,962	111,207	0.24	1.06	1.12	1.35
2009	347,107	82,567	92,737	96,616	126,585	0.24	1.12	1.17	1.53
2010	351,714	77,719	86,302	93,828	115,147	0.22	1.11	1.21	1.48
2011	354,583	76,174	80,466	91,068	103,044	0.21	1.06	1.20	1.35
2012	357,452	79,475	86,948	92,229	110,634	0.22	1.09	1.16	1.39
2013	360,320	80,344	87,414	97,617	145,081	0.22	1.09	1.21	1.81
2014	363,189	80,238	86,722	102,742	130,000	0.22	1.08	1.28	1.62
2015	366,058	76,480	81,124	84,188	117,794	0.21	1.06	1.10	1.54
Recent 5-Year Average (2011-2015)		78,542	84,535	93,569	121,311	0.22	1.08	1.19	1.54
Recent 5-Year Max (2011-2015)		80,344	87,414	102,742	145,081	0.22	1.09	1.28	1.81

Table 4 Existing Influent BOD Loadings

Year	Population	TSS Loads (lbs/day)				Per Capita Load (pcd)	TSS Peak Factors		
		Average	Max 30-day	Max 7-day	Max Day		Max 30-day	Max 7-day	Max Day
2000	305,648	79,840	85,008	115,786	257,907	0.26	1.06	1.45	3.23
2001	310,255	77,615	88,213	101,754	139,845	0.25	1.14	1.31	1.80
2002	314,861	82,828	93,641	115,510	134,193	0.26	1.13	1.39	1.62
2003	319,468	84,120	89,713	98,173	138,549	0.26	1.07	1.17	1.65
2004	324,074	94,119	143,114	151,513	222,153	0.29	1.52	1.61	2.36
2005	328,681	80,188	86,048	92,003	125,513	0.24	1.07	1.15	1.57
2006	333,288	78,863	86,445	93,388	116,290	0.24	1.10	1.18	1.47
2007	337,894	75,686	82,673	91,327	172,690	0.22	1.09	1.21	2.28
2008	342,501	80,845	88,926	109,705	166,589	0.24	1.10	1.36	2.06
2009	347,107	78,835	86,296	93,133	120,533	0.23	1.09	1.18	1.53
2010	351,714	75,583	85,207	95,669	124,775	0.21	1.13	1.27	1.65
2011	354,583	76,115	81,433	93,311	129,071	0.21	1.07	1.23	1.70
2012	357,452	74,792	85,740	90,053	111,128	0.21	1.15	1.20	1.49
2013	360,320	76,247	85,997	127,626	218,960	0.21	1.13	1.67	2.87
2014	363,189	77,406	86,010	111,875	228,242	0.21	1.11	1.45	2.95
2015	366,058	73,034	75,708	85,299	104,207	0.20	1.04	1.17	1.43
Recent 5-Year Average (2011-2015)		75,519	82,978	101,633	158,322	0.21	1.10	1.34	2.09
Recent 5-Year Max (2011-2015)		77,406	86,010	127,626	228,242	0.21	1.15	1.67	2.95

Table 5 Existing Influent TSS Loadings

Year	Population	TKN Loads (lbs/day)				Per Capita Load (pcd)	TKN Peak Factors		
		Average	Max 30-day	Max 7-day	Max Day		Max 30-day	Max 7-day	Max Day
2000	305,648	10,989	11,414	12,145	16,656	0.036	1.04	1.11	1.52
2001	310,255	11,172	11,683	12,729	15,423	0.036	1.05	1.14	1.38
2002	314,861	11,229	11,876	13,084	14,886	0.036	1.06	1.17	1.33
2003	319,468	11,314	12,249	12,809	15,218	0.035	1.08	1.13	1.35
2004	324,074	12,059	13,570	13,218	14,865	0.037	1.13	1.10	1.23
2005	328,681	12,403	13,716	14,654	19,708	0.038	1.11	1.18	1.59
2006	333,288	13,130	13,951	14,789	16,288	0.039	1.06	1.13	1.24
2007	337,894	12,914	13,383	14,327	15,955	0.038	1.04	1.11	1.24
2008	342,501	13,175	13,889	14,538	15,551	0.038	1.05	1.10	1.18
2009	347,107	13,523	14,248	15,100	17,248	0.039	1.05	1.12	1.28
2010	351,714	13,404	13,833	14,738	16,200	0.038	1.03	1.10	1.21
2011	354,583	13,497	13,930	14,894	18,882	0.038	1.03	1.10	1.40
2012	357,452	13,594	14,344	15,039	17,269	0.038	1.06	1.11	1.27
2013	360,320	14,046	14,552	15,518	19,437	0.039	1.04	1.10	1.38
2014	363,189	14,402	15,654	16,492	26,558	0.040	1.09	1.15	1.84
2015	366,058	14,498	15,666	16,124	20,448	0.040	1.08	1.11	1.41
Recent 5-Year Average (2011-2015)		14,008	14,829	15,613	20,519	0.039	1.06	1.11	1.46
Recent 5-Year Max (2011-2015)		14,498	15,666	16,492	26,558	0.040	1.09	1.15	1.84

Table 6 Existing Influent TKN Loadings

Year	Population	NH3 Loads (lbs/day)				Per Capita Load (pcd)	NH3 Peak Factors		
		Average	Max 30-day	Max 7-day	Max Day		Max 30-day	Max 7-day	Max Day
2000	305,648	6,596	6,926	7,298	8,031	0.022	1.05	1.11	1.22
2001	310,255	6,776	7,114	7,694	9,525	0.022	1.05	1.14	1.41
2002	314,861	7,135	7,633	8,328	10,661	0.023	1.07	1.17	1.49
2003	319,468	7,281	7,988	8,519	10,299	0.023	1.10	1.17	1.41
2004	324,074	7,497	7,882	8,543	9,421	0.023	1.05	1.14	1.26
2005	328,681	7,319	8,254	8,720	10,918	0.022	1.13	1.19	1.49
2006	333,288	8,093	8,661	9,093	9,918	0.024	1.07	1.12	1.23
2007	337,894	8,049	8,529	9,222	13,432	0.024	1.06	1.15	1.67
2008	342,501	8,027	8,439	9,233	10,859	0.023	1.05	1.15	1.35
2009	347,107	8,283	8,710	9,361	11,399	0.024	1.05	1.13	1.38
2010	351,714	8,226	8,447	9,395	14,087	0.023	1.03	1.14	1.71
2011	354,583	8,346	8,801	9,577	13,276	0.024	1.05	1.15	1.59
2012	357,452	8,637	9,171	9,511	10,540	0.024	1.06	1.10	1.22
2013	360,320	8,841	9,486	10,078	13,221	0.025	1.07	1.14	1.50
2014	363,189	9,082	9,771	10,378	11,255	0.025	1.08	1.14	1.24
2015	366,058	9,413	10,057	10,534	13,471	0.026	1.07	1.12	1.43
Recent 5-Year Average (2011-2015)		8,864	9,457	10,016	12,353	0.025	1.07	1.13	1.40
Recent 5-Year Max (2011-2015)		9,413	10,057	10,534	13,471	0.026	1.08	1.15	1.59

Table 7 Existing Influent NH_3-N Loadings

Year	Population	Total Phosphorus Loads (lbs/day)				Per Capita Load (pcd)	Total Phosphorus Peak Factors		
		Average	Max 30-day	Max 7-day	Max Day		Max 30-day	Max 7-day	Max Day
2000	305,648	2,099	2,234	2,344	2,944	0.0069	1.06	1.12	1.40
2001	310,255	2,043	2,126	2,292	3,098	0.0066	1.04	1.12	1.52
2002	314,861	2,029	2,170	2,267	2,662	0.0064	1.07	1.12	1.31
2003	319,468	2,086	2,232	2,389	2,856	0.0065	1.07	1.15	1.37
2004	324,074	2,200	2,454	2,479	2,907	0.0068	1.12	1.13	1.32
2005	328,681	2,116	2,228	2,388	2,885	0.0064	1.05	1.13	1.36
2006	333,288	2,164	2,325	2,522	3,001	0.0065	1.07	1.17	1.39
2007	337,894	2,112	2,217	2,363	2,580	0.0063	1.05	1.12	1.22
2008	342,501	2,169	2,290	2,507	3,083	0.0063	1.06	1.16	1.42
2009	347,107	2,102	2,229	2,321	2,915	0.0061	1.06	1.10	1.39
2010	351,714	1,945	2,016	2,136	2,520	0.0055	1.04	1.10	1.30
2011	354,583	1,867	1,976	2,125	2,350	0.0053	1.06	1.14	1.26
2012	357,452	1,818	1,907	2,021	2,511	0.0051	1.05	1.11	1.38
2013	360,320	1,824	1,876	2,148	2,683	0.0051	1.03	1.18	1.47
2014	363,189	1,902	2,136	2,169	3,087	0.0052	1.12	1.14	1.62
2015	366,058	1,933	2,077	2,140	2,496	0.0053	1.07	1.11	1.29
Recent 5-Year Average (2011-2015)		1,869	1,995	2,120	2,626	0.0052	1.07	1.13	1.41
Recent 5-Year Max (2011-2015)		1,933	2,136	2,169	3,087	0.0053	1.12	1.18	1.62

Table 8 Existing Influent TP Loadings

PROJECTED FLOWS AND WASTELOADS

In the previous facilities planning studies by the District, several methods have been used to project future flows and BOD, TSS, TKN, NH_3-N, and TP loadings. The methodology used in this technical memorandum takes into account the observed decrease (or lack of increase) in influent flows and loadings over the past decade, even while the service area grew with respect to residential population. We have assumed the measured and observed flow and loadings trends are real (that is, accurately measured) and explained generally as follows:

§ Reduced flows are a result of reduced water consumption by the residential, commercial, and industrial community. This has been observed by the Madison Water Utility and by other communities as people become more educated about water conservation and began implementing water reduction measures. While this trend may continue to decrease per capita wastewater flows discharged to the NSWWTP, we have made the assumption that the average per capita flows will remain approximately the same as the current long-term average (2006 through 2015) rate of 117 gpcd.

§ Wasteload (BOD, TSS, and TP) reductions (or lack of increases) are the result of industrial loading decreases. The per capita loadings measured over the past 5 years will be used to project future loadings in proportion to the anticipated population increases in the District service area.

A. Flow Projections

As noted previously, average influent flows to the NSWWTP have been fairly stable, and average per capita flow rates have generally decreased over the past 10 to 15 years. To develop future average flows to the NSWWTP, we used influent flow data from 2006 to 2015, which included a few higher flow years (2007 through 2010). Based on this data, the average annual per capita flow is approximately 117 gpcd (Table 3). Although in the past few years the average per capita flows have been less than this average value, we recommend using the longer term average of 117 gpcd to account for future wet weather events and flow variability. While this may be a conservative assumption, we believe this is appropriate given the highly variable nature of any given year with respect to rainfall and associated wet weather events. This also provides some cushion for unplanned industrial growth in the District’s service area.

Design average flows for the future years of 2020, 2030, and 2040 were developed by multiplying the projected populations in those future years by the average per capita flow of 117 gpcd. The projected average annual flows to NSWWTP are shown in Table 9, with a planning year (2040) estimate of 53.6 mgd. This is an approximate 37 percent increase over the current (year 2011 to 2015) average flow of about 39.0 mgd.

To estimate future maximum 30-day, maximum 7-day, and maximum day flows, the peaking factors shown in Table 3 were multiplied by the future design average flow of 53.6 mgd. The future design flows are summarized in Table 9. It is important to note that the use of existing peaking factors to project future peak design flows essentially assumes that future I/I will increase proportionally to the increase in average flows. This was a base assumption in the previous Technical Memorandum No. 4 on peak flow management alternatives.

In addition, the year 2040 peak design flow of 180 mgd was previously projected through hydraulic modeling of the historical NSWWTP influent flows over several decades, which was presented in Technical Memorandum No. 4. To date, the previous peak flow was about 136 mgd in June 2013. While the maximum capacity of all of the District’s pump stations that discharge directly to NSWWTP is currently approximately 209 mgd, the modeling predicted a peak value of approximately 176 mgd. Therefore, although it is possible to pump more than 180 mgd to the NSWWTP, we recommend a peak design flow of 180 mgd be utilized for the purpose of this facilities planning project.

	Peaking Factor	**2020**	**2030**	**2040**
MMSD Population Projection	---	383,904	419,596	455,288
Design Flow Summary				
Average Day (mgd)	---	42.00	47.80	53.60
Maximum 30-day (mgd)	1.32	55.63	63.31	71.00
Maximum 7-day (mgd)	1.72	72.35	82.34	92.34
Maximum Day (mgd)	1.97[1]	82.74	94.17	105.59
Peak Hourly Flow (mgd)	3.36[2]	141	160	180

[1]99.95th percentile highest daily flow used to calculate peaking factor.
[2]Based on modeling results presented in Technical Memorandum No. 4.

Table 9 Future Design Flow Summary

B. Wasteload Projections

The per capita and future design loadings for BOD, TSS, TKN, NH3-N, and TP were developed using an analysis similar to that employed for the flow projections (Table 10). Per capita loadings were determined using existing influent plant loading data, which were divided by the estimated population over time to calculate a per capita loading. This data was previously presented in Tables 4 through 8. Projections of future average loadings were then developed using populations projection provided earlier multiplied by the 2011 through 2015 per capita loading rates, and these are presented in Figures 4 through 8 and in Table 10. Future design peak loading rates (maximum 30-day, maximum 7-day, and maximum day) are based on current peaking factors for each parameter (refer to Tables 4 through 8).

	Peaking Factor	2020	2030	2040
MMSD Population Projection	—	383,904	419,596	455,288
Design BOD Loading Summary				
Average Day (lbs/day)	—	82,904	90,671	98,438
Maximum 30-day (lbs/day)	1.14	94,167	102,989	111,811
Maximum 7-day (lbs/day)	1.31	108,437	118,597	128,756
Maximum Day (lbs/day)	1.85	153,236	167,592	181,948
Design TSS Loading Summary				
Average Day (lbs/day)	—	79,276	86,703	94,130
Maximum 30-day (lbs/day)	1.17	92,552	101,223	109,894
Maximum 7-day (lbs/day)	1.69	133,964	146,515	159,065
Maximum Day (lbs/day)	3.02	239,700	262,157	284,613
Design TKN Loading Summary				
Average Day (lbs/day)	—	15,019	16,426	17,832
Maximum 30-day (lbs/day)	1.13	16,997	18,567	20,158
Maximum 7-day (lbs/day)	1.18	17,695	19,353	21,010
Maximum Day (lbs/day)	1.46	21,942	23,997	26,052
Design Ammonia-Nitrogen Loading Summary				
Average Day (lbs/day)	—	9,560	10,455	11,350
Maximum 30-day (lbs/day)	1.14	10,929	11,953	12,976
Maximum 7-day (lbs/day)	1.19	11,368	12,433	13,498
Maximum Day (lbs/day)	1.52	14,535	15,896	17,258
Design Total Phosphorus Loading Summary				
Average Day (lbs/day)	—	1,979	2,164	2,349
Maximum 30-day (lbs/day)	1.11	2,204	2,410	2,617
Maximum 7-day (lbs/day)	1.16	2,299	2,514	2,729
Maximum Day (lbs/day)	1.65	3,274	3,580	3,887

Table 10 Future Design Wasteload Summary

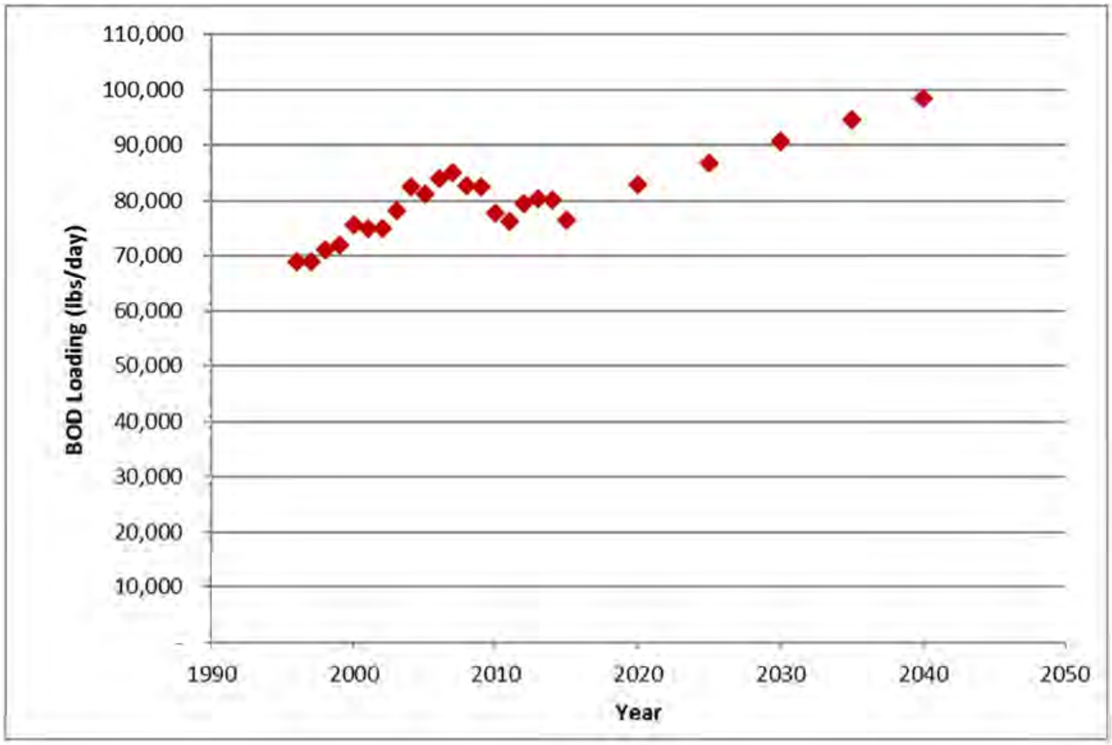

Figure 4 NSWWTP Historical and Projected Future Average BOD Loadings

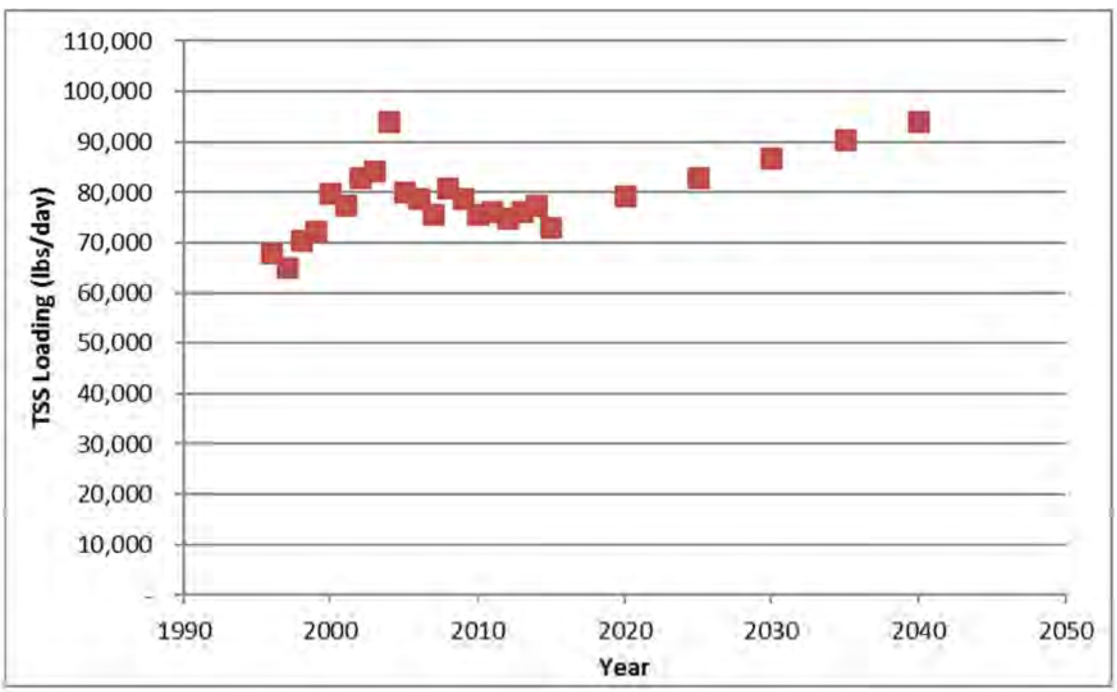

Figure 5 NSWWTP Historical and Projected Future Average TSS Loading

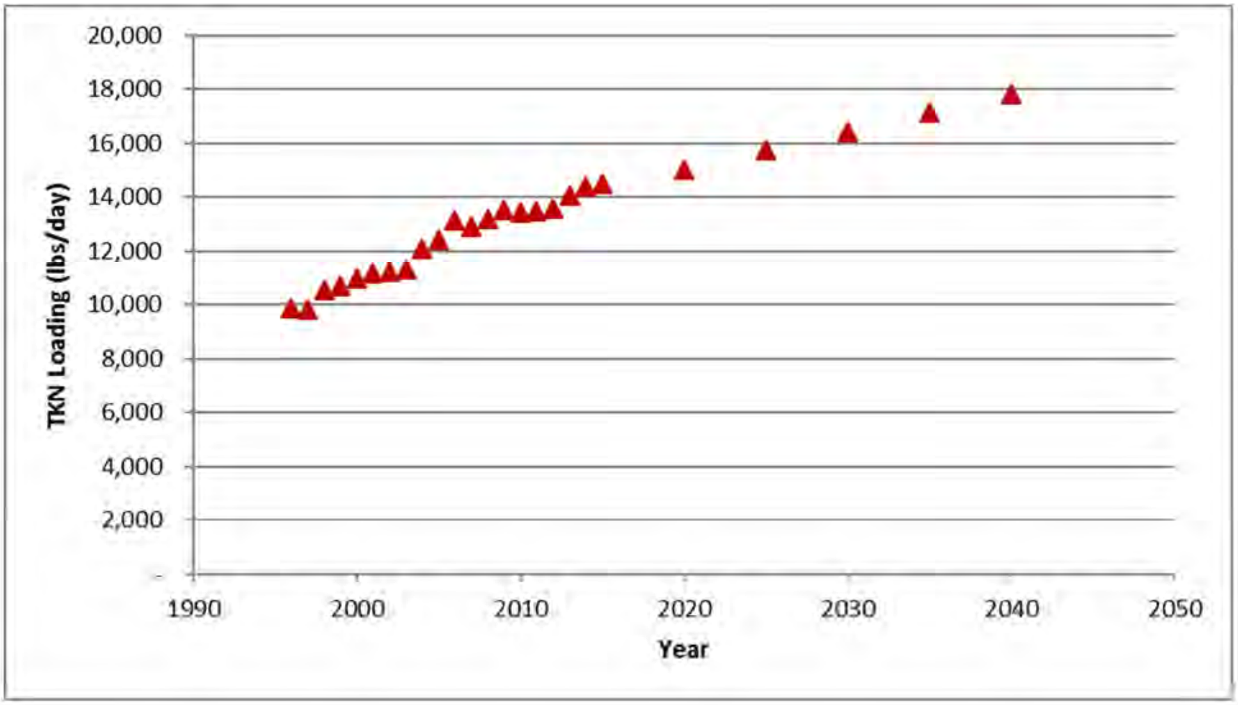

Figure 6 NSWWTP Historical and Projected Future Average TKN Loadings

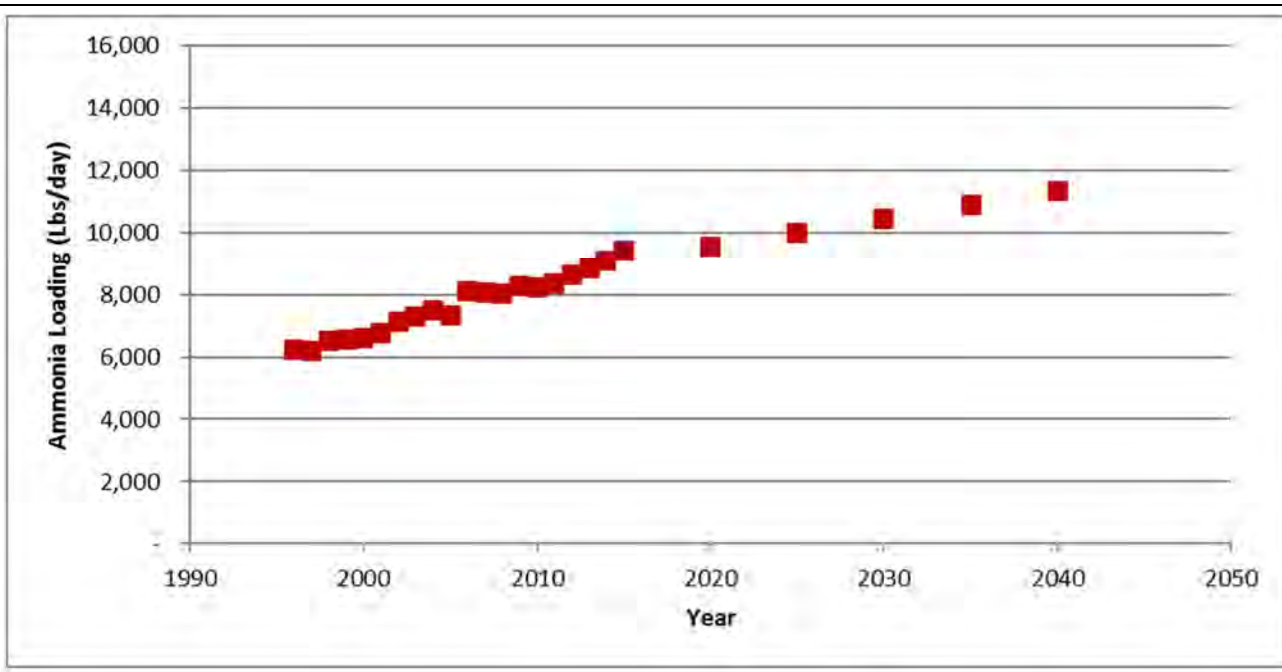

Figure 7 NSWWTP Historical and Projected Future Average Ammonia-Nitrogen Loadings

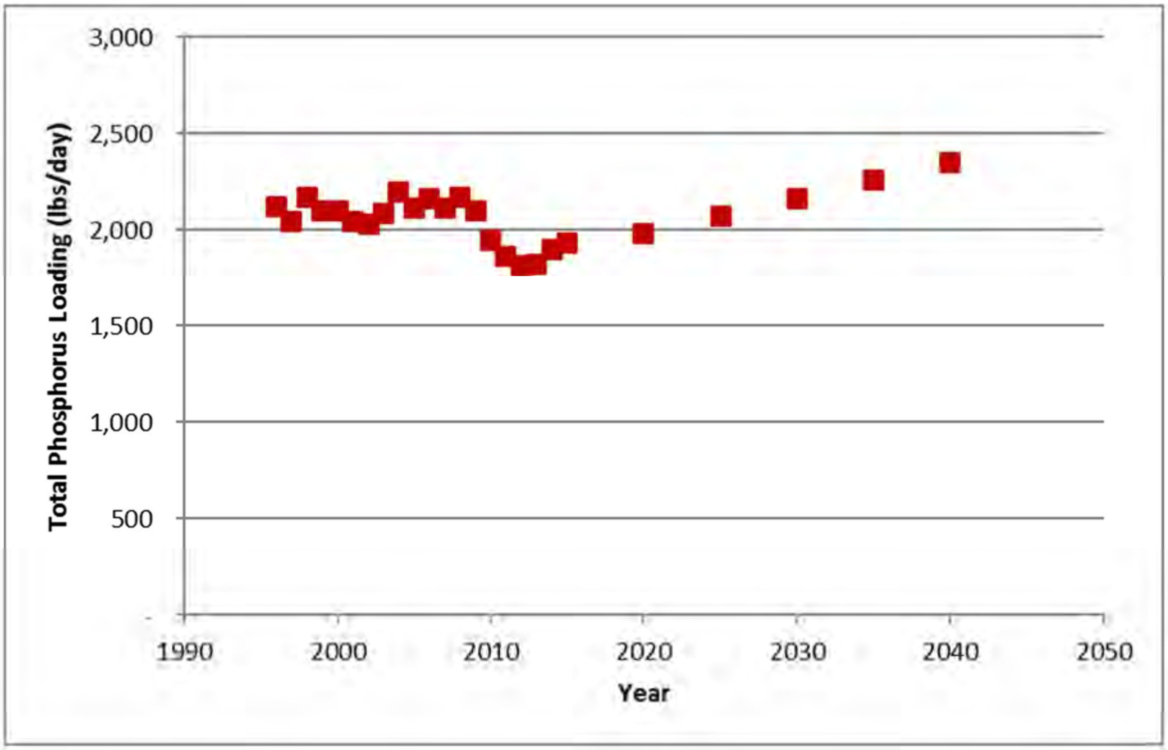

Figure 8 NSWWTP Historical and Projected Future Average Total Phosphorus Loadings

APPENDIX
CARPC POPULATION AND PRELIMINARY RAW WASTEWATER PROJECTIONS

From: Rupiper, Mike [mailto:miker@capitalarearpc.org]
Sent: Wednesday, April 13, 2016 9:48 AM
To: Mike Simon
Cc: Todd Gebert
Subject: RE: 2040 Plant Flow Forecast

Mike,

Here is the 2040 Plant Flow forecast table using the "dry weather" flow data you sent.

Year	Avg. Dry Weather Flow MGD	MMSD Population (DOA)	Avg. Dry Weather Flow gpcpd	
2000	37.50	305,648	123	
2010	39.02	351,714	111	
2040	*48.57*	*437,777*	*111*	*low*
2040	*51.14*	*437,777*	*117*	*average*
2040	*53.71*	*437,777*	*123*	*high*

If you want/need to use a single number rather than a range, I think it would be reasonable to use the DOA based 2040 population projection (437,777) and the 2010 per capita dry weather flow (111 gpd), knowing that the population forecast variance based on the TAZ data could be about 4% higher but that the 2015 dry weather flow per capita is about 5% lower.

Let me know if you need any additional information and/or if you would like this sent in a letter instead.

FYI – I will be out of the office all of next week.

Thanks

- Mike

Mike Rupiper, PE

Director of Environmental Resources Planning

Capital Area Regional Planning Commission

210 Martin Luther King Jr. Blvd. Room 362

Madison, WI 53703

Phone: 608-266-9283

From: Mike Simon [mailto:MikeS@madsewer.org]
Sent: Tuesday, April 12, 2016 4:35 PM
To: Rupiper, Mike
Cc: Todd Gebert
Subject: RE: 2040 Plant Flow Forecast

Mike,

The following list shows the lowest monthly flows by year from 2000 to 2014:

2000 37.50 (January)
2001 38.46 (January)
2002 37.22 (January)
2003 36.70 (January)
2004 37.77 (January)
2005 33.66 (October)
2006 38.91 (January)
2007 38.69 (January)
2008 40.88 (November)
2009 40.15 (November)
2010 39.02 (December)
2011 36.97 (November)
2012 34.09 (December)
2013 36.03 (December)
2014 35.26 (December)

The per capita number used in the Master Plan projections was 116 gpcpd for both the low and high 2030 projections. What we saw in 2015 was about 105.

Mike

CAPITAL AREA REGIONAL PLANNING COMMISSION

210 Martin Luther King Jr. Blvd. Room 362 Madison, WI 53703 Phone: 608-266-4137 Fax: 608-266-9117 www.CapitalAreaRPC.org info@CapitalAreaRPC.org

March 23, 2016

Mr. Michael E. Simon, PE, MBA
Assistant Chief Engineer & Director
Madison Metropolitan Sewerage District
1610 Moorland Road
Madison, WI 53713-3398

Re: 2040 Average Total Plant Flow Forecast

Dear Mr. Simon,

As requested, the Capital Area Regional Planning Commission is providing a forecasted range of the likely 2040 average total plant flow at the Madison Metropolitan Sewerage District. The forecast uses historical flow and MMSD service area population data to derive the historical average total plant flow for the four previous census years in gallons per capita per day. CARPC's official 2040 population forecast for the MMSD service area is 437,777 people. A range of recent historical average total plant flow was used with the 2040 population forecast to generate a likely range of 2040 average total plant flow.

Year	Avg. Flow MGD	MMSD Population	Avg. Flow gpcpd	
1980	36.66	228,528	160	
1990	34.92	259,580	135	
2000	42.10	305,648	138	
2010	42.97	351,714	122	
2040	*53.41*	*437,777*	*122*	*low*
2040	*56.91*	*437,777*	*130*	*average*
2040	*60.41*	*437,777*	*138*	*high*

We look forward to our continuing collaboration with the Madison Metropolitan Sewerage District. Please contact me if you require additional information or have any questions.

Sincerely,

Mike Rupiper

Mike Rupiper, PE
Director of Environmental Resources Planning

REGIONAL PLANNING COMMISSION

210 Martin Luther King Jr. Blvd. Room 362 Madison, WI 53703 Phone: 608-266-4137 Fax: 608-266-9117 www.CapitalAreaRPC.org info@CapitalAreaRPC.org

December 21, 2015

Mr. Michael E. Simon, P.E., M.B.A.
Assistant Chief Engineer & Director
Madison Metropolitan Sewerage District
1610 Moorland Road
Madison, WI 53713-3398

RE: Population Trends and Forecasts

Dear Mr. Simon:

Enclosed are the Capital Area Regional Planning Commission's updated Population Trends and Forecasts for the Madison Metropolitan Sewerage District. The attached documents detail the following:

- Official 2040 Population Forecasts
- Unofficial 2070 Population Forecasts
- Exhibit A - "Overview of Population, Household, and Employment Projections"
- Adopting Resolution CARPC No. 2015-12
- WDNR approval letter dated December 21, 2015

We look forward to our continuing collaboration with the Madison Metropolitan Sewerage District in 2016. Please contact me if you require additional information or have any questions.

Sincerely,

Mike Rupiper

Mike Rupiper, PE
Director of Environmental Resources Planning
Capital Area Regional Planning Commission

Enclosures as noted

Population Trends and Forecasts
for the Madison Metropolitan Sewerage District

	1980	1990	2000	2010	2040	*2070*
Central USA	218,344	245,390	268,850	302,935	367,749	*471,827*
Cottage Grove USA	901	1,131	4,059	6,230	9,509	*11,115*
Dane USA			799	995	1,400	*1,632*
Fox Bluff LSA			240	240	240	*240*
Kegonsa LSA			2,228	2,252	2,252	*2,252*
Morrisonville USA			352	323	340	*355*
Northern USA	5,393	7,160	9,901	13,022	18,892	*23,500*
Verona USA			7,306	10,645	16,878	*20,067*
Waubesa LSA			2,027	2,027	2,027	*2,027*
Waunakee USA	3,890	5,899	9,000	12,159	17,604	*21,595*
Windsor Prairie LSA			509	509	509	*509*
Westport LSA			377	377	377	*377*
MMSD	**228,528**	**259,580**	**305,648**	**351,714**	**437,777**	***555,496***

Official 2040 Forecasts

Population forecasts for urban and limited service areas in 2040 were developed by the Capital Area Regional Planning Commission (CARPC) based closely on the Wisconsin Department of Administration (DOA) Demographic Services Center adopted numbers for Dane County and its Minor Civil Divisions. *Exhibit A - "Overview of Population, Household, and Employment Projections"*, provides a detailed description of the methodology. These official population forecasts have been adopted by CARPC Resolution No. 2015-12 as an amendment to the *Dane County Water Quality Plan* and the *Dane County Land Use and Transportation Plan.* The 2040 forecasts have been provided to the Wisconsin Department of Natural Resources and were approved as an amendment to the *Dane County Water Quality Management Plan,* in their letter dated December 21, 2015. These official 2040 forecasts are required to be used for facilities planning purposes.

Unofficial 2070 Forecasts

The 2070 forecasts were developed from a least squares linear regression of historic and 2020 - 2040 forecasted populations for each urban service area. They are not official forecasts. The official 2070 population forecasts will not be developed until 2040 - 2045.

Exhibit A

“Overview of Population, Household, and Employment Projections”

"Overview of Population, Household, and Employment Projections"

December, 2015

Capital Area Regional Planning Commission

Employment Projection Summary

Projection of employment in the Capital Area Regional Planning Commission's (CARPC) land demand methodology is based on two main elements:

- Projected labor force at the county-level, which are used as a control total, and
- Projected rate of change in employment at the ZIP code level.

1. **Projected labor force** is derived from Department of Administration's (DOA) age-sex projections for Dane and its adjacent counties. The methodology projects the employed labor force as follows:
    a. Historical labor force participation rates (LFPR) by age group at the national level are used to project future LFPRs.
        i. Based on Bureau of Labor Statistics (BLS) analysis, LFPRs are assumed to decline further from their current levels for almost all age groups.
        ii. This decline in participation is slowed to account for Dane County's higher historical LFPRs.
        iii. The total working-age population projected by DOA is multiplied by its respective age group's LFPR.
        iv. The total number of labor force participants is adjusted to reflect the observed trend from 1990—2010 in the number of workers residing in Dane County who also work in Dane County.[1]
        v. The total from the previous step is further adjusted to reflect a 5% unemployment rate, which is held constant through the projection period.

    b. For adjacent counties, the proportion of employed workers commuting into Dane County is calculated for 1990, 2000, and 2010 based on Census Flow data.
        i. The change in proportion of employed workers from each county commuting into Dane County is then projected out to 2050.
        ii. Each contributing countys' total population aged 16—75+ is multiplied by its rate of residents commuting to Dane County for work.

    c. The totals from steps "v" of item "a" and "ii" of item "b" above are summed. *This is the total employed labor force projected for Dane County.*

[1] The observed trend suggests a near-constant value of around 92%.

2. **Change in employment** is based on 1994—2014 County Business Patterns (CBP) and ZIP Code Business Patterns (ZBP) data from BLS.
    a. Observed private employment at the ZIP code level is projected out to the year 2050.
        i. Data points for 2009, 2010, and 2011 are removed to control for the major drops in employment observed during the recession.
        ii. Average annual increase in employment is calculated for the remaining years and projected out to the year 2050 for each Urban Service Area (USA). For those USAs with rapidly declining growth or with negative projection values at or before the end year of the projection period, employment loss is slowed. The average annual loss is halved in each successive 5-year period. This stabilizes employment levels for these communities by the year 2050.[2]

    b. Government employment is calculated based on observed ratios of government employee class (local, state, and Federal) to population at the county level between 1994 and 2014.
        i. Due to no appreciable change in the ratios observed, the median ratio (1994—2014[3]) of local and Federal employees to residents is used.
        ii. The ratio of State employees to residents is based on the observed decrease in State employees from 1994—2014[3]. This trend is projected out to the end year of 2050.
        iii. The county-wide ratio of local governmental employees to residents is applied to the total population for each USA. The ratios of state and Federal employees per citizen is applied to the total Dane County population projection and then added to government employment within the Central Urban Service Area (CUSA).

    c. Totals from “a” and “b” above are summed to arrive at an employment projection for each USA.

3. **Adjustment based on County control total**—The projected change in employment numbers in section “2” above are controlled to the county’s employed labor force generated in section “1.”

[2] Note: This applies to *private employment only.* In some instances, the final employment number for a USA appears to fluctuate. This is due to the addition of government employment, which is a function of population growth in the CARPC projections.
[3] Excluding the years: 2009, 2010, and 2011.

Projection of Population, Households, and Population in Households

CARPC’s projections (population, households, and population in households) are based closely on DOA’s adopted numbers for Dane County and its Minor Civil Divisions (MCDs). In developing the revised CARPC land demand methodology, staff relied on five primary projection numbers for each USA: population, population in households, households, labor force, and employees.

The analysis of these additional measurements reflects a more detailed, nuanced approach taken in this methodology. Residuals or remainders of these projection numbers provide additional measurements. For example, household size is a residual of households and population in households; changes in household size are not projected independently. The difference between population and population within households is subtle but meaningful. For the purpose of residential land demand, “population in households” was utilized. In the case of projecting future *per capita* land uses like civic or recreational functions, “population” was utilized. The difference between these numbers reflects the population in group homes, nursing homes, etc. So, while the entire population of a community is served by a civic land use; only increase of the population within households is considered when projecting land demand for residential uses.

1. **Changes to Existing CARPC Projection Methods**—Upon review of CARPC’s current methodology, CARPC staff concluded that the distinction between MCDs and the USAs is no longer functionally meaningful for the purposes of generating population and household numbers because the USA process deals primarily with the increment of change. While there is a difference in population between an MCD and the corresponding USA, in most cases this is only a five percent difference in population and household numbers. DOA projection numbers are used *as the USA numbers* in cases where a USA contains or is contained by a single MCD e.g. City of Stoughton vs. Stoughton USA. In cases where multiple MCDs exist in a USA, e.g. the CUSA, the projection number are the aggregate of those MCDs. Since the focus of the USA amendment process is on the *addition of new development land* to service areas, and because new development overwhelmingly requires a full compliment of services, it can be assumed that—with very few exceptions—new urban development land in response to population changes will occur as additions to an existing civil division and its USA. In effect, it is not necessary to project USA populations independent from the existing DOA household projections. However, making minor adjustments in special cases is required.

2. **Adjustments to DOA Projections**—Assumptions about the growth of the Outlying Urban Service Areas (OUSAs) crossing county lines have been in place for several years. These assumptions about growth patterns of the Belleville, Brooklyn, Cambridge, and Edgerton USAs are continued in this methodology.

    a. Belleville and Cambridge USAs: All future growth is assumed to be in the Dane County portion of the USA. The population growth is based on the population projected for both sides of the Dane County border.

b. Brooklyn USA: Future growth is assumed to occur in both Dane and Green counties. The Dane County growth projection is based only on the Dane County portion of Brooklyn's population.

c. Edgerton USA: Based on the City's comprehensive plan and confirmation by the City Administrator, it is assumed that 42% of future growth will occur within Dane County. Forty-two percent of the total population change from the Dane County and Rock County portions of Edgerton—as forecast by the DOA—is allocated to the Edgerton USA.

3. **Unique Population Projection Cases**—In a handful of cases, the service area and MCD boundaries are not suitably coincident.

   a. *Central Urban Service Area (CUSA)* —The CUSA is comprised of the following communities either in whole or in part: City of Fitchburg[4], City of Madison, City of Middleton, City of Monona, Village of Maple Bluff, Village of McFarland, Village of Shorewood Hills, Town of Blooming Grove, and Town of Madison.[5] Additional minor adjustments were made to account for other town contributions. (See section "c." below.)

   b. *Northern*—The Northern USA is comprised of land in the Village of DeForest, Town of Vienna, and the Town of Windsor. There is also a small amount of land within the Town of Burke. For the purposes of residential projections, growth within the Village of DeForest and Town of Windsor are considered. Land in the USA contributed by Burke contains very few residents and is overwhelmingly industrial in use. An additional supporting factor in this assumption is the observed decline in both percentage and number of Vienna residents in "urban" areas between the 2000 and 2010 Census. It is assumed that all residential growth within DeForest and the balance of "urban" development reflected for the Town of Windsor in the Census will account for the residential growth within the Northern USA. Additionally, it is expected that the proportion of Windsor's population within the Northern USA will continue to increase. The percent of Windsor's population living in "urban areas" increased by *five percent* between the 2000 and 2010 Census. [59—64%] Windsor's proportion of households within "urban areas" increased by *six percent* over the

[4] An adjustment (subtraction) to the CUSA totals is made to compensate for the proportion of Fitchburg *not within* the CUSA. Although Fitchburg has become increasingly more "urban," by the Census definition [85—90%, in 2000—2010], a proportion of the population still exists in rural areas. It is assumed that this trend will continue, however the percentage of urban households has been fixed at 98% for 2040 to reflect the fact that some residents are likely to remain in "rural" areas.

[5] In addition there is a very small amount of land outside of these contributing entities that is within the CUSA. However, these fragments are inconsequential to the consideration of *future* land demand as the bulk of the land area is added at the request of the nine entities listed above in response to their growth; requests by other towns are the exception rather than the rule.

same period. [61—67%] For the purpose of USA growth, it is expected that this Census trend will continue over the coming decades. [6]

c. *Town Land within USAs*—The overwhelming majority of households and lands within USAs are found within the primary municipality for which each USA is named, e.g. the Sun Prairie Urban Service Area's households are over 99% City of Sun Prairie residences. Minor adjustments are made to each USA to account for the contributions of these non-primary communities. On average the increase to the DOA numbers to account for town contributions is on the order of *one-half of one percent*. While the adjustments are relatively minor when considering USA population and household totals, in some cases a larger proportion of a town's residents and households exist within a USA. One notable case is the Town of Westport; over half of the households in Westport are within the Central Urban Service Area. The 2010 Land Use Inventory is used to estimate the number of town households within each USA. This proportion is assumed to remain relatively consistent[7] and is multiplied by the DOA's projections so that, as the community grows, its contribution to the USA does as well. Population and Population-in-Household numbers were calculated for the adjustments based on the DOA's people-per-household averages by community (USA).

The following are examples of USAs that contain more than *five percent* of one or more adjacent towns' households:

i. *Central USA* —Towns of Westport (55.8%), Verona (12.9%), and Middleton (7.5%)
ii. *Deerfield USA* —Town of Deerfield (5.3%)
iii. *Stoughton USA* —Town of Dunkirk (15.8%)

The actual adjustment made to each USA (percent change from the DOA/CARPC figure) is minor; the range of adjustment is between *zero and three-and-one-half percent. Two thirds* of the USA totals were unadjusted from the quantities generated by the base methodology. The following USAs were adjusted by more than *one-half of a percent* at one or more of the five-year intervals in the projection period:

i. *Belleville USA*—Accounting for the Town of Montrose (15) households

---

[6] It should also be noted that the Town of Windsor elected to incorporate following a ballot in 2015. This may affect the balance within the Northern USA (Formerly—in part—the Deforest USA) to the point where Windsor contributes an ever-increasing quantity of households and requires additional lands. All the more reason that the projections should reflect an increasing concentration within "urban areas" and increasing proportion of Windsor's overall population and households within the Northern USA.

[7] This assumption is validated by comparing the 2000 and 2010 Census' "percent in urbanized area" statistics for the towns. In most cases, significant changes over the decade were attributable to changes in definition of "urban" by the Census Bureau or other reclassifications at the municipal level i.e. annexations, etc.

ii. *Black Earth USA* — Accounting for the Town of Black Earth (3) households
iii. *Cottage Grove USA* — Accounting for the Town of Cottage Grove (14) households
iv. *Central USA* — Accounting for the Towns of Westport (995), Middleton (149), Burke (139), and Verona (96) households
v. *Deerfield USA* — Accounting for the Town of Deerfield (29) households
vi. *Stoughton USA* — Accounting for the Towns of Dunkirk (124) households
vii. *Waunakee USA* — Accounting for the Town of Westport (28) households

d. *Koshkonong*—Koshkonong USA is presumed to follow the observed trend in population and number of households in those Census blocks most closely coinciding with its borders. Values are taken from Decennial Census counts. All of the land within the Koskonong USA exists in the Town of Albion.

REGIONAL PLANNING COMMISSION

210 Martin Luther King Jr. Blvd. Room 362 Madison, WI 53703 Phone: 608-266-4137 Fax: 608-266-9117 www.CapitalAreaRPC.org info@CapitalAreaRPC.org

Resolution CARPC No. 2015-12

Adoption of 2040 Population, Housing and Employment Projections; Adoption of Land Demand Projections for Service Areas within Dane County

WHEREAS, the Capital Area Regional Planning Commission has adopted, amended and reaffirmed the *Dane County Land Use and Transportation Plan* and *Water Quality Plan*; and

WHEREAS, said plans have been amended through June 2015; and

WHEREAS, the *Dane County Land Use and Transportation Plan* and the *Dane County Water Quality Plan* are based on population and employment projections and associated land demands as outlined in Wisconsin Administrative Codes Chapter NR121; and

WHEREAS, population and employment projections and associated land demands are routinely updated with the availability of new Census data and using county-wide population projections from the Wisconsin Department of Administration; and

WHEREAS, population and employment projections address recommendations made by Curt Paulsen, Professor of Urban and Regional Planning at the University of Wisconsin-Madison, in his review and evaluation of CARPC land demand methodology, at the request of CARPC; and

WHEREAS, CARPC staff has followed a population and employment projection protocol with consultation with, and concurrence from, the Wisconsin Department of Administration as required by NR121.

NOW, THEREFORE, BE IT RESOLVED that in accordance with Chapter NR 121, the Capital Area Regional Planning Commission adopts the 2040 population and employment projections and associated land demand quantities shown in Table 1 (attached) as an amendment to the *Dane County Water Quality Plan* and the *Dane County Land Use and Transportation Plan.*

October 8, 2015
Date Adopted

Larry Palm, Chairperson

State of Wisconsin
DEPARTMENT OF NATURAL RESOURCES
101 S. Webster Street
Box 7921
Madison WI 53707-7921

Scott Walker, Governor
Cathy Stepp, Secretary
Telephone 608-266-2621
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December 21, 2015

DNR File No. DC-0170

Steve Steinhoff
Deputy Director
Capital Area Regional Planning Commission
City County Building, Room 362
210 Martin Luther King Jr. Blvd
Madison WI 53703

Subject: Adoption of 2040 Population, Housing, and Employment Projections; Adoption of Land Demand Projections for Service Areas within Dane County

Dear Mr. Steinhoff:

We have completed our review of the proposed update to the Dane County Water Quality Management Plan submitted to the Department on December 11, 2015 by the Capital Area Regional Planning Commission (CARPC). The plan update incorporates the population and employment projections, and associated land demands, created by CARPC using county-wide population projections from the Wisconsin Department of Administration. The Capital Area Regional Planning Commission adopted Resolution CARPC No. 2015-12 approving the plan update at its October 8, 2015 meeting, following a public hearing. The Department hereby approves the plan update.

The plan update becomes part of Wisconsin's Areawide Water Quality Management Plan, and will be forwarded to the US Environmental Protection Agency to meet the requirements of the Clean Water Act of 1987 (Public Law 92-500 as amended by Public Law 95-217) and outlined in the federal regulations 40 CFR, part 35.

This review is an equivalent analysis action under s. NR 150.20(2)(a)3, Wis. Adm. Code. By means of this review, the Department has complied with ch. NR 150, Wis. Adm. Code, and with s. 1.11, Stats.

The approval of this plan update does not constitute approval of any other local, state or federal permit that may be required for sewer construction or associated land development activities.

If you believe that you have a right to challenge this decision, you should know that the Wisconsin statutes and administrative rules establish time periods within which requests to review Department decisions must be filed. For judicial review of a decision pursuant to sections 227.52 and 227.53, Wis. Stats., you have 30 days after the decision is mailed, or otherwise served by the Department, to file your petition with the appropriate circuit court and serve the petition on the Department. Such a petition for judicial review must name the Department of Natural Resources as the respondent.

To request a contested case hearing pursuant to section 227.42, Wis. Stats, you have 30 days after the decision is mailed, or otherwise served by the Department, to serve a petition for hearing on the Secretary of the Department of Natural Resources. All requests for contested case hearings must be made in accordance with section NR 2.05(5), Wis. Adm. Code, and served on the Secretary in accordance with section NR 2.03, Wis. Adm. Code. The filing of a request for a contested case hearing does not extend the 30 day period for filing a petition for judicial review.

Sincerely,

Timothy R. Asplund
Monitoring Section Chief
Bureau of Water Quality

APPENDIX C–TECHNICAL MEMORANDUM NO. 3
CONDITION ASSESSMENTS

Technical Memorandum No. 3 for the

Madison Metropolitan Sewerage District, Madison, Wisconsin

Condition Assessments
2016 Liquid Processing Facilities Plan

Prepared by:

STRAND ASSOCIATES, INC.®
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August 2016
Revised May 2017
Revised June 2017

STRAND ASSOCIATES®

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APPENDIX E–PHOTOS AND DRAWINGS

This memorandum includes a summary of the general condition assessments that were conducted for the facilities planning project. In addition, more detailed evaluations were conducted on East Primary Tank No. 1 and No. 2, as well as on the 54-inch east primary influent pipe, and a summary of those assessments is presented in this memorandum.

INTRODUCTION

The Madison Metropolitan Sewerage District (District) is currently developing an asset management plan under a separate contract with a third party. One of the goals of this 2016 Liquid Processing Facilities Plan was to establish baseline asset data by conducting Level 2 condition assessments for the major assets and asset groups included within the scope of this planning project. These assessments included the equipment, control panels and electrical distribution equipment, structures, and related infrastructure associated with the Nine Springs Wastewater Treatment Plant (NSWWTP) headworks, primary clarifiers, activated sludge process, final clarifiers, UV disinfection, and hydraulic control elements. The main focus was to capture condition assessment data and estimate the remaining life and replacement costs for these assets. Summaries of the data will be provided in a digital format to the District. Also, the data will be used to evaluate the null-alternatives of the LPFP

CONDITION ASSESSMENT OVERVIEW AND PROCESS

The condition assessment rating templates for the various asset types were provided by the District and are based on a third-party developed approach that is part of the asset management planning project that is ongoing. The condition assessments were grouped into three major categories: process mechanical, electrical, and structures. A summary of the asset categories is given below with respect to the assets involved in the condition assessments for this project. See Appendices A.1 and A.2 for a list of the assets by category and by building/structure, respectively. A total of 624 individual assets were included in the asset lists from the District, and approximately 60 of those assets were not assessed because the asset was not accessible, not operating, or had previously been removed from service.

Process Mechanical–This category includes pumps, blowers, compressors, clarifier collectors, screens, grit systems, conveyors, gates, valves, samplers, and related wastewater equipment. This project included assessment of approximately 351 assets within this category.

Electrical–This category includes motors, variable frequency drives (VFDs), control panels, motor control centers (MCCs), switchgear, and related electrical systems. Instrumentation is included in this category, but the assessments did not include individual pieces of instrumentation. This project included assessment of approximately 191 assets within this category.

Structures–This category generally includes concrete wastewater structures such as clarifiers, tanks, and channels, as well as weirs, railing, grating, and other similar structural features. This project included assessment of approximately 82 assets within this category.

Prior to conducting the condition assessments, a workshop with the District, the District's third party asset management consultant, and Strand Associates, Inc.® (Strand) staff was conducted to review the condition assessment process, protocol, and deliverables. Condition assessments were conducted in the months of May and June 2016, by Strand staff. Strand staff visually observed the assets and applied the rating criteria (provided by the District; see Appendix B) for each of the assets. The data was entered via tablet computer using forms developed for the District. Photographs of the assets were taken and tagged to the asset within the database. If any asset received a poor rating (4 or 5 on a scale of 1 through 5), a photograph of the part of the asset that led to the poor rating was taken if possible to include within the database for that specific asset. Where practical, mechanical and electrical assessments were conducted with the equipment in service and operating.

The database was developed in Microsoft SQL Server 2012 for data storage and Access 2013 for data entry. Several forms and code libraries were created using Visual Basic for Applications on the data entry side and ActiveX Data Objects for passing data back and forth with SQL Server. On the data storage side, several custom scripts were developed in Transact-SQL, most of which are set to run automatically when data is entered.

This application was intended to be used on PCs running Microsoft Windows 7 and Office 2010 or above, and all devices that are used to collect data are required to have both Access 2010 or above as well as SQL Server Express 2012 or above. During development, it was tested on Microsoft Surface Pro devices, both generation 3 and 4 running Windows 8.1 and Windows 10, as well as Office 2013. The tablets were used in the field to take photographs and enter data during the field condition assessments. The tablets were then synced in the office with the database for data storage and updating.

GENERAL CONDITION ASSESSMENT RESULTS

The majority of assets generally appear to be in good condition with ratings of 3 or better in all categories; 98 assets received at least one rating of 4 or 5, and the list of these assets is included Appendix C. Of the assets that received a low rating of 4 or 5, the majority were the result of asset age and parts availability rather than a defect or obvious condition deterioration.

All asset data is stored in the database noted above. Summaries of each asset's condition can be viewed or printed as required, but are not included in this facilities plan.

EAST PRIMARY INFLUENT PIPE

A. Background Information

The east primary influent pipe is a 54-inch prestressed concrete cylinder pipe (PCCP). The pipe was installed in approximately 1975 as part of the fifth addition to the NSWWTP, and it conveys wastewater approximately 500 feet from Junction Structure No. 2 to the east primary clarifier influent channel. The District previously videotaped the inside of the pipe in 2007, and the video footage was provided to Strand for review. We note that the video footage is about 10 years old at the time of this facilities planning project, and the pipe condition has likely deteriorated more since then. We recommend televising the line again before a final plan for its rehabilitation is developed.

B. Capacity and Condition

Based on hydraulic analysis conducted on the NSWWTP, the existing 54-inch pipe has capacity to accommodate approximately 85 million gallons per day (mgd) before surcharging the primary influent splitter weirs. Based on the evaluations of the peak flow management alternatives being considered (Technical Memorandum No. 4, TM4) to convey approximately 180 mgd through the plant, approximately 90 mgd to the east side is desired. The modeled water surface in the flow splitter structure effluent troughs to the east plant is 27.71 feet under the recommended peak flow plan, assuming the 54-inch pipe is reused, which results in a surcharge of the existing weir elevation of 27.00 feet. This surcharge would likely result in more flow being diverted to the west plant (west side primary), which, under the recommended future hydraulic conditions, is acceptable. Therefore, the existing 54-inch east primary influent pipe may be able to be used throughout the planning horizon of this facilities plan. If the hydraulic model does not accurately predict the future plant hydraulics at the influent splitter structure, some modifications to the structure may be needed. Further, if a condition assessment of the existing 54-inch pipe identifies a more urgent need to replace the pipe (see below), a larger pipe should be installed.

Strand reviewed the closed-circuit televising (CCTV) video of the sewer conducted by the District in 2007. There appears to be a significant amount of sediment and grease in the sewer, which at times impeded movement of the camera. In addition, since the pipe was not empty, the bottom portion of the pipe could not be viewed. The pipe shows signs of corrosion throughout the entire length. In many locations, concrete aggregate is exposed, although none of the pre-stressing wire was visible in the video. Our general assessment is that the pipe is not in imminent danger of failing and could be reused if adequate rehabilitation of the pipe were implemented. Detailed notes related to the CCTV review are contained in Appendix D.

C. Rehabilitation Opinion of Costs

Rehabilitation of the sewer will require that the flows in the system be bypassed around the segment to be worked on. There is a parallel pipe, diameter varies from 60 inches to 36 inches, which also conveys flow from Junction Structure No. 2 to the east primary clarifier influent channel. However, this parallel pipe does not have adequate capacity to handle the full forward flow at the plant, and for the purposes of this evaluation, some bypass pumping costs are included.

Rehabilitation options focused on trenchless alternatives (vs. conventional “open cut” techniques). This would involve application of a coating that is applied once the system has been thoroughly cleaned. The coatings evaluated included a corrosion-resistant cementitious lining, a polymer-based spray-on lining system, and epoxy coatings. The costs for coating options range from about $300 to $600 per lineal foot and include the necessary preparation work and access chambers for equipment and personnel. Total budgetary costs, including pipe cleaning, bypass pumping, engineering, and contingencies, are in the range of $300,000 to $600,000. Full replacement of the pipe would be expected to be in the range of $500,000 to $800,000. As previously noted, we recommend televising the line again before developing a final rehabilitation plan.

D. Null Alternative Discussion

The "do-nothing" alternative, or null alternative, would continue to use the 54-inch pipe in its existing condition. There are no definitive capital or O&M costs associated with this alternative. At the time of the 2007 video of the pipe, the general assessment was that the pipe could probably last for another 20 years, although it is not possible to predict the remaining life based on the video. Similarly, it is not possible to predict the remaining life of the pipe at the current time without further inspection.

In the event of a catastrophic failure of the pipe because of its continuing deterioration, the cost of emergency pumping and pipe repair would likely exceed $50,000, and could be much more than $100,000 depending on the location and extent of the failure. A failure would also likely result in a discharge of untreated wastewater to nearby surface waters, which could result in fines as well as poor public perception. In addition, such an event would necessitate the need to fully rehabilitate or replace the pipe in the very near future after the event. If the null alternative is to be considered a viable option, we recommend inspection of the pipe to assess its condition.

EAST PRIMARY TANKS NO. 1 and NO. 2

A. Background and Description

The condition of East Primary Tanks No. 1 and No. 2 were assessed in more detail because of the tank age, which is more than 80 years old as these tanks were constructed in the early 1930s. The below-grade walls, slabs, columns, and beams were observed on April 4, 2016. At-grade slabs and walkways were observed on May 3, 2016. Representative photos are included in Appendix E.

Primary Tanks 1 (Photo 1) and 2 (Photo 2) are identical open-air reinforced concrete tanks with overall dimensions of 32 feet 7 inches wide by 86 feet 10 inches long (see Appendix E for Record Drawing Plan and Sections). The two tanks are separated by a full height dividing wall supporting an elevated cantilevered walkway slab. Tank depth varies from 11 feet at the north end to 12 feet at the south end. Each tank is divided into two 15-foot-wide bays separated by a 2-foot-high knee wall situated between a row of 12-inch by 24-inch concrete columns supporting a 2-foot 3-inch-deep beam and a 6-inch-deep elevated cantilevered walkway slab. The deep beam provides support for the chain and flight clarifier mechanism. Transverse elevated walkways are located at the midpoint of the tank and span from the center walkway to exterior tank walls.

An influent channel runs the full width of the south end of the tanks with an inlet structure situated at the center of the two tanks. Each tank is connected to the influent channel by four 9-inch high by 6-foot 6-inch-long inlet ports. A 10-foot 8-inch-wide, 8-inch deep, elevated slab runs the length of the south end of the tanks adjacent to the influent channel and inlet ports. The elevated slab is supported by edge beams along the north and south edges of the slab. An effluent channel, elevated slab, and scum troughs run the width of the north end of the tanks. Each tank is connected to the effluent channel by four 9-inch-high by 6-foot 6-inch-long outlet ports. Existing plans indicate outlet weirs are located at each outlet port.

Photographs of the major concerns are included in Appendix E. The following paragraphs summarize the condition of these two primary tanks (see Appendix E for photographs).

B. Primary Tank No. 1

1. Structural Integrity and Function

§ Upper sections of vertical tank walls at the inlet end beneath the elevated slabs exhibited areas of cracking, delamination, and spalled concrete (Photo 3). Areas of delamination were easily dislodged using a hammer.

§ Elevated slab edge beams at the inlet end exhibited areas of exposed reinforcing, cracking, delamination, and spalled concrete on bottom and vertical faces (Photo 4). Areas of delamination were easily dislodged using a hammer. Exposed reinforcing was corroded with minor section loss.

§ Underside of the elevated slab at the inlet end exhibited areas of spalled concrete with exposed corroded reinforcing (Photo 5).

§ Underside of the elevated slab at outlet end exhibited areas of spalled and delaminated concrete (Photo 6).

§ Vertical walls/beams over outlet ports exhibited cracked and delaminated concrete with some exposed corroded reinforcing.

§ Underside of the transverse elevated walkways exhibited areas of cracked and delaminated concrete. Areas of delamination were easily dislodged using a hammer.

§ Underside and edges of the cantilevered walkway slabs were observed to have a few cracks and spalls (Photo 7).

§ Top edges of the effluent channel exhibited sections of cracked and spalled concrete.

§ No movement was evident in the structure components.

2. Surface Deterioration

§ The following surfaces were noted to be in good condition with very little or no deterioration:

o Base slab surface
o Vertical tank walls
o Columns
o Knee wall between columns
o Beam spanning across columns

§ Inlet port walls had significant surface deterioration

§ Outlet port walls had significant surface deterioration.

§ Underside of the elevated slab at inlet end had significant deterioration with exposed reinforcing and concrete spalls evident. Aggregate was exposed due to poor initial concrete consolidation.

§ Underside of the transverse walkway slabs exhibited areas of exposed aggregate due to poor initial concrete consolidation.

§ Underside of the elevated slab at outlet end above outlet ports had significant deterioration with concrete spalls evident.

§ Top surface of the elevated slab at inlet end exhibited areas of wear with areas of exposed aggregate present (Photo 8).

§ Top surface of the elevated walkways exhibited areas of wear with large patches of exposed aggregate present (Photo 9).

§ Top surface edges of the elevated slab at outlet end exhibited areas of spalled concrete (Photo 10).

§ Exposed faces of edge beams exhibited areas of exposed aggregate due to poor initial concrete consolidation (Photo 11).

§ Top edges of the scum trough contained small sections of spalled concrete.

3. Foundation

§ No settlement or erosion was evident.

4. Mechanism and Other Items

§ Chain and flight clarifier mechanism connections to the support beams appeared sound with no cracking or corrosion observed.

§ Chain and flight clarifier mechanism generally appeared sound with no cracking or corrosion observed.

§ Surface of drive shaft exhibited moderate pitting with some corrosion (Photo 12).

§ Minor corrosion was observed on chain link fence and fence post base plates with little impact on strength or function.

§ Corrosion was evident on outlet weir operator support plates.

§ Corrosion was evident on motor support with little impact on strength.

§ Condition of the outlet weirs could not be observed.

C. Primary Tank No. 2

1. Structural Integrity and Function

§ Vertical wall beneath west end of scum trough in west bay exhibits a large crack and delaminated concrete continuous under end of trough. Concrete sounds hollow when tapped with hammer (Photo 13).

§ Elevated slab edge beams at inlet end exhibited areas of exposed reinforcing, cracking, delamination, and spalled concrete on bottom and vertical faces (Photo 14). Areas of delamination were easily dislodged by hammer. Exposed reinforcing was corroded with minor section loss.

§ Underside of elevated slab at inlet end exhibited areas of spalled concrete with exposed corroded reinforcing.

§ Underside of the elevated slab at outlet end exhibited areas of spalled and delaminated concrete.

§ Vertical walls/beams over the outlet ports exhibited cracked and delaminated concrete with some exposed corroded reinforcing. Some section loss of the beam has occurred over the length of port opening.

§ Underside and edges of the cantilevered walkway slabs have spalled edges and exposed reinforcing.

§ Underside of the transverse elevated walkways exhibited areas of exposed reinforcing.

§ Top edges of effluent channel exhibited sections of cracked and spalled concrete.

§ East tank wall shows horizontal crack beneath bearing end of scum trough (Photo 15).

§ Edge of the transverse walkway exhibits a few cracks and exposed reinforcing.

§ No movement was evident in the structure components.

2. Surface Deterioration

§ The following surfaces were noted to be in good condition with very little or no deterioration:

- Base slab
- Vertical tank walls
- Columns
- Knee wall between columns
- Beam spanning across columns

§ Inlet port walls had significant surface deterioration.

§ Outlet port walls had significant surface deterioration (Photo 16).

- Underside of the elevated slab at inlet end had significant deterioration with exposed reinforcing and concrete spalls evident (Photo 17). Aggregate was exposed due to poor initial concrete consolidation.
- Underside of the transverse walkway slabs exhibited areas of exposed aggregate due to poor initial concrete consolidation.
- Underside of elevated slab at the outlet end above the outlet ports had areas of deterioration with delaminated concrete.
- Top surface and edges of the elevated slab at inlet end exhibited areas of wear with large areas of exposed aggregate present (Photo 18).
- Top surface of the elevated walkways exhibited areas of wear with large patches of exposed aggregate present (Photo 19).
- Top surface edges of the elevated slab at outlet end exhibited small areas of spalled concrete.
- Exposed faces of the edge beams exhibited areas of exposed aggregate due to poor initial concrete consolidation.
- Top edges of the scum trough contained sections of spalled concrete (Photo 20).

3. Foundation

- No settlement or erosion was evident.

4. Mechanism and Other Items

- Chain and flight clarifier mechanism connections to the support beams appeared sound with no cracking or corrosion observed.
- Chain and flight clarifier mechanism generally appeared sound with no cracking or corrosion observed. Surface of drive shaft exhibited moderate pitting with some corrosion.
- Minor corrosion was observed on chain link fence and fence post base plates with little impact on strength or function. Some concrete cracking at baseplates (Photo 21).
- Corrosion was evident on outlet weir operator support plates (Photo 22).
- Condition of the outlet weirs could not be observed.

D. <u>Inlet Structure</u>

1. Structural Integrity

- Top slab exhibited several cracks (Photo 23).
- No movement was evident in the structure components.

2. Surface

   § Top surface and edges exhibited spalled concrete (Photo 24).

3. Foundation

   § No settlement or erosion was evident.

E. Overall Assessment and Rehabilitation Budget

East Primary Tanks No. 1 and No. 2 remain viable structures for continued use as primary clarifiers. The defects observed with these tanks are consistent with tanks in this service, and considering the age of the tanks at more than 80 years, the tanks are in reasonably good condition. Some concrete rehabilitation work should be budgeted to maintain the usefulness of the tanks before the deterioration becomes too severe.

For the purposes of this report, concrete rehabilitation would include concrete removal, replacement, and overlay methods, depending on the location and severity of the deterioration. Based on our experience on several similar recent projects, we recommend budgeting approximately $450,000 for the engineering and construction services to rehabilitate the tanks.

F. Null Alternative Discussion

The null alternative would leave the tanks in their current condition without any improvements. The tank structures will last more than 20 years without any rehabilitation, though the condition will continue to deteriorate. The likely failure mode would be further concrete deterioration, which could create problems with the clarifier mechanism/scum removal operation, concrete spalling in areas that could result in reinforcing corrosion and deterioration, and potentially employee safety on deteriorated concrete walkways.

We do not recommend leaving the tanks in their current condition. Rehabilitation projects of this type are common and typically very successful at restoring the function and integrity of such structures.

APPENDIX A.1
ASSETS BY CATEGORY

Appendix A.1 - Assets by Category

Group Buildings and Grounds

Type Auto Samplers

Equipment Auto Samplers

Asset ID	Asset Description	Process Description	Asset Type	Building	Remaining Useful Life	Replacement Cost	Comments	Worst Rating
SAM0001	ACB4: Sampler A, Plant 3 RAS, ACB4	Aeration Control (WAS and RAS)	SAMPLER	ACB4	5-10 years	$7,500.00		5

Type Tanks

Equipment Tanks

Asset ID	Asset Description	Process Description	Asset Type	Building	Remaining Useful Life	Replacement Cost	Comments	Worst Rating
TNK3501	PT01: Primary Tank 1, E101, PT01	Primary Clarification	TANK,PRIM	PT01	15+ years	$225,000.00	corroding/chipping concrete on sides and walkways minor cracking above waterline no tag	3
TNK3502	PT02: Primary Tank 2, E102, PT02	Primary Clarification	TANK,PRIM	PT02	15+ years	$225,000.00	no tag concrete walkway corroding, rebar exposed surface cracks	3
TNK3505	PT05: Primary Tank 5, PT05	Primary Clarification	TANK,PRIM	PT05	15+ years	$200,000.00	no tag minir cracking above waterline wood weir is warping	2
TNK3506	PT06: Primary Tank 6, PT06	Primary Clarification	TANK,PRIM	PT06	15+ years	$200,000.00	no tag minor cracking warping wood weir	2

TNK3507	PT07: Primary Tank 7, PT07	Primary Clarification	TANK,PRIM	PT07	15+ years	$200,000.00	no tag minor cracking warping wood weir	2
TNK3508	PT08: Primary Tank 8, PT08	Primary Clarification	TANK,PRIM	PT08	15+ years	$200,000.00	no tag minor cracking warping wood weir corroding concrete walkway	2
TNK3509	PT09: Primary Tank 9, PT09	Primary Clarification	TANK,PRIM	PT09	15+ years	$200,000.00	no tag minor cracking warping wood weir fence has a hole in it	2
TNK3510	PT10: Primary Tank 10, PT10	Primary Clarification	TANK,PRIM	PT10	15+ years	$200,000.00	no tag minor cracking warping wood weir fence has a hole in it	2
TNK3511	PT11: Primary Tank 11, PT11	Primary Clarification	TANK,PRIM	PT11	15+ years	$200,000.00	no tag minor cracking warping wood weir fence has a hole in it	2
TNK3512	PT12: Primary Tank 12, PT12	Primary Clarification	TANK,PRIM	PT12	15+ years	$200,000.00	no tag minor cracking warping wood weir fence has a hole in it	2
TNK3513	PT13: Primary Tank 13, PT13	Primary Clarification	TANK,PRIM	PT13	15+ years	$200,000.00	no tag minor cracking warping wood weir fence has a hole in it	2
TNK3514	PT14: Primary Tank 14, PT14	Primary Clarification	TANK,PRIM	PT14	15+ years	$200,000.00	no tag minor cracking warping wood weir fence has a hole in it	2
TNK3515	PT15: Primary Tank 15, PT15	Primary Clarification	TANK,PRIM	PT15	15+ years	$200,000.00	no tag minor cracking warping wood weir fence has a hole in it	2

TNK3516	PT16: Primary Tank 16, PT16	Primary Clarification	TANK,PRIM	PT16	15+ years	$200,000.00	no tag minor cracking warping wood weir fence has a hole in it	2
TNK3517	PT17: Primary Tank 17, PT17	Primary Clarification	TANK,PRIM	PT17	15+ years	$200,000.00	minor deterioration rust\deterioration on weirs	2
TNK3518	PT18: Primary Tank 18, PT18	Primary Clarification	TANK,PRIM	PT18	15+ years	$200,000.00	minor deterioration rust\deterioration on weirs	2
TNK3519	PT19: Primary Tank 19, PT19	Primary Clarification	TANK,PRIM	PT19	15+ years	$200,000.00	minor deterioration rust\deterioration on weirs	2
TNK3520	PT20: Primary Tank 20, PT20	Primary Clarification	TANK,PRIM	PT20	15+ years	$200,000.00	minor deterioration rust\deterioration on weirs	2
TNK3521	PT21: Primary Tank 21, PT21	Primary Clarification	TANK,PRIM	PT21	15+ years	$200,000.00	minor deterioration rust\deterioration on weirs	2
TNK3801	AT01: Aeration Tank 1	Aeration Process	TANK, AER	AT01	15+ years	$200,000.00	NE end has about a 10x1ft strip of concrete deterioration on walkway large cracks above waterline see pics no tag	2
TNK3802	AT02: Aeration Tank 2	Aeration Process	TANK, AER	AT02	15+ years	$200,000.00	middle has about a 5x1ft strip of concrete deterioration on walkway large cracks above waterline about 90% of grates between at1 & at2 rusted see pics no tag	3

TNK3803	AT03: Aeration Tank 3	Aeration Process	TANK, AER	AT03	15+ years	$200,000.00	NW corner has concrete deterioration on walkway large cracks above waterline see pics no tag	2
TNK3804	AT04: Aeration Tank 4	Aeration Process	TANK, AER	AT04	15+ years	$200,000.00	minor concrete deterioration large cracks above waterline about 75% of grates between at3 & at4 rusted see pics no tag	2
TNK3805	AT05: Aeration Tank 5	Aeration Process	TANK, AER	AT05	15+ years	$200,000.00	some concrete deterioration on walkway about 90% of grates between at5 & at6 rusted see pics no tag	2
TNK3806	AT06: Aeration Tank 6	Aeration Process	TANK, AER	AT06	15+ years	$200,000.00	some concrete deterioration above waterline large cracks above waterline see pics no tag	3
TNK3807	AT07: Aeration Tank 7	Aeration Process	TANK, AER	AT07	15+ years	$200,000.00	not tagged. In service	3
TNK3808	AT08: Aeration Tank 8	Aeration Process	TANK, AER	AT08	15+ years	$200,000.00	In service. Not tagged	3
TNK3809	AT09: Aeration Tank 9	Aeration Process	TANK, AER	AT09	15+ years	$200,000.00	In service. Not tagged	3
TNK3810	AT10: Aeration Tank 10	Aeration Process	TANK, AER	AT10	15+ years	$200,000.00	In service. Not tagged. Concrete spalling at Sw corner of tank. Grating needed between AT10 & AT11 at aeration piping. See photos	4
TNK3811	AT11: Aeration Tank 11	Aeration Process	TANK, AER	AT11	15+ years	$200,000.00	Not tagged. In service	2
TNK3812	AT12: Aeration Tank 12	Aeration Process	TANK, AER	AT12	15+ years	$200,000.00	Not tagged. In service	2

TNK3813	AT13: Aeration Tank 13	Aeration Process	TANK, AER	AT13	15+ years	$200,000.00	large crack in concrete walkway between at13 & at14 minor cracks above waterline	2
TNK3814	AT14: Aeration Tank 14	Aeration Process	TANK, AER	AT14	15+ years	$200,000.00	large crack in concrete walkway between at13 & at14 minor cracking above waterline	2
TNK3815	AT15: Aeration Tank 15	Aeration Process	TANK, AER	AT15	15+ years	$200,000.00	minor cracking above waterline	2
TNK3816	AT16: Aeration Tank 16	Aeration Process	TANK, AER	AT16	15+ years	$200,000.00	fence needed on 3\4 of walkway minor cracking above waterline	2
TNK3817	AT17: Aeration Tank 17	Aeration Process	TANK, AER	AT17	15+ years	$200,000.00	holes in fence where pipes used to go vent piping needs to stick out a couple more in to not drip on wall	2
TNK3818	AT18: Aeration Tank 18	Aeration Process	TANK, AER	AT18	15+ years	$200,000.00	minor cracking above waterline about 75% of fence rusted	2
TNK3919	AT19: Aeration Tank 19	Aeration Process	TANK, AER	AT19	15+ years	$200,000.00	fence about 80% rusted minor cracks above waterline	2
TNK3920	AT20: Aeration Tank 20	Aeration Process	TANK, AER	AT20	15+ years	$200,000.00	minor cracking above waterline	2
TNK3921	AT21: Aeration Tank 21	Aeration Process	TANK, AER	AT21	15+ years	$200,000.00	some minor cracking above waterline conduit run laying on ground	2
TNK3922	AT22: Aeration Tank 22	Aeration Process	TANK, AER	AT22	15+ years	$200,000.00	minir cracking above waterline	2

TNK3923	AT23: Aeration Tank 23	Aeration Process	TANK, AER	AT23	15+ years	$200,000.00	some minor cracking above waterline	2
TNK3924	AT24: Aeration Tank 24	Aeration Process	TANK, AER	AT24	15+ years	$200,000.00		2
TNK3925	AT25: Aeration Tank 25	Aeration Process	TANK, AER	AT25	15+ years	$200,000.00	some minor cracking above waterline	2
TNK3926	AT26: Aeration Tank 26	Aeration Process	TANK, AER	AT26	15+ years	$200,000.00	some minor cracking above waterline	2
TNK3927	AT27: Aeration Tank 27	Aeration Process	TANK, AER	AT27	15+ years	$200,000.00	some minor cracking above waterline	2
TNK3928	AT28: Aeration Tank 28	Aeration Process	TANK, AER	AT28	15+ years	$200,000.00	some minor cracking above waterline	2
TNK3929	AT29: Aeration Tank 29	Aeration Process	TANK, AER	AT29	15+ years	$200,000.00	2ft wide chipped\damaged concrete extending below waterline	2
TNK3930	AT30: Aeration Tank 30	Aeration Process	TANK, AER	AT30	15+ years	$200,000.00		2
TNK4101	FC01: Final Clarifier 1	Secondary Clarification	TANK,FINAL	FC01	15+ years	$200,000.00	3 cracks extending below waterline between 9 & 12 oclock (6 oclock is bridge staircase on ground) fence pushed in at 12 oclock foundation not evaluated no tag	2
TNK4102	FC02: Final Clarifier 2	Secondary Clarification	TANK,FINAL	FC02	15+ years	$200,000.00	2 very large cracks extending below waterline between 7 & 8 oclock. Previously patched slightly damaged fence & tank exterior see photos no tag	3

TNK4103	FC03: Final Clarifier 3	Secondary Clarification	TANK,FINAL	FC03	15+ years	$200,000.00	cracking and rust at base of fence 4 oclock multiple cracks reaching below waterline 15-20% rusting on steel more fence needed by bridge stairs exterior concrete damage see photos no tag	3
TNK4104	FC04: Final Clarifier 4	Secondary Clarification	TANK,FINAL	FC04	15+ years	$200,000.00	parts typically under water rusting, see photos 90% of fence rusted and partially damaged cracks below waterline not determined due to metal support around outside which is 25% rusted bridge to walk on 85% rusted, railings fine no tag	3
TNK4105	FC05: Final Clarifier 5	Secondary Clarification	TANK,FINAL	FC05	15+ years	$200,000.00	80% of fence rusted, damaged at 4 oclock about half of troughs 50% rust new paint on bridge and railings no tag	2
TNK4106	FC06: Final Clarifier 6	Secondary Clarification	TANK,FINAL	FC06	15+ years	$200,000.00	new paint on bridge and railings mostly rusted fence about 40% of troughs rusred, flaking rust no tag	2
TNK4107	FC07: Final Clarifier 7	Secondary Clarification	TANK,FINAL	FC07	15+ years	$200,000.00	new paint on bridge and railings missing weirs at 6 oclock minor fence rust no tag	2

TNK4108	FC08: Final Clarifier 8	Secondary Clarification	TANK,FINAL	FC08	15+ years	$200,000.00	2 weirs missing by 6 oclock air binding of effluent inbdrop down pipe complete fence required near stairs some touch up paint required on stairs and railing minor cracking at 80% of fence posts no tag	2
TNK4109	FC09: Final Clarifier 9	Secondary Clarification	TANK,FINAL	FC09	15+ years	$200,000.00	complete fence needed rust on stairs and bridge missing fence some air binding at effluent no tag	2
TNK4110	FC10: Final Clarifier 10	Secondary Clarification	TANK,FINAL	FC10	15+ years	$200,000.00	no tag	2
TNK4111	FC11: Final Clarifier 11	Secondary Clarification	TANK,FINAL	FC11	15+ years	$200,000.00	not tagged. Large gap in fence near bridge.	2
TNK4112	FC12: Final Clarifier 12	Secondary Clarification	TANK,FINAL	FC12	15+ years	$200,000.00	some rust on stairs and bridge fence needed on other half of clarifier center part of scraper mechanism out of balance. One side at water level, other side below water level	2
TNK4113	FC13: Final Clarifier 13	Secondary Clarification	TANK,FINAL	FC13	15+ years	$200,000.00	bridge, stairs, & railings about 50% rusted 2 exterior cracks extending below grade at 7 oclock	2

TNK4114	FC14: Final Clarifier 14	Secondary Clarification	TANK,FINAL	FC14	15+ years	$200,000.00	80% of fence rusted scraper mechanism not balanced 50% of bridge, stairs,, railing rusted	2
TNK4115	FC15: Final Clarifier 15	Secondary Clarification	TANK,FINAL	FC15	15+ years	$200,000.00	rust on scraper mechansim 5% about 60% rusted stairs, walkway, railings	2
TNK4116	FC16: Final Clarifier 16	Secondary Clarification	TANK,FINAL	FC16	15+ years	$200,000.00		2
TNK4117	FC17: Final Clarifier 17	Secondary Clarification	TANK,FINAL	FC17	15+ years	$200,000.00	75% rusted under bridge 50% rusted walkway and railing	2
TNK4118	FC18: Final Clarifier 18	Secondary Clarification	TANK,FINAL	FC18	15+ years	$200,000.00	about 75% rusted bridge, stairs, railings rusted bridge support fence needed rusty scraper 1sq ft chunk of concrete missing at 12 oclock rust on exterior scraper circle bout 75% rusted fence cracking of repaired exterior above water line, scraper mech out of balance flaking rust interior scraper circle no tag	2
TNK4119	FC19: Final Clarifier 19	Secondary Clarification	TANK,FINAL	FC19	15+ years	$200,000.00	walkway, railing, stairs 75% rusted bubbling flaky rust on interior an exterior scraper circle significant algae growth no tag	2

Type Uncategorized

Equipment Uncategorized

Asset ID	Asset Description	Process Description	Asset Type	Building	Remaining Useful Life	Replacement Cost	Comments	Worst Rating
CHA3501	Primary Influent Channel East	Primary Clarification	CHANNEL	EAST PRI TNK	>15 years	$200,000.00	deterioration of concrete worse near tanks 1 & 2	2
CHA3502	Primary Influent Channel West	Primary Clarification	CHANNEL	WEST PRI TNK	>15 years	$200,000.00	minor deterioration	2
CHA3503	Primary Effluent Channel East	Primary Clarification	CHANNEL	EAST PRI TNK	>15 years	$200,000.00	more corrosion near tanks 1 & 2 grates at end of tanks 1 & 2 too small	2
CHA3504	Primary Effluent Channel West	Primary Clarification	CHANNEL	EAST PRI TNK	>15 years	$200,000.00	cracks from top of channel to troughs, see pic	2
CHA3801	RAS Channel for East Plant, Plants 1 & 2	Aeration Process	CHANNEL	EAST AERATION TNKS	>15 years	$200,000.00	minor cracks and corrosion	2
CHA4401	EDC : Effluent Diversion Structure and Channel south of Effluent Storage Tanks 1 & 2.	Effluent Pumping	CHANNEL	EFF STORAGE TANK 1	>15 years	$200,000.00	leaking through the wood weir cracks and corrosion	3
UVC4301	EFFB: U.V. Channel 1	UV Disinfection	CHANNEL	EFF BLDG	15+ years	$50,000.00	thorough inspection not available no tag	1
UVC4302	EFFB: U.V. Channel 2	UV Disinfection	CHANNEL	EFF BLDG	15+ years	$50,000.00	thorough inspection not available no tag	1
UVC4303	EFFB: U.V. Channel 3	UV Disinfection	CHANNEL	EFF BLDG	15+ years	$50,000.00	thorough inspection not available no tag	1
UVC4304	EFFB: U.V. Channel 4	UV Disinfection	CHANNEL	EFF BLDG	15+ years	$50,000.00	thorough inspection not available no tag	1

UVC4305	EFFB: U.V. Channel 5	UV Disinfection	CHANNEL	EFF BLDG	15+ years	$50,000.00	thorough inspection not available no tag	1
UVC4306	EFFB: U.V. Bypass Channel 1	UV Disinfection	CHANNEL	EFF BLDG	15+ years	$50,000.00	thorough inspection not available no tag	1
UVC4307	EFFB: U.V. Bypass Channel 2	UV Disinfection	CHANNEL	EFF BLDG	15+ years	$50,000.00	thorough inspection not available no tag	1

Group Electrical

Type 2/4/6 Pole HV & LV Electric Motors

Equipment 2/4/6 Pole HV & LV Electric Motors

Asset ID	Asset Description	Process Description	Asset Type	Building	Remaining Useful Life	Replacement Cost	Comments	Worst Rating
MTR3502	PT01: Motor, Long Collector Drive E101, PT01	Primary Clarification	MOTOR	PT01	<5 years	$1,000.00		1
MTR3504	PT02: Motor, Long Collector Drive E102, PT02	Primary Clarification	MOTOR	PT02	<5 years	$1,000.00		1
MTR3505	PT05: Motor E115, Cross Collector Drive, PT05	Primary Clarification	MOTOR	PT05	<5 years	$1,000.00		1
MTR3506	PT05: Motor, Long Collector Drive E105, PT05	Primary Clarification	MOTOR	PT05	<5 years	$1,000.00		1
MTR3507	PT06: Motor E116, Cross Collector Drive, PT06	Primary Clarification	MOTOR	PT06	5-10 years	$1,000.00		1

MTR3508	PT06: Motor E106, Long Collector Drive, PT06 Stock Code # 010203 for Motor and 002038 Coupling Flange	Primary Clarification	MOTOR	PT06	10-15 years	$1,000.00	1
MTR3509	PT07: Motor E107, Long Collector Drive, PT07 Stock Code # 010203 for Motor and 002038 Coupling Flange	Primary Clarification	MOTOR	PT07	10-15 years	$1,000.00	1
MTR3510	PT07: Motor E117, Cross Collector Drive, PT07	Primary Clarification	MOTOR	PT07	5-10 years	$1,000.00	1
MTR3512	PT08: Motor, Long Collector Drive E108, PT08	Primary Clarification	MOTOR	PT08	5-10 years	$1,000.00	1
MTR3513	PT09: Motor E219, Cross Collector Drive, PT09	Primary Clarification	MOTOR	PT09	5-10 years	$1,000.00	1
MTR3514	PT09: Motor, Long Collector Drive E209, PT09 Stock Code # 010203 for Motor and 002038 Coupling Flange	Primary Clarification	MOTOR	PT09	5-10 years	$1,000.00	1
MTR3515	PT10: Motor E220, Cross Collector Driver, PT10	Primary Clarification	MOTOR	PT10	<5 years	$1,000.00	1
MTR3516	PT10: Motor E210, Long Collector Driver, PT10 Stock Code # 010203 for Motor and 002038 Coupling Flange	Primary Clarification	MOTOR	PT10	5-10 years	$1,000.00	1

MTR3517	PT11: Motor E220, Cross Collector Drive, PT11	Primary Clarification	MOTOR	PT11	5-10 years	$1,000.00	1
MTR3518	PT11: Motor E211, Long Collector Drive, PT11 Stock Code # 010203 for Motor and 002038 Coupling Flange	Primary Clarification	MOTOR	PT11	5-10 years	$1,000.00	1
MTR3519	PT12: Motor E222, Cross Collector Drive, PT12	Primary Clarification	MOTOR	PT12	5-10 years	$1,000.00	1
MTR3520	PT12: Motor E212, Long Collector Drive, PT12 Stock Code # 010203 for Motor and 002038 Coupling Flange	Primary Clarification	MOTOR	PT12	10-15 years	$1,000.00	1
MTR3521	PT13: Motor E223, Cross Collector Drive, PT13	Primary Clarification	MOTOR	PT13	10-15 years	$1,000.00	1
MTR3523	PT14: Motor E224, Cross Collector Drive, PT14	Primary Clarification	MOTOR	PT14	5-10 years	$1,000.00	1
MTR3524	PT14: Motor E214, Long Collector Drive, PT14 Stock Code # 010203 for Motor and 002038 Coupling Flange	Primary Clarification	MOTOR	PT14	5-10 years	$1,000.00	1
MTR3525	PT15: Motor E225, Cross Collector Drive, PT15	Primary Clarification	MOTOR	PT15	5-10 years	$1,000.00	1
MTR3527	PT16: Motor E226, Cross Collector Drive, PT16	Primary Clarification	MOTOR	PT16	5-10 years	$1,000.00	1

MTR3528	PT16: Motor E216, Long Collector Drive, PT16 Stock Code # 010203 for Motor and 002038 Coupling Flange	Primary Clarification	MOTOR	PT16	5-10 years	$1,000.00		1
MTR3529	PT17: Motor, Cross Collector Drive, PT17	Primary Clarification	MOTOR	PT17	5-10 years	$1,000.00	Not Running	N/A
MTR3530	PT17: Motor, Long Collector Drive, PT17	Primary Clarification	MOTOR	PT17	5-10 years	$1,000.00		1
MTR3531	PT18: Motor, Cross Collector Drive, PT18	Primary Clarification	MOTOR	PT18	10-15 years	$1,000.00		1
MTR3532	PT18: Motor, Long Collector Drive, PT18	Primary Clarification	MOTOR	PT18	5-10 years	$1,000.00		1
MTR3533	PT19: Motor, Cross Collector Drive, PT19	Primary Clarification	MOTOR	PT19	10-15 years	$1,000.00		1
MTR3534	PT19: Motor, Long Collector Drive, PT19	Primary Clarification	MOTOR	PT19	5-10 years	$1,000.00		1
MTR3535	PT20: Motor, Cross Collector Drive, PT20	Primary Clarification	MOTOR	PT20	5-10 years	$1,000.00		1
MTR3536	PT20: Motor, Long Collector Drive, PT20	Primary Clarification	MOTOR	PT20	5-10 years	$1,000.00		1
MTR3537	PT21: Motor, Cross Collector Drive, PT21	Primary Clarification	MOTOR	PT21	5-10 years	$1,000.00		1
MTR3538	PT21: Motor, Long Collector Drive, PT21	Primary Clarification	MOTOR	PT21	5-10 years	$1,000.00		1
MTR3552	PT08: Motor E118, Cross Collector Drive, PT08 Stock Code # 010203 for Motor and 002038 Coupling Flange	Primary Clarification	MOTOR	PT08	5-10 years	$1,000.00	Not Running	N/A

MTR3554	PT15: Motor E215, Long Collector Drive, PT15 Stock Code # 010203 for Motor and 002038 Coupling Flange	Primary Clarification	MOTOR	PT15	5-10 years	$1,000.00		1
MTR3555	PT13: Motor E213, Long Collector Drive, PT13 (New in 2011) Stock Code # 010203 for motor and 002038 Coupling Flange	Primary Clarification	MOTOR	PT13	5-10 years	$1,000.00		1
MTR3801	BB1 : Motor, Aurora Protected Water Pump 1, Blower	Aeration Process	MOTOR	BLWR BLDG 1	5-10 years	$3,000.00	Not Running	N/A
MTR3802	BB1 : Motor, Aurora Protected Water Pump 2, Blower	Aeration Process	MOTOR	BLWR BLDG 1	5-10 years	$3,000.00	Not Running	N/A
MTR3807	AT07: Motor, Anaerobic Recycle Pump P-AT7	Aeration Process	MOTOR	AT07			Submersible pump - not accessible	N/A
MTR3821	BB1 : Motor, Heat Recovery Pump 1, Blower Building 1	Aeration Process	MOTOR	BLWR BLDG 1	5-10 years	$3,000.00	Not running	N/A
MTR3822	BB1 : Motor, G982, Heat Recovery Pump 2, Blower Building 1	Aeration Process	MOTOR	BLWR BLDG 1	5-10 years	$3,000.00	Not Running	N/A
MTR3823	BB1 : Motor, Lube Oil Cooling Pump 4, Blower Building 1	Aeration Process	MOTOR	BLWR BLDG 1	10-15 years	$2,000.00	Not Running	N/A
MTR3825	BB1 : Motor, Jacket Water & LOCW makeup water pump, Blower Building 1	Aeration Process	MOTOR	BLWR BLDG 1	5-10 years	$1,000.00	Not Running	N/A

MTR3826	BB1 : Motor, Blower 2 C432, Blower Building 1	Aeration Process	MOTOR	BLWR BLDG 1	10-15 years	$150,000.00		1
MTR3828	BB1 : Motor, Blower 3 C433, Blower Building 1	Aeration Process	MOTOR	BLWR BLDG 1	10-15 years	$150,000.00		1
MTR3832	BB1 : Motor, Blower 5, Blower Building 1(Two speed motor)	Aeration Process	MOTOR	BLWR BLDG 1	10-15 years	$150,000.00		2
MTR3850	BB1 : Motor, Primary Roll and Secondary Air Filter 1, Blower Building 1	Aeration Process	MOTOR	BLWR BLDG 1	5-10 years	$1,000.00		1
MTR3851	BB1 : Motor, Primary Roll and Secondary Air Filter 2, Blower Building 1	Aeration Process	MOTOR	BLWR BLDG 1	5-10 years	$1,000.00		1
MTR3852	BB1 : Motor, Primary Roll and Secondary Air Filter 3, Blower Building 1	Aeration Process	MOTOR	BLWR BLDG 1	5-10 years	$1,000.00		1
MTR3855	BB1 : Motor, Jacket Water Pump 4, Blower Building 1	Aeration Process	MOTOR	BLWR BLDG 1	5-10 years	$4,000.00	Not Running	N/A
MTR3856	BB1 : Motor, Lube Oil Coolant Radiator,(new 2003)Blower Building 1	Aeration Process	MOTOR	BLWR BLDG 1	10-15 years	$2,000.00		2
MTR3857	BB1 : Motor, Jacket Water Pump 5, Blower Building 1	Aeration Process	MOTOR	BLWR BLDG 1	10-15 years	$4,000.00	Not Running	N/A
MTR3858	BB1 : Motor, Lube Oil Cooling Pump 5, Blower Building 1	Aeration Process	MOTOR	BLWR BLDG 1	10-15 years	$1,000.00	move to electrical-motor not running	1
MTR3859	BB1 : Motor, Jacket Water Radiator Fan, Blower Building 1	Aeration Process	EQP,MISC	BLWR BLDG 1	5-10 years	$1,000.00	move to electrical-motor not running	N/A

MTR3860	BB1 : Motor, Primary Roll and Secondary Air Filter 4, Blower Building 1	Aeration Process	MOTOR	BLWR BLDG 1	5-10 years	$1,000.00		1
MTR3861	BB1 : Motor, Primary Roll and Secondary Air Filter 5, Blower Building 1	Aeration Process	MOTOR	BLWR BLDG 1	5-10 years	$1,000.00		1
MTR3901	BB2 : Motor, Protected Water Pump 5-1, Blower	Aeration Process	MOTOR	BLWR BLDG 2	5-10 years	$4,000.00	Not running	N/A
MTR3902	BB2 : Motor, Protected Water Pump 5-2, Blower	Aeration Process	MOTOR	BLWR BLDG 2	5-10 years	$4,000.00	Not Running	N/A
MTR3921	AT21: Motor, Anaerobic Recycle Pump P-AT21	Aeration Process	MOTOR	AT21			Submersible pump - not accessible	N/A
MTR3924	AT24: Motor, Anaerobic Recycle P-AT24	Aeration Process	MOTOR	AT24			Submersible pump - not accessible	N/A
MTR3925	AT25: Motor, Anaerobic Recycle P-AT25	Aeration Process	MOTOR	AT25			Submersible pump - not accessible	N/A
MTR3928	AT28: Motor, Anaerobic Recycle P-AT28	Aeration Process	MOTOR	AT28			Submersible pump - not accessible	N/A
MTR3929	BB2 : Motor, Blower 1, A311, Blower Building 2	Aeration Process	MOTOR	BLWR BLDG 2	5-10 years	$250,000.00		1
MTR3933	BB2 : Motor, Blower 2, A312, Blower Building 2	Aeration Process	MOTOR	BLWR BLDG 2	5-10 years	$250,000.00	Not running	N/A
MTR3937	BB2 : Motor, Blower 3, A313, Blower Building 2	Aeration Process	MOTOR	BLWR BLDG 2	5-10 years	$250,000.00	Not assessed - not running	N/A

MTR3941	AG2 : Motor, Drainage Pump 1	Aeration Process	MOTOR	AER GLRY 2	5-10 years	$2,500.00		1
MTR3942	AG2 : Motor, Drainage Pump 2	Aeration Process	MOTOR	AER GLRY 2	5-10 years	$2,500.00	10 HP, 1200 rpm	2
MTR3966	BB2 : Motor, Hot Water Circulating Pump 5-1, Blower Building 2	Aeration Process	MOTOR	BLWR BLDG 2	5-10 years	$1,000.00	3 HP	N/A
MTR3967	BB2 : Motor, Hot Water Circulating Pump 5-2, Blower Building 2	Aeration Process	MOTOR	BLWR BLDG 2	5-10 years	$1,000.00	Not Running	N/A
MTR3973	BB2 : Motor, HSP-1, Heat Transfer Pump, Blower Building 2, new 6/2013	Aeration Process	MOTOR	BLWR BLDG 2	10-15 years	$1,000.00		3
MTR4001	ACB1: Motor, C152, WAS Pump 2	Aeration Control (WAS and RAS)	MOTOR	ACB1	5-10 years	$5,000.00	NOT RUNNING	N/A
MTR4019	ACB4: Motor B371, RAS Pump 1, ACB4 - (two speed motor)	Aeration Control (WAS and RAS)	MOTOR	ACB4	10-15 years	$10,000.00		3
MTR4020	ACB4: Motor B372, RAS Pump 2, ACB4 - (two speed motor)	Aeration Control (WAS and RAS)	MOTOR	ACB4	10-15 years	$10,000.00	Not Running	N/A
MTR4021	ACB4: Motor B373, RAS Pump 3, ACB4 - (two speed motor)	Aeration Control (WAS and RAS)	MOTOR	ACB4	10-15 years	$10,000.00		2
MTR4022	ACB4: Motor B374, RAS Pump 4, ACB4 - (two speed motor)	Aeration Control (WAS and RAS)	MOTOR	ACB4	10-15 years	$10,000.00	Not Running	N/A

Type Control Panels

Equipment Control Panels

Asset ID	Asset Description	Process Description	Asset Type	Building	Remaining Useful Life	Replacement Cost	Comments	Worst Rating
CPN3801	BB1 : Engine Blower Control PanelLocated in Blower Building No. 1	Aeration Process	PANEL,CON	BLWR BLDG 1	<5 years	$20,000.00		5
CPN3802	BB1 : Control Panel. Blowers 2, 3, 4, 5	Aeration Process	PANEL,CON	BLWR BLDG 1	5-10 years	$75,000.00		5
CPN3902	BB2 : Control Panel, Zenith Auto Transfer Switch	Aeration Process	PANEL,CON	BLWR BLDG 2	<5 years	$20,000.00		5
CPN3903	BB2 : Control Panel for Blower #1, and associated electrical control devices, Blower Building 2	Aeration Process	PANEL,CON	BLWR BLDG 2	5-10 years	$40,000.00		5
CPN3904	BB2 : Control Panel for Blower #2, and associated electrical control devices, Blower Building 2	Aeration Process	PANEL,CON	BLWR BLDG 2	5-10 years	$40,000.00	AB Panelview Plus 1500 SLC 5/04 PLC	5
CPN3905	BB2 : Control Panel for Blower #3, and associated electrical control devices, Blower Building 2	Aeration Process	PANEL,CON	BLWR BLDG 2	5-10 years	$40,000.00	Panelview Plus 1500 SLC 5/04 PLC	5
CPN3906	BB2 : Control Panel, TCP-4, Temperature Control Panel	Aeration Process	PANEL,CON	BLWR BLDG 2	<5 years	$15,000.00		5
CPN3907	BB2 : Control Panel, Blower Building 2	Aeration Process	PANEL,CON	BLWR BLDG 2	5-10 years	$75,000.00		5

CPN4002	ACB2: Control Panel,East Secondary Meter Panel No.2Panel located in Aeration Control Building #2	Aeration Control (WAS and RAS)	PANEL,CON	ACB2	<5 years	$50,000.00		5
CPN4003	ACB3: Control Panel, ACB3	Aeration Control (WAS and RAS)	PANEL,CON	ACB3	<5 years	$50,000.00		5
CPN4004	ACB4: Control Panel, ACB4	Aeration Control (WAS and RAS)	PANEL,CON	ACB4	<5 years	$75,000.00		5
CPN4005	ACB4 : Control Panel, Zenith Auto Transfer Switch, Aeration Control Building 4	Aeration Process	PANEL,CON	ACB4	<5 years	$10,000.00		5
CPN4006	ACB3: Control Panel, Compressor 2A, 2B RAS Level Bubbler System	Aeration Control (WAS and RAS)	PANEL,CON	ACB3	5-10 years	$25,000.00		5
CPN4101	FC : Control Panel, Final Clarifiers	Secondary Clarification	PANEL,CON	NINE SPRINGS WWTP	5-10 years	$10,000.00		5
CPN4401	EFFB: Control Panel, Effluent Building	Effluent Pumping	PANEL,CON	EFF BLDG	5-10 years	$75,000.00		5
CPN4408	EFFB : Control Panel, Zenith Auto Transfer Switch For T71 & T72	Aeration Process	PANEL,CON	EFF BLDG	<5 years	$10,000.00		5
CPN4411	EFFB: Control Panel, TCP-70-1, Unit Heaters & Fans	Effluent Pumping	PANEL,CON	EFF BLDG	10-15 years	$15,000.00		3
CPN4412	MV3: Control Panel, Pressure Relief System	Effluent Pumping	CONTRL PNL	MTR VLT 3	>15 years	$10,000.00		1

SCC4300	EFFB: U.V. System Control Center, Includes PLC & Panel View	UV Disinfection	ELECT, SER	EFF BLDG	5-10 years	$30,000.00	Not much in the panel. A SLC PLC 5/04 and an old CRT A-B 1200e PanelView. No Ethernet communications. Only PLC with serial communications.	4

Type Lighting Equip & Sys

Equipment Lighting Equip & Sys

Asset ID	Asset Description	Process Description	Asset Type	Building	Remaining Useful Life	Replacement Cost	Comments	Worst Rating
LPN3501	PSPB2: Lighting Panel	Primary Clarification	PANEL,LGHT	PSPB2	5-10 years	$7,500.00	120/208V, 3P, 4W No MCB	5
LPN3900	BB2 : Lighting/Distribution Panel, DP51, Upper Level	Aeration Process	PANEL,ELE	BLWR BLDG 2	5-10 years	$7,500.00	120/208V, 3P, 4W 400A MCB	5
LPN3901	BB2 : Lighting Panel, LP51, Lower Level	Aeration Process	PANEL,LGHT	BLWR BLDG 2	5-10 years	$7,500.00	120/208V, 3P, 4W 125A MCB	4
LPN3902	BB2 : Lighting Panel, LP52, Upper Level	Aeration Process	PANEL,LGHT	BLWR BLDG 2	5-10 years	$7,500.00	120/208V, 3P, 4W 125A MCB	5
LPN3903	AG2 : Lighting Panel , LP-44, Aeration Gallery 2	Aeration Process	PANEL,LGHT	AER GLRY 2	10-15 years	$7,500.00		4
LPN3904	AG2 : Lighting Panel , LP-45, Aeration Gallery 2	Aeration Process	PANEL,LGHT	AER GLRY 2	5-10 years	$7,500.00	120/208V, 3P, 4W 100A MCB	5
LPN4002	ACB2: Lighting Panel, L82Square D Panelboard, 120/208V, Three PhaseLocated in Aeration Control Building #2	Aeration Control (WAS and RAS)	PANEL,LGHT	ACB2	5-10 years	$7,500.00	120/208V, 3P, 4W 100A MCB	5

Asset ID	Asset Description	Process Description	Asset Type	Building	Remaining Useful Life	Replacement Cost	Comments	Worst Rating
LPN4003	ACB2: Lighting Panel, L85Westinghouse Panelboard, 120/208V, Three PhaseLocated in Aeration Control Building #2	Aeration Control (WAS and RAS)	PANEL,LGHT	ACB2	5-10 years	$7,500.00	120/208V, 3P, 4W 100A MCB	5
LPN4401	EFFB: Lighting Panel L71, In MCC Room	Effluent Pumping	PANEL,LGHT	EFF BLDG	5-10 years	$7,500.00	120/208V, 3ph, 4W. 100 amp main.	5
LPN4402	EFFB: Lighting Panel L72, In Pump Room	Effluent Pumping	PANEL,LGHT	EFF BLDG	5-10 years	$7,500.00	120/208V, 3ph, 4W. 70 amp main.	5
LPN4403	EFFB: Lighting Panel L73, In Control Room	Effluent Pumping	PANEL,LGHT	EFF BLDG	5-10 years	$7,500.00	120/208V, 3ph, 4W. 90 amp main.	5
LPN4404	EFFB: Lighting/Dist Panel DP71, In MCC Room	Effluent Pumping	PANEL,LGHT	EFF BLDG	5-10 years	$7,500.00	120/208V, 3ph, 4W. 250 amp main.	5

Type Metering

Equipment Metering

Asset ID	Asset Description	Process Description	Asset Type	Building	Remaining Useful Life	Replacement Cost	Comments	Worst Rating
TRN0101	ACB1: Meter & Transmitter, Power Monitor	Aeration Control (WAS and RAS)	METER,POW	ACB1	10-15 years	$5,000.00	Meter inside MCC, no display	2
TRN0457	U15 : Power Quality Meter, S1-13 Main 2, New 2015	Nine Springs Power Distribution System	METER,POW	ELEC BLDG U15	10-15 years	$5,000.00		2
XMT4001	ACB2: Power Quality Meter MCC-ACB-2				15+ years	$5,000.00	GE PQM II Series Power Monitor	1

Type Motor Control Centers

Equipment	Motor Control Centers							
Asset ID	Asset Description	Process Description	Asset Type	Building	Remaining Useful Life	Replacement Cost	Comments	Worst Rating
MCC3901	BB2 : MCC, MCC-P51, A396, East Panel, Blower Building 2	Aeration Process	MCC	BLWR BLDG 2	10-15 years	$125,000.00	600A	5
MCC3902	BB2 : MCC, MCC-P52, A397, West Panel, Blower Building 2	Aeration Process	MCC	BLWR BLDG 2	10-15 years	$125,000.00		5
MCC3903	BB2 : Medium Voltage Starter Panel, M7, Blower Building 2	Aeration Process	MCC	BLWR BLDG 2	10-15 years	$200,000.00		2
MCC4000	ACB1: MCC, Square D Motor Control Center, MCC-ACB-1 Located in Aeration Control Building #1	Aeration Control (WAS and RAS)	MCC	ACB1	15+ years	$125,000.00		5
MCC4003	ACB4: MCC-P41, Westinghouse Motor Control Center P41Located at Aeration Control Building #4	Aeration Control (WAS and RAS)	MCC	ACB4	10-15 years	$150,000.00		5
MCC4004	ACB4: MCC-P42, Westinghouse Motor Control Center P42Located at Aeration Control Building #4	Aeration Control (WAS and RAS)	MCC	ACB4	10-15 years	$150,000.00		5
MCC4301	EFFB: U.V. MCC Panel,	UV Disinfection	MCC	EFF BLDG	10-15 years	$150,000.00	600A Westinghouse Five Star motor control center	5
MCC4401	EFFB: MCC, P71, Effluent Building	Effluent Pumping	MCC	EFF BLDG	10-15 years	$75,000.00		5
MCC4402	EFFB: MCC, P72, Effluent Building	Effluent Pumping	MCC	EFF BLDG	10-15 years	$75,000.00	600A main breaker	5

Type Transformers

Equipment Transformers

Asset ID	Asset Description	Process Description	Asset Type	Building	Remaining Useful Life	Replacement Cost	Comments	Worst Rating
FRM3501	PSPB2: Transformer, Lighting Panel	Primary Clarification	TRANSFORM	PSPB2	5-10 years	$15,000.00		5
FRM3901	BB2 : Transformer, T-51, Blower Building 2	Aeration Process	TRANSFORM	BLWR BLDG 2	5-10 years	$35,000.00	480V to 120/208V, 3P, delta-wye, 150 kVA	5
FRM3902	BB2 : Transformer, T-52, Blower Building 2	Aeration Process	TRANSFORM	BLWR BLDG 2	5-10 years	$35,000.00	480V to 120/208V, 3P, delta-wye, 150 kVA	5
FRM4401	ACB4: Transformer, T41, feeds Zenith CPN	Aeration Control (WAS and RAS)	TRANSFORM	ACB4	5-10 years	$15,000.00	Loud buzzing sound 480V to 120/208V, delta-wye	5
FRM4411	EFFB : Transformer, XFRM 711	UV Disinfection	TRANSFORM	EFF BLDG	5-10 years	$25,000.00		1
FRM4412	EFFB : Transformer, XFRM 712	UV Disinfection	TRANSFORM	EFF BLDG	5-10 years	$25,000.00		1
FRM4413	EFFB : Transformer, XFRM 713	UV Disinfection	TRANSFORM	EFF BLDG	5-10 years	$25,000.00		1
FRM4414	EFFB : Transformer, XFRM 714	UV Disinfection	TRANSFORM	EFF BLDG	5-10 years	$25,000.00		1
FRM4415	EFFB : Transformer, T71	UV Disinfection	TRANSFORM	EFF BLDG	5-10 years	$20,000.00		5
FRM4416	EFFB : Transformer, T72	UV Disinfection	TRANSFORM	EFF BLDG	5-10 years	$20,000.00		5

Type Uncategorized

Equipment Uncategorized

Asset ID	Asset Description	Process Description	Asset Type	Building	Remaining Useful Life	Replacement Cost	Comments	Worst Rating

BNK4301	EFFB: U.V. Bank A Unit 1, D311, Lamps & Quartz Tubes, Effluent Building	UV Disinfection	UV BANK	EFF BLDG		$10,000.00	Not assessed - not accessible	N/A
BNK4302	EFFB: U.V. Bank B Unit 1, D312, Lamps & Quartz Tubes, Effluent Building	UV Disinfection	UV BANK	EFF BLDG		$10,000.00	Not assessed - not accessible	N/A
BNK4303	EFFB: U.V. Bank A Unit 2, D321, Lamps & Quartz Tubes, Effluent Building	UV Disinfection	UV BANK	EFF BLDG		$10,000.00	Not assessed - not accessible	N/A
BNK4304	EFFB: U.V. Bank B Unit 2, D322, Lamps & Quartz Tubes,Effluent Building	UV Disinfection	UV BANK	EFF BLDG		$10,000.00	Not assessed - not accessible	N/A
BNK4305	EFFB: U.V. Bank A Unit 3, D331, Lamps & Quartz Tubes,Effluent Building	UV Disinfection	UV BANK	EFF BLDG		$10,000.00	Not assessed - not accessible	N/A
BNK4306	EFFB: U.V. Bank B Unit 3, D332, Lamps & Quartz Tubes,Effluent Building	UV Disinfection	UV BANK	EFF BLDG		$10,000.00	Not assessed - not accessible	N/A
BNK4307	EFFB: U.V. Bank A Unit 4, D341, Lamps & Quartz Tubes,Effluent Building	UV Disinfection	UV BANK	EFF BLDG		$10,000.00	Not assessed - not accessible	N/A
BNK4308	EFFB: U.V. Bank B Unit 4, D342, Lamps & Quartz Tubes,Effluent Building	UV Disinfection	UV BANK	EFF BLDG		$10,000.00	Not assessed - not accessible	N/A

BNK4309	EFFB: U.V. Bank A Unit 5, D351, Lamps & Quartz Tubes,Effluent Building	UV Disinfection	UV BANK	EFF BLDG		$10,000.00	Not assessed - not accessible	N/A
BNK4310	EFFB: U.V. Bank B Unit 5, D352, Lamps & Quartz Tubes, Effluent Building	UV Disinfection	UV BANK	EFF BLDG		$10,000.00	Not assessed - not accessible	N/A
MPN4401	EFFB: Meter Panel, Effluent Building	Effluent Pumping	PANEL,METR	EFF BLDG	<5 years	$10,000.00		5
PDC4301	EFFB: Power Distribution Center, U.V. Channel 1, Bank A, Includes Breaker, GFI, PLC, & Ballast, Cabinet Air Conditioning Unit, Effluent Building	UV Disinfection	PDC	EFF BLDG	5-10 years	$50,000.00	No Ethernet communications. Only serial to PLC processor.	4
PDC4302	EFFB: Power Distribution Center, U.V. Channel 1, Bank B, Includes Breaker, GFI, PLC, & Ballast	UV Disinfection	PDC	EFF BLDG	5-10 years	$50,000.00	No Ethernet communications. Only serial to PLC	4
PDC4303	EFFB: Power Distribution Center, U.V. Channel 2, Bank A, Includes Breaker, GFI, PLC, & Ballast, Cabinet Air Conditioning Unit	UV Disinfection	PDC	EFF BLDG	5-10 years	$50,000.00	No Ethernet communications. Only serial to PLC.	4
PDC4304	EFFB: Power Distribution Center, U.V. Channel 2, Bank B, Includes Breaker, GFI, PLC, & Ballast	UV Disinfection	PDC	EFF BLDG	5-10 years	$50,000.00	No Ethernet communications. Only serial to PLC.	4

PDC4305	EFFB: Power Distribution Center, U.V. Channel 3, Bank A, Includes Breaker, GFI, PLC, & Ballast, Cabinet Air Conditioning Unit	UV Disinfection	PDC	EFF BLDG	5-10 years	$50,000.00	No Ethernet communications. Only serial to PLC.	4
PDC4306	EFFB: Power Distribution Center, U.V. Channel 3, Bank B, Includes Breaker, GFI, PLC, & Ballast	UV Disinfection	PDC	EFF BLDG	5-10 years	$50,000.00	No Ethernet communications. Only serial to PLC. Rack 23 cable connector missing. Under repair. Intrenal ballasts and PLC processor missing.	4
PDC4307	EFFB: Power Distribution Center, U.V. Channel 4, Bank A, Includes Breaker,GFI, PLC, & Ballast, Cabinet Air Conditioning Unit	UV Disinfection	PDC	EFF BLDG	5-10 years	$50,000.00	No Ethernet communications. Ony serial to PLC. Panel is running relatively hot.	4
PDC4308	EFFB: Power Distribution Center, U.V. Channel 4, Bank B, Includes Breaker, GFI, PLC, & Ballast	UV Disinfection	PDC	EFF BLDG	5-10 years	$50,000.00	No Ethernet communications. Only serial to PLC.	4
PDC4309	EFFB: Power Distribution Center, U.V. Channel 5, Bank A, Includes Breaker, GFI, PLC, & Ballast, Cabinet Air Conditioning Unit	UV Disinfection	PDC	EFF BLDG	5-10 years	$50,000.00	No Ethernet communications. Only serial to PLC.	4
PDC4310	EFFB: Power Distribution Center, U.V. Channel 5, Bank B, Includes Breaker, GFI, PLC, & Ballast	UV Disinfection	PDC	EFF BLDG	5-10 years	$50,000.00	No Ethernet communications. Only serial to PLC.	4

PNL4300	EFFB: Panel View , in the System Control Center for all U.V.'s	UV Disinfection	PANEL,CON	EFF BLDG	<5 years	$5,000.00	CRT Panelview. A-B 1200e.	5
PPI4300	EFFB: Process Piping and Valves for U.V. System	UV Disinfection	PIPING	EFF BLDG			NOT ASSESSED - Piping System	N/A
PWS3901	BB2 : Protected Water (W3) System, Blower Building 2	Aeration Process	EQP,MISC	BLWR BLDG 2	5-10 years	$30,000.00	NOT ASSESSED - Piping System	N/A
QMT3103	HEAD: Flow Meter Venturi, P.S. 2 Headworks	Influent Metering and Sampling	METER,FLOW	HEADWORKS	5-10 years (eletrical components), 15+ years	$50,000.00		2
QMT3104	HEAD: Flow meter Venturi, P.S. 7 Headworks	Influent Metering and Sampling	METER,FLOW	HEADWORKS	5-10 years (eletrical components), 15+ years	$50,000.00		1
QMT3105	HEAD: Flow Meter Venturi, P.S. 8 Headworks	Influent Metering and Sampling	METER,FLOW	HEADWORKS	5-10 years (eletrical components), 15+ years	$50,000.00		1
QMT3106	HEAD: Flow Meter Venturi, P.S. 11 Headworks	Influent Metering and Sampling	METER,FLOW	HEADWORKS	5-10 years (eletrical components), 15+ years	$50,000.00		2
QMT3109	HEAD: Flow Meter, Venturi, Influent from PS18	Influent Metering and Sampling	METER,FLOW	HEADWORKS	5-10 years (eletrical components), 15+ years	$50,000.00		2
TRN0007	AG1 : Meter & Transmitter C363, Flow, RAS From ACB3, Aeration Gallery 1	Aeration Control (WAS and RAS)	METER,FLOW	AER GLRY 1	<5 years	$20,000.00		5
TRN0014	ACB4: Meter & Transmitter, B196, Power, MCC P41, ACB4	Aeration Control (WAS and RAS)	METER,POW	ACB4	<5 years	$5,000.00		5

TRN0015	ACB4: Meter & Transmitter B197, Power, MCC P42, ACB4	Aeration Control (WAS and RAS)	METER,POW	ACB4	<5 years	$5,000.00	5
TRN0018	AG1 : Meter & Transmitter C231, Flow, WAS Plant 1, Aeration Gallery 1	Aeration Control (WAS and RAS)	METER,FLOW	AER GLRY 1	<5 years	$6,000.00	5
TRN0072	BB1 : Meter & Transmitter, RPM, Blower 1, Blower Building 1	Aeration Process	METER,RPM	BLWR BLDG 1	<5 years	$1,000.00	5
TRN0073	BB1 : Meter & Transmitter, Power, Blower 2, Blower Building 1	Aeration Process	METER,POW	BLWR BLDG 1	<5 years	$5,000.00	5
TRN0074	BB1 : Meter & Transmitter, Power, Blower 3, Blower Building 1	Aeration Process	METER,POW	BLWR BLDG 1	<5 years	$5,000.00	5
TRN0075	BB1 : Meter & Transmitter, Power High, Blower 4, Blower Building 1	Aeration Process	METER,POW	BLWR BLDG 1	<5 years	$5,000.00	5
TRN0076	BB1 : Meter & Transmitter, Power Low, Blower 4, Blower Building 1	Aeration Process	METER,POW	BLWR BLDG 1	<5 years	$5,000.00	5
TRN0077	BB1 : Meter & Transmitter, Power High, Blower 5, Blower Building 1	Aeration Process	METER,POW	BLWR BLDG 1	<5 years	$5,000.00	5
TRN0078	BB1 : Meter & Transmitter, Power Low, Blower 5, Blower Building 1	Aeration Process	METER,POW	BLWR BLDG 1	<5 years	$5,000.00	5

TRN0080	BB1 : Meter & Transmitter, Temp. Switch, Gas Engine Radiator Oil, Blower Building 1	Aeration Process	METER,TEMP	BLWR BLDG 1	5-10 years	$1,000.00		5
TRN0081	BB1 : Meter & Transmitter, Temp. Switch, Gas Engine Radiator Water, Blower Building 1	Aeration Process	METER,TEMP	BLWR BLDG 1	10-15 years	$1,000.00		1
TRN0082	BB1 : Meter & Transmitter, Power, Blower Building 1	Aeration Process	METER,POW	BLWR BLDG 1	<5 years	$5,000.00		4
TRN0083	BB2 : Meter & Transmitter, Power, MCC P51, Blower Building 2	Aeration Process	METER,POW	BLWR BLDG 2	<5 years	$5,000.00		5
TRN0084	BB2 : Meter & Transmitter, Power, MCC P52, Blower Building 2	Aeration Process	METER,POW	BLWR BLDG 2	<5 years	$5,000.00		5
TRN0214	U15: Power Metering for MCC-U15-1, New 10/2014	Nine Springs Power Distribution System	METER,POW	ELEC BLDG U15	15+ years	$5,000.00		2
TRN0284	U15 : Power Quality Meter, S1-12 Main 1, New 2012	Nine Springs Power Distribution System	METER,POW	ELEC BLDG U15	15+ years	$5,000.00		2
TRN2911	Head: Level Transmitter, A797, SPU Conditioning Tank (Maci Pit)				15+ years	$10,000.00		1
TRN3801	BB1 : Transmitter C329, Pressure, Gas Blower 1, Blower Building 1	Aeration Process	XMTR,PRESS	BLWR BLDG 1	5-10 years	$5,000.00		4

TRN4401	MV3 : Meter & Transmitter D222, Flow, Effluent Meter Vault 3	Effluent Pumping	METER,FLOW	MTR VLT 3	10-15 years	$5,000.00		2
TRN4403	EFFB: Meter & Transmitter LT-160, In UV inlet well outside of the Effluent Building.	Effluent Pumping	XMTR,LEVEL	EFF BLDG		$5,000.00	Not assessed - not accessible	N/A
TRN4404	EFFB: Meter & Transmitter D300, In UV inlet well inside the Effluent Building.	Effluent Pumping	XMTR,LEVEL	EFF BLDG		$5,000.00	Not assessed - not accessible	N/A
TRN4405	MV3 : Meter & Transmitter, Effluent Flow Meter, Effluent Meter Vault 3	Effluent Pumping	METER,FLOW	MTR VLT 3	10-15 years	$5,000.00		2
TRN4406	MV3 : Meter & Transmitter, Effluent Pressure Meter, Effluent Meter Vault 3	Effluent Pumping	METER,FLOW	MTR VLT 3	10-15 years	$5,000.00		2
VFD0550	U15 : Variable Frequency Drive, Anaerobic Pump, AT21, South Wall, Elec Bldg U15	Aeration Process	VFD	ELEC BLDG U15	15+ years	$30,000.00		2
VFD0551	U15 : Variable Frequency Drive, Anaerobic Pump, AT24, South Wall, Elec Bldg U15	Aeration Process	VFD	ELEC BLDG U15	15+ years	$30,000.00		2
VFD0553	U15 : Variable Frequency Drive, Anaerobic Pump, AT28, South Wall, Elec Bldg U15	Aeration Process	VFD	ELEC BLDG U15	15+ years	$30,000.00		4

VFD0554	U15 : Variable Frequency Drive, Anaerobic Pump, AT25, South Wall, New 2014, Elec Bldg U15	Aeration Process	VFD	ELEC BLDG U15	15+ years	$30,000.00		4
VFD2902	HEAD: VFD for Motor and W4 Pump 2, A992, Headworks	W4 Water	VFD	HEADWORKS	15+ years	$40,000.00		3
VFD2904	HEAD: VFD for Motor and W4 Pump 3, A993, Headworks, new 6/2013	W4 Water	VFD	HEADWORKS	15+ years	$40,000.00		3
VFD2905	HEAD: VFD for Motor and W4 Pump 1, A991, New 2015	W4 Water	VFD	HEADWORKS	15+ years	$40,000.00		3
VFD3811	ACB2: VFD, Aeration Tank 12, Anaerobic Recycle Pump, P-NT12-1	Aeration Process	VFD	ACB2	10-15 years	$30,000.00		4
VFD3813	ACB2: VFD, Aeration Tank 18, Anaerobic Recycle Pump, P-NT18-1	Aeration Process	VFD	ACB2	10-15 years	$30,000.00		4

Group Process Mechanical

Type All gate types

Equipment All gate types

Asset ID	Asset Description	Process Description	Asset Type	Building	Remaining Useful Life	Replacement Cost	Comments	Worst Rating
SGT2013	HEAD: Inlet Sluice Gate A751 Maci	Headworks Screening	GATE,SLUI	HEADWORKS	15+ years	$5,000.00		1
SGT2014	HEAD: Inlet Sluice Gate A752 Maci	Headworks Screening	GATE,SLUI	HEADWORKS	15+ years	$5,000.00		1

SGT2015	HEAD: Inlet Sluice Gate A753 Maci	Headworks Screening	GATE,SLUI	HEADWORKS	15+ years	$5,000.00		1
SGT2016	HEAD: Inlet Sluice Gate A754 Maci	Headworks Screening	GATE,SLUI	HEADWORKS	15+ years	$5,000.00		1
SGT3112	HEAD: Outlet Sluice Gate PS07 SL-25-01 Headworks,	Influent Metering and Sampling	GATE,SLUI	HEADWORKS	15+ years	$15,000.00		2
SGT3113	HEAD: Outlet Sluice Gate PS08 SL-25-02 Headworks	Influent Metering and Sampling	GATE,SLUI	HEADWORKS	15+ years	$15,000.00		2
SGT3114	HEAD: Outlet Sluice Gate PS18 SL-25-03 Headworks	Influent Metering and Sampling	GATE,SLUI	HEADWORKS	15+ years	$15,000.00		2
SGT3115	HEAD: Outlet Sluice Gate PS02 SL-25-04 Headworks	Influent Metering and Sampling	GATE,SLUI	HEADWORKS	15+ years	$15,000.00		2
SGT3116	HEAD: Outlet Sluice Gate Furture PS SL-25-05 Headworks	Influent Metering and Sampling	GATE,SLUI	HEADWORKS	15+ years	$15,000.00		2
SGT3117	HEAD: Outlet Sluice Gate PS11SL-25-06 Headworks	Influent Metering and Sampling	GATE,SLUI	HEADWORKS	15+ years	$15,000.00		2
SGT3204	HEAD: Outlet Slide Gate SG-25-07, Grit Basin 1	Grit Removal	GATE,SLUI	HEADWORKS	15+ years	$25,000.00		2
SGT3205	HEAD: Inlet Channel Slide Gate A802, Grit Basin 2	Grit Removal	GATE,SLUI	HEADWORKS	15+ years	$25,000.00		2
SGT3206	HEAD: Inlet Slide Gate SG-25-03, Grit Basin 2	Grit Removal	GATE,SLUI	HEADWORKS	15+ years	$15,000.00		1
SGT3207	HEAD: Bypass Slide Gate SG-25-04, Grit Basin 2	Grit Removal	GATE,SLUI	HEADWORKS	15+ years	$15,000.00		2

SGT3208	HEAD: Outlet Slide Gate SG-25-08, Grit Basin 2	Grit Removal	GATE,SLUI	HEADWORKS	15+ years	$25,000.00		1
SGT3209	HEAD: Inlet Channel Slide Gate A803, Grit Basin 3	Grit Removal	GATE,SLUI	HEADWORKS	15+ years	$25,000.00		2
SGT3210	HEAD: Inlet Slide Gate SG-25-05, Grit Basin 3	Grit Removal	GATE,SLUI	HEADWORKS	15+ years	$15,000.00		1
SGT3211	HEAD: Bypass Slide Gate SG-25-06, Grit Basin 3	Grit Removal	GATE,SLUI	HEADWORKS	15+ years	$15,000.00		1
SGT3212	HEAD: Outlet Slide Gate SG-25-09, Grit Basin 3	Grit Removal	GATE,SLUI	HEADWORKS	15+ years	$25,000.00		1
SGT3213	HEAD: Inlet Channel Slide Gate A801, Grit Basin 1	Grit Removal	GATE,SLUI	HEADWORKS	15+ years	$25,000.00		2
SGT3214	HEAD: Inlet Slide Gate SG-25-01, Grit Basin 1	Grit Removal	GATE,SLUI	HEADWORKS	15+ years	$15,000.00		1
SGT3215	HEAD: Bypass Slide Gate SG-25-02, Grit Basin 1	Grit Removal	GATE,SLUI	HEADWORKS	15+ years	$15,000.00		1
SGT3301	FLOW: 60" Slide Gate SG-23-03 on North Wall East Junction Chamber	Flow Splitting to East and West Plants	GATE,SLUI	EAST JUCTION CHMB	15+ years	$25,000.00	some flaking rust not operated	2
SGT3302	FLOW: 54" Slide Gate SG-23-04 on East Wall East Junction Chamber	Flow Splitting to East and West Plants	GATE,SLUI	EAST JUCTION CHMB	15+ years	$25,000.00	flaking rust not operated	2
SGT3303	MV2 : Slide Gate SG-23-01 downward opening, excess flow, Flow Splitting	Flow Splitting to East and West Plants	PIPING	MTR VLT 2	15+ years	$20,000.00		2

SGT3304	MV2 : Slide Gate SG-23-02 downward opening, excess flow, Flow Splitting	Flow Splitting to East and West Plants	PIPING	MTR VLT 2	15+ years	$20,000.00		2
SGT3807	AT07: Sluice Gate, In Primary Effluent Channel to AT07	Aeration Process	GATE,SLUI	AT07	15+ years	$10,000.00	no tag minor rust not operated	3
SGT4101	FC01: Sluice Gate, Final Clarifier 1	Secondary Clarification	GATE,SLUI	FC01	5-10 years	$10,000.00	no tag	3
SGT4102	FC02: Sluice Gate, Final Clarifier 2	Secondary Clarification	GATE,SLUI	FC02	5-10 years	$10,000.00	80-90% rusted no tag	3
SGT4103	FC03: Sluice Gate, Final Clarifier 3	Secondary Clarification	GATE,SLUI	FC03	5-10 years	$10,000.00	not operated, extremely rusted no tag	3
SGT4104	FC04: Sluice Gate, Final Clarifier 4	Secondary Clarification	GATE,SLUI	FC04	5-10 years	$10,000.00	not operated significant rust, flaking rust no tag	4
SGT4105	FC05: Sluice Gate, Final Clarifier 5	Secondary Clarification	GATE,SLUI	FC05	10-15 years	$10,000.00	flaking rust no tag	3
SGT4106	FC06: Sluice Gate, Final Clarifier 6	Secondary Clarification	GATE,SLUI	FC06	10-15 years	$10,000.00	flaking rust no tag	3
SGT4107	FC07: Sluice Gate, Final Clarifier 7	Secondary Clarification	GATE,SLUI	FC07	10-15 years	$15,000.00	not much rust no tag	N/A
SGT4108	FC08: Sluice Gate, Final Clarifier 8	Secondary Clarification	GATE,SLUI	FC08	10-15 years	$15,000.00	looks like there might be damage in bottom right corner no tag	2
SGT4110	FC10: Sluice Gate, Final Clarifier 10	Secondary Clarification	GATE,SLUI	FC10	10-15 years	$15,000.00	minor rust	2
SGT4111	FC11: Sluice Gate, Final Clarifier 11	Secondary Clarification	GATE,SLUI	FC11	10-15 years	$15,000.00		2
SGT4118	FC08: Sluice Gate, Final Clarifier 8, 2005	Secondary Clarification	GATE,SLUI	FC08	15+ years	$10,000.00	no tag	2
SGT4119	FC09: Sluice Gate, Final Clarifier 9, 2005	Secondary Clarification	GATE,SLUI	FC09	15+ years	$15,000.00	no tag	2

SGT4301	EFFB: Sluice Gate & Actuator, U.V. 1 Inlet	UV Disinfection	GATE,SLUI	EFF BLDG	15+ years	$25,000.00		2
SGT4302	EFFB: Sluice Gate & Actuator, U.V. 2 Inlet	UV Disinfection	GATE,SLUI	EFF BLDG	15+ years	$25,000.00	not operated no tag	2
SGT4303	EFFB: Sluice Gate & Actuator, U.V. 3 Inlet	UV Disinfection	GATE,SLUI	EFF BLDG	15+ years	$25,000.00		2
SGT4304	EFFB: Sluice Gate & Actuator, U.V. 4 Inlet	UV Disinfection	GATE,SLUI	EFF BLDG	15+ years	$25,000.00	not operated no tag	2
SGT4305	EFFB: Sluice Gate & Actuator, U.V. 5 Inlet	UV Disinfection	GATE,SLUI	EFF BLDG	15+ years	$25,000.00		2
SGT4306	EFFB: Sluice Gate & Actuator (1) U.V. Bypass Channel 1 Inlet	UV Disinfection	GATE,SLUI	EFF BLDG	15+ years	$25,000.00	no unit tag minor corrosion gate not operated no tag	2
SGT4307	EFFB: Sluice Gate & Actuator(2) U.V. Bypass Channel 2 Inlet	UV Disinfection	GATE,SLUI	EFF BLDG	15+ years	$25,000.00	no tag minor surface deterioration not operated no tag	2
SGT4308	EFFB: Sluice Gate, (3) U.V. Bypass,(outside) Effluent Building	UV Disinfection	GATE,SLUI	EFF BLDG	15+ years	$15,000.00	NO TAG. COULD ONLY SEE UPPER OPERATOR.	2
SGT4401	EST : Sluice Gate (North), East Effluent Tank	Effluent Pumping	GATE,SLUI	EFF TANKS	15+ years	$15,000.00	not running not tagged	2
SGT4402	EST : Sluice Gate (North), West Effluent Tank	Effluent Pumping	GATE,SLUI	EFF TANKS	15+ years	$15,000.00	no tag minor surface deterioration not operated	2
SGT4403	EST : Sluice Gate (South), East Effluent Tank	Effluent Pumping	GATE,SLUI	EFF TANKS	15+ years	$15,000.00	no tag needs grating minor surface deterioration not operated	2

Asset ID	Asset Description	Process Description	Asset Type	Building	Remaining Useful Life	Replacement Cost	Comments	Worst Rating
SGT4404	EST : Sluice Gate (South), West Effluent Tank	Effluent Pumping	GATE,SLUI	EFF TANKS	15+ years	$15,000.00	no tag needs grating minor surface deterioration not operated	2

Type All valve types

Equipment All valve types

Asset ID	Asset Description	Process Description	Asset Type	Building	Remaining Useful Life	Replacement Cost	Comments	Worst Rating
MEQ4402	MV3: Pressure relief system, Meter Vault 3	Effluent Pumping	EQP,MISC	MTR VLT 3	5-10 years	$25,000.00		3

Type Auto Samplers

Equipment Auto Samplers

Asset ID	Asset Description	Process Description	Asset Type	Building	Remaining Useful Life	Replacement Cost	Comments	Worst Rating
SAM0002	ACB4: Sampler B, Plant 4 RAS, ACB4	Aeration Control (WAS and RAS)	SAMPLER	ACB4	5-10 years	$7,500.00		5
SAM0003	ACB4: Sampler C, Plant 3 WAS, ACB4	Aeration Control (WAS and RAS)	SAMPLER	ACB4	5-10 years	$7,500.00		5
SAM0004	ACB4: Sampler D, Plant 4 WAS, ACB4	Aeration Control (WAS and RAS)	SAMPLER	ACB4	5-10 years	$7,500.00		5
SAM0005	ACB1: Sampler, Waste Activated Sludge, Aeration Control Bldg 1	Aeration Control (WAS and RAS)	SAMPLER	ACB1	5-10 years	$7,500.00		5
SAM0006	ACB2: Sampler, Plant 1 Return Activated SludgeLocated in Aeration Control Building #2	Aeration Control (WAS and RAS)	SAMPLER	ACB2	5-10 years	$7,500.00		5

Asset ID	Asset Description	Process Description	Asset Type	Building	Remaining Useful Life	Replacement Cost	Comments	Worst Rating
SAM0007	ACB3: Sampler, Plant 2 RAS, ACB3	Aeration Control (WAS and RAS)	SAMPLER	ACB3	5-10 years	$7,500.00		5
SAM0008	ACB3: Sampler, Plant 2 WAS, ACB3	Aeration Control (WAS and RAS)	SAMPLER	ACB3	5-10 years	$7,500.00		5
SAM0021	AG2: Sampler, West Primary Effluent for West Plant, 2001, Blower Building 2	Aeration Process	SAMPLER	AER GLRY 2	10-15 years	$7,500.00		4

Type Compressor

Equipment Compressor

Asset ID	Asset Description	Process Description	Asset Type	Building	Remaining Useful Life	Replacement Cost	Comments	Worst Rating
COM4401	EFFB: Air Compressor/Motor Unit C1, Bubbler System, Effluent Building	Effluent Pumping	COMPR,AIR	EFF BLDG	10-15 years	$3,000.00	NOT RUNNING	1
COM4402	EFFB: Air Compressor/Motor Unit C2, Bubbler System, Effluent Building	Effluent Pumping	COMPR,AIR	EFF BLDG	10-15 years	$3,000.00	NOT RUNNING	1

Type Diaphragm pump

Equipment Diaphragm pump

Asset ID	Asset Description	Process Description	Asset Type	Building	Remaining Useful Life	Replacement Cost	Comments	Worst Rating
EJC4102	ACB4: Pneumatic Ejector 1, scum, ACB4	Secondary Clarification	EJECTOR	ACB4	10-15 years	$40,000.00		4

Type Filters

Equipment	Filters							
Asset ID	Asset Description	Process Description	Asset Type	Building	Remaining Useful Life	Replacement Cost	Comments	Worst Rating
AFE3801	BB1 : Primary Roll and Secondary Air Filters 1, Blower Building 1	Aeration Process	EQP,MISC	BLWR BLDG 1	5-10 years	$5,000.00	Filters are dirty	3
AFE3802	BB1 : Primary Roll and Secondary Air Filters 2, Blower Building 1	Aeration Process	EQP,MISC	BLWR BLDG 1	5-10 years	$5,000.00	Filters are dirty	3
AFE3803	BB1 : Primary Roll and Secondary Air Filters 3, Blower Building 1	Aeration Process	EQP,MISC	BLWR BLDG 1	5-10 years	$5,000.00		2
AFE3804	BB1 : Primary Roll and Secondary Air Filters 4, Blower Building 1	Aeration Process	EQP,MISC	BLWR BLDG 1	5-10 years	$5,000.00	minor deterioration, most like new	2
AFE3805	BB1 : Primary Roll and Secondary Air Filters 5, Blower Building 1	Aeration Process	EQP,MISC	BLWR BLDG 1	5-10 years	$5,000.00		2
AFE3902	BB2 : Primary Roll and Secondary Air Filters 1	Aeration Process	EQP,MISC	BLWR BLDG 2	5-10 years	$5,000.00	some minor surface deterioration	2
AFE3903	BB2 : Primary Roll and Secondary Air Filters 2	Aeration Process	EQP,MISC	BLWR BLDG 2	5-10 years	$5,000.00	some minor surface deterioration	2
AFE3904	BB2 : Primary Roll and Secondary Air Filters 3	Aeration Process	EQP,MISC	BLWR BLDG 2	5-10 years	$5,000.00	some minor deterioration	2

Type Gearboxes

Equipment	Gearboxes							
Asset ID	Asset Description	Process Description	Asset Type	Building	Remaining Useful Life	Replacement Cost	Comments	Worst Rating
FDR4102	FC02: Flocculator Drive & Mechanism Unit C132, Final Clarifier 2	Secondary Clarification	UNIT,DRIVE	FC02	5-10 years	$50,000.00	not running not tagged	3

RED2001	HEAD: Reducer Drive Motor 1 A710, Screen Unit 1, Omala 220 oil, Headworks	Headworks Screening	REDUCER	HEADWORKS	5-10 years	$5,000.00		1
RED2002	HEAD: Reducer Screen Drive Motor 2 A720 Screen Unit 2, Omala 220 oil, Headworks	Headworks Screening	REDUCER	HEADWORKS	5-10 years	$5,000.00		1
RED2004	HEAD: Reducer Screen Drive Motor 4 A740 Screen Unit 4, Omala 220 oil, Headworks	Headworks Screening	REDUCER	HEADWORKS	5-10 years	$5,000.00		2
RED2005	HEAD: Reducer Drive Unit, Conveyor belt A780, Headworks	Headworks Screening	REDUCER	HEADWORKS	5-10 years	$5,000.00		2
RED3206	HEAD: Reducer Drive Unit, Grit Auger 1, A860, Headworks Bldg	Grit Removal	REDUCER	HEADWORKS	5-10 years	$5,000.00		1
RED3207	HEAD: Reducer Drive Unit, Grit Auger 2, A870, Headworks Bldg	Grit Removal	REDUCER	HEADWORKS	5-10 years	$5,000.00		1
RED3208	HEAD: Reducer Drive Unit, Grit Auger 3, A880, Headworks Bldg	Grit Removal	REDUCER	HEADWORKS	5-10 years	$5,000.00		1
RED3501	PT01: Reducer, Long Collector E101, PT01	Primary Clarification	REDUCER	PT01	<5 years	$15,000.00	no tag deteriorating equip pad flaking rust on reducer exterior not running	3
RED3502	PT01: Reducer E101, Cross Collector, PT01	Primary Clarification	REDUCER	PT01	<5 years	$15,000.00		3
RED3503	PT02: Reducer, Long Collector E102, PT02	Primary Clarification	REDUCER	PT02	<5 years	$15,000.00	no tag deteriorating equip pad rusting not running	3

RED3504	PT02: Reducer E102, Cross Collector, PT02	Primary Clarification	REDUCER	PT02	<5 years	$15,000.00		2
RED3505	PT05: Reducer E115, Cross Collector, PT05	Primary Clarification	REDUCER	PT05	<5 years	$15,000.00	no tag bubbling flaky rust deteriorating equip pad not running	3
RED3506	PT05: Reducer, Long Collector, E105, PT05	Primary Clarification	REDUCER	PT05	<5 years	$15,000.00	no tag exterior rust deteriorating equip pad not running	3
RED3507	PT06: Reducer E116, Cross Collector, PT06	Primary Clarification	REDUCER	PT06	<5 years	$15,000.00	no tag exterior flaking rust deteriorating equip pad not running	3
RED3508	PT06: Reducer E106, Long Collector, PT06	Primary Clarification	REDUCER	PT06	<5 years	$15,000.00	no tag exterior flaking rust deteriorating equip pad not running	3
RED3509	PT07: Reducer E117, Cross Collector, PT07	Primary Clarification	REDUCER	PT07	<5 years	$15,000.00	no tag exterior flaking rust deteriorating equip pad not running	3
RED3510	PT07: Reducer E107, Long Collector, PT07	Primary Clarification	REDUCER	PT07	<5 years	$15,000.00	no tag exterior flaking rust deteriorating equip pad not running	3
RED3511	PT08: Reducer E118, Cross Collector, PT08	Primary Clarification	REDUCER	PT08	<5 years	$15,000.00	no tag exterior flaking rust deteriorating equip pad not running	3
RED3512	PT08: Reducer, Long Collector E108, PT08	Primary Clarification	REDUCER	PT08	<5 years	$15,000.00	no tag exterior flaking rust deteriorating equip pad not running	3

RED3513	PT09: Reducer E219, Cross Collector, PT09	Primary Clarification	REDUCER	PT09	<5 years	$15,000.00	no tag exterior flaking rust deteriorating equip pad not running	3
RED3514	PT09: Reducer E209, Long Collector, PT09	Primary Clarification	REDUCER	PT09	<5 years	$15,000.00	no tag exterior flaking rust deteriorating equip pad not running	3
RED3515	PT10: Reducer E220, Cross Collector, PT10	Primary Clarification	REDUCER	PT10	<5 years	$15,000.00	no tag exterior flaking bubbling rust deteriorating equip pad not running	3
RED3516	PT10: Reducer E210, Long Collector, PT10	Primary Clarification	REDUCER	PT10	<5 years	$15,000.00	no tag exterior flaking rust deteriorating equip pad not running	3
RED3517	PT11: Reducer E220, Cross Collector, PT11	Primary Clarification	REDUCER	PT11	<5 years	$15,000.00	no tag exterior flaking rust deteriorating equip pad not running	3
RED3518	PT11: Reducer E211, Long Collector, PT11	Primary Clarification	REDUCER	PT11	<5 years	$15,000.00	no tag exterior flaking rust deteriorating equip pad not running	3
RED3519	PT12: Reducer E222, Cross Collector, PT12	Primary Clarification	REDUCER	PT12	<5 years	$15,000.00	no tag exterior flaking rust deteriorating equip pad not running	3
RED3520	PT12: Reducer E212, Long Collector, PT12	Primary Clarification	REDUCER	PT12	<5 years	$15,000.00	no tag exterior flaking rust deteriorating equip pad not running	3

RED3521	PT13: Reducer E223, Cross Collector, PT13	Primary Clarification	REDUCER	PT13	<5 years	$15,000.00	no tag exterior flaking rust deteriorating equip pad not running	3
RED3522	PT13: Reducer E213, Long Collector, PT13	Primary Clarification	REDUCER	PT13	<5 years	$15,000.00	no tag exterior flaking rust deteriorating equip pad not running	3
RED3523	PT14: Reducer E224, Cross Collector, PT14	Primary Clarification	REDUCER	PT14	<5 years	$15,000.00	no tag exterior flaking rust deteriorating equip pad not running	3
RED3524	PT14: Reducer E214, Long Collector, PT14	Primary Clarification	REDUCER	PT14	<5 years	$15,000.00	no tag exterior flaking rust deteriorating equip pad not running	3
RED3525	PT15: Reducer E225, Cross Collector, PT15	Primary Clarification	REDUCER	PT15	<5 years	$15,000.00	no tag exterior flaking rust deteriorating equip pad not running	3
RED3526	PT15: Reducer E215, Long Collector, PT15	Primary Clarification	REDUCER	PT15	<5 years	$15,000.00	no tag exterior flaking rust deteriorating equip pad not running	3
RED3527	PT16: Reducer E226, Cross Collector, PT16	Primary Clarification	REDUCER	PT16	<5 years	$15,000.00	no tag exterior flaking rust deteriorating equip pad not running	3
RED3528	PT16: Reducer E216, Long Collector, PT16	Primary Clarification	REDUCER	PT16	<5 years	$15,000.00	no tag exterior flaking rust deteriorating equip pad not running	3
RED3529	PT17: Reducer, Cross Collector, PT17	Primary Clarification	REDUCER	PT17	<5 years	$15,000.00	no tag exterior rust not running	2

RED3530	PT17: Reducer, Long Collector, PT17	Primary Clarification	REDUCER	PT17	<5 years	$15,000.00	no tag exterior rust not running	2
RED3531	PT18: Reducer, Cross Collector, PT18	Primary Clarification	REDUCER	PT18	<5 years	$15,000.00	no tag exterior rust not running	2
RED3532	PT18: Reducer, Long Collector, PT18	Primary Clarification	REDUCER	PT18	<5 years	$15,000.00	no tag exterior rust not running	2
RED3533	PT19: Reducer, Cross Collector, PT19	Primary Clarification	REDUCER	PT19	<5 years	$15,000.00	no tag exterior rust	2
RED3534	PT19: Reducer, Long Collector, PT19	Primary Clarification	REDUCER	PT19	<5 years	$15,000.00	no tag exterior rust	2
RED3535	PT20: Reducer, Cross Collector, PT20	Primary Clarification	REDUCER	PT20	<5 years	$15,000.00	no tag exterior rust not running	2
RED3536	PT20: Reducer, Long Collector, PT20	Primary Clarification	REDUCER	PT20	<5 years	$15,000.00	minor deterioration rust\deterioration on weirs	2
RED3537	PT21: Reducer, Cross Collector, PT21	Primary Clarification	REDUCER	PT21	<5 years	$15,000.00		2
RED3538	PT21: Reducer, Long Collector, PT21	Primary Clarification	REDUCER	PT21	<5 years	$15,000.00		2
RED3601	HEAD: Reducer A891, Conveyor Snail, Headworks	Grit Removal	REDUCER	HEADWORKS	5-10 years	$5,000.00		3
RED4101	FC01: Lower Reducer, Collector Drive, Final Clarifier 1	Secondary Clarification	REDUCER	FC01	10-15 years	$15,000.00	couldNotEvaluate Bearings orTEmP	3
RED4102	FC01: Reducer C131, Flocculator Drive, Final Clarifier 1	Secondary Clarification	REDUCER	FC01	5-10 year	$15,000.00	~ equipment not running	3
RED4103	FC02: Lower Reducer, Collector Drive, Final Clarifier 2	Secondary Clarification	REDUCER	FC02	10-15 years	$15,000.00	could not evaluate temp or vibration not tagged	3

RED4104	FC02: Reducer C132, Flocculator Drive, Final Clarifier 2	Secondary Clarification	REDUCER	FC02	5-10 years	$15,000.00	not tagged or rrunning	3
RED4105	FC03: Lower Reducer, Collector Drive, Final Clarifier 3	Secondary Clarification	REDUCER	FC03	10-15 years	$15,000.00	not tagged could not evaluate vibration or temp	3
RED4106	FC03: Reducer C243, Flocculator, Final Clarifier 3	Secondary Clarification	REDUCER	FC03	5-10 years	$15,000.00	not tagged not running	3
RED4107	FC04: Lower Reducer, Collector Drive, Final Clarifier 4	Secondary Clarification	REDUCER	FC04	5-10 years	$15,000.00	not tagged not running	3
RED4108	FC04: Reducer C244, Flocculator, Final Clarifier 4	Secondary Clarification	REDUCER	FC04	10-15 years	$15,000.00	Not tagged Not running	2
RED4113	FC07: Lower Reducer, Collector Drive, Final Clarifier 7	Secondary Clarification	REDUCER	FC07	10-15 years	$15,000.00	Not tagged. Not safe to access	2
RED4115	FC08: Lower Reducer, Collector Drive, Final Clarifier 8	Secondary Clarification	REDUCER	FC08	10-15 years	$15,000.00	Not tagged	2
RED4117	FC09: Lower Reducer, Collector Drive, Final Clarifier 9	Secondary Clarification	REDUCER	FC09	10-15 years	$15,000.00	Not tagged	2
RED4119	FC10: Lower Reducer, Collector Drive, Final Clarifier 10	Secondary Clarification	REDUCER	FC10	10-15 years	$15,000.00	not tagged	2
RED4121	FC11: Lower Reducer, Collector Drive, Final Clarifier 11	Secondary Clarification	REDUCER	FC11	10-15 years	$15,000.00	not tagged or running	2
RED4122	FC11: Reducer C361, Flocculator Drive, Final Clarifier 11	Secondary Clarification	REDUCER	FC11	10-15 years	$15,000.00	Not tagged or running	2
RED4123	FC12: Lower Reducer, Collector Drive, Final Clarifier 12	Secondary Clarification	REDUCER	FC12	10-15 years	$15,000.00	not tagged	3

RED4124	FC12: Reducer B232, Flocculator Drive, Final Clarifier 12	Secondary Clarification	REDUCER	FC12	5-10 years	$15,000.00	Not tagged or running	3
RED4125	FC13: Lower Reducer, Collector Drive, Final Clarifier 13	Secondary Clarification	REDUCER	FC13	10-15 years	$15,000.00	not tagged. Standing water in centerof drive.	2
RED4126	FC13: Reducer B233, Flocculator Drive, Final Clarifier 13	Secondary Clarification	REDUCER	FC13	5-10 years	$15,000.00	not tagged orrunning	3
RED4127	FC14: Lower Reducer, Collector Drive, Final Clarifier 14	Secondary Clarification	REDUCER	FC14	10-15 years	$15,000.00	not tagged	2
RED4128	FC14: Reducer B234, Flocculator Drive, Final Clarifier 14	Secondary Clarification	REDUCER	FC14	10-15 years	$15,000.00	not tagged or running	2
RED4129	FC15: Lower Reducer, Collector Drive, Final Clarifier 15	Secondary Clarification	REDUCER	FC15	10-15 years	$15,000.00	NOT TAGGED	2
RED4130	FC15: Reducer B235, Flocculator Drive, Final Clarifier 15	Secondary Clarification	REDUCER	FC15	10-15 years	$15,000.00	NOT TAGGED OR RUNNING	2
RED4131	FC16: Lower Reducer, Collector Drive, Final Clarifier 16	Secondary Clarification	REDUCER	FC16	10-15 years	$15,000.00	not tagged	3
RED4132	FC16: Reducer B236, Flocculator Drive, Final Clarifier 16	Secondary Clarification	REDUCER	FC16	5-10 years	$15,000.00	not tagged or running	3
RED4133	FC17: Lower Reducer, Collector Drive, Final Clarifier 17	Secondary Clarification	REDUCER	FC17	5-10 years	$15,000.00	not tagged	3
RED4134	FC17: Reducer B237, Flocculator Drive, Final Clarifier 17	Secondary Clarification	REDUCER	FC17	5-10 years	$15,000.00	not on no tag	3
RED4135	FC18: Lower Reducer, Collector Drive, Final Clarifier 18	Secondary Clarification	REDUCER	FC18	5-10 years	$15,000.00	not tagged	3

RED4136	FC18: Reducer B238, Flocculator Drive, Final Clarifier 18	Secondary Clarification	REDUCER	FC18	5-10 years	$15,000.00	not tagged or running	3
RED4137	FC19: Lower Reducer, Collector Drive, Final Clarifier 19	Secondary Clarification	REDUCER	FC19	10-15 years	$15,000.00	no tag not operating some surface wear	2
RED4138	FC19: Reducer B239, Flocculator Drive, Final Clarifier 19	Secondary Clarification	REDUCER	FC19	5-10 years	$15,000.00	no tag not running some deterioration	3
RED4139	FC01: Upper Reducer, Collector Drive, Final Clarifier 1	Secondary Clarification	REDUCER	FC01	10-15 years	$15,000.00		2
RED4140	FC02: Upper Reducer, Collector Drive, Final Clarifier 2	Secondary Clarification	REDUCER	FC02	10-15 years	$15,000.00		2
RED4141	FC03: Upper Reducer, Collector Drive, Final Clarifier 3	Secondary Clarification	REDUCER	FC03	10-15 years	$15,000.00		2
RED4142	FC04: Upper Reducer, Collector Drive, Final Clarifier 4	Secondary Clarification	REDUCER	FC04	10-15 years	$15,000.00	not tagged not in service	2
RED4143	FC07: Upper Reducer, Collector Drive, Final Clarifier 7	Secondary Clarification	REDUCER	FC07	10-15 years	$15,000.00	Not tagged	2
RED4144	FC08: Upper Reducer, Collector Drive, Final Clarifier 8	Secondary Clarification	REDUCER	FC08	10-15 years	$15,000.00	Not tagged	2
RED4145	FC09: Upper Reducer, Collector Drive, Final Clarifier 9	Secondary Clarification	REDUCER	FC09	10-15 years	$15,000.00	Motor is tagged with red tag. Slight noise but my come from motor.	2
RED4146	FC10: Upper Reducer, Collector Drive, Final Clarifier 10	Secondary Clarification	REDUCER	FC10	10-15 years	$15,000.00	not tagged	2
RED4147	FC11: Upper Reducer, Collector Drive, Final Clarifier 11	Secondary Clarification	REDUCER	FC11	10-15 years	$15,000.00	not tagged or running	2

RED4148	FC12: Upper Reducer, Collector Drive, Final Clarifier 12	Secondary Clarification	REDUCER	FC12	10-15 years	$15,000.00	not tagged	3
RED4149	FC13: Upper Reducer, Collector Drive, Final Clarifier 13	Secondary Clarification	REDUCER	FC13	10-15 years	$15,000.00	Shows signs of leaking lube	3
RED4150	FC14: Upper Reducer, Collector Drive, Final Clarifier 14	Secondary Clarification	REDUCER	FC14	10-15 years	$15,000.00		2
RED4151	FC15: Upper Reducer, Collector Drive, Final Clarifier 15	Secondary Clarification	REDUCER	FC15	10-15 years	$15,000.00	Leaking lube	2
RED4152	FC16: Upper Reducer, Collector Drive, Final Clarifier 16	Secondary Clarification	REDUCER	FC16	10-15 years	$15,000.00	minor lube leakage	2
RED4153	FC17: Upper Reducer, Collector Drive, Final Clarifier 17	Secondary Clarification	REDUCER	FC17	10-15 years	$15,000.00		2
RED4154	FC18: Upper Reducer, Collector Drive, Final Clarifier 18	Secondary Clarification	REDUCER	FC18	10-15 years	$15,000.00		2
RED4155	FC19: Upper Reducer, Collector Drive, Final Clarifier 19	Secondary Clarification	REDUCER	FC19	10-15 years	$15,000.00	some wear	2
RED4156	FC05: Reducer, Collector Drive, New 2014, Final Clarifier 5	Secondary Clarification	REDUCER	FC05	>15 years	$15,000.00	Not tagged. Could not access lower drive	1
RED4157	FC06: Reducer, Collector Drive, New 2014, Final Clarifier 6	Secondary Clarification	REDUCER	FC06	>15 years	$15,000.00	Not tagged. Could not acces lower drive.	1

Type Grit Removal

Equipment Grit Removal

Asset ID	Asset Description	Process Description	Asset Type	Building	Remaining Useful Life	Replacement Cost	Comments	Worst Rating

GRU3215	HEAD: Grit Concentrator 1B, New 10/2014, Headworks Bldg.	Grit Removal	EQP,MISC	HEADWORKS	10-15 years	$40,000.00		1

Type Metering

Equipment Metering

Asset ID	Asset Description	Process Description	Asset Type	Building	Remaining Useful Life	Replacement Cost	Comments	Worst Rating
IMT4301	EFFB: U.V. Intensity Meters, Effluent Building	UV Disinfection	METER	EFF BLDG		$10,000.00	Not assessed - not accessible	N/A

Type Uncategorized

Equipment Uncategorized

Asset ID	Asset Description	Process Description	Asset Type	Building	Remaining Useful Life	Replacement Cost	Comments	Worst Rating
ACU3501	AG1 : Air Compressor Unit, Bowling Alley, Aeration Gallery 1,	Primary Clarification	COMPR,AIR	AER GLRY 1	5-10 years	$7,500.00	no tag not running surface deterioration	3
ACU3800	BB1 : Air Compressor Unit 1, Blower Building 1	Aeration Process	COMPR,AIR	BLWR BLDG 1	10-15 years	$7,500.00	not running	2
ACU3802	BB1 : Air Compressor Unit 2, Oil Turbo T-68, Blower Building 1	Aeration Process	COMPR,AIR	BLWR BLDG 1	10-15 years	$7,500.00	not running	2
ACU4402	EFFB: Air Compressor on Hydraulic Oil Accumulater, Duplex, Air, oil Morlina 100, Effluent Building	Effluent Pumping	COMPR,AIR	EFF BLDG	10-15 years	$7,500.00	no tag not running	2

ACU4403	EFFB: Air Compressor Unit, C1 & C2 for Bubblers 1 & 2, Supplies Air to Bubble Flow Ctrl Panel, Effluent Building	Effluent Pumping	COMPR,AIR	EFF BLDG	10-15 years	$10,000.00	not running like new	1
BLO3801	BB1 : Blower 1, C431, Blower Building 1	Aeration Process	BLOWER	BLWR BLDG 1	>15 years	$630,000.00	not tagged. Oil leaking at casing.	4
BLO3802	BB1 : Blower 2 C432, Blower Building 1	Aeration Process	BLOWER	BLWR BLDG 1	>15 years	$630,000.00	not running	2
BLO3803	BB1 : Blower 3 C433, Blower Building 1	Aeration Process	BLOWER	BLWR BLDG 1	>15 years	$630,000.00	not running	2
BLO3804	BB1 : Blower 4, Blower Building 1	Aeration Process	BLOWER	BLWR BLDG 1	>15 years	$630,000.00	not running	4
BLO3805	BB1 : Blower 5, Blower Building 1	Aeration Process	BLOWER	BLWR BLDG 1	>15 years	$630,000.00		4
BLO3901	BB2 : Blower 1, A311, Blower Building 2	Aeration Process	BLOWER	BLWR BLDG 2	>15 years	$1,100,000.00	not running paint looks newer part of jacket on pipe deteriorating, see pics	1
BLO3902	BB2 : Blower 2, A312, Blower Building 2	Aeration Process	BLOWER	BLWR BLDG 2	>15 years	$1,100,000.00	not running paint looks newer part of jacket on pipe deteriorating, see pics	1
BLO3903	BB2 : Blower 3, A313, Blower Building 2	Aeration Process	BLOWER	BLWR BLDG 2	>15 years	$1,100,000.00	Oil on top of drive and filter smoking	2
CBL3601	HEAD: Snail A891, Grit Dewatering, Headworks	Grit Removal	EQP,MISC	HEADWORKS	5-10 years	$170,000.00		3
DRI2004	HEAD: Drive Unit, Lipactor 1 A781, Screening Headworks	Headworks Screening	EQP,MISC	HEADWORKS	5-10 years	$5,000.00		2
DRI2005	HEAD: Drive Unit, Lipactor 2 A782, Screening Headworks	Headworks Screening	EQP,MISC	HEADWORKS	5-10 years	$5,000.00		3

DRI2006	HEAD: Drive Unit, Lipactor 3 A783, Screening Headworks	Headworks Screening	UNIT,DRIVE	HEADWORKS	5-10 years	$5,000.00		2
DRI2015	HEAD: Drive Unit, Conveyor belt A780 Headworks	Headworks Screening	EQP,MISC	HEADWORKS	5-10 years	$5,000.00		3
DRI3201	HEAD: Drive Unit 1, A810, Grit Basin 1, Omala 68, Headworks	Grit Removal	UNIT,DRIVE	HEADWORKS	10-15 years	$45,000.00		2
DRI3202	HEAD: Drive Unit 2, A820, Grit Basin 2, Omala 68, Headworks	Grit Removal	UNIT,DRIVE	HEADWORKS	10-15 years	$45,000.00		2
DRI3203	HEAD: Drive Unit 3, A830, Grit Basin 3, Omala 68, Headworks	Grit Removal	UNIT,DRIVE	HEADWORKS	10-15 years	$45,000.00		2
DRI4101	FC01: Collector Drive & Mechanism Unit C121, Final Clarifier 1	Secondary Clarification	UNIT,DRIVE	FC01	5-10 years	$160,000.00	No ID TAG	3
DRI4102	FC02: Collector Drive & Mechanism Unit C122, Final Clarifier 2	Secondary Clarification	UNIT,DRIVE	FC02	10-15 years	$160,000.00		2
DRI4103	FC03: Collector Drive & Mechanism Unit C233, Final Clarifier 3	Secondary Clarification	UNIT,DRIVE	FC03	10-15 years	$200,000.00	not tagged	2
DRI4104	FC04: Collector Drive & Mechanism Unit C234, Final Clarifier 4	Secondary Clarification	UNIT,DRIVE	FC04	10-15 years	$170,000.00	not tagged not running	2
DRI4105	FC05: Collector Drive & Mechanism Unit C235, Final Clarifier 5	Secondary Clarification	UNIT,DRIVE	FC05	10-15 years	$170,000.00	not tagged	1
DRI4106	FC06: Collector Drive & Mechanism Unit C236, Final Clarifier 6	Secondary Clarification	UNIT,DRIVE	FC06	10-15 years	$170,000.00	Not tagged	1
DRI4107	FC07: Collector Drive & Mechanism Unit C337, Final Clarifier 7	Secondary Clarification	UNIT,DRIVE	FC07	10-15 years	$230,000.00	Not tagged	1

DRI4108	FC08: Collector Drive & Mechanism Unit C338, Final Clarifier 8	Secondary Clarification	UNIT,DRIVE	FC08	10-15 years	$230,000.00	Not tagged Open railing near drive	1
DRI4109	FC09: Collector Drive & Mechanism Unit C339, Final Clarifier 9	Secondary Clarification	UNIT,DRIVE	FC09	10-15 years	$230,000.00	Not tagged	1
DRI4110	FC10: Collector Drive & Mechanism Unit C340, Final Clarifier 10	Secondary Clarification	UNIT,DRIVE	FC10	10-15 years	$230,000.00	not tagged.Railing open near drive.	2
DRI4111	FC11: Collector Drive & Mechanism Unit, Final Clarifier 11	Secondary Clarification	UNIT,DRIVE	FC11	10-15 years	$230,000.00	Not tagged. Not inservice	1
DRI4112	FC12: Collector Drive & Mechanism Unit B212, Final Clarifier 12	Secondary Clarification	UNIT,DRIVE	FC12	10-15 years	$260,000.00	not tagged	2
DRI4113	FC13: Collector Drive & Mechanism Unit B213, Final Clarifier 13	Secondary Clarification	UNIT,DRIVE	FC13	5-10 years	$260,000.00	not tagged. Running, but not in service.	3
DRI4114	FC14: Collector Drive & Mechanism Unit B214, Final Clarifier 14	Secondary Clarification	UNIT,DRIVE	FC14	10-15 years	$260,000.00	not tagged	2
DRI4115	FC15: Collector Drive & Mechanism Unit B215, Final Clarifier 15	Secondary Clarification	UNIT,DRIVE	FC15	10-15 years	$260,000.00	not tagged	2
DRI4116	FC16: Collector Drive & Mechanism Unit B216, Final Clarifier 16	Secondary Clarification	UNIT,DRIVE	FC16	10-15 years	$260,000.00	not tagged	2
DRI4117	FC17: Collector Drive & Mechanism Unit, Final Clarifier 17	Secondary Clarification	UNIT,DRIVE	FC17	5-10 years	$260,000.00		2
DRI4118	FC18: Collector Drive & Mechanism Unit B218, Final Clarifier 18	Secondary Clarification	UNIT,DRIVE	FC18	5-10 years	$260,000.00	not tagged	3
DRI4119	FC19: Collector Drive & Mechanism Unit B219, Final Clarifier 19	Secondary Clarification	UNIT,DRIVE	FC19	5-10 years	$260,000.00	rusty scraper mech rusty unit drive	3

EJC3501	GCB : Pneumatic Ejector 1,scum, Gas Control Building	Primary Clarification	EJECTOR	GAS CNTR BLDG	10-15 years	$40,000.00	pneumatic ejector some surface deterioration	2
EJC3502	AG1 : Pneumatic Ejector 1,scum, Bowling Alley, Aeration Gallery 1,	Primary Clarification	EJECTOR	AER GLRY 1	10-15 years	$40,000.00	pneumatic ejector some surface deterioration not running	2
EJC3504	AG2 : Pneumatic Ejector 1, scum, Aeration Gallery 2	Primary Clarification	EJECTOR	AER GLRY 2	10-15 years	$40,000.00	pneumatic ejector. Not running	2
EJC3505	AG2 : Pneumatic Ejector 2, scum, Aeration Gallery 2	Primary Clarification	EJECTOR	AER GLRY 2	10-15 years	$40,000.00	not running	2
EJC4101	ACB3: Pneumatic Ejector, scum, ACB3	Secondary Clarification	EJECTOR	ACB3	10-15 years	$40,000.00	pneumatic ejector minor surface wear looks like theres a stripped wire, see pics some corrosion near stripped wire	1
EJC4103	ACB4: Pneumatic Ejector 2,(scum) ACB4	Secondary Clarification	EJECTOR	ACB4	10-15 years	$40,000.00	pneumatic ejector not running minor surface deterioration possible leakage, see pics	4
FDR4101	FC01: Flocculator Drive & Mechanism Unit C131, Final Clarifier 1	Secondary Clarification	UNIT,DRIVE	FC01	5-10 years	$50,000.00	not running:no temp, oscillation, or noise assessed about 15% rusted surface	N/A
FDR4103	FC03: Flocculator Drive & Mechanism Unit C243, Final Clarifier 3	Secondary Clarification	UNIT,DRIVE	FC03	5-10 years	$50,000.00	not tagged not running	3
FDR4104	FC04: Flocculator Drive & Mechanism Unit C244, Final Clarifier 4	Secondary Clarification	UNIT,DRIVE	FC04	5-10 years	$50,000.00	Not running	2

FDR4111	FC11: Flocculator Drive & Mechanism Unit C361, Final Clarifier 11	Secondary Clarification	UNIT,DRIVE	FC11	5-10 years	$50,000.00	Not tagged or running	2
FDR4112	FC12: Flocculator Drive & Mechanism Unit B232, Final Clarifier 12	Secondary Clarification	UNIT,DRIVE	FC12	5-10 years	$50,000.00	not tagged or running	3
FDR4113	FC13: Flocculator Drive & Mechanism Unit B233, Final Clarifier 13	Secondary Clarification	UNIT,DRIVE	FC13	5-10 years	$50,000.00	not tagged or running	3
FDR4114	FC14: Flocculator Drive & Mechanism Unit B234, Final Clarifier 14	Secondary Clarification	UNIT,DRIVE	FC14	5-10 years	$50,000.00	not tagged or trunning	2
FDR4115	FC15: Flocculator Drive & Mechanism Unit B235, Final Clarifier 15	Secondary Clarification	UNIT,DRIVE	FC15	5-10 years	$50,000.00	NOT TAGGED OR RUNNING	2
FDR4116	FC16: Flocculator Drive & Mechanism Unit B236, Final Clarifier 16	Secondary Clarification	UNIT,DRIVE	FC16	5-10 years	$50,000.00	not tagged or running	3
FDR4117	FC17: Flocculator Drive & Mechanism Unit B237, Final Clarifier 17	Secondary Clarification	UNIT,DRIVE	FC17	5-10 years	$50,000.00	not operating no tag	3
FDR4118	FC18: Flocculator Drive & Mechanism Unit B238, Final Clarifier 18	Secondary Clarification	UNIT,DRIVE	FC18	5-10 years	$50,000.00	not tagged or running	3
FDR4119	FC19: Flocculator Drive & Mechanism Unit B239, Final Clarifier 19	Secondary Clarification	UNIT,DRIVE	FC19	5-10 years	$50,000.00	surface rust not running	3

GRU3205	HEAD: Grit Concentrator 3A Headworks S/N or Job # 03-11921-00-W	Grit Removal	EQP,MISC	HEADWORKS	10-15 years	$40,000.00		2
GRU3206	HEAD: Grit Concentrator 3B Headworks S/N or Job # 03-11921-00-W	Grit Removal	EQP,MISC	HEADWORKS	10-15 years	$40,000.00	grit concentrator minor surface deterioration	2
GRU3211	HEAD: Grit Concentrator 1A Headworks, New in December of 2011.S/N or Job # 03-11920-00-W, Part # 67C174-300	Grit Removal	EQP,MISC	HEADWORKS	10-15 years	$40,000.00		2
GRU3212	HEAD: Grit Concentrator 2A, NEW 2013, Headworks Job # 03-11919-00-W	Grit Removal	EQP,MISC	HEADWORKS	10-15 years	$40,000.00		2
GRU3213	HEAD: Grit Concentrator 2B, NEW 2013, Headworks Job # 03-11919-00-W	Grit Removal	EQP,MISC	HEADWORKS	10-15 years	$40,000.00	grit concentrator minor surface deterioration	2
MEQ0102	HEAD: Auger, A895 (Screw Conveyor) Grit Dewatering from snail to dumpster, Headworks	Grit Removal	EQP,MISC	HEADWORKS	5-10 years	$40,000.00		1
MEQ2001	HEAD: Screen Unit 1,A710, Headworks	Headworks Screening	EQP,MISC	HEADWORKS	10-15 years	$330,000.00		3
MEQ2002	HEAD: Screen Unit 2, A720, Headworks	Headworks Screening	EQP,MISC	HEADWORKS	10-15 years	$330,000.00		2
MEQ2004	HEAD: Screen Unit 4, A740, Headworks	Headworks Screening	EQP,MISC	HEADWORKS	10-15 years	$330,000.00		2

MEQ2005	HEAD: Screenings Launder Trough Headworks	Headworks Screening	EQP,MISC	HEADWORKS	5-10 years	$50,000.00		4
MEQ2009	HEAD: Lisep 1 A771 Headworks	Headworks Screening	EQP,MISC	HEADWORKS	5-10 years	$50,000.00		3
MEQ2011	HEAD: Lisep 2 A772 Headworks	Headworks Screening	EQP,MISC	HEADWORKS	5-10 years	$50,000.00		3
MEQ2014	HEAD: Lisep 3 A773 Headworks	Headworks Screening	EQP,MISC	HEADWORKS	5-10 years	$50,000.00		3
MEQ2016	HEAD: Lipactor 1 Headworks, Manual 11217	Headworks Screening	EQP,MISC	HEADWORKS	5-10 years	$50,000.00		2
MEQ2017	HEAD: Lipactor 2 Headworks, Manual 11217	Headworks Screening	EQP,MISC	HEADWORKS	5-10 years	$50,000.00		3
MEQ2018	HEAD: Lipactor 3 Headworks, Manual 11217	Headworks Screening	EQP,MISC	HEADWORKS	5-10 years	$50,000.00		3
MEQ2902	HEAD: W4 Strainer 1 A981	W4 Water	EQP,MISC	HEADWORKS	<5 years	$40,000.00		4
MEQ2903	HEAD: W4 Strainer 2 A982	W4 Water	EQP,MISC	HEADWORKS	<5 years	$40,000.00		4
MEQ2904	HEAD: Sodium Hypochlorite Injection Assembly NaOCI	W4 Water	PUMP	HEADWORKS	5-10 years	$1,000.00		3
MEQ3203	HEAD: Grit Auger 1, A860, Headworks Bldg	Grit Removal	EQP,MISC	HEADWORKS	10-15 years	$40,000.00		2
MEQ3205	HEAD: Grit Auger 2, A870, Headworks Bldg	Grit Removal	EQP,MISC	HEADWORKS	10-15 years	$40,000.00		2
MEQ3207	HEAD: Grit Auger 3, A880, Headworks Bldg	Grit Removal	EQP,MISC	HEADWORKS	10-15 years	$40,000.00		2
MEQ3800	BB1 : Engine Cooling Sys., Blower Building 1	Aeration Process	EQP,MISC	BLWR BLDG 1			retired-remove from list	N/A

MEQ3801	BB1 : Air Cooled Heat Exchanger Fan, Blower Building 1	Aeration Process	EQP,MISC	BLWR BLDG 1			retired-remove from list	N/A
MEQ3802	BB1 : Jacket Water Air Separator 3, Blower Building 1	Aeration Process	EQP,MISC	BLWR BLDG 1	>15 years	$10,000.00	Insulated. Ins jacket damaged.Could not evaluate condition. Equipment category not defined.	1
MEQ3803	BB1 : Jacket Water Heat Exchanger 3, Blower Building 1	Aeration Process	EQP,MISC	BLWR BLDG 1	10-15 years	$30,000.00	Completely Insulated. Could not evaluate condition. Insulation damaged.	N/A
MEQ3804	BB1 : Jacket Water Expanion Tank 5, Blower Building 1	Aeration Process	EQP,MISC	BLWR BLDG 1	10-15 years	$3,000.00	Equipment type not defined	2
MEQ3805	BB1 : Jacket Water Expanion Tank 2, Blower Building 1	Aeration Process	EQP,MISC	BLWR BLDG 1	10-15 years	$3,000.00	Equipment type not defined.	2
MEQ3806	BB1 : Jacket Water Radiator Fan, Blower Building 1	Aeration Process	EQP,MISC	BLWR BLDG 1			retired-remove from list	N/A
MEQ3807	BB1 : Jacket Water Radiator 1, Blower Building 1	Aeration Process	EQP,MISC	BLWR BLDG 1	10-15 years	$50,000.00	Equipment type not defined	3
MEQ3809	BB1 : Lube Oil Cooling Air Separator, Blower Building 1	Aeration Process	EQP,MISC	BLWR BLDG 1	10-15 years	$2,500.00	couldn’t evaluate due to jacket cover damaged jacket on pipe, see pics	2
MEQ3810	BB1 : Lube Oil Cooling Expanion Tank 3, Blower Building 1	Aeration Process	EQP,MISC	BLWR BLDG 1	10-15 years	$2,500.00	couldn’t evaluate due to jacket cover damaged jacket, see pics	2
MEQ3812	BB1 : Lube Oil Cooler 1, Blower Building 1	Aeration Process	EQP,MISC	BLWR BLDG 1	10-15 years	$50,000.00	lube oil heat exchanger not running minor suface deterioration	1

MEQ3814	BB1 : Lube Oil Coolant Radiator Fan, Blower Building 1	Aeration Process	EQP,MISC	BLWR BLDG 1	<5 years	$10,000.00	Equipment type not defined.	4
MEQ3815	BB1 : Exhaust Heat Exchanger, Model ECXWV-2870-1.5 SPCL Bare fire tube exhaust waste heat recovery silencer, New 2008, Blower Building 1	Aeration Process	EQP,MISC	BLWR BLDG 1	10-15 years	$75,000.00		2
MEQ4401	EFFB: Hydraulic Oil Accumulater, Effluent Building	Effluent Pumping	EQP,MISC	EFF BLDG	10-15 years	$50,000.00	NOT RUNNING. INCLUDES ACU4402.	1
PMP2007	HEAD: Maci Pump, Spare, SN 18893-H2453	Headworks Screening	PUMP	HEADWORKS	5-10 years	$30,000.00		3
PMP2008	HEAD: Maci Pump, Position 3, SN 18893-H24536	Headworks Screening	PUMP	HEADWORKS	5-10 years	$30,000.00		2
PMP2009	HEAD: Maci Pump, Position 1, SN 18893-H424571	Headworks Screening	PUMP	HEADWORKS	5-10 years	$30,000.00		3
PMP2010	HEAD: Pump, Macerator Grit Pump, A750, Headworks	Headworks Screening	PUMP	HEADWORKS	5-10 years	$34,000.00		1
PMP2012	HEAD: Maci Pump, Position 2/4	Headworks Screening	PUMP	HEADWORKS	5-10 years	$30,000.00	spare pump currently not in service	2
PMP2901	HEAD: Pump 1 A991, W4, Headworks	W4 Water	PUMP	HEADWORKS	5-10 years	$15,000.00		4
PMP2902	HEAD: Pump 2 A992, W4, Headworks	W4 Water	PUMP	HEADWORKS	5-10 years	$15,000.00		2
PMP2903	HEAD: Pump 3 A993, W4, Headworks	W4 Water	PUMP	HEADWORKS	5-10 years	$15,000.00		3

PMP2906	HEAD: Sodium Hypochlorite Metering Pump & Motor 1, A995, A96528970P11036046 1New 2010 NaOCl-P-01	W4 Water	PUMP	HEADWORKS	5-10 years	$10,000.00		3
PMP2907	HEAD: Sodium Hypochlorite Metering Pump & Motor 2, A996, A96528970P11036045 9New 2010 NaOCl-P-01	W4 Water	PUMP	HEADWORKS	5-10 years	$10,000.00		2
PMP3201	HEAD: Grit Pump 1-A, A817	Grit Removal	PUMP	HEADWORKS	10-15 years	$34,000.00		2
PMP3202	HEAD: Grit Pump 1-B, A818	Grit Removal	PUMP	HEADWORKS	10-15 years	$34,000.00		2
PMP3203	HEAD: Grit Pump 2-A, A827	Grit Removal	PUMP	HEADWORKS	10-15 years	$34,000.00		2
PMP3205	HEAD: Grit Pump 3-A, A837	Grit Removal	PUMP	HEADWORKS	10-15 years	$34,000.00		3
PMP3206	HEAD: Grit Pump 3-B, A838	Grit Removal	PUMP	HEADWORKS	10-15 years	$34,000.00		3
PMP3207	HEAD: Grit Pump 2-B, A828	Grit Removal	PUMP	HEADWORKS	10-15 years	$34,000.00		1
PMP3501	PSPB1: Pump, Primary Sludge Pump 1, E131, Primary Sludge Pumping Building 1	Primary Clarification	PUMP	PSPB1	5-10 years	$40,000.00	not running paint looks newer some specs of dried sludge on it, possible minor leaks?	1
PMP3502	PSPB1: Pump, Primary Sludge Pump 2, E132, Primary Sludge Pumping Building 1	Primary Clarification	PUMP	PSPB1	5-10 years	$40,000.00	not running paint looks newer some specs of dried sludge on it, possible minor leaks?	1

PMP3503	PSPB1: Pump, Primary Sludge Pump 3, E133, Primary Sludge Pumping Building 1	Primary Clarification	PUMP	PSPB1	5-10 years	$40,000.00	not running paint looks newer some specs of dried sludge on it, possible minor leaks?	1
PMP3504	PSPB1: Pump, Primary Sludge Pump 4, E134, Primary Sludge Pumping Building 1	Primary Clarification	PUMP	PSPB1	5-10 years	$40,000.00	not running paint looks newer some specs of dried sludge on it, possible minor leaks?	1
PMP3505	PSPB2: Pump E245, Primary Sludge Pump 1	Primary Clarification	PUMP	PSPB2	5-10 years	$40,000.00	No flow of seal water detected. Suction & discharge gauges not operating.	2
PMP3506	PSPB2: Pump E246, Primary Sludge Pump 2	Primary Clarification	PUMP	PSPB2	5-10 years	$40,000.00	Not running	2
PMP3507	PSPB2: Pump E247, Primary Sludge Pump 3	Primary Clarification	PUMP	PSPB2	5-10 years	$40,000.00	Not running.	2
PMP3509	PSPB2: See Notes, Pump E239, Primary Sludge Pump 5, Primary Sludge Pumping Building 2	Primary Clarification	PUMP	PSPB2			No asset located with this tag	N/A
PMP3510	PG2 : Pump A201, Primary Sludge Pump 3, Primary Gallery 2	Primary Clarification	PUMP	PRIMARY GALLERY 2	<5 years	$40,000.00	not running rust, deterioration, & wear on casing 36691 hr run time	3
PMP3511	PG2 : Pump A202, Primary Sludge Pump 2 , Primary Gallery 2	Primary Clarification	PUMP	PRIMARY GALLERY 2	<5 years	$40,000.00	not running rust, deterioration, & wear on casing 43236 hr run time	3
PMP3512	PG2 : Pump A203, Primary Sludge Pump 1, Primary Gallery 2	Primary Clarification	PUMP	PRIMARY GALLERY 2	<5 years	$40,000.00	not running a lot of rust, deterioration, & wear on casing and pad 42273 hr run time	3

PMP3801	BB1 : Pump, Aurora Protected Water Pump 1, Blower	Aeration Process	PUMP	BLWR BLDG 1	5-10 years	$5,000.00	leaked before, during, & after pumping severe deterioration of casing, bolts, equip pad, & supports loud noise heard above blower noise giant pool of water 10834 hr runtime	5
PMP3802	BB1 : Pump, Drain Oil 1, Blower Building 1	Aeration Process	PUMP	BLWR BLDG 1			Retired	N/A
PMP3805	BB1 : Pump, Lube Oil Cooling Pump 5, Blower Building 1	Aeration Process	PUMP	BLWR BLDG 1	5-10 years	$7,000.00	not running	2
PMP3806	BB1 : Pump, Jacket Water and LOCW Makeup water pump, Blower Building 1	Aeration Process	PUMP	BLWR BLDG 1	5-10 years	$5,000.00	not running slight wear	2
PMP3807	BB1 : Pump, Lube oil cooling pump 4, Blower Building 1	Aeration Process	PUMP	BLWR BLDG 1	5-10 years	$7,000.00		2
PMP3808	BB1 : Pump, Jacket Water Pump 5, Blower Building 1	Aeration Process	PUMP	BLWR BLDG 1	5-10 years	$25,000.00	pump casing Very hot some minor surface deterioration jacket on influent pipe coming off jacket on effluent damaged	3
PMP3809	BB1 : Pump, Aurora Protected Water Pump 2, Blower	Aeration Process	PUMP	BLWR BLDG 1	<5 years	$5,000.00	leaking evident severe deterioration of casing, bolts, equip pad, & supports loud noise heard above blower noise giant pool of water 10650 hr runtime	5

PMP3810	BB1 : Pump, Heat Transfer Pump 2, Blower Building 1	Aeration Process	PUMP	BLWR BLDG 1			retired-remove from list	N/A
PMP3811	BB1 : Pump, Jacket Water Pump 4, Blower Building 1	Aeration Process	PUMP	BLWR BLDG 1	5-10 years	$25,000.00	Ver hot pump casing inluent pipe jacket coming off effluent pipe jacket damaged medium corrosion on pump and support	3
PMP3814	BB1 : Pump 2, G982, Heat Recovery Pump, Blower Building 1,	Aeration Process	PUMP	BLWR BLDG 1	<5 years	$10,000.00	significant corrosion not running	3
PMP3817	AT07: Pump, Loc: AT07, SN 9670035, Anaerobic Recycle	Aeration Process	PUMP	AT07	10-15 years	$50,000.00	NOT ASSESSED - Submersible Pump not accessible.	N/A
PMP3818	AT12: Pump, Loc: AT12, SN 9670032, Anaerobic Recycle, P-NT12-1	Aeration Process	PUMP	AT12	10-15 years	$50,000.00	NOT ASSESSED - Submersible Pump not accessible.	N/A
PMP3820	AT18: Pump, Loc: AT18, SN 9670034, Anaerobic Recycle, P-NT18-1	Aeration Process	PUMP	AT18	10-15 years	$50,000.00	NOT ASSESSED - Submersible Pump not accessible.	N/A
PMP3821	BB1 : Pump 1, Heat Recovery Pump, Blower Building 1	Aeration Process	PUMP	BLWR BLDG 1	5-10 years	$10,000.00	minor corrosion not running	2
PMP3822	BB1 : Pump, Lube oil filling pump, Blower Building 1	Aeration Process	PUMP	BLWR BLDG 1	5-10 years	$7,000.00	not running no tag can be removed from list	2
PMP3924	AT24: Pump, Loc: AT24, SN 9660032, Anaerobic Recycle	Aeration Process	PUMP	AT24	10-15 years	$50,000.00	NOT ASSESSED - Submersible Pump not accessible.	N/A
PMP3925	AT25: Pump, Loc: AT25, SN 9650031, Anaerobic Recycle	Aeration Process	PUMP	AT25	10-15 years	$50,000.00	NOT ASSESSED - Submersible Pump not accessible.	N/A

PMP3926	AT13: Pump, Loc: AT13, SN 9660033, Anaerobic Recycle, P-NT13-1	Aeration Process	PUMP	AT13	10-15 years	$50,000.00	NOT ASSESSED - Submersible Pump not accessible.	N/A
PMP3927	AT21: Pump, Loc: AT21, SN 9670033, Anaerobic Recycle	Aeration Process	PUMP	AT21	10-15 years	$50,000.00	NOT ASSESSED - Submersible Pump not accessible.	N/A
PMP3928	AT28: Pump, Loc: AT28, SN 9650032, Anaerobic Recycle	Aeration Process	PUMP	AT28	10-15 years	$50,000.00	NOT ASSESSED - Submersible Pump not accessible.	N/A
PMP3929	AG2 : Pump, Drainage Pump 1	Aeration Process	PUMP	AER GLRY 2	5-10 years	$20,000.00	minor surface deterioration	2
PMP3930	AG2 : Pump, Drainage Pump 2	Aeration Process	PUMP	AER GLRY 2	5-10 years	$20,000.00	minor deterioration	2
PMP3937	BB2 : Pump, Protected Water Pump 5-1, Blower	Aeration Process	PUMP	BLWR BLDG 2	5-10 years	$5,000.00	not running good amount if surface deterioration, mainly on support pad	2
PMP3938	BB2 : Pump, Protected Water Pump 5-2, Blower	Aeration Process	PUMP	BLWR BLDG 2	5-10 years	$5,000.00	not running good amount if surface deterioration, mainly on support pad	2
PMP4003	ACB3: Pump C355, WAS 1, ACB3	Aeration Control (WAS and RAS)	PUMP	ACB3	5-10 years	$25,000.00	not running. Rust near seal housing	3
PMP4004	ACB3: Pump C356, WAS 2, ACB3	Aeration Control (WAS and RAS)	PUMP	ACB3	5-10 years	$25,000.00	A lot of rust around top of volute and around seal casing.	3
PMP4005	ACB4: Pump B351, WAS 1, ACB4	Aeration Control (WAS and RAS)	PUMP	ACB4	5-10 years	$25,000.00		2
PMP4006	ACB4: Pump B352, WAS 2, ACB4	Aeration Control (WAS and RAS)	PUMP	ACB4	5-10 years	$25,000.00	not running	2
PMP4007	ACB4: Pump B353, WAS 3, ACB4	Aeration Control (WAS and RAS)	PUMP	ACB4	5-10 years	$25,000.00	not running. Gasket material displaced. See photo.	2

PMP4008	ACB2: Pump, C251, RAS 1	Aeration Control (WAS and RAS)	PUMP	ACB2	10-15 years	$80,000.00		2
PMP4009	ACB2: Pump C252, RAS 2, ACB2	Aeration Control (WAS and RAS)	PUMP	ACB2	10-15 years	$100,000.00	not running	2
PMP4010	ACB2: Pump C253, RAS 3, ACB2	Aeration Control (WAS and RAS)	PUMP	ACB2	10-15 years	$100,000.00	not running. Volute, shaft, and coupling guard rusted	3
PMP4012	ACB3: Pump C351, RAS 1, ACB3	Aeration Control (WAS and RAS)	PUMP	ACB3	10-15 years	$100,000.00		2
PMP4013	ACB3: Pump C352, RAS 2, ACB3	Aeration Control (WAS and RAS)	PUMP	ACB3	10-15 years	$100,000.00	not running significant rust on exterior looks to have leaked ras previously seal water pooled at motor shaft connection	3
PMP4014	ACB3: Pump, RAS 3	Aeration Control (WAS and RAS)	PUMP	ACB3	10-15 years	$100,000.00	not running rusty base rust on pump has been painted over	2
PMP4016	ACB4: Pump B371, RAS 1, ACB4	Aeration Control (WAS and RAS)	PUMP	ACB4	10-15 years	$150,000.00		3
PMP4017	ACB4: Pump B372, RAS 2, ACB4	Aeration Control (WAS and RAS)	PUMP	ACB4	10-15 years	$150,000.00	not running	2
PMP4018	ACB4: Pump B373, RAS 3, ACB4	Aeration Control (WAS and RAS)	PUMP	ACB4	10-15 years	$150,000.00	slight rattle medium corrosion on motor side 53934 hr runtime	3
PMP4019	ACB4: Pump B374, RAS 4, ACB4	Aeration Control (WAS and RAS)	PUMP	ACB4	10-15 years	$150,000.00	not running corrosion by motor 47275 hr run time	2

PMP4022	ACB1: Pump, C152, WAS Pump 2	Aeration Control (WAS and RAS)	PUMP	ACB1	5-10 years	$25,000.00	not running base has significant amounts of pitted rust inside near motor has some rust looks out of service, newer one next to it not in CA pump next to it is pmp4039, good condiion	3
PMP4027	ACB2: Pump, C254, WAS 3	Aeration Control (WAS and RAS)	PUMP	ACB2	5-10 years	$25,000.00		2
PMP4036	ACB3 : FC Dewatering Pump 1	Aeration Control (WAS and RAS)	PUMP	ACB3	10-15 years	$80,000.00	not running no exterior rust/corrosion no rust/corrosion near motor shaft no exterior rust/corrosion on support str	1
PMP4301	EFFB: Pump, U.V. Cleaning System Pump	UV Disinfection	PUMP	EFF BLDG	5-10 years	$20,000.00	not running	2
PMP4302	EFFB: Pump, U.V. Channel Dewatering	UV Disinfection	PUMP	EFF BLDG	10-15 years	$20,000.00	not running	1
PMP4401	EFFB: Pump D201, Effluent Pump 1, Effluent Building	Effluent Pumping	PUMP	EFF BLDG	10-15 years	$240,000.00	not running 26766 hr run time	2
PMP4402	EFFB: Pump D202, Effluent Pump 2, Effluent Building	Effluent Pumping	PUMP	EFF BLDG	10-15 years	$240,000.00	not running 20160 hr run time	2
PMP4403	EFFB: Pump D203, Effluent Pump 3, Effluent Building	Effluent Pumping	PUMP	EFF BLDG	10-15 years	$240,000.00	No pressure or flow detected omn seal water system.	2
PMP4404	EFFB: Pump D204, Effluent Pump 4, Effluent Building	Effluent Pumping	PUMP	EFF BLDG	10-15 years	$240,000.00	Not running.	3

PMP4405	EFFB: Pump D205, Effluent Pump 5, Effluent Building	Effluent Pumping	PUMP	EFF BLDG	10-15 years	$240,000.00	some surface rusting minor rattling from pump on side of seal water gauges 16276 hr run time	2
PMP4406	SH1 : Pump, Effluent Storage Tank Drain Pump 1, Shop 1	Effluent Pumping	PUMP	SHOP 1	5-10 years	$15,000.00	not running a lot of flaking rust	3
PMP4407	SH1 : Pump, Effluent Storage Tank Drain Pump 2, Shop 1	Effluent Pumping	PUMP	SHOP 1	5-10 years	$15,000.00	not running a lot of flaking rust	3
PMP4408	EFFB: Pump, Effluent Sampler, Effluent Building	Effluent Pumping	PUMP,SAMPL	EFF BLDG	5-10 years	$3,000.00	not running some equip pad deterioration	2
PMP4409	EFFB: Pump, Effluent Sampler For Plants 1 & 2, Effluent Building	Effluent Pumping	PUMP,SAMPL	EFF BLDG	5-10 years	$3,000.00		1
PMP4410	EFFB: Pump, Effluent Sampler For Plant 3, Effluent Building	Effluent Pumping	PUMP,SAMPL	EFF BLDG	5-10 years	$3,000.00		1
PMP4411	EFFB: Pump, Effluent Sampler For Plant 4, Effluent Building	Effluent Pumping	PUMP,SAMPL	EFF BLDG	5-10 years	$3,000.00	pump casing amnd effluent pipe significantly rusted some equip pad deterioration	2
PMP4416	EFFB: Pump, Hydraulic Oil Pump 1, Effluent Building	Effluent Pumping	PUMP	EFF BLDG	5-10 years	$3,000.00	not rotary lobe, this is a vane pump not running	2
PMP4417	EFFB: Pump, Hydraulic Oil Pump 2, Effluent Building	Effluent Pumping	PUMP	EFF BLDG	5-10 years	$3,000.00	vane pump not running	2
PMP4419	EFFB: Pump 1, Badger Mill Creek Effluent Pump 1, Effluent Building	Effluent Pumping	PUMP	EFF BLDG	10-15 years	$100,000.00		3

PMP4420	EFFB: Pump 2, Badger Mill Creek Effluent Pump 2, Effluent Building	Effluent Pumping	PUMP	EFF BLDG	10-15 years	$100,000.00	not running minor surface deterioration	2
PPU5101	LAGOON PUMP STA: Lagoon Submersible Chopper Pumping Unit L101,Vaughan MN SE4P4, SN84256, 50hp, 1770 rpm,460v, 3ph, 1.15 sf Explosion proof	Effluent Pumping	PUMP	LAGOON PUMP STA	10-15 years	$50,000.00	NOT ASSESSED - Piping System	N/A
VLV2903	HEAD: Valve, on 12 inch line, effluent to the Headworks Building as W4 water, underground.	W4 Water	PIPING	HEADWORKS		$10,000.00	manual, underground valve should be removed from list	N/A

APPENDIX A.2
ASSETS BY BUILDING/STRUCTURE

Appendix A.2 - Assets by Building

Building

Process Description

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
TRN2911	Electrical	Uncategorized	Uncategorized	Head: Level Transmitter, A797, SPU Conditioning Tank (Maci Pit)		15+ years	$10,000.00
XMT4001	Electrical	Metering	Metering	ACB2: Power Quality Meter MCC-ACB-2		15+ years	$5,000.00

Building ACB1

Process Description Aeration Control (WAS and RAS)

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
MCC4000	Electrical	Motor Control Centers	Motor Control Centers	ACB1: MCC, Square D Motor Control Center, MCC-ACB-1 Located in Aeration Control Building #1	MCC	15+ years	$125,000.00
MTR4001	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	ACB1: Motor, C152, WAS Pump 2	MOTOR	5-10 years	$5,000.00
PMP4022	Process Mechanical	Uncategorized	Uncategorized	ACB1: Pump, C152, WAS Pump 2	PUMP	5-10 years	$25,000.00
SAM0005	Process Mechanical	Auto Samplers	Auto Samplers	ACB1: Sampler, Waste Activated Sludge, Aeration Control Bldg 1	SAMPLER	5-10 years	$7,500.00

TRN0101	Electrical	Metering	Metering	ACB1: Meter & Transmitter, Power Monitor	METER,POW	10-15 years	$5,000.00

Building ACB2

Process Description Aeration Control (WAS and RAS)

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
CPN4002	Electrical	Control Panels	Control Panels	ACB2: Control Panel,East Secondary Meter Panel No.2Panel located in Aeration Control Building #2	PANEL,CON	<5 years	$50,000.00
LPN4002	Electrical	Lighting Equip & Sys	Lighting Equip & Sys	ACB2: Lighting Panel, L82Square D Panelboard, 120/208V, Three PhaseLocated in Aeration Control Building #2	PANEL,LGHT	5-10 years	$7,500.00
LPN4003	Electrical	Lighting Equip & Sys	Lighting Equip & Sys	ACB2: Lighting Panel, L85Westinghouse Panelboard, 120/208V, Three PhaseLocated in Aeration Control Building #2	PANEL,LGHT	5-10 years	$7,500.00
PMP4008	Process Mechanical	Uncategorized	Uncategorized	ACB2: Pump, C251, RAS 1	PUMP	10-15 years	$80,000.00
PMP4009	Process Mechanical	Uncategorized	Uncategorized	ACB2: Pump C252, RAS 2, ACB2	PUMP	10-15 years	$100,000.00
PMP4010	Process Mechanical	Uncategorized	Uncategorized	ACB2: Pump C253, RAS 3, ACB2	PUMP	10-15 years	$100,000.00

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
PMP4027	Process Mechanical	Uncategorized	Uncategorized	ACB2: Pump, C254, WAS 3	PUMP	5-10 years	$25,000.00
SAM0006	Process Mechanical	Auto Samplers	Auto Samplers	ACB2: Sampler, Plant 1 Return Activated SludgeLocated in Aeration Control Building #2	SAMPLER	5-10 years	$7,500.00

Process Description Aeration Process

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
VFD3811	Electrical	Uncategorized	Uncategorized	ACB2: VFD, Aeration Tank 12, Anaerobic Recycle Pump, P-NT12-1	VFD	10-15 years	$30,000.00
VFD3813	Electrical	Uncategorized	Uncategorized	ACB2: VFD, Aeration Tank 18, Anaerobic Recycle Pump, P-NT18-1	VFD	10-15 years	$30,000.00

Building ACB3

Process Description Aeration Control (WAS and RAS)

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
CPN4003	Electrical	Control Panels	Control Panels	ACB3: Control Panel, ACB3	PANEL,CON	<5 years	$50,000.00
CPN4006	Electrical	Control Panels	Control Panels	ACB3: Control Panel, Compressor 2A, 2B RAS Level Bubbler System	PANEL,CON	5-10 years	$25,000.00
PMP4003	Process Mechanical	Uncategorized	Uncategorized	ACB3: Pump C355, WAS 1, ACB3	PUMP	5-10 years	$25,000.00
PMP4004	Process Mechanical	Uncategorized	Uncategorized	ACB3: Pump C356, WAS 2, ACB3	PUMP	5-10 years	$25,000.00

PMP4012	Process Mechanical	Uncategorized	Uncategorized	ACB3: Pump C351, RAS 1, ACB3	PUMP	10-15 years	$100,000.00
PMP4013	Process Mechanical	Uncategorized	Uncategorized	ACB3: Pump C352, RAS 2, ACB3	PUMP	10-15 years	$100,000.00
PMP4014	Process Mechanical	Uncategorized	Uncategorized	ACB3: Pump, RAS 3	PUMP	10-15 years	$100,000.00
PMP4036	Process Mechanical	Uncategorized	Uncategorized	ACB3 : FC Dewatering Pump 1	PUMP	10-15 years	$80,000.00
SAM0007	Process Mechanical	Auto Samplers	Auto Samplers	ACB3: Sampler, Plant 2 RAS, ACB3	SAMPLER	5-10 years	$7,500.00
SAM0008	Process Mechanical	Auto Samplers	Auto Samplers	ACB3: Sampler, Plant 2 WAS, ACB3	SAMPLER	5-10 years	$7,500.00

Process Description Secondary Clarification

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
EJC4101	Process Mechanical	Uncategorized	Uncategorized	ACB3: Pneumatic Ejector, scum, ACB3	EJECTOR	10-15 years	$40,000.00

Building ACB4

Process Description Aeration Control (WAS and RAS)

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
CPN4004	Electrical	Control Panels	Control Panels	ACB4: Control Panel, ACB4	PANEL,CON	<5 years	$75,000.00
FRM4401	Electrical	Transformers	Transformers	ACB4: Transformer, T41, feeds Zenith CPN	TRANSFORM	5-10 years	$15,000.00
MCC4003	Electrical	Motor Control Centers	Motor Control Centers	ACB4: MCC-P41, Westinghouse Motor Control Center P41Located at Aeration Control Building #4	MCC	10-15 years	$150,000.00

MCC4004	Electrical	Motor Control Centers	Motor Control Centers	ACB4: MCC-P42, Westinghouse Motor Control Center P42Located at Aeration Control Building #4	MCC	10-15 years	$150,000.00
MTR4019	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	ACB4: Motor B371, RAS Pump 1, ACB4 - (two speed motor)	MOTOR	10-15 years	$10,000.00
MTR4020	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	ACB4: Motor B372, RAS Pump 2, ACB4 - (two speed motor)	MOTOR	10-15 years	$10,000.00
MTR4021	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	ACB4: Motor B373, RAS Pump 3, ACB4 - (two speed motor)	MOTOR	10-15 years	$10,000.00
MTR4022	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	ACB4: Motor B374, RAS Pump 4, ACB4 - (two speed motor)	MOTOR	10-15 years	$10,000.00
PMP4005	Process Mechanical	Uncategorized	Uncategorized	ACB4: Pump B351, WAS 1, ACB4	PUMP	5-10 years	$25,000.00
PMP4006	Process Mechanical	Uncategorized	Uncategorized	ACB4: Pump B352, WAS 2, ACB4	PUMP	5-10 years	$25,000.00
PMP4007	Process Mechanical	Uncategorized	Uncategorized	ACB4: Pump B353, WAS 3, ACB4	PUMP	5-10 years	$25,000.00
PMP4016	Process Mechanical	Uncategorized	Uncategorized	ACB4: Pump B371, RAS 1, ACB4	PUMP	10-15 years	$150,000.00
PMP4017	Process Mechanical	Uncategorized	Uncategorized	ACB4: Pump B372, RAS 2, ACB4	PUMP	10-15 years	$150,000.00
PMP4018	Process Mechanical	Uncategorized	Uncategorized	ACB4: Pump B373, RAS 3, ACB4	PUMP	10-15 years	$150,000.00

PMP4019	Process Mechanical	Uncategorized	Uncategorized	ACB4: Pump B374, RAS 4, ACB4	PUMP	10-15 years	$150,000.00
SAM0001	Buildings and Grounds	Auto Samplers	Auto Samplers	ACB4: Sampler A, Plant 3 RAS, ACB4	SAMPLER	5-10 years	$7,500.00
SAM0002	Process Mechanical	Auto Samplers	Auto Samplers	ACB4: Sampler B, Plant 4 RAS, ACB4	SAMPLER	5-10 years	$7,500.00
SAM0003	Process Mechanical	Auto Samplers	Auto Samplers	ACB4: Sampler C, Plant 3 WAS, ACB4	SAMPLER	5-10 years	$7,500.00
SAM0004	Process Mechanical	Auto Samplers	Auto Samplers	ACB4: Sampler D, Plant 4 WAS, ACB4	SAMPLER	5-10 years	$7,500.00
TRN0014	Electrical	Uncategorized	Uncategorized	ACB4: Meter & Transmitter, B196, Power, MCC P41, ACB4	METER,POW	<5 years	$5,000.00
TRN0015	Electrical	Uncategorized	Uncategorized	ACB4: Meter & Transmitter B197, Power, MCC P42, ACB4	METER,POW	<5 years	$5,000.00

Process Description Aeration Process

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
CPN4005	Electrical	Control Panels	Control Panels	ACB4 : Control Panel, Zenith Auto Transfer Switch, Aeration Control Building 4	PANEL,CON	<5 years	$10,000.00

Process Description Secondary Clarification

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
EJC4102	Process Mechanical	Diaphragm pump	Diaphragm pump	ACB4: Pneumatic Ejector 1, scum, ACB4	EJECTOR	10-15 years	$40,000.00
EJC4103	Process Mechanical	Uncategorized	Uncategorized	ACB4: Pneumatic Ejector 2,(scum) ACB4	EJECTOR	10-15 years	$40,000.00

Building AER GLRY 1

Process Description Aeration Control (WAS and RAS)

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
TRN0007	Electrical	Uncategorized	Uncategorized	AG1 : Meter & Transmitter C363, Flow, RAS From ACB3, Aeration Gallery 1	METER,FLOW	<5 years	$20,000.00
TRN0018	Electrical	Uncategorized	Uncategorized	AG1 : Meter & Transmitter C231, Flow, WAS Plant 1, Aeration Gallery 1	METER,FLOW	<5 years	$6,000.00

Process Description Primary Clarification

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
ACU3501	Process Mechanical	Uncategorized	Uncategorized	AG1 : Air Compressor Unit, Bowling Alley, Aeration Gallery 1,	COMPR,AIR	5-10 years	$7,500.00
EJC3502	Process Mechanical	Uncategorized	Uncategorized	AG1 : Pneumatic Ejector 1,scum, Bowling Alley, Aeration Gallery 1,	EJECTOR	10-15 years	$40,000.00

Building AER GLRY 2

Process Description Aeration Process

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
LPN3903	Electrical	Lighting Equip & Sys	Lighting Equip & Sys	AG2 : Lighting Panel , LP-44, Aeration Gallery 2	PANEL,LGHT	10-15 years	$7,500.00

LPN3904	Electrical	Lighting Equip & Sys	Lighting Equip & Sys	AG2 : Lighting Panel , LP-45, Aeration Gallery 2	PANEL,LGHT	5-10 years	$7,500.00
MTR3941	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	AG2 : Motor, Drainage Pump 1	MOTOR	5-10 years	$2,500.00
MTR3942	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	AG2 : Motor, Drainage Pump 2	MOTOR	5-10 years	$2,500.00
PMP3929	Process Mechanical	Uncategorized	Uncategorized	AG2 : Pump, Drainage Pump 1	PUMP	5-10 years	$20,000.00
PMP3930	Process Mechanical	Uncategorized	Uncategorized	AG2 : Pump, Drainage Pump 2	PUMP	5-10 years	$20,000.00
SAM0021	Process Mechanical	Auto Samplers	Auto Samplers	AG2: Sampler, West Primary Effluent for West Plant, 2001, Blower Building 2	SAMPLER	10-15 years	$7,500.00

Process Description Primary Clarification

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
EJC3504	Process Mechanical	Uncategorized	Uncategorized	AG2 : Pneumatic Ejector 1, scum, Aeration Gallery 2	EJECTOR	10-15 years	$40,000.00
EJC3505	Process Mechanical	Uncategorized	Uncategorized	AG2 : Pneumatic Ejector 2, scum, Aeration Gallery 2	EJECTOR	10-15 years	$40,000.00

Building AT01

Process Description Aeration Process

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
TNK3801	Buildings and Grounds	Tanks	Tanks	AT01: Aeration Tank 1	TANK, AER	15+ years	$200,000.00

Building AT02

Process Description Aeration Process

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
TNK3802	Buildings and Grounds	Tanks	Tanks	AT02: Aeration Tank 2	TANK, AER	15+ years	$200,000.00

Building AT03

Process Description Aeration Process

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
TNK3803	Buildings and Grounds	Tanks	Tanks	AT03: Aeration Tank 3	TANK, AER	15+ years	$200,000.00

Building AT04

Process Description Aeration Process

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
TNK3804	Buildings and Grounds	Tanks	Tanks	AT04: Aeration Tank 4	TANK, AER	15+ years	$200,000.00

Building AT05

Process Description Aeration Process

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
TNK3805	Buildings and Grounds	Tanks	Tanks	AT05: Aeration Tank 5	TANK, AER	15+ years	$200,000.00

Building AT06

Process Description Aeration Process

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
TNK3806	Buildings and Grounds	Tanks	Tanks	AT06: Aeration Tank 6	TANK, AER	15+ years	$200,000.00

Building AT07

Process Description Aeration Process

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
MTR3807	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	AT07: Motor, Anaerobic Recycle Pump P-AT7	MOTOR		
PMP3817	Process Mechanical	Uncategorized	Uncategorized	AT07: Pump, Loc: AT07, SN 9670035, Anaerobic Recycle	PUMP	10-15 years	$50,000.00
SGT3807	Process Mechanical	All gate types	All gate types	AT07: Sluice Gate, In Primary Effluent Channel to AT07	GATE,SLUI	15+ years	$10,000.00
TNK3807	Buildings and Grounds	Tanks	Tanks	AT07: Aeration Tank 7	TANK, AER	15+ years	$200,000.00

Building AT08

Process Description Aeration Process

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
TNK3808	Buildings and Grounds	Tanks	Tanks	AT08: Aeration Tank 8	TANK, AER	15+ years	$200,000.00

Building AT09

Process Description: Aeration Process

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
TNK3809	Buildings and Grounds	Tanks	Tanks	AT09: Aeration Tank 9	TANK, AER	15+ years	$200,000.00

Building: AT10

Process Description: Aeration Process

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
TNK3810	Buildings and Grounds	Tanks	Tanks	AT10: Aeration Tank 10	TANK, AER	15+ years	$200,000.00

Building: AT11

Process Description: Aeration Process

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
TNK3811	Buildings and Grounds	Tanks	Tanks	AT11: Aeration Tank 11	TANK, AER	15+ years	$200,000.00

Building: AT12

Process Description: Aeration Process

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
PMP3818	Process Mechanical	Uncategorized	Uncategorized	AT12: Pump, Loc: AT12, SN 9670032, Anaerobic Recycle, P-NT12-1	PUMP	10-15 years	$50,000.00
TNK3812	Buildings and Grounds	Tanks	Tanks	AT12: Aeration Tank 12	TANK, AER	15+ years	$200,000.00

Building AT13

Process Description: Aeration Process

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
PMP3926	Process Mechanical	Uncategorized	Uncategorized	AT13: Pump, Loc: AT13, SN 9660033, Anaerobic Recycle, P-NT13-1	PUMP	10-15 years	$50,000.00
TNK3813	Buildings and Grounds	Tanks	Tanks	AT13: Aeration Tank 13	TANK, AER	15+ years	$200,000.00

Building AT14

Process Description: Aeration Process

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
TNK3814	Buildings and Grounds	Tanks	Tanks	AT14: Aeration Tank 14	TANK, AER	15+ years	$200,000.00

Building AT15

Process Description: Aeration Process

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
TNK3815	Buildings and Grounds	Tanks	Tanks	AT15: Aeration Tank 15	TANK, AER	15+ years	$200,000.00

Building AT16

Process Description: Aeration Process

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
TNK3816	Buildings and Grounds	Tanks	Tanks	AT16: Aeration Tank 16	TANK, AER	15+ years	$200,000.00

Building AT17

Process Description Aeration Process

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
TNK3817	Buildings and Grounds	Tanks	Tanks	AT17: Aeration Tank 17	TANK, AER	15+ years	$200,000.00

Building AT18

Process Description Aeration Process

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
PMP3820	Process Mechanical	Uncategorized	Uncategorized	AT18: Pump, Loc: AT18, SN 9670034, Anaerobic Recycle, P-NT18-1	PUMP	10-15 years	$50,000.00
TNK3818	Buildings and Grounds	Tanks	Tanks	AT18: Aeration Tank 18	TANK, AER	15+ years	$200,000.00

Building AT19

Process Description Aeration Process

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
TNK3919	Buildings and Grounds	Tanks	Tanks	AT19: Aeration Tank 19	TANK, AER	15+ years	$200,000.00

Building AT20

Process Description: Aeration Process

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
TNK3920	Buildings and Grounds	Tanks	Tanks	AT20: Aeration Tank 20	TANK, AER	15+ years	$200,000.00

Building: AT21

Process Description: Aeration Process

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
MTR3921	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	AT21: Motor, Anaerobic Recycle Pump P-AT21	MOTOR		
PMP3927	Process Mechanical	Uncategorized	Uncategorized	AT21: Pump, Loc: AT21, SN 9670033, Anaerobic Recycle	PUMP	10-15 years	$50,000.00
TNK3921	Buildings and Grounds	Tanks	Tanks	AT21: Aeration Tank 21	TANK, AER	15+ years	$200,000.00

Building: AT22

Process Description: Aeration Process

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
TNK3922	Buildings and Grounds	Tanks	Tanks	AT22: Aeration Tank 22	TANK, AER	15+ years	$200,000.00

Building: AT23

Process Description: Aeration Process

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost

TNK3923	Buildings and Grounds	Tanks	Tanks	AT23: Aeration Tank 23	TANK, AER	15+ years	$200,000.00

Building AT24

Process Description Aeration Process

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
MTR3924	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	AT24: Motor, Anaerobic Recycle P-AT24	MOTOR		
PMP3924	Process Mechanical	Uncategorized	Uncategorized	AT24: Pump, Loc: AT24, SN 9660032, Anaerobic Recycle	PUMP	10-15 years	$50,000.00
TNK3924	Buildings and Grounds	Tanks	Tanks	AT24: Aeration Tank 24	TANK, AER	15+ years	$200,000.00

Building AT25

Process Description Aeration Process

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
MTR3925	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	AT25: Motor, Anaerobic Recycle P-AT25	MOTOR		
PMP3925	Process Mechanical	Uncategorized	Uncategorized	AT25: Pump, Loc: AT25, SN 9650031, Anaerobic Recycle	PUMP	10-15 years	$50,000.00
TNK3925	Buildings and Grounds	Tanks	Tanks	AT25: Aeration Tank 25	TANK, AER	15+ years	$200,000.00

Building AT26

Process Description Aeration Process

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
TNK3926	Buildings and Grounds	Tanks	Tanks	AT26: Aeration Tank 26	TANK, AER	15+ years	$200,000.00

Building AT27

Process Description Aeration Process

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
TNK3927	Buildings and Grounds	Tanks	Tanks	AT27: Aeration Tank 27	TANK, AER	15+ years	$200,000.00

Building AT28

Process Description Aeration Process

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
MTR3928	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	AT28: Motor, Anaerobic Recycle P-AT28	MOTOR		
PMP3928	Process Mechanical	Uncategorized	Uncategorized	AT28: Pump, Loc: AT28, SN 9650032, Anaerobic Recycle	PUMP	10-15 years	$50,000.00
TNK3928	Buildings and Grounds	Tanks	Tanks	AT28: Aeration Tank 28	TANK, AER	15+ years	$200,000.00

Building AT29

Process Description Aeration Process

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost

TNK3929	Buildings and Grounds	Tanks	Tanks	AT29: Aeration Tank 29	TANK, AER	15+ years	$200,000.00

Building AT30

Process Description Aeration Process

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
TNK3930	Buildings and Grounds	Tanks	Tanks	AT30: Aeration Tank 30	TANK, AER	15+ years	$200,000.00

Building BLWR BLDG 1

Process Description Aeration Process

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
ACU3800	Process Mechanical	Uncategorized	Uncategorized	BB1 : Air Compressor Unit 1, Blower Building 1	COMPR,AIR	10-15 years	$7,500.00
ACU3802	Process Mechanical	Uncategorized	Uncategorized	BB1 : Air Compressor Unit 2, Oil Turbo T-68, Blower Building 1	COMPR,AIR	10-15 years	$7,500.00
AFE3801	Process Mechanical	Filters	Filters	BB1 : Primary Roll and Secondary Air Filters 1, Blower Building 1	EQP,MISC	5-10 years	$5,000.00
AFE3802	Process Mechanical	Filters	Filters	BB1 : Primary Roll and Secondary Air Filters 2, Blower Building 1	EQP,MISC	5-10 years	$5,000.00
AFE3803	Process Mechanical	Filters	Filters	BB1 : Primary Roll and Secondary Air Filters 3, Blower Building 1	EQP,MISC	5-10 years	$5,000.00

AFE3804	Process Mechanical	Filters	Filters	BB1 : Primary Roll and Secondary Air Filters 4, Blower Building 1	EQP,MISC	5-10 years	$5,000.00
AFE3805	Process Mechanical	Filters	Filters	BB1 : Primary Roll and Secondary Air Filters 5, Blower Building 1	EQP,MISC	5-10 years	$5,000.00
BLO3801	Process Mechanical	Uncategorized	Uncategorized	BB1 : Blower 1, C431, Blower Building 1	BLOWER	>15 years	$630,000.00
BLO3802	Process Mechanical	Uncategorized	Uncategorized	BB1 : Blower 2 C432, Blower Building 1	BLOWER	>15 years	$630,000.00
BLO3803	Process Mechanical	Uncategorized	Uncategorized	BB1 : Blower 3 C433, Blower Building 1	BLOWER	>15 years	$630,000.00
BLO3804	Process Mechanical	Uncategorized	Uncategorized	BB1 : Blower 4, Blower Building 1	BLOWER	>15 years	$630,000.00
BLO3805	Process Mechanical	Uncategorized	Uncategorized	BB1 : Blower 5, Blower Building 1	BLOWER	>15 years	$630,000.00
CPN3801	Electrical	Control Panels	Control Panels	BB1 : Engine Blower Control PanelLocated in Blower Building No. 1	PANEL,CON	<5 years	$20,000.00
CPN3802	Electrical	Control Panels	Control Panels	BB1 : Control Panel. Blowers 2, 3, 4, 5	PANEL,CON	5-10 years	$75,000.00
MEQ3800	Process Mechanical	Uncategorized	Uncategorized	BB1 : Engine Cooling Sys., Blower Building 1	EQP,MISC		
MEQ3801	Process Mechanical	Uncategorized	Uncategorized	BB1 : Air Cooled Heat Exchanger Fan, Blower Building 1	EQP,MISC		
MEQ3802	Process Mechanical	Uncategorized	Uncategorized	BB1 : Jacket Water Air Separator 3, Blower Building 1	EQP,MISC	>15 years	$10,000.00

MEQ3803	Process Mechanical	Uncategorized	Uncategorized	BB1 : Jacket Water Heat Exchanger 3, Blower Building 1	EQP,MISC	10-15 years	$30,000.00
MEQ3804	Process Mechanical	Uncategorized	Uncategorized	BB1 : Jacket Water Expanion Tank 5, Blower Building 1	EQP,MISC	10-15 years	$3,000.00
MEQ3805	Process Mechanical	Uncategorized	Uncategorized	BB1 : Jacket Water Expanion Tank 2, Blower Building 1	EQP,MISC	10-15 years	$3,000.00
MEQ3806	Process Mechanical	Uncategorized	Uncategorized	BB1 : Jacket Water Radiator Fan, Blower Building 1	EQP,MISC		
MEQ3807	Process Mechanical	Uncategorized	Uncategorized	BB1 : Jacket Water Radiator 1, Blower Building 1	EQP,MISC	10-15 years	$50,000.00
MEQ3809	Process Mechanical	Uncategorized	Uncategorized	BB1 : Lube Oil Cooling Air Separator, Blower Building 1	EQP,MISC	10-15 years	$2,500.00
MEQ3810	Process Mechanical	Uncategorized	Uncategorized	BB1 : Lube Oil Cooling Expanion Tank 3, Blower Building 1	EQP,MISC	10-15 years	$2,500.00
MEQ3812	Process Mechanical	Uncategorized	Uncategorized	BB1 : Lube Oil Cooler 1, Blower Building 1	EQP,MISC	10-15 years	$50,000.00
MEQ3814	Process Mechanical	Uncategorized	Uncategorized	BB1 : Lube Oil Coolant Radiator Fan, Blower Building 1	EQP,MISC	<5 years	$10,000.00
MEQ3815	Process Mechanical	Uncategorized	Uncategorized	BB1 : Exhaust Heat Exchanger, Model ECXWV-2870-1.5 SPCL Bare fire tube exhaust waste heat recovery silencer, New 2008, Blower Building 1	EQP,MISC	10-15 years	$75,000.00

