

**FINAL
REPORT**

**Phosphorus Removal
Evaluation for the Geneva
Wastewater Treatment
Facility**

City of Geneva

March 2015



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Appendix C	Envision’s Self Assessment Checklist
Appendix D	Capacity Assessment Memorandum
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Section 1

Introduction

The City of Geneva Wastewater Treatment Facility (GWWTF) has a permitted Average Daily Flow (ADF) of 5.0 mgd and a Peak Flow (PF) of 12.5 mgd through the biological train. The existing main liquids treatment train is composed of coarse screening, intermediate pump station, aerated grit removal, primary clarification, conventional activated sludge system designed for nitrification, and UV disinfection. The facility can also handle an additional 3.5 mgd of flow diverted to an excess flow treatment train. Excess peak flows are diverted after primary clarification and routed to a chlorine contact chamber to then be blended back with the main treatment train flows. The solids train is composed of RAS/WAS pumping, WAS holding tanks, centrifuge thickening, anaerobic digestion, and dewatering via centrifuges. Centrate and digester supernate are handled by aerated sidestream treatment tanks that get routed back to the coarse screens. Biosolids are stored in a solids building and are then land applied as Class B sludge.

The purpose of this report is to provide the City of Geneva (City) with an evaluation of phosphorus removal alternatives as part of the City's Water and Wastewater Facility Plan Update, which can be used to assist the City in complying with the upcoming phosphorus regulations.

1.1 Phosphorus Removal Project Background

In January 2015, the City of Geneva received a final National Pollutant Discharge Elimination System (NPDES) permit from the Illinois Environmental Protection Agency (IEPA) for GWWTF, which includes annual average limitations on the load and concentration of total phosphorus. The annual average limit for total phosphorus concentration is set at 1.0 mg/L while the annual average limit of total phosphorus load is permitted at 42 lbs/day (based on a design average flow of 5.0 mgd) or 104 lbs/day (based on a design maximum flow of 12.5 mgd). Further, a feasibility evaluation for total phosphorus removal down to 0.5 mg/L is also required as part of the new NPDES permit. Lower limits of phosphorus may be imposed in the future by various regulatory entities.

Nutrient removal capacity obtained from the existing conventional biological processes at GWWTF is limited. Thus, improvements to GWWTF are required in order to meet a lower limit of phosphorus in future regulations. Final compliance with the annual average phosphorus limitations will be enforced in July 2019. Implementation schedule for phosphorus limitation for GWWTF is outlined as follows:

- Issuance of draft NPDES permit – **August 13, 2014**
- Final NPDES permit effective date – **January 8, 2015**
- Deadline for phosphorus removal feasibility report – **January 2016**
- Submission of plans and specifications for treatment modifications– **July 2017**
- Construction completion – **July 2018**
- Achieve annual concentration and loading effluent limitations for total phosphorus – **July 2019**

Before final compliance, GWWTF is required to operate to maximize phosphorus removal.

1.2 Objectives

A significant part of this evaluation is the development of alternatives for meeting a 1.0 mg/L monthly average total phosphorus (TP) in the short term (Phase I), and the preliminary assessment for meeting a 0.5 mg/L monthly average TP limit in the long term (Phase II), as required by the IEPA. To evaluate phosphorus removal alternatives that can be implemented at GWWTF, CDM Smith performed the following tasks:

- Collect and review existing influent phosphorus levels, as well as GWWTF operational data. Coupled with flow projections, the City's draft NPDES permit effluent limitations were used to provide design criteria within the planning period.
- Conduct a two-week intensive sampling effort for a more accurate characterization of the raw influent and primary effluent at GWWTF and subsequently, a BioWin ® model calibration. BioWin ® model is used to simulate existing facilities and process modifications.
- Confirm chemical usage and solids production resulting from the chemical phosphorus removal through bench-scale jar tests.

Evaluation of phosphorus removal improvements at GWWTF aims at optimizing the existing facilities and analyzing impacts of phosphorus removal mechanisms on unit operations and treatment processes. Specifically, CDM Smith evaluated the following improvements:

- Optimizing the volume of the aeration basin treatment zone to incorporate Enhanced Biological Phosphorus Removal (EBPR)
- Incorporating chemical phosphorus removal by providing multiple metal salt feed locations to minimize chemical usage and solids production and achieve phosphorus limits
- Evaluating effects of phosphorus-rich sidestream treatment

Alternative combinations of biological process improvements, chemical process improvements, and solids process improvements may be identified as required to achieve the effluent goals. To meet future regulations for a lower limit of phosphorus, CDM Smith evaluated the following additional alternatives for phosphorus removal:

- Implementation of a tertiary solids removal process coupled with chemical phosphorus removal
- Implementation of technologies that do not require tertiary solid removal processes for achieving low TP limits

As part of the overall implementation plan for this project, CDM Smith provided a recommendation plan for meeting the phosphorus limits for the updated NPDES permit and also cost and implementation requirements for meeting a lower limit in the future. The implementation plan will include preliminary layout for the improvements and preliminary cost estimates.

1.3 Report Organization

This report is organized as below:

- Section 1 – Introduction: providing project background, task objectives, and report organization.
- Section 2 – Geneva Wastewater Treatment Facility Influent Data: evaluating historical influent data at GWWTF and the data collected from the intensive nutrient sampling.
- Section 3 – Permitting/Regulatory Requirements: describing current and proposed nutrient requirements for GWWTF.
- Section 4 – Phosphorus Removal Mechanisms: describing EBPR and chemical phosphorus removal as phosphorus removal mechanisms.
- Section 5 – Phase I Phosphorus Removal Alternatives: presenting EBPR processes and chemical phosphorus removal as viable removal mechanisms to reduce total phosphorus concentration to 1.0 mg/L. Process description, impacts, and order of magnitude opinion of probable construction and O&M costs are included for each alternative.
- Section 6 – Phase II Phosphorus Removal Alternatives: presenting preliminary alternative description to further lower total phosphorus limit to 0.5 mg/L. Order of magnitude opinion of probable construction and O&M costs are also included.
- Section 7 – Evaluation of Treatment Alternatives –describing the evaluation criteria selected for the screening of alternatives for phase I and phase II phosphorus removal. This section also provides the final evaluation of the alternatives. A final recommendation of the alternative to implement in each phase is also included in this section.
- Section 8 – Summary and Conclusions: presenting recommended alternative for phase I and phase II phosphorus removal based on findings from the previous sections.

Appendices to the report contain the following information:

- Appendix A - Present Worth Cost Analysis for Alternatives
- Appendix B - Jar Testing Results
- Appendix C - Envision's Self Assessment Checklist
- Appendix D - Capacity Assessment Memorandum
- Appendix E - Aeration Improvements Memorandum
- Appendix F - Phosphorus Alternatives Workshop Presentation and Evaluation Matrix

1.4 Acknowledgements

CDM Smith would like to acknowledge the invaluable efforts from the GWWTF operations staff in assisting with this report preparation, specifically their commitment and dedication through the intensive wastewater characterization sampling program that required significant sample collection preparation, laboratory analyses, and shipping samples for external analyses. Likewise, operations staff also showed their commitment to this project by performing a significant number of jar tests for evaluating different metal salts for chemical phosphorus removal.

CDM Smith believes that the operations staff's efforts provided the required information for optimizing the evaluation of alternatives for the GWWTF, and provided the Engineer with sufficient data to optimize solutions to the problems presented. This ultimately should translate into significant capital and O&M cost savings for the City of Geneva when upgrading the GWWTF to comply with the proposed total phosphorus requirements.

Section 2

Geneva Wastewater Treatment Facility Influent Data

A detailed evaluation of the influent wastewater characteristics and flows for the GWWTF was performed and summarized in the Design Flows and Loads Technical Memorandum (TM). The TM considered a twenty year design period (i.e., through 2034). Of special importance to this TP alternatives evaluation, is to note that the GWWTF does not monitor TKN, TN, or TP so there is little historical data available on those parameters.

2.1 Projected Flows and Loads

Table 2-1 shows a summary of the projected flows and loads for the GWWTF for the twenty-year design period.

Table 2-1 GWWTF Projected 2035 Flows and Loads

GWWTF Influent (2010-2013)		Avg of daily	95%ile of 30 d	95%ile of daily
PEAKING FACTORS		ADF	ADMM	MD
Flow		1.00	1.30	1.52
CBOD ₅		1.00	1.34	1.43
TSS		1.00	1.41	1.64
NH ₄ -N		1.00	1.28	1.41
DESIGN FLOWS AND LOADS		ADF	ADMM	MD
Flow	mgd	4.95	6.42	7.53
BOD ₅	mg/L	173	231	210
	lb/d	9,256	12,370	13,203
TSS	mg/L	181	255	253
	lb/d	9,710	13,665	15,783
NH ₄ -N	mg/L	9	12	11
	lb/d	493	618	678

2.2 Intensive Nutrient Campaign Data

As part of the development of the wastewater facility process simulation model using BioWin®, a level 2 calibration of the model was conducted through an intensive nutrient campaign. The two-week composite sampling and analysis characterized site-specific influent COD, phosphorus, and applicable nitrogen fractions. The City collected and analyzed 24-hour flow-weighted composite samples from the raw influent, primary effluent, and final effluent.

Additionally, the intensive sampling campaign served as the basis for determining the TKN and TP loads in the influent, as these two parameters are not routinely measured at the facility. It is noted that the influent nutrient loads include the sidestream contribution. With the information from the sampling campaign a mass balance around the facility was performed to identify the percent contribution of nitrogen and phosphorus from the sidestreams, which yielded a TN contribution of 9 percent and a TP contribution of 15 percent of the influent load. Table 2-2 shows the selected nutrient criteria for this evaluation.

Table 2-2 – Nutrient Data for GWWTF

	ADMM		ADF	
	Conc. mg/L	Mass load lb/d	Conc. mg/L	Mass load lb/d
TKN	23	1,232	19	785
TP	7	375	5	207

Notes:

1. NH_4 /TKN ratio of 0.51 was determined from sampling campaign

The ADMM and ADF TN loads were determined using the intensive sampling calculated NH_4 /TKN ratio and the ADMM or ADF NH_4 concentration in the Design Flows and Loads TM. Similarly for TP, the COD/TP ratio was used to establish the ADMM and ADF concentrations based on the ADMM and ADF COD from the Flows and Loads TM. All estimated values were checked against typical domestic wastewater data from other facilities and were found to be within the expected ranges, indicating a high level of confidence in the estimations.

Section 3

Permitting/Regulatory Requirements

The GWWTF has an NPDES permit from the IEPA to discharge to the Fox River. Load and concentration limits on phosphorus have recently been implemented in the NPDES permits issued to the Fox River dischargers. Additionally, the Fox River Study Group (FRSG) is in the process of identifying necessary measures to resolve impairments in the Fox River due to nutrient pollution. The FRSG is currently evaluating management scenarios and nutrient reductions from various sources as part of the Fox River Implementation Plan (FRIP). Permitting and regulatory requirements pertaining to phosphorus are dependent upon the conclusion of the FRIP.

3.1 Current Permit Requirements

In January 2015, a final NPDES permit was issued by the IEPA for the GWWTF which includes annual average limits for TP concentration of 1.0 mg/L and TP load of 42 lbs/day (based on a design ADF of 5.0 mgd) or 104 lbs/day (based on a design PF of 12.5 mgd). These phosphorus effluent limits are included in the permit pending completion of the FRIP. The conditions and effluent limits outlined in the final permit may be modified based on findings of an approved FRIP.

The final NPDES permit will be effective for three years and a permit renewal application is required at the end of the permit cycle. Upon expiration of the 3-year permit, IEPA will develop and reissue the permits based on the findings and recommendations in the FRIP, which is scheduled to be finalized by the end of 2015.

As part of the newly issued NPDES permit, the City is required to complete the following tasks with respect to phosphorus monitoring and removal:

- By January 2016 submit a phosphorus removal feasibility report specific to GWWTF on the method, time frame and costs for reducing its phosphorus loading to levels equivalent to monthly average discharges of 1 mg/L and 0.5 mg/L on a seasonal basis and on a year round basis. The report is to evaluate the economic feasibility of phosphorus removal at different effluent limitation values.
- Initiate recommendations for FRIP that identifies phosphorus input reductions by point source discharges, non-point source discharges, and other measures necessary to reduce oxygen demand and offensive condition impairments in the Fox River.
- Upon permit renewal, consider and incorporate recommended FRSG phosphorus input reduction implementation projects that can be implemented during the next permit term.

For the duration of the permit, the City must operate the existing facilities to optimize phosphorus removal. In addition, the City is also required to monitor the wastewater effluent for total phosphorus, dissolved phosphorus, nitrate/nitrite, total kjeldahl nitrogen (TKN), ammonia, total nitrogen (calculated), alkalinity, and temperature at least once a month. Necessary monitoring is conducted for modeling and evaluation of impacts on the receiving stream.

3.2 Proposed Effluent Nutrient Limits

The IEPA is proposing to include a limitation of 1.0 mg/L Phosphorus applied on an annual rolling average basis. In order to provide time to evaluate the recommendations made in the FRIP, the limits are to be enforced in July 2019, 4½ years from the issuance of the final NPDES permit. The City must achieve annual concentration and loading effluent limitations for total phosphorus by that time. A summary of regulated parameters in the final NPDES permit is shown in Table 3-1.

A further lower limit of 0.5 mg/L of total phosphorus is also likely to be discussed in the future. Evaluation of phosphorus removal to meet a lower limit of 0.5 mg/L is included in this report as Phase II Phosphorus Removal Alternatives. It should be noted that limitation to total phosphorus included in the NPDES permit is only applicable to the final discharge of the GWWTF liquids treatment train. Discharge from the excess flow treatment only requires monitoring of total phosphorus.

Table 3-1 Summary of Regulated Parameters in GWWTF 2015 Final NPDES Permit

Parameter	Load Limits lbs/day			Concentration Limits mg/L		
	DAF (DMF)			Monthly Average	Weekly Average	Daily Maximum
	Monthly Average	Weekly Average	Daily Maximum			
CBOD ₅	667 (1,334)	1,334 (2,669)		20	40	
Suspended Solids	834 (1,668)	1,501 (3,002)		25	45	
pH	Shall be in the range of 6 to 9 Standard Units					
Fecal Coliform	Daily Maximum shall not exceed 400 per 100 mL (May through October)					
Chlorine Residual						0.05
Ammonia Nitrogen as (N)						
Mar.-May/Sept. - Oct.	63 (156)		75 (188)	1.5		1.8
Jun. - Aug.			58 (146)			1.4
Nov. - Feb.			142 (354)			3.4
Total Nitrogen	Monitor Only					
Dissolved Phosphorus	Monitor Only					
Nitrate/Nitrite	Monitor Only					
Total Kjeldahl Nitrogen (TKN)	Monitor Only					
Alkalinity	Monitor Only					
Temperature	Monitor Only					
			Annual Average			Annual Average
Total Phosphorus (as P)			42 (104)			1.0
				Monthly Average not less than	Weekly Average not less than	Daily Minimum
Dissolved Oxygen						
Mar.-Jul.				N/A	6.0	5.0
Aug. - Feb.				3.5	4.0	3.5

Notes: DAF – Daily average flow, DMF – Daily maximum flow

Section 4

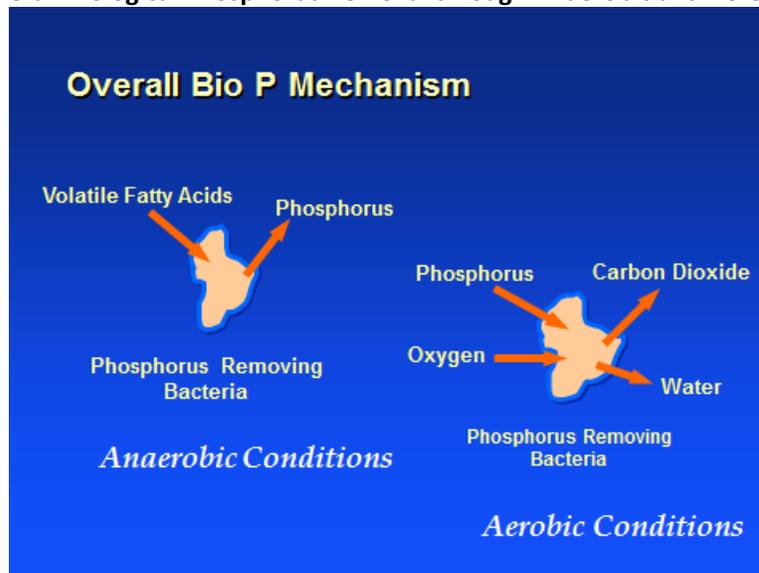
Phosphorus Removal Mechanisms

Phosphorus is removed by converting it to a solid form and then removing the solids. Phosphorus removal is generally achieved biologically and/or chemically. All wastewater treatment facilities remove some phosphorus, as it is incorporated into new biomass that is then wasted from the system. Enhanced Biological Phosphorus Removal (EBPR) process increases the quantity of phosphorus that is incorporated into the biomass. Chemical phosphorus removal is accomplished by adding metal salts to react with the phosphorus to form metal phosphate precipitates and other phosphorus solids.

4.1 Enhanced Biological Phosphorus Removal (EBPR)

Biological P removal is categorized into two processes; (a) normal biological P removal that consists of the uptake of P to satisfy the nutrient requirements of the microorganisms as BOD is metabolized and (b) enhanced biological P removal, or EBPR. EBPR relies on enhancing the growth of aerobic microorganisms known as P accumulating organisms (PAO). PAO are capable of storing orthophosphate (the soluble form of P) in excess of their biological growth requirements. This uptake occurs in the aerobic process; however, some PAO can also use nitrate to store the orthophosphate in the anoxic zone as well. The growth of PAO is enhanced by incorporating anaerobic zones into the treatment process. Under anaerobic conditions the PAO convert readily available organic matter such as volatile fatty acids (VFA) to carbon storage compounds called polyhydroxyalkanoates (PHA). PAO use energy generated through the breakdown of polyphosphate molecules to create PHA which results in the release of phosphorus in the anaerobic zone. In the aerobic zone, the PAO use the PHA as energy to take up P that was released in the anaerobic zone, then the P removal process is completed by removing the PAO in the excess (waste) activated sludge. Biological P removal through anaerobic and aerobic processes is illustrated in Figure 4-1.

Figure 4-1 Overall Biological Phosphorus Removal through Anaerobic and Aerobic Conditions

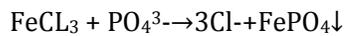
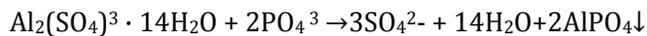


Based on process modeling and experience, the EBPR process alone cannot reliably achieve compliance with Phase II limits and will need to be supplemented with another process. However, optimized EBPR performance will minimize the amount of phosphorus that must be removed chemically. The most important factor affecting the ability of the EBPR to reduce effluent phosphorus is release of stored phosphorus after it has been aerobically taken up. When the EBPR biomass encounters anaerobic conditions, it will release stored phosphorus. This release can occur in multiple locations at a wastewater treatment facility.

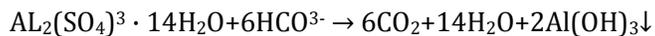
4.2 Chemical Phosphorus Removal (Chem-P)

Traditional chemical phosphorus removal theory involves the addition of a metal salt to adsorb and precipitate the soluble phosphorus from the incoming wastewater by either sedimentation or interception (media filtration). There are two reactions in traditional chem-P theory. The following chemical equations show the reactions for the two most commonly used salts in chem-P, alum and ferric chloride:

1. Transformation of soluble phosphorus to insoluble phosphate.



2. Additional salts reaction with alkalinity to form metal hydroxide precipitate.



However, recently it is believed that instead of phosphate precipitation, the main soluble phosphorus removal mechanism is surface complexation, by forming a hydroxide metal oxide upon the salt addition that adsorbs soluble phosphorus, along with coprecipitation of colloidal phosphorus particles.

Chemical phosphorus removal with metal salts increases the amount of solids generated due to the formation of metal-phosphate and metal hydroxide precipitates resulting from the reaction of the salt with other soluble impurities in the influent stream. Addition of metal salts could take place in several locations of the process, allowing for redundancy during the operation of the system. Literature reports support the theory that multiple points of application can result in better removal efficiencies at lower overall coagulant doses.

The most common locations for chemical addition are the primary clarifiers or the mixed liquor at or upstream of the splitter box feeding the secondary clarifiers. This latter feed point allows for chemical sludge to be formed and mostly removed in the clarifiers. Because the RAS flow recycles most of the secondary clarifier solids to the aeration basins, chemical addition at the secondary clarifiers will also result in chemical solids in the aeration basins as well. For improved removal efficiency, chemical feed to the clarifier effluent should also be considered. The solids formed in the secondary clarifier would be removed in a subsequent solids separation step.

Side stream recycle within a WWTF are also potential chemical addition points because of the high phosphorus concentrations often found in these waste streams. Thickener or dewatering sidestreams

are likely sources as exhibited by the high phosphorus concentrations that have been reported in these flows.

Addition of metal salts for chemical precipitation can consume alkalinity and depress the solution pH. The NPDES permit limits on pH is between 6.0 and 9.0. During wastewater treatment using activated sludge processes, substantial alkalinity can be consumed during nitrification and alkalinity could remain low if a possible denitrification process cannot produce adequate alkalinity. Therefore, both pH and alkalinity were measured in the evaluation of chemical phosphorus removal. Low pH also affects EBPR systems as glycogen accumulating organisms (GAOs) outcompete PAOs for substrate, preventing phosphorus release in the anaerobic zone in combined (EBPR + chem) systems.

The GWWTF uses UV disinfection as the method for achieving bacterial discharge limits, thus, it is important to understand if the process used for phosphorus removal could have potential impacts on these systems. It is widely known that the chemical precipitation process used to remove phosphorus from wastewater effluents can also have positive impacts on the color, organic carbon, and total suspended solids in wastewater effluent. Conversely, residual iron from ferric coagulants may adversely impact UV performance because of increased inorganic fouling of quartz sleeves, which is also a function of hardness in the effluent. Additionally, because UV disinfection inactivates microorganisms at specific UV wavelengths, residual iron can have a negative impact on the transmittance of UV through wastewater. These issues are typically associated with ferric iron, although ferrous iron can also have an impact; impact threshold concentrations, which are concentrations that result in UVT decreases from 91 to 90 percent have been reported at 0.057 mg/L for ferric iron (Fe^{3+}) and 9.6 mg/L for ferrous iron (Fe^{2+}) (Bolton et al. 2001). Thus, residual dissolved iron concentrations should be taken into consideration in evaluating chemical phosphorus removal.

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Section 5

Phase I Phosphorus Removal Alternatives

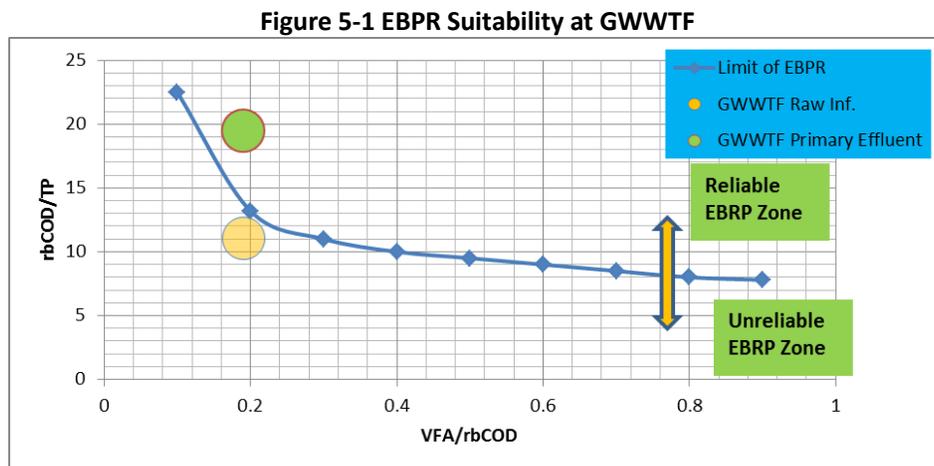
This section will describe the alternatives for achieving the TP limit of 1.0 mg P/L annual average, with a mass loading of 42 lb P/d and 102 lb P/d under peak flow conditions (12.5 mgd). In order for GWWTF to meet this limit reliably, we recommend planning for achieving Orthophosphate (OrthoP) concentration of 0.8 mg P/L for Phase I.

Phase II TP removal alternatives are discussed in the next section.

5.1 Enhanced Biological Phosphorus Removal (EBPR) Alternatives

In order for EBPR alternatives to be feasible from an operational standpoint, certain conditions must be obtained. They include:

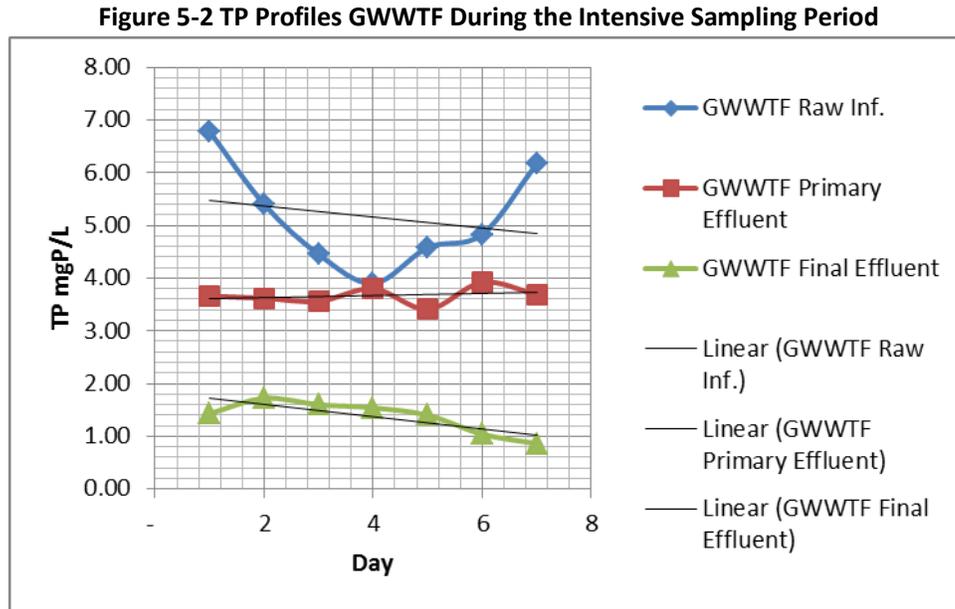
- In general terms, when the COD/TP ratio is above 40, then EBPR is considered to be feasible. However, certain flowsheets configurations are better suited depending of the COD/TP ratio. In the case of Geneva, the intensive sampling period yielded an average COD/TP ratio of 74, indicating proper conditions for EBPR for most flowsheets used for removing TP.
- rbCOD/TP Ratio. Even though the COD/TP ratio is a good indicator of EBRP potential, a more accurate measure is the rbCOD/TP ratio (rbCOD – readily biodegradable COD) of the influent to the EBPR reactor (clarifier effluent). This ratio illustrates the amount of VFA available to drive the desired OrthoP release in the anaerobic zone. Figure 5-1 shows the limit of rbCOD/TP to VFA fraction required for EBPR.



As seen in the Figure 5-1, the GWWTF rbCOD/TP exhibits very good EBPR potential. However, data suggest that keeping the current primary clarifier mode of operation will provide with a much more reliable EBPR system. This can be explained by the fact that the relatively long sludge retention in the primary clarifier is allowing the formation of VFAs, which conditions the influent to the reactor very

well for EBPR. Note that all the data used for developing the GWWTF influent nutrient numbers comes from the intensive sampling campaign, which has a limited number of data points.

Another way to validate the EBPR suitability for the GWWTF, is to analyze the TP data during the intensive sampling campaign. Figure 5-2 shows the influent, primary effluent and final effluent TP concentrations during the sampling period.

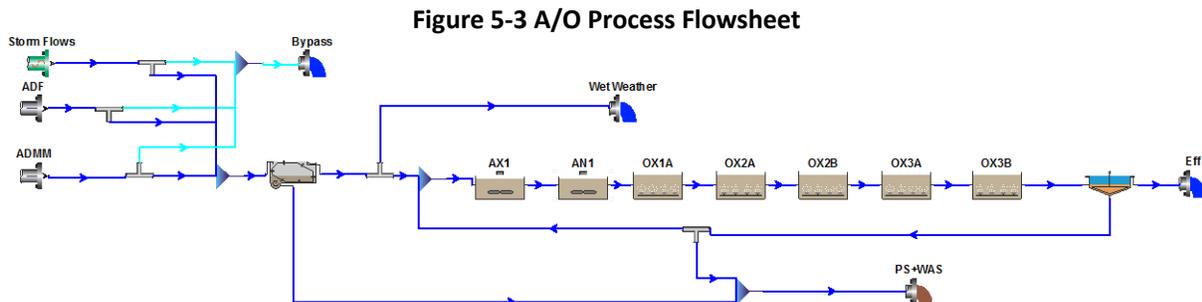


From Figure 5-2 it is noticeable that the current GWWTF is operated in an incidental EBPR mode, due to the aeration system limitations which create proper conditions for OrthoP release in the first pass of each train.

For all the reasons exposed above, CDM Smith feels very confident about the possible implementation of EBPR at the GWWTF. Below are the proposed flowsheets to achieve EBPR.

5.1.1 A/O Process – Alternative 1

Originally known as the Phoredox system developed in South Africa, the A/O process (anaerobic/oxic) is a simple combination of different environmental conditions in series, that promote the release and subsequent uptake of OrthoP in the AN (anaerobic) and OX (oxic) zones respectively. Figure 5-3 shows the A/O process configuration.



To implement this process at the GWWTF, the existing aeration tanks will have to be reconfigured to allow the addition of an AN zone at the head end of each basin train. The addition of baffle walls to isolate this zone from the rest of the basin is required.

Figures 5-4 and 5-5 show the proposed basins modifications for each of the two existing trains to reconfigure the basins to A/O at the GWWTF. Calibrated Biowin™ models were used to determine the reactor partitioning volume splits for providing EBPR as well as to confirm that the proposed configuration provides similar nitrification capacity to actual conditions under ADF, ADMM and PHF conditions.

Table 5-1 illustrates the advantages and disadvantages of this configuration.

Table 5-1 A/O Advantages and Disadvantages

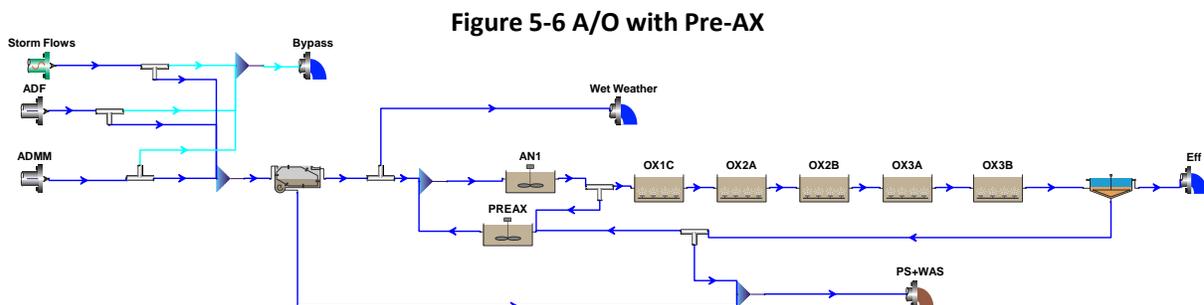
Advantages	Disadvantages
Simplest implementation	Exposure to NOx interference
Requires the less amount of structural components (baffle walls)	Configuration more conducive for a carbonaceous BOD removal (standard activated sludge) flowsheet than a nitrifying activated sludge like GWWTF due to the NOx formation in the OX zone.
Reasonable amount of volume required for the AN zone.	

A preliminary level opinion of probable construction and operation costs was developed for this alternative.

Appendix A shows the capital and operational costs for the alternative.

5.1.2 A/O Process with RAS Pre-Denitrification – Alternative 2

This process flowsheet uses the preanoxic reactor in the Modified Johannesburg Configuration before mixing the RAS flows with the influent wastewater stream, to allow for DO and NOx depletion prior to the AN zone in an AX (anoxic) zone. However, an internal recycle stream to the Pre-AX zone is required to provide sufficient carbon to drive the denitrification process. After the Influent + Pre-AX flows are mixed, the flowsheet is configured in an A/O configuration. Figure 5-6 shows the proposed flowsheet.



To prevent OX water intrusion in the AN zone, weir wall is required to create a positive head condition from the AN to the OX zone, which will be done using the energy from the RAS pumps.

Figures 5-7 and 5-8 show the proposed basins modifications to reconfigure the each of the trains to A/O with Pre-AX at the WWTF.

Table 5-2 illustrates the advantages and disadvantages of this configuration.

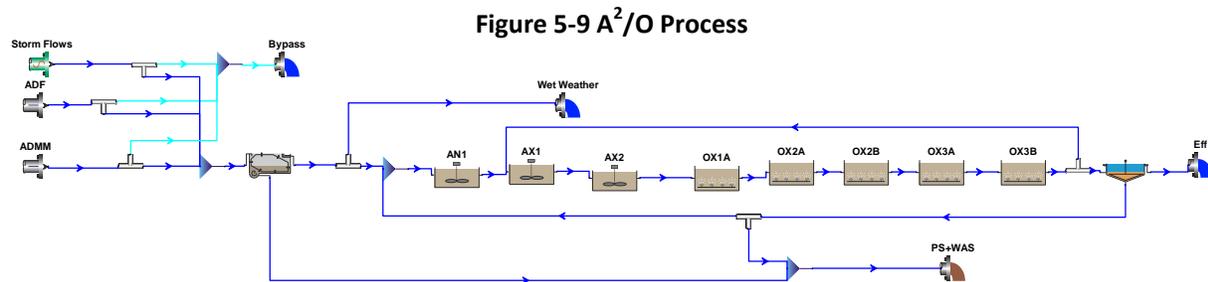
Table 5-2 A/O with Pre-AX Advantages and Disadvantages

Advantages	Disadvantages
Removes NOx interferences	Provides some limited denitrification, even though it is not sought
Recovers alkalinity in the PRE-AX reactor	More complex flowsheet
Provides the most OX volume of all alternatives, so it provides the most sustained peak flows treatment capacity before losing ammonia removal compared to the other alternatives.	Requires more equipment than A/O
Achieves higher degree of EBPR treatment compared to Alternative 1	

Appendix A shows the capital and operational costs for the alternative.

5.1.3 A²/O Process – Alternative 3

This process flowsheet is typically used when some level of TN removal is desired (typically to around 8 mg N/L), by providing an AN/AX/OX configuration to remove OrthoP, reduce TN, and transform NH₄ in each zone respectively. This process is proposed to minimize the NOx interferences in the anaerobic zone by denitrifying in the main process stream. Figure 5-9 shows a flowsheet of this process.



Figures 5-10 and 5-11 show the proposed basins modifications to reconfigure the trains to A²/O at the WWTF.

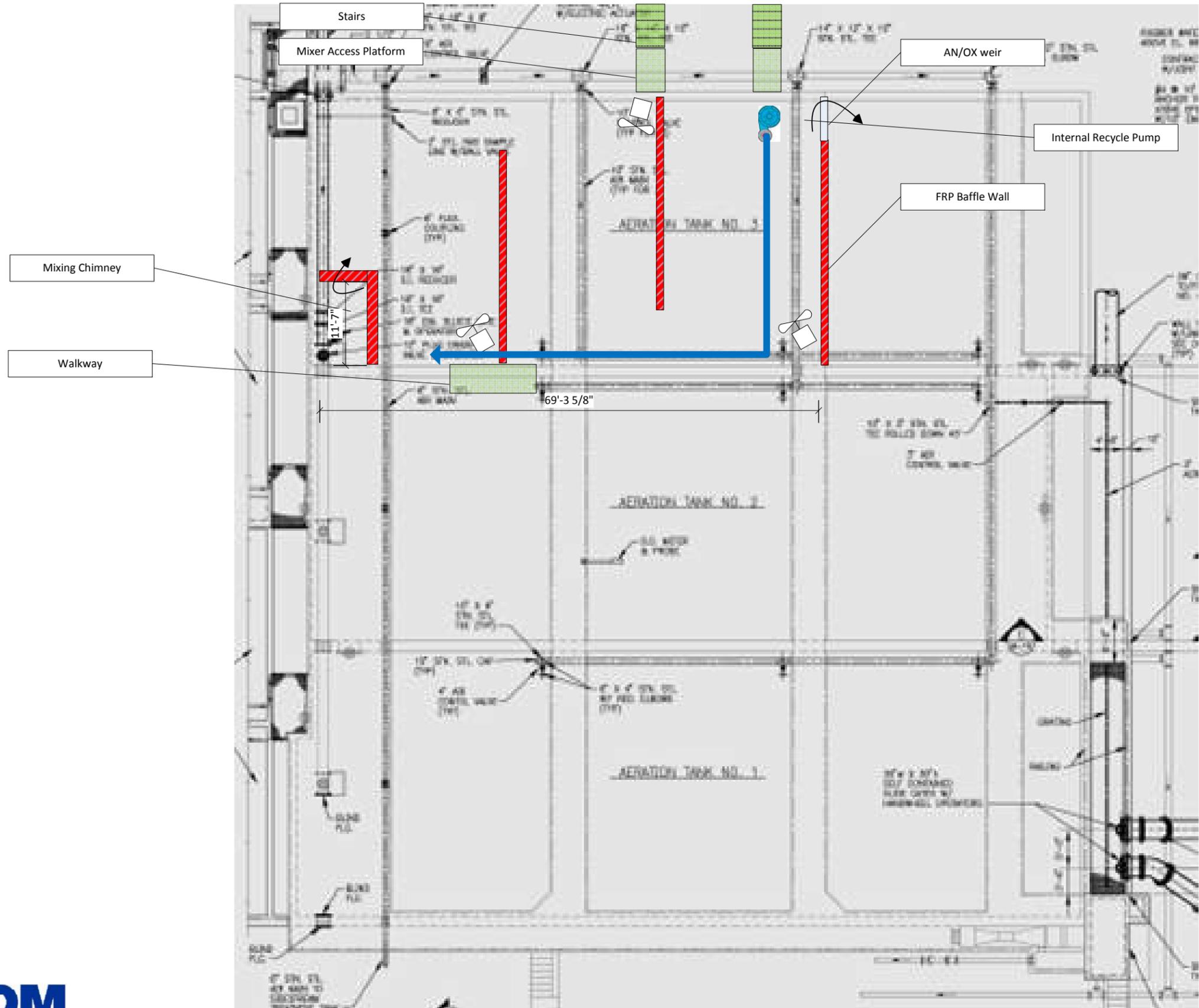
Table 5-3 illustrates the advantages and disadvantages of this configuration.

