312 W Whitewater Street | Whitewater, WI 53190

Wastewater Facility Plan
Technical Memorandum 3
Nutrient Management

City of Whitewater
July 2014

Prepared by:

Donohue & Associates, Inc.

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

Donohue Project No.: 12600

FACILITY PLANNING
TM 3 NUTRIENT MANAGEMENT
CITY OF WHITEWATER

TABLE OF CONTENTS

Chapter I – Purpose and Background Information 1
1.1 Purpose 1
1.2 Background Information 1
Chapter II – Design Basis 2
2.1 Hydraulics 2
2.2 Filter Sizing 3
Chapter III – Disc Filters 5
3.1 Technology Overview 5
3.2 Application 7
Chapter IV – ContinUous Backwash Filters 8
4.1 Technology Overview 8
4.2 Application 9
Chapter V – Clean Waters, Healthy Economy Act 10
5.1 Overview 10
Chapter VI – Conclusions 12
6.1 Alternative Comparison 12
6.2 Recommendations 14

LIST OF TABLES

Table 1: 2035 Design Loadings 1
Table 2: Nutrient Management Alternatives Strategic Direction Evaluation Summary 13

LIST OF FIGURES

Figure 1: Filtration Head Available 2
Figure 2: 2010-2013 Influent Flow Distribution 3
Figure 3: Predicted Effluent Phosphorous Concentrations with 4 mgd Fine Filter Capacity 4
Figure 4: Cloth Media Disc Filter Flow Path 5
Figure 5: Example of a Fixed Disk Cloth Media Filtration System 5
Figure 6: Example Schematic of a Chemical Addition Tank (Courtesy of Kruger) 6

FACILITY PLANNING
TM 3 NUTRIENT MANAGEMENT
CITY OF WHITEWATER

Figure 7: Continuous Backwash Filter 8
Figure 8: Potential Clean Waters, Healthy Economy Payments 11
Figure 9: Alternative Cumulative Present Worths 12
Figure 10: Alternative Cumulative Present Worths with Future Disc Filter Installation 13

APPENDICES

Appendix TM3-A: Technology Screening
Appendix TM3-B: Additional Figures
Appendix TM3-C: Economic Evaluation

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 a forthcoming low level phosphorous limit expected to be formally issued in the fall of 2014 when the facility's discharge permit is renewed. This permit is expected to contain a monthly average phosphorous limit of 0.225 mg/L and a six month seasonal phosphorous limit of 0.075 mg/L. The purpose of this Technical Memorandum (TM 3) is to evaluate nutrient management technologies for the City of Whitewater's wastewater treatment facility that will meet the new effluent requirements.

1.2 BACKGROUND INFORMATION

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

An initial screening of nutrient management technologies was conducted as part of a February 18, 2014 Evaluation Workshop with City of Whitewater personnel. Technologies summaries from the Workshop are included in Appendix TM3-A. The initial technologies discussed included:

- Deep Bed Sand Filters
- Continuous Backwash Filters
- Disc Filters
- Tertiary Membranes
- Fuzzy Filters
- Actiflo

After discussion it was determined that continuous backwash filters and disc filters merited further evaluation. The Clean Waters, Healthy Economy Act was also discussed as a potential nutrient management alternative.

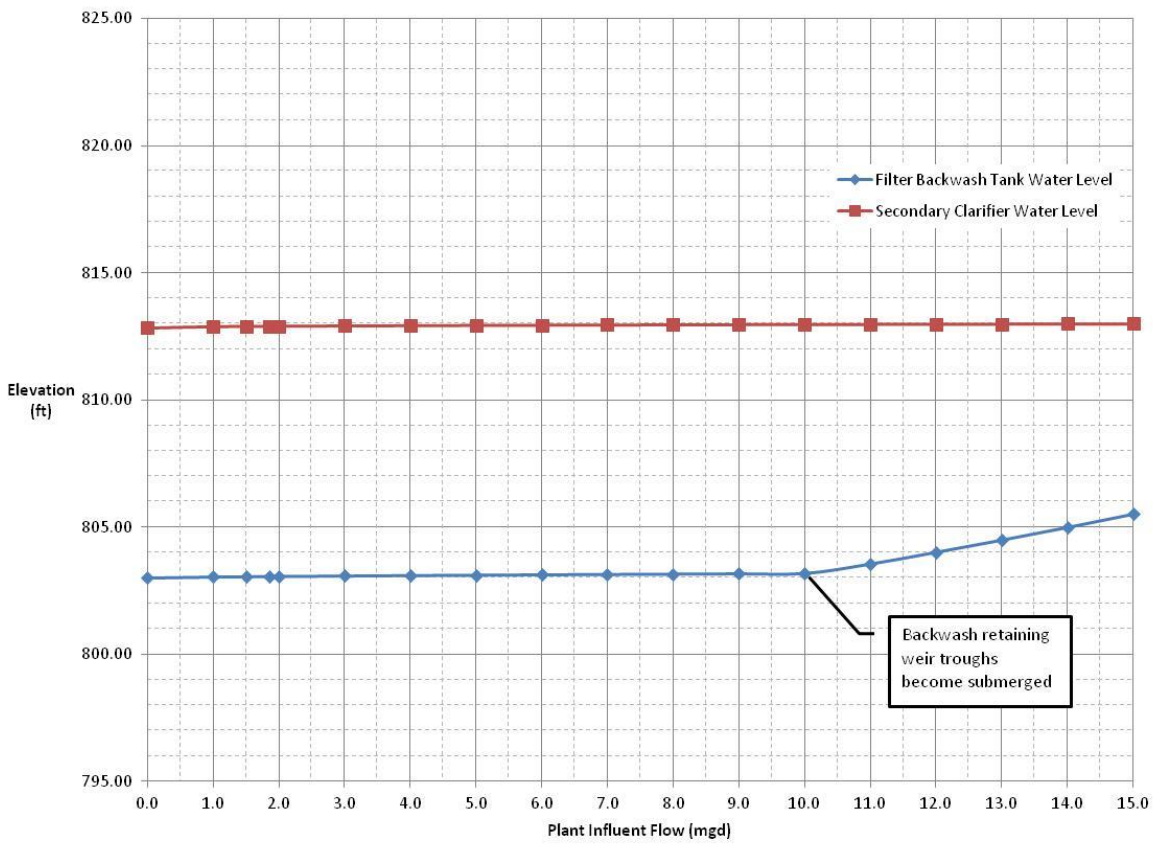
CHAPTER II – DESIGN BASIS

2.1 HYDRAULICS

Hydraulics is one of the largest challenges when adding a tertiary treatment technology for low level phosphorus requirements. Many facilities have little to no hydraulic head available between the secondary clarifiers and disinfection process, and an effluent pump station is required for the tertiary treatment technology. This effluent pump station requirement can add significant capital and operational costs to a project.

TM 5 - Hydraulic Capacity evaluates the existing hydraulic situation at the plant in detail. For the Whitewater wastewater treatment facility, there is approximately 10 feet of head between the water surface of the secondary clarifiers and the existing filter backwash tank upstream of UV disinfection as shown in Figure 1. This head should allow the installation of additional filtration capacity without the need for a new pump station.

Figure 1: Filtration Head Available



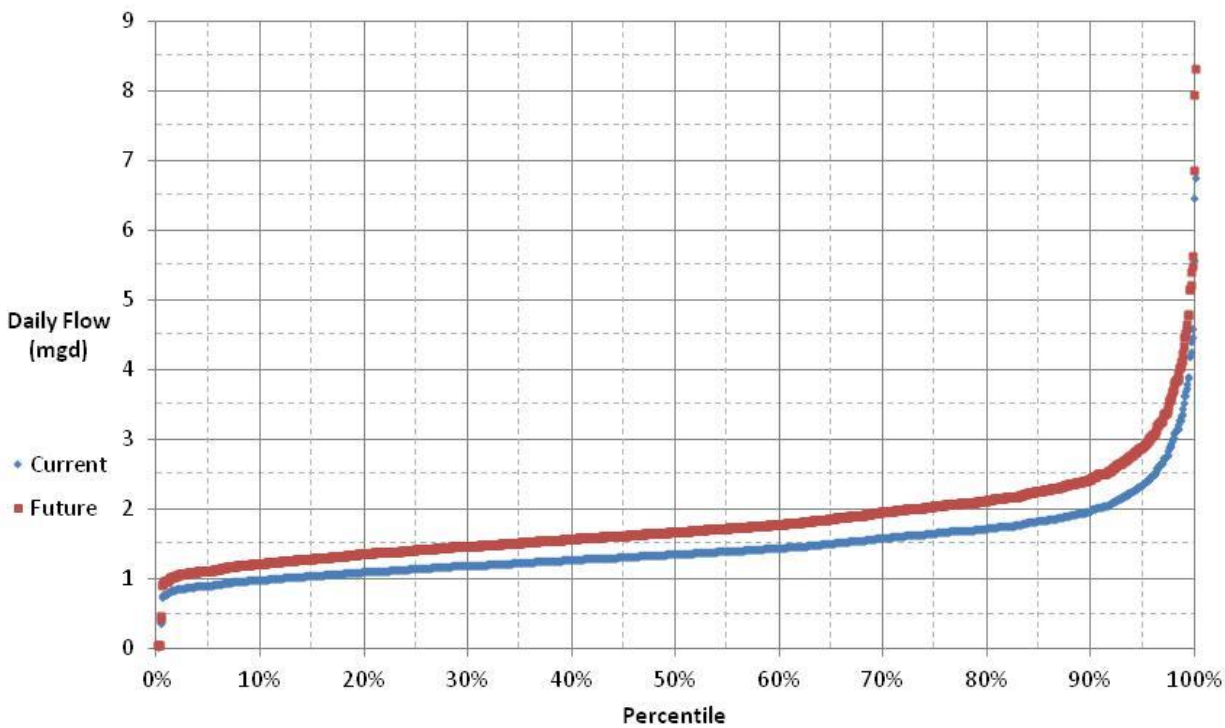
2.2 FILTER SIZING

Sizing new effluent fine filters to treat the complete peak hourly design flow of 11.0 mgd to meet low level phosphorous limits is not cost effective or necessary. The bulk of phosphorus will be removed in the secondary treatment system (discussed in TM 6 Liquids Treatment in detail). Polishing to achieve the very low effluent phosphorous limits will be accomplished by chemical precipitation of secondary effluent followed by effluent filtration making use of new fine filters and existing effluent filters, depending on plant flows.

