

Wastewater Ephemeralization: Achieving Better Treatment with Less Energy and Chemicals

Albert Bock



Military Point Regional Advanced Wastewater Treatment Facility

Since 2009, the 7-mil-gal-per-day (mgd) Military Point Regional Advanced Wastewater Treatment Facility (MPAWTF), operated by Bay County Utility Services and co-owned by Bay County, City of Callaway, City of Parker, and City of Springfield, has been working to improve its wastewater treatment plant performance and energy efficiency to offset future energy price increases and comply with the newest regulatory effluent permit requirements.

The facility personnel implemented new and innovative process technologies, in combination with energy conservation programs and process changes, so that the facility could address the upcoming challenges in the industry. This article provides an overview of the newly installed technology and process control strategies that deliver a more consistent and cost-effective wastewater treatment plant operation.

The turnkey accomplishments of the technology and operating procedures include improved effluent results, enriched biosolids treatment, chemical savings for phosphorous removal, and significantly reduced aeration rates for the operation of the treatment facility. Their implementation improved the treatment plant performance and effluent quality results considerably, while also reducing energy and chemical

requirements in the treatment process. This concept is known as wastewater ephemeralization.

Energy and chemical reduction provides multiple economic and environmental benefits, including reduced air pollution and greenhouse gas emissions, and results in reduced operating costs, which saves money for the utility.

With pumps, motors, and other equipment operating 24 hours a day, seven days a week, MPAWTF is one of the largest consumers of energy in Bay County. The high level of energy and operating costs is what led the utility to make the energy and process improvements in the wastewater treatment plant infrastructure and operations, which guarantees the utility customer quality service at a reasonable cost that also meets the environmental requirements.

Starting in 2009 Bay County Utility Services developed a portfolio of wastewater ephemeralization projects that identified energy efficiency improvements and new operating technologies, and evaluated alternatives to minimize rising energy and chemical costs for the wastewater treatment plant operation.

The MPAWTF wastewater ephemeralization projects included:

- ◆ Operating one biological nutrient removal (BNR) train instead of two BNR trains

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- ◆ Eliminating aerobic digestion and introducing facultative biosolids stabilization technology
- ◆ Electrical cost reduction by changing from fixed power usage rate to real-time pricing (RTP)
- ◆ Alternation of BNR aeration control, changing aeration from dissolved oxygen to ammonia control

Wastewater Ephemeralization Projects Overview

Operating One Biological Nutrient Removal Train Instead Of Two

The MPAWTF was put on-line in 2000. The annual flows from 2003 to 2008 averaged 3.8 mgd and were significantly below the rated capacity limit. Until 2009 the treatment facility was run utilizing the full treatment plant capacity, with two BNR treatment trains on-line.

The aeration blowers for the treatment plant process with two BNR trains on-line were operated in a lead-and-lag configuration and controlled by the residual dissolved oxygen (DO) concentration. Typically, in the afternoon, during the daily high flows under this configuration, the lag blower came on-line as a backup for the lead blower and contributed to a significant increase in energy usage and demand.

A study conducted in 2009 showed that the operation of MPAWTF would be more cost-efficient, while also improving the treatment performance, by only operating one BNR basin until the average daily flows exceed 4.2 mgd.

Eliminating Conventional Aerobic Digestion Process: Introducing Facultative Biosolids Stabilization Technology

In 2011 Bay County Utility Services implemented a new digester process technology

and discontinued the conventional aerobic digester process. The new digester technology changed the digester operation from continuously run aeration cycles to efficient nutrient-controlled digester aeration, which promotes facultative biosolids stabilization environments and reduces the digester aeration run times by greater than 80 percent. The digester aeration cycles are strictly controlled by the digester nutrient ammonia and phosphorous levels, which are measured by a nutrient analyzer system.

The previous conventional aerobic digester stabilization process involved lengthy aeration times, resulting in high energy costs and slow biosolids hydrolysis rates. The conventional aerobic digestion process also reduced the digester pH and alkalinity levels and triggered the release of large amounts of phosphorous from the aerated digester biosolids. Consequently, digester sidestream phosphorous concentrations, often exceeding 250 mg/L PO₄-P, were returned to the mainstream wastewater treatment plant during decanting and biosolids dewatering.

