Inside MAWSA.

How One Municipal Authority Upgraded its Wastewater Facilities and Tweaked Operations for Maximum Results

By Michele Braas, PE, RETTEW

In a small borough of rural Lancaster County, mandated wastewater treatment plant upgrades and operator improvements have led to impressively low effluent levels.

When the Pennsylvania Department of Environmental Protection (PADEP) rolled out mandates for effluent discharge levels, Manheim Borough worked diligently to retrofit its 40-year-old facility to maintain its existing footprint, and has since achieved phosphorous and nitrogen levels at less than half of those required by the PADEP.

The Manheim Area Water & Sewer Authority (MAWSA), formerly known as Manheim Borough Authority, has exceeded expectations and won an Honor Award in 2012 from the American Council of Engineering Companies of Pennsylvania.

How it Began

In September of 2005, the PADEP met with MAWSA and its wastewater engineer, RETTEW, to review the agency's plan to assign new total nitrogen and total phosphorus effluent limits for wastewater treatment plant discharges within the state. The wastewater treatment plant would need to achieve an average of 6.0 miligrams per liter total nitrogen and 0.8 miligrams per liter total phosphorus discharge concentrations, based on 2010 flows.

The PADEP was imposing these standards as a part of Pennsylvania's plan to improve conditions in the Chesapeake Bay Watershed.

At that time, MAWSA operated a trickling filter plant rated for 1.2 organic and 2.3 hydraulic million gallons per day (MGD). MAWSA's trickling filter technology would not meet the proposed nutrient limits on its own. To increase nitrate and nitrite removal at its wastewater facility the treatment system would need , anoxic zones – areas without oxygen.

MAWSA retained RETTEW to perform an analysis of the existing facility, with the goal to determine capacity and process abilities for those upcoming discharge limits. The study also included options to upgrade or modify the associated onsite facilities to meet future needs.

After meeting to strategize future needs and preferences, RETTEW and MAWSA evaluated the following alternatives: sequencing batch reactors, oxidation ditches, activated sludge with additional media, and fixed film filters. These were selected based on their ability to meet the new discharge requirements and MAWSA's familiarity with the processes.

After study completion, RETTEW recommended installation of a biological nutrient reduction (BNR) upgrade, consisting of a phased oxidation ditch with integral anoxic tanks. An oxidation ditch is a continuous flow activated sludge system, with the main treatment processes isolated in separate oxidation ditches. The conditions of each ditch are altered between aerobic and anoxic conditions, thus achieving the desired treatment level.

The system recommendation from RETTEW included an anaerobic selector for biological phosphorus removal, followed by a dual oxidation ditch system with the alternating conditions to remove biological nitrogen.

The study also recommended upgrades to associated parts of the wastewater treatment site, including new return sludge and waste-activated sludge pumps, new variable-speed drives on influent pumps, two new 41-foot diameter final clarifiers, a 2,900-gallon supplementary carbon feed facility, a 12,000-gallon ferric chloride chemical feed system, and a 6,400-square-foot biosolids storage facility. Installing these upgrades would not only help to meet the new nutrient discharge limits, but would also position MAWSA to meet more stringent discharge levels in the future if PADEP updated its guidelines again. The system also enables the Authority to produce Class A biosolids.

How it Changed

MAWSA authorized RETTEW to proceed with the design and permitting steps, including the necessary topographic surveys, geotechnical investigations, wetland delineation, and flood analysis. RETTEW's team coordinated with PADEP and nearby municipalities to meet all permitting and regulatory requirements.

The project was released for construction bidding in mid-2009, seeking both a general contractor and an electrical contractor. The upgrades were slated for completion in the summer of 2011, meeting PADEP's mandate to complete all upgrades by April 2012.

Shortly after the bids went out, the construction phase of the project broke ground. Low bidders Wickersham Construction and Engineering, Inc. and Gettle, Inc. managed the plant upgrades. The engineering design specified all upgrades to take place in the same footprint as the existing facility, which added complexity to the construction process.

Treatment operations needed to remain continuous throughout the upgrade construction and installation. To accomplish this, the timeline for construction was strictly adhered to, allowing the new commissioning procedures to occur simultaneously with the decommissioning of the existing facilities.

Throughout the construction process, some unforeseen challenges surfaced. During excavation, the team discovered the presence of several unmarked and abandoned vaults and structures underground. These items were not shown on the as-built drawings.

