Walnut Creek WWTP and Hornsby Bend Biosolids Management Plant Improvements and Expansion
Austin, Texas

2023 Technical Design Report
Texas Tech University

Prepared for:
WEFTEC 2023 Student Design Competition
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Abstract

The Walnut Creek Wastewater Treatment Plant (WWTP) is operated by Austin Water. Currently, the plant utilizes a conventional activated sludge (CAS) treatment system with a pseudo-Ludzack-Ettinger process as well as inline flow equalization basins (FEBs) where alkalinity adjustments are made prior to biological treatment. Due to the continued development within the City of Austin, there is a need for an upgrade and expansion of Walnut Creek WWTP. The main objectives in developing a recommended design for the expansion to the new permitted capacity include converting the existing CAS system to biological nutrient removal (BNR), upgrading existing units as needed, and implementing a phosphorus sequestration technology at the Hornsby Bend Biosolids Management Plant (BMP) to recover and remove increased phosphorus in the sludge due to the implementation of the BNR system. The recommended A^2/O design considered performance and operator preference and will ensure all units meet Texas Commission on Environmental Quality (TCEQ) requirements. An Opinion of Probable Construction Cost (OPCC), an estimate for annual operation and maintenance costs (O&M), and a construction schedule of the expansion are included.

Project Team Effort

Brennan Riley, *Project Manager*

Brennan Riley is a graduate student from Corpus Christi, Texas and will be graduating in August 2023 with master's and bachelor's degrees in environmental engineering with a minor in civil engineering. Her industry experience consists of two internships with Freese and Nichols, Inc. as a Water/Wastewater Treatment Intern, where she worked on developing life-cycle costs, drafting client submittals, and aiding in the design of several wastewater treatment plant upgrades. Currently Ms. Riley works as a graduate research assistant in the NASA-funded Advanced Water Recovery System Laboratory conducting a year-long experiment investigating the gas production from anammox bioreactors. Her industry and research experience were helpful as the role of project manager as well as in assessing costs, client needs, and reviewing regulations.

Kieran Atkin, *Project Engineer I*

Kieran Atkin is a graduate student from Katy, Texas and will be graduating in May 2023 with master's and bachelor's degrees in environmental engineering with a minor in civil engineering. His industry experience consists of one summer internship with Jacob & Martin Engineering as an Environmental Engineering Intern where he worked on GIS models, pipelines, hydraulic profiles, and concrete construction. At Jacob & Martin, he went on multiple site visits to familiarize himself with how the construction process occurs and to gain knowledge about the design of water and sewer lines. The internship experience helped Mr. Atkin gain skills in InfoWater and AutoCAD, which helped design drafts for process flow diagrams, as well as assisting with the development of the hydraulic profile.

Leah McDonald, *Project Engineer I*

Leah McDonald is a graduate student from Kingsbury, Texas and will be graduating in May 2023 with master's and bachelor's degrees in environmental engineering with a minor in civil engineering. Her industry experience consists of two summer internships with BGE, Inc. as a Public Works Intern and one summer internship with Freese and Nichols, Inc. as a Water/Wastewater Treatment Intern. At BGE, she assisted with projects to improve stormwater drainage infrastructure, assess no adverse impact studies, assisted with construction phase services, and helped perform an inflow and infiltration study. At Freese and Nichols, she evaluated the capacity of a wastewater treatment plant, assisted with the beginning stages of the development of a hydraulic profile, and worked on drafting memos and other technical reports for client submittals. The internship experiences helped develop skills that were needed to review the regulations, to ensure that the existing and proposed treatment processes would meet the regulation requirements, and to assist with the development of the hydraulic profile.

Mathew Rotman, *Project Engineer I*

Mathew Rotman is a graduate student from Pflugerville, Texas, and will be graduating in May 2023 with master's and bachelor's degrees in environmental engineering with a minor in civil engineering. His industry experience is research-based consisting of his study abroad program in Costa Rica where he developed a thesis connecting the relationship between agroforestry and wastewater management. As a research student, he witnessed the detrimental effects of the tragedy of the commons and the inverse effects which it had on the ecosystems of Costa Rica. His latest experience at Texas Tech University has led him to develop skills in both tertiary treatments, and design software for this project.

Elizabeth Routon, *Project Engineer I*

Elizabeth Routon is a graduate student from Graham, Texas and will be graduating in May 2023 with master's and bachelor's degrees in environmental engineering with minors in civil engineering and environmental studies. Her industry experience began in the summer of 2019 when she interned with Southern Bleachers, Inc. in Graham as an engineering project manager that consisted of assisting project managers in planning, tracking, and execution for projects across the engineering teams. Her latest industry experience was working with Weaver Consultants Group as a solid waste intern during the summer of 2022. She worked on tasks such as CLOMRs, LOMRs, SLERs, GLERs, SWPPPs, permitting, and other documents coordinated by TAC 330. These internship experiences helped Ms. Routon to develop skills in Civil3D, that was beneficial for drafting process flow diagrams and site layouts. She also further developed skills in GIS, which was beneficial in assessing the floodplain analysis for the expansion.

Additional Individuals to Assist in Project Effort

Dr. Clifford Fedler (Texas Tech University), Dr. W. Andrew Jackson (Texas Tech University), Wesley Tait (Carollo Engineers), Paula Monaco (Plummer), Murali Erat (Freese and Nichols)

MA Representatives

Danny Roberts (Ardurra), Tori Haugvoll (Black & Veatch), Noe Martinez (Austin Water)

Executive Summary

The Walnut Creek Wastewater Treatment Plant (WWTP) is Austin's largest WWTP. It is located east of downtown Austin and serves north and central Austin. The Walnut Creek WWTP is currently rated for an annual average daily flow (AADF) of 75 million gallons per day (MGD) with a two-hour peak flow (PF) of 165 MGD. The need for expansion is the result of the fact that the plant has reached 75 percent of its permitted capacity. To accommodate the increasing flows expected, Austin Water is tasking teams with designing the expansion to an AADF of 100 MGD and a PF of 300 MGD. Additionally, there is a new phosphorus limit and requirement of nitrate reporting for the effluent. These new limits will require the conversion from the existing conventional activated sludge (CAS) process to a biological nutrient removal (BNR) process. With the conversion to BNR, Walnut Creek's sludge will have a significant increase in phosphorus concentration.

Sludge from the plant is not processed on-site and is pumped to Hornsby Bend Biosolids Management Plant (BMP) where it is blended with sludge from South Austin Regional WWTP. Walnut Creek currently contributes 50 percent of the influent flow to the solids processing plant. To avoid Hornsby Bend's ponds and solids processing facility from being overloaded with phosphorus, a phosphorus sequestration technology needs to be implemented to remove the phosphorus from the process streams and to produce a reusable product.

An expansion plan for Walnut Creek WWTP has been developed according to the regulations outlined by Texas Administrative Code (TAC) Chapter 217. The recommended upgrades have been determined and capacity analysis performed to ensure compliance. The upgrades and recommended modifications are detailed in *Table 1*. A solids balance was performed on the recommended design to ensure that the upgrades allow the plant's effluent to meet the Texas Pollutant Discharge Elimination System (TPDES) permit limits. The A^2/O expansion upgrades will have a capital cost of approximately \$140,800,000 and an annual operation and maintenance (O&M) cost of \$19,500,000. Construction for this project will occur in two phases and will be completed in 20 months.

Table 1: Summary of Recommended Upgrades for Walnut Creek WWTP Expansion

Component	Proposed Upgrade (No. of Units)
Pump Station	Add Pump Station (1) with Horizontal Dry-Pit Pumps (9)
Peak Flow Storage Basin	Add Square Offline Peak Flow Basin (2)
Primary Clarifier	Add Circular Clarifiers (3)
BNR Basin	Replace (6) CAS with A^2O BNR Technology and Add (9)
Secondary Clarifier	Add Circular Clarifiers (3)
Filtration	Add Rotary Cloth Filtration (4)
Disinfection	Add Ultraviolet Disinfection (4)
Solids Handling	Retrofit Gravity Thickener to Aerated Sludge Holding Tank
Phosphorus Sequestration	Add Ostara Pearl Struvite Generator (1)
Odor Control	Add Carbon Adsorption Unit (1)

1.0 Introduction

Every year, the Water Environment Association of Texas (WEAT) hosts the Texas Water Conference and holds state-level student design competitions. For the 2022-2023 competition, Walnut Creek Wastewater Treatment Plant (WWTP) has been selected. Due to the increasing flow rates, the Austin Water Walnut Creek Wastewater Treatment Plant needs to be expanded and upgraded to meet the Texas Commission on Environmental Quality (TCEQ) permit parameters. In developing a recommended design that meets the TCEQ requirements, plant aesthetic concerns will also be addressed in relation to the surrounding anthropogenic and environmental areas. Refer to *Appendix A* for a list of acronyms and abbreviations used throughout the report.

2.0 Project Overview

2.1 Site Background

The Walnut Creek WWTP is located at 7113 FM 969, Austin, Texas and is operated by Austin Water. The WWTP was originally constructed in 1979 and consisted of a headworks (HW) facility, a primary treatment complex (PTC), an activated sludge complex (ASC), and a gravity filtration facility. In 1980, a gravity sludge thickener was added, and an additional PTC and ASC were implemented in 1990. The last expansion that brought the WWTP to the current capacity was completed in 2005 when a third ASC and a second HW were built (*Figure 1*). Photographs of the current site can be found in *Appendix J*.

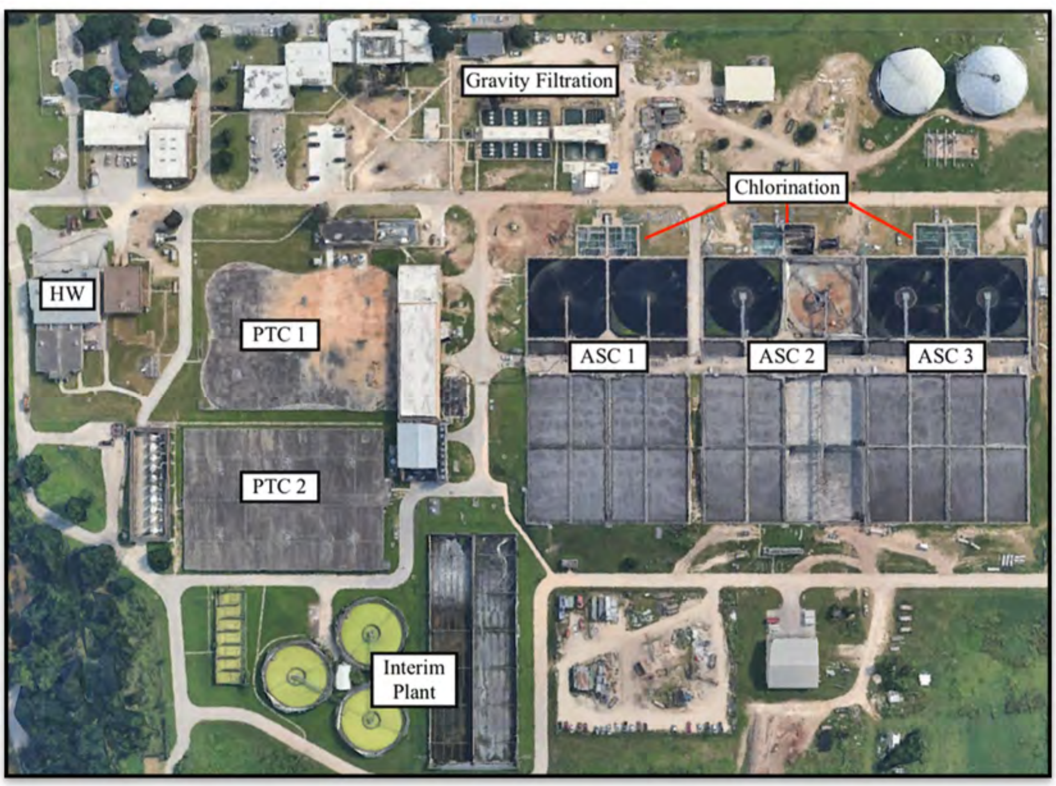


Figure 1: Aerial Image of Walnut Creek WWTP

2.2 Purpose

The Walnut Creek WWTP currently serves north and central Austin, including several industrial users that contribute large amounts of ammonia with low organics. To accommodate increasing flows from continuous population growth, as well as the plant reaching 75% of its design flow, there is a need for expansion. As a result, a new phosphorus limit provides a need for BNR to replace the existing CAS process. The design team evaluated the existing process units and designed an upgraded plant that includes BNR, a phosphorus sequestration system at Hornsby Bend BMP, and updated process units, most of which currently fail to meet TCEQ criteria.

2.3 Design Standards

The wastewater standards provided by WEAT include the permitted flows for each phase, TPDES permit limits, and design influent parameters (*Table 2*), which includes nitrate and total dissolved solids reporting. The influent parameters were utilized when the solids balance was performed to ensure that the recommended design meets the future effluent permits. 30 TAC Chapter 217 includes the TCEQ criteria required for the design of selected treatment units. Solids handling processes and odor control units are also to abide by 30 TAC 312 and 30 TAC 309.13.

Table 2: Walnut Creek WWTP TPDES Permit Limits

Parameter	Permit Phase 1	Permit Phase 2	Permit Phase 3
$cBOD_5$ (mg/L)	10	10	10
TSS (mg/L)	15	15	15
Ammonia (mg/L)	2	2	2
TP (mg/L)	-	-	1
E. coli (CFU)	126	126	126

3.0 Existing Facility

3.1 Process Description

The influent flow enters the plant through two HW facilities, HW 1 and HW 2 (*Figure 1*). Each HW facility contains two coarse screens and two aerated grit chambers. The grit collection also contains one grit pump per grit chamber (four in total) and two grit washers (both located in HW 2). From the HW facilities, the flow moves via gravity to a flow distribution box and then to either of the two below-grade PTCs, PTC 1 or PTC 2. Each PTC consists of two square primary clarifiers and two flow equalization basins (FEBs) equipped with magnesium hydroxide pumps for alkalinity dosing. The flow is pulled from the bottom of the FEBs via the settled wastewater pumps, that are made up of two different sized pumps (eight in total), and the flow is then pumped to the ASCs (*Figure 1*). After pumping to secondary treatment, the flow moves via gravity throughout the remainder of the plant.

Each of the three ASCs are comprised of two treatment trains, for a total of six treatment trains. Each treatment train has one aeration basin, one flocculation basin, and one secondary clarifier. The flow is pumped into a splitter box and into one of the six aeration basins, where the plant currently operates a pseudo-Ludzack Ettinger process. Each basin is split into six grids, with membrane diffusers in the first two grids and ceramic diffusers in all remaining grids. There is currently no aeration in the first two zones, minimal aeration in the third zone, and high aeration in the remaining zones. The flow then moves through flocculation basins, which are currently not in use but remain functional, and then to the inlet stilling well of the secondary clarifiers. Effluent flows over the clarifier weirs, into effluent troughs, and on to tertiary treatment. For solids return and wasting in the secondary treatment units, there are five return activated sludge (RAS) pumps per ASC (two per train + one standby) and three waste activated sludge (WAS) pumps per ASC (one per train + one standby).

For tertiary treatment, the water flows from the effluent troughs to one of six serpentine basins, where chlorine is used as a disinfectant. The water then moves through filtration, which consists of four mono-media filters (using only sand) and six multi-media filters (using sand and anthracite). The water is then dechlorinated with sulfur dioxide before being sent to the outfall.

3.2 Current Solids Handling

Walnut Creek WWTP conveys its sludge from the primary clarifiers and thickened WAS (effluent of the gravity thickener) to Hornsby Bend BMP, that produces Class A biosolids. About 50 percent of Hornsby Bend's influent flow is attributed to the sludge sent from Walnut Creek, while the other half of its influent flow comes from South Austin Regional WWTP, for a total of 1 MGD. Since Walnut Creek is converting from CAS treatment to BNR, phosphorus will need to be sequestered and sustainably disposed of from the streams at Hornsby Bend to ensure that the facility does not become a phosphorus sink. Any remaining water from anaerobic digestion is treated at the Side Stream Treatment Plant. Hornsby Bend also has evaporation ponds and approximately 300 acres of hay fields that are used as a land application site. Effluent from the Side Stream Treatment Plant as well as filtrate from dewatering is sent to either the evaporation ponds or is land applied.

3.3 Current Odor Control

Odor control is necessary to protect the operators and the surrounding areas from hazardous gases such as hydrogen sulfide, methane, and carbon monoxide, as well as for aesthetic purposes. Currently, Walnut Creek WWTP uses carbon adsorption as its odor control technology. The HW and PTCs are enclosed, which aids in controlling odors.

3.4 Capacity Analysis

A capacity analysis was performed to assess the current operational process units present at the Walnut Creek WWTP based on the current TCEQ parameters, and to assess how the current units would handle the increase in AADF from 75 MGD to 100 MGD. The results of the capacity analysis determine which units need to be upgraded to remain in compliance for the next two permit phases. See *Appendix C* for detailed calculations. *Table 3* below shows a summary of the capacity analysis. "Fail" indicates that this unit does not meet TCEQ requirements in the specific phase and it will need to be upgraded. The current treatment train can handle 55 MGD with a peaking factor of 1.5 (and using a factor of safety of 1.5), and the limiting units are the primary clarifiers.

Table 3: Summary of Capacity Analysis

Train Type	Technology	Phase		
		1*	2**	3***
Preliminary	Mechanical Bar Screens	Pass	Pass	Pass
	Grit Chambers (HW 1)	Pass	Pass	Pass
	Grit Chambers (HW 2)	Pass	Pass	Pass
Primary	Primary Clarifiers	Fail	Fail	Fail
	Flow Equalization Basins	Pass	Pass	Pass
	Settled Wastewater Pumps	Pass	Fail	Fail
Secondary	Aeration Basins	Fail	Fail	Fail
	Final Clarifiers	Fail	Fail	Fail
Tertiary	Chlorination	Fail	Fail	Fail
	Dechlorination	Pass	Pass	Pass
	Filtration	Fail	Fail	Fail
Solids Handling	Gravity Thickener	Pass	Pass	Pass

*AADF = 75 MGD, 2-hr PF = 165 MGD
**AADF = 75 MGD, 2-hr PF = 225 MGD
***AADF = 100 MGD, 2-hr PF = 300 MGD

4.0 Design Considerations

4.1 Criterion

A matrix outlining the advantages and disadvantages of three potential possibilities was made, and an evaluation criterion was constructed to choose the suggested treatment unit designs. The design team applied a weighted factor to each criterion to provide a score to each alternative. The lower the design matrix score, the better design option chosen for the expansion. Refer to *Appendix E* for the matrix.

4.2 BNR Selection

The BNR process for the first treatment train option is the 5-stage Modified Bardenpho method, that consists of five zones: anaerobic, anoxic, aerobic, a second anoxic, and a second aerobic zone (*Figure 2*). The Modified Bardenpho process is the most complex configuration of treatment zones out of the BNR systems that are being evaluated due to it having the greatest number of basins, but it has the most effective nutrient removal of all the options (Kang et al., 2008). An internal nitrogen recycle line is also added to the process, but like the other two processes, this is a relatively minor addition to the plant.

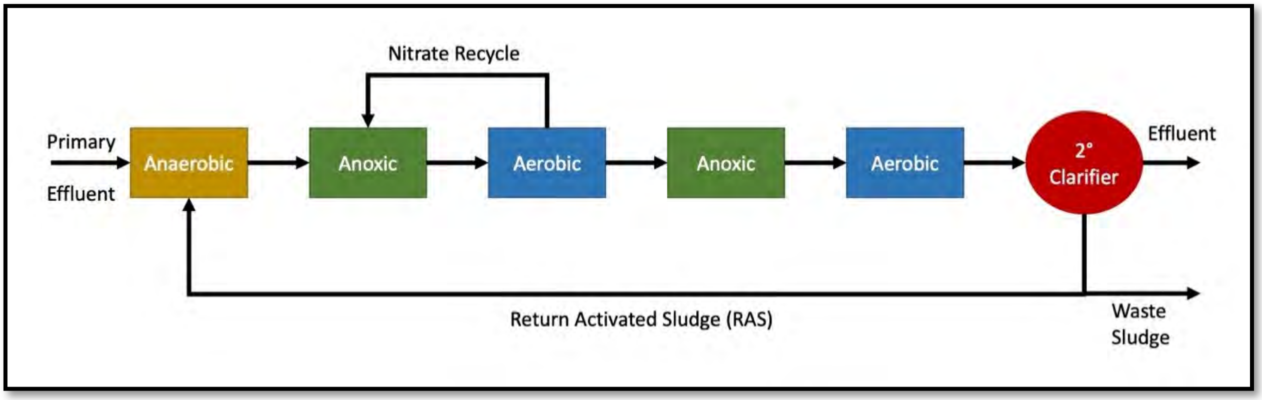


Figure 2: Modified Bardenpho Process Flow Diagram

The second BNR system that was evaluated was the Modified University of Cape Town (MUCT) process. The MUCT process has four basins consisting of one anaerobic zone, two anoxic zones, and one aerobic zone (*Figure 3*). The primary advantage of this approach is that it reduces the nitrate loading on the anaerobic zone, enhancing its capacity to remove phosphorus. Additionally, it is effective at removing nitrogen (Kang et al., 2008). The MUCT process uses three recycle streams as opposed to the two recycle streams in the A^2/O process, hence it calls for more operation and maintenance-related labor and requires specialized personnel.

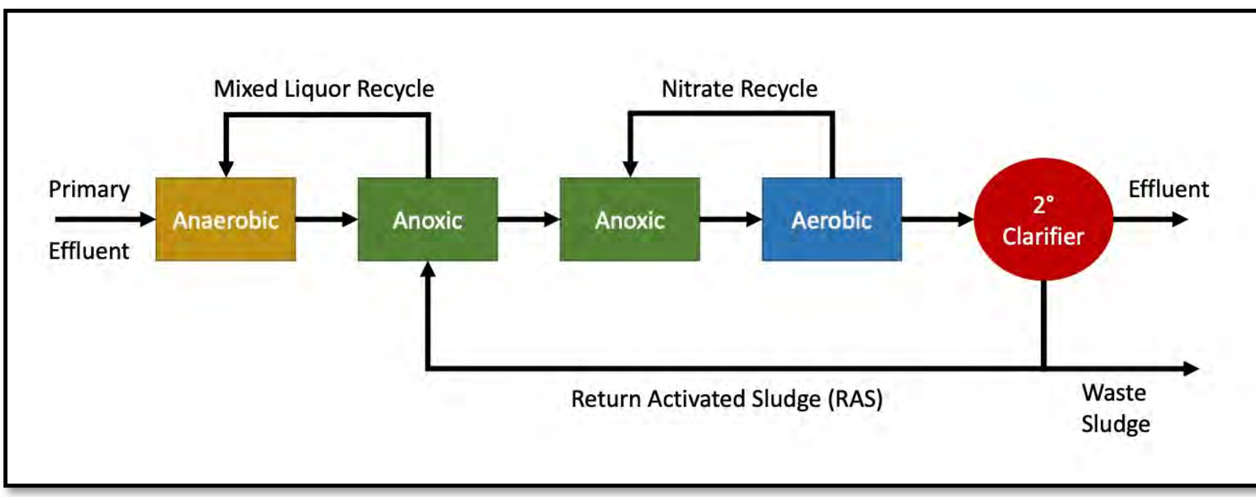


Figure 3: Modified University of Cape Town Process Flow Diagram

The final BNR process alternative considered was the A^2/O configuration. This method allows for the simultaneous removal of nitrogen and phosphorus. The A^2/O design consists of an anaerobic, an anoxic, and an aerobic (oxic) zone, with a recycle line returning nitrate from the aerobic basin to the anaerobic basin, and a sludge recycle line returning phosphorus accumulating organisms (PAOs) back to the anaerobic basin (*Figure 4*) (Metcalf & Eddy, 2014). Overall, this process would be the least difficult to implement. Compared to the other alternatives such as the Modified Bardenpho, this process only requires three separate zones. The existing aeration basins could be retrofitted easily to include the anaerobic and anoxic zones. An internal recycle line would also need to be added between the anoxic and aerobic basins, but this is a relatively minor addition. Therefore, the A^2/O treatment system was chosen for the BNR upgrade.

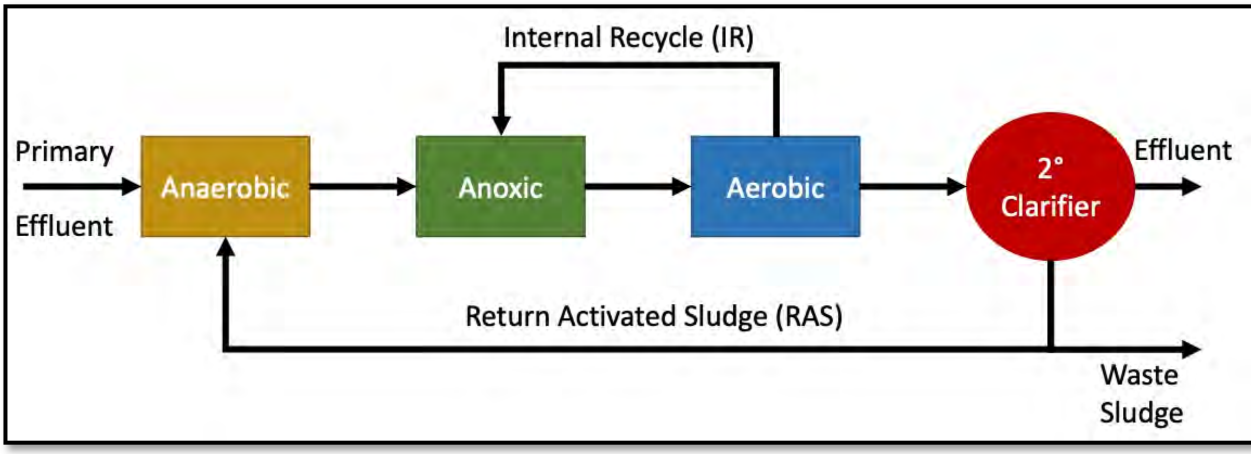


Figure 4: A^2/O Process Flow Diagram

4.3 Clarifier Design

Currently under rule 30 TAC 217.6, the design engineer can request variances from 30 TAC 217. Based on discussions with practicing engineers, it is industry standard to request a variance from the rules 30 TAC 217.129.(c)(5) and 30 TAC 217.152.(d)(5) which states that the effluent weir loading rates for primary and secondary clarifiers should not exceed 30,000 gallons per day at peak flow per linear foot of weir length. This variance is allowed by the TCEQ based on advancements and efficiencies of clarifier technologies. Following this industry advice, the primary and secondary clarifiers were designed based solely on the surface loading rate and detention time.

5.0 Recommended Design

Due to the existing plant's capacity of 55 MGD, it would be more hydraulically favorable to construct a new treatment train to handle the added flow. With this new configuration, 55 MGD AADF (and two-hour peak flow at a 1.5 peaking factor) will be conveyed to the existing plant, and any remaining flow will be conveyed to the new treatment train. This will allow for minimal adjustments to the existing treatment train. The proposed site layout can be seen in *Figure 5*.

5.1 Existing Treatment Train

Since the coarse screens and grit chambers have the necessary capacity, they will not be evaluated for upgrades and all influent flow will be sent through the HWs. The BNR process must be implemented in the existing treatment train. The aerobic basins have enough capacity to insert an anoxic zone prior to the aeration zone. Anaerobic basins will be constructed and inserted before the proposed anoxic zone, directly south of the existing ASCs. This will enable the existing treatment train to perform phosphorus and nitrogen removal with limited adjustments to the rest of the existing plant. This upgrade will be performed after the new treatment train is constructed so that the entire plant can remain in operation (see *Chapter 8: Construction Sequencing* or *Appendix I* for further details).

5.2 New Treatment Train

5.2.1 Primary Treatment

The proposed treatment train will be constructed on the remaining plot of land owned by the City of Austin directly south of the existing plant. New roadways will be constructed so that all new units are accessible for maintenance. A new pump station (PS) will be constructed after the HW facilities and before a new junction box which conveys flow to the PTCs. This will intercept all flow leaving the HW facilities and from this PS, flow will either be sent to the existing treatment train or the new treatment train. This PS will utilize nine horizontal dry pit pumps and the proposed location for this unit is directly south of the interim plant. For odor control treatment, an additional carbon adsorption unit will be added in the odor control complex to mitigate the odors released from the new treatment train units. Carbon adsorption was chosen for the new odor control unit as this is already in place at the existing plant and it is said to be an effective method of odor control based on conversations with operators.

Currently Walnut Creek WWTP utilizes FEBs after the primary clarifiers. In communication with the operators, these FEBs are essential for managing wet weather flow and dosing magnesium hydroxide for alkalinity purposes. For the new treatment train, two peak flow storage basins will be constructed (one in Phase 2, two in Phase 3). These peak flow basins are designed to reduce the peaking factor of the new and existing treatment train to 1.5. The location of these units will be east of the new PS. Alkalinity will be dosed for the new treatment train using a static in-line mixer in the pipe directly before BNR.

Three circular primary clarifiers total (one in Phase 2, two in Phase 3) are to be added so that the surface loading rate and detention time can meet TCEQ requirements, with a safety factor of 1.5. Circular clarifiers were selected due to their reliability and ease of operation. These basins will be located directly east of the proposed peak flow basins. See *Figure 5* for unit locations on the proposed site layout.

5.2.2 Secondary Treatment

Four BNR complexes will be constructed Phase 2 and five BNR complexes will be constructed for Phase 3, for a total of nine complexes when fully completed. The complexes will be located directly east of the proposed primary clarifiers. As previously discussed, the A^2/O BNR configuration will be implemented in both treatment trains. This will result in each BNR complex consisting of one anaerobic zone, one anoxic zone, and one aerobic zone. This will facilitate nitrification, denitrification, and phosphorus removal.

The design team proposes three final clarifiers total (one in Phase 2, two in Phase 3) will be added so that the surface loading rate and detention time can meet what is required by TCEQ with a safety factor of 1.5. These basins will be circular and identical in size to the primary clarifiers that will be implemented. The proposed location of these final clarifiers is directly east of the new BNR basins. See *Figure 5* for unit locations on the proposed site layout.

5.2.3 Tertiary Treatment

With new technology and sustainability as a focus, the tertiary units proposed in the new treatment train include cloth filtration and ultraviolet (UV) disinfection. Filtration will take place before disinfection as low turbidity is an important parameter for UV disinfection. There will be three filtration units added in Phase 2, and an additional unit will be added in Phase 3. Each unit contains 22 cloth disks. The proposed location of the filtration complex is directly south of the secondary clarifiers. Cloth filtration was chosen to reduce operational costs of replacing media for the current gravity filtration system, as well as for its small footprint.

For the disinfection system, four modules will be added in Phase 2, and an additional four modules will be added in Phase 3. UV disinfection was chosen to increase environmental sustainability by reducing potential disinfection byproducts in the effluent and to decrease operational hazards which may occur with chlorine disinfection. UV disinfection complexes also usually have a small footprint. The UV complex will be located west of the filtration facility. See *Figure 5* for unit locations on the proposed site layout.

5.3 Solids Handling

The existing plant utilizes a gravity thickener which has sufficient capacity for Phases 2 and 3. However there is a risk of phosphorus release under anoxic conditions which could occur in gravity thickeners. This could lead to struvite formation in the thickener's effluent pipes, that would increase O&M costs and potentially disrupt the solids handling process. This may also lead to decreased phosphorus recovery at Hornsby Bend BMP. Since closing the phosphorus loop and recovering phosphorus from the solids at Hornsby Bend BMP creates a more sustainable treatment practice, it is recommended that the existing gravity thickener be retrofitted to an aerated sludge holding tank, that would have a much lower chance of enabling phosphorus release, making this the most feasible and sustainable option for Walnut Creek WWTP's solids handling. Sludge pumping capacity would be increased, and a sludge dual mixer/aeration system would be included in the basin, however, this would be the most cost-effective option over time for preventing phosphorus release.

Table 4 below production at Walnut Creek WWTP, which includes the volume of screenings and grit based on assumed percentages of influent flow (Metcalf & Eddy, 2014). This table also includes sludge production from primary and secondary clarifiers, estimated based on a solids balance performed by the design team.

Table 4: Summary of Sludge Production

Parameter	Phase 2	Phase 3
Screening Waste (yd^3/d)	8.50	15.0
Grit Waste (yd^3/d)	6.00	10.5
Primary Sludge (ppd)	101,000	134,000
Secondary Sludge (ppd)	46,000	61,500
Total Sludge (ppd)	147,000	199,500

5.4 Phosphorus Sequestration

As previously discussed, a phosphorus sequestration technology must be implemented at Hornsby Bend BMP. The design team proposes implementing one Ostara Pearl© struvite crystallization reactor (and its associated equipment) at Hornsby Bend BMP for the purpose of phosphorus sequestration. Excess magnesium is injected into the flow that combines with ammonium and phosphate to form struvite crystals in the Ostara Pearl© struvite crystallization reactor, thus removing soluble phosphorus from the wastewater stream (Metcalf & Eddy, 2014). Pellets of struvite are formed at the end of this process, which can be sold to end users as fertilizer.

Some advantages to using struvite crystallization reactors instead of alternative methods (like ion exchange or metal salt addition) are that they allow for a cost-effective disposal method, help to alleviate issues caused by struvite in downstream pipes, and the option of re-use for struvite pellets as fertilizer promotes sustainability practices within wastewater treatment. This entire process keeps phosphorus out of receiving bodies of water (via BNR treatment) and prevents the phosphorus from ending up in a landfill, or back into surface waters (via sequestration from solids). The ability to sell these pellets to end users may also help alleviate the operational costs of Hornsby Bend BMP.

6.0 Hydraulic Profile

The existing plant was evaluated to ensure that the implementation of the BNR process would not negatively affect the hydraulics. The main headlosses that would occur are from the weirs between the basins, that cause minor headloss (2.5 inches). Because there are multiple feet of room between the water surface in the aeration basins and the final clarifiers, there is enough head hydraulically to add the additional anaerobic and anoxic basins.

