

Low Cost Disc Filtration Provides Cheap Water for Public Use in Florida

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ABSTRACT

Lake City Florida has upgraded their Wastewater Treatment Plant to Public Access Reuse (PAR) utilizing a Cloth Disc Filter to satisfy nitrogen permit requirements, reduce water consumption, and provide an inexpensive water source to the public. Lake City's Secondary Wastewater Treatment Plant, originally built in the 1970's land applies its wastewater. To upgrade to the PAR system, Lake City added a cloth disc filter, high level disinfection using Sodium Hypochlorite, and a 1 Million Gallon Precon storage tank. The FlowTex™ cloth disc filter manufactured by Entex Technologies Inc. of Chapel Hill, North Carolina is the core technology behind Lake City's reuse water system. The filter removes suspended solids and is Title 22 approved, which means the technology is proven to meet the performance requirements for Reuse Water in the state of California. The city's reuse water system is used to irrigate public land, such as farms, golf courses, subdivisions, and parks. One of the challenges of adding the reuse system was defining the permit requirements with the Florida Department of Environmental Protection (DEP) and obtaining a permit for the reuse system. Once the permits were obtained, the Reuse System was successfully started and tested to demonstrate proper installation, operation, and performance of the system. The system was initially tested with PA-13 nylon pile cloth media. Later, the media was replaced with a newly-developed PES-13 polyester pile cloth media, and the system was re-tested. The Reuse Water System benefits, design concept, permit requirements, performance testing procedures, results, and challenges are examined.

KEYWORDS:

Cloth Media Filter, Disc Filter, Reclaim Water, Reuse Water, Tertiary Treatment, Filtration, Title 22, Total Suspended Solids (TSS), Turbidity (NTU), FlowTex™

INTRODUCTION

With population increases and environmental factors, water shortages are widespread and communities require innovative technologies to meet water demands. The wastewater industry is beginning to recognize that in addition to treating water, they can create sought-after products that generate revenue. Reuse water is one such product that is an inexpensive, alternative water source for the community. “Water reuse can be defined as the use of reclaimed water for a direct beneficial purpose. Reclaimed water, also known as recycled water, is water recovered from domestic, municipal, and industrial wastewater treatment plants that has been treated to standards that allow safe reuse” (Haering 2009). One of the challenges of implementing a reuse system is it requires coordination with the Environmental Protection Agency (EPA) regulators to revise treatment permits; these systems are not widespread, and regulations are not standardized. The core product that enables a cost effective reuse system is a Tertiary or “polishing” Cloth Disc Filter to remove remaining solids that weren’t captured during the treatment process.

The Cloth Disc Filter is a user-friendly, high performance filter that removes suspended solids as small as 10 microns. That’s important to meet the stringent effluent requirements for a reuse system. This is a cost-effective solution over traditional technologies and benefits include small footprint, ease of operation, flexible configurations, and ability to monitor discharge quality from individual disc segments. Each disc is made up of two independent segments that are easily replaced without dewatering the filter, which eliminates down-time, saving time and money.

Lake City, Florida upgraded the Wastewater Treatment Plant, originally built in the 1970’s to Public Access Reuse (PAR) as a low cost solution to reduce water consumption and satisfy nitrogen permit limits to the nearby Ichetucknee Springs. The PAR upgrade was eligible for a grant from the water management district as it adds an additional source of water for the community, which reduces use of ground water supply and extends the life of the Water Treatment Plant. Many cities face similar problems with water shortages and more stringent regulations that require innovative, low cost solutions like this reuse water system. Before the PAR upgrade, the plant land-applied their wastewater effluent to a not-for-public use pine tree farm known as the “spray field”, but was limited on total nitrogen. The PAR system allows the plant to divert water from the spray field to satisfy the nitrogen permit. The city achieved a cost savings of 33% or 1.5 million dollars by upgrading to a reuse system instead of an advanced treatment plant that could remove additional nitrogen! In fact, the nitrogen is considered a benefit for the PAR system, as the water is used to irrigate farms, subdivisions, and golf courses where synthetic nitrogen is typically used in fertilizers.

