FINAL

WWTF TOTAL NITROGEN UPGRADE STUDY
TOWN OF EPPING, NEW HAMPSHIRE

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INTRODUCTION

Underwood Engineers was commissioned by the Town of Epping to undertake a study to establish the necessary upgrades to the WWTF to achieve a potential total nitrogen limit of 3.0 mg/L. Underwood subsequently engaged the services of Hazen and Sawyer (Hazen) to provide peer review and advanced BNR expertise.

The Town of Epping, New Hampshire owns and operates a 0.5 MGD biological nutrient removal membrane bioreactor (BNR MBR) wastewater treatment facility. The facility discharges to the Lamprey River which flows to the Great Bay Estuary. The facility has recently been issued two (2) new EPA NPDES Permits:

- A total nitrogen general permit which covers Epping and eleven (11) other seacoast communities discharging to Great Bay.
- A general permit for the rest of the plant's discharge parameters which was issued to the majority of New Hampshire facilities with a design flow of less than 1.0 MGD.

The current total nitrogen permit requires Epping to "hold the load" meaning that the permit level is set at the average total pounds of nitrogen that was estimated to be discharged by the facility during the calendar years 2012–2016. While this TN limit is currently achievable, if Epping desires to connect additional entities to the wastewater collection system and increase their average daily flows, additional treatment will be required to meet the current limits. Further, it is important to understand that the current permit included provisions for communities to participate in an adaptive management approach which involves tracking and efforts to achieve reductions of non-point source nitrogen discharges within the Town's borders. Epping has recently made efforts to participate in adaptive management measures. Regardless, this study investigates upgrades at the WWTF to be able to achieve a future potential total nitrogen permit limit of 3 mg/L, not knowing what the future will hold.

The Town also has stringent limits for $CBOD_5$, TSS, Total Phosphorus and Zinc. These will also need to be considered when looking at treatment options.

Further, Epping replaced their hollow fiber membranes with flat sheet membranes in 2021 as the hollow fiber membranes had reached the end of their useful life and the Town wished to try a different membrane technology. Within eight (8) months of startup of the first of three (3) trains, the plant experienced unanticipated hydraulic capacity issues with the new membranes. The new flat sheet membranes were not able to successfully pass the specified hydraulic design flows, so the Town has begun the process of converting back to hollow fiber membranes and two (2) of three (3) trains are currently complete.

In the near term (EOY 2024), Epping wishes to continue to use their MBR process and also begin taking septage and additional sewer connections. This study also looks at what is needed to allow that to happen reliably.

SECTION 1 – HISTORIC DATA REVIEW

1.1 BACKGROUND

For the purposes of this TN Upgrade Study, Underwood reviewed five (5) years of historical data from January 2019 through December 2023. Charts for each of the following influent parameters can be found in ***Appendix A***: Flow, $CBOD_5$, and TSS.

CBOD and TSS concentrations have been fairly consistent over the five (5) year period and are consistent with typical medium strength municipal wastewater (Metcalf and Eddy reference). However, it is evident that the influent flows to the plant have increased significantly since the Fall of 2022. It is suspected that new infiltration/inflow sources have developed in the collection system, and it is recommended that the Town undertake I/I Investigations to try to identify and manage/reduce these flows.

Two (2) other important influent parameters are TKN and Total Phosphorous. Unfortunately, the Town does not normally monitor these two (2) parameters, therefore the amount of data available is limited to that collected during the 7-day influent characterization testing done as part of this study. The seven (7) days of data collected are consistent with TKN and TP values typical of municipal wastewater (see ***Table 2.1*** in Section 2). ***Table 1.1*** below presents the historic values for these five (5) parameters at the Epping WWTF with assumed peaking factors applied where historical ones could not be calculated.

Note, regular influent sampling of TKN and TP should be practiced at Epping for process control even though it is not required by permit. Underwood recommends Epping perform biweekly influent ammonia, TKN, TP, and ortho-P testing utilizing their HACH colorimeter and digestion unit.

Table 1.1 – Historic Influent Values

PARAMETER	VALUE	PEAKING FACTOR
Average Daily Flow	0.224 MGD	1.00
Max Month Flow	0.313 MGD	1.40
Max Week Flow	0.373 MGD	1.67
Max Day Flow	0.504 MGD	2.25
Peak Hour Flow	482 GPM = 0.694 MGD	3.10
Average Biweekly $CBOD_5$	241 mg/L	1.00
Max Month $CBOD_5$	390 mg/L	1.62
Average Biweekly TSS	152 mg/L	1.00
Max Month TSS	300 mg/L	1.97
Average TKN	46 mg/L*	1.00
Max Month TKN	64 mg/L*	1.40 (assumed)
Average TP	6.4 mg/L	1.00
Max Month TP	9.0 mg/L	1.40 (assumed)

Note: * Denotes from characterization study.

For the 7-day special sampling program, samples were taken after fine screening but before grit removal. It is important to note that Epping desires to accept septage at the facility and the dewatered septage filtrate is introduced downstream of the normal influent sampling point. In September 2019, after the new septage receiving and dewatering facilities were put on-line, Underwood requested the Town take samples of the combined WAS and septage dewatering filtrate from the screw press and analyze it for $CBOD_5$, TSS, TKN and TP. The average concentrations of two (2) such samples were as follows: $CBOD_5$ = 130 mg/L: TSS = 886 mg/L: TKN = 96 mg/L: TP = 12 mg/L. While these values are approximately 2 to 3 times the strength of typical municipal wastewater (except for COD), they are considerably less than raw septage which was the reason for sending received septage straight to dewatering as to not overload the MBR treatment process.

SECTION 2 - INFLUENT WASTEWATER CHARACTERIZATION

2.1 BACKGROUND

While the historic data presented in ***Section 1*** is helpful, a more in-depth characterization of the influent wastewater is necessary to provide sufficient input into the Biowin process modeling software to yield reliable predictive results. For this reason, an intensive 7-day influent characterization study was conducted during October and November 2023. Twenty (20) 4-hour flow proportioned composite samples were collected over the course of several weeks to include each day of the week and to capture diurnal and weekday versus weekend variations in wastewater flows and loads.

The objective of the characterization was to determine the Epping WWTF influent total and soluble fractions for COD, BOD_5, nitrogen and phosphorus. The effluent was also sampled to understand the non-biodegradable soluble COD that passes through the process. It should be noted that the major sidestream at the WWTF, the dewatering filtrate, was not sampled as dewatering was not being performed during the sampling time period. This sidestream discharges to the intermediate pump station which pumps to the 2mm screen and the MBR influent channel, which are downstream of the influent sampling point. It therefore is not accounted for in the normal influent sampling and needs to be added in when considering loads to the biological process. This sidestream is strongest when septage is being received and combined with the plant WAS prior to dewatering. Refer to ***Table 3.3*** for the strength of this septage/WAS filtrate sidestream.

Samples were collected using the Epping WWTF automatic composite samplers over a 24-hour period. The influent sampler is located upstream of the grit removal tank and the effluent sampler is located downstream of the UV system. Grab samples were also taken from the recycle header at the MBR’s to determine MLSS parameters in the biological process tanks.
In addition to sample collection, each sample was prepared in the Epping WWTF laboratory before being bottled and sent out for analysis.

Composite influent samples were separated into three (3) aliquots. Aliquot 1 was mixed using a high-speed blender for analysis of total COD, $CBOD_5$, TP, TKN and Alkalinity. A second aliquot was flocculated using a zinc sulfate stock solution and then pH adjusted with sodium hydroxide (6N) to elevate the pH to just under 10.5, then the sample was filtered at 1.5um for determining soluble COD (floc/filtered COD). The third aliquot was a portion poured directly into sample bottles for TSS/VSS and VFAs, with the remaining portion filtered at 1.5 um for soluble COD, $CBOD_5$, TKN, and NH3-N. PO_4-P was filtered using 0.45 µm filter.

For effluent, the composite sample was separated into two (2) aliquots, where one (1) aliquot was used to determine soluble COD (floc/filtered COD), and the second aliquot was directly bottled for analysis of COD, TKN, and NH3-N. Note the second aliquot was not filtered since this is effluent from the membranes which have an effective pore size of 0.04 µm.

The difference between the influent floc/filtered COD and effluent floc/filtered COD is a measure of the readily biodegradable soluble COD (rbCOD). The influent COD is filtered and measures all the soluble COD, which includes colloids that pass through the filter. The influent COD prepared by dosing with zinc sulfate, rapid mixing, settling and then filtering the supernatant removes the colloids. The effluent COD prepared by the same method measures the unbiodegradable soluble COD that comes in and passes through the plant.

The MLSS grab sample was also separated into two (2) aliquots, where one (1) aliquot was mixed using a high-speed blender for total COD. The second aliquot had a portion poured directly into the sample bottle for TSS/VSS, and the remaining portion filtered at 1.5 µm for soluble COD.

The laboratory results for the total and soluble fractions allow estimates for each of the components to be made and utilized in the BioWin process modeling. The results for the Epping wastewater key fractions are summarized in ***Table 2.1*** below with the complete data results included in ***Appendix B***.

Table 2.1 – Wastewater Characterization Results

		RAW INFLUENT																			
		TSS	VSS	COD	COD	COD	BOD	BOD	TP	PO4-P	TKN	TKN	NO3-N	NO2-N	TN	NH3-N	NH3-N	Alkalinity	VFA	Inf pH	Inf Flow
DATE	DAY			tot.	1.5μ gf	ff	tot.	1.5μ gf	tot.		tot.	1.5μ gf			tot.		1.5u gf		as H2C2O4		
		(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)		(mgd)
Tue-Oct 31-23	0			670	280	170	290	120	5.4	2.7	40.0	35.0	0.0	0.0	40.0	31.0	31.0	190.0	225.0	7.9	0.2160
Thu-Nov 2-23	1	243	192	740	260	190	360	140	6.3	3.5	45.0	39.0	0.0	0.0	45.0	35.0	34.0	210.0	425.0	7.86	0.2166
Sat-Nov 4-23	2	216	202	750	360	220	450	220	6.5	3.9	44.0	44.0	0.0	0.0	44.0	35.0	36.0	220.0		7.54	0.2248
Mon-Nov 6-23	3	232	212	620	220	170	270	130	6.4	3.6	46.0	43.0	0.0	0.0	46.0	37.0	37.0	230.0	225.0	7.65	0.2030
Wed-Nov 15-23	4	260	247	690	250	190	350	170	7.1	4.3	58.0	45.0	0.0	0.0	58.0	39.0	39.0	240.0		7.93	0.1981
Fri-Nov 17-23	5			680	320	220	360	190	6.6	4.2	44.0	46.0	0.0	0.0	44.0	38.0	40.0	230.0		7.67	0.1992
Sun-Nov 19-23	6			700	390	250	420	220	6.7	4.4	44.0	44.0	0.0	0.0	44.0	38.0	39.0	230.0		7.57	0.1931
Mon-Dec 4-23																			49.0	7.71	0.2501
Wed-Dec 6-23																			44.0	7.54	0.2387
AVERAGE		238	213	693	297	201	357	170	6.4	3.8	45.9	42.3	0.0	0.0	45.9	36.1	36.6	221.4	193.6	7.70	0.2155
STD DEV		19	24	44	62	30	64	42	0.5	0.6	5.7	3.9	0.0	0.0	5.7	2.7	3.2	16.8	157.2	0.15	0.0195
	MAX	260	247	750	390	250	450	220	7.1	4.4	58.0	46.0	0.0	0.0	58.0	39.0	40.0	240.0	425.0	7.93	0.2501
	MIN	216	192	620	220	170	270	120	5.4	2.7	40.0	35.0	0.0	0.0	40.0	31.0	31.0	190.0	44.0	7.54	0.1931

The Epping influent during the sampling period would be characterized as a medium-to-high-strength wastewater during a dry period with less I/I coming to the Plant. A notable component that stood out was the high level of VFAs in the influent. Given the high values measured in the first three (3) samples, Underwood had two (2) additional tests run to further characterize the VFA components and found that formic acid was unusually high. This high level of formic acid could suggest an industrial type of influent being discharged to the Epping WWTF. However, high VFAs is generally considered good for biological nutrient removal. For modeling purposes, only the Acetic and Propionic VFA components are used.

BioWin requires characterization of specific influent wastewater parameters that are used in the model calculations. ***Table 2.2*** below presents the BioWin parameters estimated from the Epping wastewater fractions sampling program. ***Table 2.3*** below presents the wastewater ratios that were used to check the validity of the sampling data.

Table 2.2 – Select BioWin Parameters

		RAW INFLUENT						
DATE	DAY	ISS (mg/L)	F_{BS} (mgCOD/ mgCOD)	F_{US} (mgCOD/ mgCOD)	F_{CV} (mgCOD/ mgVSS)	F_{NUS} (mgN/ mgN)	F_{PO4} (mgP/ mgP)	F_{NA} (mgN/ mgN)
Tue-Oct 31-23	0		0.25	0.03		0.00	0.50	0.78
Thu-Nov 2-23	1	51	0.26	0.03	2.50	0.01	0.56	0.78
Sat-Nov 4-23	2	14	0.29	0.02	1.93	0.00	0.60	0.80
Mon-Nov 6-23	3	20	0.27	0.03	1.89	0.00	0.56	0.80
Wed-Nov 15-23	4	13	0.28	0.03	1.78	0.01	0.61	0.67
Fri-Nov 17-23	5		0.32	0.02		0.02	0.64	0.86
Sun-Nov 19-23	6		0.36	0.02		0.02	0.66	0.86
AVERAGE		25	0.29	0.03	2.03	0.01	0.59	0.79
STD DEV		18	0.04	0.00	0.32	0.01	0.05	0.06
	MAX	51	0.36	0.03	2.50	0.02	0.66	0.86
	MIN	13	0.25	0.02	1.78	0.00	0.50	0.67

Table 2.3 – Wastewater Ratio Checks

		RAW INFLUENT												
DATE	DAY	TSS / COD (mg/mg)	COD / BOD (mg/mg)	TSS / BOD (mg/mg)	BODf / BODt (mg/mg)	ISS / COD (mg/mg)	ISS / TSS (mg/mg)	VSS / TSS (mg/mg)	TKN / COD (mg/mg)	TP / COD (mg/mg)	COD gf / COD tot (mg/mg)	COD ff / COD tot (mg/mg)	TKN/BOD (mg/mg)	TP/BOD (mg/mg)
Sun-Oct 22-23	0		2.31		0.41				0.06	0.008	0.42	0.25	0.14	0.02
Tue-Oct 24-23	1	0.33	2.06	0.68	0.39	0.07	0.21	0.79	0.06	0.009	0.35	0.26	0.13	0.02
Thu-Oct 26-23	2	0.29	1.67	0.48	0.49	0.02	0.06	0.94	0.06	0.009	0.48	0.29	0.10	0.01
Sat-Oct 28-23	3	0.37	2.30	0.86	0.48	0.03	0.09	0.91	0.07	0.010	0.35	0.27	0.17	0.02
Mon-Oct 30-23	4	0.38	1.97	0.74	0.49	0.02	0.05	0.95	0.08	0.010	0.36	0.28	0.17	0.02
Wed-Nov 1-23	5		1.89		0.53				0.06	0.010	0.47	0.32	0.12	0.02
Fri-Nov 3-23	6		1.67		0.52				0.06	0.010	0.56	0.36	0.10	0.02
AVERAGE		0.34	1.98	0.69	0.47	0.03	0.10	0.90	0.07	0.009	0.43	0.29	0.132	0.018
STD DEV		0.04	0.26	0.16	0.05	0.02	0.07	0.07	0.01	0.001	0.08	0.04	0.028	0.003
	MAX	0.38	2.31	0.86	0.53	0.07	0.21	0.95	0.08	0.010	0.56	0.36	0.170	0.024
	MIN	0.29	1.67	0.48	0.39	0.02	0.05	0.79	0.06	0.008	0.35	0.25	0.098	0.014

Based on ***Table 2.2*** and ***Table 2.3*** above, the Epping influent wastewater could be characterized as typical municipal wastewater, with the most noteworthy findings described below.

F_{BS} – The fraction of readily biodegradable COD is an indicator of the potential for both phosphorus and nitrogen removal. The Epping wastewater F_{BS} measured during the characterization program was estimated to be 26% of the total COD. Typical municipal fractions are 16%. This indicates a highly available fraction of COD that can be used for nutrient removal.

BOD/TKN Ratio – The ability of the wastewater to provide a readily available carbon source for denitrification can be estimated using the BOD to TKN ratio of the wastewater entering an activated sludge anoxic zone. Typical municipal wastewater has a BOD/TKN ratio of 4:1 to 5:1. Higher ratios can affect the nitrification process and lower ratios can reduce the denitrification potential. A measured ratio of 7.8:1 indicates that the Epping wastewater is slightly negative for nitrification but very positive for denitrification.

The high F_{BS} and BOD/TKN ratio coupled with the high influent VFA content indicates that the Epping influent wastewater is favorable for effective biological nutrient removal.

SECTION 3 - DESIGN FLOWS AND LOADS

3.1 BACKGROUND

When considering design flows and loads for the Epping WWTF, it is important to note that Epping's discharge permit to the Lamprey River is one of the most stringent permits that exists in New Hampshire. BOD_5 and TSS limits are in the single digits and TP is 0.26 mg/L. (See ***Table 3.1*** for Summary of Epping WWTF Permit Limits). The current effluent discharge limit is 0.5 MGD and the likelihood of being able to increase the discharge flow above that value is extremely low due to the rules governing anti-backsliding and anti-degradation within the receiving stream. Fortunately, the current historic average daily flow to the Epping facility is 0.224 MGD or 45% of 0.5 MGD, with significant capacity for growth. For these reasons it is recommended that the total nitrogen (TN) upgrade design criteria also incorporate an average day design flow of 0.5 MGD.

Table 3.1 – WWTF General Permit Limits Summary

PARAMETER	AVERAGE MONTHLY	MAX. WEEK	MAX. DAY
$CBOD_{5\ Jun – Oct}$	5 mg/L	8 mg/L	10 mg/L
$CBOD_{5\ Nov - May}$	8 mg/L	12 mg/L	38 mg/L
$TSS_{Jun – Oct}$	3 mg/L	4 mg/L	6 mg/L
$TSS_{Nov – May}$	5 mg/L	8 mg/L	33 mg/L
pH	6.5 to 8	-	-
DO	> 7 mg/L	-	-
TRC	0.033 mg/L	-	0.057 mg/L
TR Zn	0.195 mg/L	-	0.195 mg/L
TP	0.26 mg/L / 1.1 lb/d	-	Report

NH_3 - N $_{Nov-May}$	7.2 mg/L / 30 lb/d	-	10.8 mg/L / 45 lb/d
NH_3 - N $_{Jun-Oct}$	1.4 mg/L / 5.8 lb/d	-	2.0 mg/L / 8.3 lb/d
TN $_{Apr-Oct}$	43 lbs/d (7 mos. rolling avg.)	-	-

Table 3.2 presents the proposed influent loading design criteria for the TN Upgrade. Peaking factors for influent flow have been matched to the historic peaking factors established in ***Section 1*** with the exception of peak hourly flow. While peak flows have been recorded by SCADA since October 2019, the influent fine screen causes phantom peak flows to be seen at the influent flow meter each time it actuates to clean the screen. Further, the recorded numbers are the peak instantaneous flow during the 24-hour day and not the average flow over the peak hour. To ascertain the true peak hourly flow rates, two (2) days of 5-minute data were exported from SCADA and analyzed to determine the average flow discharged for each hour of the day. Underwood chose 11/3/23 which was a day in the middle of the influent characterization sampling period that matched the annual average flow of 224,000 GPD, and 1/10/24 which matched the maximum day flow seen at the plant in the last five (5) years at 592,000 GPD. Based on this data (refer to chart in ***Appendix A***), we determined that the peak hourly flow rate on an average day is currently 207 gpm and on the maximum day is 482 gpm. This results in a peak hourly flow rate of 694,000 gpd and a peaking factor of 3.10. This is the basis for the peak hour peaking factor cited in ***Table 1.1*** and used in ***Tables 3.2*** and ***3.3***.

Table 3.2 – Existing and 20-Yr Design Flows and Loads

PARAMETER	EXISTING VALUE	20-YR DESIGN VALUE
Average Daily Flow	0.224 MGD	0.50 MGD
Max Month Flow	0.313 MGD	0.70 MGD

Max Week Flow	0.373 MGD	0.835 MGD
Max Day Flow	0.504 MGD	1.125 MGD
Peak Hour Flow	0.694 MGD	1.55 MGD
Average Biweekly $CBOD_5$	450 lbs/d	1,005 lbs/d
Max Month $CBOD_5$	729 lbs/d	1,626 lbs/d
Average Biweekly TSS	284 lbs/d	634 lbs/d
Max Month TSS	560 lbs/d	1,251 lbs/d
Average TKN	86 lbs/d	192 lbs/d
Max Month TKN	120 lbs/d	267 lbs/d
Average TP	12.0 lbs/d	26.7 lbs/d
Max Month TP	16.8 lbs/d	37.5 lbs/d

Table 3.3 below includes revised flows and loads associated with up to 30,000 GPD of septage/WAS filtrate and new flows from planned developments currently on the books of 75,000 GPD (2023). Please note that the 20-YR Design Values in ***Table 3.2*** above do not include a septage load since we have assumed Epping will want to max out how much domestic waste they can take over time and will phase out septage receiving as they approach 0.5 MGD.

Table 3.3 – Desired Flows and Loads EOY 2024

PARAMETER	EXISTING VALUE	NEW CONNECTIONS	SEPTAGE/WAS FILTRATE	NEW VALUE EOY 2024
Average Daily Flow	0.224 MGD	0.075 MGD	0.030 MGD	0.329 MGD
Max Month Flow	0.313 MGD	0.105 MGD	0.030 MGD	0.448 MGD
Max Week Flow	0.373 MGD	0.125 MGD	0.030 MGD	0.528MGD
Max Day Flow	0.504 MGD	0.169 MGD	0.030 MGD	0.703 MGD

Peak Hour Flow	0.694 MGD	0.233 MGD	N/A	0.927 MGD
Average Biweekly $CBOD_5$	450 lbs/d	151 lbs/d	33 lbs/d	634 lbs/d
Max Month $CBOD_5$	729 lbs/d	244 lbs/d	33 lbs/d	1,006 lbs/d
Average Biweekly TSS	284 lbs/d	95 lbs/d	222 lbs/d	601 lbs/d
Max Month TSS	560 lbs/d	188 lbs/d	222 lbs/d	970 lbs/d
Average TKN	86 lbs/d	29 lbs/d	24 lbs/d	139 lbs/d
Max Month TKN	120 lbs/d	40 lbs/d	24 lbs/d	184 lbs/d
Average TP	12.0 lbs/d	4.0 lbs/d	3.0 lbs/d	19.0 lbs/d
Max Month TP	16.8 lbs/d	5.6 lbs/d	3.0 lbs/d	25.4 lbs/d

The flow and load in ***Table 3.3*** for the New Value EOY 2024 are also used in modeling the short-term upgrade.

SECTION 4 - TECHNOLOGY SCREENING WORKSHOP

4.1 BACKGROUND

Prior to delving into intense engineering evaluations for the proposed TN upgrade at the Epping WWTF, it was important to evaluate the options available to the Town and collectively identify the upgrade option best suited for Epping to achieve the goals of their current and anticipated discharge permit limits. To prepare for the screening workshop, Underwood compiled a treatment technology summary document that was circulated to the participants of the workshop in advance so they could familiarize themselves with the available options. This package can be seen in ***Appendix C***.

On Wednesday, October 24, 2023, the treatment alternatives workshop was held at the Epping WWTF including Epping staff, Underwood Engineers staff, and Dr. Rob Sharp of Hazen as the expert peer reviewer. During the workshop, each of twelve (12) different TN removal upgrade technologies were discussed and four (4) tertiary filtration technologies were discussed. Each can be seen in the pre-workshop package included in ***Appendix C***.

A key recognition at the treatment alternatives workshop was the fact that the 3 mg/L average monthly TSS limit in Epping's permit dictates that membrane filtration be utilized whether it be part of an MBR process or as a tertiary filtration step following an alternate secondary treatment process. It is both UE's and Hazen's opinion that the other tertiary filtration technologies available cannot reliably meet a 3 mg/L TSS limit and the manufacturers of those technologies are not willing to offer performance guarantees stating they can meet that limit.

The final discussions at the treatment alternatives workshop focused on identifying the most important factors to Epping. In all, twelve (12) factors were identified with the two (2) most critical factors being reliability and redundancy. Each of the twelve (12) participants of the workshop voted for their top three (3) considerations and the results of that voting can be seen in ***Table 4.1*** below.

Table 4.1 – Screening Workshop Voting

FACTORS	SCORING				
	1	**2**	**3**	**4**	**5**
RELIABILITY	3	1	4		
PROVEN NE TECHNOLOGY	3	2			
BYPASS POTENTIAL		2	1	2	
CAPITAL COSTS	1		1	1	4
LABOR REQUIREMENTS		2	1		
FUNDING POTENTIAL		1		2	1
O&M COSTS	1			1	1
HYDRAULIC CAPACITY		1	1		1
SEPTAGE COMPATIBILITY				3	1
BACKUP REDUNDANCY			1		
NEED FOR EQ/STORAGE					1

Note: Factors were scored by nine (9) people with #1 being most important and #5 being least important.

From the above voting, a blank (not filled out) technology rating matrix was generated which can be seen in ***Appendix C***. Following the workshop, three (3) Underwood Engineers' Senior Wastewater staff and Dr. Rob Sharp of Hazen independently scored the four (4) highest ranked technologies from the workshop. Each of those four (4) scoresheets can be found in ***Appendix C***.

All four (4) engineers independently ranked the 4-Stage Bardenpho treatment with membrane tertiary filtration as the top ranked TN upgrade alternative followed by MBR technology utilizing the 4-Stage Bardenpho configuration as the second highest ranked treatment alternative.

Following the individual rankings, Underwood Engineers and Hazen met to discuss the outcome and spoke at length about Epping's current infrastructure and what it would take to build a conventional Bardenpho process and meet an effluent TSS of 3.0 mg/L. The following major points were raised:

- Switching from MBR to conventional activated sludge would require a reduction in the MLSS from 8,000 mg/L to 3,500 mg/L, requiring 2.3 times the volume for tankage/treatment. This means capital costs for the upgrade would be significantly more.
- To separate the MLSS from the secondary effluent will require the construction of secondary clarifiers which are not needed with the MBR process, adding more capital cost.
- To meet a 3.0 mg/L TSS limit the conventional Bardenpho process will require secondary clarifiers and tertiary membrane filtration. Underwood and Hazen maintain no tertiary process can reliably meet that TSS limit other than membrane filtration.
- Based on their experience, Hazen maintains that tertiary membrane filtration can require as much attention as MBR membranes and often requires equivalent O&M, including backwashing and recovery cleaning.
- The conventional Bardenpho process with tertiary filtration will involve more unit processes which will result in the need for more staff to operate and maintain the system, and higher electrical costs.
- Based on their experience, Hazen has seen the MBR process work very successfully all over the country and at plants much larger than Epping. The key is conservative design

with sufficient redundancies and protections (peak flow buffering, additional membrane capacity, redundant and effective pre-treatment (fine screens), automated cleaning, etc.)

- The footprint required to construct the conventional Bardenpho process would infringe on the space needed to construct the 1.5 MW solar field that is under design and construction as part of an ongoing RD funding package.

Collectively, Underwood and Hazen concluded that the higher capital and operation and maintenance costs associated with conventional Bardenpho treatment with membrane tertiary filtration is not the best option for Epping since Epping already has MBR facilities in place that are operational. The major factors that caused MBR technology to score second is lack of significant use in New England, and Epping's existing MBR design which lacks sufficient controls and redundancies for it to operate reliably. MBR technology when designed and operated properly is a very robust and reliable form of treatment which is practiced successfully worldwide and at some of the largest treatment facilities in the world. For these reasons, Underwood Engineers and Hazen conclude that the TN upgrade alternative best suited to Epping is an MBR upgrade to incorporate the Bardenpho process with additional controls and redundancies.

SECTION 5 - EPPING AND MBR TECHNOLOGY

5.1 BACKGROUND

Between 2000 and 2002 the Epping Lagoon Wastewater Treatment Facility was converted to a Membrane Bioreactor (MBR) Treatment Facility with the lagoons kept as influent storage and equalization. For approximately 20 years the Epping MBR facility functioned by utilizing hollow fiber membranes manufactured originally by Zenon and sold under the tradename ZeeWeed. In the first years of operation the plant struggled during times of cold weather to pass enough flow through the membranes to prevent the storage lagoons from overfilling. After a couple of years of operation, it was recognized that the cold water being introduced from the storage lagoons to the process was below 10°C and was causing hydraulic restrictions with the membranes. To combat this, Zenon worked with the Town to supply additional membranes to accommodate an influent temperature as low as 5ºC. Initially this helped, but as the membranes began to age and fatigue due to lack of proper pretreatment ahead of the membranes and regularly scheduled backwashing and recovery cleaning, the membranes fouled over time and the plant struggled again with insufficient hydraulic throughput. In 2014, after 12 years of operation, the membranes were completely replaced with a new set of ZeeWeed hollow fiber membranes which improved the situation but in a very short period hydraulic throughput was again an issue due to insufficient pretreatment and cleaning. Pulling ice cold water out of the lagoons in the winter months also inhibited the nitrifying bacteria in the process and resulted in numerous ammonia violations. In 2016, EPA issued an Administrative Order to the Town to analyze the MBR system and identify remedial actions to obtain adequate hydraulic capacity and bring the treatment plant into compliance with its discharge permit. Underwood was initially retained in late 2016, and in 2017 Underwood issued a report entitled “WWTF Biological Nutrient Removal Evaluation”. The report identified multiple deficiencies with the following being the most egregious:

- Replace the failed fine and micro screens in the Headworks Building which were no longer operable.
- Stop bringing cold lagoon water to the process during the winter months to prevent mixed liquor temperatures from dropping below 8°C.
- Stop taking raw septage in the influent of the plant.
- **Perform routine maintenance and recovery cleans with the proper chemicals at the manufacturer recommended frequencies**.

The plant implemented these changes starting in 2018. Once the plant stopped taking raw septage in the influent and stopped taking cold water from the lagoons into the MBR process the effluent quality quickly improved and came back into compliance. Issues with hydraulic throughput continued as it took until 2019 to get the fine and micro screen equipment replaced. However, despite doing better with maintenance and recovery cleans, the ZeeWeed membranes were failing due to earlier poor maintenance. Given the historic frustrations plant staff had with the ZeeWeed membranes, the Town wished to try another style of membranes. In 2021/2022, Epping replaced the ZeeWeed hollow fiber membranes with flat sheet polymeric membranes manufactured by Weise Water. Initially only Train 3 was converted in March 2021 and a six-month long pilot was performed to confirm the efficacy of the new membranes. The new membranes performed acceptably during the six-month pilot albeit they were not tested at the lowest design temperature of 8ºC. Because the remaining two (2) trains of ZeeWeed membranes were failing, the Town proceeded with replacement in Trains 1 and 2 with the Weise Water membranes. In late 2021 the new membranes in Train 3 began to fail in the form of both plugging hydraulically and passing solids to the effluent. By Spring 2022, the other two (2) trains of new membranes experienced similar issues. From late 2021 until spring of 2023, the Town performed multiple recovery cleans with citric acid and chlorine and at elevated temperatures and unfortunately the initial hydraulic throughput of the new membranes could not be recovered. Further, the new membranes were less robust than the ZeeWeed membranes and multiple component failures within the membrane cassettes occurred. In late 2022, a workshop was held to determine the best option to remedy the situation and regain hydraulic capacity with a reliable treatment system. At that time, the Town decided to go back to the ZeeWeed hollow fiber membranes which they had had decent success with despite improper pretreatment and insufficient cleaning. In 2023, membranes in both Train 3 and Train 2 were replaced with ZeeWeed hollow fiber membranes. (Prior to their installation, the Town swapped out their 2mm step-screen with a 2mm perforated plate screen as desired by the membrane manufacturer). Since their installation, the Town has been practicing regular maintenance cleaning on each MBR train on Monday, Wednesday and Friday with Monday and Friday being chlorine cleans and Wednesday being citric acid cleans. Underwood established a protocol for plant staff on a weekly basis to run each train from 5 GFD to 20 GFD and record the resultant transmembrane pressures. So far, the ZeeWeed membrane performance has been excellent and despite seeing a mixed liquor drop from 62°F at initial installation down to 46.4ºF (8°C), the transmembrane pressures have not changed drastically and at 46.4ºF, were still well within acceptable parameters. This is over a 6+ month period of operation for Train 3 and a 4+ month operation for Train 2. The results of these weekly tests can be seen in ***Appendix D***.

Hydraulic performance testing of the new ZeeWeed membranes was conducted on January 19, 2024 (Train 3) and January 26, 2024 (Train 2). Underwood had previously generated a hydraulic performance testing protocol which was reviewed and approved by NHDES. This protocol is attached in ***Appendix D***. The protocol requires plant staff to artificially increase flow and decrease flow to a given MBR train to mimic the conditions that would occur around the peak design flow to the membranes. The flow is ramped up during the first hour, run at the peak flow for the second hour, and ramped down during the third hour. Sampling of the MLSS and permeate is performed during the three-hour test and the transmembrane pressure of the train cannot exceed acceptable values. The test is then repeated a second time after a chlorine maintenance clean is performed to confirm that the system is able to recover to the lower TMPs after cleaning. The results of the hydraulic testing can be seen in the tables in ***Appendix D***.

The testing was done at a flow of 299 gpm per train or 430,000 gpd which matches the design specification provided by Veolia for the Epping ZeeWeed purchase. The MLSS quality fell within the specified design parameters during the testing. The MLSS temperature during the 12 hours of testing varied from a low of 44.8°F to a high of 47.2°F. The testing results were very favorable for both trains with the highest TMPs seen at the end of the one-hour peak flow period at -4.7 psi, well under the -7.5-psi shutdown pressure of the ZeeWeed membranes. Further, each train exhibited similar values before and after the chlorine maintenance clean suggesting that the membranes did not foul significantly during the first test and that the cleaning kept them at their original performance.

These positive results support that the hollow fiber membranes are capable of passing the design hydraulic flow rates at the lowest design temperature when in a new and clean condition. The downfall of membranes in the past at Epping has been due to improper pretreatment and failure to carry out routine maintenance (chlorine and citric acid cleaning). In order for the membranes to function reliably long term, the Epping WWTF requires multiple additional upgrades. Underwood Engineers and Hazen recommend the following improvements be implemented for continued use of MBR technology at Epping:

1. Implement and enforce a stringent FOG monitoring and removal program within the sewer collection system.

2. A third set of ZeeWeed membranes should be installed in Train 1 so all three (3) existing treatment trains are equipped with Veolia's latest membranes.
3. The two (2) storage lagoons should be abandoned and closed per the EPA Administrative Order (AO). New covered concrete peak flow buffer tank(s) should be constructed.
4. A separate Headworks Building should be constructed to house two (2) micro screens (2mm) and the existing Headworks Building modified to house two)2) fine screens (6mm), given they only have one (1) of each currently with no redundancy.
5. New divider walls should be constructed to house the membranes separate from the biological reactors and the recycle pumps moved inside the membrane space. Additional piping/valves should be added to allow any of three (3) membrane tanks to be on-line at a time.
6. Additional chemical feed piping and controls should be added to allow automated backwashing and recovery cleaning of the membranes.
7. A foam/scum spray system should be added to the biological reactors and membrane tanks.
8. A more conservative rating for the ZeeWeed membrane hydraulic capacity of 6 GFD for ADF and 12 GFD for peak flow should be utilized. This translates to an ADF of 150,000 gpd per membrane tank and a peak of 300,000 gpd per membrane tank, after one subtracts for membrane backwashing and cleaning downtime.
9. N+1 spare membranes should be kept wetted in a membrane tank available for use should acute plugging of the on-line membranes occur.

Graphically these recommended upgrades can be seen in ***Appendix F, Figures 1-3*.**

Note that long-term fouling is being accounted for by derating the hydraulic capacity of the membranes up front, sizing the system for future flows not yet connected, performing regular maintenance and recovery cleaning before the membranes have degraded too far, and providing N+1 membranes so that extra membranes are available to lighten the load on all membranes over time if need be before a replacement occurs. UE and Hazen are recommending sizing the membranes for a design maximum throughput of 12 GFD which is a comfortable throughput to run an MBR facility at continuously. Membranes at MBR facilities commonly last 7 to 10 years before needing to be replaced, sometimes longer. We recommend that a time frame of five (5) years be utilized in Epping until more historic data can be gathered at which time the duration may be extended.

SECTION 6 - BIOWIN MODELING OF BARDENPHO MBR

6.1 BIOWIN MODELING

In order to assess the treatment capacity of the biological system at the Epping WWTF, EnviroSim BioWin (version 6.2) modeling software was used. Inputs for existing conditions are as defined in ***Section 2*** of this report. Extensive modeling was performed for existing conditions, near term conditions (EOY 2024), and 20-year design conditions with assumed more stringent total nitrogen limits (3.0 mg/L). The modeling results are summarized in ***Appendix E*** of this report.

6.2 EXISTING CONDITIONS

Currently Epping's ADF is 224,000 gpd and its NPDES permits require a total nitrogen limit of 43 lbs/d to be met on a 7-month rolling average from April – October, an ammonia of 1.4 mg/L from June-October, and an ammonia of 7.2 mg/L from November-May. Utilizing current influent loads and assuming the membranes are housed in separate membrane tanks, the BioWin modeling predicts each bioreactor tank can treat 83,500 gpd and meet the current TN and ammonia limits using cyclic aeration. The backup to this evaluation can be seen in ***Appendix E***. These results indicate that all three (3) existing bioreactors are needed to treat existing flows to meet permit. To further support this finding, the plant has recently witnessed the loss of TN removal capability when only two bioreactors were operating. This loss of nitrogen removal was due to insufficient biological treatment capacity with only two trains in service, and not due to limitations in the membrane capacity. With all three (3) biological tanks in service, only two (2) membrane tanks are required, with the third providing N+1 redundancy/backup to meet the current permit at an average flow of up to 250,500 gpd.

6.3 SHORT-TERM CONDITIONS

In the short term (EOY 2024), Epping would like to be able to add additional flows and loads to the plant in the form of septage that is processed through dewatering and new connections that are planned for the near future. In order to meet current permit conditions of 43 lb/d TN on a seasonal monthly rolling average under maximum month loading conditions (see ***Table 3.2***), four (4) bioreactors are required, and three (3) membrane tanks need to be on-line with one (1) membrane tank available for backup. It is recommended that the fourth membrane tank and fourth bioreactor tank be constructed within the existing aerated WAS storage tank. This upgrade would include the extension of the membrane enclosure and Operations Building to accommodate the new MBR treatment train. At this time, the existing UV disinfection system will also have to be replaced with a larger unit capable of treating a peak flow of 1.0 MGD. Graphically this can be seen in ***Appendix F, Figures 4-5***.

A note of caution with respect to septage receiving; septage received should be limited to residential septage of no more than 20,000 gpd (plus 10,000 gpd of WAS) processed through the dewatering equipment and only dewatered septage filtrate passed through a 2mm perforated plate screen should be introduced to the MBRs. Only residential septage from reputable haulers should be accepted and the Town should conduct regular septage quality testing to prevent non-septic tank waste from being discharged. Epping will have to make this a priority and establish and implement a testing protocol that is random to mitigate the potential for issues.

In the event that Epping does not receive more stringent TN or ammonia limits and there is a desire to expand to handle the permitted ADF of 500,000 gpd, this would require the construction of a fifth and sixth biological tank and either a fifth membrane tank or additional membrane square footage in each of four (4) membrane tanks to ensure the membrane flux rates remain below an average of 6 GFD and a peak of 12 GFD.

6.4 20-YEAR DESIGN CONDITIONS

For the 20-year design condition, it was assumed that under the worst-case scenario Epping's NPDES permit will include a total nitrogen limit of 12.51 lbs/d (3.0 mg/L at 0.5 MGD), potentially year-round. In order to meet the lower TN limit, a 4-Stage Bardenpho process is needed which requires larger biological tanks. To implement this advanced BNR treatment process, it is proposed that two (2) of the existing biological tanks be combined to make a 2-pass, 4-Stage Bardenpho configuration as shown in ***Appendix F, Figures 6-8***. The BioWin process model was used to size the various treatment zones (oxic, anoxic, etc.) in the 4-Stage process. Utilizing 20-year projected influent flow and loads and assuming a 4-Stage Bardenpho MBR configuration shown in ***Appendix F, Figures 6-8,*** the BioWin model predicts that each train of the new proposed process can treat 125,000 gpd and meet a TN limit of 3.0 mg/L down to 46.4ºF (8°C). This assumes that septage receiving is phased out to be able to treat 0.5 MGD ADF of municipal wastewater. The results of the modeling effort are presented in ***Appendix E***. To treat 20-year design ADF of 0.5 MGD to an effluent TN of 3.0 mg/L will require four (4) parallel 2-pass trains of the 4-Stage Process ***Appendix F, Figures 6-8*** to be on-line and three (3) of the associated membrane tanks in service with one (1) membrane tank for backup (assumes additional membrane square footage added to each of the four (4) tanks). This will also require an extension to the existing membrane enclosure and Operations Building to accommodate additional membrane modules to meet the 6 GFD average and 12 GFD peak membrane flux rates. Graphically this can be seen in ***Appendix F, Figures 6-8***. Performance of the configuration is presented in ***Appendix F*** for the maximum month loading at 8-20ºC. Note that for all BioWin modeling, the design MLSS of the system was 8,000 mg/L at average daily flow and 10,000 mg/L at max month flow.

SECTION 7 - RECOMMENDED PERIPHERAL COMPONENT UPGRADES

7.1 PEAK FLOW BUFFER TANKS

As mentioned previously, Underwood recommends the MBR system be designed to handle a peak flow of two (2) times the average day flow, which for Epping is 0.448 MGD currently, 0.658 MGD in the near term, and 1.0 MGD at the 20-year design flow.

The recommended surface area of membranes has been calculated such that the loading at the peak flow is 12 GFD, a very comfortable loading rate that can be sustained for extended periods without fouling the membranes. We are therefore recommending that the peak flow buffer tank volume be equal to the maximum day flow to the plant minus the peak flow to the MBR system at 12 GFD. The peak flow buffer tank(s) would function to store the short-term diurnal peaks that come into the plant each day that are above the peak flow sent to the MBR system. In the worst case, on the day that the maximum day flow comes into the plant, the peak flow buffer tank(s) would be filled to the volumes show below in ***Table 7.1***.

Table 7.1 Peak Flow Buffer Tank Volume

Condition (MGD)	ADF (MGD)	MBR Peak Flow (MGD)	Max Day Flow (MGD)	Buffer Volume (MGD)
Current	0.224	0.448	0.504	0.056
Near Term (EOY 2024)	0.329	0.658	0.703	0.045
20-Yr Design	0.500	1.000	1.125	0.125

Based on ***Table 7.1*** above, the most that would need to be stored in the peak flow buffer tanks would be 125,000 gal at the 20-year design flow. Assuming that the next day after the maximum day flow would be equal to or less than 87.5% of the maximum day flow would allow the buffer tank(s) to be completely drained back to the MBR system that day.

Two (2) 75,000 gal covered concrete peak flow buffer tanks are recommended for a total of 150,000 gal at the 20-year design flow which provides a safety factor of 20%. The tanks would be built in the Lagoon 1 footprint closest to the Intermediate Pump Station where they would fill by gravity whenever the incoming flow to the wet well was greater than the peak flow being pumped to the MBR system. When the incoming flow drops below the peak flow being pumped to the MBR system the tanks will drain to the wet well and be pumped to the MBR system.

Given that the buffer tanks will at worst take 48 hours to fill and drain, our recommended design would incorporate a steep bottom slope and a spray wash nozzle system designed to spray the tank sides and bottom to rinse solids and debris to the sump end to assist it flowing back to the intermediate pump station by gravity. We do not see the need for aeration, mixing or sludge removal mechanisms given that the tank will fill and draw within 24-hours with rare exception. The limited duration that peak flows will be in the tanks does not warrant aeration and will only result in additional equipment that goes unused. With the membranes conservatively designed to pass 2X the ADF, the peak flow buffer tanks will only see flow when the influent flow rate is greater than 1.0 MGD and will empty as soon as the influent flow drops below 1.0 MGD. The flow will only be greater than 1.0 MGD during periods that exceed the design max week flow rate. Refer to ***Appendix F***, **Figure 1** for a site plan showing the location and footprint of the proposed peak flow buffer tanks.

Note that the numerous additional protections that we have recommended (good FOG program, redundant screens, peak flow buffer tanks, scum spray in aeration tanks, below surface transfer to membrane tanks, separate membrane tanks, heated enclosure over membrane tanks, low loading rate to membranes, N+1 membranes, automated maintenance and recovery cleaning) all combine to create a robust system that is much less likely to experience FOG blinding and much more capable of handling short term peaks without requiring extreme measures or the need to completely bypass systems given available redundancy.

7.2 REDUNDANT INFLUENT SCREENS

Proper screening of the MBR influent is critical to the successful long-term operation of the membranes. Currently Epping only has a single fine screen and a single micro screen in its Headworks and when either of these screens fail the flow must be diverted to the storage lagoons until repairs are made. Given that the lagoons must be closed as required by an EPA AO, insufficient storage volume will soon exist to hold influent flow long enough for screen repairs to occur. Therefore, it is critical that a redundant set of screens be constructed.

Underwood proposes that a new building be constructed adjacent to the existing Headworks Building to house the 2mm micro screens. This will facilitate construction as the new 2mm micro screen can be installed and put into operation and then the existing 2mm micro screen can be taken offline and moved into the new building. Once the existing 2mm micro screen is moved, construction can continue to create a new channel in the existing Headworks to locate a new 6mm fine screen. Graphically this approach can be seen in ***Appendix F, Figures 2-3***.

7.3 AERATED WAS STORAGE

The Epping WWTF has an existing aerated waste active sludge (WAS) storage tank with a volume of 60,000 gals. The tank is parallel to the three (3) MBR bioreactors and has the same dimensions. Current WAS flows are on the order of 4,500 gpd. Per Env-Wq 716.05, storage shall be provided for five (5) days at the maximum design generation rate. This means at least 22,500 gpd of storage volume is needed.

The WAS tank has been repurposed temporarily as a peak flow buffer tank per an EPA AO. WAS is currently being sent to the septage holding tanks instead which have a combined storage volume of 24,000 gpd. This suffices for now but will not suffice to handle the near-term (EOY 2024) goals of the Town to increase the plant ADF to 329,000 gpd.

Sequentially, once the first peak flow buffer tank is constructed, the existing WAS tank could be returned to being a WAS tank. But in order to accommodate a flow increase to 329,000 gpd, the existing WAS tank will need to be converted to a fourth bioreactor and fourth membrane tank and there will be a need to construct new aerated WAS holding tanks at that time.

Therefore, we are recommending that when the decision is made to increase flow to 329,000 gpd, new aerated WAS storage tanks should be constructed adjacent to the existing screened septage storage tanks. Graphically this can be seen in ***Appendix F, Figure 1***.

SECTION 8 - COST OPINIONS

8.1 BACKGROUND

To project the cost of modifications to the treatment plant, conceptual level cost opinions for various improvements were prepared. These conceptual cost opinions should not be considered as detailed engineering cost estimates or construction bids since detailed construction plans and specifications are not available to provide quantity takeoffs. As a result, the cost opinions provided should be considered approximate and revised cost estimates should be developed after preliminary engineering has been performed. A contingency has been included for each of the costs to account for costs not easily quantified at this conceptual level of investigation. Allowances have also been included to cover project development costs, which include permitting, design engineering, construction observation, and construction administration services.

Where appropriate, budgetary prices were obtained from equipment manufacturers for major pieces of equipment, and estimates of major material quantities were determined, such as for concrete in major structures. Unit prices from recent construction jobs were used for items such as excavation, concrete, and major piping.

Building/enclosure costs were determined using "per square foot" prices. As preliminary engineering has not been performed to provide sufficient detail to generate estimates of electrical, heating and ventilation work, "allowances" were assigned for those items.

Costs contained in this report should be adjusted accordingly based on the ENRCCI index if tasks are not undertaken in the immediate future.

The cost opinions presented below are broken up into separate sections based on critical upgrades, short or near term upgrades, and total nitrogen upgrades.

8.2 CRITICAL UPGRADES

As stated elsewhere in this report, there are certain critical upgrades that Underwood recommends be implemented to bring the plant up to current design standards relative to redundancies and controls. These upgrades should be performed regardless of whether additional flows are accepted in the future. These upgrades include:

- A third set of ZeeWeed membranes in Train 1 (ongoing)
- The two (2) storage lagoons should be abandoned and closed (ongoing)
- New covered concrete peak flow buffer tank
- A separate Headworks Building to house two (2) micro screens
- The existing Headworks Building should be modified to house two (2) fine screens
- New divider walls to keep the membranes separate from the biological reactors
- Additional piping/valves to allow any of three (3) membrane tanks to be on-line at a time
- Additional chemical feed piping and controls to allow automated backwashing and recovery cleaning of the membranes
- A foam/scum spray system in the biological reactors and membrane tanks
- A new, larger backup generator

The above proposed critical upgrades, not including the top two (2) bullets which are underway, are estimated to cost **$4.87M**. The individual costs opinions for the various areas can be seen in ***Appendix G***.

8.3 SHORT-TERM (NEAR-TERM) UPGRADES

Epping has a number of proposed developments on the books that would like to connect to the municipal wastewater collection system but currently cannot as a moratorium is in place until the critical upgrades are done. The Town would also like to start back up taking septage from in town at a controlled rate. In order to accommodate near-term (EOY 2024) ADF flows of 329,000 gpd, additional improvements must be made including:

- A second new covered concrete peak flow buffer tank
- A fourth bioreactor and MBR tank
- Membrane enclosure and Ops Bldg. extensions
- Upgraded 1.0 MGD UV disinfection equipment
- New aerated WAS storage tanks

The above short-term upgrades are estimated to cost **$6.69M**. The individual costs opinions for the various areas can be seen in ***Appendix G***.

8.4 TOTAL NITROGEN UPGRADES

There is the potential in the not too distant future that Epping could be required to perform upgrades to achieve even lower total nitrogen effluent levels, potentially as low as 3.0 mg/L. Through this study, we have determined that the most efficient way for Epping to accomplish that is to continue with the use of MBR technology, but to reconfigure the plant to a 4-Stage Bardenpho arrangement to include two (2) aerobic tanks and two (2) anoxic tanks (no free oxygen) in each train. To accommodate the full permitted flow of the pant of 0.5 MGD ADF would require four (4) trains with a total tank volume per train of approximately 120,000 gallons. That means that two (2) of the existing bioreactors would have to be combined to compose one (1) train of 4-Stage Bardenpho MBR, and the following additional improvements would be required:

- Four (4) additional basins (Two (2) additional 2-pass, 4-Stage biological trains) the size of the current aeration/membrane tanks
- Membrane enclosure and Ops Bldg. extensions
- Conversion of the process from cyclic aeration to a 4-Stage Bardenpho configuration
- Additional membrane square footage added to each of four (4) membrane tanks

The above total nitrogen upgrades utilizing 4-Stage Bardenpho MBR are estimated to cost **$15.94M**. The individual cost opinions for the various areas can be seen in ***Appendix G***.

Note that the NHDES has specifically requested that this report include a conceptual cost opinion of what it would cost to achieve a 3.0 mg/L TN effluent at 0.5 MGD ADF utilizing conventional 4-Stage Bardenpho (no MBR). Underwood did not model this scenario with BioWin but based on the assumption that the operating MLSS would be less than half of the MBR form, at least double the bioreactor volume will be needed for biological treatment, and the following additional improvements would be required:

- Upgrades to the Intermediate Pump Station
- Four (4) additional basins (Two (2) additional 2-pass, 4-Stage biological trains) the size of the current aeration/membrane tanks
- Membrane enclosure and Ops Bldg. extensions
- Conversion of the process from cyclic aeration to a 4-Stage Bardenpho configuration
- Additional membrane square footage added to each of four (4) membrane tanks
- New secondary clarifiers
- New denitrification filters
- New Micro-C chem feed building
- New tertiary membrane filtration

The above total nitrogen upgrades utilizing conventional 4-Stage Bardenpho are estimated to cost **$38.88M**. The individual cost opinions for the various components can be seen in ***Appendix G***. This compares to a total cost of **$27.51M** to achieve the same level of treatment utilizing 4-Stage Bardenpho MBR.

SECTION 9 - CONCLUSIONS AND RECOMMENDATIONS

9.1 CONCLUSIONS

The following conclusions can be made based on the TN evaluations that have been conducted for the Epping WWTF:

- At existing flows and loads (no septage), the Epping WWTF appears capable of meeting the existing TN limit of 43 lbs/d on a seven-month rolling average basis provided that all three (3) bioreactors are operated, and the process aeration is cycled (current operation).
- The existing MBR system at Epping has insufficient redundancies and controls for long-term reliable operation. A third set of ZeeWeed membranes, peak flow buffer tank, redundant 2mm and 6mm screens, membrane tank separation walls and piping, fully automatic backwashing and recovery chemical cleaning, and foam spray system should be constructed before additional flow is taken into the plant.
- To accommodate near-term (EOY 2024) ADF flows of 329,000 gpd, additional improvements must be made including a fourth bioreactor and MBR tank, membrane enclosure and Ops Bldg. extensions, upgraded 1.0 MGD UV disinfection equipment, and new aerated WAS storage tanks.
- To accommodate flows of 0.5 MGD, a fifth and sixth bioreactor would have to be constructed.
- To treat the permitted ADF of 0.5 MGD at the maximum month mass load to an effluent TN of 3.0 mg/L at 8°C will require a total of eight bioreactors (Four (4) 2-pass, 4-Stage biological trains) the size of the current biological tanks, membrane enclosure and Ops Bldg. extensions, and conversion of the process from cyclic aeration to a 4-Stage Bardenpho configuration.
- Based on an effluent limit of 3.0 mg/L TSS, and considering capital costs, operating costs, and labor requirements, should a lower TN limit be imposed, Epping will best be served staying with MBR technology and converting from cyclic aeration operation to a 4-Stage Bardenpho configuration.

These conclusions are shown in ***Table 9.1*** below summarized for each milestone, including costs.

Table 9.1 Work Item Summary

Work Item	Cost Opinion 2024	Current Existing Flows & Permit	Short-Term (EOY 2024) Flows at Current Permit	0.5 MGD ADF at Current Permit	0.5 MGD ADF at Future 3.0 mg/L TN
ZeeWeed Membranes in Train 1 and Automated Backwashing	In Progress	X			
Peak Flow Buffer Tank (each)	$1,063,000	X	X		
New Hdwks Bldg. w/ two 2mm Screens & Mod. Hdwks Bldg w/ two 6mm Screens	$2,720,000	X			
New Walls for Membrane Tanks & Piping & Scum Spray & Automated Recovery Cleaning	$548,000	X			
New Backup Generator	$541,000	X			
4th Bioreactor & Membrane Tank in WAS Tank & Membrane Encl & Ops Bldg Exten & New UV	$4,818,000		X		
New WAS Tank	$811,000		X		
New Bioreactors 5&6 & More Membrane Surface Area in Membrane Tanks 1-4	$7,816,000			X	
New Bioreactors 5-8, Membrane Encl & Ops Bldg Ext., More Membrane Surface Area in Membrane Tanks 1-4, and All 8 MBRs reconfig to 4-Stage Bardenpho	$15,942,000				X
Total Cost	**$ N/A**	**$ 4,872,000**	**$ 6,692,000**	**$ 7,816,000**	**$ 15,942,000**

Note: Columns 5 and 6 are not additive; they are either/or.

9.2 RECOMMENDATIONS

The following recommendations are being made based on the TN evaluations that have been conducted for the Epping WWTF:

- Epping should raise and appropriate the funds to complete the recommended MBR redundancies and controls as soon as possible. A warrant article for at least this work should be scheduled for March 2025.
- Epping is eligible for several funding opportunities including: NHDES CWSRF and SAG, Rural Development, CDFA CBBG, and Congressional Directed Spending (CDS). The Town should immediately apply to all of these agencies to maximize low interest loans and grant opportunities.
- If Epping wishes to expand the influent flow to the plant to the near term (EOY 2024) 329,000 gpd ADF, they should immediately begin discussions with the new connections to determine connections fees and other financial assistance to fund the additional improvements needed as described in ***Table 9.1*** above. If the decision is to proceed, this work should be added to the March 2025 warrant article value. Note that a NHDES issued sewer moratorium currently exists which would have to be lifted to add this new flow.
- Epping should continue to be an active member and financial contributor to MAAM and should immediately retain an engineer to draft an Adaptive Management Plan for the Town for submittal to EPA and NHDES in accordance with the expectations of the Great Bay Total Nitrogen General NPDES Permit which Epping is subject to. Failure to do so will result in a more stringent individual TN permit being issued to Epping as early as 2026 or sooner.
- Epping should immediately begin conducting CCTV inspections in their collection system to identify and remove sources of I/I to reduce extraneous influent flows to the plant. Underwood recommends Epping CCTV 20% of the collection system each year for the next five (5) years starting with the WWTF Sub-basin and the Mill Street Pump Station Sub-Basin C.

- The existing backup generator at the Epping WWTF is aged and undersized. Several important loads are shed when emergency power must be used including the electric unit heaters in the Headworks Building and the septage receiving and dewatering areas. Underwood recommends that Epping replace the existing backup generator with a larger unit capable of running all critical power systems without load shedding.

Note 1. The proposed separation walls between the bioreactors and the membrane tanks will provide numerous benefits. The benefits include 1) keeps the membranes in separate tanks from the bioreactors to allow FOG to be broken down, 2) below surface transfer of MLSS from bioreactors to membrane tanks without surface scum connection and transfer, 3) piping and valves to allow any one (1) of the membrane tanks to be turned on or taken offline for cleaning regardless of which bioreactors are on line, 4) smaller membrane tank volumes so that recovery cleaning can be performed in situ without excessive chemical usage to modify pH of entire bioreactor and also less liquid volume to neutralize after cleaning, and 5) will expedite the rate at which recovery cleans can be done without having to individually move and clean membrane modules in the DIP tanks.

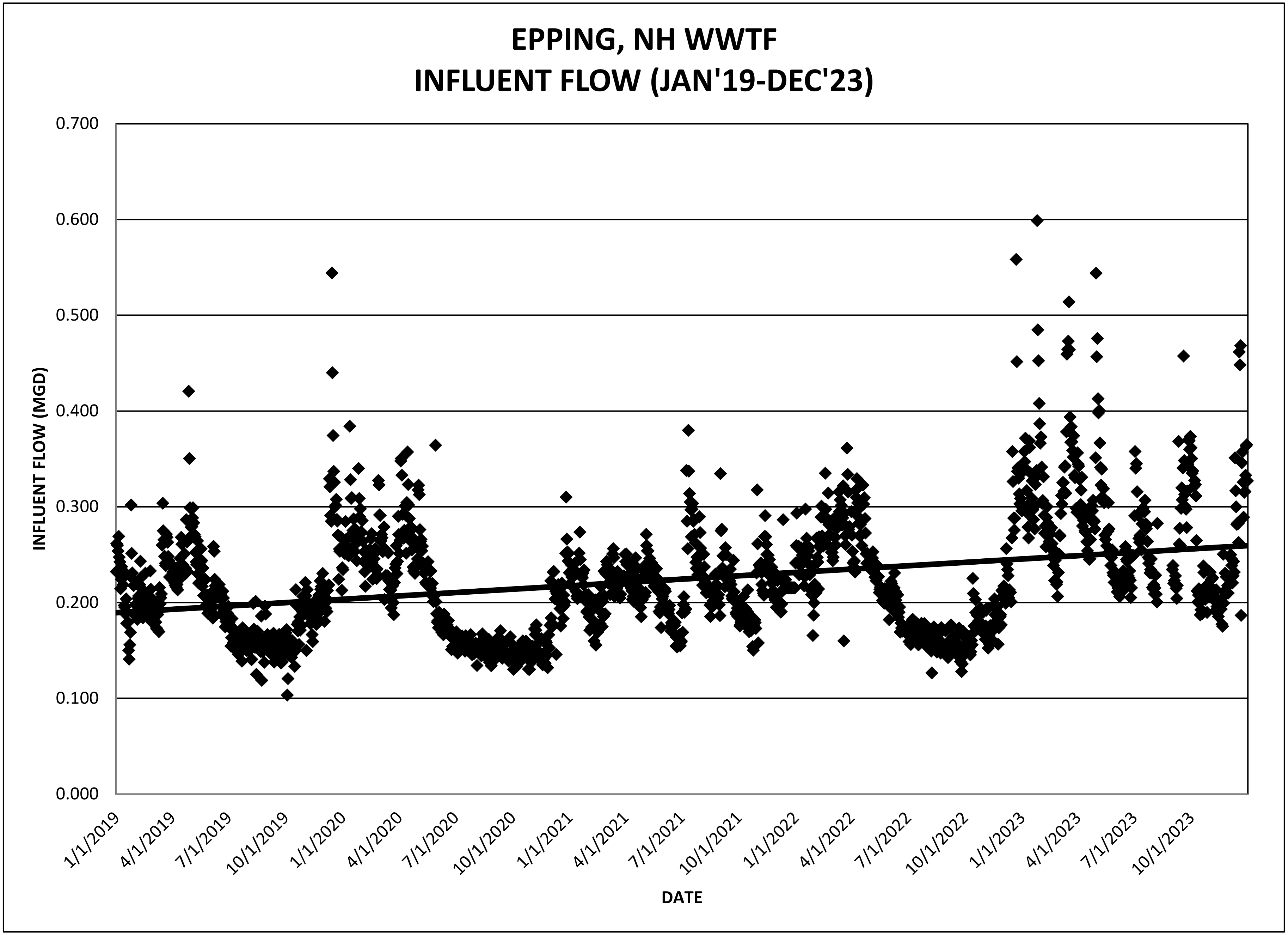
Note 2. Based on the BioWin modeling we have performed; we believe supplemental carbon will be required to achieve a TN as low as 3.0 mg/L. A final design will most likely utilize Micro C as the carbon source.

Note 3. We have discussed the option of screening the system WAS for better MBR operation with Veolia (the ZeeWeed membrane manufacturer). They do sell a system to do it, but it is still considered innovative and has not been installed at many locations. Space should be provided in a final design for this potential add-on, but it has not been included it in the conceptual design.

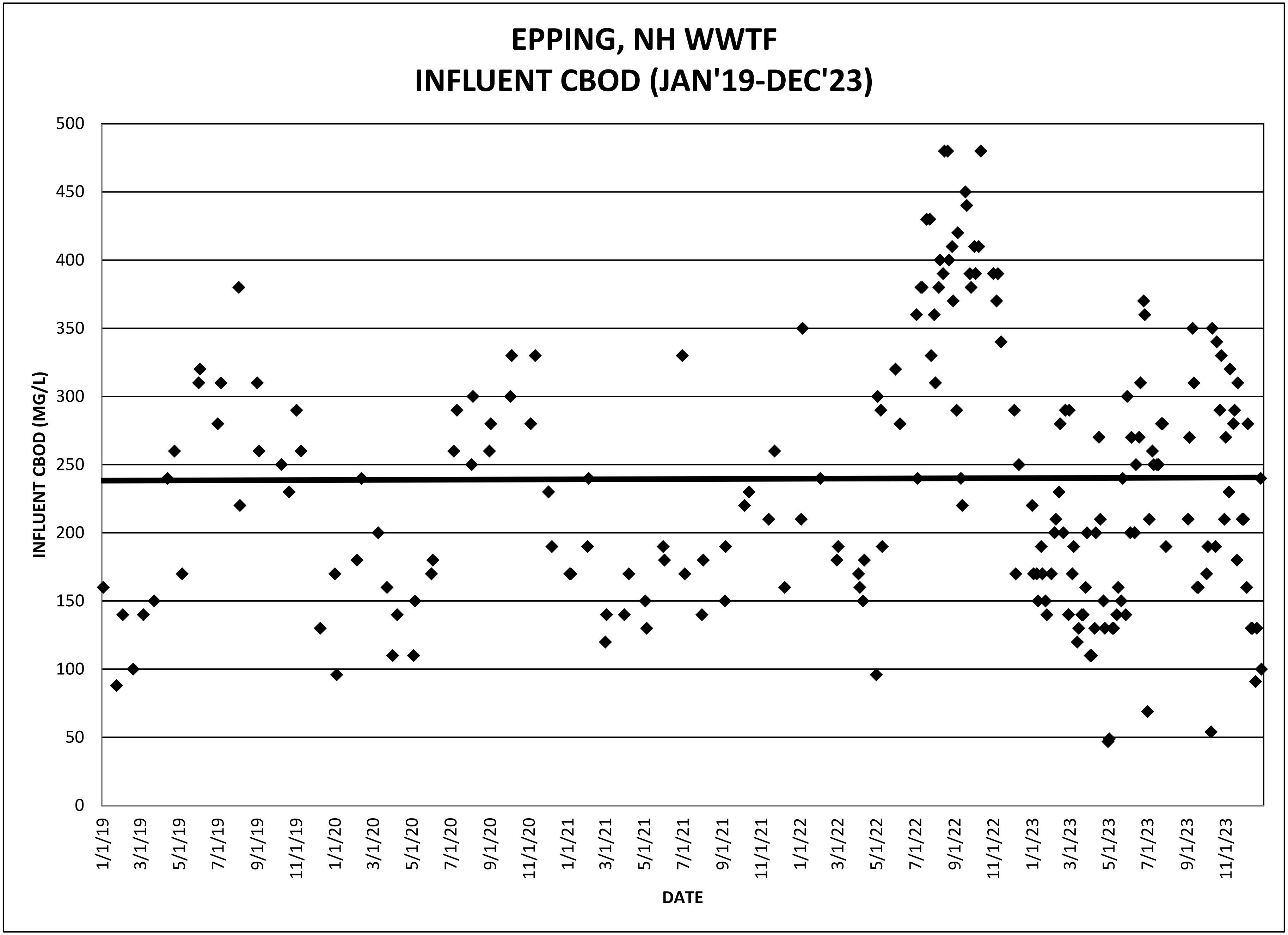
Note 4. As part of this Total Nitrogen Upgrade Study for the Town of Epping, NH WWTF, NHDES required that the effort be peer-reviewed by a third party firm with BNR and MBR expertise. To satisfy that requirement, Underwood engaged Hazen to perform the third-party review. Hazen has authored an independent technical memorandum summarizing the results of their review which can be found in ***Appendix H***.

APPENDIX A

Data Charts



N:\PROJECTS\EPPING, NH\REALNUM\2987 WWTF Total Nitrogen Upgrade\08 Comp\Data\2987 2014_2023 WWTF Data


EPPING, NH WWTF
INFLUENT CBOD (JAN'19-DEC'23)
INFLUENT CBOD (MG/L)
500
450
400
350
300
250
200
150
100
50
0
1/1/19
3/1/19
5/1/19
7/1/19
9/1/19
11/1/19
1/1/20
3/1/20
5/1/20
7/1/20
9/1/20
11/1/20
1/1/21
3/1/21
5/1/21
7/1/21
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7/1/22
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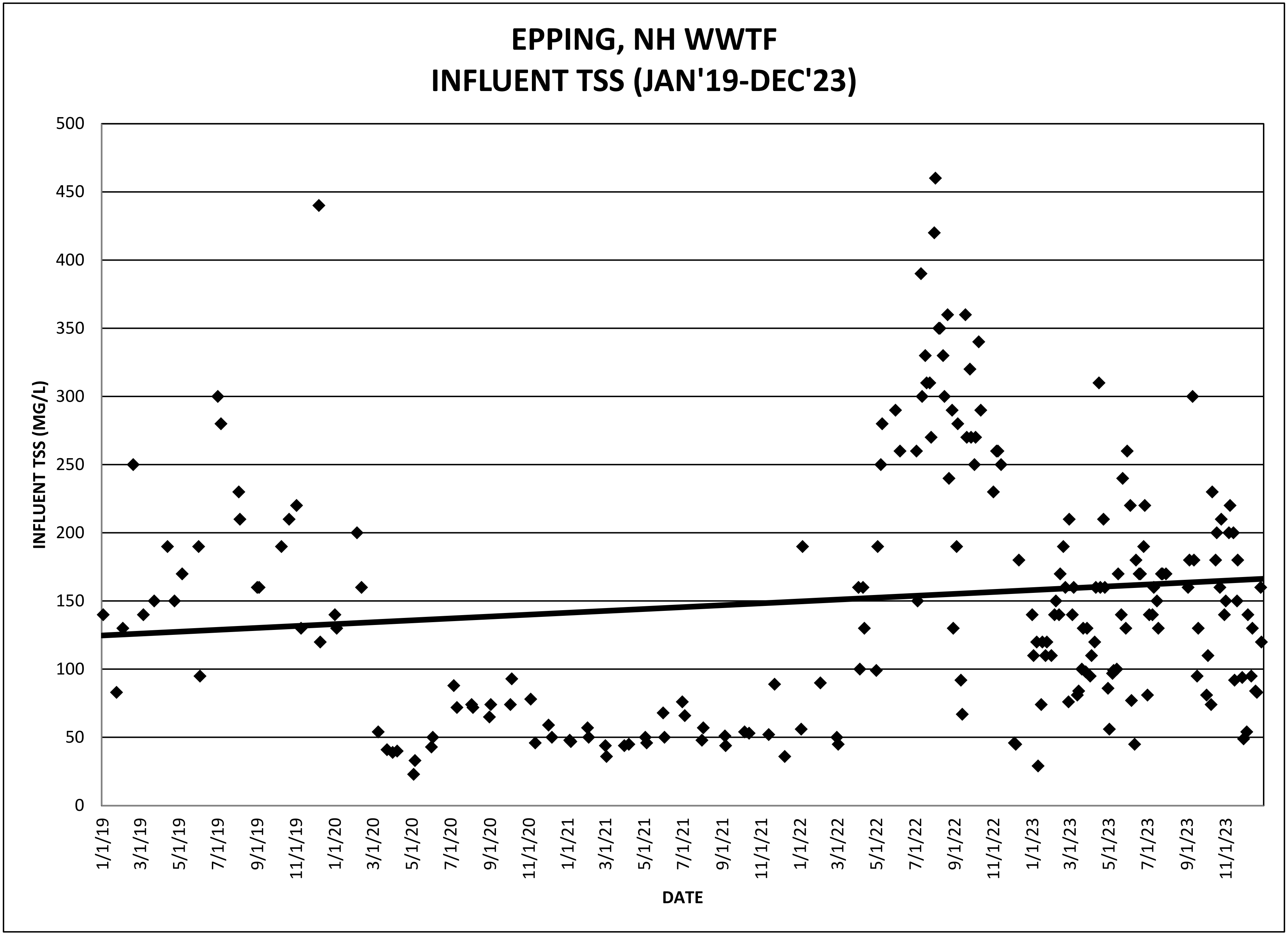
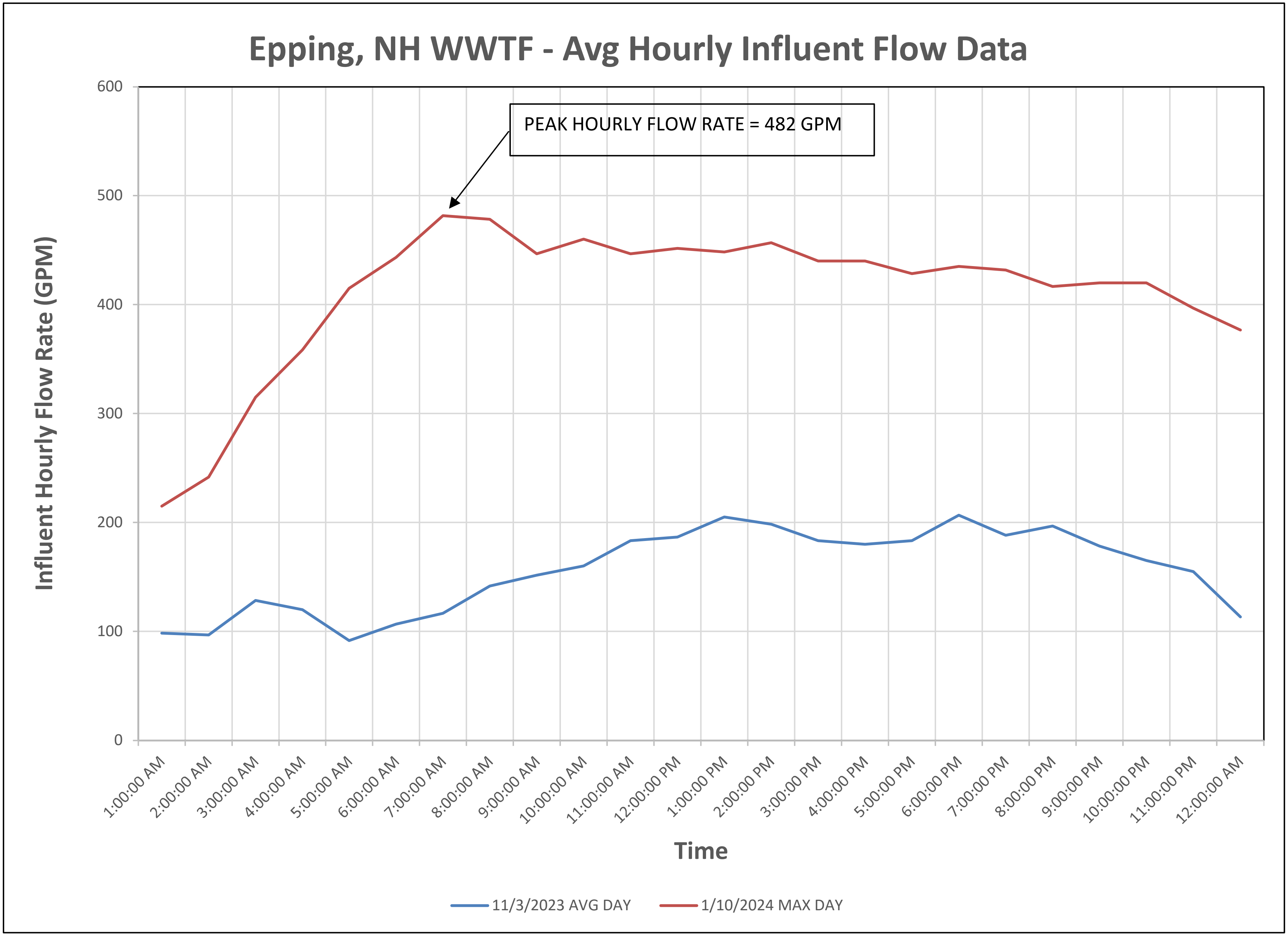
3/1/23
5/1/23
7/1/23
9/1/23
11/1/23
DATE



N:\PROJECTS\EPPING, NH\REALNUM\2987 WWTF Total Nitrogen Upgrade\08 Comp\Data\2987 2014_2023 WWTF Data


Epping, NH WWTF - Avg Hourly Influent Flow Data
PEAK HOURLY FLOW RATE = 482 GPM
Influent Hourly Flow Rate (GPM)
600
500
400
300
200
100
0
1:00:00 AM
2:00:00 AM
3:00:00 AM
4:00:00 AM
5:00:00 AM
6:00:00 AM
7:00:00 AM
8:00:00 AM
9:00:00 AM
10:00:00 AM
11:00:00 AM
12:00:00 PM
1:00:00 PM
2:00:00 PM
3:00:00 PM
4:00:00 PM
5:00:00 PM
6:00:00 PM
7:00:00 PM
8:00:00 PM
9:00:00 PM
10:00:00 PM
11:00:00 PM
12:00:00 AM
Time
11/3/2023 AVG DAY
1/10/2024 MAX DAY

APPENDIX B

Laboratory Testing Results

Eastern Analytical, Inc.
professional laboratory and drilling services

Steven Clifton
Underwood Engineers, Inc. (Portsmouth)
25 Vaughan Mall, Unit #1
Portsmouth , NH 03801

Laboratory Report for:

Eastern Analytical, Inc. ID:	269241
Client Identification:	Epping WWTF, Epping NH / UE Job 2987-01
Date Received:	11/1/2023

Enclosed are the analytical results per the Chain of Custody for sample(s) in the referenced project. All analyses were performed in accordance with our QA/QC Program, NELAP and other applicable state requirements. All quality control criteria was within acceptance criteria unless noted on the report pages. Results are for the exclusive use of the client named on this report and will not be released to a third party without consent.

The following information is contained within this report: Sample Conditions summary, Analytical Results/Data, Quality Control data (if requested) and copies of the Chain of Custody. This report may not be reproduced except in full, without the written approval of the laboratory.

The following standard abbreviations and conventions apply to all EAI reports:
< : "less than" followed by the reporting limit
> : "greater than" followed by the reporting limit
%R : % Recovery

Certifications:
Eastern Analytical, Inc. maintains certification in the following states: Connecticut (PH-0492), Maine (NH005), Massachusetts (M-NH005), New Hampshire/NELAP (1012), Rhode Island (269), Vermont (VT1012), New York (12072) and West Virginia (9910C). Please refer to our website at www.easternanalytical.com for a copy of our certificates and accredited parameters.

References:
- EPA 600/4-79-020, 1983
- Standard Methods for Examination of Water and Wastewater, 20th, 21st, 22nd & 23rd edition or noted revision year.
- Test Methods for Evaluating Solid Waste SW 846 3rd Edition including updates IVA and IVB
- Hach Water Analysis Handbook, 4th edition, 1992
- ASTM International

If you have any questions regarding the results contained within, please feel free to contact customer service. Unless otherwise requested, we will dispose of the sample(s) 6 weeks from the sample receipt date.

We appreciate this opportunity to be of service and look forward to your continued patronage.

Sincerely,

Lorraine Olashaw — 11.15.23

Lorraine Olashaw, Lab Director — Date

SAMPLE CONDITIONS PAGE

EAI ID#: **269241**

Client: **Underwood Engineers**

Client Designation: **Epping WWTF, Epping NH / UE Job 2987-01**

Temperature upon receipt (°C): 2.5

Acceptable temperature range (°C): 0-6

Received on ice or cold packs (Yes/No): Y

Lab ID	Sample ID	Date Received	Date/Time Sampled		Sample Matrix	% Dry Weight	Exceptions/Comments (other than thermal preservation)
269241.01	1-1	11/1/23	11/1/23	07:00	aqueous		Adheres to Sample Acceptance Policy
269241.02	1-2	11/1/23	11/1/23	07:00	aqueous		Adheres to Sample Acceptance Policy
269241.03	1-3	11/1/23	11/1/23	07:00	aqueous		Adheres to Sample Acceptance Policy
269241.04	1-4	11/1/23	11/1/23	07:00	aqueous		Adheres to Sample Acceptance Policy
269241.05	1-5	11/1/23	11/1/23	07:00	aqueous		Adheres to Sample Acceptance Policy
269241.06	1-6	11/1/23	11/1/23	07:00	aqueous		Adheres to Sample Acceptance Policy
269241.07	1-7	11/1/23	11/1/23	07:00	aqueous		Adheres to Sample Acceptance Policy
269241.08	1-8	11/1/23	11/1/23	07:00	aqueous		Adheres to Sample Acceptance Policy
269241.09	1-9	11/1/23	11/1/23	07:00	aqueous		Adheres to Sample Acceptance Policy
269241.1	1-10	11/1/23	11/1/23	07:00	aqueous		Adheres to Sample Acceptance Policy
269241.11	1-11	11/1/23	11/1/23	07:00	aqueous		Adheres to Sample Acceptance Policy
269241.12	1-12	11/1/23	11/1/23	09:30	aqueous		Adheres to Sample Acceptance Policy
269241.13	1-13	11/1/23	11/1/23	09:30	aqueous		Adheres to Sample Acceptance Policy
269241.14	1-14	11/1/23	11/1/23	09:30	aqueous		Adheres to Sample Acceptance Policy

All results contained in this report relate only to the above listed samples.

Unless otherwise noted:

- *Hold times, preservation, container types, and sample conditions adhered to EPA Protocol.*
- *Solid samples are reported on a dry weight basis, unless otherwise noted. pH/Corrosivity, Flashpoint, Ignitability, Paint Filter, Conductivity and Specific Gravity are always reported on an "as received" basis.*
- *Analysis of pH, Total Residual Chlorine, Dissolved Oxygen and Sulfite were performed at the laboratory outside of the recommended 15 minute hold time.*
- *Samples collected by Eastern Analytical, Inc. (EAI) were collected in accordance with approved EPA procedures.*

LABORATORY REPORT

EAI ID#: **269241**

Client: **Underwood Engineers**

Client Designation: **Epping WWTF, Epping NH / UE Job 2987-01**

Sample ID:	1-1	1-12						
Lab Sample ID:	269241.01	269241.12						
Matrix:	aqueous	aqueous						
Date Sampled:	11/1/23	11/1/23		Analysis				
Date Received:	11/1/23	11/1/23	**Units**	**Date**	**Time**	**Method**	**Analyst**	
Solids Suspended	**192**	**8300**	mg/L	11/07/23	16:40	2540D-11	ABL	
Solids Volatile Suspended	**195**	**6800**	mg/L	11/07/23	16:40	2540E-11	ABL	

Sample ID:	1-2					
Lab Sample ID:	269241.02					
Matrix:	aqueous					
Date Sampled:	11/1/23		Analysis			
Date Received:	11/1/23	**Units**	**Date**	**Time**	**Method**	**Analyst**
Ammonia-N	**31**	mg/L	11/07/23	13:05	TM NH3-001	PEN
TKN	**40**	mg/L	11/08/23	16:53	4500N$_{org}$C/NH3D	PEN
Total Phosphorus-P	**5.4**	mg/L	11/04/23	9:55	365.1	SEL
COD	**670**	mg/L	11/02/23	9:00	H8000	JCS

LABORATORY REPORT

EAI ID#: **269241**

Client: **Underwood Engineers**

Client Designation: **Epping WWTF, Epping NH / UE Job 2987-01**

Sample ID: 1-3

Lab Sample ID: 269241.03
Matrix: aqueous
Date Sampled: 11/1/23
Date Received: 11/1/23

		Units	Analysis Date	Analysis Time	Method	Analyst
BOD	**290**	mg/L	11/02/23	12:01	5210B-11	MNT

Sample ID: 1-4

Lab Sample ID: 269241.04
Matrix: aqueous
Date Sampled: 11/1/23
Date Received: 11/1/23

		Units	Analysis Date	Analysis Time	Method	Analyst
Ammonia-N GF	**31**	mg/L	11/07/23	13:08	TM NH3-001	PEN
TKNGF	**35**	mg/L	11/09/23	17:44	$4500N_{org}C/NH3D$	GRS
CODGF	**280**	mg/L	11/02/23	9:00	H8000	JCS

The designation of GF after the analyte indicates that it was filtered through a 1.5 micron glass fiber filter to analysis.

LABORATORY REPORT

EAI ID#: **269241**

Client: **Underwood Engineers**
Client Designation: **Epping WWTF, Epping NH / UE Job 2987-01**

Sample ID: 1-5

Lab Sample ID:	269241.05						
Matrix:	aqueous						
Date Sampled:	11/1/23		Analysis				
Date Received:	11/1/23	**Units**	**Date**	**Time**	**Method**	**Analyst**
BODGF	**120**	mg/L	11/02/23	12:07	5210B-01	MNT

Sample ID: 1-6

Lab Sample ID:	269241.06					
Matrix:	aqueous					
Date Sampled:	11/1/23		Analysis			
Date Received:	11/1/23	**Units**	**Date**	**Time**	**Method**	**Analyst**
Alkalinity Total (CaCO3)	**190**	mg/L	11/02/23	9:26	2320B-11	BAF

The designation of GF after the analyte indicates that it was filtered through a 1.5 micron glass fiber filter to analysis.

LABORATORY REPORT

EAI ID#: **269241**

Client: **Underwood Engineers**

Client Designation: **Epping WWTF, Epping NH / UE Job 2987-01**

Sample ID:	1-7						
Lab Sample ID:	269241.07						
Matrix:	aqueous						
Date Sampled:	11/1/23		Analysis				
Date Received:	11/1/23	**Units**	**Date**	**Time**	**Method**	**Analyst**
Ortho Phosphate-P	**2.7**	mg/L	11/01/23	16:27	365.1	SEL

Sample ID:	1-8	1-10	1-13					
Lab Sample ID:	269241.08	269241.1	269241.13					
Matrix:	aqueous	aqueous	aqueous					
Date Sampled:	11/1/23	11/1/23	11/1/23		Analysis			
Date Received:	11/1/23	11/1/23	11/1/23	**Units**	**Date**	**Time**	**Method**	**Analyst**
CODGF	**170**	**26**	**34**	mg/L	11/02/23	9:00	H8000	JCS

The designation of GF after the analyte indicates that it was filtered through a 1.5 micron glass fiber filter to analysis.

LABORATORY REPORT

EAI ID#: **269241**

Client: **Underwood Engineers**

Client Designation: **Epping WWTF, Epping NH / UE Job 2987-01**

Sample ID: 1-9

Lab Sample ID: 269241.09
Matrix: aqueous
Date Sampled: 11/1/23
Date Received: 11/1/23

		Units	Analysis Date	Time	Method	Analyst
Ammonia-N	**1.3**	mg/L	11/07/23	13:11	TM NH3-001	PEN
TKN	**1.2**	mg/L	11/06/23	17:09	$4500N_{org}C/NH3D$	GRS
COD	**20**	mg/L	11/02/23	9:00	H8000	JCS

Sample ID: 1-14

Lab Sample ID: 269241.14
Matrix: aqueous
Date Sampled: 11/1/23
Date Received: 11/1/23

		Units	Analysis Date	Time	Method	Analyst
COD	**5100**	mg/L	11/02/23	9:00	H8000	JCS

1-9: The matrix spike duplicate for TKN associated with this sample exhibited recoveries outside the acceptance criteria. The matrix spike and all other QC were in control.

QC REPORT

EAI ID#: **269241**

Client: **Underwood Engineers**

Client Designation: **Epping WWTF, Epping NH / UE Job 2987-01**

Parameter Name	Blank	LCS	LCSD	Units	Date of Analysis	Limits	RPD	Method
Solids Suspended	< 5	880 (95 %R)	NA	mg/L	11/7/23	85 - 115		2540D-11
Solids Volatile Suspended	< 5	280 (97 %R)	NA	mg/L	11/7/23	85 - 115		2540E-11
Alkalinity Total (CaCO3)	< 1	10 (101 %R)	10 (104 %R) (3 RPD)	mg/L	11/2/23	85 - 115	20	2320B-11
Ammonia-N	< 0.05	1.9 (95 %R)	2.0 (100 %R) (4 RPD)	mg/L	11/7/23	87 - 104	20	TM NH3-001
Ammonia-N GF		NA	NA	mg/L		90 - 110	20	TM NH3-001
TKN	< 0.5	9.8 (98 %R)	10 (100 %R) (2 RPD)	mg/L	11/6/23	90 - 111	20	4500N_{org}C/NH3D-11
TKNGF		NA	NA	mg/L		90 - 110	20	4500N_{org}C/NH3D-97
Total Phosphorus-P	< 0.01	0.31 (103 %R)	0.31 (102 %R) (1 RPD)	mg/L	11/4/23	90 - 110	20	365.1
Ortho Phosphate-P	< 0.01	0.31 (105 %R)	0.32 (106 %R) (1 RPD)	mg/L	11/1/23	90 - 110	20	365.1
BOD	< 6	230 (115 %R)	220 (112 %R) (3 RPD)	mg/L	11/2/23	84 - 115	20	5210B-11
BODGF		NA	NA	mg/L		84 - 115	20	5210B-01
COD	< 10	100 (101 %R)	99 (99 %R) (2 RPD)	mg/L	11/2/23	85 - 115	20	H8000
CODGF		NA	NA	mg/L		85 - 115	20	H8000

*/! Flagged analyte recoveries deviated from the QA/QC limits. Unless noted, flagged data does not impact the sample data.

Raw Data

EAI ID#: **269241**

Client:

Client Designation: **Epping WWTF, Epping NH / UE Job 2987-01**

EAI ID#	Sample ID	Parameter	Raw Data	RepValue	DilFac	DL	Units	Date/Time Analyzed	Matrix	Method
269241.01	1-1	Solids Suspended	192.5	192	1	5	mg/L	11/7/2023 16:40	AqTot	2540D-11
269241.12	1-12	Solids Suspended	8333.3	8300	1	5	mg/L	11/7/2023 16:40	AqTot	2540D-11
269241.01	1-1	Solids Volatile Suspended	195	195	1	5	mg/L	11/7/2023 16:40	AqTot	2540E-11
269241.12	1-12	Solids Volatile Suspended	6766.7	6800	1	5	mg/L	11/7/2023 16:40	AqTot	2540E-11

PHOENIX
Environmental Laboratories, Inc.

Tuesday, November 14, 2023

Attn: Front Office
Eastern Analytical
51 Antrim Ave
Concord, NH 03301

Project ID: 269241
SDG ID: GCP41352
Sample ID#s: CP41352

This laboratory is in compliance with the NELAC requirements of procedures used except where indicated.

This report contains results for the parameters tested, under the sampling conditions described on the Chain Of Custody, as received by the laboratory. This report is incomplete unless all pages indicated in the pagination at the bottom of the page are included.

A scanned version of the COC form accompanies the analytical report and is an exact duplicate of the original.

If you are the client above and have any questions concerning this testing, please do not hesitate to contact Phoenix Client Services at ext.200. The contents of this report cannot be discussed with anyone other than the client listed above without their written consent.

Sincerely yours,

Phyllis Shiller

Phyllis Shiller
Laboratory Director

NELAC - #NY11301
CT Lab Registration #PH-0618
MA Lab Registration #M-CT007
ME Lab Registration #CT-007
NH Lab Registration #213693-A,B

NJ Lab Registration #CT-003
NY Lab Registration #11301
PA Lab Registration #68-03530
RI Lab Registration #63
VT Lab Registration #VT11301

587 East Middle Turnpike, P.O. Box 370, Manchester, CT 06040
Telephone (860) 645-1102

PHOENIX

Environmental Laboratories, Inc.
587 East Middle Turnpike, P.O.Box 370, Manchester, CT 06045
Tel. (860) 645-1102 Fax (860) 645-0823

ACCREDITED IN ACCORDANCE WITH nelac
NY # 11301

Sample Id Cross Reference

November 14, 2023

SDG I.D.: GCP41352

Project ID: 269241

Client Id	Lab Id	Matrix
1-11	CP41352	WATER

PHOENIX

Environmental Laboratories, Inc.
587 East Middle Turnpike, P.O.Box 370, Manchester, CT 06045
Tel. (860) 645-1102 Fax (860) 645-0823

ACCREDITED IN ACCORDANCE WITH nelac
NY # 11301

Analysis Report

November 14, 2023

FOR: Attn: Front Office
Eastern Analytical
51 Antrim Ave
Concord, NH 03301

Sample Information		Custody Information		Date	Time
Matrix:	WATER	Collected by:		11/01/23	7:00
Location Code:	EASTANAL-NH	Received by:	SW	11/06/23	15:55
Rush Request:	Standard	Analyzed by:	see "By" below		
P.O.#:	61116				

Laboratory Data

SDG ID: GCP41352
Phoenix ID: CP41352

Project ID: 269241
Client ID: 1-11

Parameter	Result	RL/ PQL	Units	Dilution	Date/Time	By	Reference	
Volatile Fatty Acids	225	60.0	mg/L	1	11/11/23	JY	SM5560C-01	1

1 = This parameter is not certified by the primary accrediting authority (NY NELAC) for this matrix. NY NELAC does not offer certification for all parameters at this time.