The high phosphorous return loads from the aerobic digester units overloaded the biological BNR phosphorus removal process and required the daily application of aluminum sulfate to maintain the effluent phosphorous concentrations below the acceptable regulatory levels. The addition of alum for phosphorous removal also caused a pH lowering and alkalinity scavenging of the BNR mixed liquor due to the properties of the chemical. This required the addition of another chemical (lime) to restabilize the BNR pH levels.

The new facultative digester process technology reduces the soluble phosphorous content of the digester biosolids liquid phase by over 90 percent, completely without the use of chemicals. The process provides over 80 percent in aeration power cost reduction, as well as savings in chemical cost for effluent phosphorous removal and sludge dewatering. The improved biosolids hydrolysis rates provide a faster reduction of the organic biosolids content and result in reduced sludge hauling costs.

Electrical Cost Reduction by Changing Energy Rate to Real-Time Pricing Rate Structure

In 2013 Bay County Utility Services and Gulf Power Company conducted a survey to investigate further energy cost reduction options. Gulf Power introduced Bay County staff to its RTP program, which gives Bay County the option of paying the actual energy cost of electricity at any given time, instead of being charged a consistent energy rate charge under

contract. The energy RTP model charges the customer hour by hour for the electricity usage accordingly.

Bay County evaluated the wastewater treatment power consumption profiles throughout the years and identified critical equipment and process sections that are necessary to run at all times for the treatment process. The study showed that the RTP model

would be economically beneficial in the long term and provides the utility additional cost savings.

In October 2013 Bay County started to operate all utility facilities under the RTP energy model and its responsibilities include a minimum one-year commitment to operate under the model. With the change of the util-

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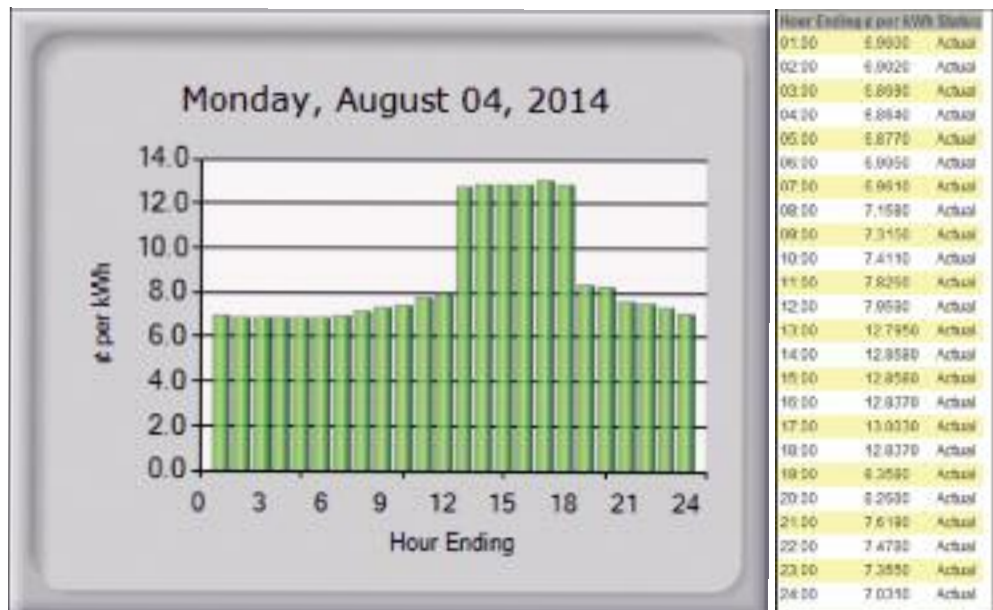