The PAR system was tested to verify compliance with the design requirements, which include effluent Total Suspended Solids (TSS) less than 5 mg/L, turbidity averages less than 2 Nephelometric Turbidity Units (NTU) and never above 5 NTU. The reuse system requirements are similar to California’s Title 22 requirements for reuse water, which is important because these standards are highly regarded and often applied to projects outside of California. Initially, the filter unit was successfully tested with PA-13 nylon pile cloth media, which is Title 22 approved. Later, the media was replaced with a newly-developed PES-13 polyester pile cloth media, which provides added protection against chlorine. Occasionally, the filter cloth may require chemical cleaning using chlorine to prevent organic fouling and sanitize the filter discs and basin. In some installations, chlorine is used upstream of the filter. During performance testing and subsequent operation, both cloth media types met the required treatment objectives.

METHODOLOGY

Lake City upgraded their secondary treatment plant to a PAR system that features a 4 Million Gallon per Day (mgd) FlowTex™ Cloth Disc Filter manufactured by Entex Technologies Inc. of Chapel Hill, North Carolina, see Figure 1. Key features include outside-to-inside flow, cloth is cleaned with a rotating vacuum head while discs remain stationary, and each disc is made up of two segments. The twelve disc filter in painted steel tank is designed to operate at peak capacity with three of twelve discs out of service. The design of this filter allows for independent operation of two sets of 6 discs (12 discs total) in a single tank providing redundancy without the expense of a second filter tank. To perform backwash and sludge removal operations, each set of 6 discs includes a waste pump, drive motor, 2 backwash valves, and a sludge valve.



Figure 1. FlowTex Cloth Disc Filter, Model D84x12 DS, 12-disc filter in painted steel tank.

The Cloth Media Filter has several modes of operation including filtration, backwash, and sludge removal. During filtration, the waste pumps and drives are off, and backwash and sludge valves are closed. The influent valve is open allowing effluent from the city's Wastewater Treatment Plant to be filtered and sent to the ground storage tank for final disinfection and distribution to customers through the reuse water main (RWM). The backwash mode is triggered when either the liquid level reaches the high level position or the backwash interval timer has elapsed. During backwash mode of operation, 3 out of 12 discs are backwashed at a time using the associated waste pump, drive motor, and backwash valve. The backwash vacuum head runs bi-directional for better media cleaning. The cycle repeats for the second set of discs. The backwash cycle is completed after the last set of discs is backwashed and the liquid level drops below the high level

position. Sludge removal is triggered when the sludge removal timer has elapsed. The sludge removal line is isolated with the electrically actuated valve. The sludge valve opens and the waste pump turns on. The pump draws liquid through the sludge line located at the bottom of the filter tank. Sludge removal is completed when the sludge removal timer has elapsed.

In addition to the filter, the city added a 1.0 Million Gallon (MG) Precon Ground Storage Tank with High Level Disinfection using Sodium Hypochlorite, a flow control structure to gravity feed plant effluent to the filter and storage tank, and reclaimed water piping grid, see Figure 2 and Figure 3. The PAR system was brought online in the summer of 2012 and reclaimed water is being sent to the first customer, Tice Farms. The city is currently expanding the piping grid to additional customers, and the PAR system is expandable to four ground storage tanks.