The hydraulic profile (*Figure 6* and *Figure 7*) for the proposed treatment train was modeled to ensure the plant would operate hydraulically as intended. The new treatment train is designed so that after the water is diverted to the new proposed pump station, the water will only be pumped up once at the beginning and then flow by gravity through the remainder of the process units to the outfall. The total amount of headloss accounted for is the headloss through each unit, the headloss in the pipe due to friction, and the minor losses throughout the piping system due to bends, fittings, and junction boxes. The pipe diameters and the design flow are based on PF to ensure the pipes would be large enough to convey the water during large flow events. However, while the pipes were designed to minimize losses during the PF, the velocities for the AADF were checked to ensure that there would be a minimum of 1-3 ft/s to avoid solids from settling within the piping system. The equations used for this process as well as detailed calculations and drawings can be found in *Appendix G.*

GENERAL NOTES

N

LEGEND

- EXISTING UNIT
- PHASE 2
- PHASE 3
- ROADWAY
- INTERIM FACILITY
- PROPERTY BOUNDARY
- 150 FOOT BUFFER
- FEMA FLOOD ZONE

0 250 500

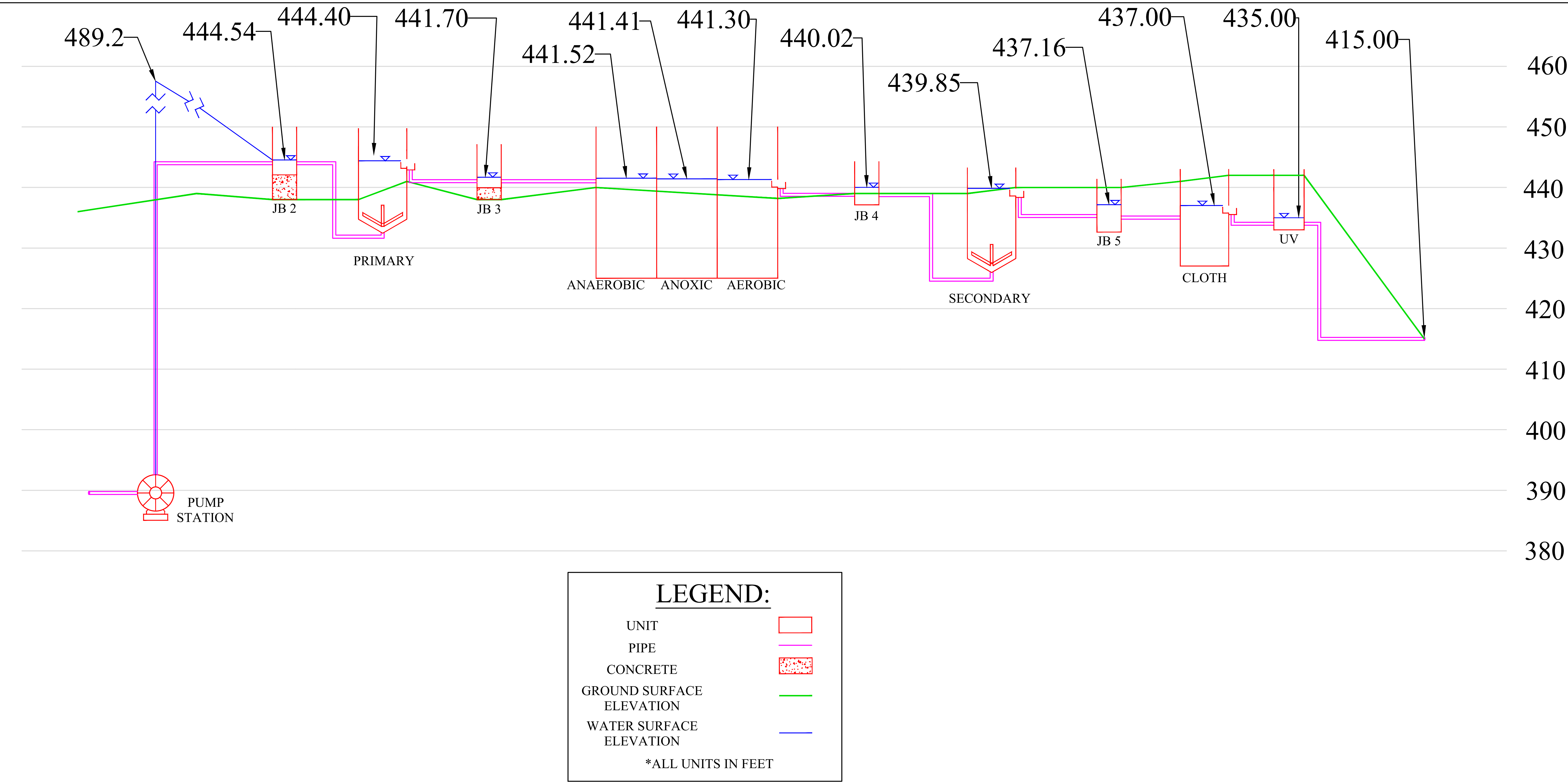
WALNUT CREEK WASTEWATER TREATMENT PLANT

WWTP SITE LAYOUT

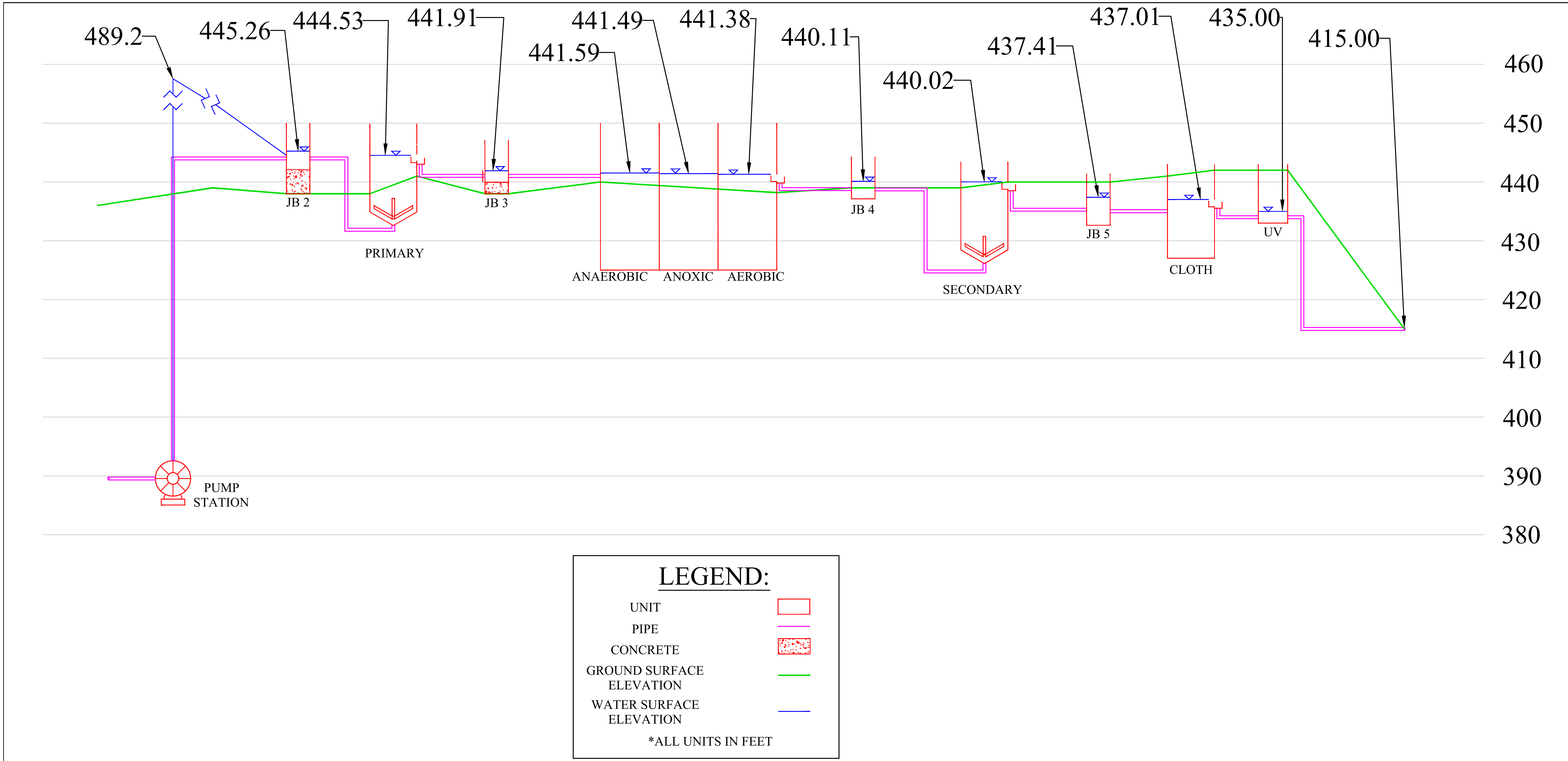
7/25/2023
DATE

Mathew Rotman
MATHEW ROTMAN

DESIGNED BY	WEAT TEAM
DRAWN BY	M. ROTMAN
CHECKED BY	L. MCDONALD



DESIGNED BY: K.A.	PREPARED FOR AUSTIN WATER	WALNUT CREEK WASTE WATER TREATMENT PLANT UPGRADE	FIGURE 6: WALNUT CREEK HYDRAULIC PROFILE PHASE 2	SHEET 01 OF 02
DRAWN BY: K.A.				SCALE: N.T.S.
CHECKED BY: L.M.				



DESIGNED BY: K.A. DRAWN BY: K.A. CHECKED BY: L.M.	PREPARED FOR AUSTIN WATER	WALNUT CREEK WASTE WATER TREATMENT PLANT UPGRADE	FIGURE 7: WALNUT CREEK HYDRAULIC PROFILE PHASE 3	SHEET 02 OF 02 SCALE: N.T.S.

7.0 Cost Analysis

An Opinion of Probable Construction Cost (OPCC) was developed for both Phases 2 and 3 (see *Appendix H* for detailed calculations). These analyses are preliminary and are subject to change based on market prices, manufacturer selections, and contractor bids. A contingency of 30 percent was applied to allow for changes in costs from the initial estimate to the time of construction. The total cost for implementing the proposed improvements for Phase 2 is **$95,400,000** and **$39,300,000** for Phase 3. This results in a total cost of **$140,800,000**.

Table 5: Opinion of Probable Construction Cost Summary

Item	Phase 2	Phase 3
Primary	$14,200,000	$6,890,000
Secondary	$17,700,000	$18,800,000
Tertiary	$8,720,000	$1,320,000
Odor Control	$416,000	-
Solids Handling	$500,000	-
Phosphorus Sequestration	$9,900,000	-
Paving, Earthwork, and Erosion Control	$12,500,000	$28,000
Other Costs	$31,900,000	$12,200,000
Total Per Phase	**$95,400,000**	**$39,300,000**
Total Overall	**$140,800,000**	

An opinion of probable annual O&M cost (*Figure 8*) was also developed based on electrical, maintenance, sludge disposal, chemical, and labor costs. See *Appendix H* for detailed calculations. This analysis resulted in a total estimated annual O&M cost for the newly constructed upgrades of **$17,050,000**.

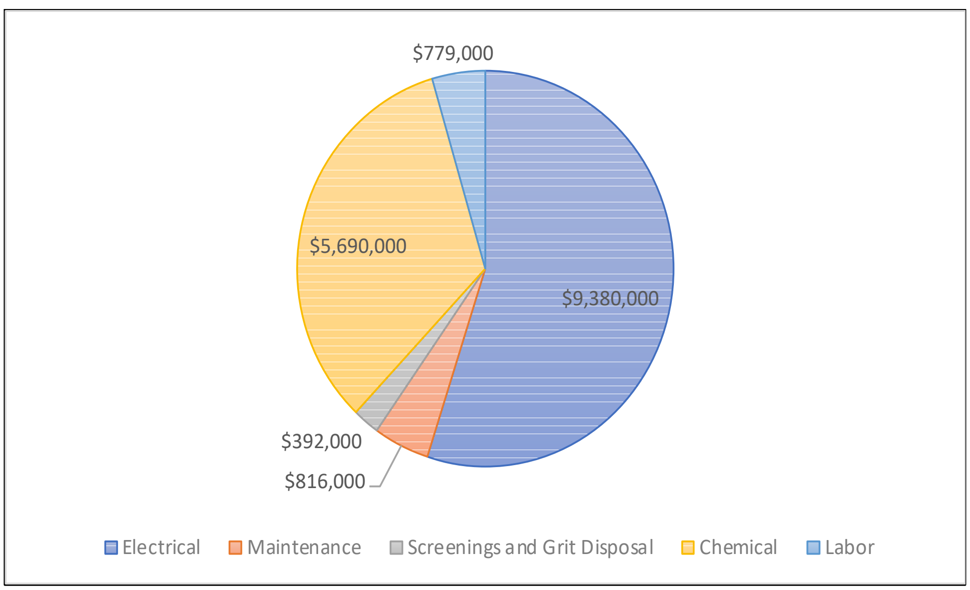


Figure 8: Annual Operation and Maintenance Costs Summary

8.0 Construction Sequencing

The development of the chosen design method will take place over two stages (*Table 6*). To guarantee that the facility can remain operational while construction is taking place, these two stages are necessary. The construction will occur over 20 months to ensure that the expansion is complete by the permit deadline in March 2025. For Stage 1, construction will take approximately 13 months. Following this, construction will take approximately 7 months in Stage 2.

Table 6: Proposed Construction Sequence with Order of Operation

Construction Sequencing Schedule Overview	
Task No.	**Task Name**
	Stage 1
	New Treatment Train Construction
1	Influent Pump Station
2	Peak Basins
3	Primary Clarifiers
4	BNR Complexes
5	Final Clarifiers
6	Cloth Filtration
7	UV Disinfection
8	Gravity Thickener to Sludge Holding Basin
9	Hornsby Bend BMP Pearl Reactor
	Stage 2A
10	Existing Plant BNR Modification
	Stage 2B
11	Primary Clarifiers
12	BNR Complexes
13	Final Clarifiers
14	Cloth Filtration
15	UV Disinfection

Stage 1 construction will include the bidding process, excavation, site work for construction of the additional treatment train, and the lift station installation with pumps. The additional treatment train that will be constructed includes peak basins, primary clarifiers, BNR complexes, secondary clarifiers, UV disinfection, and rotary cloth filtration. These units will be constructed to meet the 75 MGD demand. Stage 1 construction will also consist of installing an Ostara Pearl© 10K reactor at Hornsby Bend BMP for phosphorus sequestration and retrofitting the gravity thickener to a sludge holding basin. The duration for the unit construction consists of assessments, equipment and unit testing, piping, and installation of the new units.

To ensure that the plant is capable of remaining online during construction, Stage 2A will serve as the modification of the CAS in the existing plant to BNR. Stage 2B construction will follow this after the existing train construction is complete and fully online. Stage 2B includes the remaining peak basins, primary clarifiers, BNR complexes, and secondary clarifiers added to the new treatment train to meet the 100 MGD demand. Details can be found in *Appendix I*.

It is important to note that the client should consider requesting a TCEQ extension to their permit to avoid an expedited construction on a large expansion such as this. An additional option is choosing a CMAR (Construction Management At-Risk) or Design-Build construction project to meet the 2025 deadline. Detail on the optional TCEQ extension 5-year construction schedule is provided in *Appendix I*.

9.0 Conclusion

The design team conducted a capacity analysis to evaluate Walnut Creek WWTP's ability to handle the existing and future design flows. A selection of the best process upgrades was then determined by using a design matrix to ensure long-term plant sustainability. This recommended design includes the conversion to BNR using the A^2/O process, additional clarifying units, offline storage tanks to avoid overloading units, technology changes for efficient removal and treatment, and phosphorus removal units for the new TPDES permit limit. The additions and modifications will sustain excellent performance and resilience to meet the TPDES and TCEQ criteria for effluent regulations.

Once this upgrade is fully constructed, there will be space on the site available for future expansion. For ultimate buildout, a new treatment train can be added in the space southeast of the treatment train added during this expansion (*Figure 9*). If the need for more expansion than the space available allows, the design team recommends implementing an enhanced secondary treatment process, such as Integrated Fixed Film Activated Sludge (IFAS) (Gellner, n.d.) or a BioMag® System (Evoqua Water Technologies, 2022). Either of these enhanced secondary treatment processes would increase the capacity of the plant, allowing for further upgrades on the space-limited site.

10.0 Acknowledgement

The 2023 design team would like to extend our profound thanks to everyone who has helped and guided us. We would like to express our sincere appreciation to WEAT for organizing the Student Design Competition and allowing us to participate. Special thanks to Danny Roberts and Tori Haugvoll, the chairs of the WEAT Student Design Competition, and Austin Water for sponsoring the prompt. Finally, we wish to express our gratitude to our WEAT mentor Mr. Wesley Trait, and our advisors Dr. Andrew Jackson and Dr. Clifford Fedler for devoting their time and energy to guiding and aiding us while we completed this project.

GENERAL NOTES

N

LEGEND

- EXISTING UNIT
- FUTURE EXPANSION
- ROADWAY
- INTERIM FACILITY
- PROPERTY BOUNDARY

0 250 500

WALNUT CREEK WASTEWATER TREATMENT PLANT

WWTP ULTIMATE SITE LAYOUT

7/25/2023
DATE

Mathew Rotman
MATHEW ROTMAN

DESIGNED BY	WEAT TEAM
DRAWN BY	M. ROTMAN
CHECKED BY	L. MCDONALD

Appendix A: Acronyms and Abbreviations

AADF – Annual Average Daily Flow
ASC – Activated Sludge Complex
A^2/O – Anaerobic/Anoxic/Oxic
BNR – Biological Nutrient Removal
BMP – Biosolids Management Plant
CAS – Conventional Activated Sludge
CMAR – Construction Management At-Risk
DO – Dissolved Oxygen
FEB – Flow Equalization Basin
HW – Headworks
IFAS – Integrated Fixed Film Activated Sludge
MGD – Million Gallons per Day
MUCT – Modified University of Cape Town
O&M – Operation and Maintenance
OPCC – Opinion of Probable Construction Cost
PAO – Phosphorus Accumulating Organism
PF – Peak Flow
PTC – Primary Treatment Complex
PS – Pump Station
RAS – Return Activated Sludge
TAC – Texas Administrative Code
TCEQ – Texas Commission on Environmental Quality
TPDES – Texas Pollutant Discharge Elimination System
UV – Ultraviolet
WAS – Waste Activated Sludge
WEAT – Water Environment Association of Texas
WWTP – Wastewater Treatment Plant

Appendix B: References

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Appendix C: Capacity Analysis

C.1 Existing Units Capacity Analysis

C.1.1 Existing Mechanical Bar Screens

The preliminary treatment units will remain as they are for the design phases for the WCWWTP. Splitting the flow 50/50, 50% going to headworks 1 and 50% going to headworks 2, the screens can meet TCEQ standards. A velocity between 1-3ft/s was chosen to see if the max water surface elevation is less than the max elevation listed of 7.6ft. A sample calculation for the velocity calculations for the mechanical coarse screens are shown below.

$$Permit\ Phase\ 2\ AADF = 75MGD$$

$$Headworks\ 1\ Flow\ to\ each\ Screen: \frac{Q*0.5}{2} = \frac{\left(116\frac{ft^3}{s}\right)*0.5}{2} = 29\frac{ft^3}{s}$$

$$Headworks\ 2\ Flow\ to\ each\ Screen: \frac{Q*0.5}{2} = \frac{\left(116\frac{ft^3}{s}\right)*0.5}{2} = 29\frac{ft^3}{s}$$

$$Width = 9ft$$

$$Max\ WSEL = 7.6ft$$

$$WSEL = \frac{Q}{v*W} = \frac{(29\frac{ft^3}{s})}{\left(1\frac{ft}{s}\right)*(9ft)} = 3.2ft$$

Water surface elevations for each coarse screen was calculated to see if the max water surface elevation was below the max elevation. Values for the velocities and water surface elevation are shown below in the following tables.

3/4" Coarse Screens HW1 (Flow Split Evenly)				
Characteristics:	Phase 2 (AADF/PF)		Phase 3 (AADF/PF)	
Total Flow (ft^3/s)	116	349	155	465
Flow to Each Screen (ft^3/s)	29	87	39	116
Width (ft)	9.0	9.0	9.0	9.0
Velocity (ft/s)	1.0	2.0	1.0	2.0
WSEL (ft)	3.2	4.8	4.3	6.5

3/8" Coarse Screens HW2 (Flow Split Evenly)				
Characteristics:	Phase 2 (AADF/PF)		Phase 3 (AADF/PF)	
Total Flow (ft^3/s)	116	349	155	465
Flow to Each Screen (ft^3/s)	29	87	39	116
Width (ft)	9.0	9.0	9.0	9.0
Velocity (ft/s)	1.0	2.0	1.0	2.0
WSEL (ft)	3.2	4.8	4.3	6.5

C.1.2 Existing Aerated Grit Chambers

The grit chambers as well will also not be modified for our preliminary selection. TCEQ requires that the hydraulic detention time for the aerated grit chambers be greater than 3 minutes. From the following table and calculations, it is found that the hydraulic detention time for the existing grit chambers meet requirements.

$$Area\ of\ Headworks\ 1\ Grit\ Chamber = 1080ft^2$$
$$Area\ of\ Headworks\ 2\ Grit\ Chmaber = 1695ft^2$$
$$Length\ of\ Headworks\ 1\ Grit\ Chamber = 60ft$$
$$Length\ of\ Headworks\ 2\ Grit\ Chamber = 94ft$$
$$Width\ of\ Headworks\ 1\ Grit\ Chamber = \frac{Area}{Length} = \frac{1080ft^2}{60ft} = 18ft$$
$$Width\ of\ Headworks\ 2\ Grit\ Chamber = \frac{Area}{Length} = \frac{1695ft^2}{94ft} = 18ft$$
$$Volume\ of\ Headworks\ 1\ Grit\ Chmaber = Area * Height = (1080ft^2) * (20ft) = 21600ft^3$$
$$Volume\ of\ Headworks\ 2\ Grit\ Chmaber = Area * Height = (1695ft^2) * (20ft) = 33900ft^3$$
$$Detention\ Time\ HW1\ Grit\ Chamber = \frac{Volume}{Q} = \frac{21600ft^3}{1743\frac{ft^3}{min}} = 12.4min$$
$$Detention\ Time\ HW2\ Grit\ Chamber = \frac{Volume}{Q} = \frac{33900ft^3}{1743\frac{ft^3}{min}} = 19.5min$$

Detention times for peak flows and phase 3 flows were calculated and can be found in the tables below for both headworks.

Aerated Grit Chamber HW1 (Flow Split Evenly)				
Characteristics:	**Phase 2 (AADF/PF)**		**Phase 3 (AADF/PF)**	
Total Flow (ft^3/min)	6,971	20,912	9,294	27,883
Flow to Each Chamber (ft^3/min)	1,743	5,228	2,324	6,971
Volume (ft^3)	21600	21600	21600	21600
Detention Time (min)	12.4	4.1	9.3	3.1

Aerated Grit Chamber HW2 (Flow Split Evenly)				
Characteristics:	**Phase 2 (AADF/PF)**		**Phase 3 (AADF/PF)**	
Total Flow (gal/min)	6,971	20,912	9,294	27,883
Flow to Each Chamber (gal/min)	1,743	5,228	2,324	6,971
Volume (ft^3)	33900	33900	33900	33900
Detention Time (min)	19.5	6.5	14.6	4.9

C.1.3 Existing Primary Clarifiers

The following parameters were given by the project statements. The peak flows were converted to MGD to keep all units the same. All TCEQ regulations were calculated and analyzed for all three Phases. For this appendix, only sample calculations for Permit Phase 1 are provided. All equations were used the same for all Phases and only the AADF and 2-HR PF were changed to correlate to the Permit Phase.

Phase 1 AADF = 75 MGD
Phase 1 2-HR PF = 114,583 gpm (1440 min./1day) (10^{-6}) = 165 MGD
Number of clarifiers = 4
Side water depth = 12.45 ft
Length of clarifier = 120 ft
Area = $(120\text{ ft})^2 = 14{,}400\text{ ft}^2$
Volume of each clarifier = 1.49 MG (10^6) = 1,490,000 gal

The total AADF and 2-HR PF are the total flows flowing to all four clarifiers. It is assumed that the clarifiers receive even amounts of the total flows. With this, the AADF and 2-HR PF were divided between the four clarifiers.

Phase 1 AADF per clarifier

$$Q = \frac{75\ MGD}{4\ clarifiers} = 18.75\text{ MGD}$$

Phase 1 2-HR PF per clarifier

$$Q = \frac{165\ MGD}{4\ clarifiers} = 41.25\text{ MGD}$$

The first TCEQ regulation analysis was the velocity flowing through the inlet stilling well. The clarifier cannot have a velocity > 0.15 ft/s at peak flow. From the plant drawings provided, the inlet stilling well radius is found to be 15 ft. The specific steps to calculating the velocity for Permit Phase 1 are seen below.

$$A_{inlet\ well} = \pi r^2$$

$$A_{inlet\ well} = \pi(15ft)^2 = 706.86\ ft^2$$

$$Q_{P2HF} = \frac{41.25\ MGD\ (10^6)}{7.48\ \frac{gal}{ft^3}(86400\ \frac{s}{day})} = 63.83 ft^3/s$$

$$V = \frac{Q}{A}$$

$$V = \frac{63.83 ft^3/s}{706.86 ft^2} = 0.09\ ft/s$$

$$0.09\frac{ft}{s} < \ 0.15\frac{ft}{s}$$

The clarifiers at Phase 1 meet TCEQ requirements.
Next, the surface loading rate of each clarifier was calculated. TCEQ states the SLR cannot exceed 1200 gpd/ft^2 at design flow and 1800 gpd/ ft^2 at peak flow. Example calculations for Phase 1 are shown.

$$SLR = \frac{Q}{A}$$

$$SLR_{AADF} = \frac{18.75\ MGD(10^6)}{14400\ ft^2} = 1{,}302.08\ gpd/ft^2$$

$$1{,}302.08\frac{gpd}{ft^2} > 1{,}200\ gpd/ft^2$$

$$\text{SLR}_{\text{2-HR PF}} = \frac{41.25\ MGD(10^6)}{14400\ ft^2} = 2{,}864.58\frac{gpd}{ft^2}$$

$$2{,}864.58\frac{gpd}{ft^2} > 1{,}800\frac{gpd}{ft^2}$$

The clarifiers at permit phase 1 fail TCEQ requirements for both design and peak flow.
The next TCEQ regulation evaluated was detention time. The minimum detention time at design flow is 0.9 hours and at peak flow 1.8 hours.

$$\text{Detention time} = \frac{V}{Q}$$

$$\text{Detention Time}_{\text{AADF}} = \frac{1{,}490{,}000\ gal}{18.75\ MGD\ (10^6)}\left(\frac{24\ hours}{day}\right) = 1.91\ hrs$$

$$\text{Detention Time}_{\text{2-HR PF}} = \frac{1{,}490{,}000\ gal}{41.25\ MGD\ (10^6)}\left(\frac{24\ hours}{day}\right) = 0.87\ \text{hrs}$$

Following detention time, the weir loading rate was then calculated and compared to TCEQ requirements. The weir loading rate cannot exceed 30,000 gpm/ft at peak flow. The weir for each clarifier is placed around the perimeter of the square basin. The weir length for each clarifier is then calculated as seen below.

$$WL = L \times 4 = 120\ ft\ \times 4 = 480\ ft$$

$$\text{WLR} = \frac{Q}{WL}$$

$$\text{WLR}_{\text{2-HR PF}} = \frac{41.25\ MGD(10^6)}{440\ FT} = 85{,}937.50\frac{gpd}{linear\ ft}$$

$$85{,}937.50\frac{gpd}{linear\ ft} > 30{,}000\frac{gpd}{linear\ ft}$$

The clarifiers at Phase 1 do not meet TCEQ requirements for weir loading rate.

C.1.4 Existing Settled Wastewater Pumps

For the settled wastewater pumps, the information below was provided in the project statement.

Pumping from FEB: 5 pumps x 20,800 gpm

Pumping from wet well: 3 pumps x 18,500 gpm

Upon evaluating the capacity of pumps according to TCEQ requirements, TCEQ states the total firm capacity must be greater than the total peak flow. TCEQ also states, one of the largest pumps is to be considered offline and not accounted for in the total firm capacity. This calculation and evaluation process is shown below.

$$Firm\ Capacity = (4\ Pumps\ \times 20{,}800\ gpm) + (3\ pumps\ \times 18{,}500\ gpm) = 138{,}700\ gpm$$

$$Firm\ capacity = 138{,}700\ gpm\ \times \frac{1440\ min}{day} \times\ 10^{-6} = 199.7\ MGD$$

$$Q_{Peak,Phase1} = 165\ MGD$$

$$199.7\ MGD > 165\ MGD$$

$$Q_{Peak,Phase2} = 225\ MGD$$

$$199.7\ MGD < 225\ MGD$$

$$Q_{Peak,Phase3} = 300\ MGD$$

$$199.7\ MGD < 300\ MGD$$

The settled wastewater pumps only meet TCEQ requirements for Permit Phase 1.

C.1.5 Existing Aeration Basins

For the BOD Loading Rate, the calculation used the equation below. The value for the concentration of BOD used was from the influent value and the converting it lb/ft^3 from mg/L. The influent flow rate used was the permitted AADF value, and the basin volume was the total aeration basin volume of all basins added together.

BOD$_5$ Loading Rate

$$Loading\ Rate = C * (\frac{Q}{V})$$

C = Concentration of BOD (lb/ft^3)
Q = Influent Flow Rate (ft^3/d)
V = Total Basin Volume (1000 ft^3)
For a 75 MGD Flow

$$Loading\ Rate = \left(0.01405\frac{lb}{ft^3}\right) * \frac{10.03^6\ \frac{ft^3}{d}}{(3.82^6\ ft^3)/1000\ ft^3} = 36.9\ \frac{lb\ BOD_5}{day * 1000\ ft^3}$$

The maximum flowrate was calculated by back calculating the flow value using the maximum loading rate allowed by TCEQ.

Maximum Flowrate based on Loading Rate Limit

$$Q = 45\ \frac{lb\ BOD_5}{day * 1000\ ft^3} * (\frac{V}{C})$$

$$Q = 45\ \frac{lb\ BOD_5}{day * 1000\ ft^3} * \frac{(3.82^6\ ft^3)/1000\ ft^3}{0.01405\frac{lb}{ft^3}} * \frac{7.48\ gal}{10^6\ MG} = 91.5\ MGD$$

C.1.6 Existing Final Clarifiers

To find the surface loading rate, the total flow rate coming in was divided by the total area of the clarifiers. The surface area of each clarifier was given.

Surface Loading Rate

$$Surface\ Loading\ Rate = \frac{Q}{A}$$

Q = Influent Flow Rate (gpd)
A = Total Clarifier Area (ft^2)
For a 165 MGD Flow

Phase 1 2-HR PF = 114,583 gpm (1440 min./1day) = 1.65(10^8) gpd
Number of clarifiers = 6
Area = 19,700 ft^2

$$Surface\ Loading\ Rate = \frac{1.65(10^8)gpd}{(19{,}700\ ft^2) * 6} = 1{,}396\ \frac{gpd}{ft^2}$$

To find the weir loading rate, the total flow coming in was divided by the total weir length of the clarifiers. The weirs for the final clarifiers are around the perimeter of the clarifiers, so the weir length per clarifier is equal to the clarifier perimeter.

Weir Loading Rate

$$Weir\ Loading\ Rate = \frac{Q}{WL}$$

Q = Influent Flow Rate (gpd)
WL = Total Clarifier Weir Length (ft)
For a 165 MGD Flow
Phase 1 2-HR PF = 114,583 gpm (1440 min./1day) = $1.65(10^8)$ gpd
Weir Length per Clarifier = $((19{,}700\ ft^2)^{1/2})*4$ = 560 ft

$$Weir\ Loading\ Rate = \frac{1.65(10^8)gpd}{(560\ ft)*6} = 49{,}107\ \frac{gpd}{ft}$$

The detention time was calculated by dividing the total volume of the clarifiers by the total flow coming in. The volume for each clarifier was given.

Detention Time

$$Detention\ Time = \frac{V}{Q}$$

V = Total Clarifier Volume (gal)
Q = Influent Flow Rate (gpd)
For a 165 MGD Flow
Phase 1 2-HR PF = 114,583 gpm (1440 min./1day) = $1.65(10^8)$ gpd
Volume Per Clarifier = 2.5 MG*10^6 = 2,500,000 gal

$$Detention\ Time = \frac{(2{,}500{,}000\ gal)*6}{1.65(10^8)gpd} = 0.091\ d\left(\frac{24\ hr}{1\ d}\right) = 2.18\ hr$$

The inlet stilling well velocity was determined by dividing the total flow coming in by the total area of the clarifier inlet stilling well. The diameter of the inlet stilling well was found in the record drawings.

Inlet Stilling Well Velocity

$$Inlet\ Stilling\ Well\ Velocity = \frac{Q}{A}$$

Q = Inlet Flow Rate (ft^3/s)
A = Area of Clarifier Inlet Stilling Well (ft^2)
For a 165 MGD Flow
Phase 1 2-HR PF $= 165\ \text{MGD} * (10^6) * \frac{1\ ft^3}{7.48\ gal} * \frac{1\ d}{86{,}400\ s} = 255.31\ \frac{ft^3}{s}$
Area of Clarifier Inlet Stilling Well = $\pi(r^2) = \pi*(16\ ft)^2 = 804.23\ ft^2$

$$Inlet\ Stilling\ Well\ Velocity = \frac{\left(255.31\ \frac{ft^3}{s}\right)}{804.23\ ft^2*6} = 0.053\ \frac{ft}{s}$$

The total capacity was calculated by multiplying the area of the clarifier by the maximum surface loading rate allowed by TCEQ. That gave the total capacity per clarifier which was then multiplied by the amount of clarifiers to get the total capacity.

Total Capacity

$$Capacity\ per\ Clarifier = A * SLR$$

A = Area Per Clarifier (ft^2)
SLR = Max Surface Loading Rate (gpd/ft^2)
For a Maximum Surface Loading Rate of 1,200 gpd/ft^2

A = 19,700 ft^2
SLR = 1,200 gpd/ft^2

$$Capacity\ per\ Clarifier = (19{,}700\ ft^2) * \left(1{,}200\ \frac{gpd}{ft^2}\right) * (10^{-6}) = 23.64\ MGD$$

$$Total\ Capacity = 23.64\ MGD * 6 = 141.8\ MGD$$

C.1.7 Existing Chlorine Contact Basins

Chlorine Contact Basin Sizing

The sizing of the chlorine contact basin was retrieved from the engineering drawings.

V = (L·W·H)
L = Length = 53 ft
W= Width = 53 ft
H = Height = 15.3 ft

The capacity per basin was calculated. The capacity per basin is .32 MG.

$$\text{Capacity of 1 Basin} = \frac{42{,}977.7\text{ft}^3 * 7.48}{10^6} = .32\ \text{MG}$$

Chlorine Contact Time for a Single Phase

To calculate the chlorine contact time for peak flow. The capacity of one chlorine contact basin was divided by the flow. The flow is assumed to be the same per basin.

$$\text{Chlorine Contact Time}_{\text{2-HR PF}} = \frac{V}{Q}$$

For the first peak flow, 114,583 gpm, the chlorine contact time is 16.9 minutes.

$$\text{Chlorine Contact Time}_{\text{2-HR PF}} = \frac{322173.6\ gal}{\left(\frac{114{,}583\ \frac{gal}{min}}{6\ basins}\right)} = 16.9\ \text{min}$$

Chlorine Dosage

First, determine the chlorine concentration from TCEQ Table K.1. needed for efficient disinfection. The sample calculations are for the first peak flow phase.

Table K.1. - Minimum Design Chlorine Concentration Needed for Disinfection
Chlorine Dosage = 6 mg/L

Next, utilized the TCEQ Treatment Capacity equation for phase 1 peak flow.

$$Phase\ 1\ TCEQ\ Treatment\ Capacity\ (ppd) = Phase\ 1\ PF * Chlorine\ Dosage * 8.34$$
$$= 165\ GMD * 6\frac{mg}{L} * 8.34 = 8{,}257\ \text{ppd}$$

According to TCEQ, for phase 1 peak flow the treatment capacity is 8,257 ppd.

C.1.8 Existing Gravity Filtration

First, determine the surface area of all filters with largest filter offline. The sample calculations are for the first peak flow phase.

Filter Rate Capacity Analysis

$$SA_{mono} = (1080 * 4)ft^2 = 4320\ ft^2$$

$$SA_{dual} - SA_{Large\ Filter} = (1088 * 6)ft^2 - 1088\ ft^2 = 5440\ ft^2$$

Then determine the total number of possible flux for each type of filter media with TCEQ filter rate requirement.

$$Total\ Possible\ Flux\ Mono - Media = SA_{mono} * Fl_{TCEQ} = 4320\ ft^2 * 6\ \frac{gpm}{ft^2} = 25{,}920\ gpm$$

$$Total\ Possible\ Flux\ Dual\ Media = (SA_{dual} - SA_{Large\ Filter})\ Fl_{TCEQ}$$
$$= 5440\ ft^2 * 8\frac{gpm}{ft^2} = 43{,}520\ gpm$$
$$Total\ Possible\ Flux\ = Flux\ Mono - Media + Flux\ Dual\ Media$$
$$Total\ Possible\ Flux = 25{,}920 gpm + 43{,}520 gpm = 69{,}440\ gpm$$

69,440 gpm = 100 MGD

Finally compare the flow coming into unit and TCEQ maximum capacity.
Flowrate = Q = 100 MGD < 165 MGD
The filtration system does not meet TCEQ regulations.

Filter Backwash Flowrate

The backwash system requirements stated in TAC§217.191(c) (1) requires a single media deep bed filter to provide a minimum backwash flowrate of 6.0 gpm/ft^2 of media area. The pump rate of the pump was divided by the surface area of the mono media filter to calculate the filter backwash flowrate.

$$Filter\ Backwash\ Flowrate\ Mono - media = \frac{Pump\ Rate}{SA_{mono}} = \frac{22{,}000\ gpm}{1080\ ft^2} = 20.4\frac{gpm}{ft^2}$$

With a centrifugal pump providing a pumping rate of 22,000 gpm/ft^2 at 48 feet, the predicted backwash flowrate for mono-media is 20.4 gpm/ft^2, which passes the TCEQ requirement of a minimum 6 gpm/ft^2 .

C.1.9 Existing Dechlorination

First, determine the pipeline volume.

$$Pipe\ Volume = \ Pipe_{injection\ pt} * \frac{1}{4}\pi d^2 = 4800\ ft * \frac{1}{4} * \pi * 8ft^2 * 7.48 * 10^{-6} = 1.80\ MG$$

Next calculate the dechlorination contact time for the first peak flow permit phase.

$$\text{Dechlorination Contact Time}_{\text{Pipe}} = \frac{V}{Q} = \frac{1.80\ MG}{165\ MGD} * 86400 = 945\ sec$$

The minimum required TCEQ dechlorination contact time required is 20 seconds.
Since 945 sec > 20 secs. The TCEQ requirement for dechlorination is met.

C.2 Proposed Units Capacity Analysis

C.2.1 Proposed Pump Station

Phase 2: 7 pumps x 37.5 MGD = 262.5 MGD
Phase 3: 9 pumps x 37.5 MGD = 337.5 MGD

Phase 2

$$Firm\ Capacity = (6\ Pumps\ \times 37.5\ MGD) = 225\ MGD$$

$$Q_{Peak,Phase2} = 40.5\ MGD$$
$$225\ MGD > 40.5\ MGD$$

Phase 3

$$Firm\ Capacity = (8\ Pumps\ \times 37.5\ MGD) = 300\ MGD$$

$$Q_{Peak,Phase3} = 78\ MGD$$
$$300\ MGD > 78\ MGD$$

The settled wastewater pumps only meet TCEQ requirements for Permit Phase 2 and Phase 3.

