

Memorandum

To George Meservey, Director of Planning & Community Development

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Subject **Town of Orleans, MA
Water Quality and Wastewater Planning
Facilities Engineering – Preliminary Design Report (25% Design) Downtown Area
Task 10.1.C.5 - Update WWTF Process Selection - Final**

Project Number 60476644

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Date September 20, 2018

Approvals	Date	Signature / Initials
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1. Introduction

In addition to evaluating “non-traditional” technologies, a component of the Water Quality and Planning effort currently on-going with the Town of Orleans (Town) includes evaluating conventional treatment options to address areas of the town where non-traditional technologies would not be sufficient to address water quality, regulatory, economic development and other needs. Previous evaluations have identified the Downtown Area commercial district as well as the residential area in the vicinity of Meetinghouse Pond Area as two areas of town where conventional wastewater treatment is the appropriate solution to the Town’s requirements.

Even under the banner of conventional wastewater treatment, there is a broad range of technology options available. This Technical Memorandum (TM) identifies the design basis for the treatment facility, evaluates various unit processes, recommends technologies for selection, and presents preliminary design information. While initially intended to be part of this TM, the discussion of collection system design and treated effluent conveyance and disposal has been addressed under separate cover.

2. Flows and Loading

A. Initial and Design Flows and Loadings

The Orleans WWTF is proposed to be constructed in two phases. The first phase will accommodate the Downtown Area with associated infiltration/inflow (I/I), as well as septage receiving. The second phase will accommodate the capacity requirements for the Meetinghouse Pond Area with associated I/I. The second phase would be scheduled for construction approximately 10 years after the first phase, subject to funding approval for the design and construction of the Meetinghouse Pond collection system. While this preliminary design report focuses on the design of Phase 1 of the WWTF, the design concept incorporates many of the features intended to accommodate both Phases where it makes sense from a construction cost standpoint to do so. This will be discussed in further detail later on in this Technical Memorandum.

In order to estimate the existing wastewater flows, a 95 percent factor was applied to the 2014 and 2015 water usage data.

- Future wastewater flows for the Downtown Area were predicted based on a preferred build-out scenario previously evaluated for the Town, as summarized in the *Final Memorandum on Management of Future Downtown Wastewater Flows and Biosolids* (May 2016).
- Future wastewater flows for the Meetinghouse Pond Area were predicted based on current zoning regulations (as of March 2016). These future flows were used to develop the design annual average wastewater flow to the WWTF.
- Infiltration/Inflow flows were developed based on TR-16 - Guides for the Design of Wastewater Treatment Works, (2011 Edition as Revised in 2016) by the New England Interstate Water Pollution Control Commission. An allowance was added to the future wastewater flows to account for the normal aging of piping systems based on 300 gpd/in. diameter/mile of gravity sewer.

Even after the completion of a sewage collection and transmission system for these two areas, there will still be a significant amount of properties in Town that continue to rely on septic systems. In addition, there will continue to be a need for septage disposal capacity to service the surrounding communities in the lower/outer Cape. Based on a previous study¹, the former Tri-Town Septage Treatment Facility averaged in the order of 9 million gallons of septage annually over the past several years. The sewerage of some parts of the Town will obviously decrease septage generation within Orleans. In addition, some permanent loss of market might be expected from some of the communities proximate to the Yarmouth-Dennis facility, as it has expanded operations to fill the void left by the closure of the Tri-Town Septage Treatment Facility. AECOM has conservatively prorated the Tri-Town Septage Treatment Facility receiving rates on a town by town basis to what they might be expected to be in the future and has arrived at a projected “high-end” septage loading of 6 million gallons annually, or 16,500 gal/d. While this rate will depend on how the Town chooses to operate the proposed WWTF at Overland Way, this is considered a reasonable assumption with which to estimate loadings to the facility.

Table 1 summarizes the future build-out flows used for the design basis of the WWTF.

¹ AECOM. Cape Cod Commission 208 Water Quality Management Plan Update Task Order 12D – *Technical Memorandum on Barnstable County Septage Analysis*. June, 2016. (revised March 2018)

Table 1: WWTF Annual Average Flow

Area	Future Wastewater Flow (with Build-out) Annual Average (gpd)
WWTF – Phase 1	245,400
Downtown	212,000
Downtown I/I	16,800
Septage	16,500
WWTF – Phase 2	104,600
Meetinghouse Pond	96,600
Meetinghouse Pond I/I	8,000
WWTF Total – Phase 1 + Phase 2	350,000

In order to estimate the minimum and maximum hourly, daily, and monthly flows, data from treatment plants in Falmouth, Chatham, and Provincetown were reviewed and compared to literature values. It was assumed that the Town of Chatham is most similar to the Town of Orleans due to its close proximity and similar demographic. Peaking factors developed from Chatham’s historical operating data were very similar to peaking factors found in the literature² for the minimum and maximum month conditions, which are important in the development of the biological treatment system design. Peaking factors for the more extreme max/min day and hour conditions were dampened in the Chatham data compared to literature values, however max day peaking factors similar to literature values were seen at Provincetown. It was therefore concluded that defaulting to literature guidelines was the appropriate course and the literature peaking factors were used to generate minimum and maximum hourly, daily, and monthly flows for use in the design of the Orleans WWTF. The peaking factor comparison and selection is shown in Table 2.

² “TR-16, Guides for the Design of Wastewater Treatment Works”, New England Interstate Water Pollution Control Commission, 2011. “Wastewater Engineering, Treatment and Resource Recovery”, Metcalf & Eddy, 5th ed.

Table 2: Flow Peaking Factor Selection

	Min. Hour: AA	Min Day: AA	Min Month: AA	Max Month: AA	Max Day: AA	Max Hour: AA
Falmouth	---	0.65	0.80	1.3	1.8	---
Provincetown	---	0.36	0.45	2.1	2.8	---
Chatham	---	0.54	0.75	1.4	1.9	---
Design (Phase 1)	0.17	0.39	0.85	1.4	2.6	4.8
Design (Phase 2)	0.18	0.39	0.85	1.4	2.5	4.5

The design flows for both phases were determined by applying the selected peaking factors from Table 2 on their respective design annual average flow. The design intent accommodates the high end peaks, which are considered conservative. The WWTF will incorporate parallel trains of the more major process steps to accommodate seasonal shut down of some process equipment should seasonal variation during low flow (i.e. – winter) periods be less than anticipated. As important as flow projections however, an estimate of pollutant mass loadings is required to properly size WWTFs. Because there is no existing sewage collection or treatment system in place, there is no data from which to project sewage pollutant concentrations. Normal textbook³ ranges for the key parameters of BOD, TKN and TSS are as shown in Table 3 below. To reflect the fact that this will be a new collection system where inflow/infiltration will be low, the concentrations were assumed to be on the medium to higher end of the range. These concentrations were applied to the annual average flow to determine annual average mass loadings.

Table 3: Assumed Sewage Pollutant Concentrations

Constituent	Typical Ranges			Value Assumed
	Low	Medium	High	
BOD, mg/l	110	190	350	270
TKN, mg/l	20	40	70	55
TSS, mg/l	120	210	400	310

These concentrations were applied to the annual average flow to determine annual average mass loadings. Mass loading peaking factors for maximum month and maximum day conditions, which differ from flow peaking factors, were based on TR-16 recommendations, and resulted in the following summary of sewage flow/loads

³ "Wastewater Engineering, Treatment and Reuse", Metcalf & Eddy, 4th ed.

Table 4: Design Sewage Flows & Loads

<u>Sewage Flows/Loads</u>					
Phase - 1	Min Month	Annual Average	Max Month	Max Day	Peak Hour
Flow, gpd	194,600	228,900	320,500	595,100	1,098,720
BOD, lbs/d		515	649	825	
TSS, lbs/d		592	769	1,124	
TKN, lbs/d		105	130	147	

Phases - 1 & 2	Min Month	Annual Average	Max Month	Max Day	Peak Hour
Flow, gpd	283,500	333,500	466,900	833,800	1,500,750
BOD, lbs/d		751	946	1,202	
TSS, lbs/d		862	1,121	1,638	
TKN, lbs/d		153	190	214	

To address what impact septage receiving would have, actual annual average data from the former Tri-Town Septage Treatment Facility was used. It was anticipated that 6 MG/year septage would be brought to the facility, which is approximately 16,500 gpd averaged over 7 days per week. It was assumed that septage will be processed with biosolids from the facility, so that only septage filtrate would be mixed with raw sewage influent to reduce solids loadings on the biological process. The assumed characteristics of the septage are as shown in Table 5.

Table 5: Assumed Sewage Pollutant Concentrations

<u>Assumed Values</u>		
Constituent	Concentration	Data Source
BOD, mg/l	2,300	Tri-town STF
TKN, mg/l	590	EPA ⁴
Sol. TKN, mg/l	110	Tri-town STF
TSS, mg/l	3,600	Tri-town STF

A flow weighted average of the sewage and septage filtrate characteristics, in combination with the design annual average flow, was used to define annual average pollutant loadings to the secondary treatment (i.e. biological) process. Similar to flows, max month and max day sewage loadings were prorated off of annual average loadings based on peaking factors derived from TR-16 - Guides for the Design of Wastewater Treatment Works, (2011 Edition as Revised in 2016) by the New England Interstate Water Pollution Control Commission.

⁴ No Tri-town data on total TKN, data obtained from "Guide to Septage Treatment and Disposal", EPA, Sept. 1994

Peaking factors for septage receiving were based off of data from the Tri-Town facility for septage receipts from the town of Orleans. Note that the annual average, max month, and max day loading are the only conditions considered relevant to the design of the biological process. The more extreme conditions of flow are considered for hydraulic capacity reasons only.

The overall design secondary influent flows and loadings for both Phases of the treatment plant design are shown in a Mass Balance diagram found at the end of this report. Because there are slight differences in the internal recycle streams between the two biological systems evaluated, mass balances were performed for both options, however for the sake of simplicity, the slightly higher of the two options (SBR) is presented.

Table 6: Design Secondary Influent Flows & Loads

<u>Secondary Influent Flows/Loads</u>					
	Min	Annual	Max	Max	Peak
Phase - 1	Month	Average	Month	Day	Hour
Flow, gpd	224,713	264,368	374,649	689,120	792,500
BOD, lbs/d		626	800	1,022	
TSS, lbs/d		725	948	1,359	
TKN, lbs/d		136	172	199	
Design Temp, 'C	10				
	Min	Annual	Max	Max	Peak
Phase - 1 & 2	Month	Average	Month	Day	Hour
Flow, gpd	321,163	377,839	535,928	957,417	1,101,000
BOD, lbs/d		884	1,127	1,446	
TSS, lbs/d		1,030	1,346	1,940	
TKN, lbs/d		188	238	276	

B. Anticipated Permit Limits

The Orleans WWTF will be regulated by the Massachusetts Department of Environmental Protection (MassDEP) under its Bureau of Resource Protection's Division of Water Pollution Control. The Massachusetts Groundwater Discharge Permit Program (314 CMR 5.00), requires any person who discharges, or proposes to discharge, pollutants to the groundwaters of the Commonwealth to obtain a discharge permit pursuant to G.L. c.21 s.43.

The permitted wastewater treatment facility must be operated by a Certified Wastewater Treatment Plant Operator in accordance with the "Rules and Regulations for Certification of Operators of Wastewater Treatment Facilities" (257 CMR 2.00). The permit holder bears the ultimate responsibility of providing for the proper operation and maintenance of the facilities in accordance with "Operation and Maintenance and Pretreatment Standards for Wastewater Treatment Works and Indirect Discharges" (314 CMR 12.00). Based on conversations with MassDEP, the anticipated limits of the Orleans WWTF are summarized in Table 7.

Table 7: Anticipated Effluent Permit Limits

Constituent	Anticipated Effluent Limit
BOD, mg/L	30
TSS, mg/L	30
TN, mg/L	10
Fecal Coliform, cfu/100 mL	200

3. Review of Process Equipment and Tankage Options

The following sections document key considerations and assumptions for the recommended preliminary design of the WWTF. Various manufacturer quotes were obtained and reviewed for each major piece of equipment. Table 8 summarizes the manufacturers that supplied quotes for the various pieces of equipment. Initial quotes were received as part of the draft PDR in Spring 2017, and revised quotes were received, where applicable, as part of the updates for the final version of this TM in Summer 2018. As will be discussed, the selection of the biological process impacts many of the other systems discussed, requiring a cost comparison at the full treatment plant level for the two options. This is discussed further, beginning on page 18. Future design development will further specify acceptable vendors for each major piece of equipment.

Table 8: Preliminary Equipment Quotes

Unit Processes	Vendor	
Preliminary Screening	Hydro-Dyne-6mm	Lakeside (for SBR)
	Hydro-Dyne-2mm (2)	Lakeside (for MBR)
CBD	Xylem/Sanitaire	Aquarius
Mixing Blowers	Aerzen	Kaeser
Biological Process		
SBR Package (including aeration system and mixing, etc.)	AquaSBR	
	Xylem	
	GE Zenon	
MBR Package (including aeration system and mixing, etc.)	Koch	
	Fibracast	
Filter	AquaSBR	Kruger/Hydrotech
UV	Trojan	Wedeco
	Ozonia	
Septage Receiving	Lakeside	Huber
Sludge Thickener	Parkson-RDT	Huber-Disk Thickener
	Charter-GBT	Huber-Screw Thickener
	Andritz	
Odor Control		
Biofilters	BioRem	
Carbon Canister	ECS	

Unit Processes	Vendor
Pumps	
EQ-MBR	ABS
EQ-SBR	ABS
Effluent Discharge	ABS

A. Headworks Screening

The preliminary design includes screening at the headworks of the facility. Inclined rotary drum and center flow screens were evaluated for the basis for design, depending on the screening requirements of the downstream process options evaluated. Center flow screens utilizing a perforated plate are appropriate for processes requiring extremely fine screening (i.e. membrane bioreactors) however they are generally more costly than inclined rotary drum screens. Rotary drum screens are commonly used for more conventional processes (i.e. sequencing batch reactors).

B. Biological Unit Process Alternatives

A previous evaluation⁵ of biological treatment alternatives based on qualitative factors concluded that membrane bioreactors (MBRs) were favored over four other alternatives. The second and third ranked alternatives, Conventional Activated Sludge (CAS) and Sequencing Batch Reactors (SBRs), were ranked very close to one another. Of these two, AECOM's experience on smaller treatment facilities is that SBRs are far more cost effective than CAS on both a capital and life cycle cost basis. For the purposes of doing a more quantitative economic comparison of options, SBRs were chosen as a point of comparison to the MBR technology.

1) Membrane Bioreactors (MBRs)

The MBR process consists of a suspended growth biological reactor integrated with an ultra-filtration membrane system that has a 0.1-micron or less effective pore size. The membranes, supplied as cartridges, are submerged in an aeration tank in direct contact with the mixed liquor (see Figure 1). Using a vacuum ("permeate") pump, treated water is drawn through the membranes and discharged. Air is introduced at the bottom of the membrane module producing turbulence, which scours the external surface of the membranes transferring rejected solids away from the membrane surface. This airflow also provides a portion of the oxygen needed for respiration. Concentrated sludge is pumped from the bottom of the tank and a portion of the mixed liquor is recycled to the head of the aeration zone.



Figure 1: Membrane Bioreactor Example - Fibrecast FibrePlate (Fibrecast)

The membranes may be paired with many of the more commonly applied activated sludge processes. For the purposes of this evaluation, the membranes are coupled with a Modified Ludzack-Ettinger (MLE) configuration for nitrogen removal. MLE is the most commonly used nitrogen removal process used with MBR. In the MLE-MBR process, mixed liquor is recycled from membrane tank to anoxic tank as shown in the Figure 2. The nitrate-N (NO₃-N) in the recycled mixed liquor, when mixed with raw incoming wastewater under anoxic conditions denitrifies, gets reduced to elemental nitrogen, which then bubbles off as a gas into the atmosphere.

⁵ "Town of Orleans, MA, Water Quality and Wastewater Planning, Task Number 1 – Facilities Engineering, Deliverable 1.c.10, March 2016"

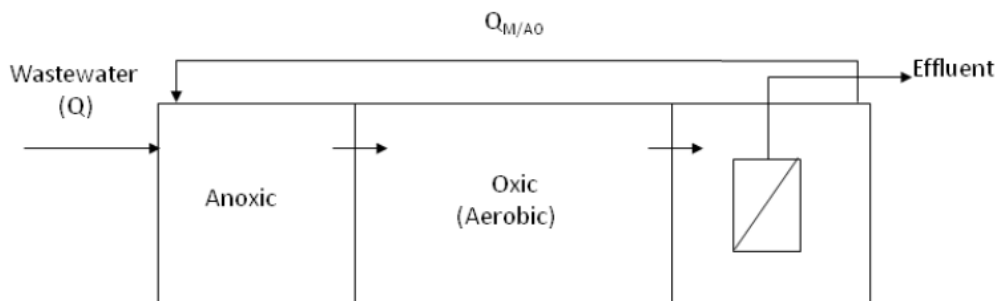


Figure 2: Process Schematic of MLE/MBR Configuration

Periodically the membranes require cleaning which is typically an automated process as prescribed with the membrane equipment manufacturer which occurs within the tank. Cleaning consists of adding a solution of sodium hypochlorite to the MBR tanks using chemical feed pumps and a citric acid wash. In addition, the membranes must be removed from the bioreactor tank for inspection every one to two years.

