Filter Backwash Storage Design for Western Branch WRRF

Preliminary Design Report

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Section 1. Abstract

The Western Branch Water Resources Recovery Facility (WRRF), which is designed to treat 30 million gallons of wastewater each day, faces disproportionately high flows because of precipitation and groundwater inflow and infiltration into the vast network of pipes that bring wastewater to the plant. WSSC Water, the owner and operator of Western Branch WRRF, presented concerns about potential violations of the strict nitrogen and phosphorus limits set by the State of Maryland to this design team and tasked the team with mitigation of the problem. The proposed solution targets the dirty backwash water produced by the 11 anthracite filters, which are currently bypassed during periods of high flows. The proposed design is a 3-million-gallon backwash storage tank, which can hold the dirty backwash during high flow periods to allow the filters to continue to operate. This preliminary design report includes the justification and design of the backwash storage tank, hydraulics, and solids handling, in addition to a cost estimation and preliminary project schedule.

Section 2. Executive Summary

Western Branch Water Resources Recovery Facility (WRRF) is a wastewater treatment plant in Upper Marlboro, MD with a design flow of 30 million gallons per day (MGD). Owned and operated by WSSC Water, the facility runs with the goal of returning clean water back into the environment in an affordable, clean, sustainable way through advanced treatment. Treatment processes include activated sludge treatment, tertiary filtration, and UV disinfection units to ensure that the final effluents comply with National Pollutant Discharge Elimination System (NPDES) effluent limits.

Due to aging pipes and increased rainfall events, infiltration and inflow (I&I) poses a significant problem to the utility. During wet weather events resulting in high flows, wastewater moves through the treatment process at a faster rate, which can cause the clarifiers to overflow. This is turn increases the concentration of solids in the filter influent and the frequency at which filter backwashing must occur. Since backwash water from the filters is sent directly back to the influent, the combination of filter backwash and high inflow to the plant overwhelms the influent pump station, resulting in flooding of the facility basement. To reduce the treatment load, the filters are bypassed during these periods, which results in decreased effluent quality and could lead to potential permit violations [3][4][6].

Reducing I&I flows by directly replacing leaky pipes is both time-consuming and costly. This design team proposes the design of a dirty backwash storage tank to house additional backwash flow before returning it to the influent pump station. The backwash tank connects to the filters via a pump-and-pipe network. Hydraulic analysis was conducted to estimate the power required for the pump to convey the dirty backwash water from the filters to the proposed storage tank. Various solutions for handling the higher flows, types of tanks, and total suspended solids were presented to WSSC Water. After a systematic analysis with decision matrices, it was decided that a pre-cast concrete tank was the optimal solution. Rather than provide mixing in the tank, the most cost-effective solids handling solution was determined to be routinely flushing out the backwash storage tank.

This report presents the details of the recommended design, including the process flow diagram, tank volume, dimensions, material, and solids handling; site layout with the backwash tank; hydraulics recommendations; operation and maintenance (O&M); system impact; and relevant regulations and permits. Finally, at the end of this report, a preliminary cost estimation is presented as well as a proposed schedule. The main cost breakdowns are material costs of the tank, pipes and pumps, pre-construction major costs, construction cost (including oversight and management), and O&M. After the final design is presented and the report is submitted to the client, the project would enter the bid phase and construction phase, followed by testing and inspection at the end.

Section 3. Introduction

3.1 Site Summary

The Western Branch Water Resources Recovery Facility (WRRF), located in Upper Marlboro, MD, serves an area of 113 square miles, covering the natural drainage basin of the Western Branch [13]. The facility has a design flow of 30 million gallons per day (MGD) and must adhere to low-level concentrations of nitrogen and phosphorus content in addition to other effluent parameters. ***Figure 1*** shows an aerial view of the plant. The facility is owned by WSSC Water, whose primary mission is to provide safe, reliable, affordable water to the community in a sustainable manner, minimizing negative effects to the environment.

Figure 1. Western Branch WRRF

Figure 2. Close-up Showing the Eleven Filters, Abandoned Backwash Pump Building, and Abandoned 60' Diameter Clarifier for Backwash Storage

Figure 3. Operational Sand and Anthracite Filter

3.2 Treatment Process

Western Branch WRRF employs activated sludge, filtration, and Ultraviolet (UV) disinfection treatment processes. After the initial bar screen and aerated grit removal, the wastewater passes through three stages of activated sludge bioreactors and clarifiers, N-stripping channels, and denitrification activated sludge, which remove a significant amount of the nitrogen. Next, wastewater is sent to eleven anthracite filters, which serve to remove solids and the contaminants attached to those solids. The filters are periodically backwashed to remove particles from clogging the filters. The dirty backwash water is pumped to the influent pump station to be treated again. Finally, the UV treatment disinfects the water to remove pathogens before it is discharged into the Western Branch. A process flow diagram of the existing system is shown in ***Figure 4***, which was provided to the design team by WSSC Water.

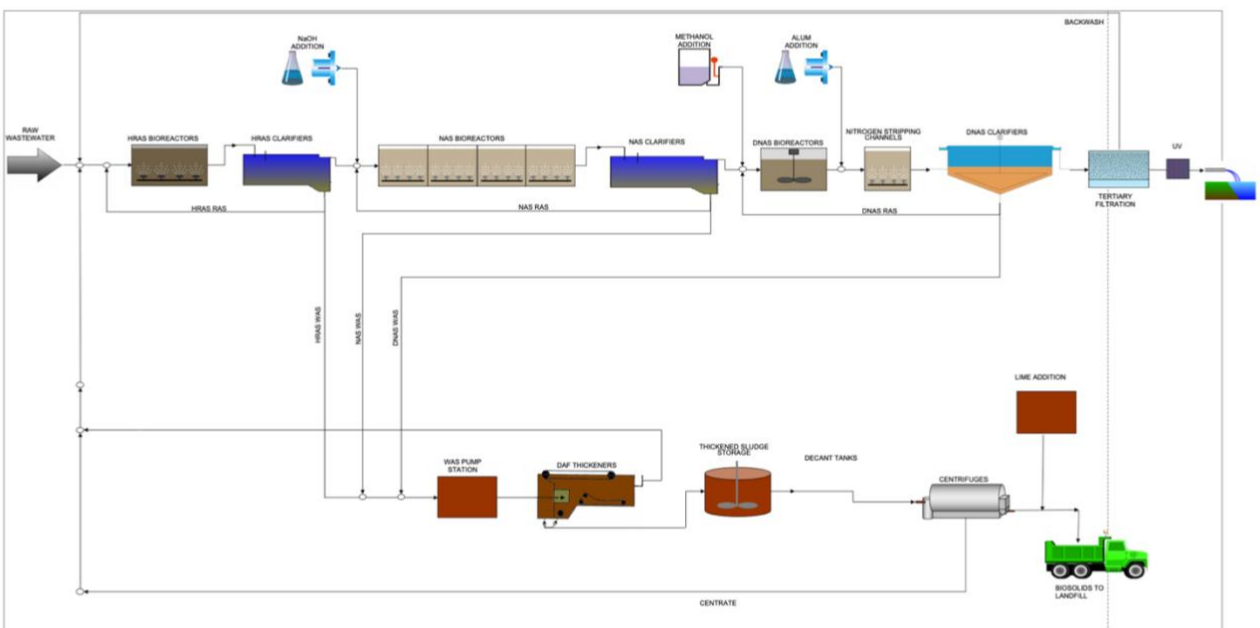

Figure 4. Process Flow Diagram of Western Branch WRRF

3.3 Project Objectives

Inflow and infiltration (I&I) significantly affects Western Branch WRRF. I&I is defined as excess groundwater and stormwater that enters sewer systems through leaking pipes. Due to I&I in WSSC

Water's vast network of aging pipes, this treatment plant sees flows close to 100 MGD, which is over triple the design flow rate of 30 MGD.

WSSC Water currently addresses these problems by performing I&I analyses and gradual pipe replacements; however, due to the many miles of pipes in place and the cost of replacement, high flows at Western Branch WRRF continue. Many other wastewater treatment plants on the East Coast face the same problems of aging infrastructure, increased storm events, and high flows. During wet weather events resulting in high flows, wastewater moves through the treatment process at a faster rate, which can cause the clarifiers to overflow. This is turn increases the concentration of solids in the filter influent and the frequency at which filter backwashing must occur. At Western Branch WRRF, the combination of filter backwash and high inflow to the plant overwhelms the influent pump station, resulting in flooding of the facility basement. To reduce the treatment load, the treatment process also bypasses the filters during these periods. This necessary action decreases the quality of the effluent water further and can result in a permit violation.

The objective of this project was to design a solution to the problem of filter bypass and influent pump station flooding.

3.4 Regulatory Drivers

Western Branch WRRF discharges to the Western Branch, which is a protected water body for marine and estuarine aquatic life. The treatment facility must therefore comply with Maryland's strict nutrient removal regulations for nitrogen and phosphorus.

National Pollutant Discharge Elimination System (NPDES) effluent limits for the Western Branch WRRF include TSS (30 mg/L) and Total P (Annual loading limited based on 0.3 mg/L). ***Appendix D*** lists the effluent limitations from the treatment plant's NPDES Discharge Permit. To meet these nutrient limits, Maryland treatment plants such as Western Branch WRRF employ tertiary treatment in the form of anthracite filters in addition to primary and secondary treatment. When the filters are bypassed, the concentration of TSS and Total P (primarily the particulate fraction) in the final effluent can be significantly higher than when the filters are operating. Given the stringent limit on Total P, the inability to provide filtration during high flow events increases the risk of exceeding NPDES permit limits [6].

Wastewater treatment plants that avoid permit violations save money, protect the environment, and are recognized by the National Association of Clean Water Agencies (NACWA) with Peak Performance Awards for 100% permit compliance [1]. Western Branch WRRF currently holds a NACWA Platinum Award for permit compliance. Designing a solution to the problem of filter bypass during storm events can thereby improve the treatment capability of the plant, prevent damage to local ecological communities, and reduce the risk of permit violations.

3.5 Element Definitions

In this design report, key elements include: the filters, the pumps (also referred to as backwash pumps / pump station / spent backwash pump station), tank (backwash tank / backwash storage tank), and influent pump station (influent wet wells / raw sewage pump station). In order to provide a visual of the system, these key elements are identified below on the Google Earth image of Western Branch in ***Figure 5***.

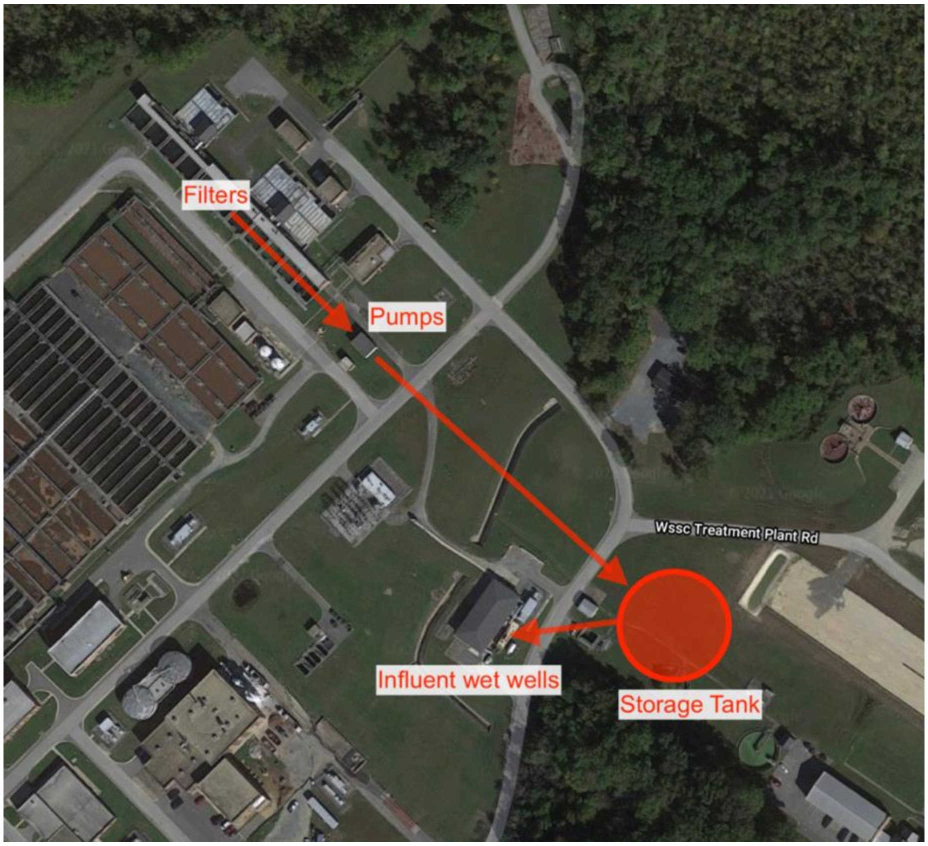

Figure 5. Aerial Photograph of Filters, Pumps, Influent Wet Wells, and Storage Tank at Western Branch WRRF

Section 4. Alternatives Analysis

During an initial literature review, alternative technologies were considered for several parts of the project. This included the consideration of multiple solutions for handling the dirty backwash water, types of storage tanks, and solids handling systems. Decision analysis matrices (***Table 1, 2, and 3***) were created to compare the different technologies on a variety of metrics. Several methods were evaluated in each of the matrices based on research and information provided by the clients and technical advisor.

The design criteria were chosen for the matrix, and each criterion was assigned a weight. In the decision matrices, weighted sums were used to determine the total score of that alternative, with scores ranging from 1 (worst) to 5 (best) for each design criterion.

4.1 Backwash Bypass Mitigation Technologies

4.1.1 Fix Inflow and Infiltration (I&I) in All Pipes

The complete elimination of I&I flows would require no introduction of any groundwater, stormwater, or clean waters, which is infeasible in a real-world systems. Many complex, interrelated components can contribute to inflow, such as roof downspouts, sump pumps, and drains from fountains, yards, streets, and driveways. As a result, preventing all inflow sources would be resource-exhaustive, disruptive, and expensive. Similarly, the infiltration component is closely related to the tightness of pipes and manholes, and it is necessary to recognize that certain amount of infiltration is permitted in the design, as well as unavoidable [3].

This method would reduce the amount of excess water that entered the plant during high rainfall periods. This solution would be extremely complex and expensive because so much of the peak flow is the result of I&I during heavy rain periods. Given that 113 square miles are served by the WRRF, this would become very costly and would not be efficient.

Eliminating all I&I entering Western Branch WRRF is infeasible; however, WSSC Water continues to perform water line replacement and rehabilitation projects to reduce I&I and improve efficiency of water conveyance. Regardless, these water line construction projects are not enough to prevent high flows to the treatment plant.

4.1.2 Design Influent Equalization Basin

The goal of an influent flow equalization tank is to hold water at the plant inflow so that the amount of water moving through the plant is constant regardless of influent flows. An equalization basin is designed such that complete mixing occurs and no Biological Oxygen Demand (BOD) reduction takes place in the basin [3].

The most important benefit of an equalization basin is to store peak flows and release water during low-flow periods, therefore eliminating the shock peak water load during storm events to filters. However, this solution was determined to be both expensive and impractical since the plant receives up to 100 MGD during high flow periods, requiring an extremely large tank [4] [10].

4.1.3 Design Backwash Storage Tank

For this solution, dirty filter backwash water would not return directly to the plant inflow, but would be stored in a tank during high flow periods when the volume of water already stored in the influent wet well is too large to accommodate more water. This solution proved to be the most cost effective and would provide a significant benefit to the plant during periods of high backwashing and inflow.

4.1.4 Replace Filters with Continuous Backwash Filters

Continuous backwash filters are an upflow filter technology that operate by continually rinsing the media while water is being processed [17]. This type of filter is desirable because in ordinary circumstances, it eliminates costs associated with backwash pumps, wet wells, and solids treatment associated with less often backwashing filters. This solution was not selected, however, because it would not solve the problem of high flows; in fact, it could make the problem worse since continuous backwash filters require an even larger volume of water to backwash.

