AZ Water WEF Student Design Competition Water Reclamation Facility Expansion

Clear Treatment Inc.

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CENE 486

5/3/2024

Project Introduction

Rainbow Valley Water Reclamation Facility

- Current Capacity = 0.75 MGD
- Design Capacity = 3 MGD

Reason for Expansion

- Population Growth
- Land Development

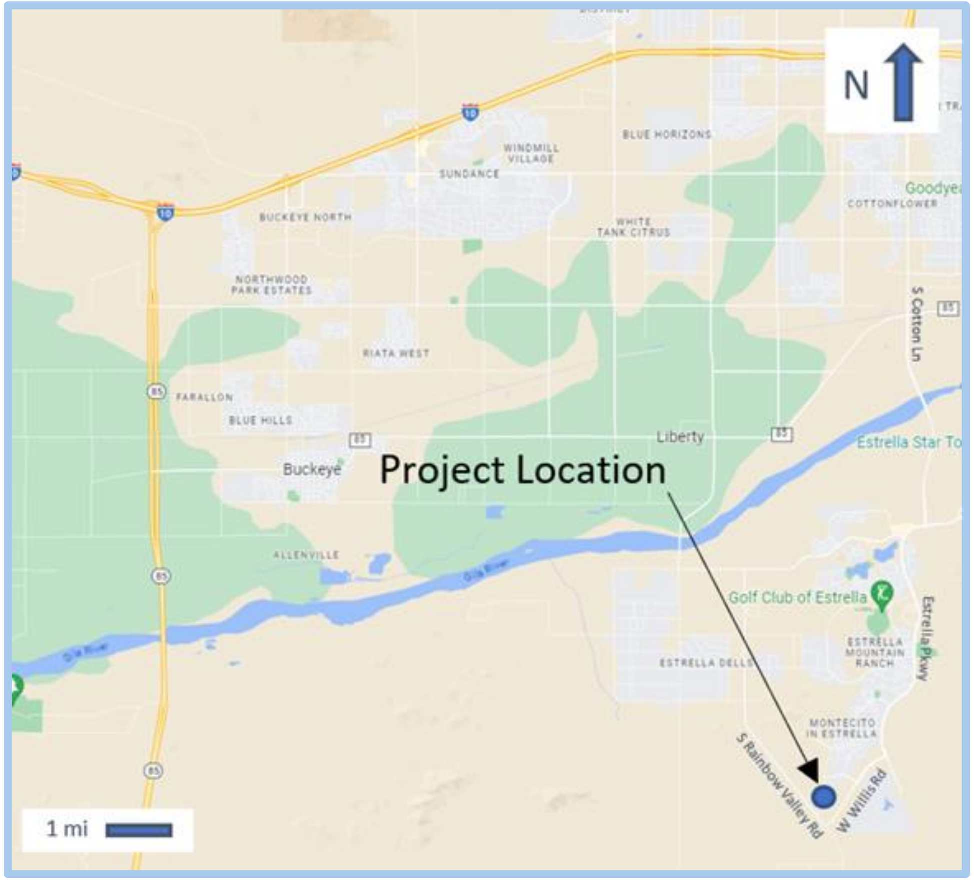
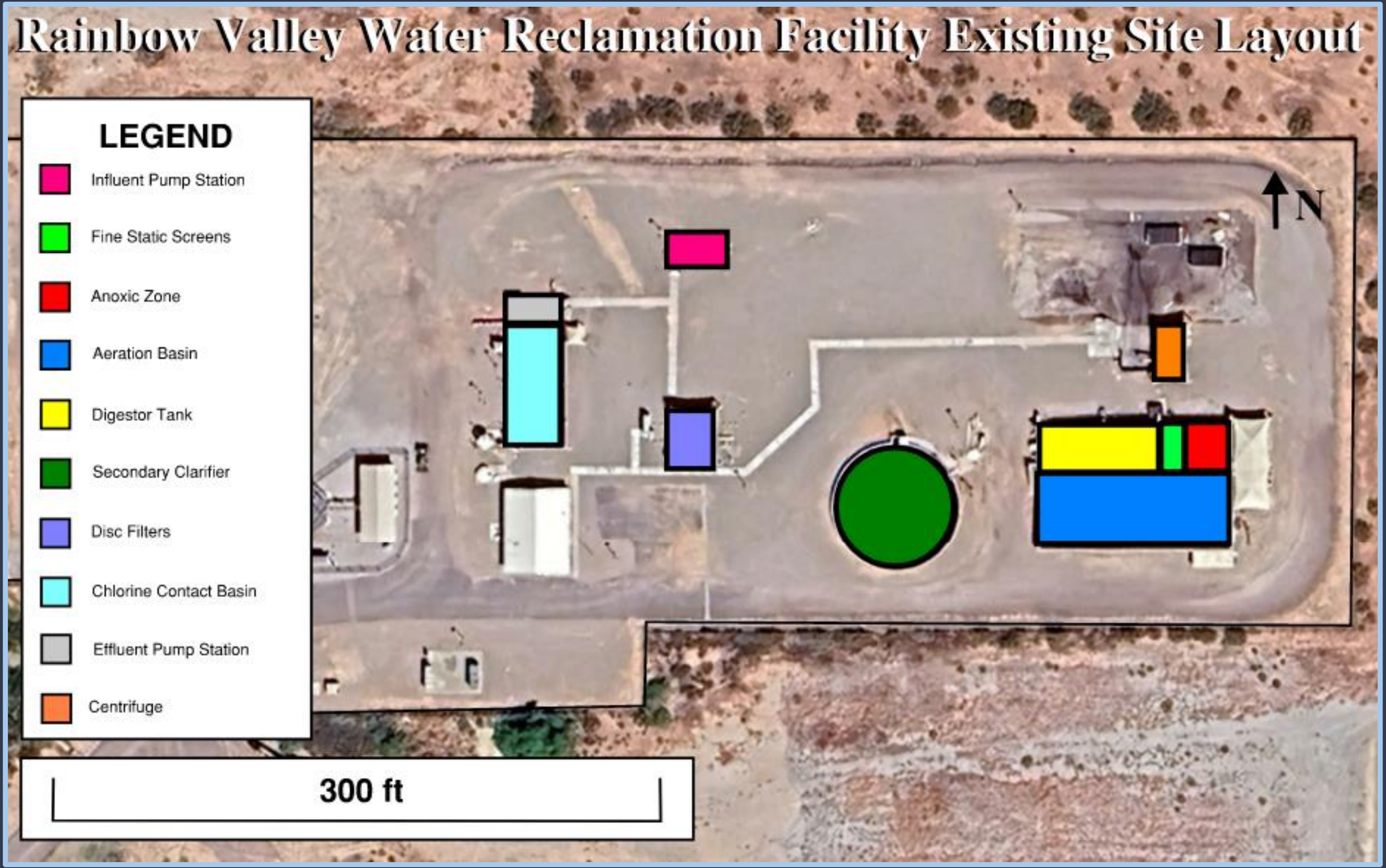


Figure 1: Project Vicinity [1]


Rainbow Valley Water Reclamation Facility Existing Site Layout
LEGEND
Influent Pump Station
Fine Static Screens
Anoxic Zone
Aeration Basin
Digestor Tank
Secondary Clarifier
Disc Filters
Chlorine Contact Basin
Effluent Pump Station
Centrifuge
N
300 ft

Project Requirements

- Provide Redundancy
- Address Odor Control
- Produce Class A+ Effluent
- Produce Class B Biosolids
- Meet Effluent Limits

Table 1: Effluent Limits [2]

Effluent Limits	
TSS	<10 mg/L
BOD	<10 mg/L

Preliminary Treatment (Screening) Alternatives

Fine Screen

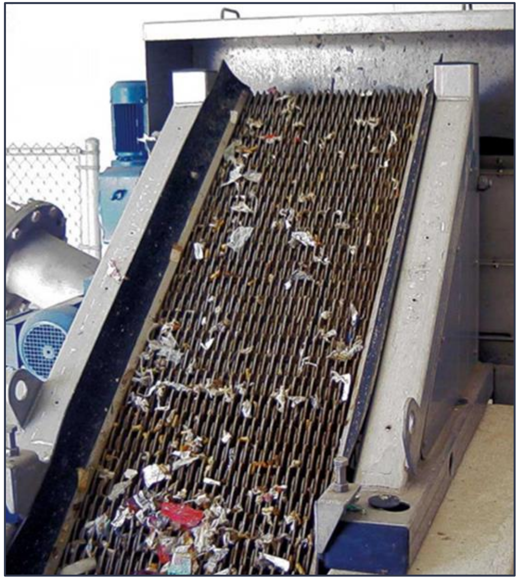


Figure 2: Fine Screen Example [3]

Static Screen

Figure 3: Static Screen Example [4]

Step Screen

Figure 4: Step Screen Example [5]

Preliminary Treatment (Screening)				
Criteria	**Weight (%)**	**Fine Screen**	**Step Screen**	**Static Screen**
Capital Cost	30	3	1	2
Maintenance & Operation	25	3	2	1
Construction Time/Constructability	15	2	1	3
Odor Control	10	2	3	1
Social & Environmental Impacts	10	2	3	1
Staffing	10	3	2	1
Weighted Average	**100**	**2.65**	**1.75**	**1.6**

Table 2: Screening Decision Matrix

Preliminary Treatment (Screening) Decision Matrix

Preliminary Treatment (Grit Chamber) Alternatives

Aerated Grit Chamber

Figure 5: Aerated Grit Chamber Example [6]

Horizontal Flow Grit Chamber

Figure 6: Horizontal Flow Grit Chamber Example [7]

Vortex Grit Chamber

Figure 7: Vortex Grit Chamber Example [8]

Preliminary Treatment (Grit Chamber)				
Criteria	**Weight (%)**	**Aerated Grit Chamber**	**Horizontal Flow Grit Chamber**	**Vortex-Type Grit Chamber**
Capital Cost	25	3	2	1
Removal Efficiency	20	2	3	3
Construction Time/Constructability	15	2	1	3
Maintenance & Operation	10	2	1	3
Footprint	20	2	1	3
Energy Consumption	10	1	3	2
Weighted Average	**100**	**2.15**	**1.85**	**2.4**

Table 3: Grit Chamber Decision Matrix

Preliminary Treatment (Grit Chamber) Decision Matrix

Equalization Basin Alternatives

In-Line Equalization Basin

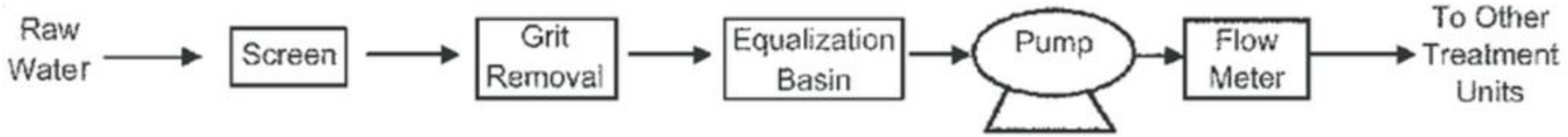


Figure 8: In-Line Equalization Basin Example [9]

Side-Line Equalization Basin

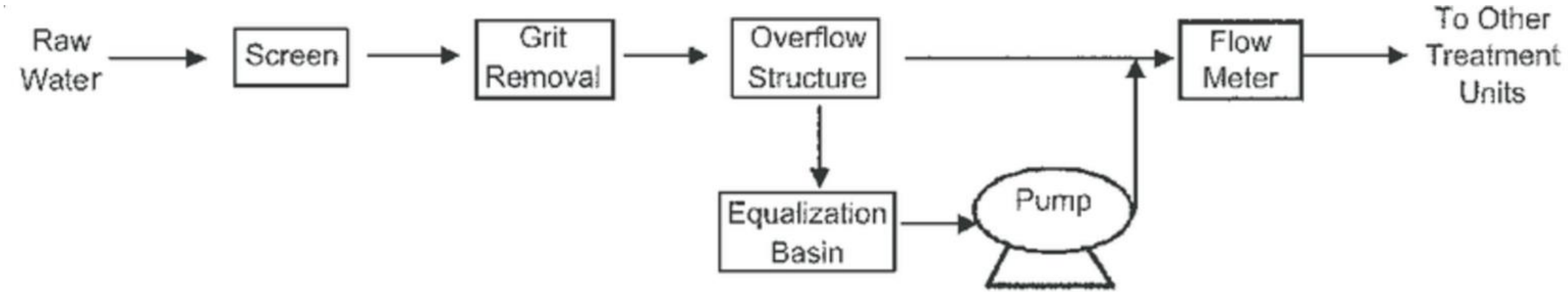


Figure 9: Side-Line Equalization Basin Example [9]

Equalization Basin			
Criteria	**Weight (%)**	**In-Line Basin**	**Side-Line Basin**
Relative Cost	40	2	1
Maintenance and Operation	25	2	1
Construction Time/Constructability	20	2	1
Staffing	15	2	1
Weighted Average	**100**	**2**	**1**

Table 4: Equalization Basin Decision Matrix

Equalization Basin Decision Matrix

Primary Treatment Alternatives

Bridge Support Clarifier

Figure 10: Bridge Support Clarifier Example [10]

Column Support Clarifier

Figure 11: Column Support Clarifier Example [11]

Primary Treatment (Primary Clarifier)			
Criteria	**Weight (%)**	**Bridge Support Clarifier**	**Column Support Clarifier**
Capital Cost	40	1	2
Surface Area Requirements	25	1	2
Construction Time/Constructability	20	1	2
Maintenance & Operation	15	2	1
Weighted Average	**100**	**1.15**	**1.85**

Table 5: Primary Clarifier Decision Matrix

Primary Treatment Decision Matrix

Secondary Treatment Alternatives

Conventional Activated Sludge

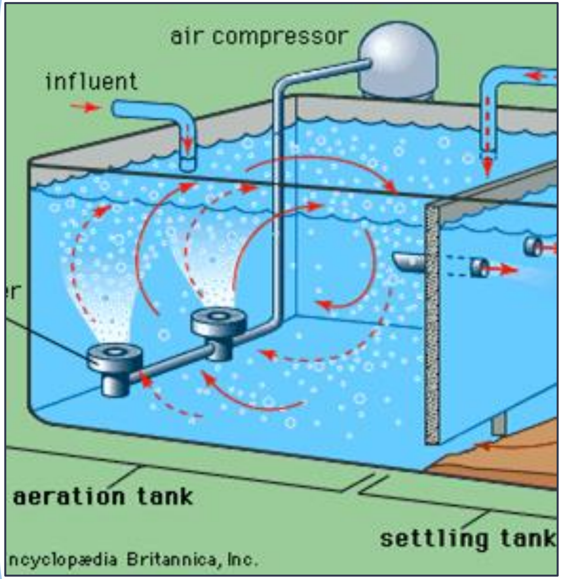


Figure 12: Conventional Activated Sludge Example [12]

Membrane Bioreactor

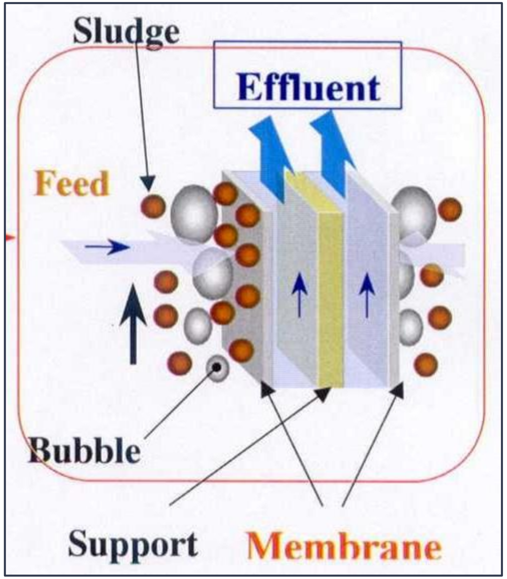


Figure 13: Membrane Bioreactor Example [13]

Moving Bed Bioreactor

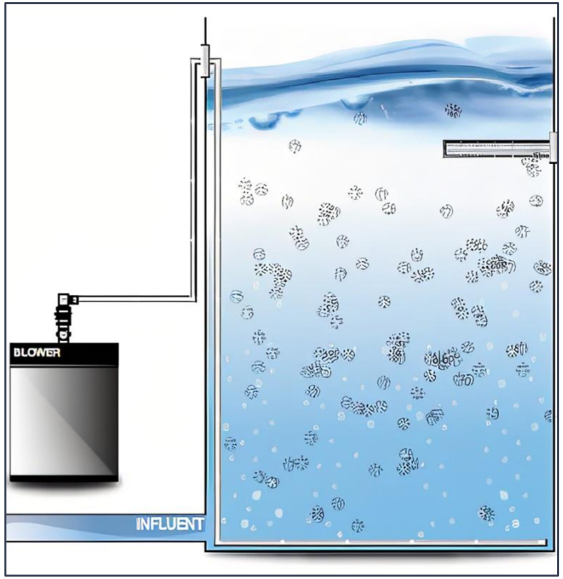


Figure 14: Moving Bed Bioreactor Example [14]

Secondary Treatment				
Criteria	**Weight (%)**	**Conventional Activated Sludge**	**Membrane Bioreactor**	**Moving Bed Bioreactor**
Capital Cost	20	1	3	2
Maintenance & Operation Cost	25	3	1	1
Construction Time/Constructability	25	2	1	2
Life Cycle Cost	15	3	1	1
Footprint	10	1	2	3
Removal Efficiency	5	1	2	3
Weighted Average	**100**	**2.05**	**1.55**	**1.75**

Table 6: Secondary Treatment Decision Matrix

Secondary Treatment Decision Matrix

Advanced Treatment Alternatives

Disc Filter

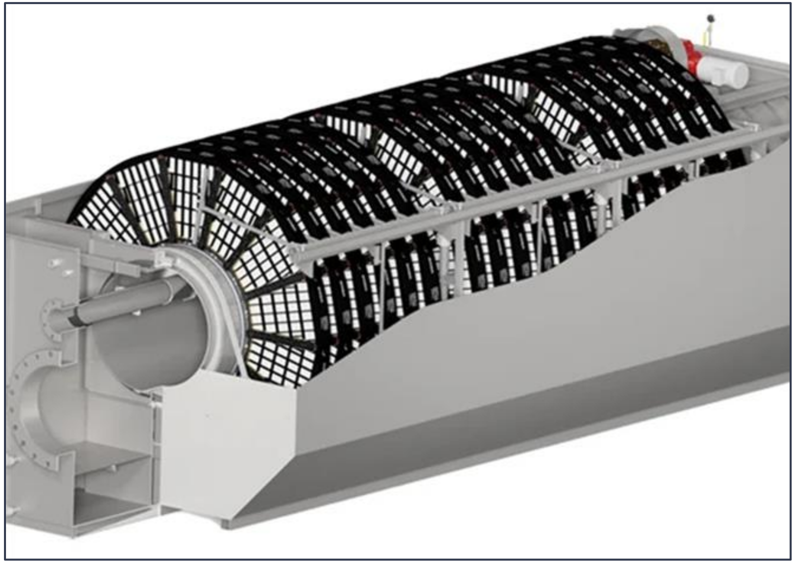


Figure 15: Disc Filter Example [15]