In general, the benefits to the MBR treatment process include:

- Ability to meet very stringent effluent limits needed for water reuse;
- Smaller footprint than other alternatives;
- Ability to combine secondary clarification and tertiary filtration in a single unit operation;

In general, drawbacks to the MBR treatment process include:

- High life cycle cost due to higher electrical demands/consumption primarily as a result of the aeration requirements;
- Membrane cleaning requires some units to be off-line for treatment;
- Sophisticated timing units and pressure monitoring required for scouring (cleaning); and
- Process control modifications are necessary to adapt system to loading variations.

2) Sequencing Batch Reactors (SBR)

SBRs are often used for medium to smaller facilities. On Cape Cod, Provincetown, Falmouth and Mass Maritime Academy are examples of where SBRs are employed. SBRs combine the function of the bioreactor and settling tank into one vessel. The SBR runs in a sequential cycle broken up into different segments for filling, reacting, settling and decanting. Although they do not require a separate settling tank, they typically require flow equalization, which reduces the cost/space savings that would otherwise be realized.



Figure 3: Sequencing Batch Reactors (Aqua-Aerobic Systems, Inc.)

Processes such as nitrification (the oxidation of ammonia-nitrogen to nitrate, $\text{NO}_3\text{-N}$) and denitrification (the removal of nitrate by denitrifying bacteria) can be accomplished along with biochemical oxygen demand (BOD) reduction and organic solids stabilization in a single reactor vessel. Most denitrification processes require a supplemental organic carbon source, which is usually a simple carbohydrate such as methanol. By introducing a portion of the incoming waste before the denitrification segment of the SBR cycle, or alternating aerobic anoxic periods during part of the cycle, it is possible to achieve biochemical oxygen demand reduction and nitrogen removal in a single reactor without methanol addition.

The SBR process has been successfully used in industrial and municipal applications for many years. There are five operational steps in the SBR process: (1) fill; (2) react (aeration); (3) settle (clarification); (4) draw (decant); and (5) idle (sludge wasting). The SBR treatment system would consist of multiple tanks with inlets for raw wastewater; air diffusers with associated compressors and piping; a sludge draw off mechanism at the bottom to waste sludge; a decant mechanism to remove the clarified supernatant after settling; and a control mechanism to time and sequence the process. A minimum of two separate tanks are provided for continuous flow-through applications such that one tank receives the wastewater flow filling the tank while the other tank processes the wastewater.

3) Technical Evaluation of Biological Unit Processes

The biological process selected impacts several other design aspects of the WWTF, including:

- MBR requires finer screening at 2 mm, whereas SBR only requires 6 mm. Additionally, the screening is more critical for MBR operation, such that increased redundancy is required compared to the SBR option.
- The equalization tank pumps must be slightly larger to accommodate increased Total Dynamic Head (TDH) when pumping to an SBR compared to an MBR.
- SBR requires a process building, post filtration cloth disk filters, and pumps. The MBR requires a staging/laydown area for access to the membrane tank as well as a small enclosed building to house the chemical feed equipment and pumps.
- SBR option includes a post-equalization tank whereas MBR does not require this. However, the MBR option does include an effluent pump station.

Because the selection of the biological process impacts other units in the treatment train, a full capital cost analysis for complete treatment plants, incorporating each option, needed to be completed. This analysis and resultant recommendation are presented later in this document. A further discussion of components common to either option continues as follows.

C. Sludge Thickening Alternatives

The sludge handling system is intended to thicken combined WAS and septage from approximately 0.5 percent solids to 4 to 6 percent solids for off-site disposal. Further dewatering was not selected, as the seasonal variation in both wastewater flow and septage receiving may make it difficult to consistently achieve the degree of dewatering that would be required for disposal. Therefore, the system was designed for thickening only. Because sludge/septage thickening loads are subject to a fair amount of uncertainty, it is sensible to initially size the system for the Phase – 1 loads with the ability to add an additional unit should growth require it. The system was designed to operate 8 hours/day for 5 days/week under annual average conditions, based on the design basis in Table 9.

Table 9: Sludge Thickening Design Basis

Item, 7-d/week basis	Annual Average	Max Month	Max. Week
Plant Flow, gal/d	228,900	320,460	384,552
WAS Production, gal/d	10,243	13,001	15,611
WAS Production, lbs/d	513	651	781
Septage Receiving, gal/d	16,500	22,319	22,319
Septage Receiving, lbs/d	496	671	671
Blend Production, gal/d	26,743	35,320	37,930
Blend Production, lbs/d	1009	1321	1452
Blend TSS, %	0.45%	0.45%	0.46%
Assumed Processing Schedule, d/wk	5	6	6
Assumed Processing Schedule, h/d	8	8	10
Hydraulic Throughput Required, gpm	78	86	74
Solids Loading, lbs/m	2.9	3.2	2.8

Several technologies were evaluated to determine the most cost-effective and efficient method for thickening combined biological sludge and septage at the facility. The technologies evaluated include Disk Thickener, Inclined Screw Thickener, Rotary Drum Thickener (RDT), and Gravity Belt Thickener.

1) Disk Thickener

The disk thickener consists of a stainless steel flocculation tank and tilted cylinder with a rotating stainless steel filter cloth. Flocculated sludge pools at the low point of the disk and static plows on top of the filter open up furrows so water can pass through. A scraper at the outlet pushes thickened sludge from the disk. The filter cloth is cleaned by a spray bar from the underside. The typical performance of these units is to produce 4 to 6 percent solids and 95 percent separation efficiency.



Figure 4: Disk Thickener (Huber, Inc.)

2) Screw Thickener

The screw thickener feeds conditioned sludge into an inclined cylinder that includes a wedge wire basket. A shafted screw slowly rotates and allows the sludge to be conveyed toward the top as liquid flows through the basket and toward a drain at the bottom. These systems typically include spray bars with an automatic wash system. The typical performance of these units is 4 to 6 percent solids with greater than 95 percent capture.



Figure 5: Example of Disk Thickener (Huber Technology, Inc.)

3) Rotary Drum Thickener (RDT)

Rotary Drum Thickeners (RDT) consists of a horizontal rotating basket with several zones of a variety of woven mesh sizes. Conditioned sludge is fed into the rotating screened drums, allowing the water to separate from the solids. Finer mesh is typically used at the feed end, where sludge is thinner, and progresses to larger openings for liquid removal. RDTs are enclosed units and consist of compact designs. Like the screw and disk thickeners, there is an automated wash down process requiring little operator intervention.



Figure 6: Example of Rotary Drum Thickener (Parkson Corporation)

4) Gravity Belt Thickener (GBT)

Gravity Belt Thickeners (GBT) feed sludge (typically conditioned with polymer) onto a moving belt, which allows the water to drain through the belt as the concentrating sludge moves along. The belts are not enclosed, which can cause odor, corrosion and housekeeping issues. They have an adequate service life, however, they require more manual maintenance for cleaning. Typically large volumes of water are required to hose down equipment after each cycle, which can also cause slip hazards for operators. While this technology is time proven, and what was in use at the Tri-Town facility, most new installations are opting for the smaller, more enclosed features of the previous options.

Comparison - The compact footprint, containment of odors, degree of automation make each of the first three options preferred over GBTs. Compared to the screw or disk thickeners. RDTs had a slight advantage based on cost considerations. The design basis assumes the use of an RDT but this can be further evaluated as the design progresses.

D. Odor Control Technologies

Odor control is an important consideration to any treatment facility. Biofilters, chemical scrubbers and activated carbon are all commonly used odor control technologies. Chemical wet scrubbers are commonly applied at larger WWTFs that already have a need for large chemical storage facilities. For smaller facilities, avoiding the hazards of chemical receiving and handling often eliminates wet scrubbers from further consideration. For that reason, activated carbon and biofilters were the two technologies that were evaluated for the Orleans WWTF. The preliminary design includes odor control for the septage receiving garage, headworks building, sludge storage tanks, and equalization tank. The system was designed based on air changes per hour from literature value and assuming that the tanks (WAS, TWAS, and Equalization) were half-full.

Table 10: Odor Control Design Basis

Area	Volume Vapor Space (ft ³)	Air Changes Per Hour	Volume Air (ft ³ /min)
Septage Receiving Garage	21,000	18	6,300
Headworks Building	4,500	18	1,350
Sludge Storage	12,000	8	1,600
Raw Sewage Equalization (EQ)	26,000	8	3,500
Total			12,750

1) Activated Carbon

An activated carbon is a proven odor control technology that works by adsorbing chemical contaminants from a polluted air stream onto high surface area carbon granules. These small-footprint systems have few controls and are easy to operate. Though the system has a low initial capital cost, carbon media replacement can be costly and the anticipated frequency of change-outs must be considered.

2) Biofilter

Biofilters have become an increasingly applied proven odor control technology that operates based on adsorption and bacterial decomposition of odorous compounds. Moisture levels on the media and biofilm are maintained with either potable water or treated effluent. The system has a larger foot-print and the media is anticipated to treat odors for a minimum of ten years before media replacement may be necessary.

Comparison - Because of significant differences in both capital and operating cost between the two options, a preliminary Life Cycle Cost Analysis (“LCCA”) was completed to compare the two odor control technologies. The carbon system replacement costs were based on carbon-media replacement every 550 days for an approximate cost of \$42,000 each change-out. Biofilter media replacement costs were estimated at \$90,000 with replacement required at year 10. The LCCA showed the carbon 20-year LCC is approximately \$1.53M and the biofilter 20-year LCC is approximately \$1.77M. The biofilter system has a 20-year LCC cost approximately 16 percent higher than the carbon cost. Although considered within the margin of uncertainty of the estimate, the basis of design will be carbon, due to the much smaller footprint requirements and considerably lower installed capital cost.

E. Post Filtration

A second solids barrier is recommended for the SBR option. While an SBR can typically produce an effluent with solids concentrations well within permit requirements, the sensitivity of the primary disposal options under consideration (i.e. Wick Wells), make including a second solids barrier in the WWTF design prudent. The final step in the MBR process is membrane filtration, which provides a physical barrier to solids discharges, making post-filtration unnecessary for MBRs. Three common technologies for post-filtration include sand filters, cloth disks, and a continuous backwash filters. Cloth disk filters are typically the technology of choice to follow SBRs. They are compact, have a low hydraulic profile, are tolerant of solids upsets, and are energy efficient. The Provincetown WWTF has cloth disk filters following their SBRs.

F. Disinfection

The two most common disinfection systems are sodium hypochlorite (NaOCl) and ultraviolet (UV). Disinfection with NaOCl can tolerate more variable effluent quality but requires storage and handling of NaOCl, which is extremely corrosive. UV disinfection is a safe alternative that uses UV light to penetrate the cell wall of the microorganism, rendering it inactive. It does not require dechlorination or have associated disinfection by-products. The operation does not have the safety and logistical concerns from chemical delivery as the NaOCl disinfection system. The UV system requires a relatively small, compact footprint but requires consistently clean effluent to achieve disinfection standards. Since the proposed design includes post-filtration, good effluent quality is ensured and UV can be selected. UV can be configured in open channel or in closed conduits. This preliminary design assumed the UV system would be located in closed conduits because it fits within the hydraulic profile of either biological process which include pumping from the plant to the effluent disposal location. Additionally, the closed conduit can be placed out of the elements in the basement of the Administration/Laboratory building.

G. Infrastructure, Tankage, and Miscellaneous Systems

1) Administration/Laboratory Building

The Administration and Laboratory building is designed to be a space for offices, a small laboratory, and miscellaneous equipment. The first floor will consist of offices, a small laboratory, messing facilities and maintenance space. Adjacent to the office space on the first bay will be a truck bay which will house septage offloading with preliminary screening. This area will also house the sludge thickening equipment. A basement under both the offices and truck bay will house the blowers providing air to equalization basins, WAS storage tank, and TWAS storage tank, as well as the UV system, plant water, sludge thickener feed pump, and miscellaneous process equipment. The building will be designed with an aesthetically appealing exterior as will be further described in the Architectural Section of this report.

2) Septage Receiving

The design assumes that the WWTF can accept an annual average of 16,500 gpd of septage. This capacity is expected to accommodate the non-sewered areas of Orleans, as well as allows for some additional capacity to accept septage from surrounding Towns. Although the 16,500 gpd is an annual average and receiving will likely happen during weekdays, the storage and equalization aspects of the design mean that the load on the biological process will be more evenly spread-out.

The Sludge Acceptance Plant features a septage receiving system with screens and raking mechanisms, as well as wash press system and grit removal. The septage will then be pumped into the Waste Sludge Storage tank, where it will then be mixed with waste sludge from the biological process and subsequently thickened for off-site disposal. Filtrate from the sludge thickening process will flow to the Equalization Tank where it is mixed with screened sewage and sent to the biological process for treatment. The septage is routed directly to sludge storage rather than to equalization in order to reduce the solids load to the biological process.

3) Headworks and Equalization

The proposed headworks system consists of preliminary fine screen(s) followed by covered flow equalization tanks. The headworks structure will be mounted on-top of the sludge storage tanks and will be enclosed in a small building for weather protection and odor control. Raw wastewater will enter the influent channel in the center from underneath in order to adequately distribute the flow. There will be two channels with diamond plate covers. For the SBR option, the headworks will consist of one 6 mm screen and one manual bar rack. The 6 mm screen will be sized for the Phase 1 and Phase 2 combined flow, as this is most economical. For the MBR option, the initial headworks system will consist of two 2 mm screen channels, both sized for the Phase 1 and Phase 2 flow. This allows for one duty and one stand-by screen. A manual bar rack is not an option for the MBR because its performance requires finer screening and even temporary bypassing of the screen could result in damage to the membranes. Both headworks systems will collect screenings in a barrel and have a grated platform to provide access to the screens. Because the headworks system is upstream of any flow equalization, the screens are designed for peak hourly flow, which is 1.5 MGD for Phases 1 and 2 combined. The headworks layout for both options is shown in Figure 7 and Figure 8.

The preliminary design includes two equalization tanks, each sized at approximately 150,000 gal. They are designed to be made common by the opening of a gate valve separating the two tanks. Both tanks may need to be used as the Phase 1 design flows are reached. However, one tank should be sufficient during start-up, and during the winter months when the seasonal flows are lower. Because the tanks are below grade and have common wall construction with the some of the other below grade tankage, it is prudent from a construction cost standpoint to build both initially. The volume required was based on the desire to mitigate peak hourly flows within a peak day scenario such that the peak hour flow to downstream processes would be limited to the anticipated max day flow for Phase 2 of 833,800 gpd, plus a 15 percent allowance for recycles, etc. The equalization tank will receive filtrate flow from the sludge thickening system, and in the case of the SBR option, backwash from filter cleaning cycles. The equalization tanks will be covered with odor control.

Three 50 percent pumps (2 duty, 1 standby) sized for Phase 1 flows will pump the wastewater from the equalization tank to the biological treatment process. The tank will also include one additional guard rail assembly and space for a future pumps if needed for Phase 2 implementation. The equalization tank pumps are sized slightly larger for the SBR option, due to the higher hydraulic grade line associated with the SBRs.

4) Post Equalization/Effluent Pump Station

SBRs discharge flow on a non-continuous basis. In the design proposed for the Orleans WWTF, at peak flow each SBR will discharge flow for 75 min for every 6 hour cycle (i.e. batch). To normalize flow through the disinfection process and ultimately to the effluent disposal beds, a post-equalization tank is provided for the SBR option. This tank would be sized at approximately 100,000 gallon to accommodate peak flow SBR discharges, which include an allotment for sludge thickening filtrate and filter backwash. The tank would be located partially below grade in order to receive flow by gravity from the cloth disk filters.

A post-equalization tank is not required for the MBR option, as MBRs discharge flow essentially on a continuous basis, however a partially below grade effluent pump station would be needed to receive flow from the MBRs and pump it through the disinfection system out to the effluent disposal beds. The effluent pump station wet-well would be 20 feet by 8 feet, with a depth of 10 feet. It would be sized to accommodate four pumps, two duty and one standby for Phase 1 flows, with space to accommodate an additional duty pump for Phase 2.

