Reclaimed Water Storage: A Dirty Little Secret

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Reclaimed water (RCW), in general, is a complex commodity; when there is an abundance being produced, there is limited demand, and when there is excess demand, there is insufficient supply. The solution seems straight forward—lots of storage—and thus, the development of large, open-top, wet weather storage ponds to hold the valuable resource. But, this simple solution has a dirty little secret, laden with nutrients and exposed to sunshine: algal blooms that complicate treatment and distribution.

Several municipalities along the west coast of Florida have been dealing with the effects of algal blooms in their storage ponds. The algae can't be sent into the distribution network directly because it fouls the downstream irrigation systems and results in increased maintenance and frustrated customers. Although the solution seems simple on the surface, the problem is multifaceted. Simply chlorinating the water to eradicate the algae can require large doses of chemicals and promotes the production of trihalomethanes (THMs), while still leaving algal structures and debris to foul the downstream systems. Reprocessing the water within the wastewater facility can be expensive and unsuccessful; returning the water creates operational challenges for each unit process, adds operational cost, and comingling the water within the compliance zones can result in recontamination of the effluent.

Pilot Study

In response to these operational issues and customer complaints, the Manatee County Utilities Department (County) implemented an aggressive program to address the algae produced in its storage ponds. The first step of the program started with the enumeration of the algae generated in the storage ponds to identify the type and size of the target material. The County operates eight individual ponds, most of which are unlined for seasonal storage, with a total volume of 728 mil gal (MG).

Each pond was sampled to determine the total cell numbers present and their species. In all cases, blue-green algae (Cyanobacteria) were the most abundant phylum of bacteria present in the RCW sampled, constituting, at a minimum, 80 percent of algae present by cell quantity. In the remaining 20 percent of the algae enumerated, yellow-green algae, green algae, diatoms, flagellates, and blue-green algae were present in varying concentrations. Blue-green algae are able to reduce nitrogen and carbon dioxide in aerobic conditions. This lends to algal growth in open-top RCW storage ponds, given the presence of nitrogen in the effluent of wastewater treatment processes and the abundance of sunlight available in the Florida climate.

A particle distribution was also performed on the samples collected from the storage ponds. Typical RCW industry practice would suggest solids larger than 200 microns must be removed in order to prevent clogging of residential irrigation systems. However, the County would like to accommodate microirrigation systems, which have greater removal requirements. Manufacturers of microirrigation system components recommend a filtration removal of 74 microns to prevent discharge orifice bridging and subsequent clogging of microirrigation systems. This filtration criterion is also recommended for microirrigation systems in the University of Florida's Institute of Food and Agricultural Sciences (IFAS) publications: *Media Filters for Trickle Irrigation in Florida*, *Screen Filters in Trickle Irrigation Systems*, *Settling Basins for Trickle Irrigation in Florida*, and *Principles of Microirrigation*; and Oregon State University's publication, *Drip Irrigation: An Introduction*.

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Florida sands typically range in size from 50 to 350 microns, with a size distribution of 80 percent < 275 microns, 60 percent < 200 microns, 25 percent < 150 microns, and 10 percent < 75 microns. Abundant quantities of sand are commonly found in unlined storage pond water, which are typically used for reclaimed water storage at treatment facilities in the state.

The volume of particles was calculated per milliliter, assuming the particle size is the particle's true diameter, such that a particle is a clean sphere. The particle volume for each diameter was multiplied by the corresponding particle count. This analysis illustrates the volume of particles that have the opportunity to be filtered based on the filter mesh size and sample results. For example, a 50-micron screen would have the opportunity to collect approximately 45 percent

