BIOLOGICALLY ACTIVE FILTRATION

FOR TASTE AND ODOR CONTROL AT LAKE MANATEE WATER TREATMENT PLANT

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OVERVIEW

The Lake Manatee Water Treatment Plant (plant) is located on the southwestern bank of Lake Manatee in eastern Manatee County (county), Florida. It is the only municipal drinking water plant owned and operated by the county and has a rated capacity of 84 mil gal per day (mgd). The plant provides drinking water for customers throughout the county and includes wholesale supplies to the City of Bradenton, City of Longboat Key, City of Palmetto, Braden River Utilities, and Sarasota County.

The plant treats both surface water from Lake Manatee and groundwater from two wellfields and is designed to treat up to 54 mgd using conventional surface water treatment, including coagulation, flocculation, powdered activated carbon (PAC) adsorption, sedimentation, multimedia filtration, and blending with treated groundwater prior to disinfection, storage, and distribution. Up to 30 mgd of groundwater is treated in a separate groundwater treatment basin that includes degasification, lime softening, and sedimentation prior to blending with treated surface water.

MANMADE RESERVOIR

Lake Manatee is a manmade reservoir that was created by building a dam on the Manatee River, which discharges into the Gulf of Mexico approximately 20 miles west of the plant. The ~1,450-acre reservoir has a history of algal blooms, typically when lake levels are low and water temperatures are high, and the blooms are mainly from cyanobacteria (blue-green algae).

Algal blooms in drinking water sources have received attention across the United States due to the potential for toxic byproducts in the raw source water at treatment plants.

The algal blooms in Lake Manatee cause nuisance taste and odor compounds that are detectable at very low concentrations. The two compounds that are measured and treated at the plant are 2-Methylisoborneol (MIB) and (4S,4aS,8aR)-4,8a-Dimethyl-1,2,3,4,5,6,7,-octahydronaphthalen-4a-ol (geosmin), which are metabolites of cyanobacteria and actinobacteria. These two compounds are not removed below detection thresholds—they can be as low as 5-10 ng/L—by conventional treatment processes, and create an earthy, musty taste and odor in the drinking water.

The plant has been effectively used PAC for treatment of these two compounds, which is consumed in the treatment process, where it's injected at the beginning of the surface water treatment process and removed

Figure 1. 3-D rendering of the biological treatment unit exterior

in the sedimentation basins and filters. Unfortunately, annual PAC costs have been as high as $1 million and have significantly impacted the facility's operational expenses.

The staff at the plant performed extensive research and pilot testing to determine a more cost-effective treatment of MIB and geosmin. A past superintendent for the facility, Bruce MacLeod, spearheaded the county's research and testing for viable alternatives. The testing revealed that biologically active filtration (BAF) is an effective and cost-efficient treatment method for removal of the target compounds. The BAF has been used for years in municipal drinking water treatment for disinfection byproduct attenuation downstream of ozone disinfection; however, the plant will be the first municipal water treatment plant (WTP) to use BAF at the head of the plant. Biological treatment prior to conventional treatment will utilize the background nutrients of the water source and avoid the potential risks associated with a biological process at the end of the treatment process, while still allowing for the addition of PAC prior to BAF if ever needed.

Pilot testing also evaluated different types of filter media and various empty bed contact times over a range of MIB and geosmin influent concentrations. As a separate project, the plant is planning to convert the existing multimedia filters in basins A and B to membrane filtration. The combination of BAF and the ultrafiltration membranes accomplishes two of treatment goals: better taste and odor removal and reliably lower effluent turbidities.

BIOLOGICAL TREATMENT UNIT PROJECT

The county's biological treatment unit (BTU) project involved building a three-story structure, installing 42-in.-diameter yard piping and tie-ins at the existing congested facility, incorporating a separate backwash equalization and return system, replacing the septic systems, and connecting the plant with the county's wastewater collection system. The 3-D renderings of the BTU shown in Figures 1 and 2 show the complexity of the facility design.

As often occurs in older facilities that have experienced a number of expansions and improvements over the years, many challenges were encountered during the site location and pipeline alignments (Figure 3). For example, geotechnical investigations determined that piles were needed for the foundation of the BTU structure, so 175 auger cast piles were designed as part of the building foundation. Extensive subsurface utility engineering

