312 W Whitewater Street | Whitewater, WI 53190

Wastewater Facility Plan
Technical Memorandum 6
Liquids Treatment Evaluation

City of Whitewater
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Prepared by:

Donohue & Associates, Inc.

3311 Weeden Creek Rd. | Sheboygan, WI 53081
Phone: 920.208.0296 | www.donohue-associates.com

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FACILITY PLANNING
TM6 LIQUIDS TREATMENT ALTERNATIVES
CITY OF WHITEWATER

TABLE OF CONTENTS

Chapter I – Purpose and Background Information 1
1.1 Purpose 1
1.2 Design Loadings 1
Chapter II – Primary Clarifier Operation 2
2.1 Technology Overview 2
2.2 Energy Balance Comparison 2
2.3 Recommendation 4
Chapter III – Rotating biological contactors 5
3.1 Existing RBC Facilities 5
3.2 RBC Improvements 5
3.3 Performance Metrics 5
Chapter IV – Activated Sludge 7
4.1 Technology Overview 7
4.2 Secondary Clarifier Evaluation 7
4.3 Process Configuration Comparison 9
4.4 Preliminary Process Sizing 11
4.5 Modeling Evaluations 11
4.5.1 Steady-State Evaluations 11
4.5.2 Sensitivity Analysis 13
4.5.3 Diurnal Evaluation 16
4.5.4 Recommended Configuration 17
4.6 Performance Metrics 21
Chapter V – Activated Sludge with CoMag 23
5.1 Technology Overview 23
5.2 Secondary Clarifier Evaluation 24
5.3 Performance Metrics 24
Chapter VI – Moving Bed Biofilm Reactor 26
6.1 Technology Overview 26
6.2 Secondary Clarifier Evaluation 27
6.3 Process Configuration 27
6.4 Process Performance Evaluation 27
6.4.1 Steady-State Results 28

FACILITY PLANNING
TM6 LIQUIDS TREATMENT ALTERNATIVES
CITY OF WHITEWATER

6.4.2 Diurnal Response 29
6.4.3 Recommended Configuration 30
6.5 Performance Metrics 30
Chapter VII – Membrane Bioreactor 32
7.1 Technology Overview 32
7.2 Impact on Secondary Clarifiers 32
7.3 Process Configuration 32
7.4 Process Performance Evaluation 33
7.5 Performance Metrics 34
Chapter VIII – Alternatives Comparison 35
8.1 Capital Cost Comparison 35
8.1.1 RBC 36
8.1.2 Activated Sludge 36
8.1.3 Activated Sludge with Comag 39
8.1.4 MBBR 40
8.1.5 MBR 41
8.1.6 Capital Cost Comparison 42
8.2 Economic Evaluation 43
8.3 Operating Metrics Comparison 44
8.4 Recommendation 46

LIST OF TABLES

Table 1: 2035 Design Loadings 1
Table 2: Assumptions made for energy balance comparison of primary clarifier operation 2
Table 3: Loading conditions evaluated for the impact of primary clarification 3
Table 4: Comparison of three primary clarifier operational alternatives 3
Table 5: Comparison metrics for RBCs 6
Table 6 Preliminary aeration basin sizing 11
Table 7 Metrics for Activated sludge 22
Table 8 Metrics for Activated sludge with Comag 25
Table 9 Metrics for MBBR 31
Table 10 Metrics for MBR 34
Table 11 Capital cost comparison 42

FACILITY PLANNING
TM6 LIQUIDS TREATMENT ALTERNATIVES
CITY OF WHITEWATER

Table 12 20-year TPW comparison 43
Table 13 Comparison of operating metrics for each alternative 45

LIST OF FIGURES

Figure 1 Limiting SVI value for the range of operating MLSS values is less than the minimum design standard, indicating that additional final clarifier capacity will be required 8
Figure 2 Three activated sludge configurations evaluated for the Whitewater activated sludge system . 10
Figure 3 Average day performance results for the three configurations evaluated 12
Figure 4 UCT effluent phosphorus sensitivity 14
Figure 5 MUCT effluent phosphorus sensitivity 15
Figure 6 A2O effluent phosphorus sensitivity 16
Figure 7 Average day diurnal effluent phosphorus performance for the UCT and MUCT configurations . 17
Figure 8 Process schematic of the UCT process 18
Figure 9 Process schematic of the UCT process including flow directions 19
Figure 10 Process schematic for future MUCT process to achieve TN limits below 10 mg/L 20
Figure 11 Schematic of the Activated Sludge with Comag system (Evoqua Water Technologies) 23
Figure 12 Images of an MBBR/IFAS system during installation and operation 26
Figure 13 Examples of IFAS retention sieves 26
Figure 14 MBBR Process Configurations 27
Figure 15 Average day performance of the MBBR with and without IMLR 29
Figure 16 Dynamic performance results for the MBBR with recycle flows 29
Figure 17 MBR layout (Ovivo) 33
Figure 18 Example membrane unit (GE Energy) 33
Figure 19 Historic discipline specific construction costs based on constructed projects 35
Figure 20 Activated Sludge Option 1 layout 37
Figure 21 Activated Sludge Option 2 layout 38
Figure 22 Activated Sludge Option 3 layout 39
Figure 23 Activated Sludge with Comag layout 40
Figure 24 MBBR layout 41
Figure 25 MBR layout 42
Figure 26 Economic analysis of the evaluated alternatives 43

FACILITY PLANNING
TM6 LIQUIDS TREATMENT ALTERNATIVES
CITY OF WHITEWATER

APPENDICES

Appendix TM6-A: CEPT Mass Balance
Appendix TM6-B: Alternatives Mass Balances
Appendix TM6-C: Secondary Clarifier Evaluation
Appendix TM6-D: Special Sampling
Appendix TM6-E: Activated Sludge Modeling Report
Appendix TM6-F: MBBR Modeling Report
Appendix TM6-G: Capital Cost Estimates
Appendix TM6-H: Capital Cost Estimates – Activated Sludge Options

CHAPTER I – PURPOSE AND BACKGROUND INFORMATION

1.1 PURPOSE

As discussed in TM 2: Flows, Loadings, and Existing Conditions, one of the primary concerns facing the wastewater treatment facility is the condition of the liquids treatment unit processes for secondary treatment. The RBC facility has served its useful life, providing a high quality water for Whitewater Creek for several decades. The replacement of these RBCs is the focus of this TM. The following process modifications were considered:

- Operation of the primary clarifiers, which determines the load to the secondary process
- Upgraded RBC facilities
- Activated sludge
- Activated sludge with Comag
- Moving bed biofilm reactor (MBBR)
- Membrane bioreactor (MBR)

For each modification, technology overview, secondary clarifier evaluation, process performance evaluation, and operation metrics were developed. Capital costs, economic analysis, and metric comparison are included in Section 8.

1.2 DESIGN LOADINGS

TM 2 established the current and design flows and loadings that will be used in this evaluation. Table 1 summarizes the 20-year design flows and loadings expected.

Table 1: 2035 Design Loadings

Parameter	Average Day	Max Day	Max Week	Max Month
Flow	1.85 mgd	8.4 / 11[1] / 15 mgd[2]	5.2 mgd	3.8 mgd
BOD_5	3,065 ppd	5,562 ppd	4,640 ppd	4,015 ppd
TSS	4,112 ppd	11,595 ppd	8,031 ppd	6,381 ppd
$N\text{-}NH_3$	348 ppd	568 ppd	526 ppd	458 ppd
TP	86.1 ppd	246 ppd	160 ppd	135 ppd

1. Peak Hour
2. Peak Instantaneous Flow

CHAPTER II – PRIMARY CLARIFIER OPERATION

2.1 TECHNOLOGY OVERVIEW

Primary clarifiers are a valuable asset for a wastewater treatment facility. Significant quantities of BOD and TSS can be removed in the primary clarifiers with very little energy input. Primary sludge is also more energetic than secondary sludge, and produces a higher biogas yield than secondary sludge when anaerobically digested.

Primary clarifier performance can be enhanced by the addition of a chemical precipitate to the clarifiers. Applying chemically enhanced primary treatment (CEPT) can result in both energy savings and increased energy production. CEPT is currently the case at the Whitewater facility, where approximately 50% of the alum added for phosphorus control is added to the primary clarifiers. This results in BOD and TSS removal efficiencies that average 40 and 75%, respectively. A typical primary clarifier would achieved between 25 and 30% BOD removal and 50 to 60% TSS removal.

This chapter evaluates the overall energy impact of CEPT at Whitewater, and will make a recommendation concerning the future operation of the primary clarifiers. Three primary clarifier alternatives will be evaluated:

1. CEPT
2. Typical Primary Treatment
3. No Primary Treatment

2.2 ENERGY BALANCE COMPARISON

For the energy balance comparison of the three primary clarifier operational strategies, a simplified mass balance of the Whitewater facility was completed. This should be viewed as a "thought experiment" that highlights the differences between the three primary clarifier operations. The major assumptions for the energy balance evaluation are shown in Figure 2. Calculations were based on an activated sludge system achieving nitrification and denitrification. The loading conditions evaluated are shown in Table 3.

Table 2: Assumptions made for energy balance comparison of primary clarifier operation

	CEPT	Primary Clarifiers	No Primary Clarification
BOD Removal	40%	25%	0%
TSS Removal	85%	60%	0%
TKN Removal	10%	10%	0%
Secondary Treatment	Denitrifying A.S.	Denitrifying A.S.	Denitrifying A.S.
Secondary sludge yield (lbVS/lb BOD)	0.65	0.65	0.65
Biogas Production (cu ft/lbVS-day)	15	15	15
Digester Performance (%VS Destroyed)	55%	55%	45%

Table 3: Loading conditions evaluated for the impact of primary clarification

Parameter	Value	
Flow	1.5	mgd
BOD	210	mg/l
TSS	274	mg/l
TKN	47	mg/l
TP	6	mg/l

The results of the mass balance analysis are provided in Appendix TM6-A, with a summary in Table 4. Primary clarifiers have a net positive impact on energy use and energy production. CEPT has a slightly higher net cost than primary clarifiers operated without CEPT, but the chemical added in the primary clarifiers also provides 50% of the phosphorus removal. A major advantage of both CEPT and conventional primary clarifier operation is the reduction in secondary treatment basin size. The CEPT basins will required 26% less volume than basins operated with conventional primary clarifiers, and 45% less volume than basins with no primary clarification.

Table 4: Comparison of three primary clarifier operational alternatives

	CEPT	Primary Clarifiers	No Primary Clarification
Secondary Energy Use (kw/day)	-1,052	-1,145	-1,505
Potential Electricity Production (kw/day)	887	872	612
Net Electricity (kw/day)	-165	-274	-893
Hauled Sludge Production (ppd)	1,889	1,856	2,268
Hauled Sludge Production (gpd)	3,475	3,416	4,173
Alum Use (gpd)	40	0	0
Net Electrical Cost	-$4,828	-$7,988	-$26,073
Net Chemical Cost	-$20,440	$0	$0
Net Solids Hauling Cost	-$50,742	-$49,871	-$60,929
Net Cost	-$76,011	-$57,859	-$87,003
Secondary Treatment BOD Load (ppd)	1,445	1,970	2,627
Secondary Treatment Basin Decrease Compared to No Primary Clarifiers	-45%	-25%	0

It should be emphasized that the above energy balance is based on a single condition, and merely provides a “snapshot” into the relative impacts of CEPT, primary clarifiers, and no primary clarifiers. The intent was to simply provide information to enable an assumption for the subsequent liquids treatment evaluation.

2.3 RECOMMENDATION

Primary clarifiers provide a treatment for minimal energy cost, and actually lead to increased energy production in systems with anaerobic digesters and biogas utilization. Operating the primary clarifiers in CEPT mode provides added energy benefits, but a large driver for CEPT operation is also the decreased capital required for the secondary treatment basins. Based on the energy balance and impacts on secondary treatment, CEPT operation will be assumed for the secondary treatment evaluation.

CHAPTER III –ROTATING BIOLOGICAL CONTACTORS

3.1 EXISTING RBC FACILITIES

The existing Rotating Biological Contactors (RBCs) have served the City of Whitewater for over 20 years, and have provided a relatively high quality of effluent water. However, as noted during Workshop 1 and TM 2, the existing facilities have significant infrastructure issues and need major attention to ensure capacity in the future. Full replacement of the RBCs was recommended during Workshop 1, and this alternative will be evaluated as part of this section.

3.2 RBC IMPROVEMENTS

During the evaluation workshop, the following improvements were discussed for improvements to the RBC facilities:

- Replacement of all shafts and RBC media with a 4 train system with 10 shafts per train with a total surface area of 5,392,000 ft^2.
- Demolition of existing RBC buildings
- Conversion to air driven RBC suitable for outdoor operation
- Hydraulic improvements to alleviate hydraulic restrictions identified in TM 5

It was assumed that the existing final clarifiers would provide sufficient capacity for a fixed film/biofilm process.

3.3 PERFORMANCE METRICS

The improved RBCs would provide similar performance to the existing RBC facility. Effluent ammonium concentrations below 1 mg/L and single digit cBOD concentrations would continue to be achievable with the RBC technology. Effluent TSS from the secondary clarifiers would achieve TSS concentrations in the 15 to 20 mg/L range, which would be further reduced by the existing tertiary filters.

Phosphorus removal would be achieved by chemical addition, similar to the existing operation. Continued multi-point chemical addition would be recommended, with an annual cost of $71,540 per year. This does bind the phosphorus, limiting the anaerobic digester sidestream phosphorus recycle dosing. The required dosing for sidestream loads is currently achieved in the liquids stream, and the $71,540 would include this chemical requirement. Chemical phosphorus removal in the liquids stream would limit struvite harvesting potential from the anaerobic digester sidestreams.

With respect to nitrogen removal, the RBCs are capable of nitrification, but an additional process would be required for denitrification and nitrogen removal. Either a tertiary denitrification filter, or an upstream suspended growth denitrifying reactor would be required.

The table of metrics for evaluation developed in TM 1 is presented in Table 5. Calculations used to develop these metrics are summarized in TM6-B. These metrics will be compared for all alternatives.

Table 5: Comparison metrics for RBCs

Metric	RBCs
Energy required (kw/day)	1,360
Energy production potential (kw/day)	806
Biosolids production rate (tons/year)	485
Chemical requirement – Liquids (gallons/year)	51,100
Chemical requirements – Sidestream (gallons/year)	0
Nitrogen removal potential	ADDITIONAL PROCESS REQUIRED
Sidestream phosphorus recovery potential (tons/year)	MINIMAL
Reuse quality water (gallons/year)	DOWNSTREAM FILTRATION REQUIRED
Operational complexity (Scale 1 to 10)	8
Operational flexibility (Scale 1 to 10)	3
Impact on emerging contaminants (Relative ranking)	4

CHAPTER IV – ACTIVATED SLUDGE

4.1 TECHNOLOGY OVERVIEW

The activated sludge process relies on suspended growth bacteria to achieve treatment. Exhaustive definition are available elsewhere, but in essence bacteria are grown in aeration tanks, settled in final clarifiers, and the settled bacteria are recycled back to the aeration basins. The settling and recycling step was the major breakthrough in wastewater treatment approaches, as this allows the bacteria to be in the system for a sludge retention time (SRT) that significantly exceeds the hydraulic retention time (HRT) of the system.

One of the major benefits of an activated sludge system is the ability to achieve enhanced biological phosphorus removal (EBPR) and denitrification. This reduces chemical requirement for phosphorus removal, decreases energy requirements due to denitrification, and can achieve total nitrogen (TN) removal below 10 mg/L if required. The activated sludge configuration has a significantly higher suspended solids concentration in the final clarifier feed, and typically requires a larger final clarifier step then biofilm/fixed film processes.

While the activated sludge process is a liquids treatment process, moving to an EBPR activated sludge system has significant impacts on solids handling and management. In the absence of oxygen, sludge wasted from an EBPR activated sludge system quickly release phosphorus. This has two major impacts: waste activated sludge (WAS) cannot be co-settled with primary sludge and struvite production will occur in the anaerobic digestion process. To account for these impacts, a separate WAS processing facility and phosphorus management in the digestion complex will be required.

For the evaluation of the activated sludge alternative, the following components will need to be included:

- Aeration basins with components for EBPR and TN removal
- Secondary clarifier improvements
- Return sludge pump station
- WAS thickening facilities

The secondary clarifiers were evaluate first to determine if an additional clarifier would be required. Then, alternatives aeration basin configuration were compared, and a recommended configuration was developed. Capital and operating costs were projected for this recommended configuration.

4.2 SECONDARY CLARIFIER EVALUATION

In suspended growth systems, the secondary clarifier capacity is determined by the solids loading to the clarifier, and the settleability of sludge. The solids loading is determined by the operating mixed liquor suspended solids (MLSS) concentration in the aeration basins, and the sludge volume index (SVI) of the sludge. The lower the SVI value, the better the settleability, and the higher the applicable loading rate to the secondary clarifiers. For biological nutrient removal facilities, the SVI value is typically 90 to 150 mL/g, with a design value of 125 mL/g.

There are several methods for evaluating secondary clarifier capacity, including the solids flux analysis and state point analysis. For evaluation of the existing Whitewater secondary clarifiers, a state point analysis of the clarifiers was completed. Given the relationship between the MLSS concentration, SVI, and operational complexity, the following approach was completed for a range of MLSS concentrations:

1. Identify MLSS concentration for operation
2. For the peak instantaneous flow rate of 15 mgd, determine the SVI that would be required for the combination of MLSS concentration and 15 mgd flow rate
3. If the limiting SVI value is ***greater than*** the design value 125 mL/g, the existing clarifiers ***do provide*** sufficient solids loading capacity
4. If the limiting SVI value is ***less than*** the design value of 125 mL/g, the existing clarifiers ***do not provide*** sufficient solids loading capacity

State point calculations are included in Appendix TM6-C. A comparison of the limiting SVI value for the range of anticipated MLSS concentrations in the potential Whitewater aeration basins is shown in Figure 1. The limiting SVI is less than the design SVI value for the entire range of MLSS conditions, indicating that an addition secondary clarifier capacity will be required for the activated sludge alternative. Two options will be evaluated from a cost performance standpoint in Section 8.1.2.

- Construct a third clarifier with a diameter of 70 feet and depth of 18 feet to be used in conjunction with the existing clarifiers, or
- Construct two new final clarifiers and abandon or re-purpose existing final clarifiers
- Construct two new final clarifiers with the existing final clarifiers incorporated into the aeration basin volume

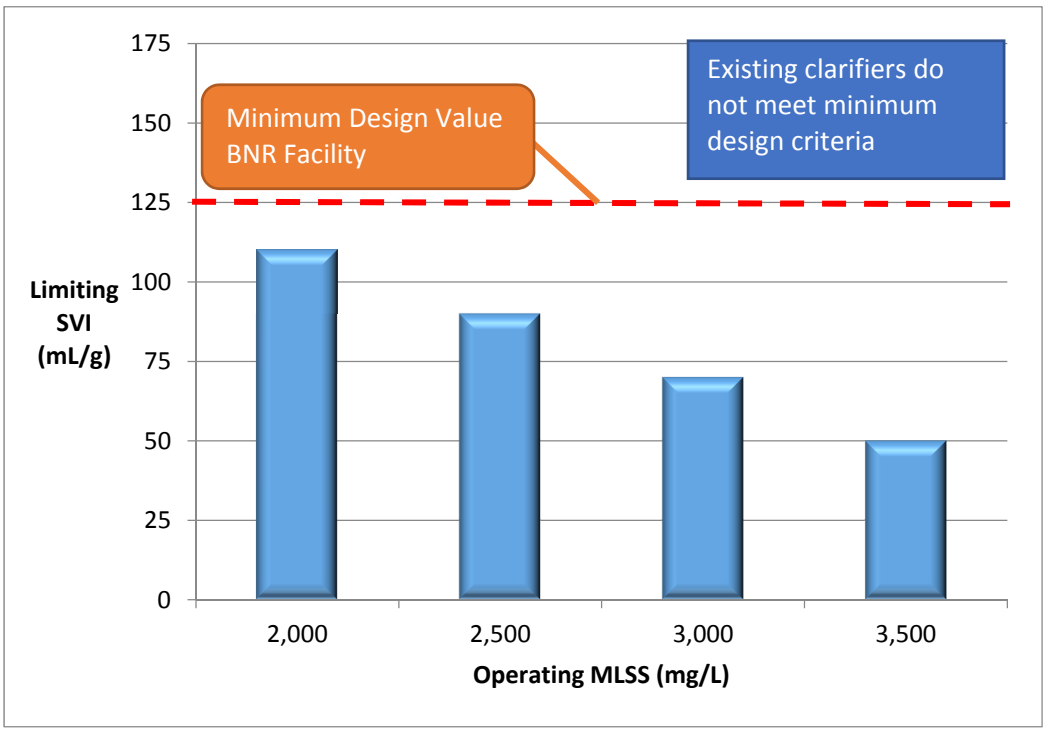


Figure 1 Limiting SVI value for the range of operating MLSS values is less than the minimum design standard, indicating that additional final clarifier capacity will be required

4.3 PROCESS CONFIGURATION COMPARISON

During facilities planning, it is important to complete a preliminary evaluation of potential aeration basin configurations based on the specific characteristics of the Whitewater wastewater. Depending on the fractionation present in the Whitewater wastewater, different configurations may be required to manage the nitrate, phosphorus, and readily degradable carbon in the system. The configuration has an impact on the number of selector zones (a.k.a. unaerated zones) required, the number of mixed liquor recycle flows required, and the projected chemical requirements. Three configurations were evaluated using the special sampling completed by the Whitewater staff in January 2014 (data included in Appendix TM6-D) in addition to the three years of historic data provided by the Whitewater staff (2011, 2012, and 2013 data sets). The three configurations for evaluation are the UCT, MUCT, and A2O process. The configurations and distinguishing characteristics of each configuration are shown in Figure 2. Evaluations were compared using process modeling in Biowin software.

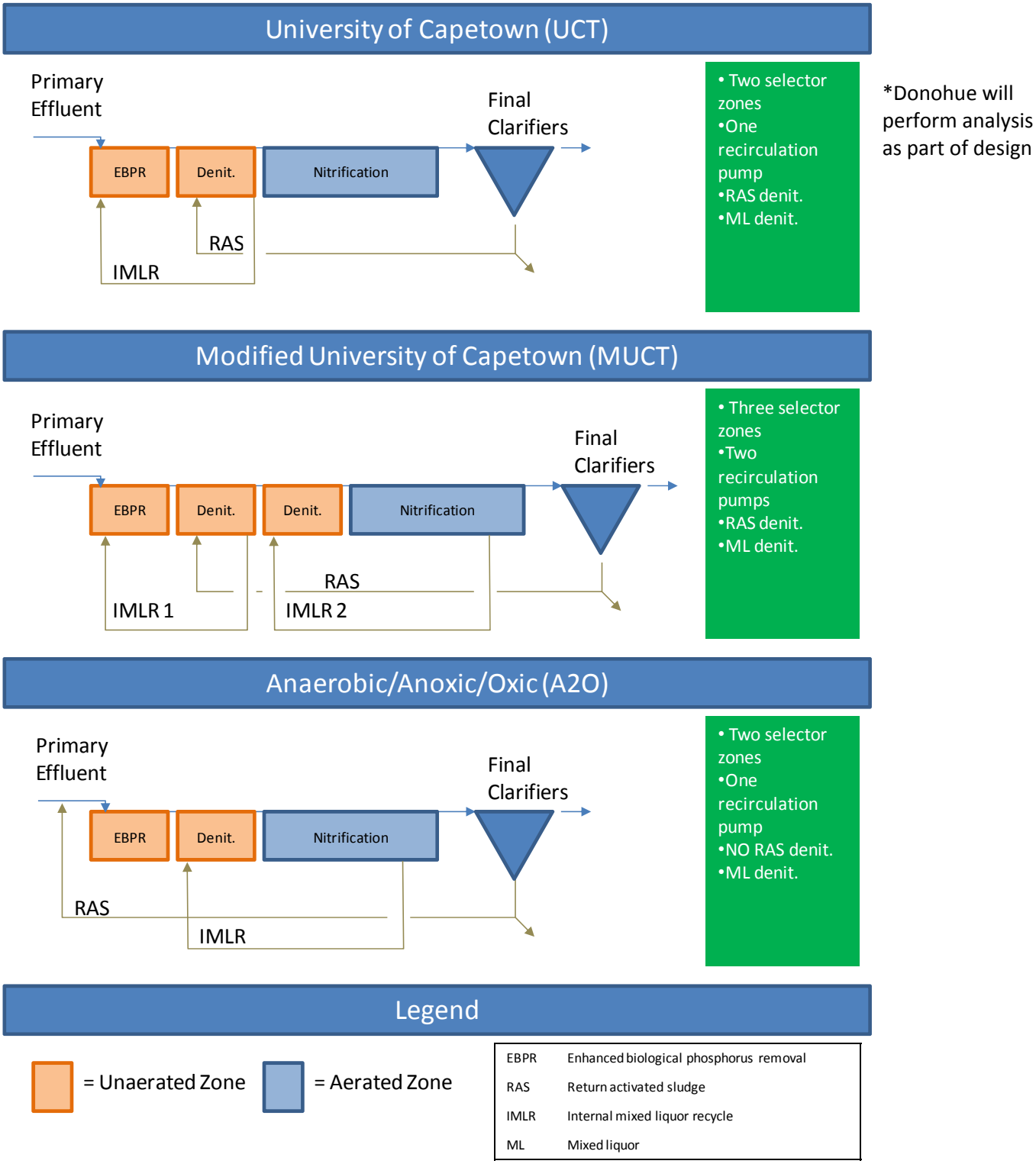


Figure 2 Three activated sludge configurations evaluated for the Whitewater activated sludge system

4.4 Preliminary Process Sizing

For preliminary evaluation, the aerobic loading at the design average day loading conditions was sized for 16.5 lbs BOD/1,000 cf-day. The selector zone volume was based on typical f/m operating parameters. A total of three trains will be evaluated, with two trains operating under current conditions and the third train operating under design conditions. A three train reactor would be required for design capacity, with two trains operated under existing loadings. The preliminary reactor sizing for the three configurations is summarized in Table 6.

Table 6: Preliminary aeration basin sizing

Section	Volume (cu ft)	Volume (MG)
Total Aerobic Volume per Train	40,500	0.30
Total Aerobic Volume	121,500	0.91
Total Selector Volume - UCT and A2O	36,450	0.27
Total Selector Volume - MUCT	54,675	0.41
Total Volume - UCT and A2O	157,950	1.18
Total Volume - MUCT	176,175	1.32

4.5 Modeling Evaluations

Modeling was completed in Biowin software. The modeling report is included in Appendix TM6-E. At the facilities planning stage, process modeling is a tool to help provide preliminary comparison of alternatives, identify feasibility of technologies, and develop budgetary cost estimates. Additional modeling would be completed during the preliminary and final design phases to tighten design parameters and provide a “right size” approach to process sizing.

4.5.1 Steady-State Evaluations

Steady state simulations were completed on using the average concentrations and characteristics from the special sampling campaign in January 2014. The steady state simulations provide insight into how the three configurations will respond to average loading conditions in terms of phosphorus removal, nitrate removal, and airflow requirements. The steady-state results are presented in Figure 3 for all three configurations.

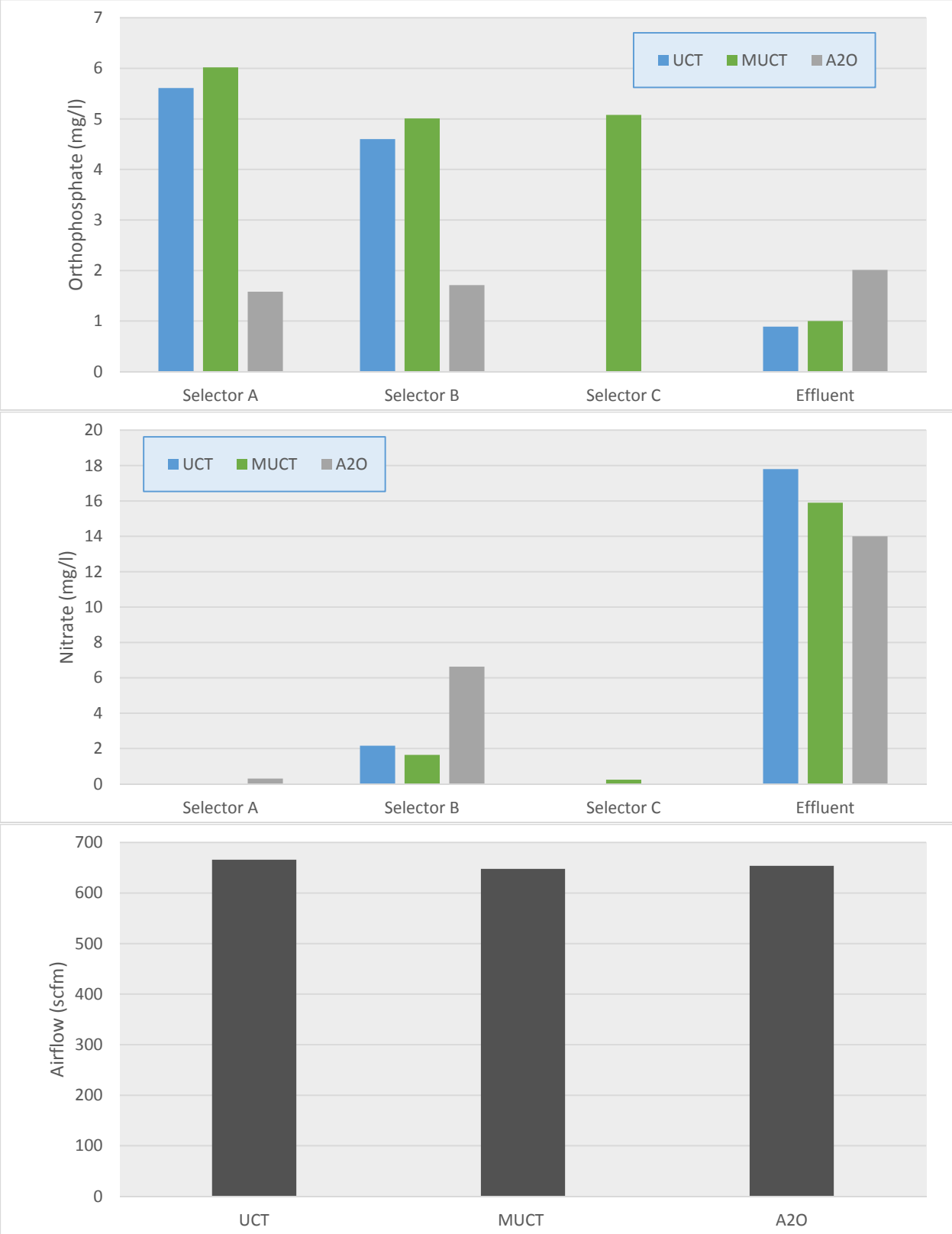


Figure 3 Average day performance results for the three configurations evaluated

Biological phosphorus removal was most efficient in the UCT and MUCT process configurations. This is the result of a separate RAS denitrification step, limiting the nitrate present in the first selector zone. Biological phosphorus removal is limited in the A2O configuration due to the nitrate conditions in the system. As seen in the nitrate results, nitrate was still present at low levels in the first selector zone for the A2O process.

In terms of nitrate removal and total nitrogen, the MUCT and A2O process both performed better than the UCT process, with the A2O process achieving the lowest effluent nitrate concentration. These higher levels of denitrification in the A2O and MUCT process configurations result in slightly lower airflow rates than the UCT process, although all three configurations varied by less than 10%.

4.5.2 Sensitivity Analysis

A sensitivity analysis was completed for all three configurations. The sensitivity analysis consists of completing a series of steady state simulations at the range of BOD:P and BOD:TKN values observed for the Whitewater wastewater facility. The following steps were completed:

- Develop histogram of the distribution of BOD:P and BOD:TKN values from the historic data
- Conduct a series of steady state simulations using the range of observed BOD:P and BOD:TKN values at average flow conditions (1.5 mgd)
- Develop a surface plot of the resulting effluent phosphorus concentration for the range of simulated BOD:P and BOD:TKN ratios
- Identify the area of the surface plot where the majority of influent conditions occur
- Compare the sensitivity of the three configurations to the variability observed in the Whitewater wastewater

The results of the sensitivity analysis are shown in Figure 4, Figure 5, and Figure 6. When interpreting the results, visualize the surface plot as a topographic map, with the effluent phosphorus concentrations serving as the contour lines. The yellow box indicates the portion of the surface map where the majority of Whitewater wastewater characteristics occur. The figure with the most blue area within the yellow box, and most blue and green area overall, would be least sensitive to the Whitewater loading conditions.