New fine filters will be sized to provide a firm treatment capacity of 4 mgd. Flows above this will be directed to the plant's existing effluent filters, which have a firm capacity of approximately 4.5 mgd. Thus a firm capacity of 8.5 mgd will be able to receive filtration. The portion of the flow above 8.5 mgd will not receive filtration and will have a phosphorous concentration equal to the secondary effluent phosphorous concentration and be bypassed to UV disinfection.

Figure 2 shows historical influent flow, as a probability distribution, for the years 2010 through 2013. As can be seen, the facility did not experience a daily flow greater than 6.8 mgd. In terms of planning period design flow, the plant's current average design flow of 1.5 mgd will be increased to 1.85 mgd and the peak daily flow will increase to 8.4 mgd.

Figure 2: 2010-2013 Influent Flow Distribution



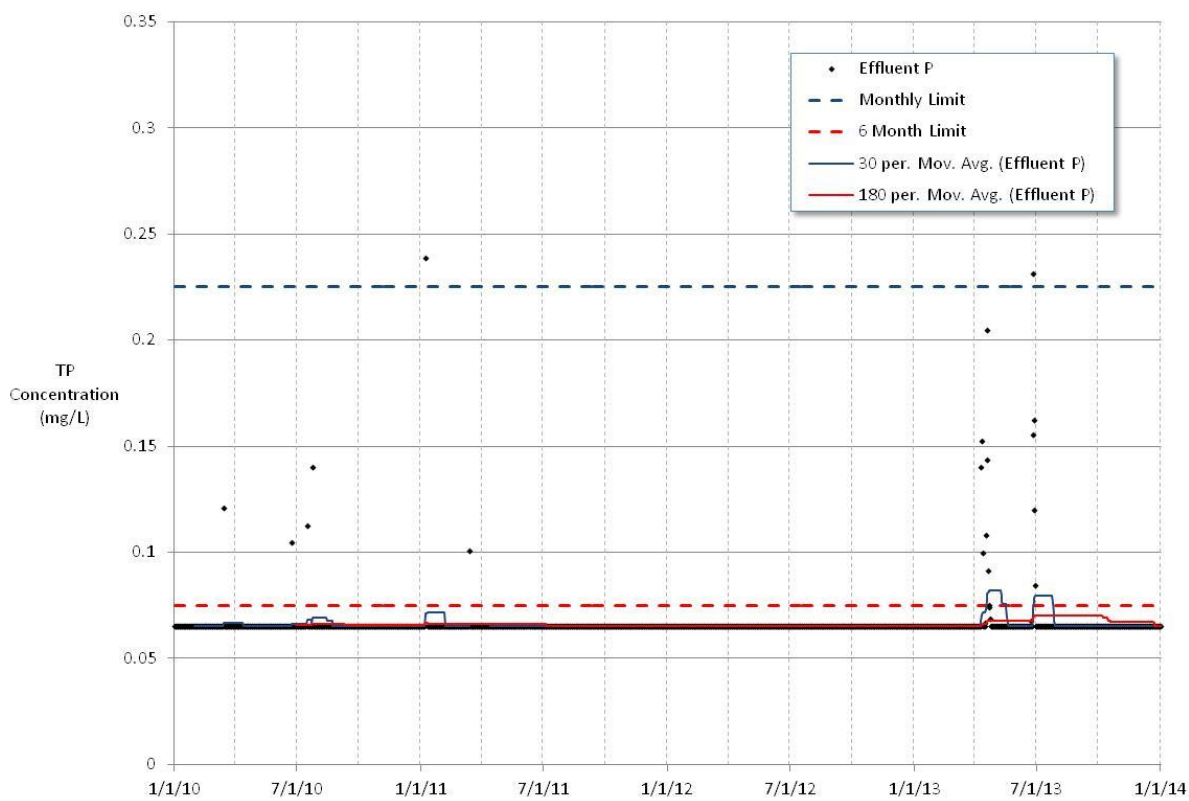
Continuous backwash filters and disc filters have shown the capability of achieving effluent phosphorous levels below 0.05 mg/L with proper chemical polishing treatment. Assuming the existing effluent filters, with proper chemical polishing, can achieve 0.4 mg/L effluent TP, and the secondary treatment system

selected in TM 6 can produce a 0.5 mg/L phosphorous effluent, a mass balance simulation to predict future effluent phosphorous was performed for the 2010-2013 flow record (daily flows multiplied by 1.23 to simulate future conditions). This simulation assumed:

- The first 4 mgd of plant flow received full treatment through the fine filter train, producing effluent phosphorous of 0.065 mg/L.
- The next 4.5 mgd of plant flow received full treatment through the existing filter train, producing effluent phosphorous of 0.4 mg/L.
- Any flows above 8.5 mgd received chemical precipitation via the secondary treatment process, producing effluent phosphorous of 0.5 mg/L.

The results of these daily simulations, in terms of projected plant combined effluent phosphorous concentration, is shown in Figure 3. As can be seen, compliance with the monthly (red line) and 6-month (blue line) limits would be achieved under every flow condition.

Figure 3: Predicted Effluent Phosphorous Concentrations with 4 mgd Fine Filter Capacity



The capability of any filter technology to meet a 0.065 mg/L effluent phosphorous concentration must be validated with onsite pilot testing prior to design and construction.

CHAPTER III – DISC FILTERS

3.1 TECHNOLOGY OVERVIEW

Disc filters remove solids at the surface of the fabric by physical straining, as shown in Figure 4. A straining material, either woven or cloth material, is mounted on disks or frames, and water flows from the outside of the filter to the inside of the filter. Disc filters achieve filtration similar to sand filters; however, the surface area per volume is greatly increased as the disc filters can be arranged such that multiple sides are exposed to the water, whereas the sand filters are flat and therefore have only one exposure surface. Disc filters also require less backwash water; perform better at elevated suspended solids concentrations; and can be installed in concrete, fiberglass, or steel tanks. An example of a fixed disk cloth media filtration system with automatic backwash is shown in Figure 5.

Figure 4: Cloth Media Disc Filter Flow Path

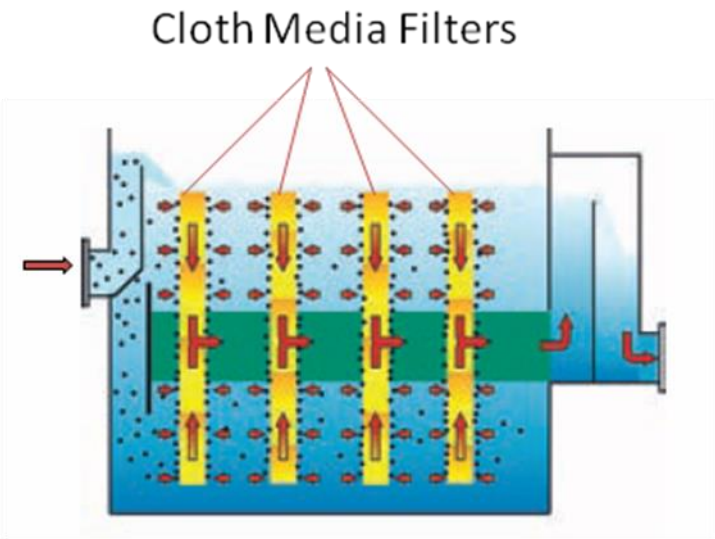
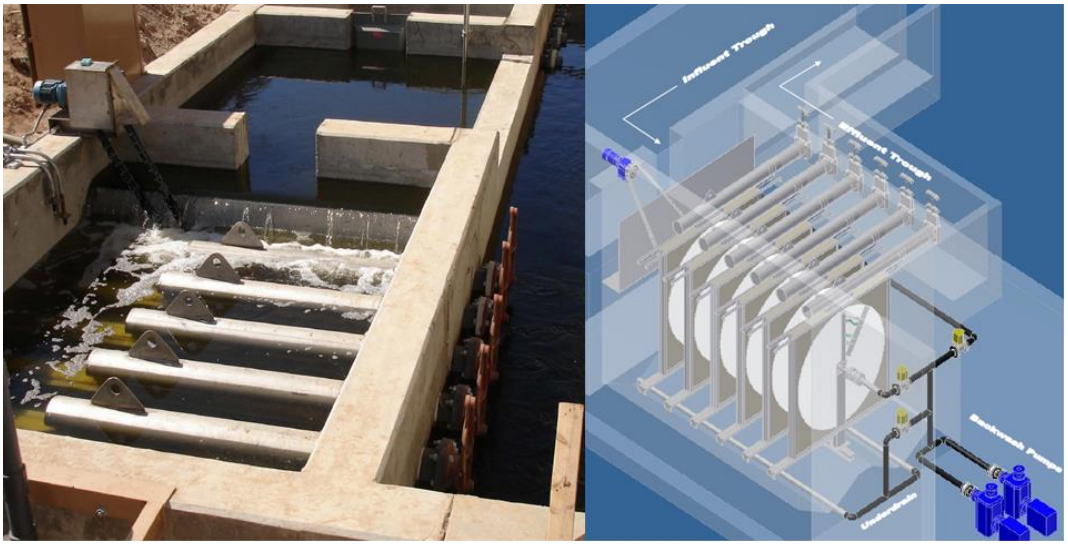


