Section 3a

Blackstone River Watershed

ENGINEERING FEASIBILITY AND COST ANALYSES OF NITROGEN REDUCTION FROM SELECTED POTWS IN MASSACHUSETTS

SECTION 3 – BLACKSTONE RIVER WATERSHED

3.1 INTRODUCTION

The Blackstone River begins in Worcester, Massachusetts at the convergence of the Middle River and Mill Brook. It flows southward through Rhode Island to Narragansett Bay. This study includes seven POTWs that discharge directly to the Blackstone River.

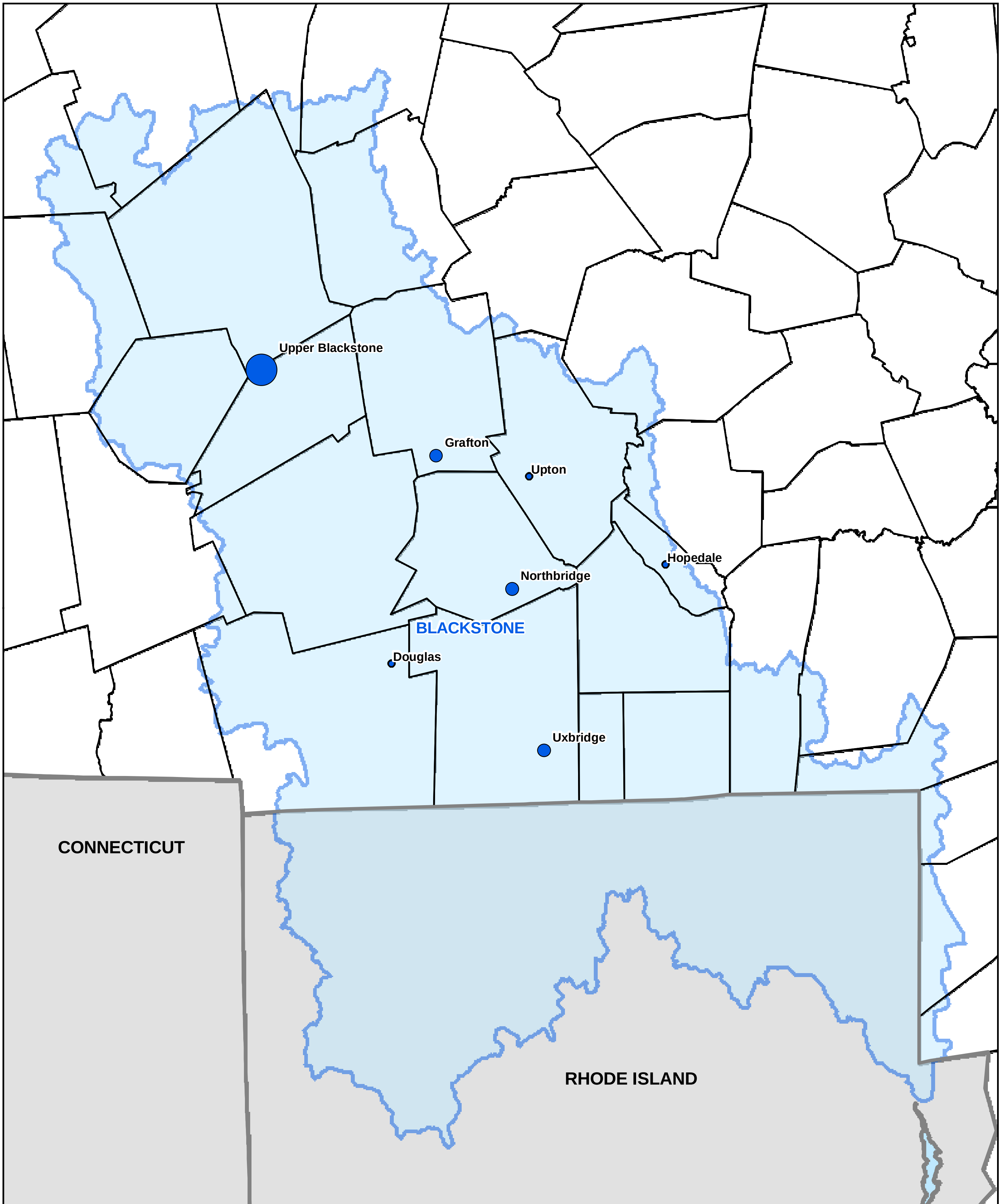
Photograph from Blackstone River Watershed Association

Figure 3.1-1 shows the Blackstone River watershed and the table below lists the seven facilities with their respective sizes. The impact of nitrogen removal at each of these facilities is presented in this section.

Table 3.1-1

BLACKSTONE RIVER POTWs

NAME OF FACILITY	PERMITTED CAPACITY
Upper Blackstone Water Pollution Abatement District	56 mgd
Grafton	2.4 mgd
Northbridge	1.8 mgd
Douglas	0.6 mgd
Upton	0.4 mgd
Uxbridge	2.5 mgd
Hopedale	0.6 mgd



N

POTW Permitted Flow Range (mgd)

0.1-1.0
1.1 - 5.0
5.1 - 10.0
10.1 - 50.0
50.1 - 100.0

Watershed
MA Town Boundaries

0 1 2 4 Miles

STEARNS & WHELER LLC
Environmental Engineers & Scientists

HYANNIS, MASSACHUSETTS

DATE: 10/31/07 JOB No.: 61625

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ENGINEERING FEASIBILITY AND COST ANALYSES OF NITROGEN REDUCTION FROM SELECTED POTWS IN MASSACHUSETTS

Permitted Flows for POTWs in Blackstone Watershed
Figure 3-1-1

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3.2 UPPER BLACKSTONE WATER POLLUTION ABATEMENT DISTRICT

A. **Introduction.** The Upper Blackstone Water Pollution Abatement District's (UBWPAD) regional wastewater treatment facility is located at 50 Route 20 in Millbury, MA. It has a permitted annual average capacity of 56 mgd. The facility serves the City of Worcester as well as Auburn, Cherry Valley Sewer District, Holden, Millbury, Rutland, West Boylston, and portions of Oxford, Paxton, Shrewsbury, and Sutton as well as treating septage and sludge from numerous other communities.

The original treatment facility was constructed around the 1880s and has been upgraded several times since. Prior to this decade, the current facility was last upgraded in 1976. The facility is now in the construction phase of the second of a four phase, multi-year upgrade.

B. **Existing Facilities.**

1. **Description of Existing Facilities.** Flow enters the facility by both gravity and force main. The raw sewage first passes through preliminary treatment which consists of mechanical bar screens and aerated grit chambers. The flow is then conveyed by gravity through a Parshall flume and then to primary treatment.

Aerial photo from www.google.com

After primary treatment, the flow is conveyed by gravity to the aeration tanks. The facility currently has six existing mechanical aeration tanks and is in the process of converting the six tanks to three long plug flow tanks and adding a fourth tank. Each tank will be 500 ft long by 84 ft wide with a 14.3 ft sidewater depth. All tanks will be in the A^2/O process configuration for biological nitrogen and phosphorus removal. The system also has the flexibility to operate in the A/O mode and MLE mode, depending on the season. The modified tanks will have a sidewater depth that varies form 15.9 ft at the anaerobic zone to 14.3 ft in the aerobic zone. All of the aeration tanks will have diffused aeration once the second phase of construction is complete in August 2009. The aeration tanks are followed by six existing and soon to be two additional new 14.6 ft deep, 140 ft diameter secondary clarifiers.

Secondary effluent flows into the chlorine contact tanks where the flow is disinfected and then dechlorinated prior to being discharged to the Blackstone River.

The facility also includes a wet weather discharge to manage peak flows on-site. Although the preliminary and primary treatment facilities are designed to treat a peak hour flow of 160 mgd, the advanced treatment system is designed to handle a peak hour flow of 120 mgd and a maximum day flow of 80 mgd. Flow in excess of the advanced treatment flow capacity is discharged through the wet weather discharge after being chlorinated and dechlorinated. The blend of the wet weather discharge and the advanced treatment discharge is still expected to meet the permit limits under statistically expected storm events.

Waste activated sludge at the facility is thickened in flotation thickeners prior to being combined with primary sludge from the primary treatment system. The combined sludges are then dewatered in a belt filter press prior to incineration in multiple hearth furnaces. A process flow schematic is shown in Figure 3.2-1.