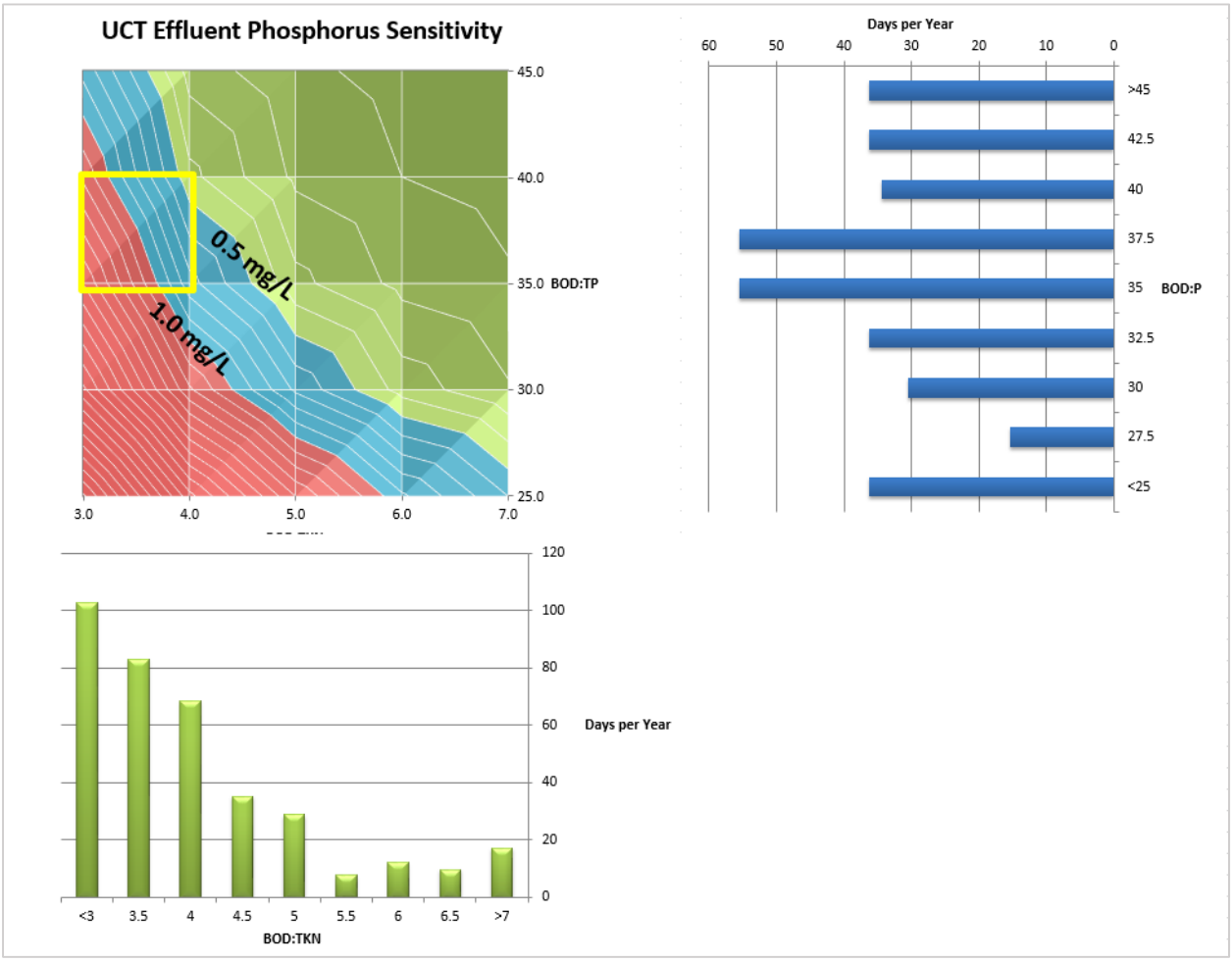


Figure 4 UCT effluent phosphorus sensitivity; the yellow box indicates the area with the highest occurrence

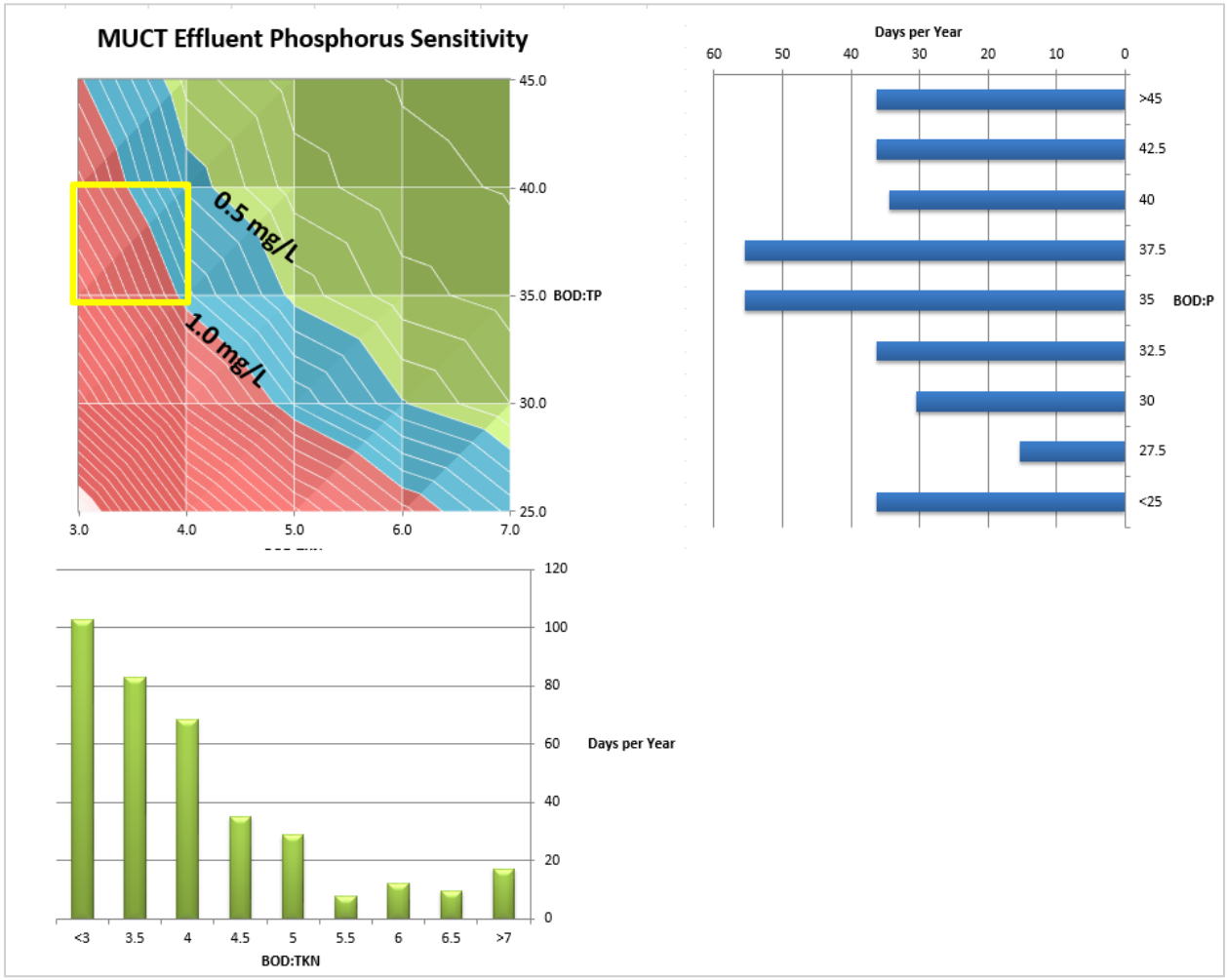


Figure 5 MUCT effluent phosphorus sensitivity; the yellow box indicates the area with the highest occurrence

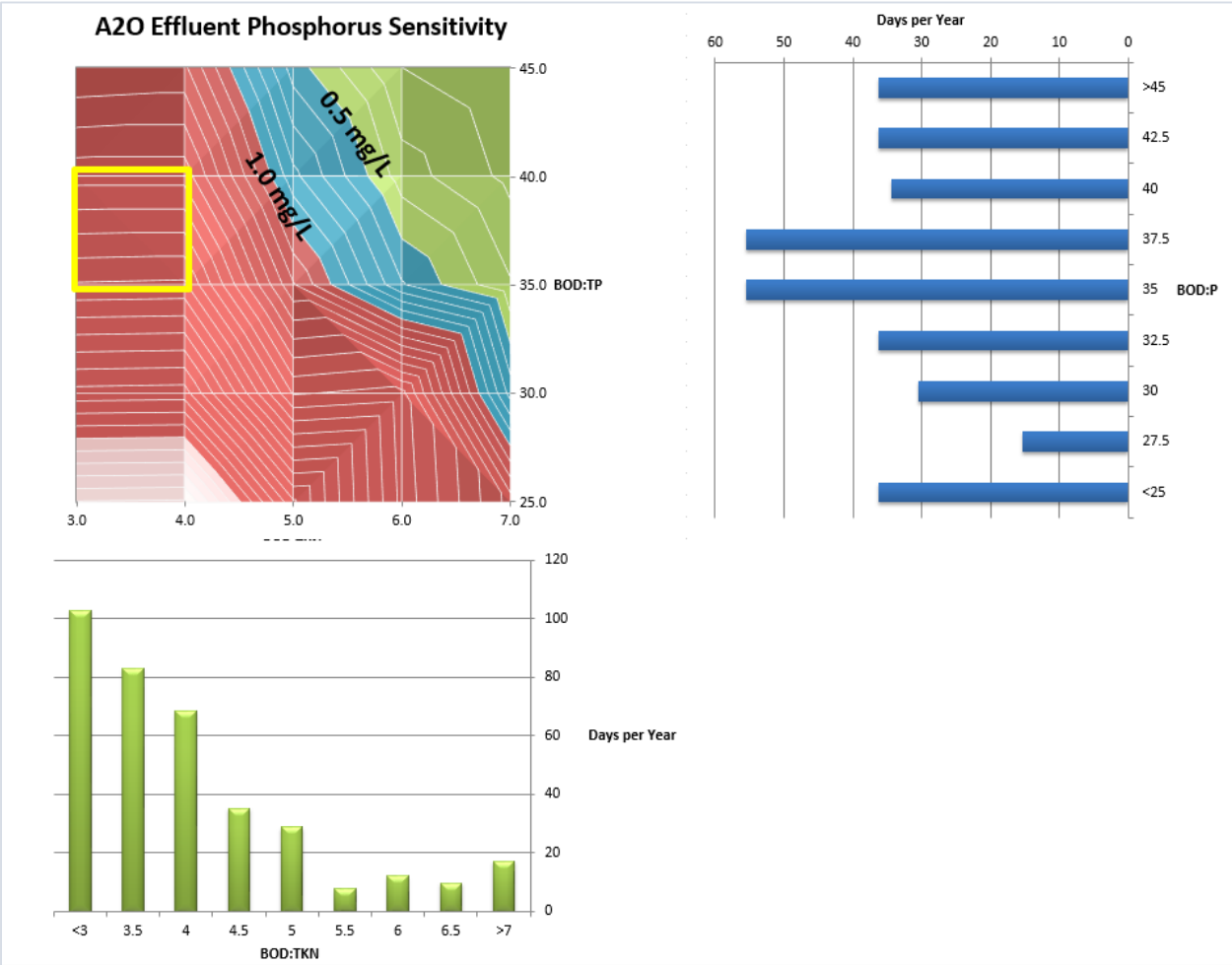


Figure 6 A2O effluent phosphorus sensitivity; the yellow box indicates the area with the highest occurrence

Based on the results of the sensitivity analysis, the UCT process is the least sensitive to the variability in Whitewater loading conditions, although the MUCT process had similar results. The A2O process results in the least amount of time when the effluent phosphorus concentration would be less than 1 mg/L.

4.5.3 Diurnal Evaluation

A third evaluation was completed that looked at the dynamic variability of phosphorus removal performance over a 24-hour period of time. Constant concentrations were assumed for BOD, TSS, TKN, and TP, but the flow rate was varied based on a typical day flow pattern for the Whitewater facility. The dynamic phosphorus results are shown in Figure 7 for the UCT and MUCT process. The UCT process was slightly less sensitive to dynamic variations, although both the UCT and MUCT process performed similarly.

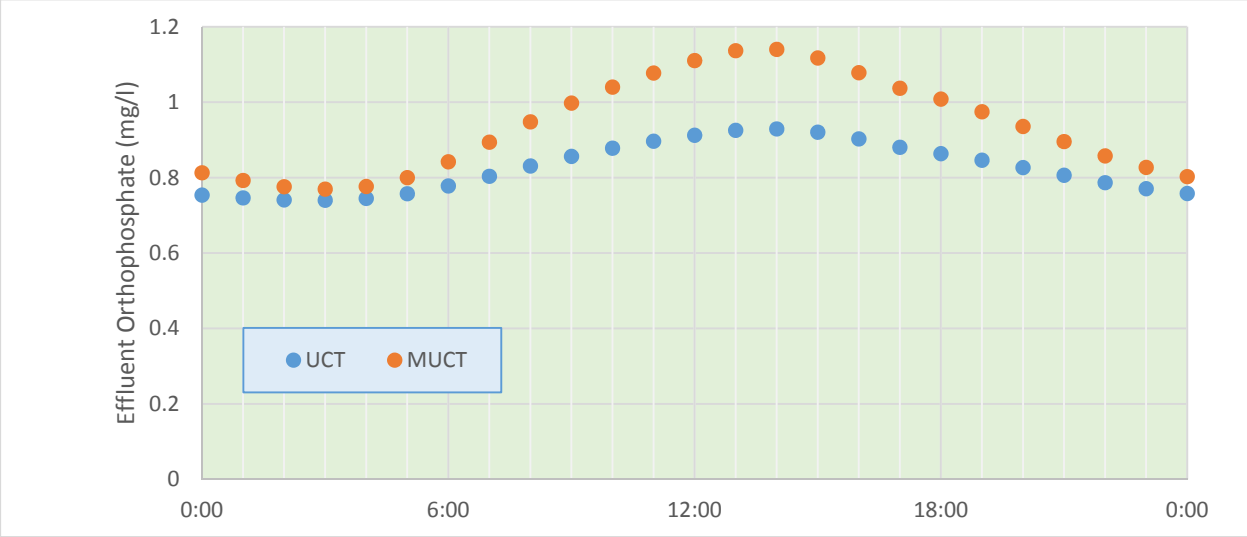
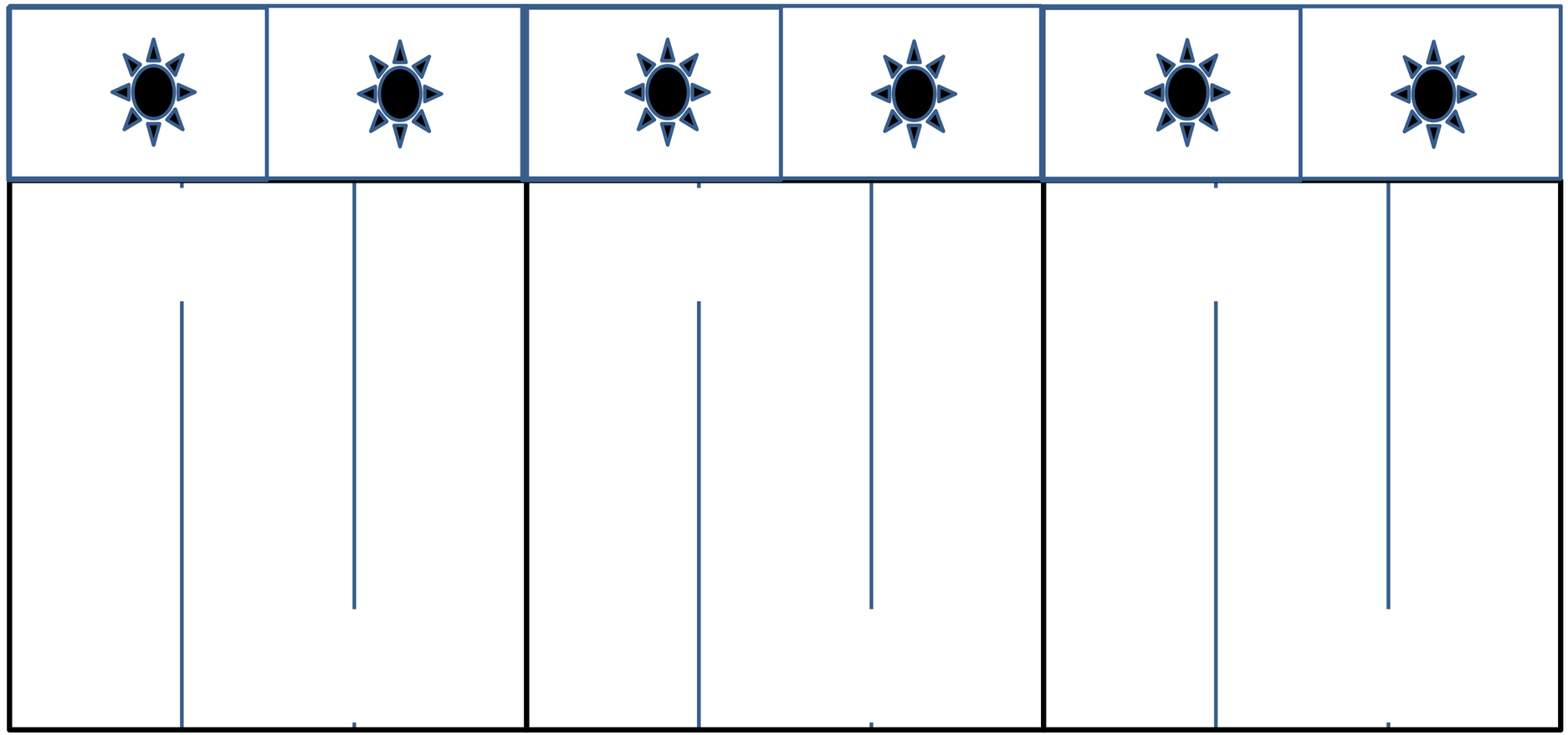


Figure 7 Average day diurnal effluent phosphorus performance for the UCT and MUCT configurations

4.5.4 Recommended Configuration

Based on the three modeling evaluations, the UCT process appears best suited for Whitewater current treatment requirements and wastewater characteristics. Schematics of the UCT process configuration are shown in Figure 8 and Figure 9. As discussed, two trains would be operated under current conditions, with the third train providing capacity for future loads. If a TN limit is required, additional electron donor would be required to reduce TN limits below 10 mg/L. In this case, the process could be converted to the MUCT configuration. This configuration is shown in Figure 10.



Note: Operate 2 of 3 trains at startup

Section	Depth (ft)	Width (ft)	Length(ft)	Volume (cu ft)	Volume (MG)	3 Trains Aerobic Loading (lbs/1000 cu ft-day)	3 Trains Total Loading (lbs/1000 cu ft-day)	3 Trains Aerobic HRT (hours)	3 Trains Selector HRT (hours)	2 Trains Aerobic Loading (lbs/1000 cu ft-day)	2 Trains Total Loading (lbs/1000 cu ft-day)	2 Trains Aerobic HRT (hours)	2 Trains Selector HRT (hours)
Selector 1A, 2A, 3A	18	15	22.5	6,075	0.05								
Selector 1B, 2B, 3B	18	15	22.5	6,075	0.05								
AB 1A, 2A, 3A	18	15	50	13,500	0.10								
AB 1B, 2B, 3B	18	15	50	13,500	0.10								
AB 1C, 2C, 3C	18	15	50	13,500	0.10								
Total Aerobic Volume per Train				40,500	0.30								
Total Aerobic Volume				121,500	0.91								
Total Selector Volume				36,450	0.27								
Total Volume				157,950	1.18								
Selector/Aerobic				30.0%	30.0%								
Total Aerobic L:W			10										
Current Loading						13.4	10.3	14.5	4.4	20.1	15.4	9.7	2.9
Design ADF Loading						16.5	12.7	11.8	3.5	24.8	19.0	7.9	2.4
Future ADF Loading						32.6	25.1	6.0	1.8	48.9	37.6	4.0	1.2

FIGURE 8
PROCESS SCHEMATIC OF UCT PROCESS

CITY OF WHITEWATER
WASTEWATER FACILITIES PLAN
WHITEWATER, WISCONSIN

DONOHUE

JULY 2014

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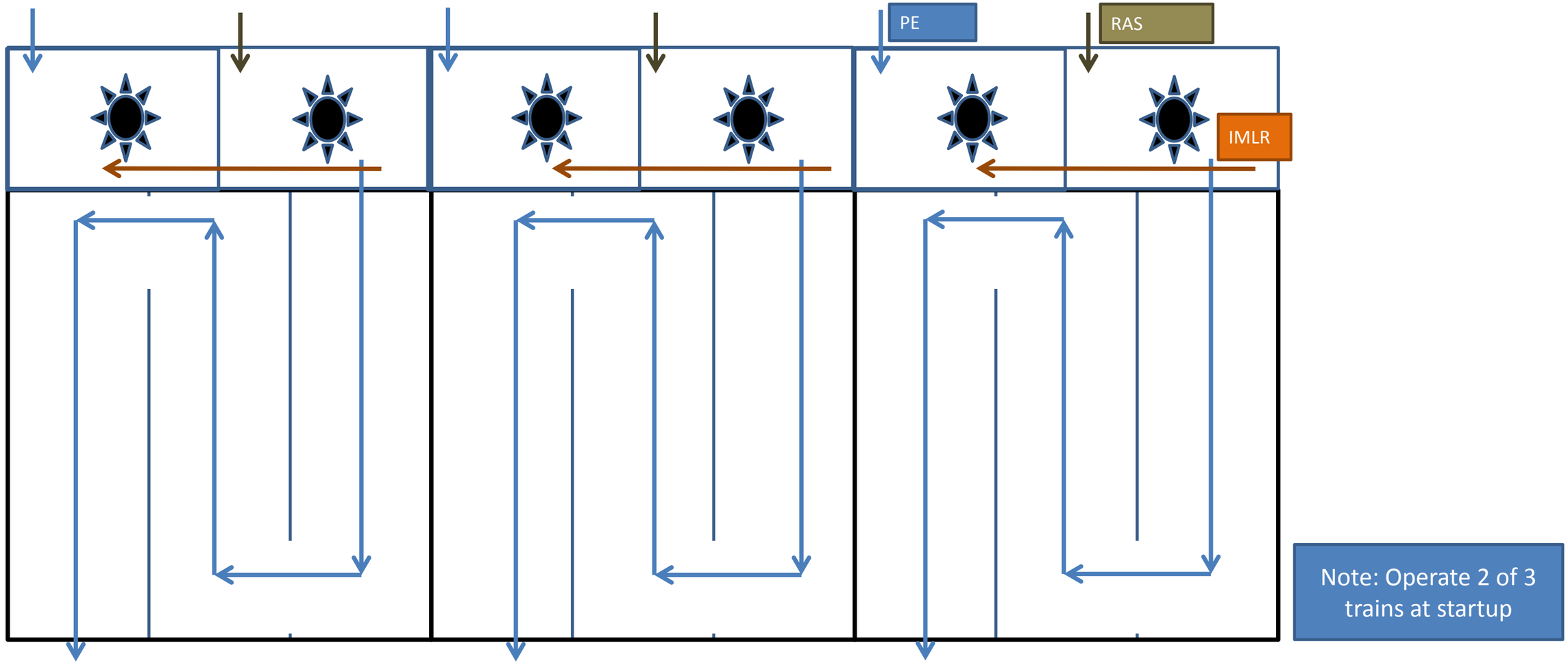


Note: Operate 2 of 3 trains at startup

						3 Trains				2 Trains			
Section	Depth (ft)	Width (ft)	Length(ft)	Volume (cu ft)	Volume (MG)	Aerobic Loading (lbs/1000 cu ft-day)	Total Loading (lbs/1000 cu ft-day)	Aerobic HRT (hours)	Selector HRT (hours)	Aerobic Loading (lbs/1000 cu ft-day)	Total Loading (lbs/1000 cu ft-day)	Aerobic HRT (hours)	Selector HRT (hours)
Selector 1A, 2A, 3A	18	15	22.5	6,075	0.05								
Selector 1B, 2B, 3B	18	15	22.5	6,075	0.05								
AB 1A, 2A, 3A	18	15	50	13,500	0.10								
AB 1B, 2B, 3B	18	15	50	13,500	0.10								
AB 1C, 2C, 3C	18	15	50	13,500	0.10								
Total Aerobic Volume per Train				40,500	0.30								
Total Aerobic Volume				121,500	0.91								
Total Selector Volume				36,450	0.27								
Total Volume				157,950	1.18								
Selector/Aerobic				30.0%	30.0%								
Total Aerobic L:W			10										
Current Loading						13.4	10.3	14.5	4.4	20.1	15.4	9.7	2.9
Design ADF Loading						16.5	12.7	11.8	3.5	24.8	19.0	7.9	2.4
Future ADF Loading						32.6	25.1	6.0	1.8	48.9	37.6	4.0	1.2

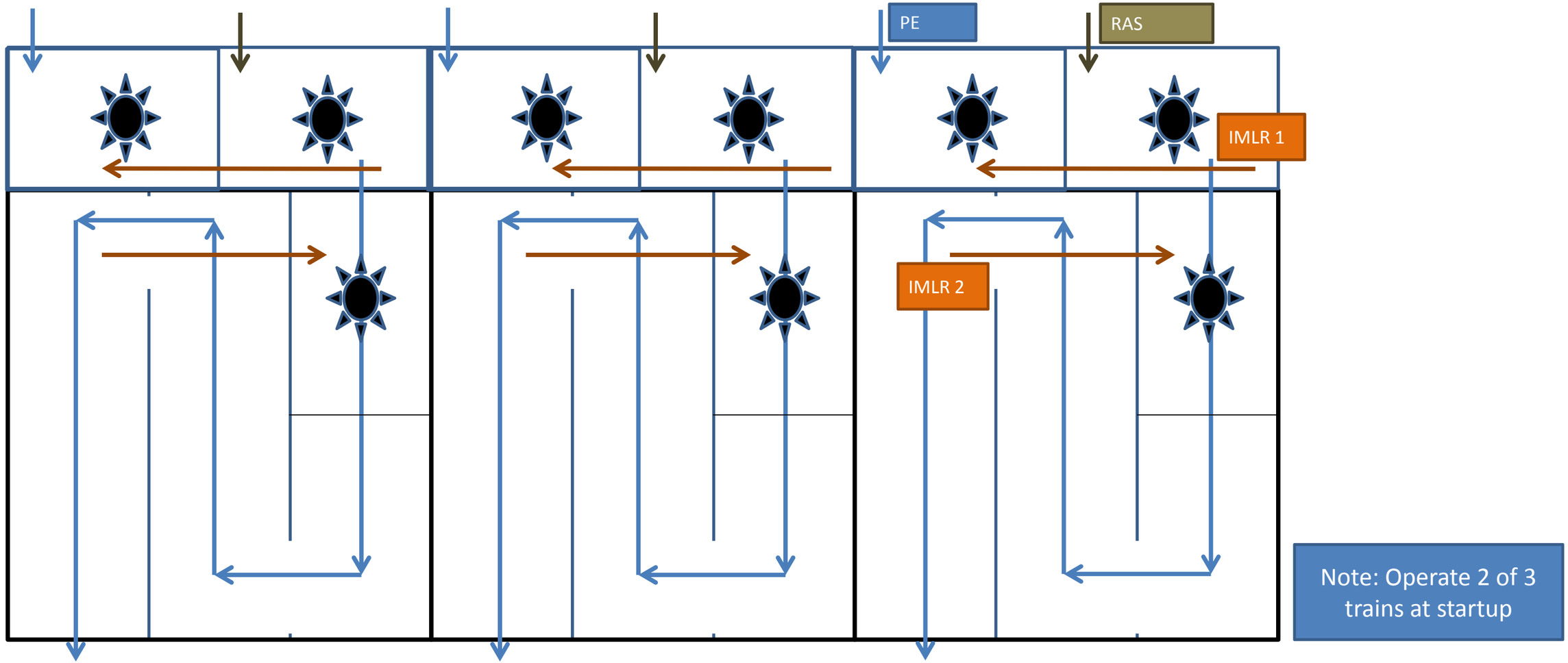
FIGURE 9
PROCESS SCHEMATIC OF UCT PROCESS INCLUDING FLOW DIRECTIONS

CITY OF WHITEWATER
WASTEWATER FACILITIES PLAN
WHITEWATER, WISCONSIN

DONOHUE

JULY 2014

12600



						3 Trains				2 Trains			
Section	Depth (ft)	Width (ft)	Length(ft)	Volume (cu ft)	Volume (MG)	Aerobic Loading (lbs/1000 cu ft-day)	Total Loading (lbs/1000 cu ft-day)	Aerobic HRT (hours)	Selector HRT (hours)	Aerobic Loading (lbs/1000 cu ft-day)	Total Loading (lbs/1000 cu ft-day)	Aerobic HRT (hours)	Selector HRT (hours)
Selector 1A, 2A, 3A	18	15	22.5	6,075	0.05								
Selector 1B, 2B, 3B	18	15	22.5	6,075	0.05								
AB 1A, 2A, 3A	18	15	50	13,500	0.10								
AB 1B, 2B, 3B	18	15	50	13,500	0.10								
AB 1C, 2C, 3C	18	15	50	13,500	0.10								
Total Aerobic Volume per Train				40,500	0.30								
Total Aerobic Volume				121,500	0.91								
Total Selector Volume				36,450	0.27								
Total Volume				157,950	1.18								
Selector/Aerobic				30.0%	30.0%								
Total Aerobic L:W			10										
Current Loading						13.4	10.3	14.5	4.4	20.1	15.4	9.7	2.9
Design ADF Loading						16.5	12.7	11.8	3.5	24.8	19.0	7.9	2.4
Future ADF Loading						32.6	25.1	6.0	1.8	48.9	37.6	4.0	1.2

FIGURE 10
PROCESS SCHEMATIC FOR FUTURE MUCT PROCESS TO ACHIEVE TN LIMITS BELOW 10 MG/L

CITY OF WHITEWATER
WASTEWATER FACILITIES PLAN
WHITEWATER, WISCONSIN

DONOHUE

JULY 2014

12600

4.6 PERFORMANCE METRICS

As discussed, the UCT process will be capable of achieving a 1 mg/L effluent phosphorus concentration. Some chemical polishing will be required to achieve a 0.5 mg/L effluent concentration. The phosphorus accumulated in the activated sludge system would be released during anaerobic digestion. Assuming 35% of the accumulated phosphorus is released during digestion, this phosphorus would need to either be treated chemically in the sidestream or recovered via struvite harvesting. The chemical addition for the activated sludge evaluation would include the chemical added for CEPT.

Total nitrogen removal would be achievable in the activated sludge system, although a process configuration change to MUCT would be required. Achieving a TN of 10 mg/L would also require an external carbon source.

The table of metrics for evaluation developed in TM 1 is presented in Table 7. Calculations used to develop these metrics are summarized in Appendix TM6-B. These metrics will be compared for all alternatives.

Table 7: Metrics for Activated sludge

Metric	Activated Sludge
Energy required (kw/day)	1,050
Energy production potential (kw/day)	886
Biosolids production rate (tons/year)	344
Chemical requirement – Liquids (gallons/year)	28,000
Chemical requirements – Sidestream (gallons/year)	9,000
Nitrogen removal potential	PROCESS MODIFICATION; NO NEW TANKAGE OR PROCESSES
Sidestream phosphorus recovery potential (tons/year)	30
Reuse quality water (gallons/year)	DOWNSTREAM FILTRATION REQUIRED
Operational complexity (Scale 1 to 10)	4
Operational flexibility (Scale 1 to 10)	9
Impact on emerging contaminants (Relative ranking)	5

CHAPTER V – ACTIVATED SLUDGE WITH COMAG

5.1 TECHNOLOGY OVERVIEW

An alternative to conventional activated sludge is to supplement the suspended growth with an iron substance commonly referred to as magnetite. This magnetite can serve as a ballast for biological flocs, embedding itself in the floc structure and resulting in significantly more dense flocs. These high density flocs settle rapidly during the clarification step, resulting in a reduction in the required surface area for the secondary clarifiers. The activated sludge system can also operate at a higher MLSS concentration, reducing the required aeration tank volume by 10 top 25%.

This process has been developed under the trademark name Comag. The major piece of proprietary equipment involves the magnetite recovery device. As shown in Figure 11, the device recovers magnetite from the waste activated sludge (WAS) and recycles the recovered material to the aeration basins. Some magnetite is lost on an annual basis and is replenished at a low flow, constant feed location. The activated sludge plus Comag process was evaluated for its impact on secondary clarifier capacity and from a process performance standpoint.

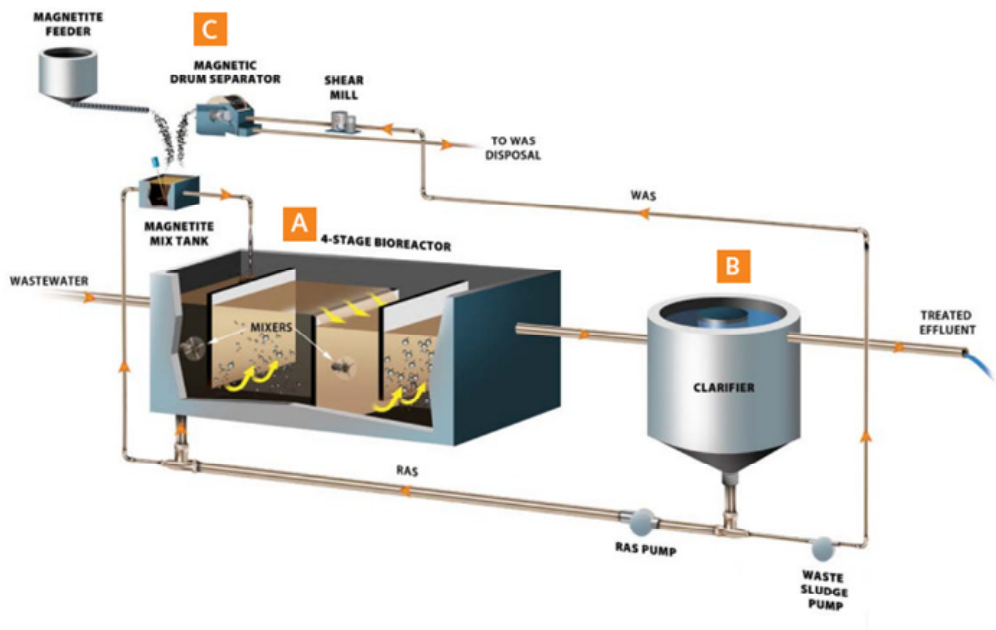


Figure 11 Schematic of the Activated Sludge with Comag system (courtesy of Evoqua Water Technologies)

5.2 SECONDARY CLARIFIER EVALUATION

With the Comag process, secondary clarifiers can be loaded at a significantly higher rate than with conventional activated sludge. Due to the high settling velocity of the Comag floc particles, surface overflow rates (SORs) of 1,500 to 1,750 gpd/sf can be utilized in Comag facilities. Based on the capacity evaluation discussed in TM 2, the existing secondary clarifiers would provide sufficient secondary capacity with a Comag system.

5.3 PERFORMANCE METRICS

From a process performance standpoint, the activated sludge system with Comag would perform similarly to the activated sludge system in terms of phosphorus removal. Additional denitrification has been reported in the dense flocs of a Comag system, but this is highly dependent on site specific operational parameters. The Comag system would require a volume of magnetite to be added to the system on an annual basis.

The table of metrics for evaluation developed in TM 1 is presented in Table 8. Calculations used to develop these metrics are summarized in Appendix TM6-B. These metrics will be compared for all alternatives.

Table 8 Metrics for Activated sludge with Comag

Metric	Activated Sludge with Comag
Energy required (kw/day)	1,050
Energy production potential (kw/day)	886
Biosolids production rate (tons/year)	344
Chemical requirement – Liquids (gallons/year)	28,000
Chemical requirements – Sidestream (gallons/year)	9,000
Nitrogen removal potential	PROCESS MODIFICATION; NO NEW TANKAGE OR PROCESSES
Sidestream phosphorus recovery potential (tons/year)	30
Reuse quality water (gallons/year)	DOWNSTREAM FILTRATION REQUIRED
Operational complexity (Scale 1 to 10)	2
Operational flexibility (Scale 1 to 10)	9
Impact on emerging contaminants (Relative ranking)	5

CHAPTER VI –MOVING BED BIOFILM REACTOR

6.1 TECHNOLOGY OVERVIEW

The moving bed biofilm reactor technology is a submerged biofilm reactor system, with floating plastic media placed in a tank with a length to width ratio of approximately 1:1. The plastic media is submerged, and for aerobic processes air is supplied through medium bubble diffusers on the bottom of the tank. No suspended solids are included in the system, although a solids contact basin can be included downstream of the MBBR process to increase sludge settleability. Examples of installation of this floating media are shown in Figure 12.

Figure 12 Images of an MBBR/IFAS system during installation and operation

The floating media in an MBBR system is retained in the basins through installation of baffle walls with retention sieves, as shown in Figure 13. Media is added to a packing density of between 30 and 60% of the volume of the MBBR tank. To prevent clogging of these retention sieves, a ¼" fine screen upgrade would be required in the headworks.

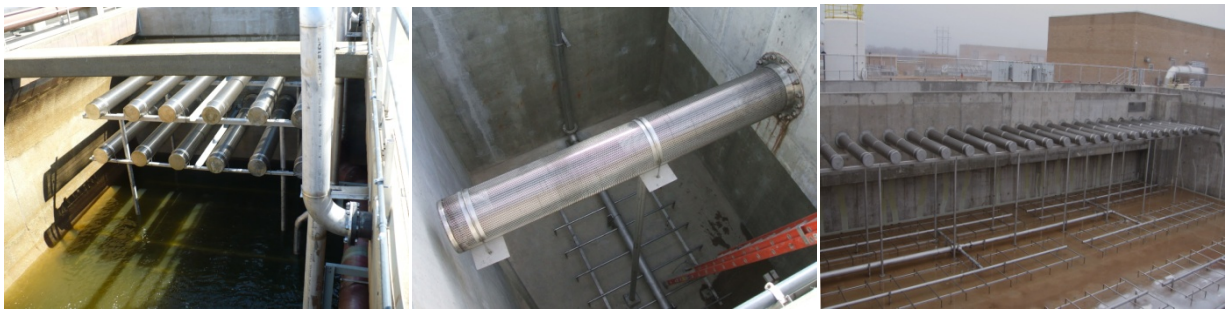


Figure 13 Examples of IFAS retention sieves

One of the major advantages of the MBBR process is that in maintains a biofilm process for the Whitewater facility, while still achieving nitrogen removal and increased operational flexibility. From an expandability standpoint, the MBBR capacity could be increased by increasing the packing density of floating media at a later date.

