MWMC Eugene-Springfield WPCF Facility Plan—Secondary Treatment Alternatives

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Executive Summary

As part of the Facility Plan Update for the Metropolitan Wastewater Management Commission (MWMC), alternatives were evaluated for increasing the secondary treatment capacity at the Eugene-Springfield Water Pollution Control Facility (WPCF). An increase in base capacity is necessary to comply with the anticipated 2025 National Pollutant Discharge Elimination System (NPDES) maximum month and maximum week permit conditions. It is also necessary to increase the secondary treatment wet season capacity so that a blended treatment strategy can be used to accommodate the flows resulting from the 5-year 24-hour rainfall event without resulting in sanitary sewer overflows. Federal effluent blending policy is still evolving; however, for the alternatives presented to be successful, a key underlying assumption is that some level of effluent blending would continue to be an acceptable approach to treating the peak wet weather flows. Preliminary cost estimates were developed for the purpose of comparing alternatives and are based on similar capacity increases for all alternatives considered.

The following alternatives were considered for expanding the capacity of the secondary treatment facilities:

- Alternative 1 – Expand existing secondary treatment system to match existing operations
- Alternative 2 – Modify existing secondary treatment to step-feed plug-flow with anoxic selectors
- Alternative 3 – Modify existing secondary treatment to a partial membrane bioreactor process

The alternatives analysis presented in this technical memorandum was conducted with the assumption that no net increase in biochemical oxygen demand (BOD) and total suspended

solids (TSS) mass would be included in future NPDES permits and dry season nitrification will be required to achieve a maximum month effluent concentration of 12 mg/L as is currently required in the existing NPDES permit. All alternatives also include an increase in secondary treatment capacity to 165 mgd and include baffling enhancement of the existing eight secondary clarifiers, as outlined in the *Secondary Clarifier Enhancement Alternatives Analysis* technical memorandum.

Evaluation of the alternatives included both a relative cost comparison and a non-monetary evaluation. Improvements that are common to the alternatives were not included in the relative cost comparison. Only improvements that were unique to each alternative were included. The results from the relative cost and non-monetary comparisons are summarized in Table 1.

TABLE 1
Summary of Cost and Non-Cost Comparisons
MWMC Facility Plan, Eugene-Springfield

Alternative	Capital Cost (millions of 2004 dollars)	Non-Monetary Comparison (based on maximum of 30 points)
Alternative 1 – Expand existing	$39.0	15
Alternative 2 – Modify existing to step feed with anoxic selector process	$19.3	27
Alternative 3 – Modify existing to a partial membrane bioreactor process	$47.2	24

All alternatives considered would provide adequate treatment to meet the 2025 NPDES anticipated permit conditions. Alternatives 1 and 2 would require the use of tertiary filtration to provide Level IV reuse and process reliability. Alternative 3 does not require the use of tertiary filtration, a consideration that is reflected in the cost evaluation. Alternative 2 is the recommended alternative for secondary treatment improvements because it provides the following advantages over the other alternatives:

- Increases bioreactor capacity by increasing the mixed liquor concentration
- Modifications can be constructed within the existing infrastructure footprint
- Process reduces solids loading to the secondary clarifiers
- Improves sludge settleability and provides for its control
- Provides consistent and complete nitrification
- Provides process flexibility for seasonal operation
- Provides efficient operation to reduce capital and operations and maintenance costs (e.g., alkalinity recovery without mixed liquor recycle pumping)
- Maximizes use of existing facilities
- Provides highest long-term capacity at the lowest cost

Introduction

This technical memorandum has been prepared as part of the Metropolitan Wastewater Management Commission (MWMC) Facility Plan Update (MWMC Project No. 80010) and evaluates secondary treatment alternatives at the Eugene-Springfield Water Pollution Control Facility (WPCF). An increase in base secondary treatment capacity is necessary to comply with the anticipated 2025 National Pollutant Discharge Elimination System (NPDES) maximum month and maximum week permit conditions. It is also necessary to increase the secondary treatment wet season capacity so that a blended treatment strategy can be used to accommodate the flows resulting from the 5-year 24-hour rainfall event without resulting in sanitary sewer overflows (SSOs).

Secondary treatment facilities at the WPCF consist of biological treatment and clarification. Two 8.9-million-gallon aeration basins, each with four cells (2.2 –million gallons each), eight 130-foot-diameter secondary clarifiers, an aeration system, and a return activated sludge (RAS) pump station provide biological treatment.

The capacity of the secondary treatment facilities is dependent on both the aeration basins and secondary clarifiers working together. Either facility can limit capacity depending on the mode of operation and seasonal effluent limits. The original facilities could operate in four modes: plug-flow, step-feed, complete mix and contact stabilization. The contact stabilization mode provided the highest capacity rating for the facility. The existing original maximum month dry weather capacity was estimated at 49 million gallons per day (mgd) and the maximum month wet weather capacity was estimated at 75 mgd.

The existing secondary treatment capacity noted above was estimated prior to the dry weather nitrification requirement imposed by the 2002 NPDES permit. The new effluent ammonia limit requires a monthly average of 12 milligrams per liter (mg/L) and a maximum day of 22 mg/L from May 1 through October 31. Current maximum month dry weather capacity assessments accounting for nitrification estimate the secondary treatment capacity with one aeration basin out of service and operating in a plug-flow mode at 29 to 32 mgd. High flows occurring in May, June, and late October combine with lower wastewater temperatures, making it difficult to achieve the monthly average ammonia limit. In addition, the higher solids loading to the secondary clarifiers as a result of nitrification make it difficult to achieve the low 10 mg/L monthly total suspended solids (TSS) concentration limit.

Wet season (November 1 through April 30) operations do not require nitrification. The maximum month wet weather secondary treatment capacity is estimated at 75 mgd. The peak diurnal wet weather secondary treatment capacity has been assessed at 103 to 111 mgd, limited by the secondary clarifiers' inability to provide sufficient effluent quality at high surface overflow rates. Historically, wet weather flows in excess of 103 mgd are diverted around secondary treatment and blended with secondary effluent before entering the chlorine contact basins. Current and historical peak wet weather flows exceed 200 mgd; the exact peak flow values are unknown because the WPCF is unable to accurately measure flows above approximately 200 mgd and because the collection system is unable to deliver the peak flows to the WPCF. Collection system modeling estimates peak flows at the 5-year, 24-hour rainfall event to be 265 mgd and 277 mgd for the existing and 2025 conditions, respectively. However, because of the peak flow management approach recommended in the *Peak Flow Management Alternatives* technical memorandum, the flow through secondary treatment will be limited to 160 to 165 mgd.

Existing secondary treatment capacity will need to be expanded to accommodate the future dry weather and wet weather peak week and maximum month flows. In addition to providing a base capacity increase, this will also increase the facility's ability to handle peak wet weather flows. Alternatives have been developed to evaluate the most effective expansion approach to meet the future needs of the facility. These alternatives are presented below.

Existing Facilities

The MWMC WPCF currently has a total of eight activated sludge basins to provide biological secondary treatment. The original design was intended to operate in complete mix, plug-flow, or contact stabilization mode. The original aeration system consisted of six centrifugal blowers and coarse bubble aeration. In 1996, three of the eight aeration basins were modified and the coarse bubble aeration systems were replaced with fine bubble membrane diffusers.

The secondary treatment average dry weather capacity was estimated at 49 mgd prior to the issuance of the new 2002 NPDES permit. This capacity was based on an adequate solids retention time (SRT) to remove 5-day carbonaceous biological oxygen demand ($CBOD_5$) only and does not account for any nitrification. At the same time, the peak hour wet weather treatment capacity was estimated at 103 mgd, limited by secondary clarification capacity. The introduction of nitrification in the 2002 NPDES permit stresses the facility's operation during dry weather as a result of the high solids concentrations maintained in the aeration basins to provide the SRT required for nitrification and the secondary clarifier's inability to handle those additional solids. Historically for wet weather peak flows, primary effluents in excess of 103 mgd are diverted around secondary treatment and blended with secondary effluent and disinfected prior to disposal.

Secondary clarification takes place using the original eight secondary clarifiers constructed in 1984. Mixed liquor is split to each secondary clarifier using sluice gates. Each secondary clarifier is 130 feet in diameter, uses inboard launders, and contains a rapid sludge removal (RSR) mechanism that draws return sludge from the clarifier floor with the use of polyvinyl chloride (PVC) suction tubes. Secondary scum is removed from the surface of the clarifier and flows by gravity to the secondary scum pump station located in the secondary control complex. Recent data indicate the wet weather peak hour capacity of the secondary clarifers to be 111 mgd, somewhat more than the 103 mgd estimated originally. Operations staff have been able to pass these higher peak flows; however, flow management techniques are required for the facility to stay within permit limits.

Return sludge is removed from each clarifier through the RSR mechanism. The return sludge flow can be adjusted from each clarifier using electrically operated and controlled weir gates. Return sludge flows by gravity to the RAS pump station. Four vertical turbine pumps lift the activated sludge to a control structure where the RAS is distributed back to the aeration basins through four parallel pipes. Activated sludge is then distributed to each aeration basin through a submerged diffuser header. The waste activated sludge (WAS) flow rate is controlled using flow meters and control valves. The WAS flows by gravity to the gravity belt thickener (GBT) and receives subsequent digestion.

Table 2 summarizes the secondary treatment unit processes and equipment at the WPCF.