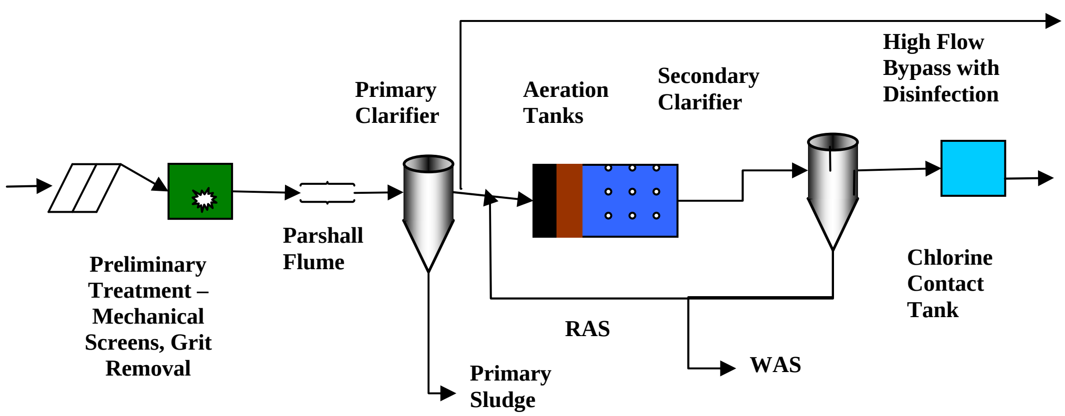


FIGURE 3.2-1: PROCESS FLOW SCHEMATIC – EXISTING FACILITY

The UBWPAD accepts septage from its member communities as well as from other communities. The septage receiving facilities discharge septage prior to the preliminary treatment process. The facility also accepts sludge from a number of communities. Sludge from outside the facility is mixed with facility sludge in the sludge holding tanks prior to being dewatered. In addition, the UBWPAD receives flows from the City of Worcester, which has combined sewers.

The facility has three samplers – one located downstream of preliminary treatment, one located downstream of the primary effluent, and one located at the plant effluent.

The UBWPAD has typically operated with four of the six existing aeration tanks and four of the secondary clarifiers (the south battery) in operation and used the north battery to manage high flows.

The plant has 53 full and part-time employees. This crew does not serve any collection systems or off site pumping stations.

Design flows and loads for the current upgrade (from the Contract Documents for the Phase II upgrade) are shown below in Table 3.2-1.

Table 3.2-1

DESIGN INFLUENT FLOW AND CONCENTRATIONS

PARAMETER	VALUE
Average Annual (design flow)	45 mgd
BOD	191 mg/L
TSS	196 mg/L
TKN	24 mg/L
TP	4.3 mg/L

2. **Summary of Plant Data.** Data from January 2004 through December 2006 was provided by the District for this study. A summary of the monthly data is shown in Table 3.2-2. Seasonal and annual average maximum month data are summarized in the table.

Table 3.2-2
UPPER BLACKSTONE WPAD
Millbury, Massachusetts
Monthly Averages 2003-2006

GENERAL		INFLUENT										EFFLUENT										
DATE		INF	pH	BOD	TSS	TVSS	TKN	TEMP	DO	AMMONIA NITROGEN	NO2/ NO3	DO	BOD	CBOD	TSS	TVSS	NO2 + NO3	TKN	TN	AMMONIA NITROGEN	ALKALINITY	OUTFALL TEMP
Month	Year	MGD		mg/L	mg/L	mg/L	mg/L	Deg F	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	Deg C
January	2004	36.7	7.1	197	155	137	0	52	3.2	14.7	0.7	8.9	13.7	10.2	9.0	8.0	2.7			10.1	118.1	50
February	2004	31.3	7.2	215	203	178	0	52	3.0	19.5	0.6	8.8	14.6	10.7	9.1	7.9	3.3			12.1	86.8	51
March	2004	34.7	7.1	186	210	184	0	52	5.4	15.2	0.4	8.4	10.9	6.3	7.9	6.7	2.2			7.6	64.1	53
April	2004	61.0	7.0	102	112	94	0	52	7.0	7.2	1.0	8.0	16.4	12.4	13.5	10.6	1.0			5.6	70.9	52
May	2004	40.9	7.0	147	152	128	0	59	4.1	11.6	0.6	7.8	9.2	7.1	8.8	7.3	1.5			8.7	66.9	61
June	2004	29.7	7.0	212	184	159	0	64	2.7	16.1	0.8	7.5	7.5	3.8	7.3	6.3	1.9			6.7	58.5	67
July	2004	28.5	6.8	203	180	153	22	68	1.0	15.6	0.4	7.3	8.3	4.2	9.9	8.6	4.5			2.1	42.5	72
August	2004	27.6	6.9	199	194	163	22	70	2.0	13.9	0.1	7.2	6.8	4.6	8.4	7.3	4.2			1.8	47.0	73
September	2004	33.4	6.9	192	172	151	23	69	2.9	13.7	0.6	7.3	5.6	4.4	5.4	4.8	3.8			0.9	44.2	71
October	2004	33.9	7.2	180	168	148	21	65	3.2	13.4	1.0	7.8	6.2	3.7	5.8	5.2	5.0			1.2	52.8	65
November	2004	33.9	7.2	190	186	159	26	61	3.5	15.6	0.7	8.4	14.1	8.7	12.6	10.4	5.8			3.0	45.6	60
December	2004	46.3	7.1	148	131	113	17	55	5.6	11.5	1.0	8.6	10.9	7.3	9.0	11.5	3.2			6.9	66.6	54
January	2005	46.7	7.1	142	120	109	19	51	6.9	13.1	1.2	9.1	10.0	7.9	8.0	6.8	1.4			10.8	107.5	51
February	2005	43.8	7.1	158	133	118	18	50	6.9	11.3	1.0	8.9	8.9	7.1	7.4	6.3	1.6			8.9	79.8	49
March	2005	44.8	7.0	154	124	108	19	50	5.2	12.1	1.0	8.8	13.2	7.0	8.7	9.2	1.4			9.3	76.9	50
April	2005	57.8	6.9	122	107	88	15	53	6.4	7.7	2.0	7.9	12.8	9.9	8.1	6.7	1.7			6.3	64.9	53
May	2005	45.4	7.0	128	132	116	17	56	4.7	11.8	1.0	7.7	10.0	7.0	7.8	6.6	1.7			7.8	70.3	58
June	2005	34.9	7.0	186	184	156	22	62	3.2	13.7	0.4	7.6	7.9	5.4	8.5	6.9	1.4			9.7	87.7	66
July	2005	34.0	7.1	179	167	142	21	67	3.1	12.8	0.5	7.4	6.3	4.0	7.0	5.9	2.8			2.6	52.3	70
August	2005	27.4	7.0	220	203	170	26	71	1.6	20.7	0.0	7.3	4.6	3.0	4.3	3.8	4.3			1.8	50.2	74
September	2005	27.8	7.0	230	218	186	27	71	1.5	21.2	0.8	7.3	7.6	5.1	8.9	7.7	7.8			7.2	63.8	73
October	2005	62.3	7.0	140	129	104	19	64	4.4	12.0	0.8	7.0	10.8	7.9	8.0	6.6	6.0			2.5	49.9	65
November	2005	47.3	7.0	152	152	124	18	60	2.9	14.8	0.0	7.8	12.3	7.5	9.9	8.5	4.2			3.6	49.6	59
December	2005	46.9	7.1	134	123	108	17	55	4.7	13.6	0.3	8.3	11.6	6.5	7.9	6.8	4.2			4.6	47.0	53
January	2006	56.8	7.1	111	93	80	14	52	6.0	11.1	1.0	8.4	13.5	8.3	10.6	8.6	2.4			6.2	59.7	51
February	2006	52.3	7.1	118	92	73	14	51	6.4	12.8	1.6	8.9	10.3	7.7	7.9	6.2	1.9			8.4	73.8	50
March	2006	26.6	7.2	185	150	131	24	53	5.4	19.2	0.5	9.2	8.2	4.5	6.0	5.4	0.5			13.7	104.1	54
April	2006	25.7	7.2	188	158	136	27	56	4.6	17.5	0.3	8.8	10.2	5.1	8.1	6.7	2.0			7.8	74.0	58
May	2006	40.5	7.0	143	125	103	17	58	4.5	9.8	1.3	7.4	17.3	12.2	11.6	9.7	2.9			2.8	52.9	59
June	2006	45.7	6.9	107	131	105	17	61	4.5	7.8	0.5	7.2	12.9	10.1	11.0	8.5	3.4			2.1	52.3	63
July	2006	27.7	6.8	163	168	139	21	67	3.2	12.7	0.2	7.3	5.9	3.2	6.6	5.6	6.6	3.0	9.6	1.6	43.5	71
August	2006	24.5	6.9	193	174	149	24	71	3.4	16.5	0.4	7.1	7.2	3.8	7.2	6.2	6.0	9.3	15.3	7.4	80.8	74
September	2006	23.2	6.9	203	181	157	26	69	2.7	17.0	0.8	7.3	7.1	2.9	5.6	4.8	7.8	6.4	14.2	5.0	65.6	70
October	2006	26.0	6.9	190	170	147	28	65	2.5	17.4	0.5	7.6	8.8	4.1	5.8	5.0	2.6	6.5	9.1	4.1	52.5	65
November	2006	40.4	6.9	114	118	101	17	60	3.6	11.0	0.3	7.4	9.6	4.7	6.1	4.7	1.4	6.2	7.6	4.5	58.3	60
December	2006	30.4	7.0	164	147	130	22	58	4.2	15.0	0.9	8.0	11.9	4.1	6.0	5.2	4.3	5.9	10.2	5.9	65.6	58
Min. Month		23.2	6.8	102	92	73	0	50	1.0	7.2	0.0	7.0	4.6	2.9	4.3	3.8	0.5			0.9	42.5	49
Seasonal Average		**34.1**	**7.0**	**179**	**168**	**143**	**19**	**65**	**3.1**	**14.3**	**0.6**	**7.4**	**8.3**	**5.3**	**7.7**	**6.5**	**4.1**			**4.2**	**57.4**	**68**
Average		**38.2**	**7.0**	**167**	**154**	**132**	**17**	**60**	**4.1**	**13.9**	**0.7**	**7.9**	**10.1**	**6.4**	**8.2**	**7.0**	**3.3**	**6.2**	**11.0**	**5.9**	**65.2**	**61**
Max. Month		62.3	7.2	230	218	186	28	71	7.0	21.2	2.0	9.2	17.3	12.4	13.5	11.5	7.8			13.7	118.1	74