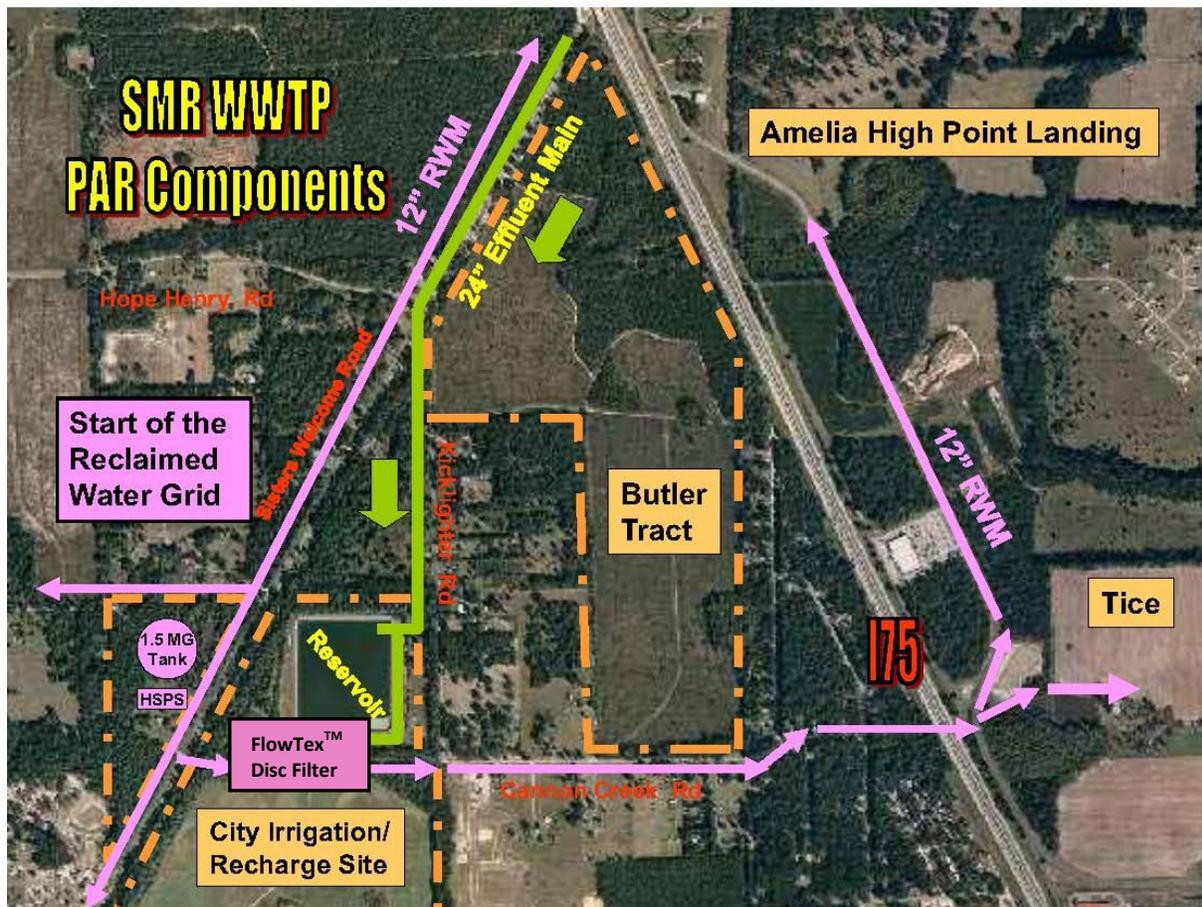


Figure 2. Lake City Public Access Reuse (PAR) Components.



Figure 3. Precon One MG Ground Storage Tank with High-Level Disinfection using Sodium Hypochlorite.

Lake City, Florida's Extended Aeration Activated Sludge for Domestic Wastewater Treatment located on St. Margaret's Street is permitted for 2.95 mgd at average design flow (AADF). The plant features an Influent Pump Station, two Parkson Aquaguard mechanical bar Screens (One presently installed. The second will come with the upgrade going out for bid at the end of September 2013), Manual Bar Screen, and one Vortex (Pista Grit) removal system. In the upcoming upgrade to St Margaret's two 1.01 MG Aeration basins are being converted from Surface Aeration to Fine Air Diffusers and blowers with submersible mixers (total 2.02 MG) control operated via D.O./ORP probes. For the upgrade, the Flow splitter structure will be modified for better aeration basin discharge flow control to three clarifiers. The St. Margaret's Plant also features two recently retrofitted 0.25 MG clarifiers and a third 0.5 MG unit, as well as a 0.13 MG two channel Chlorine Contact Chamber. There are two 0.3 (total 0.6 MG) Digesters being converted over to Course Air diffuser/blowers with submersible mixers and an additional Course Air Diffuser type 0.35 MG Digester will be added for a total digest capacity of 0.95 MG. The current Belt Press will be replaced with a Centrifuge. From there, the bio-solids are land applied to the City owned application site. Treated effluent is split between the City owned tree farm known as the "spray fields" and the PAR system.