Table 5-3 A/O with Pre-AX Advantages and Disadvantages

Advantages	Disadvantages
Provides the best selection as there will be AN and AX selection	Requires the most structural components of all EBPR alternatives
Provides TN treatment for possible future TN limits	Minimizes the OX volume which reduces the ability of the facility to treat sustained peak weather flows
Widely used configuration	Requires more energy used due to the high NOx recycle required to achieve denitrification.
Recovers alkalinity in the AX zone	Requires more mixing equipment due to the larger unaerated zones and the different AN and AX zones.

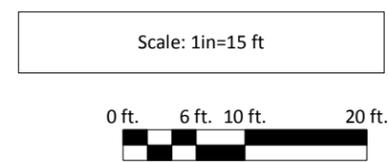
Appendix A shows the capital and operational costs for the alternative.

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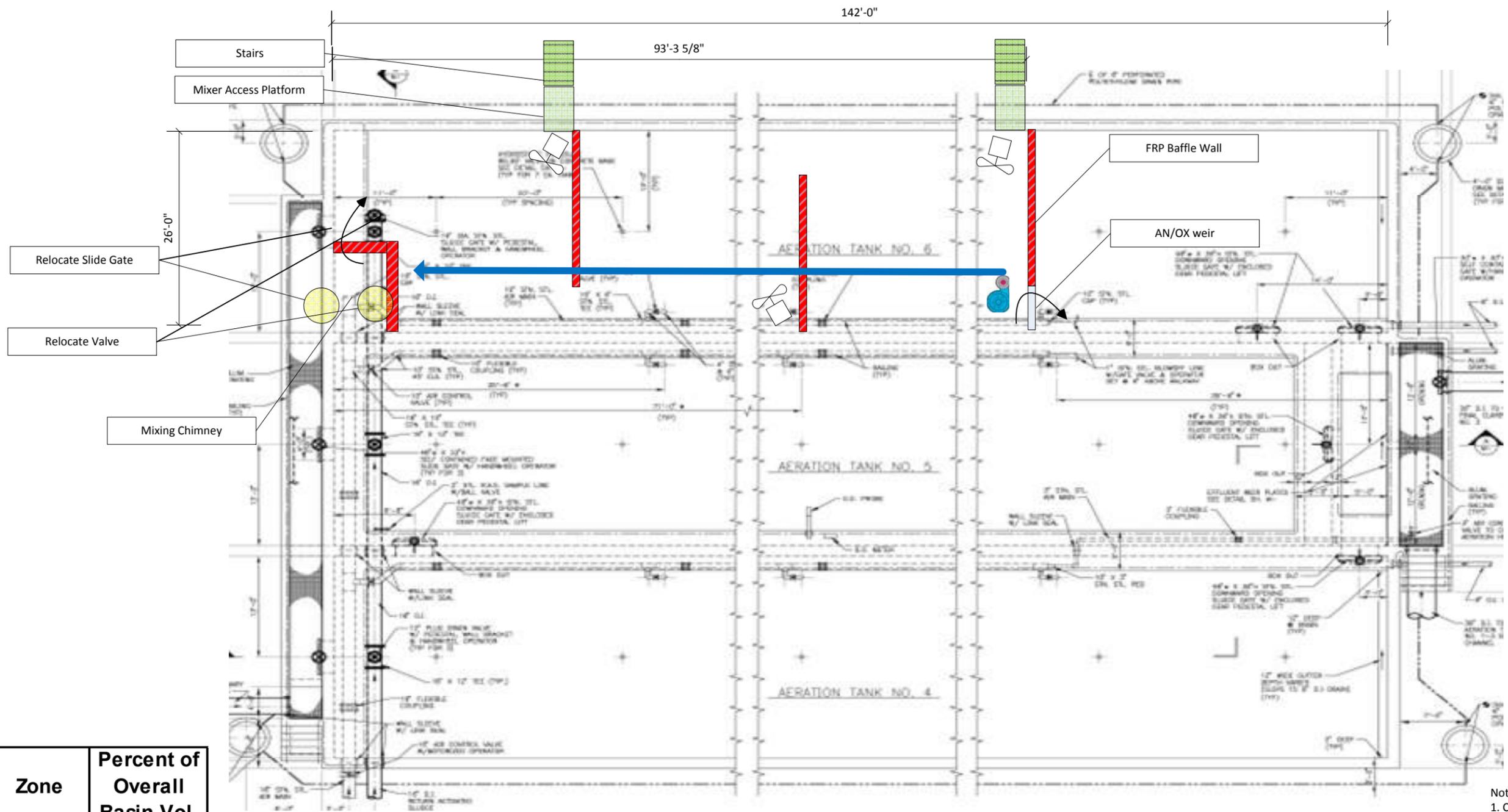
Zone	Percent of Overall Basin Vol.
AN	22%
OX	78%

Notes:
 1. Configuration assumes complete redistribution/replacement of diffusers throughout the basin



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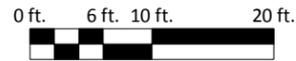
Figure 5-4
EBPR Alternative 1
Train 1



Zone	Percent of Overall Basin Vol.
AN	22%
OX	78%

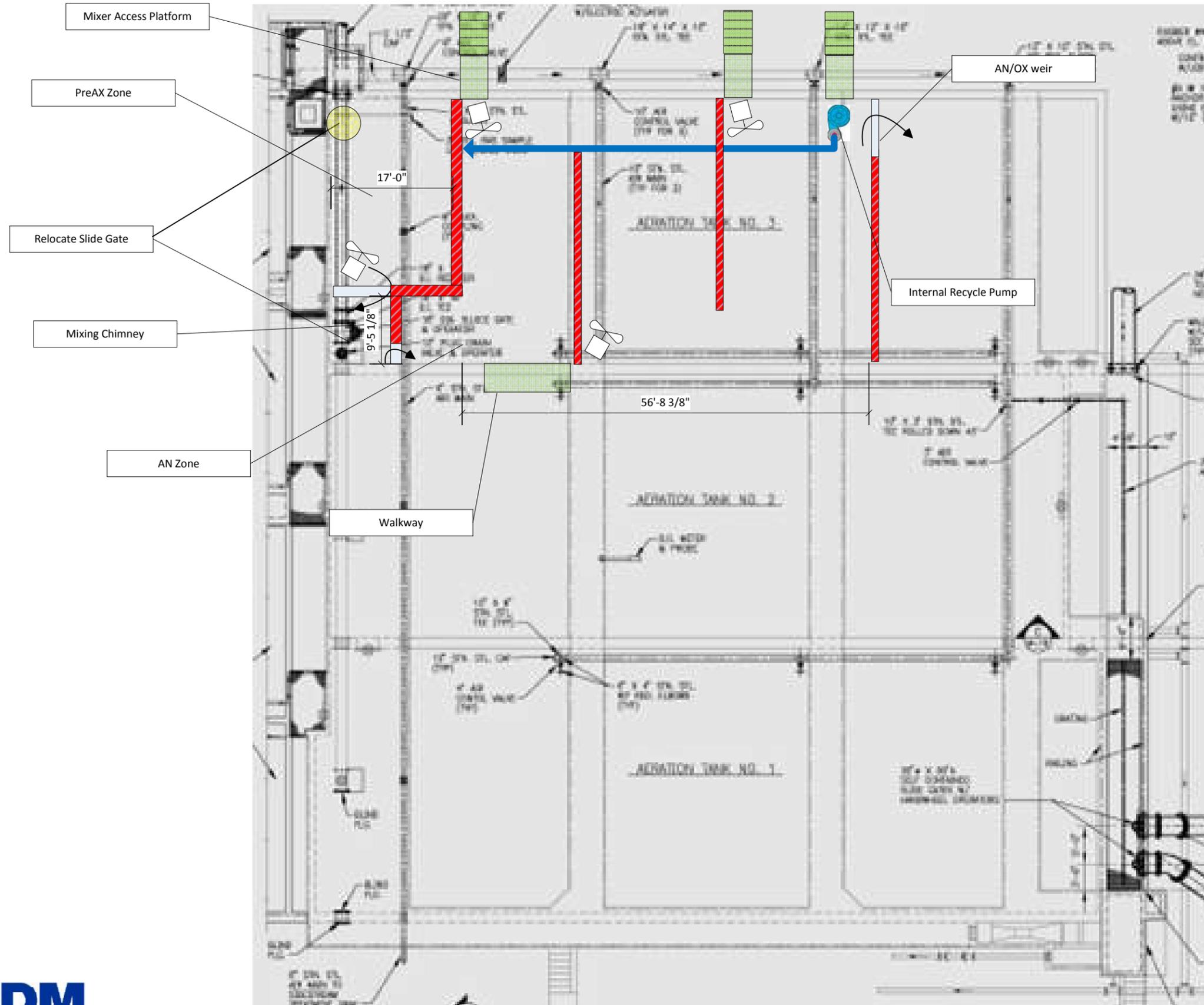
Notes:
 1. Configuration assumes complete redistribution/replacement of diffusers throughout the basin

Scale: 1in=15 ft



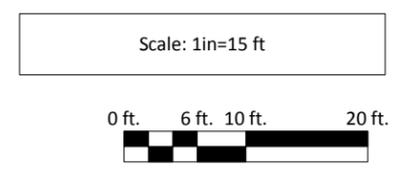
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Figure 5-5
EBPR Alternative 1
Train 2



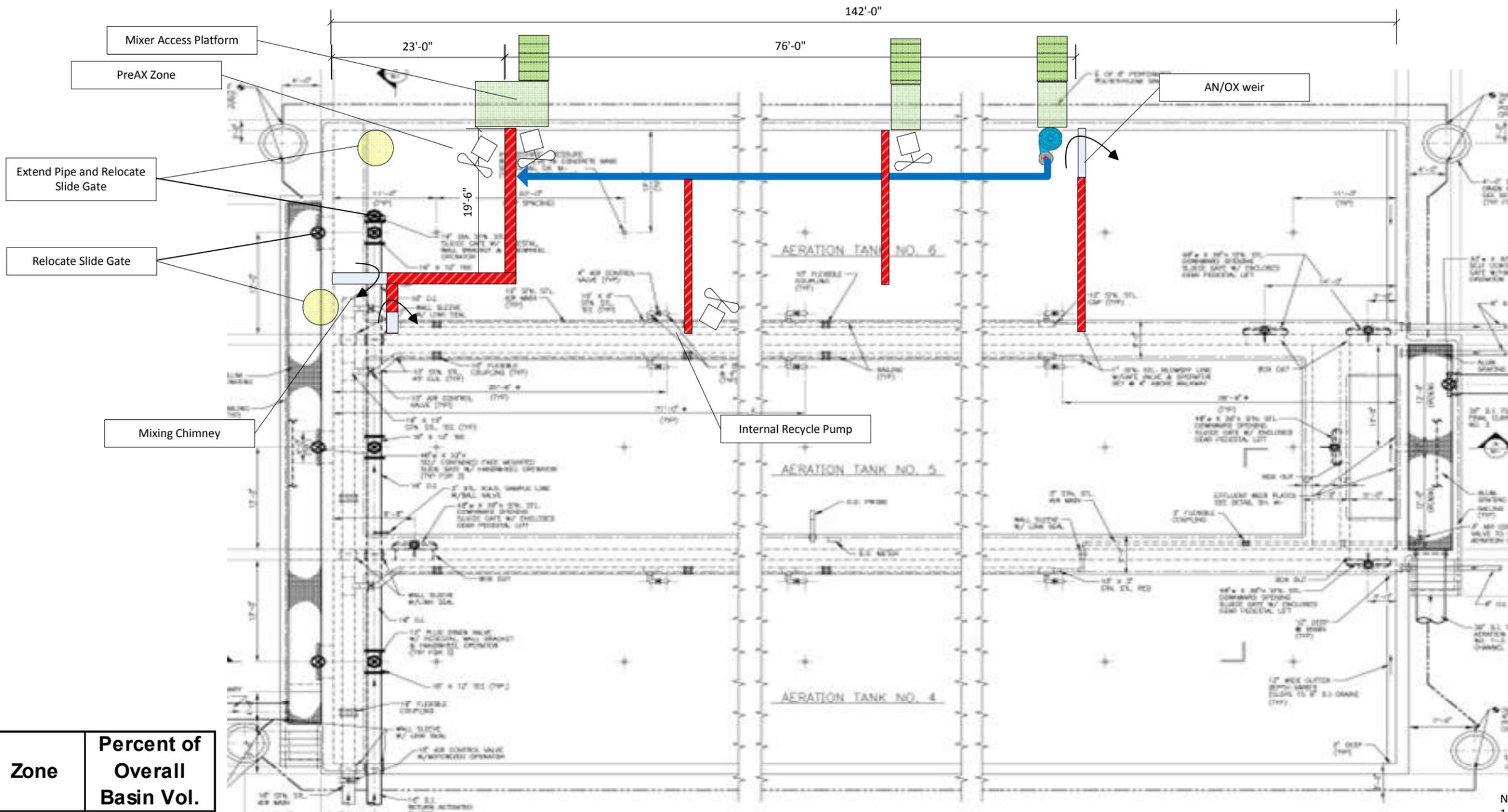
Zone	Percent of Overall Basin Vol.
PreAX	4%
AN	18%
OX	78%

Notes:
 1. Configuration assumes complete redistribution/replacement of diffusers throughout the basin



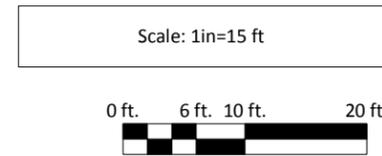
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Figure 5-7
EBPR Alternative 2
Train 1



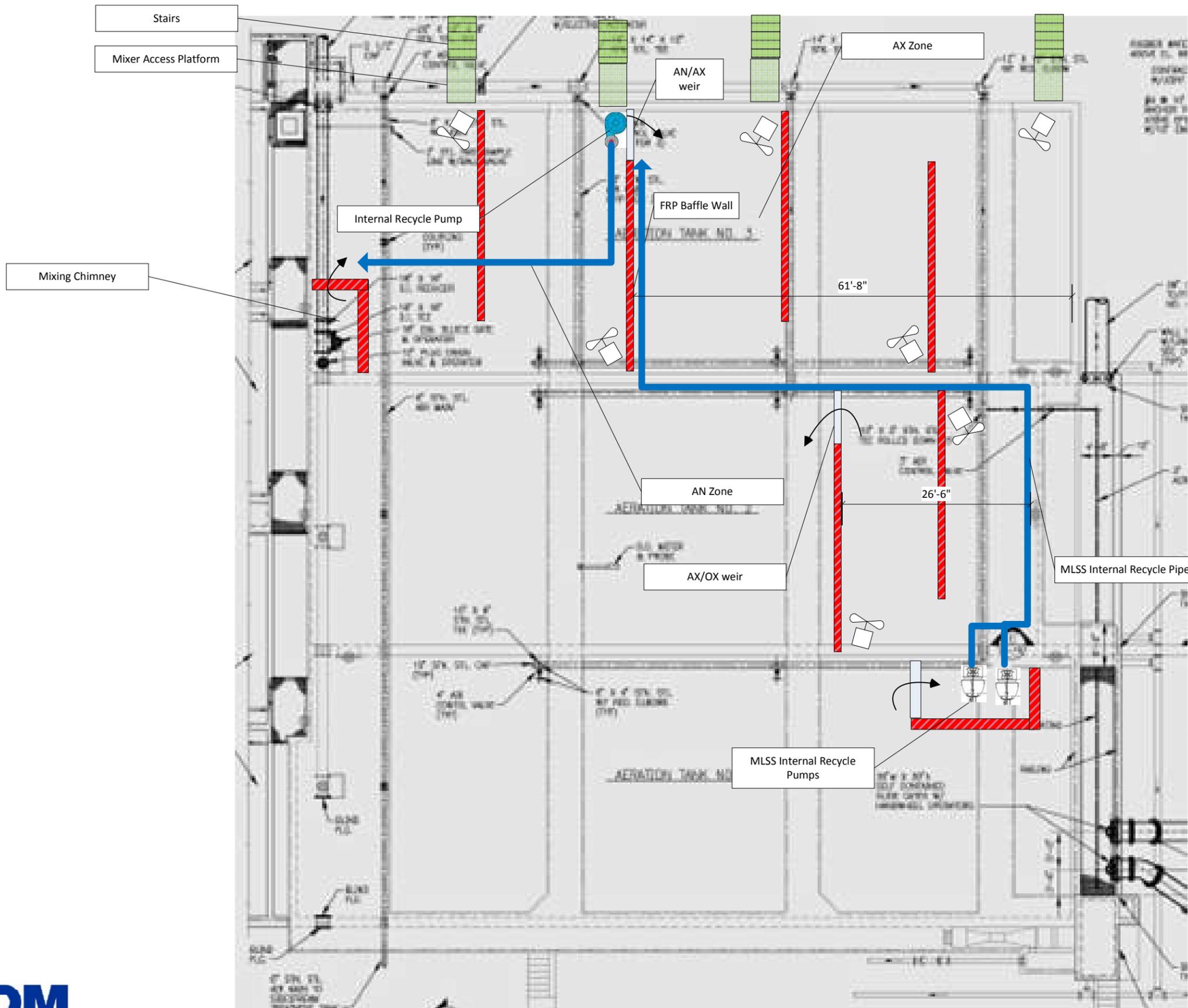
Zone	Percent of Overall Basin Vol.
PreAX	4%
AN	18%
OX	78%

Notes:
 1. Configuration assumes complete redistribution/replacement of diffusers throughout the basin



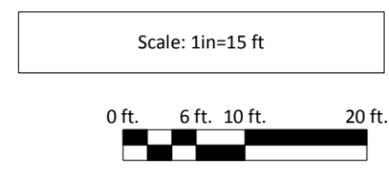
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Figure 5-8
EBPR Alternative 2
Train 2



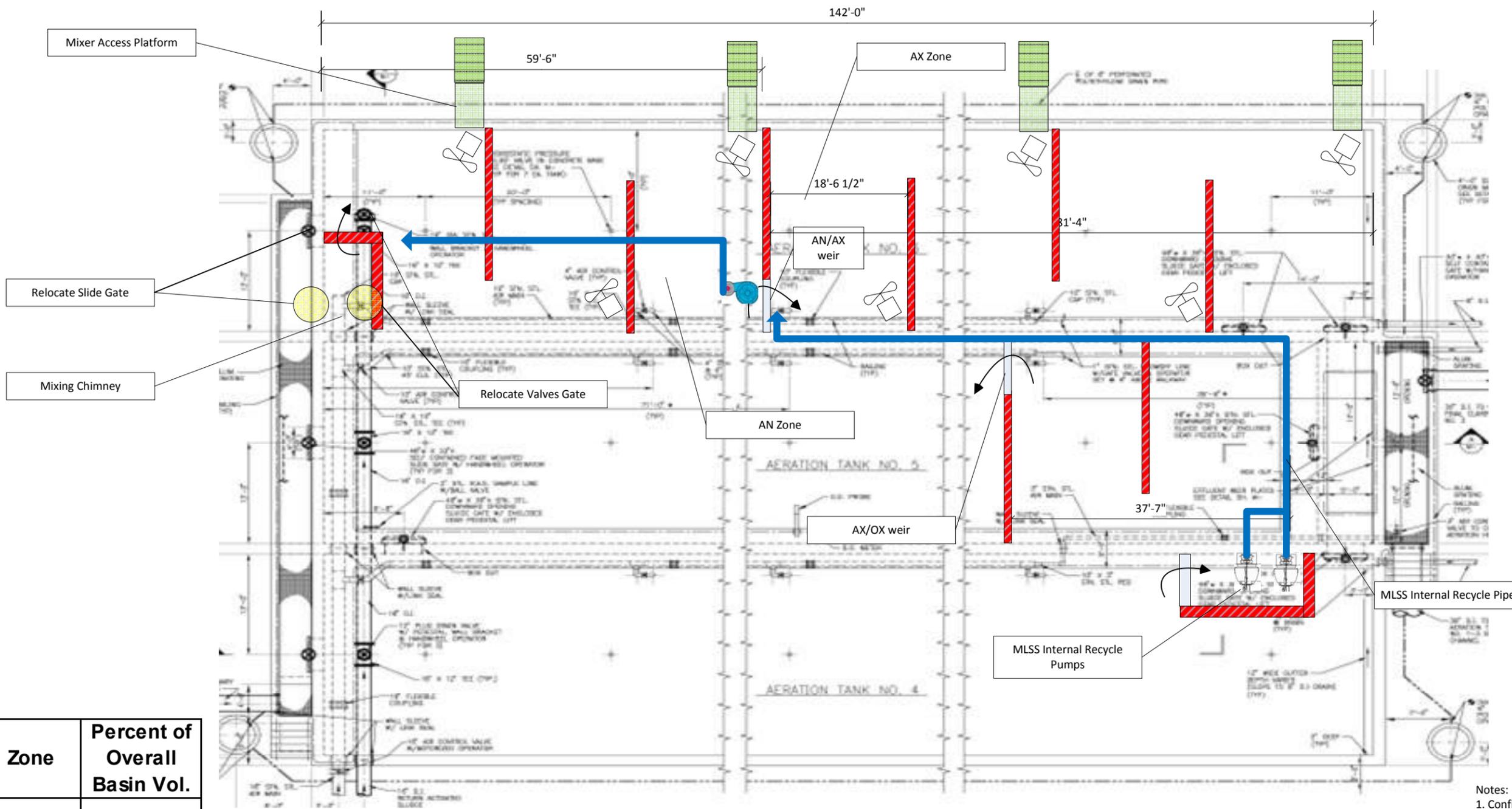
Zone	Percent of Overall Basin Vol.
AN	14%
AX	28%
OX	58%

Notes:
 1. Configuration assumes complete redistribution/replacement of diffusers throughout the basin



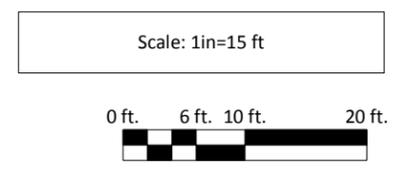
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Figure 5-10
EBPR Alternative 3
Train 1



Zone	Percent of Overall Basin Vol.
AN	14%
AX	28%
OX	58%

Notes:
 1. Configuration assumes complete redistribution/replacement of diffusers throughout the basin



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Figure 5-11
EBPR Alternative 3
Train 2

5.2 Chemical Phosphorus Removal (Chem-P) Alternatives

During the development of this evaluation, a jar test effort for evaluating alum and ferric chloride salts was performed by GWWTF staff, with the goals of understanding the performance of chem-P processes at the facility and to gather the required data for developing the chem-p alternative.

A key factor for the standalone chem-p alternative is the fact that with the proposed aeration system improvements planned, the SVIs for this facility are expected to increase, which may in turn increase the amount TSS in the effluent, directly impacting this facility's ability to meet low TP limits. This is not the case if either an EBPR alternative or a standalone chem-P alternative with anaerobic selectors in the aeration tank is implemented.

5.2.1 Metal Salt Evaluation

A metal salt evaluation including extensive metal salt jar testing using alum and ferric chloride was performed by GWWTF staff. The results from the jar testing effort are shown in appendix B.

The jar testing effort included development of the metal response curves at different feeding location in the process including influent, secondary effluent, sidestreams, etc.

5.2.1.1 Background

Jar testing was conducted on process water from the GWWTF in October and December 2014 to evaluate alum (aluminum sulfate) and ferric (ferric chloride) as alternative metal salts for chemical phosphorus removal. The primary objectives of the jar testing were as follows:

- Select the most cost-effective metal salt and determine the effective dosage range
- Compile sufficient data to evaluate chem-p against other alternatives.

Alum vs. Ferric: Properties

Although other metal salts are sometimes used, experience, economics, and availability result in alum and ferric being the most practical options. Both react with phosphorus similarly, forming either a metal phosphate or metal hydroxides to which phosphorus is incorporated. Both alum and ferric are available as solutions that are relatively easy to store and feed. Although each has a different theoretical optimum pH, in wastewater applications the optimum pH appears to be approximately 6.8 for both with a treatability pH range shown to be fairly broad. The required dosage of either is based on the same theoretical ratio of moles metal to moles phosphorus. However, the actual effective dosage is affected by many variables and is best determined through jar testing. Further, the properties of the two solutions differ in terms of solution strength, metal concentration, and current price as shown in **Table 5-4** below.

Table 5-4 Properties of Alum and Ferric Chloride Solutions

Property	Alum	Ferric Chloride
Chemical Formula	$\text{Al}_2(\text{SO}_4)_3 \cdot 14\text{H}_2\text{O}$ MW = 594 g/mol	FeCl_3 MW = 162 g/mol
Active metal	Aluminum (Al) MW = 27 g/mol	Iron (Fe) MW = 55.85 g/mol
Solution weight (S.G.)	11.1 lb/gal (SG=1.33)	11.8 lb/gal (SG = 1.41)
Chemical Concentration	48% $\text{Al}_2(\text{SO}_4)_3 \cdot 14\text{H}_2\text{O}$ 5.3 lb $\text{Al}_2(\text{SO}_4)_3 \cdot 14\text{H}_2\text{O}$ /gal soln	40% FeCl_3 4.7 lb FeCl_3 /gal soln
Metal Concentration	0.48 lb Al/gal soln 57.6 g Al/L soln 2.13 mol Al/L soln	1.61 lb Fe/gal soln 194 g Fe/L soln 3.47 mol Fe/L soln
Metal per Chemical	0.09 lb Al/lb $\text{Al}_2(\text{SO}_4)_3 \cdot 14\text{H}_2\text{O}$ 1.53 mol Al/lb $\text{Al}_2(\text{SO}_4)_3 \cdot 14\text{H}_2\text{O}$	0.34 lb Fe/lb FeCl_3 2.80 mol Fe/lb FeCl_3
Dose to Deliver 0.1 mmol metal/L	2.7 mg Al/L	5.6 mg Fe/L
Average Delivered Price*	\$ 295/ton $\text{Al}_2(\text{SO}_4)_3 \cdot 14\text{H}_2\text{O}$ \$ 0.785/gal soln \$1.64/lb Al \$0.098/mol Al	\$ 385/ton FeCl_3 \$0.905/gal soln \$0.56/lb Fe \$0.069/mol Fe

* Pricing is based on quotes from Chemtrade Logistics and Hawkins Chemical for delivery to Geneva, IL.

Because alum concentration units can be confusing (sometimes reported as Al_2O_3 , sometimes as $\text{Al}_2(\text{SO}_4)_3$ with 18 waters of hydration rather than 14, sometimes with no waters of hydration), most properties above have been expressed on the basis of the active metal (Al or Fe). For clarity, chemical dosages throughout the discussion below will likewise be expressed on the basis of mass Al or Fe or volume of solution as shown in Table 5-4. Note that although the concentration of alum solution is fairly consistent, ferric chloride solutions vary in concentration according to the season. Concentration is reduced during cold weather (to 38% or less) to prevent crystallization during shipping and increased during warm weather (to 42%) when crystallization is not an issue.

5.2.1.2 Alum vs. Ferric: Chemical Storage, Feed and Handling

Liquid alum solution presents no special handling challenges or hazards except that spills become slick upon evaporation, so they should be contained and cleaned. Indoors alum should be stored in a closed tank of 316 stainless steel, crosslinked HDPE, or FRP. Mild steel or 304 stainless are not suitable.

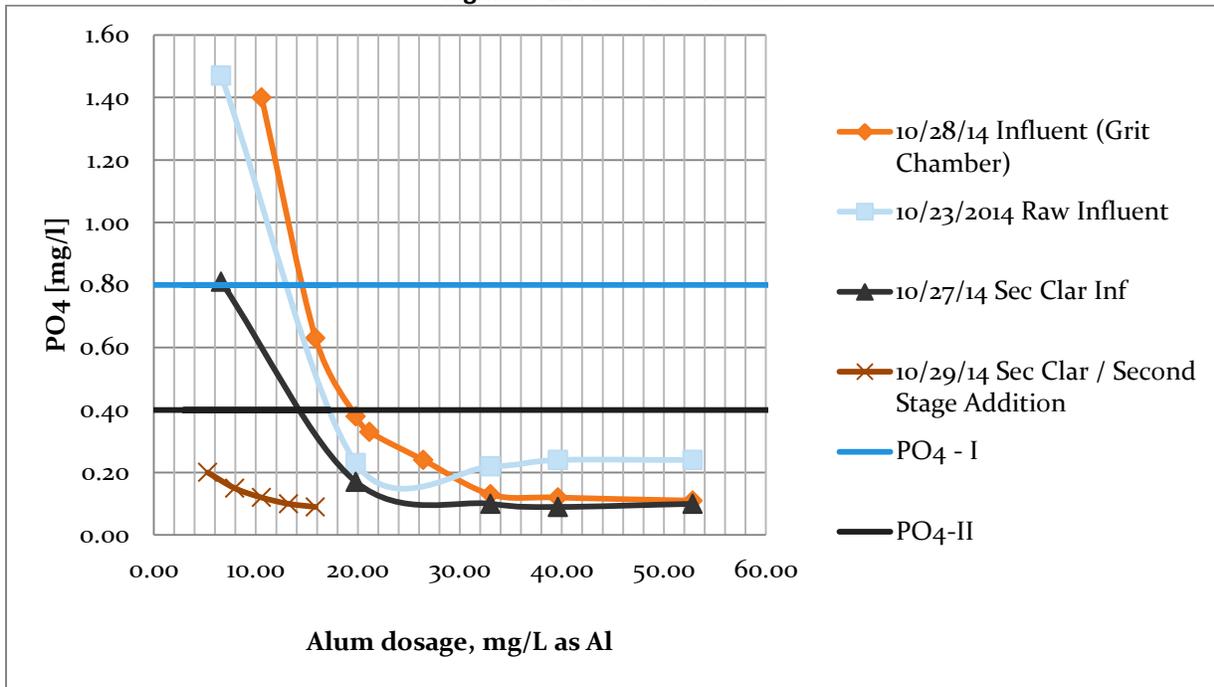
Ferric solutions are highly corrosive to most metals including carbon steel, 304 stainless steel and 316 stainless steel. Ferric should be handled only by personnel with face shields, rubber gloves, and other protective clothing. Tanks should be of crosslinked HDPE or FRP and should be protected from UV light and solar heating with suitable pigments, jackets and/or insulation. Positive displacement metering pumps should have wetted parts of polypropylene, PVC or fluorocarbon, ceramic and carbon. Both traditional diaphragm metering pumps and magnetically driven gear pumps are suitable. For piping, schedule 80 PVC or CPVC, with solvent welded joints are recommended and should be buried, painted, or shielded from UV light. Any wetted metal at the tanks, pumps or piping must be Hastelloy C276, or must be fluorocarbon encapsulated.

For planning purposes, all materials suitable for both alum and ferric will be selected. This includes cross-linked HDPE double walled tanks, schedule 80 PVC piping, and metering pumps and appurtenances with fluorocarbon coatings.

5.2.1.3 Alum Tests

Figure 5-12 illustrates the results of the alum jar tests with the OrthoP concentrations being plotted against the alum dosages. The treatment goals for the two originally anticipated phases, 0.8 mg/L for Phase I and 0.4 mg/L for Phase II, are plotted on the chart in horizontal lines to help identify the alum dosage need for meeting each phase limit. For comparison, the figure also shows the results from the full-scale phosphorus test conducted by GWWTF staff.

Figure 5-12 Alum Test Results



As shown in Figure 5-12, the final OrthoP concentration with alum addition is dependent upon the initial OrthoP concentrations, indicating the further down the process the chemical is added, the more chemical savings can be realized.

For the purposes of the TP alternatives evaluation, the curves representing chemical addition before the biological systems will be used for conservatism. With alum addition, 18 mg Al/L will be needed to meet the Phase I limit (treatment goal is 0.8 mg/L OrthoP) and 20 mg Al/L will be needed to meet the Phase II limit (treatment goal is 0.4 mg/L OrthoP).

5.2.1.4 Ferric Tests

Figure 5-13 illustrates the results of the ferric chloride jar tests with the OrthoP concentrations being plotted against the Ferric dosages.

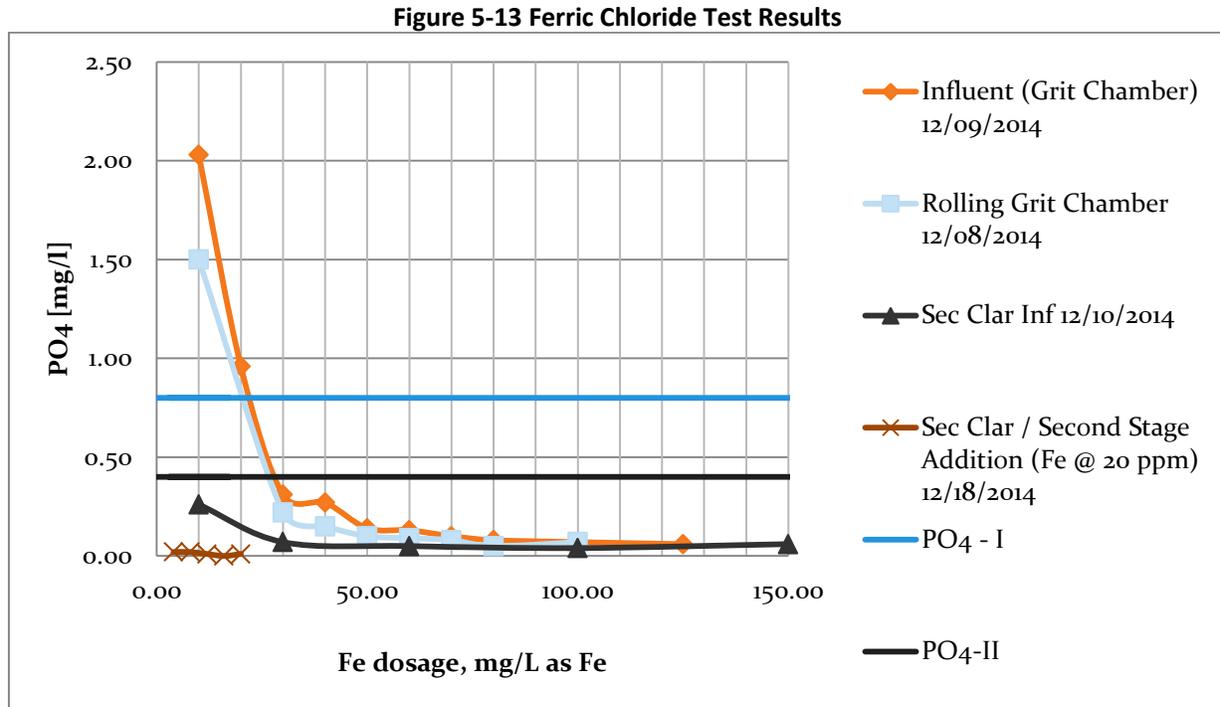


Figure 5-13 shows behavior similar to Figure 5-12, even though ferric chloride seems to require higher dosages to remove OrthoP to the desired levels compared to alum. The figure shows that a ferric chloride dose of 20 mg Fe/L satisfies the requirements of the Phase I requirements, whereas the Phase II requirements seem to be met with a 28 mg Fe/L dosage, based on the results from samples prior to the biological system.

5.3.2.3 Alum vs. Ferric Design Dosages Requirements

Table 5-5 is the summary of the chemical feed dosage requirements for both alum and ferric in terms of design dosages and average feed rates (fed prior to the final clarifiers).

Table 5-5 Design Dosages Requirements

Chemical Feed	Metal	Phase I	Phase II	Notes
Design Dosages mg Metal/L	Alum	11	18	
	Ferric	20	28	
Solution Feed Rates gpd	Alum	936	1532	@ 50% Alum and ADF
	Ferric	642	898	@38% Ferric Chloride and ADF

An important thing to note regarding metal salts behavior, is that the TP removal is related to the OrthoP concentration at the feeding location. Therefore, a multi-stage chemical feed approach would be the most beneficial approach for the GWWTF, as treating high TP sidestreams as well as low OrthoP locations (such as secondary clarifier effluent), would provide chemical savings, should chem-P be implemented in either Phase I or II.

