C-43 West Basin Storage Reservoir Water Quality Component

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Acronyms and Abbreviations

ac	Acre
CERP	Comprehensive Everglades Restoration Plan
cfs	Cubic Feet Per Second
CPE	Chlorinated Polyethylene
CY	Cubic Yard
DEP	Department of Environmental Protection
FAV	Floating Aquatic Vegetation
FDOT	Florida Department of Transportation
FRP	Fiber Reinforced Plastic
gpd	Gallons Per Day
gpm	Gallons Per Minute
HDPE	High-Density Polyethylene
HWTT	Hybrid Wetland Treatment Technology
LF	Linear Feet
mgd	Million Gallons Per Day
mg/L	Milligrams Per Liter
NEEPP	Northern Everglades and Estuaries Protection Program
O&M	Operation and Maintenance
RAS	Return Activated Sludge
SAV	Submerged Aquatic Vegetation
SCADA	Supervisory Control and Data Acquisition
SF	Square Feet
SFWMD	South Florida Water Management District
STA	Stormwater Treatment Area
TKN	Total Kjeldahl Nitrogen
TN	Total Nitrogen
TOC	Total Organic Carbon
TP	Total Phosphorus
TSS	Total Suspended Solids
USACE	United States Army Corps of Engineers
VSS	Volatile Suspended Solids
WAS	Waste Activated Sludge
WBSR	West Basin Storage Reservoir
WQC	Water Quality Component
WQFS	Water Quality Feasibility Study

1.0 Background/Introduction

On January 10, 2019, Governor Ron DeSantis signed Executive Order 19-12, calling for greater protection of Florida's environment and water quality. The Executive Order directed the state's agencies to take an aggressive approach to address some of the environmental issues plaguing the state, with a significant emphasis on south Florida and recent harmful algal blooms associated with blue-green algae. Specifically, the Executive Order directed the Florida Department of Environmental Protection (DEP) to "work with the South Florida Water Management District (SFWMD) to add stormwater treatment to the C-43 reservoir to provide additional treatment and improve the quality of water leaving this important storage component" of the Comprehensive Everglades Restoration Plan (CERP).

The C-43 West Basin Storage Reservoir (WBSR) project is designed to capture and store water from Lake Okeechobee and the C-43 basin during Florida's rainy season. The reservoir is under construction on a 10,700-acre (ac) parcel owned by SFWMD in Hendry County and is a 50–50 cost-share between SFWMD and the United States Army Corps of Engineers (USACE). Fully constructed, the C-43 WBSR will store approximately 57 billion gallons of water (approximately 170,000 ac-feet) for the congressionally authorized CERP project. The project, expected to be completed in 2023 (see Table 1-1), will include construction of two 5,000-ac reservoir storage cells (Cells 1 and 2), three pump stations, a perimeter canal along with associated water control structures, and required improvements to the State Road 80 Bridge and the Townsend Canal, which ultimately connects to the Caloosahatchee River.

Table 1-1. C-43 WBSR Contractual Construction Schedule

Schedule	Date
Construction Start	June 3, 2019
Substantial Completion	December 31, 2023
Start of First Fill	First wet season event after substantial completion (likely summer 2024)

Depending on storage needs, water depth in the reservoir will range from 15 to 25 feet. All water stored in the reservoir is protected for the environment by a water reservation rule and will be released on a regulated schedule to help achieve minimum flow requirements at the S-79 structure (Franklin Lock and Dam) during dry season low-flow conditions. The water reservations rule for the Caloosahatchee River (C-43 WBSR) is defined in subsection 40E-10.041(3), Florida Administrative Code. This project is one component of a larger restoration project for the Caloosahatchee River and Estuary and will comprise a large portion of the overall water storage requirement for the Caloosahatchee River Watershed.

It is imperative that releases from the C-43 WBSR do not contribute to impairments of downstream water quality constituents compared to existing conditions in the Caloosahatchee River Watershed. DEP identified the Caloosahatchee Estuary to be impaired for total nitrogen (TN). DEP has not identified the Caloosahatchee River and Estuary to be impaired for total phosphorus (TP), but this nutrient is also considered for reduction in the water from the C-43 WBSR. The reduction of nutrient concentrations and loads to these waterbodies is required by the Northern Everglades and Estuaries Protection Program (NEEPP), which was passed by the Florida Legislature and signed into law in 2007 and amended in 2016, and by the Caloosahatchee River and Estuary Total Maximum Daily Load adopted in 2009 by DEP (DEP, 2009).

To examine conventional and innovative biological, physical, and chemical technologies available and applicable to treating water entering and discharging from the C-43 WBSR or reducing potential algal biomass within the C-43 WBSR, SFWMD, DEP, and local governments (Working Group) partnered to develop the C-43 WBSR Water Quality Feasibility Study (WQFS) (J-Tech, 2020). A group of alternatives and technologies were evaluated based on scalability, confidence in performance estimates, available Florida case studies, residuals production, habitat benefits, ecosystem services, energy efficiency, land requirements, operation and maintenance (O&M) requirements, and schedule of implementation. Cost effectiveness was also evaluated. The WQFS recommended four alternatives for post-storage treatment as well as an in-reservoir alum treatment, which were further evaluated in the Water Quality Component (WQC) Siting Evaluation.

In the first part of the Siting Evaluation, J-Tech evaluated potential locations for the C-43 WBSR WQC by identifying areas with existing or future constraints. Based on the constraints in the surrounding area and to ensure that the C-43 WBSR project would not be impacted, the SFWMD-owned lands to the north of the reservoir were identified as the best option for locating the WQC. J-Tech also determined options to route water from the C-43 WBSR to each WQC alternative for treatment and then to route treated water back to the river. Updated water quality targets were developed for the purpose of the Siting Evaluation and additional analysis was performed to ensure the sizing of the technologies was appropriate. The four treatment technologies recommended in the WQFS remained feasible in terms of overall performance for the refined TN, TP, and total suspended solids (TSS) concentration targets in milligrams per liter (mg/L). As part of the Siting Evaluation, minor modifications were made to the acreage required for each alternative. Table 1-1 summarizes key observations about each technology as a result of this analysis. Overall, the Siting Evaluation criteria matrix ranked the technologies in the following order: (1) post-storage alum treatment, (2) sand filter with Bold and Gold®, (3) hybrid wetland treatment technology (HWTT), and (4) stormwater treatment area (STA) with Bold and Gold®.

Table 1-2. Siting Evaluation Estimated Discharge Concentrations and Updates to WQC Alternatives

Alternative	TP Discharge (mg/L)	TN Discharge (mg/L)	TSS Discharge (mg/L)	Area Change	Update from WQFS
Alum (post-storage)	0.086	1.00	3.33	No change	Reduced alum dose from 0.30 mg/L or 1,500 gallons per day (gpd) to 0.25 mg/L or 1,250 gpd.
HWTT	0.080	1.23	2.35	Adjusted	Reduced total system area from 660 ac to 439 ac.
STA (925-ac) with Bold and Gold®	0.059	1.22	2.12	Adjusted	Assuming vendor-supplied removal rates for Bold and Gold®, system meets TN and TP targets. STA meets all targets. Media filter bed area increased to 105 ac.
Sand filter with Bold and Gold®	0.056	1.19	1.95	Adjusted	Assuming vendor-supplied removal rates for Bold and Gold®, system meets TN and TP targets. Media filter bed area increased to 105 ac.

In addition, through a parallel effort, the in-reservoir alum treatment system was evaluated to determine an appropriate alum dosing to reduce algal blooms. This in-reservoir alum treatment will also help to reduce TN and TP concentrations leaving the reservoir to improve the efficiency of the post-storage WQC treatment.

This Final Conceptual Design Report refines the conceptual plan and costs and develops conceptual construction schedules, operations plans, and permitting needs for the alternatives.

1.1 Sizing Assumptions

Based on the Siting Evaluation results, the period of record 90th percentile values in the reservoir outflow for TN, TP, and TSS were selected to represent maximum inflow concentrations to the WQC options. In Section 2.0 through Section 5.0, the design assumes no reduction in concentration during reservoir storage through either natural or alum-assisted sedimentation and assimilation and are therefore conservative (i.e., higher than expected). Updated costs are provided in Section 8.0, which include the estimated reductions from the in-reservoir alum treatment system, which is in design. The sizing is also based on achieving the median dry season water quality target concentrations from the S-79 data to ensure that C-43 WBSR discharges are the same as or better than the river quality.

1.2 Changes in Conceptual Features and Costs

As the Conceptual Design progressed from draft to final, comments received from SFWMD and adjustments proposed by J-Tech led to changes in the features, assumptions, and costs for each WQC option. Adjustments were made for each option using the following guidelines:

- Unit costs for earthwork were standardized
- Installation cost percentages were reduced
- Hydraulic control structure costs were reduced
- Unit costs for collection and distribution piping were updated with recent quotes available within the project area
- Field and office overhead was reduced
- Contingency was reduced to 20%
- Engineering, planning, and construction management costs were removed
- Roadway and bridge costs were increased
- Riprap costs were reduced
- Alum quantities were reduced to factor in the expected in-reservoir alum treatment performance

2.0 Option 1: Post-storage Alum Treatment System

Alum is a well-established chemical treatment approach shown to achieve more than 50% reductions of TP, TN, and TSS in Florida's surface waters (e.g., Harper, 2015). The treatment of surface waters with alum in drinking water plants is common practice throughout the industry. The design of this system has been adapted from that approach with a focus on both cost efficiency and ease of O&M.

The post-storage alum treatment system for the C-43 WBSR consists of an alum addition system followed by flash mixing, mechanical flocculation, and settling. To improve efficiency and manage residual volume, a sludge recirculation and removal system would be installed in the settling basin. Design influent and effluent quality targets are shown in Table 2-1. The influent flow criteria were derived from the C-43 WBSR Project Implementation Report model projections. Influent water quality criteria were derived from DBHYDRO data for the S-78 monitoring station (J-Tech, 2021a). Effluent criteria were based upon median dry season river water quality concentrations (J-Tech, 2021a). Where effluent values are not provided in Table 2-1, no specific effluent criterion was set for that parameter.

Table 2-1. Post-storage Alum Treatment System Design Influent and Effluent

Parameter	Influent	Effluent
Peak Flow, cubic feet per second (cfs)	600	600
Average Flow, cfs	457	457
TSS, mg/L	5[1]	3
Organic Nitrogen, mg/L	1.41	-
Ammonia Nitrogen, mg/L	0.17	-
Nitrate + Nitrite, mg/L	0.23	-
TN, mg/L	1.81	1.2
Soluble Reactive Phosphorus, mg/L	0.094	-
Organic Phosphorus, mg/L	0.058	-
TP, mg/L	0.200[2]	0.080

1. Influent TSS was assumed based on historical pond effluent values.
2. TP was increased from the period of record 90th percentile value (0.152 mg/L), only for this option, to reflect the required organic phosphorus content of TSS (0.02 grams of phosphorus per gram of volatile suspended solids [VSS]), assuming 75% VSS fraction of the TSS.

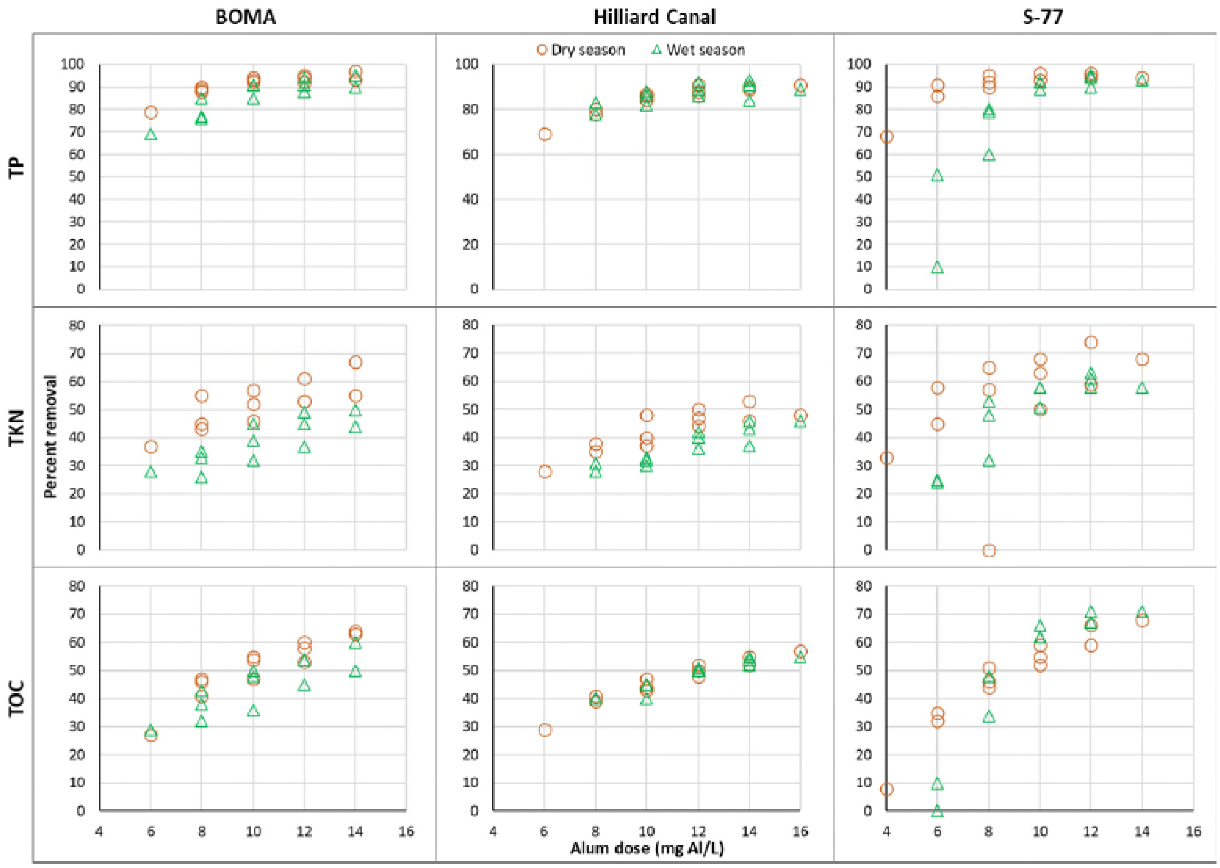
The influent values in Table 2-1, unless otherwise noted, reflect the period of record 90th percentile values in the S-78 influent concentrations to the reservoir cells and assumes no treatment/changes within the cells prior to the post-storage alum treatment system. The influent values to the post-storage alum system are conservative; actual values are anticipated to be lower for the phosphorus fractions because of the in-reservoir alum treatment system (designed to achieve 0.080 mg/L in the reservoir effluent), as described in Section 7.0.

2.1 Design Calculations

Treatment of surface waters with alum is typically focused upon achieving low effluent TSS and turbidity. The goals of the C-43 WBSR post-storage alum treatment system are somewhat different as the goals are not particulate and turbidity related but to achieve effluent TN and TP goals. However, the mechanisms of achieving these goals are very similar. Turbidity control is about coagulation of colloidal material with alum and the subsequent solids removal (TSS reduction). Alum, when added to water, quickly hydrolyzes to hydrous aluminum oxides that can both coagulate colloidal particles (i.e., turbidity removal) and adsorb orthophosphorus. These hydrous aluminum oxides will then settle, thereby removing both phosphorus and colloids from solution. Hydrous aluminum oxides do not have a direct effect on nitrogen species other than the nitrogen that is associated with colloidal and particulate organics. Thus, the nitrogen effectiveness of the alum treatment system is highly dependent upon coagulation efficiency and TSS removal.

Jar tests performed by SFWMD (SFWMD, 2021) investigated the effectiveness of alum addition upon influent water quality. Influent TN ranged between 1.5 mg/L and 1.3 mg/L. At the lowest alum dosages tested (6–8 mg/L) TN removal was between 67% and 74% (0.9 to 1.0 mg/L). As the C-43 WQC design TN goal is to reduce 1.81 mg/L to 1.2 mg/L, this indicates that the needed alum dosage is in the 6 mg/L to 8 mg/L range for the post-storage treatment system. This dosage was also found to reduce the TP values to the 0.04 mg/L range, which is well below the 0.080 mg/L design target. The dosage can be modified during operation to minimize alum use, if possible to still achieve the target nutrient concentrations.

The jar tests indicated that coagulation and solids removal is a critical component of effective alum treatment. This can be seen in the jar test data by comparing the TP, total Kjeldahl nitrogen (TKN), and total organic carbon (TOC) removal data from the three sampling locations (Boma, Hilliard Canal, and S-77) at various dosages (see Figure 2-1).



Source: SFWMD (see Appendix D)

Figure 2-1. Summary of Jar Test Results

While TKN and TOC showed reasonably linear responses to alum dosage, except perhaps at the highest dosage, the TP profile was markedly different. The TP profile can be explained by increased TSS removal as the dosage increased, which is reflective of better settling as the alum TSS concentration increased. This is a very typical pattern for phosphorus removal in jar tests. In contrast, the TKN and TOC profiles were linear and showed very similar patterns. This finding indicates coagulation (converting colloidal material to settleable material) was in place for the removal of these two components. The higher dosages and TSS concentration resulted in a linear response for all but the highest dosages. Tests that "flatten" out at the highest dosage indicate full coagulation.

There are two primary approaches in the field for achieving these types of results. One is the approach used in the jar tests where more chemical is added to get the needed TSS/coagulation values and settling results. The second approach uses solids recirculation from the settled sludge back to the flocculation stage to increase the TSS values and thus improve settling without having to increase the alum dosage. Sludge is either continuously or intermittently wasted as needed. The latter approach is being proposed for the WQC to achieve the treatment goals and to reduce operating costs of this facility.

Figure 2-2 shows a process flow diagram of the proposed post-storage alum facility. Effluent from the C-43 WBSR is pumped to the post-storage alum facility for treatment, which has the following processes:

1. Alum Rapid Mix: A mechanically mixed alum addition system in a concrete tank to rapidly disperse the alum into solution and blend in the recirculated alum sludge.
    a. Alum Storage System: Either expand existing in-reservoir alum storage or locate a new storage tank farm near off-line system.
2. Alum Flocculation: Provide time for coagulation and develop a well settling floc prior to entering the settling basin in an earthen basin.
3. Settling: Earthen basin with a level of sludge (to be determined) for automated alum sludge removal.
4. Solids Handling: This is envisioned as a centrifuge dewatering system in a building. An optional approach is to either seasonally drain and dry the sludge in the settling basins or provide a separate sludge drying bed system adjacent to the settling cells.

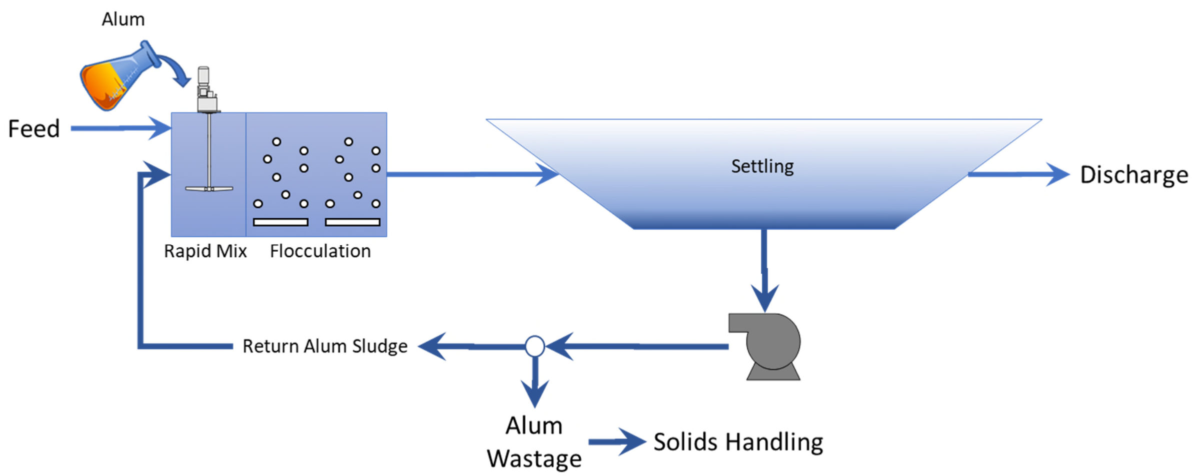


Figure 2-2. Proposed Post-storage Alum Treatment System Process Flow Diagram

The proposed post-storage alum system was simulated in Sumo© Simulation platform by Dynamita (www.dynamita.com) version 21. Appendix A includes the Sumo model output that summarizes performance calculations.

Influent characterization was set up to match the values shown in Table 2-1. Figure 2-3 shows the Sumo process flow diagram. The settling model was calibrated manually assuming that the effluent TSS from the settler would be 3 mg/L (5 mg/L was assumed for the reservoir effluent). As part of detailed design, calibration of the settling and coagulation model would be conducted based on the jar test results.

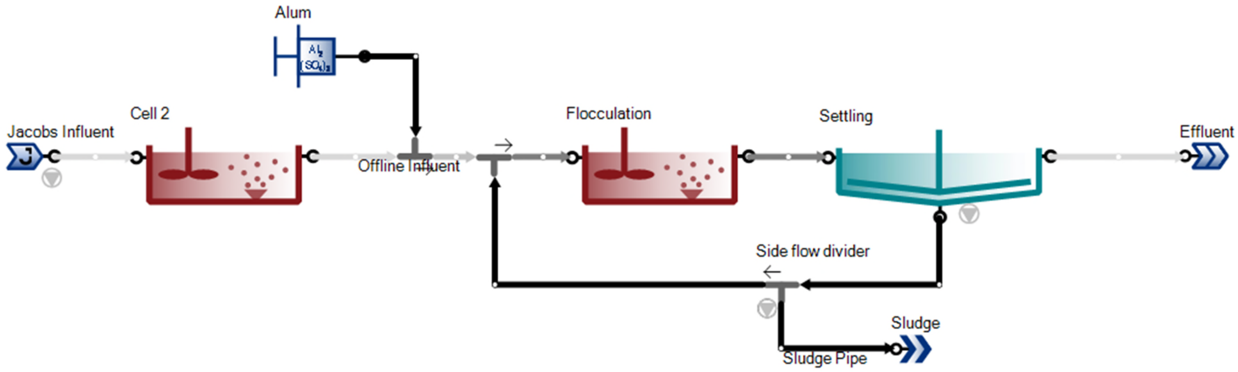


Figure 2-3. Process Flow Diagram for Sumo Simulation of Post-storage Alum Treatment System

The design basis for each unit process is given in Table 2-2.

Table 2-2. Post-storage Alum Treatment System Design Basis

Parameter	Influent	Units
Influent		
Peak Total Pumping Capacity	600	cfs
Average Pumping Rate	457	cfs
Daily Pumping Duration	12	Hours/day
Number of Pumps	To be determined	
Design TP	0.20	mg/L
Design TN	1.81	mg/L
Design TSS	5	mg/L
Effluent		
Design Effluent TN	1.2	mg/L
Target Effluent TP	0.080	mg/L
Estimated Effluent TSS	3	mg/L
Alum Dosage		
Minimum	1.0	mg/L
Average	3.0	mg/L
Peak	6.0	mg/L
Bulk Alum		
Strength	49	Percent weight as $Al_2(SO_4)_3{\cdot}14H_2O$
Density	11.10	Pounds/gallon
Alum Usage		
Minimum Flow Criteria	50% of Average Flow (229 cfs)	
Minimum Total Alum Flow	1.73	Gallons per minute (gpm)
Average Flow Criteria	Water Quality Goals (457 cfs)	
Average Total Alum Flow	10.4	gpm
Daily Average Total Alum Flow	7,489	gpd
Peak Flow Criteria	Water Quality Goals (600 cfs)	
Peak Total Alum Flow	27.3	gpm
Bulk Alum Storage		
On-Site Storage Capacity	14	Days at Average Dosage and Flows
	104,841	Gallons
Delivery Truck Size	11,600	Gallons

Parameter	Influent	Units
Bulk Tank Sizing	Receive One Tanker Load at 10% full	
Minimum Bulk Tank Size	12,760	Gallons
Estimated Number of Bulk Tanks	8	
Bulk Tank Liquid Volume	13,800	Gallons each
Estimated Bulk Tank Diameter	12	Feet
Estimated Bulk Tank Height	16.5	Feet
Tank Type	Vertical Double-walled Fiber Reinforced Plastic (FRP)	
Alum Rapid Mix System		
Number	2 Parallel	Concrete Rapid Mix Tanks
Contact Time at Average Flow	1.0	Minutes
Volume Each	13,710	Cubic feet
Estimated Dimensions Each	Length: 37 feet x Width: 37 feet x Depth: 10 feet	Feet
Alum Control Approach	Flow Proportional dosing interlocked with influent pump and automated shutoff valve	
Alum Mixer	2	Vertical Turbine Mixers
Target Shear Rate (G Value)	≈400	1/second
Estimated Mixer Motor	125	Horsepower each
Flocculation		
Number	2 Parallel	Earthen Basins
Number of Stages	2	Each
Target Shear Rates (1^{st} / 2^{nd})	75 / 30	1/second
Estimated Dimensions Each	Length: 165 feet x Width: 250 feet x Depth: 10 feet	Feet
Flocculation Mechanism	To be determined	
Settling		
Number	2 Parallel	Earthen basin
Peak Loading Rate	0.4	gpm/square foot
Area Each	336,645 (7.73)	Square feet (acres)
Estimated Dimensions Each	Length: 1,350 feet x Width: 250 feet x Depth: 10 feet	Feet
Sludge Removal	At least 25% of the sludge area needs to have sludge removal. Overall approach is to be determined	
Sludge Pumping	≈ 5.0	Million gallons per day (mgd)
Sludge Wasting	≈ 1.0	mgd
Average Mass of Solids Produced (12 hour/day operation at 457 cfs)	14.6	Tons dry solids/day
Estimated Sludge Concentration	1.0	Percent weight
Dewatering		
Method	To be determined, currently mechanical centrifuge dewatering	

The footprint of the alum treatment system would require approximately 50 ac, consisting of 17 ac of settling ponds and approximately 20 ac for mixing, centrifugation, chemical storage facilities, and related administrative and access infrastructure. Water from the C-43 WBSR would be pumped at an average flow of 457 cfs from the reservoir's north perimeter canal to an inflow canal of approximately 1,100 linear feet (LF) and then flow by gravity to the treatment area. Alum for nutrient removal would be fed to the facilities' inflow canal via a liquid alum feed system from a storage tank yard.

Water from the inflow canal would be split to flow to two parallel concrete rapid mix basins to provide flash mixing of the alum with vertical turbine mixers. The water from the rapid mix basins will flow by gravity to two parallel earthen flocculation basins with high-density polyethylene (HDPE) liners via a conveyance canal of approximately 608 LF. The flocculation basins will be approximately three million gallons each, and the entire flocculation zone will be preliminarily aerated with a diffused air system via two 200-horsepower blowers to provide an airflow of approximately 6,500 standard cubic feet per minute. After the flocculation basins, flow will be directed over a submerged weir, 250 feet in length, in each basin to provide hydraulic separation between the flocculation basins and sedimentation basins. The earthen sedimentation basins will be HDPE lined and hold approximately 25 million gallons each.

The sedimentation basins are designed to settle out solids created by the alum treatment system during peak flow conditions. After sedimentation, the final treated effluent flow will be discharged by gravity to a collection canal of approximately 457 LF that sends flow to the Townsend Canal.

Minimal water losses are expected with this WQC option. Evaporation losses would only occur on the 17-ac sedimentation basins, and rainfall on the basins should mostly offset these losses in a water year. There should be no seepage losses as the flocculation and sedimentation basins would be lined.

The alum treatment system was sized to yield average outflow concentrations of 0.08 mg/L of TP and 1.2 mg/L of TN. These concentrations have been shown to be achievable at other full-scale alum facilities in Florida. For example, similar performance ranges were noted for the Upper Lake Lafayette Nutrient Reduction Facility in Tallahassee, where the inflow TP range of 0.05–0.3 mg/L is reduced by 74% to a range of less than 0.01–0.1 mg/L (City of Tallahassee, 2018). Similarly, a 68% reduction in TN was measured, where inflow TN is reduced from a range of 0.3–0.8 mg/L to 0.05–0.4 mg/L.

Based upon additional analysis using the SUMO model, the in-reservoir aluminum concentration is estimated to be 0.27 mg/L, which would largely be in particulate form and is well below the state standard of 1.5 mg/L in Chapter 62-302.530(5), Florida Administrative Code. This concentration is also below the United States Environmental Protection Agency Criterion Continuous Concentration of 0.9 mg/L, assuming a total hardness of 191 mg/L, reservoir pH of 6.8, and TOC concentration of 20 mg/L.

A portion of the settled sludge will be recirculated to the rapid mix basins to improve nutrient removal, coagulation, and settling. The target TSS concentration in the flocculation basins is 100–200 mg/L. A portion of this sludge will be pumped to dewatering for sludge mass management.

Settled solids that accumulate in the sedimentation basins will be preliminarily pumped to a centrifuge dewatering facility. Alternative approaches include drying in basin during the off-season or dedicated sludge drying beds.

2.2 Water Quality Performance

The post-storage alum treatment system was assessed in Sumo© Simulation platform by Dynamita (www.dynamita.com) version 21. Table 2-3 summarizes conceptual performance of the post-storage alum treatment system.

Table 2-3. Option 1 Post-storage Alum Treatment System Conceptual Performance

Parameter	Influent	Units
Influent		
Peak Total Pumping Capacity	600	cfs
Average Pumping Rate	457	cfs
Daily Pumping Duration	12	Hours/day
Number of Pumps	To be determined	
Design TP	0.20	mg/L
Design TN	1.81	mg/L
Design TSS	5	mg/L
Effluent		
Design Effluent TN	1.2	mg/L
Target Effluent TP	0.080	mg/L
Estimated Effluent TSS	3	mg/L

2.3 Conceptual Cost

Capital costs were estimated by pricing materials required for storage, dosing, and related items, and applying standard markups. Operational costs were derived and updated from the WQFS. The total net present value was calculated over a 50-year period.

2.3.1 Capital Cost

The capital cost for the post-storage alum treatment includes the grading; berm construction; excavation; construction of alum feed systems, flocculation mixers, floc and sedimentation wetlands, and rapid mix flocculation tanks; and conveyance. Unit pricing for water conveyance construction includes pump stations, water control structures built as cast-in-place box culverts, local access bridges, and excavation/embankment. The estimated capital cost for the combined post-storage alum treatment system is $92.1 million. Table 2-4 provides the conceptual capital costs. Appendix B includes details on the individual components of the treatment technology equipment and materials.

Table 2-4. Option 1 Post-storage Alum Treatment System Conceptual Capital Cost

Item	Unit Design Criteria	Quantity	Basis	Unit Cost	Estimated Cost
TECHNOLOGY – EQUIPMENT AND MATERIALS					
Flocculation Rapid Mix	Appendix B	1	LS	$1,096,000	$1,096,000
Sedimentation Basin	Appendix B	1	LS	$15,778,646	$15,778,646
Liquid Chemical Alum	Appendix B	1	LS	$822,000	$822,000
Flocculation Mixers	Appendix B	1	LS	$786,000	$786,000
Emulsion Polymer System	Appendix B	3	LS	$40,000	$120,000
Cake Conveyance System	Appendix B	3	LS	$65,000	$195,000
Dewatering Unit	Appendix B	3	LS	$600,000	$1,800,000
Waste Activated Sludge (WAS) Pump Station	Appendix B	1	LS	$1,009,389	$1,009,389
Dewatering Building	Appendix B	1	LS	$1,407,000	$1,407,000
Total Equipment Cost (TEC)					**$23,014,035**
Freight and Taxes		3%	of TEC		$690,421
Spare Parts		1%	of TEC		$230,140
Purchased Equipment Cost – Delivered (PECD)					**$23,934,597**

Item	Unit Design Criteria	Quantity	Basis	Unit Cost	Estimated Cost
TECHNOLOGY CONSTRUCTION – INSTALLATION					
Equipment Installation		30%	of TEC		$7,180,379
Process Piping		1.0%	of TEC		$239,346
Instrumentation and Controls		1.0%	of TEC		$239,346
Electrical		1.0%	of TEC		$239,346
Civil		1.0%	of TEC		$239,346
Concrete		1.0%	of TEC		$239,346
Structural Steel		1.0%	of TEC		$239,346
Architectural		1.0%	of TEC		$239,346
Service Facilities		1.0%	of TEC		$239,346
Total Technology Direct Cost (TTDC)					**$9,095,147**
CONVEYANCE CONSTRUCTION – INSTALLED					
Pump Station	Includes inflow piping, based on historical SFWMD data for pump station construction per cfs	611	cfs	$50,000	$30,550,000
Inflow Water Control Structure	1 double barrel 8' x 8' box culvert at 70 LF	140	LF	$8,000	$1,120,000
Outfall Water Control Structure	3 single barrel 8' x 8' box culvert at 55 LF each	165	LF	$9,000	$1,485,000
Discharge Water Control Structure	Overflow spillway	50	LS	$15,000	$750,000
Inflow Canal	Excavation, hauling, spreading, compaction, grading, and slope protection	8,703	cubic yard (CY)	$10	$87,030
Site Bridges	2 two-lane Florida Department of Transportation (FDOT) Florida slab beam at 30' x 100' = 3,000 square feet (SF) each (6,000 SF total)	6,000	SF	$420	$2,520,000
Total Installed Conveyance (TIC)					**$36,512,030**
TOTAL DIRECT COST (TDC)	PECD+TTDC+TIC				**$69,541,773**
Mobilization		4%	of TDC		$2,781,671
Subtotal					**$72,323,444**
Bonds, Insurance		1.5%	of TDC		$1,043,127
Contractor's Profit		7%	of TDC		$4,867,924
Contingency		20%	of TDC		$13,908,355
Total Direct Cost + Indirect Cost, Including Profit + Contingency	**Total Probable Construction Cost (TPCC)**				**$92,142,850**

2.3.2 O&M Cost

O&M costs for the post-storage alum treatment system include the yearly cost for the alum for treatment, annual power cost for the system, and maintenance and repair. The cost of alum per dry ton used is $202. Other O&M activities would include general field operations, SCADA hydrologic data management, and water quality monitoring. The O&M cost for the alum treatment system is estimated at $9.6 million (Table 2-5).

Table 2-5. Option 1 Post-storage Alum Treatment System Conceptual O&M Cost

Parameter	Value	Notes
Annual Treatment System Power Cost ($)	$103,610	At a cost of $0.10 per kilowatt hour
Average Annual Alum Cost	$1,509,112	Based on an estimate of 7,471 dry tons of alum per year at a cost of $202 per dry ton
Annual Sludge Hauling Cost	$554,800	Based on an estimate of 13,870 wet tons produced per year at a hauling cost of $40 per wet ton
Polymer Cost per year	$234,768	Based on an estimated 70,080 pounds of polymer needed per year at a cost of $3.35 per pound
Annual Dewatering Power Cost ($)	$103,127	
Estimated Annual Labor Cost Alum	$100,800	One staff member operating dewatering system for 8 months at a rate of $35 per hour
Maintenance & Repair Annual Cost	$122,089	For equipment that needs to be replaced every 15 or 25 years
Field Operations	$410,000	
Supervisory Control and Data Acquisition (SCADA) Hydro Management	$52,000	
Water Quality Data Collection/Management	$83,000	
Field Operations	$545,000	
Total Annual O&M Cost	$6,186,826	
Other Cost	0.2	
Subtotal Annual O&M Cost	$7,424,191	
Contingency	0.3	
Final Total Annual O&M Cost	**$9,651,448**	

2.3.3 Life Cycle (Net Present Value) Cost

The life cycle cost, presented in a net present value, is used to compare the estimated cost of the treatment systems over a designated time frame, which is determined to be a 50-year lifespan. This cost accounts for all yearly O&M costs and the capital cost of the treatment system. The estimated life cycle cost for the post-storage alum treatment system over a 50-year lifespan is $403.8 million assuming an annual discount rate of 0.05. Complete replacements of alum pumps and related chemical storage hardware were included for years 15, 25, 30, 45, and 50 to be consistent with conservative cost assumptions applied for the in-reservoir alum treatment system.

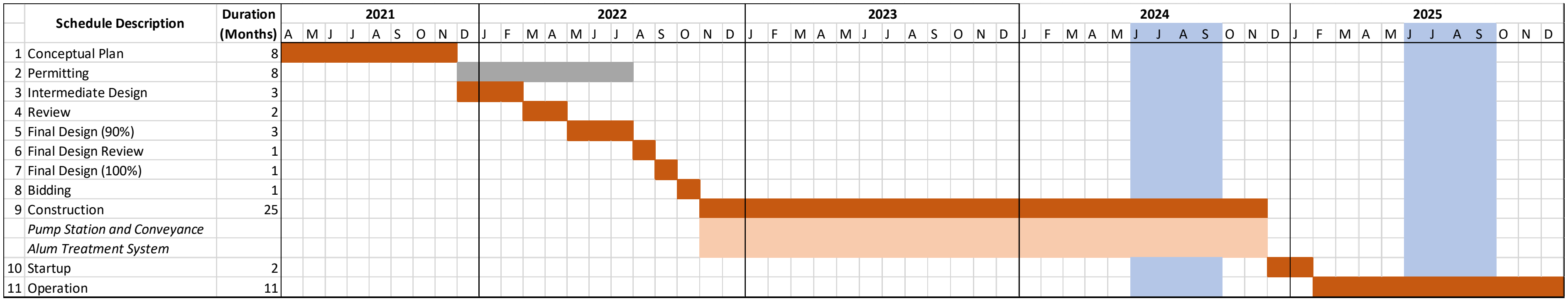
Table 2-6. Option 1 Post-storage Alum Treatment System Conceptual Life Cycle Cost

Year	Cost	Notes
0	$92,142,850	Estimated capital costs
1	$9,941,171	
2	$10,239,406	
3	$10,546,588	
4	$10,862,986	
5	$11,188,876	
6	$11,524,542	
7	$11,870,278	
8	$12,226,386	
9	$12,593,178	
10	$12,970,973	
11	$13,360,103	
12	$13,760,906	
13	$14,173,733	
14	$14,598,945	
15	$16,492,915	15-year equipment replacement

Year	Cost	Notes
16	$15,488,021	
17	$15,952,661	
18	$16,431,241	
19	$16,924,178	
20	$17,431,904	
21	$17,954,861	
22	$18,493,507	
23	$19,048,312	
24	$19,619,761	
25	$26,315,555	25-year equipment replacement
26	$20,814,605	
27	$21,439,043	
28	$22,082,214	
29	$22,744,680	
30	$25,695,424	2nd 15-year equipment replacement
31	$24,129,831	
32	$24,853,726	
33	$25,599,338	
34	$26,367,318	
35	$27,158,338	
36	$27,973,088	
37	$28,812,281	
38	$29,676,649	
39	$30,566,949	
40	$31,483,957	
41	$32,428,476	
42	$33,401,330	
43	$34,403,370	
44	$35,435,471	
45	$40,032,633	3rd 15-year equipment replacement
46	$37,593,491	
47	$38,721,296	
48	$39,882,935	
49	$41,079,423	
50	$55,098,927	2nd 25-year equipment replacement
Net Present Value	**$403,716,536**	**50-year life cycle cost estimate**
Number of Years, N	50	
Annual Discount Rate	0.05	
Annual Inflation	0.03	

2.4 Construction Schedule

The construction schedule is a sequence of phases including design, construction, and operation (Figure 2-4). The design phase incorporates conceptual and final design, review processes, and permitting evaluation. This phase began in April 2021 with conceptual design and would be completed by September 2022. Once final design is completed, the project would go out to bidding and construction, which is expected to be finished in November 2024. The final operation phase begins following a two-month startup that is used to optimize the system before beginning treatment of the reservoir effluent.



Note: Months highlighted in blue are the estimated times of reservoir filling.

Figure 2-4. Option 1 Post-storage Alum Treatment Construction Schedule

2.5 Draft Operations Plan

Operation of the post-storage alum treatment system would vary throughout a typical year based upon whether the reservoir is in the filling, storage, or discharge phase. The filling phase would be the preferred time for all basic maintenance activities, including annual inspection as well as repair and replacement of pumps, meters, and all mechanical and electrical components. Settling ponds would be dredged, and solids would be dewatered and stockpiled. Chemical storage tanks would be emptied and inspected. The area around the tanks would require general cleaning, as appropriate. The tanks would be supplied with level monitors/alarms as well as leak detectors. These would need periodic maintenance. The fill system would consist of a tanker connection valve to direct the bulk alum to the appropriate tank. Each tank discharge (to the dosing point) would have a basket strainer that would need occasional cleaning (weekly to monthly during the reservoir filling season) to protect the downstream valves from plugging.

The alum dosage system would consist of a flow meter and control valve system at each pump inlet channel. The valve actuator and flow meter would need occasional maintenance, in addition to recommended flow meter calibration. As in any submerged piece of equipment, the alum mixer would require regular maintenance as recommended by the equipment supplier.

During the storage cycle, the system would be placed in a mode of operational readiness in anticipation of seasonal discharge. Alum storage would be expected to be kept at a minimum volume. Operating staff would be assigned to other maintenance activities. Operational staffing plans would be reviewed and maintained on a weekly basis. Water levels in the settling basins would be maintained at a static normal pool level.

Prior to the discharge cycle, system readiness would be reviewed before initiation of flow; alum tanks would be filled; and all mechanical, electrical, and hydraulic features would be reviewed and brought to operational readiness. Operations would need to choose which tank to be filled based on the level in that tank and its ability to receive a full tanker load. Care would need to be taken to not overfill tanks.

During the discharge cycle, the system would be operated as designed. The initial alum dosage would be based upon most recent reservoir water quality monitoring results. Regular sampling and testing would be conducted on the reservoir water and the water at the outlet of the mixing, flocculation, and settling basin outflow to determine if dosages should be raised or lowered, depending on the water quality goals. Alum dosing would be flow paced using the chemical metering system. At a minimum, outflow monitoring parameters would include nutrients, TSS, aluminum, sulfate, specific conductance, and pH. A detailed monitoring plan would be developed during final design if this option is selected as the WQC Plan.

The post-storage alum addition system would be automated assuming that the pumping system would only operate during off peak power hours, preliminarily set at 12 hours per day. Alum flow would be proportional to the influent flow to the post-storage treatment system. During non-operational hours, only the flocculation would stay in operation to keeps solids from irreversibly setting within the flocculation zone. It is assumed that the non-peak power operation would be at night.

If it is decided to use a mechanical dewatering system (i.e., centrifuge versus drying beds), waste alum sludge would be sent to a holding tank/pond overnight and then the sludge would be dewatered during an eight hour shift (or less) during the day period. The storage tank would be sized to allow sludge transfer and no dewatering for three days, and it would include the ability to auto-decant excess water (to reduce tank size). This eliminates the need for weekend dewatering operations. Neither drying bed (in-tank or dedicated drying bed) would require daily operations. For the in-tank option, one or both settling basins would be drained at the start of the non-operational season, and the accumulated sludge would be allowed to dry. Prior to the start of treatment season, sludge would be removed with a tractor to prepare the basins for the next season. For the dedicated drying bed option, intermittent manual removal of the dried material would occur per the decisions in the design and operations report.

During the discharge cycle, typical operational activities anticipated from the alum treatment system include the following:

- Coordination and supervision of chemical deliveries
- Tank farm maintenance and cleaning (monthly)
- Flow meter and control valve maintenance (monthly)
- Mechanical mixer maintenance, per manufacturer recommendation (twice per year)
- Dosage monitoring: weekly during the first months, then monthly while in operation
- Flow checks

3.0 Option 2: Sand Filter with Bold and Gold®

Option 2 is a combination of a full-scale sand filter and a parallel media filtration facility. The sand filter would provide a sustainable alternative to implementing a full-scale treatment wetland but at a reduced area. The key working assumption for the sand filter and Bold and Gold® facility is that the differences in hydraulic loading rates between the two types of systems can be used to allocate systems to fit within available land area to achieve the water quality targets. The sand filter hydraulic loading rate appropriate for the range of TN and TP reductions required for this application is on the order of two feet/day (60 centimeters/day). Similarly, the Bold and Gold® media filtration beds are capable of a significantly greater hydraulic throughput of five inches/hour (305 centimeters/day) (Environmental Conservation Solutions, 2020). Although the Bold and Gold® has a higher loading rate, the sand filter is also recommended to make this option more cost-effective. Both systems offer the benefit of a simpler operational approach, compared to the other options, consisting primarily of hydraulic flow maintenance and management of the site media surface and vegetation.

On average, 20% (91 cfs) of the average daily flow of 457 cfs would be routed to a 92-ac sand filter. The sand filter is estimated to reduce TN and TP concentrations by 29% and 40%, respectively. The media filtration beds are expected to treat to lower concentrations than the study objectives, as detailed in the Bold and Gold® submittal (Environmental Conservation Solutions, 2020). For Option 2, 80% (366 cfs) of the average daily flow would be treated through the Bold and Gold® media filtration beds. As a result, the total flow treated by the sand filter and Bold and Gold® system would be 457 cfs. The expected removal efficiencies for the system at this hydraulic loading are 40% for TN, 85% for TP, and 55% for TSS. The combined flows from both components would yield average system outflow concentrations of 1.1 mg/L of TN, 0.036 mg/L of TP, and 1.5 mg/L of TSS.

A pilot test of the Bold and Gold® media was conducted by SFWMD in parallel with the development of the conceptual design. Between September 14, 2020 and April 21, 2021, 24 sampling events occurred.

Results of the testing at hydraulic loading rates similar to the proposed application for Option 2 indicated TN reductions ranging from 17% to 46% and averaging 30%. Inorganic nitrogen (nitrate-nitrogen and ammonia-nitrogen) was removed to method detection limits and accounted for most of the TN reduction; however, this is a small component of the TN found in the Caloosahatchee River. These results are supportive of the concept of using Bold and Gold® media filtration. However, results for TP removal after five months of operation indicate that the media is a net source of TP, with outflow concentrations higher than inflow concentrations for most of the samples. These results are not consistent with all previous applications of Bold and Gold® (Marty Wanielista, pers. comm., April 7, 2021), and the source of the TP appeared to be the sand used in the media mixture. Similarly, results indicate that the media is a net source of dissolved iron, cobalt, and pyrene. While the latter compounds are below significant effects thresholds, their detection in the outflow was thought to be related to the tire crumb included in the media (Marty Wanielista, pers. comm., April 7, 2021). These departures from expected performance pose a potential concern with the use of Bold and Gold® as a treatment media, and Dr. Wanielista advised that another media, iron filings-based green environmental media, which is an iron-amended sand media that does not include tire crumbs, would likely be more appropriate. For the purposes of the analysis in this Conceptual Design Report, the treatment assumptions for Bold and Gold® provided by the vendor were used. However, based on the pilot study results, it appears that Bold and Gold® is not appropriate for the WQC. Appendix D is a memorandum prepared by SFWMD summarizing the results of the Bold and Gold® pilot project.

Option 2 is proposed for the S-4 parcel located to the north of the C-43 WBSR perimeter canal. The total area of the WQC is proposed to be 298 ac, of which the total Bold and Gold® treatment area is estimated to be 124 ac, based upon the proportion (80%) of total system flow treated. Each of the sand filter and Bold and Gold® treatment area components would be subdivided into two treatment cells each to allow for maintenance. Access roads and conveyance infrastructure would comprise the remaining area.

Water from the C-43 WBSR would be pumped from the perimeter canal to the treatment cells through an open distribution channel. Water would flow by gravity through parallel discharges to the distribution channels of the sand filter and the Bold and Gold® system. Water filtering through the sand filter and the Bold and Gold® beds would be collected by underdrains, discharged over weirs, routed by gravity to collector channels, and sent to the discharge channel to the perimeter canal then to the Townsend Canal and ultimately to the Caloosahatchee River.

3.1 Design Calculations

Table 3-1 summarizes the treatment model performance estimates for the sand filter for the designated area, hydraulic loading, and average inflow nutrient concentrations anticipated from the reservoir under the conservative assumption of no in-reservoir reduction of nutrients. The treatment model is derived from the p-K-C* model, which is a first-order model developed for treatment wetland design and performance analysis (Kadlec and Wallace, 2009), and it is calibrated to available performance data from constructed large-scale sand filters currently operating in Florida (Jacobs, unpublished).

Table 3-2 summarizes the treatment model performance estimates for the Bold and Gold® media filter for the designated area, hydraulic loading, and average inflow nutrient concentrations anticipated from the reservoir under the conservative assumption of no in-reservoir reduction of nutrients. The treatment model is derived from the p-K-C* treatment wetland model and is calibrated to performance data provided by the vendor.

There are minimal water losses expected with this WQC option. Evaporation losses should be minimal from the sand filter and Bold and Gold® system, and rainfall on the system should mostly offset these losses in a water year. In addition, there should be no seepage losses as the media beds would be lined.

3.2 Water Quality Performance

Table 3-1 summarizes the conceptual performance for the sand filter portion, and Table 3-2 summarizes the conceptual performance for the Bold and Gold® portion of the system.

Table 3-1. Option 2 Sand Filter Conceptual Performance

Simple PkC* Design Model (Wastewater Parameters)

Project Name	Option 2. Sand Filter	User inputs indicated by white boxes. Pop-up notes indicated by red triangles.
Project Number		

General Inflow Data

Parameter	Value	Units
Annual Average Daily Flow	91	cfs
Converted Flow	222,641	m^3/d
Wastewater Temperature	23.9	°C

Water Quality Characteristics

Parameter		TSS			NH_4-N		TN	TP	FC	
Influent Concentration, mg/L	C_i =	4.7					1.81	0.1520		
Average Target Effluent Conc., mg/L	C_e =							0.08		
Desired Confidence Percentile		0.5			0		0.5	0.5	0.5	
Max Month/Annual Factor		1.7			2.5		1.6	1.8	2.6	
Design Target Conc., mg/L	C_d =							0.0		
Wetland Background Limit, mg/L	C^* =	0.5			0		0.9	0.02	300	
Reduction fraction to target	$F_e = 1 - C_e/C_i$ =	1.000			No Value		1.000	0.474	No Value	
Reduction fraction to background	$F_b = 1 - C^*/C_i$ =	0.894					0.503	0.868		
Areal Rate Constant, 20°C, m/y	k_{20} =	492			25		164	152	83	
Temperature Factor	θ =	1.00			1.04		1.05	1.00	1.00	
P-Factor	P =	6			6		6	3	3	
Areal Rate Constant, m/y	k_T =	492			29.1		198.4	152	83	
Area required for each parameter, ac		C*>Cd	C*>Cd		C*>Cd		C*>Cd	299.0	C*>Cd	

Required Treatment Wetland Area

Required Treatment Wetland Area	A_{max} =	**299.0**	acres	Displays minimum wetland area to treat all pollutants down to desired targets
		121.0	ha	
User Defined Area	A_{user} =	**92.0**	acres	User specified wetland area; leave blank if you wish to use A_{max} (above) for effluent calculations below.
		37.2470	ha	

Final Effluent Concentrations and Percent Removal

Area (ha) used for Calculations =	37.2	TSS			NH_4-N		TN	TP	FC	
Design Target Conc., mg/L	C_d =						1.0	0.044		
Influent concentrations, mg/L	C_i =	4.7					1.81	0.152		
Effluent concentrations, mg/L		1.1			0.0		1.29	0.091		
Percent Reduction (by concentration)		76%					29%	40%		
Mass Loading (lb/day)		2306					888	75		
Mass Loading (kg/ha/d)		28.1					10.8	0.9		
Mass Out (lb/day)		549			0		633	44		
Mass Out (kg/ha/d)		6.7			0.0		7.7	0.5		
Percent Reduction (by mass)		76%					29%	40%		

Hydraulic Properties Based on Area and Flow

Gravel Diameter (cm)		Approx Aspect Ratio (L:W) = (1:1)	1
Bed Depth (m)	1.2	Length (m)	610
Porosity e (%)	55%	Width (m)	610
Volume Water (m3)	249827	Bottom Slope (m/m)	0
Volume Media (m3)	204404	**Hydraulic Constraints**	
Bed Conductivity k (m/d)	10500	G_1, Drainability	0.00
Design Outlet Water Depth h_0 (m)	1.10	G_3, Distance Thickening/Thinning	176.02

Hydraulic Loading Rate, q (cm/d)	HLR =	59.8	cm/d
Nominal Hydraulic Residence Time (d)	HRT =	1.1	days

Table 3-2. Option 2 Bold and Gold® Conceptual Performance

Simple PkC* Design Model (Wastewater Parameters)

Project Name	Option 2. Bold&Gold® Media Filtration Beds
Project Number	

User inputs indicated by white boxes.
Pop-up notes indicated by red triangles.
Reference: Kadlec and Wallace, 2006
Treatment Wetlands. Boca Raton: CRC Press, Inc.

General Inflow Data

Parameter	Value	Units
Annual Average Daily Flow	369	cfs
Converted Flow	902,795	m^3/d
Wastewater Temperature	23.9	°C

Add Results to NADB Plots

Water Quality Characteristics

Parameter		BOD5	TSS	Organic N	NH_4-N	$NO_{2/3}$-N	TN	TP	FC	
Influent Concentration, mg/L	C_i =		4.7	1.41	0.17	0.2	1.810	0.152		
Average Target Effluent Conc., mg/L	C_e =			0.56	0.07	0.09	0.72	0.123		
Desired Confidence Percentile		0.5		0.5	0.5	0.5	0.5	0.5	0.5	
Max Month/Annual Factor		1.7	1.9	1.8	2.5	2.5	1.6	1.8	3.0	
Design Target Conc., mg/L	C_d =			0.3	0.0	0.0	0.5	0.1		
Wetland Background Limit, mg/L	C^* =	2	0.50	0.5	0	0	0.8	0.02	40	
Reduction fraction to target	$F_e = 1 - C_e/C_i$=	No Value	1.000	0.600	0.600	0.600	0.600	0.191	No Value	No Value
Reduction fraction to background	$F_b = 1 - C^*/C_i$ =		0.894	0.645	1.000	1.000	0.558	0.868		
Confidence-based Rate Constant, 20°C, m/y	k_{20} =	33	977	2683	517	3962	3107	3750	83	
Temperature Factor	θ =	1.00	1.000	1.05	1.05	1.11	1.06	1.00	1.00	
P-Factor	P =	1	6	6	6	6	6	6.0	3	
Areal Rate Constant, m/y	k_T =	33	977	3245.3	623.3	5952.2	3842.3	3750.31	83	
Area required for each parameter, ac		C*>Cd	C*>Cd	C*>Cd	706.5	641.5	C*>Cd	23.7	C*>Cd	C*>Cd

Required Treatment Wetland Area

Required Treatment Wetland Area	A_{max} =	**706.5**	acres	Displays minimum wetland area to treat all pollutants down to desired targets
		286.0	ha	
User Defined Area	A_{user} =	**124.0**	acres	User specified wetland area; leave blank if you wish to use A_{max} (above) for effluent calculations below.
		50.2	ha	

Final Effluent Concentrations and Percent Removal

Area (ha) used for Calculations =	**50.2 ha**	BOD5	TSS	Organic N	NH_4-N	$NO_{2/3}$-N	TN	TP	FC	
Design Target Conc., mg/L	C_d =			0.313	0.027	0.037	0.453	0.068		
Influent concentrations, mg/L	C_i =		4.7	1.410	0.170	0.230	1.810	0.152		
Confidence-based Effluent concentration, mg/L	C_e =		1.6	0.525	0.506	0.057	1.088	0.022		
Percent Reduction (by concentration)			66%	63%	-198%	75%	40%	85%		
Mass Loading (lb/day)			9349	2805	338	458	3601	302		
Mass Loading (kg/ha/d)			84.5	25.4	3.1	4.1	32.5	2.7		
Mass Out (lb/day)			3205	1044	1007	114	2164	45		
Mass Out (kg/ha/d)			29.0	9.4	9.1	1.0	19.6	0.4		
Percent Reduction (by mass)			66%	63%	-198%	75%	40%	85%		

Hydraulic Properties Based on Area and Flow

Percent Open Water	40%	Transition Side Slopes (H:V) - (4:1)	4			Override
Marsh Zone Depth (m)	1.5	Berm Side Slopes (H:V) - (4:1)	4	# of Deep Zones	14	
Deep Zone Depth (m)	1.5	Approx Aspect Ratio (L:W) - (1:1)	1	Deep Zone Bot Length	20	
Volume (m3)	738952					

Hydraulic Loading Rate, q	HLR =	179.8	cm/d
Nominal Hydraulic Residence Time, days	HRT =	0.8	days

3.3 Conceptual Cost

Capital costs were estimated by pricing materials required for construction of the conveyance and treatment components of the system, and by applying standard markups. Operational costs were derived and updated from the WQFS. The total net present value was calculated over a 50-year period.

3.3.1 Capital Cost

Capital cost of the sand filter with Bold and Gold® treatment system includes the construction of the distribution channels, treatment cells including the berms and structures, and collection channels to remove the treated water. All capital cost estimates were based on similar sand filter construction scaled up to the designated treatment cell sizes used here. The cost of the sand filters and the Bold and Gold® are similar with the main difference being the cost of sand installation versus the Bold and Gold®

installation. The capital cost is estimated at $422.0 million. Table 3-3 provides the conceptual capital costs for the sand filter with Bold and Gold® treatment system.

Table 3-3. Option 2 Sand Filter with Bold and Gold® Conceptual Capital Cost

Item	Unit Design Criteria	Quantity	Basis	Unit Cost	Estimated Cost
TECHNOLOGY - EQUIPMENT AND MATERIALS					
Silt Fence & Erosion Control	Length of site perimeter	17,160	LF	$1	$17,160
Clear & Grub	Site area	238	AC	$300	$71,280
Perimeter Berm	Includes borrow, haul, spread, compaction, and slope protection	134,139	CY	$10	$1,341,391
Site Grading, Interior Berm Construction	Includes site leveling for borrow and berm construction	524,946	CY	$10	$5,249,460
Haul Offsite Soil	Calculated from terrain model and design plan and profile	44,282	CY	$3	$132,846
Interior WQC – Sand Media	Calculated from terrain model and design plan and profile	458,979	CY	$26	$11,933,452
Interior WQC – Bold and Gold® Media	Calculated from terrain model and design plan and profile	1,022,109	CY	$187	$191,185,526
Drainage Gravel	Calculated as a 1-foot depth across area	696,960	CY	$15	$10,454,400
Liner	Calculated based on area	529,633	SF	$5	$2,648,167
Non-woven Geotextile	Calculated based on area	543,125	CY	$3	$1,629,375
Rip Rap	Calculated as a two-foot riprap apron near surface inlet areas	13,367	CY	$228	$3,050,674
Rip Rap 9"-12" Limestone with Geotextile		13,367	CY	$90	$1,203,000
30" Chlorinated Polyethylene (CPE) Perforated Pipe	Calculated based on bed length	16,972	LF	$105	$1,782,060
36" CPE Perforated Pipe	Calculated based on bed length	17,457	LF	$126	$2,199,582
24" Perforated pipe	Calculated based on bed length	12,962	LF	$115	$1,490,630
42" CPE Pipe	Calculated based on bed length	3,059	LF	$162	$495,558
Total Equipment Cost (TEC)					**$231,782,782**
Freight and Taxes		3%	of TEC		$6,953,483
Spare Parts		1%	of TEC		$2,317,828
Purchased Equipment Cost - Delivered (PECD)					**$241,054,093**
TECHNOLOGY CONSTRUCTION - INSTALLATION					
Equipment Installation		10%	of TEC		$23,178,278
Process Piping		1.0%	of TEC		$2,317,828
Instrumentation and Controls		1.0%	of TEC		$2,317,828
Electrical		1.0%	of TEC		$2,317,828
Civil		1.0%	of TEC		$2,317,828
Concrete		1.0%	of TEC		$2,317,828
Structural Steel		1.0%	of TEC		$2,317,828
Architectural		1.0%	of TEC		$2,317,828
Service Facilities		1.0%	of TEC		$2,317,828
Total Technology Direct Cost (TTDC)					**$41,720,901**
CONVEYANCE CONSTRUCTION - INSTALLED					
Pump Station	Includes inflow piping, based on historical SFWMD data for pump station construction per cfs	423	EA	$50,000	$21,125,000

Item	Unit Design Criteria	Quantity	Basis	Unit Cost	Estimated Cost
Interior Water Control Structure	8 single barrel 6' x 4' box culverts at 60 LF each	480	LF	$8,000	$3,840,000
Outfall Water Control – Piping	1 double barrel 8' x 8' box culvert at 275 LF	550	LF	$9,000	$4,950,000
Site Roadways	Includes import of rock base, spreading, grading, and compaction	19,341	CY	$35	$676,935
Site Bridges	2 two-lane FDOT Florida slab beam at 30' x 100' = 3,000 SF each (6,000 SF total)	6,000	LF	$420	$2,520,000
Total Installed Conveyance (TIC)					**$33,111,935**
TOTAL DIRECT COST (TECHNOLOGY & CONVEYANCE)	PECD+TTDC+TIC				**$315,886,929**
Mobilization		4%	of TDC		$12,635,477
Subtotal					**$328,522,406**
Bonds, Insurance		1.5%	of TDC		$4,738,304
Contractor's Profit		7%	of TDC		$22,996,568
Contingency		20%	of TDC		$65,704,481
Total Direct Cost + Indirect Cost, Including Profit + Contingency	**Total Probable Construction Cost (TPCC)**				**$421,961,759**

3.3.2 O&M Cost

The O&M costs for the sand filter with Bold and Gold® treatment system consist primarily of the removal, disposal, and replacement of media after years of treatment. Other O&M activities would include general field operations, SCADA hydrologic data management, water quality monitoring, exotic vegetation control, and public use access maintenance. The O&M cost for the system is estimated at $1.0 million. Table 3-4 provides a summary of the O&M costs.

Table 3-4. Option 2 Sand Filter with Bold and Gold® Conceptual O&M Cost

Parameter	Value
Sand Replacement (5 year interval, annualized)	$70,000
Surface Scarification	$50,000
Sand Filter Cover Maintenance	$120,000
Field Operations	$323,000
SCADA Hydro Management	$79,000
Water Quality Data Collection/Management	$110,000
Exotic Vegetation Control	$35,000
Public Use	$5,000
Field Operations	$552,000
Total Annual O&M Cost	$672,000
Other Cost	0.2
Subtotal Annual O&M Cost	$806,400
Contingency	0.3
Final Total Annual O&M Cost	**$1,048,320**

3.3.3 Life Cycle (Net Present Value) Cost

The life cycle cost for the sand filter with Bold and Gold® is presented for a 50-year lifespan, which is estimated at $459.8 million. Table 3-5 presents the net present value cost for the treatment system.

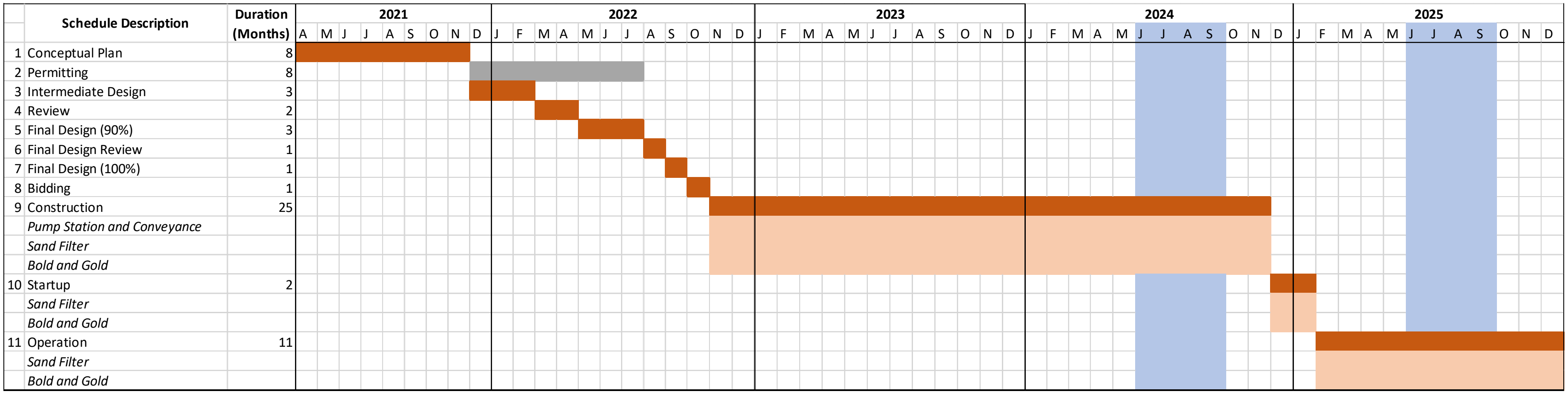
Table 3-5. Option 2 Sand Filter with Bold and Gold® Conceptual Life Cycle Cost

Year	Cost
0	$421,961,579
1	$1,226,559
2	$1,263,356
3	$1,301,256
4	$1,340,294
5	$1,380,503
6	$1,421,918
7	$1,464,575
8	$1,508,513
9	$1,553,768
10	$1,600,381
11	$1,648,392
12	$1,697,844
13	$1,748,780
14	$1,801,243
15	$1,855,280
16	$1,910,939
17	$1,968,267
18	$2,027,315
19	$2,088,134
20	$2,150,778
21	$2,215,302
22	$2,281,761
23	$2,350,214
24	$2,420,720
25	$2,493,342
26	$2,568,142
27	$2,645,186
28	$2,724,542
29	$2,806,278
30	$2,890,466
31	$2,977,180
32	$3,066,496
33	$3,158,490
34	$3,253,245
35	$3,350,843
36	$3,451,368
37	$3,554,909
38	$3,661,556
39	$3,771,403
40	$3,884,545
41	$4,001,081
42	$4,121,114
43	$4,244,747
44	$4,372,089
45	$4,503,252
46	$4,638,350
47	$4,777,500
48	$4,920,825
49	$5,068,450
50	$5,220,503
Net Present Value	**$459,844,281**

Year	Cost
Number of Years, N	50
Annual Discount Rate	0.05
Annual Inflation	0.03

3.4 Construction Schedule

The construction schedule is a sequence of phases, which revolve around design, construction, and operation (Figure 3-1). The design phase incorporates conceptual and final design, review processes, and permitting evaluation. This phase began in April 2021 with conceptual design and would be completed in September 2022. Once final design is completed, the project would go out to bidding and construction, which is expected to be finished in November 2024. The final operation phase begins following a two-month startup period that is used to optimize the system before beginning treatment of the designed reservoir effluent.