RL/PQL=Reporting/Practical Quantitation Level (Equivalent to NELAC LOQ, Limit of Quantitation) ND=Not Detected at RL/PQL
BRL=Below Reporting Level L=Biased Low

Comments:

If you are the client above and have any questions concerning this testing, please do not hesitate to contact Phoenix Client Services at ext.200. The contents of this report cannot be discussed with anyone other than the client listed above without their written consent.

Phyllis Shiller, Laboratory Director
November 14, 2023
Reviewed and Released by: Anil Makol, Project Manager

PHOENIX
Environmental Laboratories, Inc.
587 East Middle Turnpike, P.O.Box 370, Manchester, CT 06045
Tel. (860) 645-1102

ACCREDITED IN ACCORDANCE WITH nelac
NY # 11301

QA/QC Report

November 14, 2023

QA/QC Data

SDG I.D.: GCP41352

Parameter	Blank	Blk RL	Sample Result	Dup Result	Dup RPD	LCS %	LCSD %	LCS RPD	MS %	MSD %	MS RPD	% Rec Limits	% RPD Limits	
QA/QC Batch 705974 (mg/L), QC Sample No: CP41349 (CP41352)														
Volatile Fatty Acids	BRL	60.0	425	325	26.7							85 - 115	20	r
Comment:														
Additional criteria matrix spike acceptance range is 75-125%.														

r = This parameter is outside laboratory RPD specified recovery limits.

If there are any questions regarding this data, please call Phoenix Client Services at extension 200.

RPD - Relative Percent Difference
LCS - Laboratory Control Sample
LCSD - Laboratory Control Sample Duplicate
MS - Matrix Spike
MS Dup - Matrix Spike Duplicate
NC - No Criteria
Intf - Interference

Phyllis Shiller

Phyllis Shiller, Laboratory Director
November 14, 2023

Tuesday, November 14, 2023

Criteria: None

State: NH

Sample Criteria Exceedances Report

GCP41352 - EASTANAL-NH

SampNo	Acode	Phoenix Analyte	Criteria	Result	RL	Criteria	RL Criteria	Analysis Units

*** No Data to Display ***

Phoenix Laboratories does not assume responsibility for the data contained in this exceedance report. It is provided as an additional tool to identify requested criteria exceedences. All efforts are made to ensure the accuracy of the data (obtained from appropriate agencies). A lack of exceedence information does not necessarily suggest conformance to the criteria. It is ultimately the site professional's responsibility to determine appropriate compliance.

PHOENIX

Environmental Laboratories, Inc.
587 East Middle Turnpike, P.O.Box 370, Manchester, CT 06045
Tel. (860) 645-1102 Fax (860) 645-0823

ACCREDITED IN ACCORDANCE WITH nelac NY # 11301

Analysis Comments

November 14, 2023 SDG I.D.: GCP41352

The following analysis comments are made regarding exceptions to criteria not already noted in the Analysis Report or QA/QC Report: None.

CHAIN-OF-CUSTODY RECORD

Eastern Analytical, Inc.
professional laboratory and drilling services

EAI ID# **269241** Page 1

Sample ID	Date Sampled	Matrix	aParameters		Sample Notes
1-11	11/1/2023 07:00	aqueous	Subcontract - Total Volatile Fatty Acids (VFA)	41352	2.3 Wapk

EAI ID# **269241** Project State: NH

Project ID: 6134

Company Phoenix Environmental Labs
Address 587 East Middle Turnpike
Address Manchester , CT 06040
Account #
Phone # (860) 645-1102

Results Needed: Preferred Date: Standard
RUSH Due Date: ________

QC Deliverables
☐ A ☐ A+ ☒ B ☐ B+ ☐ C ☐ MA MCP

Notes about project:
Email login confirmation, pdf of results and invoice to customerservice@easternanalytical.com.

PO #:61116 EAI ID# **269241**

Data Deliverable (circle)
Excel NH EMD EQuIS ME EGAD

Call prior to analyzing, if RUSH charges will be applied.

Samples Collected by:

Relinquished by	Date/Time	Received by
[signature]	11-6-23 7:40	Lisa Burton
Lisa Burton	11-6-23 12:50	[signature]
[signature]	11-6-23 15:55	[signature]

Eastern Analytical, Inc. 51 Antrim Ave Concord, NH 03301 Phone: (603)228-0525 1-800-287-0525 customerservice@easternanalytical.com

As a subcontract lab to EAI, you will defend, indemnify and hold Eastern Analytical, Inc., its officers, employees, and agents harmless from and against any and all liability, loss, expense or claims for injury or damages arising out of the performance against this chain of custody but only in proportion to and to the extent such liability, loss, expense, or claims for injury or damages are caused by or result from the negligent or intentional acts or omissions of you as a subcontract lab, your officers, agents or employees

Page 1 of 2

CHAIN-OF-CUSTODY RECORD

BOLD FIELDS REQUIRED. PLEASE CIRCLE REQUESTED ANALYSIS.

269241

SAMPLE I.D.	SAMPLING DATE/TIME *IF COMPOSITE, INDICATE BOTH START & FINISH DATE/TIME	MATRIX (SEE BELOW)	GRAB/*COMPOSITE	VOC: 524.2 / 524.2 MTBE ONLY	VOC: 8260B 624 VTICs 1,4 DIOXANE	VOC: 8021B	VOC: 8015B GRO MAVPH	SVOC: 8270D 625 ABN PAH EDB DBCP	SVOC: TPH8100 L1 L2	SVOC: 8015B DRO MAEPH	SVOC: PEST 608 PCB 608 PEST 8081A PCB 8082	SVOC: OIL & GREASE 1664 TPH 1664	TCLP: TCLP 1311 ABN METALS VOC PEST HERB	INORGANICS: BOD CBOD TS TSS TDS	INORGANICS: Br Cl F SO_4 NO_2 NO_3 NO_2NO_3	INORGANICS: TKN NH_3 TN T. PHOS. O. PHOS.	INORGANICS: pH T. RES. CHLORINE SPEC. CON. T. ALK.	INORGANICS: COD PHENOLS TOC DOC	INORGANICS: TOTAL CYANIDE TOTAL SULFIDE	INORGANICS: REACTIVE CYANIDE REACTIVE SULFIDE FLASHPOINT IGNITABILITY	MICRO: TOTAL COLIFORM E. COLI FECAL COLIFORM	MICRO: ENTEROCOCCI HETEROTROPHIC PLATE COUNT	METALS: DISSOLVED METALS (LIST BELOW)	METALS: TOTAL METALS (LIST BELOW)	OTHER	OTHER	OTHER	OTHER	# OF CONTAINERS	NOTES MeOH VIAL #
1-1	10/31 @ 7am 11/1 @ 7am	WW	C											✓																/VSS
1-2	↓	WW	C													✓		✓												COD/TKN NH3, TP
1-3		WW	C											✓																BOD
1-4		WW	C															✓												Soluble COD
1-5		WW	C											✓																Soluble BOD
1-6		WW	C														✓													Alkalinity
1-7		WW	C													✓														O.phos
18		WW	C															✓												COD
1-9		WW	C													✓		✓												COD/TKN NH3
1-10		WW	C															✓												COD

MATRIX: A-AIR; S-SOIL; GW-GROUND WATER; SW-SURFACE WATER; DW-DRINKING WATER; WW-WASTE WATER

PRESERVATIVE: H-HCL; N-HNO_3; S-H_2SO_4; Na-NaOH; M-MEOH

PROJECT MANAGER: Steve Clifton, Stephen Smith

COMPANY: Underwood Engineers

ADDRESS: 25 Vaughan Mall

CITY: Portsmouth STATE: NH ZIP: 03801

PHONE: Smith 603-854-3236; Clifton 603-475-3814 EXT.:

E-MAIL: sclifton@underwoodengineers.com; ssmith@underwoodengineers.com

SITE NAME: Epping WWTF, Epping NH

PROJECT #: UE Job 2987-01

STATE: NH MA ME VT OTHER:

REGULATORY PROGRAM: NPDES: RGP POTW STORMWATER GWP, OIL FUND BROWNFIELD OTHER: NA process

QUOTE #: 1020770 PO #:

QA/QC REPORTING

A B C

MA MCP

TEMP. 2.5 C

ICE? YES No

REPORTING OPTIONS

PRELIMS: YES OR NO

ELECTRONIC OPTIONS

PDF EXCEL

EQUIS

OTHER

TURN AROUND TIME

24hr* 48hr*

3 - 4 DAYS*

5 DAY 7 DAY

10 DAY

*Pre-approval Required

SAMPLER(S): P. Michael Bidondo

RELINQUISHED BY:	DATE:	TIME:	RECEIVED BY:
[signature]	11/1	10:40am	[signature]
[signature]	11-01-23	14:30	NH
RELINQUISHED BY:	DATE:	TIME:	RECEIVED BY:
RELINQUISHED BY:	DATE:	TIME:	RECEIVED BY:

METALS: 8 RCRA 13 PP FE, MN PB, CU

OTHER METALS:

SAMPLES FIELD FILTERED? ☑ YES ☐ NO

NOTES: (IE: SPECIAL DETECTION LIMITS, BILLING INFO, IF DIFFERENT)

•Some -
1-4, 1-5, 1-7, 1-8,
1-10, 1-13 field filtered
w/ 1.5 micron

SITE HISTORY:

SUSPECTED CONTAMINATION:

FIELD READINGS:

Eastern Analytical, Inc.
professional laboratory and drilling services

51 Antrim Avenue | Concord, NH 03301 | Tel: 603.228.0525 | 1.800.287.0525 | E-Mail: CustomerService@EasternAnalytical.com | www.EasternAnalytical.com

(WHITE: Lab Copy GREEN: Customer Copy)

CHAIN-OF-CUSTODY RECORD

BOLD FIELDS REQUIRED. PLEASE CIRCLE REQUESTED ANALYSIS.

269241

SAMPLE I.D.	SAMPLING DATE/TIME *IF COMPOSITE, INDICATE BOTH START & FINISH DATE/TIME	MATRIX (SEE BELOW)	GRAB/*COMPOSITE	VOC: 524.2 / 524.2 MTBE ONLY	VOC: 8260B 624 VTICs / 1,4 DIOXANE	VOC: 8021B	VOC: 8015B GRO MAVPH	SVOC: 8270D 625 / ABN PAH EDB DBCP	SVOC: TPH8100 L1 L2	SVOC: 8015B DRO MAEPH	SVOC: PEST 608 PCB 608 / PEST 8081A PCB 8082	SVOC: OIL & GREASE 1664 TPH 1664	TCLP: TCLP 1311 ABN METALS / VOC PEST HERB	INORGANICS: BOD CBOD / TS TSS TDS	INORGANICS: Br Cl F SO_4 / NO_3 NO_2 NO_3NO_2	INORGANICS: TKN NH_3 TN / T. PHOS. O. PHOS.	INORGANICS: pH T. RES. CHLORINE / SPEC. CON. T. ALK.	INORGANICS: COD PHENOLS TOC DOC	INORGANICS: TOTAL CYANIDE TOTAL SULFIDE	INORGANICS: REACTIVE CYANIDE REACTIVE SULFIDE / FLASHPOINT IGNITABILITY	MICRO: TOTAL COLIFORM E. COLI / FECAL COLIFORM	MICRO: ENTEROCOCCI / HETEROTROPHIC PLATE COUNT	METALS: DISSOLVED METALS (LIST BELOW)	METALS: TOTAL METALS (LIST BELOW)	OTHER: VFA	OTHER	OTHER	OTHER	# OF CONTAINERS	NOTES MeOH VIAL #
1-11	10/31 @ 7am 11/1 @ 7am	WW	C																						✓					VFA
1-12	11/1 @ 9:30am		G											✓																TSS/VSS
1-13	11/1 @ 9:30am		G															✓												COD
1-14	11/1 @ 9:30am		G															✓												COD

MATRIX: A-AIR; S-SOIL; GW-GROUND WATER; SW-SURFACE WATER; DW-DRINKING WATER; WW-WASTE WATER

PRESERVATIVE: H-HCL; N-HNO_3; S-H_2SO_4; Na-NaOH; M-MEOH

PROJECT MANAGER: Steve Clifton, Stephen Smith

COMPANY: Underwood Engineers

ADDRESS: 25 Vaughan Mall

CITY: Portsmouth STATE: NH ZIP: 03801

PHONE: Smith 603-854-3236; Clifton 603-475-3814 EXT.:

E-MAIL: sclifton@underwoodengineers.com; ssmith@underwoodengineers.com

SITE NAME: Epping WWTF, Epping NH

PROJECT #: UE Job 2987-01

STATE: NH MA ME VT OTHER:

REGULATORY PROGRAM: NPDES: RGP POTW STORMWATER GWP, OIL FUND BROWNFIELD OTHER: NA process

QUOTE #: 1020770 PO #:

QA/QC REPORTING

A B C

MA MCP

TEMP. 2.5 C

ICE? YES NO

REPORTING OPTIONS

PRELIMS: YES OR NO

ELECTRONIC OPTIONS

PDF EXCEL EQUIS

OTHER

TURN AROUND TIME

24hr* 48hr*

3 - 4 DAYS*

5 DAY 7 DAY

10 DAY

*Pre-approval Required

METALS: 8 RCRA 13 PP FE, MN PB, CU

OTHER METALS:

SAMPLES FIELD FILTERED? ☑ YES ☐ NO

NOTES: (IE: SPECIAL DETECTION LIMITS, BILLING INFO, IF DIFFERENT)

See First Sheet

SAMPLER(S): P Michael Bidondo

RELINQUISHED BY:	DATE:	TIME:	RECEIVED BY:
[signature]	11/1	10:40am	[signature]
[signature]	11-01-23	14:30	NH

SITE HISTORY:

SUSPECTED CONTAMINATION:

FIELD READINGS:

Eastern Analytical, Inc.
professional laboratory and drilling services

51 Antrim Avenue | Concord, NH 03301 | Tel: 603.228.0525 | 1.800.287.0525 | E-Mail: CustomerService@EasternAnalytical.com | www.EasternAnalytical.com

(WHITE: Lab Copy GREEN: Customer Copy)

269241

Day Sampled	Day Collected	Sample ID	Intended Analysis	Comments
Tuesday	Wednesday	1-1	Influent TSS/VSS	Blended
Tuesday	Wednesday	1-2	Influent COD/TKN/Ammonia/Total P	Blended
Tuesday	Wednesday	1-3	Influent BOD	
Tuesday	Wednesday	1-4	Influent Soluble COD/TKN/Ammonia	Eastern Analytical to Filter in the lab to 1.5 micron
Tuesday	Wednesday	1-5	Influent Soluble BOD	Eastern Analytical to Filter in the lab to1.5 micron
Tuesday	Wednesday	1-6	Influent Alkalinity	
Tuesday	Wednesday	1-7	Influent Orthophosphate	Filtered in Field with 1.5 micron
Tuesday	Wednesday	1-8	Influent Floc Filtered COD	Filtered in Field with 1.5 micron
Tuesday	Wednesday	1-9	Effluent COD/TKN/Ammonia	MBR effluent (0.04 micron)
Tuesday	Wednesday	1-10	Effluent Floc Filtered COD	Filtered in Field with 1.5 micron
Tuesday	Wednesday	1-11	Influent VFA	
Wednesday	Wednesday	1-12	MLSS/MLVSS	
Wednesday	Wednesday	1-13	MLSS Soluble COD	Filtered in Field with 1.5 micron
Wednesday	Wednesday	1-14	MLSS Blended COD	Blended

Eastern Analytical, Inc.
professional laboratory and drilling services

Steven Clifton
Underwood Engineers
25 Vaughan Mall, Unit #1
Portsmouth , NH 03801

Laboratory Report for:

Eastern Analytical, Inc. ID:	269417
Client Identification:	Epping WWTF, Epping NH / UE Job 2987-01
Date Received:	11/3/2023
Report revision/reissue:	Revision, replaces report dated 11/15/2023
Revision information:	Subcontract data has been revised.

Enclosed are the analytical results per the Chain of Custody for sample(s) in the referenced project. All analyses were performed in accordance with our QA/QC Program, NELAP and other applicable state requirements. All quality control criteria was within acceptance criteria unless noted on the report pages. Results are for the exclusive use of the client named on this report and will not be released to a third party without consent.

The following information is contained within this report: Sample Conditions summary, Analytical Results/Data, Quality Control data (if requested) and copies of the Chain of Custody. This report may not be reproduced except in full, without the written approval of the laboratory.

The following standard abbreviations and conventions apply to all EAI reports:
< : "less than" followed by the reporting limit
> : "greater than" followed by the reporting limit
%R : % Recovery

Certifications:
Eastern Analytical, Inc. maintains certification in the following states: Connecticut (PH-0492), Maine (NH005), Massachusetts (M-NH005), New Hampshire/NELAP (1012), Rhode Island (269), Vermont (VT1012), New York (12072) and West Virginia (9910C). Please refer to our website at www.easternanalytical.com for a copy of our certificates and accredited parameters.

References:
- EPA 600/4-79-020, 1983
- Standard Methods for Examination of Water and Wastewater, 20th, 21st, 22nd & 23rd edition or noted revision year.
- Test Methods for Evaluating Solid Waste SW 846 3rd Edition including updates IVA and IVB
- Hach Water Analysis Handbook, 4th edition, 1992

If you have any questions regarding the results contained within, please feel free to contact customer service. Unless otherwise requested, we will dispose of the sample(s) 6 weeks from the sample receipt date.

We appreciate this opportunity to be of service and look forward to your continued patronage.

Sincerely,

Lorraine Olashaw   11·21·23

Lorraine Olashaw, Lab Director   Date

SAMPLE CONDITIONS PAGE

EAI ID#: **269417**

Client: **Underwood Engineers**

Client Designation: **Epping WWTF, Epping NH / UE Job 2987-01**

Temperature upon receipt (°C): 3.7

Acceptable temperature range (°C): 0-6

Received on ice or cold packs (Yes/No): Y

Lab ID	Sample ID	Date Received	Date/Time Sampled		Sample Matrix	% Dry Weight	Exceptions/Comments (other than thermal preservation)
269417.01	2-1	11/3/23	11/3/23	07:00	aqueous		Adheres to Sample Acceptance Policy
269417.02	2-2	11/3/23	11/3/23	07:00	aqueous		Adheres to Sample Acceptance Policy
269417.03	2-3	11/3/23	11/3/23	07:00	aqueous		Adheres to Sample Acceptance Policy
269417.04	2-4	11/3/23	11/3/23	07:00	aqueous		Adheres to Sample Acceptance Policy
269417.05	2-5	11/3/23	11/3/23	07:00	aqueous		Adheres to Sample Acceptance Policy
269417.06	2-6	11/3/23	11/3/23	07:00	aqueous		Adheres to Sample Acceptance Policy
269417.07	2-7	11/3/23	11/3/23	07:00	aqueous		Adheres to Sample Acceptance Policy
269417.08	2-8	11/3/23	11/3/23	07:00	aqueous		Adheres to Sample Acceptance Policy
269417.09	2-9	11/3/23	11/3/23	07:00	aqueous		Adheres to Sample Acceptance Policy
269417.1	2-10	11/3/23	11/3/23	07:00	aqueous		Adheres to Sample Acceptance Policy
269417.11	2-11	11/3/23	11/3/23	07:00	aqueous		Adheres to Sample Acceptance Policy
269417.12	2-12	11/3/23	11/3/23	08:30	aqueous		Adheres to Sample Acceptance Policy
269417.13	2-13	11/3/23	11/3/23	08:30	aqueous		Adheres to Sample Acceptance Policy
269417.14	2-14	11/3/23	11/3/23	08:30	aqueous		Adheres to Sample Acceptance Policy

All results contained in this report relate only to the above listed samples.

Unless otherwise noted:

- *Hold times, preservation, container types, and sample conditions adhered to EPA Protocol.*
- *Solid samples are reported on a dry weight basis, unless otherwise noted. pH/Corrosivity, Flashpoint, Ignitability, Paint Filter, Conductivity and Specific Gravity are always reported on an "as received" basis.*
- *Analysis of pH, Total Residual Chlorine, Dissolved Oxygen and Sulfite were performed at the laboratory outside of the recommended 15 minute hold time.*
- *Samples collected by Eastern Analytical, Inc. (EAI) were collected in accordance with approved EPA procedures.*

LABORATORY REPORT

EAI ID#: **269417**

Client: **Underwood Engineers**

Client Designation: **Epping WWTF, Epping NH / UE Job 2987-01**

Sample ID:	2-1	2-12					
Lab Sample ID:	269417.01	269417.12					
Matrix:	aqueous	aqueous					
Date Sampled:	11/3/23	11/3/23		Analysis			
Date Received:	11/3/23	11/3/23	Units	Date	Time	Method	Analyst
Solids Suspended	**240**	**7700**	mg/L	11/08/23	10:50	2540D-11	MNT
Solids Volatile Suspended	**190**	**5900**	mg/L	11/09/23	10:50	2540E-11	MNT

Sample ID:	2-2					
Lab Sample ID:	269417.02					
Matrix:	aqueous					
Date Sampled:	11/3/23		Analysis			
Date Received:	11/3/23	Units	Date	Time	Method	Analyst
Ammonia-N	**35**	mg/L	11/07/23	16:13	TM NH3-001	PEN
TKN	**45**	mg/L	11/08/23	18:34	$4500N_{org}C$/NH3D	PEN
Total Phosphorus-P	**6.3**	mg/L	11/08/23	14:50	365.1	PHA
COD	**740**	mg/L	11/06/23	8:45	H8000	JCS

LABORATORY REPORT

EAI ID#: **269417**

Client: **Underwood Engineers**

Client Designation: **Epping WWTF, Epping NH / UE Job 2987-01**

Sample ID: 2-3

Lab Sample ID: 269417.03
Matrix: aqueous
Date Sampled: 11/3/23
Date Received: 11/3/23

		Units	Analysis Date	Analysis Time	Method	Analyst
BOD	**360**	mg/L	11/03/23	16:30	5210B-11	PEN

Sample ID: 2-4

Lab Sample ID: 269417.04
Matrix: aqueous
Date Sampled: 11/3/23
Date Received: 11/3/23

		Units	Analysis Date	Analysis Time	Method	Analyst
Ammonia-N GF	**34**	mg/L	11/07/23	16:16	TM NH3-001	PEN
TKNGF	**39**	mg/L	11/09/23	17:47	4500N_{org}C/NH3D	GRS
CODGF	**260**	mg/L	11/06/23	8:45	H8000	JCS

The designation of GF after the analyte indicates that it was filtered through a 1.5 micron glass fiber filter to analysis.

LABORATORY REPORT

EAI ID#: **269417**

Client: **Underwood Engineers**

Client Designation: **Epping WWTF, Epping NH / UE Job 2987-01**

Sample ID: 2-5

Lab Sample ID:	269417.05						
Matrix:	aqueous						
Date Sampled:	11/3/23			**Analysis**			
Date Received:	11/3/23	**Units**	**Date**	**Time**		**Method**	**Analyst**
BODGF	**140**	mg/L	11/03/23	16:41		5210B-01	PEN

Sample ID: 2-6

Lab Sample ID:	269417.06						
Matrix:	aqueous						
Date Sampled:	11/3/23			**Analysis**			
Date Received:	11/3/23	**Units**	**Date**	**Time**		**Method**	**Analyst**
Alkalinity Total (CaCO3)	**210**	mg/L	11/06/23	9:15		2320B-11	BAF

The designation of GF after the analyte indicates that it was filtered through a 1.5 micron glass fiber filter to analysis.

LABORATORY REPORT

EAI ID#: **269417**

Client: **Underwood Engineers**

Client Designation: **Epping WWTF, Epping NH / UE Job 2987-01**

Sample ID:	2-7						
Lab Sample ID:	269417.07						
Matrix:	aqueous						
Date Sampled:	11/3/23		Analysis				
Date Received:	11/3/23	Units	Date	Time	Method	Analyst
Ortho Phosphate-P	**3.5**	mg/L	11/04/23	7:18	365.1	SEL

Sample ID:	2-8	2-10	2-13					
Lab Sample ID:	269417.08	269417.1	269417.13					
Matrix:	aqueous	aqueous	aqueous					
Date Sampled:	11/3/23	11/3/23	11/3/23		Analysis			
Date Received:	11/3/23	11/3/23	11/3/23	Units	Date	Time	Method	Analyst
CODGF	**190**	**23**	**59**	mg/L	11/06/23	8:45	H8000	JCS

The designation of GF after the analyte indicates that it was filtered through a 1.5 micron glass fiber filter to analysis.

LABORATORY REPORT

EAI ID#: **269417**

Client: **Underwood Engineers**

Client Designation: **Epping WWTF, Epping NH / UE Job 2987-01**

Sample ID: 2-9

Lab Sample ID: 269417.09

Matrix: aqueous

Date Sampled: 11/3/23

Date Received: 11/3/23

		Units	Analysis Date	Analysis Time	Method	Analyst
Ammonia-N	**1.2**	mg/L	11/07/23	16:19	TM NH3-001	PEN
TKN	**1.5**	mg/L	11/09/23	17:42	4500N_{org}C/NH3D	GRS
COD	**20**	mg/L	11/06/23	8:45	H8000	JCS

Sample ID: 2-14

Lab Sample ID: 269417.14

Matrix: aqueous

Date Sampled: 11/3/23

Date Received: 11/3/23

		Units	Analysis Date	Analysis Time	Method	Analyst
COD	**5700**	mg/L	11/06/23	8:45	H8000	JCS

QC REPORT

EAI ID#: **269417**

Client: **Underwood Engineers**

Client Designation: **Epping WWTF, Epping NH / UE Job 2987-01**

Parameter Name	Blank	LCS	LCSD	Units	Date of Analysis	Limits	RPD	Method
Solids Suspended	< 5	880 (95 %R)	910 (98 %R) (3 RPD)	mg/L	11/8/23	85 - 115	20	2540D-11
Solids Volatile Suspended	< 5	280 (98 %R)	290 (101 %R) (3 RPD)	mg/L	11/9/23	85 - 115	20	2540E-11
Alkalinity Total (CaCO3)	< 1	9.5 (95 %R)	9.8 (98 %R) (3 RPD)	mg/L	11/6/23	85 - 115	20	2320B-11
Ammonia-N	< 0.05	1.9 (95 %R)	2.0 (100 %R) (4 RPD)	mg/L	11/7/23	87 - 104	20	TM NH3-001
Ammonla-N GF		NA	NA	mg/L		90 - 110	20	TM NH3-001
TKN	< 0.5	9.9 (99 %R)	10 (101 %R) (1 RPD)	mg/L	11/8/23	90 - 111	20	$4500N_{org}C$/NH3D-11
TKNGF		NA	NA	mg/L		90 - 110	20	$4500N_{org}C$/NH3D-97
Total Phosphorus-P	< 0.01	0.30 (100 %R)	0.30 (99 %R) (1 RPD)	mg/L	11/8/23	90 - 110	20	365.1
Ortho Phosphate-P	< 0.01	0.31 (104 %R)	0.32 (106 %R) (2 RPD)	mg/L	11/4/23	90 - 110	20	365.1
BOD	< 6	210 (105 %R)	NA	mg/L	11/3/23	84 - 115		5210B-11
BODGF		NA	NA	mg/L		84 - 115		5210B-01
COD	< 10	99 (99 %R)	99 (99 %R) (1 RPD)	mg/L	11/6/23	85 - 115	20	H8000
CODGF	< 10	99 (99 %R)	99 (99 %R) (1 RPD)	mg/L	11/6/23	85 - 115	20	H8000

*/! Flagged analyte recoveries deviated from the QA/QC limits. Unless noted, flagged data does not impact the sample data.

Raw Data

EAI ID#: **269417**

Client:

Client Designation: **Epping WWTF, Epping NH / UE Job 2987-01**

EAI ID#	Sample ID	Parameter	Raw Data	RepValue	DilFac	DL	Units	Date/Time Analyzed	Matrix	Method
269417.01	2-1	Solids Suspended	243.243243	240	1	5	mg/L	11/8/2023 10:50	AqTot	2540D-11
269417.12	2-12	Solids Suspended	7733.33333	7700	1	5	mg/L	11/8/2023 10:50	AqTot	2540D-11
269417.01	2-1	Solids Volatile Suspended	191.9	190	1	5	mg/L	11/9/2023 10:50	AqTot	2540E-11
269417.12	2-12	Solids Volatile Suspended	5933.3	5900	1	5	mg/L	11/9/2023 10:50	AqTot	2540E-11

PHOENIX
Environmental Laboratories, Inc.

Tuesday, November 21, 2023

Attn: Front Office
Eastern Analytical
51 Antrim Ave
Concord, NH 03301

Project ID: 269417
SDG ID: GCP41349
Sample ID#s: CP41349

This laboratory is in compliance with the NELAC requirements of procedures used except where indicated.

This report contains results for the parameters tested, under the sampling conditions described on the Chain Of Custody, as received by the laboratory. This report is incomplete unless all pages indicated in the pagination at the bottom of the page are included.

A scanned version of the COC form accompanies the analytical report and is an exact duplicate of the original.

Enclosed are revised Analysis Report pages. Please replace and discard the original pages. If you are the client above and have any questions concerning this testing, please do not hesitate to contact Phoenix Client Services at ext.200. The contents of this report cannot be discussed with anyone other than the client listed above without their written consent.

Sincerely yours,

Phyllis Shiller

Phyllis Shiller
Laboratory Director

NELAC - #NY11301
CT Lab Registration #PH-0618
MA Lab Registration #M-CT007
ME Lab Registration #CT-007
NH Lab Registration #213693-A,B
NJ Lab Registration #CT-003
NY Lab Registration #11301
PA Lab Registration #68-03530
RI Lab Registration #63
VT Lab Registration #VT11301

PHOENIX
Environmental Laboratories, Inc.
587 East Middle Turnpike, P.O.Box 370, Manchester, CT 06045
Tel. (860) 645-1102 Fax (860) 645-0823

ACCREDITED IN ACCORDANCE WITH nelac
NY # 11301

SDG Comments

November 21, 2023

SDG I.D.: GCP41349

Version 2: The VFA was reanalyzed past hold time at the clients request and is reported below.

PHOENIX
Environmental Laboratories, Inc.
587 East Middle Turnpike, P.O.Box 370, Manchester, CT 06045
Tel. (860) 645-1102 Fax (860) 645-0823

ACCREDITED IN ACCORDANCE WITH nelac
NY # 11301

Sample Id Cross Reference

November 21, 2023

SDG I.D.: GCP41349

Project ID: 269417

Client Id	Lab Id	Matrix
2-11	CP41349	WATER

PHOENIX

Environmental Laboratories, Inc.
587 East Middle Turnpike, P.O.Box 370, Manchester, CT 06045
Tel. (860) 645-1102 Fax (860) 645-0823

ACCREDITED IN ACCORDANCE WITH nelac NY # 11301

Analysis Report

November 21, 2023

FOR: Attn: Front Office
Eastern Analytical
51 Antrim Ave
Concord, NH 03301

Sample Information		Custody Information		Date	Time
Matrix:	WATER	Collected by:		11/03/23	7:00
Location Code:	EASTANAL-NH	Received by:	SW	11/06/23	15:55
Rush Request:	Standard	Analyzed by:	see "By" below		
P.O.#:	61134				

Laboratory Data

SDG ID: GCP41349
Phoenix ID: CP41349

Project ID: 269417
Client ID: 2-11

Parameter	Result	RL/ PQL	Units	Dilution	Date/Time	By	Reference	
Volatile Fatty Acids	180	60.0	mg/L	1	11/20/23	JY	SM5560C-01	1

1 = This parameter is not certified by the primary accrediting authority (NY NELAC) for this matrix. NY NELAC does not offer certification for all parameters at this time.

RL/PQL=Reporting/Practical Quantitation Level (Equivalent to NELAC LOQ, Limit of Quantitation) ND=Not Detected at RL/PQL
BRL=Below Reporting Level L=Biased Low

Comments:

If you are the client above and have any questions concerning this testing, please do not hesitate to contact Phoenix Client Services at ext.200.
The contents of this report cannot be discussed with anyone other than the client listed above without their written consent.

Phyllis Shiller

Phyllis Shiller, Laboratory Director
November 21, 2023
Reviewed and Released by: Kathleen Cressia, QA/QC Officer

PHOENIX

Environmental Laboratories, Inc.
587 East Middle Turnpike, P.O.Box 370, Manchester, CT 06045
Tel. (860) 645-1102

QA/QC Report

November 21, 2023

QA/QC Data

SDG I.D.: GCP41349

Parameter	Blank	Blk RL	Sample Result	Dup Result	Dup RPD	LCS %	LCSD %	LCS RPD	MS %	MSD %	MS RPD	% Rec Limits	% RPD Limits
QA/QC Batch 705974 (mg/L), QC Sample No: CP41349 (CP41349)													
Volatile Fatty Acids	BRL	60.0	180	260	NC							85 - 115	20
Comment:													
Additional criteria matrix spike acceptance range is 75-125%.													
QA/QC Batch 707166 (mg/L), QC Sample No: CP41349 (CP41349)													
Volatile Fatty Acids	BRL	60.0	180	260	NC							85 - 115	20
Comment:													
Additional criteria matrix spike acceptance range is 75-125%.													

If there are any questions regarding this data, please call Phoenix Client Services at extension 200.

RPD - Relative Percent Difference
LCS - Laboratory Control Sample
LCSD - Laboratory Control Sample Duplicate
MS - Matrix Spike
MS Dup - Matrix Spike Duplicate
NC - No Criteria
Intf - Interference

Phyllis Shiller

Phyllis Shiller, Laboratory Director
November 21, 2023

Tuesday, November 21, 2023

Criteria: None

State: NH

Sample Criteria Exceedances Report

GCP41349 - EASTANAL-NH

SampNo	Acode	Phoenix Analyte	Criteria	Result	RL	Criteria	RL Criteria	Analysis Units

*** No Data to Display ***

Phoenix Laboratories does not assume responsibility for the data contained in this exceedance report. It is provided as an additional tool to identify requested criteria exceedences. All efforts are made to ensure the accuracy of the data (obtained from appropriate agencies). A lack of exceedence information does not necessarily suggest conformance to the criteria. It is ultimately the site professional's responsibility to determine appropriate compliance.

PHOENIX
Environmental Laboratories, Inc.
587 East Middle Turnpike, P.O.Box 370, Manchester, CT 06045
Tel. (860) 645-1102 Fax (860) 645-0823

NY # 11301

Analysis Comments

November 21, 2023

SDG I.D.: GCP41349

The following analysis comments are made regarding exceptions to criteria not already noted in the Analysis Report or QA/QC Report: None.

CHAIN-OF-CUSTODY RECORD

Eastern Analytical, Inc.
professional laboratory and drilling services

EAI ID# **269417** Page 1

Sample ID	Date Sampled	Matrix	aParameters	Sample Notes
2-11	11/3/2023 07:00	aqueous	Subcontract - Total Volatile Fatty Acids (VFA)	41349 2.3 week

EAI ID# **269417** Project State: NH

Project ID: 6134

Company Phoenix Environmental Labs
Address 587 East Middle Turnpike
Address Manchester , CT 06040
Account #
Phone # (860) 645-1102

Results Needed: Preferred Date: Standard
RUSH Due Date: ________

QC Deliverables
☐ A ☐ A+ ☒ B ☐ B+ ☐ C ☐ MA MCP

Notes about project:
Email login confirmation, pdf of results and invoice to customerservice@easternanalytical.com.

PO #:61134 EAI ID# **269417**

Data Deliverable (circle)
Excel NH EMD EQuIS ME EGAD

Call prior to analyzing, if RUSH charges will be applied.

Samples Collected by: ________ 11-6-23 7:45

Relinquished by | Date/Time | Received by
11-6-23 12:50

Relinquished by | Date/Time | Received by
11-6-23 15:55

Eastern Analytical, Inc. 51 Antrim Ave Concord, NH 03301 Phone: (603)228-0525 1-800-287-0525 customerservice@easternanalytical.com

CHAIN-OF-CUSTODY RECORD

BOLD FIELDS REQUIRED. PLEASE CIRCLE REQUESTED ANALYSIS.

269417

SAMPLE I.D.	SAMPLING DATE/TIME *IF COMPOSITE, INDICATE BOTH START & FINISH DATE/TIME	MATRIX (SEE BELOW)	GRAB/*COMPOSITE	VOC: 524.2 / 524.2 MTBE ONLY	VOC: 8260B 624 VTICs 1,4 DIOXANE	VOC: 8021B	VOC: 8015B GRO MAVPH	SVOC: 8270D 625 ABN PAH EDB DBCP	SVOC: TPH8100 L1 L2	SVOC: 8015B DRO MAEPH	SVOC: PEST 608 PCB 608 PEST 8081A PCB 8082	SVOC: OIL & GREASE 1664 TPH 1664	TCLP: TCLP 1311 ABN METALS VOC PEST HERB	INORGANICS: BOD CBOD TS TSS TDS	INORGANICS: Br Cl F SO_4 NO_2 NO_3 NO_2NO_3	INORGANICS: TKN NH_3 TN T. PHOS. O. PHOS.	INORGANICS: pH T. RES. CHLORINE SPEC. CON. T. ALK.	INORGANICS: COD PHENOLS TOC DOC	INORGANICS: TOTAL CYANIDE TOTAL SULFIDE	INORGANICS: REACTIVE CYANIDE REACTIVE SULFIDE FLASHPOINT IGNITABILITY	MICRO: TOTAL COLIFORM E. COLI FECAL COLIFORM	MICRO: ENTEROCOCCI HETEROTROPHIC PLATE COUNT	METALS: DISSOLVED METALS (LIST BELOW)	METALS: TOTAL METALS (LIST BELOW)	OTHER	OTHER	OTHER	OTHER	# OF CONTAINERS	NOTES MeOH VIAL #
2-1	11/2 @ 7am 11/3 @ 7am	WW	C											✓																TSS/VSS
2-2		WW	C													✓		✓												COD/TKN/NH3, TP
2-3		WW	C											✓																BOD
2-4		WW	C													✓		✓												Soluble COD/TKN/NH3
2-5		WW	C											✓																Soluble BOD
2-6		WW	C														✓													Alkalinity
2-7		WW	C													✓														O.phos
2-8		WW	C															✓												floc filtered COD
2-9		WW	C													✓		✓												COD/TKN/NH3
2-10		WW	C															✓												floc filtered COD

MATRIX: A-AIR; S-SOIL; GW-GROUND WATER; SW-SURFACE WATER; DW-DRINKING WATER; WW-WASTE WATER

PRESERVATIVE: H-HCL; N-HNO_3; S-H_2SO_4; Na-NaOH; M-MEOH

PROJECT MANAGER: Steve Clifton, Stephen Smith

COMPANY: Underwood Engineers

ADDRESS: 25 Vaughan Mall

CITY: Portsmouth STATE: NH ZIP: 03801

PHONE: Smith 603-854-3236; Clifton 603-475-3814 EXT.:

E-MAIL: sclifton@underwoodengineers.com; ssmith@underwoodengineers.com

SITE NAME: Epping WWTF, Epping NH

PROJECT #: UE Job 2987-01

STATE: NH MA ME VT OTHER:

REGULATORY PROGRAM: NPDES: RGP POTW STORMWATER GWP, OIL FUND BROWNFIELD OTHER: NA process

QUOTE #: 1020770 PO #:

QA/QC REPORTING

A B C

MA MCP

TEMP. 3.7 °C

ICE? YES NO

REPORTING OPTIONS

PRELIMS: YES OR NO

ELECTRONIC OPTIONS

PDF EXCEL

EQUIS

OTHER

TURN AROUND TIME

24hr* 48hr*

3 - 4 DAYS*

5 DAY 7 DAY

10 DAY

*Pre-approval Required

METALS: 8 RCRA 13 PP FE, MN PB, CU

OTHER METALS:

SAMPLES FIELD FILTERED? ☑ YES ☐ NO

NOTES: (IE: SPECIAL DETECTION LIMITS, BILLING INFO, IF DIFFERENT)

2-2, 2-3, 2-14 = blended in field

2-8, 2-10, 2-13 = UE 1.5 µ filter

2-7 = UE .45 µ filter

2-4, 2-5 = EAI to filter to 1.5 µ @ lab

SITE HISTORY:

SUSPECTED CONTAMINATION:

FIELD READINGS:

SAMPLER(S): P Michael Bidondo 0945

RELINQUISHED BY:	DATE:	TIME:	RECEIVED BY:
Paul [illegible]	11/3/23	9:30am	E. Halvorson
E. Halvorson	11-3-23	1420	[signature]

51 Antrim Avenue | Concord, NH 03301 | Tel: 603.228.0525 | 1.800.287.0525 | E-Mail: CustomerService@EasternAnalytical.com | www.EasternAnalytical.com

(WHITE: Lab Copy GREEN: Customer Copy)

Page 2 of 2

CHAIN-OF-CUSTODY RECORD

269417

BOLD FIELDS REQUIRED. PLEASE CIRCLE REQUESTED ANALYSIS.

SAMPLE I.D.	SAMPLING DATE/TIME *IF COMPOSITE, INDICATE BOTH START & FINISH DATE/TIME	MATRIX (SEE BELOW)	GRAB/*COMPOSITE	VOC: 524.2 / 524.2 MTBE ONLY	VOC: 8260B 624 VTICs 1,4 DIOXANE	VOC: 8021B	VOC: 8015B GRO MAVPH	SVOC: 8270D 625 ABN PAH EDB DBCP	SVOC: TPH8100 L1 L2	SVOC: 8015B DRO MAEPH	SVOC: PEST 608 PCB 608 PEST 8081A PCB 8082	SVOC: OIL & GREASE 1664 TPH 1664	TCLP: TCLP 1311 ABN METALS VOC PEST HERB	INORGANICS: BOD CBOD TS TSS TDS	INORGANICS: Br Cl F SO_4 NO_2 NO_3 NO_2NO_3	INORGANICS: TKN NH_3 TN T. PHOS. O. PHOS.	INORGANICS: pH T. RES. CHLORINE SPEC. CON. T. ALK.	INORGANICS: COD PHENOLS TOC DOC	INORGANICS: TOTAL CYANIDE TOTAL SULFIDE	INORGANICS: REACTIVE CYANIDE REACTIVE SULFIDE FLASHPOINT IGNITABILITY	MICRO: TOTAL COLIFORM E. COLI FECAL COLIFORM	MICRO: ENTEROCOCCI HETEROTROPHIC PLATE COUNT	METALS: DISSOLVED METALS (LIST BELOW)	METALS: TOTAL METALS (LIST BELOW)	OTHER: VFA	OTHER	OTHER	OTHER	# OF CONTAINERS	NOTES MeOH VIAL #
2-11	11/2 @ 7am 11/3 @ 7am	WW	C																						✓					VFA
2-12	11/3 @ 8:30am	WW	G											✓																TSS/VSS MLSS
2-13		WW	G															✓												soluble COD
2-14		WW	G															✓												MLSS blended COD

MATRIX: A-AIR; S-SOIL; GW-GROUND WATER; SW-SURFACE WATER; DW-DRINKING WATER; WW-WASTE WATER

PRESERVATIVE: H-HCL; N-HNO_3; S-H_2SO_4; Na-NaOH; M-MEOH

PROJECT MANAGER: Steve Clifton, Stephen Smith

COMPANY: Underwood Engineers

ADDRESS: 25 Vaughan Mall

CITY: Portsmouth STATE: NH ZIP: 03801

PHONE: Smith 603-854-3236; Clifton 603-475-3814 EXT.:

E-MAIL: sclifton@underwoodengineers.com; ssmith@underwoodengineers.com

SITE NAME: Epping WWTF, Epping NH

PROJECT #: UE Job 2987-01

STATE: NH MA ME VT OTHER:

REGULATORY PROGRAM: NPDES: RGP POTW STORMWATER GWP, OIL FUND BROWNFIELD OTHER: NA process

QUOTE #: 1020770 PO #:

QA/QC REPORTING

A B C

MA MCP

TEMP. 3.7 C

ICE? YES NO

REPORTING OPTIONS

PRELIMS: YES OR NO

ELECTRONIC OPTIONS

PDF EXCEL

EQUIS

OTHER

TURN AROUND TIME

24hr* 48hr*

3 - 4 DAYS*

5 DAY 7 DAY

10 DAY

*Pre-approval Required

METALS: 8 RCRA 13 PP FE, MN PB, CU

OTHER METALS:

SAMPLES FIELD FILTERED? ☑ YES ☐ NO

NOTES: (IE: SPECIAL DETECTION LIMITS, BILLING INFO, IF DIFFERENT)

see front

SAMPLER(S): P Michael Bidonde

RELINQUISHED BY:	DATE:	TIME:	RECEIVED BY:
[signature]	11/3/23	0815	Eric Halvorson
Eric Halvorson	11-3-23	1420	[signature]

SITE HISTORY:

SUSPECTED CONTAMINATION:

FIELD READINGS:

Eastern Analytical, Inc.

professional laboratory and drilling services

51 Antrim Avenue | Concord, NH 03301 | Tel: 603.228.0525 | 1.800.287.0525 | E-Mail: CustomerService@EasternAnalytical.com | www.EasternAnalytical.com

(WHITE: Lab Copy GREEN: Customer Copy)

Eastern Analytical, Inc.
professional laboratory and drilling services

Steven Clifton
Underwood Engineers
25 Vaughan Mall, Unit #1
Portsmouth , NH 03801

Laboratory Report for:

Eastern Analytical, Inc. ID:	269451
Client Identification:	Epping WWTF, Epping NH | UE Job 2987-01
Date Received:	11/6/2023

Enclosed are the analytical results per the Chain of Custody for sample(s) in the referenced project. All analyses were performed in accordance with our QA/QC Program, NELAP and other applicable state requirements. All quality control criteria was within acceptance criteria unless noted on the report pages. Results are for the exclusive use of the client named on this report and will not be released to a third party without consent.

The following information is contained within this report: Sample Conditions summary, Analytical Results/Data, Quality Control data (if requested) and copies of the Chain of Custody. This report may not be reproduced except in full, without the written approval of the laboratory.

The following standard abbreviations and conventions apply to all EAI reports:
< : "less than" followed by the reporting limit
> : "greater than" followed by the reporting limit
%R : % Recovery

Certifications:
Eastern Analytical, Inc. maintains certification in the following states: Connecticut (PH-0492), Maine (NH005), Massachusetts (M-NH005), New Hampshire/NELAP (1012), Rhode Island (269), Vermont (VT1012), New York (12072) and West Virginia (9910C). Please refer to our website at www.easternanalytical.com for a copy of our certificates and accredited parameters.

References:
- EPA 600/4-79-020, 1983
- Standard Methods for Examination of Water and Wastewater, 20th, 21st, 22nd & 23rd edition or noted revision year.
- Test Methods for Evaluating Solid Waste SW 846 3rd Edition including updates IVA and IVB
- Hach Water Analysis Handbook, 4th edition, 1992
- ASTM International

If you have any questions regarding the results contained within, please feel free to contact customer service. Unless otherwise requested, we will dispose of the sample(s) 6 weeks from the sample receipt date.

We appreciate this opportunity to be of service and look forward to your continued patronage.

Sincerely,

Lorraine Olashaw — 11.15.23
Lorraine Olashaw, Lab Director — Date

SAMPLE CONDITIONS PAGE

EAI ID#: **269451**

Client: **Underwood Engineers**

Client Designation: **Epping WWTF, Epping NH | UE Job 2987-01**

Temperature upon receipt (°C): 2.7

Acceptable temperature range (°C): 0-6

Received on ice or cold packs (Yes/No): Y

Lab ID	Sample ID	Date Received	Date/Time Sampled		Sample Matrix	% Dry Weight	Exceptions/Comments (other than thermal preservation)
269451.01	3-1	11/6/23	11/5/23	10:00	aqueous		Adheres to Sample Acceptance Policy
269451.02	3-2	11/6/23	11/5/23	10:00	aqueous		Adheres to Sample Acceptance Policy
269451.03	3-3	11/6/23	11/5/23	10:00	aqueous		Adheres to Sample Acceptance Policy
269451.04	3-4	11/6/23	11/5/23	10:00	aqueous		Adheres to Sample Acceptance Policy
269451.05	3-5	11/6/23	11/5/23	10:00	aqueous		Adheres to Sample Acceptance Policy
269451.06	3-6	11/6/23	11/5/23	10:00	aqueous		Adheres to Sample Acceptance Policy
269451.07	3-7	11/6/23	11/5/23	10:00	aqueous		Adheres to Sample Acceptance Policy
269451.08	3-8	11/6/23	11/5/23	10:00	aqueous		Adheres to Sample Acceptance Policy
269451.09	3-9	11/6/23	11/5/23	10:00	aqueous		Adheres to Sample Acceptance Policy
269451.1	3-10	11/6/23	11/5/23	10:00	aqueous		Adheres to Sample Acceptance Policy

All results contained in this report relate only to the above listed samples.

Unless otherwise noted:

- *Hold times, preservation, container types, and sample conditions adhered to EPA Protocol.*
- *Solid samples are reported on a dry weight basis, unless otherwise noted. pH/Corrosivity, Flashpoint, Ignitability, Paint Filter, Conductivity and Specific Gravity are always reported on an "as received" basis.*
- *Analysis of pH, Total Residual Chlorine, Dissolved Oxygen and Sulfite were performed at the laboratory outside of the recommended 15 minute hold time.*
- *Samples collected by Eastern Analytical, Inc. (EAI) were collected in accordance with approved EPA procedures.*

LABORATORY REPORT

EAI ID#: **269451**

Client: **Underwood Engineers**

Client Designation: **Epping WWTF, Epping NH | UE Job 2987-01**

Sample ID: 3-1

Lab Sample ID: 269451.01
Matrix: aqueous
Date Sampled: 11/5/23
Date Received: 11/6/23

		Units	Analysis Date	Analysis Time	Method	Analyst
Solids Suspended	**220**	mg/L	11/08/23	10:50	2540D-11	MNT
Solids Volatile Suspended	**200**	mg/L	11/09/23	10:50	2540E-11	MNT

Sample ID: 3-2

Lab Sample ID: 269451.02
Matrix: aqueous
Date Sampled: 11/5/23
Date Received: 11/6/23

		Units	Analysis Date	Analysis Time	Method	Analyst
Ammonia-N	**35**	mg/L	11/13/23	11:36	TM NH3-001	PEN
TKN	**44**	mg/L	11/09/23	14:56	4500N_{org}C/NH3D	GRS
Total Phosphorus-P	**6.5**	mg/L	11/08/23	14:51	365.1	PHA
COD	**750**	mg/L	11/06/23	12:10	H8000	JCS

LABORATORY REPORT

EAI ID#: **269451**

Client: **Underwood Engineers**

Client Designation: **Epping WWTF, Epping NH | UE Job 2987-01**

Sample ID:	3-3
Lab Sample ID:	269451.03
Matrix:	aqueous
Date Sampled:	11/5/23
Date Received:	11/6/23

		Units	Analysis Date	Analysis Time	Method	Analyst
BOD	**450**	mg/L	11/06/23	15:18	5210B-11	ABL

Sample ID:	3-4
Lab Sample ID:	269451.04
Matrix:	aqueous
Date Sampled:	11/5/23
Date Received:	11/6/23

		Units	Analysis Date	Analysis Time	Method	Analyst
Ammonia-N GF	**36**	mg/L	11/13/23	11:39	TM NH3-001	PEN
TKNGF	**44**	mg/L	11/13/23	15:27	$4500N_{org}C/NH3D$	GRS
CODGF	**360**	mg/L	11/06/23	12:10	H8000	JCS

The designation of GF after the analyte indicates that it was filtered through a 1.5 micron glass fiber filter to analysis.

LABORATORY REPORT

EAI ID#: **269451**

Client: **Underwood Engineers**

Client Designation: **Epping WWTF, Epping NH | UE Job 2987-01**

Sample ID: 3-5

Lab Sample ID: 269451.05
Matrix: aqueous
Date Sampled: 11/5/23
Date Received: 11/6/23

		Units	Analysis Date	Analysis Time	Method	Analyst
BODGF	**220**	mg/L	11/06/23	15:09	5210B-01	ABL

Sample ID: 3-6

Lab Sample ID: 269451.06
Matrix: aqueous
Date Sampled: 11/5/23
Date Received: 11/6/23

		Units	Analysis Date	Analysis Time	Method	Analyst
Alkalinity Total (CaCO3)	**220**	mg/L	11/13/23	10:31	2320B-11	BAF

The designation of GF after the analyte indicates that it was filtered through a 1.5 micron glass fiber filter to analysis.

LABORATORY REPORT

EAI ID#: **269451**

Client: **Underwood Engineers**

Client Designation: **Epping WWTF, Epping NH | UE Job 2987-01**

Sample ID:	3-7						
Lab Sample ID:	269451.07						
Matrix:	aqueous						
Date Sampled:	11/5/23			Analysis			
Date Received:	11/6/23	Units	Date	Time	Method	Analyst	
Ortho Phosphate-P	**3.9**	mg/L	11/07/23	8:27	365.1	SEL	

Sample ID:	3-8	3-10					
Lab Sample ID:	269451.08	269451.1					
Matrix:	aqueous	aqueous					
Date Sampled:	11/5/23	11/5/23		Analysis			
Date Received:	11/6/23	11/6/23	Units	Date	Time	Method	Analyst
CODGF	**220**	**21**	mg/L	11/06/23	12:10	H8000	JCS

The designation of GF after the analyte indicates that it was filtered through a 1.5 micron glass fiber filter to analysis.

LABORATORY REPORT

EAI ID#: **269451**

Client: **Underwood Engineers**

Client Designation: **Epping WWTF, Epping NH | UE Job 2987-01**

Sample ID: 3-9

Lab Sample ID: 269451.09
Matrix: aqueous
Date Sampled: 11/5/23
Date Received: 11/6/23

		Units	Analysis Date	Analysis Time	Method	Analyst
Ammonia-N	**1.3**	mg/L	11/13/23	11:42	TM NH3-001	PEN
TKN	**1.2**	mg/L	11/09/23	14:59	4500N_{org}C/NH3D	GRS
COD	**16**	mg/L	11/06/23	12:10	H8000	JCS

QC REPORT

EAI ID#: **269451**

Client: **Underwood Engineers**

Client Designation: **Epping WWTF, Epping NH | UE Job 2987-01**

Parameter Name	Blank	LCS	LCSD	Units	Date of Analysis	Limits	RPD	Method
Solids Suspended	< 5	880 (95 %R)	910 (98 %R) (3 RPD)	mg/L	11/8/23	85 - 115	20	2540D-11
Solids Volatile Suspended	< 5	280 (98 %R)	290 (101 %R) (3 RPD)	mg/L	11/9/23	85 - 115	20	2540E-11
Alkalinity Total (CaCO3)	< 1	11 (112 %R)	10 (100 %R) (11 RPD)	mg/L	11/13/23	85 - 115	20	2320B-11
Ammonia-N	< 0.05	2.0 (100 %R)	2.0 (100 %R) (0 RPD)	mg/L	11/13/23	87 - 104	20	TM NH3-001
TKN	< 0.5	9.9 (99 %R)	10 (100 %R) (1 RPD)	mg/L	11/9/23	90 - 111	20	$4500N_{org}$C/NH3D-11
Total Phosphorus-P	< 0.01	0.30 (100 %R)	0.30 (99 %R) (1 RPD)	mg/L	11/8/23	90 - 110	20	365.1
Ortho Phosphate-P	< 0.01	0.31 (104 %R)	0.31 (105 %R) (0 RPD)	mg/L	11/7/23	90 - 110	20	365.1
BOD	< 6	220 (111 %R)	NA	mg/L	11/6/23	84 - 115		5210B-11
COD	< 10	99 (99 %R)	99 (99 %R) (1 RPD)	mg/L	11/6/23	85 - 115	20	H8000
CODGF	< 10	99 (99 %R)	99 (99 %R) (1 RPD)	mg/L	11/6/23	85 - 115	20	H8000

*/! Flagged analyte recoveries deviated from the QA/QC limits. Unless noted, flagged data does not impact the sample data.

Raw Data

EAI ID#: **269451**

Client:

Client Designation: **Epping WWTF, Epping NH | UE Job 2987-01**

EAI ID#	Sample ID	Parameter	Raw Data	RepValue	DilFac	DL	Units	Date/Time Analyzed	Matrix	Method
269451.01	3-1	Solids Suspended	216	220	1	5	mg/L	11/8/2023 10:50	AqTot	2540D-11
269451.01	3-1	Solids Volatile Suspended	202	200	1	5	mg/L	11/9/2023 10:50	AqTot	2540E-11

Page 1 of 1

CHAIN-OF-CUSTODY RECORD

BOLD FIELDS REQUIRED. PLEASE CIRCLE REQUESTED ANALYSIS.

269451

SAMPLE I.D.	SAMPLING DATE/TIME *IF COMPOSITE, INDICATE BOTH START & FINISH DATE/TIME	MATRIX (SEE BELOW)	GRAB/*COMPOSITE	VOC: 524.2 / 524.2 MTBE ONLY	VOC: 8260B / 624 / 1,4 DIOXANE / VTICs	VOC: 8021B	VOC: 8015B GRO / MAVPH	SVOC: 8270D / ABN / PAH / 625 / EDB / DBCP	SVOC: TPH8100 / L1 / L2	SVOC: 8015B DRO / MAEPH	SVOC: PEST 608 / PEST 8081A / PCB 608 / PCB 8082	SVOC: OIL & GREASE 1664 / TPH 1664	TCLP: TCLP 1311 / VOC / PEST / ABN / METALS / HERB	INORGANICS: BOD / TS / CBOD / TSS / TDS	INORGANICS: Br / NO_2 / Cl / NO_3 / F / NO_3NO_2 / SO_4	INORGANICS: TKN / T. PHOS. / NH_3 / O. PHOS. / TN	INORGANICS: pH / SPEC. CON. / T. RES. CHLORINE / T. ALK.	INORGANICS: COD / PHENOLS / TOC / DOC	INORGANICS: TOTAL CYANIDE / TOTAL SULFIDE	INORGANICS: REACTIVE CYANIDE / FLASHPOINT / REACTIVE SULFIDE / IGNITABILITY	MICRO: TOTAL COLIFORM / FECAL COLIFORM / E. COLI	MICRO: ENTEROCOCCI / HETEROTROPHIC PLATE COUNT	METALS: DISSOLVED METALS (LIST BELOW)	METALS: TOTAL METALS (LIST BELOW)	OTHER	OTHER	OTHER	OTHER	# OF CONTAINERS	NOTES MeOH VIAL #
3-1	Start 11/4 10am Finish 11/5 10am	WW	C											✓																TSS/VSS
3-2																✓		✓												COD/TKN/NH_3-TP
3-3														✓																BOD
3-4																✓		✓												Soluble COD TKN/NH_3
3-5														✓																Soluble BOD
3-6																	✓													Alkalinity
3-7																✓														PO_4-P
3-8																		✓												Floc. filtered COD
3-9																✓		✓												COD/TKN/NH_3
3-10																		✓												Floc. filtered COD

MATRIX: A-AIR; S-SOIL; GW-GROUND WATER; SW-SURFACE WATER; DW-DRINKING WATER; WW-WASTE WATER

PRESERVATIVE: H-HCL; N-HNO_3; S-H_2SO_4; Na-NaOH; M-MEOH

PROJECT MANAGER: Steve Clifton, Stephen Smith

COMPANY: Underwood Engineers

ADDRESS: 25 Vaughan Mall

CITY: Portsmouth STATE: NH ZIP: 03801

PHONE: Smith 603-854-3236; Clifton 603-475-3814 EXT.:

E-MAIL: sclifton@underwoodengineers.com; ssmith@underwoodengineers.com

SITE NAME: Epping WWTF, Epping NH

PROJECT #: UE Job 2987-01

STATE: NH MA ME VT OTHER:

REGULATORY PROGRAM: NPDES: RGP POTW STORMWATER GWP, OIL FUND BROWNFIELD OTHER: NA process

QUOTE #: 1020770 PO #:

QA/QC REPORTING

A B C

MA MCP

TEMP. 2.7 C

ICE? YES / NO

REPORTING OPTIONS

PRELIMS: YES OR NO

ELECTRONIC OPTIONS

PDF EXCEL

EQUIS

OTHER

TURN AROUND TIME

24hr* 48hr*

3 - 4 DAYS*

5 DAY 7 DAY

10 DAY

*Pre-approval Required

SAMPLER(S): Paul Michael Bidonde

RELINQUISHED BY:	DATE:	TIME:	RECEIVED BY:
Paul [signature]	11/5/23	12:47	F/ISSE
F/ISSE	11/6/23	08:00	BAF

METALS: 8 RCRA 13 PP FE, MN PB, CU

OTHER METALS:

SAMPLES FIELD FILTERED? ☑ YES ☐ NO

NOTES: (IE: SPECIAL DETECTION LIMITS, BILLING INFO, IF DIFFERENT)

3-4 & 3-5 = EAI to 1.5μ filter

3-2, 3-3, 3-6 = UE field blend

3-8 & 3-10 = UE field 1.5μ filter

3-7 = UE field .45μ filter

3-9 = MBR eff. (.45μ)

SITE HISTORY:

SUSPECTED CONTAMINATION:

FIELD READINGS:

Eastern Analytical, Inc.

professional laboratory and drilling services

Steven Clifton
Underwood Engineers
25 Vaughan Mall, Unit #1
Portsmouth , NH 03801

Laboratory Report for:

Eastern Analytical, Inc. ID:	269533
Client Identification:	Epping WWTF, Epping NH / UE Job 2987-01
Date Received:	11/7/2023
Report revision/reissue:	Revision, replaces report dated 11/20/2023
Revision information:	Revised to include, raw data, per customers request.

Enclosed are the analytical results per the Chain of Custody for sample(s) in the referenced project. All analyses were performed in accordance with our QA/QC Program, NELAP and other applicable state requirements. All quality control criteria was within acceptance criteria unless noted on the report pages. Results are for the exclusive use of the client named on this report and will not be released to a third party without consent.

The following information is contained within this report: Sample Conditions summary, Analytical Results/Data, Quality Control data (if requested) and copies of the Chain of Custody. This report may not be reproduced except in full, without the written approval of the laboratory.

The following standard abbreviations and conventions apply to all EAI reports:

< : "less than" followed by the reporting limit
> : "greater than" followed by the reporting limit
%R : % Recovery

Certifications:
Eastern Analytical, Inc. maintains certification in the following states: Connecticut (PH-0492), Maine (NH005), Massachusetts (M-NH005), New Hampshire/NELAP (1012), Rhode Island (269), Vermont (VT1012), New York (12072) and West Virginia (9910C). Please refer to our website at www.easternanalytical.com for a copy of our certificates and accredited parameters.

References:
- EPA 600/4-79-020, 1983
- Standard Methods for Examination of Water and Wastewater, 20th, 21st, 22nd & 23rd edition or noted revision year.
- Test Methods for Evaluating Solid Waste SW 846 3rd Edition including updates IVA and IVB
- Hach Water Analysis Handbook, 4th edition, 1992

If you have any questions regarding the results contained within, please feel free to contact customer service. Unless otherwise requested, we will dispose of the sample(s) 6 weeks from the sample receipt date.

We appreciate this opportunity to be of service and look forward to your continued patronage.

Sincerely,

Lorraine Olashaw, Lab Director — Date: 11.30.23

SAMPLE CONDITIONS PAGE

EAI ID#: **269533**

Client: **Underwood Engineers**

Client Designation: **Epping WWTF, Epping NH / UE Job 2987-01**

Temperature upon receipt (°C): **2.8**
Acceptable temperature range (°C): 0-6

Received on ice or cold packs (Yes/No): Y

Lab ID	Sample ID	Date Received	Date/Time Sampled		Sample Matrix	% Dry Weight	Exceptions/Comments (other than thermal preservation)
269533.01	4-1	11/7/23	11/7/23	07:00	aqueous		Adheres to Sample Acceptance Policy
269533.02	4-2	11/7/23	11/7/23	07:00	aqueous		Adheres to Sample Acceptance Policy
269533.03	4-3	11/7/23	11/7/23	07:00	aqueous		Adheres to Sample Acceptance Policy
269533.04	4-4	11/7/23	11/7/23	07:00	aqueous		Adheres to Sample Acceptance Policy
269533.05	4-5	11/7/23	11/7/23	07:00	aqueous		Adheres to Sample Acceptance Policy
269533.06	4-6	11/7/23	11/7/23	07:00	aqueous		Adheres to Sample Acceptance Policy
269533.07	4-7	11/7/23	11/7/23	07:00	aqueous		Adheres to Sample Acceptance Policy
269533.08	4-8	11/7/23	11/7/23	07:00	aqueous		Adheres to Sample Acceptance Policy
269533.09	4-9	11/7/23	11/7/23	07:00	aqueous		Adheres to Sample Acceptance Policy
269533.1	4-10	11/7/23	11/7/23	07:00	aqueous		Adheres to Sample Acceptance Policy
269533.11	4-11	11/7/23	11/7/23	07:00	aqueous		Adheres to Sample Acceptance Policy
269533.12	4-12	11/7/23	11/7/23	07:00	aqueous		Adheres to Sample Acceptance Policy
269533.13	4-13	11/7/23	11/7/23	07:00	aqueous		Adheres to Sample Acceptance Policy
269533.14	4-14	11/7/23	11/7/23	07:00	aqueous		Adheres to Sample Acceptance Policy

All results contained in this report relate only to the above listed samples.

Unless otherwise noted:

- *Hold times, preservation, container types, and sample conditions adhered to EPA Protocol.*
- *Solid samples are reported on a dry weight basis, unless otherwise noted. pH/Corrosivity, Flashpoint, Ignitability, Paint Filter, Conductivity and Specific Gravity are always reported on an "as received" basis.*
- *Analysis of pH, Total Residual Chlorine, Dissolved Oxygen and Sulfite were performed at the laboratory outside of the recommended 15 minute hold time.*
- *Samples collected by Eastern Analytical, Inc. (EAI) were collected in accordance with approved EPA procedures.*

LABORATORY REPORT

EAI ID#: **269533**

Client: **Underwood Engineers**

Client Designation: **Epping WWTF, Epping NH / UE Job 2987-01**

Sample ID:	4-1	4-12					
Lab Sample ID:	269533.01	269533.12					
Matrix:	aqueous	aqueous					
Date Sampled:	11/7/23	11/7/23		Analysis			
Date Received:	11/7/23	11/7/23	**Units**	**Date**	**Time**	**Method**	**Analyst**
Solids Suspended	**230**	**6400**	mg/L	11/08/23	10:50	2540D-11	MNT
Solids Volatile Suspended	**210**	**5100**	mg/L	11/09/23	10:50	2540E-11	MNT

Sample ID:	4-2					
Lab Sample ID:	269533.02					
Matrix:	aqueous					
Date Sampled:	11/7/23		Analysis			
Date Received:	11/7/23	**Units**	**Date**	**Time**	**Method**	**Analyst**
Ammonia-N	**37**	mg/L	11/15/23	10:45	TM NH3-001	PEN
TKN	**46**	mg/L	11/13/23	16:13	4500N_{org}C/NH3D	GRS
Total Phosphorus-P	**6.4**	mg/L	11/11/23	9:08	365.1	SEL
COD	**620**	mg/L	11/13/23	9:40	H8000	JCS

4-1: 50mL was filtered.
4-12: 4mL was filtered.

LABORATORY REPORT

EAI ID#: **269533**

Client: **Underwood Engineers**

Client Designation: **Epping WWTF, Epping NH / UE Job 2987-01**

Sample ID: 4-3

Lab Sample ID: 269533.03
Matrix: aqueous
Date Sampled: 11/7/23
Date Received: 11/7/23

		Units	Analysis Date	Analysis Time	Method	Analyst
BOD	**270**	mg/L	11/08/23	14:34	5210B-11	GRS

Sample ID: 4-4

Lab Sample ID: 269533.04
Matrix: aqueous
Date Sampled: 11/7/23
Date Received: 11/7/23

		Units	Analysis Date	Analysis Time	Method	Analyst
Ammonia-N GF	**37**	mg/L	11/15/23	10:48	TM NH3-001	PEN
TKNGF	**43**	mg/L	11/13/23	16:16	$4500N_{org}C$/NH3D	GRS
CODGF	**220**	mg/L	11/13/23	9:40	H8000	JCS

The designation of GF after the analyte indicates that it was filtered through a 1.5 micron glass fiber filter prior to analysis.

LABORATORY REPORT

EAI ID#: **269533**

Client: **Underwood Engineers**

Client Designation: **Epping WWTF, Epping NH / UE Job 2987-01**

Sample ID: 4-5

Lab Sample ID: 269533.05
Matrix: aqueous
Date Sampled: 11/7/23
Date Received: 11/7/23

		Units	Analysis Date	Analysis Time	Method	Analyst
BODGF	**130**	mg/L	11/08/23	14:38	5210B-01	GRS

Sample ID: 4-6

Lab Sample ID: 269533.06
Matrix: aqueous
Date Sampled: 11/7/23
Date Received: 11/7/23

		Units	Analysis Date	Analysis Time	Method	Analyst
Alkalinity Total (CaCO3)	**230**	mg/L	11/13/23	10:31	2320B-11	BAF

The designation of GF after the analyte indicates that it was filtered through a 1.5 micron glass fiber filter prior to analysis.

LABORATORY REPORT

EAI ID#: **269533**

Client: **Underwood Engineers**

Client Designation: **Epping WWTF, Epping NH / UE Job 2987-01**

Sample ID:	4-7						
Lab Sample ID:	269533.07						
Matrix:	aqueous						
Date Sampled:	11/7/23		Analysis				
Date Received:	11/7/23	**Units**	**Date**	**Time**	**Method**	**Analyst**
Ortho Phosphate-P	**3.6**	mg/L	11/07/23	14:34	365.1	SEL

Sample ID:	4-8	4-10	4-13						
Lab Sample ID:	269533.08	269533.1	269533.13						
Matrix:	aqueous	aqueous	aqueous						
Date Sampled:	11/7/23	11/7/23	11/7/23		Analysis				
Date Received:	11/7/23	11/7/23	11/7/23	**Units**	**Date**	**Time**	**Method**	**Analyst**
CODGF	**170**	**19**	**34**	mg/L	11/13/23	9:40	H8000	JCS

The designation of GF after the analyte indicates that it was filtered through a 1.5 micron glass fiber filter prior to analysis.

LABORATORY REPORT

EAI ID#: **269533**

Client: **Underwood Engineers**

Client Designation: **Epping WWTF, Epping NH / UE Job 2987-01**

Sample ID: 4-9

Lab Sample ID: 269533.09
Matrix: aqueous
Date Sampled: 11/7/23
Date Received: 11/7/23

		Units	Analysis Date	Analysis Time	Method	Analyst
Ammonia-N	**0.76**	mg/L	11/15/23	10:51	TM NH3-001	PEN
TKN	**0.92**	mg/L	11/16/23	17:54	$4500N_{org}C/NH3D$	GRS
COD	**19**	mg/L	11/13/23	9:40	H8000	JCS

Sample ID: 4-14

Lab Sample ID: 269533.14
Matrix: aqueous
Date Sampled: 11/7/23
Date Received: 11/7/23

		Units	Analysis Date	Analysis Time	Method	Analyst
COD	**6300**	mg/L	11/13/23	9:40	H8000	JCS

QC REPORT

EAI ID#: **269533**

Client: **Underwood Engineers**

Client Designation: **Epping WWTF, Epping NH / UE Job 2987-01**

Parameter Name	Blank	LCS	LCSD	Units	Date of Analysis	Limits	RPD	Method
Solids Suspended	< 5	880 (95 %R)	910 (98 %R) (3 RPD)	mg/L	11/8/23	85 - 115	20	2540D-11
Solids Volatile Suspended	< 5	280 (98 %R)	290 (101 %R) (3 RPD)	mg/L	11/9/23	85 - 115	20	2540E-11
Alkalinity Total (CaCO3)	< 1	11 (112 %R)	10 (100 %R) (11 RPD)	mg/L	11/13/23	85 - 115	20	2320B-11
Ammonia-N	< 0.05	2.0 (100 %R)	2.0 (99 %R) (1 RPD)	mg/L	11/15/23	87 - 104	20	TM NH3-001
TKN	< 0.5	9.7 (97 %R)	10 (103 %R) (6 RPD)	mg/L	11/13/23	90 - 111	20	$4500N_{org}C$/NH3D-11
Total Phosphorus-P	< 0.01	0.30 (100 %R)	0.30 (101 %R) (1 RPD)	mg/L	11/11/23	90 - 110	20	365.1
Ortho Phosphate-P	< 0.01	0.31 (104 %R)	0.32 (106 %R) (2 RPD)	mg/L	11/7/23	90 - 110	20	365.1
BOD	< 6	200 (99 %R)		mg/L	11/8/23	84 - 115		5210B-11
COD	< 10	98 (98 %R)	100 (100 %R) (2 RPD)	mg/L	11/13/23	85 - 115	20	H8000
CODGF	< 10	98 (98 %R)	100 (100 %R) (2 RPD)	mg/L	11/13/23	85 - 115	20	H8000

*/! Flagged analyte recoveries deviated from the QA/QC limits. Unless noted, flagged data does not impact the sample data.

Raw Data

EAI ID#: **269533**

Client:

Client Designation: **Epping WWTF, Epping NH / UE Job 2987-01**

EAI ID#	Sample ID	Parameter	Raw Data	RepValue	DilFac	DL	Units	Date/Time Analyzed	Matrix	Method
269533.01	4-1	Solids Suspended	232	230	1	5	mg/L	11/8/2023 10:50	AqTot	2540D-11
269533.12	4-12	Solids Suspended	6350	6400	1	5	mg/L	11/8/2023 10:50	AqTot	2540D-11
269533.01	4-1	Solids Volatile Suspended	212	210	1	5	mg/L	11/9/2023 10:50	AqTot	2540E-11
269533.12	4-12	Solids Volatile Suspended	5075	5100	1	5	mg/L	11/9/2023 10:50	AqTot	2540E-11

PHOENIX
Environmental Laboratories, Inc.

Tuesday, November 14, 2023

Attn: Front Office
Eastern Analytical
51 Antrim Ave
Concord, NH 03301

Project ID: 269533
SDG ID: GCP44709
Sample ID#s: CP44709

This laboratory is in compliance with the NELAC requirements of procedures used except where indicated.

This report contains results for the parameters tested, under the sampling conditions described on the Chain Of Custody, as received by the laboratory. This report is incomplete unless all pages indicated in the pagination at the bottom of the page are included.

A scanned version of the COC form accompanies the analytical report and is an exact duplicate of the original.

If you are the client above and have any questions concerning this testing, please do not hesitate to contact Phoenix Client Services at ext.200. The contents of this report cannot be discussed with anyone other than the client listed above without their written consent.

Sincerely yours,

Phyllis Shiller
Laboratory Director

NELAC - #NY11301
CT Lab Registration #PH-0618
MA Lab Registration #M-CT007
ME Lab Registration #CT-007
NH Lab Registration #213693-A,B
NJ Lab Registration #CT-003
NY Lab Registration #11301
PA Lab Registration #68-03530
RI Lab Registration #63
VT Lab Registration #VT11301

PHOENIX
Environmental Laboratories, Inc.
587 East Middle Turnpike, P.O.Box 370, Manchester, CT 06045
Tel. (860) 645-1102 Fax (860) 645-0823

ACCREDITED IN ACCORDANCE WITH nelac
NY # 11301

Sample Id Cross Reference

November 14, 2023

SDG I.D.: GCP44709

Project ID: 269533

Client Id	Lab Id	Matrix
4-11	CP44709	WATER

PHOENIX

Environmental Laboratories, Inc.
587 East Middle Turnpike, P.O.Box 370, Manchester, CT 06045
Tel. (860) 645-1102 Fax (860) 645-0823

ACCREDITED IN ACCORDANCE WITH nelac
NY # 11301

Analysis Report

November 14, 2023

FOR: Attn: Front Office
Eastern Analytical
51 Antrim Ave
Concord, NH 03301

Sample Information		Custody Information		Date	Time
Matrix:	WATER	Collected by:		11/07/23	7:00
Location Code:	EASTANAL-NH	Received by:	CP	11/09/23	16:21
Rush Request:	Standard	Analyzed by:	see "By" below		
P.O.#:	61150				

Laboratory Data

SDG ID: GCP44709
Phoenix ID: CP44709

Project ID: 269533
Client ID: 4-11

Parameter	Result	RL/ PQL	Units	Dilution	Date/Time	By	Reference	
Volatile Fatty Acids	225	60.0	mg/L	1	11/11/23	JY	SM5560C-01	1

1 = This parameter is not certified by the primary accrediting authority (NY NELAC) for this matrix. NY NELAC does not offer certification for all parameters at this time.

RL/PQL=Reporting/Practical Quantitation Level (Equivalent to NELAC LOQ, Limit of Quantitation) ND=Not Detected at RL/PQL
BRL=Below Reporting Level L=Biased Low

Comments:

If you are the client above and have any questions concerning this testing, please do not hesitate to contact Phoenix Client Services at ext.200.
The contents of this report cannot be discussed with anyone other than the client listed above without their written consent.

Phyllis Shiller

Phyllis Shiller, Laboratory Director
November 14, 2023
Reviewed and Released by: Anil Makol, Project Manager

PHOENIX

Environmental Laboratories, Inc.
587 East Middle Turnpike, P.O.Box 370, Manchester, CT 06045
Tel. (860) 645-1102

ACCREDITED IN ACCORDANCE WITH nelac
NY # 11301

QA/QC Report

November 14, 2023

QA/QC Data

SDG I.D.: GCP44709

Parameter	Blank	Blk RL	Sample Result	Dup Result	Dup RPD	LCS %	LCSD %	LCS RPD	MS %	MSD %	MS RPD	% Rec Limits	% RPD Limits	
QA/QC Batch 705974 (mg/L), QC Sample No: CP41349 (CP44709)														
Volatile Fatty Acids	BRL	60.0	425	325	26.7							85 - 115	20	r

Comment:

Additional criteria matrix spike acceptance range is 75-125%.

r = This parameter is outside laboratory RPD specified recovery limits.

If there are any questions regarding this data, please call Phoenix Client Services at extension 200.

RPD - Relative Percent Difference
LCS - Laboratory Control Sample
LCSD - Laboratory Control Sample Duplicate
MS - Matrix Spike
MS Dup - Matrix Spike Duplicate
NC - No Criteria
Intf - Interference

Phyllis Shiller

Phyllis Shiller, Laboratory Director
November 14, 2023

Tuesday, November 14, 2023

Criteria: None

State: NH

Sample Criteria Exceedances Report

GCP44709 - EASTANAL-NH

SampNo	Acode	Phoenix Analyte	Criteria	Result	RL	Criteria	RL Criteria	Analysis Units

*** No Data to Display ***

Phoenix Laboratories does not assume responsibility for the data contained in this exceedance report. It is provided as an additional tool to identify requested criteria exceedences. All efforts are made to ensure the accuracy of the data (obtained from appropriate agencies). A lack of exceedence information does not necessarily suggest conformance to the criteria. It is ultimately the site professional's responsibility to determine appropriate compliance.

PHOENIX

Environmental Laboratories, Inc.
587 East Middle Turnpike, P.O.Box 370, Manchester, CT 06045
Tel. (860) 645-1102 Fax (860) 645-0823

ACCREDITED IN ACCORDANCE WITH nelac NY # 11301

Analysis Comments

November 14, 2023 SDG I.D.: GCP44709

The following analysis comments are made regarding exceptions to criteria not already noted in the Analysis Report or QA/QC Report: None.

CHAIN-OF-CUSTODY RECORD

Eastern Analytical, Inc.
professional laboratory and drilling services

EAI ID# **269533** Page 1

Sample ID	Date Sampled	Matrix	aParameters	Sample Notes
4-11	11/7/2023 07:00	aqueous	Subcontract - Total Volatile Fatty Acids (VFA)	44709

1X250mL Plastic

EAI ID# **269533** Project State: NH
Project ID: 6134

Company: Phoenix Environmental Labs
Address: 587 East Middle Turnpike
Address: Manchester , CT 06040
Account #:
Phone #: (860) 645-1102

Results Needed: Preferred Date: Standard
RUSH Due Date: ________

QC Deliverables
☐ A ☐ A+ ☒ B ☐ B+ ☐ C ☐ MA MCP

Notes about project:
Email login confirmation, pdf of results and invoice to customerservice@easternanalytical.com.

PO #:61150 EAI ID# **269533**

Data Deliverable (circle)
Excel NH EMD EQuIS ME EGAD

Call prior to analyzing, if RUSH charges will be applied.

Samples Collected by: ________

Relinquished by	Date/Time	Received by
[signature]	11/9/23 7:27	Shelly
Shelly	11/9/23 1145	[signature]
[signature]	11/9/23 1700	[signature]

Eastern Analytical, Inc. 51 Antrim Ave Concord, NH 03301 Phone: (603)228-0525 1-800-287-0525 customerservice@easternanalytical.com

Page 1 of 2

CHAIN-OF-CUSTODY RECORD

269533

BOLD FIELDS REQUIRED. PLEASE CIRCLE REQUESTED ANALYSIS.

SAMPLE I.D.	SAMPLING DATE/TIME *IF COMPOSITE, INDICATE BOTH START & FINISH DATE/TIME	MATRIX (SEE BELOW)	GRAB/*COMPOSITE	VOC: 524.2 / 524.2 MTBE ONLY	VOC: 8260B 624 VTICs 1,4 DIOXANE	VOC: 8021B	VOC: 8015B GRO MAVPH	SVOC: 8270D 625 ABN PAH EDB DBCP	SVOC: TPH8100 L1 L2	SVOC: 8015B DRO MAEPH	SVOC: PEST 608 PCB 608 PEST 8081A PCB 8082	SVOC: OIL & GREASE 1664 TPH 1664	TCLP: TCLP 1311 ABN METALS VOC PEST HERB	INORGANICS: BOD CBOD TS TSS TDS	INORGANICS: Br Cl F SO_4 NO_2 NO_3 NO_2NO_3	INORGANICS: TKN NH_3 TN T. PHOS. O. PHOS.	INORGANICS: pH T. RES. CHLORINE SPEC. CON. T. ALK.	INORGANICS: COD PHENOLS TOC DOC	INORGANICS: TOTAL CYANIDE TOTAL SULFIDE	INORGANICS: REACTIVE CYANIDE REACTIVE SULFIDE FLASHPOINT IGNITABILITY	MICRO: TOTAL COLIFORM E. COLI FECAL COLIFORM	MICRO: ENTEROCOCCI HETEROTROPHIC PLATE COUNT	METALS: DISSOLVED METALS (LIST BELOW)	METALS: TOTAL METALS (LIST BELOW)	OTHER				# OF CONTAINERS	NOTES MeOH VIAL #
4-1	11/6 @ 7am - 11/7 @ 7am	WW	C											✓																TSS/VSS
4-2																✓		✓												COD/TKN/ NH3/TP
4-3														✓																BOD
4-4																✓		✓												Soluble COD/TKN/NH3
4-5														✓																Soluble BOD
4-6																	✓													Alkalinity
4-7																✓														O.Phos
4-8																		✓												Floc. Filtered COD
4-9																✓		✓												COD/TKN/ NH3
4-10																		✓												Floc Filtered COD

MATRIX: A-AIR; S-SOIL; GW-GROUND WATER; SW-SURFACE WATER; DW-DRINKING WATER; WW-WASTE WATER

PRESERVATIVE: H-HCL; N-HNO_3; S-H_2SO_4; Na-NaOH; M-MEOH

PROJECT MANAGER: Steve Clifton, Stephen Smith

COMPANY: Underwood Engineers

ADDRESS: 25 Vaughan Mall

CITY: Portsmouth STATE: NH ZIP: 03801

PHONE: Smith 603-854-3236; Clifton 603-475-3814 EXT.:

E-MAIL: sclifton@underwoodengineers.com; ssmith@underwoodengineers.com

SITE NAME: Epping WWTF, Epping NH

PROJECT #: UE Job 2987-01

STATE: NH MA ME VT OTHER:

REGULATORY PROGRAM: NPDES: RGP POTW STORMWATER GWP, OIL FUND BROWNFIELD OTHER: NA process

QUOTE #: 1020770 PO #:

QA/QC REPORTING

A B C

MA MCP

TEMP. 2.8 C

ICE? YES NO

REPORTING OPTIONS

PRELIMS: YES OR NO

ELECTRONIC OPTIONS

PDF EXCEL

EQUIS

OTHER

TURN AROUND TIME

24hr* 48hr*

3 - 4 DAYS*

5 DAY 7 DAY

10 DAY

*Pre-approval Required

SAMPLER(S): Paul Michael Bidondo

RELINQUISHED BY:	DATE:	TIME:	RECEIVED BY:
[signature]	11/7/23	10:30 AM	[signature]
[signature]		1300	NH

METALS: 8 RCRA 13 PP FE, MN PB, CU

OTHER METALS:

SAMPLES FIELD FILTERED? ☐ YES ☐ NO

NOTES: (IE: SPECIAL DETECTION LIMITS, BILLING INFO, IF DIFFERENT)

4-2, 4-3, 4-6, & 4-14 = UE blend
4-8, 4-10, 4-13 = UE 1.5µ filt
4-7 = UE .45µ filter in field
4-9 = MBR effluent (~~Above~~ .04µ)
4-4, 4-5 = EAI 1.5µ lab filter

SITE HISTORY:

SUSPECTED CONTAMINATION:

FIELD READINGS:

Eastern Analytical, Inc.
professional laboratory and drilling services
51 Antrim Avenue | Concord, NH 03301 | Tel: 603.228.0525 | 1.800.287.0525 | E-Mail: CustomerService@EasternAnalytical.com | www.EasternAnalytical.com

(WHITE: Lab Copy GREEN: Customer Copy)

CHAIN-OF-CUSTODY RECORD

BOLD FIELDS REQUIRED. PLEASE CIRCLE REQUESTED ANALYSIS.

269533

SAMPLE I.D.	SAMPLING DATE/TIME *IF COMPOSITE, INDICATE BOTH START & FINISH DATE/TIME	MATRIX (SEE BELOW)	GRAB/*COMPOSITE	VOC: 524.2 / 524.2 MTBE ONLY	VOC: 8260B 624 VTICs 1,4 DIOXANE	VOC: 8021B	VOC: 8015B GRO MAVPH	SVOC: 8270D 625 ABN PAH EDB DBCP	SVOC: TPH8100 L1 L2	SVOC: 8015B DRO MAEPH	SVOC: PEST 608 PCB 608 PEST 8081A PCB 8082	SVOC: OIL & GREASE 1664 TPH 1664	TCLP: TCLP 1311 ABN METALS VOC PEST HERB	INORGANICS: BOD CBOD TS TSS TDS	INORGANICS: Br Cl F SO_4 NO_2 NO_3 NO_2NO_3	INORGANICS: TKN NH_3 TN T. PHOS. O. PHOS.	INORGANICS: pH T. RES. CHLORINE SPEC. CON. T. ALK.	INORGANICS: COD PHENOLS TOC DOC	INORGANICS: TOTAL CYANIDE TOTAL SULFIDE	INORGANICS: REACTIVE CYANIDE REACTIVE SULFIDE FLASHPOINT IGNITABILITY	MICRO: TOTAL COLIFORM E. COLI FECAL COLIFORM	MICRO: ENTEROCOCCI HETEROTROPHIC PLATE COUNT	METALS: DISSOLVED METALS (LIST BELOW)	METALS: TOTAL METALS (LIST BELOW)	OTHER: VFA	OTHER	OTHER	OTHER	# OF CONTAINERS	NOTES MeOH VIAL #
4-11	11/6 7am-11/7 7am	WW	C																						✓					VFA
4-12	11/7	↓	G											✓																MLSS / MLVSS
4-13	11/7		G															✓												MLSS soluble COD
4-14	11/7		G															✓												MLSS Blended COD

MATRIX: A-AIR; S-SOIL; GW-GROUND WATER; SW-SURFACE WATER; DW-DRINKING WATER; WW-WASTE WATER

PRESERVATIVE: H-HCL; N-HNO_3; S-H_2SO_4; Na-NaOH; M-MEOH

PROJECT MANAGER: Steve Clifton, Stephen Smith
COMPANY: Underwood Engineers
ADDRESS: 25 Vaughan Mall
CITY: Portsmouth STATE: NH ZIP: 03801
PHONE: Smith 603-854-3236; Clifton 603-475-3814 EXT.:
E-MAIL: sclifton@underwoodengineers.com; ssmith@underwoodengineers.com
SITE NAME: Epping WWTF, Epping NH
PROJECT #: UE Job 2987-01
STATE: NH MA ME VT OTHER:
REGULATORY PROGRAM: NPDES: RGP POTW STORMWATER GWP, OIL FUND BROWNFIELD OTHER: NA process
QUOTE #: 1020770 PO #:

QA/QC REPORTING
A B C
MA MCP

TEMP. 2.8 C
ICE? YES NO

REPORTING OPTIONS
PRELIMS: YES OR NO

ELECTRONIC OPTIONS
PDF EXCEL
EQUIS
OTHER

TURN AROUND TIME
24hr* 48hr*
3 - 4 DAYS*
5 DAY 7 DAY
10 DAY
*Pre-approval Required

METALS: 8 RCRA 13 PP FE, MN PB, CU
OTHER METALS:
SAMPLES FIELD FILTERED? ☐ YES ☐ NO
NOTES: (IE: SPECIAL DETECTION LIMITS, BILLING INFO, IF DIFFERENT)
See front page

SAMPLER(S): Paul Michael Bidorde

RELINQUISHED BY:	DATE:	TIME:	RECEIVED BY:
[signature]	11/7		[signature] 11/7/23 1200
[signature] 11/7/23		1300	NH

SITE HISTORY:
SUSPECTED CONTAMINATION:
FIELD READINGS:

Eastern Analytical, Inc.

professional laboratory and drilling services

Steven Clifton
Underwood Engineers
25 Vaughan Mall, Unit #1
Portsmouth , NH 03801

Laboratory Report for:

Eastern Analytical, Inc. ID: 270200
Client Identification: Epping WWTF, Epping NH / UE Job 2987-01
Date Received: 11/16/2023

Enclosed are the analytical results per the Chain of Custody for sample(s) in the referenced project. All analyses were performed in accordance with our QA/QC Program, NELAP and other applicable state requirements. All quality control criteria was within acceptance criteria unless noted on the report pages. Results are for the exclusive use of the client named on this report and will not be released to a third party without consent.

The following information is contained within this report: Sample Conditions summary, Analytical Results/Data, Quality Control data (if requested) and copies of the Chain of Custody. This report may not be reproduced except in full, without the written approval of the laboratory.

The following standard abbreviations and conventions apply to all EAI reports:

< : "less than" followed by the reporting limit
> : "greater than" followed by the reporting limit
%R : % Recovery

Certifications:
Eastern Analytical, Inc. maintains certification in the following states: Connecticut (PH-0492), Maine (NH005), Massachusetts (M-NH005), New Hampshire/NELAP (1012), Rhode Island (269), Vermont (VT1012), New York (12072) and West Virginia (9910C). Please refer to our website at www.easternanalytical.com for a copy of our certificates and accredited parameters.

References:
- EPA 600/4-79-020, 1983
- Standard Methods for Examination of Water and Wastewater, 20th, 21st, 22nd & 23rd edition or noted revision year.
- Test Methods for Evaluating Solid Waste SW 846 3rd Edition including updates IVA and IVB
- Hach Water Analysis Handbook, 4th edition, 1992
- ASTM International

If you have any questions regarding the results contained within, please feel free to contact customer service. Unless otherwise requested, we will dispose of the sample(s) 6 weeks from the sample receipt date.

We appreciate this opportunity to be of service and look forward to your continued patronage.