Sand Filter

Figure 16: Sand Filter Example [16]

Advanced Treatment			
Criteria	**Weight (%)**	**Disc Filters**	**Sand filters**
Capital Cost	30	2	1
Constructability/Construction Time	10	2	1
Maintenance & Operation	25	2	1
Removal Efficiency	35	2	1
Weighted Average	**100**	**2**	**1**

Table 7: Advanced Treatment Decision Matrix

Advanced Treatment Decision Matrix

Disinfection Alternatives

Chlorine Contact Basin

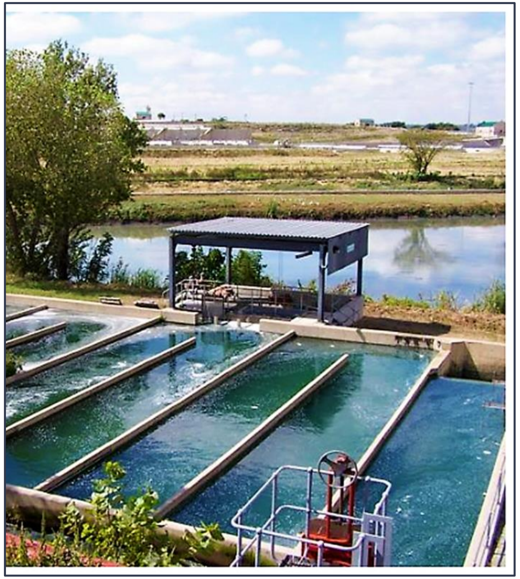


Figure 17: Chlorine Contact Basin Example [17]

Ultraviolet Disinfection

Figure 18: UV Disinfection Example [18]

Ozone Disinfection

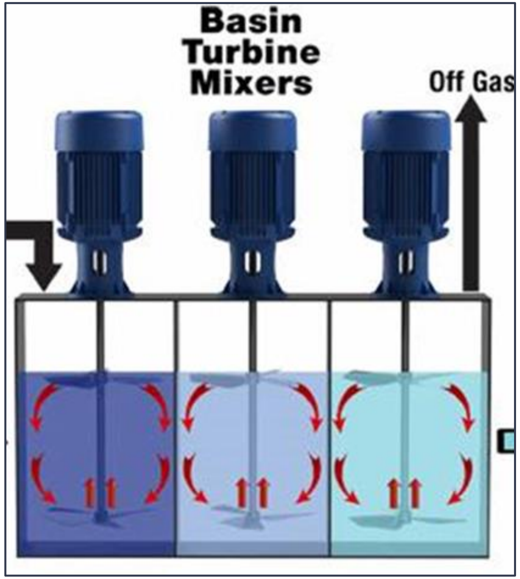


Figure 19: Ozone Disinfection Example [19]

Disinfection				
Criteria	**Weight (%)**	**Chlorination Tank**	**UV**	**Ozone**
Relative Cost	30	2	3	1
Surface Area Requirements	20	1	3	2
Social & Environmental Impacts	10	1	3	2
Maintenance & Operation	15	3	2	1
Disinfection Rate	25	1	2	3
Weighted Average	**100**	**1.6**	**2.6**	**1.8**

Table 8: Disinfection Decision Matrix

Disinfection Decision Matrix

Solids Management Alternatives

Centrifuge

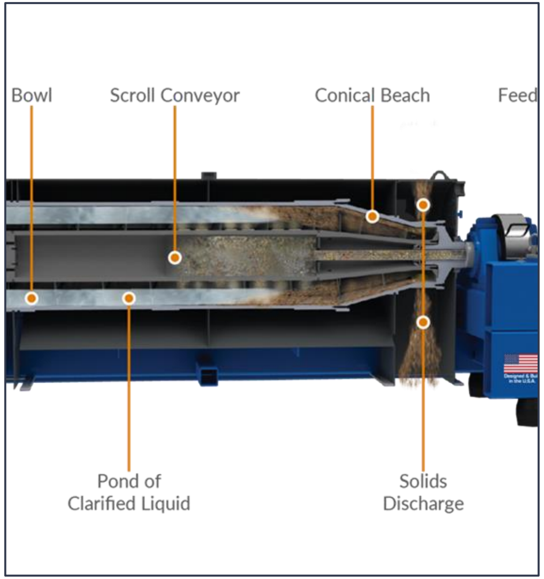


Figure 20: Centrifuge Example [20]

Drying Bed

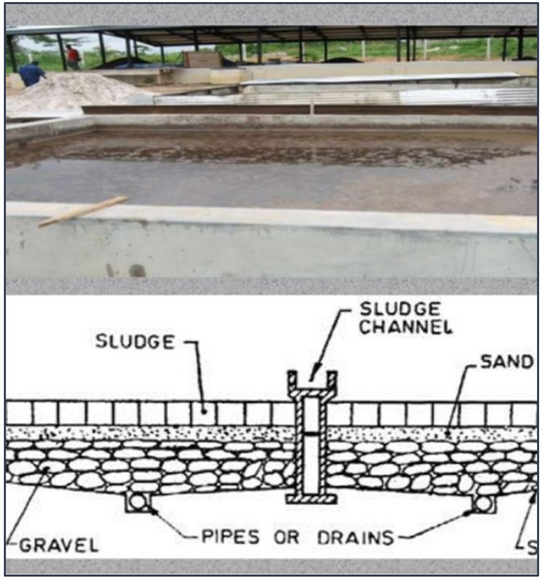


Figure 21: Drying Bed Example [21]

Filter Press

Figure 22: Filter Press Example [22]

Solids Management				
Criteria	**Weight (%)**	**Centrifuge**	**Drying Beds**	**Filter Press**
Relative Cost	30	2	1	3
Environmental/Social Impacts	10	3	1	2
Drying Time	20	3	1	2
Surface Area Requirements	25	3	1	2
Maintenance & Operation	15	3	1	2
Weighted Average	**100**	**2.7**	**1**	**2.3**

Table 9: Solids Management Decision Matrix

Solids Management Decision Matrix

FLOW CAPACITY: 4 MGD

- **6mm Spiral Fine Screen**
- **95% Grit Removal**

NUMBER OF UNITS: 2

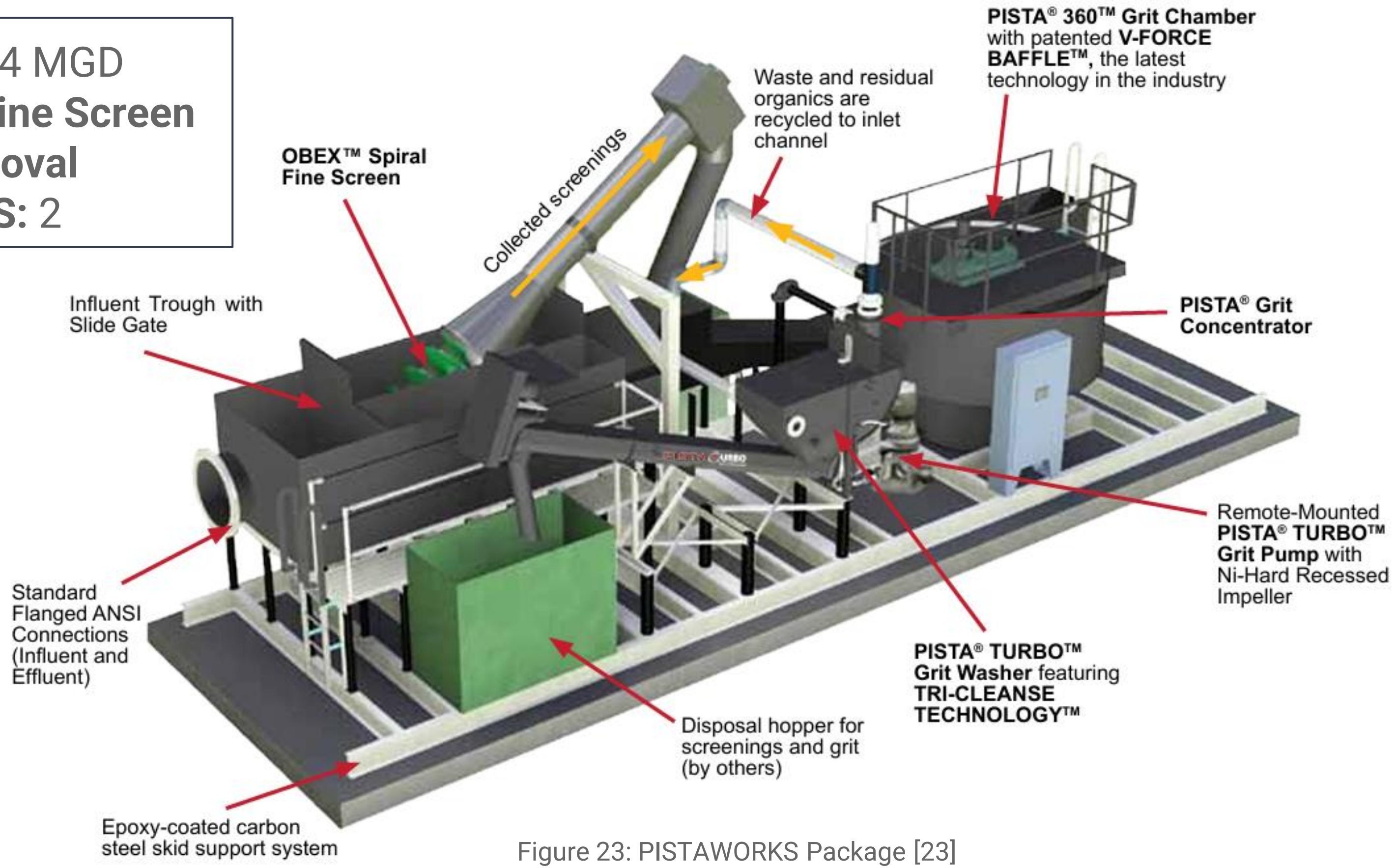


Figure 23: PISTAWORKS Package [23]

PISTAWORKS Screening and Grit Removal All-in-One Package

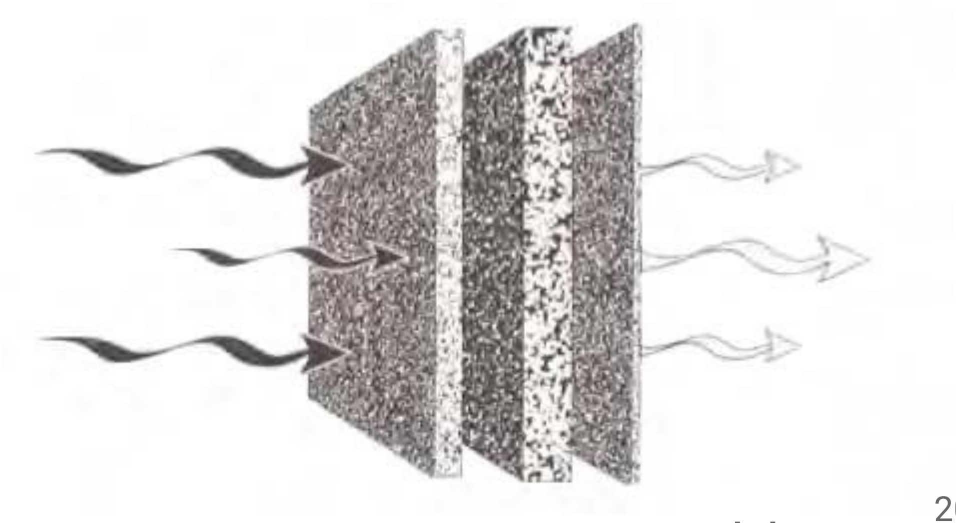
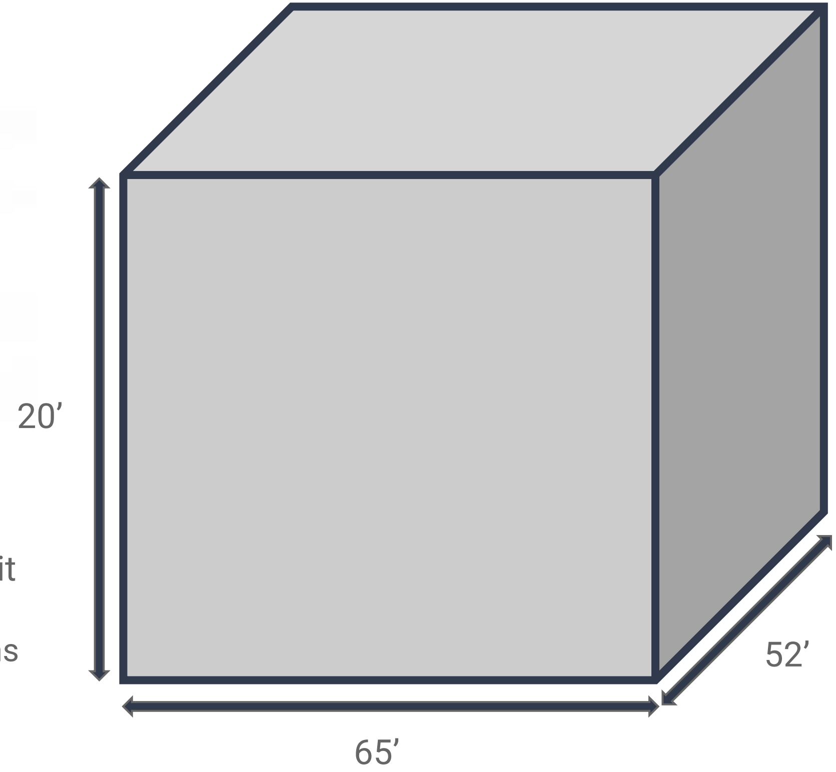


Figure 24: Activated Carbon Schematic [24]

- Concrete block building will cover the screen and grit chamber units
- Ventilation systems and activated granular carbon drums will purify odor from air



Odor Control

Air Requirement	512 ft^3/min
Freeboard	2.5 ft

Peak Hour Flow for 0.75 MGD = 2.66 MGD

$$\frac{2.66\ MGD}{0.75\ MGD} = \frac{x}{3\ MGD}$$

$$x = 10.6\ MGD$$

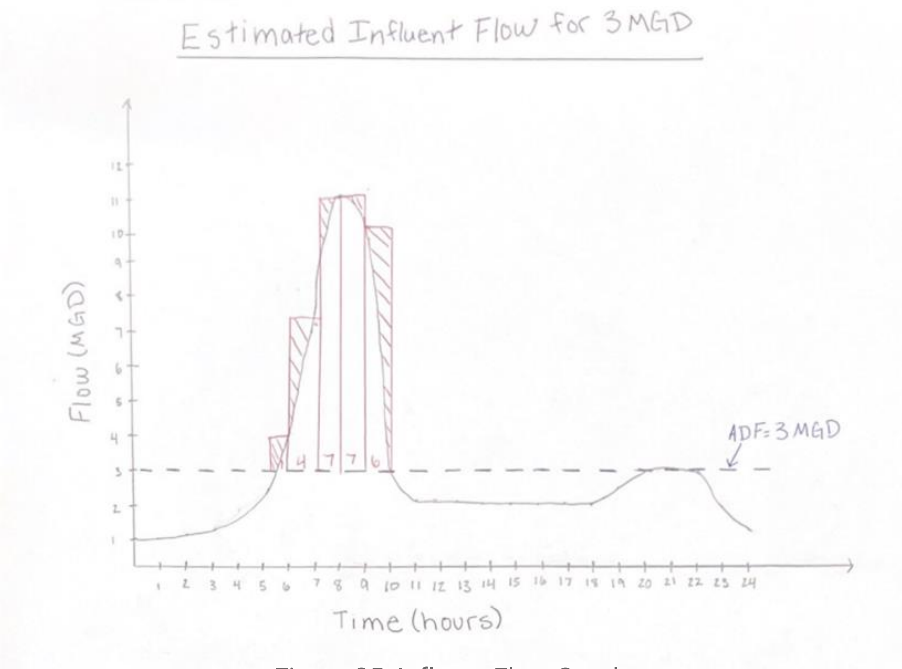


Figure 25: Influent Flow Graph

Equalization Basin Design

NUMBER OF UNITS: 2
DIAMETER: 65’
SIDE WATER DEPTH: 10’ 2”