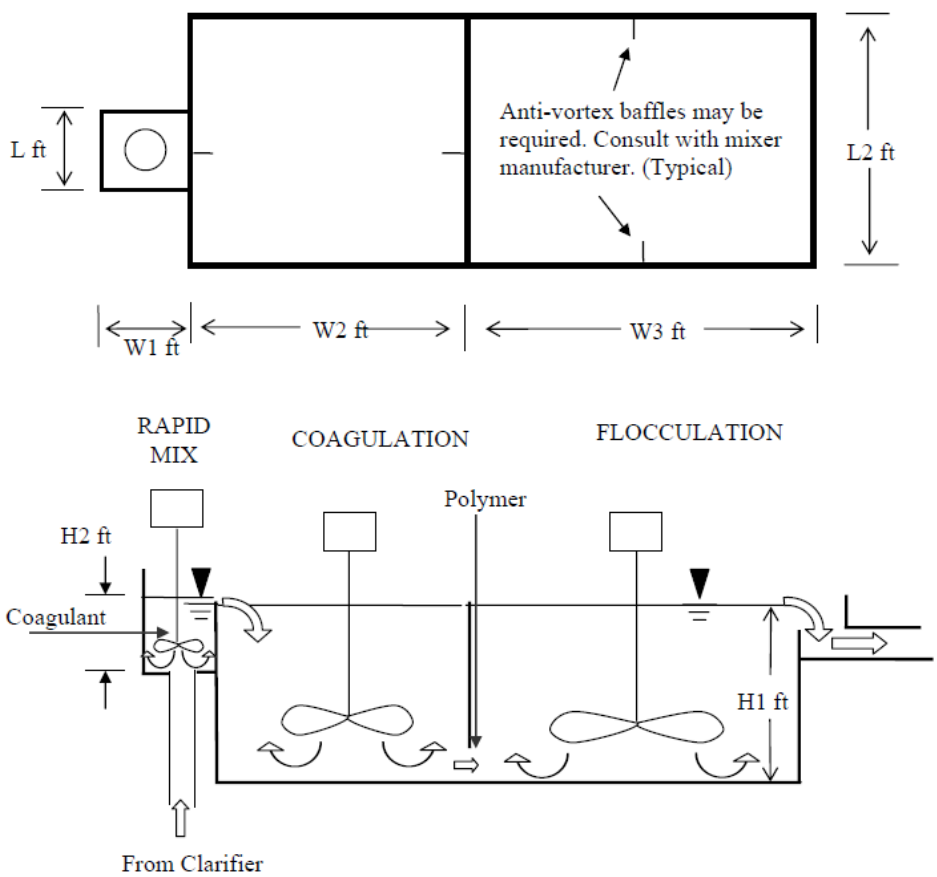
Figure 5: Example of a Fixed Disk Cloth Media Filtration System



Disc media filters are backwashed similarly to the granular media filters, and the backwash water is again returned to the head of the facility. Disc filter backwash rates are significantly lower than granular media filters, with disc filter backwash rates typically in the range of 1 to 4% of forward flow. Multiple units are included, with the number varying with the manufacturer. The media in disc filters is more expensive than the sand, but less material is required and smaller tanks are required with the cloth media.

For low level phosphorus removal, the disc filters have been reported to achieve effluent concentrations below 0.3 mg/L without upstream chemical addition. However, for lower concentrations an upstream chemical addition tank would be required. This chemical addition tank would consist of three compartments: a rapid mix basin, coagulation basin, and maturation/flocculation basin. A schematic of this basin is shown in Figure 6. This chemical tank ensures efficient chemical binding of any soluble phosphorus that leaves the activated sludge system in the secondary effluent. The flocculated solids from this system would then be removed in the disc filters. Effluent phosphorus concentrations as low as 0.05 mg/L have been reported for disc filtration pilot systems with efficient chemical addition.

Figure 6: Example Schematic of a Chemical Addition Tank (Courtesy of Kruger)



3.2 APPLICATION

Implementation of this alternative would include the installation of:

- A splitter box between the secondary clarifiers and filters to divide flow to a chemical addition tank preceding the new continuous backwash filters and existing effluent filters and bypass high flows (over 7.5 mgd) around filtration.
- A chemical coagulation and flocculation tank approximately 19’ x19’ preceding the filters.
- A 39’ x 50’ fine filter building containing:
    - Alum and polymer feed facilities for use in the coagulation and flocculation basins.
    - Two disc filter units with a capacity of 4.0 mgd each providing for one redundant filter unit.

Appendix TM3-B contains a conceptual site plan for this alternative. A detailed economic evaluation was performed estimating the initial cost, annual operational costs, and the overall present worth for this alternative and is contained in Appendix TM3-C. Installation of disc filters has an estimated construction cost of $3,991,000 and a 20-year present worth of $5,877,000.

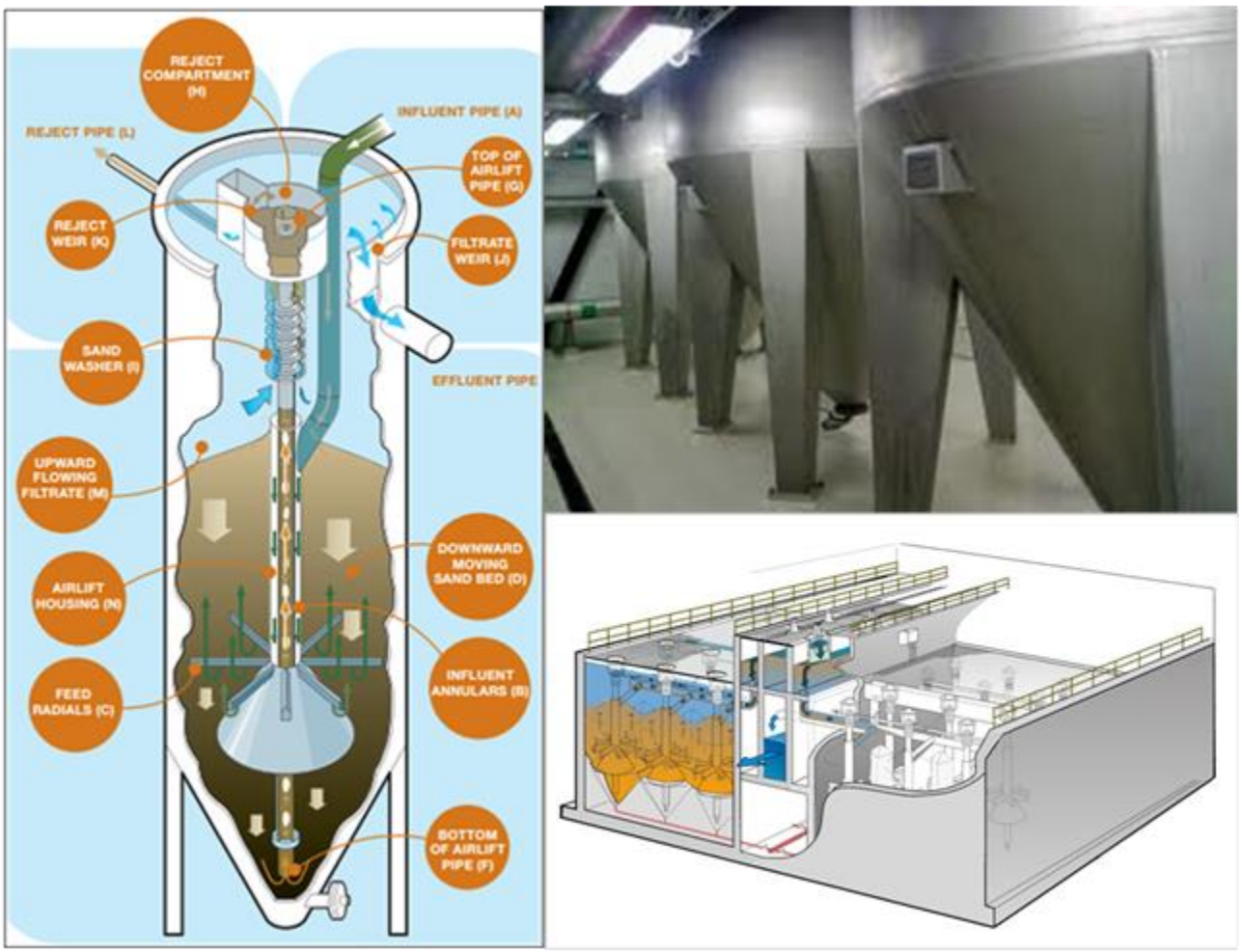
CHAPTER IV – CONTINUOUS BACKWASH FILTERS

4.1 TECHNOLOGY OVERVIEW

Continuous backwash filtration is very similar to the existing effluent filters with the exception that the filtration depth is typically deeper and flows up through the filter, rather than downward. As a result continuous backwash filters are more difficult to fit within existing hydraulic profiles.

The deeper filtration beds allow for very high levels of TSS removal, and as such are capable of achieving effluent TP below 0.05 mg/L with proper chemical conditioning and two stage operations. The units are continuously backwashed using a small air supply functioning as an airlift pump to scour and clean the filtration media, after which it is returned to the bulk tank volume. Figure 7 provides a schematic image of a single unit along with examples of how the units can be installed either individually or in common tankage.

Figure 7: Continuous Backwash Filter



4.2 APPLICATION

Implementation of this alternative would include the installation of:

- A splitter box between the secondary clarifiers and filters to divide flow to a chemical addition tank preceding the new continuous backwash filters and existing effluent filters and bypass high flows (over 7.5 mgd) around filtration.
- A chemical coagulation and flocculation tank approximately 19’ x19’ preceding the filters.
- A 57’ x 70’ fine filter building containing:
    - Alum and polymer feed facilities for use in the coagulation and flocculation basins.
    - Continuous backwash filter units with a total capacity of 4.0 mgd consisting of 5 filter modules with two cells per module.

Appendix TM3-B contains a conceptual site plan for this alternative. A detailed economic evaluation was performed estimating the initial cost, annual operational costs, and the overall present worth for this alternative and is contained in Appendix TM3-C. Installation of continuous backwash filters has an estimated construction cost of $5,583,000 and a 20-year present worth of $7,154,000.