Table 1. Alternatives Matrix for Backwash Bypass Mitigation

Criteria (weight) / Solution	**Capital Cost (0.40)**	**Maintenance Cost (0.10)**	**Aesthetics (0.05)**	**Space (0.05)**	**Effectiveness (0.25)**	**Future Storms Resiliency (0.15)**	**Weighted Score**
Fix I&I in all pipes	1	1	4	5	4	2	2.25
Design EQ basin	2	4	1	1	3	4	2.65
Design Backwash Storage Tank	4	4	2	2	2	3	3.15
Replace filters with constantly backwashing filters	3	3	4	5	1	1	2.35

4.2 Tank Material Alternatives

4.2.1 Precast Concrete

A precast concrete tank would be produced by a commercial tank manufacturer out of concrete. This tank option would be cast by a tank company, offsite, and then delivered to the site in sections to be assembled. This option was chosen because it had a lower cost than a cast in place tank.

4.2.2 Cast in Place Concrete

A cast in place concrete tank would be cast and assembled on site. This method was found to be more expensive than a precast tank.

4.2.3 Steel Tanks

Bolted steel, stainless steel, and glass fused steel tanks were also considered. However, the costs of the steel tanks were much higher, and they had higher maintenance costs such as repainting and concerns about rust. Although they are available in larger sizes that would meet the needs of this project, they were not cost effective compared to concrete tanks [5].

4.2.4 Fiberglass

While aesthetically pleasing and relatively durable, this type of tank was not available in the size needed for this project at a competitive price.

Table 2. Alternatives Matrix for Tank Material

Criteria (weight) / Tank type	**Capital Cost (0.5)**	**Maintenance Cost (0.25)**	**Longevity (0.15)**	**Aesthetics (0.1)**	**Weighted Score**
Precast Concrete	5	5	5	3	4.8
Cast in Place Concrete	4	5	5	3	4.3
Bolted Steel	2	2	2	3	2.1
Stainless Steel	2	2	2	3	2.1
Glass Fused to Steel	1	2	2	3	1.6
Fiberglass	1	2	2	3	1.6

4.3 Tank Elevation

The hydraulics allowed for two options: an above or below ground tank. The first option was to drain backwash by gravity to a below ground storage tank and pump up to the influent pump station wet wells. The second option to pump backwash up to the storage tank and drain it by gravity to the influent pump station wet wells. The design team chose an above ground storage tank to avoid costs associated with excavation of the storage tank.

4.4 Solids Handling Alternatives

4.4.1 Manually Flush Tank

This solution would involve having plant operators enter the tank during periods of low water level in the tank to flush the solids in the tank. The solids would be flushed back to the influent wet well. This solution would be cost effective and would not require significant additional equipment.

4.4.2 Remotely Flush Tank

A possibility that was considered was installing water cannons on the top of the tank that could be used to flush the tank remotely. While this would reduce the labor required to manually rinse the tanks, it would increase capital costs.

4.4.3 Plate Settlers

Plate settlers pass flow through angled plates to increase settling area for sludge [12]. Given the low solids content of the filter backwash water, plate settlers proved to be unnecessary for the design.

4.4.4 Sedimentation Tank

A sedimentation tank would involve allowing the solids to settle and then be pumped out to solids disposal. Since the water in the tank would not be held in the tank for more than about a day, a sedimentation tank was determined to be unnecessary. In addition, a turbidity profile of the backwash showed that solids settling would be minimal.

4.4.5 Submersible Mixer

Mixing would allow the solids to remain suspended while stored in the backwash storage tank. However, this method would prove difficult due to the size of the tank. If multiple mixers were used, costs would be very high.

4.4.6 Central Mixing Impeller

This type of mixer would also be difficult to implement in the tank because of the size. The central mixing would likely only be effective in the middle of the tank.

4.4.7 Submersible Aerator

Aerators can provide mixing in large tanks such as equalization basins. Installing aerators would provide additional capital and operation costs that were found to be unnecessary for the project.

Table 3. Alternatives Matrix for Solids Handling

Criteria (weight) / Solution type	**Feasibility (0.5)**	**Cost (0.25)**	**Longevity (0.15)**	**Operator Maintenance (0.1)**	**Weighted Score**
Manually Flush Tank	5	5	5	1	4.6
Remotely Flush Tank	5	3	4	5	4.35
Plate Settlers	3	2	4	4	3
Sedimentation Tank	5	1	3	4	3.6
Submersible Mixer	2	3	2	5	2.55
Central Mixing Impeller	2	3	2	5	2.55
Submersible Aerator	1	3	1	5	1.9

Section 5. Design Assumptions

5.1 Tank Volume

To determine the optimal volume of the backwash storage tank, assumptions governing the influent filter flows and backwash filter flows were determined under both normal and high-flow conditions. High flow conditions in this case are defined by the signal to bypass the filters in the wastewater process in the current treatment process design. The signal is operated by the wet well level measurement, which records the vertical level of the influent wastewater at the influent pump station. If the wet well level surpasses 160”, the signal to bypass the filters is activated. For each condition, a set of numerical assumptions is made for the purpose of simulating the new system. Approximately 1-5 years of recent data is available to set these assumptions. The datasets used include the total daily effluent, total daily filter backwash effluent, and the hourly wet well level.

The filter backwash process lasts 127 minutes and consists of two drawdown periods, air scour, and low and high backwash flows pushed up through the filters. This process produces approximately 170,000 gallons for a single backwash. For the simulation of the backwash system, assumptions about the flow into and out of the proposed storage tank are necessary. These assumptions are drawn from the backwash daily effluent data which provides close to 3 years of daily total volumes of backwash. The daily backwash effluent values were used to find the number of backwashes performed by the 11 filters each day.

The next set of assumptions required to model the backwash flow and proposed storage is to differentiate between normal and high-flow conditions. For this purpose, normal flow is considered the condition when the wet well level is below 160", that is the filters are operational under the current treatment process. High flows are then when the wet well level reads above 160", when the filters are currently bypassed. For the backwash effluent. The 'normal' condition backwash flows are approximated at the mean value of 12.5 backwashes per day, equivalent to 88,541 gal/hr. 'High-flow' conditions approximate the backwash flow using the 99th percentile of the backwashes per hour data which is used to return a backwash effluent rate of 141,666 gal/hr. This value was selected to approximate the backwashing rate when the filters are operating at full capacity without being bypassed due to high flows.

5.1.1 Model 1: Backwash Storage Event Percentiles

The first model approaches backwash storage from the angle of individual high-flow events that require storage to prevent the bypassing of tertiary treatment. These 'events' are modeled by a dataset that uses the hourly wet well level measurements to identify the length of each high-flow event composed of one or more consecutive hours of the process bypassing the filters. The hours are then multiplied by the high-flow backwash rate in gal/hr to output the storage required to hold the backwash water produced by each event. The full model functions and explanations are found in ***Appendix C.3.1***. The output of this model is the percent of events that different sizes of tanks would hold under these assumptions. A plot of the results is shown in ***Figure 6*** This model shows that a 3-million-gallon tank would hold every event between 11-1-2019 and 11-30-2020 with returns on larger tanks diminishing but still significant above 1.5 million gallons. The major limitation of this model is the assumption that the high-flow events are independent, and that the storage tank would be allowed to completely empty no matter the gap between events.

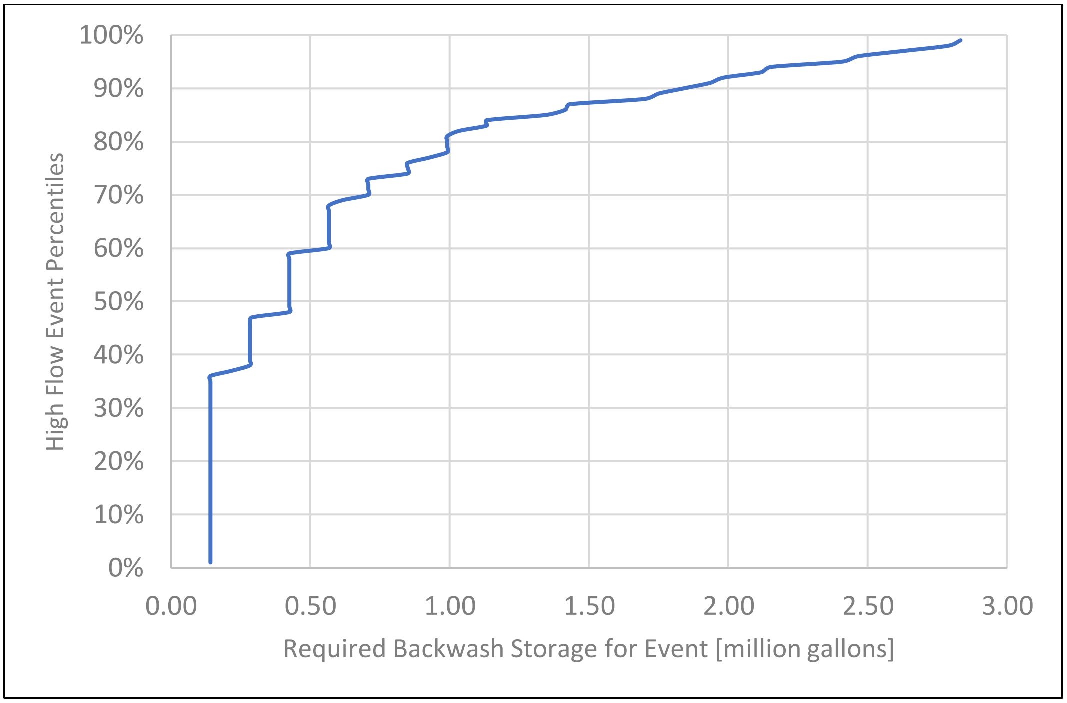

Figure 6. Volume of Backwash Storage Necessary for Each Percentile High Flow Event

5.1.2 Model 2: Backwash Storage Simulation

The second model developed to find the optimal storage tank volume is designed to simulate the proposed storage tank system. The model inputs include the hourly wet well levels which determine whether the system is experiencing normal or high flow conditions each hour. These outputs are then used to determine the percentage of time in hours/hours that a particular size of storage tank would be able to successfully store the dirty backwash. For each set of conditions, the previously mentioned backwash rates add water to the storage tank each hour. The additional assumption in this model is the outflow rate from the storage tank. Storage outflow occurs only during normal flow due to the proposed system preventing backwash flow from the tank instead of backwash flow directly from the filters as is currently the case. The storage outflow rate in this model is varied for different outputs because the available data inhibits the determination of an accurate constant or influent flow dependent outflow rate. Optimally, the storage outflow will be adjusted to match the influent flow level so that the storage tank is drained quickly without inducing high-flow conditions. The base/minimum level of storage outflow is the taken from the 99th percentile of backwash effluent because it represents the backwash outflow into the influent pump station at full capacity. The functions and calculations for this model are found in ***Appendix C.3.2***. For the outputs of this model in ***Table 4***, the storage outflow is varied between the base value and twice the base value, for tank sizes of 2, 2.5, 3, and 3.5 million gallons. These sizes were selected based on the results of the first model.

Table 4. Results of Backwash Storage Simulation

2MG Tank	
Storage Outflow Rate	**Hrs Complete Storage (%)**
Base	92.61
Base×1.25	96.06
Base×1.5	97.63
Base×2	99.05

2.5MG Tank	
Storage Outflow Rate	**Hrs Complete Storage (%)**
Base	94.35
Base×1.25	97.16
Base×1.5	98.67
Base×2	99.70

3MG Tank	
Storage Outflow Rate	**Hrs Complete Storage (%)**
Base	95.47
Base×1.25	98.04
Base×1.5	99.24
Base×2	99.92

3.5MG Tank	
Storage Outflow Rate	**Hrs Complete Storage (%)**
Base	96.72
Base×1.25	98.59
Base×1.5	99.49
Base×2	100.00

Unlike the percentile model, this simulation accounts for the fact that the storage tank will not always be able to empty between high-flow events, the uncertainty in the storage outflow and the use of a constant value means that the model is best for comparing tank sizes and is less optimal for determining precise performance levels. Additional uncertainty in the models presented come from questions about the performance of filters under high flow conditions. This data is unavailable because of the bypass function prevents filters from consistently undergoing these conditions. As referenced in the introduction, high flows can introduce more solids into the filter influent which could induce more frequent backwashing, increasing the total backwash effluent during high flows. Finally, the models are best for comparing tank sizes and are less optimal for use in determining precise performance levels.

5.1.3 Volume Model Results

With the information produced using the storage percentile and simulation models, the optimal volume for a backwash storage tank at this site is determined to be between 2.5 and 3 million gallons. The percentile model shows that a significant number of events would not be contained by smaller tanks. The systematic underestimation of the load on a storage tank by the model indicates that the tank would still have occurrences where the filters would have to be bypassed due to a lack of storage. The second model indicates that beyond 2.5-3 million gallons the return on adding more storage diminishes. Another important note is that the high-flow events that occur less often are also more impactful due to the volumes of water that flow from the treatment plant with a lower standard of contaminant removal. Other constraints will factor into the final size of the tank.

5.1.4 Flow Diagram

A diagram, shown in ***Figure 7***, of relevant flows was created to visualize the flow balance used in the tank volume calculations.

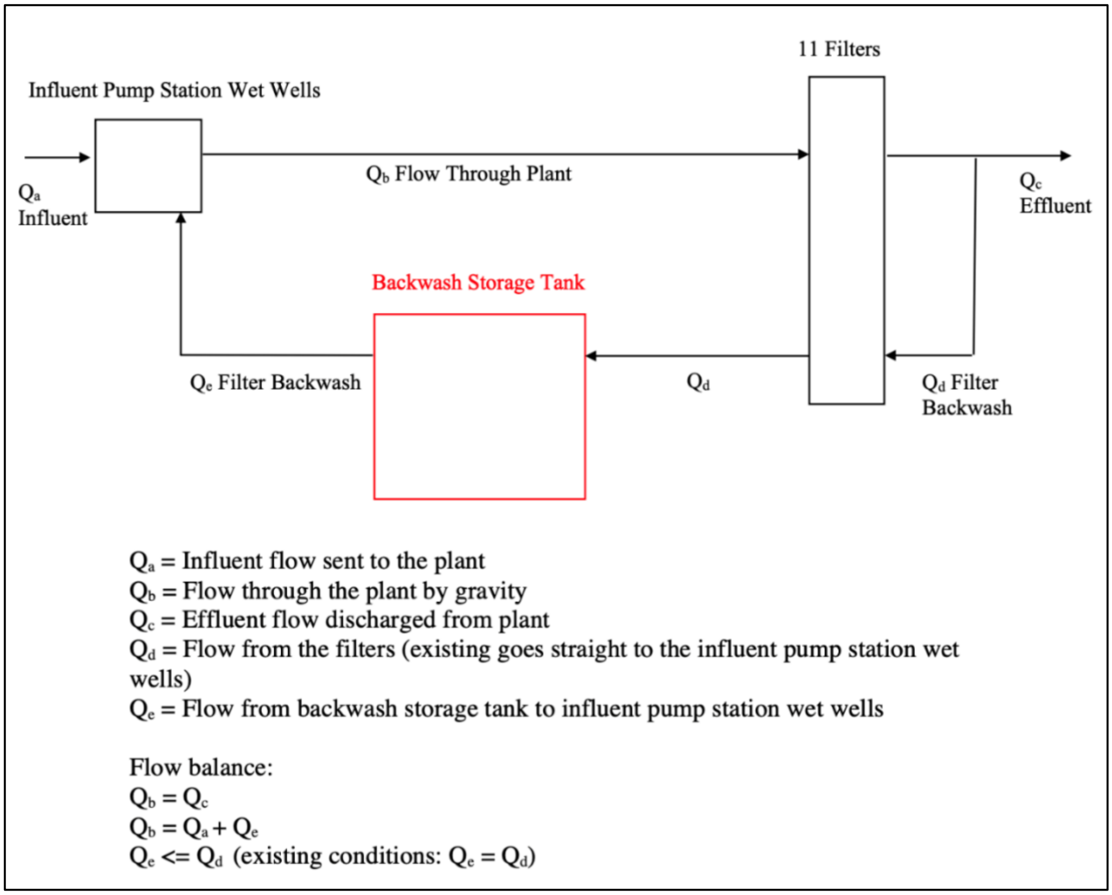

Figure 7. Flow Diagram

5.2 Solids Assumptions

A backwash profile of one of the filters was completed at the Western Branch WWRF. Water was sampled a total of 14 times over a 14:36 time period. In each of these samples, water was collected from the filter, during backwashing and transferred to a bottle. The turbidity (in NTU) was measured at the site.