Figure 1. Hour-by-Hour Real-Time Pricing Power Usage Charge

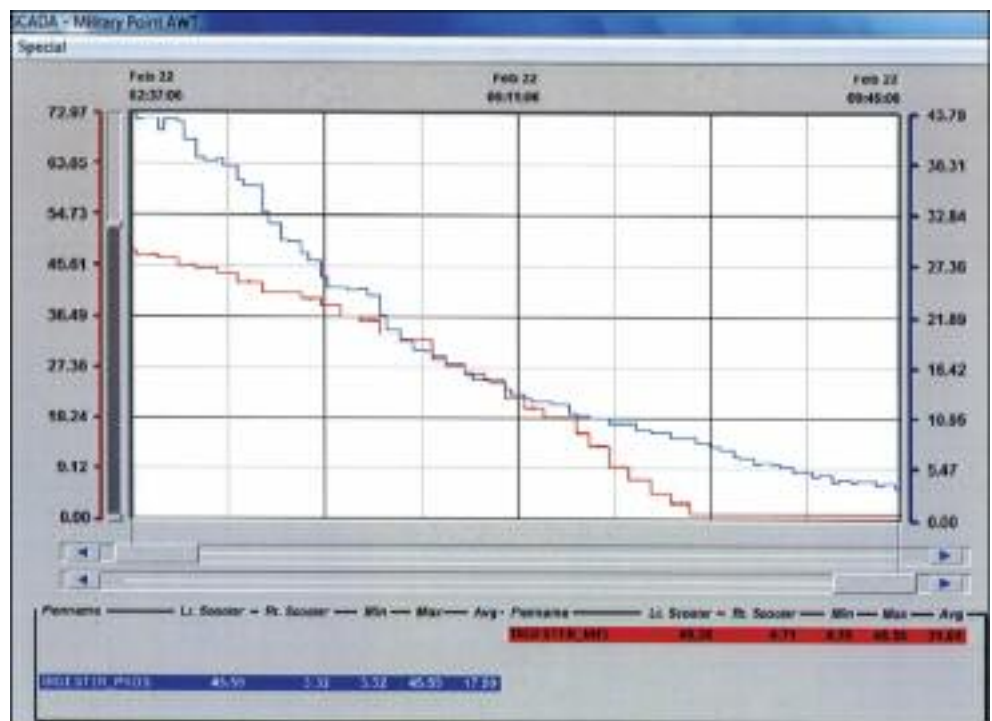


Figure 2. MPAWTF Facultative Biosolids Stabilization Process SCADA Trend Chart: Ammonium and Phosphorous Reduction During Digester Aeration Cycle

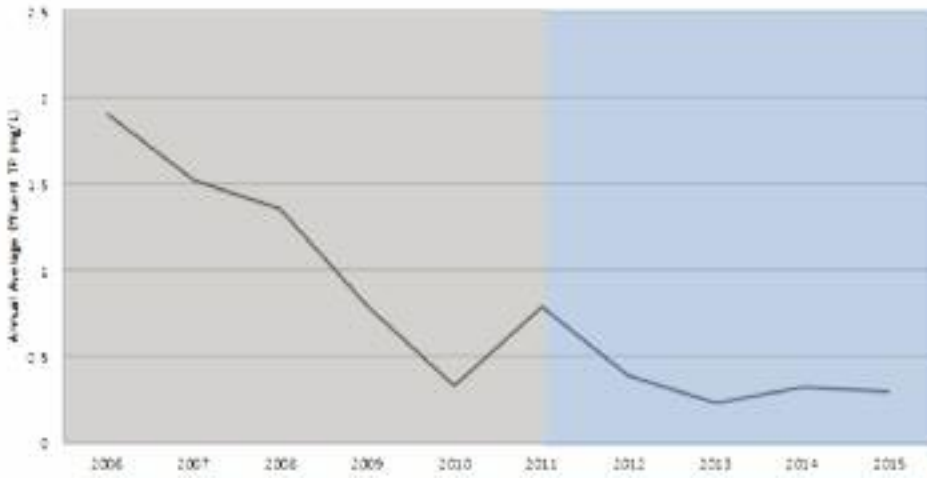


Figure 3. MPAWTF Annual Average Effluent Total Phosphorous Concentrations Before and After Implementation of Facultative Biosolids Stabilization Process