C.2.2 Proposed Primary Clarifiers

Phase 2

Phase 2 AADF = 27 MGD
Phase 2 2-HR PF = 27 MGD * 1.5 peak factor = 40.5 MGD
Number of clarifiers = 3
Side water depth = 12 ft
Length of clarifier = 150 ft
Area = Π*(75 ft)^2 = 17,672 ft^2
Volume of each clarifier = 17,672 ft^2 * 12 ft = 212,058 ft^3 = 1.58 MG

Phase 2 AADF per clarifier

$$Q = \frac{27\ MGD}{3\ clarifiers} = 9\ \text{MGD}$$

Phase 2 2-HR PF per clarifier

$$Q = \frac{40.5\ MGD}{3\ clarifiers} = 13.5\ \text{MGD}$$

$$A_{inlet\ well} = \pi r^2$$
$$A_{inlet\ well} = \pi(11.25\ ft)^2 = 398\ ft^2$$
$$Q_{P2HF} = \frac{13.5\ MGD\ (10^6)}{7.48\ \frac{gal}{ft^3}(86400\frac{s}{day})} = 20.88\ ft^3/s$$
$$V = \frac{Q}{A}$$

$$V = \frac{20.88\ ft^3/s}{398\ ft^2} = 0.052\ ft/s$$
$$0.052\frac{ft}{s} < \ 0.15\frac{ft}{s}$$

The clarifiers meet the TCEQ requirements for Phase 2.

$$\text{SLR} = \frac{Q}{A}$$
$$\text{SLR}_{\text{AADF}} = \frac{9\ MGD(10^6)}{17{,}672\ ft^2} = 509\ gpd/ft^2$$
$$509\ \frac{gpd}{ft^2} < 1{,}200\ gpd/ft^2$$
$$\text{SLR}_{\text{2-HR PF}} = \frac{13.9\ MGD(10^6)}{17{,}672\ ft^2} = 787\ \frac{gpd}{ft^2}$$
$$787\frac{gpd}{ft^2} < 1{,}800\frac{gpd}{ft^2}$$

The clarifiers meet the TCEQ requirements for Phase 2.

$$\text{Detention time} = \frac{V}{Q}$$
$$\text{Detention Time}_{\text{ AADF}} = \frac{1{,}580{,}000\ gal}{9\ MGD\ (10^6)}\left(\frac{24\ hours}{day}\right) = 4.21\ hrs$$

$$\text{Detention Time}_{\text{ 2-HR PF}} = \frac{1{,}580{,}000\ gal}{13.5\ MGD\ (10^6)}\left(\frac{24\ hours}{day}\right) = 2.8\ \text{hrs}$$

$$WL = 2P\ r = 2\ \times P \times 75\ ft\ = 471\ ft$$
$$\text{WLR} = \frac{Q}{WL}$$
$$\text{WLR}_{\text{ 2-HR PF}} = \frac{13.25\ MGD(10^6)}{471\ FT} = 28{,}131\frac{gpd}{linear\ ft}$$
$$28{,}131\frac{gpd}{linear\ ft} < 30{,}000\frac{gpd}{linear\ ft}$$

The clarifiers meet the TCEQ requirements for Phase 2.

<u>Phase 3</u>

Phase 3 AADF = 52 MGD
Phase 2 2-HR PF = 27 MGD * 1.5 peak factor = 78 MGD
Number of clarifiers = 3
Side water depth = 12 ft
Length of clarifier = 150 ft
Area = Π*(75 ft)^2 = 17,672 ft^2
Volume of each clarifier = 17,672 ft^2 * 12 ft = 212,058 ft^3 = 1.58 MG

Phase 3 AADF per clarifier

$$\text{Q} = \frac{52\ MGD}{6\ clarifiers} = 8.6\ \text{MGD}$$

Phase 3 2-HR PF per clarifier

$$Q = \frac{78\ MGD}{6\ clarifiers} = 13\ \text{MGD}$$

$$A_{inlet\ well} = \pi r^2$$
$$A_{inlet\ well} = \pi(11.25\ ft)^2 = 398\ ft^2$$
$$Q_{P2HF} = \frac{13\ MGD\ (10^6)}{7.48\ \frac{gal}{ft^3}(86400\ \frac{s}{day})} = 20.11\ ft^3/s$$
$$V = \frac{Q}{A}$$
$$V = \frac{20.11\ ft^3/s}{398\ ft^2} = 0.051\ ft/s$$
$$0.051\frac{ft}{s} < \ 0.15\frac{ft}{s}$$

The clarifiers meet the TCEQ requirements for Phase 3.

$$\text{SLR} = \frac{Q}{A}$$
$$\text{SLR}_{\text{AADF}} = \frac{8.6\ MGD(10^6)}{17{,}672\ ft^2} = 486.6\ gpd/ft^2$$
$$486.6\ \frac{gpd}{ft^2} < 1{,}200\ gpd/ft^2$$
$$\text{SLR}_{\text{2-HR PF}} = \frac{13\ MGD(10^6)}{17{,}672\ ft^2} = 736\ \frac{gpd}{ft^2}$$
$$736\frac{gpd}{ft^2} < 1{,}800\frac{gpd}{ft^2}$$

The clarifiers meet the TCEQ requirements for Phase 3.

$$\text{Detention time} = \frac{V}{Q}$$
$$\text{Detention Time}_{\text{ AADF}} = \frac{1{,}580{,}000\ gal}{8.6\ MGD\ (10^6)}\left(\frac{24\ hours}{day}\right) = 4.4\ hrs$$

$$\text{Detention Time}_{\text{ 2-HR PF}} = \frac{1{,}580{,}000\ gal}{13\ MGD\ (10^6)}\left(\frac{24\ hours}{day}\right) = 2.91\ \text{hrs}$$

$$WL = 2P\ r = 2\ \times P \times 75\ ft\ = 471\ ft$$
$$\text{WLR} = \frac{Q}{WL}$$
$$\text{WLR}_{\text{ 2-HR PF}} = \frac{13\ MGD(10^6)}{471\ FT} = 27{,}600\ \frac{gpd}{linear\ ft}$$
$$27{,}600\frac{gpd}{linear\ ft} < 30{,}000\frac{gpd}{linear\ ft}$$

The clarifiers meet the TCEQ requirements for Phase 3.

C.2.3 Proposed Aeration Basins

<u>BOD_5 Loading Rate for Phase 2</u>

$$Loading\ Rate = C * (\frac{Q}{V})$$

C = Concentration of BOD (lb/ft^3)
Q = Influent Flow Rate (ft^3/d)
V = Total Basin Volume ($1000\ ft^3$)

C = 209.34 mg/L (from solids balance) = 0.013 lb/ft^3
Q = 20 MGD = $2.67*10^6\ ft^3/d$
V = (17.9 ft)(70 ft)(215ft)(4 basins) = 1,077,580 ft^3

$$Loading\ Rate = \left(0.013 \frac{lb}{ft^3}\right) * \frac{2.67 * 10^6 \frac{ft^3}{d}}{\frac{1{,}077{,}580\ ft^3}{1000} ft^3} = 32.4 \frac{lb\ BOD_5}{day * 1000\ ft^3}$$

<u>BOD_5 Loading Rate for Phase 3</u>

$$Loading\ Rate = C * (\frac{Q}{V})$$

C = Concentration of BOD (lb/ft^3)
Q = Influent Flow Rate (ft^3/d)
V = Total Basin Volume ($1000\ ft^3$)

C = 209.34 mg/L (from solids balance) = 0.013 lb/ft^3
Q = 45 MGD = $6.02*10^6\ ft^3/d$
V = (17.9 ft)(70 ft)(215ft)(9 basins) = 2,424,555 ft^3

$$Loading\ Rate = \left(0.013 \frac{lb}{ft^3}\right) * \frac{6.02 * 10^6 \frac{ft^3}{d}}{\frac{2{,}424{,}555\ ft^3}{1000} ft^3} = 32.4 \frac{lb\ BOD_5}{day * 1000\ ft^3}$$

Both phases are lower than the TCEQ Maximum Loading Rate of 35 lb $BOD_5/d/1000\ ft^3$.

C.2.4 Proposed Final Clarifiers

<u>Phase 2</u>

Phase 2 AADF = 27 MGD
Phase 2 2-HR PF = 27 MGD * 1.5 peak factor = 40.5 MGD
Number of clarifiers = 3
Side water depth = 12 ft
Length of clarifier = 150 ft
Area = $\Pi*(75\ ft)^2 = 17{,}672\ ft^2$
Volume of each clarifier = 17,672 ft^2 * 12 ft = 212,058 ft^3 = 1.58 MG

Phase 2 AADF per clarifier

$$Q = \frac{27\ MGD}{3\ clarifiers} = 9\ \text{MGD}$$

Phase 2 2-HR PF per clarifier

$$Q = \frac{40.5\ MGD}{3\ clarifiers} = 13.5\ \text{MGD}$$

$$A_{inlet\ well} = \pi r^2$$
$$A_{inlet\ well} = \pi(11.25\ ft)^2 = 398\ ft^2$$
$$Q_{P2HF} = \frac{13.5\ MGD\ (10^6)}{7.48\ \frac{gal}{ft^3}(86400\ \frac{s}{day})} = 20.88\ ft^3/s$$
$$V = \frac{Q}{A}$$
$$V = \frac{20.88\ ft^3/s}{398\ ft^2} = 0.052\ ft/s$$
$$0.052\frac{ft}{s} < \ 0.15\frac{ft}{s}$$

The clarifiers meet the TCEQ requirements for Phase 2.

$$\text{SLR} = \frac{Q}{A}$$
$$\text{SLR}_{\text{AADF}} = \frac{9\ MGD(10^6)}{17{,}672\ ft^2} = 509\ gpd/ft^2$$
$$509\ \frac{gpd}{ft^2} < 1{,}200\ gpd/ft^2$$
$$\text{SLR}_{\text{2-HR PF}} = \frac{13.9\ MGD(10^6)}{17{,}672\ ft^2} = 787\frac{gpd}{ft^2}$$
$$787\frac{gpd}{ft^2} < 1{,}800\frac{gpd}{ft^2}$$

The clarifiers meet the TCEQ requirements for Phase 2.

$$\text{Detention time} = \frac{V}{Q}$$
$$\text{Detention Time}_{\text{ AADF}} = \frac{1{,}580{,}000\ gal}{9\ MGD\ (10^6)}\left(\frac{24\ hours}{day}\right) = 4.21\ hrs$$

$$\text{Detention Time}_{\text{ 2-HR PF}} = \frac{1{,}580{,}000\ gal}{13.5\ MGD\ (10^6)}\left(\frac{24\ hours}{day}\right) = 2.8\ \text{hrs}$$

$$WL = 2P\ r = 2\ \times P \times 75\ ft\ = 471\ ft$$
$$\text{WLR} = \frac{Q}{WL}$$
$$\text{WLR}_{\text{ 2-HR PF}} = \frac{13.25\ MGD(10^6)}{471\ FT} = 28{,}131\frac{gpd}{linear\ ft}$$
$$28{,}131\frac{gpd}{linear\ ft} < 30{,}000\frac{gpd}{linear\ ft}$$

The clarifiers meet the TCEQ requirements for Phase 2.

Phase 3

Phase 3 AADF = 52 MGD
Phase 2 2-HR PF = 27 MGD * 1.5 peak factor = 78 MGD
Number of clarifiers = 3
Side water depth = 12 ft
Length of clarifier = 150 ft
Area = Π*(75 ft)^2 = 17,672 ft^2
Volume of each clarifier = 17,672 ft^2 * 12 ft = 212,058 ft^3 = 1.58 MG

Phase 3 AADF per clarifier

$$Q = \frac{52\ MGD}{6\ clarifiers} = 8.6\ \text{MGD}$$

Phase 3 2-HR PF per clarifier

$$Q = \frac{78\ MGD}{6\ clarifiers} = 13\ \text{MGD}$$

$$A_{inlet\ well} = \pi r^2$$

$$A_{inlet\ well} = \pi(11.25\ ft)^2 = 398\ ft^2$$

$$Q_{P2HF} = \frac{13\ MGD\ (10^6)}{7.48\ \frac{gal}{ft^3}(86400\ \frac{s}{day})} = 20.11\ ft^3/s$$

$$V = \frac{Q}{A}$$

$$V = \frac{20.11\ ft^3/s}{398\ ft^2} = 0.051\ ft/s$$

$$0.051\frac{ft}{s} < \ 0.15\frac{ft}{s}$$

The clarifiers meet the TCEQ requirements for Phase 3.

$$\text{SLR} = \frac{Q}{A}$$

$$\text{SLR}_{\text{AADF}} = \frac{8.6\ MGD(10^6)}{17{,}672\ ft^2} = 486.6\ gpd/ft^2$$

$$486.6\ \frac{gpd}{ft^2} < 1{,}200\ gpd/ft^2$$

$$\text{SLR}_{\text{2-HR PF}} = \frac{13\ MGD(10^6)}{17{,}672\ ft^2} = 736\ \frac{gpd}{ft^2}$$

$$736\frac{gpd}{ft^2} < 1{,}800\frac{gpd}{ft^2}$$

The clarifiers meet the TCEQ requirements for Phase 3.

$$\text{Detention time} = \frac{V}{Q}$$

$$\text{Detention Time}_{\text{ AADF}} = \frac{1{,}580{,}000\ gal}{8.6\ MGD\ (10^6)}\left(\frac{24\ hours}{day}\right) = 4.4\ hrs$$

$$\text{Detention Time}_{\text{2-HR PF}} = \frac{1{,}580{,}000\ gal}{13\ MGD\ (10^6)}\left(\frac{24\ hours}{day}\right) = 2.91\ \text{hrs}$$

$$WL = 2P\,r = 2\ \times P \times 75\ ft\ = 471\ ft$$

$$\text{WLR} = \frac{Q}{WL}$$

$$\text{WLR}_{\text{2-HR PF}} = \frac{13\ MGD(10^6)}{471\ FT} = 27{,}600\,\frac{gpd}{linear\ ft}$$

$$27{,}600\,\frac{gpd}{linear\ ft} < 30{,}000\,\frac{gpd}{linear\ ft}$$

The clarifiers meet the TCEQ requirements for Phase 3.

C.2.5 Proposed Cloth Filters

<u>Phase 2</u>

Phase 2 AADF 27 MGD
Phase 2 2-hr peak 52 MGD
Number of Units 3
Disk per Unit 18
Total Disk 54

Total Square Foot Area 5,810 ft2

$$Capacity = 5{,}810ft^2 \cdot \frac{6.5gpm}{ft^2} = 37{,}765gpm = 54MGD$$

<u>Phase 3</u>

Phase 2 AADF 40.5 MGD
Phase 2 2-hr peak 78 MGD
Number of Units 5
Disk per Unit 25
Total Disk 110

Total Square Foot Area 11,836 ft2

$$Capacity = 11{,}836ft^2 \cdot \frac{6.5gpm}{ft^2} = 76{,}934gpm = 110.7MGD$$

C.2.6 Proposed UV Disinfection

<u>Phase 2</u>

Phase 2 AADF 27 MGD
Phase 2 2-hr peak 52 MGD
Transmittance 65%
TSS 15mg/L
Dose 30 mj/cm^2
Discharge 126 CFU/100mL

$$Flowrate\ per\ Lamp = \frac{\left(\left(\frac{30mj}{cm^2}\right)\right)^{-(1.0.65)}}{(10^{-2.428})(65^{3.126})(0{,}63)} = \frac{760.4L}{\min \quad \cdot Lamp}$$

$$Capacity = \frac{760.4L}{\min \quad \cdot Lamp} \cdot 180Lamps = 136{,}872\ \frac{L}{min} = 52MGD$$

Phase 3

Phase 2 AADF 40.5 MGD
Phase 2 2-hr peak 78 MGD
Transmittance 65%
TSS 15mg/L
Dose 30 mj/cm^2
Discharge 126 CFU/100mL

$$Flowrate\ per\ Lamp = \frac{\left(\left(\frac{30mj}{cm^2}\right)\right)^{-(1.0.65)}}{(10^{-2.428})(65^{3.126})(0{,}63)} = \frac{760.4L}{\min \quad \cdot Lamp}$$

$$Capacity = \frac{760.4L}{\min \quad \cdot Lamp} \cdot 300Lamps = 228{,}120\ \frac{L}{min} = 78MGD$$

Appendix D: Solids Balance

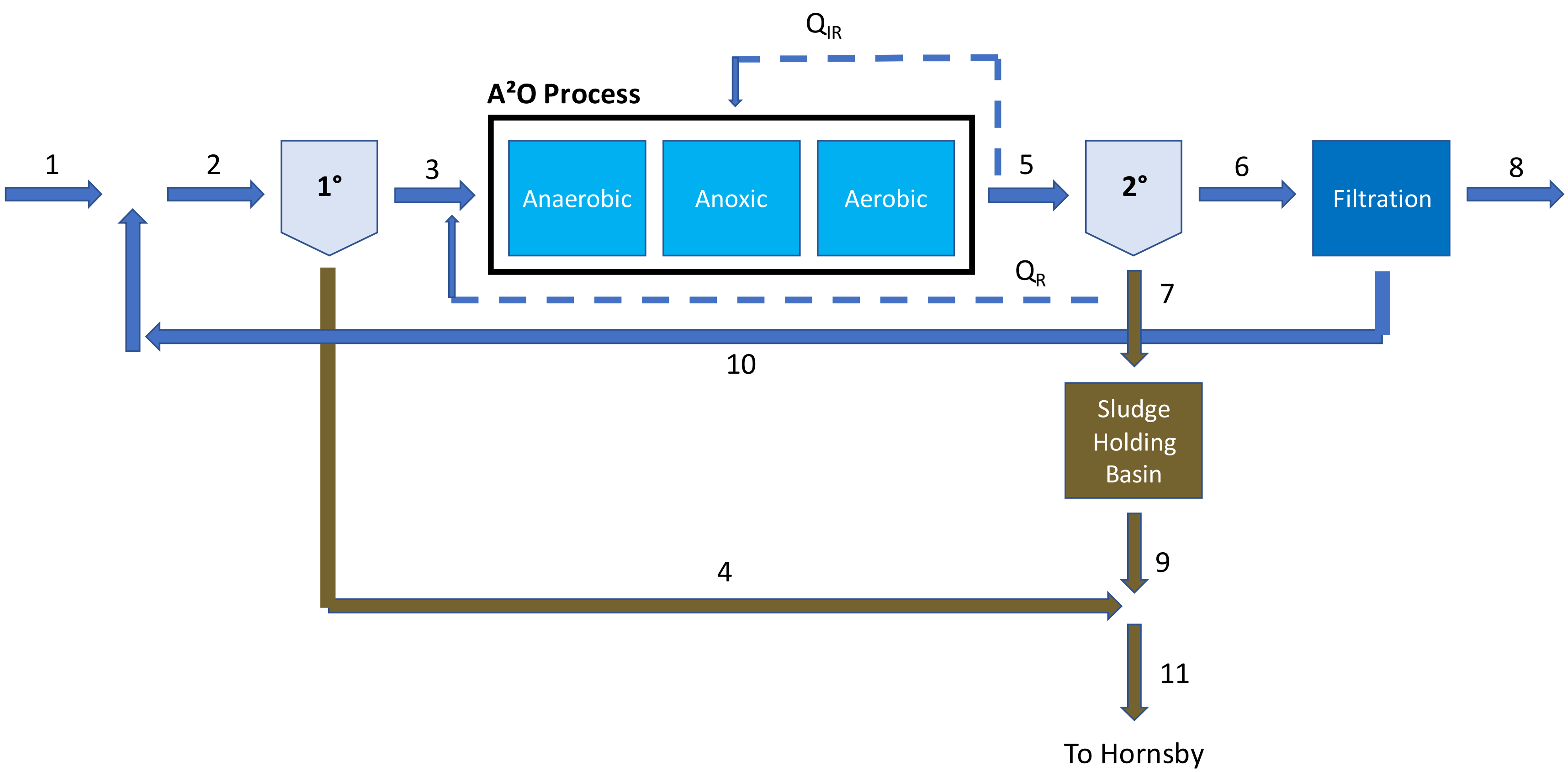


Figure D.1: Overall Solids Balance Flow Diagram

D.1.1. Primary Treatment

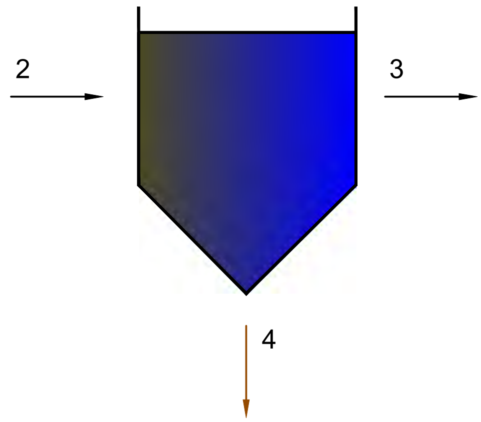


Table D.1.1. Primary Treatment Assumptions

Assumptions*			
Parameter	**Value**	**Units**	**Source**
Primary Clarifier Removal Efficiency	60	%	Typical Value
TSS_4	30,000	g/m^3	Typical Value
VSS/TSS ratio	0.72	g VSS/g TSS	Given – Influent Parameters
Initial Fraction of Particulate Phosphorus, f_p	0.01	g P/g VSS	Typical Value
Fraction of Particulate Nitrogen	0.12	g N/g VSS	Typical Value
Fraction Degradable (f_d)	0.80	g COD/g VSS	Typical Value

*There is an overall assumption that soluble concentrations are unaffected by physical treatment units, like clarifiers. The soluble concentration of constituents is only assumed to change when there is a chemical or biological reaction occurring within a unit. Also, total constituent concentrations are equal to the sum of the particulate and soluble concentrations.

Calculations:

These calculations are performed using the final iteration of the Phase 3 solids balance. Since three loops, or iterations, were performed to reach proper calculations, the Q_2 is calculated by adding the flow of return Line 12 to Line 1.

$$Q_2 = Q_{1\,loop\,3} + Q_{12\,loop\,2} = 378{,}541\frac{m^3}{d} + 23{,}789\frac{m^3}{d} = 402{,}330\frac{m^3}{d}$$

$$TSS_2 = \frac{P_{TSS1\,loop\,3} + P_{TSS12\,loop2}}{Q_2} = \frac{9.46\times 10^7\frac{g}{d} + 6.20\times 10^6\frac{g}{d}}{402{,}330\frac{m^3}{d}} = 250.6\frac{g}{m^3}$$

$$P_{TSS2} = Q_2\,(TSS_2) = 402{,}330\frac{m^3}{d}\left(250.6\frac{g}{m^3}\right) = 1.01\times 10^8\frac{g}{d}$$

$$VSS_2 = TSS_2(0.72) = 250.6\frac{g}{m^3}\,(0.72) = 180.4\frac{g}{m^3}$$

$$P_{VSS2} = Q_2\,(VSS_2) = 402{,}330\frac{m^3}{d}\left(180.4\frac{g}{m^3}\right) = 7.26\times 10^7\frac{g}{d}$$

$$N_{P2} = VSS_2\ (0.12) = 180.4\frac{g}{m^3}(0.12) = 21.65\frac{g}{m^3}$$

$$N_{s2} = \frac{P_{Ns1\ loop\ 3} + P_{Ns12\ loop\ 2}}{Q_2} = \frac{1.26\ \times 10^7\frac{g}{d} + 1.19\ \times\ 10^4\frac{g}{d}}{404{,}330\frac{m^3}{d}} = 31.45\frac{g}{m^3}$$

$$P_{S2} = \frac{P_{Ps1\ loop\ 3} +\ P_{Ps12\ loop\ 2}}{Q_2} = \frac{1.67\ \times 10^6\frac{g}{d} + 1.19\ \times\ 10^4\frac{g}{d}}{404{,}330\frac{m^3}{d}} = 4.17\frac{g}{m^3}$$

Using P_{VSS2} and the assumption that 60% of solids are removed in the primary clarifier, P_{VSS3} and P_{VSS4} can be calculated.

$$P_{VSS3} =\ 0.4\ (P_{VSS2}) = 0.4\ (7.26 \times\ 10^7\ g/d) = 2.90 \times\ 10^7 g/d$$

$$P_{VSS4} = 0.6\ (P_{VSS2}) = 0.6\ (7.26 \times 10^7 g/d) = 4.36 \times 10^7\ g/d$$

The assumption that the f_p = 0.01 g P/g VSS applies only to the first loop. A new f_p must be calculated based on the combined lines.

$$f_{pnew} = \frac{P_{Pp1\ loop\ 3} + P_{Pp12\ loop\ 2}}{P_{VSS1\ loop3}} = \frac{6.81 \times 10^5\frac{g}{d} + 3.24 \times 10^5\frac{g}{d}}{6.81 \times 10^7\frac{g}{d}} = 0.015$$

With this new f_p, the VSS concentrations for Lines 3 and 4 can be calculated.

$$VSS_4 =\ TSS_4\ (0.72) = 30{,}000\frac{g}{m^3}(0.72) = 21{,}600\frac{g}{m^3}$$

$$Q_4 = \frac{P_{VSS4}}{VSS_4} = \frac{4.36 \times 10^7\frac{g}{d}}{21{,}600\frac{g}{m^3}} = 2{,}017\frac{m^3}{d}$$

$$Q_3 =\ Q_2 -\ Q_4 = 402{,}330\frac{m^3}{d} - 2{,}017\frac{m^3}{d} = 400{,}313\frac{m^3}{d}$$

$$VSS_3 = \frac{P_{VSS3}}{Q_3} = \frac{2.90\ \times 10^7\frac{g}{d}}{400{,}313\frac{m^3}{d}} = 72.54\frac{g}{m^3}$$

$$TSS_3 = \frac{VSS_3}{0.72} = \frac{72.54\frac{g}{m^3}}{0.72} = 100.8\frac{g}{m^3}$$

$$N_{P3} =\ VSS_3\ (0.12) =\ 72.54\frac{g}{m^3}(0.12) = 8.70\frac{g}{m^3}$$

$$N_{p4} = VSS_4\ (0.12) = 21{,}600\frac{g}{m^3}(0.12) = 2{,}592\frac{g}{m^3}$$

$$N_{s2} =\ N_{s3} =\ N_{s4} = 31.45\frac{g}{m^3}$$

$$N_{T2} =\ N_{p2} +\ N_{s2} = 22.65\frac{g}{m^3} + 31.45\frac{g}{m^3} = 53.11\frac{g}{m^3}$$

$$N_{T3} = 8.70\frac{g}{m^3} + 31.45\frac{g}{m^3} = 40.16\frac{g}{m^3}$$

$$N_{T4} = 2{,}592\frac{g}{m^3} + 31.45\frac{g}{m^3} = 2{,}623\frac{g}{m^3}$$

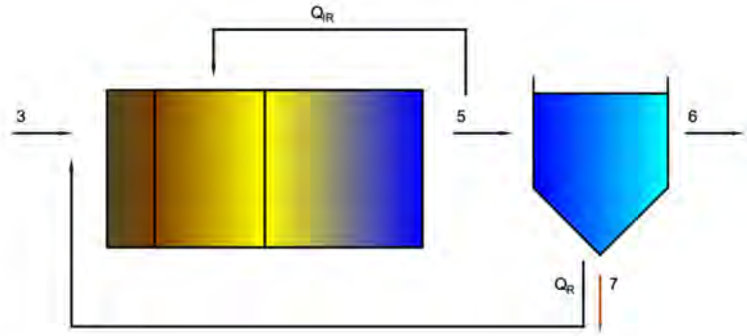
$$P_{P2} = 0.015(VSS_2) = 0.015\left(180.4\frac{g}{m^3}\right) = 2.66\frac{g}{m^3}$$

$$P_{P3} = 0.015\left(72.54\frac{g}{m^3}\right) = 1.07\frac{g}{m^3}$$
$$P_{P4} = 0.015\left(21{,}600\frac{g}{m^3}\right) = 318.6\frac{g}{m^3}$$
$$P_{s2} = P_{S3} = P_{s4} = 4.17\frac{g}{m^3}$$
$$P_{T2} = P_{P2} + P_{s2} = 2.66\frac{g}{m^3} + 4.17\frac{g}{m^3} = 6.83\frac{g}{m^3}$$
$$P_{T3} = 1.07\frac{g}{m^3} + 4.17\frac{g}{m^3} = 5.24\frac{g}{m^3}$$
$$P_{T4} = 318.6\frac{g}{m^3} + 4.17\frac{g}{m^3} = 322.8\frac{g}{m^3}$$
$$bCOD_{p2} = VSS_2(1.42)(0.8) = 180.4\frac{g}{m^3}(1.42)(0.8) = 205.0\frac{g}{m^3}$$
$$bCOD_{p3} = 72.54\frac{gVSS}{m^3}(1.42)(0.8) = 82.41\frac{g}{m^3}$$
$$bCOD_{p4} = 21{,}600\frac{gVSS}{m^3}(1.42)(0.8) = 24{,}538\frac{g}{m^3}$$
$$bCOD_{s2} = bCOD_{s3} = bCOD_{s4} = \frac{P_{bCODs1\ loop\ 3} + P_{bCODs12\ loop\ 2}}{Q_2}$$
$$= \frac{5.05\times 10^7\frac{g}{d} + 4.76\times 10^4\frac{g}{d}}{402{,}330\frac{m^3}{d}} = 125.7\frac{g}{m^3}$$
$$bCOD_{T2} = bCOD_{p2} + bCOD_{s2} = 205.0\frac{g}{m^3} + 125.7\frac{g}{m^3} = 330.7\frac{g}{m^3}$$
$$bCOD_{T3} = 82.41\frac{g}{m^3} + 125.7\frac{g}{m^3} = 208.2\frac{g}{m^3}$$
$$bCOD_{T4} = 24{,}538\frac{g}{m^3} + 125.7\frac{g}{m^3} = 24{,}663\frac{g}{m^3}$$

For the mass loadings for each line, these were calculated in the same way. An example will be shown using TSS, but mass loadings for the other constituents were found using the same method.

$$P_{TSS2} = Q_2(TSS_2) = 402{,}330\frac{m^3}{d}\left(250.6\frac{g}{m^3}\right) = 1.01\times 10^8\frac{g}{d}$$
$$P_{TSS3} = Q_3(TSS_3) = 400{,}313\frac{m^3}{d}\left(100.8\frac{g}{m^3}\right) = 4.03\times 10^7\frac{g}{d}$$
$$P_{TSS4} = Q_4(TSS_4) = 2{,}017\frac{m^3}{d}\left(30{,}000\frac{g}{m^3}\right) = 6.05\times 10^7\frac{g}{d}$$

D.1.2. Biological Nutrient Removal



The table below shows the biological rate coefficients and other assumed values necessary for this portion. Some concentration values like S_o, Q, TKN, and VSS_i, are values taken from Line 3 since that is the line feeding into the BNR system. All sample calculations are done using the values from the final iteration of the Phase 3 solids balance performed. The biological rate coefficients were temperature corrected. The following table shows values used for this part of the solids balance.

Table D.1.2. BNR Assumptions

Parameter	Value	Temperature Corrected Value	Unit	Source
Factor of Safety	1.5	[-]	[-]	Assumed
Q	400,313	[-]	m^3/d	Line 3
Influent bCOD$_s$, S$_o$	208.2	[-]	g/m^3	Line 3
Effluent bCOD$_s$, S$_e$	2	[-]	g/m^3	Assumed
Effluent N$_s$, S$_{ne}$	0.5	[-]	g/m^3	Assumed
Effluent P$_s$, P$_e$	0.5	[-]	g/m^3	Assumed
Effluent NO_3-N, NO_3-N$_e$	7.0	[-]	g/m^3	Assumed
TKN	40.2	[-]	g/m^3	Line 3
Y_{oc}	0.4	[-]	[-]	Typical Value*
K_{doc}	0.12	0.098	/d	Typical Value*
$\hat{\mu}_{oc}$	6.0	4.93	/d	Typical Value*
K_{soc}	20.0	[-]	g/m^3	Typical Value*
Y_n	0.12	[-]	[-]	Typical Value*
K_{dn}	0.08	0.066	/d	Typical Value*
$\hat{\mu}_n$	0.75	0.62	/d	Typical Value*
K_{sn}	0.74	[-]	g/m^3	Typical Value*
K_o	0.5	[-]	g/m^3	Typical Value*
DO	2.0	[-]	g/m^3	Typical Value*
f_{nd}	0.2	[-]	g COD/g VSS	Typical Value*

*Retrieved from Metcalf & Eddy, 2014, Table 8-14.

Temperature Corrected Values at 15°C:

$$K_{15} = K_{20}\Theta^{(15-20)}$$

$$K_{doc} = (0.12\ d^{-1}) * 1.04^{(15-20)} = 0.098\ d^{-1}$$

$$\hat{\mu}_{oc} = (6\ d^{-1}) * 1.04^{(15-20)} = 4.93\ d^{-1}$$

$$K_{dn} = (0.08\ d^{-1}) * 1.04^{(15-20)} = 0.066\ d^{-1}$$

$$\hat{\mu}_{\boldsymbol{n}} = (0.75\ d^{-1}) * 1.04^{(15-20)} = 0.62\ d^{-1}$$

The first step to designing the BNR system is calculating the mean cell residence time based on nitrifying bacteria and adding a safety factor of 1.5.

$$\Theta_{cn} = \left(\left(\frac{\hat{\mu}_n S_{ne}}{K_{sn} + S_{ne}}\left[\frac{DO}{DO + K_o}\right]\right) - K_{dn}\right)^{-1}$$

$$\Theta_{cn} = \left(\left(\frac{(0.62\ d^{-1})\left(0.5\frac{g}{m^3}\right)}{\left(0.74\ \frac{g}{m^3}\right) + \left(0.5\frac{g}{m^3}\right)}\left[\frac{\left(2\ \frac{g}{m^3}\right)}{\left(2\ \frac{g}{m^3}\right) + \left(0.5\ \frac{g}{m^3}\right)}\right]\right) - 0.066\ d^{-1}\right)^{-1} = 7.52\ d$$

$$\Theta_{cn} = \Theta_{cn} * SF = 7.52\ d * 1.5 = 11.3\ d$$

The next step is to calculate the solids production rate for the system.

$$P_{XVSS} = P_{xoc} + P_{xocpp} + P_{xn} + P_{xnpp} + P_{xi}$$

$$P_{xoc} = \frac{QY_{oc}(S^o - S_{e)}}{1 + K_{doc}\Theta_{cn}} = \frac{\left(400{,}313\frac{m^3}{d}\right)(0.4)(208.2\ \frac{g}{m^3} - 2\ \frac{g}{m^3})}{1 + (0.098\ d^{-1})(11.3\ d)} = 1.56 \times 10^7\ g/d$$

$$P_{xocpp} = P_{xoc}\Theta_{cn} f_{nd} K_{doc} = \left(1.56 \times 10^7\frac{g}{d}\right)(11.3\ d)(0.2)(\ 0.098\ d^{-1}) = 3.48 \times 10^6\ g/d$$

$$P_{Xbio} = P_{xoc} + P_{xocpp} = 1.56 \times 10^7\frac{g}{d} + 3.48 \times 10^6\frac{g}{d} = 1.91 \times 10^7\ g/d$$

To calculate the solids production for the nitrifiers, the amount of nitrate produced in the system can be used to represent the amount of nitrogen used within the system. Nitrate produced should be calculated to represent (S_n^o-S_{ne}). That is an iterative process, but the change found was around 1% through iteration so the first value calculated will be used.

$$NO_3 - N_p = TKN - S_{ne} - \frac{0.12 * P_{xbio}}{Q} = 40.16\ \frac{g}{m^3} - 0.5\ \frac{g}{m^3} - \frac{0.12\left(1.91 \times 10^7\frac{g}{d}\right)}{400{,}313\frac{m^3}{d}}$$
$$= 33.93\ \frac{g}{m^3}$$

$$P_{xn} = \frac{\left(400{,}313\frac{m^3}{d}\right)(0.12)(33.93\ \frac{g}{m^3})}{1 + (0.066\ d^{-1})(11.3\ d)} = 9.36 \times 10^5\ g/d$$

$$P_{xnpp} = \left(9.36 \times 10^5 \frac{g}{d}\right)(11.3\ d)(0.2)(0.066\ d^{-1}) = 1.39 \times 10^5\ g/d$$

$$P_{xi^o} = \left(400{,}313\frac{m^3}{d}\right)\left(14.51\ \frac{g}{m^3}\right) = 5.81 \times 10^6\ g/d$$

$$\begin{aligned} P_{XVSS} &= P_{xoc} + P_{xocpp} + P_{xn} + P_{xnpp} + P_{xi} \\ &= 1.56 \times 10^7 \frac{g}{d} + 3.48 \times 10^6 \frac{g}{d} + 9.36 \times 10^5 \frac{g}{d} + 1.39 \times 10^5 \frac{g}{d} + 5.81 \times 10^6 \frac{g}{d} \\ &= 2.60 \times 10^7\ g/d \end{aligned}$$

After the solids production is found, the aerobic volume can be calculated.

$$P_{XVSS} = \frac{(MLVSS)(Volume_{aerobic})}{\Theta_{cn}}$$

$$2.60 \times 10^7\ g/d = \frac{(2500\ \frac{g}{m^3})(Volume_{aerobic})}{11.3\ d}$$

$$Volume_{aerobic} = 117{,}234\ m^3$$

The volume must meet the TCEQ Organic Loading Rate of 35 lb BOD_5/d/1000 ft^3. The calculated volume gave a loading rate above that, so the volume was then adjusted to 156,000 m^3 to meet the requirement.

$$Volume_{aerobic\ adjusted} = 156{,}000\ m^3$$

Values such as the effluent flow (Q_e) coming from the secondary treatment process units, the flow for the return activated sludge line (Q_r), and the flow for the waste activated sludge line (Q_w) need to be determined for use later.

$$P_{XVSS} = Q_w X_w + Q_e X_e$$

$$Q_3 = Q_w + Q_e$$

$$P_{XVSS} = Q_w X_w + (Q_3 - Q_w) X_e$$

$$2.60 \times 10^7\ g/d = Q_w(8{,}000\ \frac{g}{m^3}) + (400{,}313\frac{m^3}{d} - Q_w)(15\ \frac{g}{m^3})$$

$$Q_w = 2{,}503\ \frac{m^3}{d}$$

$$Q_e = Q_3 - Q_w$$

$$Q_e = 400{,}313\frac{m^3}{d} - 2{,}503\ \frac{m^3}{d} = 397{,}811\ \frac{m^3}{d}$$

$$0 = (Q_3 + Q_r)X_{MLVSS} - Q_eX_e - Q_wX_w - Q_rX_r$$

$$0 = \left(400{,}313\frac{m^3}{d} + Q_r\right)(2500\ \frac{g}{m^3}) - (397{,}811\ \frac{m^3}{d})(15\ \frac{g}{m^3}) - (2{,}503\ \frac{m^3}{d})(8{,}000\ \frac{g}{m^3}) - Q_r(8{,}000\ \frac{g}{m^3})$$

$$Q_r = 177{,}236\ \frac{m^3}{d}$$

To calculate the anoxic volume, first the IR needs to be calculated. Since this is an iterative process, the anoxic volume must first be assumed. The initial anoxic volume was assumed to be 35% of the aerobic volume, which gives a starting anoxic volume of 54,600 m^3.

$$IR = \frac{NO_3 - N_p}{NO_3 - N_e} - 1 - \frac{Q_r}{Q}$$

$$IR = \frac{33.93\ \frac{g}{m^3}}{7\ \frac{g}{m^3}} - 1 - \frac{177{,}236\frac{m^3}{d}}{400{,}313\frac{m^3}{d}} = 3.36$$

$$\frac{F}{mb} = \frac{QS^o}{X_{aoc}Volume_{anoxic}}$$

$$X_{aoc} = \frac{\Theta_{cn}Y(S_o - S_e)}{\Theta(1 + K_d\Theta_{cn})}$$

$$\Theta = \frac{Volume_{aerobic}}{Q}$$

$$\Theta = \frac{156{,}000\ m^3}{400{,}313\ \frac{m^3}{d}} = 0.389\ \text{d}$$

$$X_{aoc} = \frac{(11.3\ d)(0.4)(208.2\ \frac{g}{m^3} - 2\ \frac{g}{m^3})}{(0.389\ d)(1 + (0.0986\ d^{-1})(11.3\ d))} = 1{,}132\ g/m^3$$

$$\frac{F}{mb} = \frac{(400{,}313\ \frac{m^3}{d})(208.2\ \frac{g}{m^3})}{(1{,}132\frac{g}{m^3})(54{,}600\ m^3\ )} = 1.35$$

To find the SDNR, after the F/mb ratio is found, the rbCOD/bCOD ratio must be found. Since the information wasn't given, rbCOD was assumed to be 90 g/m^3 as that is a typical value for municipal wastewater.

$$\frac{rbCOD}{bCOD} = \frac{90\ \frac{g}{m^3}}{208.2\ \frac{g}{m^3}} = 0.43$$

Using the graph in Metcalf and Eddy, the SDNR was found to be 0.29 g NO_3-N/g biomass*d and was temperature corrected.

$$SDNR = (0.29\ d^{-1}) * 1.04^{(15-20)} = 0.196\ \frac{g\ NO_3 - N}{g\ biomass\ (d)}$$

To evaluate the assumed value for the anoxic volume, the nitrate nitrogen that is required to be removed from the system must be calculated.

$$P(NO_3 - N\ )_r = (Q_{IR} + Q_r)(NO_3 - N_e)$$

$$P(NO_3 - N\ )_r = \left(\left(400{,}313\frac{m^3}{d}\right)(3.36) + \left(177{,}236\ \frac{m^3}{d}\right)\right)\left(7\ \frac{g}{m^3}\right) = 1.07 \times 10^7\frac{g}{d}$$

To be conservative, the goal for the predicted nitrate removal is to be 10-20% greater than what is required to be removed for the effluent value chosen. The volume chosen allows for 15% excess predicted nitrate removal compared to the required nitrate removal.

$$P(NO_3 - N\ )_{RP} = Volume_{anoxic}X_{aoc}SDNR$$

$$P(NO_3 - N\ )_{RP} = (54{,}600\ m^3\ )\left(1{,}131\frac{g}{m^3}\right)(0.196) = 1.21 \times 10^7\frac{g}{d}$$

Since the values ensure the targeted excess nitrate removal, which was 15% for Phase 3, the initial assumption for the volume of the anoxic basin is acceptable.