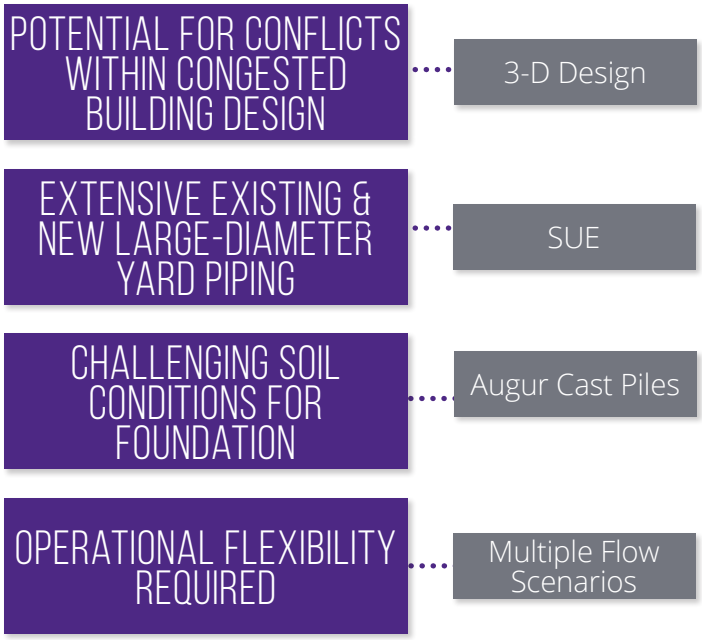

Figure 3. Challenges and Solutions

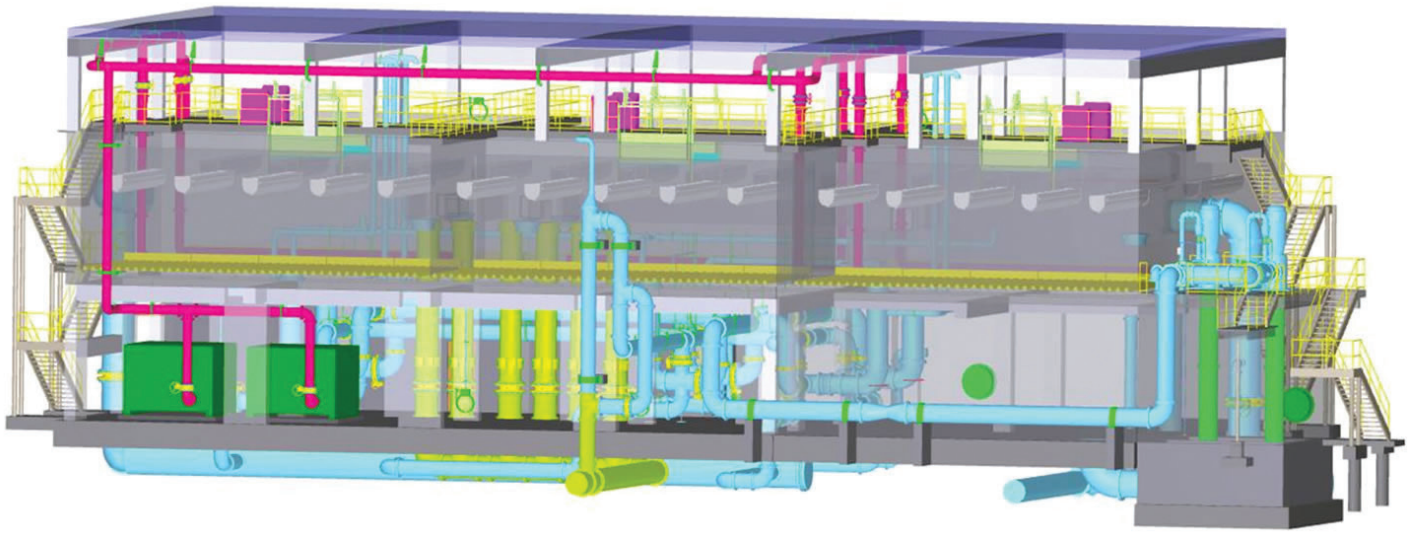

Figure 2. 3-D Rendering of the biological treatment unit section

designates and locates were performed to minimize conflicts and design changes during construction (Figure 4). In addition, the plant staff wanted flexibility for the selection of source water routing to and bypassing the BTU, so tie-ins to the existing 30- and 42-in. raw water lines were designed (Figure 5). This will allow the operators to send raw lake water to the BTU prior to conventional treatment at either or both basins A and B, or bypass the BTU altogether.