Note: Months highlighted in blue are the estimated times of reservoir filling.

Figure 3-1. Option 2 Sand Filter with Bold and Gold® Construction Schedule

3.5 Draft Operations Plan

Operation of the combined sand filter and Bold and Gold® system would vary throughout a typical year based upon whether the reservoir is in the filling, storage, or discharge phase. The filling phase would be the preferred time for all basic maintenance activities, including annual inspection, sand filter and Bold and Gold® media replacement (if warranted), berm maintenance, and repair and replacement of pumps, meters, and all hydraulic control structures. In general, maintenance is anticipated to be simpler than the alum-based options, but the overall area required would entail more land-based maintenance activities. These would include berm mowing and repair, non-native species removal, and media bed discing. Hydraulic maintenance would require periodic (possibly monthly) application of flow to the media beds to sustain microbial communities necessary for treatment.

During the storage cycle, the system would be placed in a mode of operational readiness in anticipation of seasonal discharge. The sand filter media surface would be scarified by discing, as recommended by the vendor, to maintain hydraulic conductivity by removing biomass and loosening the sand. The sand filter would be dried down prior to discing. This discing would occur at least annually during the reservoir filling period, and up to monthly during the reservoir discharge period. Water would be maintained by water control structures in the Bold and Gold® basins to prevent dry out. To prevent inadvertent wildlife use of the sand filter, the surface could be maintained with a shallow (e.g., one foot or less) surface water depth.

Prior to the discharge cycle, system readiness would be reviewed prior to initiation of flow; basins would be filled, if required; and all mechanical, electrical, and hydraulic features would be reviewed and brought to operational readiness.

During the discharge cycle, the system would be operated to maintain water depths above the media surface to facilitate distribution. Flow distribution would be monitored and adjusted to achieve target hydraulic loading rates for each cell and media type. Regular sampling and testing would be conducted on the reservoir water and the water at the outlet the sand filter and Bold and Gold® media collector channels to demonstrate performance and facilitate operational adjustments. A detailed monitoring plan would be developed during final design if this option is selected as the WQC Plan.

During the discharge cycle, typical operational activities anticipated from the sand filter with Bold and Gold® system include the following:

- Flow meter and control valve maintenance (monthly)
- Flow and level checks
- Water quality monitoring
- Periodic scarification of sand filter beds
- Vegetation observations for preemptive vegetation removal

4.0 Option 3: Hybrid Wetland Treatment Technology

HWTT includes design, construction, and operation of a facility that combines wetland and chemical treatment approaches to reduce phosphorus (DeBusk, 2009). The treatment uses chemical coagulants added to the inlet end of a sequence of a settling basin and treatment wetlands, containing one or more deep-water zones, to capture the resulting floc material. The combination of active sorption, particle coagulation and settling, and final wetland polishing results in the reduction of phosphorus. The coagulant used for the HWTT is alum (Watershed Technologies, LLC, 2014). Other forms of alum (e.g., polyaluminum chloride and sodium aluminate) were used in previous studies (Watershed Technologies, LLC, 2014). Additional features of the technology include pumped recirculation of alum floc or reusing floc to extend the functional life of the coagulant for reduction of phosphorus in the water column or to minimize phosphorus remobilization from sediment. The reuse of the dried, stable floc helps reduce the residual management efforts. Case studies of the technology have occurred at multiple locations in the Northern Everglades in basins S-65D, S-65E, S-154, and S-191. DeBusk (2009) states the HWTT is effective at removing phosphorus and improving water quality at each system. A key recommendation for the C-43 WBSR WQC was to use floating aquatic vegetation (FAV) and submerged aquatic vegetation (SAV) to reduce the nitrogen concentration.

4.1 Design Calculations

Sizing and treatment estimation for the HWTT system was performed by Watershed Technologies, LLC. The HWTT system would be contained within SFWMD-owned parcels S-4 and S-5, which are referred to here as the central parcel and western parcel, respectively. The system would be operated on a parallel basis, i.e., alum dosing would be performed in both parcels. The dual facilities would be used in tandem for most of the time with the central parcel operating for highest flows. The central parcel maximum treatment capacity would be 486 cfs, and the western parcel maximum capacity would be 125 cfs for a total site maximum capacity of 611 cfs.

The HWTT system uses 452-ac, consisting of two treatment trains with multiple treatment ponds in series (Table 4-1). The mixing pond, where alum is mixed with water from the C-43 WBSR, would require approximately 1-ac of land in total (two, 0.5-ac ponds). In each treatment train, water would move through two settling ponds to allow for floc (alum and nutrients) to settle out to the bottom of the cell. The wetland treatment facility would include FAV and SAV ponds. The estimated total acreage for the settling, FAV, and SAV ponds is 89-ac, 56-ac, and 141-ac, respectively, for a total pond treatment land area of approximately 286-ac.

Table 4-1. Option 3 HWTT Project Components and Areas

WATERSHED TECHNOLOGIES, LLC HWTT	
C43 WBSR PROJECT COMPONENTS	
COMPONENT	**ACRES**
Mixing Chambers	1
Settling Ponds	88.8
FAV Ponds	55.8
SAV Ponds	141.3
Drying Beds	115.1
Supporting Facilities:	
Internal Embankments	28
Perimeter Buffer	15
Miscellaneous	7
TOTAL	452

Source: Watershed Technologies, LLC, 2021

Supporting facilities include the areas required for access (internal access roads, perimeter access road, and embankments), chemical storage/dosing facilities, and miscellaneous areas such as those used for storage, parking, pump station pads, and other similar uses. The total land area for supporting facilities for the HWTT would be approximately 50-ac.

Solids would be pumped to the drying beds after accumulating in the settling ponds. The drying beds allow for passive dewatering of the solids material that is a byproduct of the treatment process through evapotranspiration and seepage. The drying beds are sized based on an assumed solids accumulation rate in the settling ponds. Based on the anticipated flows to be treated, four drying beds would be required at an average of approximately 29-ac each. The total land area for residuals handling and solids storage would be 115-ac.

There are minimal water losses expected with this WQC option. Evaporation losses would occur in the sedimentation basin and wetland basins, and rainfall on the basins should mostly offset these losses in a water year. In addition, there should be minimal seepage losses as most of the basins would be lined. Seepage losses would primarily occur in the wetland basins and be captured in seepage collection ditches. If this option is selected as the WQC Plan, as part of the final design phase, additional site investigations and modeling would be conducted to quantify any seepage losses and evaluate options to prevent seepage losses from affecting the minimum flow and level requirements.

4.2 Water Quality Performance

The HWTT system was assessed using spreadsheet and performance data provided by Watershed Technologies, LLC, the HWTT system vendor. Table 4-2 summarizes HWTT performance for TN and TP.

Table 4-2. Option 3 HWTT Conceptual Performance

Month	HWTT Treated Flow to Achieve TP Outflow Targets Reservoir Inflow TP (mg/L)	Reservoir Outflow/HWTT Inflow TP (mg/L)	Outflow Target (mg/L)	HWTT Outflow Conc (mg/L)	Total Flow (cfs)
1	0.152	0.152	0.088	0.084	450.00
2	0.152	0.152	0.088	0.084	611.00
3	0.152	0.152	0.088	0.084	529.00
4	0.152	0.152	0.088	0.084	550.00
5	0.152	0.152	0.088	0.084	611.00
6	0.152	0.152	0.088	0.084	489.00
7	0.152	0.152	0.088	0.084	548.00
8	0.152	0.152	0.088	0.084	256.00
9	0.152	0.152	0.088	0.084	189.00
10	0.152	0.152	0.088	0.084	339.00
11	0.152	0.152	0.088	0.084	450.00
12	0.152	0.152	0.088	0.084	450.00
Total					***5472.0***
Average	***0.152***	***0.152***	***0.088***	***0.084***	***456.0***

Month	HWTT Treated Flow to Achieve TN Outflow Targets Reservoir Inflow TN (mg/L)	Reservoir Outflow/HWTT Inflow TN (mg/L)	Outflow Target (mg/L)	HWTT Outflow Conc (mg/L)	Total Flow (cfs)
1	1.810	1.810	1.230	1.230	450.00
2	1.810	1.810	1.230	1.230	611.00
3	1.810	1.810	1.230	1.230	529.00
4	1.810	1.810	1.230	1.230	550.00
5	1.810	1.810	1.230	1.230	611.00
6	1.810	1.810	1.230	1.230	489.00
7	1.810	1.810	1.230	1.230	548.00
8	1.810	1.810	1.230	1.230	256.00
9	1.810	1.810	1.230	1.230	189.00
10	1.810	1.810	1.230	1.230	339.00
11	1.810	1.810	1.230	1.230	450.00
12	1.810	1.810	1.230	1.230	450.00
Total					***5472.0***
Average	***1.810***	***1.810***	***1.230***	***1.230***	***456.0***

Source: Watershed Technologies, LLC, 2021
Note: Flows are the 90th percentile values for each month in the spreadsheet model output.

4.3 Conceptual Cost

Capital costs were estimated by pricing materials required for storage, dosing, and related items and applying standard markups. Operational costs were derived and updated from the WQFS. The total net present value was calculated over a 50-year period.

4.3.1 Capital Cost

The HWTT system capital cost is estimated between to be $68.6 million. Table 4-3 provides a summary of the conceptual capital cost by category.

Table 4-3. Option 3 HWTT Conceptual Capital Cost

Item	Unit Design Criteria	Quantity	Basis	Unit Cost	Estimated Cost
Erosion Control	Appendix C	1	LS		$138,404
Contact Chamber	Appendix C	1	LS		$1,279,005
Settling Pond	Appendix C	1	LS		$6,185,832
FAV Pond	Appendix C	1	LS		$707,882

Item	Unit Design Criteria	Quantity	Basis	Unit Cost	Estimated Cost
SAV Pond	Appendix C	1	LS		$963,369
Floc Recycling Infrastructure	Appendix C	1	LS		$4,483,676
Roads and Drainage	Appendix C	1	LS		$299,638
Outflow Canal	Appendix C	1	LS		$328,844
Security Fencing	Appendix C	1	LS		$54,835
Total Equipment Cost (TEC)					**$14,441,485**
Freight and Taxes		3%	of TEC		$433,245
Spare Parts		1%	of TEC		$144,415
Purchased Equipment Cost – Delivered (PECD)					**$15,019,144**
TECHNOLOGY CONSTRUCTION – INSTALLATION					
CONSTRUCTION – DIRECT					
Equipment Installation		30%	of TEC		$4,332,446
Process Piping		1.0%	of TEC		$144,415
Instrumentation and Controls		1.0%	of TEC		$144,415
Electrical		1.0%	of TEC		$144,415
Civil		1.0%	of TEC		$144,415
Concrete		1.0%	of TEC		$144,415
Structural Steel		1.0%	of TEC		$144,415
Architectural		1.0%	of TEC		$144,415
Service Facilities		1.0%	of TEC		$144,415
Total Technology Direct Cost (TTDC)					**$5,487,764**
CONVEYANCE CONSTRUCTION – INSTALLED					
Pump Station – East (S-4)	Includes Inflow piping, based on historical SFWMD data for pump station construction per cfs	486	CFS	$50,000	$24,300,000
Pump Station – West (S-5)	Includes Inflow piping, based on historical SFWMD data for pump station construction per cfs	125	CFS	$50,000	$6,250,000
Outfall Water Control Structure	2 double barrel 8' x 8' box culverts (Parcel S-4) at 470 LF (940 LF total)	940	LF	$8,000	$7,520,000
Outfall Water Control Structure	2 double barrel 8' x 8' box culverts (Parcel S-5) at 110 LF (220 LF total)	220	LF	$9,000	$1,980,000
Site Bridges	3 two-lane FDOT Florida slab beam at 30' x 100' = 3,000 SF each (9,000 SF total)	12,000	SF	$420	$5,040,000
Site Roadways	Includes import of rock base, spreading, grading, and compaction (Parcels S-4 & S-5)	34,569	CY	$35	$1,209,915
Total Installed Conveyance (TIC)					**$46,299,915**
TOTAL DIRECT COST (TECHNOLOGY & CONVEYANCE)	PECD+TTDC+TIC				**$51,787,679**
Mobilization		4%	of TDC		$2,071,507
Subtotal					**$53,859,186**
Bonds, Insurance		1.5%	of TDC		$776,815
Contractor's Profit		7%	of TDC		$3,625,138
Contingency		20%	of TDC		$10,357,536
Total Direct Cost + Indirect Cost, Including Profit + Contingency	**Total Probable Construction Cost (TPCC)**				**$68,618,675**

4.3.2 O&M Cost

The conceptual O&M cost for the HWTT system is $11.0 million as shown in Table 4-4. O&M activities would include general field operations, SCADA hydrologic data management, water quality monitoring, exotic vegetation control, and public use access maintenance.

Table 4-4. Option 3 HWTT Conceptual O&M Cost

Parameter	Value
Labor	$208,000
Chemicals	$5,943,578
Utilities/Fuel	$73,240
Equipment Tools & Supplies	$134,500
Site Cell Phone/Internet	$7,200
Ground Maintenance	$40,000
Vegetation Management	$27,700
Residual (Floc) Management	$14,280
Fringe Benefits	$15,912
Total HWTT System Maintenance	$6,464,410
Field Operations	$337,000
SCADA Hydro Management	$102,000
Water Quality Data Collection/Management	$110,000
Exotic Vegetation Control	$35,000
Public Use	$8,000
Field Operations	$592,000
Total Annual O&M Cost	$7,056,410
Other Cost	0.2
Subtotal Annual O&M Cost	$8,467,692
Contingency	0.3
Final Total Annual O&M Cost	**$11,008,000**

4.3.3 Life Cycle (Net Present Value) Cost

The net present value cost for the HWTT system is estimated to be $418.8 million (see Table 4-5).

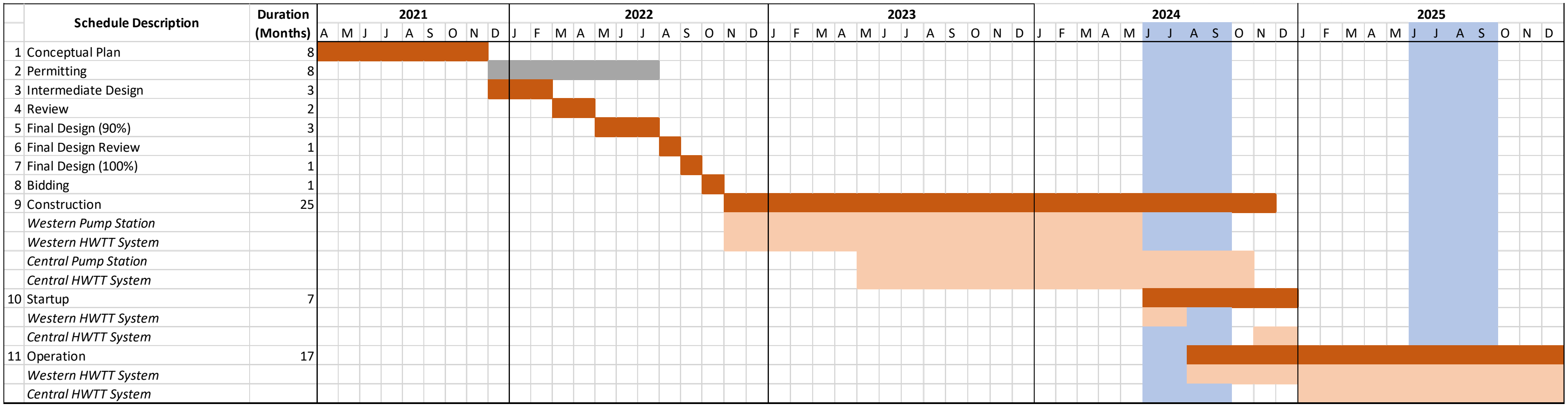
Table 4-5. Option 3 HWTT Conceptual Life Cycle Cost

Year	Cost
0	$68,618,675
1	$11,338,240
2	$11,678,387
3	$12,028,738
4	$12,389,601
5	$12,761,289
6	$13,144,127
7	$13,538,451
8	$13,944,605
9	$14,362,943
10	$14,793,831
11	$15,237,646
12	$15,694,775
13	$16,165,619
14	$16,650,587
15	$17,150,105

Year	Cost
16	$17,664,608
17	$18,194,546
18	$18,740,382
19	$19,302,594
20	$19,881,672
21	$20,478,122
22	$21,092,466
23	$21,725,240
24	$22,376,997
25	$23,048,307
26	$23,739,756
27	$24,451,948
28	$25,185,507
29	$25,941,072
30	$26,719,304
31	$27,520,883
32	$28,346,510
33	$29,196,905
34	$30,072,812
35	$30,974,997
36	$31,904,247
37	$32,861,374
38	$33,847,215
39	$34,862,632
40	$35,908,511
41	$36,985,766
42	$38,095,339
43	$39,238,199
44	$40,415,345
45	$41,627,806
46	$42,876,640
47	$44,162,939
48	$45,487,827
49	$46,852,462
50	$48,258,036
Net Present Value	**$418,804,205**
Number of Years, N	50
Annual Discount Rate	0.05
Annual Inflation	0.03

4.4 Construction Schedule

The construction schedule is a sequence of phases that revolve around design, construction, and operation (Figure 4-1). The design phase incorporates conceptual and final design, review processes, and permitting evaluation. This phase began in April 2021 with conceptual design and would be completed in September 2022. Once final design is completed, the project would go out to bidding and construction, which is expected to be finished in November 2024. The final operation phase begins with startup occurring during construction, and continuing for two months after construction completion, to optimize the system before beginning treatment of the designed reservoir effluent.



Note: Months highlighted in blue are the estimated times of reservoir filling.

Figure 4-1. Option 3 HWTT Construction Schedule

4.5 Draft Operations Plan

The HWTT system would be routinely monitored to quantify phosphorus and nitrogen removal performance and to facilitate process optimization efforts. Three levels of monitoring would be used during the operation of this facility. At a minimum, outflow monitoring parameters would include nutrients, TSS, aluminum, sulfate, specific conductance, and pH. A detailed monitoring plan would be developed during final design if this option is selected as the WQC Plan.

O&M and routine optimization of the HWTT system would focus on achieving the TN and TP outflow concentration targets as established for the WQC. The operations plan is divided into three stages of C-43 WBSR operation: (1) filling, (2) storage, and (3) discharge.

4.5.1 HWTT Operations During C-43 WBSR Filling

- Infrastructure would be inspected including above ground impoundments.
- Periodic maintenance and renewal, as necessary, of the treatment works including, but not limited to, monitoring and control instrumentation, dosing and floc pumps, and FAV and SAV would be performed.
- Chemical dosing pumps would be exercised and recalibrated; coagulant tanks and pipes would be cleaned.
- Inflow and outflow structures/areas would be cleared and maintained.
- Unwanted vegetation would be cleared.
- Roadway maintenance would be performed, as needed.
- Selected characteristics (for example, accrual depth) would be measured periodically on floc materials that accumulate within the HWTT system flow path.
- As needed, the HWTT system would be dried down for a period of two to four weeks during C-43 WBSR filling, and any biomass (including floating vegetation, fish, and algae) would be tilled into the shallow zone to expose buried alum, thereby reducing/eliminating the export of solid materials from the site by sorbing nutrients to the alum in the sediment.
- Routine maintenance of the facility would be performed, as needed.

4.5.2 HWTT Operations During C-43 WBSR Storage

- Monitoring and maintenance of equipment and vegetation in a state of readiness.

4.5.3 HWTT Operations During C-43 WBSR Discharge

- The HWTT system would be optimized to treat a range of dry and wet season pumped inflows up to the capacity of 611 cfs.
- The HWTT system would be used to quantify the most effective operational strategy for treating the C-43 WBSR discharges. The focus would be on maximizing TN and TP removal per unit mass of coagulant added by incorporating the reuse/recycle of floc materials. Dosing would be adjusted multiple times daily as needed to minimize chemical use and optimize performance.
- Routine inflow and outflow monitoring for nitrogen and phosphorus species, pH, specific conductance, color, alkalinity, and total aluminum would be performed.
- Fish residing within the settling pond would be collected and analyzed quarterly for heavy metal content.

- Standard bioassay toxicity testing, using fish and invertebrates, would be performed quarterly on system inflow and outflow waters.
- Selected characteristics (for example, accrual depth) would be measured periodically on floc materials that accumulate within the HWTT system flow path.
- System hydraulic characteristics would be monitored.
- The effectiveness of the operational and optimization efforts would be quantified by monitoring flow rates (water volume treated), chemical amendment use (concentration and volume), and routine inflow and outflow monitoring for TP. Inflow and outflow nitrogen species would also be measured periodically to characterize TN removal effectiveness of the system.
- Any unscheduled repairs would be performed, as needed.

5.0 Option 4: STA with Bold and Gold®

Option 4 is a combination of a constructed wetland (STA) with a parallel Bold and Gold® media filtration system. The individual areas were derived under the assumption that the land area available would support a 868-ac wetland, which would be expected to provide consistent treatment for 20% of the average flow (91 cfs). The estimated reductions from the STA are 36% for TN and 43% for TP. A 99-ac Bold and Gold® filter would treat 366 cfs, with the expectation that the water would be treated to lower concentrations than specified. The estimated reductions from the Bold and Gold® media are 85% for TN and 34% for TP. The total flow treated by the combined technologies would be 457 cfs.

Two variations of Option 4 (4a and 4b) were envisioned related to the treatment discharge locations. Option 4a would entail pumping treated water from the large STA across the Banana Branch Canal to a collector canal along the west side of the system and gravity discharge to the same collector canal from the smaller STA and Bold and Gold® media cells. The treated water would then be sent west to discharge into the perimeter canal west of S-482. Option 4b would entail gravity discharge from the large STA to the Banana Branch Canal with the small STA and Bold and Gold® cells discharging by gravity to the collector canal to discharge west of S-482. This alternative would eliminate the need for water to be pumped over the Banana Branch Canal.

5.1 Design Calculations

Table 5-1 summarizes treatment model performance estimates for the STA component of Option 4 for the designated area, hydraulic loading, and average inflow nutrient concentrations anticipated from the reservoir under the conservative assumption of no in-reservoir reduction of nutrients. The treatment model applied is the p-K-C* model, which is a first-order model developed for treatment wetland design and performance analysis (Kadlec and Wallace, 2009), and is calibrated to performance data from similarly loaded Florida treatment wetlands (J-Tech, 2020).

Table 5-2 summarizes the treatment model performance estimates for the Bold and Gold® media filter for the designated area, hydraulic loading, and average inflow nutrient concentrations anticipated from the reservoir under the conservative assumption of no in-reservoir reduction of nutrients. The treatment model is derived from the p-K-C* treatment wetland model and is calibrated to performance data provided by the vendor.

This WQC option could result in some water losses. Evaporation losses would occur in the Bold and Gold® and STA basins, and rainfall on the basins should mostly offset these losses in a water year. There should not be much seepage losses from the Bold and Gold® basins as these would be lined. Seepage losses would primarily occur in the STA basins and be captured in seepage collection ditches where the WQC borders adjacent landowners to mitigate offsite impacts. If this option is selected as the WQC Plan, as part of the final design phase, additional site investigations and modeling would be conducted to quantify any seepage losses and evaluate options to prevent seepage losses from affecting the minimum flow and level requirements.

5.2 Water Quality Performance

The size of the STA was reduced to 868-ac based upon the available area for the SFWMD-owned S-2 and S-4 parcels, and to account for distribution and collection channels. The analysis assumes a portion of the WQC on the west side of the Banana Branch Canal would be an STA and act as a flow way into the Bold and Gold® media. The Bold and Gold® media bed area was adjusted to 99-ac account for flow distribution and collection. As described for Option 2 (Section 3.0), results of performance data from ongoing testing by SFWMD of the Bold and Gold® media indicate favorable TN removal but a net TP export that is inconsistent with vendor experience and publications. For the purpose of the analysis in this Conceptual Design Report, the treatment assumptions for Bold and Gold® provided by the vendor were used. However, based on the results of the SFWMD pilot study, it appears that Bold and Gold® is not appropriate for the WQC. Appendix D is a memorandum prepared by SFWMD summarizing the results of the Bold and Gold® pilot project.

Table 5-1 summarizes the conceptual performance for the STA portion and Table 5-2 summarizes the conceptual performance for the Bold and Gold® portion of the system.

Table 5-1. Option 4 STA Conceptual Performance

Wetland Design Model

Area = 827.0 ac
Mean Depth = 1 ft
Porosity = 0.95
α = 0.5 fraction of ET that is transpired

Month	Temp (°C)	Hydrology: Precip in/mo	ET in/mo	Infiltration in/d	Inflow cfs	Inflow Concentration, C_i: TSS (mg/L)	ORG-N (mg/L)	NH3-N (mg/L)	NO3-N (mg/L)	TN_{seq} (mg/L)	TP (mg/L)
January	16.6	1.88	2.00	0.0	91	4.47	1.41	0.17	0.23	1.81	0.152
February	18.5	1.54	2.73	0.0	91	4.49	1.41	0.17	0.23	1.81	0.152
March	19.9	2.05	3.75	0.0	91	4.56	1.41	0.17	0.23	1.81	0.152
April	22.7	2.31	4.68	0.0	91	5.09	1.41	0.17	0.23	1.81	0.152
May	24.9	4.67	5.39	0.0	91	5.00	1.41	0.17	0.23	1.81	0.152
June	26.4	8.78	5.19	0.0	91	4.86	1.41	0.17	0.23	1.81	0.152
July	27.0	6.92	5.32	0.0	91	4.68	1.41	0.17	0.23	1.81	0.152
August	27.2	7.80	5.01	0.0	91	4.74	1.41	0.17	0.23	1.81	0.152
September	26.6	6.34	4.28	0.0	91	4.46	1.41	0.17	0.23	1.81	0.152
October	24.3	2.57	3.53	0.0	91	4.24	1.41	0.17	0.23	1.81	0.152
November	20.5	1.05	2.35	0.0	91	4.38	1.41	0.17	0.23	1.81	0.152
December	18.6	1.37	1.87	0.0	91	4.36	1.41	0.17	0.23	1.81	0.152
Mean/Total	22.8	3.9	3.8	0.0	91.4	4.61	1.41	0.17	0.23	1.81	0.152

	TSS	ORG-N	NH3-N	NO3-N	TN_{seq}	TP
C* (mg/L) =	1.3	0.9	0.01	0.01		0.02
PTIS =	3		3			3
k Percentile =		70	90	100		70
k_{20} (m/yr) =	100	27.4	85.6	133.1		16.7

Month	Hydrology: Inflow m³/d	Precip m³/d	ET m³/d	Infiltration m³/d	Outflow m³/d	Estimated Outflow Concentration, C_o: TSS (mg/L)	ORG-N (mg/L)	NH3-N (mg/L)	NO3-N (mg/L)	TN_{seq} (mg/L)	TP (mg/L)
January	223619	11165	10886	0	223898	1.53	1.10	0.098	0.097	1.30	0.090
February	223619	4351	7732	0	220238	1.54	1.09	0.092	0.082	1.27	0.091
March	223619	5809	10633	0	218795	1.54	1.08	0.087	0.073	1.24	0.091
April	223619	6551	13265	0	216905	1.58	1.07	0.078	0.057	1.21	0.091
May	223619	13236	15263	0	221592	1.57	1.05	0.070	0.045	1.17	0.089
June	223619	24892	14717	0	233794	1.54	1.04	0.063	0.038	1.14	0.086
July	223619	19620	15062	0	228178	1.54	1.04	0.062	0.037	1.14	0.088
August	223619	22090	14201	0	231508	1.54	1.04	0.061	0.036	1.14	0.087
September	223619	17951	12137	0	229434	1.52	1.04	0.064	0.038	1.14	0.088
October	223619	7287	9992	0	220914	1.52	1.06	0.073	0.049	1.18	0.090
November	223619	2973	6662	0	219930	1.53	1.08	0.086	0.069	1.24	0.091
December	223619	3887	5307	0	222200	1.53	1.09	0.092	0.082	1.26	0.091
Mean	223619	11651	11321	0	223949	1.54	1.07	0.08	0.06	1.20	0.089

	TSS	ORG-N	NH3-N	NO3-N	TN_{seq}	TP
Annual Concentration Reduction Efficiency =	67%	24%	55%	75%	34%	41%
Annual Inflow Surface Load (kg/yr) =	376,369	115,086	13,876	18,773	147,734	12,406
Annual Outflow Surface Load (kg/yr) =	125,832	87,109	6,288	4,754	98,151	7,310
Annual Surface Load Reduction (kg/yr) =	250,536	27,977	7,588	14,018	49,583	5,097
Annual Mass Reduction Efficiency =	67%	24%	55%	75%	34%	41%

Table 5-2. Option 4 Bold and Gold® Conceptual Performance

Surface Flow Simple PkC* Design Model (Wastewater Parameters)

Project Name	B&G	**User inputs indicated by white boxes.**
Project Number		**Pop-up notes indicated by red triangles.**
		Reference: Kadlec and Wallace, 2006
		Treatment Wetlands. Boca Raton: CRC Press, Inc.

General Inflow Data

Parameter	Value	Units
Annual Average Daily Flow	366	cfs
Converted Flow	895,456	m^3/d
Wastewater Temperature	23.9	°C

Add Results to NADB Plots

Water Quality Characteristics

Parameter		BOD5	TSS	Organic N	NH_4-N	$NO_{2/3}$-N	TN	TP	FC	
Influent Concentration, mg/L	C_i =		4.7	1.41	0.17	0.2	1.810	0.152		
Average Target Effluent Conc., mg/L	C_e =			0.56	0.07	0.09	0.72	0.123		
Desired Confidence Percentile		0.5		0.5	0.5	0.5	0.5	0.5	0.5	
Max Month/Annual Factor		1.7	1.9	1.8	2.5	2.5	1.6	1.8	3.0	
Design Target Conc., mg/L	C_d =			0.3	0.0	0.0	0.5	0.1		
Wetland Background Limit, mg/L	C^* =	2	0.50	0.5	0	0	0.8	0.02	40	
Reduction fraction to target	$F_e = 1 - C_e/C_i$ =	No Value	1.000	0.600	0.600	0.600	0.600	0.191	No Value	No Value
Reduction fraction to background	$F_b = 1 - C^*/C_i$ =		0.894	0.645	1.000	1.000	0.558	0.868		
Confidence-based Rate Constant, 20°C, m/y	k_{20} =	33	977	2683	517	3962	3107	3750	83	
Temperature Factor	θ =	1.00	1.000	1.05	1.05	1.11	1.06	1.00	1.00	
P-Factor	P =	1	6	6	6	6	6	6.0	3	
Areal Rate Constant, m/y	k_T =	33	977	3245.3	623.3	5952.2	3842.3	3750.31	83	
Area required for each parameter, ac		C*>Cd	C*>Cd	C*>Cd	700.7	641.5	C*>Cd	23.6	C*>Cd	C*>Cd

Required Treatment Wetland Area

Required Treatment Wetland Area	A_{max} =	**700.7**	acres	Displays minimum wetland area to treat all pollutants down to desired targets
		283.7	ha	
User Defined Area	A_{user} =	**99.0**	acres	User specified wetland area; leave blank if you wish to use A_{max} (above) for effluent calculations below.
		40.1	ha	

Final Effluent Concentrations and Percent Removal

Area (ha) used for Calculations =	**40.1 ha**	BOD5	TSS	Organic N	NH_4-N	$NO_{2/3}$-N	TN	TP	FC	
Design Target Conc., mg/L	C_d =			0.313	0.027	0.037	0.453	0.068		
Influent concentrations, mg/L	C_i =		4.7	1.410	0.170	0.230	1.810	0.152		
Confidence-based Effluent concentration, mg/L	C_e =		1.9	0.543	0.578	0.064	1.186	0.024		
Percent Reduction (by concentration)			59%	61%	-240%	72%	35%	84%		
Mass Loading (lb/day)			9273	2782	335	454	3571	300		
Mass Loading (kg/ha/d)			105.0	31.5	3.8	5.1	40.4	3.4		
Mass Out (lb/day)			3766	1071	1141	127	2339	48		
Mass Out (kg/ha/d)			42.6	12.1	12.9	1.4	26.5	0.5		
Percent Reduction (by mass)			59%	61%	-240%	72%	35%	84%		

Hydraulic Properties Based on Area and Flow

Percent Open Water	40%	Transition Side Slopes (H:V) - (3:1)	3			Override
Marsh Zone Depth (m)	1.5	Berm Side Slopes (H:V) - (3:1)	3	# of Deep Zones	8	
Deep Zone Depth (m)	1.5	Approx Aspect Ratio (L:W) - (3:1)	3	Deep Zone Bot Length	50	
Volume (m3)	588699					

Hydraulic Loading Rate, q	HLR =	223.4	cm/d
Nominal Hydraulic Residence Time, days	HRT =	0.7	days

5.3 Conceptual Cost

Capital costs were estimated by pricing materials required for conveyance, treatment, and collection components, and related items, and applying standard markups. Operational costs were derived and updated from the WQFS. The total net present value was calculated over a 50-year period.

5.3.1 Capital Cost

The capital costs for the STA with Bold and Gold® treatment system include the construction of the distribution channels, grading and berm construction for the STA and the Bold and Gold® treatment cells, and construction of the collection channels to capture and distribute the treated water. Table 5-3 presents the estimated capital cost of $421.2 million for Option 4a. Table 5-4 summarizes the estimated capital cost for Option 4b of $467.4 million.

Table 5-3. Option 4a STA with Bold and Gold® Conceptual Capital Cost

Item	Unit Design Criteria	Quantity	Basis	Unit Cost	Estimated Cost
TECHNOLOGY – EQUIPMENT AND MATERIALS					
Silt Fence & Erosion Control	Length of site perimeter	27,027	LF	$1	$27,027
Clear & Grub	Site area	1,064	AC	$300	$319,200
WQC Small – Perimeter Berm	Calculated from terrain model and design plan and profile	74,183	CY	$10	$741,829
WQC Small – Site Grading, Interior Berm Construction	Calculated from terrain model and design plan and profile	236,174	CY	$10	$2,361,735
WQC Large – Perimeter Berm	Calculated from terrain model and design plan and profile	203,323	CY	$10	$2,033,230
WQC Large – Site Grading, Interior Berm Construction	Calculated from terrain model and design plan and profile	1,101,383	CY	$10	$11,013,829
Haul Offsite Soil	Calculated from terrain model and design plan and profile	82,796	CY	$3	$248,389
Interior WQC – Bold and Gold® Media	Calculated from terrain model and design plan and profile	1,022,109	CY	$187	$191,185,526
Drainage Gravel	Calculated as a 1-foot depth	696,960	CY	$15	$10,454,400
Liner	Calculated based on area	535,124	SF	$2	$1,070,248
Non-woven Geotextile	Calculated based on area	543,125	CY	$3	$1,629,375
Rip Rap	Calculated as a two-foot riprap apron near surface inlet areas	13,367	CY	$90	$1,203,000
24" Perforated Pipe	Calculated based on cell length	12,962	LF	$115	$1,490,630
30" CPE Perforated Pipe	Calculated based on cell length	16,972	LF	$105	$1,782,060
36" CPE Perforated Pipe	Calculated based on cell length	17,457	LF	$126	$2,199,582
42" CPE Pipe	Calculated based on cell length	3,059	LF	$162	$495,558
Total Equipment Cost (TEC)					**$228,255,617**
Freight and Taxes		3%	of TEC		$609,746
Spare Parts		1%	of TEC		$2,282,556
Purchased Equipment Cost – Delivered (PEC-D)					**$231,147,919**
TECHNOLOGY CONSTRUCTION AND INSTALLATION					
Equipment Installation		10%	of TEC		$22,825,562
Process Piping		0.5%	of TEC		$1,141,278
Instrumentation and Controls		0.5%	of TEC		$1,141,278
Electrical		0.5%	of TEC		$1,141,278
Civil		0.5%	of TEC		$1,141,278
Concrete		0.5%	of TEC		$1,141,278
Structural Steel		0.5%	of TEC		$1,141,278
Architectural		0.5%	of TEC		$1,141,278
Service Facilities		0.5%	of TEC		$1,141,278
Total Technology Direct Cost (TTDC)					**$31,955,786**
CONVEYANCE CONSTRUCTION – INSTALLED					
Discharge Canal	Discharge canal to downstream of S-482	180,054	CY	$10	$1,800,540
Inflow Pump Station	Includes inflow piping, based on historical SFWMD data for pump station construction per cfs	611	EA	$50,000	$30,550,000

Item	Unit Design Criteria	Quantity	Basis	Unit Cost	Estimated Cost
Outflow Pump Station	Includes inflow piping, based on historical SFWMD data for pump station construction per cfs	90	EA	$50,000	$4,500,000
Interior Water Control Structure – 168-ac parcel	6 single barrel 8' x 4' box culverts at 60 LF each	360	LF	$8,000	$2,880,000
Outfall Water Control Structure – 825-ac parcel	3 single barrel 8' x 4' box culverts at 60 LF each	180	LF	$8,000	$1,440,000
Discharge into Collector Canal Water Control Structure	Two groups of 3 single barrel 8' x 4' box culverts at 200 LF each	1,200	LF	$8,000	$9,600,000
WQC Small – Site Roadways	Includes import of rock base, spreading, grading, and compaction	13,247	CY	$35	$463,645
WQC Large – Site Roadways	Includes import of rock base, spreading, grading, and compaction	29,411	LF	$35	$1,029,385
Site Bridges	2 two-lane FDOT Florida slab beam at 30' x 100' = 3,000 SF each (6,000 SF total)	6,000	SF	$420	$2,520,000
Total Installed Conveyance (TIC)					**$54,783,570**
TOTAL DIRECT COST (TDC)	PECD+TTDC+TIC				**$317,887,275**
Mobilization		4%	of TDC		$12,715,491
Subtotal					**$330,602,766**
Bonds, Insurance		1.5%	of TDC		$4,768,309
Contractor's Profit		7%	of TDC		$22,252,109
Contingency		20%	of TDC		$63,577,455
Total Direct Cost + Indirect Cost, Including Profit + Contingency	**Total Probable Construction Cost (TPCC)**				**$421,200,640**

Table 5-4. Option 4b STA with Bold and Gold® Conceptual Capital Cost

Item	Unit Design Criteria	Quantity	Basis	Unit Cost	Estimated Cost
TECHNOLOGY – EQUIPMENT AND MATERIALS					
Silt Fence & Erosion Control	Length of site perimeter	27,027	LF	$1	$27,027
Clear & Grub	Site area	1,064	AC	$300	$319,200
WQC Small – Perimeter Berm	Calculated from terrain model and design plan and profile	74,183	CY	$10	$741,829
WQC Small – Site Grading, Interior Berm Construction	Calculated from terrain model and design plan and profile	236,174	CY	$10	$2,361,735
WQC Large – Perimeter Berm	Calculated from terrain model and design plan and profile	203,323	CY	$10	$2,033,230
WQC Large – Site Grading, Interior Berm Construction	Calculated from terrain model and design plan and profile	1,101,383	CY	$10	$11,013,829
Haul Offsite Soil	Calculated from terrain model and design plan and profile	82,796	CY	$3	$248,389
Interior WQC – Bold and Gold® Media	Calculated from terrain model and design plan and profile	1,022,109	CY	$187	$191,185,526
Drainage Gravel	Calculated as a 1-foot depth	696,960	CY	$15	$10,454,400
Liner	Calculated based on area	535,124	SF	$5	$2,675,620
Non-woven Geotextile	Calculated based on area	543,125	CY	$3	$1,629,375
Rip Rap	Calculated as a two-foot riprap apron near surface inlet areas	13,367	CY	$90	$1,203,000
24" Perforated Pipe	Calculated based on cell length	12,962	LF	$115	$1,490,630
30" CPE Perforated Pipe	Calculated based on cell length	16,972	LF	$105	$1,782,060

Item	Unit Design Criteria	Quantity	Basis	Unit Cost	Estimated Cost
36" CPE Perforated Pipe	Calculated based on cell length	17,457	LF	$126	$2,199,582
42" CPE Pipe	Calculated based on cell length	3,059	LF	$162	$495,558
Total Equipment Cost (TEC)					**$229,860,989**
Freight and Taxes		3%	of TEC		$6,895,830
Spare Parts		1%	of TEC		$2,298,610
Purchased Equipment Cost – Delivered (PEC-D)					**$239,055,429**
TECHNOLOGY CONSTRUCTION AND INSTALLATION					
Equipment Installation		10%	of TEC		$22,986,099
Process Piping		0.5%	of TEC		$1,149,305
Instrumentation and Controls		0.5%	of TEC		$1,149,305
Electrical		0.5%	of TEC		$1,149,305
Civil		0.5%	of TEC		$1,149,305
Concrete		0.5%	of TEC		$1,149,305
Structural Steel		0.5%	of TEC		$1,149,305
Architectural		0.5%	of TEC		$1,149,305
Service Facilities		0.5%	of TEC		$1,149,305
Total Technology Direct Cost (TTDC)					**$32,180,538**
CONVEYANCE CONSTRUCTION – INSTALLED					
Discharge Canal to Downstream of S-482		180,054	CY	10	$1,800,540
Inflow Pump Station	Includes Inflow piping, based on historical SFWMD data for pump station construction per cfs	611	EA	$50,000	$30,550,000
Interior Water Control Structure – 168-ac parcel	6 single barrel 8' x 4' box culverts at 60 LF each	360	LF	$8,000	$2,880,000
Outfall Water Control Structure – 825-ac parcel	3 single barrel 8' x 4' box culverts at 60 LF each	180	LF	$8,000	$1,440,000
Discharge into Collector Canal Water Control Structure	Two groups of 3 single barrel 8' x 4' box culverts at 200 LF each	1,200	LF	$8,000	$9,600,000
WQC Small – Site Roadways	Includes import of rock base, spreading, grading, and compaction	13,247	CY	$35	$463,645
WQC Large – Site Roadways	Includes import of rock base, spreading, grading, and compaction	29,411	LF	$35	$1,029,385
Site Bridges	2 two-lane FDOT Florida slab beam at 30' x 100' = 3,000 SF each (6,000 SF total)	6,000	SF	$300	$1,800,000
Total Installed Conveyance (TIC)					**$320,799,537**
TOTAL DIRECT COST (TDC)	PECD+TTDC+TIC				**$320,799,537**
Mobilization		4%	of TDC		$12,831,981
Field and Office Overhead		16%	of TDC		$51,327,926
Subtotal					**$384,959,445**
Bonds, Insurance		1.5%	of TDC		$4,811,993
Contractor's Profit		7%	of TDC		$22,455,968
Contingency		30%	of TDC		$64,159,907
Total Direct Cost + Indirect Cost, Including Profit + Contingency	**Total Probable Construction Cost (TPCC)**				**$476,387,313**

5.3.2 O&M Cost

The O&M cost for the STA with Bold and Gold® treatment system includes maintenance of the Bold and Gold® media and maintenance of the STA vegetation with invasive vegetation management ensuring complete vegetation cover leading to full treatment. Other O&M activities would include general field operations, SCADA hydrologic data management, water quality monitoring, and public use access maintenance. Table 5-5 presents the estimated O&M cost of $1.2 million for Option 4a. Table 5-6 shows the estimated O&M cost of $1.1 million for Option 4b.

Table 5-5. Option 4a STA with Bold and Gold® Conceptual O&M Cost

Parameter	Value
Field Operations	$353,000
SCADA Hydro Management	$129,000
Water Quality Data Collection/Management	$165,000
Exotic Vegetation Control	$107,000
Public Use	$19,000
Field Operations	$773,000
Total Annual O&M Cost	$773,000
Other Cost	0.2
Subtotal Annual O&M Cost	$927,600
Contingency	0.3
Final Total Annual O&M Cost	**$1,205,880**

Table 5-6. Option 4b STA with Bold and Gold® Conceptual O&M Cost

Parameter	Value
Field Operations	$315,000
SCADA Hydro Management	$129,000
Water Quality Data Collection/Management	$165,000
Exotic Vegetation Control	$107,000
Public Use	$19,000
Field Operations	$735,000
Total Annual O&M Cost	$735,000
Other Cost	0.2
Subtotal Annual O&M Cost	$882,000
Contingency	0.3
Final Total Annual O&M Cost	**$1,146,600**

5.3.3 Life Cycle (Net Present Value) Cost

The life cycle cost for the STA with Bold and Gold® is $459.6 million for Option 4a (see Table 5-7) and $512.9 million for Option 4b (see Table 5-8).

Table 5-7. Option 4a STA with Bold and Gold® Conceptual Life Cycle Cost

Year	Cost
0	$421,200,000
1	$1,242,056
2	$1,279,318
3	$1,317,698
4	$1,357,229

Year	Cost
5	$1,397,945
6	$1,439,884
7	$1,483,080
8	$1,527,573
9	$1,573,400
10	$1,620,602
11	$1,669,220
12	$1,719,297
13	$1,770,875
14	$1,824,002
15	$1,878,722
16	$1,935,083
17	$1,993,136
18	$2,052,930
19	$2,114,518
20	$2,177,953
21	$2,243,292
22	$2,310,591
23	$2,379,909
24	$2,451,306
25	$2,524,845
26	$2,600,590
27	$2,678,608
28	$2,758,966
29	$2,841,735
30	$2,926,987
31	$3,014,797
32	$3,105,241
33	$3,198,398
34	$3,294,350
35	$3,393,180
36	$3,494,976
37	$3,599,825
38	$3,707,820
39	$3,819,054
40	$3,933,626
41	$4,051,635
42	$4,173,184
43	$4,298,379
44	$4,427,331
45	$4,560,151
46	$4,696,955
47	$4,837,864
48	$4,983,000
49	$5,132,490
50	$5,286,465
Net Present Value	**$459,561,350**
Number of Years, N	50
Annual Discount Rate	0.05
Annual Inflation	0.03

Table 5-8. Option 4b STA with Bold and Gold® Conceptual Life Cycle Cost

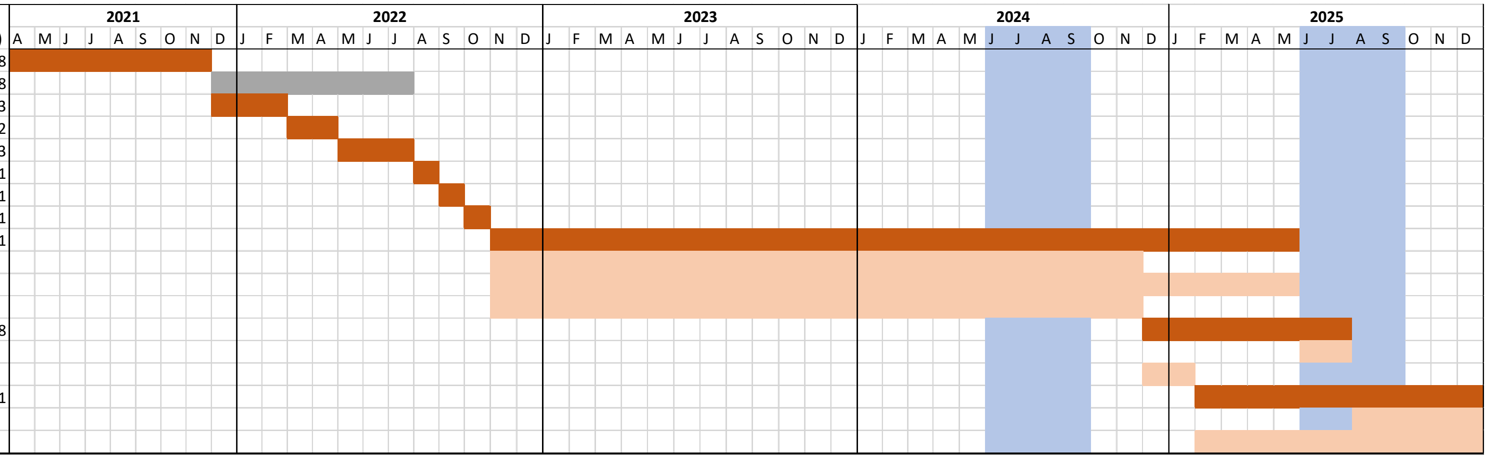
Year	Cost
0	$476,387,313
1	$1,180,998
2	$1,216,428
3	$1,252,921
4	$1,290,508
5	$1,329,224
6	$1,369,100
7	$1,410,173
8	$1,452,479
9	$1,496,053
10	$1,540,935
11	$1,587,163
12	$1,634,777
13	$1,683,821
14	$1,734,335
15	$1,786,365
16	$1,839,956
17	$1,895,155
18	$1,952,010
19	$2,010,570
20	$2,070,887
21	$2,133,014
22	$2,197,004
23	$2,262,914
24	$2,330,802
25	$2,400,726
26	$2,472,748
27	$2,546,930
28	$2,623,338
29	$2,702,038
30	$2,783,099
31	$2,866,592
32	$2,952,590
33	$3,041,168
34	$3,132,403
35	$3,226,375
36	$3,323,166
37	$3,422,861
38	$3,525,547
39	$3,631,313
40	$3,740,253
41	$3,852,460
42	$3,968,034
43	$4,087,075
44	$4,209,687
45	$4,335,978
46	$4,466,057
47	$4,600,039
48	$4,738,040
49	$4,880,181
50	$5,026,587
Net Present Value	**$512,862,853**

Year	Cost
Number of Years, N	50
Annual Discount Rate	0.05
Annual Inflation	0.03

5.4 Construction Schedule

The construction schedule is a sequence of phases that revolve around design, construction, and operation (Figure 5-1). The design phase incorporates conceptual and final design, review processes, and permitting evaluation. This phase began in April 2021 with conceptual design and would be completed in September 2022. Once final design is completed, the project would go out to bidding and construction. The STA and Bold and Gold® systems would be constructed with different end dates. The components west of the Banana Branch Canal would be expected to be completed first in November 2024, with the understanding that most of the flow from the S-473 structure could be treated through this system with the commencement of startup during the first discharge season. The STA component east of the Banana Branch Canal is expected to require more time to complete, being substantially larger in area, and would be completed in May 2025. The startup phase for the STA component could begin during the 2025 filling cycle. Both STA and Bold and Gold® components would be available to provide treatment during the second discharge cycle.

	Schedule Description	Duration (Months)
1	Conceptual Plan	8
2	Permitting	8
3	Intermediate Design	3
4	Review	2
5	Final Design (90%)	3
6	Final Design Review	1
7	Final Design (100%)	1
8	Bidding	1
9	Construction	31
	Pump Station and Conveyance	
	STA	
	Bold and Gold	
10	Startup	8
	STA	
	Bold and Gold	
11	Operation	11
	STA	
	Bold and Gold	



Note: Months highlighted in blue are the estimated times of reservoir filling.

Figure 5-1. Option 4 STA with Bold and Gold® Construction Schedule

5.5 Draft Operations Plan

Operation of the STA with Bold and Gold® media treatment system will vary throughout a typical year based upon whether the reservoir is in the filling, storage, or discharge phase. The filling phase would be the preferred time for all basic maintenance activities, including annual inspection, vegetation and Bold and Gold® media replacement (if warranted, although the media beds were designed for a 50-year life cycle), berm maintenance, and repair and replacement of pumps, meters, and all hydraulic control structures. In general, maintenance is anticipated to be simpler than the alum-based options, but the overall area required would entail more land-based maintenance activities. These would include berm mowing and repair, non-native species removal, and media bed discing. Hydraulic maintenance would require periodic (possibly monthly) application of flow to the STA and media beds to sustain wetland and microbial communities necessary for treatment.

During the storage cycle, the system would be placed in a mode of operational readiness in anticipation of seasonal discharge. Media surfaces would be scarified by discing. Water levels in the Bold and Gold® media basins would be maintained at a static level consistent with media surface but the wetland system could receive periodic (monthly) flow to maintain a hydrated sediment layer.

Prior to the discharge cycle, system readiness would be reviewed prior to initiation of flow; basins would be filled; and all mechanical, electrical, and hydraulic features will be reviewed and brought to operational readiness.

During the discharge cycle, the system would be operated to maintain water depths above the wetland bottom and media surface. Flow distribution would be monitored and adjusted to achieve target hydraulic loading rates for each cell and media type. Regular sampling and testing would be conducted on the reservoir water and the water at the outlet the wetland and Bold and Gold® media collector channels to demonstrate performance and facilitate operational adjustments. A detailed monitoring plan would be developed during final design if this option is selected as the WQC Plan.

During the discharge cycle, typical operational activities anticipated from the STA with Bold and Gold® include the following:

- Flow meter and control valve maintenance (monthly)
- Flow and level checks
- Water quality monitoring
- Periodic scarification of Bold and Gold® media beds, if required
- Vegetation management

6.0 Option 5: Sand Filter with In-reservoir Alum Treatment

Based on comments received during the Draft Conceptual Design, J-Tech identified a new option that acknowledges nutrient reductions expected from the in-reservoir alum treatment system, which is currently in design (see details in Section 7.0). The in-reservoir application of about 0.6 mg/L of aluminum, in the form of aluminum sulfate, is estimated to reduce nutrients by about 20% for TN and 30% for TP. The nutrient reduction from the in-reservoir treatment was applied to the WQC sizing needs in the design presented in this section. As shown in Table 6-1, the estimated nutrient concentrations leaving the reservoir, after alum treatment, would be close to achieving the water quality targets established for the WQC. To provide additional polishing of the reservoir flow during discharge, this option includes a post-storage sand filter for removal of suspended solids and nutrients to meet the WQC targets.

Table 6-1. Estimated TN and TP Concentrations After In-reservoir Alum Treatment and Targets

Parameter	WQC Spreadsheet Model Estimated Concentration	WQC Target Concentration
TN (mg/L)	1.34	1.23
TP (mg/L)	0.098	0.080

The sand filter is sized conceptually to be 150-ac and made up of two, 75-ac cells that fit on the SFWMD-owned western parcel (S-5). The location of this parcel would allow flows from both reservoir cells to be routed to the sand filter for treatment. Sand filtration is a proven technology and is often combined with alum treatment for potable water supply. In this application, the sand filter would help remove any micro-floc that forms from the in-reservoir alum treatment. The sand filter is designed to take flows up to 611 cfs; however, higher flows could be sent through the sand filter. Under higher flows, water may flow over the top of the sand, instead of infiltrating, but would still receive some treatment. The sand can be sourced from onsite, which makes it a cost-effective treatment media. The sand would be tested for nutrients and legacy pollutants before use in the sand filter. The sand filter would be fully lined, so there would be no seepage losses from the WQC.

6.1 Design Calculations

Table 6-2 summarizes the treatment model performance estimates for the sand filter for the designated area, hydraulic loading, and average inflow nutrient concentrations anticipated from the reservoir after in-reservoir alum treatment. The treatment model is derived from the p-K-C* model, which is a first-order model developed for treatment wetland design and performance analysis (Kadlec and Wallace, 2009), and is calibrated to available performance data from constructed large scale sand filters currently operating in Florida (J-Tech, 2020).

6.2 Water Quality Performance

The sand filter was sized at 150-ac to fit within the SFWMD S-5 parcel and to receive the maximum design flows. Table 6-2 summarizes the conceptual performance for the sand filter.

Table 6-2. Option 5 Sand Filter Conceptual Performance

Vertical Downflow Wetland Simple PkC* Design Model (Wastewater Parameters)		
Project Name	Option 5. 150 Acre Sand Filter	User inputs indicated by white boxes. Pop-up notes indicated by red triangles.
Project Number		

General Inflow Data

Parameter	Value	Units
Annual Average Daily Flow	457	cfs
Converted Flow	1,118,096	m^3/d
Wastewater Temperature	23.9	°C

Water Quality Characteristics

Parameter		TSS			NH_4-N		TN	TP	FC	
Influent Concentration, mg/L	C_i =	4.7					1.34	0.098		
Average Target Effluent Conc., mg/L	C_e =							0.08		
Desired Confidence Percentile		0.5			0		0.5	0.5	0.5	
Max Month/Annual Factor		1.7			2.5		1.6	1.8	2.6	
Design Target Conc., mg/L	C_d =							0.0		
Wetland Background Limit, mg/L	C^* =	1.3			0.01		0.9	0.02	300	
Reduction fraction to target	$F_e = 1 - C_e/C_i$=	1.000			No Value		1.000	0.184	No Value	
Reduction fraction to background	$F_b = 1 - C^*/C_i$ =	0.723					0.328	0.796		
Areal Rate Constant, 20°C, m/y	k_{20} =	492			25		164	152	83	
Temperature Factor	θ =	1.00			1.04		1.05	1.00	1.00	
P-Factor	P =	6			6		6	3	3	
Areal Rate Constant, m/y	k_T =	492			29.1		198.4	152	83	
Area required for each parameter, ac		C*>Cd	C*>Cd		C*>Cd		C*>Cd	939.8	C*>Cd	

Required Treatment Wetland Area

Required Treatment Wetland Area	A_{max} =	**939.8**	acres	Displays minimum wetland area to treat all pollutants down to desired targets
		380.5	ha	
User Defined Area	A_{user} =	**150.0**	acres	User specified wetland area; leave blank if you wish to use A_{max} (above) for effluent calculations below.
		60.7287	ha	

Final Effluent Concentrations and Percent Removal

Area (ha) used for Calculations =	**60.7**	TSS			NH_4-N		TN	TP	FC	
Design Target Conc., mg/L	C_d =						1.0	0.044		
Influent concentrations, mg/L	C_i =	4.7					1.34	0.098		
Effluent concentrations, mg/L		3.0					1.23	0.083		
Percent Reduction (by concentration)		36%					8%	16%		
Mass Loading (lb/day)		11579					3301	241		
Mass Loading (kg/ha/d)		86.5					24.7	1.8		
Mass Out (lb/day)		7401					3030	204		
Mass Out (kg/ha/d)		55.3					22.6	1.5		
Percent Reduction (by mass)		36%					8%	16%		

Hydraulic Properties Based on Area and Flow

Gravel Diameter (cm)		Approx Aspect Ratio (L:W) = (1:1)	1
Bed Depth (m)	1.2	Length (m)	779
Porosity e (%)	55%	Width (m)	779
Volume Water (m3)	407327	Bottom Slope (m/m)	0
Volume Media (m3)	333268	**Hydraulic Constraints**	
Bed Conductivity k (m/d)	10500	G_1, Drainability	0.00
Design Outlet Water Depth h_0 (m)	1.10	G_3, Distance Thickening/Thinning	883.96

Hydraulic Loading Rate, q (cm/d)	HLR =	184.1	cm/d	0.07671382	m/hr	0.16	m/hr	384
Nominal Hydraulic Residence Time (d)	HRT =	0.36	days					

6.3 Conceptual Cost

Capital costs were estimated by pricing materials required for excavation, media type and installation, flow conveyance, and related items, and applying standard markups. Operational costs were derived and updated from the WQFS. The total net present value was calculated over a 50-year period.

6.3.1 Capital Cost

Capital cost of the sand filter system includes the construction of the distribution channels, treatment cells including the berms and structures, and collection channels to remove the treated water. All capital cost estimates were based upon quantity take-offs from the conceptual plan and profile, and similar sand filter construction scaled up to the designated treatment cell sizes used here. The conceptual capital cost is estimated to be $130 million. Table 6-3 provides the conceptual capital cost for the sand filter system.

Table 6-3. Option 5 Sand Filter Conceptual Capital Cost

Item	Unit Design Criteria	Quantity	Basis	Unit Cost	Estimated Cost
TECHNOLOGY – EQUIPMENT AND MATERIALS					
Silt Fence & Erosion Control	Length of site perimeter	17,160	LF	$1	$17,160
Clear & Grub	Site area	238	AC	$300	$71,280
Perimeter Berm	Calculated from terrain model and design plan and profile	49,157	CY	$10	$491,565
Site Grading, Interior Berm Construction	Calculated from terrain model and design plan and profile	433,504	CY	$10	$4,335,040
Haul Offsite Soil	Calculated from terrain model and design plan and profile	23,398	CY	$3	$70,194
Interior WQC – Sand Media	Calculated as a 4-foot depth from terrain model and design plan and profile	968,000	CY	$26	$25,168,000
Drainage Gravel	Calculated as a 1-foot depth across sand filter area (150 ac)	242,000	CY	$15	$3,630,000
Liner, HDPE	Calculated based on sand filter area (150 ac)	529,633	SY	$5	$2,648,167
Non-woven Geotextile	Calculated based on sand filter area (150 ac)	543,125	SY	$3	$1,629,375
Rip Rap	Calculated as a two-foot riprap apron near surface inlet areas	13,367	CY	$90	$1,203,000
24" Perforated Pipe	Calculated based on sand filter length	12,962	LF	$115	$1,490,630
30" CPE Perforated Pipe	Calculated based on sand filter length	16,972	LF	$105	$1,782,060
36" CPE Perforated Pipe	Calculated based on sand filter length	17,457	LF	$126	$2,199,582
42" CPE Pipe	Calculated based on sand filter length	3,059	LF	$162	$495,558
Total Equipment Cost (TEC)					**$45,231,611**
Freight and Taxes		3%	of TEC		$1,356,948
Spare Parts		1%	of TEC		$452,316
Purchased Equipment Cost – Delivered (PECD)					**$47,040,875**
TECHNOLOGY CONSTRUCTION – INSTALLATION					
Equipment Installation		10%	of TEC		$4,523,161
Process Piping		1.0%	of TEC		$452,316
Instrumentation and Controls		1.0%	of TEC		$452,316
Electrical		1.0%	of TEC		$452,316

Item	Unit Design Criteria	Quantity	Basis	Unit Cost	Estimated Cost
Civil		1.0%	of TEC		$452,316
Concrete		1.0%	of TEC		$452,316
Structural Steel		1.0%	of TEC		$452,316
Architectural		1.0%	of TEC		$452,316
Service Facilities		1.0%	of TEC		$452,316
Total Technology Direct Cost (TTDC)					**$8,141,690**
CONVEYANCE CONSTRUCTION – INSTALLED					
Pump Station	Includes inflow piping, based on historical SFWMD data for pump station construction per cfs	611	EA	$50,000	$30,550,000
Interior Water Control Structure	8 single barrel 6' x 4' box culverts at 60 LF each	240	LF	$12,500	$3,000,000
Outfall WCS – Piping	1 double barrel 8' x 8' box culvert at 275 LF	360	LF	$17,500	$6,300,000
Site Roadways	Includes import of rock base, spreading, grading, and compaction	14,821	CY	$35	$518,735
Site Bridges	2 two-lane FDOT Florida slab beam at 30' x 100' = 3,000 SF/each (6,000 Total SF)	6,000	LF	$300	$1,800,000
Total Installed Conveyance (TIC)					**$42,168,735**
TOTAL DIRECT COST (TECHNOLOGY & CONVEYANCE)	PECD+TTDC+TIC				**$97,351,300**
Mobilization			4%	of TDC	$3,894,052
Field and Office Overhead			0%	of TDC	$0
Subtotal					**$101,245,352**
Bonds, Insurance		1.5%	of TDC		$1,460,270
Contractor's Profit		7%	of TDC		$7,087,175
Contingency		20%	of TDC		$20,249,070
Total Direct Cost + Indirect Cost, Including Profit + Contingency	**Total Probable Construction Cost (TPCC)**				**$130,041,867**

6.3.2 O&M Cost

The O&M costs for the sand filter system consist primarily of site and hydraulic management, periodic scarification of the top layer and the removal, disposal, and replacement of sand after years of treatment. Surface scarification was assumed to be performed with a tractor-pulled plough four times during a typical year. The top foot of sand was assumed to be replaced in five, 0.3-foot increments over a 20-year period. Other O&M activities would include general field operations, SCADA hydrologic data management, water quality monitoring, exotic vegetation control, and public use access maintenance. These values were estimated using the SFWMD's O&M database. The annual O&M cost for the system is estimated at $1.4 million. Table 6-4 summarizes the O&M costs.