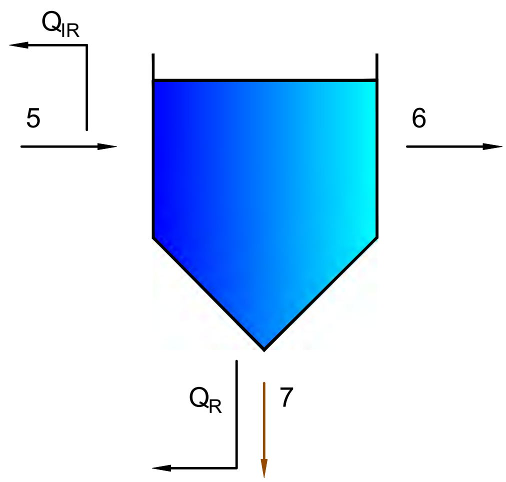
$$Volume_{anoxic} = 54{,}600\ m^3$$

The final volume for the BNR system to calculate is the anaerobic volume. This volume is only based on an assumed hydraulic retention time of 1 hour (typical value) and the incoming flow rate.

$$Volume_{anaerobic} = (HRT)Q$$

$$Volume_{anaerobic} = \left(\frac{1\ hr}{(24\ hr/1d)}\right)\left(400{,}313\ \frac{m^3}{d}\right) = 16{,}780\ m^3$$

D.1.3. Final Clarifiers



D.1.3. Final Clarifier Assumptions

Assumptions			
Parameter	**Value**	**Units**	**Source**
VSS_5	2,500	g/m^3	Assumed
VSS_6	15	g/m^3	Assumed
VSS_7	8,000	g/m^3	Assumed
$N_{s5,6,7}$	0.5	g/m^3	Assumed
$P_{s5,6,7}$	0.5	g/m^3	Assumed
$bCOD_{s5,6,7}$	2.0	g/m^3	Assumed
$NO_3^-{}_{5,6,7}$	7	g/m^3	Assumed
VSS/TSS ratio	0.72	g VSS/g TSS	Given – Influent Parameters
Fraction of Particulate Nitrogen	0.12	g N/g VSS	Typical Value
Fraction Degradable (f_d)	0.80	g COD/g VSS	Typical Value

Since Line 5 is within the control volume established for the BNR process, the flow for 5 includes the flow coming in as well as the return flow (Q_r).

$$Q_5 = Q_3 + Q_r$$

$$Q_5 = 400{,}313\frac{m^3}{d} + 177{,}236\ \frac{m^3}{d} = 577{,}549\ \frac{m^3}{d}$$

$$TSS_5 = \frac{VSS_5}{0.72} = \frac{2{,}500\ \frac{g}{m^3}}{0.72} = 3{,}472\ \frac{g}{m^3}$$

$$N_{T5} = N_{p5} + N_{s5}$$

$$N_{p5} = (0.12)VSS_5 = (0.12)(2{,}500\ \frac{g}{m^3}) = 300\ \frac{g}{m^3}$$

$$N_{T5} = 300\ \frac{g}{m^3} + 0.5\ \frac{g}{m^3} = 300.5\ \frac{g}{m^3}$$

A new particulate fraction must be calculated due to the uptake of phosphorus by the bacteria.

$$P_{T5} = P_{p5} + P_{s5}$$

$$fP_{p6,7} = \frac{(Q_3P_{T3}) - (Q_6P_{s6}) - (Q_7P_{s7})}{(Q_6VSS_6) + (Q_7VSS_7)}$$

$$fP_{p5,6,7} = \frac{\left((400{,}313\ \frac{m^3}{d})(5.42\ \frac{g}{m^3})\right) - \left((397{,}811\ \frac{m^3}{d})(0.5\ \frac{g}{m^3})\right) - \left((2{,}503\ \frac{m^3}{d})(0.5\ \frac{g}{m^3})\right)}{\left((397{,}811\ \frac{m^3}{d})(15\ \frac{g}{m^3})\right) + \left((2{,}503\ \frac{m^3}{d})(8{,}000\ \frac{g}{m^3})\right)} = 0.073$$

$$P_{p5} = (fP_{p5,6,7})VSS_5 = (0.073)\left(2{,}500\ \frac{g}{m^3}\right) = 182.5\frac{g}{m^3}$$

$$P_{T5} = 183\frac{g}{m^3} + 0.5\ \frac{g}{m^3} = 183.5\ \frac{g}{m^3}$$

$$bCOD_{T5} = bCOD_{p5} + bCOD_{s5}$$

$$bCOD_{p5} = VSS_5\left(1.42\ \frac{g\ bCOD}{g\ VSS}\right)(f_d)$$

$$bCOD_{p5} = \left(2{,}500\ \frac{g}{m^3}\right)\left(1.42\frac{g\ bCOD}{g\ VSS}\right)(0.8) = 2{,}840\ \frac{g}{m^3}$$

$$bCOD_{T5} = 2{,}840\ \frac{g}{m^3} + 2\ \frac{g}{m^3} = 2{,}842\ \frac{g}{m^3}$$

$$Q_6 = Q_e = 397{,}811\ \frac{m^3}{d}$$

$$TSS_6 = \frac{VSS_6}{0.72} = \frac{15\ \frac{g}{m^3}}{0.72} = 20.83\ \frac{g}{m^3}$$

$$N_{T6} = N_{p6} + N_{s6}$$

$$N_{p6} = (0.12)VSS_6 = (0.12)(15\ \frac{g}{m^3}) = 1.8\ \frac{g}{m^3}$$

$$N_{T6} = 1.8\ \frac{g}{m^3} + 0.5\ \frac{g}{m^3} = 2.3\ \frac{g}{m^3}$$

$$P_{T6} = P_{p6} + P_{s6}$$

$$P_{p6} = \left(fP_{p5,6,7}\right)VSS_6 = (0.073)\left(15\ \frac{g}{m^3}\right) = 1.10\frac{g}{m^3}$$

$$P_{T6} = 1.10\frac{g}{m^3} + 0.5\ \frac{g}{m^3} = 1.60\ \frac{g}{m^3}$$

$$bCOD_{T6} = bCOD_{p6} + bCOD_{s6}$$

$$bCOD_{p6} = VSS_6\left(1.42\ \frac{g\ bCOD}{g\ VSS}\right)(f_d)$$

$$bCOD_{p6} = \left(15\ \frac{g}{m^3}\right)\left(1.42\ \frac{g\ bCOD}{g\ VSS}\right)(0.8) = 17.04\ \frac{g}{m^3}$$

$$bCOD_{T6} = 17.04\ \frac{g}{m^3} + 2\ \frac{g}{m^3} = 19.04\ \frac{g}{m^3}$$

$$Q_7 = Q_r = 2{,}503\ \frac{m^3}{d}$$

$$TSS_7 = \frac{VSS_7}{0.72} = \frac{8{,}000\ \frac{g}{m^3}}{0.72} = 11{,}111\ \frac{g}{m^3}$$

$$N_{T7} = N_{p7} + N_{s7}$$

$$N_{p7} = (0.12)VSS_7 = (0.12)(8{,}000\ \frac{g}{m^3}) = 960\ \frac{g}{m^3}$$

$$N_{T7} = 960\ \frac{g}{m^3} + 0.5\ \frac{g}{m^3} = 960.5\ \frac{g}{m^3}$$

$$P_{T7} = P_{p7} + P_{s7}$$

$$P_{p7} = (fP_{p5,6,7})VSS_7 = (0.073)\left(8{,}000\ \frac{g}{m^3}\right) = 584.0\frac{g}{m^3}$$

$$P_{T7} = 584.0\frac{g}{m^3} + 0.5\ \frac{g}{m^3} = 580.5\ \frac{g}{m^3}$$

$$bCOD_{T7} = bCOD_{p7} + bCOD_{s7}$$

$$bCOD_{p7} = VSS_7\left(1.42\ \frac{gbCOD}{gVSS}\right)(f_d)$$

$$bCOD_{p7} = \left(8{,}000\ \frac{g}{m^3}\right)\left(1.42\ \frac{gbCOD}{gVSS}\right)(0.8) = 17.04\ \frac{g}{m^3}$$

$$bCOD_{T7} = 9{,}088\ \frac{g}{m^3} + 2\ \frac{g}{m^3} = 9{,}090\ \frac{g}{m^3}$$

For the mass loadings for each line, these were calculated in the same way. An example will be shown using TSS, but mass loadings for the other constituents were found using the same method.

$$P_{TSS5} = Q_5(TSS_5) = 577{,}549\frac{m^3}{d}\left(3472.2\frac{g}{m^3}\right) = 2.09 \times 10^9\frac{g}{d}$$
$$P_{TSS6} = Q_6(TSS_6) = 397{,}811\frac{m^3}{d}\left(20.83\frac{g}{m^3}\right) = 8.29 \times 10^6\frac{g}{d}$$
$$P_{TSS7} = Q_7(TSS_7) = 2{,}503\frac{m^3}{d}\left(11{,}111\frac{g}{m^3}\right) = 2.78 \times 10^7\frac{g}{d}$$

Line 7 values are the values of Line 9, as these values do not change throughoutthe sludge holding tank.

D.1.4. Filtration

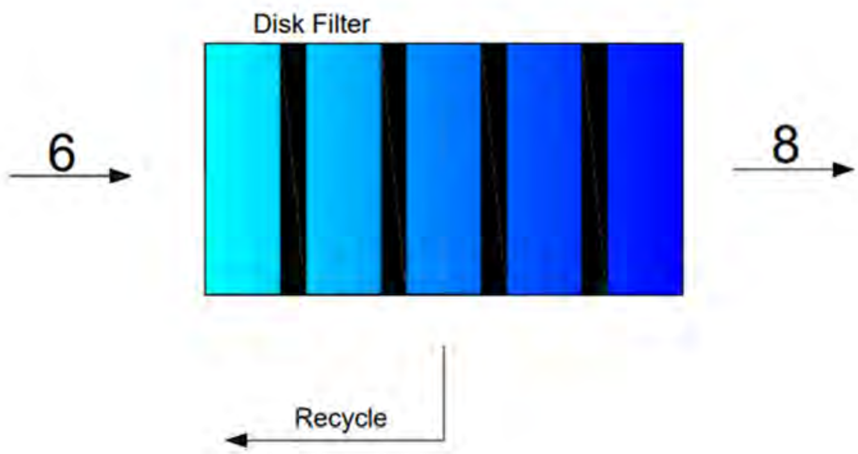


Table D.1.4. Filtration Assumptions

Assumptions*			
Parameter	**Value**	**Units**	**Source**
Filtration TSS Removal Efficiency	75	%	Typical Value*
Backwash Rate Compared to Plant Flow	6	%	Typical Value*
VSS/TSS ratio	0.72	g VSS/g TSS	Given – Influent Parameters
Fraction of Particulate Nitrogen	0.12	g N/g VSS	Typical Value
Fraction Degradable (f_d)	0.80	g COD/g VSS	Typical Value

*Retrieved from Metcalf & Eddy, 2014.

Calculated volumetric flow in Line 10 (plant recycle line) from the assumed filter backwash rate is 6% of the flow of Line 6.

$$Q_{10} = 0.06 * Q_6 = .06 * 397{,}811 \frac{m^3}{d} = 23{,}869 \frac{m^3}{d}$$

Calculated VSS in Line 10 from the mass loading rate from Line 6 with the assumption that the filters remove 75% of TSS.

$$P_{TSS10} = 0.75\,(P_{TSS6}) = 0.75\,(8.29 \times 10^6 g/d) = 6.22\, \times 10^6\ g/d$$

$$TSS_{10} = \frac{6.22 \times 10^6 \frac{g}{d}}{23{,}869 \frac{m^3}{d}} = 260.4 \frac{g\ TSS}{m^3}$$

$$VSS_{10} = TSS_{10}\,(0.72) = 260.4 \frac{g}{m^3}(0.72) = 187.5 \frac{g\ VSS}{m^3}$$

$$Np_{10} = VSS_{10}\,(0.12) = 187.5 \frac{gVSS}{m^3}(0.12) = 22.50 \frac{gNp}{m^3}$$

$$N_{T10} = N_{p10} + N_{s10}$$

$$N_{T10} = 22.50 \frac{g}{m^3} + 0.5 \frac{g}{m^3} = 23.00 \frac{g}{m^3}$$

$$P_{P10} = VSS_{10}(fPf) = 187.5 \frac{g\ VSS}{m^3}(.073) = 13.69 \frac{g}{m^3}$$
$$P_{T10} = P_{p10} + P_{s10}$$
$$P_{T10} = 13.69 \frac{g}{m^3} + 0.5 \frac{g}{m^3} = 14.19 \frac{g}{m^3}$$

$$bCOD_{T10} = bCOD_{p10} + bCOD_{s10}$$

$$bCOD_{p10} = VSS_{10}\left(1.42 \frac{g\ bCOD}{g\ VSS}\right)(f_d)$$

$$bCOD_{p10} = \left(187.5 \frac{g}{m^3}\right)\left(1.42 \frac{g\ bCOD}{g\ VSS}\right)(0.8) = 213.0 \frac{g}{m^3}$$

$$bCOD_{T10} = 213.0 \frac{g}{m^3} + 2.0 \frac{g}{m^3} = 215.0 \frac{g}{m^3}$$

Line 10 values are the values of the plant effluent, as these values do not change throughout disinfection.

For the mass loadings for Line 10, these were calculated in the same way. An example will be shown using TSS, but mass loadings for the other constituents were found using the same method.

$$P_{TSS10} = Q_{10}(TSS_{10}) = 23{,}869 \frac{m^3}{d}\left(260.4 \frac{g}{m^3}\right) = 6.22 \times 10^6 \frac{g}{d}$$

D.1.5. Sludge Line to Hornsby Bend BMP

Table D.1.5. Sludge Line to Hornsby Bend BMP Assumptions

Assumptions*			
Parameter	**Value**	**Units**	**Source**
VSS/TSS ratio	0.72	g VSS/g TSS	Given – Influent Parameters
Fraction of Particulate Nitrogen	0.12	g N/g VSS	Typical Value
Fraction Degradable (f_d)	0.80	g COD/g VSS	Typical Value

$$Q_{11} = Q_4 + Q_9 = 2{,}017 \frac{m^3}{d} + 2{,}503 \frac{m^3}{d} = 4{,}520 \frac{m^3}{d}$$
$$TSS_{11} = \frac{P_{TSS4} - P_{TSS9}}{Q_{11}} = \frac{(6.05 \times 10^7\ g/d) - (2.50 \times 10^7\ g/d)}{4{,}520\ m^3/d} = 18{,}925 \frac{g}{m^3}$$
$$VSS_{11} = TSS_{11} * 0.72 = \left(18{,}925 \frac{g}{m^3}\right) * 0.72 = 13{,}626 \frac{g}{m^3}$$
$$P_{TSS11} = Q_{11} * TSS_{11} = (4{,}520\ m^3/d) * (18{,}925\ g/m^3) = 8.55 \times 10^7 \frac{g}{d}$$

$$P_{VSS11} = Q_{11} * VSS_{11} = (4{,}520\, m^3/d) * (13{,}626\, g/m^3) = 6.16 \times 10^7 \frac{g}{d}$$

A new fraction of phosphorus must be calculated as two lines are being combined.

$$f_{p11} = \frac{P_{Pp4} + P_{Pp9}}{P_{VSS11}} = \frac{(6.42 \times 10^6\, g/d) + (1.46 \times 10^6\, g/d)}{6.16 \times 10^7\, g/d} = 0.034 \frac{gP}{gVSS}$$

$$N_{P11} = VSS_{11} * 0.12 = \left(18{,}925 \frac{g}{m^3}\right) * 0.12 = 1{,}635 \frac{g}{m^3}$$

$$N_{S11} = \frac{P_{Ns4} + P_{Ns9}}{Q_{11}} = \frac{(6.34 \times 10^4\, g/d) + (1.25 \times 10^3\, g/d)}{2{,}503\, m^3/d} = 14.31 \frac{g}{m^3}$$

$$N_{T11} = N_{P11} + N_{S11} = \left(1{,}635 \frac{g}{m^3}\right) + \left(14.31 \frac{g}{m^3}\right) = 1{,}650 \frac{g}{m^3}$$

$$P_{P11} = VSS_{11} * fP_{P11} = \left(18{,}925 \frac{g}{m^3}\right) * (0.034) = 465.6 \frac{g}{m^3}$$

$$P_{S11} = \frac{P_{Ps4} + P_{Ps9}}{Q_{11}} = \frac{(8.41 \times 10^3\, g/d) + (1.25 \times 10^3\, g/d)}{2{,}503\, m^3/d} = 2.14 \frac{g}{m^3}$$

$$P_{T11} = P_{P11} + P_{S11} = \left(456.6 \frac{g}{m^3}\right) + \left(2.14 \frac{g}{m^3}\right) = 467.7 \frac{g}{m^3}$$

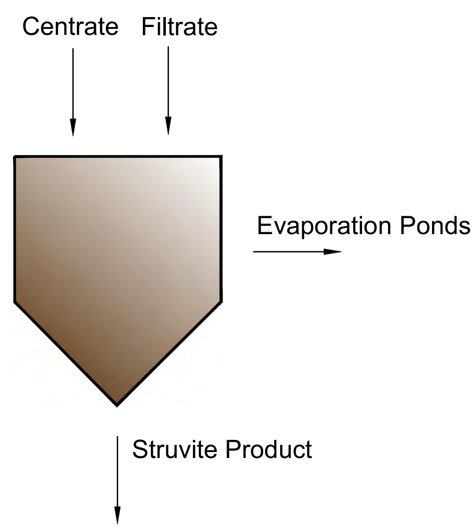
$$(NO_3 - N)_{11} = \frac{P_{(NO_3-N)_4} + P_{(NO_3-N)_9}}{Q_{11}} = \frac{(8.35 \times 10^2\, g/d) + (1.75 \times 10^4\, g/d)}{2{,}503\, m^3/d} = 4.06 \frac{g}{m^3}$$

$$bCOD_{P11} = VSS_{11} * 1.42 \frac{g\ bCOD}{g\ VSS} * f_d = \left(18{,}925 \frac{g}{m^3}\right) * \left(1.42 \frac{g\ bCOD}{g\ VSS}\right) * 0.8 = 15{,}479 \frac{g}{m^3}$$

$$bCOD_{S11} = \frac{P_{bCOD_{S4}} + P_{bCOD_{S9}}}{Q_{11}} = \frac{(2.54 \times 10^5\, g/d) + (5.01 \times 10^3\, g/d)}{5{,}420\, m^3/d} = 57.22 \frac{g}{m^3}$$

$$bCOD_{T11} = bCOD_{P11} + bCOD_{S11} = \left(15{,}479 \frac{g}{m^3}\right) + \left(57.22 \frac{g}{m^3}\right) = 15{,}536 \frac{g}{m^3}$$

D.1.6. Phosphorus Sequestration



D.1.6. Phosphorus Sequestration Assumptions

Assumptions			
Parameter	**Value**	**Units**	**Source**
Digester VSS Capture Rate	50	%	Typical Value
TSS - Belt Press	60,000	g/m^3	Typical Value
Belt Press Solids Removal Rate	90	%	Typical Value
Struvite Generator Phosphorus Recovery Rate	80	%	Typical Value
VSS/TSS ratio	0.72	g VSS/g TSS	Given – Influent Parameters
Fraction of Particulate Phosphorus in Digester	0.01	g P/g VSS	Typical Value
Fraction of Particulate Nitrogen	0.12	g N/g VSS	Typical Value
Fraction Degradable (f_d)	0.80	g COD/g VSS	Typical Value
P_{S13}	200	g/m^3	Assumed Saturation Value

Line 12 is the combination of both the solids line from the Walnut Creek (WC) WWTP as well as the South Austin Regional (SAR) WWTP. Below are the concentrations and mass flows of both the WCWWTP solids line and the SAR plant solids line. The information for SAR was given via the WEAT SDC Prompt, and then WC values were taken from the solids balance performed. Sample calculations for Phase 3 will be shown.

SAR	
$Q(m^3/d)$	2,148
$TSS(g/m^3)$	17,549
$VSS(g/m^3)$	12,615
$P_T(g/m^3)$	1,049
$P_{TSS}(g/d)$	3.77E+07
$P_{VSS}(g/d)$	2.71E+07
$P_{PT}(g/d)$	2.25E+06
$P_{PP}(g/d)$	2.71E+05

WC	
$Q(m^3/d)$	4,520
$TSS(g/m^3)$	18,925
$VSS(g/m^3)$	13,626
$P_T(g/m^3)$	467.7
$P_{TSS}(g/d)$	8.55E+07
$P_{VSS}(g/d)$	6.16E+07
$P_{PT}(g/d)$	2.11E+06
$P_{PP}(g/d)$	2.10E+06

Knowing the concentrations and mass flows for both SAR and WC, the influent concentrations and mass flows can be calculated for Hornsby Bend. A new particulate fraction of phosphorus will also need to be calculated for the influent line. The particulate fraction of phosphorous from the SAR plant was assumed to be 1%.

$$f_{P_{P12}} = \frac{P_{PPWC} + P_{PPSAR}}{P_{VSSWC}} = \frac{\left(2.10 \times 10^6 \frac{g}{d}\right) + \left(2.71 \times 10^5 \frac{g}{d}\right)}{6.16 \times 10^7 \frac{g}{d}} = 0.027$$

$$TSS_{12} = \frac{P_{TSSWC} + P_{TSSSAR}}{Q_{12}} = \frac{\left(8.55 \times 10^7 \frac{g}{d}\right) + \left(3.77 \times 10^7 \frac{g}{d}\right)}{2{,}148 + 4{,}520 \frac{m^3}{d}} = 18{,}481 \frac{g}{m^3}$$

$$VSS_{12} = TSS_{12} * 0.72 = \left(18{,}481 \frac{g}{m^3}\right) * (0.72) = 13{,}307 \frac{g}{m^3}$$

$$P_{P12} = f_{P_{P12}} * VSS_{12} = (0.027) * \left(13{,}307 \frac{g}{m^3}\right) = 356 \frac{g}{m^3}$$

$$P_{T12} = \frac{P_{PTWC} + P_{PTSAR}}{Q_{12}} = \frac{\left(2.11 \times 10^6 \frac{g}{d}\right) + \left(2.25 \times 10^6 \frac{g}{d}\right)}{6{,}667 \frac{m^3}{d}} = 655 \frac{g}{m^3}$$

$$P_{S12} = P_{T12} - P_{P12} = 655 \frac{g}{m^3} - 356 \frac{g}{m^3} = 299 \frac{g}{m^3}$$

Since it is assumed that 50% of the mass flow of VSS will be leaving the digesters, the concentrations and mass flows leaving the digesters can be calculated.

$$Q_{13} = Q_{12} = 6{,}667 \frac{m^3}{d}$$

$$P_{VSS13} = P_{VSS12} * 0.5 = \left(18{,}481 \frac{g}{m^3}\right) * \left(6{,}667 \frac{m^3}{d}\right) * (0.5) = 4.44 \times 10^7 \frac{g}{d}$$

$$VSS_{13} = \frac{P_{VSS13}}{Q_{13}} = \frac{4.44 \times 10^7 \frac{g}{d}}{6{,}667 \frac{m^3}{d}} = 6{,}653 \frac{g}{m^3}$$

$$TSS_{13} = \frac{VSS_{13}}{0.72} = \frac{6{,}653 \frac{g}{m^3}}{0.72} = 9{,}240 \frac{g}{m^3}$$

$$P_{P13} = VSS_{13} * 0.01 = 9{,}240 \frac{g}{m^3} * 0.01 = 66.53 \frac{g}{m^3}$$

Assuming that the flow is fully saturated:

$$P_{S13} = 200 \frac{g}{m^3}$$

Knowing the effluent concentrations out of the digesters, a solids balance around the dewatering belt presses can be done. The assumptions made for the dewatering belt press will apply into this section.

$$TSS_{15} = 60{,}000 \frac{g}{m^3}$$

$$VSS_{15} = 43{,}200 \frac{g}{m^3}$$

$$P_{VSS15} = 0.9 * P_{VSS13} = (0.9) * \left(4.44 \times 10^7 \frac{g}{d}\right) = 3.99 \times 10^7 \frac{g}{d}$$

$$Q_{15} = \frac{P_{VSS15}}{VSS_{15}} = \frac{3.99 \times 10^7 \frac{g}{d}}{43{,}200 \frac{g}{m^3}} = 924.2 \frac{m^3}{d}$$

$$Q_{14} = Q_{13} - Q_{15} = 6{,}667\frac{m^3}{d} - 924.2\frac{m^3}{d} = 5{,}743\frac{m^3}{d}$$

$$P_{S13} = P_{S14} = P_{S15} = 200\frac{g}{m^3}$$

$$P_{P_{S14}} = P_{S14} * Q_{14} = \left(200\frac{g}{m^3}\right) * \left(5{,}743\frac{m^3}{d}\right) = 1.15 \times 10^6\frac{g}{d}$$

The value above represents the amount of soluble phosphorus in the influent of the struvite reactor. These values were used by the manufacturer as design parameters for the struvite reactor.

D.1.7. Final Summary Tables

The tables below provide all values for all iterations of the solids balances performed. The first three tables will be for Phase 2, and the remaining three for Phase 3. As seen in the tables, the percent change in values for the final iteration are all below 5%, so the values have converged.

Permit Phase 2 Initial Values												
Concentrations												
Parameter	Units	Line 1	Line 2	Line 3	Line 4	Line 5	Line 6	Line 7	Line 8	Line 9	Line 10	Line 11
Q	m^3/d	283,905	283,905	282,485.5	1,419.5	407,458.4	280,653.9	1,831.6	263,814.6	1,831.6	16,839.2	3,251.1
TSS	g/m^3	250.0	250.0	100.5	30,000.0	3,472.2	20.8	11,111.1	5.5	11,111.1	260.4	18,732.5
VSS	g/m^3	180.0	180.0	72.4	21,600.0	2,500.0	15.0	8,000.0	3.99	8,000.0	187.5	13,487.4
[illegible]	g/m^3	55.0	55.0	42.1	2,625.4	300.5	2.3	960.5	0.98	960.5	23.0	1,633.3
[illegible]	g/m^3	21.6	21.6	8.7	2,592.0	300.0	1.8	960.0	0.48	960.0	22.5	1,618.5
[illegible]	g/m^3	33.4	33.4	33.4	33.4	0.5	0.5	0.5	0.5	0.5	0.5	14.9
[illegible]	g/m^3	6.2	6.2	5.1	220.4	173.6	1.5	554.4	0.78	554.4	13.5	408.6
[illegible]	g/m^3	1.8	1.8	0.7	216.0	173.1	1.0	553.9	0.28	553.9	13.0	406.4
[illegible]	g/m^3	4.4	4.4	4.4	4.4	0.5	0.5	0.5	0.50	0.5	0.5	2.2
$_3^-$	g/m^3	0.0	0.0	0.0	0.0	7.0	7.0	7.0	7.0	7.0	7.0	3.9
D_T	g/m^3	338.0	338.0	215.7	24,671.1	2,842.0	19.0	9,090.0	6.5	9,090.0	215.0	15,381.1
D_p	g/m^3	204.5	204.5	82.2	24,537.6	2,840.0	17.0	9,088.0	4.5	9,088.0	213.0	15,321.6
D_s	g/m^3	133.5	133.5	133.5	133.5	2.0	2.0	2.0	2.0	2.0	2.0	59.4
Mass Loading												
Q	m^3/d	283,905	283,905	282,485.5	1,419.5	407,458.4	280,653.9	1,831.6	263,814.6	1,831.6	16,839.2	3,251.1
TSS	g/d	7.10E+07	7.10E+07	2.84E+07	4.26E+07	1.41E+09	5.85E+06	2.04E+07	1.46E+06	1.83E+07	4.39E+06	6.09E+07
VSS	g/d	5.11E+07	5.11E+07	2.04E+07	3.07E+07	1.89E+07	4.21E+06	1.47E+07	1.05E+06	1.47E+07	3.16E+06	4.38E+07
[illegible]	g/d	1.56E+07	1.56E+07	1.19E+07	3.73E+06	1.22E+08	6.46E+05	1.76E+06	2.58E+05	1.76E+06	3.87E+05	5.31E+06
[illegible]	g/d	6.13E+06	6.13E+06	2.45E+06	3.68E+06	1.22E+08	5.05E+05	1.76E+06	1.26E+05	1.76E+06	3.79E+05	5.26E+06
[illegible]	g/d	9.48E+06	9.48E+06	9.44E+06	4.74E+04	2.04E+05	1.40E+05	9.16E+02	1.32E+05	9.16E+02	8.42E+03	4.83E+04
[illegible]	g/d	1.76E+06	1.76E+06	1.45E+06	3.13E+05	7.07E+07	4.32E+05	1.02E+06	2.05E+05	1.02E+06	2.27E+05	1.33E+06
[illegible]	g/d	5.11E+05	5.11E+05	2.04E+05	3.07E+05	7.05E+07	2.91E+05	1.01E+06	7.29E+04	1.01E+06	2.19E+05	1.32E+06
[illegible]	g/d	1.25E+06	1.25E+06	1.24E+06	6.25E+03	2.04E+05	1.40E+05	9.16E+02	1.32E+05	9.16E+02	8.42E+03	7.16E+03
$_3^-$	g/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.85E+06	1.96E+06	1.28E+04	1.85E+06	1.28E+04	1.18E+05	1.28E+04
D_T	g/d	9.60E+07	9.60E+07	6.09E+07	3.50E+07	1.16E+09	5.34E+06	1.66E+07	1.72E+06	1.66E+07	3.62E+06	5.00E+07
D_p	g/d	5.81E+07	5.81E+07	2.32E+07	3.48E+07	1.16E+09	4.78E+06	1.66E+07	1.20E+06	1.66E+07	3.59E+06	4.98E+07
D_s	g/d	3.79E+07	3.79E+07	3.77E+07	1.90E+05	8.15E+05	5.61E+05	3.66E+03	5.28E+05	3.66E+03	3.37E+04	1.93E+05

Permit Phase 2 Initial Iteration (Loop 1)													
Concentrations													
Parameter	Units	Line 1	Line 2	Line 3	Line 4	Line 5	Line 6	Line 7	Line 8	Line 9	Line 10	Line 11	Line 10 Old	% Change
Q	m^3/d	283,905	300,744	299,237.0	1,507.2	431,716.3	297,362.5	1,874.5	279,520.8	1,874.5	17,841.8	3,381.7	16,839	5.95%
TSS	g/m^3	250.0	250.6	100.7	30,000.0	3,472.2	20.8	11,111.1	5.5	11,111.1	260.4	18,914.0	260.42	0.00%
VSS	g/m^3	180.0	180.4	72.5	21,600.0	2,500.0	15.0	8,000.0	3.99	8,000.0	187.5	13,618.1	187.50	0.00%
N_T	g/m^3	55.0	53.2	40.3	2,623.6	300.5	2.3	960.5	0.98	960.5	23.0	1,648.5	23.00	0.00%
N_p	g/m^3	21.6	21.7	8.7	2,592.0	300.0	1.8	960.0	0.48	960.0	22.5	1,634.2	22.50	0.00%
N_s	g/m^3	33.4	31.6	31.6	31.6	0.5	0.5	0.5	0.5	0.5	0.5	14.3	0.50	0.00%
P_T	g/m^3	6.2	6.8	5.2	312.6	181.9	1.6	580.9	0.79	580.9	14.1	461.3	13.48	4.60%
P_p	g/m^3	1.8	2.6	1.0	308.4	181.4	1.1	580.4	0.29	580.4	13.6	459.2	12.98	4.78%
P_s	g/m^3	4.4	4.2	4.2	4.2	0.5	0.5	0.5	0.50	0.5	0.5	2.1	0.50	0.00%
NO_3^-	g/m^3	0.0	0.4	0.4	0.4	7.0	7.0	7.0	7.0	7.0	7.0	4.1	7.00	0.00%
$bCOD_T$	g/m^3	338.0	331.1	208.6	24,663.8	2,842.0	19.0	9,090.0	6.5	9,090.0	215.0	15,527.5	215.00	0.00%
$bCOD_p$	g/m^3	204.5	205.0	82.4	24,537.6	2,840.0	17.0	9,088.0	4.5	9,088.0	213.0	15,470.1	213.00	0.00%
$bCOD_s$	g/m^3	133.5	126.2	126.2	126.2	2.0	2.0	2.0	2.0	2.0	2.0	57.3	2.00	0.00%
Mass Loading														
Q	m^3/d	283,905	300,744	299,237.0	1,507.2	431,716.3	297,362.5	1,874.5	279,520.8	1,874.5	17,841.8	3,381.7	1.68E+04	5.95%
TSS	g/d	7.10E+07	7.54E+07	3.01E+07	4.52E+07	1.50E+09	6.20E+06	2.08E+07	1.55E+06	1.87E+07	4.65E+06	6.40E+07	4.39E+06	5.95%
VSS	g/d	5.11E+07	5.43E+07	2.17E+07	3.26E+07	1.95E+07	4.46E+06	1.50E+07	1.12E+06	1.50E+07	3.35E+06	4.61E+07	3.16E+06	5.95%
N_T	g/d	1.56E+07	1.60E+07	1.20E+07	3.95E+06	1.30E+08	6.84E+05	1.80E+06	2.74E+05	1.80E+06	4.10E+05	5.57E+06	3.87E+05	5.95%
N_p	g/d	6.13E+06	6.51E+06	2.60E+06	3.91E+06	1.30E+08	5.35E+05	1.80E+06	1.34E+05	1.80E+06	4.01E+05	5.53E+06	3.79E+05	5.95%
N_s	g/d	9.48E+06	9.49E+06	9.44E+06	4.76E+04	2.16E+05	1.49E+05	9.37E+02	1.40E+05	9.37E+02	8.92E+03	4.85E+04	8.42E+03	5.95%
P_T	g/d	1.76E+06	2.03E+06	1.56E+06	4.71E+05	7.85E+07	4.72E+05	1.09E+06	2.21E+05	1.09E+06	2.52E+05	1.56E+06	2.27E+05	10.83%
P_p	g/d	5.11E+05	7.75E+05	3.10E+05	4.65E+05	7.83E+07	3.24E+05	1.09E+06	8.09E+04	1.09E+06	2.43E+05	1.55E+06	2.19E+05	11.02%
P_s	g/d	1.25E+06	1.26E+06	1.25E+06	6.30E+03	2.16E+05	1.49E+05	9.37E+02	1.40E+05	9.37E+02	8.92E+03	7.24E+03	8.42E+03	5.95%
NO_3^-	g/d	0.00E+00	1.18E+05	1.17E+05	5.91E+02	3.02E+06	2.08E+06	1.31E+04	1.96E+06	1.31E+04	1.25E+05	1.37E+04	1.18E+05	5.95%
$bCOD_T$	g/d	9.60E+07	9.96E+07	6.24E+07	3.72E+07	1.23E+09	5.66E+06	1.70E+07	1.83E+06	1.70E+07	3.84E+06	5.25E+07	3.62E+06	5.95%
$bCOD_p$	g/d	5.81E+07	6.16E+07	2.47E+07	3.70E+07	1.23E+09	5.07E+06	1.70E+07	1.27E+06	1.70E+07	3.80E+06	5.23E+07	3.59E+06	5.95%
$bCOD_s$	g/d	3.79E+07	3.79E+07	3.78E+07	1.90E+05	8.63E+05	5.95E+05	3.75E+03	5.59E+05	3.75E+03	3.57E+04	1.94E+05	3.37E+04	5.95%

