City of Arlington
REVISED
Permeate Equalization Engineering Report

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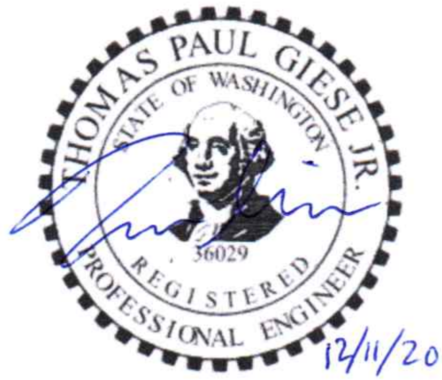

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ABBREVIATIONS AND ACRONYMS LIST

AACE	American Association of Cost Engineers
BA	Biological Assessment
BHC	BHC Consultants, LLC
City	City of Arlington
CTW	Constructed Treatment Wetlands
DNS	Determination of Non-Significance
Ecology	Washington State Department of Ecology
EPA	Environmental Protection Agency
EQ	Equalization
FEMA	Federal Emergency Management Agency
gfd	Gallons per Square Foot per Day
gpcd	Gallons per Capita per Day
gpm	Gallons per Minute
I/O	Input/Output
JARPA	Joint Aquatic Resource Permit Application
L&I	Labor and Industries
MBR	Membrane Bioreactors
MCC	Motor Control Center
MGD	Million Gallons per Day
NPDES	National Pollution Discharge Elimination System
PLC	Programmable Logic Controller
PSCAA	Puget Sound Clean Air Agency
SCADA	Supervisory Control and Data Acquisition
SEPA	State Environmental Policy Act
SERP	State Environmental Review Policy
UV	Ultraviolet
VFD	Variable Frequency Drive
WAC	Washington Administrative Code
WRF	Water Reclamation Facility
WWTP	Wastewater Treatment Plant

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1. Introduction

This section provides background on the existing facility and challenges and identifies the purpose of this report.

1.1 Background

The City of Arlington's (City) water reclamation facility (WRF) underwent a major facility upgrade and expansion with the conversion to membrane bioreactors (MBRs) in 2011. Shortly thereafter, the City completed the constructed treatment wetlands (CTW) as part of a separate project. These wetlands are currently used for treatment of stormwater runoff and filter backwash from the water treatment plant. The City is also allowed under its current National Pollutant Discharge Elimination System (NPDES) permit (WA0022560) to "primarily use reclaimed water to maintain wetland vegetation and hydrology." The NPDES permit does not otherwise specify an allowed quantity or period of discharge. However, the City has not yet exercised its ability to discharge reclaimed water to the wetlands. The current NPDES permit issued by the Washington State Department of Ecology (Ecology) on September 25, 2019 requires the City to begin submitting information for reclaimed water in the monthly discharge monitoring reports by July 1, 2021. To provide the necessary data and comply with the monitoring requirements of the current NPDES permit, the City must install instruments to continuously monitor dissolved oxygen, pH and temperature immediately downstream of the existing UV disinfection system and continuously measure flow of reclaimed water. This data must be logged in the existing SCADA system. Additionally, the existing turbidimeter must be relocated upstream of the existing UV system. Turbidity is currently logged in the existing SCADA system.

Part of the reason the City has not discharged reclaimed water to the CTW is because of limitations with the existing ultraviolet (UV) disinfection system. At the time the UV disinfection system was designed, there was miscommunication from the manufacturer about the minimum flow necessary to cool the UV reactors. Additionally, corrections to the level transducer on the influent Parshall flume during the upgrade and expansion project yielded lower influent flow measurements, such that assumed minimum flows for design were not actually realized. This resulted in the City not being able to reliably maintain adequate flow through the two UV reactors in series necessary to maintain UV reactor operation and, consequently, unable to achieve the disinfection required for production of Class A reclaimed water. Furthermore, the City had to take time to fully understand the basis of design for the CTW so as to determine how much reclaimed water the wetlands could accept while retaining flexibility to also accept stormwater.

The City still desires to discharge reclaimed water to the CTW to maintain the vegetation. Additionally, uptake of nutrients within the wetlands would further reduce nutrients discharged to the Stillaguamish River. While the City does not have specific measured or quantifiable data regarding removal of nutrients through the CTW, the design of the wetlands is such that some level of nutrient reduction is expected, as documented in the January 2010 Drainage Report prepared by Landau Associates. The City is also interested in exploring the possibility of expanding their water rights to the Stillaguamish River through the indirect discharge from the CTW. As stated in the current NPDES permit, "reclaimed water will incidentally recharge groundwater through percolation from the unlined CTW." Because of the close proximity of the wetland to the river, the generally porous alluvial soils, and the absence of other influences on the groundwater, this percolated flow will discharge as baseflow to the river. The City would like to consider this added baseflow to the river as streamflow augmentation that could allow them to increase their withdrawal from the river through their upstream Ranney collector wells. The City would maintain their direct discharge to the river through the WRF outfall so as not to "impair any existing water right downstream of the freshwater discharge point(s) of the facility unless the Permittee makes appropriate compensation or mitigation to the affected right holder." Water rights are identified as including "any permits, claims, certificates, or instream flows established pursuant to RCW 90.22 and RCW 90.54," along with existing federally reserved water rights. It is understood that recognition of such streamflow augmentation would require future modifications to the NPDES permit.

1.2 Purpose

The purpose of this report is to fulfill the applicable requirements of Chapter 173-240-060 of the Washington Administrative Code (WAC) for domestic wastewater facility engineering reports. This report summarizes current operations and challenges regarding production of reclaimed water, identifies and evaluates alternatives for addressing those challenges to better facilitate reclaimed water production, establishes recommendations for design and implementation of the selected alternative, and identifies next steps in the implementation process.

NOTE: This report has been updated from an earlier version completed in January 2020 to reflect changes in the recommendations and design of the permeate equalization system. The primary change is the conversion of only one membrane tank for equalization use, rather than both currently unused membrane tanks, to allow for addition of a fifth membrane tank to meet the capacity and redundancy needs through 2035 assuming continued use of the same membrane technology.

2. Current Operations

Currently, there are three UV reactors in two separate trains. One train has two reactors in series which is necessary to produce reclaimed water, the other train consists of a single reactor with room for an additional reactor when necessary. The single reactor provides sufficient disinfection capacity for discharge through the WRF outfall to the Stillaguamish River, but is inadequate for reclaimed water. The original design of the UV disinfection system left space to add a fourth reactor to this train to increase the capacity and reliability of reclaimed water production when needed. As it is configured now, the UV disinfection system has firm capacity sufficient for reliable discharge to the river but could only produce reclaimed water if both of the two reactors in series are active. Otherwise, discharge must be directed to the river. The two reactors in series are sized to produce reclaimed water at a rate of 2 million gallons per day (MGD), or 1,389 gallons per minute (gpm).

2.1 Zero Flow Conditions

The production of reclaimed water requires that two UV reactors operate in series at their highest output (power level three). The minimum flow rate to maintain proper cooling of these two reactors at this level has been estimated at 500 gpm, based on information provided by the manufacturer (Aquionics) and subsequent conversations and correspondence. Without proper cooling, the UV lamps will overheat and shutdown the UV reactor. This disrupts disinfection and also reduces lamp life. Similarly, to ensure adequate cooling of just a single UV reactor when discharging directly to the Stillaguamish River through the outfall, a minimum flow of 270 gpm must be maintained.

Hourly flow data for the low (Figure 2-1) and high (Figure 2-2) flow weeks of 2018 were provided by the City. Analysis of this data confirmed that there are periods in the nighttime hours when there is zero permeate flow leaving the MBRs, sometimes for periods as long as 4 hours. While a 4-hour period is atypical, zero flow conditions occur often between 3AM and 6AM during both the high and low flow weeks. This has caused issues with UV lamps overheating at times in the past and complicates production of reclaimed water by placing restrictions on when reclaimed water could be produced that could change day-to-day.

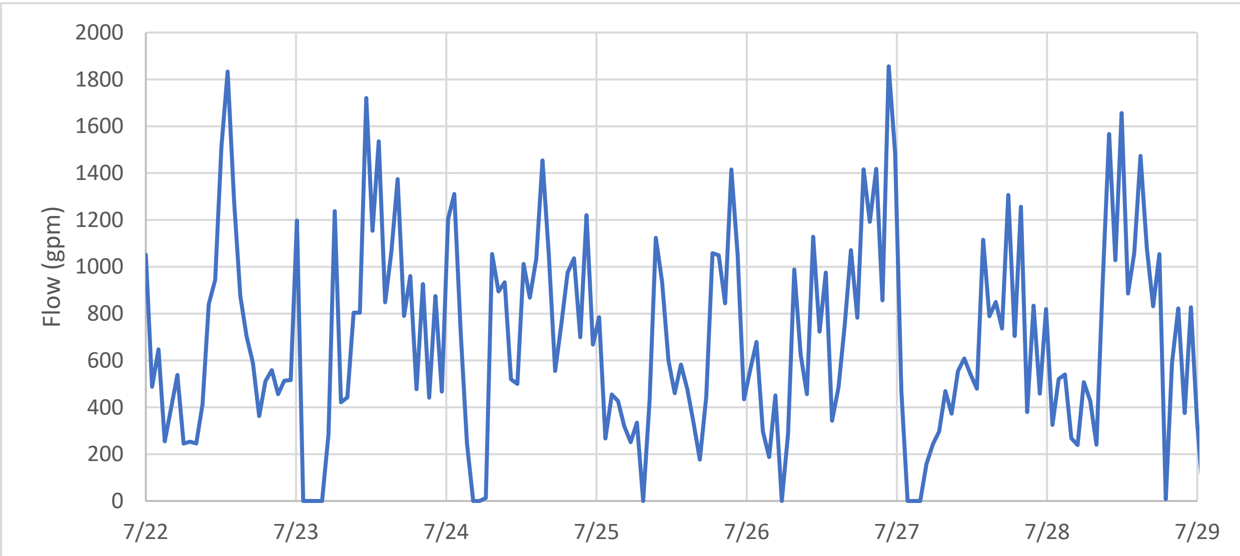

Figure 2-1 2018 Low Flow Week (7/22/18 thru 7/28/18)

