Activated Sludge Projects



Project Purpose:

This collection of projects includes improvements to the activated sludge system identified in the 2016 Liquid Processing Facilities Plan. The items included will improve energy efficiency, system reliability, and relieve existing maintenance issues associated with the activated sludge system.

A related business case evaluation is titled “Nitrite Shunt Pilot", which includes the justification for a phased conversion to the nitrite shunt activated sludge process (See Project ID A02.6). The projects identified in this “Activated Sludge Projects” business case will be impacted by the success of the nitrite shunt bench-scale testing, which is ongoing, and the near future full-scale nitrite shunt demonstration project. However, the projects identified herein are still recommended even if the long-term conversion to nitrite shunt does not occur.

Project History and Status:

Currently the plant’s east and west blower complexes supply air to the east and west plants, respectively, and are completely separate systems. During development of the 2016 Liquid Processing Facilities Plan, 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 East Blower No. 4 or No. 5. 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.

Main Blower Alternatives to Serve the NSWWTP

Two cross-connection scenarios were evaluated as part of the 2016 Liquid Processing Facilities Plan:

- Null alternative - continue operating separate blower systems for the east and west plants.
- Full capacity east-west cross-connection using new 30-inch-diameter pipe to connect the two systems.

In addition, alternate blower phasing scenarios with and without the proposed aeration cross-connection piping connection were evaluated in the 2016 Liquid Processing Facilities Plan. Both the east and west blower complexes have adequate firm capacity to provide the forecasted peak airflow conditions, so peak capacity is not a factor in establishing blower phasing. Similar to the BNR alternatives phasing, blower phasing can, and probably should, occur in conjunction with BNR decision points and project phasing.

The west blowers should be given priority for replacement over the east blowers 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 the west side does not have an engine-driven blower operating on digester gas.
- 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 following blower technologies were evaluated in the 2016 Liquid Processing Facilities Plan 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. 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. The selection of the future blower type and capacity is somewhat dependent on the success of the nitrite shunt bench-scale and full-scale demonstration projects.

Key Risks and Issues

The Key Risks and Issues associated with maintaining the current operation and equipment (null alternative) is the continued maintenance, reliability, and high-energy concerns of the existing blowers, especially on the west side. All of the plant's blowers are relatively old. The west side blowers are the newest and were installed in the 1980s. All of the blowers are recommended to be replaced within the planning horizon of the Liquid Processing Facilities Plan, and therefore it is reasonable to consider the alternatives highlighted in the facilities plan and this business case evaluation.

Economic Analysis

The present worth analysis completed for the Liquid Processing Facilities Plan for the aeration system cross-connection is presented below.

	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 include replacement of all existing blowers over the course of the planning period to highlight the impact of the cross connection piping on future blower replacement costs.

Project Recommendations

The recommended plan includes the following related projects, with general phasing included in the table below.

Aeration System and Blower Phasing

- Construct the aeration system cross-connection piping to allow more efficient use of the existing blowers and to provide improved redundancy.
- Phase west side blower replacement, with two new blowers installed at the same time as the cross-connection.
- Install the third west blower in the future when the direction of nitrite shunt has been determined. This will provide the ability to better size the final blower for actual needs.
- Several investigations are recommended in the near term as part of the activated sludge implementation strategy, including clarifier stress testing and pilot testing of nitrite shunt operation (Project A02.09). The recommended aeration system capital improvements consist of new west blowers and aeration piping cross-connect and full-plant implementation of nitrite shunt with high efficiency membrane diffusers and new secondary clarifiers (if the clarifier stress testing indicates more clarification is required). These capital improvements are summarized in the table below.

In addition to the overall aeration system and blower phasing plan, additional recommendations are noted below:

Clarifier Stress Testing

Secondary clarifier stress testing and subsequent Computational Fluid Dynamics (CFD) modeling were recommended to confirm and/or validate assumptions used in the 2016 Liquid Processing Facilities Plan. Successful stress testing and modeling could eliminate a significant cost for construction of additional final clarifiers and/or aeration basins on the west side. This testing was completed in 2018.

RAS Pump Energy Efficiency

The existing RAS pumps are believed to be adequate for continued use under the future BNR alternatives. However, MMSD staff believes the RAS pump hydraulic pumping capacity should be tested to verify installed capacity meets design data. In addition, there are opportunities to increase energy efficiency in the RAS system, including modifying the control system to include "most open valve" logic, evaluating VFD retrofits, and considering replacement of older motors with higher-efficiency motors. The budget included in the table below includes a nominal budget for minor improvements, which requires further analyses during preliminary design.

Addressing Other BNR System Maintenance Issues

A line item is included to address miscellaneous BNR system maintenance issues, such as scum beach icing control, replacement of Plant 2 RAS control valves, and other miscellaneous items that were not evaluated in the context of a facilities plan but which were identified as potential improvements by District staff. The budget included in the table below includes a nominal budget for minor improvements, which requires further analyses during preliminary design.

Component	**Opinion of Probable Cost**		
	Near Term	**Mid Term**	**Future**
Clarifier Stress Testing	$130,000		
Aeration Cross-connect Piping		$2,160,000	
Two New West Blowers*		$4,200,000	
RAS Pump Energy Efficiency Improvements		$100,000	
Other BNR System Maintenance Issues		$420,000	
One New West Blower*			$2,100,000
Full Plant Nitrite Shunt**			$17,860,000
Total	**$130,000**	**$6,880,000**	**$19,960,000**

* *This could be phased to include one new blower first, and two new blowers in the future.*

** *This project is shown to coincide with the future new blower(s). Justification was provided in the "Nitrite Shunt Full-Scale Demonstration Pilot" business case, though these future costs for full-scale conversion were not. This project is not expected to be within the 6-year CIP planning horizon.*

Project Schedule:

Near-Term Projects

	Start	Completion
Planning	2016	2017
Study	2018	2018

Mid-Term Projects

	Start	Completion
Planning	2016	2020
Design	2021	2021
Construction	2022	2023

Future Projects

	Start	Completion
Planning	2016	2023
Design	2024	2025
Construction	2025	2026

Financial Summary (2019$):

Total Project Cost – Near-Term Projects	
District Staff & Engineering	$130,000
Total	$130,000

Total Project Cost – Mid-Term Projects	
District Staff & Engineering	$1,216,000
Contractor	$6,083,000
Total	$7,299,000

Total Project Cost – Future Projects	
District Staff & Engineering	$371,000
Contractor	$1,856,000
Total	$2,227,000

Fiscal Allocation (2019$)

Near-Term Projects

	2018
Study	$130,000
Construction	$0
Total	$130,000

Mid-Term Projects

	2021	**2022**	**2023**
Engineering	$414,000	$401,000	$401,000
Construction	$0	$3,041,500	$3,041,500
Total	$414,000	$3,442,500	$3,442,500

Future Projects

	2024	2025	2026
Engineering	$125,000	$123,000	$123,000
Construction	$0	$928,000	$928,000
Total	$125,000	$1,051,000	$1,051,000