MTR3801	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	BB1 : Motor, Aurora Protected Water Pump 1, Blower Building 1	MOTOR	5-10 years	$3,000.00
MTR3802	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	BB1 : Motor, Aurora Protected Water Pump 2, Blower Building 1	MOTOR	5-10 years	$3,000.00
MTR3821	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	BB1 : Motor, Heat Recovery Pump 1, Blower Building 1	MOTOR	5-10 years	$3,000.00
MTR3822	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	BB1 : Motor, G982, Heat Recovery Pump 2, Blower Building 1	MOTOR	5-10 years	$3,000.00
MTR3823	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	BB1 : Motor, Lube Oil Cooling Pump 4, Blower Building 1	MOTOR	10-15 years	$2,000.00
MTR3825	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	BB1 : Motor, Jacket Water & LOCW makeup water pump, Blower Building 1	MOTOR	5-10 years	$1,000.00
MTR3826	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	BB1 : Motor, Blower 2 C432, Blower Building 1	MOTOR	10-15 years	$150,000.00
MTR3828	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	BB1 : Motor, Blower 3 C433, Blower Building 1	MOTOR	10-15 years	$150,000.00
MTR3832	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	BB1 : Motor, Blower 5, Blower Building 1(Two speed motor)	MOTOR	10-15 years	$150,000.00
MTR3850	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	BB1 : Motor, Primary Roll and Secondary Air Filter 1, Blower Building 1	MOTOR	5-10 years	$1,000.00

MTR3851	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	BB1 : Motor, Primary Roll and Secondary Air Filter 2, Blower Building 1	MOTOR	5-10 years	$1,000.00
MTR3852	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	BB1 : Motor, Primary Roll and Secondary Air Filter 3, Blower Building 1	MOTOR	5-10 years	$1,000.00
MTR3855	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	BB1 : Motor, Jacket Water Pump 4, Blower Building 1	MOTOR	5-10 years	$4,000.00
MTR3856	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	BB1 : Motor, Lube Oil Coolant Radiator,(new 2003)Blower Building 1	MOTOR	10-15 years	$2,000.00
MTR3857	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	BB1 : Motor, Jacket Water Pump 5, Blower Building 1	MOTOR	10-15 years	$4,000.00
MTR3858	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	BB1 : Motor, Lube Oil Cooling Pump 5, Blower Building 1	MOTOR	10-15 years	$1,000.00
MTR3859	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	BB1 : Motor, Jacket Water Radiator Fan, Blower Building 1	EQP,MISC	5-10 years	$1,000.00
MTR3860	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	BB1 : Motor, Primary Roll and Secondary Air Filter 4, Blower Building 1	MOTOR	5-10 years	$1,000.00
MTR3861	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	BB1 : Motor, Primary Roll and Secondary Air Filter 5, Blower Building 1	MOTOR	5-10 years	$1,000.00

PMP3801	Process Mechanical	Uncategorized	Uncategorized	BB1 : Pump, Aurora Protected Water Pump 1, Blower Building 1	PUMP	5-10 years	$5,000.00
PMP3802	Process Mechanical	Uncategorized	Uncategorized	BB1 : Pump, Drain Oil 1, Blower Building 1	PUMP		
PMP3805	Process Mechanical	Uncategorized	Uncategorized	BB1 : Pump, Lube Oil Cooling Pump 5, Blower Building 1	PUMP	5-10 years	$7,000.00
PMP3806	Process Mechanical	Uncategorized	Uncategorized	BB1 : Pump, Jacket Water and LOCW Makeup water pump, Blower Building 1	PUMP	5-10 years	$5,000.00
PMP3807	Process Mechanical	Uncategorized	Uncategorized	BB1 : Pump, Lube oil cooling pump 4, Blower Building 1	PUMP	5-10 years	$7,000.00
PMP3808	Process Mechanical	Uncategorized	Uncategorized	BB1 : Pump, Jacket Water Pump 5, Blower Building 1	PUMP	5-10 years	$25,000.00
PMP3809	Process Mechanical	Uncategorized	Uncategorized	BB1 : Pump, Aurora Protected Water Pump 2, Blower Building 1	PUMP	<5 years	$5,000.00
PMP3810	Process Mechanical	Uncategorized	Uncategorized	BB1 : Pump, Heat Transfer Pump 2, Blower Building 1	PUMP		
PMP3811	Process Mechanical	Uncategorized	Uncategorized	BB1 : Pump, Jacket Water Pump 4, Blower Building 1	PUMP	5-10 years	$25,000.00
PMP3814	Process Mechanical	Uncategorized	Uncategorized	BB1 : Pump 2, G982, Heat Recovery Pump, Blower Building 1,	PUMP	<5 years	$10,000.00
PMP3821	Process Mechanical	Uncategorized	Uncategorized	BB1 : Pump 1, Heat Recovery Pump, Blower Building 1	PUMP	5-10 years	$10,000.00

PMP3822	Process Mechanical	Uncategorized	Uncategorized	BB1 : Pump, Lube oil filling pump, Blower Building 1	PUMP	5-10 years	$7,000.00
TRN0072	Electrical	Uncategorized	Uncategorized	BB1 : Meter & Transmitter, RPM, Blower 1, Blower Building 1	METER,RPM	<5 years	$1,000.00
TRN0073	Electrical	Uncategorized	Uncategorized	BB1 : Meter & Transmitter, Power, Blower 2, Blower Building 1	METER,POW	<5 years	$5,000.00
TRN0074	Electrical	Uncategorized	Uncategorized	BB1 : Meter & Transmitter, Power, Blower 3, Blower Building 1	METER,POW	<5 years	$5,000.00
TRN0075	Electrical	Uncategorized	Uncategorized	BB1 : Meter & Transmitter, Power High, Blower 4, Blower Building 1	METER,POW	<5 years	$5,000.00
TRN0076	Electrical	Uncategorized	Uncategorized	BB1 : Meter & Transmitter, Power Low, Blower 4, Blower Building 1	METER,POW	<5 years	$5,000.00
TRN0077	Electrical	Uncategorized	Uncategorized	BB1 : Meter & Transmitter, Power High, Blower 5, Blower Building 1	METER,POW	<5 years	$5,000.00
TRN0078	Electrical	Uncategorized	Uncategorized	BB1 : Meter & Transmitter, Power Low, Blower 5, Blower Building 1	METER,POW	<5 years	$5,000.00
TRN0080	Electrical	Uncategorized	Uncategorized	BB1 : Meter & Transmitter, Temp. Switch, Gas Engine Radiator Oil, Blower Building 1	METER,TEMP	5-10 years	$1,000.00

TRN0081	Electrical	Uncategorized	Uncategorized	BB1 : Meter & Transmitter, Temp. Switch, Gas Engine Radiator Water, Blower Building 1	METER,TEMP	10-15 years	$1,000.00
TRN0082	Electrical	Uncategorized	Uncategorized	BB1 : Meter & Transmitter, Power, Blower Building 1	METER,POW	<5 years	$5,000.00
TRN3801	Electrical	Uncategorized	Uncategorized	BB1 : Transmitter C329, Pressure, Gas Blower 1, Blower Building 1	XMTR,PRESS	5-10 years	$5,000.00

Building BLWR BLDG 2

Process Description Aeration Process

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
AFE3902	Process Mechanical	Filters	Filters	BB2 : Primary Roll and Secondary Air Filters 1	EQP,MISC	5-10 years	$5,000.00
AFE3903	Process Mechanical	Filters	Filters	BB2 : Primary Roll and Secondary Air Filters 2	EQP,MISC	5-10 years	$5,000.00
AFE3904	Process Mechanical	Filters	Filters	BB2 : Primary Roll and Secondary Air Filters 3	EQP,MISC	5-10 years	$5,000.00
BLO3901	Process Mechanical	Uncategorized	Uncategorized	BB2 : Blower 1, A311, Blower Building 2	BLOWER	>15 years	$1,100,000.00
BLO3902	Process Mechanical	Uncategorized	Uncategorized	BB2 : Blower 2, A312, Blower Building 2	BLOWER	>15 years	$1,100,000.00
BLO3903	Process Mechanical	Uncategorized	Uncategorized	BB2 : Blower 3, A313, Blower Building 2	BLOWER	>15 years	$1,100,000.00

CPN3902	Electrical	Control Panels	Control Panels	BB2 : Control Panel, Zenith Auto Transfer Switch	PANEL,CON	<5 years	$20,000.00
CPN3903	Electrical	Control Panels	Control Panels	BB2 : Control Panel for Blower #1, and associated electrical control devices, Blower Building 2	PANEL,CON	5-10 years	$40,000.00
CPN3904	Electrical	Control Panels	Control Panels	BB2 : Control Panel for Blower #2, and associated electrical control devices, Blower Building 2	PANEL,CON	5-10 years	$40,000.00
CPN3905	Electrical	Control Panels	Control Panels	BB2 : Control Panel for Blower #3, and associated electrical control devices, Blower Building 2	PANEL,CON	5-10 years	$40,000.00
CPN3906	Electrical	Control Panels	Control Panels	BB2 : Control Panel, TCP-4, Temperature Control Panel	PANEL,CON	<5 years	$15,000.00
CPN3907	Electrical	Control Panels	Control Panels	BB2 : Control Panel, Blower Building 2	PANEL,CON	5-10 years	$75,000.00
FRM3901	Electrical	Transformers	Transformers	BB2 : Transformer, T-51, Blower Building 2	TRANSFORM	5-10 years	$35,000.00
FRM3902	Electrical	Transformers	Transformers	BB2 : Transformer, T-52, Blower Building 2	TRANSFORM	5-10 years	$35,000.00
LPN3900	Electrical	Lighting Equip & Sys	Lighting Equip & Sys	BB2 : Lighting/Distribution Panel, DP51, Upper Level	PANEL,ELE	5-10 years	$7,500.00
LPN3901	Electrical	Lighting Equip & Sys	Lighting Equip & Sys	BB2 : Lighting Panel, LP51, Lower Level	PANEL,LGHT	5-10 years	$7,500.00
LPN3902	Electrical	Lighting Equip & Sys	Lighting Equip & Sys	BB2 : Lighting Panel, LP52, Upper Level	PANEL,LGHT	5-10 years	$7,500.00

MCC3901	Electrical	Motor Control Centers	Motor Control Centers	BB2 : MCC, MCC-P51, A396, East Panel, Blower Building 2	MCC	10-15 years	$125,000.00
MCC3902	Electrical	Motor Control Centers	Motor Control Centers	BB2 : MCC, MCC-P52, A397, West Panel, Blower Building 2	MCC	10-15 years	$125,000.00
MCC3903	Electrical	Motor Control Centers	Motor Control Centers	BB2 : Medium Voltage Starter Panel, M7, Blower Building 2	MCC	10-15 years	$200,000.00
MTR3901	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	BB2 : Motor, Protected Water Pump 5-1, Blower Building 2	MOTOR	5-10 years	$4,000.00
MTR3902	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	BB2 : Motor, Protected Water Pump 5-2, Blower Building 2	MOTOR	5-10 years	$4,000.00
MTR3929	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	BB2 : Motor, Blower 1, A311, Blower Building 2	MOTOR	5-10 years	$250,000.00
MTR3933	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	BB2 : Motor, Blower 2, A312, Blower Building 2	MOTOR	5-10 years	$250,000.00
MTR3937	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	BB2 : Motor, Blower 3, A313, Blower Building 2	MOTOR	5-10 years	$250,000.00
MTR3966	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	BB2 : Motor, Hot Water Circulating Pump 5-1, Blower Building 2	MOTOR	5-10 years	$1,000.00
MTR3967	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	BB2 : Motor, Hot Water Circulating Pump 5-2, Blower Building 2	MOTOR	5-10 years	$1,000.00

MTR3973	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	BB2 : Motor, HSP-1, Heat Transfer Pump, Blower Building 2, new 6/2013	MOTOR	10-15 years	$1,000.00
PMP3937	Process Mechanical	Uncategorized	Uncategorized	BB2 : Pump, Protected Water Pump 5-1, Blower Building 2	PUMP	5-10 years	$5,000.00
PMP3938	Process Mechanical	Uncategorized	Uncategorized	BB2 : Pump, Protected Water Pump 5-2, Blower Building 2	PUMP	5-10 years	$5,000.00
PWS3901	Electrical	Uncategorized	Uncategorized	BB2 : Protected Water (W3) System, Blower Building 2	EQP,MISC	5-10 years	$30,000.00
TRN0083	Electrical	Uncategorized	Uncategorized	BB2 : Meter & Transmitter, Power, MCC P51, Blower Building 2	METER,POW	<5 years	$5,000.00
TRN0084	Electrical	Uncategorized	Uncategorized	BB2 : Meter & Transmitter, Power, MCC P52, Blower Building 2	METER,POW	<5 years	$5,000.00

Building EAST AERATION TNKS

Process Description Aeration Process

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
CHA3801	Buildings and Grounds	Uncategorized	Uncategorized	RAS Channel for East Plant, Plants 1 & 2	CHANNEL	>15 years	$200,000.00

Building EAST JUCTION CHMB

Process Description Flow Splitting to East and West Plants

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
SGT3301	Process Mechanical	All gate types	All gate types	FLOW: 60" Slide Gate SG-23-03 on North Wall East Junction Chamber	GATE,SLUI	15+ years	$25,000.00
SGT3302	Process Mechanical	All gate types	All gate types	FLOW: 54" Slide Gate SG-23-04 on East Wall East Junction Chamber	GATE,SLUI	15+ years	$25,000.00

Building EAST PRI TNK

Process Description Primary Clarification

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
CHA3501	Buildings and Grounds	Uncategorized	Uncategorized	Primary Influent Channel East	CHANNEL	>15 years	$200,000.00
CHA3503	Buildings and Grounds	Uncategorized	Uncategorized	Primary Effluent Channel East	CHANNEL	>15 years	$200,000.00
CHA3504	Buildings and Grounds	Uncategorized	Uncategorized	Primary Effluent Channel West	CHANNEL	>15 years	$200,000.00

Building EFF BLDG

Process Description Aeration Process

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
CPN4408	Electrical	Control Panels	Control Panels	EFFB : Control Panel, Zenith Auto Transfer Switch For T71 & T72	PANEL,CON	<5 years	$10,000.00

Process Description Effluent Pumping

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
ACU4402	Process Mechanical	Uncategorized	Uncategorized	EFFB: Air Compressor on Hydraulic Oil Accumulater, Duplex, Air, oil Morlina 100, Effluent Building	COMPR,AIR	10-15 years	$7,500.00
ACU4403	Process Mechanical	Uncategorized	Uncategorized	EFFB: Air Compressor Unit, C1 & C2 for Bubblers 1 & 2, Supplies Air to Bubble Flow Ctrl Panel, Effluent Building	COMPR,AIR	10-15 years	$10,000.00
COM4401	Process Mechanical	Compressor	Compressor	EFFB: Air Compressor/Motor Unit C1, Bubbler System, Effluent Building	COMPR,AIR	10-15 years	$3,000.00
COM4402	Process Mechanical	Compressor	Compressor	EFFB: Air Compressor/Motor Unit C2, Bubbler System, Effluent Building	COMPR,AIR	10-15 years	$3,000.00
CPN4401	Electrical	Control Panels	Control Panels	EFFB: Control Panel, Effluent Building	PANEL,CON	5-10 years	$75,000.00
CPN4411	Electrical	Control Panels	Control Panels	EFFB: Control Panel, TCP-70-1, Unit Heaters & Fans	PANEL,CON	10-15 years	$15,000.00
LPN4401	Electrical	Lighting Equip & Sys	Lighting Equip & Sys	EFFB: Lighting Panel L71, In MCC Room	PANEL,LGHT	5-10 years	$7,500.00
LPN4402	Electrical	Lighting Equip & Sys	Lighting Equip & Sys	EFFB: Lighting Panel L72, In Pump Room	PANEL,LGHT	5-10 years	$7,500.00

LPN4403	Electrical	Lighting Equip & Sys	Lighting Equip & Sys	EFFB: Lighting Panel L73, In Control Room	PANEL,LGHT	5-10 years	$7,500.00
LPN4404	Electrical	Lighting Equip & Sys	Lighting Equip & Sys	EFFB: Lighting/Dist Panel DP71, In MCC Room	PANEL,LGHT	5-10 years	$7,500.00
MCC4401	Electrical	Motor Control Centers	Motor Control Centers	EFFB: MCC, P71, Effluent Building	MCC	10-15 years	$75,000.00
MCC4402	Electrical	Motor Control Centers	Motor Control Centers	EFFB: MCC, P72, Effluent Building	MCC	10-15 years	$75,000.00
MEQ4401	Process Mechanical	Uncategorized	Uncategorized	EFFB: Hydraulic Oil Accumulater, Effluent Building	EQP,MISC	10-15 years	$50,000.00
MPN4401	Electrical	Uncategorized	Uncategorized	EFFB: Meter Panel, Effluent Building	PANEL,METR	<5 years	$10,000.00
PMP4401	Process Mechanical	Uncategorized	Uncategorized	EFFB: Pump D201, Effluent Pump 1, Effluent Building	PUMP	10-15 years	$240,000.00
PMP4402	Process Mechanical	Uncategorized	Uncategorized	EFFB: Pump D202, Effluent Pump 2, Effluent Building	PUMP	10-15 years	$240,000.00
PMP4403	Process Mechanical	Uncategorized	Uncategorized	EFFB: Pump D203, Effluent Pump 3, Effluent Building	PUMP	10-15 years	$240,000.00
PMP4404	Process Mechanical	Uncategorized	Uncategorized	EFFB: Pump D204, Effluent Pump 4, Effluent Building	PUMP	10-15 years	$240,000.00
PMP4405	Process Mechanical	Uncategorized	Uncategorized	EFFB: Pump D205, Effluent Pump 5, Effluent Building	PUMP	10-15 years	$240,000.00
PMP4408	Process Mechanical	Uncategorized	Uncategorized	EFFB: Pump, Effluent Sampler, Effluent Building	PUMP,SAMPL	5-10 years	$3,000.00
PMP4409	Process Mechanical	Uncategorized	Uncategorized	EFFB: Pump, Effluent Sampler For Plants 1 & 2, Effluent Building	PUMP,SAMPL	5-10 years	$3,000.00

PMP4410	Process Mechanical	Uncategorized	Uncategorized	EFFB: Pump, Effluent Sampler For Plant 3, Effluent Building	PUMP,SAMPL	5-10 years	$3,000.00
PMP4411	Process Mechanical	Uncategorized	Uncategorized	EFFB: Pump, Effluent Sampler For Plant 4, Effluent Building	PUMP,SAMPL	5-10 years	$3,000.00
PMP4416	Process Mechanical	Uncategorized	Uncategorized	EFFB: Pump, Hydraulic Oil Pump 1, Effluent Building	PUMP	5-10 years	$3,000.00
PMP4417	Process Mechanical	Uncategorized	Uncategorized	EFFB: Pump, Hydraulic Oil Pump 2, Effluent Building	PUMP	5-10 years	$3,000.00
PMP4419	Process Mechanical	Uncategorized	Uncategorized	EFFB: Pump 1, Badger Mill Creek Effluent Pump 1, Effluent Building	PUMP	10-15 years	$100,000.00
PMP4420	Process Mechanical	Uncategorized	Uncategorized	EFFB: Pump 2, Badger Mill Creek Effluent Pump 2, Effluent Building	PUMP	10-15 years	$100,000.00
TRN4403	Electrical	Uncategorized	Uncategorized	EFFB: Meter & Transmitter LT-160, In UV inlet well outside of the Effluent Building.	XMTR,LEVEL		$5,000.00
TRN4404	Electrical	Uncategorized	Uncategorized	EFFB: Meter & Transmitter D300, In UV inlet well inside the Effluent Building.	XMTR,LEVEL		$5,000.00

Process Description UV Disinfection

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost

BNK4301	Electrical	Uncategorized	Uncategorized	EFFB: U.V. Bank A Unit 1, D311, Lamps & Quartz Tubes, Effluent Building	UV BANK	$10,000.00
BNK4302	Electrical	Uncategorized	Uncategorized	EFFB: U.V. Bank B Unit 1, D312, Lamps & Quartz Tubes, Effluent Building	UV BANK	$10,000.00
BNK4303	Electrical	Uncategorized	Uncategorized	EFFB: U.V. Bank A Unit 2, D321, Lamps & Quartz Tubes, Effluent Building	UV BANK	$10,000.00
BNK4304	Electrical	Uncategorized	Uncategorized	EFFB: U.V. Bank B Unit 2, D322, Lamps & Quartz Tubes,Effluent Building	UV BANK	$10,000.00
BNK4305	Electrical	Uncategorized	Uncategorized	EFFB: U.V. Bank A Unit 3, D331, Lamps & Quartz Tubes,Effluent Building	UV BANK	$10,000.00
BNK4306	Electrical	Uncategorized	Uncategorized	EFFB: U.V. Bank B Unit 3, D332, Lamps & Quartz Tubes,Effluent Building	UV BANK	$10,000.00
BNK4307	Electrical	Uncategorized	Uncategorized	EFFB: U.V. Bank A Unit 4, D341, Lamps & Quartz Tubes,Effluent Building	UV BANK	$10,000.00

	BNK4308	Electrical	Uncategorized	Uncategorized	EFFB: U.V. Bank B Unit 4, D342, Lamps & Quartz Tubes,Effluent Building	UV BANK		$10,000.00
	BNK4309	Electrical	Uncategorized	Uncategorized	EFFB: U.V. Bank A Unit 5, D351, Lamps & Quartz Tubes,Effluent Building	UV BANK		$10,000.00
	BNK4310	Electrical	Uncategorized	Uncategorized	EFFB: U.V. Bank B Unit 5, D352, Lamps & Quartz Tubes, Effluent Building	UV BANK		$10,000.00
	FRM4411	Electrical	Transformers	Transformers	EFFB : Transformer, XFRM 711	TRANSFORM	5-10 years	$25,000.00
	FRM4412	Electrical	Transformers	Transformers	EFFB : Transformer, XFRM 712	TRANSFORM	5-10 years	$25,000.00
	FRM4413	Electrical	Transformers	Transformers	EFFB : Transformer, XFRM 713	TRANSFORM	5-10 years	$25,000.00
	FRM4414	Electrical	Transformers	Transformers	EFFB : Transformer, XFRM 714	TRANSFORM	5-10 years	$25,000.00
	FRM4415	Electrical	Transformers	Transformers	EFFB : Transformer, T71	TRANSFORM	5-10 years	$20,000.00
	FRM4416	Electrical	Transformers	Transformers	EFFB : Transformer, T72	TRANSFORM	5-10 years	$20,000.00
	IMT4301	Process Mechanical	Metering	Metering	EFFB: U.V. Intensity Meters, Effluent Building	METER		$10,000.00
	MCC4301	Electrical	Motor Control Centers	Motor Control Centers	EFFB: U.V. MCC Panel,	MCC	10-15 years	$150,000.00

PDC4301	Electrical	Uncategorized	Uncategorized	EFFB: Power Distribution Center, U.V. Channel 1, Bank A, Includes Breaker, GFI, PLC, & Ballast, Cabinet Air Conditioning Unit, Effluent Building	PDC	5-10 years	$50,000.00
PDC4302	Electrical	Uncategorized	Uncategorized	EFFB: Power Distribution Center, U.V. Channel 1, Bank B, Includes Breaker, GFI, PLC, & Ballast	PDC	5-10 years	$50,000.00
PDC4303	Electrical	Uncategorized	Uncategorized	EFFB: Power Distribution Center, U.V. Channel 2, Bank A, Includes Breaker, GFI, PLC, & Ballast, Cabinet Air Conditioning Unit	PDC	5-10 years	$50,000.00
PDC4304	Electrical	Uncategorized	Uncategorized	EFFB: Power Distribution Center, U.V. Channel 2, Bank B, Includes Breaker, GFI, PLC, & Ballast	PDC	5-10 years	$50,000.00
PDC4305	Electrical	Uncategorized	Uncategorized	EFFB: Power Distribution Center, U.V. Channel 3, Bank A, Includes Breaker, GFI, PLC, & Ballast, Cabinet Air Conditioning Unit	PDC	5-10 years	$50,000.00
PDC4306	Electrical	Uncategorized	Uncategorized	EFFB: Power Distribution Center, U.V. Channel 3, Bank B, Includes Breaker, GFI, PLC, & Ballast	PDC	5-10 years	$50,000.00

PDC4307	Electrical	Uncategorized	Uncategorized	EFFB: Power Distribution Center, U.V. Channel 4, Bank A, Includes Breaker,GFI, PLC, & Ballast, Cabinet Air Conditioning Unit	PDC	5-10 years	$50,000.00
PDC4308	Electrical	Uncategorized	Uncategorized	EFFB: Power Distribution Center, U.V. Channel 4, Bank B, Includes Breaker, GFI, PLC, & Ballast	PDC	5-10 years	$50,000.00
PDC4309	Electrical	Uncategorized	Uncategorized	EFFB: Power Distribution Center, U.V. Channel 5, Bank A, Includes Breaker, GFI, PLC, & Ballast, Cabinet Air Conditioning Unit	PDC	5-10 years	$50,000.00
PDC4310	Electrical	Uncategorized	Uncategorized	EFFB: Power Distribution Center, U.V. Channel 5, Bank B, Includes Breaker, GFI, PLC, & Ballast	PDC	5-10 years	$50,000.00
PMP4301	Process Mechanical	Uncategorized	Uncategorized	EFFB: Pump, U.V. Cleaning System Pump	PUMP	5-10 years	$20,000.00
PMP4302	Process Mechanical	Uncategorized	Uncategorized	EFFB: Pump, U.V. Channel Dewatering	PUMP	10-15 years	$20,000.00
PNL4300	Electrical	Uncategorized	Uncategorized	EFFB: Panel View , in the System Control Center for all U.V.'s	PANEL,CON	<5 years	$5,000.00
PPI4300	Electrical	Uncategorized	Uncategorized	EFFB: Process Piping and Valves for U.V. System	PIPING		

SCC4300	Electrical	Control Panels	Control Panels	EFFB: U.V. System Control Center, Includes PLC & Panel View	ELECT, SER	5-10 years	$30,000.00
SGT4301	Process Mechanical	All gate types	All gate types	EFFB: Sluice Gate & Actuator, U.V. 1 Inlet	GATE,SLUI	15+ years	$25,000.00
SGT4302	Process Mechanical	All gate types	All gate types	EFFB: Sluice Gate & Actuator, U.V. 2 Inlet	GATE,SLUI	15+ years	$25,000.00
SGT4303	Process Mechanical	All gate types	All gate types	EFFB: Sluice Gate & Actuator, U.V. 3 Inlet	GATE,SLUI	15+ years	$25,000.00
SGT4304	Process Mechanical	All gate types	All gate types	EFFB: Sluice Gate & Actuator, U.V. 4 Inlet	GATE,SLUI	15+ years	$25,000.00
SGT4305	Process Mechanical	All gate types	All gate types	EFFB: Sluice Gate & Actuator, U.V. 5 Inlet	GATE,SLUI	15+ years	$25,000.00
SGT4306	Process Mechanical	All gate types	All gate types	EFFB: Sluice Gate & Actuator (1) U.V. Bypass Channel 1 Inlet	GATE,SLUI	15+ years	$25,000.00
SGT4307	Process Mechanical	All gate types	All gate types	EFFB: Sluice Gate & Actuator(2) U.V. Bypass Channel 2 Inlet	GATE,SLUI	15+ years	$25,000.00
SGT4308	Process Mechanical	All gate types	All gate types	EFFB: Sluice Gate, (3) U.V. Bypass,(outside) Effluent Building	GATE,SLUI	15+ years	$15,000.00
UVC4301	Buildings and Grounds	Uncategorized	Uncategorized	EFFB: U.V. Channel 1	CHANNEL	15+ years	$50,000.00
UVC4302	Buildings and Grounds	Uncategorized	Uncategorized	EFFB: U.V. Channel 2	CHANNEL	15+ years	$50,000.00
UVC4303	Buildings and Grounds	Uncategorized	Uncategorized	EFFB: U.V. Channel 3	CHANNEL	15+ years	$50,000.00
UVC4304	Buildings and Grounds	Uncategorized	Uncategorized	EFFB: U.V. Channel 4	CHANNEL	15+ years	$50,000.00
UVC4305	Buildings and Grounds	Uncategorized	Uncategorized	EFFB: U.V. Channel 5	CHANNEL	15+ years	$50,000.00

UVC4306	Buildings and Grounds	Uncategorized	Uncategorized	EFFB: U.V. Bypass Channel 1	CHANNEL	15+ years	$50,000.00
UVC4307	Buildings and Grounds	Uncategorized	Uncategorized	EFFB: U.V. Bypass Channel 2	CHANNEL	15+ years	$50,000.00

Building EFF STORAGE TANK 1

Process Description Effluent Pumping

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
CHA4401	Buildings and Grounds	Uncategorized	Uncategorized	EDC : Effluent Diversion Structure and Channel south of Effluent Storage Tanks 1 & 2.	CHANNEL	>15 years	$200,000.00

Building EFF TANKS

Process Description Effluent Pumping

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
SGT4401	Process Mechanical	All gate types	All gate types	EST : Sluice Gate (North), East Effluent Tank	GATE,SLUI	15+ years	$15,000.00
SGT4402	Process Mechanical	All gate types	All gate types	EST : Sluice Gate (North), West Effluent Tank	GATE,SLUI	15+ years	$15,000.00
SGT4403	Process Mechanical	All gate types	All gate types	EST : Sluice Gate (South), East Effluent Tank	GATE,SLUI	15+ years	$15,000.00
SGT4404	Process Mechanical	All gate types	All gate types	EST : Sluice Gate (South), West Effluent Tank	GATE,SLUI	15+ years	$15,000.00

Building ELEC BLDG U15

Process Description: Aeration Process

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
VFD0550	Electrical	Uncategorized	Uncategorized	U15 : Variable Frequency Drive, Anaerobic Pump, AT21, South Wall, Elec Bldg U15	VFD	15+ years	$30,000.00
VFD0551	Electrical	Uncategorized	Uncategorized	U15 : Variable Frequency Drive, Anaerobic Pump, AT24, South Wall, Elec Bldg U15	VFD	15+ years	$30,000.00
VFD0553	Electrical	Uncategorized	Uncategorized	U15 : Variable Frequency Drive, Anaerobic Pump, AT28, South Wall, Elec Bldg U15	VFD	15+ years	$30,000.00
VFD0554	Electrical	Uncategorized	Uncategorized	U15 : Variable Frequency Drive, Anaerobic Pump, AT25, South Wall, New 2014, Elec Bldg U15	VFD	15+ years	$30,000.00

Process Description: Nine Springs Power Distribution System

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
TRN0214	Electrical	Uncategorized	Uncategorized	U15: Power Metering for MCC-U15-1, New 10/2014	METER,POW	15+ years	$5,000.00
TRN0284	Electrical	Uncategorized	Uncategorized	U15 : Power Quality Meter, S1-12 Main 1, New 2012	METER,POW	15+ years	$5,000.00

TRN0457	Electrical	Metering	Metering	U15 : Power Quality Meter, S1-13 Main 2, New 2015	METER,POW	10-15 years	$5,000.00

Building FC01

Process Description Secondary Clarification

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
DRI4101	Process Mechanical	Uncategorized	Uncategorized	FC01: Collector Drive & Mechanism Unit C121, Final Clarifier 1	UNIT,DRIVE	5-10 years	$160,000.00
FDR4101	Process Mechanical	Uncategorized	Uncategorized	FC01: Flocculator Drive & Mechanism Unit C131, Final Clarifier 1	UNIT,DRIVE	5-10 years	$50,000.00
RED4101	Process Mechanical	Gearboxes	Gearboxes	FC01: Lower Reducer, Collector Drive, Final Clarifier 1	REDUCER	10-15 years	$15,000.00
RED4102	Process Mechanical	Gearboxes	Gearboxes	FC01: Reducer C131, Flocculator Drive, Final Clarifier 1	REDUCER	5-10 year	$15,000.00
RED4139	Process Mechanical	Gearboxes	Gearboxes	FC01: Upper Reducer, Collector Drive, Final Clarifier 1	REDUCER	10-15 years	$15,000.00
SGT4101	Process Mechanical	All gate types	All gate types	FC01: Sluice Gate, Final Clarifier 1	GATE,SLUI	5-10 years	$10,000.00
TNK4101	Buildings and Grounds	Tanks	Tanks	FC01: Final Clarifier 1	TANK,FINAL	15+ years	$200,000.00

Building FC02

Process Description Secondary Clarification

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost

DRI4102	Process Mechanical	Uncategorized	Uncategorized	FC02: Collector Drive & Mechanism Unit C122, Final Clarifier 2	UNIT,DRIVE	10-15 years	$160,000.00
FDR4102	Process Mechanical	Gearboxes	Gearboxes	FC02: Flocculator Drive & Mechanism Unit C132, Final Clarifier 2	UNIT,DRIVE	5-10 years	$50,000.00
RED4103	Process Mechanical	Gearboxes	Gearboxes	FC02: Lower Reducer, Collector Drive, Final Clarifier 2	REDUCER	10-15 years	$15,000.00
RED4104	Process Mechanical	Gearboxes	Gearboxes	FC02: Reducer C132, Flocculator Drive, Final Clarifier 2	REDUCER	5-10 years	$15,000.00
RED4140	Process Mechanical	Gearboxes	Gearboxes	FC02: Upper Reducer, Collector Drive, Final Clarifier 2	REDUCER	10-15 years	$15,000.00
SGT4102	Process Mechanical	All gate types	All gate types	FC02: Sluice Gate, Final Clarifier 2	GATE,SLUI	5-10 years	$10,000.00
TNK4102	Buildings and Grounds	Tanks	Tanks	FC02: Final Clarifier 2	TANK,FINAL	15+ years	$200,000.00

Building FC03

Process Description Secondary Clarification

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
DRI4103	Process Mechanical	Uncategorized	Uncategorized	FC03: Collector Drive & Mechanism Unit C233, Final Clarifier 3	UNIT,DRIVE	10-15 years	$200,000.00
FDR4103	Process Mechanical	Uncategorized	Uncategorized	FC03: Flocculator Drive & Mechanism Unit C243, Final Clarifier 3	UNIT,DRIVE	5-10 years	$50,000.00

RED4105	Process Mechanical	Gearboxes	Gearboxes	FC03: Lower Reducer, Collector Drive, Final Clarifier 3	REDUCER	10-15 years	$15,000.00
RED4106	Process Mechanical	Gearboxes	Gearboxes	FC03: Reducer C243, Flocculator, Final Clarifier 3	REDUCER	5-10 years	$15,000.00
RED4141	Process Mechanical	Gearboxes	Gearboxes	FC03: Upper Reducer, Collector Drive, Final Clarifier 3	REDUCER	10-15 years	$15,000.00
SGT4103	Process Mechanical	All gate types	All gate types	FC03: Sluice Gate, Final Clarifier 3	GATE,SLUI	5-10 years	$10,000.00
TNK4103	Buildings and Grounds	Tanks	Tanks	FC03: Final Clarifier 3	TANK,FINAL	15+ years	$200,000.00

Building FC04

Process Description Secondary Clarification

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
DRI4104	Process Mechanical	Uncategorized	Uncategorized	FC04: Collector Drive & Mechanism Unit C234, Final Clarifier 4	UNIT,DRIVE	10-15 years	$170,000.00
FDR4104	Process Mechanical	Uncategorized	Uncategorized	FC04: Flocculator Drive & Mechanism Unit C244, Final Clarifier 4	UNIT,DRIVE	5-10 years	$50,000.00
RED4107	Process Mechanical	Gearboxes	Gearboxes	FC04: Lower Reducer, Collector Drive, Final Clarifier 4	REDUCER	5-10 years	$15,000.00
RED4108	Process Mechanical	Gearboxes	Gearboxes	FC04: Reducer C244, Flocculator, Final Clarifier 4	REDUCER	10-15 years	$15,000.00
RED4142	Process Mechanical	Gearboxes	Gearboxes	FC04: Upper Reducer, Collector Drive, Final Clarifier 4	REDUCER	10-15 years	$15,000.00

SGT4104	Process Mechanical	All gate types	All gate types	FC04: Sluice Gate, Final Clarifier 4	GATE,SLUI	5-10 years	$10,000.00
TNK4104	Buildings and Grounds	Tanks	Tanks	FC04: Final Clarifier 4	TANK,FINAL	15+ years	$200,000.00

Building FC05

Process Description Secondary Clarification

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
DRI4105	Process Mechanical	Uncategorized	Uncategorized	FC05: Collector Drive & Mechanism Unit C235, Final Clarifier 5	UNIT,DRIVE	10-15 years	$170,000.00
RED4156	Process Mechanical	Gearboxes	Gearboxes	FC05: Reducer, Collector Drive, New 2014, Final Clarifier 5	REDUCER	>15 years	$15,000.00
SGT4105	Process Mechanical	All gate types	All gate types	FC05: Sluice Gate, Final Clarifier 5	GATE,SLUI	10-15 years	$10,000.00
TNK4105	Buildings and Grounds	Tanks	Tanks	FC05: Final Clarifier 5	TANK,FINAL	15+ years	$200,000.00

Building FC06

Process Description Secondary Clarification

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
DRI4106	Process Mechanical	Uncategorized	Uncategorized	FC06: Collector Drive & Mechanism Unit C236, Final Clarifier 6	UNIT,DRIVE	10-15 years	$170,000.00
RED4157	Process Mechanical	Gearboxes	Gearboxes	FC06: Reducer, Collector Drive, New 2014, Final Clarifier 6	REDUCER	>15 years	$15,000.00
SGT4106	Process Mechanical	All gate types	All gate types	FC06: Sluice Gate, Final Clarifier 6	GATE,SLUI	10-15 years	$10,000.00

TNK4106	Buildings and Grounds	Tanks	Tanks	FC06: Final Clarifier 6	TANK,FINAL	15+ years	$200,000.00

Building FC07

Process Description Secondary Clarification

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
DRI4107	Process Mechanical	Uncategorized	Uncategorized	FC07: Collector Drive & Mechanism Unit C337, Final Clarifier 7	UNIT,DRIVE	10-15 years	$230,000.00
RED4113	Process Mechanical	Gearboxes	Gearboxes	FC07: Lower Reducer, Collector Drive, Final Clarifier 7	REDUCER	10-15 years	$15,000.00
RED4143	Process Mechanical	Gearboxes	Gearboxes	FC07: Upper Reducer, Collector Drive, Final Clarifier 7	REDUCER	10-15 years	$15,000.00
SGT4107	Process Mechanical	All gate types	All gate types	FC07: Sluice Gate, Final Clarifier 7	GATE,SLUI	10-15 years	$15,000.00
TNK4107	Buildings and Grounds	Tanks	Tanks	FC07: Final Clarifier 7	TANK,FINAL	15+ years	$200,000.00

Building FC08

Process Description Secondary Clarification

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
DRI4108	Process Mechanical	Uncategorized	Uncategorized	FC08: Collector Drive & Mechanism Unit C338, Final Clarifier 8	UNIT,DRIVE	10-15 years	$230,000.00
RED4115	Process Mechanical	Gearboxes	Gearboxes	FC08: Lower Reducer, Collector Drive, Final Clarifier 8	REDUCER	10-15 years	$15,000.00

RED4144	Process Mechanical	Gearboxes	Gearboxes	FC08: Upper Reducer, Collector Drive, Final Clarifier 8	REDUCER	10-15 years	$15,000.00
SGT4108	Process Mechanical	All gate types	All gate types	FC08: Sluice Gate, Final Clarifier 8	GATE,SLUI	10-15 years	$15,000.00
SGT4118	Process Mechanical	All gate types	All gate types	FC08: Sluice Gate, Final Clarifier 8, 2005	GATE,SLUI	15+ years	$10,000.00
TNK4108	Buildings and Grounds	Tanks	Tanks	FC08: Final Clarifier 8	TANK,FINAL	15+ years	$200,000.00

Building FC09

Process Description Secondary Clarification

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
DRI4109	Process Mechanical	Uncategorized	Uncategorized	FC09: Collector Drive & Mechanism Unit C339, Final Clarifier 9	UNIT,DRIVE	10-15 years	$230,000.00
RED4117	Process Mechanical	Gearboxes	Gearboxes	FC09: Lower Reducer, Collector Drive, Final Clarifier 9	REDUCER	10-15 years	$15,000.00
RED4145	Process Mechanical	Gearboxes	Gearboxes	FC09: Upper Reducer, Collector Drive, Final Clarifier 9	REDUCER	10-15 years	$15,000.00
SGT4119	Process Mechanical	All gate types	All gate types	FC09: Sluice Gate, Final Clarifier 9, 2005	GATE,SLUI	15+ years	$15,000.00
TNK4109	Buildings and Grounds	Tanks	Tanks	FC09: Final Clarifier 9	TANK,FINAL	15+ years	$200,000.00

Building FC10

Process Description Secondary Clarification

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost

DRI4110	Process Mechanical	Uncategorized	Uncategorized	FC10: Collector Drive & Mechanism Unit C340, Final Clarifier 10	UNIT,DRIVE	10-15 years	$230,000.00
RED4119	Process Mechanical	Gearboxes	Gearboxes	FC10: Lower Reducer, Collector Drive, Final Clarifier 10	REDUCER	10-15 years	$15,000.00
RED4146	Process Mechanical	Gearboxes	Gearboxes	FC10: Upper Reducer, Collector Drive, Final Clarifier 10	REDUCER	10-15 years	$15,000.00
SGT4110	Process Mechanical	All gate types	All gate types	FC10: Sluice Gate, Final Clarifier 10	GATE,SLUI	10-15 years	$15,000.00
TNK4110	Buildings and Grounds	Tanks	Tanks	FC10: Final Clarifier 10	TANK,FINAL	15+ years	$200,000.00

Building FC11

Process Description Secondary Clarification

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
DRI4111	Process Mechanical	Uncategorized	Uncategorized	FC11: Collector Drive & Mechanism Unit, Final Clarifier 11	UNIT,DRIVE	10-15 years	$230,000.00
FDR4111	Process Mechanical	Uncategorized	Uncategorized	FC11: Flocculator Drive & Mechanism Unit C361, Final Clarifier 11	UNIT,DRIVE	5-10 years	$50,000.00
RED4121	Process Mechanical	Gearboxes	Gearboxes	FC11: Lower Reducer, Collector Drive, Final Clarifier 11	REDUCER	10-15 years	$15,000.00
RED4122	Process Mechanical	Gearboxes	Gearboxes	FC11: Reducer C361, Flocculator Drive, Final Clarifier 11	REDUCER	10-15 years	$15,000.00

RED4147	Process Mechanical	Gearboxes	Gearboxes	FC11: Upper Reducer, Collector Drive, Final Clarifier 11	REDUCER	10-15 years	$15,000.00
SGT4111	Process Mechanical	All gate types	All gate types	FC11: Sluice Gate, Final Clarifier 11	GATE,SLUI	10-15 years	$15,000.00
TNK4111	Buildings and Grounds	Tanks	Tanks	FC11: Final Clarifier 11	TANK,FINAL	15+ years	$200,000.00

Building FC12

Process Description Secondary Clarification

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
DRI4112	Process Mechanical	Uncategorized	Uncategorized	FC12: Collector Drive & Mechanism Unit B212, Final Clarifier	UNIT,DRIVE	10-15 years	$260,000.00
FDR4112	Process Mechanical	Uncategorized	Uncategorized	FC12: Flocculator Drive & Mechanism Unit B232, Final Clarifier 12	UNIT,DRIVE	5-10 years	$50,000.00
RED4123	Process Mechanical	Gearboxes	Gearboxes	FC12: Lower Reducer, Collector Drive, Final Clarifier 12	REDUCER	10-15 years	$15,000.00
RED4124	Process Mechanical	Gearboxes	Gearboxes	FC12: Reducer B232, Flocculator Drive, Final Clarifier 12	REDUCER	5-10 years	$15,000.00
RED4148	Process Mechanical	Gearboxes	Gearboxes	FC12: Upper Reducer, Collector Drive, Final Clarifier 12	REDUCER	10-15 years	$15,000.00
TNK4112	Buildings and Grounds	Tanks	Tanks	FC12: Final Clarifier 12	TANK,FINAL	15+ years	$200,000.00

Building FC13

Process Description Secondary Clarification

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
DRI4113	Process Mechanical	Uncategorized	Uncategorized	FC13: Collector Drive & Mechanism Unit B213, Final Clarifier	UNIT,DRIVE	5-10 years	$260,000.00
FDR4113	Process Mechanical	Uncategorized	Uncategorized	FC13: Flocculator Drive & Mechanism Unit B233, Final Clarifier 13	UNIT,DRIVE	5-10 years	$50,000.00
RED4125	Process Mechanical	Gearboxes	Gearboxes	FC13: Lower Reducer, Collector Drive, Final Clarifier 13	REDUCER	10-15 years	$15,000.00
RED4126	Process Mechanical	Gearboxes	Gearboxes	FC13: Reducer B233, Flocculator Drive, Final Clarifier 13	REDUCER	5-10 years	$15,000.00
RED4149	Process Mechanical	Gearboxes	Gearboxes	FC13: Upper Reducer, Collector Drive, Final Clarifier 13	REDUCER	10-15 years	$15,000.00
TNK4113	Buildings and Grounds	Tanks	Tanks	FC13: Final Clarifier 13	TANK,FINAL	15+ years	$200,000.00

Building FC14

Process Description Secondary Clarification

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
DRI4114	Process Mechanical	Uncategorized	Uncategorized	FC14: Collector Drive & Mechanism Unit B214, Final Clarifier	UNIT,DRIVE	10-15 years	$260,000.00

FDR4114	Process Mechanical	Uncategorized	Uncategorized	FC14: Flocculator Drive & Mechanism Unit B234, Final Clarifier 14	UNIT,DRIVE	5-10 years	$50,000.00
RED4127	Process Mechanical	Gearboxes	Gearboxes	FC14: Lower Reducer, Collector Drive, Final Clarifier 14	REDUCER	10-15 years	$15,000.00
RED4128	Process Mechanical	Gearboxes	Gearboxes	FC14: Reducer B234, Flocculator Drive, Final Clarifier 14	REDUCER	10-15 years	$15,000.00
RED4150	Process Mechanical	Gearboxes	Gearboxes	FC14: Upper Reducer, Collector Drive, Final Clarifier 14	REDUCER	10-15 years	$15,000.00
TNK4114	Buildings and Grounds	Tanks	Tanks	FC14: Final Clarifier 14	TANK,FINAL	15+ years	$200,000.00

Building FC15

Process Description Secondary Clarification

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
DRI4115	Process Mechanical	Uncategorized	Uncategorized	FC15: Collector Drive & Mechanism Unit B215, Final Clarifier	UNIT,DRIVE	10-15 years	$260,000.00
FDR4115	Process Mechanical	Uncategorized	Uncategorized	FC15: Flocculator Drive & Mechanism Unit B235, Final Clarifier 15	UNIT,DRIVE	5-10 years	$50,000.00
RED4129	Process Mechanical	Gearboxes	Gearboxes	FC15: Lower Reducer, Collector Drive, Final Clarifier 15	REDUCER	10-15 years	$15,000.00

RED4130	Process Mechanical	Gearboxes	Gearboxes	FC15: Reducer B235, Flocculator Drive, Final Clarifier 15	REDUCER	10-15 years	$15,000.00
RED4151	Process Mechanical	Gearboxes	Gearboxes	FC15: Upper Reducer, Collector Drive, Final Clarifier 15	REDUCER	10-15 years	$15,000.00
TNK4115	Buildings and Grounds	Tanks	Tanks	FC15: Final Clarifier 15	TANK,FINAL	15+ years	$200,000.00

Building FC16

Process Description Secondary Clarification

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
DRI4116	Process Mechanical	Uncategorized	Uncategorized	FC16: Collector Drive & Mechanism Unit B216, Final Clarifier	UNIT,DRIVE	10-15 years	$260,000.00
FDR4116	Process Mechanical	Uncategorized	Uncategorized	FC16: Flocculator Drive & Mechanism Unit B236, Final Clarifier 16	UNIT,DRIVE	5-10 years	$50,000.00
RED4131	Process Mechanical	Gearboxes	Gearboxes	FC16: Lower Reducer, Collector Drive, Final Clarifier 16	REDUCER	10-15 years	$15,000.00
RED4132	Process Mechanical	Gearboxes	Gearboxes	FC16: Reducer B236, Flocculator Drive, Final Clarifier 16	REDUCER	5-10 years	$15,000.00
RED4152	Process Mechanical	Gearboxes	Gearboxes	FC16: Upper Reducer, Collector Drive, Final Clarifier 16	REDUCER	10-15 years	$15,000.00
TNK4116	Buildings and Grounds	Tanks	Tanks	FC16: Final Clarifier 16	TANK,FINAL	15+ years	$200,000.00

Building FC17

Process Description Secondary Clarification

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
DRI4117	Process Mechanical	Uncategorized	Uncategorized	FC17: Collector Drive & Mechanism Unit, Final Clarifier 17	UNIT,DRIVE	5-10 years	$260,000.00
FDR4117	Process Mechanical	Uncategorized	Uncategorized	FC17: Flocculator Drive & Mechanism Unit B237, Final Clarifier 17	UNIT,DRIVE	5-10 years	$50,000.00
RED4133	Process Mechanical	Gearboxes	Gearboxes	FC17: Lower Reducer, Collector Drive, Final Clarifier 17	REDUCER	5-10 years	$15,000.00
RED4134	Process Mechanical	Gearboxes	Gearboxes	FC17: Reducer B237, Flocculator Drive, Final Clarifier 17	REDUCER	5-10 years	$15,000.00
RED4153	Process Mechanical	Gearboxes	Gearboxes	FC17: Upper Reducer, Collector Drive, Final Clarifier 17	REDUCER	10-15 years	$15,000.00
TNK4117	Buildings and Grounds	Tanks	Tanks	FC17: Final Clarifier 17	TANK,FINAL	15+ years	$200,000.00

Building FC18

Process Description Secondary Clarification

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
DRI4118	Process Mechanical	Uncategorized	Uncategorized	FC18: Collector Drive & Mechanism Unit B218, Final Clarifier	UNIT,DRIVE	5-10 years	$260,000.00

FDR4118	Process Mechanical	Uncategorized	Uncategorized	FC18: Flocculator Drive & Mechanism Unit B238, Final Clarifier 18	UNIT,DRIVE	5-10 years	$50,000.00
RED4135	Process Mechanical	Gearboxes	Gearboxes	FC18: Lower Reducer, Collector Drive, Final Clarifier 18	REDUCER	5-10 years	$15,000.00
RED4136	Process Mechanical	Gearboxes	Gearboxes	FC18: Reducer B238, Flocculator Drive, Final Clarifier 18	REDUCER	5-10 years	$15,000.00
RED4154	Process Mechanical	Gearboxes	Gearboxes	FC18: Upper Reducer, Collector Drive, Final Clarifier 18	REDUCER	10-15 years	$15,000.00
TNK4118	Buildings and Grounds	Tanks	Tanks	FC18: Final Clarifier 18	TANK,FINAL	15+ years	$200,000.00

Building FC19

Process Description Secondary Clarification

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
DRI4119	Process Mechanical	Uncategorized	Uncategorized	FC19: Collector Drive & Mechanism Unit B219, Final Clarifier	UNIT,DRIVE	5-10 years	$260,000.00
FDR4119	Process Mechanical	Uncategorized	Uncategorized	FC19: Flocculator Drive & Mechanism Unit B239, Final Clarifier 19	UNIT,DRIVE	5-10 years	$50,000.00
RED4137	Process Mechanical	Gearboxes	Gearboxes	FC19: Lower Reducer, Collector Drive, Final Clarifier 19	REDUCER	10-15 years	$15,000.00

RED4138	Process Mechanical	Gearboxes	Gearboxes	FC19: Reducer B239, Flocculator Drive, Final Clarifier 19	REDUCER	5-10 years	$15,000.00
RED4155	Process Mechanical	Gearboxes	Gearboxes	FC19: Upper Reducer, Collector Drive, Final Clarifier 19	REDUCER	10-15 years	$15,000.00
TNK4119	Buildings and Grounds	Tanks	Tanks	FC19: Final Clarifier 19	TANK,FINAL	15+ years	$200,000.00

Building GAS CNTR BLDG

Process Description Primary Clarification

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
EJC3501	Process Mechanical	Uncategorized	Uncategorized	GCB : Pneumatic Ejector 1,scum, Gas Control Building	EJECTOR	10-15 years	$40,000.00

Building HEADWORKS

Process Description Grit Removal

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
CBL3601	Process Mechanical	Uncategorized	Uncategorized	HEAD: Snail A891, Grit Dewatering, Headworks	EQP,MISC	5-10 years	$170,000.00
DRI3201	Process Mechanical	Uncategorized	Uncategorized	HEAD: Drive Unit 1, A810, Grit Basin 1, Omala 68, Headworks	UNIT,DRIVE	10-15 years	$45,000.00
DRI3202	Process Mechanical	Uncategorized	Uncategorized	HEAD: Drive Unit 2, A820, Grit Basin 2, Omala 68, Headworks	UNIT,DRIVE	10-15 years	$45,000.00

DRI3203	Process Mechanical	Uncategorized	Uncategorized	HEAD: Drive Unit 3, A830, Grit Basin 3, Omala 68, Headworks	UNIT,DRIVE	10-15 years	$45,000.00
GRU3205	Process Mechanical	Uncategorized	Uncategorized	HEAD: Grit Concentrator 3A Headworks S/N or Job # 03-11921-00-W	EQP,MISC	10-15 years	$40,000.00
GRU3206	Process Mechanical	Uncategorized	Uncategorized	HEAD: Grit Concentrator 3B Headworks S/N or Job # 03-11921-00-W	EQP,MISC	10-15 years	$40,000.00
GRU3211	Process Mechanical	Uncategorized	Uncategorized	HEAD: Grit Concentrator 1A Headworks, New in December of 2011.S/N or Job # 03-11920-00-W, Part # 67C174-300	EQP,MISC	10-15 years	$40,000.00
GRU3212	Process Mechanical	Uncategorized	Uncategorized	HEAD: Grit Concentrator 2A, NEW 2013, Headworks Job # 03-11919-00-W	EQP,MISC	10-15 years	$40,000.00
GRU3213	Process Mechanical	Uncategorized	Uncategorized	HEAD: Grit Concentrator 2B, NEW 2013, Headworks Job # 03-11919-00-W	EQP,MISC	10-15 years	$40,000.00
GRU3215	Process Mechanical	Grit Removal	Grit Removal	HEAD: Grit Concentrator 1B, New 10/2014, Headworks Bldg.	EQP,MISC	10-15 years	$40,000.00
MEQ0102	Process Mechanical	Uncategorized	Uncategorized	HEAD: Auger, A895 (Screw Conveyor) Grit Dewatering from snail to dumpster, Headworks	EQP,MISC	5-10 years	$40,000.00

MEQ3203	Process Mechanical	Uncategorized	Uncategorized	HEAD: Grit Auger 1, A860, Headworks	EQP,MISC	10-15 years	$40,000.00
MEQ3205	Process Mechanical	Uncategorized	Uncategorized	HEAD: Grit Auger 2, A870, Headworks	EQP,MISC	10-15 years	$40,000.00
MEQ3207	Process Mechanical	Uncategorized	Uncategorized	HEAD: Grit Auger 3, A880, Headworks	EQP,MISC	10-15 years	$40,000.00
PMP3201	Process Mechanical	Uncategorized	Uncategorized	HEAD: Grit Pump 1-A, A817	PUMP	10-15 years	$34,000.00
PMP3202	Process Mechanical	Uncategorized	Uncategorized	HEAD: Grit Pump 1-B, A818	PUMP	10-15 years	$34,000.00
PMP3203	Process Mechanical	Uncategorized	Uncategorized	HEAD: Grit Pump 2-A, A827	PUMP	10-15 years	$34,000.00
PMP3205	Process Mechanical	Uncategorized	Uncategorized	HEAD: Grit Pump 3-A, A837	PUMP	10-15 years	$34,000.00
PMP3206	Process Mechanical	Uncategorized	Uncategorized	HEAD: Grit Pump 3-B, A838	PUMP	10-15 years	$34,000.00
PMP3207	Process Mechanical	Uncategorized	Uncategorized	HEAD: Grit Pump 2-B, A828	PUMP	10-15 years	$34,000.00
RED3206	Process Mechanical	Gearboxes	Gearboxes	HEAD: Reducer Drive Unit, Grit Auger 1, A860, Headworks	REDUCER	5-10 years	$5,000.00
RED3207	Process Mechanical	Gearboxes	Gearboxes	HEAD: Reducer Drive Unit, Grit Auger 2, A870, Headworks	REDUCER	5-10 years	$5,000.00
RED3208	Process Mechanical	Gearboxes	Gearboxes	HEAD: Reducer Drive Unit, Grit Auger 3, A880, Headworks	REDUCER	5-10 years	$5,000.00
RED3601	Process Mechanical	Gearboxes	Gearboxes	HEAD: Reducer A891, Conveyor Snail, Headworks	REDUCER	5-10 years	$5,000.00
SGT3204	Process Mechanical	All gate types	All gate types	HEAD: Outlet Slide Gate SG-25-07, Grit Basin 1	GATE,SLUI	15+ years	$25,000.00

SGT3205	Process Mechanical	All gate types	All gate types	HEAD: Inlet Channel Slide Gate A802, Grit Basin 2	GATE,SLUI	15+ years	$25,000.00
SGT3206	Process Mechanical	All gate types	All gate types	HEAD: Inlet Slide Gate SG-25-03, Grit Basin 2	GATE,SLUI	15+ years	$15,000.00
SGT3207	Process Mechanical	All gate types	All gate types	HEAD: Bypass Slide Gate SG-25-04, Grit Basin 2	GATE,SLUI	15+ years	$15,000.00
SGT3208	Process Mechanical	All gate types	All gate types	HEAD: Outlet Slide Gate SG-25-08, Grit Basin 2	GATE,SLUI	15+ years	$25,000.00
SGT3209	Process Mechanical	All gate types	All gate types	HEAD: Inlet Channel Slide Gate A803, Grit Basin 3	GATE,SLUI	15+ years	$25,000.00
SGT3210	Process Mechanical	All gate types	All gate types	HEAD: Inlet Slide Gate SG-25-05, Grit Basin 3	GATE,SLUI	15+ years	$15,000.00
SGT3211	Process Mechanical	All gate types	All gate types	HEAD: Bypass Slide Gate SG-25-06, Grit Basin 3	GATE,SLUI	15+ years	$15,000.00
SGT3212	Process Mechanical	All gate types	All gate types	HEAD: Outlet Slide Gate SG-25-09, Grit Basin 3	GATE,SLUI	15+ years	$25,000.00
SGT3213	Process Mechanical	All gate types	All gate types	HEAD: Inlet Channel Slide Gate A801, Grit Basin 1	GATE,SLUI	15+ years	$25,000.00
SGT3214	Process Mechanical	All gate types	All gate types	HEAD: Inlet Slide Gate SG-25-01, Grit Basin 1	GATE,SLUI	15+ years	$15,000.00
SGT3215	Process Mechanical	All gate types	All gate types	HEAD: Bypass Slide Gate SG-25-02, Grit Basin 1	GATE,SLUI	15+ years	$15,000.00

Process Description	Headworks Screening						
Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
DRI2004	Process Mechanical	Uncategorized	Uncategorized	HEAD: Drive Unit, Lipactor 1 A781, Screening Headworks	EQP,MISC	5-10 years	$5,000.00
DRI2005	Process Mechanical	Uncategorized	Uncategorized	HEAD: Drive Unit, Lipactor 2 A782, Screening Headworks	EQP,MISC	5-10 years	$5,000.00
DRI2006	Process Mechanical	Uncategorized	Uncategorized	HEAD: Drive Unit, Lipactor 3 A783, Screening Headworks	UNIT,DRIVE	5-10 years	$5,000.00
DRI2015	Process Mechanical	Uncategorized	Uncategorized	HEAD: Drive Unit, Conveyor belt A780 Headworks	EQP,MISC	5-10 years	$5,000.00
MEQ2001	Process Mechanical	Uncategorized	Uncategorized	HEAD: Screen Unit 1,A710, Headworks	EQP,MISC	10-15 years	$330,000.00
MEQ2002	Process Mechanical	Uncategorized	Uncategorized	HEAD: Screen Unit 2, A720, Headworks	EQP,MISC	10-15 years	$330,000.00
MEQ2004	Process Mechanical	Uncategorized	Uncategorized	HEAD: Screen Unit 4, A740, Headworks	EQP,MISC	10-15 years	$330,000.00
MEQ2005	Process Mechanical	Uncategorized	Uncategorized	HEAD: Screenings Launder Trough Headworks	EQP,MISC	5-10 years	$50,000.00
MEQ2009	Process Mechanical	Uncategorized	Uncategorized	HEAD: Lisep 1 A771 Headworks	EQP,MISC	5-10 years	$50,000.00
MEQ2011	Process Mechanical	Uncategorized	Uncategorized	HEAD: Lisep 2 A772 Headworks	EQP,MISC	5-10 years	$50,000.00
MEQ2014	Process Mechanical	Uncategorized	Uncategorized	HEAD: Lisep 3 A773 Headworks	EQP,MISC	5-10 years	$50,000.00
MEQ2016	Process Mechanical	Uncategorized	Uncategorized	HEAD: Lipactor 1 Headworks, Manual 11217	EQP,MISC	5-10 years	$50,000.00

MEQ2017	Process Mechanical	Uncategorized	Uncategorized	HEAD: Lipactor 2 Headworks, Manual 11217	EQP,MISC	5-10 years	$50,000.00
MEQ2018	Process Mechanical	Uncategorized	Uncategorized	HEAD: Lipactor 3 Headworks, Manual 11217	EQP,MISC	5-10 years	$50,000.00
PMP2007	Process Mechanical	Uncategorized	Uncategorized	HEAD: Maci Pump, Spare, SN 18893-H2453	PUMP	5-10 years	$30,000.00
PMP2008	Process Mechanical	Uncategorized	Uncategorized	HEAD: Maci Pump, Position 3, SN 18893-H24536	PUMP	5-10 years	$30,000.00
PMP2009	Process Mechanical	Uncategorized	Uncategorized	HEAD: Maci Pump, Position 1, SN 18893-H424571	PUMP	5-10 years	$30,000.00
PMP2010	Process Mechanical	Uncategorized	Uncategorized	HEAD: Pump, Macerator Grit Pump, A750,	PUMP	5-10 years	$34,000.00
PMP2012	Process Mechanical	Uncategorized	Uncategorized	HEAD: Maci Pump, Position 2/4	PUMP	5-10 years	$30,000.00
RED2001	Process Mechanical	Gearboxes	Gearboxes	HEAD: Reducer Drive Motor 1 A710, Screen Unit 1, Omala 220 oil, Headworks	REDUCER	5-10 years	$5,000.00
RED2002	Process Mechanical	Gearboxes	Gearboxes	HEAD: Reducer Screen Drive Motor 2 A720 Screen Unit 2, Omala 220 oil, Headworks	REDUCER	5-10 years	$5,000.00
RED2004	Process Mechanical	Gearboxes	Gearboxes	HEAD: Reducer Screen Drive Motor 4 A740 Screen Unit 4, Omala 220 oil, Headworks	REDUCER	5-10 years	$5,000.00

RED2005	Process Mechanical	Gearboxes	Gearboxes	HEAD: Reducer Drive Unit, Conveyor belt A780, Headworks	REDUCER	5-10 years	$5,000.00
SGT2013	Process Mechanical	All gate types	All gate types	HEAD: Inlet Sluice Gate A751 Maci Headworks	GATE,SLUI	15+ years	$5,000.00
SGT2014	Process Mechanical	All gate types	All gate types	HEAD: Inlet Sluice Gate A752 Maci Headworks	GATE,SLUI	15+ years	$5,000.00
SGT2015	Process Mechanical	All gate types	All gate types	HEAD: Inlet Sluice Gate A753 Maci Headworks	GATE,SLUI	15+ years	$5,000.00
SGT2016	Process Mechanical	All gate types	All gate types	HEAD: Inlet Sluice Gate A754 Maci Headworks	GATE,SLUI	15+ years	$5,000.00

Process Description Influent Metering and Sampling

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
QMT3103	Electrical	Uncategorized	Uncategorized	HEAD: Flow Meter Venturi, P.S. 2 Headworks	METER,FLOW	5-10 years (eletrical components), 15+ years	$50,000.00
QMT3104	Electrical	Uncategorized	Uncategorized	HEAD: Flow meter Venturi, P.S. 7 Headworks	METER,FLOW	5-10 years (eletrical components), 15+ years	$50,000.00
QMT3105	Electrical	Uncategorized	Uncategorized	HEAD: Flow Meter Venturi, P.S. 8 Headworks	METER,FLOW	5-10 years (eletrical components), 15+ years	$50,000.00
QMT3106	Electrical	Uncategorized	Uncategorized	HEAD: Flow Meter Venturi, P.S. 11 Headworks	METER,FLOW	5-10 years (eletrical components), 15+ years	$50,000.00

QMT3109	Electrical	Uncategorized	Uncategorized	HEAD: Flow Meter, Venturi, Influent from PS18	METER,FLOW	5-10 years (eletrical components), 15+ years	$50,000.00
SGT3112	Process Mechanical	All gate types	All gate types	HEAD: Outlet Sluice Gate PS07 SL-25-01 Headworks,	GATE,SLUI	15+ years	$15,000.00
SGT3113	Process Mechanical	All gate types	All gate types	HEAD: Outlet Sluice Gate PS08 SL-25-02 Headworks	GATE,SLUI	15+ years	$15,000.00
SGT3114	Process Mechanical	All gate types	All gate types	HEAD: Outlet Sluice Gate PS18 SL-25-03 Headworks	GATE,SLUI	15+ years	$15,000.00
SGT3115	Process Mechanical	All gate types	All gate types	HEAD: Outlet Sluice Gate PS02 SL-25-04 Headworks	GATE,SLUI	15+ years	$15,000.00
SGT3116	Process Mechanical	All gate types	All gate types	HEAD: Outlet Sluice Gate Furture PS SL-25-05 Headworks	GATE,SLUI	15+ years	$15,000.00
SGT3117	Process Mechanical	All gate types	All gate types	HEAD: Outlet Sluice Gate PS11SL-25-06 Headworks	GATE,SLUI	15+ years	$15,000.00

Process Description W4 Water

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
MEQ2902	Process Mechanical	Uncategorized	Uncategorized	HEAD: W4 Strainer 1 A981	EQP,MISC	<5 years	$40,000.00
MEQ2903	Process Mechanical	Uncategorized	Uncategorized	HEAD: W4 Strainer 2 A982	EQP,MISC	<5 years	$40,000.00
MEQ2904	Process Mechanical	Uncategorized	Uncategorized	HEAD: Sodium Hypochlorite Injection Assembly NaOCl	PUMP	5-10 years	$1,000.00

PMP2901	Process Mechanical	Uncategorized	Uncategorized	HEAD: Pump 1 A991, W4, Headworks	PUMP	5-10 years	$15,000.00
PMP2902	Process Mechanical	Uncategorized	Uncategorized	HEAD: Pump 2 A992, W4, Headworks	PUMP	5-10 years	$15,000.00
PMP2903	Process Mechanical	Uncategorized	Uncategorized	HEAD: Pump 3 A993, W4, Headworks	PUMP	5-10 years	$15,000.00
PMP2906	Process Mechanical	Uncategorized	Uncategorized	HEAD: Sodium Hypochlorite Metering Pump & Motor 1, A995, A96528970P110360461New 2010 NaOCl-P-01	PUMP	5-10 years	$10,000.00
PMP2907	Process Mechanical	Uncategorized	Uncategorized	HEAD: Sodium Hypochlorite Metering Pump & Motor 2, A996, A96528970P110360459New 2010 NaOCl-P-01	PUMP	5-10 years	$10,000.00
VFD2902	Electrical	Uncategorized	Uncategorized	HEAD: VFD for Motor and W4 Pump 2, A992, Headworks	VFD	15+ years	$40,000.00
VFD2904	Electrical	Uncategorized	Uncategorized	HEAD: VFD for Motor and W4 Pump 3, A993, Headworks, new 6/2013	VFD	15+ years	$40,000.00
VFD2905	Electrical	Uncategorized	Uncategorized	HEAD: VFD for Motor and W4 Pump 1, A991, New 2015	VFD	15+ years	$40,000.00
VLV2903	Process Mechanical	Uncategorized	Uncategorized	HEAD: Valve, on 12 inch line, effluent to the Headworks Building as W4 water, underground.	PIPING		$10,000.00

Building LAGOON PUMP STA

Process Description Effluent Pumping

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
PPU5101	Process Mechanical	Uncategorized	Uncategorized	LAGOON PUMP STA: Lagoon Submersible Chopper Pumping Unit L101,Vaughan MN SE4P4, SN84256, 50hp, 1770 rpm,460v, 3ph, 1.15 sf Explosion proof	PUMP	10-15 years	$50,000.00

Building MTR VLT 2

Process Description Flow Splitting to East and West Plants

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
SGT3303	Process Mechanical	All gate types	All gate types	MV2 : Slide Gate SG-23-01 downward opening, excess flow, Flow Splitting	PIPING	15+ years	$20,000.00
SGT3304	Process Mechanical	All gate types	All gate types	MV2 : Slide Gate SG-23-02 downward opening, excess flow, Flow Splitting	PIPING	15+ years	$20,000.00

Building MTR VLT 3

Process Description Effluent Pumping

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost

CPN4412	Electrical	Control Panels	Control Panels	MV3: Control Panel, Pressure Relief System	CONTRL PNL	>15 years	$10,000.00
MEQ4402	Process Mechanical	All valve types	All valve types	MV3: Pressure relief system, Meter Vault 3	EQP,MISC	5-10 years	$25,000.00
TRN4401	Electrical	Uncategorized	Uncategorized	MV3 : Meter & Transmitter D222, Flow, Effluent Meter Vault 3	METER,FLOW	10-15 years	$5,000.00
TRN4405	Electrical	Uncategorized	Uncategorized	MV3 : Meter & Transmitter, Effluent Flow Meter, Effluent Meter Vault 3	METER,FLOW	10-15 years	$5,000.00
TRN4406	Electrical	Uncategorized	Uncategorized	MV3 : Meter & Transmitter, Effluent Pressure Meter, Effluent Meter Vault 3	METER,FLOW	10-15 years	$5,000.00

Building NINE SPRINGS WWTP

Process Description Secondary Clarification

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
CPN4101	Electrical	Control Panels	Control Panels	FC : Control Panel, Final Clarifiers	PANEL,CON	5-10 years	$10,000.00

Building PRIMARY GALLERY 2

Process Description Primary Clarification

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
PMP3510	Process Mechanical	Uncategorized	Uncategorized	PG2 : Pump A201, Primary Sludge Pump 3, Primary Gallery 2	PUMP	<5 years	$40,000.00

PMP3511	Process Mechanical	Uncategorized	Uncategorized	PG2 : Pump A202, Primary Sludge Pump 2 , Primary Gallery 2	PUMP	<5 years	$40,000.00
PMP3512	Process Mechanical	Uncategorized	Uncategorized	PG2 : Pump A203, Primary Sludge Pump 1, Primary Gallery 2	PUMP	<5 years	$40,000.00

Building PSPB1

Process Description Primary Clarification

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
PMP3501	Process Mechanical	Uncategorized	Uncategorized	PSPB1: Pump, Primary Sludge Pump 1, E131, Primary Sludge Pumping Building 1	PUMP	5-10 years	$40,000.00
PMP3502	Process Mechanical	Uncategorized	Uncategorized	PSPB1: Pump, Primary Sludge Pump 2, E132, Primary Sludge Pumping Building 1	PUMP	5-10 years	$40,000.00
PMP3503	Process Mechanical	Uncategorized	Uncategorized	PSPB1: Pump, Primary Sludge Pump 3, E133, Primary Sludge Pumping Building 1	PUMP	5-10 years	$40,000.00
PMP3504	Process Mechanical	Uncategorized	Uncategorized	PSPB1: Pump, Primary Sludge Pump 4, E134, Primary Sludge Pumping Building 1	PUMP	5-10 years	$40,000.00

Building PSPB2

Process Description Primary Clarification

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
FRM3501	Electrical	Transformers	Transformers	PSPB2: Transformer, Lighting Panel	TRANSFORM	5-10 years	$15,000.00
LPN3501	Electrical	Lighting Equip & Sys	Lighting Equip & Sys	PSPB2: Lighting Panel	PANEL,LGHT	5-10 years	$7,500.00
PMP3505	Process Mechanical	Uncategorized	Uncategorized	PSPB2: Pump E245, Primary Sludge Pump 1	PUMP	5-10 years	$40,000.00
PMP3506	Process Mechanical	Uncategorized	Uncategorized	PSPB2: Pump E246, Primary Sludge Pump 2	PUMP	5-10 years	$40,000.00
PMP3507	Process Mechanical	Uncategorized	Uncategorized	PSPB2: Pump E247, Primary Sludge Pump 3	PUMP	5-10 years	$40,000.00
PMP3509	Process Mechanical	Uncategorized	Uncategorized	PSPB2: See Notes, Pump E239, Primary Sludge Pump 5, Primary Sludge Pumping Building 2	PUMP		

Building PT01

Process Description Primary Clarification

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
MTR3502	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	PT01: Motor, Long Collector Drive E101, PT01	MOTOR	<5 years	$1,000.00
RED3501	Process Mechanical	Gearboxes	Gearboxes	PT01: Reducer, Long Collector E101, PT01	REDUCER	<5 years	$15,000.00
RED3502	Process Mechanical	Gearboxes	Gearboxes	PT01: Reducer E101, Cross Collector, PT01	REDUCER	<5 years	$15,000.00

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
TNK3501	Buildings and Grounds	Tanks	Tanks	PT01: Primary Tank 1, E101, PT01	TANK,PRIM	15+ years	$225,000.00

Building PT02

Process Description Primary Clarification

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
MTR3504	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	PT02: Motor, Long Collector Drive E102, PT02	MOTOR	<5 years	$1,000.00
RED3503	Process Mechanical	Gearboxes	Gearboxes	PT02: Reducer, Long Collector E102, PT02	REDUCER	<5 years	$15,000.00
RED3504	Process Mechanical	Gearboxes	Gearboxes	PT02: Reducer E102, Cross Collector, PT02	REDUCER	<5 years	$15,000.00
TNK3502	Buildings and Grounds	Tanks	Tanks	PT02: Primary Tank 2, E102, PT02	TANK,PRIM	15+ years	$225,000.00

Building PT05

Process Description Primary Clarification

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
MTR3505	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	PT05: Motor E115, Cross Collector Drive, PT05	MOTOR	<5 years	$1,000.00
MTR3506	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	PT05: Motor, Long Collector Drive E105, PT05	MOTOR	<5 years	$1,000.00
RED3505	Process Mechanical	Gearboxes	Gearboxes	PT05: Reducer E115, Cross Collector, PT05	REDUCER	<5 years	$15,000.00
RED3506	Process Mechanical	Gearboxes	Gearboxes	PT05: Reducer, Long Collector, E105, PT05	REDUCER	<5 years	$15,000.00
TNK3505	Buildings and Grounds	Tanks	Tanks	PT05: Primary Tank 5, PT05	TANK,PRIM	15+ years	$200,000.00

Building PT06

Process Description Primary Clarification

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
MTR3507	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	PT06: Motor E116, Cross Collector Drive, PT06	MOTOR	5-10 years	$1,000.00
MTR3508	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	PT06: Motor E106, Long Collector Drive, PT06 Stock Code # 010203 for Motor and 002038 Coupling Flange	MOTOR	10-15 years	$1,000.00
RED3507	Process Mechanical	Gearboxes	Gearboxes	PT06: Reducer E116, Cross Collector, PT06	REDUCER	<5 years	$15,000.00
RED3508	Process Mechanical	Gearboxes	Gearboxes	PT06: Reducer E106, Long Collector, PT06	REDUCER	<5 years	$15,000.00
TNK3506	Buildings and Grounds	Tanks	Tanks	PT06: Primary Tank 6, PT06	TANK,PRIM	15+ years	$200,000.00

Building PT07

Process Description Primary Clarification

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
MTR3509	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	PT07: Motor E107, Long Collector Drive, PT07 Stock Code # 010203 for Motor and 002038 Coupling Flange	MOTOR	10-15 years	$1,000.00
MTR3510	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	PT07: Motor E117, Cross Collector Drive, PT07	MOTOR	5-10 years	$1,000.00

RED3509	Process Mechanical	Gearboxes	Gearboxes	PT07: Reducer E117, Cross Collector, PT07	REDUCER	<5 years	$15,000.00
RED3510	Process Mechanical	Gearboxes	Gearboxes	PT07: Reducer E107, Long Collector, PT07	REDUCER	<5 years	$15,000.00
TNK3507	Buildings and Grounds	Tanks	Tanks	PT07: Primary Tank 7, PT07	TANK,PRIM	15+ years	$200,000.00

Building PT08

Process Description Primary Clarification

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
MTR3512	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	PT08: Motor, Long Collector Drive E108, PT08	MOTOR	5-10 years	$1,000.00
MTR3552	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	PT08: Motor E118, Cross Collector Drive, PT08 Stock Code # 010203 for Motor and 002038 Coupling Flange	MOTOR	5-10 years	$1,000.00
RED3511	Process Mechanical	Gearboxes	Gearboxes	PT08: Reducer E118, Cross Collector, PT08	REDUCER	<5 years	$15,000.00
RED3512	Process Mechanical	Gearboxes	Gearboxes	PT08: Reducer, Long Collector E108, PT08	REDUCER	<5 years	$15,000.00
TNK3508	Buildings and Grounds	Tanks	Tanks	PT08: Primary Tank 8, PT08	TANK,PRIM	15+ years	$200,000.00

Building PT09

Process Description Primary Clarification

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost

MTR3513	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	PT09: Motor E219, Cross Collector Drive, PT09	MOTOR	5-10 years	$1,000.00
MTR3514	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	PT09: Motor, Long Collector Drive E209, PT09 Stock Code # 010203 for Motor and 002038 Coupling Flange	MOTOR	5-10 years	$1,000.00
RED3513	Process Mechanical	Gearboxes	Gearboxes	PT09: Reducer E219, Cross Collector, PT09	REDUCER	<5 years	$15,000.00
RED3514	Process Mechanical	Gearboxes	Gearboxes	PT09: Reducer E209, Long Collector, PT09	REDUCER	<5 years	$15,000.00
TNK3509	Buildings and Grounds	Tanks	Tanks	PT09: Primary Tank 9, PT09	TANK,PRIM	15+ years	$200,000.00

Building PT10

Process Description Primary Clarification

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
MTR3515	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	PT10: Motor E220, Cross Collector Driver, PT10	MOTOR	<5 years	$1,000.00
MTR3516	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	PT10: Motor E210, Long Collector Driver, PT10 Stock Code # 010203 for Motor and 002038 Coupling Flange	MOTOR	5-10 years	$1,000.00
RED3515	Process Mechanical	Gearboxes	Gearboxes	PT10: Reducer E220, Cross Collector, PT10	REDUCER	<5 years	$15,000.00
RED3516	Process Mechanical	Gearboxes	Gearboxes	PT10: Reducer E210, Long Collector, PT10	REDUCER	<5 years	$15,000.00

TNK3510	Buildings and Grounds	Tanks	Tanks	PT10: Primary Tank 10, PT10	TANK,PRIM	15+ years	$200,000.00

Building PT11

Process Description Primary Clarification

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
MTR3517	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	PT11: Motor E220, Cross Collector Drive, PT11	MOTOR	5-10 years	$1,000.00
MTR3518	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	PT11: Motor E211, Long Collector Drive, PT11 Stock Code # 010203 for Motor and 002038 Coupling Flange	MOTOR	5-10 years	$1,000.00
RED3517	Process Mechanical	Gearboxes	Gearboxes	PT11: Reducer E220, Cross Collector, PT11	REDUCER	<5 years	$15,000.00
RED3518	Process Mechanical	Gearboxes	Gearboxes	PT11: Reducer E211, Long Collector, PT11	REDUCER	<5 years	$15,000.00
TNK3511	Buildings and Grounds	Tanks	Tanks	PT11: Primary Tank 11, PT11	TANK,PRIM	15+ years	$200,000.00

Building PT12

Process Description Primary Clarification

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
MTR3519	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	PT12: Motor E222, Cross Collector Drive, PT12	MOTOR	5-10 years	$1,000.00

MTR3520	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	PT12: Motor E212, Long Collector Drive, PT12 Stock Code # 010203 for Motor and 002038 Coupling Flange	MOTOR	10-15 years	$1,000.00
RED3519	Process Mechanical	Gearboxes	Gearboxes	PT12: Reducer E222, Cross Collector, PT12	REDUCER	<5 years	$15,000.00
RED3520	Process Mechanical	Gearboxes	Gearboxes	PT12: Reducer E212, Long Collector, PT12	REDUCER	<5 years	$15,000.00
TNK3512	Buildings and Grounds	Tanks	Tanks	PT12: Primary Tank 12, PT12	TANK,PRIM	15+ years	$200,000.00

Building PT13

Process Description Primary Clarification

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
MTR3521	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	PT13: Motor E223, Cross Collector Drive, PT13	MOTOR	10-15 years	$1,000.00
MTR3555	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	PT13: Motor E213, Long Collector Drive, PT13 (New in 2011) Stock Code # 010203 for motor and 002038 Coupling Flange	MOTOR	5-10 years	$1,000.00
RED3521	Process Mechanical	Gearboxes	Gearboxes	PT13: Reducer E223, Cross Collector, PT13	REDUCER	<5 years	$15,000.00
RED3522	Process Mechanical	Gearboxes	Gearboxes	PT13: Reducer E213, Long Collector, PT13	REDUCER	<5 years	$15,000.00
TNK3513	Buildings and Grounds	Tanks	Tanks	PT13: Primary Tank 13, PT13	TANK,PRIM	15+ years	$200,000.00

Building PT14

Process Description Primary Clarification

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
MTR3523	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	PT14: Motor E224, Cross Collector Drive, PT14	MOTOR	5-10 years	$1,000.00
MTR3524	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	PT14: Motor E214, Long Collector Drive, PT14 Stock Code # 010203 for Motor and 002038 Coupling Flange	MOTOR	5-10 years	$1,000.00
RED3523	Process Mechanical	Gearboxes	Gearboxes	PT14: Reducer E224, Cross Collector, PT14	REDUCER	<5 years	$15,000.00
RED3524	Process Mechanical	Gearboxes	Gearboxes	PT14: Reducer E214, Long Collector, PT14	REDUCER	<5 years	$15,000.00
TNK3514	Buildings and Grounds	Tanks	Tanks	PT14: Primary Tank 14, PT14	TANK,PRIM	15+ years	$200,000.00

Building PT15

Process Description Primary Clarification

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
MTR3525	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	PT15: Motor E225, Cross Collector Drive, PT15	MOTOR	5-10 years	$1,000.00
MTR3554	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	PT15: Motor E215, Long Collector Drive, PT15 Stock Code # 010203 for Motor and 002038 Coupling Flange	MOTOR	5-10 years	$1,000.00

RED3525	Process Mechanical	Gearboxes	Gearboxes	PT15: Reducer E225, Cross Collector, PT15	REDUCER	<5 years	$15,000.00
RED3526	Process Mechanical	Gearboxes	Gearboxes	PT15: Reducer E215, Long Collector, PT15	REDUCER	<5 years	$15,000.00
TNK3515	Buildings and Grounds	Tanks	Tanks	PT15: Primary Tank 15, PT15	TANK,PRIM	15+ years	$200,000.00

Building PT16

Process Description Primary Clarification

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
MTR3527	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	PT16: Motor E226, Cross Collector Drive, PT16	MOTOR	5-10 years	$1,000.00
MTR3528	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	PT16: Motor E216, Long Collector Drive, PT16 Stock Code # 010203 for Motor and 002038 Coupling Flange	MOTOR	5-10 years	$1,000.00
RED3527	Process Mechanical	Gearboxes	Gearboxes	PT16: Reducer E226, Cross Collector, PT16	REDUCER	<5 years	$15,000.00
RED3528	Process Mechanical	Gearboxes	Gearboxes	PT16: Reducer E216, Long Collector, PT16	REDUCER	<5 years	$15,000.00
TNK3516	Buildings and Grounds	Tanks	Tanks	PT16: Primary Tank 16, PT16	TANK,PRIM	15+ years	$200,000.00

Building PT17

Process Description Primary Clarification

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost

MTR3529	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	PT17: Motor, Cross Collector Drive, PT17	MOTOR	5-10 years	$1,000.00
MTR3530	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	PT17: Motor, Long Collector Drive, PT17	MOTOR	5-10 years	$1,000.00
RED3529	Process Mechanical	Gearboxes	Gearboxes	PT17: Reducer, Cross Collector, PT17	REDUCER	<5 years	$15,000.00
RED3530	Process Mechanical	Gearboxes	Gearboxes	PT17: Reducer, Long Collector, PT17	REDUCER	<5 years	$15,000.00
TNK3517	Buildings and Grounds	Tanks	Tanks	PT17: Primary Tank 17, PT17	TANK,PRIM	15+ years	$200,000.00

Building PT18

Process Description Primary Clarification

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
MTR3531	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	PT18: Motor, Cross Collector Drive, PT18	MOTOR	10-15 years	$1,000.00
MTR3532	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	PT18: Motor, Long Collector Drive, PT18	MOTOR	5-10 years	$1,000.00
RED3531	Process Mechanical	Gearboxes	Gearboxes	PT18: Reducer, Cross Collector, PT18	REDUCER	<5 years	$15,000.00
RED3532	Process Mechanical	Gearboxes	Gearboxes	PT18: Reducer, Long Collector, PT18	REDUCER	<5 years	$15,000.00
TNK3518	Buildings and Grounds	Tanks	Tanks	PT18: Primary Tank 18, PT18	TANK,PRIM	15+ years	$200,000.00

Building PT19

Process Description Primary Clarification

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
MTR3533	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	PT19: Motor, Cross Collector Drive, PT19	MOTOR	10-15 years	$1,000.00
MTR3534	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	PT19: Motor, Long Collector Drive, PT19	MOTOR	5-10 years	$1,000.00
RED3533	Process Mechanical	Gearboxes	Gearboxes	PT19: Reducer, Cross Collector, PT19	REDUCER	<5 years	$15,000.00
RED3534	Process Mechanical	Gearboxes	Gearboxes	PT19: Reducer, Long Collector, PT19	REDUCER	<5 years	$15,000.00
TNK3519	Buildings and Grounds	Tanks	Tanks	PT19: Primary Tank 19, PT19	TANK,PRIM	15+ years	$200,000.00

Building PT20

Process Description Primary Clarification

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
MTR3535	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	PT20: Motor, Cross Collector Drive, PT20	MOTOR	5-10 years	$1,000.00
MTR3536	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	PT20: Motor, Long Collector Drive, PT20	MOTOR	5-10 years	$1,000.00
RED3535	Process Mechanical	Gearboxes	Gearboxes	PT20: Reducer, Cross Collector, PT20	REDUCER	<5 years	$15,000.00
RED3536	Process Mechanical	Gearboxes	Gearboxes	PT20: Reducer, Long Collector, PT20	REDUCER	<5 years	$15,000.00
TNK3520	Buildings and Grounds	Tanks	Tanks	PT20: Primary Tank 20, PT20	TANK,PRIM	15+ years	$200,000.00

Building PT21

Process Description Primary Clarification

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
MTR3537	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	PT21: Motor, Cross Collector Drive, PT21	MOTOR	5-10 years	$1,000.00
MTR3538	Electrical	2/4/6 Pole HV & LV Electric Motors	2/4/6 Pole HV & LV Electric Motors	PT21: Motor, Long Collector Drive, PT21	MOTOR	5-10 years	$1,000.00
RED3537	Process Mechanical	Gearboxes	Gearboxes	PT21: Reducer, Cross Collector, PT21	REDUCER	<5 years	$15,000.00
RED3538	Process Mechanical	Gearboxes	Gearboxes	PT21: Reducer, Long Collector, PT21	REDUCER	<5 years	$15,000.00
TNK3521	Buildings and Grounds	Tanks	Tanks	PT21: Primary Tank 21, PT21	TANK,PRIM	15+ years	$200,000.00

Building SHOP 1

Process Description Effluent Pumping

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
PMP4406	Process Mechanical	Uncategorized	Uncategorized	SH1 : Pump, Effluent Storage Tank Drain Pump 1, Shop 1	PUMP	5-10 years	$15,000.00
PMP4407	Process Mechanical	Uncategorized	Uncategorized	SH1 : Pump, Effluent Storage Tank Drain Pump 2, Shop 1	PUMP	5-10 years	$15,000.00

Building WEST PRI TNK

Process Description Primary Clarification

Asset ID	Group	Type	Equipment	Asset Description	Asset Type	Remaining Useful Life	Replacement Cost
CHA3502	Buildings and Grounds	Uncategorized	Uncategorized	Primary Influent Channel West	CHANNEL	>15 years	$200,000.00

APPENDIX B
ASSET RATING FORMS

Date: ______ Time: ______ Assessor Initials: ______ Company: ______

Asset ID: ______ Asset Description: ______

Asset Type: ______ Process Description ______

Building/Structure: ______ Parent ID: ______

Group: Buildings and Grounds Type: Buliding Envelope Management

Equipment: ______

A	Surface	Deterioration	
B	Surface	Leakage	
C	Structural Integrity / Function	Cracking	
D	Structural Integrity / Function	Movement	
E	Foundation	Ground Movement/ Erosion	
F	Connections	Cracking / Corrosion	

Rating Guide

A		
	1	Surface appears as new with little or no signs of deterioration.
	2	Some minor surface wear evident that has little impact on the structures strength or function.
	3	Surface deterioration becoming more evident however still little impact on structural integrity or function.
	4	Surface deterioration evident that has impacted on the assets structural integrity or function.
	5	Severe deterioration of surface presenting a high probability of the structures collapse or failure.
B		
	1	No leakage
	2	Small amount of leakage
	3	Moderate amount of leakage occurs
	4	Large amount of leakage occurs
	5	Extensive amount of water gets through roof
C		
	1	Structure sound - no cracking evident.
	2	Some minor cracking evident that has little impact on the structures strength or
	3	Cracking becoming more evident however still little impact on structural integrity or function.
	4	Cracking evident that has impacted on the assets structural integrity or function.

	5	Significant cracking evident that presents a high probability of the structures collapse or failure.
D		
	1	No movement evident.
	2	Some minor movement evident that has little impact on the structures strength or function.
	3	Asset has moved significantly however structural integrity and function are retained.
	4	Movement has impacted on the assets structural integrity or function.
	5	Movement has severe impact on structural integrity or function with a high likelihood of failure.
E		
	1	No movement/ erosion evident.
	2	Some minor movement/ erosion evident that has little impact on the structure's strength or function.
	3	Significant ground movement or erosion, however asset structural integrity and function are retained.
	4	Movement/ erosion has impacted on the asset's structural integrity or function.
	5	Movement/erosion has severe impact on structural integrity or function with a high likelihood of structural failure.
F		
	1	Connections sound - no cracking/corrosion evident
	2	Some minor cracking/corrosion evident that has little impact on the connections strength or function
	3	Cracking/corrosion becoming more evident however still little impact on structural integrity.
	4	Cracking/corrosion evident that has impacted on the structural integrity.
	5	Significant cracking/corrosion evident that presents a high probability of the connections failure.

Date: ______ Time: ______ Assessor Initials: ______ Company: ______

Asset ID: ______ Asset Description: ______

Asset Type: ______ Process Description ______

Building/Structure: ______ Parent ID: ______

Group: Buildings and Grounds

Type: Electrical/Instrumentation Equipment

Equipment: ______

A	Protective Enclosure	External Condition / Cooling / Sealing	
B	Internal Components	Deterioration / Overheating	
C	Internal Components	Age	
D	Internal Components	Availability	
E	Cabling	Color and brittleness	
F	Cabling	Insulation Resistance (Mega Test)	

Rating Guide

A		
	1	Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
	2	Coating cracked / flaking exposing undercoat < 20% of area, evidence of corrosion. Some seal wear but no dirt ingress. Ventilation and cooling adequate.
	3	Coating cracked / flaking exposing undercoat > 20% of area, panels corroding. Seal allowing some dirt ingress. Ventilation and cooling adequate.
	4	Coating cracked / flaking exposing metal > 20% of area, areas of panel heavily corroded. Seal allowing dirt ingress, contaminating components. Ventilation and cooling marginal.
	5	Coating cracked / flaking exposing metal > 40% of area. Areas of panel nearly corroded through. Seal allowing dirt ingress, contaminating components causing premature failure. Ventilation and cooling inadequate.
B		
	1	No visible deterioration. No burning smell.
	2	Some components showing minor signs of deterioration. No burning smell.
	3	Majority of components showing signs of deterioration. No burning smell.
	4	Components showing advanced signs of deterioration that will contribute to elevated temperatures and malfunction. Minor burning smell.
	5	Components overheating (smell) / malfunctioning and / or not operational. Major burning smell.
C		
	1	< 2 Years

	2	< 5 Years
	3	< 10 Years
	4	< 15 Years
	5	> 15 Years
D		
	1	Components available locally of the shelf.
	2	Components available interstate of the shelf.
	3	Components available internationally off the shelf. Spares stocked locally.
	4	Components available internationally to order.
	5	Components no longer available. Can be manufactured as specials.
E		
	1	No visible signs of color deterioration. Coating still pliable
	2	Coating pliable and providing good insulation protection however some minor signs of discoloration.
	3	Coating pliable however significant discoloration occurring
	4	Coating becoming brittle. Discoloration may or may not be present.
	5	Coating brittle and beginning to crack. Infrequent operational interruptions resulting.
F		
	1	Insulation protection as per original commissioning test.
	2	
	3	Insulation protection approximately 20 MegaOhms
	4	
	5	Insulation protection close to minimum acceptable limit

Date: ____________ Time: ________ Assessor Initials: ______ Company: __________

Asset ID: ____________ Asset Description: ________________________________

Asset Type: ______________ Process Description ______________

Building/Structure: ______________ Parent ID: ______________

Group: Buildings and Grounds Type: Fences

Equipment: ______________________

A	Fence Post & Wire / Fabric / Material	Security / Deterioration	____________

Rating Guide

A

1	Recently constructed, replaced or rehabilitated.
2	Some wear and tear but still provides good security.
3	Minor deterioration of post and wire however security function still maintained.
4	Significant deterioration of post and wire through rust, damage and loss of tension. Some breaches of security. (openings).
5	Severe deterioration of post and wire. Collapse likely in high winds or multiple locations of security breaches.

Date: ____________ Time: ________ Assessor Initials: ________ Company: __________

Asset ID: ____________ Asset Description: ______________________________

Asset Type: ______________ Process Description ______________

Building/Structure: ______________ Parent ID: ______________

Group: Buildings and Grounds Type: Fluid Measurement Instruments

Equipment: ________________________

A	Protective Enclosure	External Condition / Cooling / Sealing	
B	Internal Components	Deterioration / Overheating	
C	Internal Components	Age	

Rating Guide

A		
	1	Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
	2	Coating cracked / flaking exposing undercoat < 20% of area, evidence of corrosion. Some seal wear but no dirt ingress. Ventilation and cooling adequate.
	3	Coating cracked / flaking exposing undercoat > 20% of area, panels corroding. Seal allowing some dirt ingress. Ventilation and cooling adequate.
	4	Coating cracked / flaking exposing metal > 20% of area, areas of panel heavily corroded. Seal allowing dirt ingress, contaminating components. Ventilation and cooling marginal.
	5	Coating cracked / flaking exposing metal > 40% of area. Areas of panel nearly corroded through. Seal allowing dirt ingress, contaminating components causing premature failure. Ventilation and cooling inadequate.
B		
	1	No visible deterioration.
	2	Some components showing minor signs of deterioration
	3	Majority of components showing signs of deterioration.
	4	Components showing advanced signs of deterioration that will contribute to elevated temperatures and malfunction.
	5	Components overheating (smell) / malfunctioning and / or not operational.
C		
	1	< 2 Years
	2	< 5 Years
	3	< 10 Years
	4	< 15 Years
	5	> 15 Years

Date: ____ Time: ____ Assessor Initials: ____ Company: ____

Asset ID: ____ Asset Description: ____

Asset Type: ____ Process Description ____

Building/Structure: ____ Parent ID: ____

Group: Buildings and Grounds Type: Generators

Equipment: ____

A	Protective Enclosure	External Condition / Cooling / Sealing	
B	Internal Components	Deterioration / Overheating	
C	Internal Components	Age	
D	Cabling	Insulation Resistance (Mega) Test	
E	Cabling	Color and brittleness	
F	Use	Hours Run	

Rating Guide

A		
	1	Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
	2	Coating cracked / flaking exposing undercoat < 20% of area, evidence of corrosion. Some seal wear but no dirt ingress. Ventilation and cooling adequate.
	3	Coating cracked / flaking exposing undercoat > 20% of area, panels corroding. Seal allowing some dirt ingress. Ventilation and cooling adequate.
	4	Coating cracked / flaking exposing metal > 20% of area, areas of panel heavily corroded. Seal allowing dirt ingress, contaminating components. Ventilation and cooling marginal.
	5	Coating cracked / flaking exposing metal > 40% of area. Areas of panel nearly corroded through. Seal allowing dirt ingress, contaminating components causing premature failure. Ventilation and cooling inadequate.
B		
	1	No visible deterioration.
	2	Some components showing minor signs of deterioration
	3	Majority of components showing signs of deterioration.
	4	Components showing advanced signs of deterioration that will contribute to elevated temperatures and malfunction.
	5	Components overheating (smell) / malfunctioning and / or not operational.
C		
	1	< 5 Years
	2	> 5 Years

	3	> 10 Years
	4	> 15 Years
	5	> 20 Years
D		
	1	Insulation protection as per original commissioning test.
	2	
	3	Insulation protection approximately 20 MegaOhms
	4	
	5	Insulation protection close to minimum acceptable limit
E		
	1	No visible signs of color deterioration. Coating still pliable
	2	Coating pliable and providing good insulation protection however some minor signs of discoloration.
	3	Coating pliable however significant discoloration occurring
	4	Coating becoming brittle. Discoloration may or may not be present.
	5	Coating brittle and beginning to crack. Infrequent operational interruptions resulting.
F		
	1	Less than 10% of lifetime estimate
	2	Over 25% of life time estimate
	3	Over 50% of lifetime estimate
	4	Within 25% of lifetime estimate
	5	Within 10% of lifetime estimate

Date:		Time:		Assessor Initials:		Company:	
Asset ID:		Asset Description:					
Asset Type:		Process Description					
Building/Structure:		Parent ID:					
Group:	Buildings and Grounds	Type:	HVAC				
Equipment:							

A	Structure Appearance	Surface Deterioration	
B	Structure Appearance	Shaft, Supports, Bearing Deterioration	
C	Symptoms	Vibration / Oscillation	
D	Symptoms	Temperature	
E	Symptoms	Noise	

Rating Guide

A		
	1	Surface appears as new with little or no signs of deterioration.
	2	Some minor surface wear evident that has little impact on the structures strength or function.
	3	Surface deterioration becoming more evident however still little impact on structural integrity or function.
	4	Surface deterioration evident that has impacted on the assets structural integrity or function.
	5	Severe deterioration of surface presenting a high probability of the structures collapse or failure.
B		
	1	Shaft & supports sound - no shaft distortion or deterioration evident.
	2	Minor shaft/ support deterioration evident, no impact on the structural strength or function.
	3	Shaft distortion or bearing/housing wear evident, little impact on structural integrity or function.
	4	Shaft distortion or bearing/housing wear evident and has impacted on asset integrity or function.
	5	Significant shaft distortion or bearing/housing wear evident, high probability of fracture or failure.
C		
	1	No unusual vibration detectable
	2	Minor vibration detected
	3	Moderate vibration
	4	Considerable vibration

	5	Major vibration
D		
	1	No unusual temperature detected
	2	Minimal heat from casing using hand
	3	Heat detected by hand
	4	Heat detected by hand is uncomfortable
	5	Heat too high to assess by hand
E		
	1	No unusual noises detected.
	2	Slight whine/rattle detected.
	3	Moderate whine/rattle detected, easily heard over pump noise.
	4	Loud whine/rattle.
	5	Disturbingly loud operation/vibrations.

Date: ______ Time: ______ Assessor Initials: ______ Company: ______

Asset ID: ______ Asset Description: ______

Asset Type: ______ Process Description ______

Building/Structure: ______ Parent ID: ______

Group: Buildings and Grounds Type: Interiors

Equipment: ______

A	Life	Deterioration	______

Rating Guide

A

1	Asset appears to be in very good condition, with more than 80% of life remaining
2	Asset appears to be in good condition, with 60-80% of life remaining
3	Asset appears to be in average condition, with approx 50% of life remaining
4	Asset appears to be in poor condition, with approx 20-40% of life remaining
5	Asset appears to be in very poor condition, with less than 20% of life remaining

Date: ______ Time: ______ Assessor Initials: ______ Company: ______

Asset ID: ______ Asset Description: ______

Asset Type: ______ Process Description ______

Building/Structure: ______ Parent ID: ______

Group: Buildings and Grounds

Type: Life Safety, Fire Protection, and ADA

Equipment: ______

A	Life	Deterioration	______

Rating Guide

A

1	Asset appears to be in very good condition, with more than 80% of life remaining
2	Asset appears to be in good condition, with 60-80% of life remaining
3	Asset appears to be in average condition, with approx 50% of life remaining
4	Asset appears to be in poor condition, with approx 20-40% of life remaining
5	Asset appears to be in very poor condition, with less than 20% of life remaining

Date: ____________ Time: ________ Assessor Initials: ________ Company: __________

Asset ID: ____________ Asset Description: ________________________________

Asset Type: ______________ Process Description ______________

Building/Structure: ______________ Parent ID: ______________

Group: Buildings and Grounds Type: Pavements

Equipment: ____________________________

A	Surface Material	Cracking / Pot Holes / Depressions	________
B	Drainage	Ponding / Drainage Rate	________

Rating Guide

A		
	1	Recently constructed, remodeled, replaced, rehabilitated.
	2	Some signs of surface ageing however no deformation or cracking evident.
	3	Some obvious cracking, minor surface loss or potholes. Pavement underneath exhibiting no depressions.
	4	Cracking evident through majority of area. Some potholing and depressions occurring.
	5	Severe deterioration of surface through cracking, potholes, etc. Pavement underneath shows significant depressions.
B		
	1	Drainage quickly and effectively removes all water from pavement area with no ponding within drainage channels
	2	Water effectively removed from pavement however some ponding occurs within drainage channels
	3	Some ponding on pavement and drainage channels slow to dissipate water collected.
	4	Significant ponding of water over pavement following rains however water drained away with a few hours.
	5	Significant ponding of water over pavement for periods exceeding 24 hours following rainfall

Date: ______ Time: ______ Assessor Initials: ______ Company: ______

Asset ID: ______ Asset Description: ______

Asset Type: ______ Process Description ______

Building/Structure: ______ Parent ID: ______

Group: Buildings and Grounds Type: Plumbing Systems

Equipment: ______

A	Life	Deterioration	______
B	Service Distribution	Loss / Impact / Efficiency	______

Rating Guide

A		
	1	Asset appears to be in very good condition, with more than 80% of life remaining
	2	Asset appears to be in good condition, with 60-80% of life remaining
	3	Asset appears to be in average condition, with approx 50% of life remaining
	4	Asset appears to be in poor condition, with approx 20-40% of life remaining
	5	Asset appears to be in very poor condition, with less than 20% of life remaining
B		
	1	No visible evidence of leakage. Efficiency of distribution > 90%.
	2	Some minor signs of leakage having no impact on building occupants or environment. Efficiency of distribution > 80%.
	3	Leakage moderate but no impact on building occupants. Minor affect on environmental health. Efficiency of distribution > 70%.
	4	Significant service loss affecting building occupants and / or causing environmental health problems. Efficiency of distribution > 50%.
	5	Service loss affecting building occupants and / or causing significant environmental damage. Efficiency of distribution < 50%.

Date: ______ Time: ______ Assessor Initials: ______ Company: ______

Asset ID: ______ Asset Description: ______

Asset Type: ______ Process Description ______

Building/Structure: ______ Parent ID: ______

Group: Buildings and Grounds Type: Roofs

Equipment: ______

A	Roof Structure	Deterioration	______

Rating Guide

A

1	Appears in excellent or as new condition with no visible signs of deterioration.
2	Minor deterioration evident <10% of asset value required to restore asset to near new condition.
3	Moderate deterioration. < 30% of asset value required to restore asset to near new condition.
4	Significant deterioration. < 50% of asset value required to restore asset to near new condition.
5	Major deterioration of assets performance. Failure likely within near future .

Date: ______ Time: ______ Assessor Initials: ______ Company: ______

Asset ID: ______ Asset Description: ______

Asset Type: ______ Process Description ______

Building/Structure: ______ Parent ID: ______

Group: Buildings and Grounds Type: Site Utility Assets

Equipment: ______

A	Life	Deterioration	______
B	Service Distribution	Loss / Impact / Efficiency	______

Rating Guide

A		
	1	Asset appears to be in very good condition, with more than 80% of life remaining
	2	Asset appears to be in good condition, with 60-80% of life remaining
	3	Asset appears to be in average condition, with approx 50% of life remaining
	4	Asset appears to be in poor condition, with approx 20-40% of life remaining
	5	Asset appears to be in very poor condition, with less than 20% of life remaining
B		
	1	No visible evidence of leakage. Efficiency of distribution > 90%.
	2	Some minor signs of leakage having no impact on neighboring properties / environment. Efficiency of distribution > 80%.
	3	Leakage moderate but no impact on neighboring property. Minor affect on environment. Efficiency of distribution > 70%.
	4	Significant service loss affecting neighboring property, potential for claim for damages and / or causing environmental damage. Efficiency of distribution > 50%.
	5	Service loss affecting neighboring property, claim for damages and / or causing significant environmental damage. Efficiency of distribution < 50%.

Date: ______ Time: ______ Assessor Initials: ______ Company: ______

Asset ID: ______ Asset Description: ______

Asset Type: ______ Process Description ______

Building/Structure: ______ Parent ID: ______

Group: Buildings and Grounds Type: Structures

Equipment: ______

A	Structural Integrity / Function	Cracking	
B	Structural Integrity / Function	Movement	
C	Surface	Deterioration	
D	Foundation	Ground Movement/ Erosion	
E	Connections	Cracking / Corrosion	

Rating Guide

A		
	1	Structure sound - no cracking evident.
	2	Some minor cracking evident that has little impact on the structures strength or
	3	Cracking becoming more evident however still little impact on structural integrity or function.
	4	Cracking evident that has impacted on the assets structural integrity or function.
	5	Significant cracking evident that presents a high probability of the structures collapse or failure.
B		
	1	No movement evident.
	2	Some minor movement evident that has little impact on the structures strength or function.
	3	Asset has moved significantly however structural integrity and function are retained.
	4	Movement has impacted on the assets structural integrity or function.
	5	Movement has severe impact on structural integrity or function with a high likelihood of failure.
C		
	1	Surface appears as new with little or no signs of deterioration.
	2	Some minor surface wear evident that has little impact on the structures strength or function.
	3	Surface deterioration becoming more evident however still little impact on structural integrity or function.
	4	Surface deterioration evident that has impacted on the assets structural integrity or function.

	5	Severe deterioration of surface presenting a high probability of the structures collapse or failure.
D		
	1	No movement/ erosion evident.
	2	Some minor movement/ erosion evident that has little impact on the structure's strength or function.
	3	Significant ground movement or erosion, however asset structural integrity and function are retained.
	4	Movement/ erosion has impacted on the asset's structural integrity or function.
	5	Movement/erosion has severe impact on structural integrity or function with a high likelihood of structural failure.
E		
	1	Connections sound - no cracking/corrosion evident
	2	Some minor cracking/corrosion evident that has little impact on the connections strength or function
	3	Cracking/corrosion becoming more evident however still little impact on structural integrity.
	4	Cracking/corrosion evident that has impacted on the structural integrity.
	5	Significant cracking/corrosion evident that presents a high probability of the connections failure.

Date: ______ Time: ______ Assessor Initials: ______ Company: ______

Asset ID: ______ Asset Description: ______

Asset Type: ______ Process Description ______

Building/Structure: ______ Parent ID: ______

Group: Buildings and Grounds

Type: Vertical Transportation / Conveyance

Equipment: ______

A	Fixings	Cracking / Corrosion	______
B	Steel Structure	Coating / Steel - Cracking, Flaking Corrosion	______
C	Trolley and Crane	Coating / Function	______

Rating Guide

A		
	1	Fixing sound - no cracking/corrosion evident
	2	Some minor cracking/corrosion evident that has little impact on the fixings strength or function
	3	Cracking/corrosion becoming more evident however still little impact on structural integrity.
	4	Cracking/corrosion evident that has impacted on the structural integrity.
	5	Significant cracking/corrosion evident that presents a high probability of the fixings failure. Crane cannot be used.
B		
	1	Coating / Steel sound - no cracking or corrosion.
	2	Coating cracked / flaking exposing undercoat.
	3	Coating cracked / flaking exposing metal.
	4	Coating / undercoat cracked / flaking exposing metal. Corrosion/pitting of metal surface at any one location.
	5	Coating / undercoat cracked / flaking exposing metal. Corrosion/pitting of metal surface at several locations.
C		
	1	Coating / Steel sound - no cracking or corrosion. Functions as new.
	2	Coating cracked / flaking exposing undercoat. Functions Ok.
	3	Coating cracked / flaking exposing metal. Maintenance of function required.
	4	Coating / undercoat cracked / flaking exposing metal. Corrosion/pitting of metal surface at any one location. Extensive maintenance required.
	5	Coating / undercoat cracked / flaking exposing metal. Corrosion/pitting of metal surface at several locations. Crane/trolley does not operate.

Date: ______ Time: ______ Assessor Initials: ______ Company: ______

Asset ID: ______ Asset Description: ______

Asset Type: ______ Process Description ______

Building/Structure: ______ Parent ID: ______

Group: Electrical

Type: Electrical/Instrumentation Equipment

Equipment: ______

A	Protective Enclosure	External Condition / Cooling / Sealing	______
B	Internal Components	Deterioration / Overheating	______
C	Internal Components	Age	______
D	Internal Components	Availability	______
E	Cabling	Color and brittleness	______
F	Cabling	Insulation Resistance (Mega Test)	______

Rating Guide

A		
	1	Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
	2	Coating cracked / flaking exposing undercoat < 20% of area, evidence of corrosion. Some seal wear but no dirt ingress. Ventilation and cooling adequate.
	3	Coating cracked / flaking exposing undercoat > 20% of area, panels corroding. Seal allowing some dirt ingress. Ventilation and cooling adequate.
	4	Coating cracked / flaking exposing metal > 20% of area, areas of panel heavily corroded. Seal allowing dirt ingress, contaminating components. Ventilation and cooling marginal.
	5	Coating cracked / flaking exposing metal > 40% of area. Areas of panel nearly corroded through. Seal allowing dirt ingress, contaminating components causing premature failure. Ventilation and cooling inadequate.
B		
	1	No visible deterioration. No burning smell.
	2	Some components showing minor signs of deterioration. No burning smell.
	3	Majority of components showing signs of deterioration. No burning smell.
	4	Components showing advanced signs of deterioration that will contribute to elevated temperatures and malfunction. Minor burning smell.
	5	Components overheating (smell) / malfunctioning and / or not operational. Major burning smell.
C		
	1	< 2 Years

	2	< 5 Years
	3	< 10 Years
	4	< 15 Years
	5	> 15 Years
D		
	1	Components available locally of the shelf.
	2	Components available interstate of the shelf.
	3	Components available internationally off the shelf. Spares stocked locally.
	4	Components available internationally to order.
	5	Components no longer available. Can be manufactured as specials.
E		
	1	No visible signs of color deterioration. Coating still pliable
	2	Coating pliable and providing good insulation protection however some minor signs of discoloration.
	3	Coating pliable however significant discoloration occurring
	4	Coating becoming brittle. Discoloration may or may not be present.
	5	Coating brittle and beginning to crack. Infrequent operational interruptions resulting.
F		
	1	Insulation protection as per original commissioning test.
	2	
	3	Insulation protection approximately 20 MegaOhms
	4	
	5	Insulation protection close to minimum acceptable limit

Date: ____________ Time: ________ Assessor Initials: ________ Company: ____________

Asset ID: ____________ Asset Description: ______________________________

Asset Type: ______________ Process Description ______________

Building/Structure: ______________ Parent ID: ______________

Group: Electrical Type: Generators

Equipment: ______________________

A	Protective Enclosure	External Condition / Cooling / Sealing	________
B	Internal Components	Deterioration / Overheating	________
C	Internal Components	Age	________
D	Cabling	Insulation Resistance (Mega) Test	________
E	Cabling	Color and brittleness	________
F	Use	Hours Run	________

Rating Guide

A		
	1	Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
	2	Coating cracked / flaking exposing undercoat < 20% of area, evidence of corrosion. Some seal wear but no dirt ingress. Ventilation and cooling adequate.
	3	Coating cracked / flaking exposing undercoat > 20% of area, panels corroding. Seal allowing some dirt ingress. Ventilation and cooling adequate.
	4	Coating cracked / flaking exposing metal > 20% of area, areas of panel heavily corroded. Seal allowing dirt ingress, contaminating components. Ventilation and cooling marginal.
	5	Coating cracked / flaking exposing metal > 40% of area. Areas of panel nearly corroded through. Seal allowing dirt ingress, contaminating components causing premature failure. Ventilation and cooling inadequate.
B		
	1	No visible deterioration.
	2	Some components showing minor signs of deterioration
	3	Majority of components showing signs of deterioration.
	4	Components showing advanced signs of deterioration that will contribute to elevated temperatures and malfunction.
	5	Components overheating (smell) / malfunctioning and / or not operational.
C		
	1	< 5 Years
	2	> 5 Years

	3	> 10 Years
	4	> 15 Years
	5	> 20 Years
D		
	1	Insulation protection as per original commissioning test.
	2	
	3	Insulation protection approximately 20 MegaOhms
	4	
	5	Insulation protection close to minimum acceptable limit
E		
	1	No visible signs of color deterioration. Coating still pliable
	2	Coating pliable and providing good insulation protection however some minor signs of discoloration.
	3	Coating pliable however significant discoloration occurring
	4	Coating becoming brittle. Discoloration may or may not be present.
	5	Coating brittle and beginning to crack. Infrequent operational interruptions resulting.
F		
	1	Less than 10% of lifetime estimate
	2	Over 25% of life time estimate
	3	Over 50% of lifetime estimate
	4	Within 25% of lifetime estimate
	5	Within 10% of lifetime estimate

Date: ______ Time: ______ Assessor Initials: ______ Company: ______

Asset ID: ______ Asset Description: ______

Asset Type: ______ Process Description ______

Building/Structure: ______ Parent ID: ______

Group: Electrical Type: Med and Low Volt MCCs

Equipment: ______

A	Protective Enclosure - External	External Enclosure Condition /Cooling /Sealing	
B	Protective Enclosure - Internal	Internal Enclosure Condition/ Starters Racking/ Code Violations	
C	Internal Components	Alignment of drawout devices / Mechanical Deficiencies	
D	Internal Components	Age	
E	Internal Components	Availability of Spare Parts	
F	Internal Components	Functionality of starters.	
G	Cabling	Cables immersed in water	
G	Cabling	Color and brittleness	

Rating Guide

A		
	1	No visible deterioration /ventilation and cooling good
	2	Coating cracked /flaking exposing undercoat < 20% of area /evidence of corrosion /ventilation and cooling adequate
	3	Coating cracked /flaking exposing between 20% to 30% undercoat /evidence of corrosion /ventilation and cooling adequate
	4	Coating cracked/ flaking exposing between 30% to 50% undercoat /ventilation and cooling marginal
	5	Coating cracked/ flaking exposing greater than 50% undercoat / corrosion in some areas /ventilation and cooling not adequate
B		
	1	Starters racking good/ code compliance
	2	Starters racking good/ code compliance
	3	Starters racking difficult for up to 5% of breakers/ code compliance
	4	Starters racking difficult for up to 20% of breakers/ code compliance
	5	Starters racking difficult for more than 20% of breakers/ code violation(s)
C		

	1	Smooth/ correctly aligning/ limit switches operate correctly
	2	Slight tightness and/or alignment issues. Adjustments required
	3	Racking/ alignment issues. Component replacement required.
	4	Racking/ alignment issues, Obsolescence
	5	Major racking/ alignment issues. May result in major failure.
D		
	1	<30 Years
	2	Between 30 to 39 Years
	3	Between 40 to 44 Years
	4	Between 45 to 50 Years
	5	>50 Years
E		
	1	Components available locally off the shelf.
	2	Components available interstate off the shelf from at least two vendors.
	3	Components available interstate off the shelf from only one vendor.
	4	Components available interstate to order.
	5	Components no longer available.
F		
	1	Starters operate as intended.
	2	99% of starters operate as intended.
	3	Up to 5% of starters do not operate.
	4	Up to 10% of starters do not operate.
	5	More than 10% of starters do not operate.
G		
	1	No visible sign of tracking.
	1	No visible signs of color deterioration. Coating still pliable.
	2	Tracking visible on less than 5% of area.
	2	Coating pliable and providing good insulation protection, however some minor signs of discoloration.
	3	Coating pliable however significant deterioration.
	3	Tracking visible on 5% to 50% of area.
	4	Coating becoming brittle. Discoloration may or may not be present.
	4	Visible signs of tracking on more than 50% of area.
	5	Coating brittle and beginning to crack. Infrequent operational interruptions resulting.
	5	Visible signs of tracking. Infrequent operation interruptions.

Date: ____ Time: ____ Assessor Initials: ____ Company: ____

Asset ID: ____ Asset Description: ____

Asset Type: ____ Process Description ____

Building/Structure: ____ Parent ID: ____

Group: Electrical Type: Med Volt Switch Gear Air Break

Equipment: ____

A	Protective Enclosure - External	External Enclosure Condition /Sealing	
B	Protective Enclosure - External	Switch Operation/ Code Violations	
C	Internal Components	Blade alignment /travel stops /arc interrupter	
D	Internal Components	Age of arc interrupters	
E	Internal Components	Availability of Spare Parts	
F	Internal Components	Functionality of air switches.	
G	Cabling	Cables immersed in water	
G	Cabling	Color and brittleness	

Rating Guide

A		
	1	No visible deterioration /no leaks
	2	Coating cracked /flaking exposing undercoat < 20% of area /evidence of corrosion /some seal wear but no dirt ingress /no leaks
	3	Coating cracked /flaking exposing between 20% to 30% undercoat /evidence of corrosion /some seal wear but no dirt ingress /no leaks
	4	Coating cracked/ flaking exposing between 30% to 50% undercoat /evidence of corrosion/ dirt ingress contaminating some components /minor water leaks
	5	Coating cracked/ flaking exposing greater than 50% undercoat / corrosion in some areas / dirt ingress contaminating internal components /water leaks
B		
	1	Switch Operation/ code compliance
	2	Switch operation good for up to 95% of switches/ code compliance
	3	Switch operation good between 90% to 95% of switches/ code compliance
	4	Switch operation good between 80% to 90% of switches/ code compliance
	5	Switch operation good for less than 80% of switches/ code violation(s)
C		
	1	Smooth/ correctly aligning/ correctly penetrating /correct travel stops /correct arc interruption.

	2	Slight tightness and/or alignment /penetration /travel stops /interruption issues. Corrections required
	3	Alignment /penetration /travel stops /interruption issues. Component replacement required.
	4	Alignment /penetration /travel stops /interruption issues, Obsolescence
	5	Alignment /penetration /travel stops /interruption issues. May result in major failure. Safety hazard.
D		
	1	<10 Years
	2	Between 10 to 15 Years
	3	Between 15 to 20 Years
	4	Between 20 to 30 Years
	5	>30 Years
E		
	1	Components available locally off the shelf.
	2	Components available interstate off the shelf from at least two vendors.
	3	Components available interstate off the shelf from only one vendor.
	4	Components available interstate to order.
	5	Components no longer available.
F		
	1	Operate as intended.
	2	Up to 5% of switches do not operate as intended.
	3	Up to 10% of switches do not operate as intended.
	4	Up to 20% of switches do not operate as intended.
	5	More than 20% of switches do not operate as intended.
G		
	1	No visible sign of tracking.
	1	No visible signs of color deterioration. Coating still pliable.
	2	Tracking visible on less than 5% of area.
	2	Coating pliable and providing good insulation protection, however some minor signs of discoloration.
	3	Coating pliable however significant deterioration.
	3	Tracking visible on 5% to 50% of area.
	4	Coating becoming brittle. Discoloration may or may not be present.
	4	Visible signs of tracking on more than 50% of area.
	5	Coating brittle and beginning to crack. Infrequent operational interruptions resulting.
	5	Visible signs of tracking. Infrequent operation interruptions.

Date: ______ Time: ______ Assessor Initials: ______ Company: ______

Asset ID: ______ Asset Description: ______

Asset Type: ______ Process Description ______

Building/Structure: ______ Parent ID: ______

Group: Electrical Type: Miscellaneous Process Equipment

Equipment: ______

Date: ____ Time: ____ Assessor Initials: ____ Company: ____

Asset ID: ____ Asset Description: ____

Asset Type: ____ Process Description ____

Building/Structure: ____ Parent ID: ____

Group: Electrical Type: No-Walk-in Low Volt Switchgear

Equipment: ____

A	Protective Enclosure - External	External Enclosure Condition /Cooling /Sealing	
B	Protective Enclosure - Internal	Internal Enclosure Condition/ Breaker Racking/ Code Violations	
C	Internal Components Internal Components	Alignment of drawout devices / Mechanical Deficiencies	
D	Internal Components	Age	
E	Internal Components	Availability of Spare Parts	
F	Internal Components	Functionality of breakers.	
G	Cabling	Cables immersed in water	
G	Cabling	Color and brittleness	

Rating Guide

A		
	1	No visible deterioration /ventilation and cooling good
	2	Coating cracked /flaking exposing undercoat < 20% of area /evidence of corrosion /ventilation and cooling adequate
	3	Coating cracked /flaking exposing between 20% to 30% undercoat /evidence of corrosion /ventilation and cooling adequate
	4	Coating cracked/ flaking exposing between 30% to 50% undercoat /ventilation and cooling marginal
	5	Coating cracked/ flaking exposing greater than 50% undercoat / corrosion in some areas /ventilation and cooling not adequate
B		
	1	Breaker racking good/ code compliance
	2	Breaker racking good/ code compliance
	3	Breaker racking difficult for up to 5% of breakers/ code compliance
	4	Breaker racking difficult for up to 20% of breakers/ code compliance
	5	Breaker racking difficult for more than 20% of breakers/ code violation(s)
C		

	1	Smooth/ correctly aligning/ limit switches operate correctly
	2	Slight tightness and/or alignment issues. Adjustments required
	3	Racking/ alignment issues. Component replacement required.
	4	Racking/ alignment issues, Obsolescence
	5	Major racking/ alignment issues. May result in major failure.
D		
	1	<30 Years
	2	Between 30 to 39 Years
	3	Between 40 to 44 Years
	4	Between 45 to 50 Years
	5	>50 Years
E		
	1	Components available locally off the shelf.
	2	Components available interstate off the shelf from at least two vendors.
	3	Components available interstate off the shelf from only one vendor.
	4	Components available interstate to order.
	5	Components no longer available.
F		
	1	Breakers operate as intended.
	2	99% of breakers operate as intended.
	3	Up to 5% of breakers do not operate.
	4	Up to 10% of breakers do not operate.
	5	More than 10% of breakers do not operate.
G		
	1	No visible sign of tracking.
	1	No visible signs of color deterioration. Coating still pliable.
	2	Tracking visible on less than 5% of area.
	2	Coating pliable and providing good insulation protection, however some minor signs of discoloration.
	3	Coating pliable however significant deterioration.
	3	Tracking visible on 5% to 50% of area.
	4	Coating becoming brittle. Discoloration may or may not be present.
	4	Visible signs of tracking on more than 50% of area.
	5	Coating brittle and beginning to crack. Infrequent operational interruptions resulting.
	5	Visible signs of tracking. Infrequent operation interruptions.

Date: ______ Time: ______ Assessor Initials: ______ Company: ______

Asset ID: ______ Asset Description: ______

Asset Type: ______ Process Description ______

Building/Structure: ______ Parent ID: ______

Group: Electrical Type: No-Walk-in Med Volt Switchgear

Equipment: ______

A	Protective Enclosure - External	External Enclosure Condition /Cooling /Sealing	______
B	Protective Enclosure - Internal	Internal Enclosure Condition/ Breaker Racking/ Code Violations	______
C	Internal Components	Alignment of drawout devices / Mechanical Deficiencies	______
D	Internal Components	Age	______
E	Internal Components	Availability of Spare Parts	______
F	Internal Components	Functionality of breakers/arc chutes	______
G	Cabling	Cables immersed in water	______
G	Cabling	Color and brittleness	______

Rating Guide

A		
	1	No visible deterioration /ventilation and cooling good
	2	Coating cracked /flaking exposing undercoat < 20% of area /evidence of corrosion /ventilation and cooling adequate
	3	Coating cracked /flaking exposing between 20% to 30% undercoat /evidence of corrosion /ventilation and cooling adequate
	4	Coating cracked/ flaking exposing between 30% to 50% undercoat /ventilation and cooling marginal
	5	Coating cracked/ flaking exposing greater than 50% undercoat / corrosion in some areas /ventilation and cooling not adequate
B		
	1	Breaker racking good/ code compliance
	2	Breaker racking good/ code compliance
	3	Breaker racking difficult for up to 5% of breakers/ code compliance
	4	Breaker racking difficult for up to 20% of breakers/ code compliance
	5	Breaker racking difficult for more than 20% of breakers/ code violation(s)
C		

	1	Smooth/ correctly aligning/ limit switches operate correctly
	2	Slight tightness and/or alignment issues. Adjustments required
	3	Racking/ alignment issues. Component replacement required.
	4	Racking/ alignment issues, Obsolescence
	5	Major racking/ alignment issues. May result in major failure.
D		
	1	<30 Years
	2	Between 30 to 39 Years
	3	Between 40 to 44 Years
	4	Between 45 to 50 Years
	5	>50 Years
E		
	1	Components available locally off the shelf.
	2	Components available interstate off the shelf from at least two vendors.
	3	Components available interstate off the shelf from only one vendor.
	4	Components available interstate to order.
	5	Components no longer available.
F		
	1	Breakers operate as intended/no deterioration of arc chutes.
	2	Breakers operate as intended/up to 20% deterioration of arc chutes.
	3	Up to 5% of breakers do not operate/between 20% to 30% deterioration of arc chutes.
	4	Up to 10% of breakers do not operate/between 30% to 50% deterioration of arc chutes.
	5	More than 10% of breakers do not operate/more than 50% deterioration of arc chutes.
G		
	1	No visible sign of tracking.
	1	No visible signs of color deterioration. Coating still pliable.
	2	Tracking visible on less than 5% of area.
	2	Coating pliable and providing good insulation protection, however some minor signs of discoloration.
	3	Coating pliable however significant deterioration.
	3	Tracking visible on 5% to 50% of area.
	4	Coating becoming brittle. Discoloration may or may not be present.
	4	Visible signs of tracking on more than 50% of area.
	5	Coating brittle and beginning to crack. Infrequent operational interruptions.
	5	Visible signs of tracking. Infrequent operation interruptions.

Date: ______ Time: ______ Assessor Initials: ______ Company: ______

Asset ID: ______ Asset Description: ______

Asset Type: ______ Process Description ______

Building/Structure: ______ Parent ID: ______

Group: Electrical Type: Outdoor Liquid Filled Transform

Equipment: ______

A	Protective Enclosure - External	External Enclosure Condition /Cooling /Sealing	
B	External Components	Cooling Fans	
C	Internal Components	Age	
D	Internal Components	Pressure on gas blanketed transformers	
D	Internal Components	Temperature	
D	Internal Components	Liquid Levels in transformers tanks and bushings	
D	Internal Components	Bushing	
D	Internal Components	Availability of Spare Parts	
E	Cabling	Cables immersed in water	
E	Cabling	Color and brittleness	

Rating Guide

A		
	1	No visible deterioration /no leaks /ventilation and cooling good
	2	Coating cracked /flaking exposing undercoat < 20% of area /evidence of corrosion /some seal wear but no oil leaks /ventilation and cooling adequate
	3	Coating cracked /flaking exposing between 20% to 30% undercoat /evidence of corrosion /some oil leaks /ventilation and cooling adequate
	4	Coating cracked/ flaking exposing between 30% to 50% undercoat /evidence of corrosion/ oil leaks /enclosures ventilation and cooling marginal
	5	Coating cracked/ flaking exposing greater than 50% undercoat / corrosion in some areas/ oil leaks /ventilation and cooling not adequate
B		
	1	Operate as intended
	2	Occasionally fails to operate. Adjustments required
	3	Frequently fails to operate. Component replacement required
	4	Fans operate but oil temperature at 80% of specified value
	5	Fans operate but oil temperature at 100% of specified value

C		
	1	<30 Years
	2	Between 30 to 39 Years
	3	Between 40 to 44 Years
	4	Between 45 to 50 Years
	5	>50 Years
D		
	1	Components available locally off the shelf.
	1	No visible signs of color deterioration. No tracking. No cracks
	1	Pressure 20% above acceptable level.
	1	Temperature 20% below acceptable level
	1	Levels 20% above acceptable values.
	2	Tracking visible on less than 5% of area.
	2	Components available interstate off the shelf.
	2	Levels 10% above acceptable values.
	2	Temperature 10% below acceptable level
	2	Pressure 10% acceptable level.
	3	Temperature at the acceptable level
	3	Components available internationally off the shelf.
	3	Pressure at acceptable level.
	3	Tracking visible on 5% to 50% of area.
	3	Levels at acceptable values.
	4	Components available internationally to order.
	4	Tracking visible on more than 50% of area.
	4	Levels below acceptable values.
	4	Temperature 5% above acceptable level
	4	Pressure 10% below acceptable level.
	5	Pressure 30% below acceptable level.
	5	Levels below acceptable vales resulting in 20% increase in temperature rise above acceptable values.
	5	Temperature 20% above acceptable level
	5	Components no longer available.
	5	Visible signs of tracking. Infrequent operation interruptions.
E		
	1	No visible sign of tracking.
	1	No visible signs of color deterioration. Coating still pliable.
	2	Tracking visible on less than 5% of area.
	2	Coating pliable and providing good insulation protection, however some minor signs of discoloration.

	3	Coating pliable however significant deterioration.
	3	Tracking visible on 5% to 50% of area.
	4	Coating becoming brittle. Discoloration may or may not be present.
	4	Visible signs of tracking on more than 50% of area.
	5	Coating brittle and beginning to crack. Infrequent operational interruptions resulting.
	5	Visible signs of tracking. Infrequent operation interruptions.

Date: ______ Time: ______ Assessor Initials: ______ Company: ______

Asset ID: ______ Asset Description: ______

Asset Type: ______ Process Description ______

Building/Structure: ______ Parent ID: ______

Group: Electrical Type: Walk-in Low Volt Switchgear

Equipment: ______

A	Protective Enclosure - External	External Enclosure Condition /Cooling /Sealing	
B	Protective Enclosure - Internal	Internal Enclosure Condition/ Breaker Racking/ Code Violations	
C	Internal Components	Alignment of drawout devices / Mechanical Deficiencies	
D	Internal Components	Age	
E	Internal Components	Availability of Spare Parts	
F	Internal Components	Functionality of breakers.	
G	Cabling	Cables immersed in water	
G	Cabling	Color and brittleness	

Rating Guide

A		
	1	No visible deterioration /ventilation and cooling good
	2	Coating cracked /flaking exposing undercoat < 20% of area /evidence of corrosion /ventilation and cooling adequate
	3	Coating cracked /flaking exposing between 20% to 30% undercoat /evidence of corrosion /ventilation and cooling adequate
	4	Coating cracked/ flaking exposing between 30% to 50% undercoat /ventilation and cooling marginal
	5	Coating cracked/ flaking exposing greater than 50% undercoat / corrosion in some areas /ventilation and cooling not adequate
B		
	1	Breaker racking good/ code compliance
	2	Breaker racking good/ code compliance
	3	Breaker racking difficult for up to 5% of breakers/ code compliance
	4	Breaker racking difficult for up to 20% of breakers/ code compliance
	5	Breaker racking difficult for more than 20% of breakers/ code violation(s)
C		

	1	Smooth/ correctly aligning/ limit switches operate correctly
	2	Slight tightness and/or alignment issues. Adjustments required
	3	Racking/ alignment issues. Component replacement required.
	4	Racking/ alignment issues, Obsolescence
	5	Major racking/ alignment issues. May result in major failure.
D		
	1	<30 Years
	2	Between 30 to 39 Years
	3	Between 40 to 44 Years
	4	Between 45 to 50 Years
	5	>50 Years
E		
	1	Components available locally off the shelf.
	2	Components available interstate off the shelf from at least two vendors.
	3	Components available interstate off the shelf from only one vendor.
	4	Components available interstate to order.
	5	Components no longer available.
F		
	1	Breakers operate as intended.
	2	99% of breakers operate as intended.
	3	Up to 5% of breakers do not operate.
	4	Up to 10% of breakers do not operate.
	5	More than 10% of breakers do not operate.
G		
	1	No visible sign of tracking.
	1	No visible signs of color deterioration. Coating still pliable.
	2	Tracking visible on less than 5% of area.
	2	Coating pliable and providing good insulation protection, however some minor signs of discoloration.
	3	Coating pliable however significant deterioration.
	3	Tracking visible on 5% to 50% of area.
	4	Coating becoming brittle. Discoloration may or may not be present.
	4	Visible signs of tracking on more than 50% of area.
	5	Coating brittle and beginning to crack. Infrequent operational interruptions resulting.
	5	Visible signs of tracking. Infrequent operation interruptions.

Date: ____ Time: ____ Assessor Initials: ____ Company: ____

Asset ID: ____ Asset Description: ____

Asset Type: ____ Process Description ____

Building/Structure: ____ Parent ID: ____

Group: Electrical Type: Walk-in Med Volt Switchgear

Equipment: ____

A	Protective Enclosure - External	External Enclosure Condition /Cooling /Sealing	____
B	Protective Enclosure - Internal	Internal Enclosure Condition/ Breaker Racking/ Code Violations	____
C	Internal Components	Alignment of drawout devices / Mechanical Deficiencies	____
D	Internal Components	Age	____
E	Internal Components	Availability of Spare Parts	____
F	Internal Components	Functionality of breakers/arc chutes	____
G	Cabling	Cables immersed in water	____
G	Cabling	Color and brittleness	____

Rating Guide

A		
	1	No visible deterioration /no leaks /ventilation and cooling good
	2	Coating cracked /flaking exposing undercoat < 20% of area /evidence of corrosion /some seal wear but no dirt ingress /no leaks /ventilation and cooling adequate
	3	Coating cracked /flaking exposing between 20% to 30% undercoat /evidence of corrosion /some dirt ingress /no leaks /ventilation and cooling adequate
	4	Coating cracked/ flaking exposing between 30% to 50% undercoat /evidence of corrosion/ dirt ingress contaminating some components /water leaks on non-electrical areas /enclosures ventilation and cooling marginal
	5	Coating cracked/ flaking exposing greater than 50% undercoat / corrosion in some areas/ dirt ingress contaminating internal components /water leaks on electrical enclosures / ventilation and cooling not adequate
B		
	1	No floor warping/ breaker racking good/ code compliance
	2	Minor floor warping/ breaker racking good/ code compliance
	3	Floor warping makes breaker racking difficult for up to 5% of breakers/ code compliance
	4	Floor warping makes breaker racking difficult for up to 20% of breakers/ code compliance

	5	Floor warping makes breaker racking difficult for more than 20% of breakers/ code violation(s)
C		
	1	Smooth/ correctly aligning/ limit switches operate correctly
	2	Slight tightness and/or alignment issues. Adjustments required
	3	Racking/ alignment issues. Component replacement required.
	4	Racking/ alignment issues, Obsolescence
	5	Major racking/ alignment issues. May result in major failure.
D		
	1	<30 Years
	2	Between 30 to 39 Years
	3	Between 40 to 44 Years
	4	Between 45 to 50 Years
	5	>50 Years
E		
	1	Components available locally off the shelf.
	2	Components available interstate off the shelf from at least two vendors.
	3	Components available interstate off the shelf from only one vendor.
	4	Components available interstate to order.
	5	Components no longer available.
F		
	1	Breakers operate as intended/no deterioration of arc chutes.
	2	Breakers operate as intended/up to 20% deterioration of arc chutes.
	3	Up to 5% of breakers do not operate/between 20% to 30% deterioration of arc chutes.
	4	Up to 10% of breakers do not operate/between 30% to 50% deterioration of arc chutes.
	5	More than 10% of breakers do not operate/more than 50% deterioration of arc chutes.
G		
	1	No visible sign of tracking.
	1	No visible signs of color deterioration. Coating still pliable.
	2	Tracking visible on less than 5% of area.
	2	Coating pliable and providing good insulation protection, however some minor signs of discoloration.
	3	Coating pliable however significant deterioration.
	3	Tracking visible on 5% to 50% of area.
	4	Coating becoming brittle. Discoloration may or may not be present.
	4	Visible signs of tracking on more than 50% of area.
	5	Coating brittle and beginning to crack. Infrequent operational interruptions.
	5	Visible signs of tracking. Infrequent operation interruptions.

Date: ____________ Time: ________ Assessor Initials: ______ Company: __________

Asset ID: ____________ Asset Description: ______________________________

Asset Type: ______________ Process Description ____________

Building/Structure: ______________ Parent ID: ____________

Group: Process Mechanical Type: Actuators

Equipment: ______________________

A	External body/coating	Cracking/Flaking /Corrosion of housing	________
B	Symptoms	Noise	________

Rating Guide

A		
	1	Coating as new, no visible defects
	2	Coating showing signs of aging, no visible defects
	3	Coating loss /Deterioration exposing steel. Steel surface corroding/rusting
	4	Steel heavily corroded with large areas of surface delamination /flaking
	5	No coating or coating ineffective. Steel corroded or rusted through
B		
	1	No unusual noises detected.
	2	Slight whine/rattle detected.
	3	Moderate whine/rattle detected, easily heard over pump noise.
	4	Loud whine/rattle.
	5	Disturbingly loud operation/vibrations.

Date: ______ Time: ______ Assessor Initials: ______ Company: ______

Asset ID: ______ Asset Description: ______

Asset Type: ______ Process Description ______

Building/Structure: ______ Parent ID: ______

Group: Process Mechanical

Type: Electrical/Instrumentation Equipment

Equipment: ______

A	Protective Enclosure	External Condition / Cooling / Sealing	
B	Internal Components	Deterioration / Overheating	
C	Internal Components	Age	
D	Internal Components	Availability	
E	Cabling	Color and brittleness	
F	Cabling	Insulation Resistance (Mega Test)	

Rating Guide

A		
	1	Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
	2	Coating cracked / flaking exposing undercoat < 20% of area, evidence of corrosion. Some seal wear but no dirt ingress. Ventilation and cooling adequate.
	3	Coating cracked / flaking exposing undercoat > 20% of area, panels corroding. Seal allowing some dirt ingress. Ventilation and cooling adequate.
	4	Coating cracked / flaking exposing metal > 20% of area, areas of panel heavily corroded. Seal allowing dirt ingress, contaminating components. Ventilation and cooling marginal.
	5	Coating cracked / flaking exposing metal > 40% of area. Areas of panel nearly corroded through. Seal allowing dirt ingress, contaminating components causing premature failure. Ventilation and cooling inadequate.
B		
	1	No visible deterioration. No burning smell.
	2	Some components showing minor signs of deterioration. No burning smell.
	3	Majority of components showing signs of deterioration. No burning smell.
	4	Components showing advanced signs of deterioration that will contribute to elevated temperatures and malfunction. Minor burning smell.
	5	Components overheating (smell) / malfunctioning and / or not operational. Major burning smell.
C		
	1	< 2 Years

	2	< 5 Years
	3	< 10 Years
	4	< 15 Years
	5	> 15 Years
D		
	1	Components available locally of the shelf.
	2	Components available interstate of the shelf.
	3	Components available internationally off the shelf. Spares stocked locally.
	4	Components available internationally to order.
	5	Components no longer available. Can be manufactured as specials.
E		
	1	No visible signs of color deterioration. Coating still pliable
	2	Coating pliable and providing good insulation protection however some minor signs of discoloration.
	3	Coating pliable however significant discoloration occurring
	4	Coating becoming brittle. Discoloration may or may not be present.
	5	Coating brittle and beginning to crack. Infrequent operational interruptions resulting.
F		
	1	Insulation protection as per original commissioning test.
	2	
	3	Insulation protection approximately 20 MegaOhms
	4	
	5	Insulation protection close to minimum acceptable limit

Date: ______ Time: ______ Assessor Initials: ______ Company: ______

Asset ID: ______ Asset Description: ______

Asset Type: ______ Process Description ______

Building/Structure: ______ Parent ID: ______

Group: Process Mechanical Type: Fences

Equipment: ______

A	Fence Post & Wire / Fabric / Material	Security / Deterioration	______

Rating Guide

A

1	Recently constructed, replaced or rehabilitated.
2	Some wear and tear but still provides good security.
3	Minor deterioration of post and wire however security function still maintained.
4	Significant deterioration of post and wire through rust, damage and loss of tension. Some breaches of security. (openings).
5	Severe deterioration of post and wire. Collapse likely in high winds or multiple locations of security breaches.

Date: ____________ Time: ________ Assessor Initials: ______ Company: __________

Asset ID: ____________ Asset Description: ______________________________

Asset Type: ______________ Process Description ______________

Building/Structure: ______________ Parent ID: ______________

Group: Process Mechanical Type: Fluid Measurement Instruments

Equipment: ______________________

A	Protective Enclosure	External Condition / Cooling / Sealing	________
B	Internal Components	Deterioration / Overheating	________
C	Internal Components	Age	________

Rating Guide

A		
	1	Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
	2	Coating cracked / flaking exposing undercoat < 20% of area, evidence of corrosion. Some seal wear but no dirt ingress. Ventilation and cooling adequate.
	3	Coating cracked / flaking exposing undercoat > 20% of area, panels corroding. Seal allowing some dirt ingress. Ventilation and cooling adequate.
	4	Coating cracked / flaking exposing metal > 20% of area, areas of panel heavily corroded. Seal allowing dirt ingress, contaminating components. Ventilation and cooling marginal.
	5	Coating cracked / flaking exposing metal > 40% of area. Areas of panel nearly corroded through. Seal allowing dirt ingress, contaminating components causing premature failure. Ventilation and cooling inadequate.
B		
	1	No visible deterioration.
	2	Some components showing minor signs of deterioration
	3	Majority of components showing signs of deterioration.
	4	Components showing advanced signs of deterioration that will contribute to elevated temperatures and malfunction.
	5	Components overheating (smell) / malfunctioning and / or not operational.
C		
	1	< 2 Years
	2	< 5 Years
	3	< 10 Years
	4	< 15 Years
	5	> 15 Years

Date: ____________ Time: ________ Assessor Initials: ________ Company: ____________

Asset ID: ____________ Asset Description: ________________________________

Asset Type: ______________ Process Description ______________

Building/Structure: ______________ Parent ID: ______________

Group: Process Mechanical Type: Generators

Equipment: ________________________

A	Protective Enclosure	External Condition / Cooling / Sealing	
B	Internal Components	Deterioration / Overheating	
C	Internal Components	Age	
D	Cabling	Insulation Resistance (Mega) Test	
E	Cabling	Color and brittleness	
F	Use	Hours Run	

Rating Guide

A		
	1	Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
	2	Coating cracked / flaking exposing undercoat < 20% of area, evidence of corrosion. Some seal wear but no dirt ingress. Ventilation and cooling adequate.
	3	Coating cracked / flaking exposing undercoat > 20% of area, panels corroding. Seal allowing some dirt ingress. Ventilation and cooling adequate.
	4	Coating cracked / flaking exposing metal > 20% of area, areas of panel heavily corroded. Seal allowing dirt ingress, contaminating components. Ventilation and cooling marginal.
	5	Coating cracked / flaking exposing metal > 40% of area. Areas of panel nearly corroded through. Seal allowing dirt ingress, contaminating components causing premature failure. Ventilation and cooling inadequate.
B		
	1	No visible deterioration.
	2	Some components showing minor signs of deterioration
	3	Majority of components showing signs of deterioration.
	4	Components showing advanced signs of deterioration that will contribute to elevated temperatures and malfunction.
	5	Components overheating (smell) / malfunctioning and / or not operational.
C		
	1	< 5 Years
	2	> 5 Years

	3	> 10 Years
	4	> 15 Years
	5	> 20 Years
D		
	1	Insulation protection as per original commissioning test.
	2	
	3	Insulation protection approximately 20 MegaOhms
	4	
	5	Insulation protection close to minimum acceptable limit
E		
	1	No visible signs of color deterioration. Coating still pliable
	2	Coating pliable and providing good insulation protection however some minor signs of discoloration.
	3	Coating pliable however significant discoloration occurring
	4	Coating becoming brittle. Discoloration may or may not be present.
	5	Coating brittle and beginning to crack. Infrequent operational interruptions resulting.
F		
	1	Less than 10% of lifetime estimate
	2	Over 25% of life time estimate
	3	Over 50% of lifetime estimate
	4	Within 25% of lifetime estimate
	5	Within 10% of lifetime estimate

Date: ______ Time: ______ Assessor Initials: ______ Company: ______

Asset ID: ______ Asset Description: ______

Asset Type: ______ Process Description ______

Building/Structure: ______ Parent ID: ______

Group: Process Mechanical Type: HVAC

Equipment: ______

A	Structure Appearance	Surface Deterioration	
B	Structure Appearance	Shaft, Supports, Bearing Deterioration	
C	Symptoms	Vibration / Oscillation	
D	Symptoms	Temperature	
E	Symptoms	Noise	

Rating Guide

A		
	1	Surface appears as new with little or no signs of deterioration.
	2	Some minor surface wear evident that has little impact on the structures strength or function.
	3	Surface deterioration becoming more evident however still little impact on structural integrity or function.
	4	Surface deterioration evident that has impacted on the assets structural integrity or function.
	5	Severe deterioration of surface presenting a high probability of the structures collapse or failure.
B		
	1	Shaft & supports sound - no shaft distortion or deterioration evident.
	2	Minor shaft/ support deterioration evident, no impact on the structural strength or function.
	3	Shaft distortion or bearing/housing wear evident, little impact on structural integrity or function.
	4	Shaft distortion or bearing/housing wear evident and has impacted on asset integrity or function.
	5	Significant shaft distortion or bearing/housing wear evident, high probability of fracture or failure.
C		
	1	No unusual vibration detectable
	2	Minor vibration detected
	3	Moderate vibration
	4	Considerable vibration

	5	Major vibration
D		
	1	No unusual temperature detected
	2	Minimal heat from casing using hand
	3	Heat detected by hand
	4	Heat detected by hand is uncomfortable
	5	Heat too high to assess by hand
E		
	1	No unusual noises detected.
	2	Slight whine/rattle detected.
	3	Moderate whine/rattle detected, easily heard over pump noise.
	4	Loud whine/rattle.
	5	Disturbingly loud operation/vibrations.

Date: ____________ Time: ________ Assessor Initials: ______ Company: __________

Asset ID: ____________ Asset Description: ______________________________________

Asset Type: ______________ Process Description ______________

Building/Structure: ______________ Parent ID: ______________

Group: Process Mechanical

Type: Life Safety, Fire Protection, and ADA

Equipment: __________________________

A	Life	Deterioration	____________

Rating Guide

A

1	Asset appears to be in very good condition, with more than 80% of life remaining
2	Asset appears to be in good condition, with 60-80% of life remaining
3	Asset appears to be in average condition, with approx 50% of life remaining
4	Asset appears to be in poor condition, with approx 20-40% of life remaining
5	Asset appears to be in very poor condition, with less than 20% of life remaining

Date: ______________ Time: __________ Assessor Initials: ________ Company: ____________

Asset ID: ______________ Asset Description: ____

Asset Type: __________________ Process Description __________________

Building/Structure: __________________ Parent ID: __________________

Group: Process Mechanical Type: Miscellaneous Site Assets

Equipment: ________________________________

A	Life	Deterioration	______________

Rating Guide

A

1	Asset appears to be in very good condition, with more than 80% of life remaining
2	Asset appears to be in good condition, with 60 - 80% of life remaining
3	Asset appears to be in average condition, with approx 50% of life remaining
4	Asset appears to be in poor condition, with approx 20-40% of life remaining
5	Asset appears to be in very poor condition, with less than 20% of life remaining

Date: ______ Time: ______ Assessor Initials: ______ Company: ______

Asset ID: ______ Asset Description: ______

Asset Type: ______ Process Description ______

Building/Structure: ______ Parent ID: ______

Group: Process Mechanical Type: Motors

Equipment: ______

A	Use	Hours Run (on original windings)	
B	Symptoms	Vibration	
C	Symptoms	Temperature	
D	Symptoms	Noise	

Rating Guide

A		
	1	< 10,000
	2	> 10,000
	3	> 50,000
	4	> 100,000
	5	> 200,000
B		
	1	No unusual vibration detectable
	2	Minor vibration detected
	3	Moderate vibration
	4	Considerable vibration (wristwatch shakes)
	5	Major vibration
C		
	1	No unusual temperature detected / no burning smell
	2	Minimal heat from casing using hand / no burning smell
	3	Heat detected by hand / no burning smell
	4	Heat detected by hand is uncomfortable / minor burning smell
	5	Heat too high to assess by hand / major burning smell
D		
	1	No unusual noises detected.
	2	Slight whine/rattle detected.
	3	Moderate whine/rattle detected, easily heard over pump noise.
	4	Loud whine/rattle.

5	Disturbingly loud operation/vibrations.

Date: ______ Time: ______ Assessor Initials: ______ Company: ______

Asset ID: ______ Asset Description: ______

Asset Type: ______ Process Description ______

Building/Structure: ______ Parent ID: ______

Group: Process Mechanical Type: Pipelines-Concrete

Equipment: ______

A	Pipe Wall Internal Surface / Reinforcement	Cracking / Spalling / Erosion / Corrosion / Surface Build Up	
B	Pipe Wall External Surface / Reinforcement	Cracking / Spalling / Erosion / Corrosion / Surface Build Up	
C	Fluid	Loss / Impact / Efficiency	
D	Pipe Wall	Physical Strength	
E	Pipe Wall / Joint / Fittings	Leak Repair Frequency / 10K	

Rating Guide

A		
	1	No visible cracking / cement deterioration. No sign of erosion and / or build up of surface deposits / growths.
	2	Minor hair line cracking and / or cement deterioration. Minor signs of erosion and / or build up of surface deposits / growths.
	3	Cracks open exposing reinforcement. Evidence of reinforcing corroding. Erosion removing cement and / or build up of surface deposits / growths affecting flow.
	4	Multiple open cracks and / or reinforcement exposed and corroding. Swelling and scaling of cement. Erosion removing large areas of cement and / or build up of surface deposits / growths reducing flow.
	5	Cracks wide allowing seepage / leakage of water. Reinforcement exposed and flaking with corrosion. Concrete spalling. Erosion exposing large areas of reinforcement and / or build up of surface deposits / growths restricting flow.
B		
	1	No visible cracking / cement deterioration.
	2	Minor hair line cracking and / or cement deterioration.
	3	Cracks open exposing reinforcement. Evidence of reinforcing corroding.
	4	Multiple open cracks and / or reinforcement exposed and corroding. Swelling and scaling of cement.
	5	Cracks wide allowing seepage / leakage of water. Reinforcement exposed and flaking with corrosion. Concrete spalling.
C		
	1	No visible evidence of leakage. Efficiency of distribution > 90%.
	2	Some minor signs of leakage having no impact on neighboring properties / environment. Efficiency of distribution > 80%.

	3	Leakage moderate but no impact on neighboring property. Minor affect on environment. Efficiency of distribution > 70%.
	4	Significant water loss affecting neighboring property, potential for claim for damages and / or causing environmental damage. Efficiency of distribution > 50%.
	5	Water loss affecting neighboring property, claim for damages and / or causing significant environmental damage. Efficiency of distribution < 50%.
D		
	1	Strength as per design
	2	Strength > 90% of design.
	3	Strength < 90% of design.
	4	Strength > 75% of design.
	5	Strength < 50% of design.
E		
	1	0
	2	0
	3	> 2 / Year
	4	> 5 / Year
	5	> 10 / Year

Date: ____________ Time: ________ Assessor Initials: ________ Company: ____________

Asset ID: ____________ Asset Description: ________________________________

Asset Type: ____________ Process Description ____________

Building/Structure: ____________ Parent ID: ____________

Group: Process Mechanical Type: Pipelines-Ferrous

Equipment: ____________________

A	Pipe Wall	Steel Thickness	
B	Pipe Wall / Joint / Fittings	Leak Repair Frequency / 10K	
C	Fluid	Loss / Impact / Efficiency	
D	External Coating / Surface / Bolts	Cracking / Flaking / Corrosion	
E	Soil / Environment	Corrosion	
F	Cathodic Protection (if applicable)	Anode length or diameter remaining	

Rating Guide

A		
	1	Still has full wall thickness including corrosion allowance.
	2	Still has full wall thickness but no corrosion allowance.
	3	Loss of < 20% of design wall thickness.(1)
	4	Loss of > 20% of design wall thickness. (1)
	5	Loss of design wall thickness > 50%. (1)
B		
	1	0
	2	0
	3	> 2 / Year
	4	> 5 / Year
	5	> 10 / Year
C		
	1	No visible evidence of leakage. Efficiency of distribution > 90%.
	2	Some minor signs of leakage having no impact on neighboring properties / environment. Efficiency of distribution > 80%.
	3	Leakage moderate but no impact on neighboring property. Minor affect on environment. Efficiency of distribution > 70%.
	4	Significant water loss affecting neighboring property, potential for claim for damages and / or causing environmental damage. Efficiency of distribution > 50%.
	5	Water loss affecting neighboring property, claim for damages and / or causing significant environmental damage. Efficiency of distribution < 50%.

D		
	1	Coating as new, no defects.
	2	Coating showing signs of aging, no visible defects.
	3	Coating loss / deterioration exposing steel. Steel surface corroding / rusting.
	4	Coating loss / deterioration exposing steel. Steel corroding / rusting with surface delamination / flaking.
	5	Steel heavily corroded / rusting with large areas of surface delamination / flaking.
E		
	1	Coating as new. Soils non-corrosive.
	2	Evidence of coating aging. Soils non-corrosive.
	3	Coating visibly delaminating / exposing pipe steel at one or two points in section. Soils mildly corrosive.
	4	Coating visibly delaminating / exposing pipe steel at several places in section. Pipe steel corroding. Soils promoting corrosion.
	5	Coating visibly delaminating / exposing pipe steel over majority of section. Pipe steel heavily corroded. Soils highly corrosive.
F		
	1	>90% remaining
	2	>70% remaining
	3	>50% remaining
	4	>30% remaining
	5	>10% remaining

Date: ______ Time: ______ Assessor Initials: ______ Company: ______

Asset ID: ______ Asset Description: ______

Asset Type: ______ Process Description ______

Building/Structure: ______ Parent ID: ______

Group: Process Mechanical Type: Pipelines-Not Concrete

Equipment: ______

A	Supports / Bolts - Coating	Loss Of Coating	______
B	Pipe / Fittings / Bolts - External Surface	Cracking / Flaking	______
C	Fluid	Loss / Impact / Efficiency	______
D	Pipe Wall / Joint / Fittings	Leak Repair Frequency	______

Rating Guide

A		
	1	Coating as new, no defects.
	2	Coating showing signs of aging, no visible defects.
	3	Coating loss / deterioration exposing steel. Steel surface corroding / rusting.
	4	Coating loss / deterioration exposing steel. Steel corroding / rusting with surface delamination / flaking.
	5	Steel heavily corroded / rusting with large areas of surface delamination / flaking.
B		
	1	Surface / Coating as new, no defects.
	2	Surface / Coating showing signs of aging, no visible defects.
	3	Surface deterioration evident / coating loss. Steel surface corroding / rusting.
	4	Surface deterioration requiring maintenance. Coating loss exposing steel. Steel corroding / rusting with surface delamination / flaking.
	5	Surface badly blistered / cracked. Steel heavily corroded / rusting with large areas of surface delamination / flaking.
C		
	1	No visible evidence of leakage. Efficiency of distribution > 90%.
	2	Some minor signs of leakage having no impact on neighboring properties / environment. Efficiency of distribution > 80%.
	3	Leakage moderate but no impact on neighboring property. Minor affect on environment. Efficiency of distribution > 70%.
	4	Significant water loss affecting neighboring property, potential for claim for damages and / or causing environmental damage. Efficiency of distribution > 50%.
	5	Water loss affecting neighboring property, claim for damages and / or causing significant environmental damage. Efficiency of distribution < 50%.
D		

1	0 / Year
2	< 2 / Year
3	<= 5 / Year
4	> 5 but <= 10 / Year
5	> 10 / Year

Date: ________ Time: ________ Assessor Initials: ________ Company: ________

Asset ID: ________ Asset Description: ________

Asset Type: ________ Process Description ________

Building/Structure: ________ Parent ID: ________

Group: Process Mechanical Type: Plumbing Systems

Equipment: ________

A	Life	Deterioration	
B	Service Distribution	Loss / Impact / Efficiency	

Rating Guide

A		
	1	Asset appears to be in very good condition, with more than 80% of life remaining
	2	Asset appears to be in good condition, with 60-80% of life remaining
	3	Asset appears to be in average condition, with approx 50% of life remaining
	4	Asset appears to be in poor condition, with approx 20-40% of life remaining
	5	Asset appears to be in very poor condition, with less than 20% of life remaining
B		
	1	No visible evidence of leakage. Efficiency of distribution > 90%.
	2	Some minor signs of leakage having no impact on building occupants or environment. Efficiency of distribution > 80%.
	3	Leakage moderate but no impact on building occupants. Minor affect on environmental health. Efficiency of distribution > 70%.
	4	Significant service loss affecting building occupants and / or causing environmental health problems. Efficiency of distribution > 50%.
	5	Service loss affecting building occupants and / or causing significant environmental damage. Efficiency of distribution < 50%.

Date:		Time:		Assessor Initials:		Company:	
Asset ID:		Asset Description:					

Asset Type:		Process Description	
Building/Structure:		Parent ID:	
Group:	Process Mechanical	Type:	Positive Displacement Pumps / Blowers
Equipment:			

A	Structure Appearance	Leakage (if applicable)	
B	Structure Appearance	Supports, Bearing Deterioration	
C	Use	Motor Hours Run	
D	Symptoms	Vibration	
E	Symptoms	Temperature	
F	Symptoms	Noise	

Rating Guide

A		
	1	Appears as new.
	2	Minimal moisture on seals/joints.
	3	Water dripping from seals/joints.
	4	Water pooling on floor
	5	Water squirting/ running onto floor.
B		
	1	Shaft & supports sound - no shaft distortion or deterioration evident.
	2	Minor shaft/ support deterioration evident, no impact on the structural strength or function.
	3	Shaft distortion or bearing/housing wear evident, little impact on structural integrity or function.
	4	Shaft distortion or bearing/housing wear evident and has impacted on asset integrity or function.
	5	Significant shaft distortion or bearing/housing wear evident, high probability of fracture or failure.
C		
	1	< 5,000
	2	> 5,000
	3	> 25,000
	4	> 50,000

	5	> 100,000
D		
	1	No unusual vibration detectable
	2	Minor vibration detected
	3	Moderate vibration
	4	Considerable vibration (wristwatch shakes)
	5	Major vibration
E		
	1	No unusual temperature detected
	2	Minimal heat from casing using hand
	3	Heat detected by hand
	4	Heat detected by hand is uncomfortable
	5	Heat too high to assess by hand
F		
	1	No unusual noises detected.
	2	Slight whine/rattle detected.
	3	Moderate whine/rattle detected, easily heard over pump noise.
	4	Loud whine/rattle.
	5	Disturbingly loud operation/vibrations.

Date:		Time:		Assessor Initials:		Company:	
Asset ID:		Asset Description:					
Asset Type:		Process Description					
Building/Structure:		Parent ID:					
Group:	Process Mechanical	Type:	Process Mechanical Equipment				
Equipment:							

A	Structure Appearance	Surface Deterioration	
B	Structure Appearance	Shaft, Supports, Bearing Deterioration	
C	Symptoms	Vibration / Oscillation	
D	Symptoms	Temperature	
E	Symptoms	Noise	

Rating Guide

A		
	1	Surface appears as new with little or no signs of deterioration.
	2	Some minor surface wear evident that has little impact on the structures strength or function.
	3	Surface deterioration becoming more evident however still little impact on structural integrity or function.
	4	Surface deterioration evident that has impacted on the assets structural integrity or function.
	5	Severe deterioration of surface presenting a high probability of the structures collapse or failure.
B		
	1	Shaft & supports sound - no shaft distortion or deterioration evident.
	2	Minor shaft/ support deterioration evident, no impact on the structural strength or function.
	3	Shaft distortion or bearing/housing wear evident, little impact on structural integrity or function.
	4	Shaft distortion or bearing/housing wear evident and has impacted on asset integrity or function.
	5	Significant shaft distortion or bearing/housing wear evident, high probability of fracture or failure.
C		
	1	No unusual vibration / oscillation detectable
	2	Minor vibration / oscillation detected
	3	Moderate vibration / oscillation
	4	Considerable vibration / osciallation

	5	Major vibration / oscillation
D		
	1	No unusual temperature detected
	2	Minimal heat from casing using hand
	3	Heat detected by hand
	4	Heat detected by hand is uncomfortable
	5	Heat too high to assess by hand
E		
	1	No unusual noises detected.
	2	Slight whine/rattle detected.
	3	Moderate whine/rattle detected, easily heard over pump noise.
	4	Loud whine/rattle.
	5	Disturbingly loud operation/vibrations.

Date: ______ Time: ______ Assessor Initials: ______ Company: ______

Asset ID: ______ Asset Description: ______

Asset Type: ______ Process Description ______

Building/Structure: ______ Parent ID: ______

Group: Process Mechanical Type: Pumps (Conventional)

Equipment: ______

A	Structure Appearance	Leakage	
B	Structure Appearance	Shaft, Supports, Bearing Deterioration	
C	Use	Motor Hours Run	
D	Symptoms	Vibration / oscillation	
E	Symptoms	Temperature	
F	Symptoms	Noise	

Rating Guide

A		
	1	Appears as new.
	2	Minimal moisture on seals/joints.
	3	Water dripping from seals/joints.
	4	Water pooling on floor
	5	Water squirting/ running onto floor.
B		
	1	Shaft & supports sound - no shaft distortion or deterioration evident.
	2	Minor shaft/ support deterioration evident, no impact on the structural strength or function.
	3	Shaft distortion or bearing/housing wear evident, little impact on structural integrity or function.
	4	Shaft distortion or bearing/housing wear evident and has impacted on asset integrity or function.
	5	Significant shaft distortion or bearing/housing wear evident, high probability of fracture or failure.
C		
	1	< 10,000
	2	> 10,000
	3	> 50,000
	4	> 100,000
	5	> 200,000

D		
	1	No unusual vibration / oscillation detectable
	2	Minor vibration / oscillation detected
	3	Moderate vibration / oscillation
	4	Considerable vibration / oscillation (wristwatch shakes)
	5	Major vibration / oscillation
E		
	1	No unusual temperature detected
	2	Minimal heat from casing using hand
	3	Heat detected by hand
	4	Heat detected by hand is uncomfortable
	5	Heat too high to assess by hand
F		
	1	No unusual noises detected.
	2	Slight whine/rattle detected.
	3	Moderate whine/rattle detected, easily heard over pump noise.
	4	Loud whine/rattle.
	5	Disturbingly loud operation/vibrations.

Date: ______ Time: ______ Assessor Initials: ______ Company: ______

Asset ID: ______ Asset Description: ______

Asset Type: ______ Process Description ______

Building/Structure: ______ Parent ID: ______

Group: Process Mechanical Type: Pumps (Submersible)

Equipment: ______

A	Use	Motor Hours Run	______
B	Symptom	Noise	______

Rating Guide

A		
	1	< 10,000
	2	> 10,000
	3	> 50,000
	4	> 100,000
	5	> 200,000
B		
	1	No unusual noises detected.
	2	Slight whine/rattle detected.
	3	Moderate whine/rattle detected, easily heard over pump noise.
	4	Loud whine/rattle.
	5	Disturbingly loud operation/vibrations.

Date: ______ Time: ______ Assessor Initials: ______ Company: ______

Asset ID: ______ Asset Description: ______

Asset Type: ______ Process Description ______

Building/Structure: ______ Parent ID: ______

Group: Process Mechanical Type: Site Utility Assets

Equipment: ______

A	Life	Deterioration	______
B	Service Distribution	Loss / Impact / Efficiency	______

Rating Guide

A		
	1	Asset appears to be in very good condition, with more than 80% of life remaining
	2	Asset appears to be in good condition, with 60-80% of life remaining
	3	Asset appears to be in average condition, with approx 50% of life remaining
	4	Asset appears to be in poor condition, with approx 20-40% of life remaining
	5	Asset appears to be in very poor condition, with less than 20% of life remaining
B		
	1	No visible evidence of leakage. Efficiency of distribution > 90%.
	2	Some minor signs of leakage having no impact on neighboring properties / environment. Efficiency of distribution > 80%.
	3	Leakage moderate but no impact on neighboring property. Minor affect on environment. Efficiency of distribution > 70%.
	4	Significant service loss affecting neighboring property, potential for claim for damages and / or causing environmental damage. Efficiency of distribution > 50%.
	5	Service loss affecting neighboring property, claim for damages and / or causing significant environmental damage. Efficiency of distribution < 50%.

Date: ______ Time: ______ Assessor Initials: ______ Company: ______

Asset ID: ______ Asset Description: ______

Asset Type: ______ Process Description ______

Building/Structure: ______ Parent ID: ______

Group: Process Mechanical Type: Sludge Processing

Equipment: ______

A	Life	Deterioration	______

Rating Guide

A

1	Asset appears to be in very good condition, with more than 80% of life remaining
2	Asset appears to be in good condition, with 60-80% of life remaining
3	Asset appears to be in average condition, with approx 50% of life remaining
4	Asset appears to be in poor condition, with approx 20-40% of life remaining
5	Asset appears to be in very poor condition, with less than 20% of life remaining

Date: ____________ Time: ________ Assessor Initials: ______ Company: __________

Asset ID: ____________ Asset Description: ______________________________

Asset Type: ______________ Process Description ____________

Building/Structure: ______________ Parent ID: ____________

Group: Process Mechanical Type: Structures

Equipment: ______________________

A	Structural Integrity / Function	Cracking	
B	Structural Integrity / Function	Movement	
C	Surface	Deterioration	
D	Foundation	Ground Movement/ Erosion	
E	Connections	Cracking / Corrosion	

Rating Guide

A		
	1	Structure sound - no cracking evident.
	2	Some minor cracking evident that has little impact on the structures strength or
	3	Cracking becoming more evident however still little impact on structural integrity or function.
	4	Cracking evident that has impacted on the assets structural integrity or function.
	5	Significant cracking evident that presents a high probability of the structures collapse or failure.
B		
	1	No movement evident.
	2	Some minor movement evident that has little impact on the structures strength or function.
	3	Asset has moved significantly however structural integrity and function are retained.
	4	Movement has impacted on the assets structural integrity or function.
	5	Movement has severe impact on structural integrity or function with a high likelihood of failure.
C		
	1	Surface appears as new with little or no signs of deterioration.
	2	Some minor surface wear evident that has little impact on the structures strength or function.
	3	Surface deterioration becoming more evident however still little impact on structural integrity or function.
	4	Surface deterioration evident that has impacted on the assets structural integrity or function.

	5	Severe deterioration of surface presenting a high probability of the structures collapse or failure.
D		
	1	No movement/ erosion evident.
	2	Some minor movement/ erosion evident that has little impact on the structure's strength or function.
	3	Significant ground movement or erosion, however asset structural integrity and function are retained.
	4	Movement/ erosion has impacted on the asset's structural integrity or function.
	5	Movement/erosion has severe impact on structural integrity or function with a high likelihood of structural failure.
E		
	1	Connections sound - no cracking/corrosion evident
	2	Some minor cracking/corrosion evident that has little impact on the connections strength or function
	3	Cracking/corrosion becoming more evident however still little impact on structural integrity.
	4	Cracking/corrosion evident that has impacted on the structural integrity.
	5	Significant cracking/corrosion evident that presents a high probability of the connections failure.

Date: ______ Time: ______ Assessor Initials: ______ Company: ______

Asset ID: ______ Asset Description: ______

Asset Type: ______ Process Description ______

Building/Structure: ______ Parent ID: ______

Group: Process Mechanical Type: Valves, Gates, Hydrants

Equipment: ______

A	Sealing	Wear / Leakage	______
B	Supports / Bolts - Coating	Cracking / Flaking / Corrosion	______
C	Operation	Ease of Operation	______

Rating Guide

A		
	1	No observable deterioration. Valve sealing in good condition
	2	Some minor wear or corrosion on sealing elements
	3	Minor leakage is likely. Maintenance works will restore seal
	4	Leakage occurring although not excessive. Significant maintenance works required to restore seal
	5	Excessive leakage. Significant maintenance works required to restore seal
B		
	1	Coating as new, no defects.
	2	Coating showing signs of aging, no visible defects.
	3	Coating loss / deterioration exposing steel. Steel surface corroding / rusting.
	4	Coating loss / deterioration exposing steel. Steel corroding / rusting with surface delamination / flaking.
	5	Steel heavily corroded / rusting with large areas of surface delamination / flaking.
C		
	1	Operates as new
	2	Operates satisfactory
	3	Operation becoming difficult or internal build-up
	4	Requires mechanical assistance to fully close
	5	Does not operate over full travel

Date: ____________ Time: ________ Assessor Initials: ________ Company: __________

Asset ID: ____________ Asset Description: ______________________________

Asset Type: ______________ Process Description ____________

Building/Structure: ______________ Parent ID: ____________

Group: Process Mechanical

Type: Vertical Transportation / Conveyance

Equipment: ______________________

A	Fixings	Cracking / Corrosion	________
B	Steel Structure	Coating / Steel - Cracking, Flaking Corrosion	________
C	Trolley and Crane	Coating / Function	________

Rating Guide

A		
	1	Fixing sound - no cracking/corrosion evident
	2	Some minor cracking/corrosion evident that has little impact on the fixings strength or function
	3	Cracking/corrosion becoming more evident however still little impact on structural integrity.
	4	Cracking/corrosion evident that has impacted on the structural integrity.
	5	Significant cracking/corrosion evident that presents a high probability of the fixings failure. Crane cannot be used.
B		
	1	Coating / Steel sound - no cracking or corrosion.
	2	Coating cracked / flaking exposing undercoat.
	3	Coating cracked / flaking exposing metal.
	4	Coating / undercoat cracked / flaking exposing metal. Corrosion/pitting of metal surface at any one location.
	5	Coating / undercoat cracked / flaking exposing metal. Corrosion/pitting of metal surface at several locations.
C		
	1	Coating / Steel sound - no cracking or corrosion. Functions as new.
	2	Coating cracked / flaking exposing undercoat. Functions Ok.
	3	Coating cracked / flaking exposing metal. Maintenance of function required.
	4	Coating / undercoat cracked / flaking exposing metal. Corrosion/pitting of metal surface at any one location. Extensive maintenance required.
	5	Coating / undercoat cracked / flaking exposing metal. Corrosion/pitting of metal surface at several locations. Crane/trolley does not operate.

APPENDIX C
ASSESSMENTS WITH RATING OF 4 OR 5

Assessments with Ratings 4-5

AssetID BLO3801

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
BB1 : Blower 1, C431, Blower Building 1	A	Structure Appearance	Leakage (if applicable)	—: No Rating Given
BB1 : Blower 1, C431, Blower Building 1	B	Structure Appearance	Supports, Bearing Deterioration	2: Minor shaft/ support deterioration evident, no impact on the structural strength or function.
BB1 : Blower 1, C431, Blower Building 1	C	Use	Motor Hours Run	4: > 50,000
BB1 : Blower 1, C431, Blower Building 1	D	Symptoms	Vibration	3: Moderate vibration
BB1 : Blower 1, C431, Blower Building 1	E	Symptoms	Temperature	1: No unusual temperature detected
BB1 : Blower 1, C431, Blower Building 1	F	Symptoms	Noise	—: No Rating Given

AssetID BLO3804

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
BB1 : Blower 4, Blower Building 1	A	Structure Appearance	Leakage (if applicable)	—: No Rating Given
BB1 : Blower 4, Blower Building 1	B	Structure Appearance	Supports, Bearing Deterioration	2: Minor shaft/ support deterioration evident, no impact on the structural strength or function.
BB1 : Blower 4, Blower Building 1	C	Use	Motor Hours Run	4: > 50,000
BB1 : Blower 4, Blower Building 1	D	Symptoms	Vibration	—: No Rating Given
BB1 : Blower 4, Blower Building 1	E	Symptoms	Temperature	—: No Rating Given

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
BB1 : Blower 4, Blower Building 1	F	Symptoms	Noise	—: No Rating Given

AssetID BLO3805

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
BB1 : Blower 5, Blower Building 1	A	Structure Appearance	Leakage (if applicable)	—: No Rating Given
BB1 : Blower 5, Blower Building 1	B	Structure Appearance	Supports, Bearing Deterioration	2: Minor shaft/ support deterioration evident, no impact on the structural strength or function.
BB1 : Blower 5, Blower Building 1	C	Use	Motor Hours Run	4: > 50,000
BB1 : Blower 5, Blower Building 1	D	Symptoms	Vibration	1: No unusual vibration detectable
BB1 : Blower 5, Blower Building 1	E	Symptoms	Temperature	—: No Rating Given
BB1 : Blower 5, Blower Building 1	F	Symptoms	Noise	—: No Rating Given

AssetID CPN3801

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
BB1 : Engine Blower Control PanelLocated in Blower Building No. 1	A	Protective Enclosure	External Condition / Cooling / Sealing	2: Coating cracked / flaking exposing undercoat < 20% of area, evidence of corrosion. Some seal wear but no dirt ingress. Ventilation and cooling adequate.
BB1 : Engine Blower Control PanelLocated in Blower Building No. 1	B	Internal Components	Deterioration / Overheating	2: Some components showing minor signs of deterioration. No burning smell.
BB1 : Engine Blower Control PanelLocated in Blower Building No. 1	C	Internal Components	Age	5: > 15 Years

BB1 : Engine Blower Control PanelLocated in Blower Building No. 1	D	Internal Components	Availability	5: Components no longer available. Can be manufactured as specials.
BB1 : Engine Blower Control PanelLocated in Blower Building No. 1	E	Cabling	Color and brittleness	—: No Rating Given
BB1 : Engine Blower Control PanelLocated in Blower Building No. 1	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID CPN3802

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
BB1 : Control Panel. Blowers 2, 3, 4, 5	A	Protective Enclosure	External Condition / Cooling / Sealing	2: Coating cracked / flaking exposing undercoat < 20% of area, evidence of corrosion. Some seal wear but no dirt ingress. Ventilation and cooling adequate.
BB1 : Control Panel. Blowers 2, 3, 4, 5	B	Internal Components	Deterioration / Overheating	2: Some components showing minor signs of deterioration. No burning smell.
BB1 : Control Panel. Blowers 2, 3, 4, 5	C	Internal Components	Age	5: > 15 Years
BB1 : Control Panel. Blowers 2, 3, 4, 5	D	Internal Components	Availability	5: Components no longer available. Can be manufactured as specials.
BB1 : Control Panel. Blowers 2, 3, 4, 5	E	Cabling	Color and brittleness	—: No Rating Given
BB1 : Control Panel. Blowers 2, 3, 4, 5	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID CPN3902

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
BB2 : Control Panel, Zenith Auto Transfer Switch	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.

BB2 : Control Panel, Zenith Auto Transfer Switch	B	Internal Components	Deterioration / Overheating	1: No visible deterioration. No burning smell.
BB2 : Control Panel, Zenith Auto Transfer Switch	C	Internal Components	Age	5: > 15 Years
BB2 : Control Panel, Zenith Auto Transfer Switch	D	Internal Components	Availability	2: Components available interstate of the shelf.
BB2 : Control Panel, Zenith Auto Transfer Switch	E	Cabling	Color and brittleness	—: No Rating Given
BB2 : Control Panel, Zenith Auto Transfer Switch	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID CPN3903

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
BB2 : Control Panel for Blower #1, and associated electrical control devices, Blower Building 2	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
BB2 : Control Panel for Blower #1, and associated electrical control devices, Blower Building 2	B	Internal Components	Deterioration / Overheating	1: No visible deterioration. No burning smell.
BB2 : Control Panel for Blower #1, and associated electrical control devices, Blower Building 2	C	Internal Components	Age	5: > 15 Years
BB2 : Control Panel for Blower #1, and associated electrical control devices, Blower Building 2	D	Internal Components	Availability	5: Components no longer available. Can be manufactured as specials.
BB2 : Control Panel for Blower #1, and associated electrical control devices, Blower Building 2	E	Cabling	Color and brittleness	1: No visible signs of color deterioration. Coating still pliable

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
BB2 : Control Panel for Blower #1, and associated electrical control devices, Blower Building 2	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID CPN3904

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
BB2 : Control Panel for Blower #2, and associated electrical control devices, Blower Building 2	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
BB2 : Control Panel for Blower #2, and associated electrical control devices, Blower Building 2	B	Internal Components	Deterioration / Overheating	1: No visible deterioration. No burning smell.
BB2 : Control Panel for Blower #2, and associated electrical control devices, Blower Building 2	C	Internal Components	Age	5: > 15 Years
BB2 : Control Panel for Blower #2, and associated electrical control devices, Blower Building 2	D	Internal Components	Availability	3: Components available internationally off the shelf. Spares stocked locally.
BB2 : Control Panel for Blower #2, and associated electrical control devices, Blower Building 2	E	Cabling	Color and brittleness	1: No visible signs of color deterioration. Coating still pliable
BB2 : Control Panel for Blower #2, and associated electrical control devices, Blower Building 2	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID CPN3905

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating

BB2 : Control Panel for Blower #3, and associated electrical control devices, Blower Building 2	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
BB2 : Control Panel for Blower #3, and associated electrical control devices, Blower Building 2	B	Internal Components	Deterioration / Overheating	1: No visible deterioration. No burning smell.
BB2 : Control Panel for Blower #3, and associated electrical control devices, Blower Building 2	C	Internal Components	Age	5: > 15 Years
BB2 : Control Panel for Blower #3, and associated electrical control devices, Blower Building 2	D	Internal Components	Availability	5: Components no longer available. Can be manufactured as specials.
BB2 : Control Panel for Blower #3, and associated electrical control devices, Blower Building 2	E	Cabling	Color and brittleness	1: No visible signs of color deterioration. Coating still pliable
BB2 : Control Panel for Blower #3, and associated electrical control devices, Blower Building 2	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID CPN3906

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
BB2 : Control Panel, TCP-4, Temperature Control Panel	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
BB2 : Control Panel, TCP-4, Temperature Control Panel	B	Internal Components	Deterioration / Overheating	1: No visible deterioration. No burning smell.
BB2 : Control Panel, TCP-4, Temperature Control Panel	C	Internal Components	Age	5: > 15 Years

BB2 : Control Panel, TCP-4, Temperature Control Panel	D	Internal Components	Availability	5: Components no longer available. Can be manufactured as specials.
BB2 : Control Panel, TCP-4, Temperature Control Panel	E	Cabling	Color and brittleness	1: No visible signs of color deterioration. Coating still pliable
BB2 : Control Panel, TCP-4, Temperature Control Panel	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID CPN4002

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
ACB2: Control Panel,East Secondary Meter Panel No.2Panel located in Aeration Control Building #2	A	Protective Enclosure	External Condition / Cooling / Sealing	2: Coating cracked / flaking exposing undercoat < 20% of area, evidence of corrosion. Some seal wear but no dirt ingress. Ventilation and cooling adequate.
ACB2: Control Panel,East Secondary Meter Panel No.2Panel located in Aeration Control Building #2	B	Internal Components	Deterioration / Overheating	1: No visible deterioration. No burning smell.
ACB2: Control Panel,East Secondary Meter Panel No.2Panel located in Aeration Control Building #2	C	Internal Components	Age	5: > 15 Years
ACB2: Control Panel,East Secondary Meter Panel No.2Panel located in Aeration Control Building #2	D	Internal Components	Availability	—: No Rating Given
ACB2: Control Panel,East Secondary Meter Panel No.2Panel located in Aeration Control Building #2	E	Cabling	Color and brittleness	—: No Rating Given
ACB2: Control Panel,East Secondary Meter Panel No.2Panel located in Aeration Control Building #2	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID CPN4003

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
ACB3: Control Panel, ACB3	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
ACB3: Control Panel, ACB3	B	Internal Components	Deterioration / Overheating	2: Some components showing minor signs of deterioration. No burning smell.
ACB3: Control Panel, ACB3	C	Internal Components	Age	5: > 15 Years
ACB3: Control Panel, ACB3	D	Internal Components	Availability	—: No Rating Given
ACB3: Control Panel, ACB3	E	Cabling	Color and brittleness	—: No Rating Given
ACB3: Control Panel, ACB3	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID CPN4004

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
ACB4: Control Panel, ACB4	A	Protective Enclosure	External Condition / Cooling / Sealing	2: Coating cracked / flaking exposing undercoat < 20% of area, evidence of corrosion. Some seal wear but no dirt ingress. Ventilation and cooling adequate.
ACB4: Control Panel, ACB4	B	Internal Components	Deterioration / Overheating	2: Some components showing minor signs of deterioration. No burning smell.
ACB4: Control Panel, ACB4	C	Internal Components	Age	5: > 15 Years
ACB4: Control Panel, ACB4	D	Internal Components	Availability	—: No Rating Given
ACB4: Control Panel, ACB4	E	Cabling	Color and brittleness	—: No Rating Given
ACB4: Control Panel, ACB4	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID CPN4005

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
ACB4 : Control Panel, Zenith Auto Transfer Switch, Aeration Control Building 4	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
ACB4 : Control Panel, Zenith Auto Transfer Switch, Aeration Control Building 4	B	Internal Components	Deterioration / Overheating	2: Some components showing minor signs of deterioration. No burning smell.
ACB4 : Control Panel, Zenith Auto Transfer Switch, Aeration Control Building 4	C	Internal Components	Age	5: > 15 Years
ACB4 : Control Panel, Zenith Auto Transfer Switch, Aeration Control Building 4	D	Internal Components	Availability	—: No Rating Given
ACB4 : Control Panel, Zenith Auto Transfer Switch, Aeration Control Building 4	E	Cabling	Color and brittleness	—: No Rating Given
ACB4 : Control Panel, Zenith Auto Transfer Switch, Aeration Control Building 4	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID CPN4006

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
ACB3: Control Panel, Compressor 2A, 2B RAS Level Bubbler System	A	Protective Enclosure	External Condition / Cooling / Sealing	2: Coating cracked / flaking exposing undercoat < 20% of area, evidence of corrosion. Some seal wear but no dirt ingress. Ventilation and cooling adequate.
ACB3: Control Panel, Compressor 2A, 2B RAS Level Bubbler System	B	Internal Components	Deterioration / Overheating	2: Some components showing minor signs of deterioration. No burning smell.
ACB3: Control Panel, Compressor 2A, 2B RAS Level Bubbler System	C	Internal Components	Age	5: > 15 Years

ACB3: Control Panel, Compressor 2A, 2B RAS Level Bubbler System	D	Internal Components	Availability	1: Components available locally of the shelf.
ACB3: Control Panel, Compressor 2A, 2B RAS Level Bubbler System	E	Cabling	Color and brittleness	2: Coating pliable and providing good insulation protection however some minor signs of discoloration.
ACB3: Control Panel, Compressor 2A, 2B RAS Level Bubbler System	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID CPN4408

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
EFFB : Control Panel, Zenith Auto Transfer Switch For T71 & T72	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
EFFB : Control Panel, Zenith Auto Transfer Switch For T71 & T72	B	Internal Components	Deterioration / Overheating	1: No visible deterioration. No burning smell.
EFFB : Control Panel, Zenith Auto Transfer Switch For T71 & T72	C	Internal Components	Age	5: > 15 Years
EFFB : Control Panel, Zenith Auto Transfer Switch For T71 & T72	D	Internal Components	Availability	—: No Rating Given
EFFB : Control Panel, Zenith Auto Transfer Switch For T71 & T72	E	Cabling	Color and brittleness	2: Coating pliable and providing good insulation protection however some minor signs of discoloration.
EFFB : Control Panel, Zenith Auto Transfer Switch For T71 & T72	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID EJC4103

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating

ACB4: Pneumatic Ejector 2,(scum) ACB4	A	Structure Appearance	Leakage (if applicable)	2: Minimal moisture on seals/joints.
ACB4: Pneumatic Ejector 2,(scum) ACB4	B	Structure Appearance	Supports, Bearing Deterioration	2: Minor shaft/ support deterioration evident, no impact on the structural strength or function.
ACB4: Pneumatic Ejector 2,(scum) ACB4	C	Use	Motor Hours Run	4: > 50,000
ACB4: Pneumatic Ejector 2,(scum) ACB4	D	Symptoms	Vibration	—: No Rating Given
ACB4: Pneumatic Ejector 2,(scum) ACB4	E	Symptoms	Temperature	—: No Rating Given
ACB4: Pneumatic Ejector 2,(scum) ACB4	F	Symptoms	Noise	—: No Rating Given

AssetID FRM3501

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
PSPB2: Transformer, Lighting Panel	A	Protective Enclosure	External Condition / Cooling / Sealing	2: Coating cracked / flaking exposing undercoat < 20% of area, evidence of corrosion. Some seal wear but no dirt ingress. Ventilation and cooling adequate.
PSPB2: Transformer, Lighting Panel	B	Internal Components	Deterioration / Overheating	2: Some components showing minor signs of deterioration. No burning smell.
PSPB2: Transformer, Lighting Panel	C	Internal Components	Age	5: > 15 Years
PSPB2: Transformer, Lighting Panel	D	Internal Components	Availability	2: Components available interstate of the shelf.
PSPB2: Transformer, Lighting Panel	E	Cabling	Color and brittleness	—: No Rating Given
PSPB2: Transformer, Lighting Panel	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID FRM3901

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
BB2 : Transformer, T-51, Blower Building 2	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
BB2 : Transformer, T-51, Blower Building 2	B	Internal Components	Deterioration / Overheating	1: No visible deterioration. No burning smell.
BB2 : Transformer, T-51, Blower Building 2	C	Internal Components	Age	5: > 15 Years
BB2 : Transformer, T-51, Blower Building 2	D	Internal Components	Availability	1: Components available locally of the shelf.
BB2 : Transformer, T-51, Blower Building 2	E	Cabling	Color and brittleness	—: No Rating Given
BB2 : Transformer, T-51, Blower Building 2	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID FRM3902

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
BB2 : Transformer, T-52, Blower Building 2	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
BB2 : Transformer, T-52, Blower Building 2	B	Internal Components	Deterioration / Overheating	1: No visible deterioration. No burning smell.
BB2 : Transformer, T-52, Blower Building 2	C	Internal Components	Age	5: > 15 Years
BB2 : Transformer, T-52, Blower Building 2	D	Internal Components	Availability	1: Components available locally of the shelf.
BB2 : Transformer, T-52, Blower Building 2	E	Cabling	Color and brittleness	—: No Rating Given
BB2 : Transformer, T-52, Blower Building 2	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID FRM4401

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
ACB4: Transformer, T41, feeds Zenith CPN	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
ACB4: Transformer, T41, feeds Zenith CPN	B	Internal Components	Deterioration / Overheating	2: Some components showing minor signs of deterioration. No burning smell.
ACB4: Transformer, T41, feeds Zenith CPN	C	Internal Components	Age	5: > 15 Years
ACB4: Transformer, T41, feeds Zenith CPN	D	Internal Components	Availability	1: Components available locally of the shelf.
ACB4: Transformer, T41, feeds Zenith CPN	E	Cabling	Color and brittleness	—: No Rating Given
ACB4: Transformer, T41, feeds Zenith CPN	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID FRM4415

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
EFFB : Transformer, T71	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
EFFB : Transformer, T71	B	Internal Components	Deterioration / Overheating	1: No visible deterioration. No burning smell.
EFFB : Transformer, T71	C	Internal Components	Age	5: > 15 Years
EFFB : Transformer, T71	D	Internal Components	Availability	—: No Rating Given
EFFB : Transformer, T71	E	Cabling	Color and brittleness	—: No Rating Given
EFFB : Transformer, T71	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID FRM4416

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
EFFB : Transformer, T72	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
EFFB : Transformer, T72	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
EFFB : Transformer, T72	B	Internal Components	Deterioration / Overheating	1: No visible deterioration. No burning smell.
EFFB : Transformer, T72	B	Internal Components	Deterioration / Overheating	1: No visible deterioration. No burning smell.
EFFB : Transformer, T72	C	Internal Components	Age	5: > 15 Years
EFFB : Transformer, T72	C	Internal Components	Age	—: No Rating Given
EFFB : Transformer, T72	D	Internal Components	Availability	—: No Rating Given
EFFB : Transformer, T72	D	Internal Components	Availability	—: No Rating Given
EFFB : Transformer, T72	E	Cabling	Color and brittleness	—: No Rating Given
EFFB : Transformer, T72	E	Cabling	Color and brittleness	—: No Rating Given
EFFB : Transformer, T72	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given
EFFB : Transformer, T72	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID LPN3501

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
PSPB2: Lighting Panel	A	Protective Enclosure	External Condition / Cooling / Sealing	2: Coating cracked / flaking exposing undercoat < 20% of area, evidence of corrosion. Some seal wear but no dirt ingress. Ventilation and cooling adequate.

PSPB2: Lighting Panel	B	Internal Components	Deterioration / Overheating	2: Some components showing minor signs of deterioration. No burning smell.
PSPB2: Lighting Panel	C	Internal Components	Age	5: > 15 Years
PSPB2: Lighting Panel	D	Internal Components	Availability	1: Components available locally of the shelf.
PSPB2: Lighting Panel	E	Cabling	Color and brittleness	—: No Rating Given
PSPB2: Lighting Panel	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID LPN3900

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
BB2 : Lighting/Distribution Panel, DP51, Upper Level	A	Protective Enclosure	External Condition / Cooling / Sealing	2: Coating cracked / flaking exposing undercoat < 20% of area, evidence of corrosion. Some seal wear but no dirt ingress. Ventilation and cooling adequate.
BB2 : Lighting/Distribution Panel, DP51, Upper Level	B	Internal Components	Deterioration / Overheating	1: No visible deterioration. No burning smell.
BB2 : Lighting/Distribution Panel, DP51, Upper Level	C	Internal Components	Age	5: > 15 Years
BB2 : Lighting/Distribution Panel, DP51, Upper Level	D	Internal Components	Availability	1: Components available locally of the shelf.
BB2 : Lighting/Distribution Panel, DP51, Upper Level	E	Cabling	Color and brittleness	—: No Rating Given
BB2 : Lighting/Distribution Panel, DP51, Upper Level	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID LPN3901

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
BB2 : Lighting Panel, LP51, Lower Level	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.

BB2 : Lighting Panel, LP51, Lower Level	B	Internal Components	Deterioration / Overheating	1: No visible deterioration. No burning smell.
BB2 : Lighting Panel, LP51, Lower Level	C	Internal Components	Age	4: < 15 Years
BB2 : Lighting Panel, LP51, Lower Level	D	Internal Components	Availability	1: Components available locally of the shelf.
BB2 : Lighting Panel, LP51, Lower Level	E	Cabling	Color and brittleness	—: No Rating Given
BB2 : Lighting Panel, LP51, Lower Level	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID LPN3902

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
BB2 : Lighting Panel, LP52, Upper Level	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
BB2 : Lighting Panel, LP52, Upper Level	B	Internal Components	Deterioration / Overheating	1: No visible deterioration. No burning smell.
BB2 : Lighting Panel, LP52, Upper Level	C	Internal Components	Age	5: > 15 Years
BB2 : Lighting Panel, LP52, Upper Level	D	Internal Components	Availability	1: Components available locally of the shelf.
BB2 : Lighting Panel, LP52, Upper Level	E	Cabling	Color and brittleness	1: No visible signs of color deterioration. Coating still pliable
BB2 : Lighting Panel, LP52, Upper Level	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID LPN3903

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
AG2 : Lighting Panel , LP-44, Aeration Gallery 2	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.

AG2 : Lighting Panel , LP-44, Aeration Gallery 2	B	Internal Components	Deterioration / Overheating	1: No visible deterioration. No burning smell.
AG2 : Lighting Panel , LP-44, Aeration Gallery 2	C	Internal Components	Age	4: < 15 Years
AG2 : Lighting Panel , LP-44, Aeration Gallery 2	D	Internal Components	Availability	1: Components available locally of the shelf.
AG2 : Lighting Panel , LP-44, Aeration Gallery 2	E	Cabling	Color and brittleness	—: No Rating Given
AG2 : Lighting Panel , LP-44, Aeration Gallery 2	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID LPN3904

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
AG2 : Lighting Panel , LP-45, Aeration Gallery 2	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
AG2 : Lighting Panel , LP-45, Aeration Gallery 2	B	Internal Components	Deterioration / Overheating	1: No visible deterioration. No burning smell.
AG2 : Lighting Panel , LP-45, Aeration Gallery 2	C	Internal Components	Age	5: > 15 Years
AG2 : Lighting Panel , LP-45, Aeration Gallery 2	D	Internal Components	Availability	1: Components available locally of the shelf.
AG2 : Lighting Panel , LP-45, Aeration Gallery 2	E	Cabling	Color and brittleness	—: No Rating Given
AG2 : Lighting Panel , LP-45, Aeration Gallery 2	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID LPN4002

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
ACB2: Lighting Panel, L82Square D Panelboard, 120/208V, Three PhaseLocated in Aeration Control Building #2	A	Protective Enclosure	External Condition / Cooling / Sealing	2: Coating cracked / flaking exposing undercoat < 20% of area, evidence of corrosion. Some seal wear but no dirt ingress. Ventilation and cooling adequate.

ACB2: Lighting Panel, L82Square D Panelboard, 120/208V, Three PhaseLocated in Aeration Control Building #2	B	Internal Components	Deterioration / Overheating	2: Some components showing minor signs of deterioration. No burning smell.
ACB2: Lighting Panel, L82Square D Panelboard, 120/208V, Three PhaseLocated in Aeration Control Building #2	C	Internal Components	Age	5: > 15 Years
ACB2: Lighting Panel, L82Square D Panelboard, 120/208V, Three PhaseLocated in Aeration Control Building #2	D	Internal Components	Availability	1: Components available locally of the shelf.
ACB2: Lighting Panel, L82Square D Panelboard, 120/208V, Three PhaseLocated in Aeration Control Building #2	E	Cabling	Color and brittleness	—: No Rating Given
ACB2: Lighting Panel, L82Square D Panelboard, 120/208V, Three PhaseLocated in Aeration Control Building #2	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID LPN4003

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
ACB2: Lighting Panel, L85Westinghouse Panelboard, 120/208V, Three PhaseLocated in Aeration Control Building #2	A	Protective Enclosure	External Condition / Cooling / Sealing	2: Coating cracked / flaking exposing undercoat < 20% of area, evidence of corrosion. Some seal wear but no dirt ingress. Ventilation and cooling adequate.

ACB2: Lighting Panel, L85Westinghouse Panelboard, 120/208V, Three PhaseLocated in Aeration Control Building #2	A	Protective Enclosure	External Condition / Cooling / Sealing	—: No Rating Given
ACB2: Lighting Panel, L85Westinghouse Panelboard, 120/208V, Three PhaseLocated in Aeration Control Building #2	B	Internal Components	Deterioration / Overheating	2: Some components showing minor signs of deterioration. No burning smell.
ACB2: Lighting Panel, L85Westinghouse Panelboard, 120/208V, Three PhaseLocated in Aeration Control Building #2	B	Internal Components	Deterioration / Overheating	—: No Rating Given
ACB2: Lighting Panel, L85Westinghouse Panelboard, 120/208V, Three PhaseLocated in Aeration Control Building #2	C	Internal Components	Age	5: > 15 Years
ACB2: Lighting Panel, L85Westinghouse Panelboard, 120/208V, Three PhaseLocated in Aeration Control Building #2	C	Internal Components	Age	—: No Rating Given
ACB2: Lighting Panel, L85Westinghouse Panelboard, 120/208V, Three PhaseLocated in Aeration Control Building #2	D	Internal Components	Availability	1: Components available locally of the shelf.
ACB2: Lighting Panel, L85Westinghouse Panelboard, 120/208V, Three PhaseLocated in Aeration Control Building #2	D	Internal Components	Availability	—: No Rating Given

ACB2: Lighting Panel, L85Westinghouse Panelboard, 120/208V, Three PhaseLocated in Aeration Control Building #2	E	Cabling	Color and brittleness	—: No Rating Given
ACB2: Lighting Panel, L85Westinghouse Panelboard, 120/208V, Three PhaseLocated in Aeration Control Building #2	E	Cabling	Color and brittleness	—: No Rating Given
ACB2: Lighting Panel, L85Westinghouse Panelboard, 120/208V, Three PhaseLocated in Aeration Control Building #2	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given
ACB2: Lighting Panel, L85Westinghouse Panelboard, 120/208V, Three PhaseLocated in Aeration Control Building #2	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID LPN4401

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
EFFB: Lighting Panel L71, In MCC Room	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
EFFB: Lighting Panel L71, In MCC Room	B	Internal Components	Deterioration / Overheating	1: No visible deterioration. No burning smell.
EFFB: Lighting Panel L71, In MCC Room	C	Internal Components	Age	5: > 15 Years
EFFB: Lighting Panel L71, In MCC Room	D	Internal Components	Availability	—: No Rating Given
EFFB: Lighting Panel L71, In MCC Room	E	Cabling	Color and brittleness	—: No Rating Given

EFFB: Lighting Panel L71, In MCC Room	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID LPN4402

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
EFFB: Lighting Panel L72, In Pump Room	A	Protective Enclosure	External Condition / Cooling / Sealing	2: Coating cracked / flaking exposing undercoat < 20% of area, evidence of corrosion. Some seal wear but no dirt ingress. Ventilation and cooling adequate.
EFFB: Lighting Panel L72, In Pump Room	B	Internal Components	Deterioration / Overheating	1: No visible deterioration. No burning smell.
EFFB: Lighting Panel L72, In Pump Room	C	Internal Components	Age	5: > 15 Years
EFFB: Lighting Panel L72, In Pump Room	D	Internal Components	Availability	—: No Rating Given
EFFB: Lighting Panel L72, In Pump Room	E	Cabling	Color and brittleness	—: No Rating Given
EFFB: Lighting Panel L72, In Pump Room	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID LPN4403

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
EFFB: Lighting Panel L73, In Control Room	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
EFFB: Lighting Panel L73, In Control Room	B	Internal Components	Deterioration / Overheating	1: No visible deterioration. No burning smell.
EFFB: Lighting Panel L73, In Control Room	C	Internal Components	Age	5: > 15 Years
EFFB: Lighting Panel L73, In Control Room	D	Internal Components	Availability	—: No Rating Given
EFFB: Lighting Panel L73, In Control Room	E	Cabling	Color and brittleness	—: No Rating Given

EFFB: Lighting Panel L73, In Control Room	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID LPN4404

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
EFFB: Lighting/Dist Panel DP71, In MCC Room	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
EFFB: Lighting/Dist Panel DP71, In MCC Room	B	Internal Components	Deterioration / Overheating	1: No visible deterioration. No burning smell.
EFFB: Lighting/Dist Panel DP71, In MCC Room	C	Internal Components	Age	5: > 15 Years
EFFB: Lighting/Dist Panel DP71, In MCC Room	D	Internal Components	Availability	—: No Rating Given
EFFB: Lighting/Dist Panel DP71, In MCC Room	E	Cabling	Color and brittleness	—: No Rating Given
EFFB: Lighting/Dist Panel DP71, In MCC Room	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID MCC3901

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
BB2 : MCC, MCC-P51, A396, East Panel, Blower Building 2	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
BB2 : MCC, MCC-P51, A396, East Panel, Blower Building 2	B	Internal Components	Deterioration / Overheating	2: Some components showing minor signs of deterioration. No burning smell.
BB2 : MCC, MCC-P51, A396, East Panel, Blower Building 2	C	Internal Components	Age	5: > 15 Years
BB2 : MCC, MCC-P51, A396, East Panel, Blower Building 2	D	Internal Components	Availability	—: No Rating Given
BB2 : MCC, MCC-P51, A396, East Panel, Blower Building 2	E	Cabling	Color and brittleness	—: No Rating Given

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
BB2 : MCC, MCC-P51, A396, East Panel, Blower Building 2	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID MCC3902

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
BB2 : MCC, MCC-P52, A397, West Panel, Blower Building 2	A	Protective Enclosure	External Condition / Cooling / Sealing	2: Coating cracked / flaking exposing undercoat < 20% of area, evidence of corrosion. Some seal wear but no dirt ingress. Ventilation and cooling adequate.
BB2 : MCC, MCC-P52, A397, West Panel, Blower Building 2	B	Internal Components	Deterioration / Overheating	1: No visible deterioration. No burning smell.
BB2 : MCC, MCC-P52, A397, West Panel, Blower Building 2	C	Internal Components	Age	5: > 15 Years
BB2 : MCC, MCC-P52, A397, West Panel, Blower Building 2	D	Internal Components	Availability	—: No Rating Given
BB2 : MCC, MCC-P52, A397, West Panel, Blower Building 2	E	Cabling	Color and brittleness	—: No Rating Given
BB2 : MCC, MCC-P52, A397, West Panel, Blower Building 2	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID MCC4000

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
ACB1: MCC, Square D Motor Control Center, MCC-ACB-1 Located in Aeration Control Building #1	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
ACB1: MCC, Square D Motor Control Center, MCC-ACB-1 Located in Aeration Control Building #1	B	Internal Components	Deterioration / Overheating	1: No visible deterioration. No burning smell.

ACB1: MCC, Square D Motor Control Center, MCC-ACB-1 Located in Aeration Control Building #1	C	Internal Components	Age	5: > 15 Years
ACB1: MCC, Square D Motor Control Center, MCC-ACB-1 Located in Aeration Control Building #1	D	Internal Components	Availability	—: No Rating Given
ACB1: MCC, Square D Motor Control Center, MCC-ACB-1 Located in Aeration Control Building #1	E	Cabling	Color and brittleness	—: No Rating Given
ACB1: MCC, Square D Motor Control Center, MCC-ACB-1 Located in Aeration Control Building #1	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID MCC4003

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
ACB4: MCC-P41, Westinghouse Motor Control Center P41Located at Aeration Control Building #4	A	Protective Enclosure	External Condition / Cooling / Sealing	—: No Rating Given
ACB4: MCC-P41, Westinghouse Motor Control Center P41Located at Aeration Control Building #4	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
ACB4: MCC-P41, Westinghouse Motor Control Center P41Located at Aeration Control Building #4	B	Internal Components	Deterioration / Overheating	—: No Rating Given

ACB4: MCC-P41, Westinghouse Motor Control Center P41Located at Aeration Control Building #4	B	Internal Components	Deterioration / Overheating	2: Some components showing minor signs of deterioration. No burning smell.
ACB4: MCC-P41, Westinghouse Motor Control Center P41Located at Aeration Control Building #4	C	Internal Components	Age	—: No Rating Given
ACB4: MCC-P41, Westinghouse Motor Control Center P41Located at Aeration Control Building #4	C	Internal Components	Age	5: > 15 Years
ACB4: MCC-P41, Westinghouse Motor Control Center P41Located at Aeration Control Building #4	D	Internal Components	Availability	—: No Rating Given
ACB4: MCC-P41, Westinghouse Motor Control Center P41Located at Aeration Control Building #4	D	Internal Components	Availability	—: No Rating Given
ACB4: MCC-P41, Westinghouse Motor Control Center P41Located at Aeration Control Building #4	E	Cabling	Color and brittleness	—: No Rating Given
ACB4: MCC-P41, Westinghouse Motor Control Center P41Located at Aeration Control Building #4	E	Cabling	Color and brittleness	—: No Rating Given
ACB4: MCC-P41, Westinghouse Motor Control Center P41Located at Aeration Control Building #4	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given
ACB4: MCC-P41, Westinghouse Motor Control Center P41Located at Aeration Control Building #4	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID	MCC4004			
Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
ACB4: MCC-P42, Westinghouse Motor Control Center P42Located at Aeration Control Building #4	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
ACB4: MCC-P42, Westinghouse Motor Control Center P42Located at Aeration Control Building #4	B	Internal Components	Deterioration / Overheating	2: Some components showing minor signs of deterioration. No burning smell.
ACB4: MCC-P42, Westinghouse Motor Control Center P42Located at Aeration Control Building #4	C	Internal Components	Age	5: > 15 Years
ACB4: MCC-P42, Westinghouse Motor Control Center P42Located at Aeration Control Building #4	D	Internal Components	Availability	—: No Rating Given
ACB4: MCC-P42, Westinghouse Motor Control Center P42Located at Aeration Control Building #4	E	Cabling	Color and brittleness	—: No Rating Given
ACB4: MCC-P42, Westinghouse Motor Control Center P42Located at Aeration Control Building #4	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID	MCC4401			
Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
EFFB: MCC, P71, Effluent Building	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
EFFB: MCC, P71, Effluent Building	B	Internal Components	Deterioration / Overheating	1: No visible deterioration. No burning smell.

EFFB: MCC, P71, Effluent Building	C	Internal Components	Age	5: > 15 Years
EFFB: MCC, P71, Effluent Building	D	Internal Components	Availability	1: Components available locally of the shelf.
EFFB: MCC, P71, Effluent Building	E	Cabling	Color and brittleness	1: No visible signs of color deterioration. Coating still pliable
EFFB: MCC, P71, Effluent Building	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID MCC4402

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
EFFB: MCC, P72, Effluent Building	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
EFFB: MCC, P72, Effluent Building	B	Internal Components	Deterioration / Overheating	1: No visible deterioration. No burning smell.
EFFB: MCC, P72, Effluent Building	C	Internal Components	Age	5: > 15 Years
EFFB: MCC, P72, Effluent Building	D	Internal Components	Availability	1: Components available locally of the shelf.
EFFB: MCC, P72, Effluent Building	E	Cabling	Color and brittleness	1: No visible signs of color deterioration. Coating still pliable
EFFB: MCC, P72, Effluent Building	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID MEQ2005

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
HEAD: Screenings Launder Trough Headworks	A	Structure Appearance	Surface Deterioration	4: Surface deterioration evident that has impacted on the assets structural integrity or function.
HEAD: Screenings Launder Trough Headworks	B	Structure Appearance	Shaft, Supports, Bearing Deterioration	3: Shaft distortion or bearing/housing wear evident, little impact on structural integrity or function.

HEAD: Screenings Launder Trough Headworks	C	Symptoms	Vibration / Oscillation	—: No Rating Given
HEAD: Screenings Launder Trough Headworks	D	Symptoms	Temperature	—: No Rating Given
HEAD: Screenings Launder Trough Headworks	E	Symptoms	Noise	—: No Rating Given

AssetID MEQ2902

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
HEAD: W4 Strainer 1 A981	A	Life	Deterioration	4: Asset appears to be in poor condition, with approx 20-40% of life remaining
HEAD: W4 Strainer 1 A981	B	Service Distribution	Loss / Impact / Efficiency	3: Leakage moderate but no impact on building occupants. Minor affect on environmental health. Efficiency of distribution > 70%.

AssetID MEQ2903

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
HEAD: W4 Strainer 2 A982	A	Life	Deterioration	4: Asset appears to be in poor condition, with approx 20-40% of life remaining
HEAD: W4 Strainer 2 A982	B	Service Distribution	Loss / Impact / Efficiency	3: Leakage moderate but no impact on building occupants. Minor affect on environmental health. Efficiency of distribution > 70%.

AssetID MEQ3814

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
BB1 : Lube Oil Coolant Radiator Fan, Blower Building 1	A	Structure Appearance	Surface Deterioration	3: Surface deterioration becoming more evident however still little impact on structural integrity or function.

BB1 : Lube Oil Coolant Radiator Fan, Blower Building 1	B	Structure Appearance	Shaft, Supports, Bearing Deterioration	3: Shaft distortion or bearing/housing wear evident, little impact on structural integrity or function.
BB1 : Lube Oil Coolant Radiator Fan, Blower Building 1	C	Symptoms	Vibration / Oscillation	4: Considerable vibration / osciallation
BB1 : Lube Oil Coolant Radiator Fan, Blower Building 1	D	Symptoms	Temperature	—: No Rating Given
BB1 : Lube Oil Coolant Radiator Fan, Blower Building 1	E	Symptoms	Noise	4: Loud whine/rattle.

AssetID MPN4401

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
EFFB: Meter Panel, Effluent Building	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
EFFB: Meter Panel, Effluent Building	B	Internal Components	Deterioration / Overheating	1: No visible deterioration. No burning smell.
EFFB: Meter Panel, Effluent Building	C	Internal Components	Age	5: > 15 Years
EFFB: Meter Panel, Effluent Building	D	Internal Components	Availability	—: No Rating Given
EFFB: Meter Panel, Effluent Building	E	Cabling	Color and brittleness	—: No Rating Given
EFFB: Meter Panel, Effluent Building	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID PDC4301

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating

EFFB: Power Distribution Center, U.V. Channel 1, Bank A, Includes Breaker, GFI, PLC, & Ballast, Cabinet Air Conditioning Unit, Effluent Building	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
EFFB: Power Distribution Center, U.V. Channel 1, Bank A, Includes Breaker, GFI, PLC, & Ballast, Cabinet Air Conditioning Unit, Effluent Building	B	Internal Components	Deterioration / Overheating	1: No visible deterioration. No burning smell.
EFFB: Power Distribution Center, U.V. Channel 1, Bank A, Includes Breaker, GFI, PLC, & Ballast, Cabinet Air Conditioning Unit, Effluent Building	C	Internal Components	Age	4: < 15 Years
EFFB: Power Distribution Center, U.V. Channel 1, Bank A, Includes Breaker, GFI, PLC, & Ballast, Cabinet Air Conditioning Unit, Effluent Building	D	Internal Components	Availability	—: No Rating Given
EFFB: Power Distribution Center, U.V. Channel 1, Bank A, Includes Breaker, GFI, PLC, & Ballast, Cabinet Air Conditioning Unit, Effluent Building	E	Cabling	Color and brittleness	1: No visible signs of color deterioration. Coating still pliable
EFFB: Power Distribution Center, U.V. Channel 1, Bank A, Includes Breaker, GFI, PLC, & Ballast, Cabinet Air Conditioning Unit, Effluent Building	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID PDC4302

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
EFFB: Power Distribution Center, U.V. Channel 1, Bank B, Includes Breaker, GFI, PLC, & Ballast	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
EFFB: Power Distribution Center, U.V. Channel 1, Bank B, Includes Breaker, GFI, PLC, & Ballast	B	Internal Components	Deterioration / Overheating	1: No visible deterioration. No burning smell.
EFFB: Power Distribution Center, U.V. Channel 1, Bank B, Includes Breaker, GFI, PLC, & Ballast	C	Internal Components	Age	4: < 15 Years
EFFB: Power Distribution Center, U.V. Channel 1, Bank B, Includes Breaker, GFI, PLC, & Ballast	D	Internal Components	Availability	—: No Rating Given
EFFB: Power Distribution Center, U.V. Channel 1, Bank B, Includes Breaker, GFI, PLC, & Ballast	E	Cabling	Color and brittleness	1: No visible signs of color deterioration. Coating still pliable
EFFB: Power Distribution Center, U.V. Channel 1, Bank B, Includes Breaker, GFI, PLC, & Ballast	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID PDC4303

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
EFFB: Power Distribution Center, U.V. Channel 2, Bank A, Includes Breaker, GFI, PLC, & Ballast, Cabinet Air Conditioning Unit	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.

EFFB: Power Distribution Center, U.V. Channel 2, Bank A, Includes Breaker, GFI, PLC, & Ballast, Cabinet Air Conditioning Unit	B	Internal Components	Deterioration / Overheating	1: No visible deterioration. No burning smell.
EFFB: Power Distribution Center, U.V. Channel 2, Bank A, Includes Breaker, GFI, PLC, & Ballast, Cabinet Air Conditioning Unit	C	Internal Components	Age	4: < 15 Years
EFFB: Power Distribution Center, U.V. Channel 2, Bank A, Includes Breaker, GFI, PLC, & Ballast, Cabinet Air Conditioning Unit	D	Internal Components	Availability	—: No Rating Given
EFFB: Power Distribution Center, U.V. Channel 2, Bank A, Includes Breaker, GFI, PLC, & Ballast, Cabinet Air Conditioning Unit	E	Cabling	Color and brittleness	1: No visible signs of color deterioration. Coating still pliable
EFFB: Power Distribution Center, U.V. Channel 2, Bank A, Includes Breaker, GFI, PLC, & Ballast, Cabinet Air Conditioning Unit	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID PDC4304

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
EFFB: Power Distribution Center, U.V. Channel 2, Bank B, Includes Breaker, GFI, PLC, & Ballast	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
EFFB: Power Distribution Center, U.V. Channel 2, Bank B, Includes Breaker, GFI, PLC, & Ballast	B	Internal Components	Deterioration / Overheating	1: No visible deterioration. No burning smell.

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
EFFB: Power Distribution Center, U.V. Channel 2, Bank B, Includes Breaker, GFI, PLC, & Ballast	C	Internal Components	Age	4: < 15 Years
EFFB: Power Distribution Center, U.V. Channel 2, Bank B, Includes Breaker, GFI, PLC, & Ballast	D	Internal Components	Availability	—: No Rating Given
EFFB: Power Distribution Center, U.V. Channel 2, Bank B, Includes Breaker, GFI, PLC, & Ballast	E	Cabling	Color and brittleness	1: No visible signs of color deterioration. Coating still pliable
EFFB: Power Distribution Center, U.V. Channel 2, Bank B, Includes Breaker, GFI, PLC, & Ballast	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID PDC4305

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
EFFB: Power Distribution Center, U.V. Channel 3, Bank A, Includes Breaker, GFI, PLC, & Ballast, Cabinet Air Conditioning Unit	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
EFFB: Power Distribution Center, U.V. Channel 3, Bank A, Includes Breaker, GFI, PLC, & Ballast, Cabinet Air Conditioning Unit	B	Internal Components	Deterioration / Overheating	1: No visible deterioration. No burning smell.
EFFB: Power Distribution Center, U.V. Channel 3, Bank A, Includes Breaker, GFI, PLC, & Ballast, Cabinet Air Conditioning Unit	C	Internal Components	Age	4: < 15 Years

EFFB: Power Distribution Center, U.V. Channel 3, Bank A, Includes Breaker, GFI, PLC, & Ballast, Cabinet Air Conditioning Unit	D	Internal Components	Availability	—: No Rating Given
EFFB: Power Distribution Center, U.V. Channel 3, Bank A, Includes Breaker, GFI, PLC, & Ballast, Cabinet Air Conditioning Unit	E	Cabling	Color and brittleness	1: No visible signs of color deterioration. Coating still pliable
EFFB: Power Distribution Center, U.V. Channel 3, Bank A, Includes Breaker, GFI, PLC, & Ballast, Cabinet Air Conditioning Unit	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID PDC4306

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
EFFB: Power Distribution Center, U.V. Channel 3, Bank B, Includes Breaker, GFI, PLC, & Ballast	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
EFFB: Power Distribution Center, U.V. Channel 3, Bank B, Includes Breaker, GFI, PLC, & Ballast	B	Internal Components	Deterioration / Overheating	1: No visible deterioration. No burning smell.
EFFB: Power Distribution Center, U.V. Channel 3, Bank B, Includes Breaker, GFI, PLC, & Ballast	C	Internal Components	Age	4: < 15 Years
EFFB: Power Distribution Center, U.V. Channel 3, Bank B, Includes Breaker, GFI, PLC, & Ballast	D	Internal Components	Availability	—: No Rating Given

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
EFFB: Power Distribution Center, U.V. Channel 3, Bank B, Includes Breaker, GFI, PLC, & Ballast	E	Cabling	Color and brittleness	1: No visible signs of color deterioration. Coating still pliable
EFFB: Power Distribution Center, U.V. Channel 3, Bank B, Includes Breaker, GFI, PLC, & Ballast	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID PDC4307

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
EFFB: Power Distribution Center, U.V. Channel 4, Bank A, Includes Breaker,GFI, PLC, & Ballast, Cabinet Air Conditioning Unit	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
EFFB: Power Distribution Center, U.V. Channel 4, Bank A, Includes Breaker,GFI, PLC, & Ballast, Cabinet Air Conditioning Unit	B	Internal Components	Deterioration / Overheating	1: No visible deterioration. No burning smell.
EFFB: Power Distribution Center, U.V. Channel 4, Bank A, Includes Breaker,GFI, PLC, & Ballast, Cabinet Air Conditioning Unit	C	Internal Components	Age	4: < 15 Years
EFFB: Power Distribution Center, U.V. Channel 4, Bank A, Includes Breaker,GFI, PLC, & Ballast, Cabinet Air Conditioning Unit	D	Internal Components	Availability	—: No Rating Given
EFFB: Power Distribution Center, U.V. Channel 4, Bank A, Includes Breaker,GFI, PLC, & Ballast, Cabinet Air Conditioning Unit	E	Cabling	Color and brittleness	1: No visible signs of color deterioration. Coating still pliable

EFFB: Power Distribution Center, U.V. Channel 4, Bank A, Includes Breaker,GFI, PLC, & Ballast, Cabinet Air Conditioning Unit	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID PDC4308

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
EFFB: Power Distribution Center, U.V. Channel 4, Bank B, Includes Breaker, GFI, PLC, & Ballast	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
EFFB: Power Distribution Center, U.V. Channel 4, Bank B, Includes Breaker, GFI, PLC, & Ballast	B	Internal Components	Deterioration / Overheating	1: No visible deterioration. No burning smell.
EFFB: Power Distribution Center, U.V. Channel 4, Bank B, Includes Breaker, GFI, PLC, & Ballast	C	Internal Components	Age	4: < 15 Years
EFFB: Power Distribution Center, U.V. Channel 4, Bank B, Includes Breaker, GFI, PLC, & Ballast	D	Internal Components	Availability	—: No Rating Given
EFFB: Power Distribution Center, U.V. Channel 4, Bank B, Includes Breaker, GFI, PLC, & Ballast	E	Cabling	Color and brittleness	1: No visible signs of color deterioration. Coating still pliable
EFFB: Power Distribution Center, U.V. Channel 4, Bank B, Includes Breaker, GFI, PLC, & Ballast	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID PDC4309

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating

EFFB: Power Distribution Center, U.V. Channel 5, Bank A, Includes Breaker, GFI, PLC, & Ballast, Cabinet Air Conditioning Unit	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
EFFB: Power Distribution Center, U.V. Channel 5, Bank A, Includes Breaker, GFI, PLC, & Ballast, Cabinet Air Conditioning Unit	B	Internal Components	Deterioration / Overheating	1: No visible deterioration. No burning smell.
EFFB: Power Distribution Center, U.V. Channel 5, Bank A, Includes Breaker, GFI, PLC, & Ballast, Cabinet Air Conditioning Unit	C	Internal Components	Age	4: < 15 Years
EFFB: Power Distribution Center, U.V. Channel 5, Bank A, Includes Breaker, GFI, PLC, & Ballast, Cabinet Air Conditioning Unit	D	Internal Components	Availability	—: No Rating Given
EFFB: Power Distribution Center, U.V. Channel 5, Bank A, Includes Breaker, GFI, PLC, & Ballast, Cabinet Air Conditioning Unit	E	Cabling	Color and brittleness	1: No visible signs of color deterioration. Coating still pliable
EFFB: Power Distribution Center, U.V. Channel 5, Bank A, Includes Breaker, GFI, PLC, & Ballast, Cabinet Air Conditioning Unit	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID PDC4310

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
EFFB: Power Distribution Center, U.V. Channel 5, Bank B, Includes Breaker, GFI, PLC, & Ballast	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.