The MBBR process would require a minimum of a ¼ inch fine screen in the headworks to limit the amount of screenable material that could accumulate with in the tank. This screening improvement would be included as part of any headworks improvements associated with this phase of the project.

6.2 Secondary Clarifier Evaluation

The suspended solids leaving and MBBR would be similar to the suspended solids leaving the existing RBC process. MBBR secondary clarifiers are loaded at rates of up to 1,600 gal/sf-day (McQuarie and Boltz, *WER*, 2011). The secondary clarifier sizing was discussed with MBBR manufacturers, and the existing clarifiers will provide sufficient capacity for the MBBR system.

6.3 Process Configuration

For the MBBR process configuration, two configuration options exist:

- MBBR with IMLR and anoxic zones
- Aerobic MBBR

Schematics of the configurations are shown in Figure 14. Both configurations would provide cBOD removal and nitrification. The MBBR with IMLR and anoxic zones would also achieve denitrification, resulting in TN removal and reduced aeration costs.

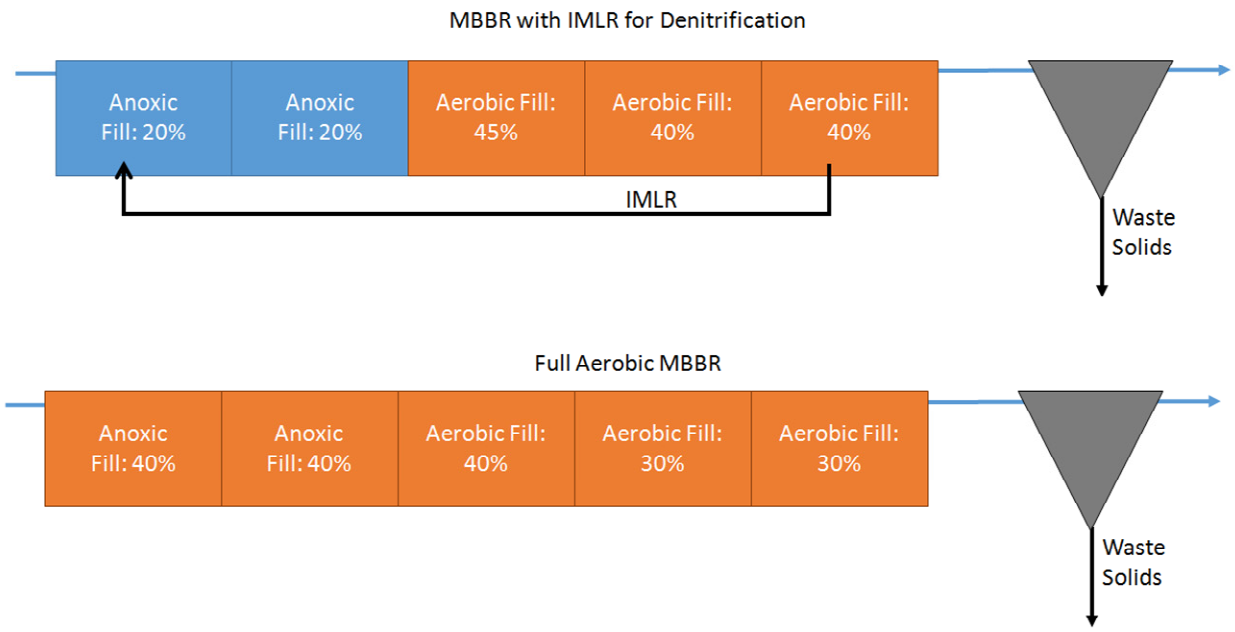


Figure 14 MBBR Process Configurations

6.4 Process Performance Evaluation

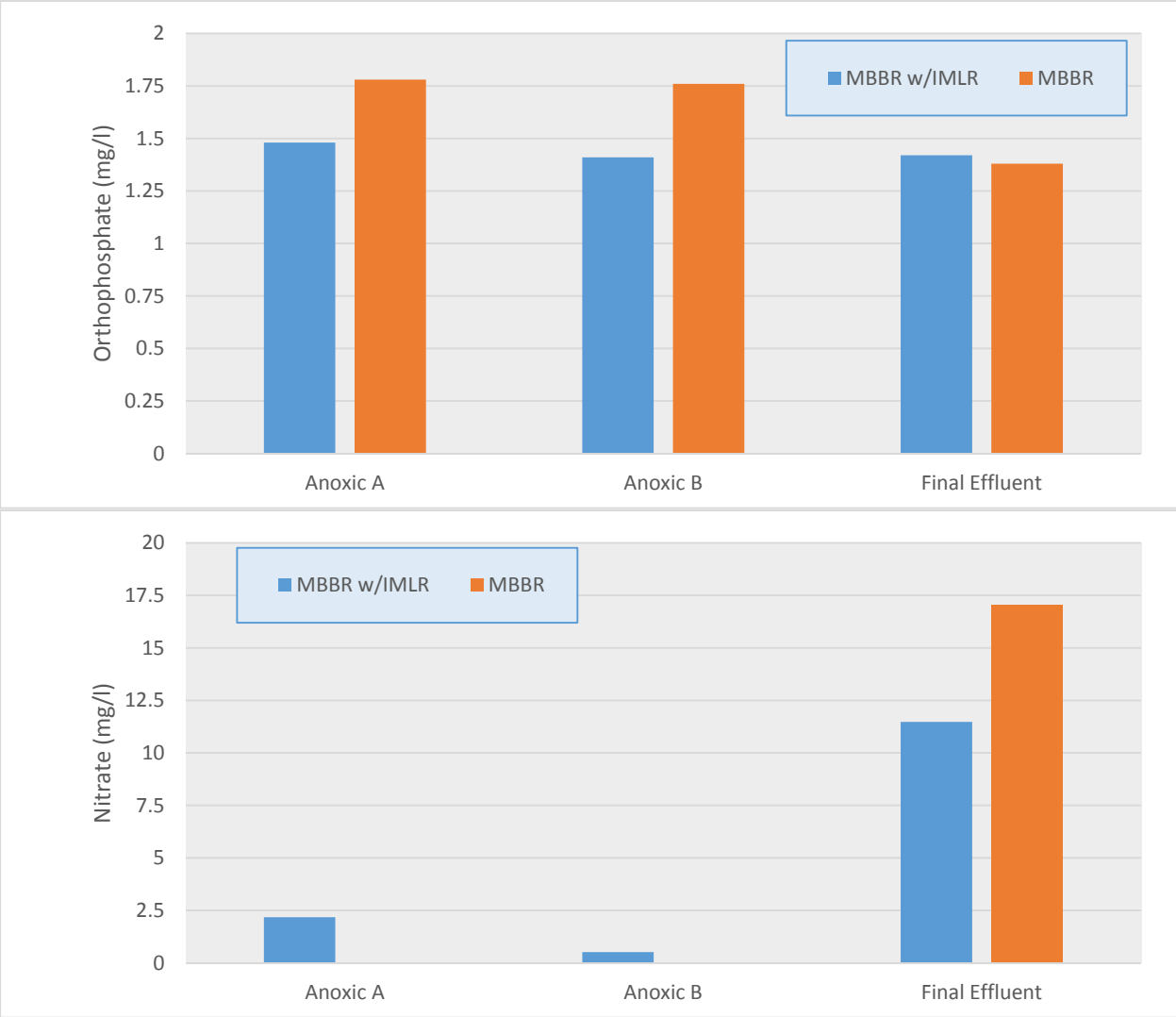
For a biofilm process, phosphorus removal would continue using chemical addition. However, with a submerged biofilm process such as the MBBR, high levels of denitrification are achievable. The performance of the MBBR was evaluated using process modeling. Modeling was completed in Biowin software. The modeling report is included in Appendix TM6-F. At the facilities planning stage, process modeling is a tool to help provide preliminary comparison of alternatives, identify feasibility of

technologies, and develop budgetary cost estimates. Additional modeling would be completed during the preliminary and final design phases to tighten design parameters and provide a "right size" approach to process sizing

With the MBBR not performing biological phosphorus removal, the simulations completed to evaluated the MBBR system were steady state simulations and diurnal flow simulations. Both configurations were evaluated for their nitrification capacity, denitrification capacity, and airflow requirements.

6.4.1 Steady-State Results

Steady state simulations were completed on using the average concentrations and characteristics from the special sampling campaign in January 2014. The steady state simulations provide insight into how the two configurations will respond to average loading conditions in terms of phosphorus removal, nitrate removal, and airflow requirements. The steady-state results are presented in Figure 15 for both configurations.



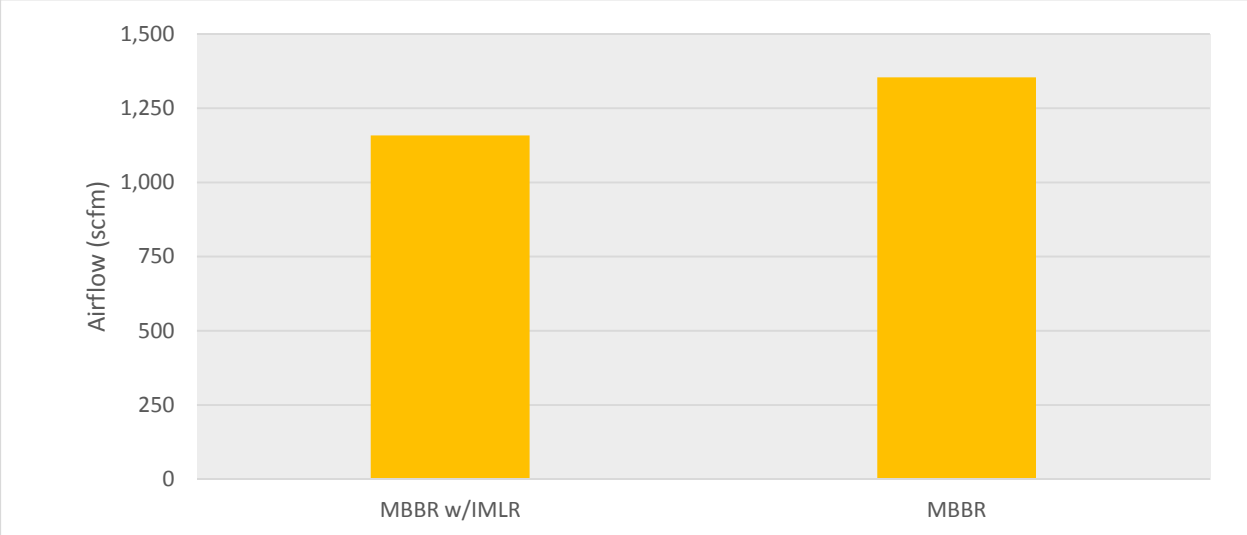


Figure 15 Average day performance of the MBBR with and without IMLR

Based on the steady-state simulations, the MBBR with recycle flows provides significantly higher levels of denitrification and a significant reduction in airflow requirements as compared to the conventional MBBR with no anoxic zones.

6.4.2 Diurnal Response

Dynamics of the nitrification and denitrification process for the MBBR with recycle flows was evaluated 24 hour period of time. Constant concentrations were assumed for BOD, TSS, TKN, and TP, but the flow rate was varied based on a typical day flow pattern for the Whitewater facility. The dynamic nitrogen results are shown in Figure 16. The nitrogen in the MBBR is less sensitive to diurnal simulations than phosphorus in the activated sludge process.

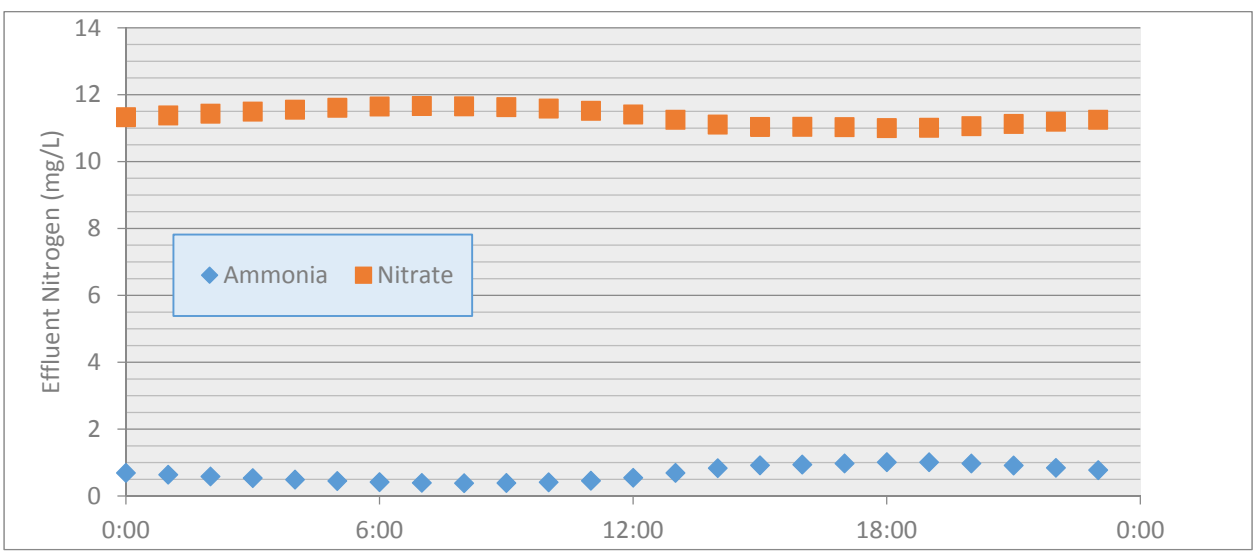


Figure 16 Dynamic performance results for the MBBR with recycle flows

6.4.3 Recommended Configuration

Based on the nitrogen removal performance and the energy savings, it is recommended that the MBBR with IMLR be considered for the MBBR alternative.

6.5 Performance Metrics

The table of metrics for evaluation developed in TM 1 is presented in Table 9. Calculations used to develop these metrics are summarized in Appendix TM6-B. These metrics will be compared for all alternatives.

Table 9: Metrics for MBBR

Metric	MBBR
Energy required (kw/day)	1,100
Energy production potential (kw/day)	806
Biosolids production rate (tons/year)	378
Chemical requirement – Liquids (gallons/year)	51,500
Chemical requirements – Sidestream (gallons/year)	0
Nitrogen removal potential	ADDITIONAL MEDIA REQUIRED TO ACHIEVE 10 MG/L, LESS EXTERNAL CARBON THAN ACTIVATED SLUDGE
Sidestream phosphorus recovery potential (tons/year)	MINIMAL
Reuse quality water (gallons/year)	DOWNSTREAM FILTRATION REQUIRED
Operational complexity (Scale 1 to 10)	7
Operational flexibility (Scale 1 to 10)	7
Impact on emerging contaminants (Relative ranking)	5

CHAPTER VII – MEMBRANE BIOREACTOR

7.1 TECHNOLOGY OVERVIEW

The membrane bioreactor (MBR) provides a single unit process that achieves both biological treatment and solids separation. Rather than relying on solids settling after the secondary biological step, membrane are inserted into aeration basin to filter the MLSS from the water. This allows the system to operate at an elevated MLSS concentration, resulting in a higher biomass quantity per unit volume than activated sludge. The result is a small footprint system that removes both nitrogen and phosphorus to low levels, while producing reuse quality effluent.

One of the main challenges associated with an MBR is the high capital cost. Membrane material is expensive, although it has decreased significantly over the past decade. In addition, high energy costs lead to a relatively high annual cost. Despite these challenges, achieving low level phosphorus concentrations without the need for secondary clarifiers or tertiary filtration provides a potential driver for the process.

7.2 IMPACT ON SECONDARY CLARIFIERS

The existing secondary clarifiers would not be required with the MBR. The existing clarifiers could either be utilized as equalization volume before the MBR or potential for waste solids thickening before anaerobic digestion.

7.3 PROCESS CONFIGURATION

A schematic of the MBR process is shown in Figure 17, which includes both anaerobic and anoxic zones for biological phosphorus removal and denitrification. Four membrane tanks are included, with each tank having 30 membrane units. This is a total of 120 membrane units to provide filtration. An example membrane unit is shown in Figure 18.

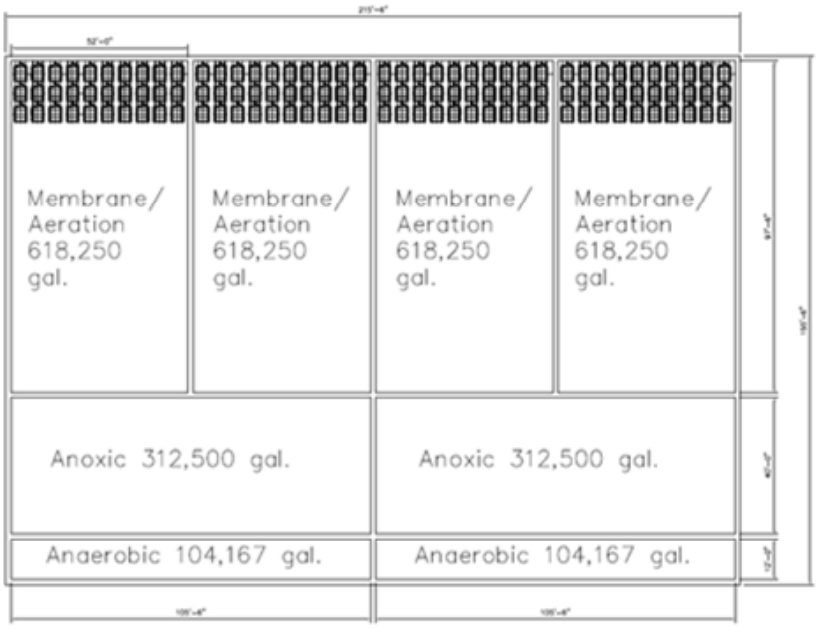


Figure 17 MBR layout (Ovivo)

Figure 18 Example membrane unit (GE Energy)

7.4 PROCESS PERFORMANCE EVALUATION

With the MBR system, biological phosphorus and biological nutrient removal are achievable. Effluent phosphorus concentrations of 0.05 mg/L are achievable with combined biological and chemical phosphorus removal. Effluent TN levels below 10 mg/L are also achievable. One of the main drivers for

achieving the ultra low level nutrients is the high level of TSS removal in a membrane system, with effluent TSS and BOD typically below 1 mg/L.

7.5 Performance Metrics

The table of metrics for evaluation developed in TM 1 is presented in Table 10. Calculations used to develop these metrics are summarized in Appendix TM6-B. These metrics will be compared for all alternatives.

Table 10: Metrics for MBR

Metric	MBR
Energy required (kw/day)	6,750
Energy production potential (kw/day)	1,005
Biosolids production rate (tons/year)	474
Chemical requirement – Liquids (gallons/year)	28,000
Chemical requirements – Sidestream (gallons/year)	9,000
Nitrogen removal potential	TN < 10 MG/L
Sidestream phosphorus recovery potential (tons/year)	30
Reuse quality water (gallons/year)	HIGHEST REUSE QUALITY
Operational complexity (Scale 1 to 10)	3
Operational flexibility (Scale 1 to 10)	5
Impact on emerging contaminants (Relative ranking)	7

CHAPTER VIII – ALTERNATIVES COMPARISON

8.1 CAPITAL COST COMPARISON

The capital cost estimates for each alternative are summarized below. Additional information is included in Appendix TM6-G. The capital cost estimates presented in this TM are decision making values based on historic construction values from past Donohue design projects. Our cost methodology is based on gathering major equipment costs, estimated concrete costs, estimating building costs, and then using construction cost percentages to estimate the discipline specific cost to develop the total construction cost. For these discipline specific construction cost percentages, Donohue compiles a running total of the percent of construction cost for the various projects where we are involved. The averages for Civil, Process-Mechanical (P-M) Piping, HVAC, Plumbing, and Electrical/Controls for several of the recent major expansion projects are shown in Figure 19.

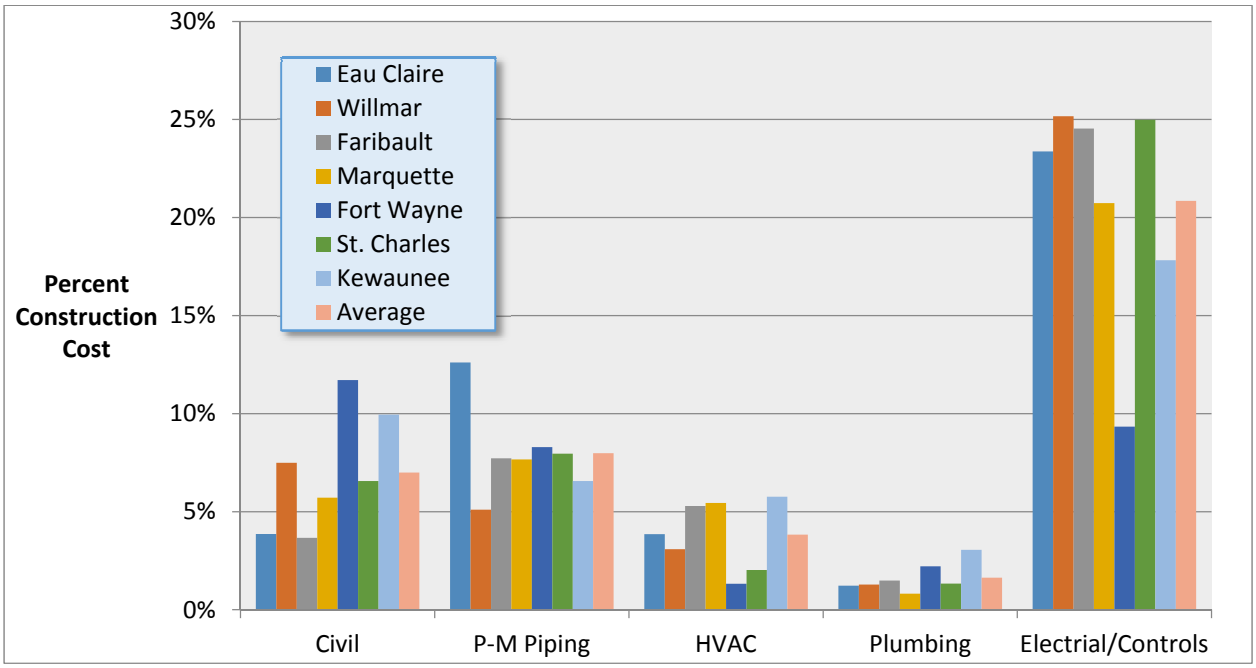


Figure 19 Historic discipline specific construction costs based on constructed projects

For the Whitewater cost estimates, the following discipline percentages were assumed for the activated sludge, activated sludge with Comag, and MBBR alternatives:

- Civil: 7%
- P-M Piping: 8%
- HVAC: 4%
- Plumbing: 1.5%
- Electrical/Controls: 20%

For the RBC alternative, no new building is planned, so the HVAC and Plumbing percentages were reduced to zero. For the MBR, the majority of the capital cost is driven by equipment costs, which can impact the accuracy of the assumed percentages. For the MBR estimate, the Civil, P-M Piping, HVAC,

and Plumbing dollar values were assumed to match the activated sludge, activated sludge with Comag, and MBBR alternatives.

All alternative costs also include estimated demolition cost for the existing RBC buildings.

8.1.1 RBC

For the RBC alternative, the existing RBCs would be replaced with air driven RBCs. The new RBCs would be housed in fiber glass covers, with the existing buildings demolished. The new RBCs would be in the same location as the existing RBCs, and utilize the same tank volume. The capital cost estimate includes:

- New RBC components
- Air drive blowers
- Existing RBC demolition
- Associated civil, piping, HVAC, and mechanical components

The total capital cost estimate for the RBCs is $12.9 M.

8.1.2 Activated Sludge

As discussed previously, the activated sludge alternative would include the UCT process with additional secondary clarification capacity. Three potential options were evaluated for capital cost:

- Option 1: Construct a third clarifier with a diameter of 70 feet and depth of 18 feet to be used in conjunction with the existing clarifiers
- Option 2: Construct two new final clarifiers and abandon or re-purpose existing final clarifiers
- Option 3: Construct two new final clarifiers with the existing final clarifiers incorporated into the aeration basin volume

Each potential option is discussed below, with the Activated Sludge option cost estimates included in Appendix TM6-H.

Option 1
A preliminary layout for Option 1 is shown in Figure 20. The reuse of the existing final clarifiers provides some risk, and the shallow depth is non-ideal for an activated sludge final clarifier due to the high solids loading rate. However, based on preliminary evaluation, the existing final clarifiers would be suitable if operated in conjunction with a new, deeper final clarifier.

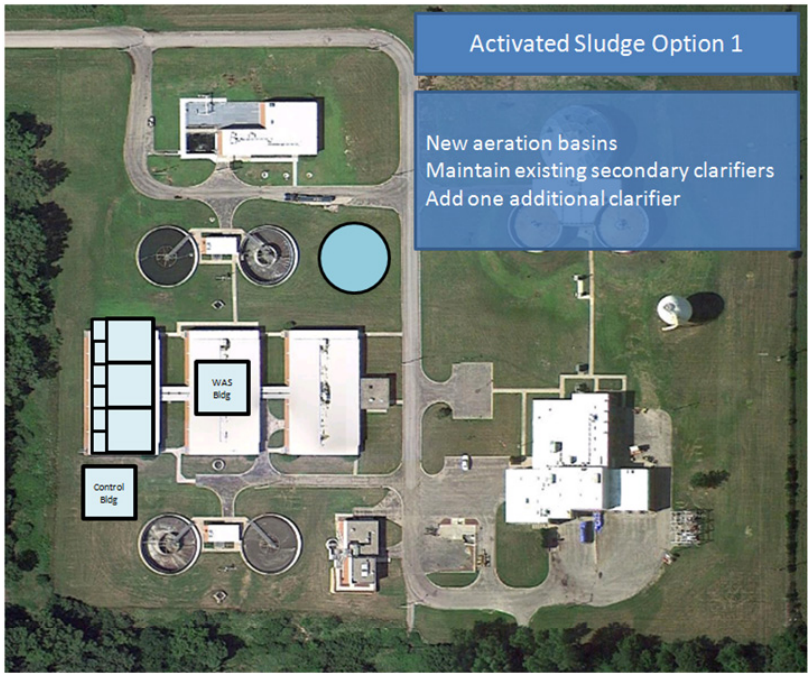


Figure 20 Activated sludge Option 1 layout

The capital cost estimate for the Activated Sludge Option 1 includes:

- New aeration basins
- One new secondary clarifier
- RAS pumping
- Secondary system control building
- WAS thickening equipment and building
- Associated civil, piping, HVAC, and mechanical components

The total capital cost estimate for Activated Sludge Option 1 is $10.7 M.

Option 2

The preliminary layout for Option 2 is shown in Figure 21. This is the optimal alternative, as 100% of the secondary clarifier volume would be designed for the activated sludge system. The existing secondary clarifiers could be re-purposed in the future as the coagulation/flocculation basins ahead of a low level phosphorus filtration step.

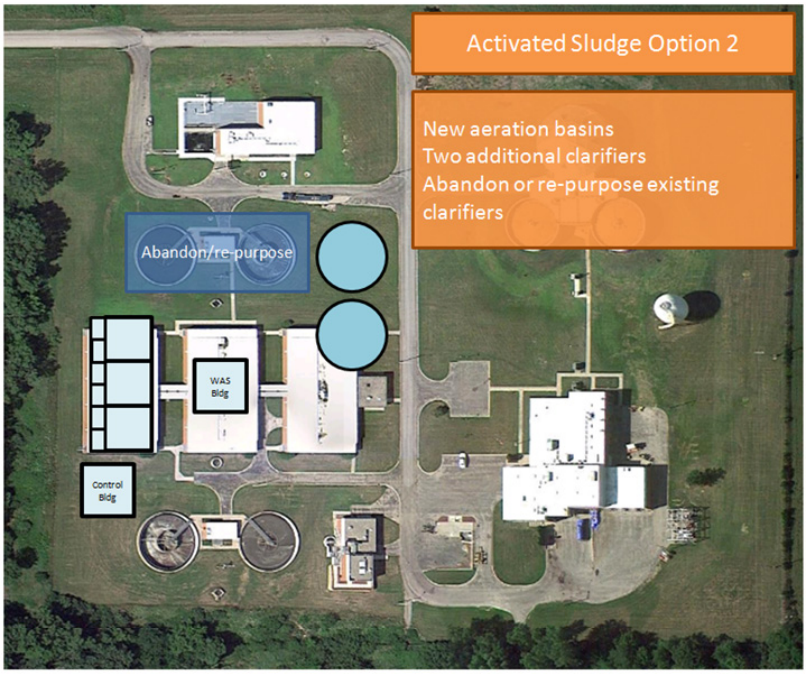


Figure 21 Activated sludge Option 2 layout

The capital cost estimate for the Activated Sludge Option 2 includes:

- New aeration basins
- Two new secondary clarifiers
- RAS pumping
- Secondary system control building
- WAS thickening equipment and building
- Associated civil, piping, HVAC, and mechanical components

The total capital cost estimate for Activated Sludge Option 2 is $11.9 M.

Option 3

Option 3 would re-purpose the existing final clarifiers as aeration basin volume. As shown in Figure 22, the total aeration basin volume would remain the same, but the existing secondary clarifiers would reduce the amount of new concrete in the aeration basins. Three passes would still be constructed with selector zones and the first portion of aeration, and then the existing secondary clarifiers would be utilized downstream of the new basins for addition aeration capacity. Two new secondary clarifiers would be constructed downstream of the existing secondary clarifiers. From a hydraulic standpoint, an additional two feet of wall height would be added to the existing secondary clarifiers. This would eliminate the concerns associated with the shallow final clarifiers for an activated sludge facility.

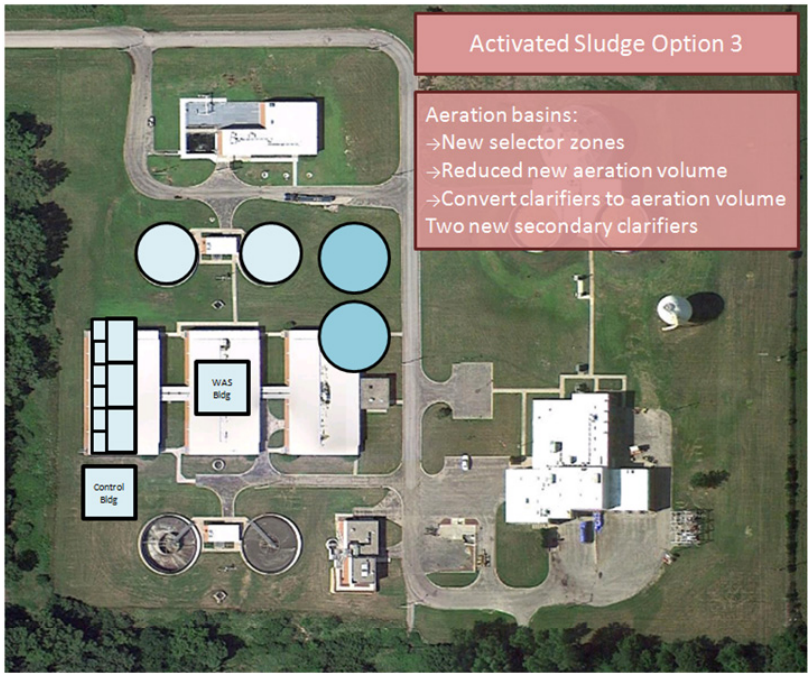


Figure 22 Activated sludge Option 3 layout

The capital cost estimate for the Activated Sludge Option 3 includes:

- New aeration basins
- Modifications to existing secondary clarifiers
- Two new secondary clarifiers
- RAS pumping
- Secondary system control building
- WAS thickening equipment and building
- Associated civil, piping, HVAC, and mechanical components

The total capital cost estimate for Activated Sludge Option 3 is $10.9 M.

Activated Sludge Option Recommendation

Based on the capital cost estimates, Option 3 will be included for the economic evaluation and comparison to other alternatives. Option 3 provides new clarifiers design for activated sludge, while still utilizing the existing final clarifiers for infrastructure needs. If the activated sludge alternative is selected, a more detailed evaluation of the Options should be completed during preliminary design.

8.1.3 Activated Sludge with Comag

The activated sludge process with Comag is similar to the conventional activated sludge alternative, although a new secondary clarifier would not be required and the aeration basins would have a reduced volume. The preliminary layout for the activated sludge with Comag alternative is shown in Figure 23.

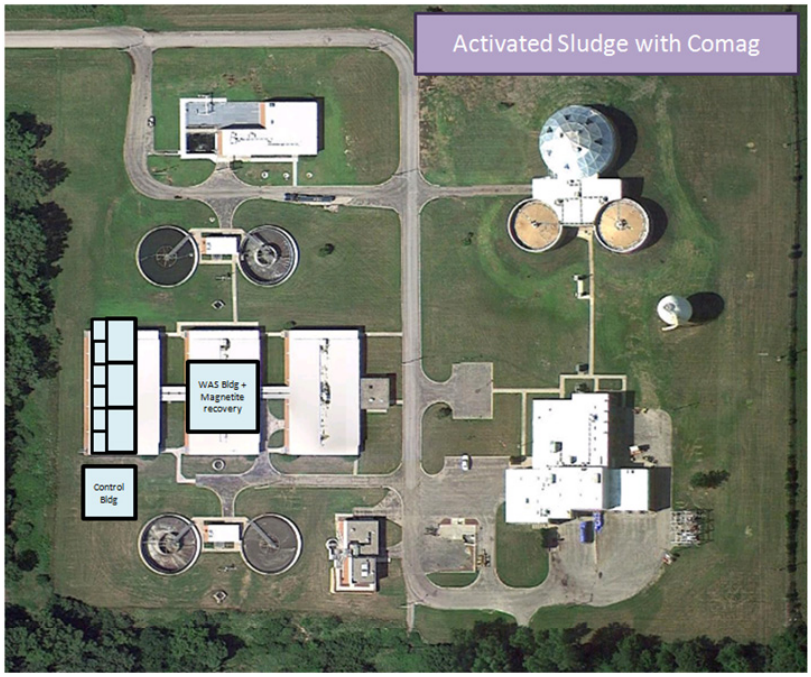


Figure 23 Activated sludge with Comag layout

The capital cost estimate for the Activated Sludge with Comag includes:

- New aeration basins
- Modifications to existing secondary clarifiers
- RAS pumping
- Secondary system control building
- WAS thickening equipment and building, including magnetite recovery
- Associated civil, piping, HVAC, and mechanical components

The total capital cost estimate for Activated Sludge with Comag is $13.3 M.

8.1.4 MBBR

The MBBR would be the most similar technology to the existing RBC facility, relying on biofilm/fixed film growth to achieve nitrification. As discussed previously, the MBBR has the added benefit of providing denitrification capacity for the system. The preliminary layout for the MBBR is shown in Figure 24.