Continued on page 16

Table 1. Summary of Manatee County Seasonal Storage Ponds

Pond Name	Area (Acres)	Pond Volume (MG)
Southwest Water Reclamation Facility (SWWRF)		
North Pond	18	58
Middle Pond	20	22
South Pond	46	64
SWWRF Totals	83	144
Southeast Water Reclamation Facility (SEWRF)		
North Pond	16	6
East Pond	63	104
South Pond	86	242
SEWRF Totals	165	352
North Water Reclamation Facility (NWRF)		
East Pond	14	6
Golf Course Pond	111	226
NWRF Totals	125	232
Manatee County Seasonal Storage Totals	373	728

Continued from page 15
of the particle volume from the County's pond water. Decreasing the filter screen size from 50 to 25 microns allowed the County the opportunity to collect approximately 20 percent more particle volume. Therefore, it was anticipated that the use of a 25-micron filter screen would give the County the opportunity to capture 65 percent of the particle volume within the storage ponds, based on the samples and the remaining particles not resulting in microirrigation fouling. This increased capture also reduces the potential for disinfection uptake, reducing chemical dosing costs. It should be noted that algae size, type, and enumeration can vary geographically, seasonally, and be based on pond depth and nutrient loading, and therefore, should be evaluated on a case-by-case basis giving consideration to these parameters.

Screening Technology

The second step of the County's program was to evaluate several screening technologies to determine the most effective equipment to use in the removal of the suspended solids from the RCW returned from the storage ponds. The County conducted evaluations and pilot studies of several separate technologies.

The Salsnes Filter™ is designed to provide primary treatment at wastewater treatment plants and other applications such as membrane pretreatment, food and dairy, the fishing industry, pulp and paper, manure dewatering, and tanneries. The filter removes solids by use of a continuously looped synthetic mesh screen that is offered in a compact and covered system providing a small footprint and odor containment. The mesh screen is available from 840 microns down to 30 microns. Solids are removed from the screen by use of an air knife and a periodic hot water wash, which is activated to remove solids that may adhere to the mesh. The screenings are collected in a hopper that feeds an auger press, which dewaters the screenings to 25-40 percent solids.

The pilot study utilizing the filter was conducted at the County's Southwest Water Reclamation Facility (SWWRF) from Sept. 30, 2009, through Oct. 7, 2009. During the pilot study, three mesh screen sizes were utilized (250, 90, and 55 microns) and samples were collected and analyzed. In summary, the mesh screen sizes utilized during the pilot did not remove significant amounts of solids until the 55-micron screen was used.

Based on the results of the pilot study and discussion with vendors, the filter is not anticipated to provide adequate removal of algae. With this type of filter, the general rule of thumb is for 25 percent of the particles to be larger than filter mesh size. The vendor of the filter concluded that, based on the algae particle size, a proper mat will not form for effective algae removal; therefore, this filter was eliminated from further consideration in this project.

The Nova Water Technologies Ultrascreen® Microfilter is used for tertiary filtration and utilizes rotating stainless steel mesh screens. The microfilter uses dynamic tangential filtration with gravity providing the driving hydraulic head condition to remove solids from the water. This means that since the filter media is rotating, filtration occurs at an angle less than 90 degrees, making the 15- to 25-micron mesh functionally smaller (similar to 10 microns) than when standing still. Continuous rotation presents a clean filtration surface for the incoming flow at all times. Hydraulic loading rates may be as high as 16 gal per minute (gpm) per sq ft.

The biomass layer accumulates on the surface of the American Iron and Steel Institute (AISI) 316 stainless steel mesh and strains out increasingly finer solids. When the influent level in the feed box rises to a preset depth, a level sensor actuates operation of the wash water pump. The back of the screen mesh is sprayed by low-pressure water, at 20 to 60 pounds per sq in (psi), for a typical 5- to 10-second period. Each disk has a dedicated spray header for efficient washing. The Nova filter was pilot-tested at the SWWRF from July 16, 2009, to August 3, 2009, where the unit demonstrated that it was effective at removing particles larger than 25 microns.