EFFB: Power Distribution Center, U.V. Channel 5, Bank B, Includes Breaker, GFI, PLC, & Ballast	B	Internal Components	Deterioration / Overheating	1: No visible deterioration. No burning smell.
EFFB: Power Distribution Center, U.V. Channel 5, Bank B, Includes Breaker, GFI, PLC, & Ballast	C	Internal Components	Age	4: < 15 Years
EFFB: Power Distribution Center, U.V. Channel 5, Bank B, Includes Breaker, GFI, PLC, & Ballast	D	Internal Components	Availability	—: No Rating Given
EFFB: Power Distribution Center, U.V. Channel 5, Bank B, Includes Breaker, GFI, PLC, & Ballast	E	Cabling	Color and brittleness	1: No visible signs of color deterioration. Coating still pliable
EFFB: Power Distribution Center, U.V. Channel 5, Bank B, Includes Breaker, GFI, PLC, & Ballast	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID PMP2901

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
HEAD: Pump 1 A991, W4, Headworks	A	Structure Appearance	Leakage	1: Appears as new.
HEAD: Pump 1 A991, W4, Headworks	B	Structure Appearance	Shaft, Supports, Bearing Deterioration	1: Shaft & supports sound - no shaft distortion or deterioration evident.
HEAD: Pump 1 A991, W4, Headworks	C	Use	Motor Hours Run	—: No Rating Given
HEAD: Pump 1 A991, W4, Headworks	D	Symptoms	Vibration / oscillation	1: No unusual vibration / oscillation detectable
HEAD: Pump 1 A991, W4, Headworks	E	Symptoms	Temperature	1: No unusual temperature detected
HEAD: Pump 1 A991, W4, Headworks	F	Symptoms	Noise	4: Loud whine/rattle.

AssetID PMP3801

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
BB1 : Pump, Aurora Protected Water Pump 1, Blower Building 1	A	Structure Appearance	Leakage	5: Water squirting/ running onto floor.
BB1 : Pump, Aurora Protected Water Pump 1, Blower Building 1	B	Structure Appearance	Shaft, Supports, Bearing Deterioration	5: Significant shaft distortion or bearing/housing wear evident, high probability of fracture or failure.
BB1 : Pump, Aurora Protected Water Pump 1, Blower Building 1	C	Use	Motor Hours Run	2: > 10,000
BB1 : Pump, Aurora Protected Water Pump 1, Blower Building 1	D	Symptoms	Vibration / oscillation	2: Minor vibration / oscillation
BB1 : Pump, Aurora Protected Water Pump 1, Blower Building 1	E	Symptoms	Temperature	1: No unusual temperature detected
BB1 : Pump, Aurora Protected Water Pump 1, Blower Building 1	F	Symptoms	Noise	5: Disturbingly loud operation/vibrations.

AssetID PMP3808

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
BB1 : Pump, Jacket Water Pump 5, Blower Building 1	A	Structure Appearance	Leakage	1: Appears as new.
BB1 : Pump, Jacket Water Pump 5, Blower Building 1	A	Structure Appearance	Leakage	—: No Rating Given
BB1 : Pump, Jacket Water Pump 5, Blower Building 1	B	Structure Appearance	Shaft, Supports, Bearing Deterioration	2: Minor shaft/ support deterioration evident, no impact on the structural strength or function.
BB1 : Pump, Jacket Water Pump 5, Blower Building 1	B	Structure Appearance	Shaft, Supports, Bearing Deterioration	—: No Rating Given

BB1 : Pump, Jacket Water Pump 5, Blower Building 1	C	Use	Motor Hours Run	—: No Rating Given
BB1 : Pump, Jacket Water Pump 5, Blower Building 1	C	Use	Motor Hours Run	—: No Rating Given
BB1 : Pump, Jacket Water Pump 5, Blower Building 1	D	Symptoms	Vibration / oscillation	—: No Rating Given
BB1 : Pump, Jacket Water Pump 5, Blower Building 1	D	Symptoms	Vibration / oscillation	1: No unusual vibration / oscillation detectable
BB1 : Pump, Jacket Water Pump 5, Blower Building 1	E	Symptoms	Temperature	—: No Rating Given
BB1 : Pump, Jacket Water Pump 5, Blower Building 1	E	Symptoms	Temperature	4: Heat detected by hand is uncomfortable
BB1 : Pump, Jacket Water Pump 5, Blower Building 1	F	Symptoms	Noise	1: No unusual noises detected.
BB1 : Pump, Jacket Water Pump 5, Blower Building 1	F	Symptoms	Noise	—: No Rating Given

AssetID PMP3809

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
BB1 : Pump, Aurora Protected Water Pump 2, Blower Building 1	A	Structure Appearance	Leakage	4: Water pooling on floor
BB1 : Pump, Aurora Protected Water Pump 2, Blower Building 1	B	Structure Appearance	Shaft, Supports, Bearing Deterioration	5: Significant shaft distortion or bearing/housing wear evident, high probability of fracture or failure.
BB1 : Pump, Aurora Protected Water Pump 2, Blower Building 1	C	Use	Motor Hours Run	2: > 10,000
BB1 : Pump, Aurora Protected Water Pump 2, Blower Building 1	D	Symptoms	Vibration / oscillation	2: Minor vibration / oscillation
BB1 : Pump, Aurora Protected Water Pump 2, Blower Building 1	E	Symptoms	Temperature	1: No unusual temperature detected

BB1 : Pump, Aurora Protected Water Pump 2, Blower Building 1	F	Symptoms	Noise	5: Disturbingly loud operation/vibrations.

AssetID PMP3811

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
BB1 : Pump, Jacket Water Pump 4, Blower Building 1	A	Structure Appearance	Leakage	1: Appears as new.
BB1 : Pump, Jacket Water Pump 4, Blower Building 1	B	Structure Appearance	Shaft, Supports, Bearing Deterioration	2: Minor shaft/ support deterioration evident, no impact on the structural strength or function.
BB1 : Pump, Jacket Water Pump 4, Blower Building 1	C	Use	Motor Hours Run	—: No Rating Given
BB1 : Pump, Jacket Water Pump 4, Blower Building 1	D	Symptoms	Vibration / oscillation	1: No unusual vibration / oscillation detectable
BB1 : Pump, Jacket Water Pump 4, Blower Building 1	E	Symptoms	Temperature	4: Heat detected by hand is uncomfortable
BB1 : Pump, Jacket Water Pump 4, Blower Building 1	F	Symptoms	Noise	1: No unusual noises detected.

AssetID PMP3821

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
BB1 : Pump 1, Heat Recovery Pump, Blower Building 1	A	Structure Appearance	Leakage	1: Appears as new.
BB1 : Pump 1, Heat Recovery Pump, Blower Building 1	B	Structure Appearance	Shaft, Supports, Bearing Deterioration	2: Minor shaft/ support deterioration evident, no impact on the structural strength or function.
BB1 : Pump 1, Heat Recovery Pump, Blower Building 1	C	Use	Motor Hours Run	—: No Rating Given
BB1 : Pump 1, Heat Recovery Pump, Blower Building 1	D	Symptoms	Vibration / oscillation	—: No Rating Given
BB1 : Pump 1, Heat Recovery Pump, Blower Building 1	E	Symptoms	Temperature	4: Heat detected by hand is uncomfortable

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
BB1 : Pump 1, Heat Recovery Pump, Blower Building 1	F	Symptoms	Noise	—: No Rating Given

AssetID PNL4300

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
EFFB: Panel View , in the System Control Center for all U.V.'s	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
EFFB: Panel View , in the System Control Center for all U.V.'s	B	Internal Components	Deterioration / Overheating	1: No visible deterioration. No burning smell.
EFFB: Panel View , in the System Control Center for all U.V.'s	C	Internal Components	Age	5: > 15 Years
EFFB: Panel View , in the System Control Center for all U.V.'s	D	Internal Components	Availability	—: No Rating Given
EFFB: Panel View , in the System Control Center for all U.V.'s	E	Cabling	Color and brittleness	1: No visible signs of color deterioration. Coating still pliable
EFFB: Panel View , in the System Control Center for all U.V.'s	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID SAM0021

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
AG2: Sampler, West Primary Effluent for West Plant, 2001, Blower Building 2	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
AG2: Sampler, West Primary Effluent for West Plant, 2001, Blower Building 2	B	Internal Components	Deterioration / Overheating	1: No visible deterioration.

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
AG2: Sampler, West Primary Effluent for West Plant, 2001, Blower Building 2	C	Internal Components	Age	4: < 15 Years

AssetID SGT4104

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
FC04: Sluice Gate, Final Clarifier 4	A	Sealing	Wear / Leakage	2: Some minor wear or corrosion on sealing elements
FC04: Sluice Gate, Final Clarifier 4	B	Supports / Bolts - Coating	Cracking / Flaking / Corrosion	4: Coating loss / deterioration exposing steel. Steel corroding / rusting with surface delamination / flaking.
FC04: Sluice Gate, Final Clarifier 4	C	Operation	Ease of Operation	1: Operates as new

AssetID TNK3810

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
AT10: Aeration Tank 10	A	Structural Integrity / Function	Cracking	3: Cracking becoming more evident however still little impact on structural integrity or function.
AT10: Aeration Tank 10	B	Structural Integrity / Function	Movement	2: Some minor movement evident that has little impact on the structures strength or function.
AT10: Aeration Tank 10	C	Surface	Deterioration	4: Surface deterioration evident that has impacted on the assets structural integrity or function.
AT10: Aeration Tank 10	D	Foundation	Ground Movement/ Erosion	—: No Rating Given
AT10: Aeration Tank 10	E	Connections	Cracking / Corrosion	—: No Rating Given

AssetID TRN0007

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
AG1 : Meter & Transmitter C363, Flow, RAS From ACB3, Aeration Gallery 1	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.

AG1 : Meter & Transmitter C363, Flow, RAS From ACB3, Aeration Gallery 1	B	Internal Components	Deterioration / Overheating	2: Some components showing minor signs of deterioration. No burning smell.
AG1 : Meter & Transmitter C363, Flow, RAS From ACB3, Aeration Gallery 1	C	Internal Components	Age	5: > 15 Years
AG1 : Meter & Transmitter C363, Flow, RAS From ACB3, Aeration Gallery 1	D	Internal Components	Availability	—: No Rating Given
AG1 : Meter & Transmitter C363, Flow, RAS From ACB3, Aeration Gallery 1	E	Cabling	Color and brittleness	—: No Rating Given
AG1 : Meter & Transmitter C363, Flow, RAS From ACB3, Aeration Gallery 1	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID TRN0014

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
ACB4: Meter & Transmitter, B196, Power, MCC P41, ACB4	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
ACB4: Meter & Transmitter, B196, Power, MCC P41, ACB4	B	Internal Components	Deterioration / Overheating	2: Some components showing minor signs of deterioration. No burning smell.
ACB4: Meter & Transmitter, B196, Power, MCC P41, ACB4	C	Internal Components	Age	5: > 15 Years
ACB4: Meter & Transmitter, B196, Power, MCC P41, ACB4	D	Internal Components	Availability	—: No Rating Given
ACB4: Meter & Transmitter, B196, Power, MCC P41, ACB4	E	Cabling	Color and brittleness	—: No Rating Given
ACB4: Meter & Transmitter, B196, Power, MCC P41, ACB4	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID TRN0015

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
ACB4: Meter & Transmitter B197, Power, MCC P42, ACB4	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
ACB4: Meter & Transmitter B197, Power, MCC P42, ACB4	B	Internal Components	Deterioration / Overheating	2: Some components showing minor signs of deterioration. No burning smell.
ACB4: Meter & Transmitter B197, Power, MCC P42, ACB4	C	Internal Components	Age	5: > 15 Years
ACB4: Meter & Transmitter B197, Power, MCC P42, ACB4	D	Internal Components	Availability	—: No Rating Given
ACB4: Meter & Transmitter B197, Power, MCC P42, ACB4	E	Cabling	Color and brittleness	—: No Rating Given
ACB4: Meter & Transmitter B197, Power, MCC P42, ACB4	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID TRN0018

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
AG1 : Meter & Transmitter C231, Flow, WAS Plant 1, Aeration Gallery 1	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
AG1 : Meter & Transmitter C231, Flow, WAS Plant 1, Aeration Gallery 1	B	Internal Components	Deterioration / Overheating	1: No visible deterioration. No burning smell.
AG1 : Meter & Transmitter C231, Flow, WAS Plant 1, Aeration Gallery 1	C	Internal Components	Age	5: > 15 Years
AG1 : Meter & Transmitter C231, Flow, WAS Plant 1, Aeration Gallery 1	D	Internal Components	Availability	—: No Rating Given

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
AG1 : Meter & Transmitter C231, Flow, WAS Plant 1, Aeration Gallery 1	E	Cabling	Color and brittleness	—: No Rating Given
AG1 : Meter & Transmitter C231, Flow, WAS Plant 1, Aeration Gallery 1	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID TRN0072

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
BB1 : Meter & Transmitter, RPM, Blower 1, Blower Building 1	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
BB1 : Meter & Transmitter, RPM, Blower 1, Blower Building 1	B	Internal Components	Deterioration / Overheating	2: Some components showing minor signs of deterioration. No burning smell.
BB1 : Meter & Transmitter, RPM, Blower 1, Blower Building 1	C	Internal Components	Age	5: > 15 Years
BB1 : Meter & Transmitter, RPM, Blower 1, Blower Building 1	D	Internal Components	Availability	—: No Rating Given
BB1 : Meter & Transmitter, RPM, Blower 1, Blower Building 1	E	Cabling	Color and brittleness	—: No Rating Given
BB1 : Meter & Transmitter, RPM, Blower 1, Blower Building 1	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID TRN0073

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
BB1 : Meter & Transmitter, Power, Blower 2, Blower Building 1	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.

BB1 : Meter & Transmitter, Power, Blower 2, Blower Building 1	B	Internal Components	Deterioration / Overheating	1: No visible deterioration. No burning smell.
BB1 : Meter & Transmitter, Power, Blower 2, Blower Building 1	C	Internal Components	Age	5: > 15 Years
BB1 : Meter & Transmitter, Power, Blower 2, Blower Building 1	D	Internal Components	Availability	—: No Rating Given
BB1 : Meter & Transmitter, Power, Blower 2, Blower Building 1	E	Cabling	Color and brittleness	—: No Rating Given
BB1 : Meter & Transmitter, Power, Blower 2, Blower Building 1	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID TRN0074

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
BB1 : Meter & Transmitter, Power, Blower 3, Blower Building 1	A	Protective Enclosure	External Condition / Cooling / Sealing	2: Coating cracked / flaking exposing undercoat < 20% of area, evidence of corrosion. Some seal wear but no dirt ingress. Ventilation and cooling adequate.
BB1 : Meter & Transmitter, Power, Blower 3, Blower Building 1	B	Internal Components	Deterioration / Overheating	1: No visible deterioration. No burning smell.
BB1 : Meter & Transmitter, Power, Blower 3, Blower Building 1	C	Internal Components	Age	5: > 15 Years
BB1 : Meter & Transmitter, Power, Blower 3, Blower Building 1	D	Internal Components	Availability	—: No Rating Given
BB1 : Meter & Transmitter, Power, Blower 3, Blower Building 1	E	Cabling	Color and brittleness	—: No Rating Given

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
BB1 : Meter & Transmitter, Power, Blower 3, Blower Building 1	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID TRN0075

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
BB1 : Meter & Transmitter, Power High, Blower 4, Blower Building 1	A	Protective Enclosure	External Condition / Cooling / Sealing	2: Coating cracked / flaking exposing undercoat < 20% of area, evidence of corrosion. Some seal wear but no dirt ingress. Ventilation and cooling adequate.
BB1 : Meter & Transmitter, Power High, Blower 4, Blower Building 1	B	Internal Components	Deterioration / Overheating	2: Some components showing minor signs of deterioration. No burning smell.
BB1 : Meter & Transmitter, Power High, Blower 4, Blower Building 1	C	Internal Components	Age	5: > 15 Years
BB1 : Meter & Transmitter, Power High, Blower 4, Blower Building 1	D	Internal Components	Availability	—: No Rating Given
BB1 : Meter & Transmitter, Power High, Blower 4, Blower Building 1	E	Cabling	Color and brittleness	—: No Rating Given
BB1 : Meter & Transmitter, Power High, Blower 4, Blower Building 1	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID TRN0076

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
BB1 : Meter & Transmitter, Power Low, Blower 4, Blower Building 1	A	Protective Enclosure	External Condition / Cooling / Sealing	2: Coating cracked / flaking exposing undercoat < 20% of area, evidence of corrosion. Some seal wear but no dirt ingress. Ventilation and cooling adequate.

BB1 : Meter & Transmitter, Power Low, Blower 4, Blower Building 1	B	Internal Components	Deterioration / Overheating	2: Some components showing minor signs of deterioration. No burning smell.
BB1 : Meter & Transmitter, Power Low, Blower 4, Blower Building 1	C	Internal Components	Age	5: > 15 Years
BB1 : Meter & Transmitter, Power Low, Blower 4, Blower Building 1	D	Internal Components	Availability	—: No Rating Given
BB1 : Meter & Transmitter, Power Low, Blower 4, Blower Building 1	E	Cabling	Color and brittleness	—: No Rating Given
BB1 : Meter & Transmitter, Power Low, Blower 4, Blower Building 1	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID TRN0077

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
BB1 : Meter & Transmitter, Power High, Blower 5, Blower Building 1	A	Protective Enclosure	External Condition / Cooling / Sealing	2: Coating cracked / flaking exposing undercoat < 20% of area, evidence of corrosion. Some seal wear but no dirt ingress. Ventilation and cooling adequate.
BB1 : Meter & Transmitter, Power High, Blower 5, Blower Building 1	B	Internal Components	Deterioration / Overheating	2: Some components showing minor signs of deterioration. No burning smell.
BB1 : Meter & Transmitter, Power High, Blower 5, Blower Building 1	C	Internal Components	Age	5: > 15 Years
BB1 : Meter & Transmitter, Power High, Blower 5, Blower Building 1	D	Internal Components	Availability	—: No Rating Given
BB1 : Meter & Transmitter, Power High, Blower 5, Blower Building 1	E	Cabling	Color and brittleness	—: No Rating Given

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
BB1 : Meter & Transmitter, Power High, Blower 5, Blower Building 1	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID TRN0078

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
BB1 : Meter & Transmitter, Power Low, Blower 5, Blower Building 1	A	Protective Enclosure	External Condition / Cooling / Sealing	2: Coating cracked / flaking exposing undercoat < 20% of area, evidence of corrosion. Some seal wear but no dirt ingress. Ventilation and cooling adequate.
BB1 : Meter & Transmitter, Power Low, Blower 5, Blower Building 1	B	Internal Components	Deterioration / Overheating	2: Some components showing minor signs of deterioration. No burning smell.
BB1 : Meter & Transmitter, Power Low, Blower 5, Blower Building 1	C	Internal Components	Age	5: > 15 Years
BB1 : Meter & Transmitter, Power Low, Blower 5, Blower Building 1	D	Internal Components	Availability	—: No Rating Given
BB1 : Meter & Transmitter, Power Low, Blower 5, Blower Building 1	E	Cabling	Color and brittleness	—: No Rating Given
BB1 : Meter & Transmitter, Power Low, Blower 5, Blower Building 1	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID TRN0080

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
BB1 : Meter & Transmitter, Temp. Switch, Gas Engine Radiator Oil, Blower Building 1	A	Protective Enclosure	External Condition / Cooling / Sealing	2: Coating cracked / flaking exposing undercoat < 20% of area, evidence of corrosion. Some seal wear but no dirt ingress. Ventilation and cooling adequate.

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
BB1 : Meter & Transmitter, Temp. Switch, Gas Engine Radiator Oil, Blower Building 1	B	Internal Components	Deterioration / Overheating	2: Some components showing minor signs of deterioration. No burning smell.
BB1 : Meter & Transmitter, Temp. Switch, Gas Engine Radiator Oil, Blower Building 1	C	Internal Components	Age	5: > 15 Years
BB1 : Meter & Transmitter, Temp. Switch, Gas Engine Radiator Oil, Blower Building 1	D	Internal Components	Availability	2: Components available interstate of the shelf.
BB1 : Meter & Transmitter, Temp. Switch, Gas Engine Radiator Oil, Blower Building 1	E	Cabling	Color and brittleness	—: No Rating Given
BB1 : Meter & Transmitter, Temp. Switch, Gas Engine Radiator Oil, Blower Building 1	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID TRN0082

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
BB1 : Meter & Transmitter, Power, Blower Building 1	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
BB1 : Meter & Transmitter, Power, Blower Building 1	B	Internal Components	Deterioration / Overheating	1: No visible deterioration. No burning smell.
BB1 : Meter & Transmitter, Power, Blower Building 1	C	Internal Components	Age	4: < 15 Years
BB1 : Meter & Transmitter, Power, Blower Building 1	D	Internal Components	Availability	—: No Rating Given
BB1 : Meter & Transmitter, Power, Blower Building 1	E	Cabling	Color and brittleness	—: No Rating Given
BB1 : Meter & Transmitter, Power, Blower Building 1	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID TRN0083

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating

BB2 : Meter & Transmitter, Power, MCC P51, Blower Building 2	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
BB2 : Meter & Transmitter, Power, MCC P51, Blower Building 2	B	Internal Components	Deterioration / Overheating	1: No visible deterioration. No burning smell.
BB2 : Meter & Transmitter, Power, MCC P51, Blower Building 2	C	Internal Components	Age	5: > 15 Years
BB2 : Meter & Transmitter, Power, MCC P51, Blower Building 2	D	Internal Components	Availability	—: No Rating Given
BB2 : Meter & Transmitter, Power, MCC P51, Blower Building 2	E	Cabling	Color and brittleness	—: No Rating Given
BB2 : Meter & Transmitter, Power, MCC P51, Blower Building 2	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID TRN0084

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
BB2 : Meter & Transmitter, Power, MCC P52, Blower Building 2	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
BB2 : Meter & Transmitter, Power, MCC P52, Blower Building 2	B	Internal Components	Deterioration / Overheating	1: No visible deterioration. No burning smell.
BB2 : Meter & Transmitter, Power, MCC P52, Blower Building 2	C	Internal Components	Age	5: > 15 Years
BB2 : Meter & Transmitter, Power, MCC P52, Blower Building 2	D	Internal Components	Availability	—: No Rating Given

BB2 : Meter & Transmitter, Power, MCC P52, Blower Building 2	E	Cabling	Color and brittleness	—: No Rating Given
BB2 : Meter & Transmitter, Power, MCC P52, Blower Building 2	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID TRN3801

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
BB1 : Transmitter C329, Pressure, Gas Blower 1, Blower Building 1	A	Protective Enclosure	External Condition / Cooling / Sealing	2: Coating cracked / flaking exposing undercoat < 20% of area, evidence of corrosion. Some seal wear but no dirt ingress. Ventilation and cooling adequate.
BB1 : Transmitter C329, Pressure, Gas Blower 1, Blower Building 1	B	Internal Components	Deterioration / Overheating	2: Some components showing minor signs of deterioration. No burning smell.
BB1 : Transmitter C329, Pressure, Gas Blower 1, Blower Building 1	C	Internal Components	Age	4: < 15 Years
BB1 : Transmitter C329, Pressure, Gas Blower 1, Blower Building 1	D	Internal Components	Availability	2: Components available interstate of the shelf.
BB1 : Transmitter C329, Pressure, Gas Blower 1, Blower Building 1	E	Cabling	Color and brittleness	2: Coating pliable and providing good insulation protection however some minor signs of discoloration.
BB1 : Transmitter C329, Pressure, Gas Blower 1, Blower Building 1	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID VFD0552

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating

U15 : See Notes...hankr, Variable Frequency Drive, Anaerobic Pump, AT25, South Wall, Elec Bldg U15	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
U15 : See Notes...hankr, Variable Frequency Drive, Anaerobic Pump, AT25, South Wall, Elec Bldg U15	B	Internal Components	Deterioration / Overheating	1: No visible deterioration. No burning smell.
U15 : See Notes...hankr, Variable Frequency Drive, Anaerobic Pump, AT25, South Wall, Elec Bldg U15	C	Internal Components	Age	4: < 15 Years
U15 : See Notes...hankr, Variable Frequency Drive, Anaerobic Pump, AT25, South Wall, Elec Bldg U15	D	Internal Components	Availability	2: Components available interstate of the shelf.
U15 : See Notes...hankr, Variable Frequency Drive, Anaerobic Pump, AT25, South Wall, Elec Bldg U15	E	Cabling	Color and brittleness	—: No Rating Given
U15 : See Notes...hankr, Variable Frequency Drive, Anaerobic Pump, AT25, South Wall, Elec Bldg U15	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID VFD0553

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
U15 : Variable Frequency Drive, Anaerobic Pump, AT28, South Wall, Elec Bldg U15	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
U15 : Variable Frequency Drive, Anaerobic Pump, AT28, South Wall, Elec Bldg U15	B	Internal Components	Deterioration / Overheating	1: No visible deterioration. No burning smell.
U15 : Variable Frequency Drive, Anaerobic Pump, AT28, South Wall, Elec Bldg U15	C	Internal Components	Age	4: < 15 Years

U15 : Variable Frequency Drive, Anaerobic Pump, AT28, South Wall, Elec Bldg U15	D	Internal Components	Availability	2: Components available interstate of the shelf.
U15 : Variable Frequency Drive, Anaerobic Pump, AT28, South Wall, Elec Bldg U15	E	Cabling	Color and brittleness	—: No Rating Given
U15 : Variable Frequency Drive, Anaerobic Pump, AT28, South Wall, Elec Bldg U15	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID VFD3811

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating
ACB2: VFD, Aeration Tank 12, Anaerobic Recycle Pump, P-NT12-1	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
ACB2: VFD, Aeration Tank 12, Anaerobic Recycle Pump, P-NT12-1	B	Internal Components	Deterioration / Overheating	1: No visible deterioration. No burning smell.
ACB2: VFD, Aeration Tank 12, Anaerobic Recycle Pump, P-NT12-1	C	Internal Components	Age	4: < 15 Years
ACB2: VFD, Aeration Tank 12, Anaerobic Recycle Pump, P-NT12-1	D	Internal Components	Availability	—: No Rating Given
ACB2: VFD, Aeration Tank 12, Anaerobic Recycle Pump, P-NT12-1	E	Cabling	Color and brittleness	—: No Rating Given
ACB2: VFD, Aeration Tank 12, Anaerobic Recycle Pump, P-NT12-1	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

AssetID VFD3813

Asset Description	Distress Mode Letter	Aspect	Distress Mode Description	Assessment Rating

ACB2: VFD, Aeration Tank 18, Anaerobic Recycle Pump, P-NT18-1	A	Protective Enclosure	External Condition / Cooling / Sealing	—: No Rating Given
ACB2: VFD, Aeration Tank 18, Anaerobic Recycle Pump, P-NT18-1	A	Protective Enclosure	External Condition / Cooling / Sealing	—: No Rating Given
ACB2: VFD, Aeration Tank 18, Anaerobic Recycle Pump, P-NT18-1	A	Protective Enclosure	External Condition / Cooling / Sealing	1: Protective enclosure / coating sound, no deterioration. Sealing and ventilation / cooling good.
ACB2: VFD, Aeration Tank 18, Anaerobic Recycle Pump, P-NT18-1	B	Internal Components	Deterioration / Overheating	—: No Rating Given
ACB2: VFD, Aeration Tank 18, Anaerobic Recycle Pump, P-NT18-1	B	Internal Components	Deterioration / Overheating	—: No Rating Given
ACB2: VFD, Aeration Tank 18, Anaerobic Recycle Pump, P-NT18-1	B	Internal Components	Deterioration / Overheating	1: No visible deterioration. No burning smell.
ACB2: VFD, Aeration Tank 18, Anaerobic Recycle Pump, P-NT18-1	C	Internal Components	Age	—: No Rating Given
ACB2: VFD, Aeration Tank 18, Anaerobic Recycle Pump, P-NT18-1	C	Internal Components	Age	—: No Rating Given
ACB2: VFD, Aeration Tank 18, Anaerobic Recycle Pump, P-NT18-1	C	Internal Components	Age	4: < 15 Years
ACB2: VFD, Aeration Tank 18, Anaerobic Recycle Pump, P-NT18-1	D	Internal Components	Availability	—: No Rating Given
ACB2: VFD, Aeration Tank 18, Anaerobic Recycle Pump, P-NT18-1	D	Internal Components	Availability	—: No Rating Given
ACB2: VFD, Aeration Tank 18, Anaerobic Recycle Pump, P-NT18-1	D	Internal Components	Availability	—: No Rating Given

ACB2: VFD, Aeration Tank 18, Anaerobic Recycle Pump, P-NT18-1	E	Cabling	Color and brittleness	—: No Rating Given
ACB2: VFD, Aeration Tank 18, Anaerobic Recycle Pump, P-NT18-1	E	Cabling	Color and brittleness	—: No Rating Given
ACB2: VFD, Aeration Tank 18, Anaerobic Recycle Pump, P-NT18-1	E	Cabling	Color and brittleness	—: No Rating Given
ACB2: VFD, Aeration Tank 18, Anaerobic Recycle Pump, P-NT18-1	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given
ACB2: VFD, Aeration Tank 18, Anaerobic Recycle Pump, P-NT18-1	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given
ACB2: VFD, Aeration Tank 18, Anaerobic Recycle Pump, P-NT18-1	F	Cabling	Insulation Resistance (Mega Test)	—: No Rating Given

APPENDIX D
DETAILED NOTES RELATED TO CCTV REVIEW OF 54-INCH EAST PRIMARY INFLUENT PIPE

MMSD 54-inch Primary Influent Line Televising Review Notes by Strand
(Televised on June 26, 2007 from junction past the elbow)

Foot Marker	Defect	PACP Code	Location	Comments
10	H2S corrosion	SAVC	9-3:00	Video a little blurry and grainy, but appears to have corrosion above high water line being chipped off by crewperson with exposed aggregate underneath; appears continuous
24.8	H2S corrosion	SAVC	9-3:00	More chipping of corroded pipe wall exposing aggregate; appears it may be half inch or more of corroded, loose concrete over sound substrate with exposed aggregate
28.7	H2S corrosion	SAVC	9-3:00	More of same with chipping at joint
53	H2S corrosion	SAVC	9-3:00	Stop with camera close up of corrosion and appears to be exposed aggregate visible without chipping at it
80.3	H2S corrosion	SAVC	9-3:00	Stop with camera close up of corrosion and appears to be exposed aggregate visible without chipping at it
84.3	debris or slight obstruction	OB	6:00	Debris or rough spot in invert below water line slowed camera briefly
84.3	Settled deposits/debris?	DS - S01	6:00	Start of continuous stretch of apparent debris in line that is slowing camera down (not visible below water line)
101.6	H2S corrosion	SAVC	9-3:00	Stop with camera close up of corrosion and appears to be exposed aggregate visible without chipping at it
209.9	H2S corrosion	SAVC	9-3:00	Stop with camera close up of corrosion and appears to be exposed aggregate visible without chipping at it
254	H2S corrosion	SAVC	9-3:00	Stop with camera close up of corrosion and appears to be exposed aggregate visible without chipping at it
270	H2S corrosion	SAVC	9-3:00	Stop with camera close up of corrosion and appears to be exposed aggregate visible without chipping at it
328	H2S corrosion	SAVC	9-3:00	Stop with camera close up of corrosion and appears to be exposed aggregate visible without chipping at it
336	H2S corrosion	SAVC	9-3:00	Stop with camera close up of corrosion and appears to be exposed aggregate visible without chipping at it
342	Possible crack	CC	12-2:00	Probably just looks like crack and is really just crack in corroded concrete material on surface
362.8	H2S corrosion	SAVC	9-3:00	Stop with camera close up of corrosion and appears to be exposed aggregate visible without chipping at it

MMSD 54-inch Primary Influent Line Televising Review Notes by Strand
(Televised on June 26, 2007 from junction past the elbow)

Foot Marker	Defect	PACP Code	Location	Comments
374.5	H2S corrosion	SAVC	9-3:00	Stop with camera close up of corrosion and appears to be exposed aggregate visible without chipping at it
421.1	H2S corrosion	SAVC	9-3:00	Stop with camera close up of corrosion and appears to be exposed aggregate visible without chipping at it
421.1				Pipe has 90 degree bend in it and water level in pipe comes up significantly. Appears that pipe may be completely full just a few feet ahead. Water appears very stagnant.
Camera	Reverses			
400				Possible joint or circumferential crack in pipe. Difficult to see due to grainy/blurry video and corrosion of pipe wall.
390				Possibility of multiple joints and/or cracks between 390-400 feet. Difficult to see due to grainy/blurry video and corrosion of pipe wall.
378.4	H2S corrosion	SAVC	9-3:00	Stop with camera close up of corrosion and appears to be exposed aggregate visible without chipping at it. Possible joint or circumferential crack there as well.
351	H2S corrosion	SAVC	9-3:00	Stop with camera close up of corrosion and appears to be exposed aggregate visible without chipping at it. Possible joint or circumferential crack there as well.
302	H2S corrosion	SAVC	9-3:00	Stop with camera close up of corrosion and appears to be exposed aggregate visible without chipping at it. Possible joint or circumferential crack there as well.
255-270	H2S corrosion	SAVC	9-3:00	Camera close up of corrosion and appears to be exposed aggregate visible without chipping at it.
252				Possible joint or circumferential crack.
210-227	H2S corrosion	SAVC	9-3:00	Camera close up of corrosion and appears to be exposed aggregate visible without chipping at it.
202				Probable joint
186				Probable joint
170				Probable joint
154-169	H2S corrosion	SAVC	9-3:00	Camera close up of corrosion and appears to be exposed aggregate visible without chipping at it.
154				Probable joint

MMSD 54-inch Primary Influent Line Televising Review Notes by Strand
(Televised on June 26, 2007 from junction past the elbow)

Foot Marker	Defect	PACP Code	Location	Comments
138				Probable joint
137.2	H2S corrosion	SAVC	9-3:00	Stop with camera close up of corrosion and appears to be exposed aggregate visible without chipping at it.
120				Probable joint or possible circumferential crack
100				Probable joint or possible circumferential crack
74-84	H2S corrosion	SAVC	9-3:00	Camera close up of corrosion and appears to be exposed aggregate visible without chipping at it.
60				Possible joint or circumferential crack.
39				Possible joint or circumferential crack.
24				Possible joint or circumferential crack.
21.9			4-5:00	Appears to be a bit of mastic or some similar type debris on side of pipe

Notes: Significant H2S or chemical corrosion affecting pipe. Between corroded concrete at surface and lower quality video, it is difficult to see if there are any structural defects besides the corroded concrete. Where corrosion was chipped at in beginning of video, it does appear that exposed aggregate is visible once corroded and loose concrete is removed. Also seems there may be significant amount of sediment and debris in pipe based on the way the camera moved at times. Water level in the pipe did not allow for viewing of the invert.

MMSD 54-inch Primary Influent line Televising Review Notes by Strand
(Televised on July 30 or August 8, 2007 from primary towards the elbow)

Foot Marker	Defect	PACP Code	Location	Comments
32.7	H2S corrosion	SAVC	11-1:00	Camera close up of what appears to be corrosion in the top of the pipe. Also appears to be exposed aggregate visible. Could also just be grease/scum.
74.8	H2S corrosion	SAVC	11-1:00	Camera close up of what appears to be corrosion in the top of the pipe. Also appears to be exposed aggregate visible. Could also just be grease/scum.
74.8	Grease & sediment			Settled sediment and deposits as well as floating grease are significant starting here.
80.9				Video distance marker appears to jump 6 feet forward.
84.4				Camera cannot proceed due to sediment and grease.

MMSD 54-inch Primary Influent Line Televising Review Notes by Strand
(Televised on June 26, 2007 from junction past the elbow)

Notes: The normal water line appears to be very high in this segment of pipe. There is dark staining and biological slime on the lower portion of the pipe from 1:00 to 11:00. It appears rather rough in texture and may likely have H2S or chemical corrosion as well. The crown of the pipe between 11:00 and 1:00 is white and may be either corroded concrete or grease, as there was a lot of grease floating in the water. Appears to have significant sediment and debris as well as floating grease in this segment of the pipe.

There was a discrepancy on the date of the televising as two different dates were indicated at the beginning of the video segment for this portion of the pipe.

APPENDIX E
PHOTOS AND DRAWINGS

Photo 1 Primary Tank 1 facing north.

Photo 2 Primary Tank No. 2 facing north.

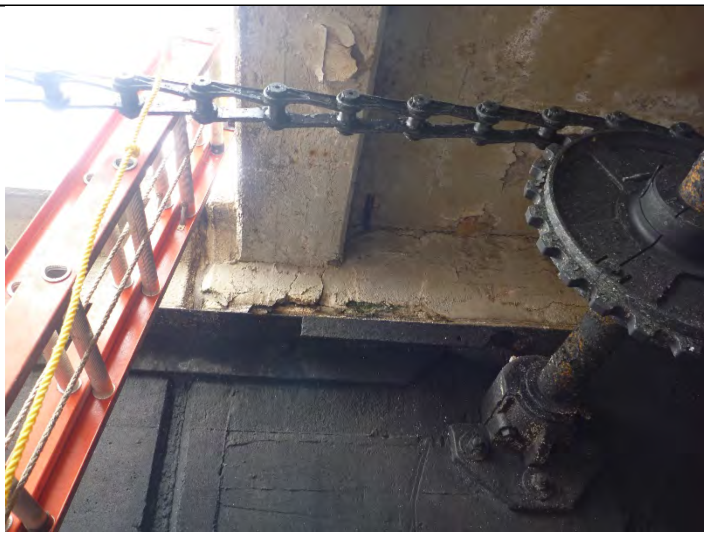

Photo 3 Primary Tank 1 vertical tank walls.

Photo 4 Primary Tank 1 elevated slab edge beam.

Photo 5 Primary Tank 1 bottom of elevated slab.

Photo 6 Primary Tank 1 bottom of elevated slab.

 Photo 7 Primary Tank 1 bottom of walkway.	 Photo 8 Primary Tank 1 top of elevated slab.
 Photo 9 Primary Tank 1 top of walkway.	 Photo 10 Primary Tank 1 edge of elevated slab.
 Photo 11 Primary Tank 1 face of edge beam.	 Photo 12 Primary Tank 1 drive shaft.

Photo 13 Primary Tank 2 vertical wall crack and delamination at scum trough bearing end.

Photo 14 Primary Tank 2 edge beam.

Photo 15 Primary Tank 2 vertical wall crack at scum trough bearing end.

Photo 16 Primary Tank 2 Outlet port wall and slab.

Photo17 Primary Tank 2 bottom of elevated slab, inlet port wall and edge beam.

Photo 18 Primary Tank 2 top of elevated slab.

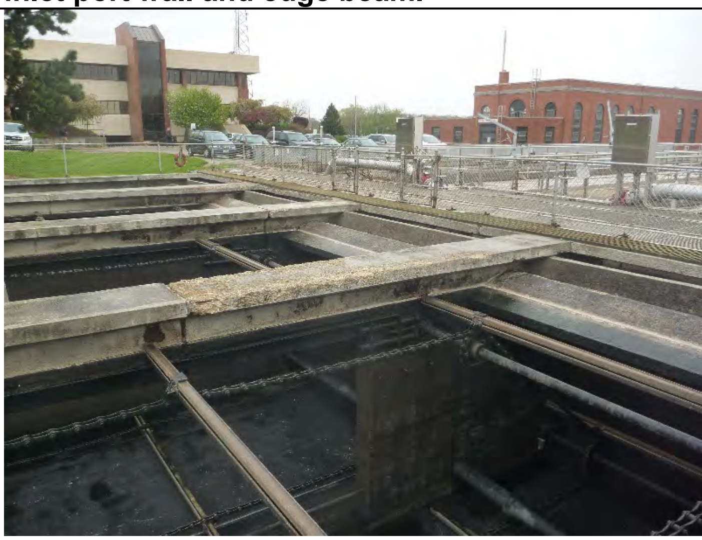

Photo 19 Primary Tank 2 top of walkway.

Photo 20 Primary Tank 2 edge of scum trough.

Photo 21 Chain link fence.

Photo 22 Outlet Weir operator plate.

Photo 23 Inlet Structure edge.

Photo 24 Inlet Structure top surface.


Dr. VJZ.
Ck. PEL
71'-7" to Digestion Tanks
93'-2"
10'-0" to Aeration Tanks
Copper pl. Expansion Joint
Side Wall, see detail Sh.# 24
El. Inv. Scum Trough 20.75
PRIMARY TANK 1
OUTLET PORT/ WEIR WALL
KNEEWALL
COLUMN
Painted Asphalt Exp. Jt.
Note:- For detail of Air plate containers see Sh.# 30
Inlet Structure See detail Sh.# 26
INLET STRUCTRUE
Structure Symmetrical about ℄ this Wall
Outlet Structure See detail Sh.# 26
24" C.I. Influent
3'-0" Gate at Walkway
Dividing Wall, see detail Sh.# 24
ELEVATED SLAB
TRANSVERSE WALKWAY
EDGE BEAM
PRIMARY TANK 2
SCUM TROUGH
ELEVATED WALKWAY
3/4" Mastic Joint
EFFLUENT CHANNEL
INFLUENT CHANNEL
Slot for chain Drive
BEAM BELOW
Air plates
1½" Grating For detail of Support see Sh.# 31
INLET PORT
Walkway, See detail Sh.# 25
Side Wall, see detail Sh.# 24
El. Inv. Scum Trough 21.50
4" C.I. BF casting, El. 22.75 See Sh.# 26
86'-10"
PLAN
Scale: 3/16"=1'-0"
N
SECTION B-B
Scale: 3/16"=1'-0"
Inlet ports. Baffles not shown. See detail below.
Copper pl. Expansion Jt.
Symmetrical about ℄ this Wall.
SECTION C-C
Scale: 3/16"=1'-0"
Outlet ports. For Weir details see Sh.# 25
Copper Plate Expansion Jt.
BEAM
25# T-rail Guide Track Full length of channels, both Tanks. Furnished under Item # B-20a.
Note: Scum Trough not shown. See detail Sh.# 25
2"x2" Wire Mesh fence with 2" O.D. corner posts, 1⅝" O.D. Int. posts & 1⅝" O.D. top rail. Provide entrance gates.
2"x6"x4'-6" creosoted yellow pine pl'k. fastened to conc. with 3-5/8"φ bronze bolts.
Wood Baffle
2" creosoted yellow pine plk. baffle
ELEVATION
Scale: 1/4"=1'-0"
SECTION
Scale: 1/2"=1'-0"
W.I. BRACKET
Scale: 1½"=1'-0"
8-Req'd.
INLET BAFFLE DETAILS
SECTION A-A
Scale: 3/16"=1'-0"
25# T-rail Guide Track 26'-0 long in each cross-collector channel. Furnished under Item # B-20a.
Motor Platform
Beam
Col.
Scum Trough
Slope
Scale: 3/16"=1'-0"
Scale: 1/4"=1'-0"
Scale: 1/2"=1'-0"
Scale: 1"=1'-0"
GREELEY & HANSEN
HYDRAULIC AND SANITARY ENGINEERS.
6 NORTH MICHIGAN AVENUE
CHICAGO, ILL.
MADISON METROPOLITAN SEWERAGE DISTRICT
MADISON WISCONSIN
ADDITIONS TO NINE SPRINGS SEWAGE TREATMENT PLANT
PRELIMINARY SETTLING TANKS-RECTANGULAR
PLAN & SECTIONS
APRIL 1934
REV. 12-11-34
REV. 10-12-34
REV. 11-16-34
RECORD DRAWINGS.
FEB -- 1938
62 - SHEETS
NO. 23
S 545
14-Y

APPENDIX D–TECHNICAL MEMORANDUM NO. 4
PEAK FLOW MANAGEMENT

Technical Memorandum No. 4 for the

Madison Metropolitan Sewerage District Madison, Wisconsin

Peak Flow Management
2016 Liquid Processing Facilities Plan

Prepared by:

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September 2016
Revised February 2017

STRAND
ASSOCIATES®

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APPENDIX F–NINTH ADDITIONAL FACILITIES PLAN EXCERPTS

One of the objectives of this 2016 Liquid Processing Facilities Plan is to estimate future peak flows for the Madison Metropolitan Sewerage District (MMSD or District) service area and determine a plan to manage the peak flows at the Nine Springs Wastewater Treatment Plant (NSWWTP). Preliminary alternatives also included peak flow management and infiltration and inflow (I/I) strategies within the contributing communities' collection systems, but detailed analysis of collection systems management alternatives were specifically excluded from the project scope.

This memorandum includes a summary of the peak flow modeling, in-plant hydraulic analyses, and peak flow management alternatives that were conducted as part of the facility planning for the NSWWTP. In addition, more detailed evaluations of the shortlisted peak flow management alternatives are presented with opinions of probable construction cost and discussion of non-monetary considerations.

DESCRIPTION OF EXISTING NSWWTP HYDRAULICS

To evaluate alternatives for peak flow management in the MMSD collection system and at the NSWWTP, an understanding of the operation and hydraulics of the current facilities is presented below. A process flow schematic of NSWWTP is presented in Figure 1.

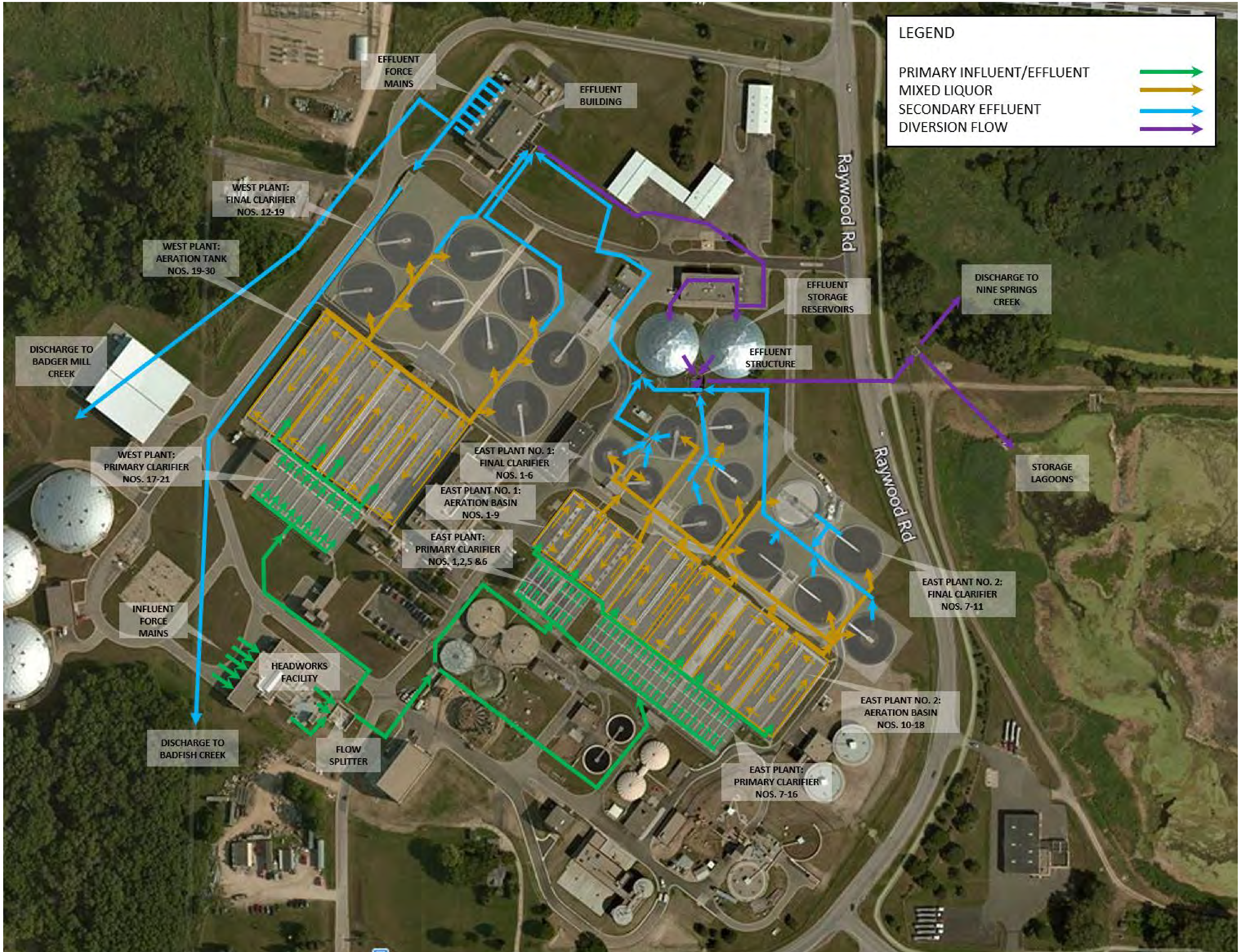
Currently, all flows from the MMSD service area are pumped by five major pumping stations to the NSWWTP for treatment. Pumped flows are discharged at the preliminary treatment building through venturi flow meters at the end of each force main. All influent flows receive preliminary treatment consisting of screening (1/4-inch band screens) and vortex grit removal. Flow from the preliminary treatment facility is then split between two complexes for primary and secondary treatment (designated herein as the west plant and the east plant) using a splitter structure. This structure also includes a pipe stub to direct flow to a future third plant at or near the existing NSWWTP site.

This splitter structure contains five weir troughs arranged so that flow in one direction in the trough is directed to the west plant and flow in the opposite direction to the east plant. These troughs can be partitioned using stop plates inserted at various locations to effectively divide the total weir and trough length in the structure between the west and east plant to achieve the desired flow split. Currently, under normal flow conditions, District staff try to achieve a flow split of approximately 55 percent to the west plant and 45 percent to the east plant to efficiently utilize existing blower capacities. During high flow events, the flow split is changed to send more flow to the east plant because of hydraulic limitations within the west plant, as well as limitations within the lagoon diversion structure within the east plant. This is discussed in greater detail later in this section.

The west plant primary and secondary treatment facilities consist of 5 rectangular primary clarifiers, 12 aeration tanks arranged in 4 trains using the University of Cape Town (UCT) process, and 8 center feed peripheral take-off final clarifiers.

The east plant primary treatment facilities consist of 14 rectangular primary clarifiers of varying sizes. The east plant secondary treatment facilities consist of 18 aeration tanks and 11 circular final clarifiers that are split into two groups:

- East Aeration Basin Nos. 1 through 6, arranged in two trains and using the A/O process, along with East Aeration Basin Nos. 7 through 9, arranged in one train and using the UCT process, flow to East Final Clarifier Nos. 1 through 6.



NINE SPRINGS WASTEWATER TREATMENT PLANT PROCESS FLOW DIAGRAM

2016 LIQUID PROCESSING FACILITIES PLAN
TECHNICAL MEMORANDUM NO. 4
PEAK FLOW MANAGEMENT
MADISON METROPOLITAN SEWERAGE DISTRICT

STRAND ASSOCIATES®

FIGURE 1

1021.015

§ East Aeration Basin Nos. 10 through 18, arranged in three trains and using the UCT process, flow to East Final Clarifier Nos. 7 through 11.

Capacities of the NSWWTP primary and final clarifiers based on overflow rates of 1,500 gal/ft^2-d and 1,200 gal/ft^2-d, respectively, are presented in Table 1.

Facility	Capacity, (mgd)
Primary Clarifiers	
West Primary Clarifiers #17-21, each	6.0
East Primary Clarifiers #1-2, each	4.0
East Primary Clarifiers #5-6, each	4.7
East Primary Clarifiers #7-16, each	4.4
West Plant Primary Treatment Capacity	30.0
East Plant Primary Treatment Capacity	61.4
Final Clarifiers	
West Final Clarifiers #12-19, each	12.8
East Final Clarifiers #1-2, each	4.6
East Final Clarifier #3, each	6.8
East Final Clarifiers #4-6, each	6.8
East Final Clarifiers #7-11, each	10.4
West Plant Final Clarifier Capacity	102.4
East Plant Final Clarifier Capacity	88.4

Table 1 NSWWTP Primary and Final Clarifiers Capacities

During high flow events, secondary effluent flows greater than the approximate 100 mgd capacity of the UV disinfection facilities are discharged directly to the lagoons. This discharge is hydraulically controlled in the Effluent Structure northwest of the east plant final clarifiers via a fixed-elevation weir within this structure. The Effluent Structure receives flow from East Final Clarifier Nos. 4 through 11, while flow from East Final Clarifier Nos. 1 through 3 discharge to a junction chamber downstream of the Effluent Structure. Secondary effluent from the west plant flows directly to the disinfection building, requiring all forward flow from the west plant to be conveyed through the disinfection channels and into the effluent pump station wet well.

Because of the existing hydraulic layout and connections on the east and west side of the plant, if flow is to be diverted directly to the lagoons without being disinfected, the flow must pass through the east plant. Based on hydraulic modeling of the plant, the weir elevation in the Effluent Structure is reached when approximately 50 mgd is conveyed from the east plant to the Effluent Building. Therefore, under current conditions, the east plant must handle approximately 50 mgd plus any flow to be discharged directly to the lagoons upstream of disinfection.

Any disinfected secondary effluent in excess of the effluent pumping capacity of the plant (about 80 mgd total, 75.5 mgd without the Badger Mill effluent pumps in operation) flows to two effluent storage reservoirs. If there continues to be disinfected secondary effluent flow in excess of the effluent pumping capacity after these reservoirs are full, the reservoirs will flow to the effluent structure and flow will be combined with any nondisinfected secondary effluent prior to discharge to the lagoons.

PEAK FLOW MODELING

Peak influent flows to the NSWWTP were modeled for current and future conditions for use in evaluating alternatives to manage peak flows. The peak flow modeling approach and the key results of the evaluation are summarized in this section. Details of the evaluation are presented in Appendix A.

A. Model Description, Development, and Calibration

The tributary area of the WWTP was modeled as a single basin to simulate the influent flows at the WWTP. The modeling approach used two software packages to generate the flow and develop the calibration. The regional hydrologic response of the Madison area to rainfall was simulated using the Hydrologic Simulation Program–FORTRAN (HSPF). This model uses rainfall and other meteorological data to simulate the continuous hydrologic response accounting for snow melt, evaporation, soil moisture storage, and groundwater flows.

The second software package is Capacity Assurance Planning Environment (CAPE). The CAPE software takes the HSPF results and applies calibration parameters to simulate the flow in the wastewater collection system. In CAPE, the measured flows are compared to the simulated flows to calibrate the model parameters that are specific to dry and wet weather flows in the sanitary sewer system.

The tributary area of the WWTP is approximately 69,000 acres (based on the 2008 CARPC report). Before reaching the plant the flow is routed through at least one or more pump stations (in some cases four pump stations). The faster hydrologic responses, such as inflow, are attenuated in the routing through such a large tributary area to the WWTP. The hydrograph shape of the influent flow to the WWTP is dominated by the slower hydrologic components.

The model was calibrated to the measured plant influent flow meter data during the 10-year period from 2006 to 2015. During this time there were 13 wet weather events suitable for calibration; 2 events in particular were very large: June 8, 2008 and June 26, 2013. During the calibration period, Pump Station 18 was not on-line. With Pump Station 18 in service, higher flows may be observed at the plant.

Figure 2 shows the simulated event volumes compared to the measured event volumes. All of the calibration events were within (or almost within) the ±20 percent envelope. The largest two events were within 10 percent of the measured values.

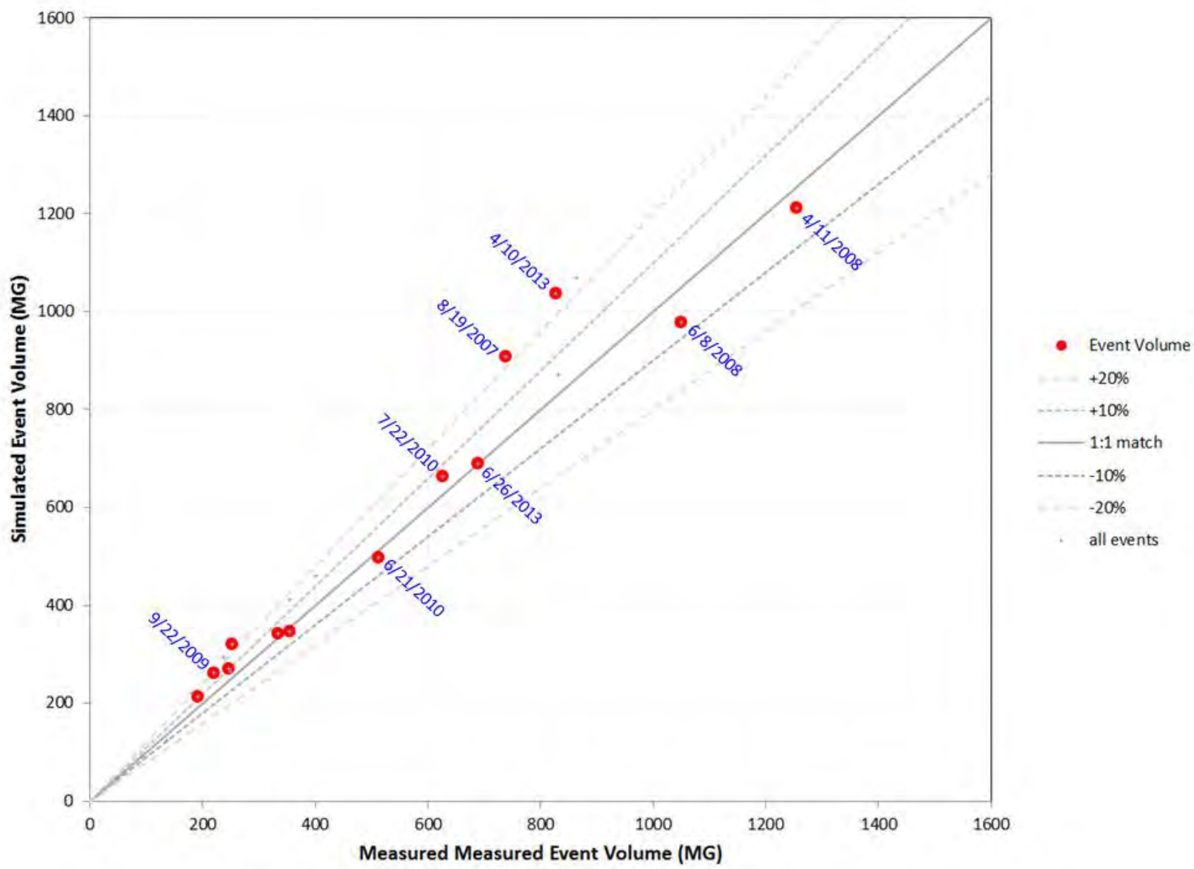


Figure 2 Wet Weather Event Volume, Calibration Goodness of Fit Scatterplot

B. Model Results

The population of the service area is projected to increase about 29 percent from 2015 to 2040. Future flows were assumed to increase 29 percent, directly proportional to the population change. This assumption implies that future development areas will have I/I rates similar to the existing system, and that degradation in the existing system will be mitigated by ongoing rehabilitation. Figure 3 shows the simulated current and future peak flows at the NSWWTP for a range of recurrence intervals. The graph also shows the existing capacity limits of the headworks, disinfection, and effluent pumping. From this figure the capacity required to meet a desired recurrence interval for the level service can be identified for current and future conditions. In addition, the sensitivity of future flows to the I/I assumption was explored by evaluating a second case that assumed only a 15 percent increase in I/I. As noted in Figure 3, this assumption does decrease the simulated peak flows and volumes, but the level of service is not significantly different.

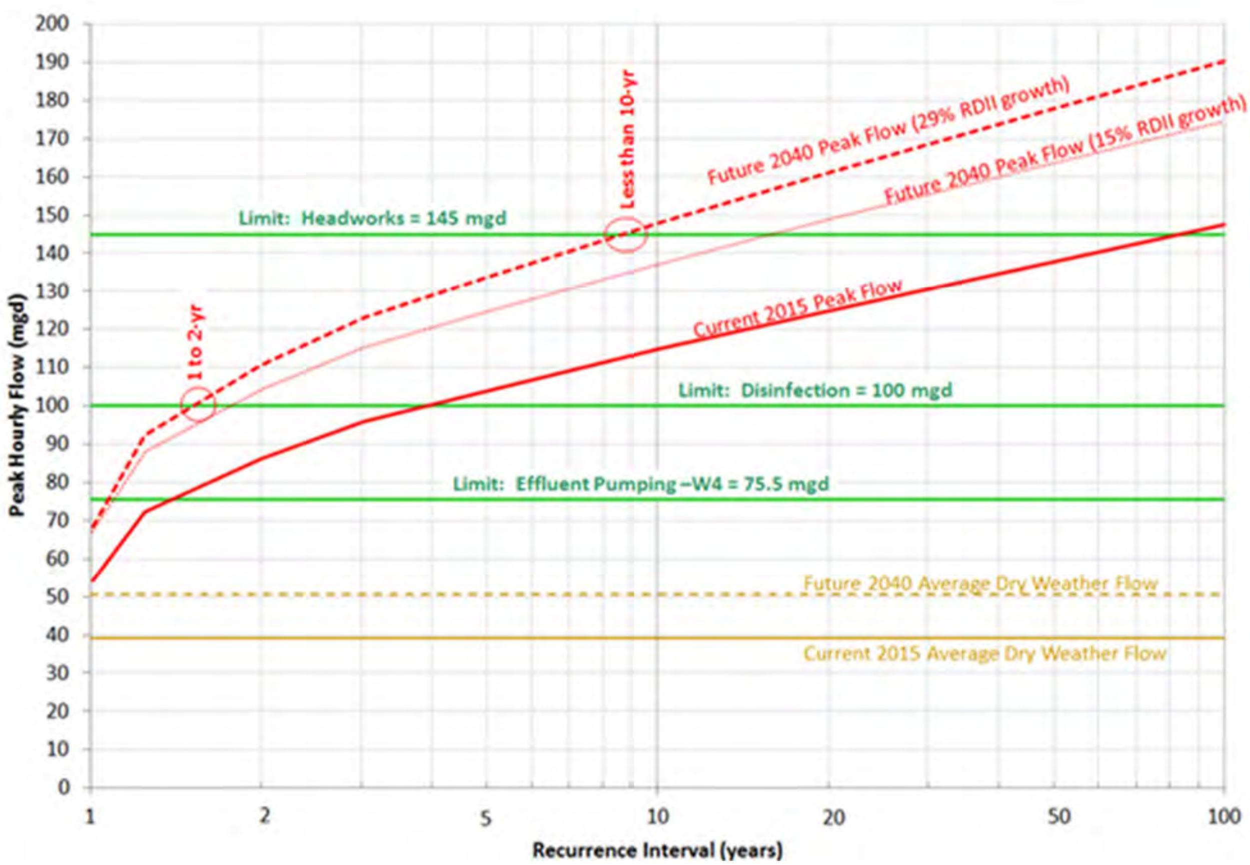


Figure 3 Future Peak Hourly Flow Frequency and Levels of Service

Figure 4 shows the recurrence interval for diversion volumes when flow exceeds the effluent pumping capacity of 75.5 mgd. Three curves are shown for the various cases that were evaluated. The existing effluent storage reservoirs and lagoon storage volume (about 51 MG total) provides a 3- to 6-year level of protection against overflows to Nine Springs Creek using the future flows. This figure can be used to estimate the level of protection that could be achieved with additional storage.

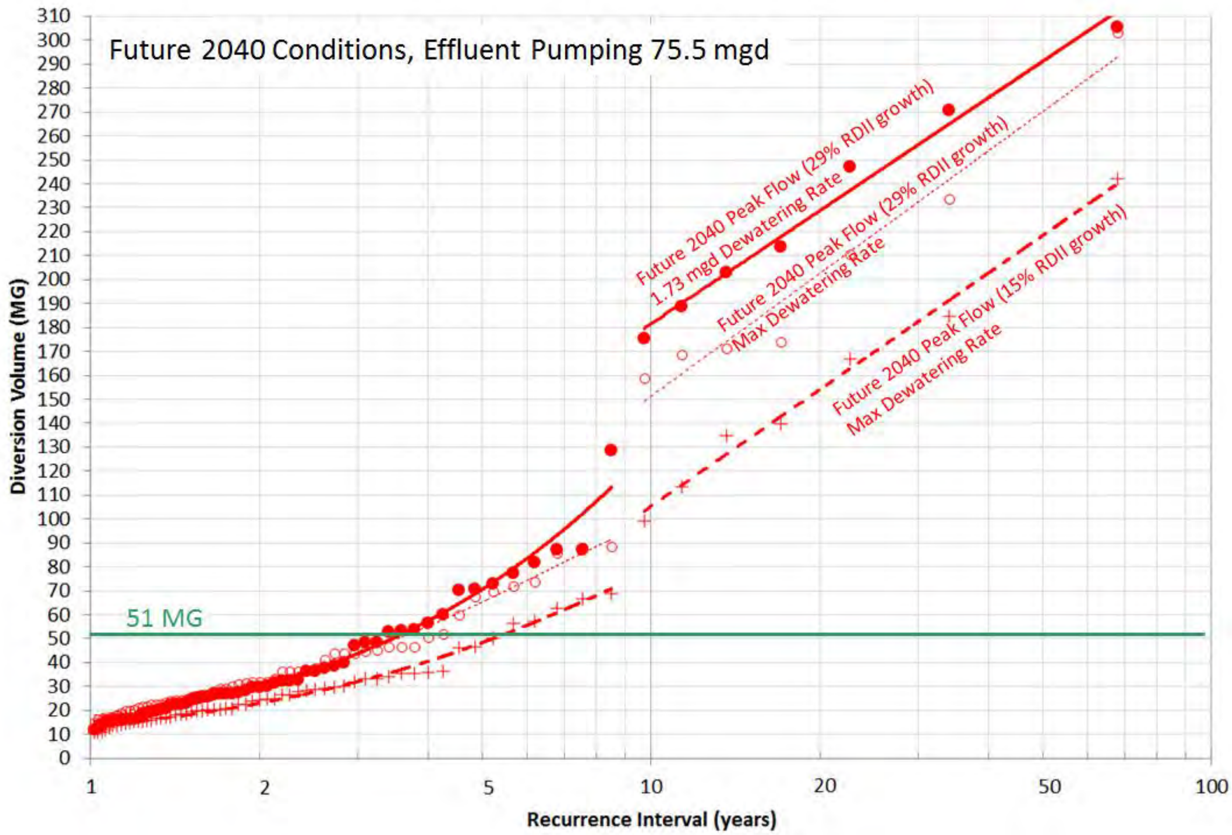


Figure 4 Future 2040, Simulated Diversion Volume vs. Recurrence Interval When Flow Exceeds 75.5 mgd

C. Level of Service

The level of service provided by the NSWWTP with respect to hydraulic capacity was evaluated for current and future flow conditions. The level of service was evaluated for headworks peak flow capacity, disinfection capacity, effluent pumping capacity, diversion to the lagoon, and overflows from the lagoon to Nine Springs Creek.

The headworks capacity was estimated to be about 145 million gallons per day (mgd) based on the District's past experience related to the hydraulic capacity of the screens. Historic flows rarely exceed the headworks capacity (prior to the construction of PS18), and the existing level of service is in the 50- to 100-year recurrence interval range. Higher flows may be possible now that PS18 is in service.

Future flows were projected based on the population growth estimates. The model projections for future flows are not limited by current pumping limitations. Based on the projections, the future the level of service would decrease significantly to a recurrence interval range of about 5 to 10 years.

The disinfection capacity is 100 mgd. The disinfection facilities have a level of service with an approximate 4-year recurrence interval under current conditions and 1 to 2 years under future conditions.

The net effluent pumping is limited to approximately 75.5 mgd. Peak flows in the plant exceed the effluent pumping capacity approximately 1 to 2 times each year under current conditions. Future conditions are expected to exceed this capacity 3 to 5 times per year. This is the level of service of the effluent pumps and it is also the frequency of diversions to storage.

When flows exceed the effluent pumping capacity, the excess flow is diverted to the two storage reservoirs and the lagoon (a total capacity of approximately 51 MG). When the volume diverted to the lagoon exceeds the storage capacity, the excess volume overflows to the Nine Springs Creek. The level of service for overflows to the creek is in the 10- to 20-year recurrence interval range for current flow conditions. Under future 2040 conditions, the frequency of overflows was estimated to be in the 3- to 6-year recurrence interval range. Figure 5 presents a summary of the level of service values for the various components of the WWTP.

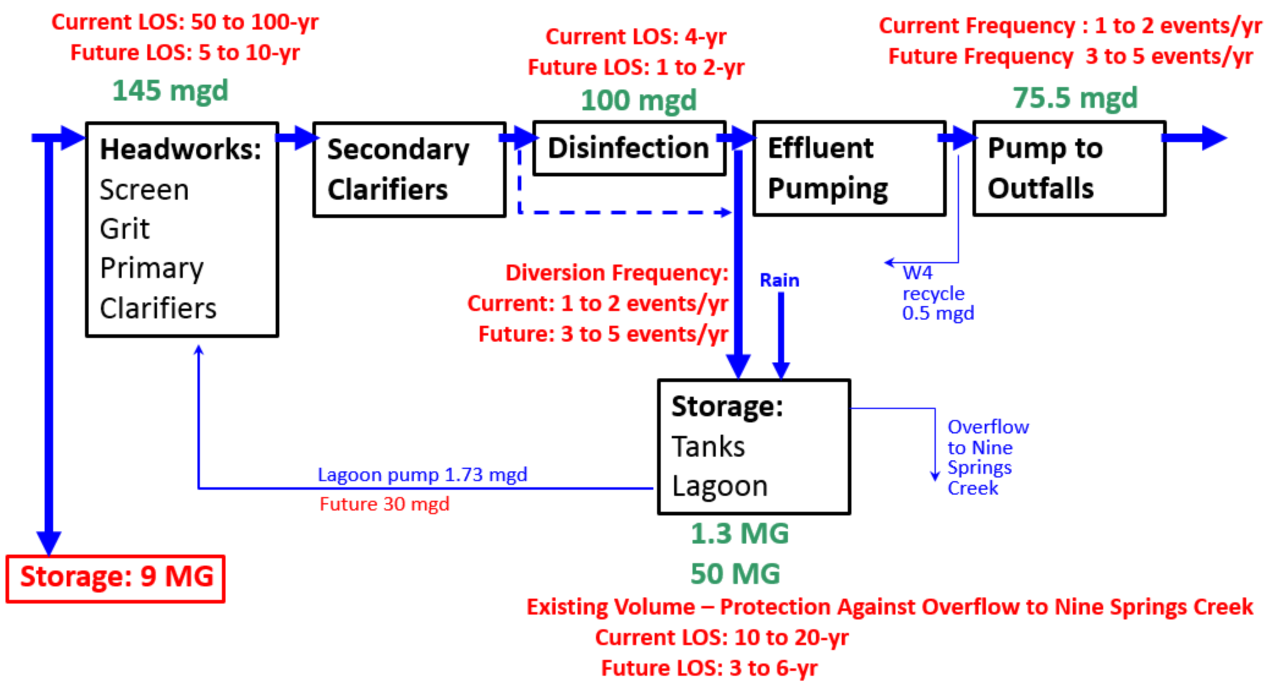


Figure 5 Level of Service Summary

D. Potential Impacts of Climate Change

Impacts of climate change on future wastewater flows were not evaluated as part of this facilities planning effort. However, the Milwaukee Metropolitan Sewerage District completed two studies to investigate the potential impacts of climate change on its facilities and operations. The objective of the first study was to investigate climate change impacts on overflow level of protection. The question was whether climate change could potentially jeopardize the anticipated benefits of the recommendations in a previously completed facilities plan. The objective of the second study was to consider potential climate change vulnerabilities for a wide range of facility operations, such as energy demand, corrosion, odors, and emissions, in addition to impacts on wastewater flows.

A review of climate change studies related to sewer systems around the country showed most studies were focused on sea level change at coastal cities. Few studies were concerned with hydrologic change impacting flows in sewer systems for inland cities like Milwaukee and Madison.

The Milwaukee studies used climate change scenarios, developed by the University of Wisconsin-Madison, to transform historic rainfall and temperature records into alternative rainfall and temperature time series that reflect climate change scenarios. The climate scenarios considered two potential levels of temperature change: one with moderate change and the other with a more significant change. Along with temperature increases, the distribution of rainfall between large and small events was altered. The second study extended the forecast horizon from mid-century to the end of the century.

Annual air temperatures are expected to increase, with the largest seasonal increases in spring and fall. Air temperature changes affect snowfall, snowmelt, and potential evapotranspiration. Large wet weather events tended to become larger and more intense, while smaller events tended to become smaller and less frequent. Surprisingly, the average annual rainfall value was approximately the same. The climate change scenarios affected the distribution of intensities, rather than the average annual rain amount.

Simulation results showed a relatively small change in peak sanitary sewer flows (less than 10 percent) and fewer sanitary sewer overflow (SSO) events with smaller volumes (25 percent less average annual SSO volume). The reduction in SSOs is most likely a consequence of the increased evaporation resulting from higher temperatures.

Climate change impacts in Madison could be expected to be similar to the Milwaukee study results. If the influence of higher temperatures on evaporation is accurately represented in the model, the dryer soil conditions may offset some of the higher intensity rainfall so that the peak flows in the sanitary sewer system are not significantly changed. With due respect for the uncertainties in the model results, the impacts of climate change in an upper Midwest location like Madison may be a modest variation from the current pattern, rather than a major hydrologic shift.

PEAK FLOW MANAGEMENT ALTERNATIVES IDENTIFICATION

Based on the analyses summarized above and the flow modeling performed (Appendix A), a future peak design flow of 180 mgd was selected for evaluation of hydraulic upgrades that may be required at the NSWWTP through the year 2040. This flow corresponds to the highest peak instantaneous flow encountered in the future flow modeling described in Appendix A, and provides a level of service of between 50 and 60 years. The existing maximum instantaneous flows experienced at the plant (prior to PS 18 coming on line) are in the range of about 135 to 140 mgd. While the absolute maximum pumping capacity to NSWWTP is greater than 180 mgd (closer to 210 mgd with Pump Station 18 on line), the level of service that would be provided by designing for such extreme events would be in excess of 100 years. While such a design could be implemented, it was decided to plan for the model-predicted peak flow of 180 mgd.

A hydraulic model of the NSWWTP was developed by Black & Veatch as part of the 10th Addition design. This model was subsequently modified by Malcolm Pirnie during the development of the 50-Year Master Plan in 2008. A further modified version of this hydraulic model was used in the peak flow analysis for the development of this Technical Memorandum. Additional modifications made to the model include changes to more accurately portray current plant operation based on discussions with MMSD staff, to better account for situations that may occur during high flow events such as submerged weirs or orifices, and to evaluate peak flow management alternatives described in this Technical Memorandum. In addition, the revisions fixed several apparent inaccuracies with respect to how the actual plant operations were modeled in previous versions.

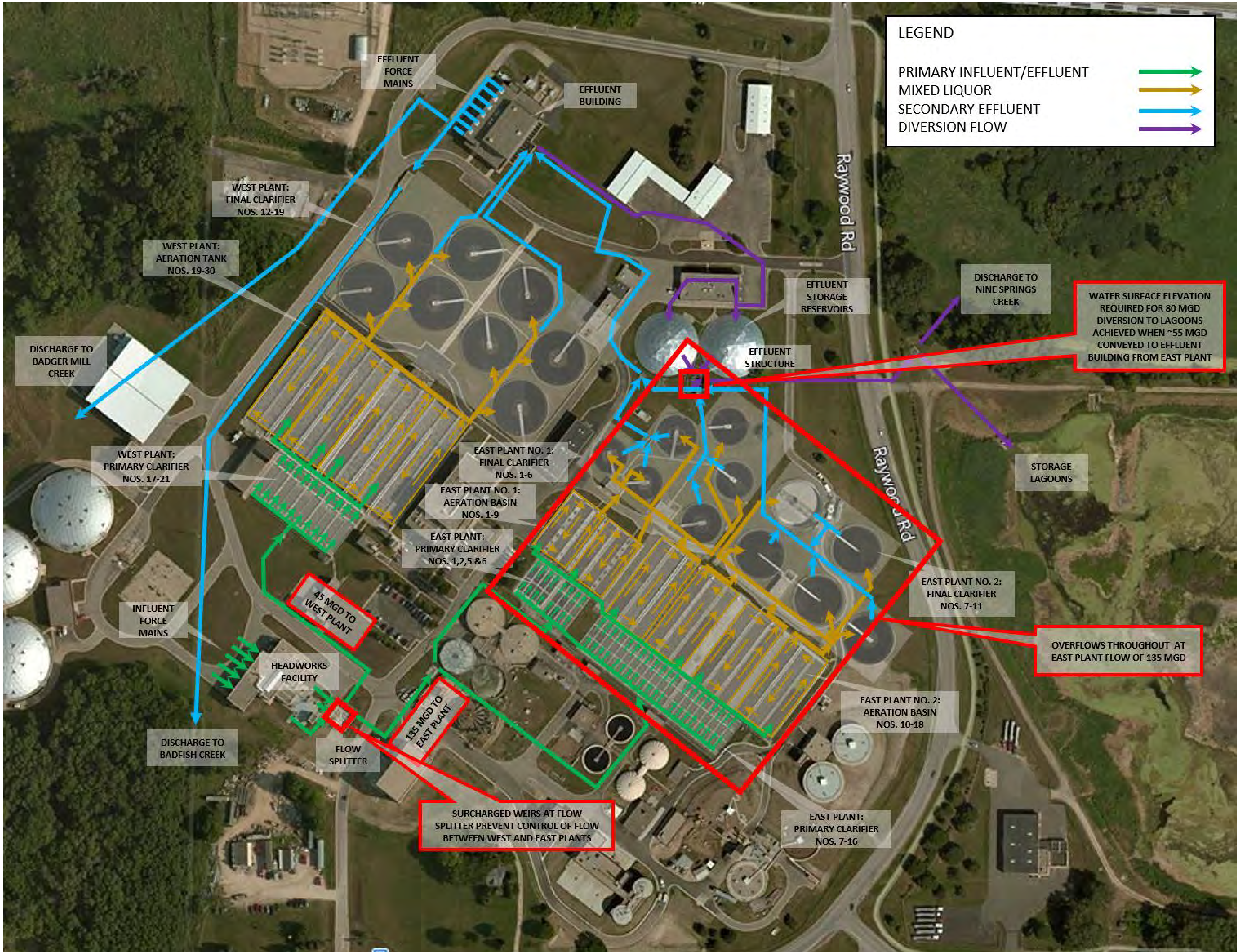
This modified model was used to identify hydraulic bottlenecks at the plant and to evaluate potential changes to alleviate these bottlenecks. Based on plant experience, it appears that the screening equipment is insufficiently sized for peak future flows of 180 mgd. This will be addressed in a later Technical Memorandum (TM6) and modifications to the screening equipment will not be included in any of the alternatives evaluated in this section.

Peak Flow Management Workshop No. 4a (WS 4a) was held on May 9, 2016. The purpose of the workshop was to present the peak flow modeling calibration and results, to identify a range of alternatives that could be used to improve peak flow management, and to conduct preliminary screening on these alternatives. A brief description of each of the alternatives developed at this workshop is presented in this section, followed by a description of the screening process used to determine which alternatives were evaluated in greater detail.

A. <u>Alternative PF0–No Change (Null Alternative)</u>

This alternative assumes no upgrades or peak flow management changes are implemented to provide increased hydraulic capacity at the NSWWTP or within the collection system. All wet weather flows would continue to be pumped to NSWWTP and managed as these flows are currently managed. Flows above about 145 mgd would create hydraulic problems at the screening facilities, and the bypass channel would need to be used. In addition, hydraulic bottlenecks at the west plant primary clarifiers and in the west final clarifier influent channels would create an overflow at the plant site. Diverting flows above approximately 65 mgd to the east plant could be done to avoid these overflows. However, the primary flow splitter to the east and west plants requires manually changing gate positions, typically under storm condition outside, which is not an easy or safe procedure. Furthermore, the Effluent Structure that controls the diversion to the lagoons is hydraulically controlled by the flow from the east plant to the disinfection building as described earlier, and therefore approximately 50 mgd must be sent to the disinfection building from the east plant prior to a diversion to the lagoons occurring. This means that at the future peak flow of 180 mgd, over 130 mgd must be sent thought the east plant (50 mgd to disinfection and 80 mgd diversion to lagoons). Based on hydraulic modeling analysis, the east plant is not capable of passing flows in excess of approximately 90 mgd with the existing Effluent Structure controlling the water surface elevation downstream of the final clarifiers, and therefore cannot pass the flow required to maintain a maximum of 100 mgd sent to the Effluent Building with the excess 80 mgd sent to the lagoon.

At the future peak flow of 180 mgd, this alternative would result in overflows of structures in both the west and east plants, more than 100 mgd of flow being discharged to UV disinfection, and a reduced ability to hydraulically control flow splitting throughout the plant. Figure 6 illustrates the hydraulic concerns at the



NULL ALTERNATIVE

HYDRAULIC ISSUES AT 180 MGD PEAK FLOW - 80 MGD OVERFLOW AT EFFLUENT STRUCTURE

2016 LIQUID PROCESSING FACILITIES PLAN
TECHNICAL MEMORANDUM NO. 4
PEAK FLOW MANAGEMENT
MADISON METROPOLITAN SEWERAGE DISTRICT

STRAND ASSOCIATES®

FIGURE 6

1021.015

plant at a peak flow of 180 mgd with 80 mgd of secondary effluent from the east plant final clarifiers topping the weir wall at the effluent structure. In this scenario, tanks throughout the east plant would overflow, and the weirs at the influent splitter structure would surcharge from the east plant such that this flow split would be uncontrollable, resulting in more flow being conveyed to the west plant. Figure 7 illustrates the hydraulic concerns at the plant with the peak flow of 180 mgd split evenly to the west and the east plants with the current hydraulic controls at the effluent structure. This scenario results in an excess of 100 mgd sent to the effluent building, while only 40 mgd of secondary effluent from the east plant final clarifiers is diverted to the lagoons at the effluent structure. Hydraulic grade line elevation results from the plant hydraulic model through various plant structures for this alternative are presented in Appendix B.

The modelled peak flows are expected to increase over time as presented at WS 4a. Under current conditions, flows above 145 mgd are rare with a recurrence interval of about 80 years. In the future planning year of 2040, however, the modeled recurrence interval is less than 10 years for such flows. Therefore, while significant problems will be rare under current conditions, the null alterative would result in more frequent significant issues as peak flow rates increase over time. For the lagoon overflow to NSC, the recurrence interval decreases from about 10 to 15 years to less than 4 years under future conditions. The lagoon overflow level of service is actually the same under all alternatives that do not include additional storage.

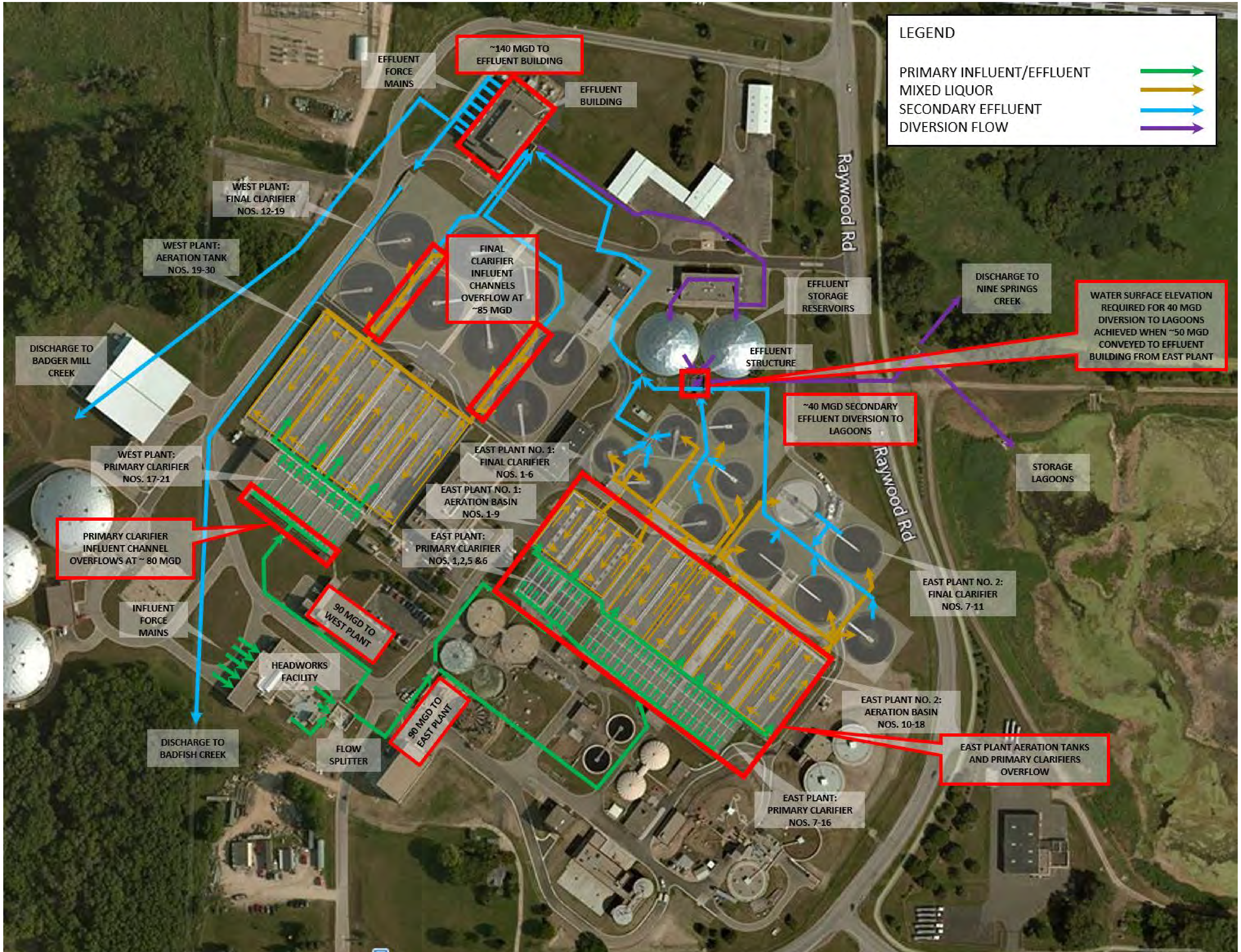
B. <u>Alternative PF1–Collection System Storage</u>

This alternative would construct storage tanks or basins within the sanitary sewer service area that would be owned by the District, the community customers, or a combination of both. While this alternative could be used on a smaller scale in conjunction with other alternatives, if successfully implemented on its own, this alternative could eliminate or significantly reduce the hydraulic upgrades needed at the NSWWTP. Typically, such tanks are constructed of concrete below ground, though aboveground tanks can also be used. Pumping and cleaning facilities would need to be provided to drain the tanks and then remove collected debris. Based on the previous discussion (see Figure 3), the volume required to eliminate the future projected plant hydraulic bottlenecks at the headworks and primary clarifiers would be about 10 mgal, though the actual location of the storage tanks may result in larger volumes being required. To provide the same level of service as existing with respect to lagoon overflows to NSC, about 200 to 250 mgal of storage is needed. This large volume of storage is likely not feasible.

This alternative would improve the level of service with respect to protecting the headworks and west primary clarifiers with respect to potential overflows within the plant. However, the level of service would not be measurably different for all downstream processes, including the lagoon overflow potential to NSC. To fully evaluate this alternative, a detailed flow study would be required to determine potential locations within the service area that could provide enough storage to reduce future peak flows to the NSWWTP. Such a study is beyond the scope of this facilities plan.

C. <u>Alternative PF2–Satellite WWTP (Full Treatment)</u>

This alternative would construct one or more satellite WWTPs to provide full treatment of wastewater in a decentralized WWTP plan. Full secondary (and possibly tertiary) WWTPs would be constructed at locations that could mitigate peak flow management issues at NSWWTP. Potential locations for additional



NULL ALTERNATIVE

HYDRAULIC ISSUES AT 180 MGD PEAK FLOW - EVEN FLOW SPLIT

2016 LIQUID PROCESSING FACILITIES PLAN

TECHNICAL MEMORANDUM NO. 4

PEAK FLOW MANAGEMENT

MADISON METROPOLITAN SEWERAGE DISTRICT

STRAND ASSOCIATES®

FIGURE 7

1021.015

WWTPs include the Verona area and the north Lake Mendota area. However, these locations have relatively small upstream service areas, and to divert enough flow to the new WWTPs to significantly benefit NSWWTP would require new pumping stations and force mains to bring flow back to these new WWTPs. If adequate peak flow could be diverted, the NSWWTP peak flow management issues could be significantly reduced or eliminated.

To fully evaluate this alternative, a detailed flow study would be required to determine potential locations within the service that could provide enough flow diversion to reduce future peak flows to the NSWWTP. The level of service area improvement at the NSWWTP is unknown at this time, and cannot be estimated unless a detailed flow study is performed. Such a study is beyond the scope of this facilities plan.

D. Alternative PF3–Satellite Wet Weather Treatment

This alternative is similar to Alternative PF2, except that the treatment plant constructed would only be used during times of significant wet weather. Treatment would likely consist of non-biological treatment schemes such as chemically enhanced primary treatment or ballasted sedimentation, along with disinfection. Discharge would be to a local water body when the plant is operational during and immediately after wet weather events.

To fully evaluate this alternative, a detailed flow study would be required to determine potential locations within the service that could provide enough flow diversion to reduce future peak flows to the NSWWTP. The level of service improvement at the NSWWTP is unknown and cannot be estimated unless a detailed flow study is performed. Such a study is beyond the scope of this facilities plan. If adequate peak flow could be diverted, the NSWWTP peak flow management issues could be significantly reduced. Based on our understanding, this type of treatment and discharge has not been implemented or permitted in Wisconsin, and we are not aware of any other entity trying to gain approval of similar treatment schemes in Wisconsin.

E. Alternative PF4–Aggressive Infiltration–Inflow Removal

The goal of this alternative is to address peak wet weather flows at the source by reducing clear water entering the sanitary sewer collection system in both public and private sewer infrastructure. I/I can be reduced through aggressive programs that address both the public (District and customer community owned interceptors and collection systems) as well as private lateral connections to the public infrastructure. This alternative would include significant I/I reduction studies and remediation work in an attempt to reduce peak wet weather flows. If adequate clear water flow could be eliminated, the NSWWTP peak flow management issues could be significantly reduced.

To fully evaluate this alternative, a detailed flow study would be required to determine potential locations within the service that could provide enough flow reduction to reduce future peak flows to the NSWWTP. The level of service improvement at the NSWWTP is unknown and cannot be estimated at this time. Such a detailed I/I study is beyond the scope of this facilities plan.

F. Alternative PF5–Public Outreach

This alternative includes education and outreach to the public, including community leaders and the system users in general. Better education could help people understand their impact at the NSWWTP and the environment in general. Outreach could include open houses, brochures, networking events, and many other initiatives. This alternative is not a stand-alone alternative, but public outreach and education should be included in any selected plan.

G. Alternative PF6–Influent Equalization at NSWWTP

This alternative is similar to Alternative PF1, and would include construction of a single large storage tank upstream of the NSWWTP on land adjacent to the NSWWTP site or nearby Pump Station No. 11 to reduce peak flows through the plant. The tank would be a minimum of 10 mgal, which is the approximate volume required to reduce peak flows to about 145 mgd through NSWWTP and minimize hydraulic backups in the headworks and primary clarifiers. The tank would be constructed of concrete. Pump Station No. 11 could be used to pump stored flows to the NSWWTP. A major new interceptor line from the NSWWTP headworks to the storage tank would be needed, and cleaning facilities would also be needed to remove collected debris. As an alternative, the tank could be constructed directly adjacent to Pump Station No. 11. This would reduce construction costs by eliminating the major interceptor pipe from the NSWWTP, as well as by eliminating the significant drain from the storage tank to Pump Station No. 11. However, upgraded screening facilities may be needed if the tank is constructed at Pump Station No. 11, since flows would not have been screened at the NSWWTP. Detailed hydraulic analyses is needed to verify that Pump Station No. 11 flows are adequate to achieve these peak flow reductions through equalization.

This alternative would not significantly reduce the lagoon overflow frequency or volume to NSC unless a tank considerable larger than 10 mgal was constructed.

H. Alternative PF7–Upgrade NSWWTP Hydraulics Only

This alternative takes the approach that wet weather flows would be conveyed to and through the plant in a manner that minimizes plant operational impacts and process overflows within the plant. The general scheme would include upgrading the headworks and primary clarifier hydraulic bottlenecks to permit a flow of about 180 mgd to pass through the plant. Additional hydraulic modifications would be included to improve overall plant control and operations during wet weather events. This alternative will maintain the current management of peak flows through the plant, and as a result, as peak flows increase over time, there will be more frequent discharges to the lagoons, and more frequent overflows from the lagoons to NSC. The level of service for this alternative is similar to the Null Alternative, with the exception that in-plant overflows (tank overflows) would be reduced or eliminated for all flows up to about 180 mgd.

I. Alternative PF8–Expand Effluent Pumping Capacity

This alternative would significantly expand the effluent pumping capacity from the NSWWTP. Currently, the effluent pumping capacity is about 80 mgd total to the two outfall locations, although it is limited to about 75.5 mgd when Badger Mill Creek is at high levels, which requires that the Badger Mill Creek discharge be shut off. This alternative would require larger and/or more effluent pumps, as well as a second force main from the plant to the outfall location at Badfish Creek. If implemented, this alternative could eliminate overflows from the lagoons to NSC. The plant bottlenecks would need to be fixed (similar to Alternative PF7) and, in addition, significant in-plant hydraulic upgrades would be needed to convey flow to the UV disinfection system. The disinfection system would also need to be expanded to accommodate the higher peak flow rates.

The existing effluent force main is nearly 60 years old, and previous/current modeling indicates that the pipe is operating near capacity, assuming like-new conditions. Significant testing would be required to increase the permissible flows and pressures through the existing force main, and it is unlikely that flows above 90 mgd would be recommended. Therefore, a second force main is assumed to be required under this alternative. The exact effluent pumping capacity required to avoid lagoon overflows has not been determined. However, a reasonable assumption is that the second force main would also be a 54-inch pipe (or perhaps marginally larger), to provide redundancy, which would result in a total available pumping capacity of about 150 to 160 mgd.

J. Alternative PF9–Upgrade NSWWTP Hydraulics and Increase NSC Discharges

This alternative is nearly the same as Alternative PF7 except that more flow would be directly discharged to NSC in addition to overflows from the lagoons. For example, all flows above 100 mgd could be directly discharged to NSC rather than to the lagoons. The benefit to this approach over Alternative PF7 is that lagoon volume management, repumping, and retreating requirements would be reduced. In addition, this is a strategic alternative that could allow the District to begin to move towards a more frequent or continuous discharge to NSC. Under current statutes and rules, a continuous discharge would not be permitted. The concept for Alternative PF9, however, could potentially be implemented if the additional phosphorus and TSS loadings to NSC were offset through a trading or similar program.

K. Alternative PF10–High-Rate Wet Weather Treatment at NSWWTP

The original concept for this alternative was similar to Alternative PF3, except that the high-rate treatment processes would be constructed at NSWWTP, and effluent from the plant would be discharged to the lagoons or possibly directly to NSC. Treatment could consist of biological or non-biological treatment along with disinfection.

A revision was made to this alternative to include evaluation of a biological contact (BC) process at the plant, which would not require construction of separate peak flow facilities but rather utilize the existing treatment facilities to provide improved treatment while reducing hydraulic impacts within the plant. This alternative could be implemented as a stand-alone process upgrade, but more likely would be implemented with an alternative that upgraded the forward flow hydraulics within the plant, such as Alternative PF7 or PF9.

L. Alternative PF11–Primary Effluent Diversion to Lagoons

This alternative would divert primary effluent to the lagoons to reduce hydraulic constraints downstream of primary treatment during high flow events. Hydraulic upgrades at the headworks and primary clarifiers would still be required. A structure would be constructed on the east primary effluent channel to divert flow to the lagoons. Primary effluent would mix with secondary effluent in the lagoons, and overflows from the lagoons would, therefore, include some partially treated wastewater. Lagoon overflow disinfection is assumed to be required for this alternative. In addition, solids deposition in the lagoons from primary effluent would increase, and there is a greater likelihood of odors at the lagoons.

M. Alternative PF12–Expand the NSWWTP Lagoon Storage Capacity

If feasible, this alternative would expand the area of the lagoons to increase the storage volume and reduce the frequency of overflows compared to no lagoon expansion. Based on the peak flow projections in the year 2040, to maintain the current level of service, the lagoon volumes would need to be increased from the existing 50 mgal to a total volume of 250 to 300 mgal. It is noted that the lagoons are part of an existing Superfund site and are generally surrounded by marshland and other environmentally sensitive areas. The lagoon berms were increased in height when the lagoons were put into service for effluent storage, and further berm increases are not likely because of the poor soils underneath the lagoons. This alternative would still require hydraulic upgrades to be made within the NSWWTP to convey flow to the lagoons.

N. Alternative PF13–Reconfigure the Lagoons to Add Flexibility

The alternative was not defined except to indicate that, potentially, the lagoons could be reconfigured to provide multiple uses, such as separate storage for primary effluent and secondary effluent. As noted for Alternative PF12, the lagoons are part of a Superfund site and any modification could result in significant risks and costs. Reconfiguration would result in less storage than is currently provided, and this alternative would require considerably more study and site investigations to define what uses could be implemented.

SCREENING OF ALTERNATIVES

The District developed an internal process to review and shortlist alternatives for more detailed evaluations. The process included developing a brief summary of each alternative, along with an array of both monetary and nonmonetary considerations. The consultant team developed the first draft of these review documents, and the District's core team met to review the information, discuss the merits of each alternative, and then develop a shortlist of alternatives to take forward from the screening process. The District selected six alternatives in addition to the null alternative (do nothing) to evaluate in more detail. A summary of the District's selection and the array used to compare alternatives are included in Appendix C. Based on this screening process, the following alternatives were selected to be evaluated further:

- Alt. PF0–Null Alternative (Do Nothing)
- Alt. PF4–Aggressive I/I Removal (high level assessment)
- Alt. PF6–Influent Equalization at NSWWTP
- Alt. PF7–Upgrade NSWWTP Hydraulics Only
- Alt. PF8–Expand Effluent Pumping Capacity
- Alt. PF9–Upgrade NSWWTP Hydraulics and Increase NSC Discharges
- Alt. PF10–High-Rate Wet Weather Treatment at NSWWTP

Each of these alternatives is further described and evaluated below.

DETAILED EVALUATION OF ALTERNATIVES

A. Alternative PF0–Null Alternative (No Change)

1. Description of Alternative and Opinion of Cost

In this alternative, peak flow management at NSWWTP would remain unchanged and there is no investment in additional infrastructure to handle peak flows. As described earlier, the existing plant is not capable of passing the anticipated future peak flows and hydraulic analyses indicate that structure overflows would result from flows over approximately 145 mgd. This would result in untreated or partially treated wastewater overflowing to the NSWWTP site and potentially flooding buildings or flowing off-site and discharging to surface waters.

An opinion of probable cost for this alternative is presented in Table 2. A detailed breakdown of this opinion of probable cost is included in Appendix D. The O&M costs associated with this alternative include UV disinfection and effluent pumping at NSWWTP and pumping stored flows from the lagoons at the plant. The maintenance cost associated with cleaning structure overflows is anticipated to be insignificant and is not included in this analysis. No capital improvements are included in this alternative.

	Alt. PF0
Opinion of Capital Costs	$0
Opinion of Annual O&M	$773,000

Table 2 Alt PF0 Opinion of Capital and O&M Cost Summary

2. Noneconomic Considerations

This alternative includes no changes to the existing plant infrastructure to handle peak flows above the hydraulic capacity of the plant. Potential benefits and limitations of this alternative are presented below.

a. Benefits

(1) No changes in plant equipment or processes for staff to become accustomed to.
(2) Maintains available space on the plant site for future upgrades or capacity expansions.

b. Limitations

(1) Does not address hydraulic constraints in the plant that will lead to tank overflows at future peak flows.
(2) Does not improve the level of service of any processes.

(3) Does not improve the level of service with respect to diversion to lagoons and overflow of lagoons to NSC.
(4) Increases health and safety concerns associated with overflows of untreated wastewater on site.
(5) Potential to discharge untreated wastewater to the environment as a result of tank overflows running off-site; potential fines related to unauthorized discharges.
(6) Risk of damage to structures and equipment during overflow events.
(7) Legal and regulatory opposition to overflows and operating a plant without adequate capacity.
(8) Negative public perception from lack of action related to plant capacity issues.

A. Alternative PF4–Aggressive I/I Removal

This alternative describes a program to aggressively reduce I/I in MMSD's conveyance system and the community customer systems tributary to MMSD's system. In the past, the District has not taken an aggressive approach to reduce I/I, particularly with its community customers. This is partly because I/I levels have generally been manageable within the District's system and at the NSWWTP, and significant wet weather problems have been rare. However, the peak flow projections developed for this planning project indicate higher peak flows at the NSWWTP, and I/I levels will only be expected to become more significant over time if I/I reduction is not a focus of the District and its community customers. In addition, the District has important energy and sustainability initiatives that support addressing wet weather concerns at the source through I/I reduction rather than building infrastructure to manage increasing levels of wet weather peak flows. This I/I reduction alternative is included in the 2016 LPFP to help define the level of effort and high level costs to establish, implement, and administer a program to aggressively reduce I/I.

There are three levels of infrastructure that contribute I/I to MMSD's treatment plant.

1. MMSD's interceptor system
2. Community customer collection systems
3. Private sewer laterals and building plumbing

The vast majority of the sewer infrastructure is in the community customer and private collection systems. Therefore, any program to aggressively reduce I/I will need to include these systems as well as the MMSD's interceptor system. An overall strategy for implementing this alternative is outlined below.

1. I/I Reduction Program Implementation Strategy

Implementation of an I/I reduction program must begin with identification of the magnitude of I/I in the system, followed by detailed investigations to identify sources of I/I, and a program to remove those sources. The main steps of such a strategy are as follows:

a. Demonstrate initial cost-effectiveness of I/I reduction program relative to other alternatives to manage peak flows.

b. Initiate stakeholder involvement program to gain stakeholder buy-in.

c. Perform I/I evaluation at plant, pump station basin, and sub-basin scales to identify high I/I areas.

d. Identify treatment plant capital and operations and maintenance costs avoided with I/I reduction.

e. Perform conveyance system evaluation to estimate conveyance improvement costs avoided with I/I reduction.

f. Identify risk and cumulative cost of damages of basement backups and SSOs sustained by choosing not to reduce I/I or increase conveyance. (This is the ongoing cost of the "do-nothing" alternative.)

g. Implement a pilot source detection program to identify sources and costs to mitigate sources

h. Re-evaluate the cost-effectiveness of I/I reduction using the information gathered from Steps c through g; consider using a monetized triple bottom line evaluation.

i. If I/I reduction cost-effectiveness is confirmed, establish I/I reduction targets or allowable peak flow performance standards in conjunction with stakeholders.

j. Implement comprehensive source detection program at all system levels.

k. Conduct pilot program to test rehabilitation technologies and demonstrate effectiveness of I/I reduction efforts.

l. Implement comprehensive I/I reduction program.

m. Measure effectiveness of I/I reduction program as it progresses.

Table 3 presents an approximate schedule for implementing a comprehensive I/I reduction program with a 25-year duration, assuming 5 years for I/I identification and source detection activities and 20 years to complete the rehabilitation.

Activity	Year
Demonstrate Initial Cost-Effectiveness of Program	0
Stakeholder Involvement	1 to 25
Identify High I/I Areas	1
Identify Avoided Costs with I/I Reduction Program and Risks of "do-nothing"	1
Implement Pilot Source Detection Program	2
Re-evaluate Cost-Effectiveness of Program using Monetized Triple Bottom Line Evaluation	2
Establish I/I Reduction Targets or Performance Standards	2
Implement Comprehensive Source Detection Program	3 to 5
Conduct Pilot Program to Test Rehabilitation Technologies and Demonstrate Effectiveness	4 to 5
Implement I/I Reduction Projects	6 to 25
Measure Effectiveness of I/I Reduction	10, 15, 20, 25

Table 3 I/I Reduction Program Implementation Schedule

Source detection begins with identifying those areas in the system with the highest I/I levels. MMSD pump station flow data, including data from the 45 smaller pump stations the District maintains for its customer communities, can be reviewed to begin to identify areas with potentially high I/I. However, temporary flow monitoring of smaller tributary areas will likely be required to effectively identify the areas with the highest I/I, and thus, the best opportunities to achieve reductions in flows. Traditional flow monitoring can be expensive because of the effort needed to obtain accurate flow data. A relatively new approach in the industry is called "micro-metering." Under this approach, flow meters are placed in the collection system at various locations for shorter durations. Rather than attempting to obtain highly accurate flow data, the objective of the micro-meter approach is to identify the relative level of I/I between meters to identify the leakiest areas. Once the leakiest areas are identified, the meters are relocated within those areas to successively identify the leakiest subareas. This process is used to focus where source detection activities are to be performed.

The most common source detection activities include the following:

§ Flow metering (both long-term and short-term micro-metering).
§ CCTV–Internal visual observation of the condition of pipes.
§ Smoke Testing–Identify direct I/I connections to the sanitary sewer system.
§ Dyed water Flooding–Identify cross connections between the storm sewer and sanitary sewer systems.
§ Rainfall Simulation–Identify indirect connections between surface runoff and the sanitary sewer system.

§ Building Plumbing Inspections–Identify cross connections from building plumbing to the sanitary sewer system.

A successful I/I reduction program for MMSD will require a partnership with the MMSD's customer communities because most of the I/I in the system is generated in either the customer community or private systems. There are several approaches that MMSD can take to accomplish I/I reduction, as described below.

§ Establish performance standards–Performance standards are standards the MMSD could implement to limit either the amount of I/I or total flow discharged to the MMSD system. These could take the form of either volume-based or peak flow-based standards. Under such a system, discharge limits would be established for each customer community or each connection point to the MMSD system. Implementation of this approach would require construction of permanent flow meters at community boundaries to measure individual community flows.

§ Establish design and construction standards for the design and construction of sewers–These can be either explicit in terms of specifying allowable rates of I/I, or implicit, such as inspection requirements to verify that sewers are being constructed in accordance with specifications. Many I/I sources in both public and private systems are found to be the result of poor construction practices. Mandatory inspections of public sewers installed by developers, as well as inspections of lateral construction and connections to the public sewer system, can be an effective way to reduce the number and productivity of I/I sources in development areas.

§ Ordinances–Some communities throughout the United States have enacted point-of-sale ordinances that require homeowners to demonstrate the integrity of their lateral and that no illegal plumbing connections exist at the time they sell their house. This approach may lessen resistance from homeowners because they are often making a financial gain on the sale of their house so the perceived economic burden for repairs is somewhat diminished. A study completed for the Milwaukee Metropolitan Sewerage District reported that roughly 50 percent of the homes in the Milwaukee area turn over ownership about every 11 years. If a similar pattern exists for Madison area homes, this type of ordinance could accomplish repairs to a substantial number of laterals and other plumbing defects in about a decade. Currently, this type of ordinance is prohibited by Wisconsin law so a change in the law would be required to implement such an approach.

§ Asset Management–Under the State of Wisconsin "SSO Regulations," all municipalities must implement a Capacity, Management, Operations and Maintenance (CMOM) program to maintain the integrity of their sewer systems. Proactive repairs of system defects are an essential part of an effective CMOM program. Regular maintenance is necessary to prevent I/I from increasing in existing systems. MMSD can support customer community efforts to implement their CMOM programs by facilitating information exchange and providing technical assistance.

§ Financial incentives–Incentives can be implemented by regional agencies, such as the MMSD, to encourage customer communities to reduce I/I in their local systems. These can take the form of rate structures that encourage the reduction of peak flow and flow volumes. They could also include rate surcharges for peak rates or volumes that exceed established thresholds. Implementation of this approach would require construction of permanent flow meters at community boundaries to measure individual community flows. Financial incentives can also take the form of grants, loans, or cost-sharing agreements to encourage the reduction of I/I. One specific type of financial incentive is a deposit-refund system. Under this system, customer communities would pay a fee for exceeding the established I/I limit. This money would be held by MMSD and given back to the customer community to reimburse them for I/I reduction costs, or held and returned to the customer community after successful reduction of I/I is demonstrated. The Milwaukee Metropolitan Sewerage District is currently implementing a private property I/I reduction program that is targeting the reduction of I/I from private property sources. Under this program, funds are allocated to each municipality in proportion to their equalized value of property to use for private property I/I reduction investigation and implementation. Work is undertaken by the municipalities and then reimbursed by the regional agency after the work is completed, up to the available allocation. Most of the work completed under this program has been the rehabilitation or repair of private laterals and disconnections of foundation drains.

§ I/I Mitigation Bank–An I/I mitigation bank is an approach whereby a community (or developer) reduces I/I in order to free up wastewater system capacity for new development. A credit is earned for reducing the peak rate of I/I. Such credits can be banked over time. These credits are then used as new developments are approved. In essence, this approach requires I/I reduction to offset the increases in peak flow required for new development so that additional wastewater system capacity is not required.

2. Opinion of Probable Costs

An initial cost to achieve I/I reduction in the District's service area was evaluated using a performance-based approach. A performance-based approach establishes the approximate cost to achieve a desired outcome, which we have defined as a reduction in I/I. Unlike a traditional construction cost approach that is focused on the cost of work done, the performance based approach assigns a unit cost to the number of gallons removed (no matter how the work is done). This approach does not define the rehabilitation methods or the location of the work, which cannot be identified or defined at this time.

The performance-based cost approach was developed by Brown and Caldwell during the 2020 Facilities Plan for the Milwaukee Metropolitan Sewerage District. The approach is an application of a protocol defined in a 2003 Water Environment Federation Research (WERF) report that summarized the results of several studies performed according to the protocol. The WERF protocol defines how the pre- and post-rehabilitation performance is to be quantified (that is, the number of gallons removed) and how the costs are to be normalized (expressed as dollars per gallon removed). The protocol specifies that the 5-year recurrence interval peak hourly flow rate be used to characterize the flow in the system. Using this protocol, I/I reduction projects that use diverse rehabilitation technologies can be plotted on a common graph.

Figure 8 is an example of a unit cost graph, showing the project data points and an approximate curve for typical unit costs. The overall trend in the data shows that the unit cost is relatively low when the initial I/I levels of an area is high. But for areas with less I/I, the unit cost is higher. This graph shows the original WERF case studies and subsequent projects that have been added to the database using the same protocol. The data points shown in the figure have a large amount of scatter and variability. There are many points on the graph that have much lower unit costs than the typical curve. The typical unit cost curve was used in this study because the nature of the I/I sources and best technologies to reduce I/I are unknown at the planning level. The results of this analysis should be understood as an initial estimate of cost.

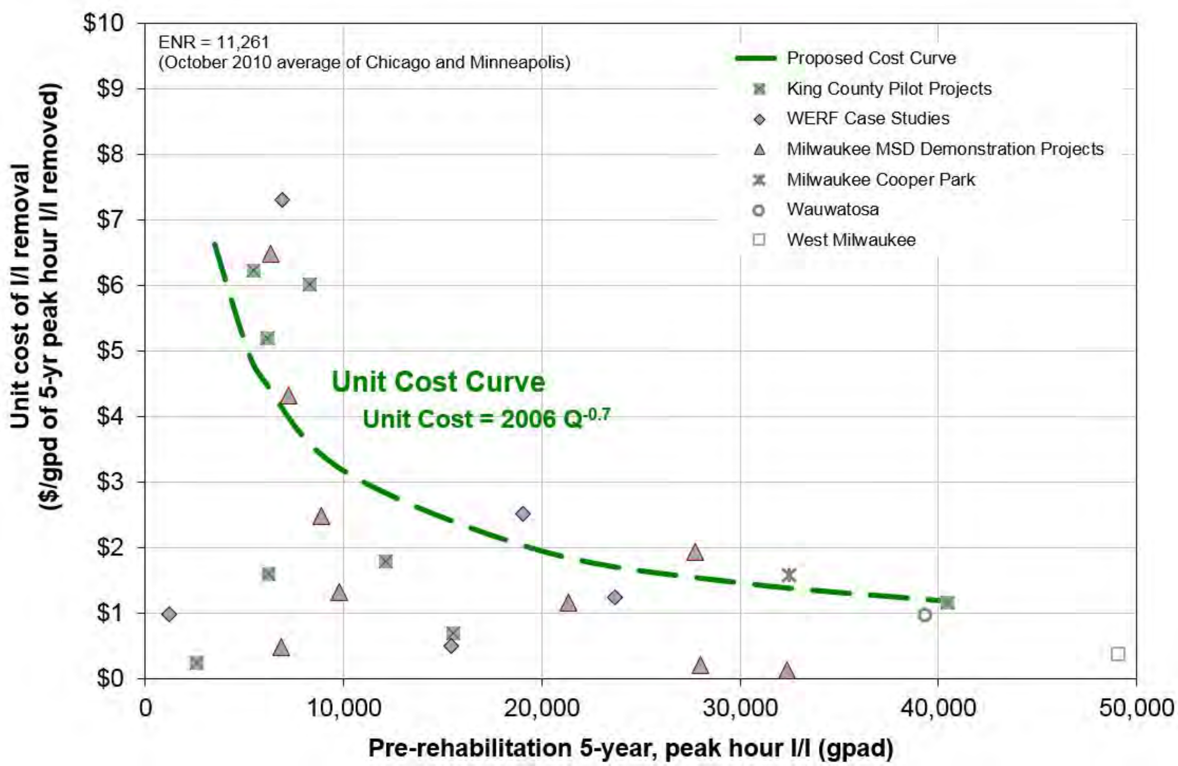


Figure 8 Performance Based Unit Cost Curve for I/I Reduction

The size of the area of consideration is an important factor. Small areas tend to have higher I/I rates per unit area than larger areas. This is a consequence of the attenuation and routing of peak flows, the distribution of rainfall over large areas, and the variability of I/I sources, which can be very concentrated in small areas, but are averaged out in large areas.

In MMSD's service area, the I/I rates are relatively low. At the NSWWTP, the current 5-year peak flow is 104 mgd for the 68,859-acre service area. The flow per unit area is 1,510 gpad. However, this area is too large to use for the evaluation of I/I, so the individual pump station areas were evaluated.

Peak hourly flow rates for each pump station area were estimated using limited flow records provided by the District. Figure 9 shows the individual pump station flow per unit area values for the 5-year peak flow event. The flow per unit area values for the pump station areas typically varied from 930 to 4000 gpad. These values reflect the flows at the pump stations which may be influenced by the capacities of the pump stations. As a result, the peak flow rates per unit area in the upstream areas could be greater where the flows are unrestricted by pump capacity. An example may be the PS2 area that serves the Isthmus west of the Capitol, which has a rate of 14,800 gpad. While this rate appears large relative to the other pump stations, it has one of the smaller pump station service areas with a very high population density, so more variability is not unusual. Furthermore, the I/I rate for PS2 is not unusually high compared to other communities. For comparison, typical I/I rates in Milwaukee are in the range of 5,000 to 15,000 gpad, and some parts exhibit rates as high as 45,000 gpad.

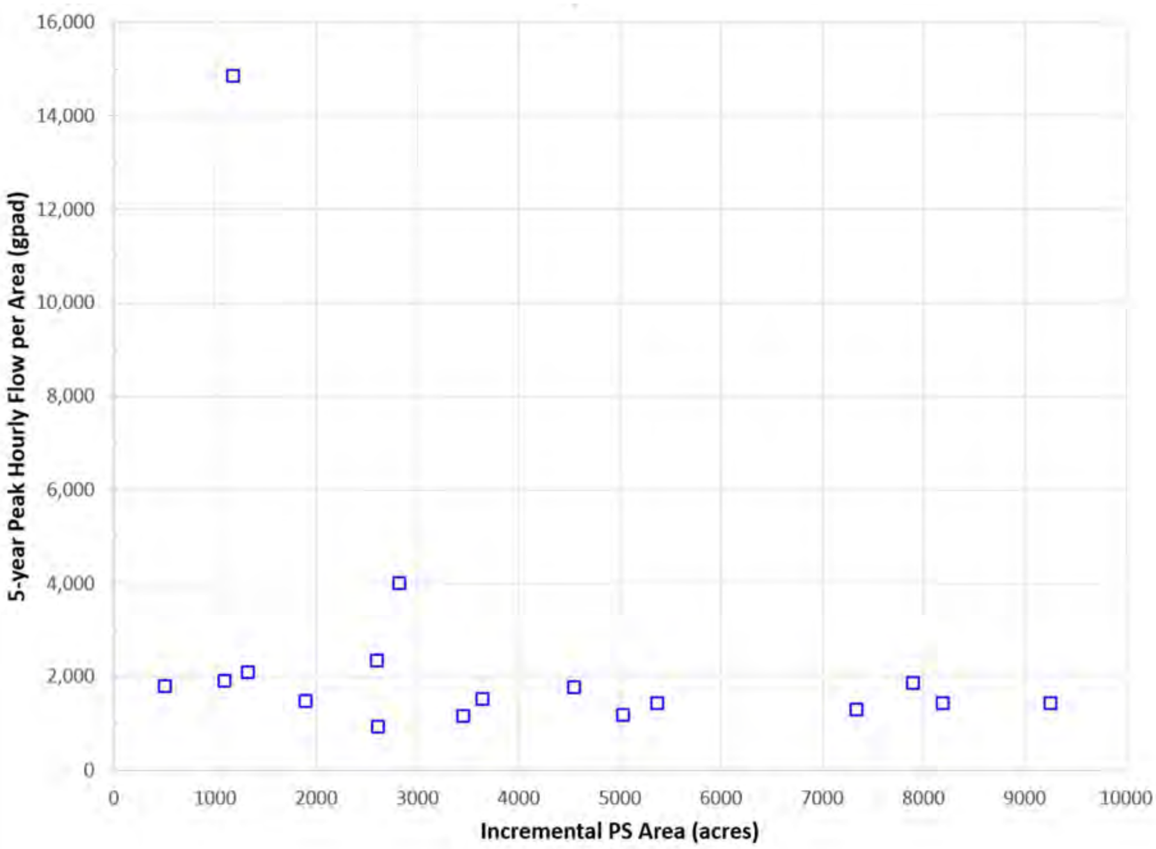


Figure 9 Existing Peak Hourly Flow Rates per Unit Area for Each Pump Station

Average monthly flows per capita are typically in the range of 100 to 150 gallons per capita per day (gpcd). The CARPC report states that the PS2 area has 11,547 households. Assuming a corresponding population of approximately 30,000 people, the average monthly flow for the PS2 area is 180 gpcd. This value is higher than the typical range, but not exceptionally high compared to other areas in the service area. Therefore, the flow values used in this evaluation are reasonable when viewed from the per capita point of view.

The performance-based I/I cost estimating method is intended to be a tool to calculate a rough cost for I/I work when only a very limited set of information is available at the initial planning stage. The method jumps over a myriad of details to get to a quick cost value. This discussion about pump station flows expressed as a flow per unit area, or a flow per capita, is useful to point out that there are special cases (such as the high density housing of PS2) that stand out different from the overall trend. But this does not limit the use of the method. It should, however, be a reminder that the results are best interpreted on the overall scale of the project after individual subarea contributions are averaged together.

The analysis used estimated values for the future 5-year peak flow at each pump station based on an assumed 29 percent growth from the existing rates, which is consistent with the overall projected increase of flow at the NSWWTP to the year 2040 (Appendix A). From that starting point, the cost of rehabilitation was estimated using the unit cost curve in Figure 8. The cost for each pump station was summed and flow reductions were scaled to present the flow reduction outcome at the WWTP. In this way, the results are interpreted for the “portfolio” as a whole, from the point of view of the flow reduction to the WWTP.

The estimated future (year 2040) 5-year peak hourly flow at the WWTP is 134 mgd. The existing 5-year peak hourly flow is 104 mgd. To reduce the I/I rates so that the future peak flow (134 mgd) is equal to the existing flow (104 mgd) (see Figure 3) will require extensive rehabilitation. Within each pump station area, there may be numerous smaller rehabilitation projects. For this analysis, it was assumed that the rehabilitation could be achieved progressively using 5 rehabilitation steps, and the cost for each step was calculated. The total cost to achieve the desired level of I/I reduction was the sum of the costs of the 5 steps. It is noted that the choice of the number of steps is not particularly significant. Using 5 steps accounts for the increasing difficulty of reducing I/I as the leakiest areas are worked on first and the later projects have increasingly higher costs to achieve the same amount of reduction.

It is likely that rehabilitation efforts will be concentrated in areas of higher I/I. In this analysis, the percentage of the pump station area to be rehabilitated was set as a modeling parameter. In one case, each entire pump station area was subject to uniform rehabilitation to the degree that was necessary to achieve the performance goal. In the second case, 50 percent of each area was assumed to be rehabilitated more thoroughly to achieve the same outcome as the first case. In the third case, only 25 percent of each area was assumed to be rehabilitated aggressively to reach the same outcome as the other cases. The logic in these cases is that it is more cost-effective to concentrate the rehabilitation efforts in the leakiest areas. The identification of the leakiest areas is not known at this time, so it is likely that the actual work will be a mixture of highly aggressive rehabilitation in some areas and less work in other areas. Evaluating these three cases help to envelope the potential cost for rehabilitation.

Figure 10 shows the reduction in flows as a function of the dollars spent on rehabilitation. The three curves for the future flow reduction are the three cases described above. The approximate cost to reduce future flows to the existing level is in the range of $220 to $330 million. This range accounts for the degree to which leakier areas can be successfully identified and successfully rehabilitated. The cost includes both public and private investment because the sources of I/I could be in any part of the collection system. I/I from private sewers could contribute more than half of the total flow based on experience in other cities.

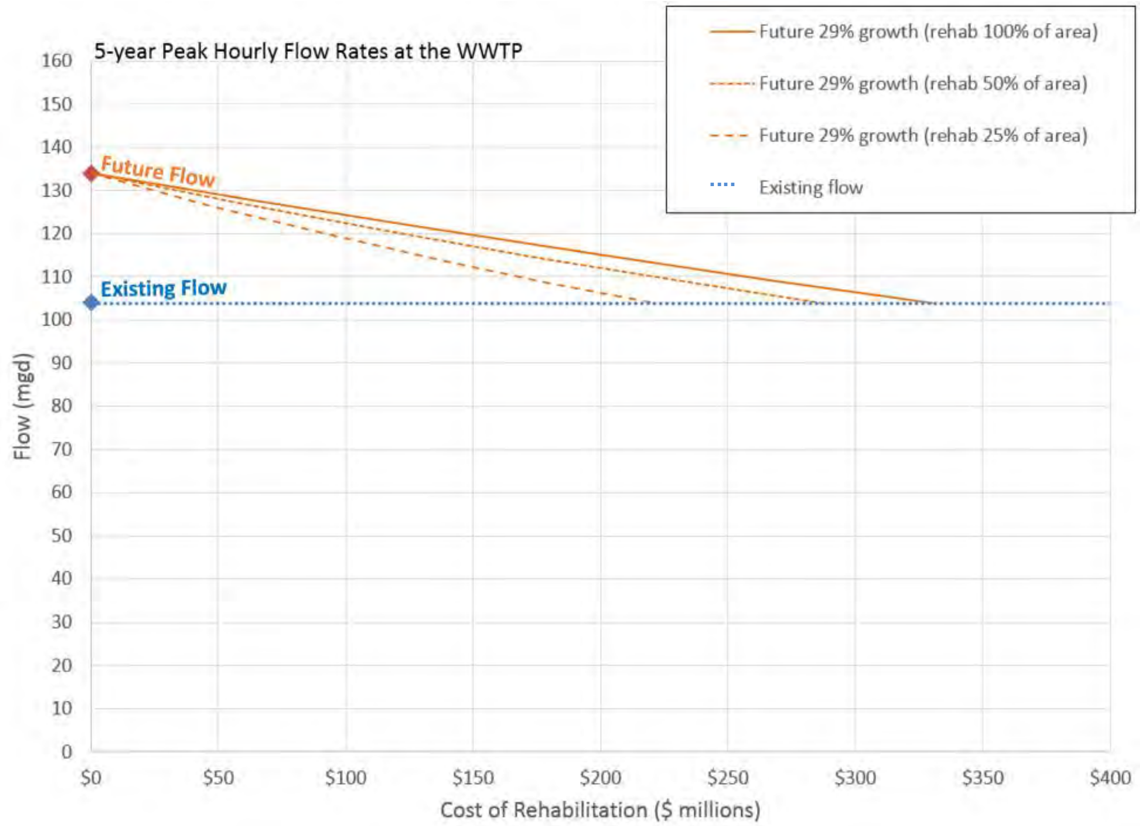


Figure 10 Estimated Cost of Rehabilitation to Reduce Future Flows to Existing Rates

In the future flow evaluation (Appendix A), there was discussion about the rate of future flow growth. This analysis is based on the assumption that future flows will be 29 percent greater than existing flows. If future peak flows are lower than the model suggests, then the cost of rehabilitation would be less. The curves in the figure above provide an envelope of likely costs. To evaluate other assumptions for growth and degree of rehabilitation, the curves in the figure can be scaled. For example, if the dry weather flow increases 29 percent but the I/I rate only increases 15 percent, then the cost is in the range of $155 to $235 million.

It is likely that the rehabilitation costs will be spread over many years. Assuming equal annual spending for 20 years, beginning 5 years after program initiation, and a discount rate of 4.375 percent (current DNR discount rate for facilities planning), the 20-year present worth of the rehabilitation is in the range of $120 to $175 million for the rehabilitation assumptions noted above. For the 15 percent I/I growth example above, the present worth is in the range of $80 to $125 million.

Whether or not a sewer system is rehabilitated to reduce I/I, there will still be a need to do ongoing maintenance to prevent degradation that would lead to a progressive growth in I/I over time. The rate of degradation is unknown. Historic flow monitoring data shows the change in flows over time. The total flow is the product of growth, development, changes is water consumption, degradation of the infrastructure, and weather variability. Therefore, a study of historic data would need to account for as many of these factors as possible to discern the change in the I/I rate over time. This type of study has not been performed as part of this facilities plan.

The performance based method can be used to estimate the cost of ongoing maintenance to prevent a growth in I/I. For this analysis it was assumed that I/I rates will increase 7 percent per decade due to degradation if no work is done. The 7 percent value is simply an assumption and is not based on any studies. However, this assumption has been used by other communities for this type of analysis. Using this assumption, the annual maintenance cost for the MMSD service area is approximately $8 to $9 million per year. This annual cost is the estimated value of maintenance for the entire service area, incurred by both MMSD and the community customers.

This performance-based cost-estimating method is intended for planning level evaluation only. The results of the performance-based method are not intended to be site-specific. That is why the results are reported for the entire MMSD service area as a function of flow reduction at the WWTP. The method is designed to be a quick method to make a preliminary estimate of the cost of I/I reduction with a minimal amount of information about the metershed (data used is simply the size of the metershed area, the initial I/I rate, and the goal for I/I reduction). The purpose of this analysis is to estimate the approximate cost for I/I reduction for use in comparing conceptual alternatives before more detailed alternative cases are developed.

3. Noneconomic Considerations

There are several noneconomic factors that must be considered in implementing an I/I reduction program. Potential benefits and limitations are outlined as follows.

a. Benefits

(1) Addresses peak flow problem at the source so costs for correcting problem are aligned with the source of the problem.
(2) Promotes local responsibility for addressing peak flows at the community customer and property owner level. It may also help protect potentially vulnerable populations.
(3) If successful, can reduce or eliminate the costs associated with collection system and treatment plant infrastructure upgrades associated with hydraulic capacity.
(4) Improves system resiliency if successful.
(5) Potentially reduces energy consumption as a result of reduced pumping.
(6) Could help to promote/improve public awareness of the need to maintain infrastructure, and improve perception of MMSD as a good steward of the environment and resources.
(7) Could help to promote customer community/MMSD cooperation.

b. Limitations

(1) Long-time frame is required for implementation.
(2) Ongoing work will be required to maintain the lower I/I rates over the long term.
(3) Success may be difficult to demonstrate in the short-term.
(4) Requires significant cooperation among numerous governmental entities; difficult to coordinate.
(5) There may be resistance from property owners if they are required to undertake private property repairs.
(6) Public perception of MMSD could be negative if benefits of program are not properly communicated or if the program does not meet expectations.
(7) Could create tension between community customers and MMSD if requirements for I/I reduction at community customer level are perceived as onerous.
(8) Successful results and outcomes cannot be assumed, and infrastructure capacity upgrades may, therefore, still be required before I/I reduction success can be demonstrated.
(9) MMSD's overall wet weather peaking factors are relatively low, which equates to lower confidence in achieving desired outcomes.

4. Reference

WERF, Water Environment Research Foundation Infiltration and Inflow Reduction Projects, 2003 study, 99-WWF-8: Reducing Peak Rainfall-Derived Infiltration/Inflow Rates–Case Studies and Protocol, 2003.

B. Alt. PF6–Influent Equalization at NSWWTP and pass 145 MGD through NSWWTP

1. Description of Alternative and Opinion of Cost

In this alternative, peak flows up to 145 mgd, the approximate hydraulic capacity of the existing NSWWTP facilities, will be conveyed to the plant. The disinfection and effluent pumping capacities of the plant will remain at 100 mgd and 80 mgd, respectively, and therefore diversions to the lagoon will still occur when these capacities are exceeded. Future peak flows above 145 mgd will be stored in a new influent equalization structure and released to the plant as flows subside following high flow events. This alternative was included in the District's 2017 Capital Improvements Plan Plant Peak Capacity Improvements analysis.

Included in this alternative are the following modifications:

a. Construct new influent equalization tank. A concrete influent storage tank will be constructed upstream of the NSWWTP on land adjacent to the NSWWTP site or nearby Pump Station No. 11 to reduce peak flows through the plant. The tank would be a minimum of 10 million gallons, which is the approximate volume required to reduce peak flows to about 145 mgd through NSWWTP and minimize hydraulic backups in the primary clarifiers.

b. A new interceptor will convey peak flows above about 145 mgd to the equalization tank from the splitter structure upstream of the primary clarifiers at NSWWTP.

c. Pump Station No. 11 would be used to pump the tank volume to the NSWWTP. A drain line from the tank to the pump station would be needed. In addition, a flushing system for the tank would be needed to clean the tank after use.

d. Alternative Consideration: If the tank were constructed near Pump Station No. 11, flow could be diverted directly to the tank from the pump station. Because Pump Station No. 11 is one of the larger pump stations, it is likely that adequate flow could be diverted form the pump station to maintain NSWWTP flows below 145 mgd. Improved screening facilities would be needed at Pump Station No. 11 to remove debris from the wastewater upstream of the tank.

A plant process flow schematic highlighting the components included in this alternative is presented as Figure 11. As described earlier, this would not significantly reduce the lagoon overflow frequency or volume to NSC. To provide the same lagoon overflow frequency as existing, approximately 200 to 250 million gallons of equalization volume would be required.

An opinion of probable cost for this alternative is presented in Table 4. A detailed breakdown of this opinion of probable cost is included in Appendix D. The operation and maintenance (O&M) costs associated with this alternative include ultraviolet (UV) disinfection and effluent pumping at NSWWTP, pumping stored flows from the lagoons at the plant, and labor to clean and maintain the influent storage tank.

For the purposes of this analysis, and based on the modeling presented earlier, it was assumed that three high flow events in the 20-year planning period would exceed 145 mgd and require the use of the influent equalization facilities. The additional pumping at Pump Station No. 11 associated with these events was considered negligible in the annual O&M costs. It was also assumed that two high flow events per year would exceed the effluent pumping capacity of NSWWTP and require the use of the lagoons. The effluent pumping and UV disinfection O&M costs are based on treating an approximate 2030 design average flow of 47 mgd. While some disinfected effluent may be discharged to the lagoon in this alternative, only to be pumped back to the plant and disinfected again, the increased energy cost associated with this additional UV disinfection is negligible over the planning period.

	Alt. PF6
Opinion of Capital Costs	$65,000,000
Opinion of Annual O&M	$777,000

Table 4 Alt PF6 Opinion of Capital and O&M Cost Summary

ALTERNATIVE PF6
INFLUENT EQUALIZATION AT NSWWTP
2016 LIQUID PROCESSING FACILITIES PLAN
TECHNICAL MEMORANDUM NO. 4
PEAK FLOW MANAGEMENT
MADISON METROPOLITAN SEWERAGE DISTRICT

STRAND ASSOCIATES®

FIGURE 11

1021.015

2. Noneconomic Considerations

This alternative includes much of the in-plant infrastructure upgrades that are required for Alternative 7 and others because it only shaves the extreme peak flows from reaching the NSWWTP. Potential benefits and limitations of this alternative are presented below.

a. Benefits

(1) Provides improved peak flow management, flexibility, and control to operations staff for both short-term and long-term operations.
(2) Reduces extreme peak flow rates through the NSWWTP, which could improve overall treatment performance during extreme wet weather events and eliminate in-plant overflows.
(3) Provides more efficient use of the West Plant facilities, which should improve treatment efficiency during wet weather events.
(4) Low construction risk and low risk of failure; relatively simple to construct.
(5) Does not require significant space at the plant.
(6) Dual-purpose site could become a public recreational asset (soccer fields, etc.).

b. Limitations

(1) Does not significantly improve the level of service with respect to diversion to lagoons and overflow of lagoons to NSC.
(2) Potential staff safety and public aesthetics concerns during tank cleaning.
(3) Requires staff to go off-site for maintenance activities.
(4) Tank cleaning will result in solids handling and management requirements; may be able to flush to Pump Station 11.
(5) Repumping of influent wastewater is required (higher energy).
(6) Likely would be constructed on a greenfield site; loss of farmland and the natural setting. May be public concerns regarding siting.
(7) Potential odors following wet weather events.
(8) Discharges to NSC might be permitted differently in the future.

C. Alt. PF7–Upgrade NSWWTP Hydraulics to Pass 180 mgd

1. Description of Alternative and Opinion of Cost

In this alternative, all wet weather flows are conveyed to and through the NSWWTP in a manner that minimizes plant operational impacts and process overflows and provides the capability to have a more equitable flow split between the west and east plants during peak flow events to better utilize the capacity within the west plant. As described earlier, the west plant has a larger final clarifier capacity based on surface area than the east plant. However, the existing Effluent Structure that directs secondary effluent to the lagoons establishes hydraulic control for the entire east plant through a fixed diversion weir elevation to the lagoons. This necessitates a majority of the peak flow to be sent to the east plant to achieve a diversion to the lagoons, which limits the flexibility and control of plant operations during high flow events. A goal of this alternative is to improve hydraulics through the plant to allow more flow to be sent to the west plant during peak flow events, better utilizing the existing infrastructure and improving treatment efficiency, while eliminating hydraulic bottlenecks that may lead to overflows of in-plant structures.

In the evaluation of this alternative, the plant hydraulic model was used to evaluate necessary upgrades for wet weather flows up to 180 mgd to be conveyed through secondary treatment at the NSWWTP, with flows above approximately 100 mgd being sent to the lagoons prior to disinfection and effluent pumping. At these peak flows, the hydraulic analysis was completed for approximately 90 mgd sent to both the west plant and the east plant at the primary influent flow splitter structure. This alternative achieves the goals of better utilizing the west plant, better controlling the flow split between the west and east plants, better controlling the flow to the lagoons and the disinfection building, and preventing in-plant overflows.

Included in this alternative are the following modifications to improve plant hydraulics at peak flows:

§ **Construct bypass channel for west primary clarifiers (Figure 12)**. Based on current plant experience and the hydraulic analysis conducted as part of this planning effort, the existing west primary clarifiers do not have hydraulic capacity to pass more than approximately 65-75 mgd without overtopping the primary clarifier walls at the influent channels. In addition, the West Primary Clarifiers rated hydraulic capacity is only about 45 mgd. The west primary clarifiers' hydraulic restraint has historically limited flow that has been sent to the west plant during peak flow events. To eliminate this hydraulic constraint, a bypass of the west primary clarifiers is included in this alternative. The proposed bypass of the west primary clarifiers consists of a bypass box with downward opening weir gate located in the west primary clarifier influent channel, a channel on the east side of the existing west primary clarifiers, and a box with a slide gate to connect to the existing primary clarifier effluent channel. The existing abandoned primary influent pipe that runs along the southeast side of the primary clarifiers could potentially be reused as part of this bypass, dependent on pipe condition. A primary clarifier bypass in this location is more cost-effective and accommodating to site conditions than constructing additional primary clarification capacity, which would only be used during peak flow events.

  Plant staff have indicated that surcharging of the primary effluent channel occurs at high flows. Based on the plant hydraulics in this area and based on discussions with plant staff, it appears that this surcharging may be the result of the primary effluent flow control valves not opening fully to alleviate the hydraulic constraint. This concern will need to be further investigated during the design of these improvements if this alternative is selected.

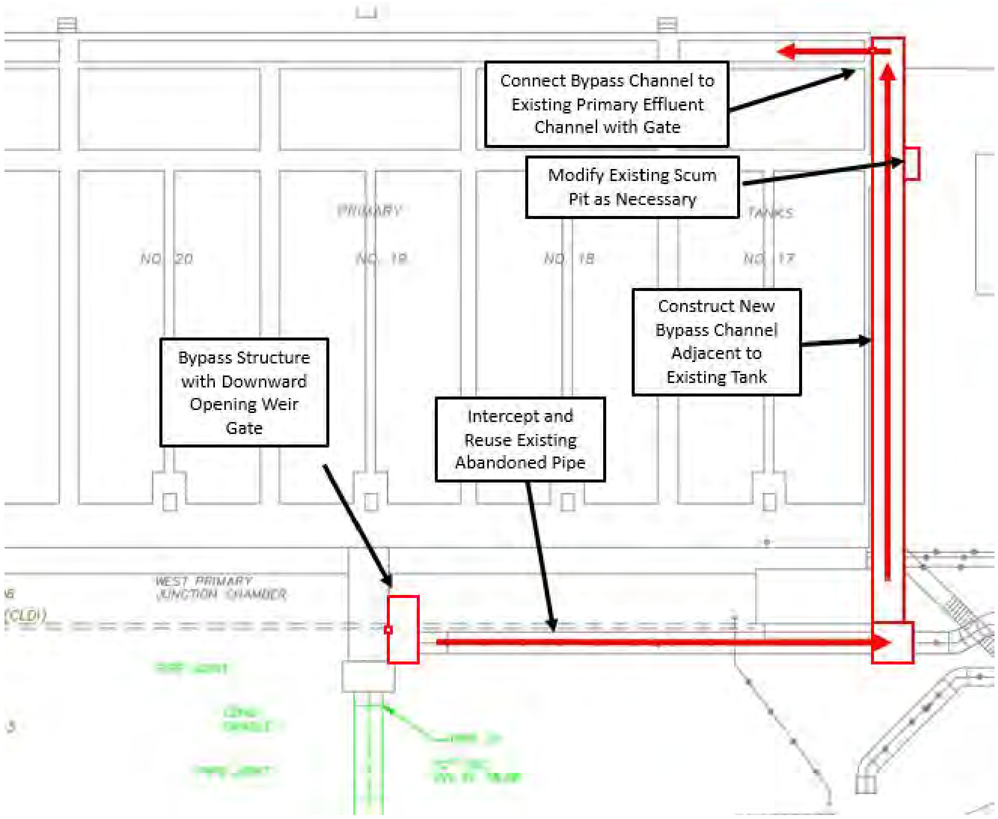


Figure 12 West Primary Clarifier Bypass Modifications

§ **Raise west final clarifier influent channel walls (Figure 13).** The west final clarifier influent channels are another hydraulic constraint at future peak flows. Based on the plant hydraulic model, these channels will overflow at a mixed liquor flow to the final clarifiers of about 100 mgd. Raising the walls of these channels by approximately 1 foot would provide adequate freeboard to eliminate channel overflows during high flows. In addition, the top slab of the channel at the site road crossing will need to be watertight to prevent overflows into the road. This may also include rerouting and relocating some channel aeration piping and valving at the road crossing. While raising channel walls does not reduce head loss through the plant during peak flow events, it can eliminate site overflows at a much lower cost than increasing the size of mixed liquor pipes that are integral to the final clarifiers or buried secondary effluent piping that are beneath the mixed liquor channels.

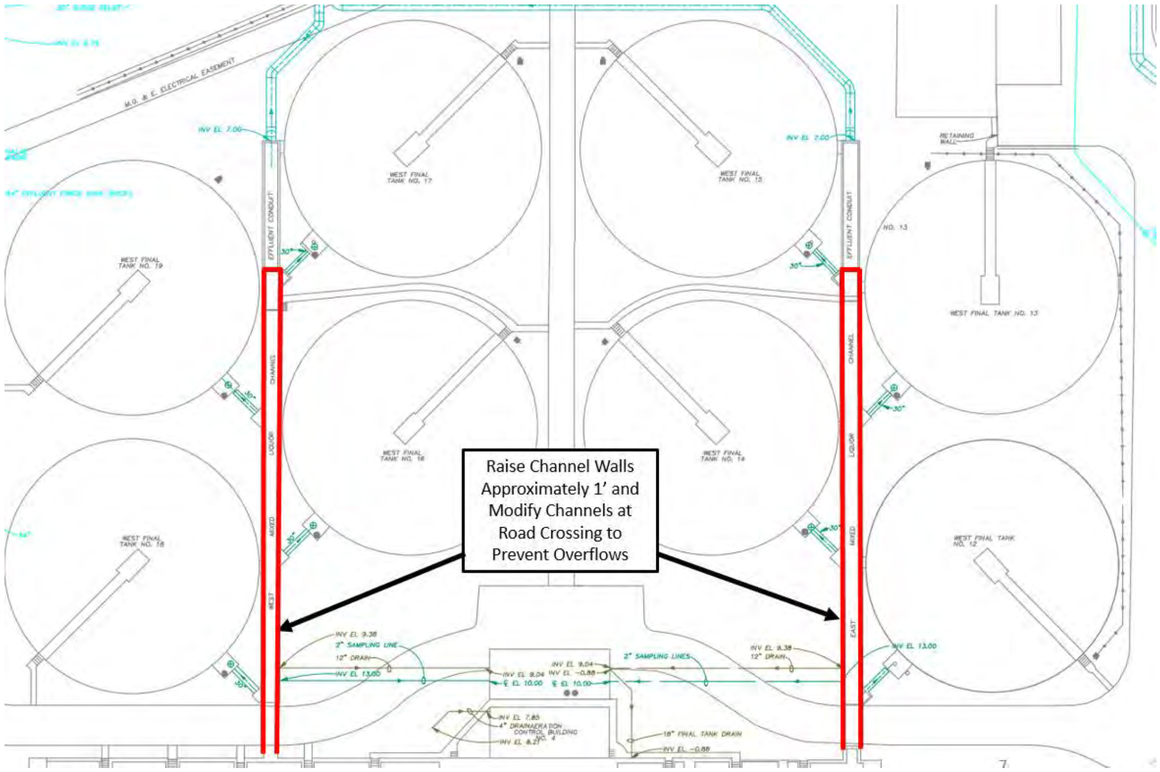


Figure 13 West Final Clarifier Influent Channel Modifications

- **Construct new lagoon diversion structure to provide flexible flow control to the lagoons and flow conveyed from the east plant to the disinfection building (Figure 14)**. This structure is anticipated to be located near the existing Effluent Structure and intercept existing piping from east plant Final Clarifier Nos. 4 to 11 and to the lagoons. Downward-opening weir gates at the new diversion structure would provide control of the water surface elevation and measurement of the flow being sent to the lagoons from the structure. This control eliminates the current fixed elevation weir that requires a very high flow rate within the east plant before initiating a diversion. Under peak flow conditions and 90 mgd sent through each of the west and east plants, this modified diversion structure will allow approximately 80 mgd to be sent to the lagoons from the east plant, with the additional 10 mgd from the east plant conveyed to the disinfection building to combine with the secondary effluent from the west plant. In addition to reducing the east plant flow required to achieve a diversion of 80 mgd to the lagoons, this modification also allows a lower downstream water surface to be maintained and eliminate hydraulic constraints between the east side aeration basins and the effluent structure. In this alternative, the disinfected secondary effluent from the effluent storage reservoirs would continue to be combined with the undisinfected secondary effluent from the new diversion structure and sent to the lagoons. Lagoon overflow discharged to Nine Springs Creek would not be disinfected in this alternative unless required.

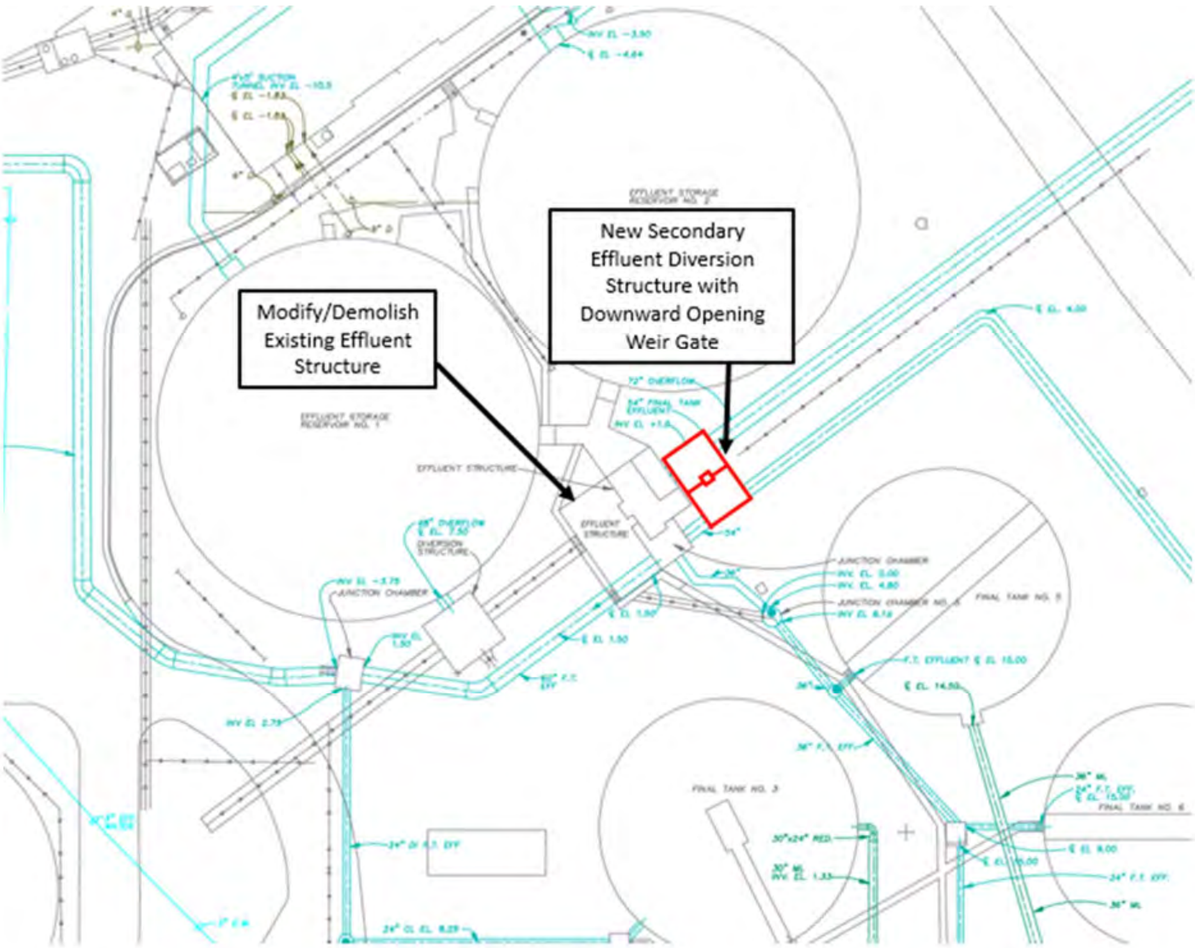
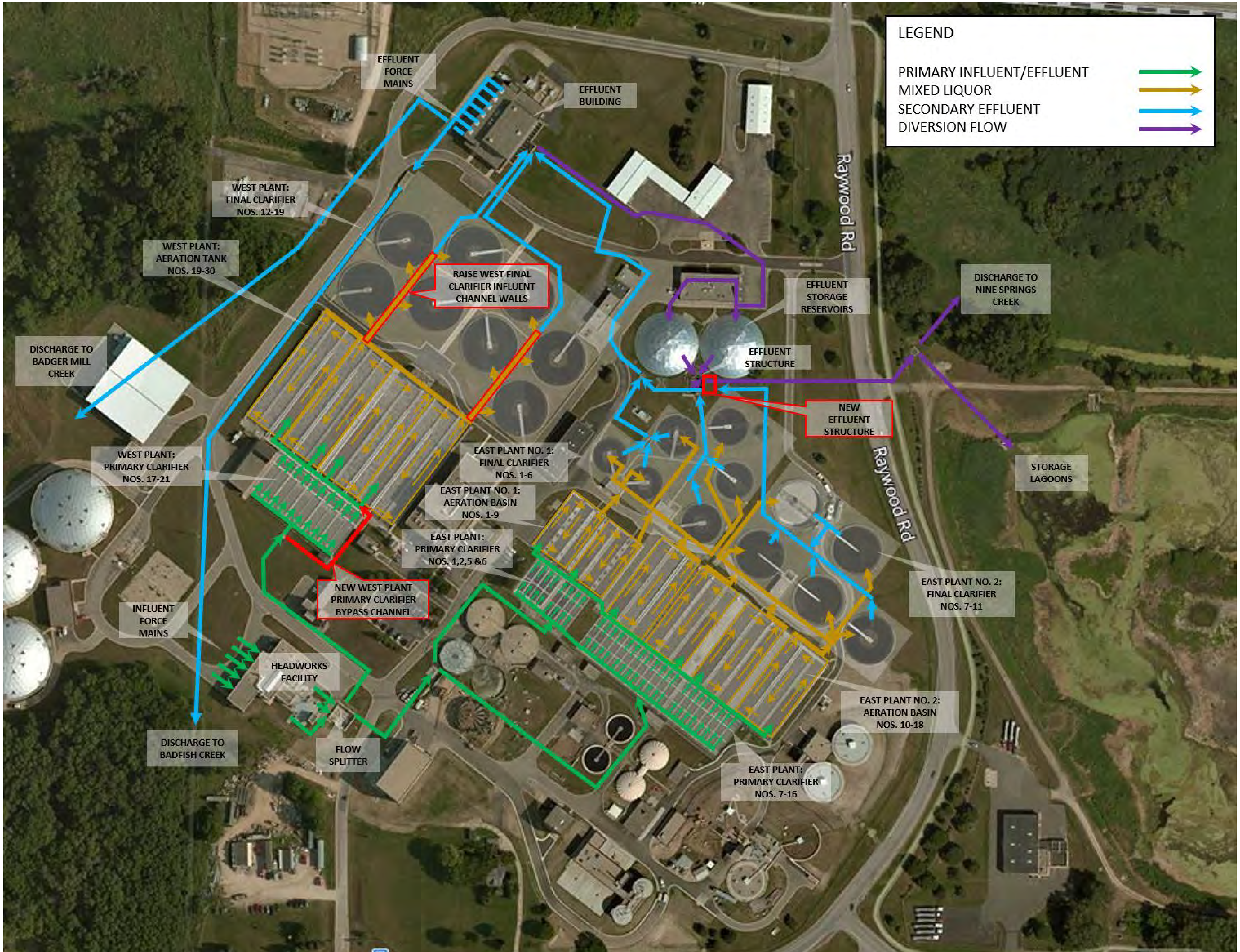


Figure 14 Effluent Structure Modifications

A plant process flow schematic highlighting the components included in this alternative is presented as Figure 15. Hydraulic grade line elevation results from the plant hydraulic model through various plant structures for this alternative are presented in Appendix B.

An opinion of probable cost for this alternative is presented in Table 5. A detailed breakdown of this opinion of probable cost is included in Appendix D. The O&M costs associated with this alternative include UV disinfection and effluent pumping at NSWWTP, pumping stored flows from the lagoons at the plant, and maintenance of the automated diversion and bypass gates.

For the purposes of this analysis, it was assumed that two high flow events per year would exceed the effluent pumping capacity of NSWWTP and require the use of the lagoons. The effluent pumping and UV disinfection O&M costs are based on treating an approximate 2030 design average flow of 47 mgd. While some disinfected effluent may be discharged to the lagoon, only to be pumped back to the plant and disinfected again, the increased energy cost associated with this additional UV disinfection is considered to be negligible over the planning period.



ALTERNATIVE PF7

UPGRADE NSWWTP HYDRAULICS ONLY

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FIGURE 15

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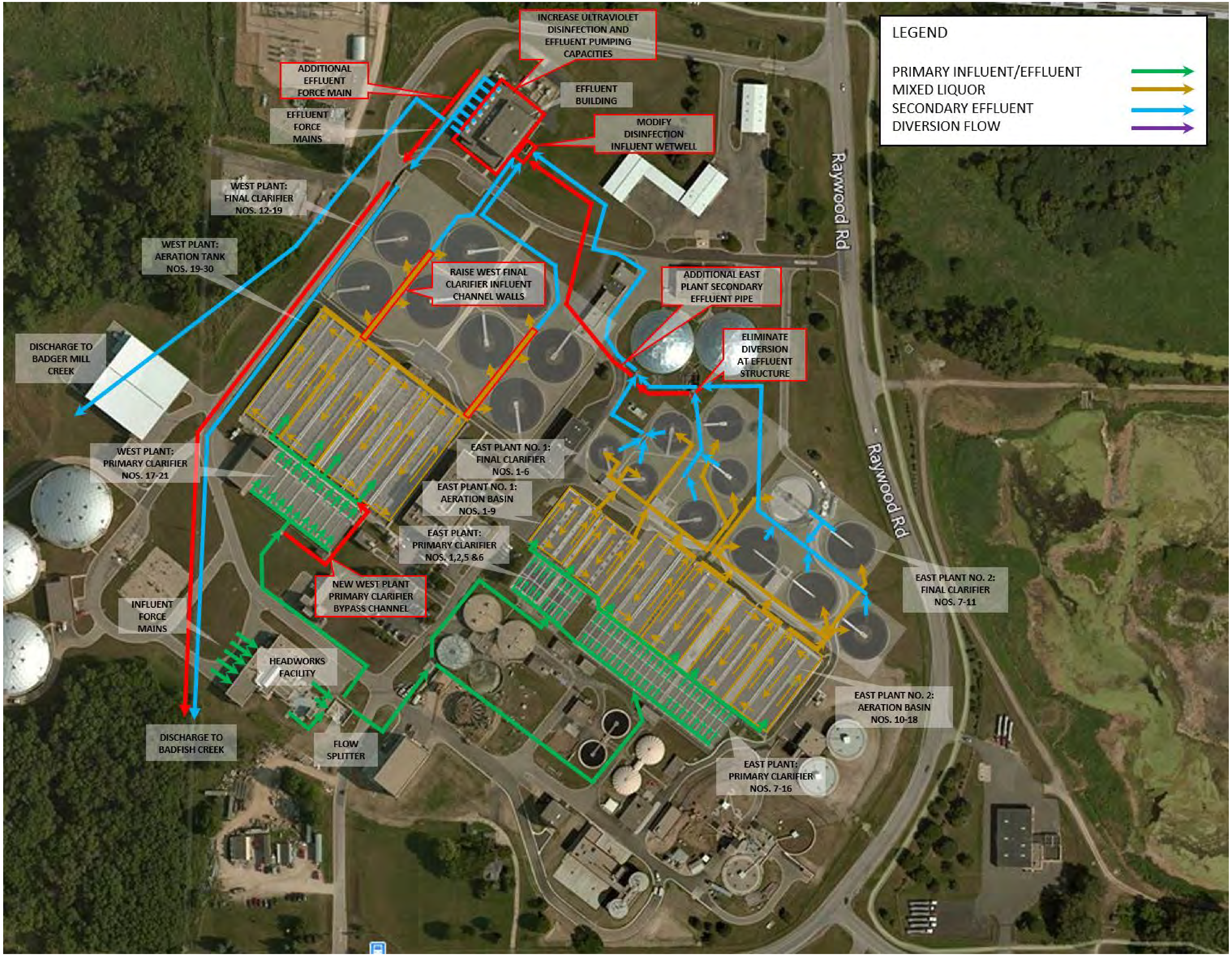

ALTERNATIVE PF8

EXPAND EFFLUENT PUMPING CAPACITY

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FIGURE 16

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	Alt. PF7
Opinion of Capital Costs	$4,100,000
Opinion of Annual O&M	$774,000

Table 5 Alt PF7 Opinion of Capital and O&M Cost Summary

2. Noneconomic Considerations

This alternative is generally the baseline alternative in which the NSWWTP hydraulics are improved to convey flow through the plant without hydraulically topping the NSWWTP structures. Potential benefits and limitations of this alternative are presented below.

a. Benefits

(1) Provides improved peak flow management, flexibility, and control to operations staff for both short-term and long-term operations.
(2) Provides more efficient use of the West Plant facilities, which should improve treatment efficiency during wet weather events.
(3) Low construction risk and low risk of failure; relatively simple to construct.
(4) Does not require additional space at the plant or greenfield development.
(5) Eliminates in-plant overflows, protecting existing equipment and facilities.
(6) Public perception of alternative likely to be positive

b. Limitations

(1) Does not improve the level of service with respect to diversion to lagoons and overflow of lagoons to NSC.
(2) Discharges to NSC might be permitted differently in the future.

D. Alt. PF8–Double NSWWTP Effluent Pumping Capacity and Upgrade Plant Hydraulics to Pass 180 mgd

1. Description of Alternative and Opinion of Cost

This alternative would eliminate diversions to the lagoons and Nine Springs Creek by improving plant hydraulics and increasing process capacities so that the 180 mgd peak flow can be disinfected and pumped to the discharges at Badfish Creek and Badger Mill Creek.

Since the disinfection and effluent pumping capacity in this alternative meets the future peak flows at NSWWTP, the existing Effluent Structure that diverts secondary effluent during high flow events is no longer necessary and could potentially be removed. However, the ability to divert flow to the lagoons is probably still warranted to provide backup in the case of a significant power failure at the effluent pump station. It is anticipated that peak flows would be split approximately evenly between the west and east plant in this alternative, and therefore the west plant hydraulic improvements included in PF7 to allow 90 mgd to be sent through the west plant are also included in this alternative. An additional secondary effluent pipe to convey flow from the east plant to the disinfection building would also be required. In addition, the UV disinfection capacity of the plant would be increased from the current capacity of approximately 100 mgd to the future peak flow of 180 mgd.

Currently, the effluent pumping capacity at NSWWTP is about 80 mgd, though it's limited to about 76 mgd when the Badger Mill Creek discharge must be turned off because of high water levels in the Creek. This alternative includes larger and/or more effluent pumps and a second force main from NSWWTP to the outfall location at Badfish Creek. A second force main was assumed to be necessary based on the age of the existing piping (approximately 60 years). In addition, a surge analysis conducted to the effluent force main for this planning project (Appendix E) indicate that the pipe is operating near its capacity assuming like-new conditions. Significant testing would be required to increase the permissible flows and pressures through the existing force main, and it is unlikely that flows above 90 mgd would be recommended.

Included in this alternative are several modifications that are also included in Alternative PF7:

§ Construct bypass channel for west primary clarifiers.
§ Raise west final clarifier influent channel walls by 1 foot and modify channel at roadway crossing to prevent overflows.
§ Construct new effluent structure to control diversions to lagoons and flow conveyed from the east plant to the disinfection building.

Additional modifications for this alternative are as follows:

§ **Install additional pipe to convey flow from the east plant to the disinfection building.** With all of the flow from the east plant being conveyed to the disinfection building rather than being diverted to the lagoon at the Effluent Structure, the existing east plant secondary effluent piping is insufficient to pass a future peak flow of 90 mgd or greater. Under the current conditions, such flows through the existing 66-inch pipe from the existing Effluent Structure to the disinfection building would result in overflows of junction chambers, final clarifiers, and aeration basins in the east plant. This alternative includes the installation of a second 66-inch pipe from the Effluent Structure to the disinfection building and modifications to the wet well at the disinfection building, Junction Chamber #7, and the Effluent Structure to accommodate this additional pipe. Existing site utilities limit the possible routes for additional piping of this size, and is anticipated to significantly increase the complexity and cost of installation.

§ **Increase UV disinfection capacity to 180 mgd.** The existing UV disinfection equipment consists of five channels with a capacity of approximately 20 mgd each, for a total capacity of 100 mgd. This alternative includes the ability to disinfect up to 180 mgd of flow within the existing UV channels. Details of this analysis will be presented in a future Technical Memorandum. However, the seven available channels provide adequate capacity for this alternative using UV equipment available today. For Alt. PF8, the incremental costs to provide 180 mgd rather than 100 mgd of disinfection is included.

§ **Double effluent pumping capacity and construct new effluent force main.** The existing effluent pumps would be replaced and the new pumps would be added to approximately double the existing effluent pumping capacity. The existing effluent pump station building would either need to be extended to the north, or a new building could be constructed to house additional effluent pumps west of the existing building and effluent force main. Costs assume a new building. An additional effluent force main, approximately 27,500 feet in length, would be installed to Badfish Creek and operated in parallel with the existing force main. The potential to increase the effluent pumping capacity and add a second force main was reviewed in detail as part of the Ninth Addition Facilities Plan in 1994, and excerpts from this plan are included in Appendix F.

A plant process flow schematic highlighting the components included in this alternative is presented as Figure 16.

An opinion of probable cost for this alternative is presented in Table 6. A detailed table breakdown of this opinion of probable cost is included in Appendix D. The O&M costs associated with this alternative include UV disinfection and effluent pumping at NSWWTP.

The effluent pumping and UV disinfection O&M costs in this alternative are based on treating an approximate 2030 design average flow of 47 mgd. While the disinfection and effluent pumping capacities are greater in this alternative than those that use the lagoon for peak flow storage, the total volume treated is the same and therefore any difference in O&M costs associated with UV disinfection and effluent pumping is considered negligible.

	Alt. PF8
Opinion of Capital Costs	$71,000,000
Opinion of Annual O&M	$738,000

Table 6 Alt PF8 Opinion of Capital and O&M Cost Summary

2. Noneconomic Considerations

This alternative is the only alternative that would be expected to significantly reduce or eliminate local discharges to NSC. Potential benefits and limitations of this alternative are presented below.

a. Benefits

(1) Provides redundant effluent pumping and conveyance capacity for improved reliability of a very critical system.
(2) Provides improved peak flow management, flexibility, and control to operations staff for both short-term and long-term operations.
(3) Provides more efficient use of the West Plant facilities, which should improve treatment efficiency during wet weather events.
(4) Provides full treatment of all flows.

(5) Eliminates lagoon overflow concerns; significantly reduces or eliminates the associated unknown future permit requirements associated with a NSC discharge.
(6) Provides redundant effluent force main, which provide more cost-effective maintenance and rehabilitation work.
(7) Maintains discharge flow to Badfish Creek.

b. Limitations

(1) Difficult construction of additional large diameter piping to the disinfection building, as well as for the additional effluent pump station and effluent force main through the NSWWTP site.
(2) Requires some additional space at the plant in congested areas.
(3) Requires significant infrastructure investment that would largely be unutilized or underutilized during much of its life.
(4) Construction impacts through environmental corridors and green fields for the force main installation.
(5) Potential public perception issues related to construction and traffic impacts.
(6) Potential impacts to Badfish Creek with respect to streambank erosion from higher peak flows.
(7) Uncertainty regulatory approval for such significant flow increases.
(8) Potentially takes the District in a direction away from a potential future local discharge to NSC and the Madison Lakes.
(9) Potentially takes the District in a direction away from decentralized treatment opportunities because of the significant cost to implement.

E. Alt. PF9–Upgrade NSWWTP Hydraulics to Pass 180 mgd with Increased Nine Springs Creek Discharge Frequency

1. Description of Alternative and Opinion of Cost

In its original context, this alternative is nearly the same as Alternative PF7 except that some flow would be directly discharged to NSC during wet weather/peak flow events in addition to overflows from the lagoons. The current UV disinfection capacity of 100 mgd and effluent pumping capacity of approximately 80 mgd will be maintained in this alternative. Effluent from the disinfection building in excess of the effluent pumping capacity will continue to be conveyed to the Effluent Storage Reservoirs. The flow from these reservoirs will combine with any secondary effluent from the east plant at a new effluent diversion structure as described in PF7. Peak flows from this structure will be split to two locations: a portion of the flow may be sent to the lagoons and a portion discharged directly to NSC. During peak flow events above the effluent pumping capacity of 80 mgd, but less than about 100 mgd, all diversion flow at this structure will be sent to the lagoons. When flows exceed 100 mgd, the flow in excess of 100 mgd will be sent to a high rate disinfection system located near the diversion structure and discharged directly to NSC. Therefore, during a peak flow event of 180 mgd, approximately 80 mgd would be discharged using the existing effluent pumping system, 80 mgd would be disinfected and discharged to NSC, and 20 would be discharged to the lagoons.

The original intent (described above) assumed that disinfection of the secondary effluent would be sufficient to discharge directly to NSC under infrequent wet weather conditions. However, based on WDNR's draft water quality memorandum received on February 13, 2017, any permitted discharge to NSC would need to receive tertiary treatment and would need to improve water quality in the phosphorus impaired segment, which would require limits that are less than the water quality criteria. These requirements are based on NSC being listed as impaired for phosphorus and TSS. In addition, because NSC is upstream of Mud Lake and Lake Waubesa, tertiary treatment is required by state statute. Therefore, implementing this alternative (infrequent wet weather discharges) would require very high levels of treatment, which is unlikely to be cost effective at this time. This is especially true since such a facility would be used very infrequently during the planning period.

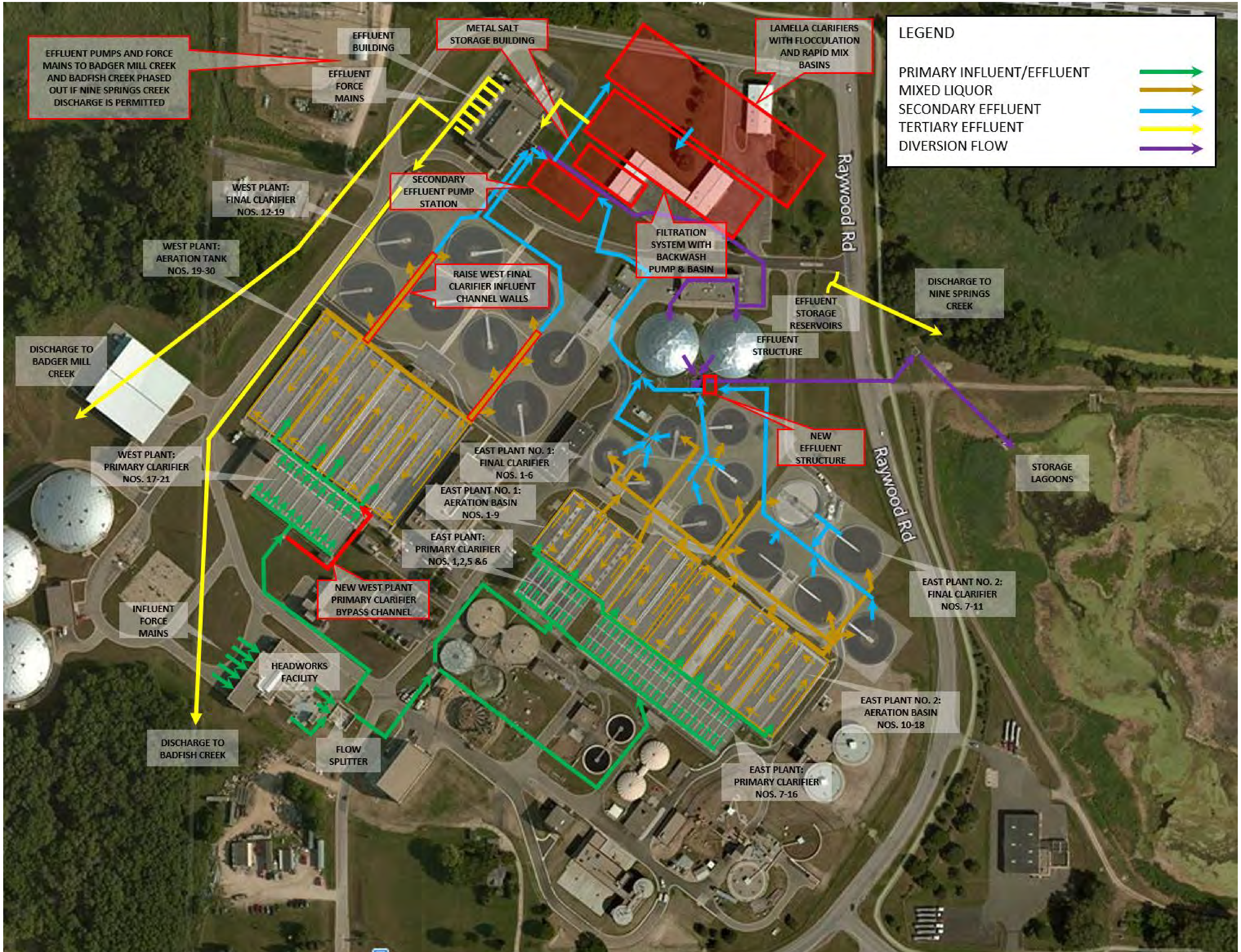
The original concept has been revised as follows: A new tertiary treatment facility would be constructed to receive secondary effluent. For planning purposes, the facility recommendations developed by CH2M in 2012 (Preliminary Nutrient Removal Cost Estimates) was assumed to be constructed for this alternative. That evaluation included a new filter influent pumping stations, new deep bed granular media filters, chemical addition facilities, and chemical coagulation facilities. We have assumed the approximate capacity (~80 mgd), location, and layout of the tertiary treatment facility would be similar. Flows above this rate would continue to be diverted to the lagoons, similar to existing conditions. A plant process flow schematic highlighting the components included in this alternative is presented as Figure 17.

Included in this alternative are the modifications that are included in PF7:

§ Construct bypass channel for west primary clarifiers.
§ Raise west final clarifier influent channel walls by 1 foot and modify channel at roadway crossing to prevent overflows.
§ Construct new effluent structure to control diversion to the lagoons and flow conveyed from the east plant to the disinfection building.

Additional modifications for this alternative are as follows:

§ **Install tertiary treatment facilities.** These facilities are described in the *Preliminary Nutrient Removal Cost Estimates* (CH2M, 2012), Scenario No. 3, which included meeting an effluent total phosphorus limit of 0.075 mg/L (anticipated actual effluent TP ~0.05 mg/L). We have assumed that additional phosphorus offsets to meet the 0.03 or 0.04 mg/L limit would be met through trading within the watershed. We note further that alternate tertiary treatment systems (CoMag, Actiflo, ClearAS) might be able to meet the lower 0.03 or 0.04 mg/L effluent phosphorus limit. Some of these systems may have lower capital and similar operating costs as the assumed granular media filtration, but for planning purposes, construction of new granular media filters will continue to be assumed.



ALTERNATIVE PF9

UPGRADE NSWWTP HYDRAULICS AND INCREASE NSC DISCHARGES

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FIGURE 17

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§ **Install additional effluent piping from the new tertiary treatment facilities to the NSC outfall.** A specific route has been assumed for planning purposes, but a more detailed route will need to be identified for this large diameter pipe (~72 inches).

In addition to the regulatory and technical (level of treatment) hurdles that would need to be addressed, public perception of this alternative may be substantially negative. In our experience, new wastewater discharges are not typically well received, especially when the discharge is to recreational use waters that are heavily used by the community. In summary, this alternative is not considered as a viable, constructible alternative within the planning period of this facilities plan.

While this approach is not currently viable, the fact remains that effluent pumping energy comprises about one-fifth of the total energy used at the NSWWTP, which is a substantial cost and represents a large carbon and energy footprint, contrary to the District's goals of energy efficiency and energy independence. In addition, the infrastructure to convey treated effluent to the current discharge locations is also substantial and will require significant capital expenditures to maintain and replace at some point in the future (refer to Alternative PF8). Therefore, we believe the District should initiate planning to identify a path to implement this alternative in the future. The regulatory hurdles and treatment challenges are significant, and this is likely a 15- to 20-year effort to address the challenges and definitively determine whether a local NSC discharge (intermittent or continuous) is truly feasible. However, if this alternative is consistent with the District's long-term vision and goals, this planning is needed.

As part of near-term and long-term planning related to this alternative, the District would likely need to initiate the following:

a. Monetized triple bottom line assessment of this alternative and other alternatives that consider nutrient removal treatment together with outfall location. The planning period should be longer than the typical 20 years to account for implementation of lower level phosphorus and nitrogen limits in the 20 to 40-year time frame.

b. Ongoing meetings and discussions with WDNR to review previous studies, future required studies, and related regulatory framework pertaining to a local NSC discharge.

c. Water quality studies related to establishing current background conditions in NSC and downstream water bodies.

d. Development political strategies to potential change state statues related to a NSC discharge, which could potentially relax the specific requirements for such a discharge.

e. Public awareness/education programs focused on establishing the financial, social, and environmental benefits associated with successful implementation of a NSC discharge.

f. Study of the impacts to BFC and BMC if the NSWWTP discharge were eliminated from these surface waters.

Since it has already been established that this alternative is not viable within the planning horizon of this facilities plan, we have not included costs for this alternative. We believe inclusion of these costs for Alternative PF9 would only make sense if the long-term (beyond 20 years) costs were included for the other alternatives, and these costs would need to include the costs related to compliance with nutrient regulations in a comprehensive triple bottom line analysis to truly be comparable.

2. Noneconomic Considerations

Potential benefits and limitations of this alternative are presented below.

a. Benefits

(1) Eliminates effluent pumping costs, which would enable the District to better meet its energy and efficiency goals. It is noted, however, that any future tertiary treatment on site will likely require the addition of an intermediate pump station. Power use will decrease overall, however.
(2) Eliminates the significant risk associated with a potential failure of the effluent force main to BFC.
(3) Would provide the ability to meet future low level phosphorus limits if BFC and BMC discharges continue and adaptive management and/or trading programs are not deemed to be cost-effective.
(4) Directs resources at the District to towards initiating a long-term plan and program to establish a future local discharge to NSC and the Madison Lakes on a continuous basis. It changes the concept of peak flow management and potential long-term discharge locations.
(5) Provides improved peak flow management, flexibility, and control to operations staff for both short-term and long-term operations.

b. Limitations

(1) The regulatory viability of a local NSC discharge is unknown at this time.
(2) May require political strategies to change state statues related to a NSC discharge.
(3) Requires significant additional space at the plant.
(4) Would likely require load trading for the relatively small amount of phosphorus and TSS discharged to NSC through the new outfall.

F. Alt. PF10–High-Rate Treatment at NSWWTP

1. Process Description and Facility Modifications

Biological contact (BC) treatment is defined as a high-rate biological process where mixed liquor or return activated sludge (RAS) is directed from a mainstream activated sludge plant to a small contact chamber with a short hydraulic detention time, where it is combined with wet weather flows and then passes to secondary clarifiers for solids-liquid separation. Figure 18 shows two possible variations of the BC process for wet weather treatment. Each configuration "borrows or uses" mixed liquor or RAS from the mainstream activated sludge process, allowing a quick startup during wet weather events. For the NSWWTP, an in-line BC configuration using Pass 3 of each of the 10 activated sludge trains is proposed as described below.

The BC process relies on the removal of particulate and colloidal material by biological flocculation in the contact chamber and also provides limited soluble substrate uptake. Biological contact can be especially advantageous for WRFs that have already invested in the required secondary clarifier capacity such as the NSWWTP. Moreover, no chemical addition is required. Biological contact has been successfully implemented at other WWTPs, such as the Orange Water and Sewer Authority's Mason Farm WWTP in Chapel Hill, NC and has generally been shown to be a cost-effective solution for WWTPs with flow peaking factors up to approximately three to four times the average design flow rate.

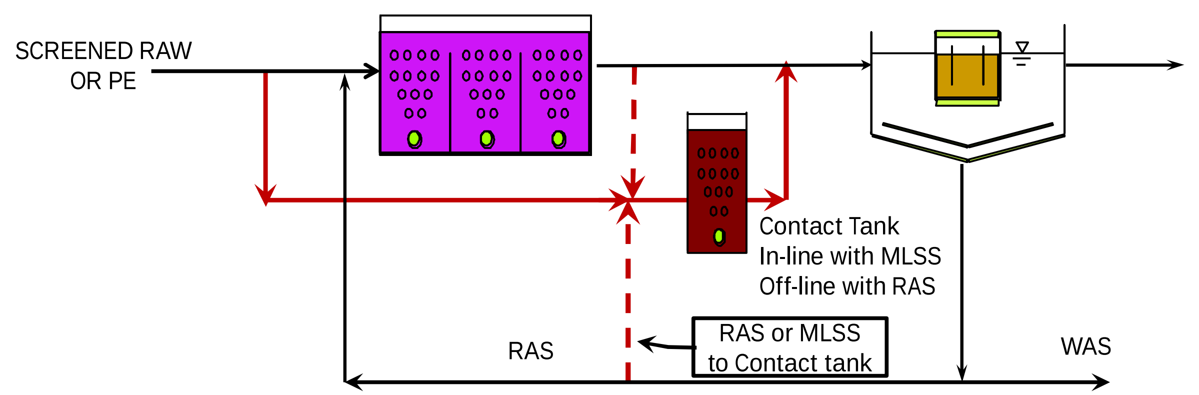

Figure 18 General Biological Contact Treatment Flow Schematic

The BC process can be implemented into the NSWWTP existing modified UCT process as shown in Figure 19 or the Plant 1 A/O system in a similar manner. The BC treatment scheme consists of the following key considerations:

a. Under normal flow conditions, the plant would operate in the existing modified UCT (or A/O) flow scheme where all screened and degritted flows are routed through the primary clarifiers and primary effluent is fed to the bioreactor anaerobic zone.
b. Under high flow conditions, plant operations would be modified as follows:
    (1) Screened and degritted primary influent flow would be treated in the primary clarifiers up to the capacity of the clarifiers. The hydraulic capacity of the East and West Primary Clarifiers is estimated to be 90 mgd and 45 mgd, respectively.
    (2) Screened and degritted flow in excess of the primary clarifier capacity would be routed to the primary clarifier effluent channel and mixed with primary effluent.

(3) Under current operations, approximately 110 mgd of secondary influent flow would be fed to Pass 1/anaerobic selector and flows in excess of 110 mgd would be routed to Pass 3. The flow distribution between Pass 1 and 3 changes if total nitrogen removal is required in the future as discussed below.

(4) Pass 3 flows would be controlled using either slide gates with electric actuators or control valves and flow meters. In the West Aeration Tanks, new 30-inch valves will replace the existing butterfly valves in the 30-inch-diameter pipeline feeding primary effluent to Pass 3. The East Aeration Tanks have two 27-inch x 27-inch gates (Tanks 3 and 6) or a single 36-inch x 36-inch gate (Tanks 9, 12, and 15). These gates would likely be demolished and replaced with a single gate (approximately 36 inches x 36 inches) per tank, and each would include an electric actuator.

(5) Flow metering to Pass 3 is not necessarily required. The gate settings can be established by a hydraulic analysis to approximately distribute the flow at the desired split. Flow meters would be provided for the West Plant since this facility will be discharging the majority of the permitted flow during peak flow events. These flow meters could potentially be eliminated from the project to reduce capital expenditures.

RAS will continue to be pumped back to the anoxic zone (or anaerobic selector in the A/O tanks) and mixed liquor flows to the existing secondary clarifiers for solids separation in accordance with typical operations.

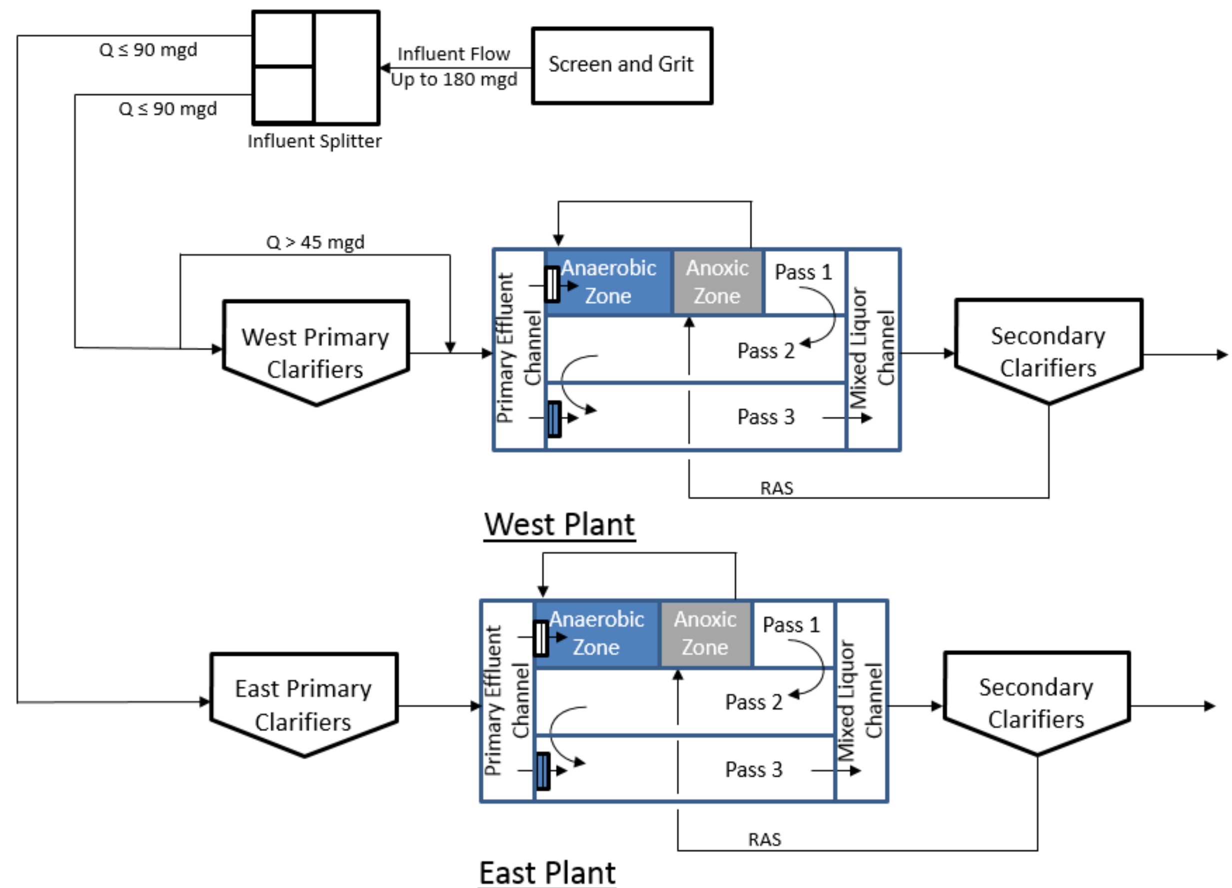

Figure 19 Proposed Biological Contact Wet Weather Process Flow Scheme at the NSWWTP

2. Design Basis and Cost Development

BC design must balance the need to provide sufficient MLSS for bioflocculation while minimizing MLSS to maintain the secondary clarifier solids loading rates (SLRs) within an acceptable level. The maximum allowable SLR capacity of the existing East and West secondary clarifiers was estimated using State Point Analysis (SPA). We assumed all clarifiers in service, RAS pumps operating at peak flow capacity and a design sludge volume index (SVI) of 125 mL/g (typical EBPR plant 90th percentile design value). Since there is an inherent uncertainty in defining secondary clarifier capacity using SPA, the calculated maximum allowable SLR was decreased or “derated” by 20 percent to account for non-ideal settling and thickening in the clarifiers resulting in a lower maximum SLR. The derated SPA yielded a maximum SLR of 42 lb/sf-d and 31 lb/sf-d for the East and West Secondary clarifiers respectively. For this effort the East Plant maximum SLR was further reduced to 37 lb/sf-d to achieve the same maximum allowable MLSS as shown in Table 7. For comparison the East plant 42 lb/sf-d SLR scenario is also presented in Table 7 to illustrate reducing the RAS peak flow from 51 mgd to 40 mgd has a limited impact on the allowable maximum month MLSS.

Based on BNR system modeling conducted under the NSWWTP Preliminary Nutrient Removal Cost Estimates prepared by CH2M Hill dated January 11, 2012, the maximum month MLSS concentration for future design loadings and no additional tankage were as follows:

§ Existing operations (A/O) MLSS = 2,740 mg/L
§ Existing operations (modified UCT) MLSS = 3,450 mg/L
§ Total nitrogen less than 10 mg/L (A/O) MLSS =3,540 mg/L
§ Total nitrogen less than 10 mg/L (modified UCT) MLSS = 4,350 mg/L

Table 7 indicates that, to maintain the maximum allowable SLR (MLSS) flows in excess of 108 mgd and 72 mgd are routed to Pass 3 under existing operations and potential future TN removal operation, respectively. In addition, under TN removal operations the internal mixed liquor recycle flows from the aerobic zone back to the anoxic zone may need to be turned off during peak flow events to reduce the SLR to acceptable levels.

The maximum month MLSS concentrations developed under the Preliminary Nutrient Removal Cost Estimates will need to be updated for the treatment scenarios selected for further analysis in Technical Memorandum 5. Technical Memorandum 5 will also investigate the need to increase the West plant RAS pumping capabilities to increase clarifier capacity and allowable SLR. It is recommended the secondary clarifiers be stress tested and subsequently modeled using computational fluid dynamic (i.e., 2Dc Secondary Clarifier Model) to define the maximum allowable SLR capacity.

Typically, 15 minutes of contact time (based upon forward flow) with a minimum MLSS concentration of 1,500 mg/L, or 20 minutes of contact time with MLSS of 1,000 mg/L, is required to achieve excellent bioflocculation for particulate and colloidal matter removal.[1] Table 7 shows the existing East and West Aeration Basin Pass 3 volumes provide 40 to 45 minutes of contact time, with MLSS concentrations well above 1,500 mg/L. Hence the existing aeration basins provide sufficient contact time to promote bioflocculation and separated dedicated contact tank is not required. Added benefits of using Pass 3 for the "contact tank" include (1) the longer aeration times will reduce effluent ammonia and provide time for additional phosphate uptake for reduced TP discharges, (2) reduced peak flows to anaerobic selector will help preserve the selector/EBPR process integrity under stressed conditions, and (3) routing flow to Pass 3 will decrease secondary clarifier solids loading rates at peak flows as indicated above.

Effluent TSS and $cBOD_5$ when operating in the BC mode are expected to be the same as achieved with the existing secondary clarifiers at high flows and should be less than 15 mg/L of TSS and $cBOD_5$ in a well operating clarifier. Daily effluent NH_3-N and TP could be higher than conventional secondary treatment depending upon the level of dilution and treatment and would need to be further investigated during preliminary design if this alternative is selected for implementation.

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[1] Esping, D. E., Krill, B., Parker, D. S. Jimenez, J. A., Fitzpatrick, J., Yang, F., and Bate, T. (2012) "Comparison of Three Wet Weather Flow Treatment Alternatives to Increase Plant Capacity." Proceedings of the Water Environment Federation 85th Annual Conference & Exposition (WEFTEC), New Orleans, LA, September 29 – October 3, 2012.

Parameter	Units	East Plant–Full RAS Capacity	PF10 Analysis	
			East Plant	West Plant
Peak Influent Flow	mgd	90	90	90
Peak RAS Flow	mgd	51	40	34
Aeration Basins				
Aeration tank volume–total	MG	12.2	12.2	11.7
Pass 3 volume–total	MG	4.1	4.1	3.9
Pass 3 hydraulic retention time at peak flow[2]	minutes	41	45	45
Secondary Clarifiers				
Clarifiers in Service	No.	11	11	8
Clarifier Surface Area–total	sf	73,690	73,690	84,547
Surface Overflow Rate	gal/sf-d	1,220	1,220	1,065
"Design" Sludge Volume Index	mL/g	125	125	125
"Design" allowable solids loading rate	lb/sf-d	42	37[1]	31
Pass 3 MLSS to clarifiers at peak flow	mg/L	2,630	2,520	2,520
Allowable Maximum Month MLSS under "normal operations" to maintain clarifier SLR under peak flow conditions				
20% Peak Secondary Influent Flow to Pass 3	mg/L	3,000	2,900	2,950
30% Peak Secondary Influent Flow to Pass 3	mg/L	3,250	3,150	3,200
40% Peak Secondary Influent Flow to Pass 3	mg/L	3,500	3,450	3,500
50% Peak Secondary Influent Flow to Pass 3	mg/L	3,800	3,800	3,900
60% Peak Secondary Influent Flow to Pass 3	mg/L	4,200	4,250	4,400
70% Peak Secondary Influent Flow to Pass 3	mg/L	4,650	4,800	5,000

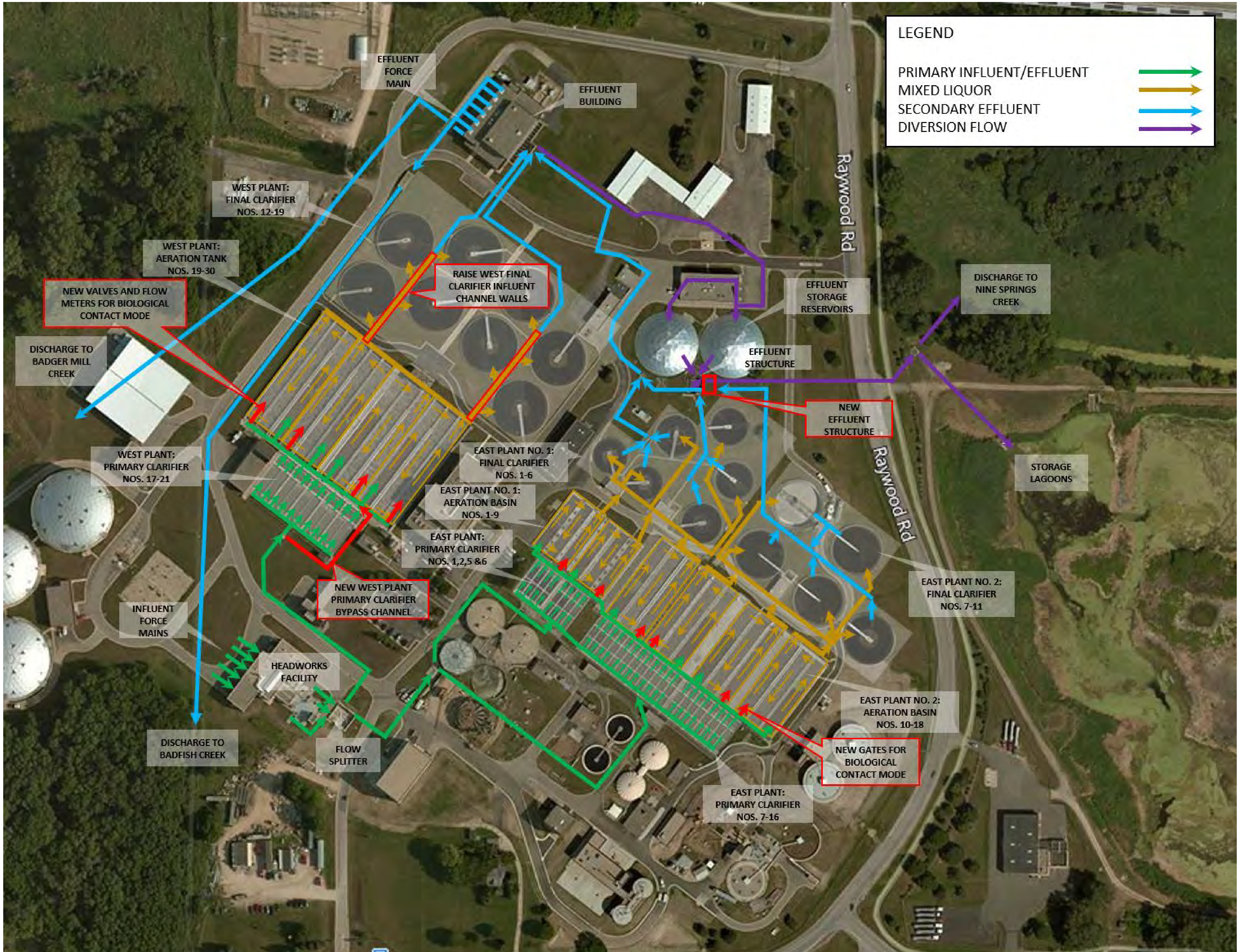
[1]East Plant SLR of 37 lb/sf-d based upon RAS flow of 40 mgd.
[2]HRT based upon forward flow including RAS flow.

Table 7 Biological Contact Preliminary Process Design Data.

In addition to the gate, valves, flow meters, and controls described previously, included in this alternative are the modifications that are included in PF7:

§ Construct bypass channel for west primary clarifiers.
§ Raise west final clarifier influent channel walls by 1 foot and modify channel at roadway crossing to prevent overflows.
§ Construct new effluent structure to control diversion to the lagoons and flow conveyed from the east plant to the disinfection building

A plant process flow schematic highlighting the components included in this alternative is presented in Figure 20.



ALTERNATIVE PF10
HIGH RATE WET WEATHER TREATMENT AT NSWWTP
2016 LIQUID PROCESSING FACILITIES PLAN
TECHNICAL MEMORANDUM NO. 4
PEAK FLOW MANAGEMENT
MADISON METROPOLITAN SEWERAGE DISTRICT

STRAND ASSOCIATES®

FIGURE 20
1021.015

An opinion of probable cost for this alternative is presented in Table 8. A detailed breakdown of this opinion of probable cost is included in Appendix D. The O&M costs associated with this alternative include UV disinfection and effluent pumping at NSWWTP, pumping stored secondary effluent from the lagoons at the plant, maintenance of the automated diversion and bypass gates, and maintenance of the gates, valves, and flow meters associated with the biological contact process.

For the purposes of this analysis, it was assumed that two high flow events per year would exceed the effluent pumping capacity of NSWWTP and require the use of the lagoons. The effluent pumping and UV disinfection O&M costs are based on treating an approximate 2030 design average flow of 47 mgd. While some disinfected effluent may be discharged to the lagoon to be pumped back to the plant and disinfected again, the increased energy cost associated with this additional UV disinfection is considered to be negligible over the planning period.

	Alt. PF10
Opinion of Capital Costs	$5,200,000
Opinion of Annual O&M	$782,000

Table 8 Alt. PF10 Opinion of Capital and O&M Cost Summary

3. Noneconomic Considerations

This alternative is not directly comparable to the other peak flow management alternatives. Alternative PF10 focuses on improving treatment performance during wet weather events. For the purpose of this Facilities Plan, we are comparing the BC peak flow treatment method to a dedicated excess flow treatment scheme such as BioMAG or BioACTIFLO, which would include construction of new tanks, buildings, and considerable additional piping and appurtenances. The following list identifies the non-economic considerations:

a. Benefits

(1) The step feed concept maximizes capacity by decreasing the clarifier solids loading rate at high flows (compared to current operations). If step feed is not used, additional aeration basins or clarifiers are required to reduce the clarifier solids loadings to acceptable levels.

(2) Low construction impact. Installation of West Primary Clarifier high flow channel to the primary effluent channel significantly less disruptive than alternatives requiring additional tankage and processes. Significantly less large diameter piping required. Less construction will translate into fewer impacts on neighbors from dust, traffic, and noise.

(3) Maximizes investment in existing infrastructure while improving peak flow treatment by utilizing existing tankage and aeration equipment for treatment.

(4) The environmental impacts of new storage or treatment facilities construction are avoided.
(5) Saves NSWWTP space for other uses or future construction.
(6) No chemicals required.
(7) Fast start-up under wet weather conditions.
(8) Simple operations compared to operating a dedicated wet weather treatment plant.
(9) Reduces asset management requirements and maintenance requirements compared to a dedicated wet weather treatment facility.
(10) Proven wet weather treatment system.
(11) Nonproprietary.
(12) Similar or better treatment efficiency anticipated.
(13) Eliminates concerns with permitting a wet weather treatment facility.

b. Limitations

(1) Compared to a dedicated wet weather auxiliary treatment system (e.g., Actiflo™ or equal) this alternative does not increase capacity beyond the projected high flows.
(2) Adds some complexity to operations with change in operation (step feed to Pass 3) at high flows.

RECOMMENDATIONS

The null alternative has the lowest capital and long-term present worth costs, mainly owing to the fact that no capital improvements would be required within the planning period. It is likely that all of the hydraulic and process structures would continue to operate efficiently under most flow conditions. However, the frequency and severity of peak flows through the plant are anticipated to increase over time, and as these events continue to occur, the potential of a larger process or hydraulic failure increases. In addition, the current split of flow through the plant during high flow events does not provide the optimum use of the existing infrastructure. Therefore, we do not recommend the null alternative.

Alternative PF7 (improve plant hydraulics) has the next lowest opinion of capital and present worth costs. In addition, this alternative provides hydraulic upgrades the should minimize structure overflows through the plant and optimize the use of both the east and west plant facilities. We recommend that Alternative PF7 be implemented regardless of other alternatives that may be implemented.

Based on the evaluations included herein, the following recommendations are provided with respect to peak flow management for the District and at the NSWWTP:

1. Implement Alternative PF10, which includes the hydraulic capacity upgrades at the NSWWTP included in in Alternative PF7, as well as upgrades to allow the activated sludge process to operate in a biological contact process mode during high flow events. This alternative provides protection against in-plant tank overflows and will provide improved treatment under high flow conditions. This alternative will not reduce the use of the lagoons or the number and extent of lagoon overflows to NSC. Overtime, under this alternative,

lagoon overflows to NSC will increase if the flow projections identified herein are realized. The capital cost for this alternative is approximately $6 million.

2. Begin evaluating in more detail potential paths forward related to implementing Alternative PF9, which includes initiation of a local permitted discharge to NSC. This alternative would be a first step towards a potential continuous future discharge to NSC at the District, which could significantly reduce energy consumption at the NSWWTP by eliminating the effluent pump station, and would account for a large percentage of the needed energy reduction goals to ultimately attain electrical neutrality at the NSWWTP. However, the WDNR has indicated (Technical Memorandum No. 2a) that discharges to NSC, even if only during wet weather events would require tertiary treatment and would likely need to meet phosphorus limits that are less than the phosphorus water quality criteria. Our recommendation is to begin planning with the WDNR for an approximate 5 or 10 mgd tertiary treatment facility that would provide acceptable effluent for discharge to NSC. This facility would be operated during wet weather events to reduce flows discharging to the lagoons, which would also reduce the chance of overflow from the lagoons to NSC. The added benefit to this facility would be the ability to evaluate low level phosphorus removal over a long term to develop costs for comparison to the adaptive management planning program. While this may appear to be a costly recommendation for limited benefit in the short-term, we believe such a measure will be needed before the District will be able to establish a continuous, local discharge to NSC.

3. Consider initiating an aggressive I/I reduction pilot study (Alternative PF4). The study would be focused on identifying one or more areas with high I/I rates, and then implementing aggressive I/I reduction measures with the goal of quantifying successes and challenges for future additional measures in other areas. In addition to the pilot study, The District should consider evaluating a monetized triple bottom line for this alternative to help compare the potential total costs with other alternatives. An aggressive I/I program will require public and private investment, significant coordination and collaboration from multiple communities and entities, and a concentrated long-term effort from the District, and a triple bottom line analysis would help in quantifying the significant social and environmental benefits and costs.

The remaining alternatives were not recommended for the following reasons:

- Alternative PF0 (Null alternative) does not address any of the hydraulic concerns that are the focus of this facilities plan.
- Alternative PF6 (Influent Equalization) has very high capital and present worth costs, and does not significantly improve overall plant hydraulics and flexibility. In addition, the potential public/aesthetic concerns could result in poor public perception.
- Alternative PF8 (Effluent Pumping Upgrades) has very high capital and present worth costs, and implementation of this alternative could make it more difficult to justify future local discharges to NSC because of the high sunk costs associated with the redundant force main.

Table 9 provides an opinion of present worth summary for all the alternatives evaluated herein.

	PF0 Null	PF4 Aggressive I/I[a]	PF6 Influent EQ	PF7 NSWWTP Hydraulic Upgrades	PF8 Effluent Pumping Upgrades	PF10 Biological Contact
Capital Cost For Alternative		$4,100,000	$65,300,000	$4,100,000	$71,300,000	$ 5,200,000
54-inch Primary Influent (TM3)[b]		$700,000	$700,000	$ 700,000	$700,000	$700,000
Effluent FM Standpipe and Surge Protection (Appendix D)[b]		$200,000	$200,000	$ 200,000	$200,000	$200,000
Total Opinion of Capital Cost	**$0**	**$5,000,000**	**$66,200,000**	**$5,000,000**	**$72,200,000**	**$ 6,100,000**
Annual O&M	$773,000	$11,000,000 to $16,000,000	$777,000	$ 774,000	$738,000	$782,000
O&M Cost PW	$10,200,000	$80,000,000 to $175,000,000	$10,200,000	$10,200,000	$9,700,000	$10,300,000
Salvage PW	$0	($400,000)	($7,300,000)	($400,000)	($6,500,000)	($400,000)
Total Opinion of Present Worth	**$10,200,000**	**$85,000,000 to $180,000,000**	**$69,000,000**	**$14,700,000**	**$75,300,000**	**$ 15,900,000**

[a] Annual O&M and present worth costs are the total projected program costs for the District, its customers, and private efforts.

[b] Costs were developed elsewhere but included here to develop total costs related to peak flow management.

Table 9 Opinion of Present Worth Summary

APPENDIX A
PEAK FLOW MODELING

Technical Memorandum No. 4a

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Prepared for: Madison Metropolitan Sewerage District

Project Title: 2016 Liquid Processing Facilities Plan

Project No.: 149052.004

Technical Memorandum

Subject: Technical Memorandum No. 4a: Peak Flow Management Modelling

Date: June 1, 2016; **Revised February 2017**

To: Jeff Klawes, Project Manager

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Executive Summary

The level of service (LOS) provided by the Nine Spring Wastewater Treatment Plant (WWTP) with respect to hydraulic capacity was evaluated for current and future flow conditions. The existing system capacities were used as the reference values to determine the frequency of events that exceed the capacities. The level of service was evaluated for: headworks peak flow capacity, disinfection rate, effluent pumping rate, diversion to the lagoon, and overflows from the lagoon to the Nine Springs Creek. Figure ES-1 is a summary of the level of service values for the various components of the WWTP.

The headworks capacity was determined to be 145 million gallons per day (mgd) based on the hydraulic capacity of the screens and entrance channel to the aeration basins. Current 2015 flows rarely exceed the headworks capacity; the level of service is in the 50 to 100-year recurrence interval range.

The population of the service area is projected to increase 29 percent from 2015 to 2040. Future flows were also assumed to increase 29 percent by 2040. The simulated future flows depend on two assumptions. The first assumption is that future dry weather flows will increase in proportion to the population change. This is a relatively straight forward assumption. The second assumption is that during wet weather events, the future infiltration and inflow will also increase 29 percent in proportion to population. This assumption implies that future development areas will have infiltration and inflow rates similar to the existing system, and that degradation in the existing system will be mitigated by on-going rehabilitation.

The sensitivity of future flows to the infiltration and inflow assumption was explored by evaluating a second case that assumed a 15 percent increase. This assumption makes a noticeable difference in the simulated peak flows and volumes, but the level of service provided is not significantly different in this second case compared to the first case with a 29 percent increase. A 15 percent increase would require additional rehabilitation above the level needed to mitigate degradation. It further expects that the lower infiltration and inflow rates can be maintained over time.

While the headworks capacity currently has a level of service in the 50 to 100-year range, future flows will increase the frequency of events that exceed the 145 mgd capacity. The future level of service will be in the 5 to 10-year recurrence interval range. If a storage facility were constructed to store the flow that exceeds the headworks capacity, a 9 MG facility would be required to store the largest event in the simulation period.

The disinfection capacity is 100 mgd. The disinfection facilities have a level of service with a 4-year recurrence interval in current conditions, and 1 to 2 years in future conditions.

Effluent pumping is limited to approximately 76 mgd because only the Badfish Creek pumps operate during large wet weather events. (The Badger Mill Creek pumps may not operate when flows in the creek are high.) Included in this rate is approximately 0.5 mgd of recycled flow that returns to the plant, so the net flow to the outfall is 75.5 mgd. This evaluation used an effluent capacity value of 75.5 mgd for the maximum discharge rate. Peak flows in the plant exceed the effluent pumping capacity approximately 1 to 2 times each year in current conditions. Future conditions are expected to exceed this capacity 3 to 5 times per year. This is the level of service of the effluent pumps and it is also the frequency of diversions to the lagoon.

When flows exceed the effluent pumping capacity, the excess flow is diverted to the two storage tanks (0.65 MG each) and the lagoon. The active lagoon volume is approximately 50 million gallons (MG). Therefore, this evaluation used a storage capacity of 51 MG for the tanks and the lagoon. When the volume diverted to the lagoon exceeds the storage capacity, the excess volume overflows to the Nine Springs Creek. The level of service of the existing 51 MG lagoon volume is in the 10 to 20-year recurrence interval range for current flow conditions. In future 2040 conditions the frequency of overflows was estimated to be in the 3 to 6-year recurrence interval range.

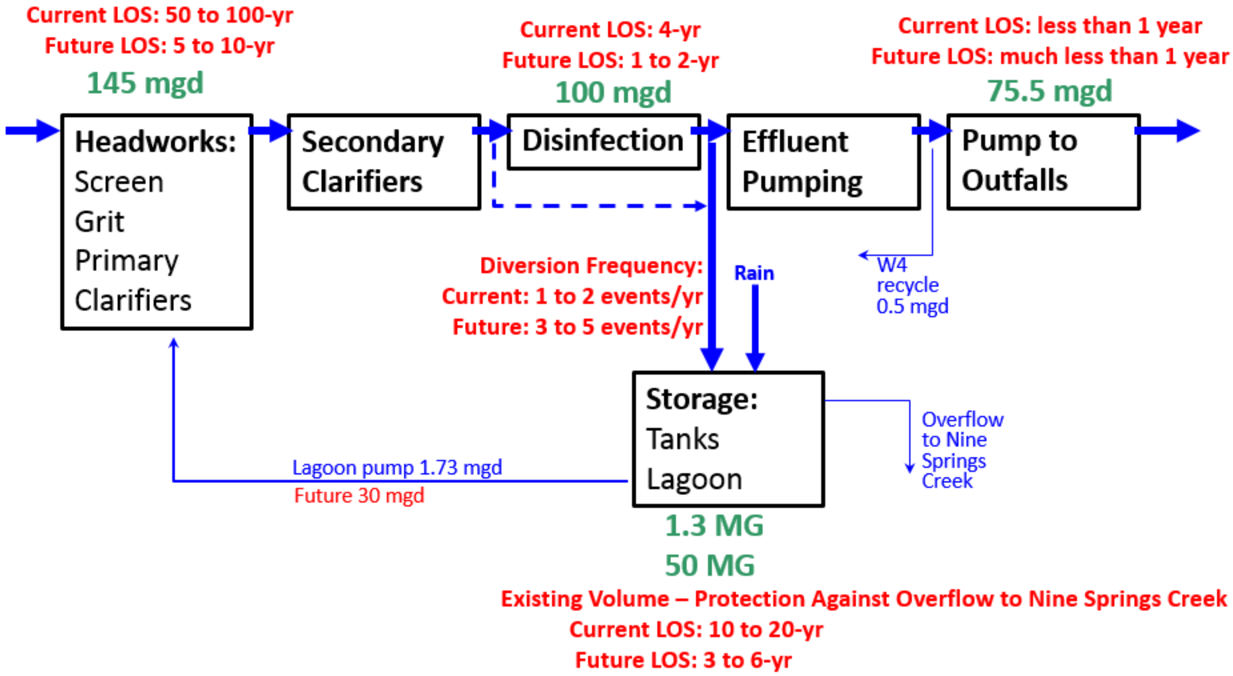

Figure ES-1. Level of Service Summary

Section 1: Review of MMSD data

1.1 Daily and Hourly Influent and Effluent Flow Records

Daily and hourly influent and effluent flow records from January 2006 to December 2015 were provided by Madison Metropolitan Sewerage District (MMSD) for this evaluation. In this 10-year period there were 13 significant wet weather events suitable for model calibration. The largest recorded hourly influent flow was 137 mgd in the 6/8/2008 event. This event had a peak daily influent flow rate of 106 mgd.

1.2 Rain Gauge Records

The long term hourly rain gauge data at the Dane County Regional Airport (Truax) was used for this evaluation. This record starts in 8/1/1948 and continues to the present (67 years).

There were three large rain events recorded during the 10-year calibration period (2006-2015). These events are summarized in Table 1-1 using the metrics of peak hourly intensity, greatest 24-hour depth, and total event depth. In some cases, the most important part of the storm that caused the peak flow conditions was a subset of the rain event with a critical depth over the duration of time leading up to the peak flow conditions. The recurrence interval of the rainfall for the critical period in the storm is listed in the table.

Table 1-1. Rain Event Characteristics

Event Date	Peak Hourly Intensity (in/hr)	Greatest 24-hour depth (inches)	Critical depth (inches) and duration	Recurrence Interval During Critical Duration (years)	Total Event Depth (inches)
8/19/2007	1.8	5.0	5.5 / 36 hr	25-yr	9.3
6/8/2008	1.3	5.3	6.3 / 36 hr	50-yr	6.5
6/26/2013	1.7	3.3	7.1 / 5 days	30-yr	7.2

Appendix A contains graphs of the rainfall intensity and cumulative depth for the three events. It also has graphs of depth-duration-frequency to estimate the rainfall recurrence interval.

1.3 Storage Lagoon Diversions and Nine Springs Diversions

The Nine Springs WWTP includes two effluent storage tanks (0.65 MG each) and a storage lagoon (approximately 50 MG active storage volume) for a total of 51 MG of storage capacity.

The storage facilities are generally used whenever the flow through the WWTP exceeds either the disinfection capacity or the effluent pumping rate. Some diversions are also made in dry weather to accommodate maintenance or other operational objectives. The wet weather diversions are the focus of this study. Historic wet weather diversions to the lagoons are presented in Figure 1-1. These values were provided by MMSD in a spreadsheet (2016 MMSD).

When the volume diverted to the lagoon exceeds the storage capacity, the excess volume overflows to the Nine Springs Creek. This was the case in the June 2008 event when 14 MG was reported to overflow on June 13 and 14, 2008.

The lagoon volume provides a relatively high level of service to prevent overflows. In the 23-year period since 1993, there has only been one overflow.

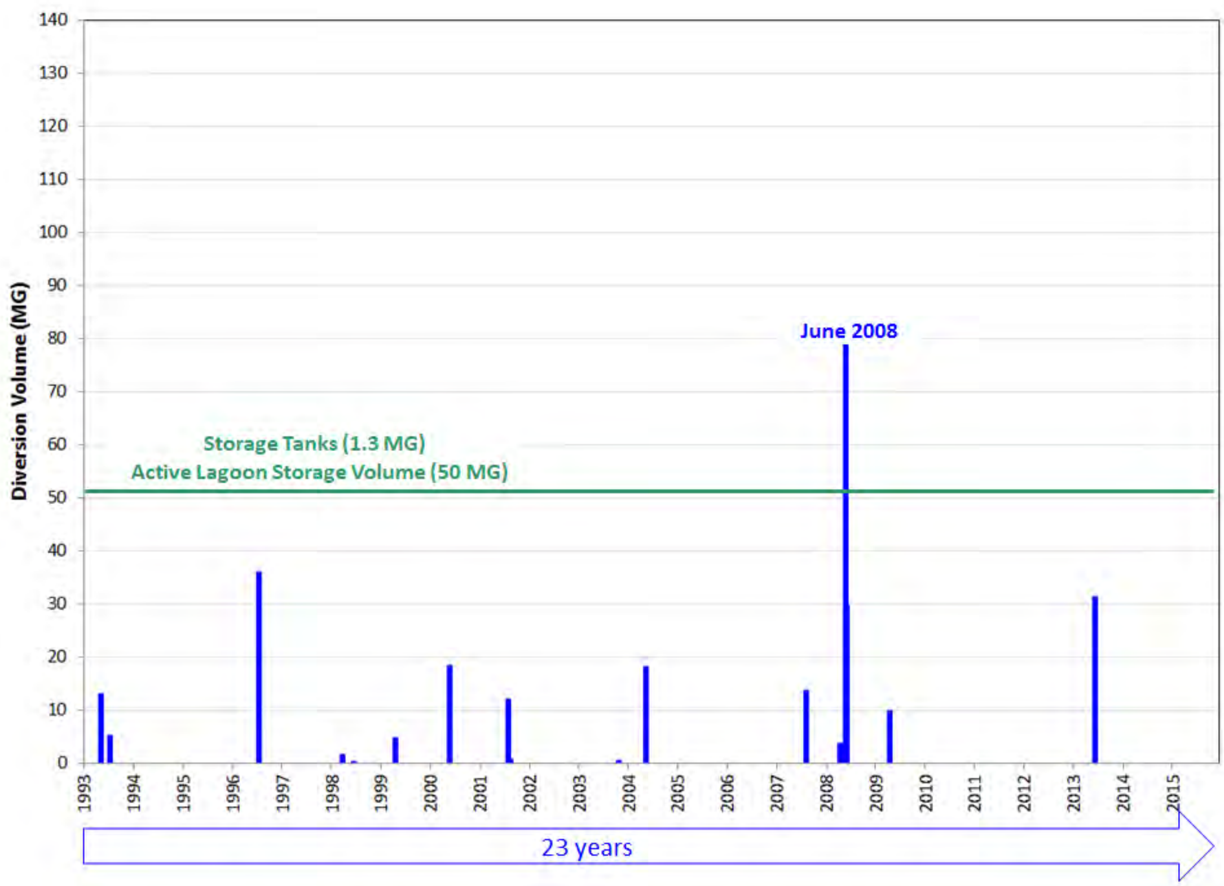

Figure 1-1. Historic Wet Weather Diversions to the Lagoon

Section 2: Hydrologic Model: Existing System (2015)

2.1 Hydrologic Model

The tributary area of the WWTP was modeled as a single basin to simulate the influent flows at the WWTP. The modeling approach used two software packages to generate the flow and develop the calibration. The regional hydrologic response of the Madison area to rainfall was simulated using the Hydrologic Simulation Program – FORTRAN (HSPF). This model uses rainfall and other meteorological data to simulate the continuous hydrologic response over a long period of time. This model accounts for snow melt, evaporation, soil moisture storage, and groundwater flows for a unit of land surface. In this way it simulates the overall hydrologic response to rainfall at the regional scale.

The second software package is called the Capacity Assurance Planning Environment (CAPE). The CAPE software takes the HSPF results and applies calibration parameters to simulate the flow in the wastewater collection system. In CAPE, the measured flows are compared to the simulated flows to calibrate the model parameters that are specific to dry and wet weather flows in the sanitary sewer system.

The two programs work together in an integrated fashion. The HSPF program is actually executed within the CAPE environment so the data transfer between the models is coordinated.

2.2 Approach

In HSPF there are four hydrologic responses: active groundwater flow, interflow in the unsaturated soil, and surface runoff from pervious and impervious areas. All of these responses are taking place in the tributary area and each of these could contribute to rainfall derived infiltration and inflow (RDII) entering the sanitary sewer system.

The first stage of the calibration requires adjustment of the HSPF parameters to get the overall hydrologic response correct (such as snow melt and evaporation). The second stage of the calibration requires adjustment of the CAPE parameters to define base sanitary flow in dry weather and the importance of various RDII components in wet weather.

The tributary area of the WWTP is approximately 69,000 acres (based on the sum of pump station service areas in 2000 as reported in the MMSD Collection System Evaluation Report, January 2009). Before reaching the plant the flow is routed through at least one or more pump stations (in some case four pump stations). The faster hydrologic responses such as pervious and impervious runoff are attenuated in the routing through such a large tributary area to the WWTP. The hydrograph shape of the influent flow to the WWTP is dominated by the slower hydrologic components which are active groundwater and interflow.

The HSPF simulation used the rainfall data from the Dane County Regional Airport (Truax). The airport is located in the northeast side of the tributary area. By using a single tributary area and a single rain gauge, it was assumed that the rainfall pattern was uniform over the tributary area. Actual rainfall is distributed in space and time. Therefore, this approach of using a single rain gauge works best for rain events that are relatively uniform. Events with larger spatial rainfall variability are not modeled as well.

2.3 Calibration

The model was calibrated to the measured influent flow meter data during the 10-year period from 2006-2015. During this time there were 13 wet weather events suitable for calibration. Two events in particular were very large: 6/8/2008 and 6/26/2013.

Figure 2-1 shows the simulated and measured flow hydrographs for the 6/8/2008 event. The measured and simulated peak flows are equal for the largest peak on 6/8/2008 and for the smaller secondary event on 6/12/2008. This event had the largest peak flow value (136 mgd) in the calibration period. The overall shapes of the hydrographs are similar in timing and recession, except that the simulated flows receded faster after than measured flows after a few days. The simulated event volume was 7 percent less than the measured volume.

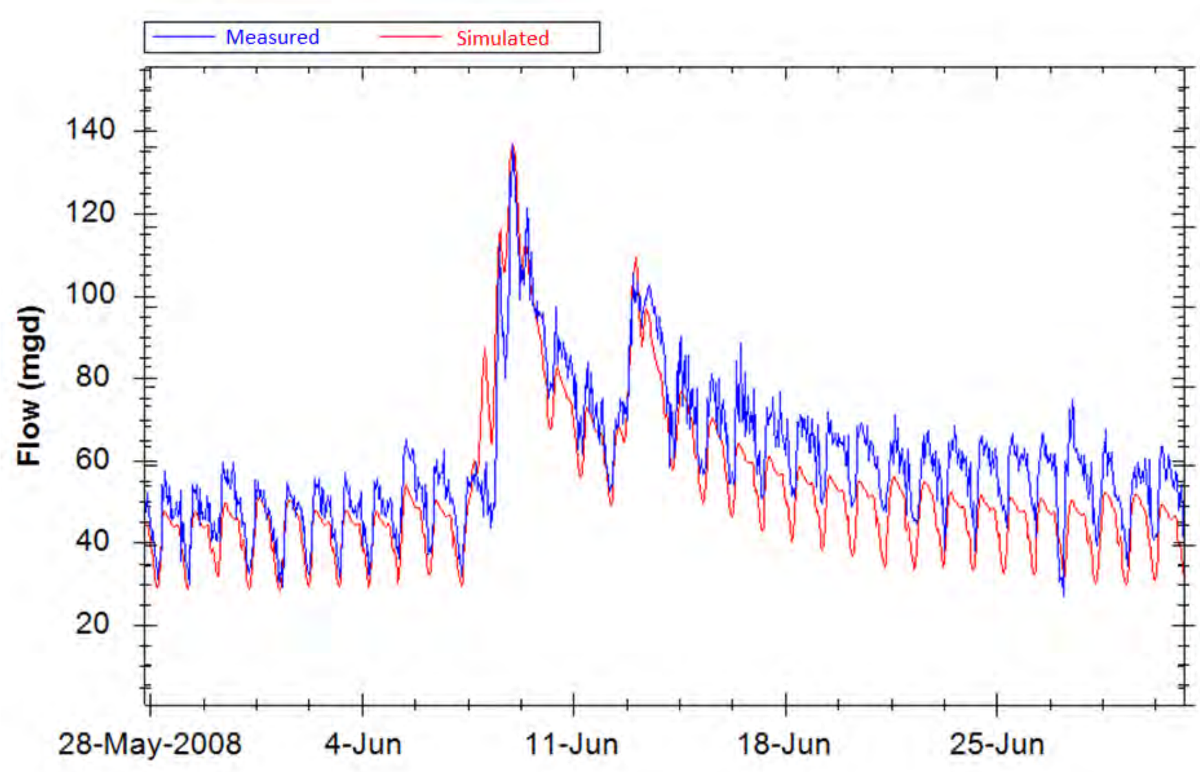

Figure 2-1. WWTP Hourly Flow: 6/8/2008 Calibration Event

Figure 2-2 shows the 6/26/2013 calibration event. The simulated peak flow was 11 percent less than the measured peak, but the event volumes were equal and the hydrographs shapes were very similar.

Figure 2-3 shows the overall view of the 10-year simulated period.