CHAPTER V – CLEAN WATERS, HEALTHY ECONOMY ACT

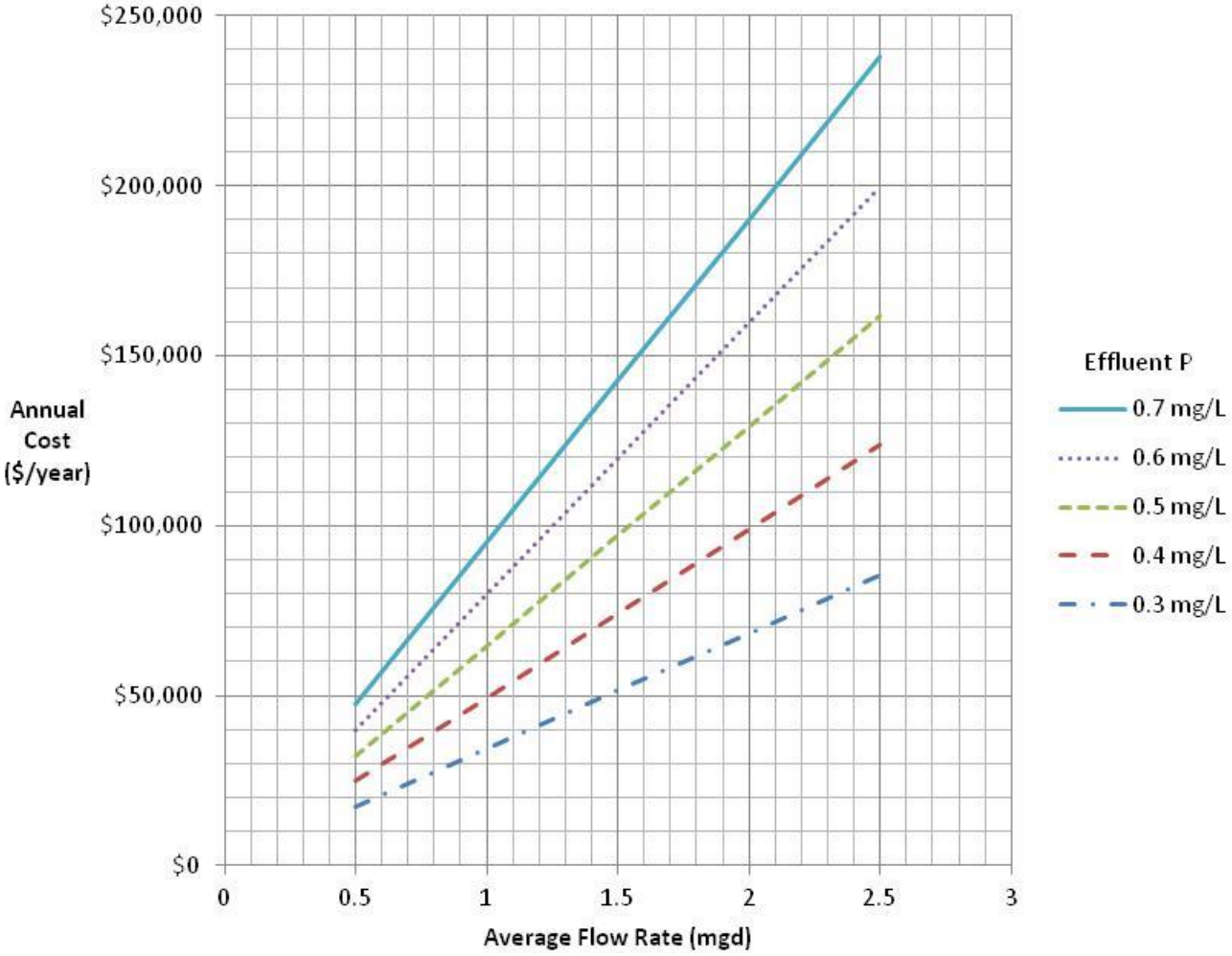
5.1 OVERVIEW

The Clean Waters, Healthy Economy Act creates an option for both municipal and industrial phosphorous point sources to receive additional time and flexibility to comply with Wisconsin's new low level phosphorous requirements. In exchange, these point sources must make gradual improvements at their own facilities while contributing financial resources toward reducing nonpoint pollution at other locations. Permittees would be required to certify that they cannot meet their new low level phosphorous limit without a major facility upgrade to opt into the proposed effluent variance. Permittees would be required to continually work toward meeting their low level limit and make improvements over time while contributing financially to help reduce nonpoint pollution in their watersheds. The effluent variance would need to be renewed in each 5-year permit cycle for a 20-year term.

Permittees would be required pay a fee based on the difference between the pounds of phosphorus in their discharge compared to a 0.075 mg/L effluent concentration. Fees would be sent to the county to improve their existing non-point phosphorous control programs or used for phosphorus reduction projects approved by the DNR. The county would be required to target the funds towards efforts that would result in the greatest phosphorus reductions.

Figure 8 on the next page shows the range of potential annual costs for the City of Whitewater assuming the proposed $50/lb of additional phosphorous beyond the City's expected six-month phosphorous limit of 0.075 mg/L with varying plant flows and effluent phosphorous concentrations.

Figure 8: Potential Clean Waters, Healthy Economy Payments



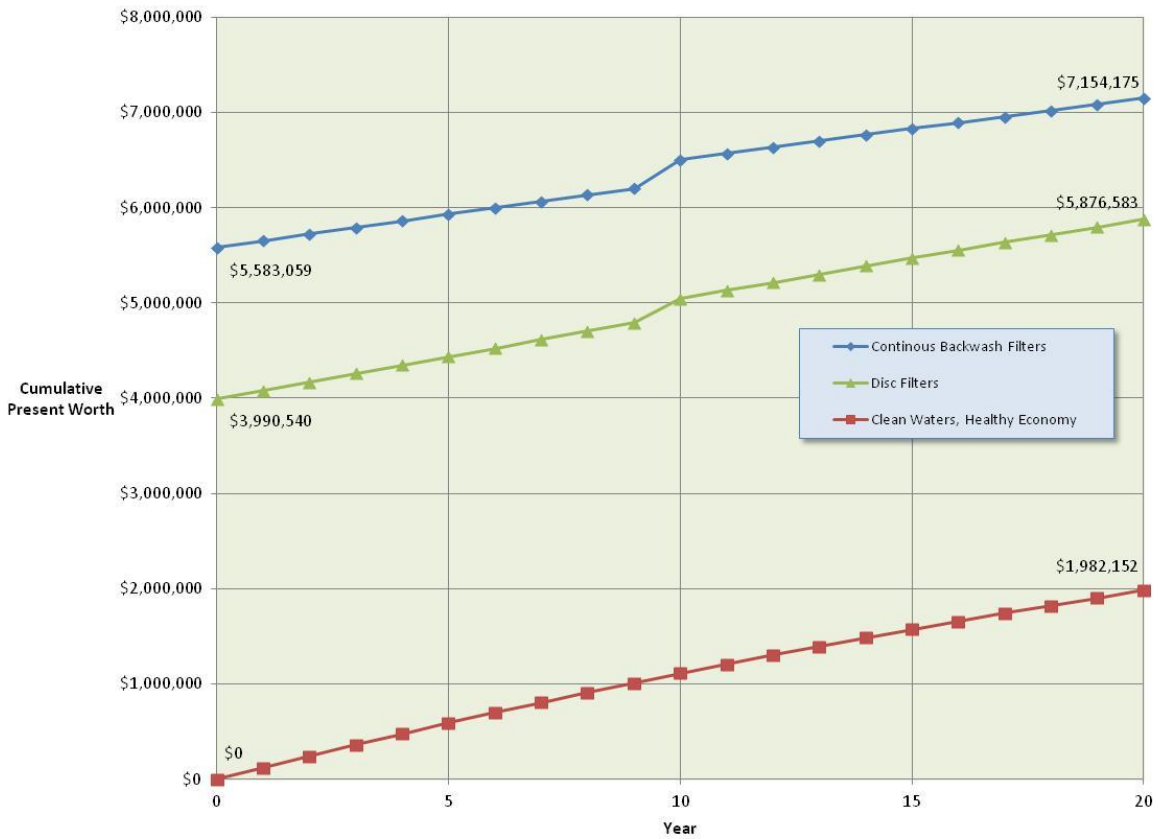
From 2010 through 2013, the wastewater treatment facility averaged 1.5 mgd of flow with an effluent phosphorous concentration of 0.63 mg/L, which corresponds to an annual payment of $127,000 to the County. The economic evaluation in Appendix TM3-C converts this annual cost to a present worth of $1,982,000.

CHAPTER VI – CONCLUSIONS

6.1 ALTERNATIVE COMPARISON

Figure 9 below shows the cumulative present worth of the considered alternatives over the 20 year planning period.

Figure 9: Alternative Cumulative Present Worths



If the Clean Waters, Healthy Economy Act passes in its current form, it will be the most cost effective solution. Even if water quality standards are not being met within the watershed and the City is required to install disc filters or another technology at a later date, it still remains a very cost effective solution, as shown in Figure 10.

Figure 10: Alternative Cumulative Present Worths with Future Disc Filter Installation