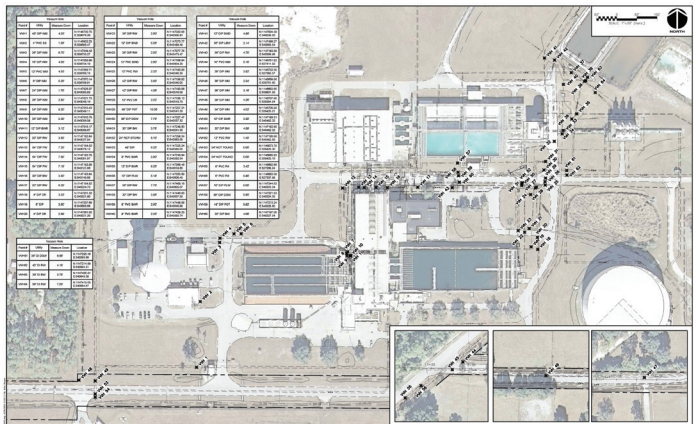

Figure 4. Subsurface Utility Engineering locates

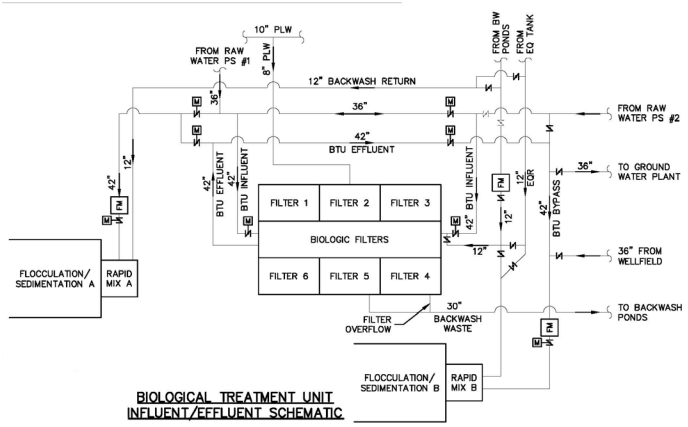

Figure 5. Flow diagram

The air scour system for the BTU was designed to provide low air flow to the BAFs when bypassed. This will maintain dissolved oxygen in the filters for the bacteria growing in the media if the filters are out of service for up to a few months. The two existing raw water pump stations at the plant did not require modifications or upgrades for the new BTU system. Effluent from the BTU will gradually flow to the head of the two existing surface water treatment basins.

BIOLOGICAL TREATMENT UNIT STRUCTURE

The new BTU structure will contain six BAFs, each with 4 ft of granular activated carbon (GAC) for the filter media. Rather than providing treatment by adsorption, the GAC will furnish a surface area upon which the naturally occurring bacteria can attach and grow. During the assimilation phase of start-up, bacteria will accumulate and grow on the filter media, thereby passing water containing MIB and geosmin. The bacteria will naturally be selected over time to biologically oxidize and grow on these compounds.

Each BAF will operate like a traditional down-flow gravity media filter. Modulating effluent valves and a level control system will maintain a constant water level in each BAF. Backwashes, including air scour, will dislodge the trapped solids in the filter media; some of the biogrowth will slough off the filters to maintain the design filtration rate and control biofilm thickness. Some incidental filtration will occur in the BAFs, but their main purpose is for taste and odor control. Another ancillary benefit determined during laboratory and pilot testing was dissolved manganese removal.

The underdrains will utilize a low-profile stainless steel design that saves on concrete tank costs because it does not require gravel. This design also allows for a lower height than most other underdrains which, when combined with the omission of gravel, saves as much as 2 ft of tank height. The slots on the underdrains were designed for BAFs to avoid fouling and plugging. Based on the county's pilot testing, empty bed contact times were determined to be 7.2 minutes at average flows of 37 mgd, and 3 minutes at peak flow of 54 mgd, with one filter out of service. Each filter cell will be 40 ft long by 19 ft wide for a design filtration rate of 10 gal per minute per sq ft (gpm/ft2) at the maximum flow 54 mgd.

The backwash rate will be 20 gpm/ft2, and the air scour rate will be 4 standard cu ft per minute per sq ft (scfm/ft2) at 6 pounds per sq in. (psi). The GAC will be manufactured from bituminous coal, having an effective size of 1 to 1.2 mm, with a maximum uniformity coefficient of 1.5. The backwash water will be stored in a clearwell on the south side of the BTU structure and pumped by one of two vertical turbine pumps, each with a capacity of 15,200 gpm. The backwash pump motors will utilize variable frequency drives to ensure proper backwash flow. The backwash water supply will be from the BTU effluent. There will be two redundant 200-horsepower rotary positive displacement blowers for the air scour system.

OTHER IMPROVEMENTS

The plant has two backwash ponds for the existing dual media filters, and a new filter backwash equalization (EQ) basin was designed for main process filter backwash. The EQ basin will accommodate the future membrane filtration facility that replaces the existing media filters and will return a steady flow of filter backwash to the existing rapid mix basins. The existing backwash ponds will be used for the BTU backwash, keeping it separate from the surface water treatment main filtration system backwash.

The plant is located in a rural area of the county that is not currently connected to its wastewater collection system. The facility currently has four separate septic systems that will be replaced with an in-plant collection system consisting of gravity sewer and multiple lift stations.

A new plant drain lift station will pump all the facility's domestic wastewater and future process wastewater through a 2-mi long, 8-in.-diameter force main that will be installed along Waterline Road. This new force main will manifold into the county's existing force main along Rye Road. There was a significant permitting effort for the design of the new force main due to wetland crossings, county pipeline separation and maintenance requirements, and other factors. Multiple horizontal directional drills were included in the design of the new force main.

Figure 6. Piping and encasement installation below the BTU

CONSTRUCTION AND PROJECT COMPLETION

Construction began in summer 2016. The contractor developed detailed bypassing and sequencing plans to meet maintenance of operation requirements, since multiple tie-ins to the raw water lines and new connections to both of the surface water treatment basins will be included. At the time this article was written, the foundation and the first floor for the BTU structure were nearly complete, 40 percent of the yard piping and duct banks had been installed, and the tank construction for the EQ tank was finished (Figures 6-10). Completion of construction and commissioning of the BTU are scheduled for the end of 2017.

Figure 7. Concrete pour for backwash pump station.

Figure 8. Pipe gallery and second-floor elevated slab construction

Figure 9. First-floor construction

Figure 10. First- and second-floor construction

ACKNOWLEDGEMENTS

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