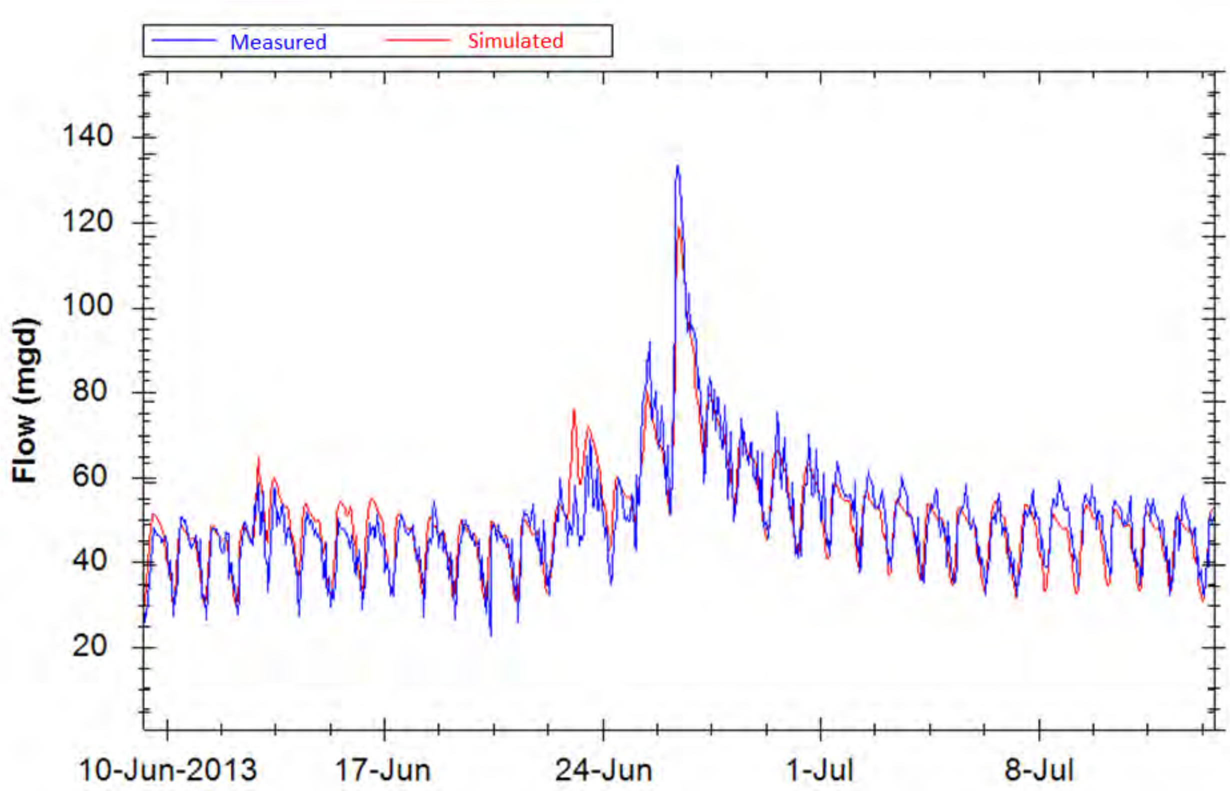

Figure 2-2. WWTP Hourly Flow: 6/26/2013 Calibration Event

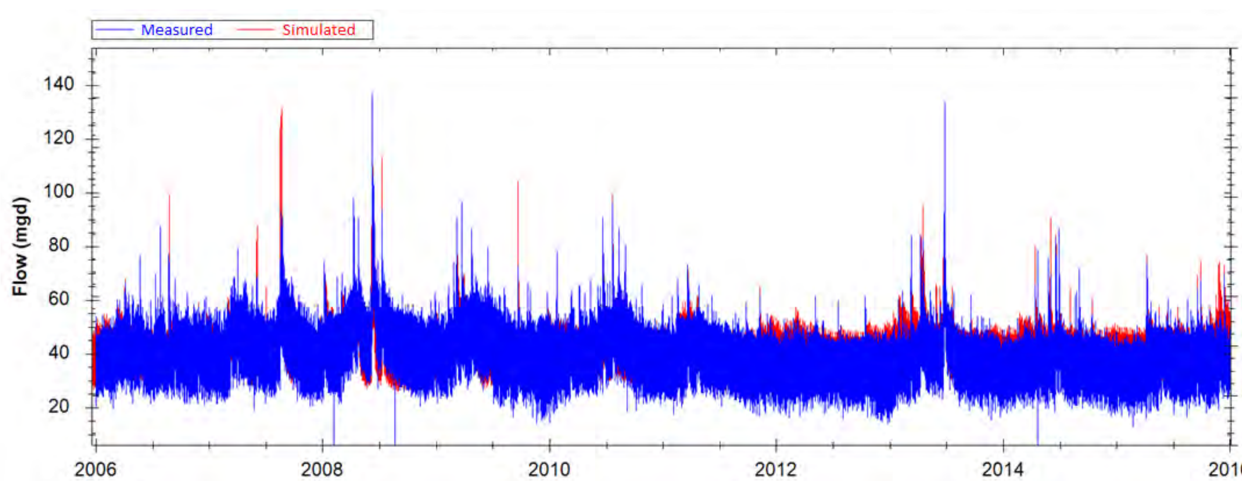

Figure 2-3. WWTP Hourly Flow: Simulated vs. Measured for the Calibration Period, 2006-2015

Figure 2-4 is a scatterplot of the simulated peak flow values vs. the measured peak flow values. This figure is a quick way to see the goodness of fit of the model for the simulated peak hourly flows. A 1:1 diagonal line on the scatterplot represents an equal match between simulated and measured values. Events above the diagonal have simulated peak flows greater than measured, and events below the line have simulated values less than measured. Additional lines on the graphs show the 10 and 20 percent error envelopes.

There are two events with simulated peak flows that were more than 20 percent greater than measured. The 8/19/2007 event was 42 percent greater than measured. Figure 2-5 shows the rainfall at four rain gauge locations for the 8/19/2007 event. In this event the rainfall recorded at the Dane County Regional Airport was approximately 60 percent greater than the average rainfall over the area (based on a comparison to daily rain totals at the UW Arboretum, Charmany Farms, and Middleton). Therefore, it is not surprising that the simulated flows are significantly greater than the measured flows in this event.

The simulated peak for the 9/22/2009 was 43 percent larger than measured. The rain distribution during the 9/22/2009 event was 36 percent greater at the Airport than the other gauge locations. As a result, the model over simulated the peak flow for this event relative to the measured value.

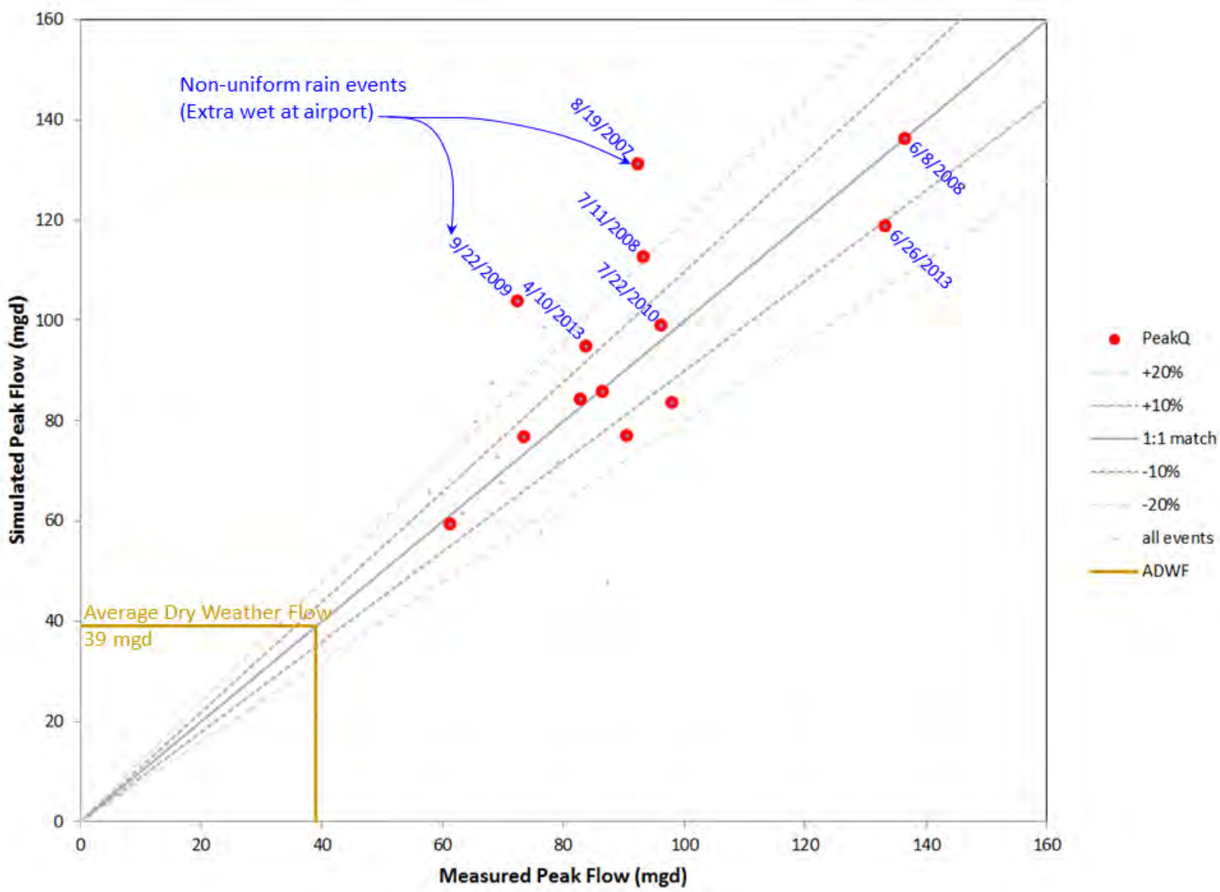

Figure 2-4. Wet Weather Peak Hourly Flow, Calibration Goodness of Fit Scatterplot

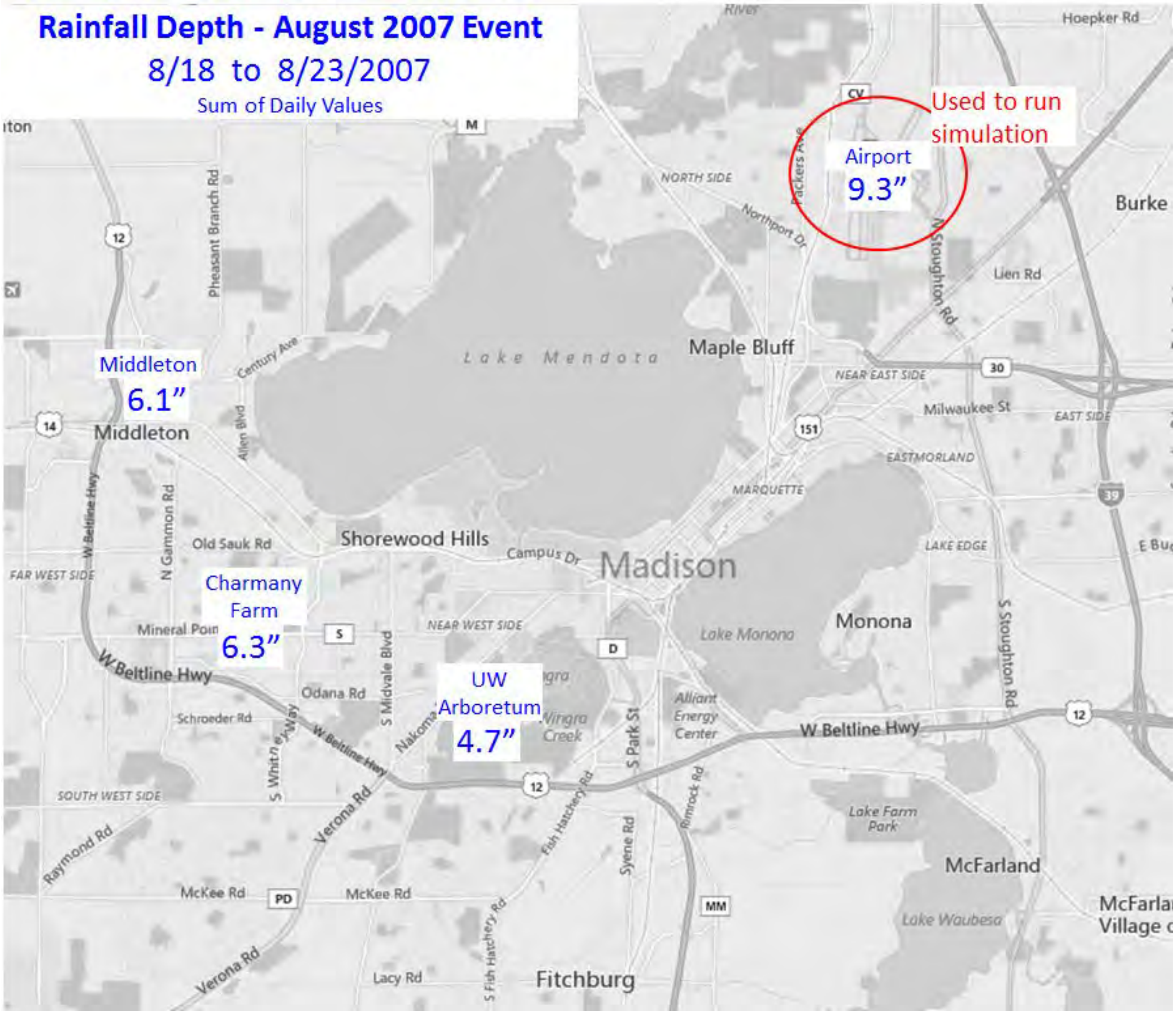

Figure 2-5. Rain Depth at Airport Relative to Other Rain Gauges in Madison, 8/19/2007 Event

Figure 2-6 is a scatterplot of the simulated and measured wet weather event volumes. All of the calibration events were within (or almost within) the ±20 percent envelope. The largest two events were within 10 percent of the measured values.

The calibration of the model is considered suitable for the evaluation of peak flows and event volumes. The next step was to use a long term rainfall record to simulate WWTP flows for several decades.

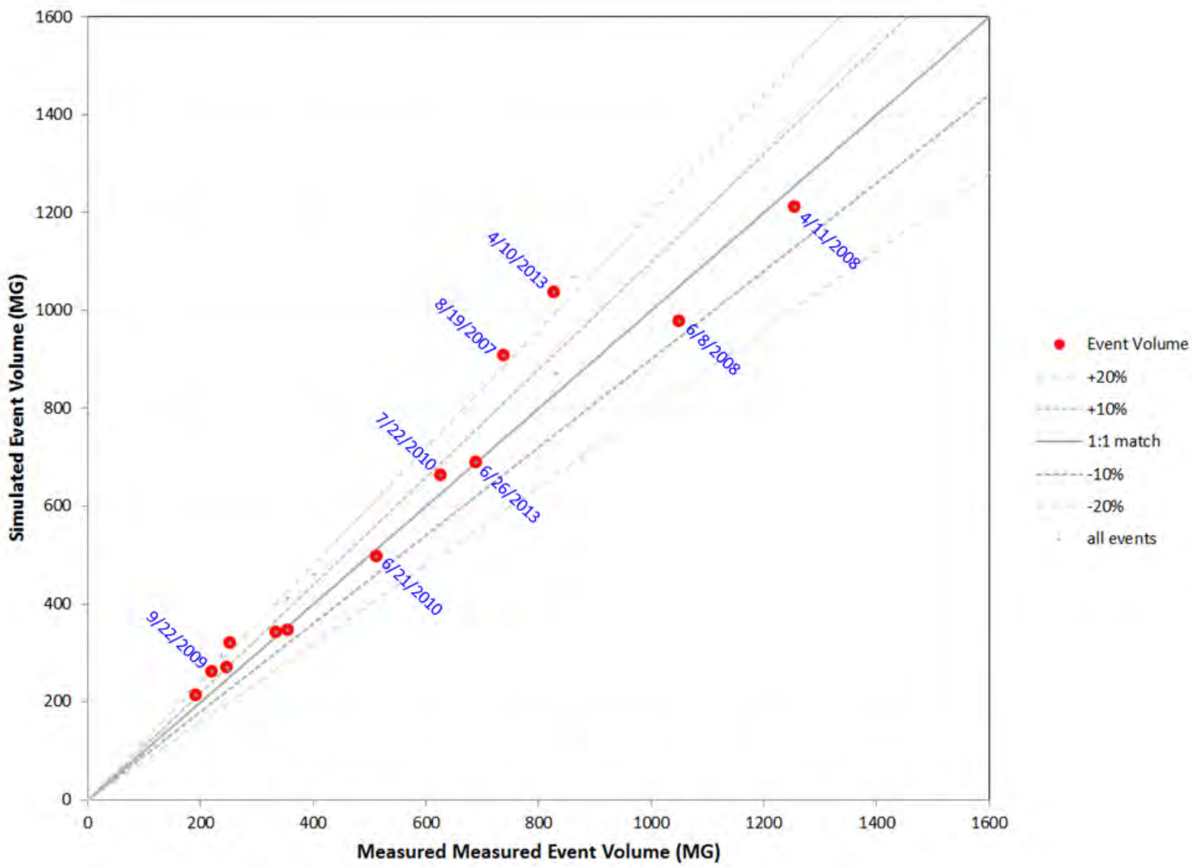

Figure 2-6. Wet Weather Event Volume, Calibration Goodness of Fit Scatterplot

Section 3: Existing Peak Flows and Storage Volumes

The level of service provided by the existing system was evaluated for peak flows and volumes. Peak influent flows were simulated using long term rainfall records to estimate the recurrence intervals associated with peak flows exceeding the unit process capacities of the existing WWTP. The frequency of events that require diversion to the lagoon were also evaluated.

3.1 Long Term Simulation

A long term simulation is not an attempt to model the historic flow record at the WWP because over time there have been many significant changes in population, development, and facilities. Instead, the long term simulation uses a long term rainfall pattern to simulate how the existing system would perform if storms like those in the record were to be experienced at this time.

A simulation was run using the 67-year Truax rain gauge record from 1949 to 2015. Figure 3-1 shows the simulated hourly flows at the WWTP. The largest simulated peak hourly flow was 141 mgd (in 1950).

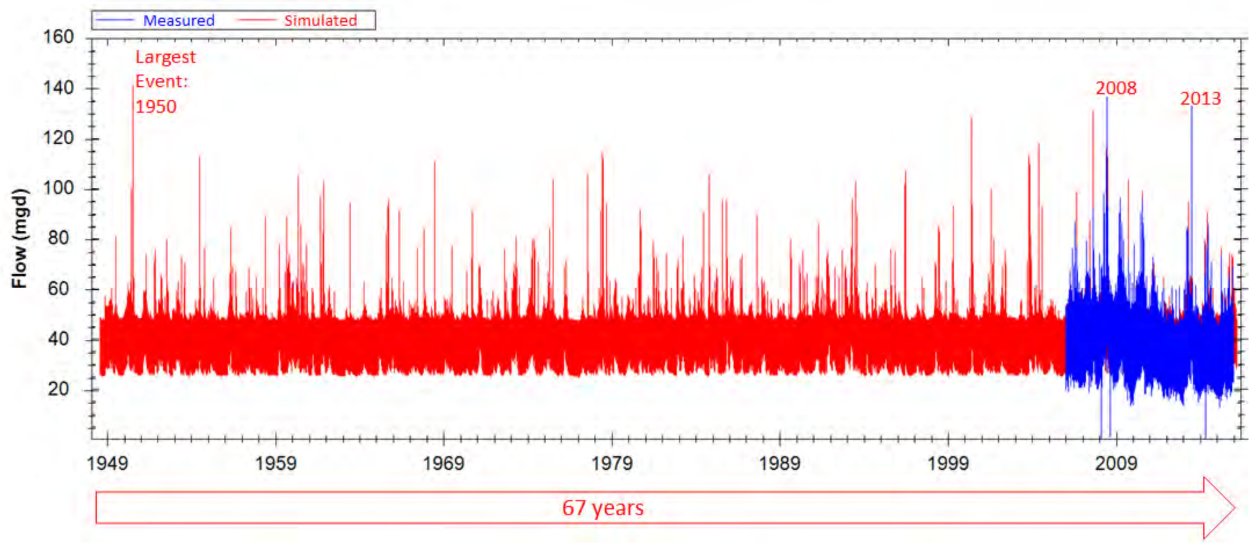

Figure 3-1. WWTP Influent Hourly Flow: Long Term Simulation for Current Conditions (2015)

3.2 Peak Flow Frequency

A flow frequency analysis of the long term simulated flows used the Log-Pearson Type III (LP3) probability distribution to fit a recurrence interval curve to the simulated data. The LP3 method is often used for quantifying the frequency of peak flows for a catchment area.

Figure 3-2 shows the recurrence interval curve for peak hourly flows at the WWTP. The two largest events in the calibration period (6/8/2008 and 6/26/2013) had measured peak hourly flows in the 130 to 140 mgd range. This corresponds to recurrence intervals in to 30 to 50-year range. The third largest event was 4/11/2008 with a peak flow of 98 mgd and a recurrence interval in the 3 to 4-year range.

Recurrence interval values should be understood to be approximate values. The concept of a recurrence interval is intended to communicate the approximate or average frequency that a particular flow rate may be experienced.

The average dry weather flow was 39 mgd. This value is marked on the figure for reference to see the increase in flow due to wet weather relative to the average flow.

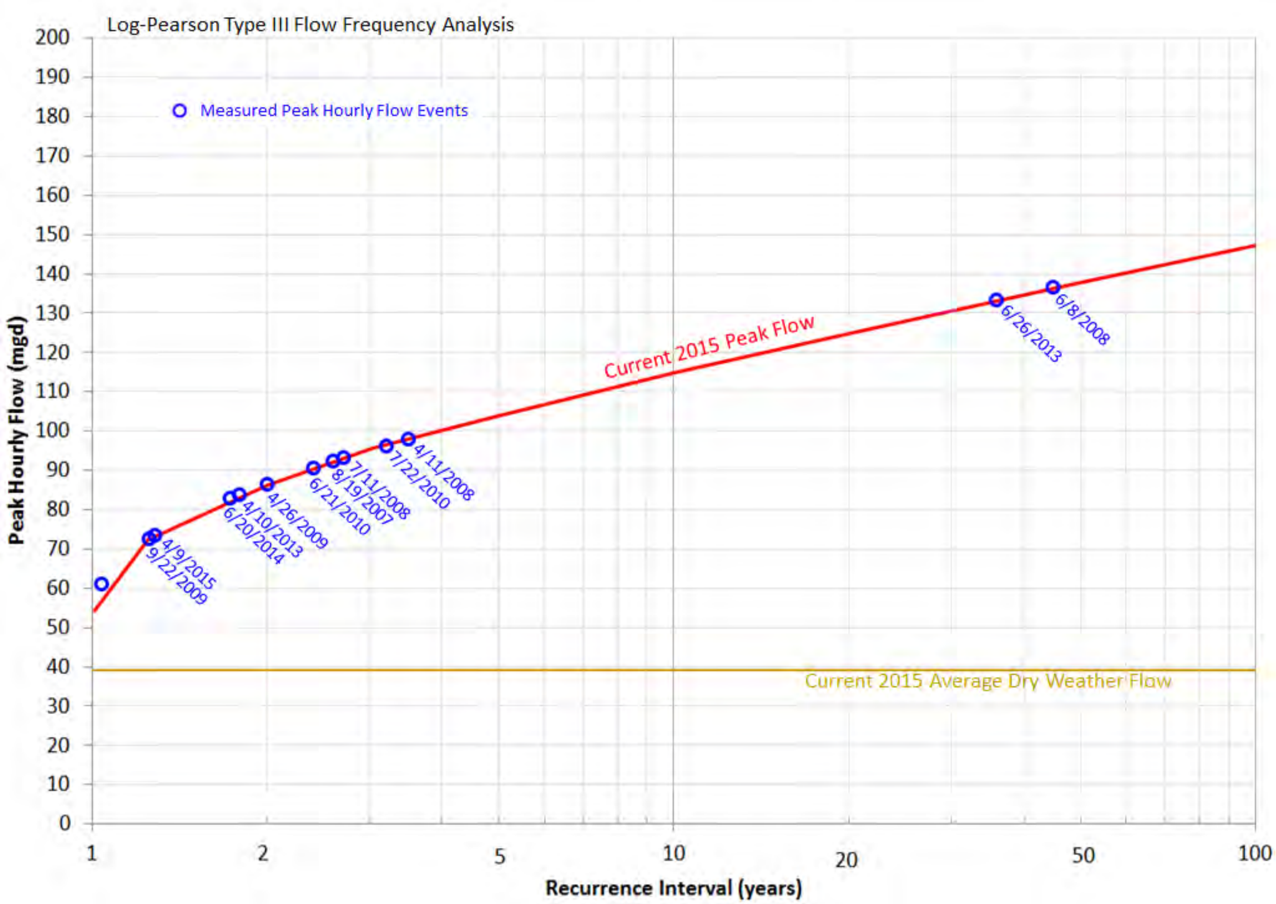

Figure 3-2. WWTP Influent Hourly Flow Recurrence Interval: Current Conditions (2015)

3.3 Hydraulic Capacity Limits and Storage Lagoon Diversions

Storage is needed when the influent flow exceeds the hydraulic capacity of the WWTP. Each of the unit processes in the WWTP has a capacity limit. These values have been documented in several previous studies. Table 3-1 is a summary of the various estimates of the capacity limits.

Table 3-1. Design/Maximum Hydraulic Capacity

Unit Process	Units	LPFP RFP	Effluent Diversion Report (2005)	Effluent Pumping Storage Report (2008)	Master Plan (2008)	Values Used in this Study
Screening	mgd	145			180	145
Grit	mgd				180	180
Primary Clarifiers	mgd				91.5	145
Entrance to Aeration	mgd	145				145
Secondary Clarifiers	mgd				189.9	190
Disinfection	mgd	100			100	100
Effluent Pumping	mgd	78	79	80	81.7	76
Storage Tanks	MG		0.65		1.3	1.3
Storage Lagoons	MG	40	55	50	66	50

Figure 3-3 is a schematic of the WWTP. The unit process capacities used for this evaluation are annotated on the schematic. The headworks group represents the unit processes upstream of the secondary clarifiers. The screens were the limiting process for the headworks with a capacity of 145 mgd. (The primary clarifiers were not considered to be the limiting process in the headworks group even though the 2008 Master Plan published a capacity of 91.5 mgd based on NR 110 rules. MMSD operations staff observations indicate that the actual hydraulic capacity of the primary clarifiers is greater. Therefore, for the purpose of this study the headworks capacity was set at 145 mgd.)

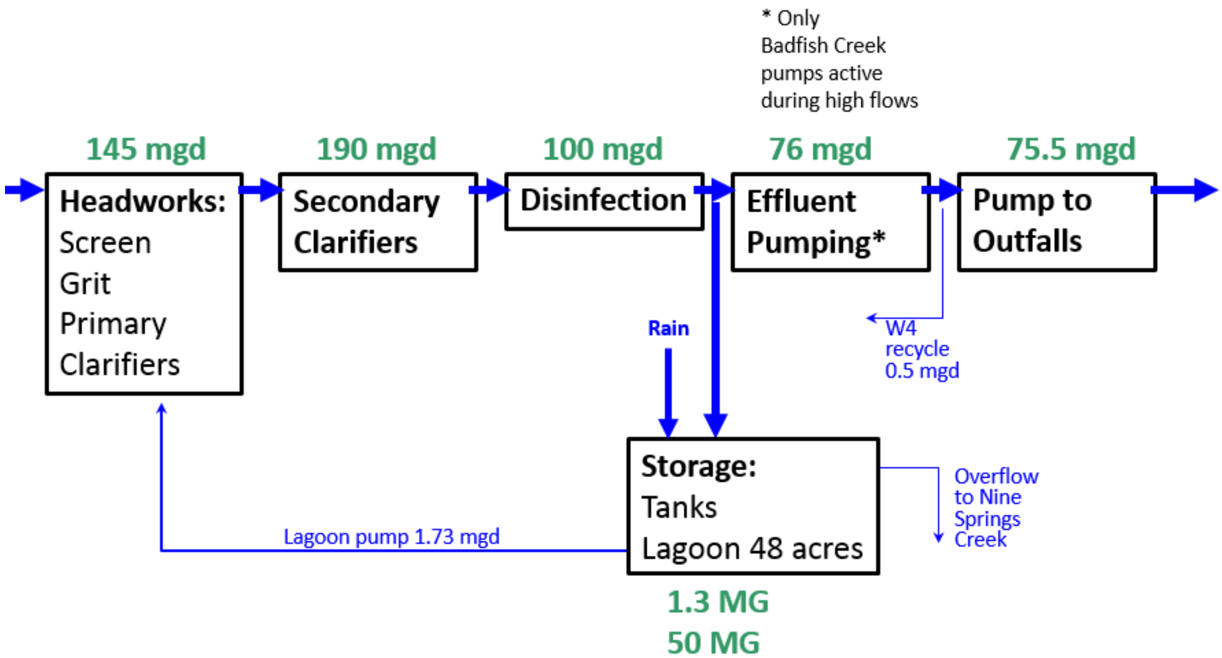

Figure 3-3. WWTP Unit Process Capacities

The effluent pumping capacity is the limiting value for the WWTP flow. Effluent can be pumped to both Badfish Creek and Badger Mill Creek. During large events the pumps to Badger Mill Creek are often turned off when the total flow in the creek is greater than 1000 cubic feet per second (cfs). This analysis assumes the pumps are only discharging to Badfish Creek. The effluent pumping limit is approximately 76 mgd based on the measured flow history. However, after the flow is measured by the effluent flow meter, a fraction of the flow is recycled to the plant. The recycle flow rate varies, but is approximately 0.5 mgd. Therefore, the net effluent to Badfish Creek is approximately 75.5 mgd. This value was used in the analysis below. Flow in excess of this limit was diverted and stored in the lagoon.

The active storage capacity of the lagoon and tanks is approximately 51 MG.

The level of service achieved by the existing system is shown in Figure 3-4 using the current peak hourly flow recurrence interval curve. The headworks capacity of 145 mgd has an approximate level of service in the 50 to 100-year range. The disinfection limit of 100 mgd has a level of service approximately equal to 4 years. The effluent pumping capacity of 75.5 mgd appears in this figure in the 1 to 2-year range, but the simulation of the diversion volumes (shown later) demonstrates that effluent pumping capacity was exceeded approximately 1 to 2 times per year.

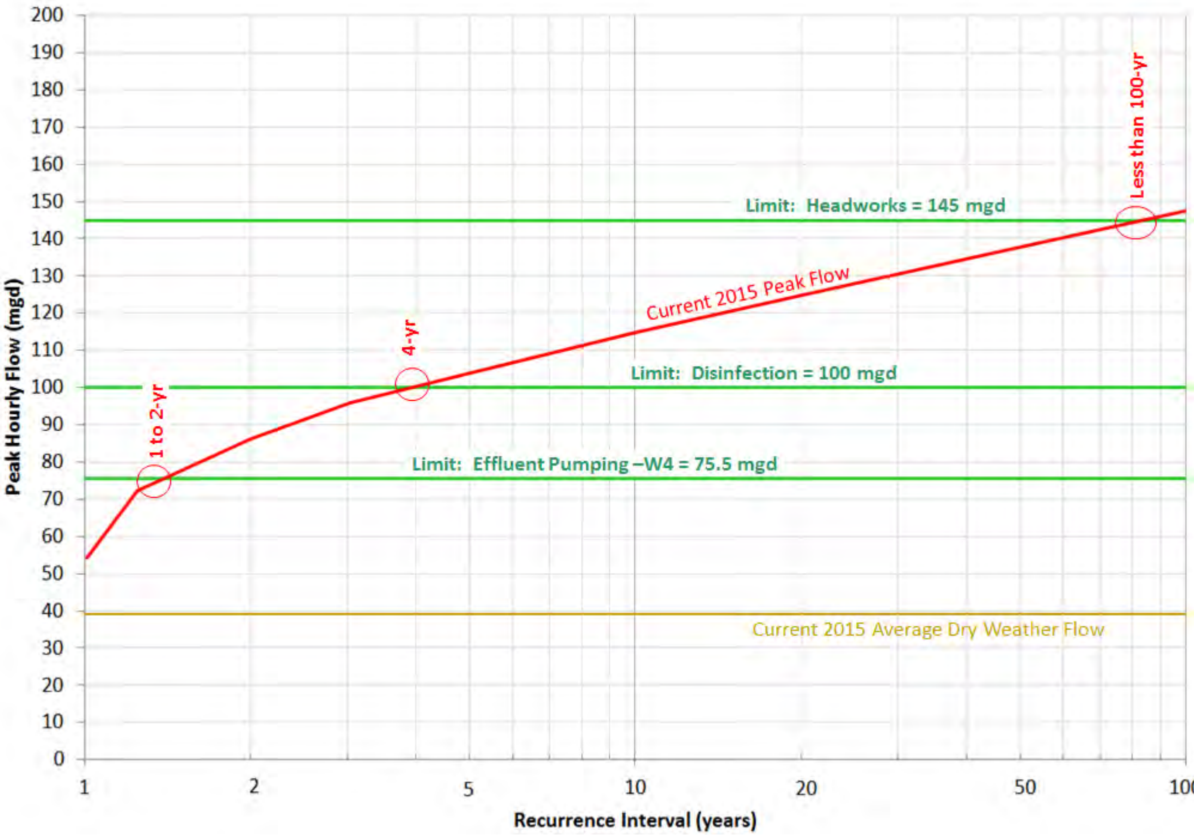

Figure 3-4. Current 2015 Level of Service

3.4 Excess Volume Diverted to the Lagoon

The long term simulation results were used to estimate the diversion volumes. A storage event was assumed to occur when the simulated flow exceeded 75.5 mgd. In this analysis the calculated diversion volume was based on the duration and magnitude of excess flow (influent – effluent). After the influent flow receded below 75.5 mgd, the lagoon was dewatered using the existing return flow pump (1.73 mgd capacity).

Rainfall collected directly on the 48-acre lagoon area can be a significant volume. A rain depth of 1 inch is equivalent to a volume of 1.3 MG. The largest rainfall event (8/19/2007) had a total rain depth of 9.3 inches. This is equivalent to 12 MG (one fourth of the lagoon volume). The calculation of diversion volumes accounts for the rain that is collected in the lagoon area.

Figure 3-5 shows the 6/8/2008 event as an example. In this case the simulated peak influent flow was 136 mgd (equal to the measured peak flow). The flow in excess of 75.5 mgd was diverted to the lagoon (with a peak diversion rate of 61 mgd). The diverted volume was 81 MG. This volume included 72 MG diverted from the WWTP and 9 MG of rain falling directly on the lagoon.

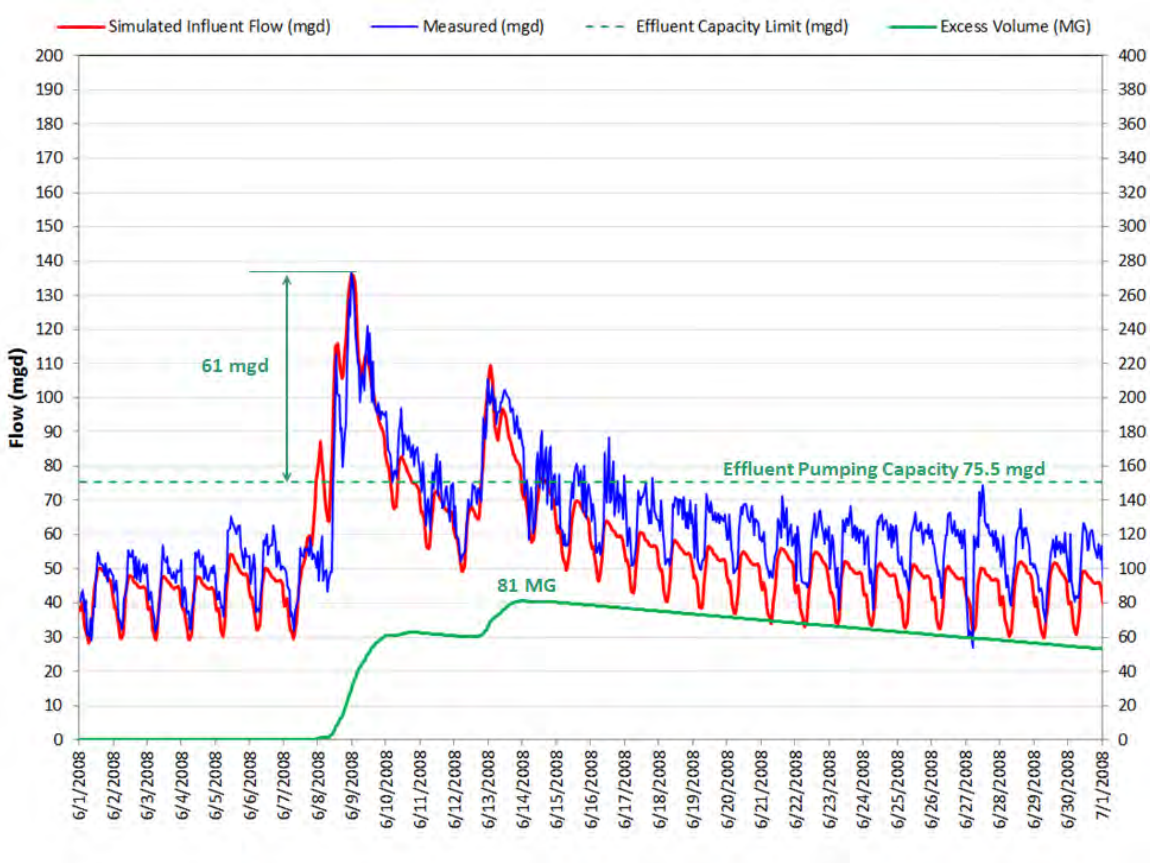

Figure 3-5. Current 2015 Effluent Pumping Limit: Lagoon Storage for the 6/8/2008 Event

Historic data for lagoon storage events are available for the 23-year period from 1993 to 2015. Figure 3-6 shows the reported volumes and the simulated volumes during this period. The simulated volumes assume a standard operating procedure for diverting and dewatering. The actual lagoon operating conditions may have been different. Therefore, differences between actual lagoon volumes and simulated volumes are to be expected. The main result of this evaluation is to observe that the model results are in the same range as the historical events overall, even if individual events are not the same.

There were 19 reported diversions in the 23-year period. This is a diversion frequency of approximately 1 event per year. The largest reported diversion was 83 MG in the 6/8/2008 event. This is greater than the maximum volume of the lagoon, so this event caused an overflow to the Nine Springs Creek.

During this same period there were 38 simulated diversion events. The simulated diversion for the 6/8/2008 event was 81 MG, which is almost equal to the reported volume.

In some events the simulated volumes were significantly greater than the reported volumes. The largest simulated diversion was 104 MG in the 8/19/2007 event (as noted earlier, the model over predicts this event because the rainfall at the Airport was greater than the average rainfall over the service area).

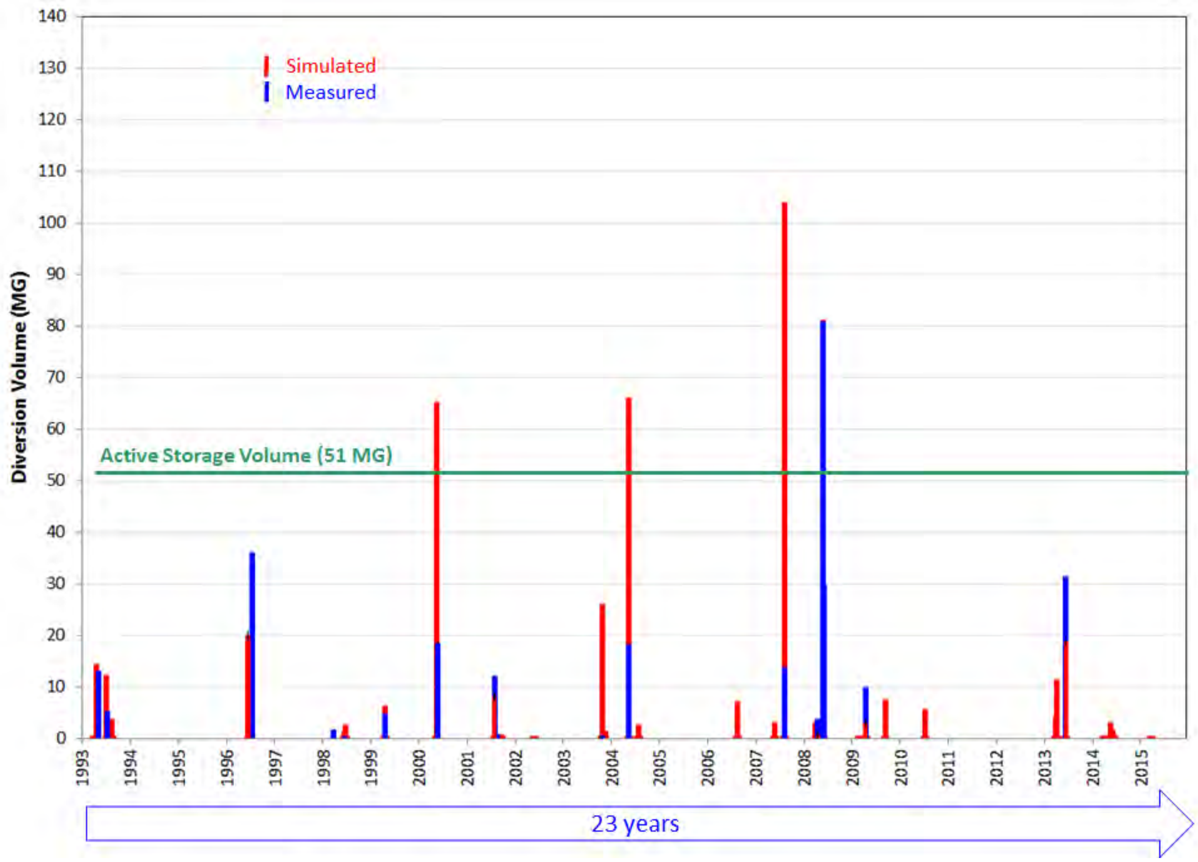

Figure 3-6. Reported and Simulated Diversion Volume: 1993 to 2015

Figure 3-7 shows the long term simulation results for hourly flow with the 75.5 mgd threshold marked in the figure. This gives an overview of the number of times the storage lagoon was used and the peak excess flow rates into the lagoon.

Figure 3-8 shows the simulated volumes diverted to the lagoon. During the 67-year simulated period there were 90 diversion events. Therefore, the frequency of events that require lagoon storage is more than one event per year. Five of the events had a volume greater than 51 MG. These events were larger than the existing lagoon capacity so the excess volume over 51 MG would overflow to the Nine Springs Creek. Five events in 67 years corresponds to a level of service in the 10 to 20-year recurrence interval range.

The model does not simulate the overflow to Nine Springs Creek. Instead, the model has an unlimited storage capacity to capture all of the flow diverted from the WWTP. As a result, the model has long dewatering times to pump the total diverted volume back to the WWTP after the simulated events.

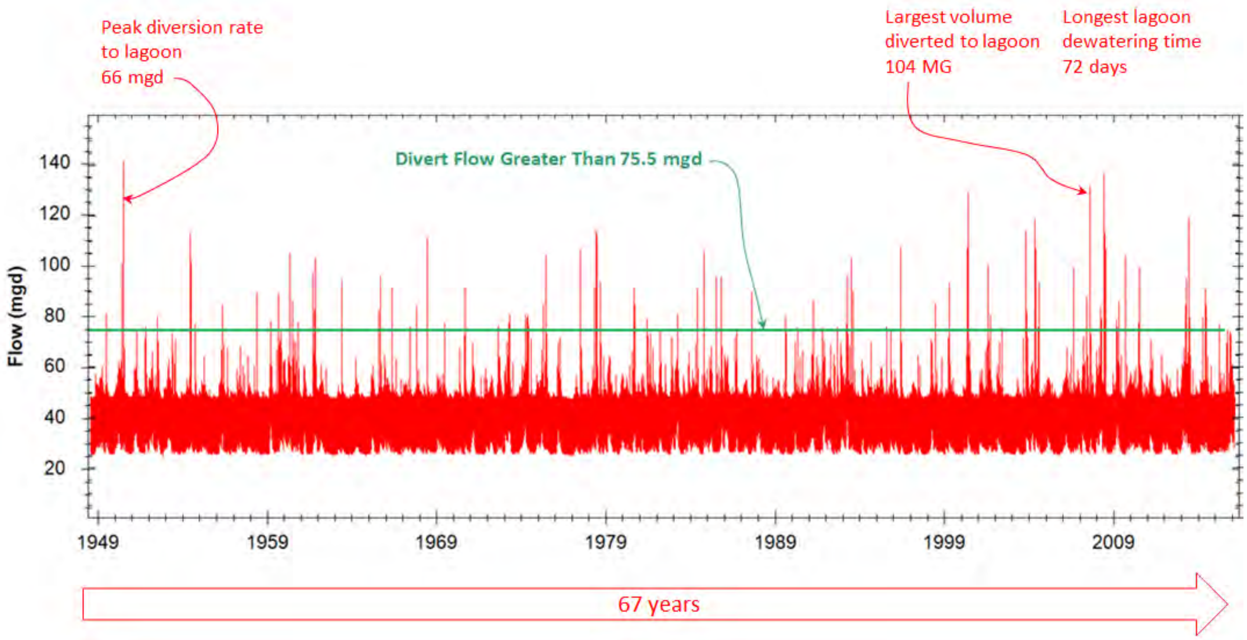

Figure 3-7. Current 2015, Simulated WWTP Influent Hourly Flow with Diversion Limit at 75.5 mgd

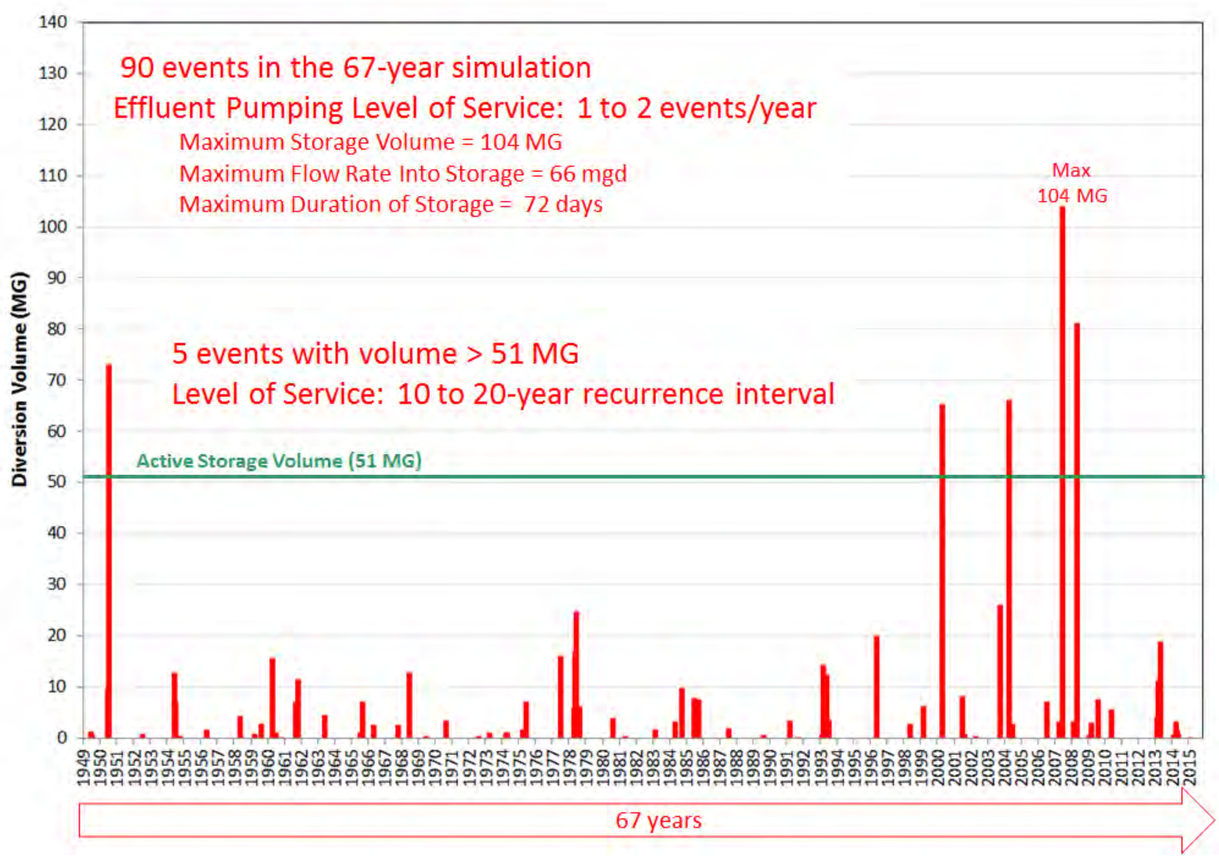

Figure 3-8. Current 2015, Simulated Diversion Volumes with Diversion Limit at 75.5 mgd

3.5 Diversion Volume Frequency

The recurrence interval of the diversion volume was estimated using a plotting position method. Figure 3-9 is a graph of diversion volumes vs. recurrence interval approximated by the Weibull plotting position. The volumes do not follow a single trend. Larger events have a higher pattern and small events have a lower pattern. This discontinuity may be due in part to the long dewatering times associated with larger events that increase the chance of having back-to-back events for which the lagoon cannot be fully dewatered between events. An approximate trend line is shown for the larger events (recurrence interval greater than 10 years).

The existing lagoon volume (51 MG) has a level of service in the 10 to 20-year recurrence interval range.

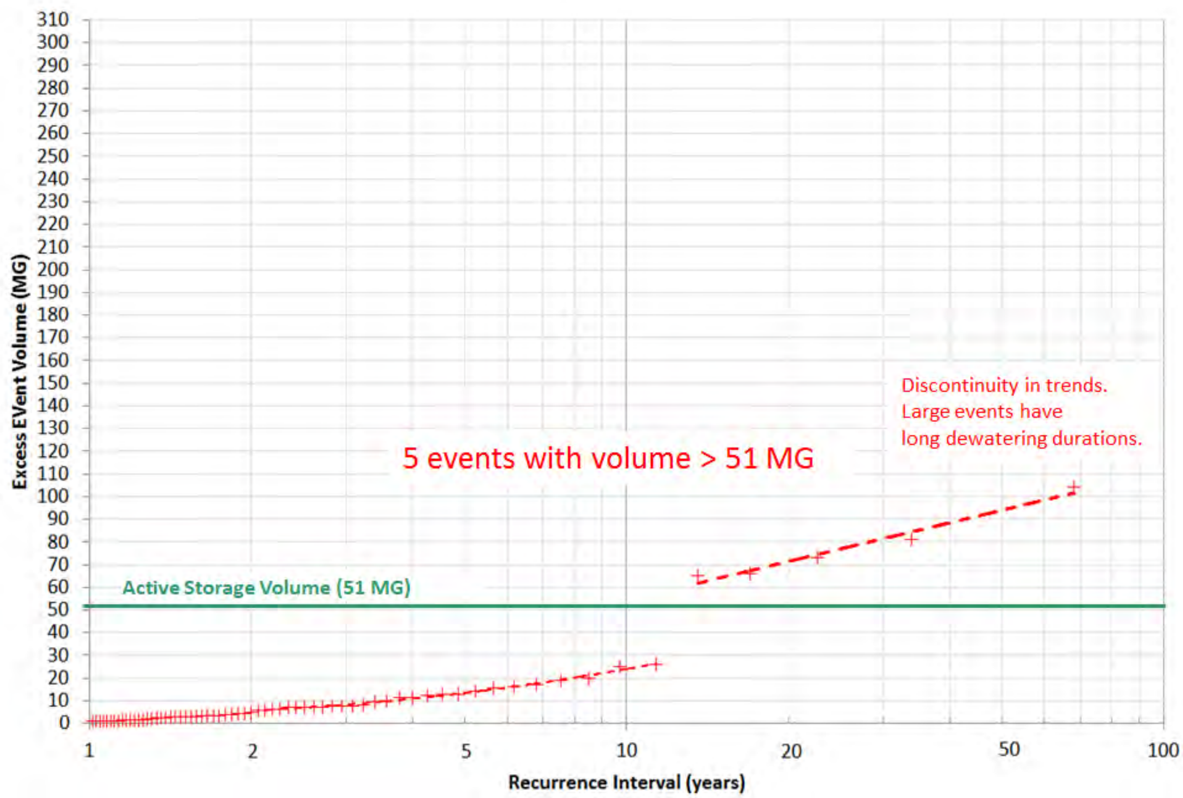

Figure 3-9. Current 2015, Simulated Diversion Volume vs Recurrence Interval

Section 4: Future 2040 Conditions

The model was used to estimate the level of service provided by the existing facilities during future 2040 flow conditions. Three existing capacity values were used: influent headworks capacity, effluent pumping capacity, and lagoon storage capacity.

4.1 Future Flow Estimates

The population of the MMSD service area is projected to increase 29 percent by 2040 based on the transportation analysis zones (TAZ) values. The TAZ values are from the 2008 CARPC Report, chapter 2, and further supplemented by email communication with Mike Simon (MMSD, 4/13/2016) and letter by Mike Ruiper (CARPC, 12/21/2015).

Per capita water use and wastewater flows have decreased in recent decades, but appear to be stabilizing with an average dry weather flow rate of 111 gallons per capita per day (gpcd) over the past 10 years, based on data provided by MMSD. Based on these trends, this analysis used future dry weather flow values that increase in proportion to the population growth. The existing average dry weather flow rate is 39.0 mgd. The future 2040 average dry weather flow rate is 50.5 mgd.

Wet weather flows depend on the RDII characteristics of the existing system and any future extensions of the system. Natural degradation over time will cause the RDII to increase in the future. New sewers in future development areas are likely to have lower RDII rates at first, but even these areas will experience degradation. Rehabilitation can mitigate the degradation if a rigorous rehabilitation program is implemented.

In this evaluation two cases were evaluated for future RDII rates. In the first case, the future RDII rates increase in proportion to the population growth (29 percent). This assumes that ongoing system rehabilitation is successful in maintaining the current RDII rates in the existing system and that future developments will have RDII rates similar to the existing system.

In the second case the future RDII rates were assumed to increase 15 percent. In this case, the RDII rates of the growth areas will need to be significantly lower than the current rates, or additional rehabilitation will be required in the current system to not just mitigate degradation, but to lower the overall rate.

For both the 29 percent and 15 percent RDII growth cases, the average dry weather flow is assumed to increase the same amount, in proportion to population growth.

4.2 Future Peak Flow Frequency

Future flows were simulated using the 67-year Truax rain gauge record from 1949 to 2015. Figure 4-1 shows the simulated flow hydrographs for the 6/8/2008 event as an example to demonstrate the increase in flows for the future conditions. In the first case, with RDII increasing 29 percent with the population growth, the peak flow was 177 mgd. In the second case, with RDII increasing 15 percent, the peak flow was 162 mgd.

The recurrence interval for peak hourly flow was estimated using the LP3 distribution. The peak flow recurrence interval curves are shown in Figure 4-2 for current and future conditions (both the 29 percent and 15 percent RDII increase cases). This figure also shows the level of service achieved by the existing facilities, when operating with future 2040 flows.

The existing headworks capacity (145 mgd) has an approximate level of service in the 50 to 100-year range for current flows. For future flows, the headworks level of service was estimated to be in the 5 to 10-year range if the RDII increases 29 percent, and in the 10 to 20-year range if the RDII increases 15 percent.

The disinfection limit of 100 mgd has a level of service approximately equal to 4 years with current flows. In the future, the disinfection limit was estimated to be exceeded once every 1 to 2 years (for both the 29 percent and 15 percent RDII cases).

The effluent pumping capacity of 75.5 mgd was exceeded more than once a year in the future flow simulation; therefore, this level of service cannot be determined from Figure 4-2. It will be discussed later in the section on diversion volume frequency.

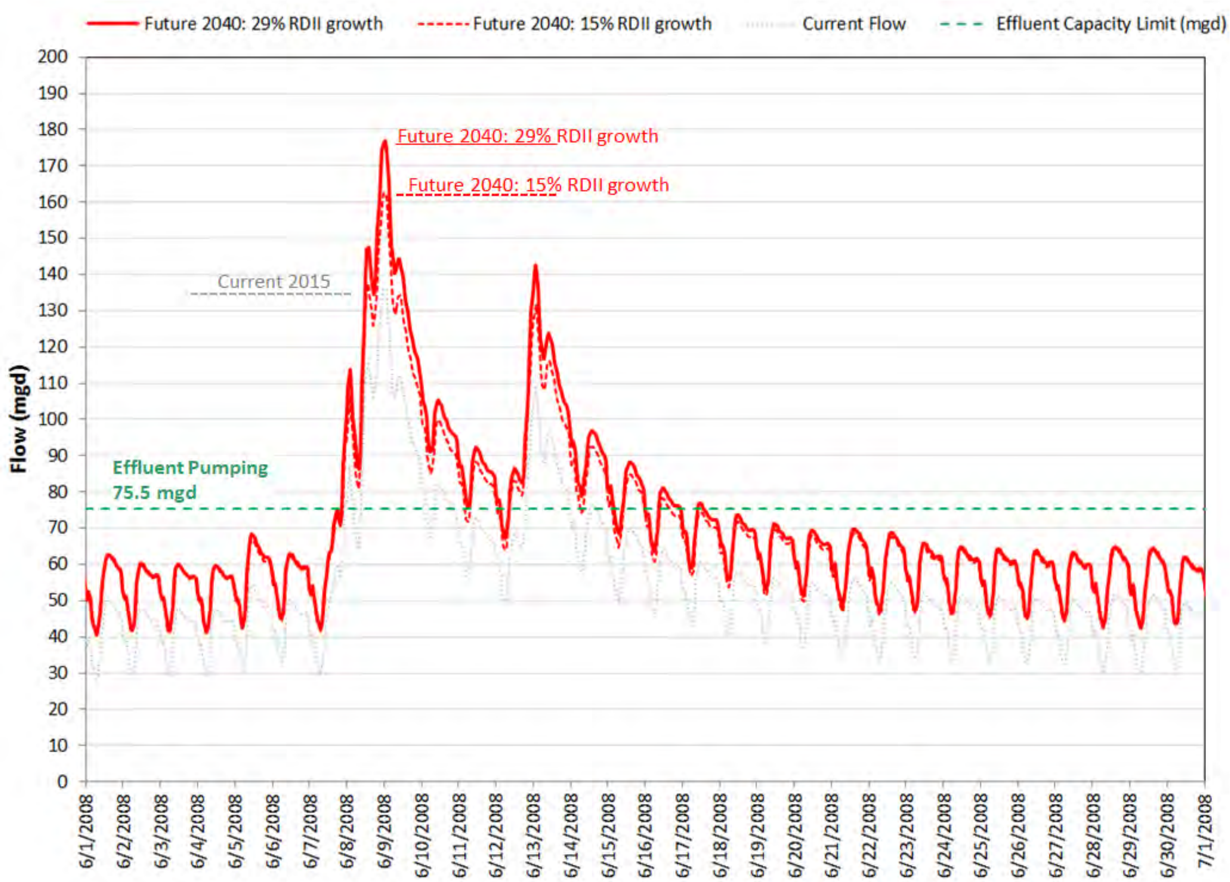

Figure 4-1. Future 2040 Flow with RDII Increased 29 percent and 15 percent, 6/8/2008 Event

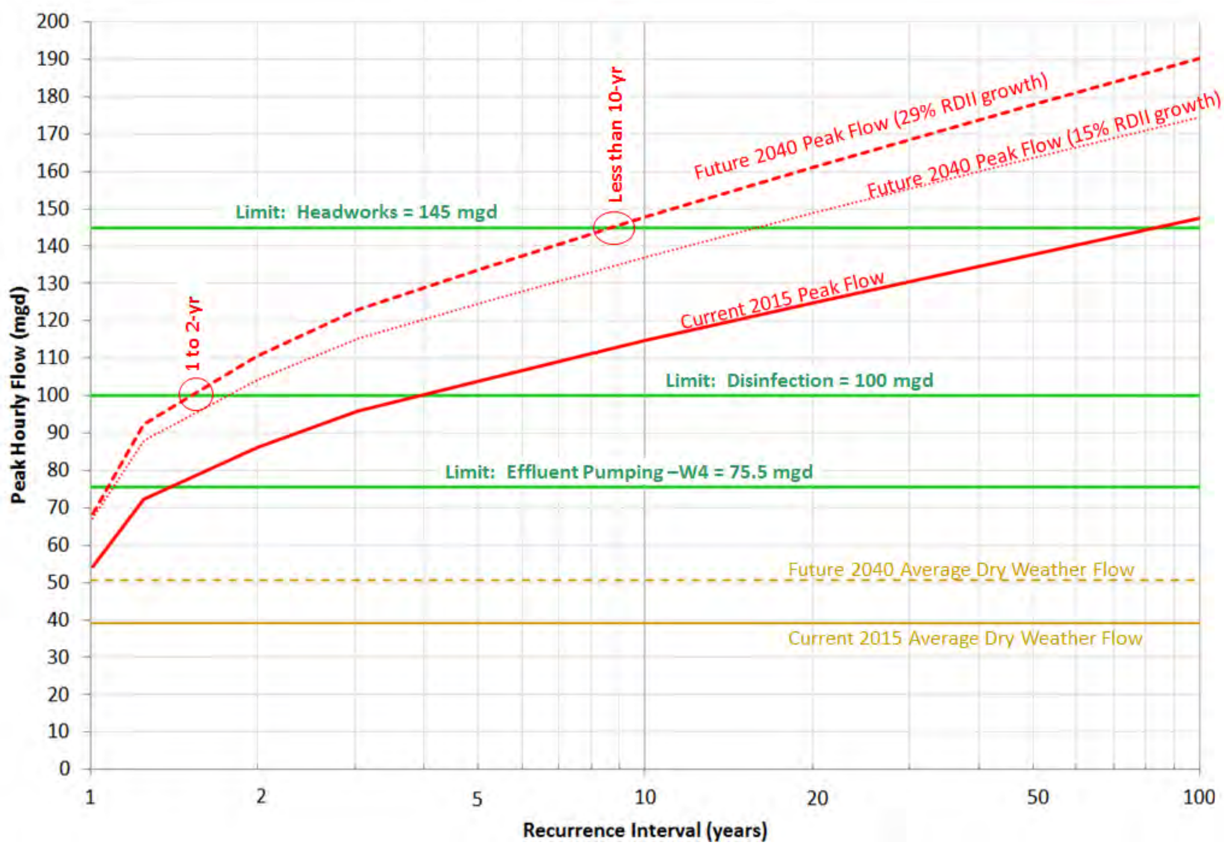

Figure 4-2. Future Peak Hourly Flow Frequency and Levels of Service

4.3 Storage for Limited Influent Headworks Capacity (145 mgd)

The headworks capacity (145 mgd) was approximately equal to the sum of the firm pump capacities before LS18 was put into service. (CARP 2009, Table 4-2: Pumping Station Capacity Evaluation).

Now with LS18 in service the sum of the influent pump capacities is greater than the headworks capacity. The sum of the firm pump capacities is approximately 211 mgd and the maximum is 223 mgd with all pumps on line (AECOM 2013, Section 13.3, p. 27).

An influent storage tank could attenuate the peak flow into the headworks to 145 mgd. In this analysis all influent flow in excess of 145 mgd was diverted to a dedicated storage tank. Figure 4-3 shows that during the 67-year simulation, there were 10 events that exceeded the 145 mgd rate. Therefore, the headworks provide a level of service in the 5 to 10-year recurrence interval range.

The largest event required 9 MG of storage. The maximum flow rate into the storage was 37 mgd. For this analysis it was assumed that the storage could be pumped out at 3 mgd so that the detention time in the tank would be approximately 3 days in the largest event. (This analysis was only performed for the future flow case with a 29 percent increase in RDII.)

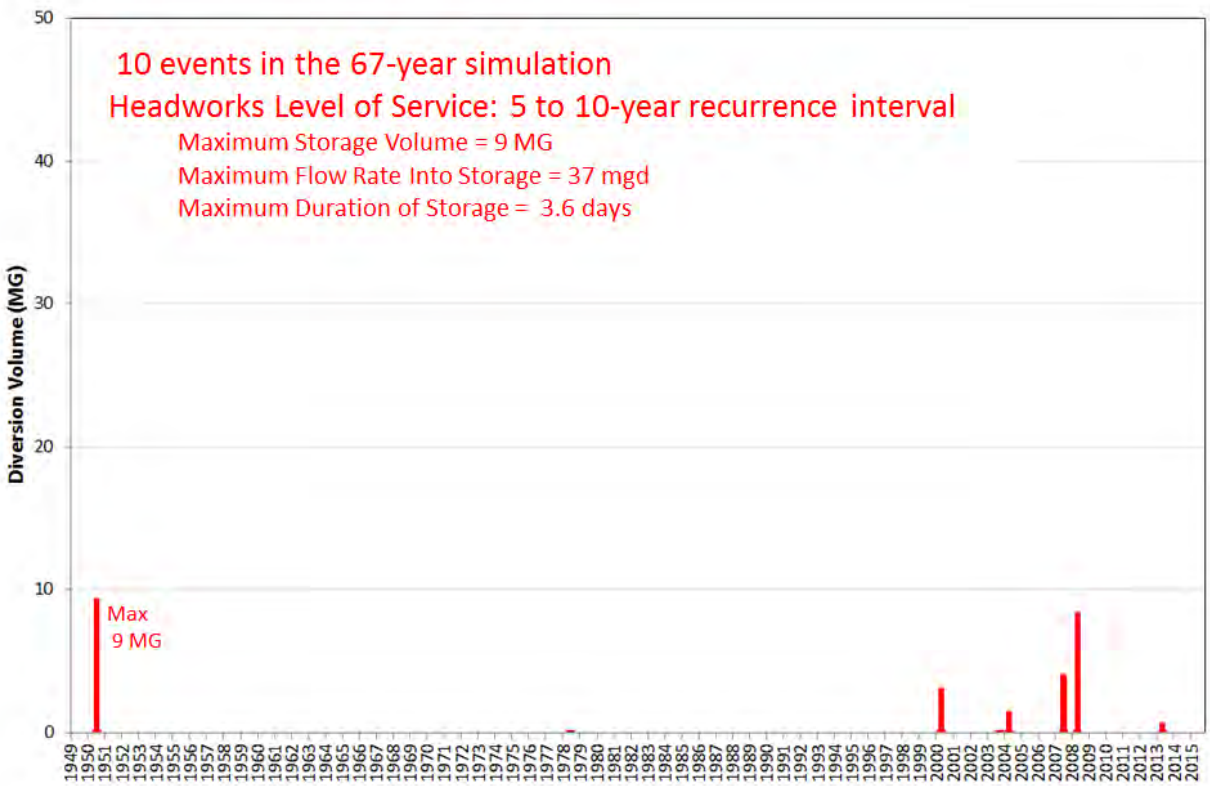

Figure 4-3. Future 20140, Simulated Storage Volumes when Influent Flow Exceeds 145 mgd

4.4 Lagoon Storage for Limited Effluent Pumping Capacity (75.5 mgd)

The level of service provided by the effluent pumps and the lagoon storage capacity was evaluated using the future 2040 flows. In this evaluation three cases were considered. The first and second cases assumed that the RDII increased 29 percent in the future, in proportion to population growth. In the third case, RDII was assumed to increase 15 percent.

In this evaluation all of the volume diverted is retained in the storage element until it can be dewatered by pumping back to the plant. (The model does not simulate the overflow to Nine Springs Creek, so this volume is not lost in the accounting.) The maximum storage volume depends to a limited degree on the lagoon dewatering rate. The existing dewatering pump has a capacity of 1.73 mgd. This pumping rate is relatively small compared to the capacity of the existing lagoon (51 MG) such that the nominal dewatering time is approximately one month. The 1.73 mgd dewatering rate was used in the first case. Because of the slow dewatering rate, there were several events in which the lagoon was only partially dewatered when a subsequent wet weather event refilled the lagoon.

In the second and third cases the lagoon was dewatered at the maximum possible rate. In these cases, whenever the influent flow rate was less than 75.5 mgd, the dewatering rate was assumed to be equal to the net available effluent pumping capacity (that is, the difference between influent flow and the full 75.5 mgd effluent capacity). Therefore, as long as there was water in the lagoon, the effluent pumps operated at 75.5 mgd until the lagoon was empty.

4.4.1 Case 1: RDII Increase 29 percent, Existing Lagoon Dewatering Pump (1.73 mgd)

Figure 4-4 shows volume diverted during the 6/8/2008 event. The simulated diversion volume was 236 MG. Dewatering using the existing pump took 186 days because there were five inches of additional rain on 7/11/2008 that increased the stored volume to a maximum of 248 MG.

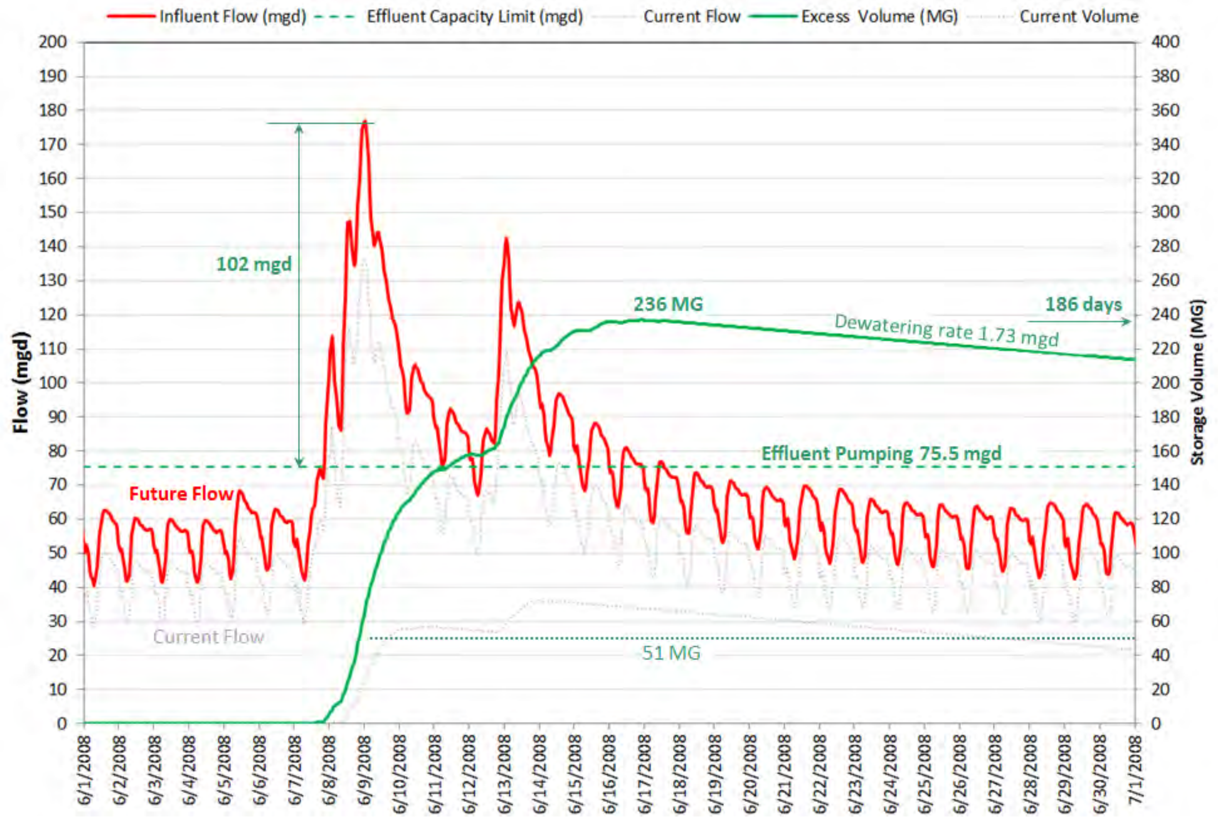

Figure 4-4. Future 2040, 29 Percent Increase in RDII (Lagoon Dewater 1.73 mgd), 6/8/2008 Event

Figure 4-5 shows the 236 simulated storage events in the 67-year simulation period. Therefore, the peak flow in the WWTP exceeded the effluent pump capacity 4 to 5 times each year. The largest simulated volume was 305 MG.

The existing lagoon volume was exceeded 20 times in the simulation. Therefore, the level of service for the existing lagoon volume was in the 3 to 4-year recurrence interval range.

The long dewatering times in Case 1 motivated the evaluation of Case 2 to determine if the maximum storage volumes and the level of service would be substantially different if the lagoons were dewatered faster.

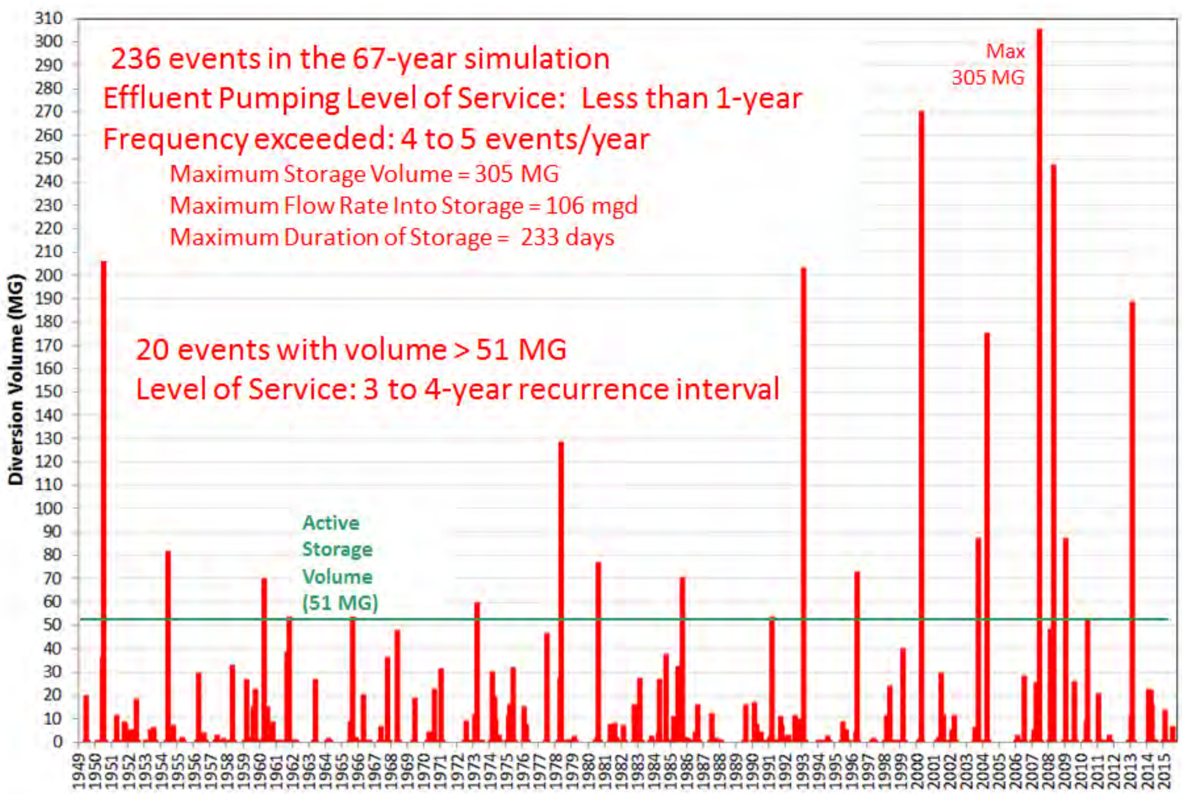

Figure 4-5. Future 2040, 29% Increase in RDII (Lagoon Dewater 1.73 mgd), Diversion Volume When Flow Exceeds 75.5 mgd

4.4.2 Case 2: RDII Increase 29%, Lagoon Dewatering at Maximum Possible Rate

Case 2 assumes that the storage volume was dewatered back into the system as fast as possible. In this case the return flow pump rate was varied to take advantage of the full effluent pumping capacity (75.5 mgd). This freed up storage volume for subsequent wet weather events. Actual lagoon operations are not as highly optimized as this dewatering assumption. Therefore, this analysis is an idealized solution that makes maximum use of existing effluent pumping capacity (if a larger lagoon return flow pump were to be installed).

Figure 4-6 shows that in the 6/8/2008 event, the diversion volume was 234 MG. The dewatering rate varied hour by hour to make full use of the available effluent pumping capacity. As a result, the volume was dewatered in 24 days (before the next large event on 7/11/2008). In this event, the maximum diverted volume was only 2 MG less than in Case 1.

Figure 4-7 shows the diverted volumes for all of the simulation events. The largest event was 303 MG (compared to 305 MG in Case 1). Maximum dewatering time was 40 days (compared to 233 days in Case 1). The dewatering rate did not make a significant difference in the total storage volume, but it did help to reduce the dewatering time.

There were 293 diversion events, so the capacity of the effluent pumps was exceeded 4 to 5 times a year. Sixteen of the events were larger than 51 MG, so the existing lagoon volume was estimated to have a 4-year level of service.

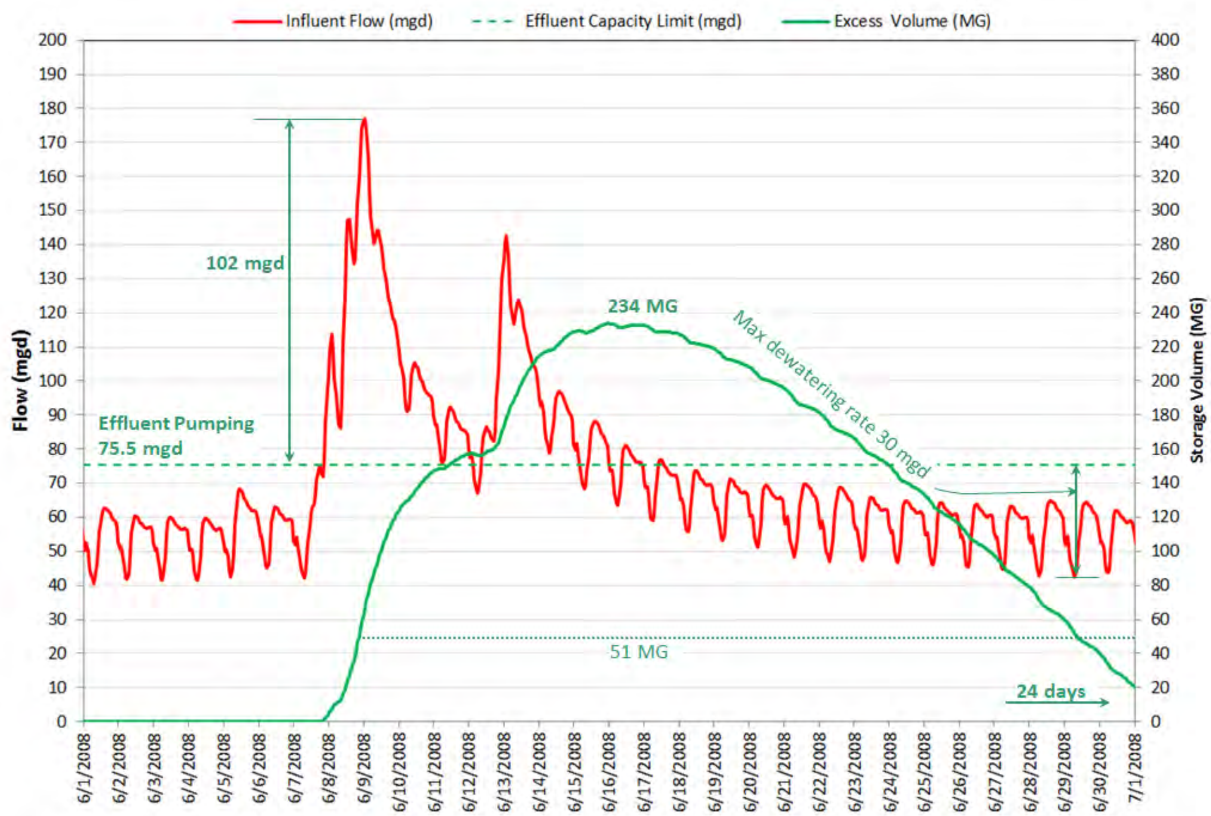

Figure 4-6. Future 2040, 29% Increase in RDII (Lagoon Dewater at Maximum Possible Rate), 6/8/2008 Event

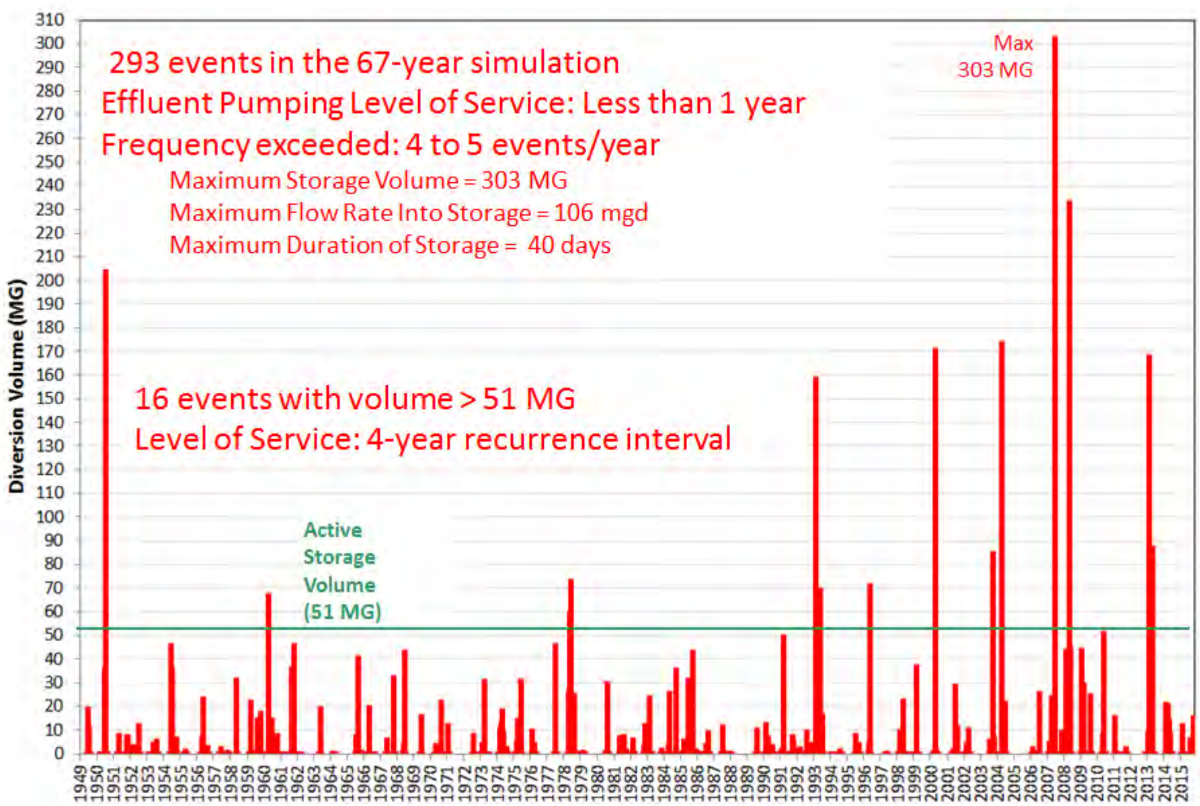

Figure 4-7. Future 2040, 29% Increase in RDII (Lagoon Dewater at Max Possible Rate), Diversion Volume When Flow Exceeds 75.5 mgd

4.4.3 Case 3: RDII Increase 15%, Lagoon Dewatering at Maximum Possible Rate

Case 3 used a 15 percent increase in the RDII for future flows. The lagoon was dewatered at the maximum possible rate. Figure 4-8 shows the 6/8/2008 event, in which the storage volume was 184 MG and the dewatering time took 21 days.

Figure 4-9 shows all of the simulated storage events. The largest event had 242 MG. The flows exceed the effluent pumping capacity approximately 4 times a year. The existing lagoon volume was estimated to have a level of service in the 5 to 6-year recurrence interval range.

The reduced RDII rate requires less storage, but the level of service provided by the existing facilities is not substantially different between the three cases. Figure 4-10 shows the storage volume recurrence intervals for all three cases. The existing lagoon volume was estimated to overflow with a frequency in the 3 to 6-year recurrence interval with future 2040 flows.

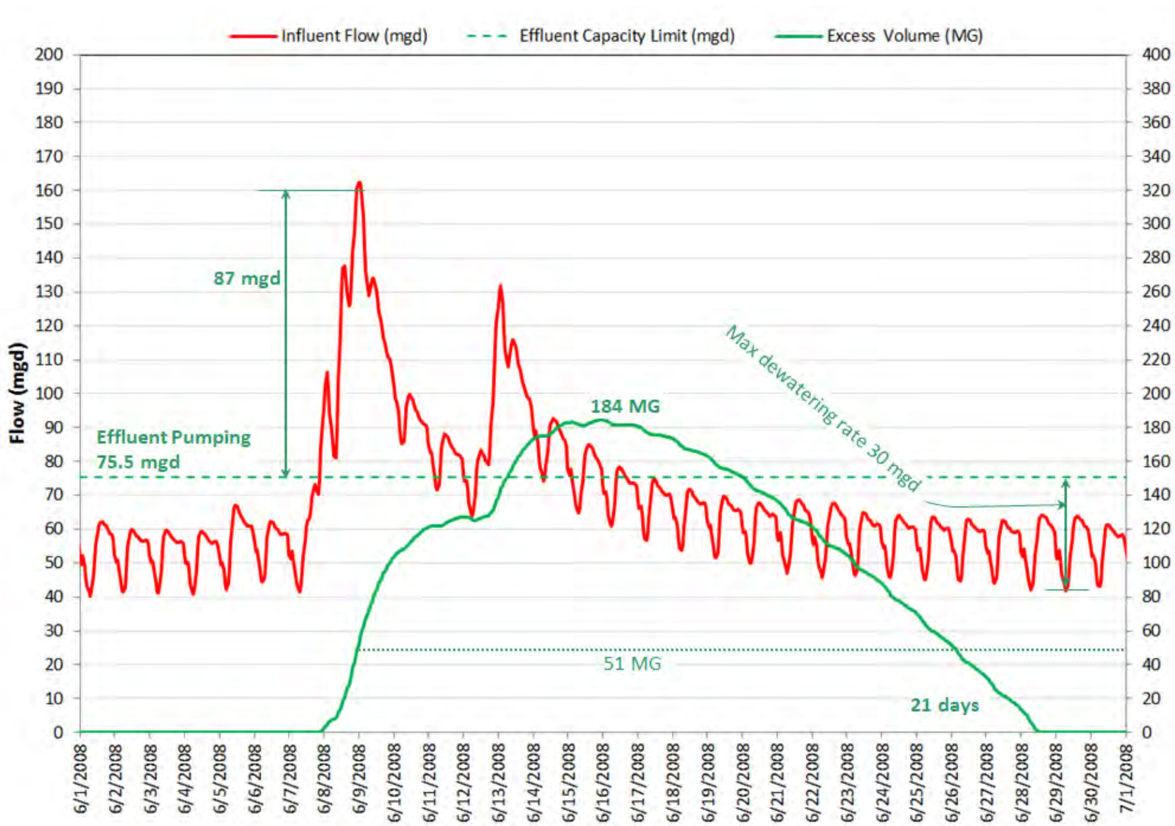

Figure 4-8. Future 2040, 15% Increase in RDII (Lagoon Dewater at Maximum Possible Rate), 6/8/2008 Event

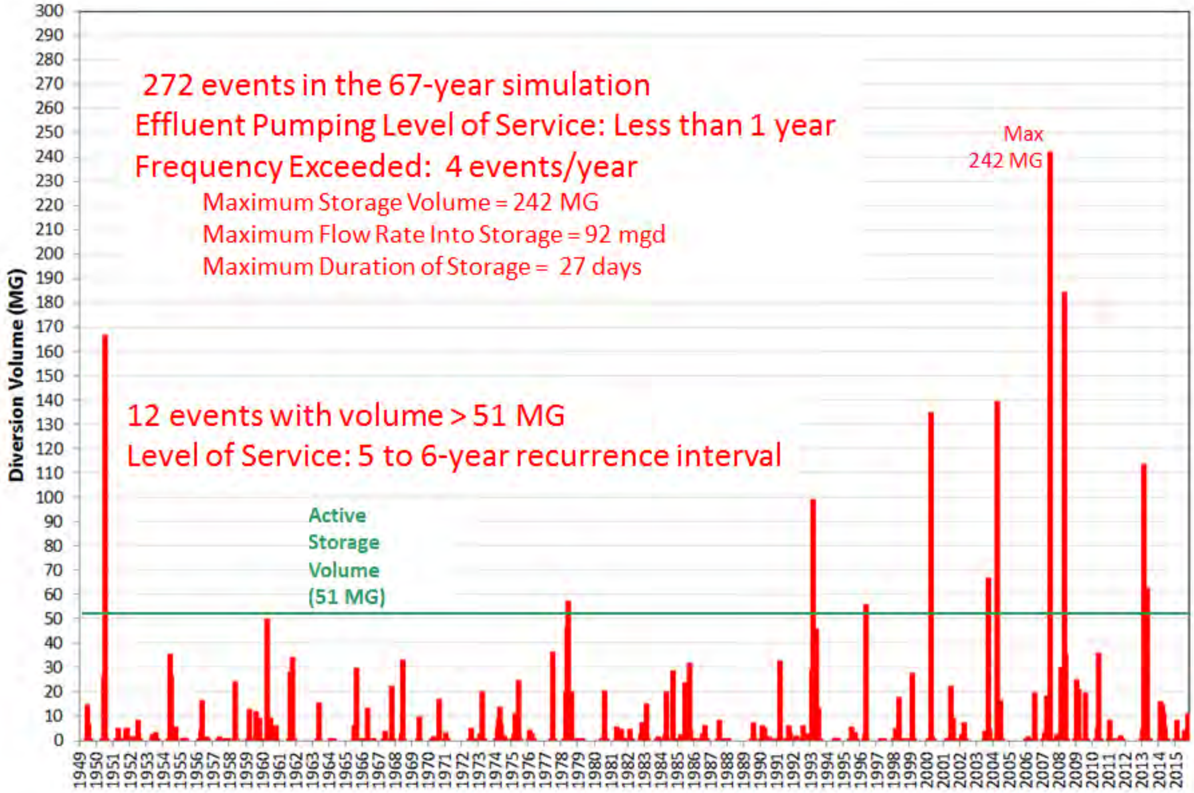

Figure 4-9. Future 2040, 15% Increase in RDII (Lagoon Dewater at Max Possible Rate), Diversion Volume When Flow Exceeds 75.5 mgd

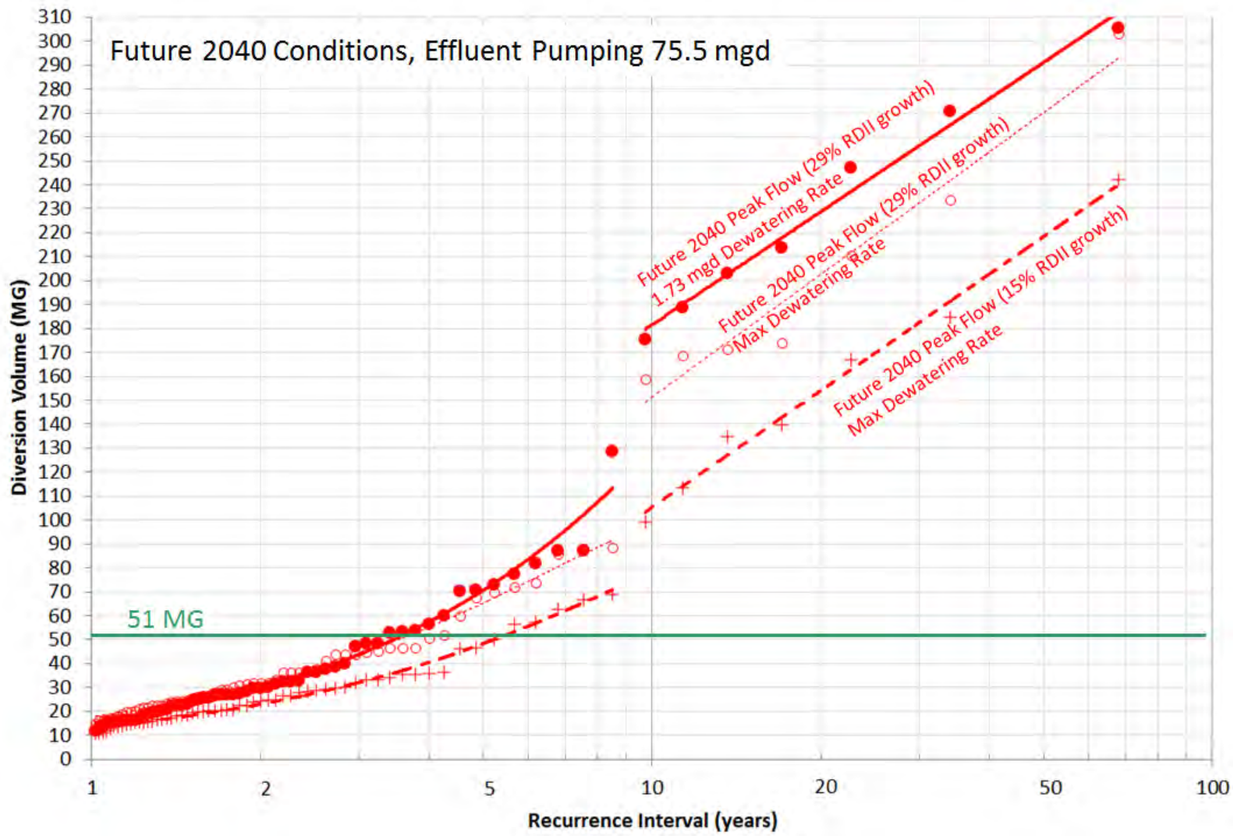

Figure 4-10. Future 2040, Simulated Diversion Volume vs Recurrence Interval, When Flow Exceeds 75.5 mgd

Section 5: Summary

The LOS provided by the Nine Spring WWTP with respect to hydraulic capacity was evaluated for current and future flow conditions. Figure 5-1 is a summary of the level of service values for the various components of the WWTP.

The headworks capacity was determined to be 145 mgd based on the hydraulic capacity of the screens and entrance channel to the aeration basins. Current (2015) flows rarely exceed the headworks capacity; the level of service is in the 50 to 100-year recurrence interval range.

The population of the service area is projected to increase 29 percent from 2015 to 2040. Future flows were also assumed to increase 29 percent by 2040. The sensitivity of future flows to the infiltration and inflow assumption was explored by evaluating a second case that assumed a 15 percent increase in RDII. This assumption makes a noticeable difference in the simulated peak flows and volumes, but the level of service provided is not significantly different in this second case compared to the first case with a 29 percent increase.

While the headworks capacity currently has a level of service in the 50 to 100-year range, future flows will increase the frequency of events that exceed the 145 mgd capacity. The future level of service will be in the 5 to 10-year recurrence interval range.

The disinfection capacity is 100 mgd. The disinfection facilities have a level of service with a 4-year recurrence interval in current conditions, and 1 to 2 years in future conditions.

Effluent pumping is limited to approximately 75.5 mgd based on the maximum discharge rate to the Badfish Creek outfall. Peak flows in the plant exceed the effluent pumping capacity approximately 1 to 2 times each year in current conditions. Future conditions are expected to exceed this capacity 3 to 5 times per year. The frequency of exceeding the effluent pumping capacity is also the frequency of diversions to the tanks and lagoon.

The storage capacity of the tanks and the lagoon is approximately 51 mg. When the volume diverted to the lagoon exceeds the storage capacity, the excess volume overflows to the Nine Springs Creek. The level of service of the existing 51 mg lagoon/storage tank volume is in the 10 to 20-year recurrence interval range for current flow conditions. In future 2040 conditions the level of service was estimated to be in the 3 to 6-year recurrence interval range.

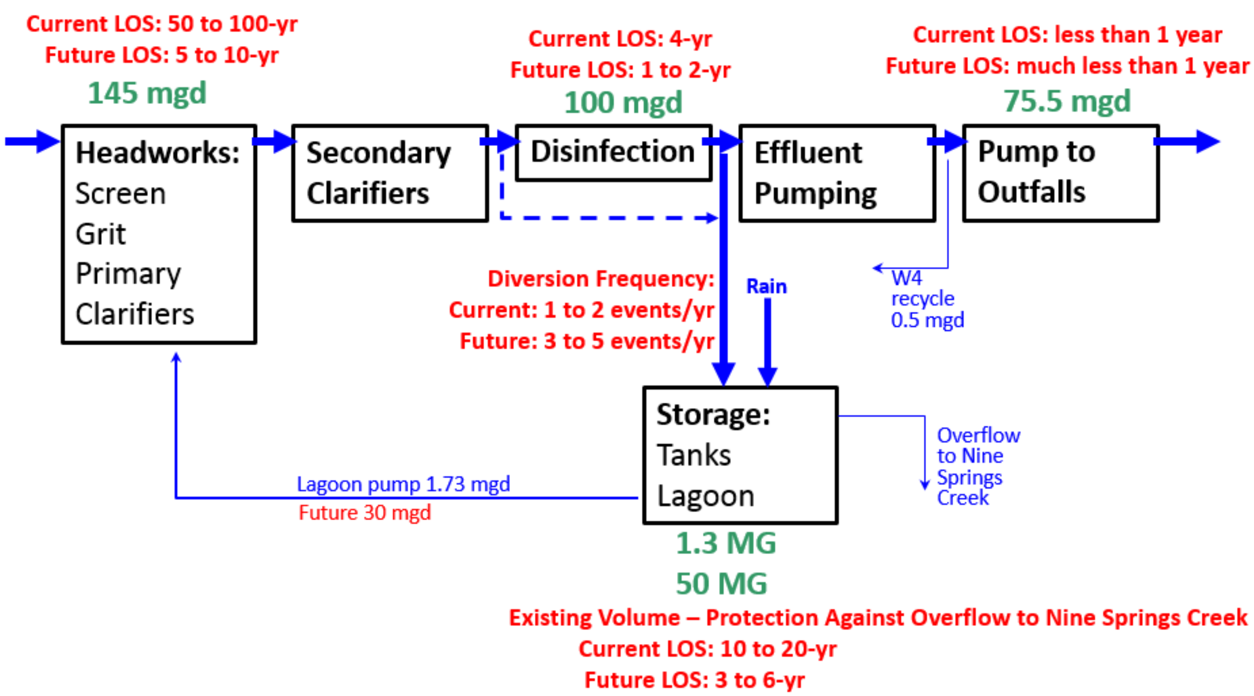

Figure 5-1. Summary of Level of Service and Frequency of Exceedance

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Attachment A: Rain Events

Rain depth-duration-frequency

There were four significant rainfall events in the calibration period. They are:

8/19/2007

6/8/2008

9/20/2009

6/26/2013

For most events, there are two graphs. The first graph shows the rainfall intensity and the cumulative rainfall depth for each event. The second graph shows the rainfall depth and duration curve plotted on the rainfall frequency curves to estimate the rainfall recurrence interval.

The 2007 and 2009 events are summarized using maps of rain event total depth based on daily values at four rain gauge locations. These maps show the spatial variability of rainfall during the events.

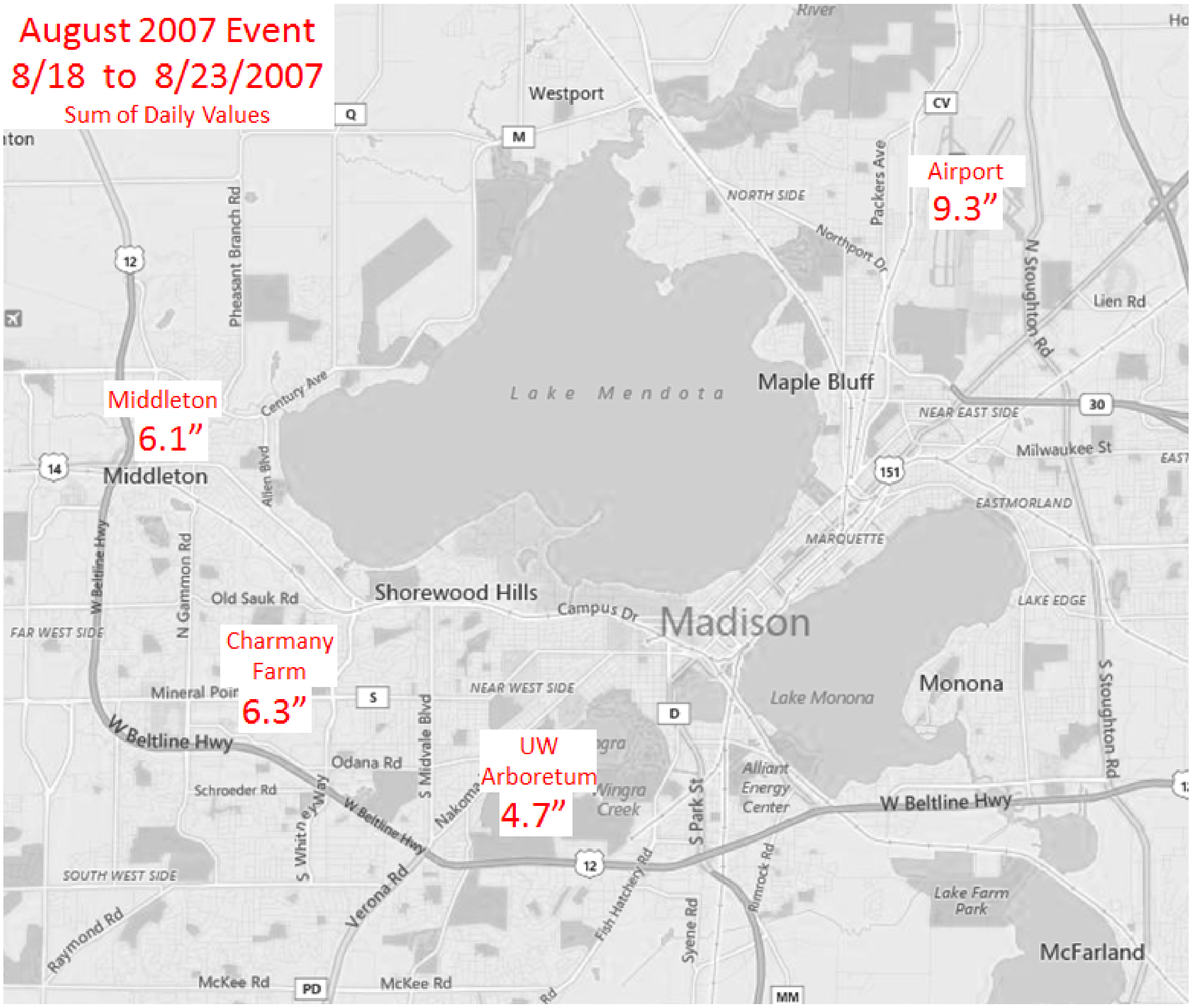

Figure A-1. Sum of Daily Rainfall Values at Four Locations, 8/19/2007 Event

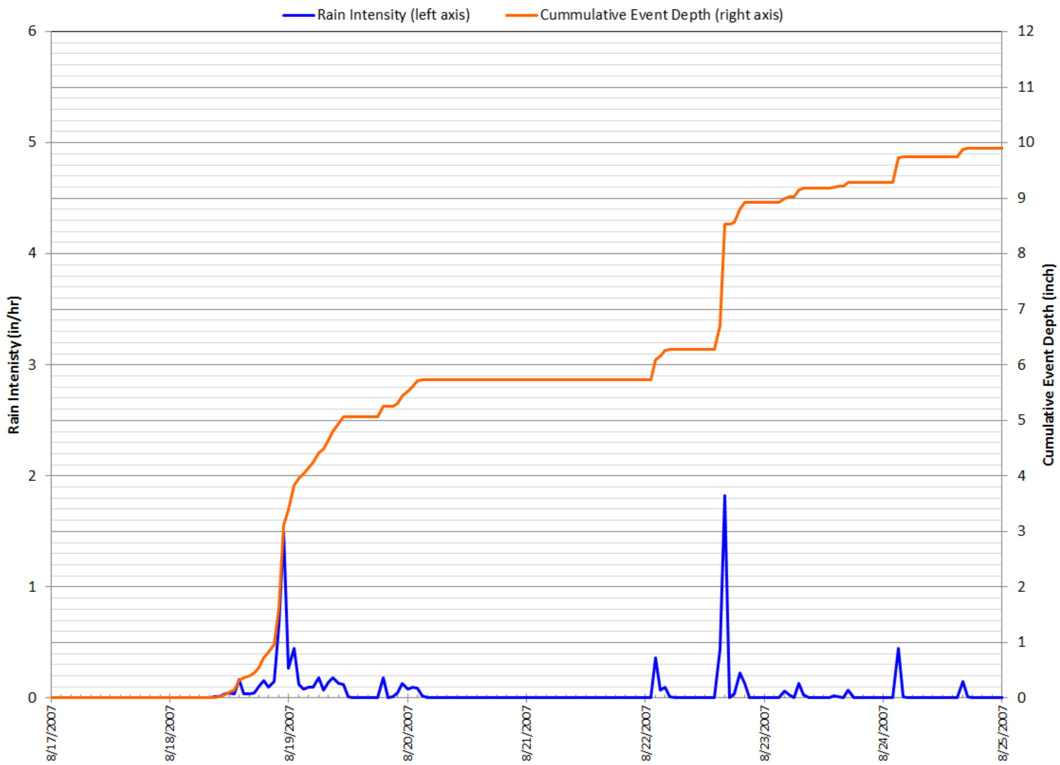

Figure A-2. Rainfall Intensity and Event Depth,8/19/2007 Event

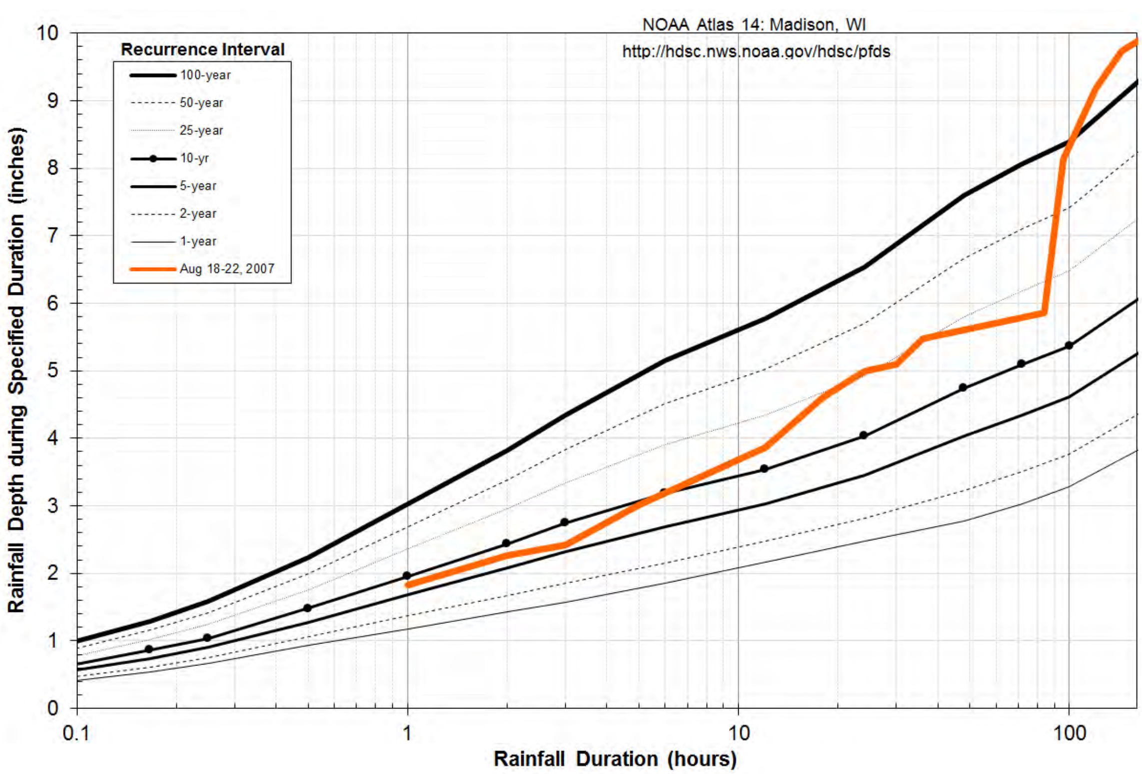

Figure A-3. Rainfall Depth-Duration-Frequency, 8/19/2007 Event

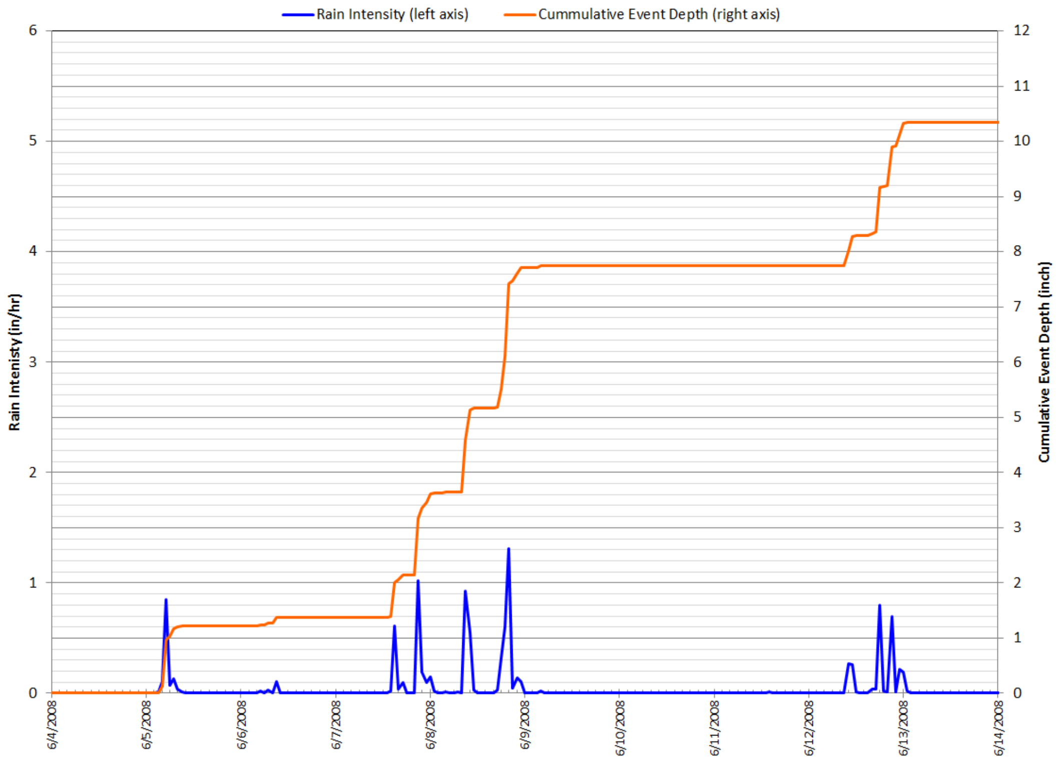

Figure A-4. Rainfall Intensity and Event Depth, 6/8/2008 Event

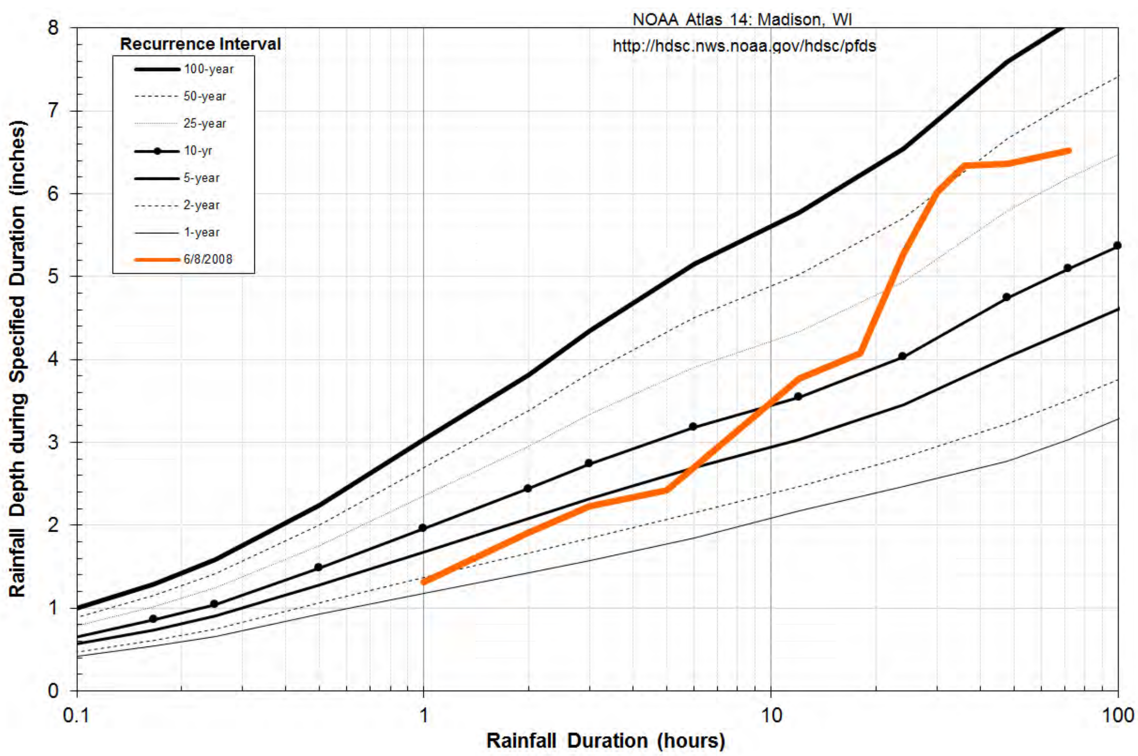

Figure A-5. Rainfall Depth-Duration-Frequency, 6/8/2008 Event

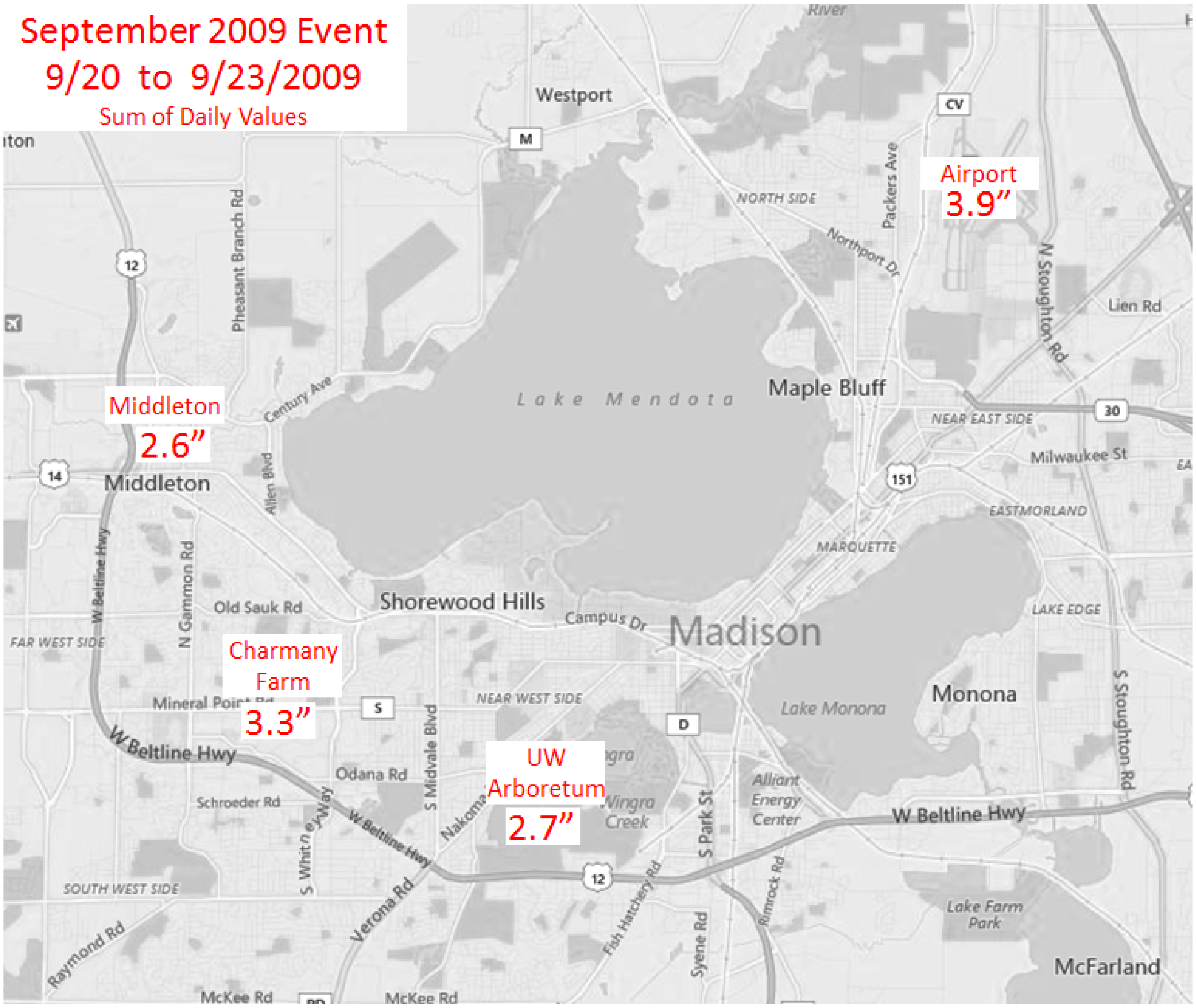

Figure A-6. Sum of Daily Rainfall Values at Four Locations, 9/20/2009 Event

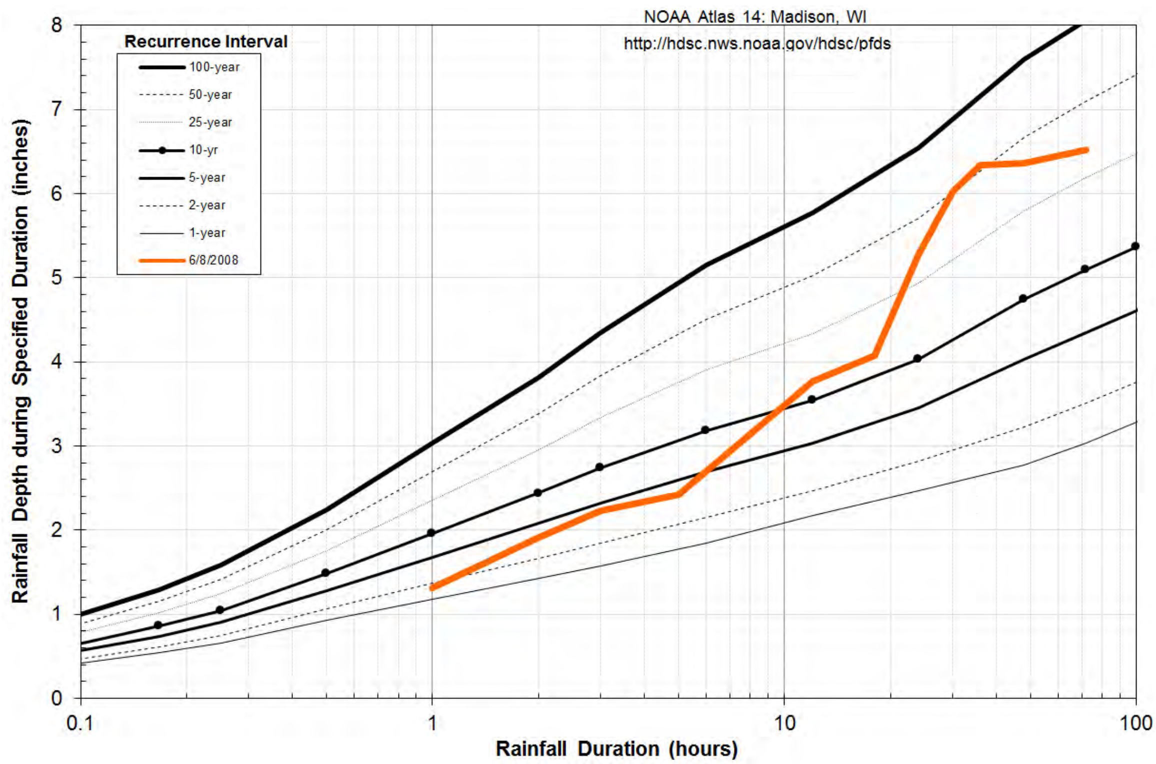

Figure A-7. Rainfall Depth-Duration-Frequency, 6/26/2013 Event

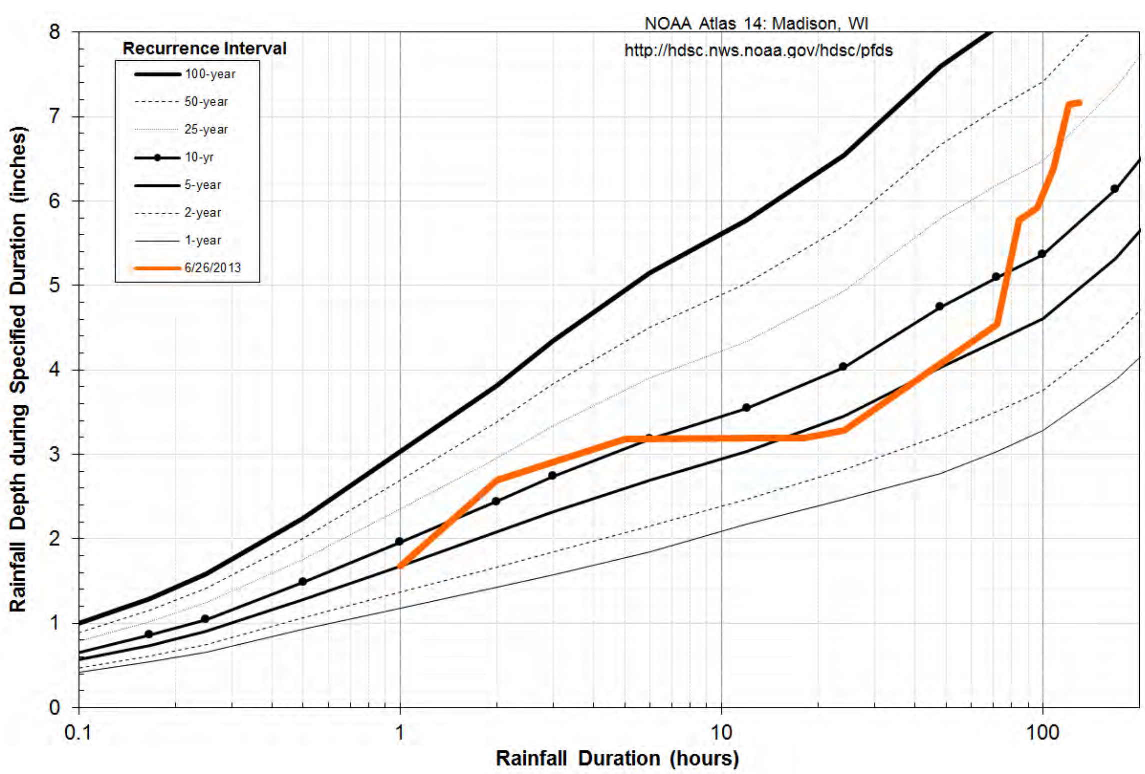

Figure A-8. Rainfall Depth-Duration-Frequency, 6/26/2013 Event

APPENDIX B
HYDRAULIC GRADE LINE ELEVATIONS

Nine Springs WWTP Peak Flow Hydraulics Analysis			
	TOW	Alt PF0 180 MGD TOTAL FLOW 57 MGD from East Plant to UV 80 MGD from East Plant to Lagoon 43 MGD from West Plant to UV	Alt PF7 180 MGD TOTAL FLOW 10 MGD from East Plant to UV 80 MGD from East Plant to Lagoon 90 MGD from West Plant to UV, 45 MGD BYPASS PCs
UV Channel	15.5	13.28	13.28
WS Elev in UV Influent Wet Well	16	14.07	14.07
Junction Chamber #6	17	16.03	14.15
Junction Chamber #4	20	23.34	16.80
East Final Clarifiers #1-6, Weir el 18.42	20	23.25	19.89
East Final Clarifiers #7 - 11, Weir el 17.00	20	24.03	17.13
Distribution Structure #7	20	25.02	17.49
East Aeration Basin Effluent Channel Near #1-9	22.5	25.14	21.39
East Aeration Basin #1-6, weir el 21.0	22.5	25.14	21.39
East Aeration Basin #7-9, weir el 21.0	22.5	25.14	21.39
East Aeration Basin Effluent Channel Near #10-18	23.5	27.01	18.13
East Aeration Basins #10 - 18, Weir el 21.0	22.5	27.01	21.43
East Primary Clarifier Effluent Channel	23.5	29.38	22.74
Primary Clarifier #7-16	23.5	29.72	23.08
East Primary Influent Channel	24.25	29.58	23.36
West Final Clarifier Effluent Channel	18.5	14.83	17.28
West Final Clarifier, weir el 16.90	19	16.94	17.34
West Final Clarifier Influent Box	19	17.22	18.57
West Final Clarifier Influent Channel	19	17.38	19.27
West Aeration Basin Effluent Channel	22.5	17.45	19.45
West Aeration Basin weir el 20.60	22.5	20.96	21.19
West Primary Effluent Channel	24.5	21.33	22.85
West Primary Clarifier weir el 22.90	24.5	23.02	23.17
West Primary Influent Channel	24.5	23.38	23.57
Junction Box #2	28	35.34	25.93
Junction Box #1	31	37.40	26.85
Flow Splitter East Plant Effluent Channel, weir el 27.00	31	39.08	27.71
Flow Splitter West Plant Effluent Channel, weir el 27.00	31	24.26	25.67

APPENDIX C
ALTERNATIVES SCREENING DOCUMENTS

Madison Metropolitan Sewerage District

1610 Moorland Road • Madison, WI 53713-3398 • P: (608) 222-1201 • F: (608) 222-2703

Memorandum

To: Randy Wirtz
Strand Associates

From: Jeff Klawes

Date: 21 July, 2016

Subject: LPFP Peak Flow Alternatives short list

MMSD staff have reviewed and evaluated the provided Alternatives PF1 – PF13 for Peak flow management. Please proceed with including the following for further analysis and evaluation in Technical Memorandum 4a.

Alternative PF4-Aggressive Infiltration-Inflow Removal

A comparison of the cost of I/I reduction to achieve the desired system performance goals to the cost of major system upgrades (additional treatment, storage or conveyance capacity) is desirable. A performance based cost estimation for planning level comparison, utilizing the methodology described in B&C Technical Paper, *Sustainable I/I Reduction: Planning Level Cost Estimation Using A Performance-Based Cost Function* is requested. The information required for traditional approaches to I/I reduction cost estimating, an I/I source identification program or sewer system evaluation survey, is not yet available and is outside of the scope of the Facility Plan work. It is our understanding that the Performance-Based Cost Function approach does not require identification of specific details and methods of I/I rehabilitation in order to proceed with a meaningful estimate of the relative cost effectiveness of I/I reduction efforts. In addition, the performance based approach should also be used to estimate the average annual cost of sustained I/I maintenance to keep I/I rates constant over the life of the infrastructure.

Further analysis of this alternative should include discussion of:

- Tasks and associated costs required to prepare an aggressive I/I reduction plan.
- Tasks required for implementation of an aggressive II reduction plan.
- Discussion of possible innovative I/I reduction strategies.

A goal of WS 4a was to brainstorm and consider alternatives for peak flow management that may be upstream of the WWTP, and/or possibly outside the current control of the District. Alternatives that include management strategies at District's pump stations or upstream of the WWTP, with the exception of an equalization facility immediately upstream of the WWTP, were excluded from further detailed evaluations without an amendment to the Professional Services Agreement.

Please prepare a proposed amendment to include a detailed evaluation of Alternative 4a as described above

Alternative PF6-Influent Equalization at NSWWTP

Alternative PF7- Upgrade NSWWTP Hydraulics Only

Alternative PF8-Expand Effluent Pumping Capacity

Technical Memorandum #8 of the 1994 update to the NSWWTP Facility Plan evaluates alternatives to increase the effluent force main capacity to meet peak flow conditions. It is our thinking that a review and update of that TM would be appropriate for an evaluation of Alternative 8. In addition to the effluent discharge to Badger Mill Creek, no significant changes have been made to the effluent pumping system. Utilization of the existing TM may prove to be a cost effective approach to Alternative 8 evaluation and also could provide continuity in the planning process.

Alternative PF9-Upgrade NSTWWTP Hydraulics and Increase NSC Discharges

Alternative PF10- High-rate Wet Weather Treatment at NSWWTP

Only include high-rate biological treatment processes

Criteria	SAM Category	PF1–COLLECTION SYSTEM STORAGE	PF2–SATELLITE WWTP (FULL TREATMENT)	PF3–SATELLITE WET WEATHER TREATMENT	PF4–AGGRESSIVE INFILTRATION-INFLOW REMOVAL	PF5–PUBLIC OUTREACH
Flexibility and Resiliency	***Community***	flexible,Smaller tanks as needed - put where needed	More options - caveats flexible resilient	Yes	Adds to resiliency if you have a tighter system Less flexible -	good for all alternatives
Short term Plant Hydraulics	***Community***	Add where/when needed	No	No, not fast enough	probably not	
Long Term Plant Hydraulics	***Community***	Flexible	Yes, if we can build fast enough. Probably	Probably	Maybe - unlikely	
Reliability / Risk of Failure	***Community***	Low risk of failure	Yes, but higher risk than tanks higher level of treatment	Okay - Higher risk of failure	Risk of failure is high, low reliability	
Construction feasibility	***Community***	Can build tanks but low areas - big tanks	Siting may be difficult - more so than tanks	Siting	standard rehab techniques, requires extensive planning, Difficult to coordinate	
Permit Requirements	***Community/ Environmental***	Zoning, Siting, conditional use	Zoning, Siting, use, discharge permit, possible stringent requirements	Never been done. Low quality.	Others? street opening permit requirements	
Capital and life cycle cost	***Economy***	10 MG tank, $30-50 MIL operating and maintenance costs low	Expensive $70/gal	High capital cost. High when operating but medium Life Cycle Cost	High cost, unknown investment, funding authority LCC - must maintain	
Capital needs synergy	***Community***	Won't take up space at plant	Potential use and users for effluent reuse & address new needs	Other community treatment	Synergy with other utilities	
Infrastructure traps	***Community***	Smaller - still traps can't undo - locks you into use	building new infrastructure often creates traps	Yes maybe less so than full treatment	No	
Resource recovery and effluent reuse	***Community***	No impact	May help with reuse/recovery	Negative impact little reuse potential	NA - No impact	
Compatible with existing	***Community***	Location must be compatible with existing area/location	Yes	Yes - preserves plant space	Yes	
Operational ease and staff safety	***Individual***	O&M relatively simple, cleaning - safety concern	Increased complexity of operations, more work.	Increase of staff and complexity	No impact	
Multi-governmental cooperation	*Community*	Siting e.g. soccer field, etc. Located on top	Potential to serve other communities requires permission to site	Potential to serve other communities siting and discharge issues	Requires numerous entities to cooperate - (Lots)	
Energy use impact renewables	***Environment***	Peak Capacity Pumping (peak shaving), Solar array, Community use, requires Construction Energy	Opportunity to build more efficient plan - more innovation. Requires more energy to run plant	Less ability to recover energy, energy user, ST duration use	Potential to reduce energy use	
Process waste generation	***Environment***	Bar screen - cleaning debris	Same quantity waste handling is decentralized	More-Chemical sludge	No impact	
Water conservation	***Environment***	No impact	New plant - opportunity to conserve water and reuse effluent	No impact?	reduce groundwater loss	
Downstream water quality	***Environment***	Improve if very large storage, otherwise no impact	Improved at new Plants	Probably worse	No impact	
Collection System SSOs and backups	***Environment / Community***	Could be helpful - more storage	Size to meet capacity needs	Sized to meeting capacity - should help	Helps reduce somewhat	
Intra/inter basin water transfers	***Environment***	No impact - could improve BMC	Help	Help	groundwater remains in basin	
Environmental Liabilities	***Environment***	Construction issues - potential leaks	Construction issues - potential upsets from siting and discharge	Chemical sludge, quality of effluent	None	
Greenfield Impacts	***Environment***	Would require a new site but may be able to mitigate some of it	Yes, Siting plant requires a footprint	Yes - Siting	None	
Time frame to implement	***Community***	Study and site could be lengthy, construct fairly quickly	Long time to implement 10 yrs. plus 10 - 15 yrs	10-15 years	would be very long term (20 yrs)-could start soon	
Construction impacts: air, noise, traffic	***Environment***	Lots - based on location	Lots	Lots	Low impacts	
Process public impact	***Community***	Odors - odor control needed Siting Issues (NIMBY)	Odors, discharge issues Siting (NIMBY)	Odors, discharge issues Siting (NIMBY) air permit and impact	Some impacts-public concerns, private property; requires management strategy for e.g. sump pump discharges	
MMSD Policies	***Community***				enforcement policy	
50 year Master Plan	***Community***					
Overall (Claudia's best guess)		Flexibility vs. siting issues	Timeframe/Permit	Timeframe/Permit/sludge/water quality/never been permitted	Different/Parallel Pilot Program?	
Potential action outside of LPFP		include in Master Plan; determine "most beneficial post 2030 location and acquire land"	Include in Master Plan; evaluate if future needs and partnerships may warrant		possibly partner opportunity with customer community; pilot; focus on sump pumps?	

Criteria	SAM Category	PF6–INFLUENT EQUALIZATION AT NSWWTP	PF7–UPGRADE NSWWTP HYDRAULICS ONLY	PF8–EXPAND EFFLUENT PUMPING CAPACITY	PF9–UPGRADE NSWWTP HYDRAULICS AND INCREASE NSC DISCHARGES
Flexibility and Resiliency	***Community***	resilient but not very flexible	neutral, some peak shaving.	not very flexible; would be resilient;	w/7 it allows more flexibility, e.g. peak shaving
Short term Plant Hydraulics	***Community***	Would address short term and might also address long-term	yes	yes	yes
Long Term Plant Hydraulics	***Community***		yes	yes	yes
Reliability / Risk of Failure	***Community***	very reliable and low risk of failure	some risk of failure; control is limited; introduces potential for failure due to pump failure	reliable, low risk of failure	less risk of failure
Construction feasibility	***Community***	relatively easy to build, large tank(s)	easy	constructable, in terms of modifications to the pumping system; not enough easements	easy
Permit Requirements	***Community/ Environmental***	nothing unusual	based on DNR limits; we consider NSC an outfall;	purchases; may trigger some issues with discharge permit; also requires various construction permits	based on DNR limits;
Capital and life cycle cost	***Economy***	capital high but op low	potentially moderate/ high for in-plant changes	high construction costs; plus pumping costs	potentially moderate high for in-plant changes
Capital needs synergy	***Community***	doesn't take up space @ the plant;	yes	potentially yes in the very long term	yes
Infrastructure traps	***Community***	no	low	low; requires more pumping of effluent away from plant.	low
Resource recovery and effluent reuse	***Community***	not impacted	n/a	no effect	n/a
Compatible with existing	***Community***	this siting would be much easier than PF1	yes	yes	yes
Operational ease and staff safety	***Individual***	general ease of operation, some concern related to staff safety for cleaning etc.	positive impact	positive impact; operational ease for pipe maintenance	positive impact
Multi-governmental cooperation	*Community*	no negative impacts anticipated	neutral	required due to pipe routing	neutral
Energy use impact renewables	***Environment***	re-pumping is required, possible peak shaving	more energy for pumping from lagoons	likely increase energy use	decrease in pumping requirement
Process waste generation	***Environment***	need to do something with the solids that get accumulated	neutral	none	neutral
Water conservation	***Environment***	n/a	neutral	neutral	neutral
Downstream water quality	***Environment***	if built at 10 "status quo" at 230 mpg would be improved	maintain as is	potential for reduced water quality	will be more discharge and impact phospherous content in downstream water body
Collection System SSOs and backups	***Environment / Community***	Should help as the pumping can be managed;	Some improvement	no collection system pumping restrictions	some improvement
Intra/inter basin water transfers	***Environment***	n/a	n/a	neutral,	n/a
Environmental Liabilities	***Environment***	construction, smell, leaks	some	issues with Bad Fish Creek (banks)	a little more
Greenfield Impacts	***Environment***	yes	none	some - need to trench; limited.	none
Time frame to implement	***Community***	relatively short	relatively short 5-15	relatively short	relatively short 5-10
Construction impacts: air, noise, traffic	***Environment***	yes	less impact on the public; some internal	some impacts but not that many	slightly more impact
Process public impact	***Community***	potential for smell, some siting impacts	neutral, increased lagoon usage	potential on easements	slightly more impact; could be positive or negative
MMSD Policies	***Community***	n/a	neutral	neutral	neutral
50 year Master Plan	***Community***	n/a	conforms	check on Masterplan	conforms
Overall (Claudia's best guess)		moderate benefits		Bad Fish Creek issues vs positive operational impact	
Potential action outside of LPFP		Master plan - consider/review role of "buffer properties": expansion, new regulation, just buffer, peak management....		Master Plan - big picture watershed management isses	Master Plan - big picture watershed management issues

Criteria	SAM Category	PF10–HIGH-RATE WET WEATHER TREATMENT AT NSWWTP	PF11–PRIMARY EFFLUENT DIVERSION TO LAGOONS	PF12–EXPAND THE NSWWTP LAGOON STORAGE CAPACITY	PF13–RECONFIGURE THE LAGOONS TO ADD FLEXIBILITY
Flexibility and Resiliency	***Community***	yes on flexibility, somewhat	neutral	yes	yes
Short term Plant Hydraulics	***Community***	yes	yes	yes	yes
Long Term Plant Hydraulics	***Community***	yes	yes	yes	yes
Reliability / Risk of Failure	***Community***	high risk of failure; new options	low	low risk/high reliabiliety	low risk/high reliabiliety
Construction feasibility	***Community***	relatively easy	normal/relatively easy	very difficult	very difficult
Permit Requirements	***Community/ E nvironmental***	permitting risks; not done before	permitting risks	very difficult	very difficult
Capital and life cycle cost	*Economy*	moderate; high operating costs for sludge disposal	low for capital; but lifecycle may be high due to need for cleaning out the lagoons.	still requires plant upgrades; possibly expensive due to construction challenges	still requires plant upgrades; possibly expensive due to construction challenges
Capital needs synergy	***Community***	no	no	no	no
Infrastructure traps	***Community***	resource traps due to chemical use,	no	none	none
Resource recovery and effluent reuse	***Community***	won't help or hinder	won't help or hinder	neutral	neutral
Compatible with existing	***Community***	not really/no	some incompatibility due to mixing of primary with secondary	yes	yes
Operational ease and staff safety	***Individual***	negative impact due to different process and use of chemicals	may have some safety or health concerns	o.k. once it is	o.k. once it is
Multi-governmental cooperation	*Community*	none	no	no	no
Energy use impact renewables	***Environment***	not much greater than regular; some for transit and chemicals	higher energy use due to desinfection at the lagoons	neutral	neutral
Process waste generation	***Environment***	produces sludge with chemicals.	solids in the lagoons	neutral	neutral
Water conservation	***Environment***	neutral	neutral	neutral, impact on wetlands	neutral
Downstream water quality	***Environment***	yes; effluent not treated to the same level as current standard	could have negative impact;	neutral	neutral
Collection System SSOs and backups	***Environment / Community***	no collection system restrictions	no collection system pumping restrictions	no collection system pumping restrictions	no collection system pumping restrictions
Intra/inter basin water transfers	***Environment***	no impact	no impact	no impact	no impact
Environmental Liabilities	***Environment***	some on the discharge; sludge in landfills	potentially high reliabilities	extensive; destroy wetlands; disturbance risk of superfund site;	extensive; destroy wetlands; disturbance risk of superfund site;
Greenfield Impacts	***Environment***	none	some due to facility	extensive	extensive
Time frame to implement	***Community***	relatively short	relatively short	relatively short	relatively short
Construction impacts: air, noise, traffic	***Environment***	in-plant; minor	relatively minor	requires trucking of mud	requires trucking of mud
Process public impact	***Community***	hauling to landfill; unclear as to the characteristics of the treated w	a lot of impact due to public opposition to this solution	recreational use may be impacted;	recreational use may be impacted;
MMSD Policies	***Community***	neutral; we have always chosen to go biologic.	discharge of primary has never been contemplated; needs to be considered carefully		
50 year Master Plan	***Community***	neutral	not considered.		
Overall (Claudia's best guess)		permit/sludge/water quality	Complicated lagoon impacts	Complicated lagoon impacts	Complicated lagoon impacts
Potential action outside of LPFP			Master Plan - big picture watershed management issues; best use of lagoons	Master Plan - big picture watershed management issues; best use of lagoons	Master Plan - big picture watershed management issues; best use of lagoons

APPENDIX D
OPINION OF PROBABLE COST SHEETS

Madison Metropolitan Sewerage District
2016 Liquid Processing Facilities Plan
Opinion of Present Worth Cost **Discount Rate** 4.375%

TM4 - Peak Flow Management
Alternative PF-0

ITEM	**Initial Capital Cost**	**Future Capital Cost**	**Replacement Year**	**Replacement Cost (P.W.)**	**20-Year Salvage Value**	**Salvage Value (P.W.)**
	$ -	$ -		$ -	$ -	$ -
Subtotal	$ -	$ -				
Piping and Mechanical	$ -	$ -		$ -	$ -	$ -
Electrical	$ -	$ -		$ -	$ -	$ -
Sitework	$ -					
Subtotal	$ -					
Contractor GCs	$ -					
Total Construction Costs	$ -					
Contingencies and Engineering Services	$ -					
Total Capital Costs	$ -			$ -	$ -	$ -
Present Worth of Capital Costs	**$ -**			$ -		$ -
O&M Costs	$ 773,000					
Total O&M Costs	$ 773,000					
Present Worth of O&M	**$ 10,165,000**					
Summary of Present Worth Costs						
Capital Cost	$ -					
Replacement	$ -					
O&M Cost	$ 10,165,000					
Salvage Value	$ -					
Total Present Worth	**$ 10,165,000**					

Note: Costs are September 2016 basis.

Madison Metropolitan Sewerage District
2016 Liquid Processing Facilities Plan
Opinion of Present Worth Cost **Discount Rate** 4.375%

TM4 - Peak Flow Management
Alternative PF-6

ITEM	Initial Capital Cost	Future Capital Cost	Replacement Year	Replacement Cost (P.W.)	20-Year Salvage Value	Salvage Value (P.W.)
Overflow Pipe to Equalization Tank	$ 1,680,000	$ -	40	$ -	$ 840,000	$ 357,000
Equalization Tank	$ 30,000,000	$ -	40	$ -	$ 15,000,000	$ 6,370,000
Overflow/Drain to PS No. 11	$ 540,000	$ -	40	$ -	$ 270,000	$ 115,000
Upgrades to Lagoon Pump Station	$ 700,000	$ -	40	$ -	$ 350,000	$ 149,000
Subtotal	$ 32,920,000	$ -				
Piping and Mechanical (5%)	$ 1,646,000	$ -	40	$ -	$ 823,000	$ 350,000
Electrical (5%)	$ 1,646,000	$ -	20	$ -	$ -	$ -
Sitework (10%)	$ 3,292,000					
Land Acquisition	$ 100,000					
Subtotal	$ 39,604,000					
Contractor GCs (10%)	$ 3,961,000					
Total Construction Costs	$ 43,565,000					
Contingencies and Engineering Services (50%)	$ 21,783,000					
Total Capital Costs	$ 65,348,000			$ -	$ 17,283,000	$ 7,341,000
Present Worth of Capital Costs	**$ 65,348,000**			$ -		$ 7,341,000
O&M Costs	$ 777,000					
Total O&M Costs	$ 777,000					
Present Worth of O&M	**$ 10,218,000**					
Summary of Present Worth Costs						
Capital Cost	$ 65,348,000					
Replacement	$ -					
O&M Cost	$ 10,218,000					
Salvage Value	$ (7,341,000)					
Total Present Worth	**$ 68,225,000**					

Note: Costs are September 2016 basis.

Madison Metropolitan Sewerage District
2016 Liquid Processing Facilities Plan
Opinion of Present Worth Cost **Discount Rate** 4.375%

TM4 - Peak Flow Management
Alternative PF-7

ITEM	**Initial Capital Cost**	**Future Capital Cost**	**Replacement Year**	**Replacement Cost (P.W.)**	**20-Year Salvage Value**	**Salvage Value (P.W.)**
Effluent Structure Modifications	$ 500,000	$ -	40	$ -	$ 250,000	$ 106,000
Raise West Final Clarifier Influent Channel Walls	$ 100,000	$ -	40	$ -	$ 50,000	$ 21,000
West Primary Clarifier Bypass Channel	$ 200,000	$ -	40	$ -	$ 100,000	$ 42,000
Upgrades to Lagoon Pump Station	$ 700,000	$ -	40	$ -	$ 350,000	$ 149,000
Subtotal	$ 1,500,000	$ -				
Piping and Mechanical (25%)	$ 375,000	$ -	40	$ -	$ 187,500	$ 80,000
Electrical (25%)	$ 375,000	$ -	20	$ -	$ -	$ -
Sitework (15%)	$ 225,000					
Subtotal	$ 2,475,000					
Contractor GCs (10%)	$ 248,000					
Total Construction Costs	$ 2,723,000					
Contingencies and Engineering Services (50%)	$ 1,362,000					
Total Capital Costs	$ 4,085,000			$ -	$ 937,500	$ 398,000
Present Worth of Capital Costs	**$ 4,085,000**			$ -		$ 398,000
O&M Costs	$ 774,000					
Total O&M Costs	$ 774,000					
Present Worth of O&M	**$ 10,178,000**					
Summary of Present Worth Costs						
Capital Cost	$ 4,085,000					
Replacement	$ -					
O&M Cost	$ 10,178,000					
Salvage Value	$ (398,000)					
Total Present Worth	**$ 13,865,000**					

Note: Costs are September 2016 basis.

Madison Metropolitan Sewerage District
2016 Liquid Processing Facilities Plan
Opinion of Present Worth Cost **Discount Rate** 4.375%

TM4 - Peak Flow Management
Alternative PF-8

ITEM	Initial Capital Cost	Future Capital Cost	Replacement Year	Replacement Cost (P.W.)	20-Year Salvage Value	Salvage Value (P.W.)
Additional Secondary Effluent Pipe from East Plant	$ 1,200,000	$ -	40	$ -	$ 600,000	$ 255,000
Raise West Final Clarifier Influent Channel Walls	$ 100,000	$ -	40	$ -	$ 50,000	$ 21,000
West Primary Clarifier Bypass Channel	$ 200,000	$ -	40	$ -	$ 100,000	$ 42,000
Ultraviolet Disinfection Equipment	$ 830,000	$ -	20	$ -	$ -	$ -
Effluent Pumps	$ 1,890,000	$ -	20	$ -	$ -	$ -
Effluent Pumping Structure Modifications	$ 500,000	$ -	40	$ -	$ 250,000	$ 106,000
Hydraulic Studies/BFC Stream Bank Costs (allowance)	$ 300,000					
New Effluent Force Main	$ 22,000,000	$ -	40	$ -	$ 11,000,000	$ 4,672,000
Subtotal	$ 27,020,000	$ -				
Piping and Mechanical (25%)	$ 6,755,000	$ -	40	$ -	$ 3,377,500	$ 1,434,000
Electrical (20%)	$ 5,404,000	$ -	20	$ -	$ -	$ -
Sitework (15%)	$ 4,053,000					
Subtotal	$ 43,232,000					
Contractor GCs (10%)	$ 4,324,000					
Total Construction Costs	$ 47,556,000					
Contingencies and Engineering Services (50%)	$ 23,778,000					
Total Capital Costs	$ 71,334,000			$ -	$ 15,377,500	$ 6,530,000
Present Worth of Capital Costs	**$ 71,334,000**			$ -		$ 6,530,000
O&M Costs	$ 738,000					
Total O&M Costs	$ 738,000					
Present Worth of O&M	**$ 9,705,000**					

Summary of Present Worth Costs	
Capital Cost	$ 71,334,000
Replacement	$ -
O&M Cost	$ 9,705,000
Salvage Value	$ (6,530,000)
Total Present Worth	**$ 74,509,000**

Note: Costs are September 2016 basis.

Madison Metropolitan Sewerage District
2016 Liquid Processing Facilities Plan
Opinion of Present Worth Cost **Discount Rate** 4.375%

TM4 - Peak Flow Management
Alternative PF-10

ITEM	Initial Capital Cost	Future Capital Cost	Replacement Year	Replacement Cost (P.W.)	20-Year Salvage Value	Salvage Value (P.W.)
Effluent Structure Modifications	$ 500,000	$ -	40	$ -	$ 250,000	$ 106,000
Raise West Final Clarifier Influent Channel Walls	$ 100,000	$ -	40	$ -	$ 50,000	$ 21,000
West Primary Clarifier Bypass Channel	$ 200,000	$ -	40	$ -	$ 100,000	$ 42,000
Gates, Valves, and Flow Meters for BC Operation	$ 409,000	$ -	20	$ -		$ -
Upgrades to Lagoon Pump Station	$ 700,000	$ -	40	$ -	$ 350,000	$ 149,000
Subtotal	$ 1,909,000	$ -				
Piping and Mechanical (25%)	$ 478,000	$ -	40	$ -	$ 239,000	$ 102,000
Electrical (25%)	$ 478,000	$ -	20	$ -	$ -	$ -
Sitework (15%)	$ 287,000					
Subtotal	$ 3,152,000					
Contractor GCs (10%)	$ 316,000					
Total Construction Costs	$ 3,468,000					
Contingencies and Engineering Services (50%)	$ 1,734,000					
Total Capital Costs	$ 5,202,000			$ -	$ 989,000	$ 420,000
Present Worth of Capital Costs	**$ 5,202,000**			$ -		$ 420,000
O&M Costs	$ 782,000					
Total O&M Costs	$ 782,000					
Present Worth of O&M	**$ 10,283,000**					
Summary of Present Worth Costs						
Capital Cost	$ 5,202,000					
Replacement	$ -					
O&M Cost	$ 10,283,000					
Salvage Value	$ (420,000)					
Total Present Worth	**$ 15,065,000**					

Note: Costs are September 2016 basis.

Madison Metropolitan Sewerage District
2016 Liquid Processing Facilities Plan
Opinion of Present Worth Cost

TM4 - Peak Flow Management
O&M Cost Summary

PF0

Equipment	Annual O&M Cost	Electric Costs/Yr	Maintenance Cost	Comments
Pumping out of lagoon	$ 6,000	$ 5,000	$ 1,000	Assumes 2 events per year that fill lagoon (or 100 MG total) and need to be pumped back at 1.73 mgd with 50 hp pump
Effluent Pumping	$ 702,000	$ 652,000	$ 50,000	Effluent pumping for approximate 2030 DAF of 47 mgd using 0.447kWh/1000 gals from MMSD effluent pumping control description. Maintenance cost increased for maintaining existing pumps
UV Equipment	$ 65,000	$ 34,000	$ 31,000	UV energy for DAF from Wedeco. Flows disinfected twice considered negligible, Maintenance costs from Wedeco proposal plus 4 hours labor for each estimated bulb replacement
Total Annual O&M	$ 773,000			

PF6

Equipment	Annual O&M Cost	Electric Costs/Yr	Maintenance Cost	Comments
Cleaning of tank	$ 4,000	$ -	$ 4,000	Assumes 3 events above 145 mgd in 20 year period, 40 hours cleaning labor per event. Probably also have additional annual maintenance with tank - inspections, yard maintenance, etc. Say additional 2 hours per week
Pumping out of lagoon/Additional Pumping at PS 11	$ 6,000	$ 5,000	$ 1,000	Assumes 2 events per year that fill lagoon (or 100 MG total) and need to be pumped back at 1.73 mgd with 100 hp pump
Effluent Pumping	$ 702,000	$ 652,000	$ 50,000	Effluent pumping for approximate 2030 DAF of 47 mgd using 0.447kWh/1000 gals from MMSD effluent pumping control description. Maintenance cost increased for maintaining existing pumps
UV Equipment	$ 65,000	$ 34,000	$ 31,000	UV energy for DAF from Wedeco. Flows disinfected twice considered negligible, Maintenance costs from Wedeco proposal plus 4 hours labor for each estimated bulb replacement
Total Annual O&M	$ 777,000			

PF7

Equipment	Annual O&M Cost	Electric Costs/Yr	Maintenance Cost	Comments
Overflow gates/actuators	$ 1,000	$ -	$ 1,000	
UV Equipment	$ 65,000	$ 34,000	$ 31,000	UV energy for DAF from Wedeco. Flows disinfected twice considered negligible, Maintenance costs from Wedeco proposal plus 4 hours labor for each estimated bulb replacement
Effluent Pumping	$ 702,000	$ 652,000	$ 50,000	Effluent pumping for approximate 2030 DAF of 47 mgd using 0.447kWh/1000 gals from MMSD effluent pumping control description. Maintenance cost increased for maintaining existing pumps
Pumping out of lagoon	$ 6,000	$ 5,000	$ 1,000	Assumes 2 events per year that fill lagoon (or 100 MG total) and need to be pumped back at 1.73 mgd with 50 hp pump
Total Annual O&M	$ 774,000			

PF8

Equipment	Annual O&M Cost	Electric Costs/Yr	Maintenance Cost	Comments
UV Equipment	$ 65,000	$ 34,000	$ 31,000	UV energy for DAF from Wedeco. Maintenance costs from Wedeco proposal plus 4 hours labor for each estimated bulb replacement
Effluent Pumping	$ 673,000	$ 652,000	$ 21,000	Effluent pumping for approximate 2030 DAF of 47 mgd using 0.447kWh/1000 gals from MMSD effluent pumping control description.
Total Annual O&M	$ 738,000			

PF10

Equipment	Annual O&M Cost	Electric Costs/Yr	Maintenance Cost	Comments
Overflow gates/actuators	$ 1,000	$ -	$ 1,000	
UV Equipment	$ 65,000	$ 34,000	$ 31,000	UV energy for DAF from Wedeco. Flows disinfected twice considered negligible, Maintenance costs from Wedeco proposal plus 4 hours labor for each estimated bulb replacement
Effluent Pumping	$ 702,000	$ 652,000	$ 50,000	Effluent pumping for approximate 2030 DAF of 47 mgd using 0.447kWh/1000 gals from MMSD effluent pumping control description. Maintenance cost increased for maintaining existing pumps
Step Feed gates/actuators	$ 8,000	$ -	$ 8,000	
Pumping out of lagoon	$ 6,000	$ 5,000	$ 1,000	Assumes 2 events per year that fill lagoon and need to be pumped back at 1.73 mgd with 50 hp pump
Total Annual O&M	$ 782,000			

APPENDIX E
EFFLUENT FORCE MAIN SURGE ANALYSES

Technical Memorandum No. 4 for the Madison Metropolitan Sewerage District, Madison, Wisconsin

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Appendix E–Effluent Force Main Surge Analyses

Prepared by:

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September 2016
Revised February 2017

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A steady state and transient analysis of the MMSD effluent force main was completed and described herein. This analysis was completed using Hammer, a commercially available transient analysis model available from Bentley Systems. This model produced results within ±10 to 15 percent of actual values. The purpose of this analysis was to evaluate the following as part of the 2016 Liquid Processing Facilities Plan:

§ Can additional flow be pumped through the existing 54-inch force main to reduce the existing hydraulic constraint of 76 mgd without compromising the pipe ratings.

§ Can improvements/upgrades to the standpipe near the end of the force main be made to keep it from overflowing, if the cause is determined to be hydraulic.

Pertinent system components and their inclusion in the model are discussed first. Physical parameters describing the system were obtained directly from MMSD.

PUMPING SYSTEM

A schematic of the system as modeled is presented in Figure 1 and 2.

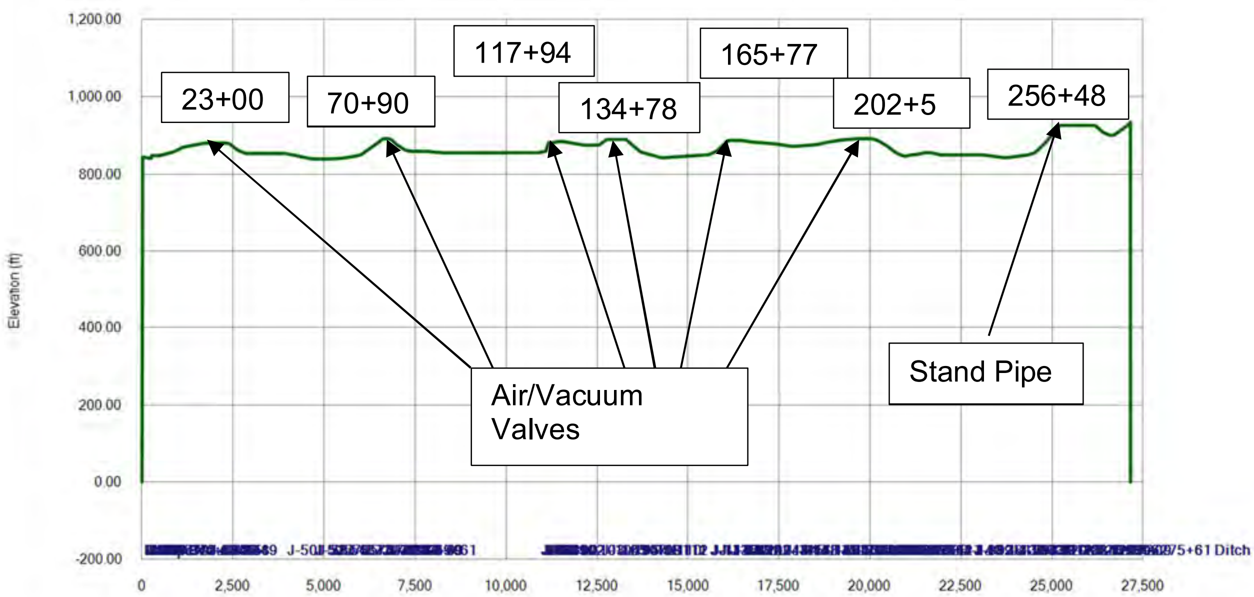


Figure 1 System Vertical Profile and Air/Vacuum Valve Locations

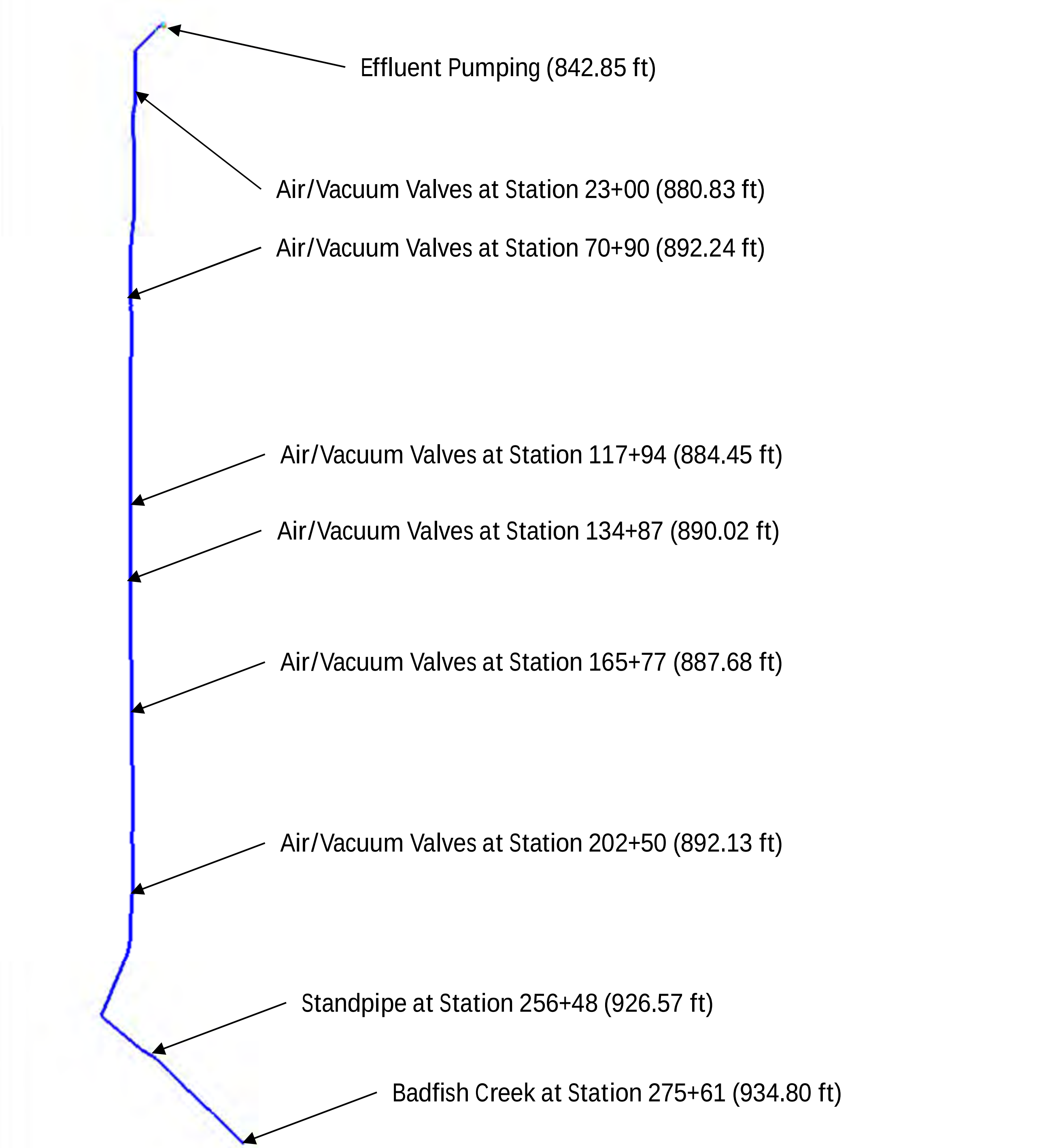


Figure 2 System Schematic–Elevations of the Forcemain Shown

Key components of the system include the following:

1. Pumps, motors, and control valves.
2. The force main with its associated air/vacuum valves, and surge relief valves.
3. Pump and pump valve control logic.

These items are described in more detail below.

1. Pumps, Motors, and Control Valve

The system consists of five Ingersoll Rand horizontal split case pumps that are driven by General Electric motors. The discharge of each pump is controlled by a hydraulically actuated Allis Chalmers Rotovalve cone valve. These pumps take suction from an adjacent wet well and deliver the flow to Badfish Creek through an effluent force main.

Table 1 describes the pumping station components, as modeled.

Pump	Design Point	Impeller Diameter (inch)	Motor RPM	Horsepower
1	16,000 gpm at 130’	24	890	800
2	16,000 gpm at 150’	25.94	890	800
3	16,000 gpm at 150’	25.94	890	800
4	16,000 gpm at 150’	25.94	890	800
5	16,000 gpm at 130’	24	890	800

Table 1 Effluent Pumping Station Components

2. Force Main, Air/Vacuum Valves, and Surge Relief Valves

The information provided indicates that the force main has a nominal pipe diameter of 54 inches and is a total of approximately 27,500 feet long. The pipe is described as prestressed concrete embedded cylinder pipe with rubber and steel joints. The fabrication specifications are dated July 1957, and the pipe was provided by the Lock Joint Pipe Company. The working pressure of this pipe is specified as 100 psi with a maximum negative head tolerance of -10 feet of water (-4 psi). Analysis results will be compared to these limits in this evaluation. Any additional allowance for surge, positive or negative, are not defined in the specification and is unknown.

The information provided indicates there are 13 air/vacuum valves installed along the pipeline at 6 locations (some locations have several valves installed). Table 2 describes the air/vacuum valves in more detail.

Location	Number of Air/Vacuum Valves	Inflow Orifice	Outflow Orifice	Manufacturer
Sta. 23+00	3	6-inch	5/16-inch	Allis-Chalmers
Sta. 70+90	2	6-inch	3/16-inch	Allis-Chalmers
Sta. 117+94	2	6-inch	3/16-inch	Allis-Chalmers
Sta. 134+78	2	6-inch	3/16-inch	Allis-Chalmers
Sta. 165+77	2	6-inch	3/16-inch	Allis-Chalmers
Sta. 202+50	2	6-inch	3/16-inch	Allis-Chalmers

Table 2 Description of Air/Vacuum Valves

Figure 1 shows the general location of the air/vacuum valves along the force main.

There are three surge relief valves at a location just south of the pumping station as described in Table 3. Records indicate these valves are set to begin relieving pressure at 80 psi.

Location	Number of Surge Valves	Size	Pressure Setting	Manufacturer
Sta. 8+00	3	8-inch	80 psi	Bailey

Table 3 Description of Surge Relief Valves

3. Pump and Valve Control Logic

Two modeling scenarios were selected from "CONTROL DESCRIPTION FOR EFFLUENT PUMPING" dated June 6, 2012 (control description). One is normal pump shutdown at the current maximum system capacity of 76 mgd. The second is a defined emergency situation with pump failure at 76 mgd.

The control description indicates that three large pumps are typically operated simultaneously to obtain 76 mgd of flow. This situation was selected as the current extreme condition encountered with regard to rate of flow and velocity. This simulation was conducted assuming all three large pumps are shut down in automatic mode with the cone valves moving from fully open to fully close in 300 seconds. Recently the cone valve close time has been changed from 300 seconds to 90 seconds. Both of these close times were simulated under the conditions described above. This is thought to be a relatively extreme test of the system since it is not likely that conditions would warrant going from maximum capacity to full shutdown without keeping other pumps in operation.

The second simulation is what is thought to be extreme power failure conditions during which the cone valves remain in operation. In this simulation the three largest pumps are operating at 76 mgd and the power fails. All three cone valves simultaneously cycle closed in 30 seconds as described in the control description.

EXISTING CONDITIONS MODELING RESULTS AND DISCUSSION

The Hammer model of the system was created using the information previously described. The pipe roughness factor was then estimated using the information provided in the control description and the pump and system-head and pump curves provided by MMSD in a graph partially dated March 11, 198* (*the final digit of this year is missing from our copy). Using this information, it was estimated that the current roughness factor of the pipe interior ranges between 125 and 135. MMSD roughness test data completed in 1977 indicates the roughness of the pipe at that time equaled 135 at 64 mgd, indicating it has not changed significantly since 1977.

A. Existing Normal Operating Conditions

As previously discussed, under previous operating conditions the effluent pumps continue to operate as the cone valves close over a time interval of 300 seconds. In the simulation the valves begin closing at 5 seconds and pumps shutoff at or near the end of the valve closing cycle (305 seconds). The maximum calculated pressure in the pipe equals 68 psi and occurs directly downstream of the pumping station between approximately Stations 6+50 to 8+50. The minimum calculated pressure occurs about 1,500 feet downstream of the pumping station and reaches approximately -6 psi. Given typical modeling uncertainty, this result indicates the system is operating a bit below the 80 psi settings for the surge relief valves and at or below the negative pressure specification of the system.

The calculated pressure envelope along the pipe profile is shown in Figure 3. When the initial pressure is not shown as a separate line in the pressure graphs, it is because the initial pressure matches the maximum pressure. The highest calculated hydraulic grade line (HGL) at the standpipe location is approximately 940 feet mean sea level (MSL). The reported top of the standpipe is at elevation 972.09 feet MSL. Under this condition, the calculated HGL is significantly below the top of the standpipe and should not cause the standpipe to overflow intermittently during shutdown of the three largest pumps under normal operating conditions.

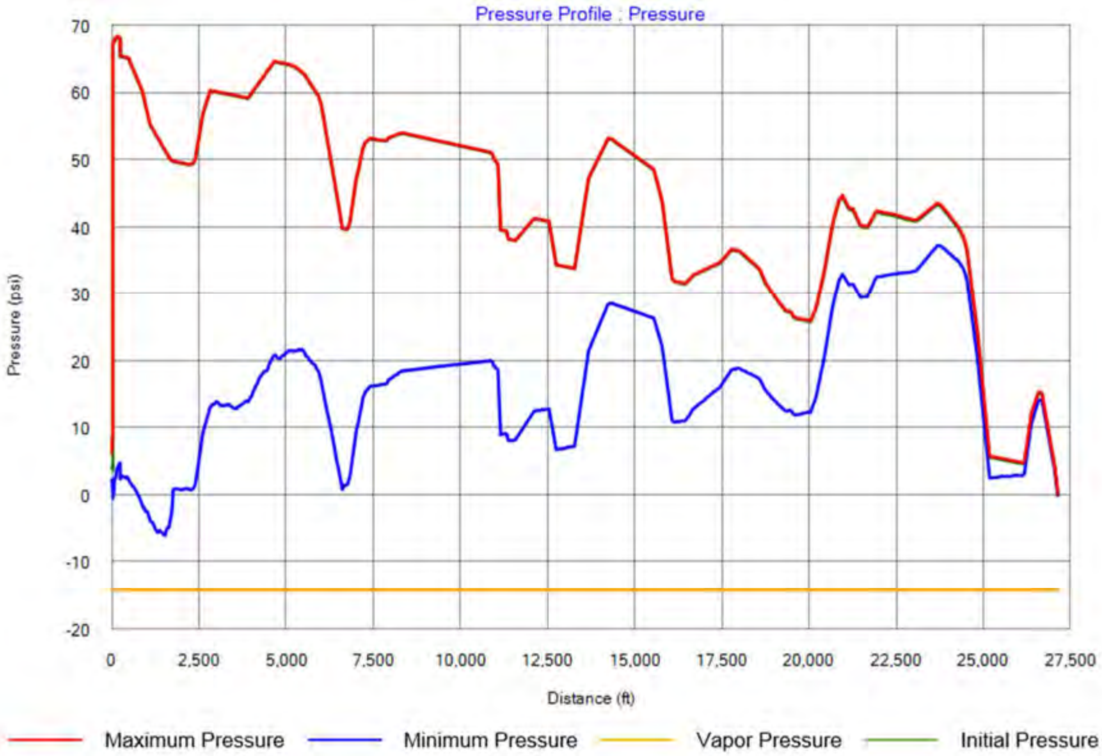


**Figure 3 Calculated Pressure Envelope along Force Main Profile
Normal Pump Shutdown at 76 mgd–300-Second Cone Valve Close Time**

A recent change to the cone valve controls under normal operating conditions has the effluent pumps continue to operate as the cone valves close over a time interval of 90 seconds. In the simulation the valves begin closing at 5 seconds and pumps shutoff at or near the end of the valve closing cycle (95 seconds). The maximum calculated pressure in the pipe equals 81 psi and occurs directly downstream of the pumping station and before the Surge Valve Vault. The minimum calculated pressure occurs at several locations but reaches approximately -12 psi near the stand pipe and -7 psi downstream of the pump station.

The calculated pressure envelope along the pipe profile under this condition is shown in Figure 4. The highest calculated hydraulic grade line (HGL) at the standpipe location is approximately 962 feet mean sea level (MSL). The reported top of the standpipe is at elevation 972.09 feet MSL. Under this condition, the calculated HGL is significantly below the top of the standpipe and should not cause the standpipe to overflow intermittently during shutdown of the three largest pumps under normal operating conditions.

These simulations indicate that pressures along the pipe profile does not exceed the maximum rating of the pipe (100 psi) under either condition. However, the occurrence of negative pressures that are less than the design capability of the pipe (-4 psi) increases with the shorter cone valve closing time.

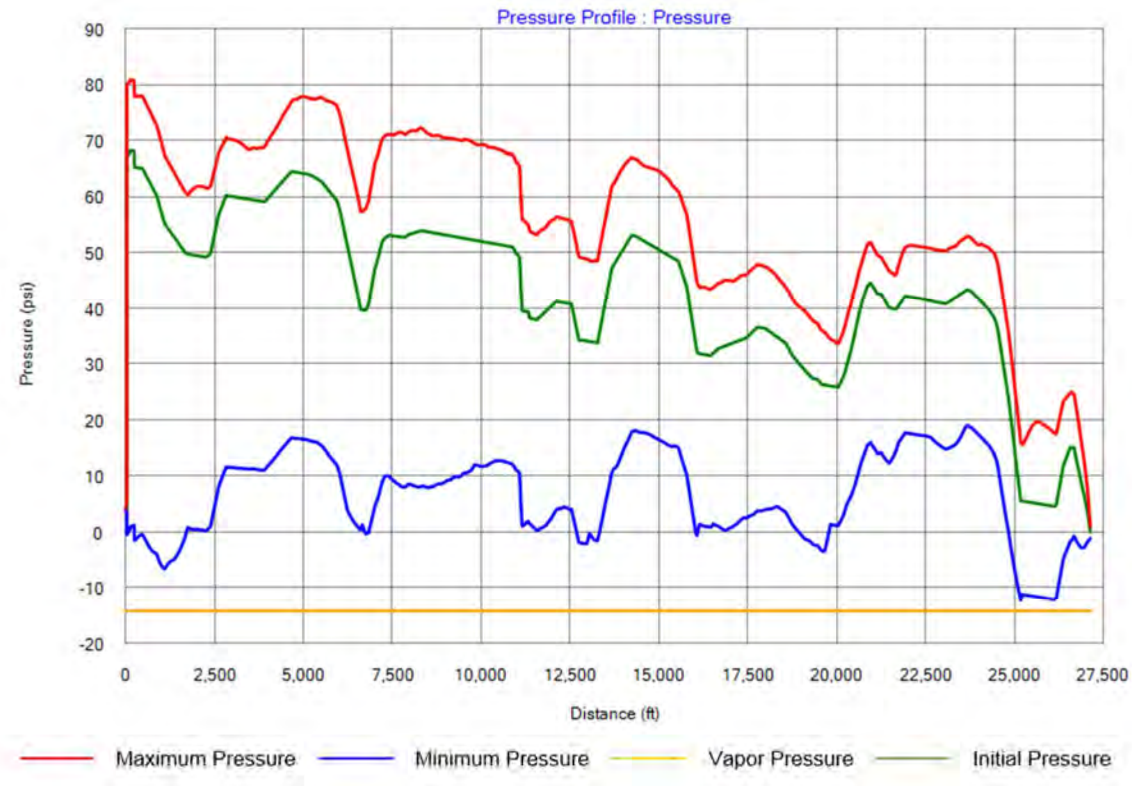


Figure 4 Calculated Pressure Envelope along Force Main Profile Normal Pump Shutdown at 76 mgd–90-Second Cone Valve Close Time

Figure 5 presents the head-discharge curves for the effluent pumps and select head–discharge curves for the effluent force main (this information was provided by MMSD). Figure 4 shows that 53,000 gpm (76 mgd) is approximately the maximum rate of flow that can be achieved using the existing pumps. This is indicated by the point of intersection between the force main head-discharge curve and the head–discharge curve of three large pumps operating together. Because of the increase in discharge head, it appears that the system may not be able to sustain this rate if the effluent level in the wet well is significantly below full. A pump curve for one of the two smaller pumps is also shown in Figure 4. This curve indicates that the shutoff (no flow) head for the two smaller pumps is at the operating point of the three largest pumps operating together under this condition. Therefore, operating them along with the three largest pumps will not increase flow in the system.

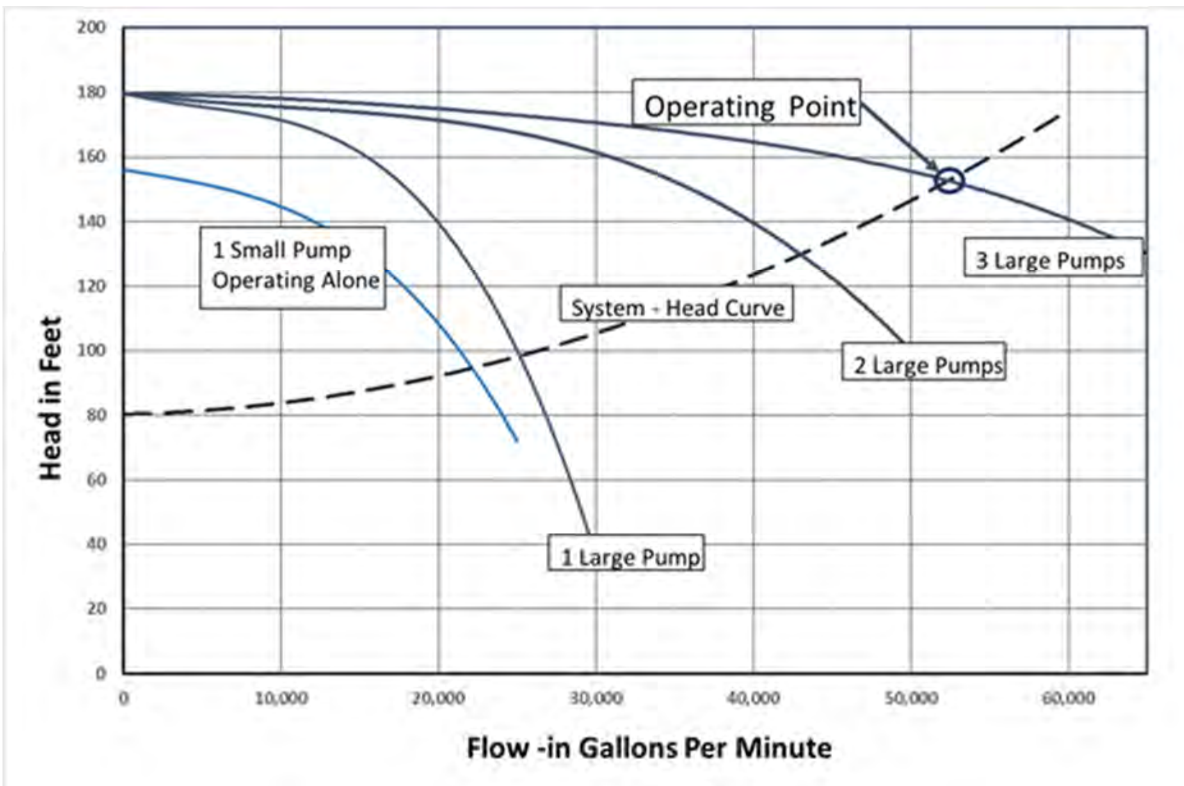


Figure 5 System-Head and Pump Discharge-Head Curves at the Effluent Pumping Station

B. Existing Emergency Operating Conditions

This simulation assumed that the three large pumps are operating together and producing 76 mgd. Power fails at 5 seconds into the simulation, initiating emergency closure of the cone valves, which is completed in 30 seconds. The simulation indicates that the pumps decelerate to a full stop in just over 15 seconds and spin backward until the valves close 30 seconds after failure. Effluent flows back from the force main into the wet well as the pumps turn in reverse. The calculated pressure envelop produced under this condition is shown in Figure 6. The maximum calculated pressure equals 68 psi and occurs directly downstream of the pumping station starting at approximately Station 6+50 to 8+50. The minimum calculated pressure at several locations and ranges between -4 psi and -12 psi.

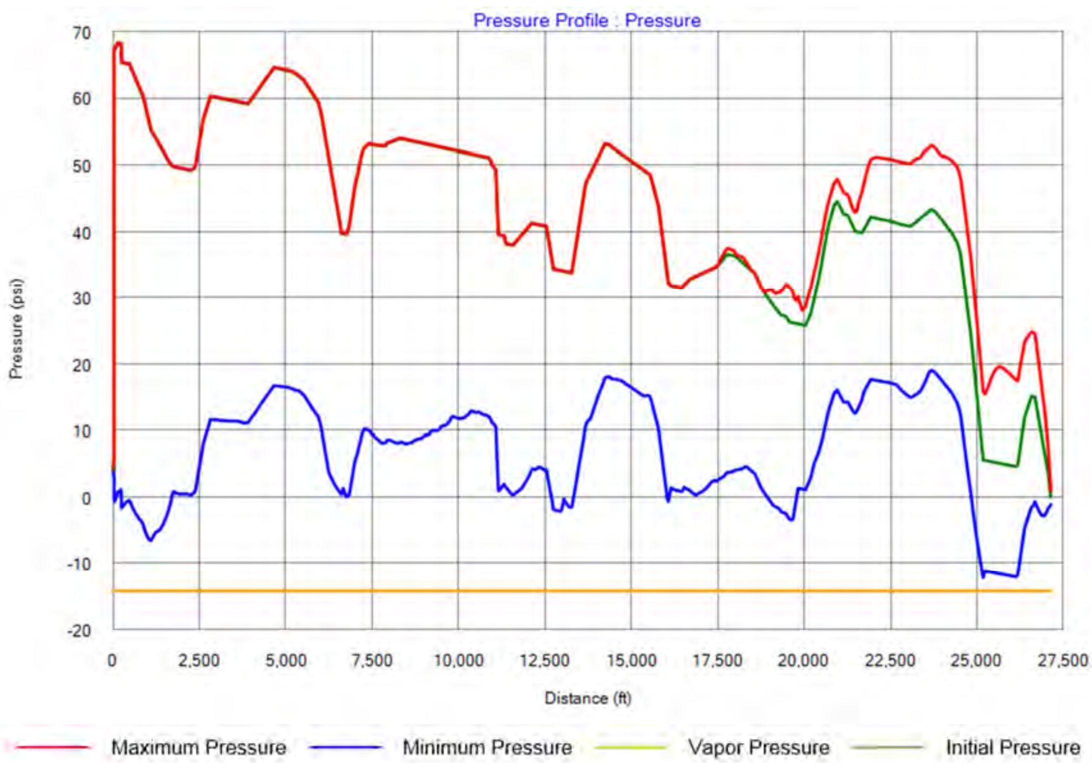


Figure 6 Calculated Pressure Envelope Along Force Main Profile
Emergency Pump Shutdown at 76 mgd–30-Second Cone Valve Close Time

A more rapid closing time for the cone valves may eliminate the backflow condition, although other effects may occur. Changes in valve operating times to eliminate the occurrence of pressures below -4 psi were not evaluated here.

Again, the maximum calculated HGL at the standpipe is approximately 962.50 feet MSL, which is approximately 10 feet below the top of the standpipe, indicating that overflow caused by the simulated hydraulic event is unlikely.

One similarity between of the simulations with cone valve closing times of 90 seconds and 30 seconds is significant negative pressures between 25,000 feet and 26,000 feet of pipe. Although not evaluated in detail, the results indicate that low pressures in this section of pipe are likely caused by pressure loss when air is drawn into the pipe through the standpipe, resulting in the calculated negative pressures shown. Simulations indicate that increasing the diameter of the standpipe may alleviate low pressure at the standpipe.

In general, the calculated negative pressures displayed in Figure 6 are lower than those shown in Figure 3, indicating the system is operating beyond its published design capability to withstand negative pressures.

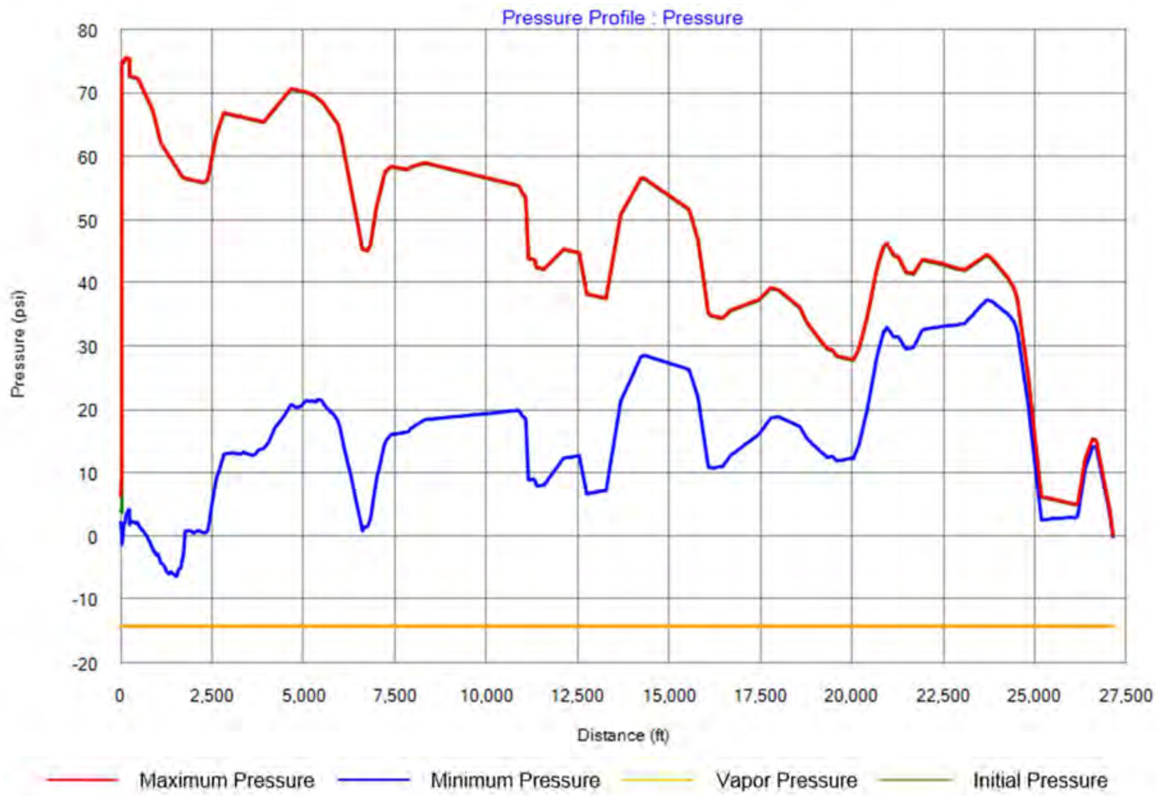
POTENTIAL FUTURE CONDITIONS MODELING RESULTS AND DISCUSSION

The Hammer model was used to simulate increased flows to determine whether the pipe could handle additional flow while staying below the maximum pressure rating for the pipe. For this simulation the existing pump curves were modified to increase the flow from the pump station to 86 mgd, which infers increased pump and motor sizes.

A. Future Normal Operating Conditions

This simulation assumes that three new pumps and motors are operating together and producing 86 mgd. In this simulation the valves begin closing at 5 seconds and pumps shut off at or near the end of the valve closing cycle (305 seconds). The maximum calculated pressure equals 76 psi and occurs along the pipe directly downstream of the pumping station. The minimum calculated pressure occurs about 1,500 feet downstream of the pumping station and reaches approximately -6 psi. Given typical modeling uncertainly this result indicates the system is operating a bit below the 80 psi settings for the surge relief valves and at or below the negative pressure capability of the system. Based on the simulations presented earlier, it appears that reduction of the cone valve closing time to 90 seconds (from 300 seconds) will increase high pressures above the 80 psi setting of the pressure relief valves and reduce the negative pressure further below the -4 psi rating of the pipe.

The calculated pressure envelope along the pipe profile is shown in Figure 7. When the initial pressure is not shown in the pressure graph, it is because the initial pressure matches the maximum pressure. The highest calculated HGL at the standpipe location is approximately 941 feet MSL. The reported top of the standpipe is at elevation 972.09 feet MSL. Under this condition, the calculated HGL is significantly below the top of the standpipe and should not cause the standpipe to overflow intermittently during shutdown of the three largest pumps under normal operating conditions.



Note: Initial pressures matched the maximum pressure for this analysis.

Figure 7 Calculated Pressure Envelope along Force Main Profile
Pump Shutdown at 86 mgd–300-Second Cone Valve Close Time

B. Future Emergency Operating Conditions

This simulation assumed that the three new large pumps are operating together and producing 86 mgd. Power fails at 5 seconds, initiating emergency closure of the cone valves, which is completed 30 seconds after the power fails. The calculated pressure envelope is shown in Figure 8. The maximum calculated pressure equals 76 psi and occurs directly downstream of the pumping station starting at approximately Station 7+00 to 8+50. The minimum calculated pressure at several locations and ranges between -4 psi and -9 psi. The minimum calculated pressures are slightly higher (less negative) than those calculated at 76 mgd because the new larger pumps and motors required to pump 86 mgd have higher estimated moments of inertia than the existing pumping equipment. These larger units slow to a stop more slowly than the existing and change system surge characteristics slightly.

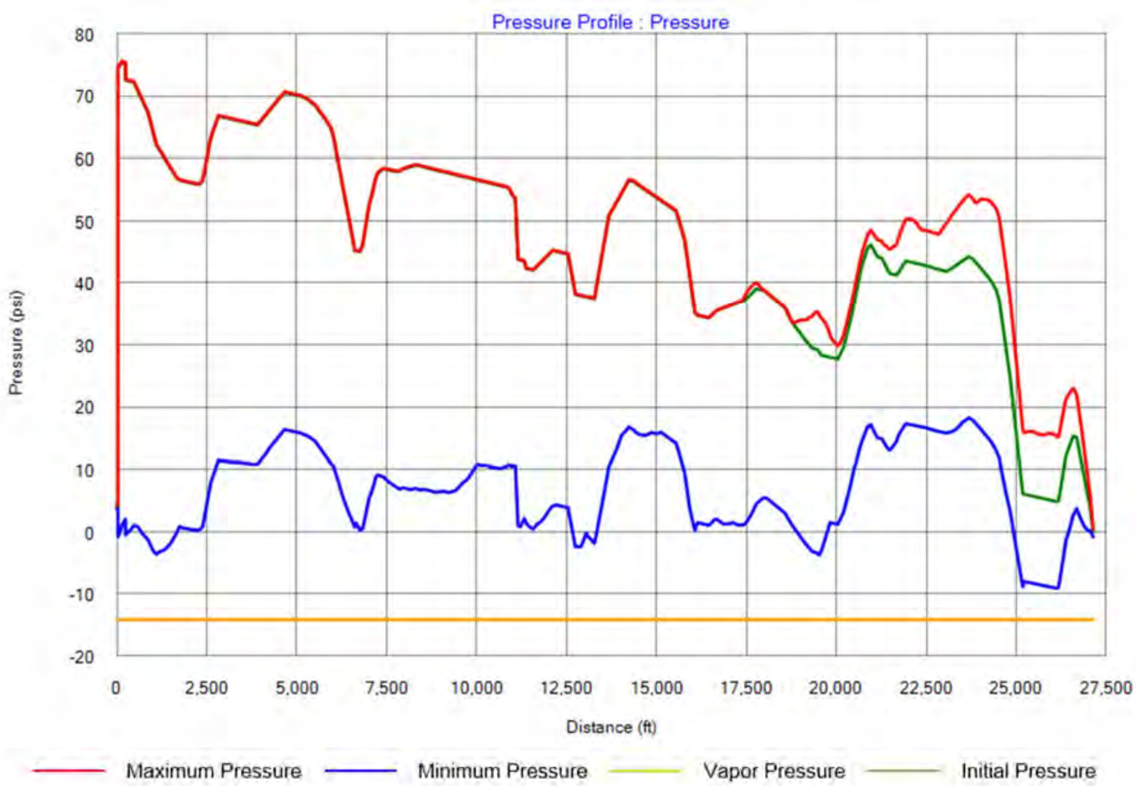


Figure 8 Calculated Pressure Envelope along Force Main Profile
Emergency Pump Shutdown at 86 mgd–30-Second Cone Valve Close Time

The simulation indicates that the pumps stop forward rotation in 23 to 25 seconds after the power fails and then begin back spinning until the cone valves are fully closed.

The maximum calculated HGL at the standpipe is approximately 963.08 feet, which is about 10 feet below the top of the standpipe, indicating that intermittent overflow is not likely under this condition.

CONCLUSIONS

A. Pipeline Capacity

This analysis indicates that negative pressure directly downstream of the pumping station are lower than the published negative working pressure capability of the pipe in at least one location under all simulated conditions. This indicates that the system is operating near, and potentially beyond, its specified negative pressure capability under the simulated conditions. In addition, negative pressures are lower (more negative) when cone valve closing times are reduced from 300 seconds to 90 seconds.

Note that the specified pipe pressures may not match the actual pipe pressure ratings. Given the age of the pipe and the unknowns with respect to actual pipe pressure ratings, significant testing of the pipe would be needed to verify actual pressure ratings for the pipe in its existing condition and to withstand potential negative pressures that would result from higher future pumping flow rates.

B. Standpipe Overflow

The hydraulic events analyzed here are not the likely cause of overflow of the standpipe. As a result, the cause of the problem is not clear, but may be caused by intermittent air or gas being expelled from the pipe and carrying some effluent with it. Without knowing the cause, it is difficult to develop a solution. Alternatives may include installation of one or more air/vacuum valves at or near the standpipe location, installation of a large diameter standpipe to reduce vertical velocities, installation of a "wide spot" within the standpipe, installation of a downturned elbow at the top of the standpipe with an elevated inlet to capture small amounts of flow and return it to the standpipe, or other approaches.

APPENDIX F
NINTH ADDITIONAL FACILITIES PLAN EXCERPTS

TECHNICAL MEMORANDUM NO. 8
FACILITY PLAN UPDATE

TO: Madison Metropolitan Sewerage District

FROM: Steve Verish
Bill Ericson

DATE: January 27, 1994
Oct. 5, 1994 (revised)

SUBJECT: Effluent Discharge System

PURPOSE

The Madison Metropolitan Sewerage District (MMSD) discharges its effluent to Badfish Creek approximately five miles south of the Nine Springs Wastewater Treatment Plant (NSWWTP). The effluent transmission force main has limited flow capacity that is exceeded during peak flow conditions. The purpose of this memorandum is to evaluate alternatives to increase the effluent force main capacity to meet peak flow conditions.

BACKGROUND

The MMSD owns and operates the Nine Springs Wastewater Treatment Plant which treats wastewater collected from the greater Madison Metropolitan area. Treated wastewater is discharged to the Badfish Creek through a 54" diameter force main approximately five miles in length. The pipeline, installed in 1957, was constructed of concrete cylinder pressure pipe. The pipeline is rated for 100 psi operating pressure and 10 feet of water vacuum. Normally this type of pipe is designed to withstand surge pressures of 40% above the operating pressure. The 40% figure is based on verbal conversation with Cretex Pressure Pipe Company (formerly Lock Joint Pipe Company) who manufactured the pipe. However, the specifications for the pipe make no mention of a surge allowance requirement. The only significant modifications to the original pipeline were the construction of a new effluent pump station in the Seventh Addition (1986) and the replacement of air & vacuum relief valves along the force main.

PAST STUDIES

The transient pressures encountered in the pipeline are of concern as well as steady state pressures. Sudden loss of power to the effluent pumps will cause pressure spikes throughout the system. The magnitude of these spikes is dependent on the pressure and flow conditions at the time of power failure, and on the presence or absence of various surge control devices installed in the pipeline.

The first study of surge conditions on the pipe line was performed by S. Logan Kerr for Mead and Hunt, Inc. in July of 1955. A graphical solution was used to predict surge conditions under various assumed operating conditions. The analysis was performed in the original design stage and the results were used to design surge protection devices for the original installation. The flow rate used was 41,650 gpm (60 mgd) and the results indicated that air & vacuum relief valves were required at pipeline high points, and that back flow through the pumps was to be allowed in the event of power failure.

A load rejection test was performed on the actual pipeline in 1959 by Mead & Hunt to determine the intensity of the pressure spikes at a power failure condition. At a flow rate of 69.5 mgd, the maximum spike recorded was 78 psi while atmospheric pressures were maintained at the summits. Subsequent study of extrapolated test data indicated that a flow rate of 75 mgd was the maximum possible with the original surge control equipment in order to keep spike pressures below 100 psi and vacuum above 10 feet of water after pump power failure.

A surge analysis was performed for the 1980 Facilities Plan Update by CH2MHILL using a proprietary computer program. Their results matched closely those obtained in the 1959 field test. The analysis also indicated that additional surge control devices were needed to protect the line at a flow rate of 82.2 mgd (peak hour flow under study at the time). The surge control system selected was a 1330 cubic foot hydro-pneumatic surge tank at the pump station and an atmospheric surge tank (9 ft. dia. x 10 ft. high) at summit 7. Cone valve and air/vacuum relief valve modifications were also called for. Based upon the recommendations in the Facilities Plan Update, the Seventh Addition to the NSWWTP included construction of a new effluent pump station and the replacement of the air/vacuum valves on the force main. Surge tanks were not installed in the Seventh Addition. There are presently three Bailey No. 428 relief valves installed on the pipeline in the effluent meter vault. They are capable of relieving over-pressure conditions only and are not capable of reacting quickly enough to prevent damage due to a transient surge condition.

The effluent pumps presently in use were performance tested in March of 1986. The objective of the test was to demonstrate that the pumps were capable of operating at the specified flow, head, and efficiency points. The test concluded that the pumps were found to be operating in accordance with the manufacturer's certified performance curves.

CURRENT SITUATION

As presented in Tech Memo No. 2, the NSWWTP presently treats approximately 40 million gallons of wastewater on an average day. In the summer of 1993, the Madison area experienced the wettest 2 month (June-July) period on record. The maximum day flow to the plant (NSWWTP) during an intense storm event in the midst of this wet period was almost 85 mgd. It is estimated that a peak hour flow of 120 mgd (83,300 gpm) occurred during the storm event, based on collection system pump information. Since the effluent pumping system does not have the capacity to handle this flow, some of the effluent overflowed to Lake Waubesa. The flow peak had a duration of about three hours that resulted in an overflow of about 13 million gallons of treated effluent (see Tech Memo No. 7). Other than the effluent storage tanks, there is essentially no storage capacity in the effluent pumping system. The effluent storage tanks have a total capacity of 1.3 million gallons; about half of the total volume is available as equalizing volume. Whenever a flow of greater than 75 mgd occurs, the effluent level in the storage tanks increases. If the peak flow duration is sufficient, the equalizing volume fills and an overflow of treated effluent occurs.

For the purpose of evaluating the hydraulic capacity of the effluent transmission system, a peak hour flow rate of 120 mgd will be used. Based upon the flow projections for the planning period in Tech Memo No. 3, the peak hour flow rates during the planning period will most likely be less than 120 mgd, but this flow rate will be used to be conservative.

EXISTING PUMPING EQUIPMENT

Effluent pumping is by means of five Ingersoll-Rand horizontal split case pumps, each with a 800 HP, 880 RPM motor. Five pumps were installed in the effluent pump station with provisions to add a sixth pump in the future. The pumps are direct drive by AC induction motors with a 900 RPM synchronous speed which generally run at approximately 880 RPM under load. Due to physical space restraints, it is not feasible to operate the existing pumps at a speed other than 900 RPM (nominal) through the use of mechanical speed changing devices. It may be possible to run the pumps below or above 900 RPM (nominal) by using variable frequency AC drives; however due to the cost of the VFD equipment, this memorandum will assume the existing pumps will run at 900 RPM (nominal). Generally speaking, VFD equipment is cost effective in pumping applications only as an alternative to throttling the flow by a valve. Slowing the pump is much more efficient than wasting energy across a throttling valve. Since this is not the case in the present situation, it will not be considered further.

Three of the existing pumps are outfitted with 25.94" diameter impellers and two are pumps are equipped with impellers trimmed to 24" to save energy when lower flow rates are practicable The existing pumps can accommodate a maximum impeller diameter of 28 inches. At 880 RPM with the existing impellers, the pumps can produce a maximum head of 175 feet at shutoff. By changing impellers to the largest possible (28"), the maximum head attainable is 210 feet (at shutoff). Figure 8-1 shows approximate pump performance curves for the existing pumps. The curves for the 25.94" impeller were taken from test data on the pumps taken on March 3, 1986. The curves for the 28" impeller were generated from the manufacturer's performance curves. The horsepower curves are represented by approximate data and are for reference purposes only. They are slightly inaccurate due to the fact that the pump efficiency varies across the flow spectrum.

FORCE MAIN

The force main has been in continuous service since 1958. During the Seventh Addition construction in 1985, the force main was taken out of service to make the connection to the new pump station. The force main was entered for inspection at that time and found to be in excellent "like new" condition. The pipe showed no signs of structural deterioration; a very thin slime layer was observed coating the interior pipe wall. This layer was easily scraped off and did not appear to be affecting the piping. The cement coating under the slime layer was smooth and sound. It is reasonable to assume that the existing force main will provide the District with reliable service through the planning period of this study.

The system curves in all figures in this tech memo have been based on the Hazen-Williams equation of the form:

$$h_f = 10.44 * L * \frac{(GPM)^{1.85}}{(C)^{1.85} * (D)^{4.8655}}$$

where:

h_f = friction head loss; feet of water

L = length of pipe; feet
GPM = flow rate; gpm
C = Hazen-Williams roughness factor; dimensionless
D = pipe diameter; inches

The pipeline length was taken as 26,301 feet based on stationing information provided by MMSD. The elevation difference between the end of the pipeline and the beginning is 81.4 feet based on the same stationing information. Therefore, the total dynamic system head is the sum of a static head of 81.4 feet and pipe friction losses at various flows derived from the Hazen-Williams equation. A high level in the effluent storage reservoirs would increase the suction head available and therefore decrease the total dynamic head. That effect, however, will be ignored in order to be conservative and provide sufficient pump head under the worst case conditions. Figure 8-2 shows system curves for three different "C" values which are in the range of possibilities for concrete cylinder pressure pipe. Generally accepted "C" values for concrete pressure pipe range from 152 to 85 depending on pipe age, condition, and quality of construction. The 1980 CH2M HILL report refers to test data recorded during pump tests on March 13, 1974. The results of that test indicated a "C" value for the force main of 130. The apparent "C" factor of the force main was the subject of a recent analysis by the District (see attached MMSD memo). On the basis of this analysis the apparent "C" factor of the existing force main is in the range of 115 to 120. This tech memo is based on an assumed "C" value of 115 to be conservative.

The effluent force main is routed over a total of eight high points or "summits". Pressure and vacuum relief valves have been installed in the pipeline at each summit to relieve the vacuum conditions caused by water column separation upon pump shutdown (failure or otherwise).

The existing effluent force main is comprised of three different classes of pipe. All three are rated for 100 psi operating pressure plus a 40% allowance for surge, and 10 feet of water vacuum. They are different only in that they are designed for 6, 12, and 20 feet of cover. Figure 8-2 shows that the head required to pump 120 mgd through the existing pipeline is 281 feet of water (122 psi) using C=115. Since the existing pipeline is rated for 100 psi, part of any solution must be to reduce the system head to below 100 psi (230 feet) at a 120 mgd flow rate.

SURGE CONSIDERATIONS

A preliminary surge analysis was performed on the existing pipeline at flow rates of 76 and 120 mgd. The analyses assumed that the existing pressure and vacuum relief valves would be allowed to open at their set points. At a flow rate of 76 mgd, the transient pressures remained within acceptable limits. Addition of a small surge tank (1759 cubic feet) to the pipeline would completely dampen the transient and reduce the peak surge pressure to 71 psig. Estimated cost for the surge tank is $62,000 (material only).

The analysis for the 120 mgd flow condition was performed assuming that the sections of pipe nearest the effluent pump could withstand 122 psi operating pressure which is the system head for the single force main at C=115. The result of the analysis was the addition of two hydro-pneumatic surge tanks with a total volume of 5728 cubic feet. Essentially, the surge tanks completely dampened the positive pressure surge and held peak system pressure to its initial value before pump power failure. Estimated cost of the two surge tanks is $204,000 (material only). Since it would not be good engineering practice to operate the pipeline above its operating pressure rating (even considering the 40% surge allowance), the system head at the 120 mgd flow must be reduced by some means in addition to the surge protection.

PRESENT SYSTEM CAPABILITIES

Figure 8-3 shows the approximate operating points of the pumping system as it presently exists. Inspection of Figure 8-3 reveals a total pumping capacity of approximately 70 mgd (assuming C=115) with all five pumps in operation. Actually, the maximum pumping capacity occurs with only the three pumps with the 25.94" impellers in operation. The combined curve for these three pumps intersects the system curve (C=115) above the shutoff head for the pumps with the 24" impellers.

Figure 8-4 shows the pump & system capabilities (neglecting surge) with the existing pump impellers changed to 28" running at 880 RPM. A total pumping capability of approximately 90 mgd is possible with larger (the largest) impellers.

IDENTIFICATION OF ALTERNATIVES

There are several alternatives evaluated, each resulting in a flow rate of 120 mgd in the effluent pipeline. Some scenarios involve five effluent pumps and some involve six. The five pump alternatives require each pump to deliver 16,666 gpm for a total flow of 120 mgd, while the six pump arrangements demand 13,889 gpm from each pump. The following table summarizes the points of possible pump operation for the existing pumps at a total flow rate of 120 mgd.

Pump Head Capability(FT)			
No. Pumps	GPM (EA.)	Impeller Size (IN)	
		25.94*	28
5	16,666	150	185
6	13,889	162	195

@ 880 rpm & 120 mgd total flow
* existing impeller size

The solutions considered all involve reducing the pumping head required at the effluent pump station to 230 feet (100 psi) or below. Three general means to accomplish this are considered. A booster pump station could be built in the existing pipeline so that the main effluent pumps only have to generate enough head to reach the booster station (112 ft.). The booster pumps would then supply the pump energy required to reach the end of the pipeline. Alternately, an additional pipeline can be built parallel to the existing pipeline. A full length parallel pipeline would lower the system head the most, while various partial lengths would decrease the system head lesser amounts with the shortest partial length parallel pipeline lowering the system head to 230 feet (existing pipeline pressure rating). Another solution would be to leave the existing effluent transmission system as is and provide additional effluent storage volume onsite. The storage facility would provide equalizing volume for peak flow events.

As stated earlier, the latest data available supports a Hazen-Williams "C" factor of 115 for the existing 54" effluent force main. A number of the alternatives identified involve new lengths of concrete cylinder pressure pipe which will be assumed to have a "C" factor of 115 for the sake of consistency and to be conservative. The alternatives and effects of each are outlined below:

1. Construct a booster pump station in the existing pipeline.

   A. Complex bypass system required
   B. High cost; both capital and O & M
   C. Additional surge control required
   D. Off site maintenance required
   E. Not redundant; compound probability for failure
   F. Large investment for small probable utilization

2. Construct a partial length 54" force main parallel to the existing 54" force main (P1-P5).

(P1) A. Parallel existing pipeline until required pump head drops to 230 ft (100 psi) @ 120 mgd.

1. Requires 9343 ft. parallel pipe
2. Requires replacing existing effluent pumps

(P2) B. Parallel existing pipeline until required pumping head drops to 195 ft @ 120 mgd.

1. Requires 15,710 ft parallel pipeline
2. Requires replacing existing effluent pump impellers
3. Requires adding a sixth pump to the effluent pump system.
4. Runs existing effluent pump motors safely (2%) into their service factor.

(P3) C. Parallel existing pipeline until required pump head drops to 185 ft @ 120 mgd.

1. Requires 17,530 ft parallel pipeline
2. Requires replacing existing effluent pump impellers
3. Runs existing effluent pump motors safely (10%) into their service factors.

(P4) D. Parallel existing pipeline until required pump head drops to 162 ft @ 120 mgd.

1. Requires 21,714 ft parallel pipeline
2. Requires no modifications to existing effluent pumps
3. Requires adding a sixth pump to the effluent pump system

(P5) E. Parallel existing pipeline until required pump head drops to 150 ft. @ 120 mgd.

1. Requires 23,897 ft. parallel pipeline
2. Requires no modifications to existing pumps

(P6) F. Construct a full length (26,301 ft) 54" force main parallel to the existing 54" force main.

1. Can use existing effluent pumps without modification
2. No additional surge control devices are required
3. Provides a redundant system

3. Construct an effluent storage facility onsite to provide equalizing volume for peak flow events.

A. Utilizes existing effluent transmission system without modifications.

B. Provides a low maintenance backup system that is simple to operate.

C. Requires a storage volume of about 20 million gallons.

EVALUATION OF ALTERNATIVES

The fundamental choice to achieve a 120 mgd transmission capacity is between building a booster pump station at some location in the pipeline and building a pipeline of some length parallel to the existing pipeline. A third alternative would leave the transmission capacity as is in lieu of onsite equalizing volume. The ramifications of each alternative are discussed briefly below.

Since the existing effluent pumps will reach their 20 year service life in the year 2006, all alternatives (except P1) include a major rebuild of the effluent pump station at the midpoint of the 20 year planning period. As explained later, alternative P1 involves replacing the main effluent pumps; therefore a major rebuild in year 2006 is not required for that alternative.

The force main terminates at an outfall aerator that discharges to the Badfish Creek. Tech Memo 8A contains an analysis of the outfall aerator and its capacity to maintain a minimum dissolved oxygen concentration of 5mg/l. The existing aerator structure can probably perform acceptably up to flow rates in the range of 75 - 80 mgd. Significant modifications to the aerator would be required to handle flow rates up to 120 mgd. In this Tech Memo, for all alternatives that upgrade the effluent transmission system to 120 mgd, costs are included for the addition of a second parallel aerator structure at the force main outfall.

BOOSTER PUMP STATION (BPS)

This section will discuss the construction of a booster pump station in the existing pipeline at station 149+01. This location was chosen as optimal in order to utilize the existing effluent pumps to their capacity without modification as well as to provide sufficient suction head for the booster pumps. This arrangement would minimize the head that the booster pumps must operate at and therefore pump size and capital investment. Figure 8-5 plots the elevation along the pipeline, pipe friction loss, and total head versus distance from the main effluent pump station. It is useful in evaluating the optimal position for the booster station in the pipeline. In order to pump at a rate of 120 mgd, each of the five existing effluent pumps must deliver 16,666 gpm. The effluent pumps are capable of 150 ft of head @ 16,666 gpm with the existing impellers running at 880 rpm. As Figure 8-6 points out, at 120 mgd the system head at station 149+01 is 112 ft, leaving 38 ft net positive suction head available to the booster pumps.

The booster pump station itself would consist of a building of approximately 10,000 square feet. It would house three 30 inch horizontal split case pumps each with a 1000 HP motor (preliminary design). Additionally, a manifold and valve arrangement would be required to bypass the booster pumps under normal flow conditions. Figure 8-7 schematically illustrates the booster pump arrangement. The pumps and valves would all have to operate automatically and be controlled from the NSWWTP. Depending on the actual location of the booster pump station, it is possible that variable speed drives may be required for the booster pumps due to low head conditions at pump start-up.

The electrical demand to run the pumps is very high and the probability that they run is very low. Even if they do run, it will be for a very short period of time. Madison Gas & Electric Company (MG&E) will have a very large investment in equipment to service the pump station with little if any opportunity to collect revenue. For this reason, MG&E estimates that they would have to charge the MMSD a standby fee on the order of $200,000 per year. If the Booster Pump Station remains a viable alternative, it would be wise to look into the possibility of running the pumps with diesel, natural gas, or propane powered reciprocating engines rather than electric motors to avoid this standby demand charge.

The booster pump system is complex by its nature. It provides no redundancy and actually compounds the possibility of malfunction in the effluent discharge system. It also introduces the possibility of power failure causing surge conditions at two different locations. Maintenance could be troublesome and costly since the station would be located approximately 3 miles from the NSWWTP. Table 8-1 outlines the major cost elements of the booster pump station. Generally speaking, at a present worth cost of $11.8 million, this solution is the costliest and provides the least flexibility.

PARTIAL OR FULL LENGTH PARALLEL PIPELINE (ALTERNATIVES P1-P6)

The objective of each of these alternatives is to lower the system head at a flow rate of 120 mgd to a value either below the pipe pressure rating or to a value which the existing effluent pumps are capable of producing with various modifications. As expected, as the parallel pipeline length increases, the cost of the pipeline increases and pumping head and the extent of the pump modifications required decrease. Figure 8-8 shows the system head curves resulting from implementation of the various parallel pipeline alternatives. Each alternative yields some savings in electric power due to decreased pump head at all flows. The estimated savings (versus the existing single pipe) at the average daily flow (weighted per Tech Memo #3) are computed and reported for each alternative.

This memorandum assumes that the parallel force main would be 54" diameter for all cases considered. It is the same size as the existing force main and simplifies calculations. The 54" size provides a representative cost for the project as minor variations in pipe size (+/- 6") would change the project cost less than 10%. An optimization study should be performed in the event that a parallel force main option is chosen.

A residential subdivision has been built near station 80 at the intersection of Meadowview & Clayton roads. The existing effluent force main runs through the subdivision and several dwellings have been built very near the easement for the force main. Options P2 - P6 require a pipeline parallel to the existing force main. Rather than attempt to route the new parallel pipeline through the subdivision near dwellings, options P2 - P6 detour the pipeline down Meadowview and Clayton roads and eventually meet the existing pipe. The detour adds about 3000 feet of pipe (and additional head loss) to options P2 - P6. Although the additional head loss resulting from the extra pipe has not been accounted for, rough calculations estimate a value of about 4 feet of water. The P6 option may require an additional 3000 foot detour due to the pipeline location in the "Oregon Heights" residential subdivision. The estimate assumes that the detour is required.

The discussion below will analyze the tasks involved in each alternative, the economics of each, and attempt to point out intangible benefits. Table 8-2 summarizes the options and estimated construction and operation and maintenance costs. The costs in Table 8-2 assume a 20 year study period with the various equipment depreciated appropriately for the study period.

Alternative P1

This option involves building a pipeline of 9,343 ft in length, the shortest of the six options. With this pipeline in place, the system head at 120 mgd is 230 ft (100 psi). The length and pressure were determined based on the pressure limitations of the existing pipe. The existing pumps cannot operate at 230 ft of head (even with the largest impellers); consequently, they would have to be replaced. For the sake of simplicity, it was assumed that the pumps and motors would be replaced, although it is possible that the existing motors may be suitable for the new pumps. This arrangement will result in a savings in power over the existing force main of approximately $15,360 annually.

Alternative P2

This option involves building a pipeline of approximately 15,710 ft. in length. The total length of installed pipeline would be about 18,710 ft. due to the detour around the residential area. Under this scenario, the system head drops to 195 feet @ 120 mgd. Each of the five existing pumps would be required to have new larger impellers (28") installed in order to produce 195 feet of head. A sixth pump with a 28" diameter impeller would also have to be installed to produce a flow rate of 120 mgd. The estimated annual savings in electrical energy is $25,828.

Alternative P3

This option involves a parallel pipeline 17,530 ft in length for a pipe length of 20,530 feet due to the rerouting of the pipeline. The system head drops to 185 feet @ 120 mgd flow. The five existing effluent pumps can handle the 120 mgd flow, however the impellers have to be changed to the largest size possible (28"). At pumping conditions of 120 mgd total and 185 feet of head, the brake horsepower required is 880 HP from each of the five motors. The 800 HP motors have a service factor of 1.15, so this arrangement runs the motors safely into their service factor. Obviously, an analysis of the motor controls and protective devices would have to be performed to be certain that they are properly set. Since a new pump is not required, the cost for this option is actually less than the P2 option. Annual electric power savings amount to approximately $28,819.

Alternative P4

This option involves building a parallel pipeline 21,714 feet in length for a total pipe length of 24,714 feet due to the rerouting. The system head is 162 feet @ 120 mgd flow. Three of the five existing effluent pumps will not have to be modified; however, the two 24" impellers would have to be replaced with 25.94" impellers, and a sixth pump with a 25.94" diameter impeller would have to be added to attain a 120 mgd system flow rate. The annual electric power savings is $35,698.

Alternative P5

This option involves building a parallel pipeline of 23,897 feet in length for a total pipe length of 26,897 feet due to the rerouting. The system head drops to 150 feet @ 120 mgd under this scenario. Three of the five existing effluent pumps will handle the flow and head without modification. The two pumps with the 24" impellers will need to be retrofitted with 25.94" impellers. Annual electric power savings amount to approximately $39,287.

Alternative P6

This option involves building a parallel pipeline of the entire length with its own discharge to the outfall ditch. The system head drops to 137 feet @ 120 mgd flow. The five existing effluent pumps will handle the flow and head without modification. Expected annual electric power savings are $43,239. There are several advantages to this system. It consists of two independent effluent force mains which would allow continuous pumping during repair or cleaning of one of the mains. There are less valves required and the valves that are required would all be located at the NSWWTP and not at some remote site dependent on communications for operation.

ONSITE EFFLUENT STORAGE (OSS)

The sludge lagoons east of the NSWWTP are no longer in service and are in the process of being cleaned out. The rehabilitation and future use of the sludge lagoons are discussed in Tech Memo No. 10. A portion of the rehabilitated lagoons could be used to provide equalizing storage during an overflow event. Figure 8-9 depicts this alternative.

The existing 72 inch overflow from the effluent reservoirs would be diverted to a 17 acre section at the west end of the lagoons. The storage lagoon would hold 20 million gallons of treated effluent overflow at a depth of about 4 feet. The effluent overflow would be returned to the treatment plant secondary effluent channel through a new pump station and force main some time after the storm event. The effluent would be pumped at a controlled rate of 1000 gpm and would then pass through UV disinfection prior to discharge through the existing force main. A second option would be to release the stored effluent overflow to the adjacent wetland in a controlled manner.

Table 8-3 is a summary of the costs for onsite effluent storage. Utilizing the rehabilitated lagoons for emergency effluent storage reduces the construction costs for this alternative so that it becomes the least cost solution by far.

RECOMMENDED ALTERNATIVE

Table 8-4 presents a summary of the present worth cost for the eight alternatives considered. Based on cost and benefit provided, the booster pump station is easily eliminated. Any of the parallel pipeline options presented will allow pumping of

120 mgd, however some of the options have funds directed to more effective areas.

Of the alternatives to increase the effluent transmission capacity, option P1 has the lowest cost. However, the existing effluent pumps are relatively new (1986) and certainly have many years of service left in them. Option P1 calls for replacing them at a cost of $657,500. That same $657,500 could install over 3,600 feet of 54" pipe to lower the system head. It is likely that the MMSD will have to continue pumping effluent to Badfish Creek through the 20 year planning period. The existing effluent force main is 37 years old and could be nearing the stage where repairs will become necessary more often. A longer parallel main would increase the chances that any area requiring repair would have a parallel force main section already in place. Effluent could then be rerouted around the area needing repair so that the flow would be uninterrupted.

Option P3 is the most cost effective of the parallel pipeline alternatives. It avoids directing funds towards new pumps and controls and instead routes the funds toward a longer parallel effluent force main. If required in the future, the pipeline could be completed to full length for an additional $2.1 million (approximate). By contrast, the completion of a full length parallel force main having already installed the P1 option would cost approximately $4 million.

The best alternative by far is to construct provisions for additional onsite effluent storage in the rehabilitated sludge lagoons. As table 8-4 shows, its present worth cost is less than one half of any other feasible alternative. The construction cost is only $352,000; less than 6% of any other feasible alternative. The small capital investment associated with this alternative will allow the District to keep funds available for other plant improvements. Should the District discontinue pumping to Badfish Creek in the future for any reason, it will not have abandoned a large capital investment with many years of service life remaining.