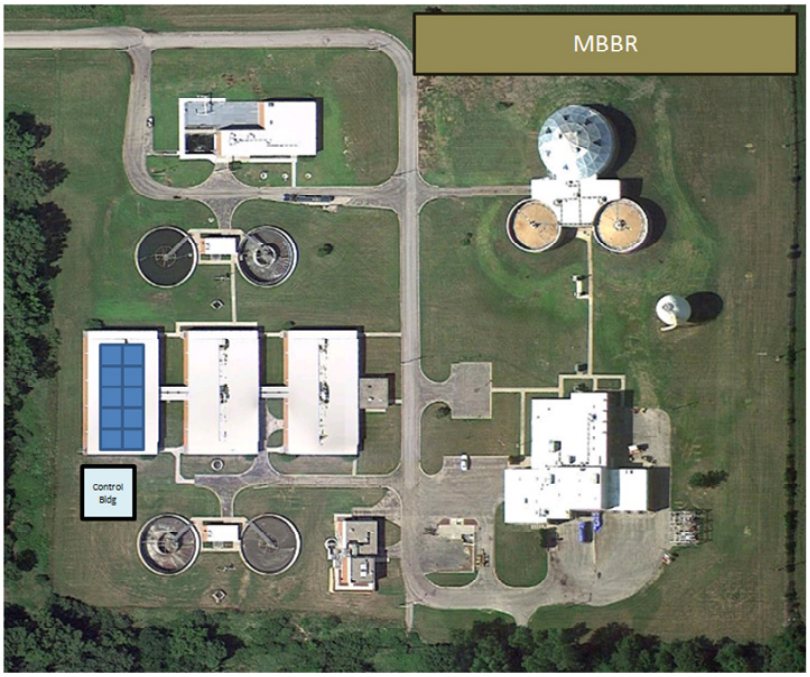


Figure 24 MBBR layout

The capital cost estimate for the MBBR alternative includes:

- New MBBR basins and associated media and retention sieves
- Modifications to existing secondary clarifiers
- Secondary system control building
- Associated civil, piping, HVAC, and mechanical components

The total capital cost estimate for the MBBR is $10.5 M. This cost does not include any potential improvements to the screens in the headworks building to achieve the required ¼ inch fine screen upstream of the MBBR system.

8.1.5 MBR

The MBR would achieve both the secondary treatment improvements required for the Whitewater facility as well as position the facility to achieve future low level phosphorus limitations. The MBR would provide the required treatment in a single unit process, eliminating the need for the existing secondary clarifiers. The preliminary layout for the MBR is shown in Figure 25.

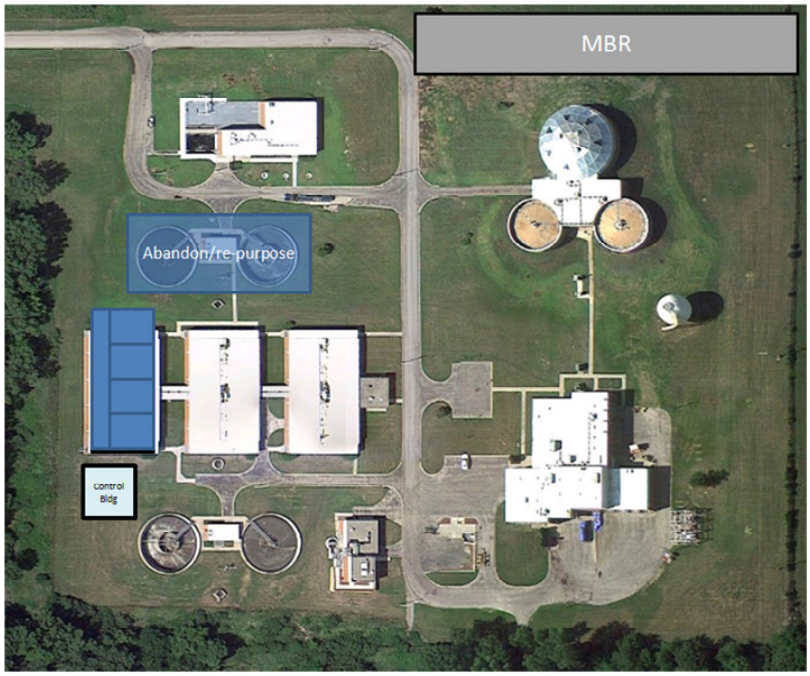


Figure 25 MBR layout

The capital cost estimate for the MBR alternative includes:

- New MBR basins and mechanical equipment
- Modifications to existing secondary clarifiers
- Secondary system control building
- Associated civil, piping, HVAC, and mechanical components

The total capital cost estimate for the MBR is $21.1 M. This cost does not include any potential improvements to the screens in the headworks building to achieve the required 1/8 inch fine screen upstream of the MBBR system.

8.1.6 Capital Cost Comparison

The capital cost comparison for the five alternatives is included in Table 11. The MBBR presented the lowest preliminary capital cost estimate.

Table 11: Capital cost comparison

Alternative	Capital Cost
RBC	$12.9 M
Activated Sludge	$10.9 M
Activated Sludge with Comag	$13.3 M
MBBR	$10.5 M
MBR	$21.1 M

8.2 Economic Evaluation

As discussed in TM 1, the cumulative economics of all five alternatives were assessed and plotted graphically. The annual costs consist of estimated energy, chemical, operating, and replacement costs. The 20-year total present worth (TPW) values summarized in Table 12, with the results shown graphically in Figure 26. For the MBR alternative, the produced water was assigned a value by assuming 100% of the water could be sold at the existing municipal water rate. The MBBR presented the lowest 20-year TPW value.

Table 12: 20-year TPW comparison

Alternative	20-Yr TPW
RBC	$19.6 M
Activated Sludge	$14.1 M
Activated Sludge with Comag	$17.9 M
MBBR	$14.1 M
MBR	$23.0 M

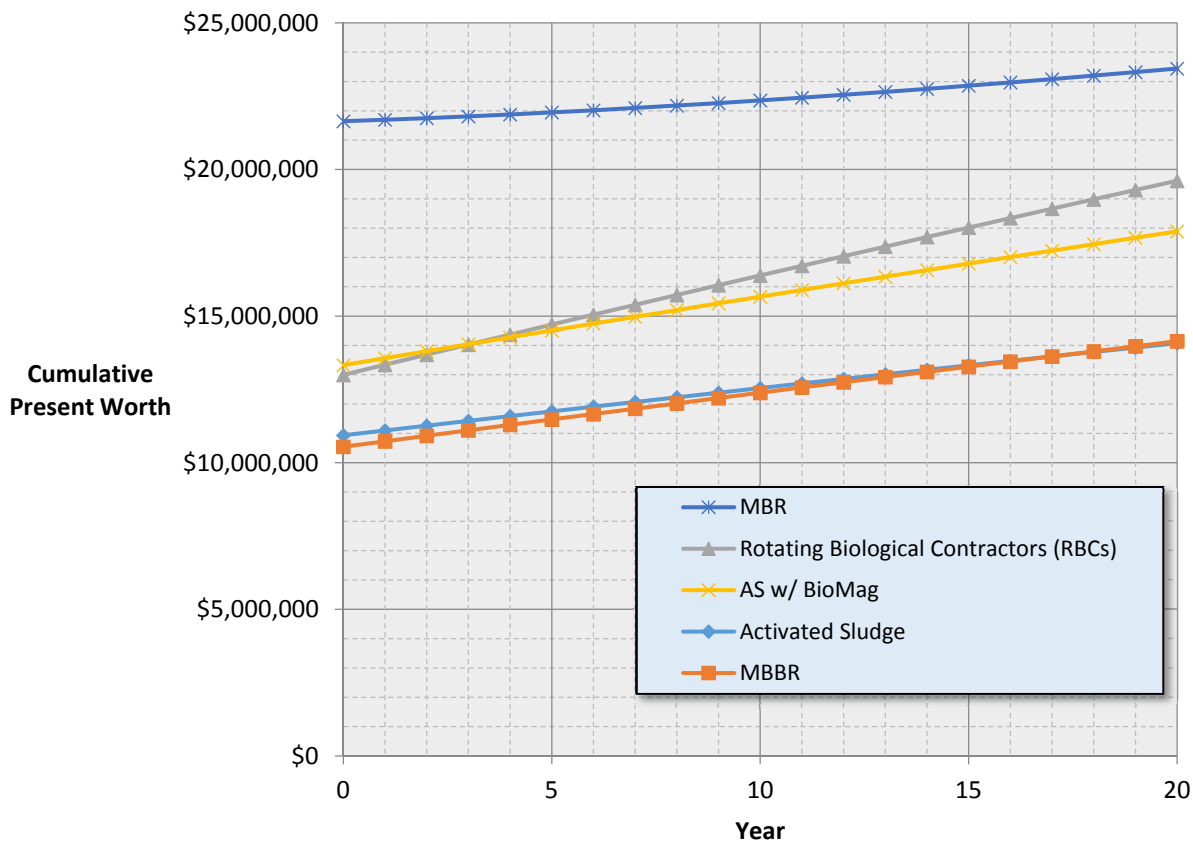


Figure 26 Economic analysis of the evaluated alternatives

8.3 Operating Metrics Comparison

The operating metrics identified in TM 1 are summarized for each Alternative in Table 13. The major takeaways from this table are:

- The activated sludge and MBBR alternatives have the lowest net energy requirement due to the denitrification impact on airflow requirements
- The activated sludge alternative has the lowest chemical usage and sludge production due to the impact of biological phosphorus removal
- Only the RBC would not be capable of meeting future TN limits
- The MBR produces a high quality effluent water that has the potential to be sold as a product, and it was assumed that 100% of this water was sold at the current municipal water rates
- The MBBR and RBC alternatives would limit the potential for struvite harvesting from the biosolids treatment train

Table 13: Comparison of operating metrics for each alternative

Metric	RBCs	Activated Sludge	Activated Sludge with Comag	MBBR	MBR
Capital Cost	$12.9 M	$10.9 M	$13.3 M	$10.5 M	$21.1 M
20-year TPW Value	$19.6 M	$14.1 M	$17.9 M	$14.1 M	$23.0 M
Energy required (kw/day)	1,360	1,050	1,050	1,100	6,750
Energy production potential (kw/day)	806	886	886	806	1,005
Biosolids production rate (tons/year)	485	344	344	378	474
Chemical requirement – Liquids (gallons/year)	51,100	28,000	28,000	51,500	28,000
Chemical requirements – Sidestream (gallons/year)	0	9,000	9,000	0	9,000
Nitrogen removal potential	ADDITIONAL PROCESS REQUIRED	TN < 15 MG/L	TN < 15 MG/L	TN < 15 MG/L	TN < 10 MG/L
Sidestream phosphorus recovery potential (tons/year)	MINIMAL	30	30	MINIMAL	30
Reuse quality water (gallons/year)	FILTRATION REQUIRED	FILTRATION REQUIRED	FILTRATION REQUIRED	FILTRATION REQUIRED	HIGHEST REUSE QUALITY
Operational complexity * (Scale 1 to 10)	8	4	2	7	3
Operational flexibility * (Scale 1 to 10)	3	9	9	7	5
Impact on emerging contaminants * (Scale 1 to 10)	4	5	5	5	7

Note: the last three categories will be finalized during the workshop on May 9, 2014

8.4 RECOMMENDATION

After discussion during the May 9, 2014 workshop and subsequent site visits to other operating wastewater treatment facilities in Sun Prairie and Wisconsin Rapids Activated Sludge Option 3 was selected as the preferred alternative. This alternative was tied for the lowest overall present worth but offered the greatest flexibility. This alternative includes:

- New aeration basins
- Modifications to existing secondary clarifiers to serve as aeration basin volume
- Two new secondary clarifiers
- RAS pumping
- Secondary system control building
- WAS thickening equipment and building
- Associated civil, piping, HVAC, and mechanical components

Appendix TM6-A

CEPT Mass Balance

Whitewater WWTP
Facility Plan Update
CEPT Mass and Energy Balance
April 2014

DONOHUE

Chemically Enhanced Primary Treatment (CEPT) - BNR Activated Sludge

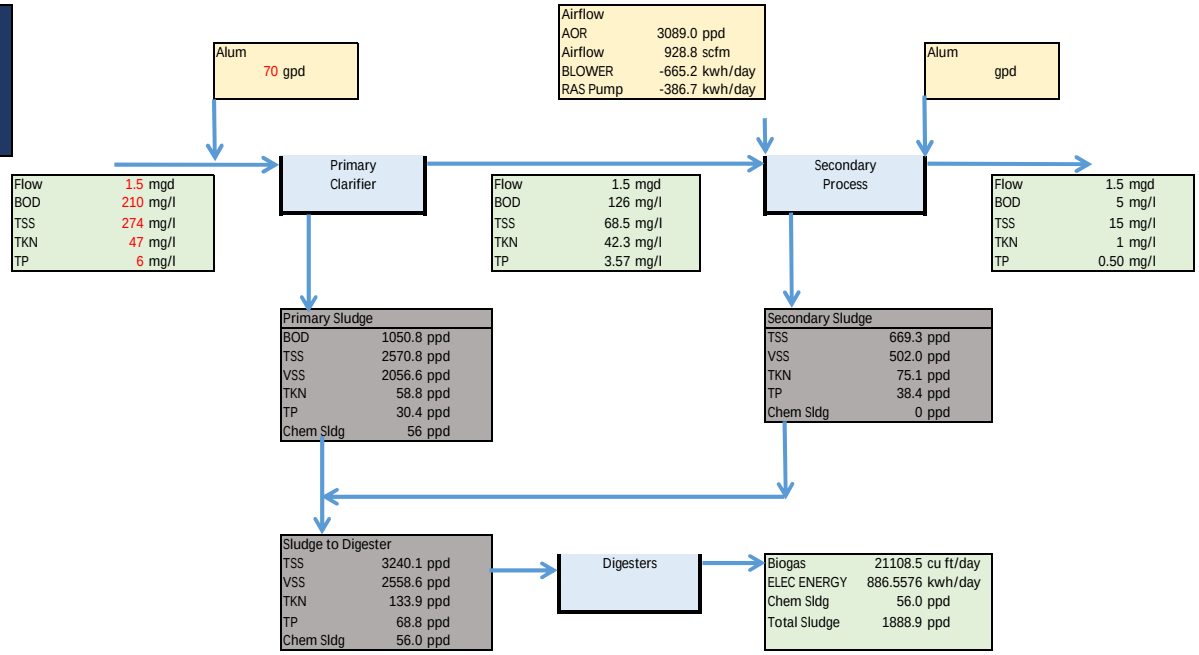
ASSUMPTIONS

Primary Performance	
TSS	75%
BOD	40%
TKN	10%

Aeration Values		
AOR		
BOD	1.1	lbsO2/lbBOD
TKN	4.57	lbsO2/lbTKN
BOD/TKN		
Airflow		
OTE	1.80%	per foot
Depth	18.00	ft
a	0.60	
b	0.98	
Temperature	20.00	oC
F	0.80	
W	0.97	
t	1.00	
C20	10.50	
C	1.00	
OTR/SOTR	0.410574	
Effluent Nitrate	18.00	mg/L
N Assimilation	6.00	mg/L
q	0.04	scfm/ppd
Power		
Improved		
	25	scfm/hp

Parameters		
WAS	0.75	VSS/TSS
Primary	0.8	VSS/TSS
Yield	0.65	lb/lb
Dig VS	55%	
Biogas Yield	15	cu ft/lbVS
PE Alum	2.3	gal/ppd
Biogas electric	1.5	kwh/m3

Summary		
Secondary Energy	-1051.9	kwh/day
Electricity Produced	886.6	kwh/day
Net Electricity	-165.4	kwh/day
Sludge	1888.9	ppd
Alum	70	gpd



Whitewater WWTP
Facility Plan Update
CEPT Mass and Energy Balance
April 2014

DONOHUE

Conventional Primary Treatment - BNR Activated Sludge

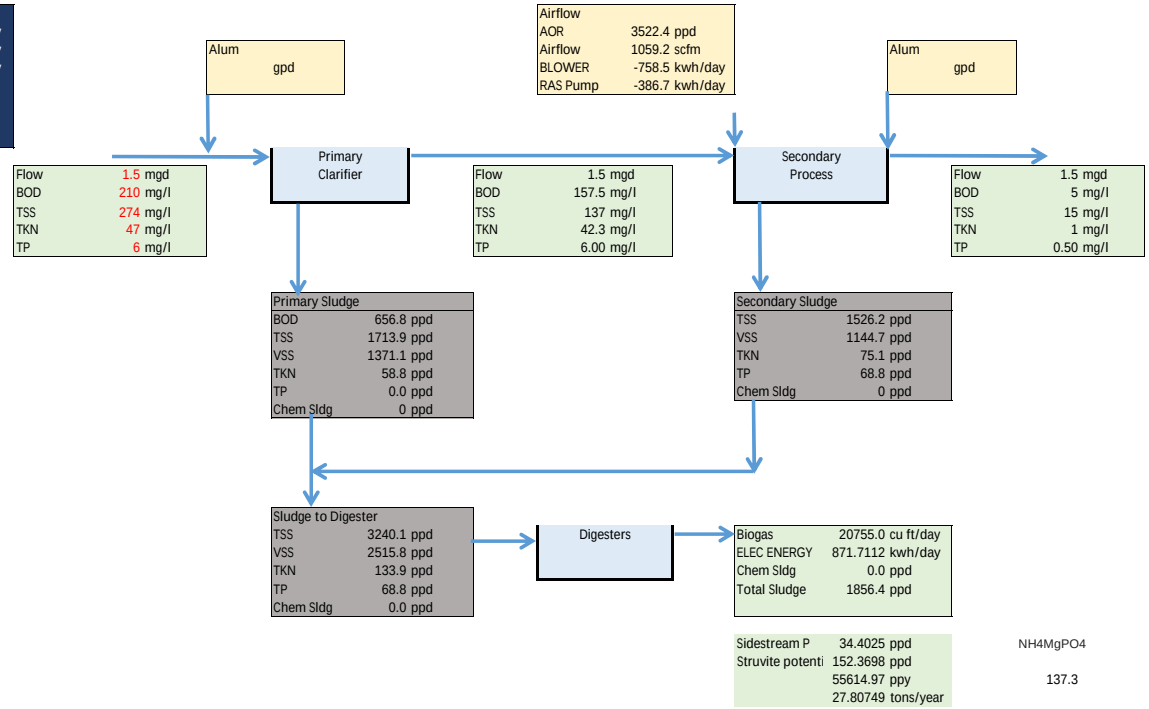
ASSUMPTIONS

Primary Performance		
TSS	50%	
BOD	25%	
TKN	10%	

Aeration Values		
AOR		
BOD	1.1	lbsO2/lbBO
TKN	4.57	lbsO2/lbTK
Airflow		
OTE	1.80%	per foot
Depth	18.00	ft
a	0.60	
b	0.98	
Temperature	20.00	oC
F	0.80	
W	0.97	
t	1.00	
C20	10.50	
C	1.00	
OTR/SOTR	0.410574	
Effluent Nitrate	18.00	mg/L
N Assimilation	6.00	mg/L
q	0.04	scfm/ppd
Power		
Improved		
	25	scfm/hp

Parameters		
WAS	0.75	VSS/TSS
Primary	0.8	VSS/TSS
Yield	0.65	lb/lb
Dig VS	55%	
Biogas Yield	15	cu ft/lbVS
PE Alum	2.3	gal/ppd
Biogas electric	1.5	kwh/m3

Summary		
Secondary Energy	-1145.3	kwh/day
Electricity Produced	871.7	kwh/day
Net Electricity	-273.6	kwh/day
Sludge	1856.4	ppd
Alum	0	gpd



Sidestream P	34.4025	ppd	NH4MgPO4
Struvite potenti	152.3698	ppd	
	55614.97	ppy	137.3
	27.80749	tons/year	

Whitewater WWTP
Facility Plan Update
CEPT Mass and Energy Balance
April 2014

DONOHUE

No Primary Treatment - Extended Aeration

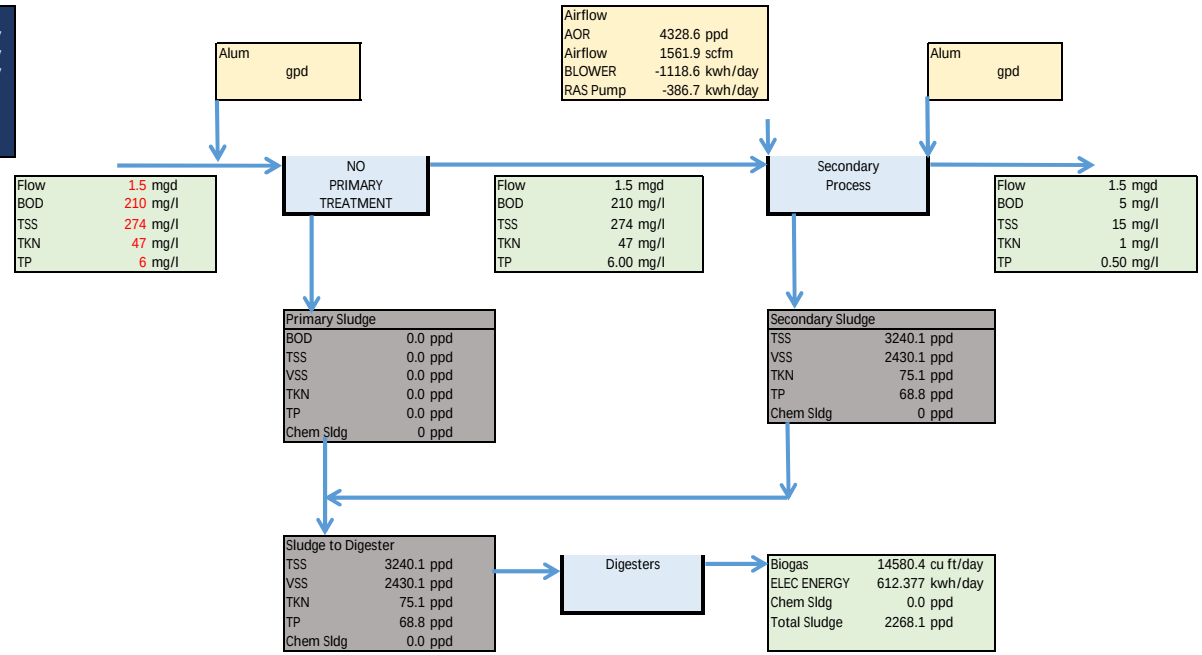
ASSUMPTIONS

Primary Performance	
TSS	0%
BOD	0%
TKN	0%

Aeration Values		
AOR		
BOD	1.1	lbsO2/lbBO
TKN	4.57	lbsO2/lbTK
Airflow		
OTE	1.80%	per foot
Depth	18.00	ft
a	0.50	
b	0.98	
Temperature	20.00	oC
F	0.80	
W	0.97	
t	1.00	
C20	10.50	
C	1.00	
OTR/SOTR	0.342145	
Effluent Nitrate	18.00	mg/L
N Assimilation	6.00	mg/L
q	0.04	scfm/ppd
Power		
Improved		
	25	scfm/hp

Parameters		
WAS	0.75	VSS/TSS
Primary	0.8	VSS/TSS
Yield	0.65	lb/lb
Dig VS	40%	
Biogas Yield	15	cu ft/lbVS
PE Alum	2.3	gal/ppd
Biogas electric	1.5	kwh/m3

Summary		
Secondary Energy	-1505.3	kwh/day
Electricity Produced	612.4	kwh/day
Net Electricity	-892.9	kwh/day
Sludge	2268.1	ppd
Alum	0	gpd



Appendix TM6-B

Alternative Mass Balances

Whitewater WWTP
Facility Plan Update
CEPT Mass and Energy Balance
April 2014

DONOHUE

No Primary Treatment - Extended Aeration

ASSUMPTIONS

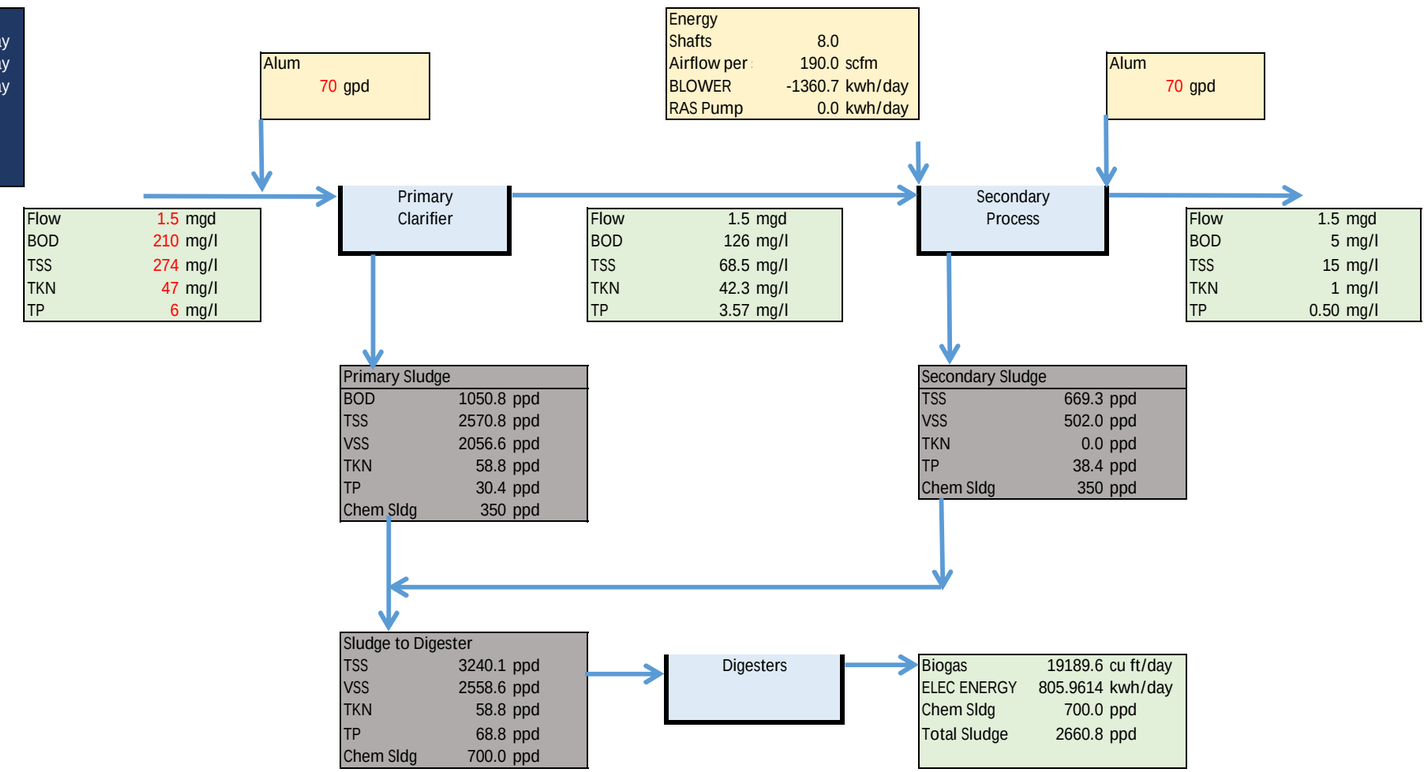
Primary Performance	
TSS	75%
BOD	40%
TKN	10%

Aeration Values		
Air Required per Shaft	190	scfm
Power Improved	20	scfm/hp

Parameters		
WAS	0.75	VSS/TSS
Primary	0.8	VSS/TSS
Yield	0.65	lb/lb
Dig VS	50%	
Biogas Yield	15	cu ft/lbVS
PE Alum	2.3	gal/ppd
Biogas electric	1.5	kwh/m3

Summary		
Secondary Energy	-1360.7	kwh/day
Electricity Produced	806.0	kwh/day
Net Electricity	-554.7	kwh/day
Sludge	2660.8	ppd
Alum	140	gpd

M&E 190 (standard-density shaft) and 270 (high-density shaft)



Whitewater WWTP
Facility Plan Update
CEPT Mass and Energy Balance
April 2014

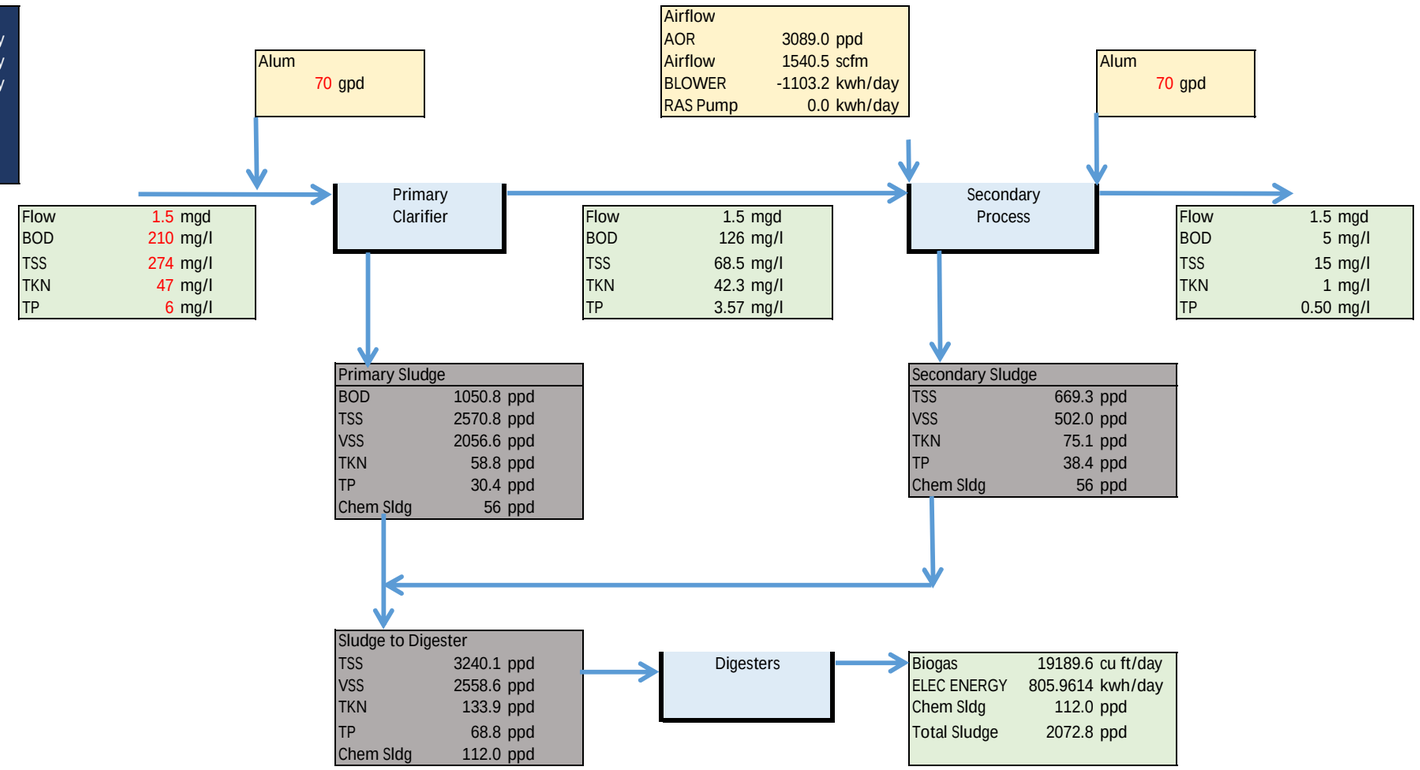
DONOHUE

No Primary Treatment - Extended Aeration

ASSUMPTIONS		
Primary Performance		
TSS	75%	
BOD	40%	
TKN	10%	
Aeration Values		
AOR		
BOD	1.1	lbsO2/lbBO
TKN	4.57	lbsO2/lbTK
Airflow		
OTE	1.10%	per foot
Depth	20.00	ft
a	0.80	
b	0.98	
Temperature	20.00	oC
F	0.80	
W	0.97	
t	1.00	
C20	10.50	
C	4.00	
OTR/SOTR	0.364574	
Effluent Nitrate	18.00	mg/L
N Assimilation	6.00	mg/L
q	0.04	scfm/ppd
Power		
Improved	25	scfm/hp

Parameters		
WAS	0.75	VSS/TSS
Primary	0.8	VSS/TSS
Yield	0.5	lb/lb
Dig VS	50%	
Biogas Yield	15	cu ft/lbVS
PE Alum	2.3	gal/ppd
Biogas electric	1.5	kwh/m3

Summary		
Secondary Energy	-1103.2	kwh/day
Electricity Produced	806.0	kwh/day
Net Electricity	-297.3	kwh/day
Sludge	2072.8	ppd
Alum	140	gpd



Whitewater WWTP
Facility Plan Update
CEPT Mass and Energy Balance
April 2014

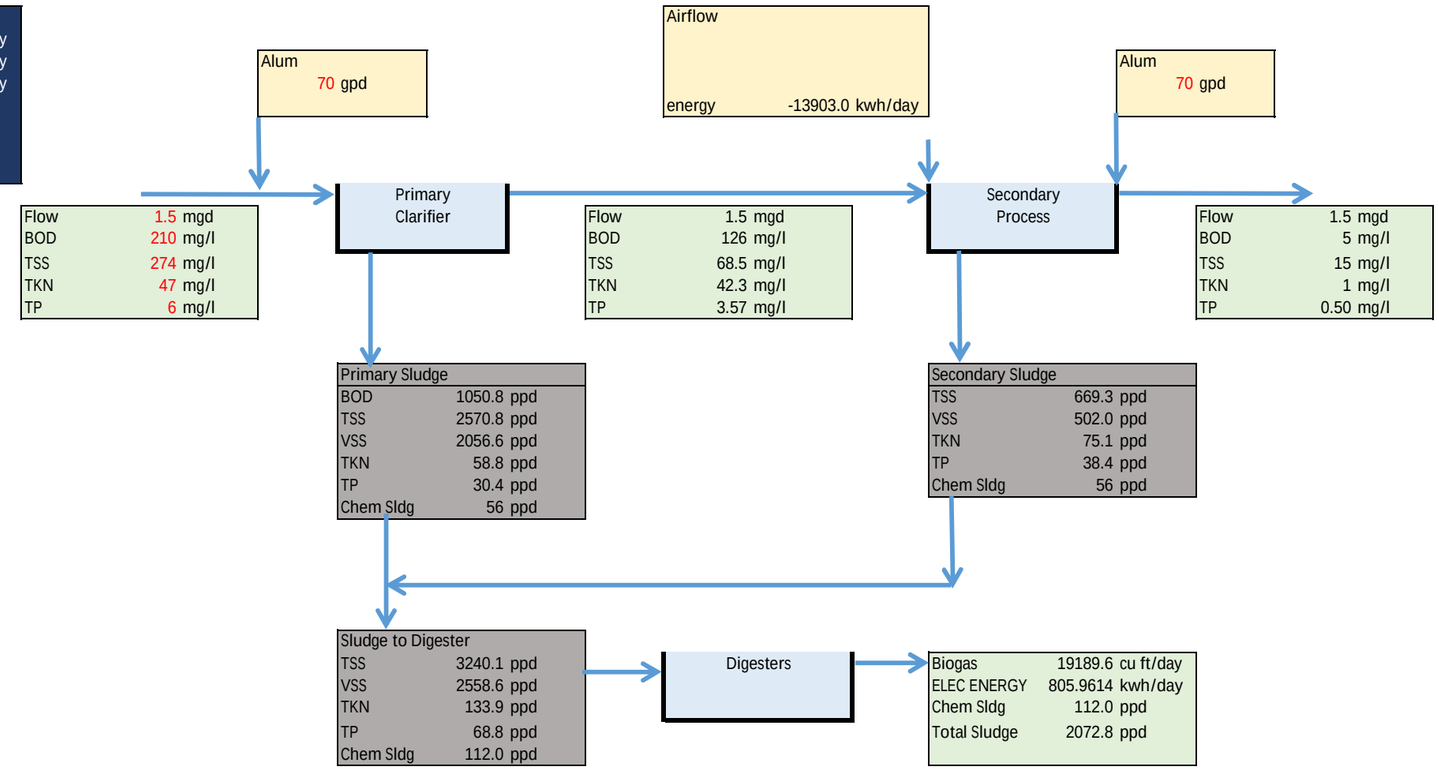
DONOHUE

No Primary Treatment - Extended Aeration

ASSUMPTIONS		
Primary Performance		
TSS	75%	
BOD	40%	
TKN	10%	
Aeration Values		
AOR		
BOD	1.1	lbsO2/lbBO
TKN	4.57	lbsO2/lbTK
Airflow		
OTE	1.10%	per foot
Depth	20.00	ft
a	0.80	
b	0.98	
Temperature	20.00	oC
F	0.80	
W	0.97	
t	1.00	
C20	10.50	
C	4.00	
OTR/SOTR	0.364574	
Effluent Nitrate	18.00	mg/L
N Assimilation	6.00	mg/L
q	0.04	scfm/ppd
Power		
Improved	25	scfm/hp