SETTLING VELOCITY: 0.094 FT/S
DETENTION TIME: 2.13 HRS
ENERGY CONSUMPTION: 13.4 kW/DAY

INFLUENT BOD: 225 mg/L
EFFLUENT BOD: 169 mg/L > 10 mg/L
INFLUENT TSS: 250 mg/L
EFFLUENT TSS: 125 mg/L > 10 mg/L

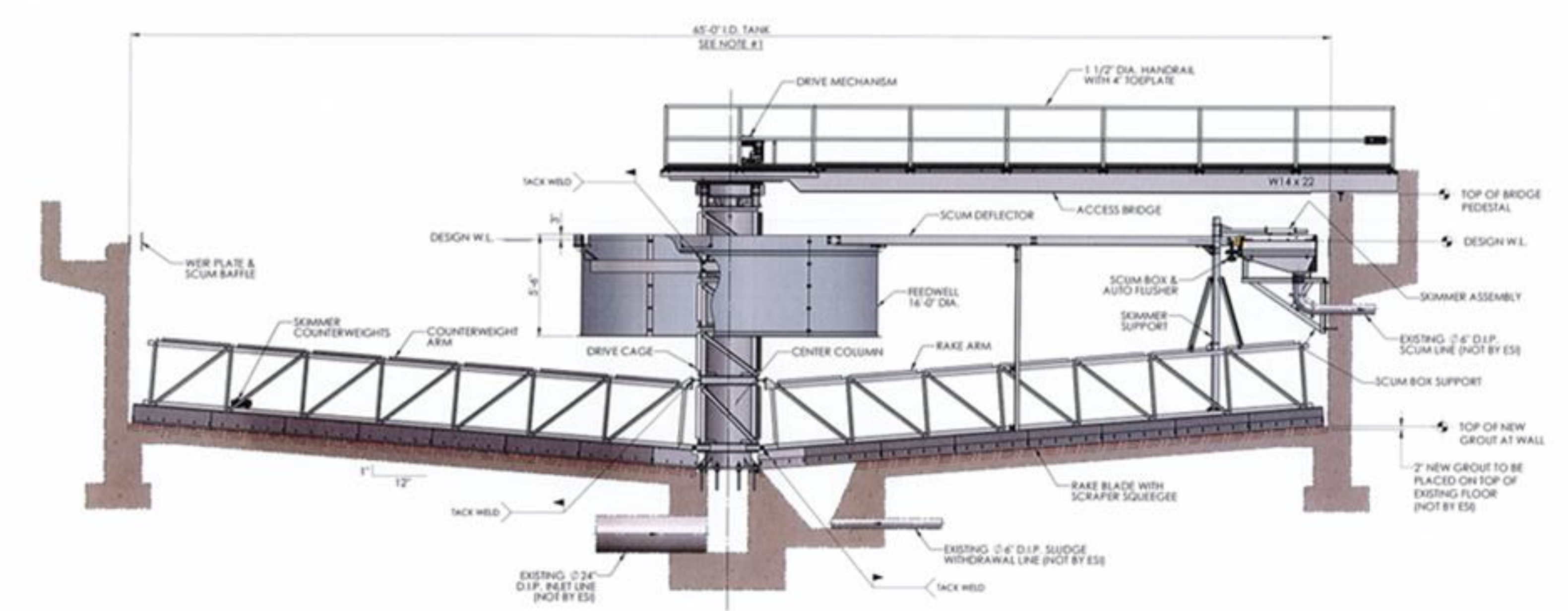
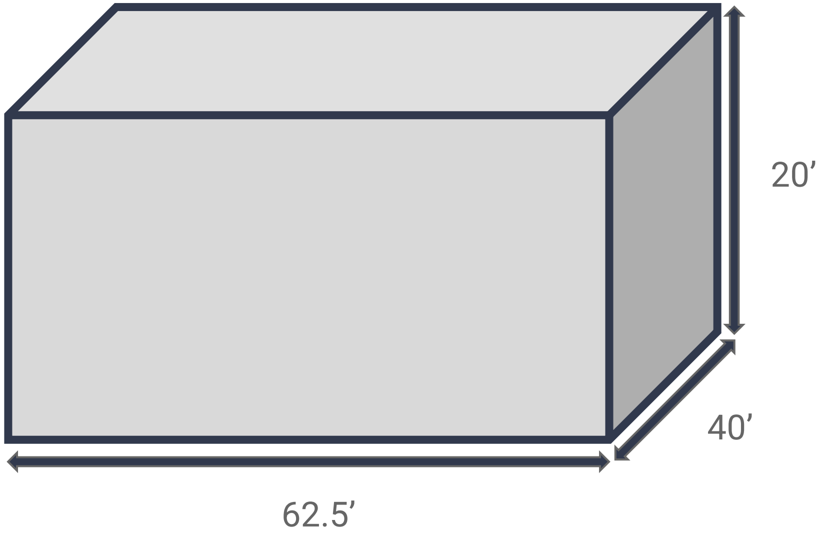


Figure 26: ENVIRODYNE Column Support Clarifier [25]

Column Support Primary Clarifier



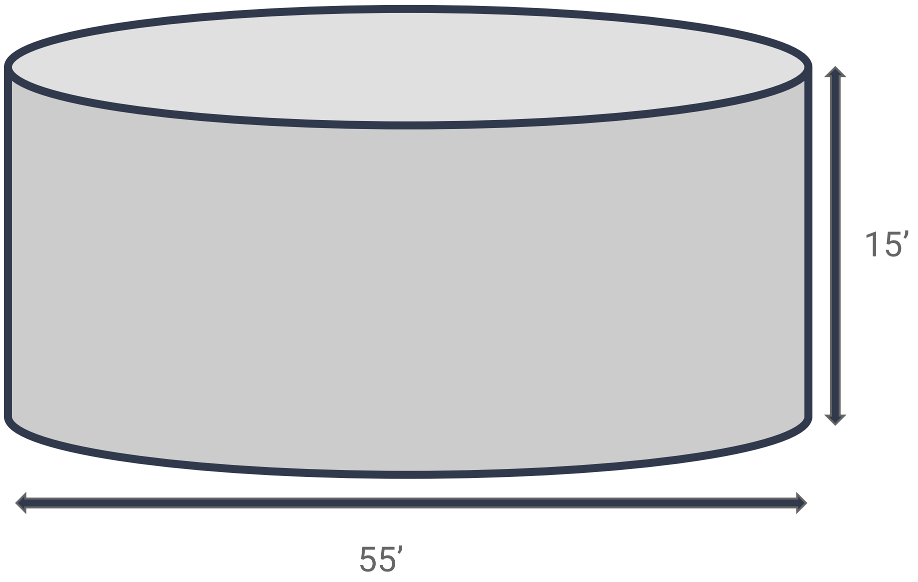
Flow Capacity	0.75 MGD
Number of Basins	5
Detention Time	9.45 HRS
Return Activated Sludge	85%
Waste Activated Sludge	15%
Influent BOD	169 mg/L
Effluent BOD	8.4 mg/L < 10 mg/L
Influent TSS	125 mg/L
Effluent TSS	12.5 mg/L > 10 mg/L

Table 10: Activated Sludge Data

Activated Sludge Design (Aeration Basin)

Flow Capacity	0.75 MGD
Number of Clarifiers	5
Detention Time	9 HRS
Energy Consumption	13.42 kW/Day
Settling Velocity	0.008 FT/S
Settling Time	31 MIN

Table 11: Secondary Clarifier Data



Activated Sludge Design (Secondary Clarifier)

FLOW CAPACITY: 3 MGD

NUMBER OF NEW UNITS: 2

PORE SIZE: 10 MICROMETERS

REMOVAL EFFICIENCY OF SUSPENDED SOLIDS: 98%

INFLUENT TSS: 12.8 MG/L
EFFLUENT TSS: 5 MG/L < 10 mg/L

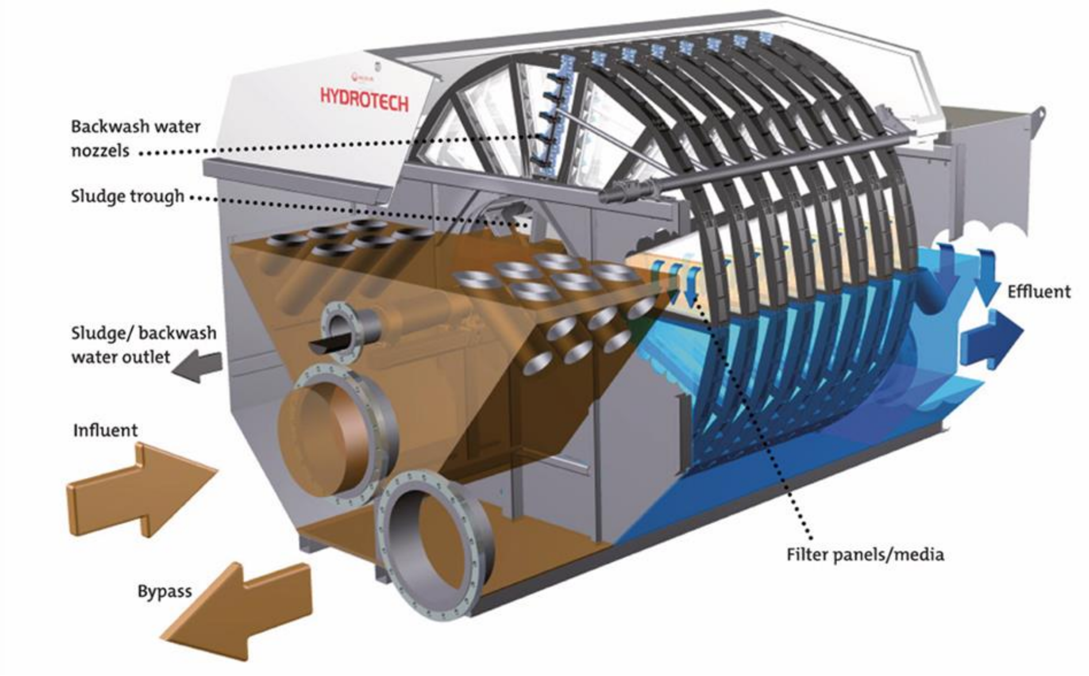


Figure 27: Hydrotech HSF2200 Disc Filter [26]

Disc Filter

FLOW CAPACITY: 0.5 MGD

NUMBER OF UNITS: 7

LENGTH: 9’ 7”

WIDTH: 1’ 6”

UV MODULES: 12 PER CHANNEL

LAMPS: 4 PER CHANNEL

UV TRANSMISSION: 65%

Figure 28: Single TrojanUV 3000 PTP Units [27]

Ultraviolet Disinfection System

FLOW CAPACITY: 190,000 GPD
NUMBER OF NEW UNITS: 3
MINIMUM SOLID CAPTURE: 95%

***Assume 15% WAS ~** 450,000 GPD

Figure 29: Andritz D4L Decanter Centrifuge [28]

Figure 30: Rubber Conveyor Belt [29]

NUMBER OF CONVEYOR BELTS: 3

Decanter Centrifuge

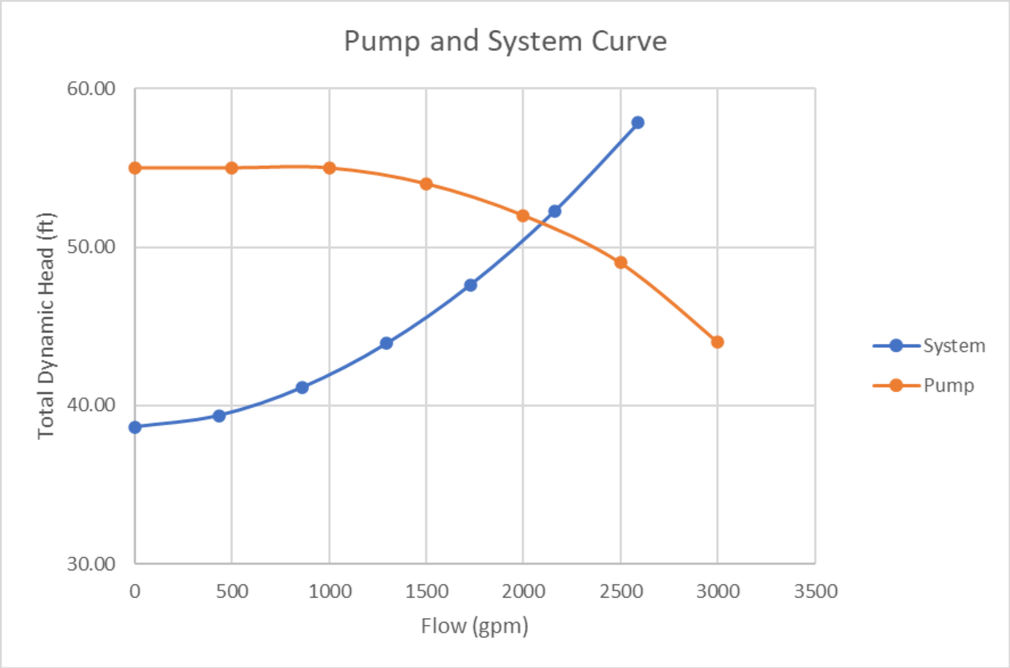


Figure 31: Pump and System Curve

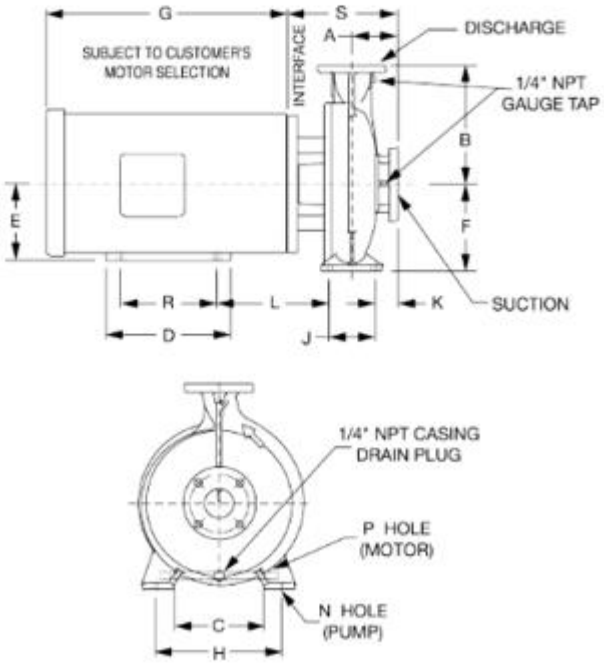
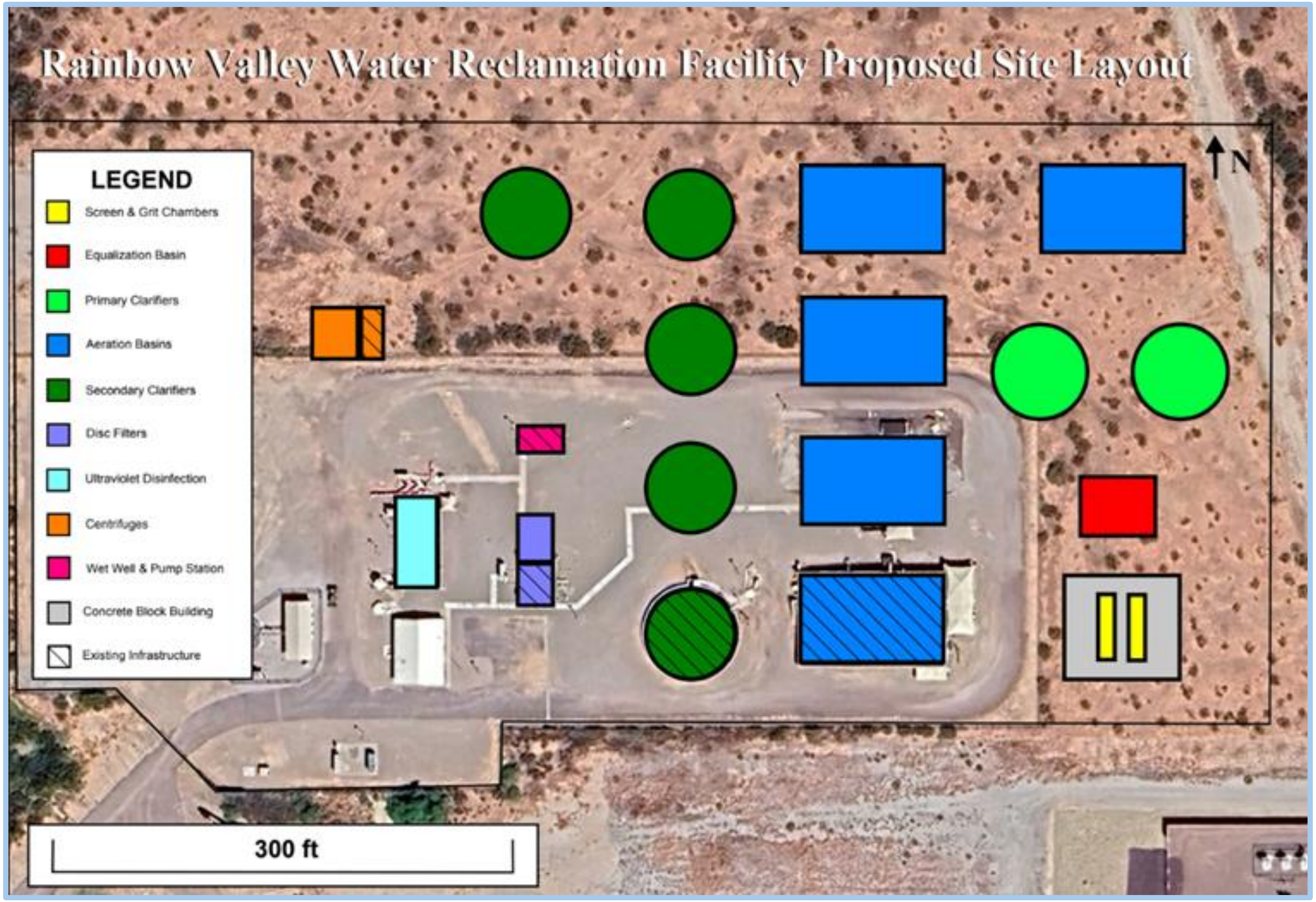
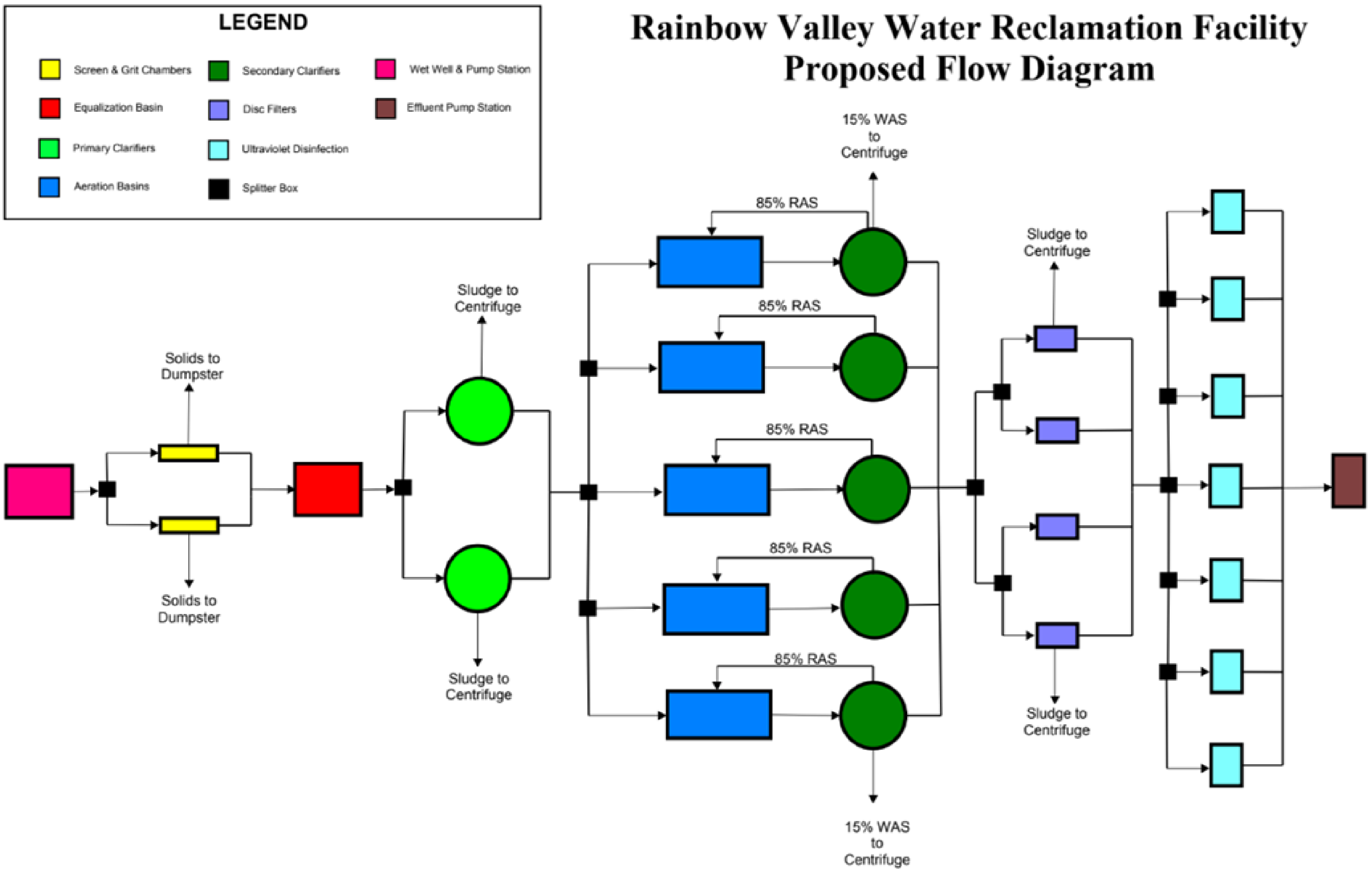