Sincerely,

Lorraine Olashaw   11·29·23
Lorraine Olashaw, Lab Director   Date

SAMPLE CONDITIONS PAGE

EAI ID#: **270200**

Client: **Underwood Engineers**

Client Designation: **Epping WWTF, Epping NH / UE Job 2987-01**

Temperature upon receipt (°C): 1.5

Acceptable temperature range (°C): 0-6

Received on ice or cold packs (Yes/No): Y

Lab ID	Sample ID	Date Received	Date/Time Sampled	Sample Matrix	% Dry Weight	Exceptions/Comments (other than thermal preservation)
270200.01	5-1	11/16/23	11/16/23 07:00	aqueous		Adheres to Sample Acceptance Policy
270200.02	5-2	11/16/23	11/16/23 07:00	aqueous		Adheres to Sample Acceptance Policy
270200.03	5-3	11/16/23	11/16/23 07:00	aqueous		Adheres to Sample Acceptance Policy
270200.04	5-4	11/16/23	11/16/23 07:00	aqueous		Adheres to Sample Acceptance Policy
270200.05	5-5	11/16/23	11/16/23 07:00	aqueous		Adheres to Sample Acceptance Policy
270200.06	5-6	11/16/23	11/16/23 07:00	aqueous		Adheres to Sample Acceptance Policy
270200.07	5-7	11/16/23	11/16/23 07:00	aqueous		Adheres to Sample Acceptance Policy
270200.08	5-8	11/16/23	11/16/23 07:00	aqueous		Adheres to Sample Acceptance Policy
270200.09	5-9	11/16/23	11/16/23 07:00	aqueous		Adheres to Sample Acceptance Policy
270200.1	5-10	11/16/23	11/16/23 07:00	aqueous		Adheres to Sample Acceptance Policy
270200.11	5-11	11/16/23	11/16/23 07:00	aqueous		Adheres to Sample Acceptance Policy
270200.12	5-12	11/16/23	11/16/23 07:00	aqueous		Adheres to Sample Acceptance Policy

All results contained in this report relate only to the above listed samples.

Unless otherwise noted:

- *Hold times, preservation, container types, and sample conditions adhered to EPA Protocol.*
- *Solid samples are reported on a dry weight basis, unless otherwise noted. pH/Corrosivity, Flashpoint, Ignitability, Paint Filter, Conductivity and Specific Gravity are always reported on an "as received" basis.*
- *Analysis of pH, Total Residual Chlorine, Dissolved Oxygen and Sulfite were performed at the laboratory outside of the recommended 15 minute hold time.*
- *Samples collected by Eastern Analytical, Inc. (EAI) were collected in accordance with approved EPA procedures.*

LABORATORY REPORT

EAI ID#: **270200**

Client: **Underwood Engineers**

Client Designation: **Epping WWTF, Epping NH / UE Job 2987-01**

Sample ID: 5-1

Lab Sample ID: 270200.01
Matrix: aqueous
Date Sampled: 11/16/23
Date Received: 11/16/23

		Analytical Matrix	Units	Analysis Date	Analysis Time	Method	Analyst
Solids Suspended	**260**	AqTot	mg/L	11/17/23	16:00	2540D-11	ABL
Solids Volatile Suspended	**250**	AqTot	mg/L	11/17/23	16:00	2540E-11	ABL

Sample ID: 5-2

Lab Sample ID: 270200.02
Matrix: aqueous
Date Sampled: 11/16/23
Date Received: 11/16/23

		Analytical Matrix	Units	Analysis Date	Analysis Time	Method	Analyst
Ammonia-N	**39**	AqTot	mg/L	11/28/23	13:00	TM NH3	GRS
TKN	**58**	AqTot	mg/L	11/27/23	16:04	$4500N_{org}C$	GRS
Total Phosphorus-P	**7.1**	AqTot	mg/L	11/22/23	14:18	365.1	PHA
COD	**690**	AqTot	mg/L	11/21/23	8:40	H8000	JCS

LABORATORY REPORT

EAI ID#: **270200**

Client: **Underwood Engineers**

Client Designation: **Epping WWTF, Epping NH / UE Job 2987-01**

Sample ID: 5-3

Lab Sample ID: 270200.03
Matrix: aqueous
Date Sampled: 11/16/23
Date Received: 11/16/23

		Analytical Matrix	Units	Analysis Date	Analysis Time	Method	Analyst
BOD	**350**	AqTot	mg/L	11/17/23	10:16	5210B-11	PEN

Sample ID: 5-4

Lab Sample ID: 270200.04
Matrix: aqueous
Date Sampled: 11/16/23
Date Received: 11/16/23

		Analytical Matrix	Units	Analysis Date	Analysis Time	Method	Analyst
Ammonia-N GF	**39**	AqDis	mg/L	11/28/23	13:02	TM NH3	GRS
TKNGF	**45**	AqDis	mg/L	11/27/23	16:07	$4500N_{org}C$	SEL
CODGF	**250**	AqDis	mg/L	11/21/23	12:55	H8000	JCS

The designation of GF after the analysis indicates that it was filtered through a 1.5 micron glass fiber filter prior to analysis.

LABORATORY REPORT

EAI ID#: **270200**

Client: **Underwood Engineers**

Client Designation: **Epping WWTF, Epping NH / UE Job 2987-01**

Sample ID: 5-5

Lab Sample ID: 270200.05
Matrix: aqueous
Date Sampled: 11/16/23
Date Received: 11/16/23

		Analytical Matrix	Units	Analysis Date	Analysis Time	Method	Analyst
BODGF	**170**	AqDis	mg/L	11/17/23	10:16	5210B-01	GRS

Sample ID: 5-6

Lab Sample ID: 270200.06
Matrix: aqueous
Date Sampled: 11/16/23
Date Received: 11/16/23

		Analytical Matrix	Units	Analysis Date	Analysis Time	Method	Analyst
Alkalinity Total (CaCO3)	**240**	AqTot	mg/L	11/21/23	9:27	2320B-11	BAF

The designation of GF after the analysis indicates that it was filtered through a 1.5 micron glass fiber filter prior to analysis.

LABORATORY REPORT

EAI ID#: **270200**

Client: **Underwood Engineers**

Client Designation: **Epping WWTF, Epping NH / UE Job 2987-01**

Sample ID: 5-7

Lab Sample ID: 270200.07
Matrix: aqueous
Date Sampled: 11/16/23
Date Received: 11/16/23

		Analytical Matrix	Units	Analysis Date	Analysis Time	Method	Analyst
Ortho Phosphate-P	**4.3**	AqDis	mg/L	11/17/23	11:06	365.1	SEL

Sample ID: 5-8

Lab Sample ID: 270200.08
Matrix: aqueous
Date Sampled: 11/16/23
Date Received: 11/16/23

		Analytical Matrix	Units	Analysis Date	Analysis Time	Method	Analyst
CODGF	**190**	AqDis	mg/L	11/21/23	12:55	H8000	JCS

The designation of GF after the analysis indicates that it was filtered through a 1.5 micron glass fiber filter prior to analysis.

LABORATORY REPORT

EAI ID#: **270200**

Client: **Underwood Engineers**

Client Designation: **Epping WWTF, Epping NH / UE Job 2987-01**

Sample ID: 5-9

Lab Sample ID: 270200.09
Matrix: aqueous
Date Sampled: 11/16/23
Date Received: 11/16/23

		Analytical Matrix	Units	Analysis Date	Analysis Time	Method	Analyst
Ammonia-N	**0.24**	AqTot	mg/L	11/28/23	13:05	TM NH3	GRS
TKN	**0.74**	AqTot	mg/L	11/27/23	16:10	$4500N_{org}C$	GRS
COD	**21**	AqTot	mg/L	11/21/23	8:40	H8000	JCS

Sample ID: 5-10

Lab Sample ID: 270200.1
Matrix: aqueous
Date Sampled: 11/16/23
Date Received: 11/16/23

		Analytical Matrix	Units	Analysis Date	Analysis Time	Method	Analyst
CODGF	**18**	AqDis	mg/L	11/21/23	12:55	H8000	JCS

The designation of GF after the analysis indicates that it was filtered through a 1.5 micron glass fiber filter prior to analysis.

LABORATORY REPORT

EAI ID#: **270200**

Client: **Underwood Engineers**

Client Designation: **Epping WWTF, Epping NH / UE Job 2987-01**

Sample ID: 5-11

Lab Sample ID: 270200.11
Matrix: aqueous
Date Sampled: 11/16/23
Date Received: 11/16/23

		Analytical Matrix	Units	Analysis Date	Analysis Time	Method	Analyst
Nitrite-N	< 0.5	AqTot	mg/L	11/17/23	9:49	353.2	ALS
Nitrate-N	< 0.5	AqTot	mg/L	11/17/23	9:49	353.2	ALS

Sample ID: 5-12

Lab Sample ID: 270200.12
Matrix: aqueous
Date Sampled: 11/16/23
Date Received: 11/16/23

		Analytical Matrix	Units	Analysis Date	Analysis Time	Method	Analyst
Nitrite-N	< 0.5	AqTot	mg/L	11/17/23	10:05	353.2	ALS
Nitrate-N	**17**	AqTot	mg/L	11/17/23	10:05	353.2	ALS

QC REPORT

EAI ID#: **270200**

Client: **Underwood Engineers**

Client Designation: **Epping WWTF, Epping NH / UE Job 2987-01**

Parameter Name	Blank	LCS	LCSD	Units	Date of Analysis	Limits	RPD	Method
Solids Suspended	< 5	870 (94 %R)		mg/L	11/17/23	85 - 115		2540D-11
Solids Volatile Suspended	< 5	280 (99 %R)		mg/L	11/17/23	85 - 115		2540E-11
Nitrite-N	< 0.5	5.3 (107 %R)	5.3 (107 %R) (0 RPD)	mg/L	11/17/23	90 - 110	20	353.2
Nitrate-N	< 0.5	5.2 (104 %R)	5.2 (103 %R) (1 RPD)	mg/L	11/17/23	90 - 110	20	353.2
Alkalinity Total (CaCO3)	< 1	11 (108 %R)	9.8 (98 %R) (9 RPD)	mg/L	11/21/23	85 - 115	20	2320B-11
Ammonia-N	< 0.05	2.0 (100 %R)	2.0 (99 %R) (1 RPD)	mg/L	11/28/23	87 - 104	20	TM NH3-001
TKN	< 0.5	9.8 (98 %R)	9.8 (98 %R) (1 RPD)	mg/L	11/27/23	90 - 111	20	4500N_{org}C/NH3D-11
Total Phosphorus-P	< 0.01	0.30 (99 %R)	0.30 (101 %R) (2 RPD)	mg/L	11/22/23	90 - 110	20	365.1
Ortho Phosphate-P	< 0.01	0.31 (105 %R)	0.32 (105 %R) (0 RPD)	mg/L	11/17/23	90 - 110	20	365.1
BOD	< 6	210 (108 %R)	220 (109 %R) (1 RPD)	mg/L	11/17/23	84 - 115	20	5210B-11
COD	< 10	94 (94 %R)	99 (99 %R) (5 RPD)	mg/L	11/21/23	85 - 115	20	H8000
CODGF	< 10	100 (101 %R)	100 (102 %R) (1 RPD)	mg/L	11/21/23	85 - 115	20	H8000

*/! Flagged analyte recoveries deviated from the QA/QC limits. Unless noted, flagged data does not impact the sample data.

Raw Data

EAI ID#: **270200**

Client:

Client Designation: **Epping WWTF, Epping NH / UE Job 2987-01**

EAI ID#	Sample ID	Parameter	Raw Data	RepValue	DilFac	DL	Units	Date/Time Analyzed	Matrix	Method
270200.01	5-1	Solids Suspended	260	260	1	5	mg/L	11/17/202 16:00	AqTot	2540D-11
270200.01	5-1	Solids Volatile Suspended	246.7	250	1	5	mg/L	11/17/202 16:00	AqTot	2540E-11

CHAIN-OF-CUSTODY RECORD

BOLD FIELDS REQUIRED. PLEASE CIRCLE REQUESTED ANALYSIS.

270200

SAMPLE I.D.	SAMPLING DATE/TIME *IF COMPOSITE, INDICATE BOTH START & FINISH DATE/TIME	MATRIX (SEE BELOW)	GRAB/*COMPOSITE	VOC: 524.2 / 524.2 MTBE ONLY	VOC: 8260B 624 VTICs 1,4 DIOXANE	VOC: 8021B	VOC: 8015B GRO MAVPH	SVOC: 8270D 625 ABN PAH EDB DBCP	SVOC: TPH8100 L1 L2	SVOC: 8015B DRO MAEPH	SVOC: PEST 608 PCB 608 PEST 8081A PCB 8082	SVOC: OIL & GREASE 1664 TPH 1664	TCLP: TCLP 1311 ABN METALS VOC PEST HERB	INORGANICS: BOD CBOD TS TSS TDS	INORGANICS: Br Cl F SO_4 NO_2 NO_3 NO_2NO_3	INORGANICS: TKN NH_3 TN T. PHOS. O. PHOS.	INORGANICS: pH T. RES. CHLORINE SPEC. CON. T. ALK.	INORGANICS: COD PHENOLS TOC DOC	INORGANICS: TOTAL CYANIDE TOTAL SULFIDE	INORGANICS: REACTIVE CYANIDE REACTIVE SULFIDE FLASHPOINT IGNITABILITY	MICRO: TOTAL COLIFORM E. COLI FECAL COLIFORM	MICRO: ENTEROCOCCI HETEROTROPHIC PLATE COUNT	METALS: DISSOLVED METALS (LIST BELOW)	METALS: TOTAL METALS (LIST BELOW)	OTHER	OTHER	OTHER	OTHER	# OF CONTAINERS	NOTES MeOH VIAL #
S-1	11/15 7am - 11/16 7am	WW	C											✓																Influent TSS/VSS
S-2																✓		✓												Influent COD/TKN/NH_3/T
S-3														✓																Influent BOD
S-4																✓		✓												Influent Solub COD/TKN/NH_3
S-5														✓																Influent Soluble BOD
S-6																	✓													Influent Alkalinity
S-7																✓														Influent O. Phos
S-8																		✓												Influent Floc. Filter C
S-9																✓		✓												Effluent COD/TKN/NH
S-10																		✓												Effluent Floc Filtered COD

MATRIX: A-AIR; S-SOIL; GW-GROUND WATER; SW-SURFACE WATER; DW-DRINKING WATER; WW-WASTE WATER

PRESERVATIVE: H-HCL; N-HNO_3; S-H_2SO_4; Na-NaOH; M-MEOH

PROJECT MANAGER: Steve Clifton, Stephen Smith

COMPANY: Underwood Engineers

ADDRESS: 25 Vaughan Mall

CITY: Portsmouth STATE: NH ZIP: 03801

PHONE: Smith 603-854-3236; Clifton 603-475-3814 EXT.: ______

E-MAIL: sclifton@underwoodengineers.com; ssmith@underwoodengineers.com

SITE NAME: Epping WWTF, Epping NH

PROJECT #: UE Job 2987-01

STATE: NH MA ME VT OTHER: ______

REGULATORY PROGRAM: NPDES: RGP POTW STORMWATER GWP, OIL FUND BROWNFIELD OTHER: NA process

QUOTE #: 1020770 PO #: ______

QA/QC REPORTING

A B C

MA MCP

TEMP. 1.5 C

ICE? YES NO

REPORTING OPTIONS

PRELIMS: YES OR NO

ELECTRONIC OPTIONS

PDF EXCEL EQUIS

OTHER ______

TURN AROUND TIME

24hr* 48hr*

3 - 4 DAYS*

5 DAY 7 DAY

10 DAY

*Pre-approval Required

SAMPLER(S): Paul Michael Bidondo

Paul M B 11/16/23 10AM

RELINQUISHED BY:	DATE:	TIME:	RECEIVED BY:
	11/16/23	12:15	Shelly
Shelly	11/16/23	13:38	Baj2

METALS: 8 RCRA 13 PP FE, MN PB, CU

OTHER METALS: ______

SAMPLES FIELD FILTERED? ☑ YES ☐ NO

NOTES: (IE: SPECIAL DETECTION LIMITS, BILLING INFO, IF DIFFERENT)

S-2, S-3, S-6 = UE blend

S-8, S-10 = UE 1.5 u field f.

S-7 = UE .45 u field filter

S-9 = MBR effluent (.04 u

SITE HISTORY: ______

SUSPECTED CONTAMINATION: ______

FIELD READINGS: ______

CHAIN-OF-CUSTODY RECORD

BOLD FIELDS REQUIRED. PLEASE CIRCLE REQUESTED ANALYSIS.

270200

SAMPLE I.D.	SAMPLING DATE/TIME *IF COMPOSITE, INDICATE BOTH START & FINISH DATE/TIME	MATRIX (SEE BELOW)	GRAB/*COMPOSITE	INORGANICS: Br Cl F SO4 NO2 NO3 NO3NO2	NOTES MeOH VIAL #
S-11	11/15 7am - 11/16 7am	WW	C	✓	Influent NO3-N/NO2
S-12	↓	↓	↓	✓	Effluent NO3-N/

VOC: 524.2, 524.2 MTBE ONLY; 8260B, 624, VTICs, 1,4 DIOXANE; 8021B; 8015B GRO, MAVPH. SVOC: 8270D, 625, ABN, PAH, EDB, DBCP; TPH8100, L1, L2; 8015B DRO, MAEPH; PEST 608, PCB 608, PEST 8081A, PCB 8082; OIL & GREASE 1664, TPH 1664. TCLP: TCLP 1311, ABN, METALS, VOC, PEST, HERB. INORGANICS: BOD, CBOD, TS, TSS, TDS; Br, Cl, F, SO_4, NO_2, NO_3, NO_3NO_2; TKN, NH_3, TN, T. PHOS., O. PHOS.; pH, T. RES. CHLORINE, SPEC. CON., T. ALK.; COD, PHENOLS, TOC, DOC; TOTAL CYANIDE, TOTAL SULFIDE; REACTIVE CYANIDE, REACTIVE SULFIDE, FLASHPOINT, IGNITABILITY. MICRO: TOTAL COLIFORM, E. COLI, FECAL COLIFORM; ENTEROCOCCI, HETEROTROPHIC PLATE COUNT. METALS: DISSOLVED METALS (LIST BELOW); TOTAL METALS (LIST BELOW). OTHER. # OF CONTAINERS.

MATRIX: A-AIR; S-SOIL; GW-GROUND WATER; SW-SURFACE WATER; DW-DRINKING WATER; WW-WASTE WATER
PRESERVATIVE: H-HCL; N-HNO_3; S-H_2SO_4; Na-NaOH; M-MEOH

PROJECT MANAGER: Steve Clifton, Stephen Smith
COMPANY: Underwood Engineers
ADDRESS: 25 Vaughan Mall
CITY: Portsmouth STATE: NH ZIP: 03801
PHONE: Smith 603-854-3236; Clifton 603-475-3814 EXT.:
E-MAIL: sclifton@underwoodengineers.com; ssmith@underwoodengineers.com
SITE NAME: Epping WWTF, Epping NH
PROJECT #: UE Job 2987-01
STATE: NH MA ME VT OTHER:
REGULATORY PROGRAM: NPDES: RGP POTW STORMWATER GWP, OIL FUND BROWNFIELD OTHER: NA process
QUOTE #: 1020770 PO #:

QA/QC REPORTING: A B C; MA MCP
TEMP. 1.5 C; ICE? YES NO

REPORTING OPTIONS: PRELIMS: YES OR NO
ELECTRONIC OPTIONS: PDF EXCEL EQUIS OTHER

TURN AROUND TIME: 24hr* 48hr*; 3 - 4 DAYS*; 5 DAY 7 DAY; 10 DAY; *Pre-approval Required

METALS: 8 RCRA 13 PP FE, MN PB, C
OTHER METALS:
SAMPLES FIELD FILTERED? ☑ YES ☐ NO
NOTES: (IE: SPECIAL DETECTION LIMITS, BILLING INFO, IF DIFFERENT) *See front

SAMPLER(S): Paul Michael Bidonde

RELINQUISHED BY:	DATE:	TIME:	RECEIVED BY:
Paul Michael B	11/16/23	12:15	Shelly
Shelly	11/16/23	13:38	BAF

SITE HISTORY:
SUSPECTED CONTAMINATION:
FIELD READINGS:

Eastern Analytical, Inc. professional laboratory and drilling services
51 Antrim Avenue | Concord, NH 03301 | Tel: 603.228.0525 | 1.800.287.0525 | E-Mail: CustomerService@EasternAnalytical.com | www.EasternAnalytical.com

(WHITE: Lab Copy GREEN: Customer Copy)

Eastern Analytical, Inc.
professional laboratory and drilling services

Steven Clifton
Underwood Engineers
25 Vaughan Mall, Unit #1
Portsmouth , NH 03801

Laboratory Report for:

Eastern Analytical, Inc. ID: 270340
Client Identification: Epping WWTF, Epping NH | UE Job 2987-01
Date Received: 11/20/2023

Enclosed are the analytical results per the Chain of Custody for sample(s) in the referenced project. All analyses were performed in accordance with our QA/QC Program, NELAP and other applicable state requirements. All quality control criteria was within acceptance criteria unless noted on the report pages. Results are for the exclusive use of the client named on this report and will not be released to a third party without consent.

The following information is contained within this report: Sample Conditions summary, Analytical Results/Data, Quality Control data (if requested) and copies of the Chain of Custody. This report may not be reproduced except in full, without the written approval of the laboratory.

The following standard abbreviations and conventions apply to all EAI reports:
< : "less than" followed by the reporting limit
> : "greater than" followed by the reporting limit
%R : % Recovery

Certifications:
Eastern Analytical, Inc. maintains certification in the following states: Connecticut (PH-0492), Maine (NH005), Massachusetts (M-NH005), New Hampshire/NELAP (1012), Rhode Island (269), Vermont (VT1012), New York (12072) and West Virginia (9910C). Please refer to our website at www.easternanalytical.com for a copy of our certificates and accredited parameters.

References:
- EPA 600/4-79-020, 1983
- Standard Methods for Examination of Water and Wastewater, 20th, 21st, 22nd & 23rd edition or noted revision year.
- Test Methods for Evaluating Solid Waste SW 846 3rd Edition including updates IVA and IVB
- Hach Water Analysis Handbook, 4th edition, 1992
- ASTM International

If you have any questions regarding the results contained within, please feel free to contact customer service. Unless otherwise requested, we will dispose of the sample(s) 6 weeks from the sample receipt date.

We appreciate this opportunity to be of service and look forward to your continued patronage.

Sincerely,

Lorraine Olashaw, Lab Director — Date: 12·4·23

SAMPLE CONDITIONS PAGE

EAI ID#: **270340**

Client: **Underwood Engineers**

Client Designation: **Epping WWTF, Epping NH | UE Job 2987-01**

Temperature upon receipt (°C): 2.7

Acceptable temperature range (°C): 0-6

Received on ice or cold packs (Yes/No): Y

Lab ID	Sample ID	Date Received	Date/Time Sampled	Sample Matrix	% Dry Weight	Exceptions/Comments (other than thermal preservation)
270340.01	6-1	11/20/23	11/18/23 10:00	aqueous		Adheres to Sample Acceptance Policy
270340.02	6-2	11/20/23	11/18/23 10:00	aqueous		Adheres to Sample Acceptance Policy
270340.03	6-3	11/20/23	11/18/23 10:00	aqueous		Adheres to Sample Acceptance Policy
270340.04	6-4	11/20/23	11/18/23 10:00	aqueous		Adheres to Sample Acceptance Policy
270340.05	6-5	11/20/23	11/18/23 10:00	aqueous		Adheres to Sample Acceptance Policy
270340.06	6-6	11/20/23	11/18/23 10:00	aqueous		Adheres to Sample Acceptance Policy
270340.07	6-7	11/20/23	11/18/23 10:00	aqueous		Adheres to Sample Acceptance Policy
270340.08	6-8	11/20/23	11/18/23 10:00	aqueous		Adheres to Sample Acceptance Policy
270340.09	6-9	11/20/23	11/18/23 10:00	aqueous		Adheres to Sample Acceptance Policy
270340.1	6-10	11/20/23	11/18/23 10:00	aqueous		Adheres to Sample Acceptance Policy
270340.11	6-11	11/20/23	11/18/23 10:00	aqueous		Adheres to Sample Acceptance Policy
270340.12	6-12	11/20/23	11/18/23 10:00	aqueous		Adheres to Sample Acceptance Policy

All results contained in this report relate only to the above listed samples.

Unless otherwise noted:

- *Hold times, preservation, container types, and sample conditions adhered to EPA Protocol.*
- *Solid samples are reported on a dry weight basis, unless otherwise noted. pH/Corrosivity, Flashpoint, Ignitability, Paint Filter, Conductivity and Specific Gravity are always reported on an "as received" basis.*
- *Analysis of pH, Total Residual Chlorine, Dissolved Oxygen and Sulfite were performed at the laboratory outside of the recommended 15 minute hold time.*
- *Samples collected by Eastern Analytical, Inc. (EAI) were collected in accordance with approved EPA procedures.*

LABORATORY REPORT

EAI ID#: **270340**

Client: **Underwood Engineers**

Client Designation: **Epping WWTF, Epping NH | UE Job 2987-01**

Sample ID: 6-1

Lab Sample ID: 270340.01
Matrix: aqueous
Date Sampled: 11/18/23
Date Received: 11/20/23

		Units	Analysis Date	Analysis Time	Method	Analyst
Solids Suspended	**210**	mg/L	11/21/23	15:30	2540D-11	ABL
Solids Volatile Suspended	**210**	mg/L	11/21/23	15:30	2540E-11	ABL

Sample ID: 6-2

Lab Sample ID: 270340.02
Matrix: aqueous
Date Sampled: 11/18/23
Date Received: 11/20/23

		Units	Analysis Date	Analysis Time	Method	Analyst
Ammonia-N	**38**	mg/L	11/30/23	13:18	TM NH3-001	PEN
TKN	**44**	mg/L	11/29/23	17:32	4500N$_{org}$C/NH3D	GRS
Total Phosphorus-P	**6.6**	mg/L	11/22/23	14:23	365.1	PHA
COD	**680**	mg/L	11/21/23	8:40	H8000	JCS

6-1: 37 mL were filtered.

LABORATORY REPORT

EAI ID#: **270340**

Client: **Underwood Engineers**

Client Designation: **Epping WWTF, Epping NH | UE Job 2987-01**

Sample ID: 6-3

Lab Sample ID: 270340.03

Matrix: aqueous

Date Sampled: 11/18/23

Date Received: 11/20/23

		Units	Analysis Date	Analysis Time	Method	Analyst
BOD	**360**	mg/L	11/20/23	9:20	5210B-11	ABL

Sample ID: 6-4

Lab Sample ID: 270340.04

Matrix: aqueous

Date Sampled: 11/18/23

Date Received: 11/20/23

		Units	Analysis Date	Analysis Time	Method	Analyst
Ammonia-N GF	**40**	mg/L	11/30/23	13:21	TM NH3-001	PEN
TKNGF	**46**	mg/L	11/29/23	17:29	4500N_{org}C/NH3D	GRS
CODGF	**320**	mg/L	11/21/23	12:55	H8000	JCS

The designation of GF after the analysis indicates that it was filtered through a 1.5 micron glass fiber filter prior to analysis.

LABORATORY REPORT

EAI ID#: **270340**

Client: **Underwood Engineers**

Client Designation: **Epping WWTF, Epping NH | UE Job 2987-01**

Sample ID: 6-5

Lab Sample ID:	270340.05
Matrix:	aqueous
Date Sampled:	11/18/23
Date Received:	11/20/23

			Analysis			
		Units	**Date**	**Time**	**Method**	**Analyst**
BODGF	**190**	mg/L	11/20/23	9:29	5210B-01	ABL

Sample ID: 6-6

Lab Sample ID:	270340.06
Matrix:	aqueous
Date Sampled:	11/18/23
Date Received:	11/20/23

			Analysis			
		Units	**Date**	**Time**	**Method**	**Analyst**
Alkalinity Total (CaCO3)	**230**	mg/L	11/21/23	9:27	2320B-11	BAF

The designation of GF after the analysis indicates that it was filtered through a 1.5 micron glass fiber filter prior to analysis.

LABORATORY REPORT

EAI ID#: **270340**

Client: **Underwood Engineers**

Client Designation: **Epping WWTF, Epping NH | UE Job 2987-01**

Sample ID: 6-7

Lab Sample ID: 270340.07
Matrix: aqueous
Date Sampled: 11/18/23
Date Received: 11/20/23

		Units	Analysis Date	Analysis Time	Method	Analyst
Ortho Phosphate-P	**4.2**	mg/L	11/20/23	9:54	365.1	PHA

Sample ID: 6-8

Lab Sample ID: 270340.08
Matrix: aqueous
Date Sampled: 11/18/23
Date Received: 11/20/23

		Units	Analysis Date	Analysis Time	Method	Analyst
CODGF	**220**	mg/L	11/21/23	12:55	H8000	JCS

The designation of GF after the analysis indicates that it was filtered through a 1.5 micron glass fiber filter prior to analysis.

LABORATORY REPORT

EAI ID#: **270340**

Client: **Underwood Engineers**

Client Designation: **Epping WWTF, Epping NH | UE Job 2987-01**

Sample ID: 6-9

Lab Sample ID: 270340.09
Matrix: aqueous
Date Sampled: 11/18/23
Date Received: 11/20/23

		Units	Analysis Date	Analysis Time	Method	Analyst
Ammonia-N	**0.39**	mg/L	11/30/23	13:24	TM NH3-001	PEN
TKN	**1.1**	mg/L	11/29/23	17:50	4500N$_{org}$C/NH3D	GRS
COD	**13**	mg/L	11/21/23	8:40	H8000	JCS

Sample ID: 6-10

Lab Sample ID: 270340.1
Matrix: aqueous
Date Sampled: 11/18/23
Date Received: 11/20/23

		Units	Analysis Date	Analysis Time	Method	Analyst
CODGF	**15**	mg/L	11/21/23	12:55	H8000	JCS

The designation of GF after the analysis indicates that it was filtered through a 1.5 micron glass fiber filter prior to analysis.

LABORATORY REPORT

EAI ID#: **270340**

Client: **Underwood Engineers**
Client Designation: **Epping WWTF, Epping NH | UE Job 2987-01**

				Analysis			
Sample ID:	6-11	6-12					
Lab Sample ID:	270340.11	270340.12					
Matrix:	aqueous	aqueous					
Date Sampled:	11/18/23	11/18/23					
Date Received:	11/20/23	11/20/23	**Units**	**Date**	**Time**	**Method**	**Analyst**
Nitrite-N	< 0.5	< 0.5	mg/L	11/20/23	9:24	353.2	ALS
Nitrate-N	< 0.5	**13**	mg/L	11/20/23	9:24	353.2	ALS

QC REPORT

EAI ID#: **270340**

Client: **Underwood Engineers**

Client Designation: **Epping WWTF, Epping NH | UE Job 2987-01**

Parameter Name	Blank	LCS	LCSD	Units	Date of Analysis	Limits	RPD	Method
Solids Suspended	< 5	870 (94 %R)	860 (93 %R) (1 RPD)	mg/L	11/21/23	85 - 115	20	2540D-11
Solids Volatile Suspended	< 5	280 (98 %R)	NA	mg/L	11/21/23	85 - 115		2540E-11
Nitrite-N	< 0.5	5.4 (107 %R)	5.3 (107 %R) (1 RPD)	mg/L	11/20/23	90 - 110	20	353.2
Nitrate-N	< 0.5	5.0 (101 %R)	5.0 (100 %R) (0 RPD)	mg/L	11/20/23	90 - 110	20	353.2
Alkalinity Total (CaCO3)	< 1	11 (108 %R)	9.8 (98 %R) (9 RPD)	mg/L	11/21/23	85 - 115	20	2320B-11
Ammonia-N	< 0.05	2.0 (101 %R)	2.0 (100 %R) (1 RPD)	mg/L	11/30/23	87 - 104	20	TM NH3-001
TKN	< 0.5	10 (102 %R)	10 (103 %R) (1 RPD)	mg/L	11/29/23	90 - 111	20	4500N_{org}C/NH3D-11
Total Phosphorus-P	< 0.01	0.30 (99 %R)	0.30 (101 %R) (2 RPD)	mg/L	11/22/23	90 - 110	20	365.1
Ortho Phosphate-P	< 0.01	0.33 (110 %R)	0.33 (110 %R) (0 RPD)	mg/L	11/20/23	90 - 110	20	365.1
BOD	< 6	220 (110 %R)	NA	mg/L	11/20/23	84 - 115		5210B-11
COD	< 10	94 (94 %R)	99 (99 %R) (5 RPD)	mg/L	11/21/23	85 - 115	20	H8000

*/! Flagged analyte recoveries deviated from the QA/QC limits. Unless noted, flagged data does not impact the sample data.

Invoice

270771

Eastern Analytical, Inc.
51 Antrim Avenue
Concord, NH 03301

(603)-228-0525
1-800-287-0525
FAX: (603)-228-4591

Job Description **270340**

Site Name: Epping WWTF, Epping NH | UE Job 2987-01
Contact: Steven Clifton
Date Received: 11/20/2023

Underwood Engineers
25 Vaughan Mall, Unit #1
Portsmouth NH 03801
ATTN: Raoul Maltais

Invoice Date	Your Order Number	Terms
12/4/2023	Verbal	1:Net 30

Quantity	Item Description	Discountable	List Price	Extended Price Gross
1	Solids, Total Suspended	N	30.00	30.00
1	Solids, Volatile Suspended	N	35.00	35.00
2	Nitrite	N	30.00	60.00
2	Nitrate	N	30.00	60.00
1	Alkalinity, Total	N	35.00	35.00
2	Ammonia	N	35.00	70.00
1	Ammonia Soluble (Glass Fiber Filter)	N	50.00	50.00
2	TKN	N	55.00	110.00
1	TKN Soluble Glass Fiber Filter	N	70.00	70.00
1	Total Phosphorus	N	45.00	45.00
1	Phosphate, Ortho	N	50.00	50.00
1	BOD	N	60.00	60.00
1	BOD Soluble Glass Fiber Filter	N	85.00	85.00
2	COD	N	35.00	70.00
3	COD Soluble (Glass Fiber Filter)	N	50.00	150.00

Gross Invoice Amount $980.00

Please pay this amount: **$980.00**

Thank you for this opportunity to be of service

Raw Data

EAI ID#: **270340**

Client:

Client Designation: **Epping WWTF, Epping NH | UE Job 2987-01**

EAI ID#	Sample ID	Parameter	Raw Data	RepValue	DilFac	DL	Units	Date/Time Analyzed	Matrix	Method
270340.01	6-1	Solids Suspended	210.810811	210	1	5	mg/L	11/21/202 15:30	AqTot	2540D-11
270340.01	6-1	Solids Volatile Suspended	205.4	210	1	5	mg/L	11/21/202 15:30	AqTot	2540E-11

Page 1 of 2

Chain-of-Custody Record

Bold Fields Required. Please Circle Requested Analysis.

Foi

270340

Sample I.D.	Sampling Date/Time *If Composite, Indicate Both Start & Finish Date/Time	Matrix (see below)	Grab/*Composite	VOC: 524.2 / 524.2 MTBE ONLY	VOC: 8260B 624 VTICs 1,4 DIOXANE	VOC: 8021B	VOC: 8015B GRO MAVPH	SVOC: 8270D 625 ABN PAH EDB DBCP	SVOC: TPH8100 L1 L2	SVOC: 8015B DRO MAEPH	SVOC: PEST 608 PCB 608 PEST 8081A PCB 8082	SVOC: OIL & GREASE 1664 TPH 1664	TCLP: TCLP 1311 ABN METALS VOC PEST HERB	Inorganics: BOD CBOD TDS TS TSS	Inorganics: Br Cl F SO_4 NO_2 NO_3 NO_2NO_3	Inorganics: TKN NH_3 TN T. PHOS. O. PHOS.	Inorganics: pH T. RES. CHLORINE SPEC. CON. T. ALK.	Inorganics: COD PHENOLS TOC DOC	Inorganics: TOTAL CYANIDE TOTAL SULFIDE	Inorganics: REACTIVE CYANIDE REACTIVE SULFIDE FLASHPOINT IGNITABILITY	Micro: TOTAL COLIFORM E. COLI FECAL COLIFORM	Micro: ENTEROCOCCI HETEROTROPHIC PLATE COUNT	Metals: DISSOLVED METALS (LIST BELOW)	Metals: TOTAL METALS (LIST BELOW)	Other	Other	Other	Other	# of Containers	Notes MeOH Vial #
6-1	10am 11/17 - 10 am 11/18	WW	C											✓																Inf TSS/VSS
6-2																✓		✓												Inf COD/TKN/NH3/TP
6-3														✓																Inf BOD
6-4																✓		✓												Inf soluble COD/TKN/NH3
6-5														✓																Inf soluble BOD
6-6																	✓													Influent Alk.
6-7																✓														Influent O.phos
6-8																		✓												Inf. floc. filtered COD
6-9																✓		✓												Eff COD/TKN/NH3
6-10	↓	↓	↓															✓												Eff floc filtered COD

Matrix: A-Air; S-Soil; GW-Ground Water; SW-Surface Water; DW-Drinking Water; WW-Waste water

Preservative: H-HCL; N-HNO_3; S-H_2SO_4; Na-NaOH; M-MEOH

Project Manager: Steve Clifton, Stephen Smith
Company: Underwood Engineers
Address: 25 Vaughan Mall
City: Portsmouth State: NH Zip: 03801
Phone: Smith 603-854-3236; Clifton 603-475-3814 Ext.:
E-Mail: sclifton@underwoodengineers.com; ssmith@underwoodengineers.com
Site Name: Epping WWTF, Epping NH
Project #: UE Job 2987-01
State: NH MA ME VT Other:
Regulatory Program: NPDES: RGP POTW STORMWATER GWP, OIL FUND BROWNFIELD Other: NA process
Quote #: 1020770 PO #:

QA/QC Reporting
A B C
MA MCP
Temp. 2.7 C
Ice? Yes No

Reporting Options
Prelims: YES or NO

Electronic Options
PDF EXCEL
EQUIS
Other

Turn Around Time
24hr* 48hr*
3 - 4 Days*
5 Day 7 Day
10 Day
*Pre-approval Required

Metals: 8 RCRA 13 PP FE, MN PB, CU
Other Metals:
Samples Field Filtered? ☑ Yes ☐ No
Notes: (ie: Special Detection Limits, Billing Info, If Different)
6-2, 6-3, 6-6 = UE blend
6-8, 6-10 = UE 1.5μ filter
6-7 = UE .45μ filter
6-9 = MBR effluent (.04μ)
*6-4, 6-5 = EAI 1.5μ lab filter
Site History:
Suspected Contamination:
Field Readings:

Sampler(s): Paul Michael Biodode

Relinquished By:	Date:	Time:	Received By:
[signature]	11/18/23	1:30pm	[signature]
[signature]	11/20/23	08:00	[signature]

Eastern Analytical, Inc.
professional laboratory and drilling services

51 Antrim Avenue | Concord, NH 03301 | Tel: 603.228.0525 | 1.800.287.0525 | E-Mail: CustomerService@EasternAnalytical.com | www.EasternAnalytical.com

(WHITE: Lab Copy GREEN: Customer Copy)

For l

CHAIN-OF-CUSTODY RECORD

BOLD FIELDS REQUIRED. PLEASE CIRCLE REQUESTED ANALYSIS.

270340

Sample I.D.	Sampling Date/Time *If Composite, Indicate Both Start & Finish Date/Time	Matrix (see below)	Grab/*Composite	VOC: 524.2 / 524.2 MTBE ONLY	VOC: 8260B 624 VTICs 1,4 DIOXANE	VOC: 8021B	VOC: 8015B GRO MAVPH	SVOC: 8270D 625 ABN PAH EDB DBCP	SVOC: TPH8100 L1 L2	SVOC: 8015B DRO MAEPH	SVOC: PEST 608 PCB 608 PEST 8081A PCB 8082	SVOC: OIL & GREASE 1664 TPH 1664	TCLP: TCLP 1311 ABN METALS VOC PEST HERB	Inorganics: BOD CBOD TS TSS TDS	Inorganics: Br Cl F SO_4 NO_2 NO_3 NO_2NO_3	Inorganics: TKN NH_3 TN T. PHOS. O. PHOS.	Inorganics: pH T. RES. CHLORINE SPEC. CON. T. ALK.	Inorganics: COD PHENOLS TOC DOC	Inorganics: TOTAL CYANIDE TOTAL SULFIDE	Inorganics: REACTIVE CYANIDE REACTIVE SULFIDE FLASHPOINT IGNITABILITY	Micro: TOTAL COLIFORM E. COLI FECAL COLIFORM	Micro: ENTEROCOCCI HETEROTROPHIC PLATE COUNT	Metals: DISSOLVED METALS (LIST BELOW)	Metals: TOTAL METALS (LIST BELOW)	Other	Other	Other	Other	# of Containers	Notes MeOH Vial #
6-11	11/17 10am-11/18 10am	WW	C												✓															Inf. NO_2-N/NO_3-N
6-12	↓	↓	↓												✓															Eff. NO_2-N/NO_3-N

MATRIX: A-AIR; S-SOIL; GW-GROUND WATER; SW-SURFACE WATER; DW-DRINKING WATER; WW-WASTE WATER

PRESERVATIVE: H-HCL; N-HNO_3; S-H_2SO_4; Na-NaOH; M-MEOH

PROJECT MANAGER: Steve Clifton, Stephen Smith

COMPANY: Underwood Engineers

ADDRESS: 25 Vaughan Mall

CITY: Portsmouth STATE: NH ZIP: 03801

PHONE: Smith 603-854-3236; Clifton 603-475-3814 EXT.:

E-MAIL: sclifton@underwoodengineers.com; ssmith@underwoodengineers.com

SITE NAME: Epping WWTF, Epping NH

PROJECT #: UE Job 2987-01

STATE: NH MA ME VT OTHER:

REGULATORY PROGRAM: NPDES: RGP POTW STORMWATER GWP, OIL FUND BROWNFIELD OTHER: NA process

QUOTE #: 1020770 PO #:

QA/QC REPORTING

A B C

MA MCP

TEMP. 2.7 C

ICE? YES NO

REPORTING OPTIONS

PRELIMS: YES OR NO

ELECTRONIC OPTIONS

PDF EXCEL EQUIS

OTHER

TURN AROUND TIME

24hr* 48hr*

3 - 4 DAYS*

5 DAY 7 DAY

10 DAY

*Pre-approval Required

SAMPLER(S): Paul Michael Bidonde

RELINQUISHED BY: Paul Michael Bidonde DATE: 11/18/23 TIME: RECEIVED BY:

RELINQUISHED BY: FVidse DATE: 11/20/23 TIME: 08:00 RECEIVED BY: BAF

RELINQUISHED BY: DATE: TIME: RECEIVED BY:

METALS: 8 RCRA 13 PP FE, MN PB, CU

OTHER METALS:

SAMPLES FIELD FILTERED? ☑ YES ☐ NO

NOTES: (IE: SPECIAL DETECTION LIMITS, BILLING INFO, IF DIFFERENT)

See front

SITE HISTORY:

SUSPECTED CONTAMINATION:

FIELD READINGS:

Eastern Analytical, Inc.

professional laboratory and drilling services

Steven Clifton
Underwood Engineers
25 Vaughan Mall, Unit #1
Portsmouth , NH 03801

NELAP ACCREDITED TNI LABORATORY

Laboratory Report for:

Eastern Analytical, Inc. ID: 270341
Client Identification: Epping WWTF, Epping NH | UE Job 2987-01
Date Received: 11/20/2023

Enclosed are the analytical results per the Chain of Custody for sample(s) in the referenced project. All analyses were performed in accordance with our QA/QC Program, NELAP and other applicable state requirements. All quality control criteria was within acceptance criteria unless noted on the report pages. Results are for the exclusive use of the client named on this report and will not be released to a third party without consent.

The following information is contained within this report: Sample Conditions summary, Analytical Results/Data, Quality Control data (if requested) and copies of the Chain of Custody. This report may not be reproduced except in full, without the written approval of the laboratory.

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< : "less than" followed by the reporting limit
> : "greater than" followed by the reporting limit
%R : % Recovery

Certifications:
Eastern Analytical, Inc. maintains certification in the following states: Connecticut (PH-0492), Maine (NH005), Massachusetts (M-NH005), New Hampshire/NELAP (1012), Rhode Island (269), Vermont (VT1012), New York (12072) and West Virginia (9910C). Please refer to our website at www.easternanalytical.com for a copy of our certificates and accredited parameters.

References:

- EPA 600/4-79-020, 1983
- Standard Methods for Examination of Water and Wastewater, 20th, 21st, 22nd & 23rd edition or noted revision year.
- Test Methods for Evaluating Solid Waste SW 846 3rd Edition including updates IVA and IVB
- Hach Water Analysis Handbook, 4th edition, 1992
- ASTM International

If you have any questions regarding the results contained within, please feel free to contact customer service. Unless otherwise requested, we will dispose of the sample(s) 6 weeks from the sample receipt date.

We appreciate this opportunity to be of service and look forward to your continued patronage.

Sincerely,

Jenna L Smith for 12·4·23

Lorraine Olashaw, Lab Director Date

SAMPLE CONDITIONS PAGE

EAI ID#: **270341**

Client: **Underwood Engineers**

Client Designation: **Epping WWTF, Epping NH | UE Job 2987-01**

Temperature upon receipt (°C): 2.7

Acceptable temperature range (°C): 0-6

Received on ice or cold packs (Yes/No): Y

Lab ID	Sample ID	Date Received	Date/Time Sampled	Sample Matrix	% Dry Weight	Exceptions/Comments (other than thermal preservation)
270341.01	7-1	11/20/23	11/20/23 05:30	aqueous		Adheres to Sample Acceptance Policy
270341.02	7-2	11/20/23	11/20/23 05:30	aqueous		Adheres to Sample Acceptance Policy
270341.03	7-3	11/20/23	11/20/23 05:30	aqueous		Adheres to Sample Acceptance Policy
270341.04	7-4	11/20/23	11/20/23 05:30	aqueous		Adheres to Sample Acceptance Policy
270341.05	7-5	11/20/23	11/20/23 05:30	aqueous		Adheres to Sample Acceptance Policy
270341.06	7-6	11/20/23	11/20/23 05:30	aqueous		Adheres to Sample Acceptance Policy
270341.07	7-7	11/20/23	11/20/23 05:30	aqueous		Adheres to Sample Acceptance Policy
270341.08	7-8	11/20/23	11/20/23 05:30	aqueous		Adheres to Sample Acceptance Policy
270341.09	7-9	11/20/23	11/20/23 05:30	aqueous		Adheres to Sample Acceptance Policy
270341.1	7-10	11/20/23	11/20/23 05:30	aqueous		Adheres to Sample Acceptance Policy
270341.11	7-11	11/20/23	11/20/23 05:30	aqueous		Adheres to Sample Acceptance Policy
270341.12	7-12	11/20/23	11/20/23 05:30	aqueous		Adheres to Sample Acceptance Policy

All results contained in this report relate only to the above listed samples.

Unless otherwise noted:

- *Hold times, preservation, container types, and sample conditions adhered to EPA Protocol.*
- *Solid samples are reported on a dry weight basis, unless otherwise noted. pH/Corrosivity, Flashpoint, Ignitability, Paint Filter, Conductivity and Specific Gravity are always reported on an "as received" basis.*
- *Analysis of pH, Total Residual Chlorine, Dissolved Oxygen and Sulfite were performed at the laboratory outside of the recommended 15 minute hold time.*
- *Samples collected by Eastern Analytical, Inc. (EAI) were collected in accordance with approved EPA procedures.*

LABORATORY REPORT

EAI ID#: **270341**

Client: **Underwood Engineers**

Client Designation: **Epping WWTF, Epping NH | UE Job 2987-01**

Sample ID: 7-1

Lab Sample ID:	270341.01
Matrix:	aqueous
Date Sampled:	11/20/23
Date Received:	11/20/23

		Units	Analysis Date	Analysis Time	Method	Analyst
Solids Suspended	**210**	mg/L	11/21/23	15:30	2540D-11	ABL
Solids Volatile Suspended	**200**	mg/L	11/21/23	15:30	2540E-11	ABL

Sample ID: 7-2

Lab Sample ID:	270341.02
Matrix:	aqueous
Date Sampled:	11/20/23
Date Received:	11/20/23

		Units	Analysis Date	Analysis Time	Method	Analyst
Ammonia-N	**38**	mg/L	11/30/23	13:27	TM NH3-001	PEN
TKN	**44**	mg/L	11/29/23	17:53	$4500N_{org}C/NH3D$	GRS
Total Phosphorus-P	**6.7**	mg/L	11/22/23	14:24	365.1	PHA
COD	**700**	mg/L	11/21/23	8:40	H8000	JCS

7-1: 50 mL were filtered.

LABORATORY REPORT

EAI ID#: **270341**

Client: **Underwood Engineers**

Client Designation: **Epping WWTF, Epping NH | UE Job 2987-01**

Sample ID: 7-3

Lab Sample ID:	270341.03
Matrix:	aqueous
Date Sampled:	11/20/23
Date Received:	11/20/23

		Units	Analysis Date	Analysis Time	Method	Analyst
BOD	**420**	mg/L	11/20/23	9:49	5210B-11	ABL

Sample ID: 7-4

Lab Sample ID:	270341.04
Matrix:	aqueous
Date Sampled:	11/20/23
Date Received:	11/20/23

		Units	Analysis Date	Analysis Time	Method	Analyst
Ammonia-N GF	**39**	mg/L	11/30/23	13:30	TM NH3-001	PEN
TKNGF	**44**	mg/L	11/29/23	17:56	$4500N_{org}C$/NH3D	GRS
CODGF	**390**	mg/L	11/21/23	12:55	H8000	JCS

The designation of GF after the analysis indicates that it was filtered through a 1.5 micron glass fiber filter prior to analysis.

LABORATORY REPORT

EAI ID#: **270341**

Client: **Underwood Engineers**

Client Designation: **Epping WWTF, Epping NH | UE Job 2987-01**

Sample ID: 7-5

Lab Sample ID: 270341.05
Matrix: aqueous
Date Sampled: 11/20/23
Date Received: 11/20/23

		Units	Analysis Date	Analysis Time	Method	Analyst
BODGF	**220**	mg/L	11/20/23	9:54	5210B-01	ABL

Sample ID: 7-6

Lab Sample ID: 270341.06
Matrix: aqueous
Date Sampled: 11/20/23
Date Received: 11/20/23

		Units	Analysis Date	Analysis Time	Method	Analyst
Alkalinity Total (CaCO3)	**230**	mg/L	11/21/23	9:27	2320B-11	BAF

The designation of GF after the analysis indicates that it was filtered through a 1.5 micron glass fiber filter prior to analysis.

LABORATORY REPORT

EAI ID#: **270341**

Client: **Underwood Engineers**

Client Designation: **Epping WWTF, Epping NH | UE Job 2987-01**

Sample ID: 7-7

Lab Sample ID: 270341.07
Matrix: aqueous
Date Sampled: 11/20/23
Date Received: 11/20/23

		Units	Analysis Date	Analysis Time	Method	Analyst
Ortho Phosphate-P	**4.4**	mg/L	11/20/23	9:57	365.1	PHA

Sample ID: 7-8

Lab Sample ID: 270341.08
Matrix: aqueous
Date Sampled: 11/20/23
Date Received: 11/20/23

		Units	Analysis Date	Analysis Time	Method	Analyst
CODGF	**250**	mg/L	11/21/23	12:55	H8000	JCS

The designation of GF after the analysis indicates that it was filtered through a 1.5 micron glass fiber filter prior to analysis.

LABORATORY REPORT

EAI ID#: **270341**

Client: **Underwood Engineers**

Client Designation: **Epping WWTF, Epping NH | UE Job 2987-01**

Sample ID: 7-9

Lab Sample ID:	270341.09
Matrix:	aqueous
Date Sampled:	11/20/23
Date Received:	11/20/23

		Units	Analysis Date	Analysis Time	Method	Analyst
Ammonia-N	**0.39**	mg/L	11/30/23	13:33	TM NH3-001	PEN
TKN	**1.1**	mg/L	11/29/23	17:59	4500N_{org}C/NH3D	GRS
COD	**17**	mg/L	11/21/23	8:40	H8000	JCS

Sample ID: 7-10

Lab Sample ID:	270341.1
Matrix:	aqueous
Date Sampled:	11/20/23
Date Received:	11/20/23

		Units	Analysis Date	Analysis Time	Method	Analyst
CODGF	**22**	mg/L	11/21/23	12:55	H8000	JCS

The designation of GF after the analysis indicates that it was filtered through a 1.5 micron glass fiber filter prior to analysis.

LABORATORY REPORT

EAI ID#: **270341**

Client: **Underwood Engineers**

Client Designation: **Epping WWTF, Epping NH | UE Job 2987-01**

Sample ID:	7-11	7-12						
Lab Sample ID:	270341.11	270341.12						
Matrix:	aqueous	aqueous						
Date Sampled:	11/20/23	11/20/23			Analysis			
Date Received:	11/20/23	11/20/23		**Units**	**Date**	**Time**	**Method**	**Analyst**
Nitrite-N	< 0.5	< 0.5		mg/L	11/20/23	9:32	353.2	ALS
Nitrate-N	< 0.5	**6.3**		mg/L	11/20/23	9:32	353.2	ALS

QC REPORT

EAI ID#: **270341**

Client: **Underwood Engineers**

Client Designation: **Epping WWTF, Epping NH | UE Job 2987-01**

Parameter Name	Blank	LCS	LCSD	Units	Date of Analysis	Limits	RPD	Method
Solids Suspended	< 5	870 (94 %R)	860 (93 %R) (1 RPD)	mg/L	11/21/23	85 - 115	20	2540D-11
Solids Volatile Suspended	< 5	280 (98 %R)	NA	mg/L	11/21/23	85 - 115		2540E-11
Nitrite-N	< 0.5	5.4 (107 %R)	5.3 (107 %R) (1 RPD)	mg/L	11/20/23	90 - 110	20	353.2
Nitrate-N	< 0.5	5.0 (101 %R)	5.0 (100 %R) (0 RPD)	mg/L	11/20/23	90 - 110	20	353.2
Alkalinity Total (CaCO3)	< 1	11 (108 %R)	9.8 (98 %R) (9 RPD)	mg/L	11/21/23	85 - 115	20	2320B-11
Ammonia-N	< 0.05	2.0 (101 %R)	2.0 (100 %R) (1 RPD)	mg/L	11/30/23	87 - 104	20	TM NH3-001
TKN	< 0.5	10 (102 %R)	10 (103 %R) (1 RPD)	mg/L	11/29/23	90 - 111	20	4500N_{org}C/NH3D-11
Total Phosphorus-P	< 0.01	0.30 (99 %R)	0.30 (101 %R) (2 RPD)	mg/L	11/22/23	90 - 110	20	365.1
Ortho Phosphate-P	< 0.01	0.33 (110 %R)	0.33 (110 %R) (0 RPD)	mg/L	11/20/23	90 - 110	20	365.1
BOD	< 6	220 (110 %R)	NA	mg/L	11/20/23	84 - 115		5210B-11
COD	< 10	94 (94 %R)	99 (99 %R) (5 RPD)	mg/L	11/21/23	85 - 115	20	H8000

*/! Flagged analyte recoveries deviated from the QA/QC limits. Unless noted, flagged data does not impact the sample data.

Raw Data

EAI ID#: **270341**

Client:

Client Designation: **Epping WWTF, Epping NH | UE Job 2987-01**

EAI ID#	Sample ID	Parameter	Raw Data	RepValue	DilFac	DL	Units	Date/Time Analyzed	Matrix	Method
270341.01	7-1	Solids Suspended	208	210	1	5	mg/L	11/21/202 15:30	AqTot	2540D-11
270341.01	7-1	Solids Volatile Suspended	200	200	1	5	mg/L	11/21/202 15:30	AqTot	2540E-11

Chain-of-Custody Record

Bold Fields Required. Please Circle Requested Analysis.

270341

Sample I.D.	Sampling Date/Time *If Composite, Indicate Both Start & Finish Date/Time	Matrix (see below)	Grab/*Composite	VOC: 524.2 / 524.2 MTBE ONLY	VOC: 8260B 624 VTICs 1,4 DIOXANE	VOC: 8021B	VOC: 8015B GRO MAVPH	SVOC: 8270D 625 ABN PAH EDB DBCP	SVOC: TPH8100 L1 L2	SVOC: 8015B DRO MAEPH	SVOC: PEST 608 PCB 608 PEST 8081A PCB 8082	SVOC: OIL & GREASE 1664 TPH 1664	TCLP: TCLP 1311 ABN METALS VOC PEST HERB	Inorganics: BOD CBOD TS TSS TDS	Inorganics: Br Cl F SO_4 NO_2 NO_3 NO_3NO_2	Inorganics: TKN NH_3 TN T. PHOS. O. PHOS.	Inorganics: pH T. RES. CHLORINE SPEC. CON. T. ALK.	Inorganics: COD PHENOLS TOC DOC	Inorganics: TOTAL CYANIDE TOTAL SULFIDE	Inorganics: REACTIVE CYANIDE REACTIVE SULFIDE FLASHPOINT IGNITABILITY	Micro: TOTAL COLIFORM E. COLI FECAL COLIFORM	Micro: ENTEROCOCCI HETEROTROPHIC PLATE COUNT	Metals: DISSOLVED METALS (LIST BELOW)	Metals: TOTAL METALS (LIST BELOW)	Other	# of Containers	Notes MeOH Vial #
7-1	11/19 5:35am – 11/20 5:30am	WW	*C											✓													Influent TSS/VSS
7-2	↓	↓	↓													✓		✓									Influent COD/ TKN/~~NH3~~ NH3/TP
7-3														✓													Influent BOD
7-4																✓		✓									Influent soluble COD/TKN/NH3
7-5														✓													Influent soluble BOD
7-6																	✓										Influent Alkalinity
7-7																✓											Influent O.Phos
7-8																		✓									Influent floc filtered COD
7-9																✓		✓									Effluent COD/TKN/NH3
7-10	↓	↓	↓															✓									Effluent floc filtered COD

Matrix: A-Air; S-Soil; GW-Ground Water; SW-Surface Water; DW-Drinking Water; WW-Waste Water

Preservative: H-HCL; N-HNO_3; S-H_2SO_4; Na-NaOH; M-MEOH

Project Manager: Steve Clifton, Stephen Smith

Company: Underwood Engineers

Address: 25 Vaughan Mall

City: Portsmouth State: NH Zip: 03801

Phone: Smith 603-854-3236; Clifton 603-475-3814 Ext.:

E-Mail: sclifton@underwoodengineers.com; ssmith@underwoodengineers.com

Site Name: Epping WWTF, Epping NH

Project #: UE Job 2987-01

State: NH MA ME VT Other:

Regulatory Program: NPDES: RGP POTW STORMWATER GWP, OIL FUND BROWNFIELD Other: NA process

Quote #: 1020770 PO #:

QA/QC Reporting

A B C

MA MCP

Temp. 3.7 C

Ice? Yes No

Reporting Options

Prelims: YES or NO

Electronic Options

PDF EXCEL

EQUIS

Other

Turn Around Time

24hr* 48hr*

3 - 4 DAYS*

5 DAY 7 DAY

10 DAY

*Pre-approval Required

Sampler(s): Paul Michael Bidonde

Relinquished By:	Date:	Time:	Received By:
Paul [signature]	11/20/23	7:42am	BAK
[signature]	11/20/23	0800	✓

Metals: 8 RCRA 13 PP FE, MN PB, CU

Other Metals:

Samples Field Filtered? ☑ Yes ☐ No

Notes: (IE: Special Detection Limits, Billing Info, If Different)

7-2, 7-3, 7-6 = UE blend

7-8, 7-10 = UE 1.5u field filter

7-7 = UE .45u field filter

7-9 = MBR effluent (.04u)

7-4, 7-5 = EAI 1.5u lab filter

Site History:

Suspected Contamination:

Field Readings:

Eastern Analytical, Inc. professional laboratory and drilling services

51 Antrim Avenue | Concord, NH 03301 | Tel: 603.228.0525 | 1.800.287.0525 | E-Mail: CustomerService@EasternAnalytical.com | www.EasternAnalytical.com

(WHITE: Lab Copy GREEN: Customer Copy)

Page 2 of 2

CHAIN-OF-CUSTODY RECORD

BOLD FIELDS REQUIRED. PLEASE CIRCLE REQUESTED ANALYSIS.

270341

				VOC				SVOC					TCLP	INORGANICS							MICRO		METALS		OTHER					
SAMPLE I.D.	**SAMPLING DATE/TIME** *IF COMPOSITE, INDICATE BOTH START & FINISH DATE/TIME	**MATRIX (SEE BELOW)**	**GRAB/*COMPOSITE**	524.2 / 524.2 MTBE ONLY	8260B 624 VTICs / 1,4 DIOXANE	8021B	8015B GRO MAVPH	8270D 625 / ABN PAH EDB DBCP	TPH8100 L1 L2	8015B DRO MAEPH	PEST 608 PCB 608 / PEST 8081A PCB 8082	OIL & GREASE 1664 TPH 1664	TCLP 1311 ABN METALS / VOC PEST HERB	BOD CBOD / TS TSS TDS	Br Cl F SO_4 / NO_3 NO_2 NO_2NO_3	TKN NH_3 TN / T. PHOS. O. PHOS.	pH T. RES. CHLORINE / SPEC. CON. T. ALK.	COD PHENOLS TOC DOC	TOTAL CYANIDE TOTAL SULFIDE	REACTIVE CYANIDE REACTIVE SULFIDE / FLASHPOINT IGNITABILITY	TOTAL COLIFORM E. COLI / FECAL COLIFORM	ENTEROCOCCI / HETEROTROPHIC PLATE COUNT	DISSOLVED METALS (LIST BELOW)	TOTAL METALS (LIST BELOW)					# OF CONTAINERS	**NOTES** MeOH VIAL #
7-11	11/19 5:30 am - 11/20 5:30 am	WW	*C												✓															Influent NO2-N / NO3-N
7-12	↓	↓	↓												✓															Effluent NO3-N / NO2-N

MATRIX: A-AIR; S-SOIL; GW-GROUND WATER; SW-SURFACE WATER; DW-DRINKING WATER; WW-WASTE WATER

PRESERVATIVE: H-HCL; N-HNO_3; S-H_2SO_4; Na-NaOH; M-MEOH

PROJECT MANAGER: Steve Clifton, Stephen Smith

COMPANY: Underwood Engineers

ADDRESS: 25 Vaughan Mall

CITY: Portsmouth STATE: NH ZIP: 03801

PHONE: Smith 603-854-3236; Clifton 603-475-3814 EXT.:

E-MAIL: sclifton@underwoodengineers.com; ssmith@underwoodengineers.com

SITE NAME: Epping WWTF, Epping NH

PROJECT #: UE Job 2987-01

STATE: NH MA ME VT OTHER:

REGULATORY PROGRAM: NPDES: RGP POTW STORMWATER

GWP, OIL FUND BROWNFIELD OTHER: NA process

QUOTE #: 1020770 PO #:

QA/QC REPORTING

A B C

MA MCP

TEMP. 2.7 C

ICE? YES NO

REPORTING OPTIONS

PRELIMS: YES OR NO

ELECTRONIC OPTIONS

PDF EXCEL

EQUIS

OTHER

TURN AROUND TIME

24hr* 48hr*

3 - 4 DAYS*

5 DAY 7 DAY

10 DAY

*Pre-approval Required

METALS: 8 RCRA 13 PP FE, MN PB, CU

OTHER METALS:

SAMPLES FIELD FILTERED? ☑ YES ☐ NO

NOTES: (IE: SPECIAL DETECTION LIMITS, BILLING INFO, IF DIFFERENT)

°See front

SAMPLER(S): Paul Michael Bidonde

RELINQUISHED BY:	DATE:	TIME:	RECEIVED BY:
[signature]	11/20/23		FMisc
FMisc	11/20/23	08:00	BAF

SITE HISTORY:

SUSPECTED CONTAMINATION:

FIELD READINGS:

Eastern Analytical, Inc. *professional laboratory and drilling services*

51 Antrim Avenue | Concord, NH 03301 | Tel: 603.228.0525 | 1.800.287.0525 | E-Mail: CustomerService@EasternAnalytical.com | www.EasternAnalytical.com

(WHITE: Lab Copy GREEN: Customer Copy)

Eastern Analytical, Inc.
professional laboratory and drilling services

Steven Clifton
Underwood Engineers
25 Vaughan Mall, Unit #1
Portsmouth , NH 03801

Subject: Laboratory Report

Eastern Analytical, Inc. ID:	271047
Client Identification:	Epping WWTF, Epping NH | UE Job 2987-01
Date Received:	12/6/2023

Dear Mr. Clifton :

Enclosed please find the report of analysis for the above identified project. As discussed, analyses were subcontracted and are listed as follows:

Analysis:	Subcontract - Volatile Fatty Acids (VFAs) ALSNY
Subcontractor Lab:	ALS Environmental

A complete copy of the report is attached. This report may not be reproduced except in full, without the written approval of the laboratory.

We appreciate this opportunity to be of service and look forward to your continued patronage.

Sincerely,

Lorraine Olashaw

Lorraine Olashaw, Lab Director

1-2-24

Date

SAMPLE CONDITIONS PAGE

EAI ID#: **271047**

Client: **Underwood Engineers**

Client Designation: **Epping WWTF, Epping NH | UE Job 2987-01**

Temperature upon receipt (°C): 0.3 **Received on ice or cold packs (Yes/No): Y**

Acceptable temperature range (°C): 0-6

Lab ID	Sample ID	Date Received	Date/Time Sampled	Sample Matrix	% Dry Weight	Exceptions/Comments (other than thermal preservation)
271047.01	8-1	12/6/23	12/5/23 07:00	aqueous		Adheres to Sample Acceptance Policy

All results contained in this report relate only to the above listed samples.

Unless otherwise noted:

- *Hold times, preservation, container types, and sample conditions adhered to EPA Protocol.*
- *Solid samples are reported on a dry weight basis, unless otherwise noted. pH/Corrosivity, Flashpoint, Ignitability, Paint Filter, Conductivity and Specific Gravity are always reported on an "as received" basis.*
- *Analysis of pH, Total Residual Chlorine, Dissolved Oxygen and Sulfite were performed at the laboratory outside of the recommended 15 minute hold time.*
- *Samples collected by Eastern Analytical, Inc. (EAI) were collected in accordance with approved EPA procedures.*

December 28, 2023

Service Request No:R2311390

Eastern Analytical, Inc.
51 Antrim Avenue
Concord, NH 03301

Laboratory Results for: EAI ID # 271047

Dear Customer Service,

Enclosed are the results of the sample(s) submitted to our laboratory December 08, 2023
For your reference, these analyses have been assigned our service request number **R2311390.**

All testing was performed according to our laboratory's quality assurance program and met the requirements of the TNI standards except as noted in the case narrative report. Any testing not included in the lab's accreditation is identified on a Non-Certified Analytes report. All results are intended to be considered in their entirety. ALS Environmental is not responsible for use of less than the complete report. Results apply only to the individual samples submitted to the lab for analysis, as listed in the report. The measurement uncertainty of the results included in this report is within that expected when using the prescribed method(s), and represented by Laboratory Control Sample control limits. Any events, such as QC failures or Holding Time exceedances, which may add to the uncertainty are explained in the report narrative or are flagged with qualifiers. The flags are explained in the Report Qualifiers and Definitions page of this report.

Please contact me if you have any questions. My extension is 7476. You may also contact me via email at Chris.Leavy@alsglobal.com.

Respectfully submitted,

ALS Group USA, Corp. dba ALS Environmental

Christopher Leavy
Project Manager

ADDRESS 1565 Jefferson Road, Building 300, Suite 360, Rochester, NY 14623
PHONE +1 585 288 5380 | FAX +1 585 288 8475
ALS Group USA, Corp.
dba ALS Environmental

ALS Environmental

Narrative Documents

ALS Environmental—Rochester Laboratory
1565 Jefferson Road, Building 300, Suite 360, Rochester, NY 14623
Phone (585) 288-5380 Fax (585) 288-8475
www.alsglobal.com

1565 Jefferson Rd, Building 300, Rochester, NY 14623 | 585-288-5380 | www.alsglobal.com

ALS Environmental

Client: Eastern Analytical, Inc.
Project: EAI ID # 271047
Sample Matrix: Water

Service Request: R2311390
Date Received: 12/08/2023

CASE NARRATIVE

All analyses were performed consistent with the quality assurance program of ALS Environmental. This report contains analytical results for samples for the Tier II level requested by the client.

Sample Receipt:

One water sample was received for analysis at ALS Environmental on 12/08/2023. Any discrepancies upon initial sample inspection are annotated on the sample receipt and preservation form included within this report. The samples were stored at minimum in accordance with the analytical method requirements.

Semivoa GC:

Method Organic Acids, 12/22/2023: The upper control criterion was exceeded for one or more analytes in the Laboratory Control Sample (LCS). There were no detections of the analyte(s) above the MRL in the associated field samples. The error associated with elevated recovery equates to a high bias. The sample data is not significantly affected. No further corrective action was appropriate.

Method Organic Acids, 12/22/2023: The matrix spike recovery of one or more of the spiked analytes was outside of control limits because of matrix interference. Analyte not detected in parent sample. No further corrective action was required.

Approved by CWZ

Date 12/28/2023

SAMPLE DETECTION SUMMARY

This form includes only detections above the reporting levels. For a full listing of sample results, continue to the Sample Results section of this Report.

CLIENT ID: 8-1			Lab ID: R2311390-001			
Analyte	**Results**	**Flag**	**MDL**	**MRL**	**Units**	**Method**
Acetic Acid	37			1.0	mg/L	Organic Acids
Propionic Acid	12			2.0	mg/L	Organic Acids

Sample Receipt Information

ALS Environmental—Rochester Laboratory
1565 Jefferson Road, Building 300, Suite 360, Rochester, NY 14623
Phone (585) 288-5380 Fax (585) 288-8475
www.alsglobal.com

SAMPLE CROSS-REFERENCE

SAMPLE #	CLIENT SAMPLE ID	DATE	TIME
R2311390-001	8-1	12/5/2023	0700

CHAIN-OF-CUSTODY RECORD

Eastern Analytical, Inc.
professional laboratory and drilling services

EAI ID# **271047** Page 1

Sample ID	Date Sampled	Matrix	aParameters	Sample Notes
8-1	12/5/2023 07:00	aqueous	Subcontract - Volatile Fatty Acids (VFAs)	

EAI ID# **271047** Project State: NH

Project ID: 6134

Company ALS Environmental (NY)
Address 1565 Jefferson Rd., Building
Address Rochester, NY 14623
Account #
Phone # 585-288-5380

Results Needed: Preferred Date: Standard
RUSH Due Date: ________
QC Deliverables
☐ A ☐ A+ ☒ B ☐ B+ ☐ C ☐ MA MCP
Notes about project:
Email login confirmation, pdf of results and invoice to customerservice@easternanalytical.com.

PO #:61361 EAI ID# **271047**
Data Deliverable (circle)
Excel NH EMD EQuIS ME EGAD
Call prior to analyzing, if RUSH charges will be applied.

Samples Collected by:
[signature] 12/7/23 1000 UPS

Relinquished by	Date/Time	Received by
	12/8/23 1145	[signature]
Relinquished by	D[illegible]	Received by

R2311390 5
Eastern Analytical, Inc.
EAI ID #271047

Eastern Analytical, Inc. 51 Antrim Ave Concord, NH 03301 Phone: (603)228-0525 1-800-287-0525 customerservice

As a subcontract lab to EAI, you will defend, indemnify and hold Eastern Analytical, Inc., its officers, employees, and agents harmless from and against any and all liabi[...]ges arising out of the performance against this chain of custody but only in proportion to and to the extent such liability, loss, expense, or claims for injury or damages are ca[...]nal acts or omissions of you as a subcontract lab, your officers, agents or employees

R2311390 5
Eastern Analytical, Inc.
EAI ID # 271047

ALS

Cooler Receipt and Preserva[tion]

Project/Client Eastern Analytical Inc. Folder Number ____

Cooler received on 12/8/23 by: MM COURIER: ALS UPS FEDEX VELOCITY CLIENT

1	Were **Custody** seals on outside of cooler?	Y N	5a	**Perchlorate** samples have required headspace?	Y N NA
2	**Custody papers** properly completed (ink, signed)?	Y N	5b	Did VOA vials, Alk, or Sulfide have sig* **bubbles**?	Y N NA
3	Did all bottles arrive in good **condition** (unbroken)?	Y N	6	Where did the bottles originate?	ALS/ROC CLIENT
4	Circle: **Wet Ice** **Dry Ice** **Gel packs** present?	Y N	7	Soil VOA received as:	Bulk Encore 5035set NA

8. Temperature Readings Date: 12/8/23 Time: 12:38 ID: IR#12 IR#11 From: Temp Blank Sample Bottle

Observed Temp (°C)	5.6						
Within 0-6°C?	Y N	Y N	Y N	Y N	Y N	Y N	Y N
If <0°C, were samples frozen?	Y N	Y N	Y N	Y N	Y N	Y N	Y N

If out of Temperature, note packing/ice condition: ________ Ice melted Poorly Packed (described below) Same Day Rule

&Client Approval to Run Samples: ________ Standing Approval Client aware at drop-off Client notified by: ________

All samples held in storage location: R002 by MM on 12/8/23 at 12:44
5035 samples placed in storage location: ____ by ____ on ____ at ____ within 48 hours of sampling? Y N

Cooler Breakdown/Preservation Check**: Date: 12/13/23 Time: 08:20 by: KC

9. Were all bottle labels complete (*i.e.* analysis, preservation, etc.)? YES NO
10. Did all bottle labels and tags agree with custody papers? YES NO
11. Were correct containers used for the tests indicated? YES NO
12. Were 5035 vials acceptable (no extra labels, not leaking)? YES NO N/A
13. Were dissolved metals filtered in the field? YES NO N/A
14. Air Samples: Cassettes / Tubes Intact Y / N with MS Y / N Canisters Pressurized Tedlar® Bags Inflated N/A

pH	Lot of test paper	Reagent	Preserved? Yes	Preserved? No	Lot Received	Exp	Sample ID Adjusted	Vol. Added	Lot Added	Final pH
≥12		NaOH								
≤2		HNO_3								
≤2		H_2SO_4								
<4		$NaHSO_4$								
5-9		For 608pest			No=Notify for 3day					
Residual Chlorine (-)		For CN, Phenol, 625, 608pest, 522			If +, contact PM to add $Na_2S_2O_3$ (625, 608, CN), ascorbic (phenol).					
		$Na_2S_2O_3$								
		ZnAcetate	-	-						
		HCl	**	**						

**VOAs and 1664 Not to be tested before analysis. Otherwise, all bottles of all samples with chemical preservatives are checked (not just representatives).

Bottle lot numbers: 090423-3EGR

Explain all Discrepancies/ Other Comments:

H_3PO_4 Lot: A0437597 exp: 12/26

HPROD	BULK
HTR	FLDT
SUB	HGFB
ALS	LL3541

Labels secondary reviewed by: ________
PC Secondary Review: ________

*significant air bubbles: VOA > 5-6 mm : WC >1 in. diameter

ALS Environmental

Miscellaneous Forms

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1565 Jefferson Road, Building 300, Suite 360, Rochester, NY 14623
Phone (585) 288-5380 Fax (585) 288-8475
www.alsglobal.com

REPORT QUALIFIERS AND DEFINITIONS

U Analyte was analyzed for but not detected. The sample quantitation limit has been corrected for dilution and for percent moisture, unless otherwise noted in the case narrative.

J Estimated value due to either being a Tentatively Identified Compound (TIC) or that the concentration is between the MRL and the MDL. Concentrations are not verified within the linear range of the calibration. For DoD: concentration >40% difference between two GC columns (pesticides/Arclors).

B Analyte was also detected in the associated method blank at a concentration that may have contributed to the sample result.

E Inorganics- Concentration is estimated due to the serial dilution was outside control limits.

E Organics- Concentration has exceeded the calibration range for that specific analysis.

D Concentration is a result of a dilution, typically a secondary analysis of the sample due to exceeding the calibration range or that a surrogate has been diluted out of the sample and cannot be assessed.

* Indicates that a quality control parameter has exceeded laboratory limits. Under the "Notes" column of the Form I, this qualifier denotes analysis was performed out of Holding Time.

H Analysis was performed out of hold time for tests that have an "immediate" hold time criteria.

Spike was diluted out.

+ Correlation coefficient for MSA is <0.995.

N Inorganics- Matrix spike recovery was outside laboratory limits.

N Organics- Presumptive evidence of a compound (reported as a TIC) based on the MS library search.

S Concentration has been determined using Method of Standard Additions (MSA).

W Post-Digestion Spike recovery is outside control limits and the sample absorbance is <50% of the spike absorbance.

P Concentration >40% difference between the two GC columns.

C Confirmed by GC/MS

Q DoD reports: indicates a pesticide/Aroclor is not confirmed (≥100% Difference between two GC columns).

X See Case Narrative for discussion.

MRL Method Reporting Limit. Also known as:
LOQ Limit of Quantitation (LOQ)
The lowest concentration at which the method analyte may be reliably quantified under the method conditions.

MDL Method Detection Limit. A statistical value derived from a study designed to provide the lowest concentration that will be detected 99% of the time. Values between the MDL and MRL are estimated (see J qualifier).

LOD Limit of Detection. A value at or above the MDL which has been verified to be detectable.

ND Non-Detect. Analyte was not detected at the concentration listed. Same as U qualifier.

Rochester Lab ID # for State Accreditations[1]

NELAP States
Florida ID # E87674
New Hampshire ID # 2941
New York ID # 10145
Pennsylvania ID# 68-786
Virginia #460167

Non-NELAP States
Connecticut ID #PH0556
Delaware Approved
Maine ID #NY01587
North Carolina #36701
North Carolina #676
Rhode Island LAO00333

[1] Analyses were performed according to our laboratory's NELAP-approved quality assurance program and any applicable state or agency requirements. The test results meet requirements of the current NELAP/TNI standards or state or agency requirements, where applicable, except as noted in the case narrative. Since not all analyte/method/matrix combinations are offered for state/NELAC accreditation, this report may contain results which are not accredited. For a specific list of accredited analytes, contact the laboratory. To verify NH accredited analytes, go to https://www4.des.state.nh.us/CertifiedLabs/Certified-Method.aspx.

Acronyms

ASTM	American Society for Testing and Materials
A2LA	American Association for Laboratory Accreditation
CARB	California Air Resources Board
CAS Number	Chemical Abstract Service registry Number
CFC	Chlorofluorocarbon
CFU	Colony-Forming Unit
DEC	Department of Environmental Conservation
DEQ	Department of Environmental Quality
DHS	Department of Health Services
DOE	Department of Ecology
DOH	Department of Health
EPA	U. S. Environmental Protection Agency
ELAP	Environmental Laboratory Accreditation Program
GC	Gas Chromatography
GC/MS	Gas Chromatography/Mass Spectrometry
LUFT	Leaking Underground Fuel Tank
M	Modified
MCL	Maximum Contaminant Level is the highest permissible concentration of a substance allowed in drinking water as established by the USEPA.
MDL	Method Detection Limit
MPN	Most Probable Number
MRL	Method Reporting Limit
NA	Not Applicable
NC	Not Calculated
NCASI	National Council of the Paper Industry for Air and Stream Improvement
ND	Not Detected
NIOSH	National Institute for Occupational Safety and Health
PQL	Practical Quantitation Limit
RCRA	Resource Conservation and Recovery Act
SIM	Selected Ion Monitoring
TPH	Total Petroleum Hydrocarbons
tr	Trace level is the concentration of an analyte that is less than the PQL but greater than or equal to the MDL.

Client: Eastern Analytical, Inc.
Project: EAI ID # 271047

Service Request: R2311390

Non-Certified Analytes

Certifying Agency: New York Department of Health

Method	Matrix	Analyte
Organic Acids	Water	Acetic Acid
Organic Acids	Water	Butanoic Acid (Butyric Acid)
Organic Acids	Water	Formic Acid
Organic Acids	Water	Lactic Acid
Organic Acids	Water	Propionic Acid

ALS Group USA, Corp.
dba ALS Environmental

Analyst Summary report

Client:	Eastern Analytical, Inc.	**Service Request:**	R2311390
Project:	EAI ID # 271047/		

Sample Name:	8-1	**Date Collected:**	12/5/23
Lab Code:	R2311390-001	**Date Received:**	12/8/23
Sample Matrix:	Water		

Analysis Method	Extracted/Digested By	Analyzed By
Organic Acids		EDEGRAY

The preparation methods associated with this report are found in these tables unless discussed in the case narrative.

Water/Liquid Matrix

Analytical Method	Preparation Method
200.7	200.2
200.8	200.2
6010C	3005A/3010A
6020A	ILM05.3
9034 Sulfide Acid Soluble	9030B
SM 4500-CN-E Residual Cyanide	SM 4500-CN-G
SM 4500-CN-E WAD Cyanide	SM 4500-CN-I

Solid/Soil/Non-Aqueous Matrix

Analytical Method	Preparation Method
6010C	3050B
6020A	3050B
6010C TCLP (1311) extract	3005A/3010A
6010 SPLP (1312) extract	3005A/3010A
7199	3060A
300.0 Anions/ 350.1/ 353.2/ SM 2320B/ SM 5210B/ 9056A Anions	DI extraction
For analytical methods not listed, the preparation method is the same as the analytical method reference.	

Sample Results

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Semivolatile Organic Compounds by GC

ALS Environmental—Rochester Laboratory
1565 Jefferson Road, Building 300, Suite 360, Rochester, NY 14623
Phone (585) 288-5380 Fax (585) 288-8475
www.alsglobal.com

Client:	Eastern Analytical, Inc.	**Service Request:**	R2311390
Project:	EAI ID # 271047	**Date Collected:**	12/05/23 07:00
Sample Matrix:	Water	**Date Received:**	12/08/23 11:45
Sample Name:	8-1	**Units:**	mg/L
Lab Code:	R2311390-001	**Basis:**	NA

Organic Acids in Aqueous Matrices by High Performance Liquid Chromatography (HPLC) 28 Day Hold Time

Analysis Method: Organic Acids

Analyte Name	Result	MRL	Dil.	Date Analyzed	Q
Acetic Acid	**37**	1.0	1	12/22/23 01:33	
Butanoic Acid (Butyric Acid)	ND U	10	1	12/22/23 01:33	
Formic Acid	ND U	1.0	1	12/22/23 01:33	
Lactic Acid	ND U	1.0	1	12/22/23 01:33	
Propionic Acid	**12**	2.0	1	12/22/23 01:33	

ALS Environmental

QC Summary Forms

ALS Environmental—Rochester Laboratory
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Semivolatile Organic Compounds by GC

ALS Environmental—Rochester Laboratory
1565 Jefferson Road, Building 300, Suite 360, Rochester, NY 14623
Phone (585) 288-5380 Fax (585) 288-8475
www.alsglobal.com

Client:	Eastern Analytical, Inc.	**Service Request:**	R2311390
Project:	EAI ID # 271047	**Date Collected:**	12/05/23
Sample Matrix:	Water	**Date Received:**	12/08/23
		Date Analyzed:	12/22/23

Duplicate Matrix Spike Summary
Organic Acids in Aqueous Matrices by High Performance Liquid Chromatography (HPLC) 28 Day Hold Time

Sample Name:	8-1	**Units:**	mg/L
Lab Code:	R2311390-001	**Basis:**	NA
Analysis Method:	Organic Acids		

		Matrix Spike RQ2316858-02			Duplicate Matrix Spike RQ2316858-03					
Analyte Name	**Sample Result**	**Result**	**Spike Amount**	**% Rec**	**Result**	**Spike Amount**	**% Rec**	**% Rec Limits**	**RPD**	**RPD Limit**
Acetic Acid	37	51.1	20.0	72	51.3	20.0	72	10-179	<1	30
Butanoic Acid (Butyric Acid)	ND U	24.0	20.0	120	24.3	20.0	121	39-161	1	30
Formic Acid	ND U	49.0	20.0	245 *	43.3	20.0	216 *	69-119	12	30
Lactic Acid	ND U	17.5	20.0	88	18.3	20.0	91	48-147	4	30
Propionic Acid	12	32.6	20.0	102	36.1	20.0	120	49-162	10	30

Results flagged with an asterisk (*) indicate values outside control criteria.

Results flagged with a pound (#) indicate the control criteria is not applicable.

Percent recoveries and relative percent differences (RPD) are determined by the software using values in the calculation which have not been rounded.

Matrix Spike and Matrix Spike Duplicate Data is presented for information purposes only. The matrix may or may not be relevant to samples reported in this report. The laboratory evaluates system performance based on the LCS and LCSD control limits.

ALS Group USA, Corp.
dba ALS Environmental

Analytical Report

Client:	Eastern Analytical, Inc.	**Service Request:**	R2311390
Project:	EAI ID # 271047	**Date Collected:**	NA
Sample Matrix:	Water	**Date Received:**	NA
Sample Name:	Method Blank	**Units:**	mg/L
Lab Code:	RQ2316858-04	**Basis:**	NA

Organic Acids in Aqueous Matrices by High Performance Liquid Chromatography (HPLC) 28 Day Hold Time

Analysis Method: Organic Acids

Analyte Name	Result	MRL	Dil.	Date Analyzed	Q
Acetic Acid	ND U	1.0	1	12/21/23 22:26	
Butanoic Acid (Butyric Acid)	ND U	10	1	12/21/23 22:26	
Formic Acid	ND U	1.0	1	12/21/23 22:26	
Lactic Acid	ND U	1.0	1	12/21/23 22:26	
Propionic Acid	ND U	2.0	1	12/21/23 22:26	

ALS Group USA, Corp.
dba ALS Environmental

QA/QC Report

Client: Eastern Analytical, Inc.
Project: EAI ID # 271047
Sample Matrix: Water

Service Request: R2311390
Date Analyzed: 12/21/23

Duplicate Lab Control Sample Summary
Organic Acids in Aqueous Matrices by High Performance Liquid Chromatography (HPLC) 28 Day Hold Time

Units:mg/L
Basis:NA

		Lab Control Sample RQ2316858-05			Duplicate Lab Control Sample RQ2316858-06					
Analyte Name	**Analytical Method**	**Result**	**Spike Amount**	**% Rec**	**Result**	**Spike Amount**	**% Rec**	**% Rec Limits**	**RPD**	**RPD Limit**
Acetic Acid	Organic Acids	24.8	20.0	124	22.7	20.0	114	80-130	9	30
Butanoic Acid (Butyric Acid)	Organic Acids	22.1	20.0	111	23.1	20.0	115	86-128	4	30
Formic Acid	Organic Acids	24.4	20.0	122 *	24.5	20.0	122 *	81-114	<1	30
Lactic Acid	Organic Acids	22.6	20.0	113	23.4	20.0	117	75-125	3	30
Propionic Acid	Organic Acids	20.0	20.0	100	21.3	20.0	107	63-153	6	30

Page 1 of 1

CHAIN-OF-CUSTODY RECORD

BOLD FIELDS REQUIRED. PLEASE CIRCLE REQUESTED ANALYSIS.

271047

SAMPLE I.D.	SAMPLING DATE/TIME *IF COMPOSITE, INDICATE BOTH START & FINISH DATE/TIME	MATRIX (SEE BELOW)	GRAB/*COMPOSITE	VOC: 524.2 / 524.2 MTBE ONLY	VOC: 8260B 624 VTICs 1,4 DIOXANE	VOC: 8021B	VOC: 8015B GRO MAVPH	SVOC: 8270D 625 ABN PAH EDB DBCP	SVOC: TPH8100 L1 L2	SVOC: 8015B DRO MAEPH	SVOC: PEST 608 PCB 608 PEST 8081A PCB 8082	SVOC: OIL & GREASE 1664 TPH 1664	TCLP: TCLP 1311 ABN METALS VOC PEST HERB	INORGANICS: BOD CBOD TS TSS TDS	INORGANICS: Br Cl F SO_4 NO_2 NO_3 NO_3NO_2	INORGANICS: TKN NH_3 TN T. PHOS. O. PHOS.	INORGANICS: pH T. RES. CHLORINE SPEC. CON. T. ALK.	INORGANICS: COD PHENOLS TOC DOC	INORGANICS: TOTAL CYANIDE TOTAL SULFIDE	INORGANICS: REACTIVE CYANIDE REACTIVE SULFIDE FLASHPOINT IGNITABILITY	MICRO: TOTAL COLIFORM E. COLI FECAL COLIFORM	MICRO: ENTEROCOCCI HETEROTROPHIC PLATE COUNT	METALS: DISSOLVED METALS (LIST BELOW)	METALS: TOTAL METALS (LIST BELOW)	OTHER: VFA	OTHER	OTHER	OTHER	# OF CONTAINERS	NOTES MeOH VIAL #
8-1	12/4 7am - 12/5 7am	WW	*C																						✓				3	Influent ~~Effluent~~ VFA

MATRIX: A-AIR; S-SOIL; GW-GROUND WATER; SW-SURFACE WATER; DW-DRINKING WATER; WW-WASTE WATER

PRESERVATIVE: H-HCL; N-HNO_3; S-H_2SO_4; Na-NaOH; M-MEOH

PROJECT MANAGER: Steve Clifton, Stephen Smith

COMPANY: Underwood Engineers

ADDRESS: 25 Vaughan Mall

CITY: Portsmouth STATE: NH ZIP: 03801

PHONE: Smith 603-854-3236; Clifton 603-475-3814 EXT.:

E-MAIL: sclifton@underwoodengineers.com; ssmith@underwoodengineers.com

SITE NAME: Epping WWTF, Epping NH

PROJECT #: UE Job 2987-01

STATE: NH MA ME VT OTHER:

REGULATORY PROGRAM: NPDES: RGP POTW STORMWATER GWP, OIL FUND BROWNFIELD OTHER: NA process

QUOTE #: 1020770 PO #:

QA/QC REPORTING

A B C

MA MCP

TEMP. 03 C

ICE? YES NO

REPORTING OPTIONS

PRELIMS: YES OR NO

ELECTRONIC OPTIONS

PDF EXCEL

EQUIS

OTHER

TURN AROUND TIME

24hr* 48hr*

3 - 4 DAYS*

5 DAY 7 DAY

10 DAY

*Pre-approval Required

METALS: 8 RCRA 13 PP FE, MN PB, CU

OTHER METALS:

SAMPLES FIELD FILTERED? ☐ YES ☑ NO

NOTES: (IE: SPECIAL DETECTION LIMITS, BILLING INFO, IF DIFFERENT)

Ink on bottle ~~labels~~ labels may be smeared by time of arrival @ lab, refer to COC or call Underwood w/any questions

SAMPLER(S): Paul Michael Bidorde

RELINQUISHED BY:	DATE:	TIME:	RECEIVED BY:
Paul M. B.	12/5/23	8:25am	Sally Kelly 12-6-23 8:56
Sally Kelly	12-6-23	12:00	NH

SITE HISTORY:

SUSPECTED CONTAMINATION:

FIELD READINGS:

Eastern Analytical, Inc.
professional laboratory and drilling services

51 Antrim Avenue | Concord, NH 03301 | Tel: 603.228.0525 | 1.800.287.0525 | E-Mail: CustomerService@EasternAnalytical.com | www.EasternAnalytical.com

(WHITE: Lab Copy GREEN: Customer Copy)

Eastern Analytical, Inc.

professional laboratory and drilling services

Steven Clifton
Underwood Engineers
25 Vaughan Mall, Unit #1
Portsmouth , NH 03801

Subject: Laboratory Report

Eastern Analytical, Inc. ID: 271747
Client Identification: Epping WWTF, Epping NH | UE Job 2987-01
Date Received: 12/19/2023

Dear Mr. Clifton :

Enclosed please find the report of analysis for the above identified project. As discussed, analyses were subcontracted and are listed as follows:

Analysis: Subcontract - Total Volatile Fatty Acids (VFA) PEL

Subcontractor Lab: ALS Environmental

A complete copy of the report is attached. This report may not be reproduced except in full, without the written approval of the laboratory.