Parameters		
WAS	0.75	VSS/TSS
Primary	0.8	VSS/TSS
Yield	0.6	lb/lb
Dig VS	50%	
Biogas Yield	15	cu ft/lbVS
PE Alum	2.3	gal/ppd
Biogas electric	1.5	kwh/m3

Summary		
Secondary Energy	-13903.0	kwh/day
Electricity Produced	806.0	kwh/day
Net Electricity	-13097.0	kwh/day
Sludge	2072.8	ppd
Alum	140	gpd



Appendix TM6-C

Secondary Clarifier Evaluation

Summary

Peak Flow	15	mgd
Clarifier		
Diameter	70	ft
Depth	10	ft

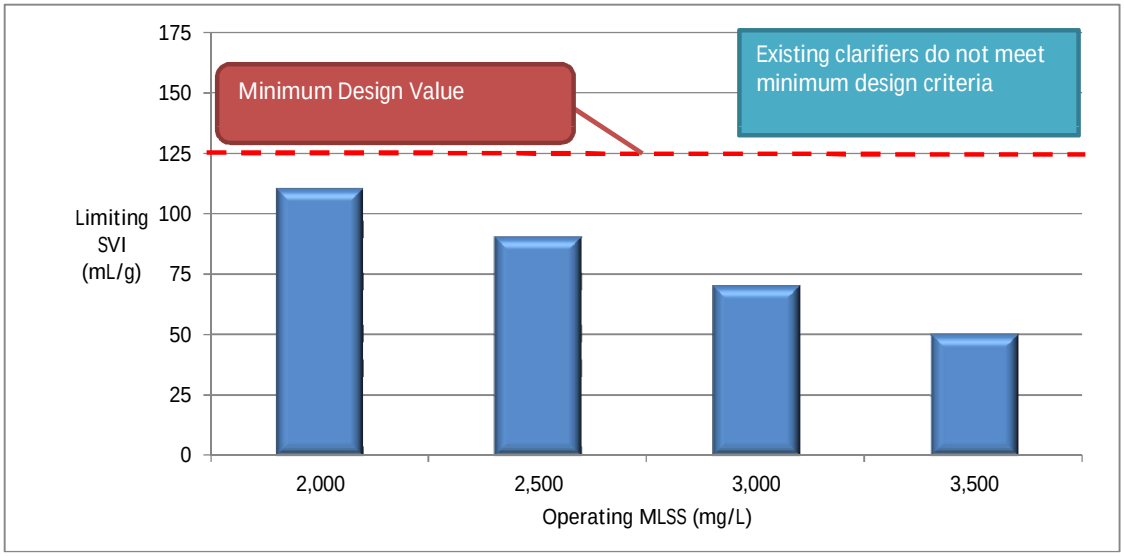
Clarifier evaluation completed using state point analysis

MLSS Range:	2,000 to 3,500 mg/L
SVI Range:	50 to 210 mL/g

RAS: 150%

Limiting SVI indicates the SVI value where the evaluated MLSS concentration would result in clarifier failure

MLSS	Limiting SVI
2,000	110
2,500	90
3,000	70
3,500	50



Secondary Clarifier State-Point Analysis Using Daigger (1995) and Ozinsky and Ekama (1995)

Descrpition Existing clarifier analysis - MLSS = 2,000 mg/L

Project Name Whitewater Facilities Plan

Project Number 12600

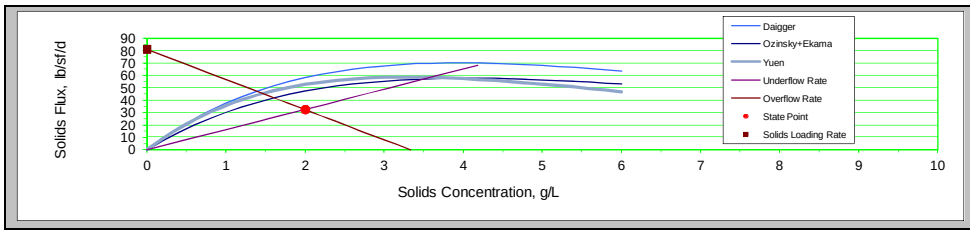
Input Parameters

	A	B	C	D	E	F	G	H	I	
Step 1 - Define The Clarifiers										
Geometries										
Shape	Circ	Circ	Circ	Circ	Circ	Circ	Circ	Circ	Circ	
Diameter	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	ft
Length	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	ft
Width	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	ft
Sidewater Depth	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	ft
Unit Surface Area	3848	3848	3848	3848	3848	3848	3848	3848	3848	sf
Number	2	2	2	2	2	2	2	2	2	
Surface Areas	7,697	7,697	7,697	7,697	7,697	7,697	7,697	7,697	7,697	sf
Step 2 - Define Forward Flow Rates	15	15	15	15	15	15	15	15	15	
Forward Flow to All Clarifiers	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	mgd
Step 3 - Define RAS Flow Rates										
% of Forward Flow (Setting)	150%	150%	150%	150%	150%	150%	150%	150%	150%	
RAS Flow to All Clarifiers	22.500	22.500	22.500	22.500	22.500	22.500	22.500	22.500	22.500	mgd
RAS Flow per Clarifier	11.250	11.250	11.250	11.250	11.250	11.250	11.250	11.250	11.250	
Step 4 - Define MLSS Concentration										
Mixed Liquor Concentration (X)	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	g/L or Kg/m^3
Step 5 - Define Maximum Solids Concentration (horizontal axis)										
Mixed Liquor Multiplier	3	3	3	3	3	3	3	3	3	
Step 6 - Settling Characteristics										
SVI Value	50	70	90	110	130	150	170	190	210	mL/g
Daigger SVI Vesilind Correlation ($V_s = V_o e^{-KX}$)										
Vo	9.793	9.054	8.502	8.062	7.695	7.381	7.106	6.862	6.642	m/h
K_{Yuen}	0.304	0.334	0.364	0.394	0.424	0.454	0.484	0.514	0.544	m^3/kg
$K_{Diagger}$	0.253	0.295	0.337	0.379	0.421	0.463	0.505	0.547	0.589	m^3/kg
Ozinsky and Ekama SVI Vesilind Correlation ($V_s = V_o e^{-KX}$)										
Vo	7.855	7.600	7.354	7.115	6.884	6.661	6.444	6.235	6.033	m/h
K	0.246	0.264	0.282	0.300	0.319	0.337	0.355	0.373	0.391	m^3/kg

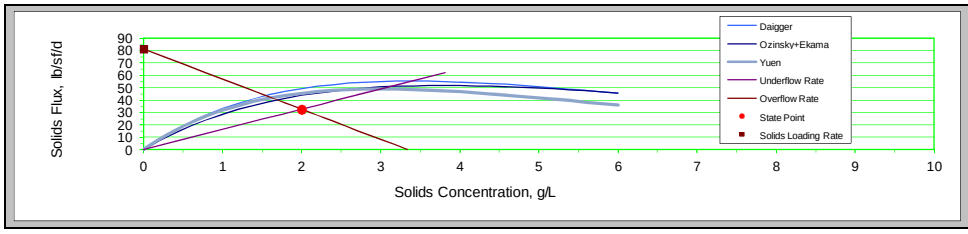
Comments:

Disclaimer:

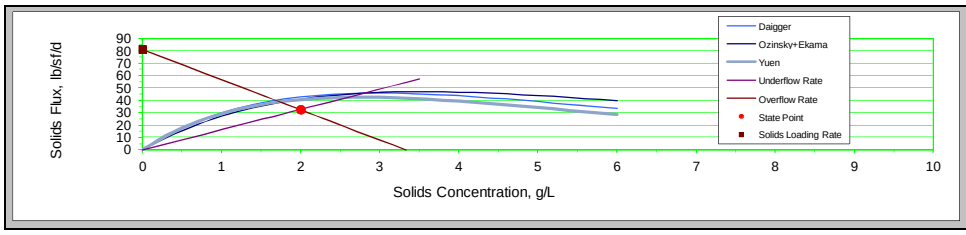
Daigger has been shown to be more accurate for poor settling solids. Ozinsky and Ekama has been shown to be more accurate for good settling solids. The flux curves below are based on correlations of data collected by the respective authors. MLSS concentrations and SVI test conditions (e.g., column height) may influence the true Vo and K values. The charts below are intended to provide guidance and insight regarding clarifier performance. However, for the reasons stated, they may not be accurate of actual clarifier performance. See Bye and Dold (1999) for more information regarding the limitations of this analysis.



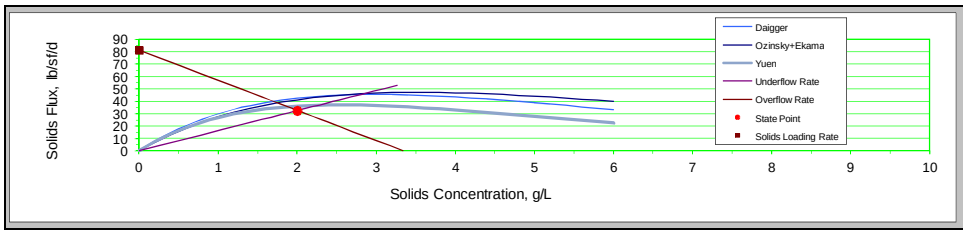
Clarifier	A	
Qrww	7.500	mgd
Qras	11.250	mgd
RAS %	150%	
MLSS	2,000	mg/L
RAS	3,333	mg/L
SVI	50	mL/g
SOR	1949	gpd/sf
SLR	81	lb/sf/d
Coefficient of Safety Curve		
State Point Coefficient		



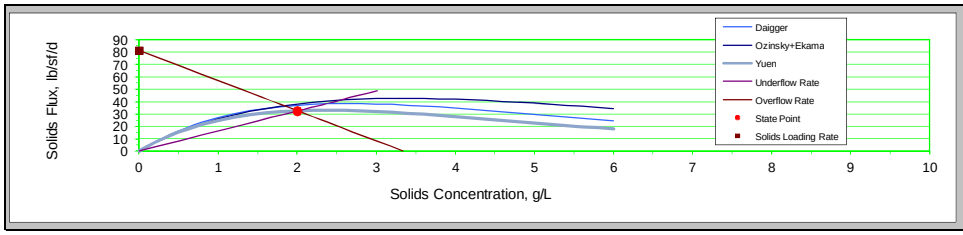
Clarifier	B	
Qrww	7.500	mgd
Qras	11.250	mgd
RAS %	150%	
MLSS	2,000	mg/L
RAS	3,333	mg/L
SVI	70	mL/g
SOR	1949	gpd/sf
SLR	81	lb/sf/d
Coefficient of Safety Curve		
State Point Coefficient		



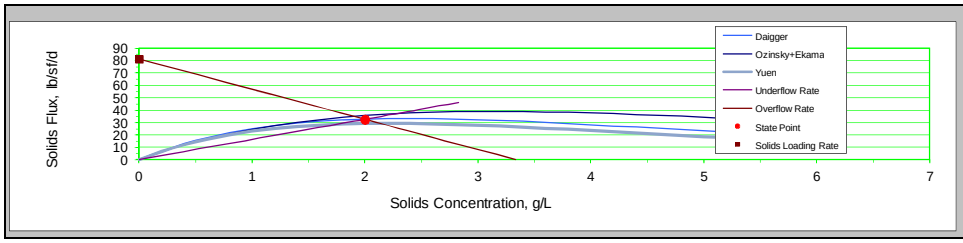
Clarifier	**C**	
Qrww	7.500	mgd
Qras	11.250	mgd
RAS %	150%	
MLSS	2,000	mg/L
RAS	3,333	mg/L
SVI	90	mL/g
SOR	1949	gpd/sf
SLR	81	lb/sf/d
Coefficient of Safety Curve		
State Point Coefficient		



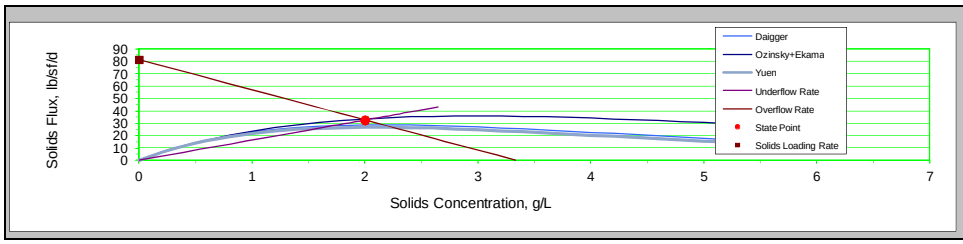
Clarifier	**D**	
Qrww	7.500	mgd
Qras	11.250	mgd
RAS %	150%	
MLSS	2,000	mg/L
RAS	3,333	mg/L
SVI	110	mL/g
SOR	1949	gpd/sf
SLR	81	lb/sf/d
Coefficient of Safety Curve		
State Point Coefficient		



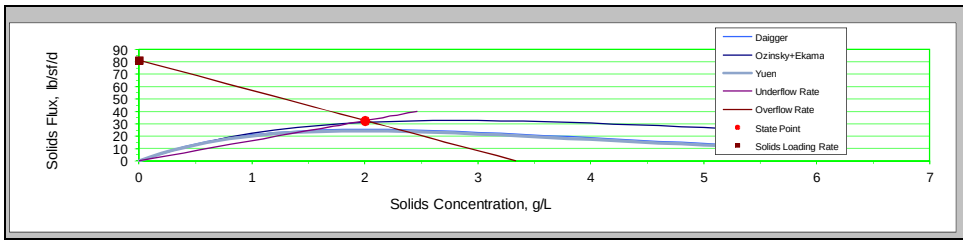
Clarifier	**E**	
Qrww	7.500	mgd
Qras	11.250	mgd
RAS %	150%	
MLSS	2,000	mg/L
RAS	3,333	mg/L
SVI	130	mL/g
SOR	1949	gpd/sf
SLR	81	lb/sf/d
Coefficient of Safety Curve		
State Point Coefficient		



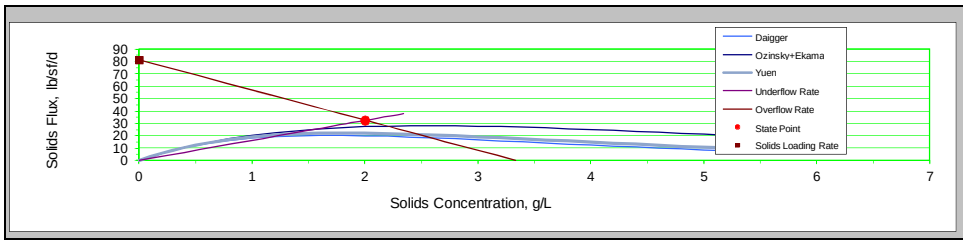
Clarifier	**F**	
Qrww	7.500	mgd
Qras	11.250	mgd
RAS %	150%	
MLSS	2,000	mg/L
RAS	3,333	mg/L
SVI	150	mL/g
SOR	1949	gpd/sf
SLR	81	lb/sf/d
Coefficient of Safety Curve		
State Point Coefficient		



Clarifier	**G**	
Qrww	7.500	mgd
Qras	11.250	mgd
RAS %	150%	
MLSS	2,000	mg/L
RAS	3,333	mg/L
SVI	170	mL/g
SOR	1949	gpd/sf
SLR	81	lb/sf/d
Coefficient of Safety Curve		
State Point Coefficient		



Clarifier	**H**	
Qrww	7.500	mgd
Qras	11.250	mgd
RAS %	150%	
MLSS	2,000	mg/L
RAS	3,333	mg/L
SVI	190	mL/g
SOR	1949	gpd/sf
SLR	81	lb/sf/d
Coefficient of Safety Curve		
State Point Coefficient		



Clarifier	**I**	
Qrww	7.500	mgd
Qras	11.250	mgd
RAS %	150%	
MLSS	2,000	mg/L
RAS	3,333	mg/L
SVI	210	mL/g
SOR	1949	gpd/sf
SLR	81	lb/sf/d
Coefficient of Safety Curve		
State Point Coefficient		

Secondary Clarifier State-Point Analysis Using Daigger (1995) and Ozinsky and Ekama (1995)

Descrpition Existing clarifier analysis - MLSS = 2,500 mg/L

Project Name Whitewater Facilities Plan

Project Number 12600

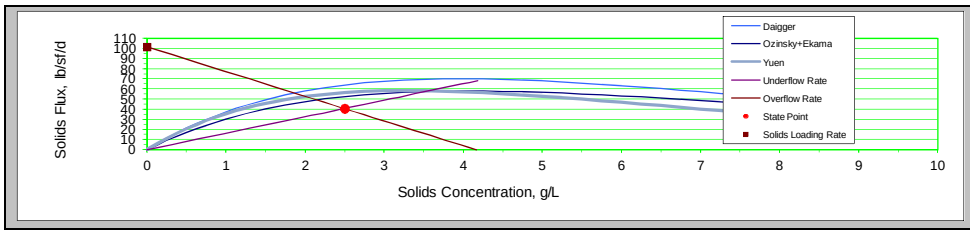
Input Parameters

	A	B	C	D	E	F	G	H	I	
Step 1 - Define The Clarifiers										
Geometries										
Shape	Circ	Circ	Circ	Circ	Circ	Circ	Circ	Circ	Circ	
Diameter	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	ft
Length	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	ft
Width	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	ft
Sidewater Depth	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	ft
Unit Surface Area	3848	3848	3848	3848	3848	3848	3848	3848	3848	sf
Number	2	2	2	2	2	2	2	2	2	
Surface Areas	7,697	7,697	7,697	7,697	7,697	7,697	7,697	7,697	7,697	sf
Step 2 - Define Forward Flow Rates	15	15	15	15	15	15	15	15	15	
Forward Flow to All Clarifiers	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	mgd
Step 3 - Define RAS Flow Rates										
% of Forward Flow (Setting)	150%	150%	150%	150%	150%	150%	150%	150%	150%	
RAS Flow to All Clarifiers	22.500	22.500	22.500	22.500	22.500	22.500	22.500	22.500	22.500	mgd
RAS Flow per Clarifier	11.250	11.250	11.250	11.250	11.250	11.250	11.250	11.250	11.250	
Step 4 - Define MLSS Concentration										
Mixed Liquor Concentration (X)	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500	g/L or Kg/m^3
Step 5 - Define Maximum Solids Concentration (horizontal axis)										
Mixed Liquor Multiplier	3	3	3	3	3	3	3	3	3	
Step 6 - Settling Characteristics										
SVI Value	50	70	90	110	130	150	170	190	210	mL/g
Daigger SVI Vesilind Correlation ($V_s = V_o e^{-KX}$)										
Vo	9.793	9.054	8.502	8.062	7.695	7.381	7.106	6.862	6.642	m/h
K_{Yuen}	0.304	0.334	0.364	0.394	0.424	0.454	0.484	0.514	0.544	m^3/kg
$K_{Diagger}$	0.253	0.295	0.337	0.379	0.421	0.463	0.505	0.547	0.589	m^3/kg
Ozinsky and Ekama SVI Vesilind Correlation ($V_s = V_o e^{-KX}$)										
Vo	7.855	7.600	7.354	7.115	6.884	6.661	6.444	6.235	6.033	m/h
K	0.246	0.264	0.282	0.300	0.319	0.337	0.355	0.373	0.391	m^3/kg

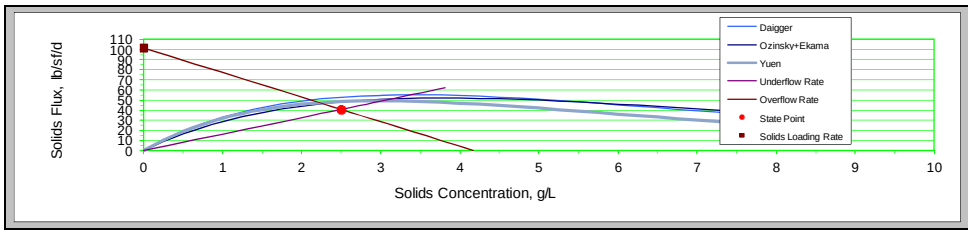
Comments:

Disclaimer:

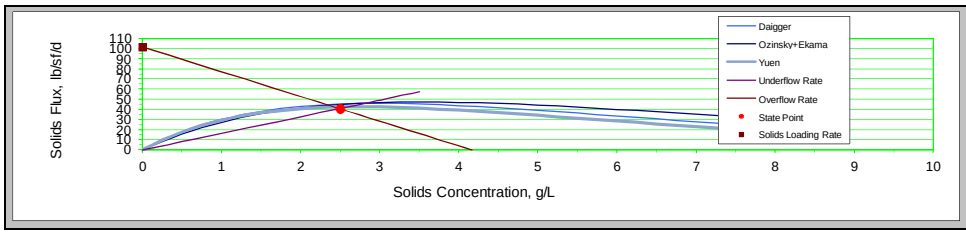
Daigger has been shown to be more accurate for poor settling solids. Ozinsky and Ekama has been shown to be more accurate for good settling solids. The flux curves below are based on correlations of data collected by the respective authors. MLSS concentrations and SVI test conditions (e.g., column height) may influence the true Vo and K values. The charts below are intended to provide guidance and insight regarding clarifier performance. However, for the reasons stated, they may not be accurate of actual clarifier performance. See Bye and Dold (1999) for more information regarding the limitations of this analysis.



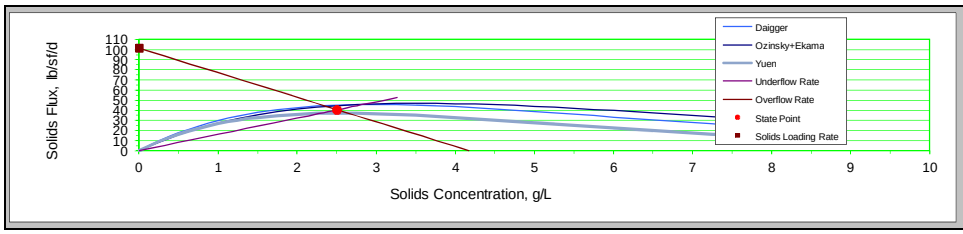
Clarifier	A	
Qrww	7.500	mgd
Qras	11.250	mgd
RAS %	150%	
MLSS	2,500	mg/L
RAS	4,167	mg/L
SVI	50	mL/g
SOR	1949	gpd/sf
SLR	102	lb/sf/d
Coefficient of Safety		
Curve		52.2
State Point		15.7
Coefficient		36.5



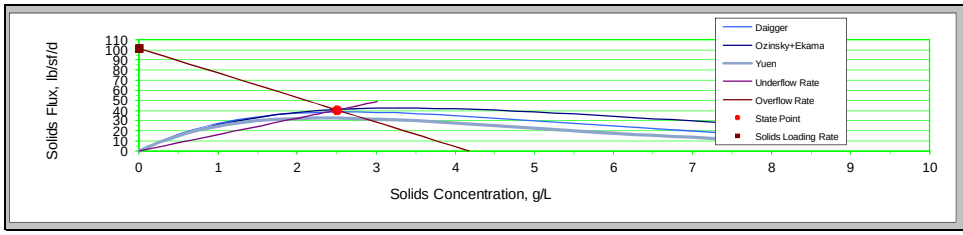
Clarifier	B	
Qrww	7.500	mgd
Qras	11.250	mgd
RAS %	150%	
MLSS	2,500	mg/L
RAS	4,167	mg/L
SVI	70	mL/g
SOR	1949	gpd/sf
SLR	102	lb/sf/d
Coefficient of Safety		
Curve		47.2
State Point		15.7
Coefficient		31.5



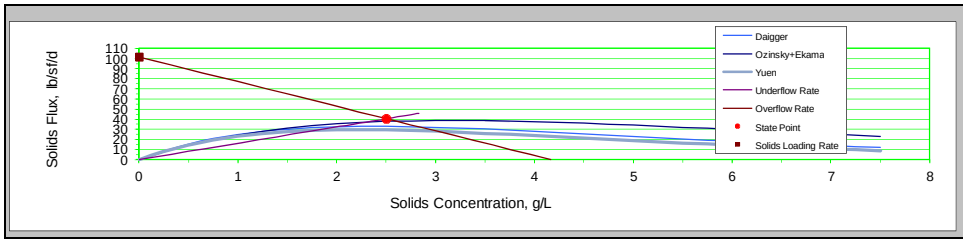
Clarifier	C	
Qrww	7.500	mgd
Qras	11.250	mgd
RAS %	150%	
MLSS	2,500	mg/L
RAS	4,167	mg/L
SVI	90	mL/g
SOR	1949	gpd/sf
SLR	102	lb/sf/d
Coefficient of Safety		
Curve		42.1
State Point		15.7
Coefficient		26.4



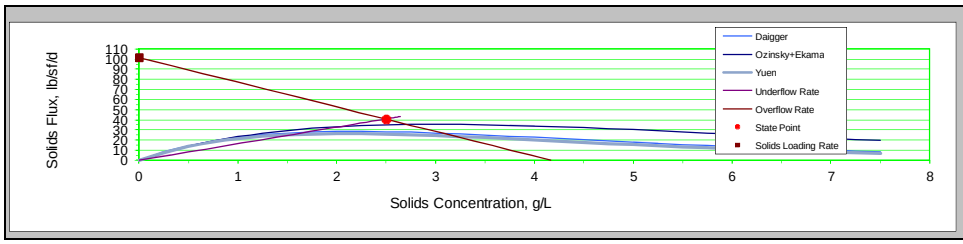
Clarifier	D	
Qrww	7.500	mgd
Qras	11.250	mgd
RAS %	150%	
MLSS	2,500	mg/L
RAS	4,167	mg/L
SVI	110	mL/g
SOR	1949	gpd/sf
SLR	102	lb/sf/d
Coefficient of Safety		
Curve		37
State Point		15.7
Coefficient		21.3



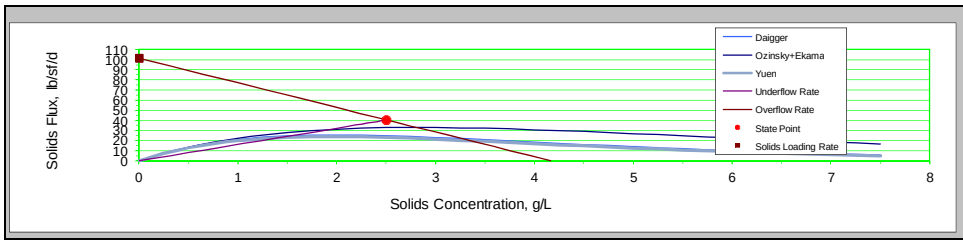
Clarifier	E	
Qrww	7.500	mgd
Qras	11.250	mgd
RAS %	150%	
MLSS	2,500	mg/L
RAS	4,167	mg/L
SVI	130	mL/g
SOR	1949	gpd/sf
SLR	102	lb/sf/d
Coefficient of Safety		
Curve		32.8
State Point		15.7
Coefficient		17.1



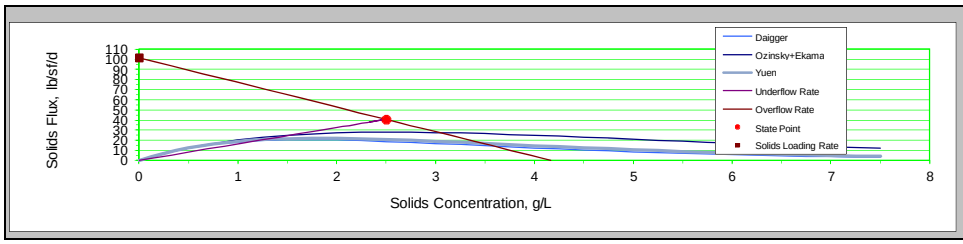
Clarifier	F	
Qrww	7.500	mgd
Qras	11.250	mgd
RAS %	150%	
MLSS	2,500	mg/L
RAS	4,167	mg/L
SVI	150	mL/g
SOR	1949	gpd/sf
SLR	102	lb/sf/d
Coefficient of Safety		
Curve		29.2
State Point		15.7
Coefficient		13.5



Clarifier	G	
Qrww	7.500	mgd
Qras	11.250	mgd
RAS %	150%	
MLSS	2,500	mg/L
RAS	4,167	mg/L
SVI	170	mL/g
SOR	1949	gpd/sf
SLR	102	lb/sf/d
Coefficient of Safety		
Curve		26
State Point		15.7
Coefficient		10.3



Clarifier	H	
Qrww	7.500	mgd
Qras	11.250	mgd
RAS %	150%	
MLSS	2,500	mg/L
RAS	4,167	mg/L
SVI	190	mL/g
SOR	1949	gpd/sf
SLR	102	lb/sf/d
Coefficient of Safety		
Curve		23.9
State Point		15.7
Coefficient		8.2



Clarifier	I	
Qrww	7.500	mgd
Qras	11.250	mgd
RAS %	150%	
MLSS	2,500	mg/L
RAS	4,167	mg/L
SVI	210	mL/g
SOR	1949	gpd/sf
SLR	102	lb/sf/d
Coefficient of Safety		
Curve		17.4
State Point		15.7
Coefficient		1.7

Secondary Clarifier State-Point Analysis Using Daigger (1995) and Ozinsky and Ekama (1995)

Descrpition Existing clarifier analysis - MLSS = 3,000 mg/L

Project Name Whitewater Facilities Plan

Project Number 12600

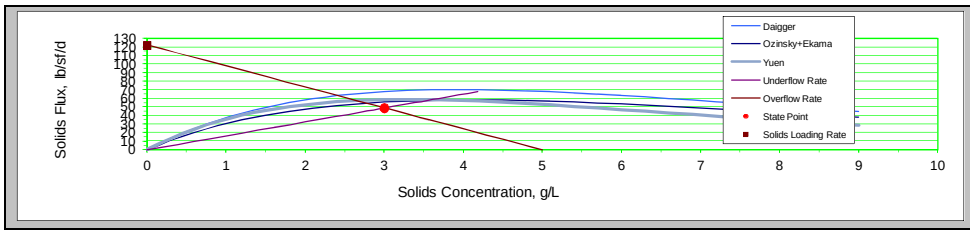
Input Parameters

	A	B	C	D	E	F	G	H	I	
Step 1 - Define The Clarifiers										
Geometries										
Shape	Circ	Circ	Circ	Circ	Circ	Circ	Circ	Circ	Circ	
Diameter	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	ft
Length	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	ft
Width	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	ft
Sidewater Depth	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	ft
Unit Surface Area	3848	3848	3848	3848	3848	3848	3848	3848	3848	sf
Number	2	2	2	2	2	2	2	2	2	
Surface Areas	7,697	7,697	7,697	7,697	7,697	7,697	7,697	7,697	7,697	sf
Step 2 - Define Forward Flow Rates	15	15	15	15	15	15	15	15	15	
Forward Flow to All Clarifiers	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	mgd
Step 3 - Define RAS Flow Rates										
% of Forward Flow (Setting)	150%	150%	150%	150%	150%	150%	150%	150%	150%	
RAS Flow to All Clarifiers	22.500	22.500	22.500	22.500	22.500	22.500	22.500	22.500	22.500	mgd
RAS Flow per Clarifier	11.250	11.250	11.250	11.250	11.250	11.250	11.250	11.250	11.250	
Step 4 - Define MLSS Concentration										
Mixed Liquor Concentration (X)	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	g/L or Kg/m^3
Step 5 - Define Maximum Solids Concentration (horizontal axis)										
Mixed Liquor Multiplier	3	3	3	3	3	3	3	3	3	
Step 6 - Settling Characteristics										
SVI Value	50	70	90	110	130	150	170	190	210	mL/g
Daigger SVI Vesilind Correlation ($V_s = V_o e^{-KX}$)										
Vo	9.793	9.054	8.502	8.062	7.695	7.381	7.106	6.862	6.642	m/h
K_{Yuen}	0.304	0.334	0.364	0.394	0.424	0.454	0.484	0.514	0.544	m^3/kg
$K_{Diagger}$	0.253	0.295	0.337	0.379	0.421	0.463	0.505	0.547	0.589	m^3/kg
Ozinsky and Ekama SVI Vesilind Correlation ($V_s = V_o e^{-KX}$)										
Vo	7.855	7.600	7.354	7.115	6.884	6.661	6.444	6.235	6.033	m/h
K	0.246	0.264	0.282	0.300	0.319	0.337	0.355	0.373	0.391	m^3/kg

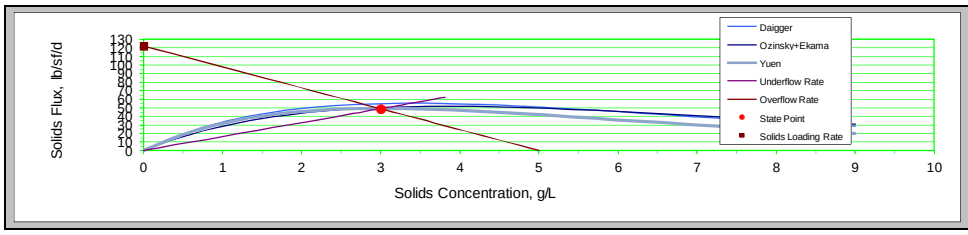
Comments:

Disclaimer:

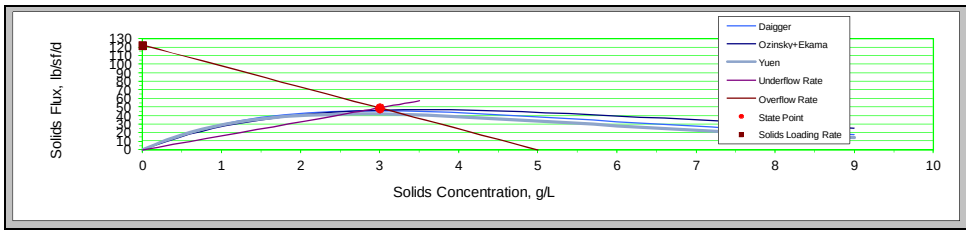
Daigger has been shown to be more accurate for poor settling solids. Ozinsky and Ekama has been shown to be more accurate for good settling solids. The flux curves below are based on correlations of data collected by the respective authors. MLSS concentrations and SVI test conditions (e.g., column height) may influence the true Vo and K values. The charts below are intended to provide guidance and insight regarding clarifier performance. However, for the reasons stated, they may not be accurate of actual clarifier performance. See Bye and Dold (1999) for more information regarding the limitations of this analysis.