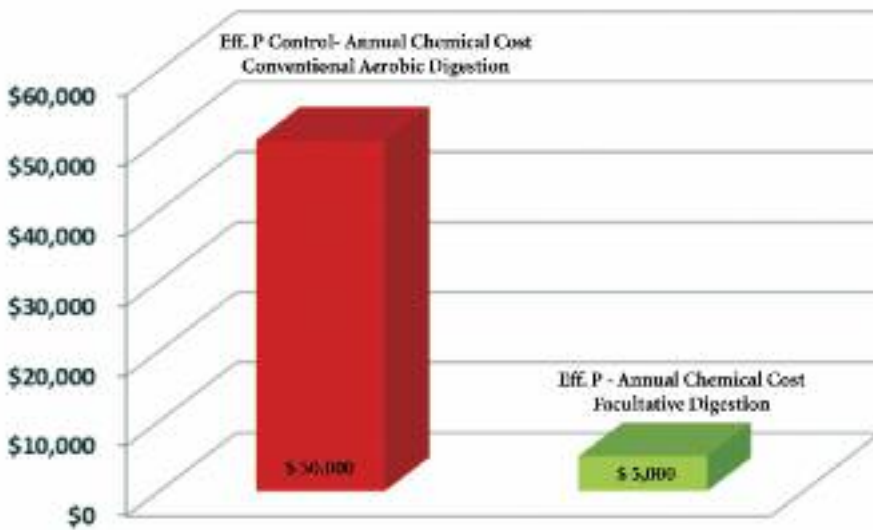


Figure 4. MPAWTF Digester Operation: Annual Chemical Cost for Effluent Phosphorous Control Before and After Implementation of Facultative Biosolids Stabilization Process

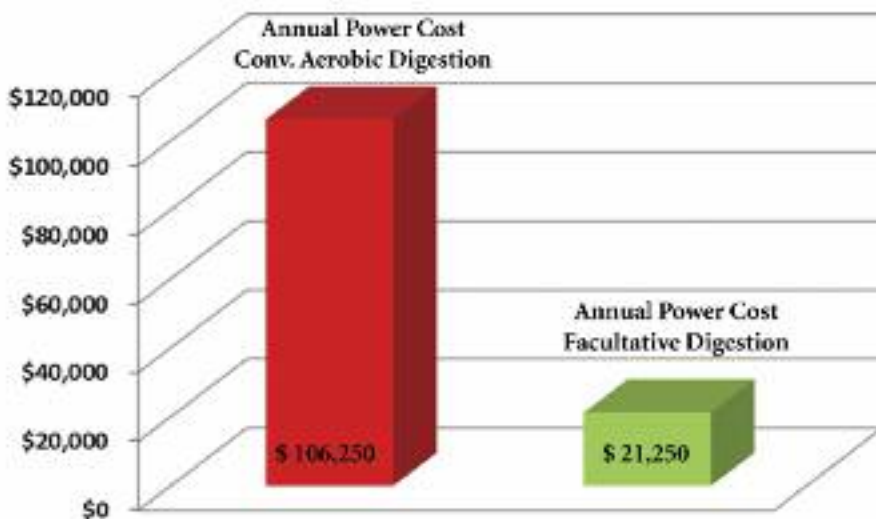


Figure 5. MPAWTF Digester Operation: Annual Power Cost Savings Before and After Implementation of Facultative Biosolids Stabilization Process

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ity power pricing model to RTP in October 2013, Bay County wastewater staff reduced the need of high power usage throughout the daily critical-peak high-energy pricing tariffs (Figure 1). The MPAWTF supervisor checks the peak high-energy pricing tariffs two days in advance and plans the treatment plant operation accordingly. The utility has identified point sources of treatment processes that can be turned off and put on standby until the critical-peak high-energy pricing tariffs have passed.