The St. Margaret's plant effluent National Pollutant Discharge Elimination System (NPDES) permit requirements are shown in Table 1, and the PAR system permit requirements are shown in Table 2.

Table 1. NPDES Effluent Permit requirements for St. Margaret’s St. Wastewater Treatment Plant.

Flow Rate AADF (mgd)		cBOD				TSS Single Sample (ppm)
2.95		Annual avg (ppm)	Monthly avg (ppm)	Weekly avg (ppm)	Single Sample (ppm)	5.0
		20	30	45	60	
pH (S.U)	Fecal Coliform (per 100 mls)			Total Chlorine Residual (ppm)		
Min – 6.0	Annual avg.	Monthly avg.	Single Sample	0.5		
Max – 8.5	200	200	800			

Table 2. NPEDS Effluent Permit Requirements for PAR System.

Flow Rate (mgd)		cBOD				TSS Single Sample (ppm)
AADF (mgd)	Peak (gph)	Annual avg (ppm)	Monthly avg (ppm)	Weekly avg (ppm)	Single Sample (ppm)	5.0
3.0	211,000	20	30	45	60	
pH (S.U)	Fecal Coliform Single Sample (per 100 mls)		Min Total Chlorine Residual (ppm)		Turbidity (NTU)	
Min – 6.0	25		1.0		Daily avg.	Single Sample
Max – 8.5					2.0	5.0

The NPEDS permit requirements for the PAR system are similar to California’s Title 22 Regulations. According to the State of California Division of Drinking Water and Environmental Management (2012) Title 22 regulations state that “the turbidity of the filtered wastewater does not exceed any of the following:

- (A) An average of 2 NTU within a 24-hour period;
- (B) 5 NTU more than 5 percent of the time within a 24-hour period; and
- (C) 10 NTU at any time”

The Cloth Disc Filter includes a Hach 1720E Turbidimeter that continuously monitors effluent turbidity. If the effluent turbidity rises above the warning setpoint of 2.0 NTU, an alarm is generated. If the turbidity continues to rise above the shutdown setpoint of 5.0 NTU, the filter enters reject mode whereby flow is diverted from the ground storage tank to the “spray field” reservoir. While in reject mode, the filter continues to monitor effluent quality. If the effluent quality drops below 2.0 NTU for a continuous period of 5 minutes, the filter alarm condition must be manually acknowledged by a licensed operator that has physically verified the turbidity below 5.0 NTU. Then the system returns to reuse mode whereby filtered effluent is sent to the ground storage tank. Diversion of flow is accomplished using motor-operated reject and reuse valves.

Influent flow rate is monitored and controlled via the filter system. The filter flow is measured using an influent flowmeter that is connected to the filter’s control panel. Along with the flowmeter, a motor-operated influent valve was provided to control the flow rate to the filter. The influent valve normally remains in the fully open position, only modulating when necessary to limit the filter influent flow to the maximum flow setpoint (4 mgd).

The Cloth Disc Filter was originally supplied with PA-13 pile cloth media, which is Title 22 approved for reuse water as defined by the state of California. Later, Entex completed development of PES-13 pile cloth media, and replaced the Lake City filter cloth media with the new media. Both cloth media’s are similar in that they have a woven pile construction with polyester backing material, 13mm pile height, and 10 micron nominal pore size opening. However, the PA-13 media has a nylon fiber pile while the PES-13 has a polyester pile. The polyester is more chemically resistant than nylon, which adds protection during chemical cleaning of the filters and applications that require chemical dosing prior to the filter. Both the PA-13 and PES-13 pile cloth medias were tested at Lake City, Florida and met the specified treatment objectives, as well as Title 22 requirements. In addition to wastewater treatment projects in the state of California, Title 22 regulations are often applied to projects in other states because of the strict criteria and testing required for a technology to receive Title 22 approval. Lake City, Florida did not require the technology to be Title 22 approved, but has similar effluent standards to Title 22.