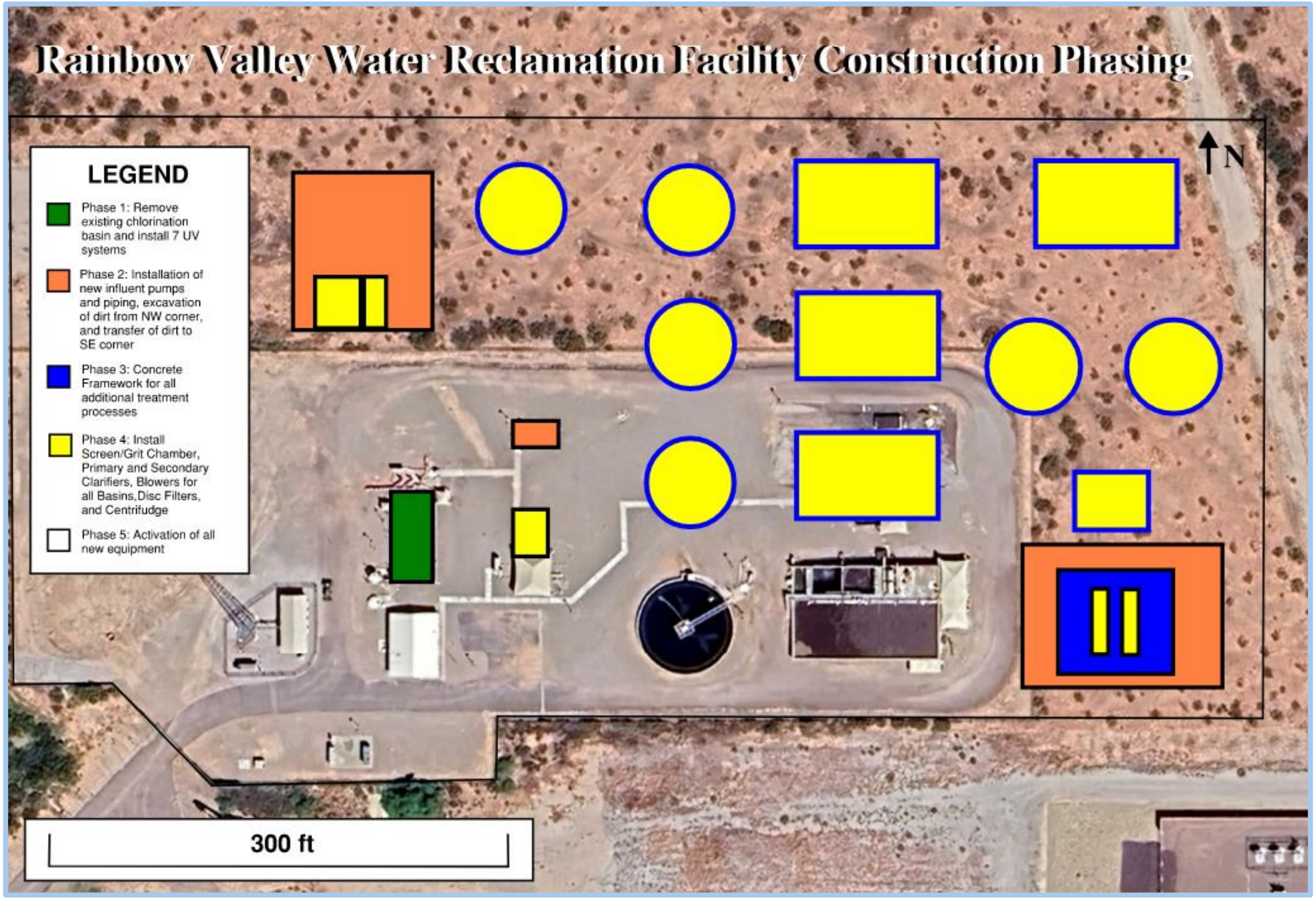
Figure 32: Taco CI4009D Pump [30]

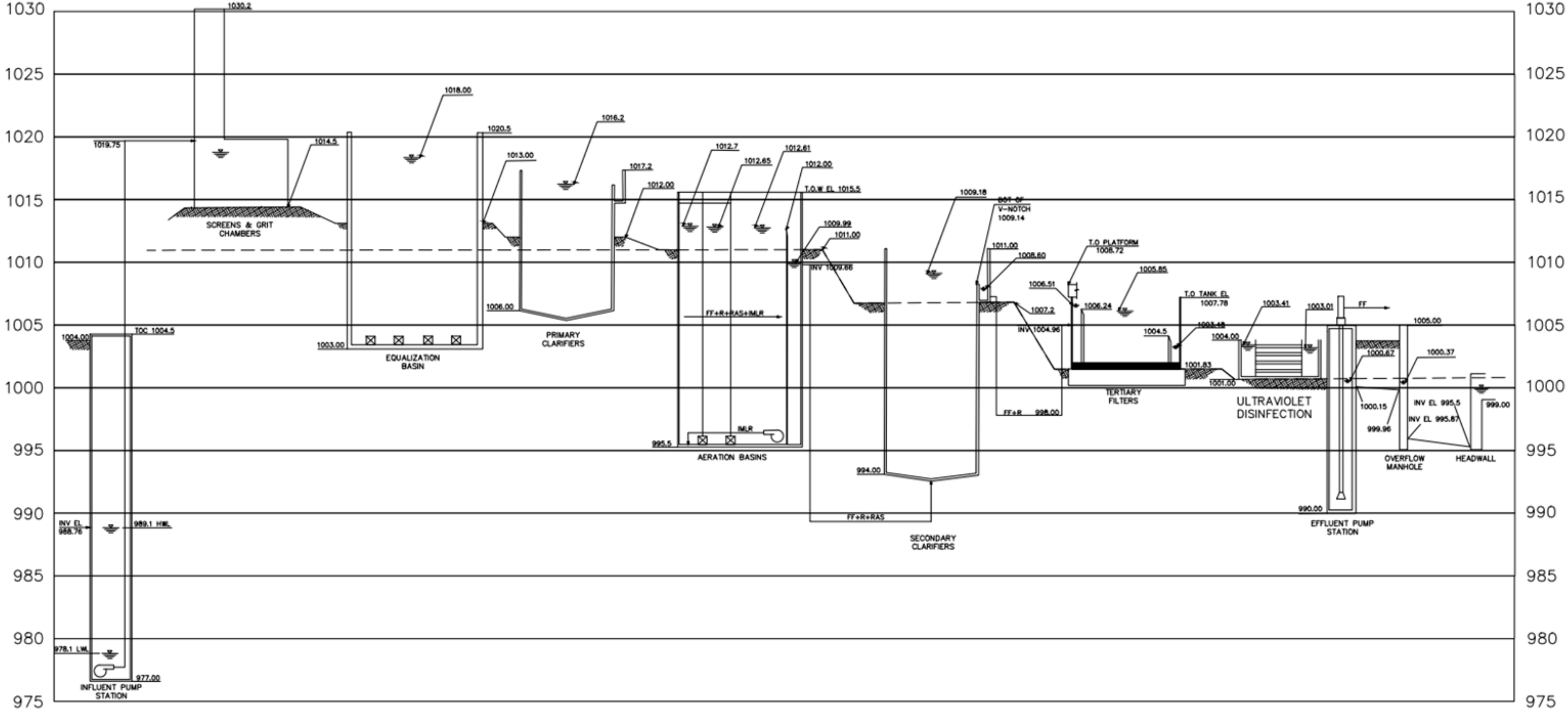
Hydraulic Analysis


Rainbow Valley Water Reclamation Facility Proposed Site Layout
LEGEND
Screen & Grit Chambers
Equalization Basin
Primary Clarifiers
Aeration Basins
Secondary Clarifiers
Disc Filters
Ultraviolet Disinfection
Centrifuges
Wet Well & Pump Station
Concrete Block Building
Existing Infrastructure
N
300 ft



LEGEND
Screen & Grit Chambers
Equalization Basin
Primary Clarifiers
Aeration Basins
Secondary Clarifiers
Disc Filters
Ultraviolet Disinfection
Splitter Box
Wet Well & Pump Station
Effluent Pump Station
Rainbow Valley Water Reclamation Facility
Proposed Flow Diagram
Solids to Dumpster
Solids to Dumpster
Sludge to Centrifuge
Sludge to Centrifuge
15% WAS to Centrifuge
85% RAS
85% RAS
85% RAS
85% RAS
85% RAS
15% WAS to Centrifuge
Sludge to Centrifuge
Sludge to Centrifuge


Rainbow Valley Water Reclamation Facility Construction Phasing
LEGEND
Phase 1: Remove existing chlorination basin and install 7 UV systems
Phase 2: Installation of new influent pumps and piping, excavation of dirt from NW corner, and transfer of dirt to SE corner
Phase 3: Concrete Framework for all additional treatment processes
Phase 4: Install Screen/Grit Chamber, Primary and Secondary Clarifiers, Blowers for all Basins, Disc Filters, and Centrifudge
Phase 5: Activation of all new equipment
N
300 ft



Proposed Hydraulic Profile

Includes:

- Earthwork ~ $65,000
- Concrete Excavation & Installation ~ $265,000
- Capital & Installation Cost of Prefabricated Equipment ~ $5,610,000
- Activated Sludge Process ~ $22,000,000
- Pipes, Pumps, & Splitter Boxes ~ $2,900,000
- Odor Control ~ $40,000

Total Engineers Opinion of Probable Cost
$31,617,180

Engineers Opinion of Probable Cost

Annual Operation & Maintenance Cost
$4,731,950

Operation:

- Energy Consumption ~ $1,514,300
- Labor ~ $190,000

Maintenance ~ $2,900,000

- Inspections
- Oil Changes
- Replacements of Parts
- Cleaning of Parts

Operation and Maintenance Cost Analysis

		People (Social)		Planet (Environmental)		Price (Economic)		Total	Max-Min	SI
Alternative 1: Implementation of the Project	**Positive Impacts**	-More residential opportunity -More jobs provided	70	-More wastewater treated -Addition of odor control	55	-More money into economy -More land development Score: 75	75	200	20	180
	Negative Impacts	-Close housing to the facility -City may grow too fast		-Construction will disrupt area -More odorous gas		-Very expensive project -Higher O&M cost				
Alternative 2: Not Implementing the Project	**Positive Impacts**	-City would remain less crowded -City resources used elsewhere	40	-No disruption to the existing land -More free land around the facility	65	-City can use money elsewhere -Lower O&M cost remain	65	140	30	110
	Negative Impacts	-Less housing opportunities -Less access to additional reclaimed water.		-Natural water sources would be utilized more -Lack of odor control		-Less land development -Additional treated water needed transported to the city				

Impact Analysis

Citations

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Questions?

We competed at the AZ Water Student Design Competition on April 23rd and we won!!

Detailed Decision Matrices

Preliminary Treatment (Screening)				
Criteria	Weight (%)	Fine Screen	Step Screen	Static Screen
Capital Cost	30	3	1	2
		$180,000.00	$250,000.00	$200,000.00
Maintenance & Operation	25	3	2	1
		Regular inspections to ensure proper functioning, mechanical/self cleaning design, easy maintenance	Periodic inspection of step surfaces, no regular lubrication, adjustment of step spacing as needed, removal of accumulated debris	Frequent inspections of screens and damages/wear, self cleaning design, chemical use for cleaning
Construction Time/Constructability	15	2	1	3
		Moderate construction time, prefabricated (involves welding or bolting), requires skilled labor for precise installation	Higher construction time, prefabricated (involves welding), mechanical components to install, less specialized labor	Shorter construction time due to straightforward design, prefabricated so simple installation process, minimal labor skills
Odor Control	10	2	3	1
		Are mostly installed with enclosures to route fouled air through an odor control system	Installed with enclosures and includes proper ventilation system to mitigate odors	Must be uncovered to clean, would need additional technologies to properly ventilate odors
Social & Environmental Impacts	10	2	3	1
		Good worker safety from minimized hazards, reduced risk of clogging downstream and has sustainable operation	Improves worker safety because of enclosed design, reduces odor efficiently, reduces wear of downstream equipment and has efficient screening operation	Enclosed system helps worker safety, limited flexibility for adjusting screens, prevents clogging, sustainable operation
Staffing	10	3	2	1
		Minimal staffing since they are self cleaning and automated, requires little attention, operators inspect for damage while supervisors ensure proper functioning	Moderate staffing, need to monitor mechanical bars for specific spacing and maintain screens, remove accumulated debris, bars manually cleaned and inspected by maintenance staff, supervisors oversee efficient operation	Some staffing needed, regularly inspected and maintained by maintenance personnel, clean screen surface, need supervisors to oversee operation
Weighted Average	100	2.65	1.75	1.6

Preliminary Treatment (Grit Chamber)				
Criteria	Weight (%)	Aerated Grit Chamber	Horizontal Flow Grit Chamber	Vortex-Type Grit Chamber
Capital Cost	25	3	2	1
		$134,000.00	$148,800.00	$186,000.00
Removal Efficiency	20	2	3	3
		Removal of particals greater than 0.21mm	Removal of particals greater than 0.2mm	Removal of particles greater than 0.2mm
Construction Time/Constructability	15	2	1	3
		Prefabricated and has moderate construction time, flexible constructability, has mechanical components and concrete structures	Moderate to long construction time, requires concrete channel/basin, not complicated construction, flexible and straight forward design, oldest and widely used type of grit removal	Prefabricated and has short construction time, good constructability, relatively straightforward design, requires skilled labor
Maintenance & Operation	10	2	1	3
		Requires additional labor fro operation due to complexity of equiptment	Extensive maintenace reuired due to excessive wear on equitpment	Requires high-pressure agitation to loosen grit compacted in the sump
Footprint	20	2	1	3
		Relatively large duee to aeration tank needed	Large land area required for long channel/basin required	Small land area required due to small equitpment
Energy Consumption	10	1	3	2
		High energy consumption due to air being introduced at a high rate	Low energy consumption since flow is controlled to be slow to allow particles to settle	Moderate energy comsuption needed for rotating turbine
Weighted Average	**100**	**2.15**	**1.85**	**2.4**

Preliminary Treatment (Equalization Basin)			
Criteria	**Weight (%)**	**In-Line Basin**	**Side-Line Basin**
Relative Cost	40	2 No additional equipment and piping	1 Additional equipment and piping
Maintenance and Operation	25	2 No additional equipment and piping	1 Additional equipment and piping
Construction Time/Constructability	20	2 No additional equipment and piping	1 Additional equipment and piping
Staffing	15	2 No additional equipment and piping	1 Additional equipment and piping
Weighted Average	**100**	2	1

Primary Treatment (Primary Clarifier)			
Criteria	**Weight (%)**	**Bridge Support Clarifier**	**Column Support Clarifier**
Capital Cost	40	1	2
		65' diameter~ $450,000	65' diameter~ $314,000
Surface Area Requirements	25	1	2
		Multiple clarifiers <40' diameter	One clarifier >40' diameter
Construction Time/Constructability	20	1	2
		Full span bridge	Half span bridge
Maintenance & Operation	15	2	1
		Supports accessible by bridge	Supports submerged
Weighted Average	**100**	**1.15**	**1.85**

Secondary Treatment				
Criteria	Weight (%)	Convention Activated Sludge	Membrane Bioreactor	Moving Bed Bioreactor
Capital Cost	20	1	3	2
		$11,000,000.00	$4,431,818.00	$6,352,500.00
Maintenance & Operation Cost	25	3	1	1
		Would require 5 treatment trains to operate. Continuous and well-timed supply of oxygen is required during operation. No media or filters to clean. Blowers may need to be inspected 1-2 times a year to ensure proper aeration is being completed. Small maintenance and operation costs.	Would require 36 small treatment trains to operate. Require in-place membrane cleaning 2-4 times per year. Air scour is also used to clean the membranes. They can be cleaned in the MLSS so does not require the basin to be drained. Continuous aeration and sludge management is required. Higher maintenance and operation costs because of the units required.	Would require 42 small units to maintain and operate. Cleaning of biofilm on the media is required frequently. Sludge removal in the system is required along with continuous aeration. Relatively higher maintenance and operation costs because of the number of units required.
Construction Time/Constructability	25	2	1	2
		5 treatment trains required (1 train exisitng, 4 new to construct). Concrete tanks must be constructed on site. Assembly units like pumps, motors, pipes, and blowers must be installed. Requires relatively large construction time. Less excavation required because the existing facility would be utilzed.	36 treatment trains required. Concrete tanks must be constructed on site. Membrane unit is prefabricated and can be installed by local technicians. Requires large construction time because of the number of tanks that need to be built. Existing infrastructure will have to be demolished.	42 units are required. Prefabricated units available that can be installed by local technicians. Placement of 42 units will take a long time. Existing infrastructure would have to be demolished.