The point sources include:

- ◆ Biosolids dewatering process
- ◆ Digester aeration
- ◆ Taking basins off-line
- ◆ Rejecting pond returns

Alternation of Biological Nutrient Removal Aeration Control: Changing Aeration From Dissolved Oxygen to Ammonia Control

In 2014 Bay County Utility staff continued with its energy conservation efforts and evaluated the BNR aeration process control strategy. The previous BNR aeration process control method was based on maintaining a residual DO of 1.8 mg/l to 2.0 mg/l at all times after the first BNR aeration zone.

The study that was conducted showed significant power cost savings and that long-term economic benefits were achieved by converting the wastewater treatment plant aeration control from residual DO to the more efficient ammonia control. Ammonia-controlled BNR operation precisely evaluates the required air demand and treats the incoming nitrogen and biochemical oxygen demand (BOD) loads more cost-effectively than conventional DO control. In addition to electrical cost savings, ammonia-controlled BNR operation includes other wastewater treatment plant process advantages, such as better handling of the BNR BOD and alkalinity inventories, which are directly related to the performance of nitrogen and phosphorous removal.

Wastewater Ephemeralization Project Results

Operating One Biological Nutrient Removal Train Instead Of Two Trains

By operating only one BNR train instead of two trains at flows below 4.2 mgd, MPAWTF was able to operate the facility with only one aeration blower and a reduced quantity of BNR mixers and internal recycle pumps. This operating practice reduced the monthly energy usage charges by an average of 22,000

kilowatt-hours (kWh). The total annual power usage cost savings averaged approximately \$23,000.

Eliminating Aerobic Digestion Process: Introducing Facultative Biosolids Stabilization Technology

The newly introduced facultative biosolids stabilization process changed the control of the digester aeration from continuous aeration to nutrient-controlled aeration patterns. The process precisely monitors the ammonia and phosphorous levels of the digester biosolids and adjusts the aeration rates accordingly (Figure 2). The process technology provides the utility numerous benefits in operation and maintenance cost savings and achieves improved performance results in biosolids treatment and digester sidestream quality, which directly impacts the wastewater treatment plant BNR total phosphorous inventory and, respectively, the effluent phosphorous concentrations.

The new facultative biosolids process reduced the soluble phosphorous content of the digester sidestream return flows by over 90 percent to less than 10mg/L without the use of phosphorus removing chemicals. The high phosphorous removal rate of the digester process consequently maintains the BNR phosphorous inventory concentrations at low levels.

Since 2011 MPAWTF was able to discontinue the daily chemical feed for effluent phosphorus removal and maintained effluent permit compliance below 0.3 mg/l (annual average P) as shown in Figure 3. The annual chemical cost savings for effluent phosphorous removal averaged over \$45,000 (Figure 4).

The facultative digester process technology also reduced the overall digester aeration time by more than 80 percent, resulting in a substantial reduction in the digester process energy costs, with savings of more than 80 percent. The process reduced the annual digester power usage by over 800,219 kWh, which is equivalent to \$85,000 in power cost savings (Figure 5).

The facultative anoxic digester treatment environment provides much faster biosolids hydrolysis rates than the previous operated aerobic digester process and results in a 30 percent faster reduction of the organic biosolids content. The increased digester biosolids hydrolysis rates provide cost savings in polymer usage and sludge disposal.

The combined savings for power costs and chemicals for phosphorous removal alone exceed \$130,000 per year, with improved effluent phosphorous water quality results. The long-

term savings that are realized will be significant.

Electrical Cost Reduction by Changing Energy Rate to Real-Time Pricing Rate Structure

The MPAWTF experienced an average of 9.26 percent power cost reduction since operating under the RTP pricing model and has

been practicing a demand response plan for load sharing that calls for only operating the essential equipment necessary for the wastewater treatment process during the high power usage rates. Since implementation of the RTP energy model, Bay County Utility Services has saved approximately \$26,000 a year in electrical costs.

