Rochester Water Reclamation Plant

2019 Facilities Plan

Technical Memorandum 10: Whole Plant Evaluation

TM 10 of 13 | J4325

LOWER ENERGY // CLEAN DESIGN
DECREASED MAINTENANCE // INNOVATIVE PROCESSES

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List of Abbreviations

ABC	Aeration Basin Complex
A/O	anaerobic/oxic
BC	Brown and Caldwell
BNR	biological nutrient removal
City	City of Rochester
d	day(s)
DO	dissolved oxygen
EBPR	enhanced biological phosphorus removal
ft	foot/feet
fps	feet per second
GBT	gravity belt thickener
gpd	gallon(s) per day
gpm	gallon(s) per minute
GT	gravity thickener
GTO	gravity thickener overflow
HPOAS	high-purity oxygen activated sludge
HRT	hydraulic retention time
kg	kilogram(s)
lb	pound(s)
LF	linear foot/feet
m	meter(s)
mg	milligram(s)
G	million gallons
mgd	million gallons per day
MLR	mixed liquor recycle
MLSS	mixed liquor suspended solids
RAS	return activated sludge
s	second(s)
scfm	standard cubic feet per minute
S2EBPR	sidestream enhanced biological phosphorus removal
SND	simultaneous nitrification denitrification
SRT	solids retention time
TKN	total Kjeldahl nitrogen
T	ton(s)
TM	technical memorandum
TN	total nitrogen
TP	total phosphorus
TSS	total suspended solids
VFA	volatile fatty acid
WAS	waste activated sludge
WRP	Water Reclamation Plant
WSE	water surface elevation

Section 1: Executive Summary

This technical memorandum (TM) presents the City of Rochester (City) Water Reclamation Plant (WRP) whole plant considerations for the proposed liquid and solids stream improvements. Areas discussed include options and recommendations for implementing a single activated sludge process, re-routing of existing thickening and dewatering recycles, liquid stream facility phasing, and considerations for sidestream enhanced biological phosphorus removal (S2EBPR).

1.1 Single Activated Sludge System

The liquid stream alternative evaluation (BC, 2019) recommends the Aeration Basin Complex (ABC) continue to operate in an anaerobic/oxic (A/O) biological nutrient removal (BNR) flow scheme and the high purity oxygen activated sludge (HPOAS) train be converted into a parallel A/O system. The evaluation noted the two parallel systems could be unified into a single activated sludge BNR system to simplify operations and provide improved redundancy by combining the Final Clarifiers 1-5 return activated sludge (RAS) flows, adding a RAS distribution structure, wasting sludge from a common RAS line/splitter box, and equally splitting mainstream flow to each “train".

Three alternatives were evaluated to implement a single A/O configuration. The alternatives differ in how the main liquid stream flow is split between the existing ABC and converted HPOAS bioreactors and can be characterized as follows.

- Alternative 1: Primary Influent Flow Split
- Alternative 2: Primary Effluent Flow Split
- Alternative 3: Mixed Liquor Flow Split

Each alternative above includes the following to achieve a single activated sludge concept:

- Combines return activated sludge (RAS) flows from all clarifiers to make one homogenous sludge and then routes the flow to either a new RAS distribution box or non-mixed reactor zone.
- Diverts excess ABC train mixed liquor to Final Clarifiers 1-4 to maximize capacity of the existing clarifiers and prevent overloading Final Clarifier 5.

Primary effluent and mixed liquor flow splitting offer the advantage of equal loading to the two aeration trains as primary effluent is combined prior to feeding the aeration tanks. Combining primary effluent allows Primary Clarifiers 1–3 to be used in parallel, providing more redundancy, eliminating the need for an additional primary clarifier in the future, and allowing the dewatering/thickening recycles to be routed to either Primary Clarifier 1/2 or the plant headworks without impacting the secondary treatment loadings balance. Primary effluent flow splitting is more desirable than mixed liquor flow splitting as it has a lower capital cost. Also, since flow is not routed through the existing first stage HPOAS (Alternative 3) reactors prior to primary effluent flow splitting, Alternative 2 provides an additional 1.7 feet of hydraulic head. Hence, Alternative 2: Primary Effluent Flow Splitting is recommended.

1.2 Thickening Recycles

Gravity belt thickener (GBT) filtrate from waste activated sludge (WAS) and digested sludge thickening are currently returned to the headworks pumping station. Plant staff have noted that this recycle flow increases influent pumping energy and affects influent sampling accuracy. The recycle flow rate will more than double through the addition of gravity thickener overflow (GTO) following the planned primary sludge gravity thickener (GT) installation in Phase 3 of the planned plant upgrade program.

Under the current plant hydraulic configuration, all solids processing recycle flows must be routed to the plant influent wet well so that the load is divided proportionally between the ABC and HPO trains. By implementing a single activated sludge system with primary effluent flow splitting, GBT filtrate and GTO can be rerouted to the Primary Clarifier 1/2 inlet for sedimentation and then evenly distributed between the aeration trains in the primary splitting structure. This configuration saves constructing an additional flow splitter structure to distribute solids stream recycles between the ABC and HPO trains and is estimated to save $6500 per year in influent pumping energy if both the GBT filtrate and GTO flows are considered.

1.3 Project Phasing

Figures 4-1 and 4-2 show the project phasing for the recommended A/O treatment pathway based upon the proposed facilities required for Design Year 2035 and 2045 single activated sludge system. Capital costs for converting the existing plant to an A/O configuration to meet year 2035 design loadings is approximately $37 million (2020 dollars). Expansion of the plant to further reduce total nitrogen (TN) and total phosphorus (TP) discharges at Design Year 2045 loadings can increase capital costs by $14 million to $90 million (2020 dollars) depending upon the level of treatment desired.

Figure 4-3 shows the project phasing for an emerging innovative A/O simultaneous nitrification denitrification (SND) flow scheme which uses hydrocyclones for improving sludge quality and is capable of reducing average effluent TN discharges below 10 mg N/L. Capital costs for converting the existing plant to an A/O SND configuration to meet year 2035 design loadings is approximately $43 million (2020 dollars). Expansion of the plant to meet year 2045 increase capital costs by $17 million.

To date there is limited operating data on full-scale SND systems with hydrocyclones gravimetric selective wasting. Given the potential energy saving and significant capital savings for reducing TN discharges, this alternative should continue to be monitored and should be considered for full-scale demonstration testing on the existing ABC system. This alternative is consistent with the recommended plan of implementing Pathway 2's A/O single activated sludge concept above.

1.4 Sidestream Enhanced Biological Phosphorus Removal

S2EBPR is an emerging technology which incorporates a sidestream anaerobic mixed liquor or RAS hydrolysis and fermentation reactor, in lieu of or in addition to a traditional mainstream anaerobic selector, for purposes of enhanced biological phosphorus removal (EBPR). This TM presents a high-level overview of how two S2EBPR configurations–Sidestream RAS Fermentation with and without Supplemental Carbon–could be implemented into the proposed liquid stream improvements.

Section 2: Single Activated Sludge System

The Liquids Stream Alternative Analysis TM (BC, 2019) recommended the Aeration Basin Complex (ABC) continue to operate in an anaerobic/oxic (A/O) biological nutrient removal (BNR) flow scheme and the high purity oxygen activated sludge (HPOAS) train be converted into a parallel A/O system to meet current permit limitations. The evaluation noted the two parallel systems could be unified into a single activated sludge BNR system to simplify operations and provide improved redundancy by combining the Final Clarifiers 1-5 return activated sludge (RAS) flows, adding a RAS distribution structure, wasting sludge from a common RAS line/splitter box, and equally splitting main stream flow to each “train". This section presents three alternatives to combine the parallel A/O trains into a single activated sludge BNR system.

To create a single activated sludge system with parallel tanks, the RAS and/or mixed liquor suspended solids (MLSS) must be combined to create one homogenous solids stream flow. The simplest method to do this is to combine the RAS flows from all final clarifiers and then distribute the RAS to the aeration tanks. For the Rochester Water Reclamation Plant (WRP), the ABC train has five A/O basins in 2045 while the converted HPOAS train has the equivalent of 3.5 trains. To maintain equal loadings on the aeration basins, roughly 60 percent of the daily and peak flows must be routed to the ABC train. To maximize use and capacity of the existing Final Clarifiers, flows in excess of Final Clarifier 5 (and possibly Final Clarifier 6 in the future) must be routed to Final Clarifier 1-4. This is achievable as Final Clarifier 5’s elevation is roughly 1.5 feet higher than Final Clarifiers 1-4. Thus, each single activated sludge concept features RAS in-pipe mixing via a common RAS line and the ability to divert ABC aeration basin effluent mixed liquor flows to Final Clarifiers 1-4. Since Final Clarifier 5 is 1.5 feet higher than Final Clarifier 1-4, mixed liquor flow to Final Clarifier 1-4 must be controlled to prevent excess flow being routed to Final Clarifier 1-4. Flow control must be completed in a way which minimizes mixed liquor floc break-up such as a control box with a modulating submerged gate to maintain the control box liquid level equal to the HPO train hydraulic grade line at the point of introduction. Final Clarifier 5 (and 6) flow can be controlled using a flow meter and control valve to baseload Final Clarifier 5 to minimize flow adjustments. An alternative to isolate Final Clarifiers for the ABC and HPO trains and control flow to the ABC clarifiers using cutthroat flumes or control vales with meters.

Three different alternatives were evaluated to accomplish the one plant or single activated sludge concept:

- Alternative 1: Primary Influent Flow Split
- Alternative 2: Primary Effluent Flow Split
- Alternative 3: Mixed Liquor Flow Split

2.1 Alternative 1: Primary Influent Flow Split

Figure 2-1 presents a conceptual layout of a single plant activated sludge system relying on primary influent flow splitting. Key features include combing all RAS returns into a single pipeline which feeds an RAS distribution box, and ABC aeration tank effluent mixed liquor flow diversion to Final Clarifiers 1-4. The RAS distribution box has cutthroat flumes and is sized to represent one aeration basin train. If one aeration train is out of service in the ABC train, one ABC RAS distribution flume gate is closed to distribute flow to each train in the proper proportion.