We appreciate this opportunity to be of service and look forward to your continued patronage.

Sincerely,

Lorraine Olashaw, Lab Director

1.5.24
Date

SAMPLE CONDITIONS PAGE

EAI ID#: **271747**

Client: **Underwood Engineers**

Client Designation: **Epping WWTF, Epping NH | UE Job 2987-01**

Temperature upon receipt (°C): 3.0

Acceptable temperature range (°C): 0-6

Received on ice or cold packs (Yes/No): Y

Lab ID	Sample ID	Date Received	Date/Time Sampled	Sample Matrix	% Dry Weight	Exceptions/Comments (other than thermal preservation)
271747.01	9-1	12/19/23	12/7/23 07:00	aqueous		Adheres to Sample Acceptance Policy

All results contained in this report relate only to the above listed samples.

Unless otherwise noted:

- *Hold times, preservation, container types, and sample conditions adhered to EPA Protocol.*
- *Solid samples are reported on a dry weight basis, unless otherwise noted. pH/Corrosivity, Flashpoint, Ignitability, Paint Filter, Conductivity and Specific Gravity are always reported on an "as received" basis.*
- *Analysis of pH, Total Residual Chlorine, Dissolved Oxygen and Sulfite were performed at the laboratory outside of the recommended 15 minute hold time.*
- *Samples collected by Eastern Analytical, Inc. (EAI) were collected in accordance with approved EPA procedures.*

January 04, 2024

Service Request No:R2311882

Eastern Analytical, Inc.
51 Antrim Avenue
Concord, NH 03301

Laboratory Results for: EAI ID # 271747

Dear Customer Service,

Enclosed are the results of the sample(s) submitted to our laboratory December 21, 2023
For your reference, these analyses have been assigned our service request number **R2311882.**

All testing was performed according to our laboratory's quality assurance program and met the requirements of the TNI standards except as noted in the case narrative report. Any testing not included in the lab's accreditation is identified on a Non-Certified Analytes report. All results are intended to be considered in their entirety. ALS Environmental is not responsible for use of less than the complete report. Results apply only to the individual samples submitted to the lab for analysis, as listed in the report. The measurement uncertainty of the results included in this report is within that expected when using the prescribed method(s), and represented by Laboratory Control Sample control limits. Any events, such as QC failures or Holding Time exceedances, which may add to the uncertainty are explained in the report narrative or are flagged with qualifiers. The flags are explained in the Report Qualifiers and Definitions page of this report.

Please contact me if you have any questions. My extension is 7476. You may also contact me via email at Chris.Leavy@alsglobal.com.

Respectfully submitted,

ALS Group USA, Corp. dba ALS Environmental

Christopher Leavy
Project Manager

ADDRESS 1565 Jefferson Road, Building 300, Suite 360, Rochester, NY 14623
PHONE +1 585 288 5380 | FAX +1 585 288 8475
ALS Group USA, Corp.
dba ALS Environmental

ALS Environmental

Narrative Documents

ALS Environmental—Rochester Laboratory
1565 Jefferson Road, Building 300, Suite 360, Rochester, NY 14623
Phone (585) 288-5380 Fax (585) 288-8475
www.alsglobal.com

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ALS Environmental

Client: Eastern Analytical, Inc.
Project: EAI ID # 271747
Sample Matrix: Water

Service Request: R2311882
Date Received: 12/21/2023

CASE NARRATIVE

All analyses were performed consistent with the quality assurance program of ALS Environmental. This report contains analytical results for samples for the Tier II level requested by the client.

Sample Receipt:

One water sample was received for analysis at ALS Environmental on 12/21/2023. Any discrepancies upon initial sample inspection are annotated on the sample receipt and preservation form included within this report. The samples were stored at minimum in accordance with the analytical method requirements.

Semivoa GC:

No significant anomalies were noted with this analysis.

Approved by ______________________ Date 01/04/2024

ALS Environmental

SAMPLE DETECTION SUMMARY

This form includes only detections above the reporting levels. For a full listing of sample results, continue to the Sample Results section of this Report.

CLIENT ID: 9-1 **Lab ID: R2311882-001**

Analyte	Results	Flag	MDL	MRL	Units	Method
Acetic Acid	32			1.0	mg/L	Organic Acids
Formic Acid	96			1.0	mg/L	Organic Acids
Lactic Acid	2.5			1.0	mg/L	Organic Acids
Propionic Acid	12			2.0	mg/L	Organic Acids

ALS Environmental

Sample Receipt Information

ALS Environmental—Rochester Laboratory
1565 Jefferson Road, Building 300, Suite 360, Rochester, NY 14623
Phone (585) 288-5380 Fax (585) 288-8475
www.alsglobal.com

Client: Eastern Analytical, Inc.
Project: EAI ID # 271747

Service Request:R2311882

SAMPLE CROSS-REFERENCE

SAMPLE #	CLIENT SAMPLE ID	DATE	TIME
R2311882-001	9-1	12/7/2023	0700

CHAIN-OF-CUSTODY RECORD

Eastern Analytical, Inc.
professional laboratory and drilling services

EAI ID# **271747** Page 1

Sample ID	Date Sampled	Matrix	aParameters	Sample Notes
9-1	12/~~17~~ 7 AWB 12/20/23 /2023 07:00	aqueous	Subcontract - Volatile Fatty Acids (VFAs)	

EAI ID# **271747** Project State: NH
Project ID: 6134

Company ALS Environmental (NY)
Address 1565 Jefferson Rd., Building
Address Rochester, NY 14623
Account #
Phone # 585-288-5380

Results Needed: Preferred Date: Standard
RUSH Due Date: ________
QC Deliverables
☐ A ☐ A+ ☒ B ☐ B+ ☐ C ☐ MA MCP
Notes about project:
Email login confirmation, pdf of results and invoice to customerservice@easternanalytical.com.

PO #:61457 EAI ID# **271747**
Data Deliverable (circle)
Excel NH EMD EQuIS ME EGAD

Call prior to analyzing, if RUSH charges will be applied.

Samples Collected by:

Relinquished by	Date/Time	Received by
[signature]	12/20/23 1600	UPS
	12/21/23 1020	[signature]

Eastern Analytical, Inc. 51 Antrim Ave Concord, NH 03301 Phone: (603)228-0525 1-800-287-0525 customerservice@

As a subcontract lab to EAI, you will defend, indemnify and hold Eastern Analytical, Inc., its officers, employees, and agents harmless from and against any and all liability, arising out of the performance against this chain of custody but only in proportion to and to the extent such liability, loss, expense, or claims for injury or damages are cause acts or omissions of you as a subcontract lab, your officers, agents or employees

R2311882 5
Eastern Analytical, Inc.
EAI ID # 271747

ALS

Cooler Receipt and Preservati[on]

R2311882 5
Eastern Analytical, Inc.
EAI ID # 271747

Project/Client______________________ Folder Number______________

Cooler received on 12/21/23 by: RR COURIER: ALS UPS FEDEX VELOCITY CLIENT

1	Were **Custody seals** on outside of cooler?	Y N	5a	**Perchlorate** samples have required headspace?	Y N NA
2	**Custody papers** properly completed (ink, signed)?	Y N	5b	Did VOA vials, Alk,or Sulfide have sig* **bubbles**?	Y N NA
3	Did all bottles arrive in good **condition** (unbroken)?	Y N	6	Where did the bottles originate?	ALS/ROC CLIENT
4	Circle: Wet Ice Dry Ice Gel packs present?	Y N	7	Soil VOA received as: Bulk Encore 5035set	NA

8. Temperature Readings Date: 12/21/23 Time: 1248 ID: IR#12 IR#11 From: Temp Blank Sample Bottle

Observed Temp (°C)	5.2						
Within 0-6°C?	Y N	Y N	Y N	Y N	Y N	Y N	Y N
If <0°C, were samples frozen?	Y N	Y N	Y N	Y N	Y N	Y N	Y N

If out of Temperature, note packing/ice condition: ________ Ice melted Poorly Packed (described below) Same Day Rule

&Client Approval to Run Samples:________ Standing Approval Client aware at drop-off Client notified by: ________

All samples held in storage location: R002 by RR on 12/21 at 1250
5035 samples placed in storage location: ______ by ______ on ______ at ______ within 48 hours of sampling? Y N

Cooler Breakdown/Preservation Check**: Date: 12/21/23 Time: 1449 by: RR

9. Were all bottle labels complete (*i.e.* analysis, preservation, etc.)? YES NO
10. Did all bottle labels and tags agree with custody papers? YES NO
11. Were correct containers used for the tests indicated? YES NO
12. Were 5035 vials acceptable (no extra labels, not leaking)? YES NO N/A
13. Were dissolved metals filtered in the field? YES NO N/A
14. Air Samples: Cassettes / Tubes Intact Y / N with MS Y / N Canisters Pressurized Tedlar® Bags Inflated N/A

pH	Lot of test paper	Reagent	Preserved? Yes	Preserved? No	Lot Received	Exp	Sample ID Adjusted	Vol. Added	Lot Added	Final pH
≥12		NaOH								
≤2		HNO_3								
≤2		H_2SO_4								
<4		$NaHSO_4$								
5-9		For 608pest			No=Notify for 3day					
Residual Chlorine (-)		For CN, Phenol, 625, 608pest, 522			If +, contact PM to add $Na_2S_2O_3$ (625, 608, CN), ascorbic (phenol).					
		$Na_2S_2O_3$								
		ZnAcetate	-	-			**VOAs and 1664 Not to be tested before analysis. Otherwise, all bottles of all samples with chemical preservatives are checked (not just representatives).			
		HCl	**	**						

Bottle lot numbers: 090423-3EGR
Explain all Discrepancies/ Other Comments:

Phosphoric acid lot #: A0437597 exp. 12/26

HPROD	BULK
HTR	FLDT
SUB	HGFB
ALS	LL3541

Labels secondary reviewed by: RR
PC Secondary Review: ____________

*significant air bubbles: VOA > 5-6 mm : WC >1 in. diameter

Miscellaneous Forms

ALS Environmental—Rochester Laboratory
1565 Jefferson Road, Building 300, Suite 360, Rochester, NY 14623
Phone (585) 288-5380 Fax (585) 288-8475
www.alsglobal.com

REPORT QUALIFIERS AND DEFINITIONS

U Analyte was analyzed for but not detected. The sample quantitation limit has been corrected for dilution and for percent moisture, unless otherwise noted in the case narrative.

J Estimated value due to either being a Tentatively Identified Compound (TIC) or that the concentration is between the MRL and the MDL. Concentrations are not verified within the linear range of the calibration. For DoD: concentration >40% difference between two GC columns (pesticides/Arclors).

B Analyte was also detected in the associated method blank at a concentration that may have contributed to the sample result.

E Inorganics- Concentration is estimated due to the serial dilution was outside control limits.

E Organics- Concentration has exceeded the calibration range for that specific analysis.

D Concentration is a result of a dilution, typically a secondary analysis of the sample due to exceeding the calibration range or that a surrogate has been diluted out of the sample and cannot be assessed.

* Indicates that a quality control parameter has exceeded laboratory limits. Under the "Notes" column of the Form I, this qualifier denotes analysis was performed out of Holding Time.

H Analysis was performed out of hold time for tests that have an "immediate" hold time criteria.

Spike was diluted out.

+ Correlation coefficient for MSA is <0.995.

N Inorganics- Matrix spike recovery was outside laboratory limits.

N Organics- Presumptive evidence of a compound (reported as a TIC) based on the MS library search.

S Concentration has been determined using Method of Standard Additions (MSA).

W Post-Digestion Spike recovery is outside control limits and the sample absorbance is <50% of the spike absorbance.

P Concentration >40% difference between the two GC columns.

C Confirmed by GC/MS

Q DoD reports: indicates a pesticide/Aroclor is not confirmed (≥100% Difference between two GC columns).

X See Case Narrative for discussion.

MRL Method Reporting Limit. Also known as:
LOQ Limit of Quantitation (LOQ)
The lowest concentration at which the method analyte may be reliably quantified under the method conditions.

MDL Method Detection Limit. A statistical value derived from a study designed to provide the lowest concentration that will be detected 99% of the time. Values between the MDL and MRL are estimated (see J qualifier).

LOD Limit of Detection. A value at or above the MDL which has been verified to be detectable.

ND Non-Detect. Analyte was not detected at the concentration listed. Same as U qualifier.

Rochester Lab ID # for State Accreditations[1]

NELAP States
Florida ID # E87674
New Hampshire ID # 2941
New York ID # 10145
Pennsylvania ID# 68-786
Virginia #460167

Non-NELAP States
Connecticut ID #PH0556
Delaware Approved
Maine ID #NY01587
North Carolina #36701
North Carolina #676
Rhode Island LAO00333

[1] Analyses were performed according to our laboratory's NELAP-approved quality assurance program and any applicable state or agency requirements. The test results meet requirements of the current NELAP/TNI standards or state or agency requirements, where applicable, except as noted in the case narrative. Since not all analyte/method/matrix combinations are offered for state/NELAC accreditation, this report may contain results which are not accredited. For a specific list of accredited analytes, contact the laboratory. To verify NH accredited analytes, go to https://www4.des.state.nh.us/CertifiedLabs/Certified-Method.aspx.

Acronyms

ASTM	American Society for Testing and Materials
A2LA	American Association for Laboratory Accreditation
CARB	California Air Resources Board
CAS Number	Chemical Abstract Service registry Number
CFC	Chlorofluorocarbon
CFU	Colony-Forming Unit
DEC	Department of Environmental Conservation
DEQ	Department of Environmental Quality
DHS	Department of Health Services
DOE	Department of Ecology
DOH	Department of Health
EPA	U. S. Environmental Protection Agency
ELAP	Environmental Laboratory Accreditation Program
GC	Gas Chromatography
GC/MS	Gas Chromatography/Mass Spectrometry
LUFT	Leaking Underground Fuel Tank
M	Modified
MCL	Maximum Contaminant Level is the highest permissible concentration of a substance allowed in drinking water as established by the USEPA.
MDL	Method Detection Limit
MPN	Most Probable Number
MRL	Method Reporting Limit
NA	Not Applicable
NC	Not Calculated
NCASI	National Council of the Paper Industry for Air and Stream Improvement
ND	Not Detected
NIOSH	National Institute for Occupational Safety and Health
PQL	Practical Quantitation Limit
RCRA	Resource Conservation and Recovery Act
SIM	Selected Ion Monitoring
TPH	Total Petroleum Hydrocarbons
tr	Trace level is the concentration of an analyte that is less than the PQL but greater than or equal to the MDL.

Client: Eastern Analytical, Inc.
Project: EAI ID # 271747

Service Request: R2311882

Non-Certified Analytes

Certifying Agency: New York Department of Health

Method	Matrix	Analyte
Organic Acids	Water	Acetic Acid
Organic Acids	Water	Butanoic Acid (Butyric Acid)
Organic Acids	Water	Formic Acid
Organic Acids	Water	Lactic Acid
Organic Acids	Water	Propionic Acid

ALS Group USA, Corp.
dba ALS Environmental

Analyst Summary report

Client:	Eastern Analytical, Inc.	**Service Request:**	R2311882
Project:	EAI ID # 271747/		

Sample Name:	9-1	**Date Collected:**	12/7/23
Lab Code:	R2311882-001	**Date Received:**	12/21/23
Sample Matrix:	Water		

Analysis Method	Extracted/Digested By	Analyzed By
Organic Acids		EDEGRAY

The preparation methods associated with this report are found in these tables unless discussed in the case narrative.

Water/Liquid Matrix

Analytical Method	Preparation Method
200.7	200.2
200.8	200.2
6010C	3005A/3010A
6020A	ILM05.3
9034 Sulfide Acid Soluble	9030B
SM 4500-CN-E Residual Cyanide	SM 4500-CN-G
SM 4500-CN-E WAD Cyanide	SM 4500-CN-I

Solid/Soil/Non-Aqueous Matrix

Analytical Method	Preparation Method
6010C	3050B
6020A	3050B
6010C TCLP (1311) extract	3005A/3010A
6010 SPLP (1312) extract	3005A/3010A
7199	3060A
300.0 Anions/ 350.1/ 353.2/ SM 2320B/ SM 5210B/ 9056A Anions	DI extraction
For analytical methods not listed, the preparation method is the same as the analytical method reference.	

ALS Environmental

Sample Results

ALS Environmental—Rochester Laboratory
1565 Jefferson Road, Building 300, Suite 360, Rochester, NY 14623
Phone (585) 288-5380 Fax (585) 288-8475
www.alsglobal.com

Semivolatile Organic Compounds by GC

ALS Environmental—Rochester Laboratory
1565 Jefferson Road, Building 300, Suite 360, Rochester, NY 14623
Phone (585) 288-5380 Fax (585) 288-8475
www.alsglobal.com

Client:	Eastern Analytical, Inc.	**Service Request:**	R2311882
Project:	EAI ID # 271747	**Date Collected:**	12/07/23 07:00
Sample Matrix:	Water	**Date Received:**	12/21/23 12:20
Sample Name:	9-1	**Units:**	mg/L
Lab Code:	R2311882-001	**Basis:**	NA

Organic Acids in Aqueous Matrices by High Performance Liquid Chromatography (HPLC) 28 Day Hold Time

Analysis Method: Organic Acids

Analyte Name	Result	MRL	Dil.	Date Analyzed	Q
Acetic Acid	**32**	1.0	1	12/29/23 15:18	
Butanoic Acid (Butyric Acid)	ND U	10	1	12/29/23 15:18	
Formic Acid	**96**	1.0	1	12/29/23 15:18	
Lactic Acid	**2.5**	1.0	1	12/29/23 15:18	
Propionic Acid	**12**	2.0	1	12/29/23 15:18	

ALS Environmental

QC Summary Forms

ALS Environmental—Rochester Laboratory
1565 Jefferson Road, Building 300, Suite 360, Rochester, NY 14623
Phone (585) 288-5380 Fax (585) 288-8475
www.alsglobal.com

ALS Environmental

Semivolatile Organic Compounds by GC

ALS Environmental—Rochester Laboratory
1565 Jefferson Road, Building 300, Suite 360, Rochester, NY 14623
Phone (585) 288-5380 Fax (585) 288-8475
www.alsglobal.com

Client:	Eastern Analytical, Inc.	**Service Request:**	R2311882
Project:	EAI ID # 271747	**Date Collected:**	12/07/23
Sample Matrix:	Water	**Date Received:**	12/21/23
		Date Analyzed:	12/29/23

Duplicate Matrix Spike Summary
Organic Acids in Aqueous Matrices by High Performance Liquid Chromatography (HPLC) 28 Day Hold Time

Sample Name:	9-1	**Units:**	mg/L
Lab Code:	R2311882-001	**Basis:**	NA
Analysis Method:	Organic Acids		

		Matrix Spike RQ2400008-05			Duplicate Matrix Spike RQ2400008-06					
Analyte Name	**Sample Result**	**Result**	**Spike Amount**	**% Rec**	**Result**	**Spike Amount**	**% Rec**	**% Rec Limits**	**RPD**	**RPD Limit**
Acetic Acid	32	46.6	20.0	75	48.7	20.0	85	10-179	4	30
Butanoic Acid (Butyric Acid)	ND U	24.8	20.0	124	25.7	20.0	129	39-161	4	30
Formic Acid	96	115	20.0	94 #	114	20.0	92 #	69-119	<1	30
Lactic Acid	2.5	17.5	20.0	75	18.0	20.0	77	48-147	3	30
Propionic Acid	12	32.4	20.0	102	31.7	20.0	98	49-162	2	30

Results flagged with an asterisk (*) indicate values outside control criteria.

Results flagged with a pound (#) indicate the control criteria is not applicable.

Percent recoveries and relative percent differences (RPD) are determined by the software using values in the calculation which have not been rounded.

Matrix Spike and Matrix Spike Duplicate Data is presented for information purposes only. The matrix may or may not be relevant to samples reported in this report. The laboratory evaluates system performance based on the LCS and LCSD control limits.

ALS Group USA, Corp.
dba ALS Environmental

Analytical Report

Client:	Eastern Analytical, Inc.	**Service Request:**	R2311882
Project:	EAI ID # 271747	**Date Collected:**	NA
Sample Matrix:	Water	**Date Received:**	NA
Sample Name:	Method Blank	**Units:**	mg/L
Lab Code:	RQ2400008-02	**Basis:**	NA

Organic Acids in Aqueous Matrices by High Performance Liquid Chromatography (HPLC) 28 Day Hold Time

Analysis Method: Organic Acids

Analyte Name	Result	MRL	Dil.	Date Analyzed	Q
Acetic Acid	ND U	1.0	1	12/29/23 12:12	
Butanoic Acid (Butyric Acid)	ND U	10	1	12/29/23 12:12	
Formic Acid	ND U	1.0	1	12/29/23 12:12	
Lactic Acid	ND U	1.0	1	12/29/23 12:12	
Propionic Acid	ND U	2.0	1	12/29/23 12:12	

ALS Group USA, Corp.
dba ALS Environmental

QA/QC Report

Client: Eastern Analytical, Inc.
Project: EAI ID # 271747
Sample Matrix: Water

Service Request: R2311882
Date Analyzed: 12/29/23

Duplicate Lab Control Sample Summary
Organic Acids in Aqueous Matrices by High Performance Liquid Chromatography (HPLC) 28 Day Hold Time

Units:mg/L
Basis:NA

		Lab Control Sample RQ2400008-03			Duplicate Lab Control Sample RQ2400008-04					
Analyte Name	**Analytical Method**	**Result**	**Spike Amount**	**% Rec**	**Result**	**Spike Amount**	**% Rec**	**% Rec Limits**	**RPD**	**RPD Limit**
Acetic Acid	Organic Acids	20.9	20.0	105	21.3	20.0	107	80-130	2	30
Butanoic Acid (Butyric Acid)	Organic Acids	23.0	20.0	115	20.9	20.0	105	86-128	9	30
Formic Acid	Organic Acids	21.8	20.0	109	22.7	20.0	114	81-114	4	30
Lactic Acid	Organic Acids	22.0	20.0	110	21.4	20.0	107	75-125	3	30
Propionic Acid	Organic Acids	19.6	20.0	98	19.7	20.0	98	63-153	<1	30

Page 1 of 1

CHAIN-OF-CUSTODY RECORD

BOLD FIELDS REQUIRED. PLEASE CIRCLE REQUESTED ANALYSIS.

FOR LAB USE ONLY

271747

SAMPLE I.D.	SAMPLING DATE/TIME *IF COMPOSITE, INDICATE BOTH START & FINISH DATE/TIME	MATRIX (SEE BELOW)	GRAB/*COMPOSITE	VOC: 524.2 / 524.2 MTBE ONLY	VOC: 8260B 624 VTICs 1,4 DIOXANE	VOC: 8021B	VOC: 8015B GRO MAVPH	SVOC: 8270D 625 ABN PAH EDB DBCP	SVOC: TPH8100 L1 L2	SVOC: 8015B DRO MAEPH	SVOC: PEST 608 PCB 608 PEST 8081A PCB 8082	SVOC: OIL & GREASE 1664 TPH 1664	TCLP: TCLP 1311 ABN METALS VOC PEST HERB	INORGANICS: BOD CBOD TS TSS TDS	INORGANICS: Br Cl F SO_4 NO_2 NO_3 NO_2NO_3	INORGANICS: TKN NH_3 TN T. PHOS. O. PHOS.	INORGANICS: pH T. RES. CHLORINE SPEC. CON. T. ALK.	INORGANICS: COD PHENOLS TOC DOC	INORGANICS: TOTAL CYANIDE TOTAL SULFIDE	INORGANICS: REACTIVE CYANIDE REACTIVE SULFIDE FLASHPOINT IGNITABILITY	MICRO: TOTAL COLIFORM E. COLI FECAL COLIFORM	MICRO: ENTEROCOCCI HETEROTROPHIC PLATE COUNT	METALS: DISSOLVED METALS (LIST BELOW)	METALS: TOTAL METALS (LIST BELOW)	VFA				# OF CONTAINERS	NOTES MeOH VIAL #
9-1	12/6-12/7 7am-7am	WW	C*																						✓				3	Influent VFA

MATRIX: A-AIR; S-SOIL; GW-GROUND WATER; SW-SURFACE WATER; DW-DRINKING WATER; WW-WASTE WATER

PRESERVATIVE: H-HCL; N-HNO_3; S-H_2SO_4; Na-NaOH; M-MEOH

PROJECT MANAGER: Steve Clifton, Stephen Smith

COMPANY: Underwood Engineers

ADDRESS: 25 Vaughan Mall

CITY: Portsmouth STATE: NH ZIP: 03801

PHONE: Smith 603-854-3236; Clifton 603-475-3814 EXT.:

E-MAIL: sclifton@underwoodengineers.com; ssmith@underwoodengineers.com

SITE NAME: Epping WWTF, Epping NH

PROJECT #: UE Job 2987-01

STATE: NH MA ME VT OTHER:

REGULATORY PROGRAM: NPDES: RGP POTW STORMWATER GWP, OIL FUND BROWNFIELD OTHER: NA process

QUOTE #: 1020770 PO #:

QA/QC REPORTING

A B C

MA MCP

TEMP. 3.0 C

ICE? YES NO

REPORTING OPTIONS

PRELIMS: YES OR NO

ELECTRONIC OPTIONS

PDF EXCEL

EQUIS

OTHER

TURN AROUND TIME

24hr* 48hr*

3 - 4 DAYS*

5 DAY 7 DAY

10 DAY

*Pre-approval Required

METALS: 8 RCRA 13 PP FE, MN PB, CU

OTHER METALS:

SAMPLES FIELD FILTERED? ☐ YES ☑ NO

NOTES: (IE: SPECIAL DETECTION LIMITS, BILLING INFO, IF DIFFERENT)

SAMPLER(S): Paul Michael Bidonde

	DATE:	TIME:	RECEIVED BY:
RELINQUISHED BY: Paul Michael Bidonde	12/7/23	8:23am	—
RELINQUISHED BY:	12/19/23	9:15	Shelly
RELINQUISHED BY: Shelly	12/19/23	10:53	NA

SITE HISTORY:

SUSPECTED CONTAMINATION:

FIELD READINGS:

Eastern Analytical, Inc.
professional laboratory and drilling services

51 Antrim Avenue | Concord, NH 03301 | Tel: 603.228.0525 | 1.800.287.0525 | E-Mail: CustomerService@EasternAnalytical.com | www.EasternAnalytical.com

(WHITE: Lab Copy GREEN: Customer Copy)

APPENDIX C

Workshop Files

Epping, NH – WWTF Total Nitrogen Upgrade Study

Alternative Technologies Evaluation Workshop

Epping WWTF Conference Room

November 29, 2023, 5:00PM to 9:00PM

Attendees: Tom Dwyer, Marc Nickerson, Scott Pim, Dennis Koch, Anthony Shea, Jake Roger, Steve Clifton, Dave Mercier, Steve Smith, Robert Sharp

Purpose:

1. Identify the best technology for Epping to evaluate to upgrade the existing WWTF to meet future anticipated TN limits of 8/5/3 mg/L along with the plant's other stringent limits

Goals:

1. Obtain consensus among all parties on the best alternative technology to evaluate alongside continued use of MBR technology for TN removal
2. Obtain consensus among all parties on the best tertiary process to evaluate alongside continued use of MBR technology for low TP and metals

Attachments:

1. Alterative technology descriptions to achieve biological TN removal and/or optimization of TN removal
2. Alterative technology descriptions to achieve tertiary effluent

Baseline Considerations (must be met):

Meet anticipated TN limits as low as 3 mg/L

Meet current permit limits (CBOD=5mg/L / TSS=3mg/L / TP=0.26mg/L / TRZ=0.195mg/L)

Other Considerations:

Septage Compatibility	Capital Costs	O&M Costs
Bypass Potential	Funding Potential	Reliability
Proven NE Technology	Needs Equalization/Storage	Labor Requirements
Innovative Technology	Requires 2mm Screening	Grease sensitivity
Hydraulic capacity	Backup/Redundancy	Phasing Ability

Workshop Schedule:

5:00-5:15PM	Introductions and opening remarks by each attendee
5:15-5:30PM	Discuss Goals of Workshop, Considerations, and Ranking
5:30-6:30PM	Discuss TN Removal Alternatives, focusing on pros/cons

1. MBR
2. Bardenpho process (4 or 5 stage)
3. Oxidation Ditch
4. Seqencing Batch Reactor
5. IFAS
6. Granular Activated Sludge
7. Annammox MBBR
8. Biological Aerated Filter
9. Membrane Aeration Bioreactor
10. Mobile Organic Biofilm
11. Microvi MNE
12. Densified Activated Sludge (optimization)

6:30-7:00PM	Break for Pizza
7:00-7:30PM	Discuss Tertiary Alternatives, focusing on pros/cons

1. Membranes
2. Sand filters
3. Cloth disc filtration
4. Ballasted flocculation
5. Reactive Filtration

7:30-8:30PM	Revisit Goals of Workshop and Weight Considerations
8:30-9:00PM	Questions

Post Workshop: UE/Hazen to score each technology based on consideration weighting by Workshop attendees; scoring for each consideration will be 1-4: 4 is best, higher total score is better.

TN Removal Technology Ranking for Epping

Consideration	Weight	MBR	Bardenpho	Oxidation Ditch	SBR
Can meet TN of 3 mg/L (Y/N)	NA	Yes	Yes w/ membranes	Yes w/ denit filter & membranes	Yes w/ denit filter & membranes
Reliability	31				
Proven NE Technology	23				
Bypass potential	15				
Capital Costs	14				
Labor Requirements	11				
Funding Potential	9				
O&M Costs	8				
Hydraulic capacity	8				
Septage Compatibility	7				
Backup/Redundancy	3				
Need for EQ/Storage	1				
Total Score = (Sum of Weight x Rank)					

OWNER: Town of Epping, NH

PROJECT: 2987 Total Nitrogen Upgrade Study

DATE: 12/5/23

Total Nitrogen (TN) Removal Technology Ranking by Steve Clifton

Parameter	MBR Bardenpho	Conventional Bardenpho	Oxidation Ditch Bardenpho	SBR
Can meet TN of 3 mg/L w/ supp cabon (Y/N)	Yes	Yes	No	No
Can meet TSS of 3 mg/L (Y/N) [(1)]	Yes	No	No	No
Secondary clarifiers required (Y/N)	No	Yes	Yes	No
Denitrification filter required (Y/N)	No	No	Yes	Yes
Polishing membranes required (Y/N)	N/A	Yes	Yes	Yes

Parameter	Weight	Rank (1 to 4)	Score	Rank (1 to 4)	Score	Rank (1 to 4)	Score	Rank (1 to 4)	Score
Reliability	31	4	124	3	93	2	62	1	31
Proven NE Technology	23	1	23	4	92	3	69	2	46
Bypass Potential	15	1	15	4	60	3	45	2	30
Capital Costs	14	4	56	3	42	1	14	2	28
Labor Requirements	11	3	33	2	22	4	44	1	11
Funding Potential	9	4	36	3	27	2	18	1	9
O&M Costs	8	3	24	2	16	4	32	1	8
Hydraulic Capacity	8	3	24	2	16	4	32	1	8
Septage Compatability	7	1	7	3	21	2	14	4	28
Backup / Redundancy	3	1	3	3	9	4	12	2	6
Need for EQ / Storage	1	1	1	3	4	3	3	2	2
TOTAL SCORE		346		402		345		207	

Notes

1. Epping WWTF Permit requires the facility to meet a summer TSS limit of 3 mg/L monthly average, 4 mg/L max week, 6 mg/L max day.
2. Assumed only allocating 1/2/3 or 4

OWNER: Town of Epping, NH

PROJECT: 2987 Total Nitrogen Upgrade Study

DATE: 12/5/23

Total Nitrogen (TN) Removal Technology Ranking by Steve Smith

Parameter	MBR Bardenpho	Conventional Bardenpho	Oxidation Ditch Bardenpho	SBR
Can meet TN of 3 mg/L w/ supp cabon (Y/N)	Yes	Yes	No	No
Can meet TSS of 3 mg/L (Y/N) (1)	Yes	No	No	No
Secondary clarifiers required (Y/N)	No	Yes	Yes	No
Denitrification filter required (Y/N)	No	No	Yes	Yes
Polishing membranes required (Y/N)	N/A	Yes	Yes	Yes

Parameter	Weight	Rank (1 to 4)	Score	Rank (1 to 4)	Score	Rank (1 to 4)	Score	Rank (1 to 4)	Score
Reliability	31	4	124	4	124	4	124	4	124
Proven NE Technology	23	2	46	4	92	3	69	4	92
Bypass Potential	15	3	45	4	60	4	60	3	45
Capitol Costs	14	4	56	2	28	1	14	1	14
Labor Requirements	11	2	22	2	22	2	22	2	22
Funding Potential	9	2	18	4	36	3	27	3	27
O&M Costs	8	4	32	2	16	1	8	2	16
Hydraulic Capacity	8	4	32	4	32	4	32	3	24
Septage Compatability	7	4	28	4	28	4	28	4	28
Backup / Redundancy	3	4	12	4	12	3	9	3	9
Need for EQ / Storage	1	1	1	3	3	3	3	3	3
	TOTAL SCORE	416		453		396		404	

Notes

1. Epping WWTF Permit requires the facility to meet a summer TSS limit of 3 mg/L monthly average, 4 mg/L max week, 6 mg/L max day.

OWNER: Town of Epping, NH

PROJECT: 2987 Total Nitrogen Upgrade Study

DATE: 12/5/23

Total Nitrogen (TN) Removal Technology Ranking by Dave Mercier

Parameter	MBR Bardenpho	Conventional Bardenpho	Oxidation Ditch Bardenpho	SBR
Can meet TN of 3 mg/L w/ supp cabon (Y/N)	Yes	Yes	No	No
Can meet TSS of 3 mg/L (Y/N) (1)	Yes	No	No	No
Secondary clarifiers required (Y/N)	No	Yes	Yes	No
Denitrification filter required (Y/N)	No	No	Yes	Yes
Polishing membranes required (Y/N)	N/A	Yes	Yes	Yes

Parameter	Weight	Rank (1 to 4)	Score	Rank (1 to 4)	Score	Rank (1 to 4)	Score	Rank (1 to 4)	Score
Reliability	31	4	124	4	124	3	93	3	93
Proven NE Technology	23	2	46	4	92	3	69	3	69
Bypass Potential	15	3	45	4	60	4	60	3	45
Capitol Costs	14	4	56	3	42	2	28	3	42
Labor Requirements	11	4	44	3	33	3	33	3	33
Funding Potential	9	3	27	4	36	4	36	4	36
O&M Costs	8	4	32	3	24	3	24	3	24
Hydraulic Capacity	8	3	24	4	32	4	32	3	24
Septage Compatability	7	3	21	4	28	4	28	3	21
Backup / Redundancy	3	3	9	4	12	4	12	3	9
Need for EQ / Storage	1	3	3	4	4	4	4	3	3
TOTAL SCORE		431		487		419		399	

Notes

1. Epping WWTF Permit requires the facility to meet a summer TSS limit of 3 mg/L monthly average, 4 mg/L max week, 6 mg/L max day.

OWNER: Town of Epping, NH

PROJECT: 2987 Total Nitrogen Upgrade Study

DATE: 12/5/23

Total Nitrogen (TN) Removal Technology Ranking by Rob Sharp

Parameter	MBR Bardenpho	Conventional Bardenpho	Oxidation Ditch Bardenpho	SBR
Can meet TN of 3 mg/L w/ supp cabon (Y/N)	Yes	Yes	No	No
Can meet TSS of 3 mg/L (Y/N) (1)	Yes	No	No	No
Secondary clarifiers required (Y/N)	No	Yes	Yes	No
Denitrification filter required (Y/N)	No	No	Yes	Yes
Polishing membranes required (Y/N)	N/A	Yes	Yes	Yes

Parameter	Weight	Rank (1 to 4)	Score	Rank (1 to 4)	Score	Rank (1 to 4)	Score	Rank (1 to 4)	Score
Reliability*	31	4	124	4	124	3	93	3	93
Proven NE Technology	23	3	69	4	92	3	69	4	92
Bypass Potential	15	3	45	4	60	4	60	4	60
Capitol Costs	14	4	56	2	28	1	14	3	42
Labor Requirements	11	3	33	3	33	3	33	3	33
Funding Potential**	9	3	27	3	27	3	27	3	27
O&M Costs	8	2	16	2	16	2	16	3	24
Hydraulic Capacity	8	3	24	4	32	4	32	3	24
Septage Compatability	7	4	28	4	28	4	28	3	21
Backup / Redundancy***	3	4	12	4	12	4	12	4	12
Need for EQ / Storage	1	1	1	3	3	3	3	1	1
	TOTAL SCORE	435		455		387		429	

* Assuming reliability relates to complete treatment train being able to meet TN of 3 mg/L, TSS of 3 mg/L and low P.
** I am not certain what the funding potential is for any of these processes so I have them all the same score -
*** Back-up redundancy can be built into all of these

Notes

1. Epping WWTF Permit requires the facility to meet a summer TSS limit of 3 mg/L monthly average, 4 mg/L max week, 6 mg/L max day.

TOWN OF EPPING, NEW HAMPSHIRE
EPPING WATER AND SEWER COMMISSION
WWTF TOTAL NITROGEN UPGRADE
TECHNOLOGY ALTERNATIVES WORKSHOP
NOVEMBER 29th, 2023

BACKGROUND

The Town of Epping, New Hampshire owns and operates a 0.5 MGD biological nutrient removal membrane bioreactor (BNR MBR) wastewater treatment facility. The facility discharges to the Lamprey River which flows to the Great Bay Estuary. In the past two years, the Facility has been issued two new EPA NPDES Permits:

- The first being a total nitrogen general permit which covers Epping and eleven other seacoast communities discharging to Great Bay,
- and the second being a general permit for the rest of the plant's discharge parameters which was issued to the majority of New Hampshire facilities with a design flow of less than 1 MGD.

The current total nitrogen permit requires Epping to "hold the load" meaning that the permit level is set at the average total pounds of nitrogen (43 lbs) that was estimated to be discharged by the Facility during the calendar years 2012–2016. While this TN limit is currently achievable, if Epping desires to connect additional entities to the wastewater collection system and increase their average daily flows, or begin receiving septage again, then additional treatment will be required to meet the current limits. Further, it is important to understand that the current permit included provisions for communities to participate in an adaptive management approach which involves tracking and attempting to achieve reductions in non-point source nitrogen sources within the respective Town's borders. EPA has stated that if adaptive management does not prove fruitful, the communities discharging effluent to the Great Bay Estuary may be faced with future potential total nitrogen permit limits of 8, 5, or 3 mg/L.

The purpose of this workshop is to vet a wide variety of potential alternatives for upgrading the Epping WWTF to reliably achieve TN removal to the limits of technology, and collectively identify the best upgrade option for Epping which will then be evaluated in greater detail for the purposes of establishing capital costs estimates for future planning and warrant article development.

Biological Treatment Processes for TN Removal

The overall objectives of the biological treatment of wastewater are to (1) transform dissolved and particulate biodegradable constituents into acceptable end products, (2) capture and incorporate suspended and nonsettleable colloidal solids into a biological floc or biofilm, (3) transform or remove nutrients, such as nitrogen and phosphorus, and (4) in some cases, remove specific trace organic constituents. These objectives are primarily accomplished through one of two styles: suspended growth and attached growth processes. In suspended growth processes, the microorganisms responsible for treatment are maintained in liquid suspension by appropriate mixing treatment. An example of this is the activated sludge process. In attached growth processes, the microorganisms responsible for the conversion of organic material or nutrients are attached to an inert packing material. The organic material and nutrients are removed from the wastewater flowing past the attached growth, also known as biofilm. An example of this is the IFAS process.

Reviewed Technologies:

1. The membrane bioreactor (MBR) process (Veolia/Zeeweed)
2. The Bardenpho process (4 Stage)
3. The oxidation ditch process (Ovivo Carrousel)
4. The sequential batch reactor (SBR) process (Aqua-Aerobics)
5. The integrated fixed film activated sludge (IFAS) process (Veolia/Kruger)
6. The granular activated sludge process (Nereda)
7. The moving bed bioreactor (MBBR) process (Veolia ANITA Mox)
8. Membrane Aeration Bioreactor Process (MABR) (Veolia Zeelung)
9. Mobile Organic Biofilm (Nuvoda)
10. MicroNiche Engineering (Microvi)
11. Densified Activated Sludge (inDENSE Hydrocyclone) (optimization)

WASTEWATER ALTERNATIVE TECHNOLOGY UPGRADES WORKSHOP

EPPING, NH

WEDNESDAY, NOVEMBER 29, 2023

Membrane Bioreactor (MBR) Process

- Hollow fiber membranes act as the solid liquid separation step in the process, in place of secondary clarifiers and tertiary filters.
- Hydraulic performance linked to water temperature; lower winter temperatures lead to decreased hydraulic performance of the membranes.
- Recommended potential pre-treatment steps include:
    - Fine screening (of the mesh or punched hole type, hollow fiber membranes typically require 1-2mm screening, compared to 2-3mm for flat plate membranes.)
    - Grease/oil removal
    - Flow equalization
- Operates at higher volumetric loading rates which leads to lower hydraulic retention times (HRT), requiring less space.
- Typically operated at longer sludge retention times (SRT),
- Susceptible to buildup and fouling of the membrane, impacting system performance.
- Increased operational demands due to time spent on membrane fouling and membrane replacement.
- Require frequent cleaning (typically 2-4 times per year) using citric acid and sodium hypochlorite solutions.
- Produces an effluent with low concentrations of bacteria, total suspended solids (TSS), biochemical oxygen demand (BOD), phosphorus, and nitrogen.
- Advantages of the MBR process over conventional biological systems include:
    - Better effluent quality
    - Smaller process footprint
    - Ease of process automation
- Disadvantages of the MBR process include:
    - Higher capital and O&M costs than conventional systems for the same throughout due to:
        - Membrane cleaning and replacement
        - Membrane fouling control
        - Energy costs associated with air scouring
    - Temperature affects the hydraulics of the membrane, water must be kept above a certain temperature to ensure peak hydraulic capacity is maintained.

Figure 1 - Membrane units outside their basin

Figure 2 - Membrane units in use

2 ZeeWeed membranes for MBR applications

The ZW500D is the core building blocks used in SUEZ's MBR applications. The ZW500D is available to our Indirect Channel partners in a 16 module or 52 module cassette. The 52 module cassette can come fully populated with modules or in two partially populated arrangements to match the desired membrane surface area.

The following table 2.1 summarizes key information for this product.

ZW500D-370 Module

ZW500D 16M Cassette

ZW500D 52M Cassette

Table 2.1: ZW500D Products for Indirect Channel Partners

Membrane Product	ZW500D 16M	ZW500D		
Modules per cassette	16	26 of 52 (26/52)	40 of 52 (40/52)	52 of 52 (52/52)
Module type	ZW500D-370	ZW500D-370		
Module surface area	370 ft^2 (34,4 m^2)	370 ft^2 (34,4 m^2)		
Surface area populated within Cassette	16 * 370 = 5920 ft^2 (550,4 m^2)	26 * 370 = 9620 ft^2 (894,4 m^2)	40 * 370 = 14800 ft^2 (1376 m^2)	52 * 370 = 19240 ft^2 (1788,8 m^2)
Cassette material	316L SS	316L SS		
Membrane Aeration	"LEAP"	"LEAP"		
Air flow	See Section 6.1.1 – Membrane Aeration			

All ZeeWeed cassettes have both permeate and membrane aeration connections. Table 2.2 details the connections for the 500D cassettes available to our Indirect channel partners.

The membrane aeration system for the ZW500D cassette is integral to the cassette frame. Air is delivered to an aeration grid on the base of the cassette frame. For full details on aeration rates and aerator configurations please refer to Section 6 – Membrane aeration.

Table 2.2: ZW500D Standard Cassette Connections

Cassette	ZW500D 16M LEAP	ZW500D 52M LEAP
Number of Permeate Connections per Cassette	2 (only 1 needs be used [typically the center connection is used and the other is capped])	1
Size of Permeate Connection	4 inch	6 inch
Permeate Connection	FNPT half coupling	Vertical pipe
Number of Aeration Connections per Cassette	1	1
Size of Aeration Connections	3 inch	3 inch
Aeration Connection	FNPT half coupling	Vertical pipe

3 ZeeWeed MBR process design

3.1 Design Flux Rates

The net hydraulic flux is the net volume of permeate produced over a period of time (e.g.: one day) divided by the membrane surface area. Net hydraulic flux is different than instantaneous hydraulic flux in that it accounts for non-production events such as backpulse/relax and maintenance cleans. The units for flux are gfd (US gallons/ft^2/d) or lmh (L/m^2/h).

3.2 Design Flux

The net hydraulic flux is the most important design parameter for the membrane filtration process. Factors affecting the selection of design flux include:

- Mixed liquor operating temperature (especially minimum design temperature)
- Type of wastewater (municipal, industrial/commercial, etc.)
- MLSS concentration in the membrane tank
- Peak flow rates and duration (peak hour, maximum day, maximum week, maximum month – definitions of these flow rates are provided in Appendix A)
- Membrane redundancy requirements, including treatment capacity when a membrane train is offline for cleaning or maintenance

Selecting the design flux requires understanding and detailed information about the application. Flux selection is a balance between cost and risk. That is, a lower design flux results in higher initial cost but in general, less maintenance and lower risk, whereas a higher design flux generally results in lower initial cost but higher maintenance and potentially higher risk.

The maximum design net hydraulic flux rates for ZeeWeed MBR systems treating municipal wastewater are provided in Table 3.1. The design net hydraulic flux values must not exceed the values in the tables for all flow conditions.

For flow conditions that are between conditions provided in the table, interpolation may be performed. For example, to determine the flux for a 48-hour sustained peak flow, a linear interpolation should be made between the MWF (7-day) limit and the MDF (1-day) limit.

The maximum design flux rates given in Table 3.1 are based on experience filtering fully nitrified mixed liquor treating typical municipal wastewater and do not apply to the following situations, where lower design fluxes are required:

- Industrial wastewater treatment – In this case, a flux of 10 GFD is recommended.
- Municipal applications where there is a significant industrial wastewater contribution.
- Other applications or conditions where the filterability or fouling characteristics of the mixed liquor are not representative of typical municipal wastewater, as indicated by operation outside of the required mixed liquor characteristics defined in Section 7 – Required Mixed Liquor Characteristics.

For all projects where any of the above situations are identified, the flux selection for the project must be reviewed and approved by your SUEZ representative.

Table 3.1: ZW500D MBR Net Hydraulic Flux

Bioreactor Temperature (°C)	Annual Average ADF		Max Month MMF		Max Week MWF		Max Day MDF		Peak Hour PHF	
	Net Flux (gfd)	Net Flux (lmh)	Net Flux (gfd)	Net Flux (lmh)	Net Flux (gfd)	Net Flux (lmh)	Net Flux (gfd)	Net Flux (lmh)	Net Flux (gfd)	Net Flux (lmh)
5	5.7	9.7	7.2	12.3	8.6	14.6	10.1	17.1	11.5	19.5
10	11.6	19.7	12.9	21.9	15.4	26.3	18.1	30.8	20.5	34.9
15	14.5	24.7	16.0	27.2	19.3	32.9	22.9	39.0	25.5	43.4
20	16.3	27.7	18.0	30.7	21.7	37.0	25.8	43.9	28.8	48.9
25	16.6	28.1	18.3	31.1	22.0	37.4	26.3	44.7	29.2	49.7
>=30	16.7	28.5	18.6	31.6	22.3	37.9	26.5	45.1	29.6	50.3

Notes:

1 Annual Average, Max Month, and Max Week net flux values are based on a membrane tank MLSS concentration of 10 g/L

2 Max Day and Peak Hour net hydraulic flux values are based on ZW tank MLSS concentration of 12 g/L

3.3 MLSS Concentration

The net hydraulic design flux values specified in Table 3.1 are based on the following MLSS concentrations in the ZeeWeed membrane tank:

- 10 g/L for Average Day, Maximum Month, and Maximum Week conditions.
- 12 g/L for Maximum Day, and Peak Hour conditions.

The increased ZeeWeed membrane tank design MLSS concentration for the Maximum Day and Peak Hour conditions accounts for the fact that the mixed liquor return rate (RAS) is typically designed based on the Maximum Month design flow for the plant, resulting in increased membrane tank MLSS concentrations during the Maximum Day and Peak Hour conditions.

MLSS concentrations must not be greater than those defined above.

3.4 Conservative Membrane Design

In the design of membrane systems, the careful consideration of operating parameters and treatment objectives is employed to select the best design option. There are however, unknown factors that can affect membrane performance. Conservative design can be applied by:

- using a lower design flux;
- leaving empty cassette spaces in the membrane tank;
- any combination of the two.

During the design of a membrane system, the ancillary non-membrane equipment required for the incorporation and potential use of the spare capacity should be taken into consideration. It is recommended that ancillary non-membrane equipment including, but not limited to, rotating equipment (pumps, blowers), mechanical equipment (headers, valves), and other infrastructure (e.g.: beams) be considered in the plant design such that utilization of the spare space requires only the addition of membrane modules or cassettes.

It is understood that these provisions are sometimes not practical for inclusion at the time of initial construction and the decision whether or not to include the equipment is at the discretion of the designer following a review of the risk and mitigation measures in place.

4 ZeeWeed MBR pretreatment

Providing proper pretreatment of the wastewater upstream of an MBR system is a key factor to successful long-term MBR operation. Pretreatment steps that should be considered include:

- Fine screening
- Grease/oil removal
- Flow equalization

Typically, a combination of one or more of these processes will be used, depending on the specific requirements of the plant.

4.1 Fine Screening

The most critical components in the MBR pretreatment process are the fine screens. It is important that the fine screens are selected, designed, installed, operated, and maintained properly in order to provide membrane protection over the life of the plant. In addition, it is important that the performance of the fine screening system (both hydraulic performance and removal efficiency) be tested and verified to ensure that it meets the design specifications, and that the performance requirements are guaranteed by the supplier in the procurement of the screens.

The general fine screening requirements for ZeeWeed MBR systems are as follows:

- Minimum required: screens with 2-mm mesh or punched hole openings.
- Redundant screens sized for peak wastewater flow are strongly recommended, so that the maximum influent wastewater flow can be processed by the screens with one screen out of service.
- The screen design, installation, and operation must not allow overflow or bypass of unscreened wastewater to the downstream side of the screen.

The screening requirements for industrial wastewater may be different from those listed above, depending on the nature of the solids that must be removed in order to protect the membranes. Thus, the screening requirement for industrial MBRs is site and source-specific and should be considered by the design engineer depending on the need.

4.2 Mixed Liquor Sieve Test

If the MBR pretreatment systems are selected, designed, installed, operated, and maintained properly, then the concentration of trash and other material in the mixed liquor should be very low. The quantity of debris in the mixed liquor can be measured by an analytical procedure known as a Sieve Test. Routine use of the Sieve Test will provide an assessment of the performance of the pretreatment systems – if the Sieve Test results are initially stable, but then later increase, it is likely an indication that the pretreatment systems are not functioning as they should. The Sieve Test procedure is included in Appendix C.

It is recommended that a Sieve Test be performed once per quarter using mixed liquor sampled from the membrane tanks. A properly performing pre-treatment system will result in a sieve test measurement of:

Material > 2-mm in size: less than 2 mg/L

If the Sieve Test results are higher than the above limits, then it is likely that the fine screens are allowing material to overflow or bypass into the MBR, and the performance of the fine screens, and the overall pretreatment process, must be reviewed and rectified in order to eliminate any sources of overflow or bypass.

4.3 Other Pretreatment Processes

4.3.1 Coarse Screening

When discussing membrane bioreactors, coarse screening generally refers to screens with an opening size of 6-mm or larger, and include many different types of screens.

ZeeWeed MBR systems have no specific requirement for coarse screens. However, there are several situations where the use of coarse screens is beneficial, including:

- The use of coarse screens upstream of fine screens will reduce the loading on the fine screens, and may allow the use of smaller and less expensive fine screens.
- Coarse screens will prevent large objects from entering and potentially causing mechanical or other damage to the down-stream equipment.

4.3.2 Grease/Oil Removal

Grease removal usually refers to the removal of fat, oil and grease (FOG). In most municipalities, there are specific guidelines that limit the discharge of FOG into the sewers and encourage FOG removal at the source. The levels of FOG typically found in domestic wastewater are not a major concern for ZeeWeed MBR plants.

However, significantly higher levels of FOG such as free oils can have a negative impact on membrane performance and must therefore be removed prior to the MBR. The oil limits in the influent are:

- **150 mg/L of emulsified oil**
- **no free oil**
- **10 mg/L of mineral or non-biodegradable oil**.

Typical FOG removal processes used in conventional activated sludge plant can also be used in ZeeWeed MBR plants.

FOG that does enter a ZeeWeed MBR plant will generally form a scum layer in the bioreactors (typically in the anoxic zone(s)). This scum layer does not impact membrane performance, but it may be an aesthetic issue in some cases.

Some fine screen manufacturers prefer that FOG removal facilities are located upstream of the fine screens, in order to minimize the risk of blinding of the screen with grease. This issue should be discussed with the fine screen manufacturer on a project-by-project basis.

4.3.3 Flow Equalization

Flow equalization is a process that can be used in ZeeWeed MBR plants to reduce the impact of severe peaking conditions and reduce the overall cost of the plant. The main factors to consider with respect to flow equalization are the size of the plant, the frequency, extent and duration of peaking conditions, and the availability of space or tank capacity. Alternatives to flow equalization as a pretreatment process include:

- Variable level bioreactor with in-tank equalization. This will result in varying MLSS concentrations as the bioreactor tank level rises and falls. Ensure an MLSS no greater than 12,000 mg/L at the lowest tank level.
- Extra membrane capacity to use during peaking conditions
- Flow equalization in the collection and transfer system

The use of flow equalization is not a specific requirement for ZeeWeed MBR plants.

As in any conventional activated sludge plants, flow equalization is used to attenuate significant flow variations due to large short-term peak flows. It is suitable for large peak hourly to peak daily flow rates in small to medium size plants.

An alternative to flow equalization is to use additional membranes that can be used during peaking conditions. This may be suitable when there is no available space for equalization tank or the plant experiences extended or seasonal peak flow conditions.

The choice between using flow equalization or extra membranes should be made by evaluating the capital and operating cost of extra membranes versus that of the equalization volume.

The benefits of flow equalization include:

- Reduction in the size and cost of downstream equipment and processes:
  - Membrane area required
  - Smaller blowers, pumps, screens
- Improved biological and membrane performance by eliminating/minimizing shock loadings on the biological system

WASTEWATER ALTERNATIVE TECHNOLOGY UPGRADES WORKSHOP

EPPING, NH

WEDNESDAY, NOVEMBER 29, 2023

Bardenpho Process – 4 Stage

- 4 Stage anoxic-aerobic-anoxic-aerobic process designed primarily for nitrogen removal.
- Nitrification occurs in the first aerobic zone, and the nitrate produced in this step is recycled back to the first anoxic zone, where it is then reduced to nitrogen gas using the BOD in the anoxic zone influent.
- The second anoxic zone provides denitrification to the portion of the flow not recycled back to the primary anoxic zone.
- Second aerobic zone strips any remaining nitrogen gas and increases dissolved oxygen concentration before clarification.
- Nitrogen removal may be limited due to factors such as:
    - Carbon source availability (carbon sources can also be added to the third stage to enhance denitrification)
    - Process kinetics
    - Anoxic and aerobic zone sizes
- Can also be modified into a 5-stage Bardenpho Process through the addition of a preliminary anaerobic zone to facilitate phosphorus removal.
- Mainly geared towards nitrogen removal, but 5-stage Bardenpho can reduce phosphorus in the effluent.
- Advantages of the process include:
    - Lower operating costs when compared to other BNR processes.
    - Requires minimal operating training
    - Reduced sludge production
- Disadvantages include:
    - Typically requires significant area for plant expansion
    - Will require tertiary filters

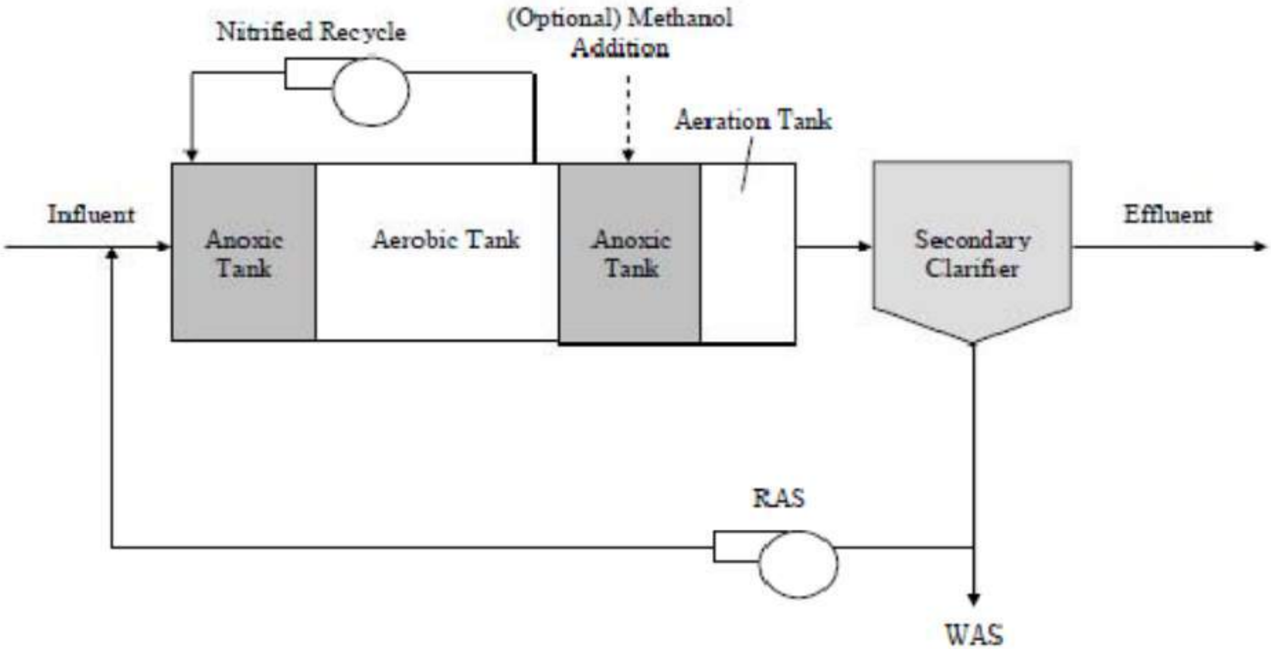


Figure 1 - 4-Stage Bardenpho Process Diagram

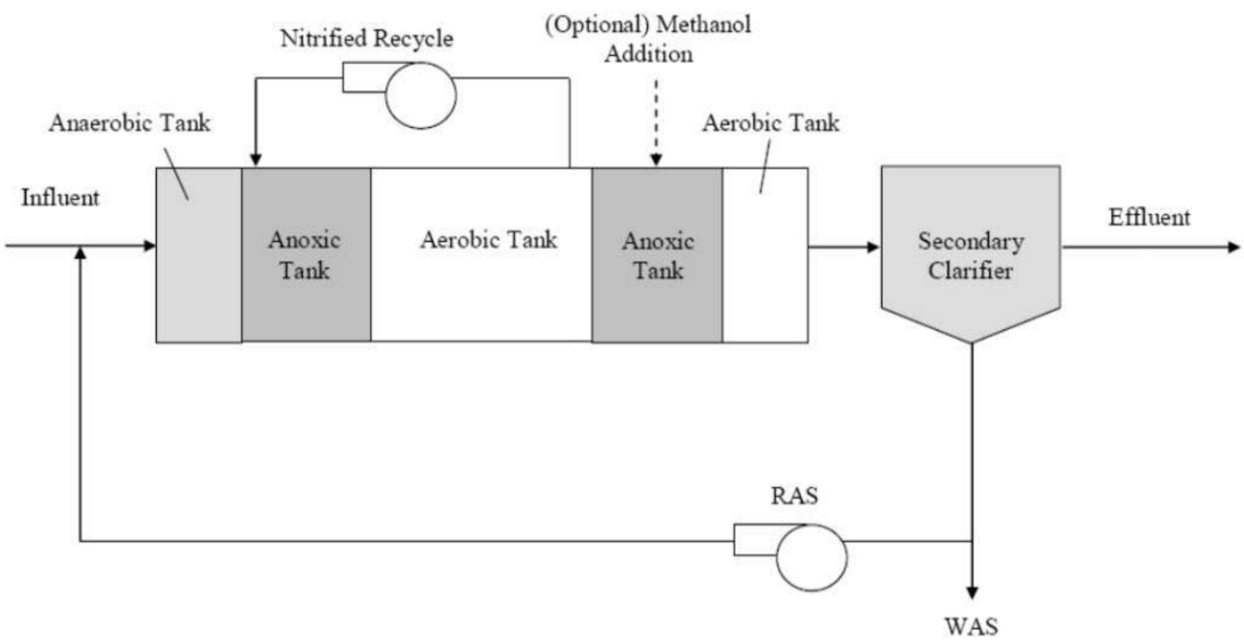


Figure 2 - 5-Stage Bardenpho Process Diagram

WASTEWATER ALTERNATIVE TECHNOLOGY UPGRADES WORKSHOP

EPPING, NH

WEDNESDAY, NOVEMBER 29, 2023

Oxidation Ditch Process

- Modified activated sludge biological treatment process that utilizes long SRTs to remove biodegradable organics.
- Typically, complete mix systems, but they can be modified to approach plug flow condition. (Note: as conditions approach plug flow, diffused air must be used to provide enough mixing. The system will also no longer operate as an oxidation ditch.)
- Systems typically consist of a single or multi-channel configuration within a ring, oval, or horseshoe-shaped basin.
- Reaeration may be necessary prior to final discharge.
- Flow to the ditch is aerated and mixed with return sludge from a secondary clarifier.
- Ditch volume is sized based on SRT required to meet effluent requirements.
- Supplemental basins can be constructed in the Oxidation Ditch to meet effluent quality requirements (see attached manufacturers sheet)
- Advantages include:
  - Long HRT and complete mixing minimize the impact of a shock load or hydraulic surge.
  - Produces less sludge than other biological treatment processes owing to extended biological activity during the activated sludge process.
  - More energy efficient with less associated costs when compared to other biological treatment processes.
- Disadvantages include:
  - Effluent suspended solids concentrations are relatively high compared to other modifications of the activated sludge process
  - Requires a larger land area than other activated sludge treatment options
  - Will require tertiary filters

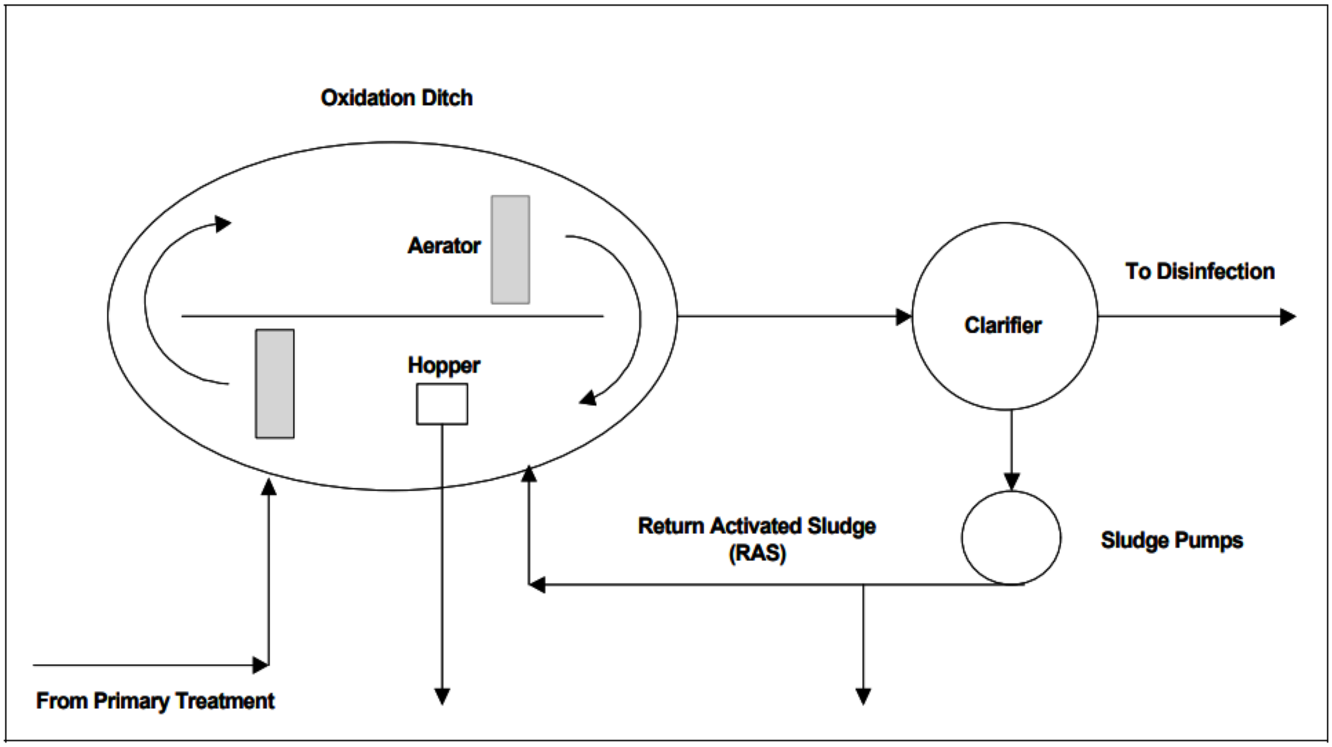


Figure 1 - Oxidation Ditch flow diagram

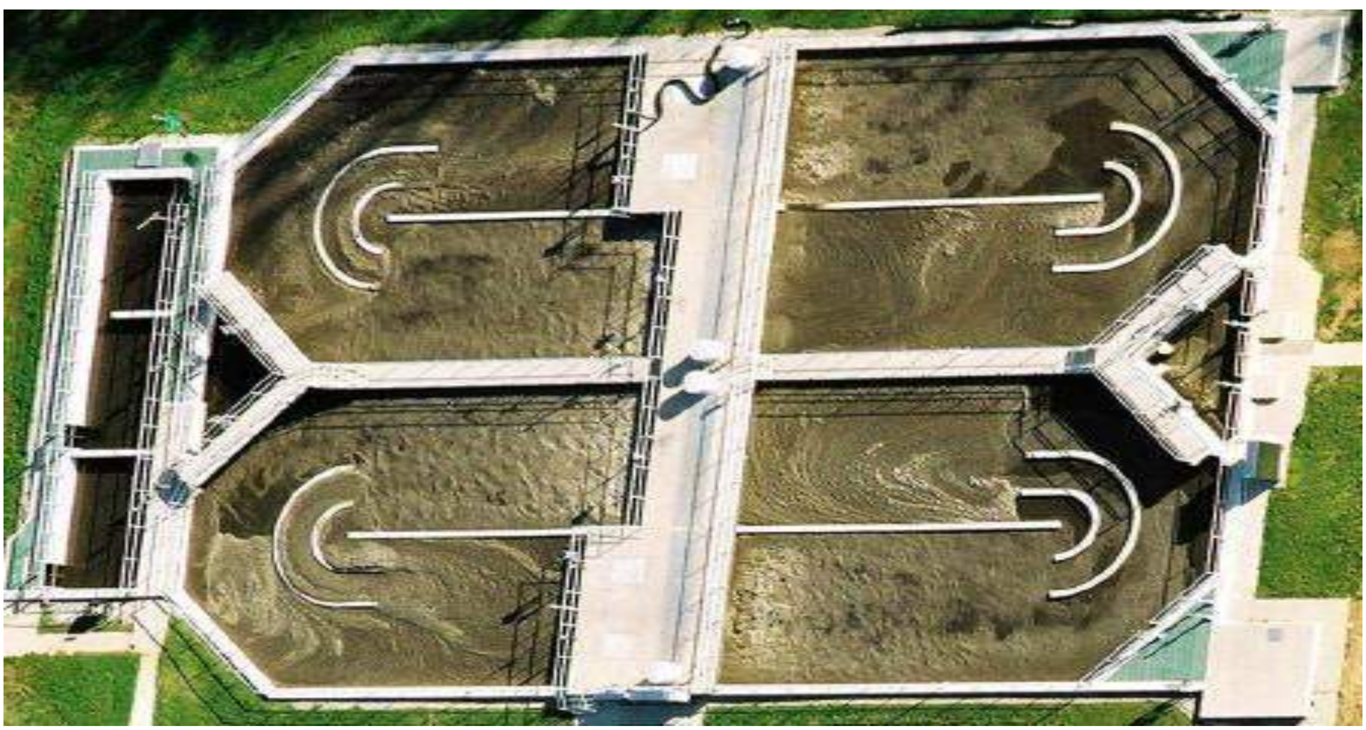


Figure 2 – Aerial view of an oxidation ditch process configuration

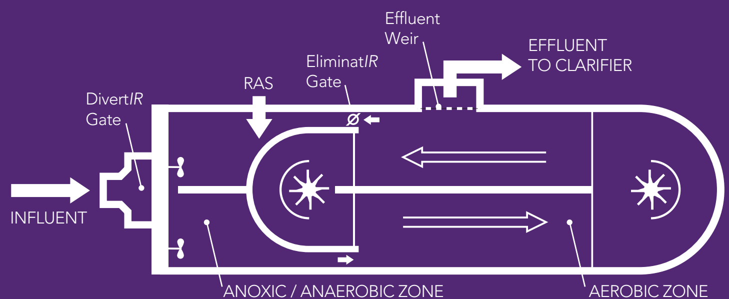
OVIVO Worldwide Experts in Water Treatment

MAXIMUM TREATMENT, MINIMUM EFFORT

Meet Stringent Nutrient Limits

Reduce Chemical and Energy Usage

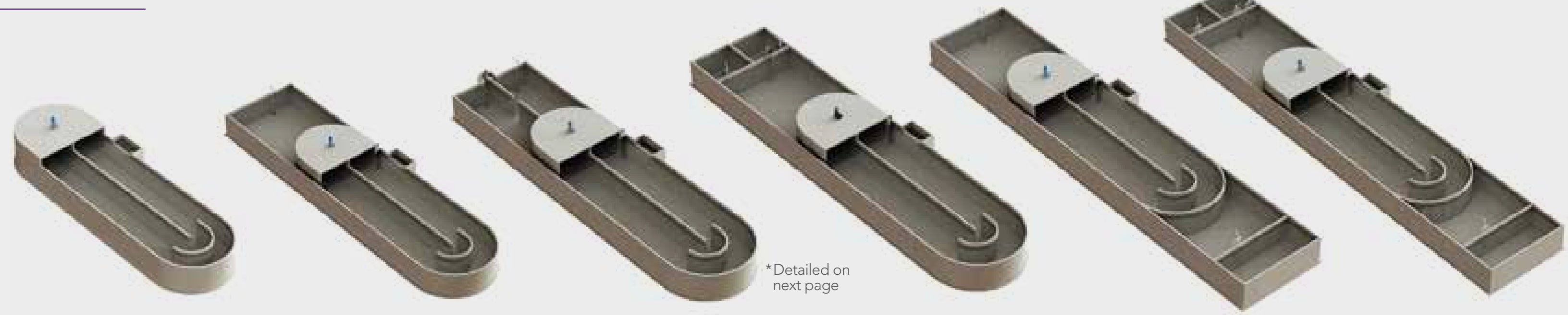
Construct, Operate and Maintain Easily



CARROUSEL® SYSTEMS

OVIVO | NUTRIENT REMOVAL

THE CARROUSEL® PROCESS FAMILY



	1-STAGE	2-STAGE	3-STAGE	3-STAGE	4-STAGE	5-STAGE
	BASIC CARROUSEL® SYSTEM	denit*IR*® CARROUSEL® SYSTEM	Alternat*IR*™ SYSTEM	A^{2}C™ SYSTEM	BARDENPHO® CARROUSEL® SYSTEM	BARDENPHO® CARROUSEL® SYSTEM
ANAEROBIC			✓	✓		✓
1ST ANOXIC		✓	✓	✓	✓	✓
AEROBIC	✓	✓	✓	✓	✓	✓
2ND ANOXIC					✓	✓
RE-AERATION					✓	✓
EFFLUENT (mg/L)	BOD≤5 NH3-N≤0.5	BOD≤5 NH3-N≤0.5 TN≤5-8	BOD≤5 NH3-N≤0.5 TN≤5-8 TP≤0.3*	BOD≤5 NH3-N≤0.5 TN≤5-8 TP≤0.3*	BOD≤5 NH3-N≤0.5 TN≤3	BOD≤5 NH3-N≤0.5 TN≤3 TP≤0.3*

*May require trim doses of metal salts

OVIVO: AN ENGINEERING PROCESS POWERHOUSE

The Ovivo Carrousel Process Team, which consists of decades of biological wastewater treatment plant design and innovation, has provided expertise and design assistance for wastewater treatment plants of all shapes, sizes, and effluent requirements.

CAPABILITIES:

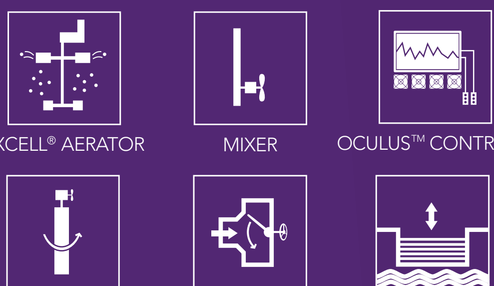
- Detailed Design Support
- Process Modeling (Biowin)
- Equipment Sizing
- Effluent Guarantees
- Water Expert Compatible
- Retrofits and Upgrades
- Automated Controls and SCADA
- Process Training and Workshops
- 3-D Modeling and CAD Support

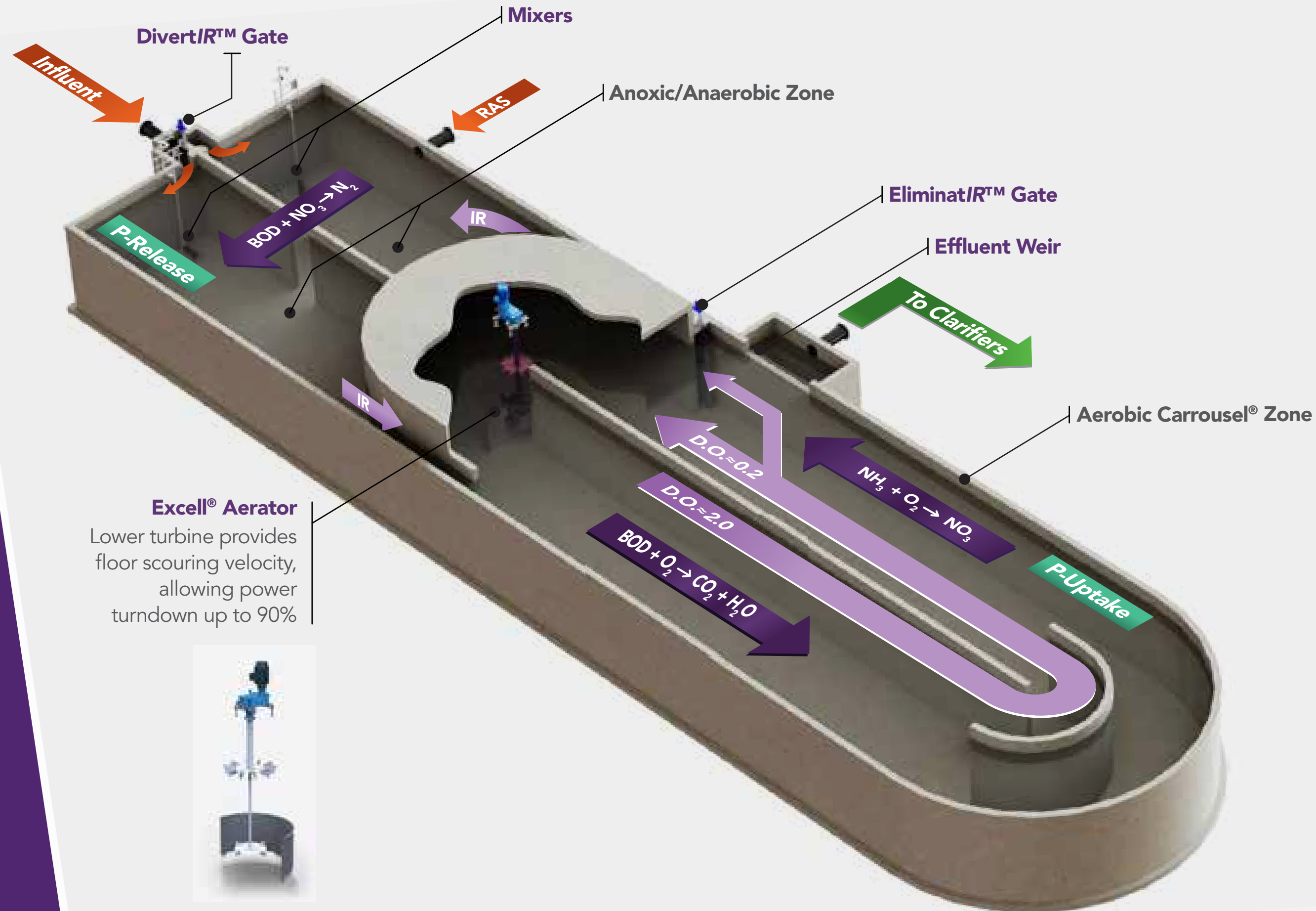
THE CARROUSEL® ALTERNAT*IR*™ SYSTEM

In the denit*IR*® Carrousel System an integral anoxic basin is added for Total Nitrogen removal without supplemental carbon addition. The internal recycle (IR) is large (6-15Q) and requires no additional pumping.

The automatically controlled Eliminat*IR*™ Gate can be used to create anaerobic cycles in the anoxic zone to achieve phosphorus removal. This is called the Alternat*IR* System.

In the aerobic (Carrousel) zone, BOD and ammonia oxidation (nitrification) proceed to completion. The Excell Aerator provides all aeration, velocity, and internal recycle pumping required at all influent loading conditions.





OVIVO:
A HISTORY OF EXCELLENCE

- **1979** — Installs 1st Carrousel® System
- **1983** — Installs 1st BNR System
- **1988** — Develops and installs 1st denit*IR*® Carrousel® System
- **1991** — Develops and installs 1st Dual-Impeller Aerator
- **1998** — Develops and installs 1st ACE™ Control System to conserve energy

ALL AERATOR MAINTENANCE FROM A CLEAN CONCRETE DECK

SYSTEM FULLY AUTOMATED TO REDUCE ENERGY AND MEET TIGHT N AND P LIMITS

NO IR PUMPS REQUIRED. IR CHANNEL DELIVERS 12Q OR HIGHER.

2001 — Develops and installs 1st Deep Tank Carrousel® System: 23 ft-SWD

2006 — Installs 600th Carrousel® System

2007 — Introduces the Excell® Aerator II: Our most efficient Dual-Impeller Aerator for BNR Systems to date!

2009 — Introduces the Elimina*IR*™ Gate to maximize, optimize and automate BNR

2010 — Introduces the Oculus™ BNR Control System

2012 — Develops and installs the first Full BNR optimization Oculus™ MCC

2013 — Introduces Ovivo® Connect℠ Asset Management System

2014 — Introduces Carrousel® Swing*IR*™ System

2019 — Introduces new ExcellAerator PRO for improved mixing

CARROUSEL® SYSTEMS:

A FORWARD LOOKING APPROACH

The Carrousel® System is a leading technology in wastewater treatment and biological nutrient removal. With over forty years of experience and more than 800 installations in North America, the Carrousel system has proven to be the most rugged, reliable and forgiving treatment system available. Each Carrousel System is engineered to achieve the highest quality effluent with the lowest cost of operation and maintenance. The Carrousel is universally praised for operational simplicity and dependable performance from start up to the most demanding situations.

Carrousel Systems offer the lowest number of aerators per basin compared to other oxidation ditch systems, such as those that use horizontal shaft aerators. This greatly simplifies installation and maintenance requirements.

At a minimum, a Carrousel System consists of a "racetrack" style reactor basin with at least one vertical shaft, low-speed mechanical aerator, the Excell® Aerator, installed in the center of one of the turns. The basic Carrousel System is capable of full BOD and Ammonia reduction. Nutrient removal is easily added to a Carrousel System via the addition of anoxic and anaerobic selector zones, or even with simple, optimized operational strategies.

The Carrousel System utilizes the Modified Lutzack-Ettinger (MLE) configuration for highly efficient denitrification. This process is known as the denit*IR*® System, where internal recycle (IR) flow is directed into the anoxic zone via a slip-stream channel using propulsion generated by the Excell Aerator. No additional energy for IR pumping is required. IR flowrate is varied by the Eliminat*IR*™ Gate. The Oculus™ Control System automatically controls the aeration rate and IR flow.

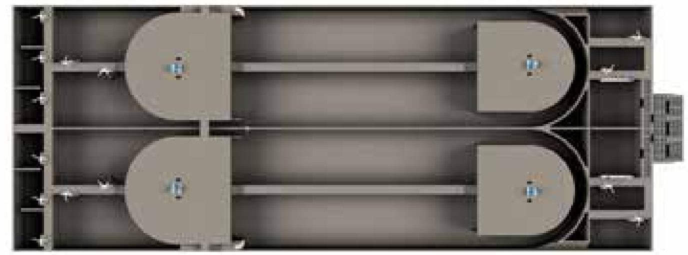
Top: The Excell® Aerator is installed at one or more of the channel turns and provides all aeration and mixing required for full nitrification and BOD removal.

Bottom: Anoxic and anaerobic basins are easily added for Total Nitrogen and Total Phosphorus removal in Ovivo's denit*IR*® configuration.

ACTIVATED SLUDGE TREATMENT AND BIOLOGICAL NUTRIENT REMOVAL

40 YEARS OF CARROUSEL® SYSTEMS

1979 - today



WASTEWATER ALTERNATIVE TECHNOLOGY UPGRADES WORKSHOP

EPPING, NH

WEDNESDAY, NOVEMBER 29, 2023

Sequencing Batch Reactor

- Sequencing batch reactor (SBR) is a fill-and-draw type of reactor system involving a single complete-mix reactor in which all the steps of the activated sludge process occur.
- Process consists of 5 basics steps : ide, fill, react, settle, and draw. More than one operating strategy is possible during most of these steps.
- Mixed liquor remains in the reactor during all cycles, eliminating the need for separate sedimentation tanks.
- After passing through screens and grit removal, wastewater enters a reactor partially filled with biomass.
- Once the reactor is full, it behaves like a conventional activated sludge system, but without a continuous influent and effluent flow.
- The aeration and mixing is discontinued after the biological reactions are complete, the biomass settles, and the treated supernatant is removed.
- Excess biomass is wasted at any point of the cycle.
- Performance of SBRs is typically comparable to conventional activated sludge systems, and depending on their mode of operation, can achieve good BOD and nutrient removal.
- Manufacturers typically provide a process guarantee to produce an effluent of less than:
  - 10 mg/L BOD
  - 10 mg/L TSS
  - 5-8 mg/L TN
  - 1-2 mg/L TP
- Advantages include:
  - Equalization, biological treatment, and secondary clarification can be achieved in a single reactor vessel.
  - Operating flexibility and control
  - Minimal footprint
  - Potential capital cost savings by eliminating clarifiers and other equipment.
- Disadvantages include:
  - A higher level of equipment sophistication is required (compared to conventional systems), resulting in a higher level of maintenance needed.
  - Potential of discharging floating or settled sludge during the DRAW or decant phase with some SBR configurations.
  - Will require tertiary filters.
  - Potential requirement for equalization after the SBR, depending on the downstream process.

Figure 2 - Individual SBR basin

Figure 1 – Aerial view of an SBR configuration

AquaSBR®
Sequencing Batch Reactor

AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

Typical AquaSBR® Applications

Biological Nutrient Removal

- 1.65 MGD Avg. Daily Flow
- Replaced flow-through activated sludge system for enhanced biological nutrient removal (EBNR) to meet Chesapeake Bay Initiative.

Phosphorus Removal

- 2.7 MGD Avg. Daily Flow
- Dissolved oxygen control optimizes power consumption
- Process control achieves 98% removal of total influent phosphorus

Nitrification

- 0.8 MGD Avg. Daily Flow
- Dual basin system. Utilizes process control via IntelliPro® system.

Reuse

- 2.0 MGD Avg. Daily Flow
- 3-basin system followed by (2) AquaDisk® cloth media filters produces reuse quality water.

Industrial Pretreatment

- .075 MGD Avg. Daily Flow
- Treating high strength dairy waste since 1991.

Retrofit

- 0.88 MGD Avg. Daily Flow
- Dual basin retrofit uses existing oxidation ditch to provide treatment flexibility and power savings

AquaSBR®
Sequencing Batch Reactor

For over 35 years, Aqua-Aerobic Systems has led the industry in sequencing batch reactor technology with performance proven and cost effective treatment systems capable of effectively removing nutrients and reducing phosphorus with the flexibility of process control that adapts to changing demands.

The AquaSBR® sequencing batch reactor provides true batch technology with all phases of treatment accomplished in a single reactor. All components are easily accessible and the advanced decant system ensures optimum quality effluent withdrawal. Treatment can be optimized with the IntelliPro® process monitoring and control system to further reduce operation and maintenance,energy costs and improve performance.

System Features and Advantages

- Independent aeration and mixing with the Aqua MixAir® system provides process advantages and lower energy consumption
- A true-batch system utilizes Mix-Fill, React-Fill, React, Settle and Decant phases within a single reactor
- No secondary clarifiers and return activated sludge (RAS) lines
- All components of the AquaSBR system are retrievable and easily accessible
- Hydraulic fluctuations are easily managed through the flexibility of a time managed process operating strategy
- Enhanced biological nutrient removal:
  - Anaerobic period during Mix-Fill phase to achieve low biological phosphorus requirements
  - Minimize metal salt usage with automated addition after biological luxury uptake to achieve <0.5 mg/l TP
- Ideal for low total nitrogen requirements:
  - Flexibility to modify aeration cycling for TN removal under changing conditions
  - Achieves total nitrogen levels down to 3.0 mg/l
- Low cost of ownership

Aqua MixAir® System

The AquaSBR sequencing batch reactor utilizes the Aqua MixAir® system by providing separate mixing with the AquaDDM® direct-drive mixer and an aeration source such as the Aqua-Jet® surface aerator or Aqua-Aerobic diffused aeration. This system has the capability to cyclically operate the aeration and mixing to promote anoxic/aerobic and anaerobic environments with low energy consumption. In addition, the Aqua MixAir system can achieve and recover alkalinity through denitrification, prevent nitrogen gas disruption in the settle phase, promote biological phosphorus removal, and control certain forms of filamentous bacteria.

Advanced Decanter

The Aqua-Aerobic floating decanter follows the liquid level, maximizing the distance between the effluent withdrawal and sludge blanket. It is an integral component to the AquaSBR system and provides reliable, dual barrier subsurface withdrawal with low entrance velocities to ensure surface materials will not be drawn into the treated effluent. The decanter is easily accessible from the side of the basin and requires minimal maintenance.

AquaSBR®

Phases of Operation

The AquaSBR sequencing batch reactor system features time-managed operation and control of aerobic, anoxic and anaerobic processes within each reactor including equalization and clarification. The AquaSBR system utilizes five basic phases of operation to meet advanced wastewater treatment objectives. The duration of any particular phase may be based upon specific waste characteristics and/or effluent objectives.

1 Mix-Fill

- Influent flow enters the reactor
- Mixing is initiated with the AquaDDM mixer to achieve complete mix of the reactor contents in the absence of aeration
- Anoxic conditions are created which facilitate removal of any residual nitrites/nitrates (NO_X) via the process of denitrification
- In systems requiring phosphorus removal, the Mix-Fill phase is extended to create anaerobic conditions where phosphorus accumulating organisms (PAO) release phosphorus then ready for subsequent luxury uptake during aeration times
- Anoxic conditions assist in the control of some types of filamentous organisms

3 React

- Influent flow is terminated creating true batch conditions
- Mixing and aeration continue in the absence of influent flow
- Biological/chemical oxygen demand (BOD/COD) and ammonia nitrogen (NH_3) reduction continue under aerated conditions
- Oxygen can be delivered on a "as needed" basis via dissolved oxygen probes while maintaining completely mixed conditions
- Provides final treatment prior to settling to meet targeted effluent objectives

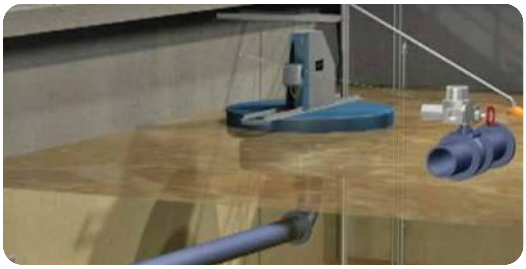
4 Settle

- Influent flow does not enter the reactor
- Mixing and aeration are terminated
- Ideal solids/liquid separation is achieved due to perfectly quiescent conditions
- Adjustable time values allow settling time to match prevailing process conditions

2 React-Fill

- Influent flow continues under mixed and aerated conditions
- Intermittent aeration may promote aerobic or anoxic conditions
- Biological/chemical oxygen demand (BOD/COD) and ammonia nitrogen (NH_3) are reduced under aerated conditions
- Luxury uptake of phosphorus is produced under aerated conditions
- NO_x is reduced under anoxic conditions
- Separation of aeration and mixing allows the aeration source to be turned down during low flow conditions to conserve energy while the system's flexibility allows nitrification/denitrification to be easily managed

5 Decant/Sludge Waste



- Influent flow does not enter the reactor
- Mixing and aeration remain off
- Decantable volume is removed by subsurface withdrawal
- Floating decanter follows the liquid level, maximizing distance between the withdrawal point and the sludge blanket
- Small amount of sludge is wasted near the end of each cycle

IntelliPro®

Process Monitoring and Control System

The IntelliPro system is a personal computer (PC) based program that interfaces with the AquaSBR system's programmable logic controller (PLC) via a network connection to assist operators in optimizing the treatment process of the plant and further reducing operating costs.