TABLE 2
WPCF Secondary Treatment Unit Processes and Equipment
MWMC Facility Plan, Eugene-Springfield

Equipment	Type	Quantity	Capacity, (each/total firm[1]/total[2])
Aeration Basins	Complete mix or plug-flow activated sludge cells, 135 ft x 135 ft x 16 ft sidewater depth, Volume = 2.2 MG each, Total Volume = 17.6 MG	2 (8 cells)	MMDW 24.5/43/49 MGD[3] MMWW 21/63/75 mgd PWWF 111 mgd
Fine Bubble Aeration (Cells 1, 2, and 3 in north train)	7-inch membrane disc diffusers, 0.28 sq in each, diffusers, Basin 1 = 4017, Basin 2 = 4014, Basin 3 = 4490.	3	10,353 / 20,706 / 32,538 scfm
Coarse Bubble Aeration (Cell 4 in north train and cells 1 through 4 in south train)	Coarse bubble stainless steel air diffusers, 24-inch	5	15,000/60,000/75,000 scfm
Aeration Blowers	Centrifugal multi-stage blowers, 1000 hp	6	17,000/85,000/102,000 scfm
Secondary Clarifiers	130-foot-diameter, 14-foot side water depth, inboard launder, rapid sludge withdrawal mechanism, 44-inch influent column	8	WWMM 9/66/75 mgd DWMM 6/43/49 mgd PWWF 111 mgd
RAS Pump Station	Vertical Turbine Pumps - 30-inch Vertical Turbine Pumps - 24-inch	2 2	23(12)/58/70 mgd
Waste Activated Sludge	One 8-inch gravity wasting, with 6-inch magnetic flow meter and 6-inch flow control valve	2	MMDW = 0.41 mgd MMWW = 0.44 mgd PWWF = 0.78 mgd
Secondary Scum Pumps	Vertical centrifugal	2	1,200/1,200/2,700 gpm

Notes:
[1] Total firm capacity is with largest unit out –of service.
[2] Total capacity is with all units in service.
[3] Capacity noted is current rated capacity in NPDES permit.

Preliminary Screening of Alternatives

Existing secondary treatment capacity will need to be expanded to accommodate the future dry weather and wet weather peak day, peak week, and maximum month flows. In addition to providing a base capacity increase, this will also increase the facility's ability to handle peak wet weather flows. Alternatives should be developed to evaluate the most effective expansion approach to meet the future needs of the facility.

This memorandum focuses on the treatment alternatives required that will maximize the use of existing facilities to provide secondary treatment, and will further expand the secondary treatment capacity as needed to meet the future flow and load requirements. In addition, the secondary treatment facilities must work in conjunction with the peak flow treatment operation to provide an overall effluent that will meet or exceed secondary treatment standards. For this analysis it has been assumed that the plant hydraulics, primary treatment capacity, existing secondary clarifiers, and disinfection unit processes at the facility will be modified or expanded as needed to accommodate the secondary treatment facility needs. It has been assumed that the existing primary clarifiers have been modified in accordance with the *Primary Clarifier Analysis and Enhancements* technical memorandum to include the addition of baffling and primary sludge thickening outside the primary clarifiers using gravity thickeners. With these modifications the peak flow capacity of the existing primary clarifiers is estimated to be 160 mgd. Furthermore, it has been assumed that the existing secondary clarifiers have been modified in accordance with the *Secondary Clarifier Enhancements Alternatives Analysis* technical memorandum. The average dry and wet weather maximum month surface overflow rate (SOR) and capacity will vary with seasonal effluent requirements and the alternative being considered.

Suitable unit process alternatives and technologies were identified in the *Preliminary Screening of Alternatives* technical memorandum for further consideration. Those alternatives are evaluated in this memorandum and include the following:

- Expand existing biological process
- Modify existing aeration basins to a step-feed, plug-flow system with anoxic selectors
- Modify existing system to a membrane bioreactor (MBR)

Flows and Loads

Flows and loads for secondary treatment facilities were developed in the *Flow and Load Projections* technical memorandum and are summarized in Table 3 for the critical conditions. The ammonia loads shown in Table 3 are higher than the historical analysis. This change from the historical values was suggested by plant operations staff to account for the recent changes in filtrate return practices from the Biosolids Management Facility (BMF).

Secondary Treatment Alternatives

Alternative 1 - Expand Existing Secondary Treatment Facilities to Match Current Operations

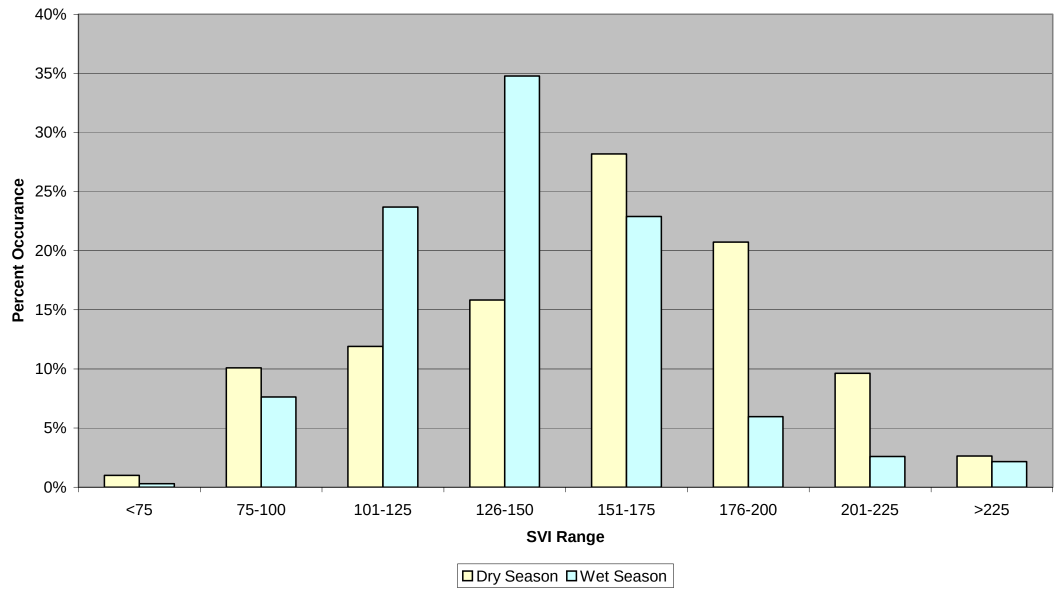
This alternative requires expansion of the secondary treatment facilities to match the current operational practices for biological treatment and secondary clarification. For this operation, all of the primary effluent and RAS is fed to the first aeration cell in each aeration basin. Sludge volume indexes (SVIs) from 1,100 dry weather days of operation show that approximately 22 percent of the measurements fall between 176 and 200 milliliters per gram (mL/g). Therefore, an SVI of 200 mL/g was used as the dry season design basis for expansion and assessing the capacity of the expanded secondary treatment facilities. SVIs from over 1,389 wet weather days of operation show that approximately 24 percent of the measurements fall between 151 and 175 mL/g. Therefore, an SVI of 175 mL/g was used as the wet season design basis for expansion and assessing the capacity of the expanded secondary treatment facilities. Figure 1 shows the historical range of SVI values. The selected SVI values will be used to assess the acceptable solids loading rates (SLRs) to the secondary clarifiers, and thus the acceptable maximum mixed liquor concentrations that can be maintained in the aeration basins.

TABLE 3
2025 Dry and Wet Season Flow and Loads Used For Secondary Treatment
MWMC Facility Plan, Eugene-Springfield

2025 Dry Season Flows and Loads			
	Maximum Month	**Maximum Week**	**Diurnal Peaking Factor**
Flow, mgd	59.3	86.2	1.41
BOD, mg/L	74,000	85,000	1.3
TSS, mg/L	87,600	112,000	1.3
Ammonia, mg/L	14,300	20,900	1.3
2025 Wet Season Flows and Loads			
	Maximum Month	**Maximum Week**	**Diurnal Peaking Factor**
Flow, mgd	110.8	165.3	[1]1.41
BOD, mg/L	74,000	90,500	1.3
TSS, mg/L	102,800	157,000	1.3
Ammonia, mg/L	15,700	23,400	1.3