TABLE 8-1: PRESENT WORTH COST FOR BOOSTER PUMP STATION ALTERNATIVE

ITEM	QTY	MATERIAL	LABOR	TOTAL	NOTES
54" Header	1	$75,000	$10,000	$85,000	Fabricated
54" Knife Gate valve	1	$53,000	$5,000	$58,000	DeZurik model "F"
54" Knife Gate valve w/act	2	$67,000	$6,000	$146,000	DeZurik "F" w/Auma
30" Pump discharge valve	4	$32,000	$5,000	$148,000	DeZurik Pumpcheck
Pumps - main	3	$465,000	$10,000	$1,425,000	Fairbanks 5823 - 30"
Pump - standby	1	$465,000	$10,000	$475,000	Fairbanks 5823 - 30"
Pump foundation	4	$5,000	$0	$20,000	28 cu yds each
Pipe support bases	30	$200	$0	$6,000	0.5 cu yds each
Piping (ft)	500	$80	$50	$65,000	
Pipe saddles	30	$600	$100	$21,000	
Building (sq. ft.)	10000	$170	$0	$1,700,000	
Land (acres)	1	$20,000	$0	$20,000	
Road (sq yd)	250	$20	$0	$5,000	
New Electric Service (ft)	4000	$50	$5	$220,000	
Transformer, pad mounted	1	$45,000	$5,000	$50,000	13.8KV/4.16KV; 3000KVA
Switchgear & Motor Controls	4	$100,000	$25,000	$500,000	
Variable Frequency Drives	4	$250,000	$5,000	$1,020,000	Req'd due to low head at start up
Telemetry/ Communications	1	$75,000	$25,000	$100,000	
Surge Protection	2	$102,000	$25,000	$254,000	Two tanks, 10'dia. x 38.8 ft
Effluent Aeration Structure	1	$50,000	$50,000	$100,000	
Connect to existing pipeline	1	$60,000	$25,000	$85,000	Excavation, tapping, etc.
SUB TOTAL				$6,503,000	
Construction Contin. (15%)				$975,450	
Engineering & Admin (10%)				$650,300	
TOTAL CONSTRUCTION				$8,128,750	
Annual maint. cost (1%)				$74,785	
Present worth cost				$720,923	
Standby power cost (annual)				$200,000	
Present worth cost				$1,928,000	
Pumping power cost (annual)*				$250,395	
Present worth cost				$2,413,808	
TOTAL O&M PRSNT WRTH COST				$5,062,730	
Depreciation, 40yr, bldgs & valves only				$1,101,000	
SALVAGE VALUE - Present Worth				*$225,595*	
Main pump st. rebuild; year 2008					
Pumps & motors	5	$91,500	$10,000	$507,500	
Misc. electrical	5	$25,000	$5,000	$150,000	
Total				$657,500	
Present Worth Cost				$297,585	
SALVAGE VALUE (dep 10yr of 20)P.W				*$67,361*	
GRAND TOTAL (P.W. COST)				$13,196,109	

*flows weighted per Tech Memo #3

TABLE 8-2: PIPELINE PRESENT WORTH COST COMPARISON

ITEM	ALTERNATIVE					
	P1	P2	P3	P4	P5	P6
PIPE LENGTH (FT)	9343	15710	17530	21714	23897	28301
DETOUR REQ'D?	N	Y	Y	Y	Y	Y (2)
TOTAL PIPE LENGTH (FT)	9343	18710	20530	24714	26897	32301
54" PIPE (FT)	$110	$110	$110	$110	$110	$110
LABOR (FT)	$70	$70	$70	$70	$70	$70
INSTALLED PIPE COST (FT)	$180	$180	$180	$180	$180	$180
PIPE COST (TOTAL)	$1,681,740	$3,367,800	$3,695,400	$4,448,520	$4,841,460	$5,814,180
PAVING REQ'D (SQ. YD)	53	1111	1156	1156	1156	1156
PAVING COST (SQ. YD)	$20	$20	$20	$20	$20	$20
PAVING COST (TOTAL)	$1,060	$22,220	$23,120	$23,120	$23,120	$23,120
VALVES (EA)	$53,000	$53,000	$53,000	$53,000	$53,000	$53,000
VALVES REQ'D	4	4	4	4	4	2
ACTUATORS (EA)	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000
ACTUATORS REQ'D	4	4	4	4	4	2
LABOR (TOTAL)	$50,000	$50,000	$50,000	$50,000	$50,000	$25,000
MANHOLES (TOTAL)	$10,000	$25,000	$30,000	$35,000	$40,000	$50,000
TOTAL ACCESSORIES	$332,000	$347,000	$352,000	$357,000	$362,000	$211,000
IMPELLERS (EA)	$30,500	$30,500	$30,500	$30,500	$30,500	$30,500
LABOR (EA)	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000
IMPELLERS REQ'D	0	5	5	2	2	0
IMPELLER COST (TOTAL)	$0	$187,500	$187,500	$75,000	$75,000	$0
PUMPS (EA)	$91,500	$91,500	$91,500	$91,500	$91,500	$91,500
PUMPS (REQ'D)	5	1	0	1	0	0
DISCH VALVES (EA)	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000
LABOR (EA)	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000
PUMP COST (TOTAL)	$657,500	$131,500	$0	$131,500	$0	$0
MOTOR CONTROLS (TOTAL)	$125,000	$125,000	$0	$125,000	$0	$0
SURGE TANKS (EA)	$102,000	$102,000	$102,000	$102,000	$102,000	$102,000
SURGE TANKS REQ'D	2	2	2	2	2	0
SURGE TANKS (LABOR)	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000
SURGE TANKS (TOTAL)	$254,000	$254,000	$254,000	$254,000	$254,000	$0
EFFLUENT AERATION STRUCTURE	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000
EASEMENT; TEMPORARY (100') **	$42,897	$85,904	$94,261	$113,471	$123,494	$148,308
EASEMENT; PERMANENT (50') **	$53,621	$107,381	$117,826	$141,839	$154,368	$185,382
SUB TOTAL	$3,247,819	$4,728,305	$4,824,107	$5,769,450	$5,933,442	$6,481,988
CONSTRUCTION CONTIN. (15%)	$487,173	$709,246	$723,616	$865,417	$890,016	$972,298
ENGINEERING & ADMIN (10%)	$324,782	$472,831	$482,411	$576,945	$593,344	$648,199
TOTAL CONSTRUCTION	$4,059,773	$5,910,381	$6,030,133	$7,211,812	$7,416,802	$8,102,485
ANNUAL POWER COST *	$235,035	$224,587	$221,578	$214,887	$211,108	$207,156
PRESENT WORTH COST	$2,265,737	$2,164,826	$2,135,993	$2,069,679	$2,035,081	$1,996,984
ANNUAL MAINTENANCE COST	$11,076	$11,076	$11,076	$11,076	$11,076	$11,076
PRESENT WORTH COST	$106,773	$106,773	$106,773	$106,773	$106,773	$106,773
TOTAL O&M PRSNT WRTH COST	$2,372,510	$2,271,599	$2,242,765	$2,176,452	$2,141,854	$2,103,758
PUMP ST REBUILD; YR 2008						
EA PUMP $131,500 TOTAL	$0	$526,000	$657,500	$526,000	$657,500	$657,500
PRESENT WORTH COST	$0	$236,088	$297,585	$236,088	$297,585	$297,585
SALVAGE VALUE (Dep 10 of 20) P.W.	*$0*	*$53,889*	*$67,361*	*$53,889*	*$67,361*	*$67,361*
SALVAGE VALUE Force main - P.W.	*$219,047*	*$426,331*	*$486,606*	*$559,195*	*$607,503*	*$727,089*
SALVAGE VALUE Pipe&Valves -P.W.	*$34,013*	*$35,550*	*$36,062*	*$36,575*	*$37,087*	*$21,617*
GRAND TOTAL (P.W. COST)	$6,179,223	$7,904,277	$8,000,454	$8,976,673	$9,144,289	$9,687,759

* flows weighted per Tech Memo #3

** Purchased land cost = $20,000/acre; temporary easement 10% purchase price; permanent easement 25% purchase price

APPENDIX E–TECHNICAL MEMORANDUM NO. 5
BIOLOGICAL NUTRIENT REMOVAL ALTERNATIVES EVALUATION

Technical Memorandum

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Prepared for: Madison Metropolitan Sewerage District

Project title: 2016 Liquid Process Facilities Plan

Project no.: 149052

Technical Memorandum 5, Version 4

Subject: Biological Nutrient Removal Alternatives Evaluation

Draft date: June 9, 2017

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List of Abbreviations

°C	degree(s) Celsius
ABAC	ammonia-based aeration control
A/O	anaerobic/oxic
AOB	ammonia-oxidizing bacteria
AP	acid phase
AVN	ammonia versus NO_x
BCE	business case evaluation
BNR	biological nutrient removal
BOD	biochemical oxygen demand
$CBOD_5$	5-day carbonaceous oxygen demand
CEPT	chemically enhanced primary treatment
CFD	computational fluid dynamics
cfm	cubic foot/feet per minute
CHP	combined heat and power
CO_2	carbon dioxide
COD	chemical oxygen demand
d	day(s)
DO	dissolved oxygen
DT	dry ton(s)
EBPR	enhanced biological phosphorus removal
EPDM	ethylene propylene diene monomer
$FeCl_3$	ferric chloride
ft^2	square foot/feet
g	gram(s)
GBT	gravity belt thickener
GHG	greenhouse gas
gpd	gallon(s) per day
HCl	hydrogen chloride
hp	horsepower
Hz	hertz
IMLR	internal mixed liquor recycle
kW	kilowatt(s)
kWh	kilowatt-hour(s)
L	liter(s)
lb	pound(s)
MBBR	moving-bed biofilm reactor
MCRT	mean cell residence time
mg	milligram(s)
MG	million gallons
$MgCl_2$	magnesium chloride
mgd	million gallons per day
mL	milliliter(s)
MLR	mixed liquor recycle
MLSS	mixed liquor suspended solids
MMSD	Madison Metropolitan Sewerage District
N	nitrogen
N_2O	nitrous oxide
N/A	not applicable
NH_3-N	ammonia-nitrogen
NO_2-N	nitrite
NO_3-N	nitrate
NOB	nitrite-oxidizing bacteria
NO_x	nitrate plus nitrite (liquid stream)
NO_x-N	nitrate + nitrite
NPDES	National Pollutant Discharge Elimination System
NSWWTP	Nine Springs Wastewater Treatment Plant
O&M	operations and maintenance
PO_4-P	phosphate phosphorus
psi	pound(s) per square inch
psig	pound(s) per square inch gauge
PTFE	polytetrafluoroethylene
PVC	polyvinyl chloride
RAS	return activated sludge
rpm	revolution(s) per minute
SAM	Sustainable Action Map
scfd	standard cubic foot/feet per day
scfm	standard cubic foot/feet per minute
SLR	solids loading rate
SOTE	standard oxygen transfer efficiency
SPA	state point analysis
SRT	solids retention time
SVI	sludge volume index
SWD	sidewater depth
TBD	to be determined
TKN	total Kjeldahl nitrogen

TM	technical memorandum
TN	total nitrogen
TOC	total organic carbon
TP	total phosphorus
TSS	total suspended solids
UCT	University of Cape Town
UV	ultraviolet
UW	University of Wisconsin
V	volt(s)
VFA	volatile fatty acid
VFD	variable-frequency drive
WIN	Watershed Improvement Network
WPDES	Wisconsin Pollutant Discharge Elimination System
WWTP	wastewater treatment plant

Executive Summary

The following five biological nutrient removal (BNR) alternatives were evaluated to accommodate projected growth through 2040, address potential future nutrient discharge requirements, and minimize energy demands at the Nine Springs Wastewater Treatment Plant (NSWWTP):

- Alternative 1 - Existing Modified University of Cape Town (UCT)
- Alternative 2 - UCT
- Alternative 3 - UCT with Sidestream Deammonification
- Alternative 4 - Main Stream Nitrite Shunt
- Alternative 5 - Chemically Enhanced Primary Treatment (CEPT) with Main Stream Nitrite Shunt

Alternative 1 - Modified UCT, is capable of reducing effluent discharges below the current permit limits while Alternatives 2 through 5 are targeted at achieving current permit discharge limits plus reducing total nitrogen (TN) discharges.

Blower and aeration system upgrades associated with these alternatives should generally be staged to benefit from coordination with future BNR and energy upgrade projects. A proposed phasing strategy for these upgrades, which was developed to complement Madison Metropolitan Sewerage District's (MMSD's) asset management and sustainability goals, is presented in Table ES-2 below.

Process Evaluation Results

Process evaluations show that the existing BNR aeration basin and secondary clarifier tankage are sufficient for Alternatives 1 through 3 (modified UCT and UCT) provided that capability to route flows greater than 110 million gallons per day (mgd) to Pass 3 are provided to minimize the secondary clarifier solids loading rates (SLR) during wet weather events (see Alternative PF10: High Rate Treatment at NSWWTP, presented in Technical Memorandum [TM] No. 4, Peak Flow Management, prepared by Strand Associates and Brown and Caldwell, dated September 2016). Alternatives 4 and 5 (nitrite shunt) require that two additional secondary clarifiers be added to the West plant to reduce secondary clarifier SLRs to acceptable levels during wet weather flows. Confirmation of the secondary clarifier solids loading rate (SLR) capacity is recommended via stress testing and subsequent computational fluid dynamics (CFD) analysis to confirm the maximum allowable SLR as increasing the assumed SLR capacity could eliminate one or both of the additional secondary clarifiers.

Process modeling also showed that the conventional Alternative 2 and 3 UCT flow schemes could reduce annual effluent TN discharges to approximately 15 milligrams per liter (mg/L) without supplemental carbon. Roughly 2,000 gallons per day (gpd) to 2,500 gpd of methanol is required to reduce annual TN discharges below 10 mg/L at 2040 flows and loadings. Adding sidestream deammonification is not cost-effective because new sidestream process tankage is needed and the Ostara effluent composes only 10 to 15 percent of the plant influent ammonia loading. In contrast, sidestream deammonification is typically cost-effective when the sidestream ammonia loading is roughly 25 to 30 percent of the influent load and existing tankage is available for use. If sidestream nitrogen loadings increase from changes in plant operations, increase in hauled food waste to the digesters, or equal, sidestream deammonification should be reconsidered. Conversely, Alternative 4, Main Stream Nitrite Shunt, can reduce annual TN discharges below 10 mg/L without carbon addition. Process evaluations for the recommended alternative(s) should be updated in detailed design based upon the BioWin™ model validation recommended in TM 5a, Wastewater Characterization and BioWin Calibration, prepared by Brown and Caldwell, dated November 11, 2016, using a minimum of 3 months of daily plant operating data and dynamic simulations that incorporate the plant influent average, maximum month, maximum week, and maximum day daily and diurnal flow and loading conditions.

Cost Comparison

Table ES-1 presents the estimated capital, operating, and net present worth for each alternative, plus the Null alternative, which maintains operations of current blower and diffuser assets. Capital costs in Table ES-1 (excluding the Null alternative) are based upon replacing the existing aeration diffuser system with fine-pore membrane disc diffusers. A net present worth evaluation of membrane disc and membrane strip diffusers shows that membrane disc diffusers have a lower capital cost and equivalent to lower life-cycle cost. Alternatives 2 and 3 (UCT and UCT with Sidestream Deammonification) capital costs are dominated by the addition of anoxic zones (mixers, mixed liquor pumping, and other tank retrofits) while Alternatives 4 and 5 (Main Stream Nitrite Shunt and CEPT with Nitrite Shunt) capital costs are associated primarily with adding two new secondary clarifiers to the West plant. Alternative 4 operating costs are significantly lower than those for other alternatives as a result of reduced aeration demands and no additional carbon (methanol or equal) required to achieve the target effluent criteria. Alternative 4's life-cycle cost is approximately 50 percent of the other TN reduction alternatives and double the Null alternative. If the two additional clarifiers can be deleted from Alternative 4 requirements, Alternative 4's life cycle would be roughly equal to the Null alternative.

Table ES-1. NSWWTP BNR Alternatives Net Present Worth Comparison

Item	Alternative, Costs in Millions					
	1: Existing Modified UCT (Null Alternative)	1: Existing Modified UCT	2: UCT	3: UCT with Sidestream Deammonification	4: Nitrite Shunt	5: CEPT with Nitrite Shunt
Predicted annual TN discharge, mgN/L	20	20	8[c]	8[b]	7.5	12
Capital cost						
Existing blowers	$0	$4.1	$16.8	$21.7	$18.4	$19.3
New blowers[a]	$0	$8.6	$21.3	$26.2	$22.8	$23.7
Operating cost[b]						
Existing blowers	$16.5	$13.5	$48.3	$45.7	$12.3	$30.2
New blowers	$10.3	$8.0	$43.5	$41.5	$7.4	$25.3
Increased biogas production and reduced natural gas	$0	$-0.1	$-0.05	$-0.1	$-0.8	$-3.0
Life-cycle cost estimate						
Existing blowers[c]	$16.5	$17.0	$65.1	$67.3	$29.8	$46.6
Deferred clarifier addition[d]	N/A	N/A	N/A	N/A	$17.8	$34.5

a. *Near term energy-saving blower modifications (one new west blower, two new east blowers).*

b. *Operating costs include blower and non-blower energy, chemical costs, and other O&M costs. Refer to Table 5-4.*

c. *Predicted annual TN discharge with carbon addition.*

d. *Net present worth estimate for scenario in which clarifier stress testing finds that clarifier addition is not required prior to the end of the planning period in 2040. This estimate includes excludes $7,700,000 in clarifier capital costs and $3,900,000 in related contingency and technical services from the base case estimate.*

Proposed BNR and Aeration System Renewal Strategy

Alternative 4, Main Stream Nitrite Shunt, offers significant operating cost, environmental, and other non-monetary benefits over Alternative 1, Existing Modified UCT, operation and other nutrient reduction alternatives. However, main stream nitrite shunt is an emerging technology with only one U.S. cold weather application operating at temperatures less than 15 degrees Celsius (°C), presenting greater risk than the UCT-based alternatives. MMSD is starting a bench-scale nitrite shunt pilot study to confirm the nitrite shunt functionality and kinetic parameters. If pilot testing is successful and additional analysis in detailed design confirms the estimated savings, full scale nitrite shunt demonstration testing is recommended.

Table ES-2 illustrates the recommended approach for moving forward with BNR facility implementation, with related staging for diffuser and blower improvements. It is recommended that MMSD pursue Alternative 4, Main Stream Nitrite Shunt, via strategic research and phased implementation in the near term as future nutrient removal requirements are established. In order to realize the forecasted aeration and carbon cost savings from nitrite shunt operation, turndown limitations must be relieved, either by cross-connecting the east and west aeration systems or by replacing at least one west blower. Other blower and diffuser improvements can be phased in as decision points are reached regarding the ultimate BNR upgrade strategy.

If nitrite shunt research and full-scale pilot testing are not successful, Alternative 2, UCT, with carbon addition, would be recommended if MMSD is required to reduce TN discharge below 10 mg/L. If the TN discharge limit is 20 mg/L, the UCT process could be operated without carbon addition.

Table ES-2. NSWWTP BNR Alternatives Phasing Strategy

Item	Approach	Timing	Justifications
BNR strategy	Nitrite shunt bench testing	Ongoing	• Evaluate cold weather performance • Improve accuracy of process modeling parameters
	Nitrite shunt full-scale demonstration in one plant	Following bench testing	• Verify cold weather performance • Confirm process modeling parameters • Confirm effluent quality • Gain experience with ammonia vs. NO_x (AVN) automated controls and sensors
	NSWWTP BioWin validation and design update	Predesign	• Validate steady-state model calibration using dynamic conditions and confirm selected alternative(s) preliminary design evaluations
	Secondary clarifier stress test	Predesign	• Determine whether additional secondary clarifiers will be triggered by growth, especially under increased SVI associated with nitrite shunt • Improve accuracy of BNR alternative evaluation
	Plant-wide implementation of nitrite shunt	Following demonstration, if successful	• Energy reduction • Effluent quality improvement
	Post-aeration improvements	Concurrent with plant-wide nitrite shunt	• Meet effluent DO requirements under high flow conditions
	UCT process improvements	If future permit requires	• Implement only if nitrite shunt testing is unsuccessful or permit limits are lower than predicted nitrite shunt effluent quality • Proven TN removal process
Diffusers	PVC condition evaluation	Near term	• Informed risk evaluation of continued near-term use of ceramic diffuser system

Table ES-2. NSWWTP BNR Alternatives Phasing Strategy

Item	Approach	Timing	Justifications
	Replace diffusers in one plant with membrane disc diffusers	Concurrent with nitrite shunt demonstration	• Match diffuser density to nitrite shunt process airflow requirements • Designed for expansion if demonstration is unsuccessful • Facilitate low DO operations and precise DO control • Life-cycle procurement to optimize diffuser energy performance
	Replace diffusers in remaining plant	Concurrent with plant-wide BNR improvements	• Match diffuser density to process airflow requirements based on final BNR configuration • Accelerate diffuser replacement if evaluation suggests embrittlement or other PVC flaws
Blowers	Replace one west blower	Near term	• Reduce failure risk • Reduce energy consumption through improved blower efficiency and reduced turndowns • Blower sizing
	Install east-west cross-connect piping	Near term	• Reduce blower energy consumption by minimizing or eliminating blower 4/5 run time and reducing over-aeration in west plants • Provide redundancy between east and west blower systems
	Replace two east blowers [a]	Concurrent with CHP project	• Coordinate new blower sizing with ongoing BNR improvements and phase-out of blower 1

a. East blower replacement not required if cross-connection piping is installed.

Section 1: Introduction

The objectives of this technical memorandum (TM) are to present an evaluation of biological nutrient removal (BNR) alternatives to improve nutrient removal, accommodate influent load growth, and consider how renewal of the existing aeration system components should be coordinated with these improvements.

The recommended improvements present an opportunity to improve sustainability by reducing energy use as well as improving effluent quality. In the Sustainable Action Map (SAM) Alternatives Summary for Liquid Stream Treatment prepared by Strand and Brown and Caldwell, dated June 2016), the following five BNR alternatives were selected for further evaluation:

- Alternative 1 - Existing Modified University of Cape Town (UCT)
- Alternative 2 - UCT
- Alternative 3 - UCT with Sidestream Deammonification
- Alternative 4 - Main Stream Nitrite Shunt
- Alternative 5 - Chemically Enhanced Primary Treatment (CEPT) with Nitrite Shunt

These alternatives differ in their ability to reduce effluent TN discharges. Alternative 1, Modified UCT, which also includes East Plant 1’s two anaerobic/oxic (A/O) trains, is capable of achieving current permit limits identified below in Section 2.2 but does not address reducing effluent TN discharges. In contrast, Alternatives 2 through 5 are targeted at achieving current permit discharge limits plus reducing TN discharges.

Following this introductory section, this TM presents this evaluation in the following sequence (numbered by section):

2. Basis of Evaluation
3. BNR Alternative Descriptions
4. BNR Process Aeration Requirements
5. BNR Cost Comparison
6. BNR Non-Economic Evaluation
7. Recommended BNR Alternative
8. Blower Evaluation
9. Aeration Controls
10. Enhanced Phosphorus Reduction
11. Recommendations

Section 2: Basis of Evaluation

This section provides the basis of evaluation for the BNR alternatives evaluation. A summary of the key design criteria is provided, including the flows and loadings, effluent water quality, process modeling, secondary clarifiers, and peak flow management.

2.1 Design Flows and Loadings

This evaluation uses the Year 2040 projected influent flows and loadings presented in TM No. 2b. For facility evaluation, three loading conditions were considered to define system requirements:

- Condition 1: Maximum month flows and loadings at the minimum month temperature to establish the mixed liquor suspended solids (MLSS) concentration for aeration basin/secondary clarifier sizing and peak aeration demands in latter zones of the aeration tank
- Condition 2: Maximum month flows and loadings at the maximum month temperature to define the peak aeration system demands
- Condition 3: Annual average flows, loadings, and temperature to define annual operating conditions

Table 2-1 summarizes the flows and loadings used in this evaluation. The influent wastewater characteristics established in TM No. 5a, were used in this evaluation. The design temperatures are based on historical daily effluent temperatures from January 1, 2013, through April 28, 2016 (influent temperatures are not available). Figure 2-1 shows the seasonal changes in effluent temperatures. For evaluation purposes, the maximum, minimum, and average monthly temperatures of 22, 11, and 15 degrees Celsius (°C), respectively, were selected.

Table 2-1. NSWWTP Alternatives Evaluation Influent Design Criteria (2040)

Parameter	Unit	Condition 1: Maximum Month Flows and Loadings	Condition 2: Maximum Month Flows and Loadings	Condition 3: Annual Average Flows and Loadings
Flow	Mgd	71	71	54
BOD	lb/d	111,800	111,800	98,400
COD [a]	lb/d	234,800	234,800	206,600
TSS	lb/d	109,900	109,900	94,100
TKN	lb N/d	20,800	20,800	17,800
TP	lb P/d	2,600	2,600	2,350
Temperature	°C	11	22	15

a. *COD loadings based upon COD:BOD of 2.1 measured during the April 2016 wastewater characterization.*

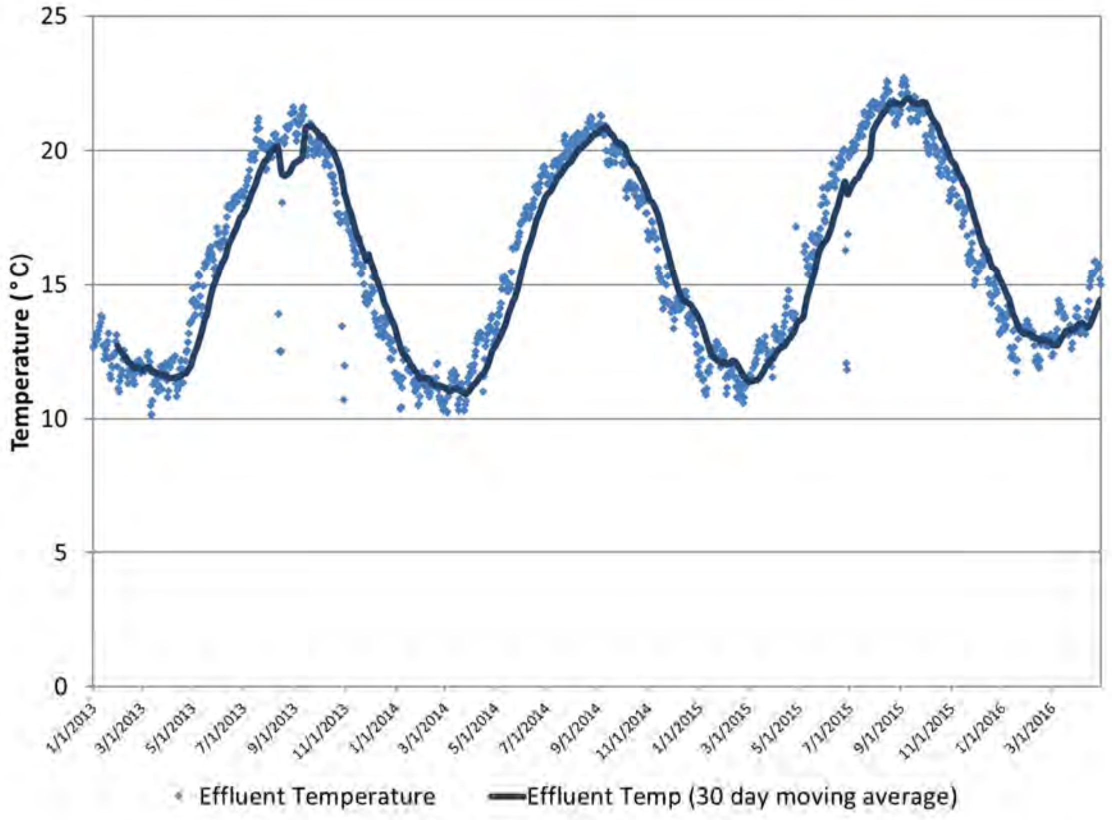


Figure 2-1. NSWWTP historical effluent temperature

2.2 Effluent Water Quality

Table 2-2 presents the effluent water quality criteria considered for this evaluation. The 5-day biochemical oxygen demand (BOD_5), total suspended solids (TSS), and ammonia-nitrogen (NH_3-N) criteria are based upon the NSWWTP existing Wisconsin Pollutant Discharge Elimination System (WPDES) permit limits for Badfish Creek. The total phosphorus (TP) discharge criterion was selected to maintain the current monthly TP discharge concentration of approximately 0.3 mg/L. The TN discharge criterion of 10 mg/L was selected to represent a typical average annual TN discharge from a BNR facility not requiring carbon addition. Weekly and daily discharges permit limits were not considered in this evaluation because Alternatives 1 through 3 were modeled using steady-state simulations as discussed in Section 2.3. Chloride discharge requirements were also not considered in this evaluation. Additional requirements for effluent dissolved oxygen (DO) are presented in Section 4.6.

Table 2-2. Alternatives Evaluation Effluent Water Quality Criteria			
Parameter	Average Period	Concentration (mg/L)	Mass Loading [a] (lb/d)
TSS	Monthly	20[b]	8,340
BOD_5	Monthly	19	7,923
NH_3-N			
May–September	Monthly	1.8 [b]	
October–April	Monthly	4.1 [b]	--
TP	Monthly	0.3	--
TN	Annual	10	--

a. Mass loadings based upon flow of 50 mgd.

b. Badger Mill Creek monthly permit limits for NH_3-N of 1.1 mg/L (May–September) and 3.8 mg/L (October–April) and monthly TSS of 10 mg/L (May–October) and 16 mg/L (November–April) are slightly more restrictive but do not change the results of this analysis.

2.3 Process Modeling

The calibrated NSWWTP BioWin™ model (Appendix A - TM5a) shown in Figure 2-2 was used to evaluate the facility requirements with the following key updates:

1. Influent flows and loadings were updated with the values presented in Section 2.1.
2. Other influent modules such as the acid phase digester sludge (AP digestate), P control, ferric chloride (FeCl3), magnesium chloride (MgCl2), and Caustic were adjusted based upon the comparatively higher influent loadings, biosolids flows, or recycle flows as appropriate under 2040 conditions.
3. Process configuration was adjusted to match each BNR alternative.
4. Pass 2 and 3 aerated zones were changed from two zones per pass to three zones per pass to reflect the existing diffuser grid layout.
5. An ammonia influent module (NH_3-N adder) was added to increase the digested sludge gravity belt thickener (GBT) recycle NH_3-N loadings because the BioWin calibration underestimated this NH_3-N recycle load. The additional NH_3-N loading was included to provide a better comparison of the impacts of adding sidestream deammonification in Alternative 3.

6.

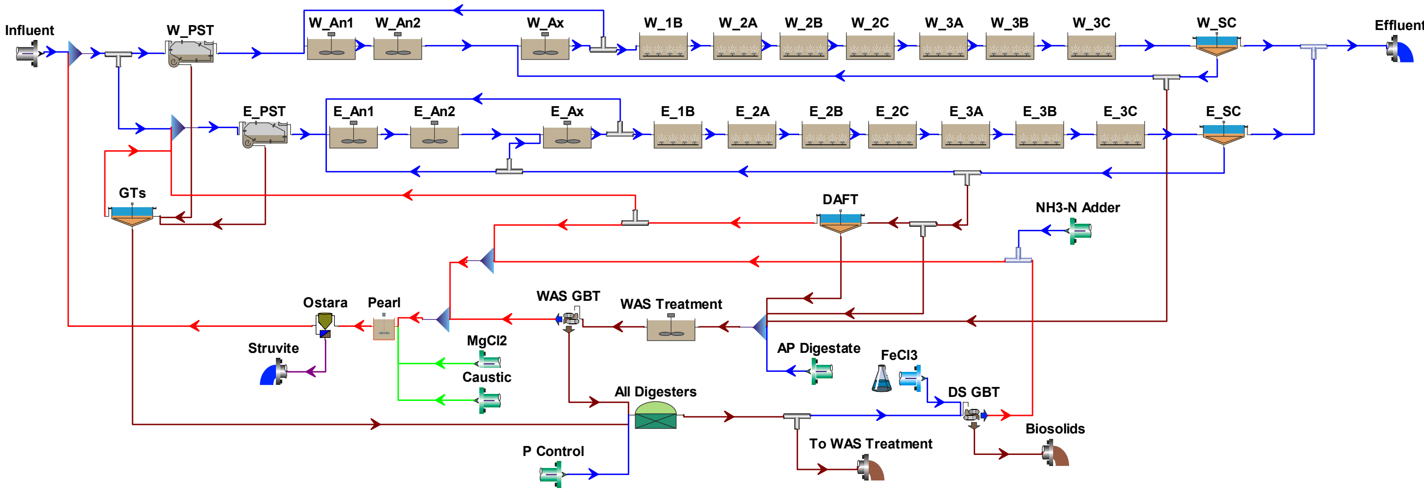


Figure 2-2. NSWWTP Calibrated BioWin model flow scheme

The model was not updated to include dewatering a fraction of the digested sludge flow stream as simulations with dewatering 20 percent of the digested sludge flow stream did not change facility requirements or predicted effluent discharges. Furthermore, aeration demands differed by less than 4 percent, which is considered negligible for a planning-level analysis.

Two modeling approaches were used in this planning-level analysis. The first approach used steady-state simulations to define the system requirements for Alternatives 1 through 3. A key criterion for system sizing is the aerobic solids retention time (SRT) required to achieve the effluent NH_3-N discharge concentration during cold weather periods. Figure 2-3 shows the predicted steady-state monthly effluent ammonia concentrations under Condition 1 (maximum month flow and load conditions at 11°C). Because steady-state simulations do not capture the dynamic impacts of changing flows and loadings, the simulated results will underpredict effluent NH_3-N. As such, an aerobic SRT well to the right of the NH_3-N curve inflection point was selected to maintain stable nitrification and achieve effluent NH_3-N discharge criteria. This analysis uses a minimum aerobic SRT of 9 days. This assumption should be confirmed during detailed design when dynamic simulations are conducted.

Nitrite shunt was not modeled using steady-state simulations because nitrite-oxidizing bacteria (NOB) outselection can be accurately modeled only under dynamic conditions. Hence, Alternatives 4 and 5 were evaluated using a 90-day dynamic influent itinerary encompassing the three monthly flow and loading conditions presented in Section 4.1 with daily flow and loading variations based upon historical operating data (escalated to 2040) and diurnal flow and loading patterns captured during the October 2014 wastewater characterization. The dynamic itineraries also included an artificial peak day flow event of 165 mgd (with peak hour flows up to 180 mgd) during the maximum month loading periods to evaluate system performance. Given the complexities and time required to model nitrite shunt with BioWin, the East and West plants were combined into a single activated sludge train, and the aeration basin influent loading is therefore assumed to be equally distributed by tank volume.

Alternatives 1 through 3 peak oxygen demands were estimated using a short dynamic simulation of the peak loading conditions developed in the 90-day itinerary to capture diurnal peaks. In addition, modeling assumes that all aeration tanks, secondary clarifiers, and other process tankage are in service.

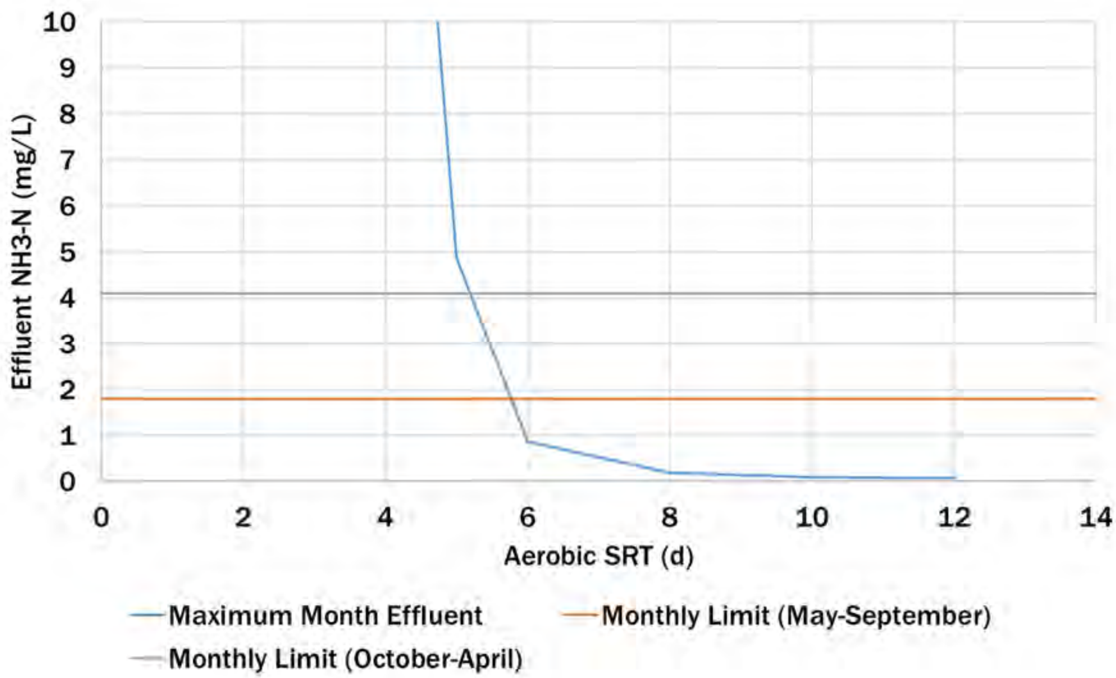


Figure 2-3. Steady-state predicted effluent ammonia versus aerobic solids retention time (Condition 1)

2.4 Secondary Clarifiers

The secondary clarifier capacity was evaluated based upon the maximum allowable SLR capacity as determined using state point analysis (SPA) assuming all clarifiers, return activated sludge (RAS) pumps, and aeration tanks are in service during peak hour flow conditions. The peak hour flow for process evaluations was defined as the flow associated with a 5-year storm event. Figure 2-4 shows that the projected 5-year storm event flow is 135 mgd. The secondary clarifiers will also need to pass the peak hydraulic flow of 180 mgd. Because there is an inherent uncertainty in defining secondary clarifier capacity using SPA, the calculated maximum allowable SLR was decreased by 20 percent to account for non-ideal settling and thickening in the clarifiers resulting in a lower maximum SLR. It is recommended that the secondary clarifiers be stress-tested with subsequent computational fluid dynamics (CFD) modeling to confirm the secondary clarifiers' solids loading rate capacity.

Table 2-3 summarizes the secondary clarifier design criteria used in this analysis. The nitrite shunt sludge volume index (SVI) of 175 milliliters per gram (mL/g) is greater than the UCT-based alternatives as the low operating dissolved oxygen (DO) levels will negatively impact sludge quality. The design SVI of 175 mL/g assumes that RAS chlorination and/or polymer is added to control bulking sludge. For the nitrite shunt alternatives, the East plant RAS pumping capacity was not increased above 37 mgd as higher RAS flows did not increase maximum SLR. Increasing the West plant RAS capacity from 34.4 mgd to 39 mgd could increase the West clarifiers' SLR capacity by 10 percent for both flow schemes, but was not considered for this evaluation. This analysis assumes polymer is added 6 month per year to reduce SVIs below 175 mL/g to estimate annual chemical requirements. Capital costs assume both RAS chlorination and polymer addition facilities are installed.

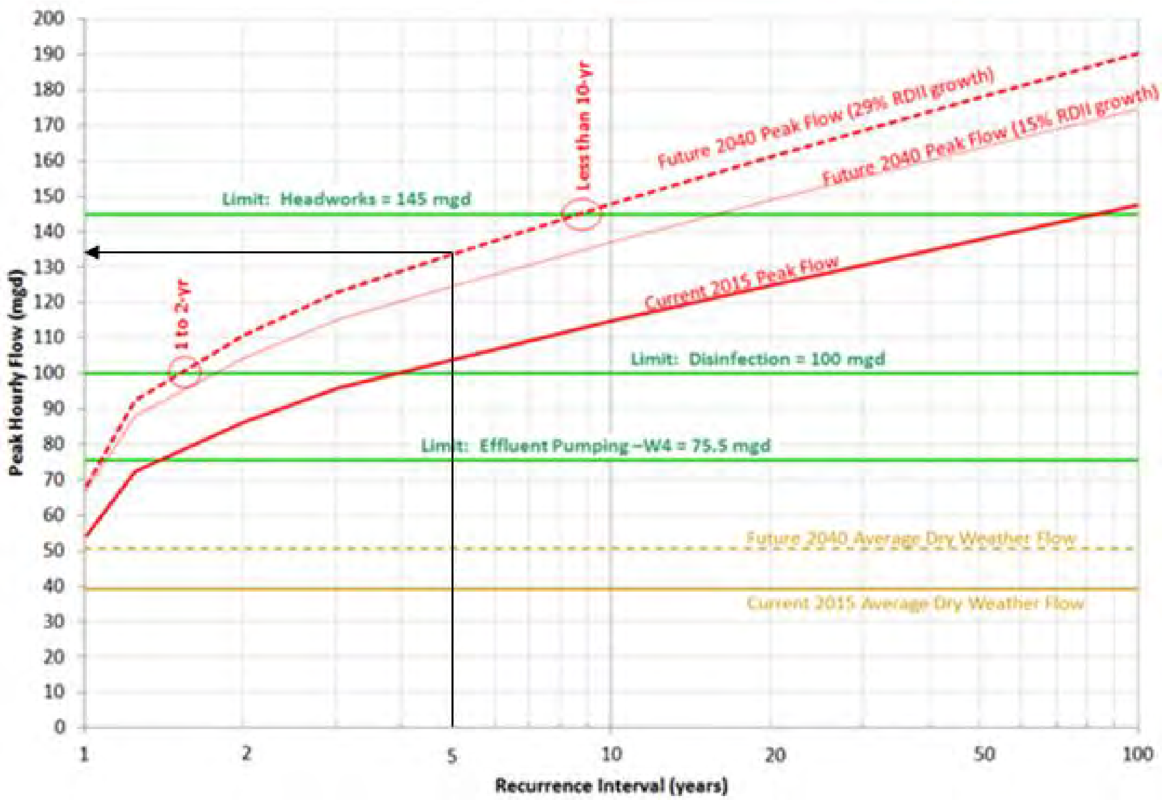


Figure 2-4. NSWWTP projected peak flows

Source: TM No. 4 prepared by Strand/Brown and Caldwell, September 2016.

Table 2-3. Secondary Clarifier Solids Loading Rate Capacity			
Item	Unit	Alternatives 1–3 UCT-Based Alternatives	Alternatives 4 and 5 Nitrite Shunt Alternatives
Peak hour flow	mgd	135	135
Design SVI	mL/g	125	175
Clarifier Surface Area [a]			
East Plant	ft^2	73,690	73,690
West Plant	ft^2	84,546	84,546
Return Sludge Flow			
East Plant	mgd	34/42	37
West Plant	mgd	34	34
Maximum Solids Loading Rate			
East Plant	lb/ft^2-d	34/38	30
West Plant	lb/ft^2-d	31	26
Surface Overflow Rate at Peak Hour Flow [b]			
East Plant	gal/ft^2-d	915	915
West Plant	gal/ft^2-d	800	800

a. *Surface area of all existing clarifiers in service.*

b. *Assumes peak hour flow of 135 mgd is split equally between East and West plants.*

2.5 Peak Flow Management

TM No. 4presented the peak flow management alternatives to hydraulically pass 180 mgd through the plant. Alternative PF10, High Rate Treatment at NSWWTP, presented the concept of biological contact treatment for peak flow events. This high-rate treatment strategy is required for Alternatives 2 through 5 to maintain acceptable secondary clarifier SLRs and is recommended for Alternative 1. As such, this evaluation assumes that each BNR alternative will incorporate biological contact treatment, which step feeds primary effluent flows in excess of roughly 100 mgd to 110 mgd to Pass 3 of the aeration tanks.

Section 3: BNR Alternative Descriptions

This section presents descriptions of the five alternatives evaluated including facility requirements, predicted effluent quality, and changes in operations such as chemical usage or biosolids production. Table 3-1 summarizes Alternatives 1 through 5 process design data at 2040 loadings. Process aeration requirements for each alternative are presented in Section 4 and blowers options are discussed in Section 8.

3.1 Alternative 1: Existing Modified UCT

Alternative 1 is the existing modified UCT flow scheme presented in Figure 3-1. This flow scheme consists of an anaerobic selector for enhanced biological phosphorus removal (EBPR), an anoxic zone that primarily denitrifies RAS/recycle flow to the selector, and aerated zones. Excluding the two A/O trains in East Plant 1, the anaerobic and anoxic zones compose roughly 16 percent and 5 percent of the total aeration basin volume, respectively.

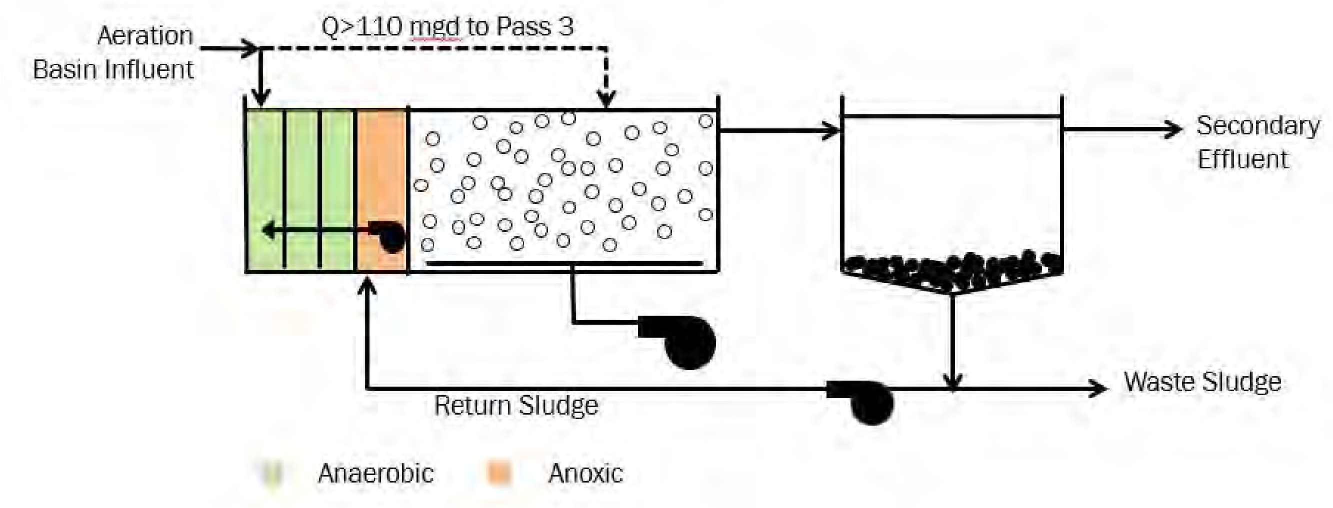


Figure 3-1. Alternative 1: existing modified UCT flow configuration

The existing aeration basin sizing and layout are sufficient to meet the target effluent criteria at an aerobic SRT of 9 days. Step feed of peak hour flows is not required to maintain clarifier SLRs below critical levels; however, routing flows to Pass 3 when influent flows exceed 110 mgd is recommended to minimize negative impacts on anaerobic selector/EBPR performance and maximize clarifier TSS removal performance. Given the maximum month MLSS concentration of roughly 2,500 mg/L results in secondary clarifier SLRs less than the maximum allowable levels in Table 3-1. This alternative provides flexibility to divert up to 20 percent more flow/load to either the West or East plant to optimize aeration system energy savings. Alternative 1 also provides a baseline to which other alternatives can be compared. 2040 annual biosolids production is estimated at 25 dry tons per day (DT/d). This analysis assumes that the East Plant 1 two A/O trains are not modified.

Table 3-1. BNR Alternatives Process Design Data (2040)						
		Alternative				
Item	Unit	1: Existing Modified UCT	2: UCT	3: UCT with Side-stream Deammonification	4: Nitrite Shunt	5: CEPT with Nitrite Shunt
Influent flow to East plant (average/peak)	Percent	50/50	50/50	50/50	50/43	50/43
East Aeration Tanks						
Total volume (existing)	MG	12.15	12.15	12.15	12.15	12.15
Anaerobic volume	% total	17	17	17	21	21
Anoxic volume	% total	4	28	28	0	0
Aerobic/total SRT	Days	9/11	9/15	9/15	12/15	15/19
Maximum month MLSS	mg/L	2,400	3,600	3,500	3,200	3,200
Mixed liquor return [a]	% E. influent	--	300	300	--	--
Anaerobic recycle [a]	% E. influent	73	73	73	--	--
East Secondary Clarifiers						
Clarifiers in service	No.	11	11	11	11	11
Pass 3 MLSS at peak hour flow	mg/L	2,400	3,100	3,000	2,750	2,750
RAS	mgd	34	42	42	37	37
Peak hour SLR	lb/ft^2-d	28	38[b]	37[b]	30	30
West Aeration Tanks						
No. of tanks	--	4	4	4	4	4
Total volume	MG	11.78	11.78	11.78	11.78	11.78
Anaerobic volume	% total	16	16	16	21	21
Anoxic volume	% total	5	28	28	0	0
Aerobic/total SRT	Days	9/10	9/15	9/15	12/15	15/19
Maximum month MLSS	mg/L	2,500	3,600	3,500	3,200	3,200
Mixed liquor return [a]	% W. influent	--	300	300	--	--
Anaerobic recycle [a]	% W. influent	60	60	60	--	--
West Secondary Clarifiers						
Clarifiers in service	--	8	8	8	10	10
Pass 3 MLSS at peak hour flow	mg/L	2,500	3,100	3,000	2,750	2,750
RAS	mgd	34.4	34.4	34.4	34.4	34.4
Peak hour SLR	lb/ft^2-d	25	31 [b]	30[2]	24	24
Predicted Effluent Quality[c]						
Monthly NH_3-N (warm/cold)	mg/L	<0.1/0.1	<0.1/0.6	<0.1/0.6	0.5/1.5	0.5/3.0
Monthly TP	mg/L	0.4	0.4	0.4	0.3	0.3
Annual TN	mg/L	20	8	8	7.5	12
Additional Annual Requirements						
Methanol	gpd	--	2,250	2,000	0	0
$FeCl_3$	gpd	--	0	0	0	1,000
Polymer	DT/yr				40[d]	125 [d]
Biosolids disposal	DT/d	--	0.7	0.5	-2.0	1.1

Table 3-1. BNR Alternatives Process Design Data (2040)						
		Alternative				
Item	Unit	1: Existing Modified UCT	2: UCT	3: UCT with Side-stream Deammonification	4: Nitrite Shunt	5: CEPT with Nitrite Shunt
Struvite production	T/d	--	0	0	0	-0.9
30% $MgCl_2$	T/d	-	0	0	0	-0.17

a. *Mixed liquor return (aerobic to anoxic) and anaerobic recycle (anoxic to anaerobic) capped at 300% and 75% of the plant influent maximum month flow, respectively.*

b. *Assumes mixed liquor return is turned off during peak flow events to minimize Pass 3 MLSS to clarifiers.*

c. *Predicted effluent BOD5 less than 5 mg/L for all alternatives.*

d. *Nitrite shunt polymer addition may also consist of RAS chlorination to minimize costs. Planning O&M costing based upon polymer addition only.*

3.1.1 Null Alternative Primary Failure Mode, Risks, and Consequences

The Null alternative assumes modified UCT operations as described above, with continued use of existing aeration equipment, including blowers and diffusers. The primary failure modes of major system components are summarized in Table 3-2 for use in evaluating the Null alternative from an asset management perspective.

Table 3-2. Summary of Alternative 1N: Null Alternative Failure Modes for Major Secondary Treatment Components				
Item	Primary Failure Mode	Failure Description	Risks	Consequences
Ceramic diffusers	• Physical mortality	• Increasing PVC piping or fitting fractures	• Need to remove the affected aeration tank from service for repair	• Increasing potential for effluent quality degradation when tanks are offline for repair • Increasing annual repair costs
West blowers	• Physical mortality	• Inability to obtain parts or service support from obsolete manufacturer	• Potential for extended blower outages increases risk of aeration failure if one or more blowers have prolonged service outages	• Potentially significant secondary treatment impact if multiple blowers are simultaneously impacted
East blowers	• Physical mortality	• Mechanical failure	• Redundant capacity likely available	• Increased energy consumption when alternate blowers are in use
Aeration controls (flow meter, control valves, DO sensors)	• Level of service	• Valves hunting • No position feedback • DO calibration failures	• Potential for increased future blower energy use because of control deficiencies	• Reduced opportunity to optimize energy consumption
RAS pumping	• No likely primary failure modes identified	• N/A	• N/A	• N/A

3.1.2 Null Alternative Capacity

The capacity status of the major components is as follows:

- Blower capacity: The forecast future peak airflow for continued use of the modified UCT process under the Null scenario is within the firm capacity of the existing east and west blower systems, assuming that diffuser air transfer efficiency is maintained at roughly current levels. However, turndown limitations limit the ability of the plant to save energy by minimizing airflow, especially on the west side of the plant.

- Diffuser capacity: The existing diffuser system capacity is sufficient, but the 1 standard cubic foot per minute (scfm)/diffuser restriction contributes to blower turndown limitations.
- Control valves: The existing control valves appear to be oversized for the projected airflow rates.
- RAS pumps: Based upon rated capacity, the existing RAS pumps have adequate firm capacity for normal load conditions and total capacity for future peak conditions. Per Madison Metropolitan Sewerage District (MMSD) staff, testing is recommended to confirm that the actual RAS pumping capacity matches the rated capacity.

3.2 Alternative 2: UCT

Alternative 2 modifies the existing plant flow scheme to reduce TN discharges by (1) adding a mixed liquor recycle (MLR) flow from the last aerobic zone to the first anoxic zone, (2) increasing the size of the existing anoxic zone, and (3) adding a carbon source to reduce TN discharge to 10 mg N/L or less. These modifications are illustrated in Figure 3-2.

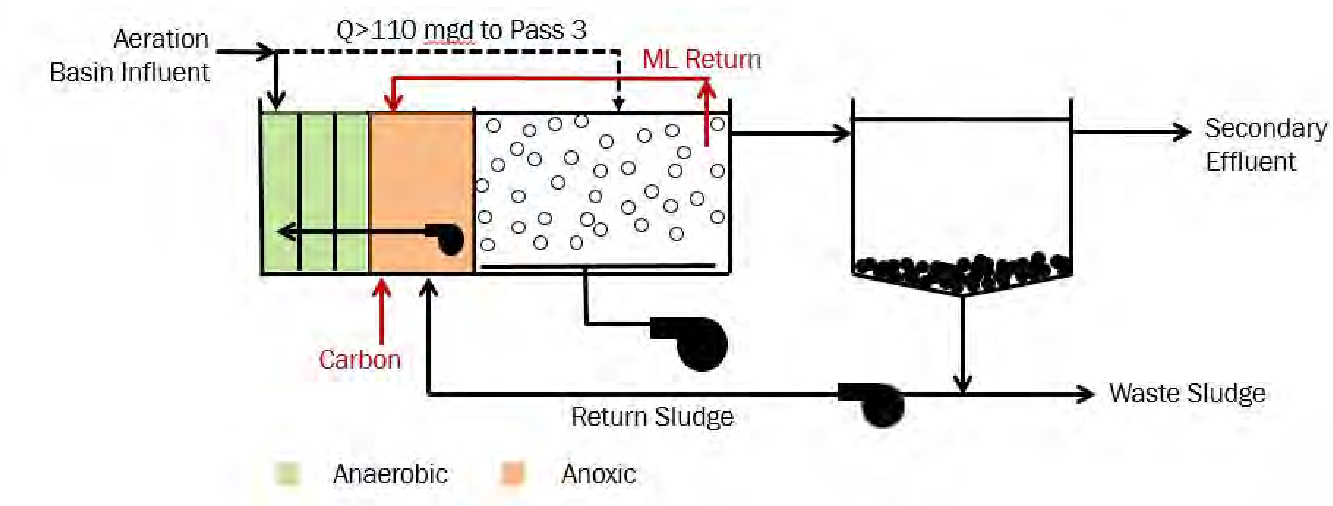


Figure 3-2. Alternative 2: UCT flow configuration

To determine the anoxic volume required, a series of steady-state simulations at average and maximum month loadings were conducted. Figure 3-3 shows that the predicted annual average effluent TN concentration without carbon (methanol) addition could not be reduced below 15 mg N/L at typical anoxic volume fractions [anoxic volume: (anoxic + aerated volume)] of 20 to 35 percent. For reference purposes converting the existing UCT train Pass 1 aerated volume to anoxic volume increases the anoxic volume fraction to 20 percent and converting the Pass 1 aerated volume plus the first aerated grid section of Pass 2 to anoxic volume increases the anoxic zone fraction to 33 percent.

Simulations showed that the UCT system is carbon-limited as MLR flows greater than roughly 100 percent of the plant influent did not decrease effluent TN. In addition, increasing the MLR greater than 100 percent increased effluent PO_4-P concentrations as the additional nitrate (NO_3-N) being recycled back to the anaerobic zone consumes the volatile fatty acids (VFAs) needed for EBPR. To address the carbon limitation in this analysis, the UCT system assumes that methanol is added as a carbon source.

In Figure 3-3 methanol addition was adjusted with the various anoxic volumes to achieve an anoxic effluent containing approximately 0.5 mg N/L of combined NO_3-N and nitrite (NO_2-N). Total methanol addition rates ranged from 2,400 to 4,300 gallons per day (gpd) under maximum month conditions and 2,600 to 3,300 gpd at average conditions with higher dosages required at the lower anoxic volume fractions. For the final simulations with an anoxic zone of 33 percent, adding 2,000 gpd of methanol at average conditions (2,250 gpd at maximum month conditions) was sufficient to reduce effluent TN discharges below 10 mg N/L and reduce the anoxic zone recycle NO_X-N (NO_3-N+NO_2-N) concentration to approximately 0.5 mg/L, which maintained current EBPR performance. Figure 3-3 also shows the predicted effluent TN with methanol addition.

This analysis assumes that the aerated grids in Pass 1 and the first aerated grid (33 percent) of Pass 2 are converted to anoxic zones. This approach simplifies design and construction. Detailed dynamic modeling is recommended during detailed design to confirm anoxic zone volume needs under dynamic loading patterns. Figure 3-4 illustrates the aeration basin modification for each process train. The East Plant 1 A/O trains should also be converted to the UCT flow scheme. Plant modifications to incorporate the UCT process configuration include the following:

- New 18,000-gallon methanol storage and metering system to feed methanol to the East and West plant secondary influent channels. The estimated cost for this system includes a building and other ancillary improvements.
- Convert Pass 1 and the first aerated grid in Pass 2 to anoxic zones by removing the associated aeration grid/system, adding two mixers to each zone, and adding a baffle wall to Pass 2 as shown in Figure 3-4.
- Relocate the existing anoxic recycle pumps to the last anoxic zone and add piping to reconnect to existing recycle piping.
- Add MLR pumping to achieve 300 percent MLR flows at maximum month flows. MLR improvements include adding two new low-head variable-speed submersible axial flow pumps per aeration basin train to route nitrified mixed liquor from the end of Pass 3 to the first anoxic zone. Each pump was designed to handle 66 percent of the maximum flow. The following preliminary pumping configuration was assumed:
  - East Plant 1: four 10 mgd pumps with 30-inch-diameter piping
  - East Plant 2: eight 15 mgd pumps with 36-inch-diameter piping
  - West Plant 3/4: eight 20 mgd pumps with 42-inch-diameter piping
- Add three nitrate+nitrite (NO_x) sensors per plant to control methanol feed and MLR flows.
- Relocate the existing Pass 2 DO sensors to farther down the pass.

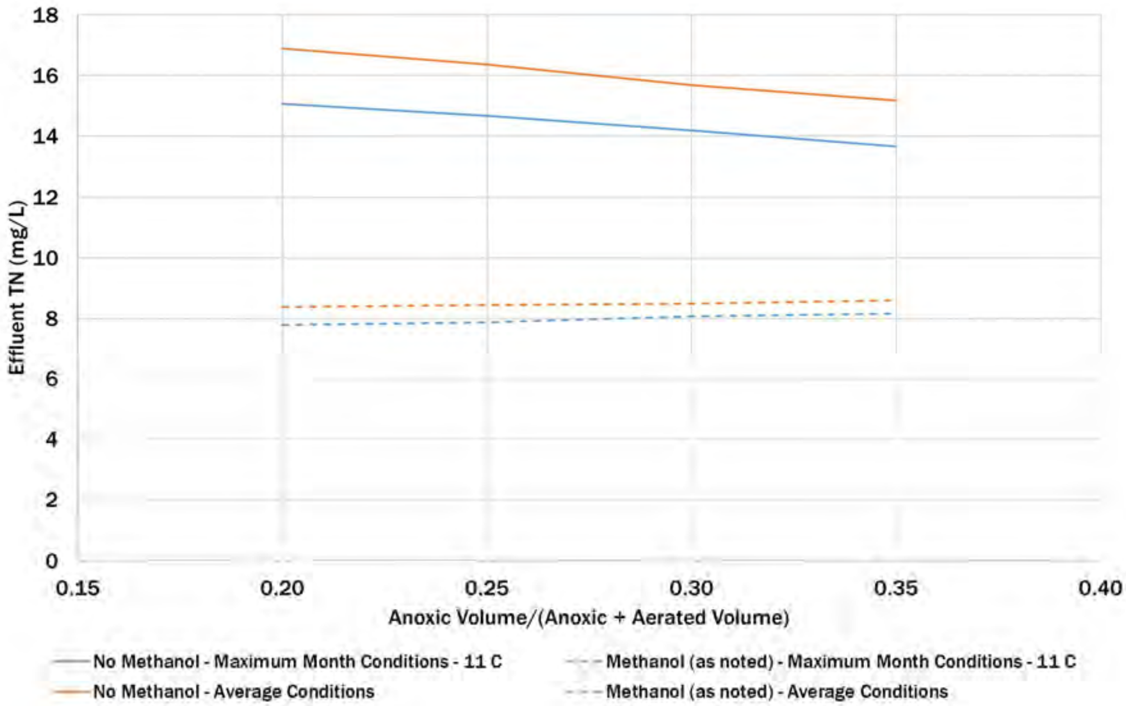


Figure 3-3. UCT configuration effluent TN without carbon addition versus anoxic volume

Table 3-1 shows that the UCT system maximum month MLSS increases to 3,600 mg/L. At this MLSS it is critical to step-feed flows in excess of 100 to 110 mgd to Pass 3 and turn off the MLR during peak flow events to reduce the MLSS concentration to 3,100 mg/L and maintain an acceptable clarifier SLR. Biosolids production remains essentially the same with UCT as additional solids generated from methanol addition are offset by the longer SRT, which reduces solids production.

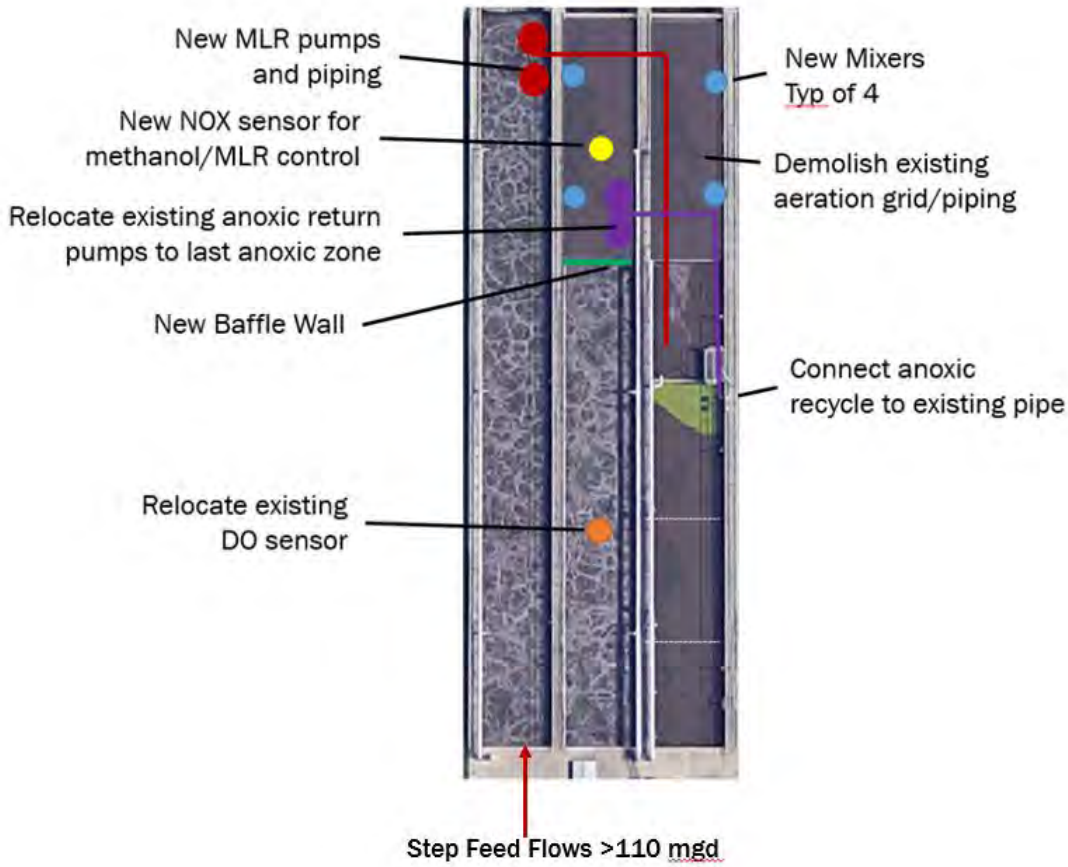


Figure 3-4. UCT configuration aeration basin modifications

3.3 Alternative 3: UCT with Sidestream Deammonification

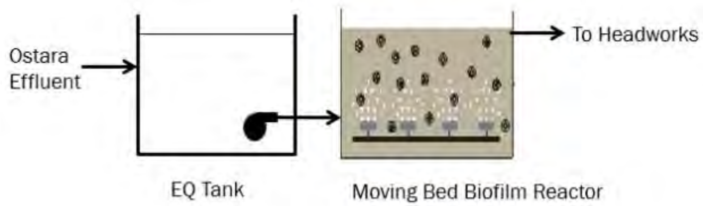
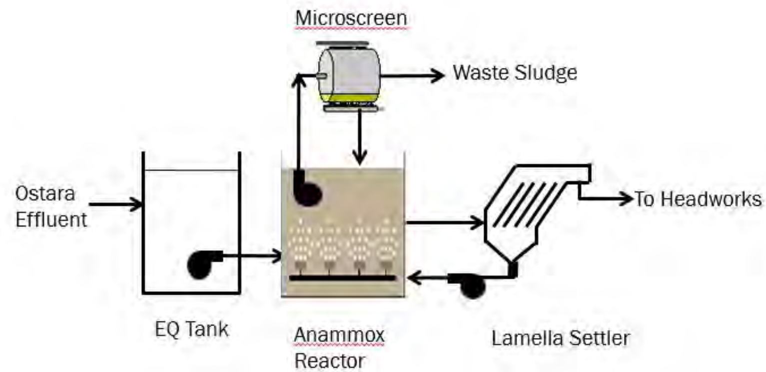
Alternative 3 combines sidestream deammonification with Alternative 2's UCT configuration in an effort to reduce UCT carbon and energy demands. Deammonification processes convert roughly 50 percent of the sidestream influent NH_3-N to NO_2-N using ammonia-oxidizing bacteria (AOB). The resulting NO_2-N and remaining NH_3-N are then converted to nitrogen gas via Anammox bacteria without carbon. The key advantage of the deammonification process is that no carbon is needed to convert ammonia to nitrogen gas.

A challenge to NSWWTP is where to implement sidestream deammonification. Because Anammox bacteria prefer temperatures greater than 30°C, treating the digested sludge filtrate would usually be preferred, but digested sludge filtrate is also required for the Ostara phosphorus recovery process as an ammonia source for struvite formation. Ostara indicates that up to 50 percent of the digested sludge filtrate could be diverted to a sidestream deammonification system; however, at 50 percent diversion, the Ostara caustic demands will increase by 20 percent to provide conditions for struvite prill formation. If 50 percent of the digested sludge filtrate is treated in sidestream deammonification at 80 percent and 85 percent removal of TN and NH_3-N, respectively, the overall sidestream TN/NH_3-N recycle loadings would decrease by 40 to 45 percent. Conversely, a recent study on a pilot system arranged with a deammonification process after an Ostara process observed an average 77 percent reduction in ammonia (Wilson, N. et al., “Piloting of Mainstream Phosphorus Recovery and Deammonification Technologies at the City of Portage Water Pollution Control Facility,” WEFTEC 2015 Proceedings). Deammonification system vendors’ proposals indicate that 80 to 90 percent NH_3-N removal can be achieved provided that the reactor temperature is maintained at 25°C. This analysis assumes that a sidestream deammonification system treating the Ostara effluent is provided to maximize nitrogen removal and subsequent methanol needs in the main stream process. A cursory life-cycle cost evaluation of treating 50 percent of the digested sludge filtrate and treating the Ostara effluent showed that both alternatives have essentially equal life-cycle value.

Table 3-3 summarizes the key components of two sidestream deammonification systems. Veolia’s ANITA™Mox is a moving-bed biofilm reactor (MBBR) while conDEA™ is a suspended growth system that uses lamella settlers for solids separation and microscreens for AOB/NOB flocculent biomass wasting. Both processes are continuous-flow systems. Manufacturer proposals are provided in Appendix C.

Effluent quality for the UCT with sidestream deammonification alternative is similar to Alternative 2, UCT, decreasing the average effluent TN to 14 to 15 mg/L without methanol addition. If effluent TN is reduced below 10 mg/L, deammonification reduces average methanol doses by approximately 10 percent. The limited reduction in methanol usage or effluent TN with sidestream deammonification correlates to the Ostara recycle ammonia load being roughly 10 to 15 percent of the influent ammonia loading.

The predicted maximum month MLSS of 3,500 mg/L was slightly less than the Alternative 2 UCT process alone. The lower MLSS can be attributed primarily to the reduced methanol requirement because the deammonification process removes less than 15 percent of the sidestream chemical oxygen demand (COD) loading.

Table 3-3. Alternative 3 Preliminary Sidestream Deammonification Components		
Item	Veolia ANITA™Mox	conDEA™
General flow scheme		
Flow equalization	• One 1 MG steel bolted tank	• One 1 MG steel bolted tank
Reactors	• 0.27 MG total • One reactor at 45.5' x 45.5' x 18 SWD • Aluminum covers	• 0.24 MG total • Two reactors at 36' x 18' x 21' SWD • Aluminum covers
Media	• K5 media: 50% fill	• N/A
Reactor mixers	• One per reactor	• One 9 hp mixer/reactor
Solids separation	• N/A	• 2 lamella settlers with RAS pumps • Microscreen
Blowers	• 2 @ 1,000 scfm, 75 hp each	• 4 @ 225 scfm, 25 hp each
Aeration system	• 4 medium-bubble grids/tank	• 10 Messner fine-pore aeration panels/reactor
Heating system	• Heat exchanger with hot water and bioreactor circulation pumps	• Heat exchanger with hot water and bioreactor circulation pumps

3.4 Alternative 4: Nitrite Shunt

Alternative 4 modifies the existing operations to promote nitrite-shunt in which ammonia is oxidized to nitrite and then reduced to nitrogen gas. Key advantages of this alternative are no carbon addition to meet TN reduction goals and reduced aeration demands. For this evaluation, the A/O flow scheme shown in Figure 3-5 operated at controlled DO levels was selected based upon full-scale nitrite shunt operations at the St. Petersburg, Florida, Southwest Reclamation Facility.

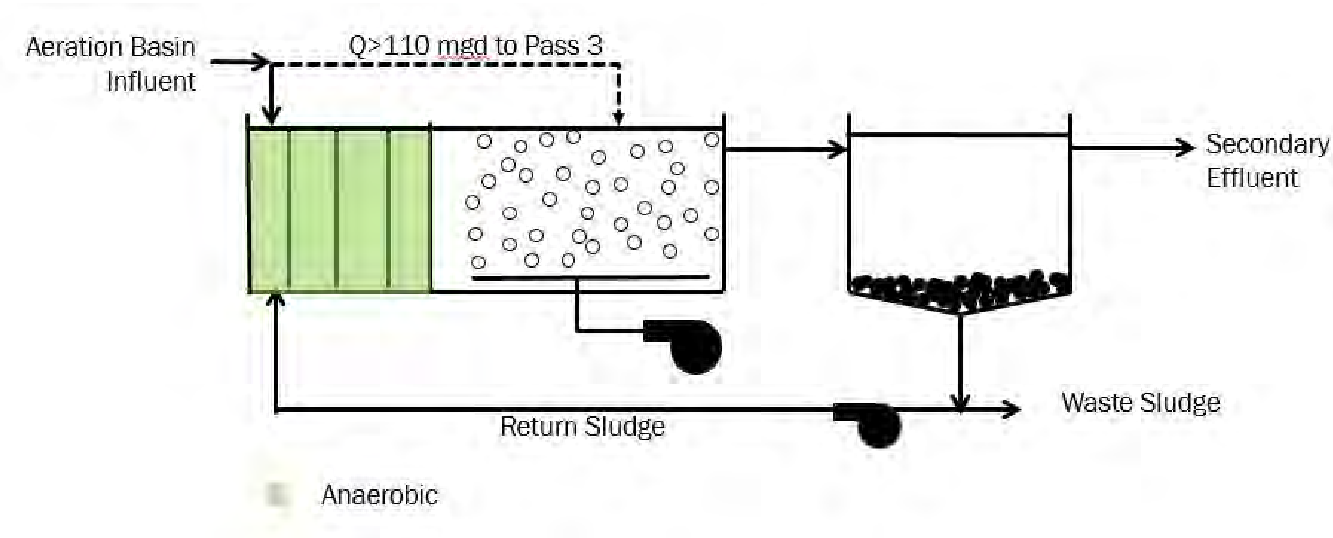


Figure 3-5. Nitrite shunt flow schematic

Nitrite shunt operations are more complex and require more online monitoring than current operations. The conceptual nitrite shunt operation consists of two process control strategies: ammonia versus NO_x (AVN) and DO control. AVN is an aeration control strategy designed to maintain equal parts of NH_3-N and NO_X-N to produce the lowest effluent TN for the amount of carbon available. AVN promotes nitrite shunt as NOB are out-selected in the aeration control process, meaning ammonia is oxidized to nitrite and subsequently denitrified to nitrogen gas, reducing carbon demands in the denitrification process. Because AVN control can result in NH_3-N discharges greater than 4 mg/L, a modified control strategy was selected. The analysis assumes that AVN is used to control the Pass 3 middle zone (Zone 3B) NH_3-N:NO_X-N relationship (ratio set at 1) and the last third of Pass 3 (Zone 3C) is aerated to 1 mg/L to further reduce NH_3-N discharge levels below target levels. Figure 3-6 shows the DO concentrations during a nitrite shunt simulation. Kinetic parameters used in the nitrite shunt operations are based upon full-scale operations at the St. Petersburg Southwest Water Reclamation Facility and should be verified for this cold weather application. Note: Nitrite shunt pilot testing at MMSD is being conducted to verify the kinetic parameters and could change the modeled DO values shown in Figure 3-6.

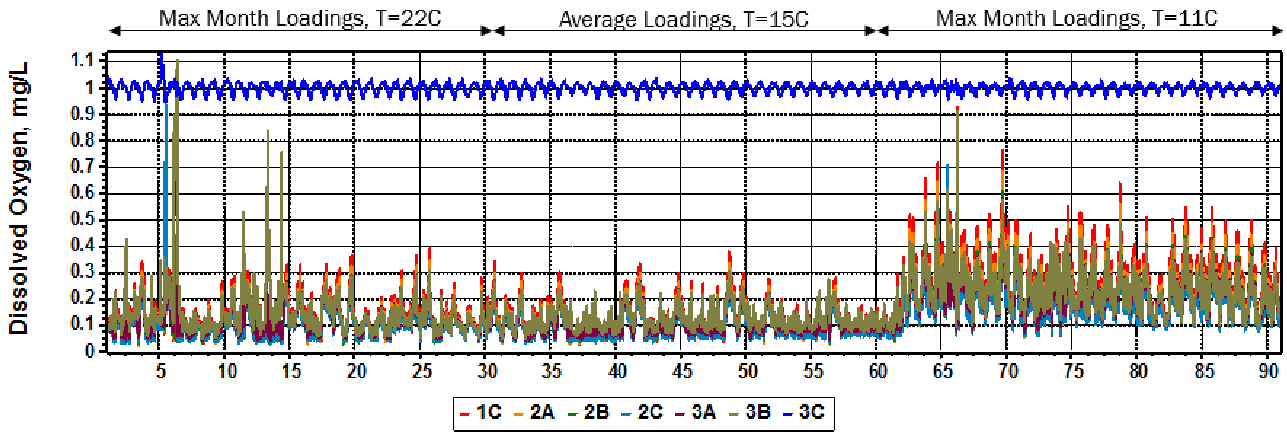


Figure 3-6. NSWWTP simulated nitrite shunt DO concentrations

Table 3-1 shows that Alternative 4 can reduce average effluent TN discharges below 10 mg/L without carbon addition and did not negatively impact EBPR performance. Figure 3-7 shows the proposed tank modifications to implement nitrite shunt. The existing aeration tank modifications consist of the following changes:

- Add ammonia/NO_x sensor to Pass 3B and a DO sensor to Pass 1 for AVN control. Recommend adding sensors to half the trains in both the East and West plants.
- Add a baffle wall between the second and third aeration grids in Pass 3.
- Add a new aeration control valve, meter, and DO sensor to control the aeration airflow in Zone 3C.
- Operationally, route RAS flow to the first anaerobic zone and stop pumping flow from the existing anoxic zone back to the first anaerobic zone.

The East Plant 1 A/O trains would be modified in a similar layout.

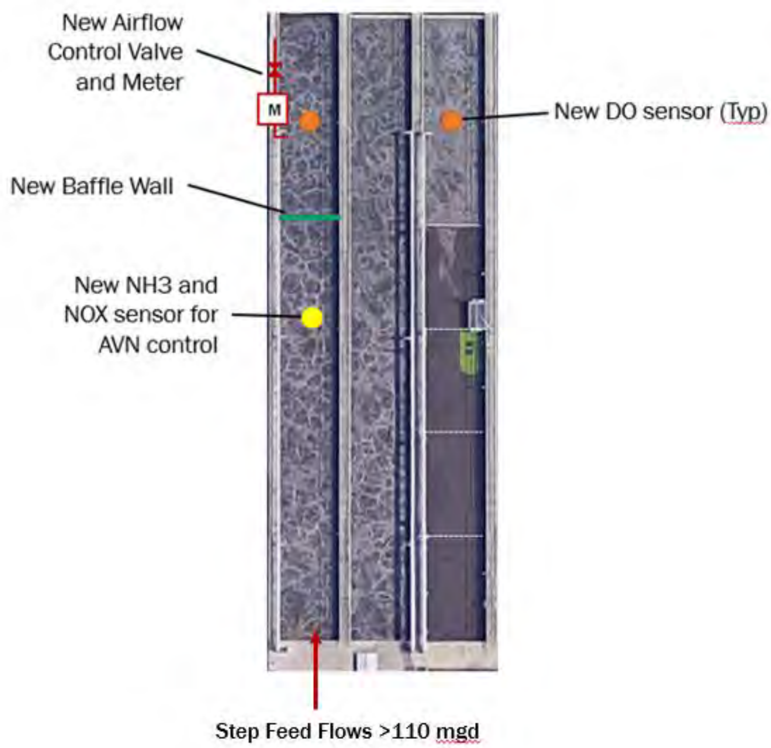


Figure 3-7. Proposed nitrite shunt modifications

To reduce monthly effluent NH_3-N discharges to less than 3 mg/L during Condition 1 loadings (max month loadings at 11°C), the aerobic SRT was increased to 12 days. Operating at the low DO levels shown in Figure 3-6 will negatively impact sludge quality. Based upon operations at St. Petersburg, Florida, a design SVI of 175 mL/g was selected for nitrite shunt operations assuming polymer addition and RAS chlorination are used during periods of poor sludge quality (SVI > 175 mL/g). The increase in aerobic SRT coupled with poorer sludge quality requires that two additional 116’ secondary clarifiers be added to the West plant, a polymer addition system be added to both the East and West plants, and 57 percent of the peak secondary influent flow be routed to the West plant to maintain acceptable clarifier SLR at peak hour flows. The capital costs for the two secondary clarifiers and polymer system are included in the life cycle cost analysis in Section 5. Routing flows greater than 100 mgd to 110 mgd to Pass 3 is required during wet weather events to maintain secondary clarifier SLRs. Alternatively, one 2.93 MG aeration basin could be added to the West or East plant to reduce SLRs in lieu of the two secondary clarifiers, but the cost for the aeration tank appears to be significantly greater than the clarifier addition. Stress testing and subsequent CFD analysis of the secondary clarifiers is recommended to confirm the clarifier SLR capacity and whether the clarifier addition is warranted under projected loading conditions.

Table 3-1 shows that annual biosolids production is reduced by roughly 8 percent because of its longer operating SRT.

3.5 Alternative 5: CEPT with Nitrite Shunt

Alternative 5, CEPT with Nitrite Shunt, combines Alternative 4 with CEPT to divert more carbon to the anaerobic digesters for increased biogas/energy production while reducing TN discharges without adding carbon (methanol).

CEPT is easily implementable by adding $FeCl_3$ and polymer upstream of the primary clarifiers in locations such as the grit tank influent and effluent channels. The amount of $FeCl_3$ added to promote additional carbon capture must be balanced with maintaining sufficient primary effluent PO_4-P to promote EBPR, which is needed for the existing Ostara struvite recovery process. Ostara reports that recent changes to the NSWWTP existing struvite recovery system have resulted in capturing 55 tons per month of struvite or approximately 50 percent of the estimated influent PO_4-P load as struvite. (Note that MMSD staff have subsequently reported struvite capture has decreased and 55 DT/d may be optimistic.) If the influent or primary effluent PO_4-P load decreases by 35 percent, the struvite recovered will also decrease accordingly. This alternative assumes that $FeCl_3$ is added to reduce primary effluent PO_4-P by 1 mg/L or 35 percent of the Alternative 4 primary effluent PO_4-P to enhance energy production and still maintain struvite recovery per direction from the SAM analysis.

Based upon bench-scale testing at NSWWTP and other facilities, a $FeCl_3$ dose of 15 mg/L with 1 mg/L polymer was selected to enhance particulate and colloidal removal while limiting phosphate removal to 1 mg/L PO_4-P. It is estimated that primary clarifier TSS and COD removal performance increase by 5 and 8 percentage points respectively at this ferric dose and annual biogas production increases by roughly 65 scfm or 15 percent. In the near term, use of this additional gas would be limited by the existing engine capacity and heat demands. If a new biogas combined heat and power (CHP) system is installed in the future, this additional gas could be used to increase the CHP output by approximately 260 kilowatts (kW).

With CEPT, an additional 1,000 gpd of 40 percent $FeCl_3$ is consumed after subtracting the estimated ferric demand added to the digesters for sulfide control. The additional $FeCl_3$ will produce roughly 2.5 DT/d of chemical solids; however, longer operating SRTs decrease the waste sludge, effectively reducing the overall biosolids increase to 1.1 DT/d compared to Alternative 1. CEPT also reduces the recoverable phosphate by 450 pounds per day (lb/d), which reduces struvite production by 0.9 T/d and a corresponding decrease in $MgCl_2$ consumption of 0.17 T/d. Adding 15 mg/L of $FeCl_3$ results in increasing the effluent chloride levels by roughly 10 mg/L, but is not expected to impact ultraviolet (UV) system operation.

Alternative 5 reduces annual effluent TN discharge to 12 mg/L without impacting predicted effluent TP concentrations. To reduce effluent NH_3-N to 3 mg/L in cold weather, the aerobic SRT was increased to 15 days. Similar to Alternative 4, the increase in design SVI requires two additional 116' foot diameter secondary clarifiers or one additional 2.93 MG aeration basin be added to the West plant to maintain acceptable secondary clarifier SLRs along with the modification described in Section 3.4. CEPT will require a new 2,000-square-foot (ft^2) chemical building near the headworks/influent splitter structure. The chemical building will house the new 18,000-gallon $FeCl_3$ storage tank, $FeCl_3$ metering pumps, and polymer feed equipment.

Section 4: BNR Process Aeration Requirements

This section presents a summary of the existing fine-pore aeration system, diffuser screening, basis of evaluation, and 2040 process aeration airflow requirements for each BNR alternative.

4.1 Existing Fine-Pore Diffuser System

The aerated zones in the four activated sludge plants currently use ceramic fine-pore diffusers and polyvinyl chloride (PVC) air distribution grids that were installed as part of the MMSD 7th Addition to the NSWWTP project in 1986. The East and West plants were constructed in phases, with differing tank depths and diffuser submergences, as shown in Table 4-1.

Table 4-1. NSWWTP Diffuser Mounting Summary

Parameter	Unit	East (1–6)	East (7–18)	West
Submergence	Ft	14.7	14.8	15.8
Floor to diffuser face	Ft	0.8	2.25	0.8

Plant staff reported that diffuser grid maintenance issues have been infrequent, but are disruptive to operations when they occur. Maintenance issues have included couplings that loosened and a few cracked pipes that needed to be repaired.

It is difficult to forecast the remaining useful life of the PVC diffuser grid based on industry experience as no WWTPs have operating systems significantly older than NSWWTP’s. Materials testing would be required to determine whether the PVC piping has degraded and needs to be replaced to maintain aeration reliability. Refer to the specific recommendations in Section 11.1.3 for additional detail.

4.2 Replacement Diffuser Technology Screening

A diffuser technology screening was conducted to reduce the number of diffuser alternatives considered in this preliminary investigation. Table 4-2 summarizes the advantages and disadvantages of different diffuser technologies considered for this evaluation. Membrane disc and membrane strip diffuser technologies were selected as they bracket the expected range of available efficiencies and costs and define whether the higher capital cost of high-efficiency diffusers could be justified for future diffuser retrofits. All of the diffuser technologies presented in Table 4-2 are potentially viable alternatives that could be considered during detailed design of a diffuser retrofit. The design process could include an evaluated bid that would select between competing diffuser designs based on a structured analysis of life-cycle costs.

Operating staff have noted that the high density and abnormally high mounting of the diffusers in the membrane strip diffuser (“Gold Series”) trial area makes movement through the aeration tank more difficult. This observation should be considered for the future diffuser design because most of the diffuser alternatives will have higher density than the current ceramic system. Most diffuser designs can be modified by clustering the diffusers to create safer passages for diffuser access.

Table 4-2. Fine-Pore Diffuser Alternatives

Type	Representative Manufacturers	SOTE / ft[a]	Advantages	Disadvantages
Ceramic disc	Xylem / Sanitaire	1.2%–2.8%	• Longest service life • Liquid HCl cleaning system now available	• No "check valve" mechanism for on / off service • Lower SOTE, but lower fouling rate • Previous MMSD experience and UW research suggested diffuser minimum flows must be kept higher to avoid calcium phosphate buildup in pores
Membrane disc (EPDM standard, PTFE coating available)	Xylem / Sanitaire SSI EDI	1.5%–2.2%	• Competitive market: capital cost low • Relatively easy membrane replacement • Holders compatible with ceramic • Membrane re-seats when valve is off to prevent backflow into grid	• 7- to 10-year element replacement
Standard membrane tube (EPDM sleeve)	EDI	1.5%–2.4%	• Lowest capital cost • Fewest diffusers • Membrane reseats when valve is off to prevent backflow into grid	• Some plants have experienced joint failures and restricted flow from elastomer hardening • 7- to 10-year element replacement
OTT magnum tube (silicone sleeve)	Ott EDI	1.8%–2.7%	• Higher efficiency • May have slower loss of efficiency over time[b]	• Blowers must be sized for stretching airflow • Higher capital cost and diffuser replacement cost
Membrane strip (polyurethane)	Aerostrip Sanitaire Gold	2%–2.5%	• Highest efficiency • High turndown range • Recommended daily flexing drops airflow to clear fouling • Floor mounting west diffusers could allow for equal submergence in east and west aeration for cross-connect • Without cross-connect, floor mounting east 1–6 diffusers could lower east 7–12 diffusers by 9" to improve access	• Higher capital cost • Slightly higher pressure • Some plants report that membranes stretch over time and do not re-seat, causing mixed liquor to backflow into diffuser grid when air is off • Manufacturer suggests membrane life could exceed 15 years, but some premature "folding / creasing" failures reported

a. *Approximate "like new" diffuser standard oxygen transfer efficiency (SOTE) per foot. SOTE / ft varies with flow rate per diffuser, mean cell residence time (MCRT), and diffuser position along aeration tank length.*

b. *Rosso 2014*

4.3 Basis of Evaluation

Process aeration requirements are influenced by a number of items including process oxygen demands, dirty water oxygen transfer and diffuser fouling or alpha-F, operating DO, diffuser density, diffuser airflow, and minimum airflow for mixing. This section summarizes the basis of the process aeration airflow requirements.

4.3.1 Alpha-F

The basis for all of the alpha-F profiles used in this analysis is the off-gas testing conducted at NSWWTP (Reusser, S. R., Effects of Biological Phosphorus Removal on Plant Operations and Capacity at the Nine Springs WWTP, undated). Figure 4-1 shows the alpha-F values reported in the study. As expected, the alpha-F value increases along the length of the aeration basin. Average alpha-F values for each zone from these data were translated into the zones used for BioWin modeling purposes. Aeration basin zone nomenclature discussed here is shown in Figure 4-2.

Table 4-3 summarizes the alpha-F profiles for each BNR alternative. Alternative 1, which has the same flow configuration as tested, used the average alpha-F values for the non-step feed conditions. For Alternatives 2 and 3 (UCT alternatives) the alpha-f profile was slightly adjusted given the reduced aeration volume and impacts of MLR creating less plug-flow-like conditions. The profile was adjusted based on the percent of the total aerated length for each zone at the midpoint and the final pass values were decreased 3 to 4 percentage points to be conservative. Alternatives 4 and 5 (nitrite shunt) also used a slightly more conservative alpha-F profile compared to Alternative 1.

Table 4-3 also presents the diffuser densities [area of the diffusers (Ad) divided by the area of the tank (At)] by zone associated with these airflows. Diffuser densities represent the average diffuser density by zone for both the East and West plants (vary by up +/- 0.5 percentage points) unless specifically identified.

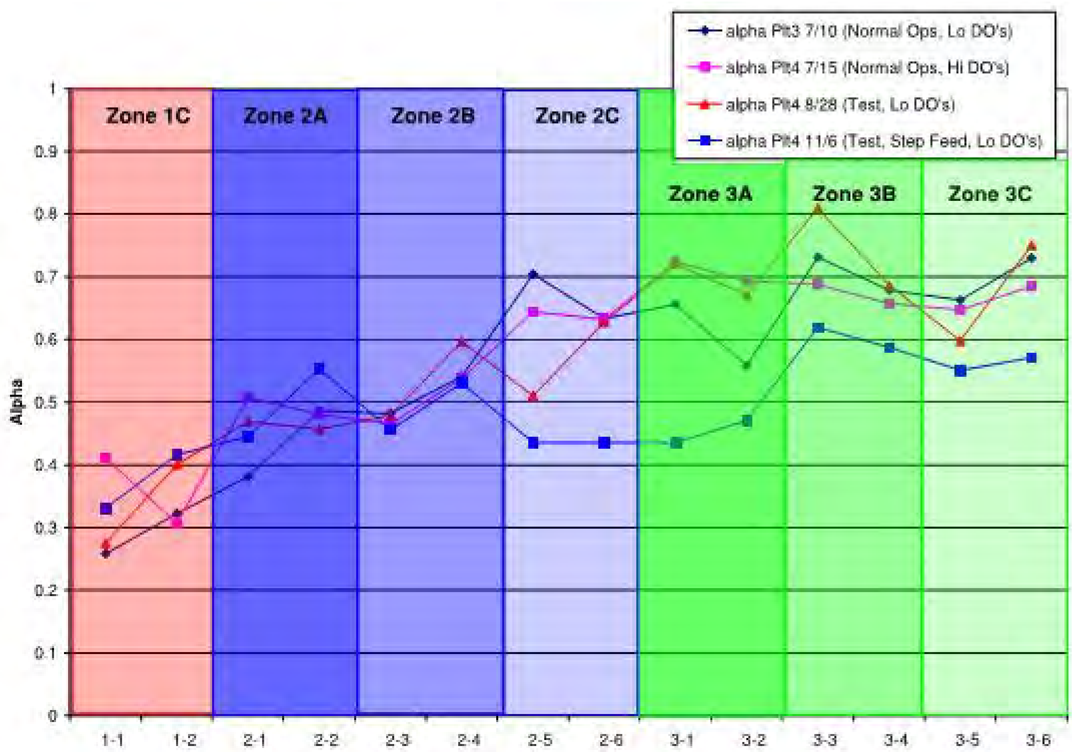


Figure 4-1. NSWWTP field-measured alpha-F profile along aeration basin length

In wet weather events when a fraction of the primary effluent is routed to Pass 3, the Pass 3 alpha-F will decrease compared to normal operating conditions as shown in Figure 4-1 (lighter blue line). Preliminary modeling indicates that the Pass 3 peak aeration demand/airflow requirements did not occur during wet weather events. During detailed design it is recommended to verify the Pass 3 oxygen demands/airflows under peak flow conditions as it could impact diffuser requirements.

Off-gas testing also indicated that the oxygen transfer efficiencies of the existing ceramic diffuser elements are similar to new ceramic diffusers.

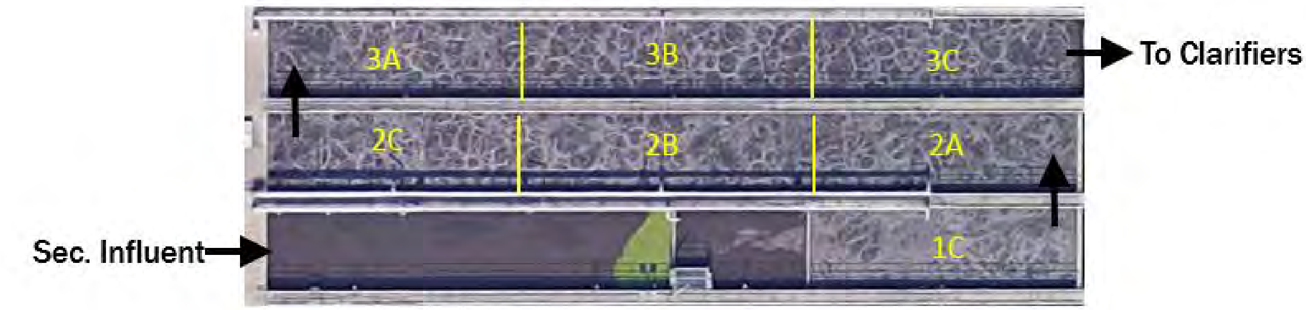


Figure 4-2. NSWWTP aeration system numbering convention

Table 4-3. BNR Alternatives Process Aeration Design Criteria and Diffuser Density (2040)								
Item	Unit	1C	2A	2B	2C	3A	3B	3C
Alpha-F								
1: Modified UCT	--	0.35	0.45	0.53	0.60	0.64	0.65	0.66
2: UCT	--	--	--	0.38	0.49	0.60	0.62	0.62
3: UCT with SS Deammonification	--	--	--	0.38	0.49	0.60	0.62	0.62
4: Nitrite Shunt	--	0.35	0.45	0.50	0.62	0.62	0.62	0.62
5: CEPT with Nitrite Shunt	--	0.35	0.45	0.50	0.62	0.62	0.62	0.62
Existing Ceramic Disc Diffuser Density, Ad/At								
1N: Modified UCT – Existing Diffuser Counts (East/West)	%	9.2/9.3	6.9/8.2	6.9/8.2	6.9/8.2	4.5/5.3	4.5/5.3	4.5/5.3
1: Modified UCT – Adjusted Diffuser Counts	%	8.0/9.1	8.0	6.5/7.8	5.7	5.2	4.7	4.7
Membrane Disc Diffuser Density, Ad/At[a]								
1: Modified UCT	%	13.0	12.3	10.5	7.5	6.5	5.1	5.1
2: UCT	%	--	--	17.1	12.4	12.9	8.8	5.1
3: UCT with SS Deammonification	%	--	--	16.6	11.9	12.4	8.6	5.2
4: Nitrite Shunt (East/West)	%	8.4/9.8	6.0/6.9	5.1/5.7	5.0/5.1	5.0/5.1	5.0/5.1	5.7/5.7
5: CEPT with Nitrite Shunt (East/West)	%	8.2/9.3	5.8/6.3	5.0/5.2	5.0/5.1	5.0/5.1	5.0/5.1	6.5/6.7
Membrane Strips Diffuser Density, Ad/At[b]								
1: Modified UCT (East/West)	%	21.6/25.0	21.3/22.9	17.4/19.4	13.5/14.9	12.3	8.4	6.4
2: UCT (East/West)	%	--	--	28.1/33.9	22.4/21.7	23.8/25.0	14.6	6.4
3: UCT with SS Deammonification (East/West)	%	--	--	27.2/32.9	21	23.5	14.3/14.3	6.4
4: Nitrite Shunt (East/West)	%	19.6/23.1	14.0/16.1	11.8/12.0	9.0/9.2	9.0/9.2	8.4/8.6	12.9/13.1
5: CEPT with Nitrite Shunt (East/West)	%	19.4/22.0	13.5/14.7	11.8/12.3	9.0/9.2	9.0/9.2	8.4/8.6	15.0/15.4

a. *Membrane disc diffuser densities – area of diffuser surface per floor area - engineer's estimate.*

b. *Membrane strip diffuser densities based on vendor designs received for Alternatives 1 and 4.*

4.3.2 Diffuser Airflow

Three fine-pore diffuser types were evaluated for projected airflow: continued use of 9-inch ceramic discs, 9-inch membrane discs, and 7.1-inch-wide by 11.5-foot-long membrane strips. Limitations were assumed for the various diffuser technologies during the aeration system evaluation. The following limitations were applied in this analysis:

- A minimum airflow of 0.06 scfm/ft^2 per aeration basin area is required to provide adequate mixing to keep solids in suspension. Mixing limitations were not encountered in this analysis at average conditions.
- The minimum airflow per ceramic diffuser was assumed to be 1.0 scfm based on plant staff operational experience to minimize diffuser fouling. Pass 3 DOs at average conditions are greater than the DO set points listed in Table 4-4 at this minimum diffuser airflow. Membrane disc diffuser minimum unit airflow was assumed to be 0.5 scfm (1.2 scfm/ft^2 diffuser area). Vendor information for the membrane strip diffusers indicates that airflows can be dropped to 0.3 scfm/ft^2 of diffuser. Minimum diffuser airflows were not encountered for either the membrane disc or strip in this analysis at average conditions.

- Peak airflow per disc diffuser was limited to 3.0 scfm to limit the pressure drop across the diffuser system. The peak diffuser airflow provided by the membrane strip manufacturer's proposed design is less than 3.0 scfm/ft^2, which is within its recommended 7 scfm/ft^2 maximum.
- Under peak conditions DO was allowed to suppress to 0.5 mg/L throughout the aerated zones in the aeration tanks.
- Alternatives 2 through 5 Pass 3C operating DO set point was 1.0 mg/L to either reduce recycled oxygen (UCT options) or reduce NH_3-N (nitrite shunt options). Based upon past low DO operations at NSWWTP, post-aeration may be required to achieve effluent DO limits. Plant staff report that they increase the Pass 3 DO set point during high flow periods. A set point of 2 to 3 mg/L is used when two effluent pumps are running and 3 to 4 mg/L when three effluent pumps are running. Refer to Section 4.6.3 for additional background on the frequency of this concern and alternatives to address low effluent DO..
- The disc diffuser density (Ad/At) was limited to a maximum of 22 percent to provide adequate space and a minimum of 5 percent to maintain mixing. Membrane strip maximum diffuser density was set at 33 percent.

4.4 Process Aeration Requirements

Table 4-4 summarizes the predicted average and peak process airflow requirements, plus the selected DO profile for each alternative. Ceramic diffusers were not considered for Alternatives 2 through 5 because diffuser airflows less than 1 scfm/diffuser are desired to maintain low operating DO levels (Alternatives 4 and 5) and reduce Pass 3C operating DO levels to 1 mg/L to minimize DO recycled in MLR (Alternatives 2 and 3).

4.4.1 Evaluation of Potential Ceramic Diffuser Distribution Optimization

A brief investigation looked at modifying the existing ceramic diffuser layout to optimize diffuser airflow conditions. The number of diffusers was adjusted to limit the peak airflow to 3.0 scfm/diffuser and under average conditions maintain a 1.0 scfm/diffuser minimum without having to provide more than the process-required air, which results in elevated DO. Optimizing the diffuser counts using this approach actually increased the peak and average overall airflows by approximately 2 percent. The modified ceramic diffuser distribution was not further considered and Table 4-4 provides airflows based on the existing diffuser layout.

Table 4-4. BNR Alternatives Process Aeration Airflows (2040)						
Item	Unit	Alternative				
		1: Existing Modified UCT	2: UCT	3: UCT with Sidestream Deammonification	4: Nitrite Shunt	5: CEPT with Nitrite Shunt
DO set point (Pass 1/2/3) [a]	mg/L	0.3/0.8/2.0	-/0.8/2.0	-/0.8/2.0	0.1/0.1/0.1[d]	0.1/0.1/0.1[d]
Existing Ceramic Diffusers (Null Alternative)						
East average airflow	scfm	17,900	--	--	--	--
West average airflow	scfm	16,200	--	--	--	--
Total average airflow	scfm	34,100	--	--	--	--
East peak airflow	scfm	32,200	--	--	--	--
West peak airflow	scfm	30,300	--	--	--	--
Total peak airflow	scfm	62,500	--	--	--	--
Membrane Disc Diffusers [b]						
East average airflow	scfm	16,000	15,700	15,100	10,400	10,500
West average airflow	scfm	14,700	14,800	14,200	11,900	12,100
Total average airflow	scfm	30,700	30,500	29,300	22,300	22,600
East peak airflow	scfm	27,700	27,100	26,100	27,400	25,900
West peak airflow	scfm	27,300	26,800	25,900	31,400	29,800
Total peak airflow	scfm	55,000	53,900	52,000	58,800	55,700
Membrane Strip Diffusers [c]						
East average airflow	scfm	14,500	14,200	13,700	9,500	9,600
West average airflow	scfm	13,900	14,000	13,400	10,900	11,000
Total average airflow	scfm	28,400	28,200	27,100	20,400	20,600
East peak airflow	scfm	25,700	25,100	24,200	25,100	23,700
West peak airflow	scfm	27,300	26,800	25,900	29,700	28,100
Total peak airflow	scfm	53,000	51,900	50,100	54,800	51,800

a. *For Alternatives 2–5 the DO in last third of Pass 3 set a 1 mg/L. DO at peak demand set to 0.5 mg/L for all alternatives.*

b. *Membrane disc airflow – engineer's estimate.*

c. *Membrane strip airflows based on vendor designs received for Alternatives 1 and 4.*

d. *Represent average DO in nitrite shunt simulation.*

4.4.2 Comparison of BNR Alternative Airflows

Table 4-4 shows that Alternative 1 airflow rates with membrane disc and membrane strip diffusers are 10 to 15 percent and 15 to 20 percent lower, respectively, than the existing ceramic diffusers. The higher ceramic diffuser airflows result primarily from lower diffuser densities of the ceramic diffuser system, which result in higher airflow per diffuser and subsequent reduction in standard oxygen transfer efficiencies (SOTE).

When comparing membrane disc diffusers, the average and peak airflow requirements for Alternatives 1 through 3 are within 5 percent and considered equal for planning purposes. Average airflows for Alternatives 4 and 5 decrease by 25 to 30 percent compared to Alternative 1. Alternative 4 peak total airflow rates increased by 5 percent while Alternative 5 total peak airflow rates remained roughly the same as Alternative 1.

Membrane strip diffuser annual and peak airflow rates are 7 percent and 5 percent lower, respectively, than the membrane disc diffusers as a result of higher diffuser SOTE. This is due to the higher flux rate (scfm/ft^2) in the disc diffusers compared to the strips.

4.5 Diffuser Net Present Worth Comparison

A diffuser net present worth evaluation was conducted to compare the net present worth of standard and high-efficiency fine-pore diffusers and is summarized in Table 4-5 (also refer to Appendix B). As noted previously, this analysis is intended to evaluate whether the increased equipment cost of high-efficiency diffusers should be included in the project's capital budget, and is not intended to be a final diffuser technology recommendation. The net present worth evaluation indicates that under similar fouling assumptions the EPDM disc and membrane strip alternatives have essentially equivalent net present worth.

The net present worth analysis is dominated by the 20-year blower energy cost which was estimated using the average airflow rates shown in Table 4-4 for Alternative 1 (Existing Modified UCT), with normal airflow variations as described in Section 5.2.1 below. The blower energy estimate is influenced by both the original diffuser efficiency and the rate and degree of fouling. Several studies have measured the air transfer efficiency loss over time for diffusers and the efficiency recovery associated with cleaning (Rosso 2014 and Rosso, Stenstrom 2006). This pattern of efficiency loss is illustrated in Figure 4-3 with the magnitude and rate of the efficiency loss differing between diffuser types and site-specific operating conditions such as MCRT.

From a net present worth estimate perspective, differences in fouling assumptions can have a significant impact on the comparison between diffuser types. Because the net present worth for the EPDM discs and polyurethane strips are essentially equal if unfouled conditions are assumed, any differences in rate of fouling and average fouling condition will cause the slower-fouling system to be favored over the more fouled diffuser system.

Fouling mechanisms differ from plant to plant, so these assumptions would need to be verified using in-plant testing of specific diffusers to refine this analysis. However, MMSD's recent experience in testing Gold Series membrane strip diffusers illustrates the challenges of quantifying the relative oxygen transfer advantages of one diffuser over another. In Xylem's Technical Bulletin (Joe Krall, October 16, 2013) conflicting observations are presented based on plant operating data and two periods of off-gas testing separated by 11 months of plant operation. Off-gas testing data suggested that the ceramic diffuser alpha-F remained consistent over this period, while the Gold Series diffuser's alpha-F advantage was reduced, especially in the A zone (Tank 12). However, Xylem called these findings into question because the data showed a very wide range of high and low variance. In addition, plant staff have noted that because of blower limitations they were not able to "flex" the Gold Series diffusers as recommended by the manufacturer to control fouling.

If the membrane strips (or one of the other diffuser technologies) can be fairly tested and found to have a fouling advantage, the high-efficiency diffusers would have a lower net present worth than the standard-efficiency diffusers. Because high-efficiency diffusers appear to be at least comparable to the standard-efficiency diffusers, additional capital budget for high-efficiency diffusers appears to be warranted.

Table 4-5. Fine-Pore Diffuser Alternatives Net Present Worth Comparison			
Item	Null Alternative (Existing Ceramic Diffusers) [d]	EPDM Disc [d]	Membrane Strip [d]
Diffuser system equipment[e, f]	-	$2,400,000	$3,400,000
Diffuser installation[e]		$230,000	$230,000
Diffuser replacement cost [f]		$1,200,000[b]	$1,200,000 [c]
Life-cycle blower energy cost [a, g]	$10,400,000	$8,600,000	$7,800,000
Life-cycle maintenance cost [h]	$520,000	$550,000	$470,000
Total net present worth	$11,000,000	$12,900,000	$13,100,000

a. *Assumes new high efficiency blowers with turndown constraints relieved.*

b. *7-year replacement cycle, $600,000 per cycle (2016 dollars).*

c. *15-year replacement cycle, $1,300,000 per cycle (2016 dollars).*

d. *Alpha-F based on values in Table 4-3.*

e. *Contingency and technical services included*

f. *Diffuser vendor quotes (Sanitaire, Aerostrip)*

g. *Continued use of the biogas blower no. 1 is assumed, with an energy cost of "zero".*

h. *Diffuser maintenance estimated as $21,000/year for EPDM disc and $19,000 per year for membrane strips, covering cleaning and miscellaneous pipe repairs. Blower maintenance is not included in this estimate.*

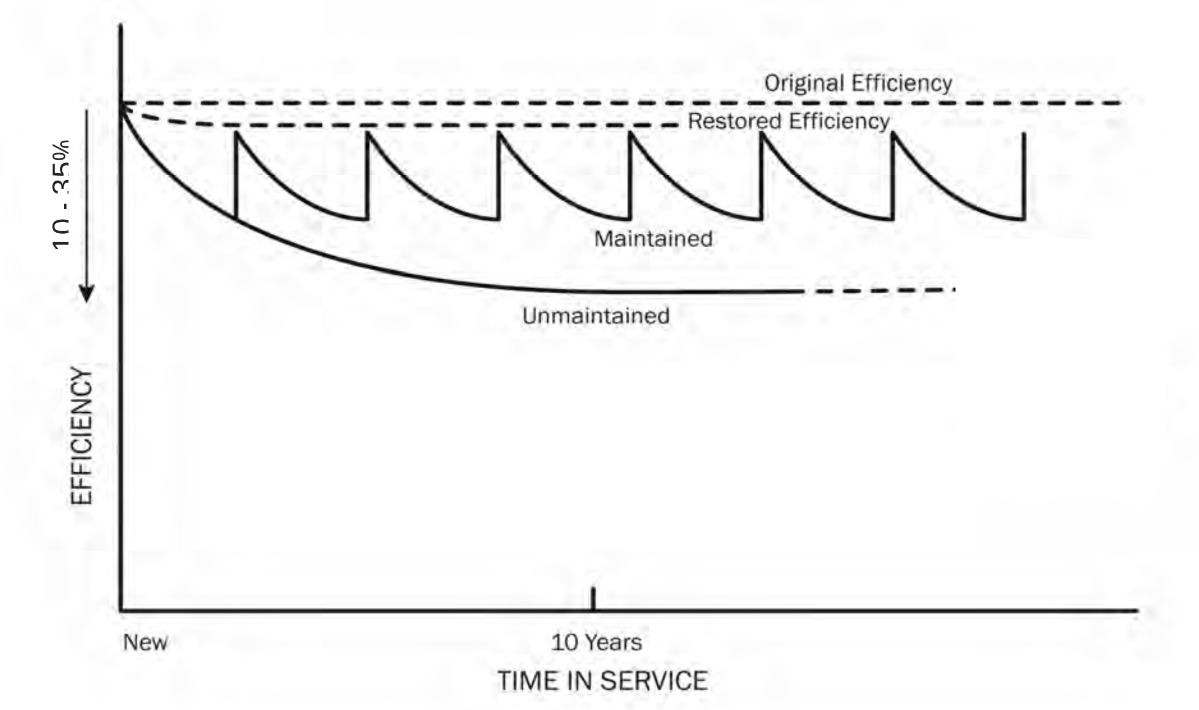


Figure 4-3. Typical fouling efficiency pattern with partial efficiency recovery following cleaning

4.6 Post-Aeration for Effluent DO Quality

This section presents requirements for post-aeration for effluent DO quality, including current conditions, impact of future BNR, post-aeration alternatives, and a preliminary alternative selection.

4.6.1 Current Conditions

NSWWTP WPDES permit includes a minimum effluent DO requirement of 5.0 mg/L. The DO concentration is continuously monitored in the effluent pump wet well and a correlation is used to estimate the DO at the Badfish Creek outfall. Operators are notified when low DO conditions occur.

Under current normal plant operating conditions the minimum effluent DO concentration is achieved through re-aeration via weirs, and other cascading flow downstream of the aeration tank. When plant effluent flow rates are high this re-aeration is reduced. In general, plant staff have indicated that when two effluent pumps are running they need to increase the Pass 3 DO set point to 2–3 mg/L to provide additional DO to meet the minimum effluent DO concentration, and when three pumps are running a Pass 3 DO of 3–4 mg/L may be used. Plant operators choose whether these manual DO set point adjustments are warranted as flows increase. The use of elevated Pass 3 DO set points is reportedly infrequent and roughly estimated by plant staff to be on the order of 10 hours per year. This frequency will increase if plant influent flows grow as projected, as shown in Figure 4-4.

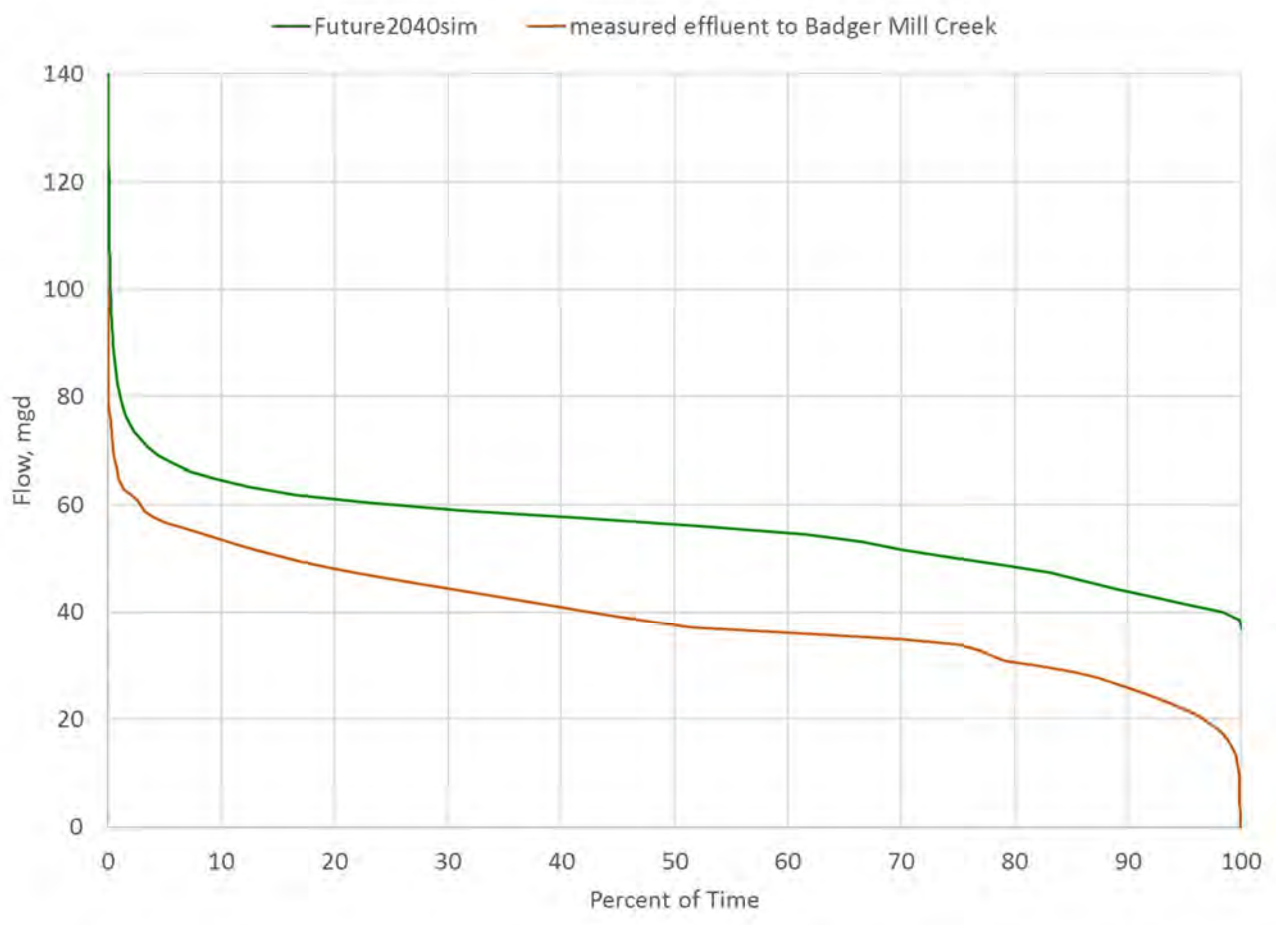


Figure 4-4. Increasing probability of high effluent flows under forecast 2040 conditions.

4.6.2 Impact of Future BNR and Growth

If either the UCT or nitrite shunt alternative is implemented in the future, intermittent elevated Pass 3 DO set points could negatively impact either BNR process. The UCT process could see a temporary increase in effluent TN from elevated DO in the mixed liquor recycle. The nitrite shunt process design includes provisions to operate the final zone in Pass 3 at 1 mg/L DO so that the effluent DO is not at the low levels typically seen in the upstream process zones under AVN control. However, the nitrate shunt biological process may be sensitive to DO greater than 1 mg/L in this zone.

4.6.3 Post-Aeration Alternatives

In light of the potential for and increasing frequency of low effluent DO periods as a result of increasing plant flows, post-aeration facilities are included in the BNR improvements. Alternative approaches for post-aeration include the following:

- Cascade aerators: Where gravity outfalls with sufficient drop are available, cascade aeration using a stair-step configuration provides a low-energy approach. However, this alternative is not feasible for MMSD's pumped effluent.
- Diffused aeration: Aeration can be accomplished with a diffused-air configuration located in tankage downstream of the secondary clarifiers. The required airflow is modest because, unlike secondary treatment aeration systems, no air is required for mixing or to meet biological oxygen demand. The post-aeration blower would operate only under high flow conditions when weir re-aeration is insufficient.
- Venturi injectors: These systems use pumped effluent sidestream routed through a venturi that aspirates ambient air. This high DO sidestream is then mixed back into the effluent to raise the bulk DO. One vendor of this type of system is Mazzai.

4.6.4 Preliminary Post-Aeration Alternative Selection

For planning purposes, the diffused-air approach was investigated to provide an initial cost estimate. The preliminary cost estimate for this system is included in Table 5-1 for the UCT and nitrate shunt alternatives.

A diffused-air system could be implemented either in new tankage or in the existing wetwell upstream of the UV system. Table 4-6 summarizes preliminary design data, assuming that diffusers are added to the existing wet well and that they can be installed during the winter when this wet well can be bypassed. The preliminary cost assumes two VFD-driven PD blowers. For this future peak day a standard diffuser system becomes very dense, so the final design may need to consider high rate diffusers such as membrane panels (e.g. Parkson, Messner).

Table 4-6. Conceptual Post-Aeration Design Parameters

Item	Units	Value
Plant flow (2040 peak day)	mgd	131
DO entering post-aeration	mg/L	1
DO leaving post-aeration	mg/L	6
Basin dimensions	ft	15 x 70
Diffuser submergence	ft	8.5
Diffuser airflow	scfm	3700
Blower motor	hp	75
Number of blowers	EA	2

Section 5: BNR Cost Comparison

This section presents the capital costs, annual operating costs, and net present worth comparison of the BNR alternatives described above, including the Null alternative of no capital improvements.

5.1 Capital Cost Comparison

Preliminary capital cost estimates for BNR Alternatives 1 through 5 are presented in Table 5-1 based on the modifications described previously in Section 3. No capital costs are considered for the Null alternative.

Two asset renewal costs are relevant to the capital cost estimate. Costs are included in Table 5-1 to replace the 30 existing control valves and differential pressure sensors associated with the aeration pass flow meters. In addition, blower replacement projects consisting of one west blower and two east blowers would add approximately $4.4 million to the capital costs presented in Table 5-1. This replacement is discussed in further detail in Section 8.

Table 5-1. BNR Alternatives Capital Cost Comparison

Item	Alternative Cost				
	1: Existing Modified UCT	2: UCT	3: UCT with Side-stream Deammonification	4: Nitrite Shunt	5: CEPT with Nitrite Shunt
Replace diffusers [a]	$1,700,000	$1,700,000	$1,700,000	$1,700,000	$1,700,000
Control valves and flow meters	$350,000	$350,000	$350,000	$350,000	$350,000
Ammonia Sensors		$250,000	250,000		
Methanol feed system		$630,000	$630,000		
Recycle pumping systems		$7,600,000	$7,600,000		
Sidestream deammonification			$3,300,000		
RAS Chlorination/ Polymer feed system[e]				$400,000	$400,000
Ferric feed system					$630,000
Two 116-ft circular secondary clarifiers[f]				$7,700,000	$7,700,000
AVN instrumentation and nitrate sensors				$1,500,000	$1,500,000
Post-aeration blower and diffusers		$610,000	$610,000	$610,000	$610,000
Subtotal	2,100,000	11,100,000	14,500,000	12,300,000	12,900,000
Contingency and professional services [b]	$1,000,000	$5,600,000	$7,200,000	$6,200,000	$6,500,000
BNR opinion of cost [c, d,]	$3,100,000	$16,700,000	$21,700,000	$18,500,000	$19,400,000

a. *Standard-efficiency diffusers. Capital costs for Alternatives 4 and 5 (nitrite shunt) include enough blank diffuser holders or connection points to allow expansion to meet the air demand for the modified UCT design. The capital cost of the higher-capacity modified UCT design is used to allocate enough estimated cost to provide this future process flexibility.*

b. *Assumed to be 50% of estimated construction costs.*

c. *Class 5, 50% conceptual level estimate level. Expected accuracy for Class 5 typically ranges from -50% to +100%.*

d. *Related peak flow management not included in this comparison.*

e. *RAS chlorination systems and polymer feed systems were installed in the Service Building in the 7th Addition. The piping is still in the ground and two neat polymer tanks are still in the Service Building, but the chlorinators and the polymer make-up systems have been removed. Some of this existing equipment may be available for re-use.*

f. *Estimated capital cost for aeration tank addition in lieu of clarifier addition is $16,000,000 without contingency and professional services.*

5.2 Annual Operation and Maintenance Costs

This section summarizes the annual operating costs for each BNR alternative. A brief summary of the basis for blower and non-blower energy consumption, engine-driven blower natural gas consumption, and energy production from increased biogas production is provided followed by annual operating costs.

The blower energy cost is expressed as a 2040 total cost, while the other operating costs are increases or decreases relative to current costs. Chemical, biosolids, and struvite annual costs are based upon the additional annual requirements presented in Table 3-1 for projected 2040 conditions. The blower and chemical costs are expected to increase over the planning period, and the life-cycle operating costs in Table 5-4 reflect this growth.

5.2.1 Blower Energy Consumption

Estimated east and west blower airflows for the BNR alternatives are summarized in Table 4-4 above. The airflows presented in Table 4-4 assume that the two blower systems would be modified and the existing turndown limitations would be relieved. In order to consider the energy consumption benefits of these blower modifications under each of the secondary process alternatives, two versions of the BNR net present worth comparison were developed, one that limited blower energy savings based on current blower turndown limits, and one that incorporated the capital costs and energy savings for new blowers. Refer to Table 5-4 below for the comparative business case evaluation (BCE) values and Section 8 for additional descriptions of the proposed blower modifications and staging considerations.

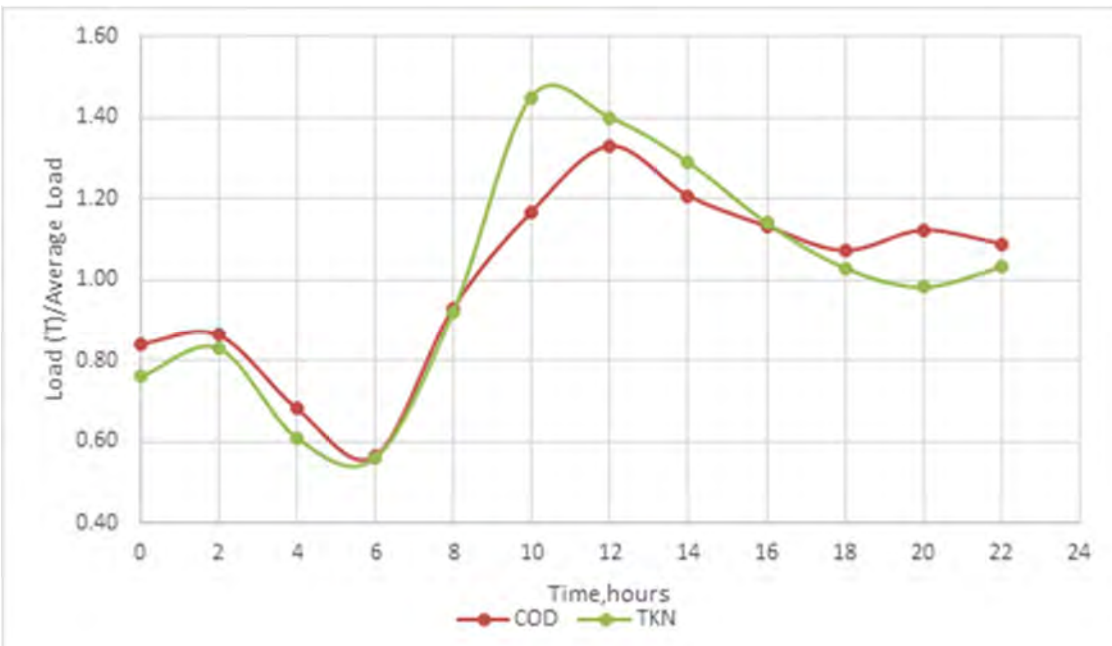


Figure 5-1. Diurnal load profile from October 2014 sampling event

In order to approximate the impact of turndown limitations on projected energy consumption, the blowers were assumed to be operating under the following normal range of conditions:

- High airflow: 25 percent of annual hours at 125 percent of the year-by-year average condition
- Average airflow: 50 percent of annual hours at the year-by-year average condition
- Low flow: 25 percent of annual hours at 75 percent of the year-by-year average condition

This distribution reflects a simplification of the diurnal load profile depicted in Figure 5-1. Energy use at projected operating conditions that were below the turndown limits of the existing blower were estimated at the minimum achievable airflow condition. As expected, this limitation significantly reduced the potential blower savings from the low-energy BNR configurations in the “existing blower” BCE.

The net present worth projection for blower energy consumption assumed that the annual average oxygen demand would increase linearly from the current value to the projected 2040 demand (see figures 8-4 and 8-5). This distinction is important because as the load grows the detrimental energy effects of the blower turndown limitations are lessened.

5.2.2 Non-Blower Energy Consumption

Table 5-2 summarizes the estimated changes in non-blower energy for the process alternatives. Note that estimated electrical use for additional anaerobic/anoxic mixers is based on 24/7 operation and would decrease if mixers were cycled on and off according to MMSD’s current practice.

Table 5-2. Non-Blower Energy Comparison

Item	Unit	Alternative				
		1: Existing Modified UCT	2: UCT	3: UCT with Sidestream Deammonification	4: Nitrite Shunt	5: CEPT with Nitrite Shunt
Additional anaerobic/anoxic mixing	kWh/year	No change	400,000	550,000	40,000	40,000
Mixed liquor pumping	kWh/year	No change	800,000	800,000	(200,000)	(200,000)
Deammonification energy	kWh/year	No change	-	60,000	-	--

5.2.3 Engine-driven Blower Natural Gas Consumption

At full capacity East blower 1 uses 160,000 standard cubic feet per day (scfd) of biogas. The two nitrite shunt airflow requirements could be satisfied by blower 1 for most of the year under projected near-term conditions. The blower energy costs for Alternatives 4 and 5 assume that blowers 4 and 5 are operated for a limited number of hours per year and that blower 1 is modulated to part load. The operating cost savings for these alternatives were estimated based on the natural gas savings from diverting biogas to boilers or engine-generators. As oxygen demands increase through the planning period, these natural gas savings are forecasted to diminish. At some point during the planning period blower 1 will likely be replaced with a motor-driven blower and these savings will convert to electrical savings with roughly similar estimated savings.

5.2.4 Energy Generation from Increased Biogas Production

Current biogas production is approximately 900,000 scfd. The CEPT alternative is estimated to increase biogas production by roughly 15 percent. Under recent operating conditions, the plant has maximized the use of available generation capacity and fulfilled its boiler fuel needs by purchasing natural gas. The additional CEPT biogas would reduce the quantity of natural gas purchased with the current biogas utilization system and increase electrical generation with a future CHP system.

5.2.5 Comparison of Annual Operating Costs

Table 5-3 summarizes the estimated first-year energy, chemical, biosolids, and struvite operating costs for each alternative. Table 5-3 also contrasts the annual operating costs of the existing blowers and new blowers with improved efficiency and improved turndown capabilities. The annual savings for new blowers varies between alternatives, ranging from $220,000 to $370,000 per year.

Table 5-3. BNR Alternatives Opinion of Probable Annual Operating Costs (2016 Dollars)						
Item	Alternative					
	1N: Null Alternative	1: Existing Modified UCT	2: UCT	3: UCT with Sidestream Deammonification	4: Nitrite Shunt	5: CEPT with Nitrite Shunt
Energy [a]						
Annual blower energy [h]						
Existing blowers [b]	$960,000	$700,000	$760,000	$702,000	$530,000	$530,000
New blowers [b, k]	$590,000	$470,000	$500,000	$480,000	$310,000	$310,000
Non-blower energy			$100,000	$125,000	($9,000)	($11,000)
Increased generation						($12,000)
Chemicals						
Methanol [j]			$1,800,000	$1,500,000		
Caustic [c]	-	-	-	-	-	-
Additional $FeCl_3$ [d]						$350,000
Polymer [e]					$140,000	$438,000
Change in magnesium chloride [f]						($22,000)
Other operating costs changes						
O&M Labor			$40,000	$95,000	$93,000	$110,000
Biosolids management [g]			$40,000	$36,000	$(146,000)	$60,000
Struvite recovery [i]						$110,000
Total operating cost						
Existing blower	$960,000	$700,000	$2,700,000	$2,500,000	$610,000	$1,600,000
Upgraded blower	$590,000	$470,000	$2,500,000	$2,200,000	$390,000	$1,300,000

a. *$0.087/kWh.*

b. *Includes natural gas savings from reduced blower 1 loading.*

c. *Caustic use is estimated to be similar for all alternatives.*

d. *$4.80/gallon.*

e. *$1.75/lb. Polymer was assumed to be required 50% of the year, which is believed to be conservative enough to also cover any chemical costs associated with infrequent use of RAS chlorination.*

f. *35% reduction from current $61,530 per year. Assumes chemical savings benefit MMSD (currently paid by Ostara).*

g. *$200/dry ton.*

h. *Ceramic diffusers for null alternative and EPDM disc diffusers for Alternatives 1 through 5.*

i. *Lost struvite revenue at $346/ton.*

j. *$2.14/gallon*

k. *New blower energy estimate reflects higher blower efficiency and reduced turndown limitations relative to the existing blower estimate.*

5.3 Net Present Worth Comparison

Table 5-4 compares the net present worth estimates for the BNR alternatives under both existing blower and new blower scenarios. It is important to note that this alternative comparison includes alternatives with differing levels of service in terms of effluent quality and process risk. These factors are considered in further detail in Section 6 below.

Alternatives 1 and 1N have the lowest net present worth in this analysis, but these alternatives have higher projected effluent TN concentrations than the other alternatives (refer to Table 6-1). The equivalent net present worth for Alternative 1N and Alternative 1 with new blowers indicates that the energy upgrades to the blowers, diffusers, and controls included in Alternative 1 provide sufficient energy savings to balance the estimated capital cost over the 20 year planning period. Similarly, the existing and new blower life-cycle costs for the BNR alternatives 2-5 are effectively equal in this analysis. However, it should be noted that this blower upgrade scope is focused on energy savings and is limited to one new west blower and two new east blowers. Section 8.4.2 provides an expanded comparison of blower replacements that includes phased-in east-west cross-connection piping and staged replacement of additional blowers as they reach the end of their useful life.

A major factor in the life-cycle cost analysis is the secondary clarifier addition associated with the nitrogen shunt alternatives. If the clarifier tank addition can be deferred or omitted as noted in Section 3.4, Alternative 4 would become approximately equivalent on a new present worth basis with continued use of Modified UCT, as shown in the last row in Table 5-4. Under current SLR assumptions the additional clarifiers would not be required until 2028 based upon current growth projections and assumed clarifier capacity.

Table 5-4. BNR Alternatives Net Present Worth Comparison

Item	Alternative, Costs in Millions					
	1N: Existing Modified UCT (Null Alternative)	1: Existing Modified UCT	2: UCT	3: UCT with Sidestream Deammonification	4: Nitrite Shunt	5: CEPT with Nitrite Shunt
Capital cost						
BNR improvements[e]	$0	$4.1	$16.8	$21.7	$18.5	$19.4
BNR improvements and new blowers[f]	$0	$8.6	$21.3	$26.2	$22.9	$23.8
Operating cost[a]						
Existing blowers	$16.5	$13.0	$48.3	$45.7	$12.3	$30.2
New blowers	$10.3	$8.0	$43.5	$41.5	$7.4	$25.3
Increased biogas production and reduced natural gas	$0	$-0.1[g]	$-0.05	$-0.1	$-0.8	$-3.0
Net present worth estimate [b, c]						
Existing blowers	$16.5	$17.0	$65.1	$67.3	$29.9	$46.7
New blowers	$10.3	$16.5	$64.8	$67.6	$29.5	$46.2
Avoided clarifier tank addition [d]	N/A	N/A	N/A	N/A	$17.8	$34.5

a. *Operating costs include blower and non-blower energy, chemical costs, and other O&M costs. Refer to Table 5-3.*

b. *Years of analysis: 2020–40.*

c. *Escalation rate: 4.0%, discount rate: 4.38%.*

d. *Net present worth estimate for scenario in which clarifier stress testing finds that clarifier addition is not required prior to the end of the planning period in 2040. This estimate is based on the new blower scenario, but excludes $7,700,000 in clarifier capital costs and $3,900,000 in related contingency and technical services from the base case estimate.*

e. *Capital cost components detailed in Table 5-1.*

f. *Capital cost components detailed in Table 5-1 plus $4.4 million in near term energy-saving blower modifications (one new west blower, two new east blowers). This line depicts the alternate scenario of a BNR upgrade with limited near term blower replacements, not complete replacement of all blowers.*

g. *Blower 1 fuel savings related to increased airflow turndown with membrane diffusers*

Section 6: BNR Non-Economic Evaluation

This section discusses the non-economic benefits and limitations of the BNR alternatives.

6.1 Benefits and Limitations

The proposed BNR upgrades provide a significant opportunity to make investments that support MMSD's core values. The BNR alternatives considered in this evaluation were selected with the support of MMSD's SAM process. This process documents the contribution of each alternative toward MMSD's values of a healthy environment, wellbeing of individuals, strong community, and vital economy. The impact on the local economy is largely captured by the net present worth comparison presented in the previous section. Key aspects of the environment and community values are summarized in the following sections.

6.1.1 Healthy Environment

This section presents potential environmental benefits and limitations resulting from the BNR upgrades, including effluent quality, energy use, and greenhouse gas (GHG) emissions.

Effluent Quality

Table 6-1 recaps the key factors relative to anticipated effluent ammonia, TP, and TN concentrations. The monthly ammonia discharge concentrations, especially during winter months, are expected to be higher for the main stream nitrite shunt alternatives than for the modified UCT and UCT alternatives.

Table 6-1. Predicted Effluent Quality Comparison

Item	Unit	Alternative				
		1: Existing Modified UCT	2: UCT	3: UCT with Side-stream Deammonification	4: Nitrite Shunt	5: CEPT with Nitrite Shunt
Monthly NH_3-N (warm/cold)	mg/L	<0.1/0.1	<0.1/0.6[c] 1.6[d]	<0.1/0.6	0.5/1.5	0.5/3.0
Monthly TP	mg/L	0.4	0.4	0.4	0.3	0.3
Annual TN	mg/L	20	15.5[a]/8[b]	≈14[a]/8[b]	7.5	12
Mature TN reduction technology	mg/L	NA	Yes	Yes	No	No

a. *No carbon addition, average conditions.*
b. *With carbon addition, average conditions.*
c. *Steady-state BioWin simulation.*
d. Dynamic BioWin Simulation

Dynamic Bio*W*in *S*imulation Energy Use

Blower Energy. The nitrogen shunt alternative significantly reduces blower energy. CEPT enhancement of nitrogen shunt further reduces net energy by producing more biogas, but the chemical costs make this approach less financially feasible.

Non-Blower Energy. The UCT process energy demands are greater than the existing because of addition of MLR system and additional mixed zones.

Greenhouse Gas Emissions

In addition to GHG emissions related to natural gas and electrical consumption, the following GHG impacts vary between BNR alternatives.

Methanol Oxidation to Carbon Dioxide (CO_2). UCT processes that use methanol as a carbon source incur a significant increase in GHG emissions because methanol is derived from fossil fuels. Some plants have begun to use alternative carbon sources such as glycerin products to reduce this impact.

N_2O from Nitrogen Treatment. Nitrous oxide (N_2O) emissions associated with nitrogen treatment are relatively small, but their impact can be significant because N_2O has a GHG impact 300 times that of CO_2. Research to better understand and quantify the mechanisms of N_2O emissions is one of the most active research areas related to GHG emissions from wastewater management. In general, field measurements have shown that plants that achieve high levels of nitrogen removal emit less N_2O and most N_2O emissions occur in aerated zones because of air stripping. This area of research should continue to be monitored, especially as data regarding N_2O emissions from nitrite shunt processes become available.

6.1.2 Strong Community and Wellbeing of Individuals

Table 6-2 summarizes the benefits and limitations of the BNR alternatives as they relate to the following factors:

- Process flexibility
- Operational complexity
- Chemical use
- Technology risk

Table 6-2. Non-Monetary Benefits and Limitations Related to Strong Communities and Individuals

BNR Alternative	Benefits	Limitations
1N: Null alternative	• Plant staff familiarity • Performance well proven at NSWWTP • Opportunity to wait for emerging technologies to mature	• Does not improve energy efficiency • Does not address risks related to aging equipment
1: Existing Modified UCT	• Same as Null alternative	• Uncertainty related to site-specific fouling characteristics of new diffuser technologies
2: UCT	• Plant staff are familiar with this configuration • Can be designed for flexible operations in nitrite shunt mode	• IMLR and supplemental carbon add some complexity for operations
3: UCT with Sidestream Deam-monification	• Can be designed for flexible operations in nitrite shunt mode • Reduces supplemental carbon requirements by 10% compared to UCT alternative • Takes advantage of shortcut denitrification process to reduce car-bon addition • Deammonification is a simple robust process that is automated • Potential to bioaugment mainstream with Anammox biomass	• Deammonification systems are patented • Additional process to operate increases complexity • Heating required in sidestream reactor to maintain deammonification activity • Deammonification installations downstream of Ostara process not proven
4: Nitrite Shunt	• Emerging technology which could set precedence for other utilities to follow • Can be designed for flexible operations in modified UCT mode	• Limited installations • May require chemical addition for low effluent TP • More complex to operate than UCT alternatives—additional nitrogen sensors and ac-curate aeration control required • Reduced SVI impact on secondary clarifiers and anticipated polymer feed and RAS chlorination to control settling.

5: CEPT with Nitrite Shunt	• Same as nitrite shunt	• Same as nitrite shunt plus the following:
		  • Additional aeration savings not predicted to be significant
		  • CEPT operations add more complexity

Section 7: Recommended BNR Alternative

This section presents a phased, flexible approach that balances net present worth, process risk, and non-monetary benefits. Refer to Section 8.5 for the related blower phasing approach.

7.1 Proposed BNR Phasing

The nitrite shunt alternative offers significant operating cost, environmental, and other non-monetary benefits. However, consideration of these benefits must be tempered by recognition that this alternative is an emerging technology with few proven full-scale installations and no applications at similar cold weather temperatures of 12 degrees Celsius.

Assuming that more stringent nitrogen permit requirements will be phased in over several years, the phased BNR strategy depicted in Figure 7-1 would allow for incremental steps toward reduced nitrogen discharges and energy consumption. Note that aeration expansions and UCT operation would be implemented only if required. The phasing approach is based upon moving forward with Alternative 4, Nitrite Shunt, and proving nitrite shunt operations at bench scale, and if successful verifying system sizing based upon pilot scale operations, and then full-scale demonstration in Plant 1 or 2. Secondary clarifier stress testing and subsequent CFD modeling are also recommended to confirm the existing clarifier SLR capacity as each TN reduction alternative has secondary clarifiers SLR at the estimated maximum allowable levels at 2040 critical flow and loading conditions. If nitrite shunt bench-scale or demonstration testing is not successful, implementation of the existing modified UCT or UCT is recommended depending upon whether a TN limit is in place.

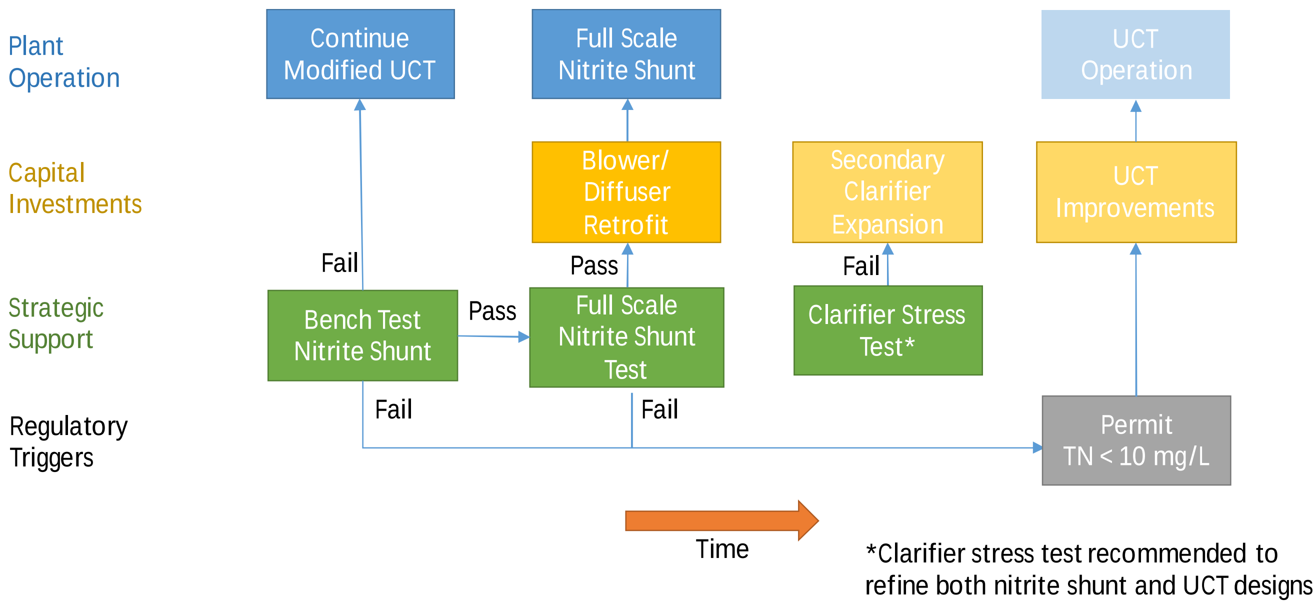


Figure 7-1. Conceptual timeline of phased BNR improvements approach

Section 8: Blower Evaluation

This section presents an evaluation of the blowers, including a review of the condition of existing blowers, a summary of available blower technologies, a preliminary screening of these blower technologies, east-west cross-connect, and blower phasing.

8.1 Existing Blower Condition

NSWWTP operates two sets of blowers serving the east and west sides of the plant. The two sets of blowers are operated and controlled independently. The existing equipment and its condition are described below.

8.1.1 East Blowers

There are five east blowers with varying types and capacities, as summarized in Table 8-1 below.

8.1.1.1 Engine-Driven Blower

East blower 1 is driven by a gas engine using biogas from the NSWWTP anaerobic digesters and is normally in service to maximize the use of biogas and reduce electrical demands. The blower 1 engine speed is controlled between 700 and 820 rpm to modulate flow and control the aeration system header pressure.

MMSD recently received a draft air permit that requires continued use of an oxidation catalyst on the engine-driven blower, but allows the engine-generators to operate without the catalyst. Continued catalyst operation on the blower engine requires diligent control of siloxanes via the gas treatment system in order to avoid poisoning the catalyst.

Blower 1 is approximately 30 years old. During the condition assessment inspectors observed an oil leak and that the blower was running hot, but it is otherwise in acceptable condition. MMSD intends to continue operating this blower for several more years because it is an integral part of its biogas utilization program. Future blower retrofits need to operate effectively in parallel with blower 1 if they are implemented prior to its replacement.

8.1.1.2 Motor-Driven Blowers

Under most operating conditions, either blower 4 (low or high) or blower 5 (low or high) provides the base air demand in parallel with the variable-speed operation of blower 1. The starting and stopping of these blowers is a manual process, as is the selection of the blower high or low speed, but changes to the blower operations are infrequent. Blowers 4 and 5 are nearly 50 years old. Mechanical issues documented by the condition assessment include:

- Shaft, supports, and bearing deterioration
- Vibration (blower 5)
- Electrical distribution system condition

The two centrifugal blowers (2 and 3) are approximately 30 years old and are seldom operated.

Table 8-1. East Blower Summary			
East Blower No.	Type and Output Control	Capacity	Motor Size
1	Positive displacement; gas engine (biogas)	7,875 cfm @ 600 rpm 9,185 cfm @ 700 rpm 10,500 cfm @ 800 rpm	~ 500 hp @ 800 rpm 160,000 scfm biogas/day
2	Centrifugal Variable inlet vanes	7,000 to 11,500 cfm	600 hp; 4,000 V
3	Centrifugal Variable inlet vanes	7,000 to 11,500 cfm	600 hp; 4,000 V
4	Positive displacement; 2-speed motor	7,760 cfm @ low speed 10,850 cfm @ high speed	375/500 hp; 4,000 V
5	Positive displacement; 2-speed motor	5,840 cfm @ low speed 9,070 cfm @ high speed	325/450 hp; 4,000 V

8.1.2 Channel Aeration

Approximately 2,500 scfm (roughly 15 percent) of the east aeration air is diverted to channel mixing and agitation air for the headworks. A lesser quantity is diverted from the west blowers for primary channel mixing.

Several energy-reducing alternatives could be explored during detailed design to reduce or eliminate this airflow, including:

- Control valve to throttle or cycle air
- Low-head blowers
- High-efficiency mixers
- Reduced headworks airflow

These channel aeration alternatives were not evaluated for this study, but should be considered in any future planning for east blower replacements.

8.1.3 West Blowers

Three 1,250 hp single-stage centrifugal blowers provide air to activated sludge plants 3 and 4, as summarized in Table 8-2. Only one blower is operated at a time and typical blower output is between 16,000 and 20,000 scfm. Inlet guide vanes on the blower inlet are modulated based on system pressure in the air main.

The primary concern with the west blowers is their inability to turn down to match normal diurnal load fluctuations, with aeration basin DO concentrations rising to 5 mg/L at night. The blowers seldom use the high end of their capacity range, but if loads are very high the blower's motors can overload. To avoid this condition, power monitoring to each blower is used to initiate alarms if the power use rises above 900 kW (~1,200 hp).

Table 8-2. West Blower Summary			
West Blower No.	Type and Output Control	Capacity	Motor Size
1	Centrifugal Variable inlet vanes	25,000 cfm	1,250 hp; 4,000 V
2	Centrifugal Variable inlet vanes	25,000 cfm	1,250 hp; 4,000 V
3	Centrifugal Variable inlet vanes	25,000 cfm	1,250 hp; 4,000 V

The west blowers were added during the 7th Addition to the NSWWTP in 1986, and are about 31years old. However, because the plant is able to operate with one of the three blower units, the operating hours are moderate for equipment of this age. Maintenance concerns noted in the conditions assessment include:

- Service support issues leading to prolonged outages and concerns about adequate redundancy
- Shaft, supports, and bearing deterioration
- Oil on top of drive and filter smoking (blowers 2 and 3)
- Vibration/oscillation (blower 3)

8.2 Available Blower Technologies

Although the existing blowers may be reaching the end of their useful life by conventional asset management expectations, the plant has maintained its equipment well and it does not appear that all blower units would need to be replaced concurrently. Instead, new blowers could be phased in over time to gain efficiency from one or two new blowers while the remaining blowers served as standby capacity.

In contrast to "greenfield" installations, future blower retrofits for MMSD must have capacity and design characteristics that reuse existing building features and electrical distribution infrastructure efficiently.

The following sections briefly describe the available blower alternatives and their applicability for MMSD east and west blower retrofits.

8.2.1 Single-Stage Integrally Geared Centrifugal Blowers

Single-stage integrally geared blowers would be similar to the existing Ingersoll Rand west blower units, although there may be some improved energy efficiency because of improvements in the blower design. The main efficiency improvement in single-stage centrifugal blowers is the addition of modulating diffuser vanes to maintain high efficiency over a range of operating airflows. The market for this type of blower is dominated by Siemens/Turblex. Other competitors include Howden/Roots, Atlas Copco, and Lone Star Blower. The current business position and performance record of these competitors would need to be verified prior to specifying them.

8.2.2 High-Speed Turbo Blowers

In recent years, high-speed turbo blowers have been widely adopted for wastewater applications because of their higher efficiency relative to older positive-displacement and multistage centrifugal blowers. These blowers use non-contact bearings to facilitate high rotational speeds and minimize frictional losses. Either air bearings or magnetic bearings serve this function, with the type varying by manufacturer.

Turbo blower units with air bearings are limited in capacity to approximately 7,500 cfm per dual core unit, up to 15,000 cfm with newer "quad" designs. Units with magnetic bearings have single cores with slightly lower airflow capacities, on the order of 9,000 cfm. This flow range is too low for a single unit to serve the expected normal west blower load. If MMSD wishes to pursue this option on the west side, the engineer would need to determine if two turbo units could be accommodated in the existing blower space.

Magnetic bearing units appear to be less prone to bearing failures than air bearing units, although the capital cost of these blowers is higher than units with air bearings. Air bearing failures typically require that the core, consisting of the motor, bearing, and rotating assembly, be removed and replaced.

Transformers would be required to be added to the electrical distribution system because high-speed turbo blowers are not typically available with 4,160-volt (V) motors, so future energy comparisons should incorporate transformer losses when comparing energy consumption between potential blower types.

8.2.3 Screw Blowers

Screw blowers are a relatively new positive-displacement blower technology. In lieu of rotating lobes, the blower is configured with meshing screws. The rotating speed of the screws is varied with a variable-frequency drive (VFD) to modulate flow. This blower design is able to achieve efficiencies that are nearly equal to single-stage integrally geared blowers and turbo blowers, with minimal decrease in efficiency over a wide turndown range. In contrast to high-speed turbo blowers, screw blowers use standard 60-hertz (Hz) VFDs and motors, and standard bearing technology.

The main limitation of screw blower technology is scale. The largest available blower capacity is approximately 4,800 scfm. As such, screw blowers are best suited to the east blower complex and to the lower projected airflows associated with nitrite shunt operation.

8.2.4 Multistage Centrifugal Blowers

Multistage blowers were commonly installed in midsize WWTPs for many years. This blower technology can provide high efficiencies at their design point. However, in variable flow applications, multistage compressors often use modulating inlet valves to throttle flow, resulting in lower overall efficiency and less turndown range than single-stage blowers.

VFDs have been proposed as a means to improve part-load efficiency, but VFDs are costly in this size and voltage, and the approach has had mixed success in other locations. The blower outlet pressure drops off quickly with reduced speed, so the speed range must be controlled within a very limited range near 100 percent.

8.3 Preliminary Screening of Blower Technologies

Tables 8-3 and 8-4 compare the suitability of the available blower technologies for east and west blower replacements, respectively. The net present worth analysis presented in Section 5.3 was based on single-staged integrally geared centrifugal blowers because they best met the criteria listed in Tables 8-3 and 8-4.

Table 8-3. Preliminary Blower Alternative Screening: West Blower Modifications

Parameter	Single-Stage Integrally Geared Centrifugal	High-Speed Turbo (Air Bearings)	High-Speed Turbo (Magnetic Bearings)	Screw	Multistage Centrifugal
Example manufacturer	Turblex, Howden Roots	Neuros, HSI, Aerzen	Sulzer ABS Spencer Turbine	Aerzen, Atlas Copco	Lamson / Hoffman
Airflow capacity comparable to existing units	Yes	Multiple units required	Multiple units required	Multiple units required	Yes
Issues with surge	Turndown and maximum head limited by surge, but bearing damage is rare.	Turndown and maximum head limited by surge. Internal controls are designed to prevent damage but core replacement due to air bearing damage has been required at several sites.	Turndown and maximum head limited by surge. Magnetic bearings appear to be more resistant to surge damage.	None	Not common
High energy efficiency	Yes	Yes	Yes	Yes	No
Standard motor and VFD	Standard motor, no VFD	High speed motor and VFD	High speed motor and VFD	Yes	Yes
Available with medium-voltage motor	Yes	No, but future electrical upgrade could accommodate	No, but future electrical upgrade could accommodate	Not standard	Yes
Preliminary feasibility assessment	Pass	No	Tentative pass	No	No

Table 8-4. Preliminary Blower Alternative Screening: East Blower Modifications

Parameter	Single-Stage Integrally Geared Centrifugal	High-Speed Turbo (Air Bearings)	High-Speed Turbo (Magnetic Bearings)	Screw	Multistage Centrifugal
Example manufacturer	Turblex, Howden Roots	Neuros, HSI, Aerzen	ABS, Spencer Turbine	Aerzen, Atlas Copco	Lamson / Hoffman
Airflow capacity comparable to existing units	Yes	Yes	Yes	Multiple Units Required	Yes
Issues with surge	Turndown and maximum head limited by surge, but bearing damage is rare.	Turndown and maximum head limited by surge. Internal controls are designed to prevent damage but core replacement due to air bearing damage has been required at several sites.	Turndown and maximum head limited by surge. Magnetic bearings appear to be more resistant to surge damage.	None	Not common
High energy efficiency	Yes	Yes	Yes	Yes	No
Parallel operation with engine-driven PD blower	Yes[a]	TBD	Yes	Yes	Yes
Standard motor and VFD	Standard motor, no VFD	High speed motor and VFD	High speed motor and VFD	Yes	Yes
Available with medium-voltage motor	Yes	No, but future electrical upgrade could accommodate	No, but future electrical upgrade could accommodate	Not standard	Yes
Preliminary feasibility assessment	Pass	No	Tentative pass	Tentative pass	No

a. Single-stage blower must have sufficient rated discharge pressure to overcome the peak pulsation pressure produced by the positive-displacement blower.

8.4 East-West Cross-Connect

Cross-connecting the east and west blower complexes has the potential to reduce energy use, simplify maintenance and operations, increase flexibility, and optimize future blower investments. This section considers the following two cross-connect scenarios:

- Partial blower cross-connect incorporating the 8-inch-diameter existing pipe to headworks
- Full capacity east-west cross-connection using new 30-inch-diameter pipe

8.4.1 Connect to West Aeration via 8-inch-diameter Existing Pipe to Headworks

During development of the 2014 energy study MMSD staff suggested a possible cross-connection of the east and west aeration systems as a means to reduce energy consumption by using excess west blower capacity within Plants 1 and 2, especially if the transferred flow of air was sufficient to eliminate normal operation of blower 4 or 5. The proposed cross-connect piping would be routed through the parking area south of the operations building as shown in Figure 8-1.

The existing 8-inch-diameter pipe currently conveys air to the headworks, where it is used to provide channel aeration before and after the screens. The water depth in this channel is between 6 and 8 feet. The airflow to the headworks area is controlled by an 8-inch manual butterfly valve located in the headworks building. Under this configuration the pressure in the proposed tie-in point would be roughly equivalent to the pressure in the East Blower air header.

The quantity of air that could be transferred to the east would be constrained by the existing 8-inch pipe diameter and the roughly 0.4 psi pressure differential that exists between the 8-inch-diameter pipe and the west header. Under these conditions the transferred air quantity would be approximately 1,500 to 1,700 scfm. The headworks airflow is roughly 400 scfm, so about 1,100 scfm would transfer to east aeration.

The estimated project cost for this crossover piping is $100,000 including contingency and technical services. This cost does not appear to be justified because it would not transfer enough air to allow blower 4 or 5 to be removed from service and reduce energy consumption.

Figure 8-1. Possible east-west air piping connection

8.4.2 Phased-in Aeration Consolidation to West Blower Building

This section evaluates a phased-in consolidation of blower capacity on the west side in order to simplify the blower system operations and maintenance (O&M) needs and minimize future spending on the east blower complex. Initially, the west blower system would be used in conjunction with engine-driven blower 1 to supply the oxygen demand in Plants 1 and 2. When blower 1 is phased out as part of a biogas utilization project or when blower 1 is out of service, the consolidation design would allow all air to be supplied from the west blowers. West blower improvements would be staged as needed to accommodate this progression, while also addressing MMSD's energy and asset management needs.

A related benefit of the full-size east-west cross-connection piping is to provide some redundancy between the east and west blower systems, so this section also considers the capacity of the East Blower building to provide air to the west aeration tanks if the west blower building loses power.

Preliminary Piping Configuration

A preliminary concept design was developed to route aeration air from the west blower system to the east blower aeration header. This design includes:

- Connection to the west aeration header in the west aeration gallery
- 30-inch-diameter aeration piping through tunnel between Plant 3 and Plant 4, including insulation to mitigate the safety concern with high-temperature piping near the walkway
- 30-inch-diameter above-grade piping from Aeration Building 4 to the East Blower building, including overhead pipe supports (see Figure 8-2)
- Connection to east aeration header with valve in blower room

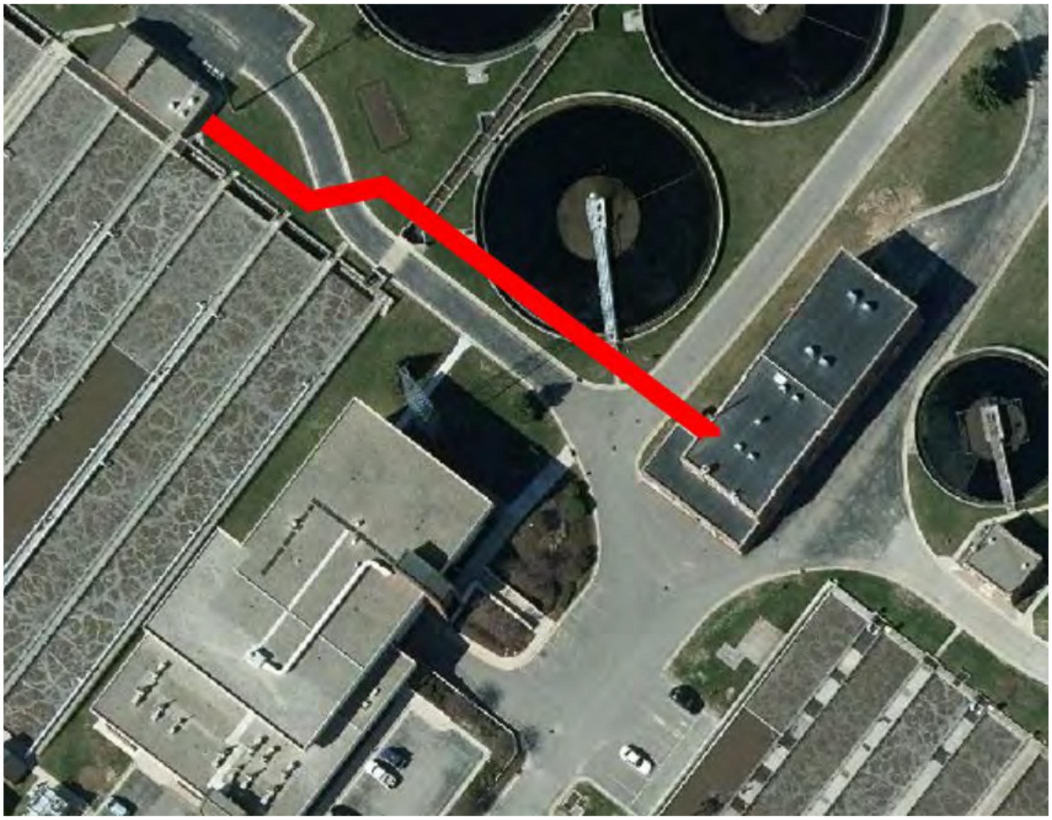


Figure 8-2. Above-grade piping between Aeration Building 4 and East Blower building

Note: Actual route to be determined during final design

Balancing East-West Airflows

As noted previously in Table 4-1, the existing diffuser submergence is 1 foot greater on the west side than on the east side. In a cross-connected configuration this difference must be throttled so that the airflow from the west does not favor the east aeration tanks. The following three alternatives are available to provide this balance:

1. Air pressure control valve between east and west air headers with 1-foot pressure drop: A control valve with precise modulating characteristics such as an iris valve (e.g., Egger) will help to stabilize the controls. The valve controller is configured to maintain pressure set points on both sides of the system.
2. Air pressure control valves on tanks 1–6, lower diffuser mounting in tanks 7–18: When new diffusers are installed in tanks 7 through 18 they could be installed at an elevation to match the west submergence. In this configuration only the airflow to tanks 1 through 6 would require throttling.
3. Lower all east diffusers to match west submergence: Some diffuser types, including the membrane strips discussed in Section 4.5, can be mounted either flush with the floor or above the floor. East and west diffuser submergence could be equalized by floor-mounting diffusers in tanks 1 through 6 and mounting the diffusers in tanks 7 through 18 at the same 15.5-foot submergence.

For this analysis, the first control valve alternative is assumed because it does not require coordination with diffuser replacement phasing. However, the second control valve alternative deserves additional future consideration because it minimizes the control valve size, lowers the diffusers in tanks 7 through 18 to a more standard mounting level, and reduces the energy wasted through the balancing control valve pressure drop. The third alternative is not recommended because it limits the potential future diffuser technologies to those that are suitable for floor mounting.

Routing East Blowers to West during West Blower Outage

The primary intent of the east-west cross-connection is to modify the plant in phases so that the west would supply all air to both the east and west aeration tanks in the long run. However, if the east blowers remain available for service they could be used in standby to supply air to the west during a west blower outage. Under this infrequent operating condition the system would need to be manually adjusted as follows:

- East blower set point increased from 8.5 to 9.0 psig.
- East-west control valve wide open
- Control valve bypass opened to further minimize pressure drop
- Plant 1 and 2 airflows manually reduced as needed to balance flows between east and west aeration

With this increased head pressure condition, the east blower airflows are reduced slightly as shown in Table 8-5. Under this operating condition, and under average east blower airflow conditions plus 25 percent for diurnal variation, 26,100 cfm would be available to supply west aeration. Based on this analysis it appears that the blower capacity in both the east and west facilities is sufficient to provide aeration in either direction.

Table 8-5. East Blower Summary

East Blower No.	Type and Output Control	Current Capacity (8.5 psig)	Cross-Connect Capacity (9.0 psig)
1	Positive displacement; gas engine (biogas)	10,500 scfm @ 800 rpm	10,100 scfm
2 and 3	Centrifugal Variable inlet vanes	7,000 to 11,500 scfm	6,650–11,100 scfm
4	Positive displacement; 2-speed motor	10,850 scfm @ high speed	10,750 scfm @ high speed
5	Positive displacement; 2-speed motor	9,070 scfm @ high speed	8,940 scfm @ high speed
Total firm capacity	-	-	40,900
Average east blower flow (average/peak diurnal)	-	-	11,800/14,800
Available capacity for west aeration (average/peak diurnal)	-	-	29,100/26,100

Estimated Cross-Connect Piping Capital Cost

Table 8-6 summarizes the probable cost of the east-west blower piping and balancing controls. This estimated cost will be used in the following section to compare the net present worth of the cross-connected blower alternative to continued investment in both the East and West Blower complexes.

Table 8-6. East-West Cross-Connect Opinion of Probable Cost	
Item	Alternative Cost
Tunnel piping, valves, and insulation	$660,000
Above-grade piping and pipe supports	$480,000
Control valve and instrumentation	$300,000
Contingency and professional services [b]	$720,000
East-west cross connect opinion of cost [a]	$2,160,000

a. Class 5, 50% conceptual level estimate level. The expected accuracy of Class 5 estimates typically ranges from -50 to +100 percent.

b. Assumed to be 50% of estimated construction costs.

Energy Impact and Coordination with Blower Replacement

The cross-connect provides some energy reduction even with existing blowers by eliminating the need to operate blower 4 or 5 and by operating the west blower in a more efficient condition closer to 100 percent capacity. The energy costs used in the net present worth comparison are based on continued Modified UCT operation with increasing airflow due to growth over the planning period. Figures 8-3 illustrate this savings in estimated blower power for the likely range of airflows.

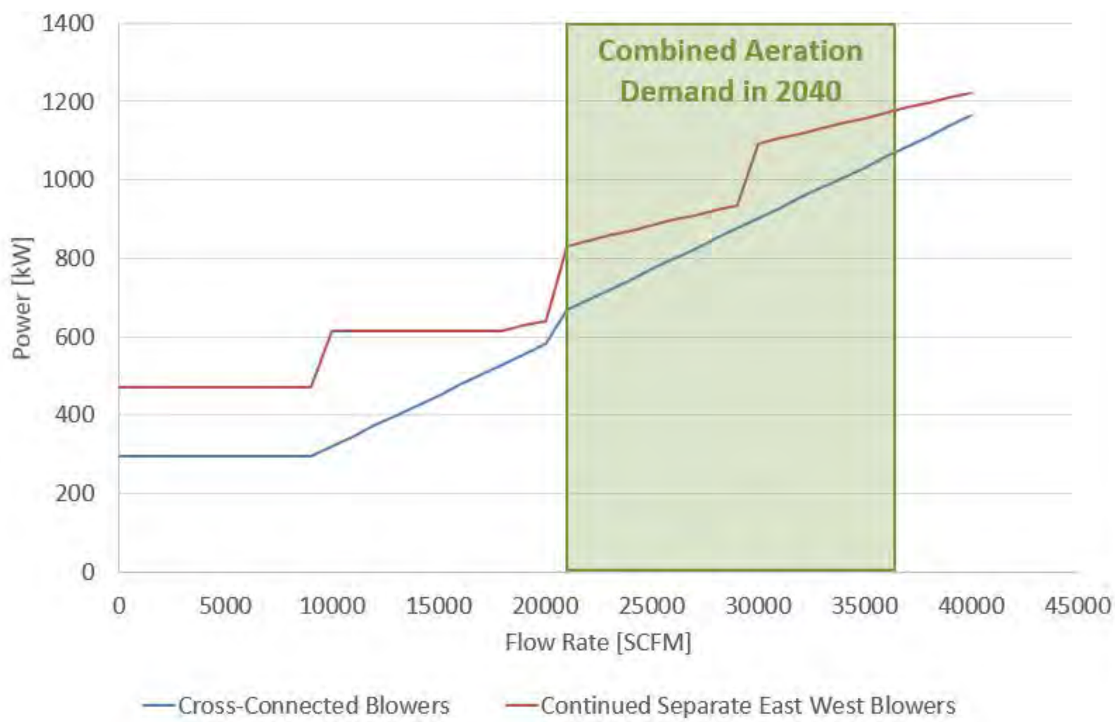


Figure 8-3. Comparison of future power requirements for separate and cross-connected blower alternatives.

Net Present Worth Comparison

Table 8-7 summarizes the phasing assumptions used for the net present worth comparison. Electrical consumption estimates were based on the “Normal Blower Mode”, with increasing airflows over the planning period. The biogas upgrade project and blower 1 decommissioning are assumed to occur around planning year 2025. At this time, under the cross-connected blower scenario all air would be supplied from the west side, using new blowers sized to provide the airflow required by the BNR approach selected for long term operations.

Demolition of the east blower equipment and building is not included in the capital cost estimate. However, the cross-connect scenario analysis assumed maintenance would decrease as the east blowers would not be actively maintained. As such, the east blowers would remain available as a back-up only until they are no longer operable due to equipment failures. In other words, if no investments are made to the east blower mechanical and electrical equipment, the ability of the east blowers to serve as a back-up for the west blowers (as described above) could be compromised over time by equipment conditions in the East Blower building, especially if the east blower equipment is idle for extended periods. Conversely, MMSD could choose to make investments to keep the east blowers available for standby service, but these investments would diminish the life cycle cost advantage of the piping cross-connection.

Table 8-8 presents the net present worth comparison of the two scenarios. Based on the phasing assumptions in Table 8-7, the cross-connected blowers scenario has a lower net present worth because it eliminates east blower replacements and electrical distribution upgrades for the East Blower building and reduces the estimated blower electrical consumption.

Table 8-7. Preliminary Phasing Assumptions for Net Present Worth Comparison

Years	West Blower Average Flow (scfm)	East Blower Average Flow (scfm)	Cross-Connected Blowers		Continued Separate East-West Blowers	
			Normal Blower Mode	Capital Improvements	Normal Blower Mode	Capital Improvements
2020–25	11,300	11,800	• Existing west blower • Blower 1	• East-west piping	• West blower • Blower 1 • Blower 4	• One new west blower • West blower electrical upgrade
2025–30	12,100	12,700	• New west blower	• Two new west blowers • West blower electrical upgrade	• New west blower • New east blower(s)	• Four new east blowers • East blower electrical upgrade
2030–35	12,900	13,400	• New west blower	• Replace remaining west blower	• New west blower • New east blower(s)	• Replace remaining west blowers
2035–40	13,600	14,100	• New west blower	-	• New west blower • New east blower(s)	-

Table 8-8. BNR Alternatives Net Present Worth Comparison		
Item	Alternative, Costs in Millions	
	Cross-Connected Blowers	Continued Separate East-West Blowers
Capital cost		
Existing blowers electrical upgrade	$1.0	$2.1
New blowers	$6.3[b]	$10.4[b]
Cross-connection piping	$2.0	$0
Blower O&M costs		
Electrical costs	$13.3	$14.3
Maintenance costs	$0.3	$0.6
Net present worth estimate [a]	$22.9	$27.4

a. *Escalation rate: 4.0%, discount rate: 4.38%.*

b. *Blower capital cost estimates are higher than those presented in Table 5-4. This table reflects estimated costs for the replacement of all existing blowers over the course of the planning period in order to highlight the impact of the cross connection piping on future blower projects.*

8.5 Blower Phasing

Figures 8-4 and 8-5 depict forecasted increases in normal and peak airflow operating ranges relative to the minimum and firm capacity ranges of the east and west blower complexes. Both the east and west blower complexes have adequate firm capacity to serve the forecast peak airflow conditions, so peak capacity is not a factor in establishing blower phasing.

Similar to the BNR alternatives phasing, blower phasing can be approached through strategic support and phased implementation in conjunction with BNR decision points. Figures 8-6 and 8-7 present a generalized timeline of blower upgrade phasing relative to BNR modifications, for both the separate and cross-connected scenarios. The following sections provide specific background on East and West plant blower phasing.

8.5.1 West Blowers

If MMSD chooses to implement blower improvements in a phased program, the west blowers should be given priority for the following reasons:

- The west blowers are limited by turndown and this constraint will limit future savings from either nitrite shunt or high-efficiency diffusers
- The potential to realize energy savings from improved blower efficiency is higher on the west because it does not have an engine-driven blower
- Despite being newer and having significant excess capacity, the west blower complex also appears to have the higher risk of prolonged outages that could impact firm blower capacity

The biggest hurdle to near-term west blower replacement is uncertainty about BNR alternative implementation. Ideally, new blowers would have flexibility to operate over the range of airflows anticipated by potential future scenarios. However, the turndown range implied by this flexibility may be greater than the range of a single blower. As such, some combination of the following approaches could be pursued, bearing in mind that the final design would need to provide firm capacity to meet the projected peak flows with a combination of one large blower and one new blower:

- Installation of a blower model that could be modified via impeller replacement or speed modification in the future
- Design for a separate channel blower to reduce aeration blower peak air demand
- Reconfiguration of the blower layout to allow two smaller blowers

8.5.2 East Blowers

The east blowers are not as limited by turndown and there are multiple redundant units, which mitigates the risk of a major aeration outage. In addition, if the nitrite shunt approach is successful it would allow Plants 1 and 2 to be operated with the engine-driven blower. However, the age and efficiency of the blowers make them candidates for replacement within the next 5 to 10 years.

Deferring the east motor-driven blower replacements will also allow for better coordination with the planned conversion to biogas engine-generators and possible east-west cross-connection piping.

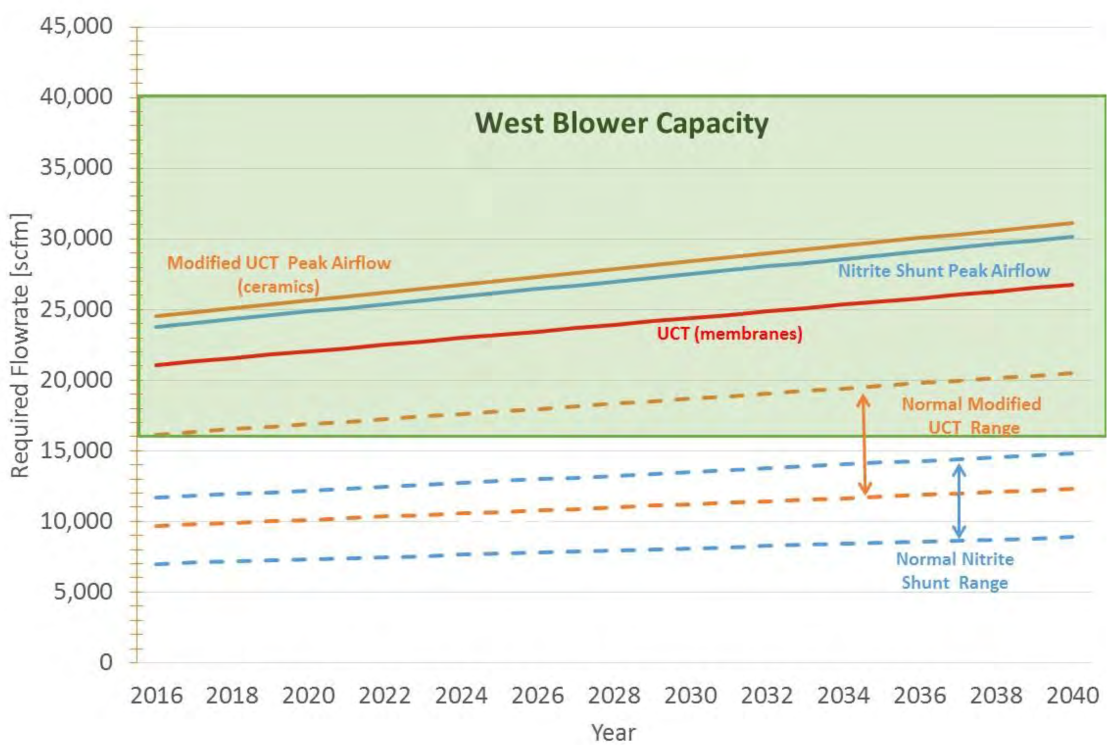


Figure 8-4. Forecast growth in west blower airflow relative to capacity

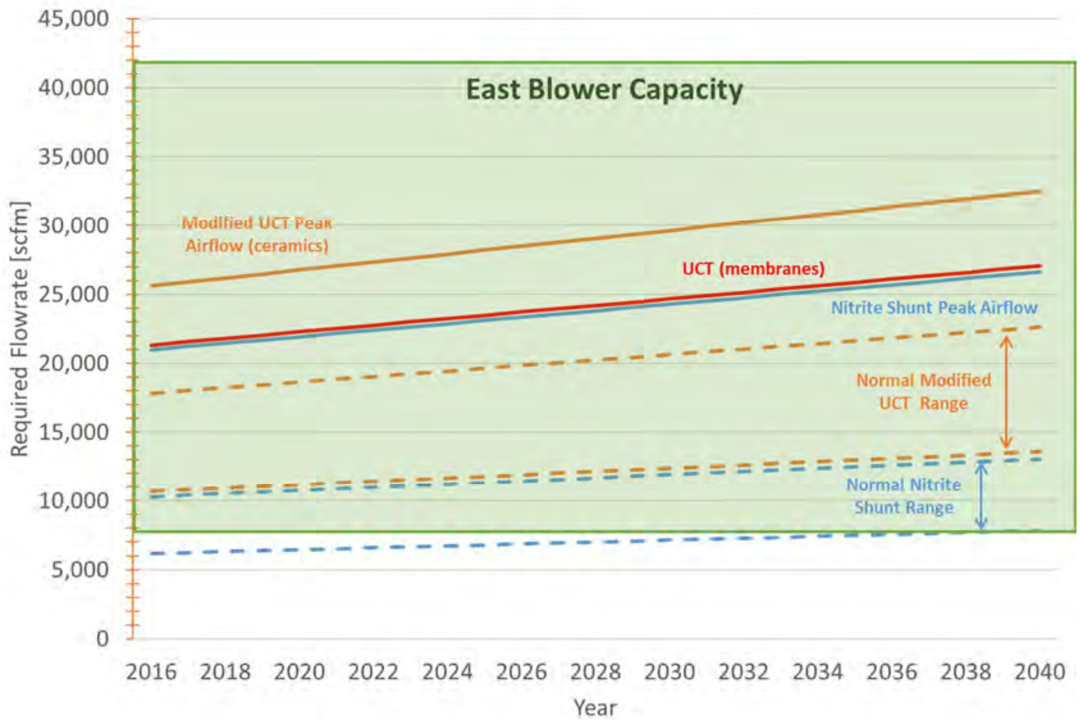


Figure 8-5. Forecast growth in east blower airflow relative to capacity

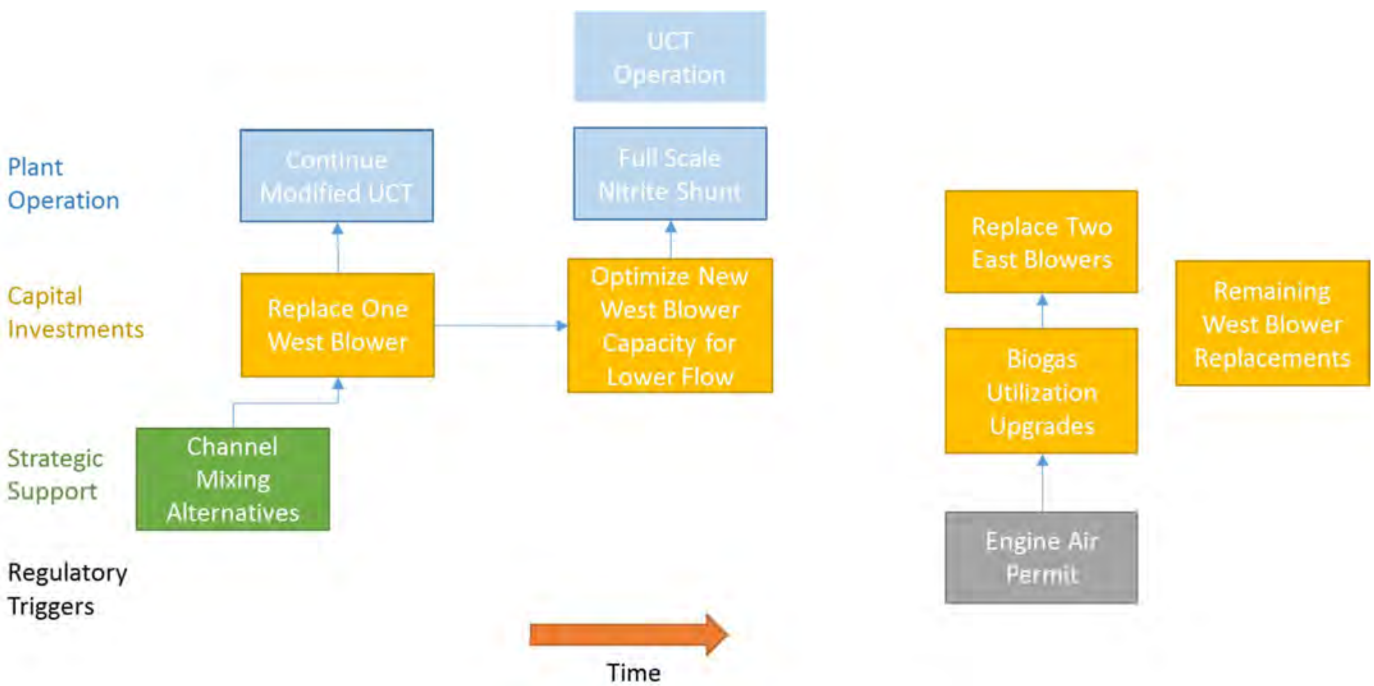


Figure 8-6. Separate east-west blower staging strategy

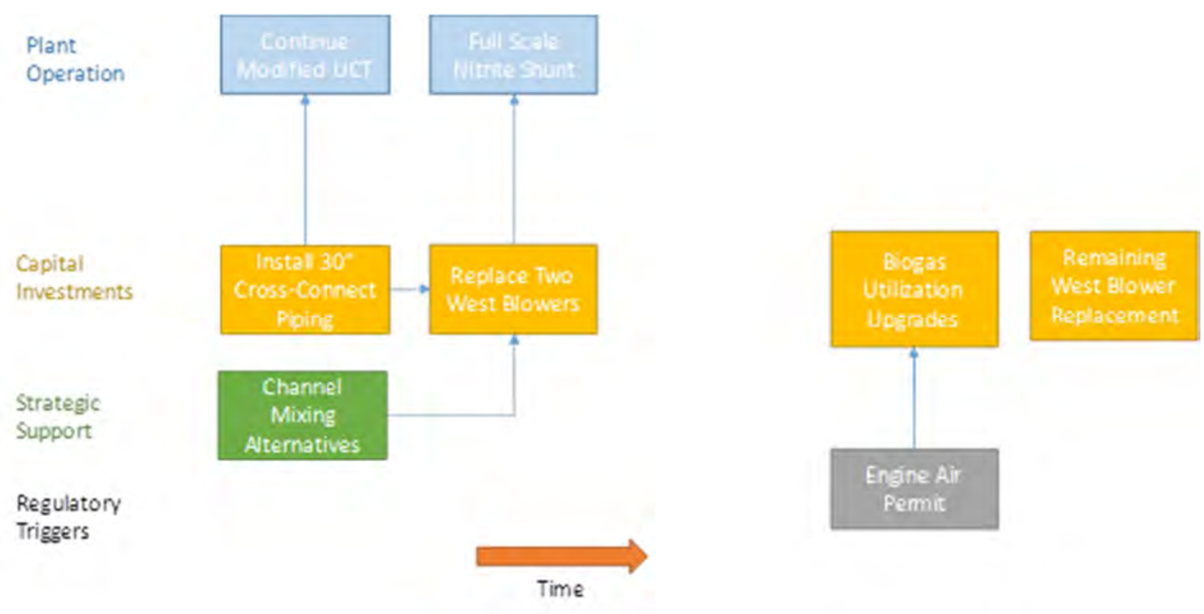


Figure 8-7. Cross-connected blower staging strategy

Section 9: Aeration Controls

This section presents an evaluation of the aeration controls, including a review of the condition of existing controls and a summary of available control technologies.

9.1 Existing Controls

The existing aeration control system for the NSWWTP BNR system uses DO control. DO sensors are located in Passes 2 and 3 of the aeration tanks. These sensors measure the bulk fluid DO and the measured value is relayed back to a controller. The controller compares the value to a set point and adjusts the control valves in the air supply piping accordingly. Current DO set points are 1.5 mg/L in Pass 2 and 3.5 mg/L in the Pass 3.

The aeration blowers are controlled on a pressure set point. If more air is required, the valves in the piping system open, which reduces the pressure in the system and calls for blowers to be ramped up or additional units to be brought online.

The DO sensors in Pass 2also control air supply to the aerated zones in Pass 1 Plant staff report that if the measured DO in Pass 2 drops below 0.4 mg/L, more air is supplied to Pass 1 However, DO measurements are rarely below 0.4 mg/L in Pass 2 because the minimum airflow per diffuser of 1 scfm generally controls the air supply rate.

9.1.1 Sensors

Nitrogen sensors available for control of advanced BNR processes include the following:

- Ammonia: Ammonia sensors use an ion-selective electrode similar to a pH probe or a cabinet analyzer.
- NO_x: NO_x sensors measure nitrate plus nitrite.
- NO_2 and NO_3: Nitrate and nitrite can be measured separately with a scanning UV probe.

- NO_2 and NO_3: Nitrate and nitrite can be measured separately with a scanning UV probe.
- Multi-parameter monitoring: New systems are available that allow monitoring of multiple parameters including E. coli, BOD, TSS, NO_2+NO_3, total organic carbon (TOC), and COD (e.g., ZAPS technologies), but their accuracy has not been proved.

9.1.2 Control Valves

The existing control valves installed in the air supply piping are the same size as the piping. This is a common situation that can lead to poor airflow control. The valve requires an adequate pressure drop to effectively control the airflow, which requires a valve several diameters smaller than the pipe size in aeration systems. For efficient nutrient removal performance, the DO and subsequently air supply rate needed to be accurately controlled. The recommended secondary upgrade project includes replacement of these valves.

9.2 Available Control Technologies

This section presents a summary of available aeration control technologies, including continued modified UCT operation, UCT alternatives, and nitrite shunt operation.

9.2.1 Continued Modified UCT Operation

As long as MMSD continues to operate using the modified UCT, the existing control strategy based on DO measurement can be continued.

Ammonia sensing could be added to this system to provide real-time information on BNR performance. If the blowers are modified to allow reduced aeration airflows, the ammonia reading could also be used by an ammonia-based aeration control (ABAC) system to trim blower airflows. This control strategy controls effluent NH_3-N to a desired set point rather than fully nitrifying the waste stream to reduce aeration demands. The air supply is modulated to achieve the effluent ammonia concentration set point. When the measured effluent ammonia is below the set point, the air supply will be reduced and subsequently DO will also drop.

Under some scenarios the aerated zones may be converted to unaerated, which are called swing zones. The unaerated zone can possibly employ denitrification, but more importantly it still contains a mass of “dormant” nitrifiers. As the ammonia load increases, the swing zone can be switched back to aerated mode, reactivating the nitrifier mass, which reduces effluent ammonia peaks.

The aeration savings from adding ammonia inputs to the aeration control system is highly dependent on how low the DO set points are in the DO-only control system. In other words, if the plant is already controlling to relatively low DO set points, the airflow reduction due to ammonia control will be minimal and most of the benefit of ammonia sensing will come from the ability to detect any decrease in nitrification performance early enough to respond appropriately. Given the low summer month NH_3-N permit limitations of 2 mg/L, ABAC provides the greatest benefit during winter conditions when the monthly average NH_3-N limit is 4 mg/L.

9.2.2 UCT Alternatives

The UCT configuration requires that the existing DO sensors in Pass 2 be relocated farther downstream at about the midpoint of the last third of the tank. An NO_x sensor is required in the last anoxic zone prior to the aerated zones. This NO_x sensor is used to pace the methanol addition and MLR to the anoxic zone.

ABAC could also be used to optimize aeration for the UCT alternatives.

9.2.3 Nitrite Shunt Operation

If MMSD pursues the nitrite shunt alternative, one of the major impacts will be increased control complexity and a need to continuously maintain the control systems’ effectiveness. Because AVN control results in a partially nitrified condition, effluent ammonia levels will be elevated compared to a completely nitrified condition in a standard UCT BNR process. Care must be taken to confirm that the resulting partially nitrified state achieved under AVN control does not exceed permitted effluent requirements for ammonia.

AVN Control. Nitrite shunt systems require AVN control to operate at the optimal point on a TN basis. The minimum TN concentration exists where aeration is controlled so ammonia and NO_x concentrations are equal. Higher airflow would reduce ammonia further but at the price of increased NO_x. Reducing the airflow has the opposite effect. The ammonia and NO_x sensors provide a signal that controls whether aeration in particular zones is turned on or off.

DO Control. A DO sensor controls the amount of air supplied when aeration is activated. The lower DO values resulting from this control strategy are critical to performance of the nitrite shunt. In particular, the DO in the final aeration zone of Pass 3 must be tightly controlled by a new control valve, airflow meter, and DO sensor. Similarly, the proposed Nitrite Shunt project scope includes new DO probes in Pass 1.

Nitrite Sensor. A separate nitrite sensor is recommended to ensure that nitrite build-up is not occurring.

Additional details on the combined AVN/DO control strategy used for nitrite shunt evaluations is provided in Section 3.

Section 10: Enhanced Phosphorus Reduction

Because of MMSD's plan to continue with the adaptive management approach (Yahara Watershed Improvement Network [Yahara WINs]) in the Badfish Creek (Rock River) watershed into the foreseeable future, it is unlikely that a TP limit below 0.5 mg/L (6-month average) would be incorporated into the NSWWTP WPDES permit within the planning period of this facilities plan. In addition, if very stringent TP limits were implemented for the Badger Mill Creek discharge location (Sugar River watershed), MMSD may discontinue discharge to Badger Mill Creek altogether, or perhaps seek trading partners to meet future water quality goals. In either case, it was decided that effluent TP limits of less than 0.5 mg/L would not be required to be met within the planning window of this facilities planning project. However, there is the potential that MMSD may want to reduce effluent TP levels in the range of 0.25 to 0.30 mg/L to reduce costs associated with the Yahara WINs program.

MMSD commissioned a recent high-level planning project in 2011–12 to study the facilities needed to meet a range of monthly effluent TP limits of 0.13 and 0.225 mg/L, annual effluent TP limits of 0.075 mg/L, and monthly TN limits of 3 to 10 mg/L. A summary TM (Preliminary Nutrient Removal Cost Estimates, prepared by CH2M Hill) was developed for that project. The purpose of the discussion below is to present a summary of that report and additional comments pertaining to the impacts that low phosphorus limits and effluent filters may have on NSWWTP operations and facilities.

10.1 6-Month Average Target Phosphorus of 0.25 to 0.30 mg/L

With respect to the current facilities planning effort, Scenario 1 from the CH2M TM represented the conditions that were most similar to the potential future effluent TP target of 0.25 to 0.30 mg/L on a 6-month average basis. Scenario 1 included a monthly TP limit of 0.225 mg/L, no total nitrogen limit, and existing ammonia limits. The effluent target of 0.11 mg/L TP was selected to achieve the 0.225 mg/L limit reliably. To meet this target effluent concentration, the following facilities were assumed:

- Deep-bed granular media filters: A total of 12 filters (10 active and 2 standby), individual area of 1,100 ft^2 were selected. Cloth disc filters were not evaluated, but would likely reduce the overall footprint and capital costs associated with effluent filtration but have a history of high maintenance requirements due to iron bacteria/biofilm buildup on the back of the filter media when adding $FeCl_3$.

- Metal salt storage and addition facilities: CH2M's process modeling for this scenario indicated that metal salts would not actually be required to meet the limit. However, a standby metal salt addition facility was assumed to be needed to reliably meet the effluent limit.
- Secondary effluent pump station: Two active and one standby 650 hp pumps were included to pump the secondary effluent to the filters.
- The filters and pumping facilities were sized to handle 79 mgd, which is approximately the capacity of the existing effluent pump station. This sizing criterion is slightly larger than the 71 mgd peak month flow criterion used for the BNR alternatives presented earlier in this TM, reflecting short-term higher flows to filtration. This maximum capacity may not be required to meet the future effluent total phosphorus limit, especially if the limit is a 6-month average limit such as is proposed under the current rules.
- The initial capital cost associated with this alternative was approximately $60 million in 2012 dollars. Annual O&M costs were estimated to be approximately $800,000.

10.2 6-Month Average Phosphorus Limit of 0.075 mg/L

This scenario represents the potential future effluent phosphorus limit based on water quality criteria for the discharge to Badger Mill Creek, and was presented as Scenario 3 in the CH2M TM:

- A target of 0.05 mg/L TP was selected to achieve the limit reliably.
- This alternative included the processes from Scenario 1, as well as a second feed point for metal salt addition, rapid-mix system, polymer storage and feed facility, flocculation basin, and lamella clarifiers.
- All processes were sized to handle a maximum flow rate of 79 mgd.
- Both the rapid-mix and flocculation systems consisted of four active trains plus a standby train.
- The initial capital cost associated with this alternative was approximately $91 million in 2012 dollars. Annual O&M costs were estimated to be approximately $2.4 million.

10.3 Chemical Addition for Tertiary Filtration

The addition of filters to meet an effluent TP limit of 0.25 to 0.30 mg/L is not expected to use a significant amount of metal salts. In fact, the previous study indicated that, on an average basis, no metal salts would need to be added. Therefore, operation of new effluent filters to reliably meet a limit in the range of 0.25 to 0.30 mg/L would not be expected to have a significant impact on the existing treatment processes and overall operation of NSWWTP, other than the considerable debt costs as well as O&M costs. However, if an effluent TP limit of 0.10 mg/L or lower were required to be met, the chemical addition required would be significant, and could impact existing operations and effluent chloride levels. Waste sludge from such operations has a high concentration of "unused" coagulant. If this unused chemical is recycled back to the plant headworks or primary clarifiers rather than a dedicated solids processing system, it will react with influent orthophosphate. Ultimately, depending on actual coagulant doses required, the recycling of coagulant could negatively impact the production of struvite in the Ostara process, which would reduce revenue from the sale of the struvite product. Finally, sludge generation from metal salt addition side reactions would increase biosolids quantities significantly, resulting in higher solids management costs.

If future, low effluent TP limits are required to be met at NSWWTP, a concept that should be explored includes using the high metal salt recycle stream to replace the existing ferric feed to the digesters for hydrogen sulfide control. This could eliminate or reduce the purchase of virgin iron salts.

Section 11: Recommendations

This section presents recommendations resulting from the study, including further investigations, addressing other BNR system issues, and a proposed approach.

11.1 Further Investigations

This section presents recommendations for further investigations, including clarifier stress testing, pilot test nitrogen shunt operation, diffuser grid PVC embrittlement investigation, diffuser grid fouling changes following Ostara and cleaning operations, and RAS pump energy efficiency.

11.1.1 Clarifier Stress Testing

As noted above, secondary clarifier stress testing and subsequent CFD modeling are recommended to confirm the existing clarifier SLR capacity as each TN reduction alternative has secondary clarifiers SLR at the estimated maximum allowable levels at 2040 critical flow and loading conditions. Stress testing and analysis should be completed as part of the facility improvements predesign to confirm facility requirements.

11.1.2 Pilot Test Nitrogen Shunt Operation

If bench-scale testing is successful, full-scale demonstration testing is recommended to further confirm process design criteria, impacts to sludge quality, and operational requirements. The full-scale demonstration test will require one plant to be operated as a nitrite shunt only plant. Converting the existing ceramic diffusers to membrane disc diffusers is required to reduce aeration airflow to the basins and provisions to independently control Zone 3C aeration is needed, or needs to be evaluated in further detail to ensure that combined discharges will meet the plant's WPDES permit. Instrumentation associated with AVN control and Zone 3C DO is also required.

11.1.3 Diffuser Grid: PVC Embrittlement Investigation

Theoretically, the existing PVC diffuser grid could be reused and optimized for projected airflow requirements for each aeration zone. However, because the system has already been in operation for 30 years it is likely that the diffuser grid will need to be replaced during the planning period. The timing of this replacement will depend on the likelihood of increasing PVC fractures under normal operation or during future diffuser element plugging or grid modifications.

Bend and tensile testing can be used to determine whether the PVC has become embrittled with age and therefore more prone to failure. The testing results would be compared with a sample of new piping, which may not match the original, but would provide an "order of magnitude" comparison to assess. In addition, materials testing firms could do cross-sectioning and examination to see if any material degradation is evident.

11.1.4 Diffuser Grid: Fouling Changes Following Ostara, Cleaning Implications

Previous investigations into ceramic diffuser fouling have implicated mineral deposits, including phosphorus and magnesium. The plant has controlled this fouling by maintaining airflows above a minimum 1 scfm/diffuser rate in order to move the water/air interface out of the ceramic stone. The Ostara process has reduced the quantity of phosphorus and magnesium recycled back to the aeration basins. The reduced phosphate concentrations also decrease the magnesium levels in the aeration basins as EBPR anaerobic phosphate release also releases magnesium into solution as magnesium serves as counter-ion to phosphate so phosphate can cross the cell membrane wall. When MMSD considers future diffuser projects and diffuser types, a small research project that revisits the Waddington (Waddington 1995) findings under current mineral loading rates could improve the accuracy of future diffuser alternatives evaluations.

In addition, Sanitaire is now offering liquid cleaning systems that may also provide another means to control ceramic diffuser fouling.

11.1.5 RAS Pump Energy Efficiency

The existing RAS pumps are suitable for continued use under the future BNR alternatives. However, there may be opportunities to increase energy efficiency in the RAS system, including:

- Modifying the control system to include “most open valve” logic
- Evaluating VFD retrofits
- Considering replacement of older motors with higher-efficiency motors

11.2 Addressing Other BNR System Maintenance Issues

Plant staff identified other BNR operating issues:

- Scum beach icing control
- Plant 2 RAS control valves
- Drainage pump—would like more
- Weir surcharge
- East and west plant flow measurement

Funding to address these issues should be included as capital budgets are established for the facility plan.

11.3 Proposed Approach

The proposed approach to BNR and asset renewal is summarized in Table 11-1.

Table 11-1. NSWWTP BNR Alternatives Phasing Strategy

Item	Approach	Timing	Justifications
BNR strategy	Nitrite shunt bench testing	Ongoing	• Evaluate cold weather performance • Improve accuracy of process modeling parameters
	Nitrite shunt full-scale demonstration in one Plant	Following bench testing	• Verify cold weather performance • Confirm process modeling parameters • Confirm effluent quality • Gain experience with AVN automated controls
	NSWWTP BioWin validation and design update	Predesign	• Validate steady-state model calibration and confirm selected alternative(s) preliminary design evaluations
	Clarifier stress test	Predesign	• Determine whether additional clarifier tankage will be triggered by growth, especially under increased SVI associated with nitrite shunt • Improve accuracy of BNR alternatives evaluation
	Plant-wide implementation of nitrite shunt	Following demonstration, if successful	• Energy reduction • Effluent quality improvement
	Post-aeration improvements	Concurrent with plant-wide nitrite shunt	• Meet effluent DO requirements under high flow conditions
	UCT process improvements	If future permit requires	• Implement only if nitrite shunt testing is unsuccessful or permit limits exceed expected nitrite shunt effluent quality

Item	Approach	Timing	Justifications
			• Proven TN removal process
Diffusers	PVC condition evaluation	Near term	• Informed risk evaluation of continued near-term use of ceramic diffuser system • Accelerate diffuser replacement if evaluation suggests embrittlement or other PVC flaws
	Replace diffusers in one plant with membrane diffusers	Concurrent with nitrite shunt demonstration	• Match diffuser density to nitrite shunt process airflow requirements • Designed for expansion if demonstration is unsuccessful • Facilitate low DO conditions and precise DO set points • Life-cycle procurement to optimize diffuser energy performance
	Replace diffusers in remaining plant	Concurrent with plant-wide BNR improvements	• Match diffuser density to process airflow requirements based on final BNR configuration
Blowers	Replace one west blower	Near term	• Reduce failure risk • Reduce energy consumption through improved blower efficiency and reduced turndowns • Blower sizing
	Install east-west cross-connect piping	Near term	• Reduce blower energy consumption by minimizing or eliminating blower 4/5 run time • Provide redundancy between east and west blower systems
	Replace two east blowers[a]	Concurrent with CHP project	• Coordinate new blower sizing with ongoing BNR improvements and phase-out of blower 1

Table 11-1. NSWWTP BNR Alternatives Phasing Strategy

a. *East blower replacement not required if cross-connection piping is installed.*

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TM No. 4, Peak Flow Management, prepared by Strand Associates and Brown and Caldwell and dated September 2016

TM 5a, Wastewater Characterization and BioWin Calibration, prepared by Brown and Caldwell and dated November 11, 2016

APPENDIX A: Technical Memorandum 5A-Wastewater Characterization and BioWin Calibration

Technical Memorandum

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Prepared for: Madison Metropolitan Sewerage District

Project Title: 2016 Liquid Processing Facilities Plan

Project No.: 149052

Technical Memorandum 5A

Subject: Wastewater Characterization and BioWin Calibration

Date: November 11, 2016

To: Randy Wirtz, P.E., Strand Engineering

From: Donavan Esping, P.E., Senior Process Engineer

Prepared by: Donavan Esping, P.E., Senior Process Engineer

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1. Objective

This memorandum summarizes the April 2016 wastewater characterization and subsequent BioWin™ wastewater treatment whole-plant steady-state calibration for the Nine Springs Wastewater Treatment Plant (NSWWTP). In addition, the April 2016 influent wastewater characteristics are compared to the October 2014 wastewater characteristics to check for seasonal variation.

2. Summary

This section provides a summary of the outcomes from the wastewater characterization and BioWin™ simulator calibration. The model was calibrated based upon steady state operations using the average operating conditions and parameters reported during April 2016 sampling period. For detailed design, the NSWWTP calibration model will need to be validated using a minimum of three months of daily plant operating data to confirm the model is calibrated to predict dynamic responses to daily and diurnal operating changes such as aeration demands, mixed liquor concentrations, primary clarifier performance, and effluent quality. The selected dynamic model validation data period should include the April 2016 special sampling period or a second wastewater characterization sampling event. The steady-state calibrated model predicts plant operations very well. A summary of key items to further validate the model are included below. Additional testing and evaluations recommended below should be completed prior to, or during, the project predesign phase.

- Reported East and West plant flows (primary effluent and secondary effluent) of approximately 25 mgd and 17 mgd, respectively during the sampling period (60% flow to East Plant) did not match the influent splitter structure gate settings which should have directed 55% of the flow to the West plant. Further evaluation into the reported flow measurements/calculations is recommended.
- Several reported sludge flows differed by more than 10% of the simulated flows. These flows (DAFT thickened sludge, waste sludge GBT sludge and filtrate, digested sludge GBT filtrate, and Ostara influent/effluent flows) should be verified.
- Influent volatile fatty acid (VFA) concentrations were conservatively set assuming the West plant primary effluent VFA concentration is equal to the measured influent VFA concentration. Additional influent and west primary effluent VFA testing is suggested to confirm this assumption. In addition, plant influent and primary effluent VFA testing during warm weather conditions (wastewater temperature greater than 20 degrees Celsius) is recommended to confirm seasonal influences on VFA production.
- Influent chemical oxygen demand (COD) characterization used 0.45 um filters to define the "filtered" COD. It is recommended that at least five days of influent COD sampling is conducted in which total COD, filtered COD using a 1.2 um filter, and flocculated/filtered COD testing is completed to define better define the colloidal COD fraction used in the BioWin™ influent COD characterization.
- Model simulations using the measured influent phosphate:total phosphorus fraction (F_{PO4}) of 0.39 result in the predicted primary effluent total phosphorus (TP) concentrations being 1.5 mgP/L to 2.5 mgP/L lower than measured values and subsequently resulting in lower phosphate (PO4-P) release in the aeration basin anaerobic zones. The calibrated model increased F_{PO4} to 0.55 matching the October 2014 F_{PO4} to provide an improved correlation with measured primary effluent TP, anaerobic selector PO4-P, and activated sludge TP:MLVSS ratio. It is recommended the plant begin measuring plant influent and primary effluent PO4-P two to three times per week to better define the F_{PO4} ratio.
- Combined recycle loadings increase the plant influent TP by nearly 50% while recycles loadings increase plant influent PO4-P loadings by 40% of the measured value and 25% of the simulated

value. Based upon measured data, the primary effluent TP concentration should not increase across the primary sedimentation tanks. The recommended influent/primary effluent PO4-P testing will help determine if struvite is being re-solubilized across the PSTs contributing to the higher primary effluent TP concentrations. Measuring the influent TP is also recommended to confirm if struvite crystal removal across the PSTs is less than TSS removal.

- The influent ordinary heterotrophs organism COD fraction (FZbh) was increased from the BioWin default of 0.02 to 0.04 to increase primary sludge hydrolysis from microbial activity to match soluble COD, total Kjeldahl nitrogen (TKN), ammonia-nitrogen (NH3-N), TP, and PO4-P concentrations in the gravity thickener overflow (GTO). A more direct measurement of the FZbh using the procedures outlined in Attachment B is recommended.
- The predicted digested sludge GBT filtrate (and Ostara influent/effluent) TKN and NH3-N concentrations are significantly less than measured values. Comparing the model predicted and measured primary effluent TKN and NH3-N concentrations, the predicted lower nitrogen levels recycled back to the aeration basins do not impact the main liquid stream calibration/evaluation. If the NH3-N concentration is artificially increased to match the digester and downstream solids processing concentrations, the primary impact is the volume of the “Pearl” struvite reactor can be decreased to match the Ostara effluent PO4-P concentration. Since the volume of the “Pearl” reactor is adjusted to match the Ostara effluent PO4-P concentration, the calibration does not artificially increase the ammonia concentration in the mesophilic/thermophilic digesters.

3. Background

The NSWWTP liquid stream processes consists of influent pumping, screening, grit removal, East and West primary sedimentation tank (PST) batteries, four nitrifying activated sludge enhanced biological phosphorus removal (EBPR) activated sludge trains, secondary clarification, and UV disinfection. Secondary effluent can be routed to the Effluent Storage Tanks and/or Storage Lagoons during periods of high flow. Primary solids are thickened in the gravity thickeners. Waste activated sludge (WAS) from Plant 2 is thickened in dissolved air flotation thickener (DAFT) and then pumped to the WAS Treatment tanks. Plant 1, 3, and 4 WAS and a fraction of the acid phase digester effluent are also routed to WAS Treatment Tanks. WAS Treatment solids are thickened with the WAS gravity belt thickeners (GBTs). Thickened WAS GBT sludge and gravity thickened primary sludge are pumped to the anaerobic digestion system which consists of continuous flow acid phase digestion and mesophilic digestion (MAD) followed by batch thermophilic digestion of roughly 17 percent of the MAD biosolids flow stream. MAD and thermophilic biosolids can be thickened with Digested Sludge (DS) GBTs or dewatered using centrifuges. Thickened biosolids are stored in the Metrogro storage tanks prior to land application. Recycle streams from the WAS GBT, DS GBT, and DAFT (roughly 50%) are routed to the Struvite Recovery System for struvite precipitation and prill formation. Struvite recovery recycles are then routed to the plant headworks. Figure 3-1 provides a simplified plant flow schematic and Figure 3-2 shows a plant aerial view.

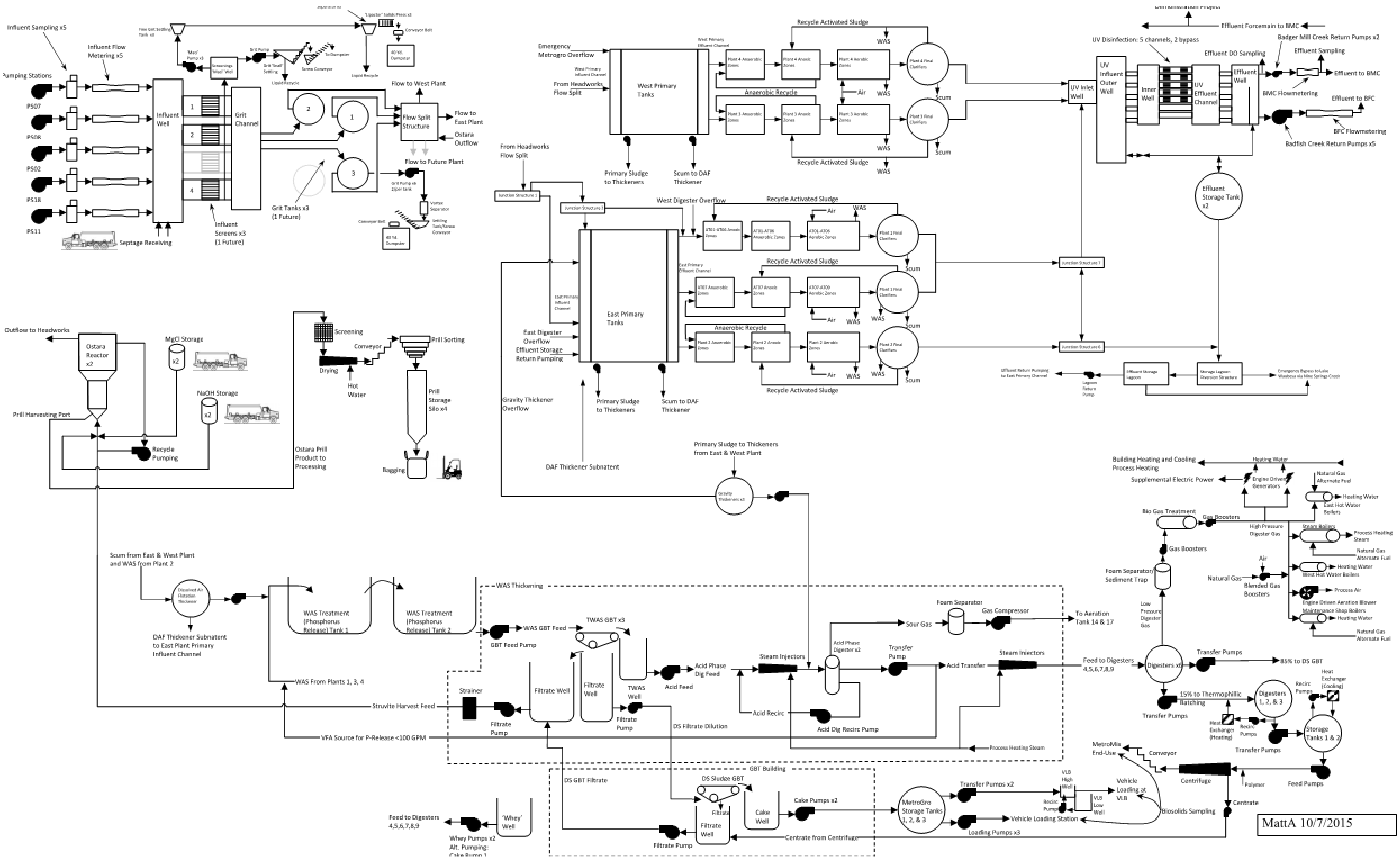


Figure 3-1. Nine Springs WWTP Flow Schematic. (Source: Madison MSD)

Figure 3-2. Nine Springs WWTP aerial view.

3.1 Calibration Configuration

BioWin™ Version 5.1 (EnviroSim Associates Limited, Hamilton, Ontario, Canada) was used for the biological process simulations. Figure 3-3 shows the NSWWTP whole-plant BioWin simulator calibration configuration. The BioWin configuration and calibration are based on plant operating data and wastewater characterization data collected from April 4 through April 17, 2016. During this period all process units and tankage was in service with the following exceptions:

- 1 of 2 acid phase digesters were in service.
- Centrifuges were off-line.

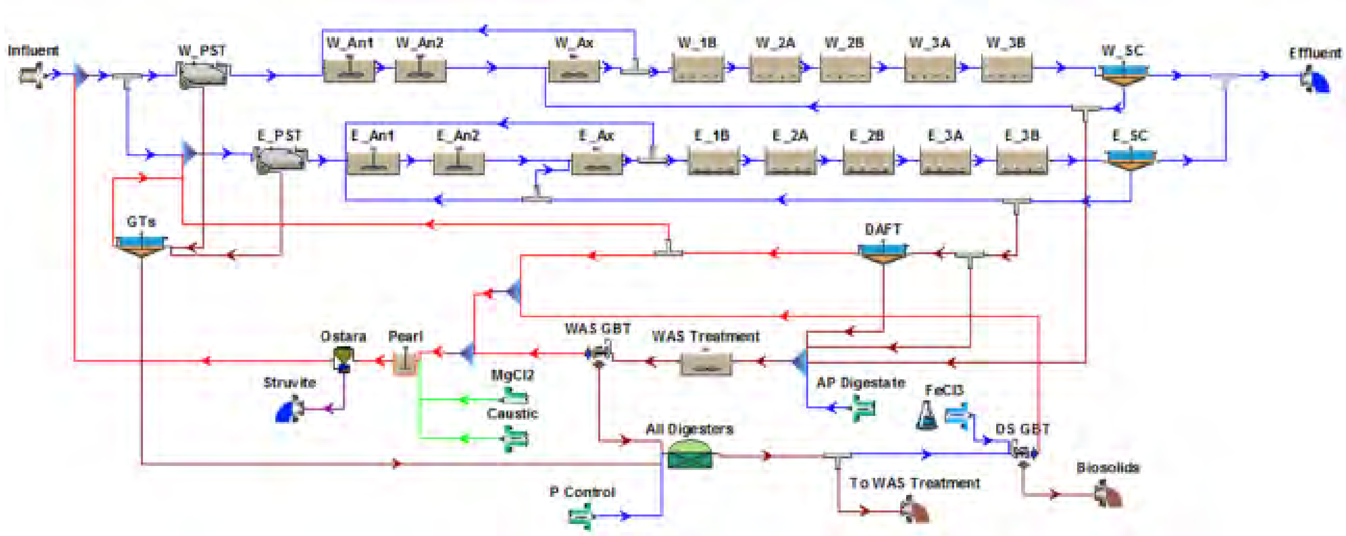


Figure 3-3. Nine Springs WWTP BioWin Calibration Flow Schematic.

The plant calibration configuration includes all key liquid and solids stream processes as follows:

- East primary sedimentation tanks (PST) are combined into one PST (E_PST) with an equivalent total surface area and solids pumping rate. The West PSTs (W_PST) are configured in the same manner.
- The East aeration basins (Plant 1 and 2) are combined into one aeration basin train. Anaerobic, anoxic and aerobic zone volumes are based upon the total volume of each zone type. The East plant return sludge flow (RAS) is split between the first anaerobic zone and anoxic zone to mimic the two existing biological nutrient removal (BNR) flow schemes (A/O and modified UCT) on the east side. Anoxic zone mixed liquor recycle (MLR) is based upon the total MLR reported. The anaerobic volume is divided into two zones as simulations showed anaerobic P-release and effluent phosphate does not change whether modeling two or three anaerobic zones. The aerobic volumes in Pass 2 and 3 are divided into two zones (2A,2B,..) as simulations with three aerated zones to mimic the current Pass 2 and 3 diffuser grid layout resulted in BioWin™ Version 5.0 (original calibration model) failing to achieve a steady state solution.
- The West aeration basins (Plant 3 and 4) are combined into one modified UCT BNR train similar to the East aeration basins.
- East secondary clarifiers are combined into one clarifier (E_SC) with an equivalent total surface area and RAS pumping rate. The West secondary clarifiers (W_SC) are configured in the same manner.
- The effluent storage tanks downstream of the secondary clarifiers are not incorporated into the model.
- Gravity thickeners are combined into one thickener (GTs) with an equivalent total surface area and thickened solids pumping rate.
- East waste sludge is split between the DAFT and WAS Treatment to simulate the Plant 2 WAS flow routed to the DAFT. Scum flows routed to the DAFT are not included in the model – typical of industry standards.

- WAS Treatment Tanks are combined into a single tank with a volume equal to the average volume during the wastewater characterization sampling period.
- All anaerobic digestion processes are combined into a single anaerobic digester of equal total volume as simulations with separate acid phase digesters, mesophilic digesters, and thermophilic digesters either failed to reach a steady state solution when the struvite chemical reactions option was turned "ON" (simulations with two aerated bioreactors per pass) or produced the same digester effluent characteristics (simulations with one aerated bioreactor per pass). To simulate the acid phase digestion effluent flow routed to the WAS Treatment tank, an acid phase digestate (AP Digestate) state variable influent module is provided with an equivalent flow routed to a sludge output module for flow balancing. Also, BioWin™ is not conducive to modeling thermophilic digesters as the maximum digester input is 40 degrees Celsius and adjustments to the digester related kinetic rates could not replicate the thermophilic digester effluent.
- Struvite pelletization is modeled using a bioreactor (Pearl) and cyclone (Ostara). The bioreactor, which has its biological growth kinetics locally set to zero, provides detention time for struvite formation while the cyclone removes a percentage of the struvite formed. The bioreactor volume needs to be adjusted to achieve the target Ostara effluent PO4-P concentration.
- An anaerobic digestion phosphorus control (P_Control) state variable module adds magnesium to the anaerobic digester to reduce the PO4-P concentration from roughly 600 to 300 mg PO4-P/L. The P_Control module also includes ammonia to account for the ammonia precipitated in struvite from magnesium addition. It should be noted initial calibration simulations included ferric chloride (FeCl3) addition to the mesophilic digesters, however it had limited impact on digester TSS or PO4-P concentrations and significantly increased the time to achieve a steady state solution – hence the final calibration does not include ferric addition to the mesophilic digesters.

4. Influent Wastewater Characterization

Process simulation modeling requires accurate characterization of the model influent carbon, nitrogen and phosphorus fractions shown in Figure 4-1. The April 2016 wastewater special sampling data were used to characterize the plant influent along with liquid and solid stream process operations. In addition, October 2014 influent wastewater characterization data was used to evaluate the variability in influent carbon and nutrient fractions. Table 4-1 summarizes the influent wastewater characteristics from both sampling events along with the BioWin™ calibration carbon and nutrient fractions. Attachment A contains the April 2016 daily wastewater characterization data.

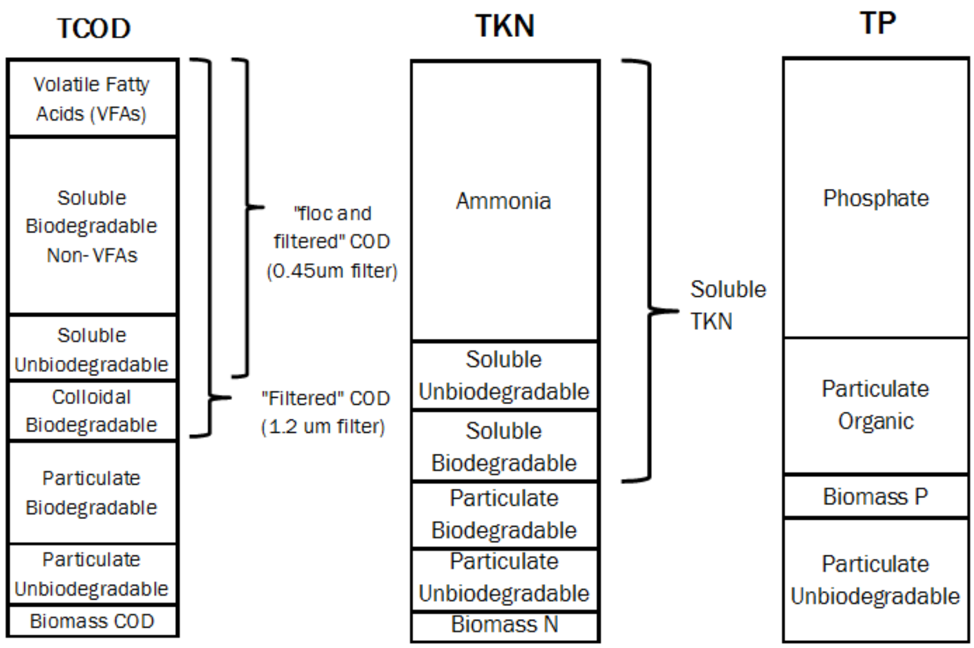


Figure 4-1. Graphical Representation of BioWin™ Influent COD, TKN, and TP fractions.

4.1 COD Characteristics

Table 4-1 shows the influent chemical oxygen demand (COD) concentrations measured in April 2016 were very similar to October 2014. The 2016 soluble COD and flocculated and filtered COD (ffCOD) data presented in Table 4-1 are screened data in which measurements from 7 of the 14 sampling days were deleted as the ffCOD concentration was greater than the corresponding soluble COD resulting in negative colloidal COD concentrations (colloidal COD = soluble COD – ffCOD). As a result, the soluble COD and ffCOD values presented under the average column are the median values of the smaller dataset as is the readily biodegradable COD fraction (Fbs) of 0.22.

The influent soluble unbiodegradable COD (Fus) of 0.06 is typical of municipal wastewaters and consistent with the October 2014 sampling event. The volatile fatty acid:readily biodegradable COD fraction (Fac) of 0.33 is representative of the average VFA concentration measured and shows relatively high influent VFA concentrations, even under lower wastewater temperatures. It is recommended that further testing be complete in warm weather conditions (influent temperatures greater than 20 degrees Celsius) to observe if the influent Fac changes with temperatures or whether the large collection system is the key contributor to VFA production.

Table 4-1. Nine Springs WWTP Influent Wastewater Characteristics.

Item	Units	April 2016		October 2014		BioWin Calibration	Typical Fractions[2]
		Average	Range	Average	Range		
Flow	mgd	41.9	39.6 - 45.3	38.1	36.9 - 38.9	41.9	
Temperature	C	13.9	13.1 - 15.3	17.5	17.2 - 18.0	12.9	
5-Day Biochemical oxygen demand (BOD5)	mg/L	254	217 - 282	256	207 - 294	250	
Total suspended soids (TSS)	mg/L	229	189 - 284	253	216 - 294	264	
Volatile suspended solids (VSS)	mg/L	238	200 - 310	224	193 - 261	228	
Alkalinity (as CaCO3)	mg/L	444	430 - 470	477	460 - 500	444	
Chemical Oxygen Demand							
Chemical Oyxgen Demand (COD)	mg/L	528	410 - 700	552	450 - 665	528	
Soluble COD (0.45um filter)	mg/L	230	150 - 350	207	170 - 270	187	
Flocculated and Filtered COD	mg/L	140	120 - 340	127	110 - 140	147	
Volatile Fatty Acids (as COD)	mg/L	39	28 - 51	--		33	
Nitrogen							
Total kjeldahl nitrogen (TKN)	mg N/L	44	42 - 46	48	44 - 54	44	
Soluble TKN	mg N/L	31	31 - 31	37	33 - 41	34	
Ammonia-nitrogen (NH3-N)	mg N/L	28	26 - 30	30	28 - 32	28	
Nitrate-nitrogen (NO3-N)	mg N/L	0.1	0.0 - 0.1	0.1	0.0 - 0.3	0.1	
Phosphorus							
Total phosphorus (TP)	mg P/L	5.8	5.3 - 6.3	6.4	5.7 - 8.0	5.8	
Soluble phosphorus	mg P/L	3.3	2.3 - 4.4	3.8	3.3 - 4.4	NA	
Ortho-phosphate (PO4-P)	mg P/L	2.2	1.8 - 3.0	3.6	2.9 - 4.3	3.2	
COD fractions							
Readily biodegradable (Fbs)	g/g TCOD	0.22	0.16 - 0.52	0.20	0.17 - 0.24	0.22	0.11 - 0.27
Unbiodegradable soluble (Fus)	g/g TCOD	0.06	0.05 - 0.08	0.055	0.047 - 0.077	0.059	0.03 - 0.09
Unbiodegradable particulate (Fup - estimated)	g/g TCOD	--		--		0.15	0.11 - 0.24
Acetate:Readily biodegradable COD (Fac)	g/g RBCOD	0.33	0.13 - 0.55	--		0.29	0.08 - 0.47
Particulate slowly biodegradable (Fxscp - estimated)	g/g SBCOD	--		--		0.85	0.68 - 0.85
Ordinary heterotrophs (FZbh - estimated)	g/g TCOD	--		--		0.04	0.01 - 0.05
Nitrogen Fractions							
Ammonia-N:TKN (Fna)	g/g TKN	0.65	0.61 - 0.70	0.64	0.58 - 0.71	0.65	0.5 - 0.73
Particulate organic nitrogen (Fnox)	g/g OrgN	--		0.61	0.43 - 0.81	0.60	0.41 - 0.71
Soluble unbiodegradable TKN (Fnus)	g/g TKN	--		0.020	0.012 - 0.025	0.02	0.01 - 0.03
N:COD ratio for unbiodegradable part. COD (FupN)	gN/gCOD	0.023	0.02 - 0.04	0.040	0.02 - 0.06	0.023	0.025 - 0.058
Phosphorus Fractions							
Phosphate-P:TP (Fpo4)	g/g TP	0.39	0.31 - 0.47	0.53	0.44 - 0.69	0.55	0.4 - 0.68
P:COD ratio for unbiodegradable part. COD (FupP)	gP/gCOD	0.012	0.004 - 0.025	0.010	0.007 - 0.017	0.01	0.007 - 0.015
Other							
COD:BOD5	g/g	2.1	1.8 - 2.9	2.2	1.8 - 2.8	2.1	1.8 - 2.7
COD:TKN	g/g	12.1	9.5 - 15.9	11.5	10.0 - 14.6	12.1	10.0 - 17.5
COD:TP	g/g	91	73 - 112	86	68 - 116	91	65 - 110
ffCOD:COD	g/g	0.31	0.21 - 0.43	0.25	0.23 - 0.29	0.28	0.19 - 0.34
VSS:TSS	g/g	0.89	0.86 - 0.92	0.89	0.83 - 0.91	0.86	0.8 - 0.9
Particulate COD:VSS	g/g	1.51	0.91 - 1.86	1.31	1.10 - 1.45	1.5	1.35 - 2.1

1. April 2016 temperatures measured in plant effluent.
2. Based upon Brown and Caldwell wastewater sampling database.

4.2 Nitrogen Characteristics

The influent ammonia to TKN fraction (Fna) during the April 2016 and October 2014 sampling events averaged roughly 0.65. This Fna fraction is typical of municipal wastewater and was used for the BioWin™ calibration. During the April 2016 sampling event, 13 of 14 soluble TKN measurements were less than the corresponding NH3-N concentration. As such, the October 2014 median soluble TKN:TKN ratio of 0.79 was used to estimate the particulate TKN concentrations to develop the BioWin™ N:COD ratio for unbiodegradable particulate COD (FupN) of 0.023, which is lower than the BioWin™ default value of 0.035.