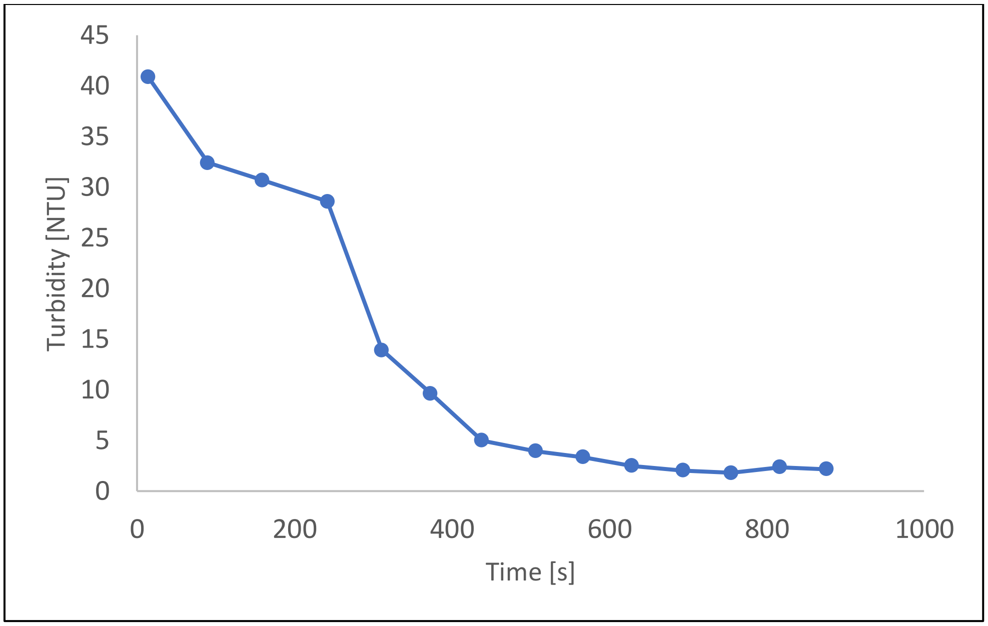

Figure 8. Turbidity Measurements Taken During Filter Backwashing

Two samples were taken for analysis in the university laboratory. However, only one of the samples had a turbidity value in mg/L measured. This sample had 851 mg/L for the 32.4 NTU sample. This value is most likely too high. Other conversion factors between NTU and mg/L were investigated, but there was no consensus value because the conversion factor would depend on the specific particles within the water.

One estimate of the total solids was approximately 181 kg, or 397 lbs. in each filter backwash, as estimated by the method in ***Appendix C.5***.

In a process flow diagram provided by the client, the suspended solids design value was found to be 165 mg/L in the filter backwash. In addition, the rate of solids produced was found to be 3126 lbs/day. This indicates that there is a significant amount of solids within the filter backwash. Based on the assumption of an average of 12.5 backwashes per day, this figure would produce an average solids per backwash of 250.1 lbs.

Another assumption made was that was that the suspended solids would generally remain suspended during the time the backwash was stored in the tank. It was not possible to determine the settling velocity of the solids in the backwash. It was assumed that there would not be significant settling that could cause build up in the storage tank.

5.3 Hydraulic Assumptions

The hydraulic design for the project included determination of the following design parameters: pipe and fitting diameter, pipe material, pipe orientation, pump model and horsepower, pump housing, tank elevation, and tank location. In order to minimize costs to the client, existing infrastructure was reused where possible. This included all pipes and the existing backwash pump station. Record drawings of the backwash pump station are included in ***Appendix E***.

Hydraulic calculations were performed to verify pipe diameter and pump size. Pipe diameter was verified by calculating water velocity in the existing pipes based upon the backwash flowrates to ensure that velocities remained below a threshold value that would cause excessive wear to pipes and fittings. Pump size was determined using the known backwash flow rates and pipe, site, and tank information, total dynamic head (TDH) was calculated across the pump. The flow rates and TDH were provided to a pump vendor, who assisted in selecting suitable pump models. The overarching equation used to perform these calculations is the energy equation from fluid mechanics, shown below. The complete hydraulic calculations are attached in ***Appendix C***.

$$\left(\frac{P_1}{\gamma} + z_1 + \frac{v_1^2}{2g}\right) - \left(\frac{P_2}{\gamma} + z_2 + \frac{v_2^2}{2g}\right) = h_f + h_{f,fitting} - h_{pump}$$

Approximately twenty years ago, the client, WSSC Water, recognized the problems caused by sending filter backwash directly back to the influent pump station. A clarifier design was proposed and constructed to store filter backwash; however, insufficient backwash tank volume resulted in the design not being utilized. The abandoned existing infrastructure is shown in ***Figure 2***.

For this team's updated design, the current pump station building was maintained in order to save upon costs of constructing a new one. The existing pump station infrastructure includes a below ground sump to equalize backwash water before it is sucked up by the pumps. In addition to the pump station and sump structures, pipes and fittings running from the filters to the pump station to the existing backwash tank to the influent pumping station wet wells were assumed to be in good enough condition to reuse for this preliminary design. Verification of the state of the piping is required prior to construction. Thus, for this report, the lengths of pipes and pipe diameter were assumed based off of the Western Branch record drawings and Google Earth measurement estimations.

While pipes and pump station were maintained, it was determined that the backwash pumps would need to be replaced to account for wear and for new TDH and flow requirements due to the larger storage tank design. The pumping requirements for flow rate were determined by the backwash flow rates in the filters. Backwash flow rates, initially photographed from the SCADA controls are Western Branch, are shown in ***Table A-1*** in ***Appendix C.***

As discussed in the alternatives analysis, the tank was chosen to be above ground. Therefore, the hydraulics required to pump backwash up to the storage tank and drain it by gravity to the influent pump station wet wells. The elevation head between the sump and high water level of the storage tank was a measurable project constraint.

Section 6. Recommended Design

After evaluating the alternatives for solving the problem of increased flows to the filters, the design team chose to store filter backwash in a new storage tank.

6.1 Process Flow Diagram

The backwash tank was incorporated into the original Western Branch WRRF process flow diagram, as shown in ***Figure 9***.

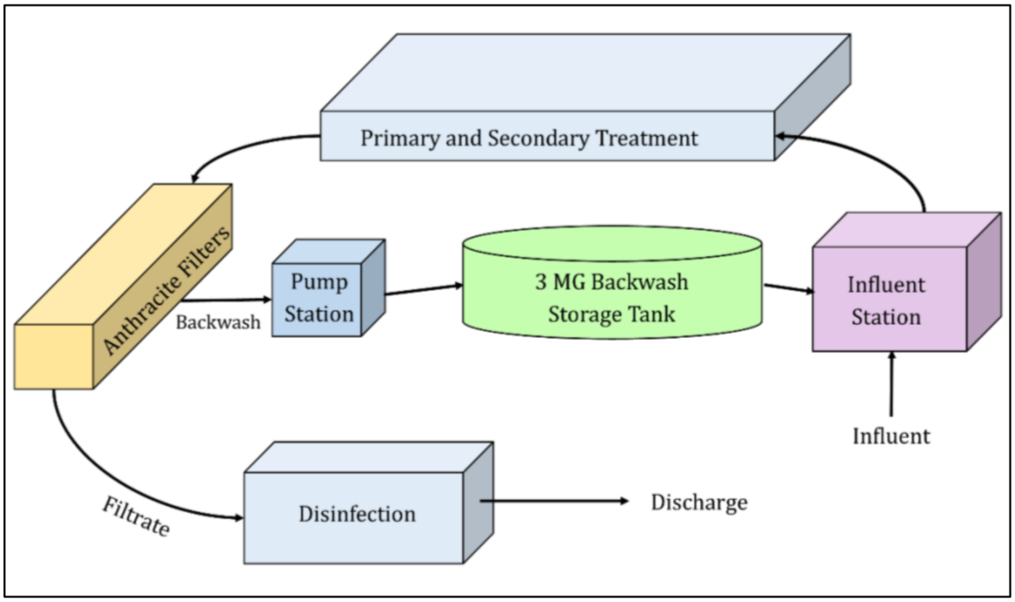

Figure 9. Proposed Process Flow Diagram

6.2 Tank Volume

The tank was sized at a total volume 3.0 million gallons. To determine the volume of the proposed storage tank, relevant historical data was analyzed to determine the optimal tank size to maximize treatment of wastewater during high flow, wet-weather periods. The volume is constrained by cost, feasibility, and available space.

6.3 Tank Dimensions and Material

The final tank is 3-million-gallon circular tank that will hold a maximum of approximately 2.7 million gallons. The radius of the tank is 80 ft. This is as large as the tank footprint can be without risking encroachment on the surrounding paths and objects. The tank height is limited to 20 ft to maintain accessibility to maintenance crews. The 2.7-million-gallon capacity allows the tank to meet the optimal tank volume determined using the storage models. The wall thickness of 1.5 ft is standard for a concrete tank of this size. The full tank parameters are listed in the following table. The tank was chosen to be constructed from precast concrete based on the results of the alternative analysis. Tank dimension calculations are shown in ***Appendix C***.

Table 5. Recommended Tank Design

Tank Parameter	Length (ft)
Radius	80
Material Height	20
Max Water Height	18
Wall Thickness	1.5

6.4 Tank Site Layout

The location of the backwash storage tank depended upon several factors. These included the hydraulics, proximity to buildings, soil type, and desires of the client. Western Branch WRRF has a few open, relatively flat areas suitable for new construction that were considered for the site of the tank.

The soil at the wastewater treatment plant property was determined to be suitable for new construction [16]. Further geotechnical investigation is required to determine foundation design for the tank and whether the chosen location is practical in application.

The final location was selected due to the clear, available space, and for the proximity to both the filters and the influent pump station. Additionally, the elevation difference between the filters, tank, and influent station will necessitate only one set of pumps. The selected location of the tank is shown in ***Figure 10***. Since this location is on top of the current abandoned clarifier, demolition of the existing backwash tank is required.

Figure 10. AutoCAD Drawing with Location of the New Backwash Tank

6.5 Recommended Hydraulic Design

The hydraulic design entails first sending filter backwash water by gravity down to the backwash pump station sump; second, pumping it up to the above ground storage tank; lastly, allowing it to flow by gravity during low flow periods to the influent pump station wet wells. A model of the system, shown in ***Figure 11***, was created in AFT Fathom, a hydraulic modeling software. The filters, backwash sump below the pumps, storage tank, and influent wet wells were modeled as reservoirs. This model includes pipes, fittings, and the pumps.

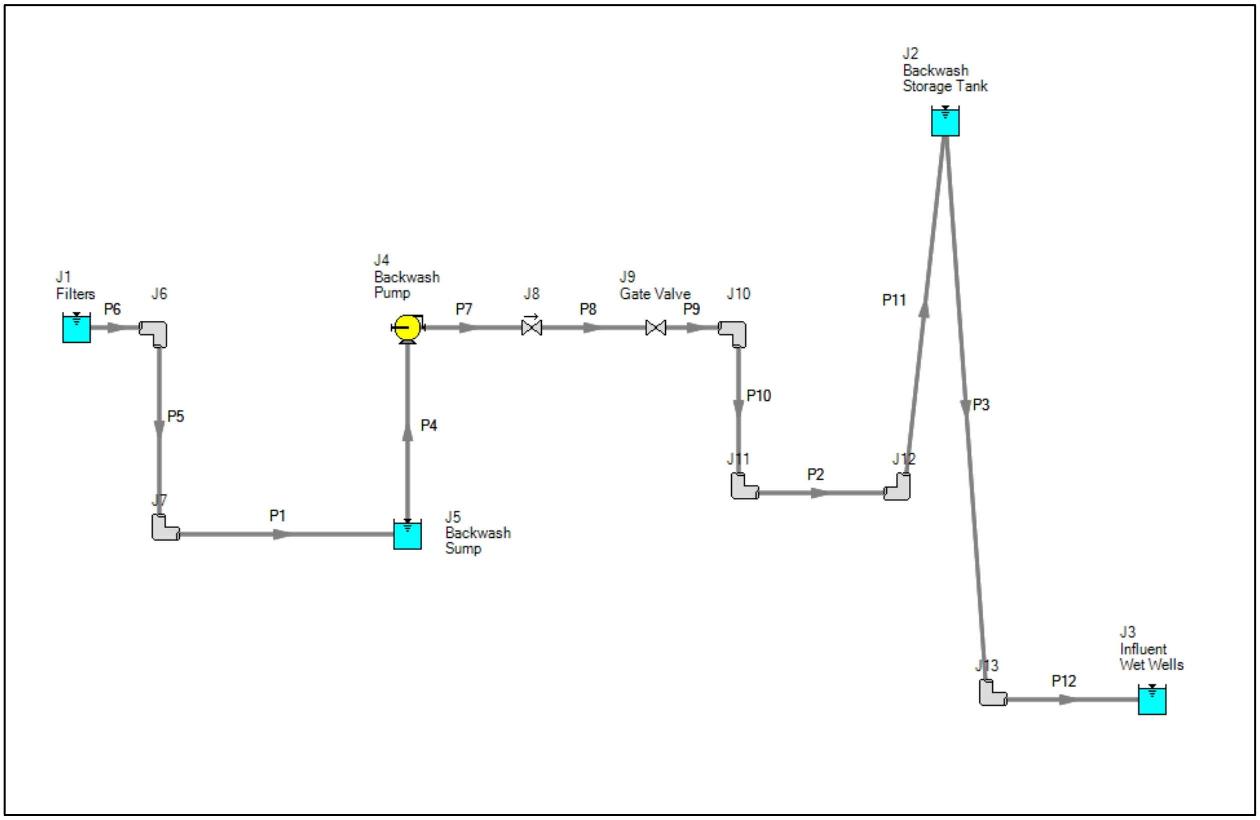

Figure 11. Hydraulic Model in AFT Fathom

The total dynamic head was calculated as detailed in ***Appendix C*** for the low and high backwash flowrates, shown below in ***Table 6***. Vertical turbine model pumps were selected as a replacement in kind of current pumps in order to continue to utilize the sumps located in the existing backwash pump station. Based upon the TDH calculations, the pumps were sized as shown in ***Table 6*** with the assistance of an equipment representative. Two pump models were selected: one to handle low flowrates and one to handle high flow rates. The control strategy assumes that during the period of high flow rate, the low flow rate pump would be switched out for the high flow rate one. Pumps were assumed to be ordered in duplicate (one duty and one standby). Pump quotes, including pump curves and cut-sheets are attached in ***Appendix E***. It is also of note that the client has suggested a cost saving alternative; namely, purchasing vertical turbine pumps (one duty and one standby) with Variable Frequency Drives (VFDs), which would be able to handle both the low and high flow rates.

Table 6. Pump Requirements Calculated with High and Low Flow Rates

Flow rate (GPM)	**Total Dynamic Head (FT)**	**Pump Driver Horsepower (HP)**	**Pump Speed (RPM)**	**Pump Quantity**
12,000	40.3	200	880	2
6,500	28.3	100	1180	2

6.6 Hydraulic Profile

A hydraulic profile of the hydraulic grade line was created using Microsoft Excel. This hydraulic grade line shows the total dynamic head in feet from the filters to the backwash storage tank for both the low and high flow rates. Pipes were assumed to be buried below ground.