5) Effluent Pumping

The effluent pumps were estimated to require 160 feet of TDH based on an effluent disposal location 5,500 linear feet away from the site and 75 feet elevation increase. The ultimate effluent disposal location has not yet been approved and therefore, this design may need to be revised if it varies significantly in distance and/or elevation. The second and third desired locations are at a similar distance and elevation compared to the site. The proposed design includes three pumps, each sized to handle 50 percent of the Phase 1 max flow along with guard rail assemblies for one future pump. In the SBR option, the pumps will be located in the post-equalization tank that follows the SBR. In the MBR option, the pumps will be located in the effluent pump station.

6) Sludge Storage

The septage received at the WWTF will be routed directly into a tank with the Waste Activated Sludge ("WAS") from the biological process prior to thickening. WAS will be transferred to the thickener located in the truck bay via a thickener feed pump located in the basement of the Admin/Lab building. After thickening, thickened WAS ("TWAS") will flow by gravity from the thickener into a TWAS tank.

Based on AECOM's experience at the Provincetown facility, transportation of thickened sludge from the lower/outer Cape can be a challenge, particularly during the summer when traffic is a concern. It is important to provide sufficient storage volume for both WAS and TWAS to accommodate maintenance outages of the thickening equipment, staff work schedules (i.e. long holiday weekends), etc. The recommended WAS and TWAS volumes and what they provide for storage capacity under both Phase 1 and Phase 2 conditions is as shown below. Note that the WAS storage volume is slightly smaller for the MBR option due to the fact that the sludge wasted from a MBR process is anticipated to be more concentrated than it would be for the SBR option.

As can be seen from Table 11, the planned volume for WAS/Septage storage for either option provides approximately 3 days storage under max week conditions at full build-out conditions. In an emergency, additional time could be gained by temporarily halting septage receiving, which makes up a significant portion of the storage tank requirements. Similarly, thickening for TWAS was based on projected max week conditions for both the Phase 1 and Phase 2.

Table 12 shows that the 25,000 gallons planned for TWAS storage provides 4 days for projected full buildout max week conditions. This provides sufficient storage volume to accommodate any short-term disruptions in transportation due to weather, traffic, or contractual issues should they arise. Again, storage time can be extended in an emergency through temporary suspension of septage deliveries.

7) Aeration Systems

Coarse bubble diffusers will be provided for mixing the equalization tank, WAS tank, and TWAS tank. The equalization tank will be mixed at an air density of 20 scfm/kcf, the WAS tank at 30 scfm/kcf, and the TWAS tank at 75 scfm/kcf all based on maximum volume. Approximately 830 scfm is required for the equalization tank, 650 scfm per WAS tank, and 240 scfm in TWAS tank. Therefore four blowers (3 duty/1 standby) rated for 575 scfm at 9.0 psig. The blowers will be configured with noise enclosures.

Additionally, the SBR or MBR system would be provided with necessary diffusers and blowers required to operate that system.

Table 11: WAS Max Week Storage Summary

Description	SBR Option		MBR Option	
	Phase 1	Phase 2	Phase 1	Phase 2
Max Week WAS Production, lbs/d	781	1,100	655	922
Assumed WAS TSS, %	0.60	0.60	0.80	0.80
Max Week WAS Production, gal/d	15,611	21,981	9,811	13,815
Septage Delivery, gal/d	22,320	22,320	22,320	22,320
Design Volume, gals	160,000		125,000	
Actual Storage Capacity, d	3.2	2.7	3.1	2.8

Notes:

1. Storage capacity includes a 25 percent factor of safety.
2. Phase 2 production and septage delivery values listed include both Phase 1 and Phase 2 flows and represents the total design rather than the incremental additional production associated with Phase 2.

Table 12: TWAS Max Week Storage Summary

Description	SBR Option		MBR Option	
	Phase 1	Phase 2	Phase 1	Phase 2
Assumed Septage TSS, mg/l	3,600	3,600	3,600	3,600
Septage TSS, lbs/d	670	670	670	670
Assumed Thickener Capture, %	90	90	90	90
Assumed TWAS TSS, %	4.0	4.0	4.0	4.0
TWAS, lbs/d	1,306	1,593	1,192	1,433
TWAS, gal/d	3,915	4,775	10,722	12,883
Design Volume, gals	25,000		25,000	
Actual Storage Capacity, d	4.8	3.9	5.2	4.4
Filtrate Flow, gal/d	34,015	39,525	28,557	31,839

Notes:

1. Storage capacity includes a 25 percent factor of safety.
2. Phase 2 production and septage delivery values listed include both Phase 1 and Phase 2 flows and represents the total design rather than the incremental additional production associated with Phase 2.

H. Capital and Life Cycle Cost Estimates for Evaluation of Preferred Plant Layout.

As previously discussed, the two options selected for comparison for the biological process were SBR and MBR. Because these two options have different requirements for both upstream (e.g. screening) and downstream (e.g. post filtration/equalization) systems, a comparison of the two required the layout and cost estimation at the full plant level for each. A comparison of the major plant systems for each is as shown in Table 13.

Table 13: Comparison of Major Plant Systems for SBR and MBR Options

Description	SBR	MBR
Headworks/Screening	1 @ 6 mm inclined drum screen, 1 @ manual bar rack	2 @ 2 mm center flow screen
Equalization	2 Tanks @ 150,000 gal/ea	2 Tanks @ 150,000 gal/ea
Reactor Tankage	2 Tanks @ 415,000 gal/ea	2 Tanks @ 131,000 gal/ea
Post Filtration	2 @ 100% cloth disk filters	3 @ 50% membrane cassettes (Ph1) 4 @ 33% membrane cassettes (Ph2)
Post Equalization/Effluent Pumping	1 Tank @ 100,000 gal	1 Tank @ 12,000 gal
Disinfection	2 UV Units with 32 lamps/ea	2 UV Units with 32 lamps/ea
Septage/WAS Storage	1 Tank @ 160,000 gal/ea	1 Tank @ 125,000 gal/ea
Thickened Sludge Storage	1 Tank @ 25,000 gal	1 Tank @ 25,000 gal

Process flow diagrams (PFDs) for the Options are as shown in Figure 9, Figure 10, and Figure 11, respectively.

A review of Table 13 shows that there are several differences between the two designs. The MBR has smaller volume requirements for the bioreactors and the sludge storage tanks, and requires a smaller effluent pump wetwell versus the larger post-equalization basin included in the SBR design. The SBR option required a lower degree of screening.

In order to assess the differences in the two designs, a cost estimate needed to be developed that included not only the cost of the process equipment for each option, but the full installed costs including tankage, buildings and ancillary equipment. Figure 7 through Figure 20 show the overall site layout, building elevations, floor plans and sections, and a preliminary hydraulic profile used in the development of construction costs for each option.

Table 14 summarizes the estimated total project cost for each of the two options. The cost estimates were derived from vendor proposals for all major process equipment, a detailed assessment of concrete, building materials, and site work required to build the necessary tanks/structures, and standard allowances for some plant wide items as follows:

- Electrical: 20 percent project cost;
- I&C: 50 percent of electrical;
- Piping: 15 percent of mechanical equipment; and
- 22 percent contractor, GC, overhead, and profit.

More detailed information on the installed costs estimates for both options are found in Appendix A.

Table 14: Summary of Installed Cost for Two Process Options

Description	MBR Option	SBR Option
Total Direct Costs (equipment, construction material, direct labor)	\$10,887,000	\$11,044,000
Contractor's General Conditions, Overhead and Profit (22% of Direct Cost)	\$2,395,000	\$2,430,000
Project Contingency (30%)	\$3,985,000	\$4,042,000
Owner Contingency (5%)	\$863,000	\$876,000
Subtotal (2 nd Qtr CY 2018)	\$18,130,000	\$18,392,000
Escalation to Construction Mid-point (assumed July 2020)	\$1,159,000	\$1,175,000
Total Project Cost	\$19,289,000	\$19,567,000

As one can see, the capital costs for the two options are extremely close, within the margin of error of the estimate; however it is appropriate to also consider the operation and maintenance (O&M) costs over longer period of time, typically 20 years. A combined evaluation of capital and O&M costs over a 20 year period is commonly referred to as life cycle cost analysis ("LCCA"). While many of the O&M costs are common between the two options, there are some differences. As an example, the MBR will include additional recirculation of mixed liquor (RAS and IR) at several multiples of influent flow while the SBR will not. The SBR option includes the disk filter which has backwashing energy expenses that the MBR does not. A complete comparison of operating costs between the two options is shown in Table 15.

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Table 15: Comparison of O&M Cost Differences for SBR and MBR Options for Phase 1

Category	SBR Option			MBR Option			
	Qty	U/M	Cost/unit	Qty	U/M	Cost/unit	Subtotal
<u>Labor</u>	8320	hrs	\$ 53	8320	hrs	\$ 53	\$ 436,800
<u>Electricity</u>							
Odor Control	138,868	kwh/yr	\$ 0.20	138,868	kwh/yr	\$ 0.20	\$ 27,774
Mixing Air	208,604	kwh/yr	\$ 0.20	192,576	kwh/yr	\$ 0.20	\$ 41,721
Reactor Air	165,910	kwh/yr	\$ 0.20	161,181	kwh/yr	\$ 0.20	\$ 33,182
Reactor Mixing	63,332	kwh/yr	\$ 0.20	43,800	kwh/yr	\$ 0.20	\$ 12,666
Scour Air	0	kwh/yr	\$ 0.20	43,800	kwh/yr	\$ 0.20	\$ 8,760
Transfer Pumps	13,547	kwh/yr	\$ 0.20	10,917	kwh/yr	\$ 0.20	\$ 8,760
Effluent Pumps	68,650	kwh/yr	\$ 0.20	68,650	kwh/yr	\$ 0.20	\$ 2,183
RAS/IR Pumps	0	kwh/yr	\$ 0.20	30,568	kwh/yr	\$ 0.20	\$ 13,730
Permeate Pumps	0	kwh/yr	\$ 0.20	30,981	kwh/yr	\$ 0.20	\$ 6,114
Filter Backwash	4,578	kwh/yr	\$ 0.20	0	kwh/yr	\$ 0.20	\$ 6,196
UV	75,161	kwh/yr	\$ 0.20	75,161	kwh/yr	\$ 0.20	\$ -
Facility Lighting, HVAC	286,399	kwh/yr	\$ 0.20	282,983	kwh/yr	\$ 0.20	\$ 15,032
Total Electricity			\$			\$	\$ 205,010
<u>Heat</u>	1	lot	\$ 26,677	1	lot	\$ 26,677	\$ 26,677
<u>Chemicals</u>							
Thickening polymer	690	gal/yr	\$ 9.41	574	gal/yr	\$ 9.41	\$ 5,404
NaOCl	0	gal/yr	\$ 2.21	154	gal/yr	\$ 2.21	\$ 341
Citric Acid	0	gal/yr	\$ 10.45	20	gal/yr	\$ 10.45	\$ 209
Soda Ash	1	lot	\$ 35,000	1	lot	\$ 35,000	\$ 35,000
Misc	1	lot	\$ 20,000	1	lot	\$ 20,000	\$ 20,000
Total Chemicals			\$			\$	\$ 61,490
			\$			\$	\$ 60,954

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Category	<u>SBR Option</u>			<u>MBR Option</u>		
	Qty	U/M	Cost/unit	Qty	U/M	Cost/unit
<u>Sludge Disposal</u>						
Transportation	985,500	gal/yr	\$ 0.066	839,500	gal/yr	\$ 0.066
Tipping	166	tons/yr	\$ 315	138	tons/yr	\$ 315
<u>Total Sludge</u>			\$ 117,242			\$ 98,868
<u>Routine Maintenance</u>	1	Lot	\$ 108,465	1	Lot	\$ 108,465
<u>Lab Costs</u>	1	Lot	\$ 17,458	1	Lot	\$ 17,458
<u>Gen'l Office Supplies & Expenses</u>	1	Lot	\$ 64,563	1	Lot	\$ 64,563
Sub-total			\$ 1,037,704			\$ 1,029,681
Contingency			10%			10%
Sub-total			\$ 1,141,475			\$ 1,132,649
Town Administration			3%			3%
			\$ 34,244			\$ 33,979
Total O&M Costs			\$ 1,175,800			\$ 1,166,700

A 20-year LCCA analysis is presented in Table 25 at the end of the TM. This analysis was based on the following assumptions:

- General Inflation Rate: 3.0 percent;
- Electricity Inflation Rate: 3.3 percent; and
- Discount Rate: 1.5 percent.

A different inflation rate for electricity was used than for general inflation based on the fact that electricity costs are driven by a number of factors above those influencing general inflation (i.e. – transmission congestion, etc.). Energy inflation was derived using projections produced by the U.S. Department of Energy's Energy Information Administration, specific to commercial users in the Northeast United States.

As shown in Table 25, the 20-year life cycle cost for the MBR Option is \$46.9 million while for the SBR Option, it is \$47.3 million. As was the case with the construction costs, the life cycle costs are close enough to be considered within the estimate's margin of error.

AECOM's original recommendation in the 2016 concept evaluation⁶ report based on qualitative rankings listed MBRs as more favorable than SBRs in total. The assessment of some of the factors that led to this recommendation has shifted somewhat in the ensuing months/years, with the benefit of further defining the compete installation of both options, and experience gained at other sites. It should be noted that the design development for the SBR option included the addition of some features aimed at leveling some of the non-economic differences between the two technologies. Areas where MBR ranked markedly higher than SBR in the previous evaluation and current thoughts on these selection criteria are as follows.

1. **Operational Complexity:** AECOM originally rated MBRs higher (more favorable) for operational complexity than SBRs. This was based on the fact that the MBR provides a barrier preventing solids carry-over to the disposal beds, making control of good solids settling characteristics within the biomass less important than with SBR systems. In the development of the design however, AECOM has included post filtration for the SBR option, which mitigates the SBRs potential for solids upsets. AECOM would additionally note that the while both the MBR and SBR/Disk Filter systems require periodic chemical cleaning, MBR systems require it as a much higher frequency (weekly vs annually). The addition of post-filtration to the current SBR design and the reduced frequency of chemical cleaning mitigate the advantage that MBRs previously displayed in the 2016 evaluation.
2. **Expansion Capability:** AECOM has laid out the design of both options to readily accommodate the future increases in flow from possible future collection system phases for the Downtown and Meeting House Pond areas.
3. **Ability to Achieve Potential Stricter Limits (P, lower N):** A review of operating data from the nearby SBR system at Provincetown indicates that their SBR system is readily achieving effluent TN concentrations well below the anticipated limit of 10 mg/l. Discussions with MassDEP do not indicate any potential for a P limit for the foreseeable future. Should one arise, both technologies, as currently laid out, would require additional systems for P removal.
4. **Compatibility with Wick Well for Effluent Disposal:** Similar to the discussion on Operational Complexity, the higher rating for MBR in this category was due to the fact that the MBR provides a solids barrier preventing solids carry-over to the disposal beds. The addition of post-filtration to the SBR design has leveled both technologies in this category.

⁶ "Town of Orleans, MA, Water Quality and Wastewater Planning, Task Number 1 – Facilities Engineering, Deliverable 1.c.10, March 2016"

5. Footprint Required: As can be seen by comparing the site plans for both options, the bioreactors for the MBR option are indeed smaller, however when all ancillaries structures, tanks, and buildings are added, the difference in overall footprint is not as significant.

In summary, features have been included in the current layout of the SBR design to mitigate some of the perceived disadvantages relative to MBRs noted in the previous evaluation. Even with these additional features, the SBR layout remains competitive from a cost standpoint.

One evaluation criterion that was not included in the previous evaluation was the commonality of the technology in the region. At all the municipal treatment plants located on Cape Cod, there are two SBR systems (Provincetown and Falmouth), but no MBR systems. Additionally, the smaller system located at the Massachusetts Maritime Academy in Bourne is an SBR system. This means that the ability to find operations staff in the region with hands-on experience with the selected technology will be easier with SBR than MBR.

AECOM believes both options remain technically viable, and by all indications, the cost differences are negligible. The fact that SBRs are more common in the region provides some benefits however in terms of locally available staff and technical support which are familiar with the technology, and believes this acts as something of a "tie-breaker". Additionally, in the months/years since the previous recommendation was made, AECOM has had some experiences with MBRs in small to medium sized municipal facilities that indicates without extensive pretreatment they are not as reliable a technology in municipal wastewater treatment applications as previously believed. As a result, AECOM's recommendation for future design development is a plant based on the SBR technology.