The primary advantage of this alternative is it has only one flow splitter structure for RAS and uses the existing primary influent flow control system for feeding the HPOAS and ABC trains. The key disadvantages include:

- Separate banks of primary clarifiers resulting in reduced redundancy or need for an additional primary clarifier in the future.
- Requires dewatering /thickening recycles be routed to the plant headworks to maintain equal ammonia loadings to both aeration tank trains.
- Secondary influent loadings may still differ as a result of differences in primary clarifier treatment performance.

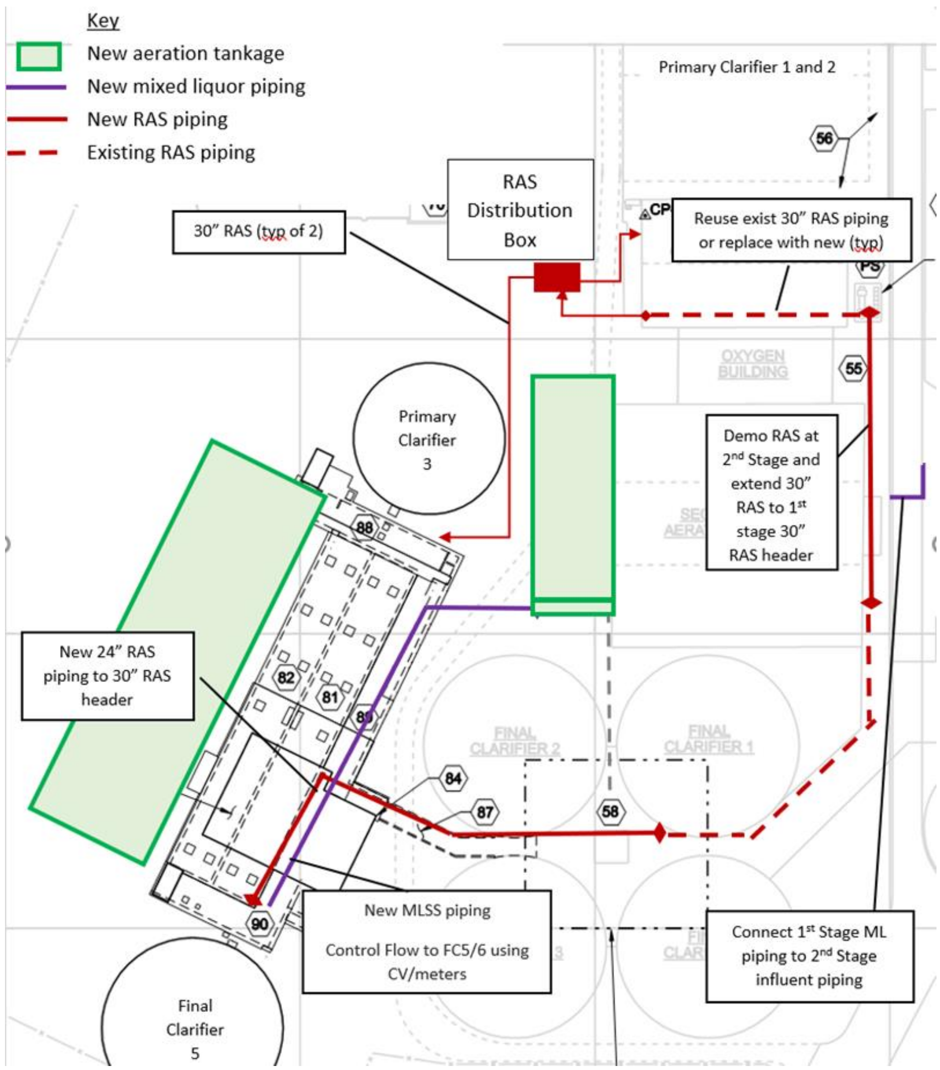

Figure 2-1. Alternative 1: Primary influent flow splitting single activated sludge conceptual layout.

2.2 Alternative 2: Primary Effluent Flow Split

Figure 2-2 presents a conceptual layout of a single plant activated sludge system with primary effluent flow splitting. Key features for this alternative include combining all RAS returns into a single pipeline which feeds a RAS distribution box, combining primary effluent from Primary Clarifiers 1-3 and then distributing flow using a distribution box, and the ABC aeration tank effluent mixed liquor flow diversion to Final Clarifiers 1-4. Both the RAS and primary effluent distribution boxes have cutthroat flumes which are sized to represent one aeration basin train. Thus, if one aeration train is out of service in the ABC train, one ABC primary influent and RAS distribution flume gate is closed to distribute flow to each train in the proper proportion.

Key advantages of this alternative are:

- Excellent flow control using passive flow distribution.
- Equal secondary influent loadings with combined primary effluent.
- Parallel primary clarifier operations provides system redundancy and eliminates need for future primary clarifier.
- Maximizes use of available hydraulic grade line between trains.
- Thickening/dewatering recycles can be routed to Primary Clarifier 1/2 without impacting loading distribution to each aeration tank train.
- No modifications required to implement TN reduction in the future.

The key disadvantage is the need for a second distribution box.

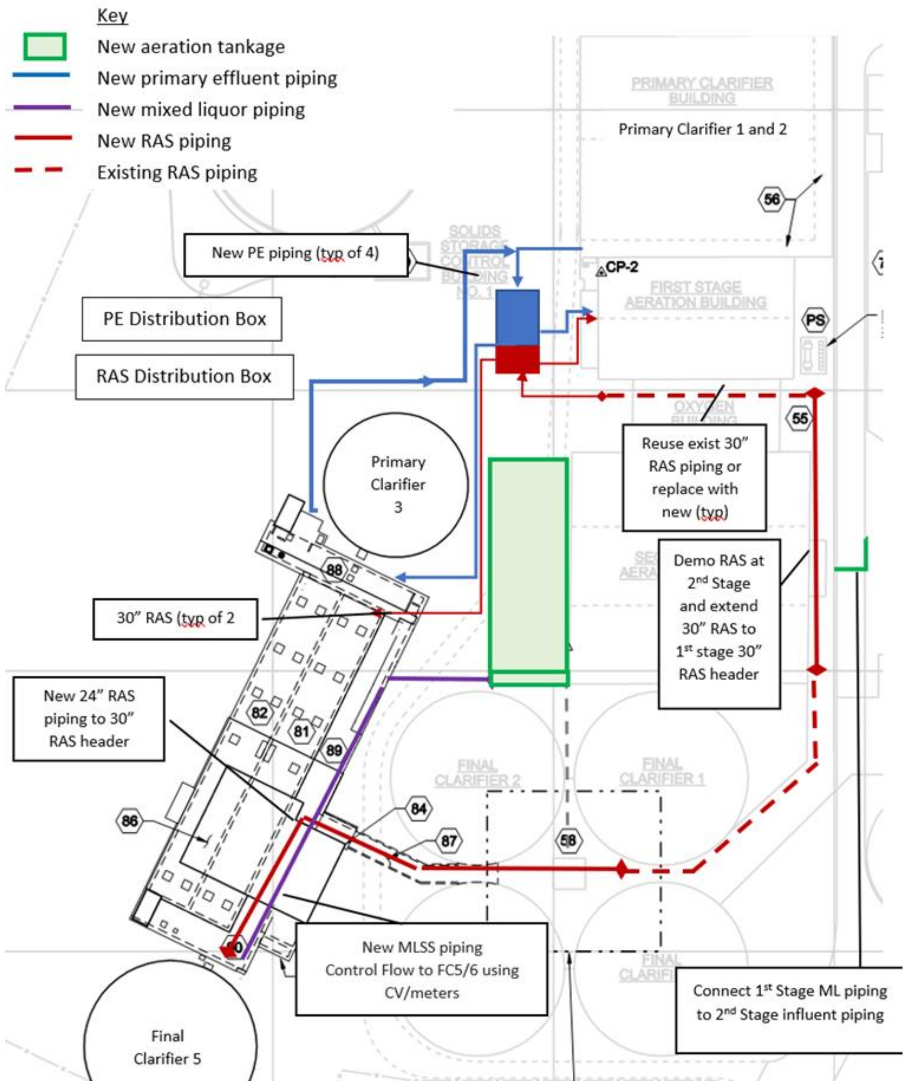

Figure 2-2. Alternative 2: Primary effluent flow splitting single activated sludge conceptual layout

2.3 Alternative 3: Mixed Liquor Flow Split

A conceptual layout for Alternative 3–Mixed Liquor Flow Split is shown in Figure 2-3. Key features for this alternative include combining all RAS returns into a single pipeline which is routed to an extension of the existing HPOAS first stage reactors, combining primary effluent from Primary Clarifiers 1-3 and routing it to the same location, a mixed liquor flow distribution box, and the ABC aeration tank effluent mixed liquor flow diversion to Final Clarifier 1-4.

Key advantages of this alternative are:

- Excellent flow control using passive flow distribution.
- Equal secondary influent loadings with mixed liquor flow splitting.
- Parallel primary clarifier operations provides system redundancy and eliminates need for future primary clarifier.
- Thickening/dewatering recycles can be routed Primary Clarifier 1/2 without impacting loading distribution to each aeration tank train.

- One flow distribution box is needed.
- Provides an additional 1 million gallons (MG) of aerated volume in the ABC trains (but not sufficient to eliminate an ABC train).
- Minor piping modifications are required to implement TN reduction in the future.
- The key disadvantages are:
- The need to add 0.6 MG of selector zone plus an additional 0.9 MG selector train in the event one selector train is out of service.
- It has the highest capital cost.
- Requires retrofits to the existing ABC anaerobic zone to convert it to an aerobic zone.