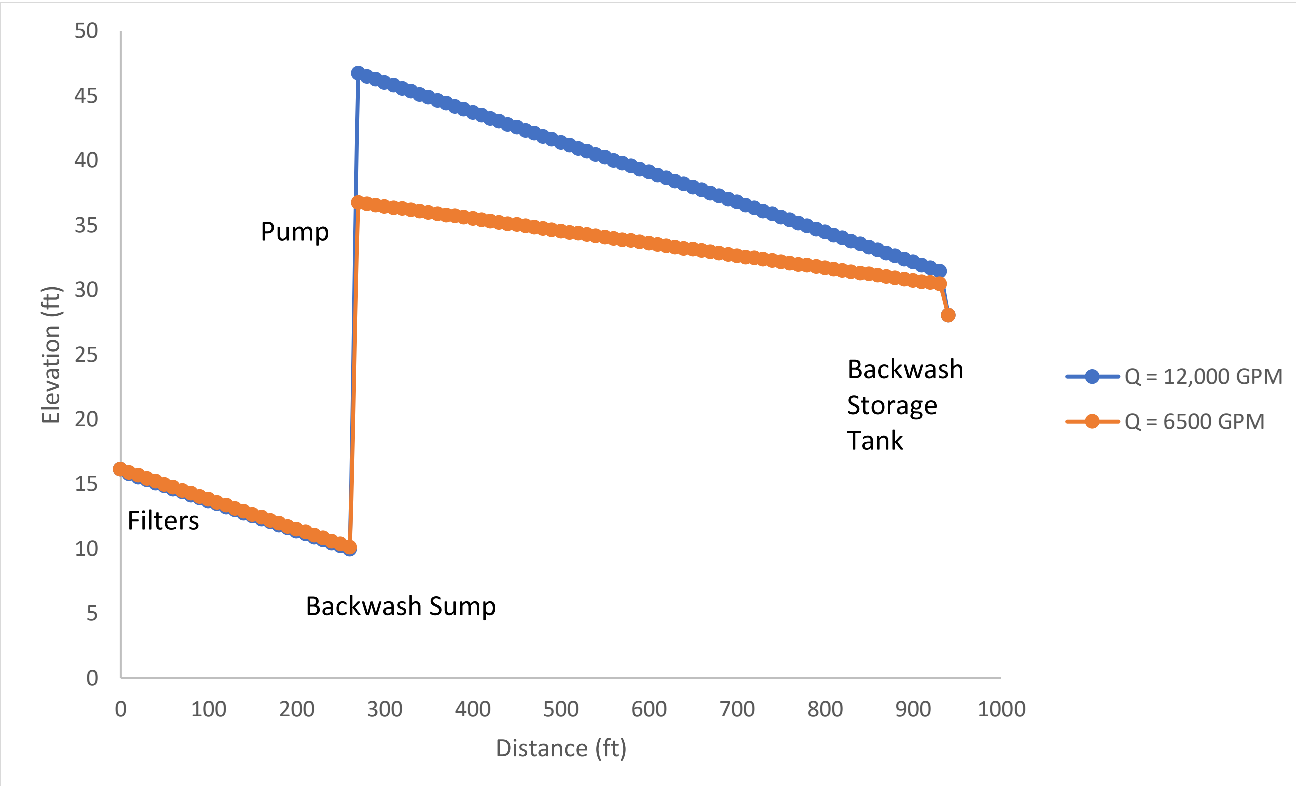

Figure 12. Hydraulic Grade Line from the Filters to the Tank

6.7 Solids Handling

The design team recommends design of a tank with solids that could be periodically removed from the bottom and pumped back to the influent wet well. Since the dirty backwash water would only stay in the tank for less than a day, the solids would remain suspended in the water, dependent on their size, settling velocity, and other properties. The solids that remained suspended in the water in the tank would travel back to the influent pump station when the water was released from the tank. Any solids that do settle would be rinsed out. During periods of low flow, where the backwash storage tank was not needed, the tank could be rinsed with hoses periodically. This rinsing could be done manually, or through water nozzles installed within the tank.

Section 7. Cost Estimation

Table 7. Cost Estimates of Major Components Included in Design

Category	**Item**	**Number**	**Unit Cost**	**Total Cost**
Tank				
	Precast 3 MG tank	1	$977,000.00	$977,000.00
Pumps				
	High Flow Pump	2	$196,315.00	$392,630.00
	Low Flow Pump	2	$121,664.50	$243,329.00
	Instrumentation and Electrical			$139,910.98
Construction				
	Equipment installation			$322,591.80
	Demolition of existing tank			$30,000.00
Labor				
	Routine maintenance	20 years		$246,358.45
Total Cost				$2,351,820.23

The largest cost of the project is the tank, which would be a precast, round concrete tank without a roof. The cost of a cast in place tank or a tank with a roof would have been significantly greater. An alternative tank, based on concrete costs provided by RK&K Civil Engineering, would have been about twice the cost (***Appendix C***). The second largest cost in the project is the pumps. Four pumps are required to provide adequate power to pump both the high and low flows during the backwashing and to provide a backup if one pump was out of service. The labor costs were calculated over twenty years, based on $75 per hour in labor and overhead and 244 hours per year in maintenance. A 5% discount rate was used to determine the net present value over the time period.

Costs of construction were provided by RK&K Civil Engineering. Equipment installation represents 20% of the equipment cost. The pump instrumentation/electrical cost is based on 22% of the pump cost. The tank demolition cost is for the removal of the abandoned clarifier, which is located at the site shown in ***Figure 2***.

Section 8. Preliminary Schedule

The preliminary schedule for the design proposed in this report is displayed in the Gantt chart in ***Figure 13***. The phases of the full design process include the design and permitting phase, the bid phase, pre-construction, construction, and post-construction. The specific timescales were developed according to WSSC Water's practices. A notable part of design process is obtaining necessary permits for erosion and sediment control, stormwater management, and construction. These permitting processes can increase the time it takes before the design phase can be completed. Because the storage tank is pre-cast concrete, the pre-construction primarily consists of the pouring and manufacturing of the tank components off-site. Importantly, testing and analysis of any in-place infrastructure such as the existing pipes to be used in the new system must take place prior to construction. Another construction step that must occur is the demolition of the existing clarifier on the planned site, which must take place before the tank can be installed. The post construction steps included show the time for substantial completion, which is the period where the treatment plant operators test and ensure the completed project is functional and compliant with the design. Prior to final completion, necessary corrections requested by the operators must be completed. From the start of design to the completion of construction will be more than 3 years; including final completion, it will take more than 4 years.

TASK NAME	START DATE	END DATE	DAYS
Design			
Design Phase	6/5/21	12/2/21	180
Begin Design	6/1/21	6/1/21	0
30% Design Submittal	6/1/21	7/31/21	60
60% Design Submittal	7/31/21	9/9/21	40
90% Design Submittal	9/9/21	10/19/21	40
100% Design Submittal	10/19/21	11/13/21	25
Final Approval	11/13/21	11/28/21	15
Design			
ESC Permitting	6/1/21	3/28/22	300
Stormwater Man.	6/1/21	3/28/22	300
Construction Permitting	6/1/21	11/23/22	540
Bid Phase			
Bid Phase	11/23/22	5/22/23	180
Pre-Construction			
Existing Infra. Testing	5/22/23	6/6/23	15
Material Lead Times	5/22/23	6/6/23	15
Precast Fabrication	6/6/23	7/21/23	45
Manufacturing	7/21/23	8/25/23	35
Precast Cure	8/25/23	9/4/23	10
Construction			
Mobilization	9/5/23	9/7/23	2
Existing Tank Demolition	9/7/23	9/27/23	20
Site Clearing & Excavation	9/27/23	10/17/23	20
Sump Pour	10/17/23	11/1/23	15
Base Pour	11/1/23	12/31/23	60
Slab Cure	12/31/23	1/30/24	30
Exterior Walls Installation	1/30/24	3/30/24	60
Grout Tension and Seal	3/30/24	5/29/24	60
Pump Installation	5/29/24	8/27/24	90
Post-Construction			
Substantial Completion	8/27/24	8/27/25	365
Final Completion	8/27/25	10/11/25	45

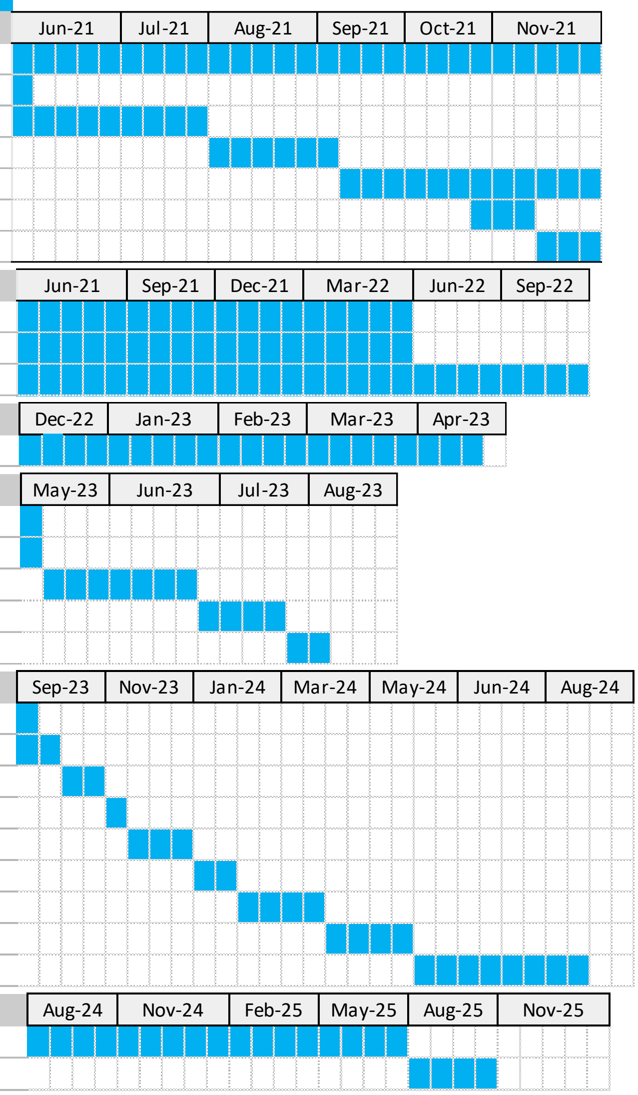

Figure 13. Proposed Schedule for Different Phases of the Project

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Appendix B. Acknowledgements

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Appendix C. Design Calculations and Model Outputs

C.1 Hydraulics: Pipe Sizing Calculations

C.1.1 Pipe Velocity Equations

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

$$A = \frac{\pi}{4}D^2$$

$$v = \frac{Q}{\frac{\pi}{4}D^2}$$

v = Velocity
Q = Flow rate
A = Cross sectional area of the pipe
D = Diameter of the pipe

C.1.2 Pipe Velocity Design Parameters

Table A-1 shows the backwash flow rates photographed from the Western Branch SCADA screen controls.

Table A-1. Western Branch Backwash Flow Parameters

Name	**Flow Setpoint (GPM)**	**Preset Time (Minutes)**
Low Backwash Setpoint	6500	2
High Backwash Setpoint	12000	12
Post Backwash Setpoint	6500	2

Pipe diameter was assumed to be 2' according to the information provided in the record drawings.

$$D = 2\,ft$$

$$Q_{low} = 6500\,GPM = 14.5\frac{ft^3}{s}$$

$$Q_{high} = 12000\,GPM = 26.7\,\frac{ft^3}{s}$$

C.1.3 Pipe Velocity Outputs

$$v_{low} = \frac{14.5}{\frac{\pi}{4}(2)^2} = 4.6\frac{ft}{s}$$
$$v_{high} = \frac{26.7}{\frac{\pi}{4}(2)^2} = 8.5\frac{ft}{s}$$

Table A-2. Maximum Pipe Velocities in Water Systems [8]

Application	**Maximum Velocity**	
	m/s	**ft/s**
General Water Service	0.9-2.4	3-8
Tap water (low noise)	0.5-0.7	2.6-2.3
Tap water	1.0-2.5	3.3-8.2
Cooling Water	1.5-2.5	4.9-8.2
Suction boiler feed water	0.5-1.0	1.6-3.3
Discharge boiler feed water	1.5-2.5	4.9-8.2
Condensate	1.0-2.0	3.3-6.5
Process Water	1.5-3	5-10
Pump discharge	1.5-3	5-10
Pump suction	0.9-2.4	3-8
Heating circulation	1.0-3.0	3.3-9.8

C.2 Hydraulics: Pump Sizing Calculations

C.2.1 Total Dynamic Head Equations

Hydraulic calculations were performed to estimate total dynamic head based on static head, major losses in the pipe, and minor losses due to fittings between the pipe leaving the backwash pump station sump and the pipe entering the top of the backwash storage tank. The total dynamic head was calculated for the low and high backwash flowrates using the energy equation, shown below.

$$\left(\frac{P_{sump}}{\gamma} + z_{sump} + \frac{v_{sump}^2}{2g}\right) - \left(\frac{P_{tank}}{\gamma} + z_{tank} + \frac{v_{tank}^2}{2g}\right) = h_f + h_{f,fitting} - h_{pump}$$
$$P_{sump} = P_{tank} = P_{atm} = 0$$
$$v_{sump}A_{sump} = v_{tank}A_{tank}$$
$$A_{sump} = A_{tank}$$
$$v_{sump} = v_{tank}$$
$$h_{pump} = \left((z_{tank} - z_{sump}) + h_f + h_{f,fitting}\right)$$

P = Pressure
z = Elevation

v = Velocity
h_f= Major head loss
$h_{f,fitting}$ = Minor head loss
h_{pump}= Total dynamic head across the pump

C.2.2 Pipe Lengths

The existing pipe lengths were estimated to be 1000 ft total. Google Earth's measuring tool was used to approximate the pipe lengths, as shown in ***Figure A-1*** and ***Figure A-2***.

Figure A-1. Pipe Distance From Filters to Pumps

Figure A-2. Pipe Distance From Pumps to Tank

C.2.3 Elevations

Elevations were determined using both information from the Western Branch record drawings, shown in ***Table A-3*** and from the MD iMAP Topography Viewer, which is an interactive GIS map in ***Figure A-3***.

Table A-3. Record Drawings Elevations

Structure	**Elevation (ft)**
Water Level in Filters	16
Low Water Level in Sump	5.5

Figure A-3. MD iMAP Topography Viewer Elevations [9]

Table A-4. MD iMAP Topography Viewer Elevations [9]

Structure	**Ground Elevation (m)**	**Elevation (ft)**	**Pipe Distance from Filters (ft)**
Filters	4.92	16.13	0
Pump	4.37	14.3	273
Storage Tank	3.39	11.1	1000

Figure A-4 was created to model the change in elevation from the filters to the location of the new backwash storage tank using the data from ***Table A-4***.

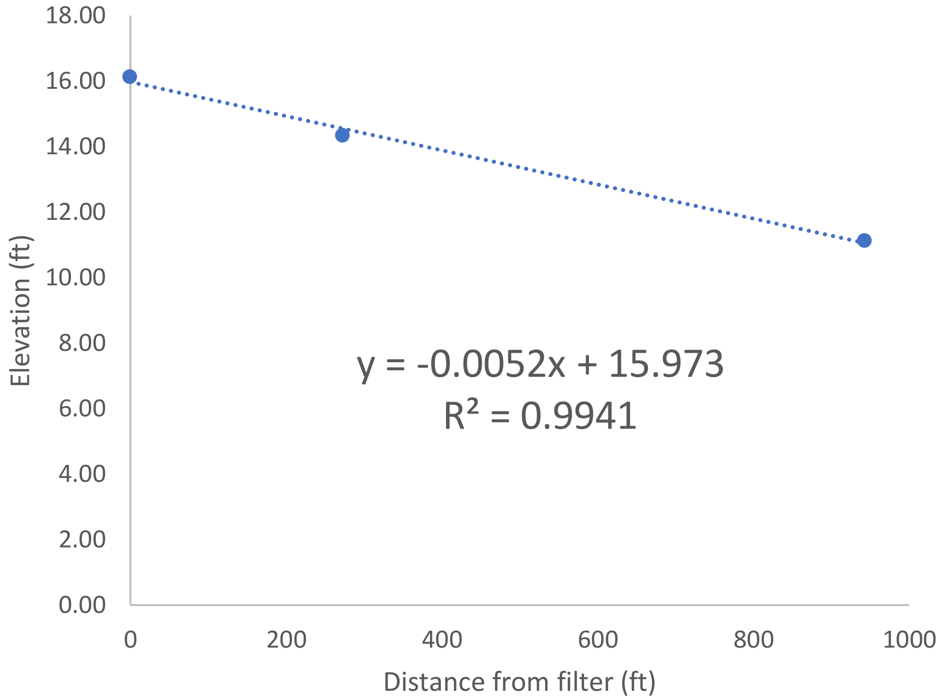

Figure A-4. Ground Elevation From the Filters to the Tank

The elevation of the high water level in the storage tank was the elevation of the ground, minus 3 feet to account for burying the tank below the frost line, plus 18 feet of maximum water in the storage tank.

$$z_{tank} = 13ft - 3\ ft + 18\ ft = 28\ ft$$

Thus, the change in elevation used for the total dynamic head calculation was found as follows.

$$z_{tank} - z_{sump} = 28 - 5.5 = 22.5\ ft$$

C.2.4 Major Loss

In order to calculate major loss, two methods were compared: using the Darcy-Weisbach equation and the Hazen Williams equation.