Permit Phase 2 Final Iteration (Loop 2)													
Concentrations													
Parameter	Units	Line 1	Line 2	Line 3	Line 4	Line 5	Line 6	Line 7	Line 8	Line 9	Line 10	Line 11	Line 10 Old	% Change
Q	m^3/d	283,905	301,747	300,234.3	1,512.5	433,160.5	298,357.3	1,877.0	280,455.8	1,877.0	17,901.4	3,389.5	17,842	0.33%
TSS	g/m^3	250.0	250.6	100.8	30,000.0	3,472.2	20.8	11,111.1	5.5	11,111.1	260.4	18,924.4	260.42	0.00%
VSS	g/m^3	180.0	180.4	72.5	21,600.0	2,500.0	15.0	8,000.0	3.99	8,000.0	187.5	13,625.6	187.50	0.00%
N_T	g/m^3	55.0	53.1	40.2	2,623.5	300.5	2.3	960.5	0.98	960.5	23.0	1,649.4	23.00	0.00%
N_p	g/m^3	21.6	21.7	8.7	2,592.0	300.0	1.8	960.0	0.48	960.0	22.5	1,635.1	22.50	0.00%
N_s	g/m^3	33.4	31.5	31.5	31.5	0.5	0.5	0.5	0.5	0.5	0.5	14.3	0.50	0.00%
P_T	g/m^3	6.2	6.8	5.2	322.8	183.0	1.6	584.5	0.79	584.5	14.2	467.7	14.10	0.60%
P_p	g/m^3	1.8	2.7	1.1	318.6	182.5	1.1	584.0	0.29	584.0	13.7	465.6	13.60	0.62%
P_s	g/m^3	4.4	4.2	4.2	4.2	0.5	0.5	0.5	0.50	0.5	0.5	2.1	0.50	0.00%
NO_3^-	g/m^3	0.0	0.4	0.4	0.4	7.0	7.0	7.0	7.0	7.0	7.0	4.1	7.00	0.00%
$bCOD_T$	g/m^3	338.0	330.7	208.2	24,663.3	2,842.0	19.0	9,090.0	6.5	9,090.0	215.0	15,535.8	215.00	0.00%
$bCOD_p$	g/m^3	204.5	205.0	82.4	24,537.6	2,840.0	17.0	9,088.0	4.5	9,088.0	213.0	15,478.6	213.00	0.00%
$bCOD_s$	g/m^3	133.5	125.7	125.7	125.7	2.0	2.0	2.0	2.0	2.0	2.0	57.2	2.00	0.00%
Mass Loading														
Q	m^3/d	283,905	301,747	300,234.3	1,512.5	433,160.5	298,357.3	1,877.0	280,455.8	1,877.0	17,901.4	3,389.5	17,842	0.33%
TSS	g/d	7.10E+07	7.56E+07	3.02E+07	4.54E+07	1.50E+09	6.22E+06	2.09E+07	1.55E+06	1.88E+07	4.66E+06	6.41E+07	6.79E+06	0.33%
VSS	g/d	5.11E+07	5.44E+07	2.18E+07	3.27E+07	1.95E+07	4.48E+06	1.50E+07	1.12E+06	1.50E+07	3.36E+06	4.62E+07	4.89E+06	0.33%
N_T	g/d	1.56E+07	1.60E+07	1.21E+07	3.97E+06	1.30E+08	6.86E+05	1.80E+06	2.74E+05	1.80E+06	4.12E+05	5.59E+06	5.96E+05	0.33%
N_p	g/d	6.13E+06	6.53E+06	2.61E+06	3.92E+06	1.30E+08	5.37E+05	1.80E+06	1.34E+05	1.80E+06	4.03E+05	5.54E+06	5.86E+05	0.33%
N_s	g/d	9.48E+06	9.49E+06	9.44E+06	4.76E+04	2.17E+05	1.49E+05	9.39E+02	1.40E+05	9.39E+02	8.95E+03	4.85E+04	9.76E+03	0.33%
P_T	g/d	1.76E+06	2.06E+06	1.57E+06	4.88E+05	7.93E+07	4.76E+05	1.10E+06	2.22E+05	1.10E+06	2.54E+05	1.59E+06	3.72E+05	0.93%
P_p	g/d	5.11E+05	8.03E+05	3.21E+05	4.82E+05	7.91E+07	3.27E+05	1.10E+06	8.17E+04	1.10E+06	2.45E+05	1.58E+06	3.63E+05	0.96%
P_s	g/d	1.25E+06	1.26E+06	1.25E+06	6.31E+03	2.17E+05	1.49E+05	9.39E+02	1.40E+05	9.39E+02	8.95E+03	7.24E+03	9.76E+03	0.33%
NO_3^-	g/d	0.00E+00	1.25E+05	1.24E+05	6.26E+02	3.03E+06	2.09E+06	1.31E+04	1.96E+06	1.31E+04	1.25E+05	1.38E+04	1.37E+05	0.33%
$bCOD_T$	g/d	9.60E+07	9.98E+07	6.25E+07	3.73E+07	1.23E+09	5.68E+06	1.71E+07	1.83E+06	1.71E+07	3.85E+06	5.27E+07	5.59E+06	0.33%
$bCOD_p$	g/d	5.81E+07	6.19E+07	2.47E+07	3.71E+07	1.23E+09	5.08E+06	1.71E+07	1.27E+06	1.71E+07	3.81E+06	5.25E+07	5.55E+06	0.33%
$bCOD_s$	g/d	3.79E+07	3.79E+07	3.78E+07	1.90E+05	8.66E+05	5.97E+05	3.75E+03	5.61E+05	3.75E+03	3.58E+04	1.94E+05	3.90E+04	0.33%

Permit Phase 3 Initial Values												
Concentrations												
Parameter	Units	Line 1	Line 2	Line 3	Line 4	Line 5	Line 6	Line 7	Line 8	Line 9	Line 10	Line 11
Q	m^3/d	378,541	378,541	376,648.3	1,892.7	543,279.3	374,206.1	2,442.2	351,753.8	2,442.2	22,452.4	4,334.9
TSS	g/m^3	250.0	250.0	100.5	30,000.0	3,472.2	20.8	11,111.1	5.5	11,111.1	260.4	18,732.5
VSS	g/m^3	180.0	180.0	72.4	21,600.0	2,500.0	15.0	8,000.0	3.99	8,000.0	187.5	13,487.4
[illegible]	g/m^3	55.0	55.0	42.1	2,625.4	300.5	2.3	960.5	0.98	960.5	23.0	1,633.3
[illegible]	g/m^3	21.6	21.6	8.7	2,592.0	300.0	1.8	960.0	0.48	960.0	22.5	1,618.5
[illegible]	g/m^3	33.4	33.4	33.4	33.4	0.5	0.5	0.5	0.5	0.5	0.5	14.9
[illegible]	g/m^3	6.2	6.2	5.1	220.4	173.6	1.5	554.4	0.78	554.4	13.5	408.6
[illegible]	g/m^3	1.8	1.8	0.7	216.0	173.1	1.0	553.9	0.28	553.9	13.0	406.4
[illegible]	g/m^3	4.4	4.4	4.4	4.4	0.5	0.5	0.5	0.50	0.5	0.5	2.2
[illegible]$_3^-$	g/m^3	0.0	0.0	0.0	0.0	7.0	7.0	7.0	7.0	7.0	7.0	3.9
[illegible]D_T	g/m^3	338.0	338.0	215.7	24,671.1	2,842.0	19.0	9,090.0	6.5	9,090.0	215.0	15,381.1
[illegible]D_p	g/m^3	204.5	204.5	82.2	24,537.6	2,840.0	17.0	9,088.0	4.5	9,088.0	213.0	15,321.6
[illegible]D_s	g/m^3	133.5	133.5	133.5	133.5	2.0	2.0	2.0	2.0	2.0	2.0	59.4
Mass Loading												
Q	m^3/d	378,541	378,541	376,648.3	1,892.7	543,279.3	374,206.1	2,442.2	351,753.8	2,442.2	22,452.4	4,334.9
TSS	g/d	9.46E+07	9.46E+07	3.79E+07	5.68E+07	1.89E+09	7.80E+06	2.71E+07	1.95E+06	2.44E+07	5.85E+06	8.12E+07
VSS	g/d	6.81E+07	6.81E+07	2.73E+07	4.09E+07	2.52E+07	5.61E+06	1.95E+07	1.40E+06	1.95E+07	4.21E+06	5.85E+07
[illegible]	g/d	2.08E+07	2.08E+07	1.59E+07	4.97E+06	1.63E+08	8.61E+05	2.35E+06	3.44E+05	2.35E+06	5.16E+05	7.08E+06
[illegible]	g/d	8.18E+06	8.18E+06	3.27E+06	4.91E+06	1.63E+08	6.74E+05	2.34E+06	1.68E+05	2.34E+06	5.05E+05	7.02E+06
[illegible]	g/d	1.26E+07	1.26E+07	1.26E+07	6.32E+04	2.72E+05	1.87E+05	1.22E+03	1.76E+05	1.22E+03	1.12E+04	6.44E+04
[illegible]	g/d	2.35E+06	2.35E+06	1.93E+06	4.17E+05	9.43E+07	5.76E+05	1.35E+06	2.73E+05	1.35E+06	3.03E+05	1.77E+06
[illegible]	g/d	6.81E+05	6.81E+05	2.73E+05	4.09E+05	9.40E+07	3.89E+05	1.35E+06	9.72E+04	1.35E+06	2.91E+05	1.76E+06
[illegible]	g/d	1.67E+06	1.67E+06	1.66E+06	8.33E+03	2.72E+05	1.87E+05	1.22E+03	1.76E+05	1.22E+03	1.12E+04	9.55E+03
[illegible]$_3^-$	g/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.80E+06	2.62E+06	1.71E+04	2.46E+06	1.71E+04	1.57E+05	1.71E+04
[illegible]D_T	g/d	1.28E+08	1.28E+08	8.13E+07	4.67E+07	1.54E+09	7.12E+06	2.22E+07	2.30E+06	2.22E+07	4.83E+06	6.67E+07
[illegible]D_p	g/d	7.74E+07	7.74E+07	3.10E+07	4.64E+07	1.54E+09	6.38E+06	2.22E+07	1.59E+06	2.22E+07	4.78E+06	6.64E+07
[illegible]D_s	g/d	5.05E+07	5.05E+07	5.03E+07	2.53E+05	1.09E+06	7.48E+05	4.88E+03	7.04E+05	4.88E+03	4.49E+04	2.58E+05

Permit Phase 3 Initial Iteration (Loop 1)														
Concentrations														
Parameter	Units	Line 1	Line 2	Line 3	Line 4	Line 5	Line 6	Line 7	Line 8	Line 9	Line 10	Line 11	Line 10 Old	% Change
Q	m^3/d	378,541	400,993	398,983.7	2,009.6	575,623.3	396,484.4	2,499.3	372,695.3	2,499.3	23,789.1	4,509.0	22,452	5.95%
TSS	g/m^3	250.0	250.6	100.7	30,000.0	3,472.2	20.8	11,111.1	5.5	11,111.1	260.4	18,914.0	260.42	0.00%
VSS	g/m^3	180.0	180.4	72.5	21,600.0	2,500.0	15.0	8,000.0	3.99	8,000.0	187.5	13,618.1	187.50	0.00%
N_T	g/m^3	55.0	53.2	40.3	2,623.6	300.5	2.3	960.5	0.98	960.5	23.0	1,648.5	23.00	0.00%
N_p	g/m^3	21.6	21.7	8.7	2,592.0	300.0	1.8	960.0	0.48	960.0	22.5	1,634.2	22.50	0.00%
N_s	g/m^3	33.4	31.6	31.6	31.6	0.5	0.5	0.5	0.5	0.5	0.5	14.3	0.50	0.00%
P_T	g/m^3	6.2	6.8	5.2	312.6	181.9	1.6	580.9	0.79	580.9	14.1	461.3	13.48	4.60%
P_p	g/m^3	1.8	2.6	1.0	308.4	181.4	1.1	580.4	0.29	580.4	13.6	459.2	12.98	4.78%
P_s	g/m^3	4.4	4.2	4.2	4.2	0.5	0.5	0.5	0.50	0.5	0.5	2.1	0.50	0.00%
NO_3^-	g/m^3	0.0	0.4	0.4	0.4	7.0	7.0	7.0	7.0	7.0	7.0	4.1	7.00	0.00%
$bCOD_T$	g/m^3	338.0	331.1	208.6	24,663.8	2,842.0	19.0	9,090.0	6.5	9,090.0	215.0	15,527.5	215.00	0.00%
$bCOD_p$	g/m^3	204.5	205.0	82.4	24,537.6	2,840.0	17.0	9,088.0	4.5	9,088.0	213.0	15,470.1	213.00	0.00%
$bCOD_s$	g/m^3	133.5	126.2	126.2	126.2	2.0	2.0	2.0	2.0	2.0	2.0	57.3	2.00	0.00%
Mass Loading														
Q	m^3/d	378,541	400,993	398,983.7	2,009.6	575,623.3	396,484.4	2,499.3	372,695.3	2,499.3	23,789.1	4,509.0	22,452	5.95%
TSS	g/d	9.46E+07	1.00E+08	4.02E+07	6.03E+07	2.00E+09	8.26E+06	2.78E+07	2.07E+06	2.50E+07	6.20E+06	8.53E+07	5.85E+06	5.95%
VSS	g/d	6.81E+07	7.23E+07	2.89E+07	4.34E+07	2.59E+07	5.95E+06	2.00E+07	1.49E+06	2.00E+07	4.46E+06	6.14E+07	4.21E+06	5.95%
N_T	g/d	2.08E+07	2.13E+07	1.61E+07	5.27E+06	1.73E+08	9.12E+05	2.40E+06	3.65E+05	2.40E+06	5.47E+05	7.43E+06	5.16E+05	5.95%
N_p	g/d	8.18E+06	8.68E+06	3.47E+06	5.21E+06	1.73E+08	7.14E+05	2.40E+06	1.78E+05	2.40E+06	5.35E+05	7.37E+06	5.05E+05	5.95%
N_s	g/d	1.26E+07	1.27E+07	1.26E+07	6.34E+04	2.88E+05	1.98E+05	1.25E+03	1.86E+05	1.25E+03	1.19E+04	6.47E+04	1.12E+04	5.95%
P_T	g/d	2.35E+06	2.71E+06	2.08E+06	6.28E+05	1.05E+08	6.30E+05	1.45E+06	2.94E+05	1.45E+06	3.36E+05	2.08E+06	3.03E+05	10.83%
P_p	g/d	6.81E+05	1.03E+06	4.13E+05	6.20E+05	1.04E+08	4.31E+05	1.45E+06	1.08E+05	1.45E+06	3.24E+05	2.07E+06	2.91E+05	11.02%
P_s	g/d	1.67E+06	1.68E+06	1.67E+06	8.40E+03	2.88E+05	1.98E+05	1.25E+03	1.86E+05	1.25E+03	1.19E+04	9.65E+03	1.12E+04	5.95%
NO_3^-	g/d	0.00E+00	1.57E+05	1.56E+05	7.88E+02	4.03E+06	2.78E+06	1.75E+04	2.61E+06	1.75E+04	1.67E+05	1.83E+04	1.57E+05	5.95%
$bCOD_T$	g/d	1.28E+08	1.33E+08	8.32E+07	4.96E+07	1.64E+09	7.55E+06	2.27E+07	2.43E+06	2.27E+07	5.11E+06	7.00E+07	4.83E+06	5.95%
$bCOD_p$	g/d	7.74E+07	8.22E+07	3.29E+07	4.93E+07	1.63E+09	6.76E+06	2.27E+07	1.69E+06	2.27E+07	5.07E+06	6.98E+07	4.78E+06	5.95%
$bCOD_s$	g/d	5.05E+07	5.06E+07	5.03E+07	2.54E+05	1.15E+06	7.93E+05	5.00E+03	7.45E+05	5.00E+03	4.76E+04	2.59E+05	4.49E+04	5.95%

Permit Phase 3 Final Iteration (Loop 2)													
Concentrations													
Parameter	Units	Line 1	Line 2	Line 3	Line 4	Line 5	Line 6	Line 7	Line 8	Line 9	Line 10	Line 11	Line 10 Old	% Change
Q	m^3/d	378,541	402,330	400,313.5	2,016.6	577,548.9	397,810.7	2,502.7	373,942.1	2,502.7	23,868.6	4,519.3	23,789	0.33%
TSS	g/m^3	250.0	250.6	100.8	30,000.0	3,472.2	20.8	11,111.1	5.5	11,111.1	260.4	18,924.4	260.42	0.00%
VSS	g/m^3	180.0	180.4	72.5	21,600.0	2,500.0	15.0	8,000.0	3.99	8,000.0	187.5	13,625.6	187.50	0.00%
N_T	g/m^3	55.0	53.1	40.2	2,623.5	300.5	2.3	960.5	0.98	960.5	23.0	1,649.4	23.00	0.00%
N_p	g/m^3	21.6	21.7	8.7	2,592.0	300.0	1.8	960.0	0.48	960.0	22.5	1,635.1	22.50	0.00%
N_s	g/m^3	33.4	31.5	31.5	31.5	0.5	0.5	0.5	0.5	0.5	0.5	14.3	0.50	0.00%
P_T	g/m^3	6.2	6.8	5.2	322.8	183.0	1.6	584.5	0.79	584.5	14.2	467.7	14.10	0.60%
P_p	g/m^3	1.8	2.7	1.1	318.6	182.5	1.1	584.0	0.29	584.0	13.7	465.6	13.60	0.62%
P_s	g/m^3	4.4	4.2	4.2	4.2	0.5	0.5	0.5	0.50	0.5	0.5	2.1	0.50	0.00%
NO_3^-	g/m^3	0.0	0.4	0.4	0.4	7.0	7.0	7.0	7.0	7.0	7.0	4.1	7.00	0.00%
$bCOD_T$	g/m^3	338.0	330.7	208.2	24,663.3	2,842.0	19.0	9,090.0	6.5	9,090.0	215.0	15,535.8	215.00	0.00%
$bCOD_p$	g/m^3	204.5	205.0	82.4	24,537.6	2,840.0	17.0	9,088.0	4.5	9,088.0	213.0	15,478.6	213.00	0.00%
$bCOD_s$	g/m^3	133.5	125.7	125.7	125.7	2.0	2.0	2.0	2.0	2.0	2.0	57.2	2.00	0.00%
Mass Loading														
Q	m^3/d	378,541	402,330	400,313.5	2,016.6	577,548.9	397,810.7	2,502.7	373,942.1	2,502.7	23,868.6	4,519.3	23,789	0.33%
TSS	g/d	9.46E+07	1.01E+08	4.03E+07	6.05E+07	2.01E+09	8.29E+06	2.78E+07	2.07E+06	2.50E+07	6.22E+06	8.55E+07	6.20E+06	0.33%
VSS	g/d	6.81E+07	7.26E+07	2.90E+07	4.36E+07	2.60E+07	5.97E+06	2.00E+07	1.49E+06	2.00E+07	4.48E+06	6.16E+07	4.46E+06	0.33%
N_T	g/d	2.08E+07	2.14E+07	1.61E+07	5.29E+06	1.74E+08	9.15E+05	2.40E+06	3.66E+05	2.40E+06	5.49E+05	7.45E+06	5.47E+05	0.33%
N_p	g/d	8.18E+06	8.71E+06	3.48E+06	5.23E+06	1.73E+08	7.16E+05	2.40E+06	1.79E+05	2.40E+06	5.37E+05	7.39E+06	5.35E+05	0.33%
N_s	g/d	1.26E+07	1.27E+07	1.26E+07	6.34E+04	2.89E+05	1.99E+05	1.25E+03	1.87E+05	1.25E+03	1.19E+04	6.47E+04	1.19E+04	0.33%
P_T	g/d	2.35E+06	2.75E+06	2.10E+06	6.51E+05	1.06E+08	6.35E+05	1.46E+06	2.96E+05	1.46E+06	3.39E+05	2.11E+06	3.36E+05	0.93%
P_p	g/d	6.81E+05	1.07E+06	4.28E+05	6.42E+05	1.05E+08	4.36E+05	1.46E+06	1.09E+05	1.46E+06	3.27E+05	2.10E+06	3.24E+05	0.96%
P_s	g/d	1.67E+06	1.68E+06	1.67E+06	8.41E+03	2.89E+05	1.99E+05	1.25E+03	1.87E+05	1.25E+03	1.19E+04	9.66E+03	1.19E+04	0.33%
NO_3^-	g/d	0.00E+00	1.67E+05	1.66E+05	8.35E+02	4.04E+06	2.78E+06	1.75E+04	2.62E+06	1.75E+04	1.67E+05	1.84E+04	1.67E+05	0.33%
$bCOD_T$	g/d	1.28E+08	1.33E+08	8.33E+07	4.97E+07	1.64E+09	7.57E+06	2.27E+07	2.44E+06	2.27E+07	5.13E+06	7.02E+07	5.11E+06	0.33%
$bCOD_p$	g/d	7.74E+07	8.25E+07	3.30E+07	4.95E+07	1.64E+09	6.78E+06	2.27E+07	1.69E+06	2.27E+07	5.08E+06	7.00E+07	5.07E+06	0.33%
$bCOD_s$	g/d	5.05E+07	5.06E+07	5.03E+07	2.54E+05	1.16E+06	7.96E+05	5.01E+03	7.48E+05	5.01E+03	4.77E+04	2.59E+05	4.76E+04	0.33%

Appendix E: Evaluation Matrix

Table E-1: Selection Matrix Template

Selection Matrix					
	Multiplier	**1**	**2**	**3**	**4**
Capital Cost	4	Lowest Cost	Intermediate-Low	Intermediate-High	Highest Cost
O&M	4	Lowest O&M	Intermediate-Low	Intermediate-High	Highest O&M
Footprint	3	Least Area	Intermediate-Low	Intermediate-High	Highest Area
Ease of Integration	3	High	Intermediate-High	Intermediate-Low	Low
Performance	2	High	Intermediate-High	Intermediate-Low	Low

Evaluation Factors
Capital Cost
- Equipment
- Construction
- Installation and Start-up

O&M
- Maintenance Cost
- Energy Cost
- Labor

Footprint
- Land Use
- Space Requirement

Ease of Integration
- Easy to construct/install
- Ability to fit into the treatment train
- Not complex
- Works well hydraulically

Performance
- Quality of product
- The ability to perform well with minimal external forces in aid of efficiency

Green – Recommended Design
Yellow – Alternative Design
Red- Not Recommended Design

Table E-2: Odor Control

Selection Matrix			
	Chemical Scrubbers	Carbon Adsorption	Biotrickling Filters
Capital Cost (4)	16	4	12
O&M (4)	16	12	4
Footprint (3)	6	6	6
Ease of Integration (3)	9	3	6
Performance (2)	2	6	4
TOTAL	49	31	32

Table E-3: Primary Clarifier

Selection Matrix			
	Rectangular	Square	Circular
Capital Cost (4)	12	12	12
O&M (4)	12	12	8
Footprint (3)	12	9	6
Ease of Integration (3)	12	3	9
Performance (2)	4	4	2
TOTAL	52	40	37

Table E-4: Pump Station Pumps

Selection Matrix			
	Chopper	Plunger	Centrifugal
Capital Cost (4)	8	12	4
O&M (4)	8	12	4
Footprint (3)	3	9	3
Ease of Integration (3)	6	9	3
Performance (2)	4	4	6
TOTAL	29	46	20

Table E-5: EQ/ Peak Basin Configurations

Selection Matrix				
	Remove Existing EQ	Keep Existing EQ	Add Peak Basin	No Peak Basin
Capital Cost (4)	4	4	16	4
O&M (4)	12	8	8	16
Footprint (3)	3	6	12	3
Ease of Integration (3)	9	6	3	12
Performance (2)	8	4	2	8
TOTAL	32	28	41	43

Table E-6: BNR Configurations

Selection Matrix			
	A^2O	Modified UCT	Modified Bardenpho
Capital Cost (4)	4	8	16
O&M (4)	4	4	16
Footprint (3)	3	3	12
Ease of Integration (3)	3	6	12
Performance (2)	8	6	2
TOTAL	22	27	58

Table E-7: Filtration

Selection Matrix			
	Gravity	Cloth Disk	Membrane
Capital Cost (4)	4	8	16
O&M (4)	16	4	4
Footprint (3)	12	6	3
Ease of Integration (3)	3	6	6
Performance (2)	4	4	2
TOTAL	39	28	31

Table E-8: Disinfection

Selection Matrix			
	Chlorination	UV	Ozone
Capital Cost (4)	12	8	16
O&M (4)	8	4	16
Footprint (3)	12	3	9
Ease of Integration (3)	3	9	6
Performance (2)	4	2	2
TOTAL	39	26	49

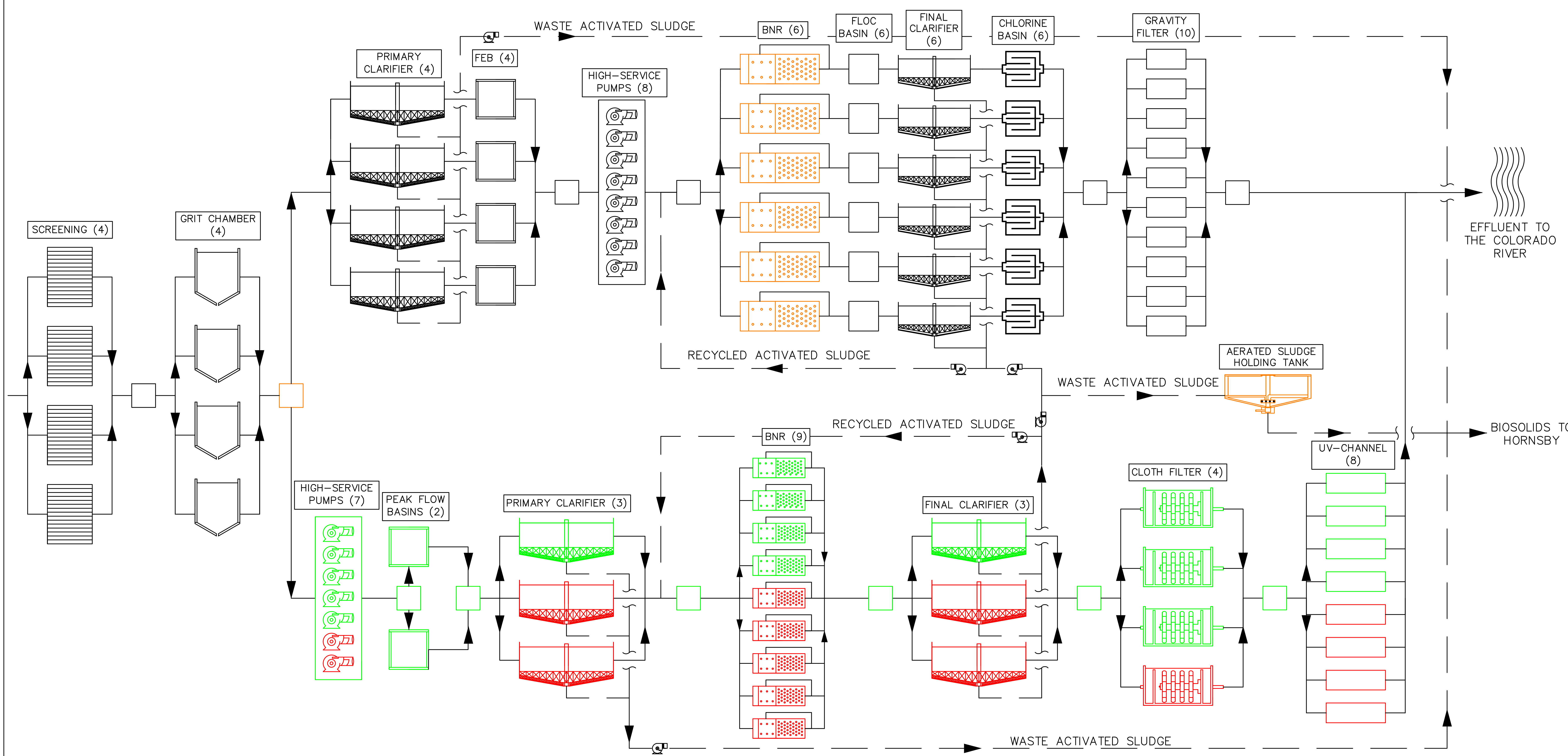
Table E-9: Solids Handling – Thickener

Selection Matrix			
	Convert to Sludge Holding Basin	Remain As-Is	Gravity Belt
Capital Cost (4)	4	4	8
O&M (4)	4	8	4
Footprint (3)	3	3	9
Ease of Integration (3)	3	3	6
Performance (2)	6	4	2
TOTAL	20	22	29

Table E-10: Phosphorus Sequestration

Selection Matrix			
	Struvite Reactor	Metal Salt Addition	Ion Exchange
Capital Cost (4)	8	12	12
O&M (4)	12	8	16
Footprint (3)	3	12	3
Ease of Integration (3)	6	12	9
Performance (2)	2	4	4
TOTAL	33	48	44

Appendix F: Proposed Process Flow Diagram



DESIGNED BY	WEAT TEAM
DRAWN BY	M. ROTMAN
CHECKED BY	L. MCDONALD
7/25/2023 DATE	*Mathew Rotman* MATHEW ROTMAN

WALNUT CREEK WWTP

PROCESS FLOW DIAGRAM

LEGEND

- EXISTING UNTIS
- MODIFIED UNITS
- PHASE 2 UPGRADES
- PHASE 3 UPGRADES

- WATER LINE
- SLUDGE LINE

GENERAL NOTES

Appendix G: Hydraulic Profile

Major losses due to friction within the pipes were calculated using the Hazen-Williams Equation. The pipes were all assumed to be ductile iron with a coefficient of 140.

$$h_f = \frac{7.73 * L * (\frac{Q}{C})^{1.852}}{D^{4.87}}$$

All minor losses within the piping system we calculated using the equation for minor losses. Typical minor loss coefficients used were used (Qasim, 1999).

$$h_m = K\frac{V^2}{2g}$$

The velocity through the pipes were determined to ensure adequate flow to prevent settling. The flows for each pipe were calculated based on the peak flow and assuming equal distribution between similar pipes. To find velocity, the relationship of Q=AV was used.

$$V = \frac{(Q\ (MGD) * \frac{1\ cfs}{0.6463\ MGD})}{\pi(r\ (ft))^2}$$

The tables below show the hydraulic profile calculations for Phases 2 and 3 for both AADF and PF.