5.2.2 Chemical Phosphorus Removal - Alternative 4

In order for chem-P to meet the Phase I TP limit of 1 mg p/L, CDM Smith believes that no tertiary processes are required. This is supported by Figure 5-12 and 5-13, where removing OrthoP to limits below 0.8 mg/L is achieved by only reasonable chemical addition in key places coupled with standard clarification processes performance. The following is a list of chemical addition points recommended for the GWWTF, noting that the intent is to provide the operators as much flexibility as possible to operate the system, but only a few actual dosing points should be used at a given time.

- Primary Clarifier Influent.
- Aeration basin effluent (secondary clarifier influent)
- WAS holding tank
- Sidestream tank influent
- Sidestream tank effluent

5.2.2.1 Chemical Feed Storage and Equipment Sizing

CDM also performed a preliminary sizing of the storage and feed facilities of both metal salts considered. An instantaneous peak factor of 3.0 was considered for offsetting the daily peak phosphorus concentrations. Table 5-6 provides a summary of these requirements.

Table 5-6 Chemical Feed Storage and Equipment Requirements¹

Storage Requirements		Phase I	Phase II
Storage Duration	days	15	
Volume Required, gal	Alum	18,254	29,871
	Ferric	12,510	17,514
Chemical Feed Pumps			
Average Feed Rate ¹ gph	Alum	51	83
	Ferric	35	49
Peak Factor	3		
Peak Feed Rate ¹ gph	Alum	152	249
	Ferric	104	146

1. Based on 50% alum or 38% ferric chloride.

5.2.2.2 Sludge Production

As seen in Table 5-4, the cost for chemical removal at the facility depends on the effluent OrthoP levels required. Consistent with the higher dosages reported from the jar tests, the estimated sludge production for both metal salts is also different.

Table 5-7 Chemical Sludge Production

Chemical Feed	Metal	Phase I	Phase II
Chemical Sludge Production lb/Mgal of facility flow	Alum	315	483
	Ferric	369	496

5.2.2.3 Layout and Cost

For this alternative, a new chemical storage building with chemical storage tanks and feed metering equipment is required. Along with this, chemical delivery piping around the site is also required. Figure 5-14 shows the proposed siting of a chemical feed building at the site.

A cost comparison of alum and ferric is summarized in Table 5-8. As shown in the table, ferric is more economical at the current market price for Phases I and II.

Table 5-8 Estimated Normalized Chemical Cost

Chemical Feed	Metal	Phase I	Phase II
Chemical Cost \$/Mgal of facility flow	Alum	193	316
	Ferric	104	146

5.3 Combined EBPR and Chemical Phosphorus Removal

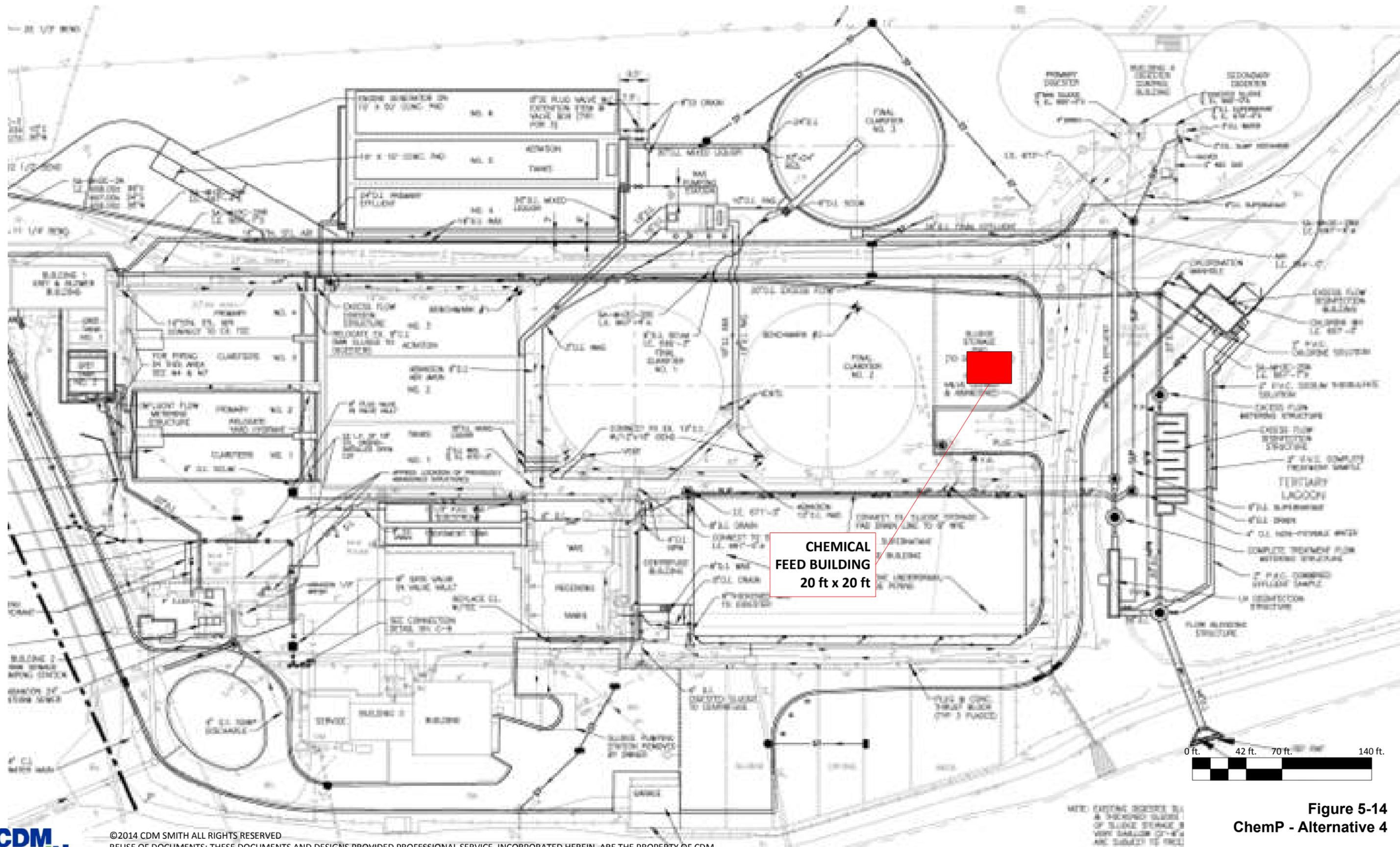
A combination of EBPR and Chem-P processes for reliably meeting TP limitations is typically practiced in WWTFs. For Phase I TP limits, the industry consensus is that EBPR systems can reliably meet TP limits between 0.5 and 1.0 mg P/L. However, most utilities prefer to have chem-P system as backup in case of facility upsets, given that the capital costs required for a backup chem-P system are very low.

One important consideration for this alternative is the fact that the GWWTF has relatively shallow final clarifiers, which are typically conducive of higher effluent TSS compared to other clarifiers, which can make meeting low TP limits challenging. However, at the same time it is acknowledged that the effluent TSS for the GWWTF based on the monthly operating reports (MOR) data has been very solid, but the reported SVIs have shown significant variability.

5.3.1 EBPR + Chemical Phosphorus Removal – Alternative 5

Chem-P can be coupled with any of the EBPR alternatives discussed above. The TP limit for phase I would be met by the EBPR system on a regular basis, leaving the chem-p system as backup. The chemical feed points would still be the same, the only requirement that will change is the storage requirements, as a standard 30 day storage volume will not be needed at the facility, and simply storage volume for two days could be provided to allow for more frequent deliveries in case of extended facility upset conditions.

Appendix A shows the capital and operational costs for the alternative.



CHEMICAL FEED BUILDING
20 ft x 20 ft



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Figure 5-14
ChemP - Alternative 4

Section 6

Phase II Phosphorus Removal Alternatives

This section will describe the alternatives for achieving the TP limit of 0.5 mg P/L annual average, with a mass loading of 21 lb P/d and 51 lb P/d under peak flow conditions (12.5 mgd). In order to meet this limit reliably, we recommend planning for achieving OrthoP of 0.4 mg P/L for Phase II. All alternatives presented in this section assume that at least one of the alternatives for Phase I has been implemented.

In order to reliably meet TP limits of 0.5 mg P/L, the industry consensus is that chem-P coupled with filtration (media filtration, membranes, etc.) or enhanced clarification processes such as ballasted clarification (CoMag, BioMag, Actiflo, etc.) is required. However, it is CDM Smith's experience that some EBPR systems meet limits of less than 0.5 mg P/L most of the time just with use of secondary processes. Data from the intensive sampling showed the OrthoP/TP influent ratio for the GWWTF to be 0.5, 20 percent above the standard domestic wastewater ratio. This means the GWWTF has more particulate TP than compared to standard domestic wastewater, which could mean that an EBPR configuration alone will likely have more challenges meeting TP limits below 0.5 mg P /L.

One of the key questions about meeting low TP limits has to do with reliability. Unfortunately, regulators seldom provide guidelines for reliability, which makes the interpretation of limits for Consulting Engineers and Utility Managers be taken as absolute points, often resulting in system designs for conditions that will be experienced very rarely, which increases the capital costs of projects.

For the purposes of this report, CDM Smith evaluated two different type of alternatives coupled with chemical addition to get down to the 0.4 mg P/L requirement. The first alternative is through the addition of conventional tertiary processes whereas the second alternative evaluated processes that would not require additional processes.

6.1 Effluent Filters and Chem-P Removal – Alternative 1

As an alternative to minimize solids carryover from the existing clarifiers and to allow proper tertiary filtration operations, new media filters can be added to meet the effluent requirements. Removal of TSS to low limits is critical for meeting low TP effluent limits in WWTFs, as typically 5 to 8 percent of the TSS mass is associated with TP, hence the need to provide a tertiary polishing step to achieve this goal.

Since the GWWTF has to meet EPA Class I reliability in their systems if expansions are anticipated, the new filtration system will be design to comply with those requirements.

There are several filtration systems available in the market that can meet proper TSS effluent requirements ranging from standard deep bed media filters to cloth filters. For the GWWTF, a deep bed media filter was assumed for this alternative for simplicity, but other technologies can be implemented.

Table 6-1 shows the required tertiary filtration system capacity analysis, for 6 units system with a total area of 2100 ft².

Table 6-1 Tertiary Filters Capacity Analysis

Hydraulic Loading	Unit	ADF	ADMM	MD	PF
Flow	mgd	5.0	6.5	8.0	12.5
All units in service	gpm/sf	1.7	2.1	2.6	4.1
One unit offline	gpm/sf	2.0	2.6	3.2	5.0

One of the challenges that adding a filtration system to the GWWTF poses is the need to provide an intermediate pump station to provide sufficient gradient for the filters to operate, as there is not enough available gradient in the current facility hydraulic profile to do so.

Expansion of the filters and the location including an assumed intermediate pump station are illustrated in Figure 5-15.

6.2 Enhanced Sedimentation and Chemical Phosphorus Removal Processes – Alternative 2

This alternative describes a technology that does not require additional treatment process and would only require modified existing infrastructure. The BioMag™ process and the use of membrane bioreactors (MBRs) would meet this objective. However, the cost of an MBR system from the capital and operational standpoint is much higher than the BioMag™ process for the effluent limitations required for Phase II, so we will only evaluate the former.

This alternative will improve the settleability of MLSS in the secondary clarifiers through an integrated biological process utilizing a ballast added directly to the mixed liquor. The BioMag™ process, developed by CWT (now under Evoqua Water technologies), employs magnetite as a ballast to create a high-density floc with better settling characteristics than conventional biological MLSS flocs. The process requires less settling area per unit of flow treated. Some pilot studies and small full scale installations have shown that this integrated system would eliminate the need for a tertiary system following an activated sludge system since it can achieve TP levels around 0.1 mg P/L. By increasing the settling characteristics of the MLSS, a higher mixed liquor can be carried in the aeration tanks, which will allow nitrification to occur at higher flow and load conditions, also enhancing wet weather flow treatment of the GWWTF significantly.

BioMag™ is effective for phosphorus removal with the addition of a metal salt, typically ferric chloride or aluminum sulfate, and polymer. Magnetite has a strong adsorption affinity for metal hydroxide flocs as well as biological flocs. The negatively charged cell walls of the bacteria in a biological floc are attracted to the magnetite, which is positively charged. The BioMag™ process, in theory, is based on enhancing the settling of both biological and chemical flocs through addition of the metal salts and excess magnetite ballast prior to the settling tanks. RAS from the settling tanks contains both biological and metal hydroxide flocs peppered with magnetite. The phosphate ions remain inert as they are bound to the metal hydroxide flocs yet still cycle through the system with the RAS. The magnetite ballast is highly attracted to a magnet and is easily recovered and recycled for continuous use. Magnetite is recovered in excess of 90-95 percent from the WAS before the WAS is sent to sludge processing to be thickened and disposed of with the rest of the facility sludge. As an inert mineral, the magnetite can be used indefinitely and never requires replacement, with only supplementation of the small percentage lost to the sludge.

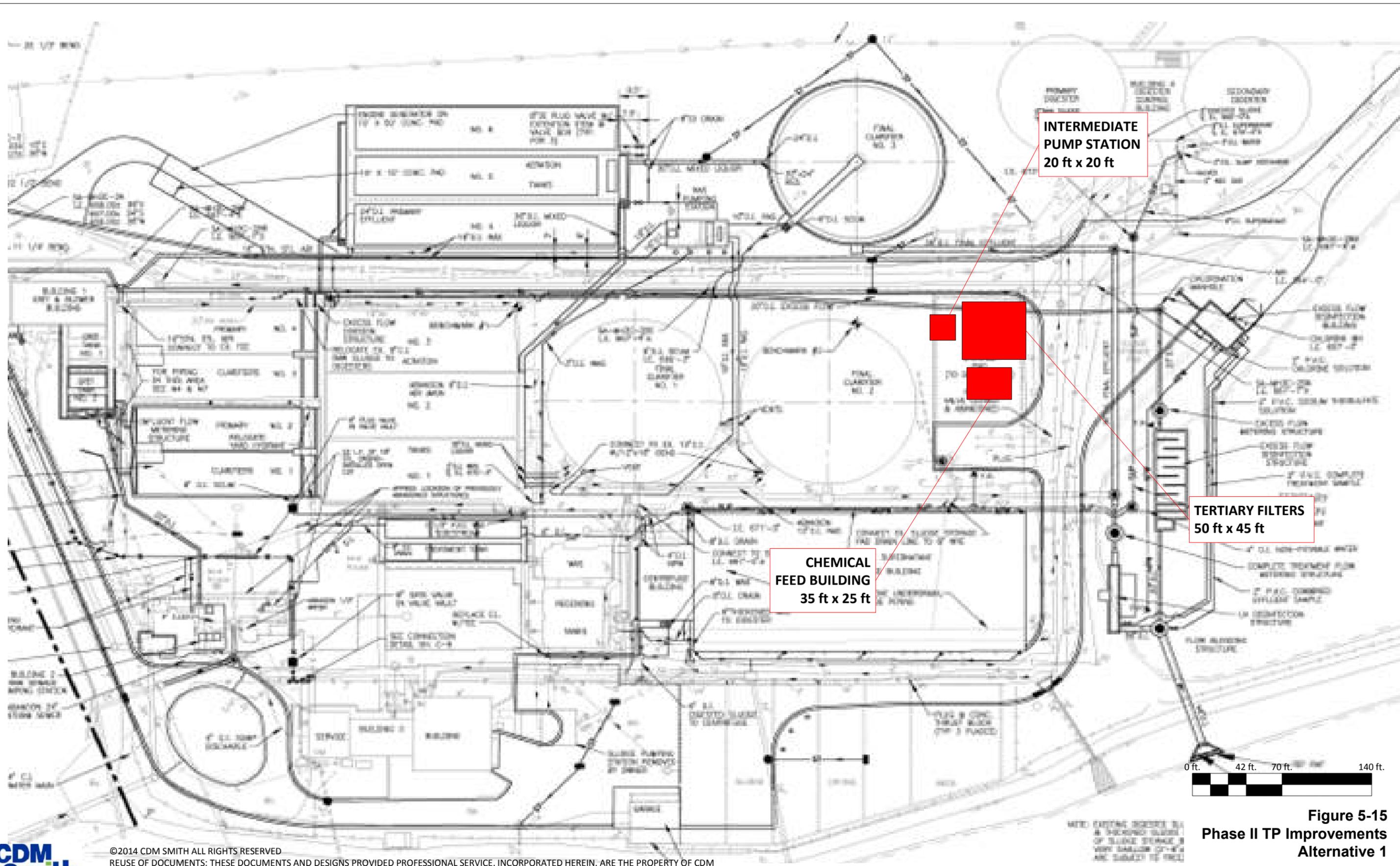


Figure 5-15
Phase II TP Improvements
Alternative 1



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The recovered magnetite combines with virgin magnetite and a sidestream of RAS in a ballast feed tank. The ballasted RAS is distributed to the influent of the nitrification tanks along with the chemical metal salt. The ballasted RAS is maintained in suspension in the nitrification tanks with mixers. The activated sludge quickly settles out and thickens in secondary clarifiers to 4 to 5 percent solids. Polymer can be added to the clarifiers to increase coagulation and settling.

A portion of the activated sludge is wasted, and a sidestream of RAS is sent to the ballast feed tank. The WAS is pumped through an inline shear mixer in order to separate the magnetite from the sludge, and then to a recovery magnet to recover the magnetite to the ballast feed tank. A schematic of the BioMag™ process is shown in Figure 5-16.

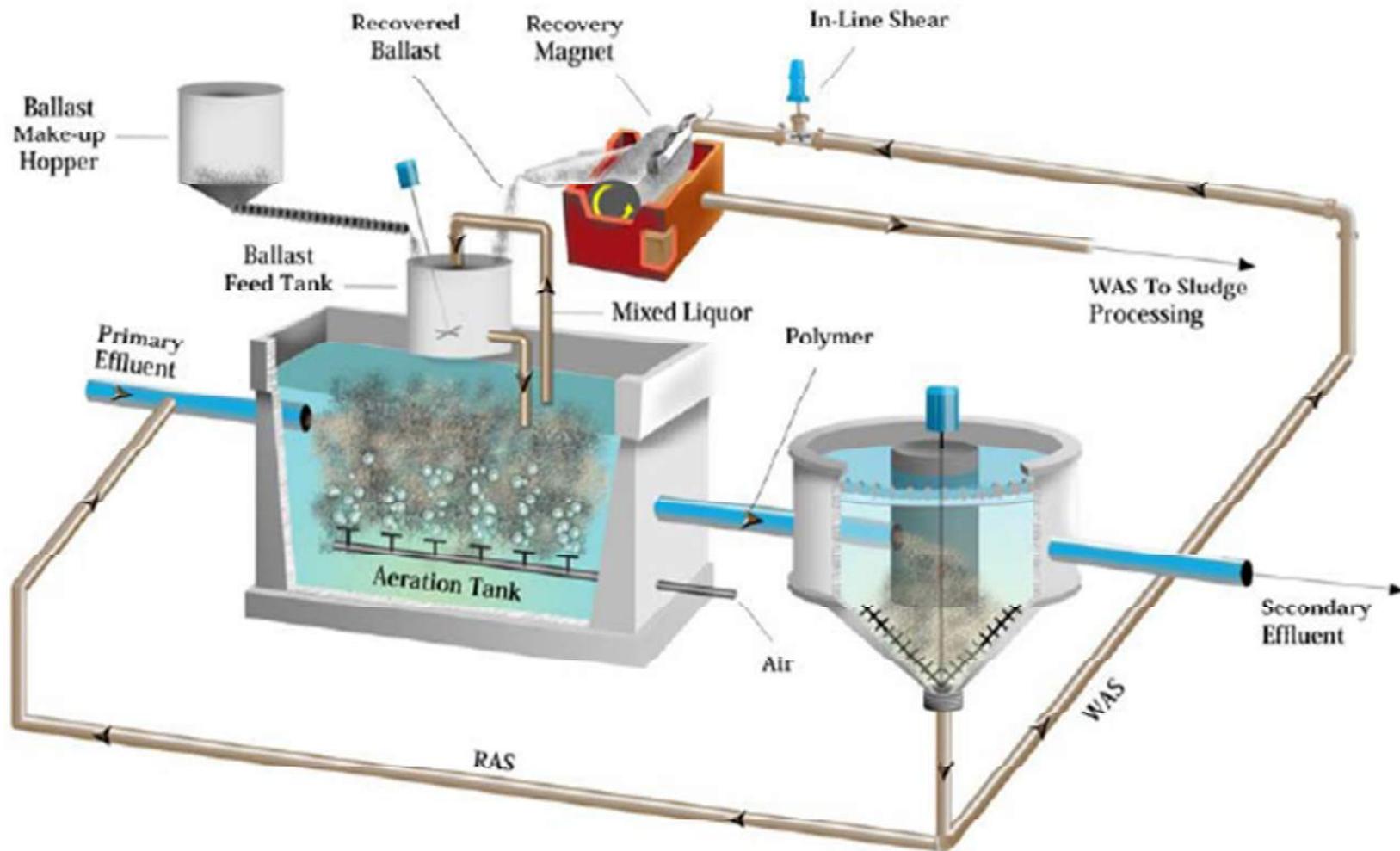
The BioMag™ system for the GWWTF would consist of a new building to house the majority of the BioMag™ equipment. The process would take place within the existing aeration basin / final clarifiers. The mechanical design is summarized in Table 6-2.

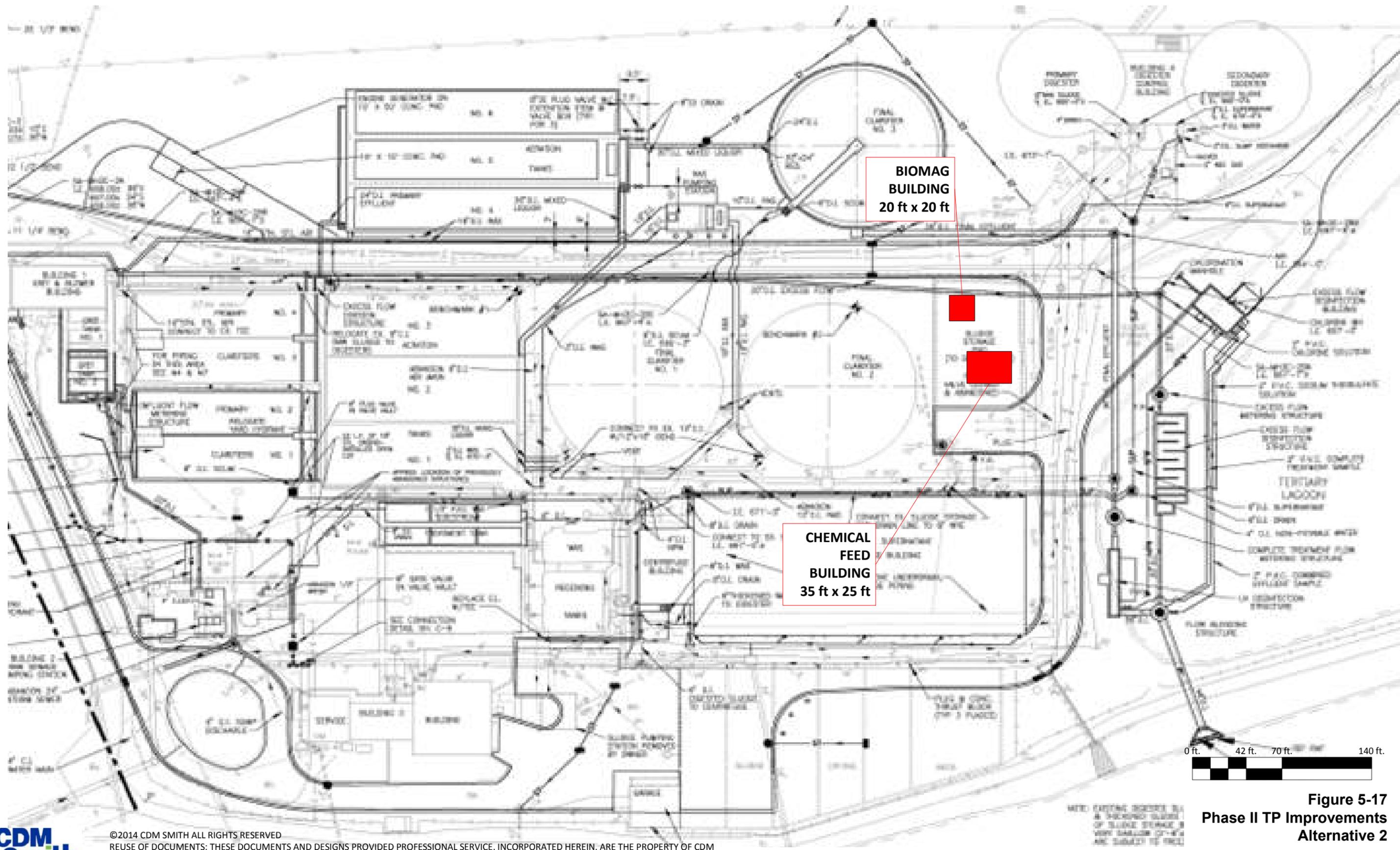
Table 6-2 BioMag™ Design Summary

Design Element	Value
Building footprint (ft x ft)	20 x 20
Treatment capacity (mgd)	>5.0 @ ADF, >12.5 A PHF
Typical headloss (ft)	No change, same as existing
Ancillary equipment supplied by vendor	2 inline shear mills, 2 magnetite recovery drums, 1 ballast tank mixer, 2 WAS feed pumps, 2 WAS wasting pumps, 2 ballasted RAS pumps, 2 air compressors, & 2 air dryers
Ancillary equipment not supplied by vendor	Aeration Basin Mixers

Figure 5-16 illustrates the BioMag™ system components, and Figure 5-17 shows a proposed site layout of the BioMag™ system for the GWWTF.

Figure 5-16 – Biomag™ Process





BIOMAG BUILDING
20 ft x 20 ft

CHEMICAL FEED BUILDING
35 ft x 25 ft

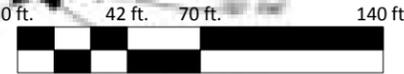


Figure 5-17
Phase II TP Improvements
Alternative 2



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NOTE: EXISTING STRUCTURES SHOWN IN THIS PLAN ARE SUBJECT TO FIELD SURVEY.

Section 7

Phase I and II Alternatives Evaluation

The purpose of this section is to present the evaluation of the alternatives in Section 6, to define the specific criteria that are relevant in deciding which alternative best suits the intentions of the City of Geneva.

For Phase I alternatives, a more detailed evaluation was performed due to the impending TP limits from IEPA. A weighted numeric factor was applied to each criterion evaluated to reflect its relative importance. Using an evaluation matrix, the five alternatives were compared on a point system to help determine which alternative is appropriate.

For Phase II, a less rigorous evaluation was performed as the goal is to provide the City and regulators with possible Phase II limits implementation scenarios, so capital and O&M costs as were the main criteria considered.

7.1 Project Alignment with Sustainable Infrastructure Guidelines

In an effort to align the TP improvements for the GWWTF with principles of sustainable infrastructure, CDM Smith performed sustainability evaluations of the different alternatives proposed to be part of the selection of the alternative to implement.

The Institute for Sustainable Infrastructure's (ISI) Envision™ Sustainability Rating System (Envision) provides a powerful tool for assessing infrastructure projects with respect to sustainability.

Envision is a unique sustainability rating system developed specifically for civil infrastructure projects which uses a holistic approach to evaluating projects against the community's needs and values over the entire project life cycle. In addition to asking the question, "Will we do the project right?" use of Envision encourages the project team to also ask the question, "Will we do the right project?"

This assessment will allow the identification of strengths and potential opportunities to increase overall sustainability at this conceptual level that could be followed during the implementation phase more rigorously. If desired by the City, the project could seek Envision achievement levels recognition which varies from bronze to platinum. This provides an opportunity for infrastructure owners and designers to be recognized for using a life cycle approach, working with communities, and using a restorative approach to infrastructure projects.

The TP improvements project for Geneva has a very important restorative component to it (i.e. restoring the Fox River quality), so recognizing the City for this restorative effort could be seen as advantageous from many angles.

The Envision rating system is divided in 5 main categories and fourteen subcategories. The five categories are listed and briefly described below.

- **Quality of Life** specifically addresses a project's impact on communities including both the health and well-being of individuals and the larger social fabric as a whole

- **Leadership** evaluates project related tasks that demonstrate effective leadership and commitment to sustainability by all parties involved in a project including the owner, team leaders, and constructors. For example: are there policies for sustainability practices in place already?
- **Resource Allocation** measures the use of renewable and non-renewable resources for the project and the benefits of managing resources to allow for a longer life of those resources.
- **Natural World** allows project teams to assess the effect of the project on the preservation and renewal of ecosystem functions. This section addresses how to understand and minimize negative impacts while considering ways in which the infrastructure can interact with natural systems in a synergistic and positive way.
- **Climate and Risk** looks at two main concepts: minimizing emissions that may contribute to increased short- and long-term risks and ensuring that infrastructure projects are resilient to short-term hazards or altered long-term future conditions.

It is noted that not all rating categories will be relevant to this project. The intent is to use this tool as another item for the evaluation process, and the get sustainable projects concepts from Stage 1 (Conceptual Design) per Envision guidelines, to make informed decisions to possibly establish a better strategy for Achieving Stage 2 (Assessment and Recognition) goals. Other sustainability tools will be used for evaluating the alternatives presented in this report.

7.2 Evaluation of Alternatives for Phase I TP Limits

7.2.1 Preliminary Opinion of Probable Cost Analyses for Phase I Treatment Alternatives

Preliminary opinion of probable construction costs (OPCCs) and probable O&M costs are presented in this section. All OPCCs in this section were developed to Class 4 estimates following the American Association of Cost Engineering (AACE) in its guideline Recommended Practice for Cost Estimation Classification, AACE.05. As such, their accuracy level is defined as -15 to +50 percent (Class 4).

All costs are in January 2015 dollars. ENR (Engineering News Record, McGraw-Hill), publishes a construction cost index to assist in comparing costs from different time periods.

7.2.1.1 Opinion of Probable Construction Costs (OPCC)

Construction cost estimates are divided into the following work categories:

- Major equipment and tankage
- Equipment installation
- Major piping valves and fittings (site piping)
- Building costs(foundation, electrical, plumbing, HVAC)
- Concrete structures
- Other miscellaneous significant costs

- Equipment electrical
- Instrumentation and Controls (I&C)
- Protective coatings

Each work category is broken into specific work items in order to prepare planning level estimates of probable construction cost. Unit costs for major equipment and their associated equipment and major piping were developed from cost information provided by local manufacturers and vendors or similar projects.

Costs have been estimated and adjusted based on project specificity and the team's experience with similar projects. A 30 percent contingency is applied to the capital costs to account for unidentified items of work.

Backup information for the construction cost estimates is provided in Appendix A.

Table 7-1 summarizes the capital cost estimates. As shown in the table, Alternatives 1 and 2 have the lowest capital cost, whereas Alternative 4 has the highest capital cost.

Table 7-1 Phase I TP Alternatives - Capital Cost Summary

Alternative	Capital Cost
1 / EPBR (A/O)	\$1,300,000
2 / EBPR (PreAx + A/O)	\$1,300,000
3 / EBPR (A2O)	\$1,600,000
4 / Chem-P	\$1,300,000
5 / EBPR + Chem-P	\$800,000

Notes:

1. Costs are in January 2015 dollars. ENR index – 9500.

Alternatives 1 and 2 have essentially the same costs even though they have slightly different components, due to the accuracy level of the estimate. This indicates that in the event of a tie between these two, cost should not be a deciding factor. Alternative 3 has slightly higher capital costs than 1 and 2 due to the more equipment and tankage modifications required, as well as more energy consumption during O&M. Alternative 4 has the highest capital cost due to the fact that a new chemical feed building is required to house chemical storage and chemical feeding equipment. Alternative 5 costs are based on either Alternative 1 or 2 for EBPR with the addition of minor chemical storage and feeding equipment.

7.2.1.2 Operation and Maintenance (O&M) and Present Worth Costs

O&M and present worth costs for the final selected alternatives presented above were developed. O&M costs are estimated for the following categories:

- Electricity/Power Costs
- Chemicals
- Maintenance Costs
- Replacement cost

Present worth cost are based on the following:

- 3.25 percent interest rate
- 20 years
- Assume construction in mid-2016

Electrical usage costs are estimated using an initial rate of \$0.06/Kw-hr, but were adjusted annually at a 3.8 percent rate to account for the projected energy increases in the Midwest. Two percent of the capital cost is used to estimate annual maintenance costs not included in other categories. Table 2 shows the annual O&M costs averaged over the 20 year evaluation period. As expected, the EBPR alternatives have considerable less O&M costs compared to the chem-p alternative. Alternative 5 was based on O&M cost for Alternative 1 or 2 with the addition of chem-p during contingencies.

Table 7-2 TP Alternatives Phase I – O&M Cost Summary

Alternative	Annual Average O&M Cost
1 / EPBR (A/O)	\$19,000
2 / EBPR (PreAx + A/O)	\$19,000
3 / EBPR (A2O)	\$56,000
4 / Chem-P	\$234,000
5 / EBPR + Chem-P	\$24,000

Notes:

1. Costs are in 2014 dollars. ENR index – 9500.

Table 7-3 provides an overall summary of the costs for the phase I alternatives considered in this report.

Table 7-3 TP Alternatives Phase I – Overall Cost Summary

Alternative	Capital Cost	Average O&M Cost	Present Worth O&M Cost	Total Present Worth Cost
1	\$651,000	\$19,000	\$417,000	\$1,068,000
2	\$651,000	\$19,000	\$417,000	\$1,068,000
3	\$1,608,000	\$56,000	\$1,252,000	\$2,860,000
4	\$1,331,000	\$234,000	\$3,400,000	\$4,731,000
5	\$811,000	\$24,000	\$489,000	\$1,300,000

Notes:

1. Costs are in 2014 dollars. ENR index – 9500.

7.2.2 Evaluation Criteria for Phase I Alternatives

The criteria for selecting the TP alternative to implement were narrowed down to 7 categories. Thorough explanations of the criteria are included to allow for a complete understanding of the scope of each.

7.2.2.1 Reliability

The reliability of a system is its ability to perform and maintain its functions and performance under all foreseeable conditions. This will include standard operation as well as projected peak conditions.

7.2.2.2 Present Worth Cost

This criterion evaluates each alternative based on their construction and O&M costs. This includes materials, labor, equipment, etc. for the capital cost portion.

The cost evaluation is based on the present worth costs calculated from the construction and O&M costs developed in Section 7. All costs are in 2014 dollars. The ENR construction cost index for mid-2014, is 9500. The cost criteria have the one of the highest weighing percentage of primary criteria, supporting its importance in the evaluation process.

The present worth cost is calculated using the estimated construction cost and the estimated O&M costs as described below. The present worth cost is calculated for both a 20 year period using a 3.25 percent “cost of money”. O&M costs are assumed to accrue annually starting at the end of the first year. For this evaluation the present worth component is listed as two separate items: capital cost and O&M cost.

Construction (Capital) Costs. Construction costs are influenced by the process type, complexity of the system, and the extent of the ancillary facilities required. Construction costs are estimated based on general preliminary site and sizing information. Major equipment costs have been obtained from other similar projects.

Operation and Maintenance Costs (O&M). Operation and Maintenance costs reflect the ongoing costs to keep the process operating. O&M costs include operating labor, power, chemicals, routine maintenance, equipment replacement and repair costs.

7.2.2.3 Additional Benefits of Technology

Additional benefits of technology refers to the ability of each alternative to provide benefits to the overall treatment system or processes that are not directly related to the primary objective of the technology and are just incidental with the implementation of the alternative.

7.2.2.4 Impact to Project Schedule / Permitability

This criterion refers to the possible effects that each alternative will have on the overall project schedule. This includes additional data validation efforts like pilot testing, or additional technology investigation due to possible performance risks.

7.2.2.5 Impact to Existing WWTF

Impacts to the existing WWTF is another important criterion in this selection process, as there are certain alternatives that have more susceptibility of affecting the existing liquid and solids trains at the WWTF, which could trigger additional capital and O&M costs; therefore, it should be considered in the evaluation.

7.2.2.6 Process Complexity (Process Operation)

Process complexity with respect to operation pertains to the level of attention, resilience, and sensitivity of each alternative regarding standard process operations.

7.2.2.7 Sustainability Considerations

This criterion will evaluate each alternative’s sustainability potential by using performing a comparative analysis of greenhouse emissions (GHE) from the different alternatives. It is noted that only GHE associated with the improvements were assessed, not the whole WWTF GHE. Additionally, Envision’s Self-Assessment Checklist was performed for the project as a complementary tool to this

evaluation and to create awareness for the implementation phase. Table 7-4 shows the GHE evaluations for the phase I TP alternatives.

Table 7-4 GHE for Phase I TP Improvements Alternatives

Alternative	Description	Process Related Generation (N ₂ O)	Energy Generation	Chemical Production	Chemical and Additional Sludge Transport	Notes
		CO ₂ unit emission Factor	296 lb CO ₂ /lb N ₂ O	1336 lb CO ₂ /MWh	0.28 lb CO ₂ /lb Alum	22.44 lb CO ₂ /gal diesel
		CO ₂ Production				
		lb CO ₂ /yr	lb CO ₂ /yr	lb CO ₂ /yr	lb CO ₂ /yr	
1	EBPR	199,658	145,496			Process emissions modeled in Biowin
2	EBPR	206,789	145,496			
3	EBPR	254,327	455,109			
4	Chem-P	159,251	60,623	46,879	63,020	1. Energy generation Includes Building HVAC and lighting. 2. Assumes chemical transported 2000 miles from the mine to the final destination and 20 miles for delivery of additional sludge produced.
5	EBPR+Chem-P	199,658	151,559	4,688	6,302	Assumes 10% C-P, and EBPR Alt 1

Appendix C contains the preliminary Self-Assessment Checklist for the Phase I TP project as a starting guide to sustainable considerations for the City.

7.2.3 Matrix Evaluation for Phase I Alternatives

In order to effectively quantify and compare the differences between the five alternatives, a matrix evaluation spreadsheet has been developed. The information used to fill out the matrix evaluation is based on a variety of background information and design features for each alternative, most of which are described in previous sections of this report. Each of the evaluation criteria in the matrix are assigned a unique weight based on their relative importance. The total weight amount of all the criteria is equal to 100. The weighing of the various factors and features of each alternative allows evaluation criteria that are more critical to the project to have a greater impact on the comparative analysis.

The evaluation ratings range from 5 to 1, with 5 being the best possible rating. The ratings reflect an evaluation of how well each alternative positively fulfills the listed criteria and how they compare against the other two alternatives. Alternatives may also receive the same ranking if they are equal in a specific criterion.

Table 7-5 shows the evaluation criteria for each alternative.

7.2.4 Evaluation Analysis for Phase I Alternatives

An evaluation matrix was developed and was completed as part of the Evaluation Workshop with City Staff. The Workshop Presentation and Evaluation Matrix are included in Appendix F.

Table 7-5 – Phase I TP Alternatives Evaluation Criteria

Criteria	Alternative 1 EPBR (A/O)	Alternative 2 – EPBR (A/O with PreAX)	Alternative 3 - EBPR (A2O)	Alternative 4 - Chem-P	Alternative - 5 EPBR+Chem-P
Reliability	1. Moderate exposure to NOx recycle streams impacting EBPR. 2. EBPR is susceptible to biological upsets impacting TP removal.	1. Less exposure to NOx recycle streams interferences. 2. EBPR is susceptible to biological upsets impacting TP removal.	1. Least exposure to NOx interferences. 2. EBPR is susceptible to biological upsets impacting TP removal.	1. Extremely Reliable. 2. Not exposed to biological upsets. 3. No	1. Most reliable alternative of all.
Capital Cost	1. Low - Makes use of existing facilities	1. Low - Makes use of existing facilities	1. Moderate - Makes use of existing facilities	1. High. Requires additional structures	Moderate to high. Requires additional structures
O&M Cost	1. Low.	1. Low.	Moderate to low	1. High chemical use cost. 2. Additional sludge disposal cost	1. Low
Additional Benefits/Drawbacks of Technology	1. Uses the resources in the influent for treatment. 2. Susceptible to upsets 3. Proven technology. 4. aSRT is reduced impacting the NH ₄ treatment capacity.	1. Uses the resources in the influent for treatment. 2. Susceptible to upsets 3. Proven technology. 4. aSRT is reduced impacting the NH ₄ treatment capacity.	1. Uses the resources in the influent for treatment. 2. Susceptible to upsets 3. Proven technology. 4. aSRT is reduced the most compared to Alternatives 1 and 2 impacting the NH ₄ treatment capacity. 5. Reduces the TN in the effluent making suitable to future TN regulations.	1. Proven technology 2. Generates more sludge that requires treatment and disposal 3. High potential for radium removal in sludge making land application potentially unviable. 4. No change in NH ₄ treatment capacity	1. Uses the resources in the influent for treatment. 2. Can deal with biological upsets easily 3. Proven technology 4. Two layers of protection for meeting TP limits
Impact to Project Schedule / Permitability	1. Moderate. Requires taking trains offline for constructing the improvements.	1. Moderate. Requires taking trains offline for constructing the improvements.	1. Moderate to high. Requires more work inside the basin compared to Alternatives 1 and 2 requiring more train downtime.	1. Fastest to implement. No dependency with facility operation.	1. Moderate. Requires taking trains offline for constructing the improvements.
Impact to existing WWTF	1. Practically no sludge increase/decrease to current process.	1. Practically no sludge increase/decrease to current process.	1. Practically no sludge increase/decrease to current process.	1. Uses WWTF area for new processes. 2. Requires additional processes	1. Uses WWTF a moderate area for new processes. 2. Requires additional processes
Process Complexity (Process Operation)	1. Moderate effort to operate the process (biological), very resilient.	1. Moderate effort to operate the process (biological), very resilient.	1. Moderate effort to operate the process (biological), very resilient. 2. More process control requirements due to the AX stage	1. Simple operation. 2. Moderate to low level of effort in operation (physical/chemical process)	1. Moderate effort to operate the biological process, but it provides simplicity to deal with upsets.
Sustainability	1. Low GHE. 2. Uses local resources for treatment.	1. Low GHE but requires slightly more energy than Alt 1. 2. Uses local resources for treatment.	1. Low GHE but requires slightly more energy than Alt 1 and 2. 2. Uses local resources for treatment.	1. Requires low energy for treatment within the GWWTF envelope, but requires more energy outside the GWWTF, increasing GHE significantly compared to other alternatives.	1. Low GHE depending on the EBPR selected. 2. Uses local resources for treatment.

7.3 Evaluation of Alternatives for Phase II TP Limits

7.3.1 Opinion of Probable Construction Costs, O&M costs, and Present Worth Costs

Preliminary opinion of probable construction costs (OPCCs) and probable O&M costs are presented in this section for the filtration alternative. For the Biomag alternative, there are limited number of installations so similar projects estimates were used and adjusted based on facility ADF capacity. All OPCCs in this section were developed to Class 5 estimates following the American Association of Cost Engineering (AACE) in its guideline Recommended Practice for Cost Estimation Classification, AACE.05. As such, their accuracy level is defined as -20 to +100 percent (Class 5), given the concept screening stage of this Phase II evaluation. Table 7-6 shows the estimated costs for the two evaluated alternatives.

Table 7-6 Phase II TP Alternatives Costs

Alternative	Capital Cost	Average O&M Cost	Present Worth O&M Cost	Total Present Worth Cost
Filtration + Chem P	\$3,860,000	\$590,000	\$9,352,000	\$13,212,000
Biomag + Chem P	\$5,668,000	\$887,000	\$15,027,000	\$20,695,000

Notes:

1. Costs are in 2014 dollars. ENR index – 9500.
2. Present Worth Costs were estimated using the criteria in Section 7.2.1.2.

Clearly the filtration alternatives are less expensive to implement compared to the enhanced sedimentation processes. Since there is sufficient area available for implementing tertiary processes, it appears that there are no drivers from enhanced sedimentation process to be implemented at the GWWTF at this point in time.

Section 8

Summary and Conclusions

CDM Smith presented TP Alternatives Evaluation results to the City of Geneva at a workshop on February 3, 2015. At the end of the workshop, Phase I TP Alternatives Evaluation Matrix was finalized with the input from the City. According to the matrix scoring, Alternative 5 had the highest score. Alternative A will be implemented in two stages. A2O will be implemented as the EBPR process for Alternative 5.

8.1 Phase I Alternative Recommendations

Alternative 5 with A2O process and back up chemical feed system will be implemented in two parts. First, A2O process improvement will be implemented for EBPR to achieve effluent TP limit of 1.0 mg/L and target effluent TP level of 0.80 mg/L for Phase 1. These improvements will be called Alternative 5A. A2O is recommended for EBPR as it provides more operational flexibility. These flexibilities include a swing anoxic/aerobic zone that is provided with mixers and fine bubble diffused aeration system. Depending on the influent loads and mixed liquor temperatures, aerobic and anoxic SRTs can be adjusted with this swing zone. Another process flexibility is switching A2O process to AO process by turning off internal recycle pumps to favor more TP removal. Figures 5-10 and 5-11 present the proposed A2O process improvements for Trains 1 and 2, respectively. The following is the summary of improvements for Alternative 5A:

- Create an anaerobic zone (14% of each Train 1 and Train 2 total volume) by using FRP baffle walls.
- Install an internal recycle pump for the anaerobic zone to improve EBPR.
- Create an anoxic zone (28% of each Train 1 and Train 2 total volume) by using FRP baffle walls.
- Install two internal recycle pumps (each with 5 mgd pumping capacity) to recycle nitrified mixed liquor from the end of the aeration basin to the head end of anoxic basin.
- Install six mixers for the new anaerobic and anoxic zones. Build support and access structures depending on the type of the mixers selected.
- Partition anoxic zone into two zones. Install fine bubble diffuser in the second part of the anoxic zone to create a swing anoxic/aerobic zone.
- Implement aeration system improvements consisting of new fine bubble diffusers and turbo blowers to provide sufficient aeration system capacity at 4.95 MGD ADF permitted treatment capacity.
- Install online probes (i.e. dissolved oxygen, oxidation-reduction) and analyzer (i.e. ortho-P analyzer) for the operation and control of the new nutrient removal process.

As stated before, the TP limit for Phase I would be achieved by the A2O process on a regular basis. Alternative 5A will be implemented first and A2O process operating data will be collected to determine if a back-up chem-P system is needed. If EBPR is found to be reliable no back-up chem-P system will be provided. However, if the A2O process experiences any unexpected TP removal upsets, a back-up chem-p system will be provided under Alternative 5B. Since this will be a back-up chem-P system, instead of a 30 day storage volume, a metal salt solution storage volume for two days could be provided to allow for more frequent deliveries in case of extended facility upset conditions. A prefabricated and air conditioned chem-P shed will be provide to house chemical metering pumps and metal salt solution totes.

8.2 Recommended Near-Term Improvements, Cost, and Implementation Schedule

The following improvements are recommended based upon discussions with City staff and the evaluations completed:

Phase 1A-

- Blower replacement and associated DO control system, piping and valves.
- Diffuser replacement
- Baffle walls
- Mixers and associated platforms (revise cost to assume more expensive type mixers).
- Recycle pumping and piping
- Allowance for concrete repairs in the reactors/basins (assumed at \$100,000)
- Allowance for grit chamber repairs (assume at \$50,000)
- Addition of six basin influent gates
- Grit/sludge removal and basin cleaning (assumed at \$25,000)

Above costs include 25% electrical allowance for items requiring electric power and 15% instrumentation and control allowance for items requiring I&C.

Phase 1B-

- Small shed to house back-up alum or ferric chemical precipitation system including one or two totes and metering pumps. My recommendation is to delay adding this system until the permit is in place and see how the biological system is behaving. Depending on the full scale results and the new permit, this may end up being a different type of system.

The estimated capital cost for above improvements is \$5,000,000. This cost includes 30% for contingency and 15% for engineering and construction management.

The following implementation schedule has been developed for the above improvements:

- Design - 8 to 10 months from NTP
- Bidding and permitting - 3 months after design
- Construction - 12 to 16 month
- Startup and testing - 1 to 2 months.

Appendix A

PW Cost Analysis

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GWTF - TP Evaluation Alternatives 1 and 2 - Capital and O&M Costs					
Capital Cost Estimate					
Item no.	Facility Description	Units	Unit Cost/Percentage	Quantity	Amount (\$)
1	Equipment	LS			\$ 81,000
2	Equipment Installation		30%		\$ 25,000
3	Piping/Valves/Fittings	LS			\$ 20,000
4	Platforms	\$/sq. ft.	\$500	120	\$ 60,000
5	Building Electrical	\$/sq. ft.	\$110		\$ -
6	Plumbing		3% of building costs		\$ -
7	HVAC				
8	Concrete Structures	\$/cy	\$1,000	0	\$ -
9	Miscellaneous (other significant/defensible costs) - FRP Baffle Walls	LS			\$ 128,000
10					
11				Subtotal	\$ 314,000
12	Equipment Electrical		25%		\$ 79,000
13	Instrumentation and Controls		15%		\$ 48,000
14	Protective Coatings		2%		\$ 7,000
15				Total	\$ 448,000
16	Construction Contingency		30%		\$ 135,000
17	Engineering, Legal, and Administration (ELA)		15%		\$ 68,000
18				Total with Contingency and ELA	\$ 651,000
19	Escalation		0%		\$ -
20				Total Capital Costs	\$ 651,000
O&M Cost Estimate					
Component		Unit			Power Cost (\$ in 20 yr)
21	NPV energy cost 20 yrs (see energy evaluation tab)				\$ 140,000
22	Average				\$ 10,000
23					
24					
25					
26					
27					
28					
29					
30				Subtotal - Power	\$ 10,000
Chemicals				Quantity	Cost (\$/yr)
31					
32					
33					
34				Subtotal - Chemicals	\$ -
Replacement of Major Equipment/Parts					
35	Replacement Cost (5% annual of capital cost)				\$ 6,000
36	Maintenance cost of equipment (2% annual of capital cost)				\$ 3,000
37				Annual O&M Average (\$)	\$ 19,000
Present Worth Calculations					
38	Present Worth O&M	n=	20		
39		i=	3.25%		
40				Present Worth O&M	\$417,000
41	Total Present Worth (Capital + O&M)				\$1,068,000

Notes:

1. Maintenance labor is not included in this estimate.
2. Cost are rounded to the nearest 1000.
3. ENR CCI index - 9500 (Year 2014)

GWTF - TP Evaluation Alternatives 1 and 2- O&M Costs					
Energy Cost Estimate					
Year	Power draw	Kw-hr/d	Annual Power Draw	Power Cost	Operating Cost
	HP		(kW-h)	(\$/kW-h)	(\$)
2013	16.8	298.37	108904.32	0.060	\$ 6,534
2014	16.8	298.37	108904.32	0.062	\$ 6,779
2015	16.8	298.37	108904.32	0.065	\$ 7,034
2016	16.8	298.37	108904.32	0.067	\$ 7,297
2017	16.8	298.37	108904.32	0.070	\$ 7,571
2018	16.8	298.37	108904.32	0.072	\$ 7,855
2019	16.8	298.37	108904.32	0.075	\$ 8,149
2020	16.8	298.37	108904.32	0.078	\$ 8,455
2021	16.8	298.37	108904.32	0.081	\$ 8,772
2022	16.8	298.37	108904.32	0.084	\$ 9,101
2023	16.8	298.37	108904.32	0.087	\$ 9,442
2024	16.8	298.37	108904.32	0.090	\$ 9,796
2025	16.8	298.37	108904.32	0.093	\$ 10,164
2026	16.8	298.37	108904.32	0.097	\$ 10,545
2027	16.8	298.37	108904.32	0.100	\$ 10,940
2028	16.8	298.37	108904.32	0.104	\$ 11,351
2029	16.8	298.37	108904.32	0.108	\$ 11,776
2030	16.8	298.37	108904.32	0.112	\$ 12,218
2031	16.8	298.37	108904.32	0.116	\$ 12,676
2032	16.8	298.37	108904.32	0.121	\$ 13,151
2033	16.8	298.37	108904.32	0.125	\$ 13,645
PRESENT WORTH					\$ 140,000

Discount Rate 3.3%
Initial Power Cost \$0.060
Power Cost Inflation Rate 3.8%

Average yearly Energy Cost \$ 10,000

GWTF - EBPR Alternative 3 Capital and O&M Costs					
Capital Cost Estimate					
Item no.	Facility Description	Units	Unit Cost/Percentage	Quantity	Amount (\$)
1	Equipment (includes tankage)	LS			\$ 269,000
2	Equipment Installation		30%		\$ 81,000
3	Piping/Valves/Fittings	LS			\$ 30,000
4	Platforms (incl Stairs)	\$/sq. ft.	\$500	160	\$ 80,000
5	Building Electrical	\$/sq. ft.	\$110		\$ -
6	Plumbing		3% of building costs		\$ -
7	HVAC				
8	Concrete Structures	\$/cy	\$1,000	0	\$ -
9	Miscellaneous (other significant/defensible costs) - FRP Baffle Walls	LS			\$ 320,000
10					
11				Subtotal	\$ 780,000
12	Equipment Electrical		25%		\$ 195,000
13	Instrumentation and Controls		15%		\$ 117,000
14	Protective Coatings		2%		\$ 16,000
15				Total	\$ 1,108,000
16	Construction Contingency		30%		\$ 333,000
17	Engineering, Legal, and Administration (ELA)		15%		\$ 167,000
18				Total with Contingency and ELA	\$ 1,608,000
19	Escalation		0%		\$ -
20				Total Capital Costs	\$ 1,608,000
O&M Cost Estimate					
Component		Unit			Power Cost (\$ in 20 yr)
21	NPV energy cost for 20 yrs (see energy evaluation tab)				\$ 437,000
22	Average				\$ 31,000
23					
24					
25					
26					
27					
28					
29					
30				Subtotal - Power	\$ 31,000
Chemicals			Quantity		Cost (\$/yr)
31					
32					
33					
34				Subtotal - Chemicals	\$ -
Replacement of Major Equipment/Parts					
35	Replacement Cost (5% annual of capital cost)				\$ 18,000
36	Maintenance cost of equipment (2% annual of capital cost)				\$ 7,000
37				Annual O&M Average (\$)	\$ 56,000
Present Worth Calculations					
38	Present Worth O&M	n=	20		
39		i=	3.25%		
40				Present Worth O&M	\$1,252,000
41	Total Present Worth (Capital + O&M)				\$2,860,000

Notes:

1. Maintenance labor is not included in this estimate.
2. Cost are rounded to the nearest 1000.
3. ENR CCI index - 9500 (Year 2014)

Geneva WWTF - Mixer Evaluation Alternative 3					
Capital and O&M Costs					
Energy Cost Estimate					
Year	Power draw	Kw-hr/d	Annual Power Draw	Power Cost	Operating Cost
	HP		(kW-h)	(\$/kW-h)	(\$)
2013	52.55	933.29	340650.12	0.060	\$ 20,439
2014	52.55	933.29	340650.12	0.062	\$ 21,205
2015	52.55	933.29	340650.12	0.065	\$ 22,001
2016	52.55	933.29	340650.12	0.067	\$ 22,826
2017	52.55	933.29	340650.12	0.070	\$ 23,682
2018	52.55	933.29	340650.12	0.072	\$ 24,570
2019	52.55	933.29	340650.12	0.075	\$ 25,491
2020	52.55	933.29	340650.12	0.078	\$ 26,447
2021	52.55	933.29	340650.12	0.081	\$ 27,439
2022	52.55	933.29	340650.12	0.084	\$ 28,468
2023	52.55	933.29	340650.12	0.087	\$ 29,535
2024	52.55	933.29	340650.12	0.090	\$ 30,643
2025	52.55	933.29	340650.12	0.093	\$ 31,792
2026	52.55	933.29	340650.12	0.097	\$ 32,984
2027	52.55	933.29	340650.12	0.100	\$ 34,221
2028	52.55	933.29	340650.12	0.104	\$ 35,504
2029	52.55	933.29	340650.12	0.108	\$ 36,836
2030	52.55	933.29	340650.12	0.112	\$ 38,217
2031	52.55	933.29	340650.12	0.116	\$ 39,650
2032	52.55	933.29	340650.12	0.121	\$ 41,137
2033	52.55	933.29	340650.12	0.125	\$ 42,680
PRESENT WORTH					\$ 437,000

Discount Rate 3.3%

Initial Power Cost \$0.060
Power Cost Inflation Rate 3.8%

Average yearly Energy Cost \$ 31,000

GWTF - EBPR Alternative 3 Capital and O&M Costs					
Capital Cost Estimate					
Item no.	Facility Description	Units	Unit Cost/Percentage	Quantity	Amount (\$)
1	Equipment (includes tankage & FRP Shed)	LS			\$ 331,000
2	Equipment Installation		30%		\$ 100,000
3	Piping/Valves/Fittings	LS			\$ 78,000
4	Gates	LS			\$ 117,000
5	Platforms (inck Stairs)	\$/sq. ft.	\$500	160	\$ 80,000
6	Building Electrical	\$/sq. ft.	\$110		\$ -
7	Plumbing		3% of building costs		\$ -
8	HVAC				
9	Concrete Structures	LS			\$ 100,000
10	Miscellaneous (other significant/defensible costs) - FRP Baffle Walls	LS			\$ 320,000
11	Sludge Cleaning and disposal	LS			\$ 25,000
12				Subtotal	\$ 1,151,000
13	Equipment Electrical		25%		\$ 288,000
14	Instrumentation and Controls		15%		\$ 173,000
15	Protective Coatings		2%		\$ 24,000
16				Total	\$ 1,636,000
17	Construction Contingency		30%		\$ 491,000
18	Engineering, Legal, and Administration (ELA)		15%		\$ 246,000
19	General Conditions		10%		\$ 164,000
20	Overhead and Profit		15%		\$ 246,000
21				Total with Contingency and ELA	\$ 2,783,000
22	Escalation		0%		\$ -
23				Total Capital Costs	\$ 2,783,000
O&M Cost Estimate					
Component		Unit			Power Cost (\$ in 20 yr)
24	NPV energy cost for 20 yrs (see energy evaluation tab)				\$ 437,000
25	Average				\$ 31,000
26					
27					
28					
29					
30					
31					
32					
33				Subtotal - Power	\$ 31,000
Chemicals			Quantity		Cost (\$/yr)
34					
35					
36					
37				Subtotal - Chemicals	\$ -
Replacement of Major Equipment/Parts					
38	Replacement Cost (5% annual of capital cost)				\$ 22,000
39	Maintenance cost of equipment (2% annual of capital cost)				\$ 9,000
40				Annual O&M Average (\$)	\$ 62,000
Present Worth Calculations					
41	Present Worth O&M	n=	20		
42		i=	3.25%		
43				Present Worth O&M	\$1,339,000
44	Total Present Worth (Capital + O&M)				\$4,122,000

Notes:

- Maintenance labor is not included in this estimate.
- Cost are rounded to the nearest 1000.
- ENR CCI index - 9500 (Year 2014)

Geneva WWTF - Mixer Evaluation Alternative 3					
Capital and O&M Costs					
Energy Cost Estimate					
Year	Power draw	Kw-hr/d	Annual Power Draw	Power Cost	Operating Cost
	HP		(kW-h)	(\$/kW-h)	(\$)
2013	52.55	933.29	340650.12	0.060	\$ 20,439
2014	52.55	933.29	340650.12	0.062	\$ 21,205
2015	52.55	933.29	340650.12	0.065	\$ 22,001
2016	52.55	933.29	340650.12	0.067	\$ 22,826
2017	52.55	933.29	340650.12	0.070	\$ 23,682
2018	52.55	933.29	340650.12	0.072	\$ 24,570
2019	52.55	933.29	340650.12	0.075	\$ 25,491
2020	52.55	933.29	340650.12	0.078	\$ 26,447
2021	52.55	933.29	340650.12	0.081	\$ 27,439
2022	52.55	933.29	340650.12	0.084	\$ 28,468
2023	52.55	933.29	340650.12	0.087	\$ 29,535
2024	52.55	933.29	340650.12	0.090	\$ 30,643
2025	52.55	933.29	340650.12	0.093	\$ 31,792
2026	52.55	933.29	340650.12	0.097	\$ 32,984
2027	52.55	933.29	340650.12	0.100	\$ 34,221
2028	52.55	933.29	340650.12	0.104	\$ 35,504
2029	52.55	933.29	340650.12	0.108	\$ 36,836
2030	52.55	933.29	340650.12	0.112	\$ 38,217
2031	52.55	933.29	340650.12	0.116	\$ 39,650
2032	52.55	933.29	340650.12	0.121	\$ 41,137
2033	52.55	933.29	340650.12	0.125	\$ 42,680
PRESENT WORTH					\$ 437,000

Discount Rate 3.3%

Initial Power Cost \$0.060
Power Cost Inflation Rate 3.8%

Average yearly Energy Cost \$ 31,000

GWTF - Chemical Phosphorus System Capital and O&M Costs					
Capital Cost Estimate					
Item no.	Facility Description	Units	Unit Cost/Percentage	Quantity	Amount (\$)
1	Major Equipment	LS	From Vendors		\$ 57,000
2	Equipment Installation		40%		\$ 23,000
3	Piping/Valves/Fittings	LS			\$ 15,000
4	Building and Foundation Costs (No Building)	\$/sq. ft.	\$250	980	\$ 245,000
5	Building Electrical	\$/sq. ft.	\$110	980	\$ 108,000
6	Plumbing		3% of building costs		\$ 11,000
7	HVAC		30% of building costs		\$ 106,000
8	Concrete Structures	\$/cy	\$1,000	40.0	\$ 40,000
9	Miscellaneous (other significant/defensible costs- stairs, grating, sump pump, etc)	LS			\$ 15,000
10				Subtotal	\$ 620,000
11	Equipment Electrical		25%		\$ 155,000
12	Instrumentation and Controls		15%		\$ 93,000
13	Protective Coatings		2%		\$ 13,000
14				Total	\$ 881,000
15	Construction Contingency		30%		\$ 265,000
16	Engineering, Legal, and Administration (ELA)		15%		\$ 133,000
17				Total with Contingency and ELA	\$ 1,279,000
18	Escalation		4%		\$ 52,000
19				Total Capital Costs	\$ 1,331,000
O&M Cost Estimate					
Component					Power Cost (\$/yr)
20	NPV energy cost for 20 years (see energy evaluation tab)				\$ 41,000
21	Average				\$ 3,000
22					\$ -
23					
24				Subtotal Annual Average - Power	\$ 3,000
Chemicals & Additional Sludge Disposal				Quantity (gal/d)	Cost (\$/yr)
24	Metal Salt			642	\$ 190,000
25	Excess Sludge Disposal (hauling and landfilling only)			1500	\$ 14,000
26					\$ -
27				Subtotal - Chemicals	\$ 204,000
Replacement of Major Equipment/Parts					
29	Replacement Cost (5% annual of capital cost)				\$ 4,000
30	Maintenance cost of equipment (2% annual of capital cost)				\$ 2,000
31	O&M Contingency		10%		\$ 21,000
32				Annual Average O&M (\$)	\$ 234,000
Present Worth Calculations					
33	Present Worth O&M	n=	20		
34		i=	3.25%		
35				Present Worth O&M	\$3,400,000
36	Total Present Worth (Capital + O&M)				\$4,731,000

Notes:

- Maintenance labor is not included in this estimate.
- Cost are rounded to the nearest 1000.

GWTF - TP Evaluation Alternative 4					
O&M Costs					
Energy Cost Estimate					
Year	Power draw	Kw-hr/d	Annual Power Draw	Power Cost	Operating Cost
	HP		(kW-h)	(\$/kW-h)	(\$)
2013	7	124.32	45376.80	0.060	\$ 2,723
2014	7	124.32	45376.80	0.034	\$ 1,563
2015	7	124.32	45376.80	0.037	\$ 1,657
2016	7	124.32	45376.80	0.039	\$ 1,756
2017	7	124.32	45376.80	0.041	\$ 1,862
2018	7	124.32	45376.80	0.043	\$ 1,974
2019	7	124.32	45376.80	0.046	\$ 2,092
2020	7	124.32	45376.80	0.049	\$ 2,217
2021	7	124.32	45376.80	0.052	\$ 2,351
2022	7	124.32	45376.80	0.055	\$ 2,492
2023	7	124.32	45376.80	0.058	\$ 2,641
2024	7	124.32	45376.80	0.062	\$ 2,800
2025	7	124.32	45376.80	0.065	\$ 2,967
2026	7	124.32	45376.80	0.069	\$ 3,146
2027	7	124.32	45376.80	0.073	\$ 3,334
2028	7	124.32	45376.80	0.078	\$ 3,534
2029	7	124.32	45376.80	0.083	\$ 3,746
2030	7	124.32	45376.80	0.088	\$ 3,971
2031	7	124.32	45376.80	0.093	\$ 4,209
2032	7	124.32	45376.80	0.098	\$ 4,462
2033	7	124.32	45376.80	0.104	\$ 4,730
PRESENT WORTH					\$ 41,000

Discount Rate 3.3%
Initial Power Cost \$0.060
Power Cost Inflation Rate 3.8%

Average yearly Energy Cost \$ 3,000

GWTF - TP Evaluation Alternative 5- Capital and O&M Costs					
Capital Cost Estimate					
Item no.	Facility Description	Units	Unit Cost/Percentage	Quantity	Amount (\$)
1	Equipment and FRP Shed	LS			\$ 142,000
2	Equipment Installation		30%		\$ 43,000
3	Piping/Valves/Fittings	LS			\$ 20,000
4	Platforms	\$/sq. ft.	\$500	120	\$ 60,000
5	Building Electrical	\$/sq. ft.	\$110		\$ -
6	Plumbing		3% of building costs		\$ -
7	HVAC				
8	Concrete Structures	\$/cy	\$1,000	0	\$ -
9	Miscellaneous (other significant/defensible costs) - FRP Baffle Walls	LS			\$ 128,000
10					
11				Subtotal	\$ 393,000
12	Equipment Electrical		25%		\$ 99,000
13	Instrumentation and Controls		15%		\$ 59,000
14	Protective Coatings		2%		\$ 8,000
15				Total	\$ 559,000
16	Construction Contingency		30%		\$ 168,000
17	Engineering, Legal, and Administration (ELA)		15%		\$ 84,000
18				Total with Contingency and ELA	\$ 811,000
19	Escalation		0%		\$ -
20				Total Capital Costs	\$ 811,000
O&M Cost Estimate					
Component		Unit			Power Cost (\$ in 20 yr)
21	NPV energy cost 20 yrs(see energy evaluation tab)				\$ 140,000
22	Average				\$ 10,000
23					
24					
25					
26					
27					
28					
29					
30				Subtotal - Power	\$ 10,000
Chemicals				Quantity	Cost (\$/yr)
31					
32					
33					
34				Subtotal - Chemicals	\$ -
Replacement of Major Equipment/Parts					
35	Replacement Cost (5% annual of capital cost)				\$ 10,000
36	Maintenance cost of equipment (2% annual of capital cost)				\$ 4,000
37				Annual O&M Average (\$)	\$ 24,000
Present Worth Calculations					
38	Present Worth O&M	n=	20		
39		i=	3.25%		
40				Present Worth O&M	\$489,000
41	Total Present Worth (Capital + O&M)				\$1,300,000

Notes:

1. Maintenance labor is not included in this estimate.
2. Cost are rounded to the nearest 1000.
3. ENR CCI index - 9500 (Year 2014)

GWTF - TP Evaluation Alternative 5- Capital and O&M Costs					
Energy Cost Estimate					
Year	Power draw	Kw-hr/d	Annual Power Draw	Power Cost	Operating Cost
	HP		(kW-h)	(\$/kW-h)	(\$)
2013	16.8	298.37	108904.32	0.060	\$ 6,534
2014	16.8	298.37	108904.32	0.062	\$ 6,779
2015	16.8	298.37	108904.32	0.065	\$ 7,034
2016	16.8	298.37	108904.32	0.067	\$ 7,297
2017	16.8	298.37	108904.32	0.070	\$ 7,571
2018	16.8	298.37	108904.32	0.072	\$ 7,855
2019	16.8	298.37	108904.32	0.075	\$ 8,149
2020	16.8	298.37	108904.32	0.078	\$ 8,455
2021	16.8	298.37	108904.32	0.081	\$ 8,772
2022	16.8	298.37	108904.32	0.084	\$ 9,101
2023	16.8	298.37	108904.32	0.087	\$ 9,442
2024	16.8	298.37	108904.32	0.090	\$ 9,796
2025	16.8	298.37	108904.32	0.093	\$ 10,164
2026	16.8	298.37	108904.32	0.097	\$ 10,545
2027	16.8	298.37	108904.32	0.100	\$ 10,940
2028	16.8	298.37	108904.32	0.104	\$ 11,351
2029	16.8	298.37	108904.32	0.108	\$ 11,776
2030	16.8	298.37	108904.32	0.112	\$ 12,218
2031	16.8	298.37	108904.32	0.116	\$ 12,676
2032	16.8	298.37	108904.32	0.121	\$ 13,151
2033	16.8	298.37	108904.32	0.125	\$ 13,645
PRESENT WORTH					\$ 140,000

Discount Rate 3.3%
Initial Power Cost \$0.060
Power Cost Inflation Rate 3.8%

Average yearly Energy Cost \$ 10,000

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Appendix B

Jar Testing Results

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City of Geneva
Wastewater Treatment Plant

Facility Plan Update Project
Chemical Phosphorus Removal Evaluation
"Preliminary" Aluminum Sulfate [Alum] Additions

"Revised" 10 November 2014

Submitted To:

CDM Smith
125 South Wacker Drive, Suite 600
Chicago, Illinois 60606

Working Solution, mg/L

Al as ppm in Jar Test (2L)

4,000	"Target"	Volume, mls	"Target"	"Actual"
1,056.87	"Actual"	12.5	25	6.6
18 mls "Concentrate" per liter		20	40	10.6
		30	60	15.9
		37.5	75	19.8
		40	80	21.1
		50	100	26.4
		62.5	125	33.0
		75	150	39.6
		100	200	52.8

Second Stage Additions

Working Solution, mg/L

Al as ppm in Jar Test (2L)

4,000	"Target"	Volume, mls	"Target"	"Actual"	
1,056.87	"Actual"	25	50	13.2	"Pretreated" 50%
18 mls "Concentrate" per liter		5	10	2.6	
		10	20	5.3	
		15	30	7.9	
		20	40	10.6	
		25	50	13.2	"optimized dosage" 26.4 ppm
		30	60	15.9	

Date:	Tuesday, October 28, 2014	SAMPLE:	Raw Influent
GRAB TIME:	10:00 AM Rolling Grit Chamber		"Evaluation of Aluminum Sulfate Additions"
RUN TIME:	2 sets of 6 Jars, (10a to Noon), end @ 4:30p		Q _{POTW} = 4.5 MGD

"Total"	TEMP °C	19.5	CONDUCTIVITY	1,548	TURBIDITY	69	ALKALINITY	432	Ortho P	5.52
Raw Influent	pH	7.80	ORP	68	TSS	349	inital pH	7.81	Acid-Hydro P	7.66
									Total P	10.83

Supernatant (Primary Effluent)	JAR 1 "Control"	JAR 2 6.6 ppm	JAR 7 10.6 ppm	JAR 8 15.9 ppm	JAR 3 19.8 ppm	JAR 9 21.1 ppm	JAR 10 26.4 ppm	JAR 4 33.0 ppm	JAR 5 39.6 ppm	JAR 6 52.8 ppm
TEMP °C	19.5	19.4	19.2	19.0	19.2	19.1	19.1	19.3	19.4	19.7
pH	7.81	7.54	7.42	7.29	7.16	7.16	7.01	6.92	6.69	6.58
CONDUCTIVITY	1,555	1,537	1,559	1,535	1,547	1,533	1,549	1,549	1,557	1,551
ORP	91	114	125	141	154	159	155	160	168	165
TURBIDITY	49	23	17	11	8.6	7.3	5.6	3.6	3.4	2.8

*YSI 6920 SONDE @ 300 MLS IN CALIBRATION CUP

ALKALINITY	420	380	363	330	313	308	270	235	209	148
inital pH	7.48	7.48	7.36	7.18	7.05	7.00	6.92	6.75	6.60	6.35
TSS	93.3	52.9	41.9	32.1	26.9	21.2	16.8	11.1	10.1	9.3
Sludge Height	90	100	100	125	140	140	150	155	175	195
Ortho P	4.07	1.08	1.40	0.63	0.38	0.33	0.24	0.13	0.12	0.11
Acid-Hydro P	4.89	2.59	1.66	0.80	0.54	0.44	0.34	0.23	0.19	0.16
Total P	5.69	2.65	1.90	0.99	0.68	0.57	0.42	0.27	0.24	0.20
Hydrolyzable P	0.82	1.51	0.26	0.17	0.16	0.11	0.10	0.10	0.07	0.05
Organic P	0.80	0.06	0.24	0.19	0.14	0.13	0.08	0.04	0.05	0.04

*PERFORMED IN 2000 MLS JAR TEST, Initial Stock Solution only 1,056.9 ppm in lieu of 4,000 ppm -- Dosage Revised 10 Nov 2014

Date:	Thursday, October 23, 2014	SAMPLE:	"PRELIMINARY" Trial Run
GRAB TIME:	11:30 AM Raw Influent		Raw Influent
RUN TIME:	Setup at 11:30a, end @ 5:30p		"Evaluation of Aluminum Sulfate Additions"

"Total"	TEMP °C	CONDUCTIVITY	TURBIDITY	ALKALINITY	Ortho P
	pH	ORP	MLSS	initial pH	Total P
No Sample Analyzed					

Supernatant	JAR 1 "Control"	JAR 2 6.6 ppm	JAR 3 19.8 ppm	JAR 4 33.0 ppm	JAR 5 39.6 ppm	JAR 6 52.8 ppm
TEMP °C	20.2	19.3	19.3	19.2	19.3	19.3
pH	7.75	7.48	7.06	6.62	6.60	6.24
CONDUCTIVITY	1,721	1,778	1,779	1,786	1,772	1,778
ORP	88	120	139	153	163	173
TURBIDITY	468	236	226	256	298	270

*YSI 6920 SONDE @ 600 MLS IN BEAKER (surface too reflective for turbidity, difficult to keep in suspension)

ALKALINITY	431	392	317	284	218	156
initial pH	Values not recorded at time of analysis...					
TSS	68.7	44.1	13.4	9.6	7.6	7.8
Sludge Height	120	140	175	190	200	210
Ortho P	2.93	1.47	0.23	0.22	0.24	0.21
Total P	4.27	2.27	0.34	0.34	0.41	0.46
AH P	Analysis not performed...					
UV Trans	0.0217	0.0305	0.0392	0.0401	0.0399	0.0427

*PERFORMED IN 2000 MLS JAR TEST, Initial Stock Solution only 1,056.9 ppm in lieu of 4,000 ppm -- Dosage Revised 10 Nov 2014

Notes:

- _____ Total Raw Influent sample was not analyzed
- _____ ergo no baseline available before clarification
- _____
- _____ Sonde pH probe requires solution movement
- _____ Sonde in general prove does not like "bumping"
- _____
- _____ Utilize ultra fast pH probe initial value from
- _____ alkalinity analysis.
- _____
- _____ Utilize TSS values in lieu of turbidity/UV trans
- _____ especially with Raw Influent (Primary Effluent)
- _____
- _____ Dosage Range too wide between 25 ppm and
- _____ 125 ppm , include additional dosage points

Date:	Wednesday, October 29, 2014	SAMPLE:	Activated Sludge MLSS Feed to Secondary Clarifiers
GRAB TIME:	10:00 AM Aeration Tanks № 1 & 4		"Evaluation of Second Stage Alum Addition"
RUN TIME:	3 "prelim" sets of 6 Jars, (10a to 1p) w/final add at 2p, end @ 6p		*Optimized Dosage of 26.4 ppm

				UV Trans	77.10					
"Blank"	TEMP °C	19.5	CONDUCTIVITY	1,549	TURBIDITY	BDL	ALKALINITY	409	Ortho P	1.62
MLSS Supernate w/o Alum Addition	pH	8.08	ORP	214	TSS	1.0	inital pH	8.02	Total P	1.75

"Control"	TEMP °C	19.60	CONDUCTIVITY	1,537	TURBIDITY	0.2	ALKALINITY	340	Ortho P	0.27
13.2 ppm Addition	pH	7.95	ORP	215	TSS	4.1	inital pH	7.28	Total P	0.35
				UV Trans	77.84					

MLSS "pretreated" w/ 13.2 ppm Alum Addition: **Second Stage**

Supernate	JAR 1 2.6 ppm	JAR 2 5.3 ppm	JAR 3 7.9 ppm	JAR 4 10.6 ppm	JAR 5 13.2 ppm	JAR 6 15.9 ppm
TEMP °C	19.6	19.6	19.5	19.6	19.6	19.6
pH	7.76	7.66	7.53	7.43	7.39	7.35
CONDUCTIVITY	1,526	1,526	1,537	1,528	1,517	1,526
ORP	214	214	218	220	221	221
TURBIDITY	2.9	3.8	4.8	4.6	4.3	4.8
*YSI 6920 SONDE @ 300 MLS IN CALIBRATION CUP						
ALKALINITY	329	321	301	288	272	259
inital pH	7.59	7.49	7.36	7.27	7.16	7.16
TSS	12.6	18.1	17.6	17.0	15.6	15.4
Sludge Height	visible accumulation of solids with increasing Alum concentration, height less than 100					
Ortho P	0.24	0.20	0.15	0.12	0.10	0.09
Total P	0.28	0.23	0.17	0.14	0.11	0.10
AH P	Analysis not performed...					
UV Trans	74.97	73.32	72.95	73.92	74.87	74.50

*PERFORMED IN 2000 MLS JAR TEST, Initial Stock Solution only 1,056.9 ppm in lieu of 4,000 ppm -- Dosage Revised 10 Nov 2014

Notes:

Aeration MLSS = 2,780 w/SVI₃₀ = 205



City of Geneva
Wastewater Treatment Plant

Facility Plan Update Project
Chemical Phosphorus Removal Evaluation
"Preliminary" Ferric Chloride Additions

22 December 2014

Submitted To:

CDM Smith
125 South Wacker Drive, Suite 600
Chicago, Illinois 60606

City of Geneva
Wastewater Treatment Facility Plan Update Project

Chemical Phosphorus Removal Evaluation

Ferric Chloride Additions

Raw Influent

Prepared by: **City of Geneva**

Date:	Tuesday, December 09, 2014	SAMPLE:	Raw Influent
GRAB TIME:	9:30 AM Rolling Grit Chamber		"Evaluation of Ferric Chloride Additions"
RUN TIME:	2 sets of 6 Jars, (10a to Noon), end @ 4:30p		Q _{POTW} = 4.7 MGD

"Total"	TEMP °C	17.3	CONDUCTIVITY	1,733	TURBIDITY	63	ALKALINITY	463	Ortho P	4.69	
	Raw Influent	pH	7.95	ORP	93	TSS	308	inital pH	7.91	Acid-Hydro P	7.34
									Total P	8.38	

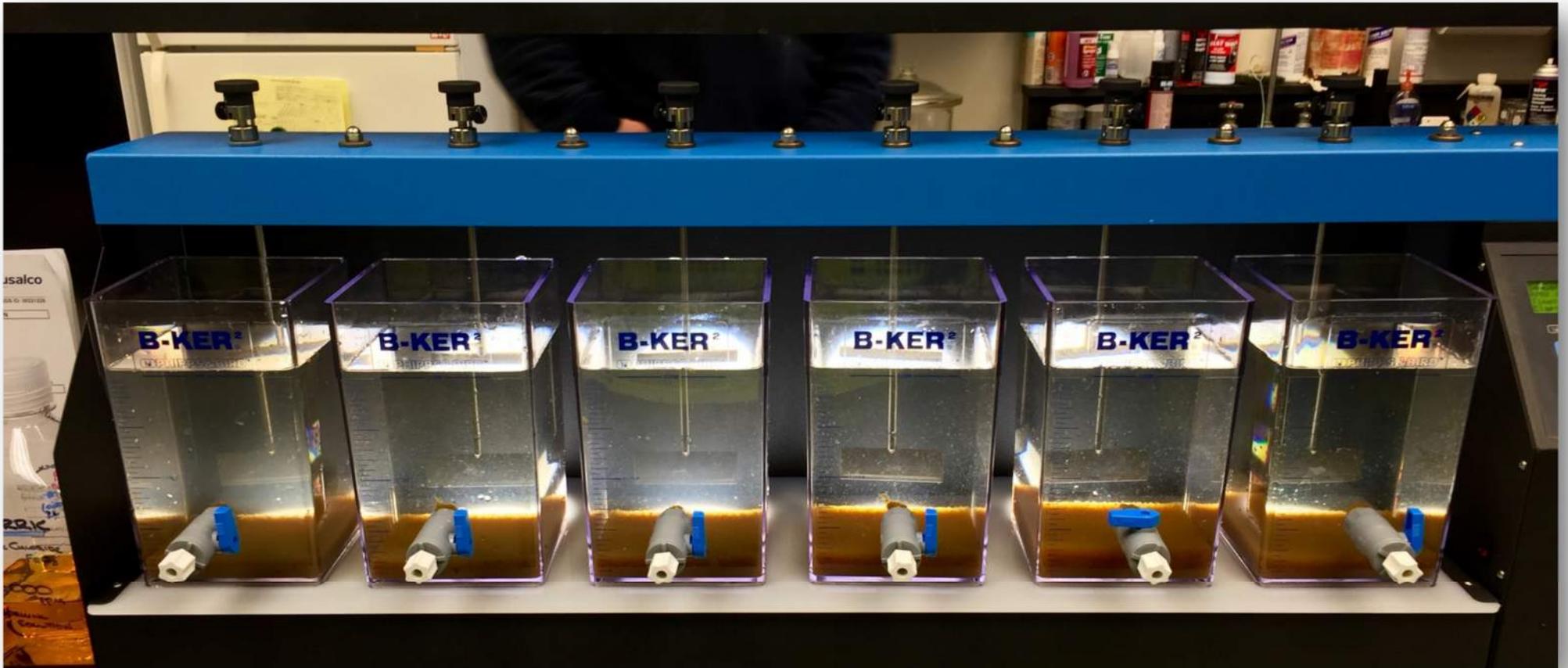
"Control"	TEMP °C	17.4	CONDUCTIVITY	1,739	TURBIDITY	38	ALKALINITY	444	Ortho P	2.05	
	Primary Effluent	pH	7.88	ORP	100	TSS	71.2	inital pH	7.87	Acid-Hydro P	4.50
									Total P	5.50	

Supernatant	JAR 2 10 ppm	JAR 3 20 ppm	JAR 4 30 ppm	JAR 5 40 ppm	JAR 6 50 ppm	JAR 7 60 ppm	JAR 8 70 ppm	JAR 9 80 ppm	JAR 10 100 ppm	JAR 11 125 ppm
TEMP °C	17.3	17.4	17.3	17.3	17.3	17.0	17.2	17.3	17.3	17.6
pH	7.63	7.44	7.31	7.08	6.98	6.85	6.74	6.66	6.32	5.68
CONDUCTIVITY	1,756	1,762	1,806	1,784	1,802	1,839	1,841	1,864	1,914	1,987
ORP	114	123	127	120	105	97	99	108	127	168
TURBIDITY	19.8	15.3	11.6	6.9	6.0	5.5	0.9	2.7	0.2	0.2

*YSI 6920 SONDE @ 300 MLS IN CALIBRATION CUP

ALKALINITY	403	372	339	296	273	238	208	179	124	55
inital pH	7.56	7.32	7.16	7.10	7.09	6.88	6.75	6.75	6.40	5.97
TSS	33.2	28.7	20.5	17.2	12.4	11.1	7.0	6.9	4.4	4.6
Sludge Height	125	140	150	180	190	190	200	225	250	280
Ortho P	2.03	0.96	0.31	0.27	0.14	0.13	0.10	0.08	0.07	0.06
Acid-Hydro P	2.38	1.17	0.41	0.33	0.16	0.13	0.07	0.06	0.02	0.00
Total P	2.87	1.47	0.62	0.52	0.32	0.29	0.21	0.19	0.14	0.13
Hydrolyzable P	0.35	0.21	0.10	0.06	0.02	0.00	-0.03	-0.02	-0.05	-0.06
Organic P	0.49	0.30	0.21	0.19	0.16	0.16	0.14	0.13	0.12	0.13

*PERFORMED IN 2000 MLS JAR TEST



Date:	Monday, December 08, 2014	SAMPLE:	Raw Influent
GRAB TIME:	10:30 AM Rolling Grit Chamber		"Evaluation of Ferric Chloride Additions"
RUN TIME:	2 sets of 6 Jars, (10a to Noon), end @ 4:30p		Q _{POTW} = 4.9 MGD

"Total"	TEMP °C	17.1	CONDUCTIVITY	1,474	TURBIDITY	112	ALKALINITY		Ortho P	4.97
Raw Influent	pH	7.72	ORP	92	TSS	348	inital pH		Acid-Hydro P	
									Total P	

Supernatant (Primary Effluent)	JAR 1 "Control"	JAR 2 10 ppm	JAR 3 30 ppm	JAR 7 40 ppm	JAR 8 50 ppm	JAR 4 60 ppm	JAR 9 70 ppm	JAR 10 80 ppm	JAR 5 100 ppm	JAR 6 150 ppm
TEMP °C	17.2	17.6	17.8	17.4	17.2	17.9	17.3	17.7	17.2	18.7
pH	7.69	7.41	6.96	6.82	6.64	6.54	6.41	6.30	5.74	3.42
CONDUCTIVITY	1,484	1,505	1,526	1,552	1,576	1,587	1,617	1,632	1,677	2,000
ORP	107	126	115	100	113	122	128	145	193	527
TURBIDITY	73	33	19	14	8.4	5.6	3.2	0.4	1.8	51.4

*YSI 6920 SONDE @ 300 MLS IN CALIBRATION CUP

ALKALINITY										4.9
inital pH										4.49
TSS	79.5	33.3	16.9	23.1	8.2	8.3	5.0	2.9	6.2	139
Sludge Height	100	145	180	ReMix	180	200	225	225	250	200
Ortho P	3.50	1.50	0.22	0.30	0.10	0.09	0.08	0.05	0.07	0.79
Acid-Hydro P										
Total P										
Hydrolyzable P										
Organic P										

*PERFORMED IN 2000 MLS JAR TEST.





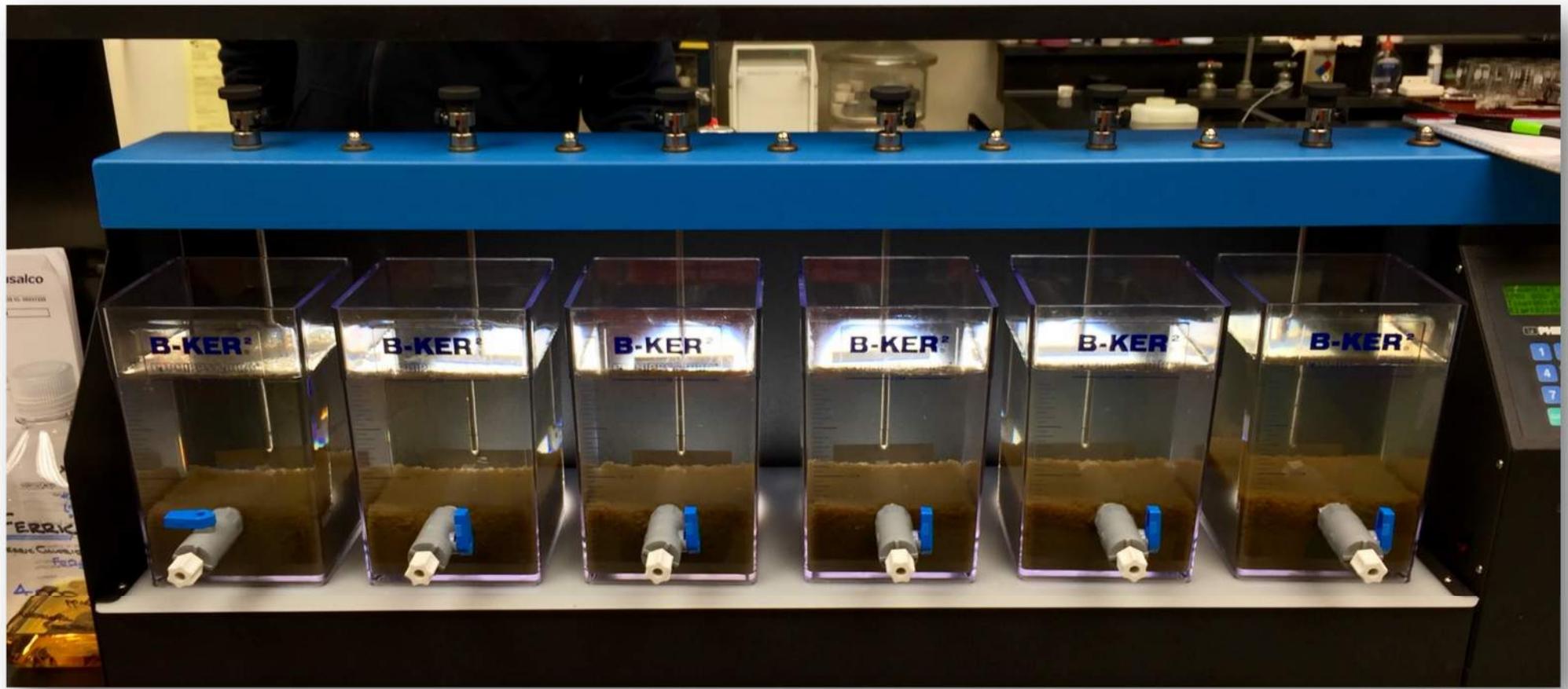
City of Geneva
Wastewater Treatment Facility Plan Update Project

Chemical Phosphorus Removal Evaluation

Ferric Chloride Additions

Activated Sludge [MLSS]

Prepared by: **City of Geneva**



salco
FERRIC
Ferric Chloride
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City of Geneva
Wastewater Treatment Facility Plan Update Project

Chemical Phosphorus Removal Evaluation

Ferric Chloride Additions

Second Stage Activated Sludge [MLSS]

Prepared by: **City of Geneva**

Date:	Thursday, December 18, 2014	SAMPLE:	Activated Sludge MLSS Feed to Secondary Clarifiers
GRAB TIME:	7:30 AM Aeration Tanks № 1 & 4		"Evaluation of Second Stage Ferric Addition"
RUN TIME:	3 "prelim" sets of 6 Jars, (8a to Noon) w/final add at 1p, end @ 5:30p		*Optimized Dosage of 40 ppm

"Blank" <small>MLSS Supernate w/o Alum Addition</small>	TEMP °C	CONDUCTIVITY	TURBIDITY	ALKALINITY	368	Ortho P	1.96
	pH	ORP	TSS	inital pH	8.08	Total P	1.05
			UV Trans	74.26			

"Control" <small>20 ppm Addition</small>	TEMP °C	CONDUCTIVITY	TURBIDITY	ALKALINITY	306	Ortho P	0.07
	pH	ORP	TSS	inital pH	7.55	Total P	0.18
			UV Trans	75.62			

Aeration MLSS = 2,696 w/SVI₃₀ = 115

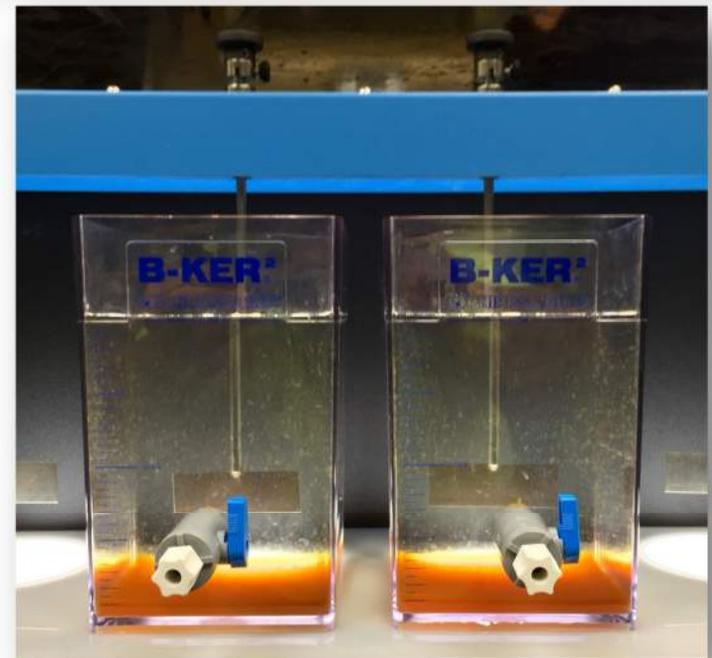
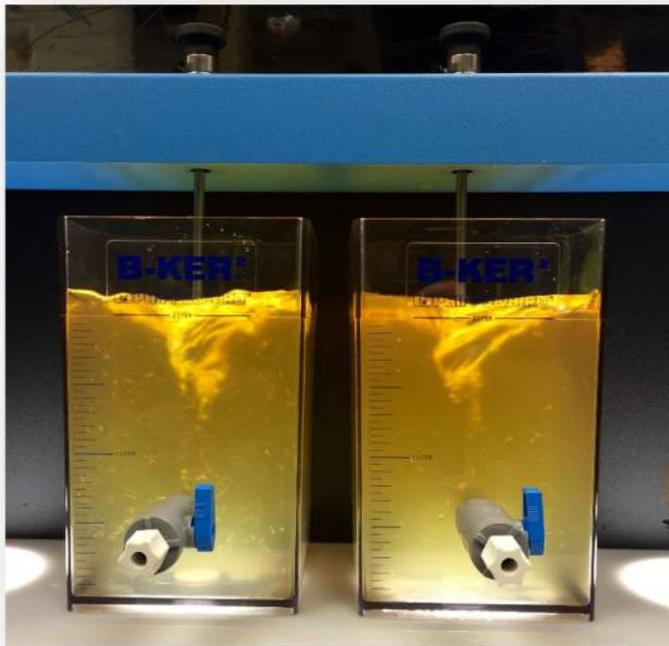
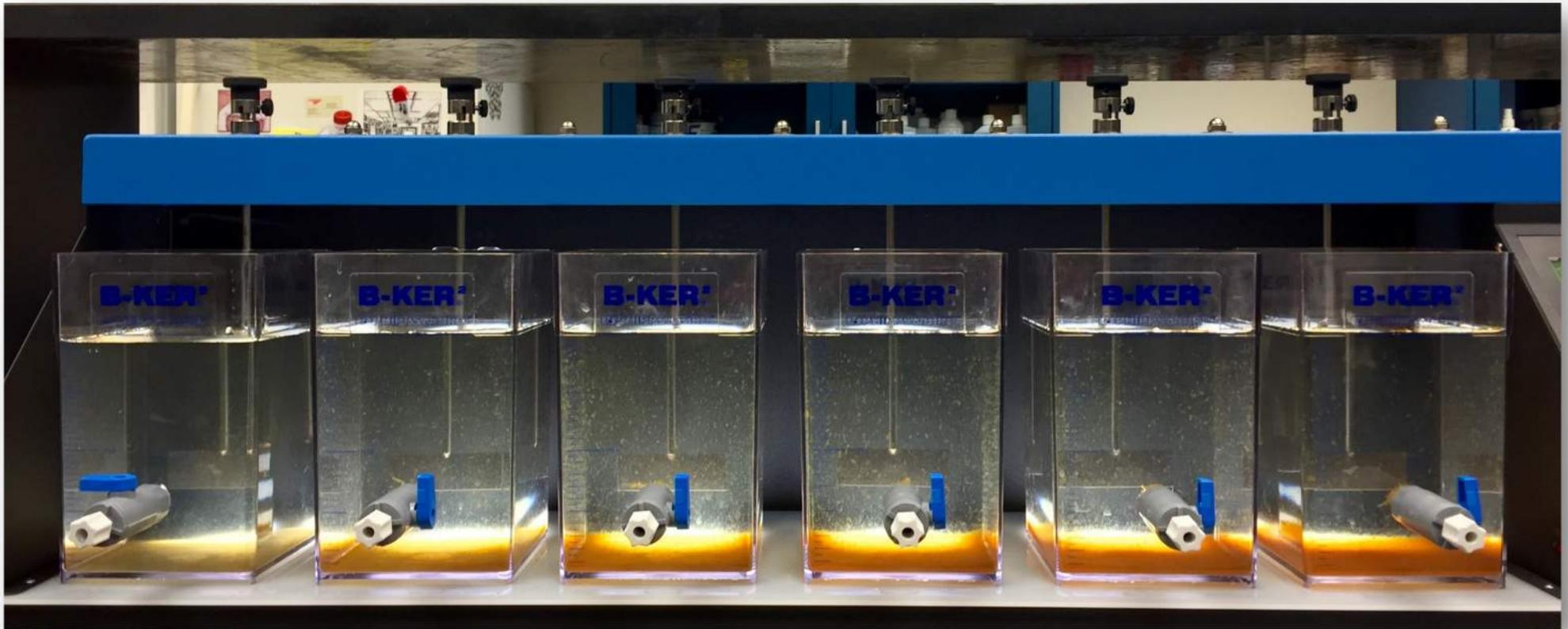
MLSS "pretreated" w/ 20 ppm Ferric Addition: **Second Stage**

Supernate	JAR 2 <small>4 ppm</small>	JAR 3 <small>8 ppm</small>	JAR 4 <small>12 ppm</small>	JAR 5 <small>16 ppm</small>	JAR 6 <small>20 ppm</small>	JAR 7 <small>24 ppm</small>	JAR 8 <small>32 ppm</small>	JAR 9 <small>40 ppm</small>
TEMP °C								
pH								
CONDUCTIVITY								
ORP								
TURBIDITY								

*YSI 6920 SONDE @ 300 MLS IN CALIBRATION CUP

ALKALINITY	297	282	268	255	241	228	199	179
inital pH	7.49	7.45	7.24	7.20	7.13	7.11	6.88	6.76
TSS	6.8	5.5	5.0	4.5	4.1	4.0	3.0	3.0
Sludge Height								
Ortho P	0.02	0.02	0.01	0.00	0.01	0.01		
Total P	0.21	0.08						
AH P								
UV Trans	65.03	67.23	68.40	69.40	71.20	72.08	64.47	72.26

*PERFORMED IN 2000 MLS JAR TEST



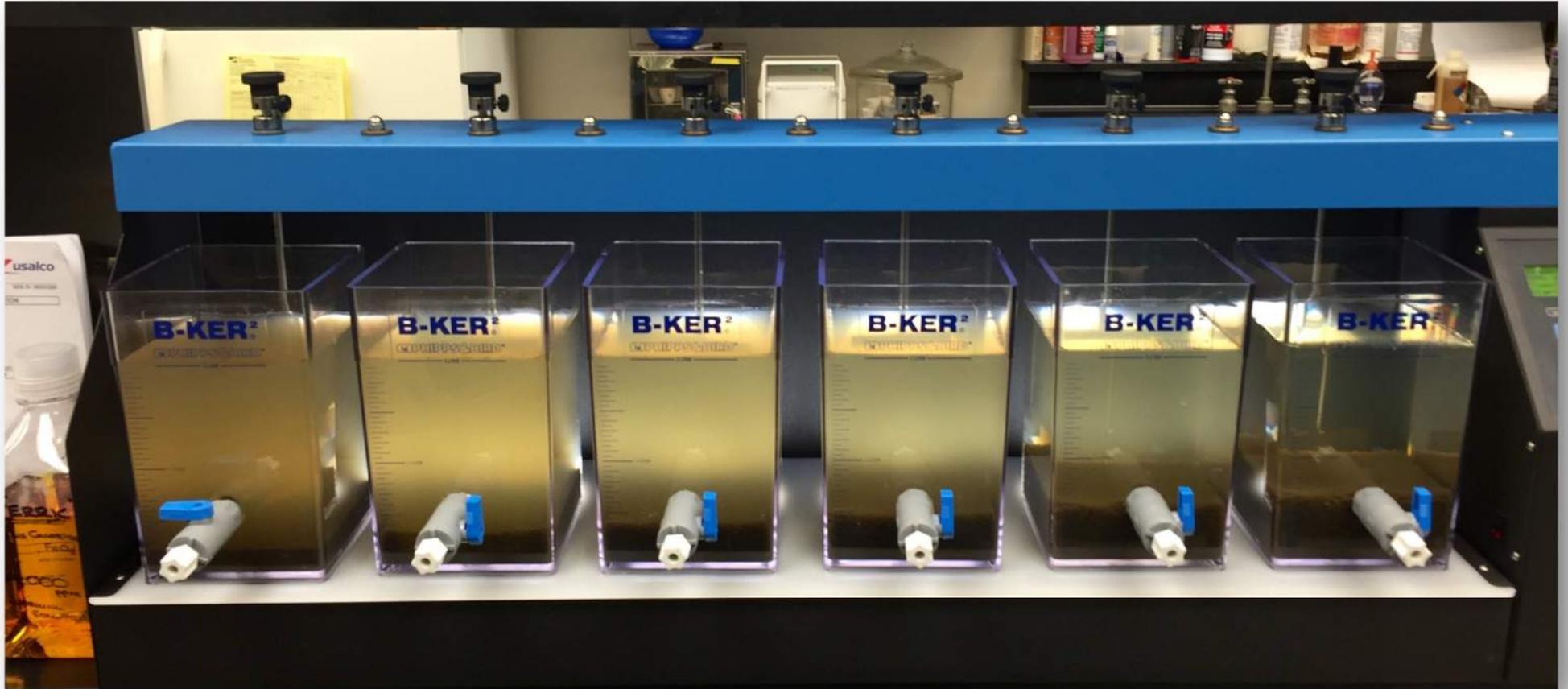
City of Geneva
Wastewater Treatment Facility Plan Update Project

Chemical Phosphorus Removal Evaluation

Ferric Chloride Additions

Sidestream Treatment

Prepared by: **City of Geneva**



Date:	Wednesday, December 17, 2014	SAMPLE:	Sidestream Treatment
GRAB TIME:	7:30 AM Sidestream Effluent		"Evaluation of Ferric Chloride Additions"
RUN TIME:			

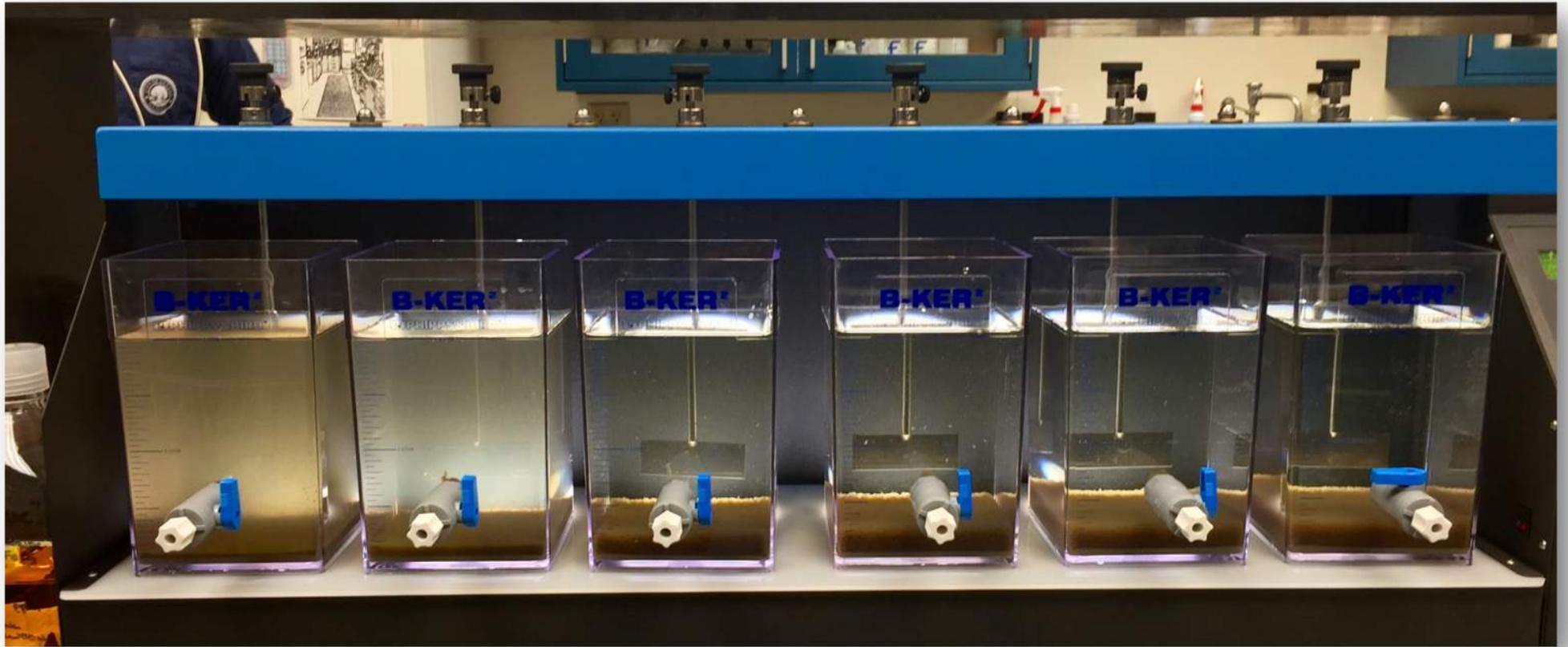
"Total" <small>50% Dilution Used</small>	TEMP °C	18.9	CONDUCTIVITY	1,755	TURBIDITY	197	ALKALINITY	100	Ortho P	18.71
	pH	6.60	ORP	226	TSS	545	inital pH	6.73	Acid-Hydro P	
									Total P	

Supernatant <small>50% Dilution</small>	JAR 1 <small>"Control"</small>	JAR 2 <small>10 ppm</small>	JAR 3 <small>30 ppm</small>	JAR 4 <small>40 ppm</small>	JAR 5 <small>50 ppm</small>	JAR 6 <small>60 ppm</small>	JAR 7 <small>100 ppm</small>	JAR 8 <small>150 ppm</small>		
TEMP °C	19.1	19.1	19.0	18.9	18.7	18.7	18.5	18.3		
pH	6.70	6.34	5.10	4.58	4.28	4.08	3.53	3.11		
CONDUCTIVITY	1,686	1,695	1,816	1,881	1,879	1,927	2,042	2,384		
ORP	210	224	326	461	510	533	557	584		
TURBIDITY	28.5	4.4	1.3	0.2	0.5	0.0	7.0	4.6		

*YSI 6920 SONDE @ 300 MLS IN CALIBRATION CUP

ALKALINITY	63.2	48.6	23.2	13.2	0	0	0	0		
inital pH	6.71	6.28	4.95	4.50	4.14	3.95	3.39	2.95		
TSS	53.6	12.9	16.9	3.0	3.8	3.9	24.1	26.2		
Sludge Height	120	160	250	275	280	325	310	260		
Ortho P	16.01	13.94	11.27	8.10	4.94	2.39	2.60	4.08		
Acid-Hydro P										
Total P										
Hydrolyzable P										
Organic P										

*PERFORMED IN 2000 MLS JAR TEST.



Addendum № 1



City of Geneva
WasteH₂O Treatment Facility
 NPDES Permit № IL0020087

Table № 1

▪ **Biochemical Oxygen Demand, 5-Day**

	Raw Influent, Total	192 mg/L	
	Jar № 1 "Control"	63.0 mg/L	1° Effluent [Supernatant]
w/o UF	Best Jar "A"	42.4 mg/L	(20 ppm Ferric)
	Best Jar "B"	26.0 mg/L	(80 ppm Ferric)

Table № 2

▪ **Jar №1 "Control"** (Supernatant)

▪ **Best Jar № 9** (80 ppm Ferric)

Raw Influent	Dissolved	vs	UF	Raw Influent	Dissolved	vs	UF
Ortho Phosphorus	2.38		3.47	Ortho Phosphorus	0.03		0.04
Acid-Hydrolyzable P	7.74		7.57	Acid-Hydrolyzable P	0.07		0.12
Total Phosphorus	4.00		3.93	Total Phosphorus	0.12		0.15

Table № 3 **Second Stage Additions**

▪ **Mix Liquor [T1/T4]** (Supernatant)

w/o Ferric Additions	Dissolved	vs	UF
Ortho Phosphorus	0.93		0.93
Acid-Hydrolyzable P			
Total Phosphorus	0.95		0.94

🎵 Note:

- Sample results for total hardness and barium are "pending" as of 22 December 2014.



**First
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Laboratories, Inc.**

IL ELAP / NELAC Accreditation # 100292

1600 Shore Road • Naperville, Illinois 60563 • Phone (630) 778-1200 • Fax (630) 778-1233

November 13, 2014

Mr. Dan Dobnick
GENEVA, CITY OF
1800 South Street
Geneva, IL 60134-2547

Project ID: "ALUM" JAR TEST'N - 50126
First Environmental File ID: 14-6544
Date Received: October 31, 2014

Dear Mr. Dan Dobnick:

The above referenced project was analyzed as directed on the enclosed chain of custody record.

All Quality Control criteria as outlined in the methods and current IL ELAP/NELAP have been met unless otherwise noted. QA/QC documentation and raw data will remain on file for future reference. Our accreditation number is 100292 and our current certificate is number 003469: effective 09/25/2014 through 02/28/2015.

I thank you for the opportunity to be of service to you and look forward to working with you again in the future. Should you have any questions regarding any of the enclosed analytical data or need additional information, please contact me at (630) 778-1200.

Sincerely,

Lorrie Walker
Project Manager



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IL ELAP / NELAC Accreditation # 100292

Case Narrative

GENEVA, CITY OF

Lab File ID: **14-6544**

Project ID: **"ALUM" JAR TEST'N - 50126**

Date Received: **October 31, 2014**

All quality control criteria, as outlined in the methods, have been met except as noted below or on the following analytical report.

The results in this report apply to the samples in the following table:

Laboratory Sample ID	Client Sample Identifier	Date/Time Collected
14-6544-001	Raw Influent COG14-240	10/28/14
14-6544-002	Raw "Control" COG14-241	10/28/14
14-6544-003	Raw Best Jar "A" COG14-242	10/28/14
14-6544-004	Raw Best Jar "B" COG14-243	10/28/14
14-6544-005	MLSS "Blank" COG14-244	10/28/14
14-6544-006	MLSS "Control" COG14-245	10/28/14
14-6544-007	MLSS "NO: 5" COG14-246	10/28/14

Sample Batch Comments:

Time of sample collection was not provided.

The following is a definition of flags that may be used in this report:

Flag	Description	Flag	Description
<	Analyte not detected at or above the reporting limit.	L	LCS recovery outside control limits.
C	Sample received in an improper container for this test.	M	MS recovery outside control limits; LCS acceptable.
D	Surrogates diluted out; recovery not available.	N	Analyte is not part of our NELAC accreditation.
E	Estimated result; concentration exceeds calibration range.	P	Chemical preservation pH adjusted in lab.
G	Surrogate recovery outside control limits.	Q	Result was determined by a GC/MS database search.
H	Analysis or extraction holding time exceeded.	S	Analysis was subcontracted to another laboratory.
J	Estimated result; concentration is less than routine RL but greater than MDL.	W	Reporting limit elevated due to sample matrix.
RL	Routine Reporting Limit (Lowest amount that can be detected when routine weights/volumes are used without dilution.)	ND	Analyte was not detected using a library search routine; No calibration standard was analyzed.



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Analytical Report

Client: GENEVA, CITY OF
Project ID: "ALUM" JAR TESTN - 50126
Sample ID: Raw Influent COG14-240
Sample No: 14-6544-001

Date Collected: 10/28/14
Time Collected:
Date Received: 10/31/14
Date Reported: 11/12/14

Analyte	Result	R.L.	Units	Flags
Total Hardness, as CaCO3				
Method: 2340B 1997				
Analysis Date: 11/12/14				
Analyzed By: BAM				
Total Hardness, as CaCO3	477	5	mg/L	
Total Metals				
Method: 200.7R4.4		Preparation Method 200.7W		
Analysis Date: 11/03/14		Preparation Date: 11/03/14		
Analyzed By: BAM		Prepped By: BSZ		
Barium	0.450	0.005	mg/L	



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Analytical Report

Client: GENEVA, CITY OF
Project ID: "ALUM" JAR TESTN - 50126
Sample ID: Raw "Control" COG14-241
Sample No: 14-6544-002

Date Collected: 10/28/14
Time Collected:
Date Received: 10/31/14
Date Reported: 11/12/14

Analyte	Result	R.L.	Units	Flags
Total Hardness, as CaCO3				
Method: 2340B 1997				
Analysis Date: 11/12/14				
Analyzed By: BAM				
Total Hardness, as CaCO3	441	5	mg/L	
Total Metals				
Method: 200.7R4.4		Preparation Method 200.7W		
Analysis Date: 11/03/14				
Analyzed By: BAM				
Preparation Date: 11/03/14				
Prepped By: BSZ				
Barium	0.223	0.005	mg/L	



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Analytical Report

Client: GENEVA, CITY OF
Project ID: "ALUM" JAR TESTN - 50126
Sample ID: Raw Best Jar "A" COG14-242
Sample No: 14-6544-003

Date Collected: 10/28/14
Time Collected:
Date Received: 10/31/14
Date Reported: 11/12/14

Analyte	Result	R.L.	Units	Flags
Total Hardness, as CaCO3				
Method: 2340B 1997				
Analysis Date: 11/12/14				
Analyzed By: BAM				
Total Hardness, as CaCO3	453	5	mg/L	
Total Metals				
Method: 200.7R4.4		Preparation Method 200.7W		
Analysis Date: 11/03/14		Preparation Date: 11/03/14		
Analyzed By: BAM		Prepped By: BSZ		
Barium	0.164	0.005	mg/L	



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Analytical Report

Client: GENEVA, CITY OF
Project ID: "ALUM" JAR TESTN - 50126
Sample ID: Raw Best Jar "B" COG14-243
Sample No: 14-6544-004

Date Collected: 10/28/14
Time Collected:
Date Received: 10/31/14
Date Reported: 11/12/14

Analyte	Result	R.L.	Units	Flags
Total Hardness, as CaCO₃	Method: 2340B 1997			
Analysis Date: 11/12/14				
Analyzed By: BAM				
Total Hardness, as CaCO ₃	405	5	mg/L	
Total Metals	Method: 200.7R4.4			
Analysis Date: 11/03/14				
Analyzed By: BAM				
Barium	0.160	0.005	mg/L	



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Analytical Report

Client: GENEVA, CITY OF
Project ID: "ALUM" JAR TESTN - 50126
Sample ID: MLSS "Blank" COG14-244
Sample No: 14-6544-005

Date Collected: 10/28/14
Time Collected:
Date Received: 10/31/14
Date Reported: 11/12/14

Analyte	Result	R.L.	Units	Flags
Total Hardness, as CaCO₃	Method: 2340B 1997			
Analysis Date: 11/12/14				
Analyzed By: BAM				
Total Hardness, as CaCO ₃	554	5	mg/L	



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Laboratories, Inc.**

IL ELAP / NELAC Accreditation # 100292

1600 Shore Road • Naperville, Illinois 60563 • Phone (630) 778-1200 • Fax (630) 778-1233

Analytical Report

Client: GENEVA, CITY OF
Project ID: "ALUM" JAR TESTN - 50126
Sample ID: MLSS "Control" COG14-245
Sample No: 14-6544-006

Date Collected: 10/28/14
Time Collected:
Date Received: 10/31/14
Date Reported: 11/12/14

Analyte	Result	R.L.	Units	Flags
Total Hardness, as CaCO₃	Method: 2340B 1997			
Analysis Date: 11/12/14				
Analyzed By: BAM				
Total Hardness, as CaCO ₃	554	5	mg/L	



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Analytical Report

Client: GENEVA, CITY OF
Project ID: "ALUM" JAR TEST'N - 50126
Sample ID: MLSS "NO: 5" COG14-246
Sample No: 14-6544-007

Date Collected: 10/28/14
Time Collected:
Date Received: 10/31/14
Date Reported: 11/12/14

Analyte	Result	R.L.	Units	Flags
Total Hardness, as CaCO₃	Method: 2340B 1997			
Analysis Date: 11/12/14				
Analyzed By: BAM				
Total Hardness, as CaCO ₃	531	5	mg/L	



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December 22, 2014

Mr. Dan Dobnick
GENEVA, CITY OF
1800 South Street
Geneva, IL 60134-2547

Project ID: Raw Influent w/ "Ferric" 50126
First Environmental File ID: 14-7355
Date Received: December 10, 2014

Dear Mr. Dan Dobnick:

The above referenced project was analyzed as directed on the enclosed chain of custody record.

All Quality Control criteria as outlined in the methods and current IL ELAP/NELAP have been met unless otherwise noted. QA/QC documentation and raw data will remain on file for future reference. Our accreditation number is 100292 and our current certificate is number 003469: effective 09/25/2014 through 02/28/2015.

I thank you for the opportunity to be of service to you and look forward to working with you again in the future. Should you have any questions regarding any of the enclosed analytical data or need additional information, please contact me at (630) 778-1200.

Sincerely,

Stan Zaworski
Project Manager



Case Narrative

GENEVA, CITY OF

Lab File ID: **14-7355**

Project ID: **Raw Influent w/ "Ferric" 50126**

Date Received: **December 10, 2014**

All quality control criteria, as outlined in the methods, have been met except as noted below or on the following analytical report.

The results in this report apply to the samples in the following table:

Laboratory Sample ID	Client Sample Identifier	Date/Time Collected
14-7355-001	COG14-234 Raw Influent	12/09/14 9:00
14-7355-002	COG14-235 Raw Control	12/09/14 9:00
14-7355-003	COG14-235 Raw Control Ultra Filter	12/09/14 9:00
14-7355-004	COG14-236 Raw "Best Ferric"	12/09/14 9:00
14-7355-005	COG14-236 Raw "Best Ferric" Ultra	12/09/14 9:00

Sample Batch Comments:

Sample acceptance criteria were met.

The following is a definition of flags that may be used in this report:

Flag	Description	Flag	Description
<	Analyte not detected at or above the reporting limit.	L	LCS recovery outside control limits.
C	Sample received in an improper container for this test.	M	MS recovery outside control limits; LCS acceptable.
D	Surrogates diluted out; recovery not available.	N	Analyte is not part of our NELAC accreditation.
E	Estimated result; concentration exceeds calibration range.	P	Chemical preservation pH adjusted in lab.
G	Surrogate recovery outside control limits.	Q	Result was determined by a GC/MS database search.
H	Analysis or extraction holding time exceeded.	S	Analysis was subcontracted to another laboratory.
J	Estimated result; concentration is less than routine RL but greater than MDL.	W	Reporting limit elevated due to sample matrix.
RL	Routine Reporting Limit (Lowest amount that can be detected when routine weights/volumes are used without dilution.)	ND	Analyte was not detected using a library search routine; No calibration standard was analyzed.



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Analytical Report

Client: GENEVA, CITY OF
Project ID: Raw Influent w/ "Ferric" 50126
Sample ID: COG14-234 Raw Influent
Sample No: 14-7355-001

Date Collected: 12/09/14
Time Collected: 9:00
Date Received: 12/10/14
Date Reported: 12/22/14

Analyte	Result	R.L.	Units	Flags
Total Metals	Method: 200.7R4.4	Preparation Method 200.7W		
Analysis Date: 12/12/14		Preparation Date: 12/12/14		
Analyzed By: BAM		Prepped By: BSZ		
Barium	0.468	0.005	mg/L	
Iron	4.21	0.05	mg/L	
Total Hardness, as CaCO3	Method: 2340B 1997			
Analysis Date: 12/15/14				
Analyzed By: BAM				
Total Hardness, as CaCO3	526	5	mg/L	



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Analytical Report

Client: GENEVA, CITY OF
Project ID: Raw Influent w/ "Ferric" 50126
Sample ID: COG14-235 Raw Control
Sample No: 14-7355-002

Date Collected: 12/09/14
Time Collected: 9:00
Date Received: 12/10/14
Date Reported: 12/22/14

Analyte	Result	R.L.	Units	Flags
Total Metals				
Method: 200.7R4.4		Preparation Method 200.7W		
Analysis Date: 12/12/14		Preparation Date: 12/12/14		
Analyzed By: BAM		Prepped By: BSZ		
Barium	0.259	0.005	mg/L	
Iron	0.97	0.05	mg/L	
Dissolved Metals				
Method: 200.7R4.4		Preparation Method 200.7W		
Analysis Date: 12/15/14		Preparation Date: 12/15/14		
Analyzed By: BAM		Prepped By: BSZ		
Iron, diss.	0.07	0.05	mg/L	
Total Hardness, as CaCO₃				
Method: 2340B 1997				
Analysis Date: 12/15/14				
Analyzed By: BAM				
Total Hardness, as CaCO ₃	482	5	mg/L	



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Analytical Report

Client: GENEVA, CITY OF
Project ID: Raw Influent w/ "Ferric" 50126
Sample ID: COG14-235 Raw Control Ultra Filtered
Sample No: 14-7355-003

Date Collected: 12/09/14
Time Collected: 9:00
Date Received: 12/10/14
Date Reported: 12/22/14

Analyte	Result	R.L.	Units	Flags
Dissolved Metals	Method: 200.7R4.4	Preparation Method 200.7W		
Analysis Date: 12/15/14		Preparation Date: 12/15/14		
Analyzed By: BAM		Prepped By: BSZ		
Iron, diss.	< 0.05	0.05	mg/L	



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Analytical Report

Client: GENEVA, CITY OF
Project ID: Raw Influent w/ "Ferric" 50126
Sample ID: COG14-236 Raw "Best Ferric"
Sample No: 14-7355-004

Date Collected: 12/09/14
Time Collected: 9:00
Date Received: 12/10/14
Date Reported: 12/22/14

Analyte	Result	R.L.	Units	Flags
Total Metals Analysis Date: 12/12/14 Analyzed By: BAM	Method: 200.7R4.4	Preparation Method 200.7W Preparation Date: 12/12/14 Prepped By: BSZ		
Barium	0.200	0.005	mg/L	
Iron	1.80	0.05	mg/L	
Dissolved Metals Analysis Date: 12/15/14 Analyzed By: BAM	Method: 200.7R4.4	Preparation Method 200.7W Preparation Date: 12/15/14 Prepped By: BSZ		
Iron, diss.	0.62	0.05	mg/L	
Total Hardness, as CaCO₃ Analysis Date: 12/15/14 Analyzed By: BAM	Method: 2340B 1997			
Total Hardness, as CaCO ₃	485	5	mg/L	



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Analytical Report

Client: GENEVA, CITY OF
Project ID: Raw Influent w/ "Ferric" 50126
Sample ID: COG14-236 Raw "Best Ferric" Ultra Filter
Sample No: 14-7355-005

Date Collected: 12/09/14
Time Collected: 9:00
Date Received: 12/10/14
Date Reported: 12/22/14

Analyte	Result	R.L.	Units	Flags
Dissolved Metals	Method: 200.7R4.4	Preparation Method 200.7W		
Analysis Date: 12/15/14		Preparation Date: 12/15/14		
Analyzed By: BAM		Prepped By: BSZ		
Iron, diss.	0.59	0.05	mg/L	



First Environmental Laboratories, Inc.

First Environmental Laboratories
 1600 Shore Road, Suite D
 Naperville, Illinois 60563
 Phone: (630) 778-1200 • Fax: (630) 778-1233
 E-mail: firstinfo@firstenv.com
 IEPA Certification #100292

CHAIN OF CUSTODY RECORD

Company Name: CITY OF SENEVA WASTEWATER TREATMENT FACILITY
 Street Address: 1800 SANTA STREET
 City: GENEVA State: ILLINOIS Zip: 60134-2649
 Phone: 630-232-4000 Fax: 630-208-9160 e-mail: DDORNIK@SENEVA.IL.GOV
 Send Report To: DAV DOBICK Via: Fax e-mail
 Sampled By: TP, MZ, JOD

Project ID: RAW INFILTR W/ "GENERIC"
 PO #: 50120

W/W = WASTEWATER

Date/Time Taken	Sample Description	Matrix	TOTAL BARIUM	TOTAL IRON	TOTAL HARDNESS	DISSOLVED IRON	ULTRA-FILTERED IRON	Comments	Lab I.D.
12-09-14	234 COG14-235 RAW INFILTR	W/W	---	---	---	---	---	14-7355-001	
12-09-14	COG14-235 RAW "CONTRAC"	W/W	---	---	---	---	---	002 / 003	
12-09-14	COG14-236 RAW "BEST FERRIC"	W/W	---	---	---	---	---	004 / 005	

FOR LAB USE ONLY:

Cooler Temperature: 0.1-6°C Yes No
 Received within 6 hrs. of collection: _____
 Ice Present: Yes No

Sample Refrigerated: Yes No
 Refrigerator Temperature: _____
 5035 Vials Frozen: Yes No
 Freezer Temperature: _____

Preservation Requirements Met: Yes No
 Need to meet: IL TACO IN RISC

Notes and Special Instructions: "DISSOLVED" SAMPLES PRE-FILTERED W/ 0.45 MICRON FILTER PRIOR TO PRESERVATION
"ULTRA-FILTERED" (UF) SAMPLES PRE-FILTERED W/ 0.45 MICRON FILTER PRIOR TO PRESERVATION

Relinquished By: [Signature] Date/Time: 12/10/14
 Relinquished By: _____ Date/Time: _____
 Received By: [Signature] Date/Time: 12/10/14
 Received By: _____ Date/Time: _____

Appendix C

Envision's Self Assessment Checklist

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**Envision Rating System
Self-Assessment Checklist
For Public Comment Only - Not for Project Use**

			Y	N	NA				
1	PURPOSE	QL1.1 Improve community quality of life	3	0	0	<div style="width: 100%;"></div>	3 of 3	NA 46%	
2		QL1.2 Stimulate sustainable growth and development	1	2	0	<div style="width: 33%;"></div>	1 of 3		
3		QL1.3 Develop local skills and capabilities	1	2	0	<div style="width: 33%;"></div>	1 of 3		
4	COMMUNITY	QL2.1 Enhance public health and safety	0	1	0	<div style="width: 0%;"></div>	0 of 1		
5		QL2.2 Minimize noise and vibration	0	0	1	<div style="width: 0%;"></div>	0 of 0		
6		QL2.3 Minimize light pollution	0	0	1	<div style="width: 0%;"></div>	0 of 0		
7		QL2.4 Improve community mobility and access	0	0	3	<div style="width: 0%;"></div>	0 of 0		No 27%
8		QL2.5 Encourage alternative modes of transportation	0	0	2	<div style="width: 0%;"></div>	0 of 0		
9		QL2.6 Improve site accessibility, safety and wayfinding	0	0	3	<div style="width: 0%;"></div>	0 of 0		
10	WELLBEING	QL3.1 Preserve historic and cultural resources	0	2	0	<div style="width: 0%;"></div>	0 of 2		Yes 27%
11		QL3.2 Preserve views and local character	2	0	0	<div style="width: 100%;"></div>	2 of 2		
12		QL3.3 Enhance public space	0	0	2	<div style="width: 0%;"></div>	0 of 0		
		TOTAL	7	7	12		7 of 14		
13	COLLABORATION	LD1.1 Provide effective leadership and commitment	1	2	0	<div style="width: 33%;"></div>	1 of 3	NA 0% 26%	
14		LD1.2 Establish a sustainability management system	1	0	0	<div style="width: 100%;"></div>	1 of 1		
15		LD1.3 Foster collaboration and teamwork	1	2	0	<div style="width: 33%;"></div>	1 of 3		
16	MANAGEMENT	LD1.4 Provide for stakeholder involvement	2	1	0	<div style="width: 66%;"></div>	2 of 3		
17		LD2.1 Pursue by-product synergy opportunities	1	0	0	<div style="width: 100%;"></div>	1 of 1		
18		LD2.2 Improve infrastructure integration	3	0	0	<div style="width: 100%;"></div>	3 of 3		
19	PLANNING	LD3.1 Plan for long-term monitoring and maintenance	2	0	0	<div style="width: 100%;"></div>	2 of 2		Yes 74%
20		LD3.2 Address conflicting regulations and policies	2	0	0	<div style="width: 100%;"></div>	2 of 2		
21		LD3.3 Extend useful life	1	0	0	<div style="width: 100%;"></div>	1 of 1		
		TOTAL	14	5	0		14 of 19		
22	MATERIALS	RA1.1 Reduce Net Embodied Energy	2	0	0	<div style="width: 100%;"></div>	2 of 2	NA 24%	
23		RA1.2 Support Sustainable Procurement Practices	1	1	1	<div style="width: 33%;"></div>	1 of 2		
24		RA1.3 Use Recycled Materials	1	0	1	<div style="width: 50%;"></div>	1 of 1		
25	RA1.4 Use Regional Materials	1	1	0	<div style="width: 50%;"></div>	1 of 2	No 17%		
26	RA1.5 Divert Waste from Landfills	2	0	1	<div style="width: 66%;"></div>	2 of 2			
27	RA1.6 Reduce Excavated Materials Taken off Site	3	0	0	<div style="width: 100%;"></div>	3 of 3	Yes 59%		
28	RA1.7 Provide for Deconstruction and Recycling	3	0	0	<div style="width: 100%;"></div>	3 of 3			
29	ENERGY	RA2.1 Reduce energy consumption	3	0	0	<div style="width: 100%;"></div>			3 of 3
30		RA2.2 Use renewable energy	0	2	0	<div style="width: 0%;"></div>			0 of 2
31	WATER	RA2.3 Commission and monitor energy systems	2	1	0	<div style="width: 66%;"></div>			2 of 3
32		RA3.1 Protect fresh water availability	4	0	3	<div style="width: 57%;"></div>		4 of 4	
33		RA3.2 Reduce potable water consumption	0	0	4	<div style="width: 0%;"></div>		0 of 0	
34		RA3.3 Monitor water systems	2	2	0	<div style="width: 50%;"></div>	2 of 4		
		TOTAL	24	7	10		24 of 31		
35	SITING	NW1.1 Preserve prime habitat	2	3	0	<div style="width: 40%;"></div>	2 of 5	NA 50%	
36		NW1.2 Protect wetlands and surface water	2	0	1	<div style="width: 66%;"></div>	2 of 2		
37		NW1.3 Preserve prime farmland	1	0	0	<div style="width: 100%;"></div>	1 of 1		
38	NW1.4 Avoid adverse geology	0	0	3	<div style="width: 0%;"></div>	0 of 0			
39	NW1.5 Preserve floodplain functions	4	1	1	<div style="width: 71%;"></div>	4 of 5	No 13%		
40	NW1.6 Avoid unsuitable development on steep slopes	2	0	0	<div style="width: 100%;"></div>	2 of 2			
41	NW1.7 Preserve greenfields	0	1	1	<div style="width: 0%;"></div>	0 of 1			
42	LAND & WATER	NW2.1 Manage stormwater	1	0	1	<div style="width: 50%;"></div>			1 of 1
43		NW2.2 Reduce pesticide and fertilizer impacts	1	0	4	<div style="width: 25%;"></div>			1 of 1
44		NW2.3 Prevent surface and groundwater contamination	0	0	3	<div style="width: 0%;"></div>			0 of 0
45	BIODIVERSITY	NW3.1 Preserve species biodiversity	0	1	3	<div style="width: 0%;"></div>		0 of 1	Yes 37%
46		NW3.2 Control invasive species	0	0	3	<div style="width: 0%;"></div>	0 of 0		
47		NW3.3 Restore disturbed soils	1	0	1	<div style="width: 50%;"></div>	1 of 1		
48		NW3.4 Maintain wetland and surface water functions	3	0	2	<div style="width: 60%;"></div>	3 of 3		
		TOTAL	17	6	23		17 of 23		
49	EMISSION	CR1.1 Reduce greenhouse gas emissions	0	2	0	<div style="width: 0%;"></div>	0 of 2	NA 50%	
50		CR1.2 Reduce air pollutant emissions	1	1	0	<div style="width: 50%;"></div>	1 of 2		
51	RESILIENCE	CR2.1 Assess climate threat	0	1	0	<div style="width: 0%;"></div>	0 of 1		No 13%
52		CR2.2 Avoid traps and vulnerabilities	1	1	0	<div style="width: 50%;"></div>	1 of 2		
53		CR2.3 Prepare for long-term adaptability	1	0	0	<div style="width: 100%;"></div>	1 of 1		
54		CR2.4 Prepare for short-term hazards	2	0	0	<div style="width: 100%;"></div>	2 of 2		
55		CR2.5 Manage heat islands effects	0	1	0	<div style="width: 0%;"></div>	0 of 1		
		TOTAL	5	6	0		5 of 11		Yes 37%

**Envision Rating System
Self-Assessment Checklist
For Public Comment Only - Not for Project Use**

Appendix D

Capacity Assessment Memorandum

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City of Geneva, IL Geneva Wastewater Treatment Facility Appendix D - Capacity Assessment

This document summarizes the individual capacities of the unit processes at the Geneva Wastewater Treatment Facility (GWTF), and includes the following sections:

Section 1 provides a description or overview of the existing facilities,

Section 2 provides a methodology for assessing capacity, and

Section 3 provides a more detailed description of the unit processes and their capacities.

1.0 INTRODUCTION AND OVERVIEW

The Geneva wastewater treatment facility (GWTF) consists of the following facilities and infrastructure:

- Headworks (coarse screening, pumping and grit removal)
- Primary clarification
- Aeration nitrification system (aeration tanks and secondary clarification)
- Side stream treatment for digester supernatant
- Disinfection (UV and chlorination/de-chlorination for peak wet weather flow)
- Yard piping and conduits
- Solids handling systems (centrifuge thickening, anaerobic digestion and centrifuge dewatering)

Plant influent passes first through the headworks that consist of a single mechanically cleaned coarse screen followed by influent pumping and grit removal. From grit removal the wastewater flows by gravity to the primary clarifiers for removal of settleable solids and particulate biochemical oxygen demand (BOD). Primary sludge is pumped to the primary digester for stabilization via anaerobic digestion. Primary effluent is then distributed to single stage aeration tanks for removal of the remaining particulate CBOD₅ and soluble CBOD₅ and ammonia. Mixed liquor from the aeration tanks is distributed to the secondary clarifiers. Secondary effluent is then disinfected via ultraviolet (UV) light with peak primary flows being chlorinated and de-chlorinated with sodium hypochlorite and sodium bisulfite, respectively. Return activated sludge is returned to the head of the aeration tanks. Waste activated sludge is thickened via a thickening centrifuge prior to digestion. Digested sludge is then dewatered by dewatering centrifuge prior to storage ultimate disposal by land application.

A flow schematic showing flow distribution is shown in **Figure 1-1**, and a site plan showing the relative locations of existing plant facilities is shown in **Figure 1-2**.

Figure 1-1: Geneva Wastewater Treatment Facility Flow Schematic

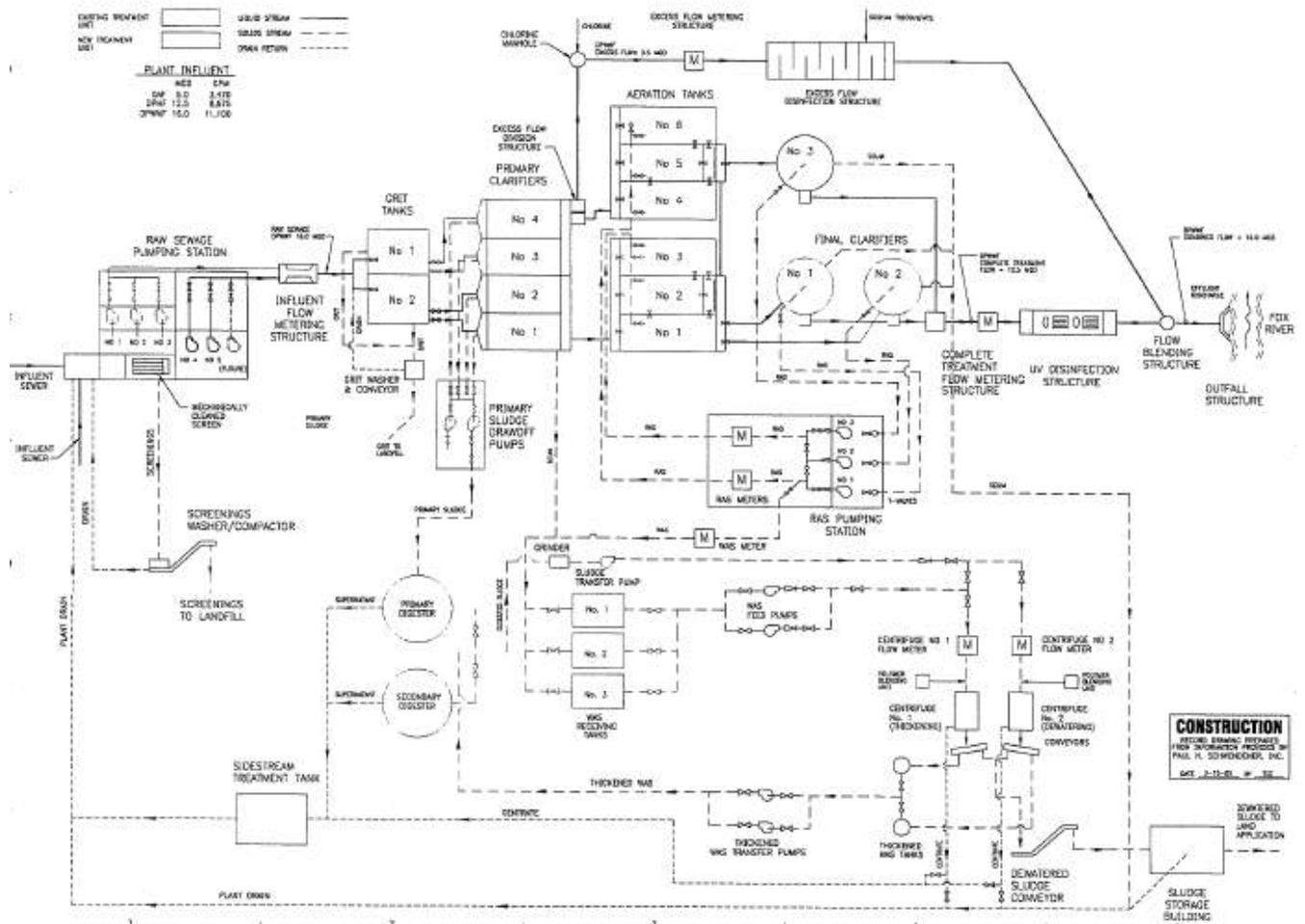


Figure 1-2: WWTP Site Plan



Table 1-1 shows the current peak capacities of the existing unit processes based on the methodology described in the following section.

Table 1-1: Current Peak Capacities of Unit Processes

Unit Process	Current Capacity	No. of Units	Basis (see Section 2 Methodology)
Wastewater			
Coarse Screen	22 MGD	1 Duty + 0 Standby	Based on a WEF MOP 8 recommended approach velocity of 3 fps. ^a Flows greater than 22 MGD may be processed, but with degradation of performance.
Influent Pumps	16 MGD	4 Duty + 1 Standby	Firm and total capacities are 16 and 20 MGD, respectively. ^b
Grit Tanks	18.4 MGD	2 Duty + 0 Standby	Rated for 18.4 MGD (@ 100 Mesh Removal) based on vendor literature and shop drawings. ^c Flows greater than 18.4 MGD may be processed, but with degradation of performance.
Primary Clarifiers	20 MGD	4 Rectangular @ 25-ft x 100-ft x 8.25	Based on a Ten States Standards (TSS) peak surface overflow rate of 2,000 gpd/sf. ^d Flows greater than 20 MGD may be processed, but with degradation of performance.
Aeration Tanks	Year 2034 BOD ₅ load condition (6,103 lb/d)	6 Tanks with a total volume of 2.0 MG	Based on a Ten States Standards aeration load condition of < 40 lb/1,000 CF. ^d
Secondary Clarifiers	14.2 MGD	2 Circular (1 out of	Based on a Ten States Standards peak hour

Unit Process	Current Capacity	No. of Units	Basis (see Section 2 Methodology)
		service) @ 95-ft dia. x 10.8-ft SWD	surface overflow rate of 1,000 gpd/sf. Flows greater than 14.2 MGD may be processed, but with degradation of performance.
Side Stream Treatment	-----	1 Tank with a total volume of 2.0 MG	No impact on peak flow treatment
UV Disinfection	12.5 MGD	2 Units	Based on manufacturer's literature
Excess Flow Chlorine Contact Tank	4.2 MGD	1 Rectangular @ 16.5-ft x 42-ft x 8. 5	Based on a Ten States Standards Contact time of 15 minutes:
Solids Handling			
Thickening Centrifuge	490 dry lb/hr	1 Duty + 0 Standby	Based on an average WAS TSS concentration of 6,527 mg/L and feed rate of 150 gpm. ^{e, f}
Digester	~80 lb VS/d/1,000 CF	1 Primary + 1 Secondary	Meets Ten States Standards for recommendation of 80 lbs VSS / 1,000 CF for a completely mixed first stage.
Dewatering Centrifuge	3,750 dry lb/hr	1 Duty + 0 Standby	Based on manufacturer's literature
Sludge Storage	65,000 CF	1 Building @ 180-ft x 80-ft x 8-ft push wall height	Greater than ½ year Storage volume. Estimated usable volume as ¾ of building space @ 180-ft x 80-ft x 6-ft sludge height. Exceeds Ten State Standards recommendation for 180 day storage volume.

2.0 METHODOLOGY

Unit process capacities can be rated in many different ways. For example, unit process that are hydraulically limited (e.g., screens, pumps, etc.) were rated using Ten States Standards recommendations. Capacities of unit processes that are loading limited are rated based on other means such as industry standards for sizing, vendor literature, etc. The following resources were used in assessing capacity of the various unit processes.

- a) Water Environment Federation Method of Practice No. 8, 2010
- b) Geneva wastewater treatment facilities (GWWTf) as-built drawings 1, 2013.
- c) Geneva WWTF shop drawings
- d) Recommended Standards for Wastewater Facilities, 2004 (Ten States Standards)
- e) "Design Flows and Loads for Aeration Improvements," CDM Smith, June 2, 2014
- f) Monthly report of operation (MRO) data for the period 2011 through August 2013
- g) Geneva WWTF National Pollutant Discharge Elimination System Permit, 2012

- h) Geneva Bio-solids Management Practices, 2012
- i) Geneva Basis of Design
- j) EPA - Class I Reliability Standards

Specific ratings are described in the following section.

3.0 EXISTING PLANT CAPACITIES

3.1 Preliminary Treatment (Headworks)

3.1.1 Screening

Raw sewage enters the plant through three interceptors and flows to a common influent channel to the mechanically cleaned bar screen. The bar screening facility has one (1) 2-foot wide channel, each with a mechanically raked screen. The screen has 1-1/2-inch clear openings inclined at a slope of 90-degrees from the horizontal. Bar screen dimensions are 2-ft wide with a discharge point approximately 18-ft above the screen invert. The screen cannot be isolated for maintenance without bypass pumping.

Based on an industry standard 3 feet per second downstream velocity, the screen is rated for a firm capacity of approximately 22 MGD. **The screen does not meet Ten States Standards or EPA Class I Reliability Standards for redundancy or emergency bypass. As such it is recommended that the screen be provided with a back-up screen or emergency bypass.**

Screened material is washed, compacted and bagged in a dumpster located immediately above the influent channel.

3.1.2 Influent Pumping

After screening wastewater flows to the influent pump wet well. Two (2) submersible (wet well) pumps and three (3) vertical centrifugal (dry well) pumps are used to pump flow to a 24-inch Parshall flume for measurement and through the remainder of the plant.

Three (3) of the raw sewage pumps share two VFDs while four (4) of the raw sewage pumps have dedicated variable speed drives. A wet well slot remains available for a sixth pump. The total and firm pumping capacities are 20 and 16 MGD, respectively. Flow and motor horsepower for the individual pumps are shown in **Table 3-1**.

Table 3-1: Influent Pump Information

Pump No.	Motor HP	Capacity (MGD)	Drive
1 - Vertical Centrifugal	40	4	VFD – shared
2 - Vertical Centrifugal	40	4	VFD – shared
3 - Vertical Centrifugal	40	4	VFD – shared
4 - Submersible	40	4	VFD – dedicated
5 - Submersible	40	4	VFD - dedicated

The headworks also include pump metering, controls and valves for flow distribution to the primary tanks. Instrumentation includes sensing, indicating, recording and totalizing for the raw sewage pumps.

3.1.3 De-gritting

Screened flow discharges to one (1) of two (2) aerated grit removal tanks. Each of the 20-ft by 20-ft by 12-ft deep tanks is sized (based on a 100 mesh removal size and specific gravity of 2.65) for a flow of about 9.2 MGD. Each aerated grit tank can be isolated using slide gates on the inlet and discharge sides of each tank. Captured grit is dewatered using one (1) grit washer and then disposed of at the landfill.

Grit removal currently appears to be adequately sized for the plant. Moreover, it appears that higher flows could be processed in the existing grit tanks, resulting in only minor degradation of grit removal.

It is noted that the air piping used for aerated grit system is tied directly to that of the blower system used for the main aeration tanks and side stream aeration tanks. The operating depth of the diffusers in the aerated grit tanks is greater than those for the aeration tanks resulting in higher system pressures in the air piping which impacts blower capacity. This phenomenon is described in greater detail in the memorandum titled “*Air Capacity Evaluation*” (April 8, 2014).

3.2 Primary Treatment

Screened and de-gritted flow is pumped to one (1) of four (4) primary clarifier tanks where settleable solids and associated CBOD₅ are removed. Each primary clarifier tank is 100-ft by 25-ft by 8.25-ft deep for a total clarifier surface area of 10,000 square feet.

At annual average and design average flows of about 3.3 and 5 MGD, the clarifiers operate at surface overflow rates of about 330 and 500 gpd/sf, respectively. **Table 3-2** shows the SORs, weir loading rates (WLRs) and hydraulic detention times (HRTs) for the range of influent flow rates currently observed by the primary clarifiers (i.e., 2-16.5 MGD). Both design average and peak SORs are well below the recommended by Ten State’s Standards (i.e., average = 1,000 gpd/sf and peak = 2,000 gpd/sf).

Table 3-2: Primary Clarifier SORs, WLRs and HRTs as a Function of Flow

Current Geneva WWTP Flow Condition	Flow	Surface Overflow Rate (SOR)	Weir Loading Rate (WLR)	Hydraulic Retention Time (HRT)
	(MGD)	(gpd/sf)	(gpd/lf)	(hrs)
	1	100	1,603	14.8
	2	200	3,205	7.4
	3	300	4,808	4.9
Annual Avg. ¹	4.3	430	6,891	3.4
Design Avg. ²	5	500	8,013	3.0
	6	600	9,615	2.5
	7	700	11,218	2.1
	8	800	12,821	1.9
	9	900	14,423	1.6
	12.5	1,250	20,032	1.2
Design Peak ³	16.5	1,650	26,442	0.9

1) Current Annual Average Flow

2) Design Average Flow Per Design Drawings

3) Design Peak Hourly Flow Per Design Drawings

To assess the existing primary clarifiers' ability to treat current and potential future peak flows an assessment of MRO data was made for the period between January 1, 2011 and October 31, 2013. **Table 3-3** shows the observed removal rates for TSS and CBOD₅ for different ranges of daily flow.

Table 3-3: Primary Clarifier Performance (1/1/10 - 8/31/13)

Primary Flow Range	Number of Data Points	Average Flow	Average Influent TSS	Average Effluent TSS	Average Influent CBOD ₅	Average Effluent CBOD ₅	TSS Removal	CBOD ₅ Removal
MGD	Days	MGD	mg/L	mg/L	mg/L	mg/L	%	%
All Flow	227	4.3	198	238	127	83	64	35
2-3	2	2.6	188	189	141	86	55	26
3-4	103	3.7	218	257	145	94	61	32
4-5	91	4.4	194	236	118	78	65	38
5-6	21	5.5	155	196	93	61	66	39
6-7	8	6.5	116	164	76	53	67	35
>7	2	7.8	142	185	76	59	64	43

Based on a review of the MRO data, the primary clarifiers are shown to perform consistently across the range of daily flow rates observed. With observed removal rates falling on the high side of textbook values (e.g., Metcalf & Eddy suggests ranges of 50-70 percent and 25-40 percent for TSS and BOD,

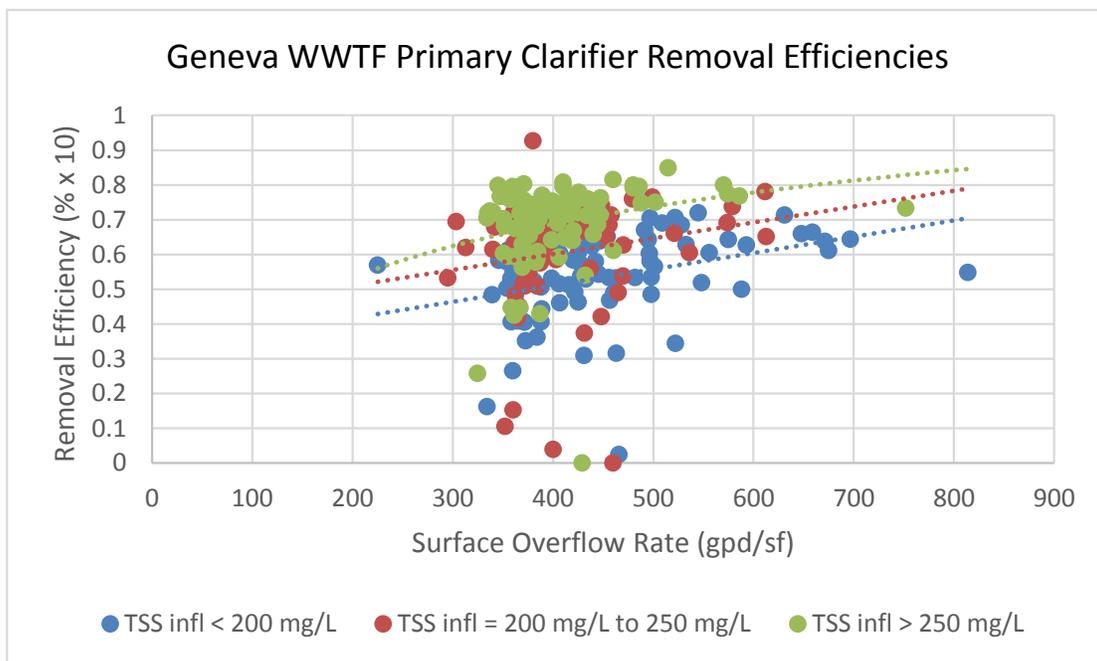
respectively) at an annual average flow of 4.3 MGD. Over the period of observation, the average removal rates for TSS and BOD were shown to be 64 and 35 percent, respectively.

To determine the impact of influent pollutant concentration on removal rates the removal rates were plotted against SORs (by influent concentration). The results are shown in **Figure 3-1**.

Because the primary clarifiers are operated within a relatively narrow range of daily flows (and associated overflow rates), the clarifiers are shown to perform well under the full range of flows.

All primary clarifiers have scraper mechanisms for sludge removal. Sludge from the primary sumps is removed by centrifugal pumps that transfer primary sludge to the primary digester.

Figure 3-1: Primary Clarifier TSS Removal Efficiencies



3.3 Secondary Treatment

There are two (2) sets of aeration basins in the activated sludge process. They are used to remove CBOD₅, phosphorus and ammonia-nitrogen. Each set has 3-pass basins that are sized as follows:

- Tanks 1, 2 and 3: 103-ft L by 33-ft wide by 11.5 deep
- Tanks 4, 5 and 6: 142-ft L by 26-ft wide by 11.5 deep

The total available aeration volume is approximately 2 MG.

While not designed with anoxic zones, air delivery in the first pass of each basin is insufficient to maintain a first pass effluent dissolved oxygen concentration of 2 mg/L. This phenomenon is described in greater detail in the Aeration Calculation Technical Memorandum (CDM Smith, April 2014). A recommendation for improvements to resolve the air deficiency is provided in the Blower Options for Aeration Improvements Technical Memorandum (CDM Smith, June 2014).

Mixed liquor from the aeration basins can be settled in one of three (3) 95-ft diameter by 10.8-ft deep circular clarifiers that are fed from aeration tanks 3 and 6. While the depth of the clarifiers are less than that recommended by Ten States Standards, the SORs are shown to be well below that recommended for single sludge nitrification.

At annual average and design average flows of about 4.3 and 5 MGD, the clarifiers operate at surface overflow rates of about 202 and 235 gpd/sf, respectively. **Table 3-4** shows the SORs, weir loading rates (WLRs) and hydraulic detention times (HRTs) for the range of influent flow rates currently observed by the secondary clarifiers (i.e., 2-12.5 MGD). Both design average and peak SORs are well below the recommended by Ten State's Standards (i.e., Design Peak Hourly Flow = 1,000 gpd/sf for single stage nitrification).

Table 3-4: Secondary Clarifier SORs, WLRs and HRTs as a Function of Flow

Current Geneva WWTP Flow Condition	Flow	Surface Overflow Rate (SOR)	Weir Loading Rate (WLR)	Hydraulic Retention Time (HRT)
	(MGD)	(gpd/sf)	(gpd/lf)	(hrs)
	1	47	1,199	13.2
	2	94	2,398	6.6
	3	141	3,597	4.4
Annual Avg. ¹	4.3	202	5,156	3.1
Design Avg. ²	5	235	5,995	2.6
	6	282	7,194	2.2
	7	329	8,393	1.9
	8	376	9,592	1.6
	9	423	10,791	1.5
Design Peak ³	12.5	588	14,988	1.1
	14.2	668	17,026	0.9

- 1) Current Annual Average Flow
- 2) Design Average Flow Per Design Drawings
- 3) Design Peak Hourly Flow Per Design Drawings

Table 3-5 shows clarifier solids loading rates (SLRs) projected (for different influent and RAS flow rates) for a total final clarifier surface area of 21,254 sf.

Table 3-5 Clarifier Solids Loading Rates

Annual Average Flow (4.3 mgd)					Design Average Flow (5.0 mgd)					Design Peak Flow (12.5 mgd)				
Q _{In}	Q _{Rec}	Q _{Total}	MLSS	SLR	Q _{In}	Q _{Rec}	Q _{Total}	MLSS	SLR	Q _{In}	Q _{Rec}	Q _{Total}	MLSS	SLR
mgd	mgd	mgd	mg/L	lb/sf/d	mgd	mgd	mgd	mg/L	lb/sf/d	mgd	mgd	mgd	mg/L	lb/sf/d
35% RAS					35% RAS					35% RAS				
4.3	1.5	5.8	1,000	2	5	1.8	6.8	1,000	3	12.5	4.4	16.9	1,000	7
4.3	1.5	5.8	2,000	5	5	1.8	6.8	2,000	5	12.5	4.4	16.9	2,000	13
4.3	1.5	5.8	3,000	7	5	1.8	6.8	3,000	8	12.5	4.4	16.9	3,000	20
4.3	1.5	5.8	4,000	9	5	1.8	6.8	4,000	11	12.5	4.4	16.9	4,000	26
4.3	1.5	5.8	5,000	11	5	1.8	6.8	5,000	13	12.5	4.4	16.9	5,000	33
50% RAS					50% RAS					50% RAS				
4.3	2.2	6.5	1,000	3	5	2.5	7.5	1,000	3	12.5	6.3	18.8	1,000	7
4.3	2.2	6.5	2,000	5	5	2.5	7.5	2,000	6	12.5	6.3	18.8	2,000	15
4.3	2.2	6.5	3,000	8	5	2.5	7.5	3,000	9	12.5	6.3	18.8	3,000	22
4.3	2.2	6.5	4,000	10	5	2.5	7.5	4,000	12	12.5	6.3	18.8	4,000	29
4.3	2.2	6.5	5,000	13	5	2.5	7.5	5,000	15	12.5	6.3	18.8	5,000	37
100% RAS					100% RAS					100% RAS				
4.3	4.3	8.6	1,000	3	5	5	10	1,000	4	12.5	12.5	25	1,000	10
4.3	4.3	8.6	2,000	7	5	5	10	2,000	8	12.5	12.5	25	2,000	20
4.3	4.3	8.6	3,000	10	5	5	10	3,000	12	12.5	12.5	25	3,000	29
4.3	4.3	8.6	4,000	14	5	5	10	4,000	16	12.5	12.5	25	4,000	39
4.3	4.3	8.6	5,000	17	5	5	10	5,000	20	12.5	12.5	25	5,000	49

Assuming a 50-100 percent return rate at peak flow and a MLSS concentration at or below 4,000 mg/L all of these SLRs are well below Ten States Standards recommended design average SLR of 35 lbs/d/sf.

Based on the SORs and SLRs projected for wet weather flows, it appears that the secondary system has capacity to treat additional wet weather flow once existing process and/or hydraulic bottlenecks are addressed.

3.3 Disinfection

The GWWTF has two Wedeco UV disinfection units capable of treating average and peak secondary treated flow of 5.0 and 12.5 MGD, respectively. The system meets Ten States Standards recommendations for 65% (minimum) UV transmittance and UV radiation dosage of not less than 30,000 uWs/cm²

To treat flows above the capacity of the UV disinfection system, the GWWTF also disinfect peak flows using sodium hypochlorite for disinfection and sodium bisulfate de-chlorination prior to discharge to the Fox River.

The chlorine contact system consists of one (1) baffled chlorine contact tank with eight (8) passes. An additional pass provides contact time and volume for de-chlorination. Each of the eight pass and one additional pass tank are provided with end-around baffling while the final tank is provided with over and under baffling. Contact times for the existing chlorine contact tank are shown in **Table 3-6**.

Table 3-6: Peak Flow Chlorine Contact Times vs Flow Rate

Geneva WWTP Flow Condition	Flow (MGD)	CCT Hydraulic Retention Time (HRT) (min)	BT Hydraulic Retention Time (HRT) (min)
	1	63.4	12.3
	2	31.7	6.1
	3.3	19.2	3.7
Design Peak	4.2	15.1	2.9
	5	12.7	2.5
	6	10.6	2.0

All of the HRTs (through the design peak) are shown to be above the 2004 Ten States Standards time of 15 minutes recommended for peak hourly flow.

A review of daily operating and effluent quality data for the period January 1, 2011 through October 31, 2013 shows that the daily maximum Fecal Coliform standard of 400 cfu per 100 ml was exceeded on one discreet occasion. This occurred during a low flow period and no excursions were observed for the peak flow facilities.

3.5 Solids Handling

3.5.1 Waste Activated Sludge (WAS) Thickening

Activated sludge is currently wasted from the secondary clarifiers and pumped to the WAS holding tanks for storage prior to thickening. The WAS storage tanks have a total volume of about 114,000 gallons. At a wasting rate of 31,000 gallons of (0.65%) sludge per day (on a 7 day per week basis) the tanks provide a storage time of about 3 to 4 days or a long week-ends worth of WAS storage.

WAS is thickened using one (1) thickening centrifuge. Based on an average WAS TSS concentration of 6,527 mg/L and a design feed rate of 150 gpm the thickening centrifuge is capable of processing 490 dry lbs/hr.

Based on a review of 2011 through August 2013 MRO data, 1,687 dry lb/d of WAS (0.031 MG x 8.34 x 6,527 mg/L TSS) is produced on a seven day per week basis. If thickened on a five (5) day per week basis, then 7/5 x 1,687 dry lb/d (or 2,362 dry lb/d) must be processed.

Assuming thickening occurs five (5) days per week, one (1) shift per day and six (6) hours per shift this equates to 787 dry lb/shift (2,362 dry lb/d per 6 hr per shift). Therefore, the existing thickening centrifuge should be sufficient to handle current and anticipated WAS thickening loads. **However, the**

individual thickening mechanism does not meet the EPA Class I Reliability Standard for redundancy. Additionally, based on conversations with plant staff it appears that the thickening centrifuge has not proven to be the most reliable of processes. If the thickening centrifuge were to be out of service, or if the centrifuge were not to operate optimally, then the thickening process would become a bottleneck to the activated sludge process. As a result, it is suggested that Geneva consider an alternative form of mechanical thickening (e.g., gravity belt or rotary drum thickener) and use the existing thickening centrifuge as a back-up to the dewatering centrifuge.

3.5.2 Anaerobic Digestion

Primary sludge and WAS are stabilized through anaerobic digestion. Primary sludge is pumped from the primary clarifiers to the primary anaerobic digester at a rate of about 18,000 gpd and solids concentration of about 0.5%. Thickened WAS is pumped to the primary digester where it is combined with the primary sludge for stabilization.

The GWWTF has two (2) 70-ft diameter digesters each with a 27-ft side water depth. Each digester can hold up to about 750,000 gallons of sludge. One digester serves as a primary digester where a majority of the digestion takes place. The primary digester is equipped with piping for transfer and recirculation through an external heat exchanger. The digester is also equipped with an internal draft tube mixer to allow for high rate or “complete” mixing.

Based on a review of 2011 through August 2013 MRO data, volatile suspended solids (VSS) load to the primary digester are calculated to be about 80 lb/1,000 cf. The VSS loading equals Ten States Standards limit for VSS loading for a completely mixed system. The impact of this higher VSS loading is minimized by the fact that digestion can continue to occur in the secondary digester.

The existing anaerobic digester system does not technically meet the EPA Class I Reliability Standard for redundancy. However, because a secondary digester exists to back-up the primary digester (typical of two stage digestion processes), nor recommendation for redundancy is provided at this time.

3.5.3 Digested Sludge Dewatering

Once digested, sludge flows from the primary digester to the secondary digester where it is settled and decanted. From the secondary digester sludge is pumped to one (1) dewatering centrifuge at a rate of about 150 gpm. Based on manufacturer’s literature the capacity of the dewatering centrifuge is about 3,750 dry lbs/d.

As with the thickening centrifuge, the dewatering centrifuge does not meet the EPA Class I Reliability Standard for redundancy. As a result, it is suggested that Geneva consider an alternative form of mechanical thickening (e.g., gravity belt or rotary drum thickener) and use the existing thickening centrifuge as a back-up to the dewatering centrifuge.

3.5.4 Dewatered Sludge Storage

The dewatered sludge (or cake) storage facility consist of a single building that is 180-ft in length by 80-ft in width and 24-ft in height to allow for loading of triaxle trucks and roll-off containers. The building is also equipped with an 8-ft high push wall to build up the cake height.

Assuming that about $\frac{3}{4}$ of the building has space available for cake storage and height of the cake pile is about 6-ft (@ 180-ft x 80-ft x 6-ft sludge height), the building has greater than $\frac{1}{2}$ year storage volume which exceeds Ten State Standards recommendation for 180 day storage volume.

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Appendix E

Aeration Improvements Memorandum

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Technical Memorandum

To: Bob VanGyseghem; City of Geneva

From: CDM Smith

Date: July 31, 2014

Subject: Blower Options for Aeration Improvements

1.0 INTRODUCTION

This memorandum summarizes the scenarios available to replace the blowers for the Geneva wastewater treatment plant (WWTP) based on projected air requirements for a twenty year design period (i.e., through 2034) with the inclusion of leachate loads from the Midway Landfill.

2.0 METHODOLOGY

Two separate air requirement methodologies were used to develop near-term and long-term air requirements for the Geneva WWTP aeration tanks. CDM Smith Activated Sludge Guidelines (Version 3, October 2011) were used to develop the actual oxygen requirement (AOR) for BOD and NH₃ removal. Design guidelines suggested by Sanitaire were used to calculate the standard oxygen requirement (SOR) under standard conditions, as well as the air required to mix the tanks using fine bubble diffusers. Using near-term (2014) and long-term (2034) design flows and loads identified in the Geneva WWTP Design Flows and Loads Memo (CDM Smith; June 2, 2014), the total air requirements for the Geneva WWTP fall into the following ranges:

- 2014
 - Minimum Air Requirement = 3,436 scfm
 - Maximum Air Requirement = 7,464 scfm
- 2034
 - Minimum Air Requirement = 3,802 scfm
 - Maximum Air Requirement = 8,300 scfm

The minimum required air in 2014 is 41% of the maximum required air in 2034, which will affect the blower replacement options available.

3.0 BLOWER REPLACEMENT OPTIONS

Based on the range of flows required for near-term and long-term air requirements, different scenarios are available to provide the required air to the aeration tanks. The required turndown between the minimum near-term air and the maximum future condition is nearly within the range of acceptable turndown for a Turblex blower, but not within the range for turbo or centrifugal blowers. Plant and City staff have indicated that future replacement of the blowers shall not include the option of Positive Displacement (PD) blowers, so the evaluation of options focused on multi-stage centrifugal, turbo, and Turblex blowers. Each of the blower options has distinct advantages and disadvantages related to near- and long-term operation, including turndown, blower cost, and other required modifications. The following scenarios were evaluated in detail as described below in Section 4.0. All scenarios assume that the existing Blower Building can be utilized and reconfigured so that a new structure is not required to house the alternatives.

1. Four (4) Turbo blowers (Three - 2,767 scfm + 1 Standby)
 - a. This option allows the full range of near- and long-term conditions to be met.
 - b. Could satisfy potential lower near-term “minimum” flows since turbo blowers can be turned down approximately 50%.
 - c. Option has full standby capabilities.
 - d. All of the blowers are identical within the system.
 - e. Portions of the header piping within the Blower Building may be used, but the inlet and discharge piping to each blower would still require modification.
2. Four (4) Multi-stage centrifugal blowers (Three - 2,767 scfm + 1 Standby)
 - a. This option allows the full range of near- and long-term conditions to be met.
 - b. Could satisfy potential lower near-term “minimum” flows since centrifugal blowers can be turned down approximately 50%.
 - c. Option has full standby capabilities.
 - d. All of the blowers are identical within the system.

- e. Centrifugal blowers do not operate at the same efficiency levels as the turbo or Turblex options.
 - f. Portions of the header piping within the Blower Building may be used, but the inlet and discharge piping to each blower would still require modification.
3. Four (4) Turblex blowers (Three - 2,767 scfm + 1 Standby)
- a. This option allows the full range of near- and long-term conditions to be met.
 - b. Could satisfy potential lower near-term “minimum” flows since Turblex blowers can be turned down approximately 50%.
 - c. Option has full standby capabilities.
 - d. All of the blowers are identical within the system.
 - e. Portions of the header piping within the Blower Building may be used, but the inlet and discharge piping to each blower would still require modification.
4. Three (3) Turbo blowers (Two - 4,150 scfm +1 Standby)
- a. This option allows the full range of near- and long-term conditions to be met.
 - b. Could satisfy potential lower near-term “minimum” flows since turbo blowers can be turned down approximately 50%.
 - c. Option has full standby capabilities.
 - d. All of the blowers are identical within the system.
 - e. Portions of the header piping within the Blower Building may be used, but the inlet and discharge piping to each blower would still require modification.
5. Three (3) Multi-stage centrifugal blowers (Two - 4,150 scfm + 1 Standby)
- a. This option allows the full range of near- and long-term conditions to be met.
 - b. Could satisfy potential lower near-term “minimum” flows since centrifugal blowers can be turned down approximately 50%.
 - c. Option has full standby capabilities.
 - d. All of the blowers are identical within the system.
 - e. Centrifugal blowers do not operate at the same efficiency levels as the turbo or Turblex options.
 - f. Portions of the header piping within the Blower Building may be used, but the inlet and discharge piping to each blower would still require modification.

6. Three (3) Turblex blowers (Two - 4,150 scfm +1 Standby)
 - a. This option allows the full range of near- and long-term conditions to be met.
 - b. Could satisfy potential lower near-term “minimum” flows since Turblex blowers can be turned down approximately 50%.
 - c. Option has full standby capabilities.
 - d. All of the blowers are identical within the system.
 - e. Portions of the header piping within the Blower Building may be used, but the inlet and discharge piping to each blower would still require modification.

The following alternatives were preliminarily evaluated for feasibility, but were eliminated from detailed cost comparison analysis due to various reasons described in each alternative, including insufficient standby capabilities, insufficient turndown capabilities, or potential operation and maintenance concerns.

7. One (1) Turblex blower (8,300 scfm)
 - a. This option has the advantage of purchasing a single, high efficiency blower to cover the entire range of required air flows. Since the acceptable turndown of a Turblex blower extends to 45% of the design condition, a single Turblex blower can nearly cover the range of near-term low flow and long-term maximum flow.
 - b. All of the existing air piping within the Blower Building, and some of the external site piping, would need to be replaced since the air velocity in the pipe would be higher than recommended.
 - c. This option does not provide for a standby blower for the times when the blower needs maintenance. When the blower was not operating, no air flow could be provided to the aeration tanks.
 - d. Does not meet wastewater standards for reliability.
8. One (1) Turbo blower (8,300 scfm)
 - a. This option has the advantage of purchasing a single, high efficiency blower. However, the turbo blower does not have the same amount of acceptable turndown (down to 50%). Therefore, it would not be able to provide the near-term low flow air requirements.
 - b. This option does not provide for a standby blower and would have issues with the existing piping being undersized for the higher air flows.
 - c. Does not meet wastewater standards for reliability.
9. Two (2) Turblex blowers (8,300 scfm + 8,300 scfm)

- a. This option has the advantage of utilizing high efficiency blowers to cover the entire range of required air flows.
 - b. The existing piping within the Blower Building would need to be revised.
 - c. This option includes full standby capability.
 - d. The control scheme could be designed to cycle the blowers between them to be able to extend the life of both blowers instead of one blower running significantly more than the other.
10. Two (2) Turbo blowers (8,300 scfm + 8,300 scfm)
- a. This option has the advantage of utilizing high efficiency blowers, but is not able to cover the full range of near- and long-term air requirements since the turbo blower does not have sufficient turndown to cover the required low end flows.
 - b. The existing piping within the Blower Building would need to be revised.
 - c. Includes full standby capability.
11. One (1) Turblex blower + Two (2) Multi-stage centrifugal blowers (8,300 scfm Turblex + 4,150 scfm multi-stage centrifugal + 4,150 scfm multi-stage centrifugal)
- a. This option has the advantage of using a high efficiency blower, with sufficient turndown to nearly cover the range of near- and long-term flows.
 - b. Option has full standby capabilities and the ability to use different configurations of blowers over the range of flows.
 - c. Piping within the Blower Building would need to be revised to accommodate this arrangement.
 - d. Plant staff would have two different types of blower systems to operate and maintain.
12. One (1) Turbo blower + Two (2) Multi-stage centrifugal blowers (8,300 scfm Turbo + 4,150 scfm multi-stage centrifugal + 4,150 scfm multi-stage centrifugal)
- a. Provides the advantage of using a high efficiency blower during the majority of the range of near-term and long-term flows, while providing Plant staff the ability to use different configurations over the range of flows.
 - b. One of the centrifugal blowers can be used to achieve the near-term minimum condition that the turbo blower turndown is unable to provide.
 - c. Option has full standby capabilities.
 - d. Piping within the Blower Building would need to be revised to accommodate this arrangement.

- e. Plant staff would have two different types of blower systems to operate and maintain.

4.0 BLOWER OPTIONS DETAILED EVALUATION

A detailed present worth analysis was not performed for Scenarios #7 – #10 because they either do not provide for standby capabilities or do not have sufficient ability to cover the entire range of flows. While Scenarios #11 and #12 were originally considered if the existing blowers would have been able to be reused, present worth analysis were not performed for these scenarios with all new blowers and because of the mixture of blower technologies that the plant would be required to maintain and operate. Therefore, options #1 - #6 were determined to be the most feasible and operator friendly alternatives for further evaluation. Alternatives #2 and #5 were also further refined into (a) and (b) alternatives to be evaluated with and without dissolved oxygen (DO) control, respectively.

Preliminary costs were obtained from representatives for each type of blower based on the average air flow requirements. The capital cost for the turbo blowers ranged from approximately \$125,000 to \$220,000 per blower, depending on the size of the blowers for the alternative, while the capital cost for the multi-stage centrifugal blowers ranged from \$65,000 to \$75,000, and the Turblex costs were in the range of \$250,000 per blower. Including other capital costs associated with changing from the plant's existing system to the new blowers and incorporating the twenty-year costs associated with operating the types of blower systems over a twenty-year time period provides for the total present worth costs shown in **Table 1** below. A sensitivity analysis was performed using different energy costs and the order of the alternatives was unchanged.

Table 1 - Geneva WWTP - Blower Evaluation Life Cycle Cost Summary

Alternative		Capital Cost	Present Worth O&M	Total Present Worth	% Difference against the lowest PW Alternative
1	High speed centrifugal - Turbo (3+1)	\$1,792,000	\$3,831,000	\$5,623,000	0%
2a	Multi-stage centrifugal (3+1) (w/ DO control)	\$1,556,000	\$4,418,000	\$5,974,000	6%
2b	Multi-stage centrifugal (3+1) (w/o DO control)	\$1,459,000	\$6,467,000	\$7,926,000	29%
3	Turblex (3+1)	\$2,541,600	\$3,739,000	\$6,280,600	10%
4	High speed centrifugal - Turbo (2+1)	\$2,015,000	\$4,347,000	\$6,362,000	12%
5a	Multi-stage centrifugal (2+1) (w/ DO control)	\$1,476,000	\$4,579,000	\$6,055,000	7%
5b	Multi-stage centrifugal (2+1) (w/o DO control)	\$1,378,000	\$5,795,000	\$7,173,000	22%
6	Turblex (2+1)	\$2,225,200	\$3,456,000	\$5,681,200	1%

Due to the relative similarity between the life cycle costs between the alternatives, other factors were considered to determine the appropriate direction to proceed.

One example would be the footprint and ceiling requirements for the new blower system. Due to their larger size, the multi-stage centrifugal blowers may not fit into the existing blower room space without building modifications. The four blower Turbo blower alternative has the lowest height requirement and upon cursory review appears to fit within the footprint of the existing building. Also upon cursory review, the three and four blower Turblex blower alternatives appear to fit within the footprint of the existing building. However, their height requirements are greater than that of the four blower Turbo blower alternative. As such, their installation may require modifications to the existing building. Their installation height would need to be confirmed with the manufacturer. Other less quantifiable issues associated with Turbo and Turblex type blowers are provided in **Table 2**.

Of particular note is the requirement for VFDs for both Turbo and Turblex blower systems. For the Turbo blower systems the VFDs are integral to the control and blower package. As such, they are factored into the footprint of the blower layout. For the Turblex blower system, the integral VFD and controls are separate from the blower, and would require additional space in an already cramped blower room.

Based on the lowest life cycle cost combined with the least space requirement, it is recommended that the four blower Turbo blower alternative be considered for future aeration requirements at the Geneva WWTP.

Table 2 - Comparison of Turbo and Turblex Type Blowers

	Turbo (direct drive) Type Blower	Turblex (integrally geared) Type Blower
Capital Cost	\$1.8M (see Table 1)	\$2.2M (see Table 1)
20-Year Life Cycle Cost	\$5.6M (see Table 1)	\$5.7M (see Table 1)
Noise	No contact on bearing surfaces means low vibration and low noise. Requires a small discharge silencer. 73 - 85 dB(A) w/o acoustical fixes during regular operation. Exceptions are startup and stoppage periods where the sound pressure exceeds normal rotating equipment levels requiring ear protection if operators are in the blower room.	Requires relatively large inlet and discharge silencers (which adds to footprint). 91-95 dB(A) w/o acoustical fixes. Typically requires ear protection for operators if working in proximity to the units.
Footprint	Similar to that of the existing multi-stage centrifugal blowers. Therefore, will fit into the existing blower room.	Slightly greater than that of the existing multi-stage centrifugal blowers, but will still fit in the existing blower room.
Method of Lubrication	None – Air No requirement from the operator	Oil (high quality) Requires operator attention (oil change)
Bearing Maintenance	Air Bearing Inspection 10 to 20 years; overhaul 10, 15, 20 years MTB ¹ magnetic bearing controller - 100,000 hrs MTB ¹ failure 200,000-300,000 hrs No backup power supply required for power outage.	MTB ¹ failure of bearing 10-12 years <ul style="list-style-type: none"> • Daily - check oil levels thru site windows • Weekly - check grease bearings • Monthly - change gearbox oil
Filter Maintenance	Air Bearing Check monthly. Typically 2 filters, changed between 1 to 6 months	Weekly inspection of intake filters, depending on blower size can have 12 filters.
Overall Maintenance	Provides better conditions for the operators (less input)	Conditions of operation will be similar to the existing multistage blowers
System Cooling	Blower core and motor cooled with blower inlet air (most designs) Air or be ducted from the outside Integral cooling system with inverter, water tank, pump and radiator. Motor driven by sinusoidal algorithm which lowers motor heat rejection and minimizes cooling requirements. Blower room will be cooler than the existing room providing more operator comfort. However, because of the environmental conditions issues listed below, upgrades to the HVAC filtration system may be needed for these units.	Blower core and motor cooled with room air Blower room environmental conditions will remain as they currently are. No HVAC changes required.
Controls	Integral control panel and PLC Single point control Lower level of operations monitoring Requires harmonics filter for 18-pulse VFD	Integral control panel and PLC Dual point controls (independent head and flow control) Higher level of operations monitoring (e.g., vibration, bearing temperature, etc.)
Overall Environmental Conditions	Units operation more susceptible to different environmental conditions: <ul style="list-style-type: none"> • Dust and particulate material has been shown to be a problem for these 	No issues related to environmental conditions have been reported with these units.

	<p>type of blowers, causing units failures.</p> <ul style="list-style-type: none"> • High moisture conditions around inlets have shown to be troublesome for these units. • Corrosion issues around the units can affect the proper operation of the system 	
Sensitivity Analysis related to Energy cost increases	<p>Due to their slightly higher turndown, if energy costs are higher than what it was anticipated in the LCC evaluation, the Turbo units would have a higher LCC cost.</p> <p>Likewise, lower than anticipated energy cost would favor these units compared to the Turblex units (LCC will be lower)</p>	<p>Due to the better turndown, if energy costs are higher than anticipated in the LCC evaluation, then the City would realize more energy savings with these units (LCC will be lower)</p> <p>Lower than anticipated energy costs would make these units less attractive.</p>
Overall technology performance	Newer technology, not really proven in the long run, but with a lot of potential.	Established technology, robust units, well proven

Notes:

1. MTB - Mean time between failure

Appendix F

Phosphorus Alternatives Workshop Presentation and Evaluation Matrix

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Phosphorus Removal Alternatives Workshop

Geneva WWTP


**CDM
Smith**

February 04, 2015

OUTLINE

- Background
 - Mechanisms of Phosphorus Removal
 - Current Plant Operations
 - Pending Phosphorus Discharge Limitations
- Alternatives Development Procedures
 - Intensive Sampling
 - Jar Testing
 - Model
- Phase I Alternatives
- Phase II Alternatives

BACKGROUND

- Three Components of Phosphorus in Wastewater

- Particulate Phosphorus (PP)
 - inorganic and organic
 - CAN be removed by sedimentation and filtration
- Soluble Reactive Phosphorus (SRP)
 - filterable
 - occur mainly in the inorganic orthophosphate (OP) form
 - CAN precipitate by reaction with metal salts
- Soluble Unreactive Phosphorus (SUP)
 - filterable organic phosphorus and polyphosphates
 - CANNOT precipitate by reaction with metal salts

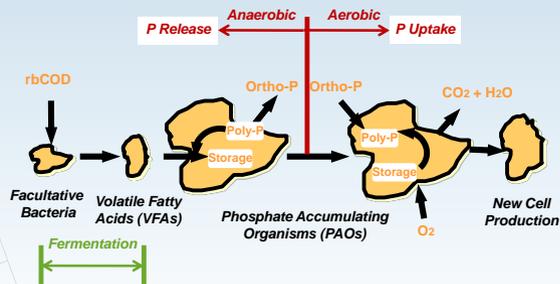
BACKGROUND

- Mechanisms of Phosphorus Removal

- Convert soluble P to insoluble P (solid form) and then removal insoluble P via solids separation
- Do not allow P stored in solids to release and recycle back into liquid stream
- Traditional Approaches:
 - Biologically – via uptake with biomass
 - Chemically – via precipitation
- Soluble unreactive phosphorus (SUP) cannot be removed either biologically or chemically

BACKGROUND

- Enhanced Biological Phosphorus Removal (EBPR)



P uptake to release ratio = 1:2

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BACKGROUND

- EBPR Process P Removal Conditions

- Anaerobic-aerobic sequencing
- Sufficient rbCOD (COD:P ratios > 45)
- No nitrates, nitrites or DO to the anaerobic zone
- No back mixing to the anaerobic zone
- Avoid secondary P release
- Provide sufficient aeration for P uptake
- Neutral pH
- Mixed liquor temperature between 4 and 28°C

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BACKGROUND

- Biological Phosphorus Removal

- Pros
 - Less chemical costs
 - Less sludge production
 - Improved process stability
 - Can be accomplished with nitrogen removal
- Cons
 - More complex process control
 - Phosphorus removal is controlled by BOD:TP ratio in wastewater
 - Potential phosphorus release in solids handling process
 - Not reliable for complying with very low P limits
 - Standby chemical feed equipment may be necessary



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BACKGROUND

- Chemical Phosphorus Removal

- Mechanisms:
 - Metal salts react with soluble P to form precipitates
 $M+3 + PO_4-3 \rightarrow MPO_4$ (insoluble)
 - Separation of metal hydroxide from liquid phase by clarification or filtration
- Most prevalent metal salts options:
 - Alum
 $Al_2(SO_4)_3 \cdot 18H_2O + 2H_3(PO_4) = 2Al(PO_4) \downarrow + 3H_2SO_4 + 18H_2O$
 - Ferric chloride
 $FeCl_3 + H_3(PO_4) = Fe(PO_4) \downarrow + 3HCl$

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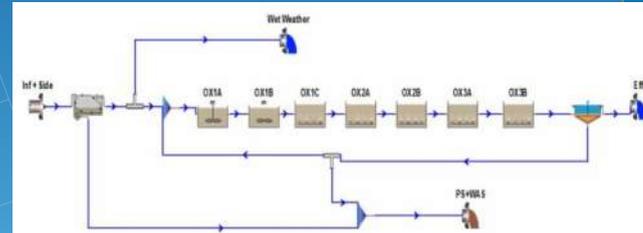
BACKGROUND

- Chemical Phosphorus Removal

- Pros
 - Simple control systems
 - Improves settling
 - Reliable for compliance
 - Can achieve very low P levels
 - Cons
 - Chemical storage and costs
 - Generate more sludge
 - Sludge handling and disposal issues
- Alkalinity supplement may be required



ALTERNATIVES DEVELOPMENT PROCEDURES



Procedure for Alternatives Development

- Physical dimensions of tanks
- Intensive sampling campaign
- Jar Testing
- Biowin model setup and calibration
- Alternatives development (model iterations)



Intensive Sampling



Raw Influent															
Date	Flow (MGD)	Temperature			pH			DO			TSS				
		10C	15C	Total	Min	Max	Mean	Min	Max	Mean	Total	Settle	Doc (mg/L)		
3-Apr-14	4.002	25.4	20.2	4.78	8.1	8.01	14.3	2.0	0.10	48.1	220	15.2	89	48	20
4-Apr-14	4.175	23.5	19.0	5.40	3.7	2.20	12.9	2.4	0.18	37.1	160	32.7	562	70	05
5-Apr-14	4.000	19.0	15.8	4.45	2.9	1.88	12.7	2.0	1.02	35.3	140	28.0	231	68	12
6-Apr-14	4.124	22.0	20.5	3.80	2.4	1.80	11.3	2.0	1.01	33.3	154	23.6	341	78	08
7-Apr-14	4.007	23.4	19.8	4.38	2.7	1.85	12.8	2.0	1.13	35.3	214	53.3	412	90	08
8-Apr-14	4.105	23.8	19.5	4.80	3.1	2.65	12.8	2.0	2.08	38.3	193	25.1	412	85	05
9-Apr-14	3.819	28.0	23.0	6.17	3.5	3.00	12.4	2.7	1.88	41.0	200	25.0	135	60	07
Mean	4.123	25.4	21.0	5.16	3.3	2.43	12.5	2.4	1.36	37.7	180	35.5	275	68	08

Primary Effluent															
Date	Flow (MGD)	Temperature			pH			DO			TSS				
		10C	15C	Total	Min	Max	Mean	Min	Max	Mean	Total	Settle	Doc (mg/L)		
3-Apr-14	4.002	22.5	18.2	3.66	3.5	2.16	12.7	2.4	0.11	35.8	70.8	17.3	91	50	20
4-Apr-14	4.175	17.4	15.0	3.02	3.1	1.74	12.3	2.0	1.21	32.7	52.8	45.2	221	50	78
5-Apr-14	4.124	21.2	21.2	2.56	2.3	1.88	12.8	2.0	1.05	33.3	92.7	53.5	229	90	02
6-Apr-14	4.124	18.8	17.7	2.70	2.8	1.83	14.4	2.0	1.09	38.8	124	46.4	252	112	06
7-Apr-14	4.007	17.4	16.8	3.41	2.5	1.85	13.6	2.0	1.10	33.7	166	48.0	207	140	124
8-Apr-14	4.105	19.0	16.0	3.80	3.0	2.21	17.3	2.1	1.28	38.8	136	40.8	201	97	78
9-Apr-14	3.819	23.0	21.0	2.80	2.8	2.04	17.1	2.0	1.05	38.8	141	62.8	246	104	72
Mean	4.123	22.6	19.4	3.35	2.9	1.95	13.6	2.1	1.08	37.2	114	51.0	214	100	75

Efficiency of Sidestream Reactor -
83% TN Removal
36% TP Removal

Parameter	Unit	Value	Limit
Ammonia Nitrogen	mg/L	0.05	1.0
Total Nitrogen	mg/L	0.5	1.5
Total Phosphorus	mg/L	0.05	0.1
Chemical Oxygen Demand	mg/L	100	150
Biochemical Oxygen Demand	mg/L	10	20



Measurements	Value	Unit	GUIDE
Main Influent concentrations			- Enter measured lab data in column on left (BOLD)
Flow	16790.8	mgd or m3/d	
Influent COD fractions	Default	Estimate	Notes
F ₁₀	0.160	0.146	from Step 1
F ₂₀	0.050	0.038	from Step 1
F ₃₀	0.130	0.165	affects BOD, VSS

Name	Value	Name	Value	Row	Outputs	Units
Flow	16790	F ₁₀ - Readily biodegradable (including Acetate)	[gCOD/g of total COD]	0.16	0.146	
Total COD mg/L	380	F _{ac} - Acetate	[gCOD/g of readily biodegradable COD]	0.15	0.083	
Total Kjeldahl Nitrogen mg/L	24	F _{10p} - Non-colloidal slowly biodegradable	[gCOD/g of slowly degradable COD]	0.75	0.835	
Total P mg/L	5.16	F ₂₀ - Unbiodegradable soluble	[gCOD/g of total COD]	0.05	0.038	
Nitrate N mg/L	0.86	F ₃₀ - Unbiodegradable particulate	[gCOD/g of total COD]	0.13	0.165	
pH	7.3	F _{1a} - Ammonia	[NH3-N/gTNH]	0.66	0.646	
Alkalinity mmol/L	6	F _{10x} - Particulate organic nitrogen	[gN/g Organic N]	0.5	0.500	
Inorganic S S mgTSS/L	42.0	F _{10s} - Soluble unbiodegradable TN	[gN/gTNH]	0.52	0.020	
Calcium mg/L	80	F _{10p1} - N:COD ratio for unbiodegradable part. COD	[gN/gCOD]	0.035	0.035	
Magnesium mg/L	15	F _{10p2} - Phosphate	[gPO4-P/gP]	3.5	0.471	
Dissolved oxygen mg/L	0	F _{10p3} - P:COD ratio for influent unbiodegradable part. COD	[gP/gCOD]	0.011	0.011	
		F _{20b} - Non-poly-P heterotrophs	[gCOD/g of total COD]	1.00E-04	0.0001	
		F _{20w} - Anaerobic methanotrophic oxidizers	[gCOD/g of total COD]	1.00E-04	0.0001	
		F _{20c} - Ammonia oxidizers	[gCOD/g of total COD]	1.00E-04	0.0001	
		F _{20d} - Nitrite oxidizers	[gCOD/g of total COD]	1.00E-04	0.0001	
		F _{20e} - Anaerobic ammonia oxidizers	[gCOD/g of total COD]	1.00E-04	0.0001	
		F _{20f} - PAOs	[gCOD/g of total COD]	1.00E-04	0.0001	
		F _{20g} - Protoprotonic acetogens	[gCOD/g of total COD]	1.00E-04	0.0001	
		F _{20h} - Acetolactate methanogens	[gCOD/g of total COD]	1.00E-04	0.0001	
		F _{20i} - H ₂ -utilizing methanogens	[gCOD/g of total COD]	1.00E-04	0.0001	

Project—Parameters—Other—General

Particulate substrate COD:VSS ratio	1.32
Particulate inert COD:VSS ratio	1.32

GUIDE

Paste data from this page to the two influent forms and the parameter form in BioWin

Zbh	0	
Xsc	41	Added to Ss for BOD calcs
Xsp	206	

Model Development & Calibration

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Technical Memorandum

To: Mr. [Name]

From: Susan Betts, P.E., RCE

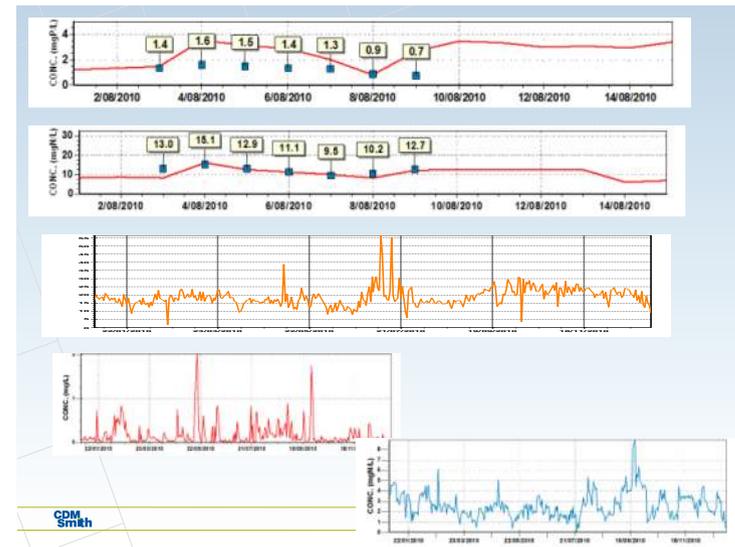
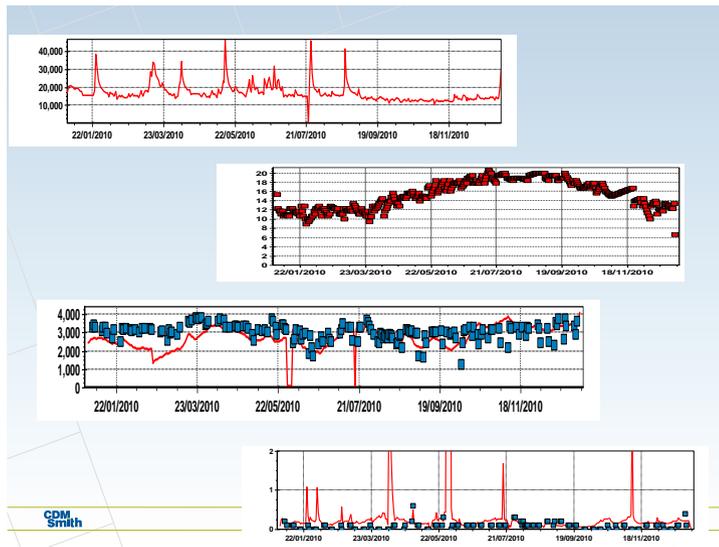
Reviewed by: Timor Davis, P.E., PhD, RCE, ASCE/ISA

Date: October 26, 2014

Subject: Denver Wastewater Treatment Facility BioWin™ Model Calibration

This technical memorandum (TM) describes the preparation of a comprehensive model for the Denver Wastewater Treatment Facility (DWWTF), using the BioWin™ simulation from CDM Smith Associates, Inc. with the goal of assessing the technology available for reducing the plant's nitrogen to attain the effluent DWWTF total phosphorus goals required by the regulatory agency.

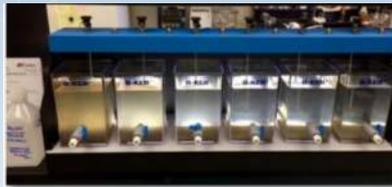
For the purpose of calibration, the TM will use the Water Environment Research Foundation's (WERF) Reference Guide of Proven Technology for Wastewater Management when referring to different nutrient conversion fractions and processes.



City of Geneva
Wastewater Treatment Plant

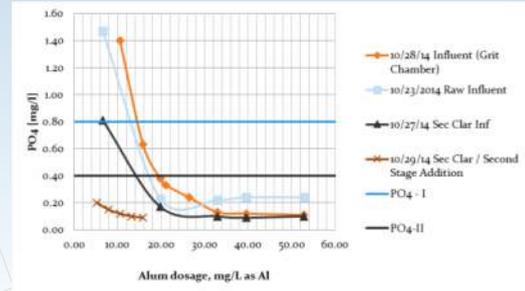
Facility Plan Update Project
Chemical Phosphorus Removal Evaluation
Preliminary Aluminum Sulfate (Alum) Additions

Submitted To:
CDM Smith
125 South Wacker Drive, Suite 600
Chicago, Illinois 60606



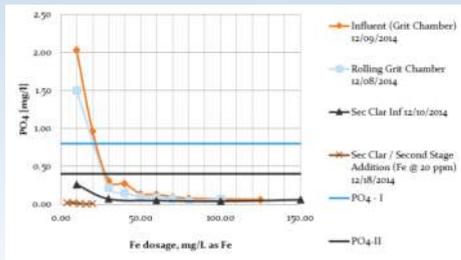
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Alum Jar Testing Results



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FeCl3 Jar Testing Results



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Comparison

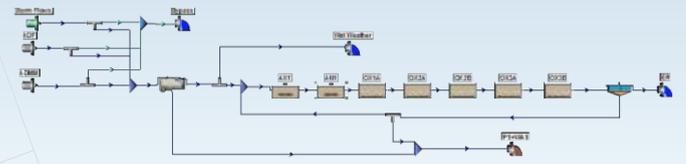


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PHASE I ALTERNATIVES

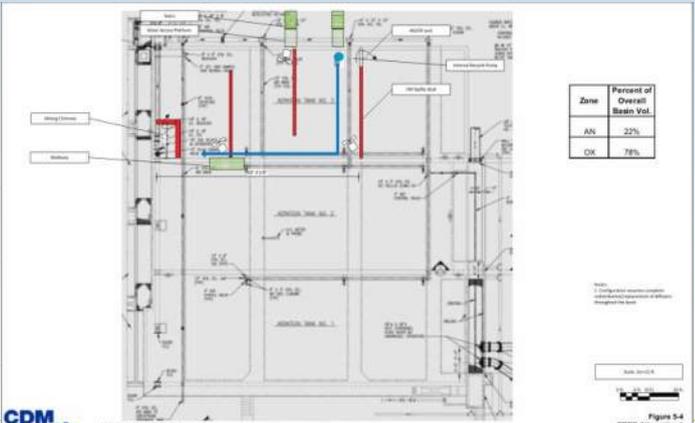
Phase I - 1.0 mg/L TP

Alternative 1 – A/O Process



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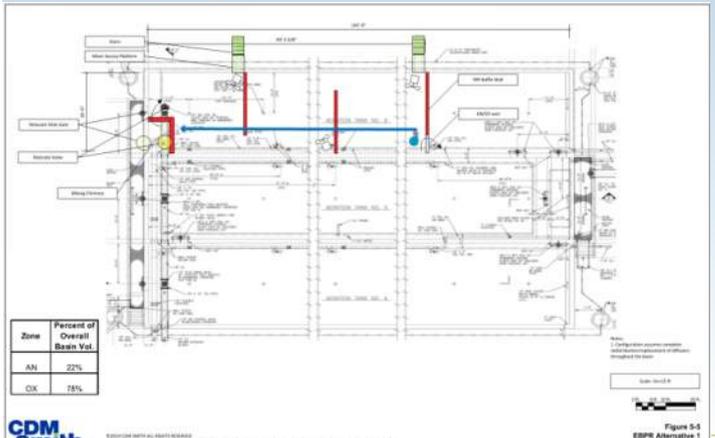
Train 1



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Figure 5-4
ESPR Alternative 1
Train 1

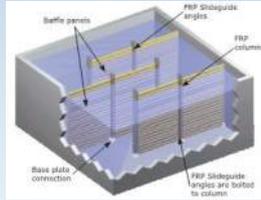
Train 2



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Figure 5-5
ESPR Alternative 1
Train 2

Elements Needed

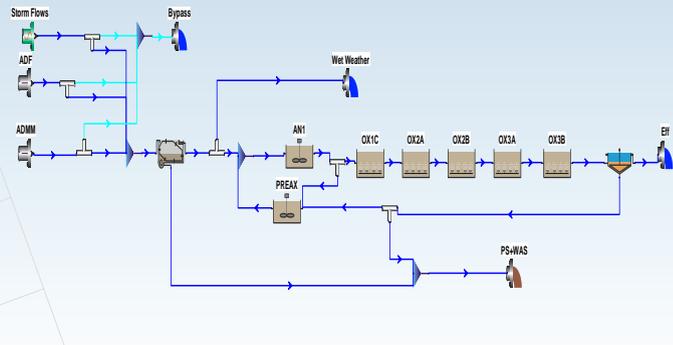


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CWTE - EF Evaluation Alternatives 1 and 2 - Capital and O&M Costs				
Capital Cost Estimate				
Item No.	Facility Description	Units	Unit Cost/Percentage	Amount (\$)
1	Structure	1.0		10,000,000
2	Equipment foundation		50%	5,000,000
3	Process Ventilation/Exhaust			10,000,000
4	Structure	1.0	100%	10,000,000
5	Mechanical Electrical	1.0	100%	10,000,000
6	Process	1.0	100%	10,000,000
7	Process	1.0	100%	10,000,000
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73	Process	1.0	100%	10,000,000
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79	Process	1.0	100%	10,000,000
80	Process	1.0	100%	10,000,000
81	Process	1.0	100%	10,000,000
82	Process	1.0	100%	10,000,000
83	Process	1.0	100%	10,000,000
84	Process	1.0	100%	10,000,000
85	Process	1.0	100%	10,000,000
86	Process	1.0	100%	10,000,000
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94	Process	1.0	100%	10,000,000
95	Process	1.0	100%	10,000,000
96	Process	1.0	100%	10,000,000
97	Process	1.0	100%	10,000,000
98	Process	1.0	100%	10,000,000
99	Process	1.0	100%	10,000,000
100	Process	1.0	100%	10,000,000

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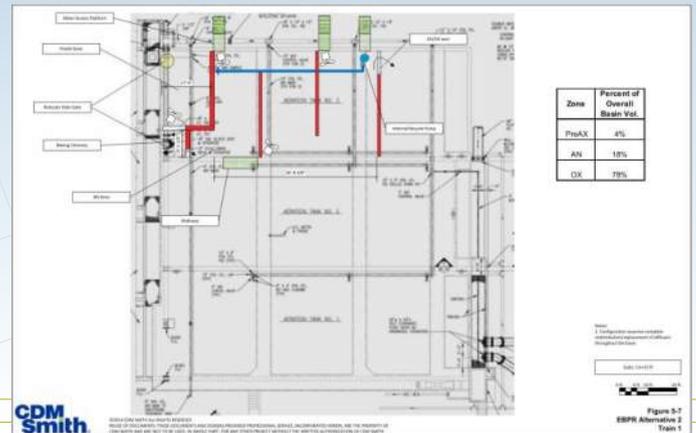
Alternative 2 A/O w/PreAX



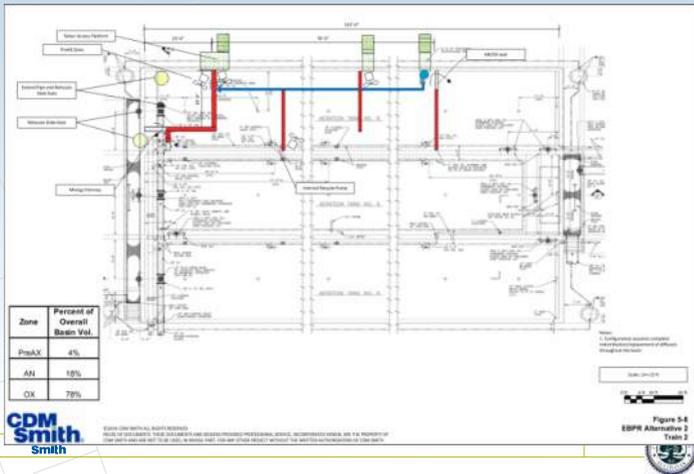
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Alternative 2 / Train 2 – Basin Mods



Alternative 2 / Train 2 – Basin Mods

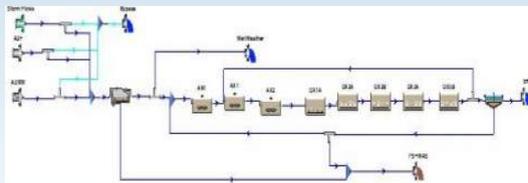


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Capital Cost Estimate				
Item No.	Facility Description	Units	Unit Cost/Percentage	Amount (\$)
1	Structure	1.0		10,000,000
2	Equipment Installation	50%		5,000,000
3	Process Technology Package	1.0	5,000,000	5,000,000
4	Structure	1.0	5,000,000	5,000,000
5	Structure	1.0	5,000,000	5,000,000
6	Structure	1.0	5,000,000	5,000,000
7	Structure	1.0	5,000,000	5,000,000
8	Structure	1.0	5,000,000	5,000,000
9	Structure	1.0	5,000,000	5,000,000
10	Structure	1.0	5,000,000	5,000,000
11	Structure	1.0	5,000,000	5,000,000
12	Structure	1.0	5,000,000	5,000,000
13	Structure	1.0	5,000,000	5,000,000
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19	Structure	1.0	5,000,000	5,000,000
20	Structure	1.0	5,000,000	5,000,000
21	Structure	1.0	5,000,000	5,000,000
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91	Structure	1.0	5,000,000	5,000,000
92	Structure	1.0	5,000,000	5,000,000
93	Structure	1.0	5,000,000	5,000,000
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95	Structure	1.0	5,000,000	5,000,000
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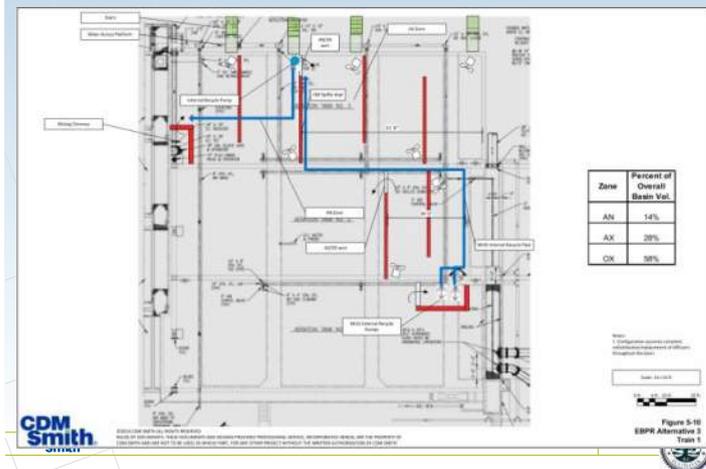
Figure 5-10
EBPR Alternative 2
Train 1

Alternative 3 A2/O Configuration



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Alternative 3 / Train 1 – Basin Mods



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GWWTF - Chemical Phosphorus System Capital and O&M Costs					
Capital Cost Estimate					
Item No.	Facility Description	Units	Unit Cost/Percentage	Quantity	Amount (\$)
1	Misc. Equipment	1.5	From Vendor		\$ 37,000
2	Exhaustion Installation		80%		\$ 33,000
3	Process V/Class/Pipeline	1.8			\$ 13,000
4	Building and Foundation Costs (See Building)	1.51	\$250	980	\$ 378,000
5	Building Electrical	1.51	\$110	980	\$ 105,000
6	Painting		1% of building costs		\$ 3,000
7	IT/SCADA		2% of building costs		\$ 6,000
8	Control Strategies	3.51	\$1,000	40	\$ 40,000
9	Miscellaneous (other significant/detachable costs - see notes, energy, energy, etc.)	1.5			\$ 15,000
10			22%	Subtotal	\$ 620,000
11	Equipment Electrical				\$ 17,000
12	Instrumentation and Controls		7%		\$ 44,000
13	Protective Coatings		3%		\$ 18,000
14				Total	\$ 814,000
15	Construction Contingency		30%		\$ 244,200
16	Design, Land, and Administration (D&A)		10%		\$ 81,400
17				Total with Contingency and D&A	\$ 1,139,600
18	Escalation		4%		\$ 45,584
19				Total Capital Cost	\$ 1,185,184
O&M Cost Estimate					
Component					Power Cost (\$/yr)
20	NPV energy cost for 20 years (see energy evaluation table)				\$ 7,000
21	Other				\$ 1,000
22					\$ 1,000
23					\$ 1,000
24				Subtotal Annual Average - Power	\$ 3,000
Chemicals & Additional Sludge Disposal					
			Quantity (ton/yr)	Cost (\$/yr)	
25	Metal Salt		642	\$ 190,000	
26	Organic Sludge (chemical sludge and landfilling cost)		1,000	\$ 1,000	
27			Subtotal - Chemicals	\$ 191,000	
Replacement of Major Equipment Parts					
28	Replacement cost (2% annual of capital cost)			\$ 4,000	
29	Maintenance cost of equipment (1% annual of capital cost)			\$ 2,000	
30	O&M Contingency		10%	\$ 12,000	
31			Annual Average O&M (\$)	\$ 18,000	
Process Waste & Effluent					
32	Process Waste (W&E)	10	70		\$ 7,000,000
33	Process Waste (W&E)	1	1,000		\$ 100,000,000
34	Total Process Waste (Capital + O&M)				\$45,000,000

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Alternative 5

EBPR + Chem-P



Chem P Shed

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GWWTF - PP Evaluation Alternative 5: Capital and O&M Costs					
Capital Cost Estimate					
Item No.	Facility Description	Units	Unit Cost/Percentage	Quantity	Amount (\$)
1	Exhaustion and NPV Shed	1.5			\$ 101,000
2	Exhaustion Installation		80%		\$ 41,000
3	Process V/Class/Storage	1.8			\$ 20,000
4	Painting	1.51	\$100	150	\$ 15,000
5	Building Electrical	1.51	\$110	980	\$ 105,000
6	IT/SCADA		2% of building costs		\$ 6,000
7	Control Strategies	3.51	\$1,000	40	\$ 40,000
8	Miscellaneous (other significant/detachable costs - see notes, energy, energy, etc.)	1.5			\$ 15,000
9			22%	Subtotal	\$ 343,000
10	Equipment Electrical				\$ 17,000
11	Instrumentation and Controls		7%		\$ 44,000
12	Protective Coatings		3%		\$ 18,000
13				Total	\$ 422,000
14	Construction Contingency		30%		\$ 126,600
15	Design, Land, and Administration (D&A)		10%		\$ 42,200
16				Total with Contingency and D&A	\$ 610,800
17	Escalation		4%		\$ 24,451
18				Total Capital Cost	\$ 635,251
O&M Cost Estimate					
Component					Power Cost (\$/yr)
19	NPV energy cost for 20 years (see energy evaluation table)				\$ 7,000
20	Other				\$ 1,000
21					\$ 1,000
22					\$ 1,000
23				Subtotal Annual Average - Power	\$ 3,000
Chemicals					
			Quantity	Cost (\$/yr)	
24	Metal Salt		642	\$ 190,000	
25	Organic Sludge (chemical sludge and landfilling cost)		1,000	\$ 1,000	
26			Subtotal - Chemicals	\$ 191,000	
Replacement of Major Equipment Parts					
27	Replacement cost (2% annual of capital cost)			\$ 4,000	
28	Maintenance cost of equipment (1% annual of capital cost)			\$ 2,000	
29	O&M Contingency		10%	\$ 12,000	
30			Annual Average O&M (\$)	\$ 18,000	
Process Waste & Effluent					
31	Process Waste (W&E)	10	70		\$ 7,000,000
32	Process Waste (W&E)	1	1,000		\$ 100,000,000
33	Total Process Waste (Capital + O&M)				\$45,000,000

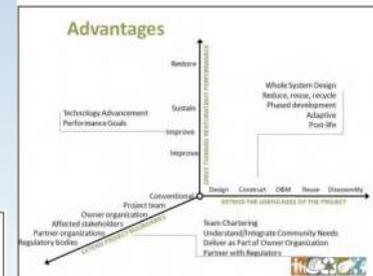
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Envision

Sustainability Rating System for Infrastructure Projects

60 Credits in 5 Categories

- QUALITY OF LIFE** Purpose, Community, Wellbeing
- LEADERSHIP** Collaboration, Management, Planning
- RESOURCE ALLOCATION** Materials, Energy, Water
- NATURAL WORLD** Siting, Land & Water, Biodiversity
- CLIMATE AND RISK** Emission, Resilience



Provides direction about how to improve project's sustainability

Envision



Award Levels

Recognition Level	Minimum Applicable Points	Minimum in Each Category
Acknowledgement of Merit	25%	5%
Silver Award	50%	8%
Gold Award	60%	15%
Platinum Award	80%	20%

Best in Class Award

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Envision Rating System
Self Assessment Checklist
For Public Comment Only - Not for Project Use

Category	Item	Y	N	NA	Score	Weight	Target
ENVIRONMENTAL QUALITY OF LIFE	EQ1.1 Increase community quality of life	1	0	0	1	10	10
	EQ1.2 Minimize vulnerability growth and development	1	0	0	1	10	10
	EQ1.3 Minimize local air quality impacts	1	0	0	1	10	10
	EQ1.4 Enhance public health and safety	1	0	0	1	10	10
	EQ1.5 Minimize noise and vibration	1	0	0	1	10	10
	EQ1.6 Minimize impacts on aesthetics	1	0	0	1	10	10
	EQ1.7 Minimize impacts on cultural resources	1	0	0	1	10	10
	EQ1.8 Minimize impacts on historic resources	1	0	0	1	10	10
	EQ1.9 Minimize impacts on paleontological resources	1	0	0	1	10	10
	EQ1.10 Minimize impacts on archaeological resources	1	0	0	1	10	10
CLIMATE CHANGE	CC1.1 Minimize greenhouse gas emissions	1	0	0	1	10	10
	CC1.2 Minimize energy and water consumption	1	0	0	1	10	10
	CC1.3 Minimize waste and recycling	1	0	0	1	10	10
	CC1.4 Minimize water use and water efficiency	1	0	0	1	10	10
	CC1.5 Minimize energy and water efficiency	1	0	0	1	10	10
	CC1.6 Minimize energy and water efficiency	1	0	0	1	10	10
	CC1.7 Minimize energy and water efficiency	1	0	0	1	10	10
	CC1.8 Minimize energy and water efficiency	1	0	0	1	10	10
	CC1.9 Minimize energy and water efficiency	1	0	0	1	10	10
	CC1.10 Minimize energy and water efficiency	1	0	0	1	10	10
WATER RESOURCES	WR1.1 Minimize water consumption	1	0	0	1	10	10
	WR1.2 Minimize water consumption	1	0	0	1	10	10
	WR1.3 Minimize water consumption	1	0	0	1	10	10
	WR1.4 Minimize water consumption	1	0	0	1	10	10
	WR1.5 Minimize water consumption	1	0	0	1	10	10
	WR1.6 Minimize water consumption	1	0	0	1	10	10
	WR1.7 Minimize water consumption	1	0	0	1	10	10
	WR1.8 Minimize water consumption	1	0	0	1	10	10
	WR1.9 Minimize water consumption	1	0	0	1	10	10
	WR1.10 Minimize water consumption	1	0	0	1	10	10
AIR QUALITY	AQ1.1 Minimize air quality impacts	1	0	0	1	10	10
	AQ1.2 Minimize air quality impacts	1	0	0	1	10	10
	AQ1.3 Minimize air quality impacts	1	0	0	1	10	10
	AQ1.4 Minimize air quality impacts	1	0	0	1	10	10
	AQ1.5 Minimize air quality impacts	1	0	0	1	10	10
	AQ1.6 Minimize air quality impacts	1	0	0	1	10	10
	AQ1.7 Minimize air quality impacts	1	0	0	1	10	10
	AQ1.8 Minimize air quality impacts	1	0	0	1	10	10
	AQ1.9 Minimize air quality impacts	1	0	0	1	10	10
	AQ1.10 Minimize air quality impacts	1	0	0	1	10	10

GHE Phase I

Alternative	Description	Process Related Generation (N ₂ O)	Energy Generation	Chemical Production	Chemical and Additional Sludge Transport	Notes
	CO ₂ unit emission factor	296	1336	0.28	22.44	From WEF NUTRI106N Report
		lb CO ₂ /lb N ₂ O	lb CO ₂ /MWh	lb CO ₂ /lb Alum	lb CO ₂ /gal diesel	
		CO ₂ Production				
		lb CO ₂ /yr	lb CO ₂ /yr	lb CO ₂ /yr	lb CO ₂ /yr	
1	EBPR	199,658	145,496			Process emissions modeled in Biowin
2	EBPR	206,789	145,496			
3	EBPR	254,327	455,109			
4	Chem-P	159,251	60,623	46,879	63,020	1. Energy generation Includes Building HVAC and lighting. 2. Assumes chemical transported 2000 miles from the mine to the final destination and 20 miles for delivery of additional sludge produced.
5	EBPR+Chem-P	199,658	151,559	4,688	6,302	Assumes 10% C-P, and EBPR Alt 1

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Phase I Alternatives Comparison

Criteria	Alternative 1 EBPR (AD)	Alternative 2 - E PBR (AD with PreA2)	Alternative 3 EBPR (AD)	Alternative 4 - Chem-P	Alternative 5 EBPR+Chem-P
Reliability	1. Moderate exposure to N ₂ O recycle streams impacting EBPR. 2. EBPR is susceptible to biological upsets impacting TP removal.	1. Less exposure to N ₂ O recycle streams. Inefficiencies. 2. EBPR is susceptible to biological upsets impacting TP removal.	1. Least exposure to N ₂ O recycle streams. 2. EBPR is susceptible to biological upsets impacting TP removal.	1. Extremely Reliable. 2. Not exposed to biological upsets. 3. No	1. Most reliable alternative of all.
Capital Cost	1. Low - Makes use of existing facilities	1. Low - Makes use of existing facilities	1. Moderate - Makes use of existing facilities	1. High. Requires additional structures	Moderate to High. Requires additional structures
O&M Cost	1. Low.	1. Low.	Moderate to low	1. High chemical use cost. 2. Additional sludge disposal cost	1. Low
Additional Benefits/Drawbacks of Technology	1. Uses the resources in the influent for treatment. 2. Susceptible to upsets 3. Proven technology. 4. aSRT is reduced impacting the NH4 treatment capacity. CS	1. Uses the resources in the influent for treatment. 2. Susceptible to upsets 3. Proven technology. 4. aSRT is reduced impacting the NH4 treatment capacity.	1. Uses the resources in the influent for treatment. 2. Susceptible to upsets 3. Proven technology. 4. aSRT is reduced the most compared to Alternatives 1 and 2 impacting the NH4 treatment capacity. 5. Reduces the TN in the effluent making suitable for future TN regulations.	1. Proven technology 2. Generates more sludge that requires treatment and disposal 3. High potential for radium removal in sludge making land application potentially unviable. 4. No change in NH4 treatment capacity.	1. Uses the resources in the influent for treatment. 2. Can deal with biological upsets easily 3. Proven technology 4. Two layers of protection for meeting TP limits
Impact to Project Schedule / Feasibility	1. Moderate. Requires taking trains offline for constructing the improvements.	1. Moderate. Requires taking trains offline for constructing the improvements.	1. Moderate to high. Requires more work inside the basin compared to Alternatives 1 and 2 requiring more train downtime.	1. Fastest to implement. No dependency with plant operation.	1. Moderate. Requires taking trains offline for constructing the improvements.
Impact to existing WWTF	1. Practically no sludge increase/decrease to current process.	1. Practically no sludge increase/decrease to current process.	1. Practically no sludge increase/decrease to current process.	1. Uses WWTF area for new processes. 2. Requires additional processes	1. Uses WWTF a moderate area for new processes. 2. Requires additional processes
Process Complexity (Process Operation)	1. Moderate effort to operate the process (biological), very resilient.	1. Moderate efforts operate the process (biological), very resilient.	1. Moderate effort to operate the process (biological), very resilient. 2. Moderate to low level of effort in operation (physical/chemical process)	1. Simple operation.	1. Moderate effort to operate the biological process, but it provides operators to deal with upsets.
Sustainability	1. Low GHE. Uses local resources for treatment.	1. Low GHE but requires slightly more energy than Alt 1. 2. Uses local resources for treatment.	1. Low GHE but requires slightly more energy than Alt 1 and 2. 2. Uses local resources for treatment.	1. Requires low energy for treatment within the WWTF envelope, but requires more energy outside the GWTF, increasing GHE significantly compared to other alternatives.	1. Low GHE (depending on the EBPR selected). 2. Uses local resources for treatment.

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Phase I Alternatives –Cost Summary (Comparative Costs ONLY)

Alternative	Capital Cost	Annual Average O&M Cost	Present Worth O&M Cost	Total Present Worth Cost
1	\$356,000	\$19,000	\$417,000	\$773,000
2	\$356,000	\$19,000	\$417,000	\$773,000
3	\$878,000	\$56,000	\$1,252,000	\$2,130,000
4	\$1,230,000	\$234,000	\$3,400,000	\$4,630,000
5	\$507,000	\$24,000	\$489,000	\$996,000

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Evaluation

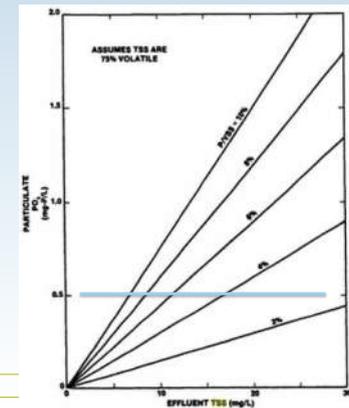
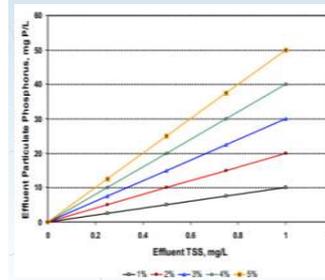
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PHASE I ALTERNATIVES

Phase I - 1.0 mg/L TP

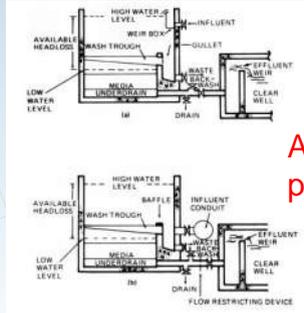
Phase II Alternatives

It's all about TSS!



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Alternative 1 - Filtration



Marlborough, Mass Westerly

Also requires pumping



Charles River Pollution Control District



Alternative 1 - Filtration

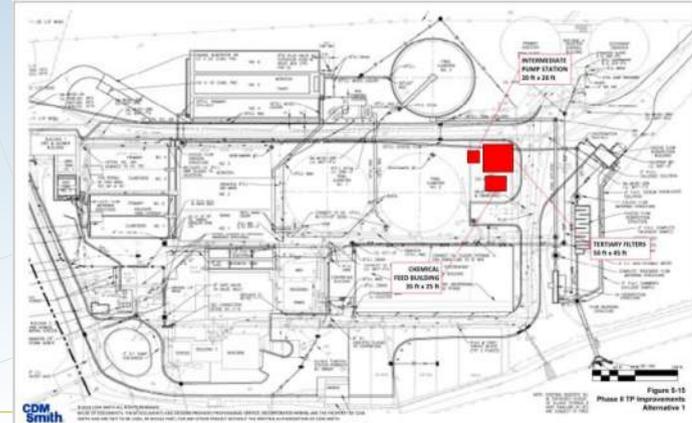
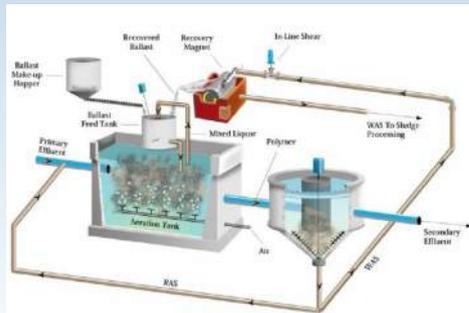


Figure 5-15
Phase 6 TP Improvements
Alternative 1



Alternative 2 - Biomag® Process



TP Removal to levels below 0.5 mg/L
Increased Plant Capacity (no additional aeration basins or clarifiers)



Alternative 2 - Biomag

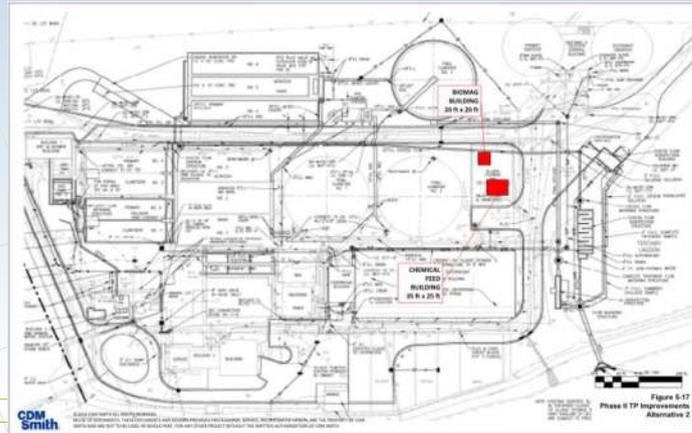


Figure 5-17
Phase 6 TP Improvements
Alternative 2



Phase II Alternatives – Costs (Comparative Only)

Alternative	Capital Cost	Average O&M Cost	Present Worth O&M Cost	Total Present Worth Cost
Filtration + Chem P	\$3,860,000	\$590,000	\$9,352,000	\$13,212,000
Biomag + Chem P	\$5,668,000	\$887,000	\$15,027,000	\$20,695,000

Implementation Schedule for Phase I

- Design – 3 to 5 months
- Bidding/Permitting – 3 months
- Construction – 6 to 8 months (depending on timing of year)



Nutrient Removal Alternatives - Alternative Evaluation Analysis Matrix

Parameter	Weight	Alternatives											
		Alternative 1 EPBR (A/O)		Alternative 2 - EPBR (A/O with PreAX)		Alternative 3 - EBPR (A2O)		Alternative 4 - Chem-P		Alternative - 5 EPBR+Chem-P			
		Rating	Wt. Rating	Rating	Wt. Rating	Rating	Wt. Rating	Rating	Wt. Rating	Rating	Wt. Rating	Rating	Wt. Rating
Reliability	20	3	60	3	60	4	80	4	80	5	100		0
Capital Cost	10	5	50	5	50	4	40	1	10	4	40		0
O&M Cost	20	5	100	5	100	4	80	1	20	4	80		0
Additional Benefits/Drawbacks of Technology	10	3	30	4	40	5	50	3	30	4	40		0
MOPO	5	3	15	3	15	2	10	5	25	2	10		0
Impact to existing WWTP (Future Capacity)	5	3	15	3	15	2	10	4	20	3	15		0
Flexibility for Future Regs	9	3	27	4	36	5	45	2	18	5	45		0
Impact to existing (sludge production)	15	5	75	5	75	5	75	1	15	4	60		0
Process Complexity (Process Operation)	5	3	15	4	20	2	10	4	20	4	20		0
Sustainability	1	5	5	4	4	3	3	1	1	3	3		0
Totals	100		392		415		403		239		413		0

High = 5
 Moderately High = 4
 Average = 3
 Lower than Average = 2
 Low = 1

Evaluation Rankings:

Best
 ↓
 Worst