Table 6-4. Option 5 Sand Filter Conceptual O&M Cost

Category/Activity	Annual Cost
Sand Replacement (5 year interval, annualized)	$314,600
Surface Scarification	$30,000
Sand Filter Cover Maintenance	$344,600
Field Operations	$323,000
SCADA Hydro Management	$79,000
Water Quality Data Collection/Management	$110,000
Exotic Vegetation Control	$35,000
Public Use	$5,000
Field Operations	$552,000
Total Annual O&M Cost	$896,600
Other Cost	0.2
Subtotal Annual O&M Cost	$1,075,920
Contingency	0.3
Final Total Annual O&M Cost	$1,398,696

6.3.3 Life Cycle (Net Present Value) Cost

The life cycle cost for the sand filter is presented for a 50-year lifespan, which is estimated at $174.5 million. Table 6-5 presents the net present value cost for the treatment system.

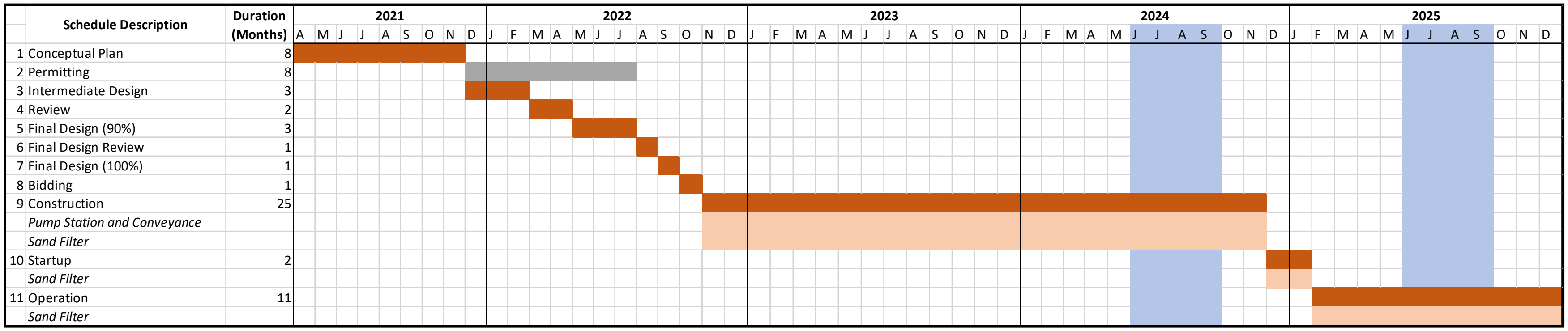
Table 6-5. Option 5 Sand Filter Conceptual Life Cycle Cost

Year	Cost
0	$130,041,867
1	$1,440,657
2	$1,483,877
3	$1,528,393
4	$1,574,245
5	$1,621,472
6	$1,670,116
7	$1,720,220
8	$1,771,826
9	$1,824,981
10	$1,879,730
11	$1,936,122
12	$1,994,206
13	$2,054,032
14	$2,115,653
15	$2,179,123
16	$2,244,496
17	$2,311,831
18	$2,381,186
19	$2,452,622
20	$2,526,201
21	$2,601,987
22	$2,680,046

Year	Cost
23	$2,760,448
24	$2,843,261
25	$2,928,559
26	$3,016,416
27	$3,106,908
28	$3,200,115
29	$3,296,119
30	$3,395,002
31	$3,496,852
32	$3,601,758
33	$3,709,811
34	$3,821,105
35	$3,935,738
36	$4,053,810
37	$4,175,425
38	$4,300,687
39	$4,429,708
40	$4,562,599
41	$4,699,477
42	$4,840,462
43	$4,985,675
44	$5,135,246
45	$5,289,303
46	$5,447,982
47	$5,611,422
48	$5,779,764
49	$5,953,157
50	$6,131,752
Net Present Value	**$174,537,063**
Number of Years, N	50
Annual Discount Rate	0.05
Annual Inflation	0.03

6.4 Construction Schedule

The construction schedule is a sequence of phases that revolve around design, construction, and operation (Figure 6-1). The design phase incorporates conceptual and final design, review processes, and permitting evaluation. This phase began in April 2021 with conceptual design and would be completed in September 2022. Once final design is completed, the project would go out to bidding and construction, which is expected to be finished in November 2024. The final operation phase begins following a two-month startup used to optimize the system before beginning treatment of the designed reservoir effluent.



Note: Months highlighted in blue are the estimated times of reservoir filling.

Figure 6-1. Option 5 Sand Filter Construction Schedule

6.5 Draft Operations Plan

Operation of the sand filter would vary throughout a typical year based upon whether the reservoir is in the filling, storage, or discharge phase. The filling phase would be the preferred time for all basic maintenance activities, including annual inspection, sand filter media replacement (if warranted), berm maintenance, and repair and replacement of pumps, meters, and all hydraulic control structures. In general, maintenance is anticipated to be simpler than the alum-based options, but the overall area required would entail more land-based maintenance activities. These would include berm mowing and repair, non-native species removal, and media bed discing. Hydraulic maintenance would require periodic (possibly monthly) application of flow to the media beds to sustain microbial communities necessary for treatment.

During the storage cycle, the system would be placed in a mode of operational readiness in anticipation of seasonal discharge. The sand filter surface would be scarified by discing, as recommended by the vendor, to maintain hydraulic conductivity by removing biomass and loosening the sand. The sand filter would be dried down prior to discing. This discing would occur at least annually during the reservoir filling period, and up to monthly during the reservoir discharge period. The sand filter system could be maintained with a dry surface level, although it is preferred to maintain water in the system to prevent bird nesting on the sand surface.

Prior to the discharge cycle, system readiness would be reviewed prior to initiation of flow; basins would be filled; and all mechanical, electrical, and hydraulic features would be reviewed and brought to operational readiness.

During the discharge cycle, the system would be operated to maintain water depths above the media surface to facilitate distribution. Flow distribution would be monitored and adjusted to achieve target hydraulic loading rates for each cell. Regular sampling and testing would be conducted on the reservoir water and the water at the outlet the sand filter collector channels to demonstrate performance and facilitate operational adjustments. A detailed monitoring plan would be developed during final design if this option is selected as the WQC Plan.

During the discharge cycle, typical operational activities anticipated from the sand filter include the following:

- Flow meter and control valve maintenance (monthly)
- Flow and level checks
- Water quality monitoring
- Periodic scarification of cells
- Vegetation observations for preemptive vegetation removal

7.0 In-reservoir Alum Treatment System

Injection of alum during reservoir filling is expected to be useful in suppressing potential nuisance algal growth within the reservoir while optimizing performance of the post-storage WQC. A key advantage of the in-reservoir alum treatment system is its ability to be designed and constructed concurrently with construction of the C-43 WBSR. As noted in Section 6.0, the in-reservoir alum system is currently in the design phase. The following description is based on the details in the Intermediate (60%) Design documents that were submitted to SFWMD for review on June 5, 2021 (J-Tech, 2021b). Details may be subject to change as the design is finalized.

Bulk liquid alum would be delivered to the site via tanker truck, offloaded using a new fill station, and stored in double-walled FRP tanks in a new tank farm. Chemical metering pumps would deliver liquid alum to the four intake channels at the C-43 WBSR S-470 pump station to aid in nutrient removal in the reservoir. Each intake channel would have dedicated flow control valves and flow meters to control the dosage. The liquid alum would be added to the discharge side of recirculation pumps mounted in the bottom of each pump bay, upstream from the suction intake for the 350-cfs pumps that deliver water to the C-43 WBSR. The tank farm would include a fill station with offloading pump, containment, and a safety shower/eyewash station. The alum feed pumps would be located in the tank farm to minimize suction piping. A sunshade (open-sided pre-engineered metal building) would be provided over the tank farm to protect the tanks, pumps, and associated equipment.

7.1 Design Calculations

The process design criteria and recommended process features are summarized in Table 7-1.

Table 7-1. In-reservoir Alum Treatment System Conceptual Design Criteria

Component	Value	Units
Influent		
Peak Total Pumping Capacity	1,500	cfs
Daily Pumping Duration	12	Hours/day
Number of Pumps	4 constant speed vertical mixed flow	
Design TP	0.15	mg/L
Design TN	1.37	mg/L
Alum Dosage		
Target Effluent TP	0.080	mg/L
Average	0.6	mg/L
Peak	2.0	mg/L
Bulk Alum		
Strength	49	Percent weight as $Al_2(SO_4)_3{\cdot}14H_2O$
Density	11.10	Pounds/gallon
Alum Usage		
Minimum Flow Criteria	One vertical mixed flow pump in service (375 cfs) at 50% of average dosage	
Minimum Total Alum Flow	0.85	gpm
Average Flow Criteria	Four vertical mixed flow pumps in service (1,500 cfs) at average dosage	
Average Total Alum Flow	6.8	gpm
Daily Average Total Alum Flow	4,916	Gallons per day
Average Flow Criteria	Four vertical mixed flow pumps in service (1,500 cfs) at peak dosage	
Average Total Alum Flow	22.8	gpm
Alum Flow Range per Channel		
Minimum	0.85	gpm
Average	1.71	gpm
Peak	5.69	gpm
Bulk Alum Storage		
On-Site Storage Capacity	14	Days at average dosage and peak flows
	68,824	Gallons

Component	Value	Units
Delivery Truck Size	11,600	Gallons
Bulk Tank Sizing	Receive one tanker load at 10% full	
Minimum Bulk Tank Size	12,760	Gallons
Estimated Number of Bulk Tanks	5	
Bulk Tank Liquid Volume	13,800	Gallons each
Estimated Bulk Tank Diameter	12	Feet
Estimated Bulk Tank Height	16.5	Feet
Tank Type	Vertical double-walled FRP	
Alum Dosing System		
Number	4	
Control Approach	Flow meter and control valve with interlocked (with channel vertical mixed flow pump) automated shutoff valve	

The C-43 WBSR in-reservoir alum treatment facility was modeled in the Sumo© Simulation platform by Dynamita (www.dynamita.com) version 19.3. The biokinetic model used for this work is the Sumo 2S model modified for alum addition. The C-43 WBSR model was built to estimate the reservoir effluent under variable feed and storage conditions. One limitation of the model is that it does not model algae directly, so the TSS settling values and in the effluent are based on typical reservoir concentrations.

Preliminary modeling targeted an effluent quality of 0.08 mg/L TP in the cell effluent. This preliminary modeling was conducted with a spreadsheet model that approximates the alum phosphorus adsorption reactions. This preliminary model indicated that an alum dosage of 0.6 mg/L would achieve the target effluent (at an influent of 0.15 mg/L TP). The Sumo model was then set up at a steady state feed rate of 750 cfs (full pump capacity assuming 12 hours per day of operation) with an alum molar dosage of 9 moles alum/mole orthophosphate. This resulted in a dosage of 0.6 mg/L aluminum or 3.4 gpm of bulk alum solution.

7.2 Water Quality Performance

The model estimated that the incoming TN concentration of 1.6 mg/L could be reduced to approximately 1.2 mg/L through reductions in nitrate, ammonia, and colloidal nitrogen (Table 7-2). The model also estimated that the incoming TP concentration of 0.15 mg/L could be reduced to less than 0.08 mg/L with large reductions in orthophosphate (Table 7-2).

Table 7-2. In-reservoir Alum Treatment System Conceptual Performance

Component	Influent	Effluent	Units
Flow Rate	484	484	mgd
Total Chemical Oxygen Demand	71	43	mg/L
TOC*	-	11.80	gram carbon per cubic meter
TSS	3.59	3.59	mg/L
VSS/TSS Ratio	0.75	0.92	gram VSS per gram TSS-1
Total Biological Oxygen Demand (5 days)	4.07	2.33	mg/L
pH**	7.50	8.53	standard units
Alkalinity	150	147	mg/L
TN	1.60	1.22	mg/L
Total Ammonia	0.056	0.001	mg/L

Component	Influent	Effluent	Units
Nitrite	Below method detection limit	Below method detection limit	mg/L
Nitrate	0.100	Below method detection limit	mg/L
TP	0.150	0.076	mg/L
Orthophosphorus, as P	0.077	0.044	mg/L

* The model has a default value for the TOC influent concentration based upon oxygen demand in the organic matter, which is estimated from TSS. The TOC in the effluent was estimated as a function of oxygen demand using default values.
** The pH response was estimated in the model as a result of biological activity.

7.3 Conceptual Cost

Capital costs were estimated by pricing materials required for storage, dosing, and related items and applying standard markups. Operational costs were derived and updated from the WQFS. The total net present value was calculated over a 50-year period.

7.3.1 Capital Cost

The capital cost estimate based on the Intermediate Design (J-Tech, 2021b) is provided in Table 7-3. The capital cost was estimated to be $4.3 million.

Table 7-3. In-reservoir Alum Treatment System Intermediate Design Capital Cost

Item	Quantity	Unit Cost	Estimated Cost
Alum Storage Tank	5	$54,405.78	$272,028.90
Alum Unloading Pump	1	$25,243.93	$25.243.93
Alum Recirculation Pumps	4	$11,943.32	$47,773.28
Alum Feed Pumps	4	$22,110.20	$88,440.81
Piping and Valves (including safety shower)	LS	$206,020.33	$206,020.33
Site Work (including clearing and grubbing, survey layout, and dewatering)	LS	$222,069.45	$222,069.45
Concrete	LS	$47,153.60	$47,153.60
Shade Building	LS	$340,429.19	$340,429.19
Grating	LS	$6,074.95	$6,074.95
Seeding, Sodding, Slope Protection	LS	$8,647.31	$8,647.31
Instrumentation and Controls	LS	$452,627.50	$452,627.50
CONSTRUCTION – DIRECT			**$1,716,509.24**
Contract Cost (SFWMD Cost Estimating Procedure)			
FOOH (JOOH)/HOOH Combined	10%		$206,859
Mobilization/Demobilization	10%		$227,545
Contractor Profit	14%		$350,420
Bonds and Insurance	2%		$57,068
PROJECT CONTRACTOR COST			$2,910,484
SFWMD Allowance Account (SIOH)	5%		$145,524
Contingency	20%		$611,202
Escalation	16%		$586,754
TOTAL PROJECT COST			**$4,253,964**

7.3.2 O&M Cost

The annual O&M cost is estimated at $659,000, which includes the cost and delivery of alum, operational maintenance, mechanical replacement, and general site upkeep and reporting, as presented in Table 7-4.

Table 7-4. In-reservoir Alum Treatment System Conceptual O&M Cost

Parameter	Value
Annual Power Cost ($)	$853
Average Annual Aluminum Cost	$207,029
Maintenance & Repair Annual Cost	$15,549
Total Annual O&M Cost	$223,431
Other Cost	0.2
Subtotal Annual O&M Cost	$268,117
Field Operations	$80,000
Hydro Data Operations	$26,000
Water Quality Data Acquisition and Management	$175,000
Final Total Annual O&M Labor & Contracts	$281,000
Total O&M	$549,117
Contingency	0.3
Final Total Annual O&M Cost	**$658,941**

7.3.3 Life Cycle (Net Present Value) Cost

The net present value of the proposed in-reservoir alum system is estimated at $25.2 million for a 50-year life cycle, with replacements of entire hardware at years 15, 25, 30, 45, and 50 (Table 7-5).

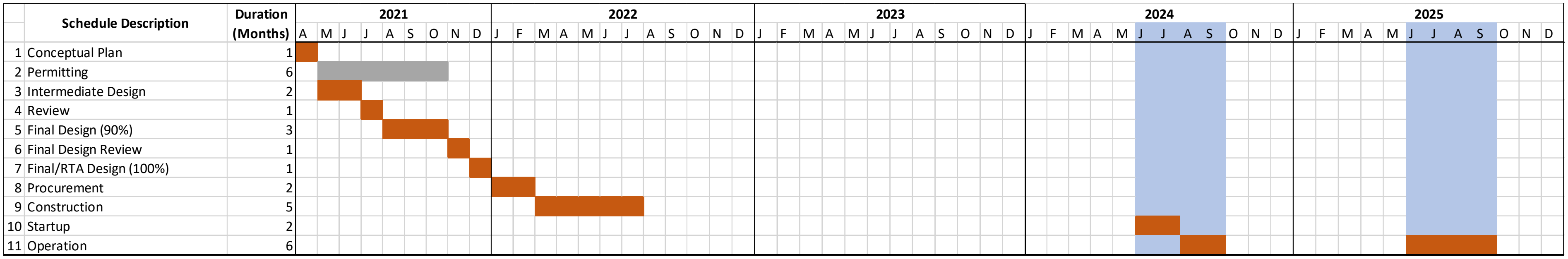
Table 7-5. In-reservoir Alum Treatment System Conceptual Life Cycle Cost

Year	Cost
0	$4,253,964
1	$678,709
2	$699,070
3	$720,042
4	$741,644
5	$763,893
6	$786,810
7	$810,414
8	$834,727
9	$859,768
10	$885,561
11	$912,128
12	$939,492
13	$967,677
14	$996,707
15	$1,026,608
16	$1,057,407
17	$1,089,129
18	$1,121,803
19	$1,155,457
20	$1,190,120
21	$1,225,824
22	$1,262,599

Year	Cost
23	$1,300,477
24	$1,339,491
25	$1,379,676
26	$1,421,066
27	$1,463,698
28	$1,507,609
29	$1,552,837
30	$1,599,422
31	$1,647,405
32	$1,696,827
33	$1,747,732
34	$1,800,164
35	$1,854,169
36	$1,909,794
37	$1,967,088
38	$2,026,100
39	$2,086,883
40	$2,149,490
41	$2,213,975
42	$2,280,394
43	$2,348,806
44	$2,419,270
45	$2,491,848
46	$2,566,603
47	$2,643,602
48	$2,722,910
49	$2,804,597
50	$2,888,735
Net Present Value	$25,216,134
Number of Years, N	50
Annual Discount Rate	0.05
Annual Inflation	0.03

7.4 Construction Schedule

The construction schedule is based on a sequence of design phases followed by bidding, construction, startup, and finally operation (Figure 7-1). The design phases are expected to be completed in December 2021. Bidding and construction would follow with construction expected to finish in July 2022. Startup is vital to optimize the system and prepare it for the high loading expected from the reservoir. An initial startup period is proposed during August and September 2023, when water could be recirculated through the inlet bays to confirm chemical feed pump operation. A final commissioning would be performed prior to or during the first initial fill in June 2024. Operation would continue in August and September 2024, and then in subsequent wet seasons.



Note: Months highlighted in blue are the estimated times of reservoir filling.

Figure 7-1. In-reservoir Alum Treatment System Construction Schedule

7.5 Draft Operations Plan

The alum storage system would consist of five double-walled FRP tanks. The area around the tanks would require general cleaning, as appropriate. The tanks would be supplied with level monitors/alarms and leak detectors, which would need periodic maintenance. The fill system would consist of a tanker connection valve to direct the bulk alum to the appropriate tank. Operations would need to choose which tank to be filled based on level in that tank, and its ability to receive a full tanker load. Care would need to be taken to not overfill tanks. Each tank discharge (to the dosing point) would have a basket strainer that would need occasional cleaning. This is needed to protect the downstream valves from plugging.

The alum dosage system would consist of a flow meter and control valve system at each pump inlet channel. The valve actuator and flow meter would need occasional maintenance, in addition to recommended flow meter calibration. The actual alum mixing equipment in each inlet channel would require regular maintenance as recommended by the equipment supplier.

From a process perspective, the alum addition system would be used to manage reservoir phosphorus levels. Given the large size of the system, the impacts of changing alum dosage would only be immediately visible in the near vicinity of the pump station outlets at the reservoir cell. Regular TP and orthophosphorus sampling should be conducted on the raw water and the water at three places within the reservoir system (near the pump station outlet, reservoir Cell 1 outlet, and reservoir Cell 2 outlet) to determine if dosages can be raised or lowered, depending on the quality goals of the system. Alum dosing would be flow paced using the chemical metering system. Final outflow samples would be collected for aluminum, sulfate, nutrients, and pH to demonstrate treatment and suitability for discharge. A detailed monitoring plan will be developed during the final design and permitting phase.

Typical operational activities anticipated from the alum treatment system include the following:

- Coordination and supervision of chemical deliveries
- Tank farm maintenance and cleaning (monthly)
- Flow meter and control valve maintenance (monthly)
- Dosage monitoring: weekly during the first months, then monthly while in operation
- Flow checks: all flows are approximately equal between lanes while in service

8.0 Updated Cost-Benefit Analysis

Given the inclusion of the in-reservoir alum treatment system into the C-43 WBSR project, the performance for all post-storage WQC options were reviewed to provide a consistent comparative basis for determining costs and benefits. For this analysis, all options were assumed to retain the original size and configuration, as the average flow rate would be the same, but the O&M requirements were expected to change, given the lower inflow TN, TP, and TSS concentrations after in-reservoir alum treatment.

Table 8-1 summarizes the expected performance for average flow for the five options. All options achieve the discharge target objectives, and Options 1, 2, and 4 achieve substantially lower TN, TP, and TSS concentrations under average flow conditions.

Table 8-1. Performance Projections by Option Including In-reservoir Alum Treatment

Option	Alternative	Area (Ac)	Flow (cfs)	Hydraulic Loading Rate (centimeters/ day)	% Flow	TN Out (mg/L)	TP Out (mg/L)	TSS Out (mg/L)
1	Alum (Post-storage)	16	457	1,726	100%	0.60	0.05	3.2
2	Sand Filter	92	91	60	20%	1.29	0.09	1.1
	Bold and Gold®*	124	366	149	80%	0.89	0.02	1.4
	Combined Flow	216	457	128	100%	0.97	0.04	1.3
3	HWTT	292	457	95	100%	1.23	0.08	2.4
4	STA	868	91	6	20%	1.10	0.06	1.5
	Bold and Gold®*	99	366	223	80%	1.03	0.02	1.9
	Combined Flow	967	457	29	100%	1.04	0.03	1.8
5	Sand Filter	150	457	184	100%	1.23	0.08	3.0

*Note: The results in the table for Bold and Gold® are based on nutrient removal performance estimates from the vendor, which are not consistent with the results from the SFWMD's pilot testing project.

For a cost-benefit comparison of the options, while factoring in the in-reservoir alum treatment, new O&M estimates were also developed for Options 1 and 3. For Option 1, the alum requirements were remodeled and revised, leading to a lower annual O&M cost of $5.1 million. For Option 3, the projected annual O&M costs were reduced by the vendor by approximately 63% to $4 million due to a reduction in chemical usage. The O&M costs for Option 2 and Option 4 did not change because the hydraulic load to the sand filter and Bold and Gold® cells in Option 2 and STA and Bold and Gold® cells in Option 4 would remain the same and, therefore, the same level of O&M would be required to maintain the surface of those cells. Table 8-2 summarizes the costs for all five options.

Table 8-2. Updated Costs by Option Including In-reservoir Alum Treatment

Option	Description	Capital Cost ($ million)	Annual O&M Cost ($ million)	50-year Net Present Value Cost ($ million)
1	Alum Treatment (Post-storage)	$92	$5.1	$259
2	Sand Filter and Bold and Gold®	$422	$1.1	$460
3	HWTT	$69	$4.0	$197
4	STA and Bold and Gold®	$421	$1.2	$460
5	Sand Filter	$130	$1.4	$175

Table 8-3 summarizes the TN removal cost-benefit analysis for the five options when calculated over a 50-year operational life cycle. The cost-benefit calculations are unit costs based upon the 50-year net present value, 50 years of removal performance, and annual unit cost based upon annual performance and O&M costs.

Table 8-3. Unit Costs for TN Removal by Option Including In-reservoir Alum Treatment

Option	Description	Capital Cost	O&M Cost	Net Present Value Cost	TN Concentration Reduction (mg/L)	50-year TN Removal (pounds)*	Net Present Value Unit Cost per TN Pound	Annual Cost per TN Pound
1	Alum Treatment (Post-storage)	$92	$5.1	$259	0.74	17,019,200	$15.22	$14.98
2	Sand Filter and Bold and Gold®	$422	$1.1	$460	0.41	9,429,557	$48.76	$5.83
3	HWTT	$69	$4.0	$197	0.14	3,219,849	$61.18	$62.11
4	STA and Bold and Gold®	$421	$1.2	$460	0.30	6,899,676	$66.61	$8.70
5	Sand Filter	$130	$1.4	$175	0.11	2,529,881	$68.98	$27.67

* 50-year removal calculated based on 457 cfs operation for 187 days each year.

Table 8-4 summarizes the TP removal cost-benefit analysis for the five options when calculated over a 50-year operational life cycle. The cost-benefit calculations are unit costs based upon the 50-year net present value, 50 years of removal performance, and annual unit cost based upon annual performance and O&M costs.

Table 8-4. Unit Costs for TP Removal by Option Including In-reservoir Alum Treatment

Option	Description	Capital Cost	O&M Cost	Net Present Value Cost	TP Concentration Reduction (mg/L)	50-year TP Removal (pounds)*	Net Present Value Unit Cost per TP Pound	Annual Cost per TP Pound
1	Alum Treatment (Post-Storage)	$92	$5.1	$259	0.048	1,103,948	$234.61	$230.99
2	Sand Filter and Bold and Gold®	$422	$1.1	$460	0.069	1,586,925	$289.74	$34.66
3	HWTT**	$69	$4.0	$197	0.018	413,981	$475.87	$483.11
4	STA and Bold and Gold®	$421	$1.2	$460	0.068	1,563,927	$293.88	$38.36
5	Sand Filter	$130	$1.4	$175	0.015	344,984	$505.82	$202.91

* 50-year removal calculated based on 457 cfs operation for 187 days each year.
** HWTT was designed to treat to the target of 0.08 mg/L of TP, whereas the other options will treat to lower concentrations.

Figure 8-1 and Figure 8-2 present the 50-year net present value unit cost and the annual O&M unit cost for TN and TP, respectively.

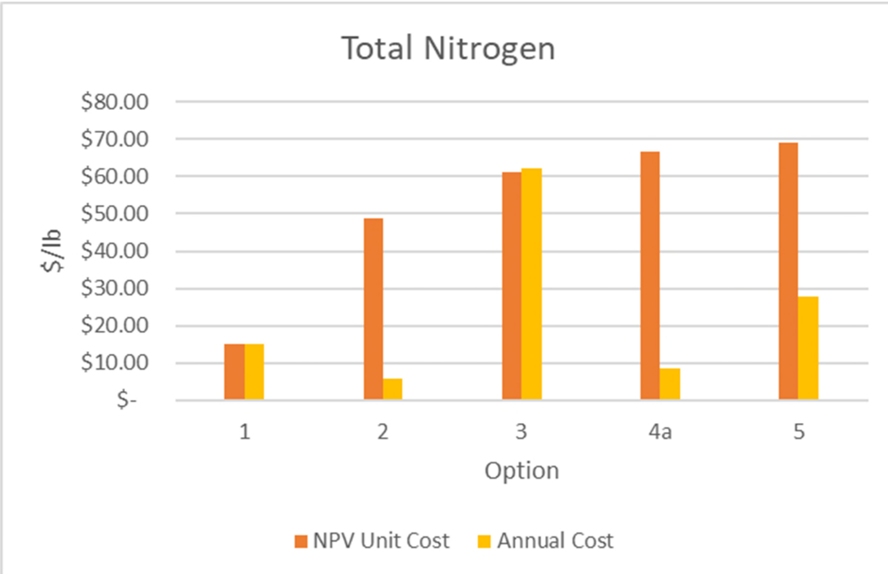


Figure 8-1. Unit Costs for TN Removal by Option Including In-reservoir Alum Treatment

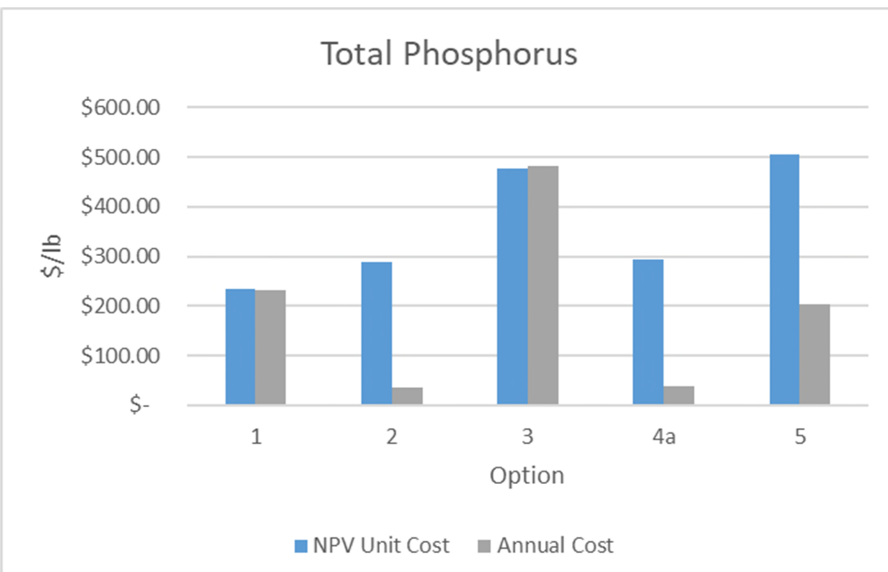


Figure 8-2. Unit Costs for TP Removal by Option Including In-reservoir Alum Treatment

From these comparisons, the following observations are provided:

- Option 1, post-storage alum treatment, provides the greatest cost-benefit in terms of net present value.
- Option 2, sand filter with Bold and Gold®, and Option 4, STA with Bold and Gold®, provide the greatest cost-benefit in terms of annual cost.
- Option 3, HWTT, has the least capital and O&M costs but a relatively high unit cost, because the system is sized to treat to the WQC targets. The other options are oversized for the reduced inflow concentrations and, therefore, "over-treat."
- Option 5, sand filter, has a relatively low annual cost but a higher net present value cost.

9.0 Permitting Requirements

The proposed C-43 WBSR WQC alternatives will be subject to certain regulatory authorizations, which are required to be obtained prior to construction. SFWMD or the construction contractor will be required to submit permit applications to state, federal, and/or local agencies for review and approval. The following permits are expected to be required or will need to be reviewed by regulatory agencies.

9.1 Federal Requirements

The majority of the WQC alternatives will likely not require a federal dredge and fill authorization under Section 404 of the Clean Water Act through USACE or DEP. If improvements to the Banana Branch Canal are deemed necessary during detailed design for conveyance of flows from the WQC, Section 404 authorization may be required for the portion of the canal north of State Road 80.

The project alternatives will require a Section 408 review and possibly a Section 408 authorization from USACE for activities that will modify the federally approved C-43 WBSR project. Potential project modifications include connections to the perimeter canal and project features near the reservoir embankment. These permits will be coordinated and submitted by SFWMD with assistance from J-Tech.

9.2 State of Florida Requirements

It will be necessary for the contractor to obtain a General Construction and/or Industrial Wastewater National Pollutant Discharge Elimination System permit prior to construction. The contractor will need to supply a Stormwater Pollution Prevention Plan, which will include all soil and sediment control measures to be implemented on the project site during construction. A NEEPP permit will be required from DEP for the project. DEP will review the plans for consistency with regulatory requirements of Chapter 373.4595, Florida Statutes.

If improvements to the Banana Branch Canal are deemed necessary for conveyance of flows from the WQC, a state lands title determination should be requested. If portions of the Banana Branch Canal are considered state-owned lands, then additional proprietary authorization may be required as part of the NEEPP permit.

A consumptive use permit should not be required as the water is already accounted for in the reservoir itself. Once an operations plan has been developed for the selected WQC alternative, the details should be reviewed for any additional permitting.

9.3 Dewatering Permits

Dewatering permits will be applied for by the contractor. The contractor will be required to submit the site-specific dewatering plan to SFWMD at least 60 days prior to the planned start date of dewatering (see specification Section 02401, Part 1.04, A, for this requirement).

9.4 Local Permits

The proposed WQC alternatives are located in Hendry County, Florida. Building construction permits are reviewed and approved and sites inspected by Hendry County Planning and Zoning Department. The alternatives will require a Site Development Permit to be issued by Hendry County. Discussions with SFWMD indicated that the site is exempt from building department review and permitting under Florida Statute 373.086.

10.0 Summary

The WQC options for treatment of C-43 WBSR flows offer a broad range of performance capabilities and operational requirements. The objectives of this Conceptual Design were to develop conceptual plans and corresponding conceptual cost estimates for comparison and to ultimately inform the selection of one alternative for detailed design and implementation.

The progression of the selected alternatives from those that were identified as the most cost-effective in the WQFS to the Conceptual Design has significantly increased the detail included in the infrastructure, O&M costs, nuances of each technology, and conveyance features to route water from the reservoir and back to the Caloosahatchee River and eventually to the downstream estuary. Earthmoving quantities increased as the design refinements moved from two-dimensional sketches to three-dimensional design. It became apparent that pump stations would be required to move water from the perimeter canal to the WQC, which varies for each alternative in size, number, and location. Conveyance features have more specific detail based on elevation and higher flows. Roads and bridges were not included previously; however, as conveyance details were better defined, these features were added to ensure existing access routes would be maintained. A contingency of 20% was included in the cost.

Following SFWMD acceptance of the in-reservoir alum treatment system, J-Tech conducted additional analyses of the WQC options to optimize post-storage water quality and identified a new option (Option 5). Table 10-1 compares physical, economic, and cost-benefit attributes of the refined WQC options, as adjusted to account for the nutrient removal from the in-reservoir alum treatment. Option 1 (post-storage alum treatment) and Option 5 (sand filter) require the smallest land area and fit on parcel S-5, whereas the other options require both the S-4 and S-5 parcels. Option 3 (HWTT) has the lowest conceptual capital cost, followed by Option 1 (post-storage alum treatment). Option 5 (sand filter) and other media filtration WQCs (Options 2 and 4) have significantly lower O&M costs than the alum-based WQCs (Options 1 and 3). Option 1 (post-storage alum treatment) has the lowest 50-year unit cost for both TN and TP removal. Option 1 (post-storage alum) and Option 5 (sand filter) could be fully constructed by the projected timing of the first discharge season for the C-43 WBSR. In terms of the 50-year net present value, Option 5 (sand filter) has the lowest cost, followed by Option 3 (HWTT), Option 1 (post-storage alum treatment), Option 2 (sand filter with Bold and Gold®), and Option 4 (STA with Bold and Gold®).

It should be noted that the cost-benefits for the two options that include Bold and Gold® (Option 2 and Option 4) are based on nutrient removal performance estimates from the vendor, which are not consistent with the results from the SFWMD pilot study using C-43 basin water. Based on the findings of the pilot study, it does not appear that Bold and Gold® is an appropriate technology to treat Caloosahatchee River water, and SFWMD has recommended that this technology not be used in the WQC (see Appendix D).

Table 10-1. Summary of WQC Options Capital, O&M, and Net Present Value Costs

Option	Alternative	Area (ac)	Treatment and Conveyance Capital ($ millions)	Annual O&M ($ millions/ year)	Net Present Value 50-year ($ millions)	Unit Cost TN Removed (50-year)	Unit Cost TP Removed (50-year)	Unit Cost TSS Removed (50-year)	Benefits	Constraints
1	Post-storage Alum	16	$92	$5.1	$259	$15.22	$234.61	$5.51	Low cost, small area required, can treat S-471 and S-473 flow, meets schedule	High annual O&M
2	Sand Filter with Bold and Gold®	92 sand filter 124 Bold and Gold®	$422	$1.1	$460	$48.76	$289.74	$9.53	Moderate area, low O&M	High cost, may not meet schedule, Bold and Gold® reductions are based on performance data from the vendor
3	HWTT	292	$69	$4.0	$197	$61.18	$475.87	$10.19	Low capital cost, moderate-high annual O&M, meets schedule	Greater annual O&M
4	STA with Bold and Gold®	868 STA 99 Bold and Gold®	$421	$1.2	$460	$66.61	$293.88	$11.03	Meets schedule, low annual O&M	Greatest long-term cost, Bold and Gold® reductions are based on performance data from the vendor
5	Sand Filter	150	$130	$1.4	$175	$68.98	$505.82	$39.37	Lowest net present value cost, moderate capital cost, moderate area required, low annual O&M, can treat flow from S-471 and S-473, meets schedule	Relatively high unit costs

11.0 References

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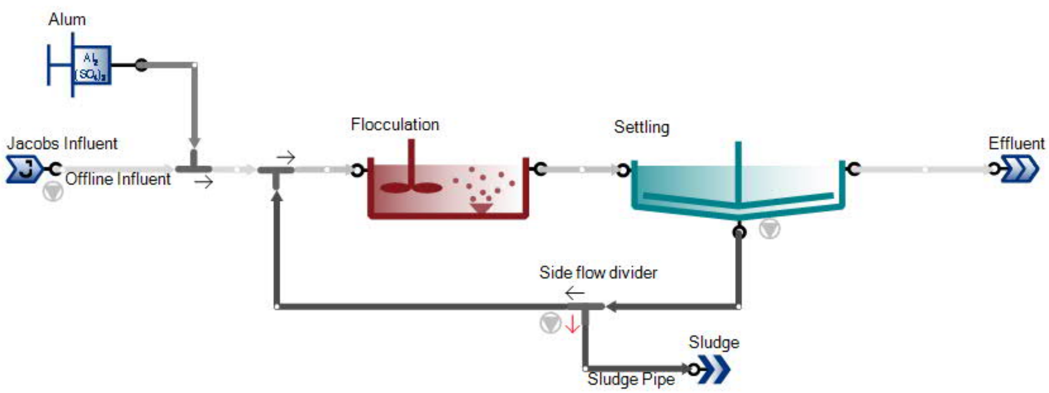
Appendix A. Sumo Model Report for Alum System

Project overview

File name:	C:\Users\bjohnso2\OneDrive - Jacobs\Documents\SFWMD Wetland\Offline Treatment Rev 2.sumo	
Report date:	Thursday, 24 June 2021 10:55:04	
Sumo version:	21.0.2	
Model:	Sumo1Alg	
Scenario:	default	
Model Options:	Other model: Sumo1Alg Input gas phase concentrations Calculate pH Precipitates are not considered	
Simulation from:	Hot start	
Stop time:	100	days
Data interval:	1	hours
Note to Reader	June 29 2021	

This version of the Sumo Model was prepared in response to reduced inflow concentrations expected based upon C-43 WBSR nutrient removal performance. Model results are presented as they are generated by the model; no attempt has been made to modify the format of the worksheets produced. All results are default formats for the program.



Project Notes

What to do here?
-Never lose your files again! Keep them attached to your project. Microsoft documents or any other files can be dragged and dropped to the note section.
-Adding schematics - copy and paste figures
-Write information regarding the project - it gets saved with it
----
Project name -
Start date of project -
Engineer name -
Engineer affiliation -
Utility -

Five Steps of Good Modeling Practice Protocol

PROJECT DEFINITION

DATA COLLECTION AND RECONCILIATION

PLANT MODEL SETUP

CALIBRATION AND VALIDATION

SIMULATION AND RESULTS INTERPRETATION

Modified parameters

Sumo1Alg - Key parameters

Symbol	Name	Value	Unit	Comment
iCV,XB	COD of biodegradable substrate in volatile solids	1.42	g COD.g VSS-1	

Sumo1Alg - HAO kinetics

Symbol	Name	Value	Unit	Comment
KP,HAO,BIND	Half-saturation of PO4 for binding on HAO	0.05	mg P/L	Based on Jar Test Fitting

Sumo1Alg - Conversion kinetics

Symbol	Name	Value	Unit	Comment
qFLOC	Rate of flocculation	1250	1/d	Based on Jar Test Calibration

Sumo1Alg - General stoichiometry

Symbol	Name	Value	Unit	Comment
iP,CB	P content of colloidal biodegradable substrate	0.001	g P.g COD-	previously 0.005
iP,CU	P content of colloidal unbiodegradable organics	0.001	g P.g COD-	previously 0.005
iP,SU	P content of soluble unbiodegradable organics	0.001	g P.g COD-1	
iCV,XB	COD of biodegradable substrate in volatile solids	1.42	g COD.g VSS-1	

Plantwide - Parameters

Symbol	Name	Value	Unit	Comment
DoseAl,molar	Aluminum Molar Dosage	40	moles Al/mole OP	

Jacobs Influent - Influent specifications

Symbol	Name	Value	Unit	Comment
Q	Flow rate	295	MGD	388 for 600 CFS, 295 for 457 CFS
TCOD	Total chemical oxygen demand	42.3	mg COD/L	Average concentration secondary effluent
TKN	Total Kjeldahl nitrogen (TKN)	1.3	mg N/L	Average concentration secondary effluent
TP	Total phosphorus	0.098	mg P/L	Average concentration secondary effluent

Jacobs Influent - pH and alkalinity

Symbol	Name	Value	Unit	Comment
SALK,input	Alkalinity (ALK)	150	mg CaCO3	Average concentration secondary effluent

Jacobs Influent - Influent fractions

Symbol	Name	Value	Unit	Comment
frVSS,TSS	Fraction of VSS/TSS	75	%	
frSCCOD,TCOD	Fraction of filtered COD (SCCOD, 1.5 µm, incl. colloids) in to	88.7	%	
frSCOD,TCOD	Fraction of flocculated filtered (SCOD, wo colloids) COD in t	71.7	%	
frVFA,SCCOD	Fraction of VFA in filtered COD (SCCOD, 1.5 µm, incl. colloid	0	%	
frSU,SCCOD	Fraction of soluble unbiodegradable organics (SU) in filtere	80	%	Fraction of filtered COD, not total COD!
frXU,TCOD	Fraction of particulate unbiodegradable organics (XU) in tot	4	%	
frXOHO,TCOD	Fraction of heterotrophs (OHO) in total COD	1	%	
frCU,CCOD	Fraction of colloidal unbiodegradable organics (CU) in collo	83	%	
frSNHx,TKN	Fraction of NHx in total Kjeldahl nitrogen (TKN)	1.5	%	
frSPO4,TP	Fraction of PO4 in total phosphorus (TP)	22.5	%	
frXALG,TCOD	Fraction of Algae in total COD	0.6	%	
frXCON,TCOD	Fraction of Consumers in total COD	0.3	%	

Jacobs Influent - Other influent constituents (usually zero)

Symbol	Name	Value	Unit	Comment
SO2	Influent DO (used if DO is modelled)	1	mg O2/L	
SMEOL	Methanol (MEOL)	0	mg COD/L	
XPHA	Stored polyhydroxyalkanoates (PHA)	0	mg COD/L	
XGLY	Stored glycogen (GLY)	0	mg COD/L	
XE,ana	Anaerobic endogenous decay products	0	mg COD/L	
XCASTO	Carbon storing organisms (CASTO)	0	mg COD/L	
XMEOLO	Anoxic methanol utilizers (MEOLO)	0	mg COD/L	
XNITO	Aerobic nitrifying organisms (NITO)	0	mg COD/L	
XAOB	Aerobic ammonia oxidizers (AOB)	0	mg COD/L	
XNOB	Nitrite oxidizers (NOB)	0	mg COD/L	
XAMX	Anammox organisms (AMX)	0	mg COD/L	
XAMETO	Acidoclastic methanogens (AMETO)	0	mg COD/L	
XHMETO	Hydrogenotrophic methanogens (HMETO)	0	mg COD/L	
SNOx	Nitrite + Nitrate (NOx)	0.02	mg N/L	
SNO2	Nitrite (NO2)	0	mg N/L	
SNO3	Nitrate (NO3)	0	mg N/L	
XPP	Stored polyphosphate (PP)	0	mg P/L	
SCH4	Dissolved methane (CH4)	0	mg COD/L	
SH2	Dissolved hydrogen (H2)	0	mg COD/L	
SFe3	Ferric ion (Fe3)	0	mg Fe/L	
SFe2	Ferrous ion (Fe2)	0	mg Fe/L	
SAl	Aluminium (Al)	0	mg Al/L	
XHFO,old	Aged unused hydrous ferric oxide (HFO,old)	0	mg Fe/L	
XHFO,H,P	P-bound hydrous ferric oxide, high surface (HFO,H,P)	0	mg Fe/L	
XHFO,L,P	P-bound hydrous ferric oxide, low surface (HFO,L,P)	0	mg Fe/L	
XHFO,H,P,old	Aged used hydrous ferric oxide, high surface (HFO,H,P,old)	0	mg Fe/L	
XHFO,L,P,old	Aged used hydrous ferric oxide, low surface (HFO,L,P,old)	0	mg Fe/L	
XHAO,old	Aged unused hydrous aluminium oxide (HAO,old)	0	mg Al/L	
XHAO,H,P	P-bound hydrous aluminium oxide, high surface (HAO,H,P)	0	mg Al/L	
XHAO,L,P	P-bound hydrous aluminium oxide, low surface (HAO,L,P)	0	mg Al/L	
XHAO,H,P,old	Aged P-bound hydrous aluminium oxide, high surface (HAO	0	mg Al/L	
XHAO,L,P,old	Aged P-bound hydrous aluminium oxide, low surface (HAO,	0	mg Al/L	

Jacobs Influent - Mixing - precipitation parameters

Symbol	Name	Value	Unit	Comment
G	Average velocity gradient in mixing tank	20	1/s	

Alum - Dose specification

Symbol	Name	Value	Unit	Comment
G	Average velocity gradient at dosage point	400	1/s	

Flocculation - Reactor settings

Symbol	Name	Value	Unit	Comment
Ntrain	Number of trains	2		
L.Vtrain	Volume per train	3.08	MG	
htank	Tank depth	10	ft	

Flocculation - Aeration settings

Symbol	Name	Value	Unit	Comment
Qair,NTP	Air flow @ standard conditions (NTP: 20 °C, 1 atm)	0	scfm	

Settling - Process settings

Symbol	Name	Value	Unit	Comment
Ntrain	Number of trains	2		
Atrain	Surface area per train	342816.825	ft2	
haverage	Depth	10	ft	
hinp	Depth of influent layer from top	5	ft	
Qsludge,targe	Sludge flow	1	MGD	

Settling - Settling parameters

Symbol	Name	Value	Unit	Comment
vbnd	Boundary settling velocity	11.25	m/h	Large flocs: max velocity
vmax	Maximum Vesilind settling velocity (v0)	20	m/h	Based on Jar Testing
rhin	Coefficient for hindered settling	0.3	L/g	Impacts blanket height
rfloc	Coefficient for flocculent settling	20	L/g	Impacts effluent solids
compron	Boundary compression concentration	5000	mg/L	Compression starts above this value
XTSS,min,max	Non-settleable TSS	1	mg/L	Minimum of two ("fraction of non-settleable solids" and "Non settleable TSS" are used

Settling - Layer number

Symbol	Name	Value	Unit	Comment
n	Number of layers	5		

Side flow divider - Flow divider parameters

Symbol	Name	Value	Unit	Comment
fr1_Q	Flow fraction to pumped	30	%	

Flows

Symbol	Jacobs Influent	Settling Sludge	Sludge	Unit
Flow rate	295	1	0.3	MGD

Performance

Symbol	Flocculation	Effluent	Settling Sludge	Unit
Total suspended solids (TSS)	35.42243789	3.206423182	9658.656222	mg TSS/L
Dissolved oxygen (O2)	1.272180897	1.272181271	1.272182175	mg O2/L
pH	6.995035627	6.99503516	6.995035807	pHunit
Total nitrogen	2.934053483	0.599707003	700.2323426	mg N/L
Total ammonia (NHx)	0.020454502	0.0204545	0.020453952	mg N/L
Nitrate and nitrite (NOx)	0.018716176	0.018716179	0.018716635	mg N/L
Total phosphorus	0.204339439	0.050330338	46.2084418	mg P/L
Orthophosphate (PO4)	0.001960679	0.00196068	0.001960578	mg P/L
Total HAOs	2.08117828	0.188387302	567.4745338	mg Al/L

Alum

Symbol	Jacobs Influent	Alum	Plant	Unit
Orthophosphate (PO4) mass flow	54.28476961	0		lbs/d
Orthophosphate (PO4) molar flow	794.9682426			mol P/d
Orthophosphate (PO4)	0.02205	0		mg P/L
Molar Rate Of Aluminum		31798.7297	31798.7297	moles.d-1
TP/Al Molar Dosage			9	Moles Al/Mole TP
Aluminum Molar Dosage			40	moles Al/mole OP
Aluminum Dosage			0.768317483	mg/L
Alum Dosage			4.871494196	g Alum.m-3
Flow rate	295000000	4075128.913		gpd

Flocculation

Symbol	Flocculation	Effluent	Settling	Unit
Total nitrogen	2.934053483	0.599707003		mg N/L
Total Kjeldahl nitrogen (TKN)	2.915337307	0.580990823		mg N/L
Nitrate and nitrite (NOx)	0.018716176	0.018716179		mg N/L
Total ammonia (NHx)	0.020454502	0.0204545		mg N/L
Soluble biodegradable organic N (from SB)	0.032127575	0.032127559		mg N/L
Particulate biodegradable organic N (from XB)	2.196040084	0.198784567		mg N/L
Particulate unbiodegradable organic N	0.207497416	0.018782572		mg N/L
Filtered chemical oxygen demand	29.99456415	29.99456405		mg COD/L
Filtered flocculated chemical oxygen demand	29.99426007	29.99425996		mg COD/L
Rate of flocculation (temperature corrected)	1250			1/d
COD of all biomasses	2.127018375	0.192536774		mg COD/L
Total HAOs	2.08117828	0.188387302		mg Al/L
Surface overflow rate (SOR)			435.7649729	gpd/ft2
Solids loading rate (SLR)			0.129249631	lbs/d/ft2

Settling

Symbol	Flocculation	Settling #1	Settling #2	Settling #3	Settling #4	Settling #5	Settling	Unit
Total suspended solids (TSS)	35.42243789	3.20642	5.82854	11.6887	11.6887	9658.66		mg TSS/L
Settling velocity		712.7108655	1268.340649	2408.003118	2408.003118	63.2611883		gpd/ft2
Boundary settling velocity							6626.444	gpd/ft2
Maximum Vesilind settling velocity (v0)							11780.34	gpd/ft2
Corrected TSS concentration above minimum		3.171	5.79312	11.6533	11.6533	9658.62		mg TSS/L
Hydraulic loading rate (HLR)							0.303627	gpm/ft2

Sludge

Symbol	Sludge	Sludge Pipe	Unit
Total suspended solids (TSS)	9658.656222	9658.656222	mg TSS/L
Total suspended solids (TSS) mass flow	24181.61779	24181.61779	lbs/d
Flow rate	0.3	0.3	MGD

Model overview

Name: Sumo1Alg

Settings

Key parameters

Symbol	Name	Value	Unit	Comment
iCV,XB	COD of biodegradable substrate in volatile solids	1.42	g COD.g VSS-1	
iCV,XU	COD of particulate unbiodegradable organics in volatile solids	1.3	g COD.g VSS-1	
iCV,BIO	COD of biomass in volatile solids	1.42	g COD.g VSS-1	
iCV,XE	COD of endogenous products in volatile solids	1.42	g COD.g VSS-1	
µNITO	Maximum specific growth rate of NITOs	0.9	1/d	
KO2,NITO,AS	Half-saturation of O2 for NITOs (AS)	0.25	mg O2/L	
KNHx,NITO,AS	Half-saturation of NHx for NITOs (AS)	0.7	mg N/L	
µOHO	Maximum specific growth rate of OHOs	4	1/d	
KSB,AS	Half-saturation of readily biodegradable substrate for OHOs (AS)	5	mg COD/L	
KO2,OHO,AS	Half-saturation of O2 for OHOs (AS)	0.15	mg O2/L	
µCASTO	Maximum specific growth rate of CASTOs	1	1/d	
qPAO,PP	Maximum polyphosphate uptake rate of PAOs	0.1	1/d	
KPO4,PAO,AS	Half-saturation of PO4 for PAOs (AS)	0.3	mg P/L	
qHYD	Rate of hydrolysis	2	1/d	

Ordinary heterotrophic organism kinetics (OHO)

Symbol	Name	Value	Unit	Comment
µOHO	Maximum specific growth rate of OHOs	4	1/d	
µFERM,OHO	Fermentation growth rate of OHOs	0.3	1/d	
bOHO	Decay rate of OHOs	0.62	1/d	
ηOHO,anox	Reduction factor for anoxic growth of OHOs	0.6		
KSB,AS	Half-saturation of readily biodegradable substrate for OHOs (AS)	5	mg COD/L	
KO2,OHO,AS	Half-saturation of O2 for OHOs (AS)	0.15	mg O2/L	
KVFA,AS	Half-saturation of VFA for OHOs (AS)	0.5	mg COD/L	
KMEOL,OHO,AS	Half-saturation of methanol for OHOs (AS)	0.1	mg COD/L	
KNOx,OHO,AS	Half-saturation of NOx for OHOs (AS)	0.03	mg N/L	
KVFA,FERM,AS	Half-saturation of VFA in fermentation of OHOs (AS)	50	mg COD/L	
LograngeVFA,FERM,AS	Effective range of logistic switch for VFA fermentation by OHOs (AS)	0.012		define range in percentage of half-saturation value
KSB,ana,AS	Half-saturation of readily biodegradable substrate in fermentation by OHOs in mainstream (AS)	5	mg COD/L	
KSB,ana,DIG	Half-saturation of readily biodegradable substrate in fermentation by OHOs in digester	350	mg COD/L	

Anoxic methanol utilizer kinetics (MEOLO)

Symbol	Name	Value	Unit	Comment
µMEOLO	Maximum specific growth rate of MEOLOs	1.3	1/d	
bMEOLO	Decay rate of MEOLOs	0.05	1/d	
qMEOL	Rate of methanol degradation by MEOLOs under anaerobic conditions	10	1/d	to clean up any remaining methanol in digesters without having to ferment mechanistically
KMEOL,AS	Half-saturation of methanol for MEOLOs (AS)	0.5	mg COD/L	
KiO2,MEOLO,AS	Half-inhibition of O2 for MEOLOs (AS)	0.05	mg O2/L	
KNOx,MEOLO,AS	Half-saturation of NOx for MEOLOs (AS)	0.03	mg N/L	

Carbon storing organism kinetics (CASTO)

Symbol	Name	Value	Unit	Comment
µCASTO	Maximum specific growth rate of CASTOs	1	1/d	
qPAO,PP	Maximum polyphosphate uptake rate of PAOs	0.1	1/d	
µFERM,PAO	Fermentation growth rate of PAOs	0.45	1/d	
µPAO,lim	Maximum specific growth rate of PAOs under P limited	0.49	1/d	
bCASTO	Decay rate of CASTOs	0.08	1/d	previously 0.05 (0.15 for Lopez et al. 2006; Hao et al., 2010)
bSTC	Rate of CASTOs maintenance on PHA and GLY	0.07	1/d	
bPP,ana	Rate of PAOs maintenance under anaerobic conditions (PP cleavage)	0.005	1/d	
qPAO,PHA	Rate of VFA storage into PHA for PAOs	7	1/d	
qGAO,GLY	Rate of VFA storage into glycogen for GAOs	4	1/d	
ηCASTO,anox	Reduction factor for anoxic growth of CASTOs	0.66		
ηbCASTO,anox	Reduction factor for anoxic decay of CASTOs	0.5		
ηbCASTO,ana	Reduction factor for anaerobic decay of CASTOs	0.25		
ηbSTC,anox	Reduction factor for anoxic maintenance of CASTOs on PHA and GLY	0.66		
ηbPP,aer	Reduction factor for aerobic maintenance of PAOs on PP	0.25		
ηbPP,anox	Reduction factor for anoxic maintenance of PAOs on PP	0.5		
KPO4,PAO,AS	Half-saturation of PO4 for PAOs (AS)	0.3	mg P/L	
LograngePO4,PAO,AS,sat	Effective range of logistic switch for PO4 uptake by PAOs	1		define range in percentage of half-saturation value
LograngePP,PAO,AS,sat	Effective range of logistic switch for PP cleavage by PAOs	0.4		define range in percentage of half-saturation value
KPHA,cle	Half-saturation of PHA for PAOs at PP cleavage	0.1	g COD.g COD-1	
KPHA	Half-saturation of PHA for PAOs	0.01	g COD.g COD-1	
KSTC	Half-saturation of PHA and GLY for PAOs	0.1	g COD.g COD-1	
KO2,CASTO,AS	Half-saturation of O2 for CASTOs (AS)	0.05	mg O2/L	
KNOx,CASTO,AS	Half-saturation of NOx for CASTOs (AS)	0.03	mg N/L	
KVFA,CASTO,AS	Half-saturation of VFA storage for CASTOs (AS)	5	mg COD/L	
KPP	Half-saturation of PP for PAOs	0.01	g COD.g COD-1	
KiPP,PAO,max	Half-inhibition of maximum PP content of PAOs	0.35	g P.g COD-1	
LograngePP,PAO,inh	Effective range of logistic switch for PP/PAO inhibition term	0.17		define range in percentage of half-inhibition value
XPP,PAO,min	PAO PP uptake booster denominator limiting term	0.1	mg COD/L	
KiPHA,PAO,max	Half-inhibition of maximum PHA content of PAOs	0.6	g COD.g COD-1	
LograngePHA,PAO,inh	Effective range of logistic switch for PHA/PAO inhibition term	0.1		define range in percentage of half-inhibition value
KMg,PAO,AS	Half-saturation of Mg (counter-ion in PP storage) for PAOs (AS)	0.001	mg Mg/L	
KK,PAO,AS	Half-saturation of K (counter-ion in PP storage) for PAOs (AS)	0.001	mg K/L	
KCa,PAO,AS	Half-saturation of Ca (counter-ion in PP storage) for PAOs (AS)	0.001	mg Ca/L	
KPP,lim	Half-saturation of PP (nutrient) for PAOs under PO4 limitation (AS)	0.002	mg P/L	
KiPO4,lim,AS	Half-inhibition of PO4 for PAOs under PO4 limitation (AS)	0.005	mg P/L	
LogsatORP,PAO,Half	Logistic half-saturation of ORP switching in fermentation of PAO	-170	mV	previously -100
LogsatORP,PAO,Slope	Logistic slope of ORP switching in fermentation of PAO	0.1	mV-1	
ηbGLY,ana	Reduction factor for anaerobic maintenance of GAOs on glycogen	0.1		
KGLY	Half-saturation of glycogen for GAOs (AS)	0.05	g COD.g COD-1	
KiGLY,GAO,max	Half-inhibition of maximum glycogen content of GAOs (AS)	0.5	g COD.g COD-1	
LograngeGLY,GAO,inh	Effective range of logistic switch for GLY/GAO inhibition term	0.12		define range in percentage of half-inhibition value
LogsatORP,GAO,Half,15	Half-value of ORP switch of glycogen storage by GAO at 15°C / 59°F	-30	mV	
LogsatORP,GAO,Half,25	Half-value of ORP switch of glycogen storage by GAO at 25°C / 77°F	-110	mV	
LogsatORP,GAO,Slope	Logistic slope of ORP switching of GAOs	0.035	mV-1	

Aerobic nitrifying organism kinetics (NITO)

Symbol	Name	Value	Unit	Comment
µNITO	Maximum specific growth rate of NITOs	0.9	1/d	
bNITO	Decay rate of NITOs	0.17	1/d	
KNHx,NITO,AS	Half-saturation of NHx for NITOs (AS)	0.7	mg N/L	
KCO2,NITO,AS	Half-saturation of CO2 for NITOs (AS)	12	mg TIC/L	if pH is not calculated
LograngeCO2,NITO,AS	Effective range of CO2 logistic switch for NITOs (AS)	2		define range in percentage of half-saturation value
KCO2,NITO,sidestream	Half-saturation of CO2 for NITOs (Sidestream)	48	mg TIC/L	if pH is not calculated
LograngeCO2,NITO,sidestream	Effective range of CO2 logistic switch for NITOs (Sidestream)	1.05		define range in percentage of half-saturation value
KCO2,NITO,pH,AS	Half-saturation of bicarbonate for NITOs (AS)	1	mmol [HCO3-]/L	if pH is calculated
LograngeCO2,NITO,pH,AS	Effective range of bicarbonate logistic switch for NITOs (AS)	1.2		define range in percentage of half-saturation value
KCO2,NITO,pH,sidestream	Half-saturation of bicarbonate for NITOs (Sidestream)	4	mmol [HCO3-]/L	if pH is calculated
LograngeCO2,NITO,pH,sidestream	Effective range of bicarbonate logistic switch for NITOs (Sidestream)	0.3		define range in percentage of half-saturation value
KO2,NITO,AS	Half-saturation of O2 for NITOs (AS)	0.25	mg O2/L	
KO2,NITO,sidestream	Half-saturation of O2 for NITOs (Sidestream)	0.5	mg O2/L	
KNOx,NITO,AS	Half-saturation of NOx for NITOs (AS)	0.03	mg N/L	
KiNH3,NITO,pH,AS	Half-inhibition of NH3 for NITOs (AS)	9999	mol [NH3].L-1	if pH is calculated

Acidoclastic methanogen kinetics (AMETO)

Symbol	Name	Value	Unit	Comment
µAMETO	Maximum specific growth rate of AMETO	0.3	1/d	
bAMETO	Decay rate of AMETOs	0.03	1/d	
KVFA,AMETO,AS	Half-saturation of VFA for AMETOs (AS)	400	mg COD/L	Non-pH
KiVFA,AMETO,AS	Haldane inhibition of VFA for AMETOs (AS)	99999	mg COD/L	Non-pH
KiO2,AMETO,AS	Half-inhibition of O2 for AMETOs (AS)	0.05	mg O2/L	
KNOx,AMETO,AS	Half-saturation of NOx for AMETOs (AS)	0.05	mg N/L	
pHlow,AMETO	pH inhibition low value for AMETOs	4.5	pHunit	
pHhigh,AMETO	pH inhibition high value for AMETOs	9.5	pHunit	

Hydrogenotrophic methanogen kinetics (HMETO)

Symbol	Name	Value	Unit	Comment
µHMETO	Maximum specific growth rate of HMETO	1.3	1/d	
bHMETO	Decay rate of HMETOs	0.13	1/d	
KH2,HMETO,AS	Half-saturation of H2 for HMETOs (AS)	0.1	mg COD/L	
KiO2,HMETO,AS	Half-inhibition of O2 for HMETOs (AS)	0.05	mg O2/L	
KNOx,HMETO,AS	Half-saturation of NOx for HMETOs (AS)	0.05	mg N/L	
pHlow,HMETO	pH inhibition low value for HMETOs	4.5	pHunit	
pHhigh,HMETO	pH inhibition high value for HMETOs	9.5	pHunit	

Precipitation kinetics

Symbol	Name	Value	Unit	Comment
qCaCO3,PREC	Rate of CaCO3 precipitation	0.1	mg/L/d	
qCaCO3,DISS	Rate of CaCO3 dissolution	0.1	mg/L/d	
qSTR,PREC	Rate of struvite precipitation	10	mg/L/d	
qSTR,DISS	Rate of struvite dissolution	10	mg/L/d	
qACP,PREC	Rate of ACP precipitation	5	mg/L/d	
qACP,DISS	Rate of ACP dissolution	5	mg/L/d	
qBSH,PREC	Rate of brushite precipitation	500	mg/L/d	
qBSH,DISS	Rate of brushite dissolution	500	mg/L/d	
qVivi,PREC	Rate of vivianite precipitation	0.01	mg/L/d	
qVivi,DISS	Rate of vivianite dissolution	0.01	mg/L/d	
KSTR,DISS	Half-saturation of struvite redissolution	0.01	mg TSS/L	
KACP,DISS	Half-saturation of ACP redissolution	0.01	mg TSS/L	
KBSH,DISS	Half-saturation of brushite redissolution	0.01	mg TSS/L	
KCaCO3,DISS	Half-saturation of CaCO3 redissolution	0.01	mg TSS/L	
KVivi,DISS	Half-saturation of vivianite redissolution	0.01	mg TSS/L	