Table G-1: Hydraulic Profile Calculations Phase 2 AADF

Location	Pipe, Fitting, or Process Unit	Diameter (in)	Width of Channel (ft)	AADF Flow (MGD)	AADF Flow (ft^3/s)	Velocity (ft/s)	Pipe/Channel Length (ft)	C or K	Headloss (ft)	WSEL (ft)
New IPS to Peak Flow Basin	Pipe Length	96	-	88.5	137	2.73	7.5	140	0.001	445.82
	JB 1 Inlet	-	-	-	-	-	-	0.5	0.058	445.82
	JB 1 Outlet	-	-	-	-	-	-	1	0.115	445.76
	Pipe Length	96	-	88.5	137	2.73	7.5	140	0.001	445.64
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.035	445.64
	Pipe Length	96	-	88.5	137	2.73	58	140	0.011	445.61
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.035	445.60
	Pipe Length	96	-	88.5	137	2.73	7.5	140	0.001	445.56
1	Peak Flow Basin	-	-	-	-	-	-	-	1.000	445.56
Peak Flow Basin to Junction Box 2	Pipe Length	54	-	20	30.9	1.95	17.5	140	0.003	444.56
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.018	444.56
	Pipe Length	54	-	20	30.9	1.95	53	140	0.010	444.54
2	JB 2 Inlet	-	-	-	-	-	-	0.5	0.029	444.53
2	JB 2 Outlet	-	-	-	-	-	-	1	0.059	444.50
Junction Box 2 to Primary Clarifier	Pipe Length	54	-	20	30.9	1.95	7.5	140	0.001	444.44
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.018	444.44
	Pipe Length	54	-	20	30.9	1.95	24.6	140	0.005	444.42
	Pipe Tee	-	-	-	-	-	-	0.2	0.012	444.42
	Pipe Length	54	-	20	30.9	1.95	7.5	140	0.001	444.41
1	Primary Clarifier	-	-	-	-	-	-	-	2.500	444.40
Primary Clarifier to Junction Box 3	Pipe Length	33	-	20	30.9	5.21	20	140	0.042	441.90
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.127	441.86
	Pipe Length	54	-	20	30.9	1.95	170	140	0.032	441.74
3	JB 3 Inlet	-	-	-	-	-	-	0.5	0.029	441.70
3	JB 3 Outlet	-	-	-	-	-	-	1	0.059	441.67

Junction Box 3 to BNR Basin	Pipe Length	54	-	20	30.9	1.95	7.5	140	0.001	441.62
	Pipe Tee	-	-	-	-	-	-	0.2	0.012	441.61
	Pipe Length	54	-	20	30.9	1.95	70	140	0.013	441.60
	Pipe Tee	-	-	-	-	-	-	0.2	0.012	441.59
	Pipe Length	54	-	20	30.9	1.95	70	140	0.013	441.58
	Pipe Tee	-	-	-	-	-	-	0.2	0.012	441.56
	Pipe Length	54	-	20	30.9	1.95	70	140	0.013	441.55
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.018	441.54
	Pipe Length	33	-	5	7.7	1.30	7.5	140	0.001	441.52
1	Anaerobic Basin Weir	-	70	5	7.7	-	-	-	0.109	441.52
1	Anoxic Basin Weir	-	70	5	7.7	-	-	-	0.109	441.41
1	Aerobic Basin	-	-	-	-	-	-	-	1.200	441.30
BNR Basin to Junction Box 4	Pipe Length	33	-	5	7.7	1.30	7.5	140	0.001	440.10
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.008	440.10
	Pipe Length	54	-	20	30.9	1.95	70	140	0.013	440.09
	Pipe Tee	-	-	-	-	-	-	0.2	0.012	440.08
	Pipe Length	54	-	20	30.9	1.95	70	140	0.013	440.07
	Pipe Tee	-	-	-	-	-	-	0.2	0.012	440.06
	Pipe Length	54	-	20	30.9	1.95	12.5	140	0.002	440.04
	Pipe 90 Bend	-	-	-	-	-	-	0.2	0.012	440.04
	Pipe Length	54	-	20	30.9	1.95	65	140	0.012	440.03
4	JB 4 Inlet	-	-	-	-	-	-	0.5	0.029	440.02
4	JB 4 Outlet	-	-	-	-	-	-	1	0.059	439.99
Junction Box 4 to Final Clarifier	Pipe Length	54	-	20	30.9	1.95	7.5	140	0.001	439.93
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.018	439.93
	Pipe Length	54	-	20	30.9	1.95	195	140	0.037	439.91
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.018	439.87
	Pipe Length	54	-	20	30.9	1.95	7.5	140	0.001	439.86
1	Final Clarifiers	-	-	-	-	-	-	-	2.500	439.85
Final Clarifier to Junction Box 5	Pipe Length	33	-	20	30.9	5.21	12.5	140	0.026	437.35
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.127	437.33
	Pipe Length	54	-	20	30.9	1.95	190	140	0.036	437.20
5	JB 5 Inlet	-	-	-	-	-	-	0.5	0.029	437.16
5	JB 5 Outlet	-	-	-	-	-	-	1	0.059	437.14
Junction Box 5 to Filter	Pipe Length	60	-	20	30.9	1.58	8.7	140	0.001	437.08
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.012	437.08
	Pipe Length	60	-	20	30.9	1.58	408	140	0.046	437.06
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.012	437.02
	Pipe Length	60	-	20	30.9	1.58	33	140	0.004	437.01
1	Disk Filters	-	-	-	-	-	-	-	2.000	437.00
Filter to UV	Pipe Length	60	-	20	30.9	1.58	20	140	0.002	435.00
1	UV Disinfection	-	-	-	-	-	-	-	0.500	435.00
UV to Outfall	Pipe Length	60	-	20	30.9	1.58	38	140	0.004	415.35
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.012	415.35
	Pipe Length	60	-	20	30.9	1.58	100.5	140	0.011	415.34
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.012	415.33
	Pipe Length	60	-	20	30.9	1.58	509.5	140	0.058	415.31
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.012	415.26
	Pipe Length	60	-	20	30.9	1.58	1182.5	140	0.135	415.24
	Bend	-	-	-	-	-	-	0.3	0.012	415.11
	Pipe Length	96	-	75	116	2.31	403	140	0.054	415.10
	Bend	-	-	-	-	-	-	0.3	0.025	415.04
	Pipe Length	96	-	75	116	2.31	143	140	0.019	415.02
1	Outfall	-	-	-	-	-	-	-	-	415
								Sum of Headloss (ft)	11.7	

Table G-2: Hydraulic Profile Calculations Phase 2 PF

Location	Pipe, Fitting, or Process Unit	Diameter (in)	Width of Channel (ft)	AADF Flow (MGD)	AADF Flow (ft^3/s)	Velocity (ft/s)	Pipe/Channel Length (ft)	C or K	Headloss (ft)	WSEL (ft)
New IPS to Peak Flow Basin	Pipe Length	96	-	88.5	137	2.73	7.5	140	0.001	447.27
	JB 1 Inlet	-	-	-	-	-	-	0.5	0.058	447.27
	JB 1 Outlet	-	-	-	-	-	-	1	0.115	447.21
	Pipe Length	96	-	88.5	137	2.73	7.5	140	0.001	447.10
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.035	447.10
	Pipe Length	96	-	88.5	137	2.73	58	140	0.011	447.06
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.035	447.05
	Pipe Length	96	-	88.5	137	2.73	7.5	140	0.001	447.02
1	Peak Flow Basin	-	-	-	-	-	-	-	1.000	447.01
Peak Flow Basin to Junction Box 2	Pipe Length	54	-	30	46.4	2.92	17.5	140	0.007	446.01
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.040	446.01
	Pipe Length	54	-	30	46.4	2.92	53	140	0.021	445.97
2	JB 2 Inlet	-	-	-	-	-	-	0.5	0.066	445.95
2	JB 2 Outlet	-	-	-	-	-	-	1	0.132	445.88
Junction Box 2 to Primary Clarifier	Pipe Length	54	-	30	46.4	2.92	7.5	140	0.003	445.75
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.040	445.74
	Pipe Length	54	-	30	46.4	2.92	24.6	140	0.010	445.71
	Pipe Tee	-	-	-	-	-	-	0.2	0.026	445.70
	Pipe Length	54	-	30	46.4	2.92	7.5	140	0.003	445.67
1	Primary Clarifier	-	-	-	-	-	-	-	2.500	445.67
Primary Clarifier to Junction Box 3	Pipe Length	33	-	30	46.4	7.82	20	140	0.089	443.17
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.285	443.08
	Pipe Length	54	-	30	46.4	2.92	170	140	0.069	442.79
3	JB 3 Inlet	-	-	-	-	-	-	0.5	0.066	442.72
3	JB 3 Outlet	-	-	-	-	-	-	1	0.132	442.66
Junction Box 3 to BNR Basin	Pipe Length	54	-	30	46.4	2.92	7.5	140	0.003	442.53
	Pipe Tee	-	-	-	-	-	-	0.2	0.026	442.52
	Pipe Length	54	-	30	46.4	2.92	70	140	0.028	442.50
	Pipe Tee	-	-	-	-	-	-	0.2	0.026	442.47
	Pipe Length	54	-	30	46.4	2.92	70	140	0.028	442.44
	Pipe Tee	-	-	-	-	-	-	0.2	0.026	442.41
	Pipe Length	54	-	30	46.4	2.92	70	140	0.028	442.39
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.040	442.36
	Pipe Length	33	-	7.5	11.6	1.95	7.5	140	0.003	442.32
1	Anaerobic Basin Weir	-	70	7.5	11.6	-	-	-	0.142	442.32
1	Anoxic Basin Weir	-	70	7.5	11.6	-	-	-	0.142	442.17
1	Aerobic Basin	-	-	-	-	-	-	-	1.200	442.03
BNR Basin to Junction Box 4	Pipe Length	33	-	7.5	11.6	1.95	7.5	140	0.003	440.83
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.018	440.83
	Pipe Length	54	-	30	46.4	2.92	70	140	0.028	440.81
	Pipe Tee	-	-	-	-	-	-	0.2	0.026	440.78
	Pipe Length	54	-	30	46.4	2.92	70	140	0.028	440.76
	Pipe Tee	-	-	-	-	-	-	0.2	0.026	440.73
	Pipe Length	54	-	30	46.4	2.92	12.5	140	0.005	440.70
	Pipe 90 Bend	-	-	-	-	-	-	0.2	0.026	440.70
	Pipe Length	54	-	30	46.4	2.92	65	140	0.026	440.67
4	JB 4 Inlet	-	-	-	-	-	-	0.5	0.066	440.64
4	JB 4 Outlet	-	-	-	-	-	-	1	0.132	440.58
Junction Box 4 to Final Clarifier	Pipe Length	54	-	30	46.4	2.92	7.5	140	0.003	440.45
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.040	440.44
	Pipe Length	54	-	30	46.4	2.92	195	140	0.079	440.40
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.040	440.32
	Pipe Length	54	-	30	46.4	2.92	7.5	140	0.003	440.28
1	Final Clarifiers	-	-	-	-	-	-	-	2.500	440.28

Final Clarifier to Junction Box 5	Pipe Length	33	-	30	46.4	7.82	12.5	140	0.055	437.78
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.285	437.73
	Pipe Length	54	-	30	46.4	2.92	190	140	0.077	437.44
5	JB 5 Inlet	-	-	-	-	-	-	0.5	0.066	437.36
5	JB 5 Outlet	-	-	-	-	-	-	1	0.132	437.30
Junction Box 5 to Filter	Pipe Length	60	-	30	46.4	2.36	8.7	140	0.002	437.17
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.026	437.16
	Pipe Length	60	-	30	46.4	2.36	408	140	0.099	437.14
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.026	437.04
	Pipe Length	60	-	30	46.4	2.36	33	140	0.008	437.01
1	Disk Filters	-	-	-	-	-	-	-	2.000	437.00
Filter to UV	Pipe Length	60	-	30	46.4	2.36	20	140	0.005	435.00
1	UV Disinfection	-	-	-	-	-	-	-	0.500	435.00
UV to Outfall	Pipe Length	60	-	30	46.4	2.36	38	140	0.009	415.64
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.026	415.63
	Pipe Length	60	-	30	46.4	2.36	100.5	140	0.024	415.61
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.026	415.58
	Pipe Length	60	-	30	46.4	2.36	509.5	140	0.123	415.56
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.026	415.44
	Pipe Length	60	-	30	46.4	2.36	1182.5	140	0.286	415.41
	Bend	-	-	-	-	-	-	0.3	0.026	415.12
	Pipe Length	96	-	75	116	2.31	403	140	0.054	415.10
	Bend	-	-	-	-	-	-	0.3	0.025	415.04
	Pipe Length	96	-	75	116	2.31	143	140	0.019	415.02
1	Outfall	-	-	-	-	-	-	-	-	415
								Sum of Headloss (ft)	13.4	

Table G-3: Hydraulic Profile Calculations Phase 3 AADF

Location	Pipe, Fitting, or Process Unit	Diameter (in)	Width of Channel (ft)	AADF Flow (MGD)	AADF Flow (ft^3/s)	Velocity (ft/s)	Pipe/Channel Length (ft)	C or K	Headloss (ft)	WSEL (ft)
New IPS to Peak Flow Basin	Pipe Length	96	-	126	195	3.88	7.5	140	0.003	446.70
	JB 1 Inlet	-	-	-	-	-	-	0.5	0.117	446.70
	JB 1 Outlet	-	-	-	-	-	-	1	0.234	446.58
	Pipe Length	96	-	63	97	1.94	7.5	140	0.001	446.35
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.018	446.35
	Pipe Length	96	-	63	97	1.94	58	140	0.006	446.33
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.018	446.32
	Pipe Length	96	-	63	97	1.94	7.5	140	0.001	446.30
1	Peak Flow Basin	-	-	-	-	-	-	-	1.000	446.30
Peak Flow Basin to Junction Box 2	Pipe Length	54	-	22.5	34.8	2.19	17.5	140	0.004	445.30
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.022	445.30
	Pipe Length	54	-	22.5	34.8	2.19	53	140	0.013	445.28
2	JB 2 Inlet	-	-	-	-	-	-	0.5	0.037	445.26
2	JB 2 Outlet	-	-	-	-	-	-	1	0.074	445.23
Junction Box 2 to Primary Clarifier	Pipe Length	54	-	45	69.6	4.38	7.5	140	0.006	445.15
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.089	445.15
	Pipe Length	54	-	45	69.6	4.38	20	140	0.017	445.06
	Pipe Tee	-	-	-	-	-	-	0.2	0.060	445.04
	Pipe Length	54	-	45	69.6	4.38	177.5	140	0.152	444.98
	Pipe Tee	-	-	-	-	-	-	0.2	0.060	444.83
	Pipe Length	54	-	45	69.6	4.38	177.5	140	0.152	444.77
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.089	444.62
	Pipe Length	54	-	15	23.2	1.46	7.5	140	0.001	444.53
1	Primary Clarifier	-	-	-	-	-	-	-	2.500	444.53
Primary Clarifier to Junction Box 3	Pipe Length	33	-	15	23.2	3.91	20	140	0.025	442.03
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.071	442.00
	Pipe Length	54	-	15	23.2	1.46	170	140	0.019	441.93

3	JB 3 Inlet	-	-	-	-	-	-	0.5	0.017	441.91
3	JB 3 Outlet	-	-	-	-	-	-	1	0.033	441.90
Junction Box 3 to BNR Basin	Pipe Length	54	-	45	69.6	4.38	7.5	140	0.006	441.86
	Pipe Tee	-	-	-	-	-	-	0.2	0.060	441.86
	Pipe Length	54	-	25	38.7	2.43	70	140	0.020	441.80
	Pipe Tee	-	-	-	-	-	-	0.2	0.018	441.78
	Pipe Length	54	-	25	38.7	2.43	70	140	0.020	441.76
	Pipe Tee	-	-	-	-	-	-	0.2	0.018	441.74
	Pipe Length	54	-	25	38.7	2.43	70	140	0.020	441.72
	Pipe Tee	-	-	-	-	-	-	0.2	0.018	441.70
	Pipe Length	54	-	25	38.7	2.43	70	140	0.020	441.68
	Pipe Tee	-	-	-	-	-	-	0.2	0.018	441.66
	Pipe Length	54	-	25	38.7	2.43	70	140	0.020	441.64
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.028	441.62
	Pipe Length	33	-	5	7.7	1.30	7.5	140	0.001	441.60
1	Anaerobic Basin Weir	-	70	5	7.7	-	-	-	0.109	441.59
1	Anoxic Basin Weir	-	70	5	7.7	-	-	-	0.109	441.49
1	Aerobic Basin	-	-	-	-	-	-	-	1.200	441.38
BNR Basin to Junction Box 4	Pipe Length	33	-	5	7.7	1.30	7.5	140	0.001	440.18
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.008	440.18
	Pipe Length	54	-	15	23.2	1.46	70	140	0.008	440.17
	Pipe Tee	-	-	-	-	-	-	0.2	0.007	440.16
	Pipe Length	54	-	15	23.2	1.46	70	140	0.008	440.15
	Pipe Tee	-	-	-	-	-	-	0.2	0.007	440.15
	Pipe Length	54	-	15	23.2	1.46	12.5	140	0.001	440.14
	Pipe 90 Bend	-	-	-	-	-	-	0.2	0.007	440.14
	Pipe Length	54	-	15	23.2	1.46	205	140	0.023	440.13
4	JB 4 Inlet	-	-	-	-	-	-	0.5	0.017	440.11
4	JB 4 Outlet	-	-	-	-	-	-	1	0.033	440.09
Junction Box 4 to Final Clarifier	Pipe Length	54	-	15	23.2	1.46	7.5	140	0.001	440.06
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.010	440.06
	Pipe Length	54	-	15	23.2	1.46	195	140	0.022	440.05
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.010	440.03
	Pipe Length	54	-	15	23.2	1.46	7.5	140	0.001	440.02
1	Final Clarifiers	-	-	-	-	-	-	-	2.500	440.02
Final Clarifier to Junction Box 5	Pipe Length	33	-	15	23.2	3.91	12.5	140	0.015	437.52
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.071	437.50
	Pipe Length	54	-	15	23.2	1.46	190	140	0.021	437.43
5	JB 5 Inlet	-	-	-	-	-	-	0.5	0.017	437.41
5	JB 5 Outlet	-	-	-	-	-	-	1	0.033	437.39
Junction Box 5 to Filter	Pipe Length	60	-	45	69.6	3.55	8.7	140	0.004	437.36
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.059	437.35
	Pipe Length	60	-	45	69.6	3.55	408	140	0.209	437.29
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.059	437.09
	Pipe Length	60	-	45	69.6	3.55	33	140	0.017	437.03
1	Disk Filters	-	-	-	-	-	-	-	2.000	437.01
Filter to UV	Pipe Length	60	-	45	69.6	3.55	20	140	0.010	435.01
1	UV Disinfection	-	-	-	-	-	-	-	0.500	435.00
UV to Outfall	Pipe Length	60	-	45	69.6	3.55	38	140	0.019	416.34
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.059	416.32
	Pipe Length	60	-	45	69.6	3.55	100.5	140	0.051	416.26
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.059	416.21
	Pipe Length	60	-	45	69.6	3.55	509.5	140	0.261	416.15
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.059	415.89
	Pipe Length	60	-	45	69.6	3.55	1182.5	140	0.605	415.83
	Bend	-	-	-	-	-	-	0.3	0.059	415.23
	Pipe Length	96	-	100	155	3.08	403	140	0.092	415.17
	Bend	-	-	-	-	-	-	0.3	0.044	415.08
	Pipe Length	96	-	100	155	3.08	143	140	0.033	415.03
1	Outfall	-	-	-	-	-	-	-	-	415
								Sum of Headloss (ft)	13.5	

Table G-4: Hydraulic Profile Calculations Phase 3 PF

Location	Pipe, Fitting, or Process Unit	Diameter (in)	Width of Channel (ft)	AADF Flow (MGD)	AADF Flow (ft^3/s)	Velocity (ft/s)	Pipe/Channel Length (ft)	C or K	Headloss (ft)	WSEL (ft)
New IPS to Peak Flow Basin	Pipe Length	96	-	126	195	3.88	7.5	140	0.003	449.02
	JB 1 Inlet	-	-	-	-	-	-	0.5	0.117	449.01
	JB 1 Outlet	-	-	-	-	-	-	1	0.234	448.90
	Pipe Length	96	-	63	97	1.94	7.5	140	0.001	448.66
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.018	448.66
	Pipe Length	96	-	63	97	1.94	58	140	0.006	448.64
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.018	448.64
	Pipe Length	96	-	63	97	1.94	7.5	140	0.001	448.62
1	Peak Flow Basin	-	-	-	-	-	-	-	1.000	448.62
Peak Flow Basin to Junction Box 2	Pipe Length	54	-	33.75	52.2	3.28	17.5	140	0.009	447.62
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.050	447.61
	Pipe Length	54	-	33.75	52.2	3.28	53	140	0.027	447.56
2	JB 2 Inlet	-	-	-	-	-	-	0.5	0.084	447.53
2	JB 2 Outlet	-	-	-	-	-	-	1	0.168	447.45
Junction Box 2 to Primary Clarifier	Pipe Length	54	-	67.5	104.4	6.57	7.5	140	0.014	447.28
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.201	447.27
	Pipe Length	54	-	67.5	104.4	6.57	20	140	0.036	447.07
	Pipe Tee	-	-	-	-	-	-	0.2	0.134	447.03
	Pipe Length	54	-	67.5	104.4	6.57	177.5	140	0.321	446.90
	Pipe Tee	-	-	-	-	-	-	0.2	0.134	446.58
	Pipe Length	54	-	67.5	104.4	6.57	177.5	140	0.321	446.44
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.201	446.12
	Pipe Length	54	-	22.5	34.8	2.19	7.5	140	0.002	445.92
1	Primary Clarifier	-	-	-	-	-	-	-	2.500	445.92
Primary Clarifier to Junction Box 3	Pipe Length	33	-	22.5	34.8	5.86	20	140	0.052	443.42
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.160	443.37
	Pipe Length	54	-	22.5	34.8	2.19	170	140	0.040	443.21
3	JB 3 Inlet	-	-	-	-	-	-	0.5	0.037	443.17
3	JB 3 Outlet	-	-	-	-	-	-	1	0.074	443.13
Junction Box 3 to BNR Basin	Pipe Length	54	-	67.5	104.4	6.57	7.5	140	0.014	443.05
	Pipe Tee	-	-	-	-	-	-	0.2	0.134	443.04
	Pipe Length	54	-	37.5	58.0	3.65	70	140	0.043	442.91
	Pipe Tee	-	-	-	-	-	-	0.2	0.041	442.86
	Pipe Length	54	-	37.5	58.0	3.65	70	140	0.043	442.82
	Pipe Tee	-	-	-	-	-	-	0.2	0.041	442.78
	Pipe Length	54	-	37.5	58.0	3.65	70	140	0.043	442.74
	Pipe Tee	-	-	-	-	-	-	0.2	0.041	442.70
	Pipe Length	54	-	37.5	58.0	3.65	70	140	0.043	442.65
	Pipe Tee	-	-	-	-	-	-	0.2	0.041	442.61
	Pipe Length	54	-	37.5	58.0	3.65	70	140	0.043	442.57
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.062	442.53
	Pipe Length	33	-	7.5	11.6	1.95	7.5	140	0.003	442.47
1	Anaerobic Basin Weir	-	70	7.5	11.6	-	-	-	0.142	442.46
1	Anoxic Basin Weir	-	70	7.5	11.6	-	-	-	0.142	442.32
1	Aerobic Basin	-	-	-	-	-	-	-	1.200	442.18
BNR Basin to Junction Box 4	Pipe Length	33	-	7.5	11.6	1.95	7.5	140	0.003	440.98
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.018	440.98
	Pipe Length	54	-	22.5	34.8	2.19	70	140	0.017	440.96
	Pipe Tee	-	-	-	-	-	-	0.2	0.015	440.94
	Pipe Length	54	-	22.5	34.8	2.19	70	140	0.017	440.93
	Pipe Tee	-	-	-	-	-	-	0.2	0.015	440.91
	Pipe Length	54	-	22.5	34.8	2.19	12.5	140	0.003	440.89
	Pipe 90 Bend	-	-	-	-	-	-	0.2	0.015	440.89
	Pipe Length	54	-	22.5	34.8	2.19	205	140	0.049	440.88

4	JB 4 Inlet	-	-	-	-	-	-	0.5	0.037	440.83
4	JB 4 Outlet	-	-	-	-	-	-	1	0.074	440.79
Junction Box 4 to Final Clarifier	Pipe Length	54	-	22.5	34.8	2.19	7.5	140	0.002	440.72
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.022	440.72
	Pipe Length	54	-	22.5	34.8	2.19	195	140	0.046	440.69
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.022	440.65
	Pipe Length	54	-	22.5	34.8	2.19	7.5	140	0.002	440.62
1	Final Clarifiers	-	-	-	-	-	-	-	2.500	440.62
Final Clarifier to Junction Box 5	Pipe Length	33	-	22.5	34.8	5.86	12.5	140	0.033	438.12
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.160	438.09
	Pipe Length	54	-	22.5	34.8	2.19	190	140	0.045	437.93
4	JB 5 Inlet	-	-	-	-	-	-	0.5	0.037	437.88
4	JB 5 Outlet	-	-	-	-	-	-	1	0.074	437.85
Junction Box 5 to Filter	Pipe Length	60	-	67.5	104.4	5.32	8.7	140	0.009	437.77
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.132	437.76
	Pipe Length	60	-	67.5	104.4	5.32	408	140	0.442	437.63
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.132	437.19
	Pipe Length	60	-	67.5	104.4	5.32	33	140	0.036	437.06
1	Disk Filters	-	-	-	-	-	-	-	2.000	437.02
Filter to UV	Pipe Length	60	-	67.5	104.4	5.32	20	140	0.022	435.02
1	UV Disinfection	-	-	-	-	-	-	-	0.500	435.00
UV to Outfall	Pipe Length	60	-	67.5	104.4	5.32	38	140	0.041	417.68
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.132	417.64
	Pipe Length	60	-	67.5	104.4	5.32	100.5	140	0.109	417.51
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.132	417.40
	Pipe Length	60	-	67.5	104.4	5.32	509.5	140	0.552	417.27
	Pipe 90 Bend	-	-	-	-	-	-	0.3	0.132	416.71
	Pipe Length	60	-	67.5	104.4	5.32	1182.5	140	1.282	416.58
	Bend	-	-	-	-	-	-	0.3	0.132	415.30
	Pipe Length	96	-	100	155	3.08	403	140	0.092	415.17
	Bend	-	-	-	-	-	-	0.3	0.044	415.08
	Pipe Length	96	-	100	155	3.08	143	140	0.033	415.03
1	Outfall	-	-	-	-	-	-	-	-	415
								Sum of Headloss (ft)	17.2	

Appendix H: Opinion of Probable Construction Cost and Annual Operation and Maintenance

Table H.1: Phase 2 Opinion of Probable Construction Cost

Phase 2 OPCC					
Item	*Item Description*	*Unit*	*$/unit*	*# of Units*	*Total Cost*
1)	***Primary***				
a.	**Sitework**	-	-	-	-
	Excavation - Primary Clarifiers	CY	$40	2,980	$120,000
	Excavation - Peak Flow Basins	CY	$40	2,000	$161,000
	Excavation- Pump Station Building	CY	$40	27,500	$1,110,000
	Shoring - Peak Flow Basins	SF	$20	1,900	$76,000
	Shoring - Primary Clarifiers	SF	$20	2,020	$40,600
	Shoring - Pump Station Building	SF	$20	24,800	$498,000
b.	**Structural**	-	-	-	-
	Structural Concrete Foundation - Peak Flow Basin	CY	$803	498	$801,000
	Structural Concrete Walls - Peak Flow Basin	CY	$736	162	$239,000
	Structural Concrete Foundation and Walls - Primary Clarifier	EA	$1,180,000	1	$1,180,000
	Structural Concrete Foundation - Pump Station	CY	$803	548	$441,000
	Structural Concrete Walls - Pump Station	CY	$736	1,380	$1,020,000
c.	**Unit Cost**	-	-	-	-
	Primary Clarifier Mechanisms	EA	$587,000	1	$587,000
d.	**Mechanical**	-	-	-	-
	Pump Station 24" Horizontal Dry-Pit Pumps	EA	$254,000	9	$2,290,000
	Peak Flow Basin Mixers	EA	$20,800	3	$62,400
	Primary Clarifier Weir Covers	EA	$227,000	1	$227,000
	Chemical Dosing Static Mixer	EA	$59,200	1	$59,200
	Chemical Dosing Injection Lance	EA	$1,400	1	$1,400
	96" Ductile Iron Piping	FT	$1,030	1,110	$1,150,000
	54" Ductile Iron Piping	FT	$578	946	$547,000

e.	**Electrical and Instrumentation**	-	-	-	-
	Pump Station Variable Frequency Drive	EA	$100,000	7	$700,000
	Heavy Electrical (25% of Subtotal)	LS	N/A	N/A	$2,830,000
				Subtotal	$14,200,000
2)	***Secondary***				
a.	**Sitework**	-	-	-	-
	Excavation - BNR, Anaerobic Basins	CY	$40	830	$33,400
	Excavation - BNR, Anoxic Basins	CY	$40	2,910	$117,000
	Excavation - BNR, Aerobic Basins	CY	$40	8,920	$359,000
	Excavation - Final Clarifiers	CY	$40	3,770	$152,000
	Shoring - BNR, Anaerobic Basins	SF	$20	720	$14,400
	Shoring - BNR, Anoxic Basins	SF	$20	1,120	$22,400
	Shoring - BNR, Aerobic Basins	SF	$20	2,280	$45,600
	Shoring - Final Clarifiers	SF	$20	2,270	$45,400
b.	**Structural**	-	-	-	-
	Structural Concrete Foundation and Walls - Final Clarifier	EA	$1,320,000	1	$1,320,000
	Structural Concrete Foundation - BNR, Anaerobic Basin	CY	$803	207	$170,000
	Structural Concrete Foundation - BNR, Anoxic Basin	CY	$803	726	$590,000
	Structural Concrete Foundation - BNR, Aerobic Basin	CY	$803	2,230	$1,800,000
	Structural Concrete Walls - BNR	CY	$736	4,660	$3,430,000
c.	**Unit Cost**	-	-	-	-
	Final Clarifier Mechanisms	EA	$660,000	1	$660,000
d.	**Mechanical**	-	-	-	-
	Fine Bubble Diffuser Aeration Grid	EA	$77,500	16	$1,240,000
	Blowers	EA	$400,000	5	$2,000,000
	Mixers	EA	$20,800	40	$832,000
	54" Ductile Iron Piping	FT	$578	2,100	$1,214,000
	33" Ductile Iron Piping	FT	$353	173	$61,000

e.	**Electrical and Instrumentation**	-	-	-	-
	Heavy Electrical (25% of Subtotal)	LS	N/A	N/A	$3,530,000
				Subtotal	$17,700,000
3)	***Tertiary***				
a.	**Sitework**	-	-	-	-
	Excavation - Cloth Filters	CY	$40	8,560	$344,000
	Excavation - UV Disinfection	CY	$40	1,430	$57,500
	Shoring - Cloth Filters	SF	$20	7,280	$146,000
	Shoring - UV Disinfection	SF	$20	2,940	$58,800
b.	**Structural**	-	-	-	-
	Structural Concrete Foundation - Cloth Filters	CY	$803	917	$737,000
	Structural Concrete Foundation - UV Disinfection	CY	$803	102	$81,800
	Below Grade Structural Concrete Walls - Cloth Filters	CY	$736	241	$178,000
	Above Grade Metal Warehouse - Cloth Filtration	SF	$10	16,500	$165,000
	Below Grade Structural Concrete Walls - UV Disinfection	CY	$736	97	$72,000
	Above Grade Metal Warehouse - UV Disinfection	SF	$10	2,750	$28,000
c.	**Unit Cost**	-	-	-	-
	UV Disinfection Modules	EA	$51,600	4	$207,000
	Cloth Filtration System (22 Disk Filter)	EA	$950,000	3	$2,850,000
d.	**Mechanical**	-	-	-	-
	96" Ductile Iron Piping	FT	$1,030	546	$563,000
	60" Ductile Iron Piping	FT	$642	2,300	$1,480,000
e.	**Electrical and Instrumentation**	-	-	-	-
	Heavy Electrical (25% of Subtotal)	LS	N/A	N/A	$1,750,000
				Subtotal	$8,720,000
4)	***Odor Control***				
a.	**Sitework**	-	-	-	-
	Excavation	CY	$40	20	$810

	Shoring	SF	$20	256	$5,120
b.	**Structural**	-	-	-	-
	Structural Concrete Foundation	CY	$803	5	$5,000
c.	**Unit Cost**	-	-	-	-
	Dual Bed Activated Carbon Unit	EA	$350,000	1	$350,000
d.	**Electrical and Instrumentation**	-	-	-	-
	Light Electrical (15% of Subtotal)	LS	N/A	N/A	$54,200
				Subtotal	$416,000
5)	***Solids Handling***				
a.	**Sitework**	-	-	-	-
	Excavation - RAS/WAS Pump Building	CY	$40	395	$15,850
	Shoring - RAS/WAS Pump Building	SF	$20	2,670	$53,400
b.	**Structural**	-	-	-	-
	Structural Concrete Foundation - RAS/WAS Pump Building	CY	$803	99	$80,000
	Structural Concrete Walls - RAS/WAS Pump Building	CY	$736	134	$99,000
c.	**Mechanical**	-	-	-	-
	Sludge Dual Mixer/Aeration System - Sludge Holding Tank	EA	$200,000	1	$200,000
	RAS/WAS Positive Displacement Pumps	EA	$25,000	8	$200,000
d.	**Electrical and Instrumentation**	-	-	-	-
	Average Electrical (20% of Subtotal)	LS	N/A	N/A	$100,000
				Subtotal	$500,000
6)	***Phosphorus Sequestration***				
a.	**Sitework**				
	Excavation- Pearl Nutrient Recovery System Building	CY	$40	190	$7,620
	Shoring- Pearl Nutrient Recovery System Building	SF	$20	288	$5,760
b.	**Structural**	-	-	-	-
	Structural Concrete Foundation	CY	$803	190	$153,000
	Metal Warehouse	SF	$10	6,080	$61,000

c.	**Unit Cost**	-	-	-	-
	Pearl Nutrient Recovery System Equipment	EA	N/A	1	$8,000,000
d.	**Electrical and Instrumentation**	-	-	-	-
	Average Electrical (20% of Subtotal)	LS	N/A	N/A	$1,650,000
				Subtotal	$9,900,000
7)	***Paving, Earthwork, and Erosion Control Improvements***				
a.	**Sitework**				
	Clearing and Grubbing	AC	$2,500	30	$75,000
	Roadway Excavation	CY	$40	2,800	$113,000
	Site Pavement	CY	$161	75,400	$12,200,000
	Fabric Fence for Perimeter	LF	$3	4,250	$12,800
	Storm Water Pollution Prevention Plan	LS	$2,000	1	$2,000
				Subtotal	$12,500,000
8)	***Other Costs***				
	General Conditions/Bonds	3%			$1,910,000
	Engineering and Surveying Fee	10%			$6,400,000
	Geotechnical Fee	3%			$1,910,000
	Inspection Fees	4%			$2,540,000
	Contingency	30%			$19,100,000
				Subtotal	$31,900,000
				Total Cost	**$95,400,000**

Table H.2: Phase 3 Opinion of Probable Construction Cost

Phase 3 OPCC					
Item	*Item Description*	*Unit*	*$/unit*	*# of Units*	*Total Cost*
1)	***Primary***				
a.	**Sitework**	-	-	-	-
	Excavation - Primary Clarifiers	CY	$40	1963	$78,900
	Shoring- Primary Clarifiers	SF	$20	73	$2,000
b.	**Structural**	-	-	-	-
	Structural Concrete Foundation and Walls - Primary Clarifier	EA	$1,100,000	3	$3,300,000
c.	**Unit Cost**	-	-	-	-
	Primary Clarifer Mechanisms	EA	$550,000	3	$1,650,000
d.	**Mechanical**	-	-	-	-
	Pump Station Pumps- 24" Horizontal Dry-Pit	EA	$254,000	3	$762,000
	Primary Clarifier Weir Covers	EA	$75,667	3	$227,000
e.	**Electrical and Instrumentation**	-	-	-	-
	Light Electrical (15% of Subtotal)	LS	N/A	N/A	$869,000
				Subtotal	$6,890,000
2)	***Secondary***				
a.	**Sitework**	-	-	-	-
	Excavation - BNR	CY	$40	4356	$175,000
	Excavation - Final Clarifiers	CY	$40	1963	$78,900
	Shoring- BNR	SF	$20	161	$3,230
	Shoring- Final Clarifiers	SF	$20	73	$1,460
b.	**Structural**	-	-	-	-
	Structural Concrete Foundation and Walls - Final Clarifier	EA	$1,100,000	3	$3,300,000
	Structural Concrete Foundation - BNR	CY	$803	4356	$3,500,000
	Structural Concrete Walls - BNR	CY	$736	3500	$2,580,000

c.	**Unit Cost**	-	-	-	-
	Final Clarifer Mechanisms	EA	$550,000	3	$1,650,000
d.	**Mechanical**	-	-	-	-
	Fine Bubble Diffused Aeration Grid	EA	$103,333	12	$1,240,000
	Mixers	EA	$20,702	24	$497,000
	Blowers	EA	$400,000	5	$2,000,000
e.	**Electrical and Instrumentation**	-	-	-	-
	Heavy Electrical (25% of Subtotal)	LS	N/A	N/A	$3,760,000
				Subtotal	$18,800,000
3)	***Tertiary***				
a.	**Unit Cost**	-	-	-	-
	UV Disinfection Channels	EA	$157,750	4	$631,000
	Filtration Main "V-Ring" Seal	EA	$1,051	5	$5,260
	Filter Media Cloths (8/disk)	EA	$469	880	$413,000
b.	**Electrical and Instrumentation**	-	-	-	-
	Heavy Electrical (25% of Subtotal)	LS	N/A	N/A	$263,000
				Subtotal	$1,320,000
4)	***Paving, Earthwork, and Erosion Control Improvements***				
a.	**Sitework**				
	Revegatation of Disturbed Areas	AC	$350	40	$14,000
	Fabric Fence for Perimeter	LF	$3	4,500	$13,500
				Subtotal	$28,000
5)	***Other Costs***				
	General Conditions/Bonds	3%			$812,000
	Engineering and Surverying Fee	10%			$2,710,000
	Geotechnical Fee	3%			$812,000
	Inspection Fees	4%			$1,090,000
	Contingency	25%			$6,760,000

		Subtotal	$12,200,000
		Total Cost	**$39,300,000**

Table H.3: Operation and Maintenance Costs

OEM				
Electrical Costs				
Component (no. of units)	**Horsepower**	**Operation (hr/day)**	**KW-hr/day**	**KW-hr/year**
Lift Station Pumps (9 online)	5553	24	99383	36,274,631
Aeration Basin Blowers (10)	3750	24	67114	24,496,644
Positive Displacement Thickener Pumps (4)	1120	24	20045	7,316,331
Sludge Thickening Blowers (3)	900	24	16107	5,879,195
BNR Basin Mixers (48)	144	24	2577	940,671
UV Lamps (360)	338	24	8110	2,960,284
Filter Backwash Pump (1) and Motor (1)	515	24	691	252,055
Odor Control Fan Motor (1)	25	24	444	1.22
			Net Total	78,119,813
			Austin Power Unit Price ($/KW-hr)	$ 0.12
			2023 Present Annual Power Cost	*$ 9,374,378*

Maintenance Costs			
Component	**Capital Cost**	**Rate**	**Maintenance Cost**
BNR System	$3,474,000	3.5%	$121,590
Odor Control System	$350,000	3.5%	$12,250
Chemical Feed System	$60,600	3.5%	$2,121.0
Pump Station System	$2,286,000	3.5%	$80,010
Primary Clarifier System	$3,752,388	3.5%	$131,334
Final Clarifier System	$3,300,000	3.5%	$115,500
UV Disinfection System	$1,464,808	3.5%	$51,268
Cloth Filtration System	$623,738	3.5%	$21,830.8
Phosphorus Recovery System	$8,000,000	3.5%	$280,000
		Total Annual	*$ 815,904*

Sludge Disposal Costs	
Component	**Ton/Year**
Headworks Disposal	13,038
Net Annual Disposal Costs	$ 391,134.00

Chemical Costs			
Component	**Consumption Rate (ton/day)**	**Chemical Unit Cost ($/ton)**	**Annual Chemical Costs ($/year)**
Magnesium Hydroxide	18.3	$500	$ 3,339,750
Ferric Chloride	9.4	$600	$ 2,068,800

Ammonia	0.5	$3,520	$ 697,782	
Crystal Green™	7.6	$150	$ (417,300)	
		Total Annual	*$ 5,689,032*	
Labor Costs				
Component (no. of units)	**Days of Operation/week**	**Man Hours /week**	**$/hr**	**Weekly Labor Costs**
Plant Supervisor (2)	5	40	$ 59.04	$ 4,723.38
Maintenance Crew (10)	5	40	$ 25.00	$ 10,000.00
Training Programs (12)			*Overall Program Cost*	$ 13,000.00
			Total Weekly	$ 14,723.38
			Total Annually	$ 778,616.00
			TOTAL ANNUAL COST	***$ 17,050,000.00***

H.1.1 Excavation

WEAT OPCC (2009 Dollars) Excavation = \$30/CY

$$Cost\ estimation\ (2023\ dollars) = WEAT\ OPCC\ estimation\ \times\ rate\ of\ inflation$$
$$\$30/CY \times 1.338 \cong \$40/CY$$

$$Total\ Excavation\ Cost\ (per\ unit) = length\ of\ unit\ \times\ width\ of\ unit \times 1\ ft\ depth$$

H.1.2 Shoring

WEAT OPCC (2009 Dollars) Shoring = \$15/SF

$$Cost\ estimation\ (2023\ dollars) = WEAT\ OPCC\ estimation\ \times\ rate\ of\ inflation$$
$$\$15/SF \times 1.338 \cong \$20/SF$$

H.1.3 Structural Concrete Foundation

WEAT OPCC (2009 Dollars) Concrete Foundation = \$600/CY

$$Cost\ estimation\ (2023\ dollars) = WEAT\ OPCC\ estimation\ \times\ rate\ of\ inflation$$
$$\$600/CY \times 1.338 \cong \$803/CY$$

$$Total\ Concrete\ Foundation\ Cost\ (per\ unit) = length\ of\ unit\ \times\ width\ of\ unit$$

H.1.4 Structural Concrete Walls

WEAT OPCC (2009 Dollars) Concrete Walls = \$550/CY

$$Cost\ estimation\ (2023\ dollars) = WEAT\ OPCC\ estimation\ \times\ rate\ of\ inflation$$
$$\$550/CY \times 1.338 \cong \$736/CY$$

$$Total\ Concrete\ Wall\ Cost\ (per\ unit) = length\ of\ unit\ \times\ width\ of\ unit \times\ 1.5\ ft\ wall\ thickness$$

H.1.5 Piping

Pipe costs based on FairFax Water (2021 Dollars) using Ductile Iron Pipe, Class 52, GFL, Zinc

FairFax Water (2021 Dollars) 24" Pipe = \$95.98/FT

$$Cost\ estimation\ (2023\ dollars) = FairFax\ Pipe\ estimation\ \times\ rate\ of\ inflation$$
$$\$95.98/FT \times 1.115 \cong \$107$$

$$Total\ Piping\ Cost\ (per\ pipe\ size) = length\ of\ unit\ \times\ pipe\ cost\ rate$$

H.1.6 Unit Mechanisms

Pump Station:
Pumps were based on a TDH of 50 ft for Phase 2 and 52 ft for Phase 3. The 24” 617 HP Horizontal Dry-Pit pump was selected (provided by Grundfos).

$$Pump\ Station\ Pump\ Cost\ Estimation$$
$$= number\ of\ pumps \times Grundfos\ cost\ estimation \left(\frac{\$}{unit}\right)$$
$$= \left(10\ pumps \times \frac{\$254{,}000}{pump}\right) + \left(10\ VFD\ controls \times \frac{\$100{,}000}{VFD\ control}\right)$$
$$= \$3{,}540{,}000$$

Clarifiers:
Primary and Final Clarifiers were designed to have 150’ diameters and a budgetary mechanism cost was provided by Monroe.

$$Clarifier\ Mechanism\ Cost\ Estimation$$
$$= number\ of\ clarifiers \times Monroe\ cost\ estimation \left(\frac{\$}{unit}\right)$$
$$= \left(12\ clarifiers \times \frac{\$550{,}000}{clarifier}\right)$$
$$= \$6{,}600{,}000$$

Chemical Dosing:
Magnesium Hydroxide will be supplied with a ½” stainless steel injection quill in a 48” 316L Stainless Steel mixer (provided by Statiflo).