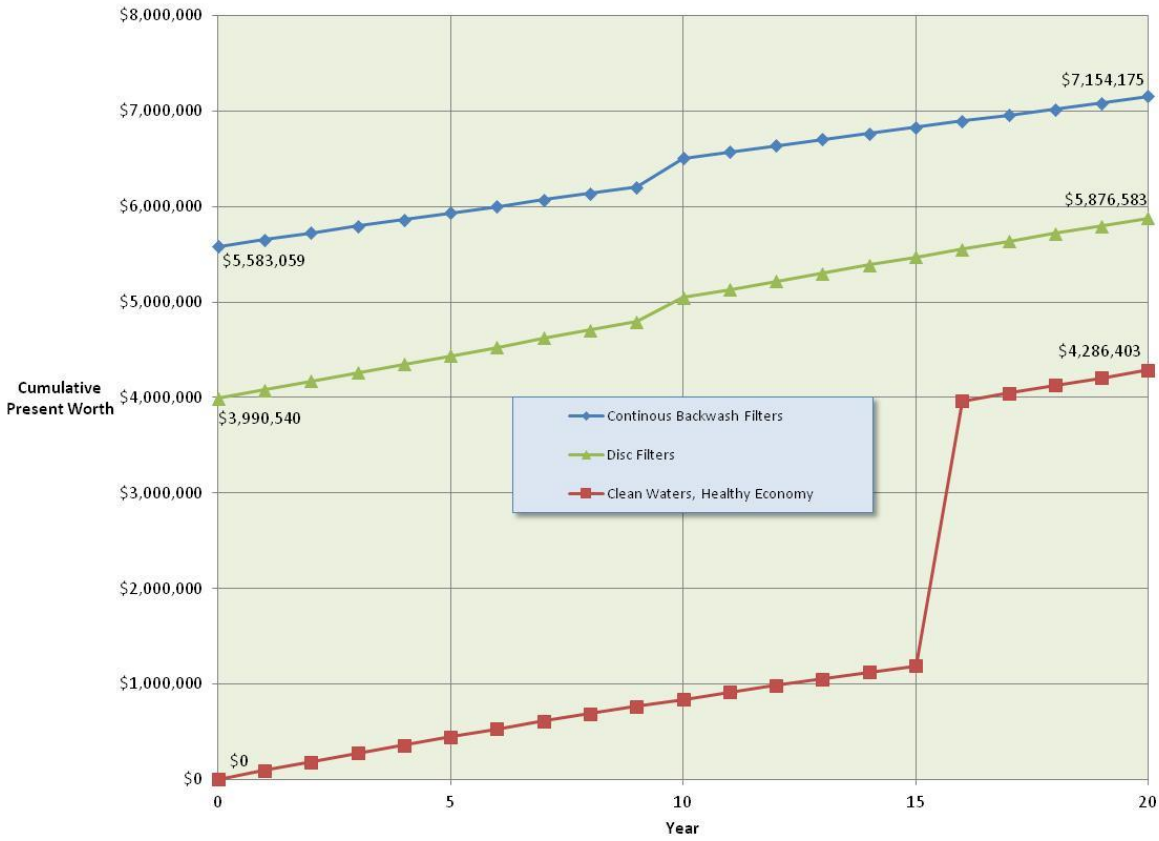


Table 2 summarizes the results of the Nutrient Management Evaluation in terms of the strategic direction criteria established in TM 1.

Table 2: Nutrient Management Alternatives Strategic Direction Evaluation Summary

Metric	Continuous Backwash Filters	Disc Filters	Clean Waters, Healthy Economy
Energy required (kwh/year)	98,860	38,386	-
Energy production potential (kwh/year)	-	-	-
Biosolids production rate (tons/year)	-	-	-
Chemical requirement – Liquids (gallons/year)	29,784	46,830	-
Chemical requirements – Sidestream (gallons/year)	-	-	-
Nitrogen removal potential	YES	NO	-
Sidestream phosphorus recovery potential (tons/year)	-	-	-
Reuse quality water (gallons/year)	-	-	-
Construction Phasing/Expandability (Scale 1 to 10)	5	7	10
Operational complexity (Scale 1 to 10)	4	7	10
Operational flexibility (Scale 1 to 10)	8	6	1
Impact on emerging contaminants (Relative ranking)	7	5	1

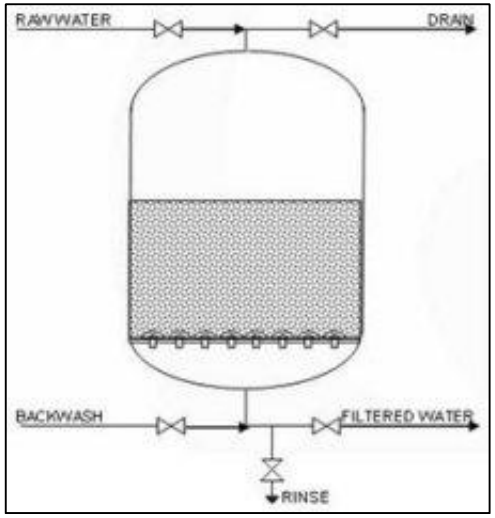
6.2 RECOMMENDATIONS

The Clean Waters, Healthy Economy act offers the greatest economic with minimal downside. Currently the act is making its way through the State Legislature. If the act passes, the City should pursue the phosphorous effluent variance available through it.

Should future fine filters be required, the City should arrange for pilot testing prior to proceeding to design to verify planning level performance assumptions. Based on the economic evaluation, a pilot comparison of the continuous backwash filters and disc filters should be conducted.

Appendix TM3-A
Technology Screening

Deep Bed Sand Filters



Energy
High backwash (up to 10%)

Phosphorus Removal
<0.1 mg/L

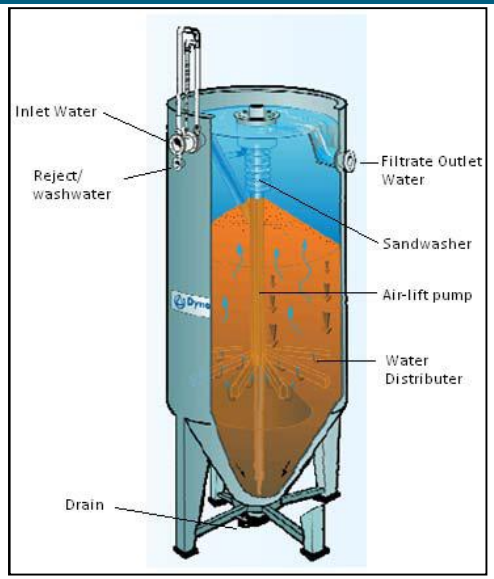
Operability
Frequent, long backwash; media

Ancillary Components
Large footprint, large building; floc tank

Reuse Water Potential
"Drinking water" quality possible

Future Regulations
Emerging: chemical adsorption and filtration

Continuous Backwash Filters



Energy
Continuous backwash (up to 10%)

Phosphorus Removal
<0.1 mg/L

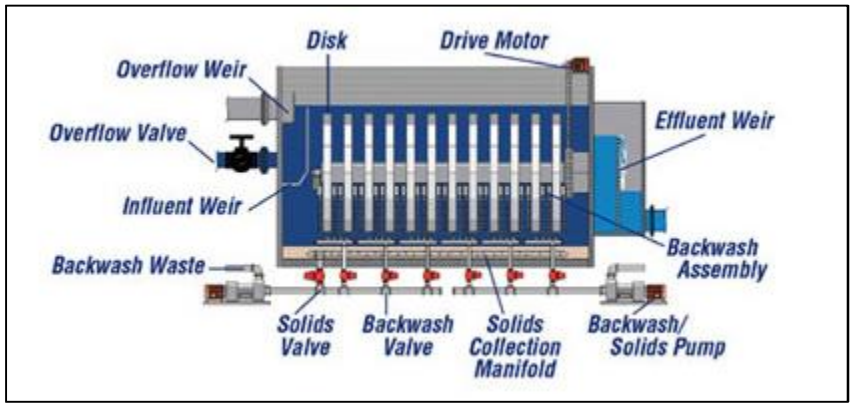
Operability
Frequent backwash; media

Ancillary Components
Modular design

Reuse Water Potential
"Drinking water" quality possible

Future Regulations
Emerging: chemical adsorption and filtration

Disc Filters



Energy
Reduced backwash (1-2%)

Phosphorus Removal
<0.075 mg/L

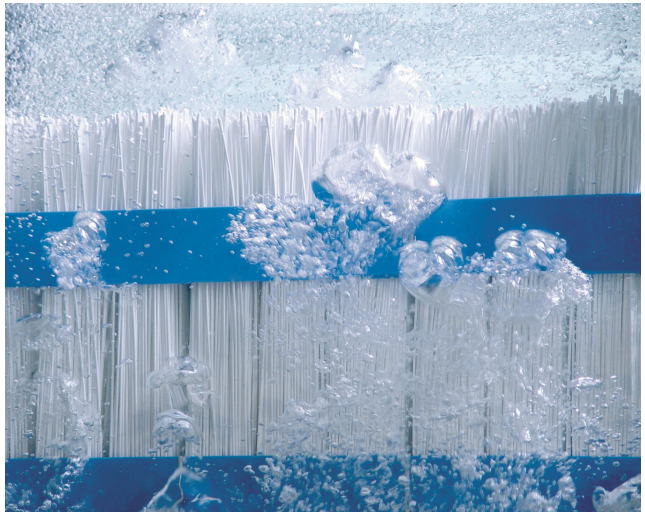
Operability
Simple operation; no media

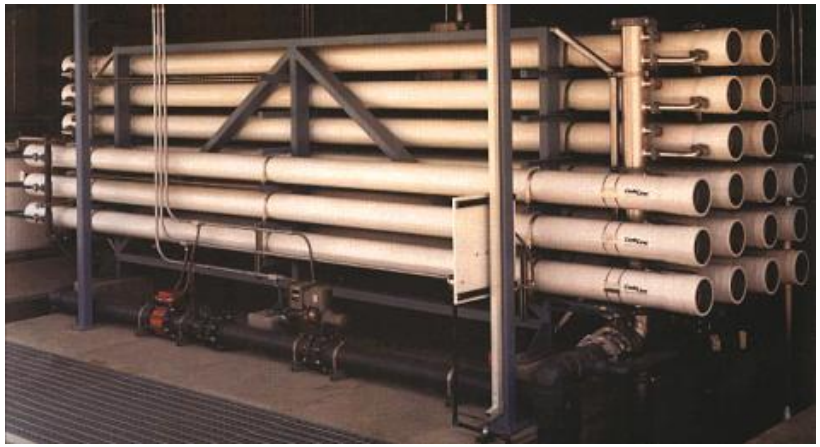
Ancillary Components
Smaller footprint; floc tank