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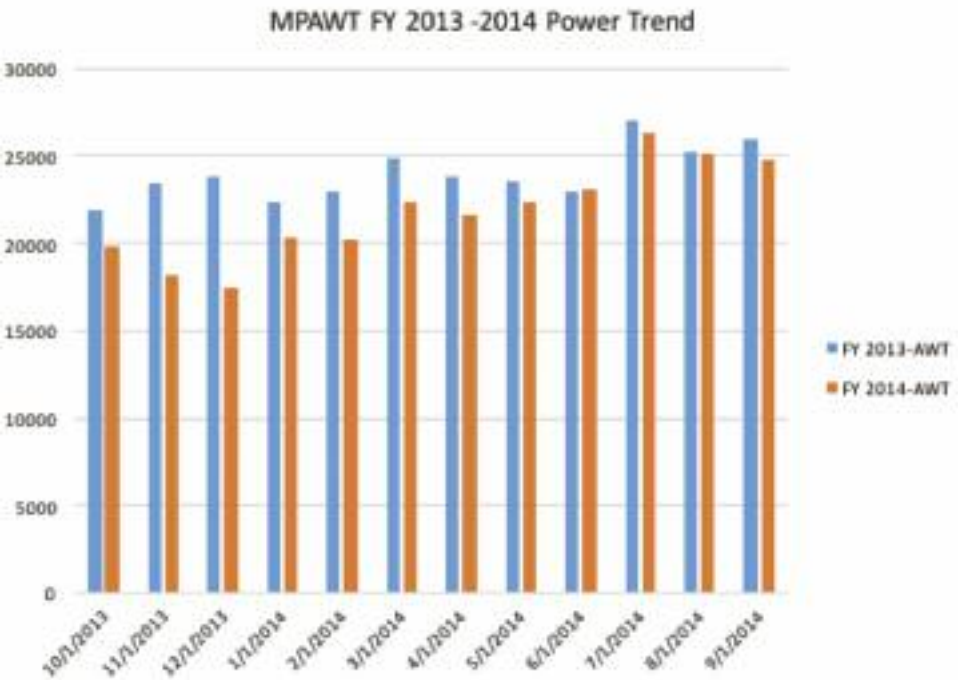


Figure 6. FY 2013 Under Fixed-Price Contract and FY 2014 Under Real-Time Pricing Contract, Month-to-Month Power Cost Reduction

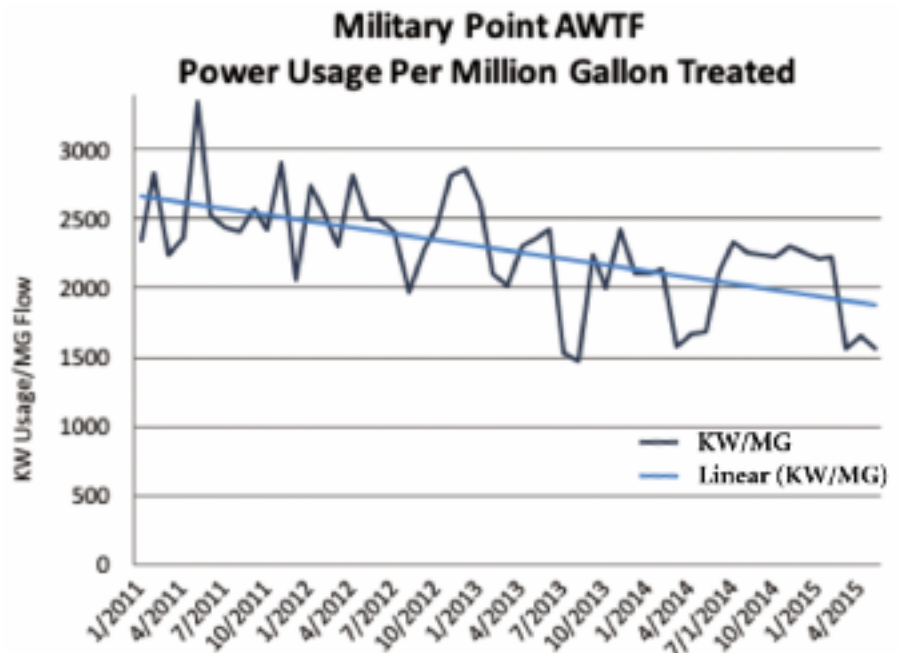


Figure 7. MPAWTF Power Usage (kWh) per MG Flow Treated

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Additional benefits of the energy plan are:

- ◆ Gulf Power Energy Company has excess generating capacity that allows the electric company to utilize its most efficient power generating plants.
- ◆ The new rate plan allows Bay County Utility Services to see the most expensive power periods two days in advance, which provides enough planning to shift some equipment usage during lower-cost periods.