Assumed influent Alkalintiy= 150 g/m^3 as $CaCO_3$
NO_3^- produced = 33.93 g/m^3

$$Alkalinity\ required\ for\ nitrification\ (via\ Metcalf\ and\ Eddy) = 7.14 \frac{g\ CaCO_3}{g\ NO_3\ produced}$$
$$Alkalinity\ produced\ (via\ Metcalf\ and\ Eddy) = 3.57 \frac{g\ CaCO_3}{g\ NO_3\ denitrified}$$
$$Alkalinity\ needed\ to\ maintain\ neutral\ pH\ (via\ Metcalf\ and\ Eddy) = 75\ g\ CaCO_3$$
$$0 = influent\ alkalinity - alkalinity\ required + alkalinity\ produced - alkalinity\ pH + alkalinity\ added$$
$$0 = 150 \frac{g}{m^3} - (7.14)\left(33.93 \frac{g}{m^3}\right) + (3.57)\left(33.93 \frac{g}{m^3} - 7 \frac{g}{m^3}\right) - 75 \frac{g}{m^3} + Alkalinity\ added$$
$$Alkalinity\ added = 71.12 \frac{g}{m^3}\ as\ CaCO_3$$

$$71.12\ \frac{g}{m^3}\ as\ CaCO_3 * \left(\frac{1\ eq}{50\ g\ CaCO_3}\right)\left(\frac{2\ eq\ Mg(OH)_2}{2\ eq\ CaCO_3}\right)\left(\frac{29.2g\ Mg(OH)_2}{1\ eq\ Mg(OH)_2}\right)$$
$$= 41.53\ \frac{g}{m^3}\ Mg(OH)_2$$

$$Phase\ 3\ Flow = 400{,}313\ \frac{m^3}{d}\ (from\ solids\ balance)$$
$$\left(41.53\ \frac{g}{m^3}\ Mg(OH)_2\right)\left(400{,}313\ \frac{m^3}{d}\right) = 16{,}625\frac{kg}{d} = 18.3\frac{ton}{d}$$
$$MgOH\ Cost\ Estimation = rate\ of\ consumption\ \left(\frac{ton}{d}\right) \times\ chemical\ unit\ cost\ \left(\frac{\$}{ton}\right)$$
$$= (18.3\frac{ton}{d}) \times \frac{\$500}{ton\ MgOH} = \$9{,}150/d$$

BNR:
Fine Bubble Diffused Aeration Grids were designed and provided by Sanitaire with a total air rate of 25,937 scfm for the BNR units. Each aeration grid was designed to have 1,476 diffusers.

$$Aeration\ Grids\ Cost\ Estimation$$
$$= number\ of grids\ \times\ Sanitaire\ cost\ estimation\ \left(\frac{\$}{unit}\right)$$
$$= \left(24\ grids\ \times \frac{\$103{,}333}{grid}\right)$$
$$= \$2{,}200{,}000$$

Blowers were designed and provided by Kaeser.

$$Blowers\ Cost\ Estimation = number\ of\ blowers\ \times\ Kaeser\ cost\ estimation\ \left(\frac{\$}{unit}\right)$$
$$= \left(10\ turbo\ blowers\ \times \frac{\$400{,}000}{blower}\right)$$
$$= \$4{,}000{,}000$$

UV Disinfection:
The UV Channels were designed as parallel UVLW-3080-24 channels (provided by Evoqua).

$$UV\ Disinfection\ Channels\ Cost\ Estimation$$
$$= number\ of\ channels\ \times\ Evoqua\ cost\ estimation\ \left(\frac{\$}{unit}\right)$$
$$= \left(10\ channels\ \times \frac{\$196{,}750}{channel}\right)$$

$$= \$1{,}967{,}375$$

Filtration:
The cloth disk filtration system estimates were based on Aqua-Aerobic Systems respective designs.

$$Cloth\ Filtration\ System\ Cost\ Estimation$$
$$= Main\ V\ Ring\ Seal\ unit \times\ AquaAerobic\ Systems\ cost\ estimation\ \left(\frac{\$}{unit}\right)$$
$$+ Media\ Cloth\ unit \times\ AquaAerobic\ Systems\ cost\ estimation\ \left(\frac{\$}{unit}\right)$$
$$= \left(8\ seal\ units\ \times \frac{\$1{,}051}{seal}\right) + \left(1{,}312\ cloth\ filters\ \times \frac{\$469}{cloth\ filter}\right)$$
$$= \$623{,}738$$

Phosphorus Recovery:
The Pearl Nutrient Recovery System design was provided by Evoqua. This includes the chemical storage tanks, bagging system, dryer/heater, and the Ostara Pearl 10K reactor. There will be 439 tons of phosphorus removed per year.

$$Pearl\ Nutrient\ Recovery\ System\ Cost\ Estimation$$
$$= Nutrient\ Recovery\ System \times\ Evoqua\ cost\ estimation\ \left(\frac{\$}{unit}\right)$$
$$= \left(1\ recovery\ system\ unit\ \times \frac{\$8{,}000{,}000}{unit}\right)$$
$$= \$8{,}000{,}000$$

$$Ferric\ Chloride\ Cost\ Estimation$$
$$= Ferric\ Chloride\ required\ \left(\frac{ton}{yr}\right) \times\ Evoqua\ cost\ estimation\ \left(\frac{\$}{ton}\right)$$
$$= \left(3{,}448 \frac{ton}{yr} \times \frac{\$600}{ton}\right)$$
$$= \$2{,}068{,}000/yr$$

$$Ammonia\ Cost\ Estimation = Ammonia\ removed\ \left(\frac{lb}{yr}\right) \times\ Evoqua\ cost\ estimation\ \left(\frac{\$}{lb}\right)$$
$$= \left(396{,}467 \frac{lb}{yr} \times \frac{\$1.76}{lb}\right)$$
$$= \$697{,}800/yr$$

$$Crystal\ Green^{\text{™}}\ Revenue\ Estimation$$
$$= CG\ Production\ (\frac{ton}{yr}) \times\ Evoqua\ cost\ estimation\ \left(\frac{\$}{ton}\right)$$
$$= \left(2{,}782\frac{ton}{yr} \times \frac{\$150}{ton}\right)$$
$$= \$417{,}200/yr$$

Appendix I: Construction Sequencing

Construction Sequencing

Walnut Creek WWTP Expansion Project

TTU WEAT 2023

Start Date: 6/1/2023 | Planned Construction Duration | Permit Expiration: 3/2025

2023: Jun 1, Jul 2, Aug 3, Sep 4, Oct 5, Nov 6, Dec 7 | 2024: Jan 8, Feb 9, Mar 10, Apr 11, May 12, Jun 13, Jul 14, Aug 15, Sep 16, Oct 17, Nov 18, Dec 19 | 2025: Jan 20

Item	Start Month	Duration
Phase 2		
Excavate, Roadways, Site Work	1	1
Pipe Installation	1	2
Install Pump Station	3	4
Install Primary Clarifiers	3	6
Install Peak Basins	3	7
Install BNR Units	4	7
Install Secondary Clarifiers	5	6
Install Cloth Filtration	6	2
Install UV Disinfection	6	2
Retrofit Thickener to Holding Basin	8	1
Install Pearl 10k Reactor	8	1
Completion for Permit Phase 2		
Phase 3A		
Modification of BNR at Existing Plant	11	6
Phase 3B		
Install Primary Clarifiers	14	6
Install BNR Units	14	7
Install Secondary Clarifiers	15	6
Install Cloth Filtration	16	2
Install UV Disinfection	17	2
Completion for Permit Phase 3		

Figure I-1: Expansion Project 20-Month Construction Schedule

Construction Sequencing with TCEQ Extension

Walnut Creek WWTP Expansion Project

TTU WEAT 2023

Start Date: 6/1/2023
End Date: 6/31/2027

🟩 **Planned Construction Duration**

Item	Start Month	Duration
Phase 1 (no. of units)		
Excavate, Roadways, Sitework	1	3
Pipe Installatioin	3	2
Install Pump Station (1)	5	6
Install Peak Basins (2)	6	8
Install Primary Clarifiers (3)	9	7
Install BNR Complexes (3)	12	10
Install Secondary Clarifiers (3)	15	7
Install Cloth Filtration (3)	16	6
Install UV Disinfection (4)	18	5
Retrofit Thickener to Holding Basin (1)	20	4
Install Pearl 10k Reactor (1)	22	2
Implement BNR at Old Plant (ASC1)	24	4
Implement BNR at Old Plant (ASC2)	28	4
Implement BNR at Old Plant (ASC3)	32	4
Phase 2		
Install Primary Clarifiers (3)	38	8
Install BNR Complexes (3)	39	10
Install Secondary Clarifiers (3)	41	7
Install Cloth Filtration (5)	43	5
Install UV Disinfection (3)	45	3

Figure I-2: Expansion Project 5-year Construction Schedule with TCEQ Extension

Appendix J: Site Visit Pictures

Figure J-1: Coarse Screen in HW 2

Figure J-2: Grit Chamber in HW 2

Figure J-3: Primary Clarifier in PTC 2

Figure J-4: Flow Equalization Basin in PTC 2

Figure J-5: Settled Wastewater Pumps in Operations Building

Figure J-6: Aeration Basin in ASC 1

Figure J-7: Flocculation Basin in ASC 1

Figure J-8: Final Clarifier in ASC 1

Figure J-9: Chlorine Contact Basin in ASC 1

Figure J-10: Gravity Filtration Unit

Figure J-11: Gravity Thickener

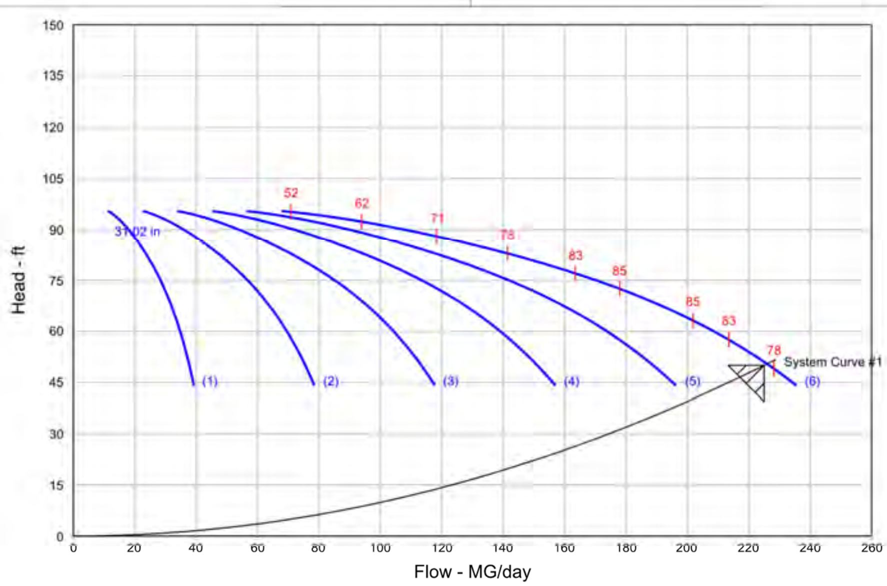
Figure J-12: Carbon Adsorption Odor Control Units

Appendix K: Manufacturing

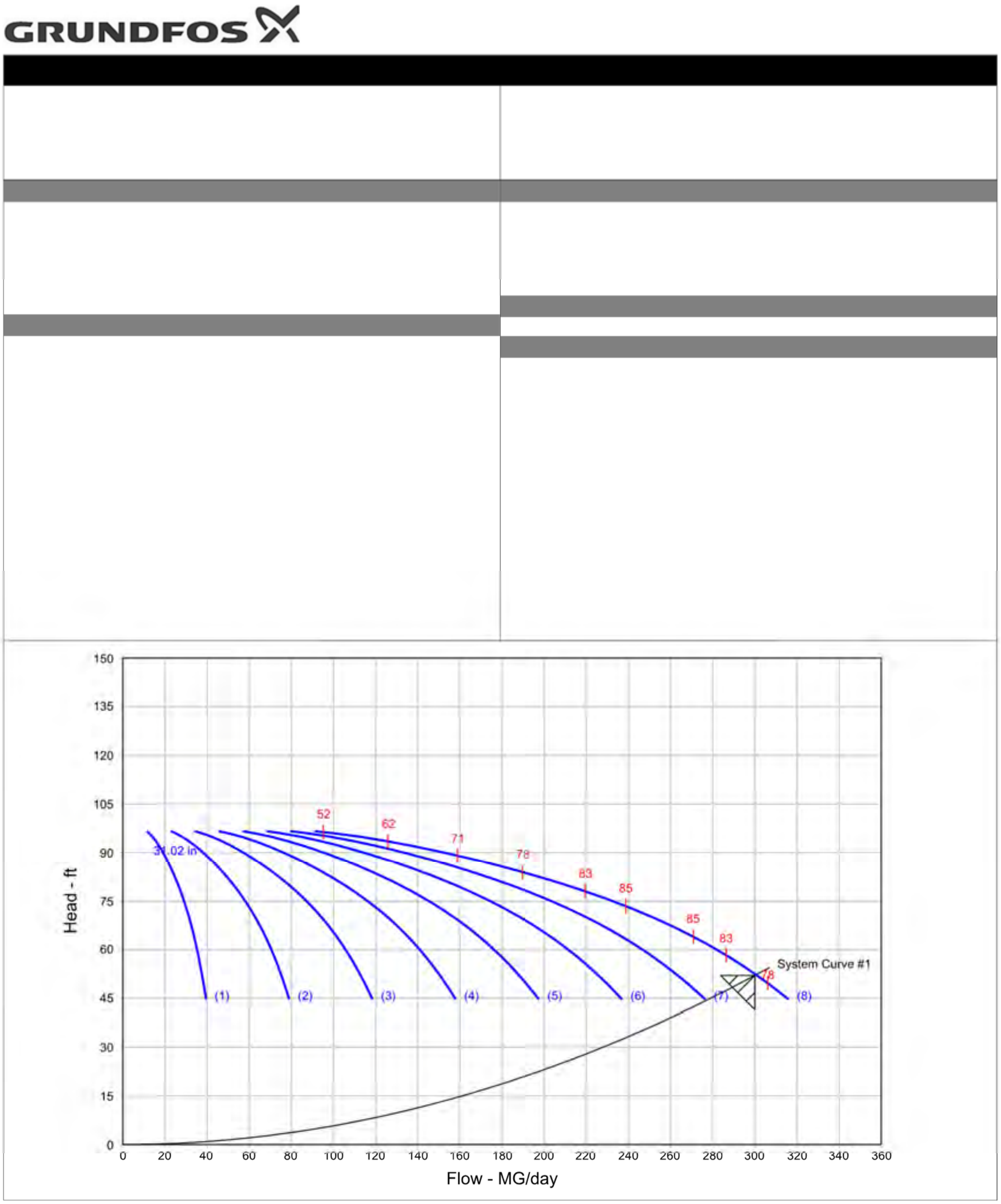
K.1 Pump Station Positive Displacement Pumps (via Grundfos)

Phase 2 Pump Performance Sheet (7 Pumps online)

GRUNDFOS



Phase 3 Pump Performance Sheet (9 Pumps online)



Additional Data on the Pump Performance

GRUNDFOS

Grundfos Quotation System 22.4.2

Pump Performance - Additional Data

Project name	: [redacted]	Tag Number	: Phase 2 (6 Duty + Spare)
Consulting engineer	:	Service	: Influent Pump Station @ WWTP
Customer	:	Model	: S4.50.A240.6170.10.78E
Customer ref. / PO	:	Quantity	: 7
Quote Number / ID	: 1885057	Quoted By (Sales Office)	: PIERCE PUMP
Date last saved	: 02/14/2023 12:28 PM	Quoted By (Sales Engineer)	: Kyle Lewis
Stages	: 1	Speed, rated	: 653 rpm

Performance Data		Stage, Speed and Solids Limits	
Head, maximum speed, rated flow	: 50.99 ft	Stages, maximum	: 1
Head maximum, rated speed	: 95.45 ft	Pump speed limit, maximum	: 713 rpm
Efficiency adjustment factor, total	: 1.00	Pump speed limit, minimum	: 713 rpm
Mechanical Limits		Curve speed limit, maximum	: 720 rpm
Torque, rated power, rated speed	: 64.70 hp/100 rpm	Curve speed limit, minimum	: 600 rpm
		Solids diameter limit	: 5.00 in
		Typical Driver Data	
		Driver speed, full load	: 700 rpm
		Driver speed, rated load	: 706 rpm
		Driver efficiency, 100% load	: N/A
		Driver efficiency, 75% load	: N/A
		Driver efficiency, 50% load	: N/A

Various Performance Data	Flow (MG/day)	Head (ft)	Efficiency (%)	NPSHr (ft)	Power (hp)
Shutoff, rated speed	0.00	87.66	-	-	230
MCSF	12.04	95.06	52.63	-	381
Rated flow, maximum speed	225.0	50.99	84.45	-	568
BEP flow, rated speed	31.73	67.99	85.60	-	442
120% rated flow, rated speed	45.00	12.65	42.58	-	234
End of curve, rated speed	39.26	44.03	74.27	-	408
Maximum value, rated speed	-	95.45	85.60	-	444

System differential pressure	@ Density, rated	@ Density, max
Differential pressure, rated flow, rated speed (psi)	22.07	22.07
Differential pressure, shutoff, rated speed (psi)	37.94	37.94

Discharge pressure	@ Suction pressure, rated	@ Suction pressure, max	@ Suction pressure, rated	@ Suction pressure, max
Discharge pressure, rated flow, rated speed (psi.g)	22.07	22.07	22.07	22.07
Discharge pressure, shutoff, rated speed (psi.g)	37.94	37.94	37.94	37.94

Ratios			
Maximum flow / rated flow, rated speed	: 104.69 %	Head rated speed / head minimum speed, rated flow	: -

Construction			
Motor	: Explosion Proof-STD Option, Best Lead time	Installation	: Dry Installation, Horizontal
Phase & Voltage	: Three Phase, 460 V	Cable	: STD

PIERCE PUMP · 9010 John W. Carpenter Frwy · Dallas, TX 75247-4520
phone: 214-320-3604 · fax: 214-328-5665

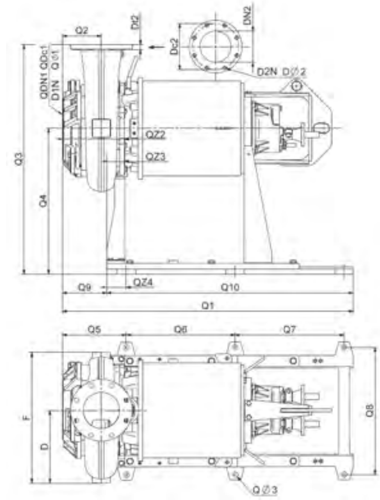
Construction Details on the Pump Station Pumps

GRUNDFOS

Grundfos Quotation System 22.4.2

General Arrangement

Project name	: [redacted]	Tag Number	: Phase 2 (6 Duty + Spare)
Consulting engineer	:	Service	: Influent Pump Station @ WWTP
Customer	:	Model	:
Customer ref. / PO	:	Quantity of pumps	: 7
Quote Number / ID	: 1885057	Quoted By (Sales Office)	: PIERCE PUMP
Date last saved	: 02/14/2023 12:28 PM	Quoted By (Sales Engineer)	: Kyle Lewis



NOT FOR CONSTRUCTION, UNLESS CERTIFIED AND REFERENCED ON ORDER

Units	D	F	DT2	Dc02	D02	D2N	DN2	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	QZ2	QZ4	QDc1	QDN1	Q03	Q01	QD1N
inches	**43.3**	**76**	**1.6**	**29.5**	**1.4**	**0.8**	**24"**	**133.9**	**23.6**	**101.4**	**43.3**	**43.5**	**39.4**	**39.4**	**44.9**	**41.1**	**86.6**	**3.1**	**60**	**38.5**	**32"**	**964**	**M33**	**1.10**

Conditions of Service		Motor Data			
Flow: 37.50 MG/day	Fluid: Cold Water	HP: 617	Encl: IP68	Phase: 3	Efficiency: 94
TDH: 50.00 ft	Temp.: 20.00 deg F	RPM: 653 rpm	Hz: 60	Voltage: 460	S.F.: 1.15

K.2 Clarifiers (Monroe Environmental, Protectolite Composites)

Conversation with Monroe Environmental Sent Via Email:

> Per our discussion, we'd figure for a budgetary cost of about $550,000 per 150' diameter clarifier mechanism. This assumes installation of the Monroe Clarifier into a concrete basin tank (pricing for tank not included). If you need to ballpark the tank, you could double the equipment cost.

Protectolite Composites, Inc. Quote for Primary Clarifier Weir Covers

PROTECTOLITE COMPOSITES INC.   The State of the Part—Customized to Your Needs

LONG DESCRIPTION QUOTATION FORM

To:	From: Karl Szasz
Company: HRM Environmental	Email: kszasz@protectolite.com
Email:	Your Reference:
Phone: 817-571-9494	Our Reference:
Fax:	Date: February 27, 2023
Re: [redacted]	Closing:

Please review the ***Budget Pricing & scope of supply*** for the Protectolite FRP components as installed for the El Paso Hickerson WWTP Improvements project.

There are *3 tanks;* each circular tank is 150' in diameter.

Protectolite™ FRP wastewater components for the clarification process are modular in design; they are made of Protectolite FRP composite and are suitable for outdoor exposure in wastewater environments. They have been installed all over North America from the deep south of El Paso, Texas to the near north of Ft. McMurray, Alberta; *for over 20+ years*, Protectolite™'s FRP wastewater products have met the tough requirements of the wastewater environment.

- *All Protectolite™ FRP components are matched-die-molded, precision made, under high heat & pressure*.
- *All FRP components are designed and manufactured by Protectolite™ Composites.*

Protectolite Composites Inc. • 84 Railside Road • Toronto, Ontario M3A 1A3 • p 416-444-4484 • f 416-444-4485
kszasz@protectolite.com • www.protectolite.com

Protectolite Composites, Inc. Quote for Primary Clarifier Weir Covers

PROTECTOLITE™ The State of the Part—Customized to Your Needs

Protectolite FRP Launder Covers with *opening to the side of the tank for each cover* are modular in design and are as previously supplied to the four 150" diameter clarifier tanks at the El Paso Hickerson facility as few years ago.

- The hinged cover size is approximately 37" x 36" and is made of ¼" thick Protectolite FRP.
- The fixed cover section is approximately 39-13/16" x 12" is made of ¼" thick Protectolite FRP.
- All covers are mounted on either FRP brackets & supports.
- All covers have a hinged section which will open to the side as pictured below.
- Assembly & anchor hardware in 304SS.

Design of Launder Covers which open to the side:

3 tank price is $226,194.50

Included in all FRP items above:

Protectolite Composites Inc. • 84 Railside Road • Toronto, Ontario M3A 1A3 • p 416-444-4484 • f 416-444-4485
kszasz@protectolite.com • www.protectolite.com

K.3 BNR (via Xylem, Kaeser, Sharpe)

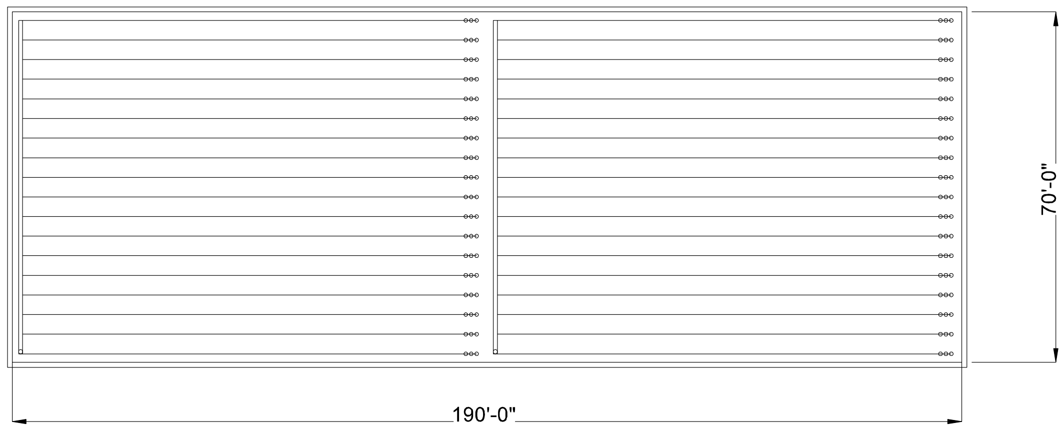
Conversation with Xylem on Aeration Grids Via Email:

Thanks for the design update! Based on the loadings, flows, and tank dimensions you had provided, I've determined a total air rate of 25,937 scfm for the six (6) 190' x 70' x 17.9' SWD tanks. Given this air flow, we would recommend two (2) diffused aeration grids per tank, with each grid having 1,476 diffusers. Phase 1 would include twelve (12) total grids with 17,712 diffusers. Attached is a prelim layout sketch of what the grid layout would look like.

Our budget price for the Phase 1 diffused aeration equipment is **$1,240,000**. Since Phase 2 would consist of the same equipment, you can use the same budgetary price.

Thanks for your patience on this. Please let me know if you have any additional questions. Good luck on your project!

Design Details on the Aeration Grids:



Single Train Information

Grid No	Grid Count	Drop Leg Ø"	Header Count	Header Spc,ft.	Header Len,ft.	Discs/ Grid	At/ Ad	Discs/ Train
1	2	10	18	3.92	91.67	1476	10.99	2952

Total Discs/Train 2952
Note: Some headers may be omitted for clarity

PRELIMINARY - THIS DRAWING IS NOT INTENDED FOR CONTRACT DOCUMENTS, SUBMITTALS OR CONSTRUCTION

Sanitaire
a xylem brand
BROWN DEER, WISCONSIN 53223

CUST NO.
DWG NO.

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WEAT Student Design
[redacted]
9" Disc Aeration System

DRAWN BY ts
DATE 2/7/23
CHKD BY
DATE
APPVD BY
DATE
MODEL
JOB XXXXX
SHEET

Conversation with Kaeser on Blowers Via Email:

The best blower for wastewater treatment is a high quality tri-lobe rotary blower. The problem with them is they max out about 2,500 to 3,200 scfm depending on the discharge pressure. So you might need 13 blowers or more total.

Think of wastewater treatment like this. . .it's a big, heavy, messy load to haul and your choices are:

- Turbo Blower is fancy like a Lamborghini. Impressive technology but not a load hauler.
- Rotary Screw blower is like an SUV. Great efficiency but the tolerances to get there give you trouble in Texas heat.
- Rotary Lobe blower is the 3/4 ton, 4 wheel drive truck. Not pretty, not fancy, but it will haul the load.
- Multi-stage centrifugal is the old, gas engine truck. Not a bad choice though. They're pretty picky about pressure.

All that said, in our industry today, only the "Turbo" blower is fashionable. I sat through a meeting recently where the operators complained to the engineer about the problems with their turbo's and how much they dislike them. They then transitioned to discussing buying two more. Go figure.

I would divide your 27 mgd into 5 trains of 5.4 mgd and 7,000 scfm each because I don't believe biological treatment is infinitely scalable. Then I would put 4 rotary lobe blowers on each train at 2,500 scfm or so. So we're talking 20 blowers total.

What I recommend you do is put in 5 turbo blowers at 9,000 scfm or so. You'll need a 42" blower manifold and a 24" air supply to each of your 3 trains.

Sharpe Quote on BNR Mixers:

Sharpe Mixers
EBARA CORPORATION

Hayward Gordon GROUP
EBARA

QUOTATION

Customer: [redacted]

Date : February 21, 2023
Validity: 60 Days
Proposal No. : Q3-73606
Est. Shipment : 18 weeks
> after drawing approval or release
>
Terms : NET 30 DAYS, OAC

Application :	**Anoxic/Anaerobic Zone Mixer** — **ON-CENTER MOUNTING**
Design conditions :	Viscosity(cps): 1 , Sp.Grav: 1.00 Temp.: Ambient Pressure: Atmospheric
Tank dimensions :	240 Wide x 840 long x 216.0 " overall height from mixer base to tank floor Tank Volume (gallons)= 179100
Liquid levels:	Design max (from tank floor): 206"; Min. Liquid Level: 111"
Equipment :	**N-SERIES HELICAL DRIVE TOP-ENTERING MIXER** Quantity : 4 **Mixer Model # 3N4 -75**
Motor :	3.00 Horsepower, @ 1750 RPM, 3PH, 60Hz, 230/460 VOLTS TE-INV.DUTY 182TC Frame, Motor Furnished by Sharpe , Mounted by Sharpe TEFC- PREMIUM EFFICIENT
Mixer Drive :	N4 Parallel Helical Gearbox with OilSafe Effective Drywell 75.4:1 Ratio, Rated at 5.18 Horsepower
Mixer mounting :	Mounting Plate Furnished
Wetted Parts :	SS316
Shaft :	3.50 "Dia. X 158 " long from mounting base, turning @ 23 RPM Includes No In-Tank Shaft Coupling
Impellers :	***26 " min. opening required to install impeller*** 88.0 "dia HYF-218 Hydrofoil Impeller Split Cast Hub Pumping Down, Turning Clockwise Looking Down
Price each USD:	***$20,702*** ***Total, (4) mixers= $82,808*** *Weight of each mixer = 800 lbs* *Freight to TX jobsite included in price* *(3) mixer for Anoxic Zone - 70 ft wide x 70 ft long x 17.9 ft deep* *(1) mixer for Anaerobic Zone - 20 ft wide x 70 ft long x 17.0 ft deep*

Please address your order to:
Hayward Gordon
5 Brigden Gate
Halton Hills, ON L7G 0A3

Note - This quote is valid for 30 days. Any order placed as a result of this proposal is subject to Sharpe Mixers Terms and Conditions.

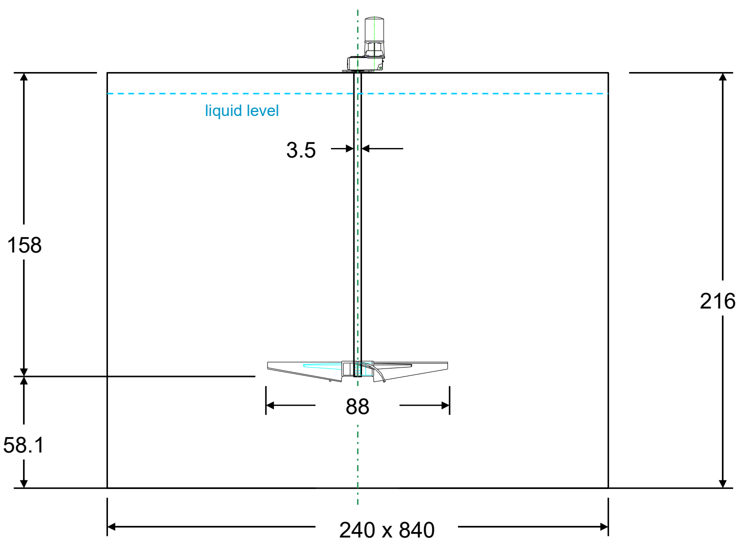
Sharpe Mixers
EBARA CORPORATION
Sharpe Mixers is now and EBARA Corporation Group Company.

Quotation prepared by: Kyle Sides
Sharpe Mixers

2/17/23 2:44 PM

Design Details on BNR Mixers:

For reference only; use certified drawings for construction. Dimensions are in inches



3 mixers per basin

Mixer weight =	800 lbs	
Design Torque =	14069 lbs-in	
Design OHM =	11345 lbs-in	
est. full tank volume =	188509 gal	*(713588 L)*
est. volume @ liquid level =	179084 gal	*(677909 L)*

NOTES: Tank / Mixer Layout intended for scaled view of in-tank components only. Mixer drive proportions may vary slightly depending on motor type or other options. Please review drawing carefully and inform Sharpe Mixers immediately if any tank dimensions are inaccurate. Drawing generated by Sharpe Mixers Q1QP mixer selection program, Copyright 2005, Seattle, WA.

Sharpe Mixers
EBARA CORPORATION

TOP ENTERING MIXER / TANK LAYOUT DETAIL

Mixer Model # ***3N4 -75*** ***Quantity:*** ***6***

Customer: [redacted]

Sharpe # ***Q3-73606***

Application: ***Anoxic/Anaerobic Zone Mixer***

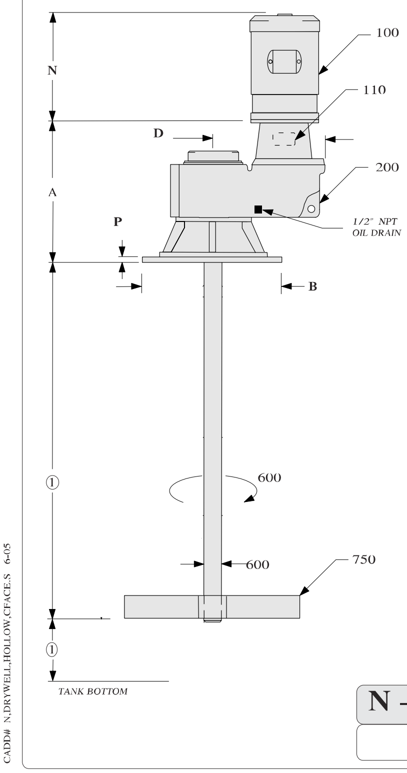
Drawing # ***L3-73606***

206-767-5660 - www.sharpemixers.com

Q1QP-020723 2/17/23 2:44 PM

Design Details on BNR Mixers:

Drawing not to scale. Dimensions are for reference only. Use certified prints for construction. Dimensions in inches.



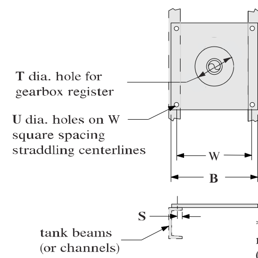
100 - MOTOR ①
110 - FLEXIBLE MOTOR COUPLING
200 - GEAR REDUCER ①
600 - SHAFT ①
750 - LOWER IMPELLER ①

①Impeller(s), shaft and other details are dependent on specific application and will be described in the Quotation/Data Sheet.

② Items are optional and will be described in the Quotation/Data Sheet if provided

③Basic weight shown in lbs is for mixer drive only, less motor and wetted parts.