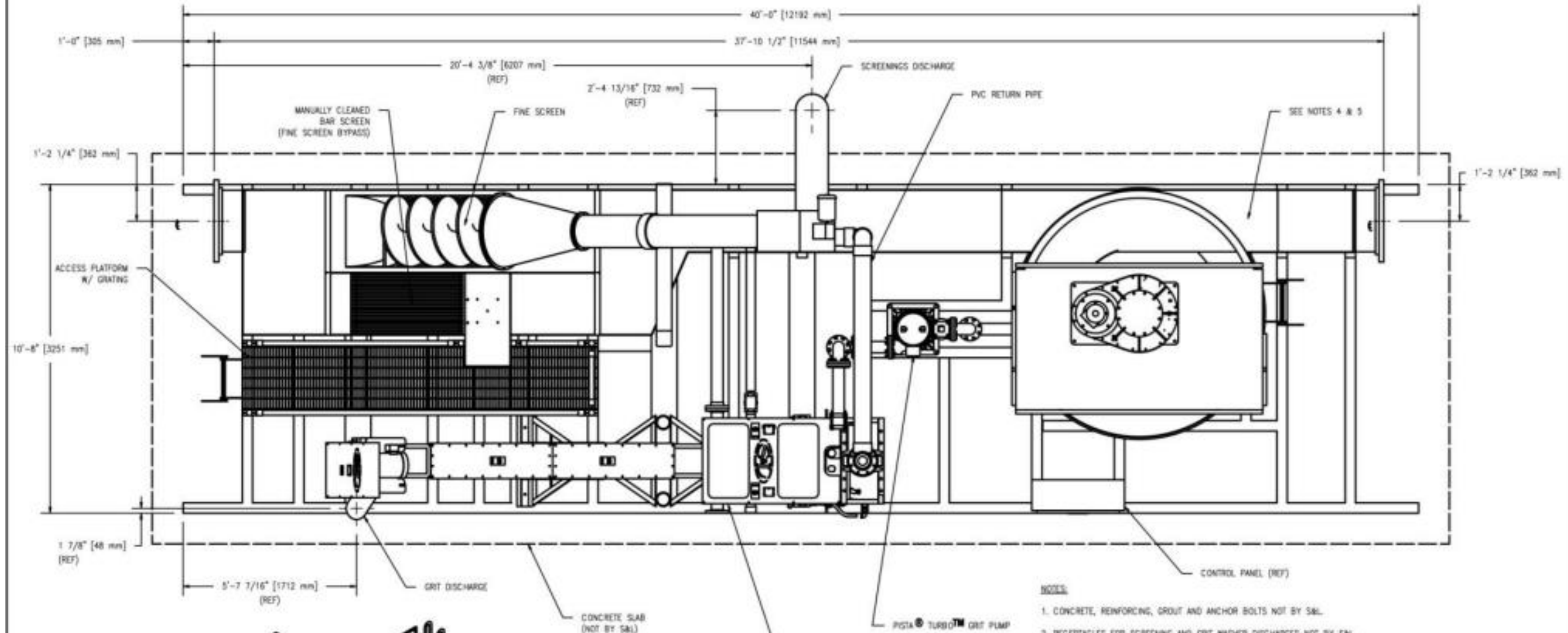
Life Cycle Cost	15	3	1	1
		Low life-cycle assessment (LCA) due to low operating and maintenance requirements.	Higher LCA as compared to CAS due to high electricity requirement and low capacity, moderate cost for maintenance, lower initial capital and operating cost compared to MBBR	Highest life cycle cost due to high electricity requirement and low capacity. Similar operating and maintenance cost to MBR, moderate membrane replacement costs but generally higher capital cost than MBR
Footprint	10	1	2	3
		Relatively large footprint. Approx 39272 additional square ft required for 3 MGD	Larger footprint than moving bed but smaller than CAS. Approx 15618 square ft required for 3 MGD. Additional square footage between units will be required	Smaller footprint but requires more facilities. Approx 10510 square ft required for 3 MGD. Additional square footage between units will be required
Ability to meet permit limits	5	1	2	3
		Meets almost all (≈90%) NPDES permit discharge limitations except for fecal coliform (requires additional disinfection). NPDES limits: BOD of 30 mg/L, meets TSS of 30-45 mg/L, achieves pH range of 6-9, meets limit residual chlorine of 0.5 mg/L, fecal coliform of 200/100 mL (30 day mean) or 400/100 mL (max daily), meets 40 mg/L TKN, achieves ammonia of 10 mg/L, achieves P limit of 5 mg/L.	Meets all (90%) NPDES permit discharge limitations: BOD of 10 mg/L, TSS of 10 mg/L, pH between 6.5 and 8.5, ammonia Nitrogen of 5 mg/L, fecal coliform of less than 200 MPN/100 mL, P range of 2-5 mg/L	Meets all (>90%) NPDES permit discharge limitations and has wide range. BOD of 20 mg/L, meets TSS of 20 mg/L, pH between 6.5 and 8.5 ammonia Nitrogen of 10 mg/L, fecal coliform of 200-1000 MPN/100 mL, P of < 1 mg/L
Weighted Average	**100**	**2.05**	**1.55**	**1.75**

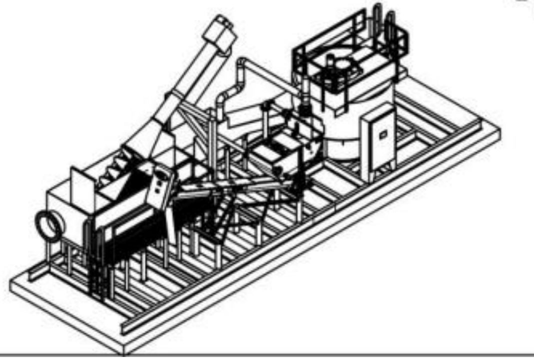
Advanced Treatment			
Criteria	**Weight (%)**	**Disc Filters**	**Sand filters**
Capital Cost	30	2	1
		$720,000.00	$1,080,000.00
Constructability/Construction Time	10	2	1
		Parts are prefabricated by the manufacture and assembled on site	Concrete for treatment basin will need to be cast onsite, pipes, pumps and underdrain will be installed
Maintenance & Operation	25	2	1
		Requires lubrication and replacement of parts and back washing of discs	Requires backwashing of soil media, inspections of pumps, and occasional replacement of soil
Removal Efficiency	35	2	1
		Removal of particles larger than 10 microns, removes nearly all BOD and TSS	Removes most of the TSS and BOD in the water
Weighted Average	**100**	**2**	**1**

Disinfection				
Criteria	**Weight (%)**	**Chlorination Tank**	**UV**	**Ozone**
Relative Cost	30	2	3	1
		Cost for large contact tank and chemicals	Cost for equipment (less than chlorination)	The cost of treatment can be relatively high in capitol and in power intensiveness
Surface Area Requirements	20	1	3	2
		Most area required for effective disinfection	Equipment requires less space than other methods	Three tanks required for ozone treatment
Social & Environmental Impacts	10	1	3	2
		Even at low concentrations, chlorine is toxic to aquatic life. Can produce large chemical smell	Physical process, so no residual effect that can be harmful to humans or aquatic life	No harmful residuals that need to be removed
Maintenance & Operation	15	**3**	**2**	**1**
		More cost effective than UV or ozone when dechlorination is not required	UV is user-friendly for operators, preventative maintenance program is necessary to control fouling of tubes	Ozone is generated onsite, so there are fewer safety problems with shipping and handling, but more complex technology, very corrosive and reactive
Disinfection Rate	25	**1**	**2**	**3**
		Can prolong disinfection even after initial treatment and can be measured to evaluate the effectiveness	Effective at inactivating most viruses, spores, and cysts	More effective than chlorine in destroying viruses and bacteria
Weighted Average	**100**	**1.6**	**2.6**	**1.8**

Solids Management				
Criteria	**Weight (%)**	**Centrifuge**	**Drying Beds**	**Filter Press**
Relative Cost	30	2	1	3
		Capital costs are more than a belt press but operation and maintenance costs can be less expensive. High energy consumption	No energy consumption, only need to build the beds. Relatively low capitol cost	Low energy consumption but requires a larger footprint
Environmental/Social Impacts	10	3	1	2
		Fairly noisy, small and unnoticeable	No noise produced but may look concerning to the public, odor and insect activity may be an issue	Less noise produced than centrifuges, odor is sometimes an issue
Drying Time	20	3	1	2
		<20 minutes	Days to weeks	>1-2 hours
Surface Area Requirements	25	3	1	2
		Smallest footprint	Large land area required	Larger than a centrifuge but smaller than drying beds
Maintenance & Operation	15	3	1	2
		Requires minimal operator attention and is easy to clean. Operations can be fully automated but starting the bowl is usually done manually.	Sludge removal is labor intensive and time consuming. Clogging of the sand and gravel bed is common which doesn't allow the liquid to drain	Can be started and stopped quickly compared to centrifuges, require more operator attention. Requires belt washing which is time consuming. Belts may need to be replaced, average belt life is 2700 running hours.
Weighted Average	**100**	**2.7**	**1**	**2.3**

PistaWorks System Record Drawings





NOTES:

1. CONCRETE, REINFORCING, GROUT AND ANCHOR BOLTS NOT BY S&L.
2. RECEPTACLES FOR SCREENING AND GRIT WASHER DISCHARGES NOT BY S&L.
3. SEE NOTES ON DESIGN SECTION OF THE PISTA® CATALOG FOR HYDRAULIC REQUIREMENTS.
4. V-FORCE BAFFLES™ CONTROL VELOCITY BY CREATING HEAD LOSS. THE BAFFLES REQUIRE A FREE FLOWING FLUME IN THE OUTLET CHANNEL.
5. MAXIMUM WATER DEPTH IN OUTLET CHANNEL IS 8" [203 mm] AT 4.0 MGD [15.1 CMD].
6. DISCHARGE CHUTE DIMENSIONS ARE FOR REFERENCE ONLY AND WILL VARY BASED UPON THE LENGTH AND ANGLE OF THE CHUTE EXTENSION REQUIRED.
7. APPROXIMATE WEIGHT: 25,000 LBS [11339 kg].
8. COPYRIGHT (C) 2011, 14 SMITH & LOVELESS®, INC.

678553/B

SHEET 1 OF 2

LET	ECN NO	DATE	BY APPV'D
B	N2014-43	11/2014	
A	N2013-52	2/2014	

DRAWN BY: NAW — DATE: 11/28/2011
CHECKED BY: JD — DATE: 11/28/2011
APPROVED BY: CGM — DATE: 4/13/2012
SCALE: NTS — CODE:
ALLOWABLE TOLERANCES — FRACTIONS: – — DECIMALS: – — ANGLES: –
ORIGINAL ISSUE: N2012-7
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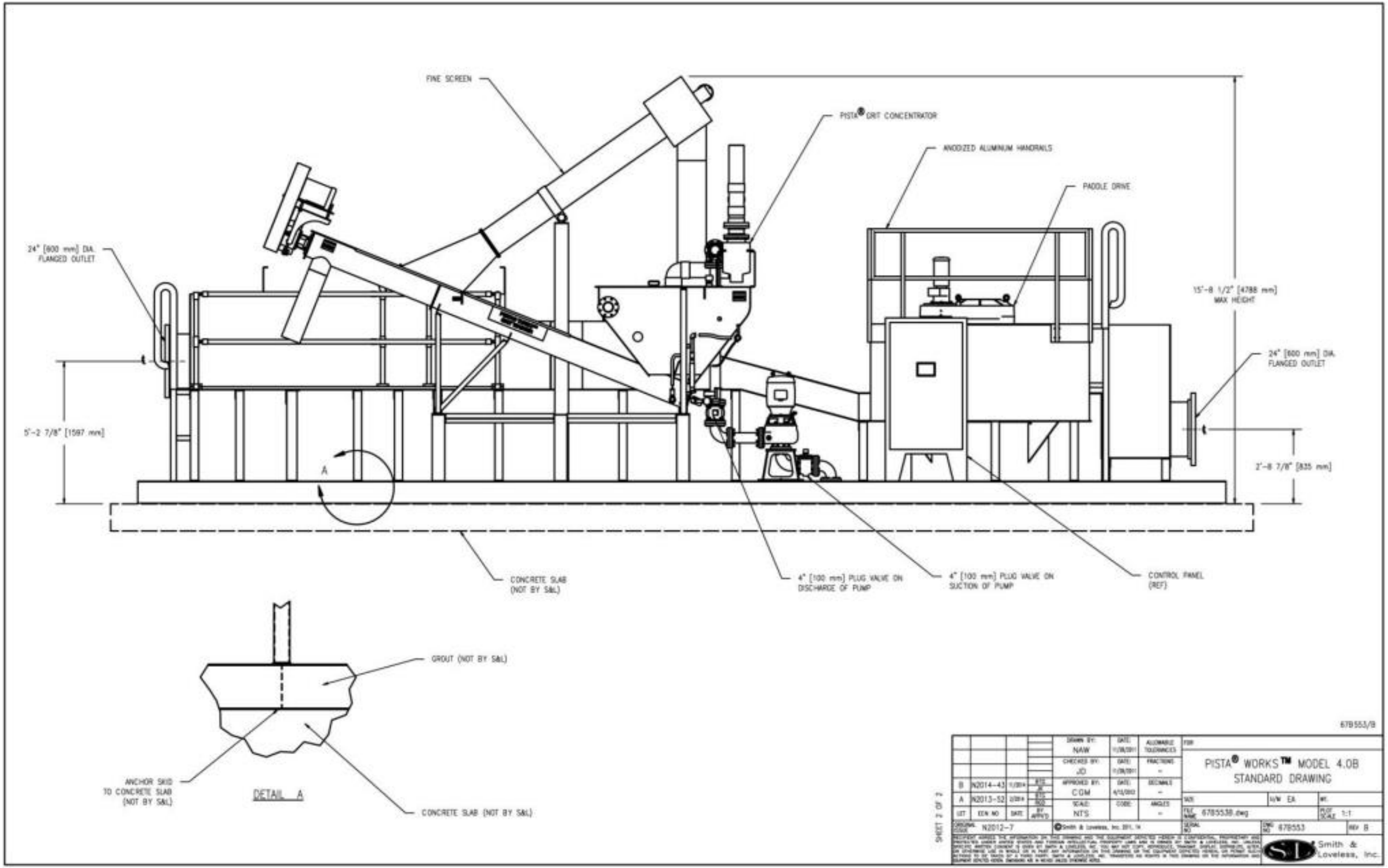
FOR

PISTA® WORKS™ MODEL 4.0B
STANDARD DRAWING

SIZE: — U/M: EA — WT:
FILE NAME: 678553B.dwg — PLOT SCALE: 1:1
SERIAL NO: — DWG NO: 678553 — REV: B

Smith & Loveless, Inc.


FINE SCREEN
PISTA® GRIT CONCENTRATOR
ANODIZED ALUMINUM HANDRAILS
PADDLE DRIVE
24" [600 mm] DIA. FLANGED OUTLET
15'-8 1/2" [4788 mm] MAX HEIGHT
24" [600 mm] DIA. FLANGED OUTLET
5'-2 7/8" [1597 mm]
2'-8 7/8" [835 mm]
A
CONCRETE SLAB (NOT BY S&L)
4" [100 mm] PLUG VALVE ON DISCHARGE OF PUMP
4" [100 mm] PLUG VALVE ON SUCTION OF PUMP
CONTROL PANEL (REF)
GROUT (NOT BY S&L)
ANCHOR SKID TO CONCRETE SLAB (NOT BY S&L)
DETAIL A
CONCRETE SLAB (NOT BY S&L)
678553/B
DRAWN BY: NAW
CHECKED BY: JD
APPROVED BY: CGM
SCALE: NTS
B N2014-43
A N2013-52
ORIGINAL ISSUE N2012-7
PISTA® WORKS™ MODEL 4.0B STANDARD DRAWING
U/M EA
PLOT SCALE 1:1
DWG NO 678553
REV B
Smith & Loveless, Inc.
SHEET 2 OF 2

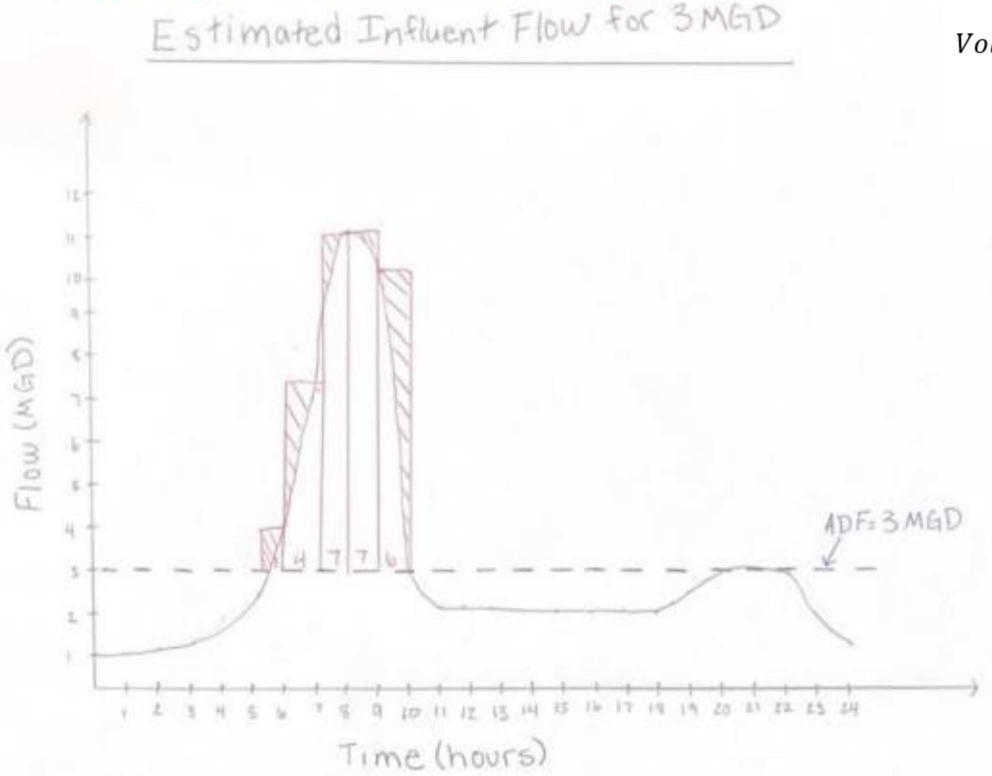
Equalization Basin Calculations

Peak Hour Flow for 0.75 MGD = 2.66 MGD

$$\frac{2.66\ MGD}{0.75\ MGD} = \frac{x}{3\ MGD}$$

$$x = 10.64\ MGD$$

*Assume 10.64 MGD as the peak hour flow for 3 MGD



Freeboard Calculations:

$$Volume\ of\ the\ Tank = 50 \times 40 \times 15 = 30{,}000\ ft^3$$

$$Volume\ of\ Inffluent = 25622.151\ ft^3$$

$$Volume\ of\ Empty\ Space = 30000 - 25622.151 = 4377.849 ft^3$$

$$Freeboard = \frac{4377.849 ft^3}{50\ ft \times 40 ft} = 2.5\ ft$$

Area Under the Curve and Above ADF Estimation:

$$1 + 4 + 7 + 7 + 6 - 2 = 23\ MGD$$

$$\frac{23\ MGD}{24\ hr/day} = 0.958\ MG/hr$$

$$\frac{0.958\ MG/hr}{5\ hr} = 0.192\ MG = 25622.151\ ft^3$$

Dimensions:

$$L \times W \times D$$

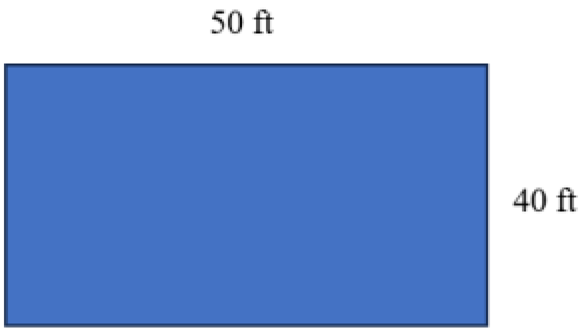
$$50\ ft \times 40\ ft \times 15\ ft$$

Air Requirements:

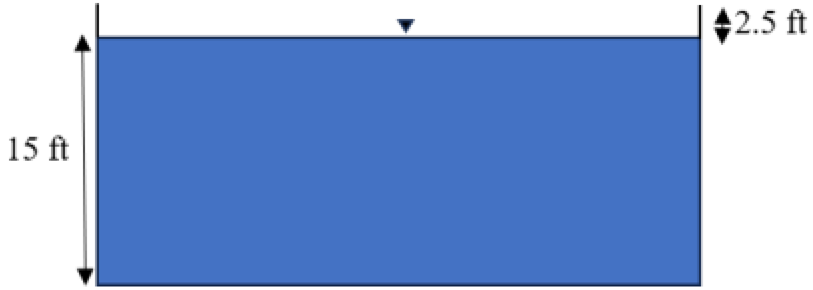
$$Air\ needed = 0.02 \times V$$

$$Air\ needed = 0.02 \times 25622.151 ft^3$$

$$Air\ needed = 512.44 \frac{ft^3}{min}$$



Planview



Profile

<u>Freeboard Calculations:</u>

$$Volume\ of\ the\ Tank = 50 \times 40 \times 15 = 30{,}000\ ft^3$$

$$Volume\ of\ Inffluent = 25622.151\ ft^3$$

$$Volume\ of\ Empty\ Space = 30000 - 25622.151 = 4377.849 ft^3$$

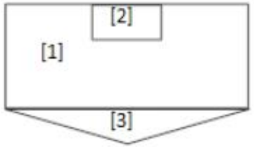
$$Freeboard = \frac{4377.849 ft^3}{50\ ft \times 40 ft} = 2.5\ ft$$

Primary Clarifier Calculations

[1] Cylinder $= \pi r^2 h$

Where: $r = radias\ (ft), h = height(ft)$

$\pi \times (32.5ft)^2 \times 10.167ft = \mathbf{33737.23\ ft^3}$



[2] Feedwell $= \pi r^2 h$

Where: $r = radias\ (ft), h = height(ft)$

$\pi \times (8ft)^2 \times 5.5ft = \mathbf{1105.84\ ft^3}$

[3] Cone $= \pi r^2 \frac{h}{3}$

Where: $r = radias\ (ft), h = height(ft)$

$\pi \times (32.5ft)^2 \times \frac{2.71ft}{3} = \mathbf{2997.54\ ft^3}$

$Total\ clarifier\ volume = 33737.33 + 2997.54 - 1105.84 = \mathbf{35628.7ft^3 = 266521.18\ gallons}$

$$Detention\ Time = \frac{Tank\ volume}{Flow\ rate} = \frac{266521.18\ gallons}{3\ MGD} = 0.089 = \mathbf{2.13\ hours}$$

$Surface\ Area = \pi r^2$

Where: $r = radias\ (ft)$

$\pi \times (32.5ft)^2 = \mathbf{3318.31\ ft^2}$

$$Surface\ Overflow\ Rate = \frac{Flow\ Rate}{Surface\ Area} = \frac{3\ MGD}{3318.31\ ft^2} = \mathbf{904.07 gpd/ft^2}$$

$$Weir\ Overflow\ Rate = \frac{Flow\ Rate}{Length\ of\ Weir} = \frac{3\ MGD}{204.2\ ft} = \mathbf{14691.48 gpd/ft}$$

$Length\ of\ Weir = \pi \times d = \pi \times 65' = 204.2\ ft$

Where $d = diameter\ (ft)$

Energy Consumption

3/4 HP motor requires 0.559 kW per hour.

$$0.559 \frac{kW}{hour} \times 24\ hours = \mathbf{13.42 \frac{kW}{day}}$$

Settling Velocity

Particle size: Diameter= 0.2mm

Specific gravity= 2.65

Average water temperature= 25 °C

Water density (25 °C) $= 997.049 \frac{kg}{m^3} = 1000\ kg/m^3$

Dynamic Viscosity (25 °C) $= 0.890\ mPa \cdot s = 0.890 \times 10^{-3}\ Pa \cdot s$

Stokes law:

$$V_s = \frac{g(\rho_s - \rho)d^2}{18\mu}$$

Where:

$g = Acceleration\ due\ to\ gravity\ \left(\frac{m}{s^2}\right)$

$\rho_s = Density\ of\ the\ particle\ \left(\frac{kg}{m^3}\right)$

$\rho = Density\ of\ the\ water\ \left(\frac{kg}{m^3}\right)$

$d = diameter\ of\ the\ particle\ (mm)$

$\mu = viscosity\ of\ the\ water\ (Pa \cdot s)$

$$V_s = \frac{\left(9.81 \frac{m}{s^2}\right)\left(2650 \frac{kg}{m^3} - 1000 \frac{kg}{m^3}\right)(2 \times 10^{-4} m)^2}{18(8.90 \times 10^{-4}\ Pa \cdot s)} = 4.04 \times 10^{-2} \frac{m}{s}$$

Check R:

$$R = \frac{d(v_s)}{\nu}$$

Where:

$\nu = kinematic\ viscosity\ \left(\frac{m^2}{s}\right)$

$d = diameter\ of\ particle\ (m)$

$v_s = velocity\ of\ the\ particle\ (\frac{m}{s})$

$kinematic\ viscosity$ (25 °C) $= 0.893 \times 10^{-6} \frac{m^2}{s}$

$$R = \frac{(2.0 \times 10^{-4}\ m)\left(4.04 \times 10^{-2} \frac{m}{s}\right)}{0.893 \times 10^{-6} \frac{m^2}{s}} = 9.05$$

**R is in the transition range so Stokes law is not valid, must use Newtons equation*

Check Cd:

$$C_D = \frac{24}{R} + \frac{3}{R^{\frac{1}{2}}} + 0.34$$

Where:

C_D = *Drag coefficient*

R = *Reynolds number*

$$C_D = \frac{24}{9.05} + \frac{3}{9.05^{\frac{1}{2}}} + 0.34 = 3.99$$

Newtons equation for settling velocity:

$$v_s = [\frac{4g(\rho_s - \rho)d}{3C_D\rho}]^{1/2}$$

Where:

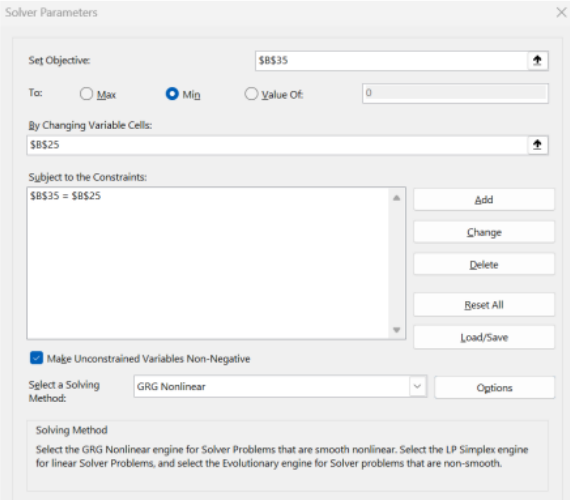
g = *Acceleration due to gravity* $\left(\frac{m}{s^2}\right)$

ρ_s = *Density of the particle* $\left(\frac{kg}{m^3}\right)$

ρ = *Density of the water* $\left(\frac{kg}{m^3}\right)$

d = *diameter of the particle (mm)*

C_D = *Drag coefficient*



Diameter	2.00E-04	m
Particle density	2650	kg/m^3
Water density	1000	kg/m^3
Temperature	25	C
Dynamic Viscosity	8.90E-04	Pa-s
Kinematic Viscosity	8.93E-07	m^2/s

Stokes' Settling Velocity

v(s) = 0.040416 m/s

Check Reynolds number

R = 9.05E+00

Because R > 1 must use Newtons equation and iterate

Use Solver

Set up the equations below and enter the value of R from B18 as a first guess

R = 6.41E+00

Calculate Newton's drag coefficient for R between 0.5 and 10^4

Cd = 5.27E+00

v(s) = 2.86E-02 m/s

Check the Reynolds number

R = 6.41E+00

A solver in excel was used to complete iterations of these calculations. The R value of 9.05 was used for the starting R value the calculate a new settling velocity. The new settling velocity is used to calculate a new R value. The process is continued until the value of R used to calculate the velocity matches the check of the Reynolds number.

Final Settling Velocity = ***0.0286 m/s = 0.0938 ft/s***

How long will it take this particle to settle in the primary clarifier?

Side water depth= 10'2"= 10.167'

Settling time= $\frac{10.167 ft}{0.0938\frac{ft}{s}} = 108.39$ *seconds* $=$ ***1 minutes 48.39 seconds***

Compare overflow rate to settling velocity:
**The settling velocity must be faster than the overflow rate to ensure that the particle have time to settle in the clarifier before the water flows out of the clarifier*

Overflow rate: 904.07 gpd/ft^2
Settling velocity: 0.0938 ft/s

Convert overflow rate to ft/s:

$1\frac{ft}{s}=7.4805\frac{gpd}{ft^2}$

$$\frac{1}{7.4805}=\frac{x}{904.07}$$

x=120.86 ft/d = 0.0014 ft/s

0.0014 ft/s < 0.0938 ft/s ***OK!***

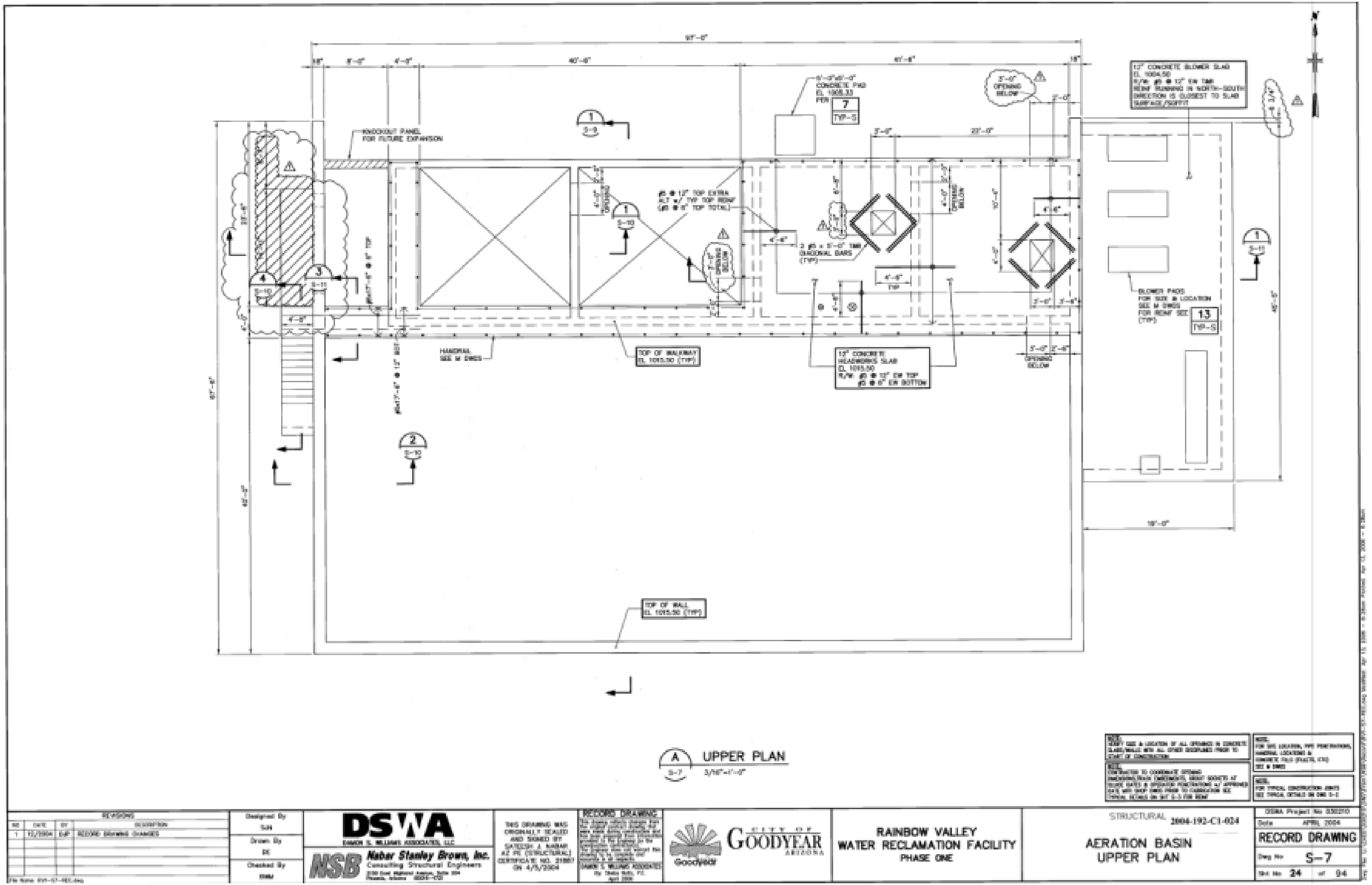
Removal of TSS and BOD primary clarifiers:

Approximate TSS removal in primary treatment: 50-65%
Approximate BOD removal in primary treatment: 25-40%

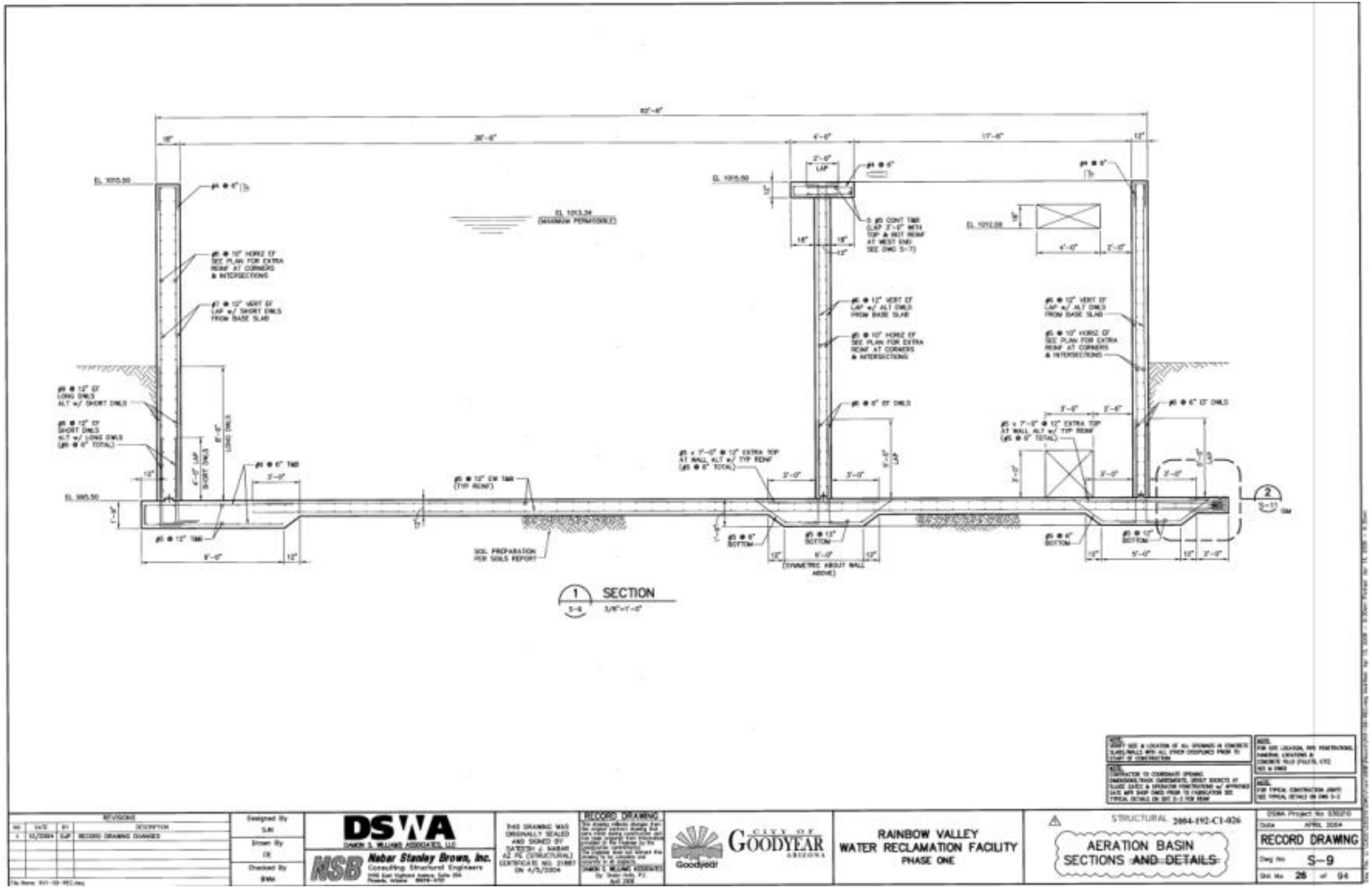
Influent in primary clarifier:
TSS= 250 mg/l
BOD= 225 mg/l

Effluent from primary clarifier:
TSS=$250\frac{mg}{l}\times 0.50=\mathbf{125\frac{mg}{l}}$
BOD= $225\frac{mg}{l}\times 0.75=\mathbf{168.75\frac{mg}{l}}$

Aeration Basin Record Drawings



97'-0"
KNOCKOUT PANEL FOR FUTURE EXPANSION
12" CONCRETE BLOWER SLAB
CONCRETE PAD
TOP OF WALKWAY EL 1015.50 (TYP)
12" CONCRETE HEADWORKS SLAB
HANDRAIL SEE M DWGS
OPENING BELOW
BLOWER PADS
TOP OF WALL EL 1015.50 (TYP)
A UPPER PLAN
S-7
DSWA
DAMON S. WILLIAMS ASSOCIATES, LLC
NSB Nabar Stanley Brown, Inc.
Consulting Structural Engineers
RECORD DRAWING
CITY OF GOODYEAR ARIZONA
RAINBOW VALLEY
WATER RECLAMATION FACILITY
PHASE ONE
STRUCTURAL
2004-192-C1-024
AERATION BASIN
UPPER PLAN
DSWA Project No 050210
Date APRIL 2004
RECORD DRAWING
Dwg No S-7
Sht No 24 of 94


SECTION
RECORD DRAWING
DSWA
DAMON S. WILLIAMS ASSOCIATES, LLC
NSB
Nabar Stanley Brown, Inc.
Consulting Structural Engineers
CITY OF
GOODYEAR
ARIZONA
RAINBOW VALLEY
WATER RECLAMATION FACILITY
PHASE ONE
STRUCTURAL 2004-192-CI-026
AERATION BASIN
SECTIONS AND DETAILS
RECORD DRAWING
S-9

Aeration Basin Calculations

The assumptions for Ks, μm, Kd, Y and MLVSS were taken from Table 23-4 from the Water and Wastewater Engineering Design 2nd Edition by Mackenzie Davis.