RESULTS AND DISCUSSION

The initial testing was performed on the PA-13 cloth pile media and went from Wednesday, June 22 through Friday, June 24, 2011. The city was on-site to conduct the test with the support of Entex’s Project Engineer, Phil Beecher. The city requested 3 influent and 3 effluent total suspended solids (TSS) grab samples on Wednesday and Thursday and 1 influent and effluent sample on Friday for a total of 7 influent and 7 effluent TSS samples. The results for the testing are shown in Table 3. The city’s PAR system’s NPDES permit requires effluent TSS average less than 5 mg/L and turbidity average less than 2 NTU, see Table 2. TSS was analyzed at the city’s laboratory and verified by a local National Environmental Laboratory Accreditation Conference NELAC Certified Laboratory. Effluent turbidity was continuously measured using a Hach 1720E turbidimeter. To satisfy the permit requirements, the filter continuously monitors the effluent turbidity and if the turbidity rises above the shutdown set point, effluent is diverted

from the PAR storage tank to the spray field reservoir used for the city’s tree farm. Influent flow was monitored using an in-line flow meter.

Table 3. Testing results from the first performance test with PA-13 cloth pile media.

Sample	Flow Rate (mgd)	Influent TSS (mg/L)	Effluent TSS (mg/L)	Effluent Turbidity (NTU)
1	2.03	1	0	1.8
2	1.54	2	0	1.8
3	2.59	1	0	1.8
4	2.24	2	0	1.7
5	2.33	5	0	1.7
6	2.44	5	0	1.8
7	2.08	1	0	1.7
AVERAGE	2.18	2.4	0	1.8

The average effluent TSS during the test was 0 mg/L, see Figure 4 and the average turbidity during the test was 1.8 NTU, see Figure 5. The average influent TSS was 2.4 mg/L. The filter met the target requirements of less than 2 NTU effluent turbidity and less than 5 mg/L effluent TSS.

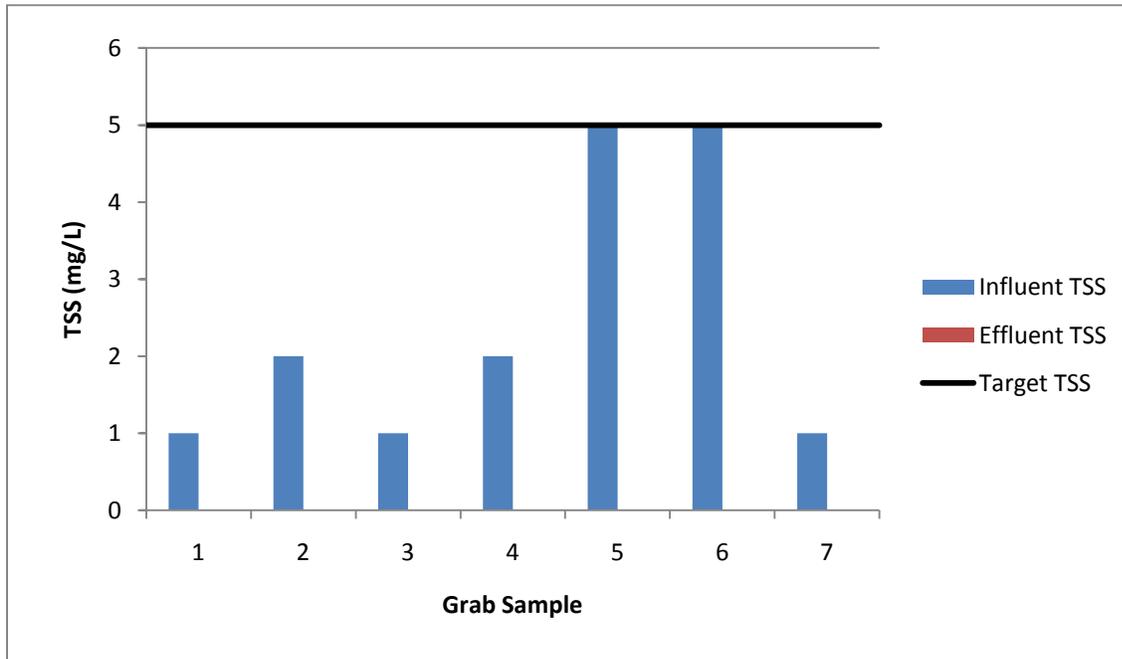


Figure 4. Filter Influent and Effluent TSS Grab Samples in mg/L for PA-13 pile cloth media.

