

City of St. Joseph, Missouri
Facilities Plan

Technical Memorandum No. TM-WW-4
Nutrient Removal Facilities



By



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B&V Project 163509

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Nutrient Removal Facilities

1.0 Executive Summary

The Missouri Department of Natural Resources (MDNR) established an ammonia limitation for the first time for the St. Joseph Water Protection Facility (WPF) in its National Pollutant Discharge Elimination System (NPDES) permit dated June 19, 2009. It is anticipated that future permits may impose more stringent ammonia limits and will, eventually, include total nitrogen and phosphorous limitations as well. Based on discussions with MDNR, it is anticipated that implementation of nutrient limits at the WPF may occur according to the approximate schedule shown in Table ES-1. This technical memorandum describes the evaluation of nutrient removal improvement alternatives and costs to meet the anticipated phasing of regulatory requirements.

Table ES-1		
Anticipated Phasing of Nutrient Removal Permit Limits ¹		
Phase	Approximate Permit Cycle Timing	Limitation Added
I	2010	Ammonia Removal ²
II	2019	Total Phosphorous Removal
III	2029	Total Nitrogen Removal
1. Anticipated timing has been established for the purposes of phasing alternatives. Actual timing has not been determined by MDNR. 2. The current (June 19, 2009) WPF permit includes an effluent ammonia limit, which could become more stringent depending on the findings of the mixing zone study required by MDNR. The ammonia limits used for Phase I are more stringent than the current permit limits to account for the possibility that the mixing zone study could require more stringent limits.		

Influent loading characteristics to the WPF were developed to determine nutrient removal configurations. The WPF receives significant influent nitrogen loadings, primarily from its wholesale industrial customers, including South St. Joseph Industrial Sewer District (SSJISD), National Beef Leathers (NBL), and Triumph Foods (TF). The significant nitrogen loading received by the WPF drives the need for complex nutrient removal facilities and considerable quantities of external carbon in order to meet anticipated regulatory limits in the future. The City is currently working with the

wholesale customers as well as other industrial users to try to reduce nutrient loadings to the WPF, which could significantly reduce the complexity and cost of treatment facilities required to meet future regulations. For the purposes of this evaluation, alternatives for the nutrient removal improvements presented in this technical memorandum are based on the projected influent loads identified in this study, assuming no future reductions from the wholesale customers and industrial users.

For ammonia removal (Phase I requirement), only one evaluated alternative was deemed operationally stable and economically viable (Figure 8, following page 25). In this alternative, industrial flow from the three wholesale customers receives additional treatment prior to being combined with the domestic flows in order to meet anticipated effluent ammonia limitations. The opinion of probable project cost for ammonia removal is \$24.7 million. Similarly for total phosphorous removal (Phase II requirement), only chemical phosphorus removal was evaluated due to requirements for additional external carbon; purchase of external carbon is costly. The opinion of probable project cost for phosphorous removal is \$3.3 million. In order to meet the Phase III total nitrogen requirements, both combined and separate treatment trains for the domestic and industrial flows were considered. The following nitrification/denitrification alternatives were evaluated:

- Alternative 1A – Activated sludge treatment for domestic flows, activated sludge treatment for wholesale industrial flows.
- Alternative 1B – Integrated fixed-film activated sludge (IFAS) treatment for domestic flows, activated sludge treatment for wholesale industrial flows.
- Alternative 1C – IFAS treatment for domestic flows, membrane bioreactor (MBR) treatment for wholesale industrial flows.
- Alternative 2A – Activated sludge treatment for combined flows.
- Alternative 2B – IFAS treatment for combined flows.

The analysis showed the separate treatment alternatives to be lower in cost when compared to the combined flow treatment alternatives. Alternative 2A was screened

from consideration before cost development as it was space prohibitive. Based on the economic and non-economic evaluation, Alternative 1B – IFAS for Domestic Flows, Activated Sludge for Wholesale Industrial Flows is the recommended alternative (Figure 11, following page 34). As shown in Table ES-2, the opinion of probable project cost for Alternative 1B is 15 percent less than the next lowest cost alternative. On both an operations and maintenance (O&M) and net present worth basis, Alternative 1B is within 10 percent of Alternative 1A and is, therefore, considered equivalent for these economic criteria at this level of study. Table ES-3 provides a summary of the net present worth costs for each alternative. On a non-economic basis, Alternative 1B offers the best balance between reduced basin volume and ease of operability of the system of all the separate industrial and domestic treatment alternatives considered. With the existing influent loading characteristics, it is recommended that Alternative 1B be implemented to meet Phase III total nitrogen removal requirements.

Table ES-2 Summary of Opinion of Probable Project Costs for Nitrification, Denitrification, and Total Phosphorous Removal ¹			
Alternative 1A Domestic Activated Sludge, Industrial Activated Sludge, \$	Alternative 1B Domestic IFAS, Industrial Activated Sludge, \$	Alternative 1C Domestic IFAS, Industrial MBR, \$	Alternative 2B Combined IFAS, \$
66,715,000	58,264,000	75,112,000	102,012,000
1. All costs presented in May 2009 dollars (ENR BCI = 4773).			

Table ES-3 Net Present Worth for Nitrification, Denitrification, and Total Phosphorous Removal ¹				
	Alternative 1A Domestic Activated Sludge, Industrial Activated Sludge, \$	Alternative 1B Domestic IFAS, Industrial Activated Sludge, \$	Alternative 1C Domestic IFAS, Industrial MBR, \$	Alternative 2B Combined IFAS, \$
Net Project Capital Present Worth ²	50,982,000	45,734,000	65,855,000	74,257,000
O&M Present Worth ³	90,180,000	92,880,000	105,760,000	101,020,000
Total Net Present Worth	141,162,000	138,614,000	171,615,000	175,277,000

Table ES-3 Net Present Worth for Nitrification, Denitrification, and Total Phosphorous Removal ¹				
	Alternative 1A Domestic Activated Sludge, Industrial Activated Sludge, \$	Alternative 1B Domestic IFAS, Industrial Activated Sludge, \$	Alternative 1C Domestic IFAS, Industrial MBR, \$	Alternative 2B Combined IFAS, \$
1. Costs given in May 2009 dollars. Present worth calculated with 20-year life cycle costs at 5% interest. 2. Net project capital present worth represents the present worth of project costs less the remaining value of facilities at the end of the 20-year life cycle. Service life for determination of replacement frequency and salvage value was projected as follows: structures – 50 years; equipment, electrical, instrumentation and controls – 20 years. 3. O&M costs were assumed to escalate at 5% per year.				

It is recommended that the City implement the nutrient removal program in the following phases. The actual date for implementation will be determined in the future by MDNR.

- **Phase I (Year 2010) – Ammonia Removal (Nitrification)**
 - Wholesale industrial activated sludge basin modifications (reuse four existing aerobic digester basins (add diffusers) and raise basin walls a total of 4 feet – 2 feet for Phase I, 2 feet for Phase III).
 - New wholesale industrial final clarifier and associated returned activated sludge (RAS)/waste activated sludge (WAS) pump station (increase clarifier size from 120 foot to 130 foot diameter to meet future Phase III needs).
 - Existing aeration basin modifications (add diffusers).
 - New centrifugal blowers within existing Blower Building.

- **Phase II (Year 2019) – Total Phosphorous Removal**
 - New chemical feed and storage system and building.

- **Phase III (Year 2029) – Total Nitrogen Removal (Nitrification/Denitrification)**
 - New IFAS fine screen building.

- Domestic oxic basins with IFAS media (reuse existing aeration basin volume).
- Domestic anoxic basins (reuse existing aeration basin volume).
- Wholesale industrial anoxic, oxic, post-anoxic, and reaeration volume (reuse six existing aerobic digester basins).
- New methanol chemical feed and storage system and building (contiguous to chemical feed facilities for phosphorous removal).

Table ES-4 summarizes the opinion of probable project cost for the phased implementation of the recommended facilities.

Table ES-4	
Opinion of Probable Project Cost for Phased Implementation of Recommended Nutrient Removal Facilities ¹	
Phase	Project Cost ^{2, 3}, \$
I – Ammonia Removal	24,740,000
II – Total Phosphorous Removal	3,314,000
III – Total Nitrogen Removal	30,498,000
Total ⁴	58,552,000
1. Costs given in May 2009 dollars. 2. Project cost includes allowances for electrical, instrumentation and controls, sitework, general requirements, contingency, and engineering, legal, and administration. 3. Project costs do not include costs for standby power generator facilities. These costs will be presented in TM-WW-9 – Site Considerations, Utility Improvements, and Ancillary Facilities. 4. Total cost includes Phase I piping not reused in Phase III.	

An aeration system evaluation was completed to determine the anticipated aeration blower needs of future facilities to be installed at the WPF. This study also evaluated the use of centrifugal blowers to replace the existing positive displacement (PD) blowers when the existing PD blowers reach the end of their useful life or can no longer provide the needed airflow due to future aeration requirements.

A comparative life cycle cost analysis determined single-stage centrifugal blowers were the lowest life cycle cost option to meet future aeration needs at the WPF; however, the life cycle cost of multi-stage blowers with adjustable-frequency drives (AFDs) was within 10 percent of the lowest cost option. At this level of study, the two options are

considered equivalent from a life cycle cost perspective. City staff has concerns with maintenance issues associated with AFDs. Therefore, the recommended replacement alternative for the existing PD blowers is five single-stage centrifugal blowers. During detailed design of the blower replacement project, evaluation of the use of multi-stage blowers with eddy current drives should be considered as an alternative to the single-stage blowers.

The existing PD blowers are unable to meet the anticipated aeration demands of the future nitrification or nitrification/denitrification (Phase I or Phase III) facilities as presented in this technical memorandum; however, City staff efforts to reduce the influent nitrogen loading from the wholesale customers and industrial users to the WPF could result in reduced air requirements. Prior to the construction of future Phase I or III facilities, air flow requirements should be revisited in light of any new WPF influent loading data. It is recommended that the existing PD blowers continue to be used to provide aeration until they reach the end of their service life or they are no longer able to meet the aeration needs of future facilities.

2.0 Purpose of Study

MDNR established an ammonia limitation for the first time for the St. Joseph WPF in its NPDES permit dated June 19, 2009. It is anticipated that future permits may impose more stringent ammonia limits and will, eventually, include total nitrogen and phosphorous limitations as well. This technical memorandum documents work performed under Phase 330B of the Wastewater Facilities Assessment – Evaluate Liquid Treatment Expansion Alternatives to Provide Nutrient Removal.

The objectives of this memorandum include:

- Conduct a preliminary alternatives screening workshop with City staff to select alternatives for further study.
- Develop process models, general site layouts, and conceptual level capital and operational cost opinions for selected treatment alternatives.
- Conduct life cycle cost comparisons of alternatives.
- Conduct an aeration blower system evaluation based on anticipated air requirements for future processes.

Phased implementation of improvements to meet ammonia limitations followed by total phosphorous removal and full nitrification/denitrification will be evaluated. Evaluations of separate and combined treatment of wholesale industrial and domestic wastewater flows will be considered.

3.0 Regulatory Requirements

Based on discussions with MDNR, it is anticipated that implementation of nutrient limits at the WPF may occur according to the approximate schedule shown in Table 1.

Table 1 Anticipated Phasing of Nutrient Removal Permit Limits ¹		
Phase	Approximate Permit Cycle Timing	Limitation Added
I	2010	Ammonia Removal ²
II	2019	Total Phosphorous Removal
III	2029	Total Nitrogen Removal
1. Anticipated timing has been established for the purposes of phasing alternatives. Actual timing has not been determined by MDNR. 2. The current (June 19, 2009) WPF permit includes an effluent ammonia limit, which could become more stringent depending on the findings of the mixing zone study required by MDNR. The ammonia limits used for Phase I are more stringent than the current permit limits to account for the possibility that the mixing zone study could require more stringent limits.		

Process alternatives presented in this technical memorandum were developed to meet anticipated permit limits for each phase as summarized in Table 2. In Phase I, a more stringent ammonia limitation is included. Phase II adds a limitation of 1 milligram per liter (mg/L) for phosphorous. In Phase III, a total nitrogen limitation of 10 mg/L is added to the limits included in the previous phases. At this time, it is unknown whether the WPF would have a specific ammonia limit under Phase III, but even if a specific permit limit were not established, ammonia effluent levels would need to be in the range of 3 mg/L to meet the overall nitrogen limitation of 10 mg/L. The anticipated permit limits presented in Table 2 will be utilized for the development of alternatives to meet each phase of the future regulatory requirements.

Table 2 Anticipated Permit Limits by Phase			
Parameter	Phase I	Phase II	Phase III
Total Suspended Solids (TSS), mg/L	30	15	15
Biochemical Oxygen Demand (BOD), mg/L	30	15	15
Ammonia (NH ₃), mg/L	5	5	3
Total Nitrogen (TKN), mg/L	-	-	10
Total Phosphorous (TP), mg/L	-	1	1

4.0 Nitrogen Removal and Process Options

The near-term (Phase I) and long-term (Phase III) limits identify effluent limits on nitrogen species that are different and require different mechanisms and technologies for removal. This section addresses the methods for removing nitrogen for Phase I and Phase III limits and the process technology options.

4.1 Stages of Nitrogen Removal

Generally, raw wastewater contains nitrogen in the form of ammonia or particulate nitrogen and soluble organic nitrogen. The majority of ammonia nitrogen (NH₃-N) is either taken up as a basic building block in the biomass generated in the activated sludge treatment process and passes through the WPF to the effluent, or is converted to nitrate and nitrite nitrogen (NO_x-N) through nitrification. Meeting the Phase I limits would require that the influent ammonia to the WPF be nitrified to NO_x-N. If either total nitrogen or NO_x-N limits are imposed (Phase III), the treatment process at the WPF must employ both a nitrification step and a denitrification step. The nitrate formed during nitrification is then biologically converted in an anoxic environment (where oxygen is not present, but nitrate is available) to nitrogen gas, which is released to the atmosphere (denitrification). To meet Phase III effluent limits, both nitrification and denitrification are required. The key to a successful total nitrogen removal strategy is to optimize the conditions for both processes.

4.1.1 Keys to Nitrification (Required for Phase I and III Limits)

To meet ammonia limits (Phase I) or total nitrogen limits (Phase III), the WPF will be required to consistently remove ammonia throughout the year. The nitrifying

bacteria used to process ammonia are slower growing compared to those required for removal of biochemical oxygen demand (BOD), thus requiring either a longer aerated solids retention time (SRT) for the activated sludge process or additional media and contact time for trickling filters and other fixed-film processes such as IFAS. It is important to note that nitrifying bacteria growth rates are impacted by temperature, dissolved oxygen (DO) concentration, pH, and BOD concentration. Cold temperatures during winter operation are generally the most limiting condition for full nitrification. Loss of nitrifying biomass could require weeks to regain an adequate nitrifying population. During that time, the effluent ammonia concentration would be in excess of 20 mg/L.

The required SRT can be achieved by either increasing the aerated volume or the mixed liquor concentration in a suspended growth process. Both approaches will require additional tankage. More clarifiers are required to handle the higher mass loading from an increased mixed liquor approach, while additional aeration tankage is required to increase SRT. An alternate approach is the use of fixed-film biomass in the aeration tank to increase the overall biomass in the system. This retains more of the biomass within the aeration tank, which results in lower solids loadings on the clarifiers and lower RAS recycle rates. Therefore, one of the following is needed to achieve the higher SRT:

- Additional aerobic volume.
- Additional clarifiers to enable the plant to achieve the higher SRT by increasing the mixed liquor suspended solids (MLSS) concentration without increasing solids loading rates to the clarifiers (and risking poor clarifier performance).
- Upgrade to a membrane bioreactor process which would allow the mixed liquor concentration and corresponding SRT to be increased.
- Addition of media to the oxic zones to improve nitrification by increasing the effective SRT without increasing the MLSS concentration.

4.1.2 Keys to Denitrification (Required for Phase III Limits)

Denitrification is a biological process utilizing microorganisms that convert nitrate into nitrogen gas, which requires anoxic conditions in the presence of a readily

biodegradable carbon source. Anoxic conditions are defined as having low concentrations of molecular oxygen (O_2), but having some significant concentrations of other oxygen-rich compounds (in this case nitrate). Following the nitrification step, the carbonaceous food source is nearly exhausted. Denitrification must occur either by adding an external carbon source (e.g. methanol) or by locating the anoxic zone before the aerated zone (so that influent soluble BOD can be used as the carbon source). Denitrification also occurs endogenously, using readily available biodegradable carbon formed through biomass decay; however, endogenous denitrification requires extremely large anoxic zone volumes, which are typically infeasible to construct within a treatment facility.

Key elements for the denitrification process to occur include:

- Adequate volume
- Readily available biodegradable carbon source
- Dependable anoxic conditions
- Adequate nitrified recycle rate

4.2 Nitrification (Phase I) Technology Overview

To meet Phase I effluent limits for ammonia, the goal is to provide adequate sludge age to establish nitrification. Unlike denitrification, achieving nitrification does not require readily biodegradable carbon. Trickling filters reduce the quantity of readily biodegradable carbon available for the denitrification step. However, when only nitrifying, the WPF can continue use of the trickling filters without increasing external carbon costs. Options for increasing biomass age are:

- Increased mixed liquor concentration. This increases solids loading on the final clarifiers.
- Use of intermediate clarifiers after the trickling filters to reduce solids loading in the aeration basins.
- Conversion of process to membrane bioreactor. Membrane bioreactors are capable of operating at higher mixed liquor concentrations, thus reducing the volume of aeration basins.

- Installation of fixed-film media in the aeration basin. The media retains biomass in the aeration basin without increasing solids loading on the final clarifiers.

For Phase I requirements, minimally invasive alternatives were considered that rely on continued use of the trickling filters and conventional activated sludge process. The fixed-film media and membrane bioreactor options are described in greater detail in the following sections.

4.3 Total Nitrogen Removal (Phase III) Technology Overview

The following sections provide background on the nitrogen removal technologies considered to achieve total nitrogen removal at the WPF – activated sludge, IFAS, and MBR.

4.3.1 Activated Sludge

To achieve total nitrogen limits of 10 mg/L, complete nitrification of ammonia to nitrate must be achieved; however, complete denitrification of the stream is not necessary. A Modified Ludzack-Ettinger (MLE) process is typically used under these conditions. Influent ammonia is nitrified to nitrate in the oxic zone. Nitrate is denitrified in the anoxic zones using readily biodegradable carbon. The MLE process places the anoxic zones at the front of the basins to utilize the carbon available in the influent waste stream. Nitrified mixed liquor is pumped from the end of the oxic zone to the anoxic zone where it is denitrified. Recycle rates typically vary between two to three times in the influent flow rate. Although this is a large flow rate, the discharge head is minimal, resulting in low horsepower pumps. Figure 1 shows a general process schematic of the MLE process.

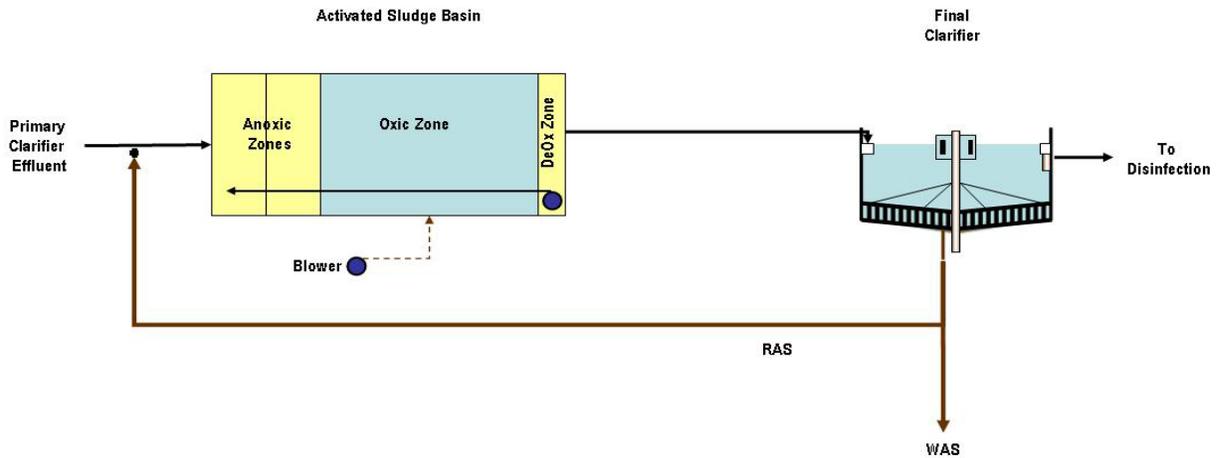


Figure 1 – Conceptual Schematic of Modified Ludzack-Ettinger Process

At the WPF, industrial wastewater nitrogen loads are significant. To fully denitrify these higher loads, which are based on historical monitoring results, supplemental carbon (methanol, sugar waste, etc.) would be required. The trickling filters currently in operation at the WPF reduce the quantity of readily biodegradable carbon available for the denitrification step, resulting in increasing chemical costs under future conditions. Therefore, once the WPF must achieve total nitrogen removal, the existing trickling filters would be removed from service.

Under certain process alternatives, a post-anoxic zone followed by re-aeration zone is required to further reduce the nitrate concentration. In this process configuration, external carbon is added to the post-anoxic zone. Figure 2 shows a conceptual schematic of the 4-Stage Bardenpho process configuration.

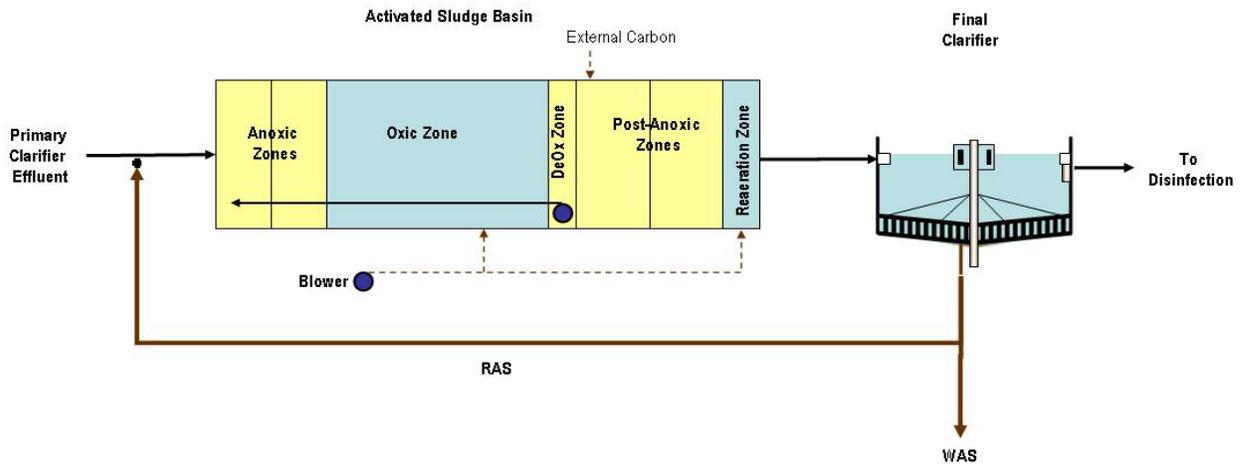


Figure 2 – Conceptual Schematic of 4-Stage Bardenpho Process

The size of the oxidic portion of the activated sludge basins is based on the mixed liquor concentration that can be maintained. To limit the size of the oxidic basins, small footprint technologies may be used to create a fixed film nitrifying biomass without overloading the clarifier. Descriptions of small foot-print technologies including IFAS and MBRs are described in the following sections.

4.3.2 Integrated Fixed-Film Activated Sludge

To minimize aeration and final clarifier volume, IFAS – a small-footprint technology – was considered. IFAS combines suspended growth and fixed-film activated sludge within the same basin, which increases the overall mass of bacteria that can be maintained in the basin without increasing the activated sludge MLSS concentration. This reduces the required basin volume, loading on clarifiers, and RAS recycle rates. The media are added to the aeration basins and maintained in suspension, which provides surface area for the biomass to attach and grow. Retention screens are used to retain the media within the basins.

There have been a number of different forms of media used in the IFAS process including free floating plastic media, sponges, rope systems, and plastic webs. Photographs of commonly used IFAS media are shown in Figure 3. Experience with the IFAS systems over the past several years has indicated that the most successful systems are based on the free floating media (plastic elements and sponges) versus fixed elements

such as ropes or plastic webs because the biofilm thickness can be better controlled, preventing the growth of nuisance microbial populations and promoting the growth of the desired microbial populations which enhance nutrient removal.



Linpor (sponge media, top left), Hydroxyl-Pac (free floating plastic media, top center), Kaldnes (free-floating plastic media, top right), US Filter Agar (free floating plastic media, bottom left), Ringlace (rope media, bottom center), Captor (sponge media, bottom right)

Figure 3 – Various Types of IFAS Media

The suspended and attached growth contributions to the overall biomass are demonstrated graphically in Figure 4. The suspended growth is the biomass in the mixed liquor which settles in the final clarifier. The attached growth fraction is the biomass that adheres to the media in the reactor. The attached growth biomass stays in the aeration basin. In Figure 4, the suspended growth biomass has a retention time of just over five days at 12° C (53.6° F) shown by the lower dashed line. Using the same basin volume and converting the process to IFAS increases the effective SRT by an additional 6.5 days provided by the attached growth population, which results in the total SRT exceeding the minimum needed for nitrification (represented by the red line).

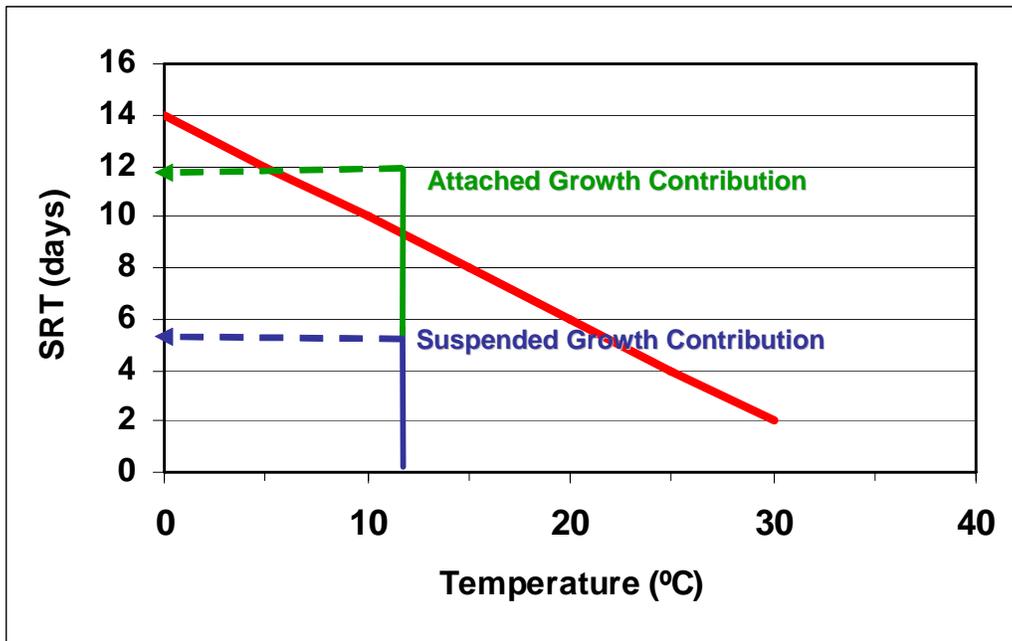


Figure 4 – Comparison of Suspended and Fixed-Film SRT

4.3.3 Membrane Bioreactor

The use of a MBR is another means to reduce aeration basin volume from that required for activated sludge. Much of the process is similar to conventional activated sludge; however, the membrane bioreactor uses a membrane zone instead of final clarifiers and any future tertiary treatment that might be required for total suspended solids (TSS) removal or lower phosphorus limits. The influent to a MBR system must be screened using fine screens with 1 to 2 millimeter (mm) openings. Fully redundant screening should be provided to protect the MBR process during planned or unplanned screen maintenance.

Several unique process considerations need to be addressed in the MBR design. The concentrated mixed liquor in the membrane zone will have a high DO concentration of 5 to 7 mg/L due to the aggressive aeration required to agitate the membranes to minimize fouling. To avoid returning DO to the anoxic zones, this mixed liquor will be returned to the oxic zone. An internal recycle from the deox zone would be directed to the anoxic zones. Figure 5 shows the process schematic for a 4-Stage MBR system.

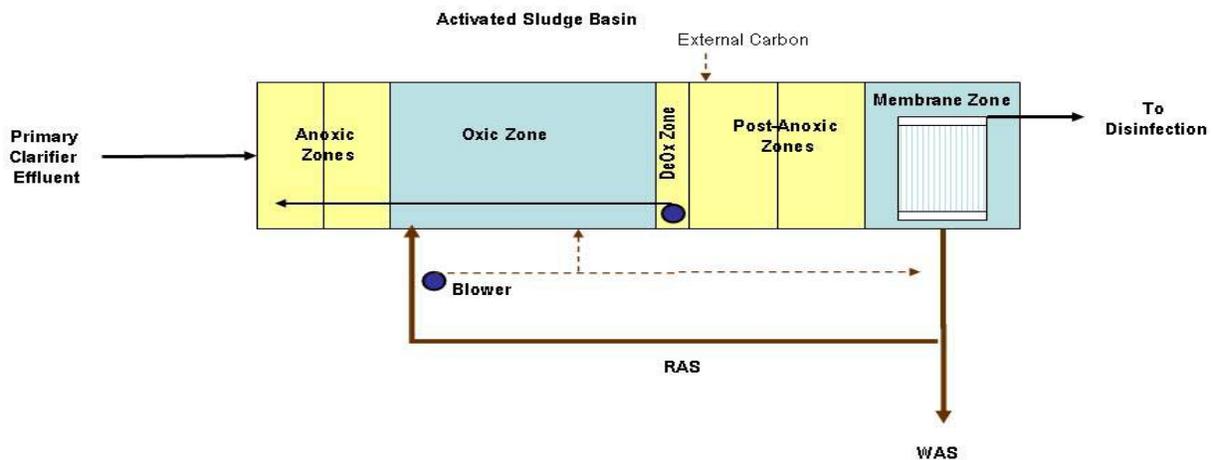


Figure 5 – Conceptual Schematic of 4-Stage MBR Process

5.0 Phosphorous Removal and Process Options (Required for Phase II)

The anticipated Phase II nutrient removal requirements place limits on total phosphorous in the effluent. Phosphorus is typically removed in one of two ways. It can either be bound into the WAS through biological phosphorus removal, or it can be chemically precipitated out using a metal salt such as alum or ferric chloride.

Biological phosphorus removal is achieved by promoting the growth of phosphorus accumulating organisms (PAOs). PAOs are selected by alternation between anaerobic conditions with readily biodegradable carbon in the form of volatile fatty acids (VFA) and aerated conditions. Anaerobic conditions require both low DO and nitrate concentrations. VFA is consumed and stored phosphorus is released during the anaerobic phase. During the aeration phase, the released phosphorus and phosphorus from the influent wastewater are taken up and stored by the PAOs. Phosphorus is ultimately removed from the system as part of the WAS. One operating concern is that the stored phosphorus can be released in subsequent solids processing steps where conditions become anaerobic or during cell decay processes such as digestion.

Key elements of biological phosphorous removal processes include the following:

- Anaerobic zones to provide dependable anaerobic conditions.
- Available VFA.
- Management of solids processing streams to prevent phosphorus release.

Another method of phosphorous removal is chemical precipitation, which depends on the incorporation of phosphate into suspended solids and subsequent removal through precipitation of these solids. Chemical precipitation is generally achieved through the use of a metal salt (i.e. alum, ferric chloride). The greatest drawback to chemical precipitation is the operational costs associated with the purchase of the metal salts and handling the resulting additional sludge, requiring dewatering and disposal. The advantage to chemical precipitation is that it allows for very dependable means of reaching very low concentrations of phosphorus. It is often utilized in conjunction with biological phosphorus removal as a trimming process to ensure low discharge concentrations.

Similar to denitrification, biological phosphorous removal requires supplemental carbon. As previously stated based on monitoring conducted at the WPF, limited carbon is available for denitrification due to the high wholesale customer industrial loading. Biological phosphorus removal would require even greater amounts of supplemental carbon. Due to the cost prohibitive nature of purchasing additional supplemental carbon, this evaluation will not consider the use of biological phosphorus removal; chemical phosphorous removal will be utilized in all alternatives presented within this technical memorandum. If nitrogen influent loadings are reduced in the future, this decision should be revisited as biological phosphorous removal might then become a viable option without requiring supplemental carbon.

6.0 Influent Loading Considerations

This section presents the anticipated influent loading conditions to the WPF. The WPF receives domestic wastewater consisting of residential, commercial, and industrial flows into the headworks and primary treatment portion of the facility. Three wholesale industrial flows, Triumph Foods (TF), National Beef Leathers (NBL), and the South St. Joseph Industrial Sewer District (SSJISD), enter the WPF downstream of the primary treatment facilities. Future influent loadings to the secondary treatment portion of the WPF, including both domestic and dedicated industrial flows, were developed in TM-WW-1 – Existing Conveyance and Water Protection Facility Assessment.

The loading data developed in TM-WW-1 were supplemented by special sampling conducted from August 4 to August 13, 2009 to better establish the influent waste stream characteristics and more accurately model the treatment system. The sampling required for compliance with the current NPDES permit focuses on effluent quality and does not include constituents relevant for assessing future nutrient removal processes. Several influent characteristics presented in TM-WW-1 were modified as a result of this evaluation as described in the following paragraphs.

The testing showed elevated nitrate concentrations in all of the wastewater sources ranging from 3.9 mg/L (domestic flow to the headworks) to 115 mg/L (from NBL). Typically, nitrate is not present in raw wastewater unless an industrial contribution causes elevated concentrations. The nitrate levels measured at the headworks, TF, and SSJISD flows may be the result of abnormal conditions or measurement errors, as these results are not expected. Influent nitrate is typically the result of using chemicals at an industry or from an upstream biological process which nitrifies the ammonia. Until further testing and evaluation can be performed, nitrate concentration in the headworks and from SSJISD and TF will be assumed to be 0 mg/L. This is reasonable because no upstream sources contributing to the TF or SSJISD flows have been identified or are suspected as contributing to elevated nitrate levels; additionally, elevated influent nitrate at the headworks is not expected for domestic waste. Additional monitoring is required to confirm these assumptions.

NBL does operate a biological treatment system from which high nitrate values could result due to nitrification occurring in the carbon removal process. The results of the supplemental sampling (115 mg/L) will be used as the influent nitrate concentration from NBL for this analysis.

TM-WW-1 indicates that the influent TSS concentration has a very high maximum month loading (590 mg/L, 138,000 lbs/day). This high loading is expected to be the result of the high levels of silt entering the WPF during wet weather events from the Whitehead and Blacksnake Creek flows; these creek flows are direct piped to the WPF at all times, but would exhibit an even greater impact on the overall TSS concentration during times of wet weather. Implementation of the stormwater separation conduits, discussed in TM-CSO-5 – Stormwater Separation Conduits, will remove an

average of 4 million gallons per day (mgd) direct creek flow from the WPF influent; even greater creek flows will be removed during wet weather events. It is anticipated that this stormwater separation will have a significant impact on the actual solids loading under peak flow conditions. For this evaluation, the maximum month TSS concentration was reduced to 164 mg/L (38,200 lbs/day) to match the maximum month peaking factor observed for BOD concentration determined in TM-WW-1. While it is typical for systems to see similar TSS and BOD loadings under maximum month conditions, this assumption should be verified with sampling following construction of the stormwater separation conduits.

Table 3 presents a summary of the influent flow and loading parameters utilized in this analysis. Efforts are currently underway to work with the source industries to reduce nitrogen loading to the WPF. The loading conditions given in Table 3 do not reflect the loading reductions that may occur from these efforts. Any resulting changes in loading rates should be factored into the analysis prior to design and construction of any ammonia or total nutrient reduction facilities.

Table 3
Anticipated WPF Influent Loading Characteristics

		Headworks			SSJISD			National Beef Leathers			Triumph Foods			Combined Industrial Loading			Total Combined Stream		
		Average	Max Month	Peak Day	Average	Max Month	Peak Day	Average	Max Month	Peak Day	Average	Max Month	Peak Day	Average	Max Month	Peak Day	Average	Max Month	Peak Day
Flow, mgd		15.6	27.9	29.8	1.9	2.5	12.9	1	1.2	2.5	1.9	2.6	3.7	4.8	6.3	19.1	20.4	34.2	48.9
Mass, lbs/day	TSS	25,000	38,200 ¹	348,000	3,400	8,500	32,000	600	1,900	4,000	1,300	6,100	49,000	5,300	16,500	85,000	30,300	54,700	433,000
	BOD	25,000	38,200	68,000	11,000	22,000	65,000	200	800	2,600	2,600	8,100	20,000	13,800	30,900	87,600	38,800	69,100	155,600
	NH ₃ -N	2,500	2,700	3,200	600	1,400	4,100	2,400	3,100	8,000	1,800	2,200	5,300	4,800	6,700	17,400	7,300	9,400	20,600
	TKN	3,000	3,300	3,900	1,100	2,600	-- ²	3,900	5,000	-- ²	2,300	2,800	-- ²	7,300	10,400	-- ²	10,300	13,700	-- ²
	NO _x -N	0 ³	0 ³	0 ³	0 ³	0 ³	-- ²	960	1,200	-- ²	0 ³	0 ³	-- ²	960	1,200	-- ²	960	1,200	-- ²
	TP	400	400	500	260	340	-- ²	83	100	-- ²	79	110	-- ²	420	550	-- ²	820	950	-- ²
Conc, mg/L	TSS	192	164 ¹	1,400	215	408	297	72	190	192	82	281	1,588	132	314	534	178	192	1,100
	BOD	192	164	274	694	1,055	604	24	80	125	164	374	648	345	588	550	228	242	382
	NH ₃ -N	19.2	11.6	12.9	37.9	67.1	38.1	288	310	384	114	102	172	120	128	109	43	32.6	51
	TKN	23.1	14.2	15.7	70.5	125	-- ²	468	504	-- ²	143	128	-- ²	182	198	-- ²	61	48	-- ²
	NO _x -N	0.0 ³	0.0 ³	0.0 ³	0.0 ³	0.0 ³	-- ²	115	115	-- ²	0.0 ³	0.0 ³	-- ²	24	22	-- ²	6	4	-- ²
	TP	3.1	1.7	2.0	16.5	16.5	-- ²	10.0	10.0	-- ²	5.0	5.0	-- ²	10.6	10.5	-- ²	4.8	3.3	-- ²

1. Measured TSS values were reduced to the values shown in this table to correspond with influent BOD levels. This reflects solids reductions to the WPF resulting from future implementation of stormwater separation conduits. The conduits will remove an average of approximately 4 mgd of creek flow from the WPF on a daily basis and even higher flows during wet weather events.
2. "--" indicates data not measured.
3. Measured values reduced to 0.0 because no upstream processes reasonably expected to result in increased nitrate levels.

7.0 Phase I – Ammonia Removal (Nitrification) Alternative Development

The WPF does not currently have total nitrogen limits. In the near term, a more stringent ammonia limit is anticipated. For the purpose of this study, it was assumed that an effluent ammonia limit near 5 mg/L could be imposed, requiring complete nitrification of the influent waste streams. Three wholesale industrial users, SSJISD, NBL, and TF, contribute approximately 75 percent of the nitrogen loading to the WPF. The high nitrogen loadings from these three wholesale customers requires additional treatment beyond that typically needed for the domestic flows in order to meet anticipated effluent ammonia limitations. Several process configurations were considered to maximize the use of the existing infrastructure.

7.1 Recommended Alternative

In one alternative, the wholesale industrial flow would enter the WPF through the industrial primary clarifier. Connections for routing TF and NBL flows to the industrial primary clarifier already exist. The connection for routing SSJISD flows was not completed during construction of the industrial primary clarifier due to some valving and tie-in issues; this connection must be completed prior to implementation of the recommended ammonia removal alternative.

The wholesale industrial flow would be routed from the industrial primary clarifier to the existing aerobic digesters where four of the six existing basins would be converted to two activated sludge process trains. The connection from the industrial primary clarifier to the existing aerobic digesters already exists except for the installation of a spool piece. Flow from the two activated sludge trains would be conveyed to a new industrial final clarifier. Effluent from the industrial final clarifier would be combined with the domestic flow from the primary clarifier effluent to enter the trickling filter pump station (Intermediate Pump Station) and be sent to the existing trickling filters. From the trickling filters, flow would be sent to the existing aeration basins consistent with existing WPF operation. Figure 6 shows the general process flow schematic. This alternative is considered the recommended ammonia removal alternative because it maximizes use of existing infrastructure in an operationally stable process.

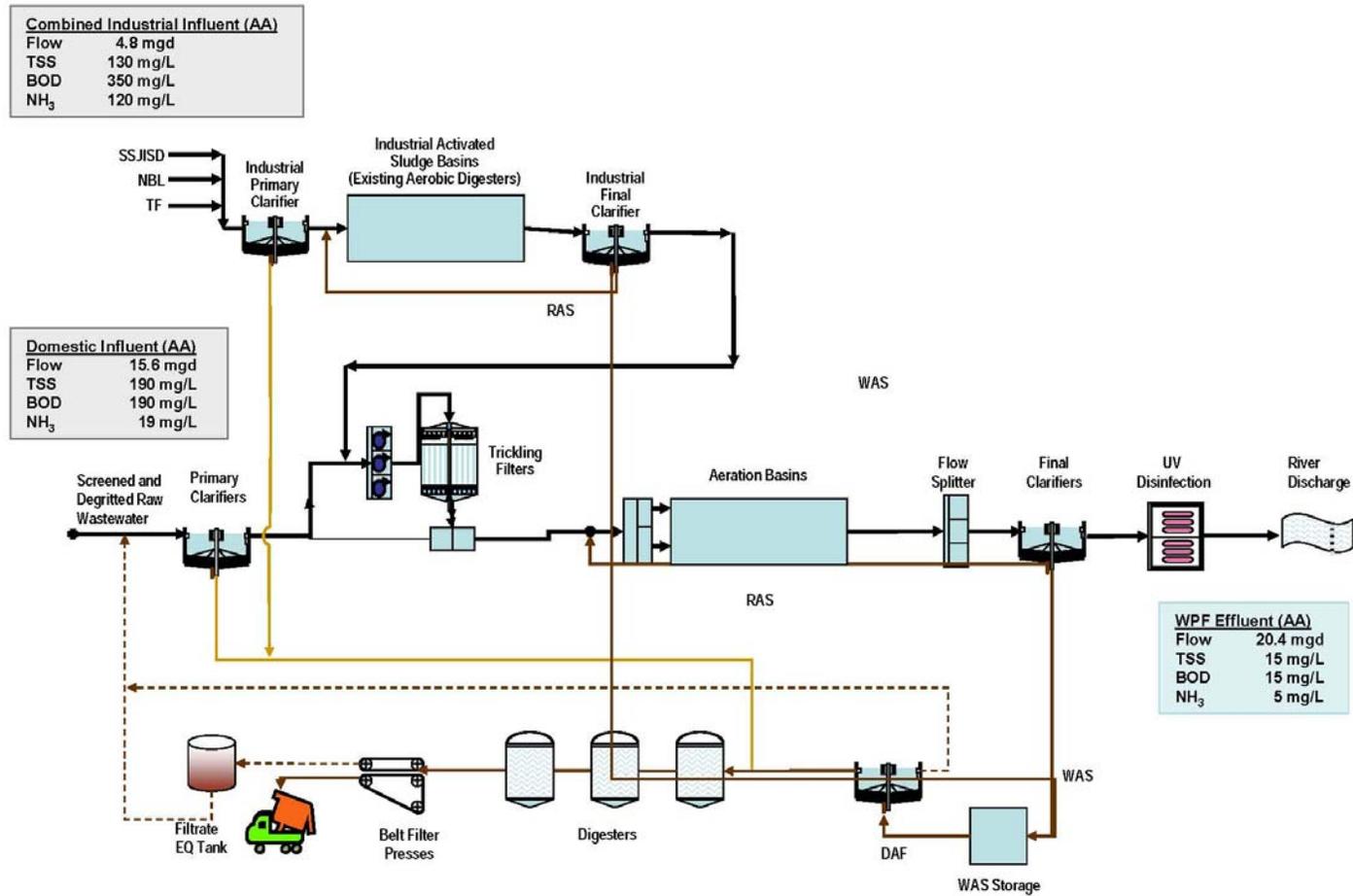


Figure 6 – General Schematic of Recommended Nitrification Alternative

7.2 Additional Alternatives Screened from Further Consideration

Other process configurations were screened but eliminated from further consideration due to concerns of process stability. Alternatives were considered to eliminate the requirement for a new clarifier and reduce costs by sending the biomass (WAS or mixed liquor) from the main process back to the industrial aeration basin (existing aerobic digester). Figure 7 shows two potential ways in which this could be implemented. Active biomass from the existing aeration basins could be returned to the industrial treatment basins either as WAS (green dashed line) or as MLSS (pink dashed line). Use of MLSS would reduce the solids loading on the clarifiers and increase capacity, but it would require separate pumping systems for each aeration basin due to the existing basin arrangement. Both arrangements have adequate aeration volume to meet the effluent requirements, but both options critically load the final clarifiers. The solids and organic loads on the trickling filters also exceed design conditions; this could result in rapid plugging of the media. The reliability of either of the arrangements is not sufficient for further consideration.

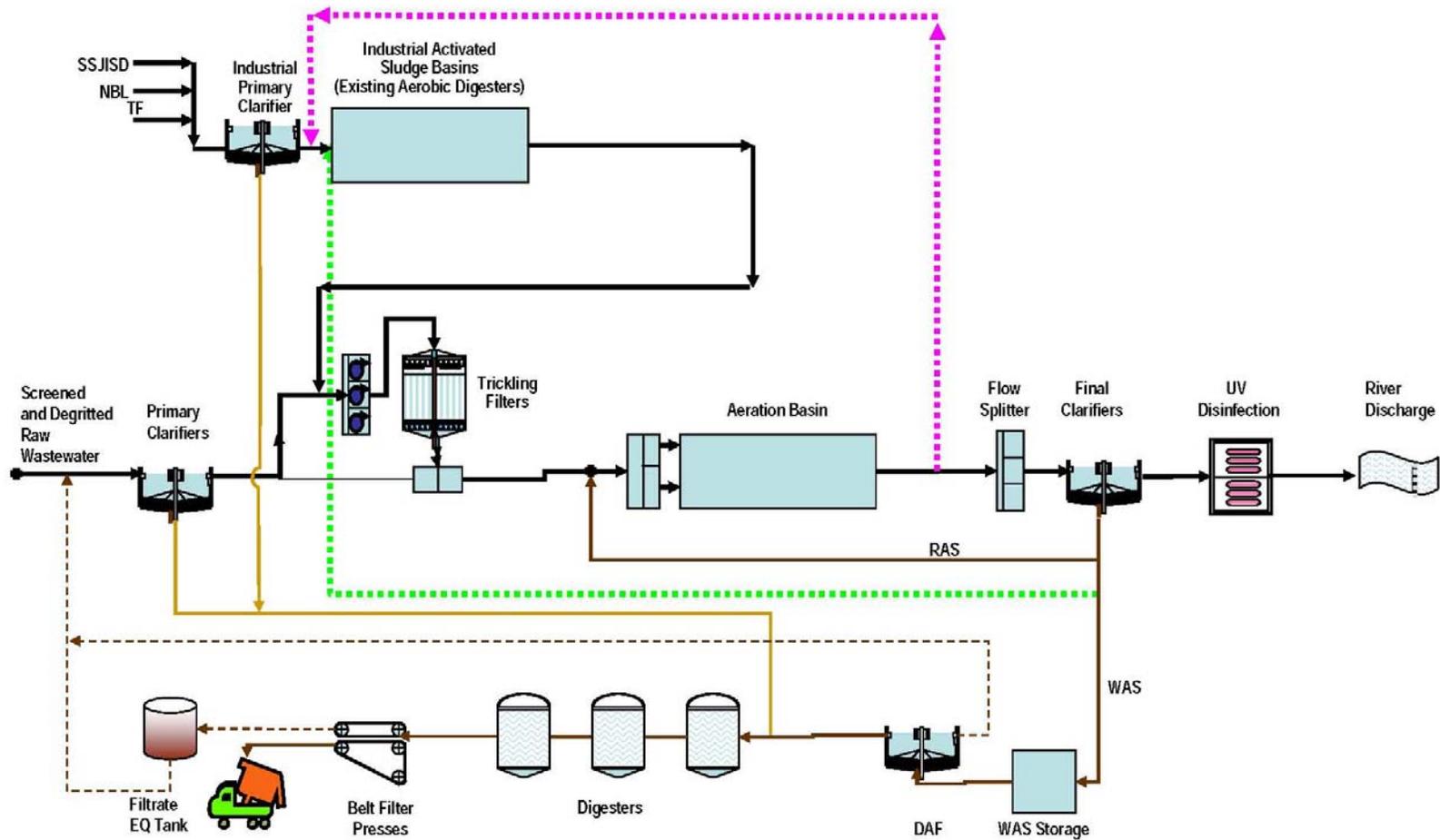


Figure 7 – General Schematic of Nitrification Alternatives Screened from Consideration

7.3 Facility Requirements for Recommended Nitrification Alternative

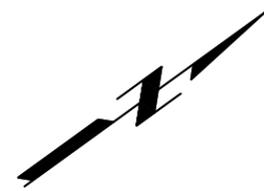
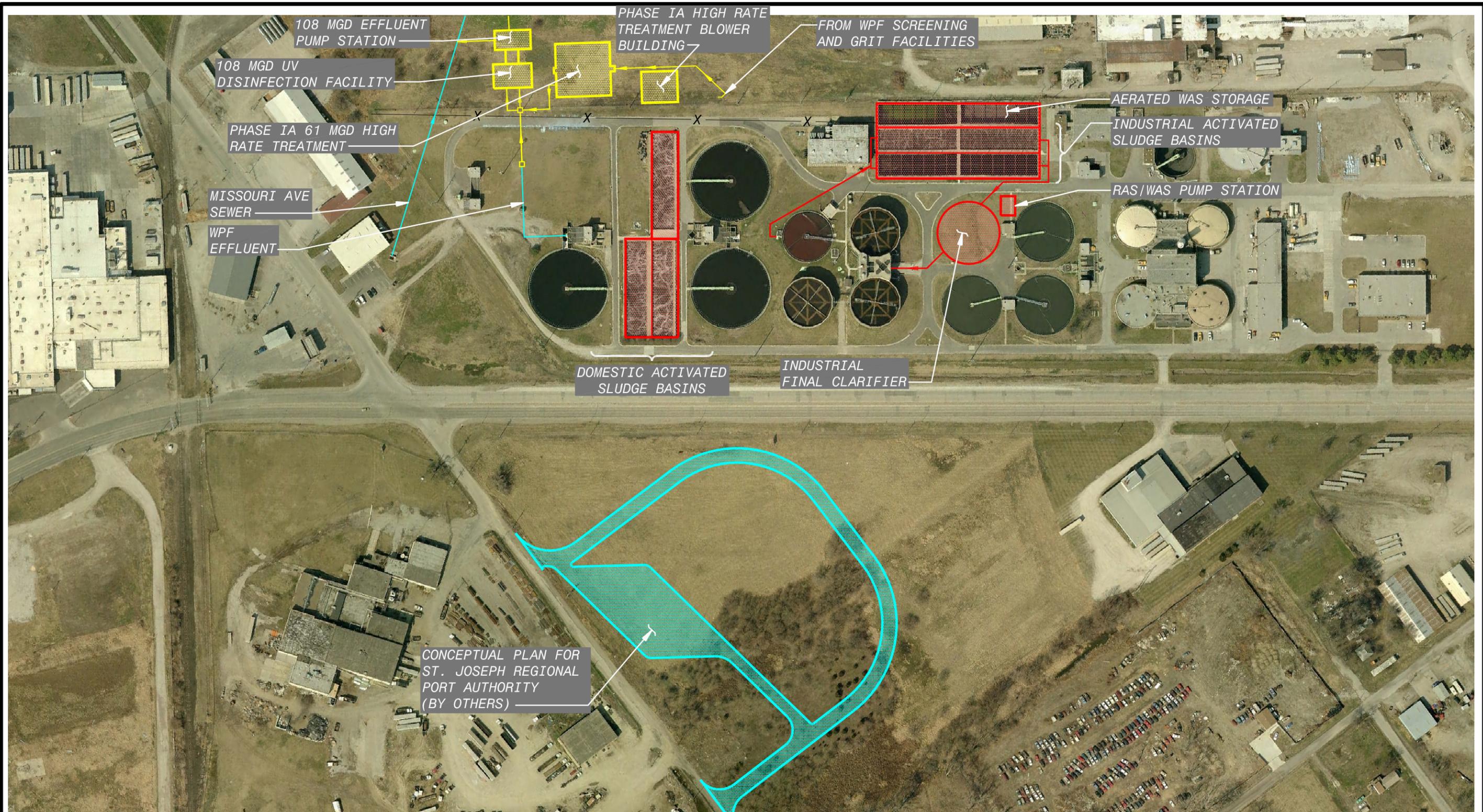
In the recommended ammonia removal (nitrification) alternative shown in Figure 8, four of the six existing aerobic digester cells would need to be reconfigured to operate as aeration basins for the industrial wastewater. Industrial flow from the City’s wholesale customers would be directed to the existing industrial primary clarifier. This primary effluent would flow to the new industrial aeration basins (existing aerobic digesters) and then to a new industrial final clarifier. Table 4 summarizes the requirements of both the aeration basin and the new final clarifier.

Table 4	
Industrial Wastewater Treatment Train Facility Sizing	
Aeration Basin	
Location	Existing Aerobic Digesters
Total Volume	4.00 MG
Max MLSS	3,067 mg/L
Industrial Final Clarifier	
Location	New Construction
Number	1
Diameter	120 ft
RAS Pumping	
Firm Capacity	6 mgd
WAS Pumping	
Max Daily Wasting	0.42 mgd
Aeration Requirements	
Max Month	34,600 scfm
Annual Average	22,700 scfm

In this alternative, the existing trickling filters would receive domestic flow from the existing primary clarifiers as well as flow from the new industrial wastewater treatment train. The existing trickling filters would continue to operate in a manner similar to their current operation. The existing Intermediate Pump Station pumps flow to the top of the trickling filters. The firm pump capacity (55 mgd) of this station is adequate to support the proposed configuration.

The existing activated sludge system would operate similar to the current operation. No changes to the basin volume/configuration or additional final clarifier capacity would be required; however, additional diffusers would be required for the

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FIGURE 8

existing aeration basins. Table 5 summarizes the requirements for the existing activated sludge system. Table 6 summarizes the aeration requirements needed.

Table 5 Existing Activated Sludge System	
Aeration Basins	
Volume	3.81 MG
Max MLSS	2,612 mg/L
Final Clarifiers	
Number	3
Diameter	160 ft
RAS Pumping	
Firm Capacity	34 mgd
WAS Pumping	
Max Daily Wasting	0.35 mgd

Table 6 Aeration Requirements for Existing Aeration Basins	
Maximum Month	12,000 scfm
Annual Average	6,100 scfm

8.0 Phase II – Total Phosphorous Removal Alternative Development

The Phase II limits will impose total phosphorus limits on the effluent. Biological phosphorus removal is often used to achieve the projected 1 mg/L limit; however without denitrification, anaerobic conditions for biological phosphorus removal could not be met. As explained in the following section, the high influent nitrogen loading to the facility prevents adequate denitrification without the aid of an external carbon source. Because biological phosphorus removal also requires readily biodegradable carbon, even more external carbon would be required to achieve biological phosphorous removal. The cost of the supplemental carbon required for biological phosphorous removal would be more than double that required for denitrification, resulting in incremental chemical costs more than 10 times greater than the operating cost of chemical phosphorous removal. Due to the cost prohibitive nature of purchasing additional supplemental carbon, the use of biological phosphorus removal will not be considered. For costing purposes, chemical phosphorous removal through chemical precipitation with ferric chloride will be included

in this evaluation as it is a common system employed in the Midwest. During preliminary design of phosphorous removal facilities, a study of the most appropriate chemical for use at the WPF should be completed. Table 7 summarizes the annual average ferric chloride dosage rates for each alternative. The process alternatives are described in more detail in the following sections.

Process Alternative	Annual Average, lb/day
1A – Activated Sludge for Domestic Flows, Activated Sludge for Industrial Flows	3,100
1B – IFAS for Domestic Flows, Activated Sludge for Industrial Flows	3,100
1C – IFAS for Domestic Flows, MBR for Industrial Flows	3,100
2A – Activated Sludge for Both Domestic and Industrial Flows	2,900
2B – IFAS for Both Domestic and Industrial Flows	2,900

As the annual average quantity of ferric chloride utilized for each alternative is within 10 percent, the most conservative feed and storage system will be applied to all alternatives. Major facilities required for ferric chloride addition include: five 5,000 gallon fiberglass reinforced plastic (FRP) storage tanks, feed pumps, and feed piping. The ferric chloride feed and storage facilities would be combined with the methanol feed and storage facilities described in further detail in the following section. Impacts of using chemical phosphorous removal on the solids system will be considered in TM-WW-6 – Biosolids Facilities.

9.0 Phase III – Total Nitrogen Removal Alternative Development

In order to develop alternatives for further study, scenarios using combined and separate nitrification/denitrification of domestic and industrial flows were considered. The advantages and disadvantages of separate and combined treatment as well as the specifics of the various configurations are presented in the following sections. The facilities are based on the worst-case industrial loadings presented in Section 6.0. If efforts to reduce industrial nutrient loadings are successful, the recommended

nitrification/denitrification facilities should be reviewed in light of the revised loading data. Reduced nutrient loading in the industrial streams has the potential to significantly reduce the facility requirements for the nitrification/denitrification scenarios. Reduction in nutrient loading to the facility might also allow biological phosphorous removal to be considered as a viable alternative in conjunction with implementation of total phosphorous removal.

9.1 Separate Domestic and Wholesale Industrial Treatment

As previously discussed, the WPF receives domestic wastewater consisting of residential, commercial, and industrial flows into the headworks and primary treatment portion of the facility. Three wholesale industrial flows, TF, NBL, and the SSJISD, enter the WPF downstream of the primary treatment facilities. The separate configuration provides separate nutrient removal facilities for the domestic flows and the dedicated industrial flows. A general schematic of this configuration is provided in Figure 9.

Table 3 and Figure 9 summarize the flows and loadings anticipated for the domestic and industrial treatment trains under the separate flow configuration. There are several advantages and disadvantages of separating the domestic and industrial flow as presented in Table 8.

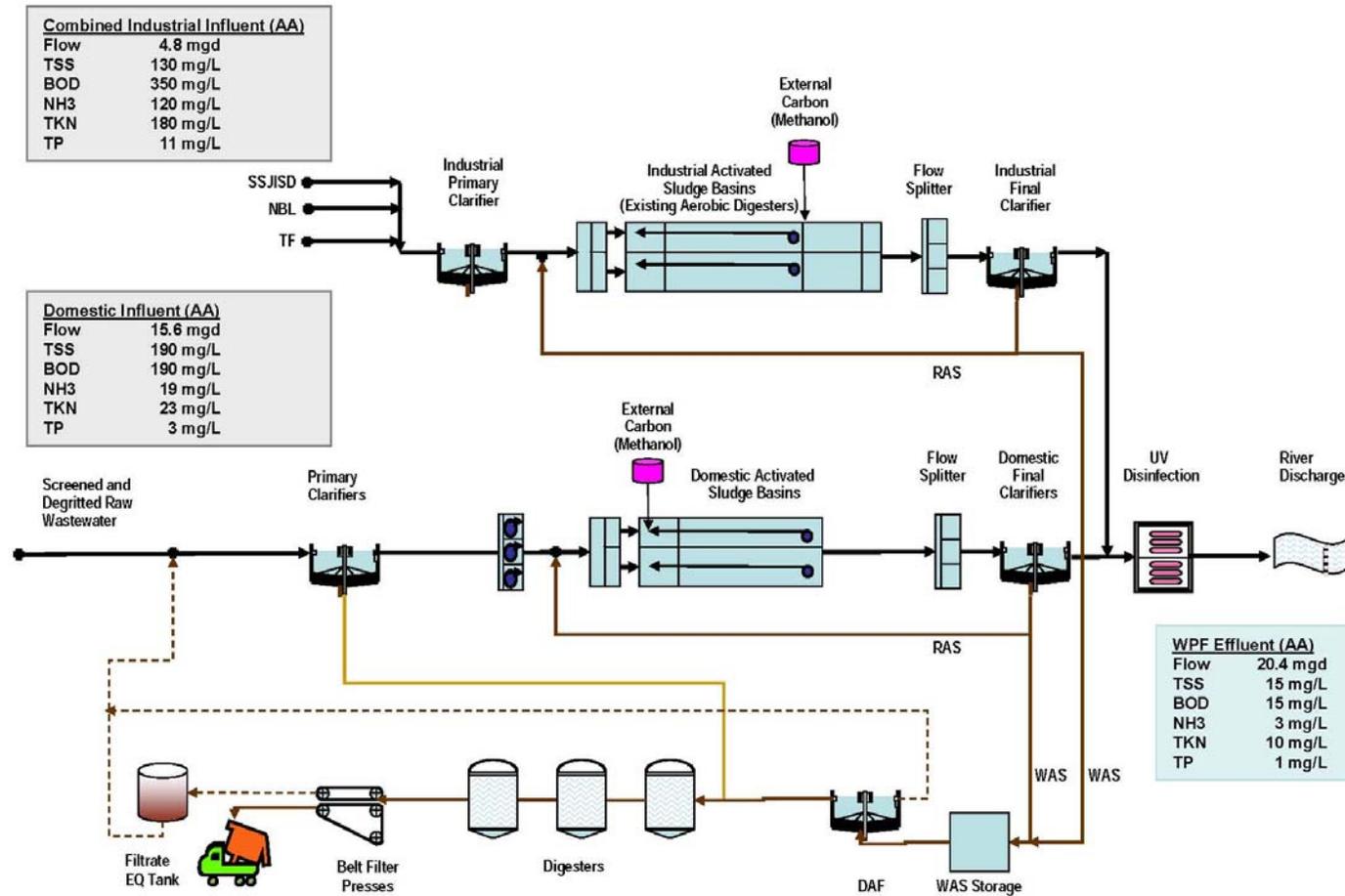


Figure 9 – General Schematic of Separated Domestic and Industrial Flow Configuration

Table 8	
Advantages/Disadvantages of Separated Domestic and Industrial Flow Configuration	
Advantages	Disadvantages
<ul style="list-style-type: none"> • Costs associated with treating wholesale industrial wastewater can be easily identified. • Separating high nitrogen wastewater from domestic wastewater will allow domestic treatment system to reduce carbon feed requirements. • Builds on investments made for ammonia removal (nitrification). 	<ul style="list-style-type: none"> • Operating separate nutrient removal processes will increase sampling, monitoring, and control requirements. • Requires addition of industrial final clarifier. If only one clarifier is provided, maintenance would require flow to the domestic treatment train on a temporary basis.

Implementation of the separated treatment process has several sub-alternatives that will be considered further:

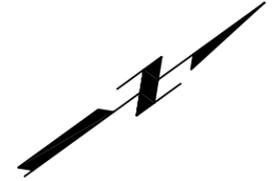
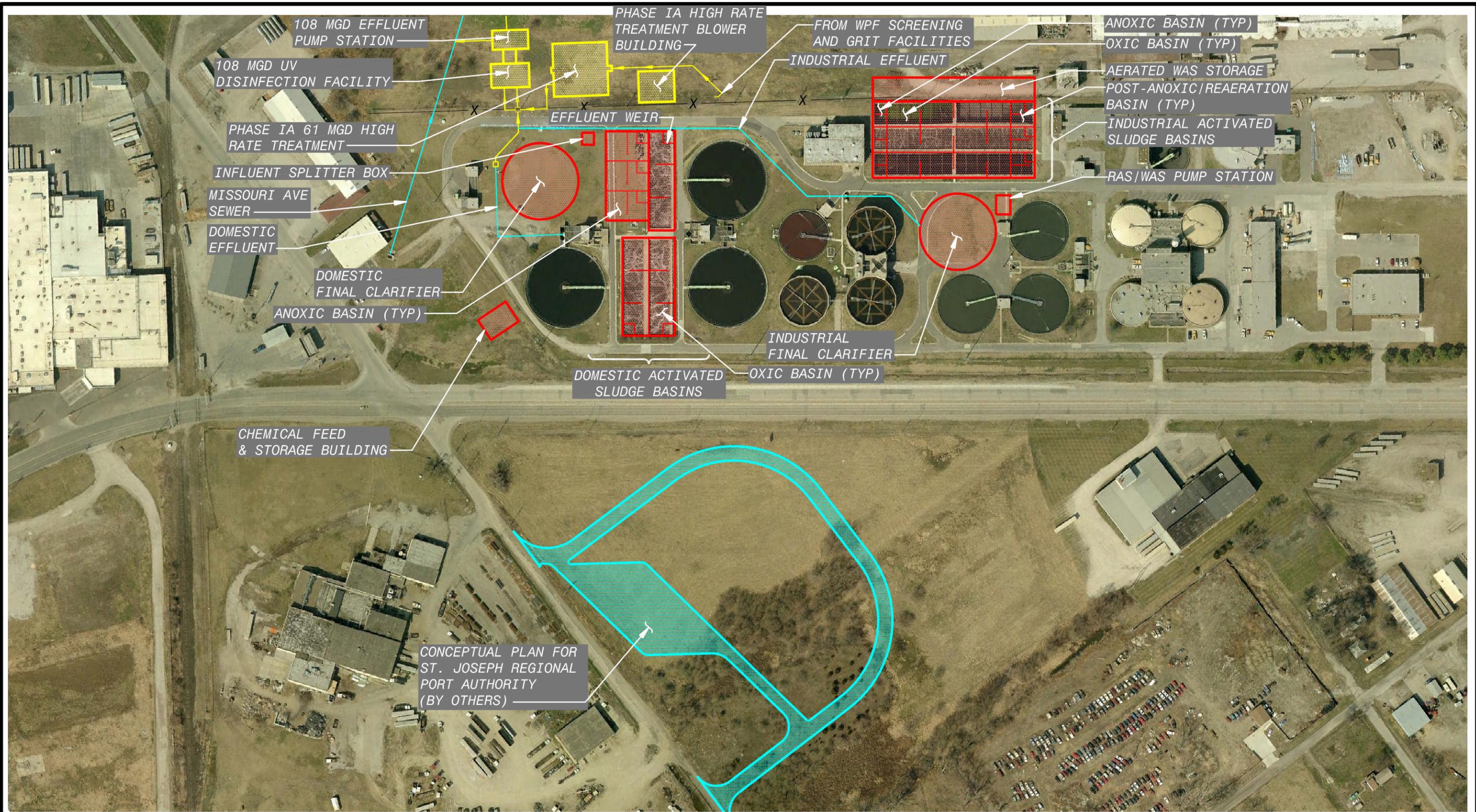
- Alternative 1A – Activated sludge treatment for domestic flows, activated sludge treatment for wholesale industrial flows.
- Alternative 1B – IFAS treatment for domestic flows, activated sludge treatment for wholesale industrial flows.
- Alternative 1C – IFAS treatment for domestic flows, MBR treatment for wholesale industrial flows.

Additional details and facility requirements for the separate configuration sub-alternatives are provided in the following sections.

9.1.1 Alternative 1A – Activated Sludge for Domestic Flows, Activated Sludge for Wholesale Industrial Flows

Activated sludge treatment of both the domestic and wholesale industrial trains requires the greatest tank volumes of all of the separate configuration alternatives. Figure 10 presents a conceptual layout of facilities for Alternative 1A. The domestic wastewater treatment design was based on confining the oxic zone requirements to the existing aeration basins. Anoxic zones would need to be constructed in basins adjacent to the existing activated sludge basins. The conceptual design is based on creating three

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ALTERNATIVE 1A
ACTIVATED SLUDGE FOR DOMESTIC FLOWS
ACTIVATED SLUDGE FOR INDUSTRIAL FLOWS

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FIGURE 10

process trains, using a two stage MLE process as described in Section 4.3.1. A four stage process must be utilized for the industrial train due to the high nitrogen loading from the industrial wastewater as determined from monitoring data collected by WPF staff. Table 9 presents the required domestic treatment facilities.

Facilities	Per Train	Total
Activated Sludge Basin		
Anoxic Volume	0.50 MG	1.50 MG
Oxic Volume	1.27 MG	3.81 MG
Total Volume	1.77 MG	5.31 MG
Mixers		
Number	2	6
Horsepower, each	6.7 hp	6.7 hp
Internal Recycle Pumps		
Number	1	3
Capacity, each	38 mgd	38 mgd
Aeration Requirements		
Annual Average	2,800 scfm	8,400 scfm
Maximum Month	3,700 scfm	11,200 scfm

In order to maintain a higher mixed liquor concentration without exceeding the design limits for solids loading rates, a fourth domestic final clarifier would be required. Table 10 summarizes the design basis for the new clarifier.

Facilities	Value
Total Number of Clarifiers	4
Total Surface Area	80,424 ft ²
New Clarifiers	
Number	1
Diameter	160 ft
Surface Overflow Rate	
Average	201 gal/ft ² /day
Maximum Month	353 gal/ft ² /day
Solids Loading Rate	
Average	6.8 ppd/ft ²
Maximum Month	22.8 ppd/ft ²

The separate wholesale industrial wastewater treatment train would utilize a 4-Stage Bardenpho process to reduce the nitrate concentration sufficiently to meet the effluent total nitrogen limit of 10 mg/L. This conventional activated sludge treatment process requires that all six of the existing aerobic digesters be converted for industrial treatment. Currently, two of the six basins are utilized for aerated WAS storage prior to feeding to the dissolved air flotation (DAF) units for thickening. If desired by the City, additional WAS holding basins could be provided to replace the storage volume lost to the industrial activated sludge basins. Table 11 describes the overall process requirements for this configuration.

Table 11		
Alternative 1A – Industrial Activated Sludge Basin Sizing		
Facilities	Per Train	Total
Activated Sludge Basin		
Anoxic Volume	0.17 MG	0.50 MG
Oxic Volume	1.33 MG	4.00 MG
Post-Anoxic Volume	0.50 MG	1.50 MG
Reaeration Volume	0.03 MG	0.10 MG
Total Volume	2.03 MG	6.10 MG
Anoxic Mixers		
Number	1	3
Horsepower, each	4.5 hp	4.5 hp
Post-Anoxic Mixers		
Number	2	6
Horsepower, each	6.7 hp	6.7 hp
Internal Recycle Pumps		
Number	1	3
Capacity, each	8 mgd	8 mgd
Aeration Requirements		
Annual Average	6,600 scfm	19,800 scfm
Maximum Month	9,100 scfm	27,200 scfm

Only one final clarifier would be provided for the wholesale industrial treatment system. Any maintenance issues on this clarifier would require that the entire wholesale industrial treatment train be taken out of service; however, provisions can be made to combine the waste streams for treatment with the domestic waste on a temporary basis in

order to perform maintenance activities. Table 12 summarizes the design basis for the new industrial final clarifier.

Table 12	
Alternative 1A – Industrial Final Clarifier Sizing	
Facilities	Value
Total Surface Area	20,106 ft ²
Final Clarifiers	
Number	1
Diameter	160 ft
Surface Overflow Rate	
Average	239 gal/ft ² /day
Maximum Month	313 gal/ft ² /day
Solids Loading Rate	
Average	11.5 ppd/ft ²
Maximum Month	25.4 ppd/ft ²
RAS Pumping Rate	
Average	4.5 mgd
Maximum Month	6.0 mgd
WAS Pumping Rate	
Average	0.32 mgd
Maximum Month	0.3 mgd

In summary, the following major facilities are required to implement nitrification/denitrification using activated sludge treatment for both of the separate domestic and industrial trains:

- Domestic Flows
 - New anoxic basins
 - Oxidic basins (reuse existing aeration basins)
 - New domestic final clarifier to supplement three existing clarifiers
- Wholesale Industrial Flows
 - Anoxic, oxidic, post-anoxic, and reaeration volume (reuse six existing aerobic digester basins)
 - New industrial final clarifier and associated RAS/WAS pump station

- Optional WAS storage basin to replace volume lost to industrial activated sludge basin

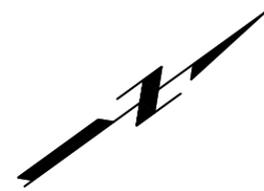
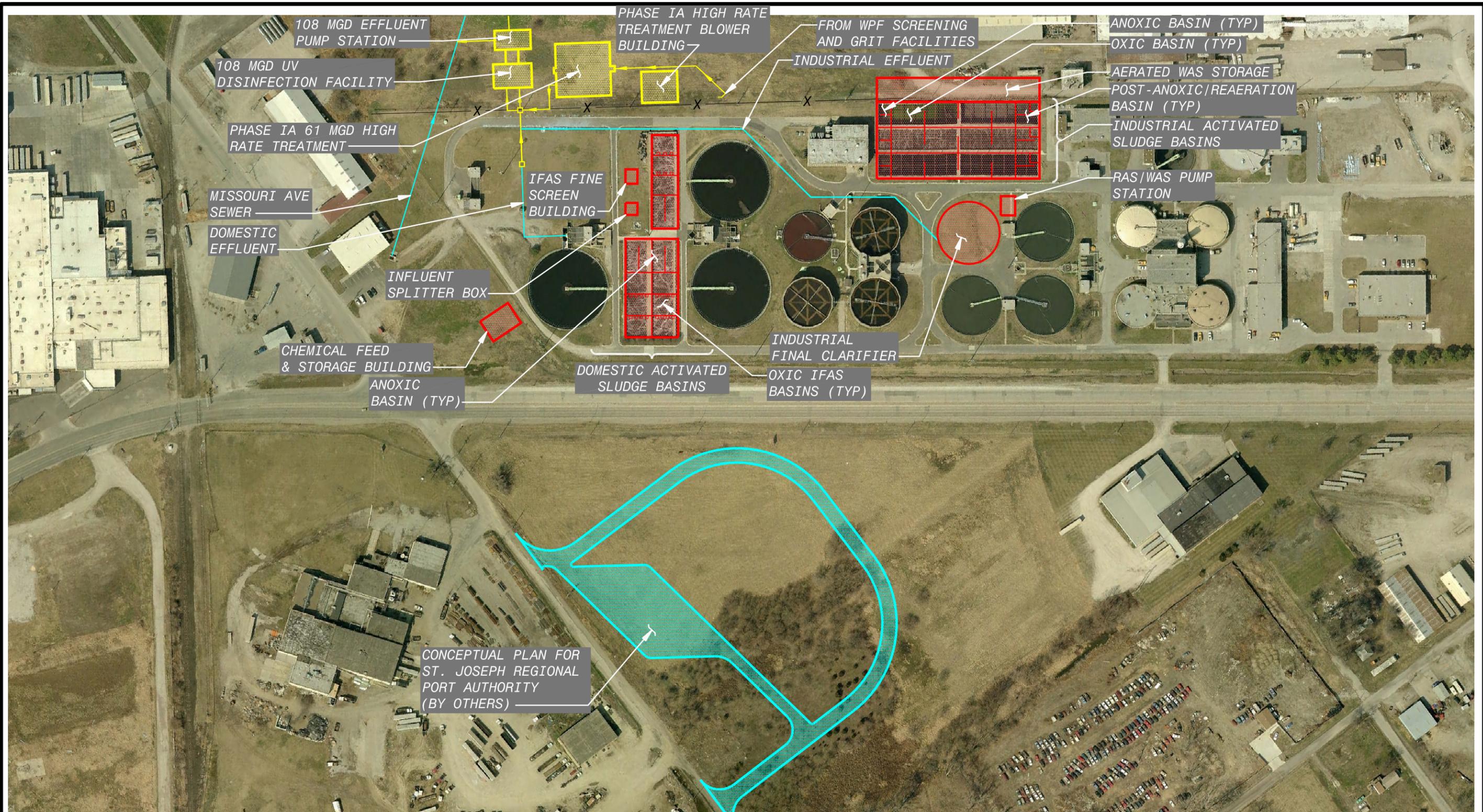
The chemical feed and storage systems for methanol (external carbon feed source) are discussed in Section 9.3 for all alternatives.

9.1.2 Alternative 1B – IFAS for Domestic Flows, Activated Sludge for Wholesale Industrial Flows

Alternative 1B is similar to Alternative 1A, except that IFAS media is utilized in the oxic zone of the domestic train. Figure 11 presents a conceptual layout of facilities for Alternative 1B. The use of the media reduces the oxic zone volume requirements and operating mixed liquor concentration within the domestic treatment train sufficiently to allow the anoxic zones to reside within the existing aeration basin volume. IFAS media does require the addition of fine screens. Preliminary sizing suggests that approximately 41 percent fill of media in the domestic oxic zones is required for the necessary level of nitrification. Table 13 presents the design basis for the new facilities.

Table 13		
Alternative 1B – Domestic IFAS Basin Sizing		
Facilities	Per Train	Total
Activated Sludge Basin		
Anoxic Volume	0.43 MG	1.28 MG
Oxic Volume	0.85 MG	2.54 MG
Total Volume	1.27 MG	3.82 MG
Mixers		
Number	2	6
Horsepower, each	5.7 hp	5.7 hp
Internal Recycle Pumps		
Number	1	3
Capacity, each	38 mgd	38 mgd
Aeration Requirements		
Annual Average	4,500 scfm	13,500 scfm
Maximum Month	5,500 scfm	16,400 scfm

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FIGURE 11

Using IFAS media allows the mixed liquor concentration to be low enough to eliminate the need for a new final clarifier. Table 14 summarizes the final clarification requirements for the domestic train.

Table 14 Alternative 1B – Domestic Final Clarifier Sizing	
Facilities	Value
Total Number of Clarifiers	3
Total Surface Area	60,318 ft ²
New Clarifiers	
Number	0
Diameter	160 ft
Surface Overflow Rate	
Average	269 gal/ft ² /day
Maximum Month	472 gal/ft ² /day
Solids Loading Rate	
Average	8.0 ppd/ft ²
Maximum Month	24.9 ppd/ft ²

No changes to the aeration and solids loading rates are necessary for the wholesale industrial treatment requirements in Alternative 1B when compared with Alternative 1A. Tables 11 and 12 summarize the industrial activated sludge basin and final clarifier sizing.

In summary, the following major facilities are required to implement nitrification/denitrification using IFAS media for the domestic train and activated sludge treatment for the industrial train:

- Domestic Flows
 - New IFAS fine screen building
 - Anoxic basins (reuse existing aeration basin volume)
 - Oxidic basins with IFAS media (reuse existing aeration basin volume)
- Wholesale Industrial Flows
 - Anoxic, oxidic, post-anoxic, and reaeration volume (reuse six existing aerobic digester basins)

- New industrial final clarifier and associated RAS/WAS pump station
- Optional WAS storage basin to replace volume lost to industrial activated sludge basin

The chemical feed and storage systems for methanol (external carbon feed source) are discussed in Section 9.3 for all alternatives.

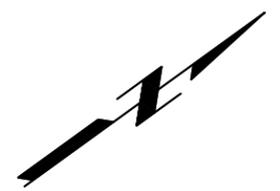
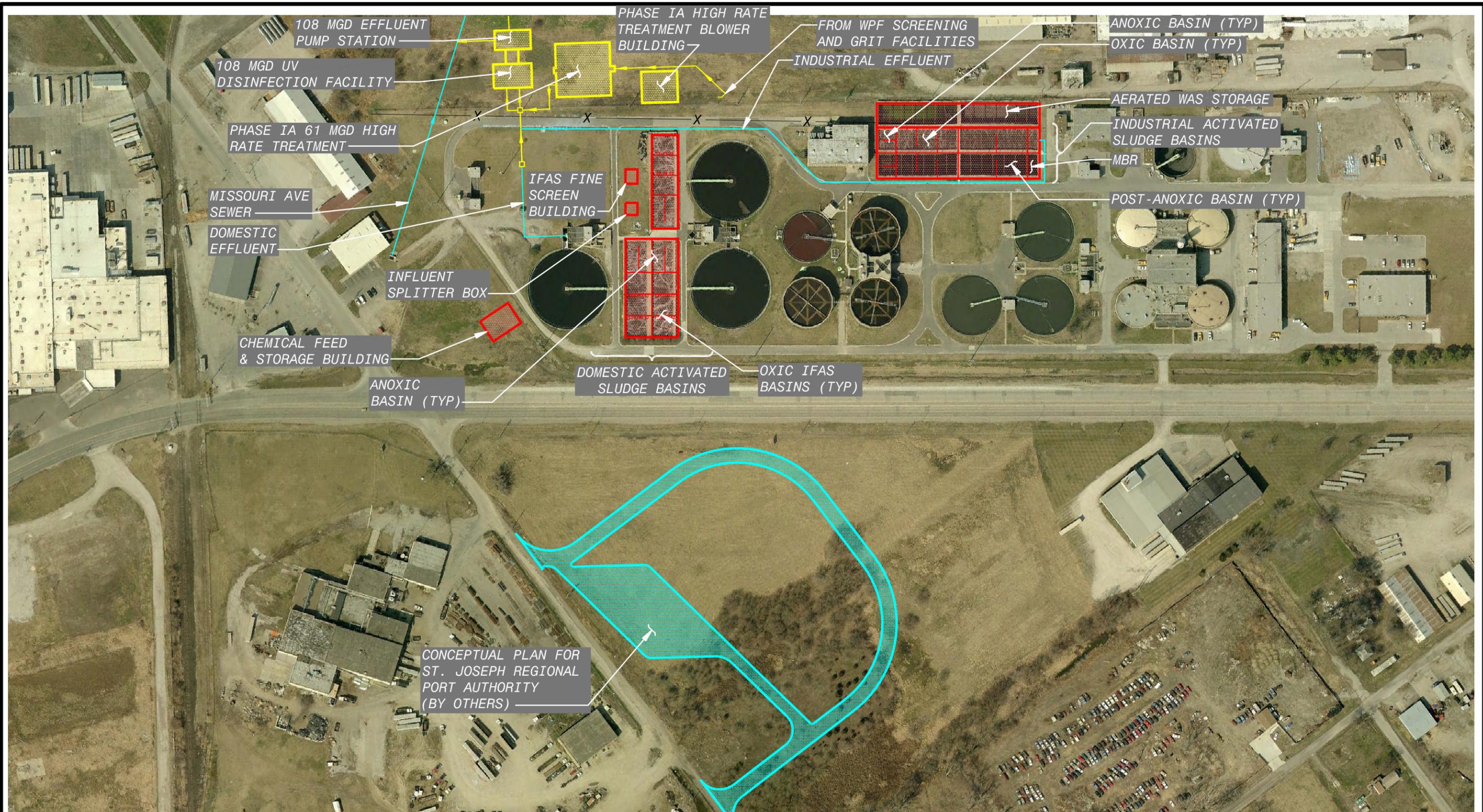
9.1.3 Alternative 1C – IFAS for Domestic Flows, MBR for Wholesale Industrial Flows

Alternative 1C is similar to Alternative 1B except that MBR technology is used to reduce the footprint of the wholesale industrial train. Figure 12 presents a conceptual layout of facilities for Alternative 1C. The domestic treatment process is identical to that for Alternative 1B as summarized in Tables 13 and 14.

Implementation of MBR treatment in the wholesale industrial train would use four of the existing six aerobic digester basins separated into two parallel treatment trains. Unlike Alternatives 1A and 1B where all six existing aerobic digester basins are utilized, Alternative 1C would allow the existing practice of using two of the aerobic digester basins for WAS storage to continue. As previously discussed, much of the MBR process is similar to the conventional activated sludge process; however, the MBR eliminates the need to construct an industrial final clarifier, but requires fine screening for the influent.

MBR sizing is particularly sensitive to peak flows as the peak flow defines the number of membranes required. For this reason, the influent flow to the industrial treatment facility would be limited to two times the maximum month industrial loading condition or 12.6 mgd. Any additional industrial flow up to the overall industrial peak day flow of 19.1 mgd can be diverted to the domestic treatment process for short periods of time. In the future, high wet weather flows could be diverted to the high rate treatment facilities constructed as part of the combined sewer overflow control program (TM-CSO-10 – Wet Weather Treatment Facilities).

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PN 163509
ALTERNATIVE 1C
IFAS FOR DOMESTIC FLOWS
MBR FOR INDUSTRIAL FLOWS

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FIGURE 12

Table 15 describes the treatment process requirements for membrane treatment of the industrial waste stream. A new industrial final clarifier is not required for this alternative.

Table 15		
Alternative 1C – Industrial MBR Basin Sizing		
Facilities	Per Train	Total
Activated Sludge Basin		
Anoxic Volume	0.25 MG	0.50 MG
Oxic Volume	1.00 MG	2.00 MG
Post-Anoxic Volume	0.75 MG	1.50 MG
MBR Volume	0.05 MG	0.10 MG
Total Volume	2.05 MG	4.10 MG
Anoxic Mixers		
Number	1	2
Horsepower, each	6.7 hp	6.7 hp
Post-Anoxic Mixers		
Number	2	4
Horsepower, each	10.0 hp	10.0 hp
Internal Recycle Pumps		
Number	1	2
Capacity, each	13 mgd	13 mgd
Aeration Requirements		
Annual Average	8,300 scfm	16,700 scfm
Maximum Month	10,400 scfm	20,900 scfm

In summary, the following major facilities are required to implement nitrification/denitrification using IFAS media for the domestic train and MBR treatment for the industrial train:

- Domestic Flows
 - New IFAS fine screen building
 - Oxic basins with IFAS media (reuse existing aeration basins)
 - Anoxic basins (reuse existing aeration basin volume)
- Wholesale Industrial Flows
 - Anoxic, oxic, post-anoxic, and reaeration volume (reuse four of the existing aerobic digester basins)
 - New MBR (within existing aerobic digester basins)

The chemical feed and storage systems for methanol (external carbon feed source) are discussed in Section 9.3 for all alternatives.

9.2 Combined Domestic and Industrial Treatment

The existing WPF is designed to treat both domestic and wholesale industrial flows in a single activated sludge process. To upgrade the existing activated sludge process for nutrient removal, significant additional infrastructure will be required, including additional final clarifiers and aeration basin volume. A general schematic of this configuration is provided in Figure 13.

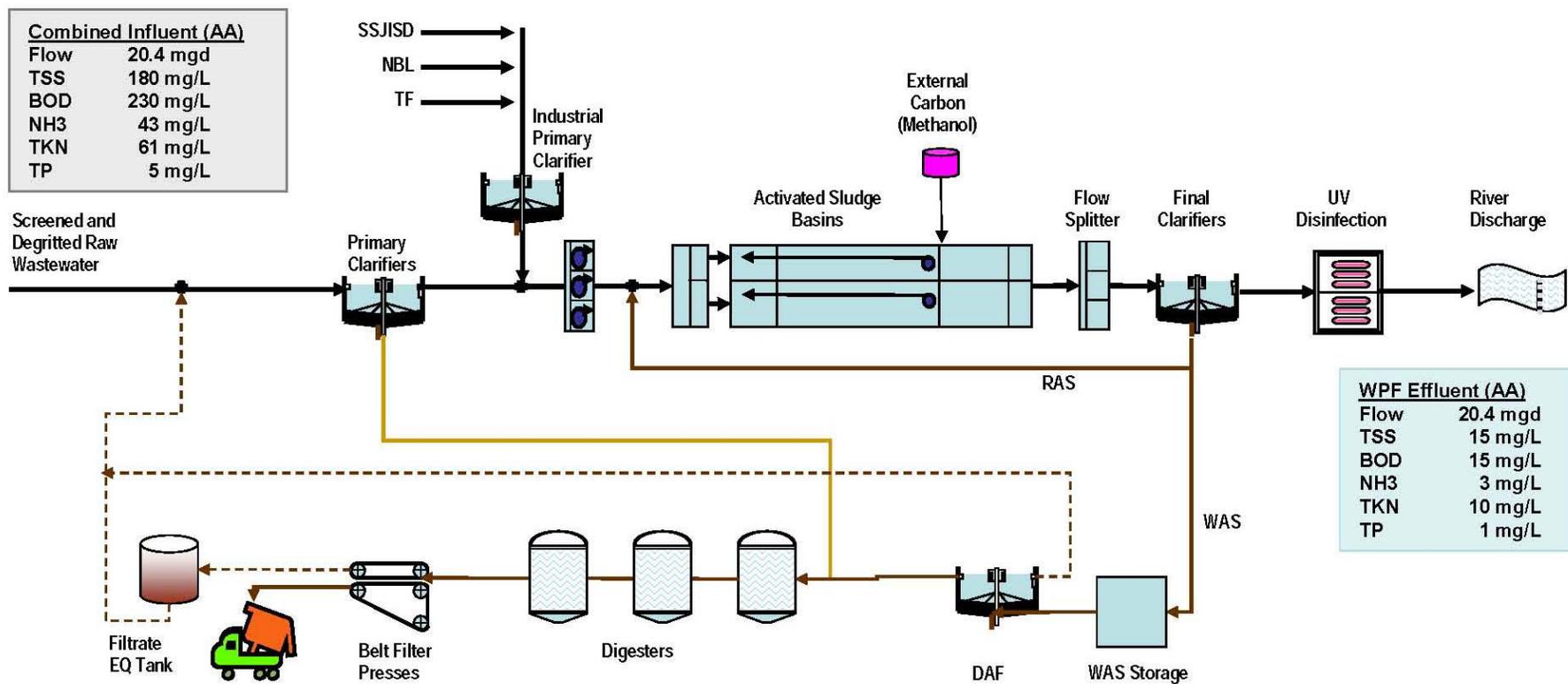


Figure 13 – General Schematic of Combined Domestic and Industrial Flow Configuration

The “Total Combined Stream” columns presented in Table 3 summarize the flows and loadings anticipated for the combined domestic and wholesale industrial flow configuration. There are several advantages and disadvantages of combining the domestic and industrial flow as presented in Table 16.

Table 16 Advantages/Disadvantages of Combined Domestic and Industrial Flow Configuration	
Advantages	Disadvantages
<ul style="list-style-type: none"> • Simplified waste treatment operation and control resulting from one treatment train. • Reduced overall number of pumps and instruments. 	<ul style="list-style-type: none"> • Costs associated with treating wholesale industrial wastewater may be difficult to separate from domestic treatment costs. • Significant volume of new tankage required without first utilizing existing aerobic digesters. • Does not take advantage of many of the facilities constructed for ammonia removal (nitrification).

Two sub-alternatives for implementation of the combined domestic and industrial treatment process were identified for consideration:

- Alternative 2A – Activated sludge treatment for combined flows.
- Alternative 2B – IFAS treatment for combined flows.

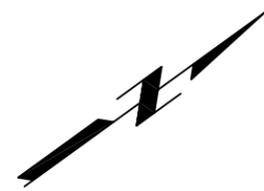
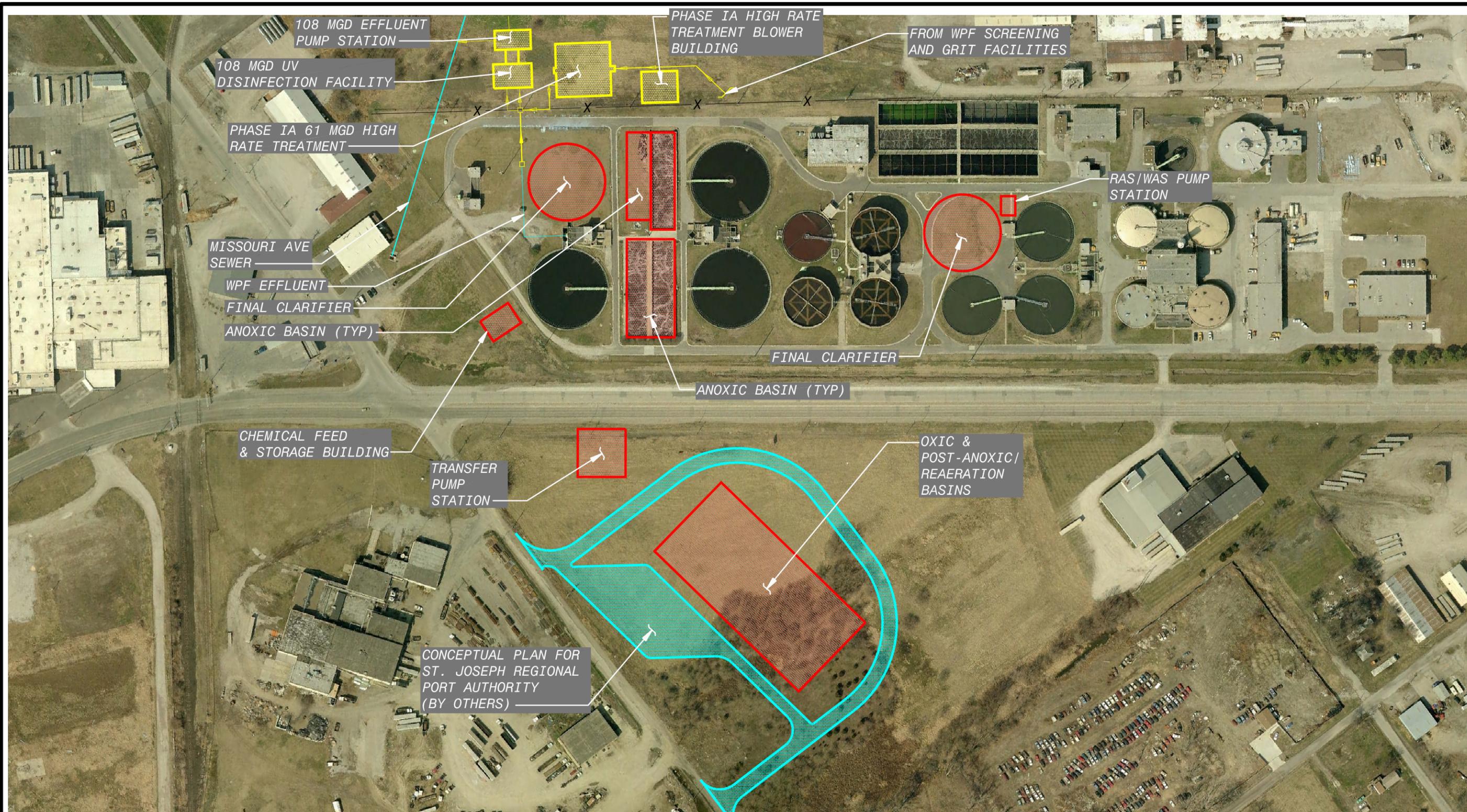
Additional details and facility requirements for the combined configuration sub-alternatives are provided in the following sections.

9.2.1 Alternative 2A – Activated Sludge for Both Domestic and Industrial Flows

Treating the waste using conventional activated sludge requires the greatest tank volume of all of the alternatives considered. Figure 14 presents a conceptual layout of the facilities for Alternative 2A.

The oxic zone volume requirements alone are nearly three times the existing aeration basin volume; therefore, additional oxic volume would be required. New oxic

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ALTERNATIVE 2A
ACTIVATED SLUDGE FOR BOTH
DOMESTIC & INDUSTRIAL FLOWS

MARCH 2010
FIGURE 14

and post-anoxic basins would be constructed on property contiguous to the WPF as shown in Figure 14. A new transfer pump station would be required to transfer flows from the new basins to the existing WPF. The anoxic zones would be constructed in and adjacent to the existing aeration basins. Additionally, two new final clarifiers would be necessary to meet the requirements for maximum solids loading. The conceptual design is based on creating four process trains. Tables 17 and 18 present a summary of the facilities required.

Table 17		
Alternative 2A – Activated Sludge Basin Sizing		
Facilities	Per Train	Total
Activated Sludge Basin		
Anoxic Volume	0.38 MG	1.50 MG
Oxic Volume	2.78 MG	11.10 MG
Post-Anoxic Volume	0.75 MG	3.00 MG
Reaeration Volume	0.04 MG	0.15 MG
Total Volume	3.94 MG	15.75 MG
Anoxic Mixers		
Number	2	8
Horsepower, each	5.0 hp	5.0 hp
Post-Anoxic Mixers		
Number	2	8
Horsepower, each	10.0 hp	10.0 hp
Internal Recycle Pumps		
Number	1	4
Capacity, each	35 mgd	35 mgd
Aeration Requirements		
Annual Average	6,100 scfm	24,500 scfm
Maximum Month	9,300 scfm	37,200 scfm

Table 18	
Alternative 2A – Final Clarifier Sizing	
Facilities	Value
Total Number of Clarifiers	5
Total Surface Area	100,530 ft ²
New Clarifiers	
Number	2
Diameter	160 ft
Surface Overflow Rate	
Average	210 gal/ft ² /day
Maximum Month	346 gal/ft ² /day
Solids Loading Rate	
Average	6.6 ppd/ft ²
Maximum Month	23.4 ppd/ft ²
RAS Pumping Rate	
Average	20 mgd
Maximum Month	34 mgd
WAS Pumping Rate	
Average	0.55 mgd
Maximum Month	0.76 mgd

In summary, the following major facilities are required to implement nitrification/denitrification using combined activated sludge treatment of both industrial and domestic flows:

- Anoxic basins (reuse existing aeration basin volume and build new basin)
- New oxic basins
- New post-anoxic/reaeration basins
- New transfer pump station
- Two new final clarifiers and associated RAS/WAS pump station for new clarifier located near existing aerobic digesters

The chemical feed and storage systems for methanol (external carbon feed source) are discussed in Section 9.3 for all alternatives.

As shown in Figure 14, the space requirement for the new oxic and post-anoxic basins for this alternative is significant. To allow for future effluent pumping, disinfection, and high rate treatment to be located west of the WPF, the new oxic and post-anoxic basins required for this alternative would need to be located east of the WPF,

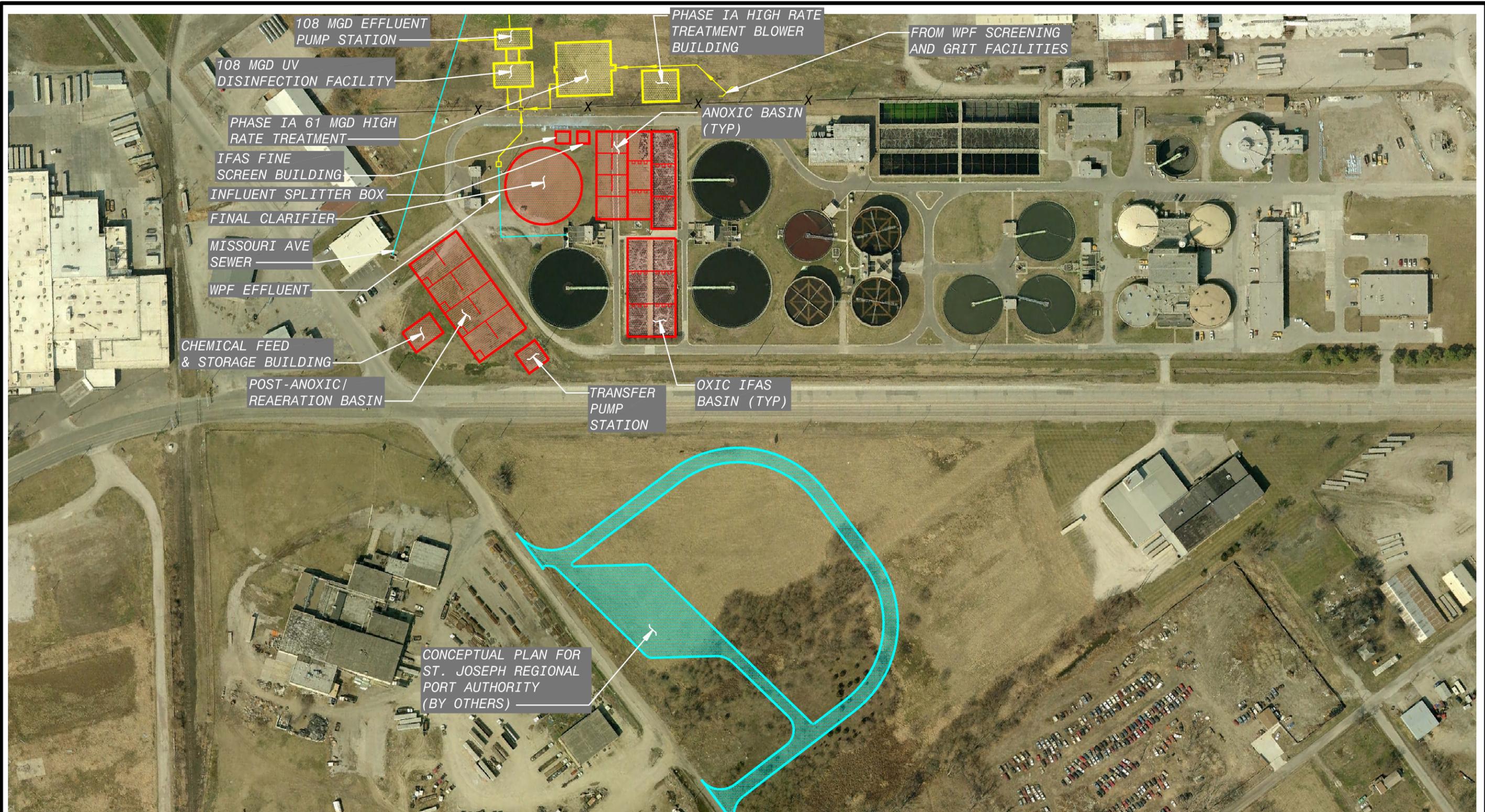
across State Route 759 (Stockyards Expressway). In addition, Alternative 2A would require a transfer pump station to get flows from the post-anoxic basins to the final clarifiers. The construction of this pump station and the vast new aeration basin zones make this alternative cost and space prohibitive when compared to the other alternatives with no significant additional benefit. As a result, Alternative 2A will be screened from further consideration and costs will not be developed for this alternative.

9.2.2 Alternative 2B – IFAS for Both Domestic and Industrial Flows

Alternative 2B utilizes IFAS media to decrease the oxic volume significantly from that required in Alternative 2A. Figure 15 presents a conceptual layout of facilities for Alternative 2B. In Alternative 2B, the overall oxic zone volume requirement can be satisfied with the three existing aeration basins as well as the previously planned fourth train aeration basin. The anoxic, post-anoxic, and reaeration zones would require new basins. By reducing the mixed liquor concentration from that in Alternative 2A, only one new final clarifier would be required. Preliminary sizing suggests that approximately 41 percent fill of media in the oxic zones is required for nitrification. Tables 19 and 20 summarize the IFAS basins and final clarifier sizing required for this alternative.

Table 19		
Alternative 2B – IFAS Basin Sizing		
Facilities	Per Train	Total
Activated Sludge Basin		
Anoxic Volume	0.38 MG	1.50 MG
Oxic Volume	1.27 MG	5.08 MG
Post-Anoxic Volume	0.90 MG	3.60 MG
Reaeration Volume	0.04 MG	0.15 MG
Total Volume	2.58 MG	10.33 MG
Anoxic Mixers		
Number	2	8
Horsepower, each	5.0 hp	5.0 hp
Post-Anoxic Mixers		
Number	2	8
Horsepower, each	12.0 hp	12.0 hp
Internal Recycle Pumps		
Number	1	4
Capacity, each	35 mgd	35 mgd

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FIGURE 15

Facilities	Per Train	Total
Aeration Requirements		
Annual Average	8,500 scfm	33,800 scfm
Maximum Month	11,600 scfm	46,400 scfm

Facilities	Value
Total Number of Clarifiers	4
Total Surface Area	80,424 ft ²
New Clarifiers	
Number	1
Diameter	160 ft
Surface Overflow Rate	
Average	265 gal/ft ² /day
Maximum Month	433 gal/ft ² /day
Solids Loading Rate	
Average	7.0 ppd/ft ²
Maximum Month	24.4 ppd/ft ²
RAS Pumping Rate	
Average	20 mgd
Maximum Month	34 mgd
WAS Pumping Rate	
Average	0.67 mgd
Maximum Month	0.92 mgd

In summary, the following major facilities are required to implement nitrification/denitrification using IFAS treatment of both industrial and domestic flows:

- New IFAS fine screen building
- New anoxic basins
- Oxidic basins with IFAS media (reuse existing aeration basin volume and build new basin)
- New post-anoxic/reaeration basins
- New transfer pump station
- New final clarifier

The chemical feed and storage systems for methanol (external carbon feed source) are discussed in Section 9.3 for all alternatives.

9.3 External Carbon Feed Requirements and Systems for All Alternatives

For most wastewater treatment facilities, the influent carbon to nitrogen ratio is adequate to meet effluent limits proposed for Phase III without adding an external carbon source to the process. Because the wholesale industrial waste streams contributing to the WPF have extremely high nitrogen loading, an external carbon source is required for further denitrification. Carbon would be dosed at the post-anoxic zone of the treatment process. The most common chemical used is methanol. The values presented in this evaluation are based on methanol, though other sources could be considered if available. Finding an appropriate local carbon source could significantly reduce the annual chemical cost associated with carbon supplementation of any of the proposed nitrification/denitrification alternatives. Table 21 presents the annual average methanol requirements for each alternative. The maximum month requirements were lower than the annual average in several scenarios because of the increase in BOD assumed during these high loading periods.

Process Alternative	Annual Average Requirement, gal/day
1A – Activated Sludge for Domestic Flows, Activated Sludge for Industrial Flows	3,200
1B – IFAS for Domestic Flows, Activated Sludge for Industrial Flows	3,400
1C – IFAS for Domestic Flows, MBR for Industrial Flows	3,250
2A – Activated Sludge for Both Domestic and Industrial Flows	3,400
2B – IFAS for Both Domestic and Industrial Flows	3,600

As the quantity of methanol utilized for each alternative is within 10 percent, the most conservative feed and storage system will be applied to all alternatives. Major facilities required for methanol addition include: five 5,600 gallon carbon steel floating roof storage tanks, explosion proof feed pumps, and feed piping. All methanol and ferric chloride feed (described previously) and storage facilities would be enclosed in a

combined chemical feed and storage building as shown in Figures 10, 11, 12, 14, and 15. Separate rooms would be provided for ferric chloride and methanol due to chemical safety and flammability concerns.

10.0 Aeration Evaluation

This evaluation is a follow-up to the blower investigation performed by Black & Veatch in 1995 and considers the anticipated aeration needs of future nutrient removal facilities to be constructed at the WPF. The study also evaluates the use of centrifugal blowers to replace the existing PD blowers when the existing PD blowers reach the end of their useful life or can no longer provide the needed airflow.

The WPF currently utilizes 13 PD blowers that have been in service for approximately 30 years. These PD blowers are divided between the aeration basin blower system and the WAS storage aeration system. The following sections provide the details of the existing blower systems.

Aeration Basin Blower System

The existing aeration basin blower system consists of eight Roots Model 1016 RAS-J rotary PD blowers with 200 horsepower (hp) motors. Six units are duty and two are standby. The blowers are divided into three pairs consisting of two blowers per pair. Each pair of blowers includes one duty blower initially equipped with a variable frequency drive (VFD) serving as the lead blower and one duty blower equipped with a constant speed motor and starter serving as the lag blower; however, the original VFDs are no longer functional and are not planned for replacement. The VFDs are bypassed and the blowers are run in constant speed mode requiring manual operation to meet daily aeration demands. Each pair of duty blowers is dedicated to each of the three existing aeration basins through a dedicated discharge header. The current operational practice is to turn blowers on and off based on the dissolved oxygen concentration as determined by manual readings of a dissolved oxygen analyzer that is monitored by plant staff once per shift.

The remaining two blowers (Blower No. 5 and No. 12) are the same capacity as the duty blowers and are standby units. These standby units are equipped with constant

speed motors and drives and can direct air to any of the three aeration basin discharge headers. Space is reserved within the Blower Building for the installation of two additional PD blowers. This space was originally provided for installation of blowers needed for a future fourth aeration basin. The capacity of the existing aeration basin blower system is shown in Table 22.

Table 22 Existing Aeration Basin Blower System Capacity		
	Per Aeration Basin	Total for 3 Aeration Basins
Firm Capacity, scfm		
Minimum ¹	1,980	5,940
Maximum	6,600	19,800
Total Capacity, scfm		
Minimum ²	15,840	21,120
Maximum	19,800	26,400 ³
1. Assumes a single PD blower with a functional VFD operating at turndown of 60%. 2. Assumes a VFD driven and a constant speed driven PD blower operating at full capacity and one standby unit operational in a basin. 3. Assumes all eight blowers operating at full capacity.		

WAS Storage Aeration System

The existing WAS storage aeration system consists of two Roots Model 1016 RAS-J rotary PD blowers with 200 hp constant speed motors and three Roots Model 1023 RAS-J rotary PD blowers with Caterpillar G353 dual-fuel gas-fired engine-drives. These engine-drives can operate on either methane from the anaerobic digesters or natural gas from the utility. The two electric motor-driven PD blowers are operated as the duty blowers supplying air to the WAS storage basins and the three engine-driven units are used as standby units. When used, the three engine-driven units are typically fueled with natural gas. The capacity of the existing WAS storage aeration system is shown in Table 23.

Table 23	
Existing WAS Storage Aeration System Capacity	
Firm Capacity, scfm	
Minimum ¹	4,950
Maximum ²	9,900
Total Capacity, scfm	
Maximum ³	24,750
WAS Storage Aeration Demand, scfm⁴	8,021
1. Assumes one constant speed electric motor-driven PD blower operating. 2. Assumes two constant speed electric motor-driven PD blowers operating. 3. Assumes two constant speed electric motor-driven PD blowers operating and three engine-driven PD blowers operating, unthrottled, at maximum capacity. 4. Assumes up to 30 scfm/1,000 cf of air demand to maintain 2 MG of completely mixed, fully aerated WAS in storage.	

A 14-inch interconnecting butterfly valve on the discharge aeration piping provides WPF operators the ability to interconnect the aeration basin system blowers and the WAS storage blowers, if desired. Therefore, all blowers could provide air to either complex. Figure 16 shows the combined blower capacity of the existing aeration systems compared to the highest total aeration demand of the future nitrification/denitrification configurations presented in the previous sections.

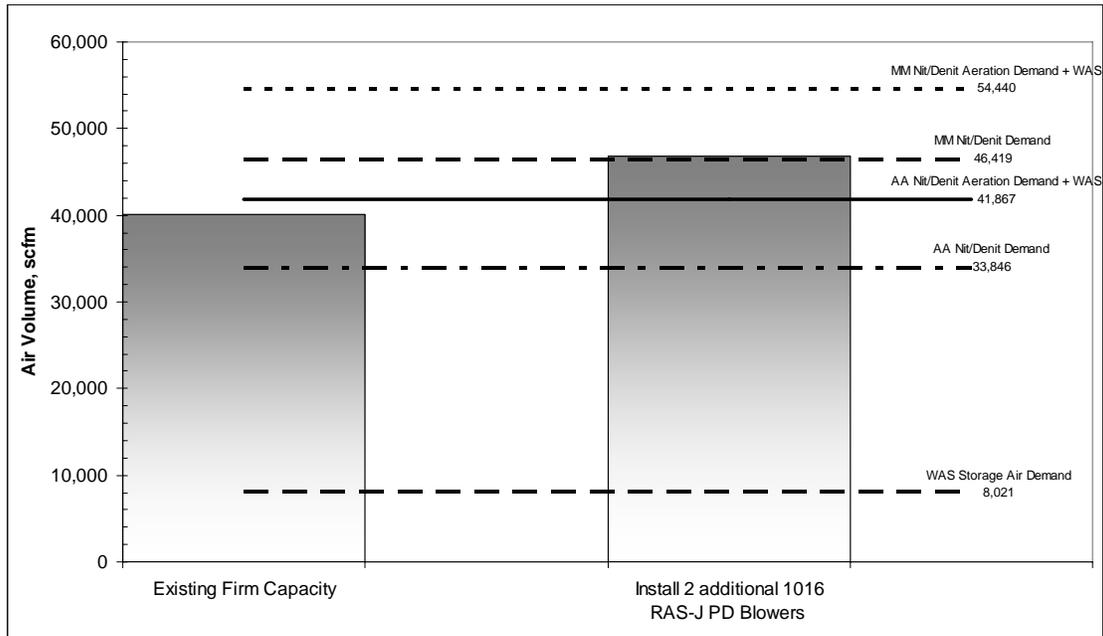


Figure 16 – Positive Displacement Blower Capacity Versus Aeration Demand

Based on the necessary air required to nitrify in the aeration basins and the need to maintain aerobic conditions in the WAS storage basins, Figure 16 shows that there is not enough blower capacity to meet the maximum month or peak day aeration demand, even if additional PD blowers are installed in the space reserved for future blowers in the Blower Building. Unless a significant reduction in wastewater load occurs, it would not be possible to meet the future aeration demands using the existing PD blowers or by installing additional PD blowers in the available space in the Blower Building. To provide enough aeration capacity to meet maximum month aeration demands and WAS storage needs using PD blowers, five additional 1061 RAS-J blowers would be required. Five additional blowers would require an expansion to the existing Blower Building.

Positive displacement blowers are generally best for applications involving small air volumes and variable discharge pressures from fluctuating water elevations, such as WAS storage basins. For large air volumes, such as required for the aeration basins, centrifugal blowers are often more economical.

One alternative that would allow the WPF to continue to benefit from the investment in the existing PD blowers would be to continue to use Blower Nos. 6 and 7 and the engine-driven Blower Nos. 13, 14, and 15 for WAS storage aeration, remove the remaining PD blowers, and install centrifugal blowers to meet the future aeration basin air demand. Installing centrifugal blowers within the same building footprint may be feasible with some modifications to the existing Blower Building.

There are several centrifugal blower technologies currently on the market; however the most common blowers used for aeration of activated sludge processes in wastewater treatment plants are multi-stage centrifugal blowers and single-stage centrifugal blowers. Multi-stage centrifugal blowers typically have lower initial capital costs and higher energy consumption than single-stage centrifugal blowers. Single-stage centrifugal blowers are more efficient than multi-stage centrifugal blowers, but employ a more complex design with a greater number of precision moving parts. This usually results in a more expensive initial capital cost for single-stage centrifugal blowers than for multi-stage centrifugal blowers. Photographs of a typical multi-stage blower and a single-stage blower are shown in Figures 17 and 18.



Figure 17 – Multi-Stage Centrifugal Blower (Gardner Denver)



Figure 18 – Single-Stage Centrifugal Blower (Turblex)

A comparison analysis of both types of aeration blowers was performed for the air volumes required for the WPF. The analysis investigated three different configuration options for aeration blowers based on an air flow requirement of 33,800 scfm which is the highest estimated annual average air demand of the nitrification/denitrification

alternatives considered to treat 20.4 mgd through secondary treatment at the WPF. While specific air requirements for nitrification/denitrification were utilized in this analysis, the air requirements for nitrification only result in a similar capacity and number of blowers. The results of this analysis apply to both treatment scenarios.

The three different options included:

- Option 1. Five multi-stage centrifugal blowers with inlet valve throttling for aeration capacity control.
- Option 2. Five multi-stage centrifugal blowers with AFDs for aeration capacity control.
- Option 3. Five single-stage centrifugal blowers (Turblex model KA22SV-GL225).

The blower coverage chart for Options 1 and 2 is shown in Figure 19, while the coverage chart for Option 3 is shown in Figure 20. Options 1 and 2 utilize the same capacity multi-stage blowers resulting in the same blower coverage for both options.

Multi-stage centrifugal blowers can typically be turned down to 60 percent of the rated capacity. Under certain conditions, normally during night-time diurnal minimum aeration demands, this 60 percent turn down capacity may result in a “gap” in blower coverage that may cause over-aeration (wasting electricity) or under-aeration (potentially detrimental to the aeration process). This coverage “gap” is shown in Figure 19. Actual minimum turndown aeration demands have not been determined. For purposes of this evaluation, minimum turndown is shown as one blower operating at the minimum turndown of 6,990 scfm. If actual minimum turndown requirements are determined to be higher than the operational range of one blower, then the “gap” in coverage may not be a concern.

Single-stage centrifugal blowers can be turned down to 45 percent of the rated capacity due to the adjustable inlet and diffuser guide vanes on the blower inlet. This 45 percent turn-down capacity allows the single-stage centrifugal blower to eliminate the “gap” in coverage experienced by multi-stage units.

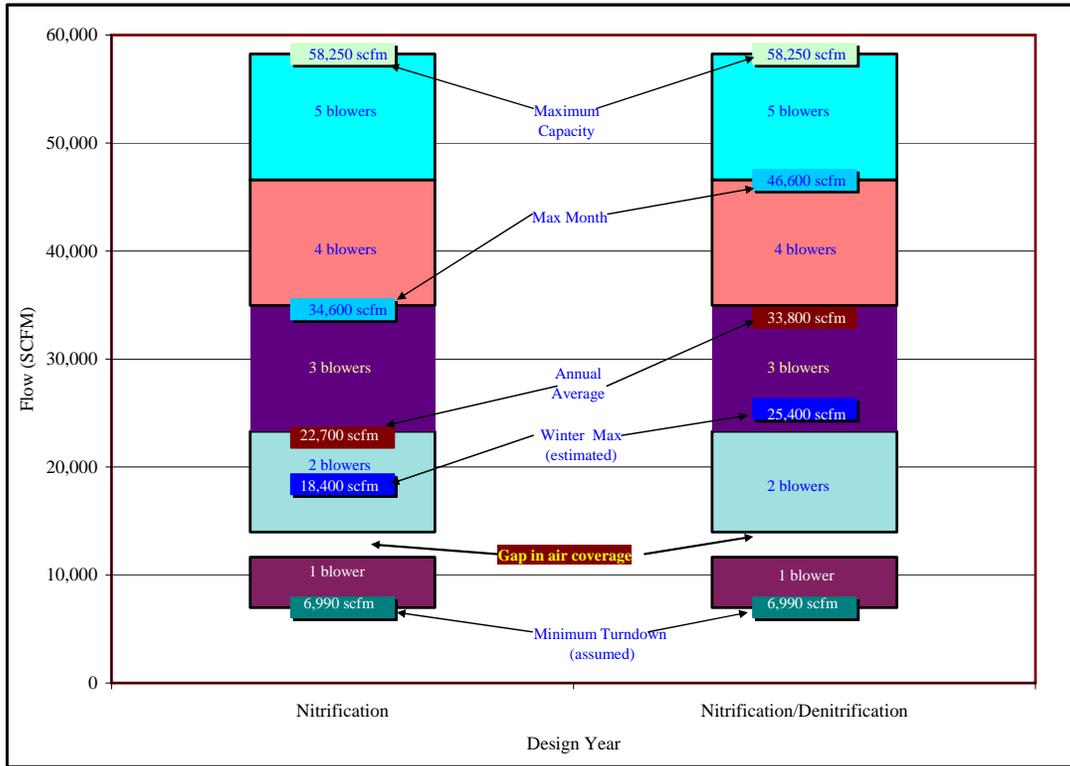


Figure 19 – Multi-Stage Blower Coverage Chart

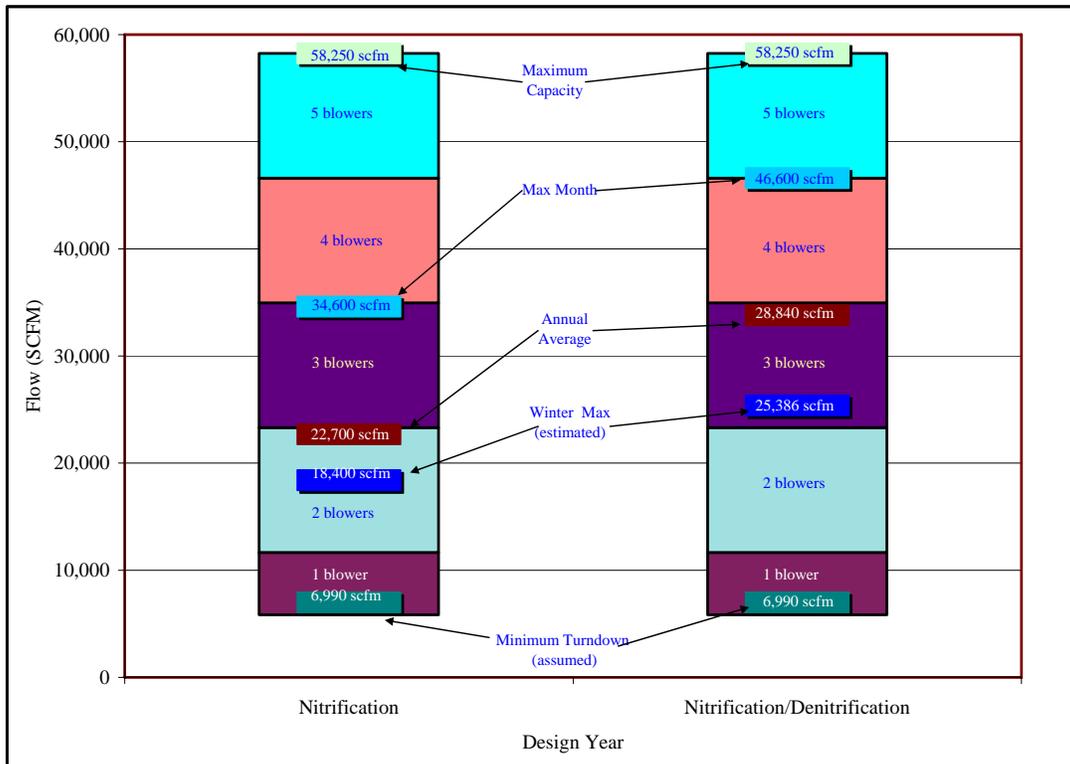


Figure 20 – Single-Stage Blower Coverage Chart

Table 24 presents the results of the comparison of multi-stage and single-stage centrifugal blowers. As indicated in Table 24, the total present worth of the multi-stage blower systems is higher than the single-stage blower systems even though the initial capital costs would be less if using multi-stage blowers.

Table 24			
Comparison of Multi-Stage and Single-Stage Centrifugal Blowers			
	Option 1 5 Multi-Stage Blowers with Inlet Valve Throttling	Option 2 5 Multi-Stage Blowers with AFD Control	Option 3 5 Single-Stage Blowers
Capital Cost ¹	\$1,862,400	\$2,878,700	\$2,906,900
Annual Power and O&M Costs (2009 dollars) ²	\$1,550,400	\$1,442,700	\$1,351,500
Payback Period ³	Baseline	9.4 years	5.3 years
Present Worth of Annual Power and O&M Costs (20 years) ^{4,5}	\$25,451,600	\$23,680,200	\$22,179,900
Total Present Worth	\$27,314,000	\$26,558,900	\$25,086,800
Percent Savings of Total Present Worth	Baseline	2.8%	8.1%
<ol style="list-style-type: none"> 1. Installed cost of equipment plus valves without allowances for building modifications, mechanical, electrical, instrumentation and controls (I&C), sitework, general requirements, contingency, or engineering, legal, and administration. 2. Electrical costs based on nitrification/denitrification process air demands. 3. Payback period is considered to be the additional years required to pay back the higher capital cost with savings from lower annual power costs beyond that of the lowest capital cost "baseline" condition. 4. Based on a power cost of \$0.10/kWhr and an average labor rate of \$32.78/hour, both calculated at an annual inflation rate of 5%. 5. For purposes of this analysis, the following yearly process air demand and power draws were considered: <ul style="list-style-type: none"> Peak Day (Maximum Capacity) Summer Conditions: 1% of each year Maximum Month Summer Conditions: 11% of each year Maximum Month Winter Conditions: 3% of each year Annual Average Conditions: 68% of each year Nightly Minimum Turndown: 17% of each year 			

From Table 24, it can be seen that the present worth of Option 3 is the lowest cost option; however, the life cycle cost of multi-stage blowers with AFDs was within 10 percent of the lowest cost option. At this level of study, the two options are considered equivalent from a life cycle cost perspective. City staff has concerns with maintenance issues associated with AFDs. Therefore, the recommended replacement alternative for the existing PD blowers is five single-stage centrifugal blowers. It is

recommended that the existing PD blowers continue to be used to provide aeration until they reach the end of their service life or they are no longer able to meet the aeration needs of future facilities. During detailed design of the blower replacement project, evaluation of the use of multi-stage blowers with eddy current drives should be considered as an alternative to the single stage blowers. It is anticipated that the costs associated with the use of eddy current drives will be comparable to the costs presented in this memorandum.

11.0 Evaluation of Alternatives

The following sections describe the evaluation of the recommended alternative for nitrification as well as the four alternatives considered for full nitrification, denitrification, and total phosphorous removal.

11.1 Economic Evaluation

The economic evaluation of each of the alternatives was based on life cycle costs using a 20-year present worth basis. The following sections present the capital and O&M costs developed for the various regulatory phases of implementation.

11.1.1 Phase I – Nitrification (Ammonia Removal)

11.1.1.1 Opinion of Probable Project Costs. A conceptual cost estimating methodology was employed to develop capital project costs for nitrification. All project costs are given in May 2009 dollars (Engineering News Record (ENR) Building Cost Index (BCI) equal to 4773). Table 25 provides a summary of the opinion of probable project costs for the recommended nitrification alternative.

Table 25	
Summary of Opinion of Probable Project Costs for Recommended Nitrification Alternative ¹	
Item	\$
Domestic Aeration Basins	147,000
Industrial Aeration Basins	1,979,000
Industrial Final Clarifier	1,678,000
Industrial RAS/WAS Pump Station	1,630,000
Blowers	4,250,000
Flood Protection/Fill (placeholder) ²	--
Site Remediation (placeholder) ²	--
<i>Subtotal</i>	<i>9,684,000</i>
Electrical, I&C, Sitework, Contractor General Requirements ³	5,230,000
<i>Subtotal</i>	<i>14,914,000</i>
Contingency ⁴	3,729,000
Land Acquisition (placeholder) ^{2,5}	--
Opinion of Probable Construction Cost	18,643,000
Engineering, Legal, and Administration ⁶	3,729,000
Opinion of Total Project Cost	22,370,000
Potential Add-Ons (Total Project Cost)	
Concrete Line Industrial Aeration Basins	6,750,000
Refurbish Industrial Aeration Basin Beams	1,400,000
Upsize Final Clarifier for Future Nutrient Removal Needs (120 ft to 160 ft diameter)	1,990,000
Raise Industrial Aeration Basin Walls for Future Nutrient Removal Needs (2 ft to 4 ft)	380,000
<ol style="list-style-type: none"> 1. All costs presented in May 2009 dollars (ENR BCI = 4773). 2. Currently, no site related costs are anticipated; however, site related costs are placeholders and must be revised following final siting of the facilities. 3. Electrical and instrumentation and controls (I&C) projected at 25% of the total of all equipment and structure costs. Sitework projected at 10% of the total of equipment, structures, electrical, and I&C costs. Contractor general requirements projected at 12% of the total of equipment, structures, electrical, I&C, and sitework costs. 4. Project contingency is projected at 25% of the total of all equipment, structures, electrical, I&C, sitework, contractor general requirements, flood protection/fill, and site remediation costs. 5. No land acquisition is anticipated for this alternative. 6. Engineering, legal, and administration (ELA) costs are projected at 20% of the total of all equipment, structures, electrical, I&C, sitework, contractor general requirements, flood protection/fill, site remediation costs, contingency, and land acquisition. 	

The required basin volumes were developed through the use of process modeling with BioWin software by EnviroSim Associated Ltd. Aeration requirements were modeled using the model as developed by Black & Veatch (1993).

Basin costs were based upon Black & Veatch project experience and unit prices appropriate for use in St. Joseph. Consistent with construction history at the WPF, it was assumed that all new basins would need to be constructed on piles. Piles were assumed to be 70 feet deep based on the 2004 DRG/CDM Wastewater Treatment Plant Expansion, R-32 project drawings and the 1973 Geotechnical Report by L. Robert Kimball.

Coarse bubble diffusers were priced for the domestic aeration basin alternatives to allow for conversion to IFAS media in the future when transition to full nitrification/denitrification is required. Fine bubble diffusers were utilized in the industrial aeration basin alternatives. Equipment costs for the diffusers were based on recent Black & Veatch project experience. Diffuser installation was projected at 20 percent of the diffuser cost. If desired, the City could add additional membrane diffusers to the existing aeration basins to avoid installation of a new diffuser system; however, costs provided represent installation of a new diffuser system.

Blower costs developed in Section 10.0 are included. For simplicity, the highest blower capital cost has been utilized for the development of Phase I improvement costs as the blower costs do not vary too widely by alternative and selection of a blower alternative is an independent decision from that of process treatment options. The cost presented in Section 10.0 has been increased to \$4.25 million to include the blowers, valves, piping, and required building modifications. Based on the current, worst-case nitrogen loadings, the existing PD blowers could not meet nitrification annual maximum month and peak day aeration rates. As a result of this analysis, new blowers, piping, and structural modifications are included as part of the nitrification improvements shown in Table 25. If influent nitrogen loadings are sufficiently reduced to allow the existing positive displacement blowers to reliably meet the air requirements, the need for new blowers could be postponed until the existing blowers reach the end of their service life.

In addition to structure and equipment costs estimated directly, other construction costs were projected by applying a percentage to appropriate project costs as indicated in Footnotes 3 and 4 of Table 25. The cost for electrical and instrumentation and controls

(I&C) was projected at 25 percent of the cost of equipment, installation, and structures. This electrical and I&C cost does not include any new or back-up power feeds; these facilities will be evaluated in TM-WW-9 – Site Considerations, Utility Improvements, and Ancillary Facilities. An allowance of 10 percent was applied for project sitework. Contractor general requirements were projected at 12 percent and contingency was set at 25 percent. Costs related to engineering, legal, and administration are reflected in a 20 percent multiplier applied to all construction costs. No site related costs are anticipated for construction of this alternative; all facilities should be constructed within the existing WPF fence-line. If final siting relocates any facilities outside the existing WPF property, site-related costs would need to be revisited.

Table 25 also includes the costs for several potential project add-ons. These items represent additional project costs that are not part of the base project needs, but may be required based on the results of additional study or City preferences. The existing aerobic digesters include steel beams, some of which have failed and fallen into the basins. The reason for adding these beams to the aerobic digesters was not documented in the construction record drawings or any other known source. As a result, there are questions regarding the structural integrity of these basins. A cost for the removal, sandblasting, epoxy painting, and reattachment of these beams with stainless steel connections is provided as an add-on in the event that additional structural analysis of these basins indicates the beams are necessary. In the event the structural analysis indicates refurbishing the existing beams is not sufficient, an add-on cost has also been provided for complete structural concrete lining of these basins. This is an expensive option and should be considered a last resort. If lining of the basins is deemed necessary, an investigation of the existing basin piling should be conducted to ensure the piles can handle the additional concrete.

Add-on costs have also been provided in the event the City wants to make additional modifications to the facility that are not specifically required for the nitrification facilities, but will be required for the future nitrification/denitrification facilities. For example, a 120 foot diameter industrial final clarifier is required for the nitrification project, but a 160 foot diameter clarifier is required for nitrification/denitrification. Due to site space constraints, the City may opt to build the

larger clarifier as part of the nitrification project to accommodate future needs. Similarly, the walls of the existing aerobic digesters need to be increased by two feet to accommodate the water level required for the nitrification alternative; however, these walls must be increased by four feet to accommodate water levels for the nitrification/denitrification project. The City may determine it is more economical to add the extra wall height during the construction of the initial nitrification project. Prior to committing to any of the “buy-up” options for future projects, the City should revisit the nitrogen influent loading projections; if it is anticipated the nitrogen loading could reduce significantly, the facilities required for complete nitrification/denitrification may reduce substantially.

Appendix A presents additional details of the development of the conceptual project costs.

11.1.1.2 Opinion of Probable Operations and Maintenance Costs. Total O&M costs were developed for the recommended nitrification alternative. O&M costs were developed based on the unit costs presented in Table 26. Unit costs shown in Table 26 for power and labor were provided by the City. Annual O&M costs were determined by applying the unit costs to O&M requirements based on usage estimates for 4.8 mgd annual average flow through the industrial train and total flow of 20.4 mgd through the WPF downstream of the primary clarifiers. Table 27 provides a summary of the opinion of probable O&M costs for the recommended alternative.

Table 26	
Recommended Nitrification Alternative O&M Unit Costs ¹	
Power ²	\$0.10/kW-hr
Labor (including benefits and overhead) ²	\$32.78/hr
1. All costs provided in May 2009 dollars.	
2. Units costs based on data provided by the City.	

Table 27	
Annual O&M Costs for Recommended Nitrification Alternative	
	\$
Power	1,032,000
Labor	48,000
Total	1,080,000

11.1.1.3 Opinion of Probable Net Present Worth Costs. The project capital and O&M costs presented previously for the recommended nitrification alternative were utilized to develop the associated life cycle cost. The present worth provides the equivalent amount of money that must be invested at a given interest rate at the start of the project in order to provide all funds necessary to construct, operate, and maintain the facilities and equipment throughout the design life of the project. The net present worth of an alternative is the sum of the present worth of the project capital and O&M costs less any remaining value of facilities at the end of the project’s design life. By capturing both project capital and O&M expenses associated with the project, the net present worth method allows the City to understand the full life cycle cost associated with the alternatives.

Table 28 presents a summary of the estimated net present worth costs developed for the recommended alternative. A 20-year design life was utilized in the present worth calculations; 2009 was assumed as “Year 0” for consistency of present worth calculations throughout the Facilities Plan. A five percent interest rate was applied. Service life for determination of replacement frequency and salvage value was estimated as follows: structures – 50 years and equipment, electrical, instrumentation and controls – 20 years. Appendix B provides further details of the net present worth development.

Table 28	
Net Present Worth for Recommended Nitrification Alternative ¹	
	\$
Net Project Capital Present Worth ²	19,092,000
O&M Present Worth ³	21,600,000
Total Net Present Worth	40,692,000
1. Costs given in May 2009 dollars. Present worth calculated with 20-year life cycle costs at 5% interest. 2. Net project capital present worth represents the present worth of project costs less the remaining value of facilities at the end of the 20-year life cycle. Service life for determination of replacement frequency and salvage value was projected as follows: structures – 50 years; equipment, electrical, instrumentation and controls – 20 years. 3. O&M costs were assumed to escalate at 5% per year.	

11.1.2 Phases II and III – Nitrification, Denitrification, and Total Phosphorous Removal

Costs for Phase II and III improvements will be presented simultaneously in the following sections for simplicity and because it is possible that the order of implementation of these phases may change.

11.1.2.1 Opinion of Probable Project Costs. A conceptual cost estimating methodology was employed to develop capital project costs for the alternatives considered. All project costs are given in May 2009 dollars (ENR BCI equal to 4773). Table 29 provides a summary of the opinion of probable project costs for the nutrient removal alternatives. The costs reflected in Table 29 are total project costs for all facilities required for the Phase II and III nitrification, denitrification, and total phosphorous removal improvements. Some of the improvements required for Phases II and III could be implemented as part of the Phase I nitrification improvements. If this is the case, the actual project cost for Phases II and III would be reduced. A recommended implementation schedule and cost break-down by phase is provided later in this technical memorandum.

Table 29
Summary of Opinion of Probable Project Costs for Nitrification, Denitrification, and Phosphorous Removal ¹

Item	Alternative 1A Domestic Activated Sludge, Industrial Activated Sludge, \$	Alternative 1B Domestic IFAS, Industrial Activated Sludge, \$	Alternative 1C Domestic IFAS, Industrial MBR, \$	Alternative 2B Combined IFAS, \$
Domestic Anoxic Basins	4,710,000	--	--	4,399,000
Domestic Oxidic Basins	3,884,000	--	--	--
Domestic Final Clarifier	2,537,000	--	--	2,537,000
Industrial Aeration Basins	5,782,000	5,782,000	--	--
Transfer Pump Station	--	--	--	7,845,000
Industrial Final Clarifier	2,537,000	2,537,000	--	--
Industrial RAS/WAS Pump Station	1,630,000	1,630,000	--	--
Domestic IFAS Basins	--	6,032,000	6,032,000	12,540,000
IFAS Screen Building	--	1,441,000	1,441,000	1,895,000
Industrial MBR Basins	--	--	15,889,000	--
MBR Screen Facility	--	--	1,421,000	--
Combined Post-Anoxic Basins	--	--	--	6,381,000
Chemical Feed and Storage Building (Methanol)	1,591,000	1,591,000	1,591,000	1,591,000
Methanol Injection Piping	300,000	300,000	232,000	64,000
Chemical Feed and Storage Building (Ferric Chloride)	1,168,000	1,168,000	1,168,000	1,168,000
Ferric Chloride Injection Piping	42,000	42,000	42,000	14,000
Blowers	4,250,000	4,250,000	4,250,000	4,250,000
Flood Protection/Fill (placeholder) ²	--	--	--	--
Site Remediation (placeholder) ²	667,000	667,000	667,000	2,190,000
<i>Subtotal</i>	<i>29,098,000</i>	<i>25,440,000</i>	<i>32,733,000</i>	<i>44,874,000</i>

Table 29
Summary of Opinion of Probable Project Costs for Nitrification, Denitrification, and Phosphorous Removal ¹

Item	Alternative 1A Domestic Activated Sludge, Industrial Activated Sludge, \$	Alternative 1B Domestic IFAS, Industrial Activated Sludge, \$	Alternative 1C Domestic IFAS, Industrial MBR, \$	Alternative 2B Combined IFAS, \$
Electrical, I&C, Sitework, Contractor General Requirements ³	15,353,000	13,378,000	17,316,000	23,050,000
<i>Subtotal</i>	<i>44,451,000</i>	<i>38,818,000</i>	<i>50,049,000</i>	<i>67,924,000</i>
Contingency ⁴	11,113,000	9,704,000	12,512,000	16,981,000
Land Acquisition (placeholder) ^{2,5}	32,000	32,000	32,000	105,000
Opinion of Probable Construction Cost	55,596,000	48,554,000	62,593,000	85,010,000
Engineering, Legal, and Administration ⁶	11,119,000	9,710,000	12,519,000	17,002,000
Opinion of Total Project Cost	66,715,000	58,264,000	75,112,000	102,012,000
Potential Add-Ons (Total Project Cost)				
Concrete Line Industrial Aeration Basins	10,050,000	10,050,000	6,750,000	--
Refurbish Industrial Aeration Basin Beams	2,160,000	2,160,000	1,440,000	--
Add WAS Storage	10,530,000	10,530,000	--	--

1. All costs presented in May 2009 dollars (ENR BCI = 4773).
2. Site related costs are placeholders and must be revised following final siting of the facilities. Site related costs are provided for chemical feed and storage, activated sludge basin volume, and transfer pump station as required by alternative.
3. Electrical and instrumentation and controls (I&C) projected at 25% of the total of all equipment and structure costs. Sitework projected at 10% of the total of equipment, structures, electrical, and I&C costs. Contractor general requirements projected at 12% of the total of equipment, structures, electrical, I&C, and sitework costs.
4. Project contingency is projected at 25% of the total of all equipment, structures, electrical, I&C, sitework, contractor general requirements, flood protection/fill, and site remediation costs.
5. Land acquisition cost is based on a projection provided by the City from a recent purchase of land directly south of the WPF.
6. Engineering, legal, and administration (ELA) costs are projected at 20% of the total of all equipment, structures, electrical, I&C, sitework, contractor general requirements, flood protection/fill, site remediation costs, contingency, and land acquisition.

The required basin volumes were developed through the use of process modeling with BioWin software by EnviroSim Associated Ltd. Aeration requirements were modeled using the model as developed by Black & Veatch (1993).

Basin costs were based upon Black & Veatch project experience and unit prices appropriate for use in St. Joseph. Consistent with construction history at the WPF, it was assumed that all new basins would need to be constructed on piles. Piles were assumed to be 70 feet deep based on the 2004 DRG/CDM Wastewater Treatment Plant Expansion, R-32 project drawings and the 1973 Geotechnical Report by L. Robert Kimball.

Coarse bubble diffusers were utilized for activated sludge basins containing IFAS media; fine bubble diffusers were utilized for other activated sludge basins. Equipment costs for the diffusers were based on recent Black & Veatch project experience. Diffuser installation was projected at 20 percent of the diffuser cost. The existing membrane diffusers would not be adequate for the total nitrification/denitrification configurations.

Aeration rates required for nitrification/denitrification are similar enough to those required for nitrification only to utilize the same blower configuration; thus, the same blower cost is shown in Table 29 as was reflected for the recommended nitrification alternative.

In addition to structure and equipment costs estimated directly, other construction costs were projected by applying a percentage to appropriate project costs as indicated in Footnotes 3 and 4 of Table 29. The cost for electrical and I&C was projected at 25 percent of the cost of equipment, installation, and structures. This electrical and I&C cost does not include any new or back-up power feeds; these facilities will be evaluated in TM-WW-9. An allowance of 10 percent was applied for project sitework. Contractor general requirements were projected at 12 percent and contingency was set at 25 percent. Costs related to engineering, legal, and administration are reflected in a 20 percent multiplier applied to all construction costs.

Additional site related costs are also reflected in the capital costs given in Table 29. The costs reflected in the table are shown as placeholders as the final site location of the nutrient removal facilities must be known in order to provide a more accurate projection of the site associated costs. Additional site area required for each alternative was estimated as the footprint of any building or structures required for the

alternative plus a 50-foot buffer around the facility. Structures anticipated to be constructed outside of the existing WPF fence-line include the chemical feed and storage building for all alternatives as well as additional WAS storage, additional activated sludge basin volume, and a transfer pump station, as appropriate to the other alternatives. As all additional property required is anticipated to be contiguous to the existing WPF fence-line, it is estimated that no additional site fill is required for flood protection. As most of the potential locations for siting additional facilities are located on industrial land with unknown environmental history, a placeholder for site remediation was included. A unit cost of \$150 per cubic yard of soil removed, considering a five foot depth over the area of the site, was used. This number should be considered as only a placeholder as site remediation costs are very specific to the site location and type of contamination encountered. Likewise, land acquisition costs were estimated at \$1.33 per square foot (sq ft) based on preliminary guidance from the City; this value was based on the purchase price of the property located to the south of the WPF. Actual land costs may vary significantly based on the site chosen. Determination of site related costs must be revisited once the actual site selection(s) have been finalized.

Table 29 also includes the costs for several potential project add-ons. As discussed in Section 11.1.1.1, potential project add-on costs have been included for refurbishing the beams in the existing aerobic digesters or concrete lining of the utilized basins if deemed necessary by future structural investigation. In addition, a cost for a new basin to provide the existing WAS storage volume is included for alternatives which utilize all six of the existing aerobic digesters (two basins are currently used for WAS holding) for the industrial activated sludge basins. This add-on provides the City with the cost for replacing the existing WAS holding volume for alternatives which remove this flexibility from the system.

As shown in Table 29, Alternative 1B – IFAS for Domestic Flows, Activated Sludge for Industrial Flows has the lowest associated project costs. This alternative is 15 percent lower than the next lowest cost alternative, Alternative 1A – Activated Sludge for Domestic Flows, Activated Sludge for Industrial Flows. At this level of study, project costs within 10 percent of each other would be considered equivalent alternatives.

Alternative 1B is more than 10 percent less expensive than the next closest alternative and thus is considered the lowest cost alternative on the basis of overall project cost.

Appendix A presents additional details of the development of the conceptual project costs.

11.1.2.2 Opinion of Probable Operations and Maintenance Costs. Total O&M costs were developed for each of the nitrification, denitrification, and total phosphorous removal alternatives. O&M costs were developed based on the unit costs presented in Table 30. Unit costs shown in Table 30 for power and labor were provided by the City. Annual O&M costs for each alternative were determined by applying the unit costs to O&M requirements based on usage estimates for 4.8 mgd annual average flow through the industrial train and 15.6 mgd of flow through the domestic train. Table 31 provides a summary of the opinion of probable O&M costs for each alternative.

Table 30 Nitrification, Denitrification, and Total Phosphorous Removal O&M Unit Costs ¹	
Power ²	\$0.10/kW-hr
Labor (including benefits and overhead) ²	\$32.78/hr
Methanol	\$2.00/gal
Ferric Chloride	\$0.15/lb
1. All costs provided in May 2009 dollars. Except for those indicated as City provided, all unit costs based on Black & Veatch project experience. 2. Units costs based on data provided by the City.	

Table 31 Annual O&M Costs for Nitrification, Denitrification, and Total Phosphorous Removal				
	Alternative 1A Domestic Activated Sludge, Industrial Activated Sludge, \$	Alternative 1B Domestic IFAS, Industrial Activated Sludge, \$	Alternative 1C Domestic IFAS, Industrial MBR, \$	Alternative 2B Combined IFAS, \$
Power	1,859,000	1,849,000	2,576,000	2,170,000
Labor	144,000	144,000	168,000	96,000
Chemicals	2,506,000	2,651,000	2,544,000	2,785,000
Total	4,509,000	4,644,000	5,288,000	5,051,000

As shown in Table 31, the annual O&M cost of Alternative 1A – Activated Sludge for Domestic Flows, Activated Sludge for Industrial Flows and Alternative 1B – IFAS for Domestic Flows, Activated Sludge for Industrial Flows are within 10 percent of each other and are considered equivalent at this level of study.

11.1.2.3 Opinion of Probable Net Present Worth Costs. The project capital and O&M costs presented previously for the nutrient removal alternatives were utilized to develop the associated life cycle cost. The present worth provides the equivalent amount of money that must be invested at a given interest rate at the start of the project in order to provide all funds necessary to construct, operate, and maintain the facilities and equipment throughout the design life of the project. The net present worth of an alternative is the sum of the present worth of the project capital and O&M costs less any remaining value of facilities at the end of the project’s design life. By capturing both project capital and O&M expenses associated with the project, the net present worth method allows the City to understand the full life cycle costs associated with each of the alternatives.

Table 32 presents a summary of the estimated net present worth costs developed for each alternative. A 20-year design life was utilized in the present worth calculations; 2009 was assumed as “Year 0” for consistency of present worth calculations throughout the Facilities Plan. A five percent interest rate was applied. Service life for determination of replacement frequency and salvage value was estimated as follows: structures – 50 years and equipment, electrical, instrumentation and controls – 20 years.

	Alternative 1A Domestic Activated Sludge, Industrial Activated Sludge, \$	Alternative 1B Domestic IFAS, Industrial Activated Sludge, \$	Alternative 1C Domestic IFAS, Industrial MBR, \$	Alternative 2B Combined IFAS, \$
Net Project Capital Present Worth ²	50,982,000	45,734,000	65,855,000	74,257,000
O&M Present Worth ³	90,180,000	92,880,000	105,760,000	101,020,000
Total Net Present Worth	141,162,000	138,614,000	171,615,000	175,277,000

Table 32				
Net Present Worth for Nitrification, Denitrification, and Total Phosphorous Removal ¹				
	Alternative 1A Domestic Activated Sludge, Industrial Activated Sludge, \$	Alternative 1B Domestic IFAS, Industrial Activated Sludge, \$	Alternative 1C Domestic IFAS, Industrial MBR, \$	Alternative 2B Combined IFAS, \$
1. Costs given in May 2009 dollars. Present worth calculated with 20-year life cycle costs at 5% interest. 2. Net project capital present worth represents the present worth of project costs less the remaining value of facilities at the end of the 20-year life cycle. Service life for determination of replacement frequency and salvage value was projected as follows: structures – 50 years; equipment, electrical, instrumentation and controls – 20 years. 3. O&M costs were assumed to escalate at 5% per year.				

As shown in Table 32, the net present worth of Alternative 1A – Activated Sludge for Domestic Flows, Activated Sludge for Industrial Flows and Alternative 1B – IFAS for Domestic Flows, Activated Sludge for Industrial Flows are within 10 percent of each other and are considered equivalent at this level of study. A review of the non-economic factors will be utilized in conjunction with the results of the economic analysis to determine the recommended nutrient removal alternative. Appendix B provides further details of the net present worth development.

11.2 Non-Economic Considerations

Many important factors beyond cost affect a facility planning decision. For nitrification, only one cost-effective, stable alternative emerged; however, for the nitrification, denitrification, total phosphorous removal process, several viable alternatives emerged. Aside from economic differentiators, there are several advantages/disadvantages of each of the alternatives. This section will focus on the advantages/disadvantages of the alternatives with separate industrial and domestic treatment trains due to the cost prohibitive nature of the combined alternatives. Table 33 provides a summary of some of the advantages/disadvantages of the separate nutrient removal alternatives.

Table 33 Advantages/Disadvantages of Separate Nutrient Removal Technologies			
	Alternative 1A Domestic Activated Sludge, Industrial Activated Sludge	Alternative 1B Domestic IFAS, Industrial Activated Sludge	Alternative 1C Domestic IFAS, Industrial MBR
Advantages	<ul style="list-style-type: none"> • One process utilized for both applications 	<ul style="list-style-type: none"> • IFAS operation relatively simple • Reduced basin volume, improved constructability and site space availability 	<ul style="list-style-type: none"> • No industrial final clarifier required • Maintains existing WAS storage capability • MBR process not impacted by solids settleability
Disadvantages	<ul style="list-style-type: none"> • Requires new industrial and domestic final clarifiers • Constructability and site space constraints due to additional basin volume required • Industrial activated sludge basin volume utilizes existing WAS storage volume 	<ul style="list-style-type: none"> • Requires new industrial final clarifier • Industrial activated sludge basin volume utilizes existing WAS storage volume • IFAS system requires additional screens (6 mm) 	<ul style="list-style-type: none"> • MBR introduces another significantly different operational process • MBR has increased mechanical complexity • MBR system requires fine screens (1-2 mm) • Membrane scouring air increases operational costs

Based on the information presented in Table 33, Alternative 1B – IFAS for Domestic Flows, Activated Sludge for Industrial Flows emerges as the recommended alternative based on non-economic considerations. This alternative represents the best balance between reduced basin volume and ease of operability of the system. The use of MBR technology in Alternative 1C adds significant complexity to the system, which is avoided in Alternative 1B. In contrast, Alternative 1A offers the simplest operation, but requires significant additional basin volume to accomplish the same level of treatment.

12.0 Conclusions and Recommendations

MDNR established an ammonia limitation for the first time for the St. Joseph WPF in its NPDES permit dated June 19, 2009. It is anticipated that future permits may impose more stringent ammonia limits and will, eventually, include total nitrogen and

phosphorous limitations as well. Nutrient removal alternatives to meet the anticipated phasing of regulatory requirements were evaluated. The sections that follow discuss conclusions and recommendations related to influent nitrogen loads, the phased implementation of nutrient removal facilities, and outcomes of the aeration evaluation.

12.1 Influent Nitrogen Loading

The WPF receives significant influent nitrogen loadings, primarily from its wholesale industrial customers, SSJISD, NBL, and TF. The significant nitrogen loading received by the WPF drives the need for complex nutrient removal facilities and considerable quantities of external carbon in order to meet anticipated regulatory limits. The City is currently working with the source industries to try to reduce nitrogen loading to the WPF, which could significantly reduce the complexity and cost of treatment facilities required to meet future regulations. The City should continue to place a high level of importance on the efforts to work with industries to find methods of reducing the nitrogen load to the WPF.

If reductions are made to the influent nitrogen into the WPF, the findings of this technical memorandum should be revisited to determine if a reduction in the proposed facilities could be made. Currently, the existing PD blowers cannot meet the aeration capacity required for nitrification only or nitrification/denitrification (Phase I or Phase III) improvements. A reduction in nitrogen loading has the potential to decrease the aeration capacity required, allowing the existing PD blowers to be employed for aeration until they reach the end of their useful life and providing significant near-term cost savings. Similarly, a reduction in nutrient loading could allow a decrease in the amount of external carbon required to drive the denitrification process to meet total nitrogen limits. This would provide a reduction in operating costs associated with the purchase of methanol. In addition, with a reduced need for external carbon, biological phosphorous removal might emerge as a viable alternative to chemical phosphorous removal to meet the total phosphorous limit. This reduction would allow operational savings associated with the purchase of chemicals for phosphorous removal. Basin volume and footprint for nitrification/denitrification could also be significantly impacted

by a reduction in influent nitrogen loading, resulting in decreased project costs associated with the construction of nutrient removal improvements.

12.2 Phased Implementation of Recommended Facilities

Based on discussions with regulators, it is anticipated that implementation of nutrient limits at the WPF may occur according to the approximate following schedule:

- Phase I – ammonia removal in 2010
- Phase II – total phosphorous removal in 2019
- Phase III – total nitrogen removal in 2029

Alternatives were evaluated to meet each of the anticipated phased alternatives. For ammonia removal, only one evaluated alternative was deemed operationally stable and economically viable for further consideration. Similarly for total phosphorous removal, only chemical phosphorus removal was evaluated due to the requirement for additional external carbon with biological phosphorous removal.

In order to meet the Phase III total nitrogen removal requirements, both combined and separate treatment trains for the domestic and industrial flows were considered. The following nitrification/denitrification alternatives were evaluated:

- Alternative 1A – Activated sludge treatment for domestic flows, activated sludge treatment for wholesale industrial flows.
- Alternative 1B – IFAS treatment for domestic flows, activated sludge treatment for wholesale industrial flows.
- Alternative 1C – IFAS treatment for domestic flows, MBR treatment for wholesale industrial flows.
- Alternative 2A – Activated sludge treatment for combined flows.
- Alternative 2B – IFAS treatment for combined flows.

The analysis showed the separate treatment alternatives to be lower in cost when compared to the combined treatment alternatives. Following the economic and non-economic evaluation, Alternative 1B – IFAS for Domestic Flows, Activated Sludge for

Wholesale Industrial Flows emerged as the recommended alternative. The opinion of probable project cost for this alternative is 15 percent less than the next lowest cost alternative. On both an O&M and net present worth basis, Alternative 1B is within 10 percent of Alternative 1A and is, therefore, considered equivalent for these economic criteria at this level of study. The opinion of probable net present worth for Alternative 1B is \$139 million (including phosphorous removal facilities). On a non-economic basis, Alternative 1B offers the best balance between reduced basin volume and ease of operability of the system of all the separate industrial and domestic treatment alternatives considered. With the existing influent loading characteristics, it is recommended that Alternative 1B be implemented to meet Phase III total nitrogen removal requirements.

As a result of a more detailed siting analysis of the recommended alternative for Phase III total nitrogen removal, it was determined that the proposed 160 foot clarifier would not fit on the site originally intended for the addition of a fourth primary clarifier, and alternate locations could not be considered due to hydraulic constraints. More detailed site layout work indicates that a 130 foot clarifier is the maximum clarifier diameter that will fit on the proposed site without costly modifications to existing facilities. As a result, the process modeling for Alternative 1B – IFAS for Domestic Flows, Activated Sludge for Wholesale Industrial Flows was updated to reflect the smaller clarifier. The results of the modeling indicate that the alternative still represents a functional design with the smaller clarifier; however, operational flexibility and performance of the process would be greatly enhanced by nitrogen loading reductions in the flows from the wholesale industrial customers.

Costs presented in Section 11.1.2.1 remain unchanged by this revision. While the more detailed layout analysis revealed the size of the industrial final clarifier should be reduced, the complexity of construction in this congested area was determined to be greater than initially projected. As a result, the cost projections presented previously for the larger diameter clarifier are still valid.

Prior to implementation of the recommended alternatives, additional study is required in a couple areas. Due to the unknown structural integrity of the existing aerobic digesters, an investigation of their structural soundness must be completed prior to utilizing the basins for either nitrification or nitrification/denitrification improvements.

In advance of implementing the nitrification/denitrification improvements, the use of a fermenter as a means to provide a carbon source should be investigated. Depending on influent loading conditions at the time, a fermenter may be able to reduce or eliminate the need for the purchase of external carbon, thereby decreasing operational costs.

Implementation of the nutrient removal program will occur in phases with some facilities included in the future nutrient removal phases constructed in the initial nitrification phase. It is recommended that the City implement the nutrient removal program in the following phases. The actual date for implementation will be determined in the future by MDNR.

- **Phase I (Year 2010) – Ammonia Removal (Nitrification)**
 - Wholesale industrial activated sludge basin modifications (reuse four existing aerobic digester basins (add diffusers) and raise basin walls a total of 4 feet – 2 feet for Phase I, 2 feet for Phase III).
 - New wholesale industrial final clarifier and associated RAS/WAS pump station (increase clarifier size from 120 foot to 130 foot diameter to meet future Phase III needs).
 - Existing aeration basin modifications (add diffusers).
 - New centrifugal blowers within existing Blower Building.

- **Phase II (Year 2019) – Total Phosphorous Removal**
 - New chemical feed and storage system and building.

- **Phase III (Year 2029) – Total Nitrogen Removal (Nitrification/Denitrification)**
 - New IFAS fine screen building.
 - Domestic oxic basins with IFAS media (reuse existing aeration basin volume).
 - Domestic anoxic basins (reuse existing aeration basin volume).
 - Wholesale industrial anoxic, oxic, post-anoxic, and reaeration volume (reuse six existing aerobic digester basins).

- New methanol chemical feed and storage system and building (contiguous to chemical feed facilities for phosphorous removal).

Table 34 provides the opinion of probable project cost for the phased implementation of the recommended facilities.

Table 34	
Opinion of Probable Project Cost for Phased Implementation of Recommended Nutrient Removal Facilities ¹	
Phase	Project Cost ^{2,3}, \$
I – Ammonia Removal	24,740,000
II – Total Phosphorous Removal	3,314,000
III – Total Nitrogen Removal	30,498,000
Total ⁴	58,552,000
1. Costs given in May 2009 dollars. 2. Project cost includes allowances for electrical, instrumentation and controls, sitework, general requirements, contingency, and engineering, legal, and administration. 3. Project costs do not include costs for standby power generator facilities. These costs will be presented in TM-WW-9 – Site Considerations, Utility Improvements, and Ancillary Facilities. 4. Total cost includes Phase I piping not reused in Phase III.	

12.3 Aeration Evaluation

An aeration system evaluation was completed to determine the anticipated aeration blower needs of future facilities to be installed at the WPF. This study also evaluated the use of centrifugal blowers to replace the existing PD blowers when the existing PD blowers reach the end of their useful life or can no longer provide the needed airflow due to future aeration requirements.

A comparative life cycle cost analysis determined single-stage centrifugal blowers were the lowest life cycle cost option to meet future aeration needs at the WPF; however, the life cycle cost of multi-stage blowers with AFDs was within 10 percent of the lowest cost option. At this level of study, the two options are considered equivalent from a life cycle cost perspective. City staff has concerns with maintenance issues associated with AFDs. Therefore, the recommended replacement alternative for the existing PD blowers is five single-stage centrifugal blowers. During detailed design of the blower

replacement project, evaluation of the use of multi-stage blowers with eddy current drives should be considered as an alternative to the single-stage blowers.

The existing PD blowers are unable to meet the anticipated aeration demands of the future nitrification or nitrification/denitrification (Phase I or Phase III) facilities as presented in this technical memorandum; however, City staff efforts to reduce the influent nitrogen loading from the wholesale customers and industrial users to the WPF could result in reduced air requirements. Prior to the construction of future Phase I or III facilities, air flow requirements should be revisited in light of any new WPF influent loading data. It is recommended that the existing PD blowers continue to be used to provide aeration until they reach the end of their service life or they are no longer able to meet the aeration needs of future facilities.

13.0 References

The following references were utilized in the preparation of this memorandum:

- Geotechnical Engineering Report (L. Robert Kimball, 1973).
- Design Concepts for Activated Sludge Diffused Aeration Systems (T.L. Johnson, Black & Veatch, Ph.D. Thesis, University of Kansas, USA, 1993).
- Blower Investigation Study (Black & Veatch, January 26, 2005).

Appendix A

Opinion of Probable Capital Cost Breakdown

St. Joseph, Missouri
TM-WW-4 - Nutrient Removal Facilities
Recommended Ammonia Removal Alternative

Item Description	Units	Unit Cost	Quantity	Total Cost
Domestic Aeration Basins				
Equipment				
Coarse Bubble Diffuser	LS			117,500
Diffuser Installation	LS	25%		29,375
				<u>147,000</u>
<i>Oxic BNR Basin</i>				
Industrial Aeration Basin				
Demolition				
Concrete	cu yd	250.00	0	-
Concrete, Cast-In-Place				
Slab on Grade	cu yd	530.00	100	53,000
Walls	cu yd	850.00	194	164,669
Suspended Slabs	cu yd	950.00	0	-
Concrete Fill	cu yd	400.00	500	200,000
Embedded Accessories	LS			11,906
Mechanical				
48-inch Influent to Industrial Aeration Basin	lin ft	720.00	400	288,000
54-inch Effluent to Final Clarifier	lin ft	810.00	300	243,000
12-inch Sludge Drain to DAF	lin ft	180.00	400	72,000
48-inch from Final Clarifier to FC Junc Box	lin ft	720.00	100	72,000
Pipe Connections to Existing Facilities	each	10,000.00	5	50,000
Metal				
Handrail	lin ft	55.00	924	50,820
Miscellaneous	LS			5,082
Painting	LS			2,400
Equipment				
Fine Bubble Diffuser	LS			576,667
Diffuser Installation	LS	25%		144,167
Piles (Depth of 70 feet)	each	4,550.00	10	45,500
				<u>1,979,000</u>
<i>Industrial Aeration Basin</i>				
Industrial Final Clarifier				
Earthwork				
Structural Excavation	cu yd	20.00	7,500	150,000
Compacted Fill	cu yd	25.00	740	18,500
Granular Fill	cu yd	35.00	480	16,800
Substructure Piping w/encasement				
42-inch Influent	lin ft	630.00	65	40,950
24-inch Sludge Drain	lin ft	360.00	60	21,600
Basin Pressure Relief				
Valve, 4-inch	each	400.00	8	3,200
Concrete				
Slab on Grade/Footings	cu yd	530.00	420	222,600
Walls	cu yd	850.00	270	229,500
Suspended Slab and Beams	cu yd	950.00	27	25,650
Fill	cu yd	400.00	40	16,000
Embedded Accessories	LS			15,140
Metal				
Handrail	lin ft	55.00	380	20,900
Scum Baffle and Weir	lin ft	125.00	360	45,000
Miscellaneous	LS			6,590
Painting	LS			33,929
Equipment				
Circular Clarifying Equipment	LS			400,000
Mechanical				
Scum Piping and Miscellaneous	LS			12,000
Piles (Depth of 70 feet)	each	4,550.00	88	399,263
				<u>1,678,000</u>
<i>Industrial Final Clarifier</i>				

St. Joseph, Missouri
TM-WW-4 - Nutrient Removal Facilities
Recommended Ammonia Removal Alternative

Item Description	Units	Unit Cost	Quantity	Total Cost
Industrial RAS Pumping Station				
Earthwork				
Structural Excavation	cu yd	20.00	2,072	41,440
Compacted Fill	cu yd	25.00	600	15,000
Granular Fill	cu yd	35.00	115	4,025
Concrete				
Slab on Grade/Footings	cu yd	530.00	175	92,750
Walls	cu yd	850.00	190	161,500
Suspended Slab and Beams	cu yd	950.00	80	76,000
Fill	cu yd	400.00	0	-
Embedded Accessories	LS			3,500
Masonry				
Lump Sum for Building	LS			92,000
Metal				
Lump Sum for Building	LS			32,000
FRP				
Guardrail and Grating	LS			1,500
Thermal/Moisture Protection	LS			10,000
Doors/Miscellaneous Specialties	LS			20,000
Painting	LS			30,000
Equipment				
Vertical End Suction Pumps	each	36,000.00	5	180,000
Progressing Cavity Pumps	each	36,000.00	3	108,000
Equipment Installation	LS	40%		115,200
Piping and Valves				
HVAC	LS			250,000
Plumbing	LS			70,000
Piles (Depth of 70 feet)	each	4,550.00	52	90,000
<i>Industrial Sludge Pumping Station</i>				<u>236,600</u>
				1,630,000
Blowers				
Calculated Separately				<u>4,250,000</u>
<i>Ammonia Removal Only Recommended Alternative Subtotal</i>				<u>9,684,000</u>
Electrical, Instrumentation, & Controls	LS	25%		2,421,000
<i>Subtotal</i>				<u>12,105,000</u>
Sitework	LS	10%		1,211,000
<i>Subtotal</i>				<u>13,316,000</u>
General Requirements	LS	12%		1,598,000
Flood Protection/Fill (placeholder)	cu yd	25.00	0	-
Site Remediation (placeholder)	cu yd	150.00	0	-
<i>Subtotal</i>				<u>14,914,000</u>
Contingency	LS	25%		3,729,000
Land Acquisition (placeholder)	sq ft	1.33		-
Opinion of Probable Construction Cost				18,643,000
Engineering, Legal, & Administration	LS	20%		3,729,000
Opinion of Probable Project Cost				22,370,000

Assumed Structure for Service Life Assessment

Assumed Equipment for Service Life Assessment

Potential Project Add-Ons

Industrial Aeration Basin Concrete Liner

Concrete, Cast-In-Place				
Slab on Grade	cu yd	530.00	2,500	1,325,000
Walls	cu yd	850.00	1,800	1,530,000
Suspended Slabs	cu yd	950.00	0	-
Concrete Fill	cu yd	400.00	0	-
Embedded Accessories	LS			64,500
<i>Basin Concrete Liner Subtotal</i>				<u>2,920,000</u>

St. Joseph, Missouri
TM-WW-4 - Nutrient Removal Facilities
Recommended Ammonia Removal Alternative

Item Description	Units	Unit Cost	Quantity	Total Cost
Electrical, Instrumentation, & Controls	LS	25%		730,000
<i>Subtotal</i>				3,650,000
Sitework	LS	10%		365,000
<i>Subtotal</i>				4,015,000
General Requirements	LS	12%		482,000
Flood Protection/Fill (placeholder)	cu yd	25.00	0	-
Site Remediation (placeholder)	cu yd	150.00	0	-
<i>Subtotal</i>				4,497,000
Contingency	LS	25%		1,124,000
Land Acquisition (placeholder)	sq ft	1.33		-
Opinion of Probable Construction Cost				5,621,000
Engineering, Legal, & Administration	LS	20%		1,124,000
Opinion of Probable Project Cost				6,750,000
<i>Industrial Aeration Basin - Refurbish Beams</i>				
Calculated Separately	basin	152,000.00	4	608,000
<i>Refurbish Beams Subtotal</i>				608,000
Electrical, Instrumentation, & Controls	LS	25%		152,000
<i>Subtotal</i>				760,000
Sitework	LS	10%		76,000
<i>Subtotal</i>				836,000
General Requirements	LS	12%		100,000
Flood Protection/Fill (placeholder)	cu yd	25.00	0	-
Site Remediation (placeholder)	cu yd	150.00	0	-
<i>Subtotal</i>				936,000
Contingency	LS	25%		234,000
Land Acquisition (placeholder)	sq ft	1.33		-
Opinion of Probable Construction Cost				1,170,000
Engineering, Legal, & Administration	LS	20%		234,000
Opinion of Probable Project Cost				1,400,000
<i>Industrial Final Clarifier - upsize from 120 ft dia to 160 ft dia for future needs</i>				
<i>Incremental Cost to Upsize Final Clarifier</i>				859,000
Electrical, Instrumentation, & Controls	LS	25%		215,000
<i>Subtotal</i>				1,074,000
Sitework	LS	10%		107,000
<i>Subtotal</i>				1,181,000
General Requirements	LS	12%		142,000
Flood Protection/Fill (placeholder)	cu yd	25.00	0	-
Site Remediation (placeholder)	cu yd	150.00	0	-
<i>Subtotal</i>				1,323,000
Contingency	LS	25%		331,000
Land Acquisition (placeholder)	sq ft	1.33		-
Opinion of Probable Construction Cost				1,654,000
Engineering, Legal, & Administration	LS	20%		331,000
Opinion of Probable Project Cost				1,990,000
<i>Industrial Aeration Basin - raise walls incremental 2 ft for future needs</i>				
<i>Incremental Cost to Raise Aeration Basin Walls</i>				163,200
Electrical, Instrumentation, & Controls	LS	25%		41,000
<i>Subtotal</i>				204,000
Sitework	LS	10%		20,000
<i>Subtotal</i>				224,000
General Requirements	LS	12%		27,000
Flood Protection/Fill (placeholder)	cu yd	25.00	0	-
Site Remediation (placeholder)	cu yd	150.00	0	-
<i>Subtotal</i>				251,000
Contingency	LS	25%		63,000
Land Acquisition (placeholder)	sq ft	1.33		-
Opinion of Probable Construction Cost				314,000
Engineering, Legal, & Administration	LS	20%		63,000
Opinion of Probable Project Cost				380,000

St. Joseph, Missouri
TM-WW-4 - Nutrient Removal Facilities
Alternative 1A - Activated Sludge for Domestic Flows, Activated Sludge for Industrial Flows

Item Description	Units	Unit Cost	Quantity	Total Cost
Domestic CAS Anoxic Basin				
Earthwork				
Structural Excavation	cu yd	20.00	10,500	210,000
Compacted Fill	cu yd	25.00	810	20,250
Granular Fill	cu yd	35.00	880	30,800
Mechanical				
60-inch Influent	lin ft	900.00	720	648,000
72-inch Effluent to Oxidic Zone	lin ft	1,080.00	560	604,800
36-inch RAS	lin ft	540.00	650	351,000
Basin Pressure Relief				
4-inch Valves	each	400.00	12	4,800
Concrete, Cast-In-Place				
Slab on Grade	cu yd	530.00	1,055	559,150
Walls	cu yd	850.00	1,410	747,300
Suspended Slabs	cu yd	950.00	25	23,750
Concrete Fill	cu yd	400.00	-	-
Embedded Accessories	LS			37,350
Metal				
Handrail	lin ft	55.00	630	34,650
Miscellaneous	LS			3,465
Painting	LS			31,200
Equipment				
Mixers (7 hp)	each	27,500.00	6	165,000
Davit Cranes	each	2,500.00	6	15,000
Equipment Installation	LS	40%		72,000
Influent Splitter Box	LS			150,000
Piles (Depth of 70 feet)	each	4,550.00	220	1,001,000
<i>Anoxic BNR Basin</i>				4,710,000
Domestic CAS Oxidic Basin				
Concrete, Cast-In-Place				
Slab on Grade	cu yd	530.00	30	15,900
Walls	cu yd	850.00	310	263,500
Suspended Slabs	cu yd	950.00	30	28,500
Concrete Fill	cu yd	400.00	400	160,000
Embedded Accessories	LS			11,550
Mechanical				
72-inch Wall Pipe Influent to Oxidic Zone	each	33,000.00	3	99,000
42-inch MLSS recycle	lin ft	630.00	1,040	655,200
48-inch Effluent to Final Clarifier	lin ft	720.00	1,510	1,087,200
Pipe Connections to Existing Facilities	each	10,000.00	9	90,000
Metal				
Handrail	lin ft	55.00	2,000	110,000
Miscellaneous	LS			11,000
Painting	LS			2,400
Equipment				
Recycle Pumps (3 - 20 mgd, 40 hp) (2 duty 1 standby)	each	50,000.00	9	450,000
Mixers (7 hp)	each	27,500.00	6	165,000
Davit Crane for Pumps	each	10,000.00	15	150,000
Equipment Installation	LS	40%		306,000
Fine Bubble Diffuser	LS			186,700
Diffuser Installation	LS	25%		46,675
Piles (Depth of 70 feet)	sq ft	4,550.00	10	45,500
<i>Oxidic BNR Basin</i>				3,884,000
Domestic Final Clarifier				
Earthwork				
Structural Excavation	cu yd	20.00	12,900	258,000
Compacted Fill	cu yd	25.00	980	24,500
Granular Fill	cu yd	35.00	830	29,050
Substructure Piping w/Encasement				
42-inch Influent	lin ft	630.00	82	51,660
24-inch Sludge Drain	lin ft	360.00	78	28,080
Basin Pressure Relief				
Valve, 4-inch	each	400.00	8	3,200

St. Joseph, Missouri
TM-WW-4 - Nutrient Removal Facilities
Alternative 1A - Activated Sludge for Domestic Flows, Activated Sludge for Industrial Flows

Item Description	Units	Unit Cost	Quantity	Total Cost
Concrete				
Slab on Grade/Footings	cu yd	530.00	660	349,800
Walls	cu yd	850.00	350	297,500
Suspended Slab and Beams	cu yd	950.00	40	38,000
Fill	cu yd	400.00	55	22,000
Embedded Accessories	LS			22,100
Metal				
Handrail	lin ft	55.00	504	27,720
Scum Baffle and Weir	lin ft	125.00	484	60,500
Miscellaneous	LS			8,822
Painting				
Equipment				
Circular Clarifying Equipment	LS			528,000
Mechanical				
Scum Piping and Miscellaneous	LS			18,093
Piles (Depth of 70 feet)	each	4,550.00	156	709,800
<i>Domestic Final Clarifier</i>				2,537,000
 Industrial CAS Basin				
Demolition				
Concrete	cu yd	250.00	0	-
Concrete, Cast-In-Place				
Slab on Grade	cu yd	530.00	185	98,050
Walls	cu yd	850.00	1,530	1,300,500
Suspended Slabs	cu yd	950.00	0	-
Concrete Fill	cu yd	400.00	745	298,000
Embedded Accessories	LS			36,900
Mechanical				
24-inch MLSS recycle	lin ft	360.00	960	345,600
48-inch Influent from Industrial BNR Basin	lin ft	720.00	400	288,000
54-inch Effluent to Final Clarifier	lin ft	810.00	300	243,000
16-inch RAS to Anoxic Zone	lin ft	990.00	350	346,500
12-inch sludge drain to DAF	lin ft	180.00	400	72,000
48-inch to Plant Effluent	lin ft	720.00	1,200	864,000
Pipe Connections to Existing Facilities	each	10,000.00	9	90,000
Metal				
Handrail	lin ft	55.00	1,010	55,550
Miscellaneous	LS			5,555
Painting				
Equipment				
Anoxic Mixers (3 - 4.5 hp)	each	27,500.00	3	82,500
Post Anoxic Mixers (6 - 7 hp)	each	27,500.00	6	165,000
Oxic Zone Mixers (6 - 7 hp)	each	27,500.00	6	165,000
Recycle Pumps (4 - 8 mgd, 1 per basin, 1 standby)	each	50,000.00	4	200,000
Davit Crane for Pumps and Mixers	each	10,000.00	19	190,000
Equipment Installation	LS	40%		321,000
Fine Bubble Diffuser	LS			453,300
Diffuser Installation	LS	25%		113,325
Piles (Depth of 70 feet)	each	4,550.00	10	45,500
<i>Industrial BNR Basin</i>				5,782,000
 Industrial Final Clarifier				
Earthwork				
Structural Excavation	cu yd	20.00	12,900	258,000
Compacted Fill	cu yd	25.00	980	24,500
Granular Fill	cu yd	35.00	830	29,050
Substructure Piping w/encasement				
42-inch Influent	lin ft	630.00	82	51,660
24-inch Sludge Drain	lin ft	360.00	78	28,080
Basin Pressure Relief				
Valve, 4-inch	each	400.00	8	3,200
Concrete				
Slab on Grade/Footings	cu yd	530.00	660	349,800
Walls	cu yd	850.00	350	297,500
Suspended Slab and Beams	cu yd	950.00	40	38,000

St. Joseph, Missouri
TM-WW-4 - Nutrient Removal Facilities
Alternative 1A - Activated Sludge for Domestic Flows, Activated Sludge for Industrial Flows

Item Description	Units	Unit Cost	Quantity	Total Cost
Fill	cu yd	400.00	55	22,000
Embedded Accessories	LS			22,100
Metal				
Handrail	lin ft	55.00	504	27,720
Scum Baffle and Weir	lin ft	125.00	484	60,500
Miscellaneous	LS			8,822
Painting				60,319
Equipment				
Circular Clarifying Equipment	LS			528,000
Mechanical				
Scum Piping and Miscellaneous	LS			18,093
Piles (Depth of 70 feet)	each	4,550.00	156	709,800
<i>Industrial Final Clarifier</i>				2,537,000
Industrial RAS Pumping Station				
Earthwork				
Structural Excavation	cu yd	20.00	2,072	41,440
Compacted Fill	cu yd	25.00	600	15,000
Granular Fill	cu yd	35.00	115	4,025
Concrete				
Slab on Grade/Footings	cu yd	530.00	175	92,750
Walls	cu yd	850.00	190	161,500
Suspended Slab and Beams	cu yd	950.00	80	76,000
Fill	cu yd	400.00	0	-
Embedded Accessories	LS			3,500
Masonry				
Lump Sum for Building	LS			92,000
Metal				
Lump Sum for Building	LS			32,000
FRP				
Guardrail and Grating	LS			1,500
Thermal/Moisture Protection	LS			10,000
Doors/Miscellaneous Specialties	LS			20,000
Painting	LS			30,000
Equipment				
Vertical End Suction Pumps	each	36,000.00	5	180,000
Progressing Cavity Pumps	each	36,000.00	3	108,000
Equipment Installation	LS	40%		115,200
Piping and Valves	LS			250,000
HVAC	LS			70,000
Plumbing	LS			90,000
Piles (Depth of 70 feet)	each	4,550.00	52	236,600
<i>Industrial Sludge Pumping Station</i>				1,630,000
Chemical Feed and Storage Building (Methanol System)				
Calculated in another tab				2,759,000
Ferric Chloride Injection Piping				
Calculated in another tab				42,000
Methanol Injection Piping				
Calculated in another tab				300,000
Blowers				
Calculated separately				4,250,000
Alternative 1A Subtotal				
				28,431,000
Electrical, Instrumentation, & Controls	LS	25%		7,108,000
<i>Subtotal</i>				35,539,000
Sitework	LS	10%		3,554,000
<i>Subtotal</i>				39,093,000
General Requirements	LS	12%		4,691,000
Flood Protection/Fill (placeholder)	cu yd	25.00	0	-
Site Remediation (placeholder)	cu yd	150.00	4,444	666,667
<i>Subtotal</i>				44,451,000

St. Joseph, Missouri
TM-WW-4 - Nutrient Removal Facilities
Alternative 1A - Activated Sludge for Domestic Flows, Activated Sludge for Industrial Flows

Item Description	Units	Unit Cost	Quantity	Total Cost
Contingency	LS	25%		11,113,000
Land Acquisition (placeholder)	sq ft	1.33	24,000	32,000
Opinion of Probable Construction Cost				55,596,000
Engineering, Legal, & Administration	LS	20%		11,119,000
Opinion of Probable Project Cost				66,720,000

Assumed Structure for Service Life Assessment
Assumed Equipment for Service Life Assessment

Potential Project Add-Ons

WAS Holding Basin

Earthwork				
Structural Excavation	cu yd	20.00	20,000	400,000
Compacted Fill		25.00	1,650	41,250
Granular Fill	cu yd	35.00	1,500	52,500
Concrete				
Slab on Grade/Footings	cu yd	530.00	1,500	795,000
Walls	cu yd	850.00	1,400	1,190,000
Suspended Slab and Beams	cu yd	950.00	0	-
Fill	cu yd	400.00	0	-
Embedded Accessories	LS			101,500
Painting	LS			30,000
Piles (Depth of 70 feet)	each	4,550.00	250	1,137,500
<i>WAS Holding Basin</i>				<i>3,748,000</i>
<i>Alternative 1A Subtotal</i>				<i>3,748,000</i>
Electrical, Instrumentation, & Controls	LS	25%		937,000
<i>Subtotal</i>				<i>4,685,000</i>
Sitework	LS	10%		469,000
<i>Subtotal</i>				<i>5,154,000</i>
General Requirements	LS	12%		618,000
Flood Protection/Fill (placeholder)	cu yd	25.00	0	-
Site Remediation (placeholder)	cu yd	150.00	8,000	1,200,000
<i>Subtotal</i>				<i>6,972,000</i>
Contingency	LS	25%		1,743,000
Land Acquisition (placeholder)	sq ft	1.33	43,200	57,000
Opinion of Probable Construction Cost				8,772,000
Engineering, Legal, & Administration	LS	20%		1,754,000
Opinion of Probable Project Cost				10,530,000

Industrial CAS Basin Concrete Liner

Concrete, Cast-In-Place				
Slab on Grade	cu yd	530.00	3,700	1,961,000
Walls	cu yd	850.00	2,700	2,295,000
Suspended Slabs	cu yd	950.00	0	-
Concrete Fill	cu yd	400.00	0	-
Embedded Accessories	LS			96,000
<i>Industrial BNR Basin</i>				<i>4,352,000</i>
<i>Alternative 1A Subtotal</i>				<i>4,352,000</i>
Electrical, Instrumentation, & Controls	LS	25%		1,088,000
<i>Subtotal</i>				<i>5,440,000</i>
Sitework	LS	10%		544,000
<i>Subtotal</i>				<i>5,984,000</i>
General Requirements	LS	12%		718,000
Flood Protection/Fill (placeholder)	cu yd	25.00	0	-
Site Remediation (placeholder)	cu yd	150.00	0	-
<i>Subtotal</i>				<i>6,702,000</i>
Contingency	LS	25%		1,676,000
Land Acquisition (placeholder)	sq ft	1.33	0	-
Opinion of Probable Construction Cost				8,378,000
Engineering, Legal, & Administration	LS	20%		1,676,000
Opinion of Probable Project Cost				10,050,000

St. Joseph, Missouri
TM-WW-4 - Nutrient Removal Facilities
Alternative 1B - IFAS for Domestic Flows, Activated Sludge for Industrial Flows

Item Description	Units	Unit Cost	Quantity	Total Cost
IFAS Fine Screen Building				
25' by 30' Building Superstructure (Single Story)	sq ft	236.00	750	177,000
Earthwork				
Structural Excavation	cu yd	20.00	622	12,439
Compacted Fill	cu yd	25.00	220	5,500
Granular Fill	cu yd	35.00	19	660
Sheeting and Dewatering	LS			
Concrete				
Slab on Grade/Footings	cu yd	530.00	38	19,978
Walls	cu yd	850.00	80	67,882
Suspended Slab and Beams	cu yd	950.00	28	26,389
Embedded Accessories	LS			2,907
Metal				
Handrail	lin ft	60.00	0	-
Painting	LS			50,000
Process piping	LS			-
HVAC	sq ft	30.00	750	22,500
Plumbing	sq ft	25.00	750	18,750
Fire Protection	sq ft	4.00	750	3,000
Lightning Protection	LS			5,000
Screening Equipment				
Fine Screens for Domestic IFAS	each	314,000.00	2	628,000
Washer Compactor	each	137,000.00	2	274,000
Piles (Depth of 70 feet)	sq ft	4,550.00	28	127,400
<i>Fine Screen Building</i>				1,441,000
Domestic IFAS Basin				
Concrete, Cast-In-Place				
Slab on Grade	cu yd	530.00	60	31,800
Walls	cu yd	850.00	445	378,250
Suspended Slabs	cu yd	950.00	60	57,000
Concrete Fill	cu yd	400.00	400	160,000
Embedded Accessories	LS			14,475
Mechanical Pipe Modifications				
42-inch influent	lin ft	180.00	680	122,400
30-inch RAS	lin ft	100.00	640	64,000
42-inch MLSS Return Line	lin ft	630.00	600	378,000
42-inch Effluent to FC	lin ft	630.00	140	88,200
Pipe Connections to Existing Facilities	each	10,000.00	6	60,000
Metal				
Handrail	lin ft	55.00	2,000	110,000
Miscellaneous	LS			11,000
Painting	LS			2,400
Equipment				
Recycle Pumps (20 mgd, 40 hp) (2/basin, 1 standby)	each	50,000.00	7	350,000
Anoxic Mixers (9 hp)	each	27,500.00	4	110,000
Supplemental Oxid Mixers (9 hp)	each	27,500.00	4	110,000
Davit Crane for Pumps	each	10,000.00	15	150,000
Equipment Installation	LS	40%		288,000
Coarse Bubble Diffuser	LS			161,000
Diffuser Installation	LS	25%		40,250
Piles (Depth of 70 feet)	sq ft	4,550.00	10	45,500
IFAS System				
IFAS Media and IFAS Sieves	LS	3,300,000.00	1	3,300,000
<i>Domestic IFAS Basin</i>				6,032,000
Industrial CAS Basin				
Demolition				
Concrete	cu yd	250.00	0	-
Concrete, Cast-In-Place				
Slab on Grade	cu yd	530.00	185	98,050
Walls	cu yd	850.00	1530	1,300,500
Suspended Slabs	cu yd	950.00	0	-
Concrete Fill	cu yd	400.00	745	298,000
Embedded Accessories	LS			36,900

St. Joseph, Missouri
TM-WW-4 - Nutrient Removal Facilities
Alternative 1B - IFAS for Domestic Flows, Activated Sludge for Industrial Flows

Item Description	Units	Unit Cost	Quantity	Total Cost
Mechanical				
24-inch MLSS recycle	lin ft	360.00	960	345,600
48-inch Influent from Industrial BNR Basin	lin ft	720.00	400	288,000
54-inch Effluent to Final Clarifier	lin ft	810.00	300	243,000
16-inch RAS to Anoxic Zone	lin ft	990.00	350	346,500
12-inch Sludge Drain to DAF	lin ft	180.00	400	72,000
48-inch to Plant Effluent	lin ft	720.00	1,200	864,000
Pipe Connections to Existing Facilities	each	10,000.00	9	90,000
Metal				
Handrail	lin ft	55.00	1,010	55,550
Miscellaneous	LS			5,555
Painting	LS			2,400
Equipment				
Anoxic Mixers (3 - 4.5 hp)	each	27,500.00	3	82,500
Post Anoxic Mixers (6 - 7 hp)	each	27,500.00	6	165,000
Oxic Zone Mixers (6 - 7 hp)	each	27,500.00	6	165,000
Recycle Pumps (4 - 8 mgd, 1 per basin, 1 standby)	each	50,000.00	4	200,000
Davit Crane for Pumps and Mixers	each	10,000.00	19	190,000
Equipment Installation	LS	40%		321,000
Fine Bubble Diffuser	LS			453,300
Diffuser Installation	LS	25%		113,325
Piles (Depth of 70 feet)	each	4,550.00	10	45,500
<i>Industrial BNR Basin</i>				5,782,000
Industrial Final Clarifier				
Earthwork				
Structural Excavation	cu yd	20.00	12,900	258,000
Compacted Fill	cu yd	25.00	980	24,500
Granular Fill	cu yd	35.00	830	29,050
Substructure Piping w/Encasement				
42-inch Influent	lin ft	630.00	82	51,660
24-inch Sludge Drain	lin ft	360.00	78	28,080
Basin Pressure Relief				
Valve, 4-inch	each	400.00	8	3,200
Concrete				
Slab on Grade/Footings	cu yd	530.00	660	349,800
Walls	cu yd	850.00	350	297,500
Suspended Slab and Beams	cu yd	950.00	40	38,000
Fill	cu yd	400.00	55	22,000
Embedded Accessories	LS			22,100
Metal				
Handrail	lin ft	55.00	504	27,720
Scum Baffle and Weir	lin ft	125.00	484	60,500
Miscellaneous	LS			8,822
Painting				60,319
Equipment				
Circular Clarifying Equipment	LS			528,000
Mechanical				
Scum Piping and Miscellaneous	LS			18,093
Piles (Depth of 70 feet)	each	4,550.00	156	709,800
<i>Industrial Final Clarifier</i>				2,537,000
Industrial RAS Pumping Station				
Earthwork				
Structural Excavation	cu yd	20.00	2,072	41,440
Compacted Fill	cu yd	25.00	600	15,000
Granular Fill	cu yd	35.00	115	4,025
Concrete				
Slab on Grade/Footings	cu yd	530.00	175	92,750
Walls	cu yd	850.00	190	161,500
Suspended Slab and Beams	cu yd	950.00	80	76,000
Fill	cu yd	400.00	0	-
Embedded Accessories	LS			3,500
Masonry				
Lump Sum for Building	LS			92,000
Metal				
Lump Sum for Building	LS			32,000
FRP				
Guardrail and Grating	LS			1,500

St. Joseph, Missouri
TM-WW-4 - Nutrient Removal Facilities
Alternative 1B - IFAS for Domestic Flows, Activated Sludge for Industrial Flows

Item Description	Units	Unit Cost	Quantity	Total Cost
Thermal/Moisture Protection	LS			10,000
Doors/Miscellaneous Specialties	LS			20,000
Painting	LS			30,000
Equipment				
Vertical End Suction Pumps	each	36,000.00	5	180,000
Progressing Cavity Pumps	each	36,000.00	3	108,000
Equipment Installation	LS	40%		115,200
Piping and Valves	LS			250,000
HVAC	LS			70,000
Plumbing	LS			90,000
Piles (Depth of 70 feet)	each	4,550.00	52	236,600
<i>Industrial RAS Pumping Station</i>				1,630,000
Chemical Feed and Storage Building (Methanol System Only)				
Calculated in another tab				1,591,000
Methanol Injection Piping				
Calculated in another tab				300,000
Blowers				
Calculated separately				4,250,000
<i>Alternative 1B Subtotal</i>				23,563,000
Electrical, Instrumentation, & Controls	LS	25%		5,891,000
<i>Subtotal</i>				29,454,000
Sitework	LS	10%		2,945,000
<i>Subtotal</i>				32,399,000
General Requirements	LS	12%		3,888,000
Flood Protection/Fill (placeholder)	cu yd	25.00		-
Site Remediation (placeholder)	cu yd	150.00	2,222	333,333
<i>Subtotal</i>				36,620,000
Contingency	LS	25%		9,155,000
Land Acquisition (placeholder)	sq ft	1.33	12,000	16,000
Opinion of Probable Construction Cost				45,791,000
Engineering, Legal, & Administration	LS	20%		9,158,000
Opinion of Probable Project Cost				54,949,000
Assumed Structure for Service Life Assessment				
Assumed Equipment for Service Life Assessment				
Chemical Feed and Storage Building (Ferric Chloride System Only)				
Calculated in another tab				1,168,000
Ferric Chloride Injection Piping				
Calculated in another tab				42,000
<i>Phosphorous Removal Subtotal</i>				1,210,000
Electrical, Instrumentation, & Controls	LS	25%		303,000
<i>Subtotal</i>				1,513,000
Sitework	LS	10%		151,000
<i>Subtotal</i>				1,664,000
General Requirements	LS	12%		200,000
Flood Protection/Fill (placeholder)	cu yd	25.00		-
Site Remediation (placeholder)	cu yd	150.00	2,222	333,333
<i>Subtotal</i>				2,197,000
Contingency	LS	25%		549,000
Land Acquisition (placeholder)	sq ft	1.33	12,000	16,000
Opinion of Probable Construction Cost				2,762,000
Engineering, Legal, & Administration	LS	20%		552,000
Opinion of Probable Project Cost				3,314,000

St. Joseph, Missouri
TM-WW-4 - Nutrient Removal Facilities
Alternative 1B - IFAS for Domestic Flows, Activated Sludge for Industrial Flows

Item Description	Units	Unit Cost	Quantity	Total Cost
Potential Project Add-Ons				
Industrial CAS Basin Concrete Liner				
Concrete, Cast-In-Place				
Slab on Grade	cu yd	530.00	3,700	1,961,000
Walls	cu yd	850.00	2,700	2,295,000
Suspended Slabs	cu yd	950.00	0	-
Concrete Fill	cu yd	400.00	0	-
Embedded Accessories	LS			96,000
				<u>4,352,000</u>
				<i>Industrial BNR Basin</i>
				<i>Alternative 1B Subtotal</i>
				4,352,000
Electrical, Instrumentation, & Controls	LS	25%		1,088,000
				<u>5,440,000</u>
				<i>Subtotal</i>
Sitework	LS	10%		544,000
				<u>5,984,000</u>
				<i>Subtotal</i>
General Requirements	LS	12%		718,000
Flood Protection/Fill (placeholder)	cu yd	25.00		-
Site Remediation (placeholder)	cu yd	150.00	0	-
				<u>6,702,000</u>
				<i>Subtotal</i>
Contingency	LS	25%		1,676,000
Land Acquisition (placeholder)	sq ft	1.33	0	-
				<u>8,378,000</u>
				Opinion of Probable Construction Cost
Engineering, Legal, & Administration	LS	20%		1,676,000
				<u>10,054,000</u>
				Opinion of Probable Project Cost
				10,054,000
WAS Holding Basin				
Earthwork				
Structural Excavation	cu yd	20.00	20,000	400,000
Compacted Fill	cu yd	25.00	1,650	41,250
Granular Fill	cu yd	35.00	1,500	52,500
Concrete				
Slab on Grade/Footings	cu yd	530.00	1,500	795,000
Walls	cu yd	850.00	1,400	1,190,000
Suspended Slab and Beams	cu yd	950.00	0	-
Fill	cu yd	400.00	0	-
Embedded Accessories	LS			101,500
Painting	LS			30,000
Piles (Depth of 70 feet)	each	4,550.00	250	1,137,500
				<u>3,748,000</u>
				<i>WAS Holding Basin</i>
				<i>Alternative 1B Subtotal</i>
				3,748,000
Electrical, Instrumentation, & Controls	LS	25%		937,000
				<u>4,685,000</u>
				<i>Subtotal</i>
Sitework	LS	10%		469,000
				<u>5,154,000</u>
				<i>Subtotal</i>
General Requirements	LS	12%		618,000
Flood Protection/Fill (placeholder)	cu yd	25.00		-
Site Remediation (placeholder)	cu yd	150.00	8,000	1,200,000
				<u>6,972,000</u>
				<i>Subtotal</i>
Contingency	LS	25%		1,743,000
Land Acquisition (placeholder)	sq ft	1.33	43,200	57,000
				<u>8,772,000</u>
				Opinion of Probable Construction Cost
Engineering, Legal, & Administration	LS	20%		1,754,000
				<u>10,526,000</u>
				Opinion of Probable Project Cost
				10,526,000

St. Joseph, Missouri
TM-WW-4 - Nutrient Removal Facilities
Alternative 1C - IFAS for Domestic Flows, MBR for Industrial Flows

Item Description	Units	Unit Cost	Quantity	Total Cost
<i>IFAS Fine Screen Building</i>				
Building Superstructure (Single Story)	sq ft	236.00	750	177,000
Earthwork				
Structural Excavation	cu yd	20.00	622	12,439
Compacted Fill	cu yd	25.00	220	5,500
Granular Fill	cu yd	35.00	19	660
Sheeting and Dewatering	LS			
Concrete				
Slab on Grade/Footings	cu yd	530.00	38	19,978
Walls	cu yd	850.00	80	67,882
Suspended Slab and Beams	cu yd	950.00	28	26,389
Embedded Accessories	LS			2,907
Metal				
Handrail	lin ft	60.00	0	-
Painting	LS			50,000
Process piping	LS			-
HVAC	sq ft	30.00	750	22,500
Plumbing	sq ft	25.00	750	18,750
Fire Protection	sq ft	4.00	750	3,000
Lightning Protection	LS			5,000
Screening Equipment				
Fine Screens for Domestic IFAS	each	314,000.00	2	628,000
Washer Compactor	each	137,000.00	2	274,000
Piles (Depth of 70 feet)	sq ft	4,550.00	28	127,400
				1,441,000
	<i>Fine Screen Building</i>			
<i>Domestic IFAS Basin</i>				
Concrete, Cast-In-Place				
Slab on Grade	cu yd	530.00	60	31,800
Walls	cu yd	850.00	445	378,250
Suspended Slabs	cu yd	950.00	60	57,000
Concrete Fill	cu yd	400.00	400	160,000
Embedded Accessories	LS			14,475
Mechanical Pipe Modifications				
42-inch Influent	lin ft	180.00	680	122,400
30-inch RAS	lin ft	100.00	640	64,000
42-inch MLSS Return Line	lin ft	630.00	600	378,000
42-inch Effluent to FC	lin ft	630.00	140	88,200
Pipe Connections to Existing Facilities	each	10,000.00	6	60,000
Metal				
Handrail	lin ft	55.00	2000	110,000
Miscellaneous	LS			11,000
Painting	LS			2,400
Equipment				
Recycle Pumps (20 mgd, 40 hp) (2/basin, 1 standby)	each	50,000.00	7	350,000
Anoxic Mixers (9 hp)	each	27,500.00	4	110,000
Supplemental Oxid Mixers (9 hp)	each	27,500.00	4	110,000
Davit Crane for Pumps	each	10,000.00	15	150,000
Equipment Installation	LS	40%		288,000
Coarse Bubble Diffuser	LS			161,000
Diffuser Installation	LS	25%		40,250
Piles (Depth of 70 feet)	sq ft	4,550.00	10	45,500
IFAS System				
IFAS Media and IFAS Sieves	LS	3,300,000.00	1	3,300,000
				6,032,000
	<i>Domestic IFAS Basin</i>			
<i>MBR Fine Screen Building</i>				
Building Superstructure (Single Story)	sq ft	264.00	375	99,000
Earthwork				
Structural Excavation	cu yd	20.00	311	6,220
Compacted Fill	cu yd	25.00	110	2,750
Granular Fill	cu yd	35.00	9	330

St. Joseph, Missouri
TM-WW-4 - Nutrient Removal Facilities
Alternative 1C - IFAS for Domestic Flows, MBR for Industrial Flows

Item Description	Units	Unit Cost	Quantity	Total Cost
Sheeting and Dewatering	LS			
Concrete				
Slab on Grade/Footings	cu yd	530.00	19	9,989
Walls	cu yd	850.00	40	33,941
Suspended Slab and Beams	cu yd	950.00	14	13,194
Embedded Accessories	LS			1,453
Metal				
Handrail	lin ft	60.00	0	-
Painting	LS			50,000
Process piping	LS			-
HVAC	sq ft	30.00	375	11,250
Plumbing	sq ft	25.00	375	9,375
Fire Protection	sq ft	4.00	375	1,500
Lightning Protection	LS			5,000
Screening Equipment				
Fine Screens for Domestic IFAS	each	350,000.00	3	1,050,000
Washer Compactor	each	Included w/ screen cost	0	-
Piles (Depth of 70 feet)	sq ft	4,550.00	28	127,400
				<u>1,421,000</u>
	<i>Fine Screen Building</i>			
 Industrial MBR Basin				
Demolition				
Concrete	cu yd	250.00	0	-
Concrete, Cast-In-Place				
Slab on Grade	cu yd	530.00	200	106,000
Walls	cu yd	850.00	1100	935,000
Suspended Slabs	cu yd	950.00	0	-
Concrete Fill	cu yd	400.00	500	200,000
Embedded Accessories	LS			27,000
Mechanical				
24-inch MLSS Recycle	lin ft	360.00	640	230,400
48-inch Influent to Industrial BNR Basin	lin ft	720.00	400	288,000
48-inch to Plant Effluent	lin ft	720.00	1400	1,008,000
Metal				
Handrail	lin ft	55.00	350	19,250
Miscellaneous	LS			1,925
Painting	LS			2,400
Equipment				
Anoxic Mixers (3 - 4.5 hp)	each	27,500.00	2	55,000
Post Anoxic Mixers (6 - 7 hp)	each	27,500.00	4	110,000
Oxic Zone Mixers (6 - 7 hp)	each	27,500.00	4	110,000
Recycle Pumps (2 - 13 mgd, 1 duty 1 standby)	each	50,000.00	4	200,000
Davit Crane for Pumps and Mixers	each	10,000.00	14	140,000
Equipment Installation	LS	40%		246,000
Fine Bubble Diffuser	LS			350,000
Diffuser Installation	LS	25%		87,500
Membrane Bioreactor				
Building Superstructure and Slab	sq ft	201.00	2,000	402,000
MBR	LS			8,000,000
Installation		40%		3,200,000
Misc. Piping	LS			105,000
Lifting Equipment	each	10,000.00	2	20,000
Piles (Depth of 70 feet)	each	4,550.00	10	45,500
				<u>15,889,000</u>
	<i>Industrial MBR Basin</i>			
 Chemical Feed and Storage Building				
	Calculated in another tab			<u>2,759,000</u>
 Ferric Chloride Injection Piping				
	Calculated in another tab			<u>42,000</u>
 Methanol Injection Piping				
	Calculated in another tab			<u>232,000</u>

St. Joseph, Missouri
TM-WW-4 - Nutrient Removal Facilities
Alternative 1C - IFAS for Domestic Flows, MBR for Industrial Flows

Item Description	Units	Unit Cost	Quantity	Total Cost
Blowers				
				4,250,000
				32,066,000
Electrical, Instrumentation, & Controls	LS	25%		8,017,000
				40,083,000
Sitework	LS	10%		4,008,000
				44,091,000
General Requirements	LS	12%		5,291,000
Flood Protection/Fill (placeholder)	cu yd	25.00	0	-
Site Remediation (placeholder)	cu yd	150.00	4,444	666,667
				50,049,000
Contingency	LS	25%		12,512,000
Land Acquisition (placeholder)	sq ft	1.33	24,000	32,000
Opinion of Probable Construction Cost				62,593,000
Engineering, Legal, & Administration	LS	20%		12,519,000
Opinion of Probable Project Cost				75,112,000

Assumed Structure for Service Life Assessment

Assumed Equipment for Service Life Assessment

Potential Project Add-Ons

Industrial CAS Basin Concrete Liner

Concrete, Cast-In-Place				
Slab on Grade	cu yd	530.00	2,500	1,325,000
Walls	cu yd	850.00	1,800	1,530,000
Suspended Slabs	cu yd	950.00	0	-
Concrete Fill	cu yd	400.00	0	-
Embedded Accessories	LS			64,500
				2,920,000
				2,920,000
Electrical, Instrumentation, & Controls	LS	25%		730,000
				3,650,000
Sitework	LS	10%		365,000
				4,015,000
General Requirements	LS	12%		482,000
Flood Protection/Fill (placeholder)	cu yd	25.00	0	-
Site Remediation (placeholder)	cu yd	150.00	0	-
				4,497,000
Contingency	LS	25%		1,124,000
Land Acquisition (placeholder)	sq ft	1.33	0	-
Opinion of Probable Construction Cost				5,621,000
Engineering, Legal, & Administration	LS	20%		1,124,000
Opinion of Probable Project Cost				6,745,000

St. Joseph, Missouri
TM-WW-4 - Nutrient Removal Facilities
Alternative 2B - IFAS for Combined Domestic and Industrial Flows

Item Description	Units	Unit Cost	Quantity	Total Cost
<i>Fine Screen Building</i>				
25' by 30' Building Superstructure (Single Story)	sq ft	240.00	750	180,000
Earthwork				
Structural Excavation	cu yd	20.00	622	12,439
Compacted Fill	cu yd	25.00	220	5,500
Granular Fill	cu yd	35.00	19	660
Sheeting and Dewatering				
	LS			
Concrete				
Slab on Grade/Footings	cu yd	530.00	38	19,978
Walls	cu yd	850.00	80	67,882
Suspended Slab and Beams	cu yd	950.00	28	26,389
Embedded Accessories	LS			2,907
Metal				
Handrail	lin ft	60.00	0	-
Painting				
	LS			50,000
Process Piping				
	LS			-
HVAC				
	sq ft	30.00	750	22,500
Plumbing				
	sq ft	25.00	750	18,750
Fire Protection				
	sq ft	4.00	750	3,000
Lightning Protection				
	LS			5,000
Screening Equipment				
Fine Screens for Combined IFAS	each	314,000.00	3	942,000
Washer Compactor	each	137,000.00	3	411,000
Piles (Depth of 70 feet)	sq ft	4,550.00	28	127,400
<i>Fine Screen Building</i>				1,895,000
<i>Anoxic Basin</i>				
Earthwork				
Structural Excavation	cu yd	20.00	10,650	213,000
Compacted Fill	cu yd	25.00	850	21,250
Granular Fill	cu yd	35.00	910	31,850
Basin Pressure Relief				
4" Valves	each	400.00	10	4,000
Concrete, Cast-In-Place				
Slab on Grade	cu yd	530.00	975	516,750
Walls	cu yd	850.00	1,465	776,450
Suspended Slabs	cu yd	950.00	0	-
Concrete Fill	cu yd	400.00	0	-
Embedded Accessories	LS			36,600
Metal				
Handrail	lin ft	55.00	770	42,350
Scum Baffle and Weir	lin ft	0.00	0	-
Miscellaneous	LS			4,235
Painting				
	LS			31,200
Equipment				
Mixers (7 hp)	each	27,500.00	8	220,000
Mechanical				
	LS			
60-inch Influent	lin ft	900.00	720	648,000
72-inch Anoxic to Oxid	lin ft	1,080.00	560	604,800
72-inch Splitter to Anoxic	lin ft	1,080.00	280	302,400
Influent Splitter Box				
	LS			150,000
Piles	sq ft	4,550.00	175	796,250
<i>Anoxic BNR Basin</i>				4,399,000
<i>IFAS Basin (one new basin and three modified)</i>				
Earthwork				
Structural Excavation	cu yd	20.00	9,300	186,000
Compacted Fill	cu yd	25.00	400	10,000
Granular Fill	cu yd	35.00	550	19,250
Concrete, Cast-In-Place				
Slab on Grade	cu yd	530.00	890	471,700
Walls	cu yd	850.00	575	488,750

St. Joseph, Missouri
TM-WW-4 - Nutrient Removal Facilities
Alternative 2B - IFAS for Combined Domestic and Industrial Flows

Item Description	Units	Unit Cost	Quantity	Total Cost
Suspended Slabs	cu yd	950.00	0	-
Concrete Fill	cu yd	400.00	400	160,000
Embedded Accessories	LS			27,975
Metal				
Handrail	lin ft	55.00	1,600	88,000
Miscellaneous	LS			8,800
Painting	LS			2,400
Equipment				
Recycle Pumps (3 - 15 mgd, 40 hp) (2 duty 1 standby)	each	50,000.00	12	600,000
Supplemental Oxid Mixers (5 hp)	each	27,500.00	8	220,000
Davit Crane for Pumps	each	10,000.00	20	200,000
Equipment Installation	LS	40%		408,000
Coarse Bubble Diffuser	LS			455,900
Diffuser Installation	LS	25%		113,975
Mechanical	LS			
36-inch RAS	lin ft	540.00	940	507,600
42-inch MLSS	lin ft	630.00	960	604,800
72-inch Oxid Effluent	lin ft	1,080.00	480	518,400
Pipe Connections to Existing Facilities	each	10,000.00	12	120,000
Piles	sq ft	4,550.00	160	728,000
IFAS System				
IFAS Media and IFAS Sieves	LS	6,600,000.00	1	6,600,000
				12,540,000
	<i>IFAS Basin</i>			
Post Anoxic Basin				
Earthwork				
Structural Excavation	cu yd	20.00	23,500	470,000
Compacted Fill	cu yd	25.00	1,100	27,500
Granular Fill	cu yd	35.00	1,700	59,500
Substructure Piping				
42-inch Influent	lin ft	630.00	500	315,000
36-inch MLSS Return	lin ft	540.00	700	378,000
RAS	lin ft			
Basin Pressure Relief				
4" Valves	each	400.00	12	4,800
Concrete, Cast-In-Place				
Slab on Grade	cu yd	530.00	2,265	1,200,450
Walls	cu yd	850.00	1,815	961,950
Concrete Fill	cu yd	400.00	0	-
Embedded Accessories	LS			61,200
Metal				
Handrail	lin ft	55.00	1,200	66,000
Scum Baffle and Weir	lin ft	0.00	0	-
Miscellaneous	LS			6,600
Painting	LS			31,200
Equipment				
Post Anoxic Mixers (12 hp)	each	30,000.00	8	240,000
Davit Crane for Mixers	each	10,000.00	8	80,000
Fine Bubble System	each	4,550.00		-
Mechanical	LS			
42-inch Influent	lin ft	630.00	480	302,400
42-inch Effluent	lin ft	630.00	400	252,000
Influent Splitter Box	LS			150,000
Piles	sq ft	4,550.00	390	1,774,500
				6,381,000
	<i>Post Anoxic Basin</i>			
Transfer Pumping Station				
Earthwork				
Structural Excavation	cu yd	20.00	9,000	180,000
Compacted Fill	cu yd	25.00	900	22,500
Granular Fill	cu yd	35.00	950	33,250
Sheeting, Shoring, Dewatering	LS			350,000

St. Joseph, Missouri
TM-WW-4 - Nutrient Removal Facilities
Alternative 2B - IFAS for Combined Domestic and Industrial Flows

Item Description	Units	Unit Cost	Quantity	Total Cost
Concrete				
Slab on Grade/Footings	cu yd	530.00	900	477,000
Walls	cu yd	850.00	1,700	1,445,000
Suspended Slab and Beams	cu yd	950.00	600	570,000
Fill	cu yd	400.00	0	-
Embedded Accessories	LS			112,000
Masonry				
Lump Sum for Building	LS			450,000
Metal				
Lump Sum for Building	LS			450,000
Thermal/Moisture Protection	LS			120,000
Doors/Miscellaneous Specialties	LS			95,000
Painting	LS			90,000
Equipment				
Pumps (10 mgd, 15 ft head, 35 hp)	each	25,000.00	3	75,000
Pumps (20 mgd, 25 ft head, 120 hp)	each	100,000.00	5	500,000
Monorail	each	50,000.00	1	100,000
Equipment Installation	LS	40%		270,000
Piping and Valves	LS			1,200,000
HVAC	LS			300,000
Plumbing	LS			95,000
Piles	each	4,550.00	200	910,000
<i>Transfer Pumping Station</i>				<u>7,845,000</u>
 Domestic Final Clarifier				
Earthwork				
Structural Excavation	cu yd	20.00	12,900	258,000
Compacted Fill	cu yd	25.00	980	24,500
Granular Fill	cu yd	35.00	830	29,050
Substructure Piping w/encasement				
42-inch Influent	lin ft	630.00	82	51,660
24-inch Sludge Drain	lin ft	360.00	78	28,080
Basin Pressure Relief				
Valve, 4-inch	each	400.00	8	3,200
Concrete				
Slab on Grade/Footings	cu yd	530.00	660	349,800
Walls	cu yd	850.00	350	297,500
Suspended Slab and Beams	cu yd	950.00	40	38,000
Fill	cu yd	400.00	55	22,000
Embedded Accessories	LS			22,100
Metal				
Handrail	lin ft	55.00	504	27,720
Scum Baffle and Weir	lin ft	125.00	484	60,500
Miscellaneous	LS			8,822
Painting				60,319
Equipment				
Circular Clarifying Equipment	LS			528,000
Mechanical				
Scum Piping and Miscellaneous	LS			18,093
Piles	each	4,550.00	156	709,800
<i>Domestic Final Clarifier</i>				<u>2,537,000</u>
 Chemical Feed and Storage Building				
Calculated in another tab				<u>2,759,000</u>
 Ferric Chloride Injection Piping				
Calculated in another tab				<u>14,000</u>
 Methanol Injection Piping				
Calculated in another tab				<u>64,000</u>

St. Joseph, Missouri
TM-WW-4 - Nutrient Removal Facilities
Alternative 2B - IFAS for Combined Domestic and Industrial Flows

Item Description	Units	Unit Cost	Quantity	Total Cost
<i>Blowers</i>				
Calculated separately				4,250,000
<i>Alternative 1A Subtotal</i>				<u>42,684,000</u>
Electrical, Instrumentation, & Controls	LS	25%		10,671,000
<i>Subtotal</i>				<u>53,355,000</u>
Sitework	LS	10%		5,336,000
<i>Subtotal</i>				<u>58,691,000</u>
General Requirements	LS	12%		7,043,000
Flood Protection/Fill (placeholder)	cu yd	25.00	0	-
Site Remediation (placeholder)	cu yd	150.00	14,600	2,190,000
<i>Subtotal</i>				<u>67,924,000</u>
Contingency	LS	25%		16,981,000
Land Acquisition (placeholder)	sq ft	1.33	79,000	105,000
Opinion of Probable Construction Cost				85,010,000
Engineering, Legal, & Administration	LS	20%		17,002,000
Opinion of Probable Project Cost				102,012,000

Assumed Structure for Service Life Assessment
Assumed Equipment for Service Life Assessment

St. Joseph, Missouri
TM-WW-4 - Nutrient Removal Facilities
All Alternatives - Chemical Feed and Storage Building

Item Description	Units	Unit Cost	Quantity	Total Cost
<i>Chemical Feed and Storage Building</i>				
Building Superstructure and Slab	sq ft	184.00	3,500	644,000
Earthwork				
Structural Excavation	cu yd	20.00	311	6,222
Compacted Fill	cu yd	25.00	350	8,750
Granular Fill	cu yd	35.00	175	6,125
Concrete				
Slab on Grade/Footings	cu ft	530.00	-	-
Pump and Tank Pads	cu ft	630.00	55	34,627
Walls	cu ft	850.00	28	23,611
Suspended Slab and Beams	cu ft	950.00	-	-
Embedded Accessories	LS			1,655
HVAC	sq ft	35.00	3,500	122,500
Plumbing	sq ft	10.00	3,500	35,000
Fire Protection	sq ft	3.50	3,500	12,250
Protective Coating for Chemical Storage Floors	sq ft	35.00	3,500	122,500
Piles	each	4,550.00	89	404,950
Ferric Chloride				
FRP Storage Tanks	gallons	6.60	25,000	165,000
Level Transmitter	each	3,500.00	5	17,500
Level Gauge	each	2,100.00	5	10,500
Pumps	each	8,400.00	4	33,600
Pump Control Panels	each	6,300.00	4	25,200
1" PVC Piping	lin ft	20.00	3,500	70,000
2" PVC Piping around Tanks	lin ft	25.00	700	17,500
Piping Devices	LS/pump	3,500.00	7	24,500
Valves	each	300.00	56	16,800
Suppliers Costs (submittals, freight, profit)	LS			76,120
Methanol				
Carbon Steel Storage Tanks	gallons	7.20	27,900	200,880
SS Floating Cover	LS			153,000
Level Transmitter	each	3,500.00	5	17,500
Level Gauge	each	2,100.00	5	10,500
Pumps - Explosion Proof	each	11,200.00	8	89,600
Pump Control Panels - Explosion Proof	each	11,200.00	8	89,600
1" Double Contained CS Piping	lin ft	40.00	2,500	100,000
2" Double Contained CS Piping around Tanks	lin ft	50.00	500	25,000
Piping Devices	LS/pump	3,500.00	4	14,000
Valves	each	300.00	32	9,600
Fire Valves	LS/tank	2,000.00	5	10,000
Flame Arrestor	LS/tank	1,500.00	5	7,500
Truck Unloading Panel - Explosion Proof	each	3,000.00	1	3,000
Eye-wash Station	each	3,000.00	1	3,000
Suppliers Costs (submittals, freight, profit)	LS			146,636
<i>Chemical Storage Subtotal</i>				<i>2,759,000</i>
Chem Strg & Feed Bldg Site Remediation (placeholder)	cu yd	150.00	4,444	667,000
Chem Strg & Feed Bldg Land Acquisition (placeholder)	sq ft	1.33	24,000	32,000
<i>Chemical Feed and Storage Building (Methanol Only)</i>				
Building and shared systems				711,095
Methanol System				879,816
<i>Chemical Storage Subtotal</i>				<i>1,591,000</i>
<i>Chemical Feed and Storage Building (Ferric Chloride Only)</i>				
Building and shared systems				711,095
Methanol System				456,720
<i>Chemical Storage Subtotal</i>				<i>1,168,000</i>

St. Joseph, Missouri
TM-WW-4 - Nutrient Removal Facilities
Cost to Refurbish Beams in Aerobic Digesters

Costs for Beam/Connection Repair and Installation

	Unit	Cost/Unit	Quantity	Total
Bracing During Construction	LS			\$10,000
Remove Beams	lb	\$1.50	25,802	\$38,703
Sandblast Beams (SP 10 Blast)	sq ft	\$8.00	2,667	\$21,338
Epoxy Coat Beams (incl. primer)	sq ft	\$6.00	2,667	\$16,003
New SS Connections	LS			\$20,000
Reinstall Beams	lb	\$1.50	25,802	\$38,703
Miscellaneous Metals	LS			\$6,870
Subtotal				\$151,617

for removing rust

PER BASIN

** Cost does not include General Requirements/Mobilization or Contingency

For All SIX BASINS **\$909,703** ADD gen reqt, etc, contingency

Per Basin Subtotal				151,617
Electrical, Instrumentation, & Controls	LS	25%		38,000
	<i>Subtotal</i>			<u>190,000</u>
Sitework	LS	10%		19,000
	<i>Subtotal</i>			<u>209,000</u>
General Requirements	LS	12%		25,000
Flood Protection/Fill (placeholder)	cu yd	25.00	-	-
Site Remediation (placeholder)	cu yd	150.00	-	-
	<i>Subtotal</i>			<u>234,000</u>
Contingency	LS	25%		59,000
Land Acquisition (placeholder)	sq ft	1.33		-
				<u>293,000</u>
Opinion of Probable Construction Cost				293,000
Engineering, Legal, & Administration	LS	20%		59,000
Opinion of Probable Project Cost				350,000

Appendix B

Opinion of Probable Net Present Worth Breakdown

St. Joseph, Missouri
 TM-WW-4 - Nutrient Removal Facilities
 Recommended Ammonia Removal Alternative

Net Present Worth

Capital Project Elements	1st Year Acquired or Installed	Life (Years)	2009 Cost (\$)	2009 Cost (\$)	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	TOTAL PRESENT WORTH	REMAINING VALUE 0.37689	NET PRESENT WORTH	EQUIVALENT ANNUAL COST 0.08024		
					Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20						
Domestic Aeration Basin																															
Structure	2009	50	\$0	\$0																											
Equipment	2009	20	\$147,000	\$147,000	\$147,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	\$568,844	\$568,844				
Industrial Aeration Basin																															
Structure	2009	50	\$1,258,000	\$1,258,000	\$1,258,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-					
Equipment	2009	20	\$721,000	\$721,000	\$721,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	\$2,790,042	\$2,790,042				
Industrial Final Clarifier																															
Structure	2009	50	\$1,262,000	\$1,262,000	\$1,262,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-					
Equipment	2009	20	\$415,000	\$415,000	\$415,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	\$1,605,919	\$1,605,919				
Industrial RAS Pumping Station																															
Structure	2009	50	\$1,226,000	\$1,226,000	\$1,226,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-					
Equipment	2009	20	\$403,200	\$403,200	\$403,200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	\$1,560,257	\$1,560,257				
Blowers																															
Equipment	2009	20	\$4,250,000	\$4,250,000	\$4,250,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	\$16,446,159	\$16,446,159				
Electrical, Instrumentation, and Controls	2009	20	\$2,421,000	\$2,421,000	\$2,421,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	\$9,368,506	\$9,368,506				
Land Acquisition	2009	10,000	\$0	\$0																											
Sitework	2009		\$1,211,000	\$1,211,000	\$1,211,000																										
General Requirements	2009		\$1,598,000	\$1,598,000	\$1,598,000																										
Flood Protection/Fill	2009		\$0	\$0																											
Site Remediation	2009		\$0	\$0																											
Contingency	2009		\$3,729,000	\$3,729,000	\$3,729,000																										
Construction Subtotal			\$18,641,200	\$18,641,200	\$18,641,200																					\$32,340,000					
Engineering, Legal, and Administration	20%	2009	\$3,728,240	\$3,728,240	\$3,728,240																										
Interest During Construction (yrs)		0																													
Opinion of Probable Project Cost			\$22,370,000	\$22,370,000	\$22,370,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	
Factored Totals			\$22,370,000	\$22,370,000	\$22,370,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$12,189,000	\$34,559,000	\$15,466,500	\$19,092,500	\$1,500,000

O&M Elements	2009 Annual Cost (\$)	2009 Year Cost (\$)	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	TOTAL PRESENT WORTH	EQUIVALENT ANNUAL COST 0.08024
			Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20		
Power	\$1,032,000	\$1,032,000		\$1,083,600	\$1,137,780	\$1,194,669	\$1,254,402	\$1,317,123	\$1,382,979	\$1,452,128	\$1,524,734	\$1,600,971	\$1,681,019	\$1,765,070	\$1,853,324	\$1,945,990	\$2,043,289	\$2,145,454	\$2,252,727	\$2,365,363	\$2,483,631	\$2,607,813	\$2,738,203		
Chemicals	\$0	\$0		\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0		
Labor	\$48,000	\$48,000		\$50,400	\$52,920	\$55,566	\$58,344	\$61,262	\$64,325	\$67,541	\$70,918	\$74,464	\$78,187	\$82,096	\$86,201	\$90,511	\$95,037	\$99,789	\$104,778	\$110,017	\$115,518	\$121,294	\$127,358		
Opinion of Probable O&M Cost	\$1,080,000			\$1,134,000	\$1,190,700	\$1,250,235	\$1,312,747	\$1,378,384	\$1,447,303	\$1,519,668	\$1,595,652	\$1,675,434	\$1,759,206	\$1,847,167	\$1,939,525	\$2,036,501	\$2,138,326	\$2,245,242	\$2,357,505	\$2,475,380	\$2,599,149	\$2,729,106	\$2,865,562		
Factored Totals			\$0	\$1,080,000	\$1,080,000	\$1,080,000	\$1,080,000	\$1,080,000	\$1,080,000	\$1,080,000	\$1,080,000	\$1,080,000	\$1,080,000	\$1,080,000	\$1,080,000	\$1,080,000	\$1,080,000	\$1,080,000	\$1,080,000	\$1,080,000	\$1,080,000	\$1,080,000	\$1,080,000	\$21,600,000	\$1,733,240

Economic Analysis Criteria:
 Interest Rate = 5.00%
 Capital Escalation Rate = 7.00%
 O&M Escalation Rate = 5.00%
 Baseline for costs = May-09
 ENR Building Cost Index = 4773

Net Present Worth = \$40,692,000

St. Joseph, Missouri
 TM-WW-4 - Nutrient Removal Facilities
 Alternative 1A - Activated Sludge for Domestic Flows, Activated Sludge for Industrial Flows

Net Present Worth

Capital Project Elements	1st Year Acquired or Installed	Life (Years)	2009 Cost (\$)	2009 Cost (\$)	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	TOTAL PRESENT WORTH	REMAINING VALUE 0.37689	NET PRESENT WORTH	EQUIVALENT ANNUAL COST 0.08024		
					Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20						
Domestic CAS Anoxic Basin																															
Structure	2009	50	\$4,453,000	\$4,453,000	\$4,453,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-						
Equipment	2009	20	\$257,000	\$257,000	\$257,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	\$994,509	\$994,509				
Domestic CAS Oxid Basin																															
Structure	2009	50	\$2,580,000	\$2,580,000	\$2,580,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-						
Equipment	2009	20	\$1,304,000	\$1,304,000	\$1,304,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	\$5,046,069	\$5,046,069				
Domestic Final Clarifier																															
Structure	2009	50	\$1,988,000	\$1,988,000	\$1,988,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-						
Equipment	2009	20	\$549,000	\$549,000	\$549,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	\$2,124,457	\$2,124,457				
Industrial CAS Basin																															
Structure	2009	50	\$4,092,000	\$4,092,000	\$4,092,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-						
Equipment	2009	20	\$1,690,000	\$1,690,000	\$1,690,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	\$6,539,767	\$6,539,767				
Industrial Final Clarifier																															
Structure	2009	50	\$1,988,000	\$1,988,000	\$1,988,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-						
Equipment	2009	20	\$549,000	\$549,000	\$549,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	\$2,124,457	\$2,124,457				
Industrial RAS Pumping Station																															
Structure	2009	50	\$1,226,000	\$1,226,000	\$1,226,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-						
Equipment	2009	20	\$403,000	\$403,000	\$403,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	\$1,559,483	\$1,559,483				
Chemical Feed and Storage Building																															
Structure	2009	50	\$1,252,000	\$1,252,000	\$1,252,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-						
Equipment	2009	20	\$1,506,000	\$1,506,000	\$1,506,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	\$5,827,745	\$5,827,745				
Ferric Chloride Injection Piping																															
Structure	2009	50	\$42,000	\$42,000	\$42,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-						
Methanol Injection Piping																															
Structure	2009	50	\$300,000	\$300,000	\$300,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-						
Blowers																															
Equipment	2009	20	\$4,250,000	\$4,250,000	\$4,250,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	\$16,446,159	\$16,446,159				
Electrical, Instrumentation, and Controls	2009	20	\$7,108,000	\$7,108,000	\$7,108,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	\$27,505,717	\$27,505,717				
Land Acquisition	2009	10,000	\$32,000	\$32,000	\$32,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-						
Sitework	2009		\$3,554,000	\$3,554,000	\$3,554,000																										
General Requirements	2009		\$4,691,000	\$4,691,000	\$4,691,000																										
Flood Protection/Fill	2009		\$0	\$0	\$0																										
Site Remediation	2009		\$666,667	\$666,700	\$666,700																										
Contingency	2009		\$11,113,000	\$11,113,000	\$11,113,000																										
Construction Subtotal			\$55,593,667	\$55,593,700	\$55,593,700																					\$68,170,000					
Engineering, Legal, and Administration	20%	2009	\$11,118,733	\$11,118,740	\$11,118,740																										
Interest During Construction (yrs)		0																													
Opinion of Probable Project Cost			\$66,710,000	\$66,710,000	\$66,710,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$68,170,000	\$109,901,113				
Factored Totals			\$66,710,000	\$66,710,000	\$66,710,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$68,170,000	\$109,901,113	\$92,403,000	\$41,420,574	\$50,982,426	\$4,100,000

O&M Elements	2009 Annual Cost (\$)	2009 Year Cost (\$)	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	TOTAL PRESENT WORTH	EQUIVALENT ANNUAL COST 0.08024
			Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20		
Power	\$1,859,000	\$1,859,000	\$1,951,950	\$2,049,548	\$2,152,025	\$2,259,626	\$2,372,607	\$2,491,238	\$2,615,800	\$2,746,590	\$2,883,919	\$3,028,115	\$3,179,521	\$3,338,497	\$3,505,422	\$3,680,693	\$3,864,727	\$4,057,964	\$4,260,862	\$4,473,905	\$4,697,600	\$4,932,480			
Chemicals	\$2,506,000	\$2,506,000	\$2,631,300	\$2,762,865	\$2,901,008	\$3,046,059	\$3,198,362	\$3,358,280	\$3,526,194	\$3,702,503	\$3,887,629	\$4,082,010	\$4,286,110	\$4,500,416	\$4,725,437	\$4,961,709	\$5,209,794	\$5,470,284	\$5,743,798	\$6,030,988	\$6,332,537	\$6,649,164			
Labor	\$144,000	\$144,000	\$151,200	\$158,760	\$166,698	\$175,033	\$183,785	\$192,974	\$202,622	\$212,754	\$223,391	\$234,561	\$246,289	\$258,603	\$271,533	\$285,110	\$299,366	\$314,334	\$330,051	\$346,553	\$363,881	\$382,075			
Opinion of Probable O&M Cost	\$4,509,000		\$4,734,450	\$4,971,173	\$5,219,731	\$5,480,718	\$5,754,754	\$6,042,491	\$6,344,616	\$6,661,847	\$6,994,939	\$7,344,686	\$7,711,920	\$8,097,516	\$8,502,392	\$8,927,512	\$9,373,887	\$9,842,582	\$10,334,711	\$10,851,446	\$11,394,018	\$11,963,719			
Factored Totals			\$0	\$4,509,000	\$4,509,000	\$4,509,000	\$4,509,000	\$4,509,000	\$4,509,000	\$4,509,000	\$4,509,000	\$4,509,000	\$4,509,000	\$4,509,000	\$4,509,000	\$4,509,000	\$4,509,000	\$4,509,000	\$4,509,000	\$4,509,000	\$4,509,000	\$4,509,000	\$4,509,000	\$90,180,000	\$7,236,277

Economic Analysis Criteria:
 Interest Rate = 5.00%
 Capital Escalation Rate = 7.00%
 O&M Escalation Rate = 5.00%
 Baseline for costs = May-09
 ENR Building Cost Index = 4773

Net Present Worth = \$141,162,000

St. Joseph, Missouri

TM-WW-4 - Nutrient Removal Facilities

Alternative 1C - IFAS for Domestic Flows, MBR for Industrial Flows

Net Present Worth

Capital Project Elements	1st Year Acquired or Installed	Life (Years)	2009 Cost (\$)	2009 Cost (\$)	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	TOTAL PRESENT WORTH	REMAINING VALUE	NET PRESENT WORTH	EQUIVALENT ANNUAL COST		
					Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20						
					1.00000	0.95238	0.90703	0.86384	0.82270	0.78353	0.74622	0.71068	0.67684	0.64461	0.61391	0.58468	0.55684	0.53032	0.50507	0.48102	0.45811	0.43630	0.41552	0.39573	0.37689						
IFAS Fine Screen Building																															
Structure	2009	50	\$539,000	\$539,000	\$539,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-					
Equipment	2009	20	\$902,000	\$902,000	\$902,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		\$1,251,456				
Domestic IFAS Basin																															
Structure	2009	50	\$4,823,000	\$4,823,000	\$4,823,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		\$11,198,093				
Equipment	2009	20	\$1,209,000	\$1,209,000	\$1,209,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		\$4,678,449				
MBR Fine Screen Building																															
Structure	2009	50	\$371,000	\$371,000	\$371,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		\$861,392				
Equipment	2009	20	\$1,050,000	\$1,050,000	\$1,050,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		\$4,063,169				
Industrial MBR Basin																															
Structure	2009	50	\$3,265,000	\$3,265,000	\$3,265,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		\$7,580,712				
Equipment	2009	20	\$12,623,500	\$12,623,500	\$12,623,500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		\$48,848,962				
Chemical Feed and Storage Building																															
Structure	2009	50	\$1,252,000	\$1,252,000	\$1,252,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		\$2,906,907				
Equipment	2009	20	\$1,506,000	\$1,506,000	\$1,506,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		\$5,827,745				
Ferric Chloride Injection Piping																															
Structure	2009	50	\$42,000	\$42,000	\$42,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		\$97,516				
Methanol Injection Piping																															
Structure	2009	50	\$232,000	\$232,000	\$232,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		\$538,660				
Blowers																															
Equipment	2009	20	\$4,250,000	\$4,250,000	\$4,250,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		\$16,446,159				
Electrical, Instrumentation, and Controls	2009	20	\$8,017,000	\$8,017,000	\$8,017,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		\$31,023,260				
Land Acquisition	2009	10,000	\$32,000	\$32,000	\$32,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		\$123,582				
Sitework	2009		\$4,008,000	\$4,008,000	\$4,008,000																										
General Requirements	2009		\$5,291,000	\$5,291,000	\$5,291,000																										
Flood Protection/Fill	2009		\$0	\$0	\$0																										
Site Remediation	2009		\$666,667	\$666,667	\$666,667																										
Contingency	2009		\$12,512,000	\$12,512,000	\$12,512,000																										
Construction Subtotal			\$62,591,167	\$62,591,200	\$62,591,200																							\$114,380,000			
Engineering, Legal, and Administration	20%	2009	\$12,518,233	\$12,518,240	\$12,518,240																										
Interest During Construction (yrs)		0																													
Opinion of Probable Project Cost			\$75,110,000	\$75,110,000	\$75,110,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$114,380,000	\$138,936,516			
Factored Totals			\$75,110,000	\$75,110,000	\$75,110,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$43,109,000	\$118,219,000	\$52,363,712	\$65,855,288	\$5,300,000

O&M Elements	2009 Annual Cost (\$)	2009 Year Cost (\$)	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	TOTAL PRESENT WORTH	EQUIVALENT ANNUAL COST	
			Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20			
			1.00000	0.95238	0.90703	0.86384	0.82270	0.78353	0.74622	0.71068	0.67684	0.64461	0.61391	0.58468	0.55684	0.53032	0.50507	0.48102	0.45811	0.43630	0.41552	0.39573	0.37689			
Power	\$2,576,000	\$2,576,000		\$2,704,800	\$2,840,040	\$2,982,042	\$3,131,144	\$3,287,701	\$3,452,086	\$3,624,691	\$3,805,925	\$3,996,221	\$4,196,033	\$4,405,834	\$4,626,126	\$4,857,432	\$5,100,304	\$5,355,319	\$5,623,085	\$5,904,239	\$6,199,451	\$6,509,424	\$6,834,895			
Chemicals	\$2,544,000	\$2,544,000		\$2,671,200	\$2,804,760	\$2,944,998	\$3,092,248	\$3,246,860	\$3,409,203	\$3,579,663	\$3,758,647	\$3,946,579	\$4,143,908	\$4,351,103	\$4,568,658	\$4,797,091	\$5,036,946	\$5,288,793	\$5,553,233	\$5,830,895	\$6,122,439	\$6,428,561	\$6,749,989			
Labor	\$168,000	\$168,000		\$176,400	\$185,220	\$194,481	\$204,205	\$214,415	\$225,136	\$236,393	\$248,213	\$260,623	\$273,654	\$287,337	\$301,704	\$316,789	\$332,629	\$349,260	\$366,723	\$385,059	\$404,312	\$424,528	\$445,754			
Opinion of Probable O&M Cost	\$5,288,000			\$5,552,400	\$5,830,020	\$6,121,521	\$6,427,597	\$6,748,977	\$7,086,426	\$7,440,747	\$7,812,784	\$8,203,424	\$8,613,595	\$9,044,275	\$9,496,488	\$9,971,313	\$10,469,878	\$10,993,372	\$11,543,041	\$12,120,193	\$12,726,203	\$13,362,513	\$14,030,638			
Factored Totals				\$0	\$5,288,000	\$5,288,000	\$5,288,000	\$5,288,000	\$5,288,000	\$5,288,000	\$5,288,000	\$5,288,000	\$5,288,000	\$5,288,000	\$5,288,000	\$5,288,000	\$5,288,000	\$5,288,000	\$5,288,000	\$5,288,000	\$5,288,000	\$5,288,000	\$5,288,000		\$105,760,000	\$8,486,456

Economic Analysis Criteria:
 Interest Rate = 5.00%
 Capital Escalation Rate = 7.00%
 O&M Escalation Rate = 5.00%
 Baseline for costs = May-09
 ENR Building Cost Index = 4773

Net Present Worth = \$171,615,000

St. Joseph, Missouri
 TM-WW-4 - Nutrient Removal Facilities
 Alternative 2B - IFAS for Combined Domestic and Industrial Flows

Net Present Worth

Capital Project Elements	1st Year Acquired or Installed	Life (Years)	2009 Cost (\$)	2009 Cost (\$)	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	TOTAL PRESENT WORTH	REMAINING VALUE 0.37689	NET PRESENT WORTH	EQUIVALENT ANNUAL COST 0.08024	
					Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20					
Fine Screen Building					1.00000	0.95238	0.90703	0.86384	0.82270	0.78353	0.74622	0.71068	0.67684	0.64461	0.61391	0.58468	0.55684	0.53032	0.50507	0.48102	0.45811	0.43630	0.41552	0.39573	0.37689					
Structure	2009	50	\$542,000	\$542,000	\$542,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-					
Equipment	2009	20	\$1,353,000	\$1,353,000	\$1,353,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	\$5,235,683	\$5,235,683			
Anoxic Basin																														
Structure	2009	50	\$4,179,000	\$4,179,000	\$4,179,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-					
Equipment	2009	20	\$220,000	\$220,000	\$220,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	\$851,331	\$851,331			
IFAS Basin (one new basin and three modified)																														
Structure	2009	50	\$10,542,000	\$10,542,000	\$10,542,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-					
Equipment	2009	20	\$1,998,000	\$1,998,000	\$1,998,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	\$7,731,630	\$7,731,630			
Post Anoxic Basin																														
Structure	2009	50	\$6,061,000	\$6,061,000	\$6,061,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-					
Equipment	2009	20	\$320,000	\$320,000	\$320,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	\$1,238,299	\$1,238,299			
Transfer Pumping Station																														
Structure	2009	50	\$6,900,000	\$6,900,000	\$6,900,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-					
Equipment	2009	20	\$945,000	\$945,000	\$945,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	\$3,656,852	\$3,656,852			
Domestic Final Clarifier																														
Structure	2009	50	\$1,988,000	\$1,988,000	\$1,988,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-					
Equipment	2009	20	\$549,293	\$549,300	\$549,300	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	\$2,125,618	\$2,125,618			
Chemical Feed and Storage Building																														
Structure	2009	50	\$1,252,000	\$1,252,000	\$1,252,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-					
Equipment	2009	20	\$1,506,000	\$1,506,000	\$1,506,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	\$5,827,745	\$5,827,745			
Ferric Chloride Injection Piping																														
Structure	2009	50	\$14,000	\$14,000	\$14,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-					
Methanol Injection Piping																														
Structure	2009	50	\$64,000	\$64,000	\$64,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-					
Blowers																														
Equipment	2009	20	\$4,250,000	\$4,250,000	\$4,250,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-					
Electrical, Instrumentation, and Controls	2009	20	\$10,671,000	\$10,671,000	\$10,671,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	\$16,446,159	\$16,446,159			
Land Acquisition	2009	10,000	\$105,000	\$105,000	\$105,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	\$41,293,403	\$41,293,403			
Sitework	2009		\$5,336,000	\$5,336,000	\$5,336,000																									
General Requirements	2009		\$7,043,000	\$7,043,000	\$7,043,000																									
Flood Protection/Fill	2009		\$0	\$0	\$0																									
Site Remediation	2009		\$2,190,000	\$2,190,000	\$2,190,000																									
Contingency	2009		\$16,981,000	\$16,981,000	\$16,981,000																									
Construction Subtotal			\$85,009,293	\$85,009,300	\$85,009,300																					\$84,410,000				
Engineering, Legal, and Administration	20%	2009	\$17,001,859	\$17,001,860	\$17,001,860																									
Interest During Construction (yrs)		0																												
Opinion of Probable Project Cost			\$102,010,000	\$102,010,000	\$102,010,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$84,410,000	\$158,046,775			
Factored Totals					\$102,010,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$31,813,000	\$133,823,000	\$59,566,167	\$74,256,833	\$6,000,000

O&M Elements	2009 Annual Cost (\$)	2009 Year Cost (\$)	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	TOTAL PRESENT WORTH	EQUIVALENT ANNUAL COST 0.08024
			Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20		
			1.00000	0.95238	0.90703	0.86384	0.82270	0.78353	0.74622	0.71068	0.67684	0.64461	0.61391	0.58468	0.55684	0.53032	0.50507	0.48102	0.45811	0.43630	0.41552	0.39573	0.37689		
Power	\$2,170,000	\$2,170,000		\$2,278,500	\$2,392,425	\$2,512,046	\$2,637,649	\$2,769,531	\$2,908,008	\$3,053,408	\$3,206,078	\$3,366,382	\$3,534,701	\$3,711,436	\$3,897,008	\$4,091,859	\$4,296,452	\$4,511,274	\$4,736,838	\$4,973,680	\$5,222,364	\$5,483,482	\$5,757,656		
Chemicals	\$2,785,000	\$2,785,000		\$2,924,250	\$3,070,463	\$3,223,986	\$3,385,185	\$3,554,444	\$3,732,166	\$3,918,775	\$4,114,713	\$4,320,449	\$4,536,472	\$4,763,295	\$5,001,460	\$5,251,533	\$5,514,110	\$5,789,815	\$6,079,306	\$6,383,271	\$6,702,435	\$7,037,556	\$7,389,434		
Labor	\$96,000	\$96,000		\$100,800	\$105,840	\$111,132	\$116,689	\$122,523	\$128,649	\$135,082	\$141,836	\$148,928	\$156,374	\$164,193	\$172,402	\$181,022	\$190,073	\$199,577	\$209,556	\$220,034	\$231,035	\$242,587	\$254,717		
Opinion of Probable O&M Cost	\$5,051,000			\$5,303,550	\$5,568,728	\$5,847,164	\$6,139,522	\$6,446,498	\$6,768,823	\$7,107,264	\$7,462,627	\$7,835,759	\$8,227,547	\$8,638,924	\$9,070,870	\$9,524,414	\$10,000,635	\$10,500,666	\$11,025,700	\$11,576,985	\$12,155,834	\$12,763,625	\$13,401,807		
Factored Totals				\$0	\$5,051,000	\$5,051,000	\$5,051,000	\$5,051,000	\$5,051,000	\$5,051,000	\$5,051,000	\$5,051,000	\$5,051,000	\$5,051,000	\$5,051,000	\$5,051,000	\$5,051,000	\$5,051,000	\$5,051,000	\$5,051,000	\$5,051,000	\$5,051,000	\$5,051,000	\$101,020,000	\$8,106,106

Economic Analysis Criteria:
 Interest Rate = 5.00%
 Capital Escalation Rate = 7.00%
 O&M Escalation Rate = 5.00%
 Baseline for costs = May-09
 ENR Building Cost Index = 4773

Net Present Worth = \$175,277,000