6. Description of Proposed WWTF

A. General

The Orleans WWTF will be designed to remove conventional pollutants (BOD and TSS) and to significantly reduce the amount of total nitrogen levels in the effluent prior to groundwater discharge. The following is a summary of the major proposed treatment components:

- Administration/Laboratory Building with Septage Receiving Truck Bay.
- Covered Headworks with Influent Mechanical Screening with manual bar rack by-pass
- Flow Equalization and Flow Splitting
- Sequencing Batch Reactor Tanks
- Process Building housing post-SBR filters and SBR blowers
- Post Equalization Tank (Effluent Pump Station);
- Ultraviolet disinfection units providing final treatment prior to disposal via groundwater discharge;
- Effluent Sampling and Flow Measurement;
- WWTF effluent piping to groundwater discharge site(s);
- Two sludge holding tanks;
- Sludge thickener, thickened sludge holding tank, and sludge load-out station; and
- Carbon adsorption for odor control to treat odorous air exhausted from the headworks, equalization tank, and sludge holding tanks.

B. Process

The major process equipment for the recommended WWTF design is as shown in Table 16.

Table 16: Recommended WWTF Major Equipment

Major Process Equipment	Description (Duty/Rating/Capacity)	Quantity	Design Basis
Preliminary Screening – 6 mm	1.1 MGD	1 Duty; 1 Manual Bar rack by-pass	Lakeside Model# 16MS-25-100 Microstrainer
Equalization Tank	150,000 gal tanks (52'x25'x16' MWL)	2	N/A
Equalization Transfer Pump	275 gpm at 40' TDH	2 Duty; 1 Standby; 1 Future	Sulzer/ABS Model XFP 100E-CB1 – 7.5 HP
SBR Reactor Tanks	415,000 gal tanks (52'x52'x18.8' MWL – Ph1) (52'x52'x20.5' MWL – Ph2)	2	Aqua-Aerobic Systems, Inc. AquaSBR
Disk Filters (post-SBR)	1,600 gpm	1 Duty, 1 Standby	Aqua-Aerobic Systems, Inc. AquaDisk Model ADFSP-54x6E
Post-Equalization Tank	100,000 gal (34' x 25' x 16' MWL)	1 Duty	N/A
Effluent Discharge Pumps	250 gpm at 135' TDH	2 Duty; 1 Standby; 1 Future	Sulzer/ABS Model XFP 101G-CB1 – 25 HP
UV	1.1 MGD; Minimum dose: >40 mJ/cm ²	1 Duty; 1 Standby 32 lamps each	WEDECO LBX 850e
Septage Receiving	400 gpm at 3% D.S.	1 Duty	Lakeside Raptor Septage Acceptance Plant
Sludge Thickening	90 gpm at 0.5% sludge concentration	1 Phase-1 2 Phase-2	Parkson ThickTech RDT 150
Odor Control	12,750 cfm	1 Duty	ECS VX-12000 Radial Activated Carbon System
Coarse Bubble Diffusers	EQ Tank: 830 scfm WAS Tank: 650 scfm TWAS Tank: 240 scfm	1 grid system/tank	Aquarius Stainless Coarse Bubble Diffused Aeration
Mixing Blowers	575 scfm at 9.0 psi	3 Duty, 1 Standby	40 HP Kaeser Compak Model DB236C

C. Civil/Site Work

Civil and site work for the WWTF will include grading, drainage, and site improvements. In general, fill slopes that are not subject to vehicular traffic will be graded at a 3 to 1 slope. Slopes that are subject to vehicular traffic will be graded at a maximum slope of 8 percent. All disturbed areas will be loamed and seeded, except where driveways or sidewalks are shown. In addition, some shrubs and trees will be provided as needed for landscaping in areas adjacent to the buildings and structures.

Areas that require routine vehicle access will be bituminous concrete roadways, consisting of a 15-inch gravel base course, a 2-1/2-inch bituminous concrete binder course and a 1-1/2-inch bituminous concrete top course. Areas that require routine pedestrian access will have concrete sidewalks. The sidewalk will consist of 4-inches of reinforced concrete on an 8-inch gravel base course and will have granite curbing.

Areas that surround structures or buildings will typically have a stone maintenance strip, which will be 6-inches thick and 3-feet wide. The stone maintenance strip will have a pervious weed barrier installed below the stone layer. The maintenance strip will have pre-molded aluminum edging material.

Painted steel bollards (approximately 4-inches in diameter and 42-inches tall) will be provided as needed to protect equipment or structures that are near roadways. Fencing will be located around the outer perimeter of the site for security.

The clearing and grubbing areas required for this project will be minimized to the extent possible. Landscaping and planting at the sites will be such that they are blended into the existing surrounding conditions to the extent possible.

D. Geotechnical

Existing soils information (borings and monitoring wells) exists from the construction of the Tri-Town Septage Treatment Facility. Additional soil information (test pits, borings and monitoring wells) was obtained during the potential groundwater disposal site investigation/evaluation. Additional borings and monitoring wells will be required at the WWTF site and the groundwater disposal site during the detailed design of these facilities.

E. Architectural

It is anticipated that the WWTF buildings will be framed with wood or metal stud interior walls, 2 inch by 6 inch at 16 inches on center or concrete block depending upon the building usage. Interior surfaces will be finished as shown on Table 17, Preliminary Room Finish Schedule. Fiberglass batt insulation will be used in all ceilings and walls.

The exterior walls of the WWTF buildings will be white cedar shingles. All doors, frames and air louvers will be anodized aluminum with colors selected during the design. All windows will be vinyl clad with insulating glass. Roof will be a prefabricated wood truss with plywood sheathing. Asphalt shingle roofing material will be used.

Table 17: Preliminary Room Finish Schedule

Description	Location						
	Floor	Base	North Wall	East Wall	South Wall	West Wall	Ceiling
First Floor							
1. Office	VT	V	G/P	G/P	G/P	G/P	A
2. Entry Area	C/S	V	G/P	G/P	G/P	G/P	A
3. Restroom	CT	V	G/P	G/P	G/P	G/P	G/P
4. Stairway	C	V	G/P	G/P	G/P	G/P	G/P
5. Chemical Area	C/SL	C/SL	G/FP	G/FP	G/FP	G/FP	G/P
6. Electrical Room	C/S	V	G/P	G/P	G/P	G/P	G/P
7. Laboratory	C/VT	V	G/P	G/P	G/P	G/P	G/P
8. Truck Bay	C/S	C	FP	FP	FP	FP	FP
Basement							
1. Equipment Area	C/S	C	C/P or C/SA P	C/P or C/SAP	C/P or C/SAP	C/P or C/SAP	C/P or C/SAP

LEGEND:

A - Acoustical Ceiling	CB - Concrete Block
P - Paint	SAP - Sound Absorption Panels
S - Sealer, hardener	CT - Ceramic Tile
V - Vinyl	WP - Waterproofing
VT - Vinyl Tile	SL - Synthetic Liner
C - Concrete	GB - Glazed Block
G - Gypsum Drywall	
FP - Fiberglass Panels	

F. Structural

All reinforced concrete structures will be designed in accordance with the latest editions of the American Concrete Institute (ACI) 318, ACI 350 and the Massachusetts Building Code. Structural concrete will be 4,000 pounds per square inch (psi) compressive strength using Type II cement conforming to ASTM C150 and aggregate conforming to ASTM C33. Reinforcing steel will be Grade 60 in accordance with ASTM A615. Tanks will be constructed as integral members of the building foundation structure.

Polyvinyl chloride (PVC) waterstops will be provided at all construction joints in hydraulic structures. Membrane waterproofing will be provided on the walls of all hydraulic structures that are common with the building and where the normal water level extends above the finish grade adjacent to the structure. Waterproofing of slabs will be provided by specifying an adequate slab thickness, or using membrane waterproofing compounds.

The following areas will be covered to control odor emissions: (a) Influent Screening and by-pass channels, (b) Equalization Tank, and (c) Sludge Holding Tanks. Concrete will be used to cover all tanks with portions of the membrane bioreactor basins that will have flat aluminum tread plate covers with recessed drop handles. Aluminum will be ASTM Alloy 6061 or 6063. Aluminum access hatches will be used on the sludge holding tanks.

G. Plumbing

The Wastewater Treatment Facility will have plumbing facilities as required to meet all local, state and national building codes. The plumbing system will be designed based on the latest edition of the following standards and codes:

- National Fire Protection Association (NFPA);
- BOCA Basic National Plumbing Code; and
- Massachusetts State Plumbing Code.

The plumbing requirements in the Wastewater Treatment Facility Building include:

- Drain piping, floor and equipment drains;
- Heating and Ventilation;
- Emergency eyewash/shower fixtures in any chemical storage location; and
- Toilet and Sink.

H. Heating and Ventilation

Heating and ventilation systems for the Wastewater Treatment Facility Building will be designed based on the latest edition of the following standards and codes:

- ASHRAE Handbook and Publications;
- BOCA Code;
- NFPA Life Safety Code; and
- TR-16 - Guides for the Design of Wastewater Treatment Works, (2011 Edition as Revised in 2016) by the New England Interstate Water Pollution Control Commission.

The outside design temperature will be based on the 97.5 percentile dry bulb winter temperature of minus 7 degrees Fahrenheit for heating. The outside summer design temperature at the 2.5 percentile is 85 degrees Fahrenheit dry bulb (70 degrees Fahrenheit wet bulb) for exhaust air ventilation. Inside design spaces will be heated to 70 degrees Fahrenheit if they are routinely occupied. Process work areas will be heated to 55 degrees Fahrenheit. Process tanks will not be heated.

All equipment and pump rooms are dry, and will be ventilated at a rate of 6 air changes per hour as outlined in NFPA 820 standards.

Hot water recirculating heat will be used with three speed electric fans on each unit heater. All HVAC Ductwork will be galvanized steel sheet metal.

I. Electrical

Electrical power for the WWTF will be serviced from the local power company. The facility will be served by a separate electrical service and separate stand-by generator for emergency power. Electrical service will be provided at 480 volt, 3-phase, 4-wire, 60 Hertz via a pad-mounted transformer. Sizing of the transformer shall be coordinated with the Power Company based on submission of electrical load sheets for this project. Three phase power will be required on-site for proposed facilities. It is assumed that 3-phase power will be picked up from the street and brought into the WWTF along the existing access road. Electrical load sheets for the facility will be compiled and submitted to the Power Company for review.

The electric service equipment shall consist of a main incoming service circuit breaker disconnect, automatic transfer switch, switchboard distribution and motor control centers including dry-type transformers and lighting panels for low voltage distribution. The electrical distribution equipment shall be housed, for the most part, within the electrical room of the WWTF. In some circumstances equipment such as lighting panels, dry-type transformers, pull-boxes, and specific control panels may be located throughout the facility as to allow proper electrical connections to specific process equipment.

The WWTF will be provided with stand-by power in the form of an on-site, diesel generator with a capacity of approximately 250 kilowatts (KW). The generator will be located outside of the building in a weatherproof, acoustical enclosure and shall be sized to operate the entire WWTF based on the designed capacity for this facility and the equipment necessary for permit compliance. The electrical controls will allow for both automatic and manual operation of the generator in order to provide stand-by power at the treatment facility. Upon power failure, the transfer switch will call for the generator to start. As soon as the generator is producing a stable 60 Hz electrical feed, the power shall be transferred. The equipment shall then be sequentially restarted, beginning with life safety functions, then the critical process equipment (such as air supply blowers) and ending with the non-critical process items. The following is a summary of the anticipated facility equipment, which shall be operated by the stand-by generator:

- Preliminary Screening (1 at 2.0 HP each);
- Mixing Blowers (3 at 40 HP each);
- Transfer Pumps (2 at 7.5 HP each);
- Aeration Blowers (2 at 40 HP each);
- SBR Disk Filters (1 at 2.5 HP);
- SBR Transfer Pumps (2 at 2.5 HP each);
- Sludge Holding Tank Pumps (1 at 5 HP);
- UV Disinfection System (1 at a total connected load of approximately 40 HP);
- Effluent Pumps (2 at 25 HP each);
- Sludge Thickener (1 at 4.5 HP);
- OC Fan (1 at 25 HP);
- Heating, Ventilation and Lighting; and
- Plant Water Skid (1 at 3 HP).

The electrical conduit for the project shall either be galvanized rigid steel, PVC coated rigid steel, Schedule 40 and Schedule 80 PVC based on the location and installation for the project. Corrosive areas, such as Headworks, Chemical Fed and Storage Areas, and Solids Storage and Processing Areas, will require the use of PVC coated or Schedule 80 PVC conduits. Galvanized rigid steel conduits shall be installed in general use areas. The intended design and installation is to provide for a long-term use capable of withstanding the harsh environments of a wastewater treatment facility.

Underground conduits shall be concrete encased between buildings and structures and for incoming electrical service. Underground conduits shall be Schedule 40 PVC, concrete encased, except galvanized rigid steel shall be used for all signal cables or unless otherwise noted, and galvanized rigid steel conduit shall be provided 10 feet from buildings or structures. Conduits will be brought into structures above grade to prevent the possibility of water leaking into lower areas of the building. Interior conduits shall be installed exposed.

All wires shall be AWG copper throughout the installation. The sizing and type of wiring insulation shall be based on the installation requirements (underground, within building) and the equipment loading requirements sized per the National Electrical Code (NEC).

Indoor lighting in the WWTF areas will be energy efficient LED fixtures. Lighting levels within the specific locations shall meet industry standards, but for the most part shall be between 25 and 30 foot candles. Site lighting shall be provided to allow general access to and from facility structures and shall be installed to allow both manual and automatic operation. General outdoor lighting shall be designed for both efficiency and economic considerations. Fixture type shall be incandescent, high-pressure sodium or metal halide as determined by the final design considerations. Explosion-proof incandescent fixtures will be provided within the Headworks building as required by code. Emergency lighting shall be provided at required locations to allow proper access as required by code.

The design will comply with the National Electrical Code (NEC) and other applicable state and local code requirements. Electrical equipment will be specified to meet the requirements of Underwriters Laboratories, Inc. (UL), National Electrical Manufacturers Association (NEMA) and other recognized industry standards. Electrical equipment design and installation will follow any available energy programs being offered by the Power Company. This will consider all available energy efficient equipment, to provide both short and long-term energy savings.

J. Instrumentation

1) General

The instrumentation and controls for the WWTF shall incorporate the use of Programmable Logic Controllers (PLC) based Supervisory Control and Data Acquisition (SCADA) system control to operate and monitor the process. The intent of the SCADA system is to provide monitoring and alarms so that 24-hour per day staffing is not necessary.

The extent of the SCADA system provided will be limited to the instrumentation and control panels supplied by each OEM (Original Equipment Manufacturer) and will be tied into one main Control Panel. The main Control Panel will provide a central location for all process monitoring and alarm conditions using an Operator Interface Panel. This panel will allow the Operator to view alarm history and manually record such events.

2) PLC System

A PLC is an industrial, real-time, solid-state control system that runs ladder logic programs. Its capacity and functionality can be expanded or modified as required. It is suitable for temperature, humidity, vibration, and voltage variations found in the WWTF. It is designed to run 24 hours a day, seven days a week. The benefits of using PLCs are high reliability, flexible control, easily modified programs, expandability, easy troubleshooting, small space requirements, low cost, and modular design. A PLC based control system will be provided by the MBR manufacturer for operation and control of their complete process.

3) Alarms

Both digital and analogue alarm conditions will be managed by the plant SCADA system. The alarm management system shall categorize alarms based on degree of criticality to safety and/or plant operations. The system shall include a call-out feature to notify on-call staff of the nature and location of the alarm conditions. An alarm/event log will be included as part of the system.

4) Instruments

Table 18 presents a preliminary list of instruments for process monitoring and control at the WWTF.

Table 18: Preliminary List of Instruments

Signal Source	Quantity	Primary Element
Influent/Headworks		
Flow	1	Magnetic Flow Meter
Channel Level	2	Ultrasonic Level Element
Headspace	2	Toxic Gas/LEL Sensor w/alarm
Flow Equalization Basins		
Tank Level	2	Ultrasonic Level Element
Headspace	2	Toxic Gas/LEL Sensor w/alarm
Tank Contents	2	pH/ORP Sensors
Bio-Reactors		
Level	2	Ultrasonic Level Element
Temp	2	Temperature Element
TSS	2	Photo optic Sensor
DO	2	LDO Probe
NH3-N	2	ISE Element
NO3-N	2	ISE Element
pH	2	ISE Element
ORP	2	Probe
WAS Flow	1	Magnetic Flow Meter
Decant Flow	1	Magnetic Flow Meter
Post Filtration		
Basin Level	2	Ultrasonic Level Element
Effluent Level	2	Ultrasonic Level Element

Signal Source	Quantity	Primary Element
Post EQ Tank		
Level	1	Ultrasonic Level Element
Effluent Flow	1	Magnetic Flow Meter
Turbidity	1	Transmissivity Sensor
Disinfection		
UV Intensity	2	Photo sensor
Biosolids Processing		
WAS Tank Level	2	Ultrasonic Level Element
TWAS Tank Level	1	Ultrasonic Level Element
Septage Receiving Flow	1	Magnetic Flow Meter

7. Process Equipment

A. General

The Orleans WWTF will require various types of piping, valves, and process equipment, as presented in the following paragraphs.