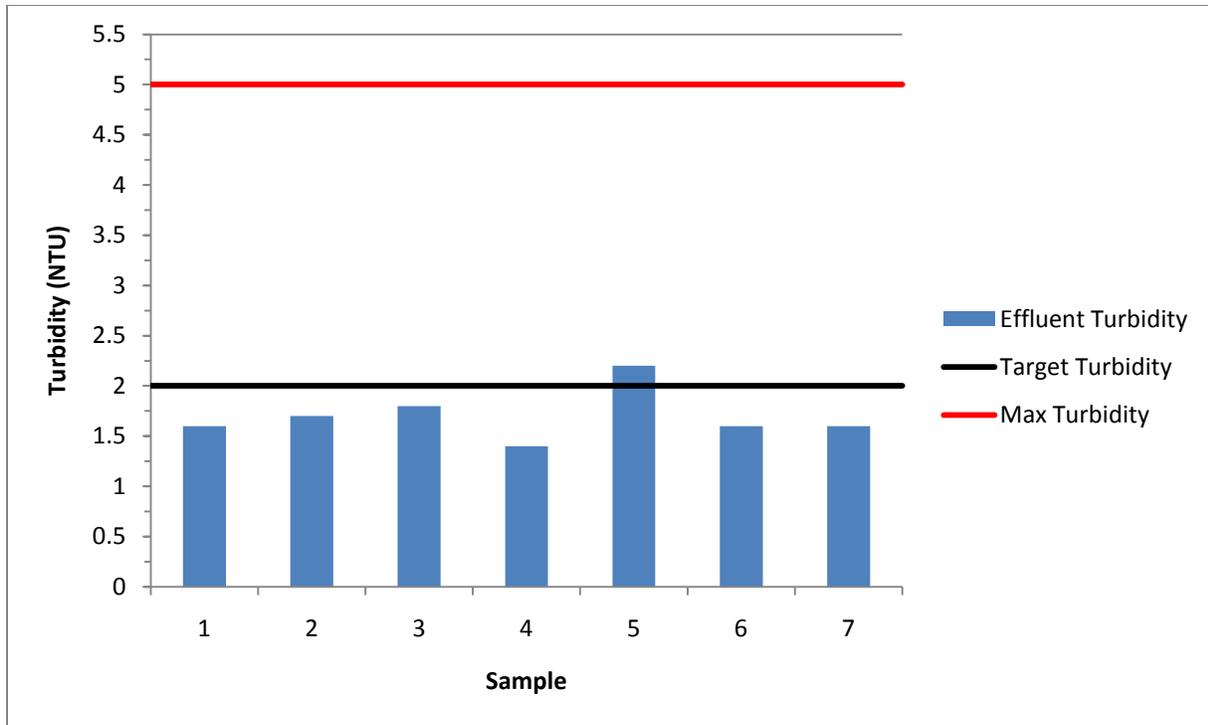


Figure 5. Filter effluent turbidity in NTU for PA-13 pile cloth media.

The final testing was performed on PES-13 cloth pile media and went from Tuesday, November 13 through Friday, November 16, 2012. A total of 12 samples were taken. The same parameters were measured for both the PA-13 and PES-13 cloth pile media tests. However, during PES-13 testing, hydraulic loading rates were adjusted from 2.2 to 7.5 gpm/sf. The max available influent flow produced the lowest hydraulic loading rate (2.2 gpm/sf) during the test. To increase the hydraulic loading, individual segments were capped off and the flow was adjusted and measured using the influent motor-operated valve and flowmeter. Thus the hydraulic loading rate was increased by adjusting the flow to the max available at the time of testing and decreasing the number of discs in operation. Capping off a disc segment is simple. Isolation caps were provided with the disc filter. Each disc segment has an individual discharge pipe that has a threaded connection in the effluent trough. The operator simply has to tighten the caps onto the discharge pipes located in the effluent trough, which wraps around the filter tank.