HFO kinetics

Symbol	Name	Value	Unit	Comment
qHFOH,AGING	Rate of XHFO,H aging	250	1/d	
qHFOL,AGING	Rate of XHFO,L aging	1	1/d	
qP,HFO,COPREC	Rate of P binding and coprecipitation on XHFO,H	150	1/d	
qP,HFO,BIND	Rate of P binding on XHFO,L	1	1/d	
qHFOH,DESORP	Rate of XHFO,H,P desorption	100	1/d	
qHFOL,DESORP	Rate of XHFO,L,P desorption	10	1/d	
qHFO,DISS	Rate of XHFO,H,P,old and XHFO,L,P,old redissolution	100	1/d	
qHFO,RED	Rate of HFO reduction with organics	2	1/d	
LogsatORP,HFO,Half	Logistic half-saturation of ORP switching in HFO reduction	-100	mV	
LogsatORP,HFO,Slope	Logistic slope of ORP switching in HFO reduction	0.1		
qFe2,OX	Rate of Fe2 oxidation	1	1/d	
KiP,HFO,DISS	Half-inhibition of PO4 in HFO redissolution	0.01	mg P/L	
LograngeP,HFO,DISS	Effective range of logistic switch for HFO redissolution	1.2		define range in percentage of half-inhibition value
KiP,HFO,DESORP	Half-inhibition of PO4 in HFO desorption	0.1	mg P/L	
KP,HFO,BIND	Half-saturation of PO4 in binding on HFO	0.1	mg P/L	

HAO kinetics

Symbol	Name	Value	Unit	Comment
KP,HAO,BIND	Half-saturation of PO4 for binding on HAO	0.05	mg P/L	Based on Jar Test Fitting
qHAOH,AGING	Rate of XHAO,H aging	75	1/d	
qHAOL,AGING	Rate of XHAO,L aging	1	1/d	
qP,HAO,COPREC	Rate of P binding and coprecipitation on XHAO,H	175	1/d	
qP,HAO,BIND	Rate of P binding on XHAO,L	1	1/d	
qHAOH,DESORP	Rate of XHAO,H,P desorption	100	1/d	
qHAOL,DESORP	Rate of XHAO,L,P desorption	10	1/d	
qHAO,DISS	Rate of XHAO,H,P,old and XHAO,L,P,old redissolution	100	1/d	
KiP,HAO,DISS	Half-inhibition of PO4 in HAO redissolution	0.001	mg P/L	
LograngeP,HAO,DISS	Effective range of logistic switch for HAO redissolution	2		define range in percentage of half-inhibition value
KiP,HAO,DESORP	Half-inhibition of PO4 in HAO desorption	0.1	mg P/L	

Common switches

Symbol	Name	Value	Unit	Comment
KNHx,BIO,AS	Half-saturation of NHx as nutrient for biomasses (AS)	0.005	mg N/L	
KPO4,BIO,AS	Half-saturation of PO4 as nutrient for biomasses (AS)	0.002	mg P/L	
KCO2,BIO,AS	Half-saturation of CO2 for biomasses (except NITOs)	1.2	mg TIC/L	
KCAT,AS	Half-saturation of strong cations (as Na+)	0.1	mg Na/L	
KAN,AS	Half-saturation of strong anions (as Cl-)	0.1	mg Cl/L	
KMg,BIO,AS	Half-saturation of Mg for biomasses (AS)	0.0001	mg Mg/L	
KCa,BIO,AS	Half-saturation of Ca for biomasses (AS)	0.0001	mg Ca/L	
ηb,anox	Reduction factor for anoxic decay	0.5		
ηb,ana	Reduction factor for anaerobic decay	0.25		
mtox,anox	Toxicity factor of anaerobes under anoxic conditions	5		
mtox,aer	Toxicity factor of anaerobes under aerobic conditions	10		
mtox,ana,max	Toxicity factor of aerobes under anaerobic conditions (maximum)	10		
pHlow	pH inhibition low value	3	pHunit	
pHhigh	pH inhibition high value	11	pHunit	

Conversion kinetics

Symbol	Name	Value	Unit	Comment
qFLOC	Rate of flocculation	1250	1/d	Based on Jar Test Calibration
qHYD	Rate of hydrolysis	2	1/d	
ηHYD,anox	Reduction factor for anoxic hydrolysis	0.5		
ηHYD,ana	Reduction factor for anaerobic hydrolysis	0.5		
KFLOC,AS	Half-saturation of colloids in flocculation (AS)	0.001	g COD.g COD-1	
KHYD,AS	Half-saturation of particulates in hydrolysis (AS)	0.05	g COD.g COD-1	
qAMMON	Rate of ammonification	0.05	1/d	
qSPB	Rate of soluble biodegradable organic P conversion	0.5	1/d	
qXE	Rate of endogenous decay products conversion	0.007	1/d	
qASSIM	Rate of assimilative nutrient production	1	1/d	
KiNHx,ASSIM,AS	Half-inhibition of NHx in NOx assimilative reduction	0.0005	mg N/L	
KNOx,ASSIM,AS	Half-saturation of NOx in NOx assimilative reduction (AS)	0.001	mg N/L	

Parameters for half saturation coefficients in biofilms

Symbol	Name	Value	Unit	Comment
fKS,biofilm	Diffusion factor for half-saturation coefficients	0.4		

Temperature dependency

Symbol	Name	Value	Unit	Comment
θμ,OHO	Arrhenius coefficient for OHO growth	1.04		
θFERM,OHO	Arrhenius coefficient for fermentation (OHO)	1.04		
θb,OHO	Arrhenius coefficient for OHO decay	1.03		
θμ,MEOLO	Arrhenius coefficient for MEOLO growth	1.06		
θb,MEOLO	Arrhenius coefficient for MEOLO decay	1.03		
θμ,CASTO	Arrhenius coefficient for CASTO growth	1.04		
θμ,PAO,lim	Arrhenius coefficient for PAO growth (P limited)	1.04		
θFERM,PAO	Arrhenius coefficient for fermentation (PAO)	1.04		
θq,PAO,PP	Arrhenius coefficient for PP storage	1.04		
θq,PAO,PHA	Arrhenius coefficient for PHA storage	1.04		
θb,CASTO	Arrhenius coefficient for CASTO decay	1.03		
θb,STC	Arrhenius coefficient for PHA and GLY storage use for maintenance	1.064		based on Lopez Vazquez et al., 2009
θb,PP,ana	Arrhenius coefficient for anaerobic PP storage	1.03		
θq,GAO,GLY	Arrhenius coefficient for GLY storage	1.072		
θμ,NITO	Arrhenius coefficient for NITO growth	1.072		
θb,NITO	Arrhenius coefficient for NITO decay	1.03		
θμ,AMETO	Arrhenius coefficient for AMETO growth	1.03		
θb,AMETO	Arrhenius coefficient for AMETO decay	1.03		
θμ,HMETO	Arrhenius coefficient for HMETO growth	1.03		
θb,HMETO	Arrhenius coefficient for HMETO decay	1.03		
θq,FLOC	Arrhenius coefficient for flocculation	1.03		
θq,HYD	Arrhenius coefficient for hydrolysis	1.03		
θq,AMMON	Arrhenius coefficient for ammonification	1.03		
θq,SPB	Arrhenius coefficient for PO4 conversion	1.03		
θq,XE	Arrhenius coefficient endogenous residual conversion	1.03		
θq,ASSIM	Arrhenius coefficient assimilative kinetics	1.03		
θq,Fe2,OX	Arrhenius coefficient for ferrous iron oxidation kinetics	1.04		
θq,HFO,RED	Arrhenius coefficient for ferric iron reduction kinetics	1.04		
Tbase	Arrhenius base temperature	20	Co	

Stoichiometric yields

Symbol	Name	Value	Unit	Comment
YOHO,VFA,ox	Yield of OHOs on VFA under aerobic conditions	0.6	g XOHO.g SVFA-1	
YOHO,VFA,anox	Yield of OHOs on VFA under anoxic conditions	0.45	g XOHO.g SVFA-1	
YOHO,SB,ox	Yield of OHOs on readily biodegradable substrate under aerobic conditions	0.67	g XOHO.g SB-1	
YOHO,SB,anox	Yield of OHOs on readily biodegradable substrate under anoxic conditions	0.54	g XOHO.g SB-1	
YOHO,SB,ana	Yield of OHOs on readily biodegradable substrate under anaerobic conditions	0.1	g XOHO.g SB-1	
YOHO,H2,ana,high	Yield of H2 production in fermentation with high VFA concentration (OHO)	0.35	g SH2.g SB-1	
YOHO,H2,ana,low	Yield of H2 production in fermentation with low VFA concentration (OHO)	0.1	g SH2.g SB-1	
YOHO,SMEOL,ox	Yield of OHOs on methanol under aerobic conditions	0.4	g XOHO.g SMEOL-1	
YMEOLO	Yield of MEOLOs on methanol	0.4	g XMEOLO.g SMEOL-1	
YCASTO,PHA,ox	Yield of CASTOs on PHA under aerobic conditions	0.639	g XCASTO.g XPHA-1	
YCASTO,PHA,anox	Yield of CASTOs on PHA under anoxic conditions	0.52	g XCASTO.g XPHA-1	
YCASTO,SB,ana	Yield of CASTOs on readily biodegradable substrate under anaerobic conditions	0.1	g XCASTO.g SB-1	
YCASTO,H2,ana,high	Yield of H2 production in fermentation with high VFA concentration (CASTO)	0.35	g SH2.g SB-1	
YCASTO,H2,ana,low	Yield of H2 production in fermentation with low VFA concentration (CASTO)	0.1	g SH2.g SB-1	
YPP,CASTO,ox	Yield of CASTOs consumed per PP uptake under aerobic conditions	0.33	g XCASTO.g XPP-1	
YPP,CASTO,anox	Yield of CASTOs consumed per PP uptake under anoxic conditions	0.23	g XCASTO.g XPP-1	
fP,VFA	Ratio of P released per VFA stored	0.65	g XPP.g SVFA-1	
iTSS,PP	TSS content of PP	3.516129032	g XTSS.g XPP-1	
YCASTO,GLY,ox	Yield of CASTOs on glycogen under aerobic conditions	0.6	g XCASTO.g XGLY-1	
YCASTO,GLY,anox	Yield of CASTOs on glycogen under anoxic conditions	0.5	g XCASTO.g XGLY-1	
YNITO	Yield of NITOs on NHx	0.24	g XNITO.g SNHx-1	
YAMETO	Yield of AMETOs on VFA	0.1	g XAMETO.g SVFA-1	
YHMETO	Yield of HMETOs on H2	0.1	g XHMETO.g SH2-1	

General stoichiometry

Symbol	Name	Value	Unit	Comment
iP,CB	P content of colloidal biodegradable substrate	0.001	g P.g COD-1	previously 0.005
iP,CU	P content of colloidal unbiodegradable organics	0.001	g P.g COD-1	previously 0.005
iP,SU	P content of soluble unbiodegradable organics	0.001	g P.g COD-1	
iCV,XB	COD of biodegradable substrate in volatile solids	1.42	g COD.g VSS-1	
fE	Fraction of endogenous products produced in biomass decay	0.08	g XE.g XBIO-1	
iN,BIO	N content of biomasses	0.07	g N.g COD-1	
iN,XE	N content of endogenous products	0.06	g N.g COD-1	
iN,CB	N content of colloidal biodegradable substrate	0.01	g N.g COD-1	previously 0.03
iN,CU	N content of colloidal unbiodegradable organics	0.01	g N.g COD-1	
iN,SU	N content of soluble unbiodegradable organics	0.01	g N.g COD-1	previously 0.05
iN,XSTR	N content of struvite	0.057075505	g N.g TSS-1	A_MN/M_MSTR
iP,BIO	P content of biomasses	0.02	g P.g COD-1	
iP,XSTR	P content of struvite	0.126214106	g P.g TSS-1	A_MP/M_MSTR
iP,XACP	P content of ACP	0.162065388	g P.g TSS-1	2*A_MP/M_MACP
iP,XBSH	P content of BSH	0.17998807	g P.g TSS-1	2*A_MP/M_MACP
iP,XVivi	P content of vivianite	0.123499858	g P.g TSS-1	2*A_MP/M_MVivi
iCV,XU	COD of particulate unbiodegradable organics in volatile solids	1.3	g COD.g VSS-1	
iCV,BIO	COD of biomass in volatile solids	1.42	g COD.g VSS-1	
iCV,XE	COD of endogenous products in volatile solids	1.42	g COD.g VSS-1	
iCV,VFA	COD of VFA in volatile solids	1.066	g COD.g VS-1	
iCV,SB	COD of readily biodegradable substrate in volatile solids	1.066	g COD.g VS-1	
iCV,MEOL	COD of methanol in volatile solids	1.5	g COD.g VS-1	
iCV,SU	COD of soluble unbiodegradable organics in volatile solids	0.926	g COD.g VS-1	
iCV,CB	COD of colloidal biodegradable substrate in volatile solids	1.8	g COD.g VS-1	
iCV,CU	COD of colloidal unbiodegradable organics in volatile solids	1.3	g COD.g VS-1	
iCV,PHA	COD of PHA in volatile solids	1.67	g COD.g VSS-1	
iCV,GLY	COD of glycogen in volatile solids	1.19	g COD.g VSS-1	
iCIT,BIO	Inorganic carbon content of biomass	0.352	g TIC.g COD-1	C5H7O2N: 32 g COD/mol C
iCIT,SB	Inorganic carbon content of SB and SU	0.286	g TIC.g COD-1	C5H7O2N: 32 g COD/mol C
iCIT,MEOL	Inorganic carbon content of methanol	0.25	g TIC.g COD-1	CH4O: 48 g COD/mol C
iCIT,CH4	Inorganic carbon content of CH4	0.188	g TIC.g COD-1	CH4: 64 g COD/mol C
iCIT,VFA	Inorganic carbon content of VFA	0.375	g TIC.g COD-1	C2H4O2: 32 g COD/mol C
iCIT,PHA	Inorganic carbon content of PHA	0.333	g TIC.g COD-1	H[C4H6O2]nOH: 36 g COD/mol C
iCIT,GLY	Inorganic carbon content of glycogen	0.375	g TIC.g COD-1	[C6H10O5]n: 32 g COD/mol C
iINORG	Inorganic content of biomass	0.11	g TSS.g COD-1	15% of VSS - Ekama
iCa,PP	Calcium content of PP	0.1	mol Ca.mol P-1	sum of the charges of Ca, Mg and K content of PP…
iMg,PP	Magnesium content of PP	0.35	mol Mg.mol P-1	…should be equal to 1…
iK,PP	Potassium content of PP	0.1	mol K.mol P-1	…e.g.: 2*0.1 + 2*0.35 + 1*0.1=1
fNa	Fraction of Na in NaCl	0.393372343	g Na.g NaCl-1	
iCa,INORG	Ca content of XINORG	0.05	g Ca.g TSS-1	
iMg,INORG	Mg content of XINORG	0.05	g Mg.g TSS-1	
fVFA,DM	fraction of SVFA not volatilized in Dry Matter analysis	50	%	

BOD stoichiometry

Symbol	Name	Value	Unit	Comment
YBOD,ult	Yield on ultimate BOD	0.95	g O2.g COD-1	
fS,BOD5,BODult	Fraction of BOD5 to ultimate BOD in soluble biodegradable substrates	0.9		
fC,BOD5,BODult	Fraction of BOD5 to ultimate BOD in colloidal biodegradable substrates	0.6		
fX,BOD5,BODult	Fraction of BOD5 to ultimate BOD in particulate biodegradable substrates	0.5		

HFO stoichiometry

Symbol	Name	Value	Unit	Comment
ASFHFO,H	Active site factor for HFO,H	1.2	mol P.mol Fe-1	
ASFHFO,L	Active site factor for HFO,L	0.2	mol P.mol Fe-1	
fH2O,HFO,TSS	Fraction of H2O loss in TSS test for HFO	0.0829	g H2O.g FeOH-1	
fH2O,HFO,VSS	Fraction of H2O loss in VSS test for HFO	0.17	g H2O.g FeOH-1	Me(OH)3 -> Me2O3 + 3H2O

HAO stoichiometry

Symbol	Name	Value	Unit	Comment
ASFHAO,H	Active site factor for HAO,H	1	mol P.mol Al-1	
ASFHAO,L	Active site factor for HAO,L	0.1	mol P.mol Al-1	
fH2O,HAO,TSS	Fraction of H2O loss in TSS test for HAO	0.173216029	g H2O.g AlOH3-1	
fH2O,HAO,VSS	Fraction of H2O loss in VSS test for HAO	0.346432058	g H2O.g AlOH3-1	2Al(OH)3 -> Al2O3 + 3H2O

Parameters for gas transfer

Symbol	Name	Value	Unit	Comment
kL,GO2,bub	Liquid-side mass transfer coefficient of O2 for gas bubbles	319.0510073	gpd/ft2	
kL,GO2,sur	Liquid-side mass transfer coefficient of O2 at liquid surface	186.5221273	gpd/ft2	
fkL,GN2	Correction factor for mass transfer of N2	100	%	
fkL,GCO2	Correction factor for mass transfer of CO2	100	%	
fkL,GCH4	Correction factor for mass transfer of CH4	100	%	
fkL,GH2	Correction factor for mass transfer of H2	100	%	
fkL,GNH3	Correction factor for mass transfer of NH3	5	%	Used to compensate for the high solubility of NH3 gas
qALPHA	Sludge retention-based alpha improvement rate component	0.0017	m3.g-1.d-1	
SALPHA,sat	Alpha indicator saturation value	1		
KSO2,ALPHA	Half-saturation of dissolved oxygen for anoxic/anaerobic alpha enhancement	0.05	mg O2/L	
fSO2,max,ALPHA	Maximum anaerobic/anoxic alpha enhancement factor (at 0 mg/l DO)	2.5		
coeffdamp,ALPHA	Coefficient of alpha first order limitation damping term	3		
powdamp,ALPHA	Power of alpha first order limitation damping term	9		
slTSS,α,def	Slope of solids-related alpha correction, default	-0.0711	m3.kg-1	
slTSS,α,coarse	Slope of solids-related alpha correction, coarse bubbles	-0.0474	m3.kg-1	
coefflead,TSS,α,mech	Leading coefficient of solids-related alpha correction, mechanical aeration	-0.000787	(kg.m-3)-2	
coefflin,TSS,α,mech	Linear coefficient of solids-related alpha correction, mechanical aeration	0.0232	m3.kg-1	
constTSS,α,mech	Constant of solids-related alpha correction, mechanical aeration	0.877		

Oxidation-reduction potential constants

Symbol	Name	Value	Unit	Comment
ORPbase	Base ORP value	-300	mV	
ORPmax,SO2	ORP max for dissolved oxygen	300	mV	
ORPmax,SNOx	ORP max for dissolved nitrate	70	mV	
KORP,SO2	Half-saturation of dissolved oxygen for ORP	0.05	mg O2/L	
KORP,SNOx	Half-saturation of NOx for anoxic ORP	0.1	mg N/L	
KORP,H2,CH4	Half-saturation of dissolved hydrogen and methane for anaerobic ORP	5	mg COD/L	

IS calculation

Symbol	Name	Value	Unit	Comment
ISlim	IS cut-off threshold for Davies activity coefficient correction	0.2	ISunit	The fmono/fdi/ftri curves have minima at 0.3 and literally couldn't be used above that
SlopeIS,corr	Slope of correction	-0.001		
ISinput,AS	Ionic strength input for activated sludge	0.02	ISunit	
ISinput,DIG	Ionic strength input for digesters	0.1	ISunit	
ISinput,sidestream	Ionic strength input for sidestream	0.1	ISunit	

TOC calculation coefficients

Symbol	Name	Value	Unit	Comment
fTOC,1	fTOC,1	0.334448	g C.g COD-1	
fTOC,2	fTOC,2	2.42475	g C.m-3	

Interstitial water content

Symbol	Name	Value	Unit	Comment
iiw,BIO	Interstitial water of biomass in volatile solids	2.33	g H2O.g VS-1	Assuming 70% of biomass cytoplasm is water

Vicinal water content

Symbol	Name	Value	Unit	Comment
ivw,XB	Vicinal water of biodegradable substrate in volatile solids	0.052	g H2O.g VS-1	Assuming 5% of H2O is associated with vicinal water for these organics
ivw,XU	Vicinal water of particulate unbiodegradable organics in volatile solids	0.052	g H2O.g VS-1	
ivw,BIO	Vicinal water of biomass in volatile solids	0.052	g H2O.g VS-1	
ivw,XE	Vicinal water of endogenous products in volatile solids	0.052	g H2O.g VS-1	
ivw,CB	Vicinal water of colloidal biodegradable substrate in volatile solids	0.052	g H2O.g VS-1	
ivw,CU	Vicinal water of colloidal unbiodegradable organics in volatile solids	0.052	g H2O.g VS-1	
ivw,PHA	Vicinal water of PHA in volatile solids	0.052	g H2O.g VS-1	
ivw,GLY	Vicinal water of glycogen in volatile solids	0.052	g H2O.g VS-1	
ivw,EPS	Vicinal water correction of EPS in volatile solids	0.052	g H2O.g VS-1	

Water of Hydration content

Symbol	Name	Value	Unit	Comment
iwh,XB	Water of hydration of biodegradable substrate in volatile solids	0.11	g H2O.g VS-1	Assuming 10% of H2O is associated with water of hydration
iwh,XU	Water of hydration of particulate unbiodegradable organics in volatile solids	0.11	g H2O.g VS-1	
iwh,BIO	Water of hydration of biomass in volatile solids	0.11	g H2O.g VS-1	
iwh,XE	Water of hydration of endogenous products in volatile solids	0.11	g H2O.g VS-1	
iwh,PHA	Water of hydration of PHA in volatile solids	0.17	g H2O.g VS-1	Assuming 15% of H2O is associated with water of hydration
iwh,GLY	Water of hydration of glycogen in volatile solids	0.17	g H2O.g VS-1	
iwh,EPS	Water of hydration correction of EPS in volatile solids	0.33	g H2O.g VS-1	Assuming 25% of H2O is associated with water of hydration

RWQM1 Algae stoichiometry

Symbol	Name	Value	Unit	Comment
fE,ALG	Fraction of particulate organic matter that becomes inert during death of algae	0.20692002	g XE.g (XB+XE)-1	Parameter value from RWQM1 (Reichert et al. 2001), original parameter nomeclature: fI,ALG

RWQM1 Consumers stoichiometry

Symbol	Name	Value	Unit	Comment
fE,CON	Fraction of particulate organic matter that becomes inert during death of consumers	0.20692002	g XE.g (XB+XE)-1	Parameter value from RWQM1 (Reichert et al. 2001), original parameter nomeclature: fI,CON
fpellets,CON	Fraction of incororated biomass that s excreted as fecal pellets	0.769874145	g XB.g XCON-1	Parameter value from RWQM1 (Reichert et al. 2001), original parameter nomeclature: fe
YCON	Yield for grazing (set to a value that avoids consumption of nutrients and oxygen)	0.2	g XCON.g XBIO-1	Parameter value from RWQM1 (Reichert et al. 2001)

RWQM1 Algae kinetics

Symbol	Name	Value	Unit	Comment
KIrr	Half-saturation light intensity	500	W.m-2	Parameter value from RWQM1 (Reichert et al. 2001), original parameter nomeclature: KI
Irr	Solar Irridance	180	W.m-2	Parameter value obtained from dataset retrieved at: https://nsrdb.nrel.gov/ 722050 ORLANDO INTL ARPT FL -5 N28 26 W081 20 29 1010 1991
μALG	Maximum specific of growth rate of algae	2	1/d	Parameter value from RWQM1 (Reichert et al. 2001), original parameter nomeclature: kgro,ALG,To
bresp,ALG	respiration rate of algae	0.1	1/d	Parameter value from RWQM1 (Reichert et al. 2001), original parameter nomeclature: kresp,ALG,To
bdeath,ALG	death rate of algae	0.1	1/d	Parameter value from RWQM1 (Reichert et al. 2001), original parameter nomeclature: kdeath,ALG,To
θALG	Arrhenius coefficient for Algae growth	0.046	Co-1	Parameter value from RWQM1 (Reichert et al. 2001), original parameter nomeclature: βALG
KHPO4,ALG	Half-saturation of hydrogen phosphate for algae	0.02	mg P/L	Parameter value from RWQM1 (Reichert et al. 2001)
KNH4,ALG	Half-saturation of ammonia for algae	0.1	mg N/L	Parameter value from RWQM1 (Reichert et al. 2001)
KO2,ALG	Half-saturation of oxygen for algae	0.2	g O.m-3	Parameter value from RWQM1 (Reichert et al. 2001)

RWQM1 Consumer kinetics

Symbol	Name	Value	Unit	Comment
μCON	Maximum specific of growth rate of consumers	0.0002	m3.gCOD-1.d-1	Parameter value from RWQM1 (Reichert et al. 2001), original parameter nomeclature: kgro,CON,To
bresp,CON	respiration rate of consumers	0.05	1/d	Parameter value from RWQM1 (Reichert et al. 2001), original parameter nomeclature: kresp,CON,To
bdeath,CON	death rate of consumers	0.05	1/d	Parameter value from RWQM1 (Reichert et al. 2001), original parameter nomeclature: kdeath,CON,To
θCON	Arrhenius coefficient for Consumers growth	0.08	Co-1	Parameter value from RWQM1 (Reichert et al. 2001), original parameter nomeclature: βCON
KO2,CON	Half-saturation of oxygen for consumers	0.5	g O.m-3	Parameter value from RWQM1 (Reichert et al. 2001)

Unit overview

Name: Plantwide
Sumo name:
Category: Other units
Unit: PlantFactory
Type: PlantFactory

Settings

Parameters

Symbol	Name	Value	Unit	Comment
DoseAl,molar	Aluminum Molar Dosage	40	moles Al/mole OP	

Table1 Disabled
No interpolation Repeated every 24 hours

Time	Sumo1Alg..Irr
h	W.m-2
0	0
1	0
2	0
3	0
4	0
5	1
6	33
7	135
8	280
9	423
10	538
11	606
12	610
13	574
14	467
15	342
16	206
17	88
18	19
19	1
20	0
21	0
22	0
23	0

Unit overview

Name: Energy center
Sumo name: EnergyCenter
Category: Other units
Unit: Energy center
Type: Energy center

Settings

Plant parameter settings

Symbol	Name	Value	Unit	Comment
PE	COD generation per person equivalent	120	g COD.PE-1	

Periphery consumer settings

Symbol	Name	Value	Unit	Comment
Pel,vent	Ventilation fixed power demand	4.666666667	kW	
Pel,water	Water supply fixed power demand	14.44748858	kW	
Pel,misc	Miscellaneous fixed power demand	2.454646067	kW	

Other variable consumers

Symbol	Name	Value	Unit	Comment
esize,ovc	Variable specific energy demand based on PE load	0	kWh/PED.a	
eflow,ovc	Variable specific energy demand based on flow	0	Wh/m3	
eCOD,ovc	Variable specific energy demand based on COD load	0	Wh/kg COD	
esolids,ovc	Variable specific energy demand based on solids load	0	Wh/kg TSS	

Other fixed consumers

Symbol	Name	Value	Unit	Comment
Pel,other	Additional fixed other power demand	0	kW	
Pel,special	Additional fixed special power demand	0	kW	

Other producers

Symbol	Name	Value	Unit	Comment
Pel,prod,other	Other fixed power production	0	kW	

Unit overview

Name: Cost center
Sumo name: CostCenter
Category: Other units
Unit: Cost center
Type: Cost center

Settings

Specific prices for purchase

Symbol	Name	Value	Unit	Comment
eEL,spec,flow	Specific energy consumption based on flow	0.21	kWh.m-3	
PriceEL,purch	Electricity price when purchased	0.00012	kUSD.kWh-1	

Water purchase price

Symbol	Name	Value	Unit	Comment
Pricewater,cons	Additional water usage cost	0.0001	kUSD.m-3	

Polymer purchase price

Symbol	Name	Value	Unit	Comment
PricePolymer	Polymer purhase cost	0.004	kUSD.kg-1	

Disposal prices

Symbol	Name	Value	Unit	Comment
Pricescreenings,disp	Screenings disposal cost based on solids mass	0.05	kUSD.TSS ton-1	
Pricegrit,disp	Grit disposal cost based on solids mass	0.05	kUSD.TSS ton-1	
Pricegrease,disp	Grease disposal cost based on solids mass	0.05	kUSD.m-3	
Pricesludge,disp	Sludge disposal cost based on solids mass	0.05	kUSD.TSS ton-1	

Product sale prices

Symbol	Name	Value	Unit	Comment
PriceXCaCO3,sale	Calcium carbonate (CaCO3) sale price	0.05	kUSD.TSS ton-1	
PriceXACP,sale	Amorphous calcium phosphate (ACP) sale price	0.03	kUSD.TSS ton-1	
PriceXSTR,sale	Struvite (STR) sale price	0.055	kUSD.TSS ton-1	
PriceXVivi,sale	Vivianite (Vivi) sale price	0.05	kUSD.TSS ton-1	

Unit overview

Name:	SRT
Sumo name:	
Category:	Other units
Unit:	SRTIcon
Type:	SRTIcon

Settings

Unit overview

Name:	Flow Dependence
Sumo name:	
Category:	Other units
Unit:	FlowDepIcon
Type:	FlowDepIcon

Settings

Unit overview

Name: Jacobs Influent
Sumo name: Influent
Category: Jacobs
Unit: Jacobs Influent
Type: Sumo12 concentration based sec effluent

Settings

Influent specifications

Symbol	Name	Value	Unit	Comment
Q	Flow rate	295	MGD	388 for 600 CFS, 295 for 457 CFS
TCOD	Total chemical oxygen demand	42.3	mg COD/L	Average concentration secondary effluent
TKN	Total Kjeldahl nitrogen (TKN)	1.3	mg N/L	Average concentration secondary effluent
TP	Total phosphorus	0.098	mg P/L	Average concentration secondary effluent
T	Temperature	20	°C	

pH and alkalinity

Symbol	Name	Value	Unit	Comment
SALK,input	Alkalinity (ALK)	150	mg CaCO3/L	Average concentration secondary effluent
pH	pH	7.1	pHunit	Average concentration secondary effluent

Influent fractions

Symbol	Name	Value	Unit	Comment
frVSS,TSS	Fraction of VSS/TSS	75	%	
frSCCOD,TCOD	Fraction of filtered COD (SCCOD, 1.5 µm, incl. colloids) in total COD	88.7	%	
frSCOD,TCOD	Fraction of flocculated filtered (SCOD, wo colloids) COD in total COD	71.7	%	
frVFA,SCCOD	Fraction of VFA in filtered COD (SCCOD, 1.5 µm, incl. colloids)	0	%	
frSU,SCCOD	Fraction of soluble unbiodegradable organics (SU) in filtered COD (SCCOD, 1.5 µm, incl. colloids)	80	%	Fraction of filtered COD, not total COD!
frXU,TCOD	Fraction of particulate unbiodegradable organics (XU) in total COD	4	%	
frXOHO,TCOD	Fraction of heterotrophs (OHO) in total COD	1	%	
frCU,CCOD	Fraction of colloidal unbiodegradable organics (CU) in colloidal COD	83	%	
frSNHx,TKN	Fraction of NHx in total Kjeldahl nitrogen (TKN)	1.5	%	
frSPO4,TP	Fraction of PO4 in total phosphorus (TP)	22.5	%	
frXALG,TCOD	Fraction of Algae in total COD	0.6	%	
frXCON,TCOD	Fraction of Consumers in total COD	0.3	%	
frXE,XOHO	Fraction of endogenous products (XE) of OHOs	20	%	
frN,SB	Fraction of N in readily biodegradable substrate (SB)	4	%	
frN,XU	Fraction of N in particulate unbiodegradable substrate (XU)	1	%	
frP,SB	Fraction of P in readily biodegradable substrate (SB)	1	%	
frP,XU	Fraction of P in particulate unbiodegradable substrate (XU)	0.1	%	

Ionic components

Symbol	Name	Value	Unit	Comment
SCa	Calcium	150	mg Ca/L	
SMg	Magnesium	15	mg Mg/L	
SK	Potassium	16	mg K/L	
SAN,ini	Other strong anions (as Cl-)	300	mg Cl/L	
SCAT,ini	Other strong cations (as Na+)	109.9	mg Na/L	

Alpha indicator - SCCOD correlation parameters

Symbol	Name	Value	Unit	Comment
KI,SCCOD,ALPHA	Half-value in filtered COD-based alpha indicator correlation	165	mg COD/L	
slSCCOD,ALPHA	Slope of filtered COD-based alpha indicator correlation	0.1		
MinSCCOD,ALPHA	Minimum of filtered COD-based alpha indicator correlation	0		
Maxww,SCCOD,ALPHA	Maximum of filtered COD-based alpha indicator correlation, waste water	0.5		
expcw,SCCOD,ALPHA	Clean water exponent of filtered COD-based alpha indicator correlation	0.05		

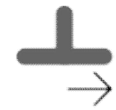
Other influent constituents (usually zero)

Symbol	Name	Value	Unit	Comment
SO2	Influent DO (used if DO is modelled)	1	mg O2/L	
SMEOL	Methanol (MEOL)	0	mg COD/L	
XPHA	Stored polyhydroxyalkanoates (PHA)	0	mg COD/L	
XGLY	Stored glycogen (GLY)	0	mg COD/L	
XE,ana	Anaerobic endogenous decay products	0	mg COD/L	
XCASTO	Carbon storing organisms (CASTO)	0	mg COD/L	
XMEOLO	Anoxic methanol utilizers (MEOLO)	0	mg COD/L	
XNITO	Aerobic nitrifying organisms (NITO)	0	mg COD/L	
XAOB	Aerobic ammonia oxidizers (AOB)	0	mg COD/L	
XNOB	Nitrite oxidizers (NOB)	0	mg COD/L	
XAMX	Anammox organisms (AMX)	0	mg COD/L	
XAMETO	Acidoclastic methanogens (AMETO)	0	mg COD/L	
XHMETO	Hydrogenotrophic methanogens (HMETO)	0	mg COD/L	
SNOx	Nitrite + Nitrate (NOx)	0.02	mg N/L	
SNO2	Nitrite (NO2)	0	mg N/L	
SNO3	Nitrate (NO3)	0	mg N/L	
XPP	Stored polyphosphate (PP)	0	mg P/L	
SCH4	Dissolved methane (CH4)	0	mg COD/L	
SH2	Dissolved hydrogen (H2)	0	mg COD/L	
SFe3	Ferric ion (Fe3)	0	mg Fe/L	
SFe2	Ferrous ion (Fe2)	0	mg Fe/L	
SAl	Aluminium (Al)	0	mg Al/L	
XHFO,old	Aged unused hydrous ferric oxide (HFO,old)	0	mg Fe/L	
XHFO,H,P	P-bound hydrous ferric oxide, high surface (HFO,H,P)	0	mg Fe/L	
XHFO,L,P	P-bound hydrous ferric oxide, low surface (HFO,L,P)	0	mg Fe/L	
XHFO,H,P,old	Aged used hydrous ferric oxide, high surface (HFO,H,P,old)	0	mg Fe/L	
XHFO,L,P,old	Aged used hydrous ferric oxide, low surface (HFO,L,P,old)	0	mg Fe/L	
XHAO,old	Aged unused hydrous aluminium oxide (HAO,old)	0	mg Al/L	
XHAO,H,P	P-bound hydrous aluminium oxide, high surface (HAO,H,P)	0	mg Al/L	
XHAO,L,P	P-bound hydrous aluminium oxide, low surface (HAO,L,P)	0	mg Al/L	
XHAO,H,P,old	Aged P-bound hydrous aluminium oxide, high surface (HAO,H,P,old)	0	mg Al/L	
XHAO,L,P,old	Aged P-bound hydrous aluminium oxide, low surface (HAO,L,P,old)	0	mg Al/L	
SN2	Dissolved nitrogen (N2)	16	mg N/L	
XCaCO3	Calcium carbonate (CaCO3)	1E-40	mg TSS/L	
XACP	Amorphous calcium phosphate (ACP)	1E-40	mg TSS/L	
XBSH	Brushite (BSH)	1E-40	mg TSS/L	
XSTR	Struvite (STR)	1E-40	mg TSS/L	
XVivi	Vivianite (Vivi)	1E-40	mg TSS/L	

Mixing - precipitation parameters

Symbol	Name	Value	Unit	Comment
G	Average velocity gradient in mixing tank	20	1/s	
KG,HFO	Half-saturation for G value for HFO	45	1/s	
KG,HAO	Half-saturation for G value for HAO	10	1/s	

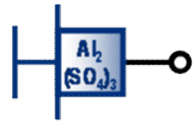
Unit overview



Name:	Side flow combiner
Sumo name:	Sideflowcombiner1
Category:	Flow elements
Unit:	Side flow combiner
Type:	Simple side flow combiner

Settings

Unit overview



Name: Alum
Sumo name: Alum
Category: Flow elements
Unit: Metal
Type: Al2(SO4)3 flow based non-S models

Settings

Dose specification

Symbol	Name	Value	Unit	Comment
G	Average velocity gradient at dosage point	400	1/s	
Q	Flow rate	0	MGD	
SAl2SO43,mass	Aluminium sulfate percent composition by mass	27	%	non-hydrated
ρAl2SO43	Density of aluminium sulfate solution	1.306108	kg.m-3	

Al2(SO4)3 price for purchase

Symbol	Name	Value	Unit	Comment
PriceAl2SO43	Al2(SO4)3 purchase price	0.2	kUSD.m-3	

Mixing - precipitation parameters

Symbol	Name	Value	Unit	Comment
KG	Half-saturation for G value	30	1/s	

Other components

Symbol	Name	Value	Unit	Comment
SVFA	Volatile fatty acids (VFA)	0	mg COD/L	
SB	Readily biodegradable substrate (non-VFA)	0	mg COD/L	
SMEOL	Methanol (MEOL)	0	mg COD/L	
CB	Colloidal biodegradable substrate	0	mg COD/L	
XB	Slowly biodegradable substrate	0	mg COD/L	
SU	Soluble unbiodegradable organics	0	mg COD/L	
CU	Colloidal unbiodegradable organics	0	mg COD/L	
XU	Particulate unbiodegradable organics	0	mg COD/L	
XPHA	Stored polyhydroxyalkanoates (PHA)	0	mg COD/L	
XGLY	Stored glycogen (GLY)	0	mg COD/L	
XE	Endogenous decay products	0	mg COD/L	
XE,ana	Anaerobic endogenous decay products	0	mg COD/L	
XOHO	Ordinary heterotrophic organisms (OHO)	0	mg COD/L	
XCASTO	Carbon storing organisms (CASTO)	0	mg COD/L	
XMEOLO	Anoxic methanol utilizers (MEOLO)	0	mg COD/L	
XNITO	Aerobic nitrifying organisms (NITO)	0	mg COD/L	
XAMETO	Acidoclastic methanogens (AMETO)	0	mg COD/L	
XHMETO	Hydrogenotrophic methanogens (HMETO)	0	mg COD/L	
SNHx	Total ammonia (NHx)	0	mg N/L	
SNOx	Nitrate and nitrite (NOx)	0	mg N/L	
SN2	Dissolved nitrogen (N2)	0	mg N/L	
SN,B	Soluble biodegradable organic N (from SB)	0	mg N/L	
XN,B	Particulate biodegradable organic N (from XB)	0	mg N/L	
XN,U	Particulate unbiodegradable organic N	0	mg N/L	
SPO4	Orthophosphate (PO4)	0	mg P/L	
XPP	Stored polyphosphate (PP)	0	mg P/L	
SP,B	Soluble biodegradable organic P (from SB)	0	mg P/L	
XP,B	Particulate biodegradable organic P (from XB)	0	mg P/L	
XP,U	Particulate unbiodegradable organic P	0	mg P/L	
SO2	Dissolved oxygen (O2)	0	mg O2/L	
SCH4	Dissolved methane (CH4)	0	mg COD/L	
SH2	Dissolved hydrogen (H2)	0	mg COD/L	
SCO2	Total inorganic carbon (CO2)	0	mg TIC/L	
XINORG	Inorganics in influent and biomass	0	mg TSS/L	
SCAT	Other strong cations (as Na+)	0	mg Na/L	
SAN	Other strong anions (as Cl-)	0	mg Cl/L	
SCa	Calcium	0	mg Ca/L	
SMg	Magnesium	0	mg Mg/L	
SK	Potassium	0	mg K/L	
SFe2	Ferrous ion (Fe2)	0	mg Fe/L	
XHFO,H	Active hydrous ferric oxide, high surface (HFO,H)	0	mg Fe/L	
XHFO,L	Active hydrous ferric oxide, low surface (HFO,L)	0	mg Fe/L	
XHFO,old	Aged unused hydrous ferric oxide (HFO,old)	0	mg Fe/L	
XHFO,H,P	P-bound hydrous ferric oxide, high surface (HFO,H,P)	0	mg Fe/L	
XHFO,L,P	P-bound hydrous ferric oxide, low surface (HFO,L,P)	0	mg Fe/L	
XHFO,H,P,old	Aged used hydrous ferric oxide, high surface (HFO,H,P,old)	0	mg Fe/L	
XHFO,L,P,old	Aged used hydrous ferric oxide, low surface (HFO,L,P,old)	0	mg Fe/L	
XHAO,old	Aged unused hydrous aluminium oxide (HAO,old)	0	mg Al/L	
XHAO,H,P	P-bound hydrous aluminium oxide, high surface (HAO,H,P)	0	mg Al/L	
XHAO,L,P	P-bound hydrous aluminium oxide, low surface (HAO,L,P)	0	mg Al/L	
XHAO,H,P,old	Aged P-bound hydrous aluminium oxide, high surface (HAO,H,P,old)	0	mg Al/L	
XHAO,L,P,old	Aged P-bound hydrous aluminium oxide, low surface (HAO,L,P,old)	0	mg Al/L	
XCaCO3	Calcium carbonate (CaCO3)	0	mg TSS/L	
XACP	Amorphous calcium phosphate (ACP)	0	mg TSS/L	
XBSH	Brushite (BSH)	0	mg TSS/L	
XSTR	Struvite (STR)	0	mg TSS/L	
XVivi	Vivianite (Vivi)	0	mg TSS/L	
XALG	Algae	0	mg COD/L	
XCON	Consumers	0	mg COD/L	
SALPHA	Alpha indicator	1		

Temperature

Symbol	Name	Value	Unit	Comment
T	Temperature	20	°C	

Unit overview

Name: Pipe2
Sumo name: Pipe2
Category: Other units
Unit: PipeL
Type: Pipe

Settings

Pipe details

Symbol	Name	Value	Unit	Comment
na	Parallel pipes	1		
l	Length	32.8084	ft	Pipe length
D	Diameter	600	mm	Use DN inner diameter
Δhgeom	Geometric head	0	ft	

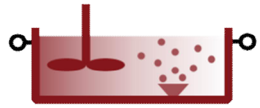
Advanced head loss parameters

Symbol	Name	Value	Unit	Comment
rr	Roughness (k)	0.15	mm	Sand roughness
z	Additional zetas	1.126		Default = Input+Output
lz	Equivalent lenght for local friction	0	ft	Alternative to zeta

Pipe viscosity variables

Symbol	Name	Value	Unit	Comment
t_cal	Calibration temperature	20		
n	Flow index	0.29		Flow index from literature at 20°C
TSS_min	Model validity threshold TSS	28	g.l-1	Lowest determined value from literature at 20°C
Ea_ty	Yield stress activation energy	2688		Temperature dependency by Arrhenius comparison
Ea_k	Fluid consistency factor activation energy	5134		Temperature dependency by Arrhenius comparison

Unit overview



Name: Flocculation
Sumo name: Flocculation
Category: Bioreactors
Unit: CSTR
Type: CSTR with diffused aeration and calculated DO

Settings

Reactor settings

Symbol	Name	Value	Unit	Comment
Ntrain	Number of trains	2		
L.Vtrain	Volume per train	3.08	MG	
htank	Tank depth	10	ft	

Aeration settings

Symbol	Name	Value	Unit	Comment
Qair,NTP	Air flow @ standard conditions (NTP: 20 °C, 1 atm)	0	scfm	
Ffouling	Diffuser fouling factor	0.8		
hsea	Elevation above sea level	656.168	ft	
hdiff,floor	Diffuser height from floor	0.656168	ft	
ddiff	Diffuser floor density (diffuser area/tank area)	0.1	m2/m2	
Adiff	Area per diffuser	0.401493884	ft2	

Initial concentrations

Symbol	Name	Value	Unit	Comment
SVFA_0	Volatile fatty acids (VFA) initial concentration	0.01	mg COD/L	
SB_0	Readily biodegradable substrate (non-VFA) initial concentration	1	mg COD/L	
SMEOL_0	Methanol (MEOL) initial concentration	1E-40	mg COD/L	
CB_0	Colloidal biodegradable substrate initial concentration	0.01	mg COD/L	
XB_0	Slowly biodegradable substrate initial concentration	14	mg COD/L	
SU_0	Soluble unbiodegradable organics initial concentration	7	mg COD/L	
CU_0	Colloidal unbiodegradable organics initial concentration	0.01	mg COD/L	
XU_0	Particulate unbiodegradable organics initial concentration	1000	mg COD/L	
XPHA_0	Stored polyhydroxyalkanoates (PHA) initial concentration	20	mg COD/L	
XGLY_0	Stored glycogen (GLY) initial concentration	3	mg COD/L	
XE_0	Endogenous decay products initial concentration	300	mg COD/L	
XE,ana_0	Anaerobic endogenous decay products initial concentration	0.1	mg COD/L	
XOHO_0	Ordinary heterotrophic organisms (OHO) initial concentration	500	mg COD/L	
XCASTO_0	Carbon storing organisms (CASTO) initial concentration	500	mg COD/L	
XMEOLO_0	Anoxic methanol utilizers (MEOLO) initial concentration	1	mg COD/L	
XNITO_0	Aerobic nitrifying organisms (NITO) initial concentration	90	mg COD/L	
XAMETO_0	Acidoclastic methanogens (AMETO) initial concentration	0.3	mg COD/L	
XHMETO_0	Hydrogenotrophic methanogens (HMETO) initial concentration	0.2	mg COD/L	
SNHx_0	Total ammonia (NHx) initial concentration	1	mg N/L	
SNOx_0	Nitrate and nitrite (NOx) initial concentration	5	mg N/L	
SN2_0	Dissolved nitrogen (N2) initial concentration	18	mg N/L	
SN,B_0	Soluble biodegradable organic N (from SB) initial concentration	0.5	mg N/L	
XN,B_0	Particulate biodegradable organic N (from XB) initial concentration	1	mg N/L	
XN,U_0	Particulate unbiodegradable organic N initial concentration	10	mg N/L	
SPO4_0	Orthophosphate (PO4) initial concentration	0.5	mg P/L	
XPP_0	Stored polyphosphate (PP) initial concentration	60	mg P/L	
SP,B_0	Soluble biodegradable organic P (from SB) initial concentration	0.01	mg P/L	
XP,B_0	Particulate biodegradable organic P (from XB) initial concentration	0.5	mg P/L	
XP,U_0	Particulate unbiodegradable organic P initial concentration	2	mg P/L	
SO2_0	Dissolved oxygen (O2) initial concentration	2	mg O2/L	
SCH4_0	Dissolved methane (CH4) initial concentration	0.01	mg COD/L	
SH2_0	Dissolved hydrogen (H2) initial concentration	0.01	mg COD/L	
SCO2_0	Total inorganic carbon (CO2) initial concentration	74	mg TIC/L	
XINORG_0	Inorganics in influent and biomass initial concentration	460	mg TSS/L	
SCAT_0	Other strong cations (as Na+) initial concentration	35	mg Na/L	
SAN_0	Other strong anions (as Cl-) initial concentration	150	mg Cl/L	
SCa_0	Calcium initial concentration	150	mg Ca/L	
SMg_0	Magnesium initial concentration	15	mg Mg/L	
SK_0	Potassium initial concentration	15	mg K/L	
SFe2_0	Ferrous ion (Fe2) initial concentration	1E-40	mg Fe/L	
XHFO,H_0	Active hydrous ferric oxide, high surface (HFO,H) initial concentration	1E-40	mg Fe/L	
XHFO,L_0	Active hydrous ferric oxide, low surface (HFO,L) initial concentration	1E-40	mg Fe/L	
XHFO,old_0	Aged unused hydrous ferric oxide (HFO,old) initial concentration	1E-40	mg Fe/L	
XHFO,H,P_0	P-bound hydrous ferric oxide, high surface (HFO,H,P) initial concentration	1E-40	mg Fe/L	
XHFO,L,P_0	P-bound hydrous ferric oxide, low surface (HFO,L,P) initial concentration	1E-40	mg Fe/L	
XHFO,H,P,old_0	Aged used hydrous ferric oxide, high surface (HFO,H,P,old) initial concentration	1E-40	mg Fe/L	
XHFO,L,P,old_0	Aged used hydrous ferric oxide, low surface (HFO,L,P,old) initial concentration	1E-40	mg Fe/L	
XHAO,H_0	Active hydrous aluminium oxide, high surface (HAO,H) initial concentration	1E-40	mg Al/L	
XHAO,L_0	Active hydrous aluminium oxide, low surface (HAO,L) initial concentration	1E-40	mg Al/L	
XHAO,old_0	Aged unused hydrous aluminium oxide (HAO,old) initial concentration	1E-40	mg Al/L	
XHAO,H,P_0	P-bound hydrous aluminium oxide, high surface (HAO,H,P) initial concentration	1E-40	mg Al/L	
XHAO,L,P_0	P-bound hydrous aluminium oxide, low surface (HAO,L,P) initial concentration	1E-40	mg Al/L	
XHAO,H,P,old_0	Aged P-bound hydrous aluminium oxide, high surface (HAO,H,P,old) initial concentration	1E-40	mg Al/L	
XHAO,L,P,old_0	Aged P-bound hydrous aluminium oxide, low surface (HAO,L,P,old) initial concentration	1E-40	mg Al/L	
XCaCO3_0	Calcium carbonate (CaCO3) initial concentration	1E-40	mg TSS/L	
XACP_0	Amorphous calcium phosphate (ACP) initial concentration	1E-40	mg TSS/L	
XBSH_0	Brushite (BSH) initial concentration	1E-40	mg TSS/L	
XSTR_0	Struvite (STR) initial concentration	1E-40	mg TSS/L	
XVivi_0	Vivianite (Vivi) initial concentration	1E-40	mg TSS/L	
H_0	Enthalpy initial concentration	83626	kJ.m-3	
SALPHA_0	Alpha indicator initial concentration	0.5		
XALG_0	Algae initial concentration	20	mg COD/L	
XCON_0	Consumers initial concentration	20	mg COD/L	

Off-gas concentrations

Symbol	Name	Value	Unit	Comment
GCO2,aer	Carbon dioxide gas (CO2) off-gas concentration under aerated conditions	1.54	%v/v	
GCH4,aer	Methane gas (CH4) off-gas concentration under aerated conditions	1E-40	%v/v	
GH2,aer	Hydrogen gas (H2) off-gas concentration under aerated conditions	1E-40	%v/v	
GO2,aer	Oxygen gas (O2) off-gas concentration under aerated conditions	18.84	%v/v	
GNH3,aer	Ammonia gas (NH3) off-gas concentration under aerated conditions	1E-40	%v/v	
GN2,aer	Nitrogen gas (N2) off-gas concentration under aerated conditions	79.62	%v/v	
GCO2,nonaer	Carbon dioxide gas (CO2) off-gas concentration under non-aerated conditions	2.3	%v/v	
GCH4,nonaer	Methane gas (CH4) off-gas concentration under non-aerated conditions	0.04	%v/v	
GH2,nonaer	Hydrogen gas (H2) off-gas concentration under non-aerated conditions	3.16	%v/v	
GO2,nonaer	Oxygen gas (O2) off-gas concentration under non-aerated conditions	1E-40	%v/v	
GNH3,nonaer	Ammonia gas (NH3) off-gas concentration under non-aerated conditions	1E-40	%v/v	
GN2,nonaer	Nitrogen gas (N2) off-gas concentration under non-aerated conditions	94.5	%v/v	

Aeration gas composition

Symbol	Name	Value	Unit	Comment
GCO2,air,inp	Carbon dioxide gas (CO2) in air input	0.04	%v/v	
GCH4,air,inp	Methane gas (CH4) in air input	1E-40	%v/v	
GH2,air,inp	Hydrogen gas (H2) in air input	1E-40	%v/v	
GO2,air,inp	Oxygen gas (O2) in air input	20.95	%v/v	
GNH3,air,inp	Ammonia gas (NH3) in air input	1E-40	%v/v	
GN2,air,inp	Nitrogen gas (N2) in air input	79.01	%v/v	

Advanced aeration settings

Symbol	Name	Value	Unit	Comment
fcover	Covered fraction of reactor surface	0	%	
fwave	Waviness factor	1.9		
Tair	Field air temperature	20	°C	
β	Beta correction factor	0.95		
fd,sat,eff	Effective saturation depth fraction	0.5		
Lair	Temperature lapse rate for air pressure calculations	0.0065	K/m	
dbubble,aer	Bubble Sauter mean diameter under aerated conditions	0.00984252	ft	
dbubble,nonaer	Bubble Sauter mean diameter under non-aerated conditions	0.0328084	ft	
εgas,aer	Gas hold up under aerated conditions	0.01	m3 gas.m-3	
εgas,nonaer	Gas hold up under non-aerated conditions	0.001	m3 gas.m-3	

Oxygen transfer efficiency correlation parameters

Symbol	Name	Value	Unit	Comment
SSOTE0	Intercept in SSOTE correlation	2.368295924	%/ft	
expSSOTE	Exponent (absolute value) in SSOTE correlation	0.01041		
SSOTEasym	Asymptote in SSOTE correlation	1.752599944	%/ft	
divd,diff	Divisor value in diffuser density correction term	0.1173	m2/m2	
powd,diff	Power value in diffuser density correction term	0.1329		
coefflead,h,diff	Leading coefficient in diffuser submergence correction term	0.011	1/m	
powh,diff	Power value in diffuser submergence correction term	1.6031		
coefflin,h,diff	Linear coefficient in diffuser submergence correction term	-0.0229	1/m	

Model specific parameters

Symbol	Name	Value	Unit	Comment
ηFLOC,Process,aer	Flocculation factor under aerated conditions	0.25		Only relevant for Sumo2C model
ηFLOC,Process,nonaer	Flocculation factor under non-aerated (mixed) conditions	0.5		Only relevant for Sumo2C model

Sanity check

Symbol	Name	Value	Unit	Comment
MLSScheckflag	MLSS sanity check	10000	g TSS/m3	Above this value the graphics change to warn about high MLSS.
SO2,checkflag	Anoxic/Anaerobic tank section sign	0.02	g O2/m3	Below this value the graphics change to indicate anoxic/anaerobic condition.

Unit overview

[redacted]

Name: Pipe3
Sumo name: Pipe3
Category: Other units
Unit: PipeL
Type: Pipe

Settings

Pipe details

Symbol	Name	Value	Unit	Comment
na	Parallel pipes	1		
l	Length	32.8084	ft	Pipe length
D	Diameter	600	mm	Use DN inner diameter
Δhgeom	Geometric head	0	ft	

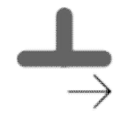
Advanced head loss parameters

Symbol	Name	Value	Unit	Comment
rr	Roughness (k)	0.15	mm	Sand roughness
z	Additional zetas	1.126		Default = Input+Output
lz	Equivalent lenght for local friction	0	ft	Alternative to zeta

Pipe viscosity variables

Symbol	Name	Value	Unit	Comment
t_cal	Calibration temperature	20		
n	Flow index	0.29		Flow index from literature at 20°C
TSS_min	Model validity threshold TSS	28	g.l-1	Lowest determined value from literature at 20°C
Ea_ty	Yield stress activation energy	2688		Temperature dependency by Arrhenius comparison
Ea_k	Fluid consistency factor activation energy	5134		Temperature dependency by Arrhenius comparison

Unit overview



Name:	Side flow combiner2
Sumo name:	Sideflowcombiner2
Category:	Flow elements
Unit:	Side flow combiner
Type:	Simple side flow combiner

Settings

Unit overview

[redacted]

Name: Pipe4
Sumo name: Pipe4
Category: Other units
Unit: PipeL
Type: Pipe

Settings

Pipe details

Symbol	Name	Value	Unit	Comment
na	Parallel pipes	1		
l	Length	32.8084	ft	Pipe length
D	Diameter	600	mm	Use DN inner diameter
Δhgeom	Geometric head	0	ft	

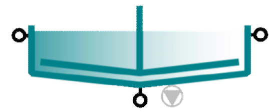
Advanced head loss parameters

Symbol	Name	Value	Unit	Comment
rr	Roughness (k)	0.15	mm	Sand roughness
z	Additional zetas	1.126		Default = Input+Output
lz	Equivalent lenght for local friction	0	ft	Alternative to zeta

Pipe viscosity variables

Symbol	Name	Value	Unit	Comment
t_cal	Calibration temperature	20		
n	Flow index	0.29		Flow index from literature at 20°C
TSS_min	Model validity threshold TSS	28	g.l-1	Lowest determined value from literature at 20°C
Ea_ty	Yield stress activation energy	2688		Temperature dependency by Arrhenius comparison
Ea_k	Fluid consistency factor activation energy	5134		Temperature dependency by Arrhenius comparison

Unit overview



Name: Settling
Sumo name: Settling
Category: Separators
Unit: Clarifier
Type: 1D layered clarifier with triple exponential settling velocity model

Settings

Process settings

Symbol	Name	Value	Unit	Comment
Ntrain	Number of trains	2		
Atrain	Surface area per train	342816.825	ft2	
haverage	Depth	10	ft	
hinp	Depth of influent layer from top	5	ft	
Qsludge,target	Sludge flow	1	MGD	

Settling parameters

Symbol	Name	Value	Unit	Comment
vbnd	Boundary settling velocity	11.25	m/h	Large flocs: max velocity
vmax	Maximum Vesilind settling velocity (v0)	20	m/h	Based on Jar Testing
rhin	Coefficient for hindered settling	0.3	L/g	Impacts blanket height
rfloc	Coefficient for flocculent settling	20	L/g	Impacts effluent solids
compron	Boundary compression concentration	5000	mg/L	Compression starts above this value
XTSS,min,max	Non-settleable TSS	1	mg/L	Minimum of two ("fraction of non-settleable solids" and "Non settleable TSS" are used
rcompr	Coefficient for compression	0.5	L/g	Slows down compression
fns	Fraction of non-settleable solids	0.1	%	Minimum of two ("fraction of non-settleable solids" and "Non settleable TSS" are used
XTSS,min,blanket	Concentration at top of sludge blanket	2500	mg/L	

Cost settings

Symbol	Name	Value	Unit	Comment
eTSS,polymer	Polymer dosage rate based on TSS load	0	g polymer/kg TSS	

Layer number

Symbol	Name	Value	Unit	Comment
n	Number of layers	5		

Layered clarifier parameters

Symbol	Name	Value	Unit	Comment
efffQ[]	Fraction of effluent flow from the layers	{100; 0; 0; 0; 0}	%	
sludgefQ[]	Fraction of sludge flow from the layers	{0; 0; 0; 0; 100}	%	

Gas phase settings

Symbol	Name	Value	Unit	Comment
fcover	Covered fraction of reactor surface	0	%	
fwave	Waviness factor	1.9		
Tair	Field air temperature	20	°C	
hsea	Elevation above sea level	656.168	ft	
α	Alpha (wastewater/clean water) factor	0.7		
β	Beta correction factor	0.95		
fd,sat,eff	Effective saturation depth fraction	0.5		
Lair	Temperature lapse rate for air pressure calculations	0.0065	K/m	
dbubble	Bubble Sauter mean diameter	0.0328084	ft	
εgas	Gas hold up (gas phase volume fraction)	0.001	m3 gas.m-3	

Off-gas concentrations

Symbol	Name	Value	Unit	Comment
GCO2	Carbon dioxide gas (CO2) off-gas concentration	2.3	%v/v	
GCH4	Methane gas (CH4) off-gas concentration	0.04	%v/v	
GH2	Hydrogen gas (H2) off-gas concentration	3.16	%v/v	
GO2	Oxygen gas (O2) off-gas concentration	1E-40	%v/v	
GNH3	Ammonia gas (NH3) off-gas concentration	1E-40	%v/v	
GN2	Nitrogen gas (N2) off-gas concentration	94.5	%v/v	