Reuse Water Potential
Low TSS

Future Regulations
Emerging: chemical adsorption and filtration

Membranes





Energy
Highest energy

Phosphorus Removal
<0.05 mg/L

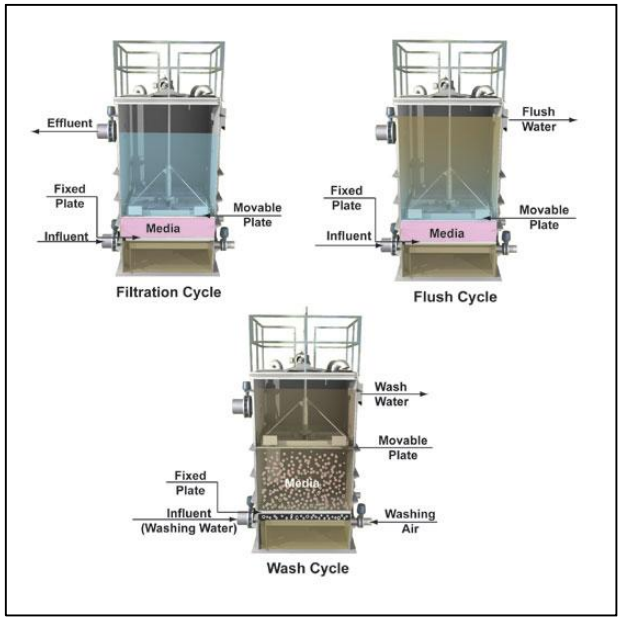
Operability
Membranes and pumps

Ancillary Components
Smaller footprint; floc tank

Reuse Water Potential
Highest quality possible

Future Regulations
Emerging: highest removal

Fuzzy Filters



Energy
Air scouring; backwash (5%)

Phosphorus Removal
<0.15 mg/L

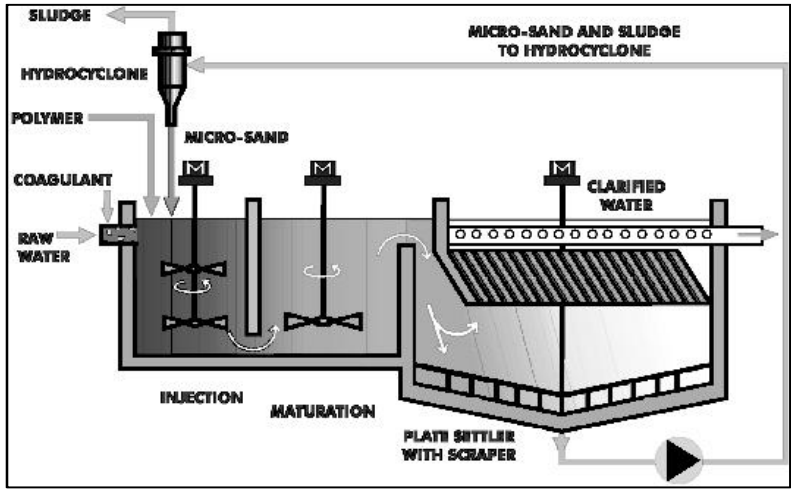
Operability
Fuzzy media replacement

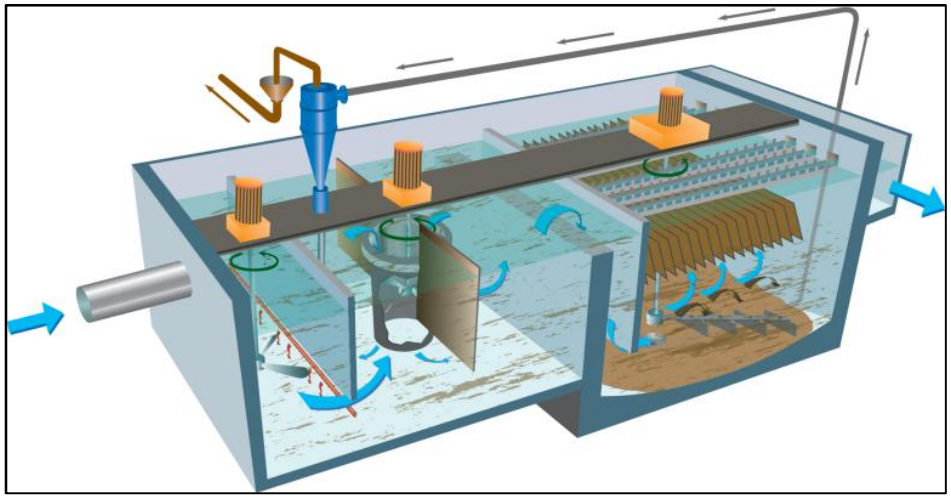
Ancillary Components
Modular design; moving parts