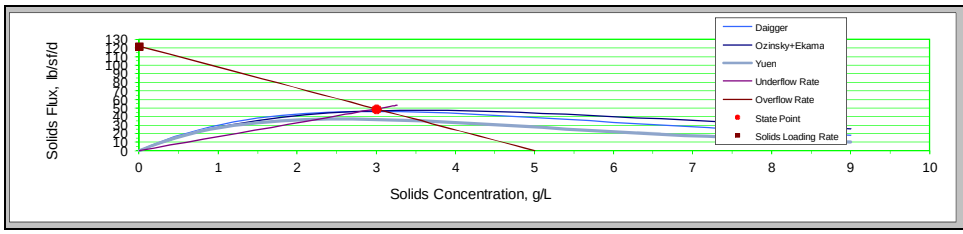
Clarifier	A	
Qrww	7.500	mgd
Qras	11.250	mgd
RAS %	150%	
MLSS	3,000	mg/L
RAS	5,000	mg/L
SVI	50	mL/g
SOR	1949	gpd/sf
SLR	122	lb/sf/d
Coefficient of Safety		
Curve		52.2
State Point		15.7
Coefficient		36.5



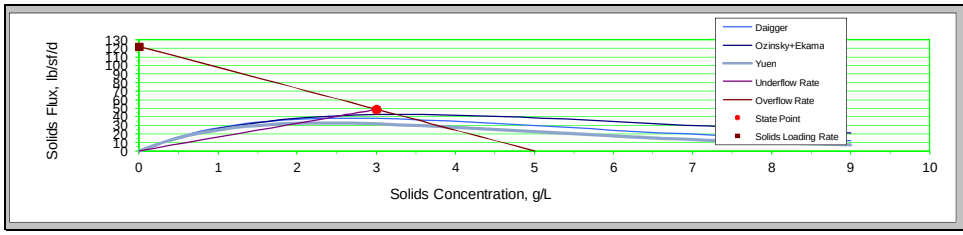
Clarifier	B	
Qrww	7.500	mgd
Qras	11.250	mgd
RAS %	150%	
MLSS	3,000	mg/L
RAS	5,000	mg/L
SVI	70	mL/g
SOR	1949	gpd/sf
SLR	122	lb/sf/d
Coefficient of Safety		
Curve		47.2
State Point		15.7
Coefficient		31.5



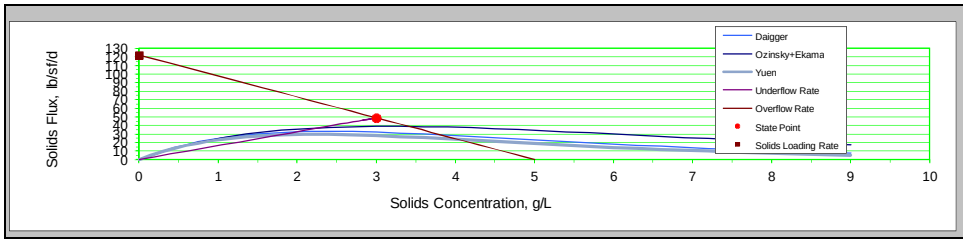
Clarifier	**C**	
Qrww	7.500	mgd
Qras	11.250	mgd
RAS %	150%	
MLSS	3,000	mg/L
RAS	5,000	mg/L
SVI	90	mL/g
SOR	1949	gpd/sf
SLR	122	lb/sf/d
Coefficient of Safety		
Curve		42.1
State Point		15.7
Coefficient		26.4



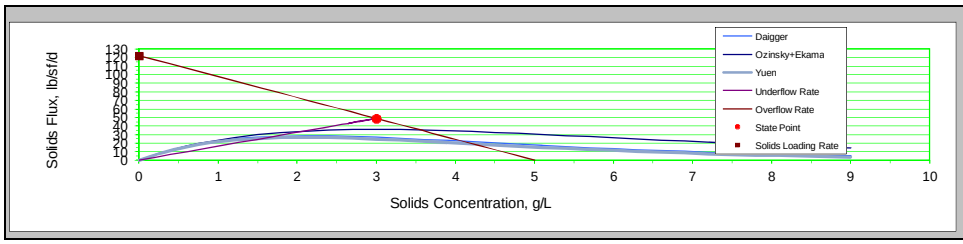
Clarifier	**D**	
Qrww	7.500	mgd
Qras	11.250	mgd
RAS %	150%	
MLSS	3,000	mg/L
RAS	5,000	mg/L
SVI	110	mL/g
SOR	1949	gpd/sf
SLR	122	lb/sf/d
Coefficient of Safety		
Curve		37
State Point		15.7
Coefficient		21.3



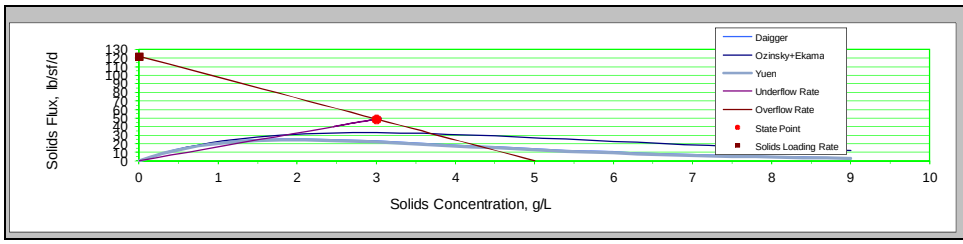
Clarifier	**E**	
Qrww	7.500	mgd
Qras	11.250	mgd
RAS %	150%	
MLSS	3,000	mg/L
RAS	5,000	mg/L
SVI	130	mL/g
SOR	1949	gpd/sf
SLR	122	lb/sf/d
Coefficient of Safety		
Curve		32.8
State Point		15.7
Coefficient		17.1



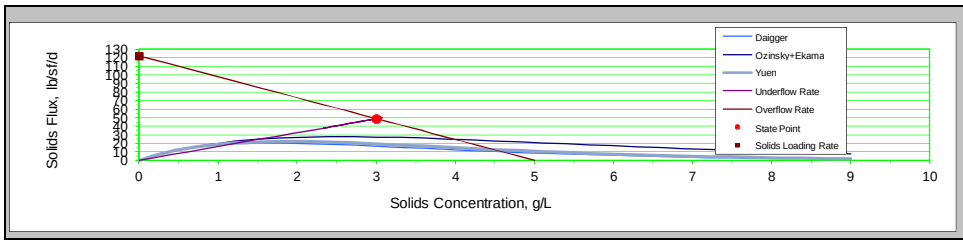
Clarifier	**F**	
Qrww	7.500	mgd
Qras	11.250	mgd
RAS %	150%	
MLSS	3,000	mg/L
RAS	5,000	mg/L
SVI	150	mL/g
SOR	1949	gpd/sf
SLR	122	lb/sf/d
Coefficient of Safety		
Curve		29.2
State Point		15.7
Coefficient		13.5



Clarifier	**G**	
Qrww	7.500	mgd
Qras	11.250	mgd
RAS %	150%	
MLSS	3,000	mg/L
RAS	5,000	mg/L
SVI	170	mL/g
SOR	1949	gpd/sf
SLR	122	lb/sf/d
Coefficient of Safety		
Curve		26
State Point		15.7
Coefficient		10.3



Clarifier	**H**	
Qrww	7.500	mgd
Qras	11.250	mgd
RAS %	150%	
MLSS	3,000	mg/L
RAS	5,000	mg/L
SVI	190	mL/g
SOR	1949	gpd/sf
SLR	122	lb/sf/d
Coefficient of Safety		
Curve		23.9
State Point		15.7
Coefficient		8.2



Clarifier	**I**	
Qrww	7.500	mgd
Qras	11.250	mgd
RAS %	150%	
MLSS	3,000	mg/L
RAS	5,000	mg/L
SVI	210	mL/g
SOR	1949	gpd/sf
SLR	122	lb/sf/d
Coefficient of Safety		
Curve		17.4
State Point		15.7
Coefficient		1.7

Secondary Clarifier State-Point Analysis Using Daigger (1995) and Ozinsky and Ekama (1995)

Descrpition Existing clarifier analysis - MLSS = 3,500 mg/L

Project Name Whitewater Facilities Plan

Project Number 12600

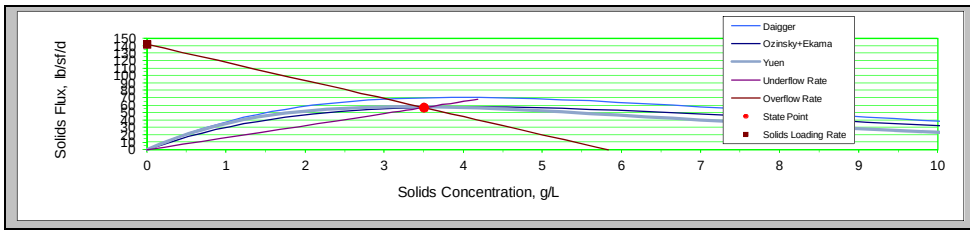
Input Parameters

	A	B	C	D	E	F	G	H	I	
Step 1 - Define The Clarifiers										
Geometries										
Shape	Circ	Circ	Circ	Circ	Circ	Circ	Circ	Circ	Circ	
Diameter	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	ft
Length	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	ft
Width	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	ft
Sidewater Depth	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	ft
Unit Surface Area	3848	3848	3848	3848	3848	3848	3848	3848	3848	sf
Number	2	2	2	2	2	2	2	2	2	
Surface Areas	7,697	7,697	7,697	7,697	7,697	7,697	7,697	7,697	7,697	sf
Step 2 - Define Forward Flow Rates	15	15	15	15	15	15	15	15	15	
Forward Flow to All Clarifiers	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	mgd
Step 3 - Define RAS Flow Rates										
% of Forward Flow (Setting)	150%	150%	150%	150%	150%	150%	150%	150%	150%	
RAS Flow to All Clarifiers	22.500	22.500	22.500	22.500	22.500	22.500	22.500	22.500	22.500	mgd
RAS Flow per Clarifier	11.250	11.250	11.250	11.250	11.250	11.250	11.250	11.250	11.250	
Step 4 - Define MLSS Concentration										
Mixed Liquor Concentration (X)	3.500	3.500	3.500	3.500	3.500	3.500	3.500	3.500	3.500	g/L or Kg/m^3
Step 5 - Define Maximum Solids Concentration (horizontal axis)										
Mixed Liquor Multiplier	3	3	3	3	3	3	3	3	3	
Step 6 - Settling Characteristics										
SVI Value	50	70	90	110	130	150	170	190	210	mL/g
Daigger SVI Vesilind Correlation ($V_s = V_o e^{-KX}$)										
Vo	9.793	9.054	8.502	8.062	7.695	7.381	7.106	6.862	6.642	m/h
K_{Yuen}	0.304	0.334	0.364	0.394	0.424	0.454	0.484	0.514	0.544	m^3/kg
$K_{Diagger}$	0.253	0.295	0.337	0.379	0.421	0.463	0.505	0.547	0.589	m^3/kg
Ozinsky and Ekama SVI Vesilind Correlation ($V_s = V_o e^{-KX}$)										
Vo	7.855	7.600	7.354	7.115	6.884	6.661	6.444	6.235	6.033	m/h
K	0.246	0.264	0.282	0.300	0.319	0.337	0.355	0.373	0.391	m^3/kg

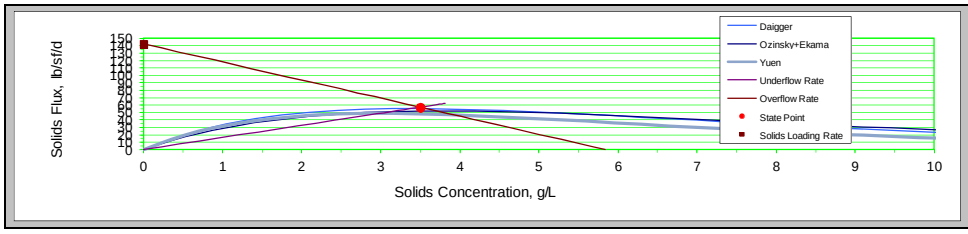
Comments:

Disclaimer:

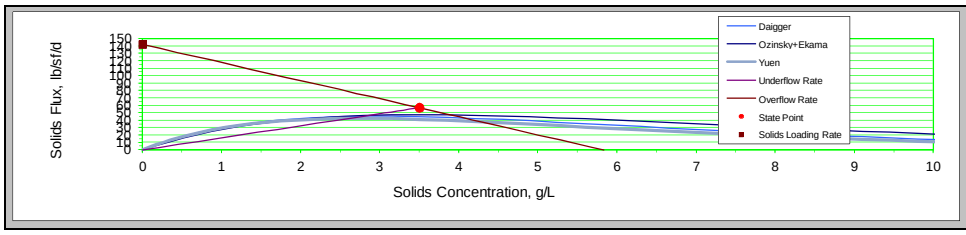
Daigger has been shown to be more accurate for poor settling solids. Ozinsky and Ekama has been shown to be more accurate for good settling solids. The flux curves below are based on correlations of data collected by the respective authors. MLSS concentrations and SVI test conditions (e.g., column height) may influence the true Vo and K values. The charts below are intended to provide guidance and insight regarding clarifier performance. However, for the reasons stated, they may not be accurate of actual clarifier performance. See Bye and Dold (1999) for more information regarding the limitations of this analysis.



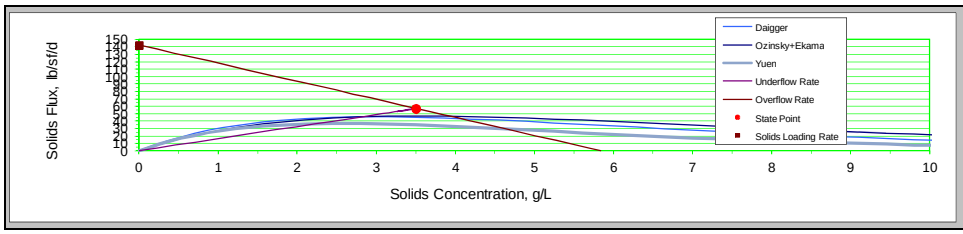
Clarifier	A	
Qrww	7.500	mgd
Qras	11.250	mgd
RAS %	150%	
MLSS	3,500	mg/L
RAS	5,833	mg/L
SVI	50	mL/g
SOR	1949	gpd/sf
SLR	142	lb/sf/d
Coefficient of Safety		
Curve		52.2
State Point		15.7
Coefficient		36.5



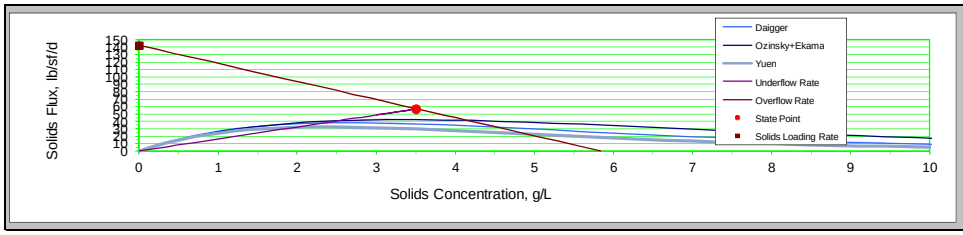
Clarifier	B	
Qrww	7.500	mgd
Qras	11.250	mgd
RAS %	150%	
MLSS	3,500	mg/L
RAS	5,833	mg/L
SVI	70	mL/g
SOR	1949	gpd/sf
SLR	142	lb/sf/d
Coefficient of Safety		
Curve		47.2
State Point		15.7
Coefficient		31.5



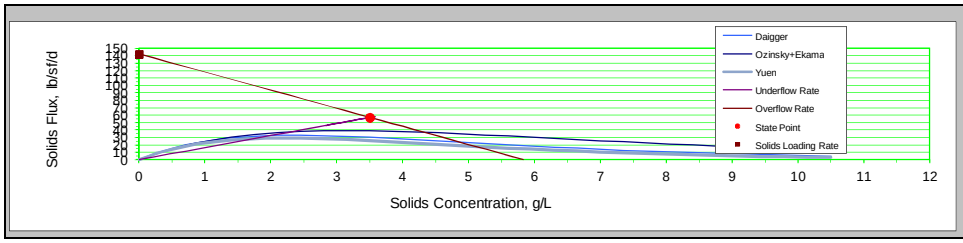
Clarifier	C	
Qrww	7.500	mgd
Qras	11.250	mgd
RAS %	150%	
MLSS	3,500	mg/L
RAS	5,833	mg/L
SVI	90	mL/g
SOR	1949	gpd/sf
SLR	142	lb/sf/d
Coefficient of Safety		
Curve		42.1
State Point		15.7
Coefficient		26.4



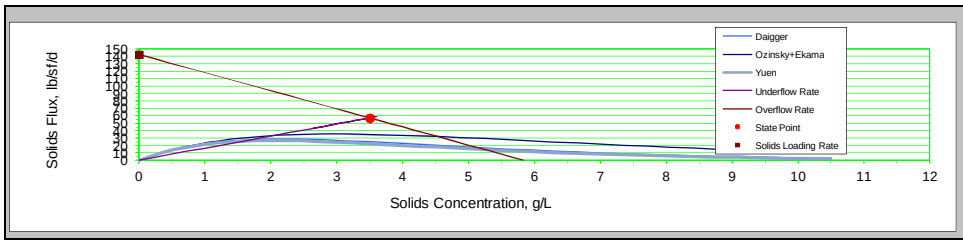
Clarifier	D	
Qrww	7.500	mgd
Qras	11.250	mgd
RAS %	150%	
MLSS	3,500	mg/L
RAS	5,833	mg/L
SVI	110	mL/g
SOR	1949	gpd/sf
SLR	142	lb/sf/d
Coefficient of Safety		
Curve		37
State Point		15.7
Coefficient		21.3



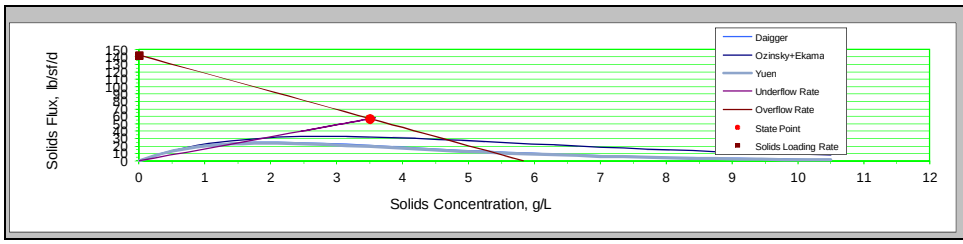
Clarifier	E	
Qrww	7.500	mgd
Qras	11.250	mgd
RAS %	150%	
MLSS	3,500	mg/L
RAS	5,833	mg/L
SVI	130	mL/g
SOR	1949	gpd/sf
SLR	142	lb/sf/d
Coefficient of Safety		
Curve		32.8
State Point		15.7
Coefficient		17.1



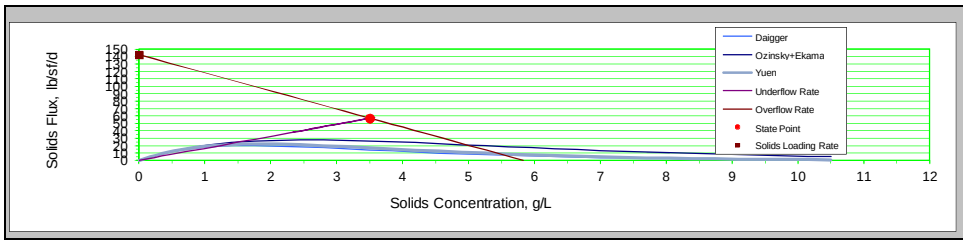
Clarifier	F	
Qrww	7.500	mgd
Qras	11.250	mgd
RAS %	150%	
MLSS	3,500	mg/L
RAS	5,833	mg/L
SVI	150	mL/g
SOR	1949	gpd/sf
SLR	142	lb/sf/d
Coefficient of Safety		
Curve		29.2
State Point		15.7
Coefficient		13.5



Clarifier	G	
Qrww	7.500	mgd
Qras	11.250	mgd
RAS %	150%	
MLSS	3,500	mg/L
RAS	5,833	mg/L
SVI	170	mL/g
SOR	1949	gpd/sf
SLR	142	lb/sf/d
Coefficient of Safety		
Curve		26
State Point		15.7
Coefficient		10.3



Clarifier	H	
Qrww	7.500	mgd
Qras	11.250	mgd
RAS %	150%	
MLSS	3,500	mg/L
RAS	5,833	mg/L
SVI	190	mL/g
SOR	1949	gpd/sf
SLR	142	lb/sf/d
Coefficient of Safety		
Curve		23.9
State Point		15.7
Coefficient		8.2



Clarifier	I	
Qrww	7.500	mgd
Qras	11.250	mgd
RAS %	150%	
MLSS	3,500	mg/L
RAS	5,833	mg/L
SVI	210	mL/g
SOR	1949	gpd/sf
SLR	142	lb/sf/d
Coefficient of Safety		
Curve		17.4
State Point		15.7
Coefficient		1.7

Appendix TM6-D

Special Sampling

Special Sampling (Donohue Request)

January 2014

Date	Influent COD mg/L	Influent COD, Filtered mg/L	Influent COD, Flocculated-Filtered mg/L	Influent BOD mg/L	Influent Filtered BOD mg/L	Influent TSS mg/L	Influent VSS mg/L	Influent TKN mg/L	Influent Ammonia mg/L	Influent Total Phosphorous mg/L	Influent Soluble Phosphorous mg/L	Influent Total Alkalinity mg/L	Influent pH su
01/01/2014				156		208			27.4				7.7
01/02/2014				196		184			29.2	5.5			7.6
01/03/2014													
01/04/2014													
01/05/2014				229		172			25.8				8.0
01/06/2014				161		180			20.4	5.2			7.8
01/07/2014				292		104			19.5				7.7
01/08/2014				208		212			24.8				7.7
01/09/2014				175		352			22.3	5.5			7.9
01/10/2014													
01/11/2014													
01/12/2014				191		476			21.2				7.9
01/13/2014													
01/14/2014													
01/15/2014				84		240			26.4	6.6			7.8
01/16/2014				251	102	660			25.6	6.2	3.0		7.7
01/17/2014													
01/18/2014													
01/19/2014				253		324			24.1				7.9
01/20/2014													
01/21/2014				223		204	200		25.3	6.1			7.9
01/22/2014	480	150	87	260	84	272	252	53.00	34.5	6.6	3.6	470	8.0
01/23/2014	400	120	61	200	72	304	300	44.00	28.5	6.6	3.0	440	7.9
01/24/2014									29.3				7.6
01/25/2014									21.6				7.7
01/26/2014	500	190	110	267	109	216	192	45.00	26.9	5.6	3.2	480	7.9
01/27/2014													7.9
01/28/2014													
01/29/2014													
01/30/2014													
01/31/2014													
Minimum	400	120	61	84	72	104	192	44.00	19.5	5.2	3.0	440	7.6
Maximum	500	190	110	292	109	660	300	53.00	34.5	6.6	3.6	480	8.0
Total	1,380	460	258	3,146	367	4,108	944	142.00	432.8	53.9	12.8	1,390	140.6
Average	460	153	86	210	92	274	236	47.33	25.5	6.0	3.2	463	7.8

Special Sampling (Donohue Request)

January 2014

Date	Primary Effluent COD, Filtered mg/L	Primary Effl. COD, Flocculated-Filtered mg/L	Primary Effluent BOD mg/L	Primary Effluent Filtered BOD mg/L	Primary Effluent TSS mg/L	Primary Effluent VSS mg/L	Primary Effluent TKN mg/L	Primary Effluent Phosphorous mg/L	Primary Effluent Soluable Phosphoro mg/L	Primary Effluent Total Alkalinity mg/L	Primary Effluent pH su	Effluent COD, Filtered mg/L	Effluent BOD mg/L
01/01/2014													<2
01/02/2014													<2
01/03/2014													
01/04/2014													
01/05/2014													3
01/06/2014													2
01/07/2014													<2
01/08/2014			118.0										<2
01/09/2014					56.0			3.73					<2
01/10/2014											8.0		
01/11/2014													
01/12/2014													<2
01/13/2014													
01/14/2014													
01/15/2014			57.0		40.0			3.96					3
01/16/2014			148.9	99.5	60.0			3.93	2.00		7.9		2
01/17/2014													
01/18/2014													
01/19/2014													3
01/20/2014													
01/21/2014			126.0		56.0	56.0		4.13			8.0		3
01/22/2014	140	77	125.7	81.5	44.0	44.0	48.00	4.23	2.15	480	8.0	15	3
01/23/2014	140	63	129.0	78.0	76.0	76.0	41.00	4.23	2.00	430	8.0	16	3
01/24/2014													
01/25/2014													
01/26/2014	200	100	157.0	102.0	60.0	104.0	43.00	3.84	1.86	440	8.0	15	2
01/27/2014													
01/28/2014													
01/29/2014													
01/30/2014													
01/31/2014													
Minimum	140	63	57.0	78.0	40.0	44.0	41.00	3.73	1.86	430	7.9	15	<2
Maximum	200	100	157.0	102.0	76.0	104.0	48.00	4.23	2.15	480	8.0	16	3
Total	480	240	861.6	361.0	392.0	280.0	132.00	28.05	8.01	1,350	47.9	46	<36
Average	160	80	123.1	90.3	56.0	70.0	44.00	4.01	2.00	450	8.0	15	<2

269.64762

Special Sampling (Donohue Request)

January 2014

Date	Effluent TSS mg/L	Effluent TKN mg/L	Effluent Total Phosphorous mg/L	Effluent Total Alkalinity mg/L	Effluent pH su
01/01/2014	1.8		0.4		7.5
01/02/2014	1.2		0.4		7.4
01/03/2014					7.2
01/04/2014					7.5
01/05/2014	3.0		0.8		7.6
01/06/2014	2.8		0.7		7.6
01/07/2014	1.5		0.6		7.4
01/08/2014	1.5		0.6		7.4
01/09/2014	1.8		0.6		7.4
01/10/2014					7.4
01/11/2014					7.7
01/12/2014	2.2		0.6		7.7
01/13/2014					7.7
01/14/2014					7.7
01/15/2014	2.7		0.7		7.5
01/16/2014	2.1		0.6		7.4
01/17/2014					7.4
01/18/2014					7.5
01/19/2014	4.1		0.8		7.4
01/20/2014					7.5
01/21/2014	4.2		0.8		7.5
01/22/2014	2.5	1.500	0.6	190.00	7.4
01/23/2014	3.5	2.100	0.7	190.00	7.5
01/24/2014					7.4
01/25/2014					7.4
01/26/2014	1.8	0.680	0.5	190.00	7.4
01/27/2014					7.7
01/28/2014					7.6
01/29/2014					7.5
01/30/2014					7.4
01/31/2014					7.6
Minimum	1.2	0.680	0.4	190.00	7.2
Maximum	4.2	2.100	0.8	190.00	7.7
Total	36.7	4.280	9.4	570.00	232.3
Average	2.4	1.427	0.6	190.00	7.5

Appendix TM6-E

Activated Sludge Model Report

BioWin user and configuration data – UCT Process

Project details

Project name: Whitewater Facilities Plan **Project ref.: 12600**

Plant name: Whitewater WWTP **User name: ldowning**

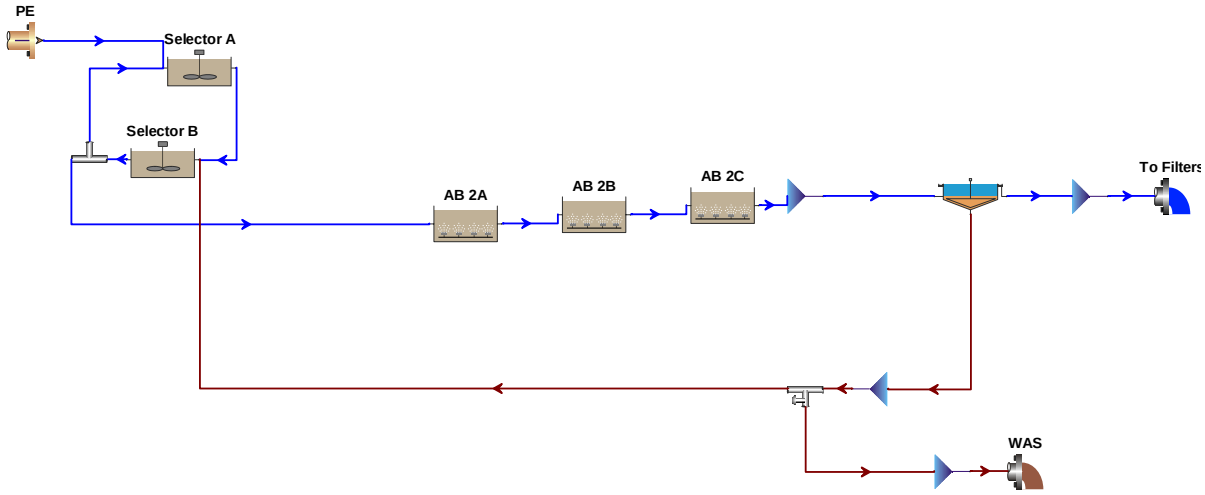
Created: 03/12/14 **Saved: 03/26/14**

Steady state solution

Target SRT: 12.00 days **SRT #0: 11.99 days**

Temperature: 10.0°C

Flowsheet



Configuration information for all Bioreactor units

Physical data

Element name	Volume [Mil. Gal]	Area [ft2]	Depth [ft]	# of diffusers
Selector A	0.0450	334.2014	18.000	Un-aerated
Selector B	0.0450	334.2014	18.000	Un-aerated
AB 2A	0.1000	742.6698	18.000	252
AB 2B	0.1000	742.6698	18.000	168
AB 2C	0.1000	742.6698	18.000	168

Operating data Average (flow/time weighted as required)

Element name	Average DO Setpoint [mg/L]
Selector A	0
Selector B	0
AB 2A	2.0
AB 2B	2.0
AB 2C	2.0

Aeration equipment parameters

Element name	k1 in C = k1(PC)^0.25 + k2	k2 in C = k1(PC)^0.25 + k2	Y in Kla = C Usg ^ Y - Usg in [m3/(m2 d)]	Area of one diffuser	% of tank area covered by diffusers [%]
Selector A	2.5656	0.0432	0.8200	0.4413	10.0000
Selector B	2.5656	0.0432	0.8200	0.4413	10.0000

AB 2A	2.5656	0.0432	0.8200	0.4413	15.0000
AB 2B	2.5656	0.0432	0.8200	0.4413	10.0000
AB 2C	2.5656	0.0432	0.8200	0.4413	10.0000

Element name	Alpha (surf) OR Alpha F (diff) [-]	Beta [-]	Surface pressure [kPa]	Fractional effective saturation depth (Fed) [-]
AB 2A	0.5000	0.9500	101.3250	0.3250
AB 2B	0.6000	0.9500	101.3250	0.3250
AB 2C	0.6000	0.9500	101.3250	0.3250

Configuration information for all BOD Influent units

Operating data Average (flow/time weighted as required)

Element name	PE
Flow	1.53000001056688
Total Carbonaceous BOD mgBOD/L	130.67
Volatile suspended solids mgVSS/L	65.82
Total suspended solids mgTSS/L	82.85
Total Kjeldahl Nitrogen mgN/L	36.00
Total P mgP/L	3.57
Nitrate N mgN/L	0
pH	7.30
Alkalinity mmol/L	6.00
Calcium mg/L	80.00
Magnesium mg/L	15.00
Dissolved oxygen mg/L	0

Element name	PE
Fbs - Readily biodegradable (including Acetate) [gCOD/g of total COD]	0.2660
Fac - Acetate [gCOD/g of readily biodegradable COD]	0.1830
Fxsp - Non-colloidal slowly biodegradable [gCOD/g of slowly degradable COD]	0.5724
Fus - Unbiodegradable soluble [gCOD/g of total COD]	0.0540
Fup - Unbiodegradable particulate [gCOD/g of total COD]	0.0900
Fna - Ammonia [gNH3-N/gTKN]	0.6200
Fnox - Particulate organic nitrogen [gN/g Organic N]	0.2500
Fnus - Soluble unbiodegradable TKN [gN/gTKN]	0.0200
FupN - N:COD ratio for unbiodegradable part. COD [gN/gCOD]	0.0350
Fpo4 - Phosphate [gPO4-P/gTP]	0.5000
FupP - P:COD ratio for unbiodegradable part. COD [gP/gCOD]	0.0110
FZbh - OHO COD fraction [gCOD/g of total COD]	0.0200
FZbm - Methylotroph COD fraction [gCOD/g of total COD]	1.000E-4
FZaob - AOB COD fraction [gCOD/g of total COD]	1.000E-4
FZnob - NOB COD fraction [gCOD/g of total COD]	1.000E-4
FZamob - ANAMMOX COD fraction [gCOD/g of total COD]	1.000E-4
FZbp - PAO COD fraction [gCOD/g of total COD]	1.000E-4
FZbpa - Propionic acetogens COD fraction [gCOD/g of total COD]	1.000E-4
FZbam - Acetoclastic methanogens COD fraction [gCOD/g of total COD]	1.000E-4
FZbhm - H2-utilizing methanogens COD fraction [gCOD/g of total COD]	1.000E-4
FZe - Endogenous products COD fraction [gCOD/g of total COD]	0

Configuration information for all Ideal clarifier units

Physical data

Element name	Volume [Mil. Gal]	Area [ft2]	Depth [ft]
Ideal clarifier11	0.2020	1500.0000	18.000

Operating data Average (flow/time weighted as required)

Element name	Split method	Average Split specification
Ideal clarifier11	Flow paced	80.00 %

Element name	Average Temperature	Reactive	Percent removal	Blanket fraction
Ideal clarifier11	Uses global setting	No	99.90	0.05

BioWin user and configuration data - MUCT

Project details

Project name: Whitewater Facilities Plan **Project ref.: 12600**

Plant name: Whitewater WWTP **User name: ldowning**

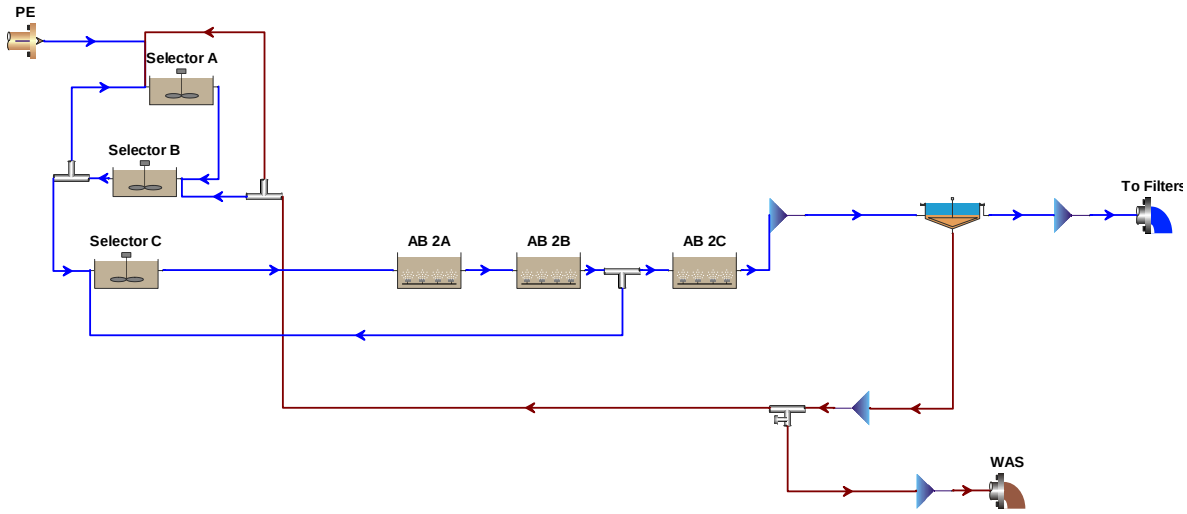
Created: 03/12/14 **Saved: 03/12/14**

Steady state solution

Target SRT: 12.00 days **SRT #0: 11.99 days**

Temperature: 10.0°C

Flowsheet



Configuration information for all Bioreactor units

Physical data

Element name	Volume [Mil. Gal]	Area [ft2]	Depth [ft]	# of diffusers
Selector A	0.0450	334.2014	18.000	Un-aerated
Selector B	0.0450	334.2014	18.000	Un-aerated
AB 2A	0.1000	742.6698	18.000	252
AB 2B	0.1000	742.6698	18.000	168
AB 2C	0.1000	742.6698	18.000	168
Selector C	0.0450	334.2014	18.000	Un-aerated