With a current average annual flow of 38.2 mgd and a permitted capacity of 56 mgd, this facility is operating at approximately 68% of its permitted capacity.

Based on the average BOD concentration of 167 mg/L and TN concentration of 21 mg/L, this wastewater has a BOD concentration that is between weak and medium strength wastewater, but a TN concentration that is clearly weak. Thus, the TN/BOD ratio is 0.13 which is low (a more typical TN/BOD ratio is 0.18).

3. **Permit Requirements and Current Performance.** The current permit for this facility was signed on December 19, 2001. Monthly permit limits that are relevant to this study are shown below in Table 3.2-3. It should be noted that interim permit limits that are less stringent than the limits presented below were established in the 2001 permit. The limits below do not become effective until the completion of the Phase II wastewater treatment facility improvements which is scheduled for August 2009.

Table 3.2-3
SELECT MONTHLY PERMIT LIMITS

PARAMETER	LIMIT
$CBOD_5$	
November – April	25 mg/L (11,676 lb/d)
June – October	4,670 lb/d
May	9,341 lb/d
TSS	
November – April	14,011 lb/d
June – October	15 mg/L (7,006 lb/d)
May	9,341 lb/d
Ammonia-Nitrogen	
December – April	12 mg/L (5,600 lbs/d)
May	5 mg/L (2,330 lbs/d)
June – October	2 mg/L (934 lbs/d)
November	10 mg/L (4,670 lbs/d)
Phosphorus (seasonal)	0.75 mg/L

The facility appears to generally be in conformance with the BOD and TSS limits and is currently undergoing an upgrade to allow it to better meet the ammonia and phosphorus limits. Since the upgraded facility will have the ability to operate in the A^2/O mode and the MLE mode, a monthly total nitrogen limit of between 8 and 10 mg/L is expected to be achieved under the design year flow of 45 mgd. An average annual limit of 8 mg/L is expected to be able to be achieved with this upgrade.

4. **Nitrogen Removal Performance.** This facility collects a wide range of both influent and effluent nitrogen data as can be seen in Table 3.2-2. It has nitrified to varying degrees over the study period and will not have the ability to denitrify until the Phase II wastewater treatment facility improvements are complete in August 2009.

C. **Nitrogen Removal Alternatives.** The loading criteria that was used for this plant includes the flows and loads shown in Table 3.2-4 below. Because there is an active upgrade for nitrogen removal occurring at this site, the table below reflects the influent concentrations developed for this upgrade. Temperature data is from actual plant data over the past three years.

Table 3.2-4

MODEL INPUT PARAMETERS AT PERMITTED CAPACITY

PERMIT CONDITION	PARAMETER	VALUE
Annual Average	Flow, mgd	56
	BOD, mg/L	219
	TSS, mg/L	243
	TN, mg/L	31
	Temperature, F	50
Seasonal	Flow, mgd	56
	BOD, mg/L	219
	TSS, mg/L	243
	TN, mg/L	31
	Temperature, F	56

The model input data was used to run uncalibrated simulations to determine planning level, order-of-magnitude costs for implementing different levels of nitrogen reduction at the facility. A discussion of operational changes or minor modifications that can be made to the facility to improve current nitrogen reduction performance as well as a presentation of the simulation results are presented in the following sections.

It should be noted that the plant is currently being upgraded to accommodate a seasonal phosphorus limit that will be achieved through the use of the anaerobic zone in the new A^2/O process. This anaerobic zone is available for use as an anoxic zone when the phosphorus limits are not in effect. This study assumed that the anaerobic zone will continue to be used seasonally.

Plant recycles were accounted for through the modeling process. An estimate for sludge accepted from other communities was included in the model.

In addition, it should also be noted that the area located north of the aeration tank currently under construction, designated for the future fifth and sixth aeration tanks, has been determined to contain hazardous waste. Cost for remediation of this waste has been estimated to cost $4,000,000 and been included in the construction cost estimate for these tanks. Because of other site constraints it is assumed that the maximum number of aeration tanks for this site is six.

These evaluations were all conducted based on the assumption that the advanced treatment facilities at the UBWPAD would treat a flow of 100 mgd based on applying a ratio consisting of the permitted flow of 56 mgd to the current design flow of 45 mgd and multiplying that by the current max month flow of 80 mgd. Thus, all new facilities were based on treating flows up to 100 mgd. These upgrades <u>do not</u> consider the terms of the current draft permit which require the facility to achieve its proposed nitrogen limits at the peak flow of the facility. Further, it was not within the scope of this study, but any further analyses of this facility would need to consider the high flow bypass and its impact on recommended upgrades. For the purpose of this study, peak flow event were not considered.

It should be noted that due to the size and operating hours of this facility, additional operators were added with each new process.

1. **Minor Modifications/Retrofits.** Because there is an active upgrade occurring at this facility that will allow the facility to achieve a seasonal effluent TN of 8-10 mg/L at the design year average annual flow of 45 mgd, there are no other minor modifications or retrofits that could occur to allow the facility to reduce total nitrogen in the effluent.

2. **Modifications Required to Meet TN of 8 mg/L.** The modifications to the facility that are required to meet an effluent TN of 8 mg/L at the permitted design flow of 56 mgd on a seasonal and annual average basis are as follows.

a. **Seasonal.** At the estimated future TN load at this facility, an MLE process can be used to achieve a seasonal average TN of 8 mg/L. The A^2/O process can also be used to achieve a seasonal average TN of 8 mg/L. In order to maintain the anaerobic (and thus the A^2/O process), IFAS would be required in the aerobic zone. The BioWin model for the A^2/O process is shown in Figure 3.2-2 below.