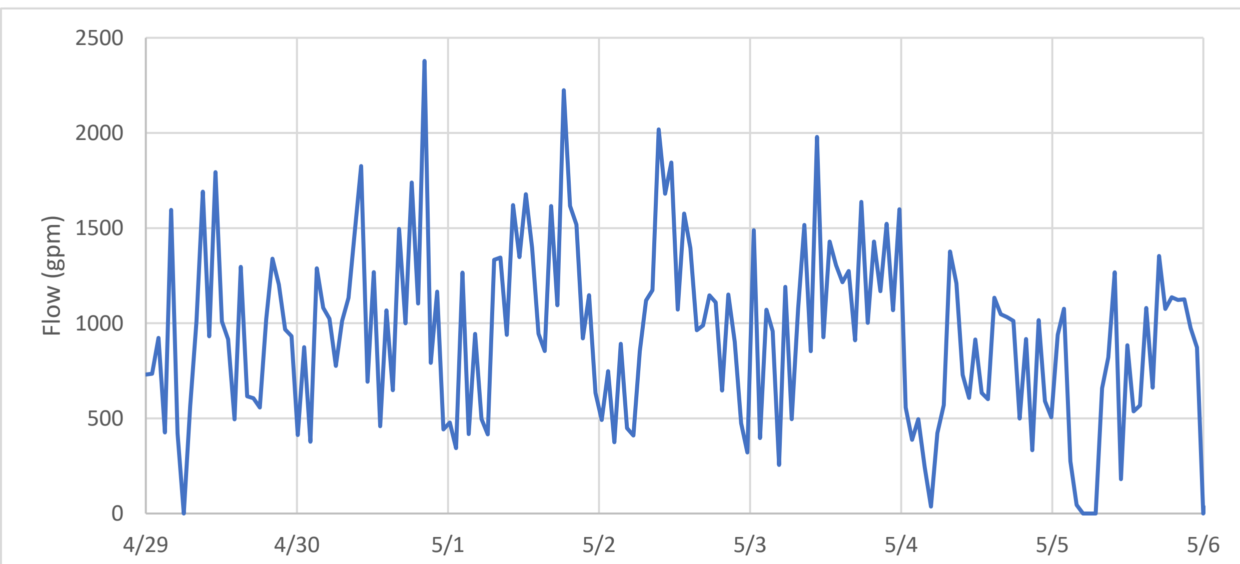

Figure 2-2 2018 High Flow Week (4/29/18 thru 5/5/18)

2.2 UV Lamp Life and Replacement

The UV lamps used by the City are medium-pressure high-intensity lamps. In 2013 and 2014, issues surfaced with lamps burning out after fewer than 300 operating hours, which should be lasting 1,000 hours or more. This was in large part due to excessive starting and stopping from high temperatures due to extended periods of low flow. Additionally, the lamp sleeves experienced repeated rapid temperature changes from this frequent starting and stopping that resulted in some of the quartz sleeves exhibiting stress fractures.

2.3 Inability to Produce Reclaimed Water

As mentioned previously, reclaimed water production has not been attempted to date, other than for initial brief periods during startup to verify effectiveness of the UV disinfection system, due to concerns with being able to maintain sufficient flow and lower than anticipated flows. Additionally, permeate flow from the membrane tanks can change rapidly. This rapid change in permeate flow can require rapid changes in output from the UV reactors. Because reclaimed water requires a very high level of disinfection, the City is concerned that the need for such rapid changes would not be conducive to maintaining compliance with Class A reclaimed water standards.

2.4 Need for Improvements

The City needs to be able to better control the flow of permeate to the UV disinfection system to ensure proper cooling, avoid rapid changes in flow that would necessitate rapid changes in UV reactor output, and allow control of reclaimed water production so the City can adjust flow to the CTW as deemed necessary to deal with changing conditions and recent/predicted storms. Furthermore, additional instrumentation is necessary to provide the continuous monitoring for reclaimed water required under the current NPDES permit, as discussed previously.

2.5 Potential Improvements

The following three different improvements were identified as feasible alternatives to address current issues with reclaimed water production:

- Cooling water loop
- Equalization of influent flow
- Equalization of permeate flow.

Although smaller UV reactors (whether just filling the space for a future fourth or replacing all existing reactors) could be installed to reduce the minimum flow necessary for reactor cooling, this would not resolve issues with overheating during periods of zero flow and would not be consistent with maintaining current and/or future disinfection capacity and reclaimed water production capabilities. For those reasons, alternatives involving smaller UV reactors were not considered.

2.5.1 Cooling Water Loop

A cooling water loop could use non-potable water or 3 water (i.e., disinfected permeate) to prevent overheating of the UV lamps. The water would be circulated through the UV reactor to maintain the minimum flow necessary for cooling. However, during periods of very low or no permeate flow, the cooling system would be forced to recirculate the same 3 water. If very low or no flow persists for a long period of time, the recirculated 3 water would heat up to the point that its ability to cool could be compromised. Alternatively, non-potable water could be supplied in whatever quantity is needed, but the City would have to pay for the non-potable water. Furthermore, a cooling water loop would not address concerns with high variability in the permeate flow impacting operation and performance of the UV disinfection system. For these reasons, use of a cooling water loop was not considered further.

2.5.2 Equalization of Influent Flow

Equalization (EQ) is most often applied to influent wastewater following screening and grit removal at the headworks. This application of EQ requires a large basin to store flow and aeration/mixing to prevent the wastewater from becoming septic. Equalization is able to even out diurnal flow variations and reduce peak flows to provide a more consistent flow to and reduce capacity needs of downstream processes. It can also be used to hold flow during maintenance activities. While equalization of influent flow would solve the issues of low and no flow periods, it would incur very a large capital expense, would require a significant amount of space, and would not address concerns with high variability in the permeate flow impacting operation and performance of the UV disinfection system. Additionally, the issue with low to no flows is expected to be reduced as the City grows and influent flow rates increase. Thus, influent equalization would be a long-term solution to a problem that may not always exist. For these reasons, influent flow equalization was not considered further.

2.5.3 Equalization of Permeate Flow

Permeate flow EQ would occur between the membrane tanks and UV disinfection. This would alleviate both issues of providing sufficient permeate flow for cooling the UV reactors and reducing variability in the flow of permeate from the membrane tanks to the UV disinfection system. Therefore, permeate equalization was evaluated further to develop recommendations for implementation.

The WRF has two membrane tanks that are currently empty. These empty tanks were built to hold additional membrane cassettes that would expand the capacity of the WRF beyond its current permitted maximum month flow of 2.67 MGD. One or both of these tanks could be used as permeate EQ volume. While the volume that could be held in these two tanks is not sufficient for true equalization (i.e., maintaining a constant flow 24/7), it is adequate to provide some buffering capacity for flow. This would allow for a minimum flow rate to be maintained for cooling during periods of no or low flow. This would also provide attenuation of rapid changes in permeate flow from the membrane tanks and some buffering capacity for high permeate flows that exceed the reclaimed water production capacity of the UV disinfection system. While this is not complete equalization of the flow, it does meet the necessary requirements while minimizing capital expense.

The currently empty membrane tanks are designed to be used to hold additional membrane cassettes. The City plans to replace their current membrane cassettes in 2022. Although there are other membrane technologies that could possibly fit more capacity in a single tank, they are not as proven as the existing membranes and could require significant improvements to the permeate and aeration systems. Therefore, it is likely the City will replace the existing membranes in kind with the same technology. In that case, the City will probably need to install membrane cassettes in one of the two tanks to maintain adequate capacity and redundancy (having a redundant membrane tank) during the next membrane life cycle, which is expected to last until nearly 2035. At that point, the City will need to reassess capacity needs to determine if a sixth membrane tank would be required during the subsequent membrane life cycle or if five membrane tanks remains adequate, allowing the sixth tank to continue to be utilized for EQ. However, if flow patterns and quantities change significantly due to growth, it is possible permeate EQ would no longer be necessary to meet the minimum flow requirements and the City could potentially make modifications to allow simultaneous reclaimed water production and river discharge, such that permeate EQ is no longer necessary. Furthermore, the City could elect to install a different membrane technology during the subsequent membrane life cycle, taking advantage of further improvements in membrane technology, that provides greater capacity in each tank, allowing permeate EQ to remain. Membrane capacity and the impacts of converting one versus two membrane tanks for EQ is discussed in more detail in Section 3.

3. Evaluation of Improvements

This section discusses the limitations for discharge of reclaimed water and evaluates how the system could function to determine the improvements that will be implemented.

3.1 Discharge Limitations

Limitations on the discharge of reclaimed water are based on several factors:

- UV reactor cooling
- Time period for reclaimed water production
- UV disinfection system capacity
- CTW operational constraints.

3.1.1 UV Reactor Cooling

As discussed in Section 2, a single UV reactor requires a minimum flow of 270 gpm for cooling. A single UV reactor is typically used when discharging effluent to the Stillaguamish River through the outfall. A second reactor would be required for river discharge only during periods of peak flows. Production of reclaimed water necessitates operating two UV reactors in series, which requires a minimum flow of 500 gpm for cooling. These minimum flows are based on information provided by and communications with Aquionics. A timeline for the UV system and log of correspondence with Aquionics is included in Appendix A.