Operating data Average (flow/time weighted as required)

Element name	Average DO Setpoint [mg/L]
Selector A	0
Selector B	0
AB 2A	2.0
AB 2B	2.0
AB 2C	2.0
Selector C	0

Aeration equipment parameters

Element name	k1 in C = k1(PC)^0.25 + k2	k2 in C = k1(PC)^0.25 + k2	Y in Kla = C Usg ^ Y - Usg in [m3/(m2 d)]	Area of one diffuser	% of tank area covered by diffusers [%]
Selector A	2.5656	0.0432	0.8200	0.4413	10.0000
Selector B	2.5656	0.0432	0.8200	0.4413	10.0000

AB 2A	2.5656	0.0432	0.8200	0.4413	15.0000
AB 2B	2.5656	0.0432	0.8200	0.4413	10.0000
AB 2C	2.5656	0.0432	0.8200	0.4413	10.0000
Selector C	2.5656	0.0432	0.8200	0.4413	10.0000

Element name	Alpha (surf) OR Alpha F (diff) [-]	Beta [-]	Surface pressure [kPa]	Fractional effective saturation depth (Fed) [-]
AB 2A	0.5000	0.9500	101.3250	0.3250
AB 2B	0.6000	0.9500	101.3250	0.3250
AB 2C	0.6000	0.9500	101.3250	0.3250

Configuration information for all BOD Influent units

Operating data Average (flow/time weighted as required)

Element name	PE
Flow	0.75
Total Carbonaceous BOD mgBOD/L	130.00
Volatile suspended solids mgVSS/L	80.00
Total suspended solids mgTSS/L	110.00
Total Kjeldahl Nitrogen mgN/L	35.00
Total P mgP/L	3.50
Nitrate N mgN/L	0
pH	7.30
Alkalinity mmol/L	6.00
Calcium mg/L	80.00
Magnesium mg/L	15.00
Dissolved oxygen mg/L	0

Element name	PE
Fbs - Readily biodegradable (including Acetate) [gCOD/g of total COD]	0.2660
Fac - Acetate [gCOD/g of readily biodegradable COD]	0.1830
Fxsp - Non-colloidal slowly biodegradable [gCOD/g of slowly degradable COD]	0.7181
Fus - Unbiodegradable soluble [gCOD/g of total COD]	0.0540
Fup - Unbiodegradable particulate [gCOD/g of total COD]	0.0900
Fna - Ammonia [gNH3-N/gTKN]	0.5530
Fnox - Particulate organic nitrogen [gN/g Organic N]	0.2500
Fnus - Soluble unbiodegradable TKN [gN/gTKN]	0.0200
FupN - N:COD ratio for unbiodegradable part. COD [gN/gCOD]	0.0350
Fpo4 - Phosphate [gPO4-P/gTP]	0.5000
FupP - P:COD ratio for unbiodegradable part. COD [gP/gCOD]	0.0110
FZbh - OHO COD fraction [gCOD/g of total COD]	0.0200
FZbm - Methylotroph COD fraction [gCOD/g of total COD]	1.000E-4
FZaob - AOB COD fraction [gCOD/g of total COD]	1.000E-4
FZnob - NOB COD fraction [gCOD/g of total COD]	1.000E-4
FZamob - ANAMMOX COD fraction [gCOD/g of total COD]	1.000E-4
FZbp - PAO COD fraction [gCOD/g of total COD]	1.000E-4
FZbpa - Propionic acetogens COD fraction [gCOD/g of total COD]	1.000E-4
FZbam - Acetoclastic methanogens COD fraction [gCOD/g of total COD]	1.000E-4
FZbhm - H2-utilizing methanogens COD fraction [gCOD/g of total COD]	1.000E-4
FZe - Endogenous products COD fraction [gCOD/g of total COD]	0

Configuration information for all Ideal clarifier units

Physical data

Element name	Volume [Mil. Gal]	Area [ft2]	Depth [ft]
Ideal clarifier11	0.2020	1500.0000	18.000

Operating data Average (flow/time weighted as required)

Element name	Split method	Average Split specification
Ideal clarifier11	Flow paced	80.00 %

Element name	Average Temperature	Reactive	Percent removal	Blanket fraction
Ideal clarifier11	Uses global setting	No	99.90	0.05

Configuration information for all Splitter units

Operating data Average (flow/time weighted as required)

Element name	Split method	Average Split specification
WAS Valve	Flowrate [Side]	0.0112515382420003
Splitter31	Fraction	0.00
Splitter3	Flow paced	150.00 %
Splitter14	Flow paced	200.00 %

BioWin user and configuration data – A2O

Project details

Project name: Whitewater Facilities Plan **Project ref.: 12600**

Plant name: Whitewater WWTP **User name: ldowning**

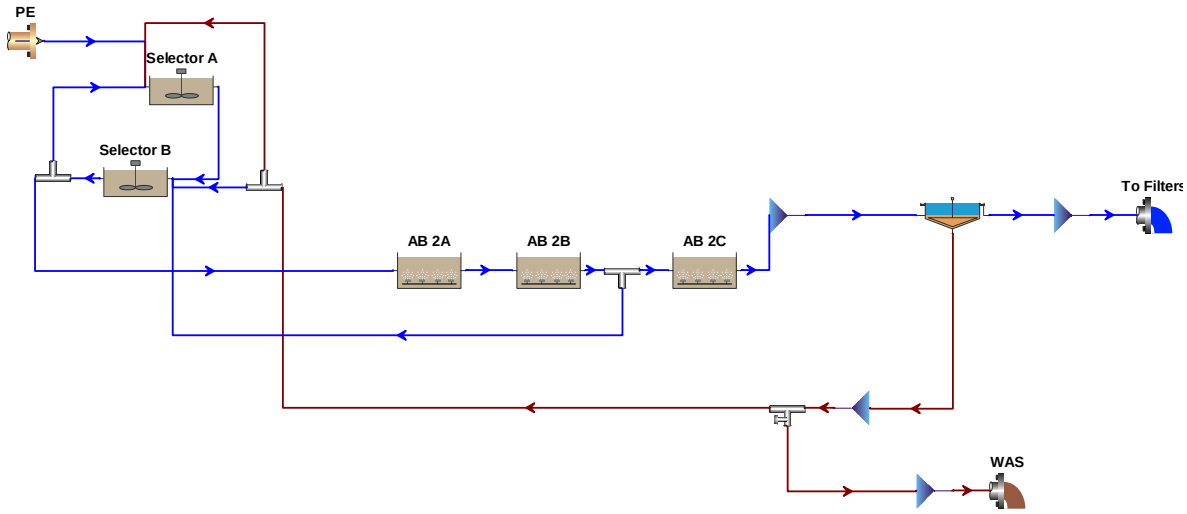
Created: 03/12/14 **Saved: 03/12/14**

Steady state solution

Target SRT: 12.00 days **SRT #0: 11.99 days**

Temperature: 10.0°C

Flowsheet



Configuration information for all Bioreactor units

Physical data

Element name	Volume [Mil. Gal]	Area [ft2]	Depth [ft]	# of diffusers
Selector A	0.0450	334.2014	18.000	Un-aerated
Selector B	0.0450	334.2014	18.000	Un-aerated
AB 2A	0.1000	742.6698	18.000	252
AB 2B	0.1000	742.6698	18.000	168
AB 2C	0.1000	742.6698	18.000	168

Operating data Average (flow/time weighted as required)

Element name	Average DO Setpoint [mg/L]
Selector A	0
Selector B	0
AB 2A	2.0
AB 2B	2.0
AB 2C	2.0

Aeration equipment parameters

Element name	Alpha (surf) OR Alpha F (diff) [-]	Beta [-]	Surface pressure [kPa]	Fractional effective saturation depth (Fed) [-]
AB 2A	0.5000	0.9500	101.3250	0.3250
AB 2B	0.6000	0.9500	101.3250	0.3250
AB 2C	0.6000	0.9500	101.3250	0.3250

Element name	Supply gas CO2 content [vol. %]	Supply gas O2 [vol. %]	Off-gas CO2 [vol. %]	Off-gas O2 [vol. %]	Off-gas H2 [vol. %]	Off-gas NH3 [vol. %]	Off-gas CH4 [vol. %]	Surface turbulence factor [-]
AB 2A	0.0350	20.9500	2.0000	18.8000	0	0	0	2.0000
AB 2B	0.0350	20.9500	2.0000	18.8000	0	0	0	2.0000
AB 2C	0.0350	20.9500	2.0000	18.8000	0	0	0	2.0000

Configuration information for all BOD Influent units

Operating data Average (flow/time weighted as required)

Element name	PE
Flow	0.75
Total Carbonaceous BOD mgBOD/L	130.00
Volatile suspended solids mgVSS/L	80.00
Total suspended solids mgTSS/L	110.00
Total Kjeldahl Nitrogen mgN/L	35.00
Total P mgP/L	3.50
Nitrate N mgN/L	0
pH	7.30
Alkalinity mmol/L	6.00
Calcium mg/L	80.00
Magnesium mg/L	15.00
Dissolved oxygen mg/L	0

Element name	PE
Fbs - Readily biodegradable (including Acetate) [gCOD/g of total COD]	0.2660
Fac - Acetate [gCOD/g of readily biodegradable COD]	0.1830
Fxsp - Non-colloidal slowly biodegradable [gCOD/g of slowly degradable COD]	0.7181
Fus - Unbiodegradable soluble [gCOD/g of total COD]	0.0540
Fup - Unbiodegradable particulate [gCOD/g of total COD]	0.0900
Fna - Ammonia [gNH3-N/gTKN]	0.5530
Fnox - Particulate organic nitrogen [gN/g Organic N]	0.2500
Fnus - Soluble unbiodegradable TKN [gN/gTKN]	0.0200
FupN - N:COD ratio for unbiodegradable part. COD [gN/gCOD]	0.0350
Fpo4 - Phosphate [gPO4-P/gTP]	0.5000
FupP - P:COD ratio for unbiodegradable part. COD [gP/gCOD]	0.0110
FZbh - OHO COD fraction [gCOD/g of total COD]	0.0200
FZbm - Methylotroph COD fraction [gCOD/g of total COD]	1.000E-4
FZaob - AOB COD fraction [gCOD/g of total COD]	1.000E-4
FZnob - NOB COD fraction [gCOD/g of total COD]	1.000E-4
FZamob - ANAMMOX COD fraction [gCOD/g of total COD]	1.000E-4
FZbp - PAO COD fraction [gCOD/g of total COD]	1.000E-4
FZbpa - Propionic acetogens COD fraction [gCOD/g of total COD]	1.000E-4
FZbam - Acetoclastic methanogens COD fraction [gCOD/g of total COD]	1.000E-4
FZbhm - H2-utilizing methanogens COD fraction [gCOD/g of total COD]	1.000E-4
FZe - Endogenous products COD fraction [gCOD/g of total COD]	0

Configuration information for all Ideal clarifier units

Physical data

Element name	Volume [Mil. Gal]	Area [ft2]	Depth [ft]
Ideal clarifier11	0.2020	1500.0000	18.000

Operating data Average (flow/time weighted as required)

Element name	Split method	Average Split specification
Ideal clarifier11	Flow paced	80.00 %

Element name	Average Temperature	Reactive	Percent removal	Blanket fraction
Ideal clarifier11	Uses global setting	No	99.90	0.05

Configuration information for all Splitter units

Operating data Average (flow/time weighted as required)

Element name	Split method	Average Split specification
WAS Valve	Flowrate [Side]	0.0112655668828138
Splitter31	Fraction	1.00
Splitter3	Flow paced	0.00 %
Splitter14	Flow paced	200.00 %

Appendix TM6-F

MBBR Model Report

BioWin user and configuration data - MBBR

Project details

Project name: Whitewater Facilities Plan **Project ref.: 12600**

Plant name: Whitewater WWTP **User name: ldowning**

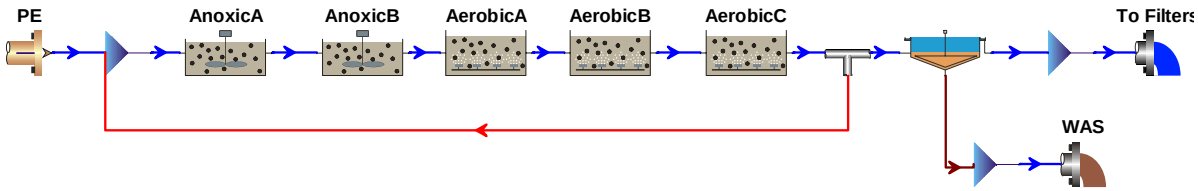
Created: 03/12/14 **Saved: 04/03/14**

Steady state solution

Target SRT: 12.00 days **SRT #0: ----- days**

Temperature: 10.0°C

Flowsheet



Configuration information for all BOD Influent units

Operating data Average (flow/time weighted as required)

Element name	PE
Flow	0.75
Total Carbonaceous BOD mgBOD/L	130.00
Volatile suspended solids mgVSS/L	65.00
Total suspended solids mgTSS/L	82.00
Total Kjeldahl Nitrogen mgN/L	43.30
Total P mgP/L	4.33
Nitrate N mgN/L	0
pH	7.30
Alkalinity mmol/L	6.00
Calcium mg/L	80.00
Magnesium mg/L	15.00
Dissolved oxygen mg/L	0

Element name	PE
Fbs - Readily biodegradable (including Acetate) [gCOD/g of total COD]	0.2660
Fac - Acetate [gCOD/g of readily biodegradable COD]	0.1830
Fxsp - Non-colloidal slowly biodegradable [gCOD/g of slowly degradable COD]	0.5675
Fus - Unbiodegradable soluble [gCOD/g of total COD]	0.0540
Fup - Unbiodegradable particulate [gCOD/g of total COD]	0.0900
Fna - Ammonia [gNH3-N/gTKN]	0.5530
Fnox - Particulate organic nitrogen [gN/g Organic N]	0.2500
Fnus - Soluble unbiodegradable TKN [gN/gTKN]	0.0200
FupN - N:COD ratio for unbiodegradable part. COD [gN/gCOD]	0.0350
Fpo4 - Phosphate [gPO4-P/gTP]	0.5000
FupP - P:COD ratio for unbiodegradable part. COD [gP/gCOD]	0.0110
FZbh - OHO COD fraction [gCOD/g of total COD]	0.0200
FZbm - Methylotroph COD fraction [gCOD/g of total COD]	1.000E-4

FZaob - AOB COD fraction [gCOD/g of total COD]	1.000E-4
FZnob - NOB COD fraction [gCOD/g of total COD]	1.000E-4
FZamob - ANAMMOX COD fraction [gCOD/g of total COD]	1.000E-4
FZbp - PAO COD fraction [gCOD/g of total COD]	1.000E-4
FZbpa - Propionic acetogens COD fraction [gCOD/g of total COD]	1.000E-4
FZbam - Acetoclastic methanogens COD fraction [gCOD/g of total COD]	1.000E-4
FZbhm - H2-utilizing methanogens COD fraction [gCOD/g of total COD]	1.000E-4
FZe - Endogenous products COD fraction [gCOD/g of total COD]	0

Configuration information for all Effluent units

Configuration information for all Ideal clarifier units

Physical data

Element name	Volume [Mil. Gal]	Area [ft2]	Depth [ft]
Ideal clarifier11	0.2020	1500.0000	18.000

Operating data Average (flow/time weighted as required)

Element name	Split method	Average Split specification
Ideal clarifier11	Flow paced	1.00 %

Element name	Average Temperature	Reactive	Percent removal	Blanket fraction

Ideal clarifier11	Uses global setting	No	99.90	0.05

Configuration information for all Media Bioreactor units

Physical data

Element name	Volume [Mil. Gal]	Area [ft2]	Depth [ft]	# of diffusers
AnoxicA	0.0673	450.0000	20.000	Un-aerated
AnoxicB	0.0673	450.0000	20.000	Un-aerated
AerobicA	0.0673	450.0000	20.000	102
AerobicB	0.0673	450.0000	20.000	102
AerobicC	0.0673	450.0000	20.000	102

Element name	Specific area [ft2/ft3]	Specific volume [ft3/ft3]	% of reactor filled with media [%]
AnoxicA	243	0.125	20.00
AnoxicB	243	0.125	20.00
AerobicA	243	0.125	45.00
AerobicB	243	0.125	45.00
AerobicC	243	0.125	40.00

Operating data Average (flow/time weighted as required)

Element name	Average DO Setpoint
AnoxicA	0
AnoxicB	0
AerobicA	4.0
AerobicB	4.0
AerobicC	4.0

Aeration equipment parameters

Element name	k1 in C = k1(PC)^0.25 + k2	k2 in C = k1(PC)^0.25 + k2	Y in Kla = C Usg ^ Y - Usg in [m3/(m2 d)]	Area of one diffuser	% of tank area covered by diffusers [%]
AnoxicA	2.5656	0.0432	0.8200	0.4413	10.0000
AnoxicB	2.5656	0.0432	0.8200	0.4413	10.0000
AerobicA	2.5656	0.0432	0.8200	0.4413	10.0000
AerobicB	2.5656	0.0432	0.8200	0.4413	10.0000
AerobicC	2.5656	0.0432	0.8200	0.4413	10.0000

Configuration information for all Splitter units

Operating data Average (flow/time weighted as required)

Element name	Split method	Average Split specification
Splitter12	Flow paced	100.00 %

Appendix TM6-G

Capital Cost Estimates – Alternative Processes

CITY OF WHITEWATER
WASTEWATER FACILITY PLAN
WHITEWATER, WI

Rotating Biological Contractors (RBCs)

INITIAL COST ESTIMATE

General Description

Cost estimate to replace the existing RBC units with new similar equipment. The existing RBC buildings would be demolished and the new RBC units would have fiberglass covers. The existing RBC tank walls would need to raised to contain peak flows. Plumbing and air lines to the RBC units would have to be buried. Secondary sludge will continue to be co-settled in the primary clarifiers.

ITEM	Units	Quantity	Unit Cost ($)	Initial Cost ($)
Architectural/Structural				
Earthwork	See Worksheet for Detailed Cost Breakdown			0
Concrete	See Worksheet for Detailed Cost Breakdown			38,600
Metals	See Worksheet for Detailed Cost Breakdown			0
Buildings	See Worksheet for Detailed Cost Breakdown			0
Demolition	See Worksheet for Detailed Cost Breakdown			302,400
RBC Equipment	Lump Sum	**1**	**5,200,000**	5,200,000
Blowers	Ea	**2**	**35,100**	70,200
Civil % Not Listed Above	%		**7%**	$604,283
Process-Mechanical Piping % Not Listed Above	%		**8%**	$690,609
Electrical % Not Listed Above	%		**12%**	$1,035,914
Instrumentation and Control % Not Listed Above	%		**8%**	$690,609
Plumbing % Not Listed Above	%		**0.0%**	$0
HVAC % Not Listed Above	%		**0%**	$0
Subtotal				*8,632,615*
Minus Major Equipment				
RBC Equipment	Lump Sum	1	5,200,000	5,200,000
Subtotal				3,432,615
Contingency (w/o Major Equipment)			**30%**	*1,029,785*
Subtotal				4,462,400
Contractor Overhead & Profit (w/o Major Equipment)			**25%**	*1,115,600*
Major Equipment Contingency			**10%**	*520,000*
Total Construction Cost				**11,298,000**
Engineering			**15%**	1,694,700
Total Initial Cost				**12,992,700**

CITY OF WHITEWATER
WASTEWATER FACILITY PLAN
WHITEWATER, WI

Rotating Biological Contractors (RBCs)

ARCHITECTURAL/STRUCTURAL WORKSHEET

ITEM	Units	Quantity	Unit Cost ($)	Initial Cost ($)
Earthwork: Dewatering	lump sum	1	0	
Earthwork: Excavation	cu yds		10	0
Earthwork: Underdrain System	sq yds			
Earthwork: Pile Foundation	ft			
Earthwork: Flood Protection Levee	cu yds			
Earthwork: Flood Protection Gravel Road	sq yds			
Earthwork:				
Earthwork				**0**
Concrete: Footings	cu yds		330	0
Concrete: Base Slab	cu yds		330	0
Concrete: Walls	cu yds	40	965	38,600
Concrete: Floor Slabs	cu yds		350	0
Concrete: Structural Slabs	cu yds		775	0
Concrete: Columns	cu yds			
Concrete: Channels	cu yds		1,009	0
Concrete: Class B Fill	cu yds		305	0
Concrete				**38,600**
Metals: Aluminum Grating	sq ft		28	0
Metals: Aluminum Handrail	ft		53	0
Metals: Aluminum Stairway	risers		414	0
Metals: Baffles and Weirs	sq ft		70	0
Metals:				
Metals				**0**
Building: One Story Brick and Block	sq ft		125	0
Building: Two Story Brick and Block	sq ft		300	0
Building:	sq ft			
Building:	sq ft			
Building:	sq ft			
Building:	sq ft			
Buildings				**0**
Demolition: Selective Concrete	cu ft		30	0
Demolition: Structure	cu ft	432,000	0.70	302,400
Demolition: Mechanical	lump sum			
Demolition:	lump sum			
Demolition				**302,400**

CITY OF WHITEWATER
WASTEWATER FACILITY PLAN
WHITEWATER, WI

Rotating Biological Contractors (RBCs)

INITIAL ANNUAL O&M COST ESTIMATE

O&M Labor

ITEM	Units	Annual Quantity	Unit Cost ($)	Annual Cost ($)
Maintenance	hours		35	0

Electricity

ITEM	Units	Annual Quantity	Unit Cost ($)	Annual Cost ($)
RBC Drives	kwh	1,959,700	0.086	168,534
Blowers	kwh	1,306,466	0.086	112,356

Natural Gas

ITEM	Units	Annual Quantity	Unit Cost ($)	Annual Cost ($)
	therm		0.71	0

Chemicals

ITEM	Units	Annual Quantity	Unit Cost ($)	Annual Cost ($)
Alum Addition	gal	48,215	1.40	67,501

CITY OF WHITEWATER
WASTEWATER FACILITY PLAN
WHITEWATER, WI

Moving Bed Bioreactor (MBBR)

INITIAL COST ESTIMATE

General Description
Cost estimate to replace the existing RBCs with a three train MBBR system. Costs include demolition of the existing RBCs and construction of new process building to house blowers, electrical components, and controls. Secondary sludge will continue to be co-settled in the primary clarifiers.

ITEM	Units	Quantity	Unit Cost ($)	Initial Cost ($)
Architectural/Structural				
Earthwork	See Worksheet for Detailed Cost Breakdown			132,222
Concrete	See Worksheet for Detailed Cost Breakdown			668,182
Metals	See Worksheet for Detailed Cost Breakdown			0
Buildings	See Worksheet for Detailed Cost Breakdown			375,000
Demolition	See Worksheet for Detailed Cost Breakdown			445,198
MBBR Equipment	Lump Sum	**1**	**2,149,000**	2,149,000
Civil % Not Listed Above	%		**7%**	$443,483
Process-Mechanical Piping % Not Listed Above	%		**8%**	$506,837
Electrical % Not Listed Above	%		**12%**	$760,256
Instrumentation and Control % Not Listed Above	%		**8%**	$506,837
Plumbing % Not Listed Above	%		**1.5%**	$95,032
HVAC % Not Listed Above	%		**4%**	$253,419
Subtotal				*6,335,467*
Minus Major Equipment				
MBBR Equipment	Lump Sum	1	2,149,000	2,149,000
Subtotal				4,186,467
Contingency (w/o Major Equipment)			**30%**	*1,255,940*
Subtotal				5,442,407
Contractor Overhead & Profit (w/o Major Equipment)			**25%**	*1,360,602*
Major Equipment Contingency			**10%**	*214,900*
Total Construction Cost				**9,166,909**
Engineering			**15%**	1,375,036
Total Initial Cost				**10,541,945**

CITY OF WHITEWATER
WASTEWATER FACILITY PLAN
WHITEWATER, WI

Moving Bed Bioreactor (MBBR)

ARCHITECTURAL/STRUCTURAL WORKSHEET

ITEM	Units	Quantity	Unit Cost ($)	Initial Cost ($)
Earthwork: Dewatering	lump sum	1	26,444	26,444
Earthwork: Excavation	cu yds	10,578	10	105,778
Earthwork: Underdrain System	sq yds			
Earthwork: Pile Foundation	ft			
Earthwork: Flood Protection Levee	cu yds			
Earthwork: Flood Protection Gravel Road	sq yds			
Earthwork:				
Earthwork				**132,222**
Concrete: Footings	cu yds		330	0
Concrete: Base Slab	cu yds	212	330	69,813
Concrete: Walls	cu yds	748	800	598,369
Concrete: Floor Slabs	cu yds		350	0
Concrete: Structural Slabs	cu yds		775	0
Concrete: Columns	cu yds			
Concrete: Channels	cu yds		1,009	0
Concrete: Class B Fill	cu yds		305	0
Concrete				**668,182**
Metals: Aluminum Grating	sq ft		28	0
Metals: Aluminum Handrail	ft		53	0
Metals: Aluminum Stairway	risers		414	0
Metals: Baffles and Weirs	sq ft		70	0
Metals:				
Metals				**0**
Building: One Story Brick and Block	sq ft	3,000	125	375,000
Building: Two Story Brick and Block	sq ft		300	0
Building:	sq ft			
Building:	sq ft			
Building:	sq ft			
Building:	sq ft			
Buildings				**375,000**
Demolition: Selective Concrete	cu ft		30	0
Demolition: Structure	cu ft	635,998	0.70	445,198
Demolition: Mechanical	lump sum			
Demolition:	lump sum			
Demolition				**445,198**

CITY OF WHITEWATER
WASTEWATER FACILITY PLAN
WHITEWATER, WI

Moving Bed Bioreactor (MBBR)

INITIAL ANNUAL O&M COST ESTIMATE

O&M Labor

ITEM	Units	Annual Quantity	Unit Cost ($)	Annual Cost ($)
Maintenance	hours		35	0

Electricity

ITEM	Units	Annual Quantity	Unit Cost ($)	Annual Cost ($)
Blowers	kwh	1,241,143	0.086	106,738
Mixers	kwh	81,001	0.086	6,966
Wall Pumps	kwh	78,388	0.086	6,741
WAS Pumps	kwh	16,331	0.086	1,404

Natural Gas

ITEM	Units	Annual Quantity	Unit Cost ($)	Annual Cost ($)
	therm		0.71	0

Chemicals

ITEM	Units	Annual Quantity	Unit Cost ($)	Annual Cost ($)
Alum Addition	gal	48,215	1.40	67,501

CITY OF WHITEWATER
WASTEWATER FACILITY PLAN
WHITEWATER, WI

Activated Sludge

INITIAL COST ESTIMATE

General Description

Cost estimate to replace the existing RBCs with an activated sludge system that repurposes the existing secondary clarifiers as aeration basins. Two new secondary clarifiers are included along with RAS pumping facilities. Costs include demolition of the existing RBCs and construction of new process building to house blowers, electrical components, and controls. Co-settling secondary sludge would be discontinued to optimize biological phosphorous removal so new mechanical thickening equipment would be required as well.

ITEM	Units	Quantity	Unit Cost ($)	Initial Cost ($)
Architectural/Structural				
Earthwork	See Worksheet for Detailed Cost Breakdown			285,985
Concrete	See Worksheet for Detailed Cost Breakdown			1,006,032
Metals	See Worksheet for Detailed Cost Breakdown			121,757
Buildings	See Worksheet for Detailed Cost Breakdown			521,375
Demolition	See Worksheet for Detailed Cost Breakdown			545,198
Diffusers	sf	**7,125**	**18**	124,688
Blowers	Ea	**3**	**126,540**	379,620
Secondary Clarifier Equipment	Ea	**2**	**142,000**	284,000
Selector Zone Mixers	Ea	**6**	**15,000**	90,000
IMLR Pumps	Ea	**3**	**20,000**	60,000
RAS Pumps	Ea	**3**	**30,000**	90,000
Sludge Thickening Equipment	Ea	**1**	**100,000**	100,000
Polymer Feed Equipment	Ea	**1**	**12,000**	12,000
Thickened Sludge Pump	Ea	**2**	**20,000**	40,000
WAS Pumps	Ea	**1**	**16,000**	16,000
Civil Not Listed Above	Ea	**1**	**7%**	$432,548
Process-Mechanical Piping Not Listed Above	Ea	**1**	**8%**	$494,340
Electrical Not Listed Above	Ea	**1**	**12%**	$741,510
Instrumentation and Control Not Listed Above	Ea	**1**	**8%**	$494,340
Plumbing Not Listed Above	Ea	**1**	**1.5%**	$92,689
HVAC Not Listed Above	Ea	**1**	**4%**	$247,170
Subtotal				6,179,252
Minus Major Equipment				
Blowers	Ea	3	126,540	379,620
Secondary Clarifier Equipment	Ea	2	142,000	284,000
RAS Pumps	Ea	3	30,000	90,000
Sludge Thickening Equipment	Ea	1	100,000	100,000
Selector Zone Mixers	Ea	6	15,000	90,000
IMLR Pumps	Ea	3	20,000	60,000
Subtotal				5,175,632
Contingency (w/o Major Equipment)			**30%**	*1,552,690*
Subtotal				6,728,322
Contractor Overhead & Profit (w/o Major Equipment)			**25%**	*1,682,081*
Major Equipment Contingency			**10%**	*94,362*
Total Construction Cost				**9,508,385**
Engineering			**15%**	1,426,258
Total Initial Cost				**10,934,642**

CITY OF WHITEWATER
WASTEWATER FACILITY PLAN
WHITEWATER, WI

Activated Sludge

ARCHITECTURAL/STRUCTURAL WORKSHEET

ITEM	Units	Quantity	Unit Cost ($)	Initial Cost ($)
Earthwork: Dewatering	lump sum	1	57,197	57,197
Earthwork: Excavation	cu yds	22,879	10	228,788
Earthwork: Underdrain System	sq yds			
Earthwork: Pile Foundation	ft			
Earthwork: Flood Protection Levee	cu yds			
Earthwork: Flood Protection Gravel Road	sq yds			
Earthwork:				
Earthwork				**285,985**
Concrete: Footings	cu yds		330	0
Concrete: Base Slab	cu yds	488	330	161,111
Concrete: Walls	cu yds	1,056	800	844,922
Concrete: Floor Slabs	cu yds		350	0
Concrete: Structural Slabs	cu yds		775	0
Concrete: Columns	cu yds			
Concrete: Channels	cu yds		1,009	0
Concrete: Class B Fill	cu yds		305	0
Concrete				**1,006,032**
Metals: Aluminum Grating	sq ft		28	0
Metals: Aluminum Handrail	ft	330	53	17,490
Metals: Aluminum Stairway	risers	49	414	20,286
Metals: Baffles and Weirs	sq ft	1,200	70	83,981
Metals:				
Metals				**121,757**
Building: One Story Brick and Block Process Bldg	sq ft	2,250	125	281,250
Building: One Story Brick and Block Thickening Bldg	sq ft	1,921	125	240,125
Building:	sq ft			
Building:	sq ft			
Building:	sq ft			
Building:	sq ft			
Buildings				**521,375**
Demolition: Selective Concrete	cu ft		30	0
Demolition: Structure	cu ft	635,998	0.70	445,198
Demolition: Mechanical	lump sum	1	100,000	100,000
Demolition:	lump sum			
Demolition				**545,198**

CITY OF WHITEWATER
WASTEWATER FACILITY PLAN
WHITEWATER, WI

Activated Sludge

INITIAL ANNUAL O&M COST ESTIMATE

O&M Labor

ITEM	Units	Annual Quantity	Unit Cost ($)	Annual Cost ($)
Maintenance	hours		35	0

Electricity

ITEM	Units	Annual Quantity	Unit Cost ($)	Annual Cost ($)
Blowers	kwh	1,241,143	0.086	106,738
RAS Pumps		97,985	0.086	8,427
WAS Pumps		16,331	0.086	1,404
Mixers	kwh	81,001	0.086	6,966
Wall Pumps	kwh	78,388	0.086	6,741

Natural Gas

ITEM	Units	Annual Quantity	Unit Cost ($)	Annual Cost ($)
	therm		0.71	0

Chemicals

ITEM	Units	Annual Quantity	Unit Cost ($)	Annual Cost ($)
Alum Addition	gal	9,643	1.40	13,500
Polymer	lb	8,611	2.50	21,528

CITY OF WHITEWATER
WASTEWATER FACILITY PLAN
WHITEWATER, WI

Activated Sludge with BioMag

INITIAL COST ESTIMATE

General Description

Cost estimate to replace the existing RBCs with a three train UCT activated sludge system with two selectors and one aeration basin per train. A BioMag system would be installed to reduce aeration basin sizing and avoid construction of a third secondary clarifier. Costs include demolition of the existing RBCs and construction of new process building to house blowers, electrical components, and controls. Co-settling secondary sludge would be discontinued to optimize biological phosphorous removal so new mechanical thickening equipment would be required as well.