Performance testing of the PES-13 cloth media was a success, meeting the treatment objectives. The filter's effluent TSS values average 1.2 mg/L, see Figure 6 and effluent Turbidities average 1.5 (NTU), shown in Figure 7. Hydraulic loading rates were tested from 3.0 to 7.5 gpm/ft², see Table 1. During performance testing, the filter consistently produced high quality effluent at flow rates at or above the plant's design flow of 4 mgd or 3.6 gpm/ft².

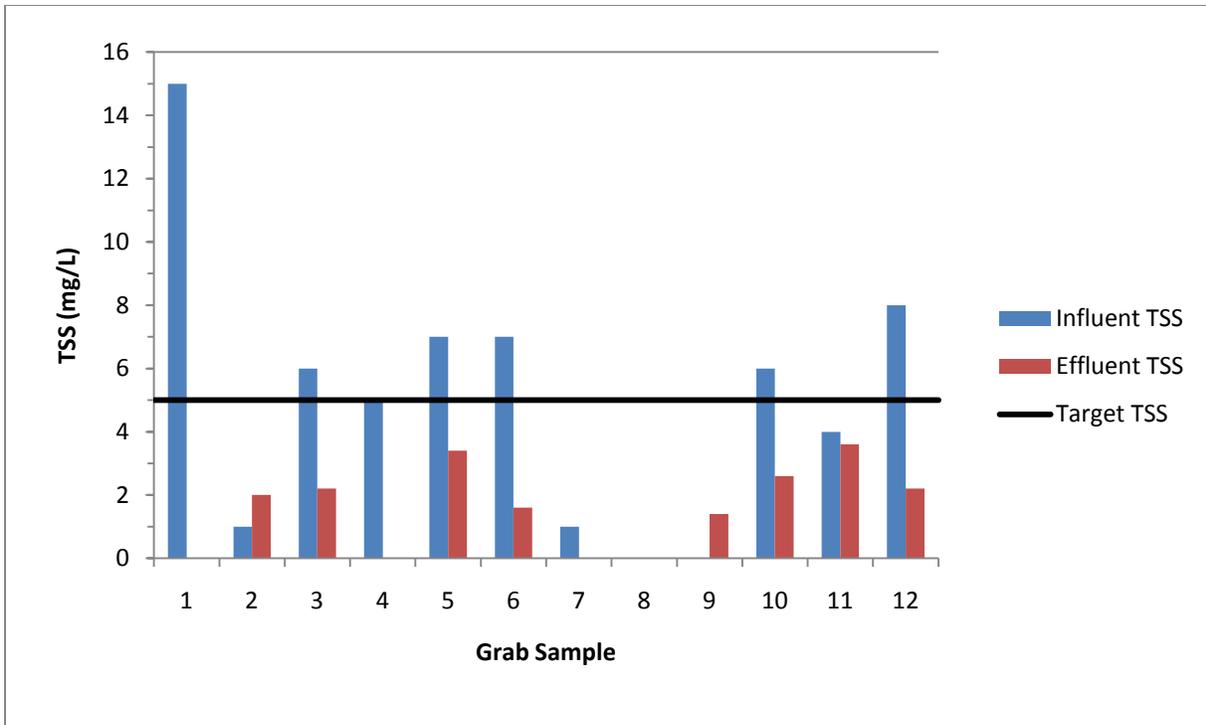


Figure 6. Filter Influent and Effluent TSS Grab Samples in mg/L for PES-13 pile cloth media.