The Darcy-Weisbach equation is shown below.

$$h_f = f\frac{L}{D}\frac{v^2}{2g}$$

f = f(Re, ε/D) the Moody friction factor
D = Diameter of the pipe = 2 ft
L = Length over which the pressure drop occurs = 1000 ft

ε = Roughness factor for the pipe = 0.06 in (Ductile Iron pipe according to Sanks, Pumping Station Design)

$$Re = \frac{vD\rho}{\mu} = \frac{8.5 \times 2 \times 1.938}{2.359 \times 10^{-5}} = 1.4 \times 10^{6}$$

ρ = 1.938 lbf-sec^2/ft^4
μ = 2.359x10^{-5} lbf-sec/ft^2 (assuming water temperature = 15°C)

$$\frac{\varepsilon}{D} = \frac{0.06}{24} = 2.5 \times 10^{-3} = 0.0025$$

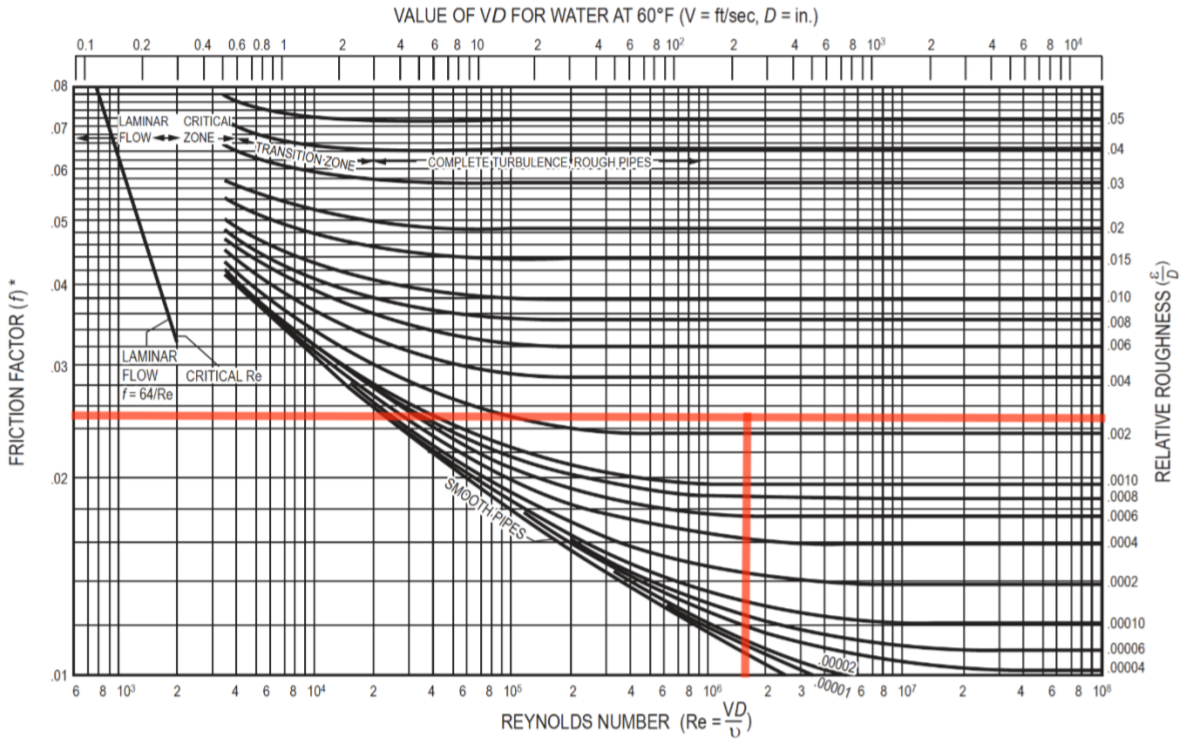

Figure A-5. Moody Diagram for Flow in Closed Conduits

$$h_{f,low} = 0.025 \times \frac{1000\ ft}{2\ ft} \times \frac{(4.6\ ft/s)^2}{2 \times 32.17\ ft/s^2} = 4.2 \text{ ft}$$

$$h_{f,high} = 0.025 \times \frac{1000\ ft}{2\ ft} \times \frac{(8.5\ ft/s)^2}{2 \times 32.17\ ft/s^2} = 14.3 \text{ ft}$$

The second method used to calculate major head loss was the Hazen Willliams equation for a circular pipe expressed as a head loss.

$$h_f = \frac{4.73L}{C^{1.852}D^{4.87}}Q^{1.852}$$

h_f = head loss (ft)

L = pipe length (ft)
D = pipe diameter (ft)
Q = flow (cfs)
C = Hazen-Williams coefficient = 110 (between 5- and 20-year-old pipe as specified in the Fundamentals of Engineering handbook)

$$h_{f,low} = \frac{4.73 \times 1000}{110^{1.852} \times 2^{4.87}} \times 14.5^{1.852} = 3.8\ ft$$

$$h_{f,high} = \frac{4.73 \times 1000}{110^{1.852} \times 2^{4.87}} \times 26.7^{1.852} = 11.9\ ft$$

Since the Hazen Williams equation is more often used in design, this method was selected over the Darcy Weisbach method to determine major loss, in ***Table A-5.***

Table A-5. Major Head Loss

Flow Rate Type	**Head Loss (ft)**
Low	3.8
High	11.9

C.2.5 Minor Loss

$$h_{f,fitting} = \frac{Kv^2}{2g}$$

K = Sum of fitting loss coefficients

This design team assumed the following fittings in ***Table A-6***, as determined from the Western Branch record drawings.

Table A-6. Fittings

Item	**Quantity**	**K** [11]
90° Flanged Regular Bend	6	0.3
Coupling	15	0.08
Gate Valve	1	0.2
Check Valve	1	2

$$K = \sum K_i = 6(0.3) + 15(0.08) + 1(0.2) + 1(2) = 5.2$$

$$h_{f,fitting,low} = \frac{Kv^2}{2g} = \frac{5.2 \times (4.6)^2}{2(32.17)} = 1.9\ ft$$

$$h_{f,fitting,high} = \frac{Kv^2}{2g} = \frac{5.2 \times (8.5)^2}{2(32.17)} = 5.9\ ft$$

Table A-7. Major Head Loss

Flow Rate	**Head Loss (ft)**
Low	1.9
High	5.9

C.2.6 Total Dynamic Head Design Calculations

$$h_{pump,low} = \left((z_{tank} - z_{sump}) + h_{f,low} + h_{f,fitting,low}\right) = 22.5 + 11.9 + 5.9 = 40.3\ ft$$
$$h_{pump,low} = \left((z_{tank} - z_{sump}) + h_{f,high} + h_{f,fitting,high}\right) = 22.5 + 3.8 + 1.9 = 28.3\ ft$$

C.3 Filter Backwash Volume Storage Model Assumptions and Equations

C.3.1 Backwash Storage Event Percentiles:

Inputs:

Consecutive Hours Bypassed – The number of consecutive hours the influent wet well level was > 160" for the 1yr of Wet Well Level Data, for each instance where the North Sensor showed the wet well level > 160".

Backwash (BW) Rate (BW/hr)– The Rate at which the filters backwash is assumed to be the 99^{th} percentile value for backwashes per hour calculated from daily backwash flows. This assumes that the backwash flow during overflow events is equal to the rate when the plant is at capacity. (0.8465 BW/hr)

BW Volume (Gal/BW) – The amount of water sent to the backwash storage tank per backwash.

Table A-8. Backwash Storage Event Percentile Model Inputs

BW Rate (BW/hr)	**BW Volume (gal/BW)**
0.8465	170,000

Outputs:

BW Storage Required (MG) – The product of the Hours Bypassed, Backwash Rate, and Backwash Volume is the Backwash Storage Required for a period where the filters are bypassed. For the entire dataset of overflow events, the 9xth percentile data point is the recommended size of the storage tank.

Calculation:

$$BW\ Storage\ Required\ (MG) = Time\ Bypassed\ (hr) \times BWRate\ \left(\frac{bw}{hr}\right) \times Water/BW\ (\frac{MG}{bw})$$

C.3.2 Backwash Storage Simulation:

Inputs:

Wet Well Level (WWL) (ft) (hourly) – The level of the influent, at the influent pump station. If the level is > 160’, the filters are bypassed.

WWL > 160’ – 0 if false (filters operating), 1 if false (filters bypassed)

BW Rate Overflow Cond. (BW/hr)– The rate at which the filters backwash is assumed to be the 99th percentile value for backwashes per hour calculated from daily backwash flows. This assumes that the backwash flow during overflow events is equal to the rate when the plant is at capacity.

BW Rate Normal Cond. (BW/hr) – The rate at which the filters are backwashed during normal levels of flow is assumed to be the mean value for backwashes per hour calculated from daily backwash flows. This assumes that the backwash flow during overflow events is equal to the rate when the plant is operating normally.

Storage Outflow Rate (MG/hr) – The rate at which water flows from the backwash storage tank. This rate is assumed to be constant as there is no flow from the storage tank during overflow conditions. The rate is calculated from the 99th percentile value for backwash flow per hour because this is the rate at which the plant at capacity can return backwash without creating overflow conditions. *Variation: During periods of frequent wet weather*

BW Volume (MG/bw) – The amount of water sent to the backwash storage tank per backwash. (0.170 MG/bw)

$\Delta t = 1$ hour

Table A-9. Backwash Storage Event Percentile Model Inputs

BW Rate (BW/hr)	
Normal Flow	High Flow
0.5208	0.8465

Outputs:

- Backwash Storage Required (Function of Time) (MG)
- Maximum Backwash Storage (MG)

Calculation:

$$At\ t\ =\ 0:\ (Assume\ Normal\ Cond.)$$

$$BW = Avg\ BW\ Rate \times BW\ Vol. - Storage\ Outflow\ Rate$$

$At\ t > 0:$

$$IF\ Under\ Normal\ Conditions\ (WWL < 160'):$$
$$BW\ Storage\ (t) = BW\ Storage\ (t-1) + Normal\ BW\ Rate \times BW\ Vol. - Storage\ Outflow\ Rate$$

$$IF\ Under\ Overflow\ Conditions\ (WWL > 160'):$$
$$BW\ Storage\ (t) = BW\ Storage\ (t-1) + Overflow\ BW\ Rate \times BW\ Vol.$$

C.4 Tank Sizing

2-foot-thick base
1.5-foot wall thickness
Circular tank: Was found to be cheaper for the same volume to build a circular tank than a rectangular one
3-million-gallon tank
20 foot tall

Conversion of volume in gallons to cubic feet

$$1gallon = 0.133681\ ft^3$$
$$3000000\ gal \times \frac{0.133681\ ft^3}{1\ gal} = 401043\ ft^3$$

Calculation of radius and area of base considering a 20-foot height:

$$footprint\ area = \frac{volume}{height}$$
$$footpint\ area = \frac{401043}{20} = 20052.15$$
$$radius = \sqrt{\frac{footprint}{\pi}}$$

$$radius = \sqrt{\frac{20052.15}{\pi}} = 79.89\ ft \approx 80\ ft$$
$$diameter = 160\ ft$$

Tank wall thickness=1.5ft

$$Base\ volume = thickness \times \pi(radius + 2)^2$$
$$Base\ volume = 2\pi(80 + 1.5)^2 = 41734.5\ ft^3$$
$$Wall\ volume = height \times \pi((radius + wall\ thickness)^2 - radius^2)$$
$$Wall\ volume = 20\pi((80 + 1.5)^2 - 80^2) = 15221.0\ ft^3$$

Conversion of cubic feet to cubic yards

$$1yd^3 = 27ft^3$$

$$Base\ volume = \frac{41734.5\ ft^3}{27\ ft^3/yd^3} = 1545.7\ yards$$

$$Wall\ area = \frac{15221.0\ ft^3}{27\ ft^3/yd^3} = 563.7\ yards$$

C.5 Solids Handling Calculations

Equation to convert measured values in NTUs to mg/L based on a single sample which was analyzed in a university lab:

$$\frac{NTU}{32.4} = \frac{mg/L}{851}$$

Equation to estimate total solids contained in a backwash:

$$total\ solids = \sum_{i=1}^{n}(t_i - t_{i-1})(s) \times turbidity_i\left(\frac{mg}{L}\right) \times flow\ rate_i\left(\frac{L}{s}\right)$$

Table A-10. Measurements Calculated to Determine the Total Solids Present in a Single Backwash, Based on Conversion From NTU to mg/L

Time (s)	Time Interval t(i)-t(i-1) (s)	Flow Rate (L/s)	Turbidity (mg/L)	Total Solids (mg)	Total Solids (kg)
14	14	410.09	1074.26	6167525	6.168
90	76	410.09	851.00	26522728	26.523
159	69	757.08	806.35	42122577	42.123
242	83	757.08	751.19	47203217	47.203
311	69	757.08	365.09	19071786	19.072
373	62	757.08	253.46	11897247	11.897
438	65	757.08	130.80	6436802	6.437
507	69	757.08	103.75	5419680	5.420
567	60	757.08	87.73	3984971	3.985
629	62	757.08	65.14	3057531	3.058
694	65	757.08	53.32	2623837	2.624
755	61	757.08	47.54	2195512	2.196
817	62	757.08	62.25	2921915	2.922
876	59	410.09	56.47	1366313	1.366
				total:	180.992

The amount of solids calculated in this section may be an overestimation due to a high probability of errors in the drying and weighing of the solids. In order to provide a more accurate estimate of the total solids, the solids should be completely dried, and multiple samples should be taken.

C.6 Cost Estimation

Tank Cost Estimation

Using volumes calculated in ***C.4*** with at 1.5-foot-thick wall and 2-foot thick base:

$$Base\ Volume \times \frac{\$800}{yd^3} = Base\ Cost$$

$$1545.7 \times \frac{\$800}{yd^3} = \$1{,}236{,}577.41$$

$$Wall\ Volume \times \frac{\$1000}{yd^3} = Wall\ Cost$$

$$563.7 \times \frac{\$1000}{yd^3} = \$563{,}741.35$$

$$Total\ Cost = Wall\ Cost + Base\ Cost$$

$$\$1{,}236{,}577.41 + \$563{,}741.35 = \$1{,}800{,}318.76$$

Table A-11. Tank Options with Pricing

Tank	Cost
Dutchland Precast Without Roof	$977,000
Dutchland Precast With Roof	$1,900,000
DN Tanks	1,900,000-2,000,000
Estimate based on costs provided by RK&K Civil Engineering	$1,800,318.76

CWEA Design Contest		4/9/21				
Western Branch Filter Backwash Storage Tank Design						
				Labor costs ($/hour)*		$75
Estimate of labor requirements for routine operation & maintenance						
Task	Frequency		Hours	Hours / year		
Backwash Pumps						
Routine inspe	weekly		1	52		
Routine main	monthly		4	48		
Annual maint	annual		24	24		
Backwash Storage Tank						
Routine inspe	monthly		2	24		
Drain & Wash	quarterly		16	64		
Level sensors,	quarterly		8	32		
				244		
Estimated annual O & M labor costs				$18,300		
* Assumes an average hourly rate of $25 for operators. Includes a 3 multiplier to account for overhead (benefits; insurance etc.)						