B. Piping

Various pipe materials will be used for the construction of the Orleans WWTF. Table 19 shows the preliminary piping legend and contains the pipe materials proposed for the design. The pipe materials may be expanded and/or refined as the project proceeds through final design.

Table 19: Piping Legend

Abbreviation	Description	Type of Flow	Pipe Material
AS	Air Supply	Pressure	Stainless Steel
DEC	Sludge Decant	Gravity	Ductile Iron
DR	Drain	Gravity	Ductile Iron
EFF	Effluent	Gravity	Ductile Iron
EFFL	Effluent to Groundwater Disposal	Gravity/Pressure	PVC
FDr	Floor Drain	Gravity	Cast or Ductile Iron
Fuel	Fuel	Pressure	Copper or Steel
INF	Influent	Pressure	Ductile Iron
ODOR	Odor Control Ductwork	Pressure	PVC (Buried) and PVC or FRP (Interior/Exposed Exterior)
OVER	Overflow	Gravity	Ductile Iron

Abbreviation	Description	Type of Flow	Pipe Material
PDr	Process Drain	Gravity	Ductile Iron
Poly	Polymer Solution Feed	Pressure	
PWD	Plant Water Discharge	Pressure	DI > 3 inch, Copper < 3 inch
PWS	Plant Water Suction	Pressure	Ductile Iron
Recird	Recirculation Discharge		
Recirs	Recirculation Suction		
SBRE	Sequencing Batch Reactor Effluent	Gravity	Ductile Iron
SBRI	Sequencing Batch Reactor Influent	Gravity	Ductile Iron
SD	Sludge Discharge	Pressure	Ductile Iron
SDr	Storm Drain	Gravity	Ductile Iron
SL	Sample Line	Pressure	Polyethylene
SPD	Sump Pump Discharge	Pressure	PVC
SS	Sludge Suction	Pressure	Ductile Iron
STD	Sludge Transfer Discharge	Pressure	Ductile Iron
STDr	Sludge Transfer Drain	Gravity	Ductile Iron
STS	Sludge Transfer Suction	Pressure	Ductile Iron
TW/DW	Town Water/Domestic Water	Pressure	DI > 3 inch, Copper < 3 inch
UV	Ultra-Violet	Pressure	Ductile Iron
VENT	Vent	Gravity	PVC
WASS	Waste Activated Sludge Suction	Pressure	Ductile Iron
WASD	Waste Activated Sludge Discharge	Pressure	Ductile Iron

C. Valves

Various valves will be used for the construction of the Orleans WWTF and are shown in Table 20 on the preliminary Valve Schedule. The valve schedule may be expanded to include additional valves as the project proceeds through final design.

Table 20: Valve Schedule

Process Description	Type of Valve
Raw Wastewater Exterior	Sluice Gate, Slide Gate or Stop Plate
Raw Wastewater Interior	Plug Valve
Effluent Interior	Solid Wedge or Resilient Seat Gate Valve
Effluent Exterior	Sluice Gate, Slide Gate or Stop Plate
Sludge	Plug Valve

Process Description	Type of Valve
Chemicals	PVC Ball Valve
Air	Butterfly Valve
SBR Influent	Motor-Operated Plug Valve
SBR Air	Motor-Operated Butterfly Valve
SBR Wasting	Motor-Operated Butterfly Valve
SBR Decant	Motor-Operated Butterfly Valve

D. Mechanical Equipment

The major mechanical/process equipment was listed in Table 16. The equipment list describes general sizing criteria and design basis information. The equipment selection may be expanded or updated as the project progresses through final design.

8. Preliminary Plans, Specifications, and Required Permits

A. Plans and Specifications

The Orleans WWTF design will require detailed Contract Documents (plans and specifications) for public bidding. The plans will be plotted on 24-inch by 36-inch vellums that will be reproduced for bidding. The specifications will be printed on 8-1/2 inch by 11-inch paper that would be reproduced for bidding. The specifications will include the MassDEP requirements for projects funded by the Massachusetts SRF Loan Program. Table 21 shows a preliminary list of drawings and Table 22 shows a preliminary list of specifications for the WWTF. These lists will be updated as the final design proceeds toward completion.

Table 21: Preliminary List of Drawings

Drawing No.	Drawing Title	Sheet No.
General		
--	Cover	1
--	Index	2
Site		
LA-1	Existing Conditions Plan	3
LA-2	Layout Plan	4
LA-3	Grading and Drainage Plan	5
LA-4	Effluent Disposal Area Plan	6
LA-5	Effluent Disposal System Section and Details	7
LA-6	Site Construction Details	8
LA-7	Site Construction Details	9
LA-8	Environmental Details I	10
LA-9	Environmental Details II	11
LA-10	Environmental Details III	12

Drawing No.	Drawing Title	Sheet No.
Architectural		
A-1	Abbreviations and Symbols	13
A-2	Building Basement and Ground Level Plans	14
A-3	Building Elevations	15
A-4	Building Sections	16
A-5	Room Finish Schedule, Door Schedule and Details	17
A-6	Miscellaneous Schedules and Details	18
Structural		
S-1	Building and Tank Foundation Plans	19
S-2	Building and Tank Ground Floor Plans	20
S-3	Roof Framing Plan and Details	21
S-4	Building Sections	22
S-5	Building Details	23
S-6	Tank Sections	24
S-7	Tank Details	25
GS-1	Notes and Details I	26
GS-2	Notes and Details II	27
Mechanical		
M-1	Abbreviations and Symbols,	28
M-2	Hydraulic Profile and Flow Schematic	29
M-3	Yard Piping	30
M-4	Basement Plans	31
M-5	Ground Floor Plans	32
M-6	Basement Sections	33
M-7	Ground Floor Sections	34
M-8	Details and Schematics I	35
M-9	Details and Schematics II	36
M-10	General Mechanical Details I	37
M-11	General Mechanical Details II	38
M-12	Force Main Plan and Profile – Number of Drawings TBD	39
M-24	Flow Diversion Structure Plan and Section	49
HVAC		
HV-1	Notes, Legends and Abbreviations	50
HV-2	Basement and Ground Floor Plan	51
HV-3	Legends, Schedules, and Details	52
Plumbing		
P-1	Notes, Legends and Abbreviations	53
P-2	Basement and Ground Floor Plan	54
P-3	Legend, Schedule, and Details	55

Drawing No.	Drawing Title	Sheet No.
Electrical		
E-1	Legend and General Notes	56
E-2	Site Plan (1" = 20')	57
E-3	Single Line Diagrams and Schematics I	58
E-4	Single Line Diagrams and Schematics II	59
E-5	Control Wiring Diagrams I	60
E-6	Control Wiring Diagrams II	61
E-7	Block Wiring Diagrams I	62
E-8	Block Wiring Diagrams II	63
E-9	Conduit and Panel Board Schedules and Details	64
E-10	Fire and Security Riser Diagram	65
E-11	Duct Bank Sections and Details	66
E-12	Lighting – Basement and Ground Floor Plans	67
E-13	Power – Basement and Ground Floor Plans	68
Instrumentation		
I-1	Legend, Symbols and Notes	69
I-2	PLC Network Diagrams	70
I-3	Instrument Installation Details	71

Table 22: Preliminary List of Specifications

Section	Title
Section 00001	Title Sheet
Section 00003	Table of Contents
BIDDING REQUIREMENTS, CONTRACT FORMS AND CONDITIONS OF THE CONTRACT	
Section 00005	Invitation to Bid
Section 00100	Instructions and Information for Bidders
Section 00300	Form for General Bid
Section 00305	Commonwealth of Massachusetts DCAM Update Statement
Section 00310	Bid Bond
Section 00350	Form for Subbid
Section 00375	Affidavit
Section 00420	Subcontract
Section 00430	Notice of Award
Section 00500	Form for Agreement
Section 00600	Payment Bond
Section 00610	Performance Bond
Section 00650	Notice to Proceed
Section 00700	General Conditions

Section	Title
Section 00852	Special Conditions - General
Section 00855	Special Conditions - Commonwealth of Massachusetts
Section 00858	Special Conditions - Permits and Licenses
Section 00859	Special Conditions – Massachusetts Equal Employment Opportunity
Section 00862	Special Conditions - MassDEP Policy Memoranda
Section 00905	Change Order Form
Section 00945	Certificate of Substantial Completion
Section 00950	Waiver of Liens
Section 00960	Certificate of Final Payment and Completion of Work
Section 00965	Transfer of Title

TECHNICAL SPECIFICATIONS

DIVISION 1 - GENERAL REQUIREMENTS

Section 01020	Allowances
Section 01025	Measurement and Payment
Section 01030	Special Requirements
Section 01090	Reference Standards
Section 01140	Environmental Protection
Section 01310	Miscellaneous Testing and Soil Data
Section 01500	Temporary Facilities
Section 01570	Traffic Management and Maintenance
Section 01640	Special Mechanical and Electrical Equipment Requirements

DIVISION 2 - SITE WORK

Section 02100	Site Preparation
Section 02220	Earthwork
Section 02440	Site Improvements
Section 02444	Chain Link Fence and Gates
Section 02483	Planting Operations
Section 02485	Loaming and Seeding
Section 02503	Paving, Curbing and Sidewalks
Section 02720	Storm Drainage Piping
Section 02725	Manholes, Catch Basins, Handholes, and Pull Boxes

DIVISION 3 – CONCRETE

Section 03100	Concrete Formwork
Section 03200	Concrete Reinforcement
Section 03250	Concrete Specialties
Section 03300	Cast-In-Place Concrete
Section 03305	Concrete Repair and Surfacing Products

Section	Title
Section 03345	Concrete Placing, Curing and Finishing
Section 03604	Non-Shrink Grout
DIVISION 4 - MASONRY	
Section 04100	Masonry
DIVISION 5 – METAL WORK	
Section 05120	Structural Steel
Section 05140	Aluminum Tank Covers
Section 05310	Metal Roof Deck
Section 05400	Cold-Formed Metal Framing
Section 05500	Miscellaneous Metal Work
DIVISION 6 – WOOD AND PLASTIC	
Section 06100	Carpentry
Section 06192	Prefabricated Wood Trusses
Section 06160	Sheathing
Section 06200	Finish Carpentry
Section 06700	Fiberglass Fabrications
Section 06800	Fiberglass Covers and Appurtenances
Section 06900	Fiberglass Weirs and Baffles
DIVISION 7 – THERMAL AND MOISTURE PROTECTION	
Section 07156	Waterproofing and Dampproofing
Section 07210	Building Insulation
Section 07240	Exterior Insulation and Finish System
Section 07311	Asphalt Shingles
Section 07317	Wood Shingles
Section 07400	Metal Roofing, Siding and Flashing
Section 07900	Sealants and Firestopping
DIVISION 8 – DOORS AND WINDOWS	
Section 08100	Metal Doors and Frames
Section 08220	Fiberglass Reinforced Plastic Doors and Frames
Section 08331	Rolling Metal Doors
Section 08510	Steel Windows
Section 08700	Finish Hardware
Section 08800	Glass and Glazing
DIVISION 9 - FINISHES	
Section 09260	Gypsum Drywall Ceilings

Section	Title
Section 09310	Ceramic Tile and Quarry Tile
Section 09510	Acoustical Ceilings
Section 09650	Resilient Flooring
Section 09661	Liner for Chemical Containment Areas
Section 09900	Painting

DIVISION 10 - SPECIALTIES

Section 10200	Louvers
Section 10420	Plaque
Section 10440	Signs
Section 10475	Emergency and Miscellaneous Equipment
Section 10520	Fire Extinguishers
Section 10800	Restroom Equipment
Section 10965	Loading Dock Bumpers

DIVISION 11 - EQUIPMENT

Section 11221	Submersible Mixers
Section 11286	Sluice Gates, Slide Gates and Operators
Section 11310	Centrifugal Pumps
Section 11315	Double Disc Sludge Pumps
Section 11317	Sump Pumps
Section 11318	Rotary Lobe Pumps
Section 11319	Plant Water System
Section 11340	Variable Frequency Drives
Section 11345	Chemical Preparation and Feed Equipment
Section 11347	Humidification and Exhaust Fan System
Section 11348	Odor Control System
Section 11350	Ultraviolet Disinfection Equipment
Section 11371	Positive Displacement Air Blower Equipment
Section 11373	Sequencing Batch Reactors
Section 11374	Effluent Filtration Equipment
Section 11375	Air Diffuser Systems
Section 11380	Wastewater Samplers

DIVISION 12 - FURNISHINGS

Section 12300	Laboratory Furnishings
Section 12670	Entrance Floor Mats
Section 12700	Furniture

DIVISION 13 - SPECIAL CONSTRUCTION

Section 13300	Instrumentation and Control System
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Section	Title
Section 13350	Field Instruments
Section 13400	Supervisory Control and Data Acquisition (SCADA) System
Section 13500	Security Surveillance System
Section 13768	Fiber Optic Media

DIVISION 14 - CONVEYING SYSTEMS

Section 14600	Monorail and Hoisting Equipment
---------------	---------------------------------

DIVISION 15 - MECHANICAL

Section 15050	Mechanical General Conditions
Section 15080	Mechanical Insulation
Section 15100	Process Piping
Section 15195	Natural Gas Piping System
Section 15300	Fire Protection
Section 15400	Plumbing Systems
Section 15500	Heating, Ventilating and Air Conditioning
Section 15950	HVAC Testing, Adjusting and Balancing

DIVISION 16 - ELECTRICAL

Section 16050	Electrical General Conditions
Section 16071	Seismic Controls for Electrical Work
Section 16085	Miscellaneous Equipment
Section 16120	Wires and Cables
Section 16130	Raceways and Fittings
Section 16140	Photovoltaic System
Section 16160	Panelboards
Section 16402	Underground Systems
Section 16426	Metal-Enclosed Drawout Switchgear-Low Voltage
Section 16450	Grounding System
Section 16500	Lighting System
Section 16601	Lighting Protection
Section 16612	Engine Generator
Section 16721	Fire Alarm System
Section 16760	Telecommunication Systems
Section 16920	Motor Control Centers
Section 16921	Switchboards
Section 16922	Electrical Power System Studies
Section 16924	Electrical Power Commissioning

B. Permits

Table 23 identifies the permits and approvals that are likely to be required for construction of the Orleans WWTF. This list will be updated as the final design proceeds toward completion.

Table 23: Preliminary List of Permits

Agency Name	Permit
Orleans Building Department	Building Permit (by Construction Contractor)
Orleans Site Plan Review Committee	Certificate of Appropriateness
Orleans Conservation Commission	Wetlands Notice of Intent/Order of Conditions*
Massachusetts Historical Commission	Certificate of Appropriateness
Old’s Kings Highway Historic District	Certificate of Appropriateness
MassDEP	Water Quality Permit*
MassDEP	Groundwater Discharge Permit
MassDEP	Plan and Specification Approval
Massachusetts Natural Heritage	Conservation Permit*
U.S. Army Corps of Engineers	Programmatic General Permit*
U.S. EPA	NPDES Permit for construction dewatering permit*

* By Construction Contractor

C. Preliminary Schedule

Table 24 shows the anticipated schedule to implement the construction of Phase 1 of the Orleans WWTF.