Reuse Water Potential
Title 22 reuse certified

Future Regulations
Emerging: chemical adsorption and filtration

Actiflo





Energy
Pumping; mixing

Phosphorus Removal
<0.075 mg/L

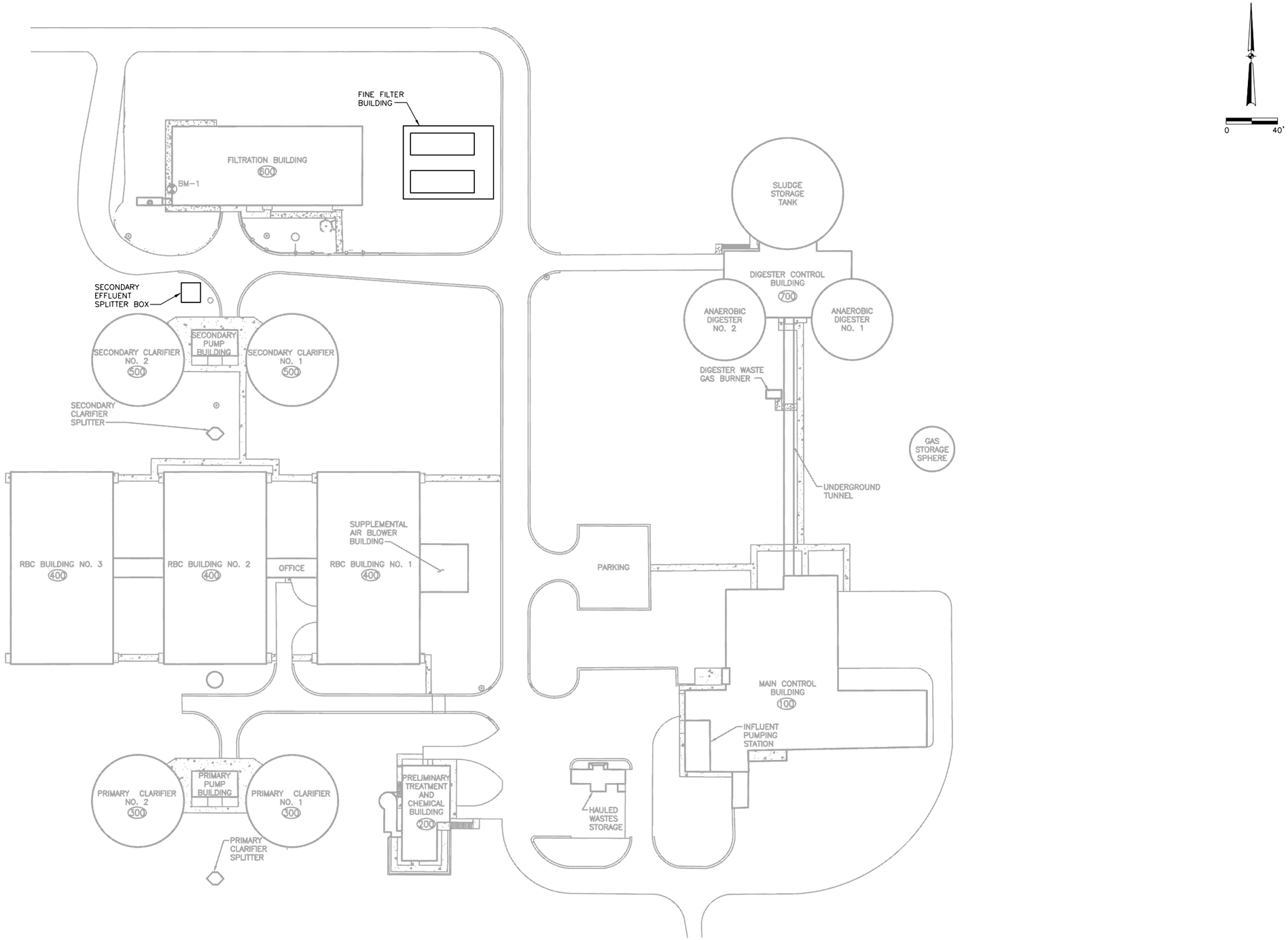
Operability
Complex; sand pumping

Ancillary Components
Hydrocyclone; sludge pumps

Reuse Water Potential
Low effluent TSS

Future Regulations
Emerging: chemical adsorption and filtration

Appendix TM3-B
Additional Figures



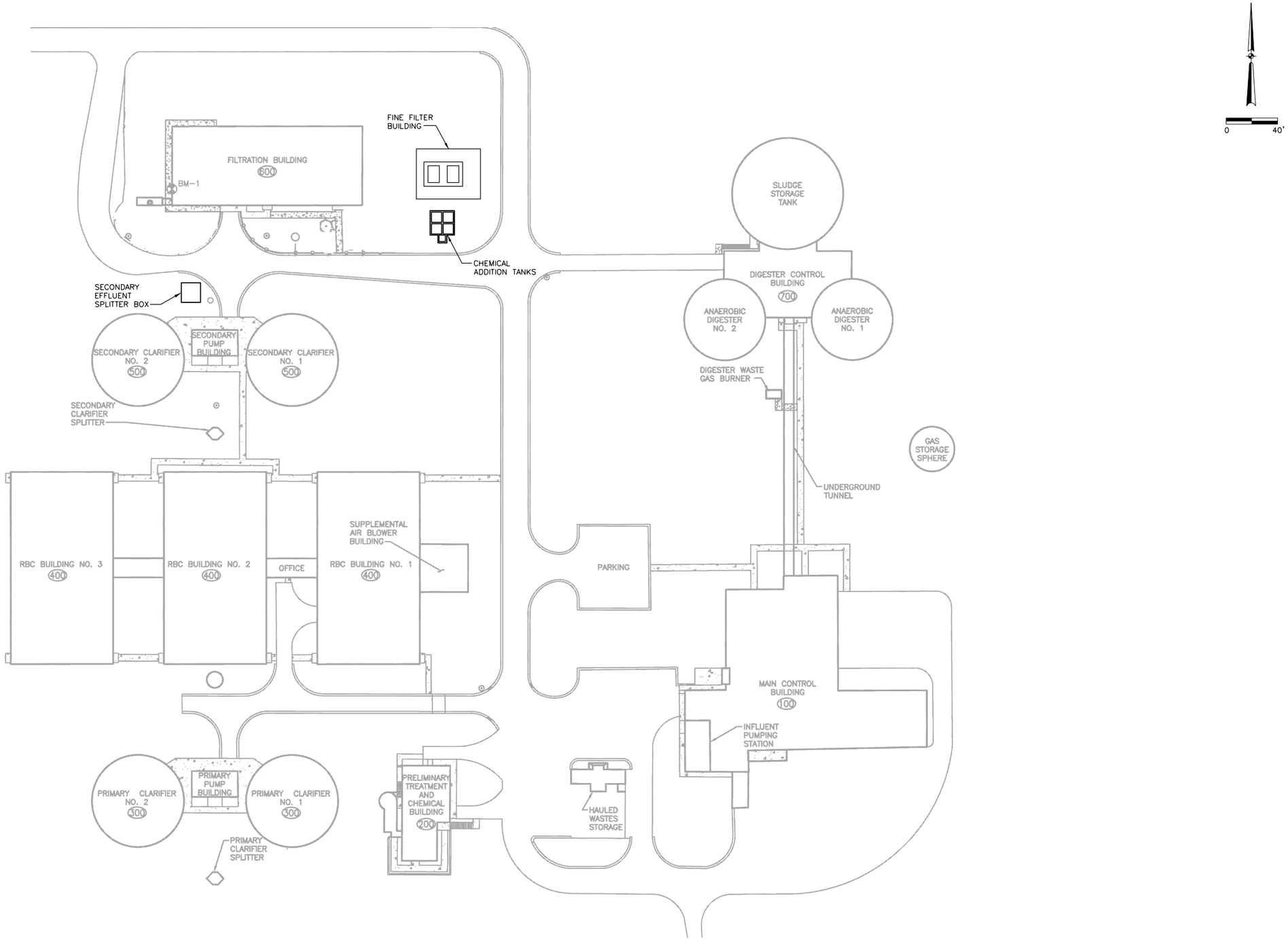
CONTINUOUS BACKWASH FILTERS
CONCEPTUAL SITE PLAN
CITY OF WHITEWATER
WASTEWATER FACILITY PLAN

WHITEWATER, WISCONSIN

DONOHUE

JULY 2014

12600



DISC FILTERS
CONCEPTUAL SITE PLAN
CITY OF WHITEWATER
WASTEWATER FACILITY PLAN

WHITEWATER, WISCONSIN

DONOHUE

JULY 2014

12600

Appendix TM3-C
Economic Evaluation

CITY OF WHITEWATER
WASTEWATER FACILITY PLAN
WHITEWATER, WI

Continous Backwash Filters

INITIAL COST ESTIMATE

General Description

This alternative involves installation of new continuous backwash filters and support facilities. The alternative provides a high degree of TSS and particulate phosphorus removal which will be necessary to meet low level phosphorus limits. It assumes the existing effluent filters are maintained operational but not used except for high flows. The alternative includes the increased chemical costs (alum and polymer) for tertiary treatment to lower effluent TP from 0.5 mg/L to 0.065 mg/L.

ITEM	Units	Quantity	Unit Cost ($)	Initial Cost ($)
Architectural/Structural				
Earthwork	See Worksheet for Detailed Cost Breakdown			87,088
Concrete	See Worksheet for Detailed Cost Breakdown			428,850
Metals	See Worksheet for Detailed Cost Breakdown			57,400
Buildings	See Worksheet for Detailed Cost Breakdown			588,000
Demolition	See Worksheet for Detailed Cost Breakdown			0
Filter Equipment	Lump Sum	1	640,200	640,200
Online P Analyzer	Each	2	19,500	39,000
Alum Storage Tanks	Each	2	9,600	19,200
Polymer Storage Tanks	Lump Sum	1	4,320	4,320
Alum Feed Pumps	Each	1	24,000	24,000
Polymer Feed Pumps	Each	1	24,000	24,000
Civil % Not Listed Above	%		3%	$89,628
Process-Mechanical Piping % Not Listed Above	%		10%	$298,759
Electrical % Not Listed Above	%		8%	$239,007
Instrumentation and Control % Not Listed Above	%		8%	$239,007
Plumbing % Not Listed Above	%		2%	$59,752
HVAC % Not Listed Above	%		5%	$149,379
Subtotal				2,987,590
Contingency			30%	896,277
Subtotal				3,883,867
Contractor Overhead & Profit			25%	970,967
Total Construction Cost				**4,854,833**
Engineering			15%	728,225
Total Initial Cost				**5,583,059**

CITY OF WHITEWATER
WASTEWATER FACILITY PLAN
WHITEWATER, WI

Continous Backwash Filters

ARCHITECTURAL/STRUCTURAL WORKSHEET

ITEM	Units	Quantity	Unit Cost ($)	Initial Cost ($)
Earthwork: Dewatering	lump sum	1	17,418	17,418
Earthwork: Excavation	cu yds	6,967	10	69,670
Earthwork: Underdrain System	sq yds			
Earthwork: Pile Foundation	ft			
Earthwork: Flood Protection Levee	cu yds			
Earthwork: Flood Protection Gravel Road	sq yds			
Earthwork:				
Earthwork				**87,088**
Concrete: Footings	cu yds		350	0
Concrete: Base Slab	cu yds	77	350	26,950
Concrete: Walls	cu yds	240	1,000	240,000
Concrete: Floor Slabs	cu yds		350	0
Concrete: Structural Slabs	cu yds		800	0
Concrete: Columns	cu yds			
Concrete: Channels	cu yds	100	1,009	100,900
Concrete: Class B Fill	cu yds	200	305	61,000
Concrete				**428,850**
Metals: Aluminum Grating	sq ft		28	0
Metals: Aluminum Handrail	ft	240	53	12,720
Metals: Aluminum Stairway	risers	20	414	8,280
Metals: Baffles and Weirs	sq ft	520	70	36,400
Metals:				
Metals				**57,400**
Building: One Story Brick and Block	sq ft	3,920	150	588,000
Building: Two Story Brick and Block	sq ft		300	0
Building:	sq ft			
Building:	sq ft			
Building:	sq ft			
Building:	sq ft			
Buildings				**588,000**
Demolition: Selective Concrete	cu ft		30	0
Demolition: Structure	lump sum			
Demolition: Mechanical	lump sum			
Demolition:	lump sum			
Demolition				**0**

CITY OF WHITEWATER
WASTEWATER FACILITY PLAN
WHITEWATER, WI

Continous Backwash Filters

INITIAL ANNUAL O&M COST ESTIMATE

O&M Labor

ITEM	Units	Annual Quantity	Unit Cost ($)	Annual Cost ($)
Maintenance	hours	312	35	10,920

Electricity

ITEM	Units	Annual Quantity	Unit Cost ($)	Annual Cost ($)
Filter Power	kwh	98,860	0.086	8,502

Natural Gas

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

Chemicals

ITEM	Units	Annual Quantity	Unit Cost ($)	Annual Cost ($)
BluPro Ferric Dose	gal	29,784	1.75	52,122

CITY OF WHITEWATER
WASTEWATER FACILITY PLAN
WHITEWATER, WI

Disc Filters

INITIAL COST ESTIMATE

General Description

This alternative involves installation of new tertiary disc filters and support facilities. Sufficient disc filters would be installed to handle a flow of 4 mgd with one filter unit out of service. The alternative provides a high degree of TSS and particulate phosphorus removal which will be necessary to meet low level phosphorus limits. It assumes the existing effluent filters are maintained operational but not used except for high flows. The alternative includes the increased chemical costs (alum and polymer) for tertiary treatment to lower effluent TP from 0.5 mg/L to 0.065 mg/L.

ITEM	Units	Quantity	Unit Cost ($)	Initial Cost ($)
Architectural/Structural				
Earthwork	See Worksheet for Detailed Cost Breakdown			12,500
Concrete	See Worksheet for Detailed Cost Breakdown			154,950
Metals	See Worksheet for Detailed Cost Breakdown			38,500
Buildings	See Worksheet for Detailed Cost Breakdown			292,500
Demolition	See Worksheet for Detailed Cost Breakdown			0
Filter Equipment	Lump Sum	1	844,690	844,690
Alum Storage Tanks	Each	2	9,600	19,200
Polymer Storage Tanks	Lump Sum	1	4,320	4,320
Civil % Not Listed Above	%		3%	$64,062
Process-Mechanical Piping % Not Listed Above	%		10%	$213,541
Electrical % Not Listed Above	%		8%	$170,833
Instrumentation and Control % Not Listed Above	%		8%	$170,833
Plumbing % Not Listed Above	%		2%	$42,708
HVAC % Not Listed Above	%		5%	$106,770
Subtotal				2,135,406
Contingency			30%	640,622
Subtotal				2,776,028
Contractor Overhead & Profit			25%	694,007
Total Construction Cost				**3,470,035**
Engineering			15%	520,505
Total Initial Cost				**3,990,540**

CITY OF WHITEWATER
WASTEWATER FACILITY PLAN
WHITEWATER, WI

Disc Filters

ARCHITECTURAL/STRUCTURAL WORKSHEET

ITEM	Units	Quantity	Unit Cost ($)	Initial Cost ($)
Earthwork: Dewatering	lump sum	1	2,500	2,500
Earthwork: Excavation	cu yds	1,000	10	10,000
Earthwork: Underdrain System	sq yds			
Earthwork: Pile Foundation	ft			
Earthwork: Flood Protection Levee	cu yds			
Earthwork: Flood Protection Gravel Road	sq yds			
Earthwork:				
Earthwork				**12,500**
Concrete: Footings	cu yds		350	0
Concrete: Base Slab	cu yds	37	350	12,950
Concrete: Walls	cu yds	142	1,000	142,000
Concrete: Floor Slabs	cu yds		350	0
Concrete: Structural Slabs	cu yds		800	0
Concrete: Columns	cu yds			
Concrete: Channels	cu yds	0	1,009	0
Concrete: Class B Fill	cu yds	0	305	0
Concrete				**154,950**
Metals: Aluminum Grating	sq ft	258	28	7,224
Metals: Aluminum Handrail	ft	172	53	9,116
Metals: Aluminum Stairway	risers	40	414	16,560
Metals: Baffles and Weirs	sq ft	80	70	5,600
Metals:				
Metals				**38,500**
Building: One Story Brick and Block	sq ft	1,950	150	292,500
Building: Two Story Brick and Block	sq ft		300	0
Building:	sq ft			
Building:	sq ft			
Building:	sq ft			
Building:	sq ft			
Buildings				**292,500**
Demolition: Selective Concrete	cu ft		30	0
Demolition: Structure	lump sum			
Demolition: Mechanical	lump sum			
Demolition:	lump sum			
Demolition				**0**