3.1.2 Time Period for Production of Reclaimed Water

The City has indicated that, at least initially, they would prefer to limit production of reclaimed water to the hours that the WRF is staffed. This will allow careful oversight of the process to ensure that adequate treatment is maintained and flow to CTW is properly managed. Therefore, reclaimed water production periods of four hours (10AM – 2PM), six hours (9AM – 3PM), and eight hours (8AM – 4PM) were considered.

3.1.3 UV Disinfection System Capacity

The existing UV disinfection system can produce a maximum of 2 MGD of reclaimed water. Two reactors in series are necessary to provide the level of disinfection needed to produce reclaimed water. Currently, only one of the two trains of UV reactors has two reactors in series. The addition of another UV reactor to the second train would allow that train to also produce reclaimed water. This would provide some redundancy in being able to produce reclaimed water, as well as double the maximum capacity to 4 MGD. Currently, if one of the two reactors in series is out of service, reclaimed water cannot be produced, and all effluent must be discharged through the outfall to the Stillaguamish River.

3.1.4 CTW Operational Constraints

The City has indicated that the CTW is capable of accepting at least 800,000 gpd of reclaimed water. This was determined based on the flow that would be received during the 24-hour design storm for which the CTW is sized. This volume is conservative in that it does not account for any of the storage capacity in the wetland cells, just their ability to infiltrate flow into the groundwater. This volume serves only as a point of reference and not a limit for reclaimed water production, as the City plans to adjust production of reclaimed water (i.e., duration, frequency and total quantity produced) based on conditions at the time and previous and forecasted storms. Consequently, the City may adjust reclaimed water production to ensure the CTW retains sufficient capacity to handle stormwater, but these considerations do not alter the available capacity for reclaimed water production at the WRF.

3.2 Permeate Equalization

As discussed in Section 2, utilization of the existing empty membrane tanks for the equalization of permeate has high potential to mitigate issues with maintaining minimum flow for reactor cooling and attenuating high variability in permeate flow. Flow data for the high flow week and low flow week during 2018 were provided by the City for analysis (see Figures 2-1 and 2-2). This analysis compared how much reclaimed water could be produced based on the three different reclaimed water production time periods mentioned above and utilizing either one or both empty MBR tanks for EQ, while providing the minimum flow necessary for UV reactor cooling and not exceeding capacity of the UV disinfection system. A summary of this analysis is provided in Table 3-1.

It is assumed that reclaimed water would be produced at the maximum rate of 2.0 MGD, based on the capacity of the UV disinfection system, as permeate flow and EQ storage would allow. This results in theoretical maximum production volumes of 333,000, 500,000 and 667,000 gallons per day for production time periods of 4, 6, and 8 hours. To determine the actual average production rate for a given time period, the measured historical permeate flow rates within each production time period were averaged and multiplied by the length of the time period to estimate the volume of permeate that would be available during that time period. This number was added to the active volume (volume between the minimum and maximum fill levels) of the EQ tanks and divided by the length of the reclaimed water production period, producing a total average reclaimed water production rate possible for the time period. If this total value equaled or exceeded the theoretical maximum production, it was assumed that reclaimed water production would be limited by capacity of the UV disinfection system. If the total value was less, then that total value was assumed to be the maximum reclaimed water production rate possible for that day. In analysis of all three reclaimed water production time periods, during the low flow or high flow weeks, and using one or two membrane tanks for EQ storage, there were no instances when the EQ tank(s) would not be refilled each day. It should be noted that intervals for which historical data was reported were slightly longer than one hour, resulting in some daily reclaimed water volumes being slightly higher than the calculated theoretical maximum due to a slightly longer time period.

In general, as the length of the reclaimed water production period is increased, the amount of reclaimed water that can be produced also increases, as the City will normally maximize the rate of reclaimed water production at the full 2 MGD capacity that currently exists. However, there could be factors relating to the CTW, maintenance activities, etc. that would cause the City to produce reclaimed water at a rate below the maximum, thereby producing less total volume over a similar or even longer duration.

Comparing the average production volumes shown in Table 3-1, using two tanks versus one tank for EQ storage yields about a 15% increase in reclaimed water production during the low flow week (comparing the second and fourth rows of the table) and just under a 10% increase during the high flow week (comparing the last two rows of the table). As this is not a large increase in volume and the fact that the City is likely to install membranes in one of the empty tanks prior to 2035, the City has selected to utilize only one of the empty membrane tanks for permeate EQ.

Table 3-1
Summary of Permeate EQ Analysis

Flow Week	Reclaimed Water Production Period Length (hours)	Number of EQ Basins	Gallons of Water Discharged								
			Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Average	Theoretical Daily Maximum
Low Flow	4	1	335,300	335,300	287,700	268,400	304,100	258,100	335,300	303,500	333,000
Low Flow	6	1	492,800	503,000	406,500	358,300	360,800	322,000	419,100	408,900	500,000
Low Flow	8	1	562,600	618,100	542,200	394,600	443,600	389,500	670,600	517,300	667,000
Low Flow	6	2	503,000	503,000	503,000	471,000	473,500	434,700	428,100	473,700	500,000
High Flow	6	1	419,100	323,200	503,000	251,500	503,000	391,600	379,600	395,800	500,000
High Flow	6	2	419,100	335,300	503,000	251,500	503,000	503,000	492,300	429,600	500,000

3.2.1 Membrane Bioreactor Capacity

As discussed in Section 2, the City currently operates membranes in four of the six tanks. The membranes in Tanks 1 through 4 have been in service for about 10 years and are approaching the end of their service life. The City expects to replace the membranes in 2022 and would like to ensure that the replacement membranes are capable of treating flows projected through the end of their service life in 2035.

Based on the *Final 2017 Amendment to the 2015 Comprehensive Wastewater Plan* (RH2, October 2017), the sewered population in 2035 is expected to increase to 22,693. Sewered population estimates and existing flows were used to estimate per capita flow rates. The current annual average per capita flow rate based on existing conditions is 67.0 gallons per capita per day (gpcd), which aligns with what was document in the comprehensive plan. The comprehensive plan assumed an increase in per capita flows to 100 gpcd by 2035 due to potential increased flows from increasing commercial and industrial development. Current flow rates suggest this has not yet been realized, but the potential for per capita flow increases due to such development remains. Projected 2035 flow rates are provided in Table 3-2 for both a 100 gpcd and 67 gpcd scenario.

Table 3-2
Projected 2035 Influent Flows

Flow Parameter	100 gpcd	67 gpcd
Average Annual Flow, MGD	2.27	1.52
Maximum Month Flow, MGD	3.43	2.30
Peak Day Flow, MGD	4.90	3.28
Peak Hour Flow, MGD	7.49	5.02

The original design flux rates are compared with flux rates under existing and projected 2035 flow rates in Table 3-3 below. Flux rates assume 3 membrane tanks in service for existing conditions and 4 in service under 2035 projected flows. The original design required more membranes to limit flux at the design peak hour flow. As a result, the design flux rates for the design maximum month and peak day flows are relatively low. Existing flows with 3 membrane tanks in service and projected 2035 flows (67 gpcd annual average) with 4 membrane tanks in service yield net flux rates below the design values. Even under the more conservative 2035 flow projections (100 gpcd annual average), Kubota indicates the resulting flux rates with 4 membrane tanks are still within typical design values for their membranes. Therefore, adding just one more membrane tank for a total of 5 tanks should provide the necessary capacity and desired redundancy through 2035, even under a more aggressive growth scenario.

Table 3-3
Net Flux Rates (gfd)

Flux Parameter	Design	2035 (100 gpcd)[1]	2035 (67 gpcd)[1]	Existing Conditions[2]
Max Month Flux	9.5	12.3	8.2	7.9
Peak Day Flux	12.2	17.5	11.7	11.2
Peak Hour Flux	26.6	26.8	17.9	17.1

Notes:
1) Flux rate calculated with four membrane basins online.
2) Flux rate calculated with three membrane basins online.

3.2.2 Control of EQ Storage

Outside of the reclaimed water production window, all flow would be discharged to the river, so it is assumed that the EQ tank would be used to maintain a minimum flow of 270 gpm to the UV reactors to ensure proper cooling. Any permeate flow in excess of 270 gpm would be used to fill the EQ tank. If permeate flow is under 270 gpm outside of the reclaimed water production window, the EQ tank would be drawn down to augment the flow and ensure that a minimum flow of 270 gpm is provided. Under most cases, this regime allows for the EQ tank to be refilled completely before the start of each reclaimed water production period. When the EQ tank is full outside of the reclaimed water production period, all permeate flow is disinfected and discharged to the river.

When EQ storage volume is available and flows exceed 2.0 MGD during the reclaimed water production period, excess flow is attenuated in the EQ tank. If the EQ tank is full at the beginning of the reclaimed water production period and permeate flow rate exceeded 2.0 MGD, it is assumed that the start of reclaimed water production would be deferred and so the time period shortened, because the EQ tank does not have the capacity to attenuate flow so that it does not exceed capacity of the UV disinfection system. Similarly, if the EQ tank fills before the end of the reclaimed production period and permeate flows exceed 2.0 MGD, the production period would end prematurely. This issue was more typical during the high flow week. Operationally, this could be mitigated to some extent by not completely filling the EQ tank and leaving some storage capacity for attenuation of permeate flows exceeding 2.0 MGD. When permeate flow drops below 2.0 MGD during the reclaimed water production period, permeate stored in the EQ tank would be used to supply the difference to maximize reclaimed water production and ensure proper cooling of the UV reactors.