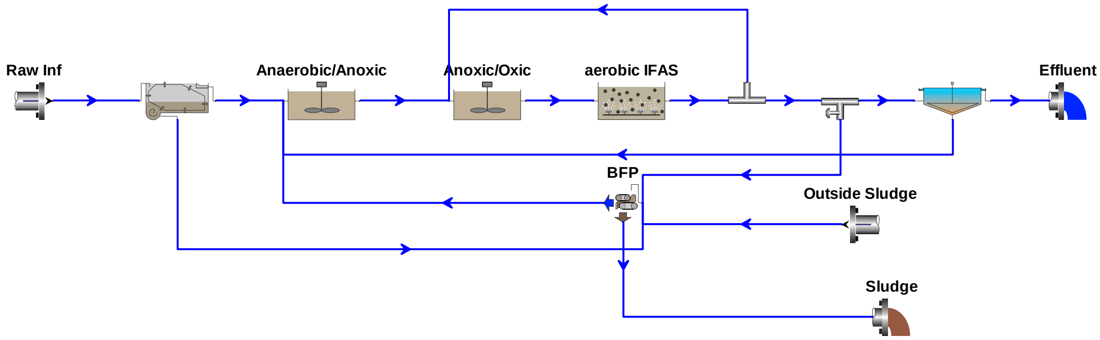


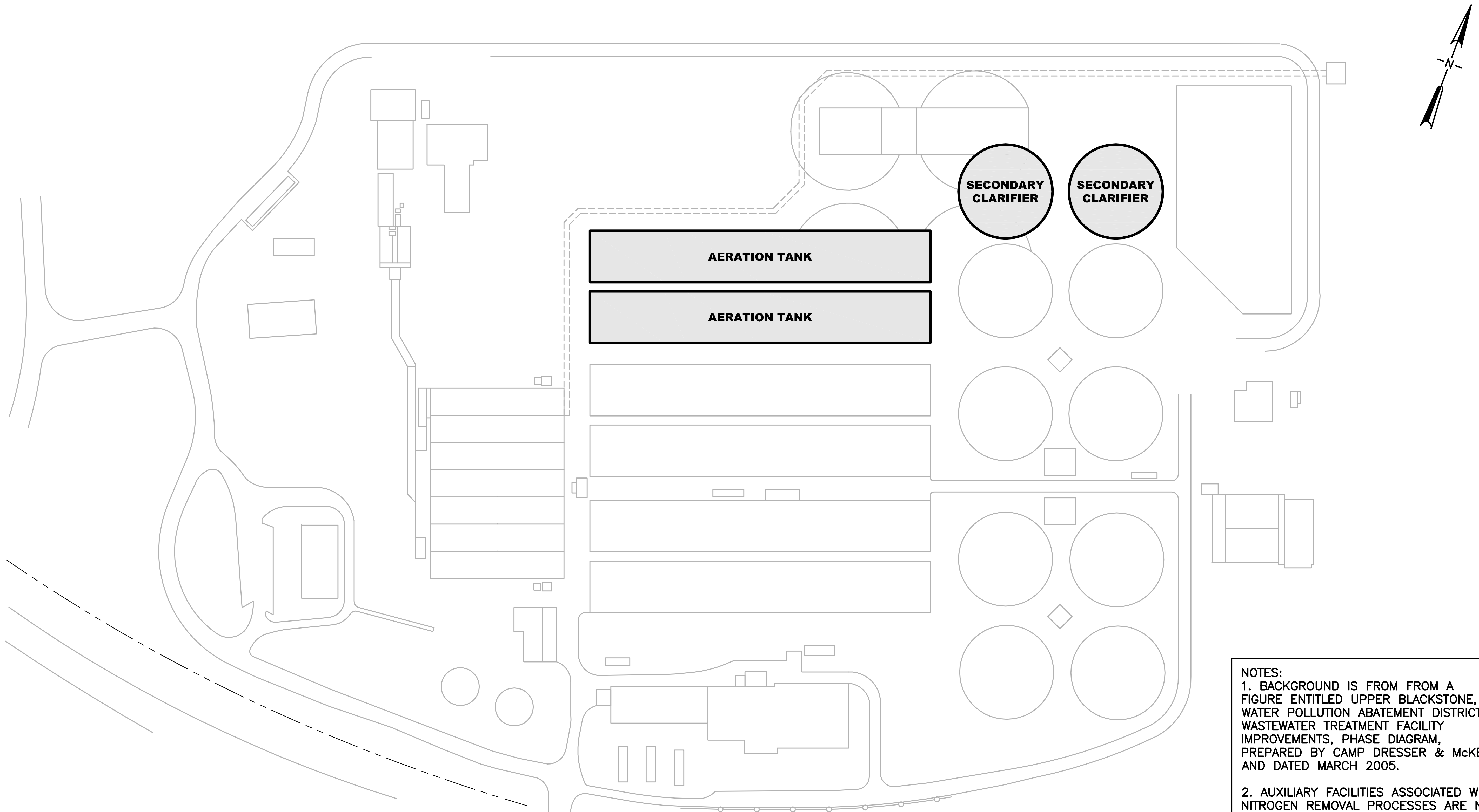
FIGURE 3.2-2: NITROGEN REMOVAL PROCESSES - SEASONAL LIMIT OF 8 mg/L

The MLE process will require a total of two additional tanks. Each of the new tanks will be the same size as the four (three existing and one new) aeration tanks.

In addition to the two new aeration tanks and in accordance with Section 2, it is also anticipated that the facility will require two additional secondary clarifiers (in addition to the existing eight) to operate at the future flow and loading condition. This assumes that the total flow through advanced treatment is 100 mgd (56 mgd/45 mgd * 80 mgd), and the balance of flow is discharged through the advanced treatment bypass. The site has adequate space for the additional clarifiers.

As shown in the site plan in Figure 3.2-3, the site has enough space for the additional aeration tanks and clarifiers. Specific information regarding the results of this analysis is shown in Table 3.2-5 below.

(continued)



NOTES:
1. BACKGROUND IS FROM FROM A FIGURE ENTITLED UPPER BLACKSTONE, WATER POLLUTION ABATEMENT DISTRICT, WASTEWATER TREATMENT FACILITY IMPROVEMENTS, PHASE DIAGRAM, PREPARED BY CAMP DRESSER & McKEE AND DATED MARCH 2005.

2. AUXILIARY FACILITIES ASSOCIATED WITH NITROGEN REMOVAL PROCESSES ARE NOT SHOWN.

150 0 150 300
1"=150'-0"

SITE PLAN
SCALE: 1"=150'-0"

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Filename: UPPER BLACKSTONE-CH3.dwg
Latest Revision: Friday, April 04, 2008

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ENGINEERING FEASIBILITY AND COST ANALYSES OF NITROGEN REDUCTION FROM SELECTED POTWS IN MASSACHUSETTS

UPPER BLACKSTONE, MASSACHUSETTS
FIGURE 3.2-3

Table 3.2-5

RESULTS FOR SEASONAL LIMIT OF 8 mg/L TN

PARAMETER	VALUE
Aerobic SRT	6.3 days
Total SRT	12 days
First Anoxic Fraction	30%
Total Anoxic Fraction	30%
Reaeration HRT	n/a
RAS Rate	100%
Total Volume	27.65 MG
Nitrate Recycle Rate	300%
Max MLSS at Loading rate	4200 mg/L
Effluent TN	8 mg/L
Methanol Addition	No
Fixed Film Required?	Yes, 40% fill
Clarifiers?	Reuse existing and add two new ones
Effluent Filtration Required?	No

Note: The anaerobic fraction for the A^2/O process is 18%

Also, the inclusion of IFAS in the activated sludge system may necessitate an upgrade to the influent screening system. Other plant modifications may be needed including upgrades to sludge handling processes. However, all facilities outside of the activated sludge process are outside of the scope of this study.

b. **Annual Average.** At the estimated future TN load at this facility, an MLE process can be used to achieve an annual average TN of 8 mg/L. The A^2/O process can also be used to achieve an average annual TN of 8 mg/L. In order to maintain the anaerobic zone in the warmer months (and thus the A^2/O process) IFAS would be required in the aerobic zone. The BioWin model for this process is shown in Figure 3.2-4 below.

(continued)

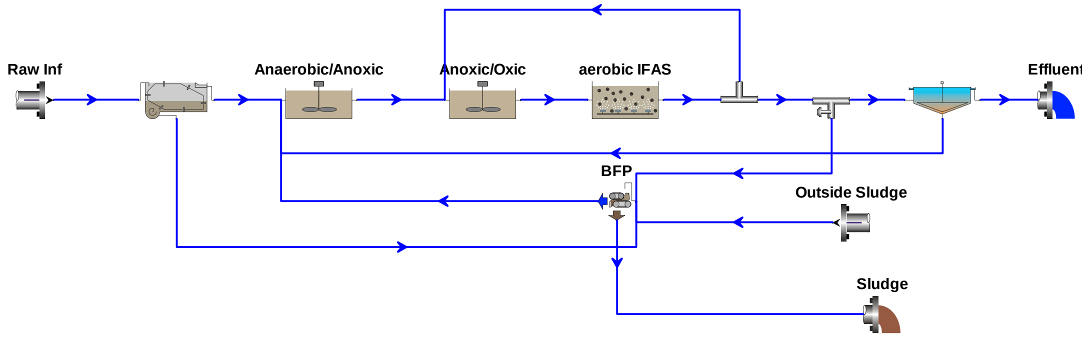


FIGURE 3.2-4:
NITROGEN REMOVAL PROCESSES – ANNUAL AVERAGE LIMIT OF 8 mg/L

Similar to the seasonal option, the MLE process will require a total of two additional tanks. Each of the new tanks will be the same size as the four (three existing and one new) aeration tanks.

In addition to the two new aeration tanks and in accordance with Section 2, it is also anticipated that the facility will require two additional secondary clarifiers (in addition to the existing eight) to operate at the future flow and loading condition. This assumes that the total flow through advanced treatment is 100 mgd (56 mgd/45 mgd * 80 mgd), and the balance of flow is discharged through the advanced treatment bypass. The site has adequate space for the additional clarifiers.