Activated Sludge		
Parameter	Value	Units
Q (flow)	3	MGD
So (BOD5)	168.75	mg/L
TSS (Secondary clarifier effluent)	125	mg/L
MLVSS (secondary clarifier effluent)	1,500	mg/L
TSS	10	mg/L
BOD5	10	mg/L
Ks	25	mg/L BOD5
μm	3	d^{-1}
Kd	0.10	d^{-1}
Y	0.60	mg VSS/mg BOD5
RAS	85	%
Was	15	%

Existing primary effluent Q:

$$Q\ (flow) = 3\ MGD * \frac{3785.4118 \frac{m^3}{d}}{1\ MGD} = 11{,}356.2354 \frac{m^3}{d}$$

Allowable soluble BOD5 in effluent (S):

$$BOD\ of\ TSS = \frac{0.85}{mg\ TSS} * \left(10 \frac{mg}{L}\right) = 8.5 \frac{mg}{L} BOD$$

$$S = BOD\ in\ effluent - BOD\ of\ TSS = 10 \frac{mg}{L} - 8.5 \frac{mg}{L} = 1.5 \frac{mg}{L}$$

$$Design\ for\ S = 1.5 \frac{mg}{L}$$

$$1.5 \frac{mg}{L} < 30 \frac{mg}{L}, Good$$

Mean cell-residence time (θc):

$$\theta c = \frac{Ks + S}{(S * \mu m) - (S * Kd) - (Ks * Kd)}$$

$$\theta c = \frac{25 \frac{mg}{L} BOD + 1.5 \frac{mg}{L} BOD}{\left(1.5 \frac{mg}{L} * 3 \frac{1}{D}\right) - \left(1.5 \frac{mg}{L} * 0.10 \frac{1}{D}\right) - \left(25 \frac{mg}{L} * 0.10 \frac{1}{D}\right)} = 14.32\ d = \theta c$$

Check Safety Factor (SF):

$$SF = \frac{\theta c}{\theta cmin} = \theta c(\mu m - Kd)$$

$$SF = 14.32\ days * \left(3 \frac{1}{D} - 0.10 \frac{1}{D}\right) = 41.54 = SF$$

Conventional loading → implied SF range of 10 > 41.54 < 80, Good

Hydraulic detention time (θ):

$$\theta = \frac{\theta c * Y(So - S)}{x(1 + Kd * \theta c)}$$

$$\theta = \frac{14.32\ d * 0.6 \frac{mg\ VSS}{mg\ BOD}\left(168.75 \frac{mg}{L} - 1.5 \frac{mg}{L}\right)}{1500 \frac{mg}{L} VSS\left(1 + \left(0.10 \frac{1}{D} * 14.32\ d\right)\right)} = 0.39392\ d\ \text{d}$$

$$\theta = 0.39392\ d * \frac{24\ h}{1\ d} = 9.45\ h = \theta$$

Volume of aeration tank (V):

The team will use the same size aeration at the facility.

L= 62'-6"

W= 40'

H= 20'

V= 1,393.1888 m^2

MLVSS fraction of MLSS :

$$Qr = 0.85Q$$

$$Qr = 9{,}652.8 \frac{m^3}{d}$$

$$X' = \frac{x}{0.85} = \frac{1.500 \frac{g}{L}}{0.85} = 1.764 \frac{g}{L} MLSS = X'$$

Return sludge concentration (Xr') of maximum return sludge flow rate (Qr)

$$X'r = \frac{X'\left[Q + Qr - \left(\frac{V}{\theta c}\right)\right]}{Q}$$

$$X'r = \frac{\left(1.764 \frac{g}{L} MLSS\right) * \left[\left(11{,}356.2354 \frac{m^3}{d} + 9{,}652.8 \frac{m^3}{d}\right) - \frac{1{,}393.1888\ m^3}{14.32\ d}\right]}{11{,}356.2354 \frac{m^3}{d}} = 3.248 \frac{g}{L} = X'r$$

$$Qw = \frac{V * X'}{\theta c * X'r} = \frac{1{,}393.1888\ m^3 * 1.764 \frac{g}{L}\ MLSS}{14.32\ d * 3.248 \frac{g}{L}} = 52.84 \frac{m^3}{d} = Qw$$

$$Mass\ flow\ rate = Qw * Xr' = \left(52.84 \frac{m^3}{d} * 3.248 \frac{g}{L}\right) * \frac{1000\ L}{m^3} * \frac{kg}{1000\ g} = 171.6 \frac{kg}{d}$$

Food to microorganism (F/M)

$$\frac{F}{M} = \frac{Q * So}{V * X} = \frac{11{,}356.2354 \frac{m^3}{d} * 168.75 \frac{mg}{L}}{1{,}393.188 * 1500 \frac{mg}{L}} = 0.917\ d = F/M$$

$$0.917 < 2\ , Good$$

Mass of sludge to be wasted each day from new activated plant

$$Yobs = \frac{Y}{1 + (Kd * \theta c)} = \frac{0.6 \frac{Kg\ VSS}{kg\ BOD5}}{1 + \left(0.10 \frac{1}{d} * 14.32\ d\right)} = 0.246 = Yobs$$

Net wasted activated sludge produced each day (VSS)

$$Px = Yobs * Q(So - S) = 0.246 * \left(11{,}356.2354 \frac{m^3}{d}\right) * \left(168.75 \frac{mg}{L} - 1.5 \frac{mg}{L}\right) = 468{,}584.79$$

$$Px = 468{,}584.79 * \left(\frac{kg}{10^3 g}\right) = 468.58 \frac{kg}{d} = Px$$

Total mass produced

$$Px' = Px * \left(\frac{1}{\frac{MLVSS}{MLSS} ratio}\right) = 468.58 \frac{kg}{d} * \left(\frac{1}{0.85}\right) = 398.297 \frac{kg}{d} = Px'$$

Mass of solids lost in effluent

$$(Q - Qw) * Xe' = \left[11{,}356.2354 \frac{m^3}{d} - 52.84 \frac{m^3}{d}\right] * \left(10 \frac{g}{m^3}\right) * \left(\frac{kg}{10^3 g}\right) = 113.03 \frac{kg}{d}$$

Mass to be wasted

$$Mass = Px' - (Q - Qw)Xe' = 398.297 \frac{kg}{d} - 113.03 \frac{kg}{d} = 285.267 \frac{kg}{d}\ (dry\ solids)$$

Mass of oxygen supplied (rbsCOD to bCOD)

$$So = \frac{168.75 \frac{g}{m^3}}{0.85} = 198.53 \frac{g}{m^3}$$

$$S = \frac{1.5 \frac{g}{m^3}}{0.85} = 1.76 \frac{g}{m^3}$$

Mass of O2

$$M_{O2} = Q * (So - S) - 1.42 * (Px)$$

$$M_{O2} = \left(11{,}356.23 \frac{m^3}{d}\right) * \left(198.53 \frac{g}{m^3} - 1.76 \frac{g}{m^3}\right) * \left(\frac{kg}{10^3 g}\right) - 1.42 * \left(468.58 \frac{kg}{d}\right)$$

$$= 1{,}569.136 \frac{kg}{d}\ Oxgen$$

O2 is 23% of air by mass

$$Air = 1{,}569.136 \frac{kg}{d} \left(\frac{1}{0.23}\right) = 6{,}822.33 \frac{kg}{d}\ Air$$

Removal for Activated Sludge

TSS removal: 58-90% (will use 90%)

BOD removal: 85-98% (will use 95%)

Influent Activated Sludge

TSS= 125 mg/L

BOD= 168.75 mg/L

Effluent Activated Sludge

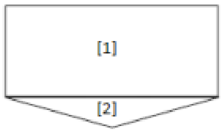
$$TSS = 125 \frac{mg}{L} * 0.10 = 12.5 \frac{mg}{L}$$

$$BOD = 168.75 \frac{mg}{L} * 0.50 = 8.4 \frac{mg}{L}$$

Secondary Clarifier Calculations

Clarifier Volume

[1] Cylinder $= \pi r^2 h$
$Where: r = radias\ (ft), h = height(ft)$
$\pi \times (27.5ft)^2 \times 15ft = \mathbf{35,637.44\ ft^3}$



[2] $Cone = \pi r^2 \frac{h}{3}$
$Where: r = radias\ (ft), h = height(ft)$
$\pi \times (27.5ft)^2 \times \frac{2.43ft}{3} = \mathbf{1,924.42\ ft^3}$

$Total\ clarifier\ volume = 35637.44 + 1924.42 = \mathbf{37,561.86\ ft^3 = 280,982.23\ gallons}$

$Detention\ Time = \frac{Tank\ volume}{Flow\ rate} = \frac{280982.23\ gallons}{0.75\ MGD} = 0.375\ days = \mathbf{9\ hours}$

$Surface\ Area = \pi r^2$
$Where: r = radias\ (ft)$
$\pi \times (27.5ft)^2 = \mathbf{2375.83\ ft^2}$

$Surface\ Overflow\ Rate = \frac{Flow\ Rate}{Surface\ Area} = \frac{0.75\ MGD}{2375.83\ ft^2} = \mathbf{315.7\ gpd/ft^2}$

$Weir\ Overflow\ Rate = \frac{Flow\ Rate}{Length\ of\ Weir} = \frac{0.75\ MGD}{172.8\ ft} = \mathbf{4340.28\ gpd/ft}$
$Length\ of\ Weir = \pi \times d = \pi \times 55' = 172.8\ ft$
$Where\ d = diameter\ (ft)$

Energy Consumption

3/4 HP motor requires 0.559 kW per hour.

$0.559 \frac{kW}{hour} \times 24\ hours = \mathbf{13.42 \frac{kW}{day}}$

Settling Velocity
Particle size:
Diameter= 1 mm
Specific gravity= 1.10
Average water temperature= 25 °C
Water density $(25\ °C) = 997.049 \frac{kg}{m^3} = 1000\ kg/m^3$
Dynamic Viscosity $(25\ °C) = 0.890\ mPa \cdot s = 0.890 \times 10^{-3}\ Pa \cdot s$

Stokes law:

$$V_s = \frac{g(\rho_s - \rho)d^2}{18\mu}$$

$$V_s = \frac{\left(9.81 \frac{m}{s^2}\right)\left(1100 \frac{kg}{m^3} - 1000 \frac{kg}{m^3}\right)(2 \times 10^{-4} m)^2}{18(8.90 \times 10^{-4}\ Pa \cdot s)} = 2.45 \times 10^{-3} \frac{m}{s}$$

Where:
$g = Acceleration\ due\ to\ gravity\ \left(\frac{m}{s^2}\right)$
$\rho_s = Density\ of\ the\ particle\ \left(\frac{kg}{m^3}\right)$
$\rho = Density\ of\ the\ water\ \left(\frac{kg}{m^3}\right)$
$d = diameter\ of\ the\ particle\ (mm)$
$\mu = viscosity\ of\ the\ water\ (Pa \cdot s)$

Check R:

$$R = \frac{d(v_s)}{v}$$

Where:

$v = kinematic\ viscosity\ \left(\frac{m^2}{s}\right)$

$d = diameter\ of\ particle\ (m)$

$v_s = velocity\ of\ the\ particle\ (\frac{m}{s})$

$kinematic\ viscosity\ (25\ °C) = 0.893\ \times 10^{-6} \frac{m^2}{s}$

$$R = \frac{(0.001\ m)\left(2.45 \times 10^{-3} \frac{m}{s}\right)}{0.893 \times 10^{-6} \frac{m^2}{s}} = 2.74$$

Final Settling Velocity = ***0.00245 m/s = 0.00804 ft/s***

How long will it take this particle to settle in the primary clarifier?

Side water depth= 15'

Settling time= $\frac{15 ft}{0.00804 \frac{ft}{s}} = 1865.67\ seconds = \mathbf{31\ minutes\ 5.67\ seconds}$

Compare overflow rate to settling velocity:
**The settling velocity must be faster than the overflow rate to ensure that the particle have time to settle in the clarifier before the water flows out of the clarifier*

Overflow rate: 315.7 gpd/ft^2
Settling velocity: 0.00804 ft/s

Convert overflow rate to ft/s:

$1 \frac{ft}{s} = 7.4805 \frac{gpd}{ft^2}$

$$\frac{1}{7.4805} = \frac{x}{315.7}$$

x=42.2 ft/d = 0.00049 ft/s

0.00049 ft/s < 0.00804 ft/s ***OK!***

Disc Filter Record Drawings

3.3.2 HSF2200 type 2, filter without tank

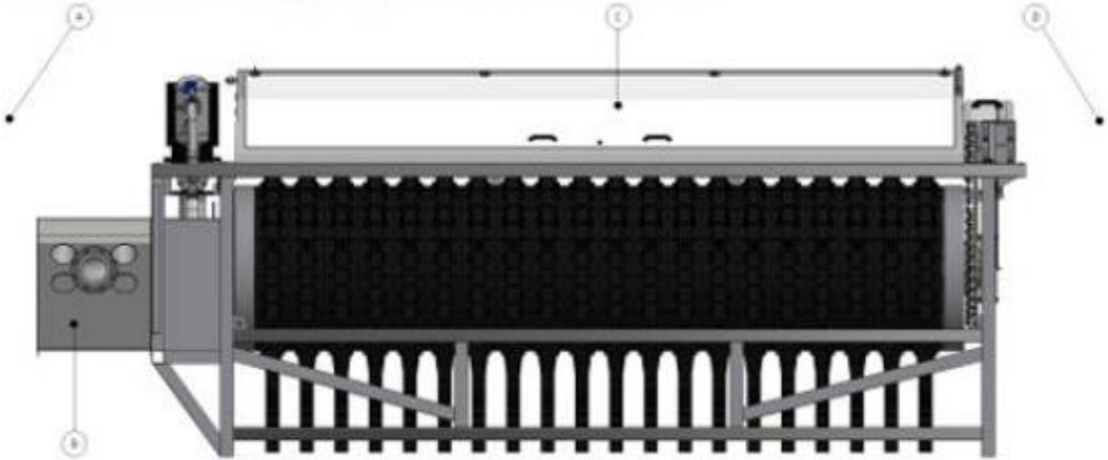


Figure 3.4 Hydrotech Disc filter in the HSF2200 series type 2 (side view).
A. Inlet side
B. Inlet passage
C. Filter cover
D. Outlet side

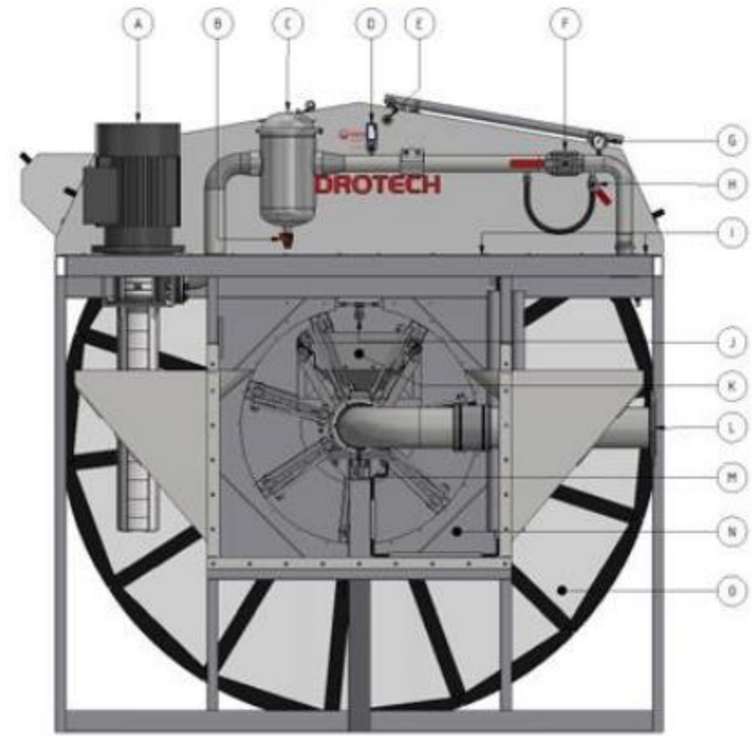


Figure 3.5 Hydrotech Disc filter in the HSF2200 series type 2 (inlet side).