The valve actuators will include local manual controls and the pump will have a hand-off-auto switch at the motor control center to allow manual control if there is a failure of automated controls. These manual controls will allow the operator to manually bypass equalization and discharge directly to the outfall, as is currently done. This may cause periods of excessive cycling of the UV reactors due to low or no flow for reactor cooling (as is currently the case at times), but could be tolerated short-term if necessary.

3.2.3 Methods of Operation

Two different methods of operation are possible for the permeate EQ tank: fill and draw and equalizing all permeate flow. In the fill and draw method, flow would only be diverted into the tank (until full) if flow exceeds 270 gpm outside of the reclaimed water production period, or if the permeate flow exceeds 2.0 MGD during the reclaimed water production period. It would be drawn out as needed to maintain a flow of 270 gpm outside the reclaimed water production period, and to maintain a flow rate of 2.0 MGD within the reclaimed water production period. This would require pumping into or out of the EQ tank to maintain these target flows. Although this is simple in concept, the high variability in permeate flow from the membrane tanks would make control of this operating method very difficult. The response times of the controls and equipment and the sensitivity of control algorithms is such that the system likely would not be able to respond in a timely manner and with the accuracy required to maintain the target flow. For this reason, a fill and draw method of operation was not selected.

Although equalizing all permeate flow requires more improvements (with the inclusion of more automated valves and piping as depicted in Figure 4-1), it simplifies control of the system and greatly improves the ability to maintain the target flows. For this method of control, all permeate flow would pass through the EQ tank during the reclaimed water production period. At low levels in the tank, permeate could flow by gravity. At higher levels, the existing permeate pumps would automatically engage to deliver flow into the EQ tank. Control of permeate flow from the membrane tanks would be unchanged, relying on existing equipment and controls that already regulate flow based on level in the membrane tanks and automatically start the permeate pumps when gravity flow is not achieving the target level in the membrane tanks. The shelf spare permeate pump would be used as a permeate EQ pump to convey flow out of the EQ tank at the desired rate, not exceeding the 2.0 MGD capacity of the UV disinfection system for production of reclaimed water.

When outside of the reclaimed water production period, permeate flow would still pass through the EQ tank until the full level is reached. At that point, flow could continue to be passed through the EQ tank or sent directly to the UV disinfection system. In either case, the permeate EQ pump would be used to maintain a minimum flow of 270 gpm to the UV disinfection system.

Consideration was given to using an inline booster pump to supply permeate to the EQ tank. This would reduce runtime of the existing permeate pumps and increase turndown. However, because of the high variability in permeate flow, there was concern the inline booster would not be able to respond adequately to rapid changes in permeate flow and there is no desire to modify how the flow of permeate from the membrane tanks is controlled, as this could have unintended effects on the membrane bioreactors. Therefore, the use of an inline booster pump was not considered further.

3.2.4 Selected Improvements

Based on the evaluation of improvements herein, the City selected to implement a permeate EQ system utilizing the following:

- One existing empty membrane tank converted to an EQ tank
- Equalizing all permeate flow in the EQ tank during production of reclaimed water
- Existing gravity flow and permeate pumps to convey permeate into the EQ tank
- Using a shelf spare permeate pump as a permeate EQ pump to control discharge from the EQ tank to the UV disinfection system.

It is believed that these improvements will provide sufficient operational flexibility, provide the necessary stability of control, maximize reclaimed water production capability, and ensure adequate membrane capacity for future growth.

4. Implementation of Selected Improvement

This section provides an overview of the major physical improvements needed to implement the proposed permeate EQ system, including improvements for power and controls, and provides an opinion of the probable construction cost.

4.1 Major Physical Improvements

Figure 4-1 schematically illustrates how the selected improvements would fit into the existing WRF. Several new actuated butterfly valves are required to control the flow of permeate from active membrane tanks and provide the ability to automatically isolate inactive membrane tanks and bypass the EQ tank. Additionally, manual valves will be installed on the inlet and outlet of the EQ tank to allow for isolation of the tank. The permeate EQ pump will be installed in space set aside for the future permeate pump associated with the Membrane Tank 6 to be utilized for EQ. Discharge from the permeate EQ pump will be delivered to the 24-inch permeate header that conveys flow to the UV disinfection system.

4.2 Process Monitoring Improvements

As discussed in Section 1, the City must install instruments to continuously monitor dissolved oxygen, pH and temperature immediately downstream of the existing UV disinfection system and continuously measure flow of reclaimed water. This data must be logged in the existing SCADA system. Flow must be measured from the reclaimed water pumps. As there is insufficient exposed piping on the reclaimed water pump discharge, a vault will need to be installed along the discharge pipeline for installation of a flow meter. There is a very short section of piping where flow is combined following disinfection through the UV reactors prior to splitting again between discharges to the river and the reclaimed water pump wet well. This short section is comprised of two large tees that are not conducive to installation of instrument probes, but does have an existing sample tap for the turbidimeter. The new pH, dissolved oxygen and temperature probes will instead be wall-mounted and fed a continuous sample stream through the sample line. If necessary, the sample line can be enlarged and/or a sample pump used to convey the sample to the instruments. The sample flow will then be returned to the effluent pipeline or routed to the building drain. As mentioned previously, the sample location will be such that the new temperature probe can also provide continuous temperature measurements during discharge to the river, which is also required under the current NPDES permit.

As the current NPDES permit requires turbidity monitoring upstream of the UV disinfection process, the existing turbidimeter must be relocated from downstream to upstream of the existing UV system. The existing turbidimeter can be relocated to the south wall of the Secondary Support Building and a new sample line tapped into the overhead 24-inch permeate pipeline to provide a sample stream, before it splits between the two UV reactor trains. The height of the permeate pipeline is such that a sample pump should not be required to provide sufficient flow to the turbidimeter. Turbidity is currently logged in the existing SCADA system.

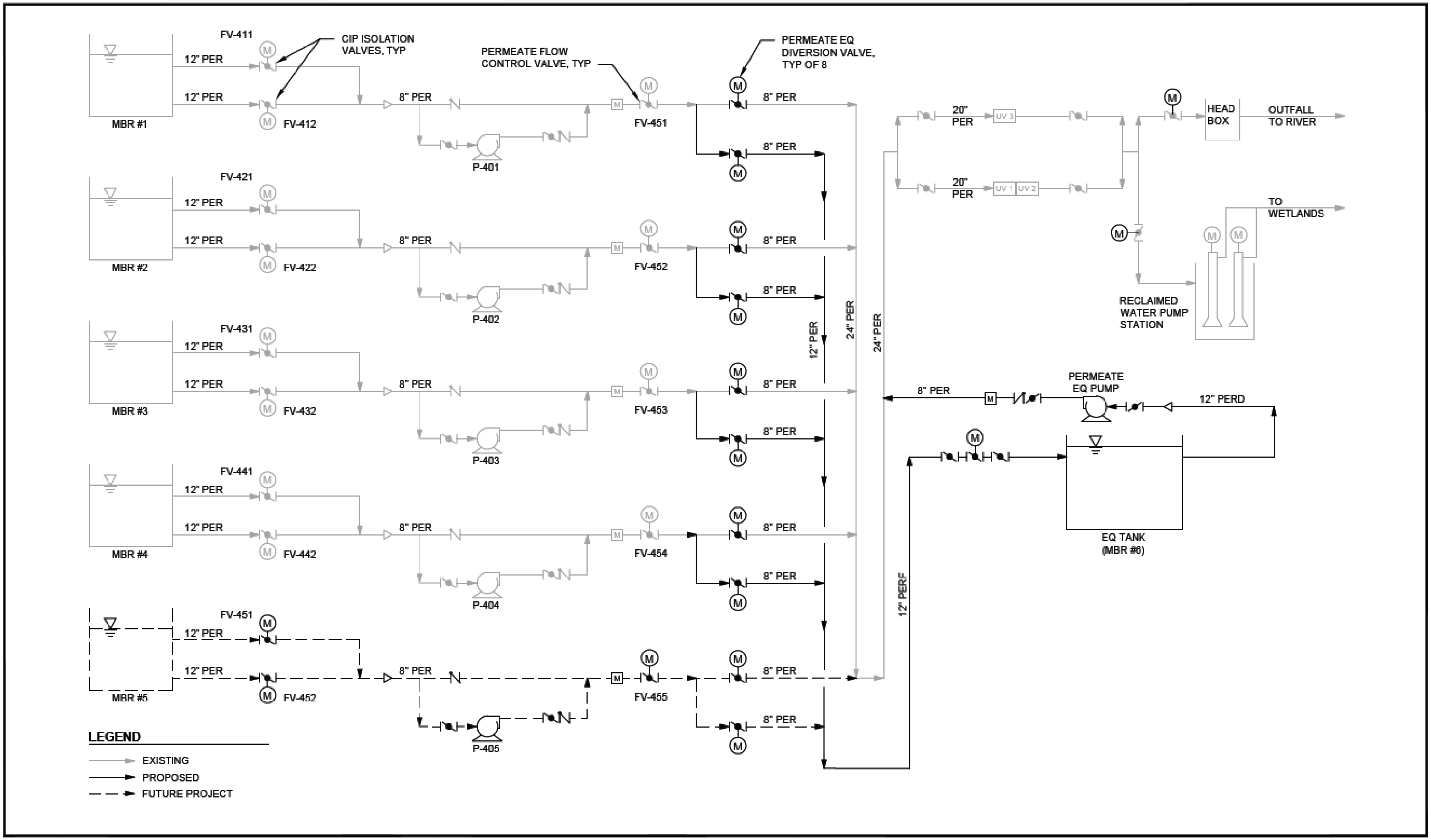

Figure 4-1 Permeate EQ Process Schematic

4.3 Cost Estimate

An opinion of probable construction cost of $1.40 million has been developed for the selected improvements based on the current 90% design that reflects a Class 1 opinion (applicable for 50% to 100% design) as defined by the American Association of Cost Engineers (AACE) and has an expected accuracy range of -10% to +15%. This estimate includes improvements for the permeate equalization system and process monitoring discussed herein, as well as digested sludge pumping improvements discussed in the *Digested Sludge Pump Evaluation Report* (BHC Consultants, January 2020). All three of these elements will be combined into a single project. Costs were developed using pricing from vendor quotes, recent construction bid tabs, and RSMeans online construction cost data. A detailed breakdown of cost items is provided in Appendix B including quantities, unit costs, and total costs. A construction contingency of 10% has been included to account for variations in the bidding environment.