CITY OF WHITEWATER
WASTEWATER FACILITY PLAN
WHITEWATER, WI

Disc Filters

INITIAL ANNUAL O&M COST ESTIMATE

O&M Labor

ITEM	Units	Annual Quantity	Unit Cost ($)	Annual Cost ($)
Maintenance	hours	312	35	10,920

Electricity

ITEM	Units	Annual Quantity	Unit Cost ($)	Annual Cost ($)
Filter Power	kwh	5,711	0.086	491
Coagulation/Flocculation Mixers	kwh	32,675	0.086	2,810

Natural Gas

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

Chemicals

ITEM	Units	Annual Quantity	Unit Cost ($)	Annual Cost ($)
Tertiary Alum Addition	gal	46,830	1.40	65,562
Tertiary Polymer Addition	lb	5,840	2.00	11,680

City of Whitewater
Wastewater Facility Plan
Whitewater, WI

Continous Backwash Filters

Present Worth Analysis Factors

Discount Rate	3.0%
Inflation Rate	0.5%
Escalation Rate (Above Inflation)	
Electricty (0-5 years)	2.0%
Electricty (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 5,583,059

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			10,920	8,502	0	52,122	71,544			5,583,059
1			10,975	8,715	0	53,425	73,114	0	70,985	5,654,043
2			11,029	8,932	0	54,761	74,723	0	70,433	5,724,476
3			11,085	9,156	0	56,130	76,370	0	69,889	5,794,366
4			11,140	9,385	0	57,533	78,058	0	69,353	5,863,719
5			11,196	9,619	0	58,971	79,786	0	68,824	5,932,543
6			11,252	9,860	0	60,446	81,557	0	68,303	6,000,846
7			11,308	10,106	0	61,957	83,371	0	67,788	6,068,634
8			11,365	10,359	0	63,506	85,229	0	67,281	6,135,914
9			11,421	10,618	0	65,093	87,132	0	66,780	6,202,694
10	319,200		11,478	10,883	0	66,721	89,082	237,515	66,286	6,506,494
11			11,536	11,155	0	68,389	91,080	0	65,798	6,572,292
12			11,594	11,434	0	70,098	93,126	0	65,317	6,637,609
13			11,651	11,720	0	71,851	95,222	0	64,842	6,702,451
14			11,710	12,013	0	73,647	97,370	0	64,373	6,766,824
15			11,768	12,313	0	75,488	99,570	0	63,910	6,830,734
16			11,827	12,621	0	77,375	101,824	0	63,453	6,894,187
17			11,886	12,937	0	79,310	104,133	0	63,002	6,957,189
18			11,946	13,260	0	81,293	106,498	0	62,557	7,019,746
19			12,005	13,592	0	83,325	108,922	0	62,117	7,081,862
20	19,200		12,065	13,931	0	85,408	111,405	10,631	61,682	7,154,175

20-Year Present Worth	**7,154,175**

Continous Backwash Filters	
Initial Cost	5,583,059
20-Year Present Worth	7,154,175
Average Annual Cost	107,799

Notes

Assumes major equipment overhaul in year 10 including airlift replacement along with airlift replacement again in year 20.

City of Whitewater
Wastewater Facility Plan
Whitewater, WI

Disc Filters

Present Worth Analysis Factors

Discount Rate	3.0%
Inflation Rate	0.5%
Escalation Rate (Above Inflation)	
Electricty (0-5 years)	2.0%
Electricty (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 3,990,540

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			10,920	3,301	0	77,242	91,463			3,990,540
1			10,975	3,384	0	79,173	93,531	0	90,807	4,081,348
2			11,029	3,468	0	81,152	95,650	0	90,159	4,171,507
3			11,085	3,555	0	83,181	97,821	0	89,520	4,261,027
4			11,140	3,644	0	85,261	100,045	0	88,888	4,349,915
5			11,196	3,735	0	87,392	102,323	0	88,265	4,438,180
6			11,252	3,828	0	89,577	104,657	0	87,649	4,525,829
7	11,000		11,308	3,924	0	91,816	107,049	8,944	87,040	4,621,813
8			11,365	4,022	0	94,112	109,499	0	86,439	4,708,252
9			11,421	4,123	0	96,465	112,009	0	85,845	4,794,098
10	226,000		11,478	4,226	0	98,876	114,581	168,165	85,259	5,047,522
11			11,536	4,331	0	101,348	117,215	0	84,679	5,132,200
12			11,594	4,440	0	103,882	119,915	0	84,106	5,216,307
13			11,651	4,551	0	106,479	122,681	0	83,540	5,299,846
14	11,000		11,710	4,665	0	109,141	125,515	7,272	82,980	5,390,099
15			11,768	4,781	0	111,869	128,419	0	82,427	5,472,526
16			11,827	4,901	0	114,666	131,394	0	81,880	5,554,407
17			11,886	5,023	0	117,533	134,442	0	81,340	5,635,746
18			11,946	5,149	0	120,471	137,566	0	80,805	5,716,552
19			12,005	5,277	0	123,483	140,766	0	80,277	5,796,829
20			12,065	5,409	0	126,570	144,045	0	79,754	5,876,583

20-Year Present Worth **5,876,583**

Disc Filters	
Initial Cost	3,990,540
20-Year Present Worth	5,876,583
Average Annual Cost	129,356

Notes

Assumes major equipment overhaul in year 10 including and filter media replacement in years 7 and 14.

City of Whitewater
Wastewater Facility Plan
Whitewater, WI

Clean Waters, Healthy Economy

Present Worth Analysis Factors

Discount Rate	3.0%
Inflation Rate	0.5%
Escalation Rate (Above Inflation)	
Electricty (0-5 years)	2.0%
Electricty (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 0

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			127,000	0	0	0	0			0
1			127,635	0	0	0	127,635	0	123,917	123,917
2			128,273	0	0	0	128,273	0	120,910	244,827
3			128,915	0	0	0	128,915	0	117,975	362,802
4			129,559	0	0	0	129,559	0	115,112	477,914
5			130,207	0	0	0	130,207	0	112,318	590,232
6			130,858	0	0	0	130,858	0	109,591	699,823
7			131,512	0	0	0	131,512	0	106,931	806,754
8			132,170	0	0	0	132,170	0	104,336	911,091
9			132,831	0	0	0	132,831	0	101,804	1,012,894
10			133,495	0	0	0	133,495	0	99,333	1,112,227
11			134,162	0	0	0	134,162	0	96,922	1,209,149
12			134,833	0	0	0	134,833	0	94,569	1,303,718
13			135,507	0	0	0	135,507	0	92,274	1,395,992
14			136,185	0	0	0	136,185	0	90,034	1,486,026
15			136,866	0	0	0	136,866	0	87,849	1,573,875
16			137,550	0	0	0	137,550	0	85,717	1,659,591
17			138,238	0	0	0	138,238	0	83,636	1,743,227
18			138,929	0	0	0	138,929	0	81,606	1,824,834
19			139,624	0	0	0	139,624	0	79,625	1,904,459
20			140,322	0	0	0	140,322	0	77,693	1,982,152

20-Year Present Worth **1,982,152**

Clean Waters, Healthy Economy	
Initial Cost	0
20-Year Present Worth	1,982,152
Average Annual Cost	133,883

Notes

Annual cost is based $50/lb for excess phosphorous beyond 0.2 mg/L at the current average annual flow 1.5 mgd and current average annual effluent phosphorous concentation of 0.63 mg/L.

City of Whitewater
Wastewater Facility Plan
Whitewater, WI

Clean Waters, Healthy Economy

Present Worth Analysis Factors

Discount Rate	3.0%
Inflation Rate	0.5%
Escalation Rate (Above Inflation)	
Electricty (0-5 years)	2.0%
Electricty (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 0

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	3,990,540		**96,000**	0	0	0	0			0
1			96,480	0	0	0	96,480	0	93,670	93,670
2			96,962	0	0	0	96,962	0	91,396	185,066
3			97,447	0	0	0	97,447	0	89,178	274,244
4			97,934	0	0	0	97,934	0	87,013	361,258
5			98,424	0	0	0	98,424	0	84,902	446,159
6			98,916	0	0	0	98,916	0	82,841	529,000
7			99,411	0	0	0	99,411	0	80,830	609,830
8			99,908	0	0	0	99,908	0	78,868	688,698
9			100,407	0	0	0	100,407	0	76,954	765,652
10			100,909	0	0	0	100,909	0	75,086	840,738
11			101,414	0	0	0	101,414	0	73,264	914,002
12			101,921	0	0	0	101,921	0	71,485	985,487
13			102,431	0	0	0	102,431	0	69,750	1,055,238
14			102,943	0	0	0	102,943	0	68,057	1,123,295
15			103,458	0	0	0	103,458	0	66,405	1,189,701
16	4,322,039		11,827	4,901	0	114,438	131,165	2,693,352	81,738	3,964,790
17			11,886	5,023	0	117,299	134,208	0	81,198	4,045,988
18			11,946	5,149	0	120,231	137,325	0	80,664	4,126,653
19			12,005	5,277	0	123,237	140,520	0	80,136	4,206,789
20			12,065	5,409	0	126,318	143,793	0	79,614	4,286,403

20-Year Present Worth **4,286,403**

Clean Waters, Healthy Economy	
Initial Cost	0
20-Year Present Worth	4,286,403
Average Annual Cost	325,401

Notes

Annual cost is based $50/lb for excess phosphorous beyond 0.2 mg/L at the current average annual flow 1.5 mgd and current average annual effluent phosphorous concentation of 0.63 mg/L.