As shown in the site plan in Figure 3.2-3, the site appears to have enough space for the additional aeration tanks and clarifiers. Specific information regarding the results of this analysis is shown in Table 3.2-6 as follows.

(continued)

Table 3.2-6

RESULTS FOR ANNUAL AVERAGE LIMIT OF 8 mg/L TN

PARAMETER	VALUE
Aerobic SRT	8 days
Total SRT	12 days
First Anoxic Fraction	32%
Total Anoxic Fraction	32%
Reaeration HRT	n/a
RAS Rate	100%
Total Volume	27.65 MG
Nitrate Recycle Rate	300%
Max MLSS at Loading Rate	4000 mg/L
Effluent TN	8 mg/L
Methanol Addition	No
Fixed Film Required?	Yes, 40% fill
Clarifiers?	Reuse existing and add two new ones
Effluent Filtration Required?	No

Also, the inclusion of IFAS in the activated sludge system may necessitate an upgrade to the influent screening system. Other plant modifications may be needed including upgrades to sludge handling processes. However, all facilities outside of the activated sludge process are outside of the scope of this study.

3. **Modifications Required to Meet a TN of 5.** The modifications to the facility that are required to meet an effluent TN of 5 mg/L on a seasonal and annual average basis are as follows.

a. **Seasonal.** At the estimated future TN load, this facility will require the MLE or A^2/O process described above and a denitrification filter to trim the nitrates to achieve a seasonal average TN of 5 mg/L. As indicated above, the MLE or A^2/O process both require six aeration tanks, the maximum number that can fit on the site, all with IFAS in the aerobic zone. The nitrogen removal processes are shown in Figure 3.2-5 below.

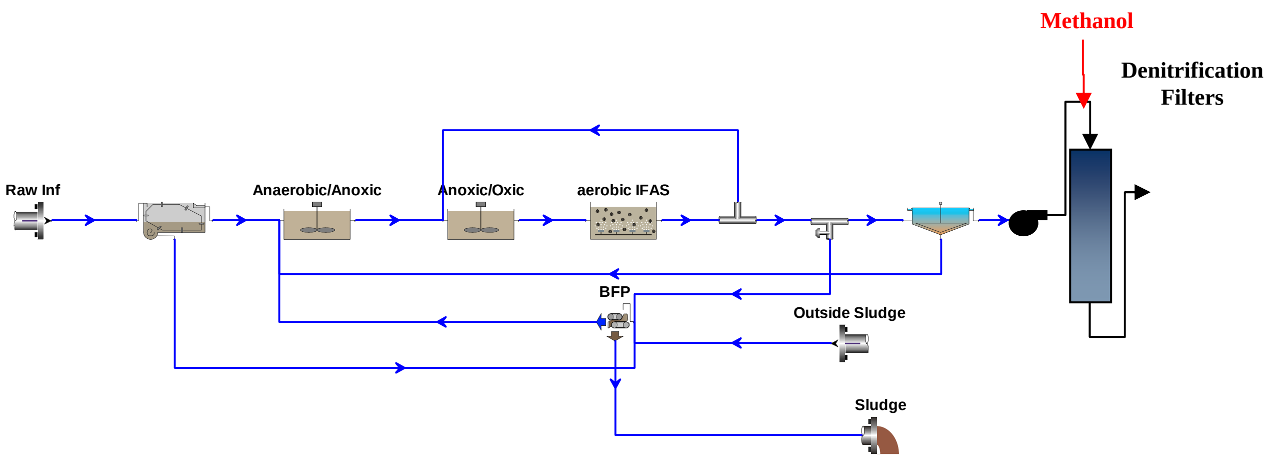


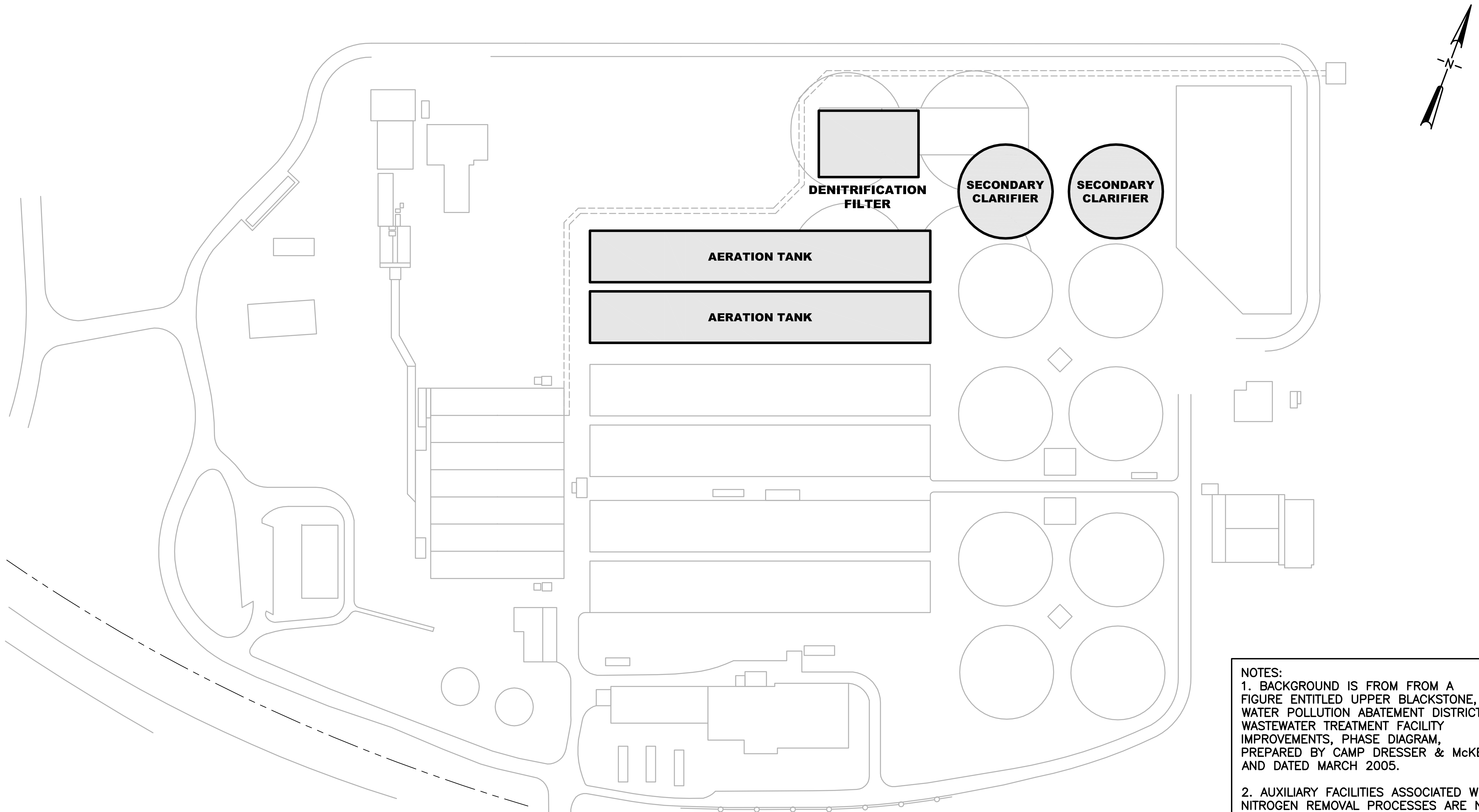
FIGURE 3.2-5: NITROGEN REMOVAL PROCESSES – SEASONAL LIMIT OF 5 mg/L

Similar to the options for achieving a TN of 8 mg/L, the MLE/ A^2/O process will require a total of two additional tanks – each the same size as the four (three existing and one new) aeration tanks. In addition, the process will require a denitrification filter to further trim the nitrates. The denitrification filter complex would have an approximate footprint of 14,500 square feet with eight cells that are approximately 30 ft by 25 ft each.

In addition to the two new aeration tanks and in accordance with Section 2, it is also anticipated that the facility will require two additional secondary clarifiers (in addition to the existing eight) to operate at the future flow and loading condition. This assumes that the total flow through advanced treatment is 100 mgd (56 mgd/45 mgd * 80 mgd), and the balance of flow is discharged through the advanced treatment bypass. The site has adequate space for the additional clarifiers.

As shown in the site plan in Figure 3.2-6, the site appears to have enough space for the additional aeration tanks, clarifiers and denitrification filter complex. Specific information regarding the results of this analysis is shown in Table 3.2-7 below.

(continued)



NOTES:
1. BACKGROUND IS FROM FROM A FIGURE ENTITLED UPPER BLACKSTONE, WATER POLLUTION ABATEMENT DISTRICT, WASTEWATER TREATMENT FACILITY IMPROVEMENTS, PHASE DIAGRAM, PREPARED BY CAMP DRESSER & McKEE AND DATED MARCH 2005.