4.4 Control and Power Improvements

The opinion of probable cost presented Appendix B includes costs for electrical and instrumentation and control work. These are associated with providing the necessary power communications, and control programming for the new permeate EQ system. Power will need to be provided to the new actuated valves and permeate EQ pump. Existing Motor Control Center No. 3 (MCC-3) includes space for addition of two future permeate pumps. One of these spaces can be used to house the variable frequency drive (VFD) for the permeate EQ pump. One of the existing valve power panels has sufficient space to power the new actuated valves.

Control programming associated with the new permeate EQ system will be added to the programmable logic controller (PLC) in the main control panel located in the Electrical Room of the MBR Support Building. Additionally, communications conduit and wire for equipment associated with the permeate EQ system will be connected to the main control panel. Conduit and wiring for the process monitoring equipment will be connected to the control panel in the SBR Support Building and programming of the SBR PLC in that panel will be modified to for the associated new equipment. Similarly, conduit and wiring for the digested sludge pumping system will be connected to the control panel in the Solids Handling Building and programming of the SHB PLC in that panel will be modified to for the associated new equipment.

5. Next Steps

This section discusses the schedule for future work to implement the selected improvements and permitting that will be required for execution of the work.

5.1 Schedule

The City will have design of the improvements completed in early 2021, after which the project will be advertised for bidding. Following advertisement, bidding, and award, it is expected construction would begin during the second quarter of 2021 and be physically complete before the end of 2021.

5.2 Permitting

As with any public utility project, the proposed improvements will require the City to obtain permits to authorize construction and operation of the new permeate EQ system. The timing and sequencing of permitting must be aligned with the design and construction schedule to avoid complicating and potentially costly delays. The following paragraphs discuss permit activities that are typically associated with wastewater treatment projects.

5.2.1 State Environmental Policy Act (SEPA)

SEPA requires state and local agencies to consider the likely environmental consequences of proposed projects before approving or denying the project. Information provided during the SEPA review process helps agency decision-makers, applicants, and the public understand how the project will affect the environment. This information can be used to change a proposal to reduce likely impacts or to condition or deny a proposal when adverse impacts are identified.

SEPA applies to decisions by every state and local agency within Washington State, including state agencies, counties, cities, ports, and special purpose districts. One agency is usually identified as the lead agency for a specific proposal. For public projects, the lead agency is the agency proposing the project and evaluating the potential adverse environmental impacts of the proposal. The City would be the lead agency for the proposed project.

A SEPA checklist has been prepared as part of the design process. The SEPA checklist identifies project goals and impacts to the environment and community and establishes the requirements for environmental review by the appropriate agencies. Following an assessment of the information contained in the SEPA checklist, a determination of significance is made. It is anticipated that a Determination of Non-Significance (DNS) will be made, meaning there are not likely significant adverse environmental impacts that have not been adequately addressed and an environmental impact statement will not be required. The City will be making the determination for this project.

5.2.2 State Environmental Review Policy (SERP)

This project should not necessitate completion of the SERP and associated cross-cutter review, as the City does not intend to seek federal funds for this project. Available federal funds, which are administered by Ecology, primarily include the Water Pollution Control Revolving Fund and Centennial Clean Water Fund. Either of these funds requires completion of the SERP for application.

5.2.3 Endangered Species Act and Sustainable Fisheries Act

Some projects require a biological assessment (BA) to determine the significance of impacts on endangered or threatened species and their habitats. A BA is comprised of an evaluation of the biological condition of the affected receiving water, disturbed land habitat and nearby area using surveys and other measurements to identify the potential impact on resident, transient, and migratory organisms. Because such impacts of the proposed project are expected to be insignificant (i.e., no significant change in effluent quality or quantity or air quality that would have adverse impacts), it is expected that a biological assessment will not be necessary.

5.2.4 Joint Aquatic Resource Permit Application (JARPA)

JARPA is a single application that can be submitted for different permits from several agencies. Permits covered by JARPA include:

- *Wetland Protection*. This project will not directly impact any wetlands. Therefore, there is no assessment of impact to wetlands and/or identification of mitigation measures that are required to be reviewed by the U.S. Department of Fish and Wildlife.
- *Shoreline Permit*. A Shoreline Permit is required for any development activity within 200 feet of the ordinary high water mark of a designated shoreline, or within the flood hazard zone of a designated shoreline, that has a total cost in excess of $5,000, or interferes with the normal public use of the water or shorelines of the state. Development activity includes those activities that interfere with the normal public use of the surface of waters overlying lands, even if only temporarily. The proposed improvements are not within the designated flood hazard area. Additionally, the project location is outside 200 feet of the ordinary high-water mark of the Stillaguamish River. Therefore, a Shoreline Permit will not be required.
- *Corps of Engineers Section 404 Permit*. A Section 404 permit is used to regulate the discharge of dredged or fill material into waters of the United States. This project will not involve any such activity within waters of the United States and so should not require a Section 404 permit.

5.2.5 Floodplain Management

According to the most recent Federal Emergency Management Agency (FEMA) flood maps, the wastewater treatment plant (WWTP) is located beyond the current 100-year flood level, as would be the proposed improvements. Therefore, a permit from FEMA for construction activity within a floodplain should not be required.

5.2.6 National Historic Preservation Act

Because people have long dwelled along shorelines and in other various regions of Washington State, a cultural resources survey is typically required for projects that involve significant disturbance of the ground to protect significant traces of their lives left behind in compliance with Executive Order 05-05. However, the proposed improvements are expected to require only very limited shallow trenching for connection of a new pipeline to an existing pipeline such that the area of disturbance will be limited to areas that had been previously excavated and filled. As a result, it is expected that a cultural resources investigation will not be required. It is also assumed that federal funds will not be utilized for this project, such that Section 106 will not supersede Governor's Executive Order 05-05.

5.2.7 NPDES Permit

Ecology is authorized by the United States Environmental Protection Agency (EPA) to administer water quality permitting in the state. Ecology administers its authority through various processes, including issuing permits to public agencies that discharge treated wastewater into rivers and streams. The City currently holds a NPDES permit (issued September 25, 2019 and modified October 16, 2019) that addresses the regulatory requirements imposed by the EPA through Ecology.

Although the proposed improvements do not impact effluent limits, effluent quantity, effluent quality, or permitted capacity it does modify the process by which the flow of permeate is controlled. Because this change to the process is not merely a simple equipment replacement or other maintenance related task, an engineering report is required. This document serves to meet the WAC requirements for submittal of an engineering report. Additionally, plans and specifications for the proposed project have already been submitted to and reviewed by Ecology in accordance with the WAC.

5.2.8 Puget Sound Clean Air Agency

The Puget Sound Clean Air Agency (PSCAA) is a special-purpose regional agency responsible for administering federal and state clean air regulations throughout King, Snohomish, Pierce and Kitsap counties. While PSCAA works closely with Ecology and EPA, it has jurisdictional authority in these counties and conducts permitting for utilities subject to air quality regulations. Because this project does not involve addition of or changes to air emissions, an air discharge permit will not be required.

5.2.9 Building Permit

As is the case with most commercial and residential construction activities, building permits must be obtained from the local jurisdiction (City of Arlington). It is unclear at this point if the proposed project will require a building permit, since there are only minor structural elements involved. The proposed improvements should be discussed with the building department to determine if a building permit is required.

5.2.10 Electrical Permits

An electrical permit must be obtained from the Washington State Department of Labor and Industries (L&I). This permit will be obtained by the contractor. The contractor will schedule inspections by L&I when appropriate to ensure compliance with all applicable codes.

5.2.11 Fire Department Plan Review

The proposed improvements do not include any changes to chemical, fire or other safety hazards that would necessitate a review by the fire department.

5.2.12 Construction Stormwater Permit

Application under Ecology's construction stormwater general permit is required for all soil-disturbing activities (including clearing, grading, and/or excavation) where one or more acres will be disturbed, and stormwater will be discharged to a receiving water directly (e.g., wetlands, creeks, unnamed creeks, rivers, marine waters, ditches, estuaries) or to storm drains that discharge to a receiving water. Because the proposed improvements will not involve earthwork activity over an area greater than one acre, coverage under the general permit will not be required.

APPENDIX A

UV System Timeline and Manufacturer Correspondence Log

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UV System Timeline

19Sep13- E-mail from Bob English (Aquionics) to Fred Rapelyea stating that he received a message from John Barch (Goble Sampson) indicating that we were having problems with our UV System. Bob said he would relay our issues to their Applications and Service Groups. This begins the process of attempting to solve our UV issues. See E-mail chains.

2Oct13 to 5Nov13- E-mails back and forth from Jason Ewing and Jeff Fischer (Aquionics) regarding testing and test procedures that Jeff would like performed. Testing delayed due to display screen on UVtronic for UV501/UV502 is unreadable and needed to be replaced.

29Oct13- Bob English sent Jason Ewing an e-mail saying that they had a used display screen for the UVtronic that we could purchase.

5Nov13- Replaced unreadable display screen on UVtronic for UV501/UV502. Jason Ewing sent e-mail to Jeff Fischer to get clarification on testing. In UV501, replaced Lamp #1 (Berson) with UV Doctor lamp SN 0143898. UV501/UV502 had a High Temp shutdown.