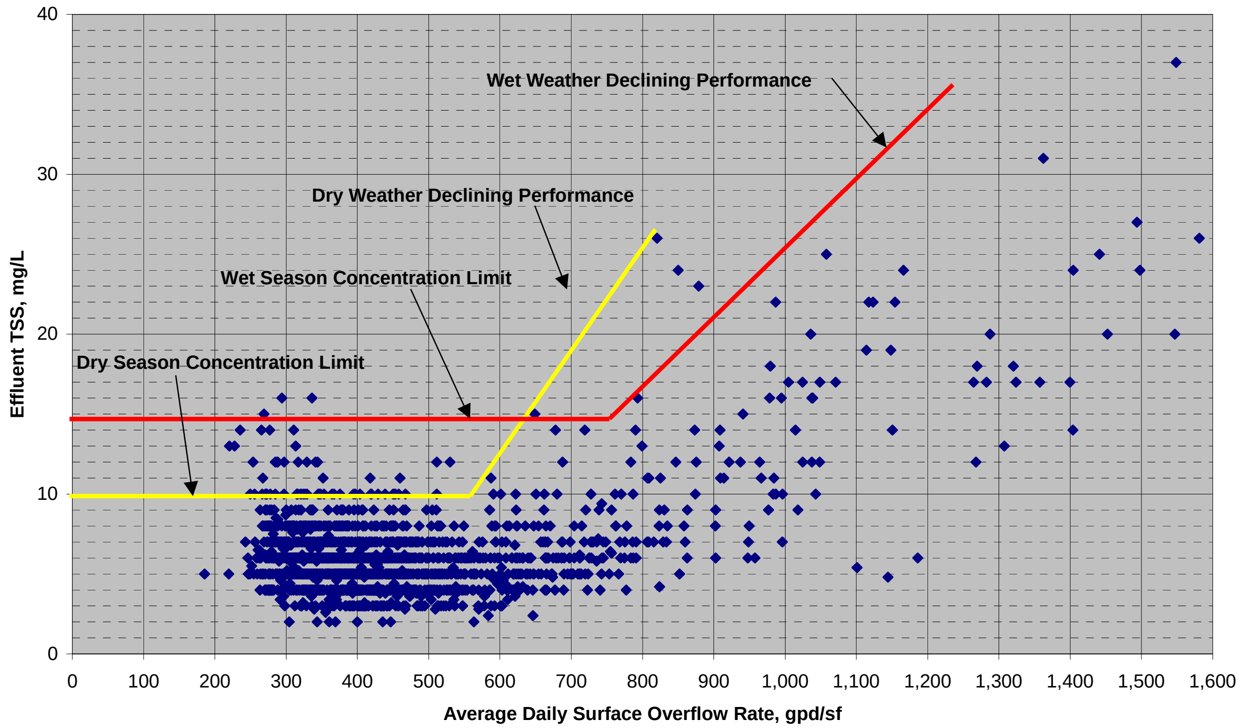
[1]The maximum diurnal flow to the secondary treatment facilities is 165.3 mgd, so no diurnal peaking factor is applied to the maximum week condition. The excess flow over 165.3 mgd is treated as primary effluent diversion.

Figure 1: Secondary Clarifier SVI
Summer = 1100 Data Points
Winter = 1389 Data Points



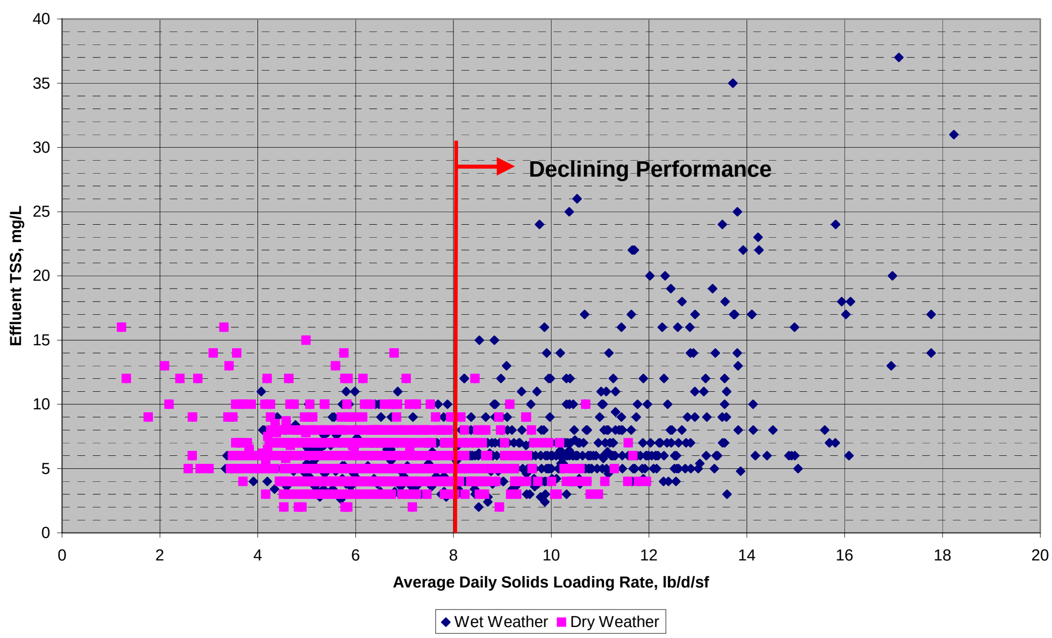
Having secondary treatment facilities that can achieve a target maximum month dry season concentration of 10 mg/L and a target maximum month wet season concentration of 15 mg/L is important when evaluating the capacity of a system that can reliably meet the NPDES permit. Figure 2 shows the historical performance of the existing secondary clarifiers plotted as effluent TSS versus average daily SOR. The diurnal peaking factors for both dry and wet season, estimated from plant flow data at 1.41 mgd, are included in these data as part of the 24-hour composite samples. These data show that the existing secondary clarifiers can achieve the target dry season effluent TSS concentration of 10 mg/L at SORs approaching 550 gallons per day per square foot (gpd/sf), although reliability is an issue. Even at low SOR values, there are still significant effluent TSS measurements above 10 mg/L. At SORs above 550 gpd/sf, there is a rapid decline in performance when assessed against the target concentration of 10 mg/L. The data also show that the existing secondary clarifiers can achieve a wet season effluent TSS concentration at SORs approaching 750 gpd/sf (see also the technical memorandum *Secondary Clarifier Enhancements – Alternative Analysis)*with somewhat more reliability than the dry season data. At SORs above 750 gpd/sf, there is a rapid decline in performance when assessed against the target concentration of 15 mg/L. The results of this analysis indicate that using a maximum month dry weather SOR of 550 gpd/sf and a maximum wet weather SOR of 750 gpd/sf is justified when assessing the capacity of the existing system.

Figure 2: Existing Secondary Clarifier Performance
Combined Wet and Dry Season Surface Overflow Rates



Secondary clarifier SLRs also have a profound impact on the secondary treatment system capacity. SLRs are determined primarily by the average influent flow rate, the peak diurnal influent flow rate, the mixed liquor concentration in the aeration basins, and the RAS flow rates. Typically, the maximum SLR for a secondary clarifier is based on the sludge SVI as discussed previously. Other factors besides the SVI influencing the maximum allowable SLR to the secondary clarifiers include clarifier geometry, return sludge flow rates, and mixed liquor concentrations. Many of the variables are dependent on the operation of the aeration basin and therefore the maximum allowable SLR is established by both the aeration basins and secondary clarifiers. Figure 3 shows the historical dry and wet season performance of the existing secondary clarifiers plotted as effluent TSS versus the average daily solids loading rate. As with the SOR data plot above, the diurnal peaking factors for both the dry and wet season are also included in these data. These data show that there is more variability in the dry season data at lower SORs, which is consistent with the historically higher SVI values shown in Figure 1 for the dry season. In other words, lower SLRs can be maintained in the dry season compared with the wet season while maintaining the same effluent TSS quality. Generally, for both dry and wet season there is a sharp decline in performance when the system operates above an average daily SLR of 8 pounds per day per square foot (lb/d/sf). Process modeling of the existing system will show that the maximum peak diurnal SLR values will almost always limit both dry and wet season secondary treatment capacity for the existing system. The maximum daily SLR values shown in Figure 3 are consistent with those predicted by the modeling effort under similar RAS and mixed liquor concentration scenarios. This confirms that the SVIs used to model the existing system are accurate when assessing the capacity of the existing system.

Figure 3: Existing Secondary Clarifier Performance
Solids Loading Rates



Based on the plant data analysis and the previous discussion, Table 4 summarizes the dry and wet season design criteria used for analysis for expanding the existing secondary treatment system.

TABLE 4
Design Criteria: Traditional Plug-Flow Aeration Basins
MWMC Facility Plan, Eugene-Springfield

Parameter	Dry Season	Wet Season
Temperature, degrees C	15.6	12.5
Nitrification Safety Factor	2.0	N/A
Aerobic Volume	100%	100%
Aerobic SRT, days	7.8	5
Max Daily SOR, gpd/sf	550	750 (825 for combined new and existing clarifiers)
SVI, mL/g	200	175

Using the design criteria outlined in Table 3, the existing secondary treatment facilities were modeled using CH2M HILL's Pro2D modeling software to assess the secondary treatment capacity under various scenarios. The results of the dry and wet season capacity analyses are shown in Figures 4 and 5, respectively. The maximum month capacity is shown in the "y" axis versus the number of secondary clarifiers in service shown on the "x" axis. Although the capacity is based on the maximum month concentrations of pollutant constituents, it also closely approximates the maximum week conditions, because both the maximum month and maximum week diurnal peaking factors were estimated at 1.41. Various capacity lines showing the number of aeration basins in service and the SOR capacity of the secondary clarifiers are plotted.