Figure A-6. Estimated Operating Costs Provided by Client for Western Branch WRRF Backwash Tank and Pumps

Appendix D. Discharge Permit

Table A-12. Maximum Effluent Limits at Western Branch WRRF [6]

		Monthly Average Loading Rate	Weekly Average Loading Rate	Daily Average Loading Rate	Monthly Average Conc	Weekly Average Conc	Daily Average Conc
Effluent Characteristics		**Pounds/Day**	**Pounds/Day**	**Pounds/Day**	**mg/L**	**mg/L**	**mg/L**
BOD	4/1 to 10/31	2,300	3,500	N/A	9	14	N/A
	11/1 to 3/31	7,500	11,300	N/A	30	45	N/A
TSS		7,500	11,300	N/A	30	45	N/A
Total Ammonia							
Nitrogen as N	4/1 to 10/31	383	N/A	N/A	1.5	N/A	N/A
	11/1 to 3/31	1,124	N/A	N/A	4.4	N/A	N/A
Total Nitrogen as N	4/1 to 10/31	770	1,150	N/A	3	4.5	N/A

Table A-13. Maximum Effluent Limits at Western Branch WRRF [6]

	Total Monthly Loading Rate	Annual Maximum Loading Rate	Monthly Average Concentration
Effluent Characteristics	**Pounds/Month**	**Pounds/Year**	**mg/L**
TSS	REPORT	2,737,500	30
Total Phosphorus-P	REPORT	27,958	REPORT
Total Nitrogen-N	REPORT	372,776	REPORT

Appendix E. Equipment Cut-sheets

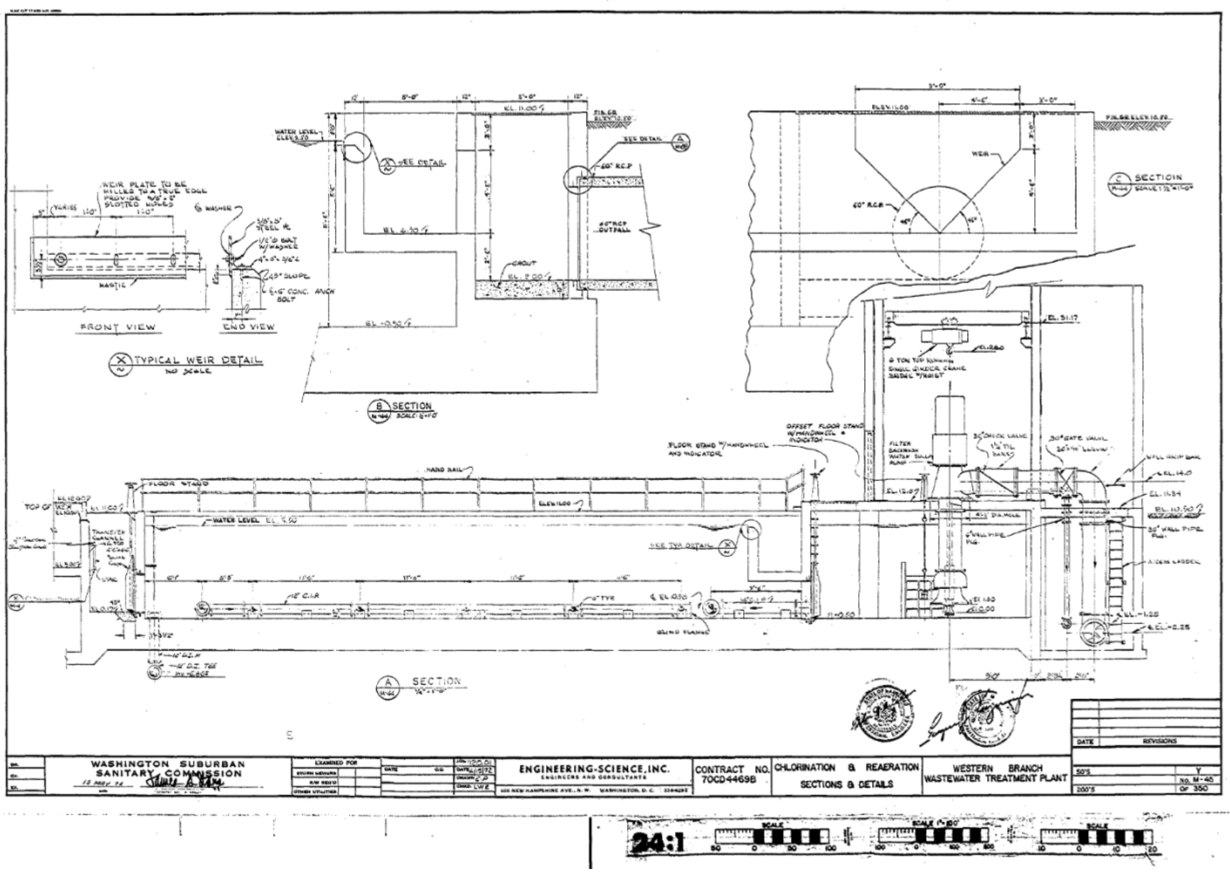

Figure A-7. Existing Backwash Pump Station Design from WSSC Water Record Drawings

Dutchland INCORPORATED

160 Route 41
Gap, PA 17527-9410

Phone 717.442.8282
Fax 717.442.9330

www.dutchlandinc.com

Specializing In Designing Manufacturing And Constructing

Waste Water Treatment Plants

Water Storage Tanks

Pumping Stations

Custom Precast Concrete Structures

B U D G E T A R Y   P R O P O S A L

March 12, 2021

Johns Hopkins University

ATTN: Annabel Mungan

RE: Backwash Storage Tank, Western Branch WSSC

Dutchland, Inc. manufactures various precast structures including, but not limited to, post-tensioned circular and rectangular concrete tanks to be used for potable water, wastewater storage, and wastewater treatment. We are pleased to offer the following proposal.

Proposal #E18039-1

Scope of Work Description:

Design, manufacture, deliver, and install the Water Storage Tank Structures. Tanks are to be installed onto a stone sub-base installed by others. All site work, site access, dewatering, and mechanical installation to be provided by others.

Design Assumptions and Standards:

1. Tank subgrade assumed to have an adequate soil bearing capacity and settlement values to support these structures with no ground or flood water conditions.
2. Tank structures are designed to Dutchland, Inc. Standard Specifications based on the latest AWWA D115 Standard.

CIRCULAR TANK OPTIONS:

C. **Inclusions:**

1. Cast-in-place reinforced concrete base slab with no slope in the basin floors.
2. Precast post-tensioned concrete walls with an 8" minimum thickness.
3. Precast post-tensioned concrete roof and roof support system.
4. Minimum compressive strength of CIP concrete shall be 4,000-PSI at 28-days.
5. Minimum compressive strength of precast concrete shall be 5,000-PSI at 28-days.
6. All reinforcement to be standard, non-epoxy coated.
7. Furnish and install base and wall joint sealant per Dutchland, Inc. design standards.
8. Onsite, third party, concrete testing for concrete installed by Dutchland, Inc.
9. All labor, material, and equipment necessary to pour bases and erect tank structures.
10. Provide shop drawings and calculations signed and sealed by a licensed Professional Engineer in the State of Maryland for Dutchland, Inc.'s scope of work.
11. Two-year limited structural warranty.

CIRCULAR OPTIONS SUMMARY TABLE					
Option #	**Description**	**Inside Diameter**	**Water Height**	**Total Volume (Gallons)**	**Total**
Option #1	Open Top Storage Tank	160’-0”	20’-0”	3,000,000	$977,000
Option #2	Covered Storage Tank	160'-0"	20'-0"	3,000,000	$1,900,000

Exclusions:

1. All site work related to access, excavation, excavation maintenance, shoring, sub-base preparation, dewatering, crane pads, delivery truck roads and pads, concrete delivery wash out areas/holes, and backfill of tank site.
2. Survey and layout work other than precast layout.
3. Dumpsters, sanitary stations, and any other temporary facilities.
4. Water, other than drinking water for employees of Dutchland, Inc.
5. Tank disinfection, waste water and water removal.
6. All cast-in materials and pipe penetrations.
7. All interior and exterior equipment and piping.
8. Sub-grade testing and tank leak testing.
9. All miscellaneous metal items including, but not limited to, access stairs, ladders, permanent and temporary handrail, permanent and temporary safety barricades, and grating and grating support.
10. Interior and exterior coatings, if required.
11. Taxes.

Thank you for allowing Dutchland, Inc. to be a part of this project.

Sincerely, Dutchland

SULZER

Pumps Equipment
Sulzer Pumps Solutions Inc.
140 Pond View Drive
Meriden 06450
UNITED STATES
Phone (203) 238-2700
Fax
www.sulzer.com

Chesapeake Enviromental Equipment
Attention
Forest Hill, MD 21050
Forest Hill, Maryland 21050
UNITED STATES

Contact	Ron Derrick
Department / Unit	Application Engineer
Phone	
Mobile phone	
E-mail	Ron.Derrick@sulzer.com
Date	12 Apr 2021

BUDGET QUOTATION

Project: Filter Backwash Storage for WSSC
Inquired at:
SULZER-Reference: USA.2323-NWW.21.2323-B0
Revision: 0

Dear ,

Thank you for your above referenced inquiry. We are pleased to submit our quotation, which is based on the technical and commercial information attached hereto.

We are confident you will find our quotation in line with your requirements. In case you have any questions, please do not hesitate to contact us.

Yours Sincerely
Sulzer Pumps Solutions Inc.

Umer Beg	Ron Derrick
Regional Manager	Application Engineer

SULZER

SCOPE OF SUPPLY:	This proposal is strictly limited to what is described in the Scope of Supply, Price Summary Page and Data Sheets. Any additional requirements of equipment, components, accessories, tests, services or documentation will be subject to Sulzer's review and approval and may require modifications to price and/or delivery schedule.
VALIDITY:	This proposal is valid for a period of 30 days from and including TODAY'S DATE.
PRICE:	The price quoted is for all items purchased at one time.
PAYMENT TERMS:	Net 30 days.
TERMS OF DELIVERY:	Terms of Delivery shall be FCA - Factory per INCOTERMS® 2020 on the date of the Purchase Order as published under the name "Incoterms" by the International Chamber of Commerce.
DELIVERY TIME:	The time of delivery shall be from complete order including but not limited to, all technical specifications, motor information and shipping instructions. During the tender validity period Sulzer reserves right to reasonable extension of the time of delivery considering available manufacturing capacity. The exact time of delivery shall be determined with the Purchaser at the time of order.
WARRANTY:	12 months from commissioning or 18 months from shipment whichever is the sooner.
COMMISSIONING AND START UP SERVICE:	Not included.
QUALITY-STANDARDS:	All our manufacturing locations are ISO 9001-2000 certified.
ORIGIN OF THE PUMPS:	Seller is a global company that sources from a supply chain consisting of its own factories and foundries, and those of its qualified subsuppliers. Pricing and delivery offered in this proposal are based upon the use of Seller's qualified global supply chain, including specific subsuppliers listed below, if any. Seller reserves the right to substitute, at its sole discretion, any subsupplier and material specified in this proposal with similarly qualified sources and suitable material based on conditions at the time of actual purchasing.
TERMS AND CONDITIONS:	Our standard terms and conditions are attached.

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Customer Price Sheet 2

Customer	Chesapeake Enviromental Equipment	Sulzer Reference ID	USA.2323-NWW.21.2323-B0
Project Name		Inquiry Date	
Inquiry Number/ID		Bid Submitted Date	
Item number	High Flow	Date last saved	12 Apr 2021 9:15 AM
Application	Not specified	Type / Size / Stages	JM-20PS-6V / 1
Pump speed	880 rpm		

Totals

Grand Total	USD 392,630	Lead Time Total	N/A

Pump

Qty	Description
2	*JM-20PS-6V 1 stage(s)* *Wet pit pump* *Head measured at CL discharge* *Product Lubrication* *TPL: 21.31 ft*
	Manufacturing Locations
	Locations (Booking company: SPSI)
1	Bowl Casting Source: Global Sourcing
	Material Class
1	Material Class: Material Class CI-BZ
	Bowl Assembly
2	Bowl Assembly Model: JM-20PS-6V 1 Stages
	Series Stage Bowl Material: Cast Iron
	Series Stage Impeller Material: AL Bronze
	Case Liner: AL Bronze
	Bowl Bearing: Bronze
	Bowl Bearing: Bronze
	Pump Shaft: 12% Chrome
	Pumpshaft Split Ring: Pumpshaft Split Ring [Per Material Class Spec]
	Pumpshaft Sleeve Coupling: 12% Chrome
	Pumpshaft Key: Pumpshaft Key [Per Material Class Spec]
	Pumpshaft Retaining Ring: Pumpshaft Retaining Ring [Per Material Class Spec]
	Suction Bell: Cast Iron
	Bell/Bowl Bolting: [Per Material Class Spec]
1	Bolting, 316SS
	Suction Bell Bearing: Bronze
	Suction Strainer: None
	Impeller Key, Split Ring, Bolting [Per Material Class Spec]
	Impeller Retainer :: Impeller Retainer [Per Material Class Spec]
	Impeller Balancing Criteria: Dynamically Balanced Impellers [ISO 1940 G2.5 (8 W/N)]
	Bowl Shaft Coatings: None
2	Catalyst Cured Epoxy
	Column Assembly
	Column Assembly: Length 18.56 ft.
	Column Taper/Adapter: 15 In. taper/adapter
	Column Pipe Material: Carbon Steel
	Column Selection
1	Column Selected 120 In. (Qty 1 per pump)
1	Column Selected 60 In. (Qty 2 per pump)
	Max Bearing Spacing: 120 in.
	Column Diameter: 24 in
	Column Wall Thickness: 0.375 in.