Initial concentrations

Symbol	Name	Value	Unit	Comment
SVFA_0[]	Volatile fatty acids (VFA) initial concentration	{0.01; 0.01; 0.01; 0.01; 0.01}	mg COD/L	
SB_0[]	Readily biodegradable substrate (non-VFA) initial concentration	{1; 1; 1; 1; 1}	mg COD/L	
SMEOL_0[]	Methanol (MEOL) initial concentration	{1E-40; 1E-40; 1E-40; 1E-40; 1E-40}	mg COD/L	
CB_0[]	Colloidal biodegradable substrate initial concentration	{0.01; 0.01; 0.01; 0.01; 0.01}	mg COD/L	
XB_0[]	Slowly biodegradable substrate initial concentration	{5.6; 5.6; 5.6; 5.6; 5.6}	mg COD/L	
SU_0[]	Soluble unbiodegradable organics initial concentration	{7; 7; 7; 7; 7}	mg COD/L	
CU_0[]	Colloidal unbiodegradable organics initial concentration	{0.01; 0.01; 0.01; 0.01; 0.01}	mg COD/L	
XU_0[]	Particulate unbiodegradable organics initial concentration	{400; 400; 400; 400; 400}	mg COD/L	
XPHA_0[]	Stored polyhydroxyalkanoates (PHA) initial concentration	{88.8; 88.8; 88.8; 88.8; 88.8}	mg COD/L	
XGLY_0[]	Stored glycogen (GLY) initial concentration	{12; 12; 12; 12; 12}	mg COD/L	
XE_0[]	Endogenous decay products initial concentration	{120; 120; 120; 120; 120}	mg COD/L	
XE,ana_0[]	Anaerobic endogenous decay products initial concentration	{0.04; 0.04; 0.04; 0.04; 0.04}	mg COD/L	
XOHO_0[]	Ordinary heterotrophic organisms (OHO) initial concentration	{200; 200; 200; 200; 200}	mg COD/L	
XCASTO_0[]	Carbon storing organisms (CASTO) initial concentration	{148; 148; 148; 148; 148}	mg COD/L	
XMEOLO_0[]	Anoxic methanol utilizers (MEOLO) initial concentration	{0.4; 0.4; 0.4; 0.4; 0.4}	mg COD/L	
XNITO_0[]	Aerobic nitrifying organisms (NITO) initial concentration	{36; 36; 36; 36; 36}	mg COD/L	
XAMETO_0[]	Acidoclastic methanogens (AMETO) initial concentration	{0.12; 0.12; 0.12; 0.12; 0.12}	mg COD/L	
XHMETO_0[]	Hydrogenotrophic methanogens (HMETO) initial concentration	{0.08; 0.08; 0.08; 0.08; 0.08}	mg COD/L	
SNHx_0[]	Total ammonia (NHx) initial concentration	{1; 1; 1; 1; 1}	mg N/L	
SNOx_0[]	Nitrate and nitrite (NOx) initial concentration	{5; 5; 5; 5; 5}	mg N/L	
SN2_0[]	Dissolved nitrogen (N2) initial concentration	{18; 18; 18; 18; 18}	mg N/L	
SN,B_0[]	Soluble biodegradable organic N (from SB) initial concentration	{0.5; 0.5; 0.5; 0.5; 0.5}	mg N/L	
XN,B_0[]	Particulate biodegradable organic N (from XB) initial concentration	{0.4; 0.4; 0.4; 0.4; 0.4}	mg N/L	
XN,U_0[]	Particulate unbiodegradable organic N initial concentration	{4; 4; 4; 4; 4}	mg N/L	
SPO4_0[]	Orthophosphate (PO4) initial concentration	{0.5; 0.5; 0.5; 0.5; 0.5}	mg P/L	
XPP_0[]	Stored polyphosphate (PP) initial concentration	{29.6; 29.6; 29.6; 29.6; 29.6}	mg P/L	
SP,B_0[]	Soluble biodegradable organic P (from SB) initial concentration	{0.01; 0.01; 0.01; 0.01; 0.01}	mg P/L	
XP,B_0[]	Particulate biodegradable organic P (from XB) initial concentration	{0.2; 0.2; 0.2; 0.2; 0.2}	mg P/L	
XP,U_0[]	Particulate unbiodegradable organic P initial concentration	{0.8; 0.8; 0.8; 0.8; 0.8}	mg P/L	
SO2_0[]	Dissolved oxygen (O2) initial concentration	{1E-40; 1E-40; 1E-40; 1E-40; 1E-40}	mg O2/L	
SCH4_0[]	Dissolved methane (CH4) initial concentration	{0.01; 0.01; 0.01; 0.01; 0.01}	mg COD/L	
SH2_0[]	Dissolved hydrogen (H2) initial concentration	{0.01; 0.01; 0.01; 0.01; 0.01}	mg COD/L	
SCO2_0[]	Total inorganic carbon (CO2) initial concentration	{74; 74; 74; 74; 74}	mg TIC/L	
XINORG_0[]	Inorganics in influent and biomass initial concentration	{184; 184; 184; 184; 184}	mg TSS/L	
SCAT_0[]	Other strong cations (as Na+) initial concentration	{35; 35; 35; 35; 35}	mg Na/L	
SAN_0[]	Other strong anions (as Cl-) initial concentration	{150; 150; 150; 150; 150}	mg Cl/L	
SCa_0[]	Calcium initial concentration	{150; 150; 150; 150; 150}	mg Ca/L	
SMg_0[]	Magnesium initial concentration	{15; 15; 15; 15; 15}	mg Mg/L	
SK_0[]	Potassium initial concentration	{15; 15; 15; 15; 15}	mg K/L	
SFe2_0[]	Ferrous ion (Fe2) initial concentration	{1E-40; 1E-40; 1E-40; 1E-40; 1E-40}	mg Fe/L	
XHFO,H_0[]	Active hydrous ferric oxide, high surface (HFO,H) initial concentration	{1E-40; 1E-40; 1E-40; 1E-40; 1E-40}	mg Fe/L	
XHFO,L_0[]	Active hydrous ferric oxide, low surface (HFO,L) initial concentration	{1E-40; 1E-40; 1E-40; 1E-40; 1E-40}	mg Fe/L	
XHFO,old_0[]	Aged unused hydrous ferric oxide (HFO,old) initial concentration	{1E-40; 1E-40; 1E-40; 1E-40; 1E-40}	mg Fe/L	
XHFO,H,P_0[]	P-bound hydrous ferric oxide, high surface (HFO,H,P) initial concentration	{1E-40; 1E-40; 1E-40; 1E-40; 1E-40}	mg Fe/L	
XHFO,L,P_0[]	P-bound hydrous ferric oxide, low surface (HFO,L,P) initial concentration	{1E-40; 1E-40; 1E-40; 1E-40; 1E-40}	mg Fe/L	
XHFO,H,P,old_0[]	Aged used hydrous ferric oxide, high surface (HFO,H,P,old) initial concentration	{1E-40; 1E-40; 1E-40; 1E-40; 1E-40}	mg Fe/L	
XHFO,L,P,old_0[]	Aged used hydrous ferric oxide, low surface (HFO,L,P,old) initial concentration	{1E-40; 1E-40; 1E-40; 1E-40; 1E-40}	mg Fe/L	
XHAO,H_0[]	Active hydrous aluminium oxide, high surface (HAO,H) initial concentration	{1E-40; 1E-40; 1E-40; 1E-40; 1E-40}	mg Al/L	
XHAO,L_0[]	Active hydrous aluminium oxide, low surface (HAO,L) initial concentration	{1E-40; 1E-40; 1E-40; 1E-40; 1E-40}	mg Al/L	
XHAO,old_0[]	Aged unused hydrous aluminium oxide (HAO,old) initial concentration	{1E-40; 1E-40; 1E-40; 1E-40; 1E-40}	mg Al/L	
XHAO,H,P_0[]	P-bound hydrous aluminium oxide, high surface (HAO,H,P) initial concentration	{1E-40; 1E-40; 1E-40; 1E-40; 1E-40}	mg Al/L	
XHAO,L,P_0[]	P-bound hydrous aluminium oxide, low surface (HAO,L,P) initial concentration	{1E-40; 1E-40; 1E-40; 1E-40; 1E-40}	mg Al/L	
XHAO,H,P,old_0[]	Aged P-bound hydrous aluminium oxide, high surface (HAO,H,P,old) initial concentration	{1E-40; 1E-40; 1E-40; 1E-40; 1E-40}	mg Al/L	
XHAO,L,P,old_0[]	Aged P-bound hydrous aluminium oxide, low surface (HAO,L,P,old) initial concentration	{1E-40; 1E-40; 1E-40; 1E-40; 1E-40}	mg Al/L	
XCaCO3_0[]	Calcium carbonate (CaCO3) initial concentration	{1E-40; 1E-40; 1E-40; 1E-40; 1E-40}	mg TSS/L	
XACP_0[]	Amorphous calcium phosphate (ACP) initial concentration	{1E-40; 1E-40; 1E-40; 1E-40; 1E-40}	mg TSS/L	
XBSH_0[]	Brushite (BSH) initial concentration	{1E-40; 1E-40; 1E-40; 1E-40; 1E-40}	mg TSS/L	
XSTR_0[]	Struvite (STR) initial concentration	{1E-40; 1E-40; 1E-40; 1E-40; 1E-40}	mg TSS/L	
XVivi_0[]	Vivianite (Vivi) initial concentration	{1E-40; 1E-40; 1E-40; 1E-40; 1E-40}	mg TSS/L	
H_0[]	Enthalpy initial concentration	{83626; 83626; 83626; 83626; 83626}	kJ.m-3	
SALPHA_0[]	Alpha indicator initial concentration	{0.5; 0.5; 0.5; 0.5; 0.5}		
XALG_0[]	Algae initial concentration	{10; 10; 10; 10; 10}	mg COD/L	
XCON_0[]	Consumers initial concentration	{10; 10; 10; 10; 10}	mg COD/L	

Model specific parameters

Symbol	Name	Value	Unit	Comment
ηFLOC,Process	Flocculation factor	0.75		Only relevant for Sumo2C model

Unit overview

[redacted]

Name: Pipe5
Sumo name: Pipe5
Category: Other units
Unit: PipeL
Type: Pipe

Settings

Pipe details

Symbol	Name	Value	Unit	Comment
na	Parallel pipes	1		
l	Length	32.8084	ft	Pipe length
D	Diameter	600	mm	Use DN inner diameter
Δhgeom	Geometric head	0	ft	

Advanced head loss parameters

Symbol	Name	Value	Unit	Comment
rr	Roughness (k)	0.15	mm	Sand roughness
z	Additional zetas	1.126		Default = Input+Output
lz	Equivalent lenght for local friction	0	ft	Alternative to zeta

Pipe viscosity variables

Symbol	Name	Value	Unit	Comment
t_cal	Calibration temperature	20		
n	Flow index	0.29		Flow index from literature at 20°C
TSS_min	Model validity threshold TSS	28	g.l-1	Lowest determined value from literature at 20°C
Ea_ty	Yield stress activation energy	2688		Temperature dependency by Arrhenius comparison
Ea_k	Fluid consistency factor activation energy	5134		Temperature dependency by Arrhenius comparison

Unit overview

Name:	Effluent
Sumo name:	Effluent1
Category:	Flow elements
Unit:	Effluent
Type:	Plant effluent

Settings

Unit overview

[redacted]

Name: Pipe6
Sumo name: Pipe6
Category: Other units
Unit: PipeL
Type: Pipe

Settings

Pipe details

Symbol	Name	Value	Unit	Comment
na	Parallel pipes	1		
l	Length	32.8084	ft	Pipe length
D	Diameter	600	mm	Use DN inner diameter
Δhgeom	Geometric head	0	ft	

Advanced head loss parameters

Symbol	Name	Value	Unit	Comment
rr	Roughness (k)	0.15	mm	Sand roughness
z	Additional zetas	1.126		Default = Input+Output
lz	Equivalent lenght for local friction	0	ft	Alternative to zeta

Pipe viscosity variables

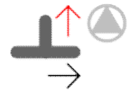
Symbol	Name	Value	Unit	Comment
t_cal	Calibration temperature	20		
n	Flow index	0.29		Flow index from literature at 20°C
TSS_min	Model validity threshold TSS	28	g.l-1	Lowest determined value from literature at 20°C
Ea_ty	Yield stress activation energy	2688		Temperature dependency by Arrhenius comparison
Ea_k	Fluid consistency factor activation energy	5134		Temperature dependency by Arrhenius comparison

Unit overview

Name:	Sludge
Sumo name:	Sludge1
Category:	Flow elements
Unit:	Sludge
Type:	Sludge output

Settings

Unit overview



Name:	Side flow divider
Sumo name:	Wastage
Category:	Flow elements
Unit:	Side flow divider
Type:	Proportional side flow divider

Settings

Flow divider parameters

Symbol	Name	Value	Unit	Comment
fr1_Q	Flow fraction to pumped	30	%	

Unit overview

Name: Pipe7
Sumo name: Pipe7
Category: Other units
Unit: PipeL
Type: Pipe

Settings

Pipe details

Symbol	Name	Value	Unit	Comment
na	Parallel pipes	1		
l	Length	32.8084	ft	Pipe length
D	Diameter	600	mm	Use DN inner diameter
Δhgeom	Geometric head	0	ft	

Advanced head loss parameters

Symbol	Name	Value	Unit	Comment
rr	Roughness (k)	0.15	mm	Sand roughness
z	Additional zetas	1.126		Default = Input+Output
lz	Equivalent lenght for local friction	0	ft	Alternative to zeta

Pipe viscosity variables

Symbol	Name	Value	Unit	Comment
t_cal	Calibration temperature	20		
n	Flow index	0.29		Flow index from literature at 20°C
TSS_min	Model validity threshold TSS	28	g.l-1	Lowest determined value from literature at 20°C
Ea_ty	Yield stress activation energy	2688		Temperature dependency by Arrhenius comparison
Ea_k	Fluid consistency factor activation energy	5134		Temperature dependency by Arrhenius comparison

Unit overview [redacted]

Name: Pipe8
Sumo name: Pipe8
Category: Other units
Unit: PipeL
Type: Pipe

Settings

Pipe details

Symbol	Name	Value	Unit	Comment
na	Parallel pipes	1		
l	Length	32.8084	ft	Pipe length
D	Diameter	600	mm	Use DN inner diameter
Δhgeom	Geometric head	0	ft	

Advanced head loss parameters

Symbol	Name	Value	Unit	Comment
rr	Roughness (k)	0.15	mm	Sand roughness
z	Additional zetas	1.126		Default = Input+Output
lz	Equivalent lenght for local friction	0	ft	Alternative to zeta

Pipe viscosity variables

Symbol	Name	Value	Unit	Comment
t_cal	Calibration temperature	20		
n	Flow index	0.29		Flow index from literature at 20°C
TSS_min	Model validity threshold TSS	28	g.l-1	Lowest determined value from literature at 20°C
Ea_ty	Yield stress activation energy	2688		Temperature dependency by Arrhenius comparison
Ea_k	Fluid consistency factor activation energy	5134		Temperature dependency by Arrhenius comparison

Unit overview [redacted]

Name:	Sludge Pipe
Sumo name:	Pipe9
Category:	Other units
Unit:	PipeL
Type:	Pipe

Settings

Pipe details

Symbol	Name	Value	Unit	Comment
na	Parallel pipes	1		
l	Length	32.8084	ft	Pipe length
D	Diameter	600	mm	Use DN inner diameter
Δhgeom	Geometric head	0	ft	

Advanced head loss parameters

Symbol	Name	Value	Unit	Comment
rr	Roughness (k)	0.15	mm	Sand roughness
z	Additional zetas	1.126		Default = Input+Output
lz	Equivalent lenght for local friction	0	ft	Alternative to zeta

Pipe viscosity variables

Symbol	Name	Value	Unit	Comment
t_cal	Calibration temperature	20		
n	Flow index	0.29		Flow index from literature at 20°C
TSS_min	Model validity threshold TSS	28	g.l-1	Lowest determined value from literature at 20°C
Ea_ty	Yield stress activation energy	2688		Temperature dependency by Arrhenius comparison
Ea_k	Fluid consistency factor activation energy	5134		Temperature dependency by Arrhenius comparison

Unit overview

Name: Offline Influent
Sumo name: Pipe10
Category: Other units
Unit: PipeL
Type: Pipe

Settings

Pipe details

Symbol	Name	Value	Unit	Comment
na	Parallel pipes	1		
l	Length	32.8084	ft	Pipe length
D	Diameter	600	mm	Use DN inner diameter
Δhgeom	Geometric head	0	ft	

Advanced head loss parameters

Symbol	Name	Value	Unit	Comment
rr	Roughness (k)	0.15	mm	Sand roughness
z	Additional zetas	1.126		Default = Input+Output
lz	Equivalent lenght for local friction	0	ft	Alternative to zeta

Pipe viscosity variables

Symbol	Name	Value	Unit	Comment
t_cal	Calibration temperature	20		
n	Flow index	0.29		Flow index from literature at 20°C
TSS_min	Model validity threshold TSS	28	g.l-1	Lowest determined value from literature at 20°C
Ea_ty	Yield stress activation energy	2688		Temperature dependency by Arrhenius comparison
Ea_k	Fluid consistency factor activation energy	5134		Temperature dependency by Arrhenius comparison

Appendix B. Cost Support for Option 1 Post-storage Alum

Flocculation Rapid Mix

Description	Quantity (English)	Unit (English)	Quantity (Metric)	Unit (Metric)	$/Unit	Total Cost
SITEWORK:						
Excavation	2,895	CY	2,213.26	m3	***$6.72***	$19,462
Imported Structural Backfill	200	CY	153.22	m3	***$50.94***	$10,209
Native Backfill	1,282	CY	980.19	m3	***$8.27***	$10,596
Haul Excess	1,613	CY	1,233.07	m3	***$8.27***	$13,330
Allowance for Misc Items	5%				$53,597.90	$2,680
Subtotal						$56,278
CONCRETE:						
Influent Channel:						
Foundation	0	CY	0.00	m3	***$541.11***	$0
Walls	0	CY	0.00	m3	***$880.79***	$0
Elevated Slab	0	CY	0.00	m3	***$1,333.77***	$0
Flocc Basin						
Foundation	161	CY	123.19	m3	***$541.11***	$87,190
Basin Walls	159	CY	121.45	m3	***$880.79***	$139,910
Over Baffle Wall	0	CY	0.00	m3	***$880.79***	$0
Under Baffle Wall	0	CY	0.00	m3	***$880.79***	$0
Serpentine Baffle Wall	0	CY	0.00	m3	***$880.79***	$0
Elevated Slab	62	CY	47.61	m3	***$1,333.77***	$83,050
Flocc Bearing Supports	14	EA			$1,088.04	$15,233
Electrical Room						
Slab on Grade	4	CY	3.21	m3	***$490.62***	$2,062
Allowance for Misc Items	5%				$327,443.98	$16,372
Subtotal						$343,816
MASONRY:	**Moderate**					
CMU Building	0	SF	0.00	m2	***$165.31***	$0
Electrical Room	113	SF	10.54	m2	***$165.31***	$18,761
Subtotal	113					$18,761
METALS:						
Aluminum Handrail	422	LF	128.71	m	***$90.92***	$38,394
Stairs (1 set per basin)	29	RISERS			***$495.92***	$4,959
Allowance for Misc Items	10%				$43,353.20	$4,335
Subtotal						$47,689
WOODS & PLASTICS:						
FRP Weir	100	LF	30.48	m	$44.38	$4,438
FRP Ladder	4	EA			$2,140.28	$8,561
Allowance for Misc Items	5%				$12,999.07	$650
Subtotal						$13,649
THERMAL & MOISTURE PROTECTION:						
Concrete Liner	0	SF	0.00	m2	**$16.00**	$0
Allowance for Misc Items	10%				$0.00	$0
Subtotal						$0

Flocculation Rapid Mix

DOORS & WINDOWS:						
Stainless Steel Door (2' x 2') for O/U Baffling	0	EA			$1,420.15	$0
Stainless Steel Door (7' x 2.5') for O/U Baffling	0	EA			$6,213.15	$0
Stainless Steel Door (2' x 2') for Serpentine Baffling	0	EA			$1,420.15	$0
Allowance for Misc Items	5%				$0.00	$0
Subtotal						$0
EQUIPMENT:						
Horizontal Paddle Wheel Flocculation Mechanism (Paddles & Drives)	100	LF	30.48	m	***$3,621.74***	$362,174
Vertical Paddle Wheel Flocculation Mechanism (Paddles & Drives)	0	EA			***$0.00***	$0
Vertical Turbine Flocculation Mechanism (Turbines & Drives)	0	hp	0.00	kW	***$0.00***	$0
Vertical Turbine Flocculator VFD's	0	hp	0.00	kW	***$0.00***	$0
Fabricated Slide Gate	2	EA			***$10,248.21***	$20,496
Allowance for Misc Items	10%				$382,670.09	$38,267
Subtotal						$420,937
ELECTRICAL:						
MCC's						
Sections	7	EA			***$11,437.23***	$22,874
AFD's						
	2	EA			***$20,072.33***	$40,145
Flocculation Mixers Stage 1 (total facility) (76 hp each)	0	EA			***$9,449.67***	$0
Flocculation Mixers Stage 2 (total facility) (0 hp each)	0	EA			***$9,449.67***	$0
Flocculation Mixers Stage 3 (total facility) (0 hp each)	0	EA			***$9,449.67***	$0
Flocculation Mixers Stage 4 (total facility) (0 hp each)	0	EA			***$9,449.67***	$0
Flocculation Mixers Stage 5 (total facility) (0 hp each)	0	EA			***$9,449.67***	$0
Flocculation Mixers Stage 6 (total facility) (0 hp each)						
Switchgear						
Units	0	EA			***$52,611.28***	$0
Electrical Conduit & Wire	434	LF	132.28	m	***$12.85***	$5,578
Allowance for Misc Items	10%				$68,597.54	$6,860
Subtotal						$75,457
INSTRUMENTS & CONTROLS						
Instruments						
Level Switch	2	EA			***$741.26***	$1,483
Number of Analog I/O Counts	5	EA			***$281.68***	$1,352

Flocculation Rapid Mix

Number of Digital I/O Counts	12	EA			*$66.71*	$801
Number of PLC's	1	EA			*$13,935.73*	$13,936
I&C Conduit & Wire	836	LF	254.81	m	*$12.85*	$10,746
Allowance for Misc Items	10%				$28,316.40	$2,832
Subtotal						$31,148
Subtotal						$1,007,735

ALLOWANCES:		User Override		
Finishes Allowance	2.00%		$1,095,364	$21,907
I&C Allowance	2.00%		$1,095,364	$21,907
Mechanical Allowance	2.00%		$1,095,364	$21,907
Electrical Allowance	2.00%		$1,095,364	$21,907

					Facility Cost Name
Facility Cost	**295,000,000**	**GPD**	**$0.00**	**$1,095,364**	FCPFC01

Sedimentation Basins

Description	Quantity (English)	Unit (English)	Quantity (Metric)	Unit (Metric)	$/Unit	Total Cost
Cell - Surface Flow						
Sitework:						
Clear & Grub	29.20	acres	11.82	ha	*$2,965.05*	$86,579
Topsoil Stripping, Stockpiling & Re-Applying	0	CY	0.00	m3	*$9.27*	$0
Excavation	0	CY	57429.54	m3	*$6.72*	$0
Backfill	0	CY	37233.82	m3	*$8.27*	$0
Cell Lining (HDPE)	768,828	SF	71426.46	m2	*$0.67*	$515,872
Rip Rap	0	CY	0.00	m3	*$65.53*	$0
Perimeter Public Deterrent Fence	0	LF	0.00	m	*$37.06*	$0
Berm	13,525	CY	10340.63	m3	*$7.41*	$0
Gravel Road on Top of Berms	0	CY	0.00	m3	*$74.13*	$0
Berm Sideslope/Upland Vegetation:						
Hydro seeding	0.00	acres	0.00	ha	*$3,228.94*	$0
Shrubs	2.99	acres	1.21	ha	*$0.00*	$0
Trees	2.99	acres	1.21	ha	*$0.00*	$0
Media:						
Sand	0.00	CY	0.00	m3	*$51.74*	$0
Gravel 1 (3/8 inch Stone)	0.00	CY	0.00	m3	*$46.55*	$0
Gravel 2 (1/2 inch Stone)	0.00	CY	0.00	m3	*$60.64*	$0
Drainage Gravel (1-1/2 inch	0.00	CY	0.00	m3	*$54.71*	$0
Peat Moss	0.00	CY	0.00	m3	*$86.00*	$0
Organic Wood Chips	0.00	CY	0.00	m3	*$70.00*	$0
Light Weight Aggregate (LWA)	0.00	CY	0.00	m3	*$95.48*	$0
LWA Transportation	0.00	mi	0.00	km	*$0.00*	$0
Zeolite	0.00	CY	0.00	m3	*$253.83*	$0
Zeolite Transportation	0.00	mi	0.00	km	*$0.00*	$0
Basalt	0.00	CY	0.00	m3	*$30.22*	$0
Basalt Transportation	0.00	mi	0.00	km	*$0.00*	$0
Other Media ()	0.00	CY	0.00	m3	*$0.00*	$0
Insulation Plywood (3/4")	0.00	SF	0.00	m2	*$1.81*	$0
Berm Insulation	0.00	SF	0.00	m2	*$1.99*	$0
Under Drain	0.00	SF	0.00	m2	*$8.66*	$0
Nuisance Wildlife Control:						
Muskrat Fence	0	LF	0.00	m	*$22.24*	$0
Geese/Other Bird Exclusion Fencing (Temporary)	0	LF	0.00	m	*$22.24*	$0
Waterfowl Overhead Wiring and Bird Scare Tape	0	acres	0.00	ha	*$2,815.71*	$0
Mosquito Control (bird nesting boxes, bat roosting boxes, chemical)	0	LS			*$741.26*	$0
Edge Plantings of Shrubs (fascines, live stakes, potted plants)	0	LF	0.00	m	*$29.65*	$0
Piping:						

Sedimentation Basins

Pipe 1 (inch diameter, Corrugated Steel)	0	LF	0.00	m	*$0.00*	$0
Pipe 2 (inch diameter, RCP)	0	LF	0.00	m	*$0.00*	$0
Pipe 3 (inch diameter, PVC)	0	LF	0.00	m	*$15.95*	$0
Pipe 4 (inch diameter, RCP)	0	LF	0.00	m	*$0.00*	$0
Pipe 5 (inch diameter, Perforated PVC)	0	LF	0.00	m	*$12.96*	$0
Pipe 6 (inch diameter, HDPE)	0	LF	0.00	m	*$0.00*	$0
Pipe 7 (inch diameter, HDPE)	0	LF	0.00	m	*$0.00*	$0
Pipe 8 (inch diameter, HDPE)	0	LF	0.00	m	*$0.00*	$0
Pipe 9 (inch diameter, HDPE)	0	LF	0.00	m	*$0.00*	$0
Pipe 10 (inch diameter, HDPE)	0	LF	0.00	m	*$0.00*	$0
Open Channel Excavation:						
Open Channel 1 (50 ' wide, 6 ' deep)	26,311	CY	20116.29	m3	*$7.41*	$195,034
Open Channel 2 (50 ' wide, 6 ' deep)	15,622	CY	11944.05	m3	*$7.41*	$115,802
Open Channel 3 (' wide, ' deep)	0	CY	0.00	m3	*$7.41*	$0
Open Channel 4 (' wide, ' deep)	0	CY	0.00	m3	*$7.41*	$0
Open Channel 5 (' wide, ' deep)	0	CY	0.00	m3	*$7.41*	$0
Open Channel 6 (' wide, ' deep)	0	CY	0.00	m3	*$7.41*	$0
Open Channel Lining:						
Open Channel 1 (Lining: RipRap)	80,049	SF	7436.84	m2	*$2.43*	$194,276
Open Channel 2 (Lining: RipRap)	47,549	SF	4417.49	m2	*$2.43*	$115,400
Open Channel 3 (Lining: None)	0	SF	0.00	m2	*$0.00*	$0
Open Channel 4 (Lining: None)	0	SF	0.00	m2	*$0.00*	$0
Open Channel 5 (Lining: Concrete)	0	SF	0.00	m2	*$7.32*	$0
Open Channel 6 (Lining: RipRap)	0	SF	0.00	m2	*$2.43*	$0
Open Channel Guard Rail (included if "Side Slope Ratio" is steeper than 3:1)						
Open Channel 1 (Lining: RipRap, Side Slope Ratio: 4)	0	LF	0.00	m	*$96.36*	$0
Open Channel 2 (Lining: RipRap, Side Slope Ratio: 4)	0	LF	0.00	m	*$96.36*	$0
Open Channel 3 (Lining: None, Side Slope Ratio:)	0	LF	0.00	m	*$96.36*	$0
Open Channel 4 (Lining: None, Side Slope Ratio:)	0	LF	0.00	m	*$96.36*	$0
Open Channel 5 (Lining: Concrete, Side Slope Ratio:)	0	LF	0.00	m	*$96.36*	$0
Open Channel 6 (Lining: RipRap, Side Slope Ratio:)	0	LF	0.00	m	*$96.36*	$0
Pumps						
Pump and Motor	0	EA			*$0.00*	$0
Pump Concrete Pad	0	sf	0.00	m2	*$490.62*	$0
Siphons						

Sedimentation Basins

Siphon	0	EA			*$0.00*	$0
Siphon Box	0	EA			***$21,839.74***	$0
Actuated Valves						
Actuated Valves (inch)	0	EA			***$6,832.14***	$0
Oxygenation System	0	lb/d	0.00	kg/d	***$0.00***	$0
Wetland Vegetation:						
Hydro seeding	0.00	acres	0.00	ha	***$3,228.94***	$0
Muck Transferring	0	CY	0.00	m3	***$37.06***	$0
Plantings (per sy density)	0	EA			***$8.90***	$0
Water Control Structures:						
Major Structures	0	EA			***$66,713.61***	$0
Moderate Structures	0	EA			***$11,118.93***	$0
Minor Structures	0	EA			***$4,447.57***	$0
Manholes (feet diameter)	0	EA			***$21,839.74***	$0
Instrumentation:						
Flow (parshall flume/magmeter)	2	EA			***$15,000.00***	$30,000
Level/w eir	2	EA			***$7,000.00***	$14,000
Ambient Conditions	0	EA			***$741.26***	$0
Allow ance for Misc Items	5%				$1,266,963.03	$63,348
TOTAL						$1,330,311

Cell - Surface Flow	**17.65**	**Acre**	**$75,371.74**	**$1,330,311**

Liquid Chemical Alum

Description	Quantity (English)	Unit (English)	Quantity (Metric)	Unit (Metric)	$/Unit	Total Cost
SITEWORK:						
Excavation	274.27	CY	209.70	m3	$6.72	$1,844
Imported Structural Backfill	264.44	CY	202.18	m3	$50.94	$13,471
Native Backfill	13.50	CY	10.32	m3	$8.27	$112
Haul Excess	260.78	CY	199.38	m3	$8.27	$2,155
Allowance for Misc Items	5%				$17,582.13	$879
Subtotal						$18,461
CONCRETE:						
Slab on Grade	107.66	CY	82.31	m3	$490.62	$52,820
Containment Walls	16.28	CY	12.44	m3	$880.79	$14,336
Bulk Tank Pads	178.72	CY	136.64	m3	$490.62	$87,684
Day Tank Pads	0.00	CY	0.00	m3	$490.62	$0
Transfer Pump Pads	0.00	CY	0.00	m3	$490.62	$0
Metering Pump Pads	2.00	CY	1.53	m3	$490.62	$981
Corridor						
Slab on Grade	0.00	CY	0.00	m3	$490.62	$0
Electrical Room						
Slab on Grade	3.78	CY	2.89	m3	$490.62	$1,853
Allowance for Misc Items	5%				$157,674.82	$7,884
Subtotal						$165,559
MASONRY:	Moderate					
Chemical Building	(102.00)	SF	(9.48)	m2	$198.37	$0
Electrical Room	102.00	SF	9.48	m2	$165.31	$16,861
Subtotal	0.00					$16,861
METALS:						
Canopy	3570.00	SF	331.66	m2	$44.56	$8,912
Metal Stairway	1	EA			$8,875.92	$8,876
Grating	1	EA			$2,130.22	$2,130
Allowance for Misc Items	10%				$19,917.68	$1,992
Subtotal						$21,909
EQUIPMENT:						
Bulk Tank	8	EA			$39,280.17	$314,241
Day Tank	0	EA			$0.00	$0
Transfer Pump	0	EA			$0.00	$0
Metering Pump	3	EA			$11,361.16	$34,083
Allowance for Misc Items	10%				$348,324.86	$34,832
Subtotal						$383,157
INSTRUMENTS & CONTROLS						
Instruments						
Chemical Tank Radar Level Transmitters	8	EA			$1,111.89	$8,895
Chemical Tank Beacons	8	EA			$1,111.89	$8,895
Day Tank Differential Pressure Transmitter	0	EA			$1,111.89	$0
Drum or Tote Weigh Scale	0	EA			$1,482.52	$0

Metering Pump Discharge Pressure Switch	3	EA			*$741.26*	$2,224
Magmeter	1	EA			*$741.26*	$741
Sump Pump Float Switch	1	EA			*$370.63*	$371
Eyewash	1	EA			*$1,111.89*	$1,112
Number of Analog I/O Counts	15	EA			*$281.68*	$4,225
Number of Digital I/O Counts	40	EA			*$66.71*	$2,669
Number of Local Panels	1	EA			*$13,935.73*	$13,936
Number of PLCs	1	EA			*$14,825.25*	$14,825
I&C Conduit & Wire	1496.00	LF	455.98	m	*$12.85*	$19,229
Allowance for Misc Items	10%				$77,121.40	$7,712
Subtotal						$84,834
MECHANICAL:						
Pipe						
Chemical Transfer Pump Suction Header Piping-CTSH (1-inch, Exposed, PVC)	0.00	LF	0.00	m	*$13.97*	$0
Chemical Transfer Pump Discharge Header Piping-CTDH (1-inch, Exposed, PVC)	0.00	LF	0.00	m	*$13.97*	$0
Chemical Metering Pump Suction Header Piping-LCSH (2-inch, Exposed, PVC)	119.00	LF	36.27	m	*$19.60*	$2,333
Chemical Metering Pump Discharge Header Piping-LCDH (1-inch, Exposed, PVC)	119.00	LF	36.27	m	*$13.97*	$1,663
Elbows						
Chemical Transfer Pump Suction Header Piping-CTSH (1-inch, Exposed, PVC)	0	EA			*$10.72*	$0
Chemical Transfer Pump Discharge Header Piping-CTDH (1-inch, Exposed, PVC)	0	EA			*$10.72*	$0
Chemical Metering Pump Suction Header Piping-LCSH (2-inch, Exposed, PVC)	12	EA			*$37.22*	$447
Chemical Metering Pump Discharge Header Piping-LCDH (1-inch, Exposed, PVC)	12	EA			*$10.72*	$129
Tees						
Chemical Transfer Pump Suction Header Piping-CTSH (1-inch, Exposed, PVC)	0	EA			*$11.16*	$0
Chemical Transfer Pump Discharge Header Piping-CTDH (1-inch, Exposed, PVC)	0	EA			*$11.16*	$0
Chemical Metering Pump Suction Header Piping-LCSH (2-inch, Exposed, PVC)	3	EA			*$51.50*	$154

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Chemical Metering Pump Discharge Header Piping-LCDH (1-inch, Exposed, PVC)	3	EA			*$11.16*	$33
End Caps						
Chemical Transfer Pump Suction Header Piping-CTSH (1-inch, Exposed, PVC)	0	EA			*$6.02*	$0
Chemical Transfer Pump Discharge Header Piping-CTDH (1-inch, Exposed, PVC)	0	EA			*$6.02*	$0
Chemical Metering Pump Suction Header Piping-LCSH (2-inch, Exposed, PVC)	2	EA			*$19.03*	$38
Chemical Metering Pump Discharge Header Piping-LCDH (1-inch, Exposed, PVC)	2	EA			*$6.02*	$12
Valves						
Chemical Metering Pump Suction Header Piping-LCSH (2-inch, Exposed, PVC, V-902, Diaphragm)	0	EA			*$60.90*	$0
Chemical Metering Pump Suction Header Piping-LCSH (2-inch, Exposed, PVC, V-902, Diaphragm)	0	EA			*$60.90*	$0
Chemical Metering Pump Suction Header Piping-LCSH (2-inch, Exposed, PVC, V-902, Diaphragm)	6	EA			*$309.89*	$1,859
Chemical Metering Pump Discharge Header Piping-LCDH (1-inch, Exposed, PVC, V-902, Diaphragm)	6	EA			*$60.90*	$365
Allowance for Misc Items	10%				$7,033.76	$703
Subtotal						$7,737
ELECTRICAL:						
# MCC Sections	7	#			*$11,437.23*	$34,312
Switchgear	0	EA			*$52,611.28*	$0
Adjustable Frequency Drives						
Metering Pumps	0	EA			***$9,519.55***	$0
User Defined Item #1	0	EA			***$9,449.67***	$0
User Defined Item #2	0	EA			***$9,449.67***	$0
User Defined Item #3	0	EA			***$9,449.67***	$0
Electrical Conduit & Wire	204.00	LF	62.18	m	*$12.85*	$2,622
Allowance for Misc Items	10%				$36,933.82	$3,693
Subtotal						$40,627
Subtotal						$739,146

ALLOWANCES:		User Override		
Finishes Allowance	2.00%		$821,273	$16,425
I&C Allowance	2.00%		$821,273	$16,425

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Mechanical Allowance	4.00%		$821,273	$32,851
Electrical Allowance	2.00%		$821,273	$16,425

Facility Cost Name

Facility Cost	**3,570**	**Building SF**	**$230.05**	**$821,273**	CFLFC01

Flocculation Mixers

Description	Quantity (English)	Unit (English)	Quantity (Metric)	Unit (Metric)	$/Unit	Total Cost
SITEWORK:						
Excavation	5,184	CY	3,963.11	m3	***$6.72***	$0
Imported Structural Backfill	818	CY	625.28	m3	***$50.94***	$0
Native Backfill	948	CY	724.71	m3	***$8.27***	$0
Haul Excess	4,236	CY	3,238.40	m3	***$8.27***	$0
Allowance for Misc Items	5%				$0.00	$0
Subtotal						$0
CONCRETE:						
Influent Channel:						
Foundation	0	CY	0.00	m3	***$541.11***	$0
Walls	0	CY	0.00	m3	***$880.79***	$0
Elevated Slab	0	CY	0.00	m3	***$1,333.77***	$0
Flocc Basin						
Foundation	757	CY	578.47	m3	***$541.11***	$0
Basin Walls	1,937	CY	1,481.21	m3	***$880.79***	$0
Over Baffle Wall	0	CY	0.00	m3	***$880.79***	$0
Under Baffle Wall	0	CY	0.00	m3	***$880.79***	$0
Serpentine Baffle Wall	0	CY	0.00	m3	***$880.79***	$0
Elevated Slab	0	CY	0.00	m3	***$1,333.77***	$0
Flocc Bearing Supports	14	EA			$5,959.42	$83,432
Electrical Room						
Slab on Grade	4	CY	3.21	m3	***$490.62***	$2,062
Allowance for Misc Items	5%				$85,494.21	$4,275
Subtotal						$89,769
MASONRY:	**Moderate**					
CMU Building	0	SF	0.00	m2	***$165.31***	$0
Electrical Room	113	SF	10.54	m2	***$165.31***	$18,761
Subtotal	113					$18,761
METALS:						
Aluminum Handrail	959	LF	292.26	m	***$90.92***	$0
Stairs (1 set per basin)	260	RISERS			***$495.92***	$0
Allowance for Misc Items	10%				$0.00	$0
Subtotal						$0
WOODS & PLASTICS:						
FRP Weir	100	LF	30.48	m	$44.38	$4,438
FRP Ladder	4	EA			$10,689.56	$42,758
Allowance for Misc Items	5%				$47,196.21	$2,360
Subtotal						$49,556

Flocculation Mixers

THERMAL & MOISTURE PROTECTION:						
Concrete Liner	0	SF	0.00	m2	**$16.00**	$0
Allowance for Misc Items	10%				$0.00	$0
Subtotal						$0
DOORS & WINDOWS:						
Stainless Steel Door (2' x 2') for O/U Baffling	0	EA			$1,420.15	$0
Stainless Steel Door (7' x 2.5') for O/U Baffling	0	EA			$6,213.15	$0
Stainless Steel Door (2' x 2') for Serpentine Baffling	0	EA			$1,420.15	$0
Allowance for Misc Items	5%				$0.00	$0
Subtotal						$0
EQUIPMENT:						
Horizontal Paddle Wheel Flocculation Mechanism (Paddles & Drives)	100	LF	30.48	m	***$3,621.74***	$362,174
Vertical Paddle Wheel Flocculation Mechanism (Paddles & Drives)	0	EA			***$0.00***	$0
Vertical Turbine Flocculation Mechanism (Turbines & Drives)	0	hp	0.00	kW	***$0.00***	$0
Vertical Turbine Flocculator VFD's	0	hp	0.00	kW	***$0.00***	$0
Fabricated Slide Gate	2	EA			***$10,248.21***	$20,496
Allowance for Misc Items	10%				$382,670.09	$38,267
Subtotal						$420,937
ELECTRICAL:						
MCC's						
Sections	7	EA			***$11,437.23***	$22,874
AFD's						
Flocculation Mixers Stage 1 (total facility) (196 hp each)	2	EA			***$36,844.95***	$73,690
Flocculation Mixers Stage 2 (total facility) (0 hp each)	0	EA			***$9,449.67***	$0
Flocculation Mixers Stage 3 (total facility) (0 hp each)	0	EA			***$9,449.67***	$0
Flocculation Mixers Stage 4 (total facility) (0 hp each)	0	EA			***$9,449.67***	$0
Flocculation Mixers Stage 5 (total facility) (0 hp each)	0	EA			***$9,449.67***	$0
Flocculation Mixers Stage 6 (total facility) (0 hp each)	0	EA			***$9,449.67***	$0
Switchgear						

Flocculation Mixers

Units	0	EA			*$52,611.28*	$0
Electrical Conduit & Wire	434	LF	132.28	m	*$12.85*	$5,578
Allowance for Misc Items	10%				$102,142.79	$10,214
Subtotal						$112,357
INSTRUMENTS & CONTROLS:						
Instruments						
Level Switch	2	EA			*$741.26*	$1,483
Number of Analog I/O Counts	5	EA			*$281.68*	$1,352
Number of Digital I/O Counts	12	EA			*$66.71*	$801
Number of PLC's	1	EA			*$13,935.73*	$13,936
I&C Conduit & Wire	836	LF	254.81	m	*$12.85*	$10,746
Allowance for Misc Items	10%				$28,316.40	$2,832
Subtotal						$31,148
Subtotal						$722,528

ALLOWANCES:		**User Override**			
Finishes Allowance	2.00%		$785,357	$15,707	
I&C Allowance	2.00%		$785,357	$15,707	
Mechanical Allowance	2.00%		$785,357	$15,707	
Electrical Allowance	2.00%		$785,357	$15,707	
					Facility Cost Name
Facility Cost	**295,000,000**	**GPD**	**$0.00**	**$785,357**	FCPFC01

Capital Costs Dewatering Facility

CAPITAL COSTS	SCREW PRESS	CENTRIFUGE
Number of Installed Dewatering Units	6	3
Equipment Cost Per Emulsion Polymer System	35000	40000
Equipment Cost Per Cake Conveyance System	55000	65000
Equipment Cost Per Dewatering Unit	$467,000	$600,000
Total Equipment Cost Per Dewatering Unit	$557,000	$705,000
Total Direct Equipment Costs	**$3,342,000**	**$2,115,000**
Installation	$501,300	$317,250
Project Installed Capital Cost	**$3,843,300**	**$2,432,250**
Dewatering Building	$1,876,000	$1,407,000
Total Project Capital Cost	**$5,719,300**	**$3,839,250**
Construction Markups		
Demolition	$0	$0
Mechanical process piping	$457,544	$307,140
Intsrumentation and control	$343,158	$230,355
Electrical	$514,737	$345,533
Capital Costs With Construction Markups	**$7,034,739**	**$4,722,278**
Contractor Markups		
Contractor Overhead	$844,169	$566,673
Contractor Profit	$703,474	$472,228
Mobilization, Demobilization, Bonds, and Insurance	$211,042	$141,668
Capital Costs With Construction and Contractor Markups	**$8,793,424**	**$5,902,847**
Contingency	$2,638,027	$1,770,854
Total Construction Cost	**$11,431,451**	**$7,673,701**
Non-Construction Costs		
Engineering, Legal and Administration	$2,286,290	$1,534,740
TOTAL CAPITAL COSTS	**$13,717,741**	**$9,208,441**

Return Activated Sludge WAS Pump Station

DESCRIPTION	QUANTITY (ENGLISH)	UNIT (ENGLISH)	QUANTITY (METRIC)	UNIT (METRIC)	$/UNIT	TOTAL COST
SITEWORK:						
Pump Station						
Excavation	546	CY	417.61	m3	$6.72	$3,672
Imported Structural Backfill	154	CY	118.03	m3	$50.94	$7,864
Native Backfill	140	CY	107.30	m3	$8.27	$1,160
Haul Excess	406	CY	310.31	m3	$8.27	$3,355
Electrical Room						
Excavation	83	CY	63.64	m3	$6.72	$560
Imported Structural Backfill	14	CY	10.47	m3	$50.94	$698
Native Backfill	63	CY	48.09	m3	$8.27	$520
Haul Excess	20	CY	15.54	m3	$8.27	$168
Allowance for Misc Items	5%				$17,996.08	$900
Subtotal						$18,896
CONCRETE:						
Pump Station						
Slab on Grade	64	CY	49.10	m3	$541.11	$34,752
Below Grade Vertical Walls	6	CY	4.50	m3	$880.79	$0
Pump Pads	4.28	CY	3.28	m3	$490.62	$2,102
Electrial Room						
Slab on Grade	7	CY	5.47	m3	$490.62	$3,513
Allowance for Misc Items	5%				$40,367.48	$2,018
Subtotal						$42,386
MASONRY:	**Moderate**					
CMU Building	0	SF	0.00	m2	$165.31	$0
Subtotal						$0
METALS:						
Pump Station Roof	0	SF	0.00	m2	$88.54	$0
Stairway	2	Risers			$495.92	$744
Handrail	159	LF	48.46	m	$90.92	$0
Allowance for Misc Items	10%				$743.88	$74
Subtotal						$818
EQUIPMENT:						
RAS Pump (Includes VFD, 1736 gpm, 30 hp per each)	3	EA			$126,397.62	$379,193
WAS Pump (Includes VFD, 347 gmp, 10 hp per each)	3	EA			$28,567.46	$85,702
Allowance for Misc Items	10%				$464,895.25	$46,490
Subtotal						$511,385

INSTRUMENTATION & CONTROLS:						
Instruments						
RAS Pump Suction Pipe Magmeter (RSP-SD	2.00	EA			***$15,694.33***	$31,389
Isolation Valve Actuators (Electric)	14.00	EA			***$6,800.71***	$0
Number of Analog I/O	3	EA			***$280.38***	$841
Number of Digital I/O Counts	84	EA			***$66.41***	$5,578
Number of Local Panels	6	EA			***$14,757.06***	$14,757
Number of PLC's	1	EA			***$13,871.63***	$13,872
I&C Conduit Wire	684.00	LF	208.48	m	***$12.79***	$8,751
Allowance for Misc Items	5%				$75,188.02	$3,759
Subtotal						$78,947
CONVEYING SYSTEMS:						
Monorail	0	LF	0.00	m	***$41.33***	$0
Monorail Crane	0	EA			***$4,091.32***	$0
Allowance for Misc Items	10%				$0.00	$0
Subtotal						$0
MECHANICAL:						
Pipe:						
RAS Pump Discharge Pipe (RSP-DD, 10 inch, Ductile Iron, Exposed)	17	LF	5.18	m	***$91.99***	$1,564
RAS Discharge Pipe Header Pipe (RSD-HD, 14 inch, Ductile Iron,	13	LF	3.96	m	***$128.78***	$1,674
RAS Pump Suction Pipe (RSP-SD, 10 inch, Ductile Iron, Exposed)	27	LF	8.08	m	***$91.99***	$2,438
RAS Suction Pipe Header Pipe (RSS-HD, 12 inch, Ductile Iron, Exposed)	9	LF	2.74	m	***$110.38***	$993
WAS Pump Discharge Pipe (WSP-DD, 4 inch, Ductile Iron, Exposed)	32	LF	9.79	m	***$36.79***	$1,182
WAS Pump Suction Pipe (WSP-SD, 4 inch, Ductile Iron, Exposed)	80	LF	24.23	m	***$36.79***	$2,925
Clarifier RAS/WAS Supply Pipe (CRW-SD, 14 inch, Ductile Iron, Buried)	12	LF	3.73	m	***$128.78***	$1,576
Elbows:						
RAS Pump Discharge Pipe (RSP-DD, 10 inch, Ductile Iron)	6.00	EA			***$1,930.67***	$11,584
RAS Discharge Pipe Header Pipe (RSD-HD, 14 inch, Ductile Iron)	0.00	EA			***$2,702.93***	$0
RAS Pump Suction Pipe (RSP-SD, 10 inch, Ductile Iron)	0.00	EA			***$1,930.67***	$0

RAS Suction Pipe Header Pipe (RSS-HD, 12 inch, Ductile Iron)	0.00	EA	*$2,316.80*	$0
WAS Pump Discharge Pipe (WSP-DD, 4 inch, Ductile Iron)	6.00	EA	*$772.27*	$4,634
WAS Pump Suction Pipe (WSP-SD, 4 inch, Ductile Iron)	2.00	EA	*$772.27*	$1,545
Clarifier RAS/WAS Supply Pipe (CRW-SD, 14 inch, Ductile Iron)	0.00	EA	*$2,702.93*	$0
End Caps:				
RAS Pump Discharge Pipe (RSP-DD, 10 inch, Ductile Iron)	0.00	EA	*$479.15*	$0
RAS Discharge Pipe Header Pipe (RSD-HD, 14 inch, Ductile Iron)	0.00	EA	*$670.81*	$0
RAS Pump Suction Pipe (RSP-SD, 10 inch, Ductile Iron)	0.00	EA	*$479.15*	$0
RAS Suction Pipe Header Pipe (RSS-HD, 12 inch, Ductile Iron)	0.00	EA	*$574.98*	$0
WAS Pump Discharge Pipe (WSP-DD, 4 inch, Ductile Iron)	0.00	EA	*$191.66*	$0
WAS Pump Suction Pipe (WSP-SD, 4 inch, Ductile Iron)	0.00	EA	*$191.66*	$0
Clarifier RAS/WAS Supply Pipe (CRW-SD, 14 inch, Ductile Iron)	0.00	EA	*$670.81*	$0
Tee:				
RAS Pump Discharge Pipe (RSP-DD, 10 inch, Ductile Iron)	3.00	EA	*$3,205.82*	$9,617
RAS Discharge Pipe Header Pipe (RSD-HD, 14 inch, Ductile Iron)	0.00	EA	*$4,488.15*	$0
RAS Pump Suction Pipe (RSP-SD, 10 inch, Ductile Iron)	0.00	EA	*$3,205.82*	$0
RAS Suction Pipe Header Pipe (RSS-HD, 12 inch, Ductile Iron)	2.00	EA	*$3,846.99*	$7,694
WAS Pump Discharge Pipe (WSP-DD, 4 inch, Ductile Iron)	0.00	EA	*$1,282.33*	$0
WAS Pump Suction Pipe (WSP-SD, 4 inch, Ductile Iron)	4.00	EA	*$1,282.33*	$5,129
Clarifier RAS/WAS Supply Pipe (CRW-SD, 14 inch, Ductile Iron)	0.00	EA	*$4,488.15*	$0
Crosses:				
RAS Pump Discharge Pipe (RSP-DD, 10 inch, Ductile Iron)	0.00	EA	*$4,274.43*	$0

Return Activated Sludge WAS Pump Station

RAS Discharge Pipe Header Pipe (RSD-HD, 14 inch, Ductile Iron)	0.00	EA			*$5,984.20*	$0
RAS Pump Suction Pipe (RSP-SD, 10 inch, Ductile Iron)	0.00	EA			*$4,274.43*	$0
RAS Suction Pipe Header Pipe (RSS-HD, 12 inch, Ductile Iron)	1.00	EA			*$5,129.32*	$5,129
WAS Pump Discharge Pipe (WSP-DD, 4 inch, Ductile Iron)	0.00	EA			*$1,709.77*	$0
WAS Pump Suction Pipe (WSP-SD, 4 inch, Ductile Iron)	0.00	EA			*$1,709.77*	$0
Clarifier RAS/WAS Supply Pipe (CRW-SD, 14 inch, Ductile Iron)	0.00	EA			*$5,984.20*	$0
Valves:						
RAS Pump Discharge Pipe (RSP-DD, 10inch)	3.00	EA			*$9,400.98*	$28,203
RAS Discharge Pipe Header Pipe (RSD-HD,	0.00	EA			*$13,161.38*	$0
RAS Pump Suction Pipe (RSP-SD, 10inch)	3.00	EA			*$9,400.98*	$28,203
RAS Suction Pipe Header Pipe (RSS-HD, 12inch)	2.00	EA			*$11,281.18*	$22,562
WAS Pump Discharge Pipe (WSP-DD, 4inch)	3.00	EA			*$3,760.39*	$11,281
WAS Pump Suction Pipe (WSP-SD, 4inch)	3.00	EA			*$3,760.39*	$11,281
Clarifier RAS/WAS Supply Pipe (CRW-SD, 14inch)	0.00	EA			*$13,161.38*	$0
Allowance for Misc Items	5%				$159,215.03	$7,961
Subtotal						$167,176
ELECTRICAL:						
# MCC Sections	8.00	EA			*$11,384.63*	$68,308
Switchgear	0.00	EA			*$52,369.29*	$0
Adjustable Frequency Drives						
RAS Pumps (Active) (30 hp each)	2.00	EA			***$13,580.07***	$0
RAS Pumps (Standby) (30 hp each)	1.00	EA			***$13,580.07***	$0
WAS Pumps (Active) (10 hp each)	2.00	EA			***$10,797.49***	$0
WAS Pumps (Standby) (10 hp each)	1.00	EA			***$10,797.49***	$0
Electrical Conduit & Wire	256.50	LF	78.18	m	*$12.79*	$3,282
Allowance for Misc Items	10%				$71,589.52	$7,159
Subtotal						$78,748
Subtotal						$898,356

User Override

ALLOWANCES:

Return Activated Sludge WAS Pump Station

Finishes Allowance	2.00%		$1,009,389	$ 20,187.79
I&C Allowance	2.00%		$ 1,009,389.27	$ 20,187.79
Mechanical Allowance	5.00%		$ 1,009,389.27	$ 50,469.46
Electrical Allowance	2.00%		$ 1,009,389.27	$ 20,187.79
Facility Cost	**120.0**	**Total Pump HP**	**$ 8,411.58**	**$1,009,389**

Appendix C. Cost Support for Option 3 HWTT

HYBRID WETLAND TREATMENT TECHNOLOGY
C-43 WEST BASIN STORAGE RESERVOIR TREATMENT PROJECT

Operations & Maintenance Cost Estimate
Scenario 3

Appended to Conceptual Design & Cost Estimates Dated April 2021

Prepared By:
Watershed Technologies, LLC

June 2021

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IV. Scenario 3: Updated Performance Assumed for Reservoir Direct Alum Injection

A. Treatment Process

A third HWTT alternative has been developed using a set of assumptions *with updated projected nutrient removal performance* from a Reservoir in-line alum injection system (Scenario 3); this Scenario is appended to the HWTT April 2021 Report. Three Scenarios provide a range of Operations and Maintenance (O&M) costs for treatment of the C-43 WBSR with HWTT. **Scenario 3 is based on various assumptions, including inflow concentrations from the Reservoir to the HWTT system of 0.098 mg/L for TP and 1.34 mg/L for TN**. The following Scenario 3 objectives for the WBSR are: (1) meet effluent water quality targets of 0.088 milligrams per liter (mg/L) for total phosphorus (TP) and 1.23 mg/L for total nitrogen (TN) with average inflow values from the Reservoir of 0.098 mg/L and 1.34 mg/L for TP and TN, respectively (Table IV-1); (2) treat a set of given daily flows with an average of 456 cubic feet per second (cfs) (Table IV-1); and (3) constrain capital facilities within the Western and Central Parcels of the designated Project available land (Figure I-1 of the April 2021 Report). The objectives for the proposal have been provided by J-Tech. The Conceptual Design and cost projections are based on various assumptions (see Section D. Assumptions Scenario 3). For Scenario 3, the TP is reduced beyond the target to 0.087 mg/L, since N reduction determines the treatment process. The HWTT removal efficiencies are based on performance of other HWTT facilities currently being operated throughout the state of Florida and contemporary jar tests being performed by the South Florida Water Management District (SFWMD). The conceptual design processes are depicted in Figure I-2 of the April 2021 Report.

Table IV-1. Treated Flow and Effluent Nutrient Targets Scenario 3.

	HWTT Treated Flow to Achieve TP Outflow Targets				
Month	Reservoir Inflow TP (mg/L)	Reservoir Outflow/HWTT Inflow TP (mg/L)	Outflow Target (mg/L)	HWTT Outflow Conc (mg/L)	Total Flow
1	0.152	0.098	0.088	0.087	450.00
2	0.152	0.098	0.088	0.087	611.00
3	0.152	0.098	0.088	0.087	529.00
4	0.152	0.098	0.088	0.087	550.00
5	0.152	0.098	0.088	0.087	611.00
6	0.152	0.098	0.088	0.087	489.00
7	0.152	0.098	0.088	0.087	548.00
8	0.152	0.098	0.088	0.087	256.00
9	0.152	0.098	0.088	0.087	189.00
10	0.152	0.098	0.088	0.087	339.00
11	0.152	0.098	0.088	0.087	450.00
12	0.152	0.098	0.088	0.087	450.00
Total					***5472.0***
Average	***0.152***	***0.098***	***0.088***	***0.087***	***456.0***
	HWTT Treated Flow to Achieve TN Outflow Targets				
Month	**Reservoir Inflow TN (mg/L)**	**Reservoir Outflow/HWTT Inflow TN (mg/L)**	**Outflow Target (mg/L)**	**HWTT Outflow Conc (mg/L)**	**Total Flow**
1	1.810	1.340	1.230	1.230	450.00
2	1.810	1.340	1.230	1.230	611.00
3	1.810	1.340	1.230	1.230	529.00
4	1.810	1.340	1.230	1.230	550.00
5	1.810	1.340	1.230	1.230	611.00
6	1.810	1.340	1.230	1.230	489.00
7	1.810	1.340	1.230	1.230	548.00
8	1.810	1.340	1.230	1.230	256.00
9	1.810	1.340	1.230	1.230	189.00
10	1.810	1.340	1.230	1.230	339.00
11	1.810	1.340	1.230	1.230	450.00
12	1.810	1.340	1.230	1.230	450.00
Total					***5472.0***
Average	***1.810***	***1.340***	***1.230***	***1.230***	***456.0***

B. Operations & Maintenance (Annual)

The projected O&M costs are based upon a set of assumptions contained within Section D. Assumptions Scenario 3. Under Scenario 3, the projected annual O&M costs are reduced by approximately 69% from the base Scenario 1 to $1,999,100 due to a reduction in chemical usage. Projected O&M costs under Scenario 3 are reduced by approximately 48% compared to Scenario 2, resulting from decreased chemical demand. All other costs are assumed to remain static and are consistent with Scenario 1. The three Scenarios provide a range of O&M costs for treatment of the C-43 WBSR with HWTT. A summary by expense type for Scenario 3 is presented in Table IV-2, and detailed Chemical costs for Scenario 2 are provided in Table IV-3.

Table IV-2. C-43 WBSR HWTT Treatment System Projected O&M by Category & Line Item Scenario 3.

WATERSHED TECHNOLOGIES, LLC HWTT						
C-43 WBSR Treatment Projected O&M Scenario 3						
See Notes & Assumptions						
Line Item Budget Category	**Description**	**Total by Line Item Category**	**%**		**Amount**	**% Allocated to Category**
Salaries	Salaries	$ 208,000	10.40%		$ 208,000	10.40%
Fringe Benefits	Fringe Benefits	15,912	0.80%		15,912	0.80%
Materials	Chemicals	1,521,878	76.13%			
	Equipment	94,180	4.71%			
	Vegetation	27,200	1.37%		1,643,258	82.20%
Residuals	Floc Management	14,280	0.71%		14,280	0.71%
Power & Fuel	Utilities/Fuel	70,450	3.52%		70,450	3.52%
Other	Berms & Grounds Maintenance	40,000	2.00%			
	Site Internet Service	7,200	0.36%		47,200	2.36%
Indirect Costs/Overhead	Indirect Costs/Overhead	0	0.00%		0	0.00%
Total		$ 1,999,100	100.00%		$ 1,999,100	100.00%

WATERSHED TECHNOLOGIES, LLC HWTT C-43 WBSR TREATMENT	
PROJECTED STATEMENT OF EXPENSES SCENARIO 3	
FOR THE YEAR ENDING DECEMBER 31, 2022	
(Unaudited)	
See Notes & Assumptions	
	Projected
Operations & Maintenance	
Labor	$ 208,000
Chemicals	1,521,878
Utilities/Fuel	70,450
Equipment, Tools & Supplies	94,180
Site Cell Phone/Internet	7,200
Ground Maintenance	40,000
Vegetation Management	27,200
Residual (Floc) Management	14,280
Fringe Benefits	15,912
Total Projected Expenses	$ 1,999,100

Materials

Materials for the HWTT system include chemicals, tools, supplies, equipment, and vegetation. Only Chemical costs vary from Scenario 1; all other costs remain static. Chemicals will be acquired from a certified chemical company at a bulk rate price. Safety procedures are followed for all deliveries and management thereafter. Disposal of the chemical residual (floc) is discussed under the O&M Residuals Section for Scenario 1 in the April 2021 Report. Detailed calculations of projected chemical costs total $1,521,878 as shown in Table IV-3 based upon an average 456 cfs and an intermittent effective dosing rate of 1.51 mg/L. The projected chemical costs are lower if the dosing rate does not fluctuate by month, that is, the average dosing rate is used for each month.

Table IV-3. Projected Chemicals Scenario 3.

C-43 WBSR HWTT TREATMENT SCENARI		31	28	31	30	31	30	31	31	30	31	31
Projected Chemicals		7	8	9	10	11	12	1	2	3	4	5
Chemicals	$ 1,521,878	$ 131,467	$ 144,079	$ 133,915	$ 158,480	$ 206,231	$ 130,883	$ 181,389	$ 60,923	$ 49,988	$ 45,460	$ 138,997
Total Monthly cfs	166,121	13,950.0	17,108.0	16,399.0	16,500.0	18,941.0	14,670.0	16,988.0	7,936.0	5,670.0	10,509.0	13,950.0
Ave. daily cfs	456.00	450.00	611.00	529.00	550.00	611.00	489.00	548.00	256.00	189.00	339.00	450.00
		Alum	Alum	Alum	Alum	Alum	Alum	Alum	Alum	Alum	Alum	Alum
Cost basis (unit)		Dry ton	Dry ton	Dry ton	Dry ton	Dry ton	Dry ton	Dry ton	Dry ton	Dry ton	Dry ton	Dry ton
Product cost per unit ($)	$ 200	200	200	200	200	200	200	200	200	200	200	200
Volume of product per unit (L)		1406	1406	1406	1406	1406	1406	1406	1406	1406	1406	1406
Al content of product (% by wt.)		4.41	4.41	4.41	4.41	4.41	4.41	4.41	4.41	4.41	4.41	4.41
Al mass (kg) per unit of product		82.4	82.4	82.4	82.4	82.4	82.4	82.4	82.4	82.4	82.4	82.4
Al concentration in product (g Al/L)		58.6	58.6	58.6	58.6	58.6	58.6	58.6	58.6	58.6	58.6	58.6
Product cost per liter ($)		0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142
Product cost per mg of Al ($)		0.000002	0.000002	0.000002	0.000002	0.000002	0.000002	0.000002	0.000002	0.000002	0.000002	0.000002
Specific gravity of product		1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33
Active ingredient in product (%)		48.5	48.5	48.5	48.5	48.5	48.5	48.5	48.5	48.5	48.5	48.5
Dosing rate (as ppm Al)	1.51	1.59	1.42	1.38	1.62	1.83	1.50	1.80	1.29	1.49	0.73	1.68
Flow rate (cfs)		1	1	1	1	1	1	1	1	1	1	1
Flow duration (days)		1	1	1	1	1	1	1	1	1	1	1
Conversion Factor cfs to L		2446575.55	2446575.55	2446575.55	2446575.55	2446575.5	2446575.55	2446575.55	2446575.55	2446575.55	2446575.55	2446575.55
Treated volume (L)		2446576	2446576	2446576	2446576	2446576	2446576	2446576	2446576	2446576	2446576	2446576
Treated volume (MG)		0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65
Volume of product required (L)		66	59	57	68	77	63	75	54	62	30	70
Volume of product required (gal)		18	16	15	18	20	17	20	14	16	8	19
Cost of product used for treated volume (L)		$9.42	$8.42	$8.17	$9.60	$10.89	$8.92	$10.68	$7.68	$8.82	$4.33	$9.96

C. Performance

The treatment discharge objectives specified for the C-43 WBSR treatment project for P and N are identified below for the HWTT system under Scenario 3; all other parameters remain the same as Scenario 1 in the April 2021 Report. All goals are attained in the proposal.

Total Phosphorus (TP) Removal

The ability to attain the C-43 WBSR Treatment Project TP goal reduction is demonstrated through performance statistics taken from the HWTT facilities shown graphically (Figure I-7 and Figure I-8 in April 2021 Report). Percent reductions range from 96% to 79%. The Trout Lake site (88% TP removal) was selected as most representative of treatment of Reservoir waters. (Wolff Ditch is not representative of performance as the site was constructed without all efficiency components due to lack of land availability.) Projected operating data for the C-43 WBSR Treatment Proposal Scenario 3, including projected TP mass removed and flow weighted concentrations in and out, are depicted graphically in Figure IV-1 and Figure IV-2; daily and total treated flows, TP mass in, TP mass out, and load are shown in Table IV-4.

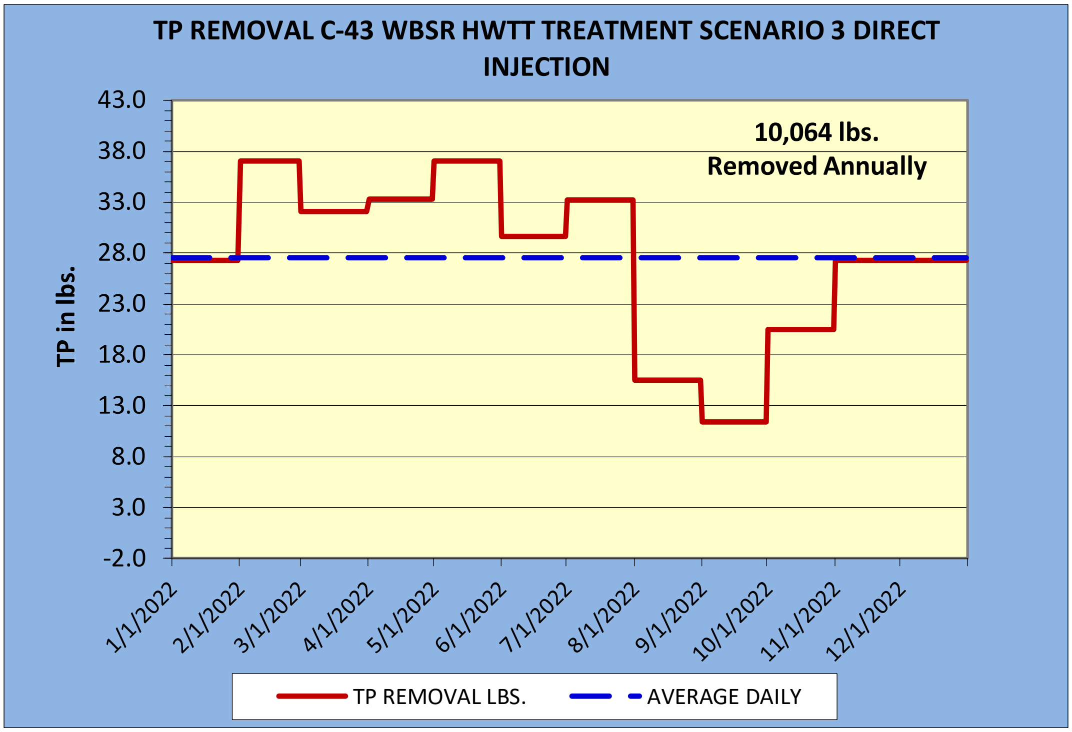

Figure IV-1. Projected Daily TP Removal C-43 WBSR HWTT Treatment System Scenario 3.