4.3 Phosphorus Characteristics

Influent TP concentrations measured in April 2016 were consistent with the October 2014 period when adjusted for influent flow rate. The PO4-P:TP (F_{PO4}) ratio of 0.39 measured in April 2016 is significantly less than the October 2014 F_{PO4} of 0.52. The October 2014 F_{PO4} is typical of municipal wastewaters. During BioWin™ calibration, the F_{PO4} fraction was increased to 0.55 to provide an improved correlation with primary effluent TP, anaerobic selector PO4-P concentrations and activated sludge TP:MLVSS ratio.

4.4 Other Characteristics

It is often useful to evaluate several additional wastewater characteristics in assessing data validity, seasonal variations, and general wastewater characteristics. These data are useful to consider as there is usually considerable day-to-day variation in concentration values; however, the ratio of COD:TKN, for example should not show large fluctuations. Table 4-1 shows several “Other” parameter ratios measured during the April 2016 sampling event are typical of municipal wastewater and consistent with the October 2014 sampling results with the following observations:

- April 2016 volatile suspended solids: total suspended solids (VSS:TSS) is represented by two data points as the measured VSS was greater than the TSS on all other days sampled.
- ffCOD:COD ratio is higher in April 2016 (compared to October 2014) corresponding to the increase in Fbs and Fus.
- Particulate COD:VSS of 1.5 is consistent with typical influent values and higher than measured in April 2014.

5. BioWin Calibration

The NSWWTP BioWin process simulator was calibrated to wastewater characterization and plant operating data collected from April 4 through 17, 2016. The model was calibrated based upon steady state operations/simulations using the average operating conditions/parameters reported during this period. For detailed design, the NSWWTP calibrated model will need to be validated using a minimum of three months of daily plant operating data to confirm the model is calibrated and accurately reflects operations with daily and diurnal operating changes such as aeration demands, mixed liquor concentrations, primary clarifier performance, solids production, unit process performance, and effluent quality. The selected dynamic model validation data period should include the April 2016 special sampling periods.

Simulator calibration generally involves combining the “operational” or “controllable” aspects of the treatment plant with the input wastewater characteristics and making adjustments to selected parameters to fit a set of plant performance data. It should be noted that often it is not possible to adjust simulator parameters such that an *exact* match between predicted and observed values is achieved. Rather, the goal in calibrating a simulator is to achieve a good correlation between the overall *trend* of predicted and observed values while minimizing the error between datasets and simulator predictions. It also is crucial to observe the simulator fit to *all* important variables. It is preferable to fit to most of the measured variables reasonably, rather than fit perfectly to one selected (albeit perhaps important) component concentration and poorly to others.

Tables 5-1 compares the measured and simulated constituent concentrations for the liquid and solids stream flows respectively. The model shows the BioWin predicted values correlate very well with the measured values on a steady-state basis. Detailed analysis of key process units is provided below.

5.1 Plant Influent

As discussed in Section 4, BioWin uses COD, TKN, and TP as the basis for process simulations. The model allows the user to input influent flow, COD, TKN, T, alkalinity, inert suspended solids, nitrite, pH, and temperature. Using the wastewater fractions input into the model, the model will then calculate additional influent parameters such as filtered COD, BOD, TSS, VSS, NH3-N, and PO4-P. Table 5-1 shows the measured and simulated influent concentrations match very well with the exception of TSS, PO4-P, and temperature. Influent VSS concentration were consistently greater than the measured TSS concentration during sampling. BioWin simulations were conducted with the influent VSS of 0.89*TSS and TSS = VSS/0.89 (assumed influent VSS:TSS ratio of 0.89 based upon October 2014 dataset). Simulations using the measured VSS concentrations and increasing the TSS concentration provided the best correlation between gravity thickened sludge production and BNR MLSS concentrations – hence VSS was used as a basis for the model influent and TSS increased above the measured values. It should be noted the plant influent TSS and VSS were analyzed by two different laboratories.

The influent PO4-P concentration (F_{PO4}) was increased from the measured average value of 2.1 to 3.2 mg PO4-P/L to improve the primary effluent TP and anaerobic selector PO4-P concentrations and match the activated sludge TP:MLVSS ratio.

The influent Fac was decreased from 0.32 to 0.29 to produce a West primary effluent VFA concentration of 37 mg/L as COD. Reducing the Fac is conservative as it assumes VFAs are not generated across the PST nor added in the Ostrarate recycle flow. Further testing is recommended to confirm this assumption.

Table 5-1. Nine Springs WWTP BioWin Steady-State Calibration Measured and Simulated Data Comparison.

Flow Stream	Flow mgd	COD mg/L	Filtered COD mg/L	BOD5 mg/L	TSS mg/L	VSS mg/L	TKN mg/L	Soluble TKN mg/L	NH3-N mg/L	NOx-N mg/L	Total P mg/L	Ortho-P mg/L	Alkalinity mg/LCaCO3	Temp. degrees C	pH S.U.	Total VFA mg/L COD
Plant Influent																
Measured	41.9	528	230	251	229	230	44		29	0.1	5.7	2.1	440	13.9	7.6	38
Simulated	41.9	528	187	250	264	228	43.7	33.6	28.2	0.1	5.8	3.2	444	12.9	7.7	33
Difference, percent	0%	0%	-19%	0%	15%	-1%	0%		-1%	0%	2%	53%	1%	-7%	1%	-12%
East Primary Effluent[1]																
Measured	19.8	305	180	162	73	74	41		31		6.5		460			
Simulated	19.7	307	190	159	91	78	39	35	31	0.0	6.0	5.1	460		7.6	52
Difference, percent	0%	1%	5%	-2%	24%	6%	-5%		0%		-7%		0%			
West Primary Effluent[1]																
Measured	22.9	300	200	173	94	91	41		30		7.1		450			
Simulated	22.8	321	186	165	105	90	39	35	30	0.1	5.1	4.1	457		7.7	36
Difference, percent	0%	7%	-7%	-4%	11%	-1%	-5%		1%		-28%		2%			
East MLSS												Selector		Aerobic SRT	TKN:VSS	TP:VSS
Measured		2600			2150	1794	135				130	28		8.0	8.5%	7.2%
Simulated		1963			1837	1339	114				103	26		8.7	8.5%	7.7%
Difference, percent		-25%			-15%	-25%	-15%				-20%	-8%		9%	0%	7%
West MLSS												Selector		Aerobic SRT	TKN:VSS	TP:VSS
Measured		2500			1900	1580	130				110	24		6.1	8.1%	6.1%
Simulated		1982			1768	1353	116				76	13		6.3	8.5%	5.6%
Difference, percent		-21%			-7%	-14%	-11%				-31%	-45%		3%	5%	-8%
East Secondary Effluent[1]																
Measured	19.4			5	4		1.8		0.3	20.8	0.2	0.2	290			
Simulated	19.3	38.5	35	2	3	2.4	1.8	1.6	0.1	20.9	0.2	0.1	288			
West Secondary Effluent[1]																
Measured	22.5			6	5		1.8		0.2	20.8	0.2	0.2	280			
Simulated	22.5	39.3	34	3	5	3.7	2.0	1.7	0.2	20.6	0.2	0.0	288			
Combined Effluent																
Measured	41.9	36	32	8	6	5	1.8		0.2		0.3	0.1				
Simulated	41.8	39	35	2	4	3	1.9	1.6	0.2	20.8	0.2	0.0				

1. *Primary effluent and secondary effluent flows assumes 55% of the influent flow routed to the west plant.*

Table 5-1. Nine Springs WWTP BioWin Steady-State Calibration Measured and Simulated Data Comparison. (continued)

Flow Stream	Flow mgd	COD mg/L	Soluble COD mg/L	BOD5 mg/L	TSS or TS mg/L	VSS or VS mg/L	TKN mg/L	Soluble TKN mg/L	NH3-N mg/L	NOx-N mg/L	Total P mg/L	Ortho-P mg/L	Alkalinity mg/L CaCO3	Temp. degrees C	pH S.U.	Total VFA mg/L COD
Primary Sludge																
Measured	1.3															
Simulated	**1.3**	**7,533**	**275**	**3,110**	**5,684**	**4,858**	**265**	**46**	**44**	**0**	**87**	**23.7**			**7.2**	**214**
Difference, percent	0%															
Gravity Thickened Primary Sludge																
Measured	0.13				58,400	49,800										
Simulated	**0.13**	**70,837**	**377**		**54,998**	**47,145**	**2181**	**60**	**59**	**0.0**	**635**	**46.5**			**7.0**	**343**
Difference, percent	2%				-6%	-5%										
Gravity Thickener Overflow																
Measured		717	355		183	168	47		40.4		22	12				
Simulated	**1.1**	**508**	**274**	**266**	**182**	**157**	**53**	**46**	**44.6**	**0.0**	**26**	**24**			**7.2**	**215**
Difference, percent		-29%	-23%		0%	-7%	13%		10%		16%	95%				
East Waste Sludge																
Measured	0.41				5800											
Simulated	**0.37**	**5,800**			**5,494**	**4,005**	**338**				**309**					
Difference, percent	-9%				-5%											
West Waste Sludge																
Measured	0.39				5180											
Simulated	**0.39**	**7,370**			**6,659**	**5,095**	**430**				**287**					
Difference, percent	0%				29%											
DAFT Thickened Sludge																
Measured	0.039				42500											
Simulated	**0.030**	**42,010**			**40,006**	**29,159**	**2,454**				**2,250**					
Difference, percent	-23%				-6%											
DAFT Underflow																
Measured	0.17	175			120		7				14	4.1				
Simulated	**0.19**	**142**			**102**	**74**	**8**		**0.1**	**21**	**6**	**0.1**				
Difference, percent		-19%			-15%		14%				-59%	-99%				
WAS Treatment																
Measured	0.643		205		12000	9300			42			188	590			
Calculated	*0.643*				*8,864*	*7,128*										
Simulated	**0.590**	**10,378**	**167**		**8,818**	**7,063**	**579**	**28**	**26**		**421**	**168**	**479**			
Difference, percent	-8%		-19%						-37%			-10%	-19%			
WAS GBT Thickened Sludge																
Measured	0.11				59,000	50,150										
Simulated	**0.09**	**63,313**	**167**	**21,083**	**54,528**	**43,675**	**3,438**	**28**	**26**		**1,730**	**168**	**480**			
Difference, percent	-15%				-8%	-13%										
WAS GBT Filtrate																
Measured	0.585	325			158	135	35		31		200	166				
Simulated	**0.49**	**349**	**167**	**141**	**157**	**126**	**38**		**26**		**173**	**168**				
Difference, percent	-16%	7%			0%	-7%	10%		-13%		-14%	1%				

Table 5-1. Nine Springs WWTP BioWin Steady-State Calibration Measured and Simulated Data Comparison. (continued)

Flow Stream	Flow mgd	COD mg/L	Soluble COD mg/L	BOD5 mg/L	TSS or TS mg/L	VSS or VS mg/L	TKN mg/L	Soluble TKN mg/L	NH3-N mg/L	NOx-N mg/L	Total P mg/L	Ortho-P mg/L	Alkalinity mg/L CaCO3	Temp. degrees C	pH S.U.	Total VFA mg/L COD
Digester Feed																
Calculated	0.23				58,672	49,959										
Simulated	0.22				54,805	45,726	2,695				1,083					
Difference, percent	-5%				-7%	-8%										
Acid Phase Digester																
Measured		73,500			49,300	40,800	2,083		735		833	488	3,240	34	5.2	10,480
Simulated to WAS Treatment		67,813	10,477	26,793	47,815	39,061	2,749	739	735		1,209	488	3,331		5.3	10,440
Difference, percent		-8%			-3%	-4%	32%		0%		45%	0%	3%			0%
Mesophilic Digesters																
Measured	0.23	25,395			28,700	19,900	2,464		1,952			283	4,404	35	7.4	
Simulated	0.22	28,905			30,113	19,442	2,805		1,428		1,099	281	4,392	36	7.1	
Difference, percent	-5%	14%			5%	-2%	14%		-27%			-1%	0%	2%		
Thermophilic Digesters																
Measured	0.037	22,440			20,400	13,500	2,262		2,244		1,537	246	6,090	58	8.15	
DS GBT Feed																
Calculated	*0.23*				*27,391*	*18,891*										
Simulated	0.22	28,905			30,113	19,442	2,805		1,428		1,099	281	4,392		7.1	
Difference, percent	-5%				10%	3%										
DS GBT Thickened Sludge																
Measured	0.134				51050											
Simulated	0.130				46,273	29,160	3,481	1,446	1,426		1,555	187	4,652			
Difference, percent	-3%				-9%											
DS GBT Filtrate Sump																
Measured	0.29	765	140		270	200	685		880		103	75				
Simulated	0.18	430	175	66	267	175	553	540	531		79	70			7.0	
Difference, percent	-38%	-44%	25%		-1%	-13%	-19%		-40%		-22%	-7%				
Ostara Influent																
Measured	0.79				266		356		214		147	123				
Simulated	0.68				187	139	178		164		147	141			7.1	
Difference, percent	-14%				-29%		-50%		-24%		1%	15%				
Ostara Effluent																
Measured	0.84				565		314		183		103	27				
Simulated	0.68	289	160	100	685	89	156	116	113		106	30			8.2	
Difference, percent	-19%				21%		-50%		-38%		3%	12%				

The influent ordinary heterotrophs organism COD fraction (FZbh) was increased from the BioWin™ default of 0.02 to 0.04 to increase primary sludge hydrolysis from microbial activity. The increase in primary sludge hydrolysis increases the soluble COD, TKN, NH3-N, TP, and PO4-P concentrations in the gravity thickener overflow (GTO) to more closely match measured values. Increasing the FZbh above 0.04 provides a better match to the measured GTO soluble COD, however the NH3-N and PO4-P also increase. The selected FZbh provides a good fit for all GTO recycle concentrations. Appendix B provides procedures to directly measure the FZbh fraction.

Influent temperature was not recorded during the sampling period. Effluent temperatures during the sampling event averaged 13.9 degrees Celsius (degrees C). Based upon observations at similar activated sludge plants, a 1 degree C increase in temperature is observed across the aeration basin. This analysis assumes the temperature increased by 1 degree C across the plant resulting in an average influent temperature of 12.9 degrees C. It should be noted the effluent temperature increased from 13.2 to 15.3 degrees C during the sampling period.

It is suggested the plant begin to monitor plant influent and primary effluent PO4-P two to three times per week to better define the F_{PO4} ratio used in defining the PO4-P concentration.

5.2 Primary Sedimentation Tanks

Reported East and West plant flows (primary effluent and secondary effluent) of approximately 25 mgd and 17 mgd, respectively during the sampling period (60% flow to East Plant) did not match the influent splitter structure gate settings which should have direct 55% of the flow to the West plant. The primary effluent (and secondary effluent) flows listed in Table 5-1 represent the MMSD staff estimated flow based upon the influent flow splitter structure gate positions. Further evaluation into the reported flow measurements/calculations is recommended.

PST performance was modeled using ideal primary clarifiers with biological reactions. East PST and West PST performance are modeled with 66% and 61% TSS removal respectively and used reported primary sludge flow rates. The selected PST TSS removals result in the predicted primary effluent COD, filtered COD, BOD5, VSS, TKN, and NH3-N concentrations being within 10% of measured values. Predicted primary effluent TSS values are greater than measured, while predicted TP concentrations are lower. Recycle loadings increase the plant influent TP by nearly 50% while recycles loadings increase plant influent PO4-P loadings by 40% of the measured value and 25% of the simulated value. Based upon measured data, the primary effluent TP concentration should not increase. The recommended influent/primary effluent PO4-P testing will help determine if struvite is being re-solubilized across the PSTs contributing to the higher primary effluent TP concentrations or if struvite solids removal across the PSTs is less than TSS removal.

Based upon measured and model results, recycle loadings increase the influent TKN and ammonia loadings by roughly 15%. Primary sludge samples were not collected for analysis.

5.3 Aeration Basins

The West aeration basin predicted MLSS is roughly 93% of the measured values. Review of plant operating data immediately prior to the calibration period shows Plant 3 and 4 were operating at aerobic SRTs roughly 13% and 11% higher than the calibration steady state SRT. Operating at the higher aerobic solids retention time (SRT) prior to the calibration period results in higher MLSS inventory in the aeration tank, hence the calibration MLSS at a lower SRT will be under-predicted. When accounting for the higher aerobic SRTs prior to calibration, the West plant predicted MLSS concentration is within 5% of the reported values. The East aeration basin predicted MLSS is roughly 85% of the measured values at a simulated aerobic SRT of 8.7 days. If the aerobic SRT is decreased to match the operating aerobic SRT of 8 days, the East plant predicted MLSS would be within 20% of the reported data. The East and West plant predicted MLVSS:MLSS ratios of 73%

and 77% respectively are lower than the plant reported MLVSS:MLSS of 79% to 80%. Further calibration/validation of the model to three months of daily operating daily (dynamic basis) is recommended to confirm the predicted MLSS and MLVSS as is confirmation of the East plant WAS flow rates.

Figure 5-1 compares the measured and predicted aeration basin profiles. The measured data profiles represent the median value of 4 aeration basin profiles collected over two days – two in the morning and two in the afternoon. The East plant NH3-N and NOx-N profiles match very well, while the West plant profiles shows higher degrees of nitrification occurring in Passes 1 and 2 than measured. The difference could be due to dissolved oxygen (DO) levels as the West plant DO was not recorded during profiles. The difference could also be the steady state flow is higher than the plant flow during basin profiling as the morning profiles showed significant nitrification (NH3-N < 5 mgN/L) while the afternoon profiles showed a closer correlation to the model predicted values. The calibrated model uses the BioWin™ default nitrification kinetic rates and constants.

In both the East and West plant, the PO4-P release predicted by the model in the anaerobic zone was less than the measured value, matched well with the anoxic zone, and slightly conservative (higher) in the Pass 1 aerated zone. Predicted Pass 2 and 3 PO4-P profiles match well with measured data. The lower predicted anaerobic zone PO4-P release is believed to be the result of the lower primary effluent PO4-P concentrations.

5.4 Secondary Effluent

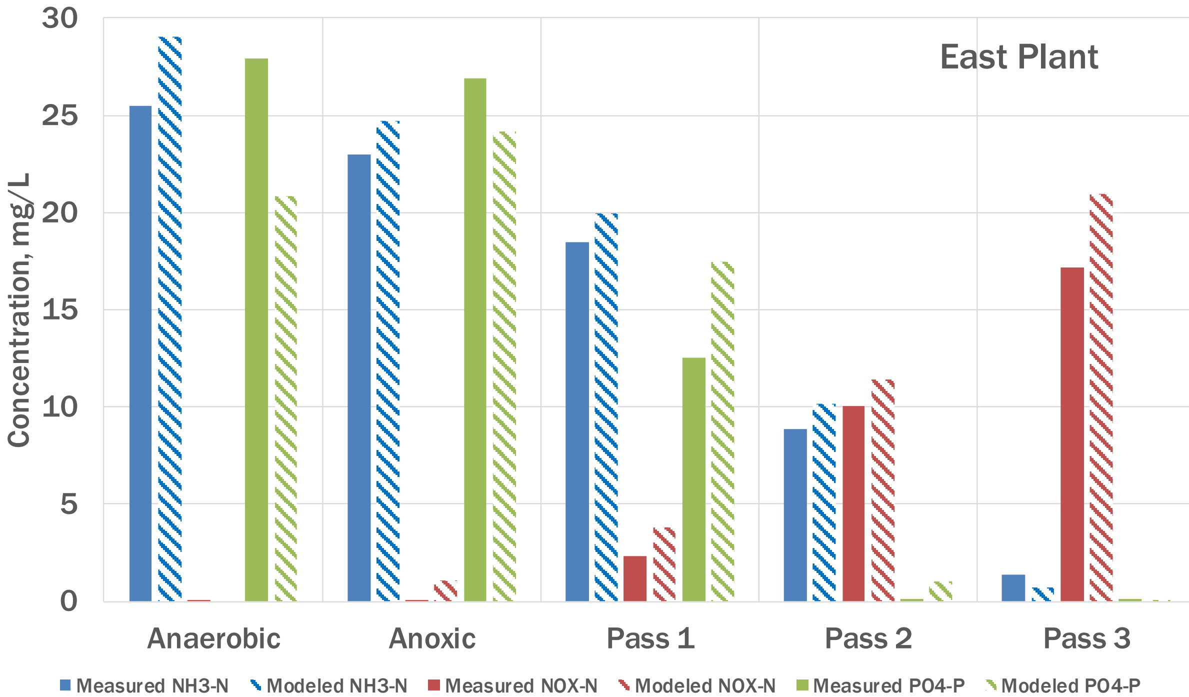
Table 5-1 shows the predicted East, West, and combined secondary effluent quality matched well with measured values with the exception of BOD5 which the model consistently under-predicted.

5.5 Gravity Thickeners

Gravity thickener overflow (GTO) TSS and thickened sludge concentrations match well with reported data when selecting a TSS capture rate of 97.1% with the biological reactions turned “ON”. This TSS capture/removal rate is higher than typical gravity thickeners TSS removals of 80% to 90%. Predicted GTO soluble COD and COD are less than measured. As noted above, the influent FZbh was increased to increase the GTO soluble COD and nutrient concentrations. The predicted nitrogen and phosphorus concentration are higher than measured, however the high values have minimal impact on the main liquid stream concentrations. For example, the predicted 6 mg/L difference in GTO NH3-N or TP equates to a 0.25 mg/L increase in the East Plant influent concentrations and the lower soluble COD is conservative for P removal.

5.6 Dissolved Air Flotation Thickener

DAFT influent flow of 0.23 mgd was selected to match the mass of solids wasted from Plant 2 to the DAFT. DAFT subnatant TSS and thickened sludge concentrations match well with reported data with a TSS capture rate of 98.5%. The DAFT module assumes no change in soluble species across the DAFT and does not capture the small phosphate release (PO4-P of 4 mg/L) measured during the April sampling period.



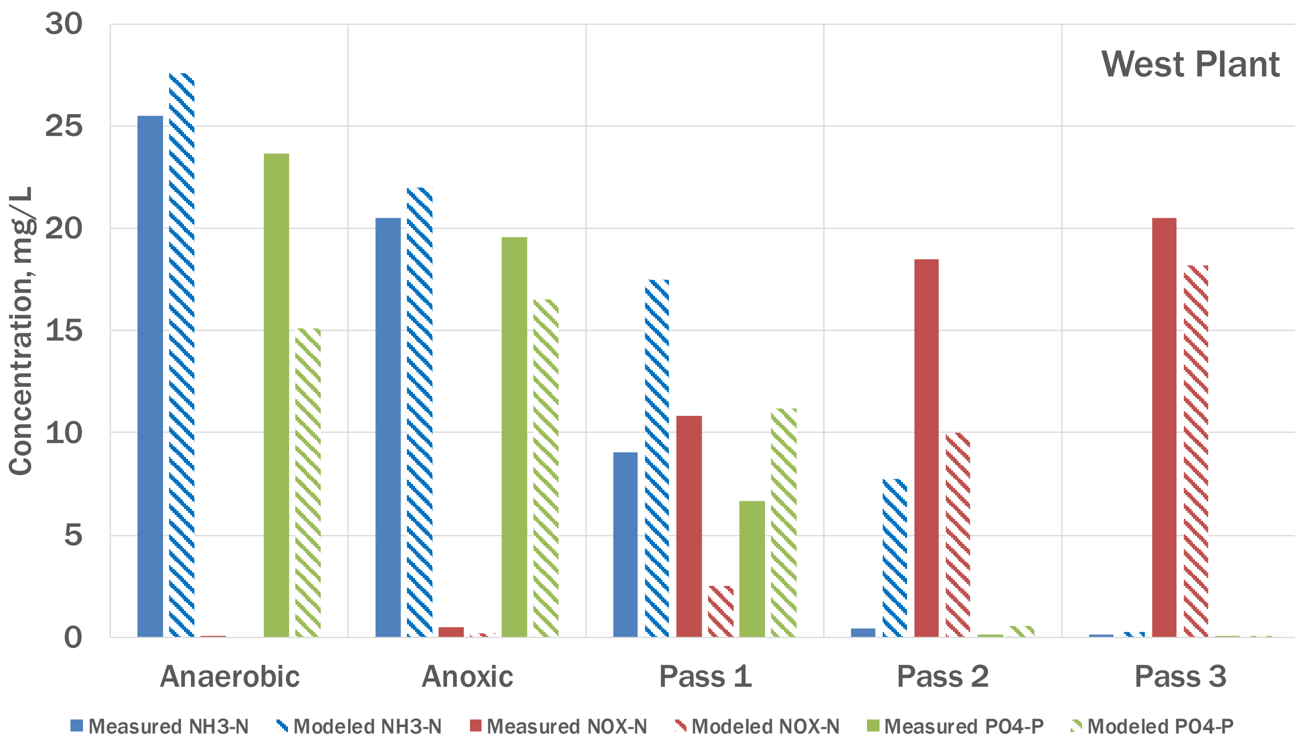


Figure 5-1. Comparison of Measured and Model Predicted Aeration Basin Nutrient Profiles.

5.7 WAS Treatment/WAS Gravity Belt Thickener

The measured WAS treatment tank total solids (TS) and volatile solids (VS) of 12,000 mg/L and 9,300 mg/L are inaccurate as the calculated influent TS and VS to the WAS Treatment tank are 8,865 mg/L and 7,130 mg/L, respectively. The WAS treatment tank performance is based upon the GBT filtrate quality to match the filtrate going to the Ostara system. As such the WAS Treatment tank local anaerobic hydrolysis factor (AS) was increased from the BioWin™ default of 0.04 to 0.07 to provide the best overall correlation with the GBT filtrate PO4-P, NH3-N, TKN, and COD concentrations.

The GBT filtrate TSS and thickened sludge concentrations match well with reported data with a TSS capture rate of 98.4%. The reported flows around the WAS Treatment/GBT system do not balance as the reported influent flow of 0.643 mgd is less than the reported 0.695 mgd. This flow balance is within reason but the higher reported GBT flows results in the modeled flows being roughly 85% to 91% of the reported flows.

5.8 Anaerobic Digesters

The simulated anaerobic digester feed rate and influent TS/VS match well with reported values. The acid phase digester (APD) influent state variable matches well with reported data. The simulated APD TP concentration is 10% greater than the measured digester feed concentration and is considered acceptable. The measured APD TP concentration is less than the digester feed TP and considered incorrect as phosphorus is conservative.

Simulated mesophilic digester effluent matches well with measured data with the exception of NH3-N which is under-predicted. Measured thermophilic digester effluent TS/ VS and COD concentrations are roughly 30% and 12% lower than the measured mesophilic digester concentrations, hence the solids production quantities will be slightly conservative. The thermophilic digester ammonia concentration is greater than the mesophilic digester as expected. In general, the model under-predicts the ammonia concentration by 25% or more and should continue to be investigated as discussed below.

5.9 Digested Sludge GBT/Ostara

The Digested Sludge GBT filtrate TSS capture rate is set at 99.4% to match the filtrate TSS concentration. The filtrate characteristics represent the combined GBT filtrate, GBT wash water flow of 0.2 mgd, 60% of the DAF subnatant, and GBT average ferric feed of 300 gpd.

The predicted digested sludge GBT filtrate (and Ostara influent/effluent) TKN and NH3-N concentrations are significantly less than measured values. Comparing the model predicted and measured primary effluent TKN and NH3-N concentrations, the lower nitrogen levels recycled back to the aeration basins (equivalent TKN and ammonia concentrations of roughly 3 and 1.5 mg/L in flow of 42 mgd) do not impact the main liquid stream calibration/evaluation as the predicted primary effluent TKN and NH3-N match well with reported values. If the NH3-N concentration is artificially increased to match the MAD (DS GBT filtrate, Ostara) NH3-N concentrations, the primary impact is the volume of the “Pearl” reactor is decreased to match the Ostara effluent PO4-P concentration. Since the volume of the “Pearl” reactor is adjusted to match the Ostara effluent PO4-P concentration, the calibration does not artificially increase the NH3-N concentration in the mesophilic/thermophilic digesters.

Attachment A: Wastewater Characterization Sampling Data

Plant Influent

Day	Date	Flow mgd	COD mg/L	SCOD mg/L	ffCOD mg/L	VFAs mg/L as COD	BOD5 mg/L	sBOD5 mg/L	TKN mg/L as N	sTKN mg/L as N	NH3 mg/L as N	(Grab) Nitrate as N, mg/L	Total P mg/L as P	Soluble P mg/L as P	OrthoP mg/L as P	Total Alk mg/L as CaCO	TSS mg/L	VSS mg/L	pH	Temp F	Notes
1	4/4/2016	42.7	410	120	240		233	70	43.0	21	26.6	0.05	5.6	3.0	2.0	440	237	38	7.6		
2	4/5/2016	41.9	560	150	120	50	276	73	44.8	26	28.8	0.07	6.3	2.6	2.1	430	269	230	7.7		
3	4/6/2016	45.3	580	170	230	51	270	82	44.5	22	27.6	0.05	5.6	3.1	1.8	440	209	220	7.6		
4	4/7/2016	43.5	510	170	140		277	78	41.5	26	29	0.08	5.4	0.03	2.3	440	229	230	7.9		
5	4/8/2016	43.1	490	160	260		246	91	43.6	25	29.2	0.13	5.6	3.2		450	199	200	7.8		
6	4/9/2016	41.5	450	250	140		229	87	41.7	26	26.2	0.07	5.6	2.9		430	215	220	7.7		
7	4/10/2016	41.6	440	130	210	32	229	81	42.7	26	27.5	0.05	5.3	2.3	1.9	440	189	220	7.8		
8	4/11/2016	42.2	520	150	150	36	217	81	42.4	25	27	0.09	5.8	3.3	2.2	440	220	230	7.6		
9	4/12/2016	41.7	490	190	140	39	276	90	45.0	27	27.4	0.07	6.2	3.4	17	470	284	310	7.7		
10	4/13/2016	41.6	580	350	250	28	270	66	45.3	31.0	29.5	0.05	6.1	3.4	2.1	460	242	250	7.6		
11	4/14/2016	41.5	580	350	340		282	120	42.8	19	28.2	0.05	5.6		2.7	440	237	250	7.6		
12	4/15/2016	40.9	700	230	180		243	89	43.9	28	29.1	0.07	6.2	4.4		450	229	270	7.7		
13	4/16/2016	39.8	520	150	170		249	85	44.6	22	30.4	0.05	5.9	4.0		450	217	260	7.6		
14	4/17/2016	39.6	560	190	220		252	170	45.7	22	29.6	0.10	6.3	3.5	3.0	440	228	210	7.6		
	Average	**41.9**	**528**	**241**	**187**	**39**	**254**	**90**	**43.7**	**31.0**	**28.3**	**0.07**	**5.8**	**3.3**	**2.2**	**444**	**229**	**238**	**7.68**		
	Median	**41.6**	**520**	**230**	**140**	**38**	**251**	**84**	**43.8**	**31.0**	**28.5**	**0.07**	**5.7**	**3.3**	**2.1**	**440**	**229**	**230**	**7.65**		
	Weighted Ave.		**528**	**240**	**186**		**254**	**90**	**43.7**		**28.3**	**0.0**	**5.8**	**3.2**	**3.7**	**444**	**229**	**224**			
	Minimum	**39.6**	**410**	**150**	**120**	**28**	**217**	**66**	**41.5**	**31.0**	**26.2**	**0.0**	**5.3**	**2.3**	**1.8**	**430**	**189**	**200**	**7.60**		
	Maximum	**45.3**	**700**	**350**	**340**	**51**	**282**	**170**	**45.7**	**31.0**	**30.4**	**0.1**	**6.3**	**4.4**	**3.0**	**470**	**284**	**310**	**7.90**		
	Count	**14**	**14**	**7**	**7**	**6**	**14**	**14**	**14**	**1**	**14**	**14**	**14**	**12**	**9**	**14**	**14**	**13**	**14.00**		

(yellow) **= Data Screened from dataset** (blue) **= Data from Madison MSD**

CALCULATIONS

		GENERAL				SOLIDS CHARACTERIZATION								COD FRACTIONS							
Day	**Date**	**COD:TKN**	**TP:TKN**	**COD:TP**	**BOD5:TSS**	**VSS:TSS**	**ISS**	**Fcvxi/s pCOD:VSS**	**pN:VSS pN=0.21*TKN**	**pP:VSS**	**FupN pN/pCOD pN=0.21TKN**	**FupP pP:pCOD**	**Fna NH3:TKN**	**COD:BOD5**	**SCOD:COD**	**RBCOD**	**colCOD**	**Fbs**	**Fus**	**Fpo4 PO4-P:TP**	**Fac VFA: RBCOD**
1	4/4/2016	9.5	0.130	73	0.98	.16	199	7.63			0.038	0.009	0.62	1.8	0.29	213	-120	0.52	0.066	0.36	
2	4/5/2016	12.5	0.140	89	1.03	0.86	39	1.78	0.039	0.02	0.024	0.009	0.64	2.0	0.27	90	30	0.16	0.054	0.33	0.55
3	4/6/2016	13.0	0.126	103	1.29	1.05	-10	1.86	0.043	0.01	0.028	0.006	0.62	2.1	0.29	198	-60	0.34	0.055	0.31	0.26
4	4/7/2016	12.3	0.130	94	1.21	1.00	0	1.48	0.041	0.02	0.023	0.016	0.70	1.8	0.33	108	30	0.21	0.063	0.43	
5	4/8/2016	11.2	0.128	88	1.24	1.01	-2	1.65	0.044	0.01	0.027	0.007	0.67	2.0	0.33	230	-100	0.47	0.061		
6	4/9/2016	10.8	0.134	81	1.07	1.02	-4	0.91	0.042	0.01	0.034	0.013	0.63	2.0	0.56	107	110	0.24	0.073		
7	4/10/2016	10.3	0.124	83	1.21	1.16	-30	1.41	0.040	0.01	0.1	0.010	0.64	1.9	0.30	173	-80	0.39	0.084	0.36	.18
8	4/11/2016	12.3	0.137	90	0.99	1.05	-11	1.61	0.039	0.01	0.052	0.007	0.64	2.4	0.29	140	-20	0.27	0.058	0.38	0.26
9	4/12/2016	10.9	0.137	80	0.97	1.09	-26	0.97	0.029	0.01	0.036	0.009	0.61	1.8	0.39	108	50	0.22	0.065	2.76	0.36
10	4/13/2016	12.8	0.134	96	1.12	1.03	-7	0.92	0.038	0.01	0.022	0.012	0.65	2.1	0.60	212	100	0.37	0.066	0.34	0.13
11	4/14/2016	13.6	0.132	103	1.19	1.05	-12	0.92	0.038	0.02	0.023	0.025	0.66	2.1	0.60	301	10	0.52	0.067	0.47	
12	4/15/2016	15.9	0.142	112	1.06	1.18	-41	1.74	0.033	0.01	0.020	0.004	0.66	2.9	0.33	148	50	0.21	0.046		
13	4/16/2016	11.7	0.133	88	1.15	1.20	-43	1.42	0.035	0.01	0.032	0.005	0.68	2.1	0.29	142	-20	0.27	0.054		
14	4/17/2016	12.3	0.138	89	1.11	0.92	18	1.76	0.045	0.01	0.030	0.007	0.65	2.2	0.34	186	-30	0.33	0.061	0.47	
	Average	12.1	0.133	91	1.11	0.89	29	1.51	0.039	0.013	0.026	0.012	0.65	2.09	0.40	153	54	0.28	0.062	0.39	0.33
	Median	12.3	0.133	89	1.11	0.89	29	1.61	0.039	0.012	0.023	0.012	0.65	2.04	0.33	108	50	0.22	0.062	0.36	0.31
	Minimum	9.5	0.124	73	0.97	0.86	18	0.91	0.029	0.007	0.020	0.004	0.61	1.76	0.27	90	10.0	0.16	0.046	0.31	0.13
	Maximum	15.9	0.142	112	1.29	0.92	39	1.86	0.045	0.023	0.036	0.025	0.70	2.88	0.60	301	110.0	0.52	0.084	0.47	0.55
	Count	14	14	14	14	2	2	11	13	13	7	7	14	14	10	7	7	7	14	9	4

East Primary Effluent

Day	Date	Reported Flow mgd	Calculated Flow mgd	COD mg/L	SCOD mg/L	VFAs mg/L as COD	BOD5 mg/L	sBOD5 mg/L	TKN mg/L as N	sTKN mg/L as N	NH3 mg/L as N	(Grab) Nitrate as N, mg/L	Total P mg/L as P	Soluble P mg/L as P	OrthoP mg/L as P	Total Alk mg/L as CaCO3	TSS mg/L	VSS mg/L	pH	Notes
1	4/4/2016	25.5	20.2	310	180		138	55	39.4		29.2		5.98			450	79	75		
2	4/5/2016	25.1	19.9	300	140		174	63	46.5		31.5		7.01			460	81	70		
3	4/6/2016	27.1	21.4	390	180		164	64	42		30.4		6.07			440	78	80		
4	4/7/2016	25.9	20.5	320	170		169	54	40.4		30.5		6.37			450	72	72		
5	4/8/2016	25.7	20.4	350	140		161	66	42.2		31.5		6.28			460	65	74		
6	4/9/2016	25.0	19.5	240	240		142	53	39.6		29.6		6.27			450	63	64		
7	4/10/2016	25.2	19.5	280	260		146	42	39.9		29.5		6.3			440	69	64		
8	4/11/2016	25.3	19.8	260	140		125	53	37.6		28.6		6.51			440	72	66		
9	4/12/2016	24.9	19.6	300	260		164	58	40.5		29.4		7.01			480	78	75		
10	4/13/2016	24.8	19.6	310	320		163	57	43.8		31.6		7.16			480	77	74		
11	4/14/2016	24.8	19.6	330	240		170	68	41.3		30.6		6.43			470	74	84		
12	4/15/2016	24.5	19.3	320	220		176	80	44		33		6.84			470	72	76		
13	4/16/2016	24.0	18.8	260	120		146	63	43.3		32.9		6.64			470	65	71		
14	4/17/2016	24.0	18.7	260	170		140	140	41		31.5		6.74			460	75	76		
	Average	**25.1**	**19.8**	**302**	**199**		**156**	**65**	**41.5**		**30.7**		**6.5**			**459**	**73**	**73**		
	Median	**25.0**	**19.6**	**305**	**180**	**0.47**	**162**	**61**	**41.2**		**30.6**		**6.5**			**460**	**73**	**74**		
	Weighted Ave			**239**	**156**		**123**	**51**	**32.7**		**24.2**		**5.1**			**361**	**57**	**57**		
	Minimum	**24.0**	**18.7**	**240**	**120**		**125**	**42**	**37.6**		**28.6**		**6.0**			**440**	**63**	**64**		
	Maximum	**27.1**	**21.4**	**390**	**320**		**176**	**140**	**46.5**		**33.0**		**7.2**			**480**	**81**	**84**		
	Count	**14**	**14.0**	**14**			**14**	**14**	**14**		**14**		**14**			**14**	**14**	**14**		

(yellow) = Data Screened from dataset; (blue) = Data from Madison MSD

CALCULATIONS

		GENERAL				SOLIDS CHARACTERIZATION								COD FRACTIONS						
Day	Date	COD:TKN	TP:TKN	COD:TP	BOD5:TSS	VSS:TSS	ISS	Fcvxi/s pCOD:VSS	pN:VSS	pP:VSS	FupN pN/pCOD	FupP pP:pCOD	Fna NH3:TKN	COD:BOD	SCOD:COD	RBCOD	colCOD	Fbs	Fus	Fpo4 PO4-P:TP
1	4/4/2016	7.9	0.152	52	1.75	0.95	4	1.73					0.74	2.2	0.58					
2	4/5/2016	6.5	0.151	43	2.15	0.86	11	2.29					0.68	1.7	0.47					
3	4/6/2016	9.3	0.145	64	2.10	1.03	-2	2.63					0.72	2.4	0.46					
4	4/7/2016	7.9	0.158	50	2.35	1.00	0	2.08					0.75	1.9	0.53					
5	4/8/2016	8.3	0.149	56	2.48	1.14	-9	2.84					0.75	2.2	0.40					
6	4/9/2016	6.1	0.158	38	2.25	1.02	-1	0.00					0.75	1.7	1.00					
7	4/10/2016	7.0	0.158	44	2.12	0.93	5	0.31					0.74	1.9	0.93					
8	4/11/2016	6.9	0.173	40	1.74	0.92	6	1.82					0.76	2.1	0.54					
9	4/12/2016	7.4	0.173	43	2.10	0.96	3	0.53					0.73	1.8	0.87					
10	4/13/2016	7.1	0.163	43	2.12	0.96	3	-0.14					0.72	1.9	1.03					
11	4/14/2016	8.0	0.156	51	2.30	1.14	-10	1.07					0.74	1.9	0.73					
12	4/15/2016	7.3	0.155	47	2.44	1.06	-4	1.32					0.75	1.8	0.69					
13	4/16/2016	6.0	0.153	39	2.25	1.09	-6	1.97					0.76	1.8	0.46					
14	4/17/2016	6.3	0.164	39	1.87	1.01	-1	1.18					0.77	1.9	0.65					
	Average	7.3	0.158	46	2.14	1	0	1.40					0.74	1.95	0.67					
	Median	7.2	0.157	44	2.13	1	-1	1.52					0.74	1.90	0.62					
	Minimum	6.0	0.145	38	1.74	1	-10	-0.14					0.68	1.69	0.40					
	Maximum	9.3	0.173	64	2.48	1	11	2.84					0.77	2.38	1.03					
	Count	14	14	14	14	14	14	14					14	14	14					

Brown AND Caldwell

West Primary Effluent

Day	Date	Reported Flow mgd	Calculated Flow mgd	COD mg/L	SCOD mg/L	VFAs mg/L as COD	BOD5 mg/L	sBOD5 mg/L	TKN mg/L as N	sTKN mg/L as N	NH3 mg/L as N	(Grab) Nitrate as N, mg/L	Total P mg/L as P	Soluble P mg/L as P	OrthoP mg/L as P	Total Alk mg/L as CaCO3	TSS mg/L	VSS mg/L	pH	Notes
1	4/4/2016	17.2	23.4	300	890		143	26	39.7		28		6.65			440	93	79		
2	4/5/2016	16.8	23.0	300	140		175	63	42.3		30.3		7.24			450	112	84		
3	4/6/2016	18.2	24.8	350	250		186	52	42.2		29.2		6.77			440	98	90		
4	4/7/2016	17.5	23.8	290	160		185	63	40.6		29.5		6.96			460	92	87		
5	4/8/2016	17.4	23.6	270	200		172	68	41.5		29.6		6.81			450	83	92		
6	4/9/2016	16.5	22.6	270	160		147	55	38.2		27.2		6.78			430	73	78		
7	4/10/2016	16.4	22.6	300	180		146	35	39.9		28.9		6.94			440	88	79		
8	4/11/2016	17.0	22.9	250	200		140	53	41.3		28.5		7.9			450	97	86		
9	4/12/2016	16.8	22.6	300	200		174	59	38.9		28		7.45			480	92	100		
10	4/13/2016	16.8	22.7	310	390		170	54	42.7		30.6		7.57			470	102	98		
11	4/14/2016	16.7	22.8	330	200		190	67	38.8		29.5		6.78			460	103	100		
12	4/15/2016	16.5	22.5	330	240		204	75	45.8		30.9		7.94			470	90	110		
13	4/16/2016	15.8	21.9	300	92		173	58	49.7		31.5		8.41			470	95	99		
14	4/17/2016	15.6	21.8	340	190		171	48.00	41.2		29.7		7.55			450	99	94		
	Average	16.8	22.9	303	200		170	55	41.6		29.4		7.3			454	94	91		
	Median	16.8	22.7	300	200		173	57	41.3		29.5		7.1			450	94	91		
	Weighted Ave			413	342		232	76	56.8		40.1		9.9			620	128	0		
	Minimum	15.6	21.8	250	92		140	26	38.2		27.2		6.7			430	73	78		
	Maximum	18.2	24.8	350	390		204	75	49.7		31.5		8.4			480	112	110		
	Count	14	14	14	13		14	14	14		14		14			14	14	14		

(yellow) = Data Screened from dataset; (blue) = Data from Madison MSD

CALCULATIONS

Day	Date	GENERAL COD:TKN	TP:TKN	COD:TP	BOD5:TSS	SOLIDS CHARACTERIZATION VSS:TSS	ISS	Fcvxi/s pCOD:VSS	pN:VSS	pP:VSS	FupN pN/pCOD	FupP pP:pCOD	Fna NH3:TKN	COD FRACTIONS COD:cBOD	SCOD:COD	[redacted]	Fpo4 PO4-P:TP
1	4/4/2016	7.6	0.168	45	1.54	0.85	14		[redacted]				0.71	2.1		[redacted]	0.00
2	4/5/2016	7.1	0.171	41	1.56	0.75	28	1.90	[redacted]				0.72	1.7	0.47	[redacted]	0.00
3	4/6/2016	8.3	0.160	52	1.90	0.92	8	1.11	[redacted]				0.69	1.9	0.71	[redacted]	0.00
4	4/7/2016	7.1	0.171	42	2.01	0.95	5	1.49	[redacted]				0.73	1.6	0.55	[redacted]	0.00
5	4/8/2016	6.5	0.164	40	2.07	1.11	-9	0.76	[redacted]				0.71	1.6	0.74	[redacted]	0.00
6	4/9/2016	7.1	0.177	40	2.01	1.07	-5	1.41	[redacted]				0.71	1.8	0.59	[redacted]	0.00
7	4/10/2016	7.5	0.174	43	1.66	0.90	9	1.52	[redacted]				0.72	2.1	0.60	[redacted]	0.00
8	4/11/2016	6.1	0.191	32	1.44	0.89	11	0.58	[redacted]				0.69	1.8	0.80	[redacted]	0.00
9	4/12/2016	7.7	0.192	40	1.89	1.09	-8	1.00	[redacted]				0.72	1.7	0.67	[redacted]	0.00
10	4/13/2016	7.3	0.177	41	1.67	0.96	4	-0.82	[redacted]				0.72	1.8	1.26	[redacted]	0.00
11	4/14/2016	8.5	0.175	49	1.84	0.97	3	1.30	[redacted]				0.76	1.7	0.61	[redacted]	0.00
12	4/15/2016	7.2	0.173	42	2.27	1.22	-20	0.82	[redacted]				0.67	1.6	0.73	[redacted]	0.00
13	4/16/2016	6.0	0.169	36	1.82	1.04	-4	2.10	[redacted]				0.63	1.7	0.31	[redacted]	0.00
14	4/17/2016	8.3	0.183	45	1.73	0.95	5	1.60	[redacted]				0.72	2.0	0.56	[redacted]	0.00
	Average	7.3	0.175	42	1.82	1	3	1.14	[redacted]				0.708	1.80	0.66	[redacted]	0.00
	Median	7.2	0.174	41	1.83	1	5	1.30	[redacted]				0.715	1.76	0.61	[redacted]	0.000
	Minimum	6.0	0.160	32	1.44	1	-20	-0.82	[redacted]				0.634	1.57	0.31	[redacted]	0.000
	Maximum	8.5	0.192	52	2.27	1	28	2.10	[redacted]				0.760	2.10	1.26	[redacted]	0.000
	Count	14	14	14	14	14	14	13	[redacted]				14	14	13	[redacted]	14

Secondary Effluent Plant 1 and 2

Day	Date	Reported Flow mgd	Calculated Flow mgd	BOD5 mg/L	TKN mg/L as N	NH3 mg/L as N	Nitrate as N, mg/L	Total P mg/L as P	OrthoP mg/L as P	Total Alk mg/L as CaCO3	TSS mg/L
1	4/4/2016	23.4	19.8	5	1.5	0.32	21.0	0.3	0.34	380	4.5
2	4/5/2016	23.3	19.5	6.8	1.3	0.15	20.0	0.22	0.19	290	4.7
3	4/6/2016	25.3	21.0	4.8	1.75	0.35	18.7	0.24	0.17	290	4.7
4	4/7/2016	24.1	20.1	13.88	3.1	0.67	18.0	0.17	0.11	290	3.0
5	4/8/2016	23.8	20.0		2.5	0.43	18.0	0.077		280	1.6
6	4/9/2016	22.6	19.1		3.5	0.23	22.0	0.14		280	2.5
7	4/10/2016	22.7	19.1	4.1	2.9	0.21	20.0	0.14	0.14	270	3.5
8	4/11/2016	23.4	19.4	5.3	1.5	0.16		0.24	0.11	280	5.2
9	4/12/2016	23.0	19.1	4.8	1.66	0.18	20.0	0.28	0.16	290	4.1
10	4/13/2016	23.0	19.2	3.8	1.39	0.07	18.9	0.17	0.14	290	2.4
11	4/14/2016	22.7	19.2	5.9	1.6	0.21	18.0	0.24	0.13	290	5.0
12	4/15/2016	22.7	18.9			0.31	14.0			360	
13	4/16/2016	21.8	18.4		1.9	0.57	19.0	0.25		290	2.5
14	4/17/2016	21.7	18.3	7.5	4.3	0.64	19.0	0.35	0.18	280	9.0
	Average	**23.1**	**19.4**	**6.2**	**2.2**	**0.32**	**18.97**	**0.2**	**0.17**	**297**	**4.1**
	Median	**23.0**	**19.2**	**5.2**	**1.8**	**0.27**	**19.00**	**0.2**	**0.15**	**290**	**4.1**
	Minimum	**21.7**	**18.3**	**3.8**	**1.3**	**0.07**	**14.0**	**0.1**	**0.11**	**270**	**1.6**
	Maximum	**25.3**	**21.0**	**13.9**	**4.3**	**0.67**	**22.0**	**0.4**	**0.34**	**380**	**9.0**
	Count	**14**	**14**	**10**	**13**	**14**	**13**	**13**	**10**	**14**	**13.0**

(yellow) **= Data Screened from dataset** (blue) **= Data from Madison MSD**

Secondary Effluent Plant 3 and 4

Day	Date	Reported Flow mgd	Calculated Flow mgd	BOD5 mg/L	TKN mg/L as N	NH3 mg/L as N	Nitrate as N, mg/L	Total P mg/L as P	OrthoP mg/L as P	Total Alk mg/L as CaCO3	TSS mg/L
1	4/4/2016	17.2	23.0	4.1	1.8	0.22	22.0	0.22	0.23	280	4.5
2	4/5/2016	16.8	22.6	5.2	1.4	0.13	21.0	0.23	0.17	280	4.0
3	4/6/2016	18.2	24.4	5.9	2	0.18	19.4	0.855	0.14	290	6.6
4	4/7/2016	17.5	23.4	13.9	1.6	0.24	18.0	0.21	0.10	280	4.0
5	4/8/2016	17.4	23.2		3.2	0.52	19.0	0.15		280	3.5
6	4/9/2016	16.5	22.2		3.4	0.33	22.0	0.18		280	4.0
7	4/10/2016	16.4	22.2	5.7	29	0.27	22.0	0.19	0.13	280	5.0
8	4/11/2016	17.0	22.5	6.0	1.64	0.185		0.25	0.15	270	5.8
9	4/12/2016	16.8	22.3	6.0	1.88	0.19	20.8	0.28	0.15	290	5.7
10	4/13/2016	16.8	22.3	5.5	1.71	0.11	20	0.325	0.15	290	6.6
11	4/14/2016	16.7	22.4	7.5	1.6	0.29	22.0	0.32	0.14	290	7.5
12	4/15/2016	16.5	22.1			0.33	21.0			360	
13	4/16/2016	15.8	21.6		1.6	0.21	20.0	0.23		300	4.5
14	4/17/2016	15.6	21.4	7.5	5	0.43	17.0	1.1	0.19	280	8.0
	Average	**16.8**	**22.5**	**6.7**	**2.2**	**0.26**	**20.32**	**0.35**	**0.15**	**289**	**5.4**
	Median	**16.8**	**22.4**	**6.0**	**1.8**	**0.23**	**20.75**	**0.23**	**0.15**	**280**	**5.0**
	Minimum	**15.6**	**21.4**	**4.1**	**1.4**	**0.11**	**17.0**	**0.15**	**0.10**	**270**	**3.5**
	Maximum	**18.2**	**24.4**	**13.9**	**5.0**	**0.52**	**22.0**	**1.1**	**0.23**	**360**	**8.0**
	Count	**14**	**14**	**10**	**12**	**14**	**13**	**13**	**10**	**14**	**13.0**

(yellow) **= Data Screened from dataset** (blue) **= Data from Madison MSD**

		Combined Effluent											
Day	Date	Reported Flow mgd	Calculated Flow mgd	COD mg/L	SCOD mg/L	BOD5 mg/L	TKN mg/L as N	NH3 mg/L as N	Total P mg/L as P	OrthoP mg/L as P	TSS mg/L	VSS mg/L	Temp
1	4/4/2016	38.3	42.8	32	27	6.6	1.6	0.16	0.31	0.22	4.9	4.2	13.2
2	4/5/2016	39.4	42.0	36	30	6.8	1.5	0.08	0.26	0.17	5.2	4.4	13.3
3	4/6/2016	43.6	45.4	61	32	8	1.7	0.25	0.3	0.16	5.1	5	13.6
4	4/7/2016	42.8	43.5	34	32	9.1	2.1	0.49	0.31	0.08	6.8	5.8	13.4
5	4/8/2016	42.2	43.2	29	30	7.4	1.7	0.30	0.31	0.13	5.5	4.7	13.4
6	4/9/2016	40.7	41.3	28	33	7.1	1.7	0.16	0.28	0.02	4.8	4.4	13.2
7	4/10/2016	39.9	41.3	38	37	9.4	1.4	0.08	0.31	0.13	4.8	4.3	13.1
8	4/11/2016	41.2	41.9	33	30	7.8	1.8	0.20	0.26	0.11	6.1	5.1	13.4
9	4/12/2016	40.8	41.4	36	32	8.5	1.7	0.20	0.29		5.7	5	13.8
10	4/13/2016	40.5	41.5	37	38	9.6	1.8	0.12	0.34		6.2	5.3	14.0
11	4/14/2016	41.4	41.6	38	39	8.9	1.9	0.22	0.29	0.13	7.1	6	14.4
12	4/15/2016	39.6	41.1	46	32	5.6	2.2	0.37	0.23	0.045	5.9	5.6	14.9
13	4/16/2016	38.2	40.0	31	28	6.3	1.9	0.35	0.37	0.131	6.2	5.2	15.1
14	4/17/2016	37.5	39.7	36	34	5.6	1.8	0.38	0.31	0.21	5.4	4.7	15.3
	Average	**40.4**	**41.9**	**37**	**32**	**7.6**	**1.8**	**0.2**	**0.3**	**0.13**	**5.7**	**5.0**	**13.9**
	Median	**40.6**	**41.6**	**36**	**32**	**7.6**	**1.8**	**0.2**	**0.3**	**0.13**	**5.6**	**5.0**	**13.5**
	Minimum	**37.5**	**39.7**	**28**	**27**	**5.6**	**1.4**	**0.1**	**0.2**	**0.02**	**4.8**	**4.2**	**13.1**
	Maximum	**43.6**	**45.4**	**61**	**39**	**9.6**	**2.2**	**0.5**	**0.4**	**0.22**	**7.1**	**6.0**	**15.3**
	Count	**14**	**14**	**14**	**14**	**14**	**14**	**14**	**14**	**12**	**14.0**	**14**	**14**
				= Data Screened from dataset					**= Data from Madison MSD**				

Aeration Basins

Plant 1

Day	Date	Reported Flow mgd	Estimated Flow mgd	MLSS mg/L	MLVSS mg/L	RAS flow mgd	RAS TSS mg/L	WAS mgd	Ana MLR mgd	DO mg/L	Airflow cfm
1	4/4/2016	10.17	8.75	2,650	2,090	4.79	6,430	0.15	5.19	3.1	6,002
2	4/5/2016	9.97	8.49	2,690	2,140	4.7	6,800	0.20	5.2	2.6	6,081
3	4/6/2016	10.67	9.00	2,340	1,860	5.14	6,400	0.20	5.24	2.1	6,109
4	4/7/2016	10.32	8.78			4.98		0.20	5.18	2.8	6,084
5	4/8/2016	10.17	8.72			4.81		0.20	5.15	1.9	6,149
6	4/9/2016	9.79	8.45			4.75		0.20	5.15	2.8	5,931
7	4/10/2016	9.77	8.42			4.63		0.20	5.11	3.1	5,773
8	4/11/2016	10.08	8.51	2,420	1,910	4.88	6,270	0.20	5.14	2.8	6,017
9	4/12/2016	9.97	8.46	2,420	1,900	4.76	6,070	0.20	5.13	2.1	6,155
10	4/13/2016	9.95	8.47	2,220	1,750	4.9	6,120	0.20	5.11	2.2	6,053
11	4/14/2016	9.9	8.53			4.86		0.20	5.15	2.2	6,110
12	4/15/2016	9.94	8.49			4.82		0.20	5.16	1.9	6,208
13	4/16/2016	9.71	8.40			4.82		0.20	5.14	2.0	6,115
14	4/17/2016	9.66	8.34			4.63		0.20	5.16	2.4	6,103
	Average	**10.0**	**8.6**	**2457**	**1942**	**4.82**	**6348**	**0.20**	**5.16**	**2**	**6064**
	Median	**10.0**	**8.5**	**2420**	**1905**	**4.82**	**6335**	**0.20**	**5.15**	**2**	**6094**
	Count	**14**	**14**	**6**	**6**	**14**	**6**	**14**	**14**	**14**	**14**

Plant 2, MLVSS:MLSS, Aerobic SRT(Hydraulic), Solids aSRT

Day	Date	Plant 2 Reported Flow mgd	Plant 2 Estimated Flow mgd	Plant 2 MLSS mg/L	Plant 2 MLVSS mg/L	Plant 2 RAS flow mgd	Plant 2 RAS TSS mg/L	Plant 2 WAS mgd	Plant 2 Ana MLR mgd	Plant 2 DO mg/L	Plant 2 Airflow cfm	MLVSS:MLSS Plant 1	MLVSS:MLSS Plant 2	Aerobic SRT(Hydraulic) Plant 1	Aerobic SRT(Hydraulic) Plant 2	Aerobic SRT(Hydraulic) East	Solids aSRT Plant 1	Solids aSRT Plant 2
1	4/4/2016	13.28	11.43	3,050	2,390	4.86	9,360	0.21	5.31	3.2	8,049	78%	79%	9.9	7.7	8.7	11.6	8.4
2	4/5/2016	13.37	11.38	3,010	2,380	4.93	9,430	0.20	5.48	2.9	8,005	79%	80%	7.5	8.2	7.9	8.3	8.6
3	4/6/2016	14.64	12.35	2,430	1,920	4.83	9,910	0.19	5.86	2.0	8,009	79%	79%	7.7	8.0	7.9	7.7	7.0
4	4/7/2016	13.8	11.74			4.77		0.20	5.61	2.5	8,169			7.6	7.8	7.7		
5	4/8/2016	13.64	11.70			4.77		0.21	5.74	2.2	8,325			7.5	7.5	7.5		
6	4/9/2016	12.84	11.08			4.88		0.21	5.59	3.7	7,672			7.6	7.9	7.8		
7	4/10/2016	12.89	11.11			4.81		0.23	5.62	3.8	7,794			7.5	7.1	7.3		
8	4/11/2016	13.37	11.29	3,240	2,520	4.91	9,650	0.20	5.67	3.0	8,007	78%	79%	7.7	8.2	8.0	8.1	9.1
9	4/12/2016	13.06	11.09	3,050	2,390	4.95	9,070	0.21	5.49	3.0	8,264	78%	79%	7.6	8.0	7.8	8.4	8.7
10	4/13/2016	13.09	11.15	2,520	1,970	4.86	9,920	0.21	5.47	3.4	8,221	78%	79%	7.7	7.8	7.8	7.7	6.5
11	4/14/2016	12.85	11.07			4.93		0.21	5.45	3.2	8,084			7.7	7.9	7.8		
12	4/15/2016	12.71	10.85			5.08		0.22	5.40	2.5	8,029			7.6	7.8	7.8		
13	4/16/2016	12.06	10.43			5.01		0.23	5.31	2.6	7,725			7.7	7.6	7.7		
14	4/17/2016	12	10.36			5.04		0.23	5.47	2.8	7,614			7.5	7.7	7.6		
	Average	**13.1**	**11.2**	**2883**	**2262**	**4.90**	**9557**	**0.21**	**5.53**	**3**	**7998**	**78%**	**79%**	**7.8**	**7.8**	**7.8**	**8.6**	**8.1**
	Median	**13.1**	**11.1**	**3030**	**2385**	**4.90**	**9540**	**0.21**	**5.48**	**3**	**8019**	**78%**	**79%**	**7.6**	**7.8**	**7.8**	**8.2**	**8.5**
	Count	**14**	**14**	**6**	**6**	**14**	**6**	**14**	**14**	**14**	**14**	**6**	**6**	**14**	**14**	**14**	**6**	**6**

= Data Screened from dataset (yellow) **= Data from Madison MSD** (blue)

Plant 1 44% Volume Plant 1 43% Flow

Activated Sludge Plant 1 and 2

Day	Date	Reported Flow mgd	Calculated Flow mgd	COD mg/L	TKN mg/L as N	Total P mg/L as P	MLSS mg/L	WAS mgd	Ana MLR mgd	MLVSS mg/L	D.O. mg/L	Airflow scfm
1	4/4/2016	23.45	20.2	2500	130	110	2000	0.36	10.50	1500	3.1	14,051
2	4/5/2016	23.34	19.9	2500	140	130	2300	0.40	10.68	1800	2.7	14,086
3	4/6/2016	25.31	21.4	2700			2,391	0.39	11.10	1,894	2.1	14,118
4	4/7/2016	24.12	20.5					0.40	10.79	1700	2.6	14,253
5	4/8/2016	23.81	20.4					0.41	10.89		2.1	14,474
6	4/9/2016	22.63	19.5					0.41	10.74		3.3	13,603
7	4/10/2016	22.66	19.5				1800	0.43	10.73	1400	3.5	13,567
8	4/11/2016	23.45	19.8	3000	210	170		0.40	10.81	2,258	2.9	14,024
9	4/12/2016	23.03	19.6	2700	120	140		0.41	10.62	2,179	2.5	14,419
10	4/13/2016	23.04	19.6	2300	120	89	1700	0.41	10.58	1300	2.8	14,274
11	4/14/2016	22.75	19.6					0.41	10.60		2.7	14,194
12	4/15/2016	22.65	19.3		150	130	2300	0.42	10.56	1794	2.2	14,237
13	4/16/2016	21.77	18.8					0.43	10.45		2.3	13,840
14	4/17/2016	21.66	18.7					0.43	10.63		2.6	13,717
	Average	**23.1**	**19.8**	**2617**	**145.0**	**128**	**2082**	**0.408**	**10.69**	**1758**	**2.7**	**14061**
	Median	**23.0**	**19.6**	**2600**	**135.0**	**130**	**2150**	**0.41**	**10.65**	**1794**	**2.7**	**14102**
	Count	**14**	**14**	**6**	**6**	**6**	**6**	**14**	**14**	**9**	**14**	**14**

Day	Date	RAS mgd	RAS TSS mg/L	COD: VSS	TP:VSS	TKN: VSS	VSS:TSS	Weighted Values MLSS	Weighted Values MLVSS	Weighted Values RAS	Recycle rate Plant 1	Recycle rate Plant 2
1	4/4/2016	9.65	6000	1.67	7.3%	8.7%	75%	2877	2260	8089	47%	37%
2	4/5/2016	9.63	5800	1.39	7.2%	7.8%	78%	2871	2276	8289	47%	37%
3	4/6/2016	9.97		1.43				2391	1894	8388	48%	33%
4	4/7/2016	9.75	6000								48%	35%
5	4/8/2016	9.58	6400								47%	35%
6	4/9/2016	9.63	5100								49%	38%
7	4/10/2016	9.44	4800				78%				47%	37%
8	4/11/2016	9.79		1.33	7.5%	9.3%		2884	2255	8184	48%	37%
9	4/12/2016	9.71		1.24	6.4%	5.5%		2777	2177	7769	48%	38%
10	4/13/2016	9.76		1.77	6.8%	9.2%	76%	2390	1875	8272	49%	37%
11	4/14/2016	9.79	5700								49%	38%
12	4/15/2016	9.90	5800		7.2%	8.4%					48%	40%
13	4/16/2016	9.83	5000								50%	42%
14	4/17/2016	9.67	6200								48%	42%
	Average	**9.72**	**5680**	**1.47**	**7.1%**	**8.14%**	**77%**	**2698**	**2123**	**8165**	**48%**	**37%**
	Median	**9.73**	**5800**	**1.41**	**7.2%**	**8.51%**	**77%**	**2824**	**2216**	**8228**	**48%**	**37%**
	Count	**14**	**10**	**6**	**6**	**6**	**4**	**6**	**6**	**6**	**14**	**14**

SRT = V/Qw*Qr/(Q+Qr)

	10,400	Plant 1 WAS, lb TSS/d
0.404	16,851	Plant 2 WAS, lb TSS/d
	27,251	Total WAS
	62%	% WAS from Plant 2
lb Aerated	MG	
86,462	4.22	Plant 1
130,094	5.41	Plant 2
216,556		Total Aerated
Aerbobic SRT		
days		
7.95	Total - East	
8.31	Plant 1	
7.72	Plant 2	
8,011	RAS Average TSS	

Aeration Basins

		Plant 3										Plant 4										MLVSS:MLSS		Aerobic SRT(Hydraulic)			Solids SRT	
Day	Date	Reported Flow mgd	Estimated Flow mgd	MLSS mg/L	MLVSS mg/L	RAS flow mgd	RAS TSS mg/L	WAS mgd	Ana MLR mgd	DO mg/L	Airflow cfm	Reported Flow mgd	Estimated Flow mgd	MLSS mg/L	MLVSS mg/L	RAS flow mgd	RAS TSS mg/L	WAS mgd	Ana MLR mgd	DO mg/L	Airflow cfm	Plant 3	Plant 4	Plant 3	Plant 4	West	Plant 3	Plant 4
1	4/4/2016	8.61	11.7	2,220	1,770	4.13	7,120	0.19	8.15	3.81	9,403	8.6	11.7	2,610	2,050	4.14	7,510	0.2	6.74	8.28	9,245	79%	80%	6.3	6.0	6.2	7.5	8.0
2	4/5/2016	8.42	11.5	2,470	1,990	4.04	7,540	0.19	8.15	3.33	9,465	8.41	11.5	2,710	2,160	4.04	7,520	0.2	6.74	8.14	9,640	80%	81%	6.3	6.0	6.1	7.9	8.3
3	4/6/2016	9.09	12.4	2,300	1,840	4.37	7,020	0.19	8.15	3.01	9,578	9.1	12.4	2,590	2,040	4.37	7,580	0.2	6.74	7.85	9,827	79%	80%	6.3	6.0	6.1	7.9	7.8
4	4/7/2016	8.75	11.9			4.2		0.19	8.15	3.29	9,469	8.77	11.9			4.21		0.2	6.74	7.89	9,678			6.3	6.0	6.2		
5	4/8/2016	8.7	11.8			4.2		0.19	8.15	2.77	9,627	8.72	11.8			4.19		0.2	6.74	7.78	9,802			6.3	6.0	6.2		
6	4/9/2016	8.23	11.3			3.99		0.19	8.15	4.29	9,230	8.25	11.3			3.99		0.2	6.74	8.31	9,455			6.3	6.0	6.2		
7	4/10/2016	8.19	11.3			3.96		0.19	8.15	4.24	9,218	8.22	11.3			3.97		0.2	6.74	8.45	9,449			6.3	6.0	6.1		
8	4/11/2016	8.48	11.5	2,460	1,950	4.07	7,000	0.19	8.15	3.39	9,469	8.49	11.5	2,540	1,990	4.09	7,350	0.2	6.74	8.11	9,730	78%	79%	6.3	6.0	6.2	8.5	7.9
9	4/12/2016	8.38	11.3	2,210	1,770	4.04	6,200	0.19	8.15	3.14	9,496	8.4	11.3	2,720	2,160	4.05	6,580	0.2	6.74	8.06	9,852	79%	80%	6.4	6.0	6.2	8.6	9.5
10	4/13/2016	8.37	11.3	2,610	2,080	4.02	6,830	0.19	8.15	3.41	9,440	8.4	11.3	2,510	1,970	4.05	7,210	0.2	6.74	8.17	9,749	78%	80%	6.3	6.0	6.2	9.2	8.0
11	4/14/2016	8.34	11.4			4.01		0.19	8.15	3.40	9,457	8.36	11.4			4.01		0.2	6.74	8.22	9,827			6.3	6.0	6.1		
12	4/15/2016	8.22	11.3			3.97		0.19	8.15	2.97	9,690	8.24	11.3			3.97		0.2	6.74	7.87	9,765			6.3	6.0	6.1		
13	4/16/2016	7.91	11.0			3.84		0.19	8.15	3.74	9,313	7.93	11.0			3.83		0.2	6.74	7.93	9,816			6.3	5.9	6.1		
14	4/17/2016	7.8	10.9			3.79		0.19	8.15	4.30	9,270	7.82	10.9			3.8		0.2	6.74	7.82	9,632			6.2	5.9	6.1		
	Average	**8.4**	**11.5**	**2378**	**1900**	**4.05**	**6952**	**0.19**	**8.15**	**3.51**	**9438**	**8.4**	**11.5**	**2613**	**2062**	**4.05**	**7292**	**0.20**	**6.74**	**8.06**	**9676**	**79%**	**80%**	**6.3**	**6.0**	**6.1**	**8.3**	**8.2**
	Median	**8.4**	**11.4**	**2380**	**1895**	**4.03**	**7010**	**0.19**	**8.15**	**3.40**	**9461**	**8.4**	**11.4**	**2600**	**2045**	**4.05**	**7430**	**0.20**	**6.74**	**8.09**	**9740**	**79%**	**80%**	**6.3**	**6.0**	**6.1**	**8.2**	**8.0**
	Count	**14**	**14**	**6**	**6**	**14**	**6**	**14**	**14**	**14**	**14**	**14**	**14**	**6**	**6**	**14**	**6**	**14**	**14**	**14**	**14**	**6**	**6**	**14**	**14**	**14**	**6**	**6**

= Data Screened from dataset (yellow)

= Data from Madison MSD (blue)

Activated Sludge Plant 3 and 4

Day	Date	Reported Flow mgd	Calculated Flow mgd	COD mg/L	TKN mg/L as N	Total P mg/L as P	MLSS mg/L	WAS mgd	Ana MLR mgd	MLVSS mg/L	D.O. mg/L	Airflow scfm		RAS mgd	RAS TSS mg/L	COD: VSS	TP:VSS	TKN: VSS	VSS:TSS
1	4/4/2016	17.21	23.38	2500	110	130	1700	0.39	14.9	1400	6.04	18,648		8.27	5900	1.79	9.3%	7.9%	82%
2	4/5/2016	16.83	22.96	2500	170	110	1900	0.39	14.9	1800	5.73	19,105		8.08	6200	1.39	6.1%	9.4%	95%
3	4/6/2016	18.19	24.80	2500	110			0.39	14.9	1,940	5.43	19,405		8.74		1.29		5.7%	
4	4/7/2016	17.52	23.76					0.39	14.9	1400	5.59	19,147		8.41	5400				
5	4/8/2016	17.42	23.63					0.39	14.9		5.27	19,429		8.39	4900				
6	4/9/2016	16.48	22.57					0.39	14.9		6.30	18,685		7.98	5000				
7	4/10/2016	16.41	22.57	2200	180	66	1900	0.39	14.9	1500	6.35	18,667		7.93	4400	1.47	4.4%	12.0%	79%
8	4/11/2016	16.97	22.94	2600	170	150		0.39	14.9	1,970	5.75	19,199		8.16		1.32	7.6%	8.6%	
9	4/12/2016	16.78	22.64	2300	130	120		0.39	14.9	1,965	5.60	19,348		8.09		1.17	6.1%	6.6%	
10	4/13/2016	16.77	22.69	2300	120	110	1900	0.39	14.9	1500	5.79	19,189		8.07		1.53	7.3%	8.0%	79%
11	4/14/2016	16.70	22.80					0.39	14.9		5.81	19,284		8.02	4500				
12	4/15/2016	16.46	22.53		130	64	2000	0.39	14.9	1580	5.42	19,455		7.94	5500		4.1%	8.2%	
13	4/16/2016	15.84	21.94					0.39	14.9		5.84	19,129		7.67	4700				
14	4/17/2016	15.62	21.81					0.39	14.9		6.06	18,902		7.59	5300				
	Average	**16.8**	**22.9**	**2414**	**140.0**	**107.1**	**1880**	**0.39**	**14.9**	**1673**	**5.8**	**19114**		**8.1**	**5180**	**1.42**	**6.4%**	**8.31%**	**84%**
	Median	**16.8**	**22.7**	**2500**	**130.0**	**110.0**	**1900**	**0.39**	**14.9**	**1580**	**5.8**	**19168**		**8.1**	**5150**	**1.39**	**6.1%**	**8.11%**	**81%**
	Count	**14**	**14**	**7**	**8**	**7**	**5**	**14**	**14**	**9**	**14**	**14**		**14**	**10**	**7**	**7**	**8**	**4**

= Calculated value from MLSS and MLVSS:MLSS of 0.79 (green)

11,016	Plant 3 WAS, lb TSS/d
12,163	Plant 4 WAS, lb TSS/d
23,178	Total WAS

lb Aerated	MG Aerated	
91,044	4.59	Plant 3
100,040	4.59	Plant 4
191,084		Total Aerated

Aerbobic SRT days	
8.24	Total - West
8.27	Plant 3
8.23	Plant 4

Brown AND Caldwell

East Aeration Basin Profiles

East Profile # 1			**Time**	**Date**	4/11/2016	am
Location	NH3-N	Nox-N	PO4-P	NO3-N	NO2-N	DO
Anaerobic	21.00	0.10	25.78	0.05	0.059	
Anoxic	19.00	0.40	21.54	0.18	0.22	
Pass 1	15.00	4.03	4.89	3.60	0.43	
Pass 2	0.40	11.72	0.07	11.00	0.72	0.3
Pass 3	6.70	17.34	0.11	17.00	0.34	3.7
East Profile # 2			**Time**	**Date**	4/11/2016	pm
Location	NH3-N	Nox-N	PO4-P	NO3-N	NO2-N	DO
Anaerobic	27.00	0.08	30.02	0.07	0.015	
Anoxic	25.00	0.06	31.00	0.05	0.018	
Pass 1	21.00	1.10	12.07	0.91	0.19	
Pass 2	9.90	9.42	0.16	8.70	0.72	0.3
Pass 3	1.50	18.20	0.07	17.00	1.2	3.0
East Profile # 3			**Time**	**Date**	4/13/2016	am
Location	NH3-N	Nox-N	PO4-P	NO3-N	NO2-N	DO
Anaerobic	24.00	0.07	28.72	0.05	0.025	
Anoxic	22.00	0.07	27.74	0.05	0.029	
Pass 1	17.00	3.09	13.05	2.70	0.39	
Pass 2	7.80	10.69	0.13	10.00	0.69	0.35
Pass 3	0.82	16.54	0.11	16.00	0.54	3.4
East Profile # 4			**Time**	**Date**	4/13/2016	pm
Location	NH3-N	Nox-N	PO4-P	NO3-N	NO2-N	DO
Anaerobic	28.00	0.05	27.08	0.05	0.0099	
Anoxic	24.00	0.07	26.11	0.05	0.021	
Pass 1	20.00	1.60	15.34	0.20	1.4	
Pass 2	10.00	8.40	0.13	5.20	3.2	0.35
Pass 3	1.30	17.00	0.08	14.00	3	3.4
East Median Values						
Anaerobic	25.50	0.08	27.90	0.05	0.02	
Anoxic	23.00	0.07	26.92	0.05	0.03	
Pass 1	18.50	2.35	12.56	1.81	0.41	
Pass 2	8.85	10.06	0.13	9.35	0.72	
Pass 3	1.40	17.17	0.10	16.50	0.87	

West Aeration Basin Profiles

West Profile # 1			**Date**	4/11/2016	**Time**	am
Location	NH3-N	Nox-N	NO3-N	NO2-N	PO4-P	DO
Anaerobic	21.00	0.08	0.06	0.022	21.5	
Anoxic	17.00	1.67	1.60	0.07	17.3	
Pass 1	4.80	15.31	15.00	0.31	32.3	
Pass 2	0.21	19.64	19.00	0.64	0.1	
Pass 3	0.11	21.01	21.00	0.013	0.1	
West Profile # 2			**Date**	4/11/2016	**Time**	pm
Location	NH3-N	Nox-N	NO3-N	NO2-N	PO4-P	DO
Anaerobic	29.00	0.06	0.05	0.012	23.8	
Anoxic	24.00	0.09	0.05	0.04	20.9	
Pass 1	13.00	9.65	9.60	0.046	2.3	
Pass 2	0.56	22.04	22.00	0.041	0.1	
Pass 3	0.20	21.02	21.00	0.023	0.1	
West Profile # 3			**Date**	4/13/2016	**Time**	am
Location	NH3-N	Nox-N	NO3-N	NO2-N	PO4-P	DO
Anaerobic	23.00	0.06	0.05	0.015	27.7	
Anoxic	19.00	0.63	0.47	0.16	21.5	
Pass 1	5.10	13.50	12.00	1.5	4.6	
Pass 2	0.25	18.02	18.00	0.023	0.2	
Pass 3	0.10	20.01	20.00	0.0084	0.1	
West Profile # 4			**Date**	4/13/2016	**Time**	pm
Location	NH3-N	Nox-N	NO3-N	NO2-N	PO4-P	DO
Anaerobic	28.00	0.16	0.12	0.037	23.5	
Anoxic	22.00	0.56	0.47	0.088	18.3	
Pass 1	13.00	7.70	2.40	5.3	8.8	
Pass 2	0.98	16.00	9.20	6.8	0.2	
Pass 3	0.19	18.02	18.00	0.02	0.1	
West Median Values						
Anaerobic	25.50	0.07	0.05	0.02	23.66	
Anoxic	20.50	0.59	0.47	0.08	19.58	
Pass 1	9.05	11.57	10.80	0.91	6.69	
Pass 2	0.41	18.83	18.50	0.34	0.15	
Pass 3	0.15	20.51	20.50	0.02	0.06	

		East Primary Sludge			West Primary Sludge		
	Date	Flow	TS	TVS	Flow	TS	TVS
Day		mgd	mg/L	mg/L	mgd	mg/L	mg/L
1	4/4/2016	0.666			0.614		
2	4/5/2016	0.668			0.625		
3	4/6/2016	0.665			0.617		
4	4/7/2016	0.665			0.623		
5	4/8/2016	0.666			0.624		
6	4/9/2016	0.668			0.617		
7	4/10/2016	0.672			0.617		
8	4/11/2016	0.671			0.597		
9	4/12/2016	0.672			0.599		
10	4/13/2016	0.670			0.621		
11	4/14/2016	0.669			0.559		
12	4/15/2016	0.671			0.529		
13	4/16/2016	0.670			0.507		
14	4/17/2016	0.669			0.504		
	Average	0.6688	#DIV/0!	#DIV/0!	0.5896	#DIV/0!	#DIV/0!
	Median	0.6692	#NUM!	#NUM!	0.6157	#NUM!	#NUM!
	Count	14	0	0	14	0	0

Gravity Thickeners

Date	Thickened PS			Overflow										
	Flow mgd	TS %	VS %	COD mg/L	TKN mg/L as N	NH3 mg/L as N	Total P mg/L as P	OrthoP mg/L as P	TSS mg/L	VSS mg/L	Alkalinity mg CaCO3/L	sCOD mg/L	SBD feet	Calculated Flow
4/4/2016	0.1296	6.1	80.0	700	41	39	23.0	11.1	230	210	490	280		1.15
4/5/2016	0.1224	5.7	84.0	690	47	40	16.0	11.4	190	160	490	370		1.17
4/6/2016	0.12096	6.0	84.0	700	49	39	18.0	14.7	180	160	490	400		1.16
4/7/2016	0.12384	5.8	86.0	730	44	39	21.0	12.4	180	170	490	430		1.16
4/8/2016	0.12096		86.0	720	51	42	18.0		190	160	500	340		1.17
4/9/2016	0.1224		85.0	700	42	40	15.0		170	150	490	270		1.16
4/10/2016	0.12528		89.0	640	57	39	11.0	11.7			490	260		1.16
4/11/2016	0.12384	6.1	83.0	660	47	40	19.0	10.4	180	160	480	390		1.14
4/12/2016	0.1296		91.0	740	39	38	28.0	1.8			530	370		1.14
4/13/2016	0.13536	5.3	85.0	720	48	40	25.0	11.4	180	150	520	430		1.16
4/14/2016	0.1368		85.0	780	47	40	23.0	13.1	170	150	500	330		1.09
4/15/2016	0.13104		87.0	800	46	42	49.0		150	130	500	390		1.07
4/16/2016	0.12672		85.0	750	52	43	24.0		160	140	500	340		1.05
4/17/2016	0.12816		85.0	710	46	44	21.0	14.0	210	280	500	370		1.05
Average	**0.127**	**5.8**	**85.357**	**717**	**47**	**40**	**22.2**	**12.3**	**183**	**168**	**498**	**355**		**1.13**
Median	**0.126**	**5.9**	**85.000**	**715**	**47**	**40**	**21.0**	**11.7**	**180**	**160**	**495**	**370**		**1.15**
Count	**14**	**6**	**14.000**	**14**	**14**	**14**	**14**	**9**	**12**	**12**	**14**	**14**		**14**

(yellow) = Data Screened from dataset; (blue) = Data from Madison MSD

CALCULATIONS

Date	Overflow											GTO Load, lb/d				
	TKN:COD	TP:TKN	COD:VSS	COD:TSS	PO4-P:TP	VSS:TSS	NH3:PO4	TP:TSS	TKN:TSS	SCOD:COD	NH3:TKN	TKN	NH3-N	TP	OrthoP	TSS
4/4/2016	0.059	0.561	3.33	3.04	0.48	0.91	3.52	0.100	0.178	0.40	0.951	394	374	221	106	2207
4/5/2016	0.068	0.340	4.31	3.63	0.71	0.84	3.50	0.084	0.247	0.54	0.851	459	391	156	112	1856
4/6/2016	0.070	0.367	4.38	3.89	0.82	0.89	2.66	0.100	0.272	0.57	0.796	475	378	174	142	1744
4/7/2016	0.060	0.477	4.29	4.06	0.59	0.94	3.15	0.117	0.244	0.59	0.886	427	378	204	120	1747
4/8/2016	0.071	0.353	4.50	3.79		0.84		0.095	0.268	0.47	0.824	497	409	175		1852
4/9/2016	0.060	0.357	4.67	4.12		0.88		0.088	0.247	0.39	0.952	407	388	145		1649
4/10/2016	0.089	0.193			1.07		3.32			0.41	0.684	553	378	107	114	
4/11/2016	0.071	0.404	4.13	3.67	0.55	0.89	3.83	0.106	0.261	0.59	0.851	449	382	181	100	1718
4/12/2016	0.053	0.718								0.50	0.974	371	362	267	17	
4/13/2016	0.067	0.521	4.80	4.00	0.46	0.83	3.50	0.139	0.267	0.60	0.833	463	385	241	110	1735
4/14/2016	0.060	0.489	5.20	4.59	0.57	0.88	3.06	0.135	0.276	0.42	0.851	428	364	209	119	1547
4/15/2016	0.058	1.065	6.15	5.33		0.87		0.327	0.307	0.49	0.913	410	374	437		1336
4/16/2016	0.069	0.462	5.36	4.69		0.88		0.150	0.325	0.45	0.827	456	377	210		1402
4/17/2016	0.065	0.457	2.54	3.38	0.67	1.33	3.14	0.100	0.219	0.52	0.957	401	384	183	122	1831
Average	**0.066**	**0.483**	**4.47**	**4.02**	**0.66**	**0.92**	**3.30**	**0.13**	**0.26**	**0.50**	**0.87**	**442**	**380**	**208**	**106**	**1719**
Median	**0.066**	**0.459**	**4.44**	**3.94**	**0.59**	**0.88**	**3.32**	**0.10**	**0.26**	**0.49**	**0.85**	**438**	**378**	**193**	**113**	**1739**
Count	**14**	**14**	**12**	**12**	**9**	**12**	**9**	**12**	**12**	**14**	**14**	**14**	**14**	**14**	**10**	**12**

Dissolved Air Flotation Thickeners

		WAS to DAFT		Thickened WAS		Subnatant					
Day	Date	Flow (Plant 2 WAS) mgd	TSS mg/L	Flow mgd	TS %	COD mg/L	TKN mg/L as N	Total P mg/L as P	OrthoP mg/L as P	TSS mg/L	Flow mgd
1	4/4/2016	0.21	9360	0.041	4.0	180	7.0	14.0	4.2	100	0.169
2	4/5/2016	0.20	9430	0.041	4.0	150	4.0	15.0	4.2	110	0.164
3	4/6/2016	0.19	9910	0.041	3.9	170	9.1	12.0	4.4	105	0.152
4	4/7/2016	0.20		0.040	3.6	140	8.1	15.0	3.6	110	0.162
5	4/8/2016	0.21		0.038	4.1	180	11.0	11.0		120	0.167
6	4/9/2016	0.21		0.038	4.3	180	4.9	11.0		110	0.176
7	4/10/2016	0.23		0.038	4.6	170	6.7	11.0	3.1	120	0.187
8	4/11/2016	0.20	9650	0.038	4.3	180	6.2	14.0	4.1	119	0.166
9	4/12/2016	0.21	9070	0.038	4.3	160	4.6	14.0	0.8	130	0.167
10	4/13/2016	0.21	9920	0.038	4.3	350	6.1	18.0			0.170
11	4/14/2016	0.21		0.039	4.4	170	4.4	12.0	3.2	120	0.175
12	4/15/2016	0.22		0.038	3.5	170	66.0	22.0		130	0.186
13	4/16/2016	0.23		0.038	4.5	180	7.8	16.0		120	0.194
14	4/17/2016	0.23		0.038	4.2	190	7.4	17.0	5.5	120	0.190
	Average	**0.212**	**9557**	**0.039**	**4.1**	**184**	**11.0**	**14.4**	**3.70**	**116**	**0.173**
	Median	**0.209**	**9540**	**0.038**	**4.3**	**175**	**6.9**	**14.0**	**4.12**	**120**	**0.169**
	Count	**14**	**6**	**14**	**14**	**0.000**	**14**	**0**	**14**	**9**	**13**

= Data from Madison MSD

CALCULATIONS

		TSS Capture	Subnatant					Subnatant Load, lb/d			
Day	Date	Percent	TKN:COD	TP:TKN	COD:TSS	PO4-P:TP	TP:TSS	TKN	Total P	OrthoP	TSS
1	4/4/2016	99.2	0.039	2.000	1.80	0.30	0.140	9.9	19.7	6.0	141
2	4/5/2016	99.1	0.027	3.750	1.36	0.28	0.136	5.5	20.5	5.8	150
3	4/6/2016	99.2	0.054	1.319	1.62	0.37		11.5	15.2	5.5	133
4	4/7/2016		0.058	1.852	1.27	0.24	0.136	10.9	20.3	4.8	149
5	4/8/2016		0.061	1.000	1.50		0.092	15.3	15.3		167
6	4/9/2016		0.027	2.245	1.64		0.100	7.2	16.1		161
7	4/10/2016		0.039	1.642	1.42	0.28	0.092	10.4	17.1	4.9	187
8	4/11/2016	99.0	0.034	2.258	1.51	0.29		8.6	19.4	5.7	165
9	4/12/2016	98.9	0.029	3.043	1.23	0.06	0.108	6.4	19.5	1.1	181
10	4/13/2016	100.0	0.017	2.951				8.6	25.5		
11	4/14/2016		0.026	2.727	1.42	0.27	0.100	6.4	17.6	4.7	176
12	4/15/2016		0.388	0.333	1.31		0.169	102.3	34.1		202
13	4/16/2016		0.043	2.051	1.50		0.133	12.6	25.8		194
14	4/17/2016		0.039	2.297	1.58	0.33	0.142	11.7	26.9	8.8	190
	Average	**99.2**	**0.063**	**2.105**	**1.474**	**0.27**	**0.123**	**16**	**21**	**5**	**169**
	Median	**99.1**	**0.039**	**2.148**	**1.500**	**0.28**	**0.133**	**10**	**20**	**6**	**167**
	Count	**6**	**14**	**14**	**13**	**9**	**11**	**14**	**14**	**9**	**13**

WAS Treatment

Day	Date	Flow mgd	SCOD mg/L	VFAs mg/L as COD	NH3 mg/L as N	OrthoP mg/L as P	Total Alk mg/L as CaCO3	TS mg/L	VS mg/L	Notes
1	4/4/2016	0.60	260		38	149	530	11,000	8700	
2	4/5/2016	0.65	180		45	176	600	12,000	9100	
3	4/6/2016	0.65	150		42	186	590	11,000	9300	
4	4/7/2016	0.65	250	19.1	44	196	520	12,000	10000	
5	4/8/2016	0.65	130		42		590	12,000	9400	
6	4/9/2016	0.65	180		44		590	13,000	9600	
7	4/10/2016	0.65	240		44	189	550	13,000	9600	
8	4/11/2016	0.65	290	15.7	42	183	550	12,000	9200	
9	4/12/2016	0.65	210	13.9	42	201	710	12,000	9000	
10	4/13/2016	0.65	260	4.6	38	189	670	12,000	9200	
11	4/14/2016	0.65	240	0.0	41	104	630	12,000	9400	
12	4/15/2016	0.65	200		38		640	12,000	9300	
13	4/16/2016	0.65	130		42		610	12,000	9400	
14	4/17/2016	0.65	180		43	222	590	12,000	9300	
	Average	0.64	207	11	41.79	180	598	12000	9321	
	Median	0.65	205	14	42.00	188	590	12000	9300	
	Minimum	0.60	130	0	38.00	104	520	11000	8700	
	Maximum	0.65	290	19	45.00	222	710	13000	10000	
	Count	14	14	5	14	10	14	14.0	14	

(shaded) = Data from Madison MSD

Gravity Belt Thickeners Treating WAS Treatment Effluent

		P-Release to GBT			Thickened WAS			Filtrate									
Day	Date	Flow mgd	TSS % TS	VSS % VS	Flow mgd	TS %	VS %	COD mg/L	TKN mg/L as N	NH3 mg/L as N	Total P mg/L as P	OrthoP mg/L as P	Sol. cBOD mg/L	TSS mg/L	VSS mg/L	SCOD mg/L	Flow mgd
1	4/4/2016	0.63	1.10	0.87	0.095	5.9	86	330	35	29	180	18	33	190	170	370	0.538
2	4/5/2016	0.71	1.20	0.91	0.114	5.8	85	300	27	40	170	158	43	257	130	390	0.599
3	4/6/2016	0.68	1.10	0.93	0.105	5.6	86	420	32	44	180	163	32	330	170	350	0.578
4	4/7/2016	0.71	1.20	1.00	0.109	5.7	83	300	32	29	180	166	33	140	120	290	0.602
5	4/8/2016	0.69	1.20	0.94	0.106	6.1	85	320	32	30	430			170	150	210	0.586
6	4/9/2016	0.71	1.30	0.96	0.108	5.5	83	300	42	30	230			130	110	360	0.602
7	4/10/2016	0.68	1.30	0.96	0.100			330	34	36	190	166	35	156	120	340	0.583
8	4/11/2016	0.72	1.20	0.92	0.106	6.2	84	310	35	30	230	166	39	150	130	180	0.613
9	4/12/2016	0.67	1.20	0.90	0.100			320	33	39	220	178	42	155	130	290	0.574
10	4/13/2016	0.71	1.20	0.92	0.105	6.2		320	27	39	180	167	34	127	130	420	0.601
11	4/14/2016	0.67	1.20	0.94	0.103	6.1	86	410	39	30	210	104	40	220	190	410	0.570
12	4/15/2016	0.71	1.20	0.93	0.113	6.1	85	420	43	31	110			210	180	320	0.594
13	4/16/2016	0.67	1.20	0.94	0.105	5.9	82	380	43	34	220			160	140	220	0.570
14	4/17/2016	0.70	1.20	0.93	0.108			350	42	29	220	173	33	140	140	290	0.589
	Average	**0.691**	**1.200**	**0.932**	**0.105**	**5.9**	**84.506**	**344**	**35.4**	**33.6**	**211**	**160**	**36**	**181**	**144**	**317**	**0.585**
	Median	**0.694**	**1.200**	**0.930**	**0.105**	**5.9**	**85.000**	**325**	**34.5**	**30.5**	**200**	**166**	**35**	**158**	**135**	**330**	**0.587**
	Count	**14**	**14**	**14**	**14**	**11**	**10.000**	**14**	**14**	**14**	**14**	**9**	**10**	**14**	**14**	**14**	**14**

(yellow) **= Data Screened from dataset**

(blue) **= Data from Madison MSD**

CALCULATIONS

		TSS Capture	Overflow										
Day	**Date**	**Percent**	**TKN:COD**	**TP:TKN**	**COD:VSS**	**COD:TSS**	**SCOD:COD**	**VSS:TSS**	**ISS**	**TP:VSS**	**TKN:VSS**	**PO4-P:TP**	**NH3:TKN**
1	4/4/2016	98.6	0.106	5.143	1.94	1.74	1.12	0.89	20	1.059	0.206	0.10	0.83
2	4/5/2016	98.3	0.090	6.296	2.31	1.17	1.3	0.51	127	1.308	0.208	0.93	1.47
3	4/6/2016	97.6	0.076	5.625	2.47	1.27	0.83	0.52	160	1.059	0.188	0.90	1.37
4	4/7/2016	99.1	0.107	5.625	2.50	2.14	0.97	0.86	20	1.500	0.267	0.92	0.91
5	4/8/2016	98.9	0.100	13.438	2.13	1.88	0.66	0.88	20	2.867	0.213		0.94
6	4/9/2016	99.2	0.140	5.476	2.73	2.31	1.2	0.85	20	2.091	0.382		0.71
7	4/10/2016		0.103	5.588	2.75	2.12	1.03	0.77	36	1.583	0.283	0.87	1.06
8	4/11/2016	99.0	0.113	6.571	2.38	2.07	0.58	0.87	20	1.769	0.269	0.72	0.86
9	4/12/2016		0.103	6.667	2.46	2.06	0.91	0.84	25	1.692	0.254	0.81	1.19
10	4/13/2016	99.1	0.084	6.667	2.46	2.52	1.31	1.02	-3	1.385	0.208	0.93	1.45
11	4/14/2016	98.5	0.095	5.385	2.16	1.86	1	0.86	30	1.105	0.205	0.50	0.77
12	4/15/2016	98.6	0.102	2.558	2.33	2.00	0.76	0.86	30	0.611	0.239		0.72
13	4/16/2016	98.9	0.113	5.116	2.71	2.38	0.58	0.88	20	1.571	0.307		0.79
14	4/17/2016		0.120	5.238	2.50	2.50	0.83	1.00	0	1.571	0.300	0.79	0.69
	Average	**98.7**	**0.104**	**6.099**	**2.4**	**2.0**	**0.76**	**0.83**	**38**	**1.512**	**0.252**	**0.75**	**0.983**
	Median	**98.9**	**0.103**	**5.607**	**2.5**	**2.1**	**0.80**	**0.86**	**20**	**1.536**	**0.246**	**0.84**	**0.882**
	Count	**11**	**14**	**14**	**14**	**14**	**8**	**14**	**14**	**14**	**14**	**10**	**14**

Ostara

		Influent						Effluent								
Day	Date	Flow mgd	TKN mg/L as N	NH3 mg/L as N	Total P mg/L as P	OrthoP mg/L as P	TSS mg/L	Flow mgd	TKN mg/L as N	NH3 mg/L as N	Total P mg/L as P	OrthoP mg/L as P	TSS mg/L	Flow (DS Filtrate + WAS GBT Filtrate) mgd	NaOH gal/d	MgCl2 gal/d
1	4/4/2016	0.89						0.92						0.84	500	763
2	4/5/2016	0.92	247	210	143.5	117.5	349	0.97	222	172	100	23.3	699	0.87	500	763
3	4/6/2016	0.87		214		119.1	311	0.92		182.5		28.6	558	0.86	500	763
4	4/7/2016	0.83						0.87						0.89	500	763
5	4/8/2016	0.92						0.98						0.88	500	763
6	4/9/2016	0.62						0.68						0.90	500	763
7	4/10/2016	0.53	371				307	0.57	336				599	0.89	500	763
8	4/11/2016	0.52						0.56						0.92	500	763
9	4/12/2016	0.53	356				224	0.60	314				511	0.82	500	763
10	4/13/2016	0.73		217		126	199	0.80		183		25.7	533	0.90	500	763
11	4/14/2016	0.93						0.97						0.87	500	763
12	4/15/2016	0.97						1.01						0.91	500	763
13	4/16/2016	0.94						0.97						0.88	500	763
14	4/17/2016	0.92			149.5	127.7	166	0.95			106	27.3	571	0.86	500	763
	Average	0.794	325	214	147	123	259	0.841	291	179	103	26	578	0.878	500	763
	Median	0.878	356	214	147	123	266	0.920	314	183	103	27	565	0.880	500	763
	Count	14	3	3	2	4	6	14	3	3	2	4	6	14	14	14

(yellow) = Data Screened from dataset; (blue) = Data from Madison MSD

CALCULATIONS

		Removals (Qi*Xi-QeXe)/(QeXe)				Recycle Load to Headworks, lb/d					Recycle Load: Influent Load (Percent)				
Day	Date	PO4-P	TP	NH3-N	TSS	TKN	NH3	Total P	OrthoP	TSS	TKN	NH3	Total P	OrthoP	TSS
1	4/4/2016														
2	4/5/2016	79%	26%	13%	-100%	1799	1394	814	189	5662	11%	14%	37%	26%	6%
3	4/6/2016	75%		10%	-80%		1398		219	4274		13%		33%	5%
4	4/7/2016														
5	4/8/2016														
6	4/9/2016														
7	4/10/2016					1607				2865	11%				4%
8	4/11/2016														0%
9	4/12/2016					1575				2564	10%				3%
10	4/13/2016	78%		8%	-169%		1221		171	3556		12%		24%	4%
11	4/14/2016														
12	4/15/2016														
13	4/16/2016														
14	4/17/2016	78%	27%		-244%			841	217	4530			40%	22%	6%
	Average	77%	26%	10%	-148%	1661	1338	827	199	3909	11%	13%	39%	26%	4%
	Median	78%	26%	10%	-134%	1607	1394	827	203	3915	11%	13%	39%	25%	4%
	Count	4	2	3	4	3	3	2	4	6	3	3	2	4	7

Acid Phase Digester Effluent

Date	Flow	VFA	TS	VS	COD	TKN	NH3	Total P	OrthoP	TS	VS	Temp	pH	Alkalinity
	mgd	mg COD/L	%	%	mg/L	mgN/L	mgN/L	mg/L as P	mg/L as P	mg/L	mg/L	C		mg/L
4/4/2016	0.2073		5.0	4.1						50,000	41500	94.1	5.23	2880
4/5/2016	0.2183		4.9	4.1	83300	2548	735	833	480	49,000	41160	93.9	5.26	3240
4/6/2016	0.2085	9,980	4.6	3.8	83300		735		496	49,000		93.5	5.24	2960
4/7/2016	0.215		4.8	3.9						49,000	41160	93.8	5.22	3240
4/8/2016	0.2092											95.8		
4/9/2016	0.2121											94.7		
4/10/2016	0.2082	11,264	5.0	4.1								93.5	5.25	3610
4/11/2016	0.2129		5.0	4.1	63700	2058	735	686	464	49,000		93.5	5.24	3450
4/12/2016	0.2141		5.0	4.2	73500	2107	735		688	49,000		93.6	5.25	3770
4/13/2016	0.2235	10,953	5.0	4.2	68600		735		448	49,000		94.7	5.31	3080
4/14/2016	0.2221		4.8	4.0								93.8	5.32	3710
4/15/2016	0.2262											94.2		
4/16/2016	0.215											95.1		
4/17/2016	0.2192	10,008	4.8	4.0	73500	1960	784	980	528	49,000		95.7	5.21	3240
Average	**0.215**	**10551**	**4.88**	**4.04**	**74317**	**2168**	**743**	**833**	**517**	**49125.0**	**41273**	**94**	**5.3**	**3318**
Median	**0.215**	**10480**	**4.93**	**4.08**	**73500**	**2083**	**735**	**833**	**488**	**49000.0**	**41160**	**94**	**5.2**	**3240**
Count	**14**	**4**	**10**	**10.000**	**6**	**4**	**6**	**3**	**6**	**8**	**3**	**14**	**10**	**10**

(blue shading) **= Data from Madison MSD**

(green shading) =Median TSS value used to calculate COD and nutrient concentrations

	Mesophilic Digester Effluent													
	Date	Flow	TS	VS	COD	TKN	NH3	Total P	OrthoP	TS	VS	Temp	pH	Alkalinity
Day		mgd	%	%	mg/L	mgN/L	mgN/L	mg/L as P	mg/L as P	mg/L	mg/L	C		mg/L
1	4/4/2016	0.22	2.9	2.0						29,000	20,200	95.8		
2	4/5/2016	0.24										92.1		
3	4/6/2016	0.23	2.8	1.9	12510		1807		290	27,800	19,100	92.4	7.4	3760
4	4/7/2016	0.23										94.3		
5	4/8/2016	0.23										92.9		
6	4/9/2016	0.23										95.5		
7	4/10/2016	0.23										95.7		
8	4/11/2016	0.23	2.9	2.0						28,600	19,900	95.7		
9	4/12/2016	0.23										95.7	7.4	
10	4/13/2016	0.24	2.9	2.0	31570		1952		225	28,700	20,200	95.6		4404
11	4/14/2016	0.24										95.7		
12	4/15/2016	0.24										95.7		
13	4/16/2016	0.23										95.8		
14	4/17/2016	0.24			19220	2464	2046	2139	283	31,000	16430	95.8		7750
	Average	0.232	2.9	1.985	25395	2464	1935	2139	266	29,020	19,166	95	7.4	5305
	Median	0.231	2.9	2.005	25395	2464	1952	2139	283	28,700	19,900	96	7.4	4404
	Count	14	4	4.000	2	1	3	1	3	5	5	14	2	3
		(yellow)	= Data Screened from dataset							(blue)	= Data from Madison MSD			

	Thermophilic Digester Effluent													
	Date	Flow	TS	VS	COD	TKN	NH3	Total P	OrthoP	TS	VS:TS	Temp	pH	Alkalinity
Day		mgd	%	%	mg/L	mgN/L	mgN/L	mg/L as P	mg/L as P	mg/L	mg/L	C		mg/L
1	4/4/2016	0.037	2.0	1.4						20,400	13,500	137		
2	4/5/2016	0.037										137		
3	4/6/2016	0.037	2.0	1.4	22440		2244		246	20,400	13,500	137	8.1	
4	4/7/2016	0.037										137		
5	4/8/2016	0.037										137		
6	4/9/2016	0.037										137		
7	4/10/2016	0.037										137		
8	4/11/2016	0.037	2.0	1.4						20,400	13,500	137		
9	4/12/2016	0.037										137	8.2	
10	4/13/2016	0.037	2.0	1.4	22440		2244		260	20,400	13,500	137		
11	4/14/2016	0.037										137		
12	4/15/2016	0.037										137		
13	4/16/2016	0.037										137		
14	4/17/2016	0.037			31900	2262	1827	1537	246	29,000	19720	137		6090
	Average	**0.037**	**2.04**	**1.35**	**25593**	**2262**	**2105**	**1537**	**251**	**22120.0**	**14744**	**137**	**8.2**	**6090**
	Median	**0.037**	**2.04**	**1.35**	**22440**	**2262**	**2244**	**1537**	**246**	**20400.0**	**13500**	**137**	**8.2**	**6090**
	Count	**14**	**4**	**4.000**	**3**	**1**	**3**	**1**	**3**	**5**	**5**	**14**	**2**	**1**
			= Data Screened from dataset								**= Data from Madison MSD**			

Digested Sludge GBT

		Feed			Thickened solids			Filtrate										
Day	Date	Flow mgd	TS (Calculated) %	VS (Calculated) %	Flow mgd	TS %	VS %	COD mg/L	SCOD mg/L	FFCOD mg/L	TKN mg/L as N	NH3 mg/L as N	Total P mg/L as P	OrthoP mg/L as P	TSS mg/L	VSS mg/L	Sol BOD mg/L	Flow mgd
1	4/4/2016	0.21	3.39	2.35	0.132	5.3		720		220	1000	670	80	9	320	210		0.30
2	4/5/2016	0.20			0.129	5.0		980	110	420	1000	940	130	75	330	220		0.27
3	4/6/2016	0.21	3.28	2.25	0.137	4.6		910		410	600	1310	91	105	348	220		0.28
4	4/7/2016	0.21			0.134	5.3		840	140	260	960	860	130	69	300	230		0.29
5	4/8/2016	0.21			0.135	5.0		670	180	280	990	880	300		260	180	50	0.29
6	4/9/2016	0.21			0.136	4.8		720	49	390	760	890	110		260	190	46	0.30
7	4/10/2016	0.21			0.134	5.0		760	240	330	660	914	79	78	264	190		0.30
8	4/11/2016	0.21	3.42	2.37	0.141	5.0		800	180	410	710	920	91	75	260	190		0.30
9	4/12/2016	0.17			0.109	4.9		770	120	280	570	1080	140	79	371	220		0.25
10	4/13/2016	0.22	3.48	2.43	0.142	4.7		810	100	400	550	820	140	62	276	260		0.29
11	4/14/2016	0.21			0.137	5.3		870	130	330	710	880	130	65	340	230		0.30
12	4/15/2016	0.22			0.135	5.7		760	92	240	610	760	69		260	180	53	0.31
13	4/16/2016	0.21			0.132	6.0		680	180	230	500	880	28		220	170	34	0.31
14	4/17/2016	0.21			0.141	5.0		570	160	220	450	615	95	44	61	180		0.28
	Average	**0.21**	**3.4**	**2.4**	**0.13**	**5.1**	**#DIV/0!**	**776**	**148.4**	**316**	**719.3**	**887.1**	**115.2**	**72**	**276**	**205**	**46**	**0.292**
	Median	**0.21**	**3.4**	**2.4**	**0.14**	**5.0**	**#NUM!**	**765**	**140.0**	**305**	**685.0**	**880.0**	**102.5**	**75**	**270**	**200**	**48**	**0.297**
	Count	**14**	**4**	**4**	**14**	**14**	**0**	**14**	**11**	**14**	**14**	**14**	**14**	**9**	**14**	**14**	**4**	**14**

(yellow) = Data Screened from dataset

(blue) = Data from Madison MSD

CALCULATIONS

		TSS Capture	Overflow													
Day	Date	Percent	TKN:COD	TP:TKN	COD:VSS	COD:TSS		VSS:TSS	ISS	TP:VSS	TKN:VSS	SCOD:COD	FCOD:SCO	NH3-N:TKN	PO4-P:TP	FFCOD:COD
1	4/4/2016	99.7	1.389	0.080	2.25	2.25		0.66	110	0.38	4.76			0.67		0.31
2	4/5/2016		1.020	0.130	2.97	2.97		0.67	110	0.59	4.55	0.11	3.82	0.94	0.58	0.43
3	4/6/2016	99.7	0.659	0.152						0.41	2.73			2.18	1.16	0.45
4	4/7/2016		1.143	0.135	2.80	2.80		0.77	70	0.57	4.17	0.17	1.86	0.90	0.53	0.31
5	4/8/2016		1.478	0.303	2.58	2.58		0.69	80	1.67	5.50	0.27	1.56	0.89		0.42
6	4/9/2016		1.056	0.145	2.77	2.77		0.73	70	0.58	4.00	0.07	7.96	1.17		0.54
7	4/10/2016		0.868	0.120						0.42	3.47	0.32	1.38	1.38	0.98	0.43
8	4/11/2016	99.8	0.888	0.128	3.08	3.08		0.73	70	0.48	3.74	0.23	2.28	1.30	0.82	0.51
9	4/12/2016		0.740	0.246						0.64	2.59	0.16	2.33	1.89	0.57	0.36
10	4/13/2016	99.8	0.679	0.255						0.54	2.12	0.12	4.00	1.49	0.44	0.49
11	4/14/2016		0.816	0.183	2.56	2.56		0.68	110	0.57	3.09	0.15	2.54	1.24	0.50	0.38
12	4/15/2016		0.803	0.113	2.92	2.92		0.69	80	0.38	3.39	0.12	2.61	1.25		0.32
13	4/16/2016		0.735	0.056	3.09	3.09		0.77	50	0.16	2.94	0.26	1.28	1.76		0.34
14	4/17/2016		0.789	0.211						0.53	2.50	0.28	1.38	1.37	0.46	0.39
	Average	**99.7**	**0.933**	**0.161**	**2.78**	**2.78**		**0.71**	**83**	**0.56**	**3.54**	**0.19**	**2.75**	**1.32**	**0.67**	**0.41**
	Median	**99.7**	**0.842**	**0.140**	**2.80**	**2.80**		**0.69**	**80**	**0.53**	**3.43**	**0.16**	**2.31**	**1.27**	**0.57**	**0.40**
	Count	**4**	**14**	**14**	**9**	**9**		**9**	**9**	**14**	**14**	**12**	**12**	**14**	**9**	**14**

Nine Springs WWTF Wastewater Characterization Study October 20-30, 2014

INFLUENT

Day	Flow	TSS	VSS	COD	sCOD	ffCOD	TBOD5	CBOD	NO3-BOD	TKN	sTKN	NH3-N	NO3-N	PO4-P	sTP	TP	Alk	Temp
10/20/2014	38.54	234	211	450	170	110	207	182	0.02	43.8	34.3	27.7	0.02	3.2	3.5	5.68	470	17.5
10/21/2014	38.35	233	207	500	200	120	257	213	0.02	48.5	41.3	31.8	0.03	4.3	3.8	6.21	500	17.5
10/22/2014	38.88	230	206	490	230	140	256	225		47.8	38.2	31	0.07	3.3	3.6	6.30	460	17.5
10/23/2014	38.71	241	212	803			239	224	0.02	45.1		29.3				6.22		17.5
10/24/2014	38.16	216	193	663			264	241		48.4		30				6.54		17.8
10/25/2014	37.38	235	207	665			241	225		45.5		32.3				5.72		18.0
10/26/2014	36.87	272	241	521			255	242		43.8		30.2				5.86		17.6
10/27/2014	38.20	270	240	636			232	186	0.02	47.6		29.8				6.31		17.6
10/28/2014	38.02	288	261	530	180	130	294	224	0.02	50.1	40.2	29.4	0.03	2.9	4.4	6.74	470	17.6
10/29/2014	37.73	294	245	540	270	140	276	250	0.02	53.8	36.8	31.8	0.26	4.1	3.3	7.96	490	17.2
10/30/2014	38.31	269	240	520	190	120	291	224	0.02	50.8	33.4	29.4	0.1	3.6	4.0	7.33	470	17.2
Average	38.10	253	224	552	207	127	256	221	0.02	47.7	37.4	30.2	0.1	3.55	3.78	6.44	477	18
min	36.87	216.00	####	450.00	170.00	110.00	207.00	182.00	0.02	43.80	33.40	27.70	0.02	2.94	3.31	5.68	460.00	17.20
max	38.88	294.00	####	665.40	270.00	140.00	294.00	250.00	0.02	53.80	41.30	32.30	0.26	4.27	4.44	7.96	500.00	18.00
Count	11	11	11	10	6	6	11	11	7	11	6	11	6	6	6	11	6	11

Values that are excluded by entering a ' infront of value

CALCULATED PARAMETERS

Calculated Parameters

Day	ISS	VSS/TSS	pN:P COD	COD/CBOD5	sCOD/COD	FFCOD/SCOD	TSS/CBOD5	Prt COD/VSS	Tot COD/VSS	TKN/COD	TKN/VSS	NH3/TKN	sTKN: TKN	Fnox	Fnus*	Fus*	Fbs*	Fpo4	sTP:TP
10/20/2014	23	0.90	0.03	2.47	0.38	0.65	1.29	1.33	2.13	0.10	0.21	0.63	0.78	0.59	0.0251	0.051	0.193	0.56	0.61
10/21/2014	26	0.89	0.02	2.35	0.40	0.60	1.09	1.45	2.42	0.10	0.23	0.66	0.85	0.43		0.052	0.188	0.69	0.61
10/22/2014	24	0.90	0.04	2.18	0.47	0.61	1.02	1.26	2.38	0.10	0.23	0.65	0.80	0.57	0.020	0.047	0.239	0.53	0.58
10/23/2014	29	0.88					1.08				0.21	0.65							
10/24/2014	23	0.89		2.75			0.90		3.44	0.07	0.25	0.62							
10/25/2014	28	0.88		2.96			1.04		3.21	0.07	0.22	0.71							
10/26/2014	31	0.89		2.15			1.12		2.16	0.08	0.18	0.69							
10/27/2014	30	0.89		3.42			1.45		2.65	0.07	0.20	0.63							
10/28/2014	27	0.91	0.03	2.37	0.34	0.72	1.29	1.34	2.03	0.09	0.19	0.59	0.80	0.48	0.024	0.077	0.168	0.44	0.66
10/29/2014	49	0.83	0.06	2.16	0.50	0.52	1.18	1.10	2.20	0.10	0.22	0.59	0.68	0.77	0.012	0.048	0.211	0.51	0.42
10/30/2014	29	0.89	0.05	2.32	0.37	0.63	1.20	1.38	2.17	0.10	0.21	0.58	0.66	0.81	0.017	0.054	0.177	0.49	0.55
Average	29	0.89	0.04	2.51	0.41	0.62	1.15	1.31	2.48	0.09	0.21	0.64	0.76	0.61	0.02	0.055	0.20	0.53	0.57
min	23.00	0.83	0.02	2.15	0.34	0.52	0.90	1.10	2.03	0.07	0.18	0.58	0.66	0.43	0.01	0.047	0.17	0.44	
max	49.00	0.91	0.06	3.42	0.50	0.72	1.45	1.45	3.44	0.10	0.25	0.71	0.85	0.81	0.03	0.077	0.24	0.69	
Median					0.39	0.62	1.12	1.33	2.29	0.10	0.21	0.63	0.79	0.58	0.02	0.052	0.19	0.52	0.59

Attachment B: Influent Active Biomass Testing

Source: Melcer, Henryk, et al. (2003) Water Environment Research Foundation Methods for Wastewater Characterization in Activated Sludge Modeling, Project 99-WWF-3. 2003.

CHAPTER 9.0

ACTIVE BIOMASS COD

9.1 Background

Heterotrophic biomass may constitute a significant component of the influent wastewater COD. Reported values of influent heterotrophic biomass range from 7 percent to 25 percent of the total influent COD (Orhon and Çokgör, 1997). If modeling processes downstream of primary clarifiers, much of this biomass may originate from excess sludge recycled to the influent of the plant (see, for example, Kappeler & Gujer, 1992). Since the continuous seeding of biomass from the influent of an activated sludge system can significantly impact the behavior of the process (particularly the solids balance and organism wash-out solids retention time), in some cases it can be important to quantify this fraction of the wastewater.

9.2 Method

A batch method for estimating the mass of active heterotrophic organisms in an activated sludge sample was proposed by Kappeler and Gujer (1992). The sample of activated sludge is combined with a sample of centrifuged wastewater supernatant. The combined sample is mixed, and the OUR is then monitored over a period of time (until there is a significant drop). This method was modified by Wentzel et al. (1995), and applied to determining the mass of active organisms in a sample of influent wastewater. In this test, a volume (typically 3 or 4 L) of influent wastewater of known COD concentration (COD_T) is mixed and aerated, and the OUR is measured semi-continuously for an extended period of approximately 10 to 20 hours as appropriate. The basis of the test is that the influent wastewater sample will contain at least a small (seed) concentration of heterotrophic bacteria ($X_{HET,0}$), the characteristic to be determined. At the start of the test, there should be an appreciable RBCOD concentration (well in excess of the half-saturation coefficient for growth), and therefore, the first part of the test should reflect a logarithmic growth phase. That is, the OUR should increase exponentially from an initial low value until the RBCOD is nearly completely consumed. Thereafter, there should be a precipitous drop in OUR.

Based on the OUR response, the mass of organisms can be estimated using an appropriate activated sludge model (such as an ASM-type model). Wentzel et al. (1995) used a simplified version of the UCT model (Dold et al., 1980), and obtained an expression relating the observed OUR at time *t* to the initial heterotroph concentration, $X_{HET,0}$. In terms of the IWA model, this expression is:

$$ln(OUR_t) = ln\left[\frac{\mu_{HET} \cdot (1-Y_{HET}) \cdot X_{HET,0}}{24 \cdot Y_{HET}}\right] + (\mu_{HET} - b_{HET}) \cdot t/24 \qquad (9.2\text{-}1)$$

where:

OUR_t = OUR at time t hours (mg/L/h)

μ_{HET} = maximum specific heterotrophic organism growth rate (/d)

Y_{HET} = yield coefficient (COD basis)

= 0.666 mg COD/mg COD

b_{HET} = death-regeneration organism decay rate

= $0.62\ (1.029)^{T-20}$ (/d)

From the above equation, a plot of *ln* (OUR_t) *versus* time (t) should yield a straight line with

$$slope = (\mu_{HET} - b_{HET})/24$$

and

$$y\text{-}intercept = ln\left[\frac{\mu_{HET} \cdot (1-Y_{HET}) \cdot X_{HET,0}}{24 \cdot Y_{HET}}\right]$$

Therefore the active heterotrophic organism concentration in the influent wastewater sample can be estimated as follows:

$$X_{HET,0} = \frac{e^{(y\text{-}intercept)} \cdot 24}{(slope \cdot 24 + b_{HET})(1-Y_{HET})/Y_{HET}} \qquad (9.2\text{-}2)$$

9.3 Example

An example of an OUR response from an aerobic batch test on raw influent wastewater is shown in Figure 9-1. From this data, a plot of *ln* (OUR_t) versus time (t) yields a straight line as shown in Figure 9-2, where the line slope and intercept are also shown.

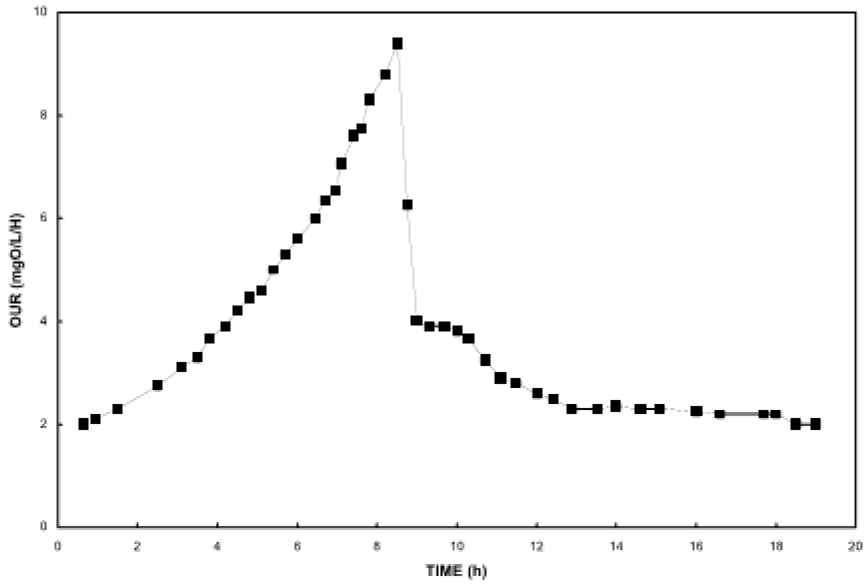


Figure 9-1. Example of OUR Response for an Aerobic Batch Test on Raw Municipal Wastewater (after Ubisi et al., 1997)

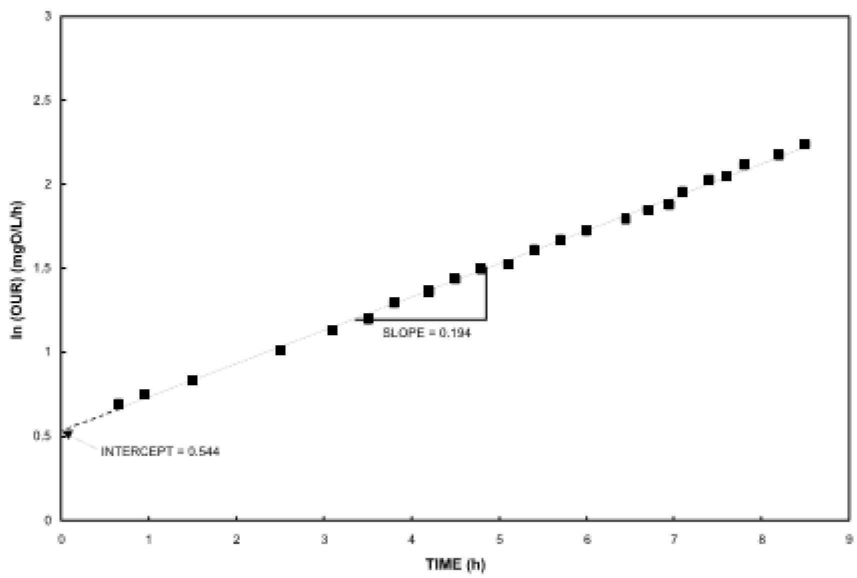


Figure 9-2. Plot of ln (OUR) versus Time for Initial Period of Increasing OUR in Figure 9-1

Using these data in equation 9.2-2:

$$X_{BH,0} = \frac{e^{0.344} \cdot 24}{(0.194 \cdot 24 + 0.62)(1-0.666)/0.666} = 15.6\ mg\ COD/L$$

This accounted for approximately 4 percent of the COD of this influent wastewater sample.

9.4 Considerations

- In the test, the OUR, particularly at the start, is low. Therefore steps should be taken to avoid any transfer of oxygen into the sample through the surface as this would cause errors in the OUR measurements. This can be achieved in several ways; for example, covering the surface with floating balls, or conducting the test in a near-full Erlenmeyer flask so as to minimize the surface exposed to the air.
- To determine if nitrification is exerting an oxygen demand during the test, samples can be analysed for nitrate and nitrite at the start and at the end of the test. However, it is unlikely that any significant nitrification will occur due to the short duration of the test and the very low concentration of nitrifiers relative to the heterotrophs.
- If the biomass component is not measured separately, this material will be reflected in the calibrated influent values of X_I and X_S. In most cases, this will not significantly impact model predictions of plant performance. However, in very high rate systems, the determination of the biomass component may be more important.

9.5 References

Dold, P.L., G.A. Ekama, and G.v.R. Marais. 1980. A general model for the activated sludge process. *Prog. Water Technol.* 12:47-77.

Kappeler, J., and W. Gujer. 1992. Estimation of kinetic parameters of heterotrophic biomass under aerobic conditions and characterization of wastewater for activated sludge modelling. *Water Sci. Tech.* 25(6):125-139.

Ubisi, M. F., T.W. Jood, M.C. Wentzel, and G.A. Ekama. 1997. Activated sludge mixed liquor heterotrophic active biomass. *Water SA* 23(3):239-248.

Wentzel, M.C., A. Mbewe, and G.A. Ekama. 1995. Batch test for measurement of readily biodegradable COD and active organism concentrations in municipal wastewaters. *Water SA* 21(2):117-124.

APPENDIX B: Diffuser Net Present Worth

From Summary Sheet:

Year of analysis	2020	**Benefits**		Assume 7 year replacement cycle	
Escalation rate	4.00%	**Capital costs**		NEORSD: $385,000 for 20,970 diffusers	
Discount rate	4.38%	**Running costs**		MMSD has 32,400 diffusers	594,850 per replacement cycle

Risk adjustments (+/- percent):

Madison
Problem/project description
Life Cycle Alternative Cost Analysis ($000s)
Membrane diffuser and Modified UCT

Expressed in 2020 dollars, unescalated -- dollars

Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Capital Outlays																															
Capital outlay 1	2,620,917																														
Diffuser Replacement																															
Capital outlay 3																															
Capital outlay 4																															
Capital outlay 5																															
Capital outlay 6																															
Total capital outlays	**2,620,917**																														
Benefits:																															
Digester Gas Credit																															
Biogas Credit to suppliment Natural G	15,896	14,946	13,997	13,048	12,099	11,150	10,200	9,251	8,302	7,353	6,404	5,455	4,505	3,556	2,607	1,658	709														
Benefit 3																															
Total benefits	**15,896**	**14,946**	**13,997**	**13,048**	**12,099**	**11,150**	**10,200**	**9,251**	**8,302**	**7,353**	**6,404**	**5,455**	**4,505**	**3,556**	**2,607**	**1,658**	**709**														
Annual Running Costs:																															
East Blower operating costs	104,515	105,559	106,603	107,647	108,691	109,735	110,779	111,823	112,867	113,911	149,016	150,060	151,104	152,148	153,192	154,236	155,626	158,340	161,055	163,769	166,484										
West Blower operating costs	273,534	276,022	278,510	281,487	284,549	287,611	290,673	293,736	296,798	299,860	302,922	305,985	309,047	312,109	315,172	318,234	321,296	324,358	327,421	330,483	333,545										
Diffuser cleaning and repair costs	21,000	21,000	21,000	21,000	21,000	21,000	21,000	21,000	21,000	21,000	21,000	21,000	21,000	21,000	21,000	21,000	21,000	21,000	21,000	21,000	21,000										
Total running costs	**399,049**	**402,581**	**406,114**	**410,134**	**414,240**	**418,346**	**422,453**	**426,559**	**430,665**	**434,772**	**472,938**	**477,045**	**481,151**	**485,257**	**489,364**	**493,470**	**497,922**	**503,698**	**509,475**	**515,252**	**521,029**										
Annual Risk Costs:																															
Risk cost 1																															
Risk cost 2																															
Risk cost 3																															
Risk cost 4																															
Risk cost 5																															
Total risk costs																															
R&R Costs:																															
R&R cost 1								600,000							600,000																
R&R cost 2																															
R&R cost 3																															
R&R cost 4																															
R&R cost 5																															
Total refurbishments								**600,000**							**600,000**																
Net Benefit/(cost)	**(3,004,071)**	**(387,635)**	**(392,116)**	**(397,086)**	**(402,141)**	**(407,197)**	**(412,252)**	**(1,017,308)**	**(422,363)**	**(427,419)**	**(466,535)**	**(471,590)**	**(476,646)**	**(481,701)**	**(1,086,757)**	**(491,812)**	**(497,213)**	**(503,698)**	**(509,475)**	**(515,252)**	**(521,029)**										

Expressed in escalated dollars with sensitivity adjustments

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Capital Outlays																															
Capital outlay 1	2,620,917																														
Diffuser Replacement																															
Capital outlay 3																															
Capital outlay 4																															
Capital outlay 5																															
Capital outlay 6																															
Total capital outlays	**2,620,917**																														
Benefits:																															
Digester Gas Credit																															
Biogas Credit to suppliment Natural G	15,896	15,544	15,139	14,677	14,154	13,565	12,907	12,174	11,362	10,465	9,479	8,397	7,213	5,921	4,514	2,986	1,327														
Benefit 3																															
Total benefits	**15,896**	**15,544**	**15,139**	**14,677**	**14,154**	**13,565**	**12,907**	**12,174**	**11,362**	**10,465**	**9,479**	**8,397**	**7,213**	**5,921**	**4,514**	**2,986**	**1,327**														
Annual Running Costs:																															
East Blower operating costs	104,515	109,781	115,302	121,088	127,153	133,510	140,171	147,152	154,467	162,132	220,580	231,010	241,922	253,338	265,279	277,771	291,484	308,431	326,267	345,037	364,786										
West Blower operating costs	273,534	287,063	301,237	316,634	332,882	349,923	367,795	386,536	406,188	426,795	448,399	471,049	494,794	519,685	545,775	573,121	601,782	631,818	663,294	696,278	730,839										
Diffuser cleaning and repair costs	21,000	21,840	22,714	23,622	24,567	25,550	26,572	27,635	28,740	29,890	31,085	32,329	33,622	34,967	36,365	37,820	39,333	40,906	42,542	44,244	46,014										
Total running costs	**399,049**	**418,685**	**439,252**	**461,345**	**484,602**	**508,982**	**534,537**	**561,323**	**589,395**	**618,816**	**700,064**	**734,388**	**770,338**	**807,989**	**847,420**	**888,712**	**932,598**	**981,154**	**1,032,103**	**1,085,558**	**1,141,638**										
Annual Risk Costs:																															
Risk cost 1																															
Risk cost 2																															
Risk cost 3																															
Risk cost 4																															
Risk cost 5																															
Total risk costs																															
R&R Costs:																															
R&R cost 1								789,559							1,039,006																
R&R cost 2																															
R&R cost 3																															
R&R cost 4																															
R&R cost 5																															
Total refurbishments								**789,559**							**1,039,006**																
Net escalated benefit/(cost)	**(3,004,071)**	**(403,140)**	**(424,113)**	**(446,667)**	**(470,448)**	**(495,417)**	**(521,631)**	**(1,338,708)**	**(578,033)**	**(608,350)**	**(690,585)**	**(725,991)**	**(763,125)**	**(802,068)**	**(1,881,911)**	**(885,726)**	**(931,271)**	**(981,154)**	**(1,032,103)**	**(1,085,558)**	**(1,141,638)**										

Life cycle cost analysis

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
PVs in 2020	(3,004,071)	(386,242)	(389,304)	(392,821)	(396,393)	(399,934)	(403,445)	(991,997)	(410,375)	(413,795)	(450,041)	(453,284)	(456,497)	(459,681)	(1,033,352)	(465,964)	(469,388)	(473,802)	(477,514)	(481,194)	(484,840)										
NPV as of 2020	**(12,893,934)**																														

From Summary Sheet:		Risk adjustments (+/- percent):		
Year of analysis	2020	Benefits		$145 membrane materials per diffuser from Mike Furst at Ovivo
Escalation rate	4.00%	Capital costs		1 to 2 hours per diffuser per Ovivo, use $52.34/hr for mechanics
Discount rate	4.38%	Running costs		3614 Units 1,280,657
				Use 2 hours to account for tank draining, etc.

Madison
Problem/project description
Life Cycle Alternative Cost Analysis ($000s)
Alternative 2 - Modified UCT with high efficiency strips

Year

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Expressed in 2020 dollars, unescalated -- dollars																															
Capital Outlays																															
Capital outlay 1	3,621,545																														
Diffuser Replacement																															
Capital outlay 3																															
Capital outlay 4																															
Capital outlay 5																															
Capital outlay 6																															
Total capital outlays	**3,621,545**																														
Benefits:																															
Digester Gas Credit																															
Biogas Credit to suppliment Natural G	17,356	16,426	15,497	14,567	13,637	12,708	11,778	10,849	9,919	8,990	8,060	7,131	6,201	5,272	4,342	3,412	2,483	1,553	624												
Benefit 3																															
Total benefits	**17,356**	**16,426**	**15,497**	**14,567**	**13,637**	**12,708**	**11,778**	**10,849**	**9,919**	**8,990**	**8,060**	**7,131**	**6,201**	**5,272**	**4,342**	**3,412**	**2,483**	**1,553**	**624**												
Annual Running Costs:																															
East Blower operating costs	101,861	101,861	101,861	101,861	102,118	103,079	104,041	105,002	105,963	106,924	107,886	108,847	109,808	110,769	111,730	112,692	113,653	148,568	149,529	150,490	151,452										
West Blower operating costs	256,073	258,355	260,636	262,918	265,199	267,480	269,762	272,043	274,797	277,605	280,413	283,221	286,029	288,837	291,645	294,453	297,260	300,068	302,876	305,684	308,492										
Diffuser cleaning and repair costs	19,000	19,000	19,000	19,000	19,000	19,000	19,000	19,000	19,000	19,000	19,000	19,000	19,000	19,000	19,000	19,000	19,000	19,000	19,000	19,000	19,000										
Total running costs	**376,935**	**379,216**	**381,497**	**383,779**	**386,317**	**389,560**	**392,802**	**396,045**	**399,760**	**403,529**	**407,298**	**411,067**	**414,837**	**418,606**	**422,375**	**426,144**	**429,913**	**467,636**	**471,405**	**475,175**	**478,944**										
Annual Risk Costs:																															
Risk cost 1																															
Risk cost 2																															
Risk cost 3																															
Risk cost 4																															
Risk cost 5																															
Total risk costs																															
R&R Costs:																															
R&R cost 1											1,280,657																				
R&R cost 2																															
R&R cost 3																															
R&R cost 4																															
R&R cost 5																															
Total refurbishments											**1,280,657**																				
Net Benefit/(cost)	**(3,981,124)**	**(362,790)**	**(366,001)**	**(369,212)**	**(372,680)**	**(376,852)**	**(381,024)**	**(385,196)**	**(389,841)**	**(394,539)**	**(1,679,895)**	**(403,937)**	**(408,636)**	**(413,334)**	**(418,033)**	**(422,732)**	**(427,430)**	**(466,083)**	**(470,782)**	**(475,175)**	**(478,944)**										

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Expressed in escalated dollars with sensitivity adjustments																															
Capital Outlays																															
Capital outlay 1	3,621,545																														
Diffuser Replacement																															
Capital outlay 3																															
Capital outlay 4																															
Capital outlay 5																															
Capital outlay 6																															
Total capital outlays	**3,621,545**																														
Benefits:																															
Digester Gas Credit																															
Biogas Credit to suppliment Natural G	17,356	17,083	16,761	16,386	15,954	15,461	14,903	14,276	13,575	12,795	11,931	10,977	9,928	8,778	7,519	6,146	4,650	3,026	1,264												
Benefit 3																															
Total benefits	**17,356**	**17,083**	**16,761**	**16,386**	**15,954**	**15,461**	**14,903**	**14,276**	**13,575**	**12,795**	**11,931**	**10,977**	**9,928**	**8,778**	**7,519**	**6,146**	**4,650**	**3,026**	**1,264**												
Annual Running Costs:																															
East Blower operating costs	101,861	105,936	110,173	114,580	119,464	125,412	131,644	138,175	145,018	152,187	159,697	167,565	175,806	184,439	193,481	202,951	212,870	289,396	302,919	317,061	331,849										
West Blower operating costs	256,073	268,689	281,904	295,747	310,245	325,431	341,335	357,991	376,079	395,118	415,079	436,005	457,941	480,934	505,034	530,292	556,763	584,503	613,572	644,031	675,944										
Diffuser cleaning and repair costs	19,000	19,760	20,550	21,372	22,227	23,116	24,041	25,003	26,003	27,043	28,125	29,250	30,420	31,636	32,902	34,218	35,587	37,010	38,491	40,030	41,631										
Total running costs	**376,935**	**394,385**	**412,628**	**431,699**	**451,936**	**473,959**	**497,020**	**521,168**	**547,099**	**574,348**	**602,901**	**632,820**	**664,167**	**697,009**	**731,417**	**767,462**	**805,220**	**910,909**	**954,981**	**1,001,121**	**1,049,425**										
Annual Risk Costs:																															
Risk cost 1																															
Risk cost 2																															
Risk cost 3																															
Risk cost 4																															
Risk cost 5																															
Total risk costs																															
R&R Costs:																															
R&R cost 1											1,895,685																				
R&R cost 2																															
R&R cost 3																															
R&R cost 4																															
R&R cost 5																															
Total refurbishments											**1,895,685**																				
Net escalated benefit/(cost)	**(3,981,124)**	**(377,301)**	**(395,867)**	**(415,313)**	**(435,982)**	**(458,498)**	**(482,117)**	**(506,892)**	**(533,524)**	**(561,553)**	**(2,486,655)**	**(621,842)**	**(654,239)**	**(688,232)**	**(723,898)**	**(761,316)**	**(800,569)**	**(907,883)**	**(953,717)**	**(1,001,121)**	**(1,049,425)**										
Life cycle cost analysis																															
PVs in 2020	(3,981,124)	(361,486)	(363,376)	(365,247)	(367,353)	(370,131)	(372,884)	(375,613)	(378,776)	(381,964)	(1,620,506)	(388,257)	(391,362)	(394,440)	(397,490)	(400,514)	(403,511)	(438,419)	(441,248)	(443,765)	(445,678)										
NPV as of 2020	**(13,083,141)**																														

APPENDIX C: Deammonification Proposals

World Water Works conDEA

Veolia ANITAMOX –*This appendix is considered confidential by vendor*

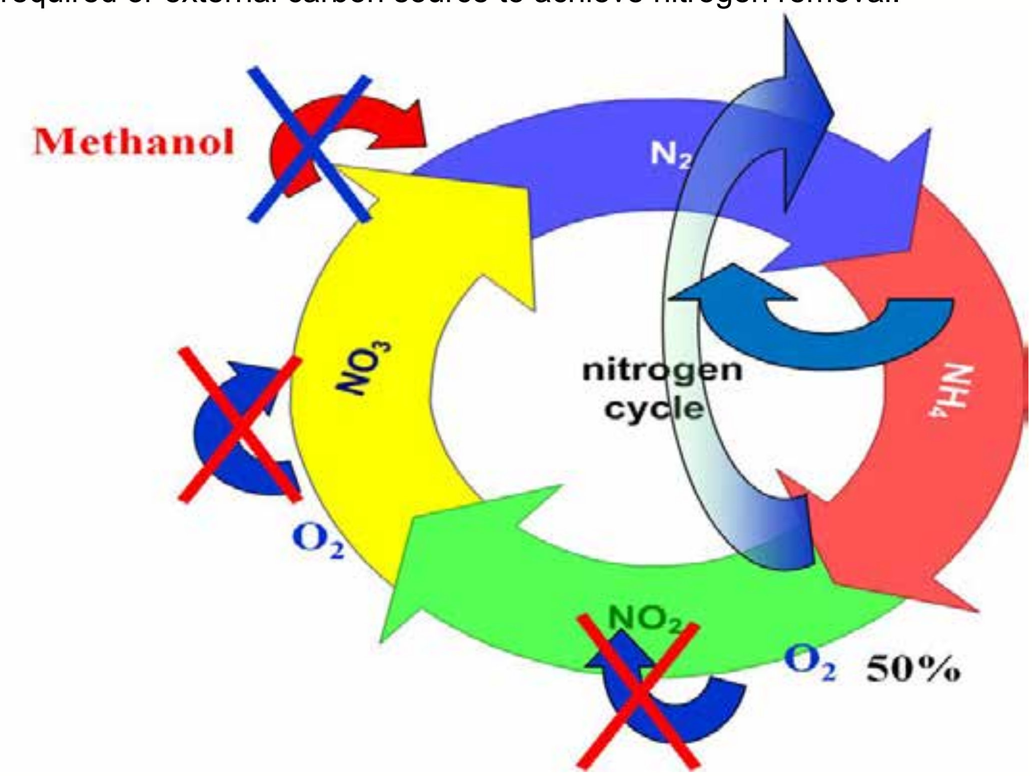
Clean Water and Energy from Wastewater

DATE: 2 December, 2016
TO: Don Esping – Brown & Caldwell
FROM: Chandler Johnson – World Water Works (WWW)
CC: Jeff Williamson, Tom Dennis – Drydon Equipment, Greg Parks - WWW
RE: Information on conDEA Treatment Process – Madison WWTP, WI – Rev0

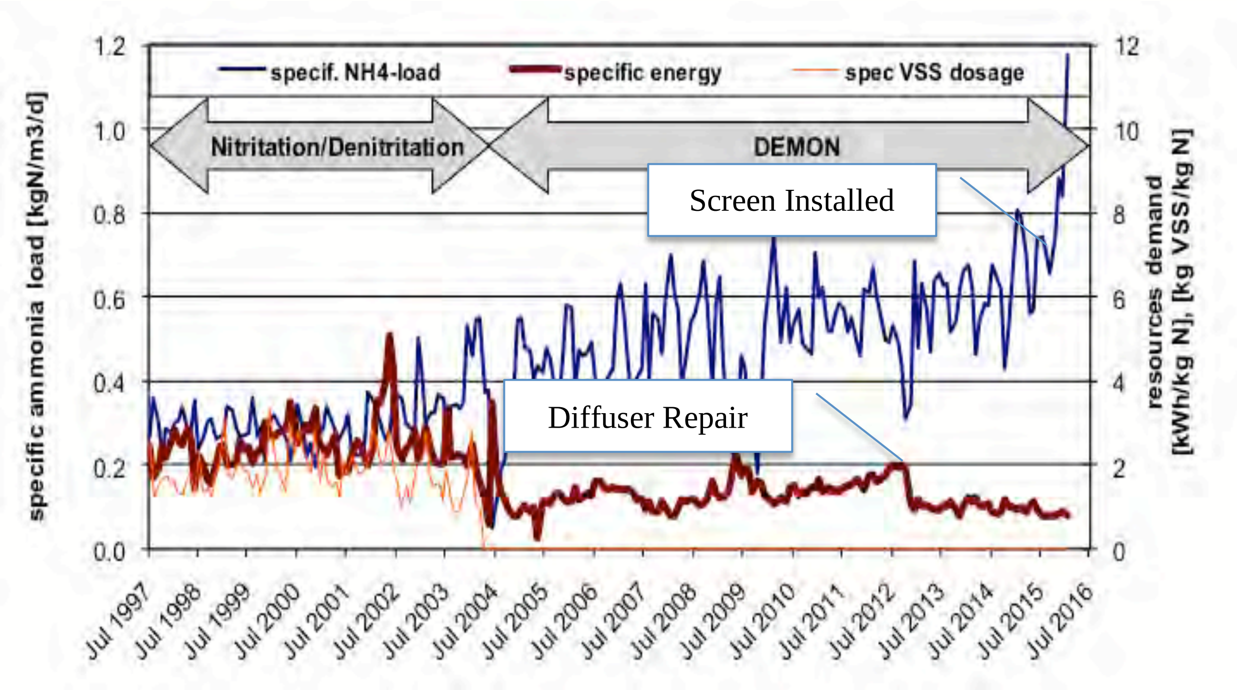
Per your request for updated design and sizing for a conDEA™ treatment system based on the **50% Filtrate and 100% of Ostara effluent**, please find below our design summary based on the information provided. Below are some graphs showing the typical cycle of a conDEA™ treatment system.

1. conDEA™ TREATMENT PROCESS

Deammonification represents a short-cut in the N-metabolism pathway and comprises of 2 steps. About half the amount of ammonia is oxidized to nitrite and then residual ammonia and nitrite is anaerobically transformed to elementary nitrogen. See this shortcut in the diagram below. By using this process there is no excess oxygen required or external carbon source to achieve nitrogen removal.



Implementation of the University of Innsbruck pH controlled strategy for the conDEA™ process for deammonification of reject water in a single sludge SBR is what this design is proposed around. The **specific energy demand of the side stream process results in 1.4 kWh per kg ammonia nitrogen removed comparing to about 6.5 kWh of mainstream treatment.** This process is achieving results of greater than 90% at the Strass WWTP (see data presented below). Biomass enrichment and conDEA™ -start up is key for this process to achieve its results in a short period of time and this proposal provides the seed sludge and start up assistance to ensure achieving the goal of efficient nitrogen removal.



Design Concept

The overall design concept for is to use one (1) new reactor for the 50% Filtrate design or two (2) new reactors for the Ostara Effluent design to create conDEA^{TM} treatment systems and EQ tank for the design conditions provided. We envision using for the 50% Filtrate design 32 ft of reactor length x 32 ft wide x 21 ft SWD for the conDEA^{TM} process while for the Ostara Effluent design would use two (2) - 36 ft of reactor length x 18 ft wide x 21 ft SWD for the conDEA^{TM} process. New mixers and aeration system will be placed in each reactor for providing the mixing energy for re-suspension of the granules, proper mixing distribution of the influent feed flow and provide the necessary aeration for nitritation. A lamella clarifier will be used to settle out the MLSS / Anammox biomass and allow the treated wastewater to be discharged. A RAS pump will be supplied with flow meter to pump the MLSS and Anammox back to the process tank. A single control panel will be provided to control process.

The Strass WWTP has been operating with a new Anammox retention system, which has proven to be very successful and will allow for the conDEA^{TM} process to a continuous process vs. the SBR mode. We see many advantages in this upgrade to the Anammox process as it will allow for a lower installed HP for the blowers, not require the Decanter and operate continuously with higher Anammox biomass retention which allows for higher operating loading rates.

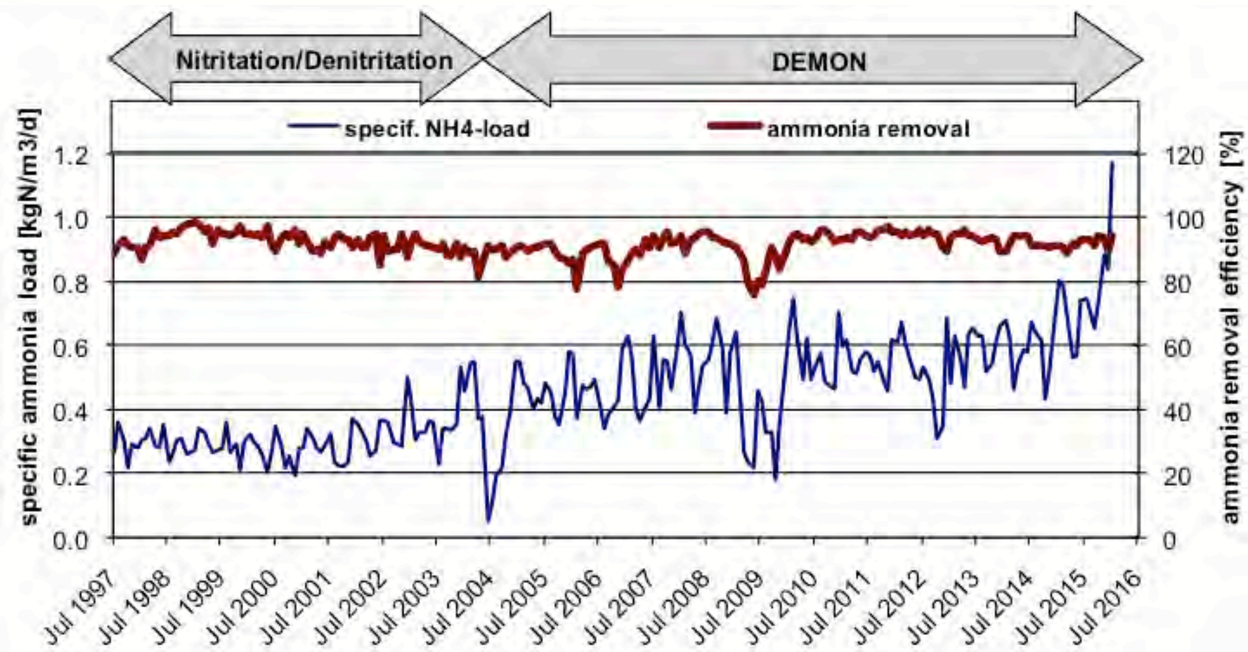
We have designed the system based on having removal efficiencies of 90% for ammonia and 80% for TIN however the aeration system is sized based on 95% ammonia removal. We have also assumed minimum operating temperature of 25C.

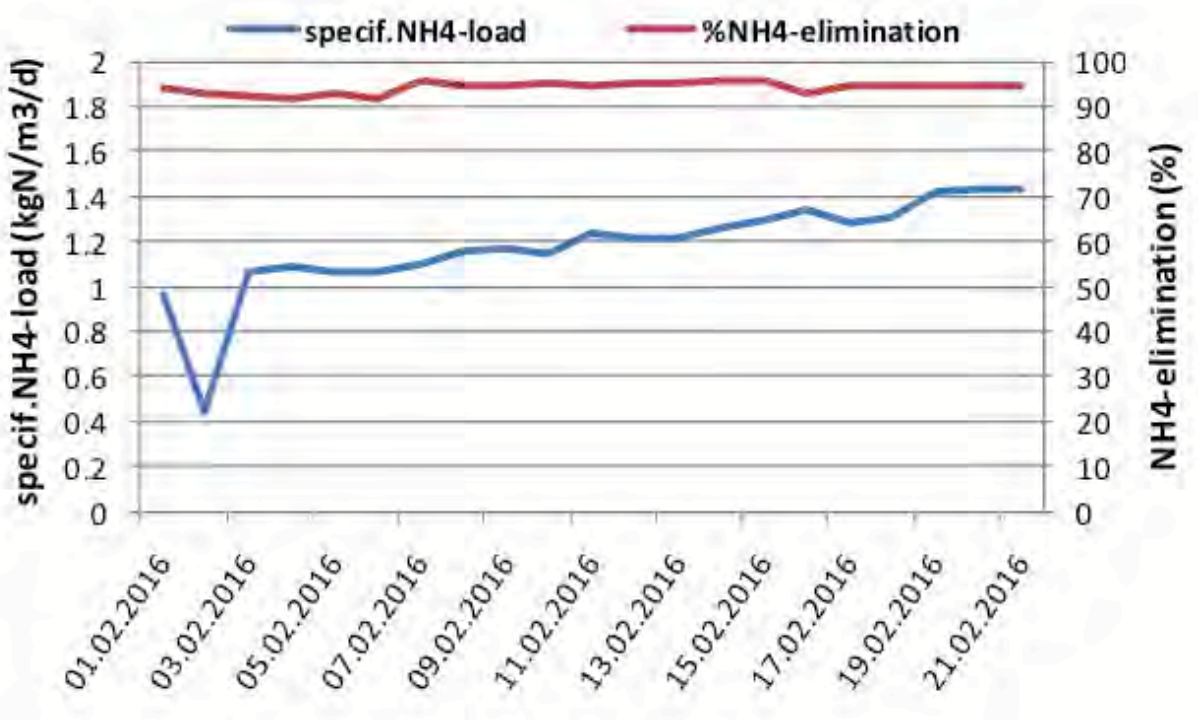
Under 50% Filtrate Loads with influent ammonia load of 1,172 lb/day, the estimated effluent ammonia using one (1) reactor will be 117 lb/day and total nitrogen will be < 235 lb/day. Under Ostara Effluent Design Loads with influent ammonia load of 1,202 lb/day, the estimated effluent ammonia using two (2) reactors will be 120 lb/day and total nitrogen will be < 240 lb/day.

conDEA™ TANK COMPONENTS

a) **Biomass Separation System** – A micro-screen will be used for this project and will have submerged pumps feeding it for a period time to waste out the AOB and NOB bacteria. The waste sludge of AOB and NOB bacteria will be discharged from the system while the underflow (Anammox bacteria) will be returned to the reactor.

Below are graphs of the loading and % removal of the Anammox treatment system at Strass WWTP in Austria using the microscreen since last fall time 2015. In February 2016, The specific load was increased to over 1.4 kg/m3-day while still maintaining greater than 90% removal of Ammonia-nitrogen.


Nitritation/Denitritation
DEMON
specif. NH4-load
ammonia removal
specific ammonia load [kgN/m3/d]
ammonia removal efficiency [%]
1.2
1.0
0.8
0.6
0.4
0.2
0.0
120
100
80
60
40
20
0
Jul 1997
Jul 1998
Jul 1999
Jul 2000
Jul 2001
Jul 2002
Jul 2003
Jul 2004
Jul 2005
Jul 2006
Jul 2007
Jul 2008
Jul 2009
Jul 2010
Jul 2011
Jul 2012
Jul 2013
Jul 2014
Jul 2015
Jul 2016

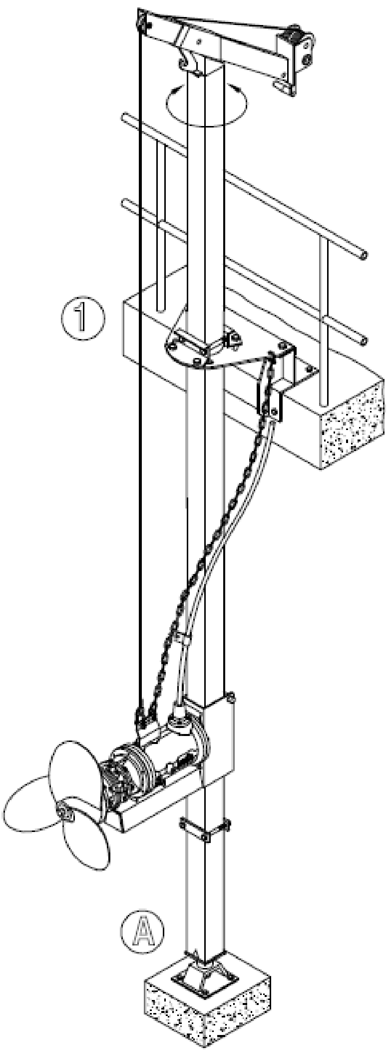

specif.NH4-load
%NH4-elimination
specif.NH4-load (kgN/m3/d)
NH4-elimination (%)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
100
90
80
70
60
50
40
30
20
10
0
01.02.2016
03.02.2016
05.02.2016
07.02.2016
09.02.2016
11.02.2016
13.02.2016
15.02.2016
17.02.2016
19.02.2016
21.02.2016

b) **<u>Instrument Float</u>** – the instruments for control of the process will be installed on a float system which will float with the level of the system. One (1) pH probe & one (1) DO probe for control of the overall operation of the process will be provided. A dedicated controller for the DO and pH is our recommendation. The conductivity probe is also to be provided with its own controller. Spare instrument locations will be provided in the instrument float for adding additional analyzers over time.

c) **<u>Seed Sludge</u>** – for the quick start up of the conDEA™ treatment process, an adequate amount of seed sludge will be supplied. The seed sludge will be shipped in as dry content possible based on the harvesting technique used and will be added to the systems as they are started up.

d) **<u>Aeration System</u>** – The Messner aeration system will be supplied in each tank. The amount of panels is provided in the scope of supply section and is subject to final design.

e) **Side Mounted Mixers** – Landia side mounted mixers will be used to maintain mixing energy within each reactor. The mixers will help re-suspend the "reds" during the start up phase of each cycle. VFD's will be provided to allow the mixers to be turned down and save on energy during the overall operation of the cycle.



f) **Lamella Clarifier** – A lamella clarifier with RAS pump will be provided to allow for a continuous operation of the Anammox treatment system. Clarified effluent will be discharged back into the main process while the RAS will be returned to the Anammox reactor. The waste stream enters the vessel and immediately the velocity is reduced to enhance particle separation. As the vessel is polypropylene, the pH can be adjusted low to enhance separation efficiencies. The waste stream passes through lamella HDPE plates which provide additional surface area for the separation to occur. The “clean” liquid is continuously removed from the top of the plates and passes through holes into an effluent trough. From the effluent trough, the wastewater gravity feeds out of the system. Heavy solids settle into a cone bottom where they can be purged on an automated basis. The system is compact, robust, cleanable, and does not have moving parts.

50% FILTRATE DESIGN

System Specifications	
Model	**SPC-300**
Max. Flow	**80 GPM**
Maximum Temp.	**<170 °F**
pH Tolerance	**1 – 12 S.U.**
Weight (approximate)	
Shipping	**2,600 lbs**
Operational	**12,300 lbs**
Dimensions (approximate)	
Overall (WxLxH)	**5’4” x 11’6” x 6’10”**
Pipe Diameters	
Outlet & Sludge	**2” (150 lb ANSI Flange)**
Standard Equipment	
Sludge Pump	**2” Air Operated Diaphragm**
Solenoid Valves	**SMC NVFS2100-5FZ**
Control Valves	**Orbinox 2” Pneumatic Knife Gate**
Materials of Construction	
Vessel	**Polypropylene**
Piping	**Polypropylene and Sch.80 PVC**
Lamella Plates	**PVC**
Platform/Grating	**Fiberglass**
Pneumatic Valves	**Cast Body / Stainless Steel Internals**
Manual Valves	**SCH 80 PVC**
Gaskets	**EPDM**

OSTARA EFFLUENT DESIGN – 1 X PROCESS TRAIN

System Specifications	
Model	**SPC-600**
Max. Flow	**225 GPM**
Maximum Temp.	**<170 °F**
pH Tolerance	**1 – 12 S.U.**
Weight (approximate)	
Shipping	**5,300 lbs**
Operational	**23,400 lbs**
Dimensions (approximate)	
Overall (WxLxH)	**7’0” x 11’1” x 12’6”**
Pipe Diameters	
Outlet	**8” (150 lb ANSI Flange)**
Sludge	**3” (150 lb ANSI Flange)**
Standard Equipment	
Sludge Pump	**3” Air Operated Diaphragm**
Solenoid Valves	**SMC NVFS2100-5FZ**
Control Valves	**Orbinox 3” Pneumatic Knife Gate**
Materials of Construction	
Vessel	**Polypropylene**
Piping	**Polypropylene and Sch.80 PVC**
Lamella Plates	**PVC**
Platform/Grating	**Fiberglass**
Pneumatic Valves	**Cast Body / Stainless Steel Internals**
Manual Valves	**SCH 80 PVC**
Gaskets	**EPDM**

g) **Blowers** – Positive displacement blowers capable of providing the necessary turndown for operation of the conDEA™ system are to be provided.

Design Case	**Model**	**Air Flow**	**Est. HP**	**Est. bHP**
50% Filtrate – 1 duty + 1 standby	GM 25S	440 SCFM	50 HP	29.9 bHP
100% Ostara Effluent – 2 duty + 2 standby	GM 10S	225 SCFM	25 HP	16.5 bHP

This blower design will allow the most flexibility in allowing the system have efficient use of blower capacity during start up and low load periods of time. The blowers will each have its own sound enclosure to maintain < 75 db sound rating. Each blower will also be equipped with a variable frequency drive unit to allow efficient turndown of the blower while maintaining the proper dissolved oxygen concentration in the conDEA™ reactor.

h) **Documentation / Design / License** – All necessary documentation and design information will be provided as well as a license for treating the Maximum Month Loads for either option.

2. CONTROLS

World Water Works provides pre-wired control panels to optimally control all equipment provided within the scope of this proposal. World Water Works includes an Ethernet connection with the control panel to allow remote access to the program and to assist in troubleshooting.

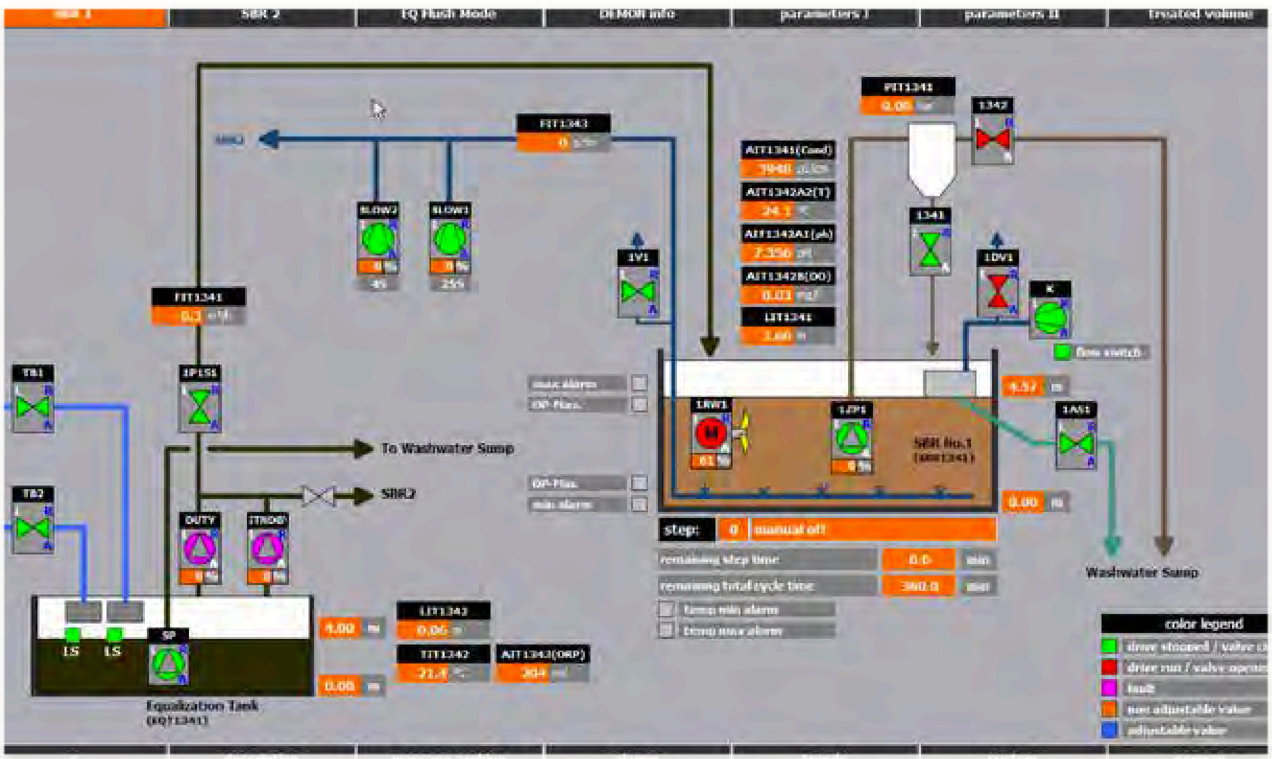
INSTRUMENTATION

Electrical Enclosure	**Hoffman, NEMA 4**
PLC	**Allen Bradley**
Software	**Allen Bradley**
Touchscreen	**15 inch Color Touch Screen**
Motor Starters	**Cutler Hammer or equiv**
Indicator & Stack Lights	**Cutler Hammer or equiv, Nema 4**
Control Buttons	**Cutler Hammer or equiv, Nema 4**
Local Disconnect	**Hubbell, NEMA 4**
Air Solenoids	**SMC**
Phase Protector	**SYMCON**

ADDITIONAL OPTIONS PROVIDED

Remote Operation Capability
UL Listed Panel
Stainless Steel Electrical Enclosure

PLC Panel – The PLC panel and control program is the heart of the conDEA™ process and its integral to our scope of supply. The PLC program will have each reactor created as a separate reactor. The reactor will have independent feed of raw centrate, aeration and mixing time. A touch panel with remote access is standard for allowing WWW access to the system and provides operational oversight.



Example HMI Screen

DESIGN FOR 25C – 50% Filtrate LOAD – NEW TANKAGE

Basic process figures	Design		Design	
Water temperature in conDEA Anammox-tank	25	°C	77	F
Load and concentration				
Daily water flow	354	m^3/d	0.094	MGD
NH4-N-load	531	kg/d	1,172	lb/day
NH4-N-concentration	1,500	mg/L	1,500	mg/L
COD soluble, degradable (estimate)	200	mg/L	200	mg/L
Suspended solids	300	mg/L	300	mg/L
COD soluble, degradable load	71	kg/d	156	lbday
Ssuspended solids load	106	kg/d	234	lb/day
Alkalinity Concentration	5,800	mg/L	5,800	mg/L
Alkalinity Load	2,055	kg/d	4,531	lbday
conDEA Anammox-tanks				
Number of tanks	1	in parallel	1	in parallel
Max. water depth	6.40	m	21.0	ft
Total volume per conDEA Anammox Reactor	609	m^3	21,504	m^3
Length of Each conDEA Anammox Treatment Reactor	9.8	m	32	ft
Width of Each conDEA Anammox Treatment Reactor	9.8	m	32	ft
Total Treatment Volume Provided	609	m^3	21,504	ft^3
Inlet				
Feeding pump per tank	32	m^3/h	143	gpm
Design of aeration system				
Oxygen consumption				
Daily oxygen consumption, operating conditions	982	kg O2/d	2,166	lb O2/d
Oxygen consumption per hour and conDEA Anammox tank, operating conditions	58	kg O2/h	129	lb O2/h
Fine bubble aeration				
Design air flow (per conDEA Anammox-tank)	743	Nm^3/h	437	SCFM

Air flows are based on 21 ft operating water level and discharge pressure of 10.5 psig

Rough Footprint would be one (1) basin at 32 ft wide x 32 ft long x 21 ft SWD, each

DESIGN FOR 25C – 100% OSTARA EFFLUENT LOAD – NEW TANKAGE

Basic process figures	Design		Design	
Water temperature in conDEA Anammox-tank	25	°C	77	F
Load and concentration				
Daily water flow	2,180	m^3/d	0.576	MGD
NH4-N-load	545	kg/d	1,202	lb/day
NH4-N-concentration	250	mg/L	250	mg/L
COD soluble, degradable (estimate)	100	mg/L	100	mg/L
Suspended solids	200	mg/L	200	mg/L
COD soluble, degradable load	218	kg/d	481	lbday
Ssuspended solids load	436	kg/d	961	lb/day
Alkalinity Concentration	1,000	mg/L	1,000	mg/L
Alkalinity Load	2,180	kg/d	4,807	lbday
conDEA Anammox-tanks				
Number of tanks	2	in parallel	2	in parallel
Max. water depth	6.40	m	21.0	ft
Total volume per conDEA Anammox Reactor	386	m^3	13,613	m^3
Length of Each conDEA Anammox Treatment Reactor	5.5	m	18	ft
Width of Each conDEA Anammox Treatment Reactor	11.0	m	36	ft
Total Treatment Volume Provided	771	m^3	27,226	ft^3
Inlet				
Feeding pump per tank	100	m^3/h	440	gpm
Design of aeration system				
Oxygen consumption				
Daily oxygen consumption, operating conditions	1,010	kg O2/d	2,226	lb O2/d
Oxygen consumption per hour and conDEA Anammox tank, operating conditions	30	kg O2/h	66	lb O2/h
Fine bubble aeration				
Design air flow (per conDEA Anammox-tank)	382	Nm^3/h	225	SCFM
Design air flow (per ALL TANKS)	764	Nm^3/h	449	SCFM

Air flows are based on 21 ft operating water level and discharge pressure of 10.5 psig

Rough Footprint would be two (2) basins at 18 ft wide x 36 ft long x 21 ft SWD, each

CONSUMABLES OF CONVENTIONAL VS. conDEA^{TM} TREATMENT SYSTEM –

DESIGN CONDITIONS

Nitrogen-Load	1,202	lb/day
Energy costs	$0.070	USD $ /kWh
Specific energy costs	0.2268	kWh/lb O2
Methanol	$0.147	USD $ /lb
Sludge	$367	USD $ /US ton

Conventional Nitrification / Denitrification				**Specific Costs (USD $ / lb N)**		**Costs per Year**
Oxygen	4.3	lb/lb N		0.0685	$	30,030
Methanol	2.3	lb/lb N		0.3391	$	148,725
Sludge	0.35	lb/lb N		0.0643	$	28,203
			TOTAL	**0.4718**	**$**	**206,957**

conDEA Anammox Treatment System				**Specific Costs (USD $ / lb N)**		**Costs per Year**
Oxygen	1.6125	lb/lb N		0.0257	$	11,261
Methanol	0	lb/lb N		0.0000	$	-
Sludge	0.03	lb/lb N		0.0055	$	2,417
			TOTAL	**0.0312**	**$**	**13,679**

Savings per year on aeration	**$**	**18,769**
Savings per year on Methanol	**$**	**148,725**
Savings per year on Sludge disposal	**$**	**25,786**
Total Operational Savings per year	**$**	**193,279**

Calculation does not include any savings from alkalinity addition required in conventional vs. conDEA^{TM} Treatment System

WWW Scope of Supply – 50% FILTRATE FLOW & LOAD – NEW TANK:

- Design & Engineering for System
- One (1) SPC-300 Lamella Clarifier with duplex RAS pump system
- Three (3) 10 inch flow control values for isolation of Clarifier and micro-screen
- Nineteen (19) Messner Aeration panels for the reactor
- One (1) SS 304L Drop pipe with manifold to feed Messner panels
- One (1) conDEA™ Biomass Separation System
- Two (2) submersible pumps (one duty + one standby) rated at 50 gpm and 5 HP motor with VFD's on each pump (operated 8 hrs per day)
- One (1) Pressure sensor with 4-20 mA output for monitoring of conDEA™ Biomass Separation system
- Two (2) Radar type level control for each conDEA™ Tank & EQ Tank
- Two (2) influent feed pumps to the conDEA™ reactor each rated for 150 gpm with VFD's on each pump. (operated 12 - 24 hrs per day) (1 duty + 1 standby)
- Two (2) Positive Displacement blowers (440 SCFM each) with VFD's on each blower (50 HP motors) (operated 14 hrs per day at design load) – (1 Duty + 1 Standby)
- One (1) – 12.2 HP side mounted mixers with VFD's for each mixer (operated 6 hr/day)
- Seed Sludge for start up of system delivered to the site
- conDEA™ Control program with panel with VFD's for blowers, submersible pump and mixers
- One (1) pH and DO probe with one (1) SC1000 controller
- One (1) Conductivity probe with one (1) SC200 controller
- One (1) Air flow insertion meter and three (3) water flow magnetic meters
- Inspection, start up and training services (8 trips / 30 days)
- 3-4 months of off-site / remote monitoring services
- **Estimated Price for above scope of supply: $1,150,000 USD**

Items not included:

Tankage for EQ tank and conDEA™ tank
Unloading, storage, installation of equipment
Electrical connections and interconnecting piping

WWW Scope of Supply – OSTARA FLOWS & LOADS – NEW TANKS:

- Design & Engineering for System
- Two (2) SPC-600 Lamella Clarifiers with each their own duplex RAS pump system
- Six (6) 10 inch flow control values for isolation of Clarifier and micro-screen
- Twenty (20) Messner Aeration panels for both reactors (10 per reactor)
- Two (2) SS 304L Drop pipes with manifolds to feed Messner panels
- Two (2) conDEA™ Biomass Separation System
- Three (3) submersible pumps (two duty + one standby) rated at 110 gpm and 10 HP motor with VFD's on each pump (operated 8 hrs per day)
- Two (2) Pressure sensor with 4-20 mA output for monitoring of conDEA™ Biomass Separation system
- Three (3) Radar type level control for each conDEA™ Tank & EQ Tank
- Three (3) influent feed pumps to the conDEA™ reactor each rated for 450 gpm with VFD's on each pump. (operated 12-24 hrs per day) (2 duty + 1 standby)
- Four (4) Positive Displacement blowers (225 SCFM each) with VFD's on each blower (25 HP motors) (operated 14 hrs per day at design load) – (1 Duty + 1 Standby per system)
- Two (2) – 9.2 HP side mounted mixers (1 per tank) with VFD's for each mixer (operated 6 hr/day)
- Seed Sludge for start up of system delivered to the site
- conDEA™ Control program with panel with VFD's for blowers, cyclone pump and mixers
- Two (2) pH and DO probes with two (2) SC1000 controllers
- Two (2) Conductivity probes with two (2) SC200 controllers
- Two (2) Air flow insertion meters and six (6) water flow magnetic meters
- Inspection, start up and training services (10 trips / 40 days)***
- 3-4 months of off-site / remote monitoring services
- **Estimated Price for above scope of supply: $1,900,000 USD**

Items not included:

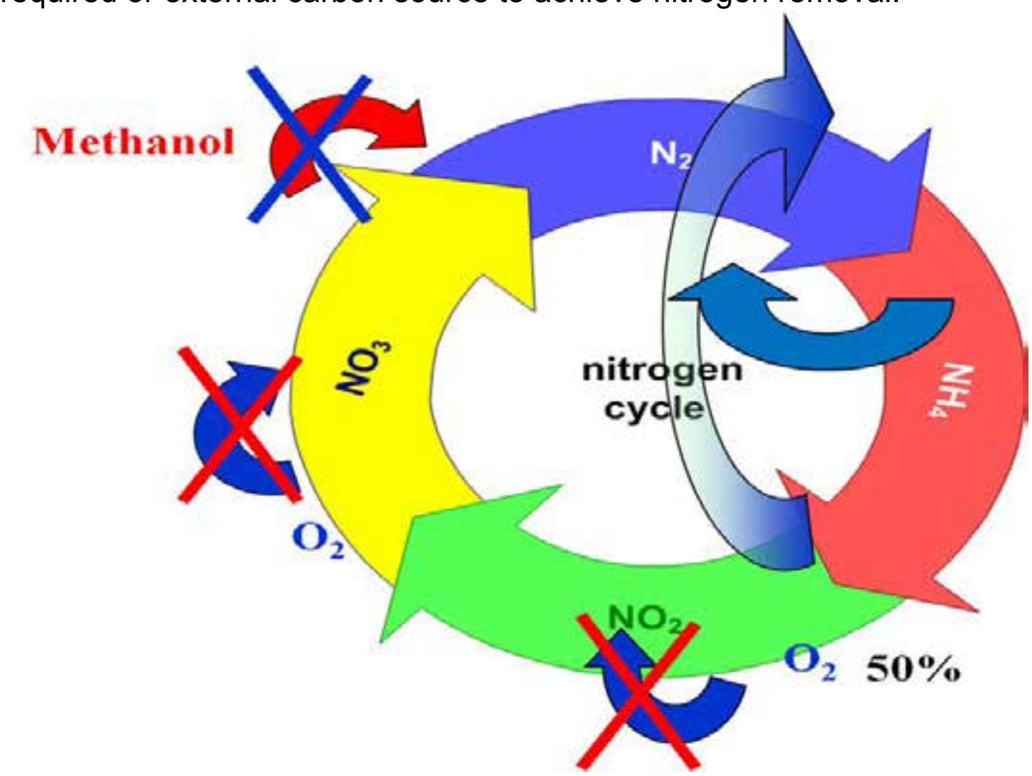
New tankage for EQ tank and conDEA™ tanks
Unloading, storage, installation of equipment
Electrical connections and interconnecting piping

DATE: 2 December, 2016
TO: Don Esping – Brown & Caldwell
FROM: Chandler Johnson – World Water Works (WWW)
CC: Jeff Williamson, Tom Dennis – Drydon Equipment, Greg Parks - WWW
RE: Information on conDEA Treatment Process – Madison WWTP, WI – Rev0

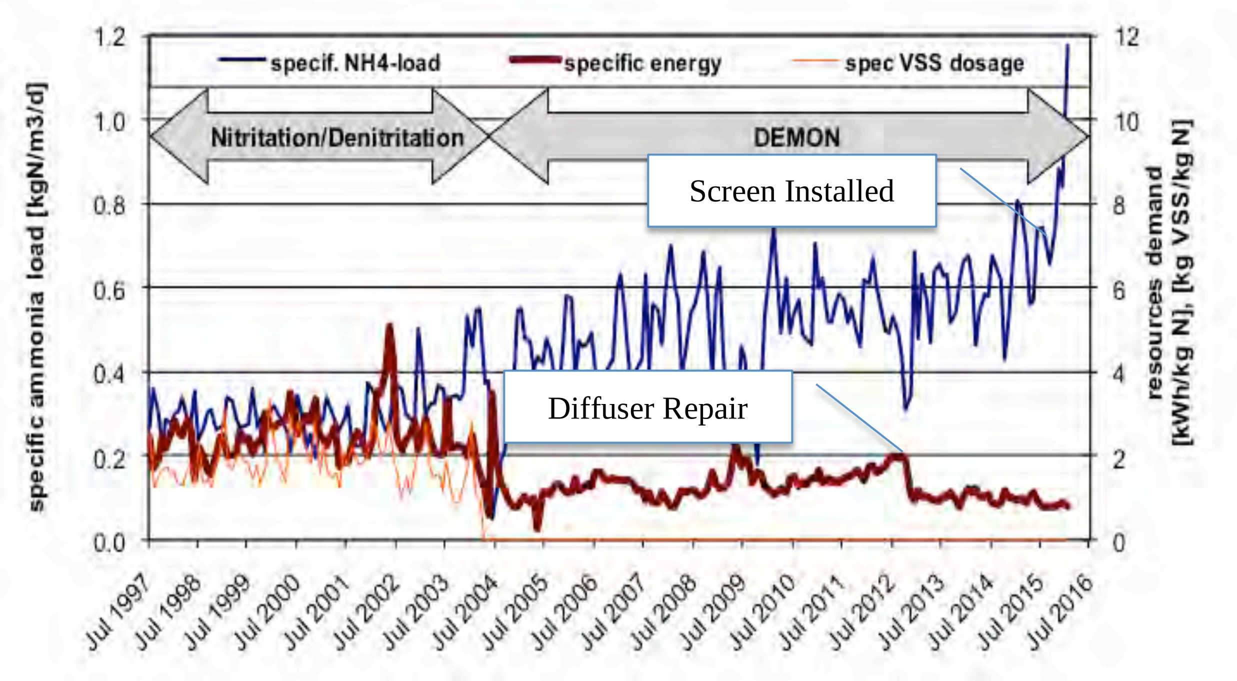
Per your request for updated design and sizing for a conDEA™ treatment system based on the **50% Filtrate and 100% of Ostara effluent**, please find below our design summary based on the information provided. Below are some graphs showing the typical cycle of a conDEA™ treatment system.

1. conDEA™ TREATMENT PROCESS

Deammonification represents a short-cut in the N-metabolism pathway and comprises of 2 steps. About half the amount of ammonia is oxidized to nitrite and then residual ammonia and nitrite is anaerobically transformed to elementary nitrogen. See this shortcut in the diagram below. By using this process there is no excess oxygen required or external carbon source to achieve nitrogen removal.



Implementation of the University of Innsbruck pH controlled strategy for the conDEA™ process for deammonification of reject water in a single sludge SBR is what this design is proposed around. The **specific energy demand of the side stream process results in 1.4 kWh per kg ammonia nitrogen removed comparing to about 6.5 kWh of mainstream treatment.** This process is achieving results of greater than 90% at the Strass WWTP (see data presented below). Biomass enrichment and conDEA™ -start up is key for this process to achieve its results in a short period of time and this proposal provides the seed sludge and start up assistance to ensure achieving the goal of efficient nitrogen removal.



Design Concept

The overall design concept for is to use one (1) new reactor for the 50% Filtrate design or two (2) new reactors for the Ostara Effluent design to create conDEA^{TM} treatment systems and EQ tank for the design conditions provided. We envision using for the 50% Filtrate design 32 ft of reactor length x 32 ft wide x 21 ft SWD for the conDEA^{TM} process while for the Ostara Effluent design would use two (2) - 36 ft of reactor length x 18 ft wide x 21 ft SWD for the conDEA^{TM} process. New mixers and aeration system will be placed in each reactor for providing the mixing energy for re-suspension of the granules, proper mixing distribution of the influent feed flow and provide the necessary aeration for nitritation. A lamella clarifier will be used to settle out the MLSS / Anammox biomass and allow the treated wastewater to be discharged. A RAS pump will be supplied with flow meter to pump the MLSS and Anammox back to the process tank. A single control panel will be provided to control process.

The Strass WWTP has been operating with a new Anammox retention system, which has proven to be very successful and will allow for the conDEA^{TM} process to a continuous process vs. the SBR mode. We see many advantages in this upgrade to the Anammox process as it will allow for a lower installed HP for the blowers, not require the Decanter and operate continuously with higher Anammox biomass retention which allows for higher operating loading rates.

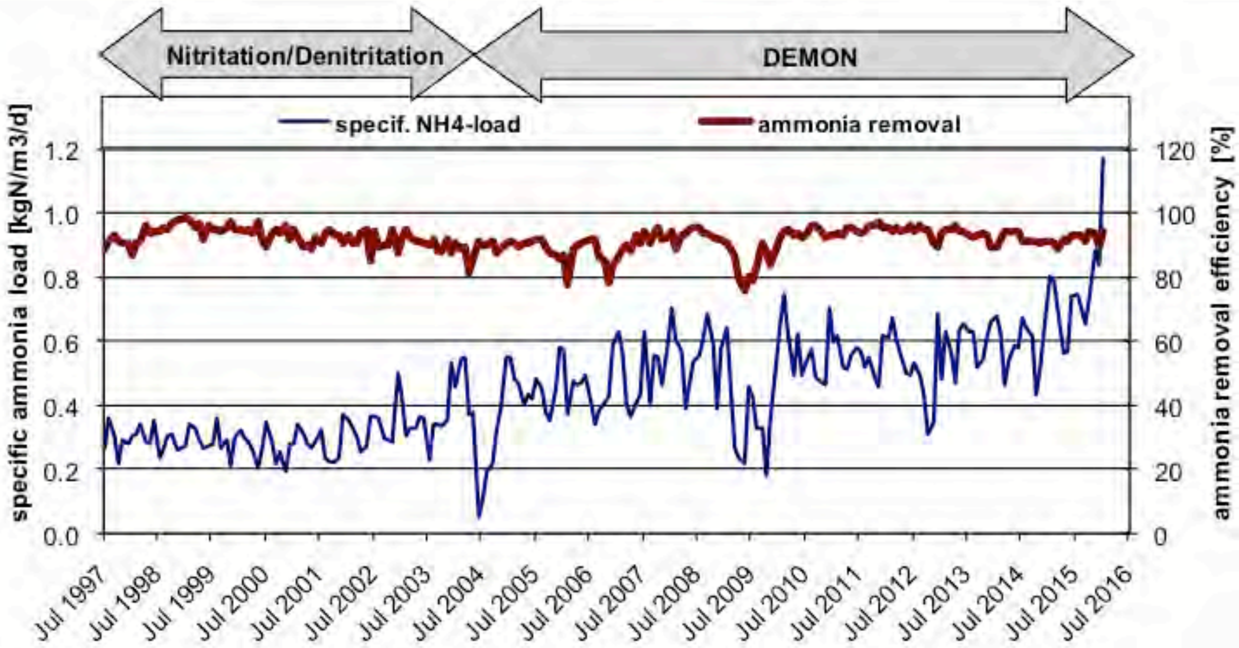
We have designed the system based on having removal efficiencies of 90% for ammonia and 80% for TIN however the aeration system is sized based on 95% ammonia removal. We have also assumed minimum operating temperature of 25C.

Under 50% Filtrate Loads with influent ammonia load of 1,172 lb/day, the estimated effluent ammonia using one (1) reactor will be 117 lb/day and total nitrogen will be < 235 lb/day. Under Ostara Effluent Design Loads with influent ammonia load of 1,202 lb/day, the estimated effluent ammonia using two (2) reactors will be 120 lb/day and total nitrogen will be < 240 lb/day.

conDEA™ TANK COMPONENTS

a) **Biomass Separation System** – A micro-screen will be used for this project and will have submerged pumps feeding it for a period time to waste out the AOB and NOB bacteria. The waste sludge of AOB and NOB bacteria will be discharged from the system while the underflow (Anammox bacteria) will be returned to the reactor.

Below are graphs of the loading and % removal of the Anammox treatment system at Strass WWTP in Austria using the microscreen since last fall time 2015. In February 2016, The specific load was increased to over 1.4 kg/m3-day while still maintaining greater than 90% removal of Ammonia-nitrogen.


Nitritation/Denitritation
DEMON
specif. NH4-load
ammonia removal
specific ammonia load [kgN/m3/d]
ammonia removal efficiency [%]
0.0
0.2
0.4
0.6
0.8
1.0
1.2
0
20
40
60
80
100
120
Jul 1997
Jul 1998
Jul 1999
Jul 2000
Jul 2001
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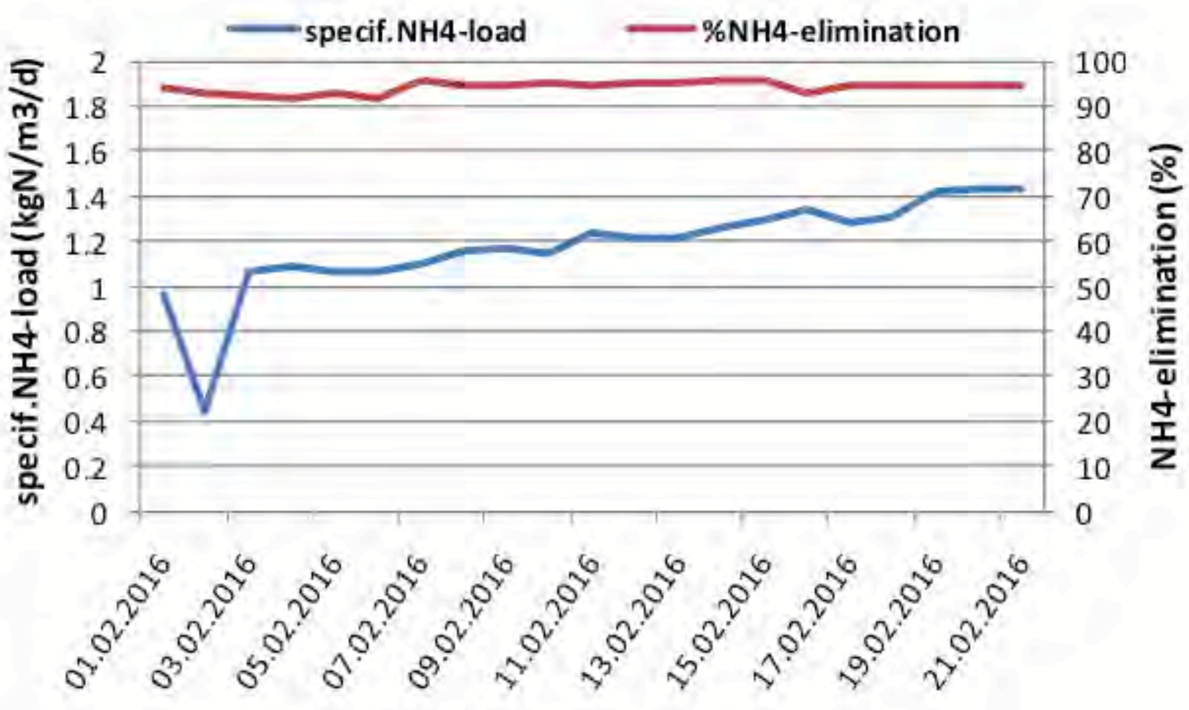
Jul 2015
Jul 2016

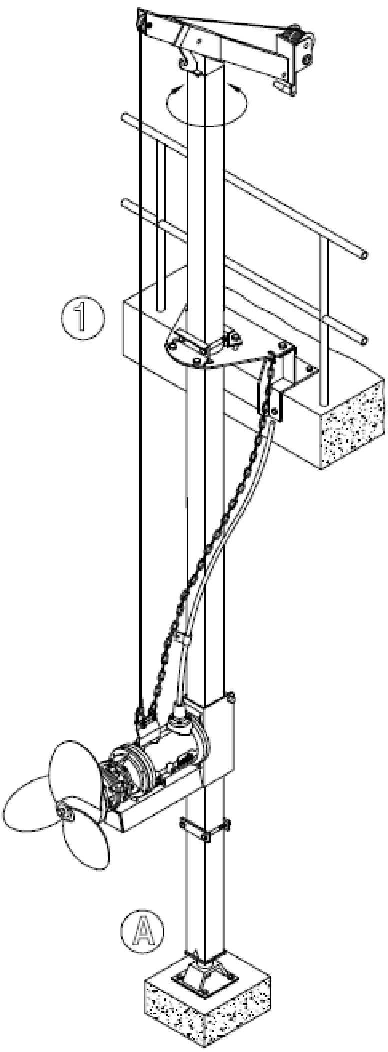

specif.NH4-load
%NH4-elimination
specif.NH4-load (kgN/m3/d)
NH4-elimination (%)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
0
10
20
30
40
50
60
70
80
90
100
01.02.2016
03.02.2016
05.02.2016
07.02.2016
09.02.2016
11.02.2016
13.02.2016
15.02.2016
17.02.2016
19.02.2016
21.02.2016

b) **<u>Instrument Float</u>** – the instruments for control of the process will be installed on a float system which will float with the level of the system. One (1) pH probe & one (1) DO probe for control of the overall operation of the process will be provided. A dedicated controller for the DO and pH is our recommendation. The conductivity probe is also to be provided with its own controller. Spare instrument locations will be provided in the instrument float for adding additional analyzers over time.


c) **<u>Seed Sludge</u>** – for the quick start up of the conDEA^{TM} treatment process, an adequate amount of seed sludge will be supplied. The seed sludge will be shipped in as dry content possible based on the harvesting technique used and will be added to the systems as they are started up.


d) **<u>Aeration System</u>** – The Messner aeration system will be supplied in each tank. The amount of panels is provided in the scope of supply section and is subject to final design.


e) **Side Mounted Mixers** – Landia side mounted mixers will be used to maintain mixing energy within each reactor. The mixers will help re-suspend the "reds" during the start up phase of each cycle. VFD's will be provided to allow the mixers to be turned down and save on energy during the overall operation of the cycle.



f) **<u>Lamella Clarifier</u>** – A lamella clarifier with RAS pump will be provided to allow for a continuous operation of the Anammox treatment system. Clarified effluent will be discharged back into the main process while the RAS will be returned to the Anammox reactor. The waste stream enters the vessel and immediately the velocity is reduced to enhance particle separation. As the vessel is polypropylene, the pH can be adjusted low to enhance separation efficiencies. The waste stream passes through lamella HDPE plates which provide additional surface area for the separation to occur. The "clean" liquid is continuously removed from the top of the plates and passes through holes into an effluent trough. From the effluent trough, the wastewater gravity feeds out of the system. Heavy solids settle into a cone bottom where they can be purged on an automated basis. The system is compact, robust, cleanable, and does not have moving parts.

50% FILTRATE DESIGN

System Specifications	
Model	**SPC-300**
Max. Flow	**80 GPM**
Maximum Temp.	**<170 °F**
pH Tolerance	**1 – 12 S.U.**
Weight (approximate)	
Shipping	**2,600 lbs**
Operational	**12,300 lbs**
Dimensions (approximate)	
Overall (WxLxH)	**5'4" x 11'6" x 6'10"**
Pipe Diameters	
Outlet & Sludge	**2" (150 lb ANSI Flange)**
Standard Equipment	
Sludge Pump	**2" Air Operated Diaphragm**
Solenoid Valves	**SMC NVFS2100-5FZ**
Control Valves	**Orbinox 2" Pneumatic Knife Gate**
Materials of Construction	
Vessel	**Polypropylene**
Piping	**Polypropylene and Sch.80 PVC**
Lamella Plates	**PVC**
Platform/Grating	**Fiberglass**
Pneumatic Valves	**Cast Body / Stainless Steel Internals**
Manual Valves	**SCH 80 PVC**
Gaskets	**EPDM**

OSTARA EFFLUENT DESIGN – 1 X PROCESS TRAIN

System Specifications	
Model	**SPC-600**
Max. Flow	**225 GPM**
Maximum Temp.	**<170 °F**
pH Tolerance	**1 – 12 S.U.**
Weight (approximate)	
Shipping	**5,300 lbs**
Operational	**23,400 lbs**
Dimensions (approximate)	
Overall (WxLxH)	**7'0" x 11'1" x 12'6"**
Pipe Diameters	
Outlet	**8" (150 lb ANSI Flange)**
Sludge	**3" (150 lb ANSI Flange)**
Standard Equipment	
Sludge Pump	**3" Air Operated Diaphragm**
Solenoid Valves	**SMC NVFS2100-5FZ**
Control Valves	**Orbinox 3" Pneumatic Knife Gate**
Materials of Construction	
Vessel	**Polypropylene**
Piping	**Polypropylene and Sch.80 PVC**
Lamella Plates	**PVC**
Platform/Grating	**Fiberglass**
Pneumatic Valves	**Cast Body / Stainless Steel Internals**
Manual Valves	**SCH 80 PVC**
Gaskets	**EPDM**

g) **Blowers** – Positive displacement blowers capable of providing the necessary turndown for operation of the conDEA™ system are to be provided.

Design Case	**Model**	**Air Flow**	**Est. HP**	**Est. bHP**
50% Filtrate – 1 duty + 1 standby	GM 25S	440 SCFM	50 HP	29.9 bHP
100% Ostara Effluent – 2 duty + 2 standby	GM 10S	225 SCFM	25 HP	16.5 bHP

This blower design will allow the most flexibility in allowing the system have efficient use of blower capacity during start up and low load periods of time. The blowers will each have its own sound enclosure to maintain < 75 db sound rating. Each blower will also be equipped with a variable frequency drive unit to allow efficient turndown of the blower while maintaining the proper dissolved oxygen concentration in the conDEA™ reactor.

h) Documentation / Design / License – All necessary documentation and design information will be provided as well as a license for treating the Maximum Month Loads for either option.

2. CONTROLS

World Water Works provides pre-wired control panels to optimally control all equipment provided within the scope of this proposal. World Water Works includes an Ethernet connection with the control panel to allow remote access to the program and to assist in troubleshooting.

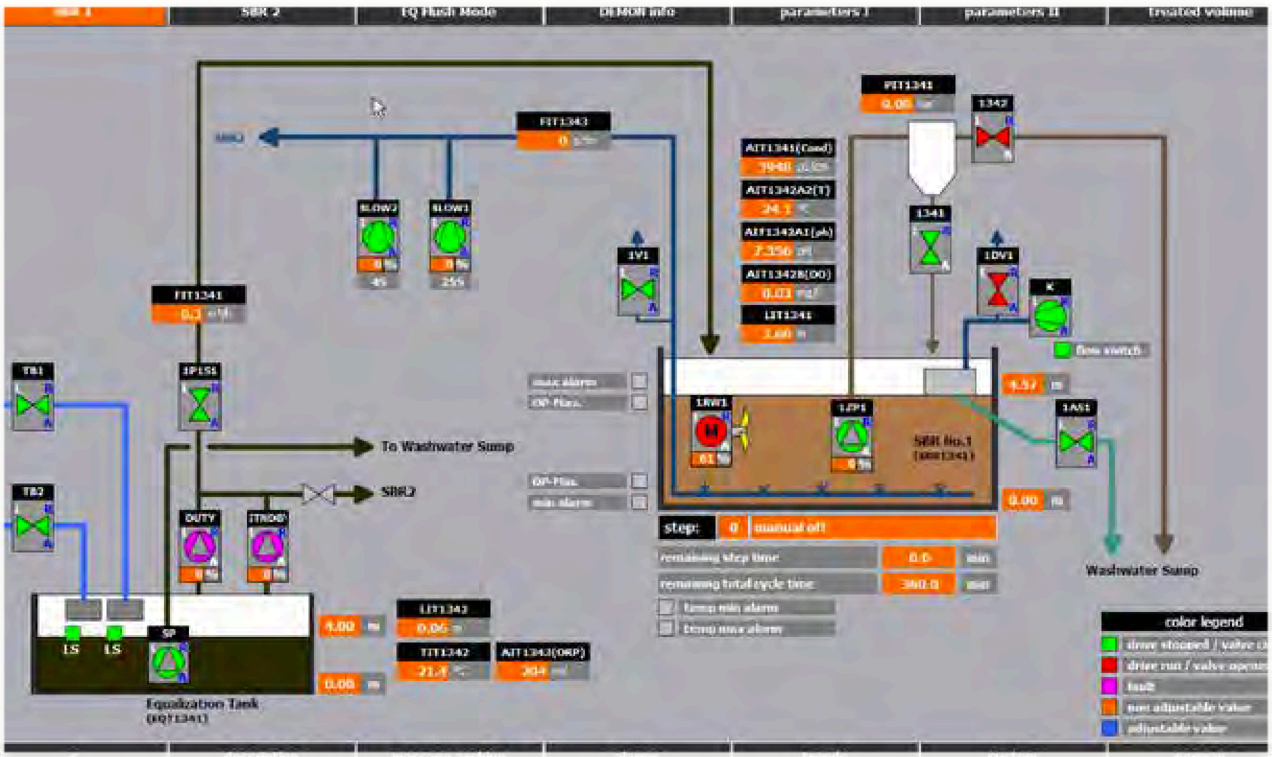
INSTRUMENTATION

Electrical Enclosure	**Hoffman, NEMA 4**
PLC	**Allen Bradley**
Software	**Allen Bradley**
Touchscreen	**15 inch Color Touch Screen**
Motor Starters	**Cutler Hammer or equiv**
Indicator & Stack Lights	**Cutler Hammer or equiv, Nema 4**
Control Buttons	**Cutler Hammer or equiv, Nema 4**
Local Disconnect	**Hubbell, NEMA 4**
Air Solenoids	**SMC**
Phase Protector	**SYMCON**

ADDITIONAL OPTIONS PROVIDED

Remote Operation Capability
UL Listed Panel
Stainless Steel Electrical Enclosure

PLC Panel – The PLC panel and control program is the heart of the conDEA™ process and its integral to our scope of supply. The PLC program will have each reactor created as a separate reactor. The reactor will have independent feed of raw centrate, aeration and mixing time. A touch panel with remote access is standard for allowing WWW access to the system and provides operational oversight.



Example HMI Screen

DESIGN FOR 25C – 50% Filtrate LOAD – NEW TANKAGE

Basic process figures	Design		Design	
Water temperature in conDEA Anammox-tank	25	°C	77	F
Load and concentration				
Daily water flow	354	m^3/d	0.094	MGD
NH4-N-load	531	kg/d	1,172	lb/day
NH4-N-concentration	1,500	mg/L	1,500	mg/L
COD soluble, degradable (estimate)	200	mg/L	200	mg/L
Suspended solids	300	mg/L	300	mg/L
COD soluble, degradable load	71	kg/d	156	lbday
Ssuspended solids load	106	kg/d	234	lb/day
Alkalinity Concentration	5,800	mg/L	5,800	mg/L
Alkalinity Load	2,055	kg/d	4,531	lbday
conDEA Anammox-tanks				
Number of tanks	1	in parallel	1	in parallel
Max. water depth	6.40	m	21.0	ft
Total volume per conDEA Anammox Reactor	609	m^3	21,504	m^3
Length of Each conDEA Anammox Treatment Reactor	9.8	m	32	ft
Width of Each conDEA Anammox Treatment Reactor	9.8	m	32	ft
Total Treatment Volume Provided	609	m^3	21,504	ft^3
Inlet				
Feeding pump per tank	32	m^3/h	143	gpm
Design of aeration system				
Oxygen consumption				
Daily oxygen consumption, operating conditions	982	kg O2/d	2,166	lb O2/d
Oxygen consumption per hour and conDEA Anammox tank, operating conditions	58	kg O2/h	129	lb O2/h
Fine bubble aeration				
Design air flow (per conDEA Anammox-tank)	743	Nm^3/h	437	SCFM

Air flows are based on 21 ft operating water level and discharge pressure of 10.5 psig

Rough Footprint would be one (1) basin at 32 ft wide x 32 ft long x 21 ft SWD, each

DESIGN FOR 25C – 100% OSTARA EFFLUENT LOAD – NEW TANKAGE

Basic process figures	Design		Design	
Water temperature in conDEA Anammox-tank	25	°C	77	F
Load and concentration				
Daily water flow	2,180	m^3/d	0.576	MGD
NH4-N-load	545	kg/d	1,202	lb/day
NH4-N-concentration	250	mg/L	250	mg/L
COD soluble, degradable (estimate)	100	mg/L	100	mg/L
Suspended solids	200	mg/L	200	mg/L
COD soluble, degradable load	218	kg/d	481	lbday
Ssuspended solids load	436	kg/d	961	lb/day
Alkalinity Concentration	1,000	mg/L	1,000	mg/L
Alkalinity Load	2,180	kg/d	4,807	lbday
conDEA Anammox-tanks				
Number of tanks	2	in parallel	2	in parallel
Max. water depth	6.40	m	21.0	ft
Total volume per conDEA Anammox Reactor	386	m^3	13,613	m^3
Length of Each conDEA Anammox Treatment Reactor	5.5	m	18	ft
Width of Each conDEA Anammox Treatment Reactor	11.0	m	36	ft
Total Treatment Volume Provided	771	m^3	27,226	ft^3
Inlet				
Feeding pump per tank	100	m^3/h	440	gpm
Design of aeration system				
Oxygen consumption				
Daily oxygen consumption, operating conditions	1,010	kg O2/d	2,226	lb O2/d
Oxygen consumption per hour and conDEA Anammox tank, operating conditions	30	kg O2/h	66	lb O2/h
Fine bubble aeration				
Design air flow (per conDEA Anammox-tank)	382	Nm^3/h	225	SCFM
Design air flow (per ALL TANKS)	764	Nm^3/h	449	SCFM

Air flows are based on 21 ft operating water level and discharge pressure of 10.5 psig

Rough Footprint would be two (2) basins at 18 ft wide x 36 ft long x 21 ft SWD, each

CONSUMABLES OF CONVENTIONAL VS. conDEA™ TREATMENT SYSTEM –

DESIGN CONDITIONS

Nitrogen-Load	1,202	lb/day
Energy costs	$0.070	USD $ /kWh
Specific energy costs	0.2268	kWh/lb O2
Methanol	$0.147	USD $ /lb
Sludge	$367	USD $ /US ton

Conventional Nitrification / Denitrification				**Specific Costs (USD $ / lb N)**	**Costs per Year**	
Oxygen	4.3	lb/lb N		0.0685	$	30,030
Methanol	2.3	lb/lb N		0.3391	$	148,725
Sludge	0.35	lb/lb N		0.0643	$	28,203
			TOTAL	**0.4718**	**$**	**206,957**

conDEA Anammox Treatment System				**Specific Costs (USD $ / lb N)**	**Costs per Year**	
Oxygen	1.6125	lb/lb N		0.0257	$	11,261
Methanol	0	lb/lb N		0.0000	$	-
Sludge	0.03	lb/lb N		0.0055	$	2,417
			TOTAL	**0.0312**	**$**	**13,679**

Savings per year on aeration	**$**	**18,769**
Savings per year on Methanol	**$**	**148,725**
Savings per year on Sludge disposal	**$**	**25,786**
Total Operational Savings per year	**$**	**193,279**

Calculation does not include any savings from alkalinity addition required in conventional vs. conDEA™ Treatment System

WWW Scope of Supply – 50% FILTRATE FLOW & LOAD – NEW TANK:

- Design & Engineering for System
- One (1) SPC-300 Lamella Clarifier with duplex RAS pump system
- Three (3) 10 inch flow control values for isolation of Clarifier and micro-screen
- Nineteen (19) Messner Aeration panels for the reactor
- One (1) SS 304L Drop pipe with manifold to feed Messner panels
- One (1) conDEA™ Biomass Separation System
- Two (2) submersible pumps (one duty + one standby) rated at 50 gpm and 5 HP motor with VFD's on each pump (operated 8 hrs per day)
- One (1) Pressure sensor with 4-20 mA output for monitoring of conDEA™ Biomass Separation system
- Two (2) Radar type level control for each conDEA™ Tank & EQ Tank
- Two (2) influent feed pumps to the conDEA™ reactor each rated for 150 gpm with VFD's on each pump. (operated 12 - 24 hrs per day) (1 duty + 1 standby)
- Two (2) Positive Displacement blowers (440 SCFM each) with VFD's on each blower (50 HP motors) (operated 14 hrs per day at design load) – (1 Duty + 1 Standby)
- One (1) – 12.2 HP side mounted mixers with VFD's for each mixer (operated 6 hr/day)
- Seed Sludge for start up of system delivered to the site
- conDEA™ Control program with panel with VFD's for blowers, submersible pump and mixers
- One (1) pH and DO probe with one (1) SC1000 controller
- One (1) Conductivity probe with one (1) SC200 controller
- One (1) Air flow insertion meter and three (3) water flow magnetic meters
- Inspection, start up and training services (8 trips / 30 days)
- 3-4 months of off-site / remote monitoring services
- **Estimated Price for above scope of supply: $1,150,000 USD**

Items not included:

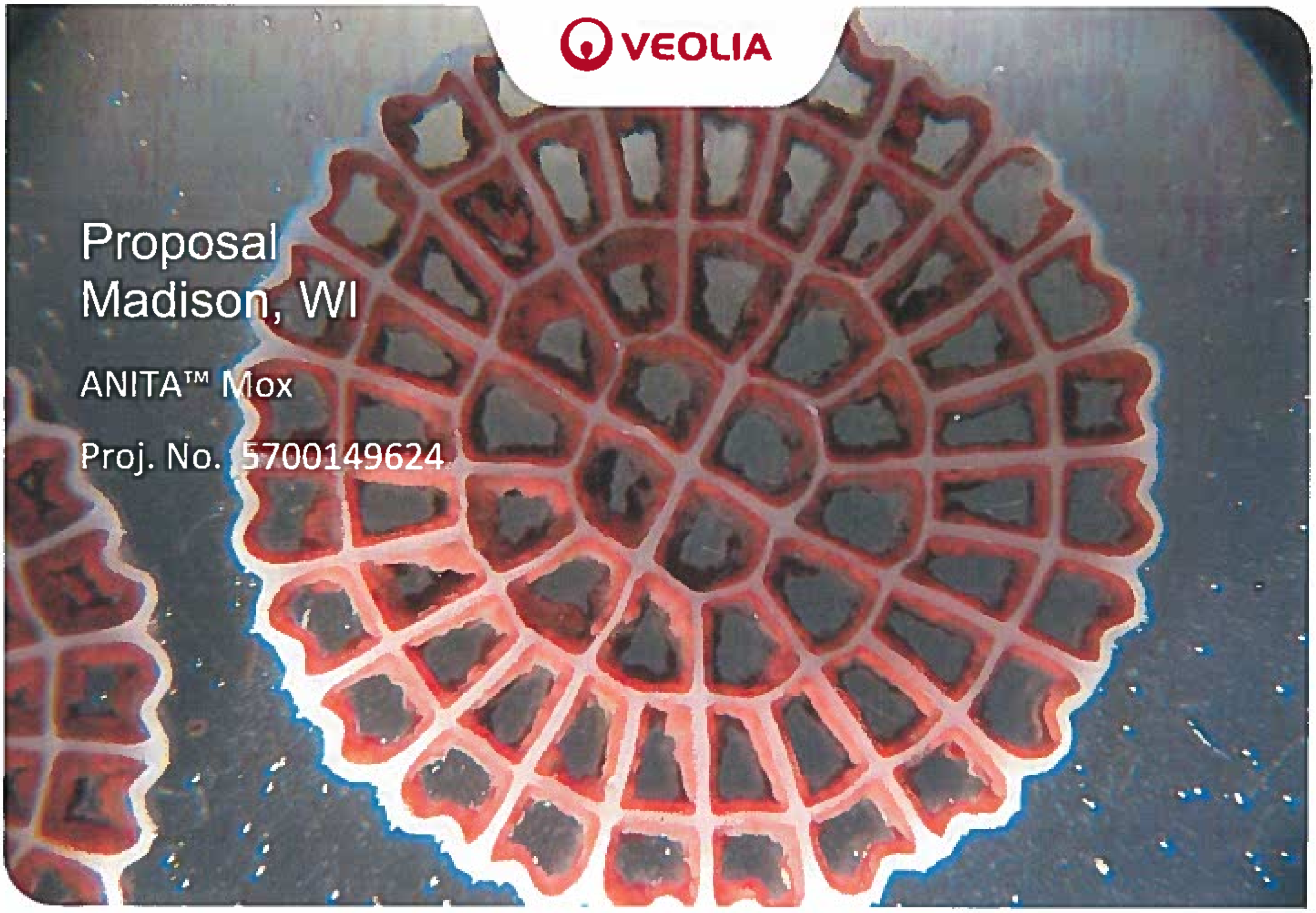
Tankage for EQ tank and conDEA™ tank
Unloading, storage, installation of equipment
Electrical connections and interconnecting piping

WWW Scope of Supply – OSTARA FLOWS & LOADS – NEW TANKS:

- Design & Engineering for System
- Two (2) SPC-600 Lamella Clarifiers with each their own duplex RAS pump system
- Six (6) 10 inch flow control values for isolation of Clarifier and micro-screen
- Twenty (20) Messner Aeration panels for both reactors (10 per reactor)
- Two (2) SS 304L Drop pipes with manifolds to feed Messner panels
- Two (2) conDEA™ Biomass Separation System
- Three (3) submersible pumps (two duty + one standby) rated at 110 gpm and 10 HP motor with VFD's on each pump (operated 8 hrs per day)
- Two (2) Pressure sensor with 4-20 mA output for monitoring of conDEA™ Biomass Separation system
- Three (3) Radar type level control for each conDEA™ Tank & EQ Tank
- Three (3) influent feed pumps to the conDEA™ reactor each rated for 450 gpm with VFD's on each pump. (operated 12-24 hrs per day) (2 duty + 1 standby)
- Four (4) Positive Displacement blowers (225 SCFM each) with VFD's on each blower (25 HP motors) (operated 14 hrs per day at design load) – (1 Duty + 1 Standby per system)
- Two (2) – 9.2 HP side mounted mixers (1 per tank) with VFD's for each mixer (operated 6 hr/day)
- Seed Sludge for start up of system delivered to the site
- conDEA™ Control program with panel with VFD's for blowers, cyclone pump and mixers
- Two (2) pH and DO probes with two (2) SC1000 controllers
- Two (2) Conductivity probes with two (2) SC200 controllers
- Two (2) Air flow insertion meters and six (6) water flow magnetic meters
- Inspection, start up and training services (10 trips / 40 days)***
- 3-4 months of off-site / remote monitoring services
- **Estimated Price for above scope of supply: $1,900,000 USD**

Items not included:

New tankage for EQ tank and conDEA™ tanks
Unloading, storage, installation of equipment
Electrical connections and interconnecting piping



Proposal
Madison, WI

ANITA™ Mox

Proj. No. 5700149624

Submitted to: Don Esping
Brown & Caldwell

Submitted by: Daniel Hurt
Application Engineer

Date: 12/5/2016

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Cary, NC 27513
tel. +1 919-677-8310 • fax +1 919-677-0082
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Water Technologies

Introduction

I. Kruger Inc. (a subsidiary of Veolia Water Technologies) is pleased to present this budgetary proposal for our ANITA™ Mox process for deammonification of the anaerobic digester and Ostera rejection water in Madison, WI. This design is based upon the information we have received from you. The influent design criteria are summarized in Table 1.

In order to achieve the expected removals as summarized in Table 2, we recommend constructing one (1) ANITA Mox process train. The tank dimensions along with other important process parameters are summarized in Table 3.

For the Ostera Effluent design, Kruger has proposed a design for 80-85% removal. If this percent removal is not required for the overall plant design, a 65-70% removal could provide a more economical solution due to reduced removal rates at lower concentrations.

It is important that each reactor have the capability for independent control of influent feed and aeration. This can be accomplished through dedicated pumps and blowers or by using high performance modulating valves. We have included one (1) modulating influent valves and one (1) dedicated blower per train as part of Kruger's Scope to meet this need. Kruger recommends the use of an equalization tank upstream of the ANITA Mox process to reduce the number of interruptions in flow to the process caused by the plant's dewatering schedule. Kruger also recommends covering the basins to minimize heat loss if significant loss is possible given the site layout.

We appreciate the opportunity to provide this proposal to you. If you have any questions or need further information, please contact our local Representative, Rob Szekeress of Peterson & Matz, Inc., or our Regional Sales Manager, Andy Szekeress, at (715)-693-5960 (andy.szekeress@veolia.com).

cc: CT, AJS, GAT, MTE, project file (Kruger)
Rob Szekeress (Peterson & Matz, Inc.)

Revision	Date	Process Eng.	Comments
0	12/02/2016	MTE	Initial, budgetary proposal.

We Know Water

I. Kruger Inc. (Kruger) is a water and wastewater solutions provider specializing in advanced and differentiating technologies. Kruger provides complete processes and systems ranging from biological nutrient removal to mobile surface water treatment. The ACTIFLO® Microsand Ballasted Clarifier, BioCon® Dryer, BIOSTYR® Biological Aerated Filter (BAF) and NEOSEP™ **MBR are just a few of the innovative technologies offered by Kruger.**

Kruger Inc. is a Veolia Water Solutions & Technologies' (VWS) company providing innovative water and wastewater treatment solutions for the U.S. municipal market. As a global company with 135 Business Units in 57 countries, **Veolia Water** with nearly 10,000 employees worldwide and with over 250 proprietary technologies is the world leader in water and wastewater treatment.

Kruger delivers unequalled **S**ervice to our customers delivering and creating **V**alue while being environmentally **R**esponsible with a focus on safety. Since 1986, Kruger has been providing leading edge technologies for biological wastewater treatment, High Rate Clarification for phosphorus removal and water treatment, filtration for TSS removal, water reuse and drinking water and Biosolids processing. Based in Cary, North Carolina, Kruger's 120 plus professionals are dedicated to providing the most technically sound solution to meet our customers' needs while following our principles of **SVR.**

Energy Focus

Kruger, along with Veolia Water Solutions & Technologies (VWS) is dedicated to delivering sustainable and innovative technologies and solutions. We offer our customers integrated solutions which include resource-efficient technology to improve operations, reduce costs, achieve sustainability goals, decrease dependency on limited resources, and comply with current and anticipated regulations.

Veolia's investments in R&D outpace that of our competition. Our focus is on delivering

- neutral or positive energy solutions
- migration towards green chemicals or zero chemical consumption
- water-footprint-efficient technologies with high recovery rates

Our carbon footprint reduction program drives innovation, accelerates adoption and development of clean technologies, and offers our customers sustainable solutions.
Kruger is benchmarking its technologies and solutions by working with our customers and performing total carbon cost analysis over the lifetime of the installation.
By committing to the innovative development of clean and sustainable technologies and solutions worldwide, Kruger and VWS will continue to maximize the financial benefits for every customer.

Process Description

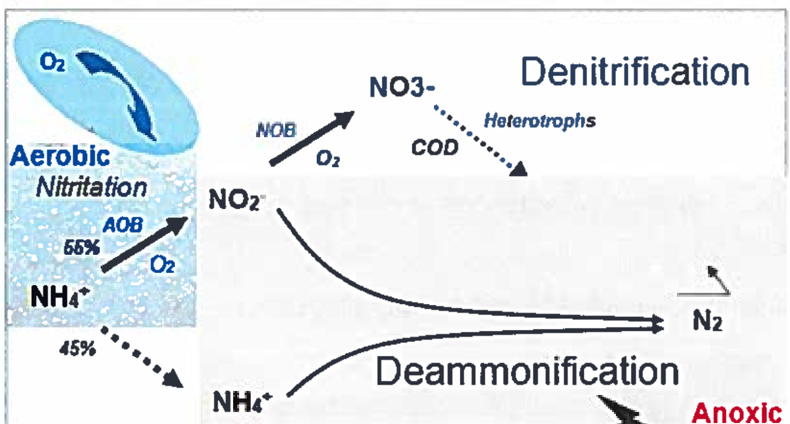
AnoxKaldnes MBBR

The MBBR process is a continuous-flow, non-clogging biofilm reactor containing moving "carrier elements" or media. The media flows with the water currents in the reactor and does not require backwashing or cleaning.

The biomass that treats the wastewater is attached to the surfaces of the media. The media is designed to provide a large protected surface area for the biofilm and optimal conditions for biological activity when suspended in water. AnoxKaldnes media is made from polyethylene and has a density slightly less then water.

The ANITA™ Mox process is a single-stage nitrogen removal process based on the MBBR platform. The process is specifically designed for treatment of waste streams with high ammonia concentrations. The system can achieve ammonia removals of up to 80-90% and total nitrogen removals of up to 75-85%. The treatment method uses only 40% of the oxygen demand of conventional nitrification, and it requires no external carbon source.

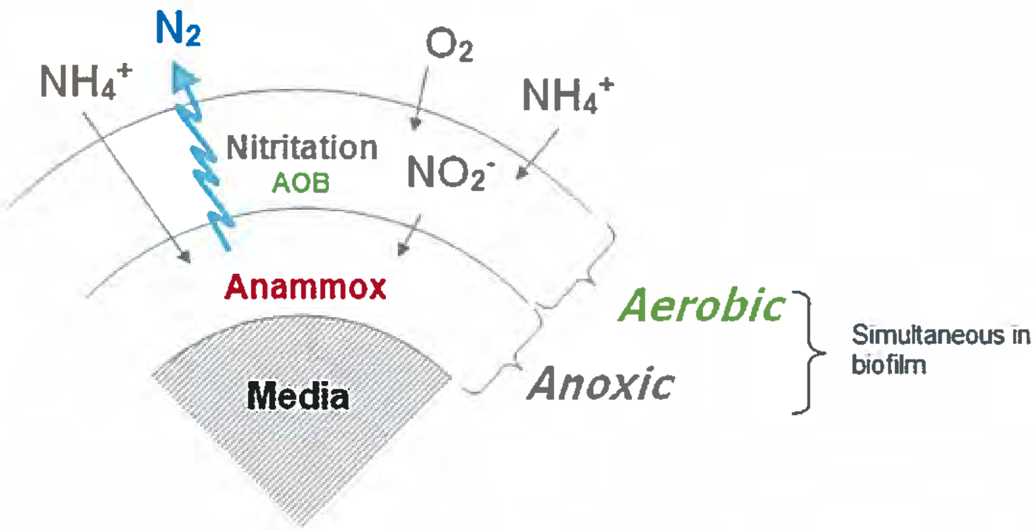
Nitrogen removal with ANITA™ Mox



$$NH_4^+ + 1.32\,NO_2^- + .066\,HCO_3^- + .13\,H^+ \rightarrow$$
$$1.02\,N_2 + .26\,NO_3^- + .066\,CH_2O_{0.5}N_{0.15} + 2.03\,H_2O$$

Anammox Reaction

The ANITA Mox process consists of an aerobic nitritation reaction and an anoxic ammonia oxidation (anammox) reaction. The two steps take place simultaneously in different layers of the biofilm. Nitritation occurs in the outer layer of the biofilm. Approximately 55% of the influent ammonia is oxidized to nitrite (NO_2^-). Anammox activity occurs in the inner layer. In this step, the nitrite produced and the remaining ammonia are utilized by the anammox bacteria and converted to nitrogen gas (N_2) and a small amount of nitrate (NO_3^-).



The aerobic and anoxic reactions occur in a single MBBR reactor. The combined biomass grows attached to the AnoxKaldnes media and is retained in the reactor by media screens. This biomass retention is an important characteristic of the system, since the anammox bacteria growth rate is very slow when compared to conventional wastewater bacteria growth rates.

AnoxKaldnes ANITA™ Mox System Configuration

Kruger proposes the ANITA™ Mox process for deammonification at the Madison, WI Nine Springs WWTP. We recommend constructing one (1) ANITA Mox MBBR process train using our K5 media.

Kruger's minimum scope of supply includes the AnoxKaldnes media, screen assemblies (to keep media in each reactor), medium bubble aeration grids, and mixers. In cases where they are needed, Kruger also provides the blowers, instrumentation and controls, SCADA, and field instruments (dissolved oxygen, nitrate, ammonia, etc.) for single-source responsibility.

Design Summary

The design assumes that the side stream entering into the proposed ANITA Mox system contains no toxic compounds and has sufficient alkalinity and that none of the equipment provided would be used in a classified area (e.g. Class 1, Division 1 or Class 1, Division 2).

The ANITA Mox influent design basis is summarized in Table 1. The target effluent criteria for the ANITA Mox system are listed in Table 2. The process design is summarized in Table 3.

Table 1: Influent Design Basis

Parameter	Units	50% Digester Recycle Values	Ostera Effluent Values
Flow, Design	MGD	0.058	0.5
Flow, Peak (to EQ)	MGD	0.14	0.72
BOD_5, Design Flow	mg/L	150	100
COD, Design Flow	mg/L	800	250
TSS, Design Flow	mg/L	300	600
NH_4-N, Design Flow	mg/L	1,500	250
Alkalinity, Design Flow[1]	mg/L	>500	1000
Elevation	ft	800[2]	
Minimum Temperature	°C	25	25 (heated)

1 Supplemental alkalinity required to optimize removals.

2 Assumed values.

Table 2: Expected Removals

Parameter	Units	Anticipated % Removal*
NH4-N (mg/L)	%	80-85
Total Inorganic Nitrogen (mg/L)	%	75-80

*Anticipated performance, not process guarantee values.