13Nov13- Jeff Fischer responded to clarifications on testing Jason Ewing sent on 5Nov13.

20Nov13- Jason Ewing tested UV502B (voltage and amperage). Unable to complete testing due to damaged multi-meter from peak voltage.

21Nov13- Jason Ewing sent Jeff Fischer an e-mail about the previous days testing on UV502B regarding the excessive voltage, excessive amperage and damaged multi-meter.

21Nov13 to 2Dec13- Aquionics and the WWTP had discussions about getting an Aquionics Tech onsite to troubleshoot component issues on UV502B.

27Nov13- Jeff Fischer sent Jason Ewing an e-mail suggesting that there might be wiring insulation issues or incorrect wiring issues causing the problems in UV502 reactor.

10Dec13- Kris Wallace signed purchase order for Aquionics to do a site visit to troubleshoot the problems with UV502.

15Jan14- Brion Courts (Aquionics) flew to Arlington WRF to diagnose UV502. We replaced Lamp #4 and Lamp #6 in UV501. We also replaced Lamps 13 through 18 in UV502. Megged all lamp wires and labeled them (no wires were found to be on the wrong lamps). Tested all of the transformers unloaded. Transformer for Lamp 13 (in UV502B cabinet) was found to have too high of a voltage. All other lamps had correct voltage. Transformers in cabinet UV502B were not tested due to time constraints.

28Jan14- In UV502, replaced lamps 19 through 24 with new lamps. Reset lamp hour meter and start logger.

6Feb14- Ordered new transformer for UV502 Lamp 13.

21Feb14- Transformer shipped

28Feb14- Transformer delivered on site.

6March14- Herm VanderHelm (Seahurst) replaced transformer for Lamp 13 in UV502B cabinet. New transformer wasn't tested because Seahurst doesn't have a meter in that range.

14Apr14- Shoreline Industrial Electric tested new transformer in UV502B cabinet for lamp 13. Also, tested Lamp 18 in cabinet UV502B for comparison. New transformer tested ok. Also tested transformers in UV502A cabinet because they weren't tested on 15Jan14 due to time constraints. Transformers in UV502A tested within normal limits.

15Apr14- Jason Ewing e-mailed Jeff Fischer results from voltage/amperage testing performed on 14Apr14. Jason's e-mail asked Jeff if the voltage/amperage readings were within normal range and what is going on with the dosages for UV501 and UV502 being significantly different at the same power levels (suggesting new bulbs and calibration issues)

16Apr14- Jeff Fischer e-mailed response from e-mail sent on 15Apr14 stating that the electrical measurements sent in the spreadsheet from 14Apr14 testing looked good and he also sent instructions on calibrating the UVector sensor.

18Apr14- The quartz sleeves were replaced in UV502 for Lamp 13 and Lamp 14 (both cracked and leaking). Replaced Lamp 14 (burned out) with Berson Lamp. Reset hour meter and start logger for Lamp 14.

21Apr14- In UV501, replaced Lamp #11 with UV Doctor lamp SN 0143886 and Lamp #5 with UV Doctor SN 0143888.

16May14- In UV501, replaced the following lamps with UV Doctor lamps; 1, 2, 3, 7, 8, 9, 10, 12.

29May14- Coordinated date with Fred Rapelyea, Sandy Boyd, and Todd Murray (Process Solutions) to discuss Reclaimed Water Production pump testing on 5June14. Sent Jeff Fischer (Aquionics) email in regards to reclaimed water dosing and set points. Also, asked Jeff about the "Reclaimed Water" button functioning. Used newly purchased lamp tester to test lamps that were suspected of being burned out. Confirmed 15 lamps were bad. 11 other lamps were tested and found to be good and usable.

30May14- Lamp faults on UV501/502 for lamps 4, 5, 7, 9, 11, 22. Lamps faulted with low operating hours (<300).

5June14- Test ran Reclaimed Water Pump P-506 with Todd Murray (Process Solutions). Reclaimed water pump discharged to the storm outfall and not through the storm water wetland. Testing was for calibrating the pump (% Hz to GPM). Todd took the data and created a pump curve for control set points. P-505 wasn't tested (seized). Jeff Fischer (Aquionics) sent e-mail about changing the settings in the programming.

10June14- Jeff sent e-mail on new controls settings in Excel format with instructions. Also, he attached the UVtronic Appendix. During the setting of these new control set points, it was found that our programming in the UVtronic doesn't have certain control features that were needed for Jeff's control strategy for reclaimed water production. Jason E-mailed Jeff back stating this. Jeff agreed with Jason's e-mail and suggested loading a newer program into the UVtronic controller. Jeff said that if the factory agrees with him, he will send the new program but someone will have to be onsite with a laptop computer and a specially fabricated cable to load the new program. Jeff will get back to Jason on how to proceed. In UV501, Lamp 7 (SN 0143880) failed with only 174 operating hours. Replaced with UV Doctor lamp (SN 0190791).

11June14- Jeff Fischer e-mailed an update stating that it was more complicated than he expected but he is still hopeful that it can be done with a few additional changes to the UVtronic programming. He says they are still in testing and should be able to confirm by the end of the week. Replaced Lamp #7 in UV-501 at only 174 operating hours. Lamp was replaced with new UV Doctor Lamp SN 0190791.

16June14- Jeff Fischer e-mailed new programming and instructions. Jeff also sent instruction on how to fabricate the special cord for the laptop/UVtronic download. Jason forwarded this e-mail to Todd Murray (Process Solutions) to see if Process Solutions can perform this work for us.

17June14- Jason called Todd Murray about e-mail he sent on 16June14. Todd said he would take a look at the e-mail today.

18June14- Jason e-mailed Todd Murray to follow up on phone call from 17June14 regarding downloading new programming into the UVtronic controller.

23June14- Jeff Fischer e-mailed Jason Ewing saying that Danny van Kuringen from Berson will be in our area sometime during the week of 14July14 and that he could load the new UVtronic program while he is here. Jeff mentioned in the e-mail that the program he sent for Process Solutions to install had a small overdosing error in it. The program Danny will install doesn't have the dosing error.

24June14- Jason Ewing e-mailed Jeff Fischer saying that Fred Rapelyea decided to go ahead and have Process Solutions install the new program with the small overdosing error as planned. This was due to the need to get the reclaimed water running as soon as possible to hydrate the Stormwater Wetland. Then in July, Danny van Kuringen can install the new program without the small overdosing error.

25June14- Todd Murray loaded new UVtronic program into UV501/UV502 controller. During loading, all lamp hours and start logger data was erased. Jason and Todd also calibrated UV501 and UV502 UVector sensor per Jeff Fischer's e-mail sent on 16Apr14. After installing the new program, Jason Ewing e-mailed Jeff Fischer explaining more issues with running the reactors in "Reclaimed Water" mode. More specifically, UV501 and UV502 were not maintaining above 80 mJ dosing during "Reclaimed Water" mode and problems with the Allen Bradley HMI not reading UV502's dosage. Jeff Fischer replied to Jason Ewing's e-mail requesting some information and setting changes. First, to verify the 80 mJ set point for reclaimed water is the same on the UVtronic as it is on the Allen Bradley HMI. Second, Jeff requested I send him the settings for the HMI secured menu UV control settings for: Dose "Reclaim is on"; Dose "Reclaim is off"; and dose step-up pause. Third, he wanted the recorded readings in the "Operator" menu sent to him. Fourth, Jeff stated there was an error in the previous settings he sent. He wanted Jason to go to the subsystem menu and change "Nr. Starting" from 1 to 2. Finally, Jeff suggested rebooting by powering off and restarting to get rid of the reading errors the HMI is having in regards to the dosage reading for UV502. Jason replied to Jeff with the above information requests and changes. Also, Jason stated to Jeff in the e-mail that the flow increases and decreased are too fast for the UV reactors to adjust or compensate for. With the erratic flow characteristics, Jason requested advice on how to adjust the settings to maintain a minimum of 80 mJ dose.

26June14- In UV502, Lamp 15 faulted. There was a small leak that may have caused a short. Removed lamp, fixed leak, dried lamp and sleeve, and reinstalled lamp. In UV503, staff replaced the following lamps with used Berson lamps; 3, 4, 10, 11, 12.

27June14- Jeff Fischer e-mailed Jason Ewing in response to the last e-mail Jason sent on 25June14. Jeff said there was a delay in power stepping of 1 minute. He suggested two things to do to keep the dosing above 80 mJ. One is to increase the dose set point to somewhere above 80mJ to create a buffer and the other is to change a setting in the "UV Control Settings" and that is to change the setting "Fail Level H" to 100%. Jeff said that this should cause the unit to immediately go into high power when the dose set point is reached. Then the power will adjust back down according to the power stepping delay. Jeff also said that if one system is running at max power and falls below the dose set point, it will take ~ 1 minute (power stepping delay) for the second unit to start.

2July14- Jason Ewing ordered wiper motor seal retaining ring for UV502.

7July14- Jason Ewing replaced wiper motor seal retaining ring for UV502.

8July14- Fred Rapelyea sent Jason Ewing an e-mail requesting that a list of all the ongoing issues with the UV system be e-mailed to him. In UV501, removed and replaced cracked quartz sleeve at the #2 lamp position. It was suggested by Jeff Fischer that it may be possible that the quartz sleeves are cracking due to the reactors turning off and on frequently and the temperature changes with cooler effluent.

9July14- Jason Ewing e-mailed Jeff Fischer with update. Jason said that the setting changes e-mailed to him on 27June14 were implemented but haven't been tested yet due to leaks and other issues. Jason also asked about the function of "Fail Level H" setting. Fred Rapelyea sent Jason Ewing an e-mail requesting that a list of all the ongoing issues with the UV system be e-mailed to him. Jason Ewing replied to Fred Rapelyea's e-mail requesting a list of all ongoing UV issues. Jeff replied to Jason's e-mail sent earlier today regarding "Fail Level H" functioning. In UV502, Lamp 21 and its quartz sleeve were damaged by rocks and replaced.

11July14- Fred Rapelyea and Jason Ewing met to go over our current UVtronic settings. Jason sent Fred e-mail with current UVtronic settings. In UV502, Lamp 15 fault. Removed and replaced lamp.

15July14- In UV502, Lamp 24 faulted. Lamp burned out after only 265 hrs. It had an excessive amount of starts. Staff replaced with slightly used Berson lamp.

17-18July14- Danny van Kuringen (Berson) visited site to trouble shoot problems with UV systems. Fred Rapelyea and Randy Norman were on site for testing. On arrival, UV503 was running. UV503 was shut down to test UV501/UV502. During UV501/UV502 start up, NTC resistor failed preventing start-up. Danny attempted to restart UV503 to make repairs to UV501/UV502. When UV503 restarted, the current detection board for lamp #12 exploded in the cabinet. New current detection boards and NTCs were shipped overnight and installed on July 18th. With the new parts, UV501/UV502 started running OK again. UV503 to be investigated on July 28th visit by Jeff Fischer (Aquionics). See Berson memorandum dated 24July14 for more info.

25July14- Fred Rapelyea e-mailed Tom Giese (formerly of Kennedy/Jenks now with BHC Consultants) explaining the issues we are having with the operation of our UV units. Fred said that there might be some design issues and asked if there was someone at Kennedy/Jenks that could help him. Tom Giese replied back with an offer to assist Fred but also gave Fred references to people at KJ that might be able to assist. Tom mentioned in his e-mail that the plant was designed on predicted flows and that those flows not only come to be but they actually decreased due to the recession. Fred forwarded this thread to Jim Kelly and updated him on his proposed course of action. Fred sent Tom another e-mail saying that although the MBRs have a minimum flow set point of 250 gpm, there are times when there are no-flow conditions that cause the UVs to shut down on Over Temp alarms. Tom responded that he would review his files to refresh his memory and get back to him.

30July14- Tom Giese sent an e-mail to Fred Rapelyea with numerous attachments of e-mails that were sent during the design phase of the UV system and what was discussed in regards to reclaimed water production. The following topics where discussed in these attached e-mails:

1. 4Oct07- E-mails between Tom Giese, Dennis Gleason, and Patrick Bollman. Tom Giese sent e-mail to Dennis Gleason requesting information about UV systems for

the future treatment plant upgrade. Tom mentioned in this e-mail that "The minimum daily flow is currently about 0.8 MGD ant there are times during the day when no flow may be coming into the plant." E-mails also discuss designing per NWRI criteria; whether they can use the existing 3000 series reactors; minimum flow requirements (which Patrick responded with 152gpm/unit); operational concerns (such as series v. parallel); and other design criteria.

2. <u>31August10-</u> RFQ (draft) addresses the need to reprogram the MBR system to maintain at least 200 gpm of flow to prevent overheating of UV lamps (thus shortening their expected life cycle). RFQ suggested reprogramming such that MBRs will rotate to maintain 200 gpm when one an MBR reaches a low level alarm. RFQ also suggested modifying UV programming to shut down UV if a signal is received that is less than 152 gpm. This RFQ was never issued but Tom Giese states that he believes that some of the programming was done (UVs shutting down when flows drop below 152 gpm).
3. <u>1Sep10-</u> E-mails between Tim Childs, Tom Giese and Ric Saavedra. Tim e-mailed Tom stating that he is going to get about a month's worth of flow data from Ric. Discussed nocturnal no-flow conditions.
4. <u>1Sept10-</u> E-mails between Bree Trembly, Tom Giese, Tim Childs, Bill Velacich, and Dennis Gleason. E-mails discussed minimum flow requirements for UV reactors. Bree recommended the minimum flow for UV system to be 250 gpm.
5. <u>23Sept10-</u> E-mails between Tom Giese, Ric Saavedra, and Tim Childs. These e-mails discuss how flow can be backed up into the aeration basins using the MBR weir gates. This is a suggestion to supplement no-flow conditions during nocturnal hours by using programming to slowly release the backed up flow during the night. *Note: This was not implemented.*
6. <u>20-21Oct10-</u> E-mails between CJ Handforth, Tim Childs, Ric Saavedra, Chris Kelsey, and Tom Giese. E-mails discussed the new software update installed on the UV system and how it will shut down the UV reactors if all 4 MBRs "go down" (no-flow conditions).
7. <u>20-28Oct10</u>- E-mails between Tom Giese, Jim Kelly, Bill Velacich, Jesse Yao, Jeff Fischer, CJ Handforth, Tim Childs, Ric Saavedra, Chris Kelsey, Kelly Brown, and David Chu. These e-mails addressed the following; installation of new programming for UV system and the calibration of the UV intensity; reclaimed water control from SCADA; QCC stated there is no provisions in the spec for UV dose control from reclaimed water to river discharge for the SCADA system; and Tom's vision of how the reclaimed water system should work (control strategy). Tom Giese states in this e-mail that none of these implements were put into the original design of the plant because initially, reclaimed water was going to be part of a future phase.

8. 5Apr11- E-mails between Chris Kelsey, James Kelly, and Tom Giese. These e-mails confirmed from Kennedy/Jenks on the meeting of the requirements for the production of reclaimed water in regards to monitoring, testing, and sizing of the UV system. Discussed limits and design criteria for reclaimed water and UV disinfection such as turbidity, transmittance, virus reduction, etc.

9. 6July11- E-mails between Tom Giese, CJ Handforth, James Kelly, and Fred Rapelyea. These e-mails addressed the programming of the UV units (hardwired tags and Ethernet tags). Also, the e-mails discussed how Aquionics should have set up the communications.

28-31July14- Jeff Fischer (Aquionics) visited onsite for troubleshooting ongoing issues with UV system and reclaimed water production issues. On the 28th, Jeff worked on UV503B performing the following: replaced current sensors for Lamp 11 and Lamp 12, removed large orange holder containing all 6 current sensors and replaced it with 6 smaller orange holders each containing one current sensor; tested transformers and capacitors; tested Lamp 10 against Lamp 12 for startup tomorrow (for comparison); added NTC into Lamp 12 circuit. On the 29th, for UV503: started UV503 and Lamp 11 immediately burned-out/failed to light (replace with used Berson lamp); removed and replaced terminal block that was causing Lamps 3 and 4 to start at the exact same time. For UV501/502: installed new program into UVtronic (replacing program installed by Todd Murray (Process Solutions) on 25June14; Jeff wrote new programming in to freeze the dose signal during wiper cleans to prevent false low dose alarms; Jeff disconnected the "auto-start" signal wire from MCC2 to prevent unwanted start-ups. On the 30th, Jeff up-loaded the new program into UV503 (with dose freezing during wiper cleans); performed 1st test run of Reclaimed Water Mode from 11:45am to 3:15pm. Dose dipped below 80 mJ limit 1 time for 1 second. On the 31st, Jeff arrived later in the afternoon (he was at another jobsite). He ended up staying 3 hours over making changes to programming.

1August14- Performed UV testing for reclaimed water production from 8:30am to 12:30pm. UV set to Auto and Huber fine screens set to Auto. Dose fell below 80 mJ limit 11 times for a total of 1 minute and 21 seconds. There were periods during this testing that there were no-flow conditions coming from the MBRs (effluent). This was due to Relax and Intermittent cycles.

4August14- Performed UV testing for reclaimed water production from 8:30am to 11:30am. Tested in manual mode at LOW and MEDIUM with Huber fine screens set to hand. Dose fell below 80 mJ limit 5 times for a total of 11 minutes and 16 seconds. While in manual mode, reactors were turning on and off and failing to start immediately do to cool down periods. This was caused by no-flow/erratic flow conditions in the effluent.

<u>11August14-</u> Todd Murray (Process Solutions) visited site and re-scaled flow meter signal from 2 MGD to 5 MGD. Original flow scaling was inadequate for our instantaneous flows. Staff performed UV testing for reclaimed water production from 8:30am to 12:30 pm. UVs set to Auto; Huber fine screens set to hand and dose set point at 90 mJ. Dose fell below 80 mJ limit 4 times for a total of 1 minute and 47 seconds. At 5:20 pm, UV501/502 Cabinet Temp High Alarm came in. At 5:54 pm, Lamp 1 Fault on UV501. At 5:58 pm and 6:00 pm, UV Intensity Low and UV Intensity Fail alarms came in respectively (related to Lamp 1 Fault).

<u>13Aug14 to 15Sep14-</u> UV503 ran with no faults. In UV501, during start-up, Lamp #1 (UV Doctor lamp SN 0143898) burned-out at 2,100 operating hours. Staff replaced lamp with slightly used Berson lamp.

<u>15Sep14-</u> At 12:41 pm, UV502 had a wiper motor fault, reset breaker and alarm. At 7:15 pm, Lamp 24 in UV502 faulted. At 10:32 pm, Flow Too High alarm came in.

<u>16Sep14-</u> At 8:08 am, staff reset Lamp 24 fault on UV502. Lamp 24 faulted again after reset. Staff performed UV testing for reclaimed water production from 8:15am to 12:15pm. UVs set to Auto, Huber fine screens set to Auto, dose set point set at 90 mJ. Dose fell below 80 mJ 4 times for a total of 25 seconds.