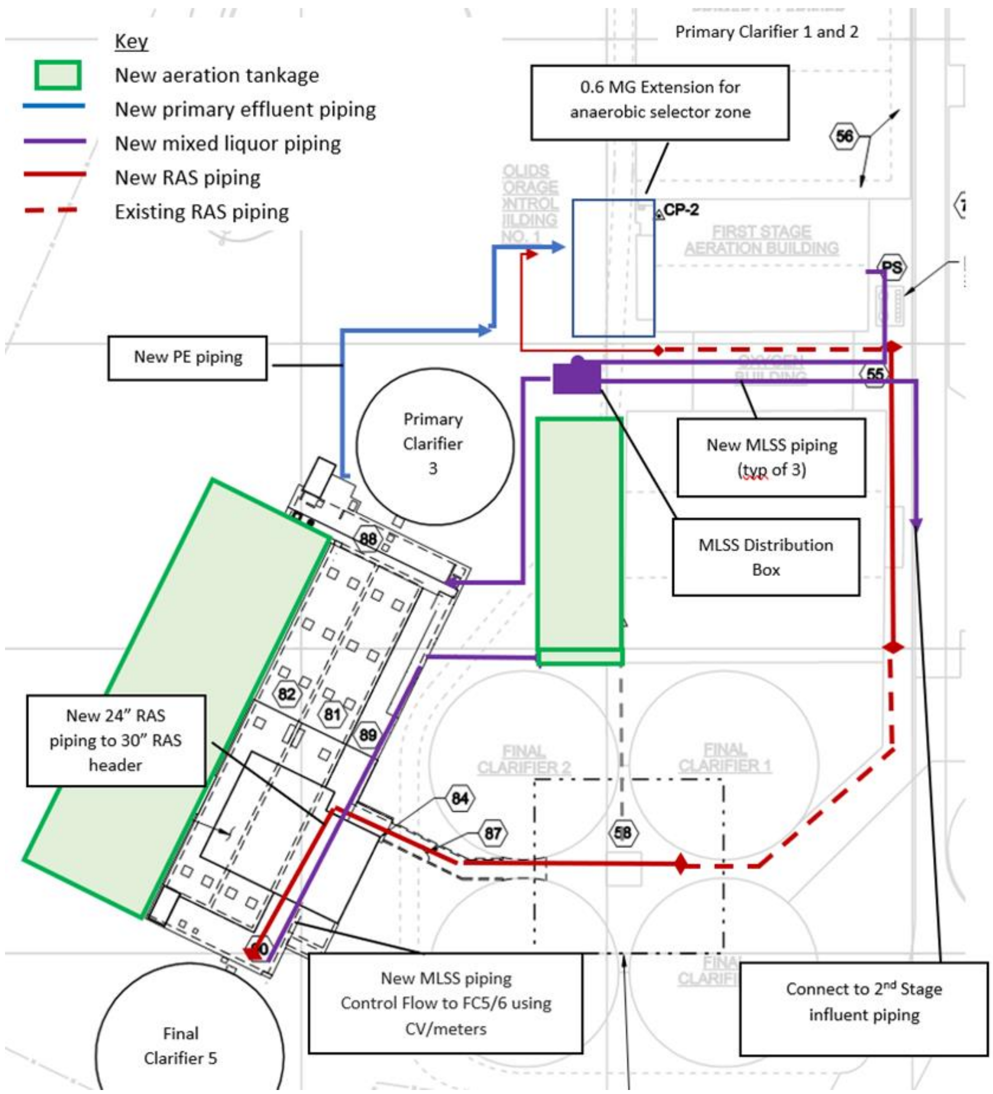

Figure 2-3. Alternative 3: Mixed Liquor flow splitting single activated sludge conceptual layout

2.4 Recommendation

Alternative 2 – Primary Effluent Flow Split is recommended for implementing a single activated sludge BNR system based upon its ability to provide equal secondary influent loadings, parallel primary clarifier operations to improve system redundancy, lower capital cost than Alternative 3, maximizes use of available hydraulic grade line between trains, thickening/dewatering recycles can be routed to Primary Clarifier 1/2 without impacting loading distribution to each aeration tank train, and no modifications are required to implement TN reduction in the future.

Section 3: Thickening Recycles

GBT filtrate from WAS and digested sludge thickening are currently returned to the headworks pumping station. Plant staff have noted that this recycle flow increases influent pumping energy and affects influent sampling accuracy. Following installation of the GT, GTO will be added to the existing recycle flows.

Recycle flow rates from the WAS and digested sludge GBTs and the primary sludge GT are summarized in Table 3-1. The total recycle flow is expected to range from approximately 540 to 1200 gallons per minute (gpm) following installation of the GT.

Table 3-1. Projected Solids Processing Recycle Flow Rates

	Units	Annual Average	Maximum Month	Maximum Day
WAS GBT Filtrate				
Current	gpd	245,000	320,000	379,000
2045	gpd	363,000	491,000	575,000
Gravity Thickener Overflow				
Current	gpd	463,000	583,000	720,000
2045	gpd	637,000	806,000	1,000,000
Digested Sludge GBT Filtrate				
Current	gpd	72,000	84,000	106,000
2045	gpd	82,000	106,750	131,750
Total recycle flow				
Current	gpd	780,000	987,000	1,205,000
2045	gpd	1,100,000	1,400,000	1,700,000
Current	gpm	540	685	840
2045	gpm	750	975	1,185

Figure 3-1 shows the preliminary routing of recycle flows to Primary Clarifiers 1/2 via approximately 700 linear feet of new piping. The pipe would be routed in the tunnels at an elevation that would surcharge the pipe so it would flow full. If the new recycle piping is installed prior to the GT start-up, consideration will need to be given to managing solids deposition under the lower pipe velocity conditions without GTO flow. Table 3-2 summarizes the design parameters for this preliminary design.

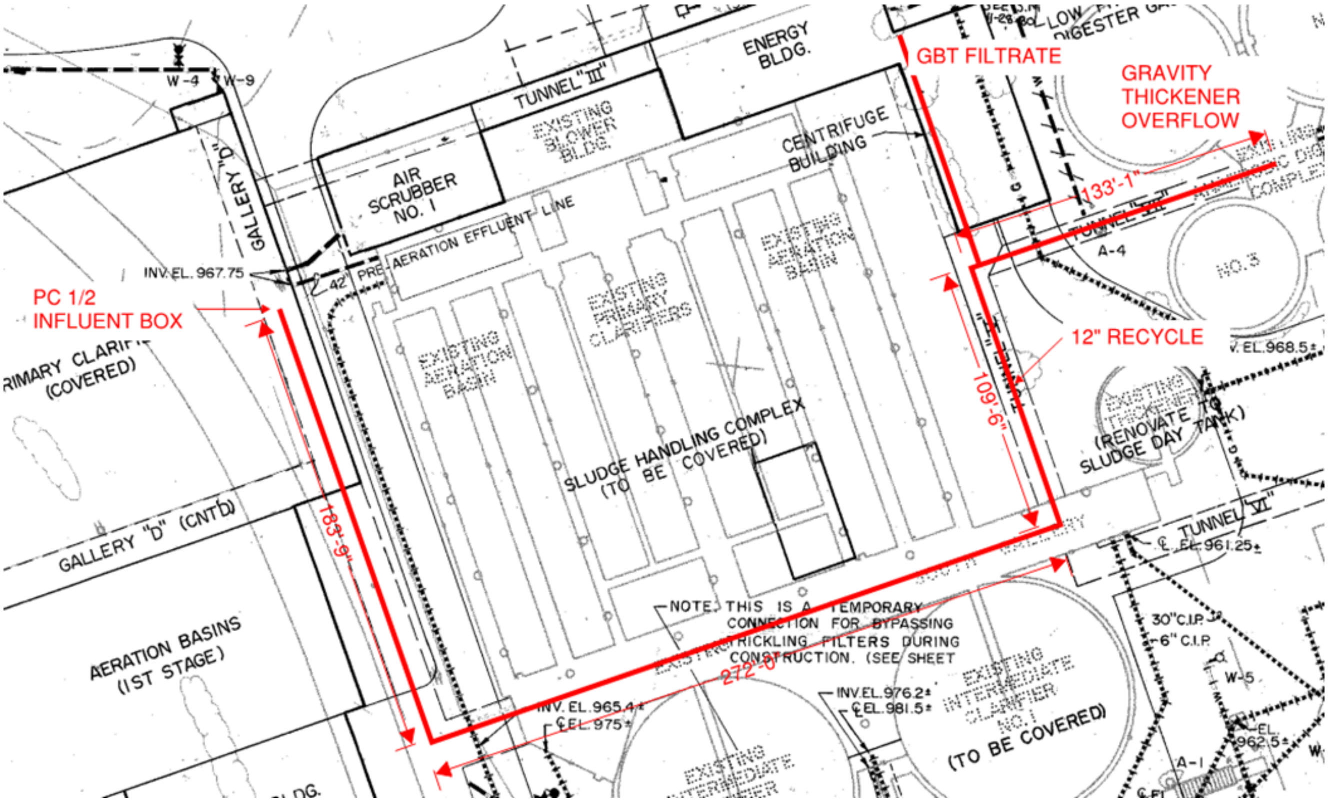

Figure 3-1. Preliminary routing of recycle piping to Primary Clarifiers 1/2

Table 3-2. Recycle Piping Preliminary Design Criteria

Item	Units	2020 AA	2045 MM
Gravity Thickener WSE	ft	991.2	
Gravity Belt Thickener Floor Elevation	ft	995.0	
Primary Clarifier 1/2 WSE	ft	985.2	
Available Gravity Flow Head	ft	6.2	
Preliminary Pipe Size	inches	14	
Flow Rate	gpm	540	1200
Velocity	fps	1.5[b]	3.4
Head loss[a]	ft	1.1	2.6

a. *Approximate value based on 700 LF pipe route with 25% additional head loss for fittings*

b. *Velocity based on recycle flows with gravity thickener. Velocity is 60% less prior to GT addition.*

Section 4: Project Phasing

This section presents the A/O liquid stream and solids stream facility improvements phasing for Year 2035 and 2045. Facility layouts for future Pathway 2 biological nutrient removal (BNR) treatment levels (BC, 2019) are also presented based upon the treatment levels shown in Table 4-1.

Table 4-1. Rochester WRP Planning Effluent Water Quality Requirements

Treatment Level	Final Effluent[a]			General Technology Comments
	Monthly Ammonia, mg N/L	Annual TN mg N/L	Monthly TP mg-P/L, (lb/d)	
Level 1	Current Permit Limits[b]	NA	0.8 mg-P/L (82 lb/d) 12-month rolling	
Level 2	< 2 mg/L	10	0.4 mg-P/L (82 lb/d) 12-month rolling	Full or partial stream filtration to meet TP limit
Level 2X	< 2 mg/L	10 mg/L as NOx-N	0.4 mg-P/L (82 lb/d) 12-month rolling	Full or partial stream filtration to meet TP limit
Level 3	< 2 mg/L	4	0.1 mg-P/L (82 lb/d) 12-month rolling	Filtration for TN and TP limit

a. *Existing permit monthly/weekly effluent $cBOD_5$ and TSS limits of 15/25 and 30/45 apply to all options with associated mass loadings of 1352/2254 kg $cBOD_5$/d and 2705/4075 kg TSS/d.*

b. *Monthly ammonia limits for December-March, April-May, June-September, and October-November are 5,10, 3, and 13 mg N/L respectively with associated mass loadings of 451, 902, 270, and 1172 kg N/d.*

4.1 Alternative 2: A/O Treatment Level 1

Figure 4-1 shows the major process tankage to convert the existing plant into a single activated sludge system A/O plant to meet Treatment Level 1 effluent criteria at Year 2035 and 2045 loading criteria. Initial improvements to provide Year 2035 capacity to the existing HPOAS train include:

- Retrofitting the existing HPOAS first stage reactors to RAS denitrification/anaerobic selectors
- Convert the HPOAS second stage reactors to fine pore aeration basins
- Add a fourth fine pore aeration cell to the said reactors
- Demolish the existing cryogenic facility
- Add a new blower building housing three 7,600 standard cubic feet per minute (scfm) blowers

The ABC train improvements include:

- Adding a third 1.4 MG ABC aeration basin
- Adding one 3,200 scfm blower
- Extending the existing ABC mixed liquor line to the Final Clarifier 1-4 influent conveyance pipeline

Additional improvements to implement the single activated sludge BNR system including the RAS discharge line improvements and RAS and PE distribution boxes discussed in Section 2.2.

Estimated capital costs for Year 2035 improvements of $37 million (2020 dollars). For Year 2045, two additional 1.4 MG ABCs are required and modifications to the Final Clarifiers 1-4 distribution box weirs to prevent the weirs from flooding are needed. These changes will add another $14 million in capital costs. Estimates of probable construction cost for the Year 2045 A/O single activated sludge plant concept are included in Attachment A.

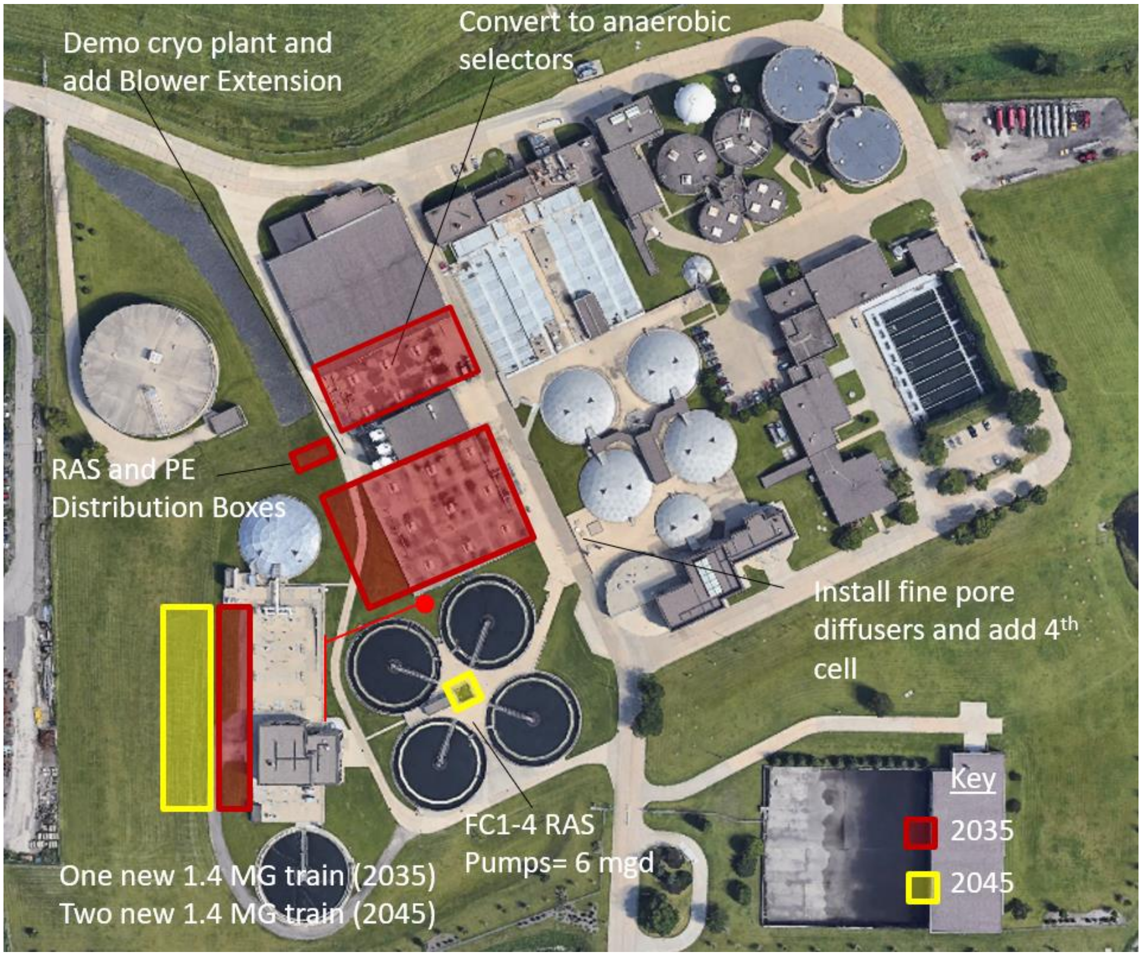

Figure 4-1 Alternative 2: A/O phasing

4.2 Treatment Level 2, 2X, and 3

Figure 4-2 shows the 2045 space needs and estimated capital costs for the Treatment Level 2, 2x, and 3 effluent requirements assuming 3- or 5-stage BNR is implemented. Treatment Level 2 assumes the existing HPOAS train is operated in a 3-stage BNR mode with one intermediate clarifier converted into a RAS denitrification zone, and the ABC train is operated as a 5-stage BNR system.

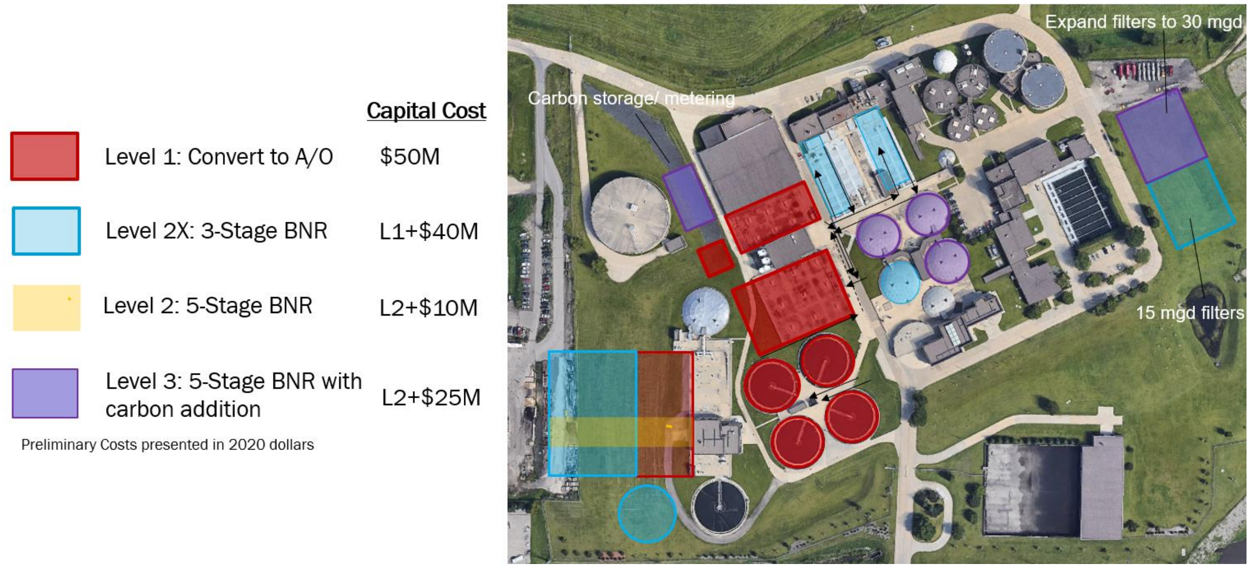

Figure 4-2. Rochester WRP potential future nutrient removal Year 2045 space layouts and capital costs

4.3 Alternative 2SND: A/O Simultaneous Nitrification Denitrification with Hydrocyclones

An emerging innovative A/O flow scheme (Alternative 2SND) which operates at low dissolved oxygen (DO) concentrations providing conditions for SND to reduce TN discharges below 10 mg/L and TP discharges below 0.8 mg/L without filtration and 0.4 mg/L with filtration (Treatment Levels 1, 2 and 2X) should also be consider. The flow scheme incorporates gravimetric selective wasting using hydrocyclones to significantly improve the poor sludge quality typically associated with low DO operations, hence reducing the capital and operating costs for TN reduction.

Figure 4-3 shows the major process tankage to convert the existing plant into a single activated sludge system A/O SND plant to meet Treatment Level 1, 2 and 2X effluent TN at Year 2035 and 2045 loading criteria. Facility sizing for all three treatment levels is the same. To reduce effluent TP discharges to Treatment Level 2/2X effluent criteria, 15 mgd of firm tertiary filtration capacity is needed as shown in Figure 4-2.

Plant improvements to meet Year 2035 and 2045 capacity are the same as described in Section 4.1 with the following additional systems.

- A hydrocyclones wasting station consisting of 12 hydrocyclones on 3 or 4 skids, hydrocyclones feed pumps, and waste sludge pumps for pumping hydrocyclones overflow to the gravity belt thickeners. It is assumed the hydrocyclones and feed pumps are housed in a new building with the overflow pumps in the existing plant tunnels/basement.
- One additional 1.4 MG ABC aeration basin for Year 2035 and 2045 conditions.
- Ammonia based aeration control system.

The estimated capital costs for Year 2035 improvements is $43 million (2020 dollars). For Year 2045, two additional 1.4 MG ABC aeration basins are required and modifications to the Final Clarifiers 1-4 distribution box weirs to prevent the weirs from flooding are needed. These changes will add another $17 million in capital costs. Opinion of probable construction cost for Alternative 2SND single activated sludge plant concept are included in Attachment B.

To date there is limited operating data on full-scale SND systems with hydrocyclones gravimetric selective wasting. Given the potential sludge quality, energy, and significant capital savings for reducing TN discharges, this alternative should continue to be monitored and be considered for full-scale demonstration testing on the existing ABC system. This alternative is consistent with the recommended plan of implementing Pathway 2's A/O single activated sludge concept above. Alternative 2SND was not evaluated to further reduce nutrient discharges to Treatment Level 3.

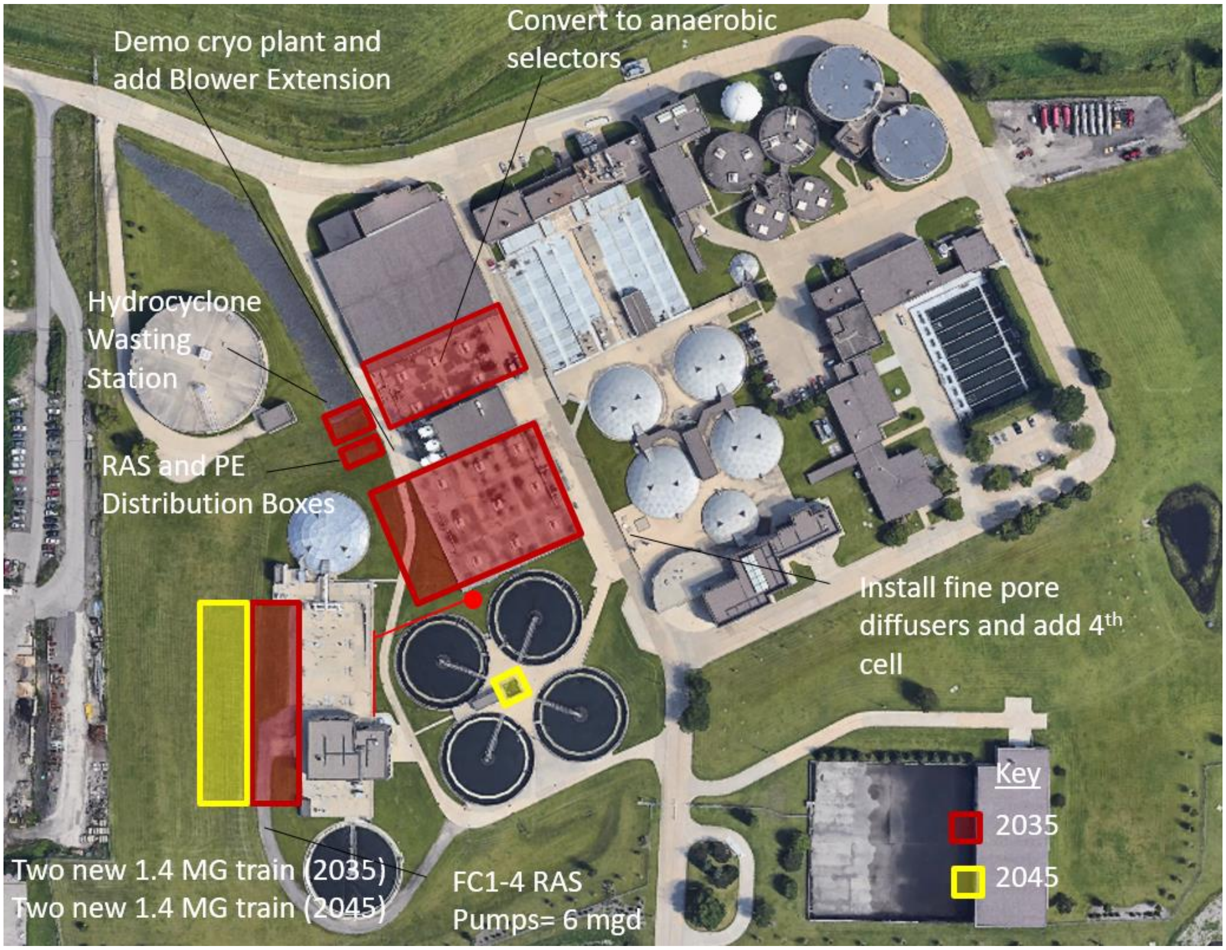

Figure 4-3. Alternative 2SND Year 2035 and 2045 phasing (Treatment Level 1, 2, and 2X)

Section 5: Sidestream Enhanced Biological Phosphorus Removal

Sidestream enhanced biological phosphorus removal (S2EBPR) is an emerging technology which incorporates a sidestream anaerobic mixed liquor or RAS hydrolysis and fermentation reactor, in lieu of or in addition to a traditional mainstream anaerobic selector, for purposes of EBPR. There are three common S2EBPR flow configuration which include the following:

- Sidestream RAS Fermentation
- Sidestream RAS Fermentation with Supplemental Carbon
- Sidestream Mixed Liquor Fermentation

Of these flow schemes, sidestream RAS fermentation is the most popular with roughly 60 operating or tested facilities in Europe. Sidestream RAS fermentation with supplemental carbon is the most common in the United States with 12 operating or tested facilities. Benefits of S2EBPR include plants demonstrating excellent TP removal performance and stability, increasing the amount of influent carbon for denitrification, potential for denitrifying phosphate accumulating organisms to reduce aeration demands, and protection of the anaerobic selector zone at high flow events. To date, process modeling to define the facility sizing and needed volatile fatty acid (VFA) load, if applicable, and system performance has not progressed where one can predict with confidence the system requirements. As such, this section presents a very high-level discussion on either sidestream RAS fermentation flow configuration could be incorporated into the recommended layout based upon general rule-of-thumb sizing criteria. Pilot testing is recommended to confirm the system requirements and performance.

5.1 Sidestream RAS Fermentation

Sidestream RAS Fermentation relies on the hydrolysis and fermentation of RAS solids to provide the needed VFA to drive the EBPR process. Typically, 5 to 20 percent of the RAS flow is diverted to the S2EBPR reactor with the remaining RAS flow routed back to the main liquid stream process. The S2EBPR reactor is either continuously or intermittently mixed and sized to provide 16 to 48 hours of hydraulic retention time (HRT). A typical sidestream RAS fermentation flow schematic for TN and TP removal is shown in Figure 5-1. If TN reduction is not required, the anoxic zone and mixed liquor recycle (MLR) could be eliminated.

Compared to Sidestream RAS Fermentation with Supplemental Carbon, this flow configuration provides simpler operations as a primary sludge fermenter is not required since needed volatile fatty acid (VFA) are generated from RAS solids hydrolysis/fermentation. A small fraction of the primary effluent can also be routed to the S2EBPR reactor to enhance performance or decrease the tank HRT. Disadvantages include potential for high odors and larger S2EBPR reactors.

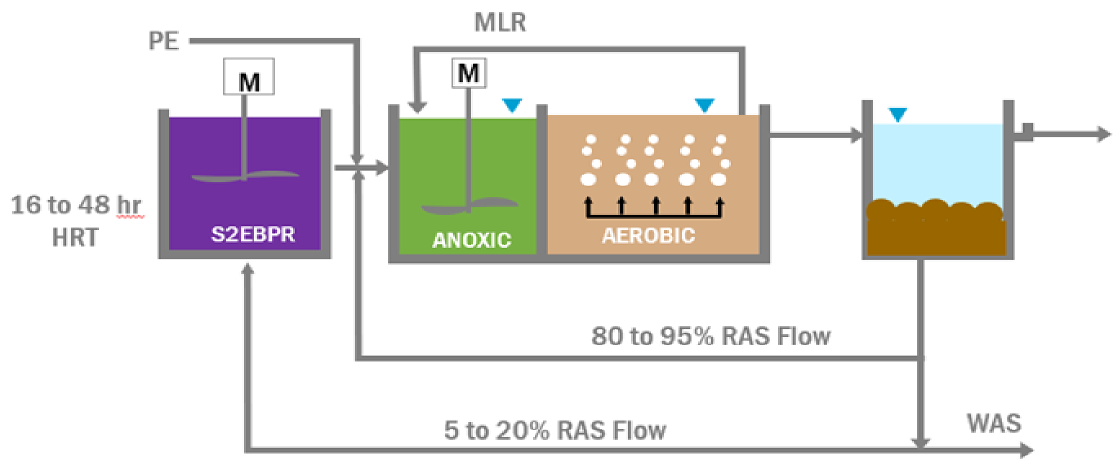

Figure 5-1. Sidestream RAS fermentation S2EBPR flow schematic

Assuming an average daily RAS flow of 8 mgd (2045 conditions) with 15 percent of the RAS flow diverted to the S2EBPR reactor, converting the proposed mainstream anaerobic selectors to S2EBPR reactors would provide an HRT of roughly 36 hours. The most effective method to modify the proposed layout to implement sidestream RAS fermentation would be:

- Select Alternative 2–Primary Effluent Flow Splitting single activated sludge system as shown in Figure 2-2.
- Use the proposed mainstream anaerobic selectors as S2EBPR reactors.
- Provide additional piping/flexibility to route primary effluent and RAS flows from their splitter boxes to the first zone downstream of the S2EBPR reactor.
- Add piping with control valves and meters to divert RAS flow from the common RAS pipeline downstream of the RAS distribution box to the ABC and HPOAS train S2EBPR reactors (converted mainstream anaerobic selectors).

5.2 Sidestream RAS Fermentation with Supplemental Carbon

Sidestream RAS Fermentation with Supplemental Carbon mixes the RAS flow with a VFA source, such as primary sludge fermentate or hauled industrial waste, in a S2EBPR reactor as shown in Figure 5-2.

The S2EBPR reactor is typically sized to provide an HRT of roughly 2 to 4 hours and solids retention time (SRT) of 2 days as solids accumulate on the tank bottom during operation. Variations of this flow scheme can be found where 20 to 50 percent of the RAS flow is routed to the S2EBPR reactor. In addition to the smaller S2EBPR reactor, primary sludge fermentation will typically generate more VFA than required for EBPR so some of the fermentate can be routed to the mainstream for denitrification if desired. Disadvantages of this approach include operation of a primary sludge fermenter, capital and operating costs for the fermenter, decreased digester gas generation, increased pumping, and potential for odors.

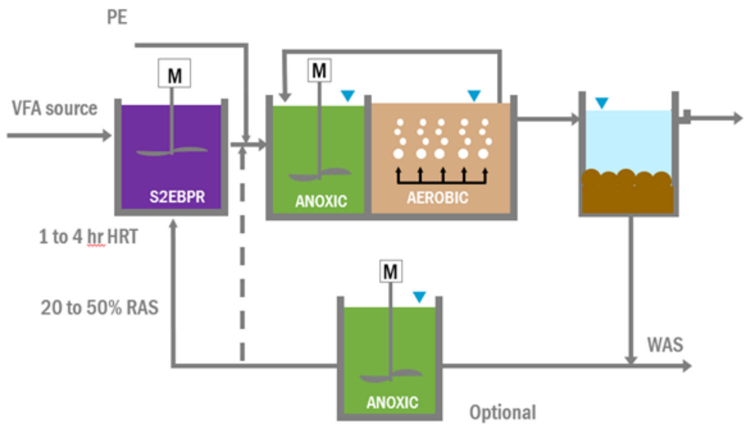

Figure 5-2. Typical sidestream RAS fermentation with supplemental carbon S2EBPR flow schematic

A constant RAS flow to the S2EBPR is recommended for stable operations. For this review, it is assumed 50 percent of the RAS flow or 4 mgd is constantly fed to a S2EBPR tank with an HRT of 4 hours. The remaining RAS is routed to the main liquid stream. The VFA source flow rate is typically very low and considered negligible for tankage sizing, hence the total volume of the S2EBPR reactor(s) is roughly 700,000 gallons.

Modifications to implement Sidestream RAS Fermentation with Supplemental Carbon include:

- Select Alternative 2–Primary Effluent Flow Splitting single activated sludge system as shown in Figure 2-2.
- Add a primary sludge fermenter or modify the proposed gravity thickener to operate as a fermenter and provide pumps and piping to route the gravity thickener overflow/fermentate to the S2EBPR reactors.
- A simple method to implement this option is to retrofit two existing intermediate clarifiers into the S2EBPR reactors and add a control valve and meter to route 4 mgd of RAS from the common 30-inch RAS line to the first of two S2EBPR reactors in series. The S2EBPR tank effluent could then be pumped back into the common RAS line feeding the RAS splitter. Under this scenario the mainstream anaerobic selectors could remain in service eliminating the need to modify the mainstream anaerobic selectors zones, be converted an anoxic zone, or be converted to aerobic zones. By maintaining the existing mainstream anaerobic selectors the system can be operated in a conventional EBPR mode or an S2EBPR mode with minimal modifications.

Note the additional solids and organic loadings which come with fermenter recycles going to the aeration tanks would need to be further analyzed.

Section 6: References

Brown and Caldwell (BC). 2019. *Water Reclamation Plant Facilities Plan Liquid Stream Alternative Evaluation Technical Memorandum.* June. Revised February 2020.

Attachment A: Alternative 2 A/O Single Activated Sludge Plant Opinion of Probable Construction Cost

City of Rochester, MN
Rochester WRP Facilities Plan
2% DESIGN, CLASS 5 ESTIMATE

Estimator	Walter, Breeze
BC Project Manager	Harold Voth
BC Office	Saint Paul
Est Version Number	8
QA/QC Reviewer	Ian Kruljac
QA/QC Review Date	10-26-2018
Alternates	Alt 02

Phase	Item	Description	Quantity	Labor Amount	Material Amount	Equip Amount	Sub Amount	Other Amount	Total Cost/Unit	Total Net Amount
01 Totals										
Alt 02 A/O Concept 2A										
04 Rehab WWTP										
01 Demoltion										
02221 _Site Demolition										
02-41-13.17	5050	Demolish, remove pavement & curb, remove bituminous pavement, 4" to 6" thick, excludes hauling and disposal fees	733.3 sy	5,239	-	2,045	-	-	9.93 /sy	7,284
02-41-13.33	4450	Minor site demolition, for disposal on site, excludes hauling, add	163.0 cy	858	-	947	-	-	11.08 /cy	1,805
02-41-19.23	0800	Rubbish handling, dumpster, 30 C.Y., 10 ton capacity, weekly rental, includes one dump per week, cost to be added to demolition cost.	2.0 week	-	1,409	-	-	-	704.45 /week	1,409
01-56-26.50	0250	Temporary fencing, chain link, rented up to 12 months, 6' high, 11 ga, over 1000'	1,000.0 lf	3,626	2,913	-	-	-	6.54 /lf	6,539
		_Site Demolition	**6,600.0 sf**	**9,723**	**4,322**	**2,992**			**2.58 /sf**	**17,037**
02999 ABC AERATION										
02-99-99.99	MISC	Selective demolition - demo baffels walls - allowance	1.0 LS	40,120	-	10,030		-	50,150.00 /LS	50,150
02-22-04.52	BC-0071	Equipment dismantling/demolition, Mixers allowance	1.0 lsum	11,011	-	4,297	-	-	15,308.10 /lsum	15,308
		ABC AERATION	**1.0 ls**	**51,131**		**14,327**			**65,458.10 /ls**	**65,458**
02999 2ND STAGE AERATION										
02-99-99.99	MISC	Selective demolition - cut top of baffels walls - allowance	1.0 LS	40,120	-	10,030		-	50,150.00 /LS	50,150
02-22-04.52	BC-0071	Equipment dismantling/demolition, Mixers motors and ox feed - allowance	1.0 lsum	36,704	-	14,323	-	-	51,027.02 /lsum	51,027
		2ND STAGE AERATION	**1.0 ls**	**76,824**		**24,353**			**101,177.02 /ls**	**101,177**
02999 Demolition of Cryogenic Facility										
46-05-00.00	----	Demo of the Cryogenic Facility	1.0 LS	***50,000***	***80,000***	***25,000***			155,000.00 /LS	155,000
		Demolition of Cryogenic Facility	**1.0 LS**	**50,000**	**80,000**	**25,000**			**155,000.00 /LS**	**155,000**
		01 Demoltion		**187,678**	**84,322**	**66,672**				**338,672**
02 Construction										
03999 ABC Aeration Basisn 1,2&3 including Collection Channel 30.5'H x 32.5'W x 250'L										
03-01-00.00	----	ABC Aeration Basisn 1,2&3 including Collection Channel From Meridian Project	1.0 LS				4,232,376		4,232,375.98 /LS	4,232,376
46-06-00.00	BC-0336	Aeration Blower 7500 scfm	1.0 ea	4,946	4,855	7,093	250,000	-	266,893.76 /ea	266,894
		ABC Aeration Basisn 1,2&3 including Collection Channel 30.5'H x 32.5'W x 250'L	**1.0 LS**	**4,946**	**4,855**	**7,093**	**4,482,376**		**4,499,269.74 /LS**	**4,499,270**
03999 Piping, Flumes, Distribution Boxes										
03-01-00.00	----	Piping, Flumes, Distribution Boxes	2.0 ea				1,577,562		788,780.90 /ea	1,577,562
		Piping, Flumes, Distribution Boxes	**1.0 LS**				**1,577,562**		**1,577,561.80 /LS**	**1,577,562**
03999 4th Train for 2nd Stage Aeration Basins										

Phase	Item	Description	Quantity	Labor Amount	Material Amount	Equip Amount	Sub Amount	Other Amount	Total Cost/Unit	Total Net Amount
03999 4th Train for 2nd Stage Aeration Basins										
03-99-99.99	MISC	4th Train for 2nd Stage Aeration Basins	1.0 LS	-	-	-	*1,410,792*	-	1,410,792.00 /LS	1,410,792
		4th Train for 2nd Stage Aeration Basins	**1.0 LS**				**1,410,792**		**1,410,792.00 /LS**	**1,410,792**
22200 DI Pipe										
22-20-00.30	BC-0031	Piping, water dist, DI, cement lined, 18' L, restrained jt, 36" dia	870.0 lnft	22,813	133,872	2,700	-	-	183.20 /lnft	159,385
22-20-00.30	BC-0046	Piping, water dist, DI, cement lined, 18' L, restrained jt, 54" dia	670.0 lnft	29,114	226,742	3,445	-	-	387.02 /lnft	259,301
22-20-00.30	BC-0051	Piping, water dist, DI, cement lined, 18' L, restrained jt, 60" dia	75.0 lnft	4,102	30,091	485	-	-	462.38 /lnft	34,679
22-20-00.30	BC-0041	Piping, water dist, DI, cement lined, 18' L, restrained jt, 48" dia	525.0 lnft	18,880	141,356	2,234	-	-	309.47 /lnft	162,470
22-05-00.10	BC-0006	Allowance - Piping, Process	1.0 ls	327,250	699,300	70,125		-	1,096,675.00 /ls	1,096,675
		DI Pipe	**2,140.0 lf**	**402,158**	**1,231,362**	**78,990**			**800.24 /lf**	**1,712,510**
31315 Rock Excavation										
31-23-16.30	0100	Drilling and blasting rock, open face, over 1500 C.Y.	16,200.0 bcy	96,112	59,956	83,169	-	-	14.77 /bcy	239,238
31-23-16.30	4500	Drilling and blasting rock, preblast survey for house, city block within zone of influence, for 6 room house, minimum	16,200.0 sf	1,728	-	-	-	-	0.11 /sf	1,728
31-23-16.42	3900	Excavating, bulk bank measure, 3 C.Y. capacity = 250 C.Y./hour, shovel, excluding truck loading	16,200.0 bcy	10,075	-	15,629	-	-	1.59 /bcy	25,704
31-23-23.18	1255	Hauling, excavated or borrow material, loose cubic yards, 20 mile round trip, 0.5 loads/hour, 20 C.Y. dump trailer, highway haulers, excludes loading	16,200.0 lcy	121,796	-	138,148	-	-	16.05 /lcy	259,944
01-54-36.50	0100	Mobilization or demobilization, dozer, loader, backhoe or excavator, above 150 H.P., up to 50 miles	1.0 ea	191	-	288	-	-	479.38 /ea	479
		Rock Excavation	**16,200.0 cy**	**229,902**	**59,956**	**237,234**			**32.54 /cy**	**527,093**
31999 Sitework										
31-99-99.99	MISC	Sitework from Meridan	1.0 LS	-	-	-	500,000	-	500,000.00 /LS	500,000
		Sitework	**1.0 LS**				**500,000**		**500,000.00 /LS**	**500,000**
46999 RAS Pumps										
46-06-20.00	BC-0146	Turbine pump, CI, 4000 GPM, 200 HP, 12" discharge	8.0 ea	33,905	125,065		-	-	19,871.24 /ea	158,970
		RAS Pumps	**1.0 LS**	**33,905**	**125,065**				**158,969.92 /LS**	**158,970**
46999 Diffusers, Pumps, mixers										
46-06-00.00	BC-0326	mixer	6.0 ea	1,014	135,998	-	-	-	22,835.35 /ea	137,012
		Diffusers, Pumps, mixers	**1.0 LS**	**1,014**	**135,998**				**137,012.12 /LS**	**137,012**
46999 HPO Train Equipment										
46-06-00.00	BC-0326	mixer	6.0 ea	1,014	135,998	-	-	-	22,835.35 /ea	137,012
46-06-00.00	BC-0336	Aeration Blower 4 (7500 scfm at 11 psig (match other three 250 HP blowers by ERG)	3.0 ea	14,838	14,565	21,278	*600,000*	-	216,893.76 /ea	650,681

Phase	Item	Description	Quantity	Labor Amount	Material Amount	Equip Amount	Sub Amount	Other Amount	Total Cost/Unit	Total Net Amount
46999 HPO Train Equipment										
46-06-00.00	BC-0046	Diffusers, fine bubble, complete (includes all hardare fully installed ending at diffuser itself and incl upstream header to top of tank/vessel/basin)	7,500.0 ea	123,654	295,448	-	-	-	55.88 /ea	419,101
46-06-20.00	BC-0146	Turbine pump, CI, 4000 GPM, 200 HP, 12" discharge	8.0 ea	33,905	125,065		-	-	19,871.24 /ea	158,970
46-00-00.01	----	HPO Flow Control Structure	1.0 LS				500,000		500,000.00 /LS	500,000
		HPO Train Equipment	**1.0 LS**	**173,411**	**571,075**	**21,278**	**1,100,000**		**1,865,764.71 /LS**	**1,865,765**
46999 Odor Control										
46-06-00.00	BC-0066	Odor control tower, complete w/ media	2.0 ea	20,029	251,839	-	-	-	135,933.77 /ea	271,868
46-06-00.00	BC-0476	Fan, foul air odor control	2.0 ea	13,218	23,735	-	-	-	18,476.41 /ea	36,953
		Odor Control	**1.0 LS**	**33,247**	**275,573**				**308,820.36 /LS**	**308,820**
46999 Blower Building										
46-06-00.00	----	Blower Building - Meridian estimate	1.0 ls				***1,000,000***		1,000,000.00 /ls	1,000,000
		Blower Building	**1.0 LS**				**1,000,000**		**1,000,000.00 /LS**	**1,000,000**
		02 Construction		**878,584**	**2,403,885**	**344,594**	**10,070,730**			**13,697,793**
03 Electrical and Instrumentation										
26001 Electrical and Instrumentation (FACTORED)										
26-00-00.02	FACTORED	Electrical (This is based on a percentage of the Total Project Costs) 15%	1.0 LS	-	-	-	***2,516,879***	-	2,516,879.00 /LS	2,516,879
27-20-00.01	FACTORED	Instrumentation (This is based on a percentage of the Total Project Costs) 10%	1.0 LS	-	-	-	***1,677,920***	-	1,677,920.00 /LS	1,677,920
		Electrical and Instrumentation (FACTORED)	**1.0 LS**				**4,194,799**		**4,194,799.00 /LS**	**4,194,799**
		03 Electrical and Instrumentation					**4,194,799**			**4,194,799**
		04 Rehab WWTP		**1,066,262**	**2,488,207**	**411,267**	**14,265,529**			**18,231,264**
		Alt 02 A/O Concept 2A		**1,066,262**	**2,488,207**	**411,267**	**14,265,529**			**18,231,264**
		01 Totals		**1,066,262**	**2,488,207**	**411,267**	**14,265,529**			**18,231,264**

Estimate Totals

Description	Rate	Hours	Amount	Totals
Labor		7,559 hrs	1,066,262	
Material			2,488,207	
Subcontract			14,265,529	
Equipment		6,589 hrs	411,267	
Other				
			18,231,265	**18,231,265**
Labor Mark-up	15.00 %		159,939	
Material Mark-up	10.00 %		248,821	
Subcontractor Mark-up	10.00 %		1,426,553	
Construction Equipment Mark-up	10.00 %		41,127	
Other - Process Equip Mark-up	8.00 %			
			1,876,440	**20,107,705**
Material Shipping & Handling	2.00 %		49,764	
Material Sales Tax	8.00 %		199,057	
Other - Process Eqp Sales Tax	8.00 %			
Net Markups			**248,821**	**20,356,526**
Contractor General Conditions	15.00 %		3,053,479	
			3,053,479	**23,410,005**
Start-Up, Training, O&M	2.00 %		468,200	
			468,200	**23,878,205**
Undesign/Undevelop Contingency	50.00 %		11,939,102	
			11,939,102	**35,817,307**
Bldg Risk, Liability Auto Ins	2.00 %		716,346	
			716,346	**36,533,653**
Payment and Performance Bonds	1.50 %		548,005	
			548,005	**37,081,658**
Escalation to Midpoint (ALL)	15.26 %		5,658,661	
Gross Markups			**5,658,661**	**42,740,319**
Total				**42,740,319**

Engineering and Admin	8,540,000
Capital cost	51,240,000

Attachment B: Alternative 2SND A/O Simultaneous Nitrification Denitrification with Hydrocyclones - Single Activated Sludge Plant Opinion of Probable Construction Cost

City of Rochester, MN
Rochester WRP Facilities Plan
2% DESIGN, CLASS 5 ESTIMATE

Estimator	Walter, Breeze
BC Project Manager	Harold Voth
BC Office	Saint Paul
Est Version Number	8
QA/QC Reviewer	Ian Kruljac
QA/QC Review Date	10-26-2018
Alternates	Alt 02C

Phase	Item	Description	Quantity	Labor Amount	Material Amount	Equip Amount	Sub Amount	Other Amount	Total Cost/Unit	Total Net Amount
01 Totals										
Alt 02C A/O Concept 2A - Cyclones										
04 Rehab WWTP										
01 Demoltion										
02221 _Site Demolition										
02-41-13.17	5050	Demolish, remove pavement & curb, remove bituminous pavement, 4" to 6" thick, excludes hauling and disposal fees	733.3 sy	5,239	-	2,045	-	-	9.93 /sy	7,284
02-41-13.33	4450	Minor site demolition, for disposal on site, excludes hauling, add	163.0 cy	858	-	947	-	-	11.08 /cy	1,805
02-41-19.23	0800	Rubbish handling, dumpster, 30 C.Y., 10 ton capacity, weekly rental, includes one dump per week, cost to be added to demolition cost.	2.0 week	-	1,409	-	-	-	704.45 /week	1,409
01-56-26.50	0250	Temporary fencing, chain link, rented up to 12 months, 6' high, 11 ga, over 1000'	1,000.0 lf	3,626	2,913	-	-	-	6.54 /lf	6,539
		_Site Demolition	**6,600.0 sf**	**9,723**	**4,322**	**2,992**			**2.58 /sf**	**17,037**
02999 ABC AERATION										
02-99-99.99	MISC	Selective demolition - demo baffels walls - allowance	1.0 LS	40,120	-	10,030		-	50,150.00 /LS	50,150
02-22-04.52	BC-0071	Equipment dismantling/demolition, Mixers allowance	1.0 lsum	11,011	-	4,297	-	-	15,308.10 /lsum	15,308
		ABC AERATION	**1.0 ls**	**51,131**		**14,327**			**65,458.10 /ls**	**65,458**
02999 2ND STAGE AERATION										
02-99-99.99	MISC	Selective demolition - cut top of baffels walls - allowance	1.0 LS	40,120	-	10,030		-	50,150.00 /LS	50,150
02-22-04.52	BC-0071	Equipment dismantling/demolition, Mixers motors and ox feed - allowance	1.0 lsum	36,704	-	14,323	-	-	51,027.02 /lsum	51,027
		2ND STAGE AERATION	**1.0 ls**	**76,824**		**24,353**			**101,177.02 /ls**	**101,177**
02999 Demolition of Cryogenic Facility										
46-05-00.00	----	Demo of the Cryogenic Facility	1.0 LS	***50,000***	***80,000***	***25,000***			155,000.00 /LS	155,000
		Demolition of Cryogenic Facility	**1.0 LS**	**50,000**	**80,000**	**25,000**			**155,000.00 /LS**	**155,000**
		01 Demoltion		**187,678**	**84,322**	**66,672**				**338,672**
02 Construction										
03999 ABC Aeration Basisn 1,2,3&4 including Collection Channel 30.5'H x 32.5'W x 250'L										
03-01-00.00	----	ABC Aeration Basisn 1,2&3 including Collection Channel From Meridian Project	1.0 LS				5,643,168		5,643,167.97 /LS	5,643,168
46-06-00.00	BC-0336	Aeration Blower 7500 scfm	1.0 ea	4,946	4,855	7,093	250,000	-	266,893.76 /ea	266,894
		ABC Aeration Basisn 1,2,3&4 including Collection Channel 30.5'H x 32.5'W x 250'L	**1.0 LS**	**4,946**	**4,855**	**7,093**	**5,893,168**		**5,910,061.73 /LS**	**5,910,062**
03999 Piping, Flumes, Distribution Boxes										
03-01-00.00	----	Piping, Flumes, Distribution Boxes	2.0 LS				1,577,562		788,780.90 /LS	1,577,562
		Piping, Flumes, Distribution Boxes	**1.0 LS**				**1,577,562**		**1,577,561.80 /LS**	**1,577,562**
03999 4th Train for 2nd Stage Aeration Basins										

Phase	Item	Description	Quantity	Labor Amount	Material Amount	Equip Amount	Sub Amount	Other Amount	Total Cost/Unit	Total Net Amount
03999 4th Train for 2nd Stage Aeration Basins										
03-99-99.99	MISC	4th Train for 2nd Stage Aeration Basins	1.0 LS	-	-	-	*1,410,792*	-	1,410,792.00 /LS	1,410,792
		4th Train for 2nd Stage Aeration Basins	**1.0 LS**				**1,410,792**		**1,410,792.00 /LS**	**1,410,792**
22200 DI Pipe										
22-20-00.30	BC-0046	Piping, water dist, DI, cement lined, 18' L, restrained jt, 54" dia	670.0 lnft	29,114	226,742	3,445	-	-	387.02 /lnft	259,301
22-20-00.30	BC-0041	Piping, water dist, DI, cement lined, 18' L, restrained jt, 48" dia	525.0 lnft	18,880	141,356	2,234	-	-	309.47 /lnft	162,470
22-20-00.30	BC-0031	Piping, water dist, DI, cement lined, 18' L, restrained jt, 36" dia	870.0 lnft	22,813	133,872	2,700	-	-	183.20 /lnft	159,385
22-20-00.30	BC-0051	Piping, water dist, DI, cement lined, 18' L, restrained jt, 60" dia	75.0 lnft	4,102	30,091	485	-	-	462.38 /lnft	34,679
22-05-00.10	BC-0006	Allowance - Piping, Process	1.0 ls	327,250	699,300	70,125		-	1,096,675.00 /ls	1,096,675
22-20-00.30	BC-0001	Piping, water dist, DI, cement lined, 18' L, restrained jt, 12" dia	700.0 lnft	5,999	17,658		-	-	33.80 /lnft	23,656
		DI Pipe	**2,840.0 lf**	**408,157**	**1,249,019**	**78,990**			**611.33 /lf**	**1,736,166**
31315 Rock Excavation										
31-23-16.30	0100	Drilling and blasting rock, open face, over 1500 C.Y.	21,600.0 bcy	128,150	79,942	110,892	-	-	14.77 /bcy	318,984
31-23-16.30	4500	Drilling and blasting rock, preblast survey for house, city block within zone of influence, for 6 room house, minimum	21,600.0 sf	2,304	-	-	-	-	0.11 /sf	2,304
31-23-16.42	3900	Excavating, bulk bank measure, 3 C.Y. capacity = 250 C.Y./hour, shovel, excluding truck loading	21,600.0 bcy	13,433	-	20,838	-	-	1.59 /bcy	34,272
31-23-23.18	1255	Hauling, excavated or borrow material, loose cubic yards, 20 mile round trip, 0.5 loads/hour, 20 C.Y. dump trailer, highway haulers, excludes loading	21,600.0 lcy	162,394	-	184,197	-	-	16.05 /lcy	346,592
01-54-36.50	0100	Mobilization or demobilization, dozer, loader, backhoe or excavator, above 150 H.P., up to 50 miles	1.0 ea	191	-	288	-	-	479.38 /ea	479
		Rock Excavation	**21,600.0 cy**	**306,473**	**79,942**	**316,216**			**32.53 /cy**	**702,631**
31999 Sitework										
31-99-99.99	MISC	Sitework from Meridan	1.0 LS	-	-	-	500,000	-	500,000.00 /LS	500,000
		Sitework	**1.0 LS**				**500,000**		**500,000.00 /LS**	**500,000**
46999 RAS Pumps										
46-06-20.00	BC-0146	Turbine pump, CI, 4000 GPM, 200 HP, 12" discharge	8.0 ea	33,905	125,065		-	-	19,871.24 /ea	158,970
		RAS Pumps	**1.0 LS**	**33,905**	**125,065**				**158,969.92 /LS**	**158,970**
46999 Diffusers, Pumps, mixers										
46-06-00.00	BC-0326	mixer	8.0 ea	1,352	181,331	-	-	-	22,835.35 /ea	182,683
		Diffusers, Pumps, mixers	**1.0 LS**	**1,352**	**181,331**				**182,682.83 /LS**	**182,683**
46999 HPO Train Equipment										
46-06-00.00	BC-0326	mixer	6.0 ea	1,014	135,998	-	-	-	22,835.35 /ea	137,012

Phase	Item	Description	Quantity	Labor Amount	Material Amount	Equip Amount	Sub Amount	Other Amount	Total Cost/Unit	Total Net Amount
46999 HPO Train Equipment										
46-06-00.00	BC-0336	Aeration Blower 4 (7500 scfm at 11 psig (match other three 250 HP blowers by ERG)	3.0 ea	14,838	14,565	21,278	*600,000*	-	216,893.76 /ea	650,681
46-06-00.00	BC-0046	Diffusers, fine bubble, complete (includes all hardare fully installed ending at diffuser itself and incl upstream header to top of tank/vessel/basin)	7,500.0 ea	123,654	295,448	-	-	-	55.88 /ea	419,101
46-06-20.00	BC-0146	Turbine pump, CI, 4000 GPM, 200 HP, 12" discharge	8.0 ea	33,905	125,065		-	-	19,871.24 /ea	158,970
35-00-00.01	----	HPO Flow Control Structure	1.0 ls				250,000		250,000.00 /ls	250,000
		HPO Train Equipment	**1.0 LS**	**173,411**	**571,075**	**21,278**	**850,000**		**1,615,764.71 /LS**	**1,615,765**
46999 Odor Control										
46-06-00.00	BC-0066	Odor control tower, complete w/ media	2.0 ea	20,029	251,839	-	-	-	135,933.77 /ea	271,868
46-06-00.00	BC-0476	Fan, foul air odor control	2.0 ea	13,218	23,735	-	-	-	18,476.41 /ea	36,953
		Odor Control	**1.0 LS**	**33,247**	**275,573**				**308,820.36 /LS**	**308,820**
46999 Blower Building										
46-06-00.00	----	Blower Building - Meridian estimate	1.0 ls				*1,000,000*		1,000,000.00 /ls	1,000,000
		Blower Building	**1.0 LS**				**1,000,000**		**1,000,000.00 /LS**	**1,000,000**
46999 Hydrocyclones										
46-00-00.01	----	Cyclones, ABAC Control Systems,	1.0 LS				371,000		371,000.00 /LS	371,000
		Hydrocyclones	**1.0 LS**				**371,000**		**371,000.00 /LS**	**371,000**
46999 Pumps										
46-06-22.00	BC-0016	Wastewater, submersible,100 GPM gpm,guide rails, base elbow with wet well	4.0 ea	43,324	132,056	-	-	-	43,845.07 /ea	175,380
46-06-22.00	BC-0016	Wastewater, submersible,100 GPM gpm,guide rails, base elbow with wet well	4.0 ea	43,324	132,056	-	-	-	43,845.08 /ea	175,380
		Pumps	**1.0 LS**	**86,649**	**264,112**				**350,760.62 /LS**	**350,761**
46999 Hydrocyclone Building										
46-06-00.00	----	Blower Building - estimate	1.0 ls				100,000		100,000.00 /ls	100,000
		Hydrocyclone Building	**1.0 LS**				**100,000**		**100,000.00 /LS**	**100,000**
		02 Construction		**1,048,140**	**2,750,972**	**423,577**	**11,702,522**			**15,925,211**
03 Electrical and Instrumentation										
26001 Electrical and Instrumentation (FACTORED)										
26-00-00.02	FACTORED	Electrical (This is based on a percentage of the Total Project Costs) 15%	1.0 LS	-	-	-	*3,059,410*	-	3,059,410.00 /LS	3,059,410
27-20-00.01	FACTORED	Instrumentation (This is based on a percentage of the Total Project Costs) 10%	1.0 LS	-	-	-	*2,039,606*	-	2,039,606.00 /LS	2,039,606
		Electrical and Instrumentation (FACTORED)	**1.0 LS**				**5,099,016**		**5,099,016.00 /LS**	**5,099,016**
		03 Electrical and Instrumentation					**5,099,016**			**5,099,016**
		04 Rehab WWTP		**1,235,818**	**2,835,294**	**490,249**	**16,801,538**			**21,362,899**

Rochester WRP Facilities Plan

Phase	Item	Description	Quantity	Labor Amount	Material Amount	Equip Amount	Sub Amount	Other Amount	Total Cost/Unit	Total Net Amount
		Alt 02C A/O Concept 2A - Cyclones		1,235,818	2,835,294	490,249	16,801,538			21,362,899
		01 Totals		1,235,818	2,835,294	490,249	16,801,538			21,362,899

Estimate Totals

Description	Rate	Hours	Amount	Totals
Labor		9,699 hrs	1,235,818	
Material			2,835,294	
Subcontract			16,801,538	
Equipment		8,316 hrs	490,249	
Other				
			21,362,899	**21,362,899**
Labor Mark-up	15.00 %		185,373	
Material Mark-up	10.00 %		283,529	
Subcontractor Mark-up	10.00 %		1,680,154	
Construction Equipment Mark-up	10.00 %		49,025	
Other - Process Equip Mark-up	8.00 %			
			2,198,081	**23,560,980**
Material Shipping & Handling	2.00 %		56,706	
Material Sales Tax	8.00 %		226,824	
Other - Process Eqp Sales Tax	8.00 %			
Net Markups			**283,530**	**23,844,510**
Contractor General Conditions	15.00 %		3,576,676	
			3,576,676	**27,421,186**
Start-Up, Training, O&M	2.00 %		548,424	
			548,424	**27,969,610**
Undesign/Undevelop Contingency	50.00 %		13,984,805	
			13,984,805	**41,954,415**
Bldg Risk, Liability Auto Ins	2.00 %		839,088	
			839,088	**42,793,503**
Payment and Performance Bonds	1.50 %		641,903	
			641,903	**43,435,406**
Escalation to Midpoint (ALL)	15.26 %		6,628,243	
Gross Markups			**6,628,243**	**50,063,649**
Total				**50,063,649**

Engineering and Admin	10,000,000
Capital cost (rounded)	60,000,000

LOWER ENERGY // CLEAN DESIGN
DECREASED MAINTENANCE // INNOVATIVE PROCESSES

Technical Memorandum 1	Influent Flows and Loadings
Technical Memorandum 2	Wastewater Characterization and BioWin Calibration
Technical Memorandum 3	Plant Hydraulic Evaluation
Technical Memorandum 4	Primary Clarifier Computational Fluid Dynamics Modeling
Technical Memorandum 5	Final Clarifier Computational Fluid Dynamics Modeling
Technical Memorandum 6	Liquid Stream Alternative Evaluation
Technical Memorandum 7	Solids Alternative Evaluation
Technical Memorandum 8	Digester Gas Management
Technical Memorandum 9	Disinfection and Outfall Evaluation
Technical Memorandum 10	Whole Plant Evaluation
Technical Memorandum 11	Heat Recovery Loop Alternative
Technical Memorandum 12	NPDES Permitting Process
Technical Memorandum 13	Industrial Discharge Wasteloads and Practices