ITEM	Units	Quantity	Unit Cost ($)	Initial Cost ($)
Architectural/Structural				
Earthwork	See Worksheet for Detailed Cost Breakdown			149,630
Concrete	See Worksheet for Detailed Cost Breakdown			831,175
Metals	See Worksheet for Detailed Cost Breakdown			49,398
Buildings	See Worksheet for Detailed Cost Breakdown			615,125
Demolition	See Worksheet for Detailed Cost Breakdown			445,198
Diffusers	sf	**7,125**	**23**	162,094
Blowers	Ea	**3**	**126,540**	379,620
RAS Pumps	Ea	**4**	**30,000**	120,000
Sludge Thickening Equipment	Ea	**1**	**100,000**	100,000
Polymer Feed Equipment	Ea	**1**	**12,000**	12,000
Thickened Sludge Pump	Ea	**2**	**20,000**	40,000
BioMag Equipment	LS	**1**	**1,800,000**	1,800,000
Civil % Not Listed Above	%		**7%**	$553,440
Process-Mechanical Piping % Not Listed Above	%		**8%**	$632,503
Electrical % Not Listed Above	%		**12%**	$948,754
Instrumentation and Control % Not Listed Above	%		**8%**	$632,503
Plumbing % Not Listed Above	%		**1.5%**	$118,594
HVAC % Not Listed Above	%		**4%**	$316,251
Subtotal				*7,906,285*
Minus Major Equipment				
Blowers	Ea	3	126,540	379,620
RAS Pumps	Ea	4	30,000	120,000
Sludge Thickening Equipment	Ea	1	100,000	100,000
BioMag Equipment	LS	1	1,800,000	1,800,000
Subtotal				5,506,665
Contingency (w/o Major Equipment)			**30%**	*1,651,999*
Subtotal				7,158,664
Contractor Overhead & Profit (w/o Major Equipment)			**25%**	*1,789,666*
Major Equipment Contingency			**10%**	*239,962*
Total Construction Cost				**11,587,913**
Engineering			**15%**	1,738,187
Total Initial Cost				**13,326,100**

CITY OF WHITEWATER
WASTEWATER FACILITY PLAN
WHITEWATER, WI

Activated Sludge with BioMag

ARCHITECTURAL/STRUCTURAL WORKSHEET

ITEM	Units	Quantity	Unit Cost ($)	Initial Cost ($)
Earthwork: Dewatering	lump sum	1	29,926	29,926
Earthwork: Excavation	cu yds	11,970	10	119,704
Earthwork: Underdrain System	sq yds			
Earthwork: Pile Foundation	ft			
Earthwork: Flood Protection Levee	cu yds			
Earthwork: Flood Protection Gravel Road	sq yds			
Earthwork:				
Earthwork				**149,630**
Concrete: Footings	cu yds		330	0
Concrete: Base Slab	cu yds	299	330	98,756
Concrete: Walls	cu yds	916	800	732,419
Concrete: Floor Slabs	cu yds		350	0
Concrete: Structural Slabs	cu yds		775	0
Concrete: Columns	cu yds			
Concrete: Channels	cu yds		1,009	0
Concrete: Class B Fill	cu yds		305	0
Concrete				**831,175**
Metals: Aluminum Grating	sq ft		28	0
Metals: Aluminum Handrail	ft	264	53	13,992
Metals: Aluminum Stairway	risers	49	414	20,286
Metals: Baffles and Weirs	sq ft	216	70	15,120
Metals:				
Metals				**49,398**
Building: One Story Brick and Block Process Bldg	sq ft	3,000	125	375,000
Building: One Story Brick and Block Thickening Bldg	sq ft	1,921	125	240,125
Building:	sq ft			
Building:	sq ft			
Building:	sq ft			
Building:	sq ft			
Buildings				**615,125**
Demolition: Selective Concrete	cu ft		30	0
Demolition: Structure	cu ft	635,998	0.70	445,198
Demolition: Mechanical	lump sum			
Demolition:	lump sum			
Demolition				**445,198**

CITY OF WHITEWATER
WASTEWATER FACILITY PLAN
WHITEWATER, WI

Activated Sludge with BioMag

INITIAL ANNUAL O&M COST ESTIMATE

O&M Labor

ITEM	Units	Annual Quantity	Unit Cost ($)	Annual Cost ($)
Maintenance	hours		35	0

Electricity

ITEM	Units	Annual Quantity	Unit Cost ($)	Annual Cost ($)
Blowers	kwh	1,241,143	0.086	106,738
RAS Pumps	kwh	97,985	0.086	8,427
BioMag Equipment	kwh	685,895	0.086	58,987

Natural Gas

ITEM	Units	Annual Quantity	Unit Cost ($)	Annual Cost ($)
	therm		0.71	0

Chemicals

ITEM	Units	Annual Quantity	Unit Cost ($)	Annual Cost ($)
Alum	gal	9,643	1.40	13,500
Polymer	lb	8,611	2.50	21,528
Magnetite Sand	lbs	102,930	0.300	30,879

CITY OF WHITEWATER
WASTEWATER FACILITY PLAN
WHITEWATER, WI

Membrane Bioreactor (MBR)

INITIAL COST ESTIMATE

General Description

Cost estimate to replace the existing RBCs with a MBR system. The existing secondary clarifiers would be repurposed to serve as equalization tanks. Costs include demolition of the existing RBCs and construction of new process building to house blowers, electrical components, and controls. Secondary sludge will continue to be co-settled in the primary clarifiers. Operating costs assume treated water can be sold to the power plant at $1.43/thousand gallons.

ITEM	Units	Quantity	Unit Cost ($)	Initial Cost ($)
Architectural/Structural				
Earthwork	See Worksheet for Detailed Cost Breakdown			144,417
Concrete	See Worksheet for Detailed Cost Breakdown			677,077
Metals	See Worksheet for Detailed Cost Breakdown			0
Buildings	See Worksheet for Detailed Cost Breakdown			730,000
Demolition	See Worksheet for Detailed Cost Breakdown			491,380
MBR Equipment	Lump Sum	**1**	**7,500,000**	7,500,000
Bridge Crane	Lump Sum	**1**	**50,000**	50,000
WAS Pumps	Ea	**2**	**16,000**	32,000
Civil % Not Listed Above	%		**2%**	$337,641
Process-Mechanical Piping % Not Listed Above	%		**4%**	$569,670
Electrical % Not Listed Above	%		**12%**	$1,680,785
Instrumentation and Control % Not Listed Above	%		**8%**	$1,120,523
Plumbing % Not Listed Above	%		**2%**	$318,379
HVAC % Not Listed Above	%		**3%**	$354,670
Subtotal				*14,006,541*
Minus Major Equipment				
MBR Equipment	Lump Sum	1	7,500,000	7,500,000
Subtotal				6,506,541
Contingency (w/o Major Equipment)			**30%**	*1,951,962*
Subtotal				8,458,503
Contractor Overhead & Profit (w/o Major Equipment)			**25%**	*2,114,626*
Major Equipment Contingency			**10%**	*750,000*
Total Construction Cost				**18,823,129**
Engineering			**15%**	2,823,469
Total Initial Cost				**21,646,599**

CITY OF WHITEWATER
WASTEWATER FACILITY PLAN
WHITEWATER, WI

Membrane Bioreactor (MBR)

ARCHITECTURAL/STRUCTURAL WORKSHEET

ITEM	Units	Quantity	Unit Cost ($)	Initial Cost ($)
Earthwork: Dewatering	lump sum	1	28,883	28,883
Earthwork: Excavation	cu yds	11,553	10	115,533
Earthwork: Underdrain System	sq yds			
Earthwork: Pile Foundation	ft			
Earthwork: Flood Protection Levee	cu yds			
Earthwork: Flood Protection Gravel Road	sq yds			
Earthwork:				
Earthwork				**144,417**
Concrete: Footings	cu yds		330	0
Concrete: Base Slab	cu yds	321	330	105,906
Concrete: Walls	cu yds	714	800	571,171
Concrete: Floor Slabs	cu yds		350	0
Concrete: Structural Slabs	cu yds		775	0
Concrete: Columns	cu yds			
Concrete: Channels	cu yds		1,009	0
Concrete: Class B Fill	cu yds		305	0
Concrete				**677,077**
Metals: Aluminum Grating	sq ft		28	0
Metals: Aluminum Handrail	ft		53	0
Metals: Aluminum Stairway	risers		414	0
Metals: Baffles and Weirs	sq ft		70	0
Metals:				
Metals				**0**
Building: One Story Brick and Block	sq ft	5,840	125	730,000
Building: Two Story Brick and Block	sq ft		300	0
Building:	sq ft			
Building:	sq ft			
Building:	sq ft			
Building:	sq ft			
Buildings				**730,000**
Demolition: Selective Concrete	cu ft		30	0
Demolition: Structure	lump sum	635,998	0.70	445,198
Demolition: Mechanical (Clarifier Conversion)	cu ft	76,969	0.60	46,181
Demolition:	lump sum			
Demolition				**491,380**

CITY OF WHITEWATER
WASTEWATER FACILITY PLAN
WHITEWATER, WI

Membrane Bioreactor (MBR)

INITIAL ANNUAL O&M COST ESTIMATE

O&M Labor

ITEM	Units	Annual Quantity	Unit Cost ($)	Annual Cost ($)
Maintenance	hours		35	0
Water Resale to Power Plant	1,000 gal	192,957	-1.430	-275,929

Electricity

ITEM	Units	Annual Quantity	Unit Cost ($)	Annual Cost ($)
MBR Equipment	kwh	2,882,000	0.086	247,852

Natural Gas

ITEM	Units	Annual Quantity	Unit Cost ($)	Annual Cost ($)
	therm		0.71	0

Chemicals

ITEM	Units	Annual Quantity	Unit Cost ($)	Annual Cost ($)
Alum Addition	gal	48,215	1.40	67,501
Sodium Hypochlorite	gal	951	2.00	1,902
Oxalic Acid	gal	190	19.560	3,716

City of Whitewater
Wastewater Facility Plan
Whitewater, WI

Rotating Biological Contractors (RBCs)

Present Worth Analysis Factors

Discount Rate	3.0%
Inflation Rate	0.5%
Escalation Rate (Above Inflation)	
Electricity (0-5 years)	2.0%
Electricity (6-20 years)	2.0%
Natural Gas	2.0%
Chemicals	2.0%

Comments

Electricity Escalation Rate = 2%

National Institute of Standards, Annual Supplement to NIST Handbook 135
Discount Rate = 3%
Inflation Rate = 0.5%
Natural Gas Escalation Rate = 2%

Life Cycle Cost Analysis

Initial Cost 12,992,700

Year (n)	Periodic Costs Replace	Periodic Costs Salvage	Annual Operational Costs O&M	Electricity	Natural Gas	Chemicals	Total Annual	PW Periodic	PW Annual	PW Cumulative
0			0	280,890	0	67,501	348,391			12,992,700
1			0	287,913	0	69,189	357,101	0	346,700	13,339,400
2			0	295,110	0	70,918	366,029	0	345,017	13,684,417
3			0	302,488	0	72,691	375,179	0	343,342	14,027,759
4			0	310,050	0	74,508	384,559	0	341,675	14,369,435
5			0	317,802	0	76,371	394,173	0	340,017	14,709,452
6			0	325,747	0	78,280	404,027	0	338,366	15,047,818
7			0	333,890	0	80,237	414,128	0	336,724	15,384,542
8			0	342,238	0	82,243	424,481	0	335,089	15,719,631
9			0	350,793	0	84,299	435,093	0	333,463	16,053,093
10			0	359,563	0	86,407	445,970	0	331,844	16,384,937
11			0	368,552	0	88,567	457,120	0	330,233	16,715,170
12			0	377,766	0	90,781	468,548	0	328,630	17,043,800
13			0	387,210	0	93,051	480,261	0	327,035	17,370,834
14			0	396,891	0	95,377	492,268	0	325,447	17,696,281
15			0	406,813	0	97,762	504,574	0	323,867	18,020,149
16			0	416,983	0	100,206	517,189	0	322,295	18,342,444
17			0	427,408	0	102,711	530,119	0	320,730	18,663,174
18			0	438,093	0	105,279	543,371	0	319,173	18,982,347
19			0	449,045	0	107,910	556,956	0	317,624	19,299,972
20			0	460,271	0	110,608	570,880	0	316,082	19,616,054

20-Year Present Worth **19,616,054**

Rotating Biological Contractors (RBCs)	
Initial Cost	12,992,700
20-Year Present Worth	19,616,054
Average Annual Cost	456,101

Notes

City of Whitewater
Wastewater Facility Plan
Whitewater, WI

Moving Bed Bioreactor (MBBR)

Present Worth Analysis Factors

Discount Rate	3.0%
Inflation Rate	0.5%
Escalation Rate (Above Inflation)	
Electricity (0-5 years)	2.0%
Electricity (6-20 years)	2.0%
Natural Gas	2.0%
Chemicals	2.0%

Comments

Electricity Escalation Rate = 2%

National Institute of Standards, Annual Supplement to NIST Handbook 135
Discount Rate = 3%
Inflation Rate = 0.5%
Natural Gas Escalation Rate = 2%

Life Cycle Cost Analysis

Initial Cost 10,541,945

Year (n)	Periodic Costs Replace	Periodic Costs Salvage	Annual Operational Costs O&M	Electricity	Natural Gas	Chemicals	Total Annual	PW Periodic	PW Annual	PW Cumulative
0			0	121,850	0	67,501	189,351			10,541,945
1			0	124,896	0	69,189	194,085	0	188,432	10,730,377
2			0	128,019	0	70,918	198,937	0	187,517	10,917,894
3			0	131,219	0	72,691	203,911	0	186,607	11,104,501
4			0	134,500	0	74,508	209,008	0	185,701	11,290,202
5			0	137,862	0	76,371	214,234	0	184,800	11,475,002
6			0	141,309	0	78,280	219,589	0	183,903	11,658,905
7			0	144,842	0	80,237	225,079	0	183,010	11,841,915
8			0	148,463	0	82,243	230,706	0	182,121	12,024,036
9			0	152,174	0	84,299	236,474	0	181,237	12,205,274
10			0	155,979	0	86,407	242,386	0	180,358	12,385,631
11			0	159,878	0	88,567	248,445	0	179,482	12,565,113
12			0	163,875	0	90,781	254,656	0	178,611	12,743,724
13			0	167,972	0	93,051	261,023	0	177,744	12,921,468
14			0	172,171	0	95,377	267,548	0	176,881	13,098,349
15			0	176,475	0	97,762	274,237	0	176,022	13,274,371
16			0	180,887	0	100,206	281,093	0	175,168	13,449,539
17			0	185,409	0	102,711	288,120	0	174,317	13,623,856
18			0	190,045	0	105,279	295,323	0	173,471	13,797,328
19			0	194,796	0	107,910	302,706	0	172,629	13,969,957
20			0	199,666	0	110,608	310,274	0	171,791	14,141,748

20-Year Present Worth	**14,141,748**

Moving Bed Bioreactor (MBBR)	
Initial Cost	10,541,945
20-Year Present Worth	14,141,748
Average Annual Cost	247,892

Notes

City of Whitewater
Wastewater Facility Plan
Whitewater, WI

Activated Sludge

Present Worth Analysis Factors

Discount Rate	3.0%
Inflation Rate	0.5%
Escalation Rate (Above Inflation)	
Electricity (0-5 years)	2.0%
Electricity (6-20 years)	2.0%
Natural Gas	2.0%
Chemicals	2.0%

Comments

Electricity Escalation Rate = 2%

National Institute of Standards, Annual Supplement to NIST Handbook 135
Discount Rate = 3%
Inflation Rate = 0.5%
Natural Gas Escalation Rate = 2%

Life Cycle Cost Analysis

Initial Cost 10,934,642

Year (n)	Periodic Costs Replace	Periodic Costs Salvage	Annual Operational Costs O&M	Electricity	Natural Gas	Chemicals	Total Annual	PW Periodic	PW Annual	PW Cumulative
0			0	130,277	0	35,028	165,305			10,934,642
1			0	133,534	0	35,903	169,437	0	164,502	11,099,145
2			0	136,872	0	36,801	173,673	0	163,704	11,262,848
3			0	140,294	0	37,721	178,015	0	162,909	11,425,757
4			0	143,801	0	38,664	182,465	0	162,118	11,587,875
5			0	147,396	0	39,631	187,027	0	161,331	11,749,206
6			0	151,081	0	40,621	191,703	0	160,548	11,909,754
7			0	154,858	0	41,637	196,495	0	159,769	12,069,523
8			0	158,730	0	42,678	201,408	0	158,993	12,228,516
9			0	162,698	0	43,745	206,443	0	158,221	12,386,737
10			0	166,765	0	44,838	211,604	0	157,453	12,544,190
11			0	170,935	0	45,959	216,894	0	156,689	12,700,879
12			0	175,208	0	47,108	222,316	0	155,928	12,856,807
13			0	179,588	0	48,286	227,874	0	155,171	13,011,979
14			0	184,078	0	49,493	233,571	0	154,418	13,166,397
15			0	188,680	0	50,731	239,410	0	153,668	13,320,065
16			0	193,397	0	51,999	245,396	0	152,922	13,472,988
17			0	198,232	0	53,299	251,531	0	152,180	13,625,168
18			0	203,188	0	54,631	257,819	0	151,441	13,776,609
19			0	208,267	0	55,997	264,264	0	150,706	13,927,315
20			0	213,474	0	57,397	270,871	0	149,975	14,077,290

20-Year Present Worth **14,077,290**

Activated Sludge	
Initial Cost	10,934,642
20-Year Present Worth	14,077,290
Average Annual Cost	216,411

Notes

City of Whitewater
Wastewater Facility Plan
Whitewater, WI

Activated Sludge

Present Worth Analysis Factors

Discount Rate	3.0%
Inflation Rate	0.5%
Escalation Rate (Above Inflation)	
Electricity (0-5 years)	2.0%
Electricity (6-20 years)	2.0%
Natural Gas	2.0%
Chemicals	2.0%

Comments

Electricity Escalation Rate = 2%

National Institute of Standards, Annual Supplement to NIST Handbook 135
Discount Rate = 3%
Inflation Rate = 0.5%
Natural Gas Escalation Rate = 2%

Life Cycle Cost Analysis

Initial Cost 13,326,100

Year (n)	Periodic Costs Replace	Periodic Costs Salvage	Annual Operational Costs O&M	Electricity	Natural Gas	Chemicals	Total Annual	PW Periodic	PW Annual	PW Cumulative
0			0	174,152	0	65,907	240,059			13,326,100
1			0	178,506	0	67,554	246,060	0	238,893	13,564,993
2			0	182,968	0	69,243	252,212	0	237,734	13,802,727
3			0	187,543	0	70,974	258,517	0	236,580	14,039,306
4			0	192,231	0	72,749	264,980	0	235,431	14,274,737
5			0	197,037	0	74,567	271,604	0	234,288	14,509,026
6			0	201,963	0	76,432	278,394	0	233,151	14,742,177
7			0	207,012	0	78,342	285,354	0	232,019	14,974,196
8			0	212,187	0	80,301	292,488	0	230,893	15,205,089
9			0	217,492	0	82,308	299,800	0	229,772	15,434,861
10			0	222,929	0	84,366	307,295	0	228,657	15,663,517
11			0	228,502	0	86,475	314,978	0	227,547	15,891,064
12			0	234,215	0	88,637	322,852	0	226,442	16,117,506
13			0	240,070	0	90,853	330,924	0	225,343	16,342,849
14			0	246,072	0	93,124	339,197	0	224,249	16,567,098
15			0	252,224	0	95,453	347,677	0	223,160	16,790,258
16			0	258,530	0	97,839	356,368	0	222,077	17,012,335
17			0	264,993	0	100,285	365,278	0	220,999	17,233,334
18			0	271,618	0	102,792	374,410	0	219,926	17,453,260
19			0	278,408	0	105,362	383,770	0	218,859	17,672,119
20			0	285,368	0	107,996	393,364	0	217,796	17,889,915

20-Year Present Worth	**17,889,915**

Activated Sludge	
Initial Cost	13,326,100
20-Year Present Worth	17,889,915
Average Annual Cost	314,276

Notes

City of Whitewater
Wastewater Facility Plan
Whitewater, WI

Activated Sludge

Present Worth Analysis Factors

Discount Rate	3.0%
Inflation Rate	0.5%
Escalation Rate (Above Inflation)	
Electricity (0-5 years)	2.0%
Electricity (6-20 years)	2.0%
Natural Gas	2.0%
Chemicals	2.0%

Comments

Electricity Escalation Rate = 2%

National Institute of Standards, Annual Supplement to NIST Handbook 135
Discount Rate = 3%
Inflation Rate = 0.5%
Natural Gas Escalation Rate = 2%

Life Cycle Cost Analysis

Initial Cost 21,646,599

Year (n)	Periodic Costs Replace	Periodic Costs Salvage	Annual Operational Costs O&M	Electricity	Natural Gas	Chemicals	Total Annual	PW Periodic	PW Annual	PW Cumulative
0			-275,929	247,852	0	73,119	45,043			21,646,599
1			-277,308	254,048	0	74,947	51,688	0	50,182	21,696,781
2			-278,695	260,400	0	76,821	58,526	0	55,166	21,751,947
3			-280,088	266,909	0	78,742	65,563	0	59,999	21,811,946
4			-281,489	273,582	0	80,710	72,804	0	64,685	21,876,631
5			-282,896	280,422	0	82,728	80,254	0	69,227	21,945,859
6			-284,311	287,432	0	84,796	87,918	0	73,630	22,019,489
7			-285,732	294,618	0	86,916	95,802	0	77,896	22,097,385
8			-287,161	301,984	0	89,089	103,912	0	82,029	22,179,413
9			-288,597	309,533	0	91,316	112,253	0	86,032	22,265,446
10			-290,040	317,272	0	93,599	120,831	0	89,910	22,355,355
11			-291,490	325,203	0	95,939	129,653	0	93,664	22,449,019
12			-292,947	333,333	0	98,337	138,724	0	97,298	22,546,317
13			-294,412	341,667	0	100,796	148,051	0	100,815	22,647,133
14			-295,884	350,208	0	103,316	157,640	0	104,219	22,751,351
15			-297,363	358,964	0	105,899	167,499	0	107,511	22,858,862
16			-298,850	367,938	0	108,546	177,634	0	110,695	22,969,558
17			-300,344	377,136	0	111,260	188,051	0	113,774	23,083,332
18			-301,846	386,565	0	114,041	198,760	0	116,750	23,200,082
19			-303,355	396,229	0	116,892	209,766	0	119,626	23,319,709
20			-304,872	406,134	0	119,815	221,077	0	122,405	23,442,114

20-Year Present Worth	**23,442,114**

Activated Sludge	
Initial Cost	21,646,599
20-Year Present Worth	23,442,114
Average Annual Cost	129,320

Notes

Appendix TM6-H

Capital Cost Estimates – Activated Sludge Options

CITY OF WHITEWATER
WASTEWATER FACILITY PLAN
WHITEWATER, WI

Activated Sludge

INITIAL COST ESTIMATE

General Description

Cost estimate to replace the existing RBCs with a three train UCT activated sludge system with two selectors and one aeration basin per train. A new secondary clarifier is included along with RAS pumping facilities. Costs include demolition of the existing RBCs and construction of new process building to house blowers, electrical components, and controls. Co-settling secondary sludge would be discontinued to optimize biological phosphorous removal so new mechanical thickening equipment would be required as well.

ITEM	Units	Quantity	Unit Cost ($)	Initial Cost ($)
Architectural/Structural				
Earthwork	See Worksheet for Detailed Cost Breakdown			259,259
Concrete	See Worksheet for Detailed Cost Breakdown			1,203,921
Metals	See Worksheet for Detailed Cost Breakdown			79,767
Buildings	See Worksheet for Detailed Cost Breakdown			521,375
Demolition	See Worksheet for Detailed Cost Breakdown			445,198
Diffusers	sf	7,125	18	124,688
Blowers	Ea	3	126,540	379,620
Secondary Clarifier Equipment	Ea	1	142,000	142,000
Selector Zone Mixers	Ea	6	15,000	90,000
IMLR Pumps	Ea	3	20,000	60,000
RAS Pumps	Ea	4	30,000	120,000
Sludge Thickening Equipment	Ea	1	100,000	100,000
Polymer Feed Equipment	Ea	1	12,000	12,000
Thickened Sludge Pump	Ea	2	20,000	40,000
WAS Pumps	Ea	1	16,000	16,000
Civil Not Listed Above	Ea	1	7%	$422,803
Process-Mechanical Piping Not Listed Above	Ea	1	8%	$483,204
Electrical Not Listed Above	Ea	1	12%	$724,806
Instrumentation and Control Not Listed Above	Ea	1	8%	$483,204
Plumbing Not Listed Above	Ea	1	1.5%	$90,601
HVAC Not Listed Above	Ea	1	4%	$241,602
Subtotal				6,040,047
Minus Major Equipment				
Blowers	Ea	3	126,540	379,620
Secondary Clarifier Equipment	Ea	1	142,000	142,000
RAS Pumps	Ea	4	30,000	120,000
Sludge Thickening Equipment	Ea	1	100,000	100,000
Selector Zone Mixers	Ea	6	15,000	90,000
IMLR Pumps	Ea	3	20,000	60,000
Subtotal				5,148,427
Contingency (w/o Major Equipment)			30%	*1,544,528*
Subtotal				6,692,956
Contractor Overhead & Profit (w/o Major Equipment)			25%	*1,673,239*
Major Equipment Contingency			10%	*83,162*
Total Construction Cost				**9,340,976**
Engineering			15%	1,401,146
Total Initial Cost				**10,742,123**

CITY OF WHITEWATER
WASTEWATER FACILITY PLAN
WHITEWATER, WI

Activated Sludge

ARCHITECTURAL/STRUCTURAL WORKSHEET

ITEM	Units	Quantity	Unit Cost ($)	Initial Cost ($)
Earthwork: Dewatering	lump sum	1	51,852	51,852
Earthwork: Excavation	cu yds	20,741	10	207,407
Earthwork: Underdrain System	sq yds			
Earthwork: Pile Foundation	ft			
Earthwork: Flood Protection Levee	cu yds			
Earthwork: Flood Protection Gravel Road	sq yds			
Earthwork:				
Earthwork				**259,259**
Concrete: Footings	cu yds		330	0
Concrete: Base Slab	cu yds	519	330	171,111
Concrete: Walls	cu yds	1,291	800	1,032,810
Concrete: Floor Slabs	cu yds		350	0
Concrete: Structural Slabs	cu yds		775	0
Concrete: Columns	cu yds			
Concrete: Channels	cu yds		1,009	0
Concrete: Class B Fill	cu yds		305	0
Concrete				**1,203,921**
Metals: Aluminum Grating	sq ft		28	0
Metals: Aluminum Handrail	ft	330	53	17,490
Metals: Aluminum Stairway	risers	49	414	20,286
Metals: Baffles and Weirs	sq ft	600	70	41,991
Metals:				
Metals				**79,767**
Building: One Story Brick and Block Process Bldg	sq ft	2,250	125	281,250
Building: One Story Brick and Block Thickening Bldg	sq ft	1,921	125	240,125
Building:	sq ft			
Building:	sq ft			
Building:	sq ft			
Building:	sq ft			
Buildings				**521,375**
Demolition: Selective Concrete	cu ft		30	0
Demolition: Structure	cu ft	635,998	0.70	445,198
Demolition: Mechanical	lump sum			
Demolition:	lump sum			
Demolition				**445,198**

CITY OF WHITEWATER
WASTEWATER FACILITY PLAN
WHITEWATER, WI

Activated Sludge

INITIAL COST ESTIMATE

General Description

Cost estimate to replace the existing RBCs with a three train UCT activated sludge system with two selectors and one aeration basin per train. Two new secondary clarifiers are included along with RAS pumping facilities. Costs include demolition of the existing RBCs and construction of new process building to house blowers, electrical components, and controls. Co-settling secondary sludge would be discontinued to optimize biological phosphorous removal so new mechanical thickening equipment would be required as well.

ITEM	Units	Quantity	Unit Cost ($)	Initial Cost ($)
Architectural/Structural				
Earthwork	See Worksheet for Detailed Cost Breakdown			285,985
Concrete	See Worksheet for Detailed Cost Breakdown			1,368,244
Metals	See Worksheet for Detailed Cost Breakdown			121,757
Buildings	See Worksheet for Detailed Cost Breakdown			521,375
Demolition	See Worksheet for Detailed Cost Breakdown			499,077
Diffusers	sf	7,125	18	124,688
Blowers	Ea	3	126,540	379,620
Secondary Clarifier Equipment	Ea	2	142,000	284,000
RAS Pumps	Ea	3	30,000	90,000
Selector Zone Mixers	Ea	6	15,000	90,000
IMLR Pumps	Ea	3	20,000	60,000
Sludge Thickening Equipment	Ea	1	100,000	100,000
Polymer Feed Equipment	Ea	1	12,000	12,000
Thickened Sludge Pump	Ea	2	20,000	40,000
WAS Pumps	Ea	1	16,000	16,000
Civil Not Listed Above	Ea	1	7%	$469,735
Process-Mechanical Piping Not Listed Above	Ea	1	8%	$536,840
Electrical Not Listed Above	Ea	1	12%	$805,260
Instrumentation and Control Not Listed Above	Ea	1	8%	$536,840
Plumbing Not Listed Above	Ea	1	1.5%	$100,657
HVAC Not Listed Above	Ea	1	4%	$268,420
Subtotal				6,710,496
Minus Major Equipment				
Blowers	Ea	3	126,540	379,620
Secondary Clarifier Equipment	Ea	2	142,000	284,000
RAS Pumps	Ea	3	30,000	90,000
Sludge Thickening Equipment	Ea	1	100,000	100,000
Selector Zone Mixers	Ea	6	15,000	90,000
IMLR Pumps	Ea	3	20,000	60,000
Subtotal				5,706,876
Contingency (w/o Major Equipment)			30%	*1,712,063*
Subtotal				7,418,939
Contractor Overhead & Profit (w/o Major Equipment)			25%	*1,854,735*
Major Equipment Contingency			10%	*94,362*
Total Construction Cost				**10,371,656**
Engineering			15%	1,555,748
Total Initial Cost				**11,927,404**

CITY OF WHITEWATER
WASTEWATER FACILITY PLAN
WHITEWATER, WI

Activated Sludge

ARCHITECTURAL/STRUCTURAL WORKSHEET

ITEM	Units	Quantity	Unit Cost ($)	Initial Cost ($)
Earthwork: Dewatering	lump sum	1	57,197	57,197
Earthwork: Excavation	cu yds	22,879	10	228,788
Earthwork: Underdrain System	sq yds			
Earthwork: Pile Foundation	ft			
Earthwork: Flood Protection Levee	cu yds			
Earthwork: Flood Protection Gravel Road	sq yds			
Earthwork:				
Earthwork				**285,985**
Concrete: Footings	cu yds		330	0
Concrete: Base Slab	cu yds	661	330	218,148
Concrete: Walls	cu yds	1,438	800	1,150,096
Concrete: Floor Slabs	cu yds		350	0
Concrete: Structural Slabs	cu yds		775	0
Concrete: Columns	cu yds			
Concrete: Channels	cu yds		1,009	0
Concrete: Class B Fill	cu yds		305	0
Concrete				**1,368,244**
Metals: Aluminum Grating	sq ft		28	0
Metals: Aluminum Handrail	ft	330	53	17,490
Metals: Aluminum Stairway	risers	49	414	20,286
Metals: Baffles and Weirs	sq ft	1,200	70	83,981
Metals:				
Metals				**121,757**
Building: One Story Brick and Block Process Bldg	sq ft	2,250	125	281,250
Building: One Story Brick and Block Thickening Bldg	sq ft	1,921	125	240,125
Building:	sq ft			
Building:	sq ft			
Building:	sq ft			
Building:	sq ft			
Buildings				**521,375**
Demolition: Selective Concrete	cu ft		30	0
Demolition: Structure	cu ft	712,967	0.70	499,077
Demolition: Mechanical	lump sum			
Demolition:	lump sum			
Demolition				**499,077**

CITY OF WHITEWATER
WASTEWATER FACILITY PLAN
WHITEWATER, WI

Activated Sludge

INITIAL COST ESTIMATE

General Description

Cost estimate to replace the existing RBCs with an activated sludge system that repurposes the existing secondary clarifiers as aeration basins. Two new secondary clarifiers are included along with RAS pumping facilities. Costs include demolition of the existing RBCs and construction of new process building to house blowers, electrical components, and controls. Co-settling secondary sludge would be discontinued to optimize biological phosphorous removal so new mechanical thickening equipment would be required as well.

ITEM	Units	Quantity	Unit Cost ($)	Initial Cost ($)
Architectural/Structural				
Earthwork	See Worksheet for Detailed Cost Breakdown			285,985
Concrete	See Worksheet for Detailed Cost Breakdown			1,006,032
Metals	See Worksheet for Detailed Cost Breakdown			121,757
Buildings	See Worksheet for Detailed Cost Breakdown			521,375
Demolition	See Worksheet for Detailed Cost Breakdown			545,198
Diffusers	sf	**7,125**	**18**	124,688
Blowers	Ea	**3**	**126,540**	379,620
Secondary Clarifier Equipment	Ea	**2**	**142,000**	284,000
Selector Zone Mixers	Ea	**6**	**15,000**	90,000
IMLR Pumps	Ea	**3**	**20,000**	60,000
RAS Pumps	Ea	**3**	**30,000**	90,000
Sludge Thickening Equipment	Ea	**1**	**100,000**	100,000
Polymer Feed Equipment	Ea	**1**	**12,000**	12,000
Thickened Sludge Pump	Ea	**2**	**20,000**	40,000
WAS Pumps	Ea	**1**	**16,000**	16,000
Civil Not Listed Above	Ea	**1**	**7%**	$432,548
Process-Mechanical Piping Not Listed Above	Ea	**1**	**8%**	$494,340
Electrical Not Listed Above	Ea	**1**	**12%**	$741,510
Instrumentation and Control Not Listed Above	Ea	**1**	**8%**	$494,340
Plumbing Not Listed Above	Ea	**1**	**1.5%**	$92,689
HVAC Not Listed Above	Ea	**1**	**4%**	$247,170
Subtotal				6,179,252
Minus Major Equipment				
Blowers	Ea	3	126,540	379,620
Secondary Clarifier Equipment	Ea	2	142,000	284,000
RAS Pumps	Ea	3	30,000	90,000
Sludge Thickening Equipment	Ea	1	100,000	100,000
Selector Zone Mixers	Ea	6	15,000	90,000
IMLR Pumps	Ea	3	20,000	60,000
Subtotal				5,175,632
Contingency (w/o Major Equipment)			**30%**	*1,552,690*
Subtotal				6,728,322
Contractor Overhead & Profit (w/o Major Equipment)			**25%**	*1,682,081*
Major Equipment Contingency			**10%**	*94,362*
Total Construction Cost				**9,508,385**
Engineering			**15%**	1,426,258
Total Initial Cost				**10,934,642**

CITY OF WHITEWATER
WASTEWATER FACILITY PLAN
WHITEWATER, WI

Activated Sludge

ARCHITECTURAL/STRUCTURAL WORKSHEET

ITEM	Units	Quantity	Unit Cost ($)	Initial Cost ($)
Earthwork: Dewatering	lump sum	1	57,197	57,197
Earthwork: Excavation	cu yds	22,879	10	228,788
Earthwork: Underdrain System	sq yds			
Earthwork: Pile Foundation	ft			
Earthwork: Flood Protection Levee	cu yds			
Earthwork: Flood Protection Gravel Road	sq yds			
Earthwork:				
Earthwork				**285,985**
Concrete: Footings	cu yds		330	0
Concrete: Base Slab	cu yds	488	330	161,111
Concrete: Walls	cu yds	1,056	800	844,922
Concrete: Floor Slabs	cu yds		350	0
Concrete: Structural Slabs	cu yds		775	0
Concrete: Columns	cu yds			
Concrete: Channels	cu yds		1,009	0
Concrete: Class B Fill	cu yds		305	0
Concrete				**1,006,032**
Metals: Aluminum Grating	sq ft		28	0
Metals: Aluminum Handrail	ft	330	53	17,490
Metals: Aluminum Stairway	risers	49	414	20,286
Metals: Baffles and Weirs	sq ft	1,200	70	83,981
Metals:				
Metals				**121,757**
Building: One Story Brick and Block Process Bldg	sq ft	2,250	125	281,250
Building: One Story Brick and Block Thickening Bldg	sq ft	1,921	125	240,125
Building:	sq ft			
Building:	sq ft			
Building:	sq ft			
Building:	sq ft			
Buildings				**521,375**
Demolition: Selective Concrete	cu ft		30	0
Demolition: Structure	cu ft	635,998	0.70	445,198
Demolition: Mechanical	lump sum	1	100,000	100,000
Demolition:	lump sum			
Demolition				**545,198**