Table 24: Preliminary Schedule

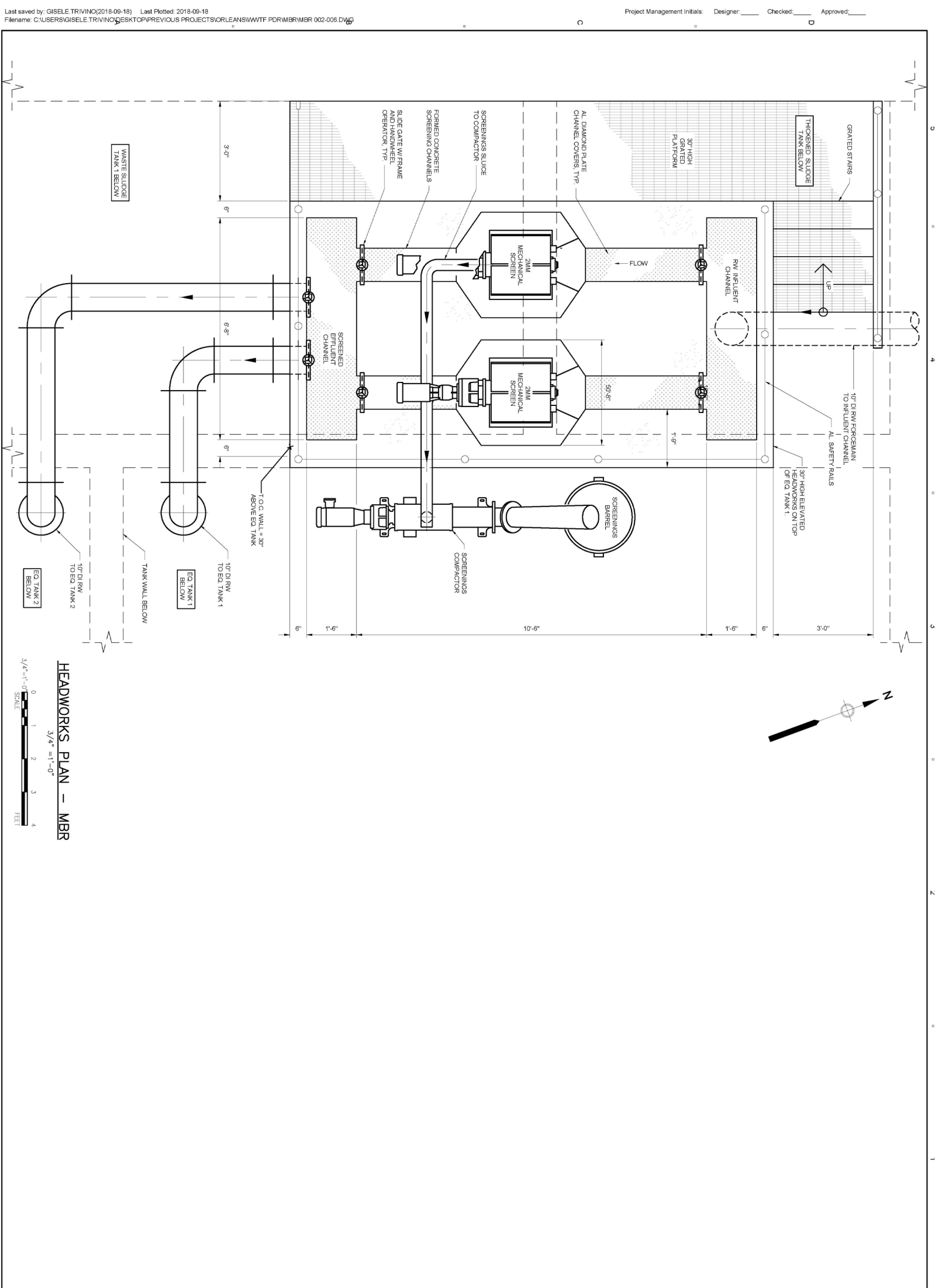
Task	Duration (Months)
Prepare Draft Plans and Specifications	8 to 12
Town and MassDEP Review	3 to 4
Finalize Plans and Specifications	1
Obtain Permits	3 to 7
Construction	12 to 18
Startup and Testing	2 to 3
Total	29 to 45

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Additional Figures and Tables

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Figure 7: Headworks Layout – MBR Option



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HEADWORKS PLAN – MBR
 3/4" = 1'-0"
 SCALE
 0 1 2 3 4
 FEET

AECOM

PROJECT
 Orleans WWTF Design
 25% Preliminary
 Design Report

CLIENT
 Town of Orleans, MA
 19 SCHOOL ROAD
 ORLEANS, MA 02853
 (508) 240-3700

CONSULTANT
 AECOM TECHNICAL SERVICES, INC.
 9 JOCK MACDONALD DRIVE
 PO BOX 1440
 WILMINGTON, MA 01897
 PHONE: (508) 833-6850
 www.aecom.com

CONSULTANTS

REGISTRATION

ISSUE/REVISION

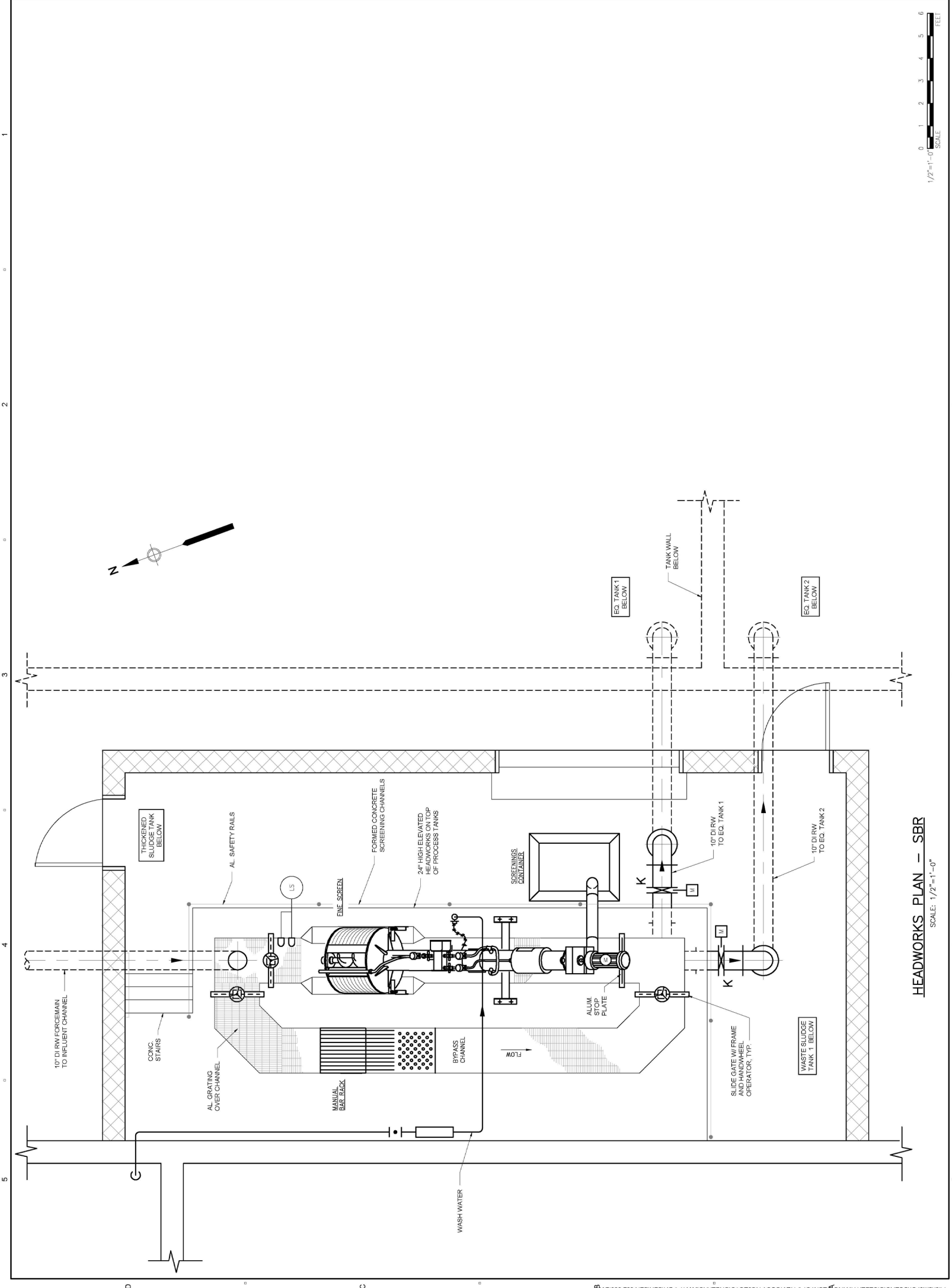
IRI	DATE	DESCRIPTION

PROJECT NUMBER
 604766-14
 Designed By: J. MARRON
 Drawn By: M. CURRAN
 Draft Check: T. PARECE
 Proj Check: J. READE
 Date: ---
 Scale: AS NOTED

DISCIPLINE
 GENERAL
 SHEET TITLE
 HEADWORKS PLAN
 MBR OPTION

SHEET NUMBER
 MBR-006

Figure 8: Headworks Layout – SBR Option



PROJECT
Orleans WWTF Design
25% Preliminary
Design Report

CLIENT
Town of Orleans, MA
19 SCHOOL ROAD
ORLEANS, MA 02653
(508) 240-3700

CONSULTANT
AECOM TECHNICAL SERVICES, INC.
100 WASHINGTON BOULEVARD
PO BOX 100
POCASETT, MA 01906
PHONE: (508) 633-6950
www.aecom.com

CONSULTANTS

REGISTRATION

ISSUE/REVISION

IRI	DATE	DESCRIPTION

PROJECT NUMBER
60475644

Designed By: J. MARRION
Drawn By: M. CURRAN
Digitl Check: T. PARECE
Proj Check: J. READE
Date: ---
Scale: AS NOTED

DISCIPLINE
GENERAL
SHEET TITLE

HEADWORKS PLAN
SBR OPTION

SHEET NUMBER
SBR-006

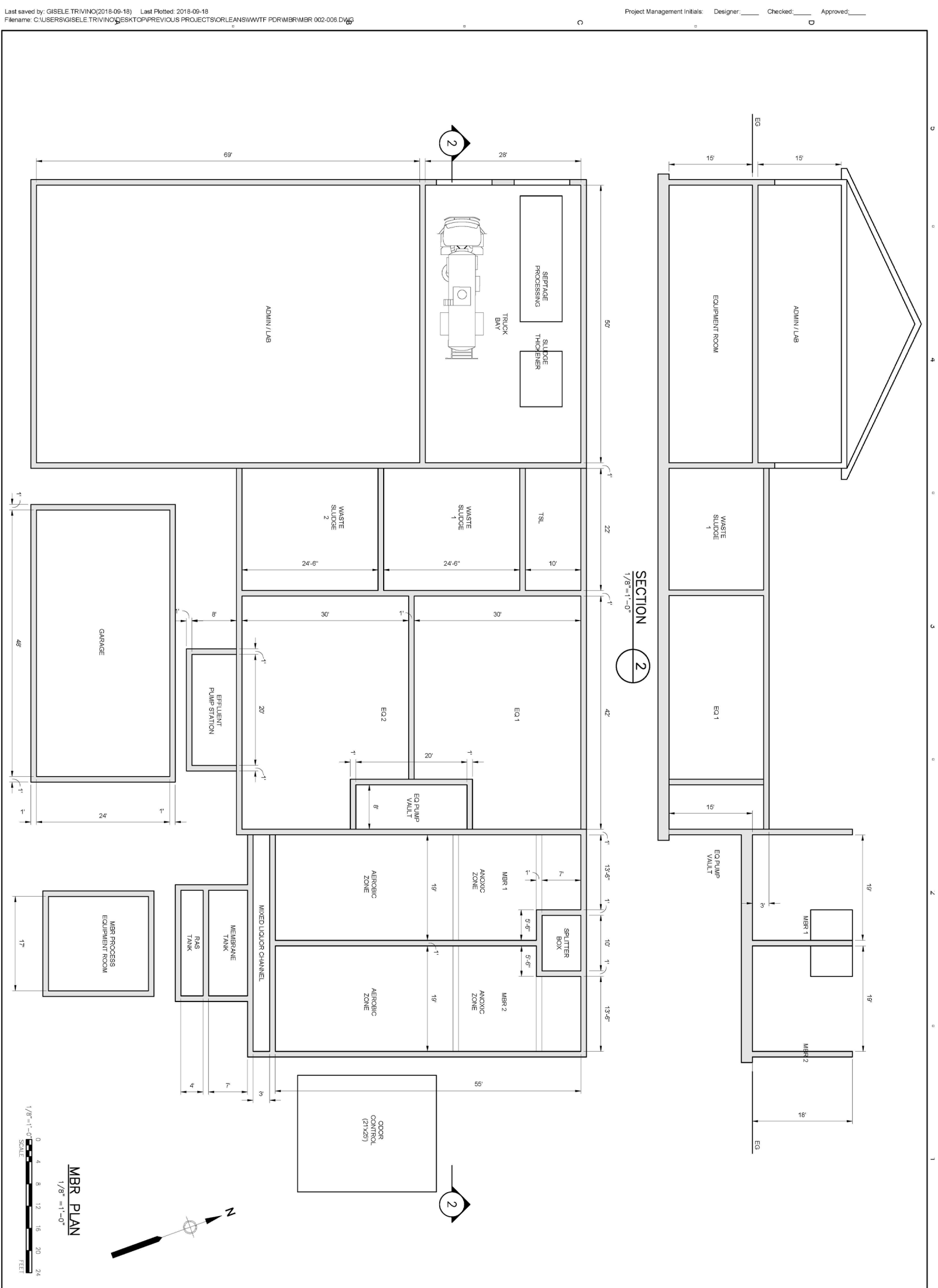


HEADWORKS PLAN – SBR
SCALE: 1/2"=1'-0"

Project Management thinks: _____
Designer: _____
Checked: _____
Approved: _____

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Pocasset, MA

Figure 13: Floor Plan & Section – MBR Option



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Project Management Initials: Designer: _____ Checked: _____ Approved: _____

AECOM

PROJECT
Orleans WWTF Design
25% Preliminary
Design Report

CLIENT
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19 SCHOOL ROAD
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CONSULTANTS

REGISTRATION

ISSUE/REVISION

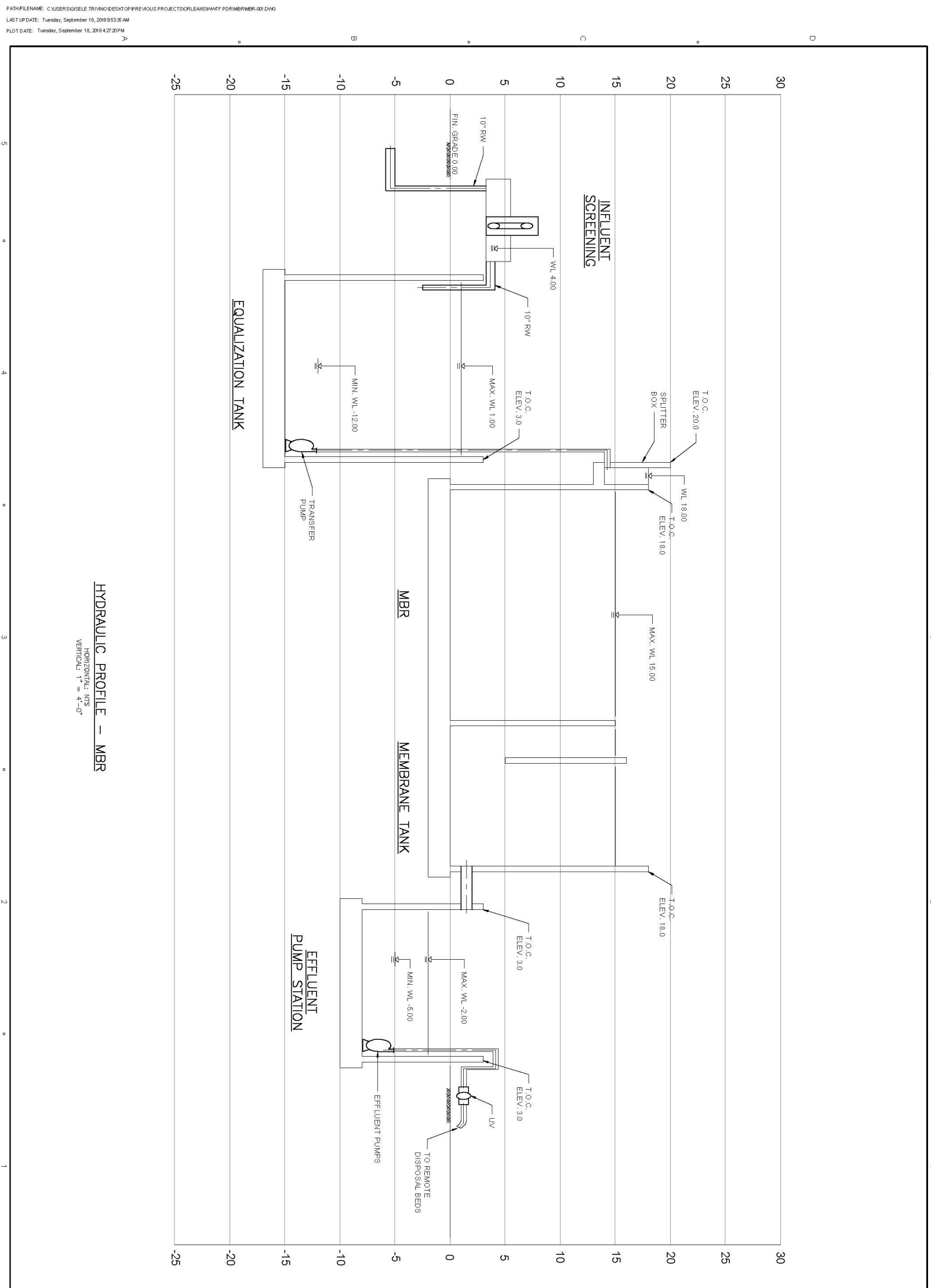
IRI	DATE	DESCRIPTION

PROJECT NUMBER
60476644

Designed By: J. MARRON
Drawn By: M. CURRAN
Draft Check: T. PARECE
Proj Check: J. READE
Date: ---
Scale: AS NOTED