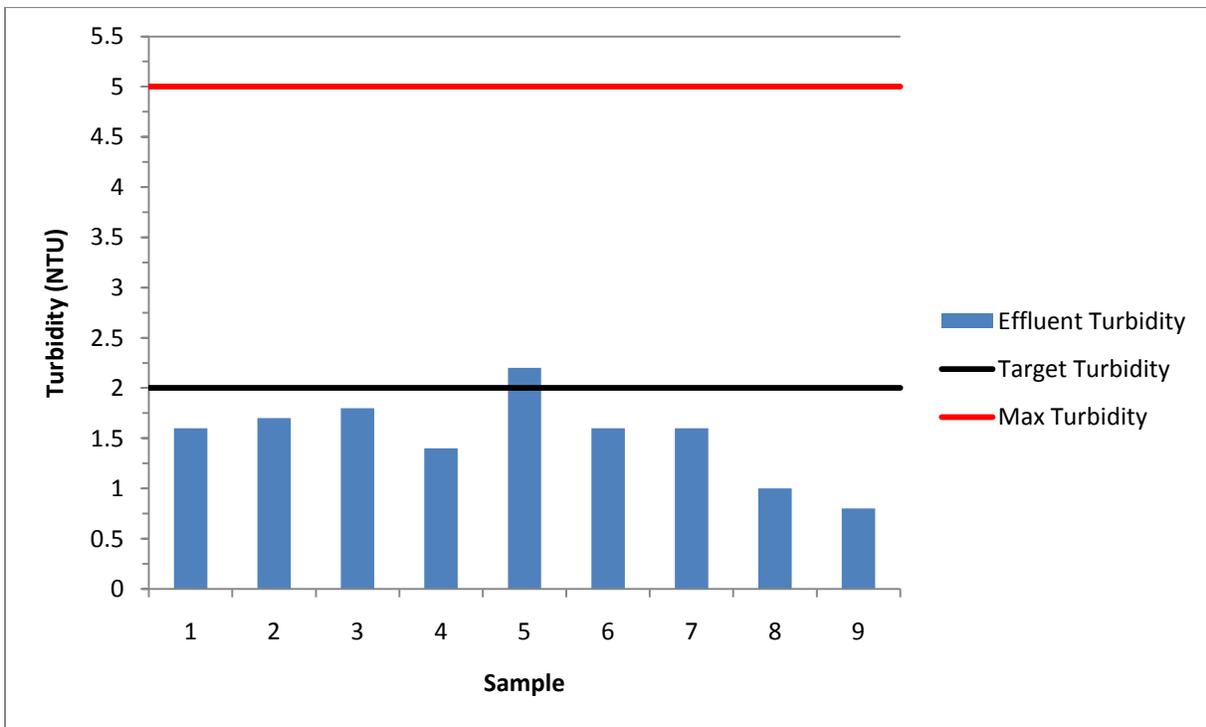


Figure 7. Filter effluent turbidity in NTU for PES-13 pile cloth media.

Table 4. Summary of Test Parameters for PES-13 pile cloth media.

Sample	Influent TSS (mg/L)	Effluent TSS (mg/L)	Effluent Turbidity (NTU)	Loading Rate (gpm/sf)	Discs Operating
1	15	0	1.6	2.2	12
2	1	2	1.7	2.8	6
3	6	2.2	1.8	4	6
4	5	0	1.4	5.9	3
5	7	3.4	2.2	7.1	3
6	7	1.6	1.6	6.8	3
7	1	0	1.6	5	3
8	0	0	1	5	3
9	0	1.4	0.8	6.1	3
10	6	2.6	NA	7.5	3
11	4	3.6	NA	7.3	3
12	8	2.2	NA	3.1	6
AVERAGE:	5	1.6	1.5	5.2	4.5

CONCLUSIONS

Lake City has successfully implemented innovative filtration technology to satisfy regulations for water reuse in Florida. During performance testing and continued operation of the Cloth Disc Filter at the Lake City, Florida Sisters Welcome Road Reclaim Water System, the filter's effluent turbidity, TSS, and hydraulic loading rates met the specified treatment objectives. Both the PA-13 nylon pile and PES-13 polyester pile cloth media produced high quality effluent.

During testing with the PA-13 media, filter effluent TSS and turbidity averaged 0 mg/L and 1.8 NTU meeting the design criteria of 5 mg/L and 2 NTU. During testing with the PES-13 media, filter effluent TSS and turbidity averaged 1.6 mg/L and 1.5 NTU respectively. The PES-13 filter media was tested at hydraulic loading rates up to 7.5 gpm/ft², well above the design target of 3.6 gpm/sf . The PES-13 pile cloth media continues to operate within the treatment objectives, with effluent TSS often non-detect and effluent turbidity down to 0.8 NTU.

The need for reuse water around the world continues to grow. Public access reuse systems like the one installed at Lake City, Florida prove that wastewater treatment plants can upgrade their existing systems to recover and conserve water, arguably life's most vital resource.

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