2. AUXILIARY FACILITIES ASSOCIATED WITH NITROGEN REMOVAL PROCESSES ARE NOT SHOWN.

150 0 150 300
1"=150'-0"

SITE PLAN
SCALE: 1"=150'-0"

Login name: JDF
Filename path: J:\60000\61265 MADEP\10\Drawings\Fig
Filename: UPPER BLACKSTONE-CH3.dwg
Latest Revision: Friday, April 04, 2008

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ENGINEERING FEASIBILITY AND COST ANALYSES OF NITROGEN REDUCTION FROM SELECTED POTWS IN MASSACHUSETTS

UPPER BLACKSTONE, MASSACHUSETTS
FIGURE 3.2-6

Table 3.2-7

FOR SEASONAL LIMIT OF 5 mg/L TN

PARAMETER	VALUE
Aerobic SRT	6.3 days
Total SRT	12 days
First Anoxic Fraction	30%
Total Anoxic Fraction	30%
Reaeration HRT	n/a
RAS Rate	100%
Total Volume	27.65 MG
Nitrate Recycle Rate	300%
Max MLSS at Loading Rate	4200 mg/L
Effluent TN	5 mg/L
Methanol Addition	Yes, in denitrification filter
Fixed Film Required?	Yes, 40% fill
Clarifiers?	Reuse existing and add two new ones
Effluent Filtration Required?	Yes, denitrification filter

Also, the inclusion of IFAS in the activated sludge system may necessitate an upgrade to the influent screening system. Other plant modifications may be needed including upgrades to sludge handling processes. However, all facilities outside of the activated sludge process are outside of the scope of this study.

b. **Annual Average.** At the estimated future TN load, this facility will require the MLE or A^2/O process described above and a denitrification filter to trim the nitrates to achieve an annual average TN of 5 mg/L. As indicated above, the MLE or A^2/O processes both require six aeration tanks all with IFAS in the aerobic zone. The nitrogen removal processes are shown in Figure 3.2-7 below.

(continued)

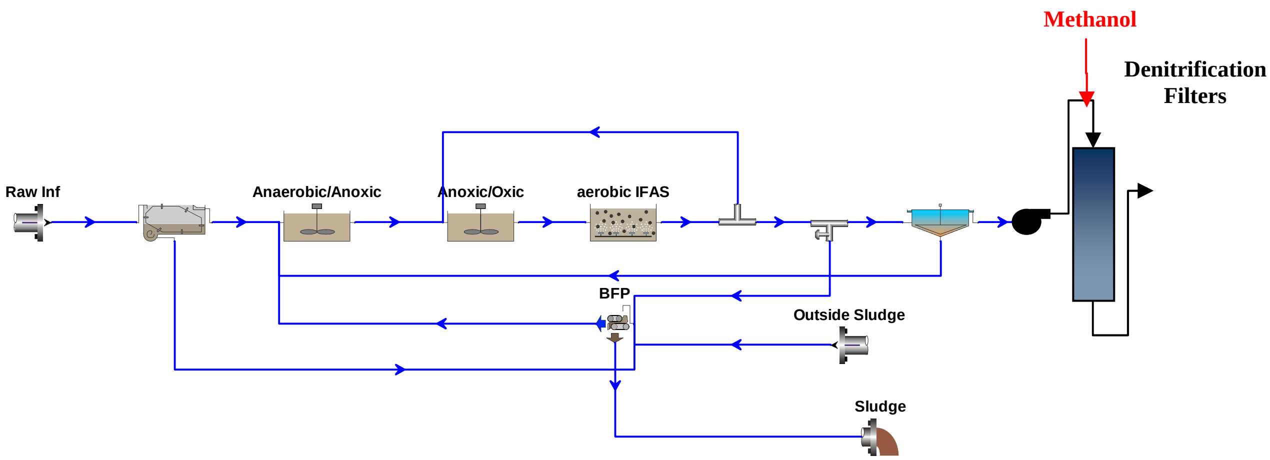


FIGURE 3.2-7: NITROGEN REMOVAL PROCESSES – ANNUAL AVERAGE LIMIT OF 5 mg/L

Similar to the options for achieving a TN of 8 mg/L, the MLE/ A^2/O process will require a total of two additional tanks – each the same size as the four (three existing and one new) aeration tanks. In addition, the process will require a denitrification filter to further trim the nitrates. The denitrification filter complex would have an approximate footprint of 14,500 square feet with eight cells that are approximately 30 ft by 25 ft each.

In addition to the two new aeration tanks and in accordance with Section 2, it is also anticipated that the facility will require two additional secondary clarifiers (in addition to the existing eight) to operate at the future flow and loading condition. This assumes that the total flow through advanced treatment is 100 mgd (56 mgd/45 mgd * 80 mgd), and the balance of flow is discharged through the advanced treatment bypass. The site has adequate space for the additional clarifiers.

As shown in the site plan in Figure 3.2-6, the site appears to have enough space for the additional aeration tanks, clarifiers and denitrification filter. Specific information regarding the results of this analysis is shown in Table 3.2-8 as follows.

Table 3.2-8

RESULTS FOR ANNUAL AVERAGE LIMIT OF 5 mg/L TN

PARAMETER	VALUE
Aerobic SRT	6.3 days
Total SRT	12 days
First Anoxic Fraction	32%
Total Anoxic Fraction	32%
Reaeration HRT	n/a
RAS Rate	100%
Total Volume	27.65 MG
Nitrate Recycle Rate	300%
Max MLSS at Loading Rate	4000 mg/L
Effluent TN	5 mg/L
Methanol Addition	Yes, in denitrification filter
Fixed Film Required?	Yes, 40% fill
Clarifiers?	Reuse existing and add two new ones
Effluent Filtration Required?	Yes, denitrification filter

Also, the inclusion of IFAS in the activated sludge system may necessitate an upgrade to the influent screening system. Other plant modifications may be needed including upgrades to sludge handling processes. However, all facilities outside of the activated sludge process are outside of the scope of this study.

4. **Modifications Required at Reduced Design Flow.** The Upper Blackstone Facility is the only one in this study that is undergoing a nitrogen removal upgrade at a reduced design flow of 45 mgd (instead of the permitted capacity of 56 mgd). Because this design flow differs from the permitted capacity, a limited evaluation of this facility was conducted to determine what upgrades would be required to achieve an average annual effluent TN limit of 5 mg/L.

In order to achieve an effluent TN limit of 5 mg/L and based on the assumptions in this report, the facility would require one additional aeration tank, IFAS in each of the five aeration tanks and at least one additional clarifier (for proper flow splitting a second clarifier may also need to be added).

D. **Plant and Cost Summary.**

Table 3.2-9 presents flow data for the Upper Blackstone Water Pollution Abatement District as well as the current nitrogen removal performance of the plant.

Table 3.2-9
PLANT FLOW AND EFFLUENT LIMIT SUMMARY

PARAMETER	VALUE
Permitted Flow (mgd)	56
Existing Flow (2004-6)	38.2
% of existing capacity	68
Current average seasonal effluent TN (mg/L) [1]	9.8
Current average annual effluent TN (mg/L) [1]	10.7
Permit Limits Seasonal Nitrification (mg/L) Year-round nitrification (mg/L) Seasonal TN Limit Annual TN Limit	 Yes (2-5) Yes (2-12) No No

1. TKN is assumed to be 1.5 mg/L

Table 3.2-10 presents the nitrogen removal processes identified in this section to achieve the four different permit conditions considered. Based on the loading conditions established for this facility and the subsequent BioWin modeling performed using this data, the facility improvements include adding two additional aeration tanks, adding IFAS to the aerobic zones of all tanks, one clarifier and, to achieve 5 mg/L TN, a denitrification filter. It should be noted that for all permit conditions, it was assumed that the anaerobic zone would remain in use for seasonal phosphorus removal. If the anaerobic volume were not required for phosphorus removal, IFAS would not be required in the tanks.

Table 3.2-10
NITROGEN REMOVAL PROCESS SUMMARY FOR UBWPAD

MINOR/ MODIFICATIONS OR RETROFITS	PROCESS TO ACHIEVE SEASONAL TN OF 8 MG/L	PROCESS TO ACHIEVE ANNUAL AVERAGE TN OF 8 MG/L	PROCESS TO ACHIEVE SEASONAL TN OF 5 MG/L	PROCESS TO ACHIEVE ANNUAL AVERAGE TN OF 5 MG/L
Undergoing an upgrade for Nitrogen Removal	A^2/O	A^2/O	A^2/O and a denitrification filter	A^2/O and a denitrification filter

The modifications required at the UBWPAD to convert to a new nitrogen removal process are summarized in Table 3.2-11.