DISCIPLINE
GENERAL
SHEET TITLE
FLOOR PLAN AND SECTION
MBR OPTION
SHEET NUMBER
MBR-005

Figure 15: Hydraulic Profile – MBR Option



HYDRAULIC PROFILE – MBR
HORIZONTAL: NTS
VERTICAL: 1" = 4'-0"

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PLOT DATE: Tuesday, September 18, 2018 4:27:20 PM



PROJECT
Orleans WWTF Design
25% Preliminary
Design Report

CLIENT
Town of Orleans, MA
19 SCHOOL ROAD
ORLEANS, MA 02653
(508) 240-9700

CONSULTANT
AECOM TECHNICAL SERVICES, INC.
9 JOHANNAN BOULEVARD
ORLEANS, MA 02653
PHONE: (508) 653-6950
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CONSULTANTS

REGISTRATION

ISSUE/REVISION

IR#	DATE	DESCRIPTION

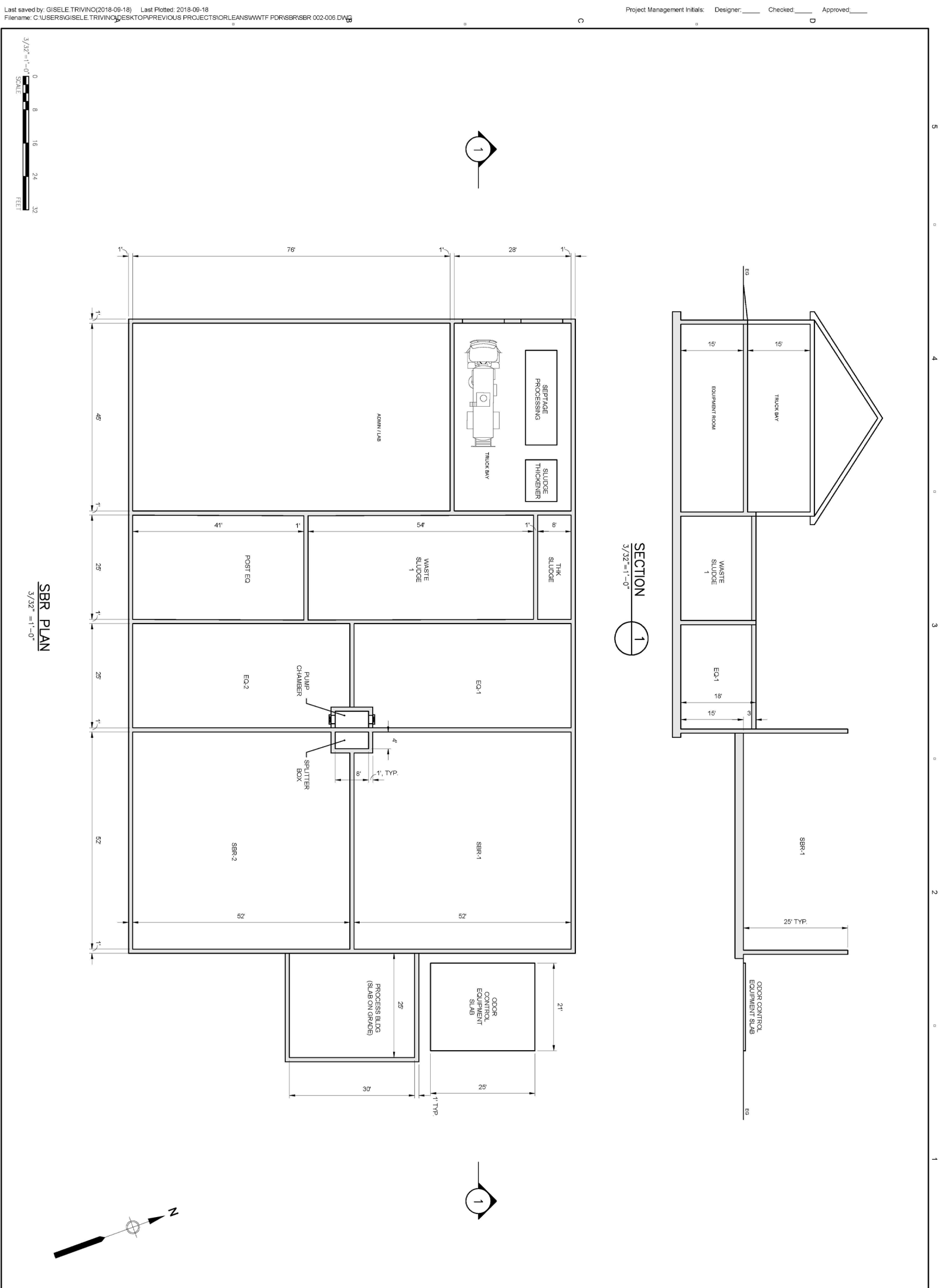
PROJECT NUMBER
60476644

Designed By: J. MARRION
Drawn By: M. CURRAN
Design Check: T. FARRECE
Proj. Check: J. READE
Date: ---
Scale: AS NOTED

DISCIPLINE
GENERAL
SHEET TITLE
HYDRAULIC PROFILE
MBR OPTION

SHEET NUMBER
MBR-001

Figure 17: Floor Plan & Section – SBR Option



Project Management Initials: Designer: _____ Checked: _____ Approved: _____

Last saved by: GISELE TRIVINO(2018-09-18) Last Plotted: 2018-09-18
Filename: C:\USERS\GISELE TRIVINO\DESKTOP\PREVIOUS PROJECTS\ORLEANS\WWTF PDR\SBR\SBR 002-006.DWG

AECOM

PROJECT
Orleans WWTF Design
25% Preliminary
Design Report

CLIENT
Town of Orleans, MA
10 SCHOOL ROAD
ORLEANS, MA 02653
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CONSULTANTS

REGISTRATION

ISSUE/REVISION

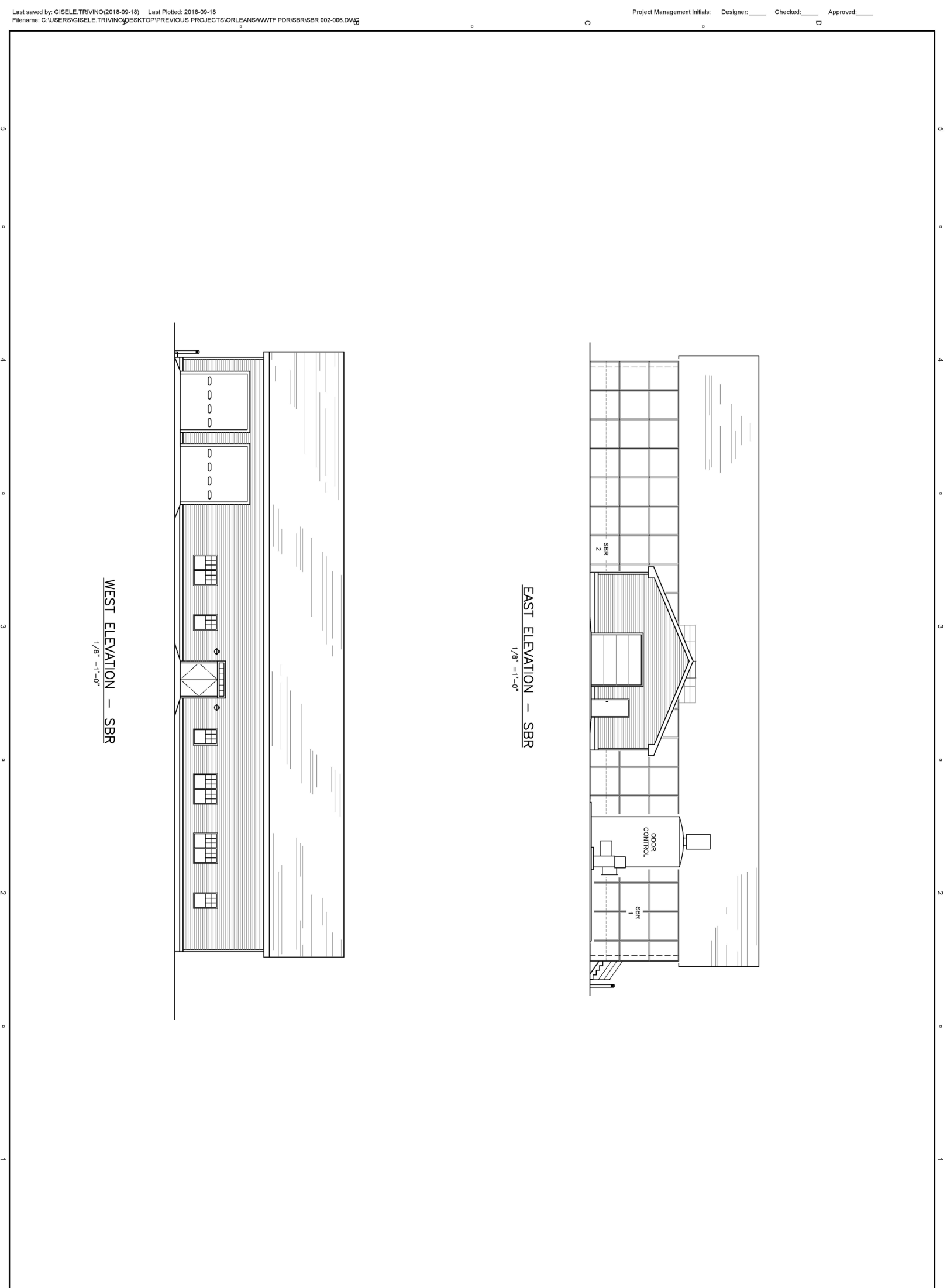
IRI	DATE	DESCRIPTION

PROJECT NUMBER
60476644
Designed By: J. MARRION
Drawn By: M. CURRAN
Digit Check: T. PAREDE
Proj Check: J. READE
Date: _____
Scale: AS NOTED

DISCIPLINE
GENERAL
SHEET TITLE
FLOOR PLAN AND SECTION
SBR OPTION

SHEET NUMBER
SBR-005

Figure 19: Elevations II of II – SBR Option



Project Management Initials: Designer: _____ Checked: _____ Approved: _____

Last saved by: GISELE TRIVINO(2018-09-18) Last Plotted: 2018-09-18
Filename: C:\USERS\GISELE.TRIVINO\DESKTOP\PREVIOUS PROJECTS\ORLEANS\WWTF PDR\SBR\SBR 002-006.DWG



PROJECT
Orleans WWTF Design
25% Preliminary
Design Report

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14 SCHOOL ROAD
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REGISTRATION

ISSUE/REVISION

IR	DATE	DESCRIPTION

PROJECT NUMBER
60476644

Designed By: J. MARRION
Drawn By: M. CURRAN
Dept Check: T. PARECE
Proj Check: J. READE
Date: ---

Scale: AS NOTED

DISCIPLINE
GENERAL SHEET TITLE

ELEVATIONS
SBR OPTION

SHEET NUMBER
SBR-003B

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Appendix A – Preliminary Detailed Cost Estimates

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JOB NO : 60476644.10.1.C
DATE : September 4, 2018
LOCATION : Orleans, MA
PREPARED BY: R Mastrogiacommo, re
CHECKED BY: J. Reade

AECOM Water
Construction Cost Estimate
WWTF - SBR vs MBR
Preliminary Design Estimate (25%)
Orleans, MA

CLIENT : Orleans, MA
PROJECT : WWTP Improvements
ACCURACY: ± 30 %
ENR CCI: 11170
CAPACITY: 0.2 MGD

GRAND SUMMARY

OPTION	DESCRIPTION	TOTAL
1	<u>WWTF</u> SBR Structures	\$ 19,566,513
2		\$ 19,288,148

ACCOUNT NO.	DESCRIPTION	QUANTITY	MAN HOURS		MATERIAL		LABOR		EQUIPMENT		TOTAL DIRECT COST
			UN	TOTAL MH	UNIT COST	TOTAL MATL	WAGE RATE	TOTAL LABOR	UNIT RATE	TOTAL EQUIP	
	THIS CONSTRUCTION COST IS BASED ON:										
	1. 25% Preliminary Design Drawings										
	2. PRICING IS BASED ON 3rd QUARTER 2018.										
	3. CONTINGENCY SHOWN IS CONTRACTOR CONTINGENCY BASED ON LEVEL OF DESIGN. OWNER CONTINGENCY NOT INCLUDED										
	4. THE SOILS AT THE SITE ARE SUITABLE FOR STANDARD EXCAVATING METHODS.										
	5. ESCALATION CONSIDERED @ 3.50% /year										
	6. IN PROVIDING OPINION OF PROBABLE CONSTRUCTION COST, THE CLIENT UNDERSTANDS THAT AECOM HAS NO CONTROL OVER THE COST OR AVAILABILITY OF LABOR, EQUIPMENT OR MATERIALS OR OVER MARKET CONDITIONS OR THE CONTRACTOR'S METHOD OF PRICING. AECOM MAKES NO WARRANTY, EXPRESS OR IMPLIED THAT THE BIDS WILL NOT VARY FROM THIS ESTIMATE.										
	7. Average wage rate calculated from 2016 Means Labor rates for Construction Industry (ENR 10.092). Used Brockton, MA (\$69.79) escalated at to the time of the estimate and added 25.9% for:										10.7%
	SS Tax	7.65%									
	Workers Comp Ins	11.60%									
	Builders Risk	0.44%									
	Other Negotiated fringe	1.60%									
	Federal Unemployment Ins	0.14%									
	State Unemployment Ins	2.93%									
	General Liability Insurance	1.57%									
	TOTAL	25.9%									
	AVERAGE Labor Rate ---->	\$97.27									
	Start Const	06/01/19									
	End Const	08/02/21									
	Final Completion	10/01/21									
	Contingency :	30%									
	Overhead & Profit Set at:	22%									
	Owners Contingency	5%									

OPTION Number	DESCRIPTION	QUANTITY	UN	MAN HOURS		MATERIAL		LABOR		EQUIPMENT		TOTAL DIRECT COST
				MHR/UNIT	TOTAL MH	UNIT COST	TOTAL MATL	WAGE RATE	TOTAL LABOR	UNIT RATE	TOTAL EQUIP	
1	<u>Civil</u> SBR Structures Sitework Landscaping Roadway Paving Granite Curbing Fencing Site Electrical Excavation for ADMIN, SLUDGE & EQ TANKS (18' Depth) Bedding Backfill Excavation for SOG (4' Depth) Controlled Fill	1 1,900 1,000 900 1 7,622 392 571 1,149 1,229	AL SY LF LF AL CY CY CY CY CY	500.00 0.04 0.20 0.10 500.00 0.20 0.20 0.20 0.20 0.20	500 76 200 90 500 1,524 78 114 230 246	10,000.00 15.00 14.00 20.00 50,000.00 0.00 12.00 0.00 0.00 12.00	10,000 28,500 14,000 18,000 50,000 0 4,708 0 0 14,754	\$97.27 \$97.27 \$97.27 \$97.27 \$97.27 \$97.27 \$97.27 \$97.27 \$97.27 \$97.27	48,637 7,393 19,455 8,755 48,637 148,285 7,633 11,102 22,346 23,919	25,000.00 2.00 2.00 1.25 1,000.00 2.00 2.00 2.00 2.00 2.00	25,000 3,800 2,000 1,125 1,000 15,244 785 1,141 2,297 2,459	\$83,637 \$39,693 \$35,455 \$27,880 \$99,637 \$163,529 \$13,125 \$12,244 \$24,643 \$41,132
	<u>Structural</u> Base Slab 24" Thick Slab on Grade 24" Thick Concrete Walls (Truck Bay & Admin - 15' high, 22" thick) Concrete Walls (Waste Sludge Tanks & EQ tanks - 17' h, 22" th) Concrete Walls (SBR tanks - 25') Ground Slab (22" thick) Concrete Columns (20" diameter, 15' grid, say 1.25 Cy/column) Roof (5' x 105) Hand Rail	1,421.2 574.3 710.9 346.3 635.8 776.3 10 198 371.0	CY CY CY CY CY CY EA EA LF	7.00 7.00 8.00 8.00 8.00 7.00 15.00 8.00 0.20	9,948 4,020 5,687 2,770 5,086 5,434 150 1,587 74	170.00 170.00 180.00 180.00 180.00 170.00 275.00 175.00 75.00	241,601 97,630 127,967 62,333 114,441 131,974 2,750 34,708 27,825	\$97.27 \$97.27 \$97.27 \$97.27 \$97.27 \$97.27 \$97.27 \$97.27 \$97.27	967,714 391,050 553,239 269,486 494,764 528,609 14,591 154,342 7,218	25.00 25.00 25.00 25.00 25.00 25.00 31.00 25.00 1.00	35,530 14,357 17,773 8,657 15,895 19,408 310 4,958 371	\$1,244,845 \$503,038 \$698,979 \$340,477 \$625,099 \$679,990 \$17,651 \$194,009 \$35,414
	<u>Headworks</u> Base Slab (Using top of EQ Tanks) Eq tanks Column Support Concrete Walls (19.5 x 11.67) Concrete Fill Wood Building over Headworks Channel (20' x 12') w/XP Elec Grating Grated Stairs Diamond Plate Hand Rail	0.0 1.0 7.7 6.6 240.0 60.0	CY AL CY CY SF SF	7.00 40.00 8.00 4.00 1.00 0.10	0 40 62 26 240 6	170.00 5,000.00 180.00 110.00 50.00 30.00	0 5,000 1,385 726 12,000 1,800	\$97.27 \$97.27 \$97.27 \$97.27 \$97.27 \$97.27	0 3,891 5,989 2,567 23,346 584	0.00 1,000.00 25.00 25.00 3.00 0.35	0 1,000 192 165 720 21	\$0 \$9,891 \$7,567 \$3,457 \$36,066 \$2,405
	H2s Coating for Sludge Tanks Splitter box upstream of headworks (assume 6'Dx10'x7')	3,774.0 1	SF EA	0.07 100.00	264 100	1.50 15,000.00	5,661 15,000	\$97.27 \$97.27	25,698 9,727	0.00 1,000.00	0 1,000	\$31,359 \$25,727