A. Backwash pump (optional)
B. Drain valve
C. Wash water filter
D. Pressure switch (protects pump from running dry) (optinal)
E. Connection, chemical cleaning
F. Shut off valve for wash pipe
G. Manometer
H. By-pass valve for nozzle check

I. Lubrication point
J. Drum lifter
K. Sludge trough
L. Sludge outlet
M. Drum bearing, inlet side
N. Inlet
O. Filter panel

UV Record Drawings

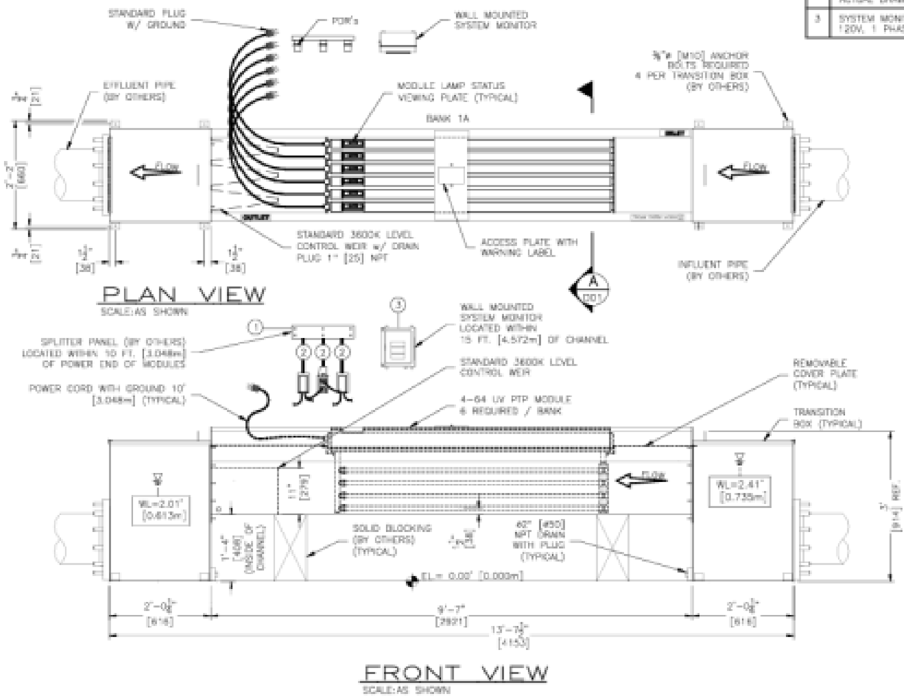
NOTES:

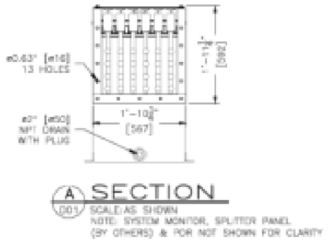
- : DO NOT SLOPE CHANNEL FLOOR.
- : CHANNEL WIDTH & DEPTH MUST BE KEPT WITHIN A TOLERANCE OF + OR – ¼" [6].
- : ANCHOR BOLTS ARE NOT SUPPLIED BY TROJAN TECHNOLOGIES.
- : BOLTS, WASHERS & NUTS FOR CONNECTION OF CHANNEL TO TRANSITION BOXES ARE PROVIDED BY TROJAN TECHNOLOGIES.
- : SYSTEM CONDUIT, WIRING, DISTRIBUTION PANELS & INTERCONNECTIONS BY OTHERS.
- : ELECTRICAL REQUIREMENTS SHOWN ARE TO SUPPLY TROJAN UV EQUIPMENT ONLY. ELECTRICAL INRUSH FACTOR TO BE ADDED AS PER LOCAL CODE.
- : ANY EXTRA OUTLETS NOT BEING USED BY TROJAN EQUIPMENT HAVE NOT BEEN INCLUDED IN THE INTERCONNECT AMPERAGE.
- : CONTRACTOR TO REVIEW ALL TROJAN TECHNOLOGIES INSTALLATION INSTRUCTIONS PRIOR TO EQUIPMENT INSTALLATION.
- : ACCESS IS REQUIRED FOR MODULE REMOVAL – NOTE THE CHANNEL WIDTH AND ENSURE ADEQUATE ACCESS IS PROVIDED TO ALL MODULES.
- : DO NOT ENCASE THE STEEL CHANNEL IN CONCRETE.
- : [ ] INDICATES MILLIMETERS UNLESS OTHERWISE SPECIFIED.

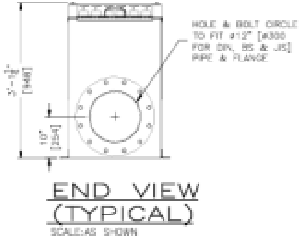
TROJAN UV3000™ PTP

EQUIPMENT INTERCONNECTIONS

No.	DESCRIPTION	FROM	TO
1	SPLITTER PANEL POWER SUPPLY 120V, 1 PHASE, 2 WIRE, ACTUAL DRAW 19.1 AMPS / SPLITTER PANEL	DISTRIBUTION PANEL (DP) (NOT SHOWN) (BY OTHERS)	SPLITTER PANEL (BY OTHERS)
2	POWER DISTRIBUTION RECEPTACLE (PDR) POWER SUPPLY 120V, 1 PHASE, 2 WIRE, ACTUAL DRAW 6.3 AMPS / PDR	SPLITTER PANEL (BY OTHERS)	PDR
3	SYSTEM MONITOR POWER SUPPLY 120V, 1 PHASE, 2 WIRE, 5 AMPS	DP (NOT SHOWN) (BY OTHERS)	SYSTEM MONITOR







MULTIPLE CHANNELS IN PARALLEL (OPTION):

- : ADDITIONAL UNITS CAN BE INSTALLED PARALLEL TO THE UNIT SHOWN.
- : ACCESS IS REQUIRED BETWEEN CHANNELS FOR MODULE REMOVAL – NOTE THE CHANNEL WIDTH AND ENSURE ADEQUATE ACCESS IS PROVIDED BETWEEN TRANSITION BOXES AND CHANNELS.

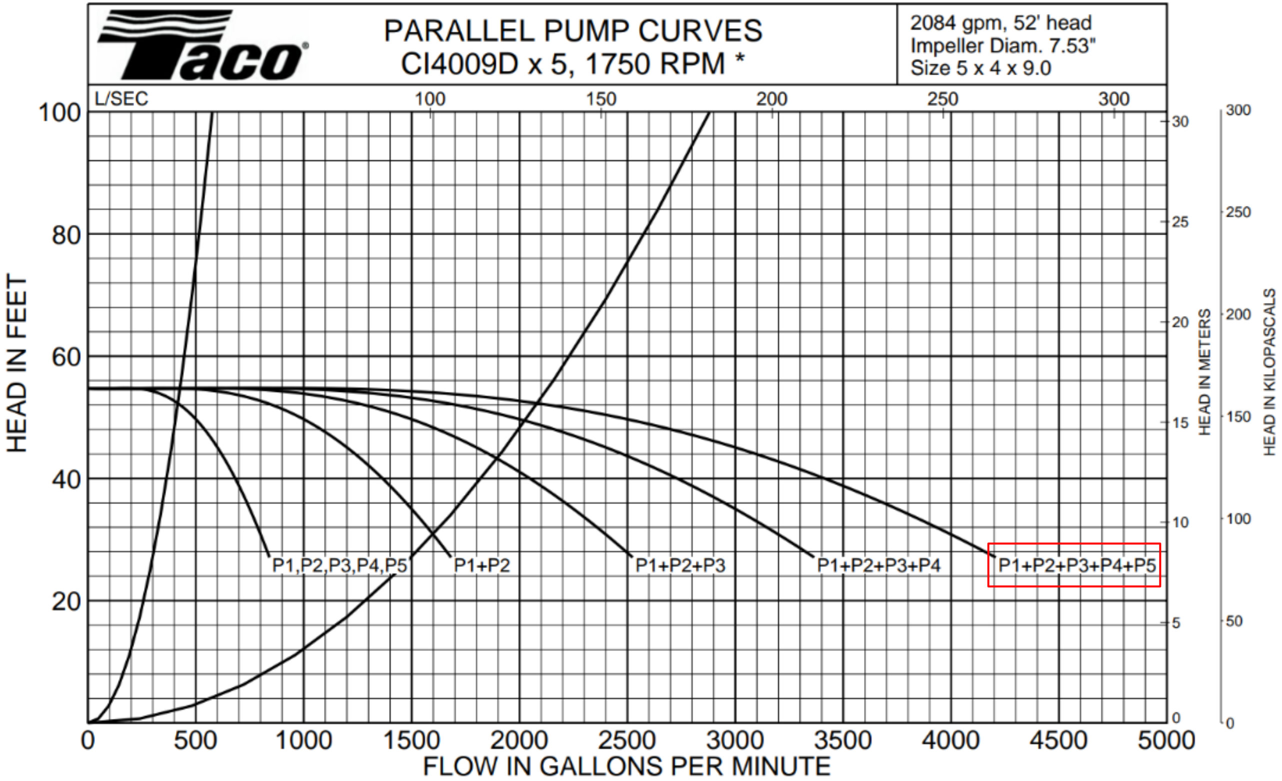
TROJAN UV

CONFIDENTIALITY NOTICE

DESCRIPTION: LAYOUT, UV3000PTP–UV3600K 1 CHANNEL 1 BANK 4 LAMPS WEIR		STANDARD DRAWING NO. 3M0518
DRAWN BY : LZ/JMM/SPM	DATE : 12JN21	REFERENCE NO. N/A
CHECKED BY : SAH	DATE : 12JN22	
APPROVED BY : CAP	DATE : 12JN22	DWG NO. D01 / REV. D
SCALE (8½x11) : NOT TO SCALE	LOG NUMBER : N/A	

Hydraulic Analysis

V (ft/s)	e/d	Nr	f	hf (ft)	hme (ft)	hmb (ft)		THD (ft)	Q (cfs)	Q (gpm)
0	4.29E-05	0.00	0.000	0.00	0.000000	9.98E-12		38.65	0	0
0.1	4.29E-05	20710.06	0.027	0.72	0.000078	9.98E-12		39.37	0.962113	431.7962
0.2	4.29E-05	41420.12	0.023	2.50	0.000311	9.98E-12		41.15	1.924226	863.5924
0.3	4.29E-05	62130.18	0.022	5.27	0.000699	9.98E-12		43.92	2.886338	1295.389
0.4	4.29E-05	82840.24	0.021	8.98	0.001242	9.98E-12		47.63	3.848451	1727.185
0.5	4.29E-05	103550.30	0.020	13.63	0.001941	9.98E-12		52.28	4.810564	2158.981
0.6	4.29E-05	124260.36	0.020	19.21	0.002795	9.98E-12		57.86	5.772677	2590.777
0.7	4.29E-05	144970.41	0.020	25.71	0.003804	9.98E-12		64.36	6.734789	3022.573
0.8	4.29E-05	165680.47	0.019	33.12	0.004969	9.98E-12		71.78	7.696902	3454.37
0.9	4.29E-05	186390.53	0.019	41.46	0.006289	9.98E-12		80.12	8.659015	3886.166
1	4.29E-05	207100.59	0.019	50.71	0.007764	9.98E-12		89.37	9.621128	4317.962
1.1	4.29E-05	227810.65	0.019	60.87	0.009394	9.98E-12		99.53	10.58324	4749.758
1.2	4.29E-05	248520.71	0.019	71.94	0.011180	9.98E-12		110.60	11.54535	5181.554
1.3	4.29E-05	269230.77	0.019	83.93	0.013121	9.98E-12		122.59	12.50747	5613.351
1.4	4.29E-05	289940.83	0.019	96.82	0.015217	9.98E-12		135.48	13.46958	6045.147
1.5	4.29E-05	310650.89	0.018	110.62	0.017469	9.98E-12		149.29	14.43169	6476.943
1.6	4.29E-05	331360.95	0.018	125.33	0.019876	9.98E-12		164.00	15.3938	6908.739
1.7	4.29E-05	352071.01	0.018	140.94	0.022438	9.98E-12		179.62	16.35592	7340.535
1.8	4.29E-05	372781.07	0.018	157.47	0.025155	9.98E-12		196.14	17.31803	7772.332
1.9	4.29E-05	393491.12	0.018	174.90	0.028028	9.98E-12		213.58	18.28014	8204.128
2	4.29E-05	414201.18	0.018	193.24	0.031056	9.98E-12		231.92	19.24226	8635.924



	Flow (gpm)	Head (ft)	BHP
One Pump	---	---	---
Two Pumps	1598	31	14.57
Three Pumps	1894	43	21.85
Four Pumps	2023	49	29.13
Five Pumps	2084	52	36.42

* This model is not suitable for single pump operation.

Economic Analysis

Engineers Opinion of Probable Construction Costs					
Item #	**Description**	**Quantity**	**Unit**	**$/Unit**	**Total Cost**
1	EARTHWORK	1	LS	$65,000.00	$65,000.00
2	CONCRETE EXCAVATION	520	CY	$19.17	$9,968.40
3	PISTAWORKS MODEL 7.0B	2	EA	$798,750.00	$1,597,500.00
4	CONCRETE SLAB FOR SCREEN/GRIT CHAMBER BUILDING	135	CY	$1,013.00	$136,755.00
5	CONCRETE BLOCKS FOR SCREEN/GRIT CHAMBER BUILDING	7518	EA	$2.51	$18,870.18
6	ACTIVATED CARBON DRUMS	4	EA	$2,772.00	$11,088.00
7	BLOWERS FOR EQUALIZATION BASIN	4	EA	$1,065.00	$4,260.00
8	CONCRETE FOR EQUALIZATION BASIN	95	CY	$1,013.00	$96,235.00
9	ENVIRODYNE PRIMARY CLARFIER EQUIPEMENT	2	EA	$244,950.00	$489,900.00
10	CONCRETE FOR PRIMARY CLARIFIER TANK	842	CY	$1,013.00	$852,946.00
11	ACTIVATED SLUDGE CONSTRUCTION (AERATION BASINS AND SECONDARY CLARIFIERS)	1	LS	$22,000,000.00	$22,000,000.00
12	VEOLIA HYDROTECH DISC FILTER	2	EA	$383,400.00	$766,800.00
13	TROJAN UV 3000 PTP	7	EA	$186,375.00	$1,304,625.00
14	ANDRITZ D4L DECANTER CENTRIFUGE	3	EA	$441,975.00	$1,325,925.00
15	20' JDV EQUIPMENT CONVEYOR BELT	3	EA	$18,105.00	$54,315.00
16	CI4009D TACO STANDARD CENTRIFUGE PUMP	5	EA	$9,407.15	$47,035.75
17	42" COMMERCIAL STEEL PIPE	580	LF	$817.92	$474,393.60
18	21" COMMERCIAL STEEL PIPE	1470	LF	$515.46	$757,726.20
19	SPLITTER BOX	13	EA	$7,987.50	$103,837.50
20	VALVES AND FITTINGS	1	LS	$1,500,000.00	$1,500,000.00
				Total	**$31,617,180.63**

Operation & Maintenance Costs					
	Item	Quantity	Unit	$/Unit	Total Cost
Influent Pumps					
Operation Cost	Energy Consumption	47584	kW-hr/year	$0.13	$6,185.92
Maintenance Cost	Inspect Pumps for Solids Blockage	24	per year	-	$0.00
				Total for 5 Pumps	**$30,929.60**
Screen/Grit Chamber					
Operation Cost	Energy Consumption	18370	kW-hr/year	$0.13	$2,388.10
Maintenance Cost	Screen Gearbox, Chamber Gear, & Grit Washer Gearbox Oil Change	2	EA/year	$790.00	$1,580.00
	Fill Grease Bearing on Classifier	12	EA/year	$20.00	$240.00
	Replace Screen Brushes	1	EA/year	$1,500.00	$1,500.00
	Grease Pump Motor	2	EA/year	$45.00	$90.00
				Total for 2 Systems	**$11,596.20**
Equalization Basin					
Operation Cost	Energy Consumption	19587	kW-hr/year	$0.13	$2,546.31
Maintenance Cost	Check for Obstructions in Blowers	12	EA/year	-	$0.00
				Total for 1 System	**$2,546.31**
Primary Clarifier					
Operation Cost	Energy Consumption	4898	kW-hr/year	$0.13	$636.74
Maintenance Cost	Grease Winsmith Reducer	12	EA/year	$45.00	$540.00
	Grease Cone Reducer	1	EA/year	$45.00	$45.00
	Primary Gear Reducer Winsmith, Secondary Gear Reducer Cone, & Main Housing Oil Bath Oil Change	1	EA/year	$260.00	$260.00
				Total for 2 Clarifiers	**$2,963.48**
Activated Sludge					
Operation & Maintenance Costs		1	LS	$4,414,776.00	**$4,414,776.00**
Disc Filter					
Operation Cost	Energy Consumption	9855	kW-hr/year	$0.13	$1,281.15
Maintenance Cost	Grease Pump Bearings	2	EA/year	$45.00	$90.00
	Inspect Drum Bearings	2	EA/year	-	$0.00
	Inspect Disc and Drum seals	2	EA/year	-	$0.00
	Grease Drum Bearings	26	EA/year	$45.00	$1,170.00
				Total for 4 Disc Filters	**$10,164.60**
Ultraviolet Disinfection					
Operation Cost	Energy Consumption	5406	kW-hr/year	$0.13	$702.78
Maintenance Cost	Replace Bulbs	48	EA/year	$127.00	$6,096.00
	Clean Glass Sleeves	48	EA/year	$70.00	$3,360.00
				Total for 7 Ultraviolet Disinfection Systems	**$71,111.46**
Centrifuge					
Operation Cost	Energy Consumption	7683	kW-hr/year	$0.13	$998.79
Maintenance Cost	Remove Any Accumulated Solids	12	EA/year	-	$0.00
	Replace Filter & Filter System if Necessary	2	EA/year	$1,020.00	$2,040.00
	Change Oil in Hydraulic Pump	2	EA/year	$260.00	$520.00
	Clean the Hydraulic Drive Oil Tank	2	EA/year	-	$0.00
	Clean the Hydraulic Drive Suction Strainer	2	EA/year	-	$0.00
				Total for 4 Centrifuges	**$14,235.16**
Labor					
Operation Cost	Grade 1 Operator	1	LS	$53,435.20	$53,435.20
	Grade 2 or 3 Operator	1	LS	$59,612.80	$59,612.80
	Grade 4 Operator	1	LS	$72,176	$72,176.00
				Total Labor Cost	**$185,224.00**
				Total Operation & Maintenance Costs Per Year	**$4,731,950.61**