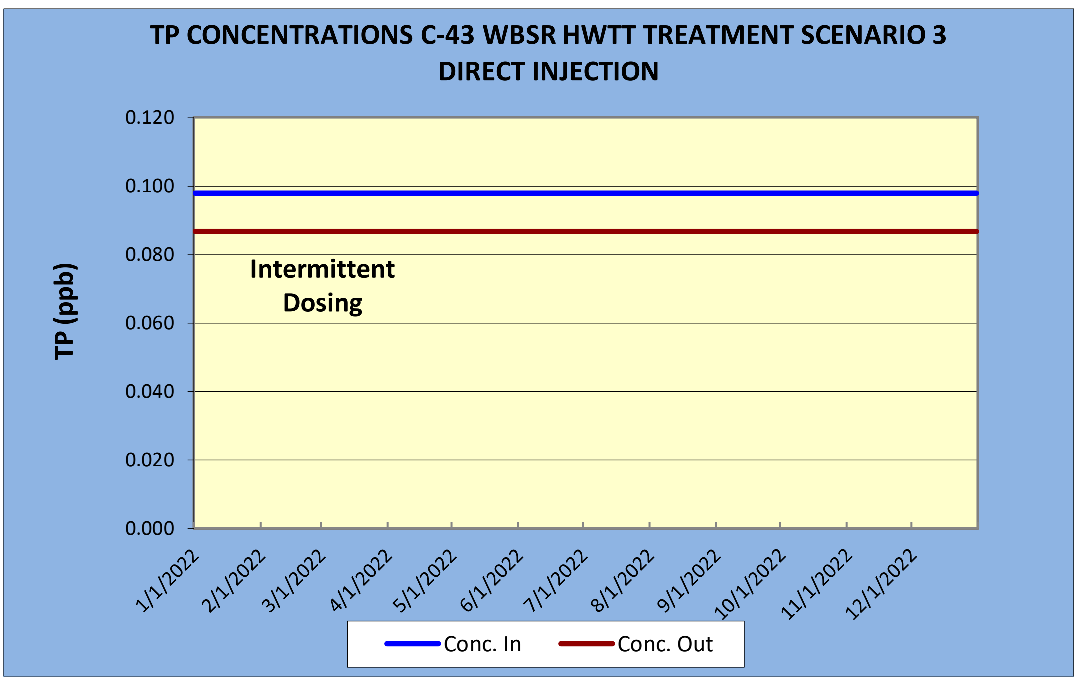

Figure IV-2. Projected Daily TP Concentrations C-43 WBSR HWTT Treatment System Scenario 3.

Table IV-4. TP Load Performance Calculations Scenario 3.

(Click to Open Linked File)

WATERSHED TECHNOLOGIES						
C-43 TP Reduction Total Scenario 3						
Period	1/1/2022	through	12/31/2022	365	days in period	
# of Days On-Line 365		# Days On-Line Flow > 0.0000 365		# Days in Period Flow > 0.0000 Less Uncontrollable Downtime: 365		% Time On-Line vs. Available Days Excl. Uncontrollable Downtime: 100%
	TP MASS (lbs.)		TP (lbs.)	AVERAGE	On-Line Unless	# Days Outflow >0
	INFLOW	OUTFLOW	REMOVAL	DAILY FLOW	Noted Otherwise	365
TOTAL	87809.9890	77746.0660	10063.9230	gpm On-Line Flow > 0	Operational/ Flow Status	
PER DAY	240.5753	213.0029	27.5724	204274.8		Comments
1/1/2022	237.8657	210.6039	27.2618	201974.0		
1/2/2022	237.8657	210.6039	27.2618	201974.0		
1/3/2022	237.8657	210.6039	27.2618	201974.0		
1/4/2022	237.8657	210.6039	27.2618	201974.0		
1/5/2022	237.8657	210.6039	27.2618	201974.0		
1/6/2022	237.8657	210.6039	27.2618	201974.0		
1/7/2022	237.8657	210.6039	27.2618	201974.0		
1/8/2022	237.8657	210.6039	27.2618	201974.0		
1/9/2022	237.8657	210.6039	27.2618	201974.0		
1/10/2022	237.8657	210.6039	27.2618	201974.0		
1/11/2022	237.8657	210.6039	27.2618	201974.0		
1/12/2022	237.8657	210.6039	27.2618	201974.0		
1/13/2022	237.8657	210.6039	27.2618	201974.0		
1/14/2022	237.8657	210.6039	27.2618	201974.0		
1/15/2022	237.8657	210.6039	27.2618	201974.0		
1/16/2022	237.8657	210.6039	27.2618	201974.0		
1/17/2022	237.8657	210.6039	27.2618	201974.0		
1/18/2022	237.8657	210.6039	27.2618	201974.0		
1/19/2022	237.8657	210.6039	27.2618	201974.0		
1/20/2022	237.8657	210.6039	27.2618	201974.0		
1/21/2022	237.8657	210.6039	27.2618	201974.0		
1/22/2022	237.8657	210.6039	27.2618	201974.0		
1/23/2022	237.8657	210.6039	27.2618	201974.0		
1/24/2022	237.8657	210.6039	27.2618	201974.0		
1/25/2022	237.8657	210.6039	27.2618	201974.0		
1/26/2022	237.8657	210.6039	27.2618	201974.0		
1/27/2022	237.8657	210.6039	27.2618	201974.0		
1/28/2022	237.8657	210.6039	27.2618	201974.0		
1/29/2022	237.8657	210.6039	27.2618	201974.0		
1/30/2022	237.8657	210.6039	27.2618	201974.0		
1/31/2022	237.8657	210.6039	27.2618	201974.0		
2/1/2022	322.9688	285.9533	37.0155	274235.9		
2/2/2022	322.9688	285.9533	37.0155	274235.9		
2/3/2022	322.9688	285.9533	37.0155	274235.9		
2/4/2022	322.9688	285.9533	37.0155	274235.9		
2/5/2022	322.9688	285.9533	37.0155	274235.9		
2/6/2022	322.9688	285.9533	37.0155	274235.9		
2/7/2022	322.9688	285.9533	37.0155	274235.9		
2/8/2022	322.9688	285.9533	37.0155	274235.9		
2/9/2022	322.9688	285.9533	37.0155	274235.9		
2/10/2022	322.9688	285.9533	37.0155	274235.9		
2/11/2022	322.9688	285.9533	37.0155	274235.9		
2/12/2022	322.9688	285.9533	37.0155	274235.9		
2/13/2022	322.9688	285.9533	37.0155	274235.9		
2/14/2022	322.9688	285.9533	37.0155	274235.9		
2/15/2022	322.9688	285.9533	37.0155	274235.9		
2/16/2022	322.9688	285.9533	37.0155	274235.9		
2/17/2022	322.9688	285.9533	37.0155	274235.9		

1

Total Nitrogen (TN) Removal

The ability to attain the C-43 WBSR Treatment Project TN goal reduction is demonstrated through performance statistics taken from the HWTT facilities shown graphically (Figure I-11 and Figure I-12 in April 2021 Report). Percent reductions range from 57% to 25%. The Trout Lake site (57% TN removal for FY 2019-2020 and cumulative removal of 63%) was selected as most representative of treatment of Reservoir waters. (Wolff Ditch and Nubbin Slough are not representative of performance as the sites were constructed without all efficiency components due to lack of land availability. Projected operating data for the C-43 WBSR Treatment Proposal Scenario 3, including projected TN mass removed and flow weighted concentrations in and out, are depicted graphically in Figure IV-3 and Figure IV-4; daily and total treated flows, TN mass in, TN mass out, and load are shown in Table IV-5.

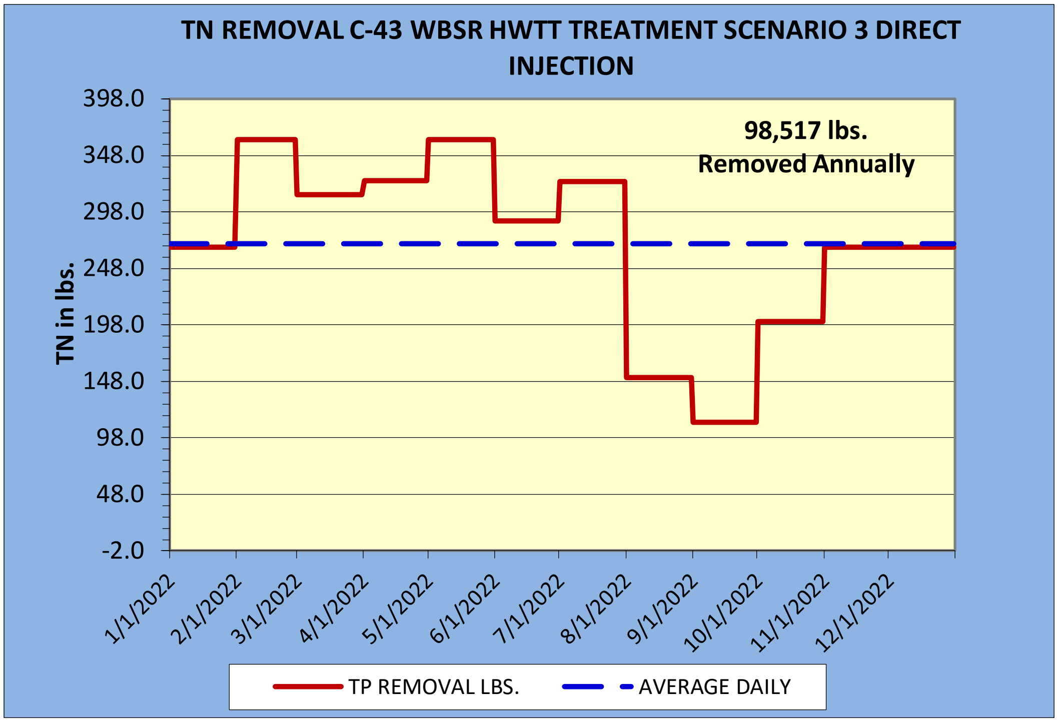

Figure IV-3. Projected Daily TN Removal C-43 WBSR HWTT Treatment System Scenario 3.

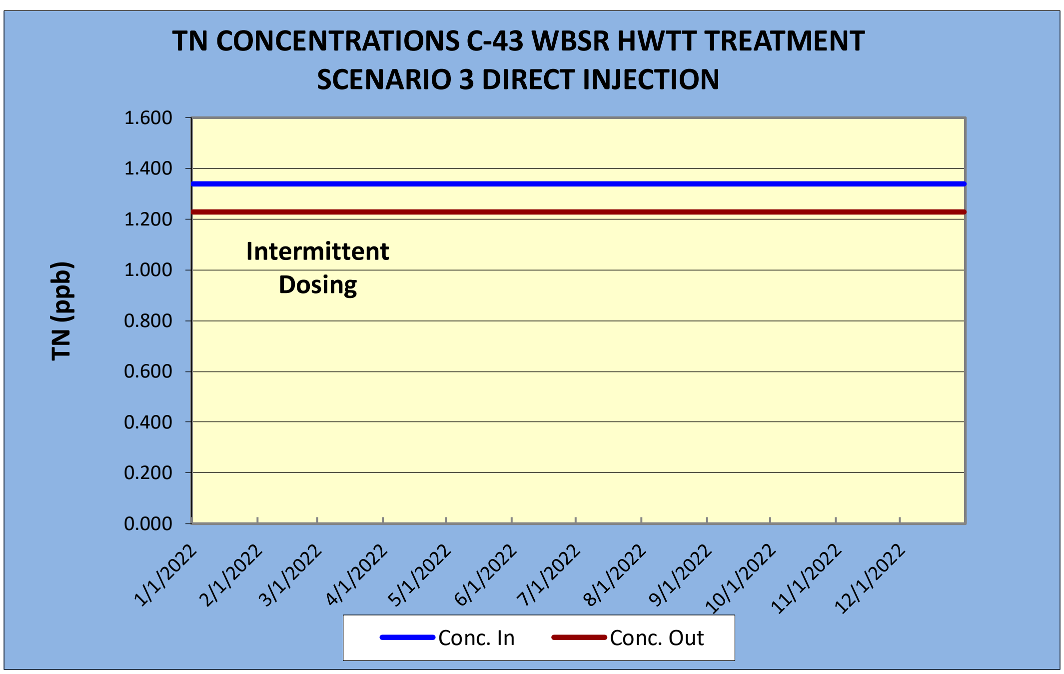

Figure IV-4. Projected Daily TN Concentrations C-43 WBSR HWTT Treatment System Scenario 3.

Table IV-5. TN Load Performance Calculations Scenario 3.

(Click to Open Linked File)

WATERSHED TECHNOLOGIES						
C-43 TN Reduction Total Scenario 3						
Period	**1/1/2022**	**through**	**12/31/2022**	**365**	**days in period**	
# of Days On-Line 365		**# Days On-Line Flow > 0.0000 365**		**# Days in Period Flow > 0.0000 Less Uncontrollable Downtime: 365**		**% Time On-Line vs. Available Days Excl. Uncontrollable Downtime: 100%**
	TN MASS (lbs.) INFLOW	**OUTFLOW**	**TN (lbs.) REMOVAL**	**AVERAGE DAILY FLOW**	**On-Line Unless Noted Otherwise**	**# Days Outflow >0 365**
				gpm On-Line Flow > 0	**Operational/ Flow Status**	**Comments**
TOTAL	**1200684.7343**	**1102167.9453**	**98516.7890**			
PER DAY	**3289.5472**	**3019.6382**	**269.9090**	**204274.8**		
1/1/2022	3252.4975	2985.6284	266.8691	201974.0		
1/2/2022	3252.4975	2985.6284	266.8691	201974.0		
1/3/2022	3252.4975	2985.6284	266.8691	201974.0		
1/4/2022	3252.4975	2985.6284	266.8691	201974.0		
1/5/2022	3252.4975	2985.6284	266.8691	201974.0		
1/6/2022	3252.4975	2985.6284	266.8691	201974.0		
1/7/2022	3252.4975	2985.6284	266.8691	201974.0		
1/8/2022	3252.4975	2985.6284	266.8691	201974.0		
1/9/2022	3252.4975	2985.6284	266.8691	201974.0		
1/10/2022	3252.4975	2985.6284	266.8691	201974.0		
1/11/2022	3252.4975	2985.6284	266.8691	201974.0		
1/12/2022	3252.4975	2985.6284	266.8691	201974.0		
1/13/2022	3252.4975	2985.6284	266.8691	201974.0		
1/14/2022	3252.4975	2985.6284	266.8691	201974.0		
1/15/2022	3252.4975	2985.6284	266.8691	201974.0		
1/16/2022	3252.4975	2985.6284	266.8691	201974.0		
1/17/2022	3252.4975	2985.6284	266.8691	201974.0		
1/18/2022	3252.4975	2985.6284	266.8691	201974.0		
1/19/2022	3252.4975	2985.6284	266.8691	201974.0		
1/20/2022	3252.4975	2985.6284	266.8691	201974.0		
1/21/2022	3252.4975	2985.6284	266.8691	201974.0		
1/22/2022	3252.4975	2985.6284	266.8691	201974.0		
1/23/2022	3252.4975	2985.6284	266.8691	201974.0		
1/24/2022	3252.4975	2985.6284	266.8691	201974.0		
1/25/2022	3252.4975	2985.6284	266.8691	201974.0		
1/26/2022	3252.4975	2985.6284	266.8691	201974.0		
1/27/2022	3252.4975	2985.6284	266.8691	201974.0		
1/28/2022	3252.4975	2985.6284	266.8691	201974.0		
1/29/2022	3252.4975	2985.6284	266.8691	201974.0		
1/30/2022	3252.4975	2985.6284	266.8691	201974.0		
1/31/2022	3252.4975	2985.6284	266.8691	201974.0		
2/1/2022	4416.1688	4053.8199	362.3489	274235.9		
2/2/2022	4416.1688	4053.8199	362.3489	274235.9		
2/3/2022	4416.1688	4053.8199	362.3489	274235.9		
2/4/2022	4416.1688	4053.8199	362.3489	274235.9		
2/5/2022	4416.1688	4053.8199	362.3489	274235.9		
2/6/2022	4416.1688	4053.8199	362.3489	274235.9		
2/7/2022	4416.1688	4053.8199	362.3489	274235.9		
2/8/2022	4416.1688	4053.8199	362.3489	274235.9		
2/9/2022	4416.1688	4053.8199	362.3489	274235.9		
2/10/2022	4416.1688	4053.8199	362.3489	274235.9		
2/11/2022	4416.1688	4053.8199	362.3489	274235.9		
2/12/2022	4416.1688	4053.8199	362.3489	274235.9		
2/13/2022	4416.1688	4053.8199	362.3489	274235.9		
2/14/2022	4416.1688	4053.8199	362.3489	274235.9		
2/15/2022	4416.1688	4053.8199	362.3489	274235.9		
2/16/2022	4416.1688	4053.8199	362.3489	274235.9		
2/17/2022	4416.1688	4053.8199	362.3489	274235.9		

1

D. Assumptions Scenario 3

The WBSR HWTT Treatment Proposal is based upon a set of assumptions and conditions. The following list specifies the major items which form the basis of this proposal for Scenario 3.

1. Inflow range to the HWTT facility is 189 to 611 cfs.
2. Average flow to the HWTT facility is 456 cfs as the daily flow.
3. Inflow is equal to outflow, that is, there is no seepage loss.
4. Inflow water quality to the Reservoir was assumed as being constant at 1.81 mg/L TN and 0.152 mg/L TP as stipulated by the JTech team. For Scenario 3, nutrient reduction performance is assumed from Reservoir treatment.
5. Effluent water quality targets are to be achieved at all times and are not annual averages.
6. Inflow and outflow pump station and associated conveyance costs are specifically excluded from the cost estimates for both capital and O&M.
7. Engineering design, permitting, surveys, construction management services, and contingencies *are not included* in the cost estimate. Mobilization, geotechnical, and surveys *are included* in the capital projections.
8. No contingencies are contained within the estimate for both capital and O&M.
9. HWTT facility effectiveness is based on performance of existing facilities in the state of Florida and jar tests performed by the SFWMD.
10. HWTT O&M costs are based in part on similar existing facilities in the state of Florida.
11. A bulk rate for chemical costs was obtained from a HWTT vendor and utilized for projected chemical costs.
12. The O&M costs consist only of direct operational expenses. The following costs are specifically ***excluded*** from this proposal: administrative and overhead, management, scientific personnel/professional service fees, laboratory fees, pump costs for delivery of water to HWTT site, and rate of return. The excluded costs noted are not necessarily all inconclusive.
13. Land fees or land acquisition costs are not included in the proposal.

HYBRID WETLAND TREATMENT TECHNOLOGY
C-43 WEST BASIN STORAGE RESERVOIR TREATMENT PROJECT

Conceptual Design & Cost Estimates

Prepared By:
Watershed Technologies, LLC

April 2021
Revised April 28, 2021

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Executive Summary

Watershed Technologies, LLC (WTLLC) is pleased to submit this proposal for the patented Hybrid Wetland Treatment Technology (HWTT) for the C-43 West Basin Storage Reservoir (WBSR) Project. HWTT has proven be an effective method for the removal of phosphorus (P), nitrogen (N) and other pathogens in waters of the State of Florida with ten systems operating across the State for over twelve years for several sites. The HWTT facilities have relatively low-cost benefit values compared to other technologies and high reduction rates for both P and N. Several of the sites have replaced non-performing projects, can be located within small areas of land, require minimal infrastructure, and can successfully treat varying qualities of water in an environmentally sound manner. Other existing HWTT systems are used to provide necessary hydration of downstream wetlands. The technology has also shown that it can be rapidly implemented, and there is no lag in treatment performance upon initiation of pulse flows after long periods of no flows or droughts. Multiple HWTT facilities have been permitted by the Florida Department of Environmental Protection (FDEP), two Water Management Districts, municipalities, and counties. Construction, performance, and operational reports are reviewed by these agencies on a regular basis.

Cost benefit values have been calculated for this proposal based upon the projected costs, stated water quality and flow specifications, no treatment performance from an in-line alum injection system, and other assumptions (Scenario 1). The projected Cost Benefit is \$51 per pound of P removed; \$6 per pound of N removed; and \$10 per pound for P and N combined. Total projected capital costs are \$18,125,924 excluding land (452 acres required), and projected annual Operations & Maintenance (O&M) is \$6,464,410. A second alternative has also been developed using a set of assumptions *with projected nutrient removal performance* from a Reservoir in-line alum injection system (Scenario 2). The projected annual O&M is reduced by approximately 40% to \$3,839,160. The two Scenarios provide a range of O&M costs for treatment of the C-43 WBSR with HWTT. The HWTT vegetated ponds additionally provide an unquantified amount of nutrient removal through the entrainment of micro-flocs generated from direct alum injection into the Reservoir in both Scenario 1 and Scenario 2. This additional benefit from pond removal of micro-floc resulting from direct alum injection has not been included in removal performance.

HWTT projects can be accessed via a proprietary Dashboard system, allowing real-time, on-line internet access to all HWTT sites. The program includes flow treated, chemical dosing levels, and system status (on-line, off-line, partial). Facility diagrams, statistics, and history are presented, and live camera views are also displayed. Several favorable articles have been written regarding HWTT; samples are included in the Other Beneficial Attributes Section of this Report.

I. Scenario 1: No Removal Performance Assumed for Reservoir Direct Alum Injection

A. Treatment Process

An HWTT conceptual treatment process (Scenario 1) has been developed to achieve the following objectives for the WBSR: (1) meet effluent water quality targets of 0.088 milligrams per liter (mg/L) for total phosphorus (TP) and 1.23 mg/L for total nitrogen (TN) with average inflow values from the Reservoir of 0.152 mg/L and 1.810 mg/L for TP and TN, respectively (Table I-1); (2) treat a set of given daily flows with an average of 456 cubic feet per second (cfs) (Table I-1); and (3) constrain capital facilities within the Western and Central Parcels of the designated Project available land (Figure I-1). The objectives for the proposal have been provided by J-Tech. The Conceptual Design and cost projections are based on various assumptions (see Section I. Assumptions; however, Scenario 1 includes the assumption of no removal performance of a Reservoir Direct Alum Injection System. For Scenario 1, the TP is reduced beyond the target to 0.084 mg/L, since N reduction determines the treatment process. The HWTT removal efficiencies are based on performance of other HWTT facilities currently being operated throughout the state of Florida and contemporary jar tests being performed by the South Florida Water Management District (SFWMD). The conceptual design processes (depicted in Figure I-2) are as follows:

- The HWTT system is contained within both the Western and Central Parcels on a parallel basis, that is, alum dosing is performed in both parcels. The dual facilities will be used in tandem for the majority of the time with the Central Parcel operating for highest flows. The Western Parcel is designed to treat up to 125 cfs, and the Central Parcel maximum treatment capacity is 486 cfs with the total site maximum capacity being 611 cfs.
- The HWTT vegetated ponds additionally provide nutrient removal through the entrainment of micro-flocs generated from direct alum injection into the Reservoir.

Process Flow Diagram

A conceptual process flow diagram was established given the known constraints as depicted in Figure I-2; however, an otherwise ideal site geometry is assumed, for example, no wetlands, which would require an increase in the area requirement for the project. The facility treatment process would consist of two identical treatment trains. Figure I-3 illustrates the single treatment train configuration with proposed raw water inflow locations. Note that the stated flow rates represent the total flow at those injection points when accounting for the sum between the two treatment trains.

Flow Equalization

No flow equalization is required as part of the HWTT facility due to the ability for chemical dosing rates to be adjusted quickly based on changing volumes and water chemistry. It is assumed that major changes in flow from the Reservoir would be relatively predictable and would be coordinated with the water quality component to maximize performance of the facility.

Distribution

One of many benefits of HWTT technology is the ability to distribute flows from one treatment element using gravity flow alone. Once water is delivered to the site from the Reservoir, either by gravity or with an inflow pump station, no additional pumping is needed to complete the process except due to head conditions wherein water would be pumped offsite following the treatment process. Following intake into the facility, water is routed between treatment ponds using standard corrugated metal culverts, and water levels are controlled through the use of riser structures.

Pre-Treatment Processes

No pre-treatment is expected for this facility based on available water quality data. Minor modifications to the site may be necessary once the water quality impacts associated with storage within the Reservoir are better identified. This pretreatment would consist of a limerock berm, which could be implemented using a small area and would only be required if Alkalinity of the water discharged from the Reservoir is ultimately lower than values currently expected based on available data.

Treatment

HWTT technology is well established throughout Florida and is currently being implemented in different watersheds, treating water with a wide range in water quality characteristics. All projects implemented to date have demonstrated the ability for the technology to decrease effluent concentrations for a variety of water quality parameters (for example, TP, TP, Total Suspended Solids (TSS), and Fecal Coliform Bacteria).

The treatment process uses either Aluminum Sulfate (alum) alone or in conjunction with Polyaluminum Chloride (PAC) depending on the Alkalinity and pH of the raw water being treated. Based on available data, alum alone should be sufficient for this facility; although, the impacts on water quality associated with storage within the Reservoir cannot be quantified at this time.

Following chemical dosing, water is routed through settling ponds where longer residence times and slower flow velocities allow floc to settle out of the water column. The settling ponds remove the vast majority of the floc material; however, following the settling ponds, additional treatment is provided by a series of natural wetland systems. These wetlands consist of both Floating Aquatic Vegetation (FAV) and Submerged Aquatic Vegetation (SAV) to provide additional physical removal of floc, which may have been too buoyant to be removed in the settling ponds, through adsorption and removal of dissolved nutrients from direct assimilation of nutrients by the vegetation. The species of vegetation selected and the potential use of Emergent Aquatic Vegetation (EAV) is dependent on site specific conditions and actual water quality characteristics of the WBSR inflow, which would be determined through the initial optimization process.

Post-Treatment Processes

Similar to pre-treatment processes, no post-treatment is expected for this facility. Depending on actual water quality characteristics, a limerock berm may be incorporated into the back end of the SAV ponds to add Alkalinity to the water prior to discharging back to the C-43 Canal. HWTT technology has proven to be effective at removing chemicals added at the beginning of the treatment process before discharging back to the receiving water body thereby preventing the need for extensive post-treatment processes.

Collection

Following treatment through the parallel treatment trains, water will be discharged via gravity to a common final collection canal at the location of the outflow pump station intake.

Chemical Supply

Alum is available in sufficient quantities to allow the facility to treat the anticipated volumes of water to the target effluent water quality limits. A bulk chemical price has been obtained from a local supplier and those prices are incorporated into the O&M costs presented in subsequent chapters of this document.

Table I-1. Treated Flow and Effluent Nutrient Targets Scenario 1.

	HWTT Treated Flow to Achieve TP Outflow Targets				
Month	Reservoir Inflow TP (mg/L)	Reservoir Outflow/HWTT Inflow TP (mg/L)	Outflow Target (mg/L)	HWTT Outflow Conc (mg/L)	Total Flow
1	0.152	0.152	0.088	0.084	450.00
2	0.152	0.152	0.088	0.084	611.00
3	0.152	0.152	0.088	0.084	529.00
4	0.152	0.152	0.088	0.084	550.00
5	0.152	0.152	0.088	0.084	611.00
6	0.152	0.152	0.088	0.084	489.00
7	0.152	0.152	0.088	0.084	548.00
8	0.152	0.152	0.088	0.084	256.00
9	0.152	0.152	0.088	0.084	189.00
10	0.152	0.152	0.088	0.084	339.00
11	0.152	0.152	0.088	0.084	450.00
12	0.152	0.152	0.088	0.084	450.00
Total					***5472.0***
Average	***0.152***	***0.152***	***0.088***	***0.084***	***456.0***

	HWTT Treated Flow to Achieve TN Outflow Targets				
Month	Reservoir Inflow TN (mg/L)	Reservoir Outflow/HWTT Inflow TN (mg/L)	Outflow Target (mg/L)	HWTT Outflow Conc (mg/L)	Total Flow
1	1.810	1.810	1.230	1.230	450.00
2	1.810	1.810	1.230	1.230	611.00
3	1.810	1.810	1.230	1.230	529.00
4	1.810	1.810	1.230	1.230	550.00
5	1.810	1.810	1.230	1.230	611.00
6	1.810	1.810	1.230	1.230	489.00
7	1.810	1.810	1.230	1.230	548.00
8	1.810	1.810	1.230	1.230	256.00
9	1.810	1.810	1.230	1.230	189.00
10	1.810	1.810	1.230	1.230	339.00
11	1.810	1.810	1.230	1.230	450.00
12	1.810	1.810	1.230	1.230	450.00
Total					***5472.0***
Average	***1.810***	***1.810***	***1.230***	***1.230***	***456.0***

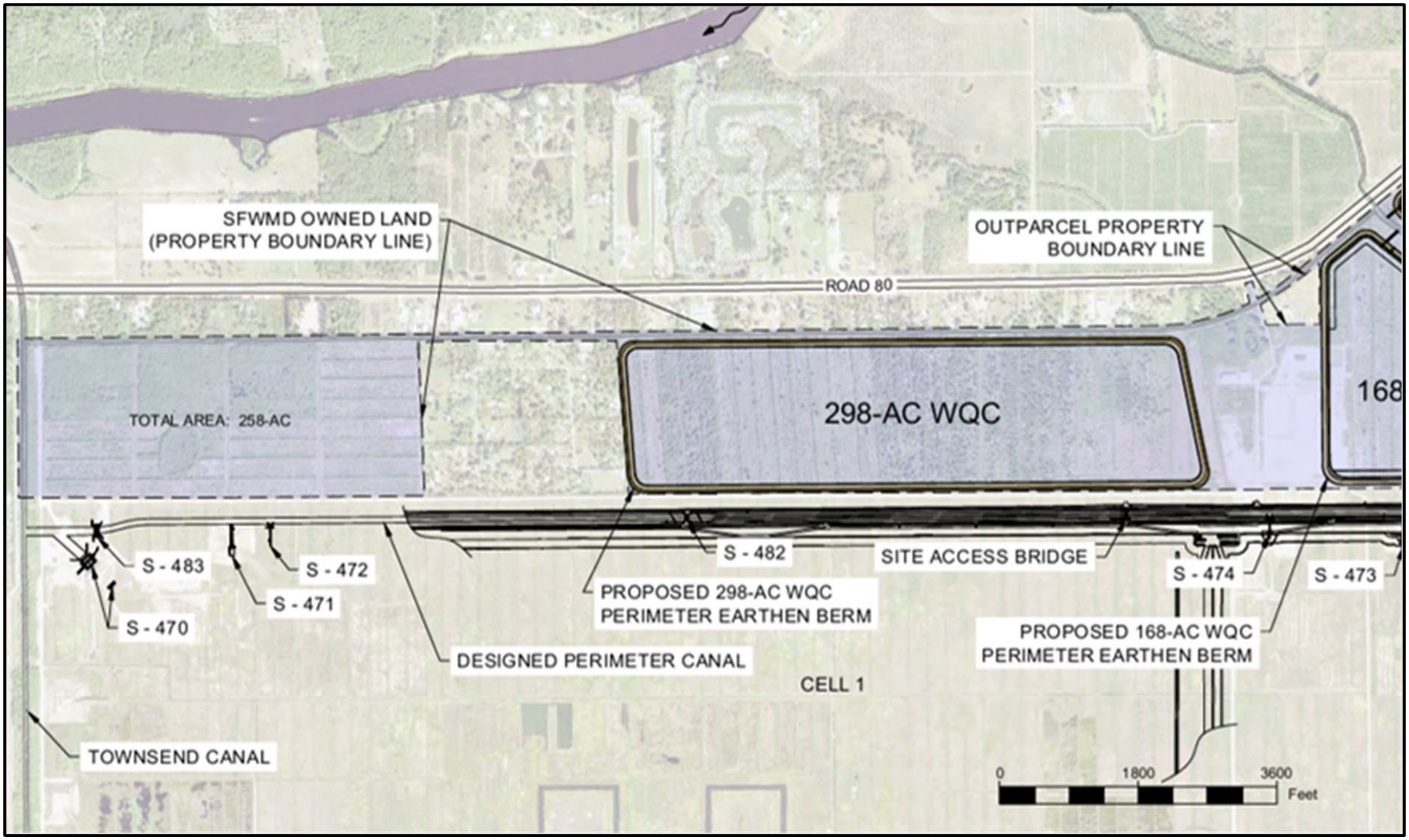


Figure I-1. Designated Parcels Available for Treatment.

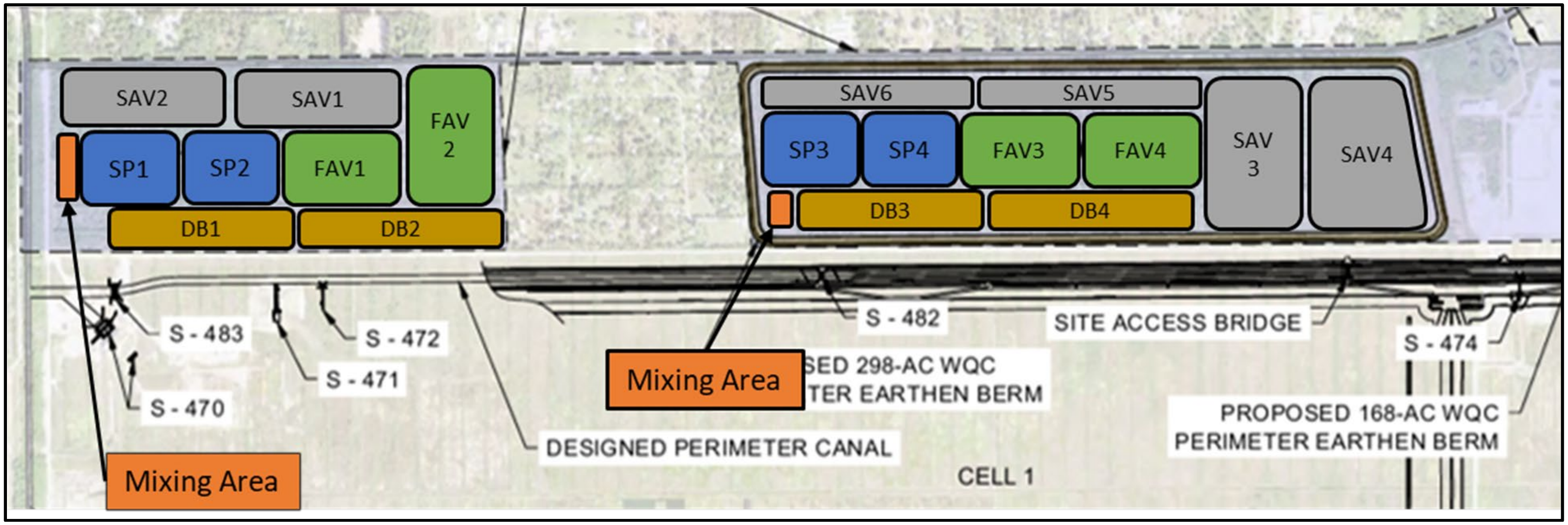


Figure I-2. Conceptual Configuration of HWTT Treatment System.

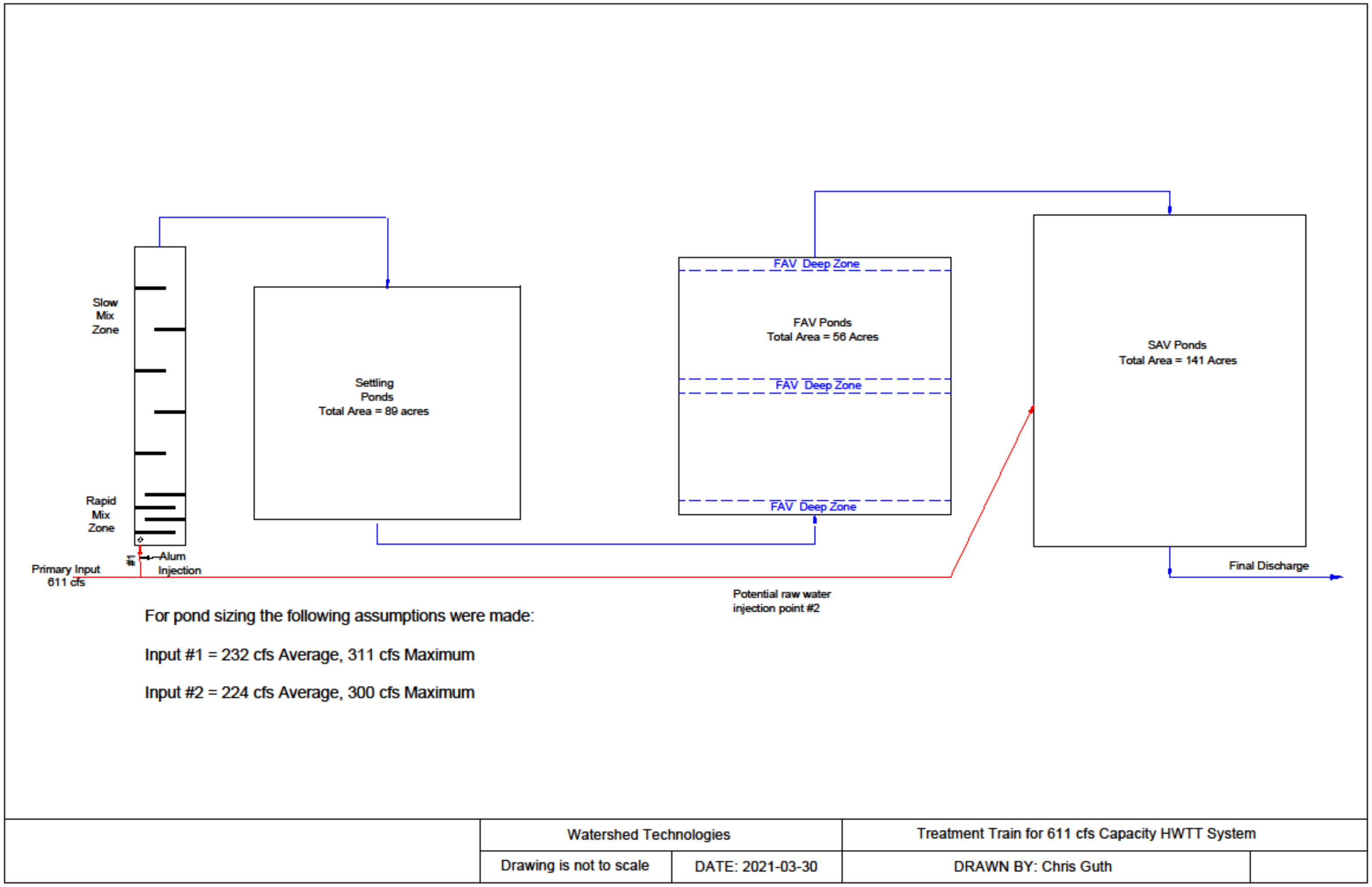


Figure I-3. Process Flow Diagram for an HWTT Treatment Train. (Flows represent the estimated total flow injected at depicted locations.)

B. Residuals Process

Collection or Removal

Alum is mixed with Reservoir discharge at the front end of the system to facilitate flocculation in the facility. The four (4) settling ponds are used to collect solids by slowing water velocities and promoting settling prior to discharge to the FAV and SAV treatment ponds. Solids which accumulate at the bottom of each of the settling ponds are in a state where they can be removed via pumping. Floc pumps installed with intakes at the base of each of the settling ponds will be used to periodically remove solids.

Volume Reduction/Dewatering

Dewatering of the treatment residual happens passively through the use of drying beds incorporated in both of the treatment trains. The drying beds are sized based on the anticipated accumulation rate of solids and are large enough to store sufficient water from the settling ponds in an effort to completely remove the solid material during a settling pond cleanout phase. The passive dewatering/volume reduction allows for minimal operating and maintenance expenses associated with this component of the treatment process.

Storage

No storage other than what is provided within the drying beds is required for solids that are produced by the treatment process. As solids dry, consolidation will occur therefore increasing the available storage volume within the drying beds for subsequent removal of solids from the settling ponds. Once solids are sufficiently dried and have accumulated to a point where insufficient storage volume exists within the drying beds, they are transported and disposed of based on the procedures outlined below.

Transfer

Transfer of dewatered solids from the drying beds will occur after the water content has decreased to a satisfactory level. A front-end loader or other readily available equipment can be used for excavating the material from the drying bed for transfer to one of two locations within the site, as described below.

Disposal Process and Location

Accumulated solids have been demonstrated to have additional potential for binding nutrients and can therefore be recycled within the system to continue providing a treatment benefit under HWTT. Typically, the solids material will be excavated and spread throughout an FAV cell during the routine maintenance period for those ponds. An additional disposal method exists if or when the neighboring reservoir dries out, which would be infrequent but likely to occur some years during project implementation. During dry-out conditions, solids material could be spread throughout the reservoir to the extent possible or alternatively transported to a disposal facility. Similar to disposal in the FAV ponds, this process would allow for quick and efficient disposal of the material, but more importantly, the method would assist in the binding of nutrients during the refilling of the Reservoir. Such binding would reduce the degree of nutrient resuspension that typically occurs when these conditions exist. Floc that accumulates in the vegetated zones could be sequestered with the patented tilling technology as necessary.

Centrate Management

No centrate will be produced as part of the HWTT facility. The solids material will be naturally dewatered through passive processes and the water content will be lost via seepage and evapotranspiration.

C. Land Area (Total)

The total projected land area for the WBSR HWTT Treatment proposal is 452 acres (Table I-2). The treatment portion is comprised of 286.9 acres; supporting facilities are 50 acres; and residuals and solids storage consist of 115.1 acres.

Table I-2. WBSR HWTT Land Area Requirements in Acres.

WATERSHED TECHNOLOGIES, LLC HWTT	
C43 WBSR PROJECT COMPONENTS	
COMPONENT	**ACRES**
Mixing Chambers	1
Settling Ponds	88.8
FAV Ponds	55.8
SAV Ponds	141.3
Drying Beds	115.1
Supporting Facilities:	
Internal Embankments	28
Perimeter Buffer	15
Miscellaneous	7
TOTAL	452

Treatment Facility

The treatment area utilizes 286.9 acres, consisting of two treatment trains with multiple treatment ponds in series. The mixing zone where chemical is mixed with the incoming raw water from the Reservoir will require approximately one (1) acre of land in total. From there, four (4) settling ponds will be constructed to allow for floc to settle out followed by FAV and SAV ponds. The estimated total acreage for the settling, FAV and SAV ponds is 88.8 acres, 55.8 acres and 141.3 acres, respectively, for a total pond treatment land area of 286.9 acres.

Supporting Facilities

Supporting facilities are considered as areas required for access (for example, internal access roads, perimeter access road, and embankments), chemical storage/dosing facilities, and miscellaneous areas such as those used for storage, parking, pump station pads, and other similar uses. The total land area for supporting facilities for the C-43 HWTT facility is anticipated as being approximately 50 acres.

Residuals Handling and Solids Storage

Solids will be pumped to the drying beds after accumulating in the settling ponds. The drying beds allow for passive dewatering of the solids material that is a biproduct of the treatment process through evapotranspiration and seepage. The drying beds are sized based on an assumed solids accumulation rate in the settling ponds. Based on the anticipated flows to be treated, four drying beds will be required sized at an average of approximately 29 acres each. The total land area for residuals handling and solids storage is therefore 115.1 acres.

Stormwater Management

No additional land area is required for management of runoff resulting from onsite rainfall. All runoff will be directed towards onsite ponds used in the treatment process except for runoff from the site perimeter buffer, which will be graded towards onsite drainage swales. This area is included in the acreage for supporting facilities above.

D. Power (Annual)

After raw water is dosed with chemical at the beginning of the treatment process, all subsequent elements rely on gravity and natural processes for treatment; therefore, the power requirement for the technology is minimal. Power is required for operating the chemical storage building and the associated equipment (for example, chemical dosing pumps and monitoring equipment). Power for operating the floc recycling pumps is also required.

It is assumed that inflow and outflow pump stations are to be excluded from this proposal; accordingly, the power requirements associated with those features are not included.

E. Fuel Consumption (Annual)

All permanent infrastructure requiring power within the HWTT facility is based on electric power. It is assumed that inflow and outflow pump stations are to be excluded from this proposal; accordingly, the power requirements associated with those features are not included. The fuel requirements are, therefore, minimal, and it is assumed that only one personnel vehicle will require fuel for operating the site. Fuel is required for operating machinery used in the periodic tilling process and is included in the unit cost for tilling in the Operations and Maintenance budget.

F. Capital Costs (2021 Dollars)

Projected capital costs of $18,125,924 for the conceptual design of the proposed WBSR HWTT Treatment system are summarized in Table I-3 by categories specified in the project specifications. Projected costs for detailed components are presented in Table I-4 in 2021 dollars. The Land Area items shown below relate to the components identified in the specifications and do NOT refer to the cost of the land. (Rounding differences occur in the calculations.)

Table I-3. WBSR HWTT Projected Capital Costs by Category

Watershed Technologies, LLC		
Projected WBSR HWTT Capital Costs by Category*		
I. Treatment Process	Distribution (I.C.)	$ 882,900.00
	Treatment Processes (I.E.)	$ 1,753,762.04
	Post-treatment Processes (I.F.)	$ 730,243.63
	Sub-total	$ 3,366,905.66
II. Residuals Process	Residual Collection (II.A.)	$ 6,185,831.96
	Residual Storage (II.A,B,C.)	$ 3,882,205.49
	Residual Transfer (II.D.)	$ 513,665.41
	Sub-total	$ 10,581,702.86
III. Land Area	Supporting Facilities (III.A.)	$ 1,402,010.55
	Treatment Facility (III.A.)	$ 1,419,288.59
	Suporting Facilities (III.B.)	$ 492,877.33
	Sub-total	$ 3,314,176.46
Other	Mobilization	$ 517,883.55
	Survey/Geotech	$ 345,255.70
	Total	$ 18,125,924.00
*See Assumptions		

Table I-4. C-43 WBSR HWTT Projected Capital Costs in 2021 Dollars.

Category	Item	C43 Quantity	Unit	Cost (2021 Dollars)
Erosion Control	staked silt fence (temporary)	161979	lf	$ 111,623.44
Erosion Control	staked turbidity barriers (temporary)	1200	lf	$ 4,609.82
Erosion Control	floating turbidity barriers (temporary)	320	lf	$ 2,634.18
Erosion Control	Construction Entrance	1	ls	$ 19,536.85
Erosion Control				$ 138,404.29
Contact Chamber	clearing/grubbing (strip and pile field topsoil)	1.0	ac	$ 987.82
Contact Chamber	pond liner installation	1	ls	$ 4,390.30
Contact Chamber	inflow piping (6 x 72" CMP, materials and installation)	600	lf	$ 131,709.08
Contact Chamber	inflow structure installation: set box, grout pipe connections, install grating, internal baffle, and slides gates	1	ls	$ 131,709.08
Contact Chamber	outflow piping (8 x 72" CMP, materials and installation)	2600	lf	$ 1,010,208.64
Contact Chamber				$ 1,279,004.92
Settling Pond	clearing/grubbing (strip and pile field topsoil; berm footprint only)	8	ac	$ 9,439.15
Settling Pond	excavation and placing fill(pond)	1062197	cy	$ 5,310,986.67
Settling Pond	embankment (berm)	117787	cy	$ 588,934.07
Settling Pond	spread topsoil over finished surfaces (berm top, interior & exterior slopes)	44361	sy	$ 19,975.88
Settling Pond	Hydroseeding (berm top, interior & exterior slopes)	44361	sy	$ 23,371.13
Settling Pond	outflow structures (8x72" CMP w/ 96" risers, materials and installation)	600	lf	$ 233,125.07
Settling Pond				$ 6,185,831.96
FAV Pond	clearing/grubbing (strip and pile field topsoil; berm footprint only)	25	ac	$ 22,829.57
FAV Pond	excavation and placing fill(pond)	0	cy	$ -
FAV Pond	embankment (berm)	80031	cy	$ 400,157.08
FAV Pond	spread topsoil over finished surfaces (berm top, interior & exterior slopes)	30142	sy	$ 13,939.21
FAV Pond	Hydroseeding (berm top, interior & exterior slopes)	30142	sy	$ 15,879.74
FAV Pond	outflow structures (8x96" CMP w/ 120" risers, materials and installation)	600	lf	$ 233,125.07
FAV Pond	vegetation stocking: import FAV from approved source and stock pond	1	ls	$ 21,951.51
FAV Pond				$ 707,882.19
SAV Pond	clearing/grubbing (strip and pile field topsoil; berm footprint only)	10	ac	$ 11,085.51
SAV Pond	excavation and placing fill(pond)	0	cy	$ -
SAV Pond	embankment (berm)	129981	cy	$ 649,903.49
SAV Pond	spread topsoil over finished surfaces (berm top, interior & exterior slopes)	48954	sy	$ 21,512.48
SAV Pond	Hydroseeding (berm top, interior & exterior slopes)	48954	sy	$ 25,790.62
SAV Pond	outflow structures (8x96" CMP w/ 120" risers, materials and installation)	600	lf	$ 233,125.07
SAV Pond	vegetation stocking: import SAV from approved source and stock pond	1	ls	$ 21,951.51
SAV Pond				$ 963,368.70

Category	Item	C43 Quantity	Unit	Cost (2021 Dollars)	
Floc Recycling Infrastructure	floating booms	1	ls	$	10,975.76
Floc Recycling Infrastructure	floating boom installation (incl. anchor materials)	1	ls	$	2,195.15
Floc Recycling Infrastructure	clearing/grubbing - drying bed (strip and pile field topsoil; berm footprint only)	7	ac	$	8,231.82
Floc Recycling Infrastructure	excavation and placing fill(pond)	0	cy	$	-
Floc Recycling Infrastructure	embankment (berm)	95786	cy	$	478,927.55
Floc Recycling Infrastructure	spread topsoil over finished surfaces - drying bed (berm only)	36075	sy	$	15,805.09
Floc Recycling Infrastructure	Hydroseeding - drying bed (berm only)	36075	sy	$	19,005.65
Floc Recycling Infrastructure	Overflow Sturcture (for each drying bed)	4	ea	$	87,806.05
Floc Recycling Infrastructure	Elevate drying bed bottom with excess fill	669413	cy	$	3,347,064.47
Floc Recycling Infrastructure	Floc pumps, piping, valves, and appurtenances (materials and installation)	4	ea	$	513,665.41
Floc Recycling Infrastructure				$	4,483,676.96
Roads and Drainage	baserock access road (8" compacted baserock, 15' wide)	7920	lf	$	124,904.11
Roads and Drainage	baserock access road (8" compacted baserock, 15' wide) - parking/misc area at each parcel and four shell rock roads that run north/south (two in each parcel)	9648	lf	$	151,026.41
Roads and Drainage	grading - site perimeter drainage swale	15	ac	$	23,707.63
Roads and Drainage				$	299,638.16
Outflow Canal	Excavation	30800	cy	$	154,000.00
Outflow Canal	Conveyance (6x72" CMP, materials and installation)	450	lf	$	174,843.80
Outflow Canal				$	-
Outflow Canal				$	328,843.80
Security Fencing	woven wire fence - site perimeter	21980	lf	$	48,249.43
Security Fencing	16' swing gate	4	ea	$	6,585.45
Security Fencing				$	54,834.88
Building & Electrical	building pad, concrete slab, pre-engineered metal building, floor drains, building electrical installation - materials and installation	1	ls	$	1,402,010.55
Building & Electrical				$	1,402,010.55
Chemical Dosing Infrastructur	tanks	1	ls	$	506,056.87
Chemical Dosing Infrastructur	dosing pumps	1	ls	$	195,648.17
Chemical Dosing Infrastructur	plumbing/electrical	1	ls	$	234,766.42
Chemical Dosing Infrastructur	lightning protection	2	ls	$	43,903.03
Chemical Dosing Infrastructur	remote monitoring/control	1	ls	$	49,779.63
Chemical Dosing Infrastructure				$	1,030,154.11
Instrumentation & Controls	pH, turbidity, remote monitoring	1	ls	$	389,134.47
Instrumentation & Controls				$	389,134.47
Construction Subtotal				$	17,262,784.99
Mobilization	Mobilization (3%)	3%		$	517,883.55
Survey/Geotech	Construction staking/testing/asbuilts (2%)	2%		$	345,255.70
Grand Total (No Contingency, CMS, Engineering Design, post construction surveys/certification)				**$**	**18,125,924.24**

G. Operations & Maintenance (Annual)

The projected Operations & Maintenance (O&M) costs are based upon a set of assumptions contained within Section I. Assumptions of this Report. A summary by expense type is presented in Table I-5, and detailed supporting schedules are provided in Table I-6 through Table I-15.

Table I-5. C-43 WBSR HWTT Treatment System projected O&M by Category & Line Item Scenario 1.

WATERSHED TECHNOLOGIES, LLC HWTT					
C-43 WBSR Treatment Projected O&M					
See Notes & Assumptions					
Line Item Budget Category	**Description**	**Total by Line Item Category**	**%**	**Amount**	**% Allocated to Category**
Salaries	Salaries	$ 208,000	3.22%	$ 208,000	3.22%
Fringe Benefits	Fringe Benefits	15,912	0.25%	15,912	0.25%
Materials	Chemicals	5,943,578	91.94%		
	Equipment	134,500	2.08%		
	Vegetation	27,700	0.44%	6,105,778	94.45%
Residuals	Floc Management	14,280	0.22%	14,280	0.22%
Power & Fuel	Utilities/Fuel	73,240	1.13%	73,240	1.13%
Other	Berms & Grounds Maintenance	40,000	0.62%		
	Site Internet Service	7,200	0.11%	47,200	0.73%
Indirect Costs/Overhead	Indirect Costs/Overhead	0	0.00%	0	0.00%
Total		$ 6,464,410	100.00%	$ 6,464,410	100.00%

WATERSHED TECHNOLOGIES, LLC HWTT C-43 WBSR TREATMENT	
PROJECTED STATEMENT OF EXPENSES	
FOR THE YEAR ENDING DECEMBER 31, 2022	
(Unaudited)	
See Notes & Assumptions	
	Projected
Operations & Maintenance	
Labor	$ 208,000
Chemicals	5,943,578
Utilities/Fuel	73,240
Equipment, Tools & Supplies	134,500
Site Cell Phone/Internet	7,200
Ground Maintenance	40,000
Vegetation Management	27,700
Residual (Floc) Management	14,280
Fringe Benefits	15,912
Total Projected Expenses	$ 6,464,410

Labor

Labor includes Field Personnel to operate, maintain, and monitor the HWTT system on a daily basis for an average cost of $208,000 annually.

Table I-6. Projected Labor Field Personnel

Watershed Technologies, LLC HWTT				
C-43 WBSR Treatment Project				
Labor Operations & Maintenance				
Field Personnel				
Site	**FTEs**	**Hourly Rate**	**# Hours per Year**	**Total Labor**
C-43	2	$ 50.00	2080	$ 208,000

Materials

Materials for the HWTT system include chemicals, tools, supplies, equipment, and vegetation. Chemicals will be acquired from a certified chemical company at a bulk rate price. Safety procedures are followed for all deliveries and management thereafter. Disposal of the chemical residual (floc) is discussed under the O&M Residuals Section. Tools, supplies, and equipment are acquired, managed, and disposed via a management tracking system. Vegetation for the FAV and SAV Ponds is managed through periodic vegetation surveys; disposal of the FAV, when necessary, is performed through tilling in the O&M Residuals Section. Detailed calculations of projected chemical costs total $5,943,578 as shown in Table I-7, based upon an average 456 cfs and an intermittent effective dosing rate of 5.88 mg/L. The projected chemical costs are $144,514 lower if the dosing rate does not fluctuate by month, that is, the average dosing rate is used for each month. Table I-8 and Table I-9 contain data on equipment, and vegetation is presented in Table I-10.

Table I-7. Projected Chemicals Scenario 1.

C-43 WBSR HWTT TREATMENT Scenario 1		31	28	31	30	31	30	31	31	30	31	31	30
Projected Chemicals	**Month**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Chemicals	$ 5,943,578	$ 513,433	$ 562,688	$ 522,996	$ 618,931	$ 805,420	$ 511,154	$ 708,400	$ 237,932	$ 195,223	$ 177,540	$ 542,844	$ 547,017
Total Monthly cfs	166,121	13,950.0	17,108.0	16,399.0	16,500.0	18,941.0	14,670.0	16,988.0	7,936.0	5,670.0	10,509.0	13,950.0	13,500.0
Ave. daily cfs	456.00	450.00	611.00	529.00	550.00	611.00	489.00	548.00	256.00	189.00	339.00	450.00	450.00
		Alum	Alum	Alum	Alum	Alum	Alum	Alum	Alum	Alum	Alum	Alum	Alum
Cost basis (unit)		Dry ton	Dry ton	Dry ton	Dry ton	Dry ton	Dry ton	Dry ton	Dry ton	Dry ton	Dry ton	Dry ton	Dry ton
Product cost per unit ($)	200	200	200	200	200	200	200	200	200	200	200	200	200
Volume of product per unit (L)		1406	1406	1406	1406	1406	1406	1406	1406	1406	1406	1406	1406
Al content of product (% by wt.)		4.41	4.41	4.41	4.41	4.41	4.41	4.41	4.41	4.41	4.41	4.41	4.41
Al mass (kg) per unit of product		82.4	82.4	82.4	82.4	82.4	82.4	82.4	82.4	82.4	82.4	82.4	82.4
Al concentration in product (g Al/L)		58.6	58.6	58.6	58.6	58.6	58.6	58.6	58.6	58.6	58.6	58.6	58.6
Product cost per liter ($)		0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142
Product cost per mg of Al ($)		0.000002	0.000002	0.000002	0.000002	0.000002	0.000002	0.000002	0.000002	0.000002	0.000002	0.000002	0.000002
Specific gravity of product		1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33
Active ingredient in product (%)		48.5	48.5	48.5	48.5	48.5	48.5	48.5	48.5	48.5	48.5	48.5	48.5
Dosing rate (as ppm Al)	5.88	6.20	5.54	5.37	6.32	7.16	5.87	7.03	5.05	5.80	2.85	6.56	6.83
Flow rate (cfs)		1	1	1	1	1	1	1	1	1	1	1	1
Flow duration (days)		1	1	1	1	1	1	1	1	1	1	1	1
Conversion Factor cfs to L		2446575.5	2446575.5	2446575.55	2446575.55	2446575.5	2446575.55	2446575.55	2446575.55	2446575.55	2446575.55	2446575.55	2446575.55
Treated volume (L)		2446576	2446576	2446576	2446576	2446576	2446576	2446576	2446576	2446576	2446576	2446576	2446576
Treated volume (MG)		0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65
Volume of product required (L)		259	231	224	264	299	245	293	211	242	119	274	285
Volume of product required (gal)		68	61	59	70	79	65	77	56	64	31	72	75
Cost of product used for treated volume (L)		$36.81	$32.89	$31.89	$37.51	$42.52	$34.84	$41.70	$29.98	$34.43	$16.89	$38.91	$40.52

Table I-8. Projected Tools & Renewal & Replacement

Watershed Technologies, LLC HWTT			
C-43 WBSR Treatment Project			
Estimated Tools & Renewal & Replacement			
Annualized Tools & Supplies HWTT Facility			$ 34,148
Exclude laboratory, fuel, pump*		75%	$ 25,611
Applicable Costs to WBSR			$ 8,537
Scaling Factor			
Deep Creek Acres	60		
C-43 Ave. acres	452		
Ratio	8		$ 68,296
Tools & Supplies			$ 68,300
R&R Equipment (per Schedule)			$ 66,200
Total Tools, Machinery & Supplies			$ 134,500
*Based on Grassy Island HWTT			

Table I-9. Projected Renewal & Replacement

Watershed Technologies, LLC HWTT		
C-43 WBSR Treatment Project		
Estimated Renewal & Replacement		
Item	**Weighted Average Estimated Life**	**Estimated R&R in 2021 Dollars**
C-43 Treatment		
Various (See Detail)	15	$ 759,400
Total Replacement Cost		$ 759,400
Annual R&R		$ 66,200

Item	Quantity	Unit Cost	Total Cost	Life	Annual R&R
Floc Pumps	4	$ 20,000	$ 80,000	8	$ 10,000
Chemical Tanks			$ 500,000	18	$ 27,800
Pond liners			$ 50,000	20	$ 2,500
Monitoring & Control			$ 86,100	5	$ 17,220
Auto	1	$ 43,300	$ 43,300	5	$ 8,660
Total R&R			$ 759,400		$ 66,200
Weighted Average Life				15	

Table I-10. Projected Vegetative Management

Watershed Technologies, LLC HWTT		
C-43 WBSR Treatment Project		
Estimated Vegetative Management		
Herbiciding	**HWTT Site Settling Pond, FAV 1&2 and SAV**	**HWTT Site Settling Pond, FAV 1&2 and SAV 1&2**
Annual	$ 1,080	$ 1,440
area in acres	16	60
per acre	$ 67.50	$ 24.00
C-43 # acres	286	286
Total C-43 Herbiciding	$ 19,298	$ 6,862
Plant Acquisition		
Purchase	$ 629	$ 3,566
area in acres	16	60
per acre	$ 39.33	$ 59.43
C-43 # acres	286	286
Total C-43 Plant Renewal	$ 11,245	$ 16,991
Total Vegetative Management	$ 30,543	$ 23,852
Average Vegetative Management Plus 1.02% Inflation		$ 27,700

Residuals

Residual costs for the HWTT system are contained within the expense item Floc Management and are represented by Tilling. Disposal of the chemical residual (floc) is typically excavated from the drying beds and spread throughout an FAV cell during the routine maintenance of those Ponds. An alternative disposal method is available if, and when, the Reservoir sufficiently dries. During drying periods, solids could be opportunistically deposited within the Reservoir to the extent possible. Detailed calculations of projected tilling costs are shown in Table I-11.

Table I-11. Projected Floc Management

Watershed Technologies, LLC HWTT					
C-43 WBSR Treatment Project					
Estimated Residual (Floc) Management					
Tilling Post Drying Bed	**# FAV Ponds Tilled per Year (in %)**	**Total # Acres FAV Pond Shallow Zone**	**# Acres Tilled per Year**	**Unit Cost**	**Total**
Tilling	50%	56	28	512	$ 14,280

Power

Power (utilities) for the proposed HWTT WBSR Project relate to the building, the chemical dosing tanks, floc pumps, and monitoring equipment. (See assumptions excluding inflow and outflow pumps.) Detailed calculations of projected utility costs are shown in Table I-12.

Table I-12. Projected Power

Watershed Technologies, LLC HWTT	
C-43 WBSR Treatment Project	
Estimated Power Building, Dosing, Floc Pumps & Monitoring	
Annualized Power Building, Dosing, Floc Pumps & Monitoring*	1,008
Scaling Factor:	
Trout Lake ave. cfs	7
Cost per ave. cfs	$ 144
C-43 ave. cfs	456.00
Projected Utilities C-43	$ 65,700
*Based on Trout Lake HWTT Facility	
Power	$ 65,700
Fuel (Per Schedule)	7,540
Total Power & Fuel	$ 73,240

Fuel

Fuel costs represent gasoline for site visits for the field personnel. Fuel associated with movement of dried floc are included under unit prices for tilling. Detailed calculations of projected utility costs are shown Table I-13.

Table I-13. Projected Fuel

Watershed Technologies, LLC HWTT		
C-43 WBSR Treatment Project		
Estimated Fuel		
Estimated Annual Truck Fuel Cost		
LaBelle to the Caloosahatchee FAVT		
LaBelle to Caloosahatchee FAVT # Miles		28.1
Trips per Day		2
Days per Week		5
Number of Weeks		52
Total Miles		14,612
Heavy Duty Truck*		
Average Mileage per Gallon*		6.4
Average Costs per Gallon**		
Regular Unleaded	$	2.800
1 Year Est. Price Growth		36%
Est. Average Price over 12 Months	$	3.304
Estimated Truck Gas Expense	$	7,540
*https://www.eia.gov/totalenergy/data/annual/showtext.php?t=pTB0208		
** FL 4/25/21 Avg Regular Unleaded Price $2.80 (AAA); -36.09& YTD (https://ycharts.com/indicators/us_gas_price)		

Other

Other costs include Berms and Ground Maintenance and Site Internet Service. Detailed calculations of these costs are shown in Table I-14 and Table I-15, respectively.

Table I-14. Projected Other Costs

Watershed Technologies, LLC HWTT			
C-43 WBSR Treatment Project			
Estimated Berms & Grounds Maintenance			
	Total # Acres	**Unit Cost***	**Total**
Berms & Grounds	50.0	$ 800	$ 40,000
*Based on HWTT Facility			

Table I-15. Projected Site Internet Service

Watershed Technologies, LLC HWTT			
C-43 WBSR Treatment Project			
Estimated Site Cell and/or Satellite Internet			
Cell and/or Satellite Internet for Remote Monitoring, Communications & Control			
including Establishment/Maintenance of Separate Networks for Site Security Cameras,			
Security Alarm Service for Chemical Storage Buildings, & Data Transmission			
Site	**Total**		
C-43	$ 7,200		

H. Performance Statistics

Each of the treatment discharge objectives specified for the C-43 WBSR treatment project are identified below for the HWTT system, including flow, P, N, TSS, and Water Quality. All goals are attained in the proposal. Projected Cost Benefit values for phosphorus, nitrogen, and phosphorus and nitrogen combined are shown in Table I-16 through Table I-18, respectively. Cost Benefit has been calculated based upon the set of Assumptions (I. Assumptions), Capital Costs (F. Capital Costs (2021 Dollars)), Operations & Maintenance Costs (G. Operations & Maintenance (Annual)), and Performance Statistics (H. Performance Statistics).