<u>17Sep14-</u> Staff performed UV testing for reclaimed water production from 9:15am to 1:15pm. UVs set to Auto, Huber fine screens set to Hand, dose set point set at 90 mJ. Dose fell below 80 mJ 5 times for a total of 58 seconds.

<u>19Sep14-</u> Jason Ewing and Sandy Boyd calibrated UV501 and UV502 UVtronic sensors per "Initial Intensity Calibration" instructions recently sent by Jeff Fischer. At 12:09 pm, shortly

after calibrating, Lamp 1 on UV501 faulted and wouldn't reset. Also had UV Intensity Low (at 12:13pm) and UV Intensity Fail (at 12:15pm) alarms.

Continuing UV related problems:

1. In UV501, Lamp 1 faults after low operating hours. Possibly a bad transformer or other issue. This is also causing Low UV Intensity and Low UV Intensity fault alarms as the intensity is read off Lamp 1.
2. When both UV501/UV502 are running, there is an excessive amount of lamp starts. Currently, we believe this is due to the erratic effluent flow characteristics. It is also believed that this is causing premature lamp and other UV system component failure.
3. With a lack of equalization basin or other form of maintaining consistent effluent flow, we are still unable run both UV reactors (without one of them shutting off from overheating or low flow signals) consistently and to maintain the proper reclaimed water dose requirements of 80 mJ.

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APPENDIX B

Opinion of Probable Construction Cost

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Arlington WRF Permeate Equalization and Digested Sludge Pumping
Engineer's Opinion of Probable Construction Costs
90% OPCC
Prepared by: C. Bryant
Reviewed by: T. Giese
Date: 12/11/2020

Bid Item No.	Bid Item Description	Unit Bid Price	Quantity	Unit	Total
1	**Mobilization/Demobilization, Bonds and Insurance (10%)**				$91,966
2	**Reclaimed Water Flow Meter Vault**				
	Excavation	$15	45	CY	$674
	Bedding	$1.50	280	CF	$420
	Backfill	$10	36	CY	$356
	Precast Vault	$7,881	1	EA	$7,881
	3' x 4' Aluminum Access Hatch	$2,500	1	EA	$2,500
	12" Flow Meter	$8,000	1	EA	$8,000
	12" DI Pipe	$221	20	LF	$4,410
	12" DI 45 Deg Elbows	$1,478	4	EA	$5,914
	12" Flange Coupling Adapter	$1,906	1	EA	$1,906
	Pratt Groundhog Valves	$5,500	2	EA	$11,000
	Valve Boxes	$250	2	EA	$500
	HDPE MJ Adapter	$165	2	EA	$329
	Equipment Installation	$6,845	1	LS	$6,845
	Silt Fence	$2	110	LF	$220
	Fence Modifications and Utility Relocation	$5,000	1	LS	$5,000
3	**Reclaimed Water and Effluent Monitoring**				
	Hach Water Quality Monitoring Panel	$21,000	1	EA	$21,000
	3/8" PVC Pipe	$20	10	LF	$205
	1/2" PVC Pipe	$23	40	LF	$914
	3/4" PVC Pipe	$24	10	LF	$243
	1" PVC Pipe	$31	50	LF	$1,555
	1/2" Ball Valve	$76	1	EA	$76
	3/4" Ball Valve	$90	1	EA	$90
	3/8" 90° Bend	$31	3	EA	$92
	1/2" 90° Bend	$31	5	EA	$154
	3/4" 90° Bend	$36	3	EA	$108
	1" 45° Bend	$50	2	EA	$101
	1" 90° Bend	$43	9	EA	$390
	1/2" x 1/4" Reducer	$36	2	EA	$72
	24" Service Saddle w/ 1/2" Connection	$481	2	EA	$961
	1/2" Corps Stop	$146	2	EA	$291
	4" Service Saddle w/ 3/4" Connection	$198	1	EA	$198
	Pipe Supports	$2,500	1	LS	$2,500
	Sample Pump	$5,000	1	EA	$5,000
	Equipment Installation	$6,500	1	LS	$6,500
	Relocate Turbidimeter	$2,000	1	LS	$2,000
4	**Digested Sludge Pumps**				
	Curb Demolition	$10	17	LF	$166
	Concrete Surface Repair	$800	1	LS	$800
	4" Pipe Demolition	$10	55	LF	$550
	4" DI Pipe	$109	62	LF	$6,756
	4" Check valve	$2,140	2	EA	$4,280
	4" Plug Valve	$725	7	EA	$5,072
	4x4x4 Tee	$810	4	EA	$3,240
	4" 90° Bend	$401	8	EA	$3,205
	Rubber expansion joint	$250	4	EA	$1,000
	Pipe Supports	$500	10	EA	$5,000
	Heat Trace and Insulation	$28	223	LF	$6,237
	Heat Trace Accessories	$763	1	LS	$763
	Pressure Sensor, Switch, Gauge Assembly	$1,500	3	EA	$4,500
	Pumps	$11,000	2	EA	$22,000
	Equipment Installation	$6,625	1	LS	$6,625
	Pump Pads	$1,000	0.55	CY	$550
	1" PVC Pipe	$31	20	LF	$622
	1" Ball Valve	$100	1	EA	$100
	1" Globe Valve	$250	1	EA	$250
	1" PVC Check Valve	$100	1	EA	$100
	1" Rotameter	$250	1	EA	$250
5	**Permeate Equalization**				
	Concrete Coring through CMU Wall	$193	2	EA	$385

	Concrete Coring through EQ Tank	$349	3	EA	$1,046
	Conduit Demoltion	$8	16	LF	$124
	Vertical Spool Demolition	$20	21	LF	$412
	Vertical Spool Cutting	$85	4	EA	$340
	Replace BFV at MBR Tank No. 4	$1,500	1	EA	$1,500
	Replace Springs at Check Valves	$600	8	EA	$4,800
	Remove and Reinstall 18" MA Pipe Supports	$1,200	2	EA	$2,400
	Modify 3/4" NG Pipe	$500	1	LS	$500
	8" DI Pipe	$141	54	LF	$7,623
	10" SST Pipe	$428	75	LF	$32,119
	12" SST Pipe	$559	11	LF	$6,150
	12" DI Pipe	$221	82	LF	$18,082
	10x10x8 Tee Fitting	$3,021	4	EA	$12,085
	8x8x8 Tee Fitting	$1,498	7	EA	$10,483
	12" 45° Fittings DI	$1,452	4	EA	$5,808
	12" 90° Fittings DI	$1,582	4	EA	$6,328
	12" 90° Fittings SST	$2,580	2	EA	$5,160
	8" Expansion Joints	$650	2	EA	$1,300
	8" 90° Fittings	$884	7	EA	$6,187
	8" Blind Flange	$394	4	EA	$1,576
	10" Cap	$790	1	EA	$790
	8" Flange Coupling Adapter	$661	7	EA	$4,630
	10" Flange Coupling Adapter	$1,906	1	EA	$1,906
	Suction and Discharge Bell Fittings	$2,580	2	EA	$5,160
	Pipe Supports	$700	25	EA	$17,500
	2" Air Release Valve	$600	3	EA	$1,800
	8" Check Valve	$4,846	1	EA	$4,846
	8" Butterfly Valve	$3,495	6	EA	$20,968
	10" and 12" Butterfly Valve	$3,495	3	EA	$10,484
	8" V-Port Ball Valve	$5,549	1	EA	$5,549
	Valve Actuators	$10,000	10	EA	$100,000
	12" 45° Fittings SST	$2,138	2	EA	$4,277
	10" 45° Fittings SST	$1,704	10	EA	$17,038
	10x12 Increaser	$1,582	1	EA	$1,582
	12x8 Reducer	$1,582	1	EA	$1,582
	8" Flow Meter	$6,000	1	EA	$6,000
	16" Penetration Link Seals	$764	4	EA	$3,057
	6" SST Pipe (Sump Piping)	$653	22	LF	$14,360
	6" 90° Bend	$884	1	EA	$884
	Sump Pump Bases	$8,500	1	EA	$8,500
	Guide Rails and Brackets	$1,500	1	LS	$1,500
	Level Transmitters	$750	1	EA	$750
	Level Transmitter Stilling Well	$1,000	1	EA	$1,000
	Level Switches	$200	2	EA	$400
	Float Switch Anchor Kit	$300	1	EA	$300
	Pressure Transmitters	$400	5	EA	$2,000
	Pump Pad	$1,000	1	CY	$500
	Permeate Pump Rehabilitation and Coating	$6,000	5	EA	$30,000
	City Furnished Permeate Pump Installation	$4,000	1	EA	$4,000
	Other Equipment Installation	$30,113	1	LS	$30,113
	Existing Fabric Supported Cover Modifications	$8,000	1	LS	$8,000
	Modify Conduits for Existing Valve Actuators & Flow Meters	$1,000	16	EA	$16,000
6	**Systems Integration**				
	Main PLC Programming	$30,000	1	LS	$30,000
	SBR PLC Programming	$15,000	1	LS	$15,000
	SHB PLC Programming	$10,000	1	LS	$10,000
	MBR PLC Programming	$15,000	1	LS	$15,000
	UV PLC Programming	$15,000	1	LS	$15,000
	SCADA System Upgrades	$45,000	1	LS	$45,000
7	**Electrical Work**				
	Electrical Equipment	$47,100	1	LS	$47,100
	Electrical Circuits	$40,700	1	LS	$40,700
	Electrical Installation	$41,500	1	LS	$41,500
8	**Force Account**	$40,000	1	LS	$40,000
	Subtotal				***$1,011,621***
	Contractor OH&P (15%)				$151,743
	Subtotal				$1,163,364
	Sales Tax (9.2%)				$107,029
	Subtotal				$1,270,393
	Contingency (10%)				$127,039
	TOTAL				**$1,397,432**