Pump

Qty	Description
	Column Connection Type: Flanged
	Lineshaft Lubrication: Product Lubrication
	Lineshaft Diameter: 1.50 in.
	Lineshaft Material: 17-4 PH
	Lineshaft Bearing Material: Cutless Rubber
	Threaded Coupling: 17-4 PH
	Bearing Retainers: Integral Retainers
	Column Bolting: Hex Hed Screw [Per Material Class Spec]
2	Bolting, 316SS
2	Column Coating: Catalyst Cured Epoxy:Carboline 891
	Discharge Head Assembly
	Discharge Head Type: JTAF Fabricated Discharge Head
2	Discharge Elbow Material: Carbon Steel
2	Discharge Head Riser Pipe & Driver Stand: Carbon Steel
2	Discharge Flange Diameter: 24 in
	Discharge Elbow Wall Thickness: 0.375 in.
2	Round Base: Carbon Steel
2	Lifting Eyes: Carbon Steel
2	Jacking Lugs: Carbon Steel
2	Coupling Guard: Aluminum
2	Discharge Head Bolting: [Per Material Class Spec]
2	Motor Base Diameter:
	Motor stand: None
2	Packing Box PlateCarbon Steel
	Headshaft Diameter: 1.50 in.
2	Discharge Headshaft Material: 17-4 PH
	Head Shaft Bearing: Bronze [C89835 Federalloy III]
	Head Shaft Couplings: Threaded Coupling
	Sole Plate Type: Standard Solepate
2	Standard Sole Plate: Carbon Steel [A36 and A53 Gr. B]
2	Stuffing Box Cast Iron
2	Discharge Head Coating: Catalyst Cured Epoxy:Carboline 891-Inside & Outside Diameter
2	Sole Plate Coatings: Catalyst Cured Epoxy:Carboline 891
	Buyout Components
	Driver Selection
	Driver Model: 449TP: 449TP
1	Driver Base Diameter: : 0.00 in
	Additional Driver Data: :
	Testing, Quality Inspections, Engineering Analysis
	Product Testing
	Non Witnessed Tests (Performance, Pump and Hydro)
1	Pump Performance Test
1	Hydro Test Bowl
1	Discharge Head Hydro Test
	Quality Inspections Processes
1	QI Material CMTR

Driver

Qty	Description
	Buyout Components
	Driver Selection
	Motor manufacturer: VHS NEMA Motor - User Defined
2	Selected Motor And Price: User Defined Motor
	Driver Manufacturer: NIDEC: NIDEC

Driver

Qty	Description
	Driver Enclosure: WP-1: WP-1
	Driver Shaft Type: Hollow shaft
	Driver Power: 200 HP
	Driver Speed: 880 RPM
1	Driver Voltage: 460 V
1	Driver Weight: 2,800.0 lb
1	Driver Height: 56.31 in

Pump Performance Datasheet

Customer	: Chesapeake Enviromental Equipment
Inquiry Number/ID	:
Item number	: High Flow
Service	: Backwash Pumps
Quantity	: 2
Sulzer Reference ID	: USA.2323-NWW.21.2323-B0
Type / Size	: JM-20PS-6V
Stages	: 1
Based on curve number	: SJM-112-006-64-11-10 Rev SJM-20PS-6V
Date of Last Update	: 12 Apr 2021 9:15 AM

Operating Conditions

Flow, rated	: 12,000.0 USgpm
Differential head / pressure, rated (requested)	: 40.30 ft
Suction pressure, rated / max	: 0.00 / 0.00 psi.g
NPSH available, rated	: Ample
Site Supply Frequency	: 60 Hz

Performance

Speed criteria	: Synchronous
Speed, rated	: 880 rpm
Impeller diameter, rated	: 12.56 in
Impeller diameter, maximum	: 13.62 in
Impeller diameter, minimum	: 11.89 in
Efficiency (bowl / pump)	: 83.80 / 82.04 %
NPSH (3% head drop) / margin required	: 25.87 / 2.00 ft
Submergence, minimum required	: 73.76 in
Ns (imp. eye flow) / Nss (imp. eye flow)	: 5,792 / 8,404 US Units
MCSF	: 4,914.7 USgpm
Head, maximum, rated diameter	: 78.39 ft
Head rise to shutoff (bowl / pump)	: 83.71 / 87.48 %
Flow, best eff. point (bowl / pump)	: 12,461.5 / 11,792.3 USgpm
Flow ratio, rated / BEP (bowl / pump)	: 96.30 / 101.76 %
Diameter ratio (rated / max)	: 92.20 %
Head ratio (rated dia / max dia)	: 97.05 %
Cq/Ch/Ce/Cn [ANSI/HI 9.6.7-2010]	: 1.00 / 1.00 / 1.00 / 1.00
Selection status	: Acceptable

Liquid

Liquid type	: Water
Additional liquid description	:
Solids diameter, max	: 0.00 in
Solids concentration, by volume	: 0.00 %
Temperature, rated / max	: 68.00 / 68.00 deg F
Fluid density, rated / max	: 1.000 / 1.000 SG
Viscosity, rated	: 1.00 cP
Vapor pressure, rated	: 0.34 psi.a

Material

Material selected	: Cast Iron Bowl, AL. Bronze Impeller

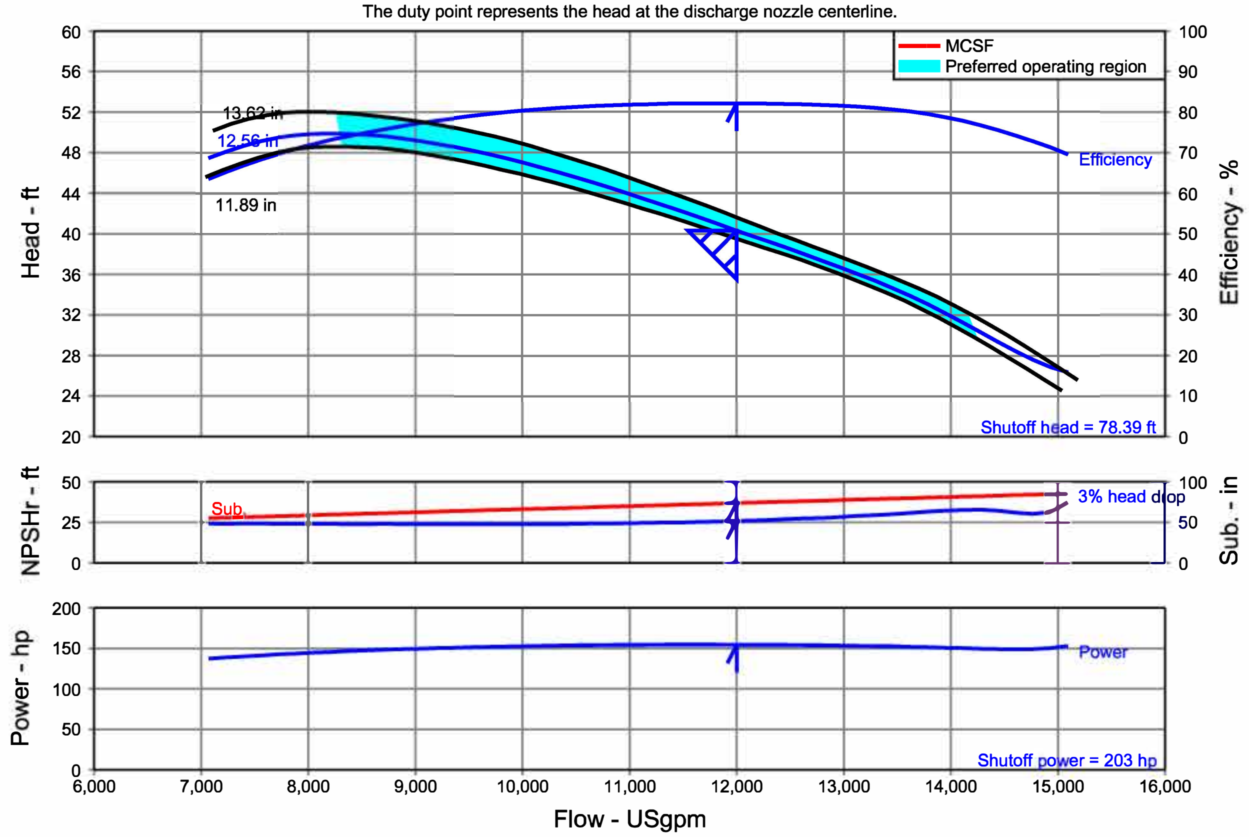
Pressure Data

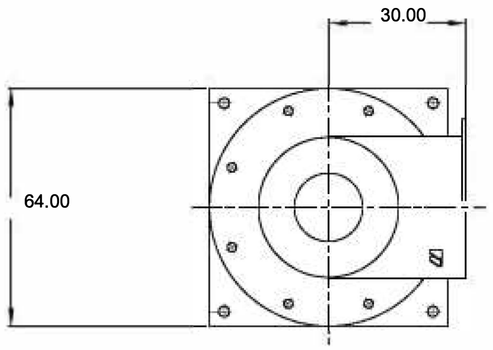
Maximum casing/bowl working pressure	: See the Additional Data page
Maximum allowable working pressure	: See the Additional Data page
Maximum allowable suction pressure	: 50.00 psi.g
Hydrostatic test pressure	: See the Additional Data page

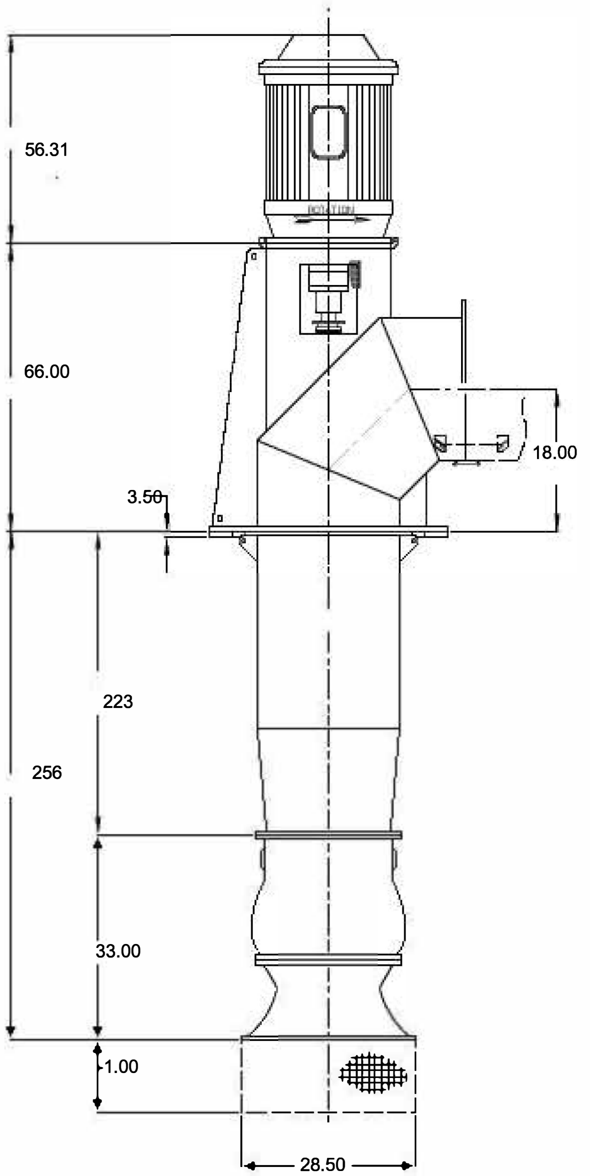
Driver & Power Data (@Max density)

Driver sizing specification	: Maximum power
Margin over specification	: 0.00 %
Service factor	: 1.00
Power, hydraulic	: 129 hp
Power (bowl / pump)	: 154 / 154 hp
Power, maximum, rated diameter	: 155 hp
Minimum recommended motor rating	: 200 hp / 149 kW

Pump performance. Adjusted for construction, viscosity, static lift to discharge nozzle centerline, friction and power losses of lineshaft and thrust bearings.
The duty point represents the head at the discharge nozzle centerline.







Pump Information	
Pump Size / stages	: JM-20PS-6V / 1
Discharge Head	: JTAF Fabricated Discharge Head
Discharge Nozzle	: 24 in / 150 # FF
Suction Nozzle	: N/A
Column	: Flanged, 24 in
Lineshaft	: 1.5 in. / Product Lubrication
Turndown	: N/A
Can Assembly	: N/A
Strainer	: None
Min Submergence	: 73.76 in
Coupling	: Threaded
Stuffing Box	: Standard
Motor Information	
Manufacturer	: N/A
Enclosure	: -
Type	: Vertical hollow shaft
Speed	: 880 RPM
Power / S.F.	: 200 hp / 1
Volt/Phase/Frequency	: 460 V / 3 / 60 Hz
Motor BD	: 0 in.
Equipment Weights (Approximate)	
Motor	: 2,800.0 lb
Discharge Head	: 4,150.0 lb
Column	: 2,456.4 lb
Baseplate	: 716.0 lb
Bowl Assembly	: -1.00 lb
Total	: 10,120.5 lb
Project Information	
Customer	: Chesapeake Enviromental Equipment
End user	: -
Project Name	: -
Country of Install	: -
Tender	: USA.2323-NWW.21.2323-B0
Curve Number	: -
Inquiry number	: -
Item number	: Item 1
Date last saved	: 12 Apr 2021
Certification	

Dimensions in , unless otherwise specified

NOTE : DO NOT USE FOR CONSTRUCTION UNLESS CERTIFIED

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Customer Price Sheet 2

Customer	Chesapeake Enviromental Equipment	Sulzer Reference ID	USA.2323-NWW.21.2323-B0
Project Name		Inquiry Date	
Inquiry Number/ID		Bid Submitted Date	
Item number	Low Flow	Date last saved	12 Apr 2021 9:48 AM
Application	Not specified	Type / Size / Stages	JM-16LS / 1
Pump speed	1180 rpm		

Totals

Grand Total	USD 243,329	Lead Time Total	N/A

Pump

Qty	Description
2	*JM-16LS 1 stage(s)* *Wet pit pump* *Head measured at CL discharge* *Product Lubrication* *TPL: 11.56 ft*
	Manufacturing Locations
	Locations (Booking company: SPSI)
1	Bowl Casting Source: Global Sourcing
	Material Class
1	Material Class: Material Class CI-BZ
	Bowl Assembly
2	Bowl Assembly Model: JM-16LS 1 Stages
	Series Stage Bowl Material: Cast Iron
	Series Stage Impeller Material: AL Bronze
	Case Liner: AL Bronze
	Bowl Bearing: Bronze
	Bowl Bearing: Bronze
	Pump Shaft: 12% Chrome
	Pumpshaft Split Ring: Pumpshaft Split Ring [Per Material Class Spec]
	Pumpshaft Sleeve Coupling: 12% Chrome
	Pumpshaft Key: Pumpshaft Key [Per Material Class Spec]
	Pumpshaft Retaining Ring: Pumpshaft Retaining Ring [Per Material Class Spec]
	Suction Bell: Cast Iron
	Bell/Bowl Bolting: [Per Material Class Spec]
1	Bolting, 316SS
	Suction Bell Bearing: Bronze
	Suction Strainer: None
	Impeller Key, Split Ring, Bolting [Per Material Class Spec]
	Impeller Retainer :: Impeller Retainer [Per Material Class Spec]
	Impeller Balancing Criteria: Dynamically Balanced Impellers [ISO 1940 G2.5 (8 W/N)]
	Bowl Shaft Coatings: None
2	Catalyst Cured Epoxy
	Column Assembly
	Column Assembly: Length 9.35 ft.
	Column Taper/Adapter: 5 In. taper/adapter
	Column Pipe Material: Carbon Steel
	Column Selection
1	Column Selected 60 In. (Qty 2 per pump)
	Max Bearing Spacing: 120 in.
	Column Diameter: 18 in.
	Column Wall Thickness: 0.375 in.
2	Column Connection Type: Flanged

Pump

Qty	Description
	Lineshaft Lubrication: Product Lubrication
	Lineshaft Diameter: 1.25
2	Lineshaft Material: 12% Chrome
2	Lineshaft Bearing Material: Cutless Rubber
2	Threaded Coupling: 12% Chrome
2	Bearing Retainers: Integral Retainers
2	Column Bolting: Hex Hed Screw [Per Material Class Spec]
2	Column Coating: Catalyst Cured Epoxy:Carboline 891
	Discharge Head Assembly
	Discharge Head Type: JTAF Fabricated Discharge Head
2	Discharge Elbow Material: Carbon Steel
2	Discharge Head Riser Pipe & Driver Stand: Carbon Steel
2	Discharge Flange Diameter: 18 in.
	Discharge Elbow Wall Thickness: 0.375 in.
2	Round Base: Carbon Steel
2	Lifting Eyes: Carbon Steel
2	Jacking Lugs: Carbon Steel
2	Coupling Guard: Aluminum
2	Discharge Head Bolting: [Per Material Class Spec]
2	Motor Base Diameter:
	Motor stand: None
2	Packing Box PlateCarbon Steel
	Headshaft Diameter: 1.25
2	Discharge Headshaft Material: 12% Chrome
2	Head Shaft Bearing: Bronze [C89835 Federalloy III]
2	Head Shaft Couplings: Carbon Steel Flanged Adjustable Coupling - 2FB
	Sole Plate Type: Standard Solepate
2	Standard Sole Plate: Carbon Steel [A36 and A53 Gr. B]
2	Stuffing Box Cast Iron
2	Discharge Head Coating: Catalyst Cured Epoxy:Carboline 891-Inside & Outside Diameter
2	Sole Plate Coatings: Catalyst Cured Epoxy:Carboline 891
	Buyout Components
	Driver Selection
	Driver Model: H444TP: H444TP
1	Driver Base Diameter: : 0.00 in
	Additional Driver Data: :
	Testing, Quality Inspections, Engineering Analysis
	Product Testing
	Non Witnessed Tests (Performance, Pump and Hydro)
2	Pump Performance Test
2	Hydro Test Bowl
2	Discharge Head Hydro Test
	Quality Inspections Processes
1	QI Material CMTR

Driver

Qty	Description
	Buyout Components
	Driver Selection
	Motor manufacturer: VSS NEMA Motor- User Defined
2	Selected Motor And Price: User Defined Motor
	Driver Manufacturer: NIDEC: NIDEC
	Driver Enclosure: WP-1: WP-1
	Driver Shaft Type: Solid shaft