RETTEW assisted the contractor with changing the construction approach, completing the base for the oxidation ditch in three concrete foundation pours while the structures were simultaneously removed.

Because of the close proximity to a nearby creek, large amounts of groundwater also became problematic during excavations and construction. The team brought in large pumps to dewater the excavations for the oxidation ditch. The contractor managed both issues smoothly, keeping the wastewater treatment upgrades on schedule and still within original estimates.

The original Opinion of Probable Construction Cost for the work was $10.4 million. The original bids were $7.8 million for general construction and $755,000 for electrical work, with an approximate total cost of $8.6 million. Even with the change orders resulting from the complications during construction, the final costs were about $9.6 million.

The pump station at MAWSA.

How the Nutrient Removal Process Works

To meet the PADEP requirements for nutrient discharge, BNR processes were incorporated into MAWSA's treatment processes. BNR typically refers to a system treating wastewater to an effluent level of: total nitrogen, 8 to 10 mg/l and total phosphorus, 1 to 3 mg/l. In a BNR wastewater treatment facility, the micro organisms used to filter the waste are intentionally stressed, resulting in several nutrient-important results: conversion of ammonia to nitrates, conversion of nitrates to nitrites, release of nitrogen gas, and release and uptake of phosphorus. To ensure these biological conversions occur, the micro-organisms' environment must be controlled, keeping the pH balance, alkalinity, carbon, and sludge age at correct levels. Without that control, the removal of total nitrogen and phosphorus can be affected.

By controlling the micro organisms and the phases of the installed oxidation ditches, MAWSA completes biological nitrogen removal through nitrification/denitrification, as well as some biological phosphorus removal.

Nitrification occurs during aeration of the fluids in the ditches. Ammonia nitrogen combines with oxygen, converting it to nitrites and nitrates. Those nutrients are then converted to nitrogen gas during the anoxic phases of the ditches. Biological phosphorus occurs when the wastewater is introduced into the anaerobic phase, followed by aeration in the ditches, which results in any excess phosphorus being destroyed by the micro-organisms.

Enhanced nutrient removal, or ENR, is a step beyond BNR processes. ENR operations result in effluent levels even lower than BNR. In fact, ENR facilities have been known to reach effluent levels as low as a total nitrogen of 3 mg/l and total phosphorus of 0.3 mg/l or less. Some wastewater treatment facilities can obtain ENR with the addition of filters or chemicals. In MAWSA's case, the organization has reached ENR-level discharges through optimizing its oxidation ditches.

A section of the oxidation ditch at MAWSA.

How MAWSA Operates

MAWSA's wastewater treatment facility does not feature typical quality influent. Its influent has low biochemical oxygen demand concentrations, averaging 160 mg/l with monthly averages as low as 50 mg/l. These low concentrations result in a low food to micro-organism ratio. Because of these conditions, the facility has provided an environment where only very long sludge-age micro-organisms can proliferate.

While a typical oxidation ditch will operate with a sludge age of 20 to 30 days, MAWSA's facility operates with a sludge age of 40 to 50 days.

These operating parameters resulted after a long period of trial and error by the Authority staff to optimize the facility for its primary discharge requirements. The older sludge age allows MAWSA to operate at lower dissolved oxygen concentrations, since the longer sludge-age micro-organisms do not require the higher levels of oxygen that shorter-age micro-organisms need to convert ammonia to nitrates and nitrites. The lower dissolved oxygen also makes it easier to maintain the anaerobic and anoxic conditions within the processes.

These facility operating conditions have a number of advantages. First, the lower dissolved oxygen needs correspond to lower energy costs. Also, because of the extended sludge age and hydraulic retention time, the micro-organisms also have been found to actually release oxygen into the wastewater. They do this through a process known as endogenous respiration, when a living organism uses its own cellular mass instead of outside organic matter to breathe. More oxygen released into the wastewater reduces the facility's need for oxygen and decreases the electricity needed.

The operations also result in less sludge per pound of carbonaceous oxidation. This brings down overall sludge production, meaning MAWSA has less chemical, electrical, and disposal costs for its biosolids.

Operating at higher sludge ages, however, also has disadvantages. The older micro-organisms are less resilient than others, so the system is more prone to quantity and quality disturbances from interruptions of flow. In addition, as mixed-liquor concentrations rise, there are more solids present that the facility's clarifiers need to settle. Also, older sludges are more granular in shape, which increases the amount of time it takes to settle the sludge. The mixed-liquid concentrations and older sludges challenge the Authority's clarifier systems.

To combat these issues, the Authority adds chemicals to assist in settling in the clarifiers. The addition of ferric chloride not only assists in settling the sludge, it also helps to remove phosphorus.

By operating with an older sludge age, MAWSA is reducing operational costs and providing optimized nutrient removal. The high sludge age ensures maximum usage of the new facilities, which in turn led to ENR-level nutrient removal results. The average monthly effluent concentrations from October 2013 through September 2014 were 2.81 mg/l for total nitrogen and .12 for total phosphorus.

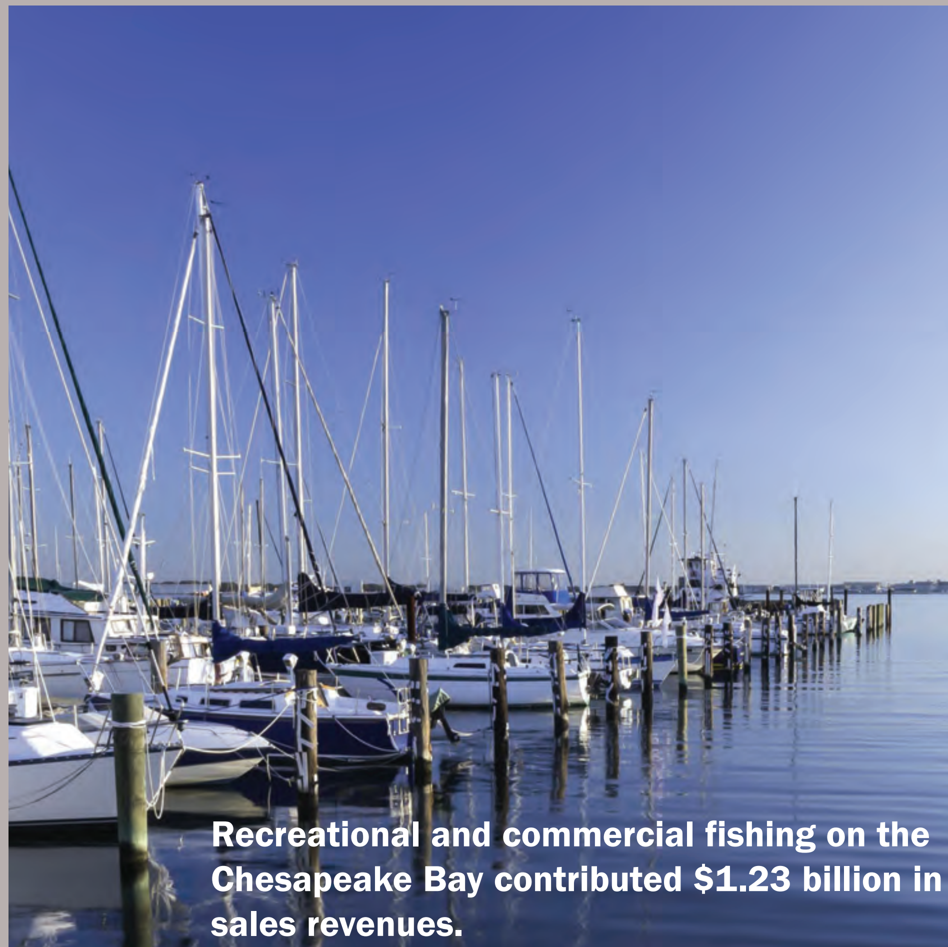
RETTEW Water Operations Specialist, Chris Foreman.

How it Helps

The significantly reduced nutrient discharges positively affect the receiving streams in southeastern Pennsylvania, which are connected through a network of waterways to tributaries of the Chesapeake Bay. MAWSA not only completed upgrades to its facilities, but continuously improved its operations to get the best possible results. The organization's insight and dedication will directly contribute to improvements in the Chesapeake Bay.

About the author

Michele Braas' work includes wastewater system and drinking water distribution system designs. She has sized and coordinated design of wastewater treatment facilities and also performs and designs BNR evaluations, sanitary sewer systems, and sewage pumping stations. Her experience includes permit and grant applications, preparing contract documents, and performing site inspections. She can be reached at 717-394-3721 or mbraas@rettew.com



Recreational and commercial fishing on the Chesapeake Bay contributed $1.23 billion in sales revenues.