Figure 4: Existing Dry Weather Secondary Treatment System Capacity

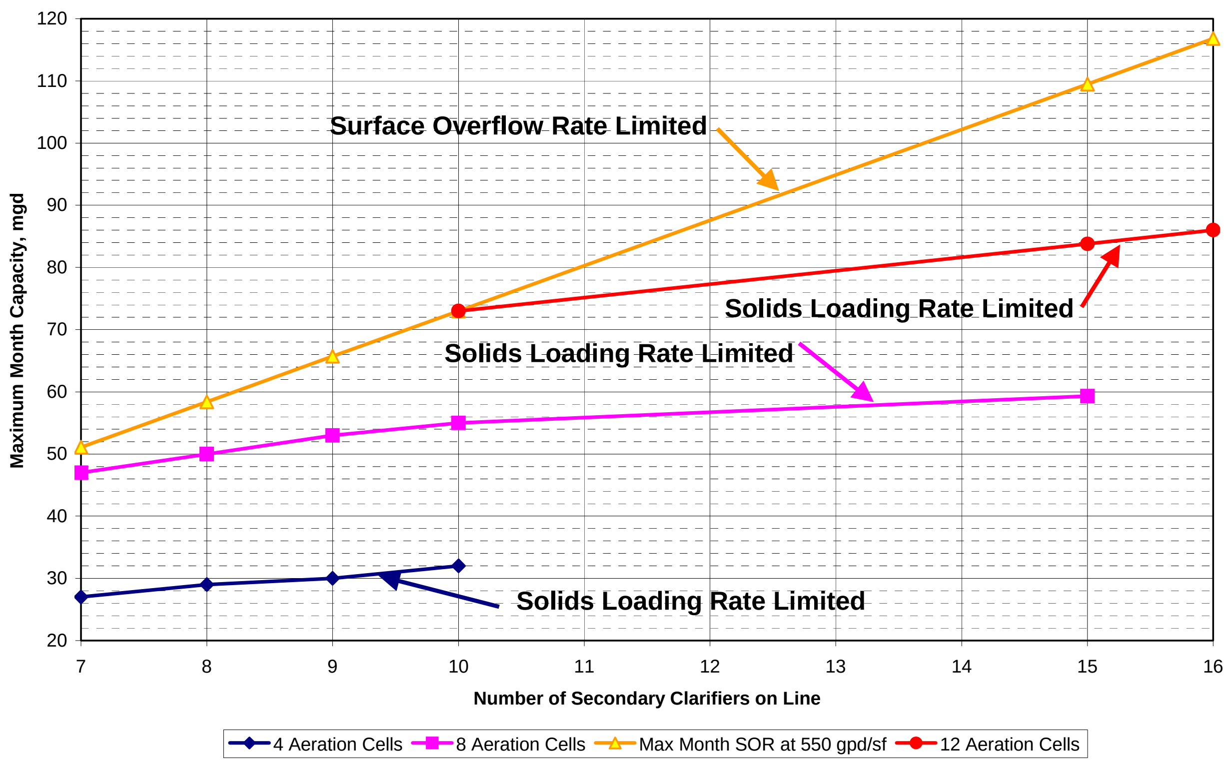


Figure 4 shows that the existing secondary treatment capacity with one aeration basin (four cells) in service and eight secondary clarifiers in service is 29 mgd, limited by the solids loading rate at the secondary clarifiers. Similarly, with two aeration basins (eight cells) in service and eight secondary clarifiers in service, the total dry season secondary treatment capacity is estimated at 50 mgd with no redundant units available, limited by the secondary clarifier SLR. The process modeling results for dry weather show that the effluent ammonia concentrations would be negligible if adequate alkalinity were present to support complete nitrification. However, historical process data show that sufficient alkalinity is not present to support complete nitrification without an alkalinity recovery process or the addition of alkalinity to the process. The effluent ammonia concentrations would be expected to be similar to those currently achieved. The modeling results also show that the dry weather capacity is always limited by the SLR and not the SOR, a result of the high mixed liquor concentrations needed to maintain nitrification.

Figure 5: Existing Wet Weather Secondary Treatment Capacity

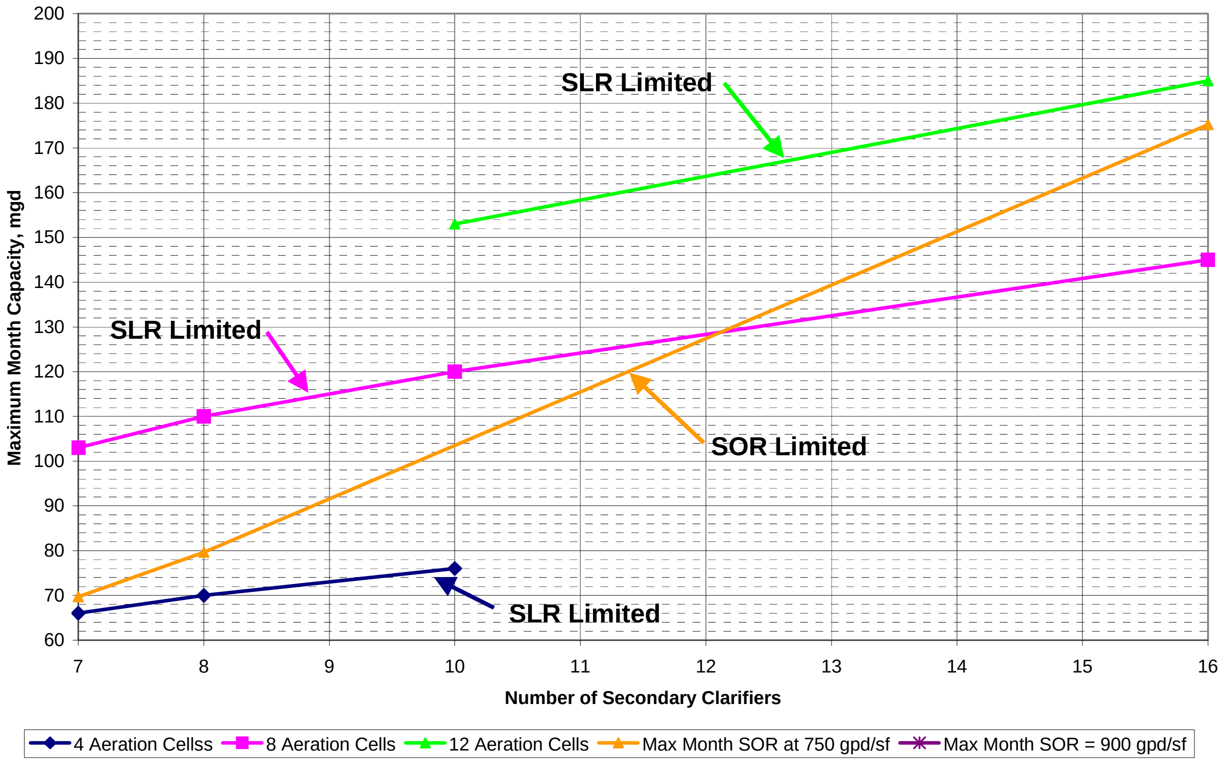


Figure 5 shows that the existing wet season secondary treatment capacity with one aeration basin (four cells) in service and eight secondary clarifiers in service is 70 mgd, limited by the solids loading rate at the secondary clarifiers. Similarly, with two aeration basins (eight cells) in service and eight secondary clarifiers in service, the total wet season secondary treatment capacity is estimated at 80 mgd, limited by the existing secondary clarifier SOR limit of 750 gpd/sf. Note that the slope of the SOR line increases with increasing secondary clarifiers. This increase in slope is caused by the increase in performance gained by the construction of new enhanced secondary clarifiers. The SOR line represents the performance of the combined existing and new secondary clarifiers.

Table 5 summarizes the facility requirements for expanding the existing secondary treatment facilities to meet the 2025 flow and load requirements. For dry weather, 15 secondary clarifiers and two aeration basins (eight cells) are needed to meet the maximum month dry weather flow. With these units in service the secondary treatment capacity is estimated at 60 mgd and is limited by the secondary clarifier SLR. Sixteen secondary clarifiers and three aeration basins (12 cells) are needed to achieve a dry weather maximum week capacity of 86 mgd, in which capacity is limited by the secondary clarifier SLR.

For wet weather, 11 secondary clarifiers and two aeration basins (eight cells) are needed to meet the maximum month wet weather flow. With these units in service the process capacity is estimated at 115 mgd and is limited by the existing secondary clarifier SOR.

Sixteen secondary clarifiers and three aeration basins (12 cells) are needed to meet the wet weather maximum week flow. With these units in service the process capacity is estimated at 173 mgd and is limited by the secondary clarifier SOR for the existing and new secondary clarifiers combined. The data show that the existing eight secondary clarifiers would not have to be enhanced to meet the projected flows if the new secondary clarifiers were constructed with baffling enhancements. However, it would still be recommended to enhance the existing secondary clarifiers in order to improve the reliability of performance.

TABLE 5
Facility Requirements for Alternative 1 at 2025
MWMC Facility Plan, Eugene-Springfield

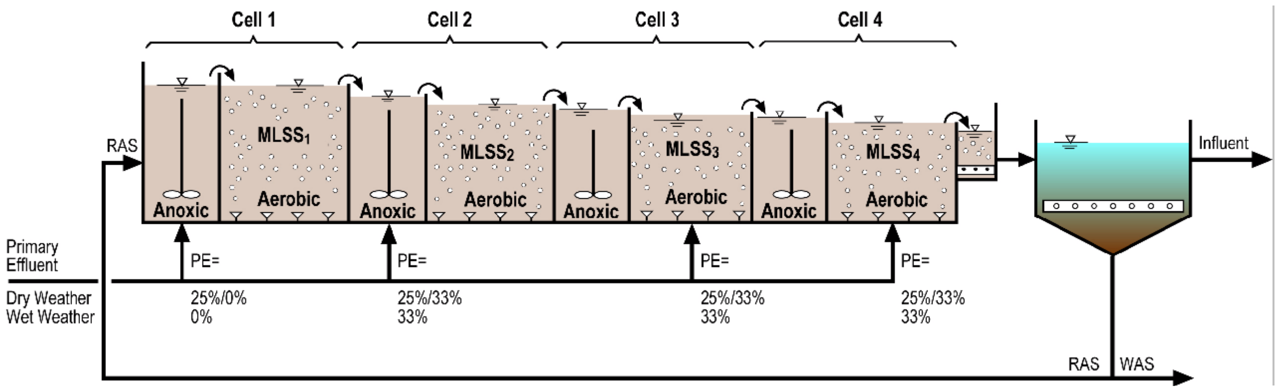
NPDES Permit Condition	Aeration Basin	Secondary Clarifiers	Total Capacity (mgd)	Required Capacity (mgd)
DWMM	2 (4 cells each)	15	60	59
DWMW	3 (4 cells each)	16	86	86
WWMM	2 (4 cells each)	11	115	111
WWMW	3 (4 cells each)	16	173	165

Alternative 2 - Modify Existing Secondary Treatment Facilities to a Step-Feed, Plug-Flow System with Anoxic Selectors

This alternative focuses on modifications to the existing aeration basins to convert them to a step-feed plug-flow with anoxic selector process. The anoxic, step-feed, plug-flow air-activated sludge process is an improvement on the complete mix or plug-flow activated sludge process used historically at the WPCF. It combines the well-known step-feed, plug-flow activated sludge process with the anoxic selector process.