Driver

Qty	Description
	Driver Power: 100 HP
	Driver Speed: 1180 RPM
1	Driver Voltage: 460 V
1	Driver Weight: 1,200.0 lb
1	Driver Height: 50.06 in

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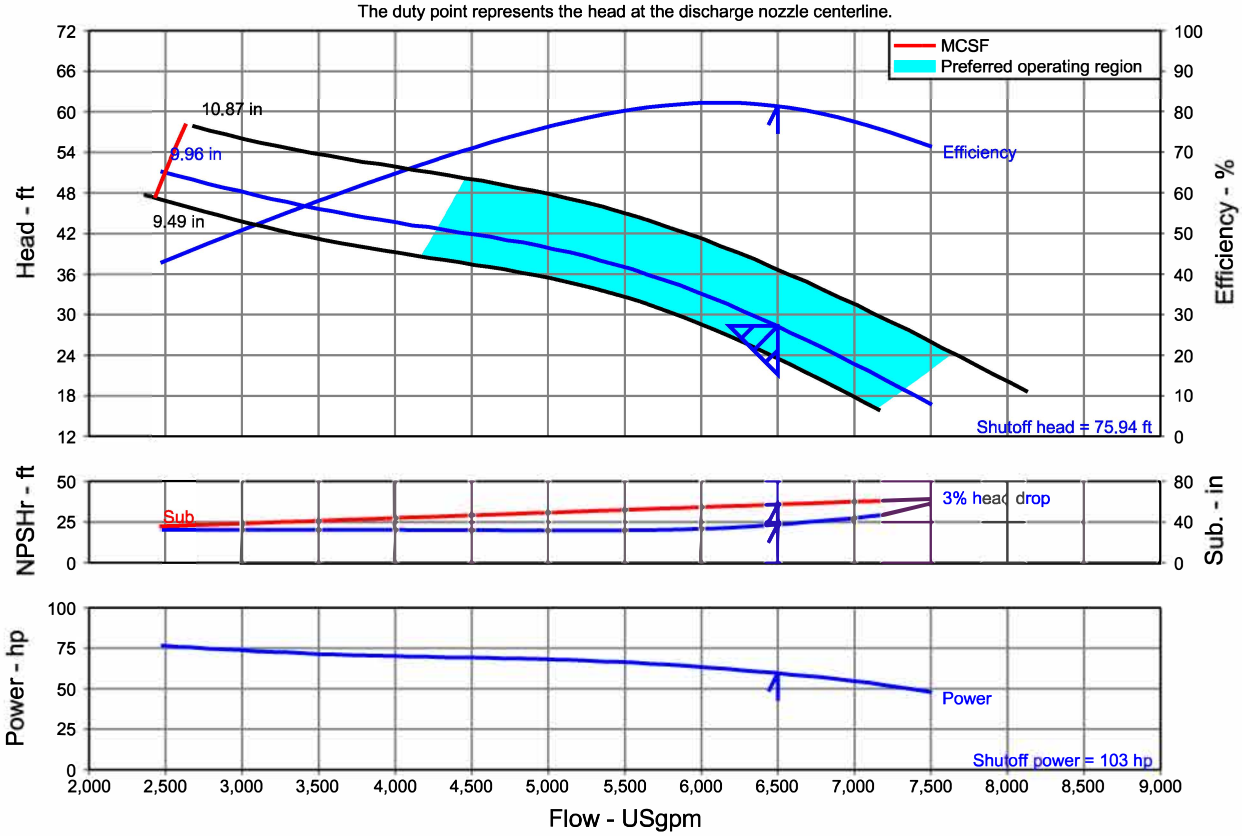
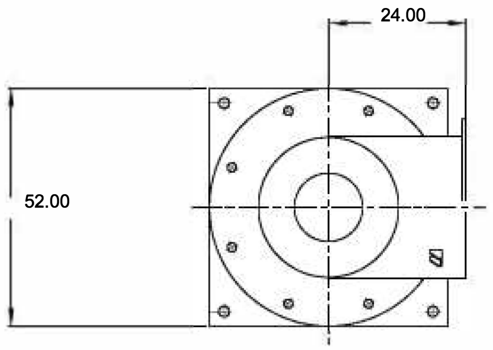
Pump Performance Datasheet

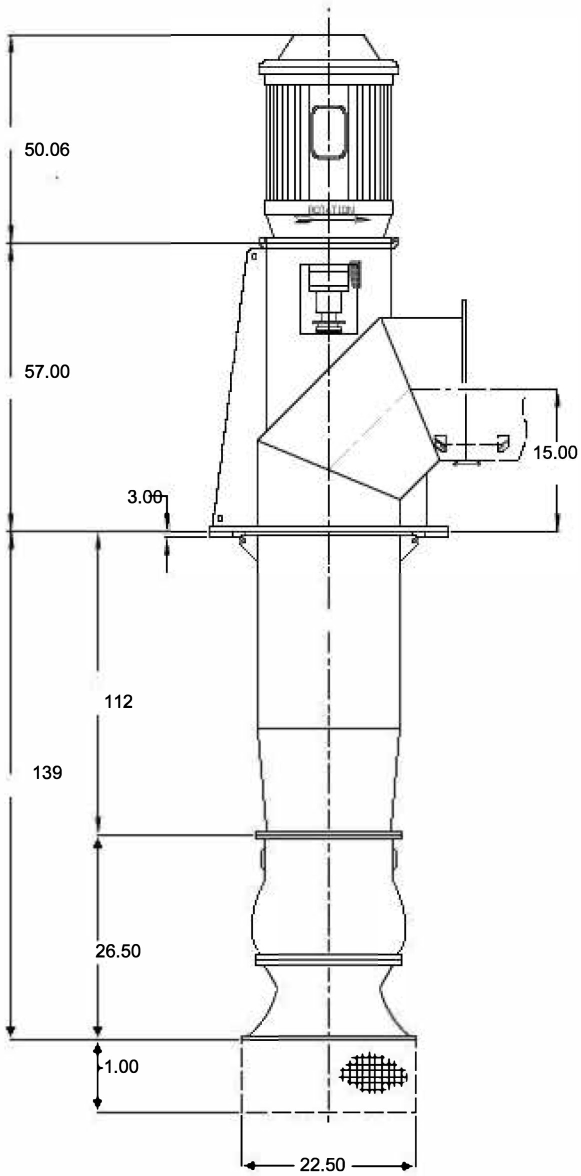
Customer	: Chesapeake Enviromental Equipment	Sulzer Reference ID	: USA.2323-NWW.21.2323-B0
Inquiry Number/ID	:	Type / Size	: JM-16LS
Item number	: Low Flow	Stages	: 1
Service	: Backwash Pumps	Based on curve number	: SJM-122-002-63-11-10 Rev SJM-16LS
Quantity	: 2	Date of Last Update	: 12 Apr 2021 9:48 AM

Operating Conditions		Liquid	
Flow, rated	: 6,500.0 USgpm	Liquid type	: Water
Differential head / pressure, rated (requested)	: 28.30 ft	Additional liquid description	:
Suction pressure, rated / max	: 0.00 / 0.00 psi.g	Solids diameter, max	: 0.00 in
NPSH available, rated	: Ample	Solids concentration, by volume	: 0.00 %
Site Supply Frequency	: 60 Hz	Temperature, rated / max	: 68.00 / 68.00 deg F
Performance		Fluid density, rated / max	: 1.000 / 1.000 SG
Speed criteria	: Synchronous	Viscosity, rated	: 1.00 cP
Speed, rated	: 1180 rpm	Vapor pressure, rated	: 0.34 psi.a
Impeller diameter, rated	: 9.96 in	**Material**	
Impeller diameter, maximum	: 10.87 in	Material selected	: Cast Iron Bowl, AL. Bronze Impeller
Impeller diameter, minimum	: 9.49 in		
Efficiency (bowl / pump)	: 83.43 / 81.29 %	**Pressure Data**	
NPSH (3% head drop) / margin required	: 23.65 / 2.00 ft	Maximum casing/bowl working pressure	: See the Additional Data page
Submergence, minimum required	: 57.45 in	Maximum allowable working pressure	: See the Additional Data page
Ns (imp. eye flow) / Nss (imp. eye flow)	: 5,990 / 9,758 US Units	Maximum allowable suction pressure	: 50.00 psi.g
MCSF	: 2,497.7 USgpm	Hydrostatic test pressure	: See the Additional Data page
Head, maximum, rated diameter	: 75.94 ft	**Driver & Power Data (@Max density)**	
Head rise to shutoff (bowl / pump)	: 150.71 / 156.97 %	Driver sizing specification	: Maximum power
Flow, best eff. point (bowl / pump)	: 6,235.5 / 6,153.4 USgpm	Margin over specification	: 0.00 %
Flow ratio, rated / BEP (bowl / pump)	: 104.24 / 105.63 %	Service factor	: 1.00
Diameter ratio (rated / max)	: 91.67 %	Power, hydraulic	: 49.70 hp
Head ratio (rated dia / max dia)	: 78.50 %	Power (bowl / pump)	: 59.57 / 59.65 hp
Cq/Ch/Ce/Cn [ANSI/HI 9.6.7-2010]	: 1.00 / 1.00 / 1.00 / 1.00	Power, maximum, rated diameter	: 77.51 hp
Selection status	: Acceptable	Minimum recommended motor rating	: 100 hp / 74.57 kW

Pump performance. Adjusted for construction, viscosity, static lift to discharge nozzle centerline, friction and power losses of lineshaft and thrust bearings. The duty point represents the head at the discharge nozzle centerline.







Pump Information	
Pump Size / stages	: JM-16LS / 1
Discharge Head	: JTAF Fabricated Discharge Head
Discharge Nozzle	: 18 in. / 150 # FF
Suction Nozzle	: N/A
Column	: Flanged, 18 in.
Lineshaft	: 1.25 in. / Product Lubrication
Turndown	: N/A
Can Assembly	: N/A
Strainer	: None
Min Submergence	: 57.45 in
Coupling	: Rigid
Stuffing Box	: Standard
Motor Information	
Manufacturer	: N/A
Enclosure	: -
Type	: Vertical solid shaft w/ Coupling
Speed	: 1180 RPM
Power / S.F.	: 100 hp / 1
Volt/Phase/Frequency	: 460 V / 3 / 60 Hz
Motor BD	: 0 in.
Equipment Weights (Approximate)	
Motor	: 1,200.0 lb
Discharge Head	: 2,150.0 lb
Column	: 894.7 lb
Baseplate	: 475.0 lb
Bowl Assembly	: -1.00 lb
Total	: 4,717.7 lb
Project Information	
Customer	: Chesapeake Enviromental Equipment
End user	: -
Project Name	: -
Country of Install	: -
Tender	: USA.2323-NWW.21.2323-B0
Curve Number	: -
Inquiry number	: -
Item number	: Item 1
Date last saved	: 12 Apr 2021
Certification	

Dimensions in , unless otherwise specified

NOTE : DO NOT USE FOR CONSTRUCTION UNLESS CERTIFIED

A Sulzer Brand SULZER

Quotation

Derek Dorey
NIDEC MOTOR CORPORATION
8050 WEST FLORISSANT AVENUE
ST. LOUIS, MO 63136
T 832-382-5654
E derek.dorey@nidec-motor.com

Date	:	April 6, 2021
Customer	:	SulzerPumps
Attention	:	Ron Derrick
Reference	:	Filter Backwash Storage

Expiration Date	:	May 6, 2021
Quote Number	:	21DDS0406C
Issued By	:	Divina de los Santos

CURRENT	PHASE	CYCLES	VOLTS
AC	3	60	460

ITEM	QTY	HP	FRAME	SPEED	ESTIMATED WEIGHT	TYPE	NET EACH	EXT NET
A	2	200	449TP	900	2800 lbs	RUS		
B	2	100	H444TP	1200	1500 lbs	RUS		

DESCRIPTION:

Item A:

- TITAN Vertical HOLLOSHAFT
- WPI Enclosure
- Random Wound
- 1.15 Service Factor on Sine Wave Power
- Class "F" Insulation
- VPI-1000 Insulation System
- 3300 ft.(1000 m) Altitude
- +40°C Ambient Temperature
- Premium Efficiency
- Vertical Centrifugal Pump Application
- 24.5 inches Base Diameter
- Coupling Size: To Be Supplied at Order Entry
- Non-Reverse Ratchet
- 12000 lbs Pricebook Thrust Value
- 4100 lbs Customer Down Thrust
- 7200 lbs Customer Shutoff Thrust
- Class "F" Rise @ 1.15 Service Factor (by Resistance)
- Direct-On-Line Start
- Continuous Duty
- 94.1 % Full Load Efficiency
- Driven Load Inertia: NEMA
- Standard Load Inertia: 4508 lb-ft2
- Starts Per Hour: 2 Cold/1 Hot (NEMA Standard)
- Counter CW Rotation FODE
- Insulated Bearing - Upper Bracket

Item B:

- NEMA Vertical HOLLOSHAFT
- WPI Enclosure
- Random Wound
- 1.15 Service Factor on Sine Wave Power
- Class "F" Insulation
- VPI-1000 Insulation System
- 3300 ft.(1000 m) Altitude
- +40°C Ambient Temperature
- Premium Efficiency
- Vertical Centrifugal Pump Application
- 16.5 inches Base Diameter
- Coupling Size: To Be Supplied at Order Entry
- Non-Reverse Ratchet
- 12250 lbs Pricebook Thrust Value
- 1900 lbs Customer Down Thrust
- 4400 lbs Customer Shutoff Thrust
- Class "F" Rise @ 1.15 Service Factor (by Resistance)
- Direct-On-Line Start
- Continuous Duty
- 94.1 % Full Load Efficiency
- Driven Load Inertia: NEMA
- Standard Load Inertia: 1181lb-ft2
- Starts Per Hour: 2 Cold/1 Hot (NEMA Standard)
- Counter CW Rotation FODE

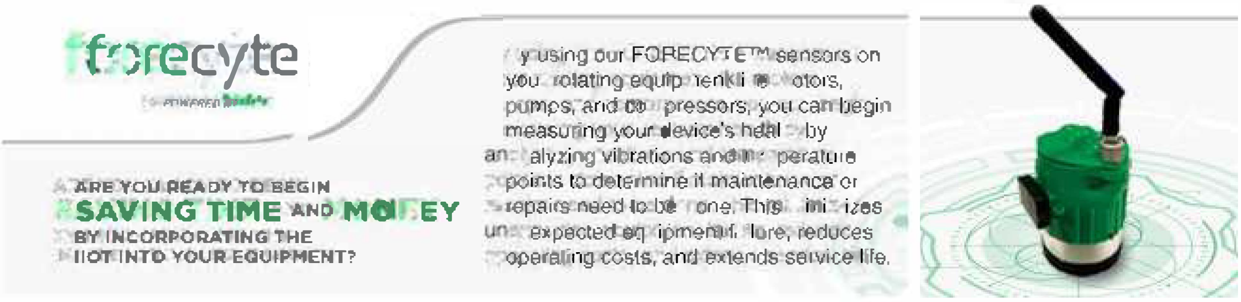
QUOTE COMMENT:

1. Quote is based on description only.

All prices are subject to a minimum price escalation of 3% quarterly for material and manufacturing increases prior to motor production beginning. Prices will be reviewed quarterly after receipt of order.

NMC Confidential

Storage Fees: As per Nidec's Standard Terms and Conditions, Ordered Goods produced by Nidec in compliance with Purchase Order requirements which cannot be shipped solely due to customer missing information, such as but not limited to carrier arrangements, will be charged 10% of the P.O. value 5 business days after Nidec customer notification.



[Click here to learn more or ask your representative about FORECYTE™.]

TERMS	ESTIMATED LEAD TIME	FREIGHT	F.O.B.
Cash in advance	Item A: 10 Weeks + Transit	Collect	Mena, AR
Cash in advance	Item B: 9 Weeks + Transit	Collect	Mena, AR

This Quotation and all related contacts and orders are subject to and governed exclusively by Nidec Motor Corporation's terms and conditions of sale, which are attached. All other terms and conditions are expressly disclaimed and rejected. By accepting this Quotation Customer expressly consents to Nidec Motor Corporation's terms and conditions of sale attached.