Table 3.2-11

REQUIRED MODIFICATIONS SUMMARY FOR THE UBWPAD AT 56 MGD

MODIFICATIONS TO ACHIEVE SEASONAL TN OF 8 MG/L	MODIFICATIONS TO ACHIEVE ANNUAL AVERAGE TN OF 8 MG/L	MODIFICATIONS TO ACHIEVE SEASONAL TN OF 5 MG/L	MODIFICATIONS TO ACHIEVE ANNUAL AVERAGE TN OF 5 MG/L	SPECIAL CONDITIONS
2 new aeration tanks with IFAS and two new clarifiers	2 new aeration tanks with IFAS and two new clarifiers	2 new aeration tanks with IFAS, two new clarifiers and a denitrification filter	2 new aeration tanks with IFAS, two new clarifiers and a denitrification filter	Hazardous waste on site

1. At 45 mgd and an annual average TN of 5 mg/L, the modifications would consist of one new aeration tank, IFAS in all tanks and at least one new clarifier.

The cost estimating procedures established in Section 2 were used to estimate capital, annual O&M, and 20-year present worth costs associated with the process changes and facility modifications summarized above. The cost estimates are included in Table 3.2-12.

Table 3.2-12

COST SUMMARY FOR NITROGEN REMOVAL AT THE UBWPAD[1] AT 56 MGD

LIMIT	CAPITAL COSTS (IN MILLIONS)	TOTAL ANNUAL COSTS[2] (IN THOUSANDS)	20-YR PRESENT WORTH (IN MILLIONS)
Minor Modifications/Retrofits	None	n/a	n/a
Seasonal Effluent TN of 8 mg/L	$130	$800	$140
Annual Average Effluent TN of 8 mg/L	$130	$1,100	$150
Seasonal Effluent TN of 5 mg/L	$180	$1,700	$200
Annual Average Effluent TN of 5 mg/L[3]	$180	$2,400	$210

1. It should be noted that these costs represent one method by which this facility can achieve the stated TN goals. It is not intended to be the most cost effective method nor the recommended method, but it represents a planning tool for MassDEP to estimate the fiscal impacts of establishing total nitrogen limits.
2. Represents incremental increase over current conditions.
3. For comparison, at a design flow of 45 mgd, the capital cost for this alternative is estimated to be $90 million.

3.3 GRAFTON

A. **Introduction.** The Grafton Wastewater Treatment Plant (WWTP) is located at 9 Depot Street in South Grafton, MA. It has a permitted annual average capacity of 2.4 mgd and serves the Town of Grafton and one building in Shrewsbury. Septage is accepted from Northborough, Westborough and Grafton.

The facility was originally constructed in 1979 as a secondary treatment facility. The major change that has occurred on the site since it was constructed is the sludge processing facilities are no longer used. Prior to 1979, the site had three sewage lagoons.

B. **Existing Facilities.**

1. **Description of Existing Facilities.** All flow is pumped to the Grafton WWTP. This flow first passes through mechanical bar screens. The flow is then conveyed by gravity to the aerated grit chambers. Ferric chloride is added prior to the bar screens for phosphorus removal.

Aerial photo taken from www.google.com

After grit removal, flow is conveyed by gravity to the clarithickeners where a combined primary and waste activated sludge settles. Primary effluent is then conveyed by gravity to the aeration tanks.

The facility has two aeration tanks. Each tank is 80 ft long by 40 ft wide with a 14 ft sidewater depth. The aeration tanks have mechanical aerators. The aeration tanks are followed by two 12 ft deep, 55 ft diameter secondary clarifiers.

Secondary effluent flows into the chlorine contact tanks each of which is located as a concentric tank around the clarifier. After disinfection, the plant flow is discharged to the Blackstone River. Sludge is hauled off site for disposal. A process flow schematic is shown in Figure 3.3-1.

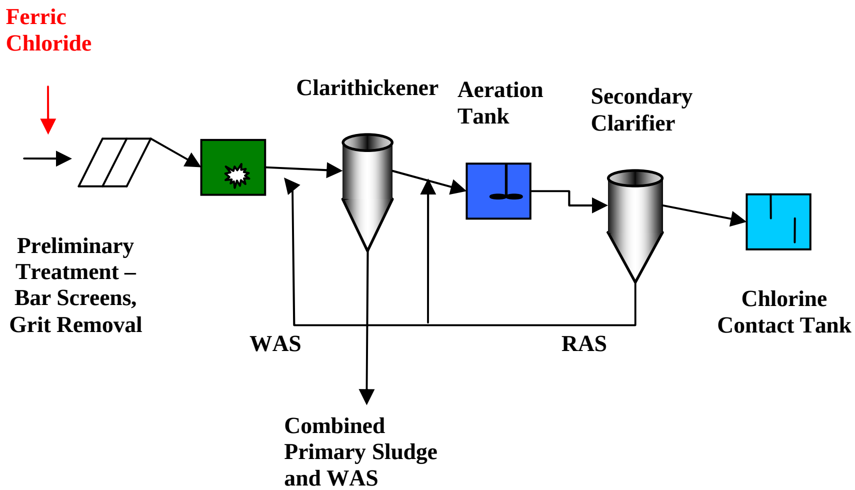


FIGURE 3.3-1: PROCESS FLOW SCHEMATIC – EXISTING FACILITY

All plant recycle flows are conveyed to an onsite pump station where they are then introduced into the plant influent prior to sampling. The effluent sampler is located after disinfection.

For the past two years, both aeration tanks have been online at the request of EPA. Prior to then, only one aeration tank was operational.

There are five employees at the facility plus a summer laborer. This group serves the plant, pump stations and collection system.

Design flows and loads for the most recent upgrade were not made available.

2. **Summary of Plant Data.** Data from January 2004 through December 2006 was provided by the Town for this study. A summary of the monthly data is shown in Table 3.3-1. Seasonal and annual average maximum month data are summarized in the table.

Table 3.3-1

GRAFTON WWTP

Grafton, Massachusetts

Monthly Averages 2004-2006

GENERAL		INFLUENT					EFFLUENT					
DATE		INF	PH	BOD	TSS	TEMP	DO	BOD	TSS	FECAL	NO2 + NO3	NH3
MONTH	YEAR	MGD		MG/L	MG/L	DEG F	MG/L	MG/L	MG/L	COLI.	MG/L	MG/L
January	2004	1.80	6.8	210	144	51	8.2	12	10			
February	2004	1.54	6.8	256	201	50	8.3	13	8		3.3	15.06
March	2004	1.66	7.0	330	277	50	8.1	10	6		2.6	14.50
April	2004	2.90	6.9	224	265	49	8.4	8	6	45	1.8	7.88
May	2004	2.08	7.0	235	277	54	7.9	9	7	48	3.0	10.00
June	2004	1.61	7.1	235	367	57	7.2	5	5	42	9.8	4.90
July	2004	1.35	6.9	243	313	60	7.2	9	6	36	10.0	3.03
August	2004	1.39	6.9	217	282	62	6.5	17	19	40	7.9	5.03
September	2004	1.53	6.8	190	296	63	6.8	11	10	6	9.7	4.16
October	2004	1.68	6.9	192	341	62	7.5	6	8	4	9.1	5.03
November	2004	1.62	7.2	351	362	59	7.6	11	4		9.3	7.50
December	2004	2.23	7.1	244	222	55	8.0	22	8		6.6	5.93
January	2005	2.66	7.0	255	201	51	8.6	16	8		2.8	12.95
February	2005	2.26	7.1	224	230	49	9.2	13	5		2.6	13.05
March	2005	2.18	7.1	270	228	48	8.9	12	5		2.1	9.64
April	2005	2.88	7.0			50	9.1				1.8	9.90
May	2005	2.27	6.9	236	204	53	8.2	9	5	16	1.1	9.70
June	2005	1.84	6.7	196	261	57	7.6	7	5	6	7.8	4.56
July	2005	1.59	6.8	149	322	60	6.8	5	6	12	11.9	4.95
August	2005	1.38	6.8	170	340	63	6.8	10	9	36	8.4	3.75
September	2005	1.41	6.9	248	368	64	6.7	6	8	11	16.4	2.30
October	2005	2.83	6.8	152	280	61	7.6	6	4	49	8.0	2.50
November	2005	2.50	7.0	278	269		8.0	15	4		13.4	5.80
December	2005	2.41	7.0	213	192	54	8.3	13	3		8.9	5.03
January	2006	2.81	7.1	202	159	51	8.9	15	5		1.1	6.40
February	2006	3.36	7.1	193	176	50	9.5	11	4		0.9	7.58
March	2006	1.83	7.1	229	304	50	9.3	6	7		0.5	11.48
April	2006	1.71	7.1	248	386	52	8.7	10	7	8	0.5	10.78
May	2006	2.33	7.0	251	328	54	7.9	11	5	18	0.7	1.92
June	2006	2.80	6.8	194	272	57	7.7	5	5	14	7.1	2.93
July	2006	1.77	6.7	218	220	60	6.7	5	3	13	0.8	2.38
August	2006	1.51	6.6	252	532	63	6.7	4	3	10	0.6	0.46
September	2006	1.48	6.8	236	342	64	6.8	4	5	12	18.4	0.65
October	2006	1.48	6.8	216	349	62	8.6	4	4	4	14.9	1.26
November	2006	1.98	7.1	305	316	59	9.5	11	5			
December	2006	1.90	7.0	270	265	56	9.1	8	6		16.1	0.75
Min. Month		1.35	6.60	149	144	48.13	6.50	4	3	4	0.46	0.46
Seasonal Average		**1.80**	**6.84**	**213**	**316**	**59.71**	**7.29**	**7.39**	**6.50**	**20.85**	**8.09**	**3.86**
Average		**2.02**	**6.94**	**232**	**283**	**55.92**	**7.97**	**9.69**	**6.23**	**21.44**	**6.46**	**6.29**
Max. Month		3.36	7.20	351	532	64.24	9.50	22.00	19.00	48.81	18.36	15.06