Table 3: Process Design Summary

Parameter	Units	50% Digester Recycle Values	Ostera Effluent Values
Number of Process Trains	-	1	1
Dimensions (Each)	ft	32 × 32 × 15 SWD	45.5 x 45.5 x 18 SWD
Volume (Each)	ft^3	15,360	37,265
Total Volume (All Reactors, All Trains)	ft^3	15,360	37,265
Recommended Freeboard for all reactors	ft	2 – 3	
Media Type:	-	K5	
Fill of Biofilm Carriers, All Reactors	%	49	50
Media Volume (All Reactors, All Trains)	ft^3	7,486	18,576
Aeration System Type	-	Medium Bubble	Medium Bubble
Residual DO, Max. Month	mg/L	1.5	1.5
Total Process Air Requirement (All Reactors, All Trains)	SCFM	~685	~982
Discharge Pressure (From Top of Drop Pipe)	psi	6.4	7.7

Scope of Supply

Kruger is pleased to present our scope of supply which includes process engineering design, equipment procurement, and field services required for the proposed treatment system, as related to the equipment specified. The work will be performed to Kruger's high standards under the direction of a Project Manager. All matters related to the design, installation, or performance of the system shall be communicated through the Kruger representative giving the Engineer and Owner ready access to Kruger's extensive capabilities.

Process and Design Engineering

Kruger will provide process engineering and design support for the system as follows:

- Process Engineering consisting of aeration system sizing and configuration, sieve and outlet design.
- Review and approval of P&I Diagram for the AnoxKaldnes ANITA Mox portion of the process. Preliminary General Arrangement Drawings and review and approval of final General Arrangement Drawings for the process. Review of reactor drawings with respect to penetrations and dimensions, excluding structural design.
- Equipment installation instructions for all equipment supplied by Kruger.

Field Services

Kruger will furnish a Service Engineer to perform the following tasks:

- Inspect installation of key pieces of equipment during construction.
- Inspect the completed system prior to startup.
- Assist the Contractor with initial startup of the system.
- Train the Owner's staff in the proper operation and maintenance of the AnoxKaldnes ANITA Mox system.
- Test and start any Kruger-supplied control equipment, including PLC programming and SCADA systems.

AnoxKaldnes ANITA™ Mox System Equipment

Option 1: 50% Digester Recycle Values

Mechanical Equipment Items	Qty	Description
AnoxKaldnes K5 Media, (ft^3)	7,486	Carrier elements are made of high density polyethylene. The total media quantity will include a volume of ~5% seeded media.
Cylindrical Screen Assemblies	2	Two (2) per reactor. 304L SS. 23"ø perforated plate pipes terminated in ANSI flanges for mounting directly to the tank wall.
Medium Bubble Aeration System	4	Four (4) air grids per reactor. 304L SS including header, lateral piping, and hardware (excluding concrete anchor bolts).
Specially Designed Mechanical Mixers	1	One (1) per ANITA Mox Reactor. Includes VFD.
Airlift Pump	2	One (1) airlift pump per ANITA Mox reactor for foam suppression.
Modulating Influent Control Valves	1	One (1) actuated BFV for each train.
Positive Displacement Blowers	1 + 1	One (1) duty plus one (1) standby. Each blower will be rated for 700 SCFM and 40 NPHP at 7.0 psig differential pressure. Includes VFD.

Instrumentation and Controls Equipment Items	Qty	Description
PLC Control Panel	1	NEMA 12 Freestanding or Wall Mount Control Panel (For Indoor Use). ControlLogix PLC; Panelview HMI; 120V Feed
pH-based Control Logic	1	For Optimum nitritation, deammonification and energy efficiency
High Level Float Switch	1	One (1) for each media zone.
DO Probe (LDO)	1	One (1) for each Aerobic zone. Aerobic Zone DO Monitoring
pH meter	1	One (1) pH meter for each ANITA Mox reactor.
Thermal Mass Flowmeter	1	One (1) for each ANITA Mox reactor for air flow control
Magnetic Flowmeter	1	One (1) magnetic flow meter per reactor to measure inf. flow.

Option 2: Ostera Effluent Values

Mechanical Equipment Items	Qty	Description
AnoxKaldnes K5 Media, (ft^3)	18,608	Carrier elements are made of high density polyethylene. The total media quantity will include a volume of ~5% seeded media.
Cylindrical Screen Assemblies	4	Four (4) per reactor. 304L SS. 23"ø perforated plate pipes terminated in ANSI flanges for mounting directly to the tank wall.
Medium Bubble Aeration System	4	Four (4) air grids per reactor. 304L SS including header, lateral piping, and hardware (excluding concrete anchor bolts).
Specially Designed Mechanical Mixers	1	One (1) per ANITA Mox Reactor. Includes VFD.
Airlift Pump	2	One (1) airlift pump per ANITA Mox reactor for foam suppression.
Modulating Influent Control Valves	1	One (1) actuated BFV for each train.
Positive Displacement Blowers	1 + 1	One (1) duty plus one (1) standby. Each blower will be rated for 1,000 SCFM and 75 NPHP at 8.3 psig differential pressure. Includes VFD.

Instrumentation and Controls Equipment Items	Qty	Description
PLC Control Panel	1	NEMA 12 Freestanding or Wall Mount Control Panel (For Indoor Use). ControlLogix PLC; Panelview HMI; 120V Feed
pH-based Control Logic	1	For Optimum nitritation, deammonification and energy efficiency
High Level Float Switch	1	One (1) for each media zone.
DO Probe (LDO)	1	One (1) for each Aerobic zone. Aerobic Zone DO Monitoring
pH meter	1	One (1) pH meter for each ANITA Mox reactor.
Thermal Mass Flowmeter	1	One (1) for each ANITA Mox reactor for air flow control
Magnetic Flowmeter	1	One (1) magnetic flow meter per reactor to measure inf. flow.

Notes Regarding System Design and Installation

- A note on concrete specifications: For any MBBR or IFAS system, regardless of manufacturer, it is sound practice to require good, quality concrete work for the process reactors. The Consulting Engineer's standard concrete specification section is typically adequate to eliminate large holes, excessive form marks, large pockets, and excessively rough areas. It is particularly important to eliminate the potential for annular space around media retention screens.
- A note on construction sequencing: It is important, particularly for IFAS installations, to have level detection and level communication systems in place and operational prior to the filling of process tanks with water and media.

Scope of Supply BY INSTALLER/PURCHASER

The scope of supply by others for the AnoxKaldnes ANITA™ Mox system should include, but is not limited to, the following items:

- All civil/site and electrical work.
- A concrete foundation for the tanks.
- Reactors to house the MBBR treatment equipment.
- All provisions for interconnecting piping.
- Unloading, storage and installation of equipment.
- Install and test all level floats, level transmitters, level alarms, and alarm communication devices prior to filling a process tank with media and water
- Centrate equalization tanks
- Cover for reactor tanks
- Temporary provisions for screened primary or secondary effluent during startup.
- Temporary reactor heating during startup.
- Mixer bridges and other structural modifications for the reactors.
- Video recording of any training activities.

Design Options

In addition to the proposed system as detailed herein, Kruger is able to further incorporate our process and controls expertise into wastewater treatment plants, allowing municipalities to meet stringent effluent requirements and future plant upgrades. Kruger is also able to offer our instrumentation and controls expertise to build upon the proposed system by providing a **customized plant-wide SCADA system** or designing a **Motor Control Center (MCC)**, providing clients a single source responsibility for plant controls. Please contact Kruger if the options above are of interest or to be included in the current proposed system or future upgrades. ***Please note that the design options listed above are not included in the pricing noted herein.***

Schedule

- Shop drawings will be submitted within 6-8 weeks of receipt of an executed contract by all parties.
- All equipment will be delivered within 18-20 weeks after receipt of written approval of the shop drawings.
- Installation manuals will be furnished upon delivery of equipment.
- Operation and Maintenance Manuals will be submitted within 90 days after receipt of approved shop drawings.

Pricing

The prices for the AnoxKaldnes ANITA™ Mox system, as defined herein, including process and design engineering, field services, and equipment supply are:

Option 1 Digester Recycle Filtrate <u>$1,050,000</u>

Option 2 Ostera Effluent <u>$1,612,000</u>

Pricing is FOB shipping point, with freight allowed to the job site. This pricing does not include any sales or use taxes. In addition, pricing is valid for ninety (90) days from the date of issue.

Please note that the above pricing is expressly contingent upon the items in this proposal and are subject to I. Kruger Inc. Standard Terms of Sale detailed herein.

<u>Kruger Standard Terms of Payment</u>

The terms of payment are as follows:

- 10% on receipt of fully executed contract
- 15% on submittal of shop drawings
- 75% on the delivery of equipment to the site

Payment shall not be contingent upon receipt of funds by the Contractor from the Owner. There shall be no retention in payments due to I. Kruger Inc. All other terms per our Standard Terms of Sale are attached.

All payment terms are net 30 days from the date of invoice. Final payment not to exceed 120 days from delivery of equipment.

I. Kruger Inc. Standard Terms of Sale

1. Applicable Terms. These terms govern the purchase and sale of the equipment and related services, if any (collectively, "Equipment"), referred to in Seller's purchase order, quotation, proposal or acknowledgment, as the case may be ("Seller's Documentation"). Whether these terms are included in an offer or an acceptance by Seller, such offer or acceptance is conditioned on Buyer's assent to these terms. Seller rejects all additional or different terms in any of Buyer's forms or documents.

2. Payment. Buyer shall pay Seller the full purchase price as set forth in Seller's Documentation. Unless Seller's Documentation provides otherwise, freight, storage, insurance and all taxes, duties or other governmental charges relating to the Equipment shall be paid by Buyer. If Seller is required to pay any such charges, Buyer shall immediately reimburse Seller. All payments are due within 30 days after receipt of invoice. Buyer shall be charged the lower of 1 ½% interest per month or the maximum legal rate on all amounts not received by the due date and shall pay all of Seller's reasonable costs (including attorneys' fees) of collecting amounts due but unpaid. All orders are subject to credit approval.

3. Delivery. Delivery of the Equipment shall be in material compliance with the schedule in Seller's Documentation. Unless Seller's Documentation provides otherwise, Delivery terms are F.O.B. Seller's facility.

4. Ownership of Materials. All devices, designs (including drawings, plans and specifications), estimates, prices, notes, electronic data and other documents or information disclosed by Seller or prepared solely by Seller or Buyer or jointly by Seller and Buyer in connection with this Agreement, and all intellectual property rights therein, shall be and remain the confidential and proprietary property of Seller, whether or not patented by Seller ("Work Product"). Buyer hereby irrevocably assigns all rights in any Work Product to Seller. Seller grants Buyer a non-exclusive, non-transferable (except to a successor-in interest to the ownership of the Equipment), paid-up license to use the Work Product solely in connection with Buyer's use, operation, repair and maintenance of the Equipment at the Jobsite defined in this Agreement. Buyer may not disclose, share, transfer, or sell any such Work Product to third parties without Seller's prior written consent and such consent may be arbitrarily withheld. Buyer agrees not to resell, transfer or give any of the biologically colonized media or bacteria from the system to any party other than Seller or any of Seller's affiliates without the prior written consent of Seller for a period of fifteen (15) years from the effective date of this Agreement. Buyer shall not cultivate bacteria or use biomass carriers retrieved from the ANITA Mox system for any research or non-research purposes without prior written consent of the Seller. Any new developments, discoveries or inventions resulting from the operation of the ANITA Mox system in which the ANITA Mox process is a component or is in any way incorporated in whole or in part shall be owned solely by the Seller.

5. Changes. Seller shall not implement any changes in the scope of work described in Seller's Documentation unless Buyer and Seller agree in writing to the details of the change and any resulting price, schedule or other contractual modifications. This includes any changes necessitated by a change in applicable law occurring after the effective date of any contract including these terms.

6. Warranty. Subject to the following sentence, Seller warrants to Buyer that the Equipment shall materially conform to the description in Seller's Documentation and shall be free from defects in material and workmanship. The foregoing warranty shall not apply to any Equipment that is specified or otherwise demanded by Buyer and is not manufactured or selected by Seller, as to which (i) Seller hereby assigns to Buyer, to the extent assignable, any warranties made to Seller and (ii) Seller shall have no other liability to Buyer under warranty, tort or any other legal theory. If Buyer gives Seller prompt written notice of breach of this warranty within 18 months from delivery or 1 year from beneficial use, whichever occurs first (the "Warranty Period"), Seller shall, at its sole option and as Buyer's sole remedy, repair or replace the subject parts or refund the purchase price therefore. If Seller determines that any claimed breach is not, in fact, covered by this warranty, Buyer shall pay Seller its then customary charges for any repair or replacement made by Seller. Seller's warranty is conditioned on Buyer's (a) operating and maintaining the Equipment in accordance with Seller's instructions, (b) not making any unauthorized repairs or alterations, and (c) not being in default of any payment obligation to Seller. Seller's warranty does not cover damage caused by chemical action or abrasive material, misuse or improper installation (unless installed by Seller). THE WARRANTIES SET FORTH IN THIS SECTION ARE SELLER'S SOLE AND EXCLUSIVE WARRANTIES AND ARE SUBJECT TO SECTION 10 BELOW. SELLER MAKES NO OTHER WARRANTIES OF ANY KIND, EXPRESS OR IMPLIED, INCLUDING WITHOUT LIMITATION, ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR PURPOSE.

7. Indemnity. Seller shall indemnify, defend and hold Buyer harmless from any claim, cause of action or liability incurred by Buyer as a result of third party claims for personal injury, death or damage to tangible property, to the extent caused by Seller's negligence. Seller shall have the sole authority to direct the defense of and settle any indemnified claim. Seller's indemnification is conditioned on Buyer (a) promptly, within the Warranty Period, notifying Seller of any claim, and (b) providing reasonable cooperation in the defense of any claim.

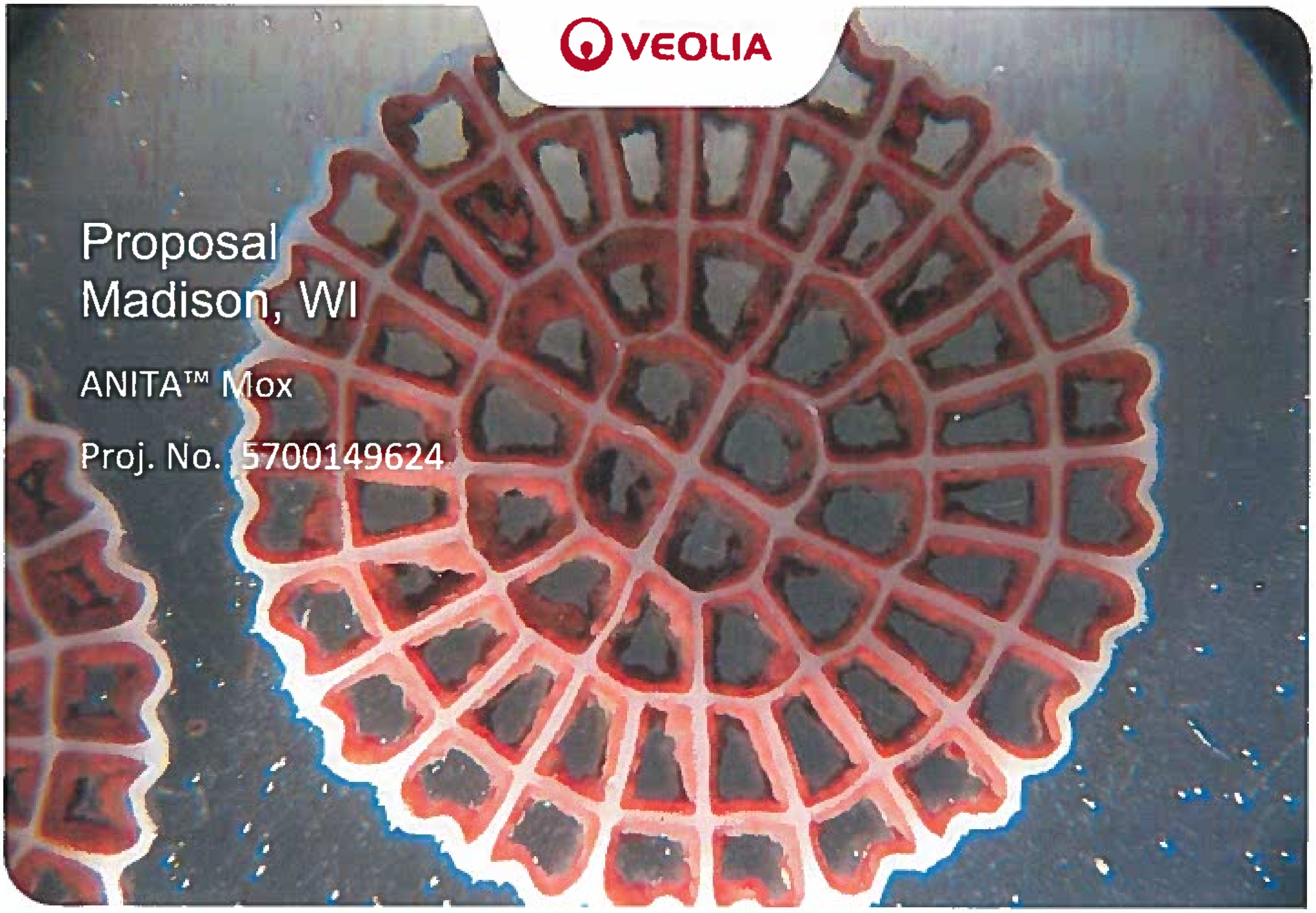
8. Force Majeure. Neither Seller nor Buyer shall have any liability for any breach (except for breach of payment obligations) caused by extreme weather or other act of God, strike or other labor shortage or disturbance, fire, accident, war or civil disturbance, delay of carriers, failure of normal sources of supply, act of government or any other cause beyond such party's reasonable control.

9. Cancellation. If Buyer cancels or suspends its order for any reason other than Seller's breach, Buyer shall promptly pay Seller for work performed prior to cancellation or suspension and any other direct costs incurred by Seller as a result of such cancellation or suspension.

10. LIMITATION OF LIABILITY. NOTWITHSTANDING ANYTHING ELSE TO THE CONTRARY, SELLER SHALL NOT BE LIABLE FOR ANY CONSEQUENTIAL, INCIDENTAL, SPECIAL, PUNITIVE OR OTHER INDIRECT DAMAGES, AND SELLER'S TOTAL LIABILITY ARISING AT ANY TIME FROM THE SALE OR USE OF THE EQUIPMENT SHALL NOT EXCEED THE PURCHASE PRICE PAID FOR THE EQUIPMENT. THESE LIMITATIONS APPLY WHETHER THE LIABILITY IS BASED ON CONTRACT, TORT, STRICT LIABILITY OR ANY OTHER THEORY.

Miscellaneous. If these terms are issued in connection with a government contract, they shall be deemed to include those federal acquisition regulations that are required by law to be included. These terms, together with any quotation, purchase order or acknowledgement issued or signed by the Seller, comprise the complete and exclusive statement of the agreement between the parties (the "Agreement") and supersede any terms contained in Buyer's documents, unless separately signed by Seller. No part of the Agreement may be changed or cancelled except by a written document signed by Seller and Buyer. No course of dealing or performance, usage of trade or failure to enforce any term shall be used to modify the Agreement. If any of these terms is unenforceable, such term shall be limited only to the extent necessary to make it enforceable, and all other terms shall remain in full force and effect. Buyer may not assign or permit any other transfer of the Agreement without Seller's prior written consent. The Agreement shall be governed by the laws of the State of North Carolina without regard to its conflict of laws provisions.

VEOLIA



Proposal Madison, WI

ANITA™ Mox

Proj. No. 5700149624

Submitted to: Don Esping
Brown & Caldwell

Submitted by: Daniel Hurt
Application Engineer

Date: 12/5/2016

This document is confidential and may contain proprietary information.
It is not to be disclosed to a third party without the written consent of Veolia Water Technologies.

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Water Technologies

Introduction

I. Kruger Inc. (a subsidiary of Veolia Water Technologies) is pleased to present this budgetary proposal for our ANITA™ Mox process for deammonification of the anaerobic digester and Ostera rejection water in Madison, WI. This design is based upon the information we have received from you. The influent design criteria are summarized in Table 1.

In order to achieve the expected removals as summarized in Table 2, we recommend constructing one (1) ANITA Mox process train. The tank dimensions along with other important process parameters are summarized in Table 3.

For the Ostera Effluent design, Kruger has proposed a design for 80-85% removal. If this percent removal is not required for the overall plant design, a 65-70% removal could provide a more economical solution due to reduced removal rates at lower concentrations.

It is important that each reactor have the capability for independent control of influent feed and aeration. This can be accomplished through dedicated pumps and blowers or by using high performance modulating valves. We have included one (1) modulating influent valves and one (1) dedicated blower per train as part of Kruger's Scope to meet this need. Kruger recommends the use of an equalization tank upstream of the ANITA Mox process to reduce the number of interruptions in flow to the process caused by the plant's dewatering schedule. Kruger also recommends covering the basins to minimize heat loss if significant loss is possible given the site layout.

We appreciate the opportunity to provide this proposal to you. If you have any questions or need further information, please contact our local Representative, Rob Szekeress of Peterson & Matz, Inc., or our Regional Sales Manager, Andy Szekeress, at (715)-693-5960 (andy.szekeress@veolia.com).

cc: CT, AJS, GAT, MTE, project file (Kruger)
Rob Szekeress (Peterson & Matz, Inc.)

Revision	Date	Process Eng.	Comments
0	12/02/2016	MTE	Initial, budgetary proposal.

We Know Water

I. Kruger Inc. (Kruger) is a water and wastewater solutions provider specializing in advanced and differentiating technologies. Kruger provides complete processes and systems ranging from biological nutrient removal to mobile surface water treatment. The ACTIFLO® Microsand Ballasted Clarifier, BioCon® Dryer, BIOSTYR® Biological Aerated Filter (BAF) and NEOSEP™ **MBR are just a few of the innovative technologies offered by Kruger.**

Kruger Inc. is a Veolia Water Solutions & Technologies' (VWS) company providing innovative water and wastewater treatment solutions for the U.S. municipal market. As a global company with 135 Business Units in 57 countries, **Veolia Water** with nearly 10,000 employees worldwide and with over 250 proprietary technologies is the world leader in water and wastewater treatment.

Kruger delivers unequalled **S**ervice to our customers delivering and creating **V**alue while being environmentally **R**esponsible with a focus on safety. Since 1986, Kruger has been providing leading edge technologies for biological wastewater treatment, High Rate Clarification for phosphorus removal and water treatment, filtration for TSS removal, water reuse and drinking water and Biosolids processing. Based in Cary, North Carolina, Kruger's 120 plus professionals are dedicated to providing the most technically sound solution to meet our customers' needs while following our principles of **SVR.**

Energy Focus

Kruger, along with Veolia Water Solutions & Technologies (VWS) is dedicated to delivering sustainable and innovative technologies and solutions. We offer our customers integrated solutions which include resource-efficient technology to improve operations, reduce costs, achieve sustainability goals, decrease dependency on limited resources, and comply with current and anticipated regulations.

Veolia's investments in R&D outpace that of our competition. Our focus is on delivering

- neutral or positive energy solutions
- migration towards green chemicals or zero chemical consumption
- water-footprint-efficient technologies with high recovery rates

Our carbon footprint reduction program drives innovation, accelerates adoption and development of clean technologies, and offers our customers sustainable solutions.
Kruger is benchmarking its technologies and solutions by working with our customers and performing total carbon cost analysis over the lifetime of the installation.
By committing to the innovative development of clean and sustainable technologies and solutions worldwide, Kruger and VWS will continue to maximize the financial benefits for every customer.

Process Description

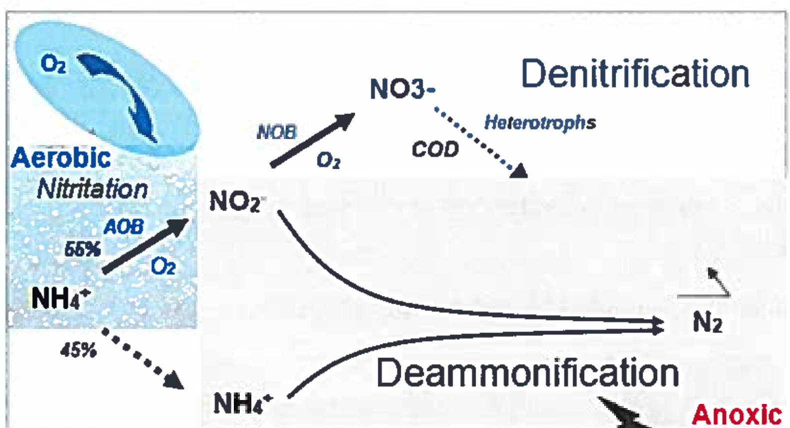
AnoxKaldnes MBBR

The MBBR process is a continuous-flow, non-clogging biofilm reactor containing moving "carrier elements" or media. The media flows with the water currents in the reactor and does not require backwashing or cleaning.

The biomass that treats the wastewater is attached to the surfaces of the media. The media is designed to provide a large protected surface area for the biofilm and optimal conditions for biological activity when suspended in water. AnoxKaldnes media is made from polyethylene and has a density slightly less then water.

The ANITA™ Mox process is a single-stage nitrogen removal process based on the MBBR platform. The process is specifically designed for treatment of waste streams with high ammonia concentrations. The system can achieve ammonia removals of up to 80-90% and total nitrogen removals of up to 75-85%. The treatment method uses only 40% of the oxygen demand of conventional nitrification, and it requires no external carbon source.

Nitrogen removal with ANITA™ Mox



$$NH_4^+ + 1.32\ NO_2^- + .066\ HCO_3^- + .13\ H^+ \rightarrow$$
$$1.02\ N_2 + .26\ NO_3^- + .066\ CH_2O_{0.5}N_{0.15} + 2.03\ H_2O$$

Anammox Reaction

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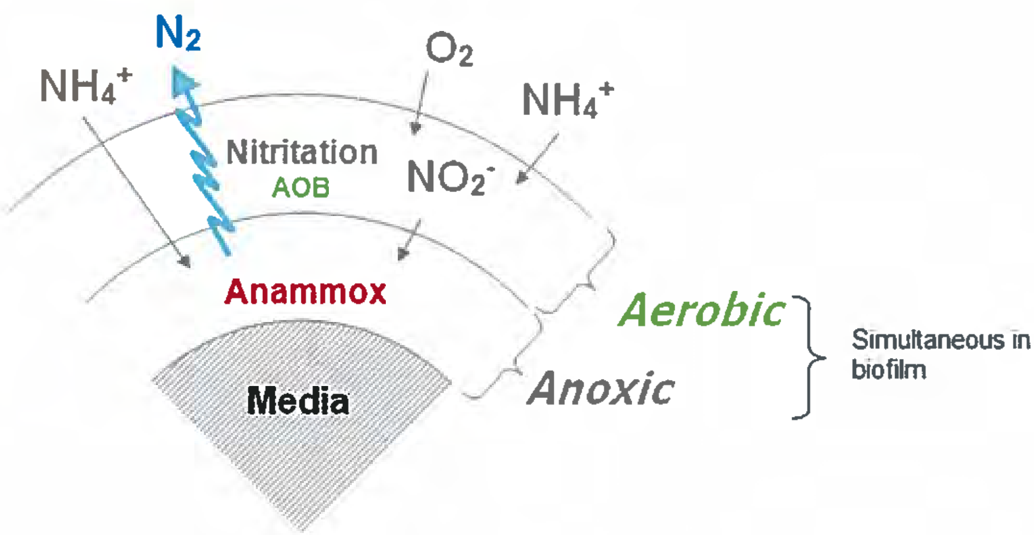

The aerobic and anoxic reactions occur in a single MBBR reactor. The combined biomass grows attached to the AnoxKaldnes media and is retained in the reactor by media screens. This biomass retention is an important characteristic of the system, since the anammox bacteria growth rate is very slow when compared to conventional wastewater bacteria growth rates.

AnoxKaldnes ANITA™ Mox System Configuration

Kruger proposes the ANITA™ Mox process for deammonification at the Madison, WI Nine Springs WWTP. We recommend constructing one (1) ANITA Mox MBBR process train using our K5 media.

Kruger's minimum scope of supply includes the AnoxKaldnes media, screen assemblies (to keep media in each reactor), medium bubble aeration grids, and mixers. In cases where they are needed, Kruger also provides the blowers, instrumentation and controls, SCADA, and field instruments (dissolved oxygen, nitrate, ammonia, etc.) for single-source responsibility.

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The design assumes that the side stream entering into the proposed ANITA Mox system contains no toxic compounds and has sufficient alkalinity and that none of the equipment provided would be used in a classified area (e.g. Class 1, Division 1 or Class 1, Division 2).

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Alkalinity, Design Flow[1]	mg/L	>500	1000
Elevation	ft	800[2]	
Minimum Temperature	°C	25	25 (heated)

1 Supplemental alkalinity required to optimize removals.

2 Assumed values.

Table 2: Expected Removals

Parameter	Units	Anticipated % Removal*
NH4-N (mg/L)	%	80-85
Total Inorganic Nitrogen (mg/L)	%	75-80

*Anticipated performance, not process guarantee values.

Table 3: Process Design Summary

Parameter	Units	50% Digester Recycle Values	Ostera Effluent Values
Number of Process Trains	-	1	1
Dimensions (Each)	ft	32 × 32 × 15 SWD	45.5 x 45.5 x 18 SWD
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Total Volume (All Reactors, All Trains)	ft^3	15,360	37,265
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Discharge Pressure (From Top of Drop Pipe)	psi	6.4	7.7

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- Process Engineering consisting of aeration system sizing and configuration, sieve and outlet design.
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Kruger will furnish a Service Engineer to perform the following tasks:

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AnoxKaldnes ANITA™ Mox System Equipment

Option 1: 50% Digester Recycle Values

Mechanical Equipment Items	Qty	Description
AnoxKaldnes K5 Media, (ft^3)	7,486	Carrier elements are made of high density polyethylene. The total media quantity will include a volume of ~5% seeded media.
Cylindrical Screen Assemblies	2	Two (2) per reactor. 304L SS. 23"ø perforated plate pipes terminated in ANSI flanges for mounting directly to the tank wall.
Medium Bubble Aeration System	4	Four (4) air grids per reactor. 304L SS including header, lateral piping, and hardware (excluding concrete anchor bolts).
Specially Designed Mechanical Mixers	1	One (1) per ANITA Mox Reactor. Includes VFD.
Airlift Pump	2	One (1) airlift pump per ANITA Mox reactor for foam suppression.
Modulating Influent Control Valves	1	One (1) actuated BFV for each train.
Positive Displacement Blowers	1 + 1	One (1) duty plus one (1) standby. Each blower will be rated for 700 SCFM and 40 NPHP at 7.0 psig differential pressure. Includes VFD.

Instrumentation and Controls Equipment Items	Qty	Description
PLC Control Panel	1	NEMA 12 Freestanding or Wall Mount Control Panel (For Indoor Use). ControlLogix PLC; Panelview HMI; 120V Feed
pH-based Control Logic	1	For Optimum nitritation, deammonification and energy efficiency
High Level Float Switch	1	One (1) for each media zone.
DO Probe (LDO)	1	One (1) for each Aerobic zone. Aerobic Zone DO Monitoring
pH meter	1	One (1) pH meter for each ANITA Mox reactor.
Thermal Mass Flowmeter	1	One (1) for each ANITA Mox reactor for air flow control
Magnetic Flowmeter	1	One (1) magnetic flow meter per reactor to measure inf. flow.

Option 2: Ostera Effluent Values

Mechanical Equipment Items	Qty	Description
AnoxKaldnes K5 Media, (ft^3)	18,608	Carrier elements are made of high density polyethylene. The total media quantity will include a volume of ~5% seeded media.
Cylindrical Screen Assemblies	4	Four (4) per reactor. 304L SS. 23"ø perforated plate pipes terminated in ANSI flanges for mounting directly to the tank wall.
Medium Bubble Aeration System	4	Four (4) air grids per reactor. 304L SS including header, lateral piping, and hardware (excluding concrete anchor bolts).
Specially Designed Mechanical Mixers	1	One (1) per ANITA Mox Reactor. Includes VFD.
Airlift Pump	2	One (1) airlift pump per ANITA Mox reactor for foam suppression.
Modulating Influent Control Valves	1	One (1) actuated BFV for each train.
Positive Displacement Blowers	1 + 1	One (1) duty plus one (1) standby. Each blower will be rated for 1,000 SCFM and 75 NPHP at 8.3 psig differential pressure. Includes VFD.

Instrumentation and Controls Equipment Items	Qty	Description
PLC Control Panel	1	NEMA 12 Freestanding or Wall Mount Control Panel (For Indoor Use). ControlLogix PLC; Panelview HMI; 120V Feed
pH-based Control Logic	1	For Optimum nitritation, deammonification and energy efficiency
High Level Float Switch	1	One (1) for each media zone.
DO Probe (LDO)	1	One (1) for each Aerobic zone. Aerobic Zone DO Monitoring
pH meter	1	One (1) pH meter for each ANITA Mox reactor.
Thermal Mass Flowmeter	1	One (1) for each ANITA Mox reactor for air flow control
Magnetic Flowmeter	1	One (1) magnetic flow meter per reactor to measure inf. flow.

Notes Regarding System Design and Installation

- A note on concrete specifications: For any MBBR or IFAS system, regardless of manufacturer, it is sound practice to require good, quality concrete work for the process reactors. The Consulting Engineer's standard concrete specification section is typically adequate to eliminate large holes, excessive form marks, large pockets, and excessively rough areas. It is particularly important to eliminate the potential for annular space around media retention screens.
- A note on construction sequencing: It is important, particularly for IFAS installations, to have level detection and level communication systems in place and operational prior to the filling of process tanks with water and media.

Scope of Supply BY INSTALLER/PURCHASER

The scope of supply by others for the AnoxKaldnes ANITA™ Mox system should include, but is not limited to, the following items:

- All civil/site and electrical work.
- A concrete foundation for the tanks.
- Reactors to house the MBBR treatment equipment.
- All provisions for interconnecting piping.
- Unloading, storage and installation of equipment.
- Install and test all level floats, level transmitters, level alarms, and alarm communication devices prior to filling a process tank with media and water
- Centrate equalization tanks
- Cover for reactor tanks
- Temporary provisions for screened primary or secondary effluent during startup.
- Temporary reactor heating during startup.
- Mixer bridges and other structural modifications for the reactors.
- Video recording of any training activities.

Design Options

In addition to the proposed system as detailed herein, Kruger is able to further incorporate our process and controls expertise into wastewater treatment plants, allowing municipalities to meet stringent effluent requirements and future plant upgrades. Kruger is also able to offer our instrumentation and controls expertise to build upon the proposed system by providing a **customized plant-wide SCADA system** or designing a **Motor Control Center (MCC)**, providing clients a single source responsibility for plant controls. Please contact Kruger if the options above are of interest or to be included in the current proposed system or future upgrades. ***Please note that the design options listed above are not included in the pricing noted herein.*

Schedule

- Shop drawings will be submitted within 6-8 weeks of receipt of an executed contract by all parties.
- All equipment will be delivered within 18-20 weeks after receipt of written approval of the shop drawings.
- Installation manuals will be furnished upon delivery of equipment.
- Operation and Maintenance Manuals will be submitted within 90 days after receipt of approved shop drawings.

Pricing

The prices for the AnoxKaldnes ANITA™ Mox system, as defined herein, including process and design engineering, field services, and equipment supply are:

Option 1 Digester Recycle Filtrate <u>$1,050,000</u>

Option 2 Ostera Effluent <u>$1,612,000</u>

Pricing is FOB shipping point, with freight allowed to the job site. This pricing does not include any sales or use taxes. In addition, pricing is valid for ninety (90) days from the date of issue.

Please note that the above pricing is expressly contingent upon the items in this proposal and are subject to I. Kruger Inc. Standard Terms of Sale detailed herein.

Kruger Standard Terms of Payment

The terms of payment are as follows:

- 10% on receipt of fully executed contract
- 15% on submittal of shop drawings
- 75% on the delivery of equipment to the site

Payment shall not be contingent upon receipt of funds by the Contractor from the Owner. There shall be no retention in payments due to I. Kruger Inc. All other terms per our Standard Terms of Sale are attached.

All payment terms are net 30 days from the date of invoice. Final payment not to exceed 120 days from delivery of equipment.

I. Kruger Inc. Standard Terms of Sale

1. Applicable Terms. These terms govern the purchase and sale of the equipment and related services, if any (collectively, "Equipment"), referred to in Seller's purchase order, quotation, proposal or acknowledgment, as the case may be ("Seller's Documentation"). Whether these terms are included in an offer or an acceptance by Seller, such offer or acceptance is conditioned on Buyer's assent to these terms. Seller rejects all additional or different terms in any of Buyer's forms or documents.

2. Payment. Buyer shall pay Seller the full purchase price as set forth in Seller's Documentation. Unless Seller's Documentation provides otherwise, freight, storage, insurance and all taxes, duties or other governmental charges relating to the Equipment shall be paid by Buyer. If Seller is required to pay any such charges, Buyer shall immediately reimburse Seller. All payments are due within 30 days after receipt of invoice. Buyer shall be charged the lower of 1 ½% interest per month or the maximum legal rate on all amounts not received by the due date and shall pay all of Seller's reasonable costs (including attorneys' fees) of collecting amounts due but unpaid. All orders are subject to credit approval.

3. Delivery. Delivery of the Equipment shall be in material compliance with the schedule in Seller's Documentation. Unless Seller's Documentation provides otherwise, Delivery terms are F.O.B. Seller's facility.

4. Ownership of Materials. All devices, designs (including drawings, plans and specifications), estimates, prices, notes, electronic data and other documents or information disclosed by Seller or prepared solely by Seller or Buyer or jointly by Seller and Buyer in connection with this Agreement, and all intellectual property rights therein, shall be and remain the confidential and proprietary property of Seller, whether or not patented by Seller ("Work Product"). Buyer hereby irrevocably assigns all rights in any Work Product to Seller. Seller grants Buyer a non-exclusive, non-transferable (except to a successor-in interest to the ownership of the Equipment), paid-up license to use the Work Product solely in connection with Buyer's use, operation, repair and maintenance of the Equipment at the Jobsite defined in this Agreement. Buyer may not disclose, share, transfer, or sell any such Work Product to third parties without Seller's prior written consent and such consent may be arbitrarily withheld. Buyer agrees not to resell, transfer or give any of the biologically colonized media or bacteria from the system to any party other than Seller or any of Seller's affiliates without the prior written consent of Seller for a period of fifteen (15) years from the effective date of this Agreement. Buyer shall not cultivate bacteria or use biomass carriers retrieved from the ANITA Mox system for any research or non-research purposes without prior written consent of the Seller. Any new developments, discoveries or inventions resulting from the operation of the ANITA Mox system in which the ANITA Mox process is a component or is in any way incorporated in whole or in part shall be owned solely by the Seller.

5. Changes. Seller shall not implement any changes in the scope of work described in Seller's Documentation unless Buyer and Seller agree in writing to the details of the change and any resulting price, schedule or other contractual modifications. This includes any changes necessitated by a change in applicable law occurring after the effective date of any contract including these terms.

6. Warranty. Subject to the following sentence, Seller warrants to Buyer that the Equipment shall materially conform to the description in Seller's Documentation and shall be free from defects in material and workmanship. The foregoing warranty shall not apply to any Equipment that is specified or otherwise demanded by Buyer and is not manufactured or selected by Seller, as to which (i) Seller hereby assigns to Buyer, to the extent assignable, any warranties made to Seller and (ii) Seller shall have no other liability to Buyer under warranty, tort or any other legal theory. If Buyer gives Seller prompt written notice of breach of this warranty within 18 months from delivery or 1 year from beneficial use, whichever occurs first (the "Warranty Period"), Seller shall, at its sole option and as Buyer's sole remedy, repair or replace the subject parts or refund the purchase price therefore. If Seller determines that any claimed breach is not, in fact, covered by this warranty, Buyer shall pay Seller its then customary charges for any repair or replacement made by Seller. Seller's warranty is conditioned on Buyer's (a) operating and maintaining the Equipment in accordance with Seller's instructions, (b) not making any unauthorized repairs or alterations, and (c) not being in default of any payment obligation to Seller. Seller's warranty does not cover damage caused by chemical action or abrasive material, misuse or improper installation (unless installed by Seller). THE WARRANTIES SET FORTH IN THIS SECTION ARE SELLER'S SOLE AND EXCLUSIVE WARRANTIES AND ARE SUBJECT TO SECTION 10 BELOW. SELLER MAKES NO OTHER WARRANTIES OF ANY KIND, EXPRESS OR IMPLIED, INCLUDING WITHOUT LIMITATION, ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR PURPOSE.

7. Indemnity. Seller shall indemnify, defend and hold Buyer harmless from any claim, cause of action or liability incurred by Buyer as a result of third party claims for personal injury, death or damage to tangible property, to the extent caused by Seller's negligence. Seller shall have the sole authority to direct the defense of and settle any indemnified claim. Seller's indemnification is conditioned on Buyer (a) promptly, within the Warranty Period, notifying Seller of any claim, and (b) providing reasonable cooperation in the defense of any claim.

8. Force Majeure. Neither Seller nor Buyer shall have any liability for any breach (except for breach of payment obligations) caused by extreme weather or other act of God, strike or other labor shortage or disturbance, fire, accident, war or civil disturbance, delay of carriers, failure of normal sources of supply, act of government or any other cause beyond such party's reasonable control.

9. Cancellation. If Buyer cancels or suspends its order for any reason other than Seller's breach, Buyer shall promptly pay Seller for work performed prior to cancellation or suspension and any other direct costs incurred by Seller as a result of such cancellation or suspension.

10. LIMITATION OF LIABILITY. NOTWITHSTANDING ANYTHING ELSE TO THE CONTRARY, SELLER SHALL NOT BE LIABLE FOR ANY CONSEQUENTIAL, INCIDENTAL, SPECIAL, PUNITIVE OR OTHER INDIRECT DAMAGES, AND SELLER'S TOTAL LIABILITY ARISING AT ANY TIME FROM THE SALE OR USE OF THE EQUIPMENT SHALL NOT EXCEED THE PURCHASE PRICE PAID FOR THE EQUIPMENT. THESE LIMITATIONS APPLY WHETHER THE LIABILITY IS BASED ON CONTRACT, TORT, STRICT LIABILITY OR ANY OTHER THEORY.

Miscellaneous. If these terms are issued in connection with a government contract, they shall be deemed to include those federal acquisition regulations that are required by law to be included. These terms, together with any quotation, purchase order or acknowledgement issued or signed by the Seller, comprise the complete and exclusive statement of the agreement between the parties (the "Agreement") and supersede any terms contained in Buyer's documents, unless separately signed by Seller. No part of the Agreement may be changed or cancelled except by a written document signed by Seller and Buyer. No course of dealing or performance, usage of trade or failure to enforce any term shall be used to modify the Agreement. If any of these terms is unenforceable, such term shall be limited only to the extent necessary to make it enforceable, and all other terms shall remain in full force and effect. Buyer may not assign or permit any other transfer of the Agreement without Seller's prior written consent. The Agreement shall be governed by the laws of the State of North Carolina without regard to its conflict of laws provisions.

APPENDIX F–TECHNICAL MEMORANDUM NO. 6
HEADWORKS AND HAULED WASTE RECEIVING

Technical Memorandum No. 6 for the Madison Metropolitan Sewerage District, Madison, Wisconsin

Headworks and Hauled Waste Receiving
2016 Liquid Processing Facilities Plan

Prepared by:

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December 2016
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STRAND ASSOCIATES®

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APPENDIX

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APPENDIX F–HAULED WASTE RECEIVING STATION PILOT TEST REPORT

One of the objectives of the 2016 Liquid Processing Facilities Plan is to investigate potential alternatives for improvements to the existing Headworks and Hauled Waste Receiving facilities at the Nine Springs Wastewater Treatment Plant (NSWWTP).

This memorandum includes a summary of the influent flow measurement, screening and screenings handling, grit washing, and hauled waste receiving analyses that were conducted as part of the facility planning for the NSWWTP. In addition, more detailed evaluations of the shortlisted alternatives are presented with opinions of probable construction cost and discussion of non-monetary considerations.

Workshop No. 6 was held on October 12, 2016, at the NSWWTP to discuss headworks operations, alternatives, and related information. The purpose of the workshop was to present and discuss alternatives for flow metering, screening and screenings handling, and hauled waste receiving, and then screen the alternatives to a shorter list to evaluate in detail.

DESCRIPTION OF EXISTING HEADWORKS AND SUMMARY OF CONCERNS

The existing Headworks Facility at the NSWWTP is located on the south side of the grounds between the Struvite Harvesting Facility and the Metrogro Storage Tanks. Five force mains from collection system pump stations (PS) enter the west side of the building into the basement Meter Vault Room. Flows are measured using venturi flow meters and sampled. The force mains discharge into a common channel in the Screen Room. Flows are split to pass through up to three center-flow band screens installed in the Screen Room to remove solid material from the influent wastewater. There is typically one screen in operation, running on a VFD, with a second screen brought into operation as warranted by high level in the influent channel, high differential between the screen inlet and outlet levels, or the high flow set point. The third screen is brought into operation based on a high influent channel level. There is space for installation of a fourth screen. After screening, the flows recombine in a channel at the east end of the building before being split to flow to the three vortex grit removal tanks. Screened and degritted wastewater flows from the grit tanks to the Flow Splitter Structure where flows are split to the east and west plants. The current capacity of the screens is 140 to 150 million gallons per day (mgd). The maximum estimated peak flow that the facilities will be required to process is 180 mgd.

Material removed from the wastewater by the screens is sluiced in the screenings launder trough to the Maci pit with recycled plant effluent water (W4). The screenings are pumped by the Maci pumps up to the secondary grit tank, Lisep and Lipactor, on the mezzanine level of the building where the screenings are degritted, dewatered, and compacted before being discharged to the haul-off waste container. Grit that accumulates in the Maci well is pumped periodically by the macerator grit pump to the grit snail that dewaters the grit and dischargers it to the haul-off waste container.

Grit that settles in the forward flow grit tanks is pumped by the grit pumps, located in the basement between the grit tanks, to the three grit concentrators/classifiers installed on the mezzanine level of the building. The classifiers remove some of the organics from the grit and then dewater the grit before discharging it to the haul-off waste container.

The NSWWTP hauled waste receiving facilities are located at the Headworks Facility along the south side of the building. The hauled waste facilities consist of a covered area into which up to two trucks can discharge. Trucks back up to an open trough and discharge into the trough through hoses matching the size of the trucks' discharge. A 6-inch hose connection is commonly used to expedite off-loading. Some haulers, based on their trucks' tank and valve configuration prefer to discharge with no hose connected. The hauled waste flows from the trough though two 8-inch pipes into the screening channel just ahead of Screen No. 4. There is no screen in the grit trap or rock trap on the hauled waste trough or pipes to prevent large objects from entering the treatment flow.

There are a number of issues related to the Headworks Facility that are the impetus for this evaluation including flow measurement, screen operations, screenings handling, and hauled waste receiving. These concerns are briefly described below and are further detailed in the following sections.

Flow measurement of the influent wastewater is an important aspect of the Headworks Facility, not only for compliance with regulatory requirements, but because billing of customer communities is based on this metering and process decisions are dependent on accurate flow metering. As such, the flow metering must be reliable and defensible. The existing venturi flow meters meet these requirements, but the meters were installed at an elevation such that the downstream hydraulics needs to be managed to provide sufficient water depth to maintain meter submergence. This is accomplished by operating the screens to maintain a higher water elevation than intended during design. Because of this, the flow velocities in the channels upstream of the screens are lower than optimal, leading to increased settlement of grit, most specifically in the area of Screen No. 4. In addition, maintaining a higher-than-desirable water level in the screening channels results in a greater likelihood of overflow of unscreened wastewater to the bypass channels on either side of the main screening channels. There is only about a 1.5-foot elevation difference between the top of the flow meter (minimum water level) and the overflow elevation. Because all the flows are pumped to the NSWWTP, the influent flow rates can and do change quickly, resulting in a very difficult level control situation upstream of the screens. One screen is always operating on variable speed control to maintain an upstream water level. This is not a practical control strategy and could potentially result in channel overflows, inaccurate metering, or both.

A complicating factor is that Screen No. 4 needs to be in service at virtually all times to prevent an undesirable accumulation of grit and rocks in front of this screen. This material is discharged in front of this screen from hauled wastes, and it builds up in front of Screen No. 4 because the pipes from the hauled waste discharge trough directly flow to that screen. The requirement to have Screen No. 4 in constant service leads to excessive wear on this screen in comparison to the other screens.

In addition to the screening channel level control problem, there are a number of issues related to screenings handling with the existing equipment, which are as follows:

1. The trough that conveys the screenings from the screens to the Maci well is relatively flat, resulting in settling of material in the trough. The lack of pitch in the trough also requires constant flow of as much as 100 gallons per minute (gpm) of W4.

2. Grit captured by screens settles in the Maci pit and causes excessive wear on the Maci pumps. These pumps are also susceptible to plugging from heavy loads of rags and require very frequent maintenance. In addition, the parts for the Maci pumps are expensive and entail long lead times because of a lack of domestic availability.

3. The Lisep and Lipactor screenings handling equipment are susceptible to plugging from heavy grease loads, particularly from hauled waste. The loads require frequent manual cleaning of this equipment.

The grit removal and handling facilities and equipment generally operate well with little attention required. The main issue is the wear on the cyclone grit concentrators installed on the grit classifiers, which requires replacement of those units. Otherwise, the grit system, which was installed as part of the Tenth Addition, has operated adequately. The nominal capacity of the grit tanks is 50 mgd each, for a total capacity of 150 mgd. Although this capacity is less than the future maximum flow of 180 mgd, it is not recommended to add a fourth grit tank given the infrequency of flow above this nominal capacity of 150 mgd and since the results of exceeding their capacity is simply a reduction in grit removal efficiency for the duration of the high flow event. Hydraulic calculations performed for analysis of the alternatives assumed three grit tanks in service.

The hauled waste facilities receive wastes from about 50 to 60 trucks per day, and in 2015 accepted between 1.6 million and 2.8 million gallons of hauled waste per month. This equates to approximately 65,000 to 120,000 gallons per day assuming five days per week operation. The demand for this service is expected to increase into the future. The 2015 revenue from hauled wastes (excluding biosolids from other local WWTPs), was approximately $500,000, and 2016 is tracking similarly. The hauled waste receiving facilities also have a number of issues that need to be addressed. These issues are detailed in a memo prepared by the District and included in Appendix A. Some of the main concerns are listed below:

1. The existing receiving trough arrangement allows large material including rocks, nuts, bolts, and other objects to enter the influent channels and damage or otherwise hamper operation of the screens and screenings handling equipment.

2. As mentioned above, the location of the discharge pipes from the hauled waste trough necessitate near constant operation of Screen No. 4.

3. The requirement for trucks to back into the discharge trough is not an efficient traffic arrangement. A drive-through arrangement with one-way traffic would be preferred.

4. The slope of the existing unloading area does not allow some trucks to discharge completely.

5. Ice accumulates in the area in the winter, creating slippery conditions.

6. Haulers are on an “honor system” with respect to the volumes they discharge. This system is susceptible to abuse as well as inaccurate and inequitable billing for service.

INFLUENT FLOW MEASUREMENT ALTERNATIVES IDENTIFICATION

A brief description of each of the influent flow measurement alternatives presented at Workshop No. 6 is included in this section. Alternative IFM4–Install Venturi Flow Meters at Pump Station (PS) Nos. 2, 3, 4, 7, 8, 11, and 18, was added at the request of the District during the workshop. Alternative IFM5-Reinstall

Venturi Flow Meters at a Lower Elevation was added at a later date upon more detailed review of the screening channel hydraulics.

These alternatives are intended to address the issue with the elevation at which the venturi flow meters are installed. Each of the force mains must be measured separately to maintain flow measurement from the various District service areas. These flow meters are used to calculate flows and loadings from the District's customers, and any change of the flow metering conditions or layout could result in a significant effort to change billing procedures. In addition, the District indicated that the flow meters should be venturi style meters, which can be calibrated more reliably and defensively than magnetic style flow meters or similar. Venturi meters have traditionally been used by the District for metering critical flows that are used for customer billing purposes.

A. Alternative IFM0–No Change (Null Alternative)

This alternative would continue operation with the existing influent venturi flow meters without changes. The current influent measurement is comprised of five venturi flow meters ranging in size from 36 to 48 inches installed in the Meter Vault Room in the lower level of the Headworks Facility to measure flows from force mains from PS Nos. 2, 7, 8, 11, and 18. Operation of the influent screens is managed to maintain adequate depth in the influent channels to provide full submergence of the venturi flow meters.

B. Alternative IFM1–New Metering Vaults

This alternative would include construction of (most likely) two metering vaults to permit installation of venturi flow meters at a lower elevation, which would allow the influent screens to be operated in a manner more suitable for maintaining desired flow velocities in the influent channels. One vault would be constructed for measurement of flows from PS Nos. 2, 7, 8, and 18. Another vault would be constructed to measure flows from PS No. 11. The existing venturis could be relocated to the new locations to reduce construction costs.

C. Alternative IFM2–New Influent Flumes

This alternative would include construction of a concrete structure to the west of the Headworks Facility in which Parshall flumes would be installed to measure flow from each force main. Pipes would have to be installed beneath the Mechanical Room and Hypochlorite Room to convey flows to the influent channel ahead of the mechanical screens. The feasibility and constructability of this alternative is questionable because of likely adverse impacting related to access to the building and traffic to the Septage Receiving area.

D. Alternative IFM3–Raise Screening Channel Elevation

This alternative would include modification of the Headworks Facility to raise the elevation of the screenings channels so that the water elevation in the channels would not need to be artificially maintained at a higher elevation than required by downstream hydraulics. Raising the screens may allow them to be used with simple screening wash presses as described below instead of the existing complex screenings handling equipment. This alternative would require modifications to the four slide gates upstream of the screens to accommodate the change in the floor elevation. Hydraulics for the influent channels would need to be assessed to determine the impact on water elevations under high flows.

After consideration of the hydraulics of this alternative, it is apparent that it is not feasible without raising the floor elevation of the entire structure. It is not practical to raise the floor of just the screening area because of the numerous elevation issues this would entail.

D. Alternative IFM4–Install Venturi Flow Meters at PS Nos. 2, 3, 4, 7, 8, 11, 18

This alternative would include construction of separate metering vaults with Venturi flow meters at each of the PS's that discharge directly to the NSWWTP.

E. Alternative IFM5-Reinstall Venturi Flow Meters at a Lower Elevation

This alternative would involve relocating the venturis to a lower elevation in the Meter Vault Room where they would discharge into individual boxes from which the influent would flow up to and through the existing pipe penetrations in the wall. This alternative would also require modification to the force mains as they approach the Headworks Building. To maintain adequate downstream distance for accurate metering, the Meter Vault Room would need to be extended to the west.

INFLUENT FLOW MEASUREMENT SCREENING OF ALTERNATIVES

The Influent Flow Measurement alternatives were discussed during Workshop No. 6. After a more detailed hydraulic analysis of the screening channels, Alternative IFM3 was eliminated as it was determined to be very difficult to construct and might not provide a viable final solution. Therefore, the following alternatives were selected to be evaluated further:

A. Alternative IFM0–Maintain the Existing Influent Flow Metering Facilities (No Change)
B. Alternative IFM1–New Venturi Metering Vaults on NSWWTP Site
C. Alternative IFM2–New Influent Parshall Flumes
D. Alternative IFM4–Install Venturi Flow Meters at PS's
E. Alternative IFM5–Reinstall Venturi Flow Meters at a Lower Elevation

Each of these alternatives is further described and evaluated below.

INFLUENT FLOW MEASUREMENT DETAILED EVALUATION OF ALTERNATIVES

A. Alternative IFM0–Maintain the Existing Influent Flow Metering Facilities (No Change)

1. Description of Alternative and Opinion of Cost

In the null alternative, the current method of operating the screens to maintain adequate depth in the screening channels to fully submerge the venturis will continue. There are no current capital costs for this alternative. Operating costs included in this analyses are the current maintenance costs of the screens. Note that the operation and maintenance (O&M) costs for the other alternatives are relative to the null alternative, and they include the expected change in maintenance costs and pumping (electrical) costs for the PS's that discharge directly to the NSWWTP for the various alternatives. Table 1 shows the opinion of capital cost and annual operating costs for this alternative.

	Alt. S0
Opinion of Capital Costs	$0
Opinion of Annual O&M	$81,000

[1] Includes the relative screen maintenance and PS power costs.

Table 1 Alt IFM0–Null Alternative Cost Summary

2. Noneconomic Considerations

This alternative does not improve the current operations of the influent screens and related facilities. Influent flow metering would continue as it currently does, and the equipment is not expected to fail or otherwise need to be replaced within the planning period. Potential benefits and limitations of this alternative are presented below.

a. Benefits

§ No disruption of current operations.

b. Limitations

§ No reduction of grit accumulation in channels without septage receiving improvements.

§ No improvement to screening operations or reductions in maintenance.

B. Alternative IFM 1–New Metering Vaults on NSWWTP Site

1. Description of Alternative and Opinion of Cost

In this alternative a new metering vault would be constructed in the open space to the west of the Headworks Building to house the venturis for the force mains from PS Nos. 2, 7, 8, and 18. This structure would be approximately 55 feet long, 25 feet wide, and 25 feet deep. The proximity of the influent force mains to the 54-inch effluent force main will require sheeting along the southwest side of the proposed structure to allow construction. A second structure to the south of the Headworks Building would be constructed to house the force main from PS No. 11. This structure would be approximately 25 feet by 25 feet and 25 feet deep. The intent of alternative would be to reuse the existing venturis in the new metering vaults. These structures are assumed to be ventilated and include a staircase for entry, similar to the access provided to the east end of the grit pump room, to enable these spaces to be accessed without requiring a confined space entry.

There is space for an additional force main and venturi in the Headworks Building. No provisions are made in this alternative to accommodate this future force main and, as such, flow from this future force main would need to be measured at the pumping station from which it originates. Figure 1 shows the proposed locations for the metering vaults.

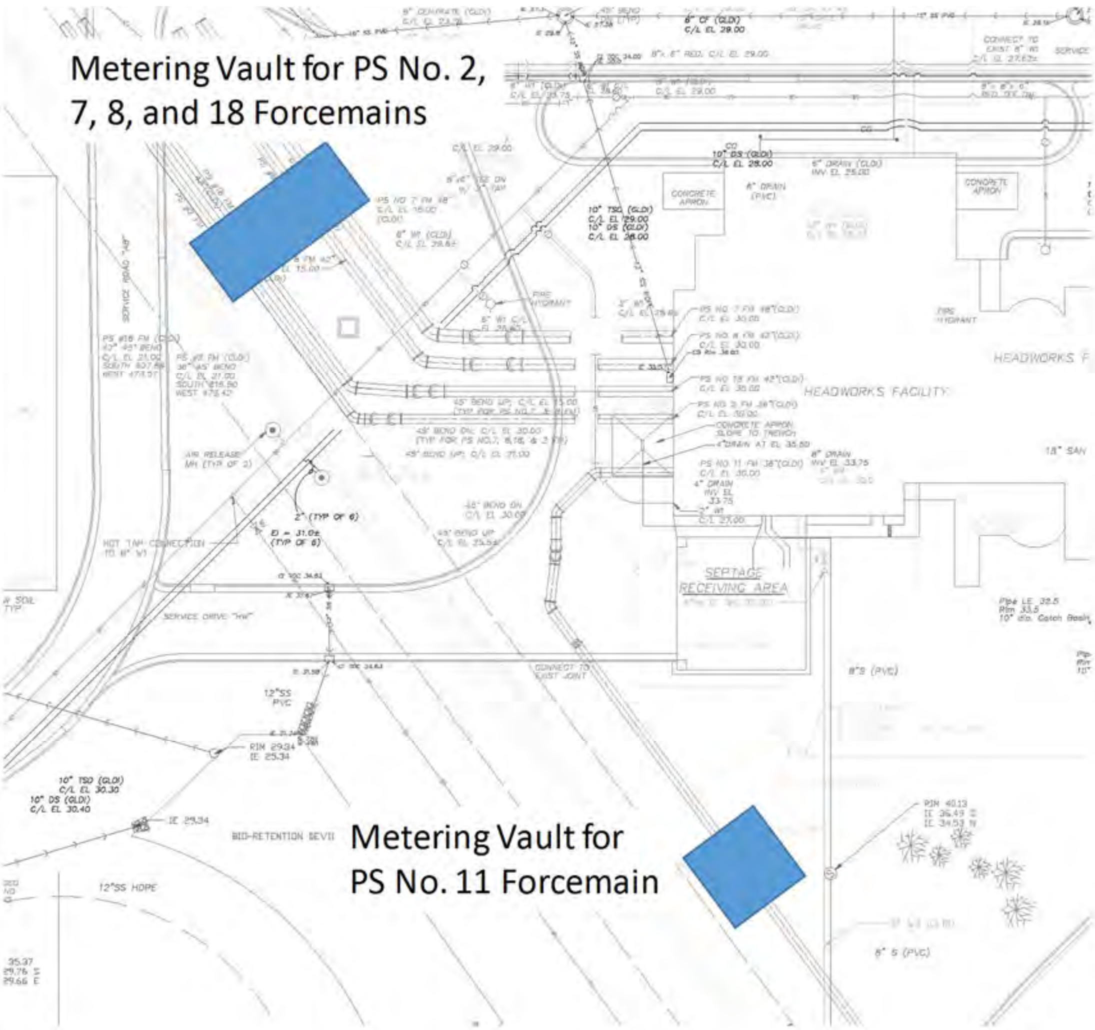


Figure 1 Location of Metering Vaults

Bypassing during construction of this alternative would be similar to the process used during the 10th addition construction. The sixth (future) force main location would be used to accept flows from each of the force mains as they are modified. An allowance of $500,000 was included in the opinion of cost to account for bypassing and bypass pumping requirements for all alternatives.

An opinion of probable cost for this alternative is presented in Table 2. A detailed breakdown of this opinion of probable cost is included in Appendix B. The structures would be designed to avoid confined space entry requirements in terms of access and ventilation. Operation and maintenance (O&M) costs for this alternative include HVAC costs for the two new vault structures. Since the water level in the channels will be lowered by approximately 2 feet, reducing the head on the PS pumps, there will be a reduction in energy costs for pumping, which is estimated to be approximately $20,000 per year. A 10 percent reduction in the current maintenance costs for the screens is assumed, and this was assumed because the screens will be operated at their intended design level, which should reduce wear on the units. Table 2 also shows the opinion of annual operating costs for this alternative.

	Alt IFM1
Opinion of Capital Costs	$3,180,000
Opinion of Annual O&M	$53,000

Table 2 Alt IFM1–New Metering Vaults Cost Summary

2. Noneconomic Considerations

This alternative, in general, is intended to lower the elevation of the venturi meters to allow the screening equipment to operate properly while still maintaining adequate influent flow metering information needed for billing purposes. Potential benefits and limitations of this alternative are presented below.

a. Benefits

§ Better influent screen performance, which should reduce pass-through of material and downstream maintenance concerns.

§ Reduced accumulation of grit in influent channels.

§ Reduced pumping energy; consistent with the District's long term goal of energy neutrality.

§ All construction on NSWWTP grounds.

b. Limitations

§ Construction adjacent to effluent force main presents a risk.

§ Uses areas on-site that may limit construction in those areas in the future.

B. Alternative IFM 2–New Influent Flumes

1. Description of Alternative and Opinion of Cost

The alternative would include construction of a new building structure west of the existing Headworks Building that would house five Parshall flumes with provisions for a sixth. During discussion of the alternatives as part of Workshop No. 6, safety concerns were raised over confined space entry required for maintenance of the flumes in Alternative IFM2. The Alternative was modified to include a structure to house the flumes, enabling access without the need for a confined space entry. The structure was assumed to be separate from the Headworks Building to avoid the need to rate the existing Mechanical Room and Hypochlorite Room as Division 1 (explosion-rated) spaces. Sodium hypochlorite delivery piping would also need to be modified to accommodate the loss of delivery truck access.

The building housing the flume would be approximately 50 feet by 55 feet. The floor elevation would be at the same elevation as the Headworks Building. To maintain 1.5 feet of freeboard at 180 mgd, based on the calculations extended from the hydraulic model, the flumes would be 70 percent submerged at 180 mgd, which is the limit of accuracy for a 4-foot Parshall flume.

The ductile iron force mains would be modified to have the force mains discharge into the flume structure at elevation 15.00 feet for the force mains from PS Nos. 7 and 8, and elevation 21.00 feet for the force mains from PS Nos. 2 and 18. Force main from PS No. 11 would have to be reconfigured slightly to allow it to enter the west end of the flume structure at elevation 25.50. Figure 2 shows the approximate location of the proposed flume structure.

An opinion of probable cost for this alternative is presented in Table 3. A detailed breakdown of this opinion of probable cost is included in Appendix B. O&M costs for this alternative include heating, ventilation, and air conditioning (HVAC) costs for the new structure. Since the water level in the channels will be higher than existing by approximately 1 foot, which increases the head on the PS pumps, there will be an increase in energy costs for pumping, which is estimated to be approximately $10,700 per year. A 10-percent reduction in the current maintenance costs for the screens is assumed because it will not be necessary to constantly have one screen in motion to maintain the appropriate water level in the channels. This should reduce wear on the units. Table 3 also shows the opinion of annual operating costs for this alternative.

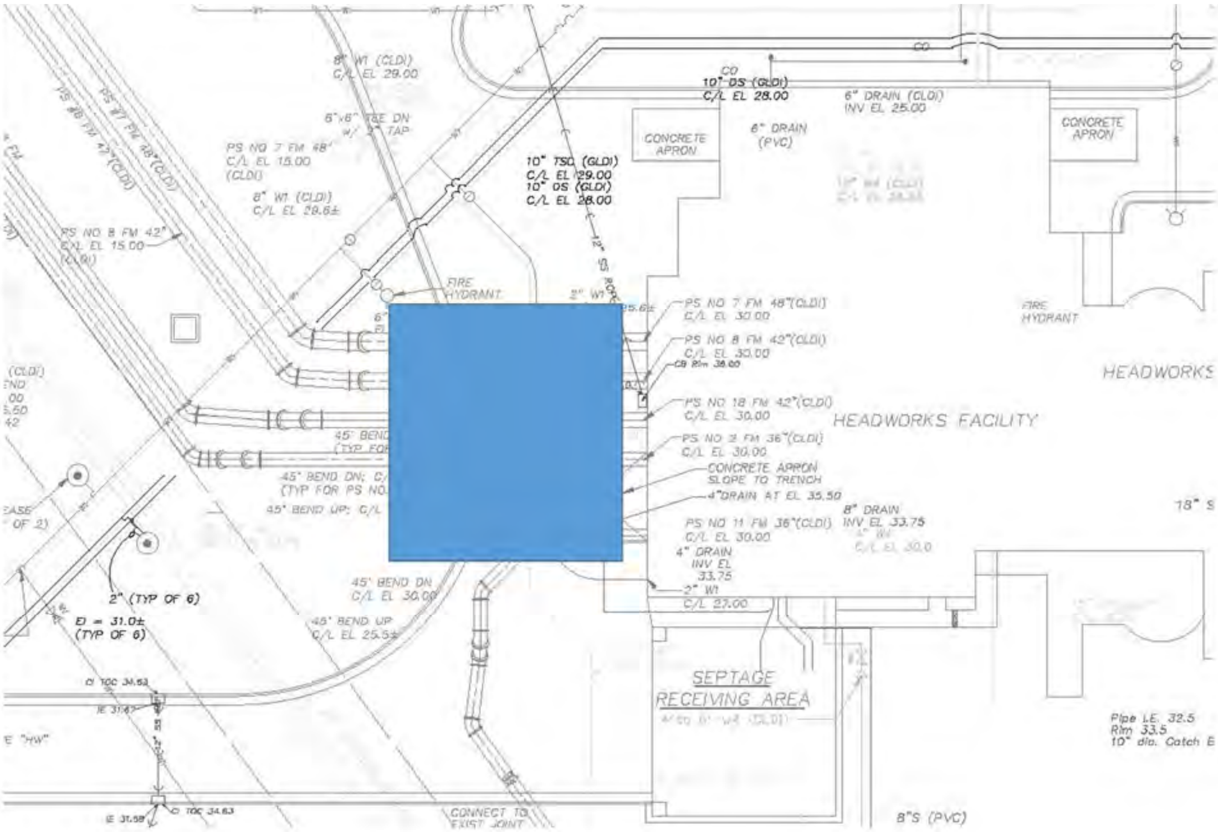


Figure 2 Location of Flume Structure

	Alt IFM3
Opinion of Capital Costs	$2,894,000
Opinion of Annual O&M	$86,000

Table 3 Alt IFM2–New Influent Flumes Cost Summary

2. Noneconomic Considerations

This alternative is intended to replace the existing venturis with a new structure. Potential benefits and limitations of this alternative are presented below.

a. Benefits

- Better influent screen performance, which should reduce pass-through of material and downstream maintenance concerns.
- All construction on NSWWTP grounds.

b. Limitations

- § Construction adjacent to effluent force main presents a risk.
- § Increased pumping energy; inconsistent with the District's long term goal of energy neutrality.
- § Uses areas on-site that may limit construction in those areas in the future.
- § Limits access to the Hypochlorite Room and Mechanical Room.

C. Alternative IFM 4–Install Venturi Flow Meters at PS Nos. 2, 3, 4, 7, 8, 11, 18

1. Description of Alternative and Opinion of Cost

The meter vault at PS No. 2, which is located in Brittingham Park, would be constructed so that the venturi would be installed in the 36-inch force main to the west tee fitting on the south side of the building. The vault would be approximately 20 feet long, 16 feet wide, and 12 feet deep. It may be difficult to locate this vault without intruding on the sand volleyball courts in the park.

A venturi meter for PS No. 3 would be installed in a manhole adjacent to the PS.

The meter vault at PS No. 4 would be constructed so that the venturi would be installed in the 16-inch force main to the west tee fitting on the south side of the building. The vault would be approximately 20 feet long, 16 feet wide, and 10 feet deep.

A venturi meter vault could not be constructed at PS No. 7 given the site constraints and that the flows from this PS are conveyed in two force mains. The flows could be measured in a vault on the NSWWTP grounds after the point where the two force mains are combined. This vault would be located to the north of the west final clarifiers and would be approximately 20 feet long, 16 feet wide, and 15 feet deep.

The meter vault at PS No. 8 would be constructed immediately adjacent to the north side of the building where the discharge pipe exits the building. The vault would be approximately 20 feet long, 16 feet wide, and 18 feet deep.

The meter vault at PS No. 11 would be constructed immediately adjacent to the east side of the building where the discharge pipe exits the building. The vault would be approximately 20 feet long, 16 feet wide, and 24 feet deep.

Although PS No. 18 has an existing magnetic flow meter to measure flows, the District has indicated that venturi flow meters are required for all flow measurement devices used for billing purposes. The venturi meter vault at PS No. 18 would need to be constructed on the east side of the building underneath the asphalt access drive where the discharge pipe exits the building. The vault would be approximately 20 feet long, 16 feet wide, and 24 feet deep. Alternatively, this vault could be constructed on the NSWWTP grounds along the north access roadway. This location would allow easier construction without disturbance of the recently paved access drive at the PS. Costs for a new metering vault at PS No. 18 were included in this alternative.

None of the structures described above will be ventilated and, as such, will require a confined space entry for maintenance activities.

An opinion of probable cost for this alternative is presented in Table 4. A detailed breakdown of this opinion of probable cost is included in Appendix B. The O&M costs for this alternative will be similar to Alternative IFM1 with the reduced pumping costs and reduction in screen maintenance costs. An increase in labor of five hours a week is assumed to account for extra time that may be spent checking on the status of the vaults at each of the remote locations. The individual vaults will not be equipped with ventilation equipment so there will be no other additional operating costs. Table 4 also shows the opinion of annual operating costs for this alternative.

	Alt IFM4
Opinion of Capital Costs	$2,919,000
Opinion of Annual O&M	$63,000

Table 4 Alt IFM4–Metering Vaults at PS's Cost Summary

2. Noneconomic Considerations

This alternative, in general, is intended to reduce the required wastewater operating level in the screening channels while still maintaining adequate influent flow metering information needed for billing purposes. Potential benefits and limitations of this alternative are presented below.

a. Benefits

§ Better influent screen performance reducing pass-through of material.

§ Reduced pumping energy; consistent with the District's long term goal of energy neutrality.

§ Reduced accumulation of grit in influent channels.

b. Limitations

§ Construction at multiple sites including at pump stations and at NSWWTP.

§ Decentralizes flow metering operations and potentially makes troubleshooting more difficult.

§ Potential construction impacts to neighboring residences and entities, including noise, vibration, truck traffic, and dust.

§ Confined space entry requirements at each metering location.

D. Alternative IFM5-Reinstall Venturi Flow Meters at a Lower Elevation

1. Description of Alternative and Opinion of Cost

The alternative would involve lowering the elevation at which the influent venturis are installed to allow them to be full at all times, regardless of the water elevation in the screening channels. This would be accomplished by relocating the pipe such that the top of the force main would be below the floor of the screening channels. This would result in the venturis being completely submerged whenever there is flow in the screening channels. A concrete box would be installed for each force main on the east wall of the Meter Vault Room into which the force main would discharge. The influent wastewater would flow up the box and enter the screening channels through the existing 48-inch pipe opening. The existing sluice gates would remain in place to allow isolation of each force main as needed. The room would likely need to be extended approximately 5 feet to the west to maintain the distance required downstream of the venturis for accurate flow measurement. The pipes and venturis would be installed at approximately floor elevation (pipe centerline elevation 22.75) and a grating platform would be constructed over the pipes, essentially covering the entire room, except for the area of the sump pit in the northeast corner. The samplers would be replaced and relocated on the grating platform. Access to the flow meters and sample lines is required for calibration and maintenance purposes, and will be provided to each side of the force mains for such purposes.

The force mains would be removed back to the 45 degree elbows and re-laid to the Headworks Building at the new venturi elevation. A temporary pipe would be installed at the location of the future force main to accept flow from each of the force mains when they are being re-laid at the new elevation. The force main from PS No. 11 is at a higher elevation (centerline 25.5) than the proposed new venturi elevation, which would result in a high point at the transition to the new elevation. For the purposes of this evaluation, an air release valve is assumed to installed. Since this force main is the southernmost in the Meter Vault Room, it may be possible to have the venturi for this force main relocated to the centerline 25.5 elevation without hampering access to the other venturis. Having the venturi at this elevation would require a minimum of 9 inches of water in the screening channels at all times to maintain submergence. This concept should be considered prior to final design. Figure 3 shows a section view of this alternative.

An opinion of probable cost for this alternative is presented in Table 5. A detailed breakdown of this opinion of probable cost is included in Appendix B. Costs for this alternative include the addition to the basement Meter Vault Room, relocation of the pipes and venturis, reconfiguration of the buried force mains, the grating platform, bypassing of each of the force mains, demolition, shoring, electrical, and site work. Table 5 also shows the opinion of annual operating costs for this alternative, which are similar to Alternative IFM1 because of the lower channel water elevation resulting in lower pumping requirements and reduced maintenance costs for the screens and screening handling equipment.

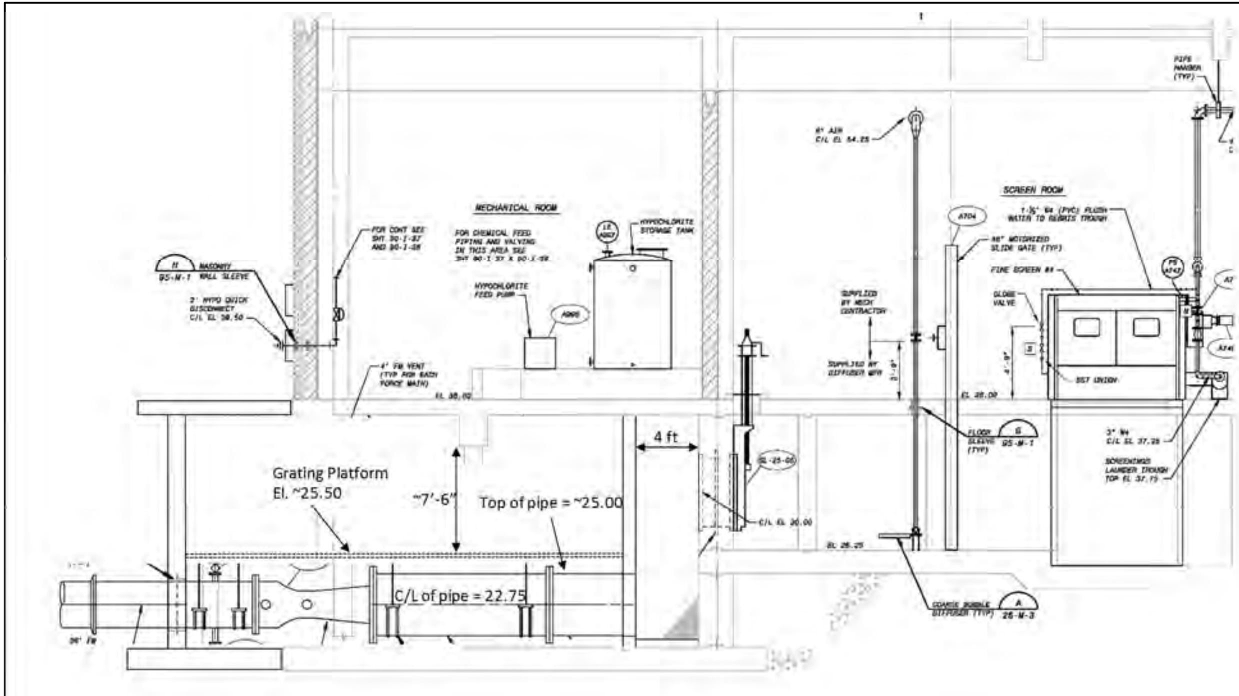


Figure 3 Alternative IFM5–Section View of Relocated Venturis

	Alt IFM4
Opinion of Capital Costs	$2,096,000
Opinion of Annual O&M	$52,000

Table 5 Alt IFM5–Relocate Venturis to Lower Elevation

2. Noneconomic Considerations

This alternative is intended to lower the existing venturis to an elevation that will be submerged regardless of screening operation. Potential benefits and limitations of this alternative are presented below.

a. Benefits

- Better influent screen performance, which should reduce pass-through of material and downstream maintenance concerns.
- All construction on NSWWTP grounds.
- Reuse of existing equipment and facilities.
- Reduced pumping energy; consistent with the District's long term goal of energy neutrality.

b. Limitations

§ Limits access to the Hypochlorite Room and Mechanical Room during construction.

INFLUENT FLOW MEASUREMENT PRESENT WORTH SUMMARY

Table 6 presents a summary of the costs for each of the Influent Flow Measurement alternatives. Based on the range of alternatives and respective costs, construction challenges, and related matters, we recommend proceeding with Alternative IFM5, which include relocating the existing venturi flow meters to a lower elevation. This alternative has the lowest capital and total present worth opinion of cost, and addresses the issue of screening channel overflow and screen control by providing a much larger variation between the minimum and maximum water level in the screening channels. This alternative also does not require additional space on-site for new metering structures.

	IFM0 No Change	IFM1 New Metering Vaults at NSWWTP	IFM2 New Flumes at NSWWTP	IFM4 New Metering Vaults at PS's	IFM5 Relocate Venturis to Lower Elevation
Total Opinion of Capital Cost	**$0**	**$3,180,000**	**$2,894,000**	**$2,919,000**	**$2,096,000**
Annual O&M	$81,000	$53,000	$86,000	$63,000	$52,000
O&M Cost PW	$1,065,000	$697,000	$1,131,000	$828,000	$684,000
Total Opinion of Present Worth	**$1,065,000**	**$3,877,000**	**$4,025,000**	**$3,747,000**	**$2,780,000**

Table 6 Influent Flow Measurement Opinion of Present Worth Summary

INFLUENT SCREENING AND SCREENINGS HANDLING ALTERNATIVES IDENTIFICATION

The Influent Screening and Screenings Handling alternatives were discussed during Workshop No. 6. A brief description of each of the alternatives presented at this workshop is presented in this section. A seventh alternative, S7–Install Chopper Pumps and Wash Presses, was added at the request of the District during the workshop.

A. Alternative S0–No Change (Null Alternative)

This alternative would continue operation with the existing band screens and screenings handling system, without changes. Screening and screenings handling equipment typically has a 15- to 20-year life. The screens have been in service for approximately 12 years and, given the age and condition of the screens and screenings handling equipment, it is assumed that all existing equipment will be replaced within 10 years and that a fourth screen will be installed at that time to provide 180 mgd projected peak hydraulic capacity, since the existing three screens have been shown to be limited to about 140 to 145 mgd

B. Alternative S1–Install Screen and Wash Press for Sluiced Screenings

This alternative would continue operation with the existing band screens and would replace the existing screenings handling system with two fine screens serving the sluice trough. These screens would discharge to dedicated screenings wash presses that would discharge to the haul-off waste container. In this alternative, the screened sluicing water would flow back to the influent channel ahead of the influent screens through an existing drain trough if the size of the trough is adequate to handle the flow. If the drain trough is inadequate, a new return trough or pipe would be installed. Floor modifications may be required in the area adjacent to the Maci well to accommodate the new screen. In addition, given the age and condition of the screens and screening handling system, it is assumed this equipment will be replaced with like equipment in 10 years. In addition, a fourth screen would also be installed at that time to provide 180 mgd peak hydraulic capacity. Every alternative that eliminates use of the existing screenings handling equipment would render use of the Eutek grit snail unnecessary, and would eliminate the Maci pumps and Maci well, macerator grit pump, secondary grit tanks, Lisep units, and Lipactors.

C. Alternative S2–Install New Band Screens and Dedicated Wash Presses

This alternative includes replacing the existing band screens and screenings handling system with new equipment. The band screens would be replaced with taller screens to allow them to discharge directly to a dedicated screenings wash press. Each wash press would discharge to either a belt conveyor or shaftless screw conveyor to carry the washed screenings to the haul-off waste container. This alternative would require installation of a fourth screen in 10 years to provide 180 mgd peak hydraulic capacity.

D. Alternative S3–Install Step Screens and Screenings Wash Presses

This alternative would involve replacement of the existing band screens with step screens and replacement of the existing screenings handling system with dedicated screenings wash presses for each screen. Each wash press would discharge to either a belt conveyor or shaftless screw conveyor to carry the washed screenings to the haul-off waste container. Modifications to the screening channels would be required to accommodate the new screens. The screen opening size could be reduced to 1/8 inch from the existing 1/4 inch with this style of screen. This alternative would not require installation of a fourth screen to provide 180 mgd peak hydraulic capacity.

E. Alternative S4–Install Travelling Rake Screens and Screenings Wash Presses

This alternative is similar to Alternative S3 and includes replacement of the existing band screens with travelling rake bar screens instead of step screens. A dedicated wash press would be installed for each screen. Each wash press would discharge to either a belt conveyor or shaftless screw conveyor to carry the washed screenings to the haul-off waste container. Modifications to the screening channels would be required to accommodate the new screens. The screen opening size could be reduced to 3/16 inch with this style of screen. This alternative would not require installation of a fourth screen to provide 180 mgd peak hydraulic capacity.

F. Alternative S5–Install Perforated Plate Screens and Screenings Wash Presses

This alternative is similar to Alternative S3 and would involve replacement of the existing band screens with perforated plate screens instead of step screens. A dedicated wash press would be installed for each screen. Each wash press would discharge to either a belt conveyor or shaftless screw conveyor to carry the washed screenings to the haul-off waste container. Modifications to the screening channels would be required to accommodate the new screens. The screen opening size could be reduced to 1/8-inch with this style screen. This alternative would require installation of a fourth screen in 10 years to provide 180 mgd peak hydraulic capacity.

G. Alternative S6–Install Moving Media Screens and Screenings Wash Presses

This alternative is similar to Alternative S3 and would involve replacement of the existing band screens with moving media screens (e.g., Parkson Aqua Guard) instead of step screens. A dedicated wash press would be installed for each screen. Each wash press would discharge to either a belt conveyor or shaftless screw conveyor to carry the washed screenings to the haul-off waste container. Modifications to the screening channels would be required to accommodate the new screens. This type of screen has opening sizes as small as 1 mm, although that size may not be practical for this application. This alternative would require installation in 10 years of a fourth screen to provide 180 mgd peak hydraulic capacity.

H. Alternative S7–Install Chopper Pumps and Wash Presses

An additional alternative was suggested during discussion at Workshop No. 6. This alternative involves the use of chopper pumps instead of the Maci pumps to pump sluiced screenings to a dewatering process. Chopper pumps may be less susceptible to wear and plugging than are the Maci pumps. Three wash presses would be installed in the mezzanine in place of the existing secondary grit tanks, Lisep units, and Lipactor equipment. Each wash press would discharge to the belt conveyor over the haul-off waste container. As with the Null Alternative, it is assumed that the existing screens will be replaced in 10 years and that a fourth screen would be installed at that time to provide 180 mgd peak hydraulic capacity.

INFLUENT SCREENING AND SCREENINGS HANDLING SCREENING OF ALTERNATIVES

During discussion of the alternatives as part of Workshop No. 6, the potential advantages and disadvantages of each of the preliminary alternatives was presented. None of the preliminary alternatives was excluded from further consideration, and an additional alternative was suggested during discussion.

Based on this screening process, the following alternatives were selected for further evaluation:

A. Alternative S0–Maintain the Existing System (Null Alternative)
B. Alternative S1–Install Screen and Wash Press for Sluiced Screenings
C. Alternative S2–Install New Band Screens and Dedicated Wash Presses
D. Alternative S3–Install Step Screens and Dedicated Wash Presses
E. Alternative S4–Install Travelling Rake Screens and Dedicated Wash Presses
F. Alternative S5–Install Perforated Plate Screens and Dedicated Wash Presses
G. Alternative S6–Install Moving Media Screens and Dedicated Wash Presses
H. Alternative S7–Install Chopper Pumps and Wash Presses

Each of these alternatives is further described and evaluated below.

INFLUENT SCREENING AND SCREENINGS HANDLING DETAILED EVALUATION OF ALTERNATIVES

A. Alternative S0–Maintain the Existing System (Null Alternative)

1. Description of Alternative and Opinion of Cost

In this alternative, the existing band screens and screenings handling equipment would be maintained. Replacement of the existing equipment, including the screens, Maci pumps, Lisep, Lipactor, macerator grit pump, and grit snail, and installation of a fourth band screen and Lisep and Lipactor is assumed in year 10 given the age and condition of the equipment and the need to accommodate the projected maximum flow.

Operating costs were assumed to be the same as the existing maintenance costs (the sum of mechanical, operations, and supplies and parts costs) of the screening operations and grit operations. These costs were provided by the District and are based on the last five years of O&M costs.

Table 7 shows the capital and operating costs for this alternative. Detailed opinions of capital cost and O&M costs are provided in Appendix C.

	Alt. S0
Opinion of Capital Costs (Year 0)	$0
Opinion of Capital Costs (Year 10)	5,564,000
Opinion of Annual O&M	**$120,000**

Table 7 Alt S0–Null Alternative Cost Summary

2. Noneconomic Considerations

This alternative does not improve the current operations of the influent screens and screenings handling. Screening and screenings handling would continue as it currently does, and the equipment will be replaced as needed within the planning period.

a. Benefits

- Continues use of equipment with remaining useful life (screens, Liseps, Lipactors, Maci pumps, macerator grit pump)

b. Limitations

- Still has water requirement for sluicing of the screenings.
- Continues using equipment that has been problematic and requires frequent attention and maintenance (Liseps, Lipactors, Maci pumps, macerator grit pump, and grit snail).

B. Alternative S1–Install Screens and Wash Press for Sluiced Screenings

1. Description of Alternative and Opinion of Cost

In this alternative, the existing band screens and sluicing trough would be maintained. The trough would discharge into new channels in which two screens, likely 1/8-inch perforated plate screens to provide the maximum capture of the screened material, would be installed. These screens, which would only be required to handle the volume of sluicing water, would discharge to two screenings wash presses. The washed screenings would discharge directly to the haul-off waste container.

Given the space restrictions and the size of the equipment, specifically the wash presses, it does not appear that there is available space for installation of two screens and wash presses in the Maci pit area. It may be possible, however, to extend the trough to the north and construct concrete channels at floor level under the mezzanine in which the screens could be installed. The wash presses would be installed on top of the channels under the mezzanine and discharge directly into the haul-off waste container. Given District staff comments about the inadequacy of the existing trench drains to handle flows from the grit classifiers, it would be necessary to cut new trench drains into the floor to convey the screened sluicing water back into the screening channels. Figure 4 shows the proposed layout for this arrangement. This concept has the advantage over the arrangement previously discussed during the workshop with respect to constructability, except for the final connection to the existing trough, without interrupting the existing screenings handling equipment.

Capital costs for this alternative include construction of the concrete channels, extension of the sluice trough, relocation of the existing stairs over the trough, costs for installation of two 2-foot-wide perforated plate screens and two wash presses, and the trench drain. This alternative also includes costs for installation of four new band screens in year 10 to accommodate the projected maximum flow and to replace the aging existing screens. Operating costs include a reduction in pumping costs related to the Maci pumps and macerator grit pump, elimination of operating and maintenance costs for the grit snail, and a reduction in maintenance costs for the screenings handling equipment since the new small screens and screenings wash presses will likely require less attention that the existing equipment.

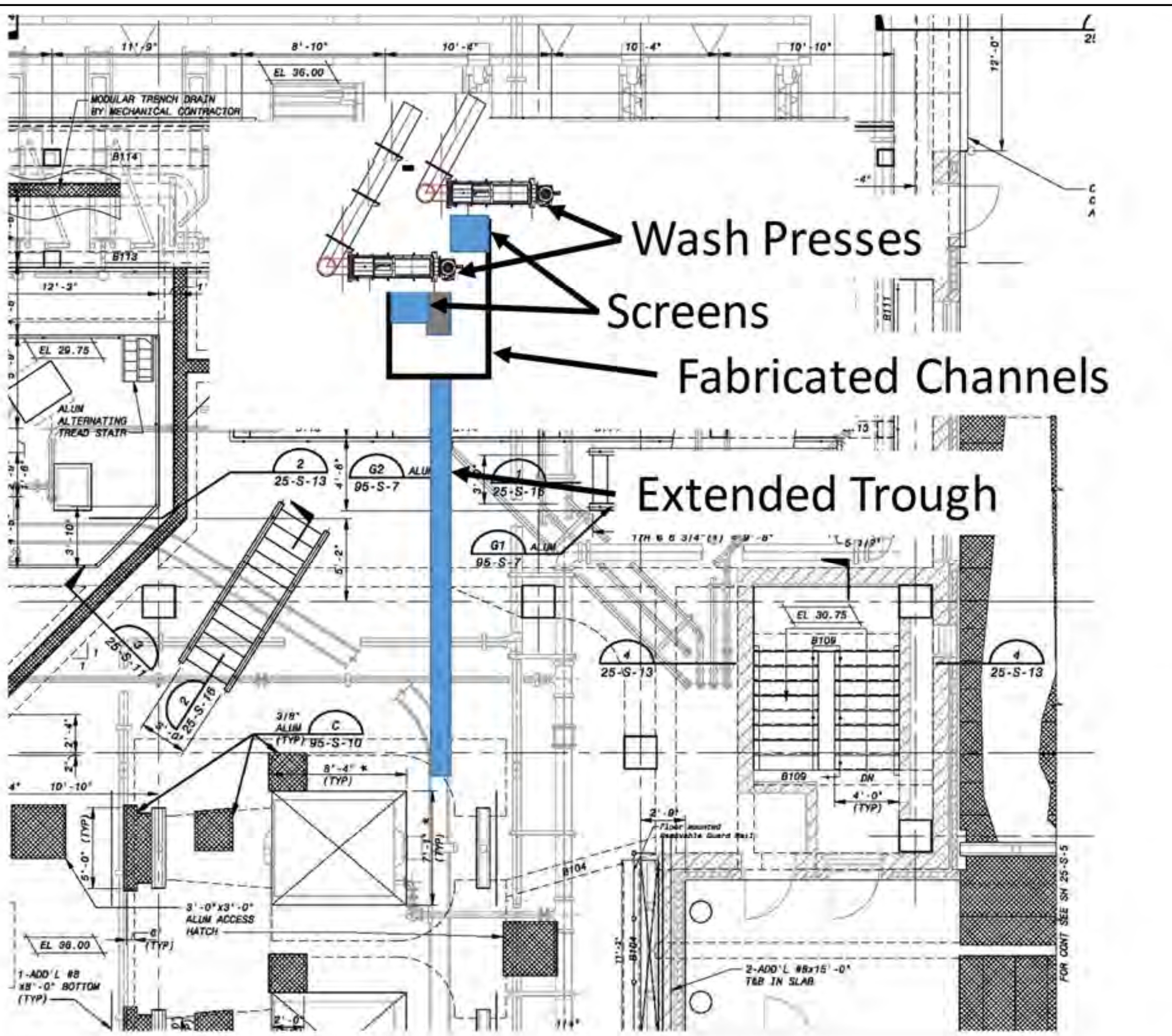


Figure 4 Alternative S1–Sluiced Screening Preliminary Layout

Table 8 shows the capital and operating costs for this alternative. Detailed opinions of capital cost and O&M costs are provided in Appendix C.

	Alt. S1
Opinion of Capital Costs (Year 0)	$1,667,000
Opinion of Capital Costs (Year 10)	$4,224,000
Opinion of Annual O&M	**$96,000**

Table 8 Alt S1–Sluiced Screening Cost Summary

2. Noneconomic Considerations

This alternative replaces the existing screenings handling equipment with new equipment to rescreen the sluiced screenings prior to washing/compacting the screenings in standard wash presses.

a. Benefits

§ Provides improved and simpler screenings handling process with fewer pieces of equipment.

§ Significantly reduces maintenance required for screenings handling.

§ Wash presses are less susceptible to plugging with heavy grease loads.

§ Eliminates the grit snail and associated maintenance.

§ If one of the two sluicing screens or washpresses is out of service, that does not require any of the main channel screens to be taken out of service.

b. Limitations

§ Still has water requirement for sluicing of the screenings to the new screens.

§ Replaces equipment that has remaining useful life (Lisep, Lipactors, Maci pumps, and macerator grit pumps).

§ May create cramped space with channels and equipment under the mezzanine.

§ Requires a fourth screen to provide 180 mgd.

C. Alternative S2–Install New Band Screens and Dedicated Wash Presses

1. Description of Alternative and Opinion of Cost

In this alternative (Figure 5), new band screens would be installed with dedicated wash presses at each screen. It is necessary to replace the existing screens to use dedicated wash presses because the discharge elevation of the existing screenings is too low to permit installation of a wash press. The wash presses would be positioned on the west side of the screens and would discharge onto a belt conveyor, which would transport the screenings to the haul-off waste container. The ability of the conveyor to reach the container without major modifications to the mezzanine would need to be verified during detailed design.

This alternative would eliminate use of the screenings trough and associated sluicing water, the Maci pumps, the macerator grit pumps, the secondary grit tank, the Lisep and Lipactor, and the grit snail. Figure 5 shows the proposed layout for this alternative.

Capital costs for this alternative include the costs for demolition of the existing screening and screenings handling equipment and installation of screening, wash press, and conveyor equipment. This alternative also includes cost for installation of a fourth band screen and wash press in year 10 to accommodate the projected maximum flow.

Operating costs include a reduction in pumping costs for the Maci pumps and macerator grit pump, a reduction in W4 pumping costs with the elimination of a constant water requirement for sluicing the screenings, elimination of O&M costs for the grit snail, and reduced maintenance costs for the screens and screenings handling equipment since the new screens and screenings wash presses will require less attention than the existing equipment.

Table 9 shows the opinion of capital and operating costs for this alternative. Detailed opinions of capital cost and O&M costs are provided in Appendix C.

	Alt. S2
Opinion of Capital Costs (Year 0)	$4,145,000
Opinion of Capital Costs (Year 10)	$1,713,000
Opinion of Annual O&M	$69,000

Table 9 Alt S2–New Band Screen Cost Summary

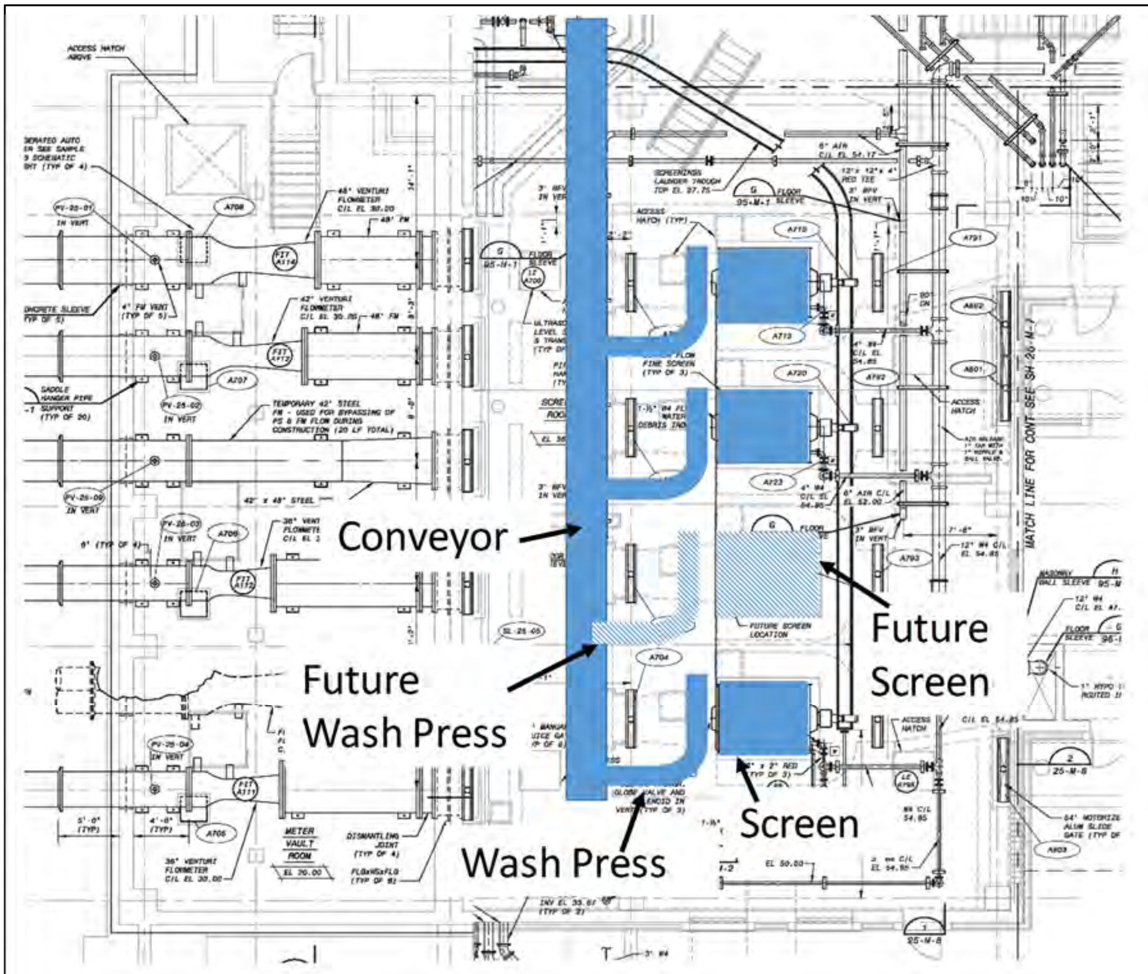


Figure 5 Proposed Alternative S2 Layout

2. Noneconomic Considerations

This alternative includes replacement of the existing band screens and existing screenings handling system with new band screens, wash presses, and a conveyor.

a. Benefits

- Provides improved and less complicated screenings handling process with fewer pieces of equipment.
- Reduces maintenance required for screenings handling equipment.
- Wash presses are less susceptible to plugging with heavy grease loads.
- Eliminates water requirement for sluicing of the screenings to the Maci pit.
- Least intrusive construction of the screenings alternatives. No changes to screenings channels required.

b. Limitations

- Conveyor across length of building.
- Will require fourth screen for 180 mgd.
- Replaces equipment that has remaining useful life (Lisep, Lipactors, Maci pumps, and macerator grit pumps).
- Access to slide gates is limited.

D. Alternative S3–Install Step Screens and Dedicated Wash Presses

1. Description of Alternative and Opinion of Cost

In this alternative new step screens would be installed with dedicated wash presses serving each screen. Significant channel modifications would be required to allow proper flow to the screens and for proper installation of the new screens in the area currently occupied by the existing center-flow band screens. The wash presses would be positioned on the east side of the screens and would discharge onto a belt conveyor located on the west side of the screens. The conveyor would transport the screenings to the haul-off waste container. The isolation slide gates upstream of the screens would also need to be replaced because of the channel modifications.

This alternative would eliminate use of the screenings trough, the Maci pumps, the macerator grit pumps, the secondary grit tank, the Lisep and Lipactor, and the grit snail. Figure 6 shows the proposed layout for this alternative. The capacity of the step screens allows the projected maximum flow of 180 mgd to be achieved without installation of a fourth screen.

Capital costs for this alternative include the costs for demolition of the existing screening and screenings handling equipment, removal of concrete upstream of the screens, replacement of the slide gates upstream of the screens, and installation of screening, wash press, and conveyor equipment. Operating costs were assumed to be similar to those for Alternative S2.

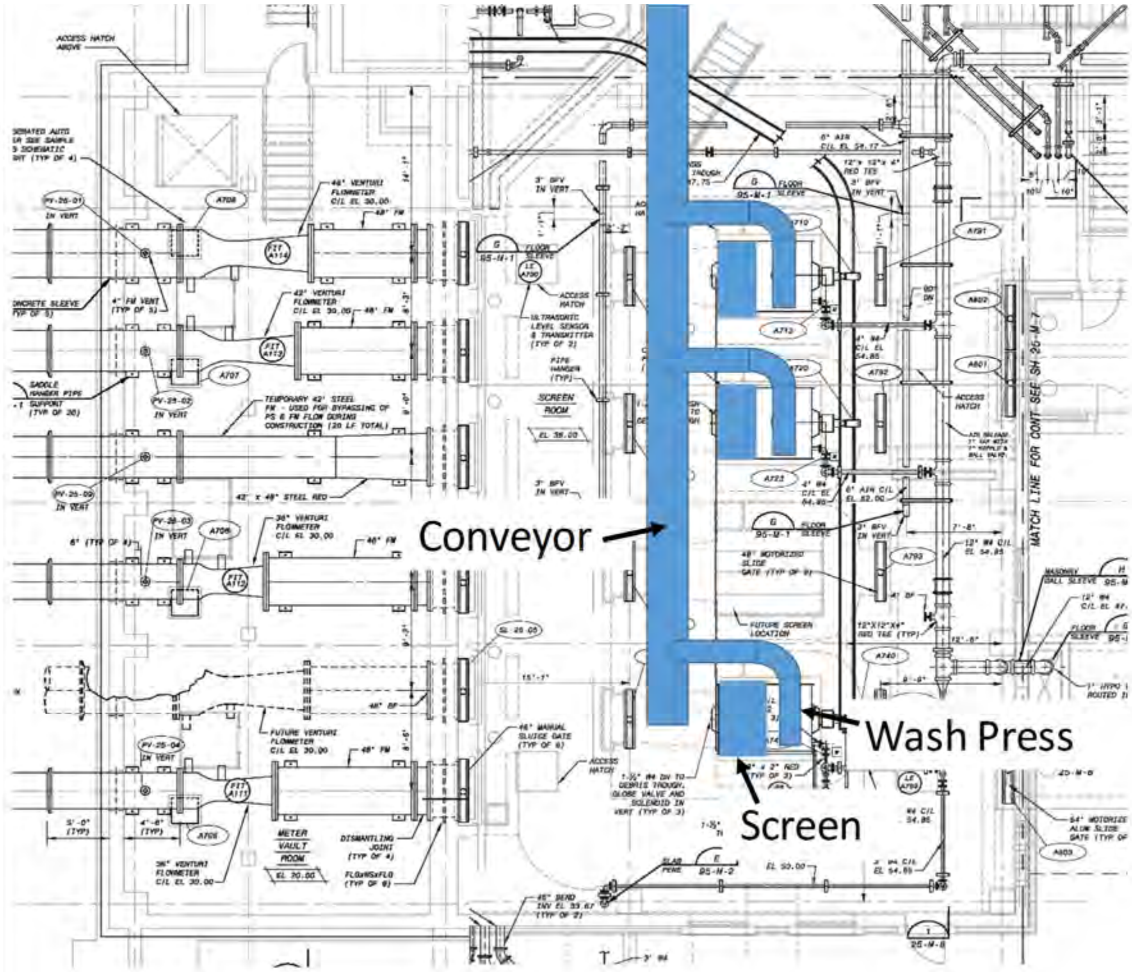


Figure 6 Proposed Alternative S3 Layout

Table 10 shows the capital and operating costs for this alternative. Detailed opinions of capital cost and O&M costs are provided in Appendix C.

	Alt. S3
Opinion of Capital Costs (Year 0)	$3,390,000
Opinion of Annual O&M	$69,000

Table 10 Alt S3–Step Screen Cost Summary

2. Noneconomic Considerations

This alternative includes replacement of the existing band screens and existing screenings handling system with new step screens, wash presses, and a conveyor.

a. Benefits

- § Provides improved and simpler screenings handling process with fewer pieces of equipment.
- § Reduces maintenance required for screenings handling.
- § Wash presses are less susceptible to plugging with heavy grease loads.
- § Eliminates water requirement for sluicing of the screenings to the Maci pit.
- § Fourth screen not required for 180 mgd.

b. Limitations

- § Constructability concerns. Significant removal of concrete from channels required to install different style screen.
- § Step screens are more susceptible to damage from larger objects.
- § Conveyor across length of building.
- § Substantial channel modifications required.
- § Replaces equipment that has remaining useful life (Lisep, Lipactors, Maci pumps, and macerator grit pumps).
- § Access to slide gates is limited.
- § Screenings capture is unlikely to be as good as band screens.

E. <u>Alternative S4–Install Travelling Rake Screens and Dedicated Wash Presses</u>

1. Description of Alternative and Opinion of Cost

This alternative is the same as Alternative S3, except that travelling rake screens would be installed instead of step screens. Travelling rake screens have the advantage of being more robust than step screens and are constructed to sustain impacts from large objects.

This alternative would eliminate use of the screenings trough, the Maci pumps, the macerator grit pumps, the secondary grit tank, the Lisep and Lipactor, and the grit snail. Figure 6 is also applicable to the layout for this screening equipment.

Capital costs for this alternative include the costs for demolition of the existing screening and screenings handling equipment, removal of concrete upstream of the screens, replacement of the slide gates upstream of the screens, and installation of screening, wash press, and conveyor equipment. Table 11 shows the opinion of capital and operating costs for this alternative. Detailed opinions of capital cost and O&M costs are provided in Appendix C.

	Alt. S4
Opinion of Capital Costs (Year 0)	$3,849,000
Opinion of Annual O&M	$69,000

Table 11 Alt S4–Travelling Rake Screen Cost Summary

2. Noneconomic Considerations

This alternative includes replacement of the existing band screens and existing screenings handling system with new travelling rake screens, wash presses, and a conveyor.

a. Benefits

- Provides improved and simpler screenings handling process with fewer pieces of equipment.
- Reduces maintenance required for screenings handling.
- Wash presses are less susceptible to plugging with heavy grease loads.
- Eliminates water requirement for sluicing of the screenings to the Maci pit.
- Screens are sturdy and better able to handle large objects without damage.
- Fourth screen not required for 180 mgd.

b. Limitations

- Conveyor across length of building.
- Substantial channel modifications required.
- Replaces equipment that has remaining useful life (Lisep, Lipactors, Maci pumps, and macerator grit pumps).
- Screenings capture is unlikely to be as good as band screens.

F. <u>Alternative S5–Install Perforated Plate Screens and Dedicated Wash Presses</u>

1. Description of Alternative and Opinion of Cost

This alternative is the same as Alternative S3 except that perforated plate screens would be installed instead of step screens. This alternative would eliminate use of the screenings trough, the Maci pumps, the macerator grit pumps, the secondary grit tank, the Lisep and Lipactor, and the grit snail. Figure 6 is also applicable to the layout for this alternative.

Capital costs for this alternative include the costs for demolition of the existing screening and screenings handling equipment, removal of concrete upstream of the screens, replacement of the slide gates upstream of the screens, and installation of screening, wash press, and conveyor equipment. This alternative also includes cost for installation of a fourth screen and wash press in year 10 to accommodate the projected maximum flow. Table 12 shows the opinion of capital and operating costs for this alternative. Detailed opinions of capital cost and O&M costs are provided in Appendix C.

	Alt. S5
Opinion of Capital Costs (Year 0)	$3,590,000
Opinion of Capital Costs (Year 10)	$1,244,000
Opinion of Annual O&M	$69,000

Table 12 Alt S5–Perforated Plate Screen Cost Summary

2. Noneconomic Considerations

This alternative includes replacement of the existing band screens and existing screenings handling system with new perforated plate screens, wash presses, and a conveyor.

a. Benefits

§ Provides improved and less complicated screenings handling process with fewer pieces of equipment.

§ Improved screenings capture over Alternatives S3 and S4.

§ Reduces maintenance required for screenings handling.

§ Wash presses are less susceptible to plugging with heavy grease loads.

§ Eliminates water requirement for sluicing of the screenings to the Maci pit.

§ Provides opportunity to design screens for existing hydraulic conditions.

b. Limitations

§ Screenings discharge requires a brush, which is a maintenance item.

§ Conveyor across length of building.

§ Substantial channel modifications required.

§ Will require fourth screen for 180 mgd.

§ Replaces equipment that has remaining useful life (Lisep, Lipactors, Maci pumps, and macerator grit pumps).

G. Alternative S6–Install Moving Media Screens and Dedicated Wash Presses

1. Description of Alternative and Opinion of Cost

This alternative is the same as Alternative S3, except that moving media screens would be installed instead of step screens. This alternative would eliminate use of the screenings trough, the Maci pumps, the macerator grit pumps, the secondary grit tank, the Lisep and Lipactor, and the grit snail. Figure 6 is also applicable to the layout for this alternative.

Capital costs for this alternative include the costs for demolition of the existing screening and screenings handling equipment, removal of concrete upstream of the screens, replacement of the slide gates upstream of the screens, and installation of screening, wash press, and conveyor equipment. This alternative also includes cost for installation of a fourth screen in year 10 to accommodate the projected maximum flow. Table 13 shows the opinion of capital and operating costs for this alternative. Detailed opinions of capital cost and O&M costs are provided in Appendix C.

	Alt. S6
Opinion of Capital Costs (Year 0)	$3,869,000
Opinion of Capital Costs (Year 10)	$1,169,000
Opinion of Annual O&M	$69,000

Table 13 Alt S6–Moving Media Screens Cost Summary

2. Noneconomic Considerations

This alternative includes replacement of the existing band screens and existing screenings handling system with new moving media screens, wash presses, and a conveyor.

a. Benefits

§ Provides improved and simpler screenings handling process with fewer pieces of equipment.

§ Improved screenings capture over Alternatives S3 and S4.

§ Reduces maintenance required for screenings handling.

§ Wash presses are less susceptible to plugging with heavy grease loads.

§ Eliminates water requirement for sluicing of the screenings to the Maci pit.

b. Limitations

§ Screenings discharge requires a brush, which is a maintenance item.

§ Conveyor across length of building.

§ Substantial channel modifications required.

§ Requires a fourth screen to provide 180 mgd of capacity.

§ Replaces equipment that has remaining useful life (Lisep, Lipactors, Maci pumps, and macerator grit pumps).

H. Alternative S7–Install Chopper Pumps and Wash Presses

1. Description of Alternative and Opinion of Cost

This alternative involves the use of chopper pumps instead of the Maci pumps. Chopper pumps may be less susceptible to wear and plugging than Maci pumps. Three wash presses would be installed in the mezzanine in place of the existing secondary grit tanks, Lisep equipment, and Lipactors. Each wash press would discharge to the belt conveyor over the haul-off waste container.

Initial capital costs for this alternative include the costs for demolition of the existing screenings handling equipment on the mezzanine, removal of the Maci pumps, installation of the chopper pumps, and installation of the wash presses.

This alternative would retain use of the existing band screens, the screenings trough, the Maci pit, macerator grit pumps, and grit snail until this equipment is replaced in 10 years. New band screens (four) and grit pumps would be installed in 10 years, similar to Alterative S2. Figure 7 shows the layout for the wash presses on the mezzanine.

Operating costs include a reduction in maintenance costs for the screenings handling equipment since the screenings wash presses will likely require less attention that the existing equipment. Grit equipment maintenance will be unchanged from the Null Alternative. Table 14 shows the opinion of capital and operating costs for this alternative. Detailed opinions of capital cost and O&M costs are provided in Appendix C.

	Alt. S7
Opinion of Capital Costs (Year 0)	$1,304,000
Opinion of Capital Costs (Year 10)	$4,673,000
Opinion of Annual O&M	$104,000

Table 14 Alt S7–Opinion of Capital and O&M Cost Summary

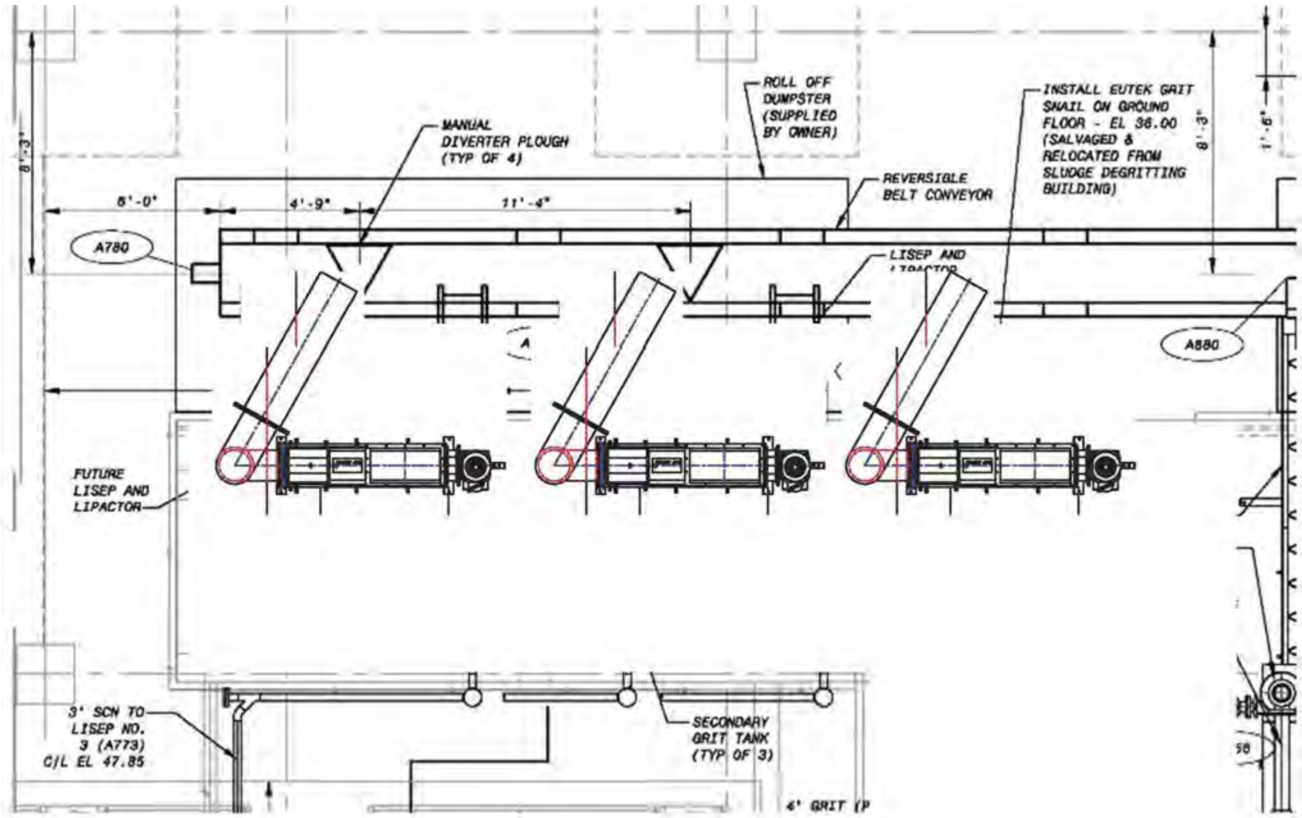


Figure 7 Layout of Screenings Wash Presses on Mezzanine (Alt. S7)

2. Noneconomic Considerations

This alternative includes replacement of the existing Maci pumps to alleviate wear and plugging issues with those pumps.

a. Benefits

- Replaces Maci pumps with pumps better suited to pumping screenings.
- Reduced maintenance of screenings handling equipment.
- Wash presses are less susceptible to plugging with heavy grease loads.

b. Limitations

- Proposed solution is not substantially different than the existing system, and may not improve maintenance requirements.
- Alternative does not address issues associated with existing screens.
- Alternative does not address issues associated with screenings trough.

- Operation of grit snail is still required.
- Water use is still high.
- Replaces equipment that has remaining useful life (Lisep, Lipactors, Maci pumps, and macerator grit pumps).

INFLUENT SCREENING AND SCREENINGS HANDLING PRESENT WORTH SUMMARY

The alternatives evaluated herein each provide a minimum influent screening capacity of 180 mgd by or before year 10. The existing equipment has been in service for about 12-13 years, and likely could last another 10 years before it would be absolutely required to be replaced. However, we believe it's in the District's best interest to update the screenings handling equipment before the end of the remaining useful life of the equipment because of the significant and frequent maintenance required on this equipment.

Table 15 provides an opinion of present worth summary, and more detailed analysis is included in Appendix C. Alternative S0 (null alternative) has the lowest opinion of 20-year total present worth, but it is only about 4 percent less than Alternative S3 (new step screens). For the purpose of this facilities planning, these costs are considered equal. The null alternative does not resolve any of the operational or maintenance issues related to influent screening. Alternative S3–New Step Screen and Wash Presses would provide an entirely new screening and screenings handling system that would be simpler to maintain over time. This alternative does have a lower “clean screen” screenings capture efficiency but if the screens are allowed to be operated to build at mat their screenings capture efficiency increases to approach that of the band screens.

Alternative S1, which includes replacing the screening sluicing, macerating, and dewatering equipment with two fine screens and screenings washer/compactors, is within 10 percent of the recommended Alternative S3. This alternative could be considered for more detailed evaluation as it continues the use of the most efficient screening equipment (band screens) yet simplifies the screenings handling equipment and processes.

Table 15 Screening Opinion of Present Worth Summary

	Null Alternative	Screen Sluiced Screenings	New Band Screens, Wash Presses	New Step Screens, Wash Presses	New Trav. Rake Screens, Wash Presses	New Perf. Plate Screens, Wash Presses	New Moving Media Screens, Wash Presses	Chopper Pumps, Wash Presses
	S0	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**
Total Opinion of Current Capital Cost	---	$1,677,000	$4,145,000	$3,390,000	$3,849,000	$3,590,000	$3,869,000	$1,304,000
Total Opinion of Future Capital Cost	$5,564,000	$4,224,000	$1,713,000	---	---	$1,415,000	$1,169,000	$4,673,000
Annual O&M	$120,000	$96,000	$69,000	$69,000	$69,000	$69,000	$69,000	$104,000
Present Worth								
O&M	$1,578,000	$1,262,000	$907,000	$907,000	$907,000	$907,000	$907,000	$1,368,000
Future Costs	$3,626,000	$2,753,000	$1,116,000	---	---	$473,000	$762,000	$3,045,000
Salvage	($1,182,000)	($897,000)	($363,000)	---	---	($153,000)	($248,000)	($992,000)
Total Opinion of Present Worth	**$4,022,000**	**$4,795,000**	**$5,805,000**	**$4,297,000**	**$4,756,000**	**$ 4,817,000**	**$5,290,000**	**$4,725,000**

GRIT WASHING ALTERNATIVES IDENTIFICATION

A brief description of each of the grit washing alternatives presented at Workshop No. 6 is presented in this section. These alternatives are intended to address the issues described previously in this technical memorandum.

A. Alternative G0–No Change (Null Alternative)

The current grit removal facilities consist of three vortex grit tanks, each serviced by two grit pumps and three grit classifiers. This alternative would continue operation with the existing grit removal and handling process, including the continued use of the grit classifiers. The existing grit classifiers have been in service for approximately 12 years and, given their age and condition, it is assumed that they will be replaced within 10 years. New drain piping would be installed from the grit classifiers to the influent channels to help alleviate the current drainage issues.

B. Alternative G1–Replacement of Grit Classifiers with Grit Washers

This alternative would replace the existing grit classifiers with grit washers, which are capable of producing a cleaner, less odorous, grit product. Given the condition of the existing grit classifiers, it is assumed that the replacement would occur in year 10. Because of the size of the grit washers, installation of a fourth washer would only be possible if the existing screenings handling equipment installed on the mezzanine were removed as discussed in the screenings alternatives described previously for Alternatives S1 through S6. New drain piping would also be installed with this alternative.

GRIT WASHING DETAILED EVALUATION OF ALTERNATIVES

A. Alternative G0–No Change (Null Alternative)

1. Description of Alternative and Opinion of Cost

In this alternative the existing grit system would be unchanged. There would be no initial capital costs and the annual operating costs (the sum of mechanical, operations, and supplies and parts cost categories) would be unchanged from current levels. We have assumed that new grit concentrators, grit tank mechanisms, and grit pumps would be installed in 10 years to replace the existing units, which will be more than 20 years old at that time. Table 16 presents the capital and operating costs for this alternative. Appendix D includes more details related to the grit handling costs.

	Alt. G0
Opinion of Capital Costs (Year 0)	$0
Opinion of Capital Costs (Year 10)	$1,893,000
Opinion of Annual O&M	$39,000

Table 16 Alt G0–Grit Handling Null Alternative Cost Summary

This alternative includes continuing the use of the existing grit handling equipment with new grit classifiers in 10 years.

a. Benefits

§ Continued use of existing equipment.

b. Limitations

§ Equipment susceptible to wear and breakdowns.

§ Dewatered grit product not as clean as with grit waters; higher odors.

B. Alternative G1–Replacement of Grit Classifiers with Grit Washers

1. Description of Alternative and Opinion of Cost

In this alternative the existing grit classifiers would be replaced with grit washers. The grit washers occupy more space than the existing classifiers but there is sufficient room on the mezzanine to install this equipment. Figure 8 shows a proposed layout for the grit washers.

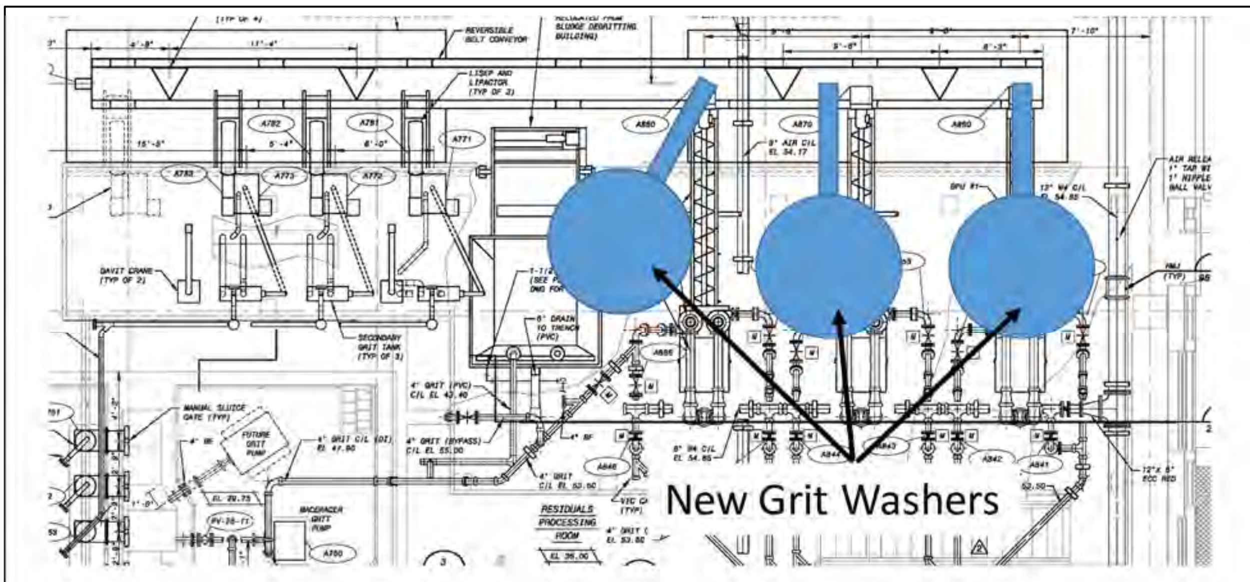


Figure 8 Proposed Grit Washer Layout

Capital costs for this alternative include the costs for demolition of the existing grit classifiers, minor piping modifications, and installation of the grit washers in 10 years, which coincides with the approximate end of the useful life of this equipment. The grit tank mechanisms and grit pumps are also assumed to be replaced at this time given their age. Table 17 presents the capital and operating costs for this alternative. Appendix D includes more details related to the grit handling costs.

While replacement of the grit classifiers with grit washers will eliminate the costs for the frequent replacement of the grit cyclones, the overall O&M costs are not expected to change because the grit washers use wash water (W4), are more complicated and required more attention than grit classifiers.

	Alt. G1
Opinion of Capital Cost (Year 0)	$0
Opinion of Capital Costs (Year 10)	$1,956,000
Opinion of Annual O&M	$40,000

Table 17 Alt G1–Grit Washer Cost Summary

2. Noneconomic Considerations

This alternative includes replacement of the existing grit classifiers to produce a cleaner final grit product.

a. Benefits

§ Cleaner grit product.

b. Limitations

§ Higher W4 demand for grit washing.

GRIT WASHING PRESENT WORTH SUMMARY

Table 18 provides an opinion of present worth summary for the grit alternatives. Given that the existing equipment is expected to last for another 10 years, replacement of the equipment in 10 years should be with new state-of-the-art equipment, which includes new grit washers (Alt G1) in lieu of grit classifiers (Alt. G0–Null Alternative). However, this recommendation is dependent on the screening alternative selected since the mezzanine is not large enough to accommodate three new grit washers without eliminating the existing screening handling equipment on that level.

	G0	G1
Opinion of Capital Cost (Year 0)	$0	$0
Opinion of Capital Cost (Year 10)	$1,893,000	$1,956,000
Annual O&M	$39,000	$40,000
Present Worth		
O&M Cost	$515,000	$526,000
Future Costs	$1,233,000	$1,275,000
Salvage	($402,000)	($415,000)
Total Opinion of Present Worth	**$1,346,000**	**$1,386,000**

Table 18 Grit Management Opinion of Present Worth Summary

HAULED WASTE RECEIVING ALTERNATIVES IDENTIFICATION

A brief description of each of the hauled waste receiving alternatives discussed at Workshop No. 6 is presented in this section. These alternatives are intended to address the issues described previously in this technical memorandum.

A. Alternative HW0–No Change (Null Alternative)

This alternative would continue operation with the existing hauled waste receiving facilities. The facilities are located at the south end of the Headworks Building and consist of a covered dumping area into which two trucks can back up to the discharge trough and empty their contents. Hauled wastes flow directly from the discharge trough into the influent channel in the Headworks Building through two 8-inch pipes.

B. Alternative HW1–Construction of a Drive-Through Hauled Waste Receiving Station at the Existing Receiving Location

This alternative would modify the existing hauled waste receiving station to allow drive-through traffic. Modifications would also include installation of automated hauled waste screening equipment, robust rock/grit handling ability, and access control using a card system or other similar system.

C. Alternative HW2–Construction of a Drive-Through Hauled Waste Station Near PS No. 3

This alternative would replace the existing hauled waste receiving station with a drive-through receiving station near PS No. 3. Modifications would be very similar to Alternative HW1. Screened hauled waste would flow by gravity to PS No. 3, which discharges to the PS No. 2 force main and ultimately to the plant headworks.

D. Alternative HW3–Construction of a Drive-Through Hauled Waste Station Near the North Truck Entrance

This alternative would replace the existing hauled waste receiving station with a drive-through receiving station near the north truck entrance in the open space to the west of Storage Building No. 2. Modifications would be very similar to Alternative HW1 and HW2. Screened hauled waste may be able to flow from this location to PS No. 3.

HAULED WASTE RECEIVING SCREENING OF ALTERNATIVES

During discussion of the alternatives during Workshop No. 6, concerns were raised over the impact of adding flows to the PS No. 2 force main (via PS No. 3 discharge of hauled wastes) within Alternatives HW2 and HW3:

§ The additional flows and loads would impact the measurements made for billing customer communities.

- Addition of another facility for hauled waste receiving and potential abandonment of an existing asset were also viewed as a negative to these alternatives.
- There is a significant potential for odor issues in close proximity to the Capital City Trail related to these alternatives.
- The space occupied by the new hauled waste facilities would take space that might have value for future treatment facilities.

For these reasons, these alternatives were eliminated from further consideration.

In addition to Alternatives HW2 and HW3, other locations on the south portion of the NSWWTP site were considered at Workshop No. 6 that could potentially flow by gravity to the Headworks Building. The main concerns with these locations include the following:

- Potential odors closer to the property line on that side of the plant.
- Additional truck traffic on the south side of the plant and potential impacts related to school bus stops in the area.
- The space has the potential to be used for future solids processing capacity needs.

Based on this screening process, only Alternative HW1–Construction of a Drive-Through Hauled Waste Receiving Station at the Headworks Building will be considered for further review along with the Null Alternative HW0. These alternatives are further described and evaluated below.

Note that we did not include the revenue generated from hauled waste receiving in this analysis. It was assumed that revenue is essentially equal for both alternatives, and the main O&M differences would be realized with respect to downstream maintenance.

HAULED WASTE RECEIVING DETAILED EVALUATION OF ALTERNATIVES

A. Alternative HW0–No Change (Null Alternative)

1. Description of Alternative and Opinion of Cost

In this alternative hauled waste receiving facilities and operations would be unchanged. There would be no capital costs for this alternative, and the annual operating costs are unchanged from the existing costs. Table 19 shows the capital and operating costs for this alternative. Appendix E provides details with respect to capital and O&M cost opinions.

	Alt. HW0
Opinion of Capital Costs	$0
Opinion of Annual O&M	$21,000

Table 19 Alt HW0–Hauled Waste Null Alternative Costs Summary

2. Noneconomic Considerations

The alternative continues use of the existing hauled waste receiving facilities unchanged and, as a result, none of the numerous issues associated with these facilities are resolved.

a. Benefits

§ No interruption to existing receiving area.

§ Reuses existing facilities that have remaining useful life.

b. Limitations

§ The numerous issues with hauled waste receiving are not addressed.

B. Alternative HW1–Construction of a Drive-Through Hauled Waste Receiving Station at the Headworks Building

1. Description of Alternative and Opinion of Cost

In this alternative the existing hauled waste receiving area will be widened to allow installation of two mechanical receiving stations equipped with rock traps and screening equipment. The existing trough would be removed and the drive would be extended to allow one-way traffic through the receiving area and to eliminate the need for trucks to back in. The drive would be sloped to allow trucks to be completely emptied. Receiving stations would be installed in an approximately 27- by 53-foot building. Because of the location and size of the building, it is likely that the existing canopy will have to be removed and several pipes will have to be relocated. Additional facilities will need to be added to allow dumping from irregular sources such as barrels, totes, porta-potties, and grease trailers. A proposed preliminary layout for the drive and building is shown in Figure 9, although other layouts should also be considered that may allow the existing canopy to remain in place. An existing stormwater bioswale would be disturbed by construction of the drive that would have to be relocated and likely enlarged to accommodate increased runoff from the increased impervious area. The ventilation system would be designed to incorporate odor control in the future if needed. No costs for an odor control system are included.

Modification of the hauled waste receiving facilities would include incorporation of more security and tracking measures to reduce the potential for unauthorized or inaccurately reported discharges. The measures would include a card or keypad activated entry gate and flow meters on the two receiving stations.

An important consideration of this alternative is the displacement of hauled waste receiving activities during construction. An alternate location for trucks to discharge would need to be identified and any temporary measures, such as a rental receiving station, would need to be put in place prior to the start of construction.

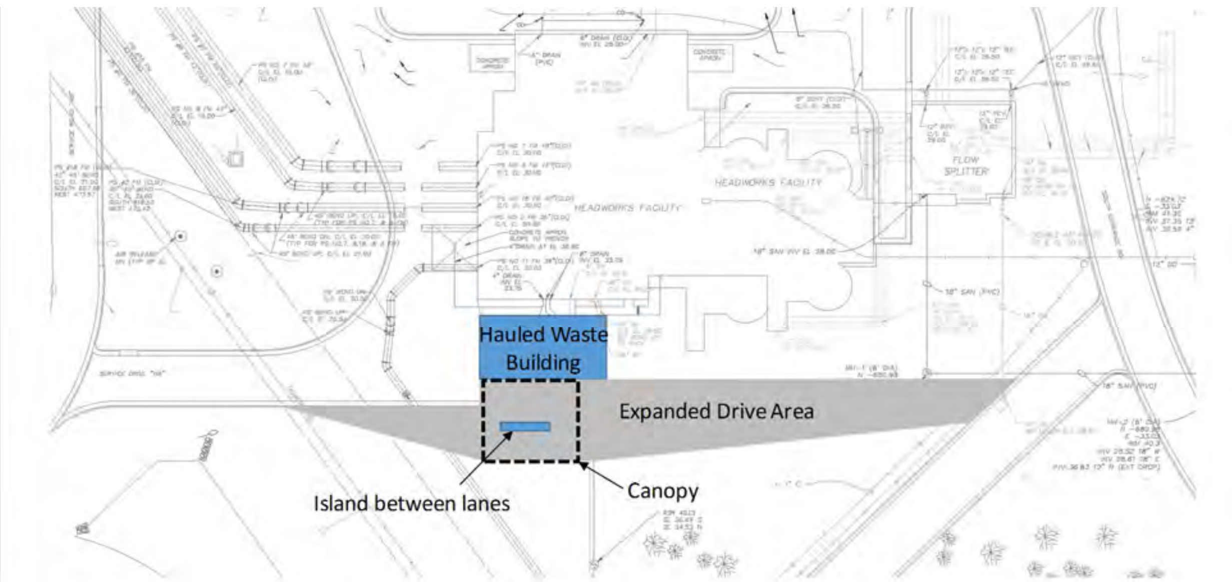


Figure 9 Proposed Expanded Hauled Waste Receiving Area Layout

Capital costs for this alternative include the costs for demolition of the existing canopy and hauled waste trough area, rental costs for a temporary receiving station, construction costs for the new building, canopy, and drive, equipment costs for the receiving stations and hauled waste access control station, fencing and gate operator, and site work (including stormwater), electrical, and heating and ventilation.

Operating costs include the current hauled waste receiving costs, operating and maintenance costs for the new hauled waste receiving stations, and HVAC costs for the new structure. Table 20 presents the capital and operating costs for this alternative. Appendix E provides details with respect to capital and O&M cost opinions.

	Alt. HW1
Opinion of Capital Costs	$2,864,000
Opinion of Annual O&M	$36,000

Table 20 Alt HW1–Opinion of Capital and O&M Cost Summary

2. Noneconomic Considerations

This alternative improves the operations of the hauled waste receiving facilities and reduces required operator attention.

a. Benefits

§ Improved traffic flow.

§ Improved safety for haulers and operators.

§ Reduced operator attention regarding unloading operations.

§ Rocks and larger objects removed prior to screening channels; reduced associated maintenance.

§ Improved security and tracking.

§ More accurate and equitable billing for services.

§ Improved accessibility to haulers.

b. Limitations

§ Hauled waste receiving operations displaced during construction.

HAULED WASTE RECEIVING PRESENT WORTH SUMMARY

Table 21 provides an opinion of present worth summary for the hauled waste receiving alternatives, and we recommend implementing Alternative HW1, which includes construction of a drive-through hauled waste receiving station to improve the operations, safety, maintenance, and function of the facility and the downstream headworks processes. The District's hauled waste receiving facilities provide a valuable resource to the community, local industry, and septage haulers. The existing facilities, while functional, require signifying attention for operations and maintenance, and winter time traffic is a safety concern with icing roadways and difficult truck maneuvering. In addition, the new system would include an automated card reader system, which will provide improved tracking, billing, and management for the various haulers and for the District.

	HW0	HW1
Total Opinion of Capital Cost	**$0**	**$2,864,000**
Annual O&M	$21,000	$36,000
Present Worth		
O&M Cost	$276,000	$473,000
Salvage	$0	($58,000)
Total Opinion of Present Worth	**$276,000**	**$3,279,000**

Table 21 Hauled Waste Opinion of Present Worth Summary

OVERALL HEADWORKS AND HAULED WASTE RECEIVING RECOMMENDATIONS

The recommendations related to the headworks and hauled waste receiving are a combination of the alternatives presented and discussed above. The timing of the execution of the improvements to these facilities may be adjusted to accommodate the condition of the various equipment involved or to combine or separate project elements to fit the needs of the District.

The recommendations for improvements include:

§ IFM5–Relocate Venturis to Lower Elevation

§ S1–Screen Sluiced Screenings or S3–Install New Step Screens and Wash Presses

§ G1–Replacement of Grit Classifiers with Grit Washers; Replace Other Equipment (Year 10)

§ HW1-Construction of a Drive-Through Hauled Waste Receiving Station at the Headworks Building

Lowering the venturis will allow the venturis to remain fully submerged regardless of the water level in the screening channels. Screening Alternative S1 allows continued use of the existing screens and has the least invasive construction requirements of the screenings alternatives. Screening Alternative S3 has the lowest present worth cost of the screenings alternatives that addresses the maintenance and operational issues related to screenings and screenings handling. The grit alternative G1–Replacement of Grit Classifiers with Grit Washers is recommended to be executed when the grit classifiers are at the end of their useful life, which is about 10 years. The HW1 alternative, Construction of a Drive-Through Hauled Waste Receiving Station at the Headworks Building, is also recommended to alleviate the issues with the existing hauled waste receiving operations.

Table 22 present the Year 0 and Year 10 opinions of probable cost of the recommended alternatives. Because of the significant ongoing concerns with the screening and hauled waste receiving operations, we have assumed the screening and hauled waste receiving improvements would occur in the near future and the grit management improvements would proceed in about 10 years. However, none of these improvements need to happen in the very near future, since all of the equipment likely has another 5 to 10 years of useful life remaining. Therefore, the timing of the project(s) can be tailored to fit the budgetary needs of the District.

Project Element	Opinion of Capital Cost Year 0	Opinion of Capital Cost Year 10
Alternative IFM5-Relocate Venturis to Lower Elevation	$2,096,000	$0
Alternative S1-Screen Sluiced Screenings[a]	$1,667,000	$4,224,000
Alternative S3-New Step Screens and Wash Presses[a]	$3,390,000	$0
Alternative G1-New Grit Washers	$0	$1,956,000
Alternative HW1-Drive-Through Hauled Waste Station	$2,864,000	$0
Totals	$6,627,000 to $8,350,000	$1,956,000 to $6,180,000

[a] These screening alternatives are mutually exclusive. District to select an alternative to implement.

Table 22 Summary of Capital Costs and Recommended Alternatives

APPENDIX A
DISTRICT HEADWORKS AND HAULED WASTE MEMO

Matt's Preliminary thoughts on Headworks/Septage Receiving redesign/improvements. We spend much time thinking about and talking about grit handling problems in the Headworks.

Introduction: we are talking about grit larger than 6mm. Perhaps one yard for each grit pumping operation that happens four times per day. There may be less grit from this operation during nighttime hours. Settling basin waste might normally be all of this quantity coming in at one load per day average. Rock in settling basin wastes can be up to 2" in diameter.

Grit in the Maci well is a problem for me. Question is: what is the source? Is it forcemain or settling basin (or all flow)?

Grit in the Maci well affects pump life and creates handling problems pumping and snail operation. Some aspects of that system work well: the snail for dewatering, the auger for elevation; however, grit and rag pumping is causing problems with pump plugging and requires much manual operator time for well cleaning.

Building a Settling Basin receiving station may seem like a good idea, but will cost significant dollars and will not address the incoming forcemain grit.

It would be far cheaper to install a grit handling system for Maci well and perhaps small bar screening system. Or grinder after grit removal.

Neither of these system address problem encountered with large object damage to pumps at stations. Neither also handles large objects that enter Maci well and require manual removal.

What is the perfect removal system if there could be one? Screening, sluicing, grit settling, large object bar screen or grinder after grit settling, chopper pump, dewatering.

Matt with some technical help from JeffK will undertake the work on these improvements.

Test at polymer building dumping settling basin waste into dumpster for dewatering. Test pumping trough grit to snail for dewatering.

Also need to install flushing water that will break up material at the top of the Maci well without disturbing grit at the bottom. This should cause a rolling action from the top that will not disturb heavy, settled material.

Need to test dumping settling basin waste in a way other than creating another facility (see caveat). If grit only is the problem, then facilities to handle this waste without a lot of additional expense might be desirable. Test facility first, then permanent facility using some existing. Caveat is that if rinsing facilities are desired or a drive through facility is desired. This does not address other needs such as slab heating for ice removal in winter etc.

Questions:
What is the source of grit and in what proportions?
Is grit damage to Maci pumps significant to justify $100,000 worth of modifications?

Is it reasonable to move grit pump to other slot with longer suction line and tee?
Can a grinder follow grit settling to chop large material to Maci well?

Present the design.

Maximize use of existing equipment.

Addressing the above does nothing for the lists of other problems.

Protecting Public Health and the Environment

Madison Metropolitan Sewerage District

CONCEPTUAL DESIGN REPORT

Headworks Improvements: Septage Receiving

July 2009

Introduction

Inputs to the plant, in the Headworks area, are plagued by three materials handling problems: grease, grit, and rags.

Grease
Grease handling is being addressed in the Solid Handling Facilities Plan.

Rags
It is possible that rag material is bypassing the screening units in one of five ways: 1) by passing through perforated plates of the screening units routinely; 2) by accumulating on the downstream side of the screening panels as a results of inefficient washing of the screening panels; 3) by passing the seals of the screening units; 4) by bypassing the screening units during high well conditions; and 5) through the "roping" together of rag material following screening. The second of these methods appear most likely at this point. This issue is being addressed, in the short-term, by replacing the spray nozzles of the screening units to better wash the screen panels.

Additional screenings handling problems arise only where Maci pumps cannot keep up with rag input to the Maci Well. Changes in grit handling may alleviate maintenance wear that results to the Maci pumps in their grit handling and may subsequently improve their ability to handle screenings.

Grit
Grit handling issues arise from the excessive amounts of grit that enter the Maci well either as a result of plant influent flow or from settling basin dumping in the Septage Receiving area.

Other Issues
There are a number of other issues that have been presented regarding the Septage Receiving area that have no easy solutions and need prioritization and criticality rating before they can be addressed. These issues are presented in lists below.

Issues/Factors

Problem Identification

Numerous issues have been identified with the Headworks facilities. These issues include the following:

1. When Screen 4 is off-line for any extended period of time (2-4 hours or more), rocks and other material settle out in front of the screen unit and overload the screen when it is put into service.

2. Nuts, bolts, and other metal objects damage screenings handling equipment after the material is picked up by the screens. This material comes primarily from settling basin loads of Septic Haulers.
3. Hoses can go down the Septage Receiving piping into the Headworks Building influent channel.
4. Debris accumulates in the discharge trough at the east end of the screening units. This can be the result of large amounts of grit material or large rag material carried and discharged by the screening units.
5. During winter, ice accumulates within the Septage Receiving area causing potential slipping problems.
6. There are cold weather problems with the hydrants in the Septage Receiving area including valve damage and hose freezing.
7. Unsanitary conditions around the whole area of Septage Receiving and the Headworks in general.
8. Grease loads from Septage Receiving or pump station well cleaning (through well pumping) clog screenings handling equipment.
9. Odors are very prevalent in the Septage Receiving area for certain load qualities.
10. Scavengers (turkeys, rodents) can be found in the Septage Receiving area that may spread pathogens and debris.
11. Various diameter hoses being used by Septage Haulers creates confusion and too much equipment in Septage Receiving area.
12. Some haulers may not be accurate in reporting on the volumes they discharge at Septage Receiving.
13. Some trucks need increased road slope to discharge completely.
14. Some trucks have discharge piping that is too low for use at the current Septage Receiving discharge area.
15. There is concern about having to back a hauling vehicle into this high traffic area.

Issues for Consideration for New Facilities

Some additional questions have arisen regarding issues that might need to be addressed if Headworks modifications are made to applicable facilities. These issues include the following:

1. How many trucks need to be able to unload at the same time?
2. How quickly should a truck be able to unload?
3. Is a drive-through facility necessary?
4. Does the unloading area need to be sloped to aid in unloading?
5. What, if any, options should be available for hose connections?
6. How will we keep out the big stuff (hoses, metal objects, etc)?
7. How should screenings be handled (Cut or not, bagged or not)?
8. How can we prevent freezing conditions? Is an enclosed area necessary?
9. If the area is not enclosed, how do we handle icing?

10. How can the hoses be drained without creating unsanitary conditions or causing ice problems?
11. How can we prevent plugging in piping leading to a receiving unit?
12. Is flow measurement necessary?
13. Do we need pH monitoring?
14. Do we need an inlet valve to be controlled by a magnetic card, etc.?
15. How do we handle odors?
16. How will samples be collected?
17. Location of hoses for washdown.
18. How will the septage water be conveyed to the Headworks (gravity, pumped)?
19. Will we handle FOG here or somewhere else?
20. Are septage storage tanks needed?
21. Minimal operator attention should be required.
22. Maximize use/reuse of existing facilities.

January 14, 2009 Meeting

A MMSD meeting was held January 14, 2009 to discuss the variety of issues with the Headworks and Septage Receiving specifically. The following is a summary of the discussion of this meeting as it relates to the first group (problem identification) of issues from above.

Grit Problem Identified

Sand, stones, gravel, nuts, and bolts were all recognized as problem issues that are a result of catch and settling basin waste. Some additional quantity of grit also enters the plant with influent flow. Diffusers were installed in the influent channel of the Headworks facilities as mitigation to grit settling in this channel. Questions have come up regarding the efficacy of this aeration. Throughout the operation of the Headworks facilities, on occasion, several cubic feet of grit and rag material has been removed from the outlet end of screening units. This is primarily a problem with screening unit four, but happens with the other two screening units as well.

Screen outlet plugging is not strictly a grit problem, nor is this problem confined to screen four. Other screening units also have occasional plugging resulting from rag material; the outlets of screen one and two rarely plug from grit material alone.

Screen unit four does carry a heavier grit loading than the other screening units.

Preliminary indications show that 30,000 gallons per week of settling basin wastes are brought to MMSD each week. Other type of septage loads have not been identified as creating specific grit problems; grease trap loads have caused problems with screenings handling equipment.

Centralized Septage Receiving Facility Declared

During the January 14, 2009 meeting, a policy statement was made by Jon Schellpfeffer that made it his preference that MMSD Septage Receiving Facilities remain at the centralized plant location rather than at satellite facilities throughout the collection system. Remote locations from the plant are difficult to maintain, supervise, and service.

Grease Handling

Currently, grease trap loads are handled in the same way as other septage loads brought to the plant. When grease loads are dumped at the facility, large chunks of grease material enter the screens. This material can cause some problems with the screening units, but generally, the problems are seen further downstream at the handling equipment.

Grease that enters the Maci well through the sluice trough system for screening material rapidly fills the well with floating solids that do not easily enter the macerator pumps. As a result of this, the well can fill and overflow with solids that do not pump easily. Grease material that does enter the pumps is moved to the Lisep (Liquid Separator) units and rapidly blinds the solid-liquid separation screens in these units.

Much operator intervention is required to first, move grease through the handling system and then finally, to clean the Lisep units of grease plugging. Grease, of course, is organic matter that can provide benefit if properly handled and treated using anaerobic digestion.

Grease Handling facilities are being investigated with the 2009 Solids Handling Facilities Plan.

Grit Handling Details

- There are two sources of grit that enter the plant: septage receiving and pumping station influent.
- Occasional screen outlet plugging can sometimes be the result of rag material as much as grit material. An exception to this seems to occur when screening unit four is off-line for an extended period of time and then put back on line. Grit material seems to accumulate in the quiescent zone on the influent side of screen four during these periods and can take a considerable time to be removed from the screening unit when on line.
- Screening unit four is run near continuously as a result of grit material accumulation on the influent side of this unit while it is off line.

- All grit that enters the treatment plant with a size larger than 6 mm - that will get picked up by fine screens - will ultimately enter the Maci well.
- The Maci well has a grit storage zone at the bottom that is approximately 4-6 inches deep. It can be estimated that this sump area will fill approximately four times per day under normal conditions.
- The Maci grit pump removes material from this sump during occasional manual pumping operations performed by operators four times per day.
- Flush water jets assist in moving grit material to the pump suction during grit pumping operation. MattA suspects that these jets also suspend grit into the screenings solution which then settles to the quiescent zone of the tank during flushing – the Maci pump suction boxes.
- Grit that is removed from the Maci well by the grit pump is piped to the grit snail for dewatering and escalation.
- The dewatered grit from the grit snail is directed to the grit screw conveyor to be escalated into a dumpster.
- Occasionally, rag material or other large objects in the Maci well are picked up by the grit pump and can cause pump or pipe plugging.
- During the beginning of the grit pumping cycle, operators attempt to remove large materials and large collections of rags from the Maci well.
- During the grit pumping cycle, screening operation must continue which has the potential of introducing additional material to the Maci well. This potential introduction of new material can be mitigated by the recent installation of a bypass arrangement that directs screening material back to the influent well to be handled again by fine screens.
- Early damage to Maci pump cutting heads has been noted by JeffM and others; possibly the result of Maci pumps handling of grit material in the Maci well.
- Some grit that enters the Maci pumps is reduced in size by the pumps to smaller than 6 mm and after recycling to the influent well, passes screening to be removed by vortex grit system.

Miscellaneous Septage Receiving Issues

What issues from the problem identification list need to be addressed? A number of issues have been presented from a desire for drive through bays to surface heating to prevent winter-time ice accumulation. What are the priorities of these? Which projects should be carried forward?

Septage receiving issues:

Problem Statements

MattA thinks the primary issue is grit that enters the Maci well. Addressing this issue, by getting grit out of the Maci well will prolong the life of Maci pumps and generally improve their performance in other ways by improving their cutting ability for material in the Maci well.

Minimize the amount of grit that enters the Maci well; grit in the Maci well causes excessive wear on the Maci pumps prior to its removal by the grit pump.

Scope/Objectives

Address Screen Washing Problems

We are uncertain whether screen washing problems started with facility installation or whether these issues have come up slowly as a result of changes in equipment. Our step at this point is to replace the nozzles on the washwater to see if original conditions are restored. This is being done primarily in response to an EIMCO request and statement that the original nozzle installation should be correct.

Currently, Eimco has a request from us to provide information about a new type of washwater nozzle for the screening units that would provide improved washing of the screen panels. It is expected that a wider spray pattern nozzle can be found to replace the current nozzles. This should improve performance and other changes may not be necessary.

We await their reply and will implement the solution.

Address Grit Handling Issues

Grit handling issues for the Maci well need to be solved to address the problem statement above. A conceptual design for a method of removing grit from the screenings flow is presented below. Results following the implementation of this design will dictate further actions.

Evaluate the Results of the Above

Given the low impact of implementation of either of the above solutions, these should be completed and evaluated for effectiveness to address the immediate needs of the Headworks.

Address the Short-comings of the Septage Receiving Area

Need to define priority for issues of Septage Receiving. (Which of the items listed is to be addressed?)

1.
2.
3.

Conceptual Design

Grit Removal

Install a grit settling tank in-line with the sluice trough that will accumulate grit through a low head-loss settling zone. The grit settling tank is to be cleaned through piping to the grit pump which will run periodically to move grit to the grit snail. During the pumping cycle, trough flush water and flush water within the grit tank will flow maintaining pump water.

With the implementation of this solution, it is expected that grit pumping for the Maci well may be reduced to once to several times per week.

A sketch of the solution:

Cost Estimate

Schedule

Generate detailed fabrication drawings

Fabrication

Installation

Startup/testing

MEMORANDUM

TO: SEPTAGE RECEIVING IMPROVEMENTS

FROM: MATT ALLEN

SUBJECT: SETTLING BASIN WASTES TO DRYING BED

DATE: 10/2/2009

Protecting Public Health and the Environment

On September 1, 2009, the plan to have haulers dump all settling basin waste to the Drying Bed was executed. The purpose of this plan was to eliminate the variable of settling basin wastes dumped to the Septage Receiving Facility and passing through the Headworks so that its impact could be better evaluated. It is desirable to know of the impacts of settling basin debris on the operation of fine screens and screenings handling equipment in the Headworks Building. Settling basin debris, it is felt, normally has the largest impact on the operation of the Screenings Handling (Maci) Well. A secondary impact is occasionally noted at the outlet troughs for the screening units.

During the first month trial of this plan, no significant impacts, either positive or negative, are noted. While a fairly large volume of wastes have been dumped, it would appear that much of the quantity is sand material.

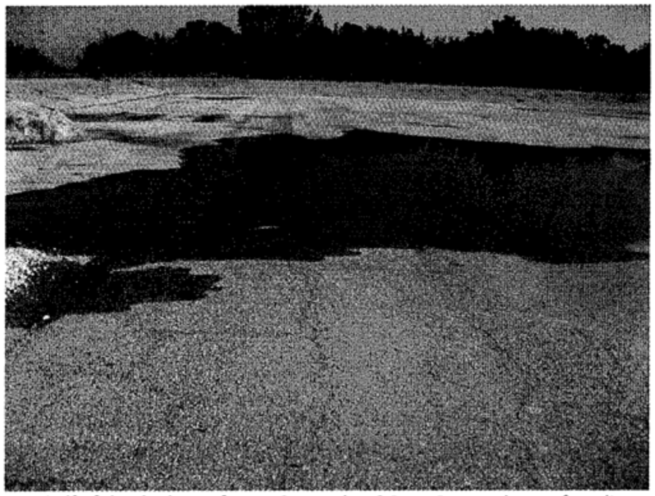
On September 3, Matt and Ralph went to the pit and observed the following:

Ralph observing materials at the Drying Bed on September 3.

Ralph sizing up gravel material mixed with sand that had been dumped at the Drying Bed as settling basin waste.

During the early part of the month, while observing materials at the Drying Bed, Ralph and Matt watched a Roto-Rooter vac truck dump at the Drying Bed. Expecting a major event, we were disappointed.

In the picture to the below, the Roto-Rooter vac truck had completed dumping perhaps several hundred gallons of waste. The flow was mostly liquid. The gravel material that can is seen in the photo was a result of the berm being washed out by the dumping to the uphill side of the berm. The intent of the berm was that it would separate vehicle tires from the material being dumped to prevent any tracking.



One-half of the discharge from a September 3 Roto-Rooter dump of settling basin waste at the Drying Bed; other half behind the photographer.

The discharge from a rinsed Dvorak truck of settling basin waste dumped on September 8, 2009.

September 14 photo showing accumulated debris at the Drying Bed. The background pile is sand stored at the Drying Bed.

Several days later, Ralph and Matt were again at the Pit when a Dvorak truck pulled in to dump. We had talked to Jeff the driver, and from his description, were expecting a significant amount of solids. We asked Jeff if he would be interested in rinsing his truck of debris.

Our thinking was that somehow, perhaps, when the Roto-Rooter truck dumped, that some amount of debris was left on the truck.

Dvorak discharged the load and we waited, and waited, and waited for something significant to come out of the truck while he rinsed the tank; no significant wastes ever did come from the truck. The picture below-left shows the end situation following the rinsing of the Dvorak truck.

By September 14, the Building and Grounds crew had to reconstruct the berm and in the process piled up the discharged waste with at least some of the berm material. The pile was not that impressive just the same.

The photo at the bottom left of this page shows the accumulated debris pile at the Drying Bed. The forward pile is accumulated settling basin waste. The Background pile is sand that is stored at the Drying Bed. This small amount of material is not viewed as being significant. Some gravel material could be found in the pile, but in limited quantity.

Toward the end of the month, more significant amounts of material began showing up in the Drying Bed. The load volumes are not tabulated here, but will need to be considered in the final assessment of this program.

A photo at the top of the next page shows a more significant amount of material that had accumulated in the Drying Bed and was collected together by the Building and Grounds crew at the end of the month. Matt estimates this volume to be about four yards of material. Again, it appears to be mostly sand with a small amount of gravel dispersed throughout the volume.

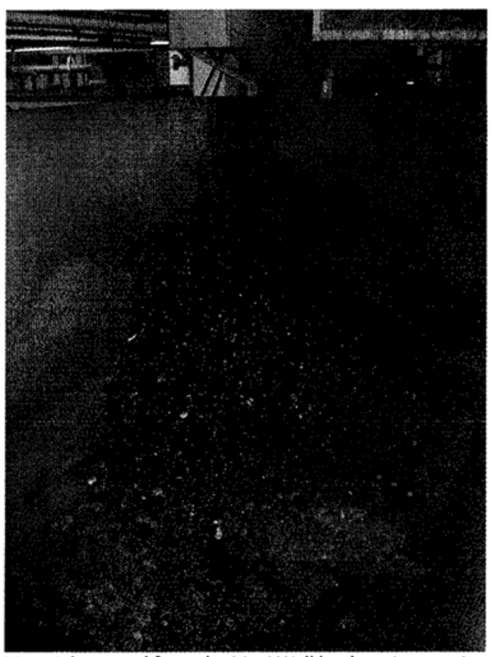
There have not been any indications that any single load of heavy gravel material was dumped in the drying bed.

September 30 photo showing accumulated debris at the Drying Bed. The background pile is sand stored at the Drying Bed.

Reports from the Building and Grounds crew, in cleaning the Septage Receiving area have also not indicted any significant dumping in that area. A solid history of the amounts of material that are cleaned out of the Septage Receiving area is not readily available.

Throughout the month, Matt recorded pictures of the types of material seen in the grit dumpster at the Headworks. No significant materials were ever seen here (though objects could have been buried by subsequent materials.) The high flow event that occurred on September 22 also seemed to yield no significant quantities of material. Though, this two may have been masked by other materials in the dumpster.

The grit material that is removed from the Maci well in the Headworks Building is pumped by the Grit Snail to a screw conveyor and then into the grit dumpster in the building. Any significant quantity of grit material that was removed from the Maci well, would appear in the southwest corner of the grit dumpster as shown in the photo below-left. Throughout the month, Matt has been observing the accumulation of grit in the dumpster. No significant differences in quantity have been seen. This is a difficult assessment to make however. Additional work is planned for characterizing the type of material that comes with the Maci well grit removal.



Material pumped from the Maci Well by the grit pump in the southwest corner of the grit dumpster. This is approximately two days of accumulation.

It must be noted that during the month, while touring the pit area, Ralph found the piece of metal material in the photo below. This would create a challenge in materials handling at the Headworks just the same. In the past many pieces of debris have been found in the Maci well at the Headworks; many types of plastics from balls and toys of all types, as well as animals and building materials. All of this is difficult to handle and creates the need for operator intervention. It is unlikely that creating a new method for dumping settling basin waste will address all or any of the issues that require operator and maintenance intervention.

A 3" X 3" metallic part found in the Drying Bed following the discharge of settling basin waste.

MEMORANDUM

TO: SEPTAGE RECEIVING IMPROVEMENTS

FROM: MATT ALLEN

SUBJECT: SETTLING BASIN WASTES TO DRYING BED II

DATE: 11/23/2009

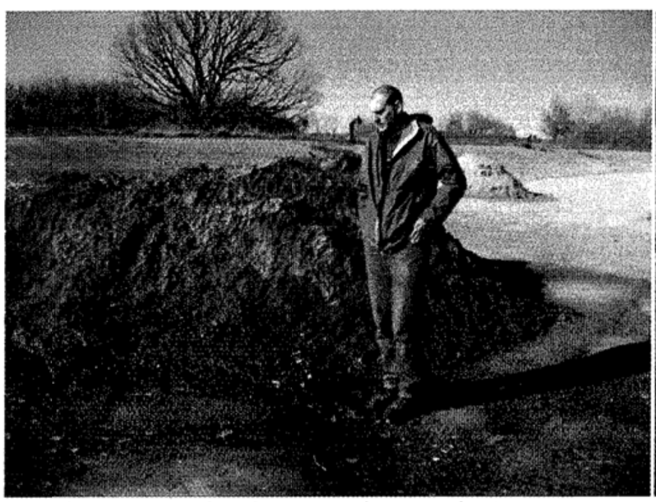
Protecting Public Health and the Environment

This memo is a follow-up to a 2 October 2009 memo on the same subject. Unique information is presented in this memo and the 2 October memo.

On September 1, 2009, the plan to have haulers dump all settling basin waste to the Drying Bed was executed. The purpose of this plan was to eliminate the variable of settling basin wastes dumped to the Septage Receiving Facility and passing through the Headworks so that its impact could be better evaluated. It is desirable to know of the impacts of settling basin debris on the operation of fine screens and screenings handling equipment in the Headworks Building. Settling basin debris, it is felt, normally has the largest impact on the operation of the Screenings Handling (Maci) Well. A secondary impact for grit is occasionally noted at the outlet troughs for the screening units.

This trial was continued through October 23, 2009. During this trial, no extremely significant impacts, either positive or negative, are noted. While a fairly large volume of wastes have been dumped in the drying bed, it would appear that much of the quantity is sand material.

Throughout this test a total of 79 tons of material was ultimately removed from the Drying Bed in nine truck loads. Two perspectives on the amount of material that we dumped in the Drying Bed can be seen below.



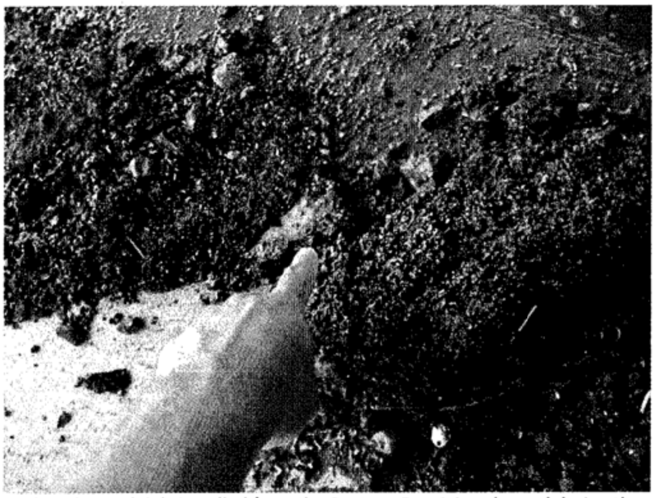
Ralph observing materials at the Drying Bed on November 2.

A 79 ton pile of material that had been dumped at the Drying Bed during the Settling Basin waste to Drying Bed trial.

During the trial, few Operator or Building and Grounds crew complaints were provided about solids material in either the Septage Receiving area or in the Headworks Building itself. Ironically, within days of the end of the test, a significant volume of material, like settling basin waste, disrupted operations in the Headworks Building to the point that Operator intervention was necessary to clear the screenings trough. In the four weeks that have passed since the end of this trial period, no other significant Settling Basin dumping events have been noted at Septage Receiving or in the Headworks Building.

The details of the November 2 grit event are as follows: On November 2, Nathaniel reported that at 1:00 to 1:30 p.m., there was a large amount of rock backed up in the sluice trough to the screen 3 inlet. He also mentioned that rock itself was good sized – it appears to be ¾ to 1" landscaping rock from looking at the grit that was pumped. Nathaniel pumped all of this through to the snail. Ralph printed out a Septage report on the wastes that were dumped. 3,400 gallons of settling basin wastes were dumped all day, but only 400 of that before 2:30. It would be great to find out what was the source for all that rock material. It may be a question without a definitive answer. A-1 Sewer reported a septic tank load picked up that day with lots of landscaping stone (2.5 gal of stone fell into the tank). It is hard to know if that comes off of the truck though during a normal dumping process.

During the trial period, Matt noted the following type of debris in the receiving channel of Septage Receiving:



Rock and gravel debris pulled from the Septage Receiving channel during the Settling Basin to Drying Bed trial.

Larger quantities of this same type of material could very likely cause problems with handling equipment in the Headworks Building. During the trial, some reports were provided by the Building & Grounds crew that lesser quantities than normal of material had been pulled from behind the receiving channel weir in the Septage Receiving area.

Quantifying the amount of material that was passing through the Headworks Building was difficult. Matt attempted to record how much grit material was being removed from the Maci well (which would be all grit material larger than 5 mm.) Without a separate receptacle (grit from the Maci Well is dumped in the grit dumpster), this measurement is impossible. No good history is available for this. However, during 2007 and 2008, most of the grit that collected in the Maci well was removed through the Grit Snail. This material was discharged to several two yard dumpsters. These dumpsters were tipped about 55 times during 2008. Each dumpster was about ¾ full when dumped. This would amount to 82.5 cu. yds. of material removed from the Maci well by the Operator's grit pumping operation. Of course, this material was from all sources not just settling basin waste.

It would be Matt's guess that 90-95% of all the material that was dumped in the Drying Bed would have passed the screens and been handled in an arguably more efficient manner by the grit tanks and grit handling system.

Headworks Issues

2011 11 08 MattA gdocs

Systems:
Screens
Sluicing
Screening Handling
Maci Well
Grit Handling
Grit Removal
Water Flow
Septage

Septage Receiving is a prob. also for icing, grit, dump point, flushing? more

Issues:

Influent Flow Meters
Installed to high.

Sampler Issues
Plugging accasionally.

Influent Well Too Small

Grit Loading and Deposition in Influent Well
In quiescent zones, exasserbated by screens out of service.

One Screen Runs Continually with Flow to Plant
Screen rapidly plug creating the need for one screening unit to run continuously with any flow to plant.

Rag Accumulation on Screenings Panels
Some panels installed backward, but even so rags hairpin around screening opening.

Rag Accumulation on Screening Structure
On the trough itself on the drive sprocket other structure

Plugging of Screening Outlet
~~Ba~~ Large rag accumulations will plug.

Too Much Sluice Water Needed to Move Rag and Grit Load
Too move material out and down trough.

Water Head Not Available throughout Trough
flush water at beginning runs out later.

Excessive Water in the Maci Well
The well is too small, no secondary, no backup.

A Shallow Trough Slope Results in Grit ~~Results in~~ deposits and Handling Issues with Large Objects
18" Head loss through out channel and large obj.

Grit Pumping Issues
Moving grit to suction, pulling in, rag plugging, getting all grit in sequence.

Grit in Maci Well Results in Pump Wear
Maci pump wear from entrained grit.

Maci Pump Maintenance Expense Tabulate costs inorganic/organic sep.
worsened by grit handling. Will always cost something

Grit Pump Plugging at Suction and in Piping
a result of rags mostly

Grit Handling Difficulties in Maci Well

Licep Grease and Rag Handling
Plugged with grease.

Distance from Screening Units to Dumpster
No clear path.

Relative Height of Dumpster and the Mezzanine
No room to go under can't get over.

Screenings Storage Capacity in Residuals Dumpster

Water Handling in the Sluice Trough System
Too much, water splashing.

Object Removal from the Maci Well
Large objects.

Too Many Pieces of Equipment
11 individual units

Rags Continue in Plant dispite best efforts to curb.

Conveyor expense?
Belt grit issues.

Grit Concentrators Wearing out

Dumpster Hauling (Weekly), but Can Accommodate well with Belt

For Each of the above Items, We Need: a Priority, Solutions, and Recommendations

APPENDIX B
INFLUENT FLOW MEASUREMENT OPINIONS OF PROBABLE COST

Madison Metropolitan Sewerage District
2016 Liquid Processing Facilities Plan
Opinion of Present Worth Cost **Discount Rate** 4.375%

TM6 - Headworks
Alternative IFM0-Null Alternative

ITEM	**Initial Capital Cost**	**Future Capital Cost**	**Replacement Year**	**Replacement Cost (P.W.)**	**20-Year Salvage Value**	**Salvage Value (P.W.)**
		$ -	20	$ -	$ -	$ -
		$ -	20	$ -	$ -	$ -
	$ -			$ -	$ -	$ -
Subtotal	$ -	$ -		$ -	$ -	$ -
Electrical and Controls (25% of equipment + structural)	$ -		20	$ -	$ -	$ -
Subtotal	$ -	$ -		$ -	$ -	$ -
Contractor GCs (10%)	$ -	$ -	20	$ -		
Total Construction Costs	$ -	$ -	0	$ -		
Contingencies and Engineering Services (50%)	$ -	$ -	20	$ -		
Total Capital Costs	$ -	$ -		$ -	$ -	$ -
Present Worth	**$ -**					
Annual O&M	**$ 81,000**					
Present Worth of O&M	**$ 1,065,000**					

Summary of Present Worth Costs

Capital Cost	$ -
Replacement	$ -
O&M Cost	$ 1,065,000
Salvage Value	$ -
Total Present Worth	**$ 1,065,000**

Note: Costs are November 2016 basis.

Madison Metropolitan Sewerage District
2016 Liquid Processing Facilities Plan
Opinion of Present Worth Cost **Discount Rate** 4.375%

TM6 - Headworks
Alternative IFM1-New Metering Vaults

ITEM	**Initial Capital Cost**	**Future Capital Cost**	**Replacement Year**	**Replacement Cost (P.W.)**	**20-Year Salvage Value**	**Salvage Value (P.W.)**
Structures - Two New Vaults	$ 885,000	$ -	20	$ -	$ -	$ -
Bypassing/Bypass Pumping	$ 500,000	$ -	20	$ -	$ -	$ -
Interior Piping	$ 250,000	$ -	20	$ -	$ -	$ -
Subtotal	$ 1,635,000	$ -				
HVAC	$ 71,000		20	$ -	$ -	$ -
Site Work	$ 44,000		20	$ -	$ -	$ -
Electrical and Controls	$ 177,000	$ -	20	$ -	$ -	$ -
Subtotal	$ 1,927,000					
Contractor GCs (10%)	$ 193,000		20	$ -	$ -	$ -
Total Construction Costs	$ 2,120,000		20	$ -	$ -	$ -
Contingencies and Engineering Services (50%)	$ 1,060,000		20	$ -	$ -	$ -
Total Capital Costs	$ 3,180,000			$ -	$ -	$ -
Present Worth	**$ 3,180,000**					
O&M Costs (See O&M Costs Table for Detail)	**$ 53,000**					
Present Worth of O&M	**$ 697,000**					

Summary of Present Worth Costs

Capital Cost	$ 3,180,000
Replacement	$ -
O&M Cost	$ 697,000
Salvage Value	$ -
Total Present Worth	**$ 3,877,000**

Note: Costs are November 2016 basis.

Madison Metropolitan Sewerage District
2016 Liquid Processing Facilities Plan
Opinion of Present Worth Cost **Discount Rate** 4.375%

TM6 - Headworks
Alternative IFM2-New Influent Flumes

ITEM	**Initial Capital Cost**	**Future Capital Cost**	**Replacement Year**	**Replacement Cost (P.W.)**	**20-Year Salvage Value**	**Salvage Value (P.W.)**
Structures - New Parshall Flume Vault	$ 702,000	$ -	20	$ -	$ -	$ -
Bypassing/Bypass Pumping	$ 500,000	$ -	20	$ -	$ -	$ -
Interior Piping	$ 120,000	$ -	20	$ -	$ -	$ -
Exterior Piping Modifications	$ 200,000	$ -	20	$ -	$ -	$ -
Subtotal	$ 1,522,000	$ -				
HVAC	$ 56,000	$ -	20	$ -	$ -	$ -
Site Work	$ 35,000	$ -	20	$ -	$ -	$ -
Electrical and Controls	$ 140,000	$ -	20	$ -	$ -	$ -
Subtotal	$ 1,753,000					
Contractor GCs (10%)	$ 176,000	$ -	20	$ -	$ -	$ -
Total Construction Costs	$ 1,929,000	$ -	20	$ -	$ -	$ -
Contingencies and Engineering Services (50%)	$ 965,000	$ -	20	$ -	$ -	$ -
Total Capital Costs	$ 2,894,000			$ -	$ -	$ -
Present Worth	**$ 2,894,000**					
O&M Costs (See O&M Costs Table for Detail)	**$ 86,000**					
Present Worth of O&M	**$ 1,131,000**					

Summary of Present Worth Costs	
Capital Cost	$ 2,894,000
Replacement	$ -
O&M Cost	$ 1,131,000
Salvage Value	$ -
Total Present Worth	**$ 4,025,000**

Note: Costs are November 2016 basis.

Madison Metropolitan Sewerage District
2016 Liquid Processing Facilities Plan
Opinion of Present Worth Cost **Discount Rate** 4.375%

TM6 - Headworks
Alternative IFM4- Metering Vaults at Pump Stations

ITEM	**Initial Capital Cost**	**Future Capital Cost**	**Replacement Year**	**Replacement Cost (P.W.)**	**20-Year Salvage Value**	**Salvage Value (P.W.)**
Structures - Vaults at Pump Stations	$ 840,000	$ -	20	$ -	$ -	$ -
Bypassing/Bypass Pumping	$ 500,000	$ -	20	$ -	$ -	$ -
Interior Piping	$ 247,000	$ -	20	$ -	$ -	$ -
Subtotal	$ 1,587,000	$ -				
Sitework	$ 42,000	$ -	20	$ -	$ -	$ -
Electrical and Controls	$ 140,000	$ -	20	$ -	$ -	$ -
Subtotal	$ 1,769,000					
Contractor GCs (10%)	$ 177,000	$ -	20	$ -	$ -	$ -
Total Construction Costs	$ 1,946,000	$ -	20	$ -	$ -	$ -
Contingencies and Engineering Services (50%)	$ 973,000	$ -	20	$ -	$ -	$ -
Total Capital Costs	$ 2,919,000			$ -	$ -	$ -
Present Worth	**$ 2,919,000**					
O&M Costs (See O&M Costs Table for Detail)	**$ 63,000**					
Present Worth of O&M	**$ 828,000**					

Summary of Present Worth Costs

Capital Cost	$ 2,919,000
Replacement	$ -
O&M Cost	$ 828,000
Salvage Value	$ -
Total Present Worth	**$ 3,747,000**

Note: Costs are November 2016 basis.

Madison Metropolitan Sewerage District
2016 Liquid Processing Facilities Plan
Opinion of Present Worth Cost **Discount Rate** 4.375%

TM6 - Headworks
Alternative IFM5- Remove and Relocate Venturis to Lower Elevation

ITEM	Initial Capital Cost	Future Capital Cost	Replacement Year	Replacement Cost (P.W.)	20-Year Salvage Value	Salvage Value (P.W.)
Demolition and Shoring	$ 70,000	$ -	20	$ -	$ -	$ -
Structure Addition	$ 295,000	$ -	20	$ -	$ -	$ -
Samplers	$ 54,000	$ -	20	$ -	$ -	$ -
Interior Piping including temporary	$ 77,000	$ -	20	$ -	$ -	$ -
Exterior Piping including temporary	$ 126,000	$ -	20	$ -	$ -	$ -
Relocate Venturis and Piping	$ 78,000	$ -	20	$ -	$ -	$ -
Bypassing/Bypass Pumping	$ 500,000	$ -	20	$ -	$ -	$ -
Subtotal	$ 1,200,000	$ -				
Sitework	$ 21,000		20	$ -	$ -	$ -
Electrical and Controls	$ 49,000	$ -	20	$ -	$ -	$ -
Subtotal	$ 1,270,000					
Contractor GCs (10%)	$ 127,000		20	$ -	$ -	$ -
Total Construction Costs	$ 1,397,000		20	$ -	$ -	$ -
Contingencies and Engineering Services (50%)	$ 699,000		20	$ -	$ -	$ -
Total Capital Costs	$ 2,096,000			$ -	$ -	$ -
Present Worth	**$ 2,096,000**					
O&M Costs (See O&M Costs Table for Detail)	**$ 52,000**					
Present Worth of O&M	**$ 684,000**					

Summary of Present Worth Costs

Capital Cost	$ 2,096,000
Replacement	$ -
O&M Cost	$ 684,000
Salvage Value	$ -
Total Present Worth	**$ 2,780,000**

Note: Costs are November 2016 basis.

Madison Metropolitan Sewerage District
2016 Liquid Processing Facilities Plan
Opinion of Present Worth Cost

TM6 - Headworks
O&M Cost Summary

IFM0 - Existing Venturi Flow Meters

	Annual O&M Cost	
Screen Maintenance	$	80,800
Total Annual O&M	$	81,000

IFM1 - New Metering Vaults

Equipment	Annual O&M Cost	
Reduced Pumping Costs	$	(21,500)
HVAC Costs	$	1,000
Screen Maintenance	$	72,700
Total Annual O&M	$	53,000

IFM2 - New Influent Flumes

Equipment	Annual O&M Cost	
Increased Pumping Costs	$	10,800
HVAC Costs	$	2,000
Screen Maintenance	$	72,700
Total Annual O&M	$	86,000

IFM3 - Raise Channel Eleviation

Equipment	Annual O&M Cost	
Screen Maintenance	$	72,700
Total Annual O&M	$	73,000

IFM4 - Metering Vaults at PSs

IFM5 - Reinstall Venturi Flow Meters at a Lower Elevation

Equipment	Annual O&M Cost	
Reduced Pumping Costs	$	(21,500)
Screen Maintenance	$	72,700
Total Annual O&M	$	52,000

APPENDIX C
SCREENING OPINIONS OF PROBABLE COST

Madison Metropolitan Sewerage District
2016 Liquid Processing Facilities Plan
Opinion of Present Worth Cost **Discount Rate** 4.375%

TM6 - Headworks
Alternative S0-Null Alternative

ITEM	Initial Capital Cost	Future Capital Cost	Future Year	Future Cost (P.W.)	20-Year Salvage Value	Salvage Value (P.W.)
Screens	$ -	$ 1,782,200	10	$ 1,161,000	$ 891,100	$ 378,000
Liseps/Lipactors	$ -	$ 540,000	10	$ 352,000	$ 270,000	$ 115,000
Grit Snail	$ -	$ 225,800	10	$ 147,000	$ 112,900	$ 48,000
Grit Pump	$ -	$ 45,200	10	$ 29,000	$ 22,600	$ 10,000
Subtotal	$ -	$ 2,593,200		$ 1,689,000	$ 1,296,600	$ 551,000
Mechanical (10% of equipment)	$ -	$ 259,300	10	$ 169,000	$ 129,650	$ 55,000
Electrical and Controls (20% of equipment)	$ -	$ 518,600	10	$ 338,000	$ 259,300	$ 110,000
Subtotal	$ -	$ 3,371,100		$ 507,000	$ 389,000	$ 165,000
Contractor GCs (10%)	$ -	$ 338,000	10	$ 220,000	$ 169,000	$ 72,000
Total Construction Costs	$ -	$ 3,709,100	10	$ 2,417,000	$ 1,854,550	$ 788,000
Contingencies and Engineering Services (50%)	$ -	$ 1,855,000	10	$ 1,209,000	$ 927,500	$ 394,000
Total Capital Costs	$ -	$ 5,564,000		$ 3,626,000	$ 2,782,000	$ 1,182,000
Present Worth	**$ -**			$ 3,626,000		$ 1,182,000
O&M Costs (See O&M Costs Table for Detail)	**$ 120,000**					
Present Worth of O&M	**$ 1,578,000**					

Summary of Present Worth Costs

Capital Cost	$ -
Future Costs	$ 3,626,000
O&M Cost	$ 1,578,000
Salvage Value	$ (1,182,000)
Total Present Worth	**$ 4,022,000**

Note: Costs are November 2016 basis.

Madison Metropolitan Sewerage District
2016 Liquid Processing Facilities Plan
Opinion of Present Worth Cost **Discount Rate** 4.375%

TM6 - Headworks
Alternative S1-Sluice Water Screens and Wash Presses

ITEM	Initial Capital Cost	Future Capital Cost	Future Year	Future Cost (P.W.)	20-Year Salvage Value	Salvage Value (P.W.)
Structural Modifications	$ 106,000	$ -	20	$ -	$ -	$ -
Screens for Sluice Water	$ 457,700	$ -	10	$ -	$ -	$ -
Wash Presses	$ 270,000	$ -	10	$ -	$ -	$ -
Screens-Replacement of Existing	$ -	$ 1,782,000	10	$ 1,161,000	$ 891,000	$ 378,000
Mechanical (10% of equipment)	$ 36,400	$ 259,300	10	$ 169,000	$ 129,650	$ 55,000
Electrical (20% of equipment)	$ 145,500	$ 518,600	10	$ 338,000	$ 259,300	$ 110,000
Subtotal	$ 1,016,000	$ 2,559,900		$ 1,668,000	$ 1,279,950	$ 543,000
Contractor GCs (10%)	$ 102,000	$ 256,000	10	$ 167,000	$ 128,000	$ 54,000
Total Construction Costs	$ 1,118,000	$ 2,815,900	10	$ 1,835,000	$ 1,407,950	$ 598,000
Contingencies and Engineering Services (50%)	$ 559,000	$ 1,408,000	10	$ 918,000	$ 704,000	$ 299,000
Total Capital Costs	$ 1,677,000	$ 4,224,000		$ 2,753,000	$ 2,112,000	$ 897,000
Present Worth	**$ 1,677,000**			$ 2,753,000		$ 897,000
O&M Costs (See O&M Costs Table for Detail)	**$ 96,000**					
Present Worth of O&M	**$ 1,262,000**					

Summary of Present Worth Costs

Capital Cost	$ 1,677,000
Future Costs	$ 2,753,000
O&M Cost	$ 1,262,000
Salvage Value	$ (897,000)
Total Present Worth	**$ 4,795,000**

Note: Costs are November 2016 basis.

Madison Metropolitan Sewerage District
2016 Liquid Processing Facilities Plan
Opinion of Present Worth Cost **Discount Rate** 4.375%

TM6 - Headworks
Alternative S2-New Band Screens and Dedicated Wash Presses

ITEM	Initial Capital Cost	Future Capital Cost	Future Year	Future Cost (P.W.)	20-Year Salvage Value	Salvage Value (P.W.)
Demolition	$ 25,000	$ -	20	$ -	$ -	$ -
Screens (3, 1 future)	$ 1,337,000	$ 581,000	10	$ 379,000	$ 290,500	$ 123,000
Wash Presses (3, 1 future)	$ 405,000	$ 135,000	10	$ 88,000	$ 67,500	$ 29,000
Conveyor	$ 170,100	$ -	20	$ -	$ -	$ -
Mechanical (10% of equipment)	$ 191,200	$ 58,100	10	$ 38,000	$ 29,050	$ 12,000
Electrical (20% of equipment)	$ 382,400	$ 116,200	10	$ 76,000	$ 58,100	$ 25,000
Subtotal	$ 2,511,000	$ 890,000		$ 581,000	$ 445,150	$ 189,000
Contractor GCs (10%)	$ 252,000	$ 252,000	10	$ 164,000	$ 126,000	$ 54,000
Total Construction Costs	$ 2,763,000	$ 1,142,000	10	$ 744,000	$ 571,000	$ 242,000
Contingencies and Engineering Services (50%)	$ 1,382,000	$ 571,000	10	$ 372,000	$ 285,500	$ 121,000
Total Capital Costs	$ 4,145,000	$ 1,713,000		$ 1,116,000	$ 857,000	$ 363,000
Present Worth	**$ 4,145,000**			$ 1,116,000		$ 363,000
O&M Costs (See O&M Costs Table for Detail)	**$ 69,000**					
Present Worth of O&M	**$ 907,000**					

Summary of Present Worth Costs

Capital Cost	$ 4,145,000
Future Costs	$ 1,116,000
O&M Cost	$ 907,000
Salvage Value	$ (363,000)
Total Present Worth	**$ 5,805,000**

Note: Costs are November 2016 basis.

Madison Metropolitan Sewerage District
2016 Liquid Processing Facilities Plan
Opinion of Present Worth Cost **Discount Rate** 4.375%

TM6 - Headworks
Alternative S3-Step Screens and Dedicated Wash Presses

ITEM	Initial Capital Cost	Future Capital Cost	Future Year	Future Cost (P.W.)	20-Year Salvage Value	Salvage Value (P.W.)
Structural Modifications	$ 148,000	$ -	20	$ -	$ -	$ -
Screens (3)	$ 891,000	$ -	20	$ -	$ 1	$ -
Wash Presses (3)	$ 405,000	$ -	20	$ -	$ 2	$ -
Conveyor	$ 170,100	$ -	20	$ -	$ 3	$ -
Mechanical (10% of equipment)	$ 146,600	$ -	20	$ -	$ -	$ -
Electrical (20% of equipment)	$ 293,200	$ -	20	$ -	$ -	$ -
Subtotal	$ 2,054,000	$ -				
Contractor GCs (10%)	$ 206,000					
Total Construction Costs	$ 2,260,000					
Contingencies and Engineering Services (50%)	$ 1,130,000					
Total Capital Costs	$ 3,390,000			$ -	$ 6	$ -
Present Worth	**$ 3,390,000**			$ -		$ -
O&M Costs (See O&M Costs Table for Detail)	**$ 69,000**					
Present Worth of O&M	**$ 907,000**					

Summary of Present Worth Costs

Capital Cost	$ 3,390,000
Future Costs	$ -
O&M Cost	$ 907,000
Salvage Value	$ -
Total Present Worth	**$ 4,297,000**

Note: Costs are November 2016 basis.

Madison Metropolitan Sewerage District
2016 Liquid Processing Facilities Plan
Opinion of Present Worth Cost **Discount Rate** 4.375%

TM6 - Headworks
Alternative S4-Travelling Rake Screens and Dedicated Wash Presses

ITEM	**Initial Capital Cost**	**Future Capital Cost**	**Future Year**	**Future Cost (P.W.)**	**20-Year Salvage Value**	**Salvage Value (P.W.)**
Structural Modifications	$ 148,000	$ -	20	$ -	$ -	$ -
Screens (3)	$ 1,105,000	$ -	20	$ -	$ -	$ -
Wash Presses (3)	$ 405,000	$ -	20	$ -	$ -	$ -
Conveyor	$ 170,100	$ -	20	$ -	$ -	$ -
Mechanical (10% of equipment)	$ 168,000	$ -	20	$ -	$ -	$ -
Electrical (20% of equipment)	$ 336,000	$ -	20	$ -	$ -	$ -
Subtotal	$ 2,332,000	$ -				
Contractor GCs (10%)	$ 234,000					
Total Construction Costs	$ 2,566,000					
Contingencies and Engineering Services (50%)	$ 1,283,000					
Total Capital Costs	$ 3,849,000			$ -	$ -	$ -
Present Worth	**$ 3,849,000**			$ -		$ -
O&M Costs (See O&M Costs Table for Detail)	**$ 69,000**					
Present Worth of O&M	**$ 907,000**					

Summary of Present Worth Costs

Capital Cost	$ 3,849,000
Future Costs	$ -
O&M Cost	$ 907,000
Salvage Value	$ -
Total Present Worth	**$ 4,756,000**

Note: Costs are November 2016 basis.

Madison Metropolitan Sewerage District
2016 Liquid Processing Facilities Plan
Opinion of Present Worth Cost **Discount Rate** 4.375%

TM6 - Headworks
Alternative S5-Perforated Plate Screens and Dedicated Wash Presses

ITEM	Initial Capital Cost	Future Capital Cost	Future Year	Future Cost (P.W.)	20-Year Salvage Value	Salvage Value (P.W.)
Structural Modifications	$ 148,000	$ 49,300	10	$ 32,000	$ 24,650	$ 10,000
Screens (3, 1 future)	$ 984,000	$ 328,000	10	$ 214,000	$ 164,000	$ 70,000
Wash Presses (3, 1 future)	$ 405,000	$ 135,000	10	$ 88,000	$ 67,500	$ 29,000
Conveyor	$ 170,100	$ -	20	$ -	$ -	$ -
Mechanical (10% of equipment)	$ 155,900	$ 32,800	10	$ 21,000	$ 16,400	$ 7,000
Electrical (20% of equipment)	$ 311,800	$ 65,600	10	$ 43,000	$ 32,800	$ 14,000
Subtotal	$ 2,175,000	$ 611,000		$ 366,000	$ 280,700	$ 120,000
Contractor GCs (10%)	$ 218,000	$ 218,000	10	$ 142,000	$ 109,000	$ 46,000
Total Construction Costs	$ 2,393,000	$ 829,000	10	$ 540,000	$ 414,500	$ 176,000
Contingencies and Engineering Services (50%)	$ 1,197,000	$ 415,000	10	$ 270,000	$ 207,500	$ 88,000
Total Capital Costs	$ 3,590,000	$ 1,244,000		$ 810,000	$ 622,000	$ 264,000
Present Worth	**$ 3,590,000**			$ 810,000		$ 264,000
O&M Costs (See O&M Costs Table for Detail)	**$ 69,000**					
Present Worth of O&M	**$ 907,000**					

Summary of Present Worth Costs

Capital Cost	$ 3,590,000
Future Costs	$ 810,000
O&M Cost	$ 907,000
Salvage Value	$ (264,000)
Total Present Worth	**$ 5,043,000**

Note: Costs are November 2016 basis.

Madison Metropolitan Sewerage District
2016 Liquid Processing Facilities Plan
Opinion of Present Worth Cost **Discount Rate** 4.375%

TM6 - Headworks
Alternative S6-Moving Media Screens and Dedicated Wash Presses

ITEM	Initial Capital Cost	Future Capital Cost	Future Year	Future Cost (P.W.)	20-Year Salvage Value	Salvage Value (P.W.)
Structural Modifications	$ 148,000	$ 49,300	10	$ 32,000	$ 24,650	$ 10,000
Screens (3, 1 future)	$ 1,114,000	$ 371,300	10	$ 242,000	$ 185,650	$ 79,000
Wash Presses (3, 1 future)	$ 405,000	$ 135,000	10	$ 88,000	$ 67,500	$ 29,000
Conveyor	$ 170,100	$ -	20	$ -	$ -	$ -
Mechanical (10% of equipment)	$ 168,900	$ 50,600	10	$ 33,000	$ 25,300	$ 11,000
Electrical (20% of equipment)	$ 337,800	$ 101,300	10	$ 66,000	$ 50,650	$ 22,000
Subtotal	$ 2,344,000	$ 708,000		$ 461,000	$ 353,750	$ 151,000
Contractor GCs (10%)	$ 235,000	$ 71,000	10	$ 46,000	$ 35,500	$ 15,000
Total Construction Costs	$ 2,579,000	$ 779,000	10	$ 508,000	$ 389,500	$ 165,000
Contingencies and Engineering Services (50%)	$ 1,290,000	$ 390,000	10	$ 254,000	$ 195,000	$ 83,000
Total Capital Costs	$ 3,869,000	$ 1,169,000		$ 762,000	$ 585,000	$ 248,000
Present Worth	**$ 3,869,000**			$ 762,000		$ 248,000
O&M Costs (See O&M Costs Table for Detail)	**$ 69,000**					
Present Worth of O&M	**$ 907,000**					

Summary of Present Worth Costs

Capital Cost	$ 3,869,000
Future Costs	$ 762,000
O&M Cost	$ 907,000
Salvage Value	$ (248,000)
Total Present Worth	**$ 5,290,000**

Note: Costs are November 2016 basis.

Madison Metropolitan Sewerage District
2016 Liquid Processing Facilities Plan
Opinion of Present Worth Cost **Discount Rate** 4.375%

TM6 - Headworks
Alternative S7-Chopper Pumps and Wash Presses

ITEM	**Initial Capital Cost**	**Future Capital Cost**	**Future Year**	**Future Cost (P.W.)**	**20-Year Salvage Value**	**Salvage Value (P.W.)**
Structural Modifications	$ 20,000	$ -	10	$ -	$ -	$ -
Wash presses	$ 405,000	$ -	20	$ -	$ -	$ -
Chopper Pumps	$ 126,000	$ -	20	$ -	$ -	$ -
Screens	$ -	$ 1,782,200	10	$ 1,161,000	$ 891,100	$ 378,000
Grit Pump	$ -	$ 45,200	10	$ 29,000	$ 22,600	$ 10,000
Grit Snail	$ -	$ 225,800	10	$ 147,000	$ 112,900	$ 48,000
Mechanical (25% of equipment)	$ 132,800	$ 259,300	10	$ 169,000	$ 129,650	$ 55,000
Electrical (20% of equipment)	$ 106,200	$ 518,600	10	$ 338,000	$ 259,300	$ 110,000
Subtotal	$ 790,000	$ 2,831,000		$ 1,844,000	$ 1,415,550	$ 601,000
Contractor GCs (10%)	$ 79,000	$ 284,000	10	$ 185,000	$ 142,000	$ 60,000
Total Construction Costs	$ 869,000	$ 3,115,000	10	$ 2,030,000	$ 1,557,500	$ 661,000
Contingencies and Engineering Services (50%)	$ 435,000	$ 1,558,000	10	$ 1,015,000	$ 779,000	$ 331,000
Total Capital Costs	$ 1,304,000	$ 4,673,000		$ 3,045,000	$ 2,337,000	$ 992,000
Present Worth	**$ 1,304,000**			$ 3,045,000		$ 992,000
O&M Costs (See O&M Costs Table for Detail)	**$ 104,000**					
Present Worth of O&M	**$ 1,368,000**					

Summary of Present Worth Costs

Capital Cost	$ 1,304,000
Future Costs	$ 3,045,000
O&M Cost	$ 1,368,000
Salvage Value	$ (992,000)
Total Present Worth	**$ 4,725,000**

Note: Costs are November 2016 basis.

Madison Metropolitan Sewerage District
2016 Liquid Processing Facilities Plan
Opinion of Present Worth Cost

TM6 - Headworks
O&M Cost Summary

S0 - Null Alternative

		Annual O&M Cost	Comments
Screen/Screenings Handling Maintenance	$	80,800	Average of 2011 - 2016 Costs
Grit Maintenance	$	39,200	Average of 2011 - 2016 Costs
Total Annual O&M Costs	$	120,000	

S1 - Screen and Wash Press for Sluiced Screenings

		Annual O&M Cost	
Screen/Screenings Handling Maintenance	$	64,600	80% of current costs
Reduced Pumping Costs	$	(5,100)	Elimination of Maci pump and grit pump-from Energy Study
Reduced Grit Maintenance	$	35,900	10% reduction in total grit maintenance labor and parts
Total Annual O&M Costs	$	96,000	

S2 - New Band Screens and Wash Presses

		Annual O&M Cost	
Screen/Screenings Handling Maintenance	$	40,400	50% of current costs
Reduced Pumping Costs	$	(5,100)	Elimination of Maci pump and grit pump-from Energy Study
Reduced Grit Maintenance	$	35,900	10% reduction in total grit maintenance labor and parts
Reduced W4 requirement	$	(2,200)	100 gpm constant flow @ 100 ft TDH = ~4 hp
Total Annual O&M Costs	$	69,000	

S3 - New Step Screens and Wash Presses

		Annual O&M Cost	
Screen/Screenings Handling Maintenance	$	40,400	50% of current costs
Reduced Pumping Costs	$	(5,100)	Elimination of Maci pump and grit pump-from Energy Study
Reduced Grit Maintenance	$	35,900	10% reduction in total grit maintenance labor and parts
Reduced W4 requirement	$	(2,200)	100 gpm constant flow @ 100 ft TDH = ~4 hp
Total Annual O&M Costs	$	69,000	

S4 - New Rake Screens and Wash Presses

		Annual O&M Cost	
Screen/Screenings Handling Maintenance	$	40,400	50% of current costs
Reduced Pumping Costs	$	(5,100)	Elimination of Maci pump and grit pump-from Energy Study
Reduced Grit Maintenance	$	35,900	10% reduction in total grit maintenance labor and parts
Reduced W4 requirement	$	(2,200)	100 gpm constant flow @ 100 ft TDH = ~4 hp
Total Annual O&M Costs	$	69,000	

S5 - New Perforated Plate Screens and Wash Presses

		Annual O&M Cost	
Screen/Screenings Handling Maintenance	$	40,400	50% of current costs
Reduced Pumping Costs	$	(5,100)	Elimination of Maci pump and grit pump-from Energy Study
Reduced Grit Maintenance	$	35,900	10% reduction in total grit maintenance labor and parts
Reduced W4 requirement	$	(2,200)	100 gpm constant flow @ 100 ft TDH = ~4 hp
Total Annual O&M Costs	$	69,000	

S6 - New Moving Media Screens and Wash Presses

		Annual O&M Cost	
Screen/Screenings Handling Maintenance	$	40,400	50% of current costs
Reduced Pumping Costs	$	(5,100)	Elimination of Maci pump and grit pump-from Energy Study
Reduced Grit Maintenance	$	35,900	10% reduction in total grit maintenance labor and parts
Reduced W4 requirement	$	(2,200)	100 gpm constant flow @ 100 ft TDH = ~4 hp
Total Annual O&M Costs	$	69,000	

S7 - Chopper Pumps and Wash Presses

		Annual O&M Cost	
Screen/Screenings Handling Maintenance	$	64,600	90% of current costs
Grit Maintenance	$	39,200	same as current
Total Annual O&M Costs	$	104,000	

APPENDIX D
GRIT HANDLING OPINIONS OF PROBABLE COST

Madison Metropolitan Sewerage District
2016 Liquid Processing Facilities Plan
Opinion of Present Worth Cost **Discount Rate** 4.375%

TM6 - Headworks
Alternative G0-Null Alternative

ITEM	Initial Capital Cost	Future Capital Cost	Future Year	Future Cost (P.W.)	20-Year Salvage Value	Salvage Value (P.W.)
Demolition	$ -	$ -	10	$ -	$ -	$ -
Equipment	$ -	$ 882,000	10	$ 575,000	$ 441,000	$ 187,000
Mechanical (10% of equipment)	$ -	$ 88,200	10	$ 57,000	$ 44,100	$ 19,000
Electrical (20% of equipment)	$ -	$ 176,400	10	$ 115,000	$ 88,200	$ 37,000
Subtotal	$ -	$ 1,147,000		$ 747,000	$ 573,300	$ 243,000
Contractor GCs (10%)	$ -	$ 115,000	10	$ 75,000	$ 57,500	$ 24,000
Total Construction Costs	$ -	$ 1,262,000	10	$ 822,000	$ 631,000	$ 268,000
Contingencies and Engineering Services (50%)	$ -	$ 631,000	10	$ 411,000	$ 315,500	$ 134,000
Total Capital Costs	$ -	$ 1,893,000		$ 1,233,000	$ 946,500	$ 402,000
Present Worth	**$ -**			$ 1,233,000		$ 402,000
O&M Costs (See O&M Costs Table for Detail)	**$ 39,200**					
Present Worth of O&M	**$ 515,000**					

Summary of Present Worth Costs

Capital Cost	$ -
Future Costs	$ 1,233,000
O&M Cost	$ 515,000
Salvage Value	$ (402,000)
Total Present Worth	**$ 1,346,000**

Note: Costs are November 2016 basis.

Madison Metropolitan Sewerage District
2016 Liquid Processing Facilities Plan
Opinion of Present Worth Cost **Discount Rate** 4.375%

TM6 - Headworks
Alternative G1-New Grit Washers

ITEM	Initial Capital Cost	Future Capital Cost	Replacement Year	Replacement Cost (P.W.)	20-Year Salvage Value	Salvage Value (P.W.)
Demolition	$ -	$ 10,000	10	$ 7,000	$ 5,000	$ 2,000
Equipment	$ -	$ 904,000	10	$ 589,000	$ 452,000	$ 192,000
Mechanical (10% of equipment)	$ -	$ 90,400	10	$ 59,000	$ 45,200	$ 19,000
Electrical (20% of equipment)	$ -	$ 180,800	10	$ 118,000	$ 90,400	$ 38,000
Subtotal	$ -	$ 1,185,000		$ 773,000	$ 592,600	$ 251,000
Contractor GCs (10%)	$ -	$ 119,000	10	$ 78,000	$ 59,500	$ 25,000
Total Construction Costs	$ -	$ 1,304,000	10	$ 850,000	$ 652,000	$ 277,000
Contingencies and Engineering Services (50%)	$ -	$ 652,000	10	$ 425,000	$ 326,000	$ 138,000
Total Capital Costs	$ -	$ 1,956,000		$ 1,275,000	$ 978,000	$ 415,000
Present Worth	**$ -**			$ 1,275,000		$ 415,000
O&M Costs (See O&M Costs Table for Detail)	**$ 40,000**					
Present Worth of O&M	**$ 526,000**					

Summary of Present Worth Costs

Capital Cost	$ -
Replacement	$ 1,275,000
O&M Cost	$ 526,000
Salvage Value	$ (415,000)
Total Present Worth	**$ 1,386,000**

Note: Costs are November 2016 basis.

Madison Metropolitan Sewerage District
2016 Liquid Processing Facilities Plan
Opinion of Present Worth Cost

TM6 - Headworks

O&M Cost Summary

G0 - Existing Grit Classifiers

	Annual O&M Cost	Comments
Grit Maintenance	$ 39,200	Mechanical, Operations, and Supplies and Parts costs
Total Annual O&M	$ 39,200	

G1 - New Grit Washers

Equipment	Annual O&M Cost	Comments
Grit Maintenance w/o cyclone replacement	$ 40,000	Small increase in power cost for stirrer motor
Total Annual O&M	$ 40,000	

APPENDIX E
HAULED WASTE OPINIONS OF PROBABLE COST

Madison Metropolitan Sewerage District
2016 Liquid Processing Facilities Plan
Opinion of Present Worth Cost **Discount Rate** 4.375%

TM6 - Headworks
Alternative HW0-Null Alternative

ITEM	**Initial Capital Cost**	**Future Capital Cost**	**Replacement Year**	**Replacement Cost (P.W.)**	**20-Year Salvage Value**	**Salvage Value (P.W.)**
No capital costs						
Subtotal	$ -	$ -		$ -	$ -	$ -
Contractor GCs (10%)	$ -	$ -	20	$ -		
Total Construction Costs	$ -	$ -	20	$ -		
Contingencies and Engineering Services (50%)	$ -	$ -	20	$ -		
Total Capital Costs	$ -	$ -		$ -	$ -	$ -
Present Worth	**$ -**			$ -		$ -
Annual O&M	**$ 21,000**					
Present Worth of O&M	**$ 276,000**					

Summary of Present Worth Costs

Capital Cost	$ -
Replacement	$ -
O&M Cost	$ 276,000
Salvage Value	$ -
Total Present Worth	**$ 276,000**

Note: Costs are November 2016 basis.

Madison Metropolitan Sewerage District
2016 Liquid Processing Facilities Plan
Opinion of Present Worth Cost **Discount Rate** 4.375%

TM6 - Headworks
Alternative HW1-Drive-Through Receiving Station

ITEM	**Initial Capital Cost**	**Future Capital Cost**	**Replacement Year**	**Replacement Cost (P.W.)**	**20-Year Salvage Value**	**Salvage Value (P.W.)**
Demolition	$ 75,000	$ -	20	$ -	$ -	$ -
Temporary Unit Rental	$ 40,000	$ -	20	$ -	$ -	$ -
Structure	$ 275,000	$ -	40	$ -	$ 137,500	$ 58,000
Equipment	$ 774,000	$ -	20	$ -	$ -	$ -
Barrel Dumpoff basin	$ 60,000					
Piping and Mechanical	$ 158,000	$ -	20	$ -	$ -	$ -
Site Work	$ 129,000	$ -	20	$ -	$ -	$ -
Subtotal	$ 1,511,000	$ -				
HVAC	$ 14,000					
Electrical and Controls	$ 210,000	$ -	20	$ -	$ -	$ -
Subtotal	$ 1,735,000					
Contractor GCs (10%)	$ 174,000					
Total Construction Costs	$ 1,909,000					
Contingencies and Engineering Services (50%)	$ 955,000					
Total Capital Costs	$ 2,864,000			$ -	$ 137,500	$ 58,000
Present Worth	**$ 2,864,000**			$ -		$ 58,000
O&M Costs (See O&M Costs Table for Detail)	**$ 36,000**					
Present Worth of O&M	**$ 473,000**					

Summary of Present Worth Costs

Capital Cost	$ 2,864,000
Replacement	$ -
O&M Cost	$ 473,000
Salvage Value	$ (58,000)
Total Present Worth	**$ 3,279,000**

Note: Costs are November 2016 basis.

Madison Metropolitan Sewerage District
2016 Liquid Processing Facilities Plan
Opinion of Present Worth Cost

TM6 - Headworks

O&M Cost Summary

HW0 - Existing Hauled Waste Receiving

	Annual O&M Cost		Comments
Hauled Waste Receving Costs	$	21,000	Average of 2011 - 2016 Costs
Total Annual O&M	$	21,000	

HW1-Drive-Through Receiving Station

	Annual O&M Cost		Comments
Hauled Waste Receving Costs	$	21,000	Average of 2011 - 2016 Costs
Equipment Maintenance	$	12,400	2% of new Equipment costs
HVAC Costs	$	2,300	Estimated
Total Annual O&M	$	36,000	

APPENDIX F
HAULED WASTE RECEIVING STATION PILOT TEST REPORT

MADISON METROPOLITAN SEWERAGE DISTRICT

Flo-beast Septage Receiving Pilot

Drew Suesse

May 2017

Background

Septage receiving operations at MMSD's Nine Springs Wastewater Treatment plant have been identified for potential upgrades as part of the Liquid Processing Facilities Plan. The current receiving station consists of a trough that haulers back up to and discharge by gravity, with flow entering Screen 4 of the headworks building (Figure 1). This configuration has a number of issues impacting maintenance and operation at the headworks building. First, the trough that haulers discharge to does not have adequate enough slope to manage debris (Figure 2). Rocks, grit, and other heavy solids often settle out in the trough before entering Screen 4's channel. This requires Building & Grounds staff to regularly clean the station by hand. Grit that does make it through has been known to cause wear on the screens and macerator well pumps. Heavy grease loads from haulers result in similar issues, and can plug screenings handling equipment. Grease plugs result in slippery, hazardous overflows in the headworks. These spills are time consuming to contain and clean up.

Figure 1 – Current septage receiving station

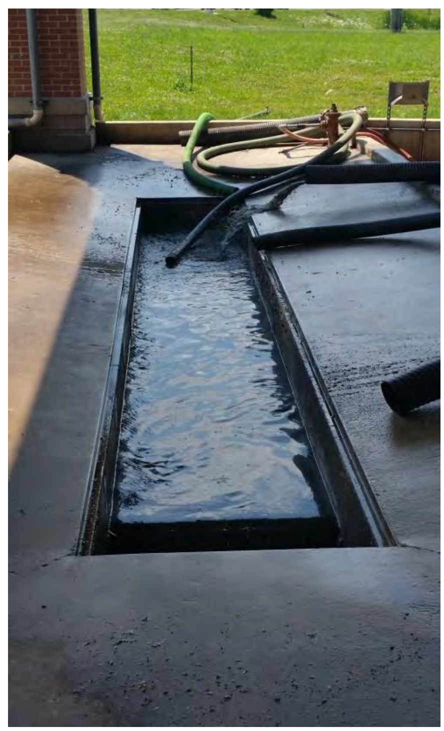


Figure 2 – Shallow slope in receiving trough

The need for reliable records of septage loads has been identified. Currently, haulers self-report the type and volume of waste they are discharging at the plant. There is no way to verify if the reported volumes are accurate. Since billing is based on volume delivered, there is some uncertainty as to whether haulers are being billed correctly.

An option proposed in the Liquid Processing Facilities Plan to address the aforementioned concerns is to construct a drive-through station with a dedicated septage receiving unit and flow monitoring system. A unit recommended for this purpose was the Enviro-Care Flo-beast. This equipment screens, washes, and dewaters debris from liquid waste streams, and has the capability of flow metering and data logging. MMSD staff worked with Rob Szekeress of Peterson & Matz, Inc. to coordinate a pilot test with the equipment during the week of May 22, 2017. Observations made over the course of four days of testing are summarized in this report.

Equipment Set-up

The Flo-beast pilot was located in the H2S media storage pit located directly south of the Boiler Building. This location was selected for multiple reasons. First, it was a large flat area that provided at least two feet of elevation between the trucks and the inlet to the pilot. This allowed for trucks to back into the drive west of the pit, hookup their hose, and discharge by gravity to the unit. The Flo-beast is capable of handling pressurized flow from the trucks, but the option for gravity flow was desired to accommodate trucks without this ability. An elevated truck also provides a stress test of the unit's flow capabilities.

Another factor considered when selecting this location was access to a potable water source for the unit's flush water. Enviro-care recommends a water source delivering 40 gpm at 60 – 80 psi. Though potable water was used for the pilot test, a discussion was had with Enviro-care personnel about the possibility of using W4 for a full-scale installation. They had indicated that using strained W4 would be acceptable, but suggested an additional strainer at the unit be installed to further polish the water and avoid plugging of spray nozzles. In addition to the flush water, a garden hose was also connected to the water source. This proved to be very useful for spraying down trucks when the hauler would open the tank valve and inevitably spill some septage onto the pavement. Electrical requirements for the pilot consisted of a 3-phase, 480 volt, 30 amp electrical connection. A service line was not located close by, so a 30 kW generator was set up in the pit area.

Also located in the pit was a dumpster to collect screenings. Since the current septage solids combine with influent screenings, it was unknown how much debris the Flo-beast could be expected to remove over the course of the week. It was ultimately decided to rent a 6-yard dumpster, with the anticipation that it may be filled by the end of the pilot. Liquid passing through the Flo-beast was discharged to a well in the pit area, which then empties to the primary clarifier's influent channel. It was quickly discovered after the first truckload that the well would not be able to handle the pilot's flow rate. Sandbags were placed around the well and a diesel Godwin pump was brought in to mitigate flooding and help transfer the effluent to the primaries.

Flo-beast Operation

The Flo-beast trialed at NSWWTP consisted of two skids. The first was referred to as the hauler station. This skid contained a 4-inch hose connection for the truck, a knife valve, flow meter, controls, and the hauler access panel. A 4-inch hose connected the hauler station to the Flo-beast screening skid. The screening skid could be classified into four parts: the inlet tank, rotating drum screen (6 mm pores), auger, and compaction zone (Figures 3 & 4). The unit piloted is Enviro-Care's Flo-beast 1200. The number refers to the outside diameter of the drum screen (mm). The 1200 is the medium-sized model with an estimated capacity of 650 gpm assuming 3 – 4% solids. A larger model (1400 mm screen, 875 gpm capacity) is available with the choice of a 6-inch inlet or two 4-inch inlets. Enviro-care also provides a “Baby Beast” with a 1000 mm screen and a 525 gpm capacity.

Figure 3 – Flo-beast Screening Skid

Figure 4 – Inlet tank and auger

The Flo-beast operates in the following manner. A hauler connects the 4-inch inlet hose to the truck. The hauler then swipes an access card in the hauler station. Each hauler receives a unique PIN which they will be prompted to enter. Following, the type of waste needs to be entered into the access panel. Newer models of the Flo-beast have the option to program screening operation based on the type of waste being hauled. For instance, if a hauler knows the load contains a large quantity of solids or grease, the Flo-beast can be programmed to run the auger longer to move more solids through, or initiate a longer flush cycle. Once the waste type has been entered, the knife valve will open and the unit will begin accepting septage.

The flow rate of septage is monitored as it travels through the hauler station and into the inlet tank. As the inlet tank fills, septage begins entering the drum screen. Solids in the septage load will begin covering the drum screen’s pores, and the level in the inlet tank will begin to rise. There are two conductivity rods in the inlet tank. When the level reaches the first rod, drum screen and auger rotation are initiated. Flights on the drum screen deposit solids into the auger’s trough, clearing the screen’s pores and allowing the liquid portion to exit the unit through an 8-inch hose. Spray nozzles and brushes located on the outside of the screen aid in the removal of solids. The rotating auger moves the solids up the trough at a 25° incline to begin dewatering. Additional spray nozzles are located along the trough. These were left off for the pilot test, but can be used to wash solids if high fecal loads are expected.

Following the auger, solids are pushed through the compaction zone, which is simply a cylindrical opening at the end of the trough. Gravity provides the dewatering here. Debris falls into a bagging system or directly into a dumpster when enough material builds up in this zone. Another spray nozzle is located in the compaction zone that can be operated to prevent material plugging.

The unit will go into a high alarm mode if the drum screen is not able to keep up with the incoming solids and the level in the inlet tank reaches the second conductivity rod. The alarm will trigger the knife gate to shut, and allow the screen to catch up with the solids. The knife gate will reopen once the level has returned to normal.

Haulers can monitor the total volume discharged on the access panel. Once the truck has emptied, haulers then press the "End Haul" button. A ticket is subsequently printed which documents the date, time, waste type, total volume, and duration of discharge. The "End Haul" button also initiates a flush cycle in the screening unit. Spray nozzles are activated and flush water enters the inlet tank. The drum screen and auger continue to run for a minute after the haul has ended to move any remaining debris to the dumpster. Length of flush cycle can be adjusted if desired.

<u>Testing</u>

Day One

On the first day of the trial, Randy Vinyard (Service Manager) and Matt Bodwell (Regional Sales Manager) from Enviro-Care arrived on site to commission the Flo-beast pilot. The pilot skids were moved into place, and final installations were made. Ralph Erickson had set up barriers at the headworks to redirect haulers to the pilot area. The first truck to use the Flo-beast was carrying waste from a meat market, and contained a considerable amount of grease and solids. The screening unit handled the solids well (Figure 5), and deposited a large amount of debris in the dumpster (Figure 6). There was some concern that the dumpster would quickly fill up based on what was seen with the first load. However, this load contained by far the highest solids content observed during the week and was atypical of most other septage.

Figure 5 – Flo-beast receiving grease and solids from meat market load

Figure 6 – Material collected from first truck

As noted above, the effluent well began to flood during the first truck (Figure 7). The hauler periodically stopped discharging to allow the well level to come down. It was decided that this would not be a practical way to run the pilot and would not be a good representation of how the Flo-beast operates. The test was paused at this point to bring in sandbags and a Godwin pump (Figure 8).

Figure 7 – Flooding of effluent well

Figure 8 – Sandbags and pump were brought in to manage flooding

The test resumed in the afternoon with greatly improved results. Though the suction hose of the pump would occasionally stick to the bottom of the well causing some flooding, the pilot was able to be operated as intended. Haulers were encouraged to pressurize their discharge, if possible, to test the hydraulic loadings to the unit. Flows up to 875 gpm were noted when doing so. The Flo-beast was able to manage these flows well, particularly if the septage contained a relatively low volume of solids (which most loads did). Hydraulic limitations were more related to the well downstream than the pilot itself. The Flo-beast did, however, go into high alarm twice. One was related to a septic load with noticeably high solids being discharged by gravity, but it quickly cleared. The other alarm resulted from a pressurized discharge, which overwhelmed the drum screen. During this event, the hauler immediately stopped discharging as a high alarm would cause the knife gate to close while the truck would continue to supply pressure. Enviro-Care staff cautioned that this would be damaging to the equipment.

The bagging system was set up partway through the day. This is similar to the system MMSD has at Pump Station 18. The end of the bag is tied off and allowed to continuously fill to form a “sausage link” as it folds over itself in the dumpster. After running the Flo-beast for a few hours it was noted that the bag was filling with water due to the wetness of the product. At some point a hole had formed in the bag, and was spilling water into the bottom of the dumpster. The screened material appeared much wetter than desirable. Randy was asked if this was normal. He indicated that it was within the range of what they typically see.

Day Two

Matt Bodwell remained on site for the second day of the pilot test. Operations continued as they had the previous afternoon with the Flo-beast receiving a combination of septic, holding tank, and grease loads throughout the day. Gravity discharge, as opposed to pressurized, was recommended to the haulers on the second day. The Godwin pump had difficulties keeping up with the pressurized flow and would result in the occasional well flooding. Using gravity discharge, maximum flows were around 450 gpm. The pilot could easily keep up with this, and no high alarms were noted for the day.

The issue of screenings wetness was observed again the second day. A pool of liquid a few inches deep was forming in the dumpster (Figures 9 & 10). This concern was mentioned to Matt again. He recommended that the frequency of spray in the compaction zone be reduced, as this was likely where the excess water was coming from. In addition, the pilot was operated once again without the bagging system to better monitor wetness of material. Minimal flushing in the compaction zone did appear to improve screening dryness. Solids from septic and holding tanks appeared to be slightly damper than the screenings typically seen in the headworks dumpster, but would likely still be acceptable to haul to a landfill. Solid grease loads and porta-potty waste appeared wet but manageable.

Figures 9 & 10 – Wet screened material collected in bagging system & liquid filling dumpster

At times, truck traffic would begin to back up (Figure 11). Each hauler would spend about 10 minutes on average at the Flo-beast. Ralph had devised a system to keep the line of haulers from getting too long. If a hauler had not yet used the pilot or if they were carrying an interesting waste load (high solids, rocks, grease, etc.), they would be asked to remain in line. If the hauler had been through the pilot before and were hauling a relatively clear load, they were directed back to the headwork's septage receiving trough. One notable truck this day was hauling exclusively porta-potty waste. Other porta-potty haulers had arrived on site, but were turned away due to having a 3-inch connection. For the pilot, a 4-inch hose with a 6-inch adapter had been used as the vast majority of trucks had one of these two sizes. The porta-potty load contained a lot of solids and garbage, but was easily managed by the Flo-beast.

Figure 11 – Line of haulers patiently waiting to use the Flo-beast

When the pilot was being shut down for the day the unit went into a flush cycle as it is programmed to do. However, the unit would not stop running in flush cycle mode. The equipment was reset, and this seemed to solve the problem.

Day Three

When the Flo-beast was turned on in the morning it once again went into an unprompted flush cycle. Matt had contacted Enviro-Care staff and it was discovered that a piece of debris had become lodged in the conductivity rods' housing, causing a short. The debris was removed and the pilot began to operate correctly. This is a common issue, and has been addressed in newer models by using fiberglass instead of metal for the housing.

Another issue observed that Enviro-Care has remedied in newer models is the buildup of material on the edge of the trough. Flights on the drum screen tended to deposit debris outside of the trough where the auger was not able to reach. A rake was kept near the pilot so staff could occasionally push the debris into the trough, though the accumulation did not appear to be impacting the operations of the screening unit. In newer models, one of the flights on the drum screen has been retrofitted with a rubber extension that reaches closer to the trough area.

Notable loads from the third day consisted of a septic tank combined with waste from a grease trap. The hauler estimated about 25 gallons of grease, but looked to be considerably more when flowing through the Flo-beast (Figures 12). The grease was mostly solid, though it left a residue coating the inside of the unit (Figure 13). Multiple flush cycles were manually prompted in an attempt to clear the grease. Despite the efforts the grease remained after numerous cycles and subsequent loads. Another interesting load came from an aging septic tank that contained a significant amount of rock debris (Figure 14). As advertised, the Flo-beast handled the rocks well and was able to pass all of them into the dumpster after a few following loads. It should be noted that screened material towards the end of the day began to look noticeably wetter again.

Figure 12 – Truckload containing grease trap waste

Figure 13 – Residual grease in inlet tank and trough

Figure 14 – Septic tank load containing rocks

Day Four

For the last day of testing, Enviro-Care changed personnel on site. Jeff Watry (Director of Operations) took over for Matt Bodwell. Much of the morning was dedicated to removing a plug of grease that had formed in the compaction zone. Material had begun plugging the exit of the compaction zone, as well as the drainage line. The heavy grease trap load seen the previous day was likely the culprit of the plug and the increasingly wet material observed. At one point, the plug had become so severe that liquid was being forced through the top of the compaction zone access hatch (Figure 15). Haulers were directed back to the headworks while Jeff manually snaked out the grease (Figure 17). Jeff believed that the plug had been allowed to develop due to the low frequency of the flushing in the compaction zone. The flushing frequency setting was increased once the plug had been removed. This seemed to have helped. Material from typical septic tank loads appeared to be much drier. However, no particularly heavy loads were received during the remainder of the pilot testing.