The monthly power cost reduction performance under the RTP model is shown in Figure 6.

The MPAWTF also implemented electrical load and demand management in October 2013. The facility successfully continued to maintain effluent permit requirements at reduced electrical demand charges. The available backup capacity of the wastewater treatment plant allows Bay County staff to comfortably shift the operation of high horsepower equipment within lower power usage periods.

Point sources for electrical demand management include:

- ◆ Biosolids dewatering process
- ◆ Digester aeration
- ◆ Taking basins off-line
- ◆ Rejecting pond return flows

Alternation of Biological Nutrient Removal Aeration Control: Changing Aeration From Dissolved Oxygen to Ammonia Control

Since the installation of the new ammonia sensors for BNR aeration control, MPAWTF experienced a significant reduction of power usage costs. The power usage for BNR aeration was reduced from 865 kWh/mil gal (MG) treated to 690 kWh/MG treated and is equivalent

to approximately \$22,000 in annual power cost savings.

The BNR is operated with a residual ammonia concentration of 1.0 mg/L after the first aeration zone, which also provides enhanced nitrogen removal results, conservation of BNR alkalinity, and prevents BNR overaeration.

Summary of Results

The MPAWTF has been recognized over the years for its outstanding achievements in efficient treatment plant operation and has won the following plant operation awards:

- ◆ 2012 Florida Department of Environmental Protection Operations Excellence Award
- ◆ 2012 Runner-Up for Florida Water and Environment Association Earle B. Phelps Award
- ◆ 2013 Winner of Florida Water and Environment Association Earle B. Phelps Award
- ◆ 2013 Florida Department of Environmental Protection Operations Excellence Award
- ◆ 2015 Runner-Up for Florida Water and Environment Association Earle B. Phelps Award

The utility staff demonstrates economical and effective methods to achieve improved wastewater effluent and biosolids performance results with substantial energy and chemical cost savings today are a very important part of the daily plant operating routine. Energy consumption and the hour-to-hour energy prices are continuously monitored by MPAWTF plant personnel.

Monthly operating reports document the energy consumption and the performance of the new process projects. With the implemen-

tation of the energy improvement projects, Bay County Utility Services was able to reverse the increasing power costs for its wastewater treatment plant operation.

The historical trend chart in Figure 7 demonstrates the power cost savings that MPAWTF experienced since the implementation of the new process implementations after 2011. The blue trend line illustrates the actual energy usage per MG treated. The new process implementations reduced the power usage from 2,700 kWh/MG to less than 2,000 kWh/MG.

The wastewater treatment plant staff is trained and skilled to identify the energy consumption rates of the wastewater treatment process sections and treat the wastewater to the most effective and reasonable cost to the customer, while at the same time meeting stringent Class III surface water permit requirements.

Bay County Utility Services identified further energy conservation measures that include the replacement of the existing plant halogen lighting with light-emitting diode (LED) fixtures and installation of variable frequency drives (VFDs). All future equipment replacements will be evaluated based on their energy efficiency and cost-effectiveness to provide the facility with the most energy-efficient infrastructure.

Since the implementation of the new process changes, MPAWTF reduced its power usage by an estimated 1,700,000 kWh per year, which is equivalent to 1,100 tons of reduced carbon emissions. The efforts of Bay County Utility Services to reduce chemicals and power costs for its treatment plant operation not only saved the customers money, it also provides a more consistent high-quality effluent into St. Andrews Bay and plays an important role when it comes to protecting the environment. ◊



Albert Bock performs a system check on the digester nutrient analyzer system.



Lloyd Kadlec, shift lead operator, at the SCADA computer checking the biological nutrient removal ammonia reduction performance.



The facility's digester during the aeration cycle performing ammonium and phosphorus reduction.