In the anoxic, step-feed, plug-flow air-activated sludge process, effluent from the primary clarifier is fed to various points along the aeration tank, which is compartmentalized into anoxic and aerobic zones. Figure 6 is a basic process flow diagram for the step-feed process. Selective organism growth in the anoxic selectors allows for sludge settleability control. Nitrification and denitrification occur in the aerobic and anoxic environment, allowing for removal of nitrogen forms from the wastewater effluent. In addition to these benefits, the anoxic, step-feed process allows the use of smaller aeration basins and secondary clarifiers, eliminates the need for mixed liquor recirculation pumping, and reduces process energy and alkalinity requirements. Thus it offers economic as well as process advantages. The basis for sizing the anoxic, step-feed, plug-flow air-activated sludge process is well-established and this process has been successfully used to meet similar criteria at a number of other treatment facilities.

FIGURE 6
WPCF Anoxic, Step-Feed Plug-Flow Process
MWMC Facility Plan, Eugene-Springfield



Because the primary effluent is introduced in portions to each zone, the total dilution effect is delayed such that the mixed liquor concentrations in the early zones are higher than in subsequent zones. This is key to the step-feed process as the mixed liquor from the first, to the second, to the third, and to the fourth zones decreases. This configuration increases the average mixed liquor concentration in the basins while reducing the solids loading rate on the secondary clarifiers. For a given mixed liquor concentration to the final clarifiers, the step-feed anoxic selector process can support a higher sludge inventory and SRT than conventional designs, increasing the treatment capacity of a given tank volume.

Pumped recirculation of nitrified mixed liquor is not required for the step-feed anoxic selector process. Nitrified mixed liquor flows out of each aerated cell directly into the subsequent anoxic selector of the following cell where denitrification occurs. Therefore, the capital and operating costs associated with the nitrified mixed liquor pumping equipment are eliminated. RAS recycle pumping would continue and performs a dual function of biomass return as well as nitrate recirculation from the secondary clarifiers.

The step-feed anoxic selector process provides for control of sludge settleability through selective organism growth, effectively reducing the SVI. The reduction in SVI enables the secondary clarifiers to be rated for a higher design solids loading rate. It is the effect of this increase in biological capacity in combination with improved sludge settleability that would allow the WPCF to increase its capacity using the existing aeration basin volume and secondary clarifiers. It was assumed that as part of the secondary treatment modifications the secondary clarifiers would be modified to include baffling to increase their capacity and provide a more reliable effluent quality.

To implement this technology at the WPCF, the existing complete mix/plug-flow aeration basins would have to be significantly modified to provide complete mixed anoxic selector zones physically separated from the aerobic zones. This may be accomplished by constructing a new dividing wall along the length of each cell in each basin to provide an anoxic selector having approximately 20 percent of the total aeration volume. This would provide four identical cells in each basin containing an anoxic selector followed by an aerobic zone. Primary effluent could then be distributed to each of these cells in various quantities to accommodate seasonal effluent requirements. Dry weather operations requiring nitrification could distribute primary effluent in the proportion of 25 percent to each cell, whereas wet weather operations where no nitrification is required could be distributed in the proportion of 25 percent to four cells or 33 percent to each of the last three cells in the aeration basin.

Table 6 summarizes the dry and wet season design criteria used for analysis of the step-feed anoxic selector process.

TABLE 6
Design Criteria: Step-Feed Anoxic Selector Process
MWMC Facility Plan, Eugene-Springfield

Parameter	Dry Season	Wet Season
Temperature, degrees C	15.6	12.5
Nitrification Safety Factor	2.0	N/A
Aerobic Volume	80%	80%
Aerobic SRT, days	7.6	4.8
Anoxic Volume	20%	20%
Anoxic/Anaerobic MCRT, days	1.9	1.2
PE Flow Split	25% to 4 cells	25% to 4 cells, or 33% to 3 cells
Max Daily SOR, gpd/sf	660	900
SVI, mL/g	110	120

Using the design criteria outlined in Table 5, the existing secondary treatment facilities were modeled using CH2M HILL's Pro2D modeling software to asses the secondary treatment capacity under various scenarios. The results of the dry and wet season capacity analyses are shown in Figures 7 and 8, respectively. The maximum month capacity is shown in the "y" axis versus the number of secondary clarifiers in service shown on the "x" axis. Various capacity lines showing the number of aeration basins in service and the SOR capacity of the secondary clarifiers are plotted.

For purposes of the dry weather capacity analysis shown in Figure 7, primary effluent was split to the last four anoxic selectors in a 25 percent ratio This operational approach maximizes the dry season capacity and allows for effluent control of ammonia in the system. Using this approach the influent alkalinity can be used efficiently and alkalinity recovery is gained in the anoxic selectors. For these simulations the effluent ammonia concentration ranged from 5.7 to 7.5 mg/L, which is below the anticipated permit level of 12 mg/L.

Plant data show that the average of 76 influent alkalinity measurements taken from April of 1998 to November of 1998 have an average of 170 mg/L, a maximum of 220 mg/L, and a minimum of 120 mg/L. A sensitivity analysis was performed to assess the effects of varying quantities of influent alkalinity on the nitrification process. The results of that analysis show that at 205 mg/L of influent alkalinity, the nitrification process is completely unimpeded. At 200 mg/L of influent alkalinity the first zone of the step feed basin becomes alkalinity-limited. This is because of the low influent alkalinity and the low alkalinity recovery rate in the first anoxic zone resulting from reduced nitrate levels in the return sludge. At 170 mg/L of influent alkalinity the second step-feed aerobic zone also becomes alkalinity- limited for nitrification; however, the model still shows that effluent ammonia concentrations are between 6.0 and 7.5 mg/L. A general assumption is that the plant currently operates under low alkalinity influent conditions to maintain an effluent ammonia concentration of less than 12 mg/L without an alkalinity recovery process. This alternative process provides for significant alkalinity recovery in the anoxic zones, from which the nitrification process will be improved and the subsequent mixed liquor pH levels will be higher than those produced by the existing process.

Figure 7 shows that the dry weather secondary treatment capacity with one of the existing aeration basins (four cells) modified and in service and all eight existing secondary clarifiers enhanced and in service would be approximately 52 mgd, limited by the solids loading rate at the secondary clarifiers. Similarly, with two of the existing aeration basins modified (eight cells) in service and all eight existing secondary clarifiers enhanced and in service, the total dry season secondary capacity is estimated at 70 mgd, limited by the secondary clarifier SOR.

Figure 7: Step Feed Dry Weather Secondary Treatment Capacity

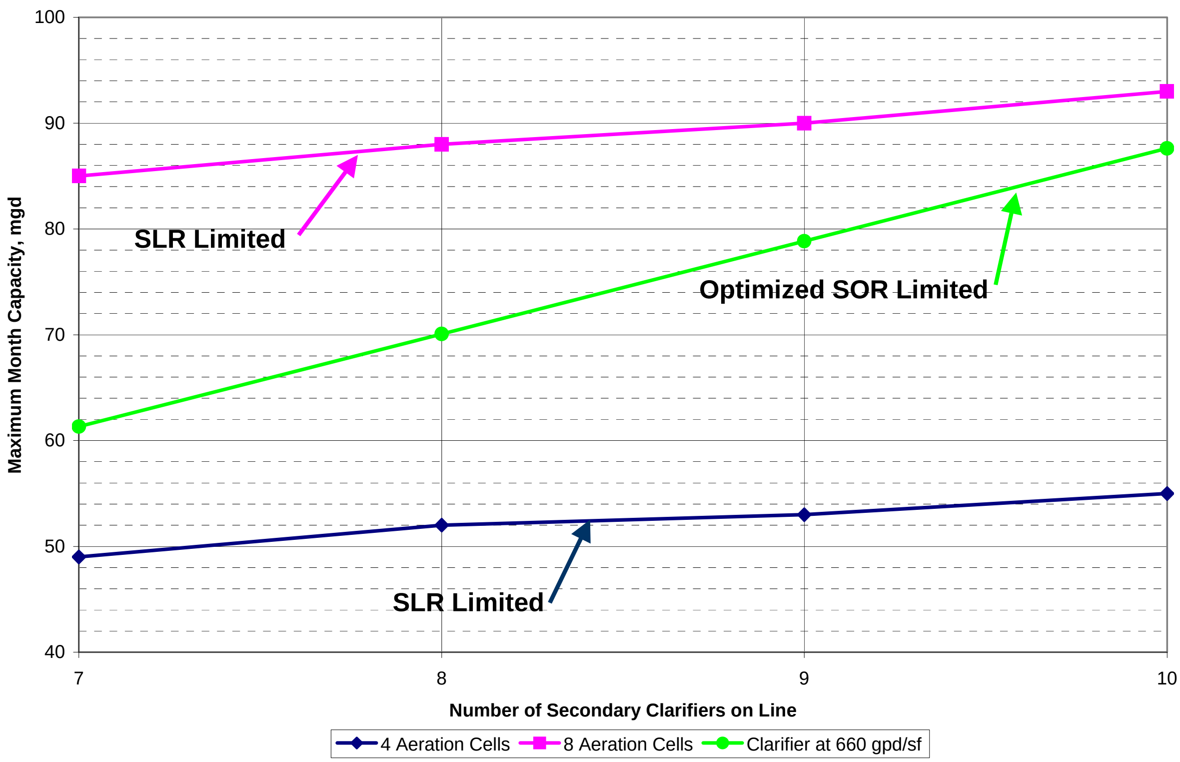


Figure 8: Step Feed Wet Weather Secondary Treatment Capacity

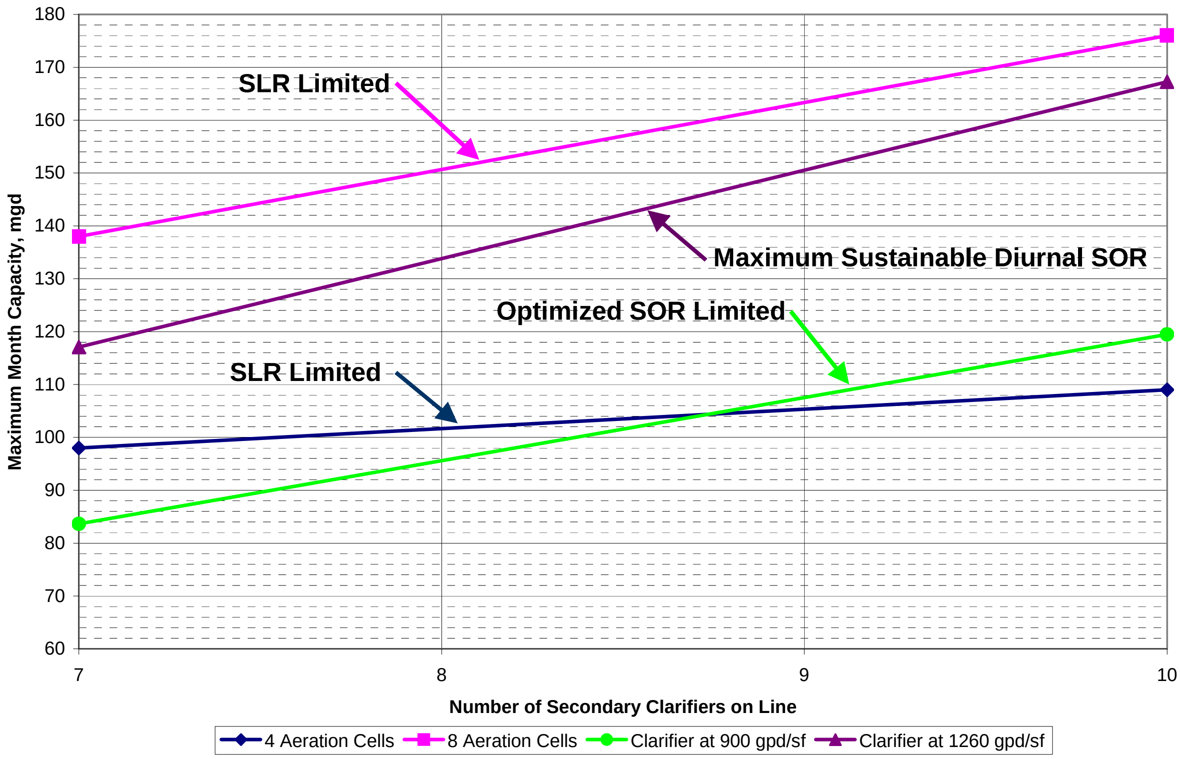


Figure 8 shows that the wet season secondary treatment capacity with one of the existing aeration basins (four cells) modified and in service and all eight existing secondary clarifiers enhanced and in service would be approximately 95 mgd, limited by the optimized secondary clarifier SOR. Similarly, with two of the existing aeration basins modified (eight cells) in service and all eight existing secondary clarifiers enhanced and in service, the total wet season secondary capacity is estimated at 133 mgd, limited by the maximum sustainable optimized secondary clarifier SOR.

Figure 9 shows the resulting modifications to the existing aeration basins to convert them to a step feed plug flow process.

Figure 9 – Step Feed Plug Flow Process Modifications

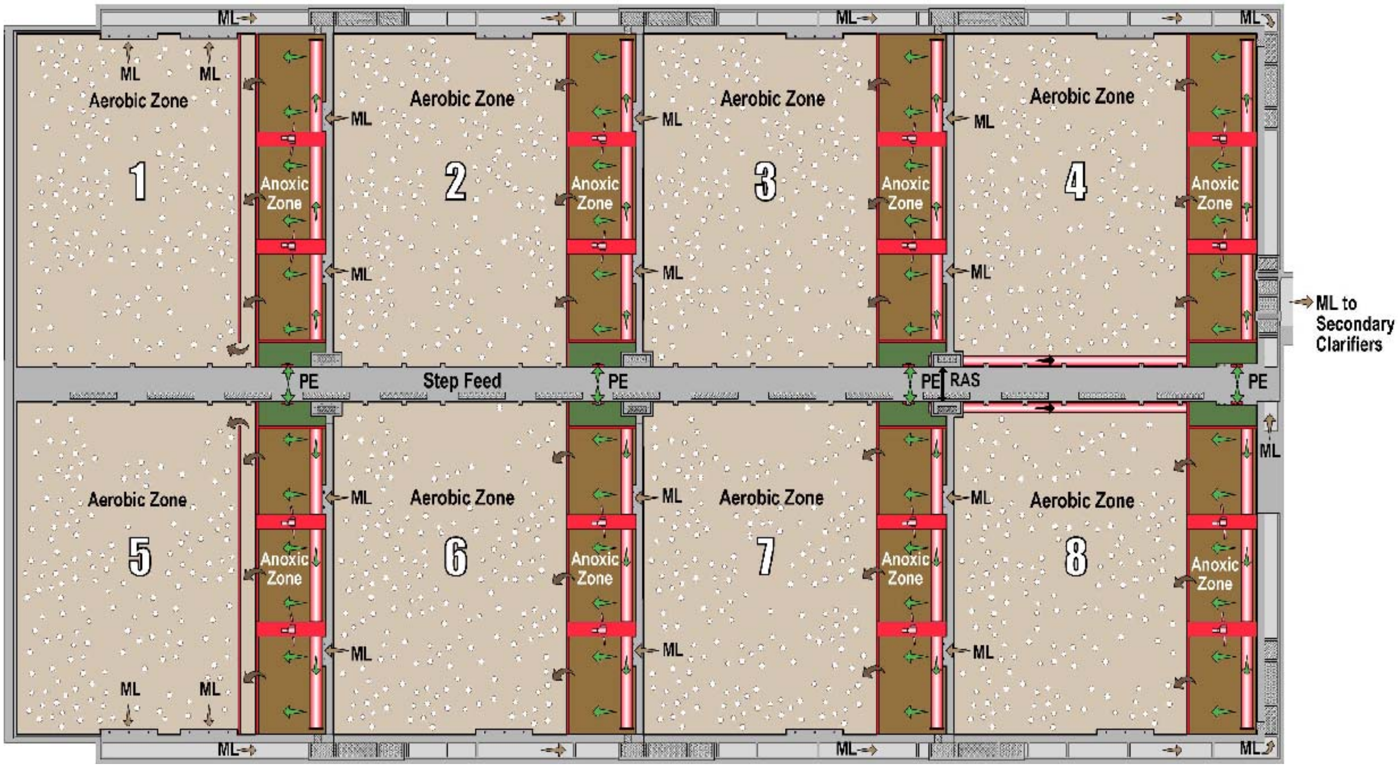


Table 7 summarizes the facility requirements for modifying the existing secondary treatment facilities to a step-feed system with anoxic selectors and enhancing the secondary clarifiers to meet the 2025 flow and load requirements. For dry weather, nine enhanced secondary clarifiers and two aeration basins (eight cells) are needed to meet the maximum month dry weather flow. With these units in service the process capacity is estimated at 70 mgd and is limited by the secondary clarifier SOR. Ten enhanced secondary clarifiers and two modified aeration basins (eight cells) are needed to achieve dry weather maximum week flows. With these units in service the process capacity is estimated at 70 mgd and is limited by the enhanced secondary clarifier SOR of 900 gpd/sf.

For wet weather, ten enhanced secondary clarifiers and two modified aeration basins (eight cells) are needed to meet the maximum month wet weather flow. With these units in service the process capacity is estimated at 119 mgd and is limited by the enhanced secondary clarifier SOR of 900 gpd/sf. Ten enhanced secondary clarifiers and two modified aeration basins (eight cells) are needed to achieve the wet season maximum week flow. Because the secondary clarifiers are all enhanced, the peak diurnal SOR can be maintained at the maximum week condition to meet the flow requirements. With these units in service the peak week secondary treatment capacity is estimated at 167 mgd and is limited by the enhanced maximum sustainable diurnal SOR of 1,260 gpd/sf.

TABLE 7
Facility Requirements for Alternative 2 at 2025
MWMC Facility Plan, Eugene-Springfield

NPDES Permit Condition	Aeration Basins	Secondary Clarifiers	Total Capacity (mgd)	Required Capacity (mgd)
DWMM	2 (4 cells each)	9	70	59
DWMW	2 (4 cells each)	10	90	86
WWMM	2 (4 cells each)	10	119	111
WWMW	2 (4 cells each)	10	167	165

Alternative 3 - Modify Existing Secondary Treatment Facilities to a Partial Membrane Bioreactor Process

This alternative focuses on modifications to the existing aeration basins to convert them to a partial MBR process. This alternative would require the use of existing facilities in parallel with new MBR facilities to upgrade the secondary treatment facilities to a capacity of 160 mgd, just as in alternatives 1 and 2. MBR processes are an emerging technology and provide some benefits over traditional aerated activated sludge processes and modified activated sludge processes. Perhaps the most notable benefits include the elimination of secondary clarifiers and the ability to produce Level IV effluent reuse water without the use of tertiary filtration.

In the MBR process primary effluent is fed to a plug-flow air-activated sludge basin where it is biologically treated to remove BOD and oxidize ammonia in the same manner as a traditional air-activated sludge process. These tanks usually contain the same anoxic selector technologies also used in traditional air-activated sludge processes for denitrification and alkalinity recovery. The biological process is exactly the same. The difference is that membrane cartridges are placed in the last air-activated sludge compartment and are used solely for liquids-solids separation. Mixed liquor flow is typically pumped through the membranes using vacuum pumps located on the downstream side of the membrane reactors. The membranes filter the mixed liquor and provide a secondary effluent having low suspended solids, typically between 1 and 5 mg/L. The effluent can be directly disinfected and used as Level IV reuse water.

For the Eugene-Springfield WPCF, the large aeration basin volume and limited secondary clarifier capacity make the facility ideal for implementation of MBRs. However, the equipment and infrastructure to implement MBRs is still very expensive and it would be cost-prohibitive to consider converting the entire existing secondary process to MBRs. For this reason it makes sense to develop an alternative that would use the existing aeration basins and secondary clarifier infrastructure in a traditional or modified configuration in combination with the implementation of MBRs to meet future facility needs.

The activated sludge for an MBR system must be a nitrifying sludge and should have an SRT adequate to achieve full-scale and complete nitrification at both summer and winter design temperatures. This is required to maintain a “non-sticky” sludge characteristic to prevent the mixed liquor from sticking to the membrane surfaces, which can cause extremely high differential head loss and subsequent membrane failure. The mixed liquor in the membrane tank, the last tank of the activated sludge process, can be maintained at 10,000 mg/L. The MBR tank volume is typically counted for purposes of computing the total SRT required. This allows the use of a smaller tank volume, but the benefits of this are partially offset by the high SRT required.

To maintain a relatively flat mixed liquor gradient from the first activated sludge tank to the last activated sludge tank (the MBR tank), a return sludge rate of four times the average design flow is recommended. It is also recommended that the biological system contain an anoxic selector to provide for alkalinity recovery in the system. The anoxic selector will require a nitrified mixed liquor return flow of two times the average primary effluent flow. Because the return sludge flow rate is so high and the MBR tank is highly aerated, it is recommended that the return sludge flow be recirculated from the MBR cell to the first aerobic cell rather than the anoxic cell to prevent unintended aeration of the anoxic cell. Nitrified mixed liquor can then be returned from the third cell to the anoxic cell at a lesser return rate.

The flow rate through a membrane, or flux rate, is temperature-dependent and for purposes of this analysis a typical industry standard peak to average flow rate was assumed to be 1.5. Table 8 outlines the biological design criteria necessary for the Eugene-Springfield WPCF to convert one aeration basin (four cells) to an MBR process.

TABLE 8
Design Criteria: Membrane Bioreactor Process
MWMC Facility Plan, Eugene-Springfield

Parameter	Dry Season	Wet Season
Temperature, degrees C	15.6	12.5
Aerobic Volume	85%	85%
Total SRT, (Including Anoxic) days	12	13
Nitrification SF	2.3	1.7
Anoxic Volume	15%	15%
Anoxic MCRT, days	1.8	2.0
MBR Tank MLSS Target, mg/L	10,200	11,000
Maximum MBR Water Depth, ft	14	14
Return Sludge Rate	4 x Influent PE	4 x Influent PE
Mixed Liquor Return Rate	2 x Influent PE	2 x Influent PE
MBR Peak to Average Flow Ratio	1.5	1.5

Using the design criteria outlined in Table 8, an MBR capacity assessment for the conversion of one aeration basin (four cells) to an MBR process was completed using CH2M HILL’s Pro2D model. Table 9 summarizes the resulting capacity assessment. Note that the capacities listed in the table represent the total maximum capacity that may be obtained in the system if adequate membranes were to be purchased and installed, not the capacity necessary to meet the 2025 flow and load capacity requirement.

TABLE 9
MBR Capacity Assessment for One Aeration Basin (Four Cells) Converted to an MBR Process
MWMC Facility Plan, Eugene-Springfield

Parameter	Dry Season	Wet Season
Aerobic Volume	3 cells at 1.89 MG	3 cells at 1.89 MG
Anoxic Volume	1 cell at 1.0 MG	1 cell at 1.0 MG
MBR Tank MLSS, mg/L	10,200	11,000
Average Capacity, MGD	40	71
Peak Diurnal Capacity, MGD	56	106

The information in Table 9 can be combined with the information presented in Alternative 2 to develop the required MBR capacity needs to meet the 2025 flow and load requirements. It is prudent to combine the Alternative 2 process modifications with the MBR technology to provide for a combined treatment system. This is because Alternative 2 maximizes the use of the existing infrastructure, provides the most process flexibility, provides alkalinity recovery required for the nitrification process, and will reduce pH impacts on the secondary effluent wastewater. Consideration should also be given to the fact that if MBRs are to be used in whole or in part, adequate capacity should be provided in the MBR system so that tertiary filtration will not be required. Therefore, the minimum average MBR capacity that should be considered is 30 mgd at dry weather flow conditions. Table 10 shows the additional MBR capacity requirements for the Eugene-Springfield WPCF secondary treatment process when combined with the Alternative 2 process modifications for one aeration basin (four cells) under several 2025 dry and wet weather flow scenarios.

From Table 10 the minimum MBR capacity requirements occur at the dry weather maximum week (DWMW) condition where the average flow is 34 mgd and the peak diurnal flow is 48 mgd. These flows fall within the maximum capacities for one aeration basin converted to an MBR system as outlined in Table 9, and meet the 30-mgd minimum capacity requirement set forth earlier for the replacement of the tertiary filtration system.

TABLE 10
MBR Capacity Requirements When Combined with Alternative 2 Process Modifications
for One Aeration Basin (Four Cells)
MWMC Facility Plan, Eugene-Springfield

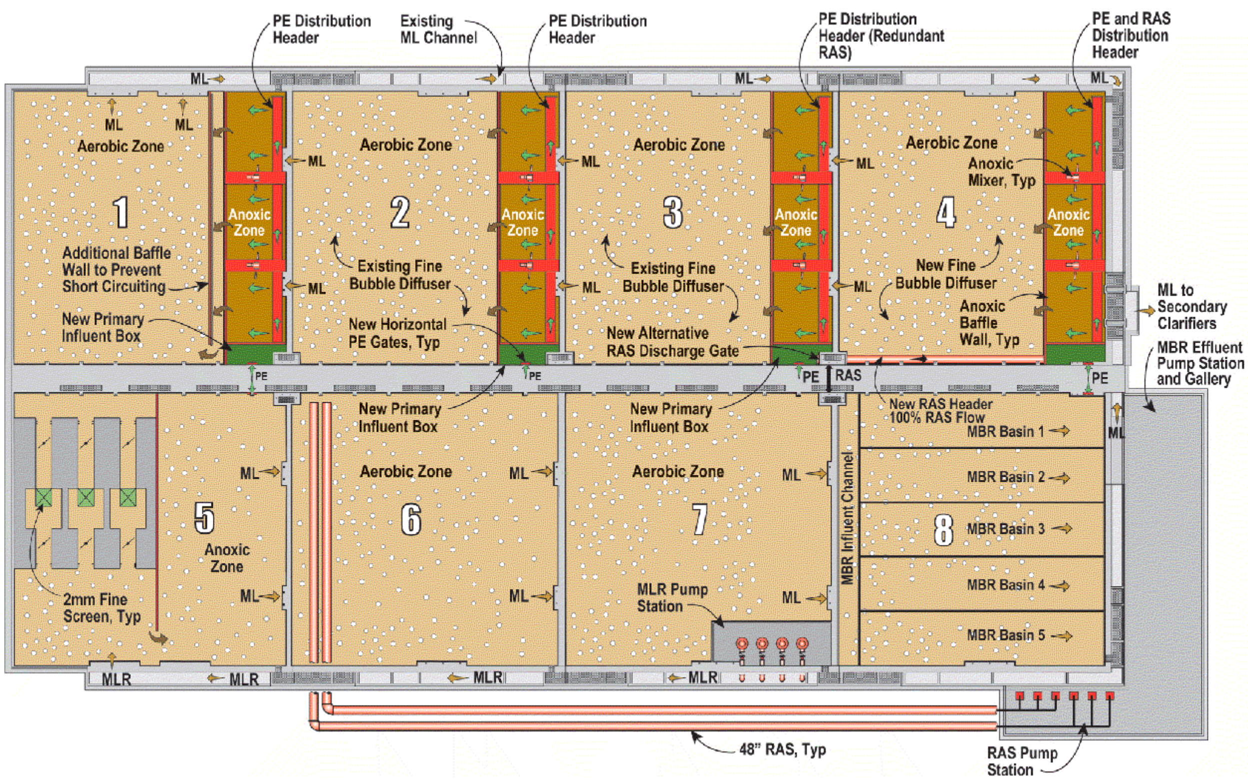
DWMM	2025 Required Capacity	Alternative 2 Capacity	MBR Required Capacity
Average	60	30	30
Peak Diurnal	84	42	42
DWMW	**2025 Required Capacity**	**Alternative 2 Capacity**	**MBR Required Capacity**
Average	86	52	34
Peak Diurnal	121	73	48

TABLE 10
MBR Capacity Requirements When Combined with Alternative 2 Process Modifications for One Aeration Basin (Four Cells)
MWMC Facility Plan, Eugene-Springfield

DWMM	2025 Required Capacity	Alternative 2 Capacity	MBR Required Capacity
WWMM	**2025 Required Capacity**	**Alternative 2 Capacity**	**MBR Required Capacity**
Average	111	95	16
Peak Diurnal	156	133	24
WWMW	**2025 Required Capacity**	**Alternative 2 Capacity**	**MBR Required Capacity**
Average	165	95	16
Peak Diurnal	165	133	32

Figure 10 shows the process modifications required to convert the existing aeration basins into a partial MBR treatment facility combined with step feed plug flow system.

Figure 10 - Existing Aeration Basins Converted to a Partial Membrane Bioreactor Process



Total infrastructure requirements necessary to implement a combined MBR and Alternative 2 secondary treatment system are shown in Table 11. It is important to note that if Alternative 3 is implemented, the tertiary filtration facilities would not be required.

TABLE 11
MBR Total Facility Requirements When Combined with Alternative 2 Process Modifications for a Complete Secondary Treatment System to Meet 2025 Capacity Needs
MWMC Facility Plan, Eugene-Springfield

Parameter	Dry Season
Conversion to Step Feed Plug Flow	One aeration basin (4 cells)
Secondary Clarifier Enhancements	8 existing secondary clarifiers
2 mm Fine Screens	3 at 25 mgd in 5 foot channel (1 redundant)
MBR Anoxic Zone	1 @ 1 MG with 4 submersible mixers
MBR Aerobic Zones	2 at 1.89 MG each
MBR Tank	1 at 1.89 MG (5 basins at 125 ft x 25 ft)
MBR Capacity	34 mgd average, 48 mgd peak
MLR Pump Station	68 mgd total, 4 pumps at 23 mgd each (1 redundant)
RAS Pump Station	135 mgd total, 6 pumps at 27 mgd each
Effluent gallery and effluent pumping	48 mgd total, effluent vacuum pumps
Membrane cleaning and chemical system	1 Citric acid cleaning system

Alternatives Cost and Non-monetary Comparison

Cost Comparison

Each alternative included the same enhancements to the existing eight secondary clarifiers. Table 12 summarizes the different facility requirements necessary to implement each alternative. These facility requirements serve as the basis for the cost comparison.

TABLE 12
Basis of Costs for Secondary Treatment Alternatives to Meet 2025 Requirements
MWMC Facility Plan, Eugene-Springfield

Basis of Costs For Alternative 1 – Expand Existing Secondary Treatment Facilities

Facility Requirements	Quantity
New Aeration Basins	1 (4 cells) same as existing
New Secondary Clarifiers	8 with enhancements
New Return Activated Sludge Pump Station	32 mgd capacity, 4 pumps at 11 mgd each
New Waste Activated Sludge Pumps	2 pumps off of new return sludge line

TABLE 12
Basis of Costs for Secondary Treatment Alternatives to Meet 2025 Requirements
MWMC Facility Plan, Eugene-Springfield

Basis of Costs For Alternative 2 – Modify Existing to Step-Feed Plug-Flow With Anoxic Selectors	
Facility Requirements	**Quantity**
Modify Both Aeration Basins to Step Feed	2 (8 cells) with anoxic selectors
New Secondary Clarifiers	2 with enhancements
Basis of Costs For Alternative 3 – Modify Existing to Partial Membrane Bioreactor	
Facility Requirements	**Quantity**
Modify North Aeration Basin to Step Feed	1 (4 cells) with anoxic selectors
New 2mm Fine Screens and channels	3 band screens at 25 mgd each
Modify South Aeration Basin to MBR	34 mgd average, 48 mgd peak
New Effluent Collection and Pumping Gallery	1 at 135 ft x 40 ft
New Mixed Liquor Return Pump Station	68 mgd capacity, 4 pumps 23 mgd each
New Return Sludge Pump Station	125 mgd capacity, 6 pumps at 27 mgd each
Citric Acid Cleaning System	1
Credit for the elimination of tertiary filtration	$20,000,000

The costs for each alternative are summarized in Table 13. Cost backup information is provided in Attachment A for each alternative.

TABLE 13
Capital Cost Comparison
MWMC Facility Plan, Eugene-Springfield

Treatment Alternative	Approximate Alternative Cost
Alternative 1 – Expand Existing	$39,040,000
Alternative 2 – Modify to Step Feed	$19,310,00
Alternative 3 – Modify to Partial MBR Process	$47,202,000

Notes:

1. Secondary Treatment Alternative Costs are shown in Attachment A
2. Alternative 3 costs include a $20,000,000 credit to account for not having to build tertiary filtration.

Non-Monetary Comparison

The purpose of a non-monetary comparison between the alternatives is to evaluate issues other than cost that may influence the selection of one alternative over the other. Issues include constructibility, operations and maintenance (O&M), performance, siting, etc. Table 14 summarizes the preliminary results of the non-monetary comparison.

TABLE 14
Non-Monetary Comparison
MWMC Facility Plan, Eugene-Springfield

Issue	Alternative 1	Alternative 2	Alternative 3
Siting	1	5	3
Constructibility	1	5	4
Effluent Performance	3	4	5
Effect on Performance of Downstream Equipment	3	4	5
Operational Flexibility -	4	5	5
Maintenance	3	4	3
Total Score (30 possible points)	15	27	24

1 = Negative/Difficult
5 = Beneficial

Conclusions and Recommendations

All alternatives considered would provide adequate treatment to meet the 2025 NPDES anticipated permit conditions. Alternatives 1 and 2 would require the use of tertiary filtration to provide Level IV reuse and process reliability. Alternative 3 does not require the use of tertiary filtration, a consideration that is reflected in the cost evaluation. Alternative 2 is the recommended alternative for secondary treatment improvements because it provides the following advantages over the other alternatives:

- Increases bioreactor capacity by increasing the mixed liquor concentration
- Modifications can be constructed within the existing infrastructure footprint
- Process reduces solids loading to the secondary clarifiers
- Improves sludge settleability and provides for its control
- Provides consistent and complete nitrification
- Provides process flexibility for seasonal operation
- Provides efficient operation to reduce capital and O&M costs (e.g., alkalinity recovery without mixed liquor recycle pumping)
- Maximizes use of existing facilities
- Provides highest long-term capacity at the lowest cost

Attachment A
Secondary Treatment Alternative Costs

Attachment A - Summary of Secondary Treatment Alternative Costs

Alternative 1 - Expand Existing Secondary Treatment Facilities

Facility Requirements	Unit Cost	Total Quantity	Total Cost
Secondary Clarifier No. 9 and ML Channel Extension	$3,760,000	1	$3,760,000
Secondary Clarifier No. 10	$2,450,000	1	$2,450,000
Secondary Clarifiers No's 11, 12, 13, 14, 15, 16	$3,105,000	6	$18,630,000
New Aeration Basin (4 cells) and PE channel	$10,900,000	1	$10,900,000
New RAS Pump Station	$2,200,000	1	$2,200,000
New PE Diversion box and pipe	$1,100,000	1	$1,100,000
Total			**$39,040,000**

Alternative 2 - Modify Existing to Step Feed Plug Flow With Anoxic Selectors

Facility Requirements	Unit Cost	Total Quantity	Total Cost
Secondary Clarifier No. 9 and Channel Extension	$3,760,000	1	$3,760,000
Secondary Clarifier No. 10	$2,450,000	1	$2,450,000
Convert South Aeration Basin to Step Feed	$6,900,000	1	$6,900,000
Convert North Aeration Basin to Step Feed	$6,200,000	1	$6,200,000
Total			**$19,310,000**

Alternative 3 - Modify Existing to Partial Membrane Bioreactor Process

Facility Requirements	Unit Cost	Total Quantity	Total Cost
Convert North Aeration Basin to Step Feed	$6,900,000	1	$6,900,000
Conversion of AB to Fine Screens	$4,084,705	1	$4,084,705
Anoxic Zone Modifications	$960,911	1	$960,911
Aerobic Zone Modifications	$694,980	1	$694,980
MLR Pump Station	$1,548,334	1	$1,548,334
RAS Pump Station	$3,176,645	1	$3,176,645
MBR Equipment, Conversion, and Gallery	$49,836,806	1	$49,836,806
Credit for Elimination of Tertiary Filtration	-$20,000,000	1	-$20,000,000
Total			**$47,202,382**