The Westech SuperDisc™ is very similar to the Nova screen, with the exception that the disc utilizes a fine woven fiberglass screen as the filter media. The vertical discs are attached to a horizontal drum-type rotor, which acts as the center axis around which the discs rotate. Each filter is fabricated from a number of fiberglass cassette and screen sizes between 10 to 60 microns. The disc was pilot-tested at the SWWRF from Sept. 1, 2010, to Sept. 5, 2010. The unit performed similarly to the Nova filter, with the exception of the backwash cycles. At the smaller mesh sizes and higher loading rate, the backwash cycle became too frequent; in some instances, the time between cycles was less than two minutes. The Nova filter was selected as the basis of design.

Process Modification

The third step in the program was to consider process improvements to reduce contributing nutrients. Currently, the County's North Water Reclamation Facility (NWRF) and Southeast Water Reclamation Facility (SEWRF) operate Carrousel® Systems with anoxic reactors to achieve nitrogen and biological oxygen demand (BOD) and biological nutrient removal to meet advanced secondary RCW standards. However, SWWRF is a conventional type-I activated sludge biological process that maintains a low solids retention time (SRT) in order to avoid converting incoming ammonia into nitrites and nitrates. The resulting effluent is high in nutrients that feed algal growth in the seasonal storage ponds on site. The County has performed an evaluation and has begun the design process to convert the existing SWWRF facility from the conventional activated sludge process to a Modified Ludzack-Ettinger (MLE) process. The modification will facilitate the conversion and the removal of nitrogen from the effluent and reduce nutrients available for the growth of algae.

The final step of the program is addressing operational issues that surround the RCW return from the seasonal storage ponds. The intake structures that provide water to the pond return pump stations are generally at or below the existing pond's bottom and are conducive for pulling sediments from the bottom of the pond. Likewise, the intake structures have a 2-in. grating at the inlet to serve as a course screen prior to water being drawn into the pump station wet well. This grating provides little protection for aquatic life, such as fish and turtles. At low pond levels, it is also possible to intake duckweed and other plant life that typically exists in the upper 18 in. of the pond's total depth.

At SWWRF, the existing 2-in. intake screenings are being replaced with 1-in. screenings. The 10 States Standards recommend screen opening sizes no larger than 1 in. for bar screens to a headworks, which provides a practical basis for sizing the intake screens. An evaluation of projected velocities under this upgrade was conducted, assuming that the screens were 50 percent blinded by solids under maximum flow conditions at all three intakes. The velocities ranged from 0.31 ft per second (fps) to 0.4 fps, falling below the recommended standard of 1 fps to protect aquatic life. At NWRF and SEWRF, the County elected to go a step further by modifying the pond bottom with a concrete apron to control debris and by installing passive Johnson Screens with ½-in. wedge wire openings. Like the grate replacements at SWWRF, these screens protect aquatic life and address potential sediment, algae, and sticks from entering the pump station.

As a part of the ongoing lake filtration project at each facility, the pond return piping is being modified to discharge into the effluent transfer wet wells. Under the existing pond return configuration, RCW from the seasonal storage ponds is returned to the influent side of the tertiary filtration, which consists of traditional traveling bridge sand media filters or cloth media filters. Neither the cloth media nor sand media filters handle the heavy loading of algae returned from the seasonal storage ponds. This greatly reduces the County's ability to return RCW from the storage ponds during periods of high RCW demand and low production of RCW from the treatment process. Given that the stored water has been returned into the wastewater treatment process train and must again comply with the domestic wastewater permit, it must now be retreated to meet effluent quality limits. The new configuration will negate bringing water into the wastewater facilities "compliance zone." Monitoring requirements will be less stringent and will accommodate return water back to the RCW system at an increased rate. This will allow the County to meet high RCW demands.

The County is just completing the first installation of the gravity filters and other improvements at the NWRF. The initial results from the first system installed have been very promising and the process improvements have yet to be implemented. Installations at other facilities are in various stages and will be in operation in the near future.