OPTION Number	DESCRIPTION	QUANTITY	UN	MAN HOURS		MATERIAL		LABOR		EQUIPMENT		TOTAL DIRECT COST
				MHR/UNIT	TOTAL MH	UNIT COST	TOTAL MATL	WAGE RATE	TOTAL LABOR	UNIT RATE	TOTAL EQUIP	
Architectural												
<u>Exterior</u>												
	12" CMU w/Cedar Shingle w/Insulation (Truck Bay/Admin)	4,470	SF	0.20	894	12.00	53,640	\$97.27	86,963	0.00	0	\$140,603
	12" CMU w/Cedar Shingle w/Insulation (Process Bldg, 20'h)	2,200	SF	0.20	440	12.00	26,400	\$97.27	42,801	0.00	0	\$69,201
<u>Roof</u>												
	Shingle Roof (truckBay/Admin)	64	SQ	14.40	924	1,008.00	64,714	\$97.27	89,928	72.00	4,622	\$159,264
	Insulation (2")	6,420	SF	0.0060	39	0.82	5,264	\$97.27	3,747	0.00	0	\$9,011
	Shingle Roof (Process Bldg)	10	SQ	14.40	144	1,008.00	10,080	\$97.27	14,008	72.00	720	\$24,808
	Insulation (2")	1,000	SF	0.0060	6	0.82	820	\$97.27	584	0.00	0	\$1,404
	Garage (24' x 48')	1,152	SF	0.70	806	85.00	97,920	\$97.27	78,442	2.00	2,304	\$178,666
	Painting		AL	400.00	0	15,000.00	0	\$97.27	0	0.00	0	\$0
Equipment												
<u>Headworks</u>												
	Preliminary Screening - 6 mm	1	EA	140	140	70,000	70,000	\$97.27	13,618	125.00	125	\$83,743
	Coarse Bubble Diffusers (EQ Tank, WAS Tank, and TWAS Tank)	1	LS	60	60	50,000	50,000	\$97.27	5,836	0.00	0	\$55,836
	Equalization Tank Pumps	3	EA	10	30	8,000	24,000	\$97.27	2,918	75.00	225	\$27,143
	Guide Rail Assemblies for future pumps	1	EA	8	8	900	900	\$97.27	778	0.00	0	\$1,678
	SBR	1	LS	500	500	443,200	443,200	\$97.27	48,637	4,432.00	4,432	\$496,269
	Includes: mixers and assemblies/support, decanter assemblies, transfer pumps, fine bubble diffusers, PD blowers, controls, and instrumentation											
	SBR - Cloth Disk Filter	1	EA	400	400	424,110	424,110	\$97.27	38,910	4,241.10	4,241	\$467,261
	Effluent Discharge Pumps	3	EA	16	48	14,000	42,000	\$97.27	4,669	140.00	420	\$47,089
	Guide Rail Assemblies for future pumps	1	EA	16	16	900	900	\$97.27	1,556	0.00	0	\$2,456
	UV (in-pipe)	1	EA	200	200	188,000	188,000	\$97.27	19,455	1,880.00	1,880	\$209,335
Admin Building												
	Blowers - 575 scfm	3	EA	25	76	24,545	73,635	\$97.27	7,364	160.00	480	\$81,479
	Septage Receiving	1	EA	600	600	250,000	250,000	\$97.27	58,365	6,000.00	6,000	\$314,365
	Sludge Thickening - RDT	1	EA	225	225	140,000	140,000	\$97.27	21,887	1,400.00	1,400	\$163,287
	RDT Feed Pump	2	EA	18	36	15,000	30,000	\$97.27	3,502	150.00	300	\$33,802
	Load out Station	1	EA	18	18	15,000	15,000	\$97.27	1,751	150.00	150	\$16,901
	Thickened Sludge Load Out Pump	2	EA	30	60	25,000	50,000	\$97.27	5,836	250.00	500	\$56,336

Area Number	DESCRIPTION	QUANTITY	UN	MAN HOURS		MATERIAL		LABOR		EQUIPMENT		TOTAL DIRECT COST
				MHR/UNIT	TOTAL MH	UNIT COST	TOTAL MATL	WAGE RATE	TOTAL LABOR	UNIT RATE	TOTAL EQUIP	
2	MBR Structures											
	Civil											
	Sitework Landscaping	1	AL	500.00	500	10,000.00	10,000	\$97.27	48,637	25,000.00	25,000	\$63,637
	Roadway Paving	1,900	SY	0.04	76	15.00	28,500	\$97.27	7,393	2.00	3,800	\$39,693
	Granite Curbing	1,000	LF	0.20	200	14,000	14,000	\$97.27	19,455	2.00	2,000	\$35,455
	Fencing	900	LF	0.10	90	20,000	18,000	\$97.27	8,755	1.25	1,125	\$27,880
	Site Electrical	1	AL	500.00	500	50,000.00	50,000	\$97.27	48,637	1,000.00	1,000	\$99,637
	Excavation for ADMIN, WASTE SLUDGE & EQ TANKS (18' Depth)	6,920	CY	0.20	1,384	0.00	0	\$97.27	134,628	2.00	13,840	\$148,468
	Bedding	347	CY	0.20	69	12.00	4,159	\$97.27	6,743	2.00	693	\$11,595
	Backfill	787	CY	0.20	157	0.00	0	\$97.27	15,304	2.00	1,573	\$16,878
	Excavation for SOG (4' Depth)	710	CY	0.20	142	0.00	0	\$97.27	13,814	2.00	1,420	\$15,235
	Controlled Fill	710	CY	0.20	142	12.00	8,521	\$97.27	13,814	2.00	1,420	\$23,755
	Excavation for Eff PS Tank	85	CY	0.20	17	0.00	0	\$97.27	1,660	2.00	171	\$1,831
	Bedding	6	CY	0.20	1	12.00	71	\$97.27	115	2.00	12	\$198
	Backfill	33	CY	0.20	7	0.00	0	\$97.27	646	2.00	66	\$712
	Structural											
	Base Slab, 24" Thick	1,124	CY	7.00	7,867	170.00	191,067	\$97.27	765,304	25.00	28,098	\$984,470
	Slab on Grade 24"	355.0	CY	7.00	2,485	170.00	60,356	\$97.27	241,752	25.00	8,876	\$310,984
	Ground Slab, 22" thick	704.8	CY	7.00	4,934	170.00	119,819	\$97.27	479,923	25.00	17,620	\$617,362
	Concrete Walls (Truck Bay & Admin - 15' high, 22" thick)	713.0	CY	8.00	5,704	180.00	128,333	\$97.27	554,824	25.00	17,824	\$700,981
	Concrete Walls (EQ and Sludge Tanks - 18' high, 22" thick)	369.1	CY	8.00	2,953	180.00	66,440	\$97.27	287,240	25.00	9,228	\$362,908
	Concrete Walls (MBR, RAS tanks, Mem Tank - 16' high)	423.7	CY	8.00	3,390	180.00	76,267	\$97.27	329,724	25.00	10,593	\$416,583
	Concrete Columns (20" diameter, 15' grid, say 1.25 Cy/column)	12	EA	15.00	180	275.00	3,300	\$97.27	17,509	31.00	372	\$21,181
	Roof (65' x 60')	144	EA	8.00	1,156	175.00	25,278	\$97.27	112,406	25.00	3,611	\$141,295
	Hand Rail	245.0	LF	0.20	49	75.00	18,375	\$97.27	4,766	1.00	245	\$23,386
	Stand Alone Tank (Eff PS)											
Base Slab	11.9	CY	7.00	83	170.00	2,015	\$97.27	8,070	0.00	0	\$10,085	
Concrete Walls	31.1	CY	8.00	249	180.00	5,600	\$97.27	24,211	0.00	0	\$29,811	
Headworks												
Base Slab (Using top of EQ Tanks)	0.0	CY	7.00	0	170.00	0	\$97.27	0	0.00	0	\$0	
Eq tanks Column Support	1.0	AL	34.00	34	4,250.00	4,250	\$97.27	3,307	850.00	850	\$8,407	
Concrete Walls (8.67 x 14.5)	7.2	CY	8.00	57	180.00	1,287	\$97.27	5,565	25.00	179	\$7,031	
Concrete Fill	8.7	CY	4.00	35	110.00	954	\$97.27	3,373	25.00	217	\$4,544	
Wood Building over Headworks Channel (15' x 13') w/XP Elec	240.0	SF	1.00	240	50.00	12,000	\$97.27	23,346	3.00	720	\$36,066	
Grating	210.0	SF	0.10	21	30.00	6,300	\$97.27	2,043	0.35	74	\$8,416	
Grated Stairs	1.0	AL	40.00	40	3,000.00	3,000	\$97.27	3,891	0.00	0	\$6,891	
Diamond Plate	60.5	SF	0.40	24	12.00	726	\$97.27	2,354	2.00	121	\$3,202	
Hand Rail	35.0	LF	0.20	7	75.00	2,625	\$97.27	681	1.00	35	\$3,341	
H2s Coating for Sludge Tanks	3,780.0	SF	0.07	265	1.50	5,670	\$97.27	25,799	0.00	0	\$31,409	

Area Number	DESCRIPTION	QUANTITY	UN	MAN HOURS		MATERIAL		LABOR		EQUIPMENT		TOTAL DIRECT COST
				MHR/UNIT	TOTAL MH	UNIT COST	TOTAL MATL	WAGE RATE	TOTAL LABOR	UNIT RATE	TOTAL EQUIP	
	Splitter box upstream of headworks (assume 6 D _X 10 ⁷)	1	EA	100.00	100	15,000.00	15,000	\$97.27	9,727	1,000.00	1,000	\$25,727
Architectural												
	<u>Exterior</u> 12" CMU w/Cedar Shingle w/Insulation (Truck Bay/Admin)	4,710	SF	0.20	942	12.00	56,520	\$97.27	91,632	0.00	0	\$148,152
	<u>Roof</u> Shingle Roof (truckBay/Admin) Insulation (2")	45 4,494	SQ SF	14.40 0.0060	647 27	1,008.00 0.82	45,300 3,685	\$97.27 \$97.27	62,950 2,623	72.00 0.00	3,236 0	\$111,485 \$6,308
	MBR Effluent End Building (17' x 20')	340	SF	0.90	306	100.00	34,000	\$97.27	29,766	2.00	680	\$64,446
	Garage (24' x 48')	1,152	SF	0.70	806	85.00	97,920	\$97.27	78,442	2.00	2,304	\$178,666
	Checked Plate Cover <i>Stand Alone Tank (Eff PS)</i>	900.0	LBS	0.015	14	0.90	810	\$97.27	1,313	0.05	45	\$2,168
Equipment												
	<u>Headworks</u> Preliminary Screening - 2 mm	2	EA	140	280	370,000	740,000	\$97.27	27,237	3,700.00	7,400	\$774,637
	Coarse Bubble Diffusers (EQ Tank, WAS Tank, and TWAS Tank) Equalization Tank Pumps Guide Rail Assemblies for future pumps	1 3.0 1.0	LS EA EA	60 8 8	60 24 8	50,000 6,000 900	50,000 18,000 900	\$97.27 \$97.27 \$97.27	5,836 2,335 778	500.00 60.00 9.00	500 180 9	\$56,336 \$20,515 \$1,687
	MBR includes: membranes and cassettes, permeate pumps, scour blowers, aeration blowers, fine bubble aeration discs, submersible mixers, chlorine metering pump, chemical dosing system, PLC, VFDs	1.0	LS	1,200	1,200	768,250	768,250	\$97.27	116,729	7,682.50	7,683	\$892,662
	Effluent Discharge Pumps Guide Rail Assemblies for future pumps UV (in-pipe)	3.0 1.0 1.0	EA EA EA	16 16 200	48 16 200	14,000 900 188,000	42,000 900 188,000	\$97.27 \$97.27 \$97.27	4,669 1,556 19,455	140.00 0.00 1,880.00	420 0 1,880	\$47,089 \$2,456 \$209,335
Admin Building												
	Blowers - 450 scfm Septage Receiving Sludge Thickening - Disk Thickener RTD Feed Pump Load out Station Thickened Sludge Load Out Pump	4.0 1.0 1.0 2.0 1.0 2.0	EA EA EA EA EA EA	25 600 225 18 18 30	101 600 225 36 18 60	24,545 250,000 140,000 15,000 15,000 25,000	98,180 250,000 140,000 30,000 15,000 50,000	\$97.27 \$97.27 \$97.27 \$97.27 \$97.27 \$97.27	9,818 58,365 21,887 3,502 1,751 5,836	160.00 6,000.00 1,400.00 150.00 150.00 250.00	640 6,000 1,400 300 150 500	\$108,638 \$314,365 \$163,287 \$33,802 \$16,901 \$56,336
	Plant Water System Plant Water/Distribution Pumps (400 gpm @322', 50 hp) Controller/Piping Odor Control (air from septage receiving garage, headworks building, sludge storage tanks, and EQ tank)	2 1 1.0	EA AL EA	32.00 120.00 380	64 120 380	21,500.00 20,000.00 206,000	43,000 20,000 206,000	\$97.27 \$97.27 \$97.27	6,226 11,673 36,964	215.00 200.00 2,060.00	430 200 2,060	\$49,656 \$31,873 \$245,024

Area Number	DESCRIPTION	QUANTITY	UN	MAN HOURS		MATERIAL		LABOR		EQUIPMENT		TOTAL DIRECT COST
				MHR/UNIT	TOTAL MH	UNIT COST	TOTAL MATL	WAGE RATE	TOTAL LABOR	UNIT RATE	TOTAL EQUIP	
	Lab Equipment/Cabinet Allowance	1	AL	450.00	450	60,000.00	60,000	\$97.27	43,773	1,000.00	1,000	\$104,773
	<u>Piping</u> Percentage of Mechanical	15%	%	3,440	516	2,660,230	399,035	\$97.27	50,193	29,752	4,463	\$453,690
	<u>Electrical</u> Percentage of Project	20%	%	38,939	7,788	4,118,912	823,782	\$97.27	757,558	160,337	32,067	\$1,613,408
	Diesel Generator w/Acoustical Enclosure (250 KW)	1	AL	125.00	125	100,000.00	100,000	\$97.27	12,159	1,000.00	1,000	\$113,159
	<u>I&C</u> 50% of Electrical	50%	%	7,788	3,894	823,782	411,891	\$97.27	378,779	32,067	16,034	\$806,704
				Subtotal								\$10,886,613
				22% Contractor, GC, Overhead and Profit								\$ 2,395,055
				30% Contingency								\$ 3,984,500
				5% Owner's Contingency								\$ 863,308
				SUBTOTAL								\$18,129,476
ESCALATION TO MID-POINT OF CONSTRUCTION				3.5%				1.83		6.4%		\$ 1,158,672
ASSUMED AT:				PER YEAR				YEARS	NON-COMPOUNDED RATE			\$ 19,288,148