System Advantages

- Real-time, online monitoring and control
- "Active Control Mode" which automatically receives, interprets and proactively adjusts in-basin instruments and process variables including biological nutrient removal, chemical addition and energy
- Reduces the operator's sampling time
- Real-time and historical graphical trending of process parameters
- BioAlert™ process notification provides corrective action to eliminate operational interruptions and upsets
- Assists in the optimization of enhanced nutrient removal
- Online operation and maintenance support
- Remote troubleshooting provides on-demand troubleshooting assistance

WASTEWATER ALTERNATIVE TECHNOLOGY UPGRADES WORKSHOP

EPPING, NH

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Integrated fixed film activated sludge (IFAS)

- An IFAS system is a hybrid process that consists of an activated sludge system in which a material to support attached biomass growth has been added in addition to the suspended biological growth in an activated sludge reactor.
- Typically, 2 different configurations, submerged mobile media IFAS (requires effluent screening of media), and submerged fixed media IFAS.
- Physical facility design considerations for an IFAS process include:
    1. Pretreatment
    2. Media retention
    3. Aeration and mixing
    4. Foam control
    5. Biofilm control
    6. Liquid-solids separation
- Appropriate pretreatment, including fine screening (3mm or less), grit removal, and primary sedimentation, is necessary to prevent the accumulation of inert material, such as rags, plastics, and sand on the media and in the tank.
- May require higher DO concentrations in the mixed liquor to maintain the oxygen needed for attached biomass if maximum nitrification rates are desired. But if simultaneous denitrification is desired, lower DO concentrations can both simulate denitrification and reduce the oxygen requirement in the aerated bioreactor because of COD stabilized using NO_x as the electron acceptor.
- Addition of attached growth to the activated sludge reactor results in a total equivalent MLSS concentration that may be 1.5 to 2 times the activated sludge MLSS concentration alone.
- Can remove more than 90% of ammonia, and 75-85% of total nitrogen without the need for an external carbon source.
- Advantages of an IFAS process include:
    - An increased treatment capacity with the same footprint due to the submerged media.
    - An increase in the effective mixed liquor concentration to as much as 4000 to 8000 mg/L.
    - The ability to phase in treatment capacity or improve performance by adding media.
    - A more stable nitrification community due to a high attached growth inventory.
    - The potential for simultaneous nitrification and denitrification by controlling loading and DO conditions
- Disadvantages include:
    - Higher energy demand associated with increased DO demands
    - Issues of media removal for diffuser maintenance
    - The need for improved influent wastewater screening
    - Will require tertiary filters

Figure 1 - IFAS system in use in Hooksett NH

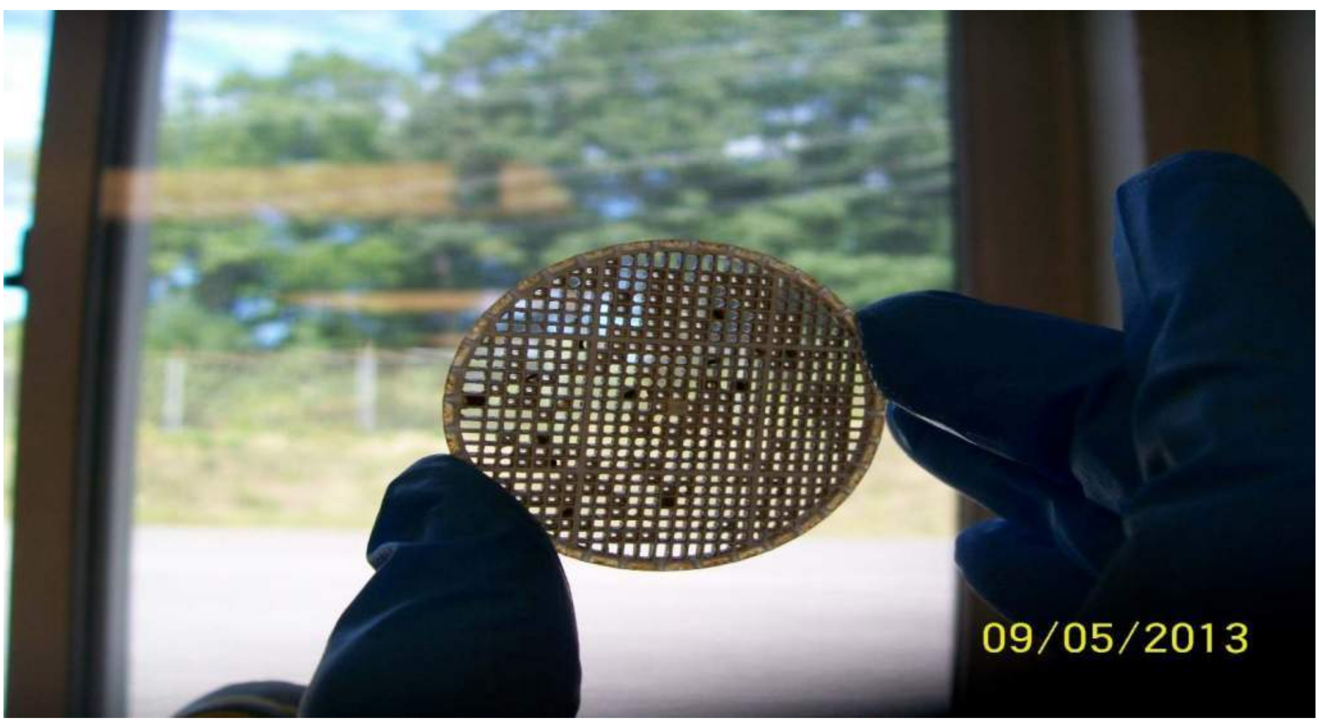


Figure 2 – Close up of IFAS media

AnoxKaldnes™ MBBR and IFAS Processes

AnoxKaldnes™ MBBR

(Moving Bed Biofilm Reactor) is a biological wastewater treatment process that utilizes specialized polyethylene carriers (media) to create a large protected surface on which biofilm can attach. The media is mixed in the reactor, and the large surface area provides more treatment capacity in a smaller volume compared to activated sludge.

AnoxKaldnes™ IFAS

Hybrid Biofilm Activated Sludge technology is an application of the IFAS process in which moving media is mixed into an activated sludge environment. The result is both fixed-film and suspended growth biomass working together and lending the strengths of each to the hybrid process. The IFAS process is excellent for retrofitting existing activated sludge plants to improve ammonia and nitrogen removal.

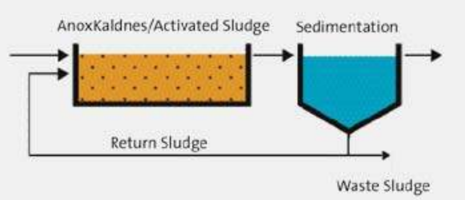
AnoxKaldnes™ IFAS for SBR

AnoxKaldnes IFAS systems can be retrofitted into a sequencing batch reactor (SBR) system. The AnoxKaldnes IFAS can increase the capacity of a SBR wastewater treatment process in the same footprint as a conventional SBR without the need for new tankage. The AnoxKaldnes IFAS for SBR uses engineered moving bed media to grow and foster nitrifying bacteria, even at low SRT's and low reactor temperatures. The process allows for greater BOD, NH_3-N, and TN removal.

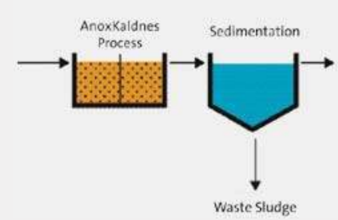
Advantages

- Simple and reliable operation
- Excellent for ammonia and total nitrogen limits (NH_3-N < 1 mg/L, NO_3-N < 1 mg/L)
- Smaller footprint than activated sludge
- Increase plant capacity for nitrification and/or denitrification
- Effective in cold water
- Accommodates a wide range of flow and load fluctuations
- Non-clogging media with a long lifespan
- Flexible design for almost any tank configuration

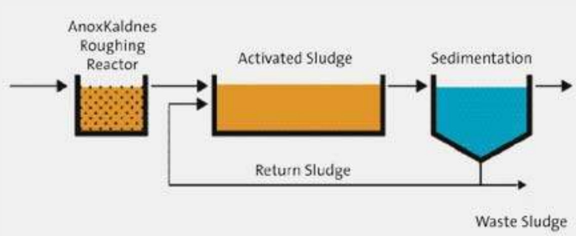
IFAS Technology



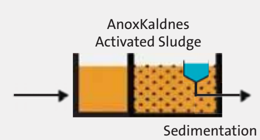
MBBR



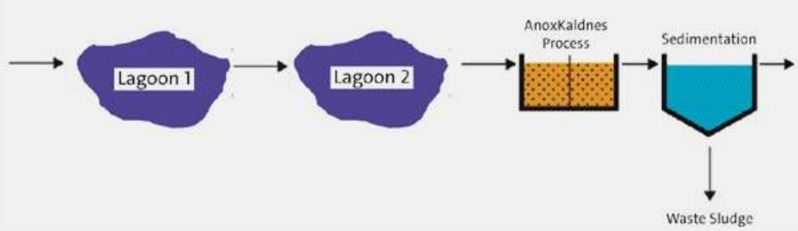
Biofilm Activated Sludge



IFAS for SBR



LagoonGuard® MBBR



AnoxKaldnes Technology Can Benefit A Wide Range of Plant Sizes

Cheyenne, WY
AnoxKaldnes MBBR

- In 2005, MBBR replaced trickling filters and was chosen because it is a biofilm process that is compatible with the existing clarifiers.
- Consists of two trains of two pre-anoxic and four aerobic reactors in series to treat 6.5 MGD and achieve BOD <10 mg/L and ammonia <2 mg/L, $NOx^{-}N$ <9 mg/L.

Providence, RI
AnoxKaldnes IFAS

- Ten parallel process trains with a treatment capacity of 77 MGD
- Existing aeration basins converted to a 4 stage process with one IFAS zone per train
- Pre-anoxic stage for denitrification using the influent BOD as a carbon source
- Aerobic Nitrification stage for BOD and Nitrification – IFAS Zone. 52% fill using AnoxKaldnes K3 media type. Total media surface area of 36.3 million square feet
- Post-anoxic stage for additional denitrification using an external carbon source
- Clarification stage for solids separation and collection

Winning Combinations

- *High rate clarification with ACTIFLO®*
- *Primary clarification with MULTIFLO*
- *Filtration with Hydrotech Discfilter*

WASTEWATER ALTERNATIVE TECHNOLOGY UPGRADES WORKSHOP

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Granular Activated Sludge Process

- Like the activated sludge process, but individual granules of biomass are responsible for treatment, rather than flocculated sludge.
- Each granule has separate aerobic, anoxic, and anerobic zones. Each granule is essentially a miniature treatment plant.
- 3 phase process done in a single tank.
    1. Simultaneous fill/draw phase
    2. React phase
    3. Settle phase
- Raw water fills the tank at the bottom while clean effluent at the top is displaced.
- Raw influent water is a rich carbon source, resulting in a high Food-to-Mass ratio at the bottom of the tank, where the particles are settled. Phosphorus release occurs because of the anerobic conditions.
- In the react phase, air is added intermittently based on either the DO concentration, the Ammonia concentration, or both. Simultaneous nitrification and denitrification occur due to the different zones in the granules.
- Granules then separate from the treated water. A quick settling time allows the process to spend more time in the react phase.
- A small amount of sludge is wasted out of the system at this time.
- Effluent an typically reach 10mg/L for BOD and TSS, as low as 3mg/L for total nitrogen, and less than 1mg/L for total phosphorus without chemical addition.
- Advantages:
    - Enhanced settling properties increases the settling rate up to 15 times faster than a sludge from a conventional activated sludge system.
    - Due to the entire process occurring in a single tank, total footprint of the treatment process can be reduced by up to 75% when compared to a conventional process.
    - A reduction in mechanical equipment needed to achieve enhanced BNR requirements lowers the construction, operating, and maintenance costs.
- Disadvantages
    - Relatively new technology (as of 2021, the oldest of the approximately 90 plants worldwide using this technology had been in operation since 2005).
    - The durability of the granules long term can be an issue, resulting in a decrease in efficiency.
    - The development of granules from municipal wastewater can take several months to complete
    - Will require tertiary filters

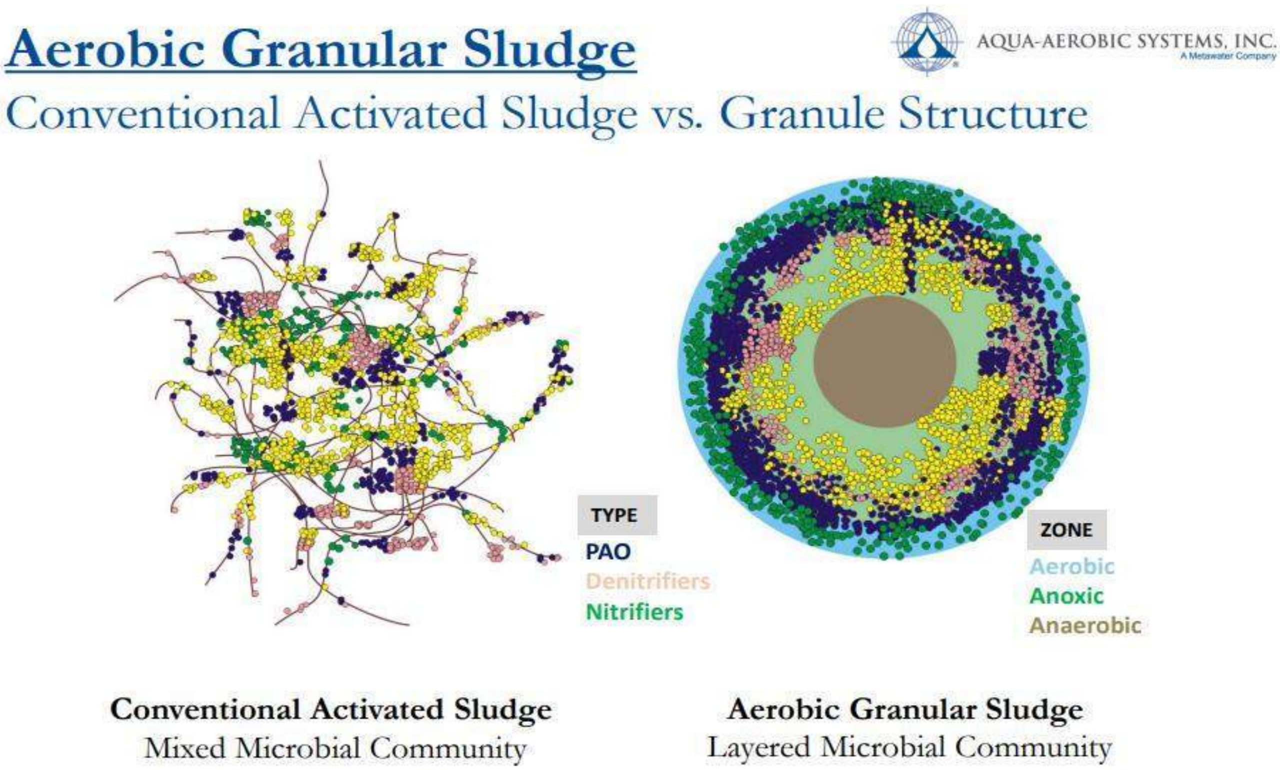


Figure 1 – Conventional Activated Sludge Particle vs. an Aerobic granular Sludge Particle

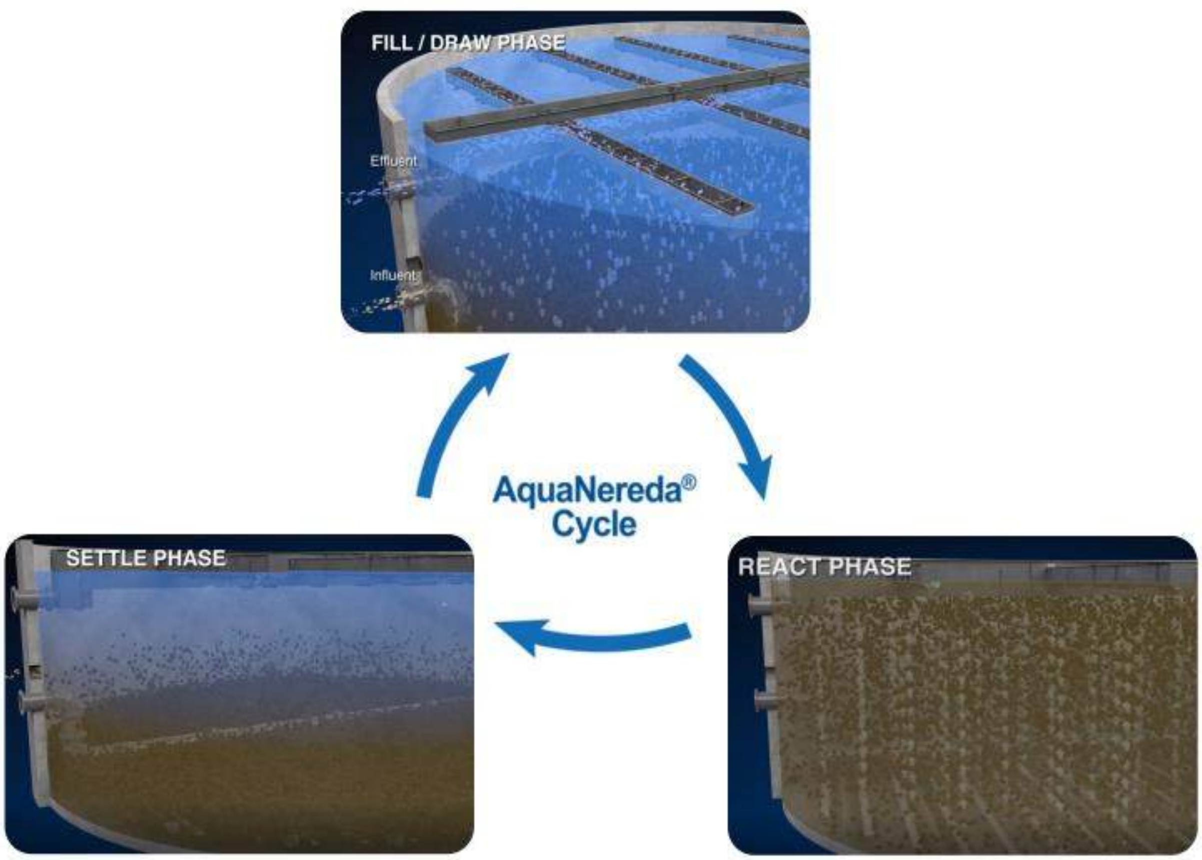


Figure 2 – Cycle Diagram of the AquaNereda Process

AquaNereda®

Aerobic Granular Sludge Technology

The AquaNereda® Aerobic Granular Sludge Technology is an innovative biological wastewater treatment system that provides advanced treatment using the unique features of aerobic granular biomass.

The aerobic granular biomass is comprised of compact granules which consist of layered microbial communities and provides superior settling compared to conventional activated sludge. Within a single tank, the process creates proper conditions to develop and reliably maintain a stable granule population without the need for a supplemental carrier. The layered aerobic and anaerobic zones within the granule allow for simultaneous processes to take place in the granular biomass, including enhanced biological phosphorus reduction and simultaneous nitrification and denitrification.

The unique process features of the AquaNereda technology translate into a flexible and compact process that offers energy efficiency and significantly lower chemical consumption culminating in a low life-cycle cost.

System Features and Advantages

- Optimal biological treatment is accomplished in one effective aeration step
- Settling properties at SVI values of 30-50 mL/g allow MLSS concentrations of 8,000 mg/l or greater
- 25% of the footprint compared to conventional activated sludge systems
- Energy savings up to 50% compared to activated sludge processes
- No secondary clarifiers, selectors, separate compartments, or return sludge pumping stations
- Proven enhanced nutrient removal (ENR)
- Robust structure of granule withstands fluctuations in chemical spikes, load, salt, pH and toxic shocks
- Significant reduction of chemicals for nutrient removal due to the layered structure and biopolymer backbone of the granule
- Ease of operation with fully automated controls
- Lowest life-cycle cost

Typical Applications

- Retrofit of existing tanks to increase treatment capacity
- Upgrade of existing treatment systems to meet BNR requirements
- New construction plants
- Municipal and industrial

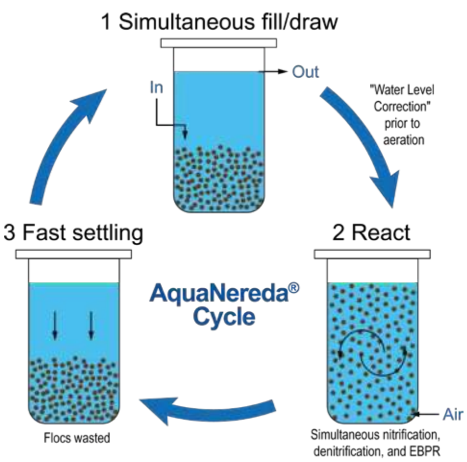
SVI_5 comparison of aerobic granular sludge (left) and conventional activated sludge (right)

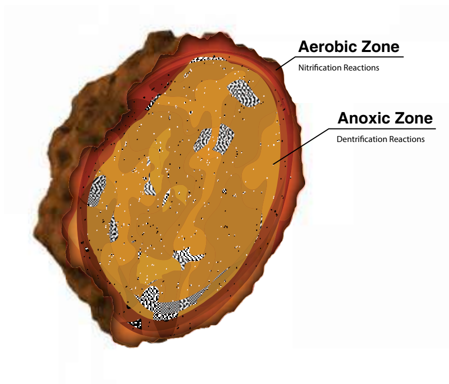
Three AquaNereda® reactors show compact design, typically 50% of a conventional plant.

Granule sample following sieve testing at the AquaNereda® demonstration facility, Rockford, IL

AquaNereda®
Batch Cycle Structure

Based on the unique characteristics of granular biomass, the AquaNereda® Aerobic Granular Sludge System uses an optimized batch cycle structure. There are three main phases of the cycle to meet advanced wastewater treatment objectives. The duration of the phases will be based upon the specific waste characteristics, the flow and the effluent objectives.





Plant Profile: Riviera Utilities Wastewater Treatment Plant at Wolf Creek - Foley, AL

The AquaNereda® Aerobic Granular Sludge System represents a step-change in the wastewater treatment industry. The new system at the Riviera Utilities Wastewater Treatment Plant at Wolf Creek consists of three aerobic granular sludge reactors operating similar to a continuous flow system with a Fill/Draw phase that alternates between reactors. Downstream polishing is performed by AquaDisk® Pile Cloth Media Filters to produce Class B reuse-quality water. Although not currently required by permit to achieve Total Nitrogen (TN) limit, the inherent BNR properties of Aerobic Granular Sludge provide TN removal now and for future permit limits. Since start-up in January 2020, the plant has consistently produced remarkable effluent quality which far surpasses current permit requirements, and in fact, already meets future anticipated TN and TP limits.

Compared to the previous conventional treatment process, AquaNereda achieves:

- Overall power cost reduction of 40%
- Zero chemical usage
- 30% of footprint
- 75% increase in treatment capacity
- Elimination of secondary clarifiers and RAS pumping
- Increased process resilience during peak wet weather
- Events and influent load variations
- Exceeds anticipated future nutrient removal requirements

Riviera Utilities WWTP Upgrade Received Distinction for Wastewater Project of the Year at the 2021 Global Water Awards

GLOBAL WATER AWARDS

Phases of Operation

1 Fill/Draw Phase

- Influent flow, substrate and readily available carbon source enter the reactor
- Anoxic and anaerobic conditions are present
- Biomass conditioning phase
- Phosphorus release to promote enhanced bio-P removal
- Treated water is discharged

2 React Phase

- Influent flow is terminated
- The biomass is subjected to aerobic and anoxic conditions
- Simultaneous nitrification/denitrification occurs
- Nitrate is transported by diffusion between outer aerated and inner anoxic layers of the granule, eliminating the need for pumping large recycle flows in the plant
- Luxury uptake of phosphorus is promoted
- Automated control of the process allows energy savings and process optimization

3 Settle Phase

- Influent flow does not enter the reactor
- Granular biomass is separated from the treated water during a very short settling phase
- Excess sludge is wasted in order to maintain the desired amount of biomass
- The system is ready for a new cycle

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Moving Bed Bioreactor (MBBR)

- The MBBR process is like the IFAS process with the use of mixed, suspended media contained within the reactor by effluent screens, except for the use of return activated sludge.
- This generally results in a higher media fill volume fraction (up to 70%), and the suspended solids concentration in the flow to the secondary clarifier may be in the range of 100 to 250 mg/L versus 2,500 mg/L to 3,500 mg/L
- Because of this relatively low suspended solids concentration in the effluent, solids recycling is not required as it is for activated sludge processes and IFAS processes. Liquid-solids separation methods other than secondary clarification may be used.
- Process designs for the MBBR also include the suspended media in anoxic zones for fixed film biological denitrification.
- Fine screening is required (3mm or less).
- With reactor effluent, filtration processes, including granular media and membrane filtration, and dissolved air floatation can be used in lieu of gravity settling.
- Capable of removing greater than 90% of ammonia and 75-85% of total nitrogen with no external carbon source needed.
- Advantages of an MBBR compared to conventional activated sludge include:
  - The smaller amount of space required
  - The simplicity of the operation, with no need for manual sludge wasting and SRT control and sludge recycle.
  - The elimination of sludge bulking in the secondary clarifiers and its effects on operation and effluent quality.
  - The ability to withstand peak wet weather flow variations.
- The disadvantages when compared to conventional activated sludge systems include:
  - A higher energy demand due to the need to operate at elevated DO concentrations
  - The need to use proprietary media
  - Issues of media removal for diffuser maintenance
  - The need for improved influent wastewater screening
  - Additional hydraulic profile headlosses due to flow through the media screening devices
  - The limitation of Phosphorus removal only by chemical addition
  - Will require tertiary filters

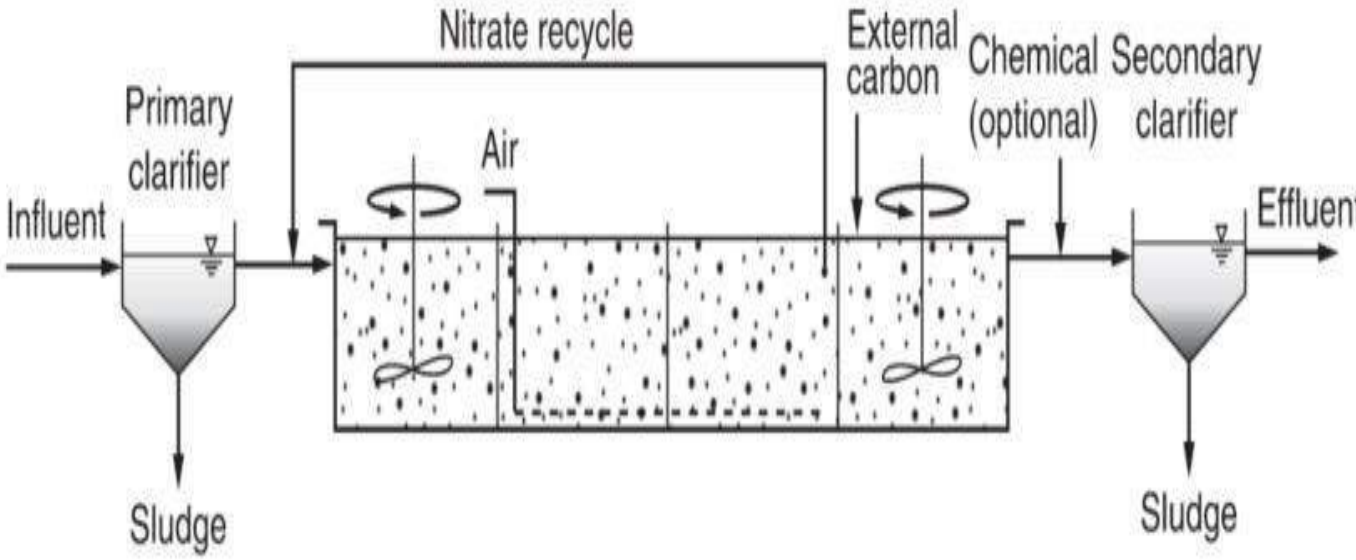


Figure 1 – Potential MBBR process flow diagram

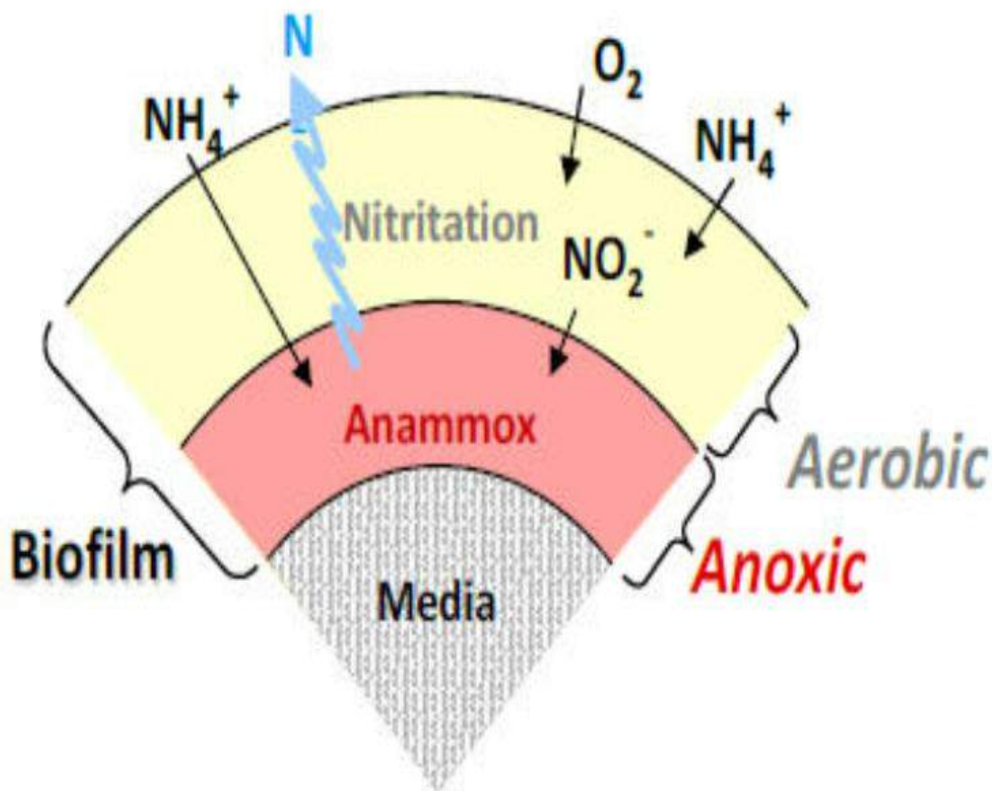


Figure 2 – Biofiolm zone breakdown

The Principle of the ANITA™ Mox Process - MBBR

ANITA™ Mox is a single-stage nitrogen removal process based on the MBBR (Moving Bed Biofilm Reactor) technology. The ANITA Mox process is used for treatment of streams highly loaded in ammonia, such as effluents from anaerobic sludge digestion, drying condensates, industrial wastewaters, and landfill leachates.

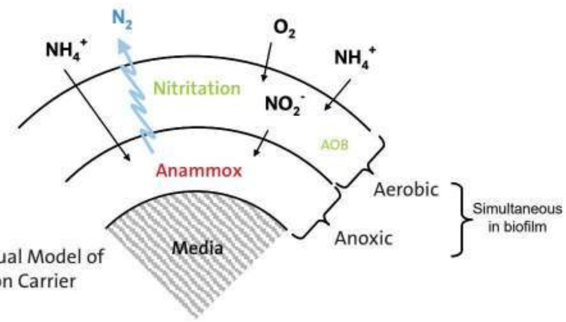
The ANITA Mox process combines aerobic nitritation and anoxic ammonia oxidation (anammox).

The two steps take place simultaneously in different layers of a biofilm. Nitritation (aerobic) occurs in the outer layer of the biofilm. A portion (55%) of the influent ammonia is oxidized to Nitrite (NO_2^-). Anammox (anoxic) activity occurs in the inner layer. In this step, the nitrite produced and the remaining ammonia are utilized by the anammox bacteria and converted to nitrogen gas (N_2) and a small amount of Nitrate (NO_3^-).

The aerobic and anoxic reactions occur in a single MBBR reactor equipped with specially designed plastic carriers that support the biofilm, thereby preventing washout of the bacteria from the reactor.

The ANITA Mox process, using a single-stage MBBR with a proven aeration control strategy, achieves ammonia removal up to 90% and total nitrogen removal in the range of 75 to 85% without external carbon addition and with lower energy cost compared to conventional nitrification-denitrification.

Process conditions in the reactor are monitored and maintained to provide the optimal environment for the combination of bacteria.



Conceptual Model of Biofilm on Carrier

The ANITA Mox effluent screens provide a positive barrier to loss of anammox bacteria, since they keep the media and biofilm in the reactor.

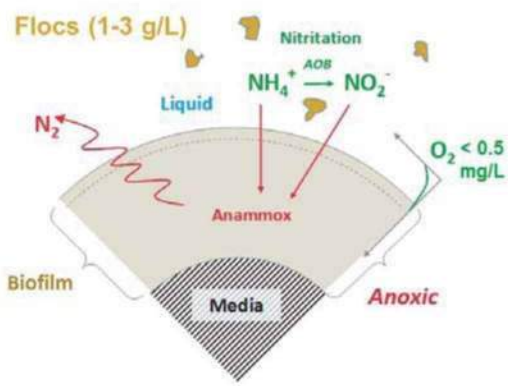
Operating Parameters, Ammonia Removal in Digester Dewatering Stream

Parameter	Conventional Nitrogen Removal	ANITA™ Mox
Oxygen Requirement (lb O_2/lb N)	4.6	1.9
MethanolConsumption (lb /lb N)	3.0	0
Sludge Production (lb VSS /lb N)	0.5 - 1.0	0.1

The IFAS Advantage

IFAS (Integrated Fixed Film Activated Sludge) technology using suspended carriers has been a proven application of the MBBR process for more than 20 years. Applying the same concept to ANITA Mox has shown some significant benefits.

As with any IFAS system, the suspended growth is retained using a clarifier. In IFAS ANITA Mox, the return of biomass to the system shifts much of the nitritation step from the biofilm to the suspended phase, where the conversion of ammonia to nitrite takes place more rapidly. IFAS ANITA Mox can achieve higher volumetric removal rates than any other anammox process, thereby reducing the size of the biological reactor. This results in a tremendous advantage in equipment sizing, reactor footprint, and overall value. Still, the choice between MBBR and IFAS ANITA Mox is site-specific. With IFAS ANITA Mox, our expert team now has two highly efficient ANITA Mox processes to offer in a complete solution.



IFAS Benefits Include:

- Volumetric Nitrogen removal rates have shown to be 2-3 times higher, thereby further reducing the footprint
- The operational DO in IFAS ANITA Mox is lower than in MBBR ANITA Mox which results in energy savings
- IFAS ANITA Mox has been shown to better handle the presence of influent COD and higher polymer doses

A Key Element of the ANITA™ Mox Process: The Carriers

A key element of the MBBR/IFAS technology is the AnoxKaldnes™ carriers, also called media. The very slow growth rate of the anammox bacteria makes their retention a critical objective of the process. Compared with other technologies, the ANITA Mox effluent screens provide a positive barrier to loss of anammox bacteria, since they keep the media and biofilm in the reactor. The media is also designed to provide a large protected surface area for the biofilm and optimal conditions for biological activity.

- Robust
- Compact
- 60% less oxygen requirement
- No external carbon needed
- Reduced sludge production

Highest volumetric loading (up to 3.0 kgN/m³/d)

Energy consumption as low as 1.1 kWh/kgN-rem

Robust, continuous process minimizes operator attention and equipment wear and tear

WASTEWATER ALTERNATIVE TECHNOLOGY UPGRADES WORKSHOP

EPPING, NH

WEDNESDAY, NOVEMBER 29, 2023

Membrane Aeration Bioreactor Process (MABR)

- The MABR process utilizes fixed film, with the biofilm fed oxygen via the membrane on which the biofilm sits.
- The two key aspects of this configuration responsible for key treatment benefits are:
    - The delivery of the oxygen in the molecular ('bubble-less') form directly into the biofilm means that the oxygen transfer efficiency is very high.
    - The flow of oxygen into the biofilm opposite of ammonia, which diffuses into the biofilm from the bulk liquid.
- The use of a membrane to deliver molecular oxygen directly into the biofilm is approximately four times more energy efficient than the use of conventional fine bubble diffusers.
- Residual (exhaust) gas from the oxygenation can be used to provide mixing and scouring of the MABR cassette.
- The growth of nitrifiers in the aerobic region provides a key advantage over suspended growth and conventional biofilm processes. It effectively increases the volume concentration of these bacteria by creating favorable conditions for their growth. The MABR process is like other biological fixed film processes in this regard.
- However, unlike other fixed film processes, the membrane increases both the overall energy efficiency of oxygen delivery to the biofilm and adds an extra element of:
    - Process control with respect to the rate of oxygen transfer into the biofilm, which increases the efficiency of oxygen transfer.
    - Intensification through concentration of the active microbiology, and the nitrifiers in particular, in the biofilm, which then permits more effective nitrification.
- The MABR process results in an effluent with low TN/TP/BOD concentrations.
- Advantages include:
    - Reduced aeration requirements associated with bubble free aeration
    - Reduced footprint
    - The passive transfer of the oxygen through the membrane into the biofilm utilizes the nitrates for an effective denitrification.
- Disadvantages include:
    - A relatively new process (first commercialization was in 2016)
    - Membrane cleaning and replacement frequencies
    - Will require tertiary filters

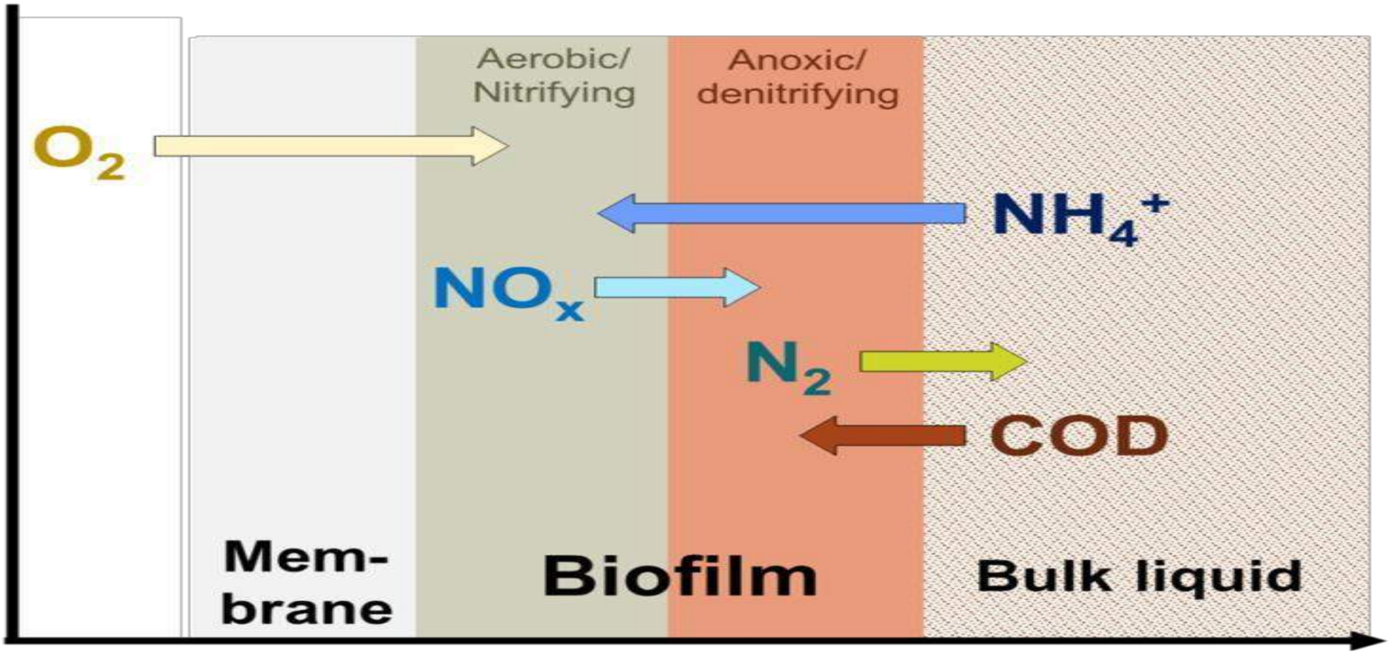


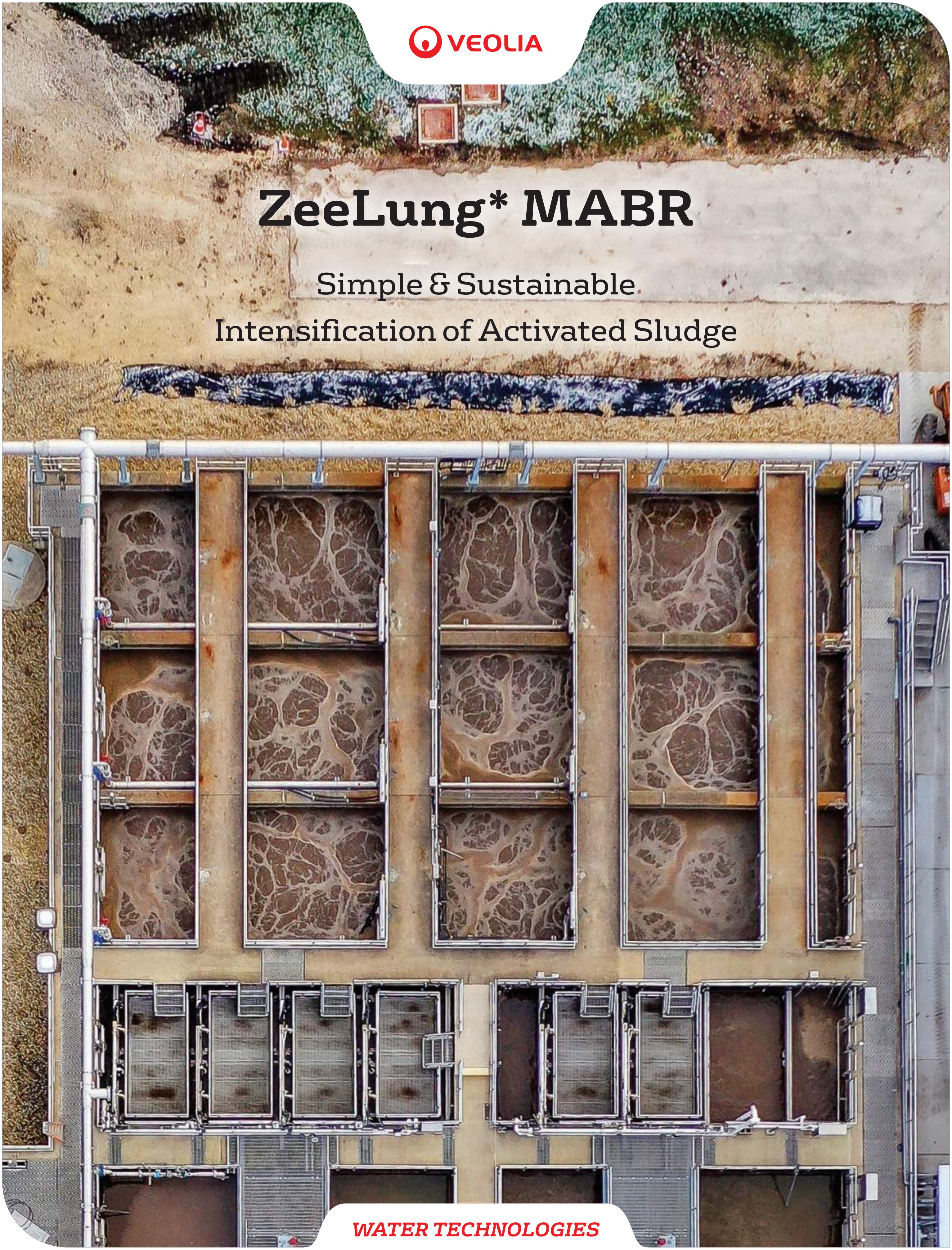
Figure 1 – MABR biofilm schematic and the associated transfer of oxygen, carbon, and nitrogen species.

Figure 2 – Membrane modules in their cassettes

VEOLIA

ZeeLung* MABR

Simple & Sustainable Intensification of Activated Sludge



WATER TECHNOLOGIES

Get more from your activated sludge assets

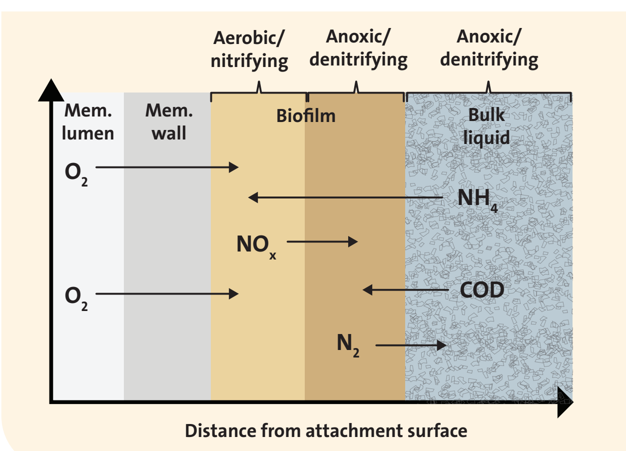
The Zeelung Membrane-Aerated Biofilm Reactor (MABR) is a game-changing technology used to upgrade conventional activated sludge plants and avoid the construction of new bioreactor tanks. ZeeLung MABR expands plant capacity and improves nutrient removal in a simple, fast and modular way while also reducing energy and mitigating GHG emissions.

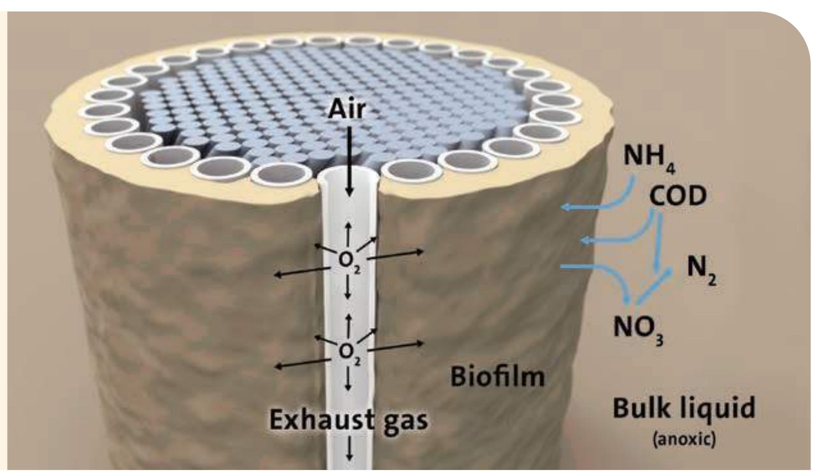
ZeeLung MABR is a simple and sustainable solution that offers:

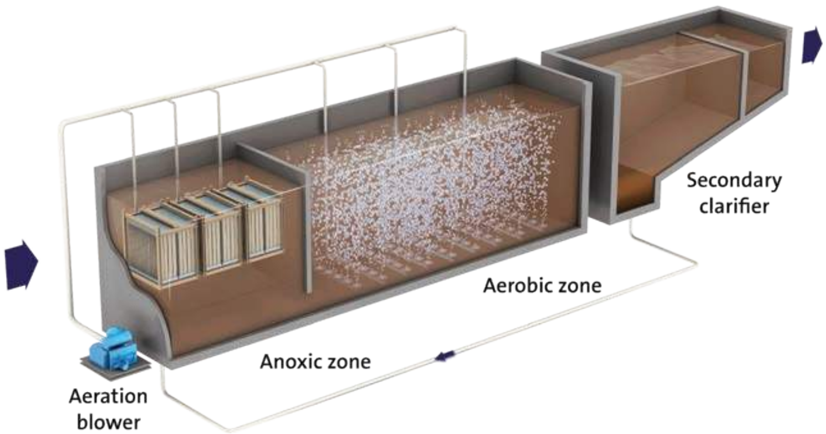
- **Process Intensification:** Up to 50% more treatment capacity in existing tanks
- **Simplicity:** Installed in existing tanks, no civil works, fast implementation
- **Resilience:** Dependable in upset conditions
- **Energy Reduction & GHG Mitigation:** 4X reduction in aeration energy & N_2O mitigation potential

How It Works

1. ZeeLung cassettes are immersed in the mixed liquor of existing tanks
2. The ZeeLung media supports the growth of a biofilm that increases the inventory of nutrient removal biomass in the system without increasing mixed liquor concentration
3. The ZeeLung media "breathes" – transferring oxygen to the biofilm at very high efficiency without the use of bubbles
4. The counter-diffusional biofilm (pollutants enter from one side & oxygen from the other side) favors the growth of nitrifying bacteria







Experience

Upgrading wastewater treatment plants for capacity expansion or nutrient removal can be complex and expensive because of the need for new tank volumes and increased energy consumption. Unlike conventional solutions, ZeeLung enables utilities to get more out of their existing wastewater treatment assets with a simple solution that also saves energy.

ZeeLung Biological Nutrient Removal Upgrade Reference Plants

Yorkville-Bristol Sanitary District

13.7 MLD
CAS upgrade
2017
USA

Aquafin Schilde

8.8 MLD
CAS upgrade
2018
Belguim

VCS Ejby Mølle

3 MLD
Ox ditch upgrade
2018
Denmark

Severn Trent Spernal

5.8 MLD
CAS upgrade
2020
UK

Hespeler WWTP

9.3 MLD
CAS upgrade
2022
Canada

VCS Søndersø

1.7 MLD
Ox ditch upgrade
2022
Denmark

Watercare Helensville

1.5 MLD
Pond upgrade
2022
New Zealand

North Toronto Treatment Plant

11.4 MLD
CAS upgrade
2023
Canada

Palo Alto

95 MLD
CAS upgrade
2026
USA

Case Studies

Increased Wastewater Treatment Capacity at **Yorkville-Bristol Sanitary District**

Population growth, the arrival of new industrial contributions and a new phosphorous removal permit required the Yorkville-Bristol Sanitary District in Yorkville, Illinois, USA to be upgraded. The existing site was footprint constrained and the end-user sought a retrofit solution that would minimize capital expenditure and avoid significant civil modifications. Yorkville chose a ZeeLung MABR upgrade because it could increase the organic treatment capacity of the plant by 45% in the existing tanks while also enabling biological phosphorous removal. The solution required ¼ of the investment compared to building a new conventional plant and was implemented in 16 months. The ZeeLung MABR system has been in operation since 2017.

1

Low-Energy Nutrient Removal at **Severn Trent Spernal**

The Spernal-Redditch Sewage Treatment Plant located near Birmingham, UK is home to Severn Trent Water's Resource Recovery and Innovation Centre where technologies compatible with a low energy and circular economy approach can be evaluated. In 2020, Severn Trent commissioned a ZeeLung MABR upgrade of an existing activated sludge lane to demonstrate the potential of the technology to treat increased ammonia loads associated with population growth and changing wastewater composition in existing infrastructure. The project has also focused on how ZeeLung MABR can reduce energy consumption and mitigate N_2O emissions to support the UK water industry commitment to carbon neutrality.

2

Future-Proof Nutrient Removal at Region of **Waterloo Hespeler WWTP**

The Region of Waterloo Hespeler WWTP was an activated sludge system that was permitted for TSS and BOD removal and was facing a need to increase capacity and anticipate a future ammonia removal requirement. Rather than building more activated sludge tanks, the Region of Waterloo upgraded the plant with a ZeeLung MABR solution in order to save 50% of the capital cost of a conventional upgrade. The ZeeLung MABR system preserves space on the site and saves aeration energy. The ZeeLung system has been in operation since 2022.

3

Reducing Nutrient Discharge to the San Francisco Bay at **Palo Alto**

The Palo Alto Regional Water Quality Control Plant has been in operation since 1934 and required upgrades to increase capacity, rehabilitate aging infrastructure, and reduce discharge of nutrients to the San Francisco Bay. A conventional approach would require the construction of new bioreactor tanks. Instead, a ZeeLung MABR upgrade was chosen because it could provide the capacity expansion and improved nutrient removal in the existing tanks, resulting in capital cost and footprint savings. The ZeeLung MABR system will be constructed in 2025-26.

4

zeeDENSE*:

Super-Intensification of Activated Sludge

zeeDENSE is an application of ZeeLung that couples MABR & inDENSE continous flow densification technology for super-intensification of activated sludge plants.

ZeeLung MABR intensifies biological capacity by up to 50% and inDENSE adds a further up to 50% intensification of secondary clarification. Waste-activated sludge or mixed liquor is processed through the inDENSE system and the dense biomass is returned to the bioreactor while the less dense biomass is wasted from the process.

zeeDENSE is tailor-made for the upgrade of activated sludge plants with modularity, process flexibility and speed of implementation.

zeeDENSE Delivers:

- Increased treatment capacity for biological reactors and secondary clarifiers
- Improved settling
- Enhanced nutrient removal, including biological phosphorous removal
- Greenhouse gas mitigation
- And more

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Mobile Organic Biofilm (MOB)

- The MOB process is a hybrid of both aerobic granular sludge and fixed film technologies.
- Utilizes a ballast, which is mobile and circulates freely through the system. This ballast is an all-natural organic cellulosic material harvested from the Kenaf plant, which contains a core with a high surface area, absorptivity, and durability. This ballast media is machined to approximately 1mm in size.
- Due to this high surface area, the ballast is capable of granulizing and growing thick biofilms on its surface.
- These granules contain stratified microbial communities, facilitating simultaneous nutrient removal.
- These granules pass through to secondary clarification, and through the use of a rotary screen, are removed from the rest of the activated sludge and recycled back to the beginning of biological treatment
- The MOB process is suitable for use in cold weather, facilitating nitrification at water temperatures down to 5°C.
- The MOB process offers improved total nitrogen and phosphorus removal, as well as consistent SVI values ranging from 60-100 mg/L, preventing washouts during high flow events
- Advantages include:
    - A reduced footprint or a significantly increased throughput for the same footprint.
    - Improved sludge dewatering, leading to reduced chemical and hauling expenses.
    - Minimal mixing and aeration reduce energy consumption compared to other fixed film and granular sludge technologies.
    - Simultaneous N and P removal.
- Disadvantages include:
    - A relatively new technology
    - Will require tertiary filters

Figure 1 – Ballast material in the Nuvoda warehouse in the middle of the harvest and purification process.

Figure 2 – Fully processed ballast material being dispursed.

NUVODA
Innovative Wastewater Solutions

Cold Weather Conditions

MOB™ Process for Cold Water Temperature Operation

- Nitrification at water temperatures down to 5 °C
- Improved Total Nitrogen & Phosphorus removal
- Consistent SVI ranging between 60-100 mg/L preventing washouts during high flow events
- Quick, simple retrofits to any process configuration without taking basins offline

Call: (919) 615-1205 | Email: Sales@NuvodaUS.com

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MicroNiche Engineering (MNE)

- Instead of relying on the growth and removal of mixed populations as sludge, the Microvi MNE process uses a high density of single, highly efficient organisms that are controlled and protected in the versatile form of a biocatalyst composite.
- Accomplished through the use of MNE to create natural habitats (microniches), which optimize the performance of organisms in bioprocesses.
- The materials used in MNE can also provide functional advantages, such as enabling the rapid transport of substrates and products, modulating the concentrations of toxic compounds, and responding in real-time to abrupt changes in operation.
- This decoupling of the wastewater treatment process from the sludge age can dramatically improve the performance of a biological system.
- Can achieve stable nitrification with a sludge age of less than 3 days, at temperatures less than 10°C.
- This process has been shown to produce effluents with ammonia concentrations reduced to less than 0.2 mg-N/L, as well as nitrate concentrations below 2mg-N/L.
- Advantages include:
    - Small footprint
    - Minimized waste production
    - Automatic operation requiring minimal operator intervention
- Disadvantages include:
    - A very new technology
    - Will require tertiary filters

Figure 1 – MNE pilot configuration in use

Figure 2 – Biocatalysts used in San Francisco side stream treatment

Consistent Nutrient Removal Demonstrated at Municipal Wastewater Plant in Alabama

Nutrients in municipal wastewater (ammonia and phosphorus) have become a global issue. Excess nutrients in effluent coming from wastewater plants leads to environmental damage including toxic conditions for aquatic life, algae blooms, and dissolved oxygen depletion.

A large municipal water and wastewater utility serving Alabama treats water that finds its way into the adjacent Gulf of Mexico, where excessive amounts of nutrients have depleted the dissolved oxygen leading to algae blooms.

The Microvi MNE™ technology for total nutrient removal combines BOD/COD removal, nitrification (ammonia removal), denitrification (nitrate removal), and phosphorus removal.

Microvi technologies provide a biological solution that can remove nutrients while recovering phosphorus as a valuable bioproduct. This project successfully demonstrated the key benefits of the Microvi solution for total wastewater treatment.

Project Details

Site Owner: Utility in Alabama, U.S.A.

Issue: Removal of Nitrogen and Phosphorus

Solution: Denitrovi™, Aerovi™, Provi™ Technologies

Key Results:

- Ammonia reduced to less than 0.2 mg-N/L
- Nitrate reduced to <2 mg-N/L
- Orthophosphate reduced to <0.1 mg-P/L
- Short system start up (<10 days)

CONTACT US TO LEARN MORE →

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Densified Activated Sludge (DAS)

- DAS is a modification to conventional activated sludge. It is the process of growing and retaining particles with improved settling characteristics. This is accomplished through higher operational MLSS concentrations (4,000 to 8,000 mg/L), while still employing gravimetric settling such as secondary clarification.
- DAS usually refers to a continuum of settling conditions that are generally characterized as having rapid settling velocities and low variability in long-term settling properties and whose composition comprises a combination of flocs and granules.
- This improved sludge settleability allows for increased secondary clarifier loading rates, which enables operating at a higher SRT to enhance nutrient removal.
- The DAS process can enhance carbon, nitrogen, and phosphorus removal, and address poor solids settling.
- Factors that have been identified as being critical to achieve densification include:
    - The control of the selector zone food to microorganism (F/M) ratio and feast to famine regimes
    - The control of shear conditions in properly loaded systems
    - Selective wasting of biomass to retain dense particles
- Advantages include:
    - Potentially reduced chemical and energy requirements compared to conventional activated sludge or MBRs.
    - An improved sludge volume index (SVI)
    - Relatively compact footprint
- Disadvantages include:
    - Requires an additional sludge conditioning step and associated equipment
    - Relatively new technology

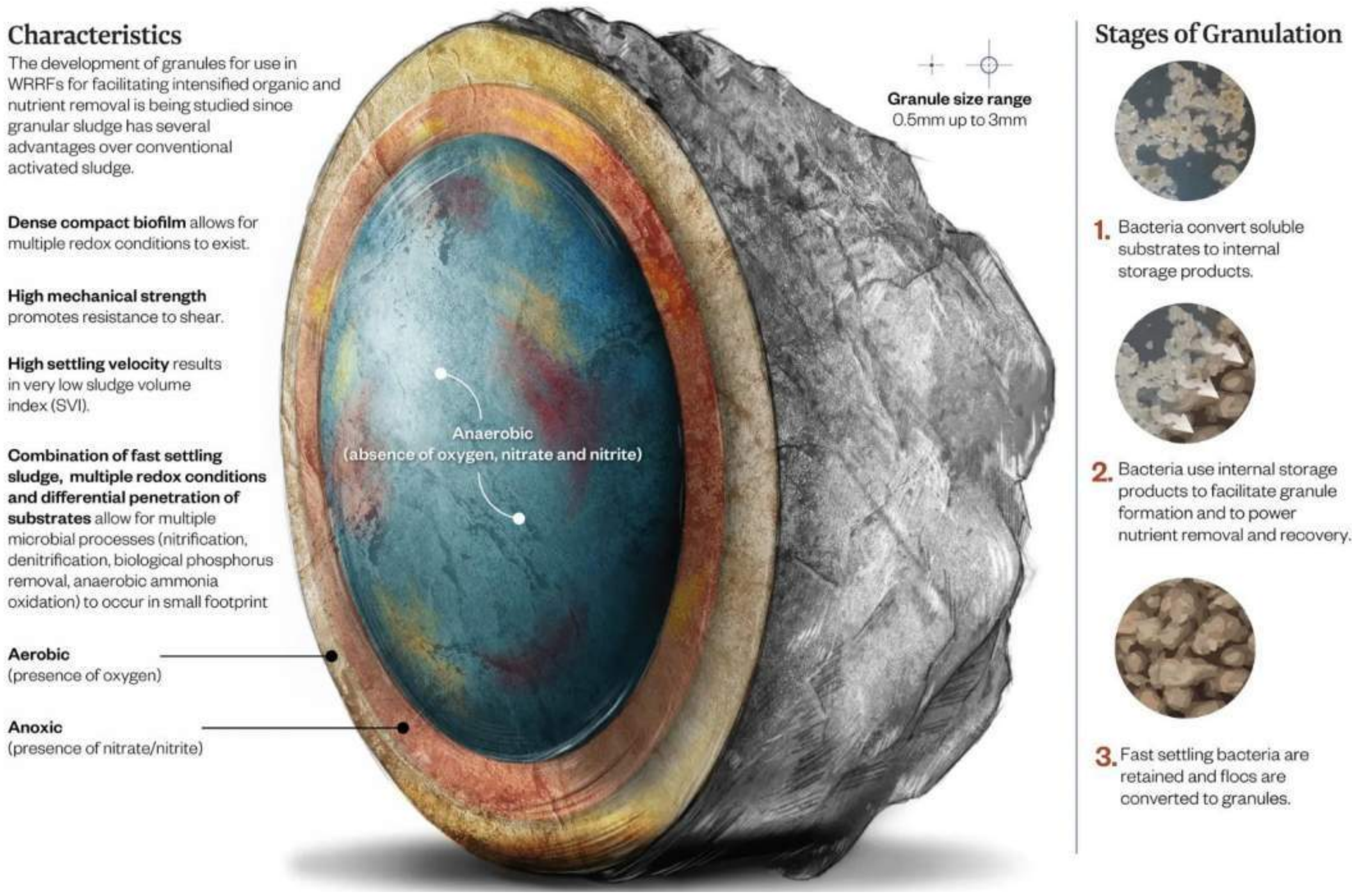


Figure 1 – Densified Activated Sludge granule zone breakdown

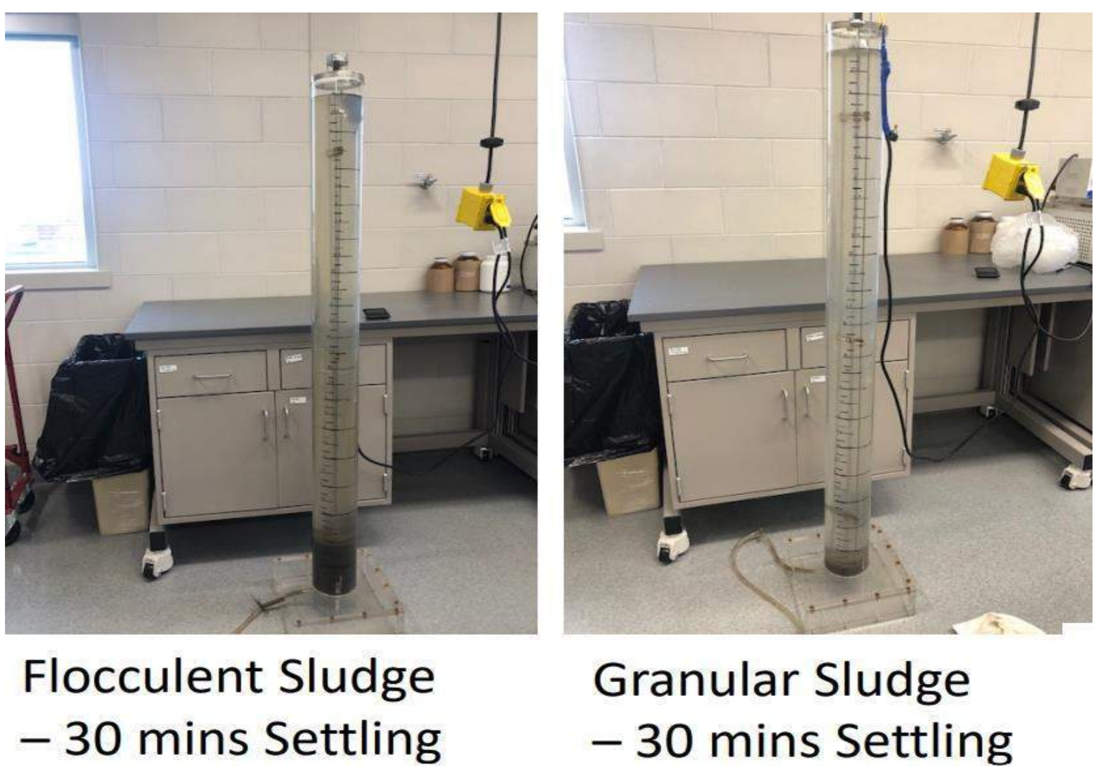


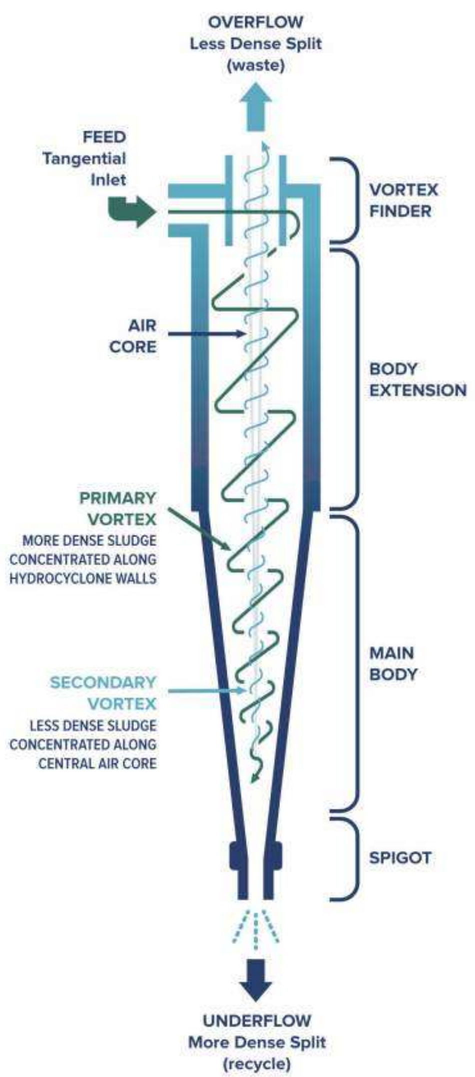
Figure 2 – Settling efficiency comparison between granular and flocculent sludge

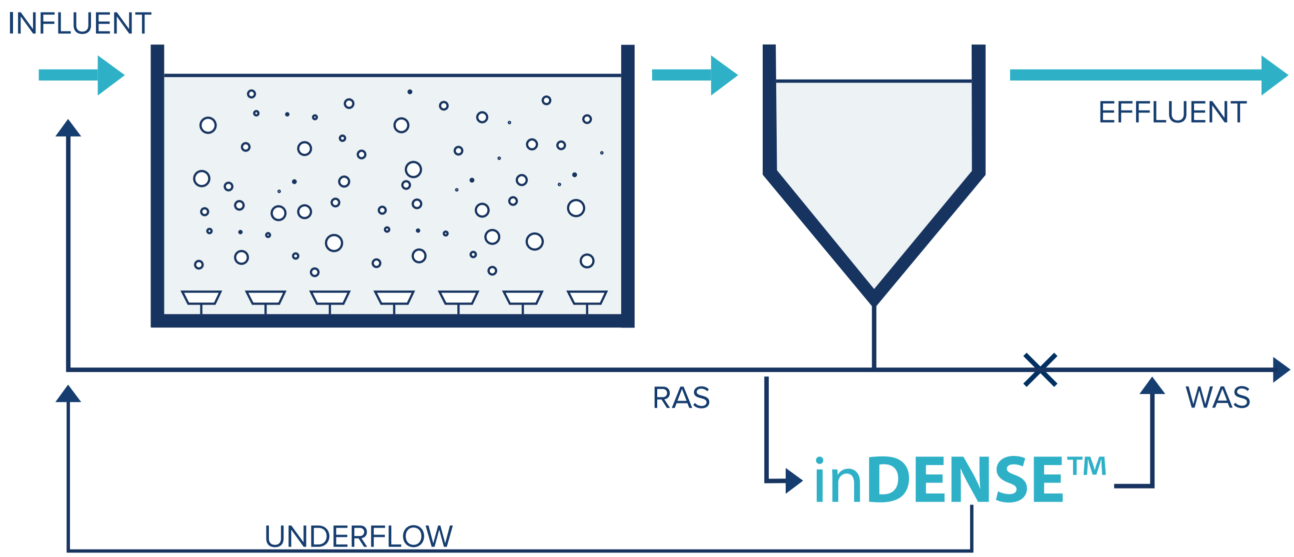
inDENSE™

World Water Works' inDENSE system increases process throughput and performance through the selection of dense sludge aggregates with improved settling rates and the promotion of enhanced biological phosphorus removal (EBPR).

inDENSE is a gravimetric selection technology that provides a method for retaining the denser biomass while wasting out the lighter fraction of the MLSS in the treatment system. Increased density can lead to improved settling characteristics which allows for the prevention of biomass loss and subsequent treatment disruptions, especially during wet weather scenarios.

Selection for faster settling particles, process configuration, and physical forces can encourage aerobic granular sludge formation. Hydrocyclones function by forcing denser flocs/solids to the cyclone walls and down through the underflow to be recycled while the lighter solids move towards the cyclone center and are pushed upwards through the overflow to be wasted. With the use of an external mechanism for selective sludge wasting and biological process configuration, facilities can gain improved operation for a **low capital cost investment.**

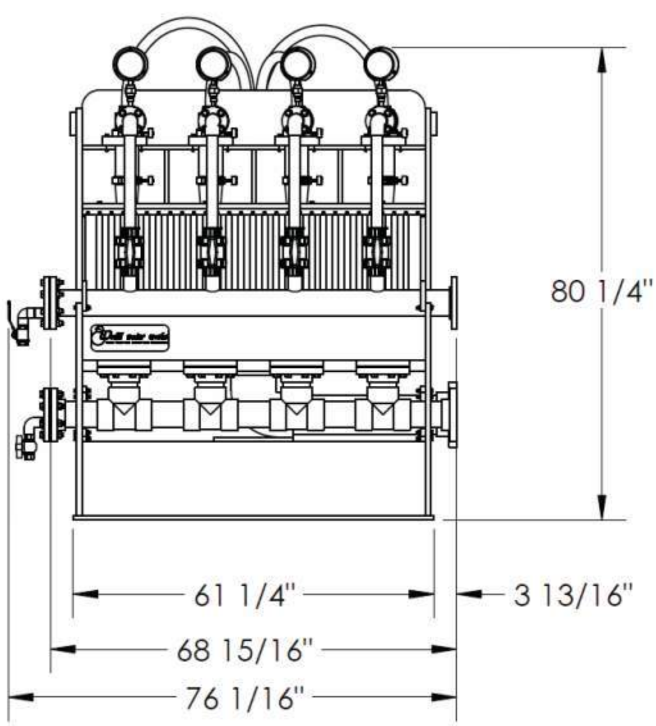


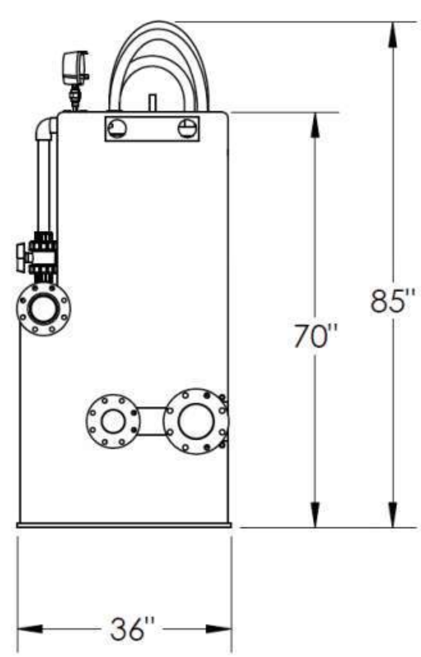


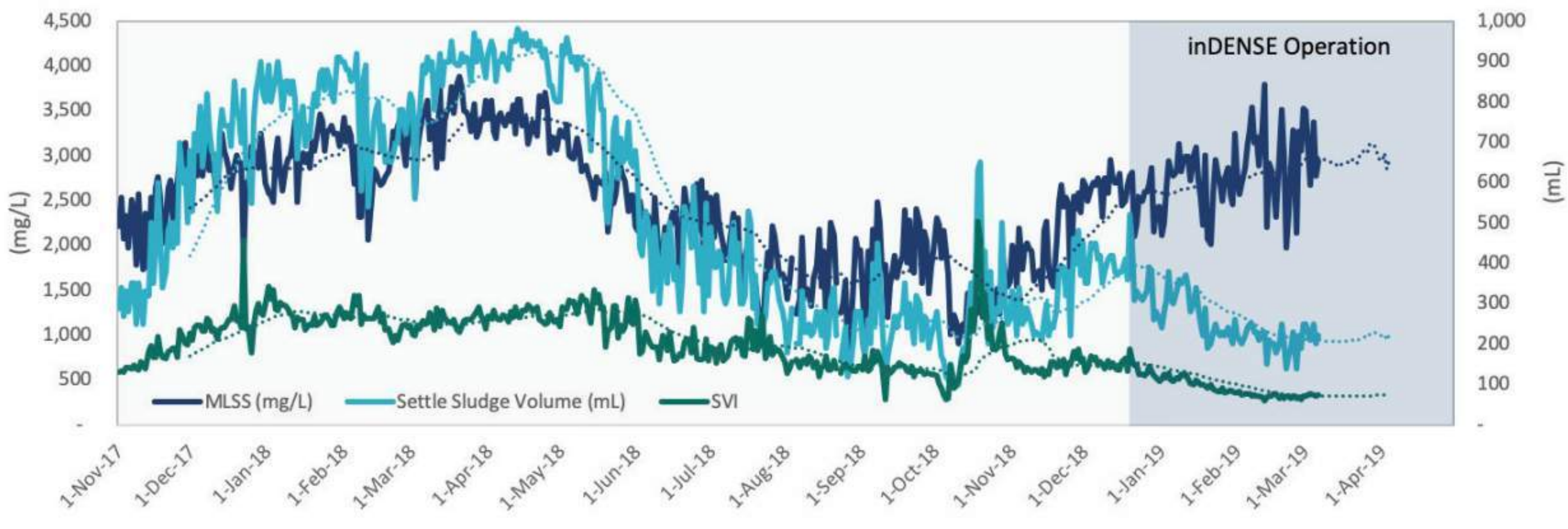
Benefits

- Enhanced nitrogen and phosphorus removal
- Promotes denser sludge selection
- Solution for poor settling MLSS
- Reduced and/or eliminated chemistry
- Easily integrated into any existing plant
- Rapid return on investment
- Minimization of sludge loss
- Operational stability

Conventional activated sludge (CAS) is the predominant wastewater treatment technology globally. One key requirement of the CAS technology is the ability to effectively separate the liquid and solid fractions. Unfavorable settleability can plague facilities seasonally or can be a chronic issue. World Water Works' inDENSE technology helps alleviate this problem.







The graph above shows performance of an activated sludge system before and after installation of the inDENSE Process. Once operational, there was an immediate reduction in the Settle Sludge Volume (SSV) and sludge volume index (SVI) with increase MLSS concentrations. Other process modifications were recommended and implemented by plant staff. The SVI is consistently in high 70's low 80's.

World Water Works, Inc. is a highly focused company in the wastewater treatment sector. We are driven to provide industrial and municipal customers proven and cost-effective wastewater treatment solutions delivering superior effluent quality.

We are a passionate and adaptable company providing value through expertly engineered products and technologies. Founded in 1998, we have unparalleled depth of application knowledge and experience.

We have offices located throughout the US, India, and UAE with a fully integrated in-house manufacturing facility at our headquarters in Oklahoma City, OK. This strategically positions us to control schedule while delivering the highest quality products and solutions at the lowest cost of ownership. Working hand-in hand with our customers, we optimize wastewater treatment solutions globally.

We at World Water Works are ensuring our wastewater treatment systems meet today's challenges while preparing for tomorrow's water needs.

Tertiary Treatment Processes

The primary purpose of tertiary treatment of wastewater is to provide an additional step after secondary clarification, with the aim of removing additional solids and nutrients from the water. Primary and secondary treatment are usually sufficient in getting water clean enough for general discharge into the environment, but tertiary treatment may be needed in cases of reuse, or discharge into sensitive receiving waters, such as estuaries, sluggish rivers, or waters close to coral reefs. In some cases, the additional treatment can occur in the same vessel as the biological treatment. Tertiary treatment can act as an extension of the conventional secondary biological treatment, further stabilizing oxygen-demanding substances in the wastewater or removing nitrogen and phosphorus. Tertiary treatment can also utilize physical-chemical separation techniques, such as flocculation/precipitation or membranes.

Reviewed Technologies:

1. Sand filters (Leopold)
2. Membrane Filtration (Veolia/Zeeweed)
3. Cloth disc filtration (Aqua-Aerobics)
4. Ballasted flocculation (Actiflo)
5. Biologically Aerated Filter (BAF) (Veolia BIOSTYR)
6. Reactive Filtration (Nexom BluePRO)

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Sand Filters

- Typically 2 main process configuration, downflow filters and upflow continuous backwash filters
- Downflow filters operate in a conventional filtration method and consist of media and support gravel supported by an underdrain.
- Upflow filters differ in that the influent wastewater flows upward through the filter, countercurrent to the movement of the sand bed. The filter media travels slowly downward and is drawn into an airlift pipe in the center of the filter. Compressed air is introduced into the airlift, drawing sand upward and scouring it. At the top of the airlift, the media is returned to the filter bed.
- Typically designed for effluent TN goals < 6 mg/L
- Heavily dependent on upstream nutrient removal performance to ensure appropriate feed conditions.
- Can be utilized to meet stringent TN and TP requirements, and can also remove solids (through reduction of the particulate org-N fraction)
- Major design considerations include:
    - A Manufacturer's experience
    - Influent weir configuration
    - Types of filter media
    - Underdrain
    - Process controls such as backwash and filter control
    - Methanol feed control (for denitrification)
- Advantages of the process include:
    - Relatively small process footprint
    - Nutrient and solids removal
- Disadvantages of the process include:
    - The need to control significant drops over the influent weir, to minimize DO entrainment, which if not controlled can reduce the efficiency with which the filter removes nitrate and increase methanol consumption (for downflow filters).
    - The need for chemical dosing

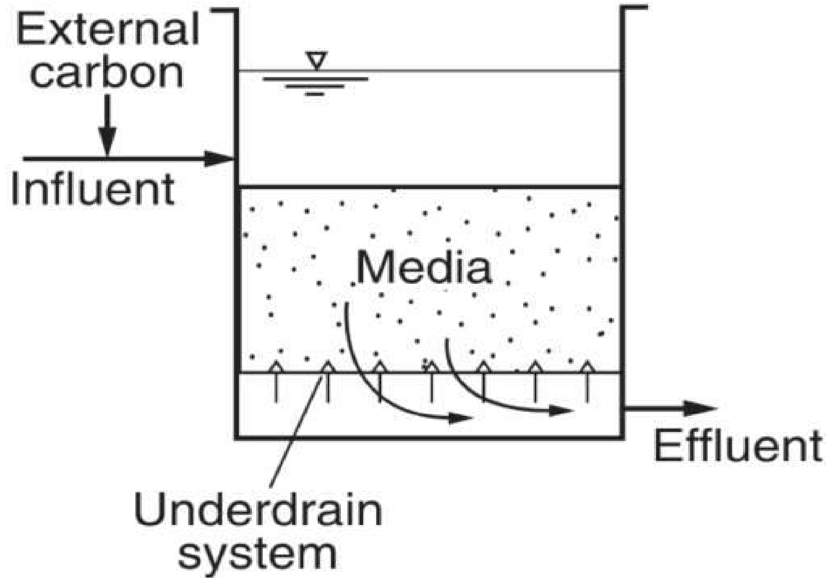


Figure 1 - Downflow Denitrification Filter Process

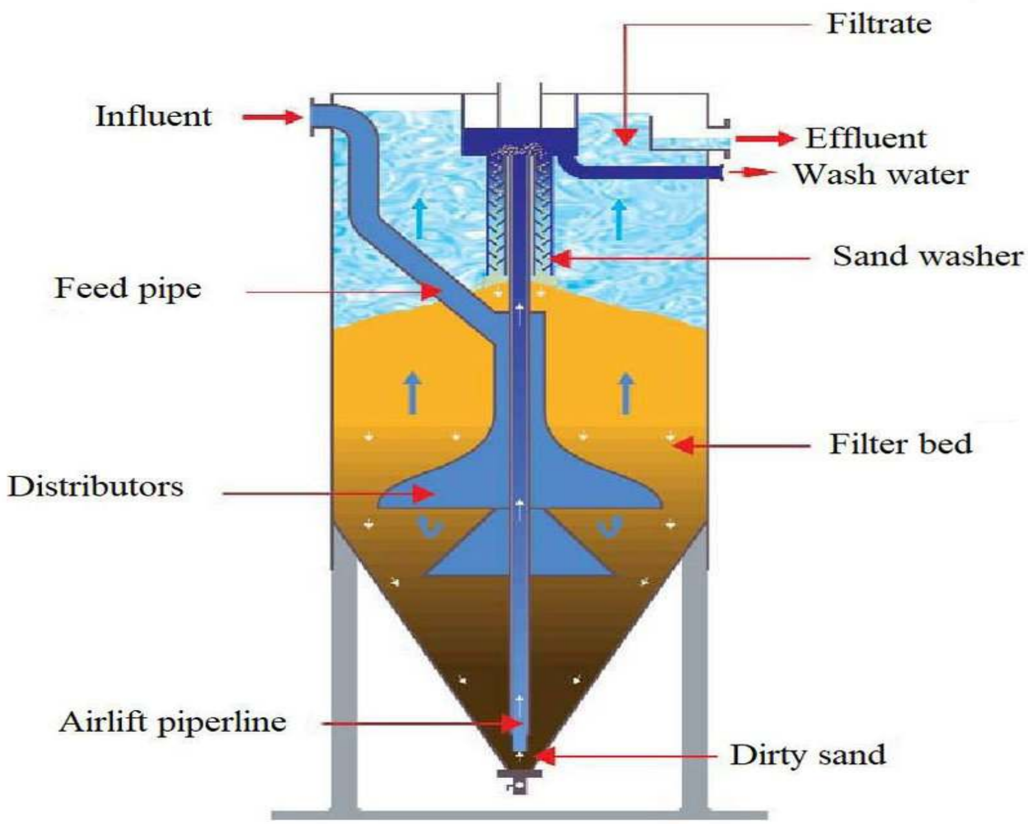
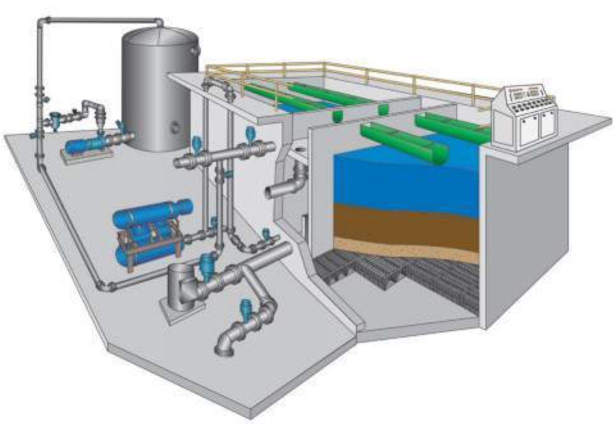


Figure 2 - Upflow Continuous Backwash Denitrification Filter Process2

xylem
Let's Solve Water

Leopold® elimi-NITE® 2.0 Denitrification System

THE NEXT GENERATION IN NUTRIENT REMOVAL



The Leopold elimi-NITE 2.0 denitrification system reduces nitrogen in the effluent stream of a wastewater treatment plant by converting nitrate nitrogen to nitrogen gas.

The biological conversion is done in an attached growth, downflow, deep bed, mono-media filter. Particulate matter is removed so insoluble phosphorus is removed as well. Since free oxygen will inhibit the activity of the denitrifying process, dissolved oxygen is biologically removed first, thereby creating an anoxic environment for denitrification. The system adds the supplemental carbon source or microbiological food needed to metabolize the nitrogen, since the preceding wastewater treatment processes have removed nearly all of the degradable carbonaceous material from the wastewater.

To ensure effective nutrient removal, the elimi-NITE 2.0 system features:

- Feedback control of the carbon source
- Several types of water level control
- Media optimization
- Backwash optimization
- Run time optimization

LEOPOLD
a xylem brand

Leopold® elimi-NITE® 2.0 Denitrification System

1612 • Leopold elimi-NITE® 2.0 Denitrification System • Master (US) • 20220805

Feedback control of the carbon source

The system's carbon source can be fed on a mass basis using the filter influent flow rate and nitrate concentration or using feed-forward control. Another control loop measuring the filter effluent nitrate concentration can be used in a feedback control system. The elimi-NITE 2.0 system offers feed-forward control coupled with feedback control to provide optimal use of methanol that can surpass a feed-forward-only control scheme. The elimi-NITE 2.0 methanol consumption can be near 100% of theoretical values and generally doesn't exceed 110% of overall consumption.

As an added benefit, the feedback portion of the unique elimi-NITE 2.0 control algorithm can achieve and control effluent nitrate concentration at a desired set-point under variable hydraulic and nitrate influent loads. In other words, a desired effluent nitrate concentration can be set and held.

The Leopold Type S underdrain with I.M.S® 1000 media retainer provides superior air and water distribution and retention of monomedia sand particles greater than 1.7 mm.

Several types of level control

Constant water level control affords the least amount of dissolved oxygen gain in the feed-water by avoiding splashing of the influent flow. This lowers the overall amount of carbon source needed to achieve process goals. Variable level control, which typically increases the overall methanol usage due to influent splash, can result in somewhat longer filter run times.

The elimi-NITE 2.0 system can use variable or constant water level control; the selection is determined by contaminant loadings and media selection.

Media optimization

After more than two decades of experience, Leopold has the expertise to select the proper media for the process application and to balance regulatory requirements with filter performance to meet treatment goals.

Furthermore, the I.M.S® 1000 precision-slotted media retainer can replace up to 14" (35 cm) of support gravel to allow additional media depth or increased filter freeboard. This results in improved air and water backwashing and cleaner media for longer filter runs.

Backwash optimization

Since media fluidization is not necessary, the filter can use very low backwash rates, sometimes as low as 6 gpm/ft² (15 m/h). Air scour rates to augment the backwash cycle can be as low as 5 SCFM/ft² (91 m/h).

Run time optimization

Depending on overall system design, run times can approach 100% of theoretical filter bed loading limits.

Let's Solve Water

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Membrane Filtration

- In addition to use in biological treatment, membranes can also be utilized for tertiary filtration.
- Membrane filtration usually follows biological treatment in water reuse applications, removing particulates, including pathogens, organic matter, and some nutrients, not removed by secondary clarification.
- The removal of particles is accomplished primarily through straining.
- For membrane use in polishing applications, the solids concentration in the feed water is lower compared to that of an MBR. Consequently, the membranes can be packed into the module tighter.
- This lower solids loading also permits higher fluxes, requiring an even smaller membrane area.
- Membrane filtration as its own separate process with separate tankage has less problems associated with cleaning compared to a MBR, because they can be cleaned in place.
- The effluent from membrane filtration typically has low concentrations of suspended solids, nutrients, and microorganisms. Soluble pollutants, particularly those of low molecular weight, will pass through the membranes.
- Advantages to conventional filtration include:
    - A smaller footprint for the same treatment capacity
    - Higher quality effluent
- Disadvantages include:
    - Increased costs associated with increased operational demands associated with membrane maintenance
    - The hydraulic capacity of the membrane is heavily reliant on the temperature of the water

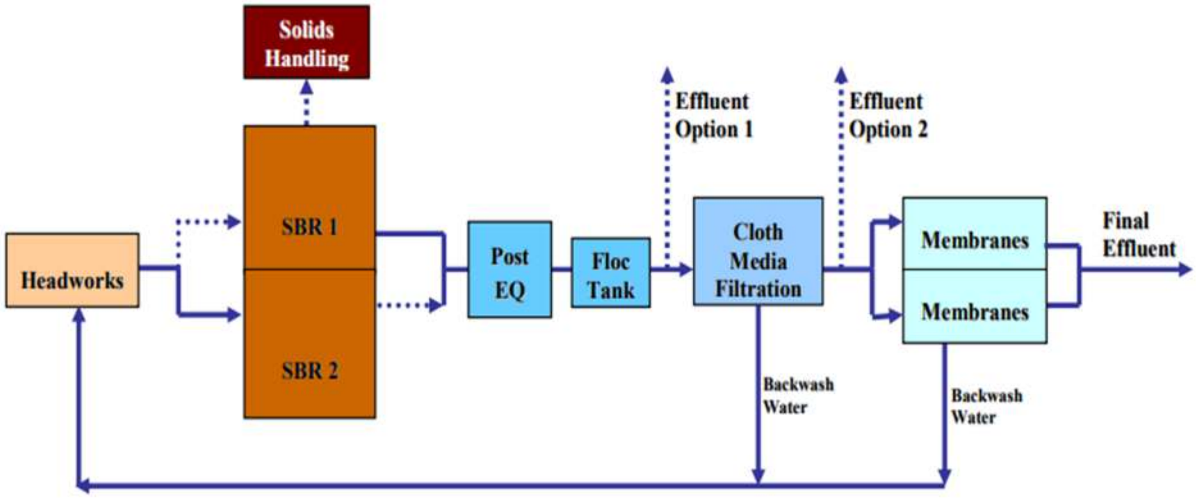

Figure 1 - Treatment process diagram utilizing tertiary membrane filtration

Figure 2 – Membrane cassettes outside of the treatment train

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Cloth Disc Filtration

- Disc filter systems are generally a continuous flow surface filtration process that, for a filter media, utilizes hollow discs which are covered in synthetic material (either cloth or metal).
- Typically, disc filters do not require clearwells or mudwells, and can operate in either a fully submerged or partially submerged mode, depending on manufacturers guidance.
- Inlet water enter the filter, discs are stationary as the cloth media is completely submerged. Solids deposit on the outside of the cloth media, forming a mat as filtrate flows through the media. The tank liquid level rises, and flow enters the filter by gravity and filtrate is collected inside the discs and discharged. Heavier solids settle to the bottom of the tank.
- Cloth disc filters perform as well or better than granular medium filters in removing turbidity and the number and size of particles, with increased surface loading and reduced backwash water requirements.
- Where chemicals are not used, the removal of coliform bacteria and viruses is on the order of 0 to 1.0 and 0 to 0.5 logs, respectively.
- Disc filters should meet the following minimum design criteria:
    - In cold climates, disc filters should be housed in heated and ventilated enclosures, due to the mechanical aspects of the systems.
    - Loading rates at the peak hourly flow should not exceed 6.5gpm/sf of filter surface area.
    - A minimum of two filter units should be provided.
- Cloth disc filters have been used in several applications, including:
    - As a replacement for depth filtration to remove residual suspended solids from secondary effluents
    - For the removal of suspended solids and algae from stabilization pond effluents
    - As a pretreatment operation before microfiltration or UV disinfection
- Advantages of cloth disc filtration include:
    - Low hydraulic profile
    - Low backwash rate
    - Low life-cycle cost
- Disadvantages of the process include:
    - Vulnerable to fouling
    - Increased operational responsibilities associated with filter cleaning and upkeep
    - Adept at particle removal, but removal of dissolved contaminants may require additional treatment

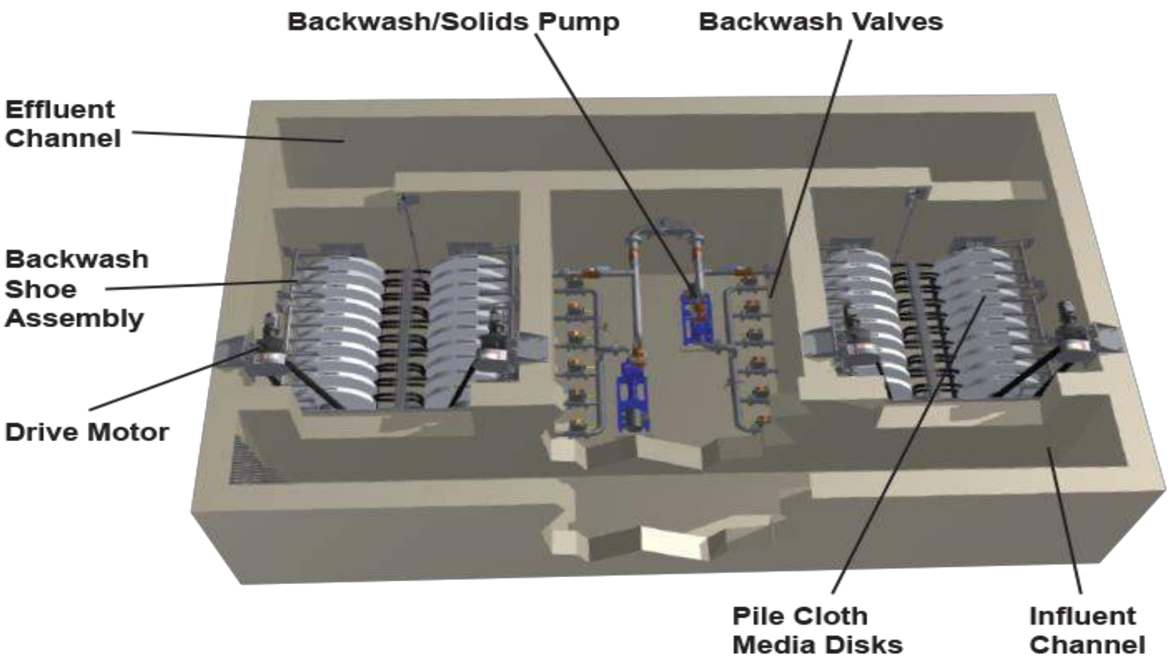


Figure 1 - Overview of a cloth disc filter process set up

Figure 2 – Cloth disc filter unit up close

Aqua-Aerobic®

Cloth Media Filter Featuring OptiFiber® Pile Cloth Media

In the early 1990s, Aqua-Aerobic Systems revolutionized tertiary treatment by introducing Pile Cloth Media Filtration utilizing a disk configuration. Since then, over 3,000 pile cloth media filtration units have been installed worldwide, and hundreds of different media have been researched and tested with a select few that are currently being applied to six mechanical configurations in a variety of applications including: water reuse, low level phosphorus, stormwater and primary treatment.

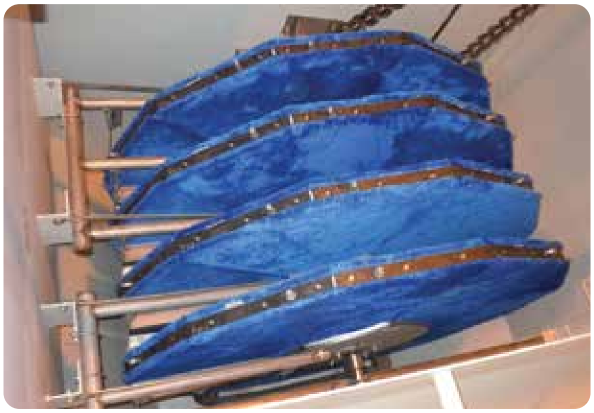
Effective Depth Filtration

The original OptiFiber® pile cloth media is specifically engineered for water and wastewater applications and designed to maximize solids removal over a wide range of particle sizes. Deep, thick, pile fibers capture particles for the most effective depth filtration. Perhaps as important, the media is engineered to backwash effectively and last over time. OptiFiber media is exclusive to the entire line of cloth media filter configurations including:

- **AquaDisk®**
- **Aqua MegaDisk®**
- **AquaPrime®**
- **AquaStorm™**
- **AquaDiamond®**
- **Aqua MiniDisk®**

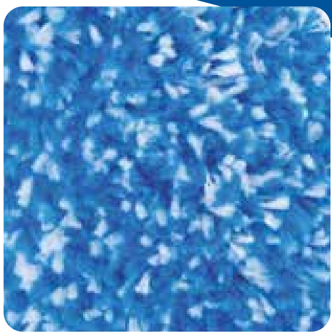
OptiFiber® Media Advantages

- Woven, precision fibers provide strength and durability
- Discrete pile fibers effectively release solids during backwash
- Open backing minimizes potential for biofouling
- Low backwash volume results in water savings and energy reduction
- Variety of application-specific cloth including 2, 5 & 10 µm nominal pore size media
- Phosphorus removal to 0.075 mg/l or less
- Ability to handle high solids conditions

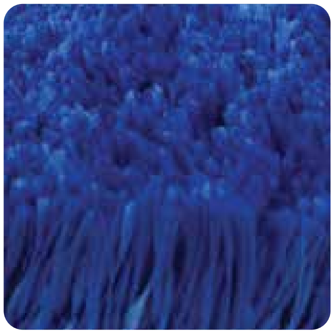


An AquaDisk® filter with OptiFiber PES-14® treats cooling tower blow-down.

OptiFiber PA2-13®



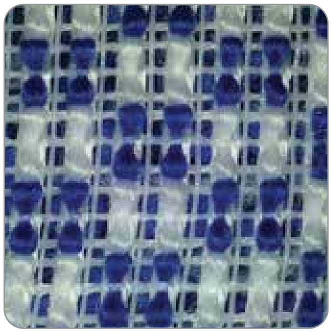
OptiFiber PES-13®



OptiFiber PES-14®

OptiFiber UFS-9™

OptiFiber PF-14®



Unique Backing Design

OptiFiber® Cloth Filtration Media
Awarded BlueTech® Research Innovation Badge

Engineered Cloth Media

The media is the most important aspect in any filter design. Today's OptiFiber® pile cloth filtration media is the result of over 30 years of continuous engineering and improvement. Each aspect of the pile cloth is design is engineered to provide an optimal design to maximize particle removal, allow for effective backwash, and maximize media life.

Hundreds of media options have been tested as part of this continuous development process. Only five of these options have made it through the rigorous testing process and met the quality standards set forth by Aqua-Aerobic Systems, Inc.

A cloth media display showcases samples of tested media with the far left panel featuring OptiFiber® media.

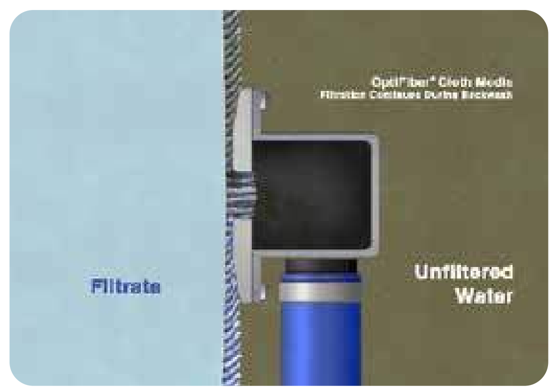
OptiFiber® Cloth Media Technology Timeline

1993	2000	2004	2006	2011	2013	2016	2017	Continued Innovation
AquaDisk® Filter	OptiFiber PA2-13® Media	AquaDiamond® Filter	OptiFiber PES-13® Media	OptiFiber PES-14® Microfiber Media	Aqua MegaDisk® Filter	AquaPrime® & AquaStorm™ Filter with OptiFiber PF-14® Media	OptFiber UFS-9® Ultrafiber Media	

Backwash System

Effective Cleaning With Less Water and Energy

Maximum cleaning of the OptiFiber® cloth media is accomplished with a unique backwash system. The backwash shoe makes direct contact with the cloth media and solids are vacuumed from the surface. During backwash, fibers fluidize to provide an efficient release of stored solids deep within the fiber depth.



Backwash shoe makes direct contact with the media.

Backwash System Advantages

- Filtration continues during backwash
- Initiated at a pre-determined liquid level or time
- Low backwash rates
- Less water volume required
- Low energy consumption

Shown is pile cloth media in its natural state (left) and its conditioned state (right).

Configurations

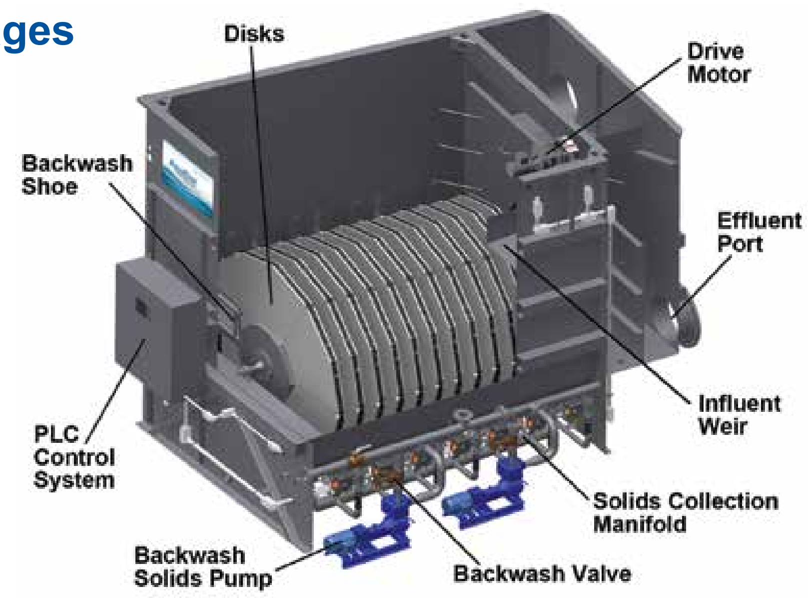
AquaDisk®

Cloth Media Filter

The cloth media “Disk” configuration was the first to enter the marketplace as an alternative to conventional granular media filtration technologies. This original configuration comprises the majority of Aqua-Aerobic cloth media filters installed today. A history of exceptional operating experience in a variety of municipal and industrial applications continues to make the AquaDisk® the tertiary filter of choice.

System Features and Advantages

- Vertically oriented cloth media disks reduce required footprint
- Each disk has six lightweight, removable segments for ease of maintenance
- Low hydraulic profile
- Higher solids and hydraulic loading rates
- Low backwash rate
- Available in painted steel, stainless steel or concrete tanks
- Fully automatic PLC control system with color touchscreen HMI
- Low cost of ownership



Modes of Operation

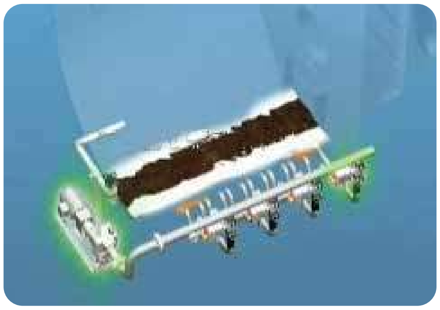
Aqua-Aerobic cloth media filter configurations operate on the same (3) modes of operation: **FILTRATION, BACKWASH** and **SOLIDS WASTING.**

Filtration Mode

- Inlet wastewater enters filter
- Cloth media is completely submerged
- Disks are stationary
- Solids deposit on outside of cloth media forming a mat as filtrate flows through the media
- Tank liquid level rises
- Flow enters the filter by gravity and filtrate is collected inside the disks and discharged
- Heavier solids settle to the tank bottom

Backwash Mode

- Solids are backwashed at a predetermined liquid level or time
- Backwash shoes contact the media directly and solids are removed by vacuum pressure using the backwash pump
- Two disks are backwashed at a time (unless a single disk is utilized)
- Disks rotate slowly
- Filtration is not interrupted
- Backwash water is directed to headworks



Solids Wasting Mode

- Heavier solids on the tank bottom are removed on an intermittent basis
- Solids are pumped back to the headworks, digester or other solids collection area of the treatment plant

Aqua MegaDisk®

Cloth Media Filter

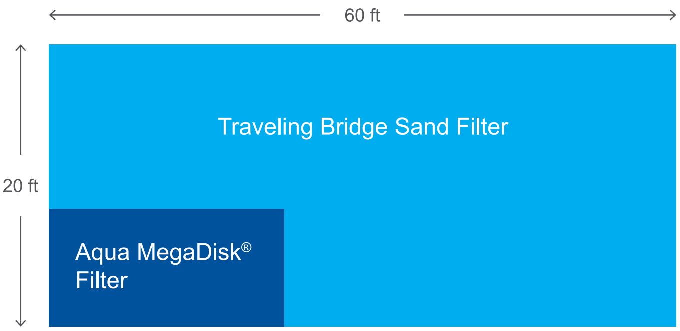
The Aqua MegaDisk® cloth media filter expands on the reliability and exceptional performance of the original AquaDisk filter, but on a larger scale. Each disk is approximately 10' in diameter. The unit features all of the same benefits and (3) modes of operation as the AquaDisk but with larger disks.

Additional Features and Advantages

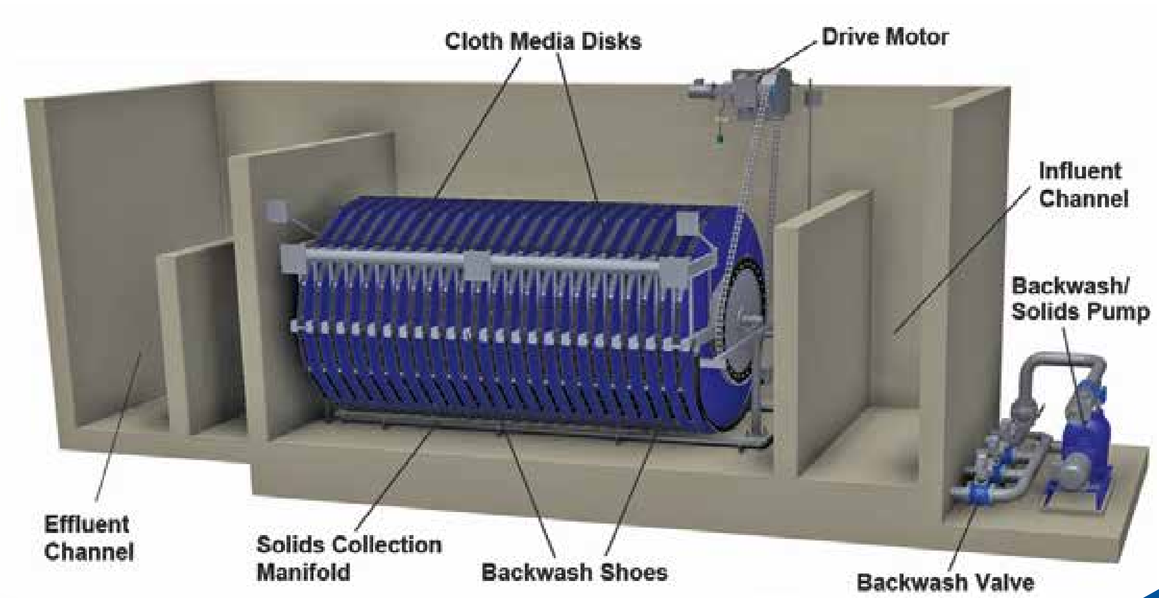
- Smallest footprint, operating in 80% less space than sand filters with comparable hydraulic capacity
- Up to 24 disks in a single filter, capable of treating 24 MGD
- Ideal for deep bed sand filter retrofits, new plants or expansions
- Lightweight segments removable without a crane

Aqua MegaDisk® (left) compared to AquaDisk® (right).

Footprint Savings Compared to Sand Filters



Internal view of the Aqua MegaDisk®



WASTEWATER ALTERNATIVE TECHNOLOGY UPGRADES WORKSHOP

EPPING, NH

WEDNESDAY, NOVEMBER 29, 2023

Ballasted Flocculation

- Ballasted flocculation is a physical-chemical treatment process that uses continuously recycled media and a variety of additives to improve the settling properties of suspended solids through improved floc bridging.
- The system consists of three zones: a mixing zone, maturation zone, and settling zone. Depending on the manufacturer, the process can all take place in one vessel, or be broken up into separate compartments.
- The objective is to create a floc with a specific gravity greater than two. Faster floc formation and decreased particle settling time allow clarification to occur up to ten times faster than with conventional clarification, allowing treatment of flows at a significantly higher rate than allowed by traditional unit processes.
- The use of a ballast material enhances floc formation, resulting in a much faster settling rate relative to traditional coagulants.
- Capable of reducing total suspended solids concentration by 80-95%, also capable of reducing phosphorus to below 2 mg/L.
- Applications of ballasted flocculation include:
  - Enhanced primary clarification
  - Enhanced secondary clarification following fixed and suspended growth media biological processes.
  - Peak flow reduction for CSO and SSO treatment.
- Advantages of ballasted flocculation include:
  - Systems using ballasted flocculation can treat a wider range of flows without reducing removal efficiencies.
  - Ballasted flocculation systems reduce the amount of coagulant used or improve settling vs. traditional systems for comparable chemical usage.
- Disadvantages include:
  - Requires operator judgement and more complex instrumentation and controls than traditional processes.
  - Pumps may be adversely affected by ballast material recycle. Lost ballast material must be occasionally replaced (except where settled sludge is recycled for use as a microcarrier/ballast.
  - Costs associated with chemical use.

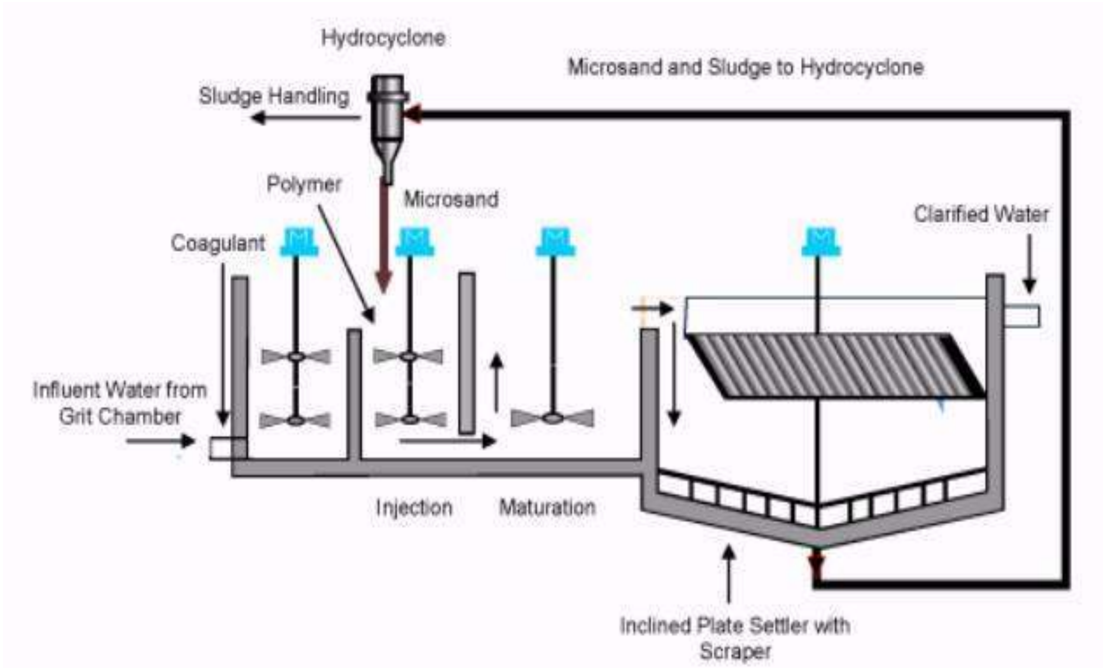


Figure 1 - Typical Ballasted Flocculation flow diagram

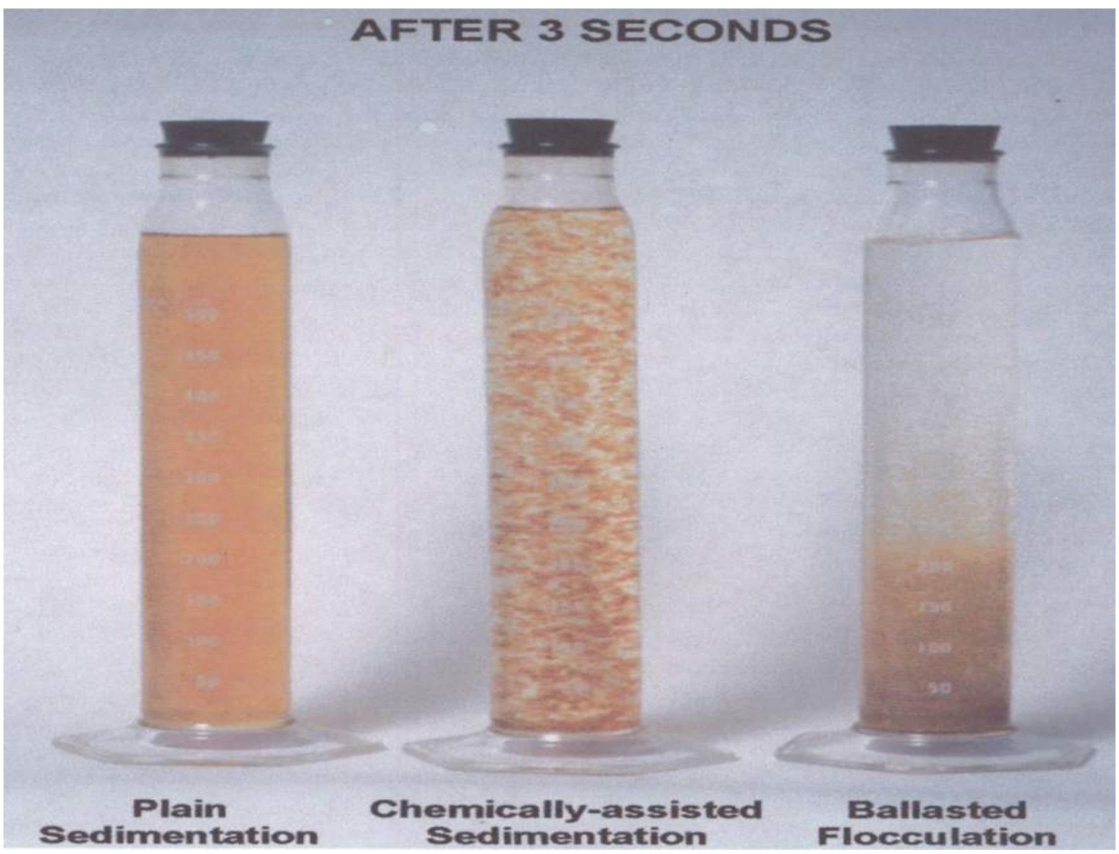


Figure 2 - Comparison of the settling achieved at 3 seconds through different primary treatment methods

ACTIFLO®

Microsand Ballasted Clarification Process

Actiflo® is a high rate, compact process developed by Veolia Water Technologies. The process operates with microsand which enhances floc formation and acts as a ballast to aid in rapid settlement of coagulated material.

The Actiflo process can be used at various stages of wastewater treatment including: enhanced primary treatment, wet weather clarification, high rate secondary clarification and final polishing for the removal of solids, phosphorus and metals.

Proven mechanical equipment is a critical component to process performance and reliability. Only the highest quality components are provided with the ACTIFLO system which includes Stamo Mixers. Stamo has been designing and servicing mixing equipment since 1949 and brings this experience and knowledge to the ACTIFLO product line.

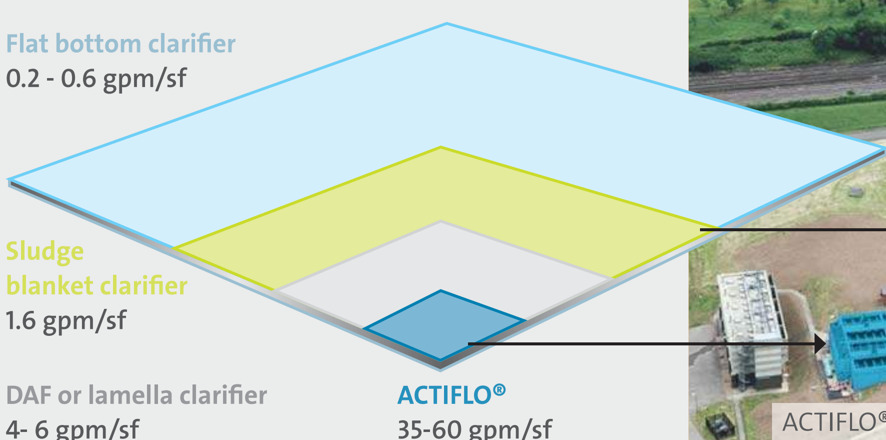
Typical ACTIFLO® Performance

Application	loading Rates gpm/sf	Phosphorus (mg/l)	sBOD (mg/l)	BOD_5 (mg/l)	TSS (mg/l)	UV Transmittiance (%)
Wet Weather	60	0.5 - 1.5	10 - 20	< 30	< 20	50 - 70
*Bio ACTIFLO™	45	0.1 - 1.0	1 - 10	< 20	< 15	60 - 70
Secondary	20	0.5 - 1.5	1 - 10	< 10	< 10	65 - 75
Tertiary	45	as low as 0.05	< 10	< 10	≤ 5	75 - 90

*Pathogen removal, post disinfection, is equivalent to or exceeds that of a conventional activated sludge plant

ACTIFLO® Compactness Displaying Its True Potential

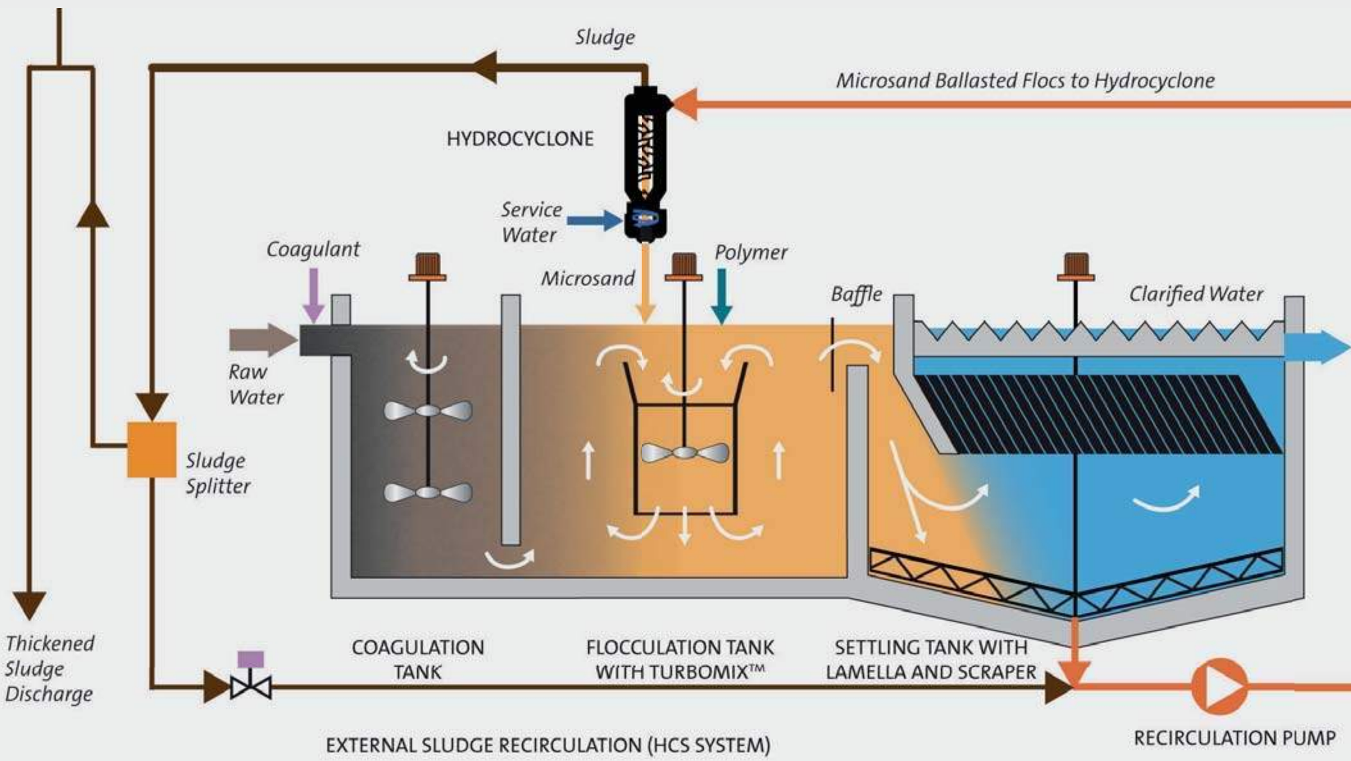
The microsand ballasted flocs display unique settling characteristics, which allow for clarifier designs with very high overflow rates and short retention times. These designs result in footprints that are 5 times smaller lamella clarifiers or dissolved air flotation (DAF) and up to 20 times smaller than conventional clarification systems.



*Surface water treatment reference

Tertiary Treatment with ACTIFLO

With tighter discharge limits being imposed on wastewater treatment plants the need for a cost effective, flexible process has evolved. Over the years, the Actiflo process has proven its effectiveness in meeting extremely low phosphorus, metals and TSS limits.



Process Benefits

- Small process footprint; suited for restricted spaces and existing basin retrofits
- Low system headloss, incorporates into most existing hydraulic profiles
- Reduced civil engineering costs
- High degree of operational flexibility
- Minimum equipment to maintain, all easily accessible

For tertiary treatment applications, the Actiflo process offers:

- Ability to treat a wide range of influent phosphorus levels to extremely low limits
- Flexibility to meet future limits (phosphorus, metals) without modifying the process train
- The same tertiary treatment trains can also be used to treat wet weather flows
- Treatment of flows with high solids concentration without impacting effluent quality (solids washout from secondary clarifiers during peak flow)
- Reduction in sludge volume by incorporating a HCS system

WASTEWATER ALTERNATIVE TECHNOLOGY UPGRADES WORKSHOP

EPPING, NH

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Biological Aerated Filter (BAF)

- A BAF process is a high-rate treatment system that employs dual functions of biological oxidation of BOD and/or ammonia and physical removal of particulate and colloidal solids by absorption and filtration.
- Influent flows upward through a submerged media bed. Air is injected through an air grid located below the bed at the bottom of the cells and rises upward concurrently with the wastewater
- Backwashing is accomplished by a series of valve operations that are controlled by the PLC. Gravity assists in removing stored solids as the media bed expands during backwash, eliminating the need for dedicated pumps, piping, valves, blowers, or controls for backwashing.
- Applications of this process include:
  - Secondary Treatment – Following primary treatment, the BAF process can remove carbon, suspended solids, and ammonia in a single stage, providing a small footprint.
  - Nitrification – The BAF process can be used to expand an existing secondary treatment process to provide tertiary removal of ammonia while providing further removal of suspended solids and carbon.
  - Denitrification – Can be in two arrangements; a denitrifying BAF can be added to an existing BAF utilized for secondary or tertiary ammonia removal. Alternatively, a denitrification BAF may be placed after an existing secondary treatment process, enabling the plant to meet low total nitrogen limits.
- Advantages include:
  - Compact footprint, suitable for constrained sites.
  - High quality effluent, even in very cold climates.
  - No periodic replenishment of media is required.
- Disadvantages include:
  - Requires screen to retain media.
  - Will require tertiary filters.

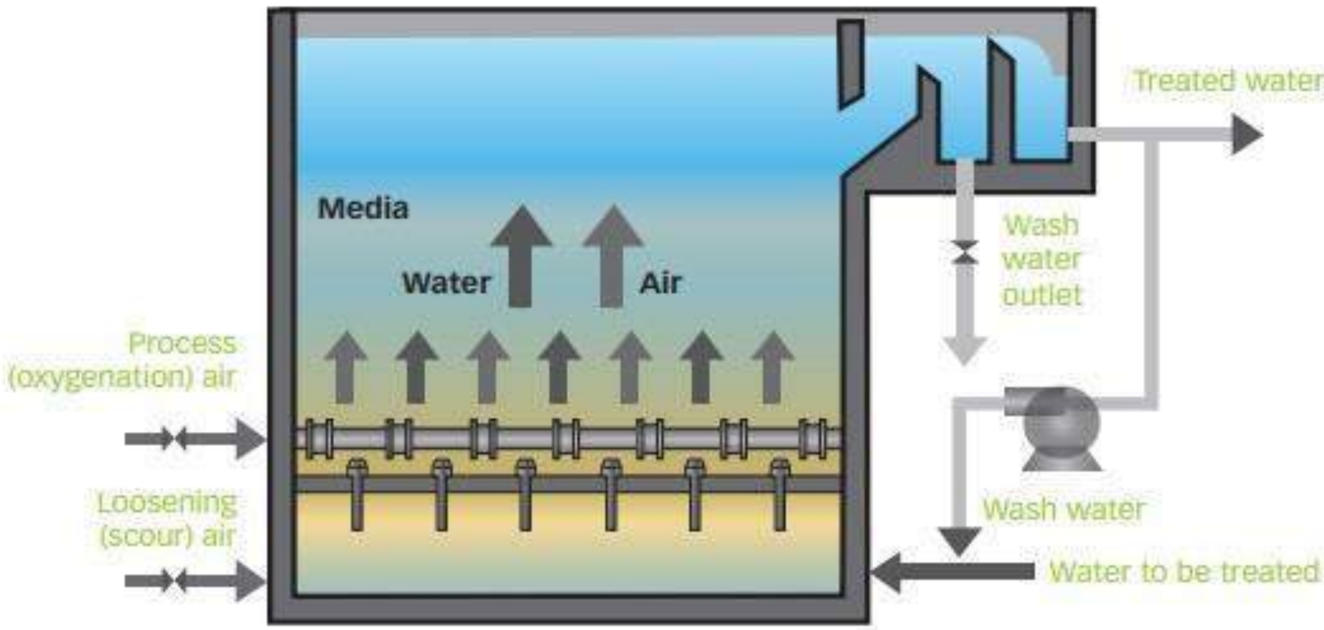


Figure 1 - BAF Process Diagram

Figure 2 – A BAF in use.

BIOSTYR® Combines Biological Treatment and Upflow Filtration for High Quality Effluent

The BIOSTYR® process combines biological treatment, clarification, and filtration into one compact system. With installations throughout the world, BIOSTYR is proven to be an exceptional technology for meeting today's stringent effluent limits. BIOSTYR is an ideal process for plants where footprint is limited, close proximity to neighborhoods is a concern, or expansion is desired.

The BIOSTYR® Process

The BIOSTYR process is a biological aerated filter (BAF) with a submerged media bed. Wastewater flows upward through the media bed. Air is injected through an air grid located below the bed at the bottom of the cell and rises upward concurrently with the wastewater.

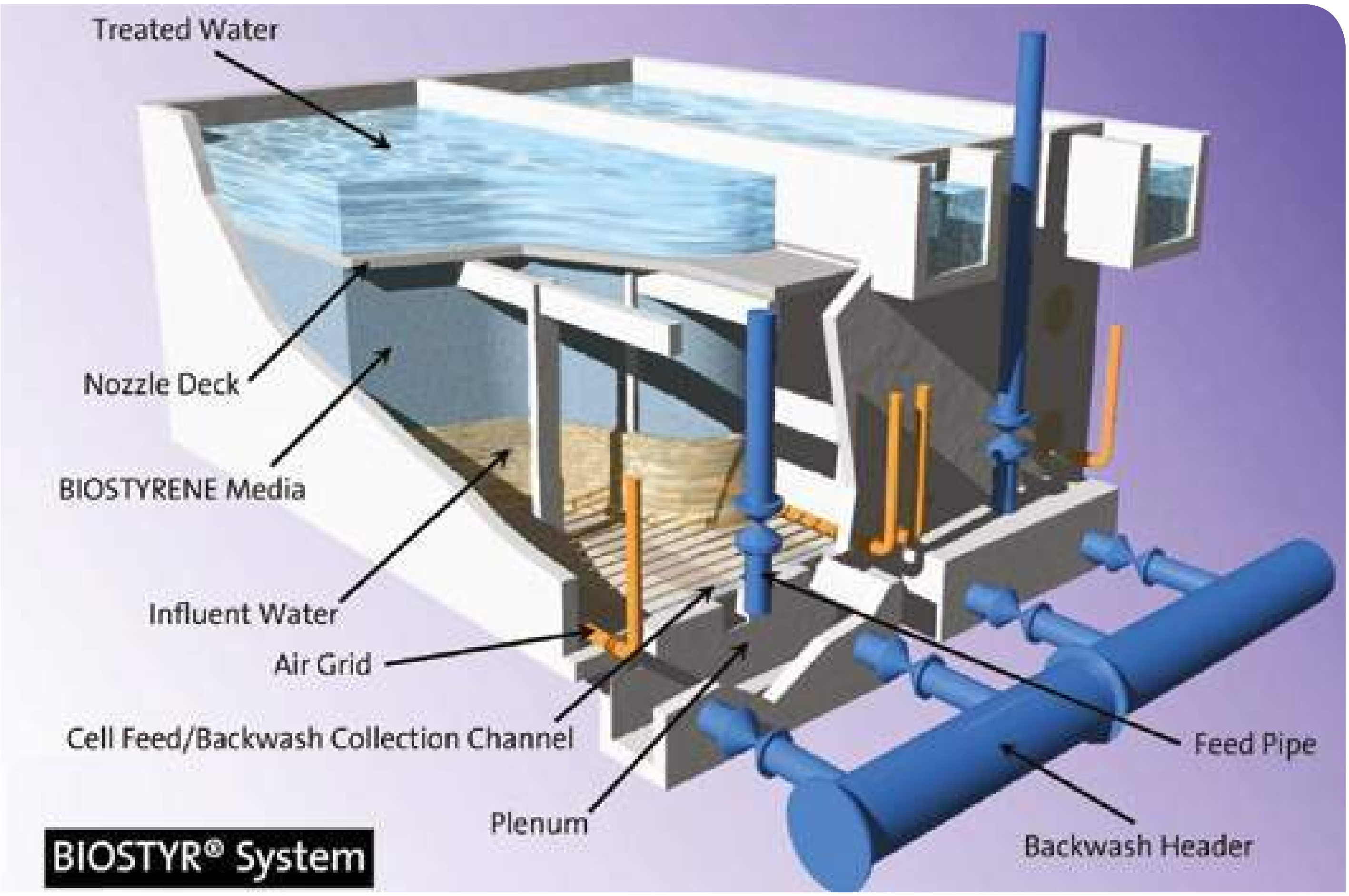
The BIOSTYR media, BIOSTYRENE™, are buoyant polystyrene beads that provide the surface area for biomass attachment. The BIOSTYRENE media is retained in the BIOSTYR cell by a pre-cast concrete nozzle deck located above the media. The nozzle deck contains nozzle-type strainers that allow water and air to pass through the cell.

The BIOSTYR backwash is a counter-current flow. The backwash water (system effluent) is stored above the media, so no separate clearwell is necessary. Backwashing is accomplished by a series of valve operations that are controlled by the PLC. Gravity assists in removing stored solids as the media bed expands during backwash; thus, not requiring dedicated pumps, piping, valves, blowers or controls for backwashing.

Top view of cells

Influent channel

Empty cell



High Quality Components Offering Superior Benefits

- Multiple, parallel filter cells, allowing for flexible operational strategies and simple expansion
- Low weight BIOSTYRENE media (~3 lbs/ft³) significantly reduces foundation and other construction costs
- Nozzle-type strainers in the pre-cast concrete nozzle slabs only contact clean, treated effluent; not susceptible to fouling
- Robust stainless steel aeration grid resists clogging, requiring no routine maintenance
- Pre-cast nozzle slabs provided by Veolia, ensuring high quality control
- Fully automated PLC based control system and centralized SCADA system, easing operation

Empty cell

Empty cell

Applications

Tahoe-Truckee, CA

Secondary Treatment

Following primary clarification, the BIOSTYR can provide secondary treatment. Removal of carbon, suspended solids and ammonia are accomplished in a single step, providing a small footprint.

Syracuse, NY

Nitrification

BIOSTYR can be used to expand an existing secondary treatment process to provide tertiary removal of ammonia while further polishing of suspended solids and carbon.

Cheshire, CT

Denitrification

BIOSTYR denitrification applications may be arranged in two configurations. A denitrification BIOSTYR can be added to an existing BIOSTYR process utilized for secondary or tertiary ammonia removal. Also, a denitrification BIOSTYR may be placed after an existing secondary treatment process, enabling the plant to meet low total nitrogen limits.

Steel tank package plant

Package Systems: Pre-engineered Solutions

For smaller flow rates, the BIOSTYR process may be provided as a steel package plant. The steel package BIOSTYR will shorten the construction schedule and reduce civil design and construction costs.

BIOSTYR®: Compact, Neighborhood Friendly Process

- Compact footprint; ideal for constrained sites
- Downstream clarifiers not necessary, decreasing operation and maintenance requirements
- Treated water of exceptional quality, even in very cold climates
- Footprint allows for process to be easily enclosed, neighborhood friendly
- No periodic replenishment or replacement of media required
- Filter influent screened at 10 mm bar or mesh; achieved by plant's headworks

Process Control Features

SCADA screen shot

- SCADA system customized for each particular application
- Open architecture software
- Process diagnostic tools and data trending
- Point-and-click navigation and control
- 24-hour alarm monitoring and notification
- KrugerLink™ remote process monitoring and control
- Systems certified integrators

WASTEWATER ALTERNATIVE TECHNOLOGY UPGRADES WORKSHOP

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Reactive Filtration

- Influent flow is distributed across almost the entire cross-sectional area of the filter near the bottom of a sand column.
- The water is filtered as it flows upward, and the sand coated with hydrous ferric oxide (HFO) attracts and reacts with phosphorus and metals. Other materials can be used for coating including aluminum and cerium.
- Sand moves downward through gravity to an airlift device while the filtered water exits near the top of the filter.
- The airlift transports the phosphorus or metals-laden media up into the washbox where the discharged HFO coating and absorbed contaminants are separated from the media. Water velocities in the washbox are carefully designed to carry away the contaminants while allowing the media to fall to the filter bed and is recoated with HFO as the cycle begins again.
- Because of this cycling, media replacement should not be needed and although chemicals are still needed for coating, this process can lead to decreased costs.
- Recycling of this backwash stream upstream can provide an added benefit of phosphorus pre-treatment in primary or secondary treatment systems.
- The phosphorus is chemically bound, leaving the plant with the plant sludge.
- Can be installed as freestanding fiberglass or stainless-steel units or integrated into preexisting multi-module concrete cells.
- Capable of producing an effluent reaching .2 mg/L of phosphorus, below 5 mg/L of total nitrogen, and µg/L – ng/L metal levels.
- Advantages of the process include:
    - Low capital and O&M costs
    - Continuous flow, no backwash interruptions, no changing media
    - Simple operation and low chemical usage ratios
- Disadvantages include:
    - Costs associated with acquiring chemicals for coating.
    - Nitrate removal applications require an additional carbon source.

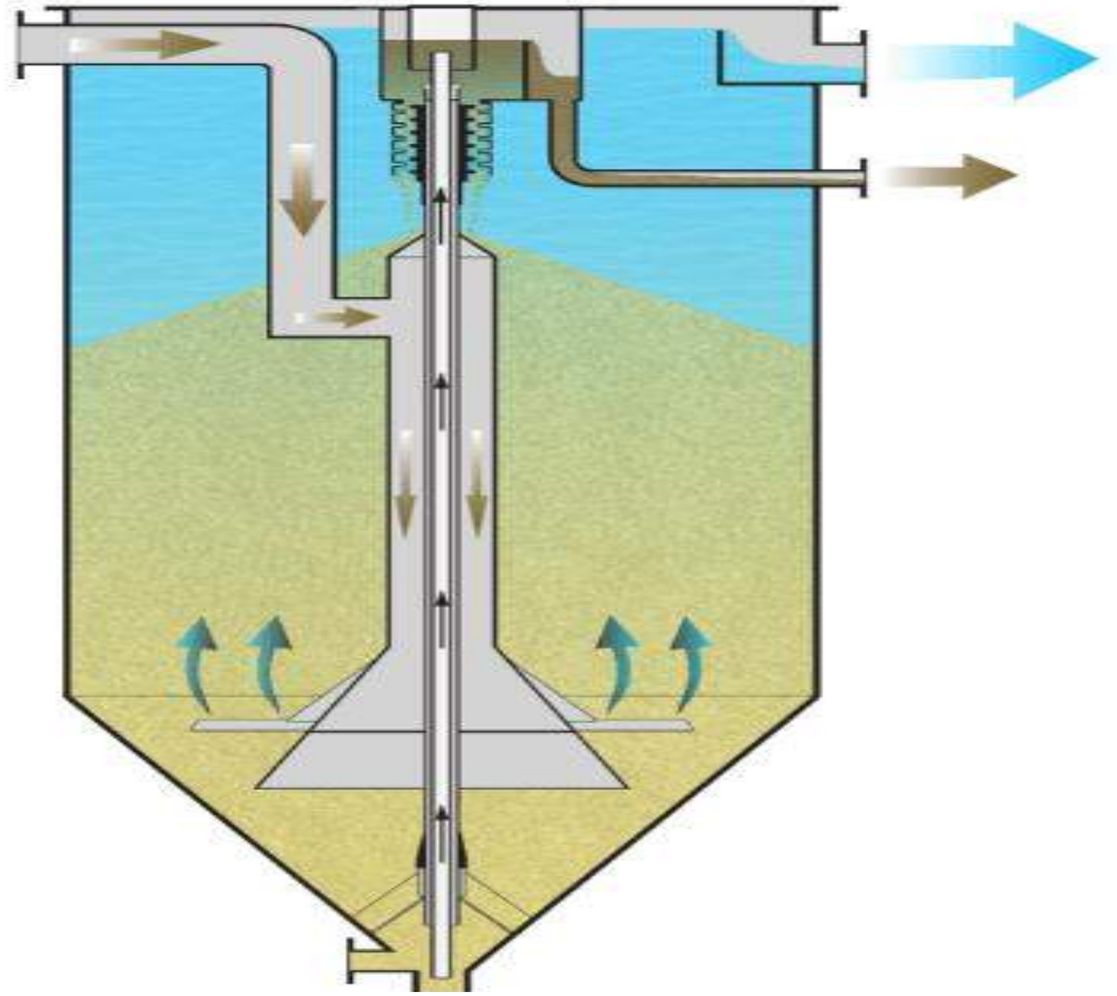


Figure 1 - Reactive filtration flow path

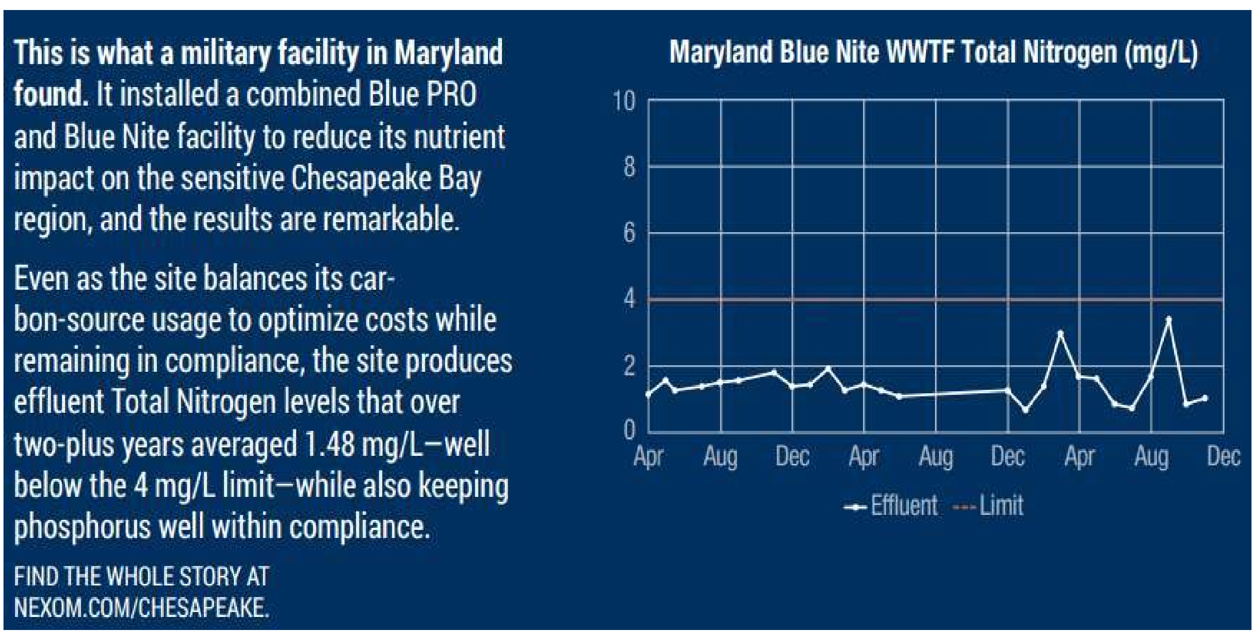


Figure 2 - Reactive filtration effluent vs. limit comparison over 2 years

REACTIVE FILTRATION FOR PHOSPHORUS & METALS

You can't choose your limits, but you can choose to beat them.

Where even low levels of phosphorus or metals can do a lot of damage, wastewater treatment plants can become targets of regulatory pressure to meet µg/L phosphorus and metals limits. Now, engineers under pressure to upgrade these plants have the tool for the job.

BluePRO®

Meeting phosphorus limits as low as 0.02 mg/L requires more than traditional coagulation and filtration techniques. That's why engineers are turning to Blue PRO's patented reactive filtration, which harnesses chemical reactions performed on the surface of granular media within a sand filter to achieve unmatched performance and efficiency.

TECHNOLOGY:

Reactive filtration in a sand filter platform

ADVANTAGES:

- Hits industry-low phosphorus levels
- Lowest capital, O&M costs
- Continuous flow; no stopping for backwash, no changing media
- Uninterrupted filtrate quality

APPLICATIONS:

- Phosphorus removal
- Trace metals removal
- Great Lakes Mercury compliance

Reactive filtration is the key.

Blue PRO® reactive filtration is based on the principle of adsorption. The process continuously regenerates a hydrous ferric oxide (HFO) coating on the sand media's surface before it comes into contact with the phosphorus- or metals-laden influent. The sand's collectively large reactive surface area guarantees contact with the targeted phosphorus or metal, which chemically binds with the HFO right on the sand media. The resulting coating, including waste HFO, phosphorus and other solids, are removed through the backwash or reject stream.

Blue PRO uses 30% less chemical than comparative technologies for ultra-low phosphorus. Coagulation followed by physical separation processes (clarifiers, filters, membranes, etc.) cannot compare to the efficiency of reactive filtration.

This reduced chemical use not only lowers costs, it also produces less sludge. Additionally, backwash can be recycled upstream for the added benefit of phosphorus pre-treatment upstream in primary or secondary treatment systems.

BluePRO®

HOW IT WORKS

Frequently asked questions.

What influent characteristics are required? The Blue PRO is surprisingly flexible as a tertiary treatment process. Several systems exist with high-strength influents between 5 and 12 mg/L P and TSS up to 50 mg/L. The ultimate treatment configuration will be dependent on the influent loads and treatment goals.

What other metals can a Blue PRO system remove? Nexom has Blue PRO® installations that are permitted for aluminum, arsenic, copper, lead, mercury, phosphorus, zinc, and other trace transition metals.

Does the media need to be replaced or topped up? Thanks to the continually-regenerative reactive filtration process, media is not a consumable. The process imparts a temporary chemical coating to the media that is stripped and reformed cyclically in situ. Many older sand filter designs of 20 years ago were prone to occasional media loss. Our washbox design, coupled with our unique control and monitoring systems, mitigates this concern. A Blue PRO system will waste almost no media in its lifetime, meaning that in a 20-year period, topping up is unlikely to be required, and the media should never need to be replaced.

Building on an impressive platform

The Centra-flo® sand filter is efficient, flexible, and approved for water reuse under California Title 22/Class 1A.

Go with the Centra-flo®

The Blue PRO filter is built on Nexom's own Centra-flo continuous-backwash sand filter process (pictured at left). In this process, influent enters the vessel A and is distributed to the cross-sectional area of the filter near the bottom of the sand column B. Water is filtered as it flows upward, encountering the sand's hydrous ferric oxide (HFO) coating in a Blue PRO configuration or the attached-growth denitrifying bacteria in a Blue Nite configuration. Meanwhile, the sand C is moving downward by gravity to an airlift device D. While the filtered water exits near the top of the filter E, the airlift transports the phosphorus- or metals-laden media up into the washbox F where the discharged HFO coating and adsorbed contaminates are separated from the media. Water velocities in the washbox are carefully designed to carry away the contaminates G while allowing the freshly-scrubbed media to fall to the filter bed H as its cycle begins again.

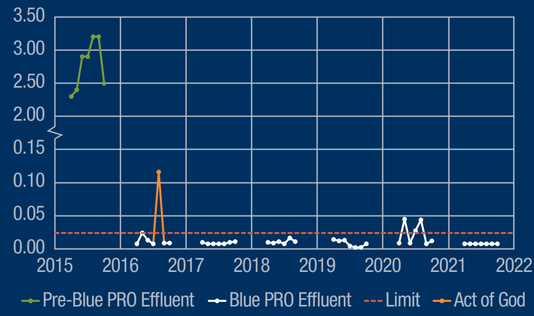
North America's lowest phosphorus limit is no match.

Faced with an unprecedented limit of 0.022 mg/L, one Alabama Blue PRO facility has averaged effluent phosphorus of only a fraction of that (excluding an isolated blip caused by an Act of God).

Since the Blue PRO is built into a Title-22/Class 1A sand filter platform, the Alabama facility not only beats its phosphorus limits, its effluent contains only 1.5 mg/L of TSS.

FIND THE WHOLE STORY AT NEXOM.COM/ULTRA-LOW.

Alabama Blue PRO WWTF Total Phosphorus (mg/L)



BluePRO®

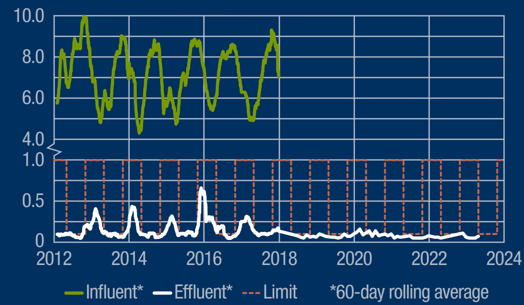
HOW IT PERFORMS

With a system that can average 13 µg/L, the constraint is not the Blue PRO. The only limit is how low you need to go, and metering your dosage to match.

For one Massachusetts Blue PRO installation (11.62 Peak MGD), this means the facility flatlines phosphorus when limits are tight in summer, and saves on dosing as limits rise.

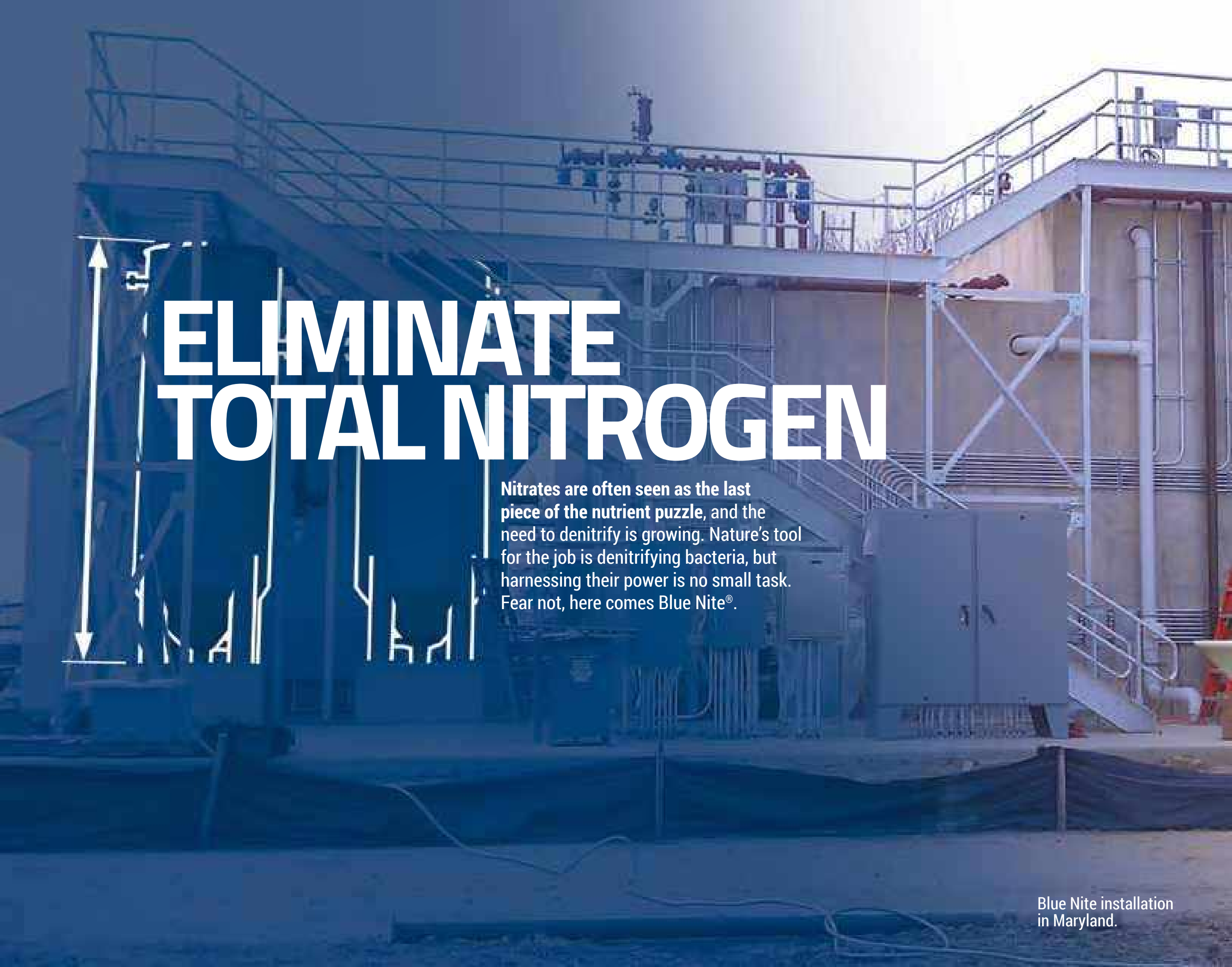
FIND THE WHOLE STORY AT NEXOM.COM/DOSING.

Massachusetts Blue PRO WWTF Total Phosphorus (mg/L)



ELIMINATE TOTAL NITROGEN

Nitrates are often seen as the last piece of the nutrient puzzle, and the need to denitrify is growing. Nature's tool for the job is denitrifying bacteria, but harnessing their power is no small task. Fear not, here comes Blue Nite®.



Blue Nite installation in Maryland.

The simple, flexible, biological way to beat nitrate limits.

Nitrogen represents a unique challenge in wastewater. Even as treatment plants remove ammonia via nitrification, the process causes an increase to the existing level of nitrates, a nutrient growing in notoriety across North America.

Blue Nite®

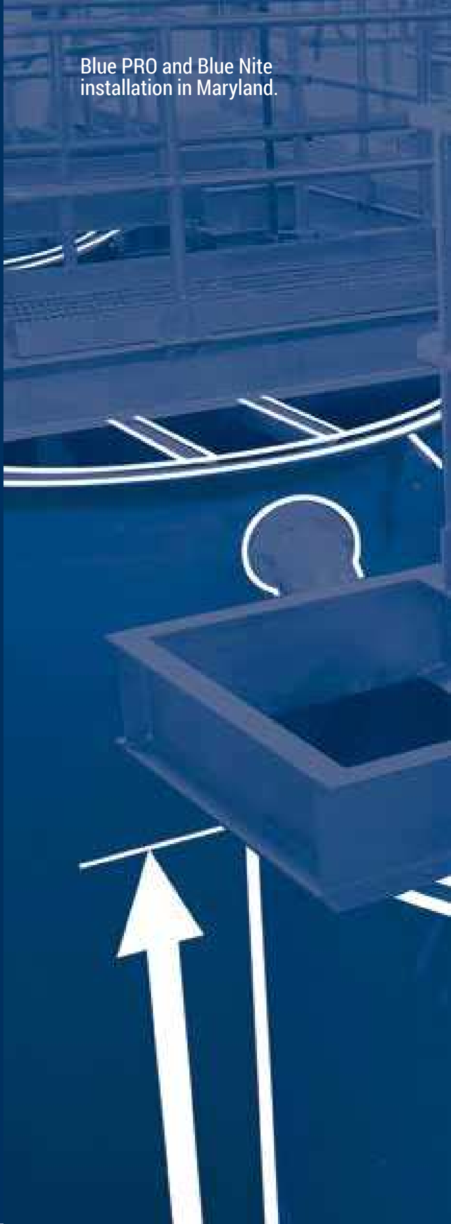
Blue Nite® is equal to the challenge nitrates present. Built upon a continuous-upflow sand filter platform, Blue Nite creates the optimal conditions required for denitrifying bacteria to thrive.

Those conditions don't happen by accident—they've been specifically designed by Nexom engineers—and **where denitrifiers take hold, nitrates don't last long.**

TECHNOLOGY:
Biological denitrification

ADVANTAGES:
- Nitrate removal to <1 mg/L
- Unique patented control system
- Lowest capital and O&M

APPLICATIONS:
- Municipal treatment
- Industrial nitrate mitigation
- Existing treatment facilities needing end-of-pipe denitrification


Blue PRO and Blue Nite installation in Maryland.

Engineered for performance.

Design hydraulic loading rates to Blue Nite® filters are determined by heterotrophic respiration rates, influent nitrate levels, nitrate variability, dissolved oxygen (DO) levels, and expected water temperatures. Nexom's design parameters, coupled with its proprietary control system, optimize the system to maintain a healthy, stable denitrifying biomass.

Nitrogen gas produced during operation is primarily released from the process as the media passes through the airlift. Removal of gas in this fashion has several benefits including:

- eliminating false readings in headloss,
- eliminating the need to backwash because of gas entrainment, and
- eliminating the gas bump or upset gas "burps" due to significant nitrogen bubble accumulation typical in static bed filters.

Blue Nite®

HOW IT WORKS

Frequently asked questions.

What carbon source does Blue Nite use? Blue Nite is flexible and can use many of the most common carbon sources, including methanol, acetic acid, ethanol, glycerin, as well as proprietary products like MicroC®.

What carbon dosing ratio does Blue Nite use? Optimal carbon dosing depends strongly on water characteristics including the dissolved oxygen and nitrate levels as well as the BOD strength of the carbon source. Nexom's chemical engineers can help you determine the ideal ratio at your site to achieve the required denitrification level.

Can our Blue Nite installation be retrofitted at a later time for Blue PRO® reactive filtration if we don't need phosphorus removal yet? Definitely, and we have helped other customers do this before. In fact, the amount of "retrofitting" required is minimal. Because the two systems utilize the same Centra-flo® granular media filtration system as a process platform, the additional infrastructure required is the Blue PRO's dosing system and virtually nothing else. (The same goes for Blue PRO installations being retrofitted for Blue Nite biological denitrification.)

One tank, many uses.

The same Centra-flo® platform supports both Blue PRO reactive filtration as well as Blue Nite biological denitrification, even in the same tank.

Biological Treatment:

Membrane Bioreactor

- Metcalf, and Eddy. *Wastewater Engineering: Treatment and Resource Recovery*. 5th ed., Burr Ridge, Il, Mcgraw-Hill Medical Pub, 2013.
- https://www.epa.gov/sites/default/files/2019-08/documents/membrane_bioreactor_fact_sheet_p100il7g.pdf
- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4931528/

Bardenpho Process (4 Stage)

- Metcalf, and Eddy. *Wastewater Engineering: Treatment and Resource Recovery*. 5th ed., Burr Ridge, Il, Mcgraw-Hill Medical Pub, 2013.
- https://www.epa.gov/sites/default/files/2019-02/documents/nutrient-control-design-manual.pdf

Oxidation Ditch Process

- Metcalf, and Eddy. *Wastewater Engineering: Treatment and Resource Recovery*. 5th ed., Burr Ridge, Il, Mcgraw-Hill Medical Pub, 2013.
- https://www3.epa.gov/npdes/pubs/oxidation_ditch.pdf

Sequential Batch Reactor (SBR)

- Metcalf, and Eddy. *Wastewater Engineering: Treatment and Resource Recovery*. 5th ed., Burr Ridge, Il, Mcgraw-Hill Medical Pub, 2013.
- https://www3.epa.gov/npdes/pubs/sbr_new.pdf

Integrated fixed film activated sludge (IFAS)

- Metcalf, and Eddy. *Wastewater Engineering: Treatment and Resource Recovery*. 5th ed., Burr Ridge, Il, Mcgraw-Hill Medical Pub, 2013.
- https://www.veoliawatertech.com/en/technologies/anita-mox
- https://www.epa.gov/sites/default/files/2019-08/documents/nutrient_control_design_manual.pdf
- https://www.newea.org/wp-content/uploads/2018/02/AC18_DMercier_27.pdf

Granular Activated Sludge Process

- https://www.tpomag.com/editorial/2017/10/new_aerobic_granular_sludge_technology_defies_convention
- https://aqua-aerobic.com/downloads/TPO1017_Technology_DeepDive_Nereda_Q&A.pdf
- https://aqua-aerobic.com/downloads/AquaNereda_AGS_Technology_WhitePaper_2019.pdf

- https://www.sciencedirect.com/science/article/pii/S2666016421000955
- https://www.sgm-inc.com/wp-content/uploads/2021/02/12-sgm-winter-forum-aquanereda-ww-aerobic-granular-sludge-system.pdf

Moving Bed Bioreactor

- Metcalf, and Eddy. *Wastewater Engineering: Treatment and Resource Recovery*. 5th ed., Burr Ridge, Il, Mcgraw-Hill Medical Pub, 2013.
- https://www.veoliawatertechnologies.com/en/technologies/anita-mox

MABR

- https://www.thembrsite.com/features/zeelung-mabr-technology-story-so-far/
- http://aquatecmaxcon.com.au/news/331-Membrane-Aerated-Biofilm-Reactor-MABR#key-advantages

Densified Activated Sludge

- https://www.hazenandsawyer.com/topics/densification
- https://www.worldwaterworks.com/technologies/indense-hydrocyclone-wasting
- https://www.wateronline.com/doc/doing-more-with-less-densified-activated-sludge-das-systems-for-water-resource-recovery-facilities-0001

Mobile Organic Biofilm

- https://www.nuvodaus.com/mob/

MNE – Microvi

- https://www.microvi.com/technology-1

Tertiary Filtration/Settling:

Denitrification Filters

- Metcalf, and Eddy. *Wastewater Engineering: Treatment and Resource Recovery*. 5th ed., Burr Ridge, Il, Mcgraw-Hill Medical Pub, 2013.
- https://www.epa.gov/sites/default/files/2019-08/documents/denitrifying_filters_fact_sheet_p100il79.pdf
- https://www.ohiowea.org/docs/Track_01_1600_Low_Total_Nitrogen_Limits_Phipps.pdf
- https://www.waterrf.org/sites/default/files/file/2022-09/Tertiary-Denitrification.pdf

Membrane Filtration

- Metcalf, and Eddy. *Wastewater Engineering: Treatment and Resource Recovery*. 5th ed., Burr Ridge, Il, Mcgraw-Hill Medical Pub, 2013.

- NEIWPCC. *TR-16 Guides for the Design of Wastewater Treatment Works*. May 2016.

Cloth Disc Filtration

- https://www.mitawatertechnologies.com/en/prodotti/cloth-filters-description/

Ballasted Flocculation

- https://nepis.epa.gov/Exe/ZyNET.exe/P100IL67.TXT?ZyActionD=ZyDocument&Client=EPA&Index=2000+Thru+2005&Docs=&Query=&Time=&EndTime=&SearchMethod=1&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=&File=D%3A%5Czyfiles%5CIndex%20Data%5C00thru05%5CTxt%5C00000032%5CP100IL67.txt&User=ANONYMOUS&Password=anonymous&SortMethod=h%7C-&MaximumDocuments=1&FuzzyDegree=0&ImageQuality=r75g8/r75g8/x150y150g16/i425&Display=hpfr&DefSeekPage=x&SearchBack=ZyActionL&Back=ZyActionS&BackDesc=Results%20page&MaximumPages=1&ZyEntry=1&SeekPage=x&ZyPURL#

BAF

- NEIWPCC. *TR-16 Guides for the Design of Wastewater Treatment Works*. May 2016.
- Metcalf, and Eddy. *Wastewater Engineering: Treatment and Resource Recovery*. 5th ed., Burr Ridge, Il, Mcgraw-Hill Medical Pub, 2013.

Reactive Filtration

- https://nexom.com/bluepro-3/m)

APPENDIX D

ZeeWeed Hydraulic Testing

2987.08

EPPING, NH – EPPING WATER & SEWER COMMISSION

FULL-SCALE MBR PILOT PREPARATION AND PROCEDURES

REV4 1/19/24

PHASE III SHORT-TERM IMPROVEMENTS

The following paragraphs describe the procedures proposed for accomplishing full-scale pilot testing for the new ZeeWeed membranes installed in MBR Train #3 and #2.

Hydraulic Testing

The peak design flow of the fully upgraded MBR system will be 694 gpm or 1.0 MGD. For each of the three trains, the peak flow per Veolia is 430,000 gpd or 299 gpm (16 gfd).

The hydraulic testing should be performed on specific days when the new membranes are scheduled to undergo a maintenance clean, which the equipment manufacturer anticipates will be needed three times a week. Two 3-hour tests will be performed on each train, with the first test before the membranes are maintenance cleaned, and the second test after the membranes are maintenance cleaned. The 1st and 3rd hour will be at an elevated flow rate of 268 gpm (14 gfd), and the 2nd hour will be at the peak design flow rate of 299 gpm (16 gfd). The testing will be performed when the MLSS is at or around 7,000 mg/L, and be scheduled to capture the coldest wastewater temperature (8 deg. C). During flow testing, Underwood will monitor permeate TSS, TOC, flow, and transmembrane pressure, tank water level and temperature, and the following MLSS parameters (note all samples will be composites of 3 grab samples; one taken each hour):

Mixed Liquor Characteristics

Parameter	Design Value	Operating Range
Mixed liquor temperature (°C)	8	8 – 30
MLSS concentration in membrane tank (mg/L)[1]	7,000	6,000 - 10,000
pH of mixed liquor in membrane tanks (SU)	7.0	6.5 – 7.5

Soluble $cBOD_5$ concentration in membrane tank (mg/L) SM5210B-11	5	≤ 5
NH_3-N concentration in membrane tanks (mg/L) SM4500-NH3C	1.0	≤ 1.0
Colloidal TOC (cTOC) concentration in membrane tanks (mg/L)[2]	10	≤ 10
Soluble alkalinity in membrane tanks (mg/L as $CaCO_3$) SM2320B	100	50 – 150
time to filter (TTF) (seconds)[3]	200	≤ 200
material greater than 2 mm in size (mg/L)[4]	1	≤ 1
Fats, Oil & Grease (FOG) (mg/L)[6]	Refer to Note 6	

1. Membrane tank MLSS concentration to be below 12,000 mg/L during all flow conditions. TSS SM2540D-11.
2. Colloidal TOC (cTOC) is the difference between the TOC measured in the MLSS filtrate passing through a 1.5 µm filter paper and the TOC measured in the membrane permeate. TOC SM5310C-11 & DOC SM5310B-11.
3. Per seller's standard time to filter (TTF) procedure.
4. Per seller's standard sieve test protocol.
5. Chemicals that are not compatible with PVDF membranes shall not be allowed in the membrane tank. Refer to attached chemical compatibility chart.
6. FOG concentration shall not exceed 150 mg/L of emulsified FOG in the feed with no free oil and less than 10 mg/L of mineral or non-biodegradable oil. FOG EPA 1664A.

EPPING NH WWTF - PHASE III SHORT TERM IMPROVEMENTS
FULL SCALE MBR TESTING - TRAIN 3
PROJECT #: 2987
PERFORMED BY: UNDERWOOD ENGINEERS

CELL KEY:
- TEXT INPUT
- FIELD MEASURED
- WWTF LAB MEASUREMENT
- SAMPLES REQUIRED
- CALCULATED CELL

Epping Membranes Train 3 Log

Pilot Test Parameters					Membrane Monitoring Parameters							MLSS Samples[3]							Permeate Samples[3]		
Date	Membrane Status	Test	Hour	Time	Influent Flow[1] GPM	Temp deg F	Temp deg F	Permeate Flow GPM	Transmembrane Pressure PSI	Tank Water Level Feet	pH	TSS[2] mg/L	Soluble CBOD mg/L	Ammonia (NH3-N) mg/L	Hardness mg/L as CaCO3	Filtered TOC[6] mg/L	Soluble Alkalinity[6] mg/L as CaCO3	FOG mg/L	TSS mg/L	TOC mg/L	cTOC[4] mg/L
1/19/2024	Pre-Cleaning	1	1	9:00 AM	268	7.1	44.8	266.0	-3.72	15.3	6.82	8200	<6	7.8	280	13	86	83.5	<2	3.7	9.3
			2	10:00 AM	299	7.3	45.1	300.0	-4.72	15.2	6.78										
			3	11:00 AM	268	7.3	45.2	267.1	-3.53	15.6											
	Post-Cleaning	2	1	1:15 PM	268	7.7	45.9	266.9	-3.75	15.2	N/A	9300	<6	2.6	300	12	65	95.5	<2	3.4	8.6
			2	2:15 PM	299	7.9	46.2	299.7	-4.65	14.9	N/A										
			3	3:15 PM	268	8.2	46.8	266.7	-3.60	15.6											

NOTES:
1 Flow for the first and third hour tests shall be at max day design flow of 268 gpm. Flow for the second hour test shall be at peak hour design flow of 299 gpm.
2 All tests shall be performed when MLSS is between 6.000 and 10,000 mg/L. Not to exceed 12.000 mg/L.
3 Each hour a grab sample shall be taken for the MLSS and Permeate Parameters. A composite sample shall be made for each test using the 3 grab samples and delivered to EAI for lab results.
4 Colloidal TOC (cTOC) is the difference between the TOC measured in the MLSS filtrate after passing through a 1.5 um filter paper, and the TOC measured in the permeate.
5 Cells with N/A means not available or no data.
6 MLSS Soluble CBOD and Alkalinity were both filterd through a 1.5 um filter paper as opposed to 0.45 um.

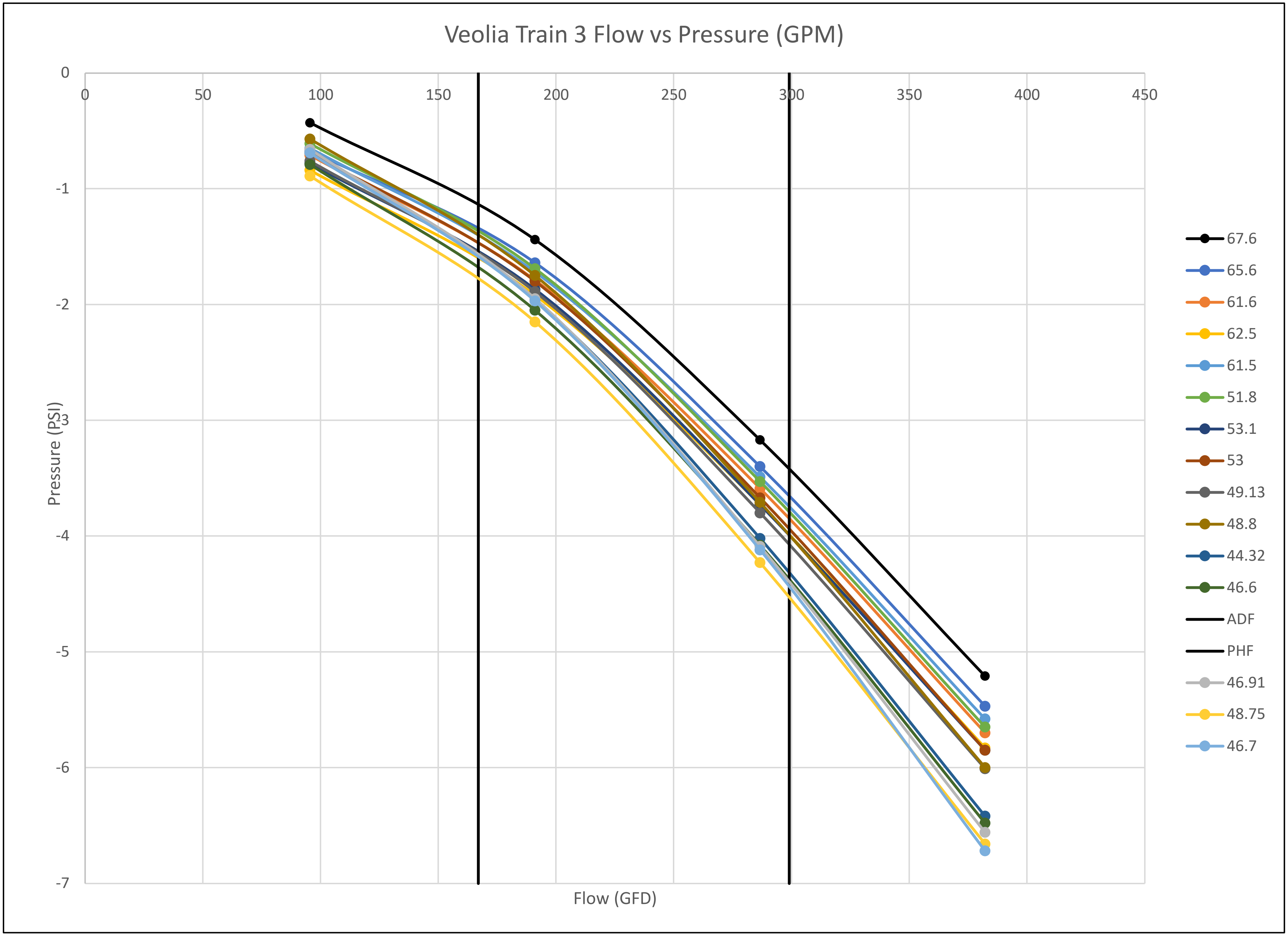
EPPING NH WWTF - PHASE III SHORT TERM IMPROVEMENTS
FULL SCALE MBR TESTING - TRAIN 2
PROJECT #: 2987
PERFORMED BY: UNDERWOOD ENGINEERS

CELL KEY:
- TEXT INPUT
- FIELD MEASURED
- WWTF LAB MEASUREMENT
- SAMPLES REQUIRED
- CALCULATED CELL

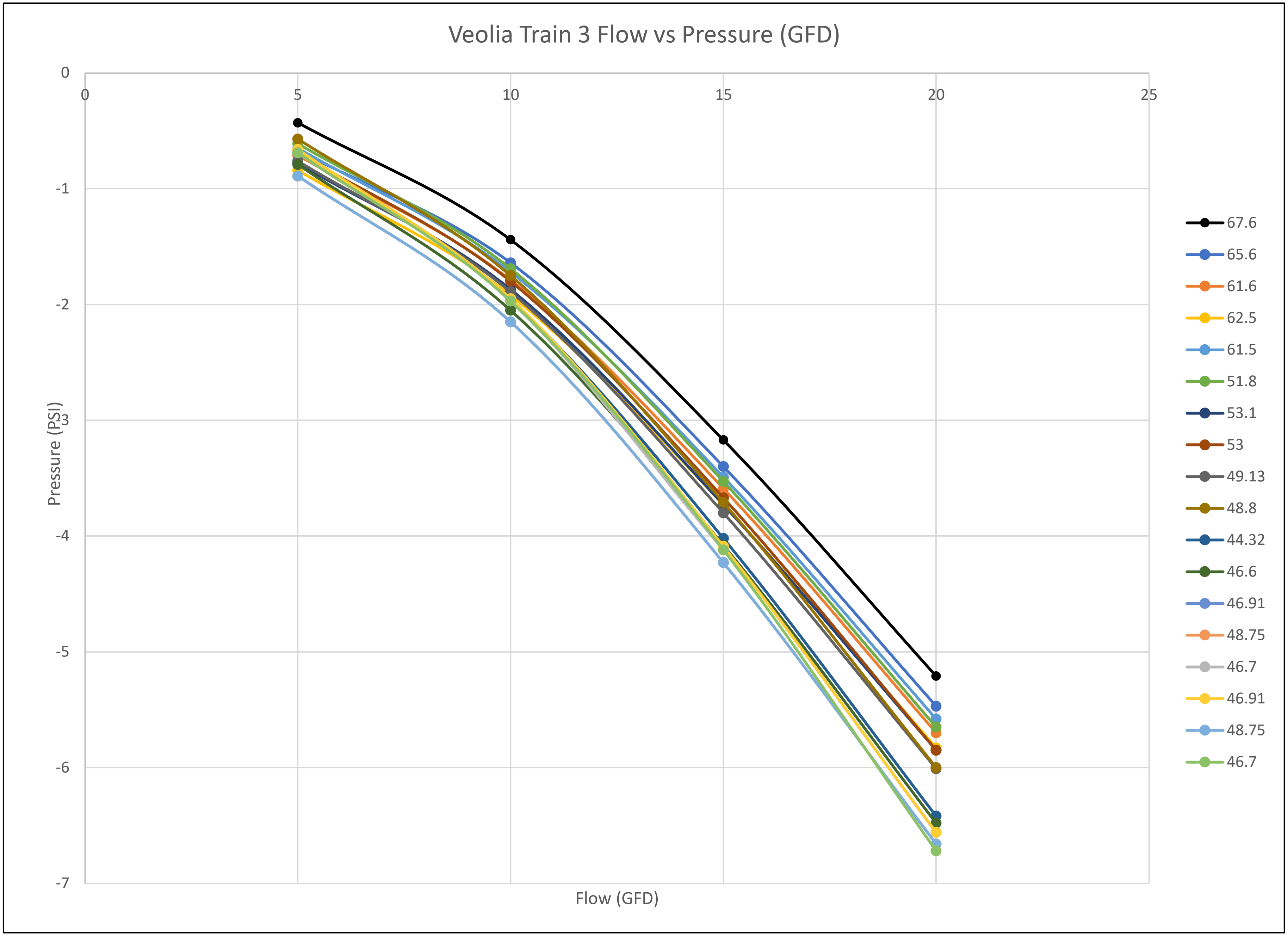
Epping Membranes Train 2 Log

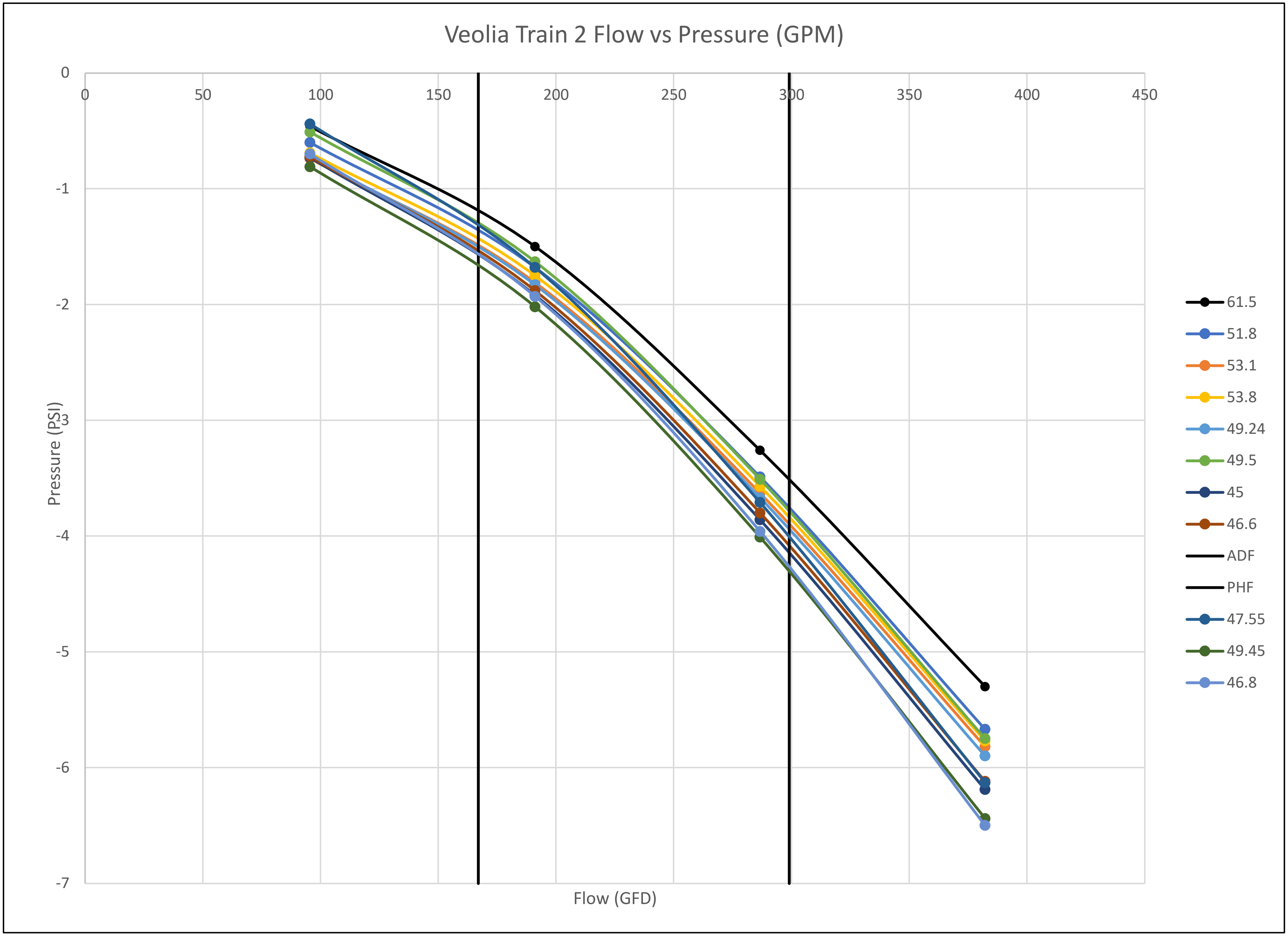
Pilot Test Parameters					Membrane Monitoring Parameters							MLSS Samples[3]							Permeate Samples[3]		
Date	Membrane Status	Test	Hour	Time	Influent Flow[1] GPM	Temp deg F	Temp deg F	Permeate Flow GPM	Transmembrane Pressure PSI	Tank Water Level Feet	pH	TSS[2] mg/L	Soluble CBOD mg/L	Ammonia (NH3-N) mg/L	Hardness mg/L as CaCO3	Filtered TOC[6] mg/L	Soluble Alkalinity[6] mg/L as CaCO3	FOG mg/L	TSS mg/L	TOC mg/L	cTOC[4] mg/L
1/26/2024	Pre-Cleaning	1	1	7:45 AM	268	7.9	46.3	265.3	-3.19	15.6	N/A	8300	<6	6.2	290	14	130	70.7	2.2	3.5	10.5
			2	8:45 AM	299	8.1	46.5	299.0	-4.27	14.8	N/A										
			3	9:45 AM	268	8.2	46.7	264.6	-3.53	14.8											
	Post-Cleaning	2	1	12:00 PM	268	8.4	47.2	265.0	-3.52	14.9	6.91	7100	<6	7.9	270	12	98	50.1	<2	3.3	8.7
			2	1:00 PM	299	8.2	46.7	298.3	-4.25	15.1	6.88										
			3	2:00 PM	268	8.1	46.6	264.7	-3.20	15.7											

NOTES:
1 Flow for the first and third hour tests shall be at max day design flow of 268 gpm. Flow for the second hour test shall be at peak hour design flow of 299 gpm.
2 All tests shall be performed when MLSS is between 6.000 and 10,000 mg/L. Not to exceed 12.000 mg/L.
3 Each hour a grab sample shall be taken for the MLSS and Permeate Parameters. A composite sample shall be made for each test using the 3 grab samples and delivered to EAI for lab results.
4 Colloidal TOC (cTOC) is the difference between the TOC measured in the MLSS filtrate after passing through a 1.5 um filter paper, and the TOC measured in the permeate.
5 Cells with N/A means not available or no data.
6 MLSS Soluble CBOD and Alkalinity were both filterd through a 1.5 um filter paper as opposed to 0.45 um.

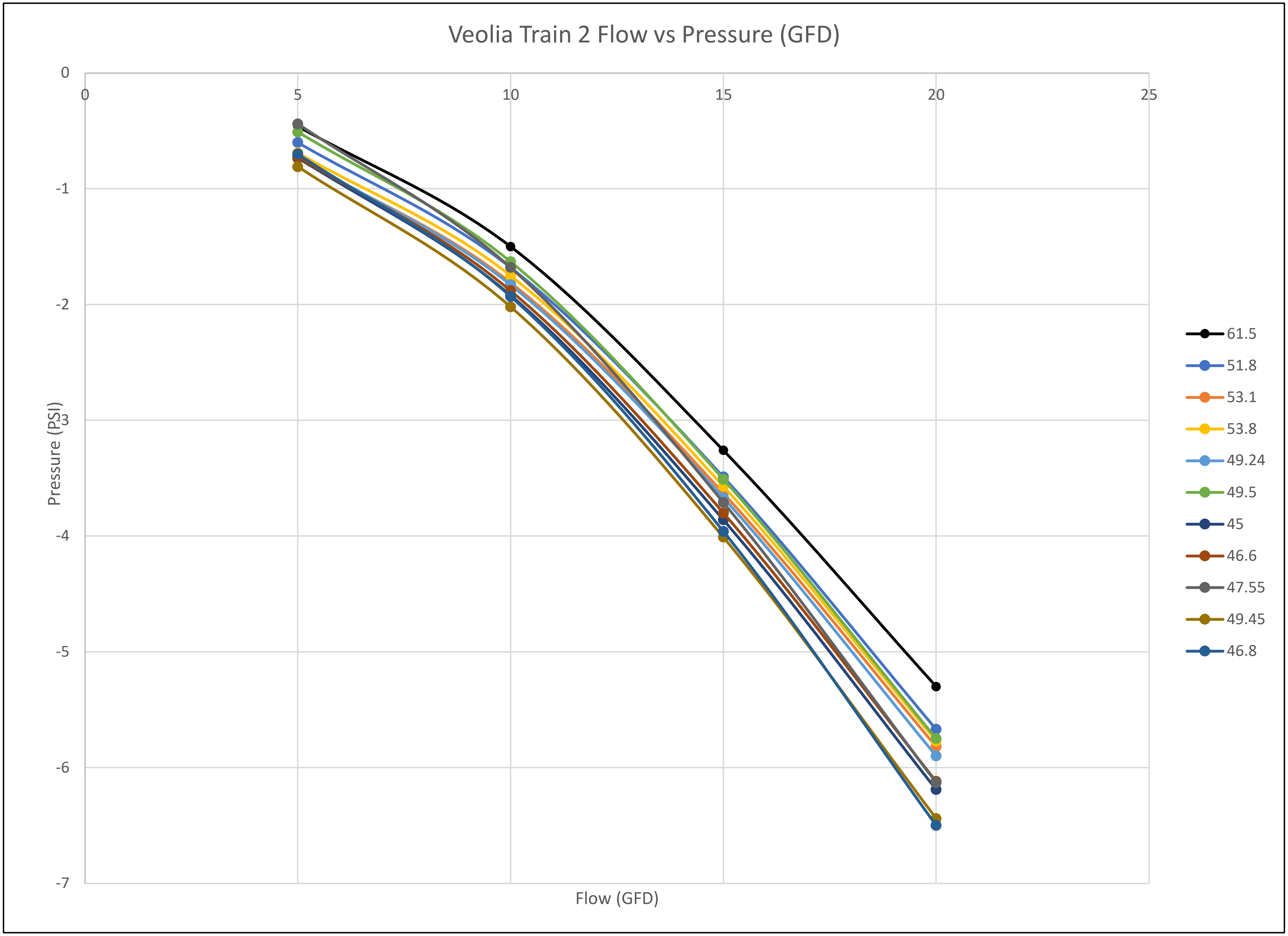


Veolia Train 3 Flow vs Pressure (GPM)
Pressure (PSI)
0
-1
-2
-3
-4
-5
-6
-7
0
50
100
150
200
250
300
350
400
450
Flow (GFD)
67.6
65.6
61.6
62.5
61.5
51.8
53.1
53
49.13
48.8
44.32
46.6
ADF
PHF
46.91
48.75
46.7


Veolia Train 3 Flow vs Pressure (GFD)
0
-1
-2
-3
-4
-5
-6
-7
Pressure (PSI)
0
5
10
15
20
25
Flow (GFD)
67.6
65.6
61.6
62.5
61.5
51.8
53.1
53
49.13
48.8
44.32
46.6
46.91
48.75
46.7
46.91
48.75
46.7



Veolia Train 2 Flow vs Pressure (GPM)
0
-1
-2
-3
-4
-5
-6
-7
0
50
100
150
200
250
300
350
400
450
Pressure (PSI)
Flow (GFD)
61.5
51.8
53.1
53.8
49.24
49.5
45
46.6
ADF
PHF
47.55
49.45
46.8



Veolia Train 2 Flow vs Pressure (GFD)
0
-1
-2
-3
-4
-5
-6
-7
0
5
10
15
20
25
Pressure (PSI)
Flow (GFD)
61.5
51.8
53.1
53.8
49.24
49.5
45
46.6
47.55
49.45
46.8

APPENDIX E

BioWin Output

APPENDIX E - Wastewater BNR Modeling

Index

Appendix E.1 Wastewater Characterization

Appendix E.1 - Wastewater Characteristics Sampling Program

Week 1 Two Week Testing Program

Point No.	Location	Type	Sunday, October 29, 2023	Monday, October 30, 2023	Tuesday, October 31, 2023	Wednesday, November 1, 2023	Thursday, November 2, 2023	Friday, November 3, 2023	Saturday, November 4, 2023
1	Influent	composite			7 am Tue to 7 am Wed		7 am Thu to 7 am Fri		10 am Sat to 10 am Sun
2	Effluent	composite			7 am Tue to 7 am Wed		7 am Thu to 7 am Fri		10 am Sat to 10 am Sun
	VFA	composite			7 am Tue to 7 am Wed		7 am Thu to 7 am Fri		
3	MLSS	Grabs				7 am Wed		7 am Fri	
						EAI to pick up after 10 am		EAI to pick up after 10 am	UE deliver to EAI before 8 am Mon

Week 2

Point No.	Location	Type	Sunday, November 5, 2023	Monday, November 6, 2023	Tuesday, November 7, 2023	Wednesday, November 8, 2023	Thursday, November 9, 2023	Friday, November 10, 2023	Saturday, November 11, 2023
1	Influent	composite		7 am Mon to 7 am Tue		Sample discarded		Sample discarded	
2	Effluent	composite		7 am Mon to 7 am Tue		pH meter failed			
	VFA	composite		7 am Mon to 7 am Tue					
3	MLSS	Grabs		Saturdays sample UE to deliver	7am Tue				
				Saturdays sample UE to deliver to EAI before 8 am Mon	EAI to pick up after 10 am		EAI to pick up after 10 am	UE deliver to EAI before 8 am Mon	

Point No.	Location	Type	Sunday, November 12, 2023	Monday, November 13, 2023	Tuesday, November 14, 2023	Wednesday, November 15, 2023	Thursday, November 16, 2023	Friday, November 17, 2023	Saturday, November 18, 2023
1	Influent	composite				7 am Wed to 7 am Thu		10 am Fri to 10 am Sat	
2	Effluent	composite				7 am Wed to 7 am Thu		10 am Fri to 10 am Sat	
3	MLSS	Grabs							
							EAI to pick up after 10 am	UE deliver to EAI before 8 am Mon	

Point No.	Location	Type	Sunday, November 19, 2023	Monday, November 20, 2023	Tuesday, November 21, 2023	Wednesday, November 22, 2023	Thursday, November 23, 2023	Friday, November 24, 2023	Saturday, November 25, 2023
1	Influent	composite	7 am Sun to 7 am Mon						
2	Effluent	composite	7 am Sun to 7 am Mon						
3	MLSS	Grabs							
			UE deliver to EAI before 8 am Mon	Friday and Sunday Samples UE deliver to EAI before 8 am Mon					

Point No.	Location	Type	Sunday, November 26, 2023	Monday, November 27, 2023	Tuesday, November 28, 2023	Wednesday, November 29, 2023	Thursday, November 30, 2023	Friday, December 1, 2023	Saturday, December 2, 2023

Point No.	Location	Type	Sunday, December 3, 2023	Monday, December 4, 2023	Tuesday, December 5, 2023	Wednesday, December 6, 2023	Thursday, December 7, 2023	Friday, December 8, 2023	Saturday, December 9, 2023
1	Influent VFA	composite		7 am Mon to 7 am Tue		7 am Wed to 7 am Thu			
					EAI to pick up after 10 am		EAI to pick up after 10 am		

Note:

This should be followed by an additional testing program in a different season (Winter/Summer or Spring/Fall)

Epping, NH WWTF Sampling Spreadsheet

NOTE: Measured parameters in red font
NOTE: Calculated parameters in blue font

		RAW INFLUENT																		
DATE	DAY	TSS (mg/L)	VSS (mg/L)	COD tot. (mg/L)	COD 1.5µ gf (mg/L)	COD ff (mg/L)	BOD tot. (mg/L)	BOD 1.5µ gf (mg/L)	TP tot. (mg/L)	PO4-P (mg/L)	TKN tot. (mg/L)	TKN 1.5µ gf (mg/L)	NO3-N (mg/L)	NO2-N (mg/L)	TN tot. (mg/L)	NH3-N (mg/L)	NH3-N 1.5u gf (mg/L)	Alkalinity (mg/L)	VFA as H2C2O4 (mg/L)	Inf pH	Inf Flow (mgd)
Tue-Oct 31-23	0			670	280	170	290	120	5.4	2.7	40.0	35.0	0.0	0.0	40.0	31.0	31.0	190.0	225.0	7.9	0.2160
Thu-Nov 2-23	1	243	192	740	260	190	360	140	6.3	3.5	45.0	39.0	0.0	0.0	45.0	35.0	34.0	210.0	425.0	7.86	0.2166
Sat-Nov 4-23	2	216	202	750	360	220	450	220	6.5	3.9	44.0	44.0	0.0	0.0	44.0	35.0	36.0	220.0		7.54	0.2248
Mon-Nov 6-23	3	232	212	620	220	170	270	130	6.4	3.6	46.0	43.0	0.0	0.0	46.0	37.0	37.0	230.0	225.0	7.65	0.2030
Wed-Nov 15-23	4	260	247	690	250	190	350	170	7.1	4.3	58.0	45.0	0.0	0.0	58.0	39.0	39.0	240.0		7.93	0.1981
Fri-Nov 17-23	5			680	320	220	360	190	6.6	4.2	44.0	46.0	0.0	0.0	44.0	38.0	40.0	230.0		7.67	0.1992
Sun-Nov 19-23	6			700	390	250	420	220	6.7	4.4	44.0	44.0	0.0	0.0	44.0	38.0	39.0	230.0		7.57	0.1931
Mon-Dec 4-23																			49.0	7.71	0.2501
Wed-Dec 6-23																			44.0	7.54	0.2387
AVERAGE		238	213	693	297	201	357	170	6.4	3.8	45.9	42.3	0.0	0.0	45.9	36.1	36.6	221.4	193.6	7.70	0.2155
STD DEV		19	24	44	62	30	64	42	0.5	0.6	5.7	3.9	0.0	0.0	5.7	2.7	3.2	16.8	157.2	0.15	0.0195
MAX		260	247	750	390	250	450	220	7.1	4.4	58.0	46.0	0.0	0.0	58.0	39.0	40.0	240.0	425.0	7.93	0.2501
MIN		216	192	620	220	170	270	120	5.4	2.7	40.0	35.0	0.0	0.0	40.0	31.0	31.0	190.0	44.0	7.54	0.1931

32 acetic, 12 propionic

Epping, NH WWTF Sampling Spreadsheet

NOTE: Measured para
NOTE: Calculated par

CALCULATED BIOWIN PARAMETERS

Assumed Sec Eff Nos: 0.5 (for F_{NUS} Calculation)

DATE	DAY	RAW INFLUENT ISS (mg/L)	F_{BS} (mgCOD/ mgCOD)	F_{US} (mgCOD/ mgCOD)	F_{CV} (mgCOD/ mgVSS)	F_{NUS} (mgN/ mgN)	F_{PO4} (mgP/ mgP)	F_{NA} (mgN/ mgN)
Tue-Oct 31-23	0		0.25	0.03			0.50	0.78
Thu-Nov 2-23	1	51	0.26	0.03	2.50		0.56	0.78
Sat-Nov 4-23	2	14	0.29	0.02	1.93		0.60	0.80
Mon-Nov 6-23	3	20	0.27	0.03	1.89		0.56	0.80
Wed-Nov 15-23	4	13	0.28	0.03	1.78		0.61	0.67
Fri-Nov 17-23	5		0.32	0.02			0.64	0.86
Sun-Nov 19-23	6		0.36	0.02			0.66	0.86
	7							
	8							
AVERAGE		25	0.29	0.03	2.03	#DIV/0!	0.59	0.79
STD DEV		18	0.04	0.00	0.32	#DIV/0!	0.05	0.06
MAX		51	0.36	0.03	2.50	0.00	0.66	0.86
MIN		13	0.25	0.02	1.78	0.00	0.50	0.67

If N_{os} = 0

F_{NUS} (mgN/ mgN)
0.00
0.01
0.00
0.00
0.01
0.02
0.02

DATE	DAY	MBR EFFLUENT									
		TSS (mg/L)	COD total (mg/L)	COD 1.5µ gf (mg/L)	COD ff (mg/L)	TP 1.5µ gf (mg/L)	PO4-P (mg/L)	TKN MBR (mg/L)	NO3-N (mg/L)	NO2-N (mg/L)	NH3-N (mg/L)
Tue-Oct 31-23	0	0	20	20	26			1.2			1.3
Thu-Nov 2-23	1	0	20	20	23			1.5			1.2
Sat-Nov 4-23	2	0	16	16	21			1.2			1.3
Mon-Nov 6-23	3	0	19	19	19			0.92			0.76
Wed-Nov 15-23	4	0	21	21	18			0.74	17.0	0.00	0.24
Fri-Nov 17-23	5	0	13	13	15			1.1	13.0	0.00	0.39
Sun-Nov 19-23	6	0	17	17	22			1.1	6.3	0.00	0.39
	7										
	8										
	9										
AVERAGE		0	18	18	21			1.1	12.1	0.0	0.8
STD DEV		0	3	3	4			0.2	5.4	0.0	0.5
MAX		0	21	21	26			1.5	17.0	0.0	1.3
MIN		0	13	13	15			0.7	6.3	0.0	0.2

DATE	DAY	MIXED LIQUOR						
		TSS (mg/L)	VSS (mg/L)	COD tot. (mg/L)	COD 1.5u gf (mg/L)	TN tot. (mg/L)	TKN tot. (mg/L)	TP tot. (mg/L)
Tue-Oct 31-23	0	8,333	6,767	5,100	34			
Thu-Nov 2-23	1	7,733	5,933	5,700	59			
Sat-Nov 4-23	2							
Mon-Nov 6-23	3	6,350	5,075	6,300	34			
Wed-Nov 15-23	4							
Fri-Nov 17-23	5							
Sun-Nov 19-23	6							
	7							
	8							
	9							
	AVERAGE	7,472	5,925	5,700	42			
	STD DEV	1,017	846	600	14			
	MAX	8,333	6,767	6,300	59			
	MIN	6,350	5,075	5,100	34			

Epping, NH WWTF Sampling Spreadsheet

NOTE: Measured parameters in red font
NOTE: Calculated parameters in blue font

OTHER RATIOS / FRACTIONS

DATE	DAY	RAW INFLUENT TSS / COD (mg/mg)	COD / BOD (mg/mg)	TSS / BOD (mg/mg)	BODf / BODt (mg/mg)	ISS / COD (mg/mg)	ISS / TSS (mg/mg)	VSS / TSS (mg/mg)	TKN / COD (mg/mg)	TP / COD (mg/mg)	COD gf / COD tot (mg/mg)	COD ff / COD tot (mg/mg)	TKN/BOD	TP/BOD
Sun-Oct 22-23	0		2.31		0.41				0.06	0.008	0.42	0.25	0.14	0.02
Tue-Oct 24-23	1	0.33	2.06	0.68	0.39	0.07	0.21	0.79	0.06	0.009	0.35	0.26	0.13	0.02
Thu-Oct 26-23	2	0.29	1.67	0.48	0.49	0.02	0.06	0.94	0.06	0.009	0.48	0.29	0.10	0.01
Sat-Oct 28-23	3	0.37	2.30	0.86	0.48	0.03	0.09	0.91	0.07	0.010	0.35	0.27	0.17	0.02
Mon-Oct 30-23	4	0.38	1.97	0.74	0.49	0.02	0.05	0.95	0.08	0.010	0.36	0.28	0.17	0.02
Wed-Nov 1-23	5		1.89		0.53				0.06	0.010	0.47	0.32	0.12	0.02
Fri-Nov 3-23	6		1.67		0.52				0.06	0.010	0.56	0.36	0.10	0.02
	7													
	8													
AVERAGE		0.34	1.98	0.69	0.47	0.03	0.10	0.90	0.07	0.009	0.43	0.29	0.132	0.02
STD DEV		0.04	0.26	0.16	0.05	0.02	0.07	0.07	0.01	0.001	0.08	0.04	0.028	0.00
MAX		0.38	2.31	0.86	0.53	0.07	0.21	0.95	0.08	0.010	0.56	0.36	0.170	0.02
MIN		0.29	1.67	0.48	0.39	0.02	0.05	0.79	0.06	0.008	0.35	0.25	0.098	0.01

Epping, NH WWTF Sampling Spreadsheet

DATE	DAY	MIXED LIQUOR VSS / TSS (mg/mg)	ISS (mg/L)	COD / VSS (mg/mg)	TKN / VSS (mg/mg)	TP / VSS (mg/mg)
Tue-Oct 31-23	0	0.81	1567	0.75		
Thu-Nov 2-23	1	0.77	1800	0.95		
Sat-Nov 4-23	2					
Mon-Nov 6-23	3	0.80	1275	1.23		
Wed-Nov 15-23	4					
Fri-Nov 17-23	5					
Sun-Nov 19-23	6					
	7					
	8					
	9					
	AVERAGE	0.79	1547	0.98		
	STD DEV	0.02	263	0.24		
	MAX	0.81	1800	1.23	0.00	0.000
	MIN	0.77	1275	0.75	0.00	0.000

Appendix E.1 - Wastewater Characteristics Results for Input into Existing Calibration Model

Existing Wastewater Characteristics for Calibration and Validation

COD Influent Data

Name	Value
Flow	0.30
COD - Total mgCOD/L	693.00
N - Total Kjeldahl Nitrogen mgN/L	45.90
P - Total P mgP/L	6.40
S - Total S mgS/L	10.00
N - Nitrate mgN/L	0.00
pH	7.70
Alkalinity mmol/L	4.43
Influent inorganic suspended solids mgISS/	25.00
Metal soluble - Calcium mg/L	80.00
Metal soluble - Magnesium mg/L	15.00
Gas - Dissolved oxygen mg/L	0.00

Paste values to:

Project > Para. > Stoichi. > Common	Value
Particulate Substrate COD:VSS Ratio	2.00
Particulate Inert COD:VSS Ratio	1.60
Cellulose COD:VSS ratio [mgCOD/mgVSS]	1.40

Paste values to:

Project > Para. > Other	Value
k1 for CODc - Xsc	0.28
k2 for CODp - Xsp	0.44

Existing Wastewater Characteristics for Calibration and Validation

COD Influent Fractions

Name	Raw Defaults	Value
Fbs - Readily biodegradable (including Acetate) [gCOD/g of total COD]	0.1600	**0.2597**
Fac - Acetate [gCOD/g of readily biodegradable COD]	0.1500	**0.2200**
Fxsp - Non-colloidal slowly biodegradable [gCOD/g of slowly degradable C	0.7500	**0.7724**
Fus - Unbiodegradable soluble [gCOD/g of total COD]	0.0500	**0.0303**
Fup - Unbiodegradable particulate [gCOD/g of total COD]	0.1300	**0.0800**
Fcel - Cellulose fraction of unbiodegradable particulate [gCOD/gCOD]	0.5000	0.5000
Fna - Ammonia [gNH3-N/gTKN]	0.6600	**0.7865**
Fnox - Particulate organic nitrogen [gN/g Organic N]	0.5000	0.5000
Fnus - Soluble unbiodegradable TKN [gN/gTKN]	0.0200	0.0200
FupN - N:COD ratio for unbiodegradable part. COD [gN/gCOD]	0.0700	0.0700
Fpo4 - Phosphate [gPO4-P/gTP]	0.5000	**0.5938**
FupP - P:COD ratio for unbiodegradable part. COD [gP/gCOD]	0.0220	0.0220
Fsr - Reduced sulfur [H2S] [gS/gS]	0.1500	0.1500
FZbh - Ordinary heterotrophic COD fraction [gCOD/g of total COD]	0.0200	0.0200
FZbm - Methylotrophic COD fraction [gCOD/g of total COD]	1.00E-04	1.000E-04
FZao - Ammonia oxidizing COD fraction [gCOD/g of total COD]	1.00E-04	1.000E-04
FZno - Nitrite oxidizing COD fraction [gCOD/g of total COD]	1.00E-04	1.000E-04
FZaao - Anaerobic ammonia oxidizing COD fraction [gCOD/g of total COD	1.00E-04	1.000E-04
FZppa - Phosphorus accumulating COD fraction [gCOD/g of total COD]	1.00E-04	1.000E-04
FZpa - Propionic acetogenic COD fraction [gCOD/g of total COD]	1.00E-04	1.000E-04
FZam - Acetoclastic methanogenic COD fraction [gCOD/g of total COD]	1.00E-04	1.000E-04
FZhm - Hydrogenotrophic methanogenic COD fraction [gCOD/g of total CC	1.00E-04	1.000E-04
FZso - Sulfur oxidizing COD fraction [gCOD/g of total COD]	1.00E-04	1.000E-04
FZsrpa - Sulfur reducing propionic acetogenic COD fraction [gCOD/g of tota	1.00E-04	1.000E-04
FZsra - Sulfur reducing acetotrophic COD fraction [gCOD/g of total COD]	1.00E-04	1.000E-04
FZsrh - Sulfur reducing hydrogenotrophic COD fraction [gCOD/g of total C	1.00E-04	1.000E-04
FZe - Endogenous products COD fraction [gCOD/g of total COD]	0.0000	0.0000

Appendix E.1 - Average Monthly Wastewater Characteristics for Input into Short Term Model

Short Term Monthly Average Wastewater Characteristics

COD Influent Data

Name	Value
Flow	125000.00
COD - Total mgCOD/L	458.00
N - Total Kjeldahl Nitrogen mgN/L	51.00
P - Total P mgP/L	6.90
S - Total S mgS/L	10.00
N - Nitrate mgN/L	0.00
pH	7.30
Alkalinity mmol/L	6.00
Influent inorganic suspended solids mgISS/	48.00
Metal soluble - Calcium mg/L	80.00
Metal soluble - Magnesium mg/L	15.00
Gas - Dissolved oxygen mg/L	0.00

Paste values to:

Project > Para. > Stoichi. > Common	Value
Particulate Substrate COD:VSS Ratio	2.00
Particulate Inert COD:VSS Ratio	1.60
Cellulose COD:VSS ratio [mgCOD/mgVSS]	1.40

Paste values to:

Project > Para. > Other	Value
k1 for CODc - Xsc	0.22
k2 for CODp - Xsp	0.36

Short Term Monthly Average Wastewater Characteristics

COD Influent Fractions

Name	Raw Defaults	Value
Fbs - Readily biodegradable (including Acetate) [gCOD/g of total COD]	0.1600	**0.2605**
Fac - Acetate [gCOD/g of readily biodegradable COD]	0.1500	**0.1651**
Fxsp - Non-colloidal slowly biodegradable [gCOD/g of slowly degradable C	0.7500	**1.0000**
Fus - Unbiodegradable soluble [gCOD/g of total COD]	0.0500	**0.0299**
Fup - Unbiodegradable particulate [gCOD/g of total COD]	0.1300	**0.0800**
Fcel - Cellulose fraction of unbiodegradable particulate [gCOD/gCOD]	0.5000	0.5000
Fna - Ammonia [gNH3-N/gTKN]	0.6600	**1.0000**
Fnox - Particulate organic nitrogen [gN/g Organic N]	0.5000	0.5000
Fnus - Soluble unbiodegradable TKN [gN/gTKN]	0.0200	0.0200
FupN - N:COD ratio for unbiodegradable part. COD [gN/gCOD]	0.0700	0.0700
Fpo4 - Phosphate [gPO4-P/gTP]	0.5000	**0.7681**
FupP - P:COD ratio for unbiodegradable part. COD [gP/gCOD]	0.0220	0.0220
Fsr - Reduced sulfur [H2S] [gS/gS]	0.1500	0.1500
FZbh - Ordinary heterotrophic COD fraction [gCOD/g of total COD]	0.0200	0.0200
FZbm - Methylotrophic COD fraction [gCOD/g of total COD]	1.00E-04	1.000E-04
FZao - Ammonia oxidizing COD fraction [gCOD/g of total COD]	1.00E-04	1.000E-04
FZno - Nitrite oxidizing COD fraction [gCOD/g of total COD]	1.00E-04	1.000E-04
FZaao - Anaerobic ammonia oxidizing COD fraction [gCOD/g of total COD	1.00E-04	1.000E-04
FZppa - Phosphorus accumulating COD fraction [gCOD/g of total COD]	1.00E-04	1.000E-04
FZpa - Propionic acetogenic COD fraction [gCOD/g of total COD]	1.00E-04	1.000E-04
FZam - Acetoclastic methanogenic COD fraction [gCOD/g of total COD]	1.00E-04	1.000E-04
FZhm - Hydrogenotrophic methanogenic COD fraction [gCOD/g of total CC	1.00E-04	1.000E-04
FZso - Sulfur oxidizing COD fraction [gCOD/g of total COD]	1.00E-04	1.000E-04
FZsrpa - Sulfur reducing propionic acetogenic COD fraction [gCOD/g of tota	1.00E-04	1.000E-04
FZsra - Sulfur reducing acetotrophic COD fraction [gCOD/g of total COD]	1.00E-04	1.000E-04
FZsrh - Sulfur reducing hydrogenotrophic COD fraction [gCOD/g of total C	1.00E-04	1.000E-04
FZe - Endogenous products COD fraction [gCOD/g of total COD]	0.0000	0.0000

Appendix E.1 - Maximum Monthly Wastewater Characteristics for Input into Short Term Model

Short Term Maximum Monthly Wastewater Characteristics

COD Influent Data

Name	Value
Flow	125000.00
COD - Total mgCOD/L	715.00
N - Total Kjeldahl Nitrogen mgN/L	66.00
P - Total P mgP/L	9.10
S - Total S mgS/L	10.00
N - Nitrate mgN/L	0.00
pH	7.30
Alkalinity mmol/L	6.00
Influent inorganic suspended solids mgISS/	48.00
Metal soluble - Calcium mg/L	80.00
Metal soluble - Magnesium mg/L	15.00
Gas - Dissolved oxygen mg/L	0.00

Paste values to:

Project > Para. > Stoichi. > Common	Value
Particulate Substrate COD:VSS Ratio	1.30
Particulate Inert COD:VSS Ratio	1.40
Cellulose COD:VSS ratio [mgCOD/mgVSS]	1.18

Paste values to:

Project > Para. > Other	Value
k1 for CODc - Xsc	0.22
k2 for CODp - Xsp	0.62

Short Term Maximum Monthly Wastewater Characteristics

COD Influent Fractions

Name	Raw Defaults	Value
Fbs - Readily biodegradable (including Acetate) [gCOD/g of total COD]	0.1600	**0.2804**
Fac - Acetate [gCOD/g of readily biodegradable COD]	0.1500	**0.1945**
Fxsp - Non-colloidal slowly biodegradable [gCOD/g of slowly degradable C	0.7500	**0.7446**
Fus - Unbiodegradable soluble [gCOD/g of total COD]	0.0500	**0.0327**
Fup - Unbiodegradable particulate [gCOD/g of total COD]	0.1300	**0.0800**
Fcel - Cellulose fraction of unbiodegradable particulate [gCOD/gCOD]	0.5000	0.5000
Fna - Ammonia [gNH3-N/gTKN]	0.6600	**0.7661**
Fnox - Particulate organic nitrogen [gN/g Organic N]	0.5000	0.5000
Fnus - Soluble unbiodegradable TKN [gN/gTKN]	0.0200	0.0200
FupN - N:COD ratio for unbiodegradable part. COD [gN/gCOD]	0.0700	0.0700
Fpo4 - Phosphate [gPO4-P/gTP]	0.5000	**0.5824**
FupP - P:COD ratio for unbiodegradable part. COD [gP/gCOD]	0.0220	0.0220
Fsr - Reduced sulfur [H2S] [gS/gS]	0.1500	0.1500
FZbh - Ordinary heterotrophic COD fraction [gCOD/g of total COD]	0.0200	0.0200
FZbm - Methylotrophic COD fraction [gCOD/g of total COD]	1.00E-04	1.000E-04
FZao - Ammonia oxidizing COD fraction [gCOD/g of total COD]	1.00E-04	1.000E-04
FZno - Nitrite oxidizing COD fraction [gCOD/g of total COD]	1.00E-04	1.000E-04
FZaao - Anaerobic ammonia oxidizing COD fraction [gCOD/g of total COD	1.00E-04	1.000E-04
FZppa - Phosphorus accumulating COD fraction [gCOD/g of total COD]	1.00E-04	1.000E-04
FZpa - Propionic acetogenic COD fraction [gCOD/g of total COD]	1.00E-04	1.000E-04
FZam - Acetoclastic methanogenic COD fraction [gCOD/g of total COD]	1.00E-04	1.000E-04
FZhm - Hydrogenotrophic methanogenic COD fraction [gCOD/g of total CC	1.00E-04	1.000E-04
FZso - Sulfur oxidizing COD fraction [gCOD/g of total COD]	1.00E-04	1.000E-04
FZsrpa - Sulfur reducing propionic acetogenic COD fraction [gCOD/g of tota	1.00E-04	1.000E-04
FZsra - Sulfur reducing acetotrophic COD fraction [gCOD/g of total COD]	1.00E-04	1.000E-04
FZsrh - Sulfur reducing hydrogenotrophic COD fraction [gCOD/g of total C	1.00E-04	1.000E-04
FZe - Endogenous products COD fraction [gCOD/g of total COD]	0.0000	0.0000

Appendix E.1 - Maximum Monthly Wastewater Characteristics for Input into Design Year Model

Design Year Maximum Monthly Wastewater Characteristics

COD Influent Data

Name	Value
Flow	125000.00
COD - Total mgCOD/L	772.00
N - Total Kjeldahl Nitrogen mgN/L	64.00
P - Total P mgP/L	9.00
S - Total S mgS/L	10.00
N - Nitrate mgN/L	0.00
pH	7.30
Alkalinity mmol/L	6.00
Influent inorganic suspended solids mgISS/	30.00
Metal soluble - Calcium mg/L	80.00
Metal soluble - Magnesium mg/L	15.00
Gas - Dissolved oxygen mg/L	0.00

Paste values to:

Project > Para. > Stoichi. > Common	Value
Particulate Substrate COD:VSS Ratio	1.63
Particulate Inert COD:VSS Ratio	1.60
Cellulose COD:VSS ratio [mgCOD/mgVSS]	1.40

Paste values to:

Project > Para. > Other	Value
k1 for CODc - Xsc	0.22
k2 for CODp - Xsp	0.62

Design Year Maximum Monthly Wastewater Characteristics

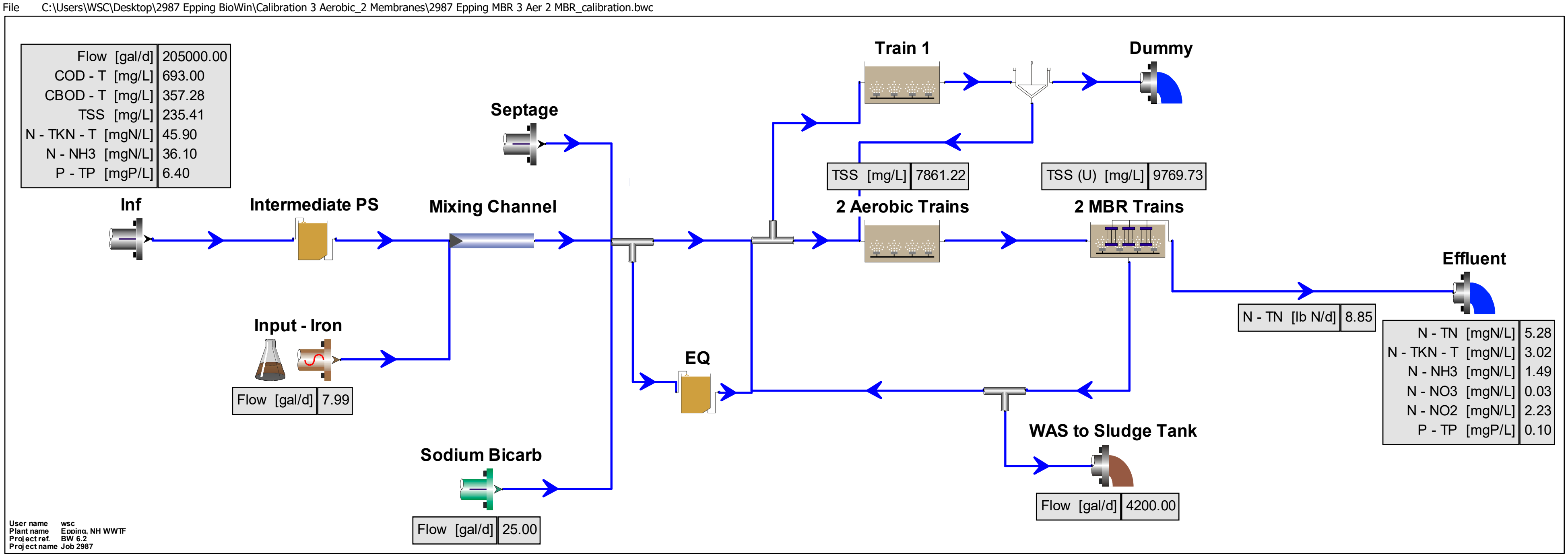
COD Influent Fractions

Name	Raw Defaults	Value
Fbs - Readily biodegradable (including Acetate) [gCOD/g of total COD]	0.1600	**0.2597**
Fac - Acetate [gCOD/g of readily biodegradable COD]	0.1500	**0.1945**
Fxsp - Non-colloidal slowly biodegradable [gCOD/g of slowly degradable C	0.7500	**0.7520**
Fus - Unbiodegradable soluble [gCOD/g of total COD]	0.0500	**0.0303**
Fup - Unbiodegradable particulate [gCOD/g of total COD]	0.1300	0.1300
Fcel - Cellulose fraction of unbiodegradable particulate [gCOD/gCOD]	0.5000	0.5000
Fna - Ammonia [gNH3-N/gTKN]	0.6600	**0.7900**
Fnox - Particulate organic nitrogen [gN/g Organic N]	0.5000	0.5000
Fnus - Soluble unbiodegradable TKN [gN/gTKN]	0.0200	0.0200
FupN - N:COD ratio for unbiodegradable part. COD [gN/gCOD]	0.0700	0.0700
Fpo4 - Phosphate [gPO4-P/gTP]	0.5000	**0.5889**
FupP - P:COD ratio for unbiodegradable part. COD [gP/gCOD]	0.0220	0.0220
Fsr - Reduced sulfur [H2S] [gS/gS]	0.1500	0.1500
FZbh - Ordinary heterotrophic COD fraction [gCOD/g of total COD]	0.0200	0.0200
FZbm - Methylotrophic COD fraction [gCOD/g of total COD]	1.00E-04	1.000E-04
FZao - Ammonia oxidizing COD fraction [gCOD/g of total COD]	1.00E-04	1.000E-04
FZno - Nitrite oxidizing COD fraction [gCOD/g of total COD]	1.00E-04	1.000E-04
FZaao - Anaerobic ammonia oxidizing COD fraction [gCOD/g of total COD	1.00E-04	1.000E-04
FZppa - Phosphorus accumulating COD fraction [gCOD/g of total COD]	1.00E-04	1.000E-04
FZpa - Propionic acetogenic COD fraction [gCOD/g of total COD]	1.00E-04	1.000E-04
FZam - Acetoclastic methanogenic COD fraction [gCOD/g of total COD]	1.00E-04	1.000E-04
FZhm - Hydrogenotrophic methanogenic COD fraction [gCOD/g of total CC	1.00E-04	1.000E-04
FZso - Sulfur oxidizing COD fraction [gCOD/g of total COD]	1.00E-04	1.000E-04
FZsrpa - Sulfur reducing propionic acetogenic COD fraction [gCOD/g of tota	1.00E-04	1.000E-04
FZsra - Sulfur reducing acetotrophic COD fraction [gCOD/g of total COD]	1.00E-04	1.000E-04
FZsrh - Sulfur reducing hydrogenotrophic COD fraction [gCOD/g of total C	1.00E-04	1.000E-04
FZe - Endogenous products COD fraction [gCOD/g of total COD]	0.0000	0.0000

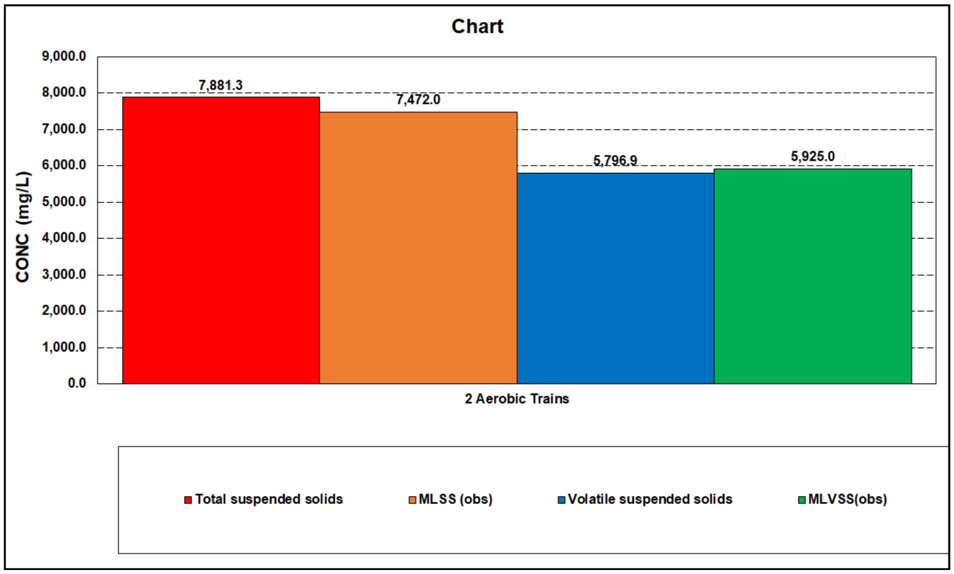
Appendix E.2 Existing WWTF BioWin Model Calibration and Validation.

Existing WWTF Setup for Calibration and Validation

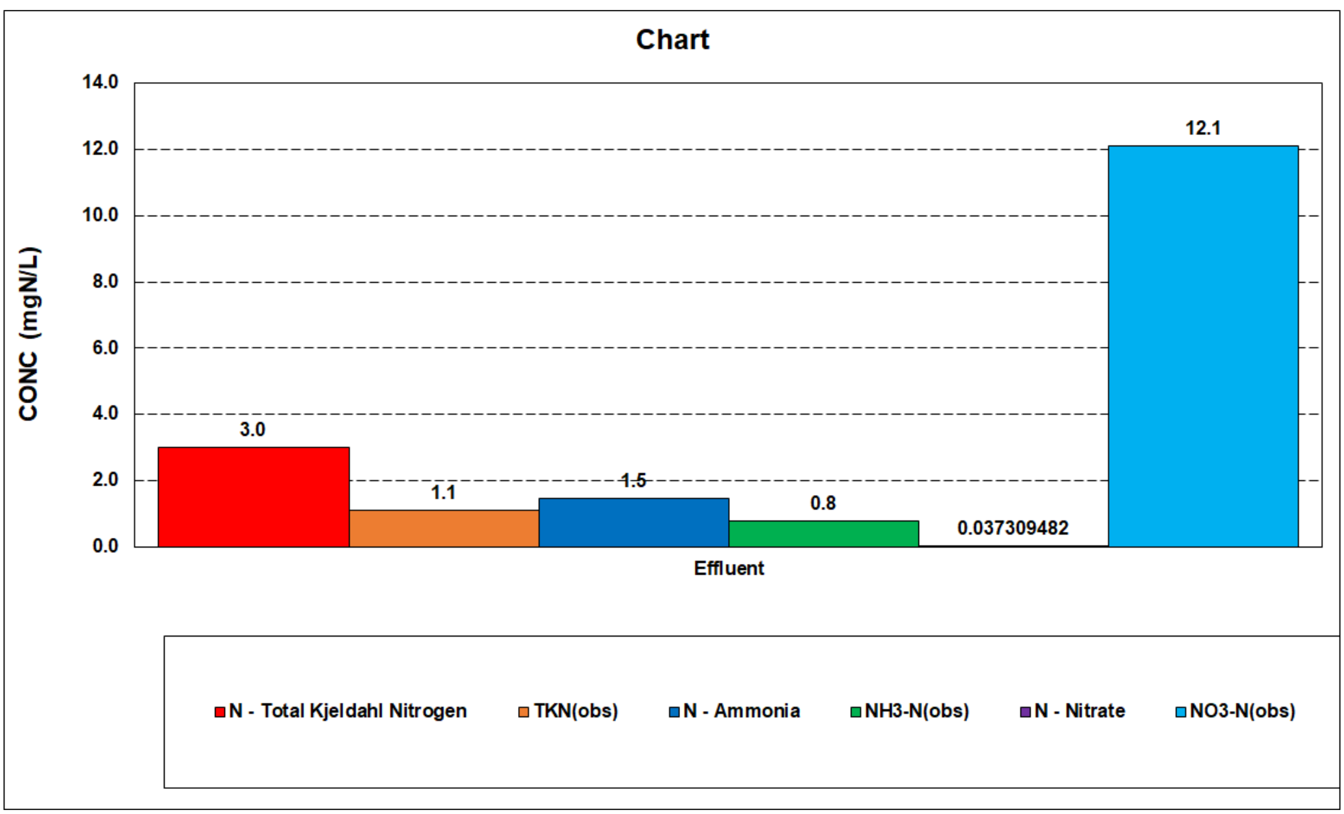
File C:\Users\WSC\Desktop\2987 Epping BioWin\Calibration 3 Aerobic_2 Membranes\2987 Epping MBR 3 Aer 2 MBR_calibration.bwc



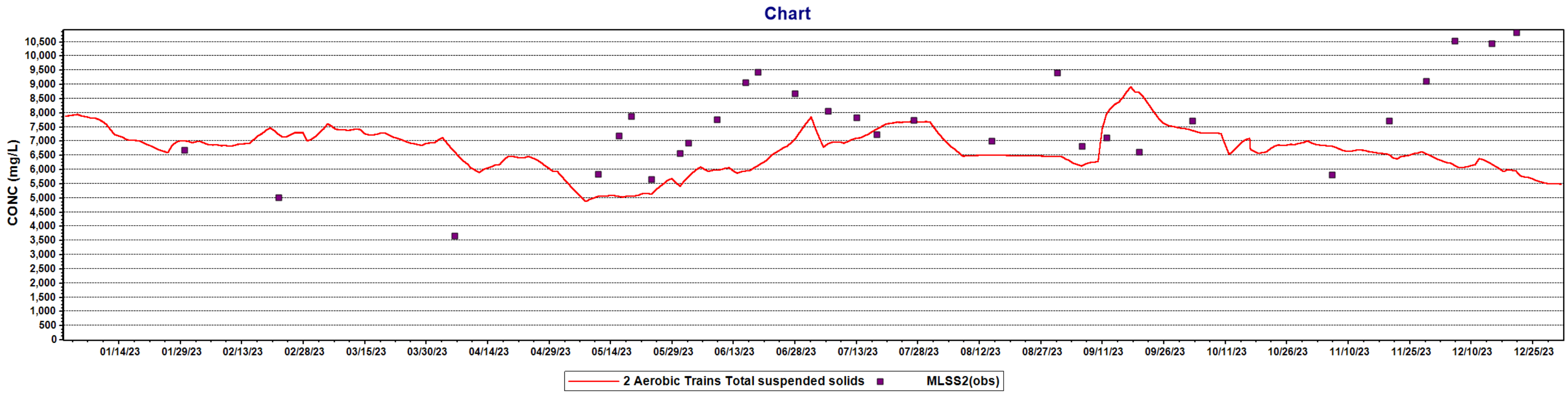
Mixed Liquor Calibration on average flow and load

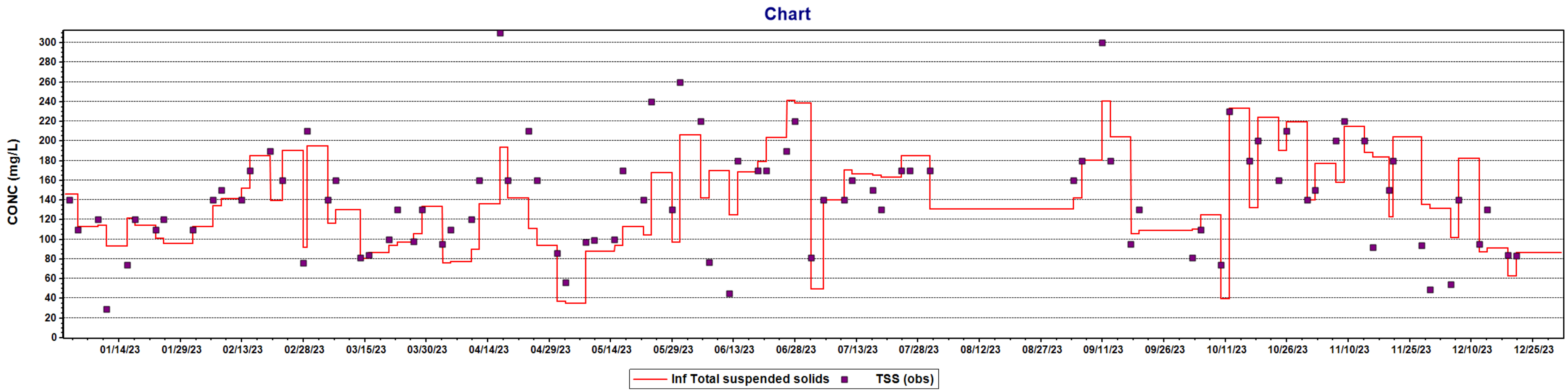


Effluent Nitrogen Calibration on average flow and load



Calibration of MLSS and Influent TSS for 2023



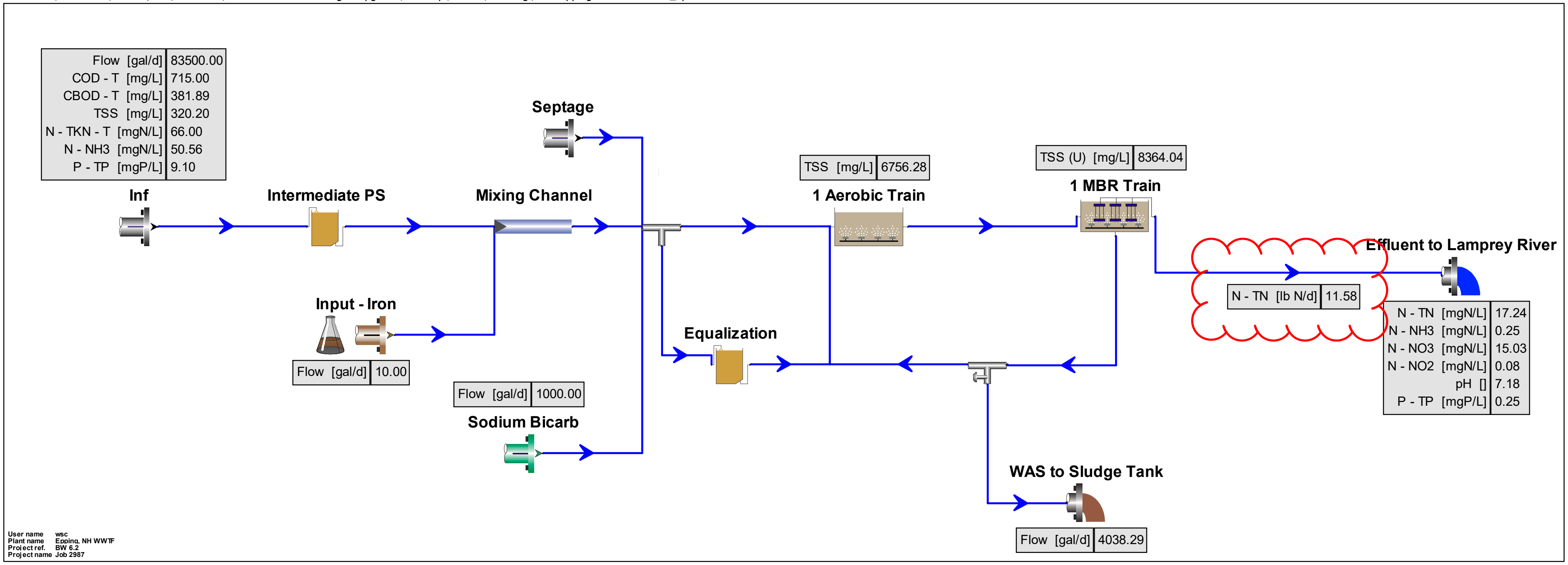


Appendix E.3 Short Term WWTF BioWin Model

Short Term Maximum Month Flow and Load Model

Short Term Maximum Month Model
Cyclic Aeration - 20 minutes on, 40 minutes off

File N:\PROJECTS\EPPING, NH\REALNUM\2987 WWTF Total Nitrogen Upgrade\08 Comp\BioWin\Modeling\2987 Epping MBR short term_update MMF.bwc



Model shows one train at 83,500 GPD and maximum month loadings run at 15 deg C.

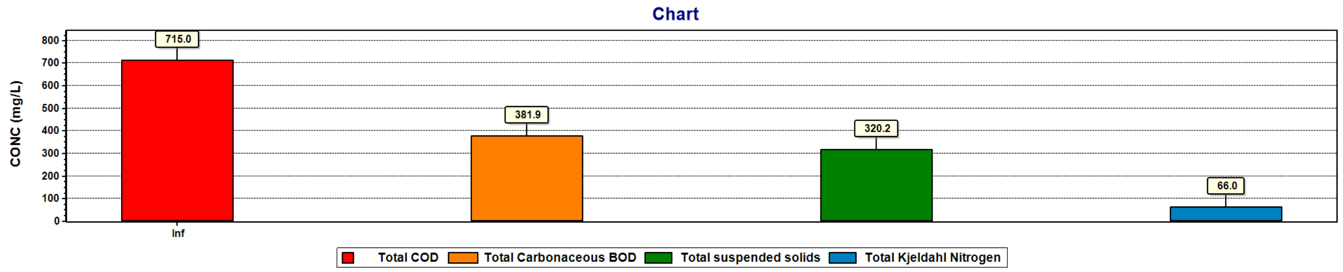
Four Trains can achieve the effluent TN requirements of 28 to 46 lb/d under a maximum month loading for a flow of 0.334 MGD.

Cyclic aeration is required with air on for 20 minutes and air off for 40 minutes achieves a TN of 46 lb/d.

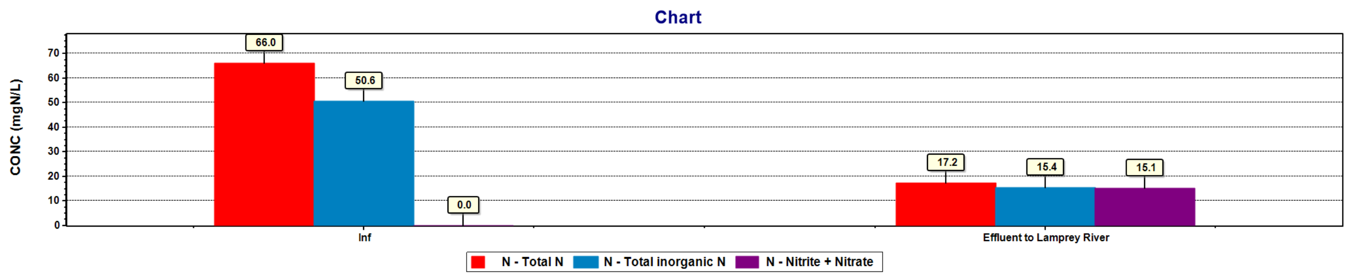
Cyclic aeration with air on for 15 minutes and off 45 minutes achieves a TN of (28 lb/d) with a slight build up of nitrites.

DO set point to achieve Simultaneous Nitrification and Denitrification (SNDN) is 1 mg/L.

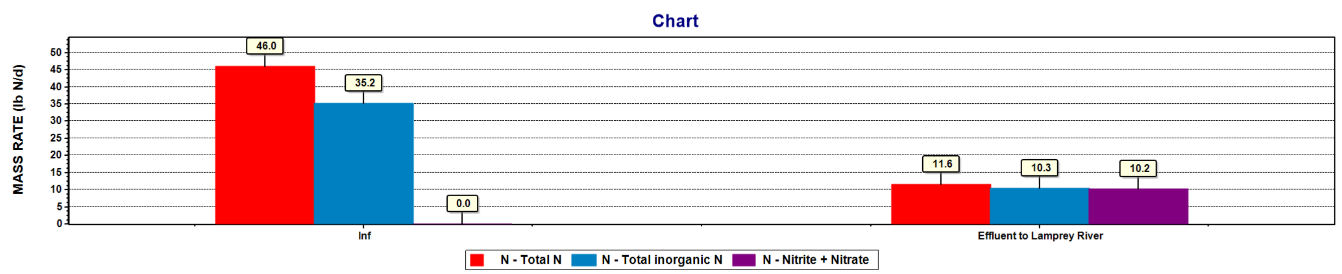
Short Term Max Month Influent Concentration Loadings



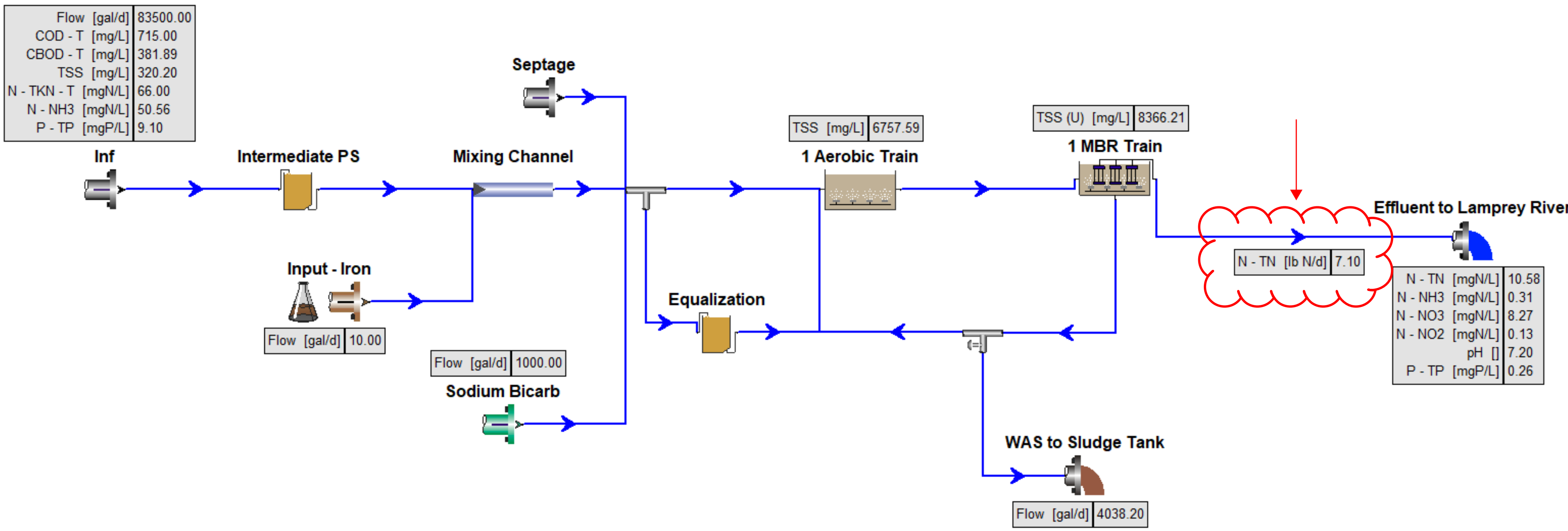
Short Term Max Month Effluent Nitrogen Concentrations at 15 deg C
Cyclic Aeration - 20 min on/40 min off



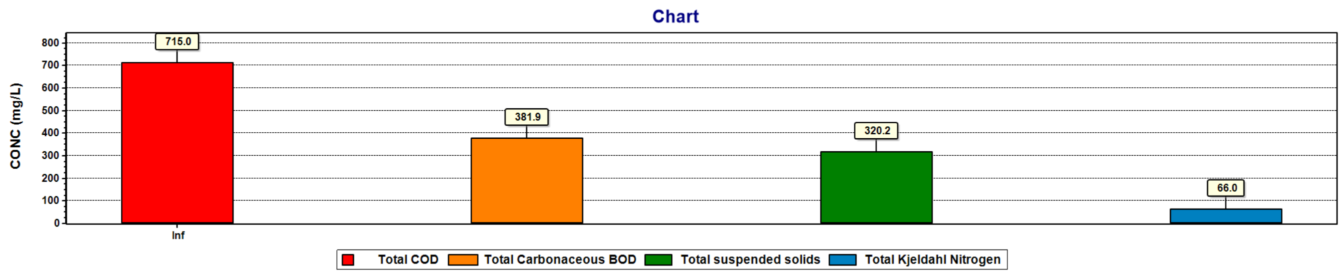
Short Term Max Month Effluent Nitrogen Mass at 15 deg C
Cyclic Aeration - 20 min on/40 min off



Short Term Maximum Month Model
Cyclic Aeration - 15 Minutes on, 45 minutes off

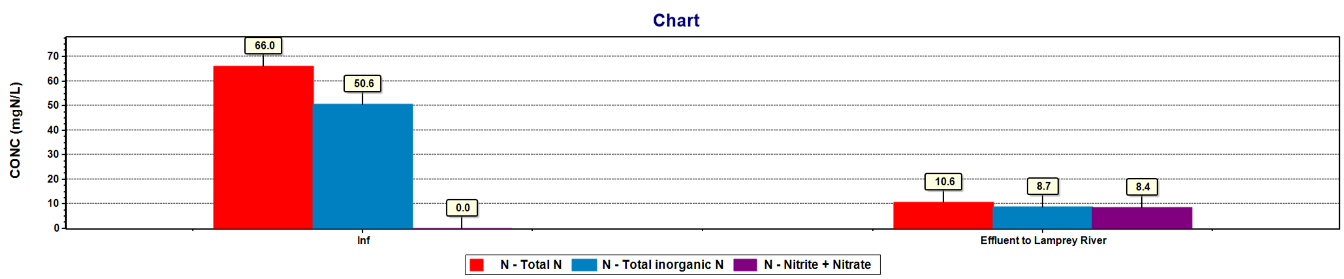


Short Term Max Month Influent Concentration Loadings



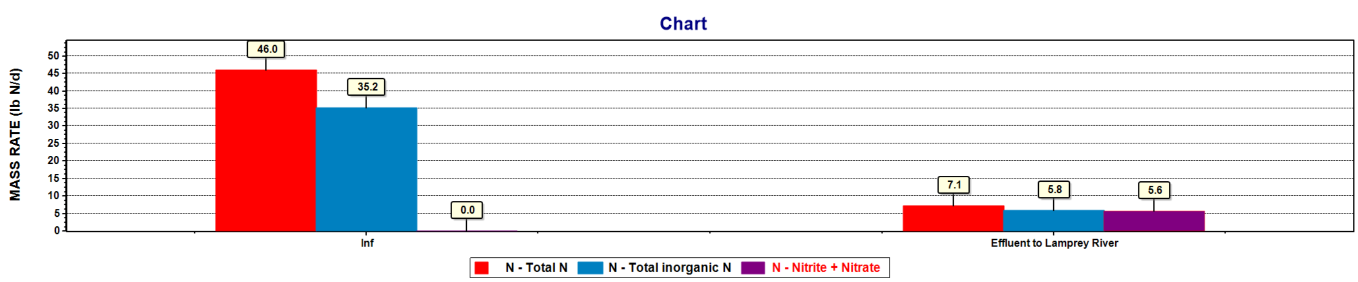
Short Term Max Month Effluent Nitrogen Concentrations at 15 deg C

Cyclic Aeration - 15 min on/45 min off



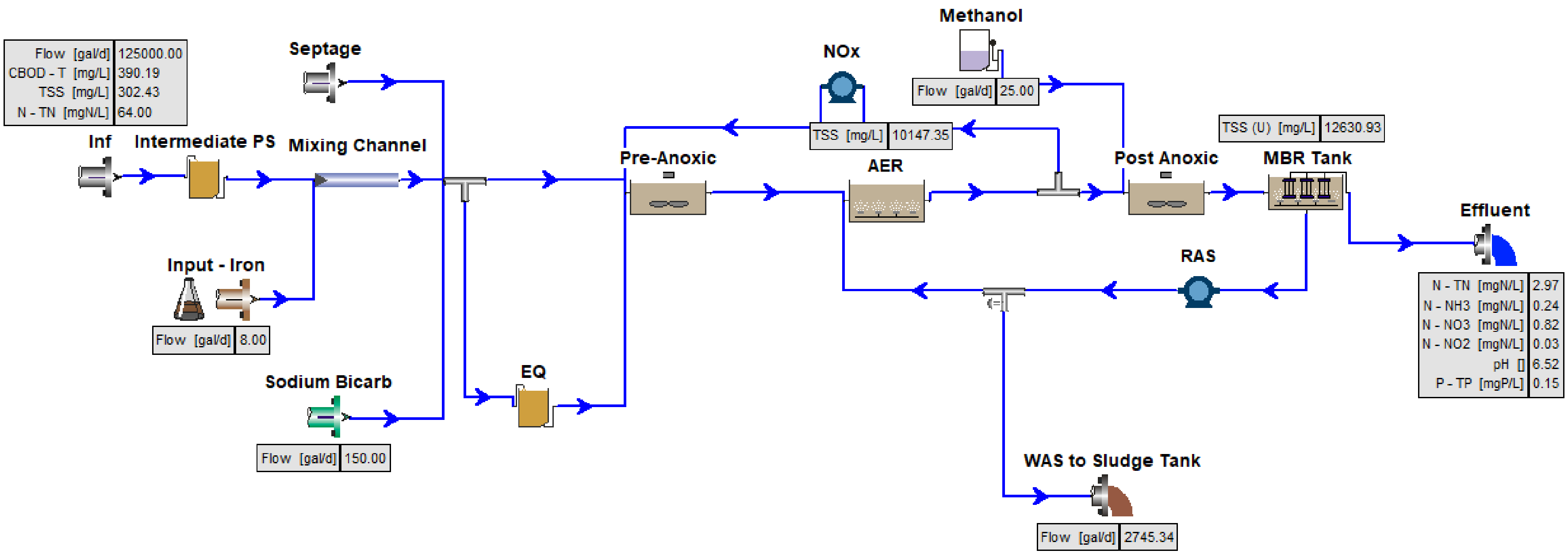
Short Term Max Month Effluent Nitrogen Mass at 15 deg C

Cyclic Aeration - 15 min on/45 min off

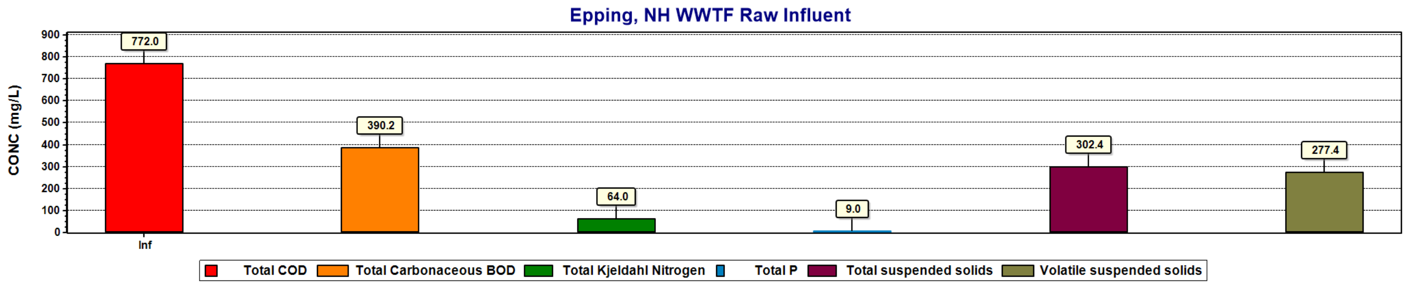


Appendix E.4 Design WWTF BioWin Model

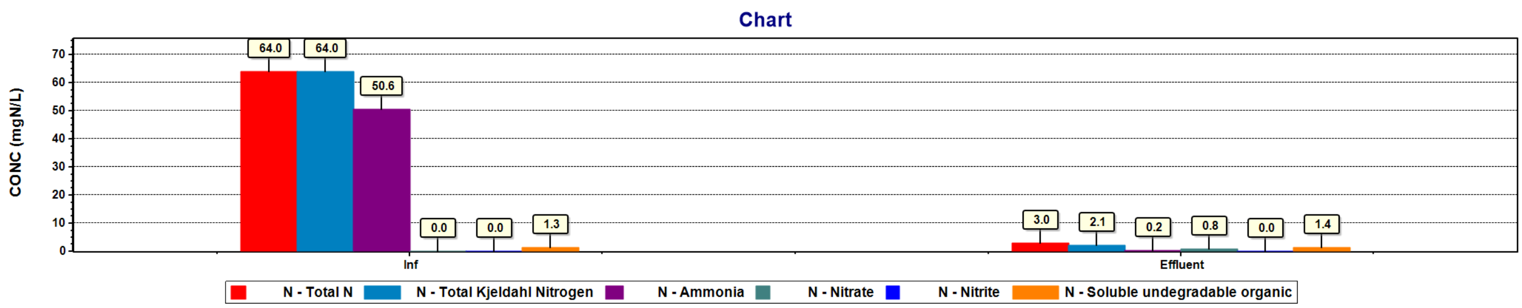
Design 4 Stage Bardenpho Maximum Month Loading at 8 deg C



Maximum Month Influent Load in Design Year



Maximum Month Influent and Effluent Nitrogen Concentrations at 8 deg C



Maximum Month Influent and Effluent Nitrogen Mass at 8 deg C

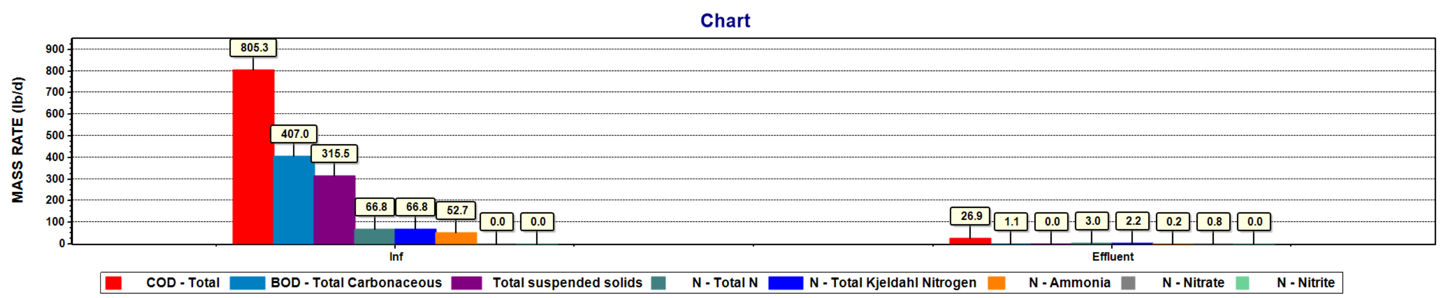


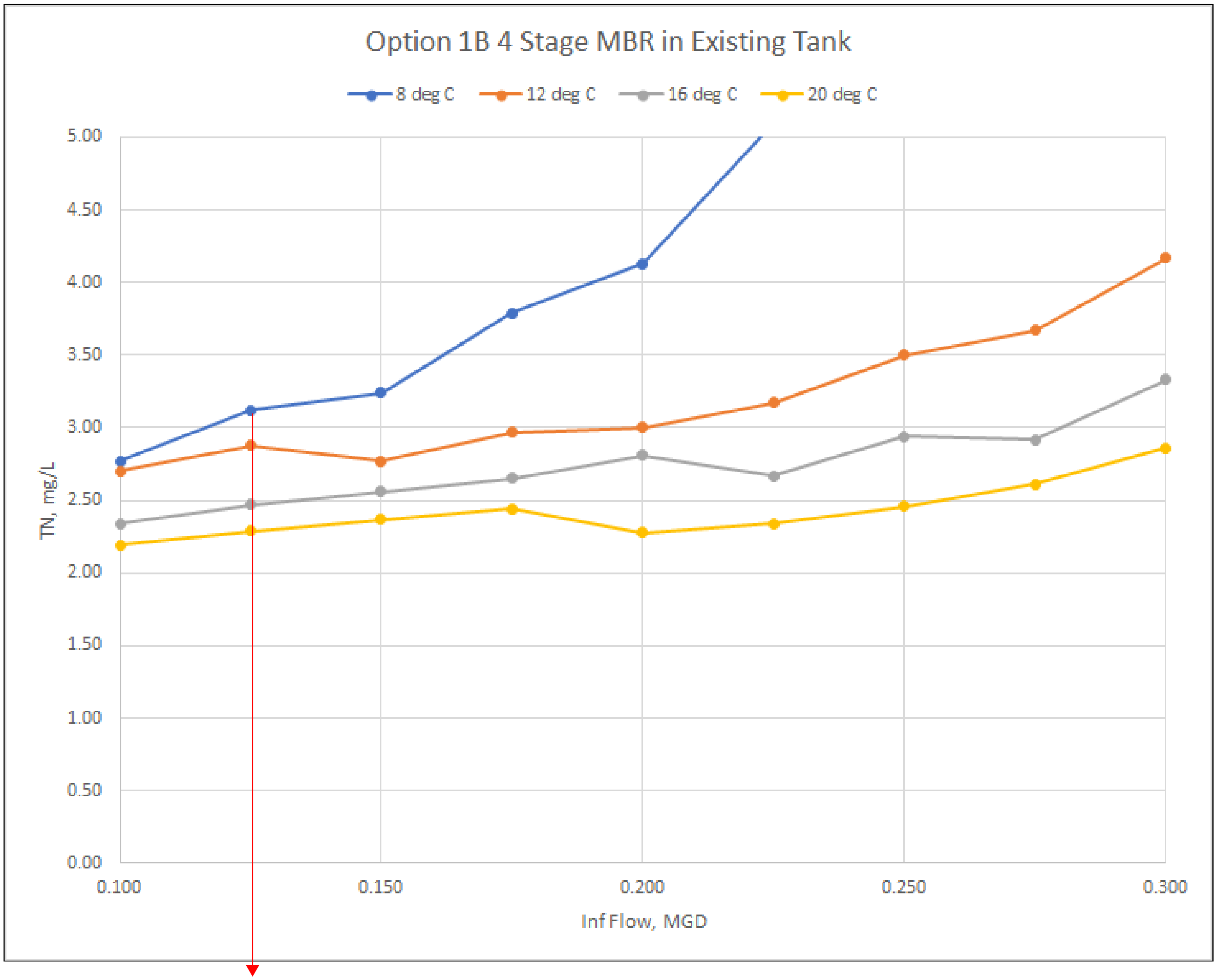
Table 3.1 Existing and Design Flows and Loads

PARAMETER	EXISTING VALUE	20-YR DESIGN VALUE	Design Concentration, mg/L*
Average Daily Flow	0.224 MGD	0.50 MGD	0.5
Max Month Flow	0.313 MGD	0.70 MGD	
Max Week Flow	0.373 MGD	0.835 MGD	
Max Day Flow	0.504 MGD	1.125 MGD	
Peak Hour Flow	0.694 MGD	1.55 MGD	
Average Biweekly CBOD5	450 lbs/d	1,005 lbs/d	
Max Month CBOD5	729 lbs/d	1,626 lbs/d	390
Average Biweekly TSS	284 lbs/d	634 lbs/d	
Max Month TSS	560 lbs/d	1,251 lbs/d	300
Average TKN	86 lbs/d	192 lbs/d	
Max Month TKN	120 lbs/d	267 lbs/d	64.0
Average TP	12.0 lbs/d	26.7 lbs/d	
Max Month TP	16.8 lbs/d	37.5 lbs/d	9.0

* Max Mon. lbs at Design ADF

Name	Value
Flow	125000
COD - Total mgCOD/L	772
N - Total Kjeldahl Nitrogen mgN/L	64
P - Total P mgP/L	9
S - Total S mgS/L	10
N - Nitrate mgN/L	0
pH	7.7
Alkalinity mmol/L	4.428
ISS Total mgISS/L	25
Metal soluble - Calcium mg/L	80
Metal soluble - Magnesium mg/L	15
Gas - Dissolved oxygen mg/L	0

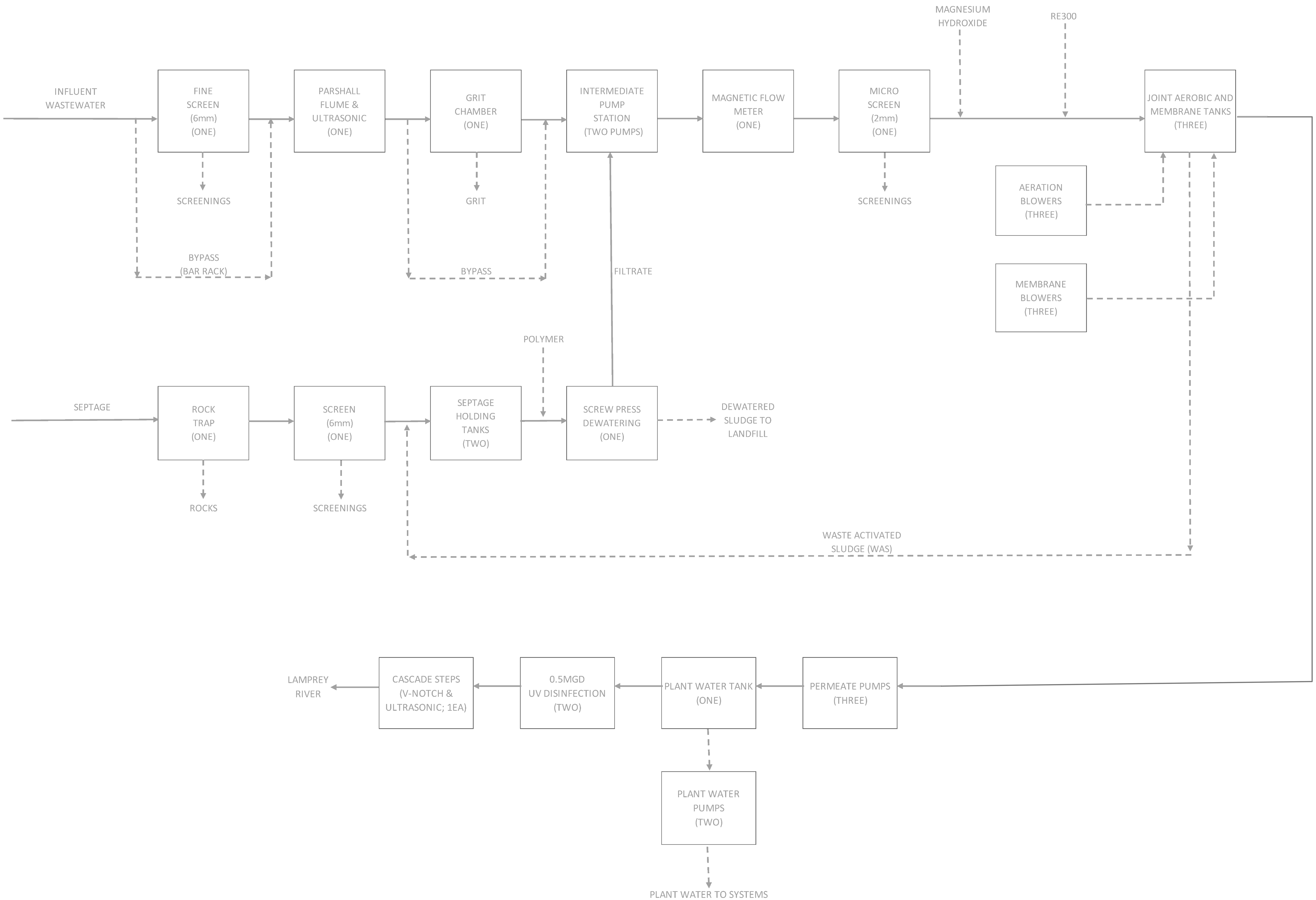
Effluent Nitrogen at Maximum Month Loading at 8 deg. C



Capacity at 8 deg C = 0.125 MGD per Train.
4 Trains required to process 0.5 MGD at maximum month mass loadings.

APPENDIX F

Conceptual Layout Figures



WWTF CURRENT BLOCK PROCESS FLOW DIAGRAM

NOT TO SCALE

ISSUE FOR APPROVAL Date By
CONSTRUCTION Date By
RECORD DRAWING Date By

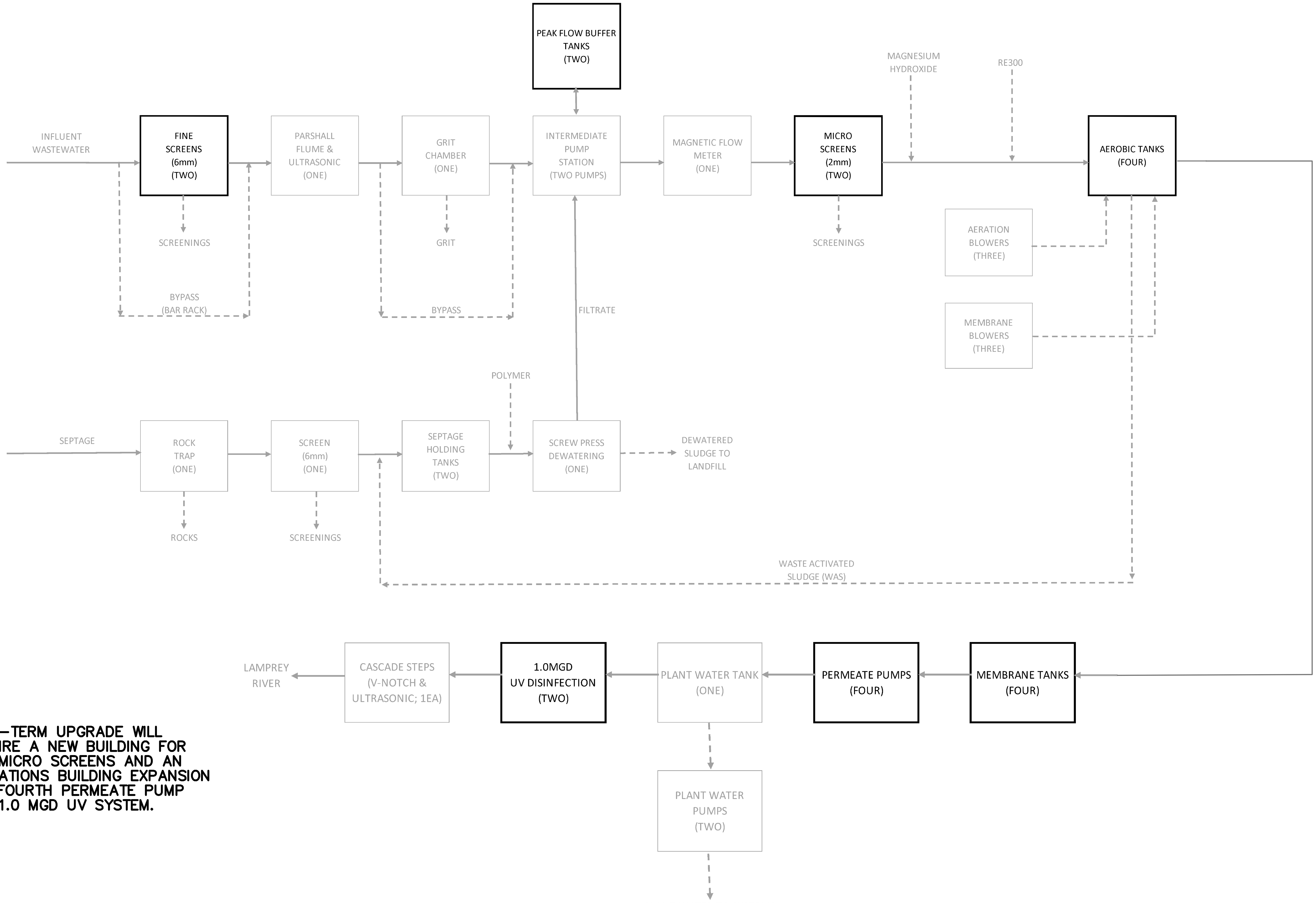
NO. | REVISIONS | APP'D

Drawn/Chk. PMB
Designed DJM
Checked DJM
Approved DJM
Date AUGUST 2024
Book No.
Project No. 2987
Dwg. ID 2987PFLOW
Scale AS SHOWN

UNDERWOOD engineers
99 North State Street, Concord, N.H. 03301
Tel. 603-230-9898 Fax. 603-230-9899

CURRENT PROCESS FLOW DIAGRAM
WWTF TOTAL NITROGEN UPGRADE
TOWN OF EPPING
EPPING, NEW HAMPSHIRE

DWG NO P1
SHEET 1 OF 3



NOTES:

1. NEAR–TERM UPGRADE WILL REQUIRE A NEW BUILDING FOR TWO MICRO SCREENS AND AN OPERATIONS BUILDING EXPANSION FOR FOURTH PERMEATE PUMP AND 1.0 MGD UV SYSTEM.

WWTF NEAR–TERM BLOCK PROCESS FLOW DIAGRAM

NOT TO SCALE

ISSUE FOR
APPROVAL Date By
CONSTRUCTION Date By
RECORD DRAWING Date By

NO.	REVISIONS	APP'D
△		
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△		
△		
△		

Drawn/Chk. PMB
Designed DJM
Checked DJM
Approved DJM
Date AUGUST 2024
Book No.
Project No. 2987
Dwg. ID 2987PFLOW
Scale AS SHOWN

UNDERWOOD engineers
99 North State Street, Concord, N.H. 03301
Tel. 603–230–9898 Fax. 603–230–9899

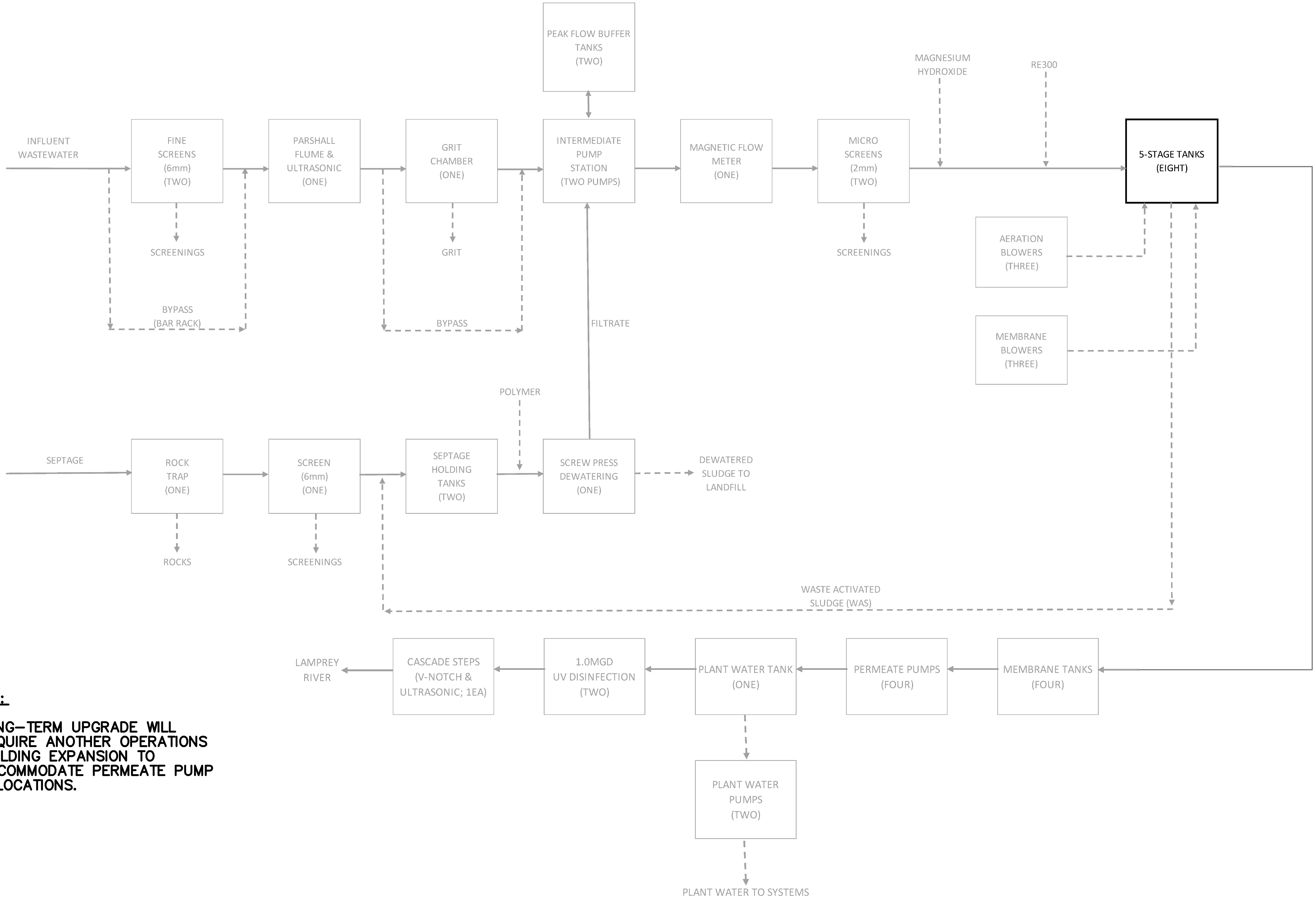
NEAR–TERM PROCESS FLOW DIAGRAM

WWTF TOTAL NITROGEN UPGRADE

TOWN OF EPPING
EPPING, NEW HAMPSHIRE

DWG NO P2

SHEET 2 OF 3



NOTES:

1. LONG-TERM UPGRADE WILL REQUIRE ANOTHER OPERATIONS BUILDING EXPANSION TO ACCOMMODATE PERMEATE PUMP RELOCATIONS.

WWTF LONG-TERM BLOCK PROCESS FLOW DIAGRAM

NOT TO SCALE

ISSUE FOR APPROVAL Date By | CONSTRUCTION Date By | RECORD DRAWING Date By

NO. | REVISIONS | APP'D

Drawn/Chk. PMB
Designed DJM
Checked DJM
Approved DJM
Date AUGUST 2024
Book No.
Project No. 2987
Dwg. ID 2987PFLOW
Scale AS SHOWN

UNDERWOOD engineers
99 North State Street, Concord, N.H. 03301
Tel. 603-230-9898 Fax. 603-230-9899

LONG-TERM PROCESS FLOW DIAGRAM

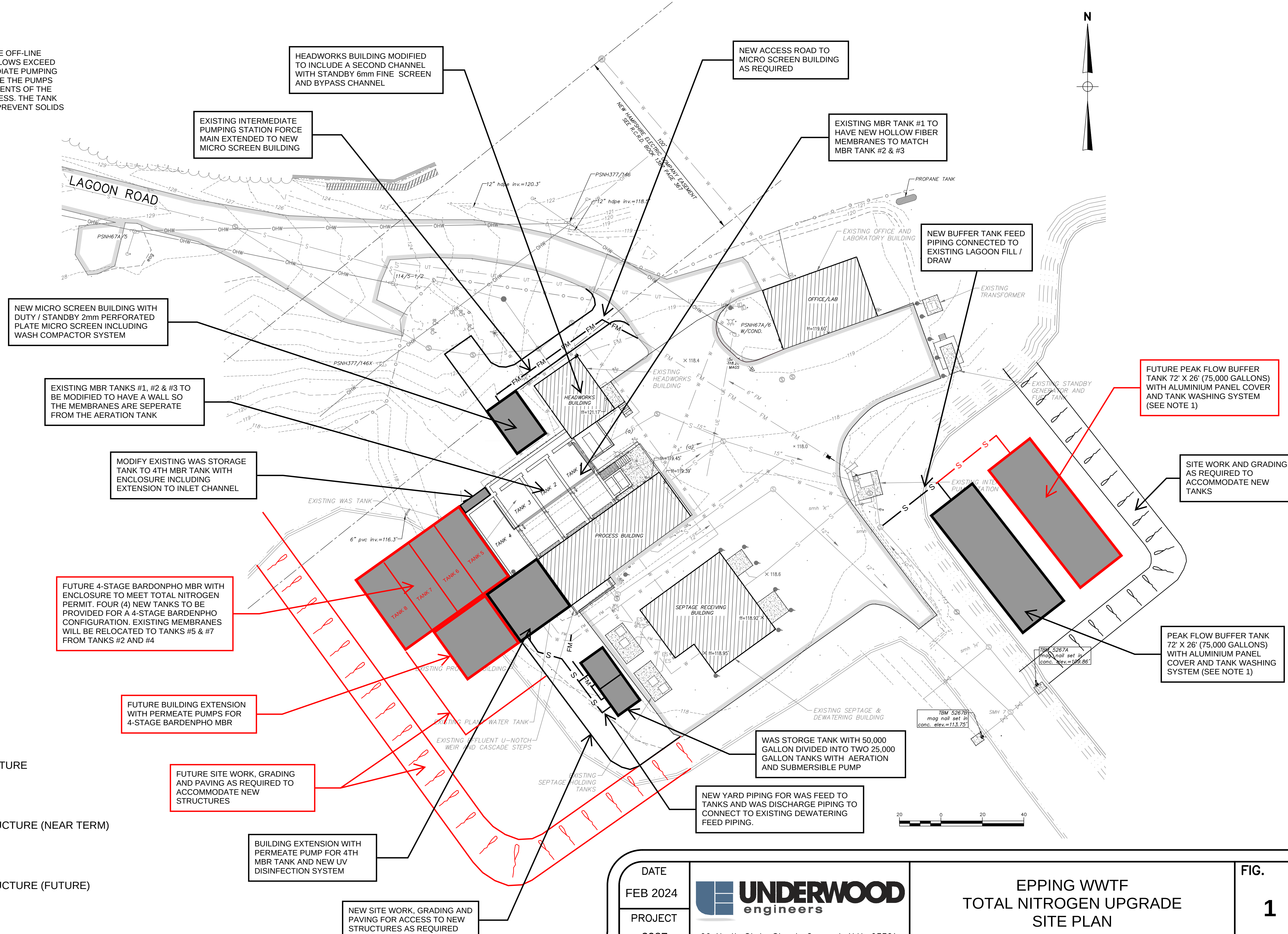
WWTF TOTAL NITROGEN UPGRADE

TOWN OF EPPING
EPPING, NEW HAMPSHIRE

DWG NO P3 | SHEET 3 OF 3

NOTES

1. PEAK FLOW BUFFER TANKS WILL BE OFF-LINE TANKS AND FILL BY GRAVITY ONCE FLOWS EXCEED THE PUMPED FLOW IN THE INTERMEDIATE PUMPING STATION. ONCE PEAK FLOWS SUBSIDE THE PUMPS WILL CONTINUE TO EMPTY THE CONTENTS OF THE TANK AND DISCHARGE TO THE PROCESS. THE TANK WILL HAVE A 5% BOTTOM SLOPE TO PREVENT SOLIDS DEPOSITION.



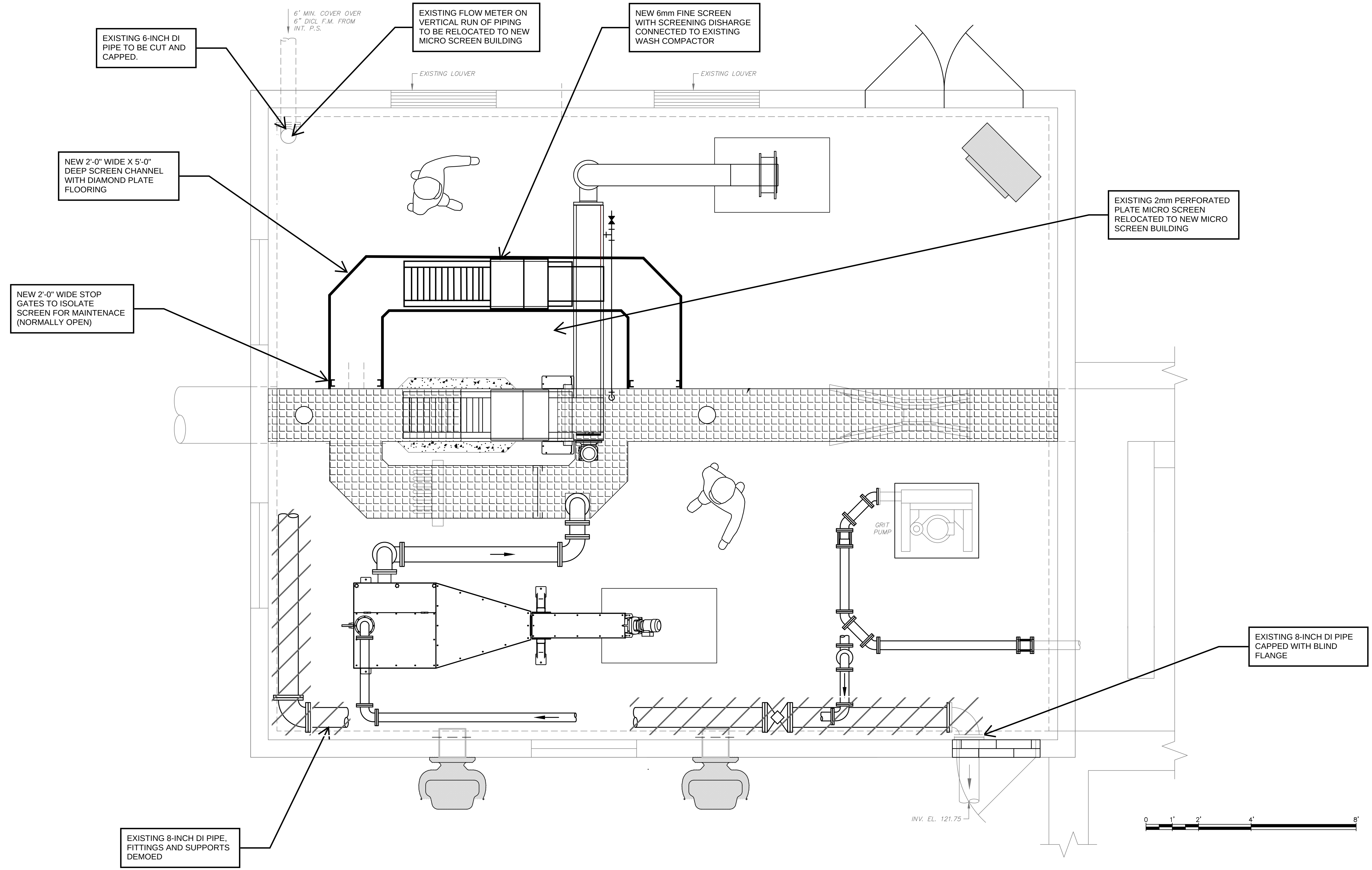
LEGEND

EXISTING STRUCTURE

PROPOSED STRUCTURE (NEAR TERM)

PROPOSED STRUCTURE (FUTURE)

DATE		EPPING WWTF TOTAL NITROGEN UPGRADE SITE PLAN	FIG.
FEB 2024	UNDERWOOD engineers		1
PROJECT	99 North State Street, Concord, N.H. 03301		
2987	Tel. 603-230-9898 Fax. 603-230-9899		



DATE		
FEB 2024	UNDERWOOD engineers	EPPING WWTF TOTAL NITROGEN UPGRADE HEADWORKS BUILDING PLAN
PROJECT 2987	99 North State Street, Concord, N.H. 03301 Tel. 603-230-9898 Fax. 603-230-9899	

FIG. 2

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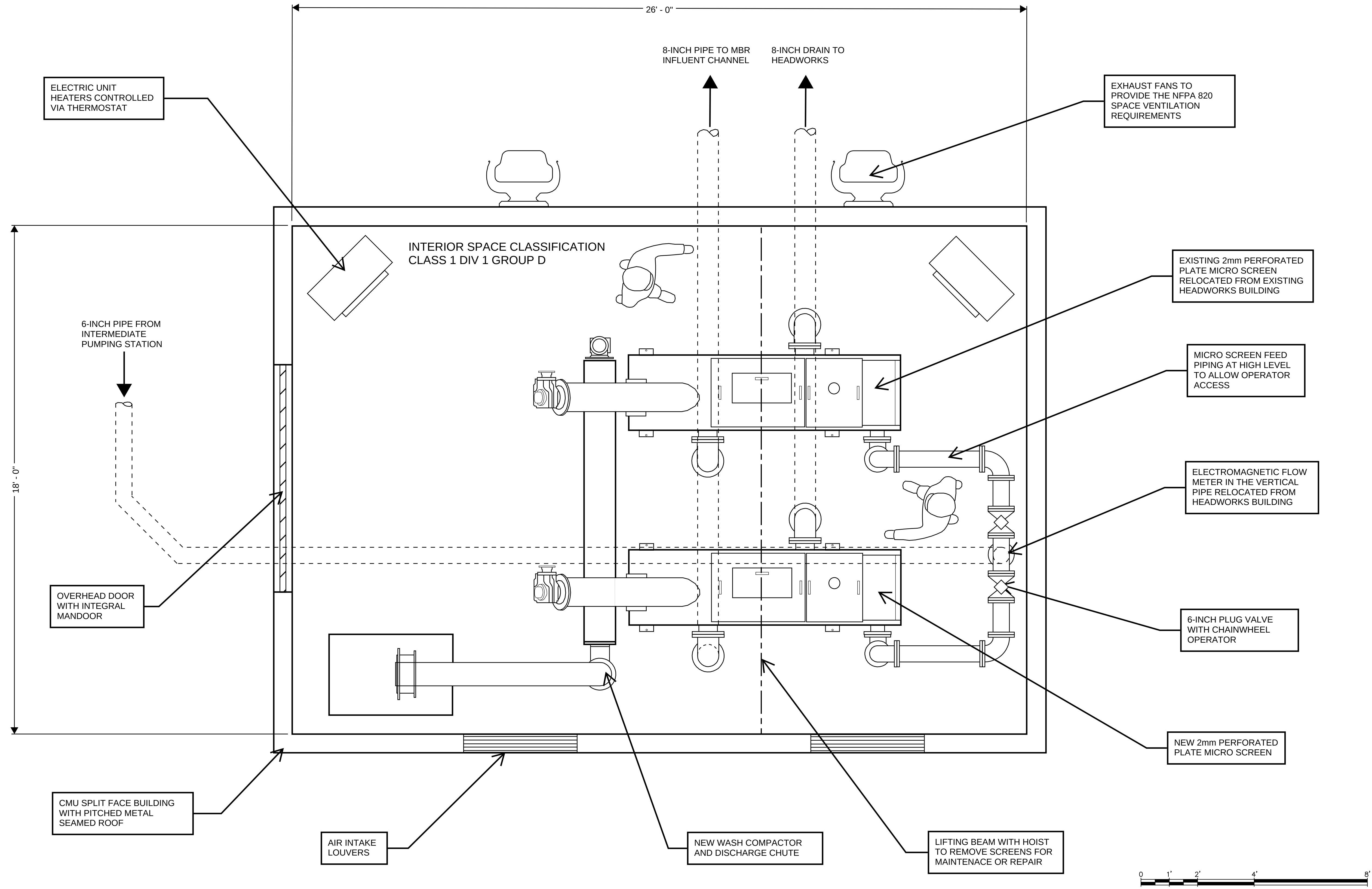
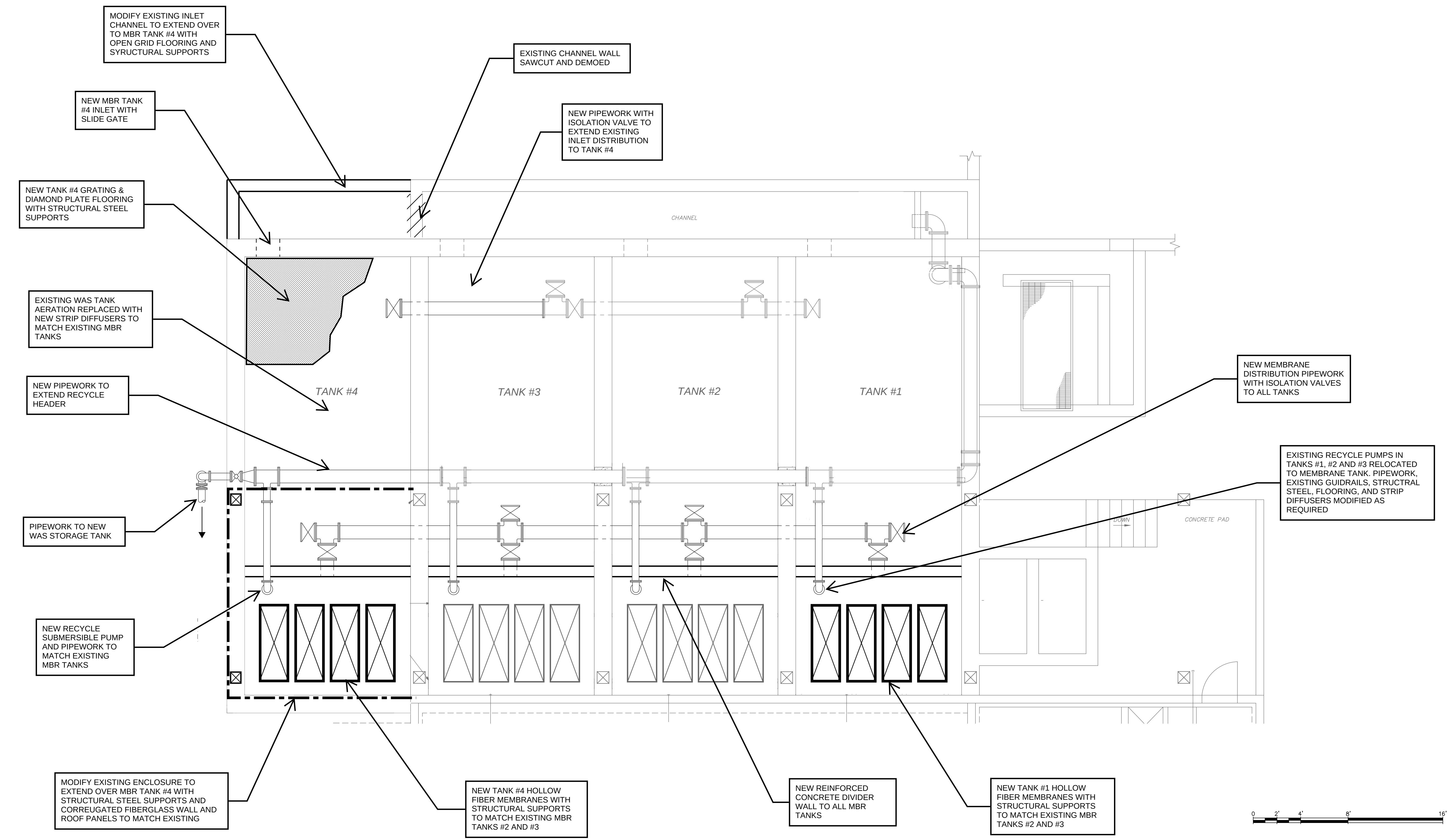


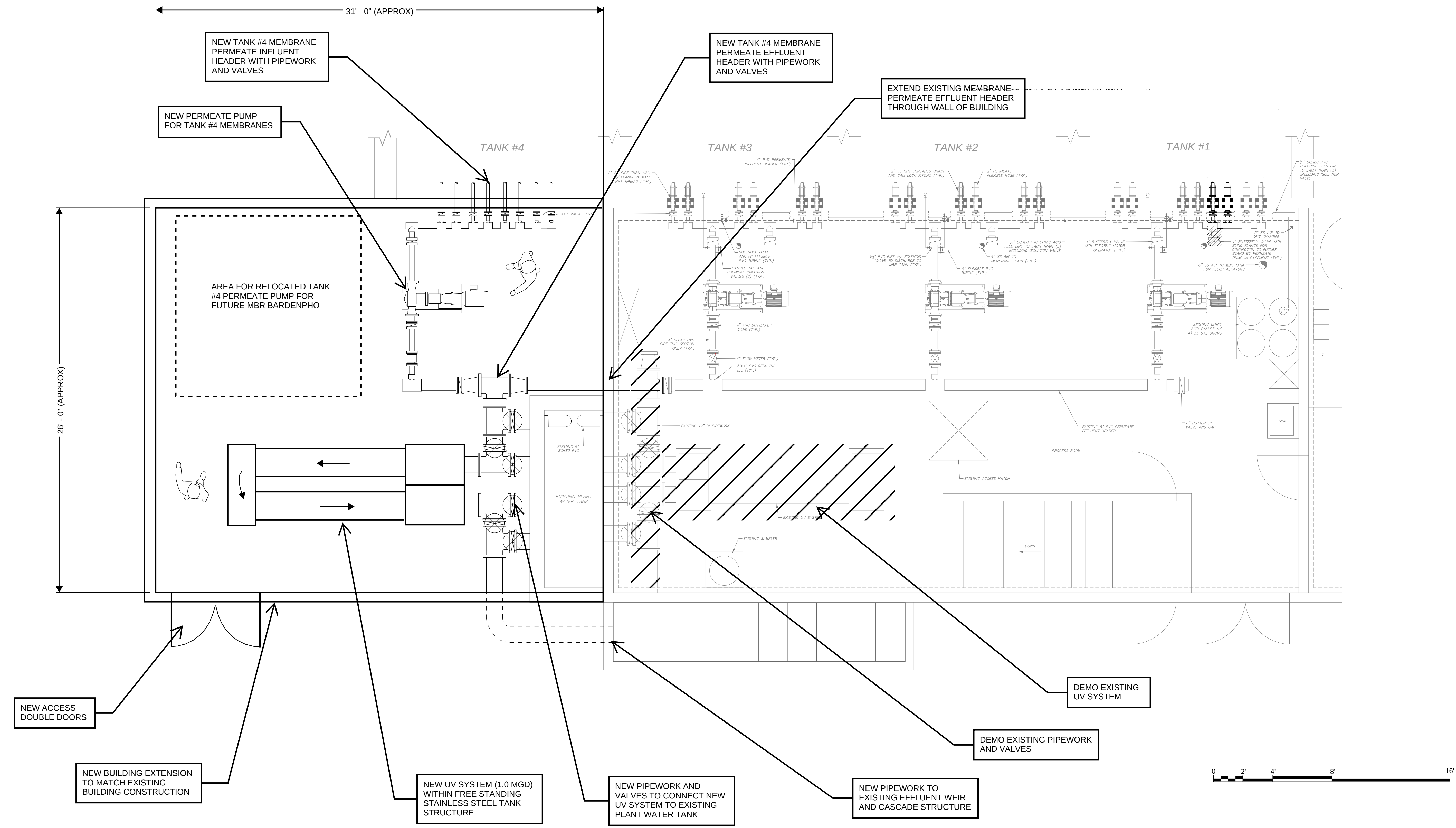
NOTES

1. MICRO SCREEN ELECTRICAL CONTROL PANEL TO BE LOCATED IN THE EXISTING ELECTRICAL ROOM OF THE SEPTAGE AND DEWATERING BUILDING.

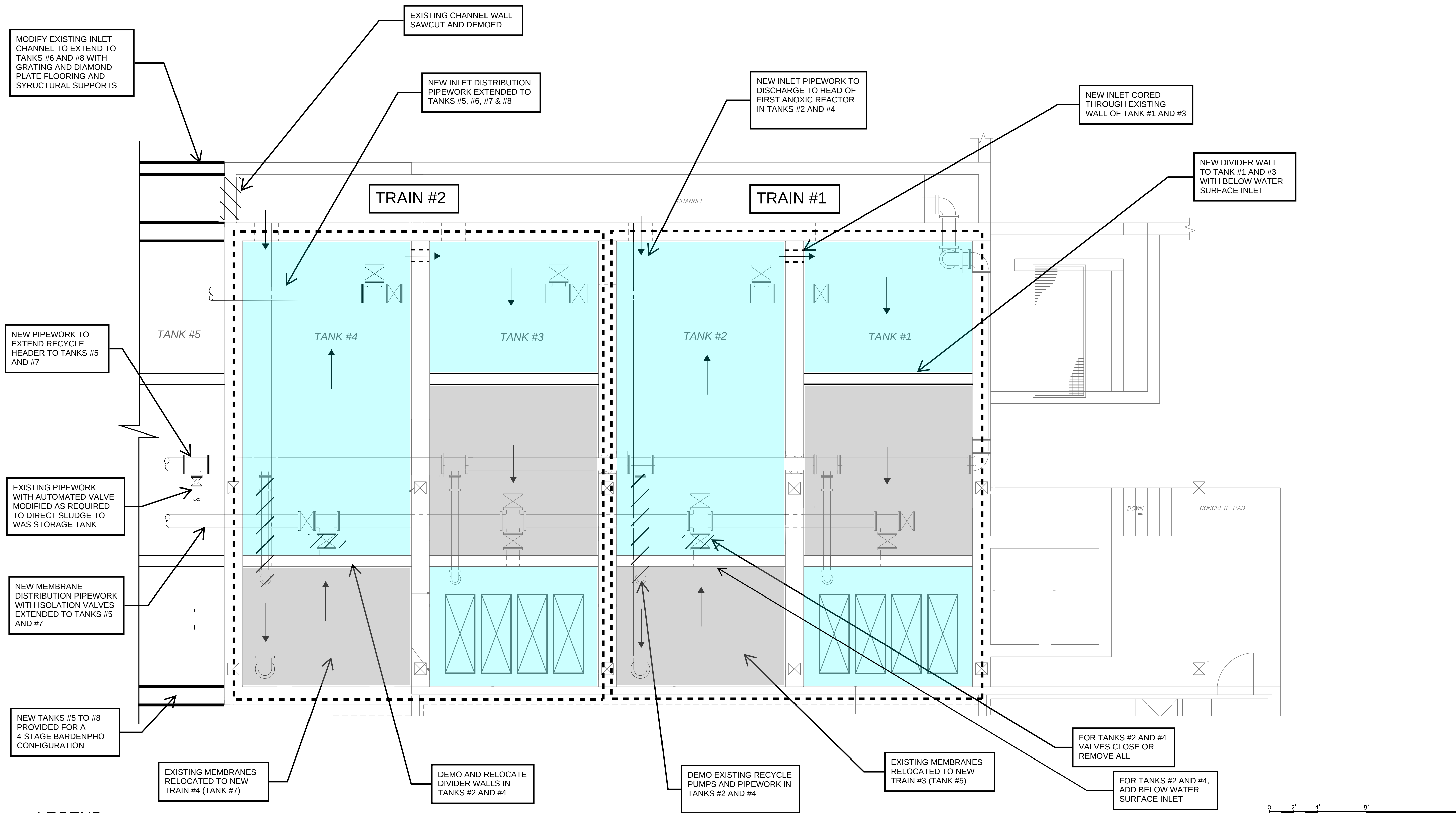
DATE			FIG.
FEB 2024	UNDERWOOD engineers	EPPING WWTF TOTAL NITROGEN UPGRADE NEW MICRO SCREEN BUILDING PLAN	3
PROJECT 2987	99 North State Street, Concord, N.H. 03301 Tel. 603-230-9898 Fax. 603-230-9899		



DATE	UNDERWOOD engineers	EPPING WWTF TOTAL NITROGEN UPGRADE MEMBRANE BIOREACTOR PLAN SHORT-TERM	FIG.
FEB 2024			4
PROJECT	99 North State Street, Concord, N.H. 03301 Tel. 603-230-9898 Fax. 603-230-9899		
2987			



DATE	UNDERWOOD engineers	EPPING WWTF TOTAL NITROGEN UPGRADE PROCESS BUILDING SHORT-TERM	FIG.
FEB 2024	99 North State Street, Concord, N.H. 03301 Tel. 603-230-9898 Fax. 603-230-9899		5
PROJECT			
2987			

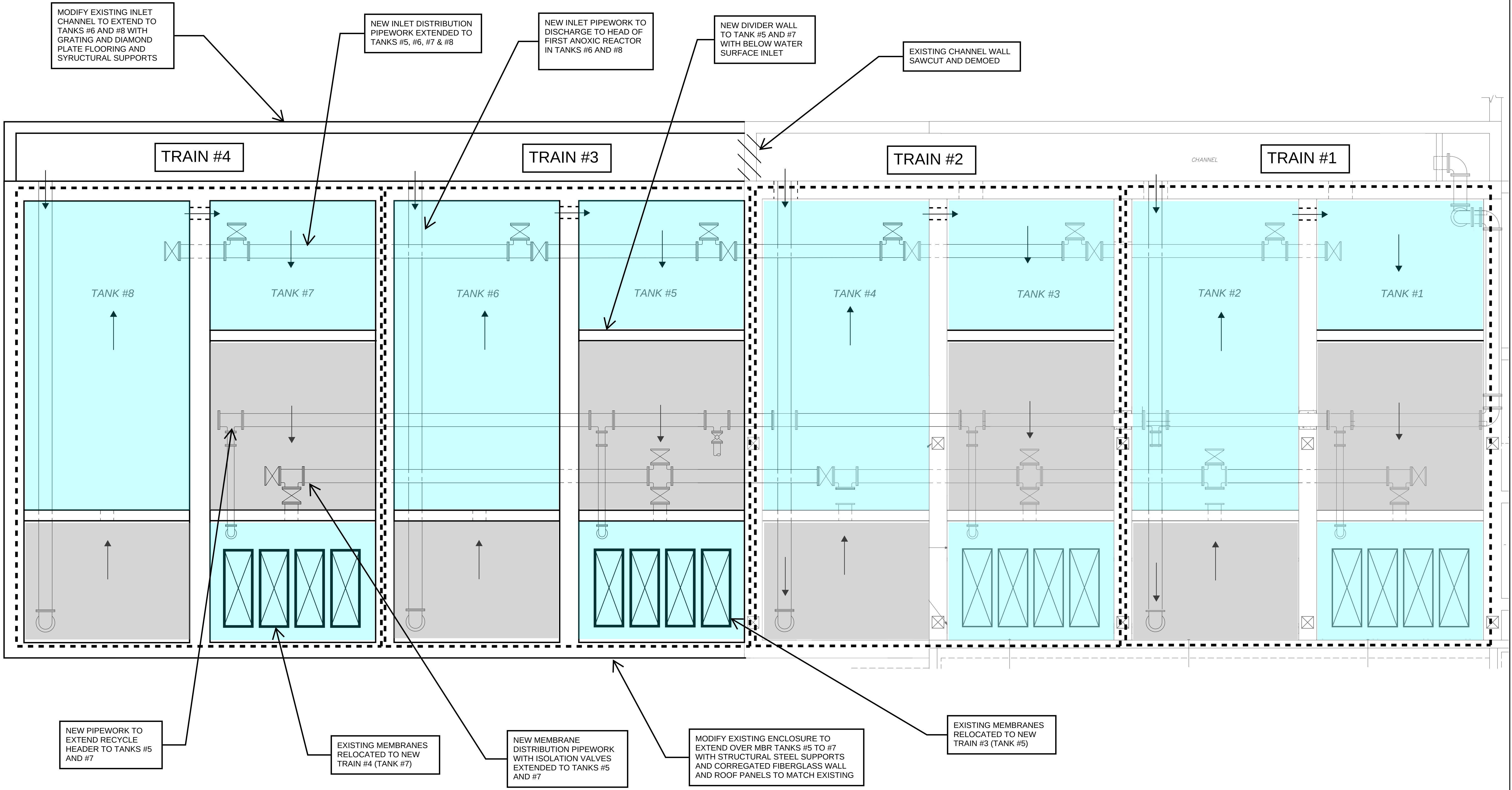


LEGEND

ANOXIC REACTOR

AEROBIC REACTOR

DATE			FIG.
FEB 2024	UNDERWOOD engineers	EPPING WWTF TOTAL NITROGEN UPGRADE MEMBRANE BIOREACTOR PLAN 4-STAGE BARDENPHO	6
PROJECT 2987	99 North State Street, Concord, N.H. 03301 Tel. 603-230-9898 Fax. 603-230-9899		

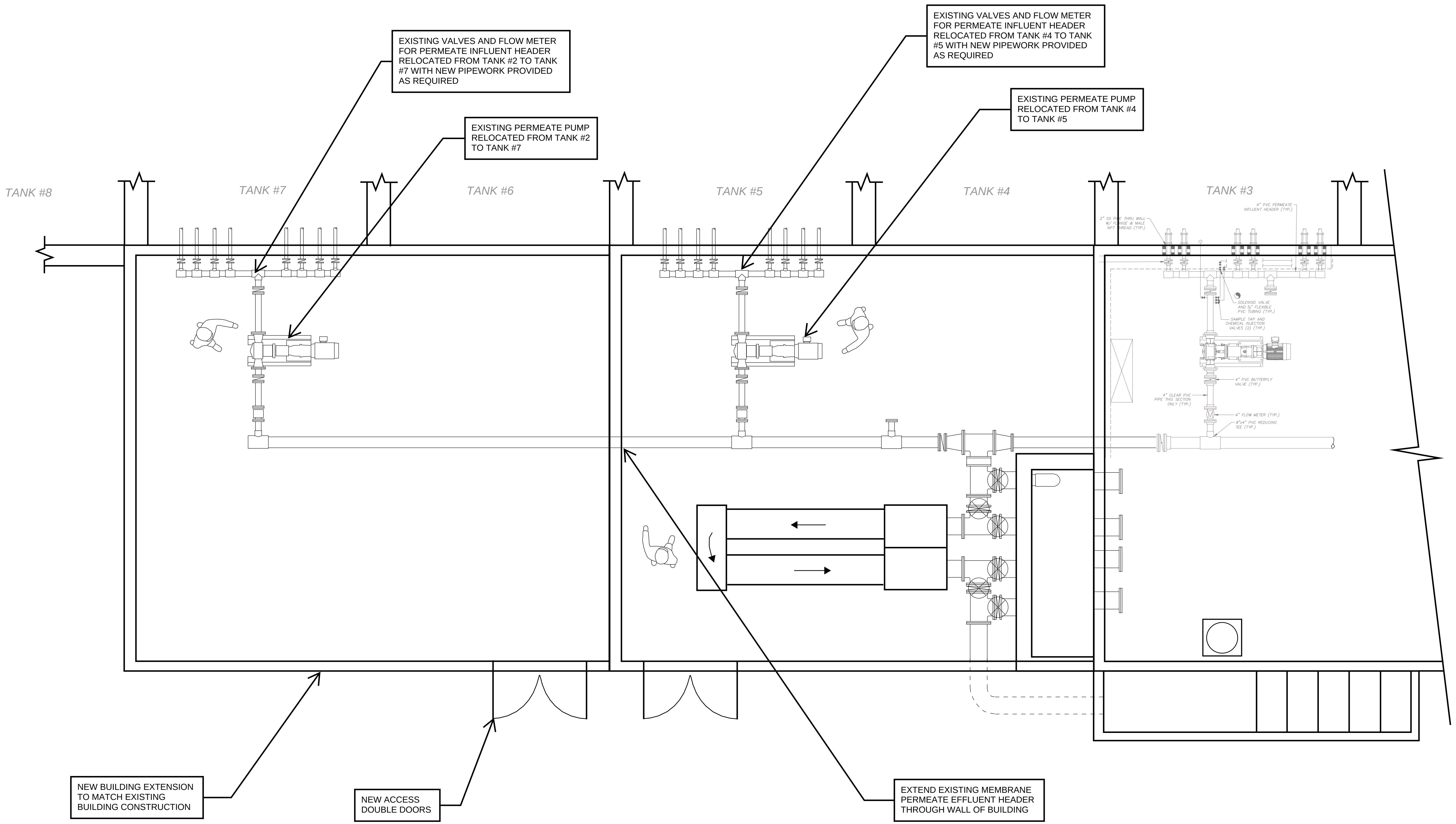


LEGEND

ANOXIC REACTOR

AEROBIC REACTOR

DATE		EPPING WWTF	FIG.
FEB 2024	UNDERWOOD engineers	TOTAL NITROGEN UPGRADE	7
PROJECT	99 North State Street, Concord, N.H. 03301	MEMBRANE BIOREACTOR PLAN	
2987	Tel. 603-230-9898 Fax. 603-230-9899	4-STAGE BARDENPHO	



DATE	UNDERWOOD engineers	EPPING WWTF	FIG.
FEB 2024	99 North State Street, Concord, N.H. 03301	TOTAL NITROGEN UPGRADE	8
PROJECT	Tel. 603-230-9898 Fax. 603-230-9899	PROCESS BUILDING	
2987		4-STAGE BARDENPHO	

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APPENDIX G

Cost Opinions

CRITICAL UPGRADES
EPPING, NH
CONCEPTUAL OPINION OF PROBABLE CONSTRUCTION & PROJECT COST
HEADWORKS BUILDING

Date: 5/16/2024

ITEM	QUANTITY	UNIT	UNIT PRICE	PROBABLE COST
GENERAL				
General Requirements (12% of construction subtotal)	1	LS	$ 30,720.00	$ 30,720.00
DEMOLITION				
Demo pipework & valves (6" & 8")	1	LS	$ 5,000.00	$ 5,000.00
CIVIL				
Concrete channel modifications	1	LS	$ 25,000.00	$ 25,000.00
Diamond plate flooring	40	SF	$ 25.00	$ 1,000.00
EQUIPMENT				
Screen (new 6mm)	1	LS	$ 125,000.00	$ 125,000.00
Screen installation	1	LS	$ 25,000.00	$ 25,000.00
ELECTRICAL & INSTRUMENTATION				
Electrical installAtion	1	LS	$ 45,000.00	$ 45,000.00
Instrumentation installation	1	LS	$ 20,000.00	$ 20,000.00
SCADA	1	LS	$ 10,000.00	$ 10,000.00

SUBTOTAL	***$ 287,000***
Contractor OH&P - 15%	$ 43,000
Contingency - 30%	$ 99,000
TOTAL PROBABLE CONSTRUCTION COST YEAR 2024	***$ 429,000***
Design Phase Engineering Services - 10%	*$ 43,000*
Construction Phase Engineering Services - 10%	*$ 43,000*
TOTAL PROJECT COST YEAR 2024	***$ 515,000***

1. Design and Construction engineering costs are <u>estimates</u> and do not reflect actual engineering costs.
2
3

CRITICAL UPGRADES AND SHORT-TERM UPGRADES
EPPING, NH
CONCEPTUAL OPINION OF PROBABLE CONSTRUCTION & PROJECT COST
PEAK FLOW BUFFER TANK

Date: 5/16/2024

ITEM	QUANTITY	UNIT	UNIT PRICE	PROBABLE COST
GENERAL				
General Requirements (12% of construction subtotal)	1	LS	$ 63,468.00	$ 63,468.00
CIVIL				
Buffer tank (reinforced concrete 75,000 gal)	1	LS	$ 200,000.00	$ 200,000.00
Buffer tank aluminium panel covers	1,340	SF	$ 85.00	$ 113,900.00
Buffer tank feed (12-inch pipe, fittings & valves)	80	LF	$ 250.00	$ 20,000.00
Site work (backfill & regrading)	1	LS	$ 50,000.00	$ 50,000.00
Plant water piping modifications	1	LS	$ 5,000.00	$ 5,000.00
EQUIPMENT				
Washwater pump	1	LS	$ 10,000.00	$ 10,000.00
Washwater pump installation	1	LS	$ 25,000.00	$ 25,000.00
MECHANICAL				
Tank washing system (pipe, fittings & valves)	1	LS	$ 25,000.00	$ 25,000.00
Tank washing system installation	1	LS	$ 35,000.00	$ 35,000.00
ELECTRICAL & INSTRUMENTATION				
Electrical installAtion	1	LS	$ 30,000.00	$ 30,000.00
Instrumentation installation	1	LS	$ 10,000.00	$ 10,000.00
SCADA	1	LS	$ 5,000.00	$ 5,000.00

SUBTOTAL	***$ 592,000***
Contractor OH&P - 15%	$ 89,000
Contingency - 30%	$ 204,000
TOTAL PROBABLE CONSTRUCTION COST YEAR 2024	***$ 885,000***
Design Phase Engineering Services - 10%	*$ 89,000*
Construction Phase Engineering Services - 10%	*$ 89,000*
TOTAL PROJECT COST YEAR 2024	***$ 1,063,000***

1. Design and Construction engineering costs are <u>estimates</u> and do not reflect actual engineering costs.
2
3

CRITICAL UPGRADES
EPPING, NH
CONCEPTUAL OPINION OF PROBABLE CONSTRUCTION & PROJECT COST
MICRO SCREEN BUILDING

Date: 5/16/2024

ITEM	QUANTITY	UNIT	UNIT PRICE	PROBABLE COST
GENERAL				
General Requirements (12% of construction subtotal)	1	LS	$ 131,712.00	$ 131,712.00
CIVIL				
Forcemain (6-inch)	50	LF	$ 250.00	$ 12,500.00
Effluent discharge (8-inch)	40	LF	$ 300.00	$ 12,000.00
Drain (8-inch)	40	LF	$ 300.00	$ 12,000.00
Plant water extension allowance	1	LS	$ 5,000.00	$ 5,000.00
Sitework & regrading	1	LS	$ 30,000.00	$ 30,000.00
Paving	1,500	SF	$ 15.00	$ 22,500.00
Excavation and backfill	1	LS	$ 15,000.00	$ 15,000.00
Building frost wall foundation and floor slab	1	LS	$ 30,000.00	$ 30,000.00
BUILDING				
Building CMU wall & metal seamed roof (18' wide x 26' long)	468	SF	$ 1,000.00	$ 468,000.00
EQUIPMENT				
Screen (new 2mm perforated)	1	LS	$ 125,000.00	$ 125,000.00
Screen wash compactor & chute	1	LS	$ 65,000.00	$ 65,000.00
New screen & wash compactor installation and relocate existing screen	1	LS	$ 75,000.00	$ 75,000.00
MECHANICAL				
Screen influent (6-inch pipe, fittings & valves)	40	LF	$ 300.00	$ 12,000.00
Effluent discharge (8-inch pipe, fittings & valves)	6	LF	$ 350.00	$ 2,100.00
Drain (8-inch pipe & fittings)	6	LF	$ 250.00	$ 1,500.00
Building HVAC	1	LS	$ 75,000.00	$ 75,000.00
Plumbing allowance	1	LS	$ 5,000.00	$ 5,000.00
ELECTRICAL & INSTRUMENTATION				
Electrical installation	1	LS	$ 100,000.00	$ 100,000.00
Instrumentation installation	1	LS	$ 20,000.00	$ 20,000.00
SCADA	1	LS	$ 10,000.00	$ 10,000.00
			SUBTOTAL	***$ 1,229,000***
			Contractor OH&P - 15%	$ 184,000
			Contingency - 30%	$ 424,000
			TOTAL PROBABLE CONSTRUCTION COST YEAR 2024	***$ 1,837,000***
			Design Phase Engineering Services - 10%	*$ 184,000*
			Construction Phase Engineering Services - 10%	*$ 184,000*
			TOTAL PROJECT COST YEAR 2024	***$ 2,205,000***

1. Design and Construction engineering costs are estimates and do not reflect actual engineering costs.
2
3

CRITICAL UPGRADES
EPPING, NH
CONCEPTUAL OPINION OF PROBABLE CONSTRUCTION & PROJECT COST
MBR TANKS 1/2/3 MODS

Date: 5/16/2024

ITEM	QUANTITY	UNIT	UNIT PRICE	PROBABLE COST
GENERAL				
General Requirements (12% of construction subtotal)	1	LS	$ 32,700.00	$ 32,700.00
CIVIL				
Membrane Tank concrete divider wall	3	EA	$ 15,000.00	$ 45,000.00
Coring for new chem feed piping to each membrane tank 1/2/3	3	EA	$ 1,000.00	$ 3,000.00
MECHANICAL				
New foam spray piping and nozzles in MBR tank	3	EA	$ 7,500.00	$ 22,500.00
New outlet header to Membrane Tanks 1/2/3	60	LF	$ 350.00	$ 21,000.00
New valves on outlet header to Membrane Tanks	6	EA	$ 1,000.00	$ 6,000.00
Relocate recycle submersible pumps & pipework modifications	3	EA	$ 35,000.00	$ 105,000.00
New chem feed piping allowance for automated recovery cleaning	3	EA	$ 5,000.00	$ 15,000.00
ELECTRICAL & INSTRUMENTATION				
Electrical installation	1	LS	$ 30,000.00	$ 30,000.00
Instrumentation installation	1	LS	$ 5,000.00	$ 5,000.00
SCADA	1	LS	$ 20,000.00	$ 20,000.00
			SUBTOTAL	***$ 305,000***
			Contractor OH&P - 15%	$ 46,000
			Contingency - 30%	$ 105,000
			TOTAL PROBABLE CONSTRUCTION COST YEAR 2024	***$ 456,000***
			Design Phase Engineering Services - 10%	*$ 46,000*
			Construction Phase Engineering Services - 10%	*$ 46,000*
			TOTAL PROJECT COST YEAR 2024	***$ 548,000***

1. Design and Construction engineering costs are <u>estimates</u> and do not reflect actual engineering costs.
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CRITICAL UPGRADES
EPPING, NH
CONCEPTUAL OPINION OF PROBABLE CONSTRUCTION & PROJECT COST
NEW STANDBY GENERATOR

Date: 5/22/2024

ITEM	QUANTITY	UNIT	UNIT PRICE	PROBABLE COST
GENERAL				
General Requirements (12% of construction subtotal)	1	LS	$ 32,370.00	$ 32,370.00
DEMOLITION				
Demo existing 200 kW standby generator	1	LS	$ 10,000.00	$ 10,000.00
CIVIL				
Restoration Allowance	1	LS	$ 3,000.00	$ 3,000.00
Paving Repairs Allowance	1	LS	$ 3,000.00	$ 3,000.00
EQUIPMENT				
New standby generator	1	EA	$ 168,750.00	$ 168,750.00
New transfer switch	1	EA	$ 20,000.00	$ 20,000.00
ELECTRICAL & INSTRUMENTATION				
Electrical installation	1	LS	$ 50,000.00	$ 50,000.00
Instrumentation installation	1	LS	$ 10,000.00	$ 10,000.00
SCADA	1	LS	$ 5,000.00	$ 5,000.00
			SUBTOTAL	***$ 302,000***
			Contractor OH&P - 15%	$ 45,000
			Contingency - 30%	$ 104,000
			TOTAL PROBABLE CONSTRUCTION COST YEAR 2024	***$ 451,000***
			Design Phase Engineering Services - 10%	*$ 45,000*
			Construction Phase Engineering Services - 10%	*$ 45,000*
			TOTAL PROJECT COST YEAR 2024	***$ 541,000***

1. Design and Construction engineering costs are estimates and do not reflect actual engineering costs.
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SHORT-TERM UPGRADES
EPPING, NH
CONCEPTUAL OPINION OF PROBABLE CONSTRUCTION & PROJECT COST
MBR TANK #4

Date: 5/16/2024

ITEM	QUANTITY	UNIT	UNIT PRICE	PROBABLE COST
GENERAL				
General Requirements (12% of construction subtotal)	1	LS	$ 130,918.80	$ 130,918.80
CIVIL				
Extend influent channel MBR inlet channel extension and modifications	1	LS	$ 25,000.00	$ 25,000.00
MBR Tank #4 membrane divider wall	1	LS	$ 15,000.00	$ 15,000.00
BUILDING				
MBR Tank #4 enclosure extension	233	SF	$ 1,000.00	$ 232,500.00
MBR Tank #4 grating & diamond plate flooring	364	SF	$ 25.00	$ 9,100.00
MBR Tank #4 open grid flooring	154	SF	$ 35.00	$ 5,390.00
MBR Tank #4 aluminum beam allowance	1	LS	$ 50,000.00	$ 50,000.00
MBR Tank #4 grating/plating/beam installation	1	LS	$ 50,000.00	$ 50,000.00
EQUIPMENT				
MBR Tank #4 hollow fiber membranes & PLC programming	1	LS	$ 350,000.00	$ 350,000.00
MBR Tank #4 aeration (fine bubble strip diffusers)	1	LS	$ 50,000.00	$ 50,000.00
Membrane installation	1	LS	$ 130,000.00	$ 130,000.00
Aeration installation	1	LS	$ 45,000.00	$ 45,000.00
MECHANICAL				
Extend existing inlet header to MBR Tank #4 (pipe, fittings & valves)	20	LF	$ 350.00	$ 7,000.00
New outlet header to MBR Tank #4 (pipe, fittings & valves)	20	LF	$ 350.00	$ 7,000.00
Relocate recycle submersible pump & pipework modifications	1	LS	$ 35,000.00	$ 35,000.00
New influent gate to Tank #4	1	LS	$ 5,000.00	$ 5,000.00
ELECTRICAL & INSTRUMENTATION				
Electrical installation	1	LS	$ 45,000.00	$ 45,000.00
Instrumentation installation	1	LS	$ 20,000.00	$ 20,000.00
SCADA	1	LS	$ 10,000.00	$ 10,000.00
SUBTOTAL				***$ 1,222,000***
Contractor OH&P - 15%				$ 183,000
Contingency - 30%				$ 422,000
TOTAL PROBABLE CONSTRUCTION COST YEAR 2024				***$ 1,827,000***
Design Phase Engineering Services - 10%				*$ 183,000*
Construction Phase Engineering Services - 10%				*$ 183,000*
TOTAL PROJECT COST YEAR 2024				***$ 2,193,000***

1. Design and Construction engineering costs are <u>estimates</u> and do not reflect actual engineering costs.
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SHORT-TERM UPGRADES
EPPING, NH
CONCEPTUAL OPINION OF PROBABLE CONSTRUCTION & PROJECT COST
MBR PROCESS BUILDING EXPANSION AND NEW UV

Date: 5/16/2024

ITEM	QUANTITY	UNIT	UNIT PRICE	PROBABLE COST
GENERAL				
General Requirements (12% of construction subtotal)	1	LS	$ 156,780.00	$ 156,780.00
DEMOLITION				
Demo existing UV and effluent pipework	1	LS	$ 5,000.00	$ 5,000.00
CIVIL				
Effluent discharge (12-inch)	20	LF	$ 250.00	$ 5,000.00
Excavation and backfill	1	LS	$ 25,000.00	$ 25,000.00
Building extension frost wall foundation and floor slab	1	LS	$ 50,000.00	$ 50,000.00
BUILDING				
Building extension CMU wall & metal seamed roof (26' wide x 31' long)	806	SF	$ 1,000.00	$ 806,000.00
EQUIPMENT				
UV system	1	LS	$ 150,000.00	$ 150,000.00
Permeate pump	1	LS	$ 15,000.00	$ 15,000.00
UV & permeate pump installation	1	LS	$ 45,000.00	$ 45,000.00
MECHANICAL				
Permeate (4-inch pipe, fittings & valves)	20	LF	$ 150.00	$ 3,000.00
Effluent discharge (12-inch pipe & fittings)	30	LF	$ 350.00	$ 10,500.00
Effluent discharge (12-inch valves)	6	EA	$ 2,000.00	$ 12,000.00
Building HVAC	1	LS	$ 75,000.00	$ 75,000.00
ELECTRICAL & INSTRUMENTATION				
Electrical installation	1	LS	$ 75,000.00	$ 75,000.00
Instrumentation installation	1	LS	$ 20,000.00	$ 20,000.00
SCADA	1	LS	$ 10,000.00	$ 10,000.00

SUBTOTAL	***$ 1,463,000***
Contractor OH&P - 15%	$ 219,000
Contingency - 30%	$ 505,000
TOTAL PROBABLE CONSTRUCTION COST YEAR 2024	***$ 2,187,000***
Design Phase Engineering Services - 10%	*$ 219,000*
Construction Phase Engineering Services - 10%	*$ 219,000*
TOTAL PROJECT COST YEAR 2024	***$ 2,625,000***

1. Design and Construction engineering costs are <u>estimates</u> and do not reflect actual engineering costs.
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SHORT-TERM UPGRADES
EPPING, NH
CONCEPTUAL OPINION OF PROBABLE CONSTRUCTION & PROJECT COST
WAS STORAGE TANK

Date: 5/16/2024

ITEM	QUANTITY	UNIT	UNIT PRICE	PROBABLE COST
GENERAL				
General Requirements (12% of construction subtotal)	1	LS	$ 48,300.00	$ 48,300.00
CIVIL				
Excavation & dewatering	1	LS	$ 75,000.00	$ 75,000.00
Reinforced concrete tank (50,000 gal)	1	LS	$ 135,000.00	$ 135,000.00
Sludge yard piping (4-inch pipe, fittings & valves)	100	LF	$ 250.00	$ 25,000.00
Air yard piping	50	LF	$ 250.00	$ 12,500.00
EQUIPMENT				
Tank access hatches	3	EA	$ 5,000.00	$ 15,000.00
Submersible pump	1	LS	$ 15,000.00	$ 15,000.00
Aeration (coarse bubble diffusers)	1	LS	$ 30,000.00	$ 30,000.00
Pump and aeration installation	1	LS	$ 45,000.00	$ 45,000.00
MECHANICAL				
Sludge discharge (4-inch pipe, fittings & valves)	20	LF	$ 250.00	$ 5,000.00
ELECTRICAL & INSTRUMENTATION				
Electrical installation	1	LS	$ 30,000.00	$ 30,000.00
Instrumentation installation	1	LS	$ 10,000.00	$ 10,000.00
SCADA	1	LS	$ 5,000.00	$ 5,000.00

SUBTOTAL	***$ 451,000***
Contractor OH&P - 15%	$ 68,000
Contingency - 30%	$ 156,000
TOTAL PROBABLE CONSTRUCTION COST YEAR 2024	***$ 675,000***
Design Phase Engineering Services - 10%	*$ 68,000*
Construction Phase Engineering Services - 10%	*$ 68,000*
TOTAL PROJECT COST YEAR 2024	***$ 811,000***

1. Design and Construction engineering costs are <u>estimates</u> and do not reflect actual engineering costs.
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WWTF UPGRADES FOR 0.5 MGD CAPACITY AT 2020 TN PERMIT
EPPING, NH
CONCEPTUAL OPINION OF PROBABLE CONSTRUCTION & PROJECT COST
MBR TANKS #5 TO #6

Date: 5/20/2024

ITEM	QUANTITY	UNIT	UNIT PRICE	PROBABLE COST
GENERAL				
General Requirements (12% of construction subtotal)	1	LS	$ 466,857.60	$ 466,857.60
CIVIL				
Extend MBR inlet channel	2	EA	$ 25,000.00	$ 50,000.00
New RC MBR tanks #5 to #6	2	EA	$ 250,000.00	$ 500,000.00
Earthwork & retaining wall to accommodate tanks footprint	1	LS	$ 125,000.00	$ 125,000.00
Dewatering allowance	1	LS	$ 125,000.00	$ 125,000.00
Sitework regrading	1	LS	$ 25,000.00	$ 25,000.00
BUILDING				
MBR Tank #5 to #6 enclosure extension	465	SF	$ 1,000.00	$ 465,000.00
MBR Tank #5 to #6 grating & diamond plate flooring	728	SF	$ 25.00	$ 18,200.00
MBR Tank #5 to #6 open grid flooring	308	SF	$ 35.00	$ 10,780.00
MBR Tank #5 to #6 aluminum beam allowance	2	EA	$ 50,000.00	$ 100,000.00
MBR Tank #5 to #6 grating/plating/beam installation	2	EA	$ 50,000.00	$ 100,000.00
EQUIPMENT				
MBR Tank #1, #2, #3 & #4 new hollow fiber membranes with more surface area	4	EA	$ 350,000.00	$ 1,400,000.00
MBR Tank #5 to #6 aeration (fine bubble strip diffusers)	2	EA	$ 50,000.00	$ 100,000.00
Membrane installation	4	EA	$ 130,000.00	$ 520,000.00
Aeration installation	2	EA	$ 45,000.00	$ 90,000.00
MECHANICAL				
Extend inlet header to MBR Tanks #5 to #6 (pipe, fittings & valves)	30	LF	$ 350.00	$ 10,500.00
Extend outlet header to MBR Tanks #5 to #6 (pipe, fittings & valves)	30	LF	$ 350.00	$ 10,500.00
Extend recycle header to MBR tanks #5 to #6 (pipe fittings & valves)	30	LF	$ 350.00	$ 10,500.00
New influent gate to Tank #5 & #6	2	EA	$ 5,000.00	$ 10,000.00
Install recycle pumps & pipework in tanks #5 & #6	2	EA	$ 35,000.00	$ 70,000.00
ELECTRICAL & INSTRUMENTATION				
Electrical installation	2	EA	$ 45,000.00	$ 90,000.00
Instrumentation installation	2	EA	$ 20,000.00	$ 40,000.00
SCADA	2	EA	$ 10,000.00	$ 20,000.00
SUBTOTAL				***$ 4,357,000***
Contractor OH&P - 15%				$ 654,000
Contingency - 30%				$ 1,503,000
TOTAL PROBABLE CONSTRUCTION COST YEAR 2024				***$ 6,514,000***
Design Phase Engineering Services - 10%				*$ 651,000*
Construction Phase Engineering Services - 10%				*$ 651,000*
TOTAL PROJECT COST YEAR 2024				***$ 7,816,000***

1. Design and Construction engineering costs are <u>estimates</u> and do not reflect actual engineering costs.
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MBR BARDENPHO TOTAL NITROGEN UPGRADE (3.0 MG/L)
EPPING, NH
CONCEPTUAL OPINION OF PROBABLE CONSTRUCTION & PROJECT COST
MBR TANKS #1 TO #4

Date: 5/20/2024

ITEM	QUANTITY	UNIT	UNIT PRICE	PROBABLE COST
GENERAL				
General Requirements (12% of construction subtotal)	1	LS	$ 195,240.00	$ 195,240.00
DEMOLITION				
Demo recycle pumps, pipework & MBR distribution valves tanks #2 & #4	1	LS	$ 15,000.00	$ 15,000.00
Demo membrane divider walls in tank #2 & #4	2	EA	$ 10,000.00	$ 20,000.00
CIVIL				
Bardenpho and membrane tank divider walls	8	EA	$ 15,000.00	$ 120,000.00
EQUIPMENT				
MBR Tank #1 & #3 new hollow fiber membranes with more surface area	2	EA	$ 350,000.00	$ 700,000.00
MBR Tank #1 to #4 aeration (fine bubble strip diffusers)	4	EA	$ 50,000.00	$ 200,000.00
Membrane installation	2	EA	$ 130,000.00	$ 260,000.00
Aeration installation	4	EA	$ 45,000.00	$ 180,000.00
Mixers in Tanks #1 to #4	4	EA	$ 13,500.00	$ 54,000.00
MECHANICAL				
New Bardenpho inlet piping (pipe, fittings & valves) to tanks #2 & #4	80	LF	$ 350.00	$ 28,000.00
ELECTRICAL & INSTRUMENTATION				
Electrical demolition	1	LS	$ 5,000.00	$ 5,000.00
Electrical installation	4	EA	$ 15,000.00	$ 60,000.00
SCADA	4	EA	$ 5,000.00	$ 20,000.00
SUBTOTAL				***$ 1,857,000***
Contractor OH&P - 15%				$ 279,000
Contingency - 30%				$ 641,000
TOTAL PROBABLE CONSTRUCTION COST YEAR 2024				***$ 2,777,000***
Design Phase Engineering Services - 10%				*$ 278,000*
Construction Phase Engineering Services - 10%				*$ 278,000*
TOTAL PROJECT COST YEAR 2024				***$ 3,333,000***

1. Design and Construction engineering costs are estimates and do not reflect actual engineering costs.
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MBR BARDENPHO TOTAL NITROGEN UPGRADE (3.0 MG/L)
EPPING, NH
CONCEPTUAL OPINION OF PROBABLE CONSTRUCTION & PROJECT COST
MBR TANKS #5 TO #8

Date: 5/20/2024

ITEM	QUANTITY	UNIT	UNIT PRICE	PROBABLE COST
GENERAL				
General Requirements (12% of construction subtotal)	1	LS	$ 607,345.20	$ 607,345.20
CIVIL				
Extend MBR inlet channel	4	EA	$ 25,000.00	$ 100,000.00
Bardenpho and membrane tank divider walls	8	EA	$ 15,000.00	$ 120,000.00
New RC MBR tanks #5 to #8 (Bardonpho configuration)	4	EA	$ 250,000.00	$ 1,000,000.00
Earthwork & retaining wall to accommodate tanks footprint	1	LS	$ 250,000.00	$ 250,000.00
Dewatering allowance	1	LS	$ 250,000.00	$ 250,000.00
Sitework regrading	1	LS	$ 50,000.00	$ 50,000.00
BUILDING				
MBR Tank #5 to #8 enclosure extension	930	SF	$ 1,000.00	$ 930,000.00
MBR Tank #5 to #8 grating & diamond plate flooring	1,456	SF	$ 25.00	$ 36,400.00
MBR Tank #5 to #8 open grid flooring	616	SF	$ 35.00	$ 21,560.00
MBR Tank #5 to #8 aluminum beam allowance	4	EA	$ 50,000.00	$ 200,000.00
MBR Tank #5 to #8 grating/plating/beam installation	4	EA	$ 50,000.00	$ 200,000.00
EQUIPMENT				
MBR Tank#5 & #7 new hollow fiber membranes with more surface area	2	EA	$ 350,000.00	$ 700,000.00
MBR Tank #5 to #8 aeration (fine bubble strip diffusers)	4	EA	$ 50,000.00	$ 200,000.00
Membrane installation	2	EA	$ 130,000.00	$ 260,000.00
Aeration installation	4	EA	$ 45,000.00	$ 180,000.00
MECHANICAL				
Extend inlet header to MBR Tanks #5 to #8 (pipe, fittings & valves)	65	LF	$ 350.00	$ 22,750.00
Extend outlet header to MBR Tanks #5 to #8 (pipe, fittings & valves)	50	LF	$ 350.00	$ 17,500.00
Extend recycle header to MBR tanks #5 to #8 (pipe fittings & valves)	60	LF	$ 350.00	$ 21,000.00
New Bardenpho inlet piping (pipe, fittings & valves) to tanks #6 & #8	80	LF	$ 350.00	$ 28,000.00
New influent gate to Tank #6 & #8	2	EA	$ 5,000.00	$ 10,000.00
Install recycle pumps & pipework in tanks #5 & #7 (relocated from tanks #2 & #4)	2	EA	$ 25,000.00	$ 50,000.00
Mixers in Tanks #5 to #8	4	EA	$ 13,500.00	$ 54,000.00
ELECTRICAL & INSTRUMENTATION				
Electrical installation	4	EA	$ 60,000.00	$ 240,000.00
Instrumentation installation	4	EA	$ 20,000.00	$ 80,000.00
SCADA	4	EA	$ 10,000.00	$ 40,000.00
			SUBTOTAL	***$ 5,669,000***
			Contractor OH&P - 15%	$ 850,000
			Contingency - 30%	$ 1,956,000
			TOTAL PROBABLE CONSTRUCTION COST YEAR 2024	***$ 8,475,000***
			Design Phase Engineering Services - 10%	*$ 848,000*
			Construction Phase Engineering Services - 10%	*$ 848,000*
			TOTAL PROJECT COST YEAR 2024	***$ 10,171,000***

1. Design and Construction engineering costs are <u>estimates</u> and do not reflect actual engineering costs.
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MBR BARDENPHO TOTAL NITROGEN UPGRADE (3.0 MG/L)
EPPING, NH
CONCEPTUAL OPINION OF PROBABLE CONSTRUCTION & PROJECT COST
MBR PROCESS BUILDING EXPANSION

Date: 5/20/2024

ITEM	QUANTITY	UNIT	UNIT PRICE	PROBABLE COST
GENERAL				
General Requirements (12% of construction subtotal)	1	LS	$ 145,620.00	$ 145,620.00
CIVIL				
Effluent discharge (12-inch)	20	LF	$ 250.00	$ 5,000.00
Excavation and backfill	1	LS	$ 25,000.00	$ 25,000.00
Building extension frost wall foundation and floor slab	1	LS	$ 50,000.00	$ 50,000.00
Paving	1,500	SF	$ 15.00	$ 22,500.00
BUILDING				
Building extension CMU wall & metal seamed roof (26' wide x 31' long)	806	SF	$ 1,000.00	$ 806,000.00
EQUIPMENT				
Relocate existing permeate pump (for tank #5 & #7)	1	LS	$ 100,000.00	$ 100,000.00
MECHANICAL				
Permeate piping allowance	1	LS	$ 20,000.00	$ 20,000.00
Air piping allowance	1	LS	$ 30,000.00	$ 30,000.00
Building HVAC	1	LS	$ 75,000.00	$ 75,000.00
ELECTRICAL & INSTRUMENTATION				
Electrical installation	1	LS	$ 50,000.00	$ 50,000.00
Instrumentation installation	1	LS	$ 20,000.00	$ 20,000.00
SCADA	1	LS	$ 10,000.00	$ 10,000.00
SUBTOTAL				***$ 1,359,000***
Contractor OH&P - 15%				$ 204,000
Contingency - 30%				$ 469,000
TOTAL PROBABLE CONSTRUCTION COST YEAR 2024				***$ 2,032,000***
Design Phase Engineering Services - 10%				*$ 203,000*
Construction Phase Engineering Services - 10%				*$ 203,000*
TOTAL PROJECT COST YEAR 2024				***$ 2,438,000***

1. Design and Construction engineering costs are estimates and do not reflect actual engineering costs.
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CONVENTIONAL BARDENPHO
EPPING, NH
CONCEPTUAL OPINION OF PROBABLE CONSTRUCTION & PROJECT COST
HEADWORKS BUILDING

Date: 8/26/2024

ITEM	QUANTITY	UNIT	UNIT PRICE	PROBABLE COST
GENERAL				
General Requirements (12% of construction subtotal)	1	LS	$ 32,340.00	$ 32,340.00
DEMOLITION				
Demo pipework & valves (6" & 8")	1	LS	$ 5,000.00	$ 5,000.00
Demo micro screen	1	LS	$ 10,000.00	$ 10,000.00
CIVIL				
Concrete channel modifications	1	LS	$ 25,000.00	$ 25,000.00
Diamond plate flooring	40	SF	$ 25.00	$ 1,000.00
EQUIPMENT				
Screen (new 6mm)	1	LS	$ 125,000.00	$ 125,000.00
Screen installation	1	LS	$ 25,000.00	$ 25,000.00
Plant water allowance	1	LS	$ 3,500.00	$ 3,500.00
ELECTRICAL & INSTRUMENTATION				
Electrical installation	1	LS	$ 45,000.00	$ 45,000.00
Instrumentation installation	1	LS	$ 20,000.00	$ 20,000.00
SCADA	1	LS	$ 10,000.00	$ 10,000.00
			SUBTOTAL	***$ 302,000***
			Contractor OH&P - 15%	$ 45,000
			Contingency - 30%	$ 104,000
			TOTAL PROBABLE CONSTRUCTION COST YEAR 2024	***$ 451,000***
			Design Phase Engineering Services - 10%	*$ 45,000*
			Construction Phase Engineering Services - 10%	*$ 45,000*
			TOTAL PROJECT COST YEAR 2024	***$ 541,000***

1. Design and Construction engineering costs are estimates and do not reflect actual engineering costs.
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CONVENTIONAL BARDENPHO
EPPING, NH
CONCEPTUAL OPINION OF PROBABLE CONSTRUCTION & PROJECT COST
INTERMEDIATE PUMP STATION UPGRADE TO 1.55 MGD

Date: 8/26/2024

ITEM	QUANTITY	UNIT	UNIT PRICE	PROBABLE COST
GENERAL				
General Requirements (12% of construction subtotal)	1	LS	$ 38,640.00	$ 38,640.00
DEMOLITION				
Demo existing pipework in wet well	1	LS	$ 5,000.00	$ 5,000.00
Demo existing submersible pumps	1	LS	$ 5,000.00	$ 5,000.00
CIVIL				
New 8" FM pipe in wet well	1	LS	$ 5,000.00	$ 5,000.00
Remove existing 6" FM yard pipe and replace with 8"	100	LF	$ 350.00	$ 35,000.00
Pavement restoration	1	LS	$ 5,000.00	$ 5,000.00
EQUIPMENT				
New submersible pumps	2	EA	$ 81,000.00	$ 162,000.00
ELECTRICAL & INSTRUMENTATION				
Electrical installation	1	LS	$ 75,000.00	$ 75,000.00
Instrumentation installation	1	LS	$ 20,000.00	$ 20,000.00
SCADA	1	LS	$ 10,000.00	$ 10,000.00

SUBTOTAL	***$ 361,000***
Contractor OH&P - 15%	$ 54,000
Contingency - 30%	$ 125,000
TOTAL PROBABLE CONSTRUCTION COST YEAR 2024	***$ 540,000***
Design Phase Engineering Services - 10%	*$ 54,000*
Construction Phase Engineering Services - 10%	*$ 54,000*
TOTAL PROJECT COST YEAR 2024	***$ 648,000***

1. Design and Construction engineering costs are estimates and do not reflect actual engineering costs.
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CONVENTIONAL BARDENPHO
EPPING, NH
CONCEPTUAL OPINION OF PROBABLE CONSTRUCTION & PROJECT COST
BNR TANKS #1 to #4

Date: 8/26/2024

ITEM	QUANTITY	UNIT	UNIT PRICE	PROBABLE COST
GENERAL				
General Requirements (12% of construction subtotal)	1	LS	$ 74,085.60	$ 74,085.60
DEMOLITION				
Demo existing inlet header piping in Tanks #1-#3	1	LS	$ 5,000.00	$ 5,000.00
Demo existing recirculation pumps and 6" discharge piping	3	EA	$ 5,000.00	$ 15,000.00
Demo existing membranes in Tanks #1-#3	3	EA	$ 5,000.00	$ 15,000.00
Demo existing permeate pumps and piping for Tanks #1-#3	3	EA	$ 5,000.00	$ 15,000.00
CIVIL				
Extend inlet channel	1	EA	$ 25,000.00	$ 25,000.00
Bardenpho tank divider walls	4	EA	$ 15,000.00	$ 60,000.00
New effluent channel	4	EA	$ 25,000.00	$ 100,000.00
BUILDING				
Tank #4 grating	518	SF	$ 35.00	$ 18,130.00
Tank #4 aluminum beam allowance	1	EA	$ 50,000.00	$ 50,000.00
Tank #4 grating and beam installation	1	EA	$ 50,000.00	$ 50,000.00
EQUIPMENT				
Tank #4 aeration (fine bubble strip diffusers)	1	EA	$ 50,000.00	$ 50,000.00
Aeration installation	1	EA	$ 45,000.00	$ 45,000.00
Mixers in Tanks #1 to #4	4	EA	$ 13,500.00	$ 54,000.00
MECHANICAL				
Extend recycle header to Tank #4 (pipe fittings & valves)	15	LF	$ 350.00	$ 5,250.00
New influent gate to Tank #4	1	EA	$ 5,000.00	$ 5,000.00
ELECTRICAL & INSTRUMENTATION				
Electrical demolition	1	EA	$ 20,000.00	$ 20,000.00
Electrical installation	1	EA	$ 60,000.00	$ 60,000.00
Instrumentation installation	1	EA	$ 20,000.00	$ 20,000.00
SCADA	1	EA	$ 10,000.00	$ 10,000.00
			SUBTOTAL	***$ 696,000***
			Contractor OH&P - 15%	$ 104,000
			Contingency - 30%	$ 240,000
			TOTAL PROBABLE CONSTRUCTION COST YEAR 2024	***$ 1,040,000***
			Design Phase Engineering Services - 10%	*$ 104,000*
			Construction Phase Engineering Services - 10%	*$ 104,000*
			TOTAL PROJECT COST YEAR 2024	***$ 1,248,000***

1. Design and Construction engineering costs are <u>estimates</u> and do not reflect actual engineering costs.
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CONVENTIONAL BARDENPHO
EPPING, NH
CONCEPTUAL OPINION OF PROBABLE CONSTRUCTION & PROJECT COST
BNR TANKS #5 TO #12

Date: 8/26/2024

ITEM	QUANTITY	UNIT	UNIT PRICE	PROBABLE COST
GENERAL				
General Requirements (12% of construction subtotal)	1	LS	$ 707,404.80	$ 707,404.80
CIVIL				
Extend inlet channel	8	EA	$ 25,000.00	$ 200,000.00
Bardenpho tank divider walls	8	EA	$ 15,000.00	$ 120,000.00
New RC BNR tanks #5 to #12 (Bardonpho configuration)	8	EA	$ 250,000.00	$ 2,000,000.00
New effluent channel	8	EA	$ 25,000.00	$ 200,000.00
Earthwork & retaining wall to accommodate tanks footprint	1	LS	$ 500,000.00	$ 500,000.00
Dewatering allowance	1	LS	$ 500,000.00	$ 500,000.00
Sitework regrading	1	LS	$ 100,000.00	$ 100,000.00
Pavement Allowance	1	LS	$ 20,000.00	$ 20,000.00
BUILDING				
MBR Tank #5 to #12 grating	4,144	SF	$ 35.00	$ 145,040.00
MBR Tank #5 to #12 aluminum beam allowance	8	EA	$ 50,000.00	$ 400,000.00
MBR Tank #5 to #12 grating/plating/beam installation	8	EA	$ 50,000.00	$ 400,000.00
EQUIPMENT				
MBR Tank #5 to #12 aeration (fine bubble strip diffusers)	8	EA	$ 50,000.00	$ 400,000.00
Aeration installation	8	EA	$ 45,000.00	$ 360,000.00
Mixers in tanks #5 & #12	8	EA	$ 13,500.00	$ 108,000.00
MECHANICAL				
Extend recycle header to Tanks #5 - #12 (pipe fittings & valves)	120	LF	$ 350.00	$ 42,000.00
New influent gate to Tanks #5 - #12	8	EA	$ 5,000.00	$ 40,000.00
ELECTRICAL & INSTRUMENTATION				
Electrical installation	8	EA	$ 15,000.00	$ 120,000.00
Instrumentation installation	8	EA	$ 20,000.00	$ 160,000.00
SCADA	8	EA	$ 10,000.00	$ 80,000.00
			SUBTOTAL	***$ 6,602,000***
			Contractor OH&P - 15%	$ 990,000
			Contingency - 30%	$ 2,278,000
			TOTAL PROBABLE CONSTRUCTION COST YEAR 2024	***$ 9,870,000***
			Design Phase Engineering Services - 10%	*$ 987,000*
			Construction Phase Engineering Services - 10%	*$ 987,000*
			TOTAL PROJECT COST YEAR 2024	***$ 11,844,000***

1. Design and Construction engineering costs are <u>estimates</u> and do not reflect actual engineering costs.
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CONVENTIONAL BARDENPHO
EPPING, NH
CONCEPTUAL OPINION OF PROBABLE CONSTRUCTION & PROJECT COST
MICRO C BUILDING

Date: 8/26/2024

ITEM	QUANTITY	UNIT	UNIT PRICE	PROBABLE COST
GENERAL				
General Requirements (12% of construction subtotal)	1	LS	$ 66,240.00	$ 66,000.00
CIVIL				
Sitework & regrading	1	LS	$ 25,000.00	$ 25,000.00
Excavation and backfill	1	LS	$ 15,000.00	$ 15,000.00
Building frost wall foundation and floor slab	1	LS	$ 25,000.00	$ 25,000.00
Pavement Allowance	1	LS	$ 5,000.00	$ 5,000.00
BUILDING				
New Building (incl. bldg elec, arch, hvac, struct)	192	SF	$ 1,000.00	$ 192,000.00
EQUIPMENT				
Bulk Tanks	2	EA	$ 33,750.00	$ 68,000.00
Pumps (2 peristaltic metering pumps)	2	EA	$ 13,500.00	$ 27,000.00
Chemical feed pipe and installation	1	LS	$ 20,000.00	$ 20,000.00
Plant water piping and eyewash station and installation	1	LS	$ 10,000.00	$ 10,000.00
HVAC allowance	1	LS	$ 50,000.00	$ 50,000.00
ELECTRICAL & INSTRUMENTATION				
Electrical Allowance	1	LS	$ 75,000.00	$ 75,000.00
Instrumentation Allowance	1	LS	$ 30,000.00	$ 30,000.00
SCADA Allowance	1	LS	$ 10,000.00	$ 10,000.00
			SUBTOTAL	***$ 618,000.00***
			Contractor OH&P - 15%	$ 93,000.00
			Contingency - 30%	$ 185,000.00
			TOTAL PROBABLE CONSTRUCTION COST Year 2024	***$ 896,000.00***
			Design Phase Engineering Services - 10%	$ 90,000.00
			Construction Phase Engineering Services - 10%	$ 90,000.00
			TOTAL PROJECT COST YEAR 2024	***$ 1,076,000.00***

1. Design and Construction engineering costs are estimates and do not reflect actual engineering costs.
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CONVENTIONAL BARDENPHO
EPPING, NH
CONCEPTUAL OPINION OF PROBABLE CONSTRUCTION & PROJECT COST
SECONDARY CLARIFIERS (3 @40' DIA)

Date: 8/26/2024

ITEM	QUANTITY	UNIT	UNIT PRICE	PROBABLE COST
GENERAL				
General Requirements (12% of construction subtotal)	1	LS	$ 511,680.00	$ 512,000.00
CIVIL				
Earthwork & retaining wall allowance	1	LS	$ 500,000.00	$ 500,000.00
Dewatering allowance	1	LS	$ 550,000.00	$ 550,000.00
Sitework regrading	1	LS	$ 100,000.00	$ 100,000.00
Concrete (includes pump room in between clarifiers)				
Clarifier Walls	279	CY	$ 1,500.00	$ 419,000.00
Clarifier Floor Slabs	393	CY	$ 1,500.00	$ 590,000.00
Clarifier Bldg Walls	74	CY	$ 1,500.00	$ 111,000.00
Clarifier Bldg Slab & Roof	142	CY	$ 1,500.00	$ 213,000.00
Influent Flow Splitter Box	1	LS	$ 50,000.00	$ 50,000.00
Pavement Allowance	1	LS	$ 20,000.00	$ 20,000.00
EQUIPMENT				
40' Dia. Clarifier Equipment (incl full trough skim, eff. baffle & weirs, and Stamford baffles)	3	EA	$ 270,000.00	$ 810,000.00
Misc. Metals (grating, rails, hatches)	1	LS	$ 75,000.00	$ 75,000.00
Weir Gates	3	EA	$ 10,000.00	$ 30,000.00
RAS Pumps w/ VFDs	3	EA	$ 27,000.00	$ 81,000.00
RAS Flow Meters	3	EA	$ 4,725.00	$ 14,000.00
WAS Pumps w/ VFDs	3	EA	$ 27,000.00	$ 81,000.00
WAS Flow Meters	3	EA	$ 4,725.00	$ 14,000.00
Process Piping/Valve Allowance	1	LS	$ 50,000.00	$ 50,000.00
Yard Piping and Valve Allowance	1	LS	$ 200,000.00	$ 200,000.00
Sludge Blanket Detectors	3	EA	$ 8,775.00	$ 26,000.00
ELECTRICAL & INSTRUMENTATION				
Electrical Allowance	1	LS	$ 250,000.00	$ 250,000.00
Instrumentation Allowance	1	LS	$ 50,000.00	$ 50,000.00
SCADA Allowance	1	LS	$ 30,000.00	$ 30,000.00
			SUBTOTAL	***$ 4,776,000.00***
			Contractor OH&P - 15%	$ 716,000.00
			Contingency - 30%	$ 1,433,000.00
			TOTAL PROBABLE CONSTRUCTION COST YEAR 2024	***$ 6,925,000.00***
			Design Phase Engineering Services - 10%	$ 693,000.00
			Construction Phase Engineering Services - 10%	*$ 693,000.00*
			TOTAL PROJECT COST YEAR 2024	***$ 8,311,000.00***

1. Design and Construction engineering costs are estimates and do not reflect actual engineering costs.
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CONVENTIONAL BARDENPHO
EPPING, NH
CONCEPTUAL OPINION OF PROBABLE CONSTRUCTION & PROJECT COST
DENITRIFICATION FILTER

Date: 8/26/2024

ITEM	QUANTITY	UNIT	UNIT PRICE	PROBABLE COST
GENERAL				
General Requirements (12% of construction subtotal)	1	LS	$ 374,400.00	$ 374,000.00
CIVIL				
Earthwork & retaining wall allowance	1	LS	$ 50,000.00	$ 50,000.00
Dewatering allowance	1	LS	$ 50,000.00	$ 50,000.00
Sitework regrading	1	LS	$ 25,000.00	$ 25,000.00
Concrete (includes pump room on one end)				
Filter Walls	298	CY	$ 1,500.00	$ 447,000.00
Filter Floor Slab & Pump Room Slab	219	CY	$ 1,500.00	$ 329,000.00
Pump Room Walls	108	CY	$ 1,500.00	$ 162,000.00
Pump Room Roof	44	CY	$ 1,500.00	$ 66,000.00
Pavement Allowance	1	LS	$ 10,000.00	$ 10,000.00
EQUIPMENT				
Denit Filter Equipment (2 cells)	1	LS	$ 1,660,500.00	$ 1,661,000.00
Process Piping/Valve Allowance	1	LS	$ 50,000.00	$ 50,000.00
Plant Water Piping Allowance	1	LS	$ 10,000.00	$ 10,000.00
Yard Piping/Valve Allowance	1	LS	$ 50,000.00	$ 50,000.00
ELECTRICAL & INSTRUMENTATION				
Electrical Allowance	1	LS	$ 150,000.00	$ 150,000.00
Instrumentation Allowance	1	LS	$ 50,000.00	$ 50,000.00
SCADA Allowance	1	LS	$ 10,000.00	$ 10,000.00
			SUBTOTAL	***$ 3,494,000.00***
			Contractor OH&P - 15%	$ 524,000.00
			Contingency - 30%	$ 1,048,000.00
			TOTAL PROBABLE CONSTRUCTION COST YEAR 2024	**$ 5,066,000.00**
			Design Phase Engineering Services - 10%	*$ 507,000.00*
			Construction Phase Engineering Services - 10%	*$ 507,000.00*
			TOTAL PROJECT COST YEAR 2024	***$ 6,080,000.00***

1. Design and Construction engineering costs are estimates and do not reflect actual engineering costs.
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CONVENTIONAL BARDENPHO
EPPING, NH
CONCEPTUAL OPINION OF PROBABLE CONSTRUCTION & PROJECT COST
TERTIARY MEMBRANES

Date: 8/26/2024

ITEM	QUANTITY	UNIT	UNIT PRICE	PROBABLE COST
GENERAL				
General Requirements (12% of construction subtotal)	1	LS	$ 545,490.00	$ 545,490.00
CIVIL				
Yard Piping allowance	200	LF	$ 350.00	$ 70,000.00
Earthwork & retaining wall allowance	1	LS	$ 100,000.00	$ 100,000.00
Dewatering allowance	1	LS	$ 100,000.00	$ 100,000.00
Sitework regrading	1	LS	$ 50,000.00	$ 50,000.00
Building and tank foundations	219	CY	$ 1,500.00	$ 328,500.00
Pavement Allowance	1	LS	$ 20,000.00	$ 20,000.00
BUILDING				
Building CMU wall & metal seamed roof	1,024	SF	$ 1,000.00	$ 1,024,000.00
EQUIPMENT				
Permeate pumps	4	EA	$ 20,250.00	$ 81,000.00
Sludge pumps	4	EA	$ 20,250.00	$ 81,000.00
Air scour blowers	3	EA	$ 33,750.00	$ 101,250.00
New hollow fiber membranes	4	EA	$ 350,000.00	$ 1,400,000.00
Membrane installation	4	EA	$ 130,000.00	$ 520,000.00
MECHANICAL				
Process piping allowance	4	EA	$ 50,000.00	$ 200,000.00
Air piping allowance	4	EA	$ 50,000.00	$ 200,000.00
Building HVAC	1	LS	$ 50,000.00	$ 50,000.00
ELECTRICAL & INSTRUMENTATION				
Electrical installation	1	LS	$ 150,000.00	$ 150,000.00
Instrumentation installation	1	LS	$ 50,000.00	$ 50,000.00
SCADA	1	LS	$ 20,000.00	$ 20,000.00

SUBTOTAL	***$ 5,091,000***
Contractor OH&P - 15%	$ 764,000
Contingency - 30%	$ 1,757,000
TOTAL PROBABLE CONSTRUCTION COST YEAR 2024	***$ 7,612,000***
Design Phase Engineering Services - 10%	*$ 761,000*
Construction Phase Engineering Services - 10%	*$ 761,000*
TOTAL PROJECT COST YEAR 2024	***$ 9,134,000***

1. Design and Construction engineering costs are <u>estimates</u> and do not reflect actual engineering costs.
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APPENDIX H

Hazen Peer Review Memorandum

Hazen

August 7, 2024

To: David Mercier, PE, Vice President, Underwood Engineers, Inc.

From: Robert Sharp, PE, PhD, Vice President, Hazen and Sawyer

cc: Sarah Galst, VP, Hazen and Sawyer

Re: Review of the Total Nitrogen Upgrade Study for the Epping, NH Wastewater Treatment Plant

Underwood Engineers contracted Hazen and Sawyer to provide technical and quality assurance review for the Total Nitrogen Upgrade Study for the Epping Wastewater Treatment Facility (WWTF) in Epping, New Hampshire. Hazen reviewed the technology evaluation and selection process, as well as the preliminary design of the different stages of upgrades that will be needed for the Epping WWTF to meet future total nitrogen limits.

Background

The Epping WWTF was designed to treat up to 0.5 MGD of municipal wastewater which is discharged to the Lamprey River. The plant's current discharge permit has seasonal CBOD, TSS, total phosphorus (TP) and ammonia nitrogen limits as shown in Table 1. The plant currently operates with one set of course and fine screens followed by a nitrifying membrane bioreactor (MBR) activated sludge process that utilizes intermittent aeration to achieve low ammonia levels and final UV disinfection. The plant site has two lagoons that serve as storage for excess flows and has, in the past, accepted significant volumes of septage. Solids at the plant are dewatered along with trucked sludge, with the dewatering filtrate being returned ahead of the fine screens and the final cake being trucked to a landfill.

Table 1: Current Epping WWTF Discharge Permit Limits

Parameter	Summer Jun 1 - Oct.31	Winter Nov 1 – May 31	Max Mo. Summer (Winter)
CBOD (mg/L)	5.0	8.0	10.0 (38)
TSS (mg/L)	3.0	5.0	6.0 (33)
TP (mg/L)	0.26	-	report
Ammonia as N (mg/L)	1.4	7.2	2.0 / (10.8)

Underwood Engineers was tasked with evaluating and selecting a treatment process for the Epping WWTF that would achieve the following;

1. Provide upgrades to preliminary treatment and MBR process to improve the reliability of the current treatment process to ensure the plant would not experience bypasses associated with treatment process failures or operational issues.

2. Expand near-term capacity to allow for trucked septage and additional flows/loads from planned sewer expansion.

3. Further expansion and upgrades to meet effluent TN limits as low as 3.0 mg/L while maintaining the current TSS limit of 3.0 mg/L for a flow capacity of 0.5 MGD.

Reliability Upgrades

As the first step toward improving the Epping WWTF's operation and performance, Underwood has recommended that the plant implement a series of upgrades to improve the reliability of the existing treatment process. These reliability upgrades are critical not only for the existing plant operations, but also for the near-term and long-term upgrades discussed later in the report. These recommended upgrades include:

1- Construction of Peak Flow Buffer Tanks: The peak flow buffer tanks would store the short-term diurnal flow peaks that come into the plant that exceed the peak flow capacity of the MBR system assuming a peak MBR flux of 12 GFD,(gal/ft^2/d) which is conservative. Underwood evaluated the peak flow buffer volume requirements under current, near-term and long-term (20 year) flow conditions and estimated a required buffer volume of 125,000 gallons. Adding a 20% safety factor, Underwood recommended two 75,000 gallons buffer tanks. In conjunction with the construction of these tanks, Underwood assumes the town of Epping will successfully complete its Infiltration and Inflow (I and I) reduction program to alleviate peak flows during wet weather. The buffer tanks are critical to maintaining reliable and consistent treatment for both the current plant operation and the future upgrades.

2- Redundant Head Works: Install a duplicate set of coarse and fine screens. Currently the plant operates with only one set of coarse and fine screens. These screens serve as preliminary and primary treatment of the influent wastewater and are essential for protecting downstream processes, including the membranes. A redundant set of screens are critical for plant reliability and to ensure the membranes are not damaged by excess solids, grit and inerts entering the MBR process. A second set of screens should be installed immediately to improve the reliability of the treatment process.

3- Segregation of Membranes. Underwood recommends that each current MBR train (3 parallel trains) be upgraded with a separation wall to separate the MBR modules from the aeration tank (AT) to create separate, self-contained MBR tanks for each train. This will allow an MBR tank to be in operation when on AT is out of service and vis-a-versa. Most importantly, this modification will allow for the automation of the membrane cleaning process (scheduled maintenance cleaning and recovery cleaning) without needing to take a complete BNR train off-line. This upgrade is highly recommended and will be needed to effectively implement the near-term and long-term upgrades described below.

4- Fats, Oil and Grease (FOG)reduction. Underwood has emphasized the need for the Town to implement and enforce a FOG reduction program. Excess FOG can impact many aspects of the treatment process including overloading/blinding screens and premature fouling of membranes. Adequate FOG reduction and management is needed to further reduce the risk of operational upsets and to prolong the life of the new membranes. In addition to controlling influent FOG, design elements can be added to the proposed AT upgrades to include scum/foam collection. FOG control within the collection system should be a priority to protect the sewer systems as well as the treatment plant.

5- Membrane Cleaning. With the installation of new Zeeweed™ membranes in the three MBR trains, it is imperative the plant follow the manufacturer's stated cleaning protocols, including scheduled maintenance cleanings (backwash) with citric acid and hypochlorous acid, and prescribed recovery cleanings. Following the manufacturer's prescribed cleaning protocols will maintain needed membrane flux rates and prolong the life of the membranes. The plant should follow all vendor recommended maintenance to ensure long-term performance of the new membranes.

6- Waste Activated Sludge (WAS) Storage: Currently the plant uses a fourth aeration tank for WAS storage. For the near-term upgrades, the fourth AT will be needed as an MBR treatment train. To this end, a new WAS storage tank will be needed to accommodate dewatering operations and to provide a wide-spot in the process for sludge management.

Process Modeling

To evaluate and design the BNR upgrades for the Epping plant, Underwood developed a BioWin process model. Underwood conducted a supplemental sampling plan that was developed with the assistance of EnviroSim, the developer of the BioWin process model software. The purpose of the supplemental sampling was to characterize the influent wastewater so that the appropriate influent characteristics could be used in the model. The model was calibrated to the plant's current process. Hazen reviewed the sampling plan and the model development with Underwood and determined both to be adequate. The model did under-predict the level of denitrification occurring in the existing plant, which is common in plants where significant simultaneous nitrification/denitrification takes place due to poorly defined aerobic/anoxic zones, or in the case of Epping current operation, intermittent aeration. By underpredicting the level of denitrification, the process model could be considered conservative with respect to total nitrogen removal. Underwood was familiar with the model and requested assistance/confirmation from both Hazen and EnviroSim on specific aspects of the model including how to account for separate MBR tanks, septage loads, and low wastewater temperatures. In general, the model showed good calibration and was appropriate for assisting in the preliminary design of the plant upgrades discussed below.

Near-Term Upgrades

For the Town of Epping to consistently and reliably meet its near-term treatment capacity (~330,000 gpd ADF) it will need additional reactor volume. The process modeling indicated that each existing AT could treat approximately 85,000 GPD of flow operating with cyclic aeration to achieve nitrogen removal and a separate MBR tank. Underwood recommended that, in addition to all reliability upgrades discussed above, the plant should convert the existing fourth AT (currently being used as a sludge storage tank) to an MBR train. This would include converting the existing sludge storage tank to an MLE reactor (pre-anoxic zone followed by aerobic zone) and a separate MBR tank. This upgrade would also require an extension to the existing MBR building. To accommodate the 4th set of MBRs. The incorporation of a fourth BNR/MBR train will provide needed redundancy and reliability to the plant to ensure they can meet their current permit limits as they increase their sewer shed and recommence limited septage receiving, which serves as an important revenue source for the Town. These upgrades were reviewed by Hazen and appear to be a sound and logical step toward improving the current plant's capacity and reliability, while preparing for more significant upgrades that will be needed to increase capacity and meet more stringent effluent limits.

Long -Term Upgrades

As requested by the State of New Hampshire, Underwood evaluated a number of treatment technologies that would allow the Epping WWTF to meet new TN standards (TN< 3 mg/L) for a design capacity of 0.5 MGD (ADWF). Underwood worked with Hazen to develop a list of potential technologies for the BNR upgrades at the Epping plant. This list included eleven options that ranged from the traditional oxidation ditch process to innovative technologies like MicroVi bioaugmentation and Mobile Organic Biofilm (Nuvoda). Underwood, with the assistance of Hazen, presented these technologies to the Town of Epping and plant staff in a workshop where a multi-criteria evaluation was conducted to determine the top four options. The non-cost criteria that were used in the evaluation included:

- Ability to meet TN < 3 mg/L and a TSS < 3 mg/L
- Reliability
- Maturity of technology
- Operation and Maintenance (O&M) requirements
- Need for equalization

After the workshop, Underwood and Hazen independently evaluated the four final technologies, and all four evaluators (3 engineers from Underwood and 1 engineer from Hazen) concluded that that the 5-stage MBR process was the most appropriate technology for the following reasons:

- 5-stage MBR can meet the most stringent effluent TN limit of 3.0 mg/L.
- 5-stage MBR can meet the current TSS limit of 3.0 mg/L without additional unit processes.
- The plant is comfortable with operating MBRs.
- With the proposed reliability upgrades (including automation of the maintenance and recovery cleaning, and improved headworks and EQ) MBR operations will be further streamlined and the MBR process will be more dependable.
- The latest generation of quality MBR technologies allows for longer membrane life, lower energy demand, and greater reliability.
- MBRs are becoming increasingly more common, especially as effluent criteria get more stringent and higher levels of treatment are needed.
- The MBR system would be able to treat peak flows up to two times design flow (1 MGD) with the engineered peak flow buffer tanks temporarily storing flows that exceed 1 MGD.

- Other options would have required tertiary membranes to reliably achieve a TSS less than 3 mg/L. Tertiary membranes have similar O&M requirements to MBRs and would require additional labor and chemical use. Other options would also have required final clarifiers and larger ATs.
- The MBR option allows for the leveraging of existing infrastructure including four existing ATs and the MBR building.

The design and preliminary cost estimate of the 5-stage MBR upgrades were determined in part from information provided by the BioWin model developed by Underwood. The modeling indicated that the upgraded 5-stage MBR process designed to treat 0.5 MGD would require four 5-stage MBR trains in parallel. This would necessitate the construction of four additional ATs of the same dimensions/volume as the existing ATs. A single train would consist of 2 ATs in-series to form a 2-pass BNR treatment train with segregated MBR tanks at the end of the second pass as shown in **Figure 1**. This upgrade would allow for Epping to treat 0.5 MGD of wastewater (or equivalent load assuming limited trucked waste/septage) to meet stringent TN and TSS limits. The design considers a number of redundancies and utilizes conservative membrane flux rates to ensure ample MBR capacity. A conceptual process flow diagram of the complete upgraded (long-term) Epping WWTF is shown in **Figure 2** below.

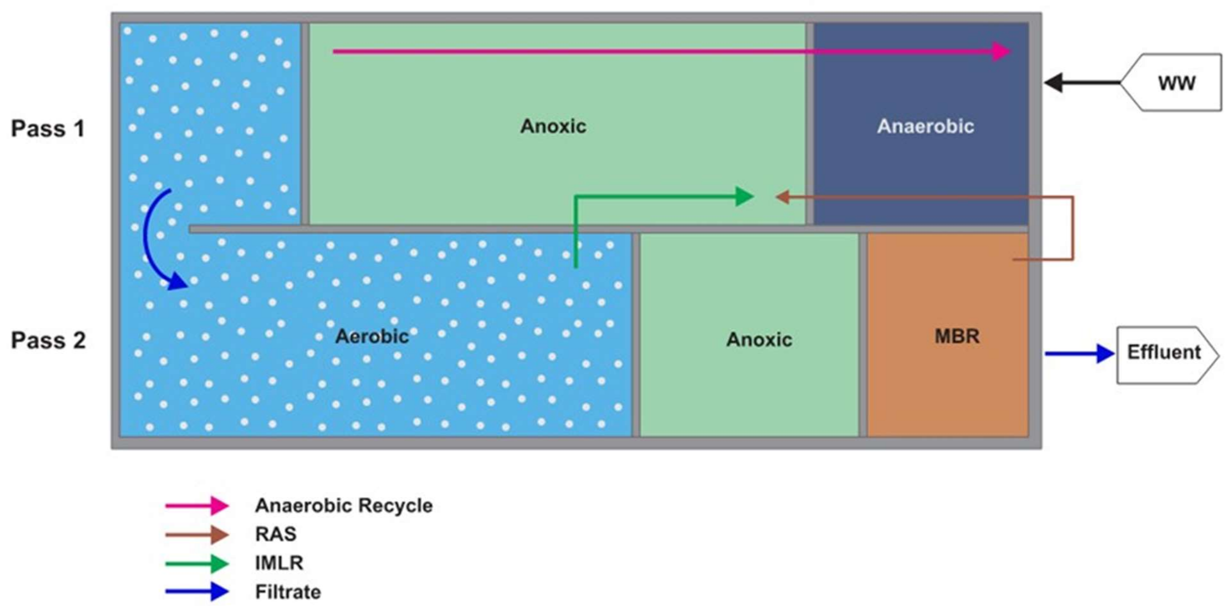

Figure 1 Conceptual Layout of the Proposed 5-Stage BNR Reactor

Summary

The process Underwood used to evaluate, plan and carryout a preliminary design for the needed upgrades at the Epping wastewater treatment plant was an effective and established practice commonly used by firms when planning and evaluating treatment plant upgrades. Utilzing a multi-criteria evaluation process, which included input from industry experts and multiple stake holders, combined with a technically sound modeling and design approach, Underwood has developed an upgrade plan and preliminary design that, if properly implemented, should allow Epping to reliably meet future capacity and regulatory requirements.

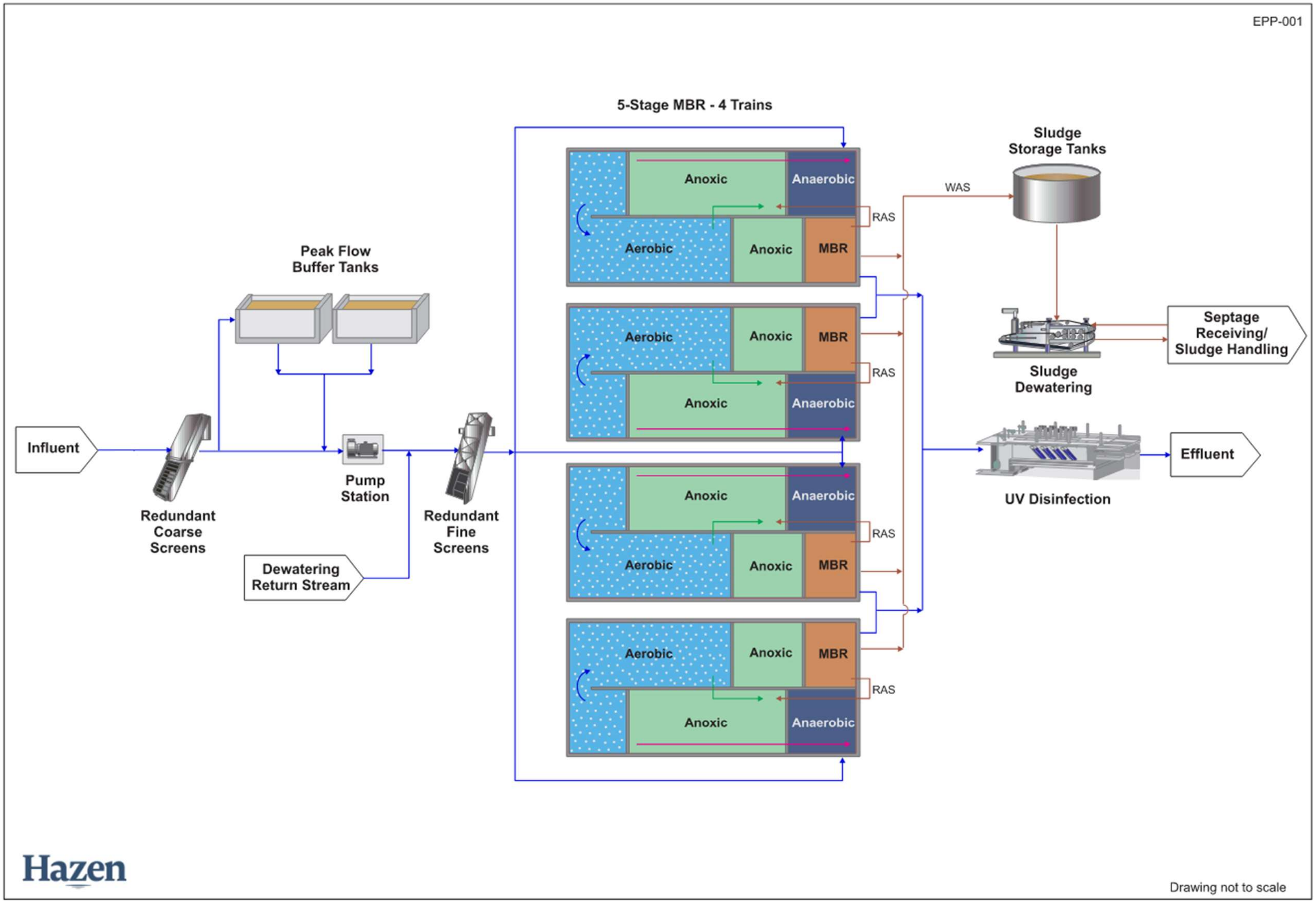

Figure 2 Conceptual Process Flow Diagram of Upgraded Epping WWTF