Figure 15 – Plug caused liquid to backup out of compaction zone

Figure 16 – Grease plug found in compaction zone

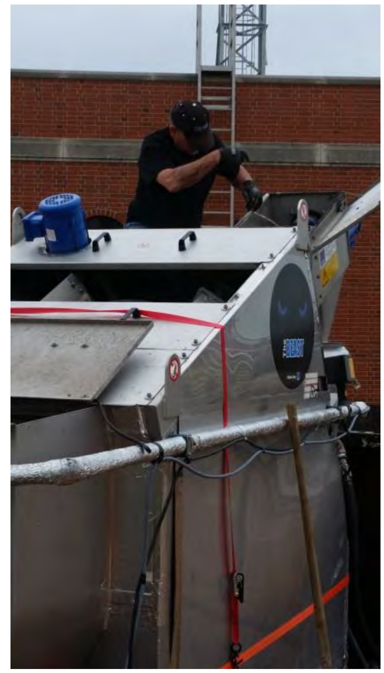


Figure 17 – Jeff Watry removing grease

Testing for the day wrapped early in order to clean and decommission the Flo-beast for shipment the following day. The inside of the unit was hosed down, as well as the surrounding pilot area. There was some concern that the dumpster may not be accepted by the rental company due to a significant amount of liquid present at the bottom. Buckets were used to bail out as much water as possible.

<u>Conclusions</u>

Hauler Data

Over the course of four days of testing (approximately 24 working hours), the Flo-beast saw at least 79 truckloads of septage (Attachment 1). This translates to around two days' worth of hauling that would typically be seen at the current receiving station. About 3 cubic yards of material were screened from 239,639 gallons of septage in total (Figure 18). The average load size was just over 3,000 gallons, with the majority of the waste coming exclusively from septic tanks (54%) or a combination of septic and holding tanks (28%). Most septic tanks were relatively low in solids (aside from the occasional landscaping stones and wipes that make their way into the trucks), and the Flo-beast had no trouble managing these loads. Only a small percentage of the haulers were carrying heavy grease or solids. Though, it should be noted that most porta-potty haulers were turned away due to their 3-inch connection. This amounted to one or two extra loads a day. While representing only a small portion of the total volume screened, the solid grease proved to be the most challenging for the Flo-beast to handle.

Figure 18 – Dumpster at the end of the week. Most liquid had been bailed out.

Solids

Overall, the Flo-beast could process most of the material delivered. Rocks were transferred to the dumpster, demonstrating that a rock trap would not be needed. Rags, leaves, hair, etc. were also easily screened out providing a clean effluent stream. A notable exception to this would be grit and liquid grease. Both of these wastes could pass through the 6 mm screen and ended up in the primaries. While the Flo-beast would address MMSD's current issue of grit and other debris settling in the trough, it would likely not alleviate the impact that grit has downstream on the headworks screen or macerator pump.

Wetness of screened material remained a concern for most of the week as detailed above. Multiple adjustments were made to the compaction zone flush water with varying success. It appears the ideal setting for material dryness would be to have minimal flushing. This needs to be weighed with the concern of grease plugging however. Enviro-Care staff had mentioned how other installations deal with solid grease loads. One plant has customized their unit to spray hot water when grease is selected as the waste type. Hot water helps to liquefy the grease so it can pass through the drum screen. This option should be explored as solid grease loads can be expected at NSWWTP.

Hydraulics

The Flo-beast was able to keep up with the discharge from most trucks. Hydraulic limitations observed during the week were not due to the pilot, but the well downstream. Both gravity and pressurized flow caused few issues, with only two high level alarms noted. With regards to high level, there is some concern about allowing haulers to discharge with pressure in a full-scale application. As noted, high level mode would cause a pressurized truck to be pushing against a closed valve. A blown hose, damage to the truck, or equipment would occur. Haulers would need to be trusted to pay attention to the access panel and be ready to stop discharging to avoid damage. Enviro-Care suggested installing flashing lights to alert a hauler to a high level situation.

Multiple units would need to be installed to accommodate the usual flow of traffic if this option is pursued. With one pilot unit, long lines would form and haulers were frequently redirected to the headworks. The current septage receiving trough can accommodate up to three trucks, with truck backups occasionally seen at busier times of the day. To meet the current capacity and provide some redundancy, three Flo-beast 1200s would likely be needed. Since the Flo-beast 1400 has the potential to include two 4-inch inlets, the option to install two of these units may be explored. However, two trucks may cause this unit to go into high level mode often based on the gravity flow rates observed during the pilot testing. Once discharging at the pilot, haulers commented that it only took slightly longer than usual. Most haulers are used to gravity discharging with a 6-inch hose as opposed to a 4.

Haulers' Impression and Data logging

Aside from some disgruntled haulers having to wait in line, the haulers' impression of the Flo-beast was generally favorable. Many took an interest in the equipment by asking questions and observing how it operates. The hauler's interaction with the equipment did not differ much from what they are currently doing (backing in, connecting hose, waste type and volume reporting, etc.). Although Enviro-Care or MMSD staffs were usually the ones accessing the hauler station due to its location, operating the unit was intuitive and could be easily used by haulers. A few individuals commented on the slope of the drive where the pilot was located. The steeper grade helped clear out the grit that settles in their trucks, and some mentioned they would like to see something similar if this unit was installed.

Monitoring of volume was also received well for the most part. It was common to hear haulers say that they have a hard time knowing exactly how much septage they are picking up, and would like to have a better idea. Enviro-Care staff would usually ask the hauler how much septage they believed they were discharging. Most estimates were in the ballpark of the recorded amount. One hauler, however, appeared to be taking advantage of the current self-reporting system. Ralph had noted that this particular hauler reports 100 gallons each time. The Flo-beast monitoring system found that the load was closer to 600 gallons. Regardless, this individual still recorded 100 gallons on his paper ticket in order to be consistent with his hauling log.

As required by DNR, septage haulers must record the amount of waste collected and the amount that is discharged at the plant. These numbers need to be consistent with each other. Further, haulers need to record the amount of each type of waste (e.g. 2,000 gallons of septic and 1,000 gallons of holding tank in a 3,000 gallon load). This presents the question of how to use the volume recorded with the Flo-beast, since it will not be able to decipher the volume of a specific waste in a combined load. The total volume recorded will also not likely match with the hauling log. Consideration will need to be taken on how to rectify differences in measured and estimated volumes to address billing and regulatory issues.

ATTACHMENT 1 - HAULER DATA

#	Date	Hauling Company	Waste Type	Total Volume (Gal)	Total Unload Time (min)	Gravity Discharge Time (min)	Pressurized Discharge Time (min)	Calculated Gravity Flow Rate (gpm)	Calculated Pressurized Flow Rate (gpm)	Comments
1	5/22	Honey Wagon	Grease	1185						Overflowed well. Meat market load
2	5/22	Speedway	Settling Tank	1500						Overflowed well
3	5/22	B&R								
4	5/22	Hellenbrand	Septic & Holding Tank	2800	6		6		466.7	
5	5/22	Honey Wagon	Septic & Holding Tank	3680	7		7		525.7	
6	5/22	Environmental Specialists	Septic & Holding Tank	4800	9	5	4			Meter Read up to 875 gpm (pressurized)
7	5/22	Kalscheur	Septic & Holding Tank	1530	4		4		382.5	
8	5/22	Honey Wagon	Sports Complex	2930	5		5		586.0	
9	5/22		Septic	3307	6		6		551.2	
10	5/22	Eckmayer	Septic & Holding & Catch Basin	3083	10	10		308.3		
11	5/22	Dvorak	Septic	2000	3		3		666.7	
12	5/22	KG Smith	Holding Tank	1600	5	5		320.0		
13	5/22	B&R	Dairy							Overflowed well
14	5/23	Honey Wagon	Grease & Holding Tank	2230	5	5		446.0		
15	5/23	A-1	Septic	1970	6	6		328.3		
16	5/23	Hellenbrand	Septic	3570	8	8		446.3		
17	5/23	Environmental Specialists	Septic & Holding Tank	5875	12	12		489.6		
18	5/23	Speedway	Septic	2182	5	5		436.4		High Solids, Generated High Alarm
19	5/23	Dvorak	Septic	2220	8	8		277.5		High rock load
20	5/23	A-1	Holding Tank	2140	7	7		305.7		Overflowed well
21	5/23	KG Smith	Septic	2450	8	8		306.3		
22	5/23	B&R	Septic & Holding Tank	1420	4	4		355.0		
23	5/23	Hubred	Septic & Holding & Porta-Potty	3050	8	8		381.3		
24	5/23	Eckmayer	Septic	2500	8	8		312.5		
25	5/23	Fort Septic		3500	6		6		583.3	
26	5/23	Speedway	Septic & Grease	1416	4	4		354.0		
27	5/23	Hellenbrand	Septic	2871	7		7		410.1	
28	5/23	Honey Wagon	Septic & Holding Tank	3381	7		7		483.0	
29	5/23	Dvorak	Septic	4187	9	6	3			Meter Read up to 725 gpm (pressurized). Switched back to Gravity
30	5/23	B&R	Septic	1261	4	4		315.3		
31	5/23	Kalscheur	Septic	4000	9	8	1			Meter read up to 620 gpm (pressurized). Switched back to Gravity
32	5/23	Honey Wagon	Septic	4700	11	11		427.3		
33	5/23	Kalscheur	Septic	2728	8	8		341.0		
34	5/23	Honey Wagon	Septic & Holding	4809	12	12		400.8		
35	5/23	Speedway	Holding Tank	1944	5	5		388.8		
36	5/23	DJ Septic	Septic & Holding Tank	5296	15	15		353.1		
37	5/23	Bergendal	Septic	3622	8	7	1			Overflowed well
38	5/23	Hubred	Septic	3386	8	8		423.3		
39	5/23	Environmental Specialists	Septic	6177	20					Valve opened early. Acutal unload time shorter than recorded
40	5/23	Bucky's	Porta-Potty	567	3	3		189.0		High solids
41	5/24	Dvorak	Holding Tank	940	5	5		188.0		
42	5/24	B&R	Septic	1080	4	4		270.0		
43	5/24	Environmental Specialists	Septic & Holding Tank	5822	13	13		447.8		
44	5/24	Elsing	Septic	3000	8	8		375.0		
45	5/24	A-1	Septic	2013	5	5		402.6		
46	5/24	Speedway	Holding Tank	2042	5	5		408.4		
47	5/24	Honey Wagon	Holding Tank	4196	9	9		466.2		
48	5/24	A-1	Septic & FOG	2612	7	7		373.1		
49	5/24	Honey Wagon	Septic	2740	7	7		391.4		
50	5/24	B&R	Septic	1080	4	4		270.0		
51	5/24	Eckmayer	Septic	3061	9	9		340.1		
52	5/24	DJ Septic	Septic & Catch Basin & Holding Tank	4782	13	13		367.8		
53	5/24	A-1	Septic	1506	7	7		215.1		
54	5/24	Fort Septic	Septic	4374	11	10	1			
55	5/24	B&R	Septic & Holding Tank	1251	3	3		417.0		
56	5/24	Kalscheur	Septic	3732	10	10		373.2		
57	5/24	Honey Wagon	Septic	4860	12	12		405.0		

#	Date	Hauling Company	Waste Type	Total Volume (Gal)	Total Unload Time (min)	Gravity Discharge Time (min)	Pressurized Discharge Time (min)	Calculated Gravity Flow Rate (gpm)	Calculated Pressurized Flow Rate (gpm)	Comments
58	5/24	Honey Wagon	Septic	2549	8	8		318.6		
59	5/24	Honey Wagon	Septic	4293	11	11		390.3		
60	5/24	Roto Rooter	Septic & Grease	2310	8	8		288.8		25 gallons from grease trap (thick grease)
61	5/24	Eckmayer	Septic	1363	4	4		340.8		
62	5/24	Fort Septic	Septic	4880	12	12		406.7		
63	5/24	Hubred	Septic	2900	8	8		362.5		
64	5/24	RDR	Septic & Catch Basin	3546	9	9		394.0		Waste was from an old septic. Lots of rocks
65	5/24	Dvorak	Septic	3911	7	1	6		651.8	
66	5/24	Roto Rooter	Septic	1140	5	5		228.0		Clear Septic
67	5/25	Honey Wagon	Holding Tank	4716	39	39				Valve opened early. Actual unload time shorter than recorded
68	5/25	Honey Wagon	Septic & Holding Tank	4001	10	10		400.1		
69	5/25	A-1	Septic	2850	8	8		356.3		
70	5/25	Hubred	Septic	3453	9	9		383.7		
71	5/25	Country Plumber	Septic & Holding Tank	3096	8	8		387.0		
72	5/25	Fort Septic	Septic	3755	9	9		417.2		
73	5/25	Environmental Specialists	Septic	6380	16	16		398.8		
74	5/25	Honey Wagon	Septic	2523	6	6		420.5		
75	5/25	Environmental Specialists	Septic	6250	14	14		446.4		
76	5/25	Hellenbrand	Septic & Holding Tank	3364	9	9		373.8		
77	5/25	DJ Septic	Septic & Holding Tank	5534	13	13		425.7		
78	5/25	Kalscheur	Holding Tank	3981	9	9		442.3		
79	5/25	Honey Wagon	Settling Tank	1886	6	6		314.3		

TOTA VOLUME: 239639 gal
AVERAGE LOAD/TRUCK: 3112 gal

	Gravity	Pressurized	
AVERAGE FLOW RATE:	364.0	530.7	gpm

SUMMARY:

Hauling Company	# of Loads
A-1	6
B&R	7
Bergendal	1
Bucky's	1
Country Plumber	1
DJ Septic	3
Dvorak	5
Eckmayer	4
Elsing	1
Environmental Specialists	6
Fort Septic	4
Hellenbrand	4
Honey Wagon	16
Hubred	4
Kalscheur	5
KG Smith	2
RDR	1
Roto Rooter	2
Speedway	5
Grand Total	78

(One unknown hauler)

Waste Type	# of Loads	% of Total Vol.
Grease Combination	5	4
Holding Tank	10	10
Porta-Potty	2	2
Septic	40	54
Septic Combination	18	28
Settling Tank	2	1
Grand Total		100.0

(Septic Combination = spetic, holding, and/or catch basin)
(Grease Combination = septic or holding tank load with significant grease content)

APPENDIX G–TECHNICAL MEMORANDUM NO. 7
EFFLUENT DISINFECTION

Technical Memorandum No. 7 for the

Madison Metropolitan Sewerage District, Madison, Wisconsin

Effluent Disinfection
2016 Liquid Processing Facilities Plan

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APPENDIX

APPENDIX–COST OPINIONS

One of the objectives of this 2016 Liquid Processing Facilities Plan is to evaluate effluent disinfection alternatives for the Madison Metropolitan Sewerage District (District) Nine Springs Wastewater Treatment Plant (NSWWTP). This memorandum includes a summary of the existing ultraviolet (UV) disinfection system, discussion of the disinfection alternatives that were initially screened, and detailed discussion of the short-listed alternatives with opinions of probable construction cost and nonmonetary considerations. Technical Memorandum No. 2a provided a summary of current and projected future disinfection requirements.

DESCRIPTION OF EXISTING EFFLUENT DISINFECTION SYSTEM

The existing UV disinfection system was manufactured by Fischer & Porter (F&P) has a horizontal bulb arrangement and was started-up in 1996. The system consists of 5 channels, 2 banks per channel, and 368 low-pressure UV lamps per bank for a total of 3,680 lamps. Two additional channels were constructed with 1 channel designated for future expansion and the other used as a bypass channel when the UV system is not in use. The system also includes a lamp sleeve chemical cleaning system, consisting of a dip tank for seasonal cleaning of the sleeves.

Soon after start-up of the UV system, F&P was acquired by Trojan Technologies. After the acquisition, the F&P UV product line was no longer manufactured, nor were replacement parts available from Trojan. Since that time, IronbrookUV has serviced many of the F&P UV systems throughout the United States, and also sells parts for the F&P systems. The District has not typically purchased replacement parts from IronbrookUV, however, choosing instead to purchase UV system parts, including control boards, through less-expensive third-party vendors. Overall, the system has performed well and disinfection permit requirements have been met. However, the system has required more maintenance, parts sourcing, and attention than anticipated.

The capacity of the 5 active UV channels is approximately 100 million gallons per day (mgd), and that design flow will be maintained following the proposed upgrades to the system. Flows above 100 mgd will be diverted to the effluent storage lagoons and recycled back to the NSWWTP for full secondary treatment, similar to the current operations. The NSWWTP effluent pumping capacity is only about 80 mgd, and expanding that capacity would require extensive pump station and force main upgrades and cost (Technical Memorandum No. 4, Alternative PF8). At this time, those pumping capacity upgrades are not anticipated, so the base case for disinfection design flow will remain at 100 mgd. However, each disinfecting alterative included in the detailed evaluation will consider the ability to expand to disinfect up to 180 mgd of flow, which is the design peak flow condition for this planning effort (refer to TM4).

EFFLUENT DISINFECTION ALTERNATIVES IDENTIFICATION

Workshop No. 7 was held on October 5, 2016, at the NSWWTP to discuss disinfection operations, alternatives, and related information. The purpose of the workshop was to present a list of disinfection alternatives and screen the alternatives down to a shorter list to evaluate in detail. A brief description of each of the alternatives presented at this workshop is presented in this section. A seventh alternative, D7–Refurbish Existing System, was added at the request of the District during the workshop.

All of the alternatives were considered for both 100 mgd and 180 mgd peak flows, and all alternatives were required to meet the current geometric mean fecal coliform limit of 400 CFU/100 ml, as well as potential future *E. coli* limits of 126 CFU/100 ml (geometric mean) and 410 CFU/100 ml (statistical threshold value). In addition, system suppliers had to consider potential future virus and coliphage limits. Each alternative would be able to meet both the fecal coliform and *E. coli* limits. Although no specific virus or coliphage limits have been published, each alternative is expected to meet potential future limits.

This section presents a brief summary of the long list of alternatives discussed at the workshop. Since the District has been using UV disinfection for nearly 30 years, and UV disinfection is considered the state-of-the-art disinfection technology at this time, it is unlikely that another disinfection technology will provide enough benefits to replace UV disinfection at the NSWWTP. Several UV technologies were selected to compare to the existing system based on the major types of UV systems available at this time. Two other chemical-based disinfection technologies were selected to compare to the UV systems.

A. Alternative D0–Continue Use of Existing F&P Horizontal UV Disinfection (Null Alternative)

This alternative would continue operating with the existing F&P UV system without upgrades or expansion. Continued use of the existing equipment would require obtaining third-party replacement parts and lamps since the equipment is no longer manufactured. The number of operating F&P UV systems in North America will continue to decline as end-users upgrade to new UV technologies and systems, and it is likely that parts and service will become more difficult to obtain, or at least more expensive to purchase. Although there are still several large plants with this 1990s-version of the F&P UV system in use, obtaining replacement parts may be difficult within the 20-year planning of this facilities plan. While it is not possible to predict the useful service life of the existing F&P UV system, we suggest the existing system cannot be expected to remain in efficient operating condition for more than another 10 years. This would put its overall operating life at about 30 years, which is 10 to 15 years beyond a typical useful service life of similar technology. Based on this, we have assumed the existing system would require replacement at about year 2026.

B. Alternative D1–Inclined Arrangement UV Disinfection (Trojan Technologies)

This alternative would include installation of the Trojan Technologies UV Signa system to replace the existing F&P system in its entirety. For a design flow of 100 mgd, three UV channels would be utilized, with 3 UV banks per channel. Each bank would have 20 lamps for a system total of 180 lamps. The 180 mgd design flow would require 5 channels with 3 UV banks per channel. Each bank would have 20 lamps for a total of 300 lamps. The lamps are 1,000-watt Trojan Solo Lamps™ that have the low power draw characteristics of a low-pressure lamp with the high output characteristics of a medium pressure lamp. The lamps are warranted for 15,000 hours of operation each and lamp output can be adjusted from 30 percent to 100 percent capacity, depending on demand. The lamps are inclined in the channel at 45 degrees. Lamp replacement can be performed while the system is in service or by tilting the banks out of the channel. The lamps are proprietary and are currently available only from Trojan or its equipment representatives. Lamp sleeve cleaning is performed using an automatic mechanical and chemical cleaning system. The mechanical cleaning system is hydraulically driven. Installation of the Trojan equipment would require modification of the channels to make them deeper and slightly narrower. Adjustable downward opening weir gates would be used to maintain the proper water level in each channel.

C. Alternative D2–Inclined Arrangement UV Disinfection (WEDECO-Xylem)

Alternative D2 would include installation of the WEDECO-Xylem Duron UV system. For the 100 mgd system, 5 channels with 3 banks per channel, and 28 lamps per bank would be required. A total of 420 low-pressure lamps would be installed. The 180 mgd system would include 7 channels, 3 banks per channel, and 28 lamps per bank for a total of 588 lamps. Each lamp has an output of 600 watts, are inclined at 45 degrees in the channel, and are warranted for 14,000 hours. The lamps are not proprietary and may be obtained from other suppliers besides WEDECO. The lamp sleeves are cleaned with an automatic wiper system powered by an electric motor. The new equipment would fit in the existing channels without modifying the channel bottoms and only minor modifications to the walls. Adjustable downward opening weir gates would be used to maintain the proper water level in each channel.

D. Alternative D3–Vertical Arrangement UV Disinfection (Suez Treatment Solutions)

Alternative D3 includes the Suez Treatment Solutions Aquaray 3X vertical lamp UV system. The 100 mgd system would include 5 channels, 2 banks per channel, 2 modules per bank, and 36 lamps per module, for a total of 720 lamps installed. The 180 mgd system would include 7 channels, 2 banks per channel, 2 modules per bank, and 36 lamps per module, for a total of 1,008 lamps installed. The lamps are 400 watts, high-intensity low pressure, and are guaranteed for 16,000 hours. The lamps are mounted vertically in the channel and can be changed without removing the modules from the channel. The lamp sleeves are cleaned mechanically using an electrical motor-driven cleaning system. The equipment would fit into the channels with minor channel modifications. Adjustable downward opening weir gates would be used to maintain the proper water level in each channel.

E. Alternative D4–Vertical Arrangement UV Disinfection (Glasco UV)

Alternative D4 includes the Glasco UV vertical system. The 100 mgd system would require 4 channels, each housing 3 banks with 2 modules per bank. The 180 mgd system would require 6 channels, 3 banks per channel, and 2 modules per bank. The system would utilize 600-watt low-pressure high-intensity lamps. The 100-mgd system would require 960 lamps and the 180-mgd system would require 1,728 lamps. The lamp sleeves would be cleaned using a pneumatically-driven mechanical cleaning system. The equipment would fit into the channels with minor channel modifications. Adjustable downward opening weir gates would be used to maintain the proper water level in each channel.

F. Alternative D5–Ozone Disinfection (Suez Treatment Solutions)

Alternative D5 includes the Suez Treatment Solutions ozone disinfection system. The 100 mgd system would include 2 liquid oxygen (LOX) tanks, 3 LOX vaporizers, 3 ozone generators and power supply units, ozone diffusers, controls, instrumentation, valves, and piping. A contact tank would be provided for approximately 8 to 10 minutes of detention time. Three ozone destruction skids would be provided to catalytically convert excess ozone to oxygen prior to being vented to the atmosphere. The new equipment could be housed in the existing Effluent Building. The LOX tanks would be stored outside, and a new contact tank would be need to be constructed. A quote for a 180 mgd ozone system was not provided by Suez Treatment Solutions.

G. Alternative D6–Peracetic Acid (Peroxychem)

Alternative D6 includes adding peracetic acid to disinfect the WWTP effluent. Peracetic acid has gained some attention and application over the last 5 years or so, particularly as a replacement for chlorine-based disinfection systems. The feed pumps, tanks, and chemical would be provided by Peroxychem. This alternative would require the construction of contact tanks to provide sufficient detention times. Feed rates and detention times would need to be determined through bench scale and possibly pilot testing. Wisconsin Administrative Code Chapter NR110 does not include the design requirements for a peracetic acid disinfection system, and such a system would require approval from the Wisconsin Department of Natural Resources prior to proceeding with design and construction.

H. Alternative D7–Refurbishing Existing UV System (IronbrookUV)

Alternative D7 was added during the disinfection workshop and includes refurbishing/major component replacement of the existing F&P system. IronbrookUV of Sharon, Ontario, Canada, refurbishes F&P systems and provided a quote to the District for the existing system. The refurbishment would include replacing control boards, ballasts, breakers, transformer, cables, UV intensity monitors, lamps and sleeves, among other items. The lamp racks would also be refurbished. This alternative does not include expanding the system beyond the existing five channels. The refurbished system would have the same number of lamps as existing, and level control would be accomplished with downward opening weir gates.

I. Disinfection Alternatives Not Considered

Chlorine-based disinfection systems were not included as viable alternatives in these evaluations. This includes both gaseous and liquid-based systems. While chlorine is still commonly used as a wastewater disinfectant, its use has decreased over the last 20 years as UV disinfection has become more popular and cost-competitive. UV systems have replaced chlorine-based disinfection even when the latter are less expensive, mainly as a result of toxicity and human health concerns with chlorine, environmental impacts of chlorine, and the desire to reduce the use and transportation of chemicals.

Specifically, chlorine-based disinfection alternatives were not considered for the following reasons:

- Chemical handling and storage concerns.
- The disinfection chemicals are toxic and can pose a hazard to employees.
- In the case of gaseous chlorine, there is a public safety concern.
- Although chlorine is still used for disinfection, the wastewater treatment industry has migrated away from its use.
- Large contact tanks would need to be constructed. Locating these tanks on-site would be problematic due to space constraints.
- The District has a long history of using UV disinfection and has not expressed any interest in using chlorine or chlorine products.
- The costs associated with reconfiguring the NSWWTP to accommodate chlorine-based disinfection would likely be higher than UV disinfection alternatives.

SCREENING OF ALTERNATIVES

The long list of alternatives was discussed and screened at a workshop held at the District on October 5, 2016. The overall concept for each alternative was presented, including high-level budgetary costs and nonmonetary considerations. Table 1 compares the six UV disinfection alternatives, including equipment costs, number of lamps, lamp warranty, power draw, and number of projects installed or planned. Based on this information, there appears to be an efficiency advantage to the newer style inclined arrangement UV systems provided by Trojan Technologies and WEDCO. These two systems project energy usage to be about 27 percent less than the existing F&P system. The refurbished UV system offered by IronbrookUV also indicates improved efficiency over the existing F&P system, including and improved lamp output for the same electrical input (32.7W output now versus 26.1W previously). However, the IronbrookUV system cannot be turned down as efficiently as the newer systems. IronbrookUV requires turning entire banks on and off to match the dose requirements. Given this, and since the same number of lamps would be provided with the refurbished system, it is not likely that any significant energy savings would be realized with a new IronbrookUV system.

Table 1 Comparison of UV Systems

Manufacturer	Equipment Costs[1,2]	Channel Modifications Required?	Number of Lamps[1]	Lamp Warranty (hours)	Average Power Draw[3] (kW)	No. of Projects >50 mgd	No. of Projects >100 mgd
Alt. D0–F&P	N/A	None	3,680	N/A	95	N/A	N/A
Alt. D1–Trojan	$1,131,500	Lower channel floor	180	15,000	69	9	3
Alt. D2–WEDECO	$1,535,000	Minor	420	14,000	68	3	1
Alt. D3–Suez	$1,400,000	Minor	720	16,000	100	15	4
Alt. D4–Glasco	$1,700,000	Minor	960	NP	115.2	1	0
Alt. D7–IronbrookUV	$1,010,000	None	3,680	16,000	95	N/A	N/A

N/A = Not Available or Not Applicable
NP = Not Provided
[1]100 mgd system design.
[2]Installation, electrical, structural costs not included
[3]Based on 40 mgd average flow

Table 2 summarizes the equipment costs and pros and cons of the eight disinfection alternatives considered.

Table 2 Disinfection Alternatives Summary–Initial Screening

Alternative	Name	Equipment Costs[1]	Pros	Cons
D0	Maintain Existing F&P UV	None other than ongoing maintenance.	§ Staff familiar with system. § No structural modifications needed.	§ Equipment and controls are 20 years old. § Likely need to replace system within 10 years. § Parts may become more difficult to source as F&P systems are replaced. § Higher energy usage compared to newer technologies.
D1	UV Disinfection (Trojan Technologies)	$1,131,500[2]	§ Manufacturer has been in the UV business for a long time. § Fewest number of lamps. § Mechanical and chemical cleaning. § Low energy usage.	§ Requires lowering channel floors. § Proprietary lamp sourcing; only manufacturer to use 1,000-W lamps. § Utilizes hydraulic system for sleeve cleaning. § Relatively new system (inclined arrangement).
D2	UV Disinfection (WEDECO-Xylem)	$1,535,000[2]	§ Manufacturer has been in the UV business for a long time. § Only minor channel modifications required. § Mechanical cleaning. § Low energy usage.	§ Relatively new system (inclined arrangement).
D3	UV Disinfection (Suez Treatment Solutions)	$1,400,000[2]	§ Manufacturer has been in the UV business for a long time. § Highest number of installations. § Only minor channel modifications required. § Mechanical cleaning. § Longest lamp warranty.	§ Potential electrical and cleaning system problems on past installations. § Higher energy usage.
D4	UV Disinfection (Glasco UV)	$1,700,000[2]	§ Only minor channel modifications required. § Mechanical cleaning.	§ Limited installations at large WWTPs. § Highest energy usage.
D5	Ozone Disinfection (Suez)	$7,250,000[2]	§ Efficient disinfectant. § Removes color from effluent. § Adds DO to effluent.	§ Requires contact basin. § Limited WWTP applications. § More complicated system compared to UV. § High equipment costs.
D6	Peracetic Acid Disinfection (Peroxychem)	$610,000[3]	§ Relatively low costs for equipment and tanks.	§ Requires contact basin. § Limited WWTP applications. § Regulatory hurdles. § Requires pilot testing. § Adds some BOD to effluent.
D7	Refurbish Existing UV System (IronbrookUV)	$1,010,000[4]	§ Staff familiar with existing system. § Lower capital costs. § Longest lamp warranty.	§ Availability of replacement parts may be an issue in the future, especially if IronbrookUV would close. § Difficult to expand beyond 140 mgd. § Older UV technology.

[1]100 mgd design flow.

[2]Includes only equipment costs. Installation, electrical, and structural costs not included.

[3]Costs are for installed equipment, bulk tanks, and piping. Also requires 5-year contract to purchase chemical at $0.78/lb PAA. Costs to not include building modifications, contact tank, piping, and related infrastructure.

[4]Installation included. Electrical, PLC, and gate costs not included.

Based on the summary provided in Table 2, as well as the discussion at the disinfection workshop, the following alternatives were short-listed and will be considered in detail in the next section.

- Alternative D0–Maintain Existing System (Null Alternative)
- Alternative D1–UV Disinfection (Trojan Technologies)
- Alternative D2–UV Disinfection (WEDECO-Xylem)
- Alternative D7–Refurbish Existing UV System (IronbrookUV)

The other four alternatives were eliminated from further consideration for the following reasons:

- Alternative D3 and D4–Vertical UV Systems: These systems were similar to each other and both had higher energy usage than both the existing UV system as well as the other UV disinfection systems being considered. Equipment capital costs were similar or higher than the other systems, and there were no nonmonetary considerations that were a driver towards investigating these systems further.

- Alternative D5–Ozone Disinfection: This system has considerably higher equipment and total system costs than the other technologies, and operating costs are expected to be the highest as well. There were no nonmonetary considerations that indicated this technology should be further evaluated.

- Alternative D6–Peracetic Acid Disinfection: This technology is being considered mainly in wet-weather treatment applications or at plants that would like to replace chlorine-based disinfection. The potential regulatory hurdles are a concern, and the fact that this chemical adds BOD (1.8 to 2.5 mg/L of BOD per mg/L of peracetic acid) to the plant discharge is an additional concern. If disinfection of lagoon overflow to Nine Springs Creek is needed in the future, peracetic acid may be a reasonable technology to consider in lieu of chlorine-based systems.

DETAILED EVALUATION OF ALTERNATIVES

This section includes a more detailed evaluation of each of the short-listed disinfection alternatives. Capital and O&M costs are developed and summarized, as are noneconominc benefits and challenges of each technology. A summary table showing comparison of the total present worth values of the four alternatives is included at the end of this section, and more detailed cost opinions and breakdowns are included in the Appendix.

O&M costs include power, lamp replacement, labor, and miscellaneous parts. Power use and lamp replacement costs were based on information provided by the manufacturers for new systems, or by the District for the existing F&P system. Labor and miscellaneous maintenance costs were provided by the District for the existing system and comparable costs for the other alternatives were estimated. Power costs are based on a value $0.086/kWH, which was developed by the District as the average power costs over the past 12 months. Present worth values include initial capital, future capital, annual O&M, and salvage value where appropriate. The discount rate used for the 20-year present worth analyses is 4.375 percent based as required by the Wisconsin Department of Natural Resources.

A. Alternative D0–Maintain Existing F&P UV System (Null Alternative)

1. Description of Alternative and Opinion of Cost

Alternative D0 would maintain the existing UV disinfection system without expanding the system or replacing equipment. Figure 1 shows an existing UV bank and control panel. Since the equipment is no longer manufactured, parts must be obtained through a third-party vendor. In addition, the control boards are currently supplied by third-party vendors. The ability to maintain a reliable supply of replacement parts and control boards may be limited in the future. This alternative also does not include expanding the system capacity beyond 100 mgd.

Figure 1 Existing UV Bank and Control Panel

Table 3 shows the annual operation and maintenance (O&M) costs for Alternative D0. Lamp replacement costs were based on year 2015 costs provided by the District and inflated by 5 percent. Labor and miscellaneous costs were based on the average costs from 2011 through 2015 provided by the District and inflated by 100 percent to account for the extended age of the system.

It was noted previously that the existing system is operating at or beyond the normal useful service life of UV technology. We recommend planning to replace or significantly refurbish the UV system within the next 10 years to avoid a catastrophic system failure, as well as to safeguard against reliance on third-party vendors selling replacement parts for systems that are no longer manufactured. The need for such parts will reduce over time as the F&P systems installed in the 1990s are taken out of service, and at some point availability of parts will become critical. Therefore, we have assumed that the system will need to be replaced and/or refurbished within 10 years to avoid a failure.

Table 3 Alternative D0–Existing F&P System Costs

Category	Annual O&M Costs
Power	$39,300[1]
Lamp Replacement	$13,200
Labor	$21,200
Misc. Maintenance	$32,200
Total Annual O&M Costs[1]	**$106,000**
Future Equipment Replacement Costs[2]	**$2,153,000**

[1]Until replacement of the system occurs. After that annual O&M costs would be similar to alternative D7.
[2]Assumes refurbishment with IronbrookUV components in year 10 as described for Alternative D7.

2. Noneconomic Considerations

Alternative D0 maintains the existing system. Noneconomic considerations for this alternative are listed below.

a. Benefits

§ District staff is familiar with system and equipment.

b. Limitations

§ Since this original equipment is no longer manufactured, replacement parts must be obtained through third-party vendors.

§ Replacement control boards must be obtained from third-party vendors.

§ The system is more than 20 years old now and is operating at or beyond its anticipated useful service life. This system will likely require more maintenance and attention over time than a new system would require.

§ Future availability of replacement parts may be diminished as other F&P installations are replaced. This is a critical consideration and could result in a loss of parts availability over a relatively short period of time, especially if IronbrookUV would cease operations.

§ Because of the number of lamps and associated head loss, capacity beyond 140 mgd is not possible without changing the system hydraulics and layout.

§ Existing flow control gates do not operate properly at high flows because of high water level in the downstream UV effluent channel.

§ Level control in the UV channels is more critical with horizontal UV lamps, which likely requires the continued use of the weighted level control gates. Continued evaluation of downward opening weir gates should be considered when this system is replaced.

B. <u>Alternative D1–UV Disinfection (Trojan Technologies)</u>

1. Description of Alternative and Opinion of Cost

Alternative D1 would replace the existing UV system with the Trojan Technologies Signa UV system. Figure 2 shows a Signa UV bank tilted out of a channel for inspection and maintenance. Figure 3 shows the proposed layout of the three Signa UV banks in a NSWWTP channel. As noted above, Trojan Technologies' design for the 100-mgd system would require 3 channels with 3 UV banks per channel.

Figure 2 Trojan Technologies Signa UV Bank

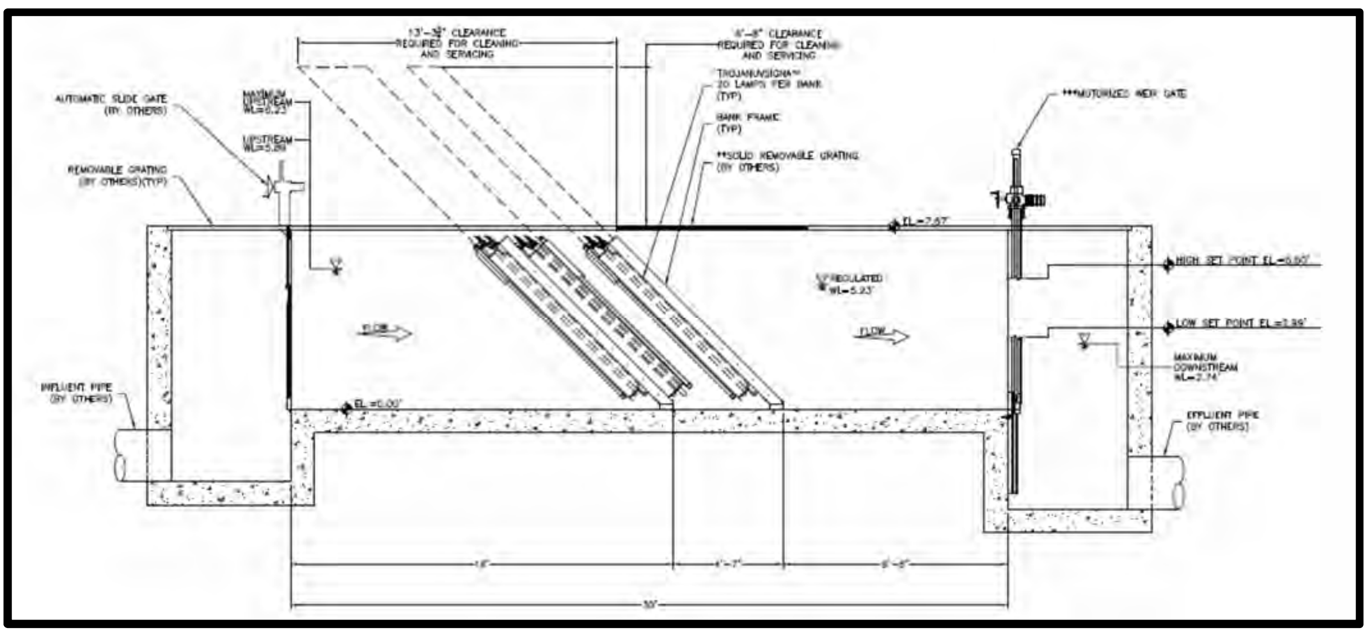

Figure 3 Trojan Technologies Proposed Layout

The lamps are 1,000-watt lamps provided only by Trojan Technologies or its equipment representatives. Trojan offers a 15,000-hour prorated warranty on each lamp. The lamps are 100 percent replaced up to 9,000 hours: the warranty is prorated from 9,000 to 15,000 hours.

Table 4 shows the opinion of capital and annual O&M costs for Alternative D1. A detailed breakdown in both capital and O&M costs is included in the Appendix. The Signa UV system will require the channel bottoms to be lowered by approximately 14 inches because of the longer bulbs and taller overall height of the equipment. Raising the channel walls to provide the additional 14 inches of depth would not be feasible because of the upstream hydraulic control requirements. In addition to the equipment and structural costs to lower the channels, additional costs include new aluminum checker plate to cover the channels.

Table 4 Alternative D1–Opinion of Capital and Annual O&M Costs

	Alternative D1
Total Opinion of Capital Costs	$3,593,000
Power	26,200
Lamp Replacement	12,100
Labor	5,300
Misc. Maintenance	7,600
Total Annual O&M Costs	$52,000

2. Noneconomic Considerations

Noneconomic considerations are listed below.

a. Benefits

- Proven technology developed by a world leader in UV system technology.
- Fewest number of lamps of all alternatives.
- Fewest number of channels required (3), which would allow the system to be expanded easily to 180 mgd.
- System includes both mechanical and chemical cleaning.
- Most installations greater than 50 mgd of the short-listed alternatives.
- Angled bulb arrangement requires less stringent flow control and provides the ability to replace the weighted gates with downward opening weir gates for level control.

b. Limitations

- § Requires channels to be lowered to accommodate the equipment.
- § Utilizes 1,000-watt bulbs that must be purchased from Trojan currently; this could change in the future if 1,000-watt bulbs become more common. Guaranteed lamp pricing would need to be established.
- § Utilizes hydraulic system for sleeve cleaning that adds complexity and potential maintenance issues to system.

C. Alternative D2–UV Disinfection (WEDECO-Xylem)

1. Description of Alternative and Opinion of Cost

Alternative D2 would replace the existing UV system with the Duron UV system manufactured by WEDECO-Xylem. Figure 4 shows Duron UV banks both in and out of channels. Figure 5 shows the proposed layout the Duron UV system at NSWWTP. As noted above, WEDECO-Xylem's design for the 100 mgd system would require five channels with three UV banks per channel.

Figure 4 WEDECO-Xylem Duron UV System

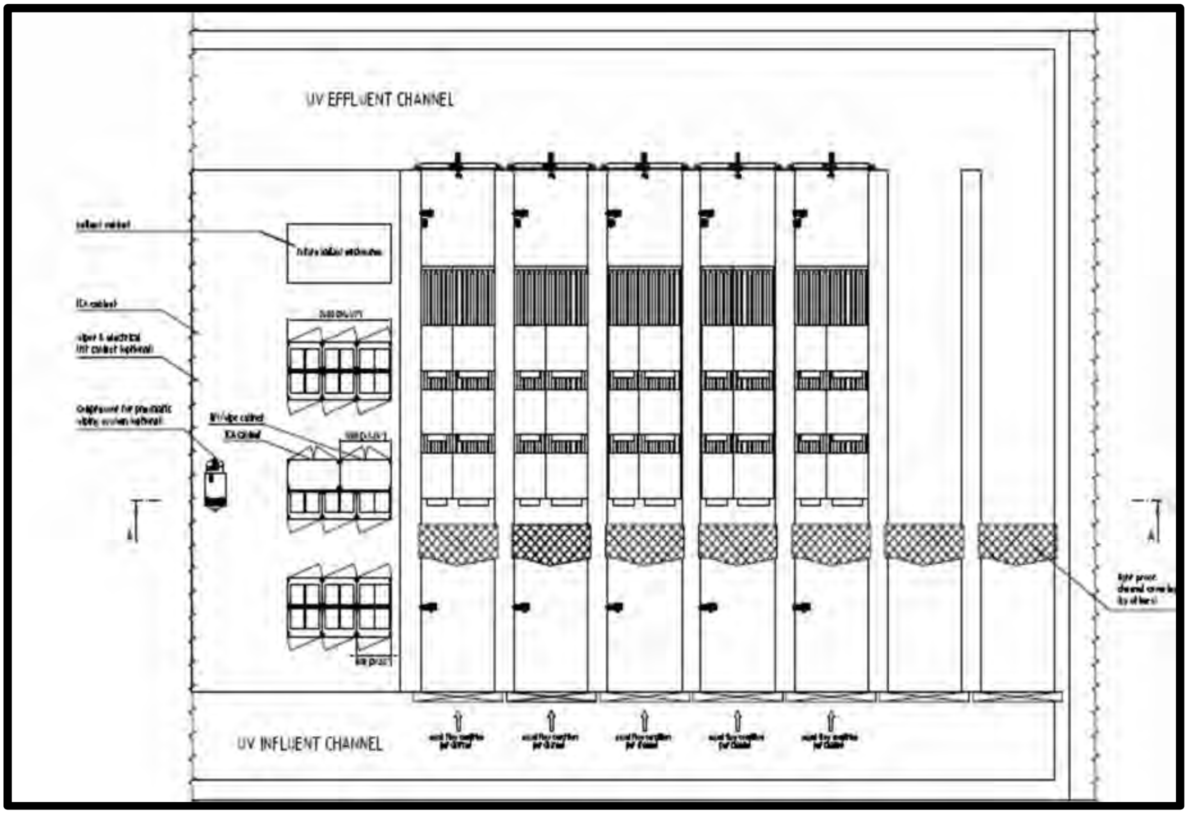

Figure 5 WEDECO-Xylem Proposed Layout

The lamps are 600 Watt lamps provided by WEDECO and other equipment vendors. WEDECO offers a 14,000 hour prorated warranty on each lamp. The lamps are 100 percent replaced up to 9,000 hours: the warranty is prorated from 9,000 to 14,000 hours.

Table 5 shows the opinion of capital and annual O&M costs for Alternative D2. A detailed breakdown in both capital and O&M costs is included in the Appendix. The Duron banks will fit in the existing channels and only require the channels to be narrowed by approximately 2.25 inches. In addition to the equipment costs, additional costs include new aluminum checker plate to cover the channels and the cost to grout the channel walls.

Table 5 Alternative D2–Opinion of Capital and Annual O&M Costs

	Alternative D2
Total Opinion of Capital Costs	$3,797,000
Power	25,700
Lamp Replacement	12,800
Labor	5,300
Misc. Maintenance	10,400
Total Annual O&M Costs	$55,000

2. Noneconomic Considerations

Noneconomic considerations are listed below.

a. Benefits

§ Proven technology developed by a world leader in UV system technology.

§ Does not require channels to be lowered; simpler retrofit than Alternative D1.

§ System includes mechanical cleaning.

§ Angled bulb arrangement requires less stringent flow control and provides the ability to replace the weighted gates with downward opening weir gates for level control.

b. Limitations

§ None identified.

D. Alternative D7–Refurbish Existing UV System (IronbrookUV)

1. Description of Alternative and Opinion of Cost

Alternative D7 includes refurbishing the existing UV system with similar equipment provided by IronbrookUV. The refurbishment would include replacing control boards, ballasts, breakers, transformer, cables, UV intensity monitors, lamps and sleeves, among other items. The lamp racks would also be refurbished. Several F&P systems have been similarly refurbished by IronbrookUV in recent years, including the systems installed at the Glenbard Wastewater Authority in Illinois (16 mgd average, 47 mgd peak) and the San Bernardino facility in California (33 mgd peak capacity). This alternative does not include expanding the system beyond the existing five channels, although expanding into the two empty channels would bring total system capacity up to approximately 140 mgd.

Table 6 shows the opinion of probable capital and O&M costs for this alternative. A detailed breakdown in both capital and O&M costs is included in the Appendix. Costs for equipment upgrades were provided by IronbrookUV and include removal and installation. In addition to the equipment costs, the costs include replacement of the existing flow control gates with new downward opening weir gates. Confirmation of this style of level control for a refurbished horizontal UV system is pending at this time. If new weir gates are not sufficient for level control, then new weighted effluent gates would be included.

Table 6 Alternative D7 Opinion of Capital and Annual O&M Costs

	Alternative D7
Total Opinion of Capital Costs	2,153,000
Power	36,000
Lamp Replacement	13,200
Labor	8,000
Misc. Maintenance	12,100
Total Annual O&M Costs	$70,000

2. Noneconomic Considerations

Noneconomic considerations are listed below.

a. Benefits

§ District staff is familiar with system and equipment.

b. Limitations

§ Future availability of replacement parts may be diminished as other F&P installations are replaced. This is a critical consideration and could result in a loss of parts availability over a relatively short period of time, especially if IronbrookUV would cease operations.

§ Because of the number of lamps and associated head loss, capacity beyond 140 mgd is not possible without changing the system hydraulics and layout.

§ Older UV technology.

§ Minimal energy savings are anticipated.

§ Existing flow control gates do not operate properly at high flows because of high water level in the downstream UV effluent channel.

§ Level control in the UV channels is more critical with horizontal UV lamps, which likely requires the continued use of the weighted level control gates. Evaluation of downward opening weir gates or new weighted gates could be considered if this alternative is selected. Capital costs include replacement of the existing weighted gates.

PRESENT WORTH SUMMARY

Table 7 provides a summary of the opinion of present worth values for the four alternatives. A detailed breakdown in present worth costs is included in the Appendix. Capital costs for all projects, except for the null alternative (D0), were assumed to be incurred at the beginning of a 20-year planning period to replace the existing UV system. The Appendix includes a breakdown of O&M costs associated with each alternative, including the assumptions or data used to develop the O&M costs.

For Alternative D0, we have assumed the system would be replaced in year 10 of the 20-year planning period. Given the critical nature of the effluent disinfection system to the environmental mission of the District, we do not recommend considering any alternative that does not replace the significant components of the system within the next 10 years. While the system remains functional, the main components have been in operation for 20 years, and we expect the system components to begin failing at a faster rate in the future.

Table 7 Opinion of Present Worth Summary

	Alternative D0 Existing F&P	Alternative D1 Trojan	Alternative D2 WEDECO	Alternative D7 IronbrookUV
Total Opinion of Capital Cost	$0	$3,593,000	$3,797,000	$2,153,000
Annual O&M	$70,000-106,000[1]	$52,000	$55,000	$70,000
Present Worth				
O&M	$1,207,000	$684,000	$723,000	$920,000
Replacement	$1,403,000[2]	$0	$0	$0
Salvage	($276,000)[3]			
Total Opinion of Present Worth	**$2,334,000**	**$4,277,000**	**$4,520,000**	**$3,073,000**

[1] $70,000/year is for years 11–20; $106,000 is for years 1–10.
[2] Capital cost for Alt. D7 assumed in year 10, brought back to the present.
[3] Salvage costs assume 50 percent of system life remaining at year 20, which is 10 years after replacement.

Alternatives D0 and D7, both of which include the refurbishment of the existing F&P system, have a lower overall present worth cost than the other two alternatives, mainly because of the significantly lower initial and future system installation costs for the IronbrookUV equipment. The IronbrookUV upgrades would continue to utilize many of the existing components, which helps reduce costs. The Trojan and WEDECO alternatives have lower annual O&M opinions of cost, which is mainly because of higher energy efficiency and reduced maintenance associated with the significantly fewer bulbs, ballasts, and associated systems.

For the purpose of this planning level evaluation, Alternatives D1 and D2 have approximately equal present worth costs, since the total present worth costs are within 10 percent of each other.

RECOMMENDATIONS

The recommended alternative for long-term disinfection at the NSWWTP is Alternative D1 or D2, which include a new UV system using the latest in UV disinfection technology. While these alternatives have a higher present worth than Alternatives D0 and D7, we believe the newer technology offers many advantages as described below.

- These systems provide improved electrical efficiency.
- These systems provide improved maintainability, which results from having only 10 to 15 percent of the bulbs of the IronbrookUV system as well as an easily removable bulb rack that does not require physical lifting of the bulb racks.
- These alternatives provide lower risk associated with the older UV technology not being supported throughout the useful service life of the equipment. Alternatives D1 and D2 represent the two largest wastewater UV system suppliers in the world, and there is a greater likelihood that these systems will be manufactured and supported for the foreseeable future compared to the IronbrookUV system. Similarly, if IronbrookUV were to cease operations, the District may find supply of replacement parts very limited within a short period of time.
- As with any item that is improved over time, having the most recent technology may allow it to be upgraded more readily as the systems continue to improve. Outdated technology typically does not accommodate such changes as readily.

If this project proceeds within the next 1 to 3 years, the evaluations included herein should provide the required level of detail needed to move into design of the system. However, if there is a delay of several years before implementation, the District may wish to revisit these evaluations to consider potential new technologies that are brought to market between now and then.

When this UV replacement project proceeds to implementation, and assuming Alternatives D1 and D2 are selected, the District may wish to design around both systems and bid them as alternates. The engineering effort associated with the channel modifications for the Trojan system (Alterative D1) is relatively minor. Including both of these UV manufacturers in the design would provide a competitive bid for the District.

APPENDIX
COST OPINIONS

Madison Metropolitan Sewerage District
2016 Liquid Processing Facilities Plan
Opinion of Present Worth Cost **Discount Rate** 4.375%

TM7 - Disinfection
Alternative D0-Null Alternative

ITEM	Initial Capital Cost	Future Capital Cost	Replacement Year	Replacement Cost (P.W.)	20-Year Salvage Value	Salvage Value (P.W.)
Equipment Costs		$ 1,010,000	10	$ 658,000	$ 505,000	$ 214,000
Structural Modifications (gates)		$ 90,000	10	$ 59,000	$ 45,000	$ 19,000
	$ -			$ -	$ -	$ -
Subtotal	$ -	$ 1,100,000		$ 717,000	$ 550,000	$ 233,000
Electrical and Controls	$ -	$ 204,000	10	$ 133,000	$ 102,000	$ 43,000
Subtotal	$ -	$ 1,304,000		$ 850,000	$ 652,000	$ 276,000
Contractor GCs (10%)	$ -	$ 131,000	10	$ 85,000		
Total Construction Costs	$ -	$ 1,435,000	10	$ 935,000		
Contingencies and Engineering Services (50%)	$ -	$ 718,000	10	$ 468,000		
Total Capital Costs	$ -	$ 2,153,000		$ 1,403,000	$ 652,000	$ 276,000
Present Worth	**$ -**			$ 1,403,000		$ 276,000

Annual O&M (First 10 years)	**$ 106,000**
Annual O&M (Next 10 years)	**$ 70,000**
Present Worth of O&M	**$ 1,207,000**

Summary of Present Worth Costs

Capital Cost	$ -
Replacement	$ 1,403,000
O&M Cost	$ 1,207,000
Salvage Value	$ (276,000)
Total Present Worth	**$ 2,334,000**

Note: Costs are November 2016 basis.

Madison Metropolitan Sewerage District
2016 Liquid Processing Facilities Plan
Opinion of Present Worth Cost **Discount Rate** 4.375%

TM7 - Disinfection
Alternative D1-Trojan Technologies UV

ITEM	Initial Capital Cost	Future Capital Cost	Replacement Year	Replacement Cost (P.W.)	20-Year Salvage Value	Salvage Value (P.W.)
Equipment Costs	$ 1,599,000	$ -	20	$ -	$ -	$ -
Demolition	$ 50,000	$ -	20	$ -	$ -	$ -
Structural Modifications	$ 293,000	$ -	20	$ -	$ -	$ -
Subtotal	$ 1,942,000	$ -				
Electrical and Controls	$ 204,000	$ -	20	$ -	$ -	$ -
Subtotal	$ 2,146,000					
Contractor GCs (10%)	$ 215,000					
Total Construction Costs	$ 2,361,000					
Contingencies and Engineering Services (50%)	$ 1,232,000					
Total Capital Costs	$ 3,593,000			$ -	$ -	$ -
Present Worth	**$ 3,593,000**			$ -		$ -
O&M Costs (See O&M Costs Table for Detail)	**$ 52,000**					
Present Worth of O&M	**$ 684,000**					

Summary of Present Worth Costs

Capital Cost	$ 3,593,000
Replacement	$ -
O&M Cost	$ 684,000
Salvage Value	$ -
Total Present Worth	**$ 4,277,000**

Note: Costs are November 2016 basis.

Madison Metropolitan Sewerage District
2016 Liquid Processing Facilities Plan
Opinion of Present Worth Cost **Discount Rate** 4.375%

TM7 - Disinfection
Alternative D2-WEDECO-Xylem UV

ITEM	**Initial Capital Cost**	**Future Capital Cost**	**Replacement Year**	**Replacement Cost (P.W.)**	**20-Year Salvage Value**	**Salvage Value (P.W.)**
Equipment Costs	$ 2,002,000	$ -	20	$ -	$ -	$ -
Demolition	$ 20,000	$ -	20	$ -	$ -	$ -
Structural Modifications	$ 105,000	$ -	20	$ -	$ -	$ -
Subtotal	$ 2,127,000	$ -				
Electrical and Controls	$ 204,000	$ -	20	$ -	$ -	$ -
Subtotal	$ 2,331,000					
Contractor GCs (10%)	$ 234,000					
Total Construction Costs	$ 2,565,000					
Contingencies and Engineering Services (50%)	$ 1,232,000					
Total Capital Costs	$ 3,797,000			$ -	$ -	$ -
Present Worth	**$ 3,797,000**			$ -		$ -
O&M Costs (See O&M Costs Table for Detail)	**$ 55,000**					
Present Worth of O&M	**$ 723,000**					

Summary of Present Worth Costs

Capital Cost	$ 3,797,000
Replacement	$ -
O&M Cost	$ 723,000
Salvage Value	$ -
Total Present Worth	**$ 4,520,000**

Note: Costs are November 2016 basis.

2016 Liquid Processing Facilities Plan
Opinion of Present Worth Cost **Discount Rate** 4.375%

TM7 - Disinfection
Alternative D7-Refurbish Existing Equipment -IronbrookUV

ITEM	Initial Capital Cost	Future Capital Cost	Replacement Year	Replacement	20-Year Salvage Value	Salvage Value (P.W.)
Equipment Costs	$ 1,010,000	$ -	20	$ -	$ -	$ -
Structural Modifications (gates)	$ 90,000	$ -	20	$ -		$ -
Subtotal	$ 1,100,000	$ -				
Electrical and Controls	$ 204,000	$ -	20	$ -	$ -	$ -
Subtotal	$ 1,304,000					
Contractor GCs (10%)	$ 131,000					
Total Construction Costs	$ 1,435,000					
Contingencies and Engineering Services (50%)	$ 718,000					
Total Capital Costs	$ 2,153,000			$ -	$ -	$ -
Present Worth	**$ 2,153,000**			$ -		$ -
O&M Costs (See O&M Costs Table for Detail)	**$ 70,000**					
Present Worth of O&M	**$ 920,000**					

Summary of Present Worth Costs

Capital Cost	$ 2,153,000
Replacement	$ -
O&M Cost	$ 920,000
Salvage Value	$ -
Total Present Worth	**$ 3,073,000**

Note: Costs are November 2016 basis.

Madison Metropolitan Sewerage District
2016 Liquid Processing Facilities Plan
Opinion of Present Worth Cost

TM7 - Disinfection
O&M Cost Summary

Null Alternative

D0 - Existing F&P System

Equipment	Annual O&M Cost	Electric Costs/Yr	kwh/year	Hr Op/Yr	Elec. Cost ($/kWH)	Materials	Comments
Power Costs	$ 39,300	$ 39,307	457,056	4,416	0.086		Power costs based on ~2300 kWH/day from 2013 Energy Roadmap Study, and increased 8 percent to account for higher flows through 10 years.
Lamp Replacement	$ 13,200					$ 13,200	Lamp replacement costs based on 2015 costs provided by MMSD and inflated by 5%.
Labor	$ 21,230						Labor costs based on average of 2011-2015 labor costs provided by MMSD and increased by 100% because of the age of the system.
Misc. Maintenance	$ 32,200					$ 32,200	Materials costs based on average of 2011-2015 costs provided by MMSD and increased by 100% based on the age of the system.
Total Annual O&M (First 10 Years)	$ 106,000						

Trojan UV Disinfection

D1 - Trojan Inclined

Equipment	Annual O&M Cost	Electric Costs/Yr	kwh/year	Hr Op/Yr	Elec. Cost ($/kWH)	Materials	Comments
Power Costs	$ 26,200	$ 26,166	304,260	4,416	0.086		Average of power consumption calculated by Trojan for 40 mgd and 53 mgd.
Lamp Replacement	$ 12,100					$ 12,100	Average of lamp replacement costs provided by Trojan at 40 mgd and 53 mgd.
Labor	$ 5,300						Assumes 50% of current average
Misc. Maintenance	$ 7,600					$ 7,640	Assumes 0.5% of installed equipment costs (materials only)
Total Annual O&M	$ 52,000						

WEDECO UV Disinfection

D2 - Wedeco Inclined

Equipment	Annual O&M Cost	Electric Costs/Yr	kwh/year	Hr Op/Yr	Elec. Cost ($/kWH)	Materials	Comments
Power Costs	$ 25,700	$ 25,723	299,104	4,416	0.086		Average of power consumption calculated by WEDECO for 40 mgd and 53 mgd.
Lamp Replacement	$ 12,810					$ 12,810	Average of lamp replacement costs provided by WEDECO at 40 mgd and 53 mgd.
Labor	$ 5,300						Assumes 50% of current average
Misc. Maintenance	$ 10,400					$ 10,360	Assumes 0.5% of installed equipment costs (materials only)
Total Annual O&M	$ 55,000						

Refurbish existing-IronbrookUV

D7 - Ironbrook UV

Equipment	Annual O&M Cost	Electric Costs/Yr	kwh/year	Hr Op/Yr	Elec. Cost ($/kWH)	Materials	Comments
Power Costs	$ 36,000	$ 36,000	412,000	4,416	0.086		Assumes 10% less than existing (improved efficiency)
Lamp Replacement	$ 13,200					$ 6,880	Assumed same as existing Alt. D0
Labor	$ 8,000						Labor costs based on 75% of average of 2011-2015 labor costs provided by MMSD.
Misc. Maintenance	$ 12,100					$ 12,075	Assumed 75% of existing average costs (materials only)
Total Annual O&M	$ 70,000						

APPENDIX H–TECHNICAL MEMORANDUM NO. 8
ELECTRICAL IMPROVEMENTS

Technical Memorandum No. 8 for the

Madison Metropolitan Sewerage District, Madison, Wisconsin

Electrical Improvements
2016 Liquid Processing Facilities Plan

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STRAND ASSOCIATES®

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INTRODUCTION TO ELECTRICAL IMPROVEMENT ALTERNATIVES

One of the objectives of this 2016 Liquid Processing Facilities Plan is to evaluate electrical improvement alternatives for the Madison Metropolitan Sewerage District (District) Nine Springs Wastewater Treatment Plant (NSWWTP). This memorandum includes a summary of the existing Headworks facility power distribution system, Blower Building controls and medium-voltage switchgear, existing unit substations U11, U12, and U13, an evaluation of indoor versus outdoor unit substation transformers, and a detailed discussion of the short-listed alternatives with opinions of probable construction cost and nonmonetary considerations.

DESCRIPTION OF THE EXISTING HEADWORKS FACILITY POWER DISTRIBUTION SYSTEM

The existing Headworks facility has two 480-volt motor control centers (MCCs), MCC-HF1 and MCC-HF2. Each MCC has a 1,000-amp main circuit breaker and the two MCC busses are interconnected with a 1,000-amp tie circuit breaker. Each MCC houses several motor starters and branch circuit breakers serving the various facility electrical loads. The MCCs are each fed with a 480-volt, 1,000-amp feeder from unit substation U15, which is fed with redundant 4.16-kV power feeds from main switchgear S1. The main unit substation that feeds the main switchgear is fed with redundant 13.8-kV utility power feeds from the Madison Gas & Electric (MG&E) Nine Springs Unit Substation located adjacent to the northwest corner of the NSWWTP.

Kirk Key interlocks are installed on the MCC main and tie circuit breakers to protect against a parallel connection between the two unit substation U15 feeders wired to each main breaker because each feed from unit substation U15 is able to be sourced from different step-down transformers at unit substation U15. District staff use kirk keys to manually open and close the main and tie circuit breakers to select which MCC busses are powered by each unit substation U15 feeder.

Over the past 20 years, NSWWTP experienced a single power outage event that resulted in a sustained loss of power at the Headworks facility, which lasted approximately 45 minutes on June 14, 2005. Continuous operation of the influent screens at the Headworks facility is critical to NSWWTP operations, and an outage lasting more than 5 minutes during high-flow events would likely cause the influent wastewater channel to flood resulting in unscreened wastewater bypassing the screens. If influent wastewater bypasses the screens, the downstream wastewater treatment processes are subject to potential solids plugging, and the resulting maintenance requirements could be significant. Specific concerns have been noted with the digestion heating system steam injectors, which are susceptible to solids plugging, as well as the potential to impact the District's Class A biosolids product if objectionable materials from screening bypasses are found in the biosolids project.

The partial electrical one-line diagram in Figure 1 shows redundant power feeds to the Headworks facility MCCs, whose power is ultimately sourced from the MG&E Nine Springs Unit Substation. The Nine Springs Unit Substation has an on-site generator able to provide backup power during a regional utility power outage; however, MG&E requires at least 2 to 3 hours to bring the generator online.

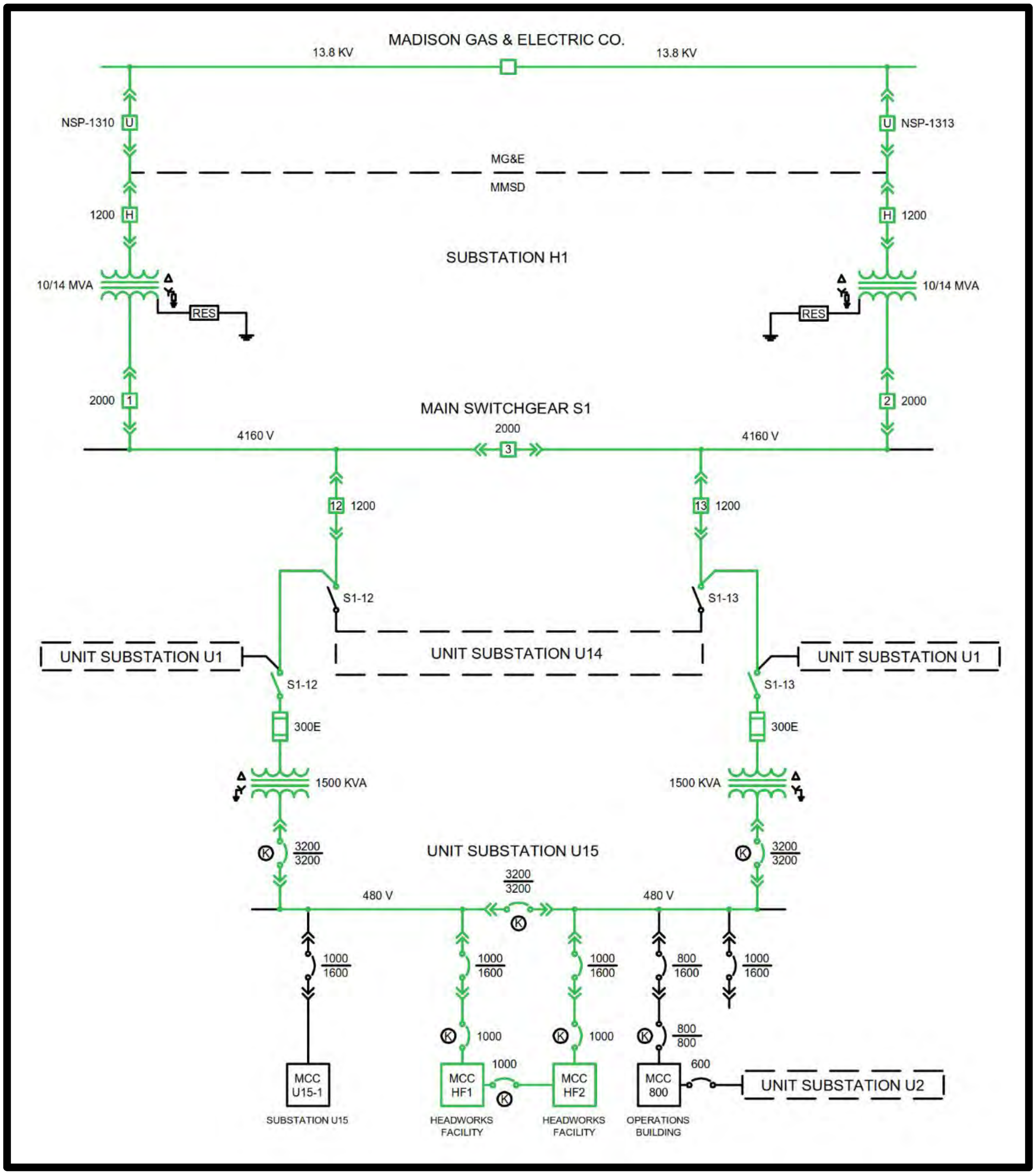

Figure 1–Partial One-Line Diagram–Headworks MCC Feeders

HEADWORKS FACILITY BACKUP POWER ALTERNATIVES IDENTIFICATION

Workshop No. 8 was held on February 6, 2017, at NSWWTP to discuss the plant's electrical reliability concerns, potential alternatives, and related information. The purpose of the workshop was to present a list of electrical alternatives, including alternatives for a backup power supply to the Headworks facility, and screen the alternatives down to a shorter list to evaluate in detail. A brief description of each of the alternatives presented at this workshop related to the Headworks facility backup power is presented in this section. A discussion of the other electrical alternatives will be included later in this memorandum.

This section presents a brief summary of the list of Headworks Facility Backup Power Supply Alternatives discussed at Workshop. No. 8.

A. Alternative HBP No. 0–No Change (Null Alternative)

This alternative would continue to power the Headworks facility with redundant power feeders from unit substation U15.

The Operations facility would continue to be powered with redundant feeders from unit substations U15 and U2.

A loss of power from both the redundant power feeds to any piece of equipment in the distribution chain back to main switchgear S1 or a loss of power from the redundant utility feeds would result in a power outage at the Headworks facility exceeding the 5 to 15-minute time it would take for influent wastewater to bypass screening equipment.

B. Alternative HBP No. 1–Stationary Diesel Generator for Headworks Facility

This alternative would provide a stationary diesel generator dedicated to powering the Headworks facility during a power outage. The main and tie circuit breakers in the Headworks facility MCCs would be replaced with electrically-controlled circuit breakers, a new electrically-controlled generator circuit breaker would be installed, and the generator control system would automatically start the generator and transfer power to the Headworks facility MCCs after a power outage event.

C. Alternative HBP No. 2–Stationary Natural Gas Generator for Headworks Facility

This alternative would provide a stationary natural gas generator dedicated to powering the Headworks Facility during a power outage. This alternative would also require the use of electrically-controlled circuit breakers in the Headworks facility MCCs, but it would eliminate the need for on-site fuel storage. However, natural gas generators are significantly more expensive than diesel generators at the size required to power the Headworks facility’s current and future electrical load, approximately 300 kilowatts (kW).

D. Alternative HBP No. 3–Portable Diesel Generator for Headworks Facility

This alternative would provide a portable diesel generator that could power the Headworks facility during a power outage or be transported to other facilities to supply emergency power, as needed. This alternative would also require the use of electrically-controlled circuit breakers in the Headworks facility MCCs. In the future, if a backup power generation system is no longer required at the Headworks facility, the District would have more opportunities to reuse a portable generator at other facilities like remote pumping stations.

Portable generators are subject to Tier 4 emissions filtering regulations and require disconnect interfaces for power and control wiring. Portable Tier 4-rated diesel generators at the size required to power the Headworks facility’s current and future electrical load, approximately 300kW, typically cost about twice as much as a stationary Tier 3-rated stationary diesel generators.

E. Alternative HBP No. 4–Stationary Diesel Generator for Headworks and Operations Facilities

This alternative would provide a stationary diesel generator dedicated to powering both the Headworks facility and a portion of the Operations facility during a power outage. The new Maintenance facility has sufficient backup battery power to allow District staff to monitor the Supervisory Control and Data Acquisition (SCADA) System when the Operations facility loses power. However, radio systems communicating with remote lift stations all connect back into the SCADA System through the Operations facility, so additional backup power at the Operations facility could improve SCADA System functionality during an extended power outage.

This alternative would increase project costs due to of the larger generator and fuel tank required to power both facilities, and the extra set of power and control conductors required to be routed from the generator to the Operations facility. In addition to new electrically-controlled circuit breakers needing to be installed in the Headworks facility MCC, an automatic transfer switch at the Operations facility and more complex controls would be required to allow the generator to power either one of the facilities if only one facility loses power, or both of the facilities during a NSWWTP-wide outage.

F. Alternative HBP No. 5–Stationary Natural Gas Generator for Headworks and Operations Facilities

This alternative would provide a stationary natural gas generator dedicated to powering both the Headworks facility and a portion of the Operations facility during a power outage. In addition to the larger generator, automatic transfer switch, additional wiring, and more complex controls, this alternative would be more expensive than Alternative HBP No. 4 because natural gas generators become significantly more expensive than diesel generators at the power rating required to power both facilities, approximately 350kW.

SCREENING OF ALTERNATIVES

Based on discussions at Workshop No. 8, the following three alternatives were short-listed and will be evaluated in detail:

- Alternative HBP No. 0–No Change (Null Alternative)
- Alternative HBP No. 1–Stationary Diesel Generator for Headworks Facility
- Alternative HBP No. 2–Stationary Natural Gas Generator for Headworks Facility

The other three alternatives were eliminated from further consideration for the following reasons:

- Alternative HBP No. 3–Portable Diesel Generator for Headworks Facility: A portable generator is considerably more expensive than a stationary generator. In addition, if the goal is to provide backup power to the Headworks facility during a power outage, it's possible that a portable generator could be in use at another facility when the Headworks facility loses power.
- Alternative HBP No. 4–Stationary Diesel Generator for Headworks and Operations Facilities: District staff agreed that the existing Operations facility's SCADA System uninterruptible power supply (UPS) batteries are adequately sized to provide backup power for approximately 70 minutes. UPS battery capacity can be expanded if future SCADA System electrical loads increase.

§ Alternative HBP No. 5–Stationary Natural Gas Generator for Headworks and Operations Facilities: District staff agreed that the existing Operations facility's SCADA System uninterruptible power supply (UPS) batteries are adequately sized to provide backup power for approximately 70 minutes. UPS battery capacity can be expanded if future SCADA System electrical loads increase.

DETAILED EVALUATION OF ALTERNATIVES

This section includes a detailed evaluation of each short-listed Headworks Facility Backup Power Supply Alternative. Budgetary opinions of probable construction costs, when applicable, and non-monetary benefits and challenges are included and summarized for each alternative.

A. Alternative HBP No. 0–No Change (Null Alternative)

1. Description of Alternative

Alternative HBP No. 0 would maintain the existing redundant power feeds to the Headworks facility MCCs as the only sources of power to the facility. With only a single power outage recorded over the past 20 years lasting about 45 minutes, the electrical utility and distribution system have proven to be robust and reliable. Electrical distribution system equipment is also routinely inspected and serviced to improve reliability. Electrical distribution equipment at the Headworks facility and upstream unit substation (U15) is less than 20 years old, and will not need to be replaced for about another 10 years. However, electrical equipment at the main NSWWTP unit substation (H1) and main switchgear (S1), while still functioning properly, was brought online in 1985 and has been in operation for about 32 years. The expected service life for this type of equipment is 30 years, so the equipment should be considered for replacement in the near future.

If the Headworks facility experiences a power outage event, depending on influent flow rates, it is reasonable to assume that influent wastewater would bypass the mechanical screening equipment if the equipment is not brought back online within about 5 to 15 minutes. However, if the Headworks facility is powered through only one of the main circuit breakers, it is not reasonable to assume that District maintenance staff will be able to troubleshoot a power outage event and adjust unit substation/MCC circuiting within 5 to 15 minutes. It would also take MG&E about 2 to 3 hours to bring the Nine Springs Unit Substation generator online during a regional utility power outage.

Currently, main switchgear S1 in the Effluent Building can automatically switch from a failed utility source to a second available utility source to quickly restore power to the plant during a utility source failure. However, there is a scenario where a failed power feed further downstream in the electrical distribution system could cause an extended outage at the Headworks facility, even if both utility sources are available. If the Headworks facility MCC circuit breakers are configured so that the MCCs are powered through both of the main circuit breaker and the tie circuit breaker is open, then at least one mechanical screen would remain in service if one of the incoming MCC main circuit breaker feeders from unit substation U15 were to fail. However, if both MCCs are being powered through only one of the MCC main circuit breakers and the tie circuit breaker, the entire facility would lose power if the in-service power feed from unit substation U15 fails. The District has been powering both MCCs from a single unit substation U15 incoming power feed since December 2015 and should consider powering the MCCs independently from each of the two incoming power feeds from unit substation U15.

2. Cost Considerations

There are no upfront costs associated with this alternative. The only cost considerations are related to the time required for District maintenance staff to clean downstream processes and the negative cost impact associated with additional debris in the biosolids products. District staff estimates that it would cost at least $1,000 to clean the process equipment if influent wastewater bypasses the mechanical screens. This cost is relatively insignificant compared to the upfront cost required to install a generator to supply backup power to the Headworks facility, as detailed under alternatives HBP No. 1 and HBP No. 2 later in this section.

3. Non-monetary Considerations

a. Benefits

§ The Headworks Facility currently has power distribution system redundancy back to the main NSWWTP unit substation, and most of the equipment is operating within its anticipated service life.

§ There is a limited history of power outages at NSWWTP; only one 45-minute outage over the past 20 years.

§ The MG&E Nine Springs substation has been upgraded to improve reliability since the previously-recorded, 45-minute outage.

b. Limitations

§ It's possible for the Headworks facility MCC circuit breakers to be configured so that the entire facility would lose power if a single incoming power feed from unit substation U15 fails.

§ Electrical equipment at the main NSWWTP unit substation H1 and main switchgear S1 has been operating for about 32 years, which is beyond its expected service life of 30 years.

§ If an outage does occur and the screens are bypassed, there could be a negative impact on downstream processes and the biosolids product.

B. Alternative HBP No. 1–Stationary Diesel Generator for Headworks Facility

1. Description of Alternative

Alternative HBP No. 1 would provide a stationary diesel generator dedicated to powering the Headworks facility during a power outage. The existing main and tie circuit breakers in the Headworks facility MCCs have Kirk Key interlocks and are manually opened or closed by hand. As a result, maintenance staff have to manually configure interlock keys and adjust MCC main and tie circuit breaker positions to select whether the MCCs are fed from one or both of the incoming power feeds from unit substation U15. If both Headworks facility MCCs lose power, District maintenance staff would have to troubleshoot what caused the power outage and adjust breaker positions to repower the MCCs. This would likely take much longer than the 5- to 15-minute window of opportunity to restore power before influent wastewater bypasses the mechanical screens.

A total loss of power to the Headworks facility can be caused by several conditions. The NSWWTP electrical distribution system includes redundant paths to supply power all the way back to the MG&E Nine Springs Substation, so it is unlikely that both power distribution paths would fail. However, a catastrophic event at main unit substation H1, main switchgear S1, or unit substation U15 could result in a total loss of power since the redundant power supply paths are routed through equipment at each of these locations.

A total loss of power at the Headworks facility is more likely to occur due to circuit breakers and switches in the distribution system being configured so that one of the redundant power distribution paths gets cuts off. For example, if main circuit breakers in the Headworks facility MCCs are configured so that only a single power feed from unit substation U15 is powering both MCCs, then the entire facility would lose power if that one power feed fails. A power feeder could fail due to a loss of supply from the electric utility, physical damage to the conductors or distribution equipment, or failed conductor insulation resulting in an arc-fault event due to conductor aging. The same condition could occur upstream if the main circuit breakers in unit substation U15 are configured so that only a single power feed from main switchgear S1 is powering both unit substation U15 switchgear busses.

Portions of below-grade, concrete-encase duct bank around NSWWTP carry both sets of conductors for the various redundant power feeds between major electrical distribution equipment. Major damage to a critical section of duct bank during excavation, while unlikely, could result in a complete loss of power to one or more NSWWTP facilities.

To automatically repower the Headworks facility MCCs within seconds after a loss of power, a standby generator must be installed along with a power transfer control system that automatically transfers the supply of power to the Headworks facility MCCs from a failed incoming feeder from unit substation U15 to an available U15 feeder, or to the new standby generator. Existing main and tie circuit breakers in the Headworks facility MCCs would need to be replaced with electrically-controlled circuit breakers, and a new electrically-controlled circuit breaker would also need to be installed in MCC-HF2 to accept a power feed from the new generator. New electrically-controlled main and tie circuit breakers can be installed in the existing circuit breaker spaces so that they are able to reuse existing MCC bus connections and incoming conduits. The new MCC section with an electrically-controlled circuit breaker for the generator power feed can be installed in place of the empty full-height MCC section that is directly connected to the MCC-HF2 bus and located directly next to the tie breaker. The new generator circuit breaker section would also include 36 inches of spare MCC bucket space (3.0 space factor). Some generator manufacturers can supply an electrically-controlled circuit breaker that is installed at the generator, which could potentially reduce some of the upfront equipment costs.

The electrically-controlled breakers would allow the new power transfer control system to monitor the unit substation U15 feeders for proper voltage, frequency, phasing, and to automatically open and close circuit breakers in the Headworks facility MCCs. This would be used to power the facility from an available unit substation U15 power feed, or automatically start the new generator and power the MCCs from the generator. The detection of a power failure condition and transfer to an available unit substation U15 power feed or to the generator can be accomplished within seconds.

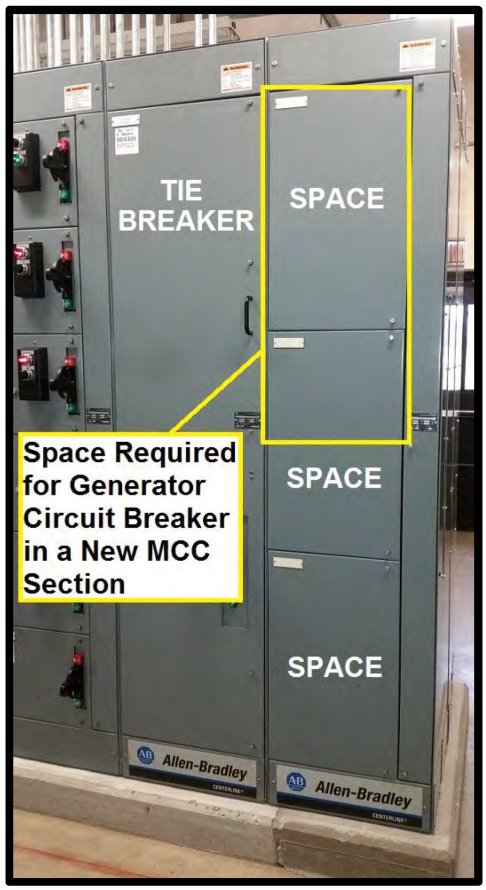

Figure 2–Headworks MCC Tie Breaker and Empty MCC-HF2 Section

After Workshop No. 8, the District staff suggested that the new generator could be wired directly into one of the new electrically-controlled main circuit breakers in the Headworks facility MCC instead of installing a fourth, electrically-controlled breaker to accept the generator feed, which could save approximately $8,000 in upfront equipment costs and require one of the redundant power feeds from unit substation U15 to be removed. While removing one power feed from unit substation U15 would eliminate the redundancy in the utility-connected power distribution system, the new generator would be available to power the Headworks facility if the one remaining power feed from unit substation U15 fails. The one-line diagrams and budgetary opinions of probable construction costs in this section detail scenarios for installing a fourth electrically-controlled circuit breaker for the generator and for using one of the main circuit breakers to accept the generator power feed.

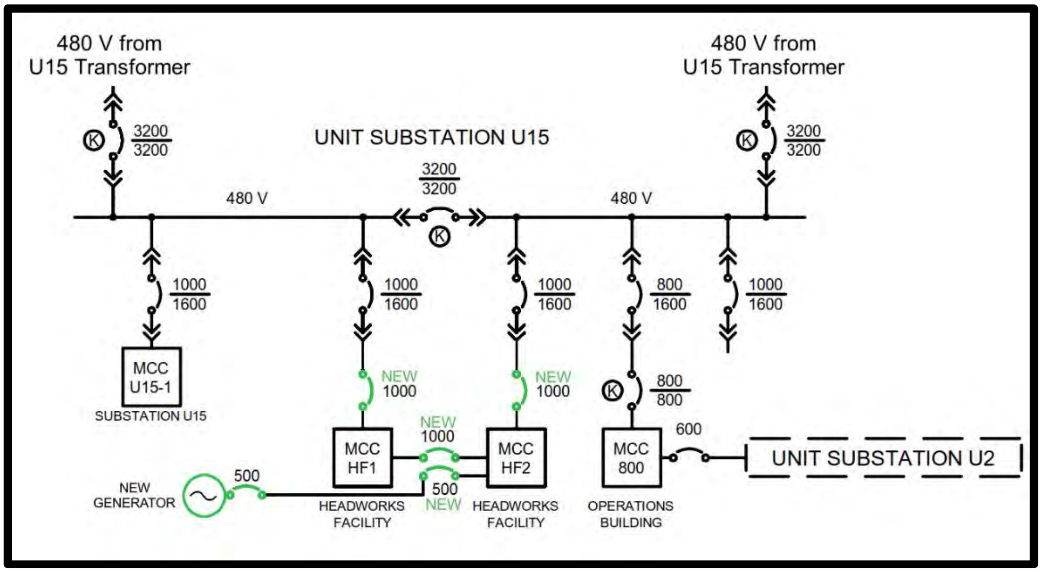

Figure 3–Four New Electrically-Controlled Circuit Breakers in Headworks MCCs

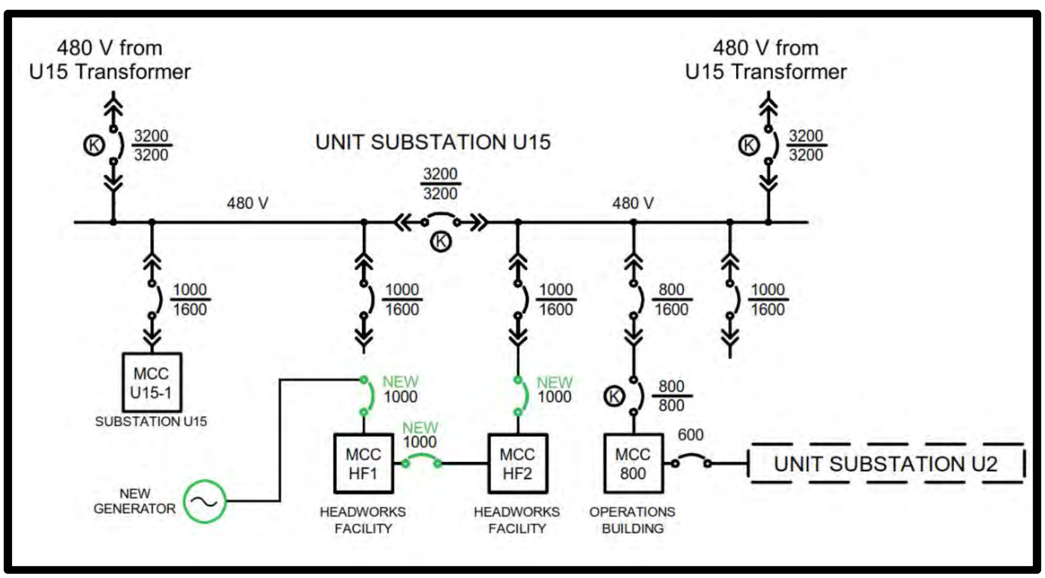

Figure 4–Three New Electrically-Controlled Circuit Breakers in Headworks MCCs

2. Generator Sizing

While the Headworks facility MCCs are fed with relatively large, 480-volt, 1,000-amp incoming power feeders each capable of supplying well over 600 kW of power, the facility only averages about 100 kW of total power consumption. Based on a peak recorded electrical demand of approximately 200 kW, a 480-volt, 300-kW generator would be sufficient to power the entire Headworks facility during a power outage with about 30 percent spare capacity for future electrical loads at the Headworks facility. The diesel fuel tank for a standby generator in this application would typically be sized to allow the generator to operate at 75 percent load for 12 to 24 hours, which would be approximately 200 to 300 gallons for a 300-kW generator. The generator frame can be mounted on top of the fuel tank to save space and avoid the need for external fuel supply piping, but field-installed fuel tank vents would need to be installed to vent the tank outdoors.

The generator size could be increased if the District plans to add more than about 25 to 30 percent more electrical load to the Headworks facility, but running an oversized generator at less than 50 percent loading can result in unburned fuel being ejected into the exhaust system, which is commonly referred to as wet stacking. Under-loaded generators require regular load-bank testing to raise engine temperatures high enough to burn off excess fuel deposits and avoid critical generator failure.

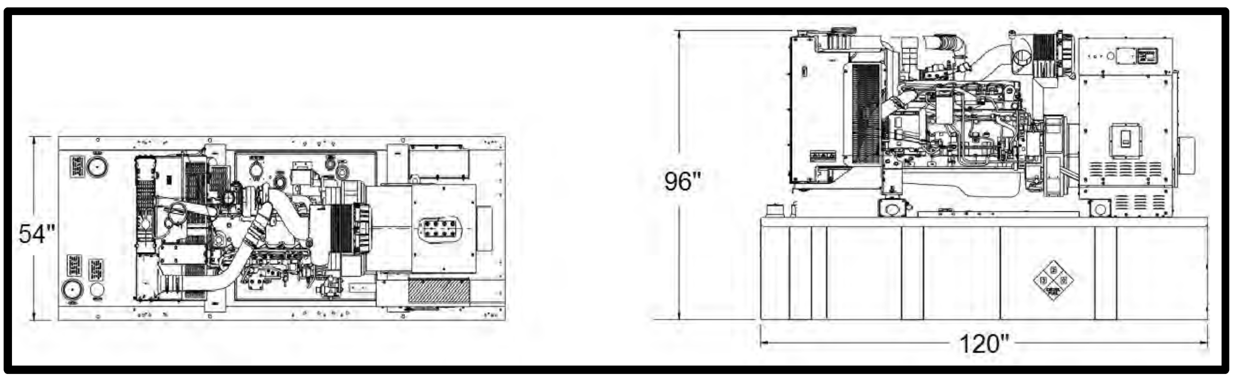

Figure 5–Approximate 300-kW Diesel Generator Size with Sub-Base Fuel Tank

3. Location

It is always preferable to locate generators indoors to avoid exposing the equipment to weather and extreme winter and summer temperatures. In addition, performing equipment maintenance and inspections is much easier with an indoor generator because a weather-protective enclosure enclosing the generator with access doors is not required. Maintenance work is also safer when performed in a well-lit space that it not exposed to weather.

The east storage room in Storage Building No. 3. is ideal because it has space to accommodate the new generator, and intake/outlet ventilation louvers can be installed in the east and north walls. This building is also located near the Headworks facility and an electrical manhole located near the southwest corner of Storage Building No. 3 provides easy access to spare conduit routed to both the Headworks facility and unit substation U15.

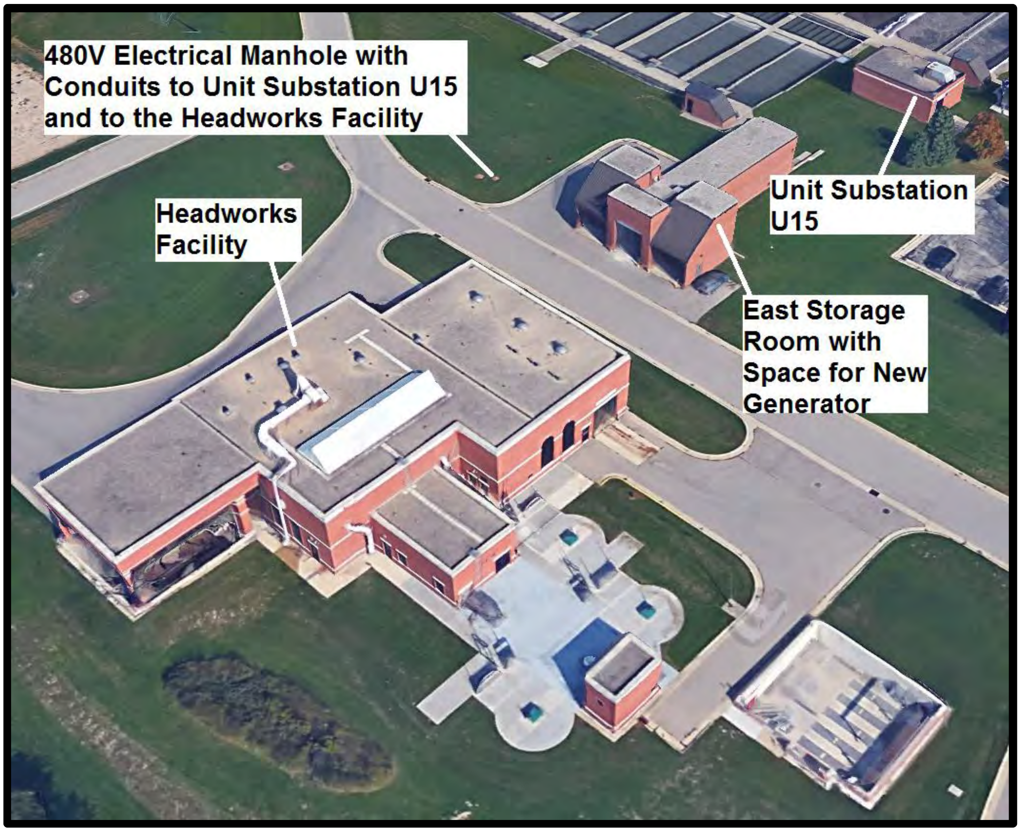

Figure 6–Recommended Generator Location

4. Engine Exhaust Filtering

Environmental Protection Agency (EPA) regulations for diesel engines require that some engines be provided with exhaust after-treatment modules that filter diesel engine emissions. Depending on the use of the generator and engine's rated power output, diesel engine exhaust particulate sizes must be smaller than the limits defined under three levels: Tier 2, Tier 3, or Tier 4.

Tier 2 and Tier 3 emissions particulate size limits are less restrictive than Tier 4. Compliance with Tier 2 or Tier 3 emissions limits is based on the engine's rated power output. Tier 4 emissions filtering requires expensive exhaust after-treatment systems that use a consumable liquid commonly referred to as diesel exhaust fluid (DEF). A Tier 4-rated diesel generator not only requires additional maintenance and DEF, but the upfront cost for a 300-kW, Tier 4 generator is approximately double that of a 300-kW, Tier 3-rated generator.

The Code of Federal Regulations Title 40, Chapter I, Subchapter C, Part 60 (40 CFR 60.4219) defines the conditions under which a diesel engine may be operated without having to filter engine emissions to Tier 4 limits. A Tier 2- or Tier 3-rated diesel generator may be operated only when utility power is unavailable or out of tolerance. However, it is possible that there could be a power outage at the Headworks facility resulting from issues within NSWWTP electrical distribution system while utility power is still available. To account for this scenario, there is a limited-use exception under 40 CFR 60.4219 (see 40 CFR 60.4219(f)) that allows Tier 2- and Tier 3-rated diesel generators to operate for up to 100 hours each year while utility power is available for maintenance and readiness testing. In addition, for 50 of those 100 hours, the generator may be operated during inter-NSWWTP outages, but cannot be used for peak shaving or demand response, unless specific conditions are met. During discussions with the Wisconsin Department of Natural Resources (WDNR), they acknowledged that the 50-hour allowance is used for applications such as this, but that they treat an unexpected loss of power to an inter-NSWWTP facility as an emergency outage event and would not count that against the 50-hour allowance. Based on this information it would be appropriate to install a 300-kW, Tier 3-rated diesel generator.

Natural gas engine-powered generators have to meet a separate set of EPA regulations for engine emissions but do not require the complex exhaust after-treatment systems required for some diesel generators. However, regardless of the type of engine used to power the generator, a WDNR construction permit is required which typically costs about $3,000.

5. Control System

A dedicated power transfer control panel could be installed to monitor power to the Headworks facility MCCs incoming power feeds and control the MCC main, tie, and generator circuit breakers and the generator, as needed to supply power to the Headworks facility. The control panel would be powered with direct current (DC)-power from the generator batteries so that the controls remain operational during a power outage and can supply the power needed to open and close the electrically-controlled circuit breakers. Alternatively, the power transfer controls could also be incorporated into the existing PLC control panel in the Headworks facility, which has a UPS for backup power. A benefit of using a dedicated controller for the power transfer controls is that the controller's programming would not be unintentionally modified during program updates in the process control PLC.

A voltage monitor would also be installed in each of the new main circuit breaker sections to sense a power failure on each of the incoming power feeds from unit substation U15. If only one of the U15 feeders fail, the control system would automatically control the circuit breakers to energize both MCCs from the available power feed. If both incoming power feeds from unit substation U15 fail, the control system would automatically start the generator and control the circuit breakers to power MCC-HF2 from the generator. The power transfer control system would automatically transfer the supply of power back to the power feeds from unit substation U15 as they become available, and then shut down the generator.

6. Storage Building No. 3 HVAC Modifications

The new generator room would require the installation of two wall louvers, sized approximately 8 feet by 8 feet, in the existing east storage room's east and north walls and a small up-blast exhaust fan in the roof to supply/exhaust air for engine combustion and engine radiator/alternator cooling. Each louver would have one or more motorized dampers controlled by the generator control system and exhaust fan starter so that the appropriate louver dampers open during exhaust fan and generator operation. The louver installations would also require minor structural modifications.

The International Building Code requires that spaces storing over 330 gallons of diesel fuel have automatic fire suppression systems like water-fed sprinklers. Using a 300-gallon fuel tank for the generator would avoid having to install automatic sprinklers and a fire alarm system in Storage Building No. 3 while still providing about 18 hours of generator runtime before refueling is required.

7. Cost Considerations

The following budgetary opinions of probable construction costs (OPCC) in Tables 1 and 2 details potential equipment and installation costs, and assumes that the District would perform all programmable logic controller (PLC) and Human-Machine Interface (HMI) programming updates. This estimate does not include estimated fees for engineering design and construction-related services.

Table 1 includes the installation of four new electrically-controlled circuit breakers in the Headworks facility MCCs to replace the existing main and tie circuit breakers, and provide a fourth circuit breaker to accept the new generator power feed.

Table 1–Alternative HBP No. 1 OPCC–Four New Circuit Breakers

Item	Qty	Price	Installation Factor	Total	Comments
1000-amp Electrically-Controlled Breaker in MCC	3	$ 33,000	1.1	$ 108,900	Inlcudes MCC drawing modifications
500-amp Electrically-Controlled Breaker in MCC	1	$ 20,000	1.2	$ 24,000	
Standby Power System Control Panel	1	$ 25,000	1.2	$ 30,000	PLC control panel with OIP. Includes documentation and testing.
Voltage Monitors for MCC Main Breakers	2	$ 300	3	$ 1,800	
300 kW Standby Generator and Fuel Tank, Shipped	1	$ 75,000	1.3	$ 97,500	Includes exhaust/vent piping installation and $3,000 DNR permit.
Ground Rod	1	$ 500	1	$ 500	
Generator Power Conduit and Wiring	1	$ 25,000	1.1	$ 27,500	
Control Conduit and Wiring	1	$ 15,000	1.1	$ 16,500	
Startup and Testing	1	$ 3,000	1	$ 3,000	
Plant SCADA System PLC/HMI Programming	1	$ 2,000	1	$ 2,000	District-provided programming for interfacing new signals with plant SCADA HMI.
HVAC Modificaitons in Generator Room	1	$ 35,000	1	$ 35,000	Roof-mounted upblast fan, elec unit heater, two wall louvers, and motorized damper.
Misc. Electrical and Integration Work	1	$ 10,000	1	$ 10,000	
Subtotal				**$ 356,700**	
Contingencies and Engineering Services (50%)				**$ 178,400**	
Total				**$ 535,100**	

Table 2 includes the installation of three new electrically-controlled circuit breakers into the Headworks facility MCCs, with one of the main circuit breakers being used to accept the new generator power feed.

Table 2–Alternative HBP No. 1 OPCC–Three New Circuit Breakers

Item	Qty	Price	Installation Factor	Total	Comments
1000-amp Electrically-Controlled Breaker in MCC	3	$ 33,000	1.1	$ 108,900	Inlcudes MCC drawing modifications
Standby Power System Control Panel	1	$ 25,000	1.2	$ 30,000	PLC control panel with OIP. Includes documentation and testing.
Voltage Monitors for MCC Main Breakers	2	$ 300	3	$ 1,800	
300 kW Standby Generator and Fuel Tank, Shipped	1	$ 75,000	1.3	$ 97,500	Includes exhaust/vent piping installation and $3,000 DNR permit.
Ground Rod	1	$ 500	1	$ 500	
Generator Power Conduit and Wiring	1	$ 25,000	1.1	$ 27,500	
Control Conduit and Wiring	1	$ 15,000	1.1	$ 16,500	
Startup and Testing	1	$ 3,000	1	$ 3,000	
Plant SCADA System PLC/HMI Programming	1	$ 2,000	1	$ 2,000	District-provided programming for interfacing new signals with plant SCADA HMI.
HVAC Modificaitons in Generator Room	1	$ 35,000	1	$ 35,000	Roof-mounted upblast fan, elec unit heater, two wall louvers, and motorized damper.
Misc. Electrical and Integration Work	1	$ 10,000	1	$ 10,000	
Subtotal				**$ 332,700**	
Contingencies and Engineering Services (50%)				**$ 166,400**	
Total				**$499,100**	

While this alternative would provide a means to reliably supply power to the Headworks facility, the upfront cost would be significant and would not offset the potential maintenance expenses resulting from influent wastewater bypassing the mechanical screens.

8. Non-monetary Considerations

a. Benefits

§ The generator control system would be able to energize the Headworks facility as quickly as 10 seconds after a loss of power on one or both of the MCC incoming power feeds from unit substation U15.

§ Diesel fuel is stored in a tank underneath the generator, so the fuel source, while limited to 12 to 24 hours before requiring a refill, is not dependent on an off-site source.

§ No additional utility services (gas, water, etc.) are required for the generator installation.

b. Limitations

§ The generator would require regular maintenance.

§ Outages lasting longer than 12 to 24 hours, depending on the fuel tank size, would require refueling.

§ Diesel fuel must be stored on-site, and given that the NSWWTP power distribution system is so reliable, it is likely that most of the fuel would not be used before is degrades and has to be replaced.

B. Alternative HBP No. 2–Stationary Natural Gas Generator for Headworks Facility

1. Description of Alternative

Similar to Alternative HBP No. 1, Alternative HBP No. 2 would provide a stationary generator dedicated to powering the Headworks facility during a power outage. However, a natural gas generator would be installed instead of a diesel generator.

Maintaining power to the Headworks facility MCCs for this alternative would require the same power transfer control system, MCC voltage monitors, and electrically-controlled MCC circuit breakers previously described under Alternative HBP No. 1. The same generator location and heating, ventilation, and air conditioning (HVAC) modifications for the east storage bay in Storage Building No. 3 previously described under Alternative HBP No. 1 would also apply to this alternative.

2. Generator Sizing

Based on the average Headworks facility electrical loading previously discussed under Alternative HBP No. 1, a 300-kW natural gas generator would also be appropriate to power current and future Headworks facility electrical loads. Natural gas generators require a gas utility line for fuel and do not require any on-site fuel storage.

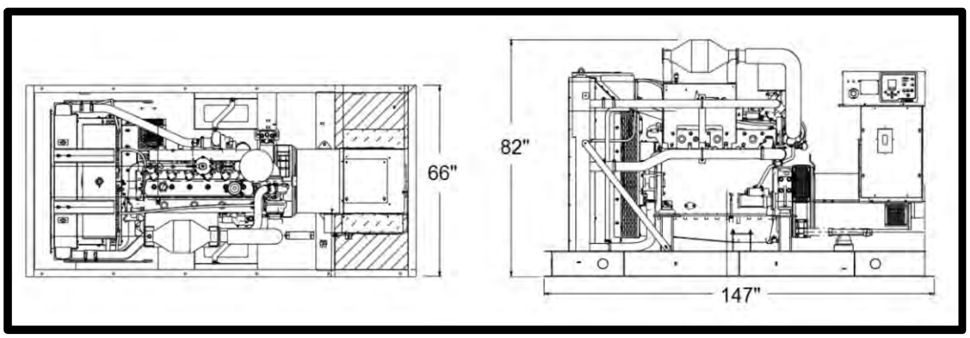

Figure 7–Approximate 300-kW Natural Gas Generator Size

3. Natural Gas Service

Natural gas piping would need to be extended to the new generator in Storage Building No. 3. There is an existing 2-inch natural gas line near Storage Building No. 3 that is sourced from an MG&E gas main routed along Moorland Road and currently feeds the Gas Control Building. Based on recorded natural gas usage by MG&E, there appears to be adequate capacity on the existing gas service line to accommodate a tap to feed a new 300-kW generator. Actual gas service capacity available for the new generator would need to be verified during detailed design.

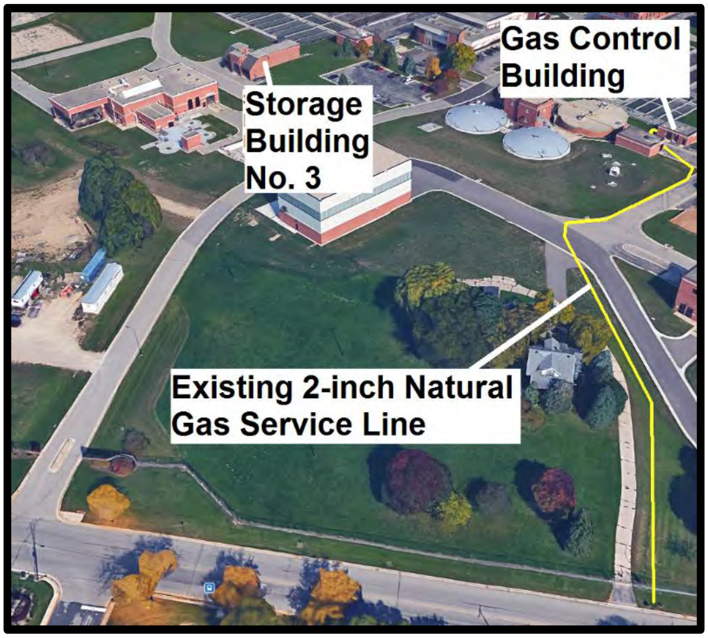

Figure 8–Existing Natural Gas Service to Gas Control Building

4. Cost Considerations

The following budgetary OPCC in Tables 3 and 4 detail potential equipment and installation costs, and assumes that the District would perform all PLC and HMI programming updates. This estimate does not include estimated fees for engineering design and construction-related services.

Table 3 includes the installation of four new electrically-controlled circuit breakers in the Headworks facility MCCs to replace the existing main and tie circuit breakers and provide a fourth circuit breaker to accept the new generator power feed.

Table 3–Alternative HBP No. 2 OPCC–Four New Circuit Breakers

Item	Qty	Price	Installation Factor	Total	Comments
1000-amp Electrically-Controlled Breaker in MCC	3	$ 33,000	1.1	$ 108,900	Inlcudes MCC drawing modifications
500-amp Electrically-Controlled Breaker in MCC	1	$ 20,000	1.2	$ 24,000	
Standby Power System Control Panel	1	$ 25,000	1.2	$ 30,000	PLC control panel with OIP. Includes documentation and testing.
Voltage Monitors for MCC Main Breakers	2	$ 300	3	$ 1,800	
300 kW Standby Generator, Shipped	1	$ 145,000	1.2	$ 174,000	Includes exhaust/vent piping installation and $3,000 DNR permit.
Generator Power Conduit and Wiring	1	$ 25,000	1.1	$ 27,500	
Control Conduit and Wiring	1	$ 15,000	1.1	$ 16,500	
Startup and Testing	1	$ 3,000	1	$ 3,000	
SCADA System PLC/HMI Programming	1	$ 2,000	1	$ 2,000	District-provided programming for interfacing new signals with plant SCADA HMI.
HVAC Modificaitons in Generator Room	1	$ 35,000	1	$ 35,000	Roof-mounted upblast fan, wall louver, and motorized damper.
Extend Natural Gas Piping to Generator	1	$ 20,000	1	$ 20,000	550 feet from 2-inch NG pipe served from MG&E valve manhole at Moorland Road. Increase pressure from MG&E and install two regulators.
Misc. Electrical and Integration Work	1	$ 10,000	1	$ 10,000	
Subtotal				**$ 452,700**	
Contingencies and Engineering Services (50%)				**$ 226,400**	
Total				**$679,100**	

Table 4 includes the installation of three new electrically-controlled circuit breakers in the Headworks facility MCCs, with one of the main circuit breakers being used for the new generator power feed.

Table 4–Alternative HBP No. 2 OPCC–Three new Circuit Breakers

Item	Qty	Price	Installation Factor	Total	Comments
1000-amp Electrically-Controlled Breaker in MCC	3	$ 33,000	1.1	$ 108,900	Inlcudes MCC drawing modifications
Standby Power System Control Panel	1	$ 25,000	1.2	$ 30,000	PLC control panel with OIP. Includes documentation and testing.
Voltage Monitors for MCC Main Breakers	2	$ 300	3	$ 1,800	
300 kW Standby Generator, Shipped	1	$ 145,000	1.2	$ 174,000	Includes exhaust/vent piping installation and $3,000 DNR permit.
Generator Power Conduit and Wiring	1	$ 25,000	1.1	$ 27,500	
Control Conduit and Wiring	1	$ 15,000	1.1	$ 16,500	
Startup and Testing	1	$ 3,000	1	$ 3,000	
SCADA System PLC/HMI Programming	1	$ 2,000	1	$ 2,000	District-provided programming for interfacing new signals with plant SCADA HMI.
HVAC Modificaitons in Generator Room	1	$ 35,000	1	$ 35,000	Roof-mounted upblast fan, wall louver, and motorized damper.
Extend Natural Gas Piping to Generator	1	$ 20,000	1	$ 20,000	550 feet from 2-inch NG pipe served from MG&E valve manhole at Moorland Road. Increase pressure from MG&E and install two regulators.
Misc. Electrical and Integration Work	1	$ 10,000	1	$ 10,000	
Subtotal				**$ 428,700**	
Contingencies and Engineering Services (50%)				**$ 214,400**	
Total				**$643,100**	

While this alternative would provide a means to reliably supply power to the Headworks facility, the upfront cost would be significant and would not offset the potential maintenance expenses resulting from influent wastewater bypassing the mechanical screens.

5. Non-monetary Considerations

a. Benefits

§ The generator control system would be able to energize the Headworks facility as quickly as 10 seconds after a loss of power on one or both of the MCC incoming power feeders.

§ No on-site fuel storage or fuel maintenance.

b. Limitations

§ The generator would require regular maintenance.

§ A natural gas utility service outage would render the generator inoperable.

§ NSWWTP natural gas utility piping needs to be extended to Storage Building No. 3.

RECOMMENDATIONS

The maintenance expense required to clean processes affected by influent wastewater bypassing the mechanical screens is insignificant when compared to the upfront expense required to install a generator, so project costs alone will not justify the installation of a new standby generator. In addition, because of the very infrequent power failures at the headworks, we recommend the null alternative (do nothing) be continued.

If the District would still like to install a generator to avoid the potential of cleaning process equipment and managing a temporary increase in biosolids debris, we recommend installing a diesel generator at the Headworks facility (Alternative HBP No. 1). This option not only provides a backup power source for the entire Headworks facility, but upgrading to electrically-controlled breakers would improve the speed at which power to the Headworks facility is switched between the two existing feeders from unit substation U15. Currently, if both MCCs are fed from one service so that only one main circuit breaker is closed and the tie circuit breaker is closed, then maintenance staff still have to manually switch power if the in-service feeder from unit substation U15 fails. The diesel engine generator in Alternative HBP No. 1 would not be operating under conditions that require Tier 4 emissions particulate filtering, so the upfront cost would be much lower than the cost associated with installing a natural gas engine generator. Additional benefits and options related to this alternative are noted below.

§ The new electrically-controlled circuit breakers would significantly reduce future electrical outage durations at the Headworks facility. The electrically-controlled circuit breakers could also be installed by themselves without the generator to eliminate concerns with a single substation U15 power source to both Headworks MCCs (i.e., tie breaker closed) failing and requiring manual transfer to the other U15 power source. This concern could also be eliminated by simply committing to always powering the Headworks MCCs independently from U15 (i.e., tie breaker open).

§ The diesel engine generator would be able to supply standby power to the facility during an electric utility outage for about 20 hours before needing to be refueled. Immediate generator operation would not rely on any off-site fuel sources.

§ The upfront cost to install a diesel engine generator would be significantly lower than the cost required to install a natural gas engine generator, and would not require any NSWWTP utilities to be modified.

DESCRIPTION OF THE EAST AERATION SYSTEM CONTROL PANEL

There are two blower buildings at the NSWWTP, the East Blower Building (Blower Building 1) and the West Blower Building (Blower Building 2). Each blower building houses several 4.16-kV motor-driven blowers, and the East Blower Building also houses an engine-driven blower.

Controls for the west blowers were upgraded by the District engineering staff about 16 years ago. PLC control panels using Allen-Bradley SLC 500 controllers were installed to control each blower, and motor control relays in each blower motor starter were also upgraded. Since then, the west blower control systems have operated reliably. During Workshop No. 8, the District agreed that while these controls have been in service for about 16 years, they do not need to be evaluated for replacement at this time. It is worth noting that Allen-Bradley recently transitioned the SLC 500 series controllers to *Active Mature* status, which means that the controllers are still fully supported, but Allen-Bradley recommends migrating to a newer product.

Figure 9–One of Three Upgraded West Blower Control Panels

However, the east blower control system, which controls Blower Nos. 2, 3, 4, 5, includes of a common control panel using hardwired relay logic and legacy panel-mounted digital controllers. Blower No. 1 is an engine-driven blower that has a separate control panel. The east blowers control panel has been in use since the original blowers were installed in the 1960s, and several undocumented modifications and adjustments have been performed over the years to keep the blowers in operation. As a result, the control panel wiring is unorganized and no reliable documentation exists to help District maintenance staff troubleshoot and correct problems that occasionally arise. District maintenance staff commented at Workshop No. 8 that problems with this control panel often require several days to diagnose and correct.

Since the original controls installation, a newer Allen-Bradley CompactLogix PLC and network switch have been installed, but only to monitor the engine-driven blower (Blower No. 1) temperatures. If the east blower controls are replaced, this PLC would be eliminated and the blower temperature sensors could be monitored by the new east blower control system.

Figure 10–East Blowers Control Panel

The east blower controls are unreliable, undocumented, and use legacy parts that are difficult to replace. The control panel should be replaced with a PLC-based control system similar to what was provided for the west blowers. Using a PLC control panel would allow the control system to easily adapt to future blower equipment upgrades. However, blower upgrades are also being considered at this time, and while upgrading the controls are a priority, the District would consider leaving the existing controls in operation if the blowers are replaced within the next 5 years, and upgrade the control panel at the same time that the blowers are upgraded. At this time, it is unlikely that the blowers will be replaced within the next 10 years, so the District should consider replacing the control system prior to the blower equipment upgrades.

EAST AERATION SYSTEM CONTROL PANEL UPGRADE ALTERNATIVES IDENTIFICATION

This section presents a brief summary of the East Blower Control System Upgrade Alternatives discussed at Workshop No. 8.

A. Alternative EBC No. 0–No Change (Null Alternative)

This alternative would leave the existing hardwired control system for Blowers No. 2, 3, 4, and 5 in operation until the blowers are replaced

B. Alternative EBC No. 1–Replace East Blower Control Panel

This alternative would provide a new dedicated PLC-based control panel for each blower in the East Blower Building (Blower Nos. 2, 3, 4, and 5). The new control panels would be built in accordance with the Process Control System (PCS) Facilities Plan and recent control system upgrades at the NSWWTP. The new control panel would be located in Aeration Control Building No. 2 to avoid the dirty and noisy environment in the East Blower Building.

SCREENING OF ALTERNATIVES

Based on discussions at Workshop No. 8, both alternatives were short-listed and will be evaluated in detail.

- Alternative EBC No. 0–No Change (Null Alternative)
- Alternative EBC No. 1–Replace East Blower Control Panel

DETAILED EVALUATION OF ALTERNATIVES

This section includes a detailed evaluation of each short-listed East Aeration System Control Panel Upgrade Alternative. Budgetary OPCC, when applicable, and non-monetary benefits and challenges are included and summarized for each alternative.

A. Alternative EBC No. 0–No Change (Null Alternative)

1. Description of Alternative

Alternative EBC No. 0 would leave the existing hardwired control panel for Blower Nos. 2, 3, 4, and 5 in the East Blower Building in operation. The control panel would be replaced during future blower equipment upgrades. The control panel is currently located in the center of the blower room, which is a relatively noisy and dirty environment.

2. Cost Considerations

There are no upfront costs associated with this alternative; however, there will likely be future costs associated with the time and materials required for NSWWTP maintenance staff to troubleshoot and repair blower control panel problems, which are not able to be reliably estimated.

The District would likely save some upfront cost by waiting to upgrade the blower control panel at the same time that the blowers are replaced because an upgraded control panel would again have to be updated to accommodate future blower equipment upgrades. However, newer PLC-based control systems are easy to interface with upgraded equipment, so the cost savings associated with Alternative EBC No. 0 would be relatively insignificant.

3. Non-monetary Considerations

a. Benefits

§ None

b. Limitations

§ The existing control panel components are very old, difficult to troubleshoot, and some replacement parts are difficult to find.

§ Future control panel problems due to aging equipment will likely require several days to troubleshoot and repair.

§ The existing control panel location in the blower building is not ideal for control equipment because it is a somewhat dirty environment, which can lead to premature equipment failure. The loud noise levels in the East Blower Building also require occupants to wear hearing protection, which complicates maintenance and troubleshooting efforts.

B. Alternative EBC No. 1–Replace East Blower Control Panel

1. Description of Alternative

Alternative EBC No. 1 would replace the existing hardwired control panel for Blower Nos. 2, 3, 4, and 5 in the East Blower Building with new dedicated PLC-based control panels for each of these blowers located in Aeration Control Building No. 2. Aeration Control Building No. 2 offers a much cleaner and less noisy environment for the control panel, which would extend equipment life and simplify maintenance efforts because staff could easily converse while troubleshooting problems. Aeration Control Building No. 1 is closer to the East Blower Building but Aeration Control Building No. 2 has direct access to the East Blower Building through aeration piping tunnels, as well as a lot of available space to locate the new control panels.

The District is currently considering blower equipment upgrades including a change from blowers powered by medium-voltage motors to blowers powered by 480-volt motors. While upgrading the control system prior to the blower equipment upgrades would require the new control panels to be modified slightly to accommodate the new equipment, new PLC-based control panels would easily be able to adapt and interface with any type of upgraded blower equipment. Continuing to use the existing outdated and undocumented control panel is risky to NSWWTP operation as equipment ages and legacy replacement parts continue to become more difficult to find.

A new remote input/output (I/O) enclosure could be installed in place of the existing blower control panel in the East Blower Building to interface with existing field wiring from the blower system equipment, including motor starters, temperature sensors, valves, etc. This remote I/O enclosure would use I/O cards that connect back to the new blower control panel located in Aeration Building No. 2 via NSWWTP's recently-upgraded network of fiber optic cabling. This enclosure would also include a touchscreen operator interface terminal (OIT), in addition to touchscreen

OITs installed on each blower control panel in Aeration Control Building No. 2, which would allow for local control of the blowers while in the East Blower Building.

Using a remote I/O enclosure would allow most of the existing field wiring to be reused until it is all replaced when the blower equipment is upgraded and provide a point of local terminal for I/O wiring to simplify maintenance while in the East Blower Building. Reusing existing wiring and avoiding the need to extend all of the wiring back to Aeration Control Building No. 2 would also simplify future blower equipment upgrades and reduce the new blower control panel installation costs.

Figure 11–East Blower Building and Aeration Control Buildings No. 1 and No. 2

2. Cost Considerations

There is a significant upfront cost required to install a new PLC control panel and remote I/O enclosure. Costs for field wiring are minimal because most of the field wiring would be able to be easily extended to the new remote I/O enclosure. The following budgetary OPCC in Table 5 details potential equipment and installation costs, and assumes that the District would perform all PLC and HMI programming updates.

Table 5–Alternative EBC No. 1 OPCC

Item	Qty	Price	Installation Factor	Total	Comments
Demolition and Controls Phasing	1	$ 29,000	1	$ 29,000	2 Electricians and 1 Integrator; 2 weeks
Blower PLC Control Panels (4 Total)					
Enclosure	4	$ 3,000	2	$ 24,000	Full-Height NEMA 12
PLC	4	$ 4,000	1	$ 16,000	Allen-Bradley CompactLogix PLC
Touchscreen OIP	4	$ 6,000	1	$ 24,000	Allen-Bradley PanelView Plus 7 1500 Touchscreen
UPS	4	$ 1,000	1	$ 4,000	1500VA True-Online UPS
Documentation	4	$ 2,000	1	$ 8,000	Shop drawings and O&M drawings
Assembly and Testing	4	$ 4,500	1	$ 18,000	
Field Testing	4	$ 2,000	1	$ 8,000	1 week
Remote I/O Enclosure					
Enclosure	1	$ 3,000	2	$ 6,000	Full-Height NEMA 12
Remote Interface Module	1	$ 2,500	1	$ 2,500	Allen-Bradley AENTR
Touchscreen OIP	1	$ 6,000	1	$ 6,000	Allen-Bradley PanelView Plus 7 1500 Touchscreen
Discrete Input Cards	8	$ 500	1	$ 4,000	Allen-Bradley 1769 Compact I/O
Discrete Output Cards	4	$ 500	1	$ 2,000	Allen-Bradley 1769 Compact I/O
Analog Input Cards	4	$ 1,000	1	$ 4,000	Allen-Bradley 1769 Compact I/O
Analog Output Cards	4	$ 1,000	1	$ 4,000	Allen-Bradley 1769 Compact I/O
RTD Input Cards	5	$ 1,500	1	$ 7,500	Allen-Bradley 1769 Compact I/O
Fiber Patch Panel and Managed Network Switch	1	$ 6,000	1	$ 6,000	Allen-Bradley Stratix 8300
UPS	1	$ 1,000	1	$ 1,000	1000VA True-Online UPS
Documentation	1	$ 2,500	1	$ 2,500	Shop drawings and O&M drawings
Assembly and Testing	1	$ 6,000	1	$ 6,000	
Field Testing	1	$ 8,000	1	$ 8,000	2 weeks
Field Conduit and Wiring Extensions					
Fiber Patch Panel and Managed Network Switch	1	$ 6,000	1	$ 6,000	Allen-Bradley Stratix 8300
Shielded Pair Cables Installed (ft)	100	$ 15	1	$ 1,500	
RTD Cables Installed (ft)	200	$ 15	1	$ 3,000	
14 AWG Control Wiring	200	$ 13	1	$ 2,600	
Junction Boxes and Terminal Strips	2	$ 2,000	1.5	$ 6,000	
Misc. Wiring and Electrical Work	1	$ 20,000	1	$ 20,000	
Misc. Starter Modifications/Interface Relays	1	$ 15,000	1	$ 15,000	Includes Updated Documentation
Plant SCADA System PLC/HMI Programming/Testing	1	$ 15,000	1	$ 15,000	District-provided programming of PLCs and SCADA HMI
Subtotal				**$ 259,600**	
Contingencies and Engineering Services (50%)				**$ 129,800**	
Total				**$ 389,400**	

3. Non-monetary Considerations

a. Benefits

§ Replacing aging equipment would reduce the likelihood of control system problems that affect blower operation.

§ New and well-documented control panels would simplify maintenance and reduce the time required to diagnose and correct problems.

§ Relocating controls to Aeration Building No. 2 would provide a cleaner and less noisy environment, which would improve equipment longevity and provide a worker-friendly environment for control system maintenance and upgrades.

§ The new remote I/O enclosure in the East Blower Building would provide a point of local control via a touchscreen OIT and access to all I/O signal wiring.

§ The new control equipment would match current NSWWTP standards and maintenance staff would have easy access to replacement parts.

b. Limitations

§ Maintenance staff would lose the convenience of having the control panel, blower equipment, and motor starters in the same room.

§ Control system modifications, while not a significant effort or expense, would be required to interface the new control panel with future blower equipment upgrades.

RECOMMENDATIONS

The recommended alternative for the east blower controls replacement is Alternative EBC No. 1. The east blower control panel is very old and replacement parts are hard to locate. In addition, the control panel wiring is undocumented and requires several days to troubleshoot and correct control system problems. Replacing the control system would greatly improve the east blower system reliability and use control equipment consistent with recent NSWWTP control system upgrades.

If the District chooses to upgrade the blowers within the next 5 years, the District could reasonably consider delaying the blower control panel upgrade until the blower equipment is upgraded with the understanding that there is an increased risk for extended control system outages as existing control panel equipment continues to age.

DESCRIPTION OF EXISTING EAST AND WEST BLOWERS MEDIUM-VOLTAGE SWITCHGEAR

The East Blower Building and the West Blower Building each house medium-voltage (4.16 kV) switchgear lineups with starters for each blower motor, except for Blower No. 1 in the East Blower Building, which is powered with a diesel engine. The East Blower Building has a main switchgear lineup with the main and tie switches and starters for Blowers No. 4 and No. 5, as well as a remote switchgear lineup with starters for Blowers No. 2 and 3. The remote lineup is powered from the main switchgear lineup with redundant power feeds. All motor starters in the West Blower Building switchgear are part of one continuous lineup. The switchgear in both buildings are powered with redundant 4.16-kV power feeds from either side of the main switchgear S1 bus-tie circuit breaker.

Both of the medium-voltage switchgear lineups are regularly inspected and maintained, but are operating beyond their expected service life of 30 years. The East Blower Building's switchgear was installed in 1963 and the West Blower Building's switchgear was installed in 1985.

The East Blower Building's medium-voltage switchgear (S141 & S142) powers the following equipment:

§ Blower No. 2: 600 horsepower (HP)

- Blower No. 3: 600 HP
- Blower No. 4: 375/500 HP (two-speed, two-winding motor)
- Blower No. 5: 315/450 HP (two-speed, two winding motor)

Figure 12–East Blower Building Medium-Voltage Switchgear (S141 & S142)

The West Blower Building's medium-voltage switchgear (M51) powers the following equipment:

- Blower No. 1: 1,250 HP
- Blower No. 2: 1,250 HP
- Blower No. 3: 1,250 HP

Figure 13–West Blower Building Medium-Voltage Switchgear (M51)

EAST AND WEST BLOWERS MEDIUM-VOLTAGE SWITCHGEAR REPLACEMENT ALTERNATIVES IDENTIFICATION

This section presents a brief summary of the list of the East and West Blowers Medium-Voltage Switchgear Replacement Alternatives discussed at Workshop No. 8.

A. Alternative BMC No. 0–No Change (Null Alternative)

This alternative would leave the existing medium-voltage switchgear in both blower buildings in operation.

B. Alternative BMC No. 1–Replace East Blower Building Switchgear

This alternative would replace the East Blower Building's medium-voltage switchgear. Both sets of medium-voltage feeder conductors from main switchgear S1 to the new switchgear would be replaced with new conductors.

C. Alternative BMC No. 2–Replace West Blower Building Switchgear

This alternative would replace the West Blower Building's medium-voltage switchgear. Both sets of medium-voltage feeder conductors from main switchgear S1 to the switchgear would be replaced with new conductors.

SCREENING OF ALTERNATIVES

Based on discussions at Workshop No. 8, all three alternatives were short-listed and will be evaluated in detail.

§ Alternative BMC No. 0–No Change (Null Alternative)
§ Alternative BMC No. 1–Replace East Blower Building Switchgear
§ Alternative BMC No. 2–Replace West Blower Building Switchgear

DETAILED EVALUATION OF ALTERNATIVES

This section includes a detailed evaluation of the East and West Blowers Medium-Voltage Switchgear Replacement Alternatives. Budgetary opinions of probable construction costs, when applicable, and non-monetary benefits and challenges are included and summarized for each alternative.

A. Alternative BMC No. 0–No Change (Null Alternative)

1. Description of Alternative

Alternative BMC No. 0 would leave both the existing East Blower Building and West Blower Building medium-voltage switchgear in place and powering the blower motors.

While there are many examples of switchgear equipment operating for more than 50 years, the expected service life for medium-voltage switchgear is 30 years. Operating beyond 30 years introduces a greater chance for arc-fault events due to failed insulation, failed switch mechanisms, failed bus hardware, etc. Operating switchgear beyond its expected service life is possible with proper routine maintenance and testing, but the risk of equipment failure will still increase as equipment ages. Risks can be minimized by reconditioning switchgear with new components, but reconditioning efforts would still not account for the improved reliability and safety that could be provided with modern switchgear.

Voltage insulating barriers are used throughout switchgear to allow energized metal parts to be placed closer together without allowing arc-faults in order to reduce enclosure sizes and simplify bus routing. These insulating barriers are usually placed around bussing, switch contacts, and termination lugs. However, the insulating properties of these barriers degrade over time and increase the potential for an arc-fault event. Insulating jackets on the medium-voltage power conductors feeding the switchgear will also degrade over time, and these conductors are usually located much closer to, or in contact with, grounded equipment like conduit, pull boxes, ground bussing, and equipment enclosures.

The West Blower Building switchgear has been in service for about 32 years and the East Blower Building switchgear has been in service for over 50 years, but have maintained consistent, reliable operation thus far. The District regularly maintains and inspects the equipment, which is likely the reason that the East Blower Building switchgear has been in operation for as long as it has been.

Since the original switchgear installations, advancements have been made in switchgear insulating technologies, switch mechanism reliability, and enclosure safety. New arc-resistant switchgear is also available to redirect the massive expansion of gas and molten conductor metal out of ducted passages and away from personnel in front of the switchgear. Photo-sensors and high-speed relays can now be used to quickly detect and clear arc-faults. Draw-out motor controller construction can also be used to improve equipment access and improve safety when maintaining equipment.

In addition to failures resulting from equipment aging, equipment grounding systems must also be considered for regular replacement. It is not uncommon for below-grade ground rods and conductors to corrode beyond the point where it can successfully transmit ground-fault currents.

2. Cost Considerations

There are no upfront costs associated with this alternative. There would be future costs associated with the time and materials required for District maintenance staff to troubleshoot and repair switchgear equipment as it fails, which are not able to be reliably estimated. However, repair costs for this equipment will continue to rise as it becomes increasingly difficult to access replacement parts.

3. Non-monetary Considerations

a. Benefits

§ If the blowers are eventually replaced with blowers using 480-volt motors, the District would avoid buying new switchgear that could not be reused to power the new 480-volt blower motors.

b. Limitations

- § The switchgear equipment is operating beyond its expected service life and the potential for equipment failures will increase as equipment ages.
- § Switchgear reliability and safety could be improved if replaced with new equipment utilizing improved operating mechanisms and draw-out motor controller construction.
- § Newer draw-out style motor starters would improve access to equipment and simplify maintenance.

B. Alternative BMC No. 1–Replace East Blower Building Switchgear

1. Description of Alternative

The East Blower Building switchgear would be replaced with a new switchgear to power the existing blower motors. A switchgear would be installed in the same location as the existing switchgear and existing below-grade, concrete-encased duct bank could be reused to refeed the new switchgear with new medium-voltage cables from main switchgear S1 in the Effluent Building.

The existing switchgear uses main-tie-main switches with Kirk Key interlocks to control switching configurations. This would allow a short outage to be taken at the existing switchgear to deenergize and disconnect the tie switch section and switchgear sections on the left side of the tie switch, while allowing Blowers No. 2, 3, and 5 to remain energized from the existing medium-voltage power feed from main switchgear S1 that powers the bussed sections on the right side of the tie switch.
The new tie switch and new switchgear sections on left side of the tie switch could then be installed, and the associated medium-voltage power feed from main switchgear S1 could be replaced and be used to energize the new left-side switchgear through the new left-side main switch. Once Blower No. 4 is energized from the new switchgear, the remaining switchgear powering Blower Nos. 2, 3, and 5 could then be replaced along with the associated medium-voltage power feed from main switchgear S1.

2. Blower Equipment Upgrades

Future blower equipment upgrades could potentially include a change from blowers using medium-voltage motors to blowers using multiple 480-volt motors. If 480-volt blower motors are selected for the upgrade, new 480-volt variable frequency drives or reduced-voltage solid-state starters, and potentially a new unit substation, would have to be installed. As a result, the new medium-voltage motor starters proposed as part of this alternative would no longer be used to power the blowers.

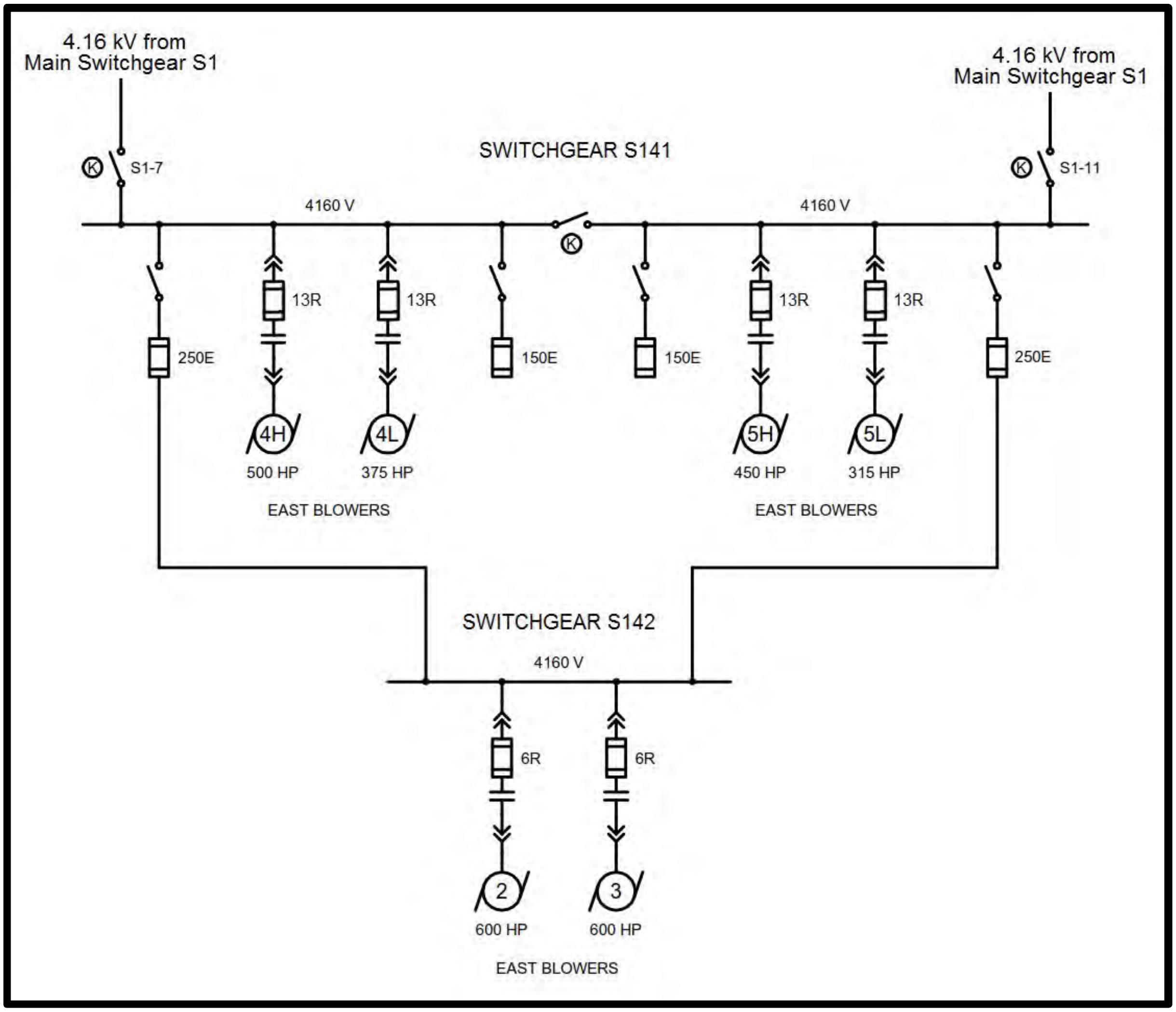

Figure 14–East Blower Building Medium-Voltage Switchgear One-Line Diagram

3. Cost Considerations

The upfront cost would be significant due medium-voltage switchgear and cable replacements, which would improve power distribution system reliability and reduce the likelihood of conductor faults. The following budgetary OPCC in Table 6 details potential equipment and installation costs. The OPCC was based on non-fused main and tie switches and draw-out style motor controllers.

Table 6–Alternative BMC No. 1 OPCC

Item	Qty	Price	Installation Factor	Total	Comments
Demolition and Phasing	1	$ 20,000	1	$ 20,000	2 Electricians for 3 weeks
Switchgear S141	1	$ 240,000	1.2	$ 288,000	
Switchgear S142	1	$ 60,000	1.2	$ 72,000	
15 kV Cable from Main Switchgear S1 to New Gear (ft)	2500	$ 104	1	$ 260,000	Reusing existing duct bank; 2~250MCM/ph
15 kV Cable from S141 to S142 (ft)	150	$ 44	1	$ 6,600	Reusing existing conduit; 4/0
15 kV Cable to Motors (ft)	200	$ 24	1	$ 4,800	Reusing existing conduit; #4 AWG
Medium Voltage Cable Terminations	1	$ 21,000	1	$ 21,000	Terminations for switchgear and motors
Misc. Controls Wiring and Interface Hardware	1	$ 30,000	1	$ 30,000	Includes record drawings
Misc. Conduit Modifications	1	$ 15,000	1	$ 15,000	Includes record drawings
Grounding System	1	$ 5,000	1	$ 5,000	
Startup and Testing	1	$ 5,000	1	$ 5,000	
Arc Flash, Coordination, and Thermographic Studies	1	$ 30,000	1	$ 30,000	
Subtotal				**$ 757,400**	
Contingencies and Engineering Services (50%)				**$ 378,700**	
Total				**$ 1,136,100**	

3. Non-monetary Considerations

a. Benefits

§ Switchgear reliability and safety would be improved.

§ Replacing aging medium-voltage cables would address concerns with the increasing potential for arc-fault events.

§ Newer draw-out style motor starters would improve access to equipment and simplify maintenance.

b. Limitations

§ If new blower equipment uses 480-volt motors, this new switchgear would need to be replaced with 480-volt variable frequency drives (VFDs) and motor controls.

C. Alternative BMC No. 2–Replace West Blower Building Switchgear

1. Description of Alternative

The West Blower Building switchgear would be replaced with new switchgear to power the existing blower motors. Switchgear would be installed in the same location as the existing switchgear and existing below-grade, concrete-encased duct bank could be reused to refeed the new switchgear with new medium-voltage cables from main switchgear S1 in the Effluent Building.

The existing switchgear uses main-tie-main switches with Kirk Key interlocks to control switching configurations. This would allow a short outage to be taken at the existing switchgear to deenergize and disconnect the tie switch section and switchgear sections on the left side of the tie switch, while allowing Blower Nos. 2 and 3 to remain energized from the existing medium-voltage power feed from main switchgear S1 that powers the bussed sections on the right side of the tie switch.

The new tie switch and new switchgear sections on left side of the tie switch could then be installed, and the associated medium-voltage power feed from main switchgear S1 could be replaced and be used to energize the new left-side switchgear through the left-side main switch. Once Blower No. 1 is energized from the new switchgear, the remaining switchgear powering Blower Nos. 2 and 3 could then be replaced along with the associated medium-voltage power feed from main switchgear S1.

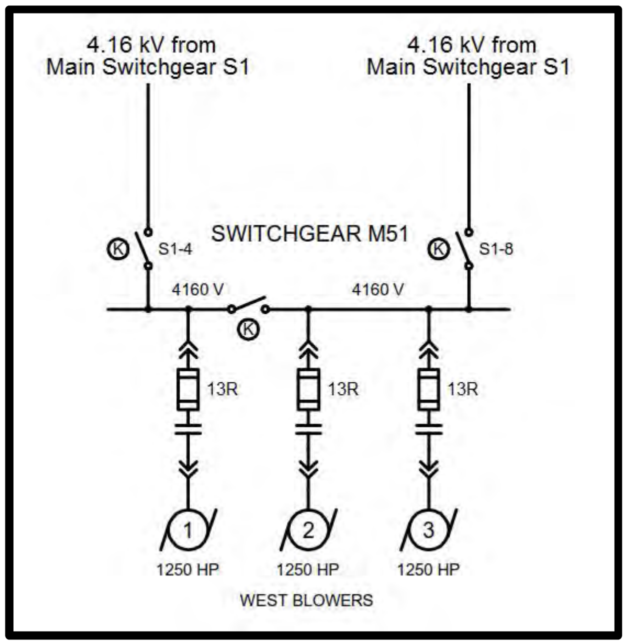

Figure 15–West Blower Building Medium-Voltage Switchgear One-Line Diagram

2. Blower Equipment Upgrades

Future blower equipment upgrades could potentially include a change from blowers using medium-voltage motors to blowers using multiple 480-volt motors. If 480-volt blower motors are selected for the upgrade, new 480-volt variable frequency drives or reduced-voltage solid-state starters, and potentially a new unit substation, would have to be installed. As a result, the new medium-voltage motor starters proposed as part of this alternative would no longer be used to power the blowers.

3. Cost Considerations

The upfront cost would be significant due medium-voltage switchgear and cable replacements, which would improve the power distribution system reliability and reduce the likelihood of conductor faults. The following budgetary OPCC in Table 7 details potential equipment and installation costs. The OPCC was based on non-fused main and tie switches and draw-out style, FVNR motor controllers.

Table 7–Alternative BMC No. 2 OPCC

Item	Qty	Price	Installation Factor	Total	Comments
Demolition and Phasing	1	$ 20,000	1	$ 20,000	2 Electricians for 3 weeks
Switchgear M51	1	$ 180,000	1.2	$ 216,000	
15 kV Cable from Main Switchgear S1 to New Gear (ft)	2600	$ 104	1	$ 270,400	Reusing existing duct bank; 2~250MCM/ph
15 kV Cable to Motors (ft)	150	$ 24	1	$ 3,600	Reusing existing conduit; #4 AWG
Medium Voltage Cable Terminations	1	$ 11,000	1	$ 11,000	Terminations for switchgear and motors
Misc. Controls Wiring and Interface Hardware	1	$ 30,000	1	$ 30,000	Includes record drawings
Misc. Conduit Modifications	1	$ 10,000	1	$ 10,000	Includes record drawings
Grounding System	1	$ 5,000	1	$ 5,000	
Startup and Testing	1	$ 5,000	1	$ 5,000	
Arc Flash, Coordination, and Thermographic Studies	1	$ 30,000	1	$ 30,000	
Subtotal				**$ 601,000**	
Contingencies and Engineering Services (50%)				**$ 300,500**	
Total				**$ 901,500**	

3. Non-monetary Considerations

a. Benefits

§ Switchgear reliability and safety would be improved.

§ Replacing aging medium-voltage cables would address concerns with the increasing potential for arc-fault events.

§ Newer draw-out style motor starters would improve access to equipment and simplify maintenance.

b. Limitations

§ If new blower equipment uses 480-volt motors, this new switchgear would need to be replaced with 480-volt VFDs and motor controls.

RECOMMENDATIONS

We recommend that the District first make a decision on what type of future blower equipment will be installed before deciding on which medium-voltage switchgear to replace. If future blower equipment upgrades will also use 4.16-kV motors, then both Alternatives BMC No. 1 and BMC No. 2 should be prioritized in order to upgrade all of the existing blower building switchgear lineups with new switchgear. The existing switchgear and associated medium-voltage conductors are operating beyond their expected service life, and new equipment would address reliability concerns and introduce equipment with enhanced operating and safety features.

DESCRIPTION OF EXISTING UNIT SUBSTATIONS U11, U12, and U13

Unit substations at the NSWWTP are used to interface with underground 4.16-kV distribution lines powered from main switchgear S1 in the Effluent Building. The unit substation transformers step the distribution system voltage down from 4.16 kV to 480 volts and then distribute 480-volt power to the various motor control centers and distribution panels in each building. For the remainder of this memorandum, unit substations will simply be referred to as unit substations.

Unit substations U11, U12, and U13 were originally installed in 1984 and brought online in 1985. Outdoor unit substations should be replaced every 25 to 30 years, and these three unit substations have been operating for about 32 years. The unit substation equipment enclosures are significantly corroded, which increases the likelihood of damage to equipment from rain, snow, and rodent intrusion. The District regularly maintains major electrical distribution equipment and also hires a consultant to periodically inspect the equipment every three years. A detailed report of the latest evaluation performed by A. C. Engineering Company, dated May 11, 2015, noted that unit substations U11, U12, and U13 are “very rusted and deteriorated,” and recommends that all equipment at these unit substations “be replaced as soon as possible.”

Unit substations U11 and U12 each have dedicated pairs of 1,500 kilovolt-ampere (kVA) transformers. Unit substation U13 has a dedicated 500 kVA transformer and is also able to be powered with a second 480-volt power feed from the distribution switchgear at nearby unit substation U2. The primary switches that feed each unit substation transformer are each independently fed from each side of the bus-tie breaker in main switchgear S1, which allows the District to power each unit substation under various power distribution configurations.

Unit substations U11 and U12 serve critical process buildings with redundant 480-volt feeders, and a critical failure in the 480-volt distribution section of these unit substations would result in an extended power outage to one or more buildings. Reliable unit substations are critical to maintaining consistent NSWWTP operation.

A. Unit Substation U11

Unit substation U11 is located directly west of the West Blower Building and serves two MCCs in the West Blower Building and two MCCs in Storage Building No. 3. The unit is located along a NSWWTP roadway and parking lot and does not have any physical barriers protecting it from vehicle traffic.

Figure 16–Unit Substation U11

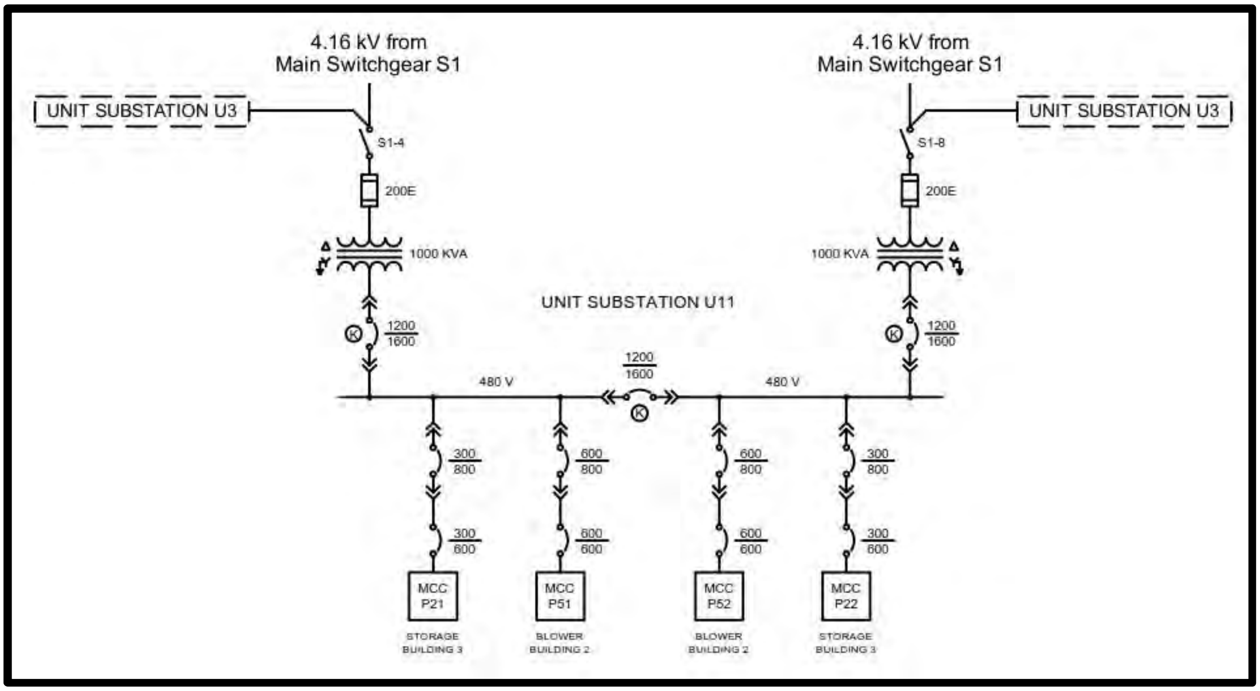

Figure 17–Unit Substation U11 One-Line Diagram

B. Unit Substation U12

Unit substation U12 is located at the northwest corner of the Effluent Building and serves the two MCCs in the Effluent Building and two MCCs in Aeration Control Building No. 4. The unit substation is located in a damp/wet area that is often shaded from sunlight, and as a result, equipment enclosures at this unit substation retain moisture longer than equipment at other unit substations that have more exposure to sunlight.

Figure 18–Unit Substation U12

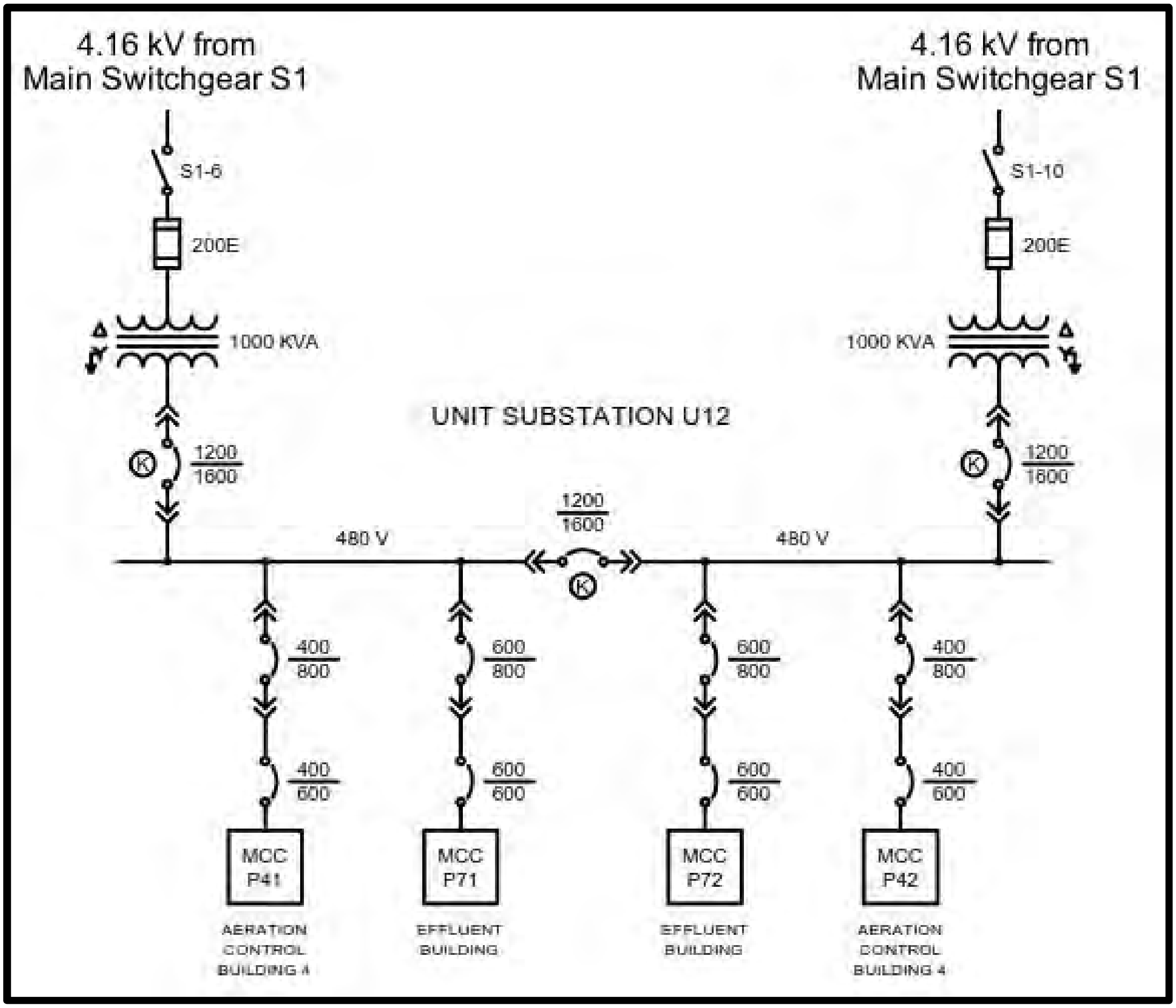

Figure 19–Unit Substation U12 One-Line Diagram

C. Unit Substation U13

Unit substation U13 is located directly west of Shop Building No. 1 and serves a disconnect switch at the Service Building, an MCC in Shop Building No. 1, and a fused disconnect switch in Shop Building No. 2. The unit substation is located along a NSWWTP roadway and has four bollards protecting it from vehicle traffic. The load on this unit substation has been significantly reduced since maintenance operations and staff moved to the recently-constructed Maintenance Building. This unit substation is unique to the others in that it has only a single transformer, but a redundant 480-volt power feed is supplied to it from unit substation U2.

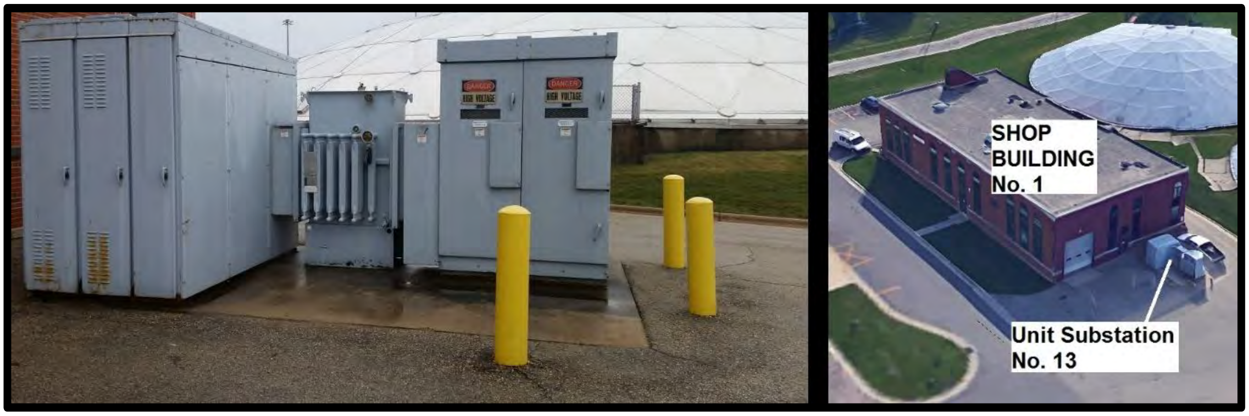

Figure 20–Unit Substation U13

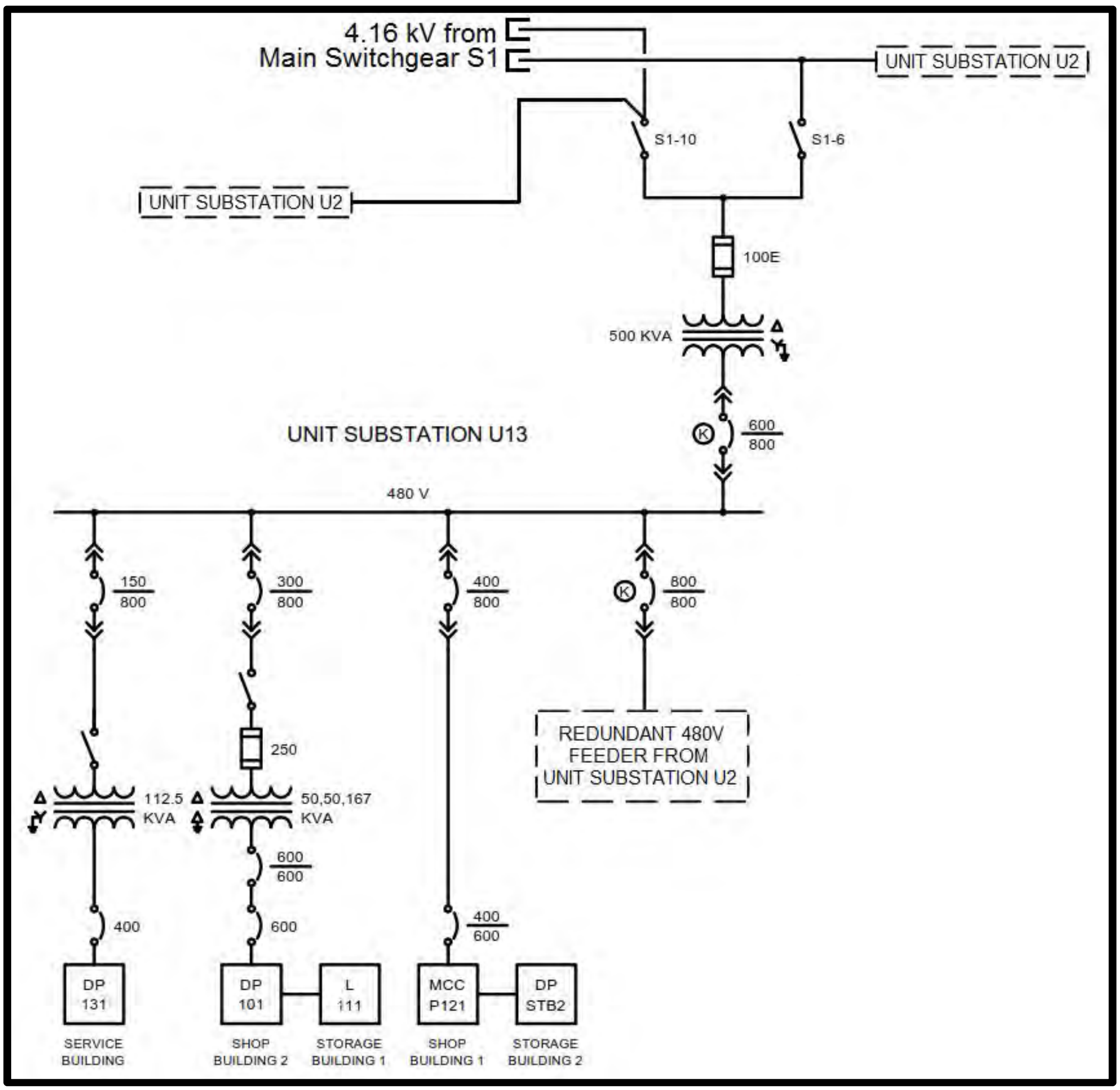

Figure 21–Unit Substation U13 One-Line Diagram

UNIT SUBSTATIONS U11, U12, and U13 REPLACEMENT ALTERNATIVES IDENTIFICATION

This section presents a brief summary of the list of the Unit substations U11, U12, and U13 Replacement Alternatives discussed at Workshop No. 8.

A. Alternative USUB No. 0–No Change (Null Alternative)

This alternative would leave existing unit substations U11, U12, and U13 in operation and serving their existing electrical loads.

B. Alternative USUB No. 1–Replace Unit Substations U11 and U12 with Two New Indoor Unit Substations and Eliminate Unit Substation U13

This alternative would replace existing unit substations U11 and U12 with two new indoor unit substations. The new U11 unit substation would be located northwest or southwest of the existing U11 location. The new U12 unit substation would be located in a drier location further south of the Effluent Building. Unit substation U13 would be removed entirely and its existing loads would be refed from existing unit substation U2 and a new 480-volt MCC in Shop Building No. 1.

C. Alternative USUB No. 2–Replace Unit Substations U11 and U12 with One New Indoor Unit Substation and Eliminate Unit Substation U13

This alternative would replace unit substations U11 and U12 with one large unit substation located relatively equidistant from the existing unit substations that would supply power to all existing loads currently fed from unit substations U11 and U12, except that unit substation U15 would refeed the Storage Building No. 3 loads. This alternative would address concerns with the existing unit substation U12 wet location and result in a net reduction of two unit substations. Unit substation U13 would be removed entirely and its existing loads would be refed from existing unit substation U2 and a new 480-volt MCC in Shop Building No. 1.

D. Alternative USUB No. 3–Replace Unit Substation U12 with One New Indoor Unit Substation and Eliminate Unit Substations U11 and U13

This alternative would replace unit substation U12 with a new unit substation located in a less-shaded location west of the Effluent Building. Existing loads fed from unit substation U11 would be refed from nearby unit substations U14 and U15. Unit substation U13 would be removed entirely and its existing loads would be refed from existing unit substation U2 and a new 480-volt MCC in Shop Building No. 1.

SCREENING OF ALTERNATIVES

Based on discussions at Workshop No. 8 the following three alternatives were short-listed and will be evaluated in detail.

§ Alternative USUB No. 0–No Change (Null Alternative)
§ Alternative USUB No. 2–Replace Unit Substations U11 and U12 with One New Indoor Unit Substation and Eliminate Unit Substation U13

§ Alternative USUB No. 3–Replace Unit Substation U12 with One New Indoor Unit Substation and Eliminate Unit Substations U11 and U13

Alternative USUB No. 1 was eliminated from further consideration because this alternative requires two new indoor unit substations to be constructed, one to replace unit substation U11 and one to replace unit substation U12. Existing unit substations U14 and U15 have spare electrical capacity and are located near the electrical loads currently served by unit substation U11. The District determined that building a new unit substation U11 dedicated to feeding only the minor electrical loads currently served by unit substation U11, was not economical.

DETAILED EVALUATION OF ALTERNATIVES

This section includes a detailed evaluation of each short-listed unit substations U11, U12, and U13 Replacement Alternative. Opinions of probable construction costs, when applicable, and non-monetary benefits and challenges are included and summarized for each alternative.

A. Alternative USUB No. 0–No Change (Null Alternative)

1. Description of Alternative

Alternative USUB No. 0 would leave existing unit substations U11, U12, and U13 in operation. Unit substation U13 now serves non-critical loads and its electrical load has been significantly reduced since maintenance operations and staff moved to the recently-constructed Maintenance Building. However, unit substations U11 and U12 serve critical processes loads that could significantly affect NSWWTP operation if unit substation equipment fails.

2. Cost Considerations

There are no upfront costs associated with this alternative. There would be future costs associated with the time and materials required for NSWWTP maintenance staff to troubleshoot and repair unit substation equipment as it fails, which are not able to be reliably estimated. However, repair costs for equipment at these unit substations will continue to rise as it becomes increasingly difficult to access replacement parts.

3. Non-monetary Considerations

a. Benefits

§ None

b. Limitations

§ Unit substation equipment is operating beyond its expected service life and the potential for equipment failure will increase as equipment ages.

§ Unit substation equipment enclosures are severely rusted, which increases the likelihood of damage to equipment from rain, snow, and rodent intrusion.

B. Alternative USUB No. 2–Replace Unit Substations U11 and U12 with One New Indoor Unit Substation and Eliminate Unit Substation U13

1. Description of Alternative

Alternative USUB No. 2 would replace unit substations U11 and U12 with one new large, indoor unit substation located relatively equidistant from both existing unit substations to serve all of the existing unit substations U11 and U12 electrical loads, except for two MCCs in Storage Building No. 3, which are currently fed from unit substation U11 but could be refed more economically from nearby unit substation U15. Unit substation U13 would be removed entirely and its existing loads would be refed from existing unit substation U2 and a new 480-volt MCC in Shop Building No. 1.

2. New Unit Substation

This alternative includes one new large unit substation to feed the existing 480-volt loads currently fed from unit substations U11 and U12. The unit substation would also include additional capacity to serve future equipment associated with NSWWTP process expansion on the west side of the NSWWTP.

The new unit substation would use the same main-tie-main circuit breaker configuration on the 480-volt distribution switchgear similar to other unit substations at the NSWWTP. The 480-volt switchgear would be fed from redundant 4.16-kV to 480-volt, step-down transformers, each fed directly from main switchgear S1. Power meters would also be included for each 480-volt main circuit breaker and be connected to the existing NSWWTP SCADA System. A 480-volt MCC would also be included in the new unit substation building to serve miscellaneous building and HVAC loads.

Based on the peak electrical loading recorded for existing unit substations U11 and U12 over the past 10 years (approximately 1,000 kVA), redundant 2,000 kVA transformers should provide adequate electrical capacity to power existing electrical loads currently fed from unit substations U11 and U12, as well as future loads associated with process expansion on the west side of the NSWWTP. Capacity would also be available to power a portion of the potential future 480-volt load associated with blower equipment upgrades in the West Blower Building. Potential future blower equipment upgrades could potentially include a change from blowers using medium-voltage motors to blowers using 480-volt motors. New 480-volt blower motors could be fed from this unit substation and/or unit substation U14.

A medium-voltage vacuum circuit breaker would be installed ahead of each transformer to allow the transformers to be isolated from the medium-voltage distribution system. New below-grade, concrete-encased duct bank would need to be installed and routed to an existing medium-voltage electrical manhole southeast of the Effluent Building so new medium-voltage cables could be installed from main switchgear S1 to the new unit substation's primary medium-voltage vacuum circuit breakers.

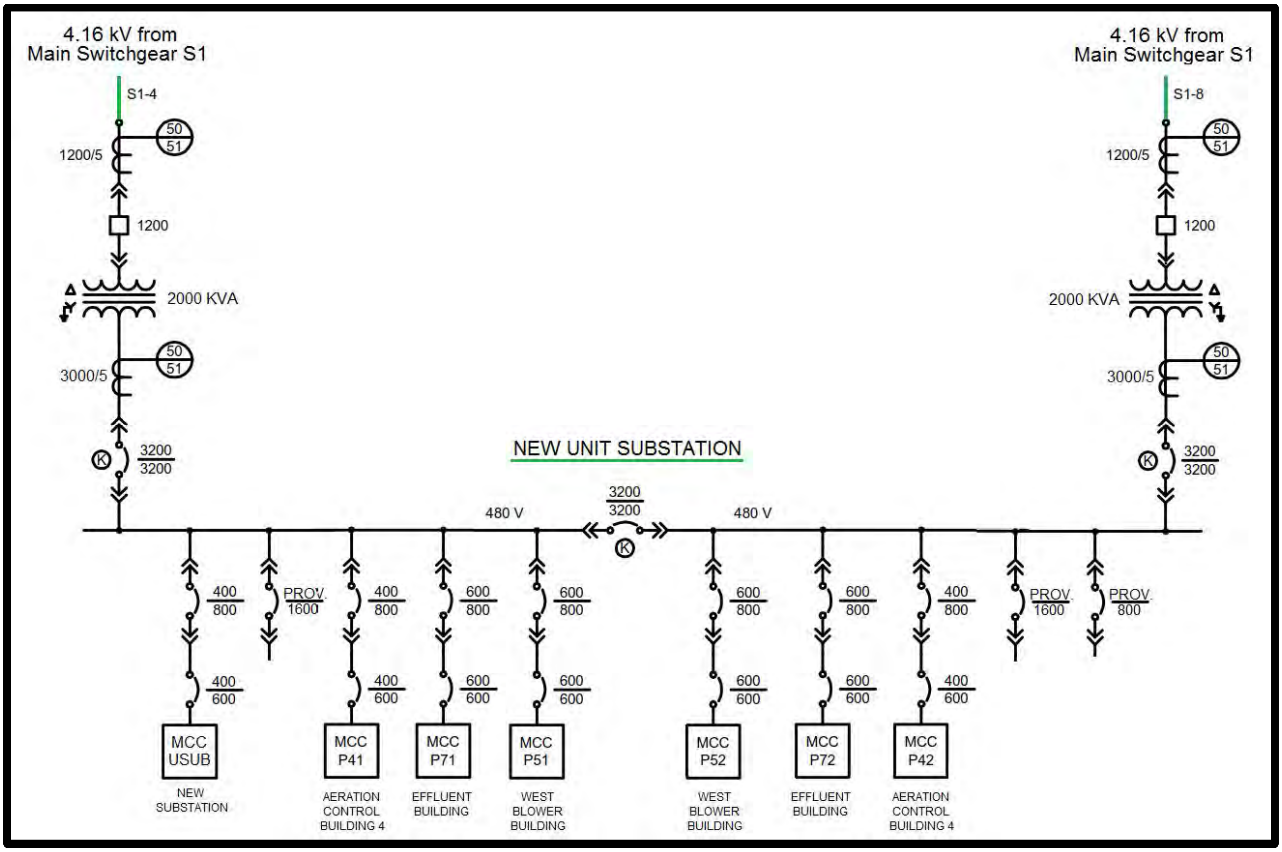

Figure 22–Alternative USUB No. 2–New Unit Substation One-Line Diagram

To limit voltage drop concerns and excessive conductor oversizing, the unit substation should be located central to loads currently served by unit substations U11 and U12. It is possible that the open area directly west of the nitrification tanks could be used for future process expansion, so the new unit substation should be located north of this area to avoid potential conflicts with NSWWTP process expansion. A recommended location for the new unit substation is identified in Figure 23. Note that this unit substation location would likely encroach on the storage lot immediately west of the proposed unit substation location, and would also likely require some earthwork to avoid conflicts with, or reroute the existing drainage swale.

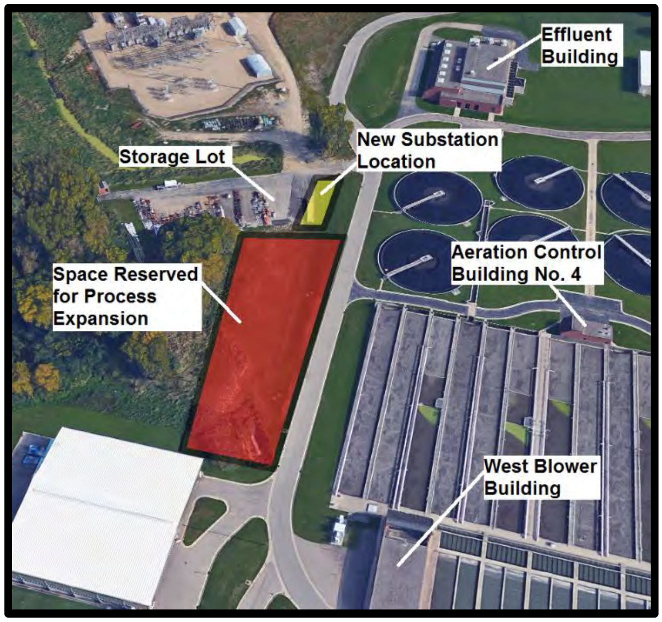

Figure 23–Alternative USUB No. 2–New Unit Substation Location

The new unit substation building construction would match newer unit substations at the NSWWTP and include a below-grade cable vault to simplify conduit and wire entrances into the unit substation distribution equipment. Heating and mechanical cooling would also be included, as needed, to maintain reasonable temperatures and humidity inside the building. The use of indoor or outdoor transformers will impact HVAC demands and building size.

The recently-installed fiber optic cabling routed between the Effluent Building and Aeration Control Building No. 4 would need to be rerouted to the new unit substation building using new concrete-encased duct bank conduit routed to an existing electrical/fiber optic manhole southwest of the Effluent Building to connect the new unit substations building PLC control panel into the existing SCADA System Ethernet network.

3. Unit Substation U11 Demolition

Unit substation U11 currently feeds 480-volt power to two MCCs in the West Blower Building and to two MCCs in Storage Building No. 3. The 480-volt switchgear in unit substation U15 has an existing 1,600-amp provisional space where a new circuit breaker can be installed, as well as a spare conduit routed to a 480-volt manhole that intercepts existing conduits routed from unit substation U11 to the Storage Building No. 3 MCCs. The Storage Building No. 3 MCCs are old and should be replaced with one new MCC to accept a single power feed from unit substation U15. Storage Building No. 3 originally had redundant MCCs with redundant unit substation power feeds because it was used as a grit processing facility, but now only powers miscellaneous building loads and a tunnel exhaust fan. The new Storage Building No. 3 MCC can be installed and refed from unit substation U15 any time before unit substation U11 is deenergized.

Common circuit breakers on each side of the main switchgear S1 bus-tie circuit breaker currently feed power to both unit substations U11 and U3, and the west blowers medium-voltage switchgear. However, the significantly increased electrical load expected to be supplied by the new unit substation and the significant load already connected to unit substation U3 and the west blowers might require that these two unit substations be powered from different circuit breakers on each side of the main switchgear S1 bus-tie breaker to avoid excessively high long-time trip settings for the associated protection relays in main switchgear S1, which could require oversized medium-voltage conductors to be installed to each unit substation, and potentially to the medium-voltage switchgear in the West Blower Building as well. Oversized conductors could conflict with existing duct bank conduit sizes or quantities, and would significantly increase upfront installation costs. Feeding the new unit substation and unit substation U3 from different circuit breakers would also be beneficial because the new unit substation could be wired to main switchgear S1 and energized before the medium-voltage power conductors currently installed from main switchgear S1 to unit substations U11 and U3 are removed.

Note that this memorandum includes an evaluation for replacing medium-voltage switchgear in the West Blower Building, so the feed from main switchgear S1 to the west blowers could potentially be planned for replacement if the west blower's switchgear is also being replaced.

After the new unit substation is brought online, but before the medium-voltage power conductors to unit substations U11 and U13 are removed, the existing West Blower Building MCCs can be refed from the new unit substation one at a time such that at least one of the MCCs will be powered at all times. Both MCCs in the West Blower Building should also be considered for replacement in the near future due to age.

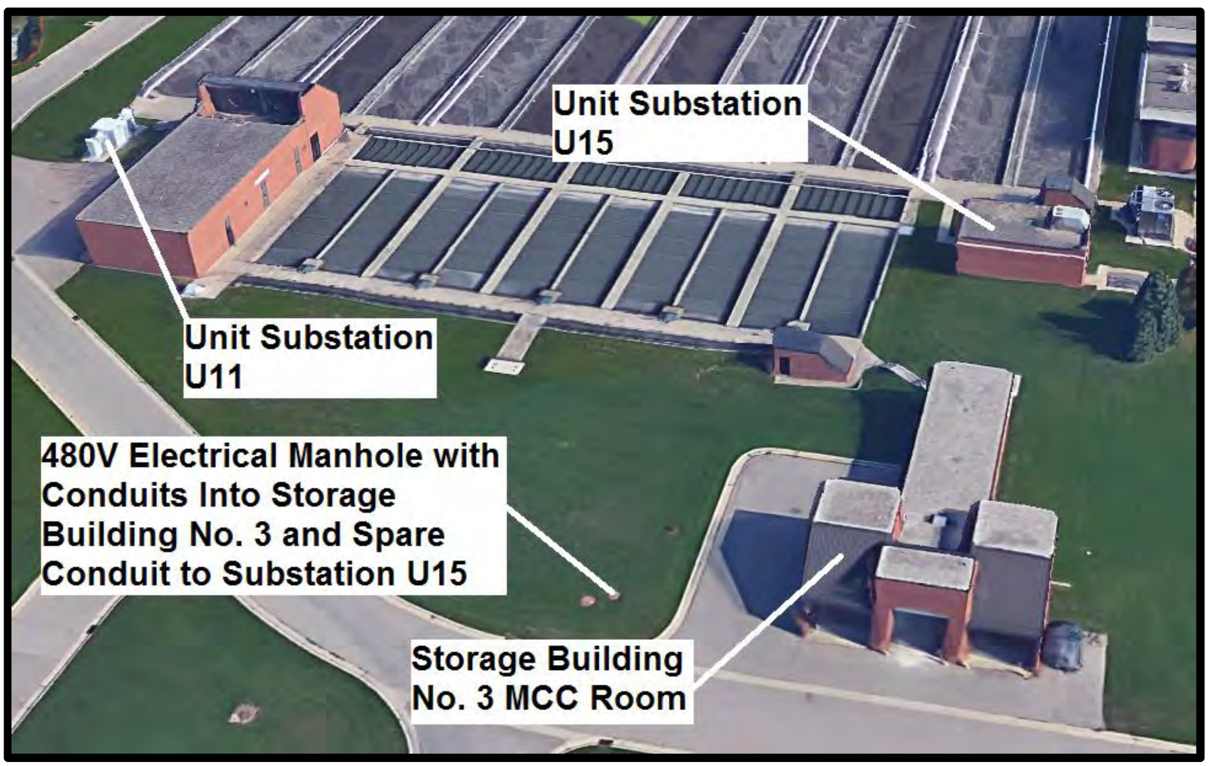

Figure 24–Storage Building No. 3 and Unit Substations U11 and U15 Site Map

Line-side taps on the fused, medium-voltage primary switches at unit substation U11 feed 4.16 kV power to the medium-voltage primary circuit breakers at unit substation U3, which would need to remain online at all times. Existing medium-voltage power conductors from main switchgear S1 to unit substation U11 and from unit substation U11 to unit substation U3 should be removed and new conductors should be installed in existing concrete-encased duct bank conduits directly from main switchgear S1 to unit substation U3. Medium-voltage conductors to each of the unit substation U3 primary circuit breakers can be replaced one at a time to keep unit substation U3 online at all times.

4. Unit Substation U12 Demolition

Unit substation U12 currently feeds 480-volt power to two MCCs in the Effluent Building and to two MCCs in Aeration Control Building No. 4. After the new combined unit substation is brought online, power feeds from existing unit substation U12 to the Effluent Building MCCs and to the Aeration Control Building No. 4 MCCs can be replaced one at a time. Both MCCs in the Effluent Building and both MCCs in Aeration Control Building No. 4 should be considered for replacement in the near future due to age.

Dedicated medium-voltage power feeds to the unit substation U12 primary switches are fed directly from main switchgear S1 and can be removed in their entirety along with unit substation U12 after all existing unit substation U12 electrical loads are powered from the new unit substation.

5. Unit Substation U13 Demolition

Unit substation U13 currently feeds 480-volt power to a disconnect switch at the Service Building, a MCC in Shop Building No. 1, and a disconnect switch in Shop Building No. 2. Shop Building Nos. 1 and 2 each sub-feed Storage Building Nos. 1 and 2 respectively, as shown in Figure 21.

The MCC in Shop Building No. 1 is old and should be replaced with a new MCC that would then feed the miscellaneous Shop Building No.1 electrical loads, which have been significantly reduced since maintenance operations moved to the new Maintenance Building. This MCC would be fed with a single 480-volt power feed from existing unit substation U2. Unit substation U2 currently supplies a 480-volt, 800-amp power feed directly to the unit substation U13 480-volt switchgear bus. Conduit for this 480-volt power feed is routed through the lower level of Shop Building No. 1 and could be easily intercepted and routed to the new MCC, and then reused to install new 480-volt power conductors from unit substation U2 to the new Shop Building No. 1 MCC. The new MCC could be powered from unit substation U2 while the existing MCC remains powered from unit substation U13 so that existing electrical loads can be moved from the existing MCC to the new MCC one at a time.

The new MCC in Shop Building No. 1 would also be used to feed 480-volt power to the Service Building disconnect switch and the Shop Building No. 2 fused disconnect switch, which would remove all loading from unit substation U13. Concrete-encased duct bank conduits at unit substation U13 could be intercepted below grade and reused for new 480-volt power feeds from the new MCC. Maintaining power to the Service Building and Shop Buildings No. 1 and 2 is not critical, so a single 480-volt power feed from unit substation U2 to the new Shop Building No. 1 MCC would be sufficient. For reference, the new Maintenance Building is only fed with a single power feed from unit substation U14. The existing step-down transformer and distribution panelboard (DP131) in the Service Building are old and should be considered for replacement.

Line-side taps on the fused medium-voltage primary switches at unit substation U13 each feed 4.16 kV power to the fused medium-voltage primary switches at unit substation U2, which would need to remain online at all times. Existing medium-voltage conductors to unit substations U13 and U2 should be removed and new conductors should be installed in existing concrete-encased duct bank conduits directly from main switchgear S1 to unit substation U2. Medium-voltage conductors to each of the unit substation U2 primary switches can be replaced one at a time to keep unit substation U2 online at all times.

Note that the existing medium-voltage conductors to unit substation U13 have been in service since the unit substation was originally brought online in 1983 and should not be spliced to extend power directly to unit substation U2. Aging medium-voltage cables are prone to insulation breakdown resulting in arc fault events, and the existing cable has been in use for over 30 years, which is beyond its expected service life.

Figure 25 shows the 480-volt power feed currently installed from unit substation U2 to unit substation U13, which would be intercepted and extended to a new MCC in Shop Building No. 1.

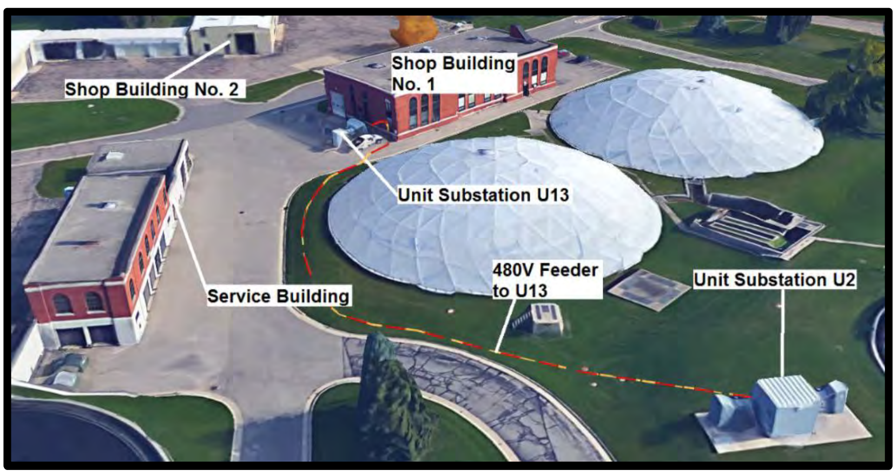

Figure 25–Unit Substation U13 Site Map

Figure 26 shows new medium voltage conductors from main switchgear S1 directly to unit substation U2. It also shows the 480-volt power feed from unit substation U2 that currently connects directly to the unit substation U13 480-volt distribution switchgear being replaced with a power feed routed to the new Shop Building No. 1 MCC (MCC-P121). New 480-volt power feeds to the Service Building disconnect switch and the Shop Building No. 2 fused disconnect switch are also shown.

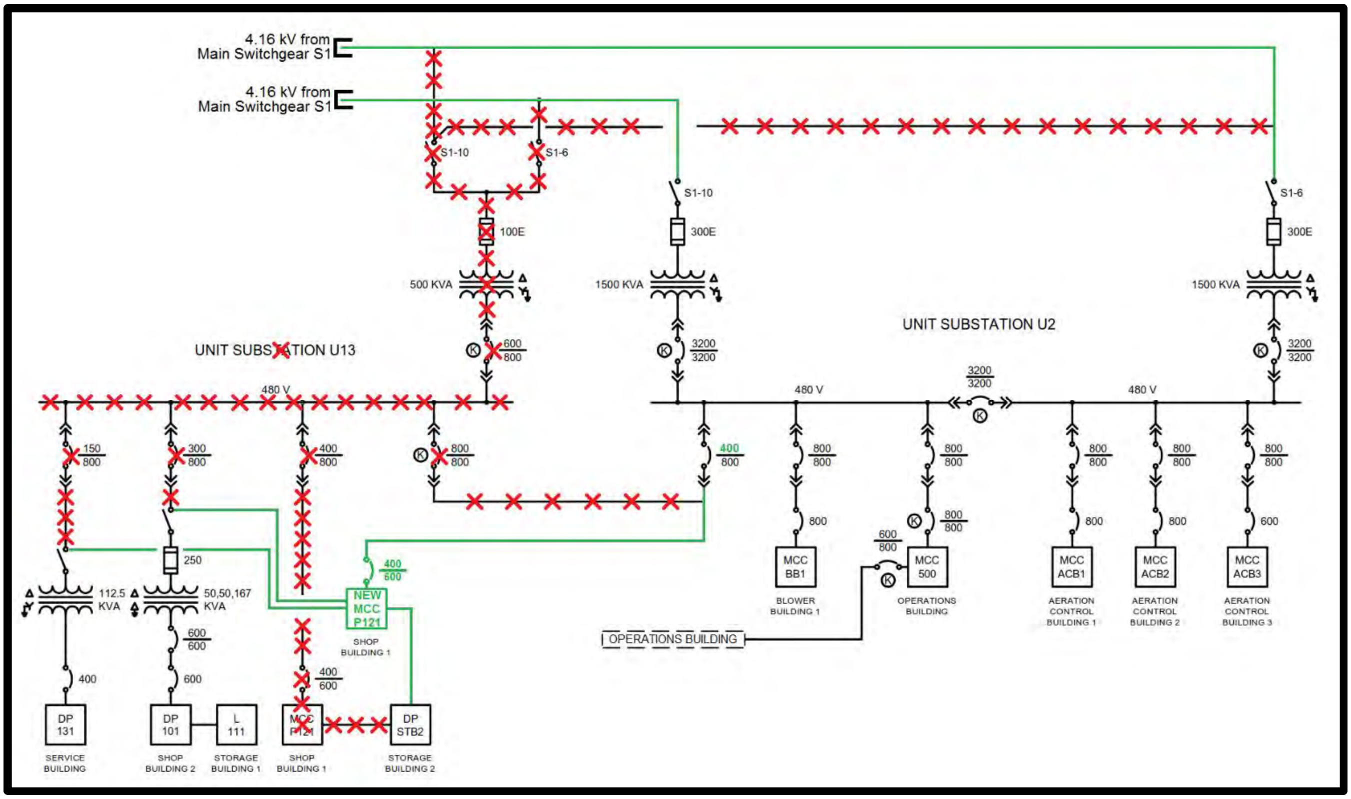

Figure 26–Alternative USUB No. 2–Unit Substations U2 and New MCC-P121 Feeders

6. Cost Considerations

The upfront cost would be significant due to the medium-voltage cable being installed from main switchgear S1 to unit substations U2 and U3 and the new unit substation, the new unit substation equipment, and the new unit substation building. Long-term operating costs would increase because outdoor unit substations are being replaced with a new unit substation building and the additional energy consumed by building electrical and HVAC loads. However, replacing old unit substation equipment and wiring would improve the power distribution system reliability and reduce the likelihood of conductor faults.

The following budgetary OPCC in Table 8 details potential equipment and installation costs, and was developed based on the use of indoor, dry-type unit substation transformers. An upfront-cost evaluation associated with the use of indoor, dry-type or outdoor, liquid-filled transformers is included later in this memorandum in alternatives USUB-XFMR No. 1 and USUB-XFMR No. 2.

Table 8–Alternative USUB No. 2 OPCC

Item	Qty	Price	Installation Factor	Total	Comments
Unit Substation U13 Removal					
Demolition and Phasing	1	$ 25,000	1	$ 25,000	2 Electricians for 3 weeks + Equipment
New MCC-P121 in Storage Building No. 1	1	$ 25,000	1.4	$ 35,000	3 sections with 480V feeders and A-B PowerMonitor 5000
Conduit/Wire Tie-In to MCC-P121	1	$ 15,000	1	$ 15,000	
235A, 15kV Cable to Unit Substation U2 (ft)	2300	$ 33	1	$ 75,900	Installed in existing duct bank conduit from S1
Medium Voltage Cable Terminations	1	$ 5,000	1	$ 5,000	Terminations for switchgear
150A, 480V Feeder to Service Building (ft)	320	$ 17	1	$ 5,440	Installed in existing duct bank conduit from new MCC-P121
300A, 480V Feeder to Shop Building No. 2 (ft)	250	$ 36	1	$ 9,000	Installed in existing duct bank conduit from new MCC-P121
400A, 480V Feeder from U2 to Shop Building No. 1 (ft)	400	$ 72	1	$ 28,800	Installed in existing duct bank conduit from Substation U2
Ductbank Conduit Tie-Ins	1	$ 15,000	1	$ 15,000	
Excavation, Backfill, and Asphalt Repair	1	$ 8,000	1	$ 8,000	
Adjust Substation U2 Circuit Breaker Settings	1	$ 2,000	1	$ 2,000	
Misc. Conduit and Wiring	1	$ 5,000	1	$ 5,000	
New Large Unit Substation to Replace U11 and U12					
Demolition and Phasing for U11 and U12	1	$ 37,000	1	$ 37,000	2 Electricians for 5 weeks + Equipment
New Unit Substation Electrical Gear	1	$ 545,000	1.15	$ 626,750	
New MCC	1	$ 20,000	1.4	$ 28,000	
Building Construction	1	$ 382,000	1	$ 382,000	
HVAC Equipment	1	$ 55,000	1	$ 55,000	
Natural Gas Service	1	$ 25,000	1	$ 25,000	New Service from MG&E
Misc. Electrical Lighting, Receptacles, etc.	1	$ 20,000	1	$ 20,000	
Route Fiber Optic Cable Through New Substaiton (ft)	1	$ 10,000	1	$ 10,000	
Ductbank to Existing Fiber/Electrical Manhole (ft)	250	$ 105	1	$ 26,250	
480V Electrical/Fiber Manhole	1	$ 6,000	1	$ 6,000	
4.16kV Electrical/Fiber Manhole	1	$ 6,000	1	$ 6,000	
New SCC	1	$ 30,000	1.2	$ 36,000	
Excavation, Backfill, and Asphalt Repair	1	$ 50,000	1	$ 50,000	
600A, 15kV Cable from S1 to New Substation (ft)	1300	$ 92	1	$ 119,600	
235A, 15kV Cable from S1 to U3 (ft)	5500	$ 39	1	$ 214,500	Installed in existing duct bank conduit
Medium Voltage Cable Terminations	1	$ 10,000	1	$ 10,000	Terminations for switchgear
400A, 480V Cable to Aeration Control Building 4 MCCs	1000	$ 60	1	$ 60,000	Installed in existing duct bank conduit
600A, 480V Cable to Effluent Building MCCs	1400	$ 70	1	$ 98,000	Installed in existing duct bank conduit
600A, 480V Cable to West Blower Building MCCs	1400	$ 70	1	$ 98,000	Installed in existing duct bank conduit
400A, 480V Cable and conduit to new MCC-USUB	50	$ 108	1	$ 5,400	Installed in existing duct bank conduit
Storage Building 3 Power Feed					
480V Breaker in U15 for Storage Building 3 MCC	1	$ 50,000	1	$ 50,000	Installation by Square D service department
New Storage Building 3 MCC	1	$ 20,000	1.5	$ 30,000	Includes conduit and wire extensions
300A, 480V Cable from U15 to New MCC	300	$ 36	1	$ 10,800	In existing duct bank and conduit
Misc. Conduit and Wiring Extensions	1	$ 10,000	1	$ 10,000	
SCADA System PLC/HMI Programming	1	$ 2,000	1	$ 2,000	District-provided programming for interfacing new power meter signals with plant SCADA HMI
Arc Flash, Coordination, and Thermographic Studies	1	$ 50,000	1	$ 50,000	
Subtotal				**$ 2,295,440**	
Contingencies and Engineering Services (50%)				**$ 1,147,700**	
Total				**$3,443,140**	

3. Non-monetary Considerations

a. Benefits

§ Replacing aging unit substation equipment would address concerns with the potential for increased equipment failures.

- § One new unit substation is being installed while three unit substations are being removed, two of which are currently located near roadways/parking lots.

- § New equipment would be located inside of a building, which helps equipment last longer and provides a safer environment for operating and maintaining the equipment.

- § Replacing aging medium-voltage cables would address concerns with the increasing potential for arc-fault events.

b. Limitations

- § The only location central to the loads served by the new unit substation impedes on an existing storage lot area and might require earthwork to avoid restricting the drainage swale.

C. <u>Alternative USUB No. 3–Replace Unit Substation U12 with One New Indoor Unit Substation and Eliminate Unit Substations U11 and U13</u>

1. Description of Alternative

Alternative USUB No. 3 would replace unit substation U12 with one new indoor unit substation located near the Effluent Building, and unit substations U11 and U13 would be removed entirely. Unit substation U11 loads would be refed from unit substation U14 located in the Metrogro Pump Station. The two MCCs in Storage Building No. 3 that are currently fed from unit substation U11 and would be replaced with one new MCC that could be powered from nearby unit substation U15. Unit substation U13 would be removed entirely and its existing loads would be refed from existing unit substation U2 and a new 480-volt MCC in Shop Building No. 1.

2. New Unit Substation U12 and Existing Unit Substation U12 Demolition

This alternative includes one new unit substation to feed the existing 480-volt loads currently fed from unit substation U12. The unit substation would also include additional capacity to serve potential future equipment associated with NSWWTP process expansion west of the Effluent Building.

New unit substation U12 would use the same main-tie-main circuit breaker configuration on the 480-volt distribution switchgear similar to other unit substations at the NSWWTP. The 480-volt switchgear would be fed from redundant 4.16-kV to 480-volt, step-down transformers, each fed directly from either side of the main switchgear S1 bus-tie circuit breaker. Power meters would also be included for each 480-volt main circuit breaker and be connected into the existing NSWWTP SCADA System. A 480-volt MCC would be included in the new unit substation U12 building to serve miscellaneous building and HVAC loads.

Based on the peak electrical loading recorded for existing unit substation U12 over the past 10 years (approximately 800 kVA), redundant 1500 kVA transformers should provide adequate electrical capacity to power existing electrical loads fed from existing unit substation U12 and future electrical loads associated with potential process expansion east of the Effluent Building. A primary medium-voltage circuit breaker would be installed ahead of each transformer to allow the transformers to be isolated from the medium-voltage distribution system.

New unit substation U12 can be installed while existing unit substation U12 remains online. One of the redundant 4.16-kV power feeds from main switchgear S1 to existing unit substation U12 can be removed and replaced with a new power feed from main switchgear S1 to new unit substation U12, allowing both the existing and new U12 to be energized at the same time. MCC loads can then be transferred from existing unit substation U12 to new unit substation U12 one at a time until all loads have been removed from existing unit substation U12. The remaining 4.16-kV power feed from main switchgear S1 to existing unit substation U12 can then be removed and replaced with a new power feed from main switchgear S1 to new unit substation U12. Existing unit substation U12 can then be removed entirely.

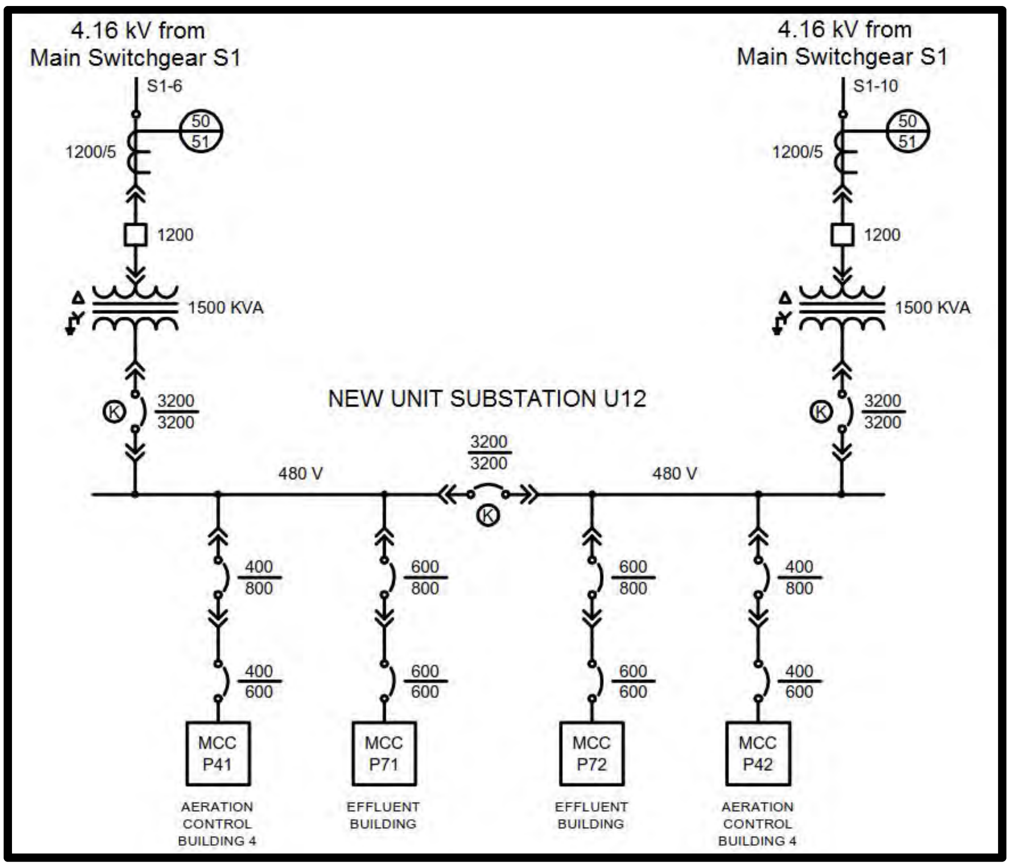

Figure 27–Alternative USUB No. 3–New Unit Substation U12 One-Line Diagram

The new unit substation building could be located southwest of the Effluent Building in the location identified for the new substation proposed under Alternative USUB No. 2. An alternative location for the new substation would be south of the Effluent Building located on the other side of the roadway/parking lot. However, this area could complicate duct bank routing because the substation would be surrounded by process piping. If the new substation is located in the same place as the existing parking lot, duct bank routing to the Effluent Building and Aeration Control Building No. 4 would be simplified.

The new unit substation would include a below-grade cable vault to simplify conduit and wire entrances into the unit substation electrical distribution equipment. New 480-volt power feeds to the Aeration Control Building No. 4 MCCs could be routed south in new concrete-encased duct bank to the 480-volt electrical manhole directly west of Aeration Control Building No. 4, and then in existing conduit from the manhole to each MCC. New 480-volt power feeds to the Effluent Building MCCs could be routed in new and existing duct bank along the west side of the Effluent building, and then in new duct bank north of the Effluent Building as needed for conduits to enter the Effluent Building Main Switchgear S1 Electrical Room, which also houses the two Effluent Building MCCs.

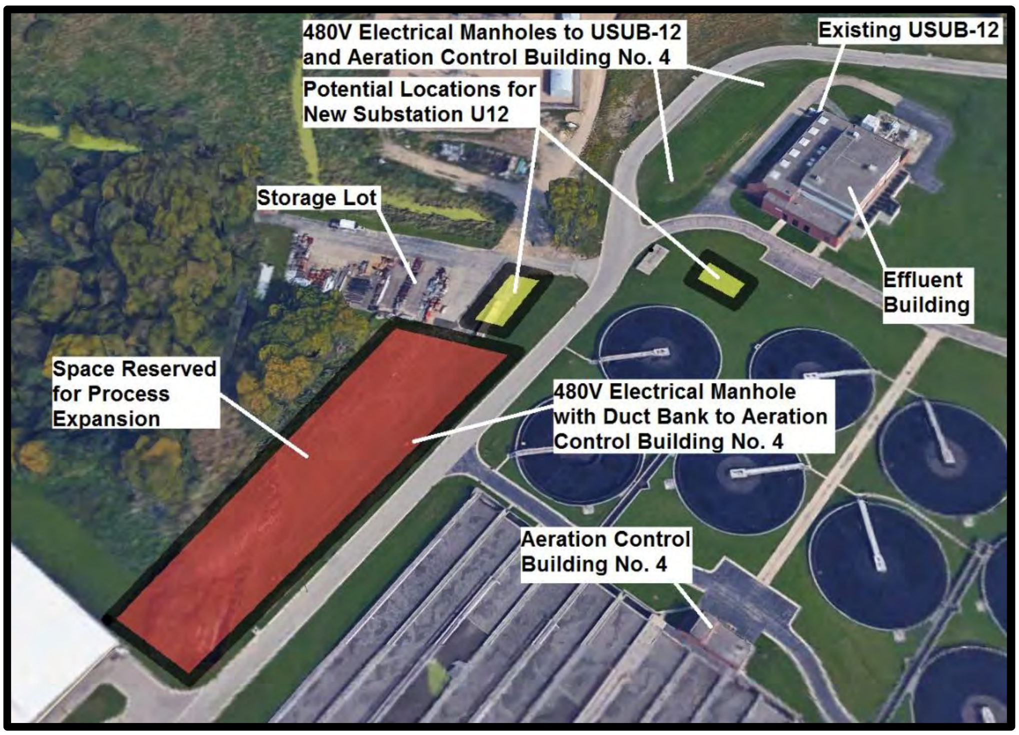

Figure 28–Alternative USUB No. 3–New Unit Substation U12 Site Map

3. Unit Substation U11 Demolition

Unit substation U11 currently feeds 480-volt power to two MCCs in the West Blower Building and to two MCCs in Storage Building No. 3. The Storage Building No. 3 MCCs would be replaced and be refed from unit substation U15 as previously described under Alternative USUB No. 2.

Existing unit substation U14 is installed in the Metrogro Pump Station and serves the pump station and Dewatering Building. New 480-volt circuit breakers can be installed in unit substation U14 and new power conductors can be installed in new below-grade, concrete-encased duct bank to the West Blower Building MCCs while unit substation U11 is still online. The new duct bank route would require a portions of the existing NSWWTP roadway asphalt to be removed and replaced.

Unit substation U14 has redundant 1500 kVA transformers with significant spare electrical capacity to accommodate the West Blower Building MCC loads, which over the past 10 years peaked at about 90 kVA. The unit substation U14 room inside the Metrogro Pump Station also has space to add a second unit substation lineup behind the existing lineup, which could be used to feed potential future 480-volt blower equipment upgrades in the West Blower Building.

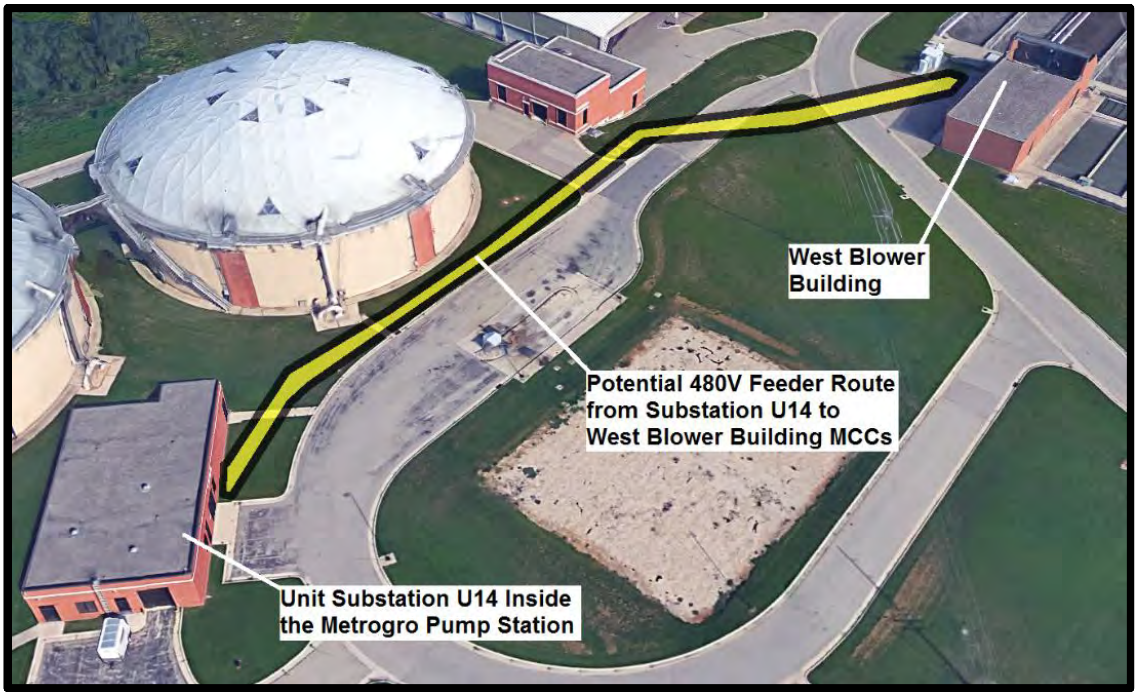

Figure 29–Alternative USUB No. 3–Duct Bank Routing from Unit Substation U14

Line-side taps on the fused medium-voltage primary switches at unit substation U11 currently feed 4.16-kV power to the medium-voltage primary circuit breakers at unit substation U3, which would need to remain online at all times. Existing medium-voltage conductors from main switchgear S1 to unit substations U11 and U3 should be removed and new conductors should be installed directly from main switchgear S1 to unit substation U3. Medium-voltage conductors to each of the unit substation U3 primary circuit breakers can be replaced one at a time to keep unit substation U3 online at all times.

After the West Blower Building MCCs are powered from unit substation U14, unit substation U15 is powering the new Storage Building No. 3 MCC, and unit substation U3 has been refed directly from main switchgear S1, unit substation U11 can be removed in its entirety.

This project would provide the District with an opportunity to upgrade the existing unit substation U14 480-volt distribution switchboards with draw-out switchgear construction. Pricing for this upgrade is included in the OPCC under Cost Considerations below.

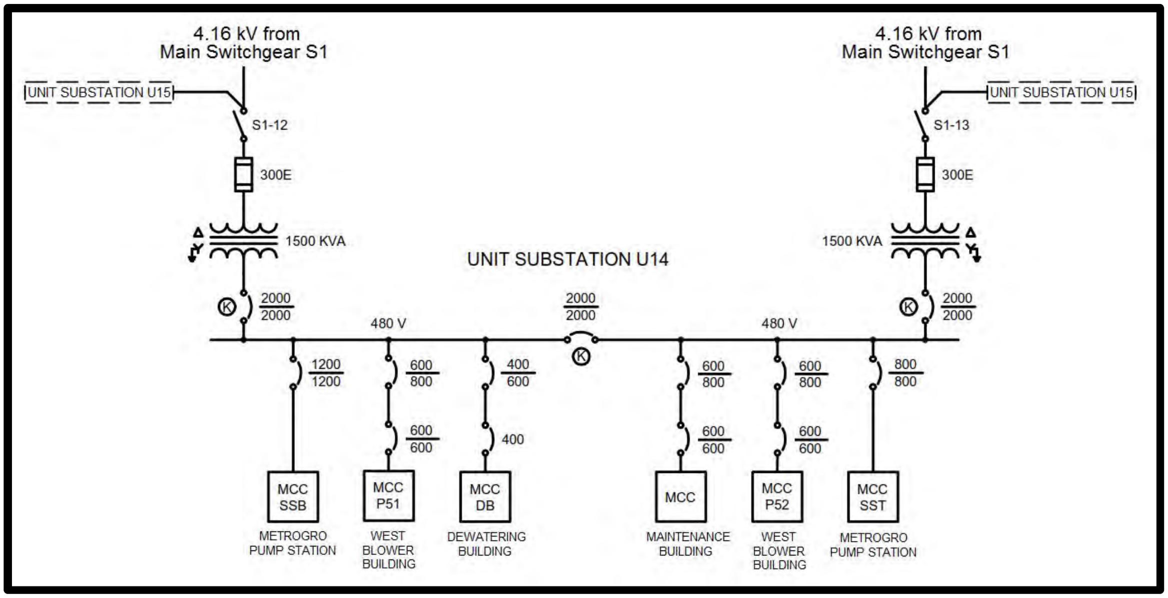

Figure 30–Alternative USUB No. 3–Updated Unit Substation U14 One-Line Diagram

4. Unit Substation U13 Demolition

For this alternative, removing unit substation U13 and refeeding its existing loads requires the same work previously described under Alternative USUB No. 2.

5. Cost Considerations

The upfront cost would be significant due to the medium-voltage cable replacements, new unit substation equipment, and new duct bank required for the 480-volt power feeds from unit substation U14 to the West Blower Building MCCs. Long-term operating costs would increase because outdoor unit substations are being replaced with a new unit substation building and the additional energy consumed by building electrical and HVAC loads. However, replacing old unit substation equipment and wiring would improve the power distribution system reliability and reduce the likelihood of conductor faults.

The OPCC also includes the cost to upgrade the 480-volt distribution sections in unit substation U14 to draw-out switchgear construction, including new circuit breakers for all existing loads and the new power feeds to the West Blower Building MCCs. Installing new circuit breakers in the existing unit substation U14 480-volt distribution sections instead of replacing the sections with draw-out switchgear could reduce the OPCC by approximately $90,000.

The following budgetary OPCC in Table 9 details potential equipment and installation costs, and was developed based on the use of indoor, dry-type unit substation transformers. An upfront-cost evaluation associated with the use of indoor, dry-type or outdoor, liquid-filled transformers is included later in this memorandum in alternatives USUB-XFMR No. 1 and USUB-XFMR No. 2.

Table 9–Alternative USUB No. 3 OPCC

Item	Qty	Price	Installation Factor	Total	Comments
Unit Substation U13 Removal					
Demolition and Phasing	1	$ 25,000	1	$ 30,000	2 Electricians for 3 weeks + Equipment
New MCC-P121 in Storage Building No. 1	1	$ 25,000	1.4	$ 35,000	3 sections with 480V feeders and A-B PowerMonitor 5000
Conduit/Wire Tie-In to MCC-P121	1	$ 15,000	1	$ 15,000	
235A, 15kV Cable from S1 to U2 (ft)	2300	$ 33	1	$ 75,900	Installed in existing duct bank conduit from Main Switchgear S1.
Medium Voltage Cable Terminations	1	$ 5,000	1	$ 5,000	Terminations for switchgear
150A, 480V Feeder to Service Building (ft)	320	$ 17	1	$ 5,440	Installed in existing duct bank conduit from new MCC-P121
300A, 480V Feeder to Shop Building No. 2 (ft)	250	$ 36	1	$ 9,000	Installed in existing duct bank conduit from new MCC-P121.
400A, 480V Feeder to Shop Building No. 1 (ft)	400	$ 72	1	$ 28,800	Installed in existing duct bank conduit from Substation U2.
Ductbank Conduit Tie-Ins	1	$ 15,000	1	$ 15,000	
Excavation, Backfill, and Asphalt Repair	1	$ 8,000	1	$ 8,000	
Adjust Substation U2 Circuit Breaker Settings	1	$ 2,000	1	$ 2,000	
Misc. Conduit and Wiring	1	$ 5,000	1	$ 5,000	
New Unit Substation U12					
Demolition and Phasing for U11 and U12	1	$ 37,000	1	$ 37,000	2 Electricians for 5 weeks + Equipment
New Unit Substation Electrical Gear	1	$ 497,000	1.15	$ 571,550	
New MCC	1	$ 20,000	1.4	$ 28,000	
Building Construction	1	$ 375,000	1	$ 375,000	
HVAC Equipment	1	$ 45,000	1	$ 45,000	
Misc. Electrical Lighting, Receptacles, etc.	1	$ 18,000	1	$ 18,000	
Fiber Optic Cable Connections	1	$ 7,500	1	$ 7,500	
480V Electrical Manhole	1	$ 6,000	1	$ 6,000	
Ductbank from New U12 to Effluent Building	380	$ 85	1	$ 32,300	
Excavation, Backfill, and Asphalt Repair	1	$ 30,000	1	$ 30,000	
235A, 15kV Cable from S1 to New U12 (ft)	600	$ 85	1	$ 51,000	
235A, 15kV Cable from S1 to U3 (ft)	5500	$ 39	1	$ 214,500	Installed in existing duct bank conduit
Medium Voltage Cable Terminations	1	$ 10,000	1	$ 10,000	Terminations for switchgear
400A, 480V Cable to Aeration Control Building 4 MCCs	1100	$ 60	1	$ 66,000	Installed in new and existing duct bank conduit
600A, 480V Cable to Effluent Building MCCs	1300	$ 70	1	$ 91,000	Installed in existing duct bank conduit
Storage Building 3 Power Feed					
480V Breaker in U15 for Storage Building 3 MCC	1	$ 50,000	1	$ 50,000	Installation by Square D service department included.
New Storage Building 3 MCC	1	$ 20,000	1.5	$ 30,000	Includes conduit and wire extensions
300A, 480V Cable from U15 to New MCC	300	$ 36	1	$ 10,800	In existing duct bank and conduit
Misc. Conduit and Wiring Extensions	1	$ 10,000	1	$ 10,000	
West Blower Building Power Feed					
Retrofit Drawout Swtichgear into U14 w/ Breakers	1	$ 130,000	1	$ 130,000	Installation by Square D service department included.
Ductbank to West Blower Building (ft)	650	$ 85	1	$ 55,250	
Excavation, Backfill, and Asphalt Repair	1	$ 20,000	1	$ 20,000	
600A, 480V Cable to West Blower Building MCCs	1400	$ 70	1	$ 98,000	Installed in new duct bank conduit
Misc. Conduit and Wiring Extensions	1	$ 15,000	1	$ 15,000	
SCADA System PLC/HMI Programming	1	$ 2,000	1	$ 2,000	District-provided programming for interfacing new power meter signals with plant SCADA HMI.
Arc Flash, Coordination, and Thermographic Studies	1	$ 35,000	1	$ 35,000	
Subtotal				**$ 2,273,040**	
Contingencies and Engineering Services (50%)				**$ 1,136,500**	
Total				**$3,409,540**	

3. Non-monetary Considerations

a. Benefits

- Replacing aging unit substation equipment would address concerns with the potential for increased equipment failures.
- One new unit substation is being installed while three unit substations are being removed, two of which are currently located near roadways/parking lots.
- This alternative takes advantage of spare capacity in existing unit substations U2, U14, and U15 to feed loads currently served by existing unit substations U11 and U13.
- New unit substation U12 equipment would be located inside of a building, which helps equipment last longer and provides a safer environment for operating and maintaining the equipment.
- Replacing aging medium-voltage cable would address concerns with aging conductor insulation that could lead to future arc-fault events.

RECOMMENDATIONS

Unit Substations U11, U12, and U13 are in poor condition and reliability will likely become an issue in the near future. A maintenance and inspection report from 2014 recommended that the equipment be replaced as soon as possible.

The recommended unit substations U11, U12, and U13 Replacement alternative is Alternative USUB No. 3. This alternative replaces three existing unit substations with one unit substation and takes advantage of existing electrical capacity in unit substations U2, U14, and U15 to power existing loads currently served by unit substations U11 and U13.

This alternative does require some NSWWTP roadway reconstruction associated with new concrete-encased duct bank conduits that would need to be routed from unit substation U14 to the West Blower Building and potentially from new U12 to existing manholes, depending on the selected location for U12. However, reusing existing unit substation capacity would reduce the size of the new unit substation building and electrical equipment, which would reduce upfront equipment and installation costs.

EVALUATION OF INDOOR AND OUTDOOR UNIT SUBSTATION TRANSFORMERS

Dry-type unit substation transformers are commonly used for indoor unit substations instead of liquid-filled transformers because they do not use oil for cooling, which eliminates the need for spill containment, they are non-flammable, and they can be located directly in line with the unit substation medium-voltage and low-voltage switchgear.

Liquid-filled transformers are commonly used for outdoor unit substations because they are sealed and use oil-filled heat-sinks to radiate heat. While locating transformers outdoors allows for a smaller unit substation building to be constructed and removes significant heat load from the building, there is a slight increase in risk of damage due to water leaks, corrosion, and rodent intrusion.

NEW UNIT SUBSTATION TRANSFORMER ALTERNATIVES IDENTIFICATION

This section presents a brief summary of the Unit Substation Transformer Alternatives discussed at Workshop No. 8.

A. Alternative USUB-XFMR No. 1–Indoor, Dry-Type, Cast-Coil Unit Substation Transformers

This alternative would include the use of indoor, dry-type, cast-coil transformers at new NSWWTP unit substations.

B. Alternative USUB-XFMR No. 2–Outdoor, Liquid-Filled Unit Substation Transformers

This alternative would include the use of outdoor, liquid-filled transformers at new NSWWTP unit substations.

SCREENING OF ALTERNATIVES

Based on discussions at Workshop No. 8, both alternatives were short-listed and will be evaluated in detail.

§ Alternative USUB-XFMR No. 1–Indoor, Dry-Type, Cast-Coil Unit Substation Transformers
§ Alternative USUB-XFMR No. 2–Outdoor, Liquid-Filled Unit Substation Transformers

DETAILED EVALUATION OF ALTERNATIVES

This section includes a detailed evaluation of both short-listed Unit Substation Transformer Alternatives. Cost comparisons are included and summarized for each alternative.

A. Alternative USUB-XFMR No. 1–Indoor, Dry-Type, Cast-Coil Unit Substation Transformers

1. Description of Alternative

Alternative USUB-XFMR No. 1 would use indoor, dry-type, cast-coil transformers for the new NSWWTP unit substations previously identified under Alternatives USUB No. 2 and USUB No. 3.

Dry-type, cast-coil unit substation transformers are commonly used for indoor unit substations instead of liquid-filled transformers because they do not require oil spill containment, are non-flammable, and can be located directly in line with the unit substation medium-voltage and low-voltage switchgear. Existing indoor unit substations at the NSWWTP currently use indoor, cast-coil, dry-type transformers and outdoor unit substations use liquid-filled transformers.

Dry-type, cast-coil transformers require less maintenance than liquid-filled transformers, although the additional maintenance required for liquid-filled transformers is relatively minor. Dry-type transformers with cast coils have superior resistance to corrosion from the corrosive gasses present at wastewater treatment facilities when compared to standard dry-type transformers. Indoor, dry-type transformers require a larger building size to house them and also add a significant heat load inside the building, which increases cooling demand during the summer months but supplements heating equipment during the winter months. Indoor transformers are also difficult to remove and replace relative to how easily outdoor transformers can be accessed and replaced.

2. Cost Considerations

Cost increases associated with using indoor versus outdoor transformers for the unit substation alternatives detailed under Alternatives USUB No. 2 and USUB No. 3 are detailed under *Paragraph C* below. Table 10 identifies the upfront budgetary equipment costs for indoor, dry-type, cast-coil transformers at the sizes proposed in Alternatives USUB No. 2 and USUB No. 3.

Table 10–Indoor, Dry-Type, Cast-Coil Transformer Equipment Costs

Substation Alternative	Transformer Size	Equipment Cost
USUB No. 2: Large Substation	2000 kVA	**$ 130,000**
USUB No. 3: Substation U12	1500 kVA	**$ 105,000**

B. Alternative USUB-XFMR No. 2–Outdoor, Liquid-Filled Unit Substation Transformers

1. Description of Alternative

Alternative USUB-XFMR No. 2 would use outdoor, liquid-filled transformers for the new NSWWTP substations previously identified under Alternatives USUB No. 2 and USUB No. 3.

Liquid-filled transformers are commonly used for outdoor unit substations because they are sealed and use heat-sink fins to radiate heat instead of open ventilation louvers and fans. The sealed construction fully protects the transformer windings from environmental damage. Locating unit substation transformers outdoors allows for a smaller unit substation building to be constructed and provides easier access to the transformers for replacement. Liquid-filled transformers are also slightly more efficient than dry-type transformers.

Liquid-filled transformers require slightly more maintenance than dry-type transformers and introduce a potential fire hazard from the use of cooling/insulating oil, although the risk of fire can be significantly reduced with the use of new less-flammable fluids. Due to the use of cooling/insulating oil, liquid spill containment structures or below-grade geo-synthetic barriers are also required to contain transformer oil leaks.

Locating transformers outdoors also provides a slight increase in risk of damage from water ingress and rodent intrusion, although this type of damage is rarely experienced. However, if paint on an outdoor transformer's enclosure is scratched, the enclosure could begin to rust and increase the likelihood of premature failure.

2. Cost Considerations

Cost increases associated with using indoor versus outdoor transformers for the unit substation alternatives detailed under Alternatives USUB No. 2 and USUB No. 3 are detailed under *Paragraph C* below. Table 11 identifies the upfront budgetary equipment costs for outdoor, liquid-filled transformers at the sizes proposed in Alternatives USUB No. 2 and USUB No. 3. There would be additional costs associated with extra conduit and wiring, and transformer oil containment structures, which are not included with the following equipment costs.

Table 11–Outdoor, Liquid-Filled Transformer Equipment Costs

Substation Alternative	Transformer Size	Additional Conduit and Wire Costs	Equipment Cost	Total Cost
USUB No. 2: Large Substation	2000 kVA	$ 28,300	$ 115,000	**$ 143,300**
USUB No. 3: Substation U12	1500 kVA	$ 17,700	$ 95,000	**$ 112,700**

C. Cost Comparisons

Table 12 demonstrates the upfront cost increase associated with larger air conditioning equipment and a larger unit substation building when using indoor, dry-type, cast-coil unit substation transformers instead of using outdoor, liquid-filled transformers for both of the new unit substations proposed in Alternatives USUB No. 2 and USUB No. 3.

Table 12–Upfront Cost Increase Associated with Using Indoor Transformers

Substation Alternative	Transformer Size	Building Width		Cooling Demand		Building Cost Increase	A/C Equipment Cost	Total Upfront Cost
		Outdoor XFMRs	Indoor XFMRs	Outdoor XFMRs	Indoor XFMRs			
USUB No. 2: Large Substation	2 x 2000 kVA	32 ft	51 ft	4 Tons	12 Tons	$ 99,750	$ 7,000	**$ 106,750**
USUB No. 3: Substation U12	2 x 1500 kVA	32 ft	51 ft	4 Tons	10 Tons	$ 99,750	$ 5,000	**$ 104,750**

While indoor transformers would require additional cooling inside the unit substation building during the summer months, the heat output from the transformer would supplement heating equipment operating during the winter months. A detailed analysis during project design would need to be performed to accurately determine the actual expected operating times for heating and cooling equipment to determine the potential operating cost savings associated with using indoor or outdoor transformers.

RECOMMENDATIONS

The recommended alternative is Unit Substation Transformer Alternative No. 2 because outdoor, liquid-filled transformers will reduce upfront costs for the unit substation building and HVAC equipment, will operate more efficiently, and will fully-protect the transformer windings from corrosive gasses. Based on the District’s consistent inspection efforts, it is reasonable to expect that liquid-filled transformers would be properly inspected and, if properly maintained, could be expected to have a longer operating life than dry-type transformers. The additional transformer maintenance associated with liquid-filled transformers is relatively minor, and transformer failure due to water or rodent ingress is unlikely.

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