MOUNTING DETAIL
PLATE MOUNT
(furnished)



MOTOR DIM'S

HP *	NEMA FRAME	'N'	WT*
1/3 -2	56C	11	37
1-1.5	143TC	11.3	41
1.5-2	145TC	11.3	50
3	182TC	11.8	65
5	184TC	12.8	87
7.5	213TC	15	145
10	215TC	16.5	160
15	254TC	19.6	310
20	256TC	21.3	345
25	284TC	20.3	425
30	286TC	21.8	455
40	324TC	26.5	575
50	326TC	26.5	634

*NEMA frames shown are for 1750 rpm motors. Weights and Outline dimensions (A,B,D,M,N) are approximate.

OVERALL DIMENSIONS

	N1	N2	N3	N4	N5	N6	N7	N8	N9
A (MAX)	13.9	15.1	16.2	19.8	22.6	24.6	29.1	29.1	35.2
B	11	11	12	14	16	18	21	24	30
D	7.95	9.73	11.03	13.03	15	16.1	17.75	20.63	25.95
J (MAX)	5.75	6.25	7	8	9	12.5	12.5	13	15
P	.38	.38	.5	.63	.75	.88	1	1.25	1.5
S	.63	.63	.75	.75	.88	.88	.88	.88	1
T	5.13	7.1	9.1	9.1	9.9	11.9	13.8	17.8	21.7
U	.43	.43	.56	.56	.68	.88	.94	1.13	1.31
③ W	9	9	10.5	12	14	16	18	21	27
WT	65	100	140	220	310	480	680	950	1600

N - SERIES HOLLOW GEARBOX OUTPUT -OIL SAFE DESIGN- W/C-FACE MOTOR

DWG NO.: S11200

SHARPE MIXERS P.O. BOX 3906 SEATTLE, WA 98124 FAX (206) 767-9170 (206) 767-5660

K.4 Cloth Filters (Aqua-Aerobic)

Aqua-Aerobic Quote For Phase 2 Filtration Unit Installation:

AquaDisk®: Operation & Maintenance Requirements

Design# 170211

AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

Project: COLLEGE STUDENT PROJECTS

Qty / Model#: 3 / ADFSC108x18E-PC

Description: AquaDisk Concrete: Model ADFSC-108 x 18E-PC

Avg Flow (Gal):	27,000,000
Influent TSS (mg/l):	10
Qty Of Disks Per Unit:	18
Area Provided/Disk:	107.6

I. LUBRICATION REQUIREMENTS

	# of Units		Minutes/Unit		Times/Year		Hours/Year
1) Backwash / Solids Waste Pump - Routine Lubrication:	3	x	5	x	12	/ 60 =	3.00
2) Backwash / Solids Waste Pump - Drain and Refill:	3	x	30	x	1	/ 60 =	1.50
3) Drive Gear Box:	3	x	30	x	0.25	/ 60 =	0.38
4) Drive Motor:	3	x	5	x	0.25	/ 60 =	0.06

TOTAL LUBRICATION REQUIREMENTS: 4.94

II. PARTS REPLACEMENT

	Replace Interval (Years)	# of Units		Minutes/Unit		Hours Per Replacement	Material Cost Per Unit	Total Material Cost
1) Main "V-Ring" Seal:	10	3	x	240	=	12.0	$1,051	$3,154
2) Filter Media Cloths (8/Disk):	7	432	x	15	=	108.0	$469	$202,608

III. POWER CONSUMPTION

1) Backwash / Solids Waste Pump (kW Hours/Year):	74,786.7
2) Disk Drive Motor (kW Hours/Year):	18,721.8
3) Power Control Panel (kW Hours/Year):	4,200.0
Total Annual Power Usage (kW Hours/Year):	97,708.5

Printed on: 2/9/2023 3:11:57PM Aqua-Aerobic Systems, Inc. CONFIDENTIAL Page 1 of 1

Aqua-Aerobic Quote For Phase 3 Filtration Unit Installation:

AquaDisk®: Operation & Maintenance Requirements

Design# **170212**

AQUA-AEROBIC SYSTEMS, INC. A Metawater Company

Project:	**COLLEGE STUDENT PROJECTS**
Qty / Model#:	**5 / ADFSC108x22E-PC**
Description:	**AquaDisk Concrete: Model ADFSC-108 x 22E-PC**

Avg Flow (Gal):	52,000,000
Influent TSS (mg/l):	10
Qty Of Disks Per Unit:	22
Area Provided/Disk:	107.6

I. LUBRICATION REQUIREMENTS

	# of Units		Minutes/Unit		Times/Year		Hours/Year
1) Backwash / Solids Waste Pump - Routine Lubrication:	5	x	5	x	12	/ 60 =	5.00
2) Backwash / Solids Waste Pump - Drain and Refill:	5	x	30	x	1	/ 60 =	2.50
3) Drive Gear Box:	5	x	30	x	0.25	/ 60 =	0.63
4) Drive Motor:	5	x	5	x	0.25	/ 60 =	0.10
TOTAL LUBRICATION REQUIREMENTS:							8.23

II. PARTS REPLACEMENT

	Replace Interval (Years)	# of Units		Minutes/Unit		Hours Per Replacement	Material Cost Per Unit	Total Material Cost
1) Main "V-Ring" Seal:	10	5	x	240	=	20.0	$1,051	$5,257
2) Filter Media Cloths (8/Disk):	7	880	x	15	=	220.0	$469	$412,720

III. POWER CONSUMPTION

1) Backwash / Solids Waste Pump (kW Hours/Year):	117,845.7
2) Disk Drive Motor (kW Hours/Year):	29,501.0
3) Power Control Panel (kW Hours/Year):	7,000.0
Total Annual Power Usage (kW Hours/Year):	154,346.7

Printed on: 2/9/2023 3:13:36PM **Aqua-Aerobic Systems, Inc. CONFIDENTIAL** **Page 1 of 1**

K.5 UV Disinfection (Evoqua)

Evoqua Specification Sheet for UV Disinfection Channels:

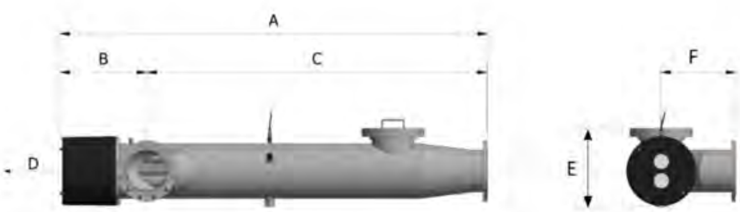
ETS-UV™

an evoqua brand

SPECIFICATION SHEET
UVLW RANGE

The UVLW is a range of 800W low pressure, high output amalgam UV systems that are validated to the 2003 and 2012 NWRI Reuse Guidelines

Model	Connection (Inches)	# of Lamps (800W)	Dimensions						Panel Dimensions		
			A	B	C	D	E	F	W	H	D
ULVW-6800-10	8	6	105	22	83	75	25	10	32	79	24
UVLW-6800-14	10	6	110	23	87	75	31	12	32	79	24
UVLW-8800-14	10	8	110	23	87	75	31	12	62	79	24
UVLW-16800-20	16	16	121	26	95	75	40	15	62	79	24
UVLW-20800-20	16	20	121	26	95	75	40	15	94	79	24
UVLW-22800-24	20	22	121	27	94	75	47	18	94	79	24
UVLW-30800-24	20	30	121	27	94	75	47	18	94	79	24
UVLW-30800-30	20	30	122	28	94	75	55	21	94	79	24
UVLW-45800-30	20	45	122	28	94	75	55	21	125	79	24



CHAMBER
316L SS
ANSI 150# flanged connections
Install inline, horizontally or vertically
Features:
Acess Hatch
Twist lock lamp connections
Dry UV intensity monitor
High purity quartz thimbles
Low voltage automatic wiper
One piece wiper ring
Temperature sensor
Drain and vent ports

CONTROL SYSTEM
NEMA 12 epoxy coated mild steel enclosure
Operational 32-113°F, RH <90%
Features:
7 HMI
Spectra II control system
MODBUS
Multiple warnings and alarms
Variable power lamps
480V/3-phase

SYSTEM OPTIONS
304 or 316 NEMA 4X enclosures
Effluent flange location
Skid mounted
Containerized
Internal/external polish or electropolish

INSTALLATION NOTES
Provide necessary maintenance space
Install in a dry area
Provide floor drain or sump
Lamps submerged at all times
Minimum of two conduits required
Chamber must be grounded

evoqua.com

Evoqua O&M costs for UV System:

[redacted]

Estimated Operation and Maintenance Costs

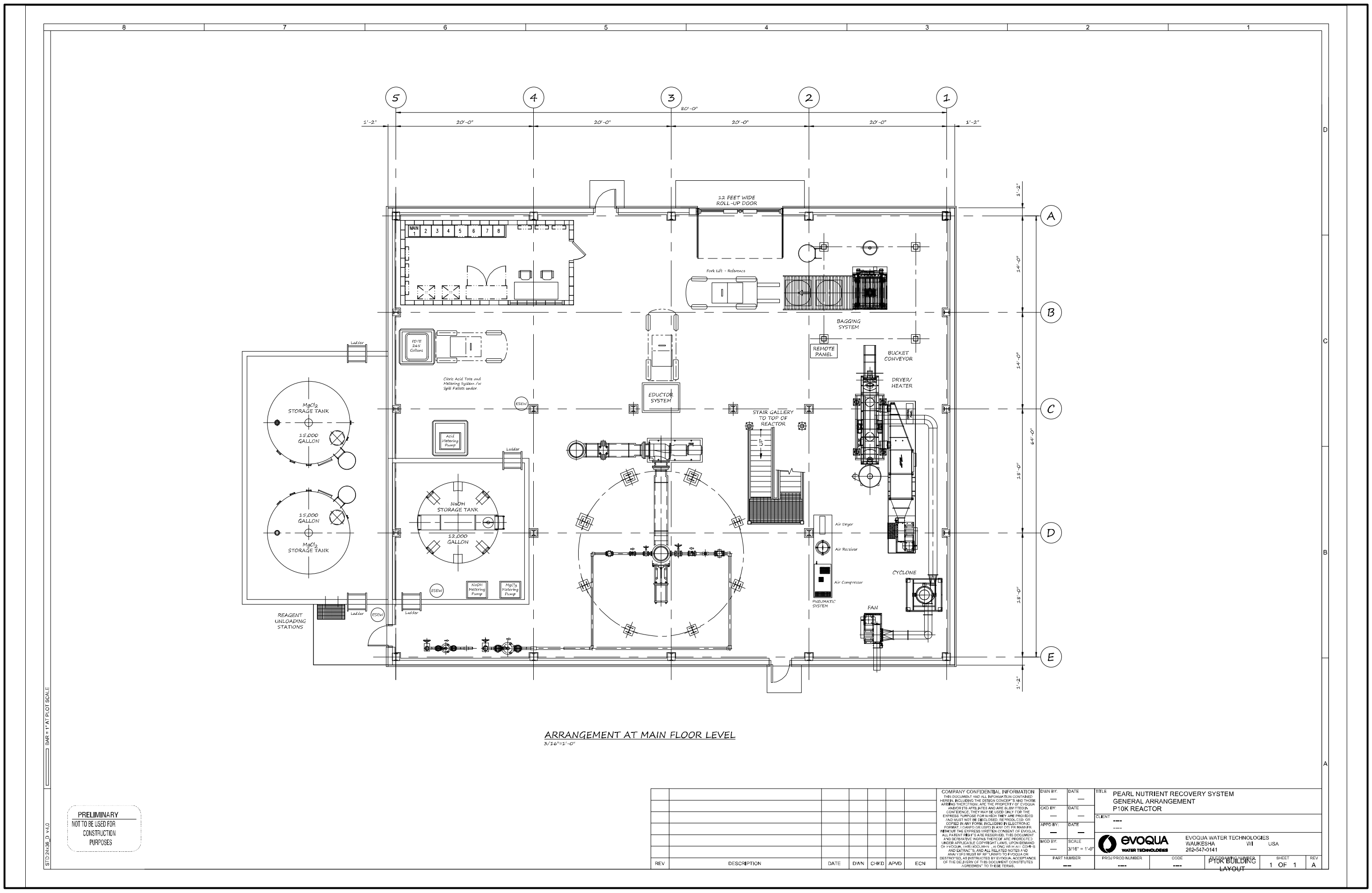
PLANT BACKGROUND	QUANTITY
Annual operating hours (hours per year)	8760
Flowrate (MGD)	78
T10% at 254 nanometers	65
TSS (mg/l)	15
UV SYSTEM	
Type of unit	UVLW-30800-24
Number of units	10
Lamps per unit	30
Total number of lamps	300
Number of lamps operating	30
Electricity (based on one reactor)	
Average lamp power (kW)	0.7
Total power (kW)	21.0
Annual power consumption (kW-hr per year)	183960
Unit cost ($ per kW)	$0.08
Annual electricity cost	$14,717
Lamps (based on one reactor)	
Number of lamps operating	30
Expected lamp life (hours)	14,000
Annual lamp replacement	19
Unit cost ($ per lamp)	$514
Annual lamp replacement cost	$9,769
Wiper Rings (based on one reactor)	
Number of wipers in the UV system	30
Expected wiper life (years)	1
Annual wiper replacement	30
Unit cost ($ per wiper ring)	$25
Annual wiper ring cost	$750
Quartz Thimbles (based on one reactor)	
Number of quartz thimbles in the UV system	30
Expected quartz thimble life (years)	3
Annual quartz thimble replacement	10
Unit cost ($ per quartz thimble)	$365
Annual quartz thimble cost	$3,650
Quartz Thimble Seals ((based on one reactor)	
Number of quartz thimble seals in the UV system	30
Expected quartz thimble seals life (years)	3
Annual quartz thimble seal replacement	10
Unit cost ($ per quartz thimble seal)	$15
Annual quartz thimble seal cost	$150
Thimble Support Seals (based on one reactor)	
Number of thimble support seals in the UV system	30
Expected thimble support seals life (years)	3
Annual thimble support seal replacement	10
Unit cost ($ per thimble support seal)	$25
Annual thimble support seal cost	$250
Electronic Ballasts (based on one reactor)	
Number of ballasts in the UV system	30
Expected ballast life (years)	5
Annual ballast replacement	6
Unit cost ($ per ballast)	$835
Annual ballast cost	$5,011
Labor (based on one reactor)	
Number of hours per week	1
Number of weeks operated per year	52
Unit cost ($ per hr)	$75
Annual labor cost	$3,900
COSTS	
Total Annual Operation and Maintenance	$38,197

ETS Company Confidential

Estimated O&M Thimble

K.6 Phosphorus Sequestration (Evoqua)

Evoqua Design Sheet for a General Arrangement of a Nutrient Recovery System for Phosphorus Sequestration:

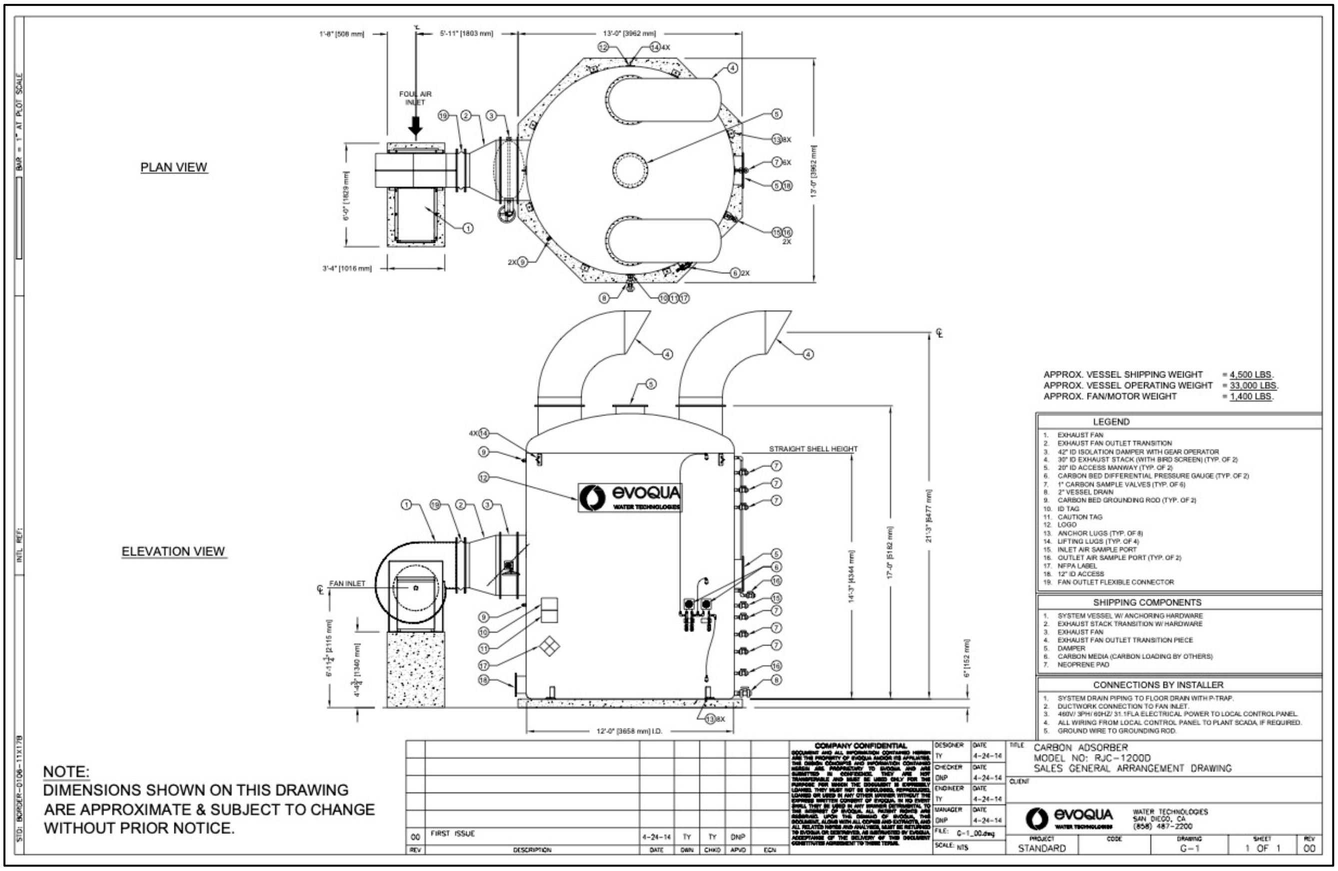


Evoqua Chemical Pricing Sheet for a Nutrient Recovery System for Phosphorus Sequestration:

ITEM	VALUE	Pearl UNITS
Ferric Chloride avoidance		
P removal	439	tons/yr
FeCl3 (40%) required	3,448	dry ton/y
Purchase price of FeCl3 (40%)	$600	$/dry ton
FeCl3 (40%) purchase cost avoidance	$2,068,800	$/yr
Alkalinity Consumption	0	dry ton NaOH
Purchase price of NaOH	$0	$/dry ton
Total Alkalinity Benefit	$0	$/yr
Fe sludge produced	2,894	dry ton/y
Cost of sludge processing	$30	$/dry ton
Cost of sludge disposal	$125	$/dry ton
Fe sludge cost avoidance	$448,600	$/yr
Total Value of Ferric Chloride avoidance	$2,517,400	*$/yr*
Ammonia		
Cost of ammonia removal	$1.76	$/lb
Quantity of ammonia removed	396,467	lb/y
Value of ammonia removal	$697,800	*$/yr*
Crystal Green® Revenue		
CG Production	2,782	ton/y
Purchase price of CG	$150	$/ton
CG revenue	$417,200	*$/yr*
Total Value of Financial Benefits	$3,632,400	$/yr
Less Operating Cost	$667,570	$/yr
Total Value of Financial Benefits	$2,964,830	$/yr

K.7 Odor Control (Evoqua)

Evoqua Detail Arrangement Drawing for a Dual Bed Carbon Adsorption Unit:

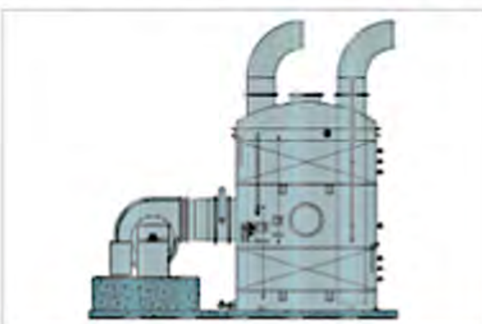


Evoqua Design Information for a Dual Bed Carbon Adsorption Unit:

RJC DESIGN INFORMATION

Model	Airflow Rate	Type	Diameter	Footprint Dimensions L x W x H*	Inlet Connection O.D.	Carbon Wt**	Operating Wt	Fan Motor	Power Supply
Unit	cfm	No. of carbon beds	ft	ft	inches	lbs	lbs	HP	FLA at 460V/3Ph/60Hz
	m^3/hr		mm	mm	mm	kgs	kgs	kW	
RJC-0600	2000	Single	6.0	11 x 7.0 x 7.75	16 3/8	2,500	4,800	5.0	7.5
	3400		1829	3352 x 2134 x 2362	416	1,136	2,182	3.7	
RJC-0800	3500	Single	8.0	14 x 9.0 x 8.5	16 3/8	4,500	8,400	7.5	10.1
	5950		2438	4277 x 2743 x 2565	416	2,045	3,818	5.5	
RJC-1000	5500	Single	10.0	16.5 x 11 x 9.5	19 3/8	7,000	13,000	10	13.5
	9350		3048	5030 x 3353 x 2870	492	3,182	5,909	7.5	
RJC-1200	8000	Single	12.0	18.75 x 13 x 10.25	23 3/4	10,200	19,000	15.0	19.1
	13600		3658	5715 x 3962 x 3124	603	4,636	8,636	11	
RJC-1000D	11000	Double	10.0	17.75 x 11 x 16	25 3/4	14,100	23,000	20	25.2
	18700		3048	5410 x 3353 x 4852	654	6,409	10,455	15	
RJC-1100D	13000	Double	11.0	19.5 x 12 x 16.75	28 5/8	17,100	28,000	25.0	31.1
	22100		3353	5944 x 3658 x 5105	721	7,773	12,727	18.5	
RJC-1200D	16000	Double	12.0	20.5 x 13 x 17	31 1/16	20,300	33,000	25.0	31.1
	27200		3658	6250 x 3962 x 5182	789	9,227	15,000	18.5	
RJC-1400D	20000	Double	14.0	23.25 x 15 x 18.3	34 1/16	27,600	45,000	40.0	49.8
	34000		4267	7087 x 4572 x 5589	865	12,545	20,455	30.0	

* Height to vessel top, excluding stack | ** Dependent upon media type, values are +/- 7%



Media

Evoqua carbon odor control systems are designed to work with a wide range of media.

Midas® OCM

For H_2S odor removal we recommend Midas® Odor Control Media. Midas OCM has the highest odor removal capacity of any media on the market (0.30 g H_2S/cc carbon) and will reduce the frequency of media changeout.

Other Media offered:

- VoCarb® UOCH-KP Caustic impregnated odor control media
- VoCarb® P60 pelletized, coal-based, virgin activated VOC carbon
- VoCarb® 48C, 36C granular, coconut shell activated carbon
- 48C granular, coconut shell activated carbon

Email odorcontrol@evoqua.com or visit www.evoqua.com/bulk to connect with an expert.

evoqua
WATER TECHNOLOGIES

4800 North Point Parkway, Suite 250, Alpharetta, GA 30022
+1 (866) 926-8420 (toll-free) +1 (978) 614-7233 (toll) www.evoqua.com

K.8 Chemical Additions (Statiflo)

Statiflo Static Pump Details for Phase 2

STATIflo

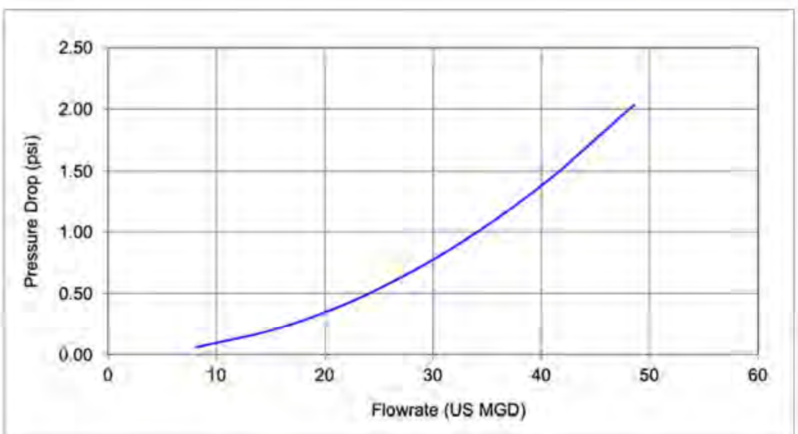
S1 PROCESS DETAILS

Customer: [redacted]
Customer Ref: Walnut Creek WWTP

Item 48" Series 650
Statiflo Ref: N49017 (40.5 MGD)
Date: 17-Feb-23

PROCESS DETAILS:			MIXER DETAILS:	
Main flowrate (Q)...........	40.5	US MGD	Nominal diameter..........	48.00 in
SG..............................	1.00		Inside diam. Std. Wall	47.24 in
Dynamic viscosity........	1.00	cP	Pitch ratio.....................	1.50 :1
Side flowrate (q)............	1.00	US gal/m	No of Elements.............	2.5
SG..............................	1.00		Element Style...............	STM
Dynamic viscosity........	1.00	cP	Dosing arrangement.......	Twin
Alpha (Q/q)...................	28125			

% Total flowrate		20%	40%	60%	80%	100%	120%
Flowrate	US MGD	8.1	16.2	24.3	32.4	40.5	48.6
Velocity	ft/s	1.03	2.06	3.09	4.12	5.15	6.18
Reynolds Number		375900	751799	1127699	1503598	1879498	2255397
Darcy Friction Factor		4	4	4	4	4	4
Delta P	psi	0.06	0.23	0.51	0.91	1.41	2.04
CoV		0.05	0.05	0.05	0.05	0.05	0.05



Notes:
With acknowledgement to the Water & Wastewater Mixing Consortium
(BHRGroup Design Guide for Liquid Blending in Pipes & Channels)
Please see your quotation for the process guarantee and operational range offered.

Checked By: Edward E. Todd
Date: 2/17/2023

Statiflo Static Pump Details for Phase 3

STATIflo

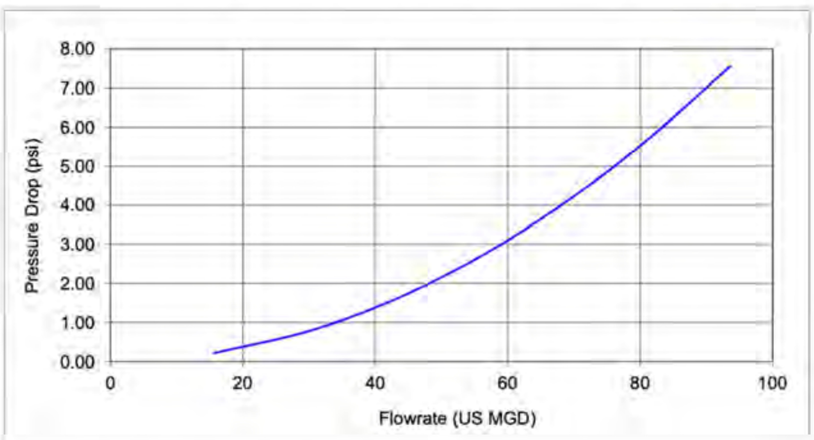
S1 PROCESS DETAILS

Customer: [redacted]
Customer Ref: Walnut Creek WWTP

Item 48" Series 650
Statiflo Ref: N49017 (78 MGD)
Date: 17-Feb-23

PROCESS DETAILS:			MIXER DETAILS:	
Main flowrate (Q)...........	78.0	US MGD	Nominal diameter..........	48.00 in
SG............................	1.00		Inside diam. Std. Wall	47.24 in
Dynamic viscosity........	1.00	cP	Pitch ratio.....................	1.50 :1
Side flowrate (q)............	1.00	US gal/m	No of Elements.............	2.5
SG............................	1.00		Element Style................	STM
Dynamic viscosity........	1.00	cP	Dosing arrangement.......	Twin
Alpha (Q/q)...................	54166			

% Total flowrate		20%	40%	60%	80%	100%	120%
Flowrate	US MGD	15.6	31.2	46.8	62.4	78.0	93.6
Velocity	ft/s	1.98	3.97	5.95	7.93	9.91	11.90
Reynolds Number		723942	1447885	2171827	2895769	3619711	4343654
Darcy Friction Factor		4	4	4	4	4	4
Delta P	psi	0.21	0.84	1.89	3.36	5.25	7.56
CoV		0.05	0.05	0.05	0.05	0.05	0.05



Notes:
With acknowledgement to the Water & Wastewater Mixing Consortium
(BHRGroup Design Guide for Liquid Blending in Pipes & Channels)
Please see your quotation for the process guarantee and operational range offered.

Checked By: Edward E. Todd
Date: 2/17/2023

Statiflo Chemical Injection Quill Details

EB-146

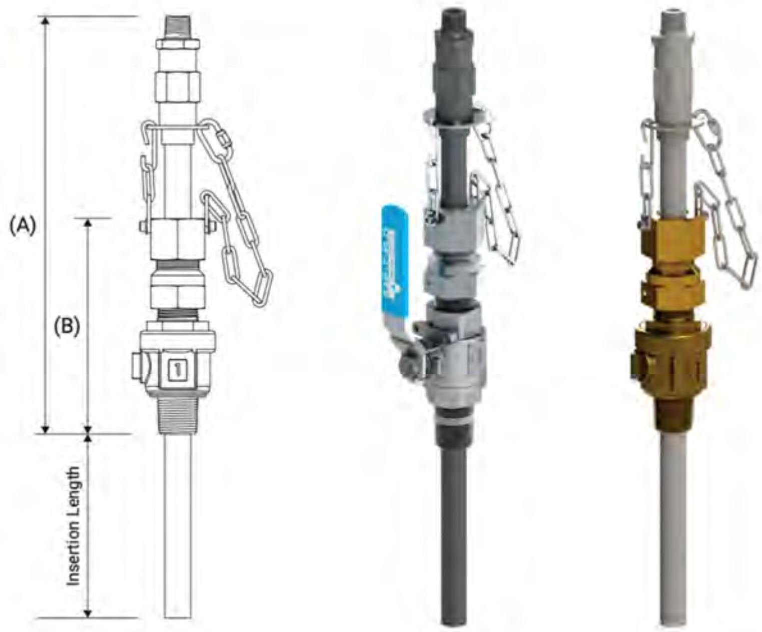
SAF·T·FLO CHEMICAL INJECTION

Standard Service Retractable Injection Quill

1" Valve x 1/2" Tube with Integrated Check Valve

SPECIFICATIONS

SAFETY RATING	150 PSI
CHECK VALVE	INTEGRATED SPRING LOADED BALL CHECK VALVE
SAF-T-SEAL TIP	OPTIONAL
QUICK DISCONNECT	N/A
VALVE/PROCESS CONNECTION SIZE	1" MNPT
INLET CONNECTION SIZE	1/2" MNPT
SOLUTION TUBE SIZE	1/2"
SOLUTION TUBE ID (PVC, CPVC & ALLOY W/SAF-T-SEAL)	0.546"
SOLUTION TUBE ID (ALLOY W/O SAF-T-SEAL)	0.622"
SOLUTION TUBE OD	0.840"
(A) OPERATING HEIGHT	13.75" - BRASS 15" - STAINLESS STEEL
(B) VALVE/GLAND LENGTH	7" - BRASS 8.25" - STAINLESS STEEL
EXTRACTION LENGTH	A + B + INSERTION LENGTH



ORDERING INFORMATION

SERIES		VALVE MATERIAL		SOLUTION TUBE MATERIAL		INSERTION LENGTH		TIP CONFIGURATION		CHECK VALVE SEAL
EB-146	-		-		-		-		-	
		B = Brass S = Stainless Steel		P = PVC C = CPVC H = Alloy C276 S = 316SS A = Alloy 20 T = Titanium Gr.2		2 = 2" 4 = 4" 6 = 6" Alloy Tubes Only 8 = 8" 10 = 10" 12 = 12" 18 = 18" 24 = 24"		0 = Standard B = 45° Bevel CV = SAF-T-Seal, FKM CE = SAF-T-Seal, EPDM *SAF-T-Seal Tip not available with Titanium Solution Tubes		V = FKM E = EPDM K = KALREZ 6375

TECH NOTES

1. Check valve spring cracking pressure is 5 PSI.
2. Main connection thread type is NPT by default. CC (AWWA) also available. Consult factory for details.
3. Maximum insertion length for 1/2" PVC and CPVC solution tubes is 6". PVC and CPVC solution tubes are not covered by warranty when used in process flows with velocities 6 fps or greater.
4. Availability of SAF-T-Seal tip with selection of Titanium solution tube material subject to change. Consult factory prior to selecting.

Statiflo Budget Quote for Static Pump and Injection Quill

STATIflo

BUDGET QUOTATION

Statiflo Corporation
75 South Church St Floor 6
Pittsfield, MA 01201
Tel: (413) 684 9911
Fax: (413) 464 8239
Email: sales@statiflocorp.com
Website: www.statiflo.com

Date: February 17, 2023

To: [redacted]

Our Quote: N49017

Project: Austin Walnut Creek WWTP Project

Subject: Budget Quotation for Static Mixer and Injection Quill

[redacted]

We thank you for your above referenced inquiry and are pleased to offer the following inline static mixer and chemical injection quill designed to your requested specifications:

SCOPE OF SUPPLY

1 each STATIFLO SERIES 650 STATIC MIXER – 48" DIAMETER x 2.5 FIXED ELEMENTS (1.5:1 Pitch Ratio)
Manufactured with mixing elements in all 316L stainless steel construction retained within a 48" standard weight carbon steel housing fitted with 48" AWWA Table 2 Class B carbon steel flanges. At the upstream end of the mixer there will be (1) 1" FNPT 316L injection boss. All carbon steel surfaces to be coated with NSF 61 approved epoxy.

Estimated Length: 96"
Estimated Weight: 2,775 Lbs.

1 each RETRACTABLE CHEMICAL INJECTION QUILL WITH INTEGRATED CHECK VALVE
Retractable injection quill with integrated check valve. Quill supplied with stainless steel isolation ball valve, and solution tube and EPDM check valve seal. Main process connection to be 1" MNPT and chemical feed connection to be 1/2" MNPT. Solution tube length to be 24" with standard (square cut) end. Quill is appropriate for Magnesium Hydroxide service. Saf-T-Flo part number EB-146-S-S-24-0-E.

The above drawing is typical only and a specific detailed drawing would be issued following order placement.

INSTALLATION & START-UP

Installation by others per Statiflo Operation & Maintenance (O & M) Manual. There are no provisions included for on-site start-up by any Statiflo personnel.

WARRANTY PERIOD

Mixer: 12 months from commissioning or 18 months from delivery, whichever is sooner.
Quill: 12 months from delivery

Statiflo Budget Quote for Static Pump and Injection Quill

STATIflo
Dynamic Leaders in Static Mixing

Quotation Reference N49017 – Dated 2/17/23

CONDITIONS OF SERVICE

According to the following process conditions, the Statiflo Motionless Mixer offered has been designed to completely and efficiently mix your miscible process streams to achieve a maximum coefficient of variation of 0.05 **at the discharge of the mixer**.

For a definition of CoV (coefficient of variation) please click: Definition of CoV

The materials of construction for this mixer have been specified by the customer, as such Statiflo can accept no responsibility for a mixer failure resulting from process error or chemical incompatibility.

PROCESS CONDITIONS

Process Medium:	**Water**	**Magnesium Hydroxide**
Flowrate:	40.5 – 78 MGD	* 2 gpm (assumed)
Viscosity:	1 cP (assumed)	1 cP (assumed)
SG:	1.0 (assumed)	1.0 (assumed)
Pressure Drop:	1.41 – 5.25 psi	

It is noted that chemical will be injected at the injection boss in the static mixer body.

* 14,000/27,000:1 Water to Chemical Ratio is high. The use of carrier water should be considered.

PRICING SUMMARY

48" Series 650 Mixer (each): $59,200.00 Net (1 Required)

Chemical Injection Quill (each): $1,400.00 Net (1 Required)

Shipping & Handling (S & H): $6,400.00 (Standard LTL Ground Service)

Total Price: $67,000.00 (Includes 1 Mixer, 1 Quill and S & H)

Delivery: 9 – 11 working weeks from approval to fabricate.

TERMS AND CONDITIONS

Prices, unless otherwise stated are net each, Ex Works Statiflo, exclusive of all applicable taxes and shipping costs. Terms of payment net 30 days. Subject to Statiflo's standard terms and conditions of sale, a copy of which is available upon request. A 3.5% service fee will be added to all credit card orders.

VALIDITY

Due to current material cost volatility, our offer will remain strictly valid for a period of 30 days. Any orders received after 30 days will not be accepted until after pricing has been reviewed and updated as required.

The pricing on this quotation includes for the following:

- The submission of general arrangement drawing for approval.
- Submission of one electronic copy of our standard installation & Maintenance Manual.

Further QA/NDE (i.e., Hydrostatic Test, AIS Compliance, etc.) is available at extra cost.

We trust our quotation meets your requirements. Should you require any further information or clarification, please do not hesitate to contact this office.

Best regards,

Edward Todd
Vice President, Operations
STATIFLO CORPORATION

Page 2

K.8 Sludge Dual Mixer/Aeration System (Mixing Systems, Inc.)

Eddy Jet Sludge Mixer Rendering: