MWMC Eugene-Springfield WPCF Facility Plan— Primary Clarifier Capacity Analysis and Enhancements

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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 capacity of the four existing primary clarifiers at the Eugene-Springfield Water Pollution Control Facility (E-S WPCF). An increase in primary clarification capacity is necessary to address both current and future peak flows. Optimizing the performance of the existing primary clarifiers maximizes the facility's existing investment in primary treatment facilities.

Current wet weather peak flows into the plant exceed 200 mgd. The current secondary treatment capacity is limited to 103 mgd and any primary effluent flows over 103 mgd must be diverted and blended with secondary effluent. Future peak wet weather flows are anticipated to increase to 277 mgd. In peak flow scenarios it is crucial that the quality of the diverted primary effluent flow be sufficient so the blended effluent can meet the current National Pollutant Discharge Elimination System (NPDES) permit for both carbonaceous biochemical oxygen demand (CBOD) and total suspended solids (TSS). Increasing both the capacity and the treatment performance of the existing primary clarifiers will ensure that the E-S WPCF can meet the current NPDES permit.

As part of the evaluation, an initial capacity assessment was completed using historical performance data from the E-S WPCF. The assessment resulted in a capacity rating for the existing primary clarifiers of 86 mgd, removing 50 percent of the TSS. This capacity rating was then used as a baseline for evaluating alternatives to enhance the existing primary clarifiers. Three alternatives were considered to increase the existing primary treatment capacity and improve performance:

- **Alternative 1 – No Improvements**

This alternative would include no modifications or improvements to the existing primary clarifiers.

- **Alternative 2 – Add Baffling to Primary Clarifiers**

  This alternative would add energy dissipating inlets (EDIs), a new adequately sized feed well, and density current baffles at the perimeter of each primary clarifier.

- **Alternative 3 – Add Baffling to Primary Clarifiers and Operate without a Sludge Blanket**

  This alternative would add EDIs, a new adequately sized feed well, and density current baffles as described in Alternative 2. This alternative would also include operating the primary clarifiers without a sludge blanket. This would be accomplished by pumping a thin primary sludge at a high flow rate from the primary clarifiers to an external thickener. This alternative would require replacing the existing primary sludge pumps and adding new thickening equipment and a new thickened primary sludge pump station.

Alternative 1 would result in no capacity increase through the primary clarifiers. Alternative 2 is expected to increase the allowable surface overflow rate (SOR) of the existing clarifiers, and thus the primary clarifier capacity, by a minimum of 20 percent. Alternative 3 is anticipated to increase the allowable SOR of the existing clarifiers, and thus the clarifier capacity, by up to 100 percent over Alternative 1. The capacity and performance of the primary clarifiers should be evaluated after the baffling improvements are complete to determine when the new thickening equipment and operational changes will need to be in place to allow the WPCF to continue to meet effluent permit requirements. Table 1 summarizes the estimated primary clarifier capacity range for each alternative.

TABLE 1
Predicted Primary Clarifier Capacity
MWMC Facility Plan, Eugene-Springfield

	Option One	Option Two	Option Three
Modification	No improvements	Clarifier Baffling	Clarifier Baffling and Operation without Sludge Blanket
Estimated Capacity (mgd)	72 – 86	86 - 103	137 - 172

Alternative 3 is recommended because it will increase the existing primary clarifier capacity up to 100 percent, a level that is comparable to the proposed secondary treatment capacity. Baffling improvements, new primary sludge pumps, sludge thickening equipment and a primary sludge pump station will be required for this alternative.

Introduction

This technical memorandum has been prepared as part of the MWMC Facility Plan Update (MWMC Project No. 80010) and includes a description of the evaluation process used to determine the approximate capacity of the four existing primary clarifiers at the plant. Preliminary observations by plant personnel indicate that the effectiveness of the primary treatment facilities is limited during peak wet weather flow events. Alternatives to increase the existing primary treatment capacity and to maximize the facility's existing investment in primary treatment infrastructure are presented.

Existing Facilities

The MWMC E-S WPCF currently uses a total of four primary clarifiers to treat screened and degritted raw sewage. The existing primary clarifiers are circular, have outboard launders, and are 135 feet in diameter with 12-foot side water depths. The influent columns are 52 inches in diameter. Each clarifier receives effluent from the plant's existing headworks through a dedicated 60-inch-diameter pipe. Influent flow is discharged through each influent column into a small-diameter influent well. Discrete particle settling occurs within the primary clarifier. The primary sludge is accumulated at the bottom of the clarifier and thickened through compaction. Primary sludge solids are drawn off with intermittent sludge pumping and a sludge blanket is maintained within the clarifier. Clarified effluent flows over a v-notch weir and into an outboard launder.

Currently, all of the plant influent, including the peak wet weather flows, must pass through the primary clarification facilities. Historical peak wet weather flows have exceeded 200 mgd on a regular basis. Plant operations personnel have observed that when the total plant flow exceeds approximately 90 mgd, the primary clarified effluent quality rapidly deteriorates and the primary sludge blanket is washed out of the clarifier, resulting in negative TSS removals.

Primary effluent from all four primary clarifiers is combined and can be either routed to the aeration basins for secondary treatment, or a portion of the primary effluent can be diverted around secondary treatment and blended with secondary effluent for subsequent disinfection. The current secondary treatment capacity is limited to 103 mgd; thus, any primary effluent flows over 103 mgd must be diverted and blended with secondary effluent. In peak flow scenarios it is crucial that the quality of the diverted primary effluent flow be sufficient so the blended effluent can meet the current NPDES permit for both CBOD and TSS. Increasing both the capacity and the treatment performance of the primary clarifiers will ensure that the E-S WPCF can meet the current NPDES requirements.

Existing Primary Clarifier Data Analysis

Existing E-S WPCF primary influent and effluent data obtained from 1992 through April 2003 were used to evaluate the current primary treatment capacity. The evaluation parameters included the following:

- Influent and effluent TSS (mg/L)

- Influent and effluent CBOD (mg/L)
- Maximum and average flow conditions for each day – mgd
- Number of primary clarifiers receiving flow

Table 2 summarizes the ranges of selected data.

TABLE 2
Ranges of Historical Primary Influent and Effluent Data
MWMC Facility Plan, Eugene-Springfield

Parameter	Minimum	Maximum
Flow (mgd)	18.6	181.8
Primary Influent TSS (mg/L)	28	538
Primary Effluent TSS (mg/L)	7	142
Primary Influent CBOD (mg/L)	16	260
Primary Effluent CBOD (mg/L)	9	250

Typically, primary clarifiers are evaluated on their ability to remove TSS as a function of the hydraulic loading, or SOR, expressed in gallons per day per square foot (gpd/sf) of clarifier area. TSS removal efficiencies versus SORs for the wet season (November 1 through April 30) of each year are shown in Figure 1. The SORs are based on the average daily flows. TSS removal percentages are based on primary influent and effluent 24-hour composite samples.

Figure 1, in conjunction with plant data and information gathered through correspondence with MWMC E-S WPCF plant staff, was used to predict the capacity of the existing primary clarifiers. For the purpose of this evaluation, clarifier failure is defined as the condition when the effluent TSS concentrations equal or exceed the influent TSS concentrations. Figure 1 illustrates two failure points at relatively low SORs; however, these data points have been omitted from the analysis because they are not typical.

The Figure 1 data illustrate three distinct groups of performance. Generally, the TSS data for SOR rates less than 1,250 gpd/sf are tightly grouped and the TSS removal efficiencies are typically greater than 50 percent. At SORs between 1,250 gpd/sf and 1,500 gpd/sf, the TSS removal data begin to scatter with slightly lower TSS removals; however, there is no apparent clarifier failure in this range. Finally, Figure 1 illustrates that at SORs exceeding 1,500 gpd/sf, the TSS data begin to scatter significantly and the clarifiers begin to experience frequent failures.

FIGURE 1

Wet Season (Nov 1 through April 30)
Surface Overflow Rate vs Primary Effluent TSS Removal Percentage

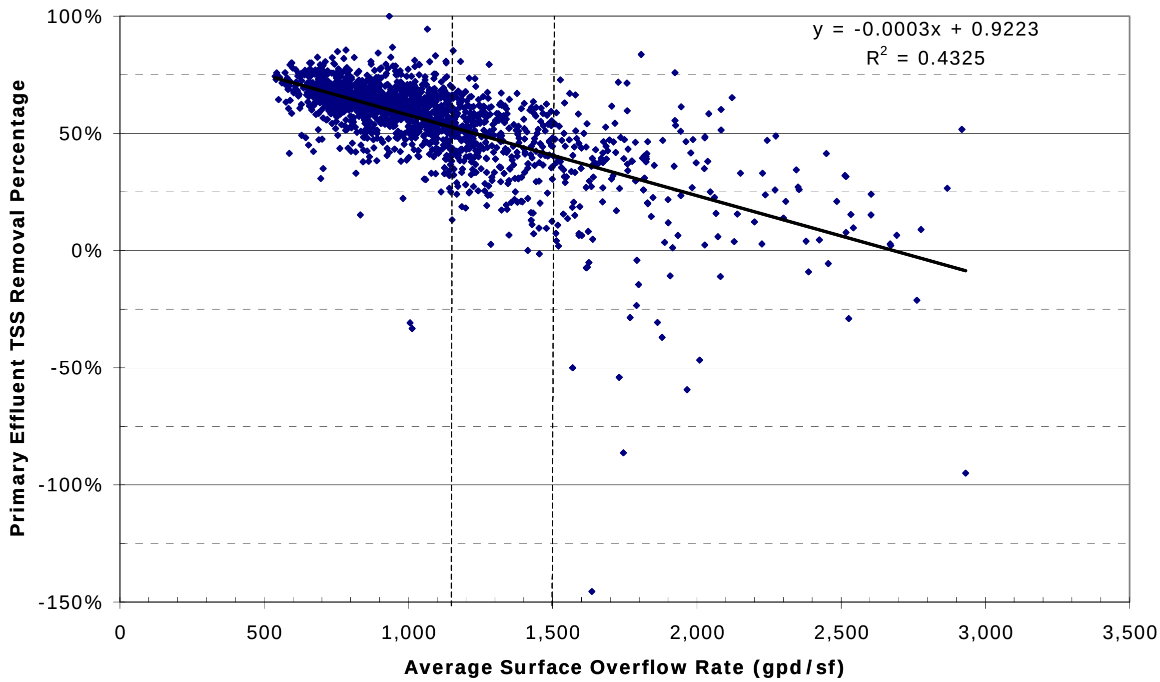

Table 3 summarizes the estimated primary clarifier performance and capacity from the historical data analysis. The findings validate the E-S WPCF operations staff observations that the clarifiers begin to fail and experience negative TSS removals at flows above 90 mgd.

TABLE 3
SORs and Capacities for the Existing Primary Clarifiers
MWMC Facility Plan, Eugene-Springfield

Surface Overflow Rate (gpd/sf)	Corresponding Flow (mgd)	Approximate TSS Removal (%)	Basis for Assumed TSS Removal
Less than 1,250	Less than 72	50	Historical Data
1,250 – 1,500	72 – 86	40	Historical Data
Greater than 1,500	Greater than 86	0	Historical Data

Preliminary Alternatives Screening

To improve the performance and increase the capacity of the existing primary clarifiers at the E-S WPCF, modifications to the primary clarifiers will be required. Several alternative technologies for accomplishing this were identified in Technical Memorandum No. 2, Preliminary Screening of Alternatives, prepared for MWMC. Alternatives identified to be further evaluated include the following:

- Baffle the existing primary clarifiers
- Baffle the existing primary clarifiers and operate without a primary sludge blanket

Each candidate process was given scores of 1 to 5 based on various performance, operations and maintenance (O&M), and implementation criteria. The ideas receiving the highest combined scores (and not screened out previously) were given more consideration for inclusion as alternatives to be evaluated. Baffle the existing primary clarifiers received the highest score at 59, followed by operation of primary clarifiers without a sludge blanket at 55. These candidate processes are incorporated into some of the alternatives outlined in this memorandum to address the expansion of the existing primary clarifier capacity.

Primary Clarifier Enhancement Alternatives

Alternative 1 – No Improvements

Alternative 1 would require no action and would result in no capacity increase. With no improvements, the primary clarifiers would be expected to begin failing as flows to the plant approached 86 mgd.

Alternative 2 – Add Baffling to Primary Clarifiers

Alternative 2 includes adding EDIs, a new adequately sized feed well, and density current baffles at the perimeter of each clarifier. Baffling techniques address essentially three concepts:

1. The dissipation of energy at the inlet to the clarifier. This is accomplished by redirecting the radial velocity currents to tangential velocities and may also include a variety of momentum cancellation techniques. This is typically accomplished with an EDI that is placed around the center column of a new or existing clarifier inlet. The EDI typically contains a number of gates or pipes used to redirect the velocity currents.
2. The elimination of radial surface currents that can carry suspended solids directly over the effluent weir, adversely impacting effluent quality. This is typically accomplished with an appropriately sized feed well. The feed well is essentially a surface baffle with an open bottom to redirect suspended solids downward and enhance discrete particle settling.
3. The dissipation or redirection of density or hydraulic currents. Density currents are typically a result of the zone settling characteristics of secondary sludge. As the sludge settles and forms a distinct sludge blanket/clarified effluent interface, the difference in density at the interface induces a radial velocity current directed outward to the perimeter wall. Experience has shown that 95 percent of the radial velocity currents occur at this interface. When the radial density current hits the perimeter wall of the clarifier, the current is directed upward and carries suspended solids with it directly to

the surface of the clarifier. This is typically the location of the effluent weir and may result in a deterioration of effluent quality.

Primary settled sludge may also exhibit some of the same density currents at the sludge blanket/clarified effluent interface, although the density current may be reduced in intensity because the interface is less pronounced. However, because primary clarifiers are typically hydraulically loaded on the order of two to three times that of a secondary clarifier, radial hydraulic currents combine with radial density currents. Density current baffles have been found to be effective at reducing the radial density and hydraulic currents in a primary clarifier, even if the primary clarifier is operated without a sludge blanket.

The density current baffle is a horizontal baffle placed on the perimeter of the clarifier wall or launder trough. It intercepts the upward velocity at the perimeter wall of the clarifier resulting from the radial density currents. The upward flow is redirected back to the center of the clarifier where the velocity is then dissipated. This baffle arrangement is better suited for secondary clarifiers that have exterior launders.

Experience has shown that baffling enhancements to primary clarifiers can provide an increase in capacity and improve the overall reliability of performance. When baffling technologies are properly applied, most retrofits result in a capacity increase from 20 to 30 percent. In the absence of stress testing data for an E-S WPCF retrofitted primary clarifier, it has been assumed conservatively that the clarifier capacity can be increased by a minimum of 20 percent. Subsequent stress testing may prove to yield a substantially higher increase in capacity as a result of baffling modifications, which would therefore be recommended as a final step in evaluating primary clarifier capacity. Table 4 estimates the SORs and TSS removal performance resulting from baffling enhancements made to the E-S WPCF primary clarifiers. With the baffling improvements, the primary clarifiers would be expected to begin failing as flows to the plant approached 103 mgd.

TABLE 4
SORs and Capacities for Primary Clarifiers with Baffling Improvements
MWMC Facility Plan, Eugene-Springfield

SOR (gpd/sf)	Corresponding Flow (mgd)	Approximate TSS Removal (%)	Basis for Assumed TSS Removal
Less than 1,500	Less than 86	50	Historical Data and Assumed Efficiency Increase
1500 – 1,800	86 - 103	40	Historical Data and Assumed Efficiency Increase
Greater than 1,800	Greater than 103	0	Historical Data and Assumed Efficiency Increase

Alternative 3 – Add Baffling to Primary Clarifiers and Operate Without a Sludge Blanket

Alternative 3 includes operational changes for the clarifiers in addition to installing baffling as described in Alternative 2. The capacity of the primary clarifiers should be evaluated after the baffling improvements are in place to determine when the new thickening equipment and operational changes will need to be in place to allow the E-S WPCF to continue to meet effluent permit requirements. Typically the sludge is pumped from the clarifier at a rate to maintain the concentration of primary sludge at less than 0.5 percent. This allows the surface overflow rates in the clarifiers to be increased substantially without the potential for washing out the primary sludge blanket as a result of excessive hydraulic currents.

Because the primary sludge is removed at a high rate and at a low solids concentration, thickening of the primary sludge would be required outside the primary clarifier prior to pumping to digestion. To allow comparison of alternatives, it was assumed that the existing primary sludge pumps would be replaced with six new primary sludge pumps and thickening would be accomplished with two new gravity thickeners. However, other thickening technologies do exist and could be reviewed further in future detailed design.

Sludge pumping operational changes combined with new baffling improvements would be expected to result in an increase in SORs of roughly 60 percent over the Alternative 2 modifications, and a 100 percent increase in capacity over Alternative 1. Well-designed and properly operated primary clarifiers can remove up to 50 to 60 percent of TSS at peak SORs of 3,000 gpd/sf. In the absence of stress testing data for an E-S WPCF retrofitted primary clarifier, it has been assumed conservatively that the TSS removal efficiency below an SOR of 2,000 gpd/sf would be 50 percent; between SORs of 2,000 to 3,000 gpd/sf, the TSS removal efficiency would be 40 percent. Subsequent stress testing may prove to yield a substantially higher increase in capacity as a result of these modifications, and would therefore be recommended as a final step in evaluating primary clarifier capacity. Table 5 summarizes the surface overflow rates and TSS removal performance resulting from baffling and operational enhancements.

TABLE 5
SORs and Capacities for Primary Clarifiers with Baffling Improvements and Operation Without a Sludge Blanket
MWMC Facility Plan, Eugene-Springfield

SOR (gpd/sf)	Corresponding Flow (mgd)	Approximate TSS Removal (%)	Basis for Assumed TSS Removal
Less than 2000	Less than 115	50	Historical Data and Assumed Efficiency Increase
2000 – 2400	115 – 137	40	Historical Data and Assumed Efficiency Increase
2400 – 3000	137 - 172	40	Industry Standards

Alternative Costs and Non-monetary Comparison

Cost Comparison

Table 6 summarizes the assumptions that the preliminary cost comparisons are based upon. Attachment 1 provides cost background information for Alternatives 2 and 3.

TABLE 6
Basis for Cost Comparison
MWMC Facility Plan, Eugene-Springfield

Alternative 1 No Improvements	Alternative 2 Add Baffling	Alternative 3 Add Baffling and Operate Without a Sludge Blanket
	New Energy Dissipating Inlet	New Energy Dissipating Inlet
	New Weir	New Weir
	New Scum Baffle	New Scum Baffle
	New Flocculation Well	New Flocculation Well
	New Skimmer Arm	New Skimmer Arm
	New Density Current Baffle	New Density Current Baffle
		Two New 50-Foot Gravity Thickeners
		Six New Primary Sludge Pumps

Table 7 summarizes the total project costs, including engineering and construction costs, for each alternative. Alternative costs are based on modifying all four primary clarifiers. Costs are expressed in 2004 dollars and should be adjusted as needed for the year of construction.

TABLE 7
Alternatives Cost Evaluation
MWMC Facility Plan, Eugene-Springfield

Alternative 1 No Improvements	Alternative 2 Add Baffling	Alternative 3 Add Baffling and Operate Without a Sludge Blanket
$0	$1,160,000	4,790,000

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 constructability, O&M, performance, siting, etc. Table 8 summarizes the preliminary results of the non-monetary comparison.

TABLE 8
Non-Monetary Comparison
MWMC Facility Plan, Eugene-Springfield

Issue	**Alternative 1 No Improvements**	**Alternative 2 Add Baffling**	**Alternative 3 Add Baffling and Operate Without a Sludge Blanket**
Siting	5	5	3
Constructability	5	5	3
Effluent Performance	-	3	5
Effect on Performance of Downstream Equipment	-	3	5
Operational Flexibility -	-	1	5
Maintenance	3	5	3
Total Score (30 possible points)	13	22	24

1 = Negative/Difficult
5 = Beneficial

Alternatives Evaluation

Alternative 1 does not increase the capacity of the existing primary clarifiers; therefore, this alternative would provide no benefit for decreasing the primary effluent TSS during peak wet weather flows. During peak flow scenarios it is crucial that the quality of the diverted primary effluent flow be sufficient so the blended effluent can meet the current NPDES permit for both CBOD and TSS. Alternative 1 may have a detrimental effect on effluent TSS concentrations when the primary sludge blanket gets washed out of the clarifier. This alternative would likely result in NPDES permit violations and is not recommended for further consideration.

Alternative 2 increases the capacity of the primary clarifiers by approximately 20 percent. Based on existing plant data and assumed performance improvements, this alternative by itself is not adequate to match the capacity of the plant's proposed secondary treatment system and it will not be adequate to fully address the peak flow issue with respect to blending while meeting the NPDES permit. This alternative does provide an excellent increase in capacity using existing infrastructure, and can be done at a reasonable cost. It also provides increased reliability in performance; however, sludge blanket washout would still occur at peak flows and eventual permit violations would be anticipated based on the design assumptions. The capacity of the primary clarifiers should be evaluated after the baffling improvements have been completed to determine when the new thickening equipment and operational changes will need be in place to allow the E-S WPCF to continue to meet effluent permit requirements.

Alternative 3 would increase the primary clarifier capacity by approximately 100 percent over Alternative 1. This increase in capacity would be well-matched with the proposed secondary treatment system capacity. Although it is the highest cost alternative, most of the capacity gained is through existing infrastructure, which maximizes the plant's existing investment while occupying very little site space. This alternative provides all the capacity and performance reliability benefits of Alternative 2, 60 percent increased capacity, excellent operational flexibility, high-quality primary effluent at high SORs, and meets all the primary clarification needs of the proposed secondary treatment system.

Conclusions and Recommendations

Based on the primary clarifier evaluation and considering ongoing efforts to increase the existing facilities treatment capacity, it is recommended that MWMC proceed with Alternative 3. Baffling improvements, new primary sludge pumps, new gravity thickening equipment and a primary sludge pump station will be required for this alternative. The existing primary treatment capacity will be increased by up to 100 percent.

Attachment 1
Cost Background Information

Primary Clarifier Improvements - Cost Background Information

Costing Approach

Two alternatives to increase the treatment capacity of the existing primary clarifiers were considered and background cost information for these alternatives is summarized in Table 1.

Table 1
Primary Clarifier Improvements Cost Information

Costs	Clarifier Baffling	Clarifier Baffling and Operation without Sludge Blanket
Cost for Baffling	N/A	$740,000
Earthwork/Yard Piping/Demolition	$100,000	$250,000
Structures	$360,000	$950,000
Equipment / Process Support	$166,000	$560,000
Landscape / Visual Screening	N/A	$211,300
Subtotal	**$626,000**	**$2,711,300**
General Conditions	$114,000	$353,000
Construction Subtotal	**$740,000**	**$3,064,300**
Assumed Construction Contingency Percentage	25%	25%
Construction Total	$925,000	$3,830,375
Assumed Engineering, Legal and Administration Percentage	25%	25%
Total Cost	**$1,156,250**	**$4,787,969**