Net Present Value

Net Present Value calculations are shown in Table I-16 through Table I-18.

Table I-16. Projected Cost Benefit Phosphorus (See Assumptions) Scenario 1.

WATERSHED TECHNOLOGIES, LLC.		
Projected Cost Benefit Analysis Phosphorus C-43 (See Assumptions)		
As of April 2021		
		Projected Present Value
Capacity Utilization:		
Average gpm		204274.8
Average cfs		457
Projected Infrastructure		
Infrastructure		$ 18,125,924
Total Capital		$ 18,125,924
Estimated Life		50
Projected Operations & Maintenance		
O&M Variable Costs Projected (Note 1)		$ 6,028,308
O&M Fixed Costs		392,492
Total Operations & Maintenance		$ 6,420,800
Present Worth O&M (Note 2)		$ 137,932,811
Projected Present Value Capital & O&M Costs		$ 156,058,735
Total Projected P Removal lb		3,048,230
Cost/Benefit $/lb.		**$ 51**
Notes:		
1. Variable Costs include costs primarily flow related including chemicals, utilities, floc mgmt.		
2. PV Calculated at Net Discount Rate	4%	
Estimated Life in Years	50	

Table I-17. Projected Cost Benefit Nitrogen (See Assumptions) Scenario 1.

WATERSHED TECHNOLOGIES, LLC.		
Projected Cost Benefit Analysis Nitrogen C-43 (See Assumptions)		
As of April 2021		
		Projected Present Value
Capacity Utilization:		
Average gpm		204274.8
Average cfs		457
Projected Infrastructure		
Infrastructure		$ 18,125,924
Total Capital		$ 18,125,924
Estimated Life		50
Projected Operations & Maintenance		
O&M Variable Costs Projected (Note 1)		$ 6,028,308
O&M Fixed Costs		392,492
Total Operations & Maintenance		$ 6,420,800
Present Worth O&M (Note 2)		$ 137,932,811
Projected Present Value Capital & O&M Costs		$ 156,058,735
Total Projected P Removal lb		25,986,074
Cost/Benefit $/lb.		**$ 6**
Notes:		
1. Variable Costs include costs primarily flow related including chemicals, utilities, floc mgmt.		
2. PV Calculated at Net Discount Rate	4%	
Estimated Life in Years	50	

Table I-18. Projected Cost Benefit Phosphorus & Nitrogen Combined (See Assumptions) Scenario 1.

WATERSHED TECHNOLOGIES, LLC.		
Projected Cost Benefit Analysis Phosphorus & Nitrogen C-43 (See Assumptions)		
As of April 2021		
		Projected Present Value
Capacity Utilization:		
Average gpm		204274.8
Average cfs		457
Projected Infrastructure		
Infrastructure in 2020 Dollars		$ 18,125,924
Total Capital		$ 18,125,924
Estimated Life		50
Projected Operations & Maintenance		
O&M Variable Costs Projected (Note 1)		$ 6,028,308
O&M Fixed Costs		392,492
Total Operations & Maintenance		$ 6,420,800
Present Worth O&M (Note 2)		$ 137,932,811
Projected Present Value Capital & O&M Costs		$ 156,058,735
Total Projected P Removal lb		10,438,355
Cost/Benefit $/lb.		**$ 10**
Notes:		
1. Variable Costs include costs primarily flow related including chemicals, utilities, floc mgmt.		
2. PV Calculated at Net Discount Rate	4%	
Estimated Life in Years	50	

Treated Flow

Attainment of the C-43 WBSR Treatment Project goal of treatment of an average of 456 cubic feet per second (cfs) with a range between 189 and 611 cfs was used as the flow basis for projections. Outflow was assumed to equal inflow; therefore, no benefits were assumed from seepage. Compared to Stormwater Treatment Area (STA) performance calculations, the effects of measured outflow can be significant.

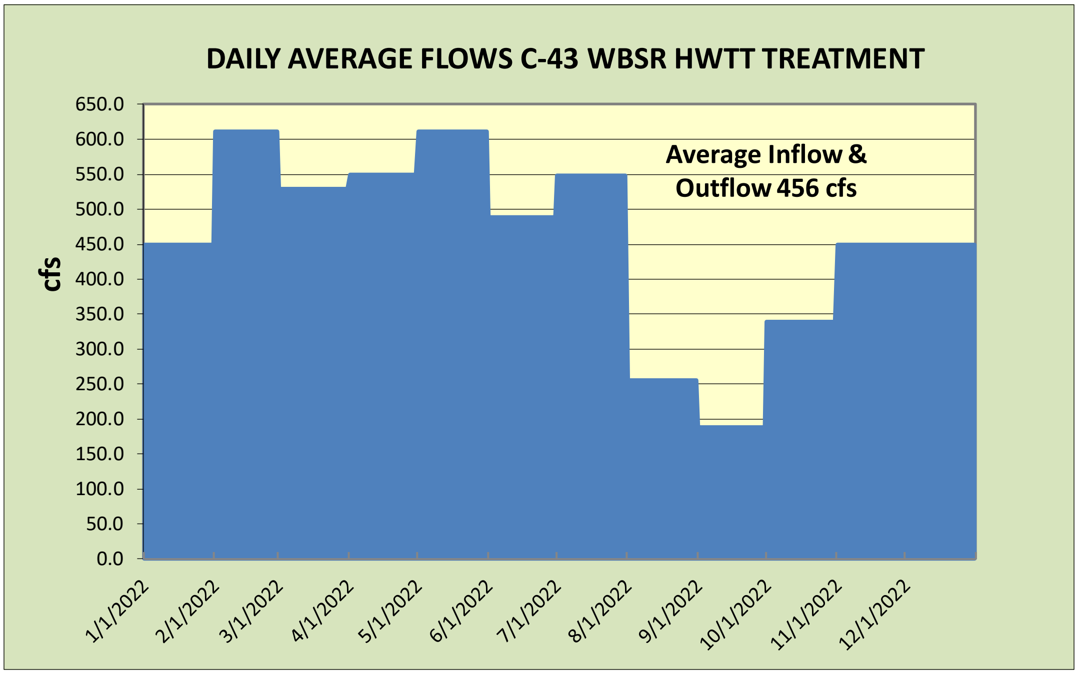


Figure I-4. Projected Daily Flows C-43 WBSR HWTT Treatment System.

Total Phosphorus (TP) Removal

The ability to attain the C-43 WBSR Treatment Project TP goal reduction is demonstrated through performance statistics taken from the HWTT facilities shown graphically below (Figure I-7 and Figure I-8. Percent reductions range from 96% to 79%. The Trout Lake site (88% TP removal) was selected as most representative of treatment of Reservoir waters. (Wolff Ditch is not representative of performance as the site was constructed without all efficiency components due to lack of land availability.) Projected operating data for the C-43 WBSR Treatment Proposal, including projected TP mass removed and flow weighted concentrations in and out are depicted graphically in Figure I-5 and Figure I-6; daily and total treated flows, TP mass in, TP mass out, and load are shown in Table I-19.

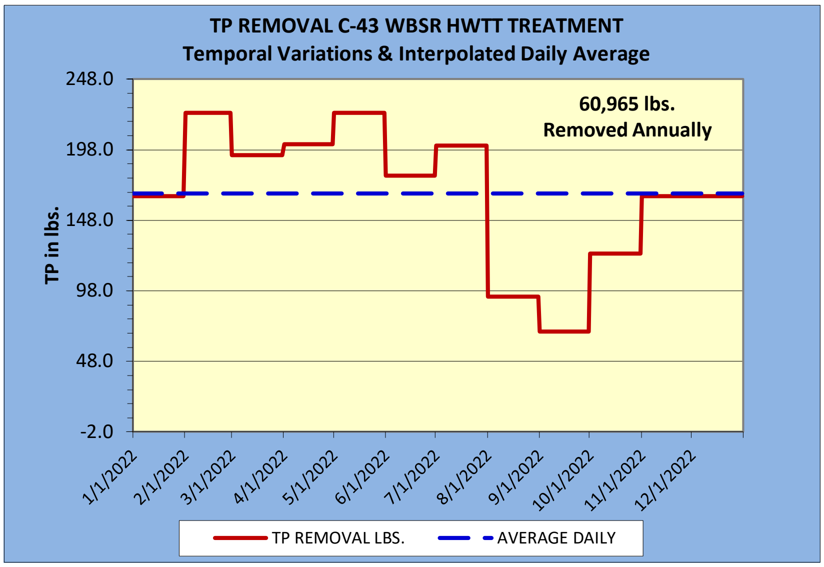


Figure I-5. Projected Daily TP Removal C-43 WBSR HWTT Treatment System Scenario 1.

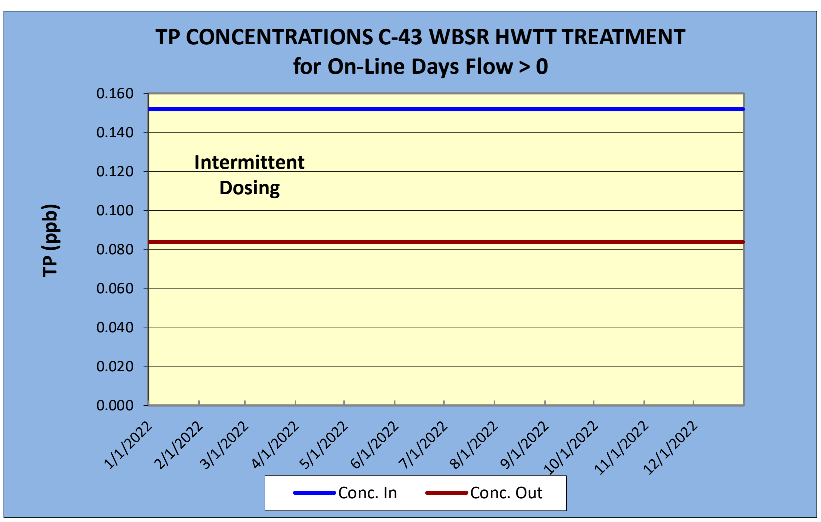


Figure I-6. Projected Daily TP Concentrations C-43 WBSR HWTT Treatment System Scenario 1.

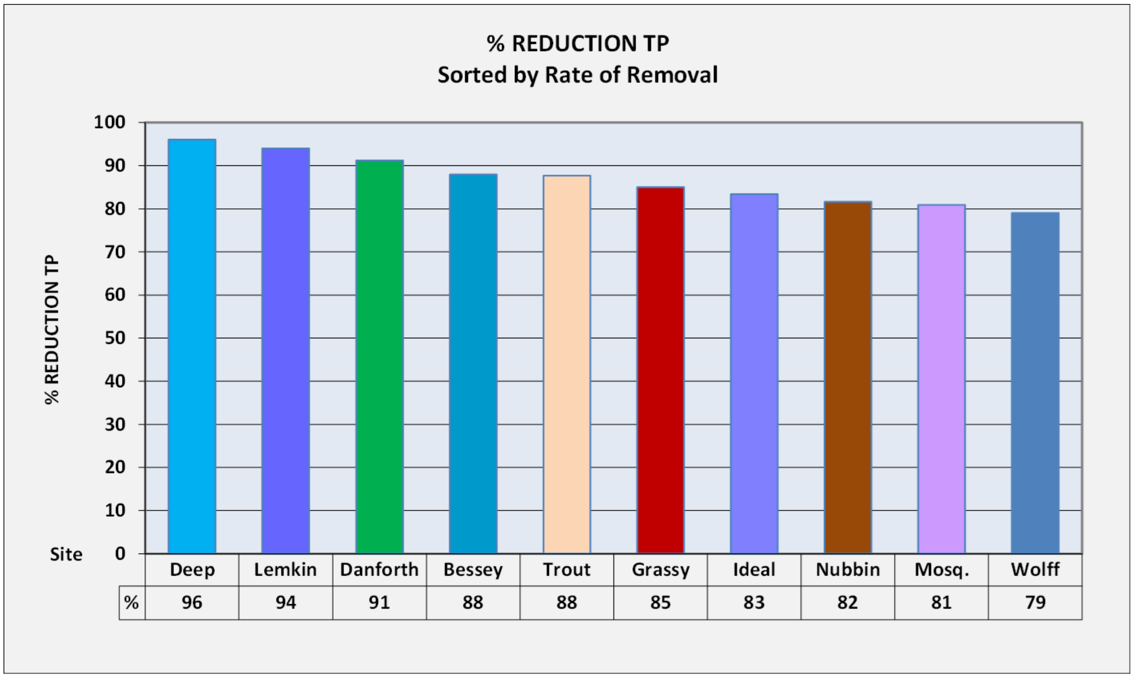


Figure I-7. Percent TP Reduction HWTT Facilities FY 2019-2020.

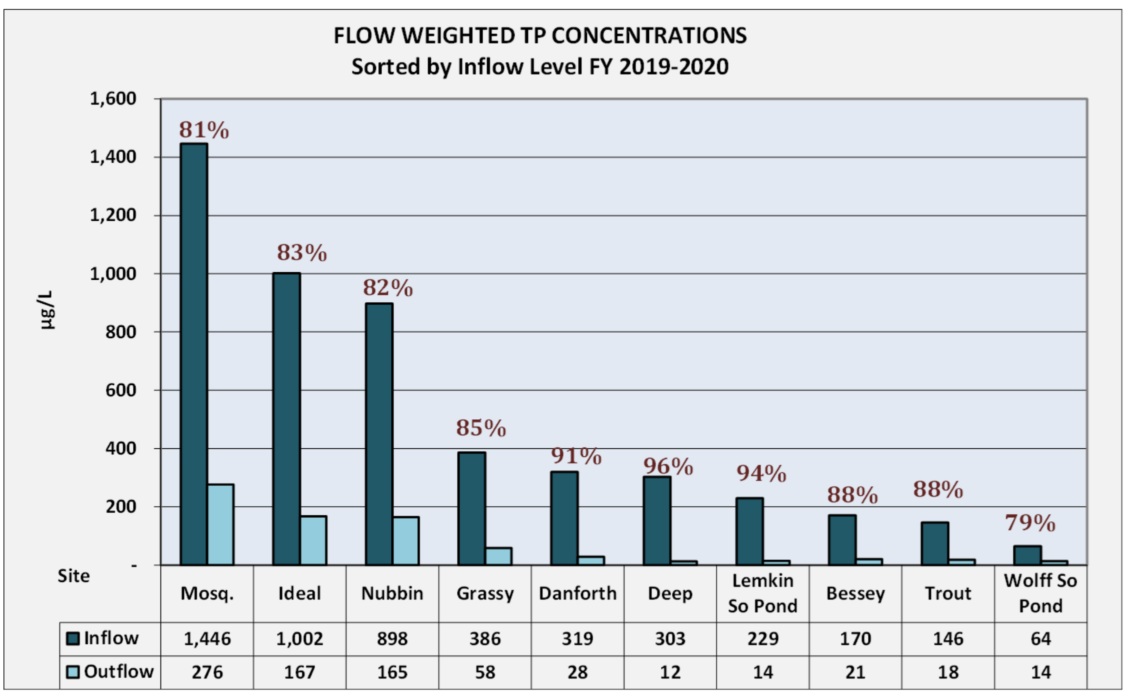


Figure I-8. FWM TP concentrations HWTT Facilities FY 2019-2020.

Table I-19. TP Load Performance Calculations Scenario 1.

(Double Click to Open Linked File)

WATERSHED TECHNOLOGIES						
C-43 TP Reduction Total						
Period	1/1/2022	through	12/31/2022	365	days in period	
# of Days On-Line	365	# Days On-Line Flow > 0.0000	365	# Days in Period Flow > 0.0000 Less Uncontrollable Downtime: 365		% Time On-Line vs. Available Days Excl. Uncontrollable Downtime: 100%
	TP MASS (lbs.) INFLOW	OUTFLOW	TP (lbs.) REMOVAL	AVERAGE DAILY FLOW	On-Line Unless Noted Otherwise	# Days Outflow >0 365
TOTAL	136202.8680	75238.2589	60964.6092	gpm On-Line Flow > 0	Operational/ Flow Status	
PER DAY	373.1585	206.1322	167.0263	204274.8		Comments
1/1/2022	368.9557	203.8106	165.1451	201974.0		
1/2/2022	368.9557	203.8106	165.1451	201974.0		
1/3/2022	368.9557	203.8106	165.1451	201974.0		
1/4/2022	368.9557	203.8106	165.1451	201974.0		
1/5/2022	368.9557	203.8106	165.1451	201974.0		
1/6/2022	368.9557	203.8106	165.1451	201974.0		
1/7/2022	368.9557	203.8106	165.1451	201974.0		
1/8/2022	368.9557	203.8106	165.1451	201974.0		
1/9/2022	368.9557	203.8106	165.1451	201974.0		
1/10/2022	368.9557	203.8106	165.1451	201974.0		
1/11/2022	368.9557	203.8106	165.1451	201974.0		
1/12/2022	368.9557	203.8106	165.1451	201974.0		
1/13/2022	368.9557	203.8106	165.1451	201974.0		
1/14/2022	368.9557	203.8106	165.1451	201974.0		
1/15/2022	368.9557	203.8106	165.1451	201974.0		
1/16/2022	368.9557	203.8106	165.1451	201974.0		
1/17/2022	368.9557	203.8106	165.1451	201974.0		
1/18/2022	368.9557	203.8106	165.1451	201974.0		
1/19/2022	368.9557	203.8106	165.1451	201974.0		
1/20/2022	368.9557	203.8106	165.1451	201974.0		
1/21/2022	368.9557	203.8106	165.1451	201974.0		
1/22/2022	368.9557	203.8106	165.1451	201974.0		
1/23/2022	368.9557	203.8106	165.1451	201974.0		
1/24/2022	368.9557	203.8106	165.1451	201974.0		
1/25/2022	368.9557	203.8106	165.1451	201974.0		
1/26/2022	368.9557	203.8106	165.1451	201974.0		
1/27/2022	368.9557	203.8106	165.1451	201974.0		
1/28/2022	368.9557	203.8106	165.1451	201974.0		
1/29/2022	368.9557	203.8106	165.1451	201974.0		
1/30/2022	368.9557	203.8106	165.1451	201974.0		
1/31/2022	368.9557	203.8106	165.1451	201974.0		
2/1/2022	500.9599	276.7295	224.2304	274235.9		
2/2/2022	500.9599	276.7295	224.2304	274235.9		
2/3/2022	500.9599	276.7295	224.2304	274235.9		
2/4/2022	500.9599	276.7295	224.2304	274235.9		
2/5/2022	500.9599	276.7295	224.2304	274235.9		
2/6/2022	500.9599	276.7295	224.2304	274235.9		
2/7/2022	500.9599	276.7295	224.2304	274235.9		
2/8/2022	500.9599	276.7295	224.2304	274235.9		
2/9/2022	500.9599	276.7295	224.2304	274235.9		
2/10/2022	500.9599	276.7295	224.2304	274235.9		
2/11/2022	500.9599	276.7295	224.2304	274235.9		
2/12/2022	500.9599	276.7295	224.2304	274235.9		
2/13/2022	500.9599	276.7295	224.2304	274235.9		
2/14/2022	500.9599	276.7295	224.2304	274235.9		
2/15/2022	500.9599	276.7295	224.2304	274235.9		
2/16/2022	500.9599	276.7295	224.2304	274235.9		
2/17/2022	500.9599	276.7295	224.2304	274235.9		

1

Total Nitrogen (TN) Removal

The ability to attain the C-43 WBSR Treatment Project TN goal reduction is demonstrated through performance statistics taken from the HWTT facilities shown graphically below (Figure I-11 and Figure I-12). Percent reductions range from 57% to 25%. The Trout Lake site (57% TN removal for FY 2019-2020 and cumulative removal of 63%) was selected as most representative of treatment of Reservoir waters. (Wolff Ditch and Nubbin Slough are not representative of performance as the sites were constructed without all efficiency components due to lack of land availability. Projected operating data for the C-43 WBSR Treatment Proposal, including projected TN mass removed and flow weighted concentrations in and out are depicted graphically in Figure I-9 and Figure I-10; daily and total treated flows, TN mass in, TN mass out, and load are shown in Table I-20.

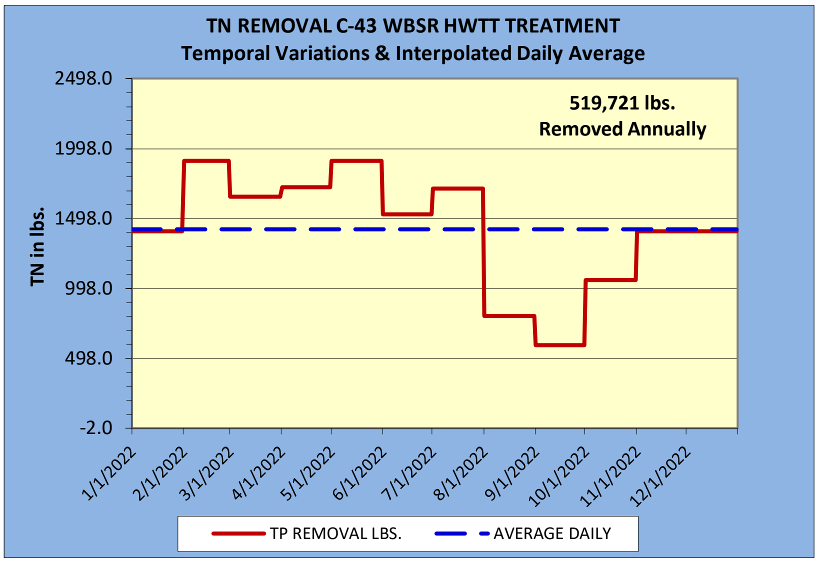


Figure I-9. Projected Daily TN removal C-43 WBSR HWTT Treatment System Scenario 1.

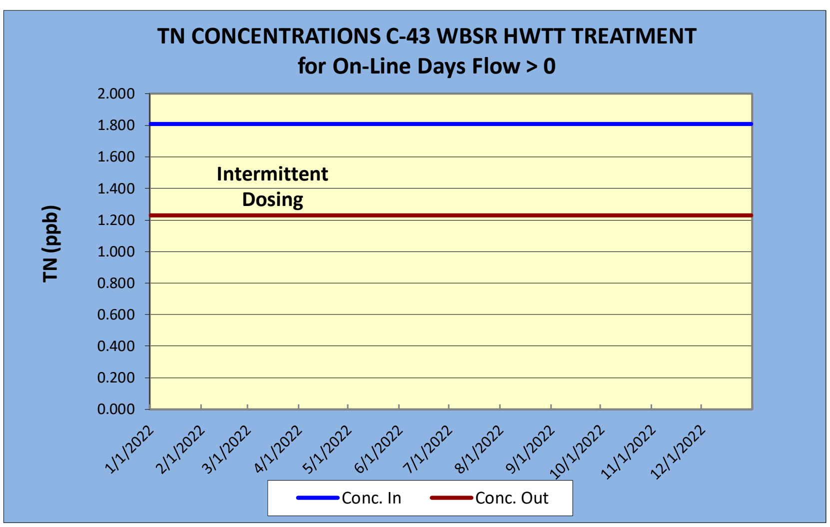


Figure I-10. Projected Daily TN concentrations C-43 WBSR HWTT Treatment System Scenario 1.

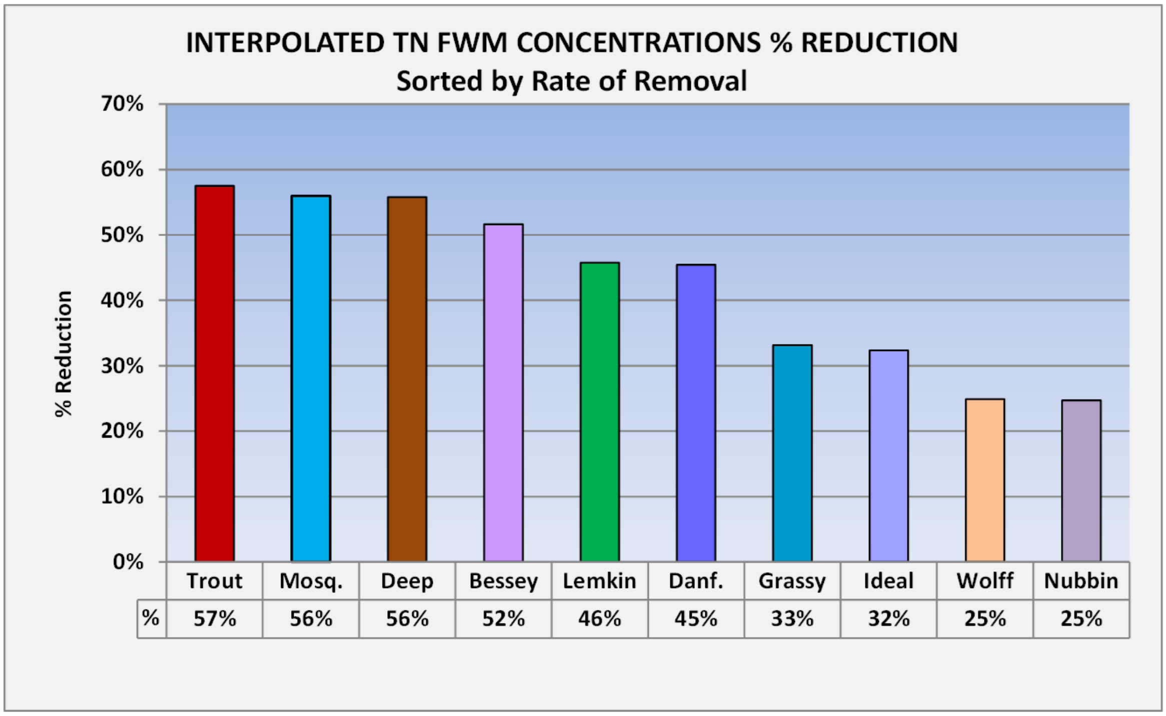


Figure I-11. Percent TN Reduction HWTT Facilities FY 2019-2020.

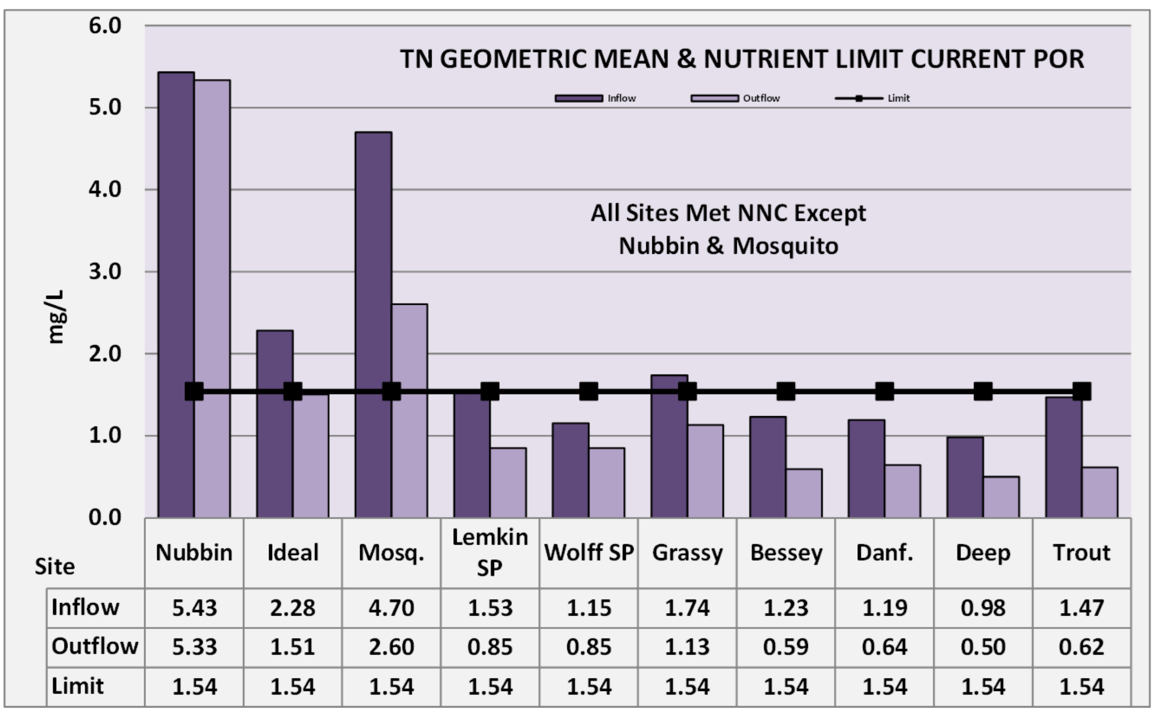


Figure I-12. Geometric Mean TN HWTT Facilities FY 2019-2020.

Table I-20. TN Load Performance Calculations Scenario 1.

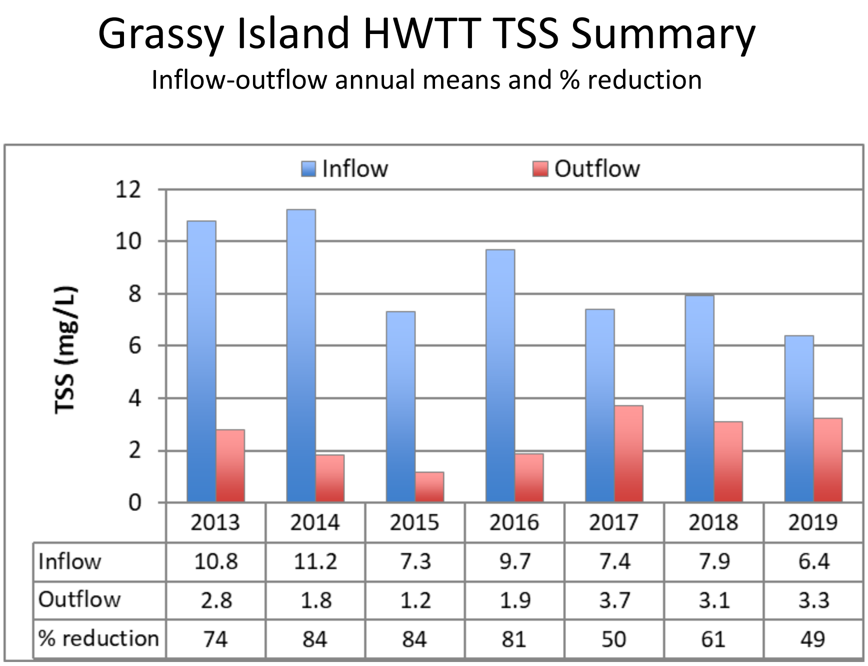
(Double Click to Open Linked File)

WATERSHED TECHNOLOGIES						
C-43 TN Reduction Total						
Period	1/1/2022	through	12/31/2022	365	days in period	
# of Days On-Line 365		# Days On-Line Flow > 0.0000 365		# Days in Period Flow > 0.0000 Less Uncontrollable Downtime: 365		% Time On-Line vs. Available Days Excl. Uncontrollable Downtime: 100%
	TN MASS (lbs.)		TN (lbs.)	AVERAGE	On-Line Unless	# Days Outflow >0
	INFLOW	OUTFLOW	REMOVAL	DAILY FLOW	Noted Otherwise	365
				gpm On-Line Flow > 0		
TOTAL	1621889.4155	1102167.9453	519721.4702		Operational/	
PER DAY	4443.5326	3019.6382	1423.8944	204274.8	Flow Status	Comments
1/1/2022	4393.4857	2985.6284	1407.8573	201974.0		
1/2/2022	4393.4857	2985.6284	1407.8573	201974.0		
1/3/2022	4393.4857	2985.6284	1407.8573	201974.0		
1/4/2022	4393.4857	2985.6284	1407.8573	201974.0		
1/5/2022	4393.4857	2985.6284	1407.8573	201974.0		
1/6/2022	4393.4857	2985.6284	1407.8573	201974.0		
1/7/2022	4393.4857	2985.6284	1407.8573	201974.0		
1/8/2022	4393.4857	2985.6284	1407.8573	201974.0		
1/9/2022	4393.4857	2985.6284	1407.8573	201974.0		
1/10/2022	4393.4857	2985.6284	1407.8573	201974.0		
1/11/2022	4393.4857	2985.6284	1407.8573	201974.0		
1/12/2022	4393.4857	2985.6284	1407.8573	201974.0		
1/13/2022	4393.4857	2985.6284	1407.8573	201974.0		
1/14/2022	4393.4857	2985.6284	1407.8573	201974.0		
1/15/2022	4393.4857	2985.6284	1407.8573	201974.0		
1/16/2022	4393.4857	2985.6284	1407.8573	201974.0		
1/17/2022	4393.4857	2985.6284	1407.8573	201974.0		
1/18/2022	4393.4857	2985.6284	1407.8573	201974.0		
1/19/2022	4393.4857	2985.6284	1407.8573	201974.0		
1/20/2022	4393.4857	2985.6284	1407.8573	201974.0		
1/21/2022	4393.4857	2985.6284	1407.8573	201974.0		
1/22/2022	4393.4857	2985.6284	1407.8573	201974.0		
1/23/2022	4393.4857	2985.6284	1407.8573	201974.0		
1/24/2022	4393.4857	2985.6284	1407.8573	201974.0		
1/25/2022	4393.4857	2985.6284	1407.8573	201974.0		
1/26/2022	4393.4857	2985.6284	1407.8573	201974.0		
1/27/2022	4393.4857	2985.6284	1407.8573	201974.0		
1/28/2022	4393.4857	2985.6284	1407.8573	201974.0		
1/29/2022	4393.4857	2985.6284	1407.8573	201974.0		
1/30/2022	4393.4857	2985.6284	1407.8573	201974.0		
1/31/2022	4393.4857	2985.6284	1407.8573	201974.0		
2/1/2022	5965.3772	4053.8199	1911.5573	274235.9		
2/2/2022	5965.3772	4053.8199	1911.5573	274235.9		
2/3/2022	5965.3772	4053.8199	1911.5573	274235.9		
2/4/2022	5965.3772	4053.8199	1911.5573	274235.9		
2/5/2022	5965.3772	4053.8199	1911.5573	274235.9		
2/6/2022	5965.3772	4053.8199	1911.5573	274235.9		
2/7/2022	5965.3772	4053.8199	1911.5573	274235.9		
2/8/2022	5965.3772	4053.8199	1911.5573	274235.9		
2/9/2022	5965.3772	4053.8199	1911.5573	274235.9		
2/10/2022	5965.3772	4053.8199	1911.5573	274235.9		
2/11/2022	5965.3772	4053.8199	1911.5573	274235.9		
2/12/2022	5965.3772	4053.8199	1911.5573	274235.9		
2/13/2022	5965.3772	4053.8199	1911.5573	274235.9		
2/14/2022	5965.3772	4053.8199	1911.5573	274235.9		
2/15/2022	5965.3772	4053.8199	1911.5573	274235.9		
2/16/2022	5965.3772	4053.8199	1911.5573	274235.9		
2/17/2022	5965.3772	4053.8199	1911.5573	274235.9		

1

Total Suspended Solids (TSS) Removal

The ability to attain the C-43 WBSR Treatment Project TSS goal of 50% reduction is demonstrated through performance statistics taken from the HWTT Grassy Island facility shown graphically below (Figure I-13). Percent reductions range from 84% to 49% over the previous 7-year period.



	2013	2014	2015	2016	2017	2018	2019
Inflow	10.8	11.2	7.3	9.7	7.4	7.9	6.4
Outflow	2.8	1.8	1.2	1.9	3.7	3.1	3.3
% reduction	74	84	84	81	50	61	49

Figure I-13. HWTT Historical TSS performance.

Water Quality Performance

HWTT can achieve low mean outflow TP and TN concentrations in waters of the State of Florida. There are various numeric TP criteria as a point of reference for projects, not formal applications of the standards. The first is a Peninsula Florida Numeric Nutrient Criteria (PF NNC) of 120 μg/L TP concentration, which includes waters of the Caloosahatchee River. There are no State of Florida numeric criteria for canals in the WBSR geographic area; the narrative nutrient criteria for the canals south of the River is no imbalance in natural populations of flora and fauna. The second criterion is the Upper Caloosahatchee River Estuary Numeric Nutrient Criteria (UCRE NNC) equal to 86 μg/L TP concentration. The NNC calculations are based upon annual geometric means not to be exceeded more than once in any three-year period. Both criteria are projected to be met by the HWTT proposed WBSR treatment system as demonstrated by continued performance at existing HWTT facilities.

There are various numeric TN criteria as a point of reference, not formal applications of the standards. The first is a PF NNC (62-302.531 Florida Administrative Code (FAC) (Numeric Interpretations of Narrative Nutrient Criteria) (FAC, 2013) of 1.54 milligrams per liter (mg/L) TN concentration, which includes waters of the Caloosahatchee River. There are no State of Florida numeric criteria for canals in the WBSR geographic area; the narrative nutrient criteria for the canals south of the River is no imbalance in natural populations of flora and fauna. The second criterion is the UCRE NNC equal to 0.82 mg/L TN concentration. The TN criteria are based on the annual geometric mean not to be exceeded more than once in any three-year period. The PF NNC criteria is projected to be met by the HWTT proposed WBSR treatment system. The water quality targets presented in the specification for this project are slightly greater than the UCRE NNC; however, the criteria is attained for all non-retrofitted HWTT sites (Figure I-12). For the Tidal Caloosahatchee, the TN level above which causes impairment ranges from 0.83 to 1.105 mg/L.

I. Assumptions Scenario 1

The WBSR HWTT Treatment Proposal is based upon a set of assumptions and conditions. The following list specifies the major items which form the basis of this proposal for Scenario 1.

1. Inflow range to the HWTT facility is 189 to 611 cfs.
2. Average flow to the HWTT facility is 456 cfs as the daily flow.
3. Inflow is equal to outflow, that is, there is no seepage loss.
4. Inflow water quality to the Reservoir was assumed as being constant at 1.81 mg/L TN and 0.152 mg/L TP as stipulated by the JTech team. For Scenario 1, no nutrient reduction is assumed from Reservoir treatment.
5. Effluent water quality targets are to be achieved at all times and are not annual averages.
6. Inflow and outflow pump station and associated conveyance costs are specifically excluded from the cost estimates for both capital and O&M.
7. Engineering design, permitting, surveys, construction management services, and contingencies *are not included* in the cost estimate. Mobilization, geotechnical, and surveys *are included* in the capital projections.
8. No contingencies are contained within the estimate for both capital and O&M.
9. HWTT facility effectiveness is based on performance of existing facilities in the state of Florida and jar tests performed by the SFWMD.
10. HWTT O&M costs are based in part on similar existing facilities in the state of Florida.
11. Net Present Values were based upon on a net discount rate of 4% over a fifty-year period. The Net Present Values are used in calculating the Cost Benefit costs per pound. Changes in the discount rate and time will affect the calculations.
12. A bulk rate for chemical costs was obtained from an HWTT vendor and utilized for projected chemical costs.
13. The O&M costs consist only of direct operational expenses. The following costs are specifically ***excluded*** from this proposal: administrative and overhead, management, scientific personnel/professional service fees, laboratory fees, pump costs for delivery of water to HWTT site, and rate of return. The excluded costs noted are not necessarily all inconclusive.
14. Land fees or land acquisition costs are not included in the proposal.

II. Scenario 2: Performance Assumed for Reservoir Direct Alum Injection

A. Treatment Process

A second HWTT alternative has also been developed using a set of assumptions *with projected nutrient removal performance* from a Reservoir in-line alum injection system (Scenario 2). The two Scenarios provide a range of O&M costs for treatment of the C-43 WBSR with HWTT. Scenario 2 is based on various assumptions, including inflow concentrations from the Reservoir to the HWTT system of 0.081 mg/L for TP and 1.502 mg/L for TN. The following Scenario 2 objectives for the WBSR are: (1) meet effluent water quality targets of 0.088 milligrams per liter (mg/L) for total phosphorus (TP) and 1.23 mg/L for total nitrogen (TN) with average inflow values from the Reservoir of 0.081 mg/L and 1.502 mg/L for TP and TN, respectively (Table II-1); (2) treat a set of given daily flows with an average of 456 cubic feet per second (cfs) (Table II-1); and (3) constrain capital facilities within the Western and Central Parcels of the designated Project available land (Figure I-1). The objectives for the proposal have been provided by J-Tech. The Conceptual Design and cost projections are based on various assumptions (see Section D. Assumptions Scenario 2). For Scenario 2, the TP is reduced beyond the target to 0.060 mg/L, since N reduction determines the treatment process. The HWTT removal efficiencies are based on performance of other HWTT facilities currently being operated throughout the state of Florida and contemporary jar tests being performed by the South Florida Water Management District (SFWMD). The conceptual design processes are depicted in Figure I-2.

Table II-1. Treated Flow and Effluent Nutrient Targets Scenario 2.

	HWTT Treated Flow to Achieve TP Outflow Targets				
Month	Reservoir Inflow TP (mg/L)	Reservoir Outflow/HWTT Inflow TP (mg/L)	Outflow Target (mg/L)	HWTT Outflow Conc (mg/L)	Total Flow
1	0.152	0.081	0.088	0.060	450.00
2	0.152	0.081	0.088	0.060	611.00
3	0.152	0.081	0.088	0.060	529.00
4	0.152	0.081	0.088	0.060	550.00
5	0.152	0.081	0.088	0.060	611.00
6	0.152	0.081	0.088	0.060	489.00
7	0.152	0.081	0.088	0.060	548.00
8	0.152	0.081	0.088	0.060	256.00
9	0.152	0.081	0.088	0.060	189.00
10	0.152	0.081	0.088	0.060	339.00
11	0.152	0.081	0.088	0.060	450.00
12	0.152	0.081	0.088	0.060	450.00
Total					***5472.0***
Average	***0.152***	***0.081***	***0.088***	***0.060***	***456.0***

	HWTT Treated Flow to Achieve TN Outflow Targets				
Month	Reservoir Inflow TN (mg/L)	Reservoir Outflow/HWTT Inflow TN (mg/L)	Outflow Target (mg/L)	HWTT Outflow Conc (mg/L)	Total Flow
1	1.810	1.502	1.230	1.230	450.00
2	1.810	1.502	1.230	1.230	611.00
3	1.810	1.502	1.230	1.230	529.00
4	1.810	1.502	1.230	1.230	550.00
5	1.810	1.502	1.230	1.230	611.00
6	1.810	1.502	1.230	1.230	489.00
7	1.810	1.502	1.230	1.230	548.00
8	1.810	1.502	1.230	1.230	256.00
9	1.810	1.502	1.230	1.230	189.00
10	1.810	1.502	1.230	1.230	339.00
11	1.810	1.502	1.230	1.230	450.00
12	1.810	1.502	1.230	1.230	450.00
Total					***5472.0***
Average	***1.810***	***1.502***	***1.230***	***1.230***	***456.0***

B. Operations & Maintenance (Annual)

The projected Operations & Maintenance (O&M) costs are based upon a set of assumptions contained within Section D. Assumptions Scenario 2 of this Report. Under Scenario 2, the projected annual O&M are reduced by approximately 40% to $3,839,160 due to a reduction in chemical usage. All other costs are assumed to remain static and are consistent with Scenario 1. The two Scenarios provide a range of O&M costs for treatment of the C-43 WBSR with HWTT. A summary by expense type for Scenario 2 is presented in Table II-2, and detailed Chemical costs for Scenario 2 are provided in Table II-3.

Table II-2. C-43 WBSR HWTT Treatment System Projected O&M by Category & Line Item Scenario 2.

WATERSHED TECHNOLOGIES, LLC HWTT						
C-43 WBSR Treatment Projected O&M Scenario 2						
See Notes & Assumptions						
Line Item Budget Category	**Description**	**Total by Line Item Category**	**%**		**Amount**	**% Allocated to Category**
Salaries	Salaries	$ 208,000	5.42%		$ 208,000	5.42%
Fringe Benefits	Fringe Benefits	15,912	0.41%		15,912	0.41%
Materials	Chemicals	3,361,938	87.57%			
	Equipment	94,180	2.45%			
	Vegetation	27,200	0.72%		3,483,318	90.73%
Residuals	Floc Management	14,280	0.37%		14,280	0.37%
Power & Fuel	Utilities/Fuel	70,450	1.84%		70,450	1.84%
Other	Berms & Grounds Maintenance	40,000	1.04%			
	Site Internet Service	7,200	0.19%		47,200	1.23%
Indirect Costs/Overhead	Indirect Costs/Overhead	(0)	0.00%		(0)	0.00%
Total		$ 3,839,160	100.00%		$ 3,839,160	100.00%

WATERSHED TECHNOLOGIES, LLC HWTT C-43 WBSR TREATMENT	
PROJECTED STATEMENT OF EXPENSES SCENARIO 2	
FOR THE YEAR ENDING DECEMBER 31, 2022	
(Unaudited)	
See Notes & Assumptions	
	Projected
Operations & Maintenance	
Labor	$ 208,000
Chemicals	3,361,938
Utilities/Fuel	70,450
Equipment, Tools & Supplies	94,180
Site Cell Phone/Internet	7,200
Ground Maintenance	40,000
Vegetation Management	27,200
Residual (Floc) Management	14,280
Fringe Benefits	15,912
Total Projected Expenses	$ 3,839,160

Materials

Materials for the HWTT system include chemicals, tools, supplies, equipment, and vegetation. Only Chemical costs vary from Scenario 1; all other costs remain static. Chemicals will be acquired from a certified chemical company at a bulk rate price. Safety procedures are followed for all deliveries and management thereafter. Disposal of the chemical residual (floc) is discussed under the O&M Residuals Section for Scenario 1. Detailed calculations of projected chemical costs total $3,361,938 as shown in Table II-3 based upon an average 456 cfs and an intermittent effective dosing rate of 3.33 mg/L. The projected chemical costs are $80,000 lower if the dosing rate does not fluctuate by month, that is, the average dosing rate is used for each month.

Table II-3. Projected Chemicals Scenario 2.

C-43 WBSR HWTT TREATMENT SCENARIO 2		31	28	31	30	31	30	31	31	30	31	31	30
Projected Chemicals	**Month**	7	8	9	10	11	12	1	2	3	4	5	6
Chemicals	$3,361,938	$ 290,421	$ 318,280	$ 295,828	$ 350,093	$ 455,579	$ 289,130	$ 400,701	$ 134,584	$ 110,426	$ 100,424	$ 307,055	$ 309,416
Total Monthly cfs	166,121	13,950.0	17,108.0	16,399.0	16,500.0	18,941.0	14,670.0	16,988.0	7,936.0	5,670.0	10,509.0	13,950.0	13,500.0
Ave. daily cfs	456.00	450.00	611.00	529.00	550.00	611.00	489.00	548.00	256.00	189.00	339.00	450.00	450.00
		Alum	Alum	Alum	Alum	Alum	Alum	Alum	Alum	Alum	Alum	Alum	Alum
Cost basis (unit)		Dry ton	Dry ton	Dry ton	Dry ton	Dry ton	Dry ton	Dry ton	Dry ton	Dry ton	Dry ton	Dry ton	Dry ton
Product cost per unit ($)	$ 200	200	200	200	200	200	200	200	200	200	200	200	200
Volume of product per unit (L)		1406	1406	1406	1406	1406	1406	1406	1406	1406	1406	1406	1406
Al content of product (% by wt.)		4.41	4.41	4.41	4.41	4.41	4.41	4.41	4.41	4.41	4.41	4.41	4.41
Al mass (kg) per unit of product		82.4	82.4	82.4	82.4	82.4	82.4	82.4	82.4	82.4	82.4	82.4	82.4
Al concentration in product (g Al/L)		58.6	58.6	58.6	58.6	58.6	58.6	58.6	58.6	58.6	58.6	58.6	58.6
Product cost per liter ($)		0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142
Product cost per mg of Al ($)		0.000002	0.000002	0.000002	0.000002	0.000002	0.000002	0.000002	0.000002	0.000002	0.000002	0.000002	0.000002
Specific gravity of product		1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33
Active ingredient in product (%)		48.5	48.5	48.5	48.5	48.5	48.5	48.5	48.5	48.5	48.5	48.5	48.5
Dosing rate (as ppm Al)	3.33	3.51	3.13	3.04	3.57	4.05	3.32	3.97	2.86	3.28	1.61	3.71	3.86
Flow rate (cfs)		1	1	1	1	1	1	1	1	1	1	1	1
Flow duration (days)		1	1	1	1	1	1	1	1	1	1	1	1
Conversion Factor cfs to L		2446575.55	2446575.5	2446575.5	2446575.55	2446575.5	2446575.55	2446575.55	2446575.55	2446575.55	2446575.55	2446575.55	2446575.55
Treated volume (L)		2446576	2446576	2446576	2446576	2446576	2446576	2446576	2446576	2446576	2446576	2446576	2446576
Treated volume (MG)		0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65
Volume of product required (L)		146	131	127	149	169	139	166	119	137	67	155	161
Volume of product required (gal)		39	35	34	39	45	37	44	32	36	18	41	43
Cost of product used for treated volume (L)		$20.82	$18.60	$18.04	$21.22	$24.05	$19.71	$23.59	$16.96	$19.48	$9.56	$22.01	$22.92

C. Performance

The treatment discharge objectives specified for the C-43 WBSR treatment project for P and N are identified below for the HWTT system under Scenario 2; all other parameters remain the same as Scenario 1. All goals are attained in the proposal.

Total Phosphorus (TP) Removal

The ability to attain the C-43 WBSR Treatment Project TP goal reduction is demonstrated through performance statistics taken from the HWTT facilities shown graphically (Figure I-7 and Figure I-8). Percent reductions range from 96% to 79%. The Trout Lake site (88% TP removal) was selected as most representative of treatment of Reservoir waters. (Wolff Ditch is not representative of performance as the site was constructed without all efficiency components due to lack of land availability.) Projected operating data for the C-43 WBSR Treatment Proposal Scenario 2, including projected TP mass removed and flow weighted concentrations in and out are depicted graphically in Figure II-1 and Figure II-2; daily and total treated flows, TP mass in, TP mass out, and load are shown in Table II-4.

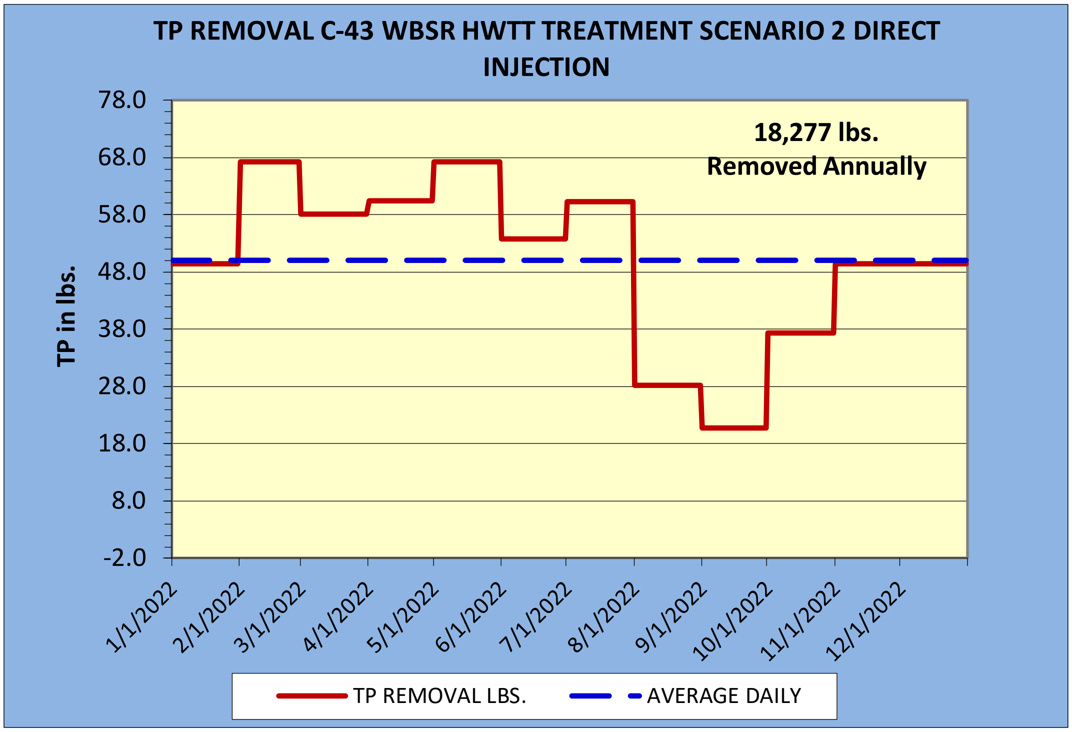


Figure II-1 Projected Daily TP Removal C-43 WBSR HWTT Treatment System Scenario 2.

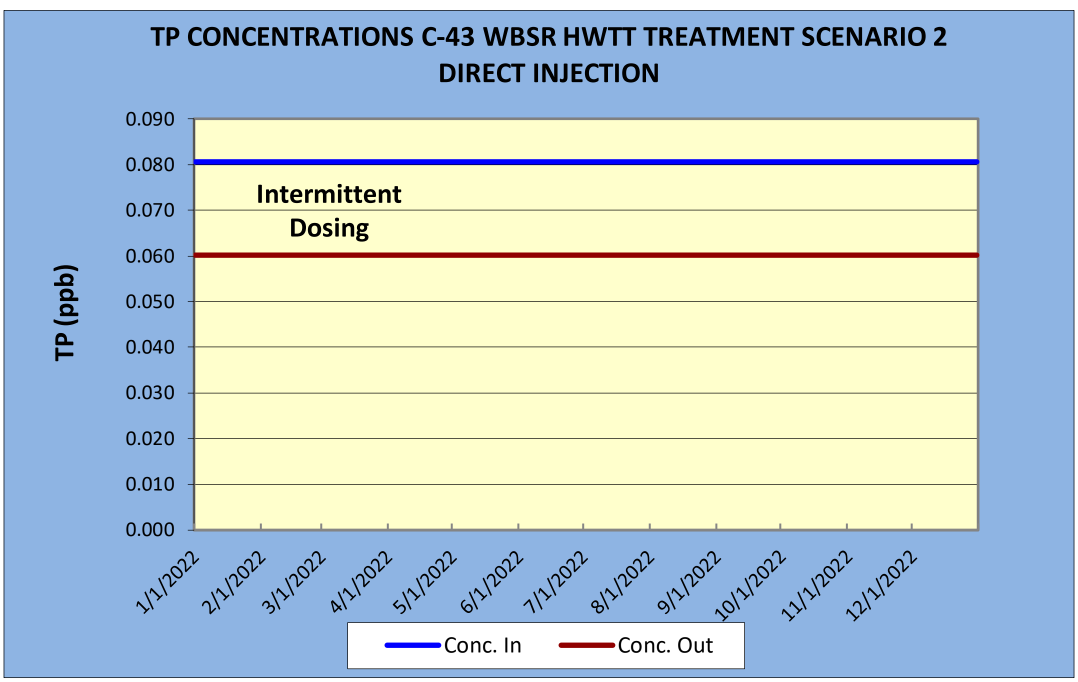


Figure II-2. Projected Daily TP Concentrations C-43 WBSR HWTT Treatment System Scenario 2.

Table II-4. TP Load Performance Calculations Scenario 2.

(Double click to open linked file.)

WATERSHED TECHNOLOGIES						
C-43 TP Reduction Total Scenario 2						
Period	1/1/2022	through	12/31/2022	365	days in period	
# of Days On-Line	365	# Days On-Line Flow > 0.0000	365	# Days in Period Flow > 0.0000 Less Uncontrollable Downtime:	365	% Time On-Line vs. Available Days Excl. Uncontrollable Downtime: 100%
	TP MASS (lbs.)		TP (lbs.)	AVERAGE	On-Line Unless	# Days Outflow >0
	INFLOW	OUTFLOW	REMOVAL	DAILY FLOW	Noted Otherwise	365
TOTAL	72187.5201	53910.9280	18276.5921	gpm On-Line Flow > 0	Operational/	
PER DAY	197.7740	147.7012	50.0729	204274.8	Flow Status	Comments
1/1/2022	195.5465	146.0376	49.5089	201974.0		
1/2/2022	195.5465	146.0376	49.5089	201974.0		
1/3/2022	195.5465	146.0376	49.5089	201974.0		
1/4/2022	195.5465	146.0376	49.5089	201974.0		
1/5/2022	195.5465	146.0376	49.5089	201974.0		
1/6/2022	195.5465	146.0376	49.5089	201974.0		
1/7/2022	195.5465	146.0376	49.5089	201974.0		
1/8/2022	195.5465	146.0376	49.5089	201974.0		
1/9/2022	195.5465	146.0376	49.5089	201974.0		
1/10/2022	195.5465	146.0376	49.5089	201974.0		
1/11/2022	195.5465	146.0376	49.5089	201974.0		
1/12/2022	195.5465	146.0376	49.5089	201974.0		
1/13/2022	195.5465	146.0376	49.5089	201974.0		
1/14/2022	195.5465	146.0376	49.5089	201974.0		
1/15/2022	195.5465	146.0376	49.5089	201974.0		
1/16/2022	195.5465	146.0376	49.5089	201974.0		
1/17/2022	195.5465	146.0376	49.5089	201974.0		
1/18/2022	195.5465	146.0376	49.5089	201974.0		
1/19/2022	195.5465	146.0376	49.5089	201974.0		
1/20/2022	195.5465	146.0376	49.5089	201974.0		
1/21/2022	195.5465	146.0376	49.5089	201974.0		
1/22/2022	195.5465	146.0376	49.5089	201974.0		
1/23/2022	195.5465	146.0376	49.5089	201974.0		
1/24/2022	195.5465	146.0376	49.5089	201974.0		
1/25/2022	195.5465	146.0376	49.5089	201974.0		
1/26/2022	195.5465	146.0376	49.5089	201974.0		
1/27/2022	195.5465	146.0376	49.5089	201974.0		
1/28/2022	195.5465	146.0376	49.5089	201974.0		
1/29/2022	195.5465	146.0376	49.5089	201974.0		
1/30/2022	195.5465	146.0376	49.5089	201974.0		
1/31/2022	195.5465	146.0376	49.5089	201974.0		
2/1/2022	265.5087	198.2867	67.2221	274235.9		
2/2/2022	265.5087	198.2867	67.2221	274235.9		
2/3/2022	265.5087	198.2867	67.2221	274235.9		
2/4/2022	265.5087	198.2867	67.2221	274235.9		
2/5/2022	265.5087	198.2867	67.2221	274235.9		
2/6/2022	265.5087	198.2867	67.2221	274235.9		
2/7/2022	265.5087	198.2867	67.2221	274235.9		
2/8/2022	265.5087	198.2867	67.2221	274235.9		
2/9/2022	265.5087	198.2867	67.2221	274235.9		
2/10/2022	265.5087	198.2867	67.2221	274235.9		
2/11/2022	265.5087	198.2867	67.2221	274235.9		
2/12/2022	265.5087	198.2867	67.2221	274235.9		
2/13/2022	265.5087	198.2867	67.2221	274235.9		
2/14/2022	265.5087	198.2867	67.2221	274235.9		
2/15/2022	265.5087	198.2867	67.2221	274235.9		
2/16/2022	265.5087	198.2867	67.2221	274235.9		
2/17/2022	265.5087	198.2867	67.2221	274235.9		

1

Total Nitrogen (TN) Removal

The ability to attain the C-43 WBSR Treatment Project TN goal reduction is demonstrated through performance statistics taken from the HWTT facilities shown graphically (Figure I-11 and Figure I-12). Percent reductions range from 57% to 25%. The Trout Lake site (57% TN removal for FY 2019-2020 and cumulative removal of 63%) was selected as most representative of treatment of Reservoir waters. (Wolff Ditch and Nubbin Slough are not representative of performance as the sites were constructed without all efficiency components due to lack of land availability. Projected operating data for the C-43 WBSR Treatment Proposal Scenario 2, including projected TN mass removed and flow weighted concentrations in and out are depicted graphically in Figure II-3 and Figure II-4; daily and total treated flows, TN mass in, TN mass out, and load are shown in Table II-5.

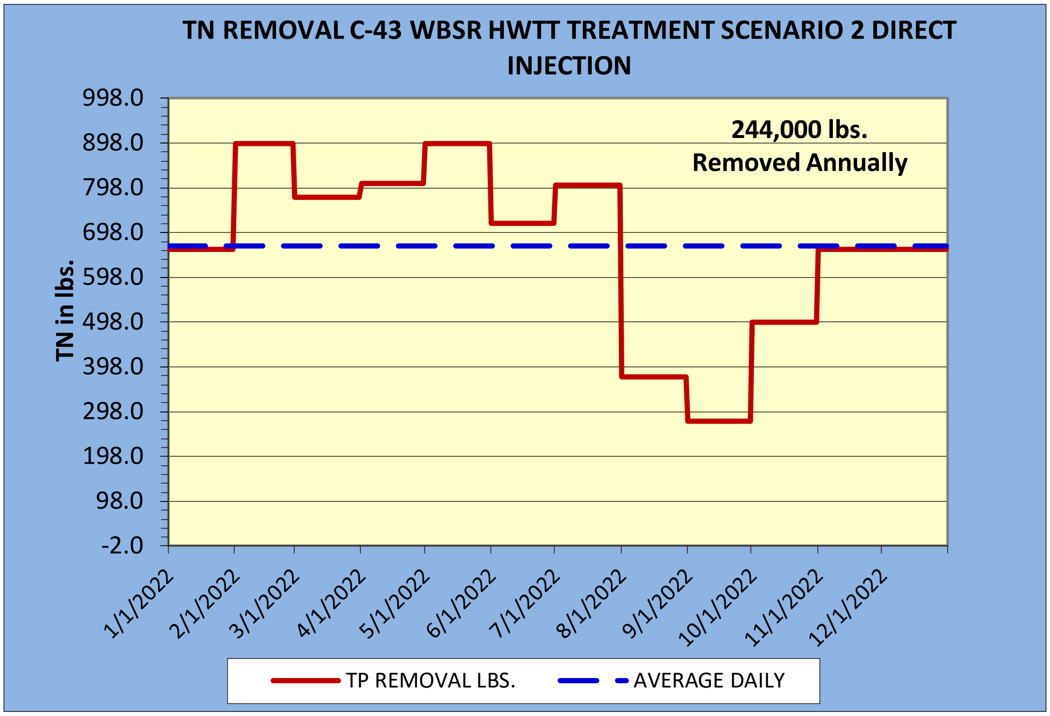


Figure II-3. Projected Daily TP Removal C-43 WBSR HWTT Treatment System Scenario 2.

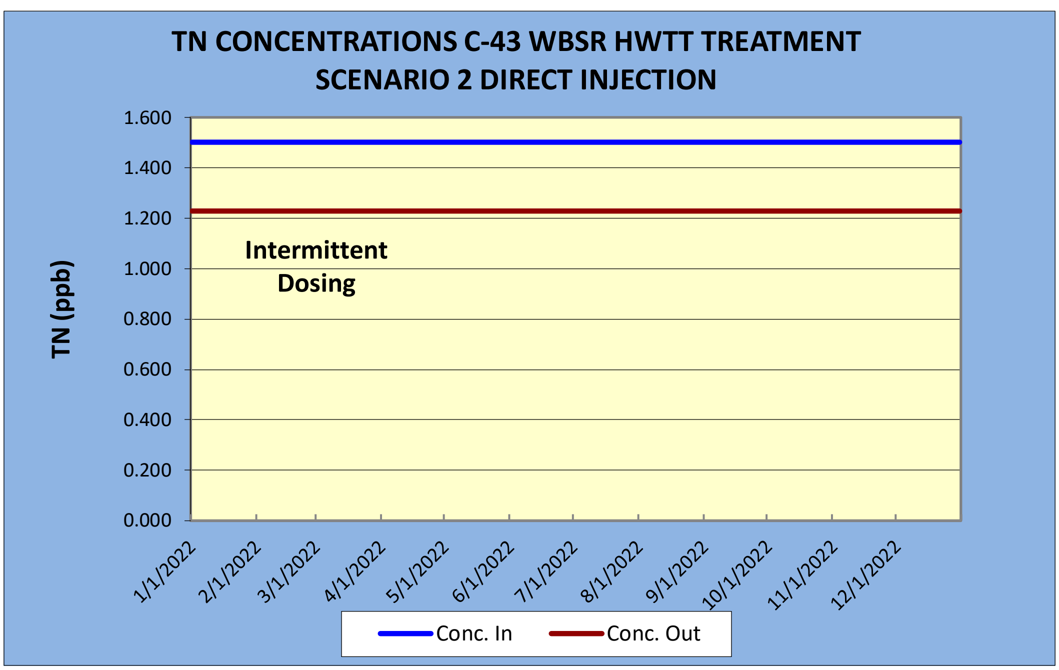


Figure II-4. Projected Daily TN Concentrations C-43 WBSR HWTT Treatment System Scenario 2.

Table II-5. TN Load Performance Calculations Scenario 2.

(Double click to open linked file.)

WATERSHED TECHNOLOGIES						
C-43 TN Reduction Total Scenario 2						
Period	**1/1/2022**	**through**	**12/31/2022**	**365**	**days in period**	
# of Days On-Line 365		**# Days On-Line Flow > 0.0000** 365		**# Days in Period Flow > 0.0000 Less Uncontrollable Downtime:** 365		**% Time On-Line vs. Available Days Excl. Uncontrollable Downtime:** 100%
	TN MASS (lbs.)		**TN (lbs.)**	**AVERAGE**	**On-Line Unless**	**# Days Outflow >0**
	INFLOW	**OUTFLOW**	**REMOVAL**	**DAILY FLOW**	**Noted Otherwise**	**365**
				gpm On-Line Flow > 0		
TOTAL	**1346168.2149**	**1102167.9453**	**244000.2695**		**Operational/**	
PER DAY	**3688.1321**	**3019.6382**	**668.4939**	**204274.8**	**Flow Status**	**Comments**
1/1/2022	3646.5931	2985.6284	660.9647	201974.0		
1/2/2022	3646.5931	2985.6284	660.9647	201974.0		
1/3/2022	3646.5931	2985.6284	660.9647	201974.0		
1/4/2022	3646.5931	2985.6284	660.9647	201974.0		
1/5/2022	3646.5931	2985.6284	660.9647	201974.0		
1/6/2022	3646.5931	2985.6284	660.9647	201974.0		
1/7/2022	3646.5931	2985.6284	660.9647	201974.0		
1/8/2022	3646.5931	2985.6284	660.9647	201974.0		
1/9/2022	3646.5931	2985.6284	660.9647	201974.0		
1/10/2022	3646.5931	2985.6284	660.9647	201974.0		
1/11/2022	3646.5931	2985.6284	660.9647	201974.0		
1/12/2022	3646.5931	2985.6284	660.9647	201974.0		
1/13/2022	3646.5931	2985.6284	660.9647	201974.0		
1/14/2022	3646.5931	2985.6284	660.9647	201974.0		
1/15/2022	3646.5931	2985.6284	660.9647	201974.0		
1/16/2022	3646.5931	2985.6284	660.9647	201974.0		
1/17/2022	3646.5931	2985.6284	660.9647	201974.0		
1/18/2022	3646.5931	2985.6284	660.9647	201974.0		
1/19/2022	3646.5931	2985.6284	660.9647	201974.0		
1/20/2022	3646.5931	2985.6284	660.9647	201974.0		
1/21/2022	3646.5931	2985.6284	660.9647	201974.0		
1/22/2022	3646.5931	2985.6284	660.9647	201974.0		
1/23/2022	3646.5931	2985.6284	660.9647	201974.0		
1/24/2022	3646.5931	2985.6284	660.9647	201974.0		
1/25/2022	3646.5931	2985.6284	660.9647	201974.0		
1/26/2022	3646.5931	2985.6284	660.9647	201974.0		
1/27/2022	3646.5931	2985.6284	660.9647	201974.0		
1/28/2022	3646.5931	2985.6284	660.9647	201974.0		
1/29/2022	3646.5931	2985.6284	660.9647	201974.0		
1/30/2022	3646.5931	2985.6284	660.9647	201974.0		
1/31/2022	3646.5931	2985.6284	660.9647	201974.0		
2/1/2022	4951.2631	4053.8199	897.4432	274235.9		
2/2/2022	4951.2631	4053.8199	897.4432	274235.9		
2/3/2022	4951.2631	4053.8199	897.4432	274235.9		
2/4/2022	4951.2631	4053.8199	897.4432	274235.9		
2/5/2022	4951.2631	4053.8199	897.4432	274235.9		
2/6/2022	4951.2631	4053.8199	897.4432	274235.9		
2/7/2022	4951.2631	4053.8199	897.4432	274235.9		
2/8/2022	4951.2631	4053.8199	897.4432	274235.9		
2/9/2022	4951.2631	4053.8199	897.4432	274235.9		
2/10/2022	4951.2631	4053.8199	897.4432	274235.9		
2/11/2022	4951.2631	4053.8199	897.4432	274235.9		
2/12/2022	4951.2631	4053.8199	897.4432	274235.9		
2/13/2022	4951.2631	4053.8199	897.4432	274235.9		
2/14/2022	4951.2631	4053.8199	897.4432	274235.9		
2/15/2022	4951.2631	4053.8199	897.4432	274235.9		
2/16/2022	4951.2631	4053.8199	897.4432	274235.9		
2/17/2022	4951.2631	4053.8199	897.4432	274235.9		

1

D. Assumptions Scenario 2

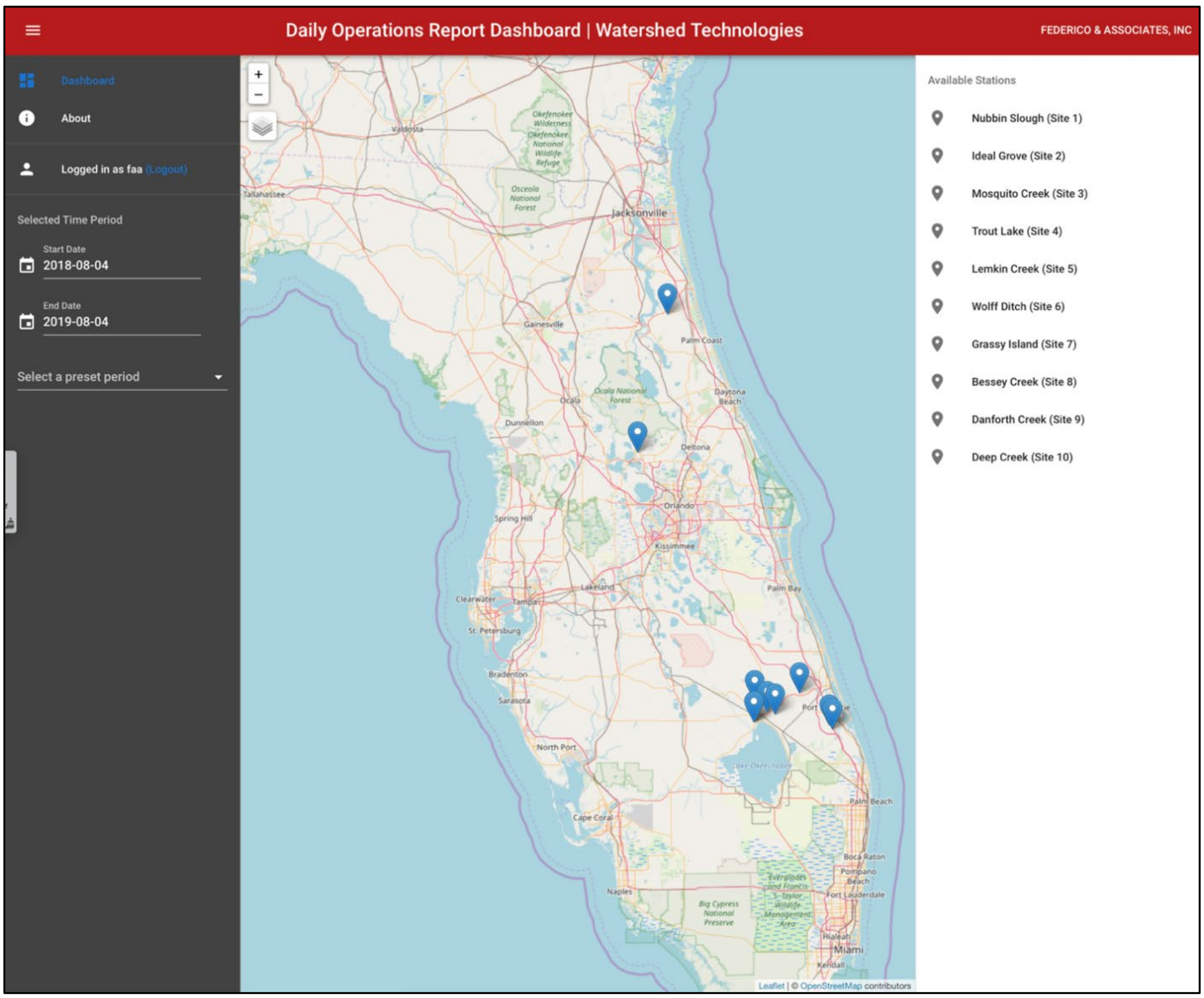
The WBSR HWTT Treatment Proposal is based upon a set of assumptions and conditions. The following list specifies the major items which form the basis of this proposal for Scenario 2.

1. Inflow range to the HWTT facility is 189 to 611 cfs.
2. Average flow to the HWTT facility is 456 cfs as the daily flow.
3. Inflow is equal to outflow, that is, there is no seepage loss.
4. Inflow water quality to the Reservoir was assumed as being constant at 1.81 mg/L TN and 0.152 mg/L TP as stipulated by the JTech team. For Scenario 2, nutrient reduction performance is assumed from Reservoir treatment.
5. Effluent water quality targets are to be achieved at all times and are not annual averages.
6. Inflow and outflow pump station and associated conveyance costs are specifically excluded from the cost estimates for both capital and O&M.
7. Engineering design, permitting, surveys, construction management services, and contingencies *are not included* in the cost estimate. Mobilization, geotechnical, and surveys *are included* in the capital projections.
8. No contingencies are contained within the estimate for both capital and O&M.
9. HWTT facility effectiveness is based on performance of existing facilities in the state of Florida and jar tests performed by the SFWMD.
10. HWTT O&M costs are based in part on similar existing facilities in the state of Florida.
11. A bulk rate for chemical costs was obtained from a HWTT vendor and utilized for projected chemical costs.
12. The O&M costs consist only of direct operational expenses. The following costs are specifically ***excluded*** from this proposal: administrative and overhead, management, scientific personnel/professional service fees, laboratory fees, pump costs for delivery of water to HWTT site, and rate of return. The excluded costs noted are not necessarily all inconclusive.
13. Land fees or land acquisition costs are not included in the proposal.

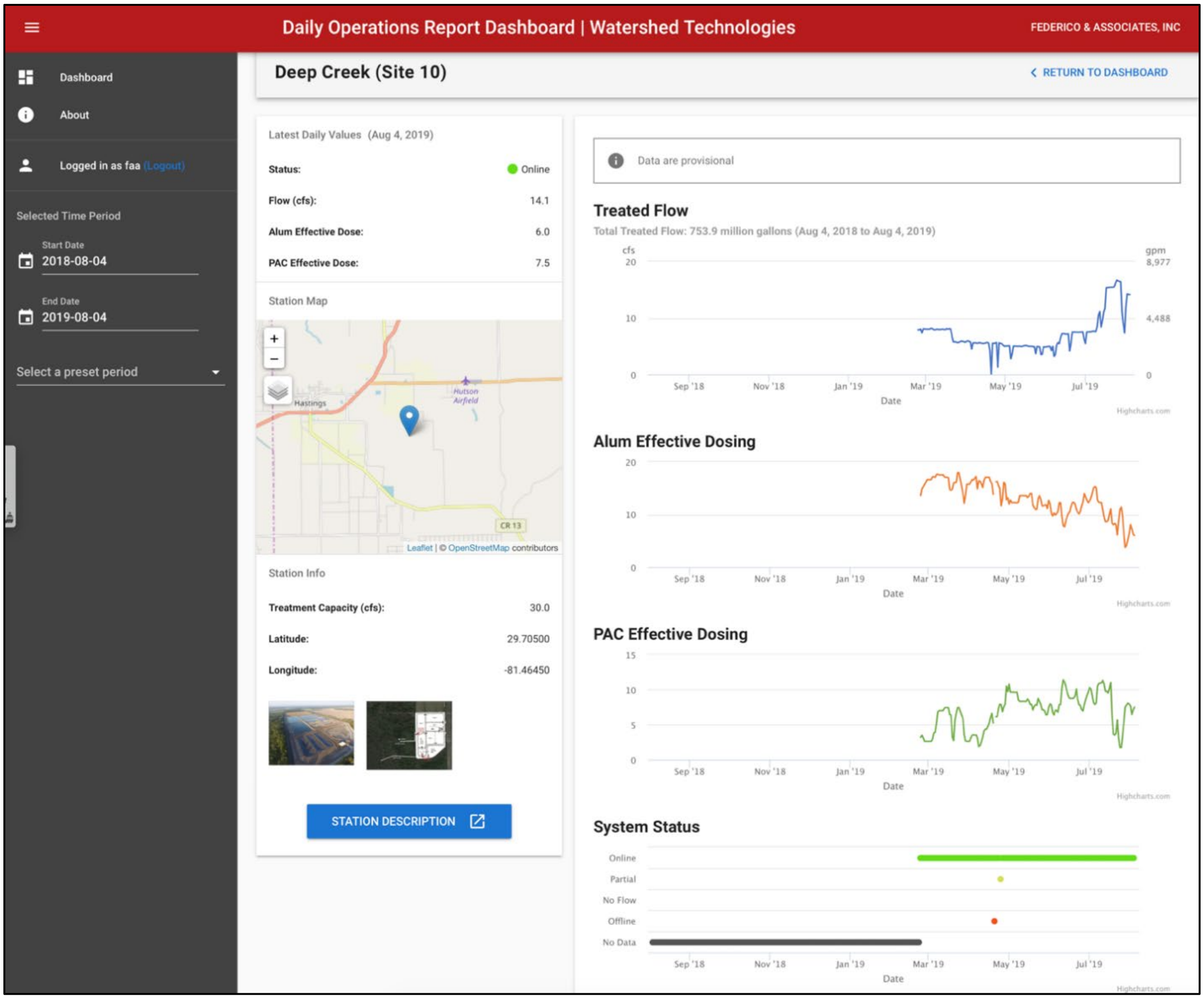
III. Other Beneficial Attributes

A. Hybrid Wetland Treatment Technology (HWTT) Description

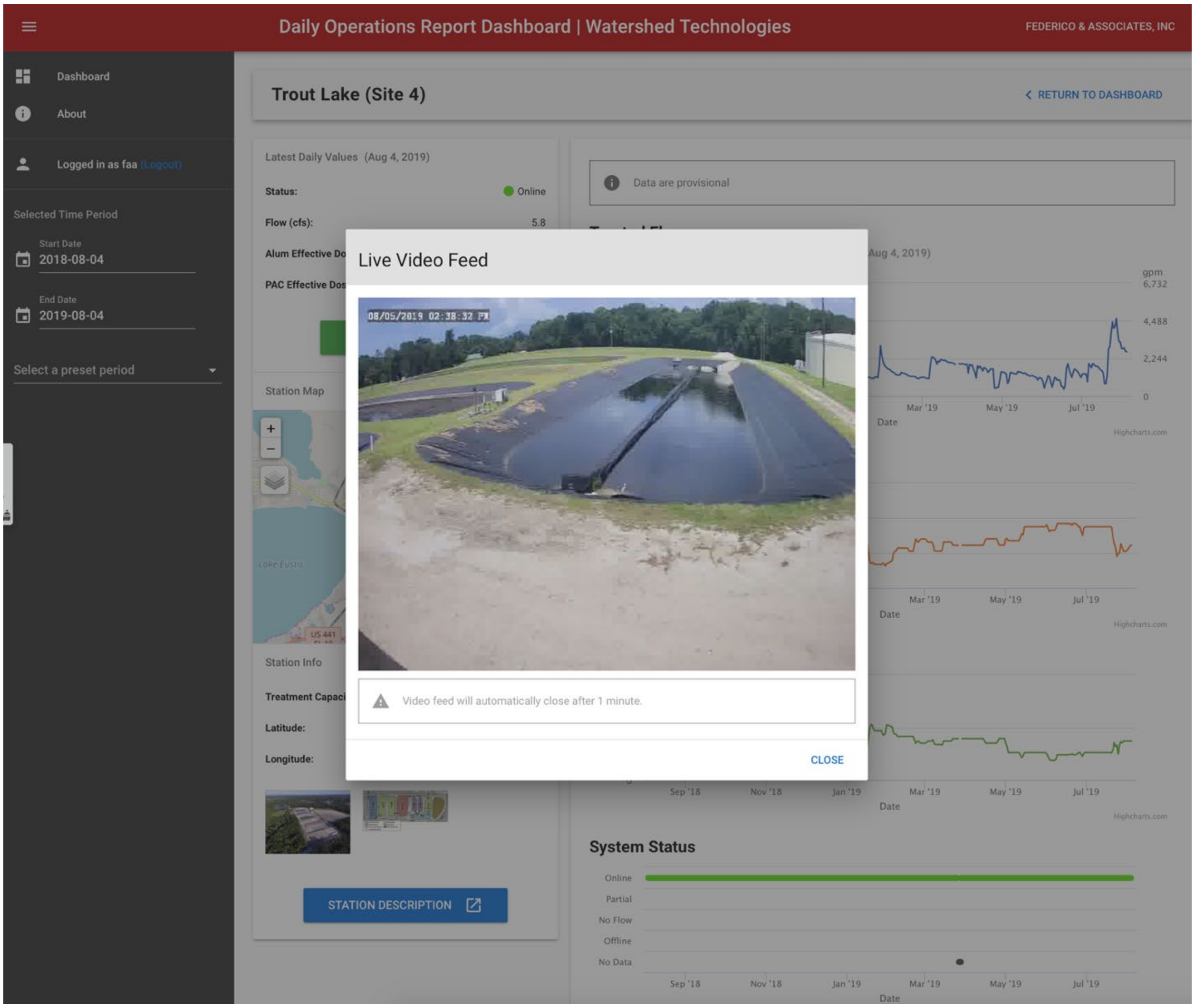
All ten HWTT projects are operational and assist the State in achieving the Total Maximum Daily Load (TMDL) for four impaired water bodies as part of the Best Management Action Plans (BMAPs). Assistance is provided through the successful removal of P and N for over 12 years at several sites. A significant level of performance data has been analyzed and reported for the ten HWTT sites since their inception. Reports and performance data are reviewed on an on-going basis by the Florida Department of Agriculture and Consumer Services (FDACS) and by multiple agencies and municipalities (South Florida Water Management District, St. Johns Water Management District, FDEP, Martin County, St. Johns County, Lake County, and the City of Eustis). The FDACS review also includes monthly operational reports for all sites, semi-annual presentations, and annual reports. An online Dashboard provides real-time data and operational statistics for all facilities.



(http://104.131.127.240/dor/). Login credentials are available upon request.



("No Data" represents the period prior to implementation of telemetry.)

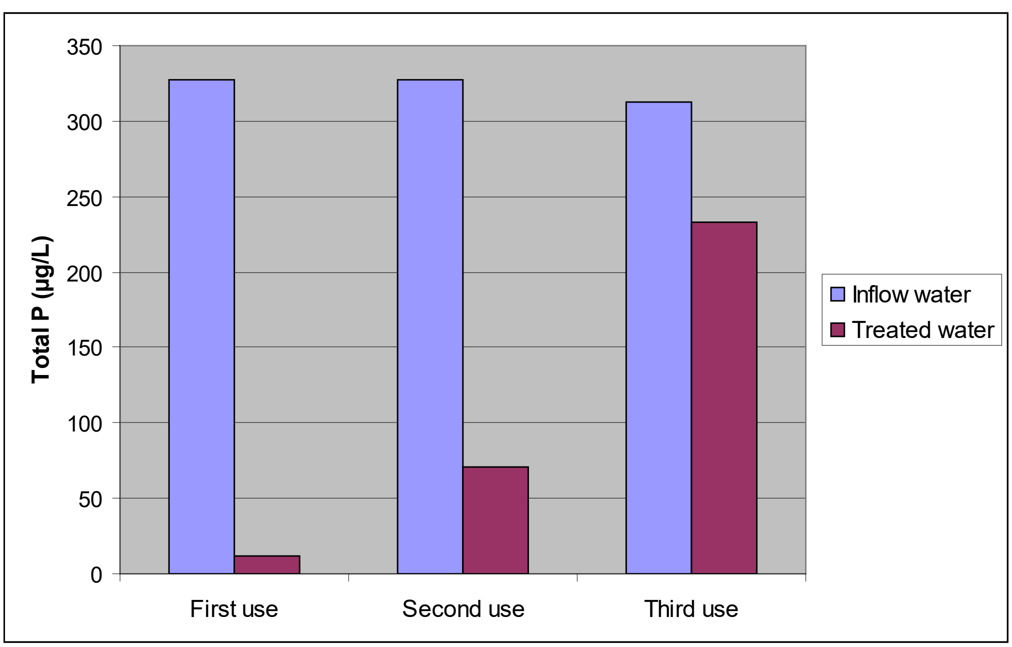


B. HWTT Performance

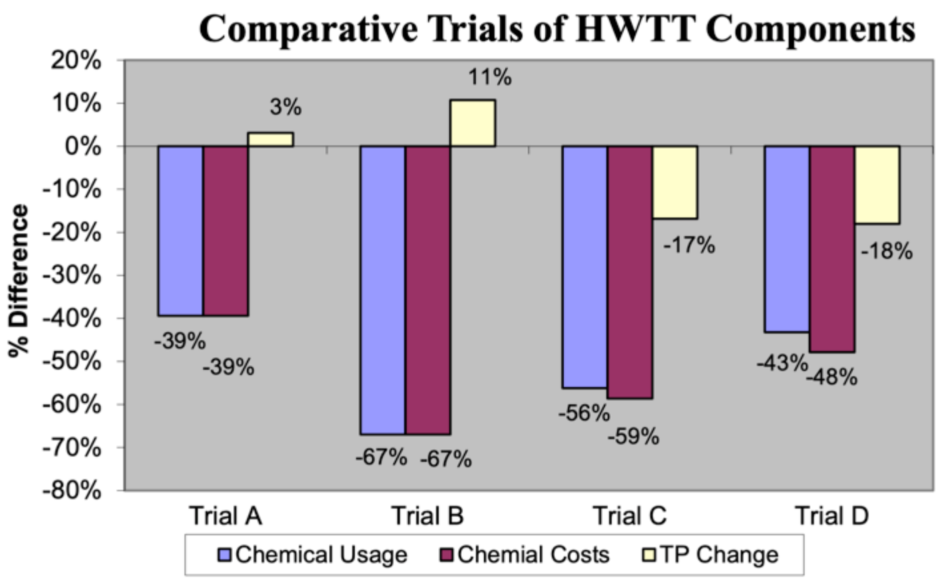
The HWTT technology includes pre-existing intellectual property represented and covered by and in three US Patents (7,014,776; 7,179,387; and 7,510,660) as well as other patents and patent applications (both allowed and pending) and related proprietary know-how and other intellectual property, including software and works of authorship noted below (collectively, the "HWTT," "HWTT Technology," or "HWTT systems") owned by Watershed Technologies, LLC. The FAVT technology includes pre-existing intellectual property represented and covered by and in three US Patents (7,074,330; 7,556,735; and 7,632,407) as well as other patents and patent applications (both allowed and pending) and related proprietary know-how and other intellectual property, including software and works of authorship noted below (collectively, the "FAVT," "FAVT Technology," or "FAVT systems") owned by Water & Soil Solutions, LLC.

HWTT uses an extremely cost-effective and highly reliable approach to treatment, demonstrating an average P removal rate of 86% with the larger sites exceeding 90% P reduction. The technology is also highly successful in the removal of N (up to 68%), and other pathogens and has replaced systems that were not performing. Key attributes are described below:

- The treatment system is comprised of chemical additives (alum) combined with vegetated and non-vegetated aquatic zones. Years of testing have shown that the use of alum does not introduce metal contamination as could the use of other chemical coagulants (for example, iron). The water discharged from the treatment site has been tested for over ten years at multiple locations and has been demonstrated to FDEP to be non-toxic to standard bioassay organisms.
- The floc produced in the treatment process is dried on-site.
- In zones with floating aquatic vegetation (FAV), ideal coverage is usually achieved by periodic harvesting; however, since FAV are predominantly water, removal is costly and inefficient. Floating Aquatic Vegetative Tilling (FAVT) overcomes these constraints in the following manner: (1) the FAV wetland assimilates additional nutrients and can grow to a high density; (2) the wetland is drained during the dry season, thereby stranding the FAV on the soil of the shallow zones to naturally desiccate; (3) if there is sufficient dried floc the material can be spread across the shallow zones (4) the plant material and floc is then tilled into the soil; (5) the wetland is reflooded; and (6) FAV that is stored in deeper zones are used to repopulate the marsh for the subsequent growth period. There are several operational treatment wetlands that have successfully implemented this approach.
- During periods when parts of the WBSR are dry, the dried floc can opportunistically be distributed over the area and tilled into the soil. The incorporated floc will assist in reducing the reflux of nutrients from the land as the Reservoir is reflooded.
- The technology can be rapidly implemented.
- No lag in treatment performance upon initiation of pulsed flows or prolonged periods of no-flow or drought.
- The technologies demonstrate cost-effective phosphorus and nitrogen removal.
- Provides the effectiveness and reliability of chemical treatment systems for P and N removal (up to 96% and 68%, respectively) while minimizing chemical use through the reuse of the residual nutrient removal capability of alum flocs.



- Significant reductions in chemical use are accomplished with intermittent dosing, internal floc recycling, and other strategies.
- Relative to conventional alum-based systems, HWTT facilities enabled a 39% to 67% reduction in chemical use in full-scale comparative trials.



- Compared to traditional wetland treatment systems, there is a significant reduction in land foot-print.
- The facility has minimal infrastructure.
- Assists in achieving restoration goals.
- Provides environmental benefits via wetland and wildlife habitat restoration and creation.
- Utilizes appropriate sequences and configurations of wetland unit processes to transform/remove additional contaminants and pathogens.

C. HWTT News Articles

Several articles have been written regarding the HWTT technology and projects. A compilation is provided below with links to the articles.

(Article Available in Submission)

Jacqui Thurlow-Lippisch

Indian River Lagoon

Bessey Creek "Hybrid Wetland Treatment Project," What's That? St Lucie River/Indian River Lagoon

Bessey Creek (winding left into today's Palm City) along exiting point for C-23 into the St Lucie River. The canal was built between 1959 and 1961. Bessey Creek used to be a flowing, clean beautiful creek–today it is polluted. (Photo Thurlow Archive, 1965)

Press Release for "Hybrid Wetland Technology

(Double Click to Access Article)

TCPALM
FLORIDA'S TREASURE COAST AND PALM BEACHES

Printer-friendly story
Read more at tcpalm.com

Bessey Creek project in Martin would cleanse water bound for Indian River Lagoon

By Mark Burneko

Friday, February 28, 2014

PALM CITY — A new type of surface water filtration system planned for Bessey Creek may provide a model for reducing the amount of nitrogen and phosphorus carried from watershed streams into the Indian River Lagoon.

The South Florida Water Management District has identified the Bessey Creek area as one of the top 10 contributors of phosphorous into the St. Lucie Estuary.

The Hybrid Wetland/Chemical Treatment Technology system combines a chemical treatment process with conventional wetlands filtration using pond water and specially selected aquatic plants.

Only six other systems of this kind, in use since 2007, have been constructed in the state, all of them along streams in Okeechobee County north of Lake Okeechobee, said Deborah Drum, Martin County's environmental quality manager.

Those systems have been effective in removing from 65 percent to 95 percent of phosphorous runoff, most of which comes from fertilizers, Drum told Martin County commissioners at a Jan. 7 meeting.

Commissioners unanimously agreed to a 30-year, $1 annual lease for 46 acres to the Florida Department of Agriculture and Consumer Services for the project, with the facility being county-owned when the lease expires.

"The design is still being worked out but the technology is new and has never been used in Martin County before," Drum said. "This is going to give us a great chance to look at the cost-effectiveness of the system and consider whether we may be able to use similar systems in the future."

State officials estimate it will cost the agency $3 million to build and operate the system, which will be adjacent to the Citrus Boulevard storm treatment area developed in 2008.

The system involves diverting and pumping a portion of the flow from Bessey Creek over a lime rock bed and mixing in a chemical such as aluminum sulfate, which settles out a large portion of the nitrogen and phosphorus. The water is further filtered in

(Double Click to Access Article)

Hybrid wetland treatment projects help reduce Trout Lake nutrient levels

By PRAKASH GANDHI

Officials in the city of [illegible] are building a major project that will help breathe new life into a polluted lake.

A $3 million hybrid wetland treatment facility will help [illegible] Trout Lake, helping to remove nutrients that have plagued the lake [illegible] years.

Last year, Watershed Technologies [illegible] leased 17 acres from the city to build the facility after the Florida Department of Environmental Protection declared Trout Lake an impaired waterbody due to high levels of phosphorus.

City officials said the project is good for the city and for the environment.

"This is a win-win situation for us," said Rick [illegible], city engineer and public works director for Eustis.

Trout Lake is on the state's list of impaired waterbodies, with current total phosphorus levels exceeding allowable levels by about 2,000 pounds per year.

A pump station has been in operation since the fall, moving water from Hicks Ditch into [illegible] at the [illegible] facility.

The Eustis City Commission recently approved construction of a second pumping facility to be used during the dry season when there is no water flow in Hicks Ditch.

The Phase 2 project is located on five acres of city property in the Country Club Manor Mobile Home Park in what was once a wastewater treatment plant.

The second pump station will take water from Trout Lake, move it through about 4,550 feet of pipe running [illegible] County Road [illegible], then east to the Phase [illegible] pump station. There it will be filtered, sent back through the pipes and pumped back into the lake.

[illegible] said it is important to bring the lake back to good health.

"Hicks Ditch pulls [illegible] amount of agricultural runoff that feeds into Trout Lake," he said. "Half of the lake is surrounded by wetlands and conservation areas."

City officials said the facility will also treat Trout Lake waters during the dry season. The [illegible] to remove more than 5,000 pounds a year of phosphorus, enabling Trout Lake to meet its TMDL target for the nutrient.

The state is [illegible] associated with the construction of the second pump station, plus maintenance and operational costs, and has agreed to fund hybrid wetland treatment facilities across the state to help clean up polluted lakes.

(Double Click to Access Article)

4.29.14
Ag Water - [illegible]
Budell

MARTIN COUNTY

BOARD OF COUNTY COMMISSIONERS
2401 S.E. MONTEREY ROAD • STUART, FL 34996

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County Administrator

MICHAEL D. DURHAM
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WEB ADDRESS
http://www.martin.fl.us

April 22, 2014

The Honorable Adam H. Putnam
Commissioner of Agriculture
Department of Agriculture and Consumer Services
The Capitol
Tallahassee, FL 32399-0800

Dear Commissioner Putnam:

On behalf of the citizens and visitors of Martin County, I extend our most sincere gratitude for your significant support for water quality improvement projects in Martin County and the Treasure Coast region. Your efforts and leadership to invest in innovative approaches to water quality improvement in partnership with local governments is greatly appreciated and will result in direct improvements to local water quality.

Martin County has been proactive in addressing water quality improvement in our local water bodies. We have spent $50 million in local stormwater projects in partnership with the state of Florida and other entities that have improved water quality and assisted Martin County with meeting our obligations under the St. Lucie Watershed Total Maximum Daily Load (TMDL) program and its associated Basin Management Action Plan (BMAP). We are interested in exploring optimal efficiencies in water treatment through innovative treatment technologies, and are particularly excited about constructing Hybrid Wetland Treatment Technology (HWTT) projects in Martin County in partnership with the Florida Department of Agriculture and Consumer Services (FDACS). Thanks to your support, we have initiated work for an HWTT project at Bessey Creek in Palm City, and if successful with additional support, we will also complete a similar project at Danforth Creek. This technology has the potential to change the approach of stormwater quality treatment by reducing the footprint of land required to build projects, and increasing treatment efficiencies. We are eager to complete these projects and test their ability to evolve our options in improving local water quality.

Thank you again for your active and effective support on water quality improvement in Martin County and on the Treasure Coast.

Sincerely,

Sarah Heard

Sarah Heard, Chair
Martin County Board of County Commissioners

SH/dd

c: Honorable Members of the Martin County Board of County Commissioners
Taryn Kryzda, County Administrator

[illegible]

Appendix D. Water Quality Alternative Treatment Technology Pilot Study Memorandum

M E M O R A N D U M

TO: Kim Fikoski, Lead Project Manager, Everglades and Local Project Coordination Section, Ecosystem Restoration and Capital Projects Division

FROM: Cassondra Armstrong, Section Administrator, Water Quality Treatment Technology Section, Water Resources Division

DATE: June 16, 2021

SUBJECT: **Water Quality Alternative Treatment Technology Pilot Study for the C-43 West Basin Storage Reservoir Water Quality Component**

Background

The purpose of this memo is to document the performance of the Bold & Gold® CTS and coagulant technologies for removing nitrogen and phosphorus from Caloosahatchee River surface water. This pilot study was initiated in August 2020, with the repurposing of six mesocosms previously used for the Water Quality Treatment and Testing Project – Phase I. Two tanks were filled with Bold & Gold® CTS, two tanks were filled with Sand, and two tanks had no medium and functioned as Controls. The initial flow rate to each of the tanks was estimated to be 0.005 gal/min/ft^2, about an order of magnitude lower than manufacture recommended flow. In January the plumbing was revised to achieve a flow rate in line with manufacturer recommendations, 0.05 gal/min/ft^2. Current hydraulic residence time is not known due to decreased water infiltration as significant plant and algae biomass now exist in the tanks. The first samples were collected September 14, 2020. Sample frequency has varied over the course of the experiment but is primarily bi-weekly.

Concurrently, two alum jar test studies were conducted, once in September 2020 and once in January/February 2021. In the first study, samples were collected from three locations along the Caloosahatchee representing Lake Okeechobee water (S-77), watershed runoff water (Hilliard Canal), and a mix of both in the river (Boma). Samples were collected once a week for a total of three sampling events. Samples were subjected to an alum jar test to assess effective dosing levels of alum. In the second study, the design of the first study was repeated with the addition of aluminum chlorohydrate (ACH) jar tests. This allowed for the comparison of alum nutrient removal performance in the wet and dry seasons and the comparison of two types of coagulants in the dry season.

Bold & Gold® CTS Results

Based on studies conducted by University of Central Florida, Bold & Gold® CTS performance was expected to be 70% removal of Total Nitrogen (TN) and 80% removal for Total Phosphorus (TP). To be conservative, Environmental Conservation Solutions proposed a 60% removal rate for TN when calculating the technology's ability to meet water quality targets for the Water Quality Component for the C-43 West Basin Storage Reservoir.

Twenty-four sampling events occurred between September 14, 2020 and April 21, 2021. Over this sampling period, TN removal by Bold & Gold® CTS ranged from 17% to 46% and averaged 30%, well below the conservative estimate of performance (Figure 1). Removal rates have not increased with time, contrary to what was expected as the microbiome in the CTS matrix matured. The Bold & Gold® CTS treatment has consistently performed better than the Sand and Control treatments, averaging 16% higher removal rate than Sand and 19% higher removal rate than the Control. Bold & Gold® CTS was very effective at removing nitrate-nitrite, removing almost 100% (Figure 2). However, nitrate-nitrite is a very small component of TN in the Caloosahatchee River, averaging less than 20% during this study.

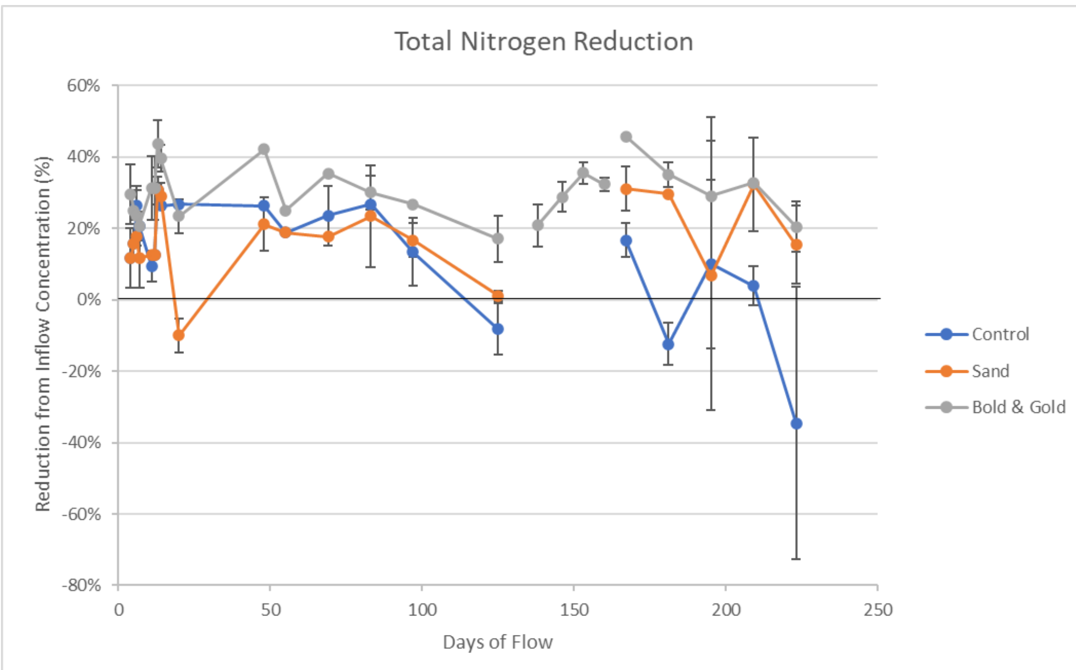

Figure 1. Total Nitrogen Reduction by Treatment

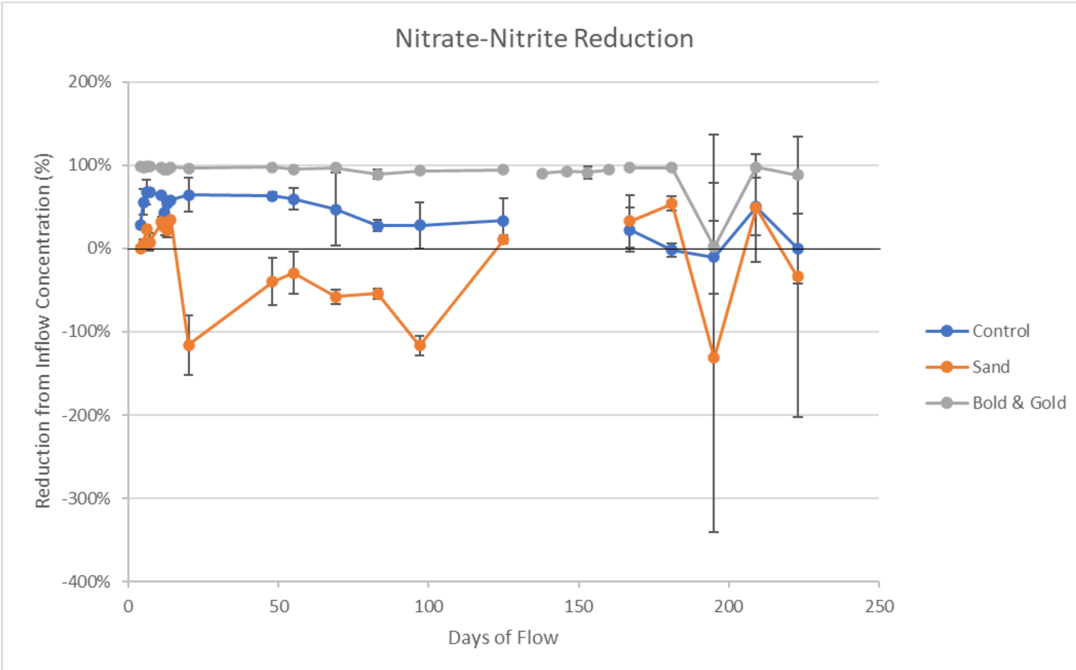

Figure 2. Nitrate-nitrite Reduction by Treatment

Over this sampling period, in the Bold & Gold® CTS and Sand treatment, TP outflow concentrations were found to be higher than inflow concentrations for most of the sampling events; in one instance more than five times higher (Figure 3). TP removal was found initially in the Sand and Bold & Gold® CTS treatment, Sand performing better than Bold & Gold® CTS, but on the 20th day of flow both treatments began producing TP. This trend continued regardless of flow rate. The Control treatment removed TP, averaging 41% removal until the last two sampling events. Subsequent sampling of the original sand matrix used for both the Sand and Bold & Gold® CTS treatments found higher than expected TP concentrations and is likely the source of TP.

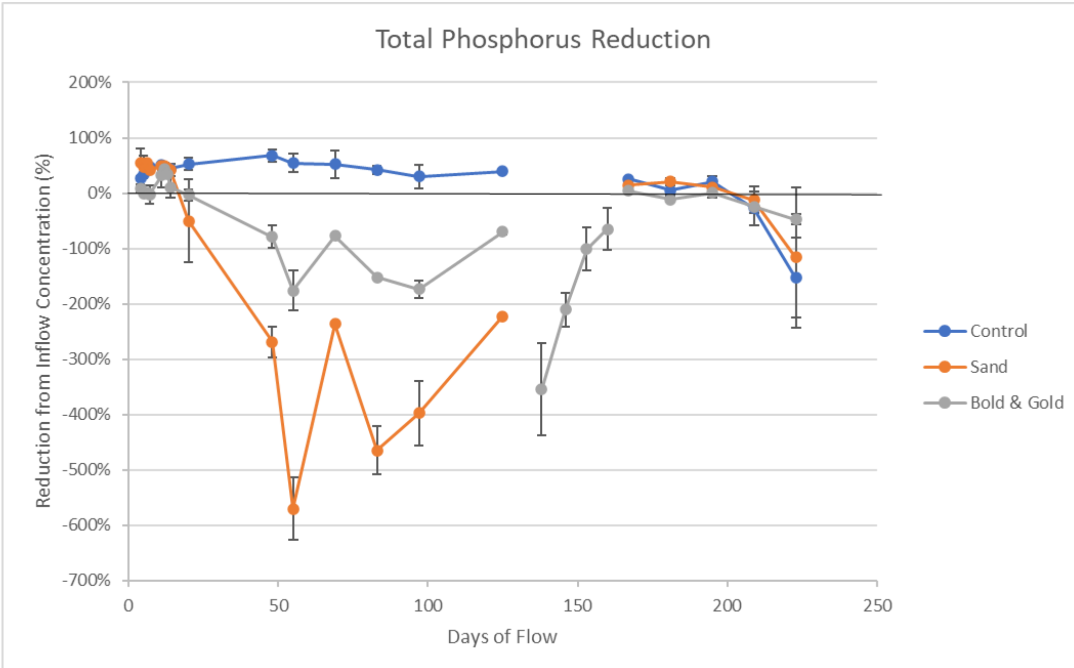

Figure 3. Total Phosphorus Reduction by Treatment

The tire crumb in the Bold & Gold® CTS treatment is likely the source of some metals found in the outflow water of those treatments. The Dissolved iron concentration in outflow water averaged 7.5 times higher than inflow concentrations from the Bold & Gold® CTS treatment (Figure 4). The Sand treatment removed some dissolved iron, averaging 50% removal before the last two sampling events when high concentrations of dissolved iron were found in the outflow water of all treatments. It is unknown why iron increased in the outflow, but the increase is unrelated to either the Bold & Gold® CTS or Sand technologies, as the Control also had elevated iron concentrations. The Control treatment averaged 11% removal before the last two sampling events. Dissolved cobalt was also found in the outflow water of the Bold & Gold® CTS, although this declined with time (Figure 5). Dissolved cobalt concentrations in the Sand and Control treatments were typically below detection with a few incidences of higher concentrations. Again, these metals are typically found in tire crumb; however, the outflow concentrations were not at levels near or exceeding Florida water quality standards for Class 3 waters.

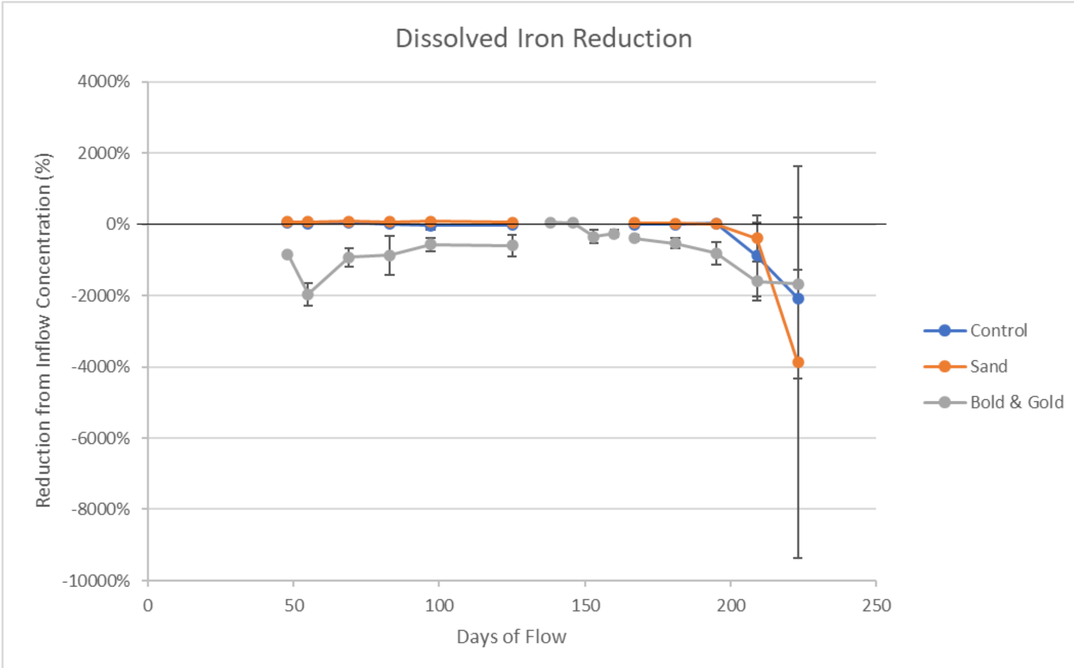

Figure 4. Dissolved Iron Reduction by Treatment

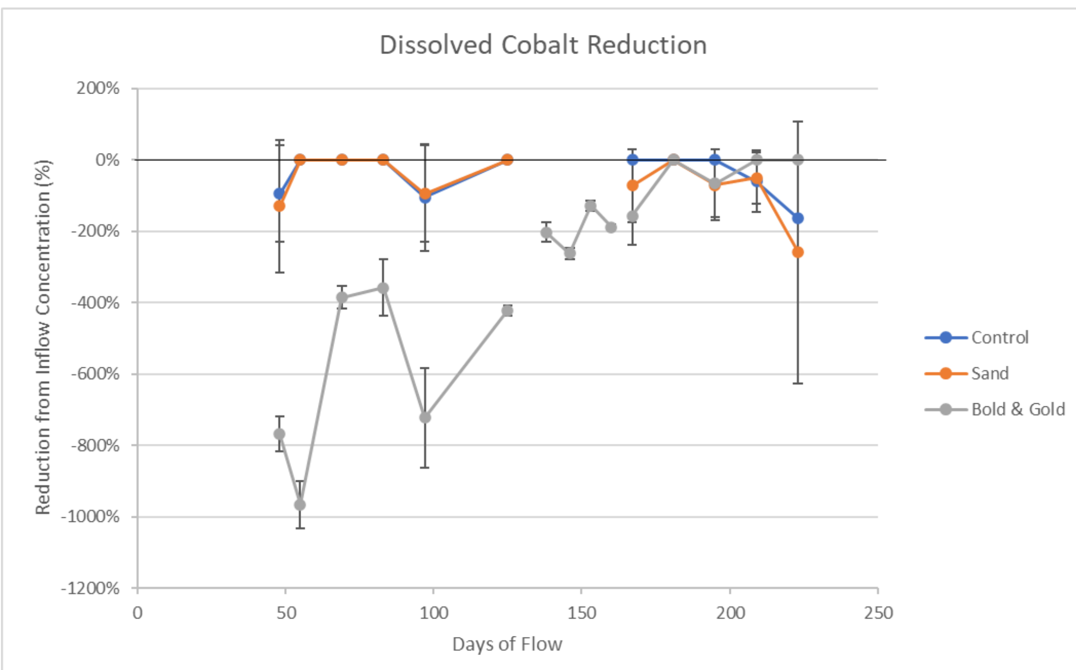

Figure 5. Dissolved Cobalt Reduction by Treatment

Aluminum Coagulant Results

Alum, aluminum sulfate, was found to effectively reduce TP and TN in both the wet and dry seasons from lake (S-77), watershed (Hilliard Canal), and river (Boma) surface water (Figure 6). At the optimum dosing level for maximum nutrient removal (12-14 mg Al/L), TN removal averaged 43% in both seasons. Dissolved organic nitrogen (DON), the dominant component of Total Kjeldahl Nitrogen (TKN) and TN in the Caloosahatchee River, was more effectively removed during the dry season in the river water and ranged from 20% to 50% in the wet season and 35% to 70% in the dry season. TP removal from river water was over 60%, with dry season removal being slightly higher than wet season removal.

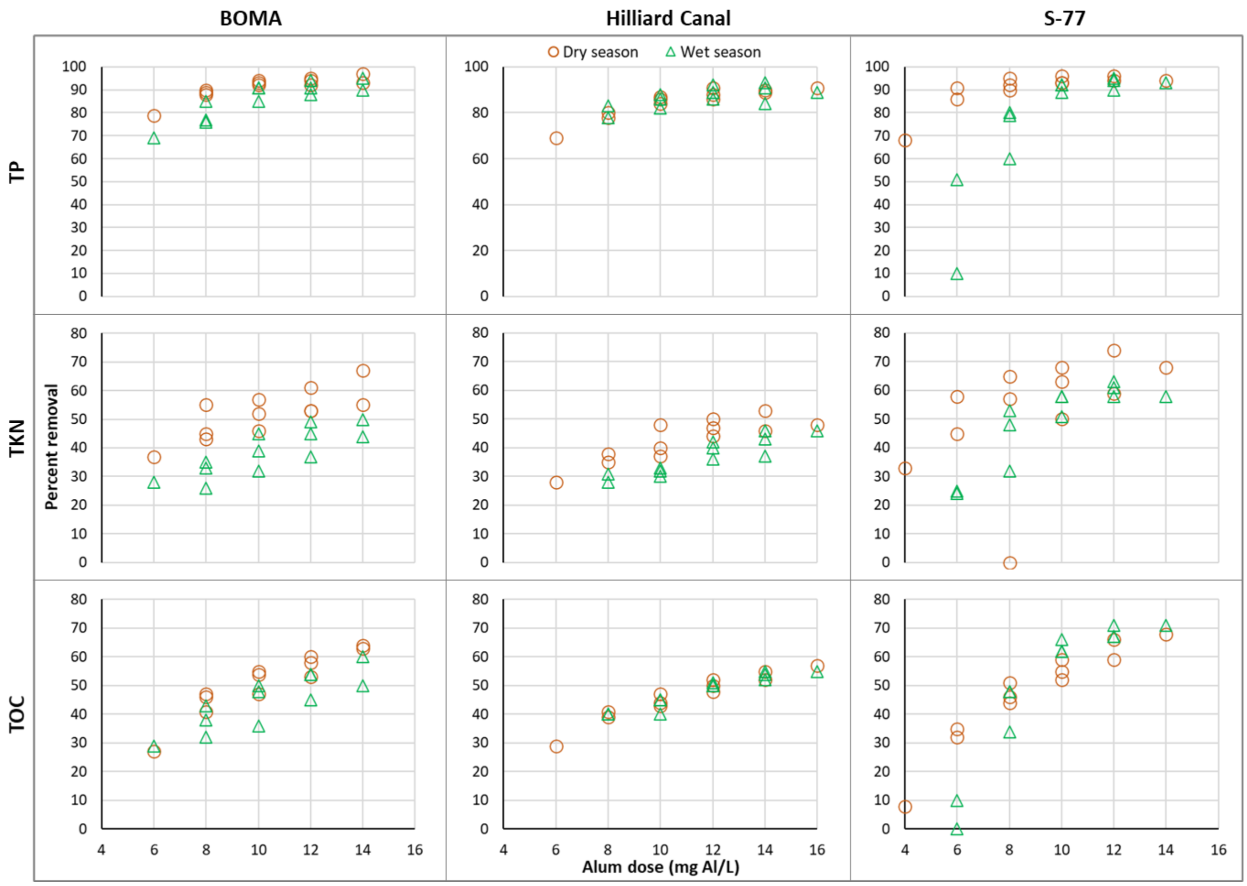

Figure 6. Comparison of percent removal of TP, TKN, and TOC at different dosing levels of alum in the wet and dry season

During the dry season sampling event, alum removal capacity was compared to ACH to determine if there were differences in effectiveness as well as impacts to water quality. For the Boma samples, alum was better than ACH at removing TN, averaging 51% removal over the three sampling events while ACH averaged 44% removal. Dissolved inorganic N forms were not generally removed by either coagulant, as expected based on previous alum studies. Phosphorus removal for different forms of P varied for the two coagulants but ranged between 69% and 98% removal (Figure 8), with soluble reactive phosphorus (SRP) removal being the same for each coagulant, alum being more effective than ACH for dissolved organic phosphorus (DOP) removal, and ACH being better for particulate phosphorus (PP) removal.

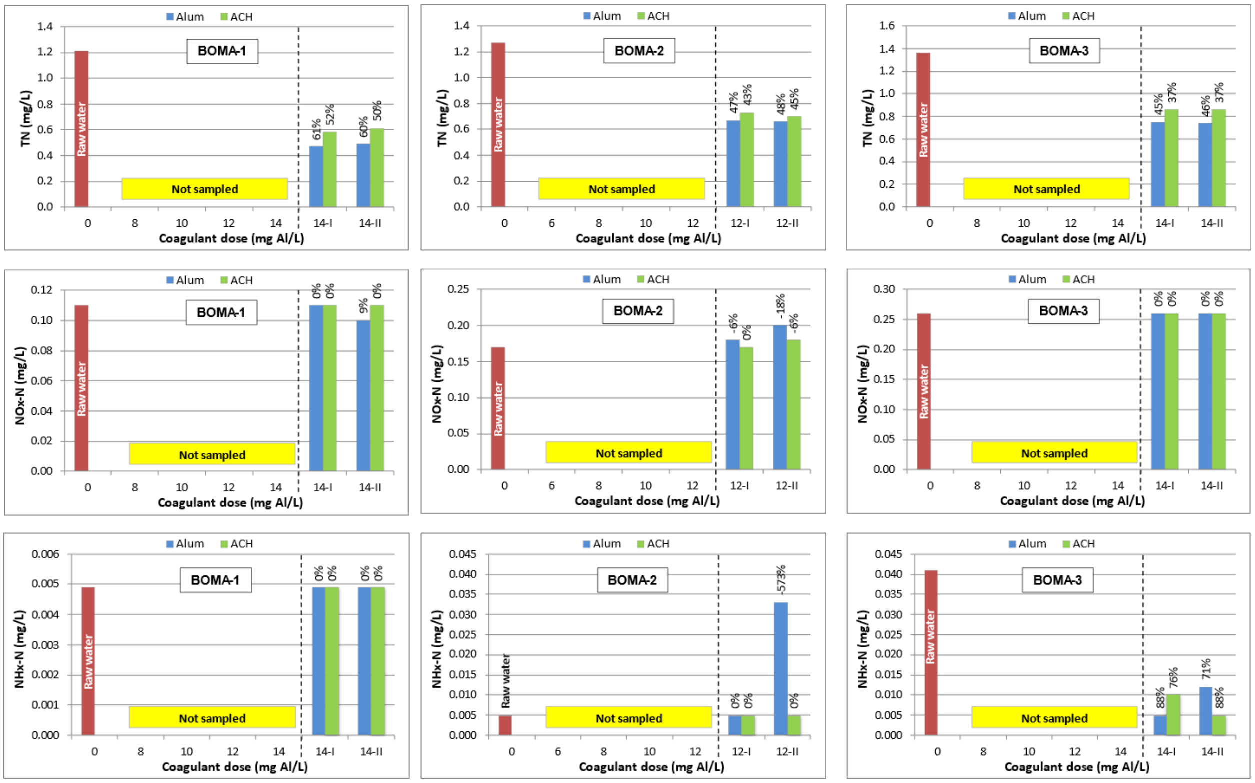

Figure 7. Response of Boma water Total Nitrogen (TN), Nitrate-Nitrite (NOx-N), and ammonia (NHx-N) concentrations to the target coagulant dose over three sampling events.

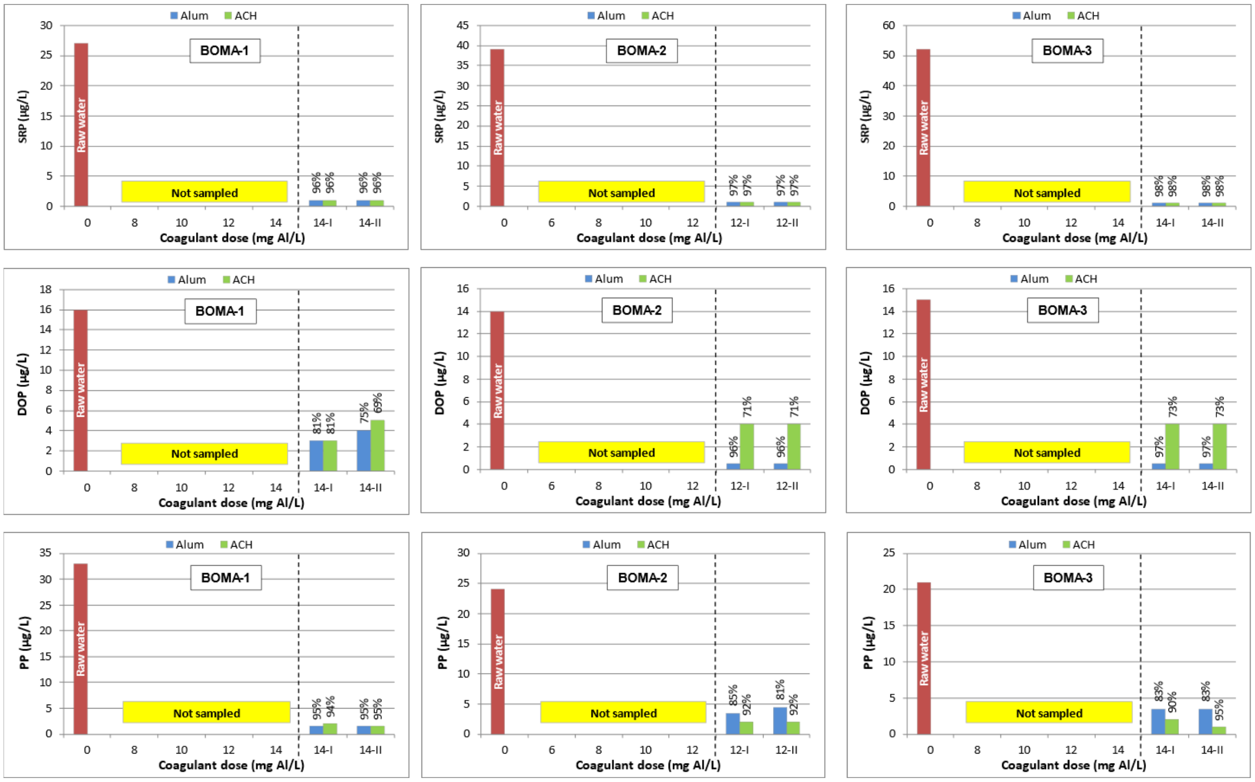

Figure 8. Response of Boma water Soluble Reactive Phosphorus (SRP), Dissolved Organic Phosphorus (DOP), and Particulate Phosphorus (PP) concentrations to the target coagulant dose over three sampling events.

With the addition of these two forms of coagulant, there was concern about the impact to water quality, especially in relation to the addition of sulfate (SO4) and aluminum (Al). As ACH is not composed of sulfate, there was no change in the sulfate concentration of the river water after dosing, while the addition of alum increased sulfate concentration 4 to 5 times higher than river water with dosing rates of 12 to 14 mg Al/L (Figure 9). The proposed dosing rate for the in-line alum injection system to the C-43 West Basin Storage Reservoir is 0.6 mg Al/L, which is the equivalent of 1 mg SO4/L, well within the variability of river water concentrations and therefore of minimal impact to water quality. Interestingly, while the dosing rates were the same for alum and ACH, water dosed with ACH had higher Al concentrations than the alum-dosed samples. The alum concentrations after dosing were about 2 times higher than river water concentrations. The proposed dosing rate for the reservoir, 0.6 mg Al/L, will add minimal Al to the water, most of which will be precipitated out. Thus, impact to Al concentrations in the water column is unlikely.

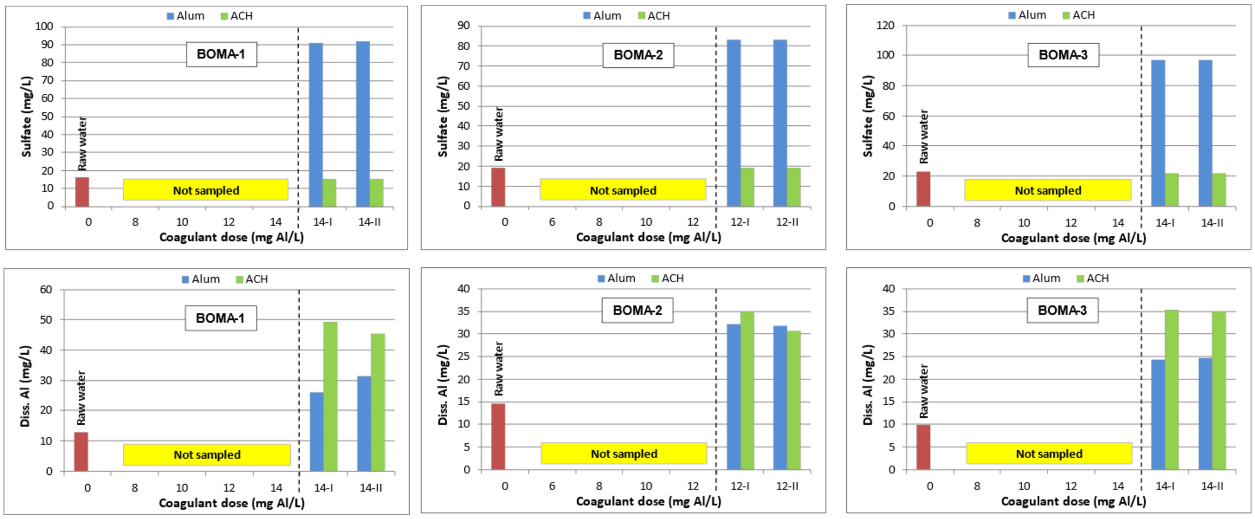

Figure 9. Impact of Coagulant Additions on Water Quality

Conclusions and Recommendations

Based on these findings, it is my opinion that Bold & Gold® CTS should not be further considered for the Water Quality Component of the C-43 West Basin Storage Reservoir. While Bold & Gold® CTS TN removal performance was a little better than the Sand treatment, the higher cost of the product makes this an unattractive option. Bold & Gold® CTS did prove to be an excellent technology for nitrate-nitrite reduction, however the Caloosahatchee water is dominated by dissolved organic nitrogen (DON), which is more difficult to remove. In addition, the elution of some heavy metals into the outflow water is concerning. The issue of the original sand containing phosphorus and thus not meeting its performance goal can be solved by sourcing the sand material from a low P environment.

Instead, I recommend the use of alum for the removal of nitrogen and phosphorus, followed by polishing with a sand filter. Alum effectively removed both nutrients, including DON, had a smaller addition of Al to the surface water than the ACH, and is less expensive than ACH. Polishing the water with a sand filter will remove some additional nutrients and capture and remove any resulting alum “microfloc” that may have remained suspended in the water during release. The sand can also be sourced onsite resulting in significant cost savings compared to the Bold & Gold® CTS technology. Smaller doses of alum could be effectively used to meet the nutrient reduction targets set by the Water Quality Component Feasibility Study, reducing cost and the resulting impact to water quality of the additional Al and SO4.

To investigate the effectiveness of lower alum dosing, the Pilot study will be modified to assess a lower dosing rate on nutrient removal, particulate removal (including algae), and impact to water quality. In addition, the impact of sand filtration maintenance, i.e., the scarification of sand surface to remove vegetative biomass, on nutrient removal performance will be assessed. This study will be completed in September 2021 and will be able to provide timely input to the Water Quality Component design and operation and maintenance plans.