With a current average annual flow of 2.02 mgd and a permitted capacity of 2.40 mgd, this facility is operating at almost 85% of its permitted capacity.

Based on the average BOD concentration of 232 mg/L, this wastewater is slightly higher than medium strength.

The plant does receive industrial flows including an airplane parts manufacturer which contributes aluminum, cadmium and molybdenum from rinse tanks. Leachate from the Southbridge landfill is also accepted.

3. **Permit Requirements and Current Performance.** The current permit for this facility has been in effect since September 30, 1999. Monthly permit limits that are relevant to this study are shown below in Table 3.3-2.

Table 3.3-2

SELECT MONTHLY PERMIT LIMITS

PARAMETER	LIMIT
(C) BOD_5	
November – May	30 mg/L
June - October	20 mg/L
TSS	
November – May	30 mg/L
June - October	20 mg/L
Ammonia-Nitrogen	
December – April	15 mg/L
May, November	10 mg/L
June - October	5 mg/L
Nitrate and Nitrite	Report

Since the most recent permit took effect, the plant has met nearly all of the above limits missing only the ammonia limits on several occasions.

4. **Nitrogen Removal Performance.** This facility does not collect influent nitrogen data. However, various effluent nitrogen data is collected and can be seen in Table 3.3-1. The plant reduced ammonia to relatively low levels for most of 2006

C. **Nitrogen Removal Alternatives.** The existing maximum month loads over the three-year data collection period were used to determine the BioWin input data. The influent data which correspond to maximum-month loads is shown in Table 3.3-3 below for each permitting scenario. The minimum temperature for the permit condition is also shown. In addition, due to a lack of influent nitrogen data, the TN/BOD ratio was estimated to be 0.18.

Table 3.3-3

EXISTING INFLUENT PARAMETERS

PERMIT CONDITION	PARAMETER	VALUE
Annual Average	Flow, mgd	2.50
	BOD, mg/L	278
	TSS, mg/L	338
	TN, mg/L	50
	Temperature, F	48
Seasonal	Flow, mgd	2.33
	BOD, mg/L	251
	TSS, mg/L	305
	TN, mg/L	45
	Temperature, F	53

The existing plant data was then projected to the permitted capacity of the facility to develop model input parameters for the average annual and seasonal model runs. This projected data is shown in Table 3.3-4.

(continued)

<u>Table 3.3-4</u>

MODEL INPUT PARAMETERS AT PERMITTED CAPACITY

PERMIT CONDITION	PARAMETER	VALUE
Annual Average	Flow, mgd	2.98
	BOD, mg/L	278
	TSS, mg/L	338
	TN, mg/L	50
	Temperature, F	48
Seasonal	Flow, mgd	2.77
	BOD, mg/L	251
	TSS, mg/L	305
	TN, mg/L	45
	Temperature, F	53

The model input data was used to run uncalibrated simulations to determine planning level, order-of-magnitude costs for implementing different levels of nitrogen reduction at the facility. A discussion of operational changes or minor modifications that can be made to the facility to improve current nitrogen reduction performance as well as a presentation of the simulation results are presented in the following sections.

Based upon our review of the site plan, the site has a designated area for two additional aeration tanks, just to the west of the existing tanks. Adding additional tanks to the west is not feasible due to the presence of a portion of the Blackstone River. The site appears to have ample other space for expansion, but with limited head between the aeration tanks and clarifiers, locating aeration tanks at more remote locations may require pumping to the secondary clarifiers. Thus, for the purposes of this report, it was assumed that two additional aeration tanks could be added to the site.

1. **Minor Modifications/Retrofits.** This facility is currently operating at over 80% of its permited capacity. At the assumed influent TN levels, it is not anticipated that the facility could achieve any appreciable nitrogen removal simply through minor modifications or retrofits.

2. **Modifications Required to Meet TN of 8.** The modifications to the facility that are required to meet an effluent TN of 8 mg/L on a seasonal and annual average basis are as follows.

a. **Seasonal.** At the assumed influent TN levels for this facility, an MLE process will not accomplish a seasonal effluent TN level of 8 mg/L. The MLE process will yield a seasonal effluent TN of 11 mg/L.

Thus, the Bardenpho process with methanol addition was explored. The Bardenpho process with methanol addition would require seven aeration tanks (five in addition to the two existing). As was explained earlier, this is unlikely to fit well on the site. Thus, the alternative that fits well given the site constraints includes the expansion of the aeration tanks to yield a total of four aeration tanks and a total of 1.34 million gallons of capacity. This volume is adequate to fully nitrify the projected loads at this facility and then nitrates can be removed through the use of denitrification filters. The denitrification filter complex would have an approximate footprint of 2900 square feet with four cells that are approximately 14 ft square each. These nitrogen removal processes are shown in Figure 3.3-2 below.

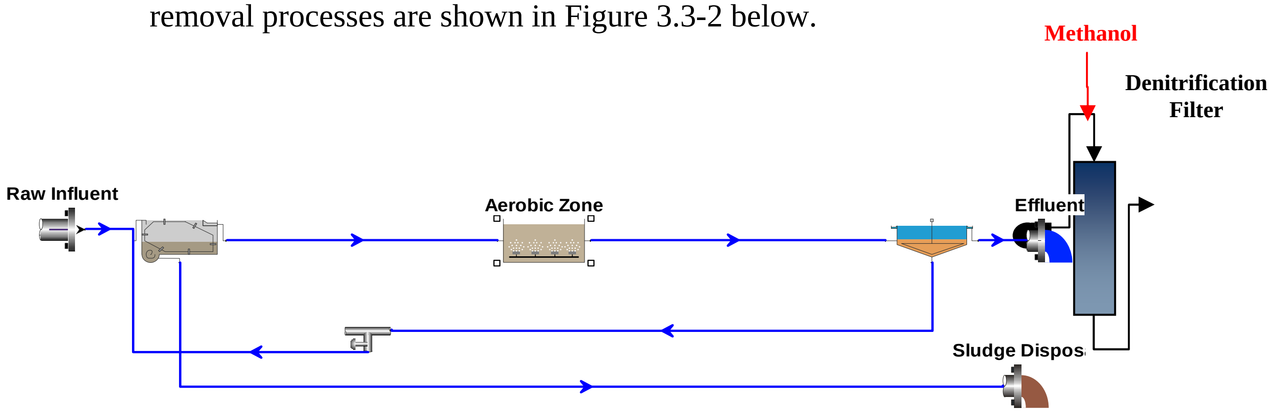


FIGURE 3.3-2: NITROGEN REMOVAL PROCESSES - SEASONAL LIMIT OF 8 mg/L

In addition to the new aeration tanks and denitrification filters, it is anticipated that one additional secondary clarifier will be required to handle the MLSS concentration. The site plan has space reserved for this clarifier. Also, it should be noted that the clarifiers at this facility are twelve feet deep. According to TR-16, clarifiers at nitrogen removal facilities should be a minimum of 13 feet deep. The clarifiers meet the minimum requirements set forth in Section 2, but they will have to be further evaluated to consider if they will require replacement or derating because of the shallow depth.

As shown in the site plan in Figure 3.3-3, the site appears to have enough space for the additional aeration tanks, clarifier and denitrification filters. Specific information regarding the results of this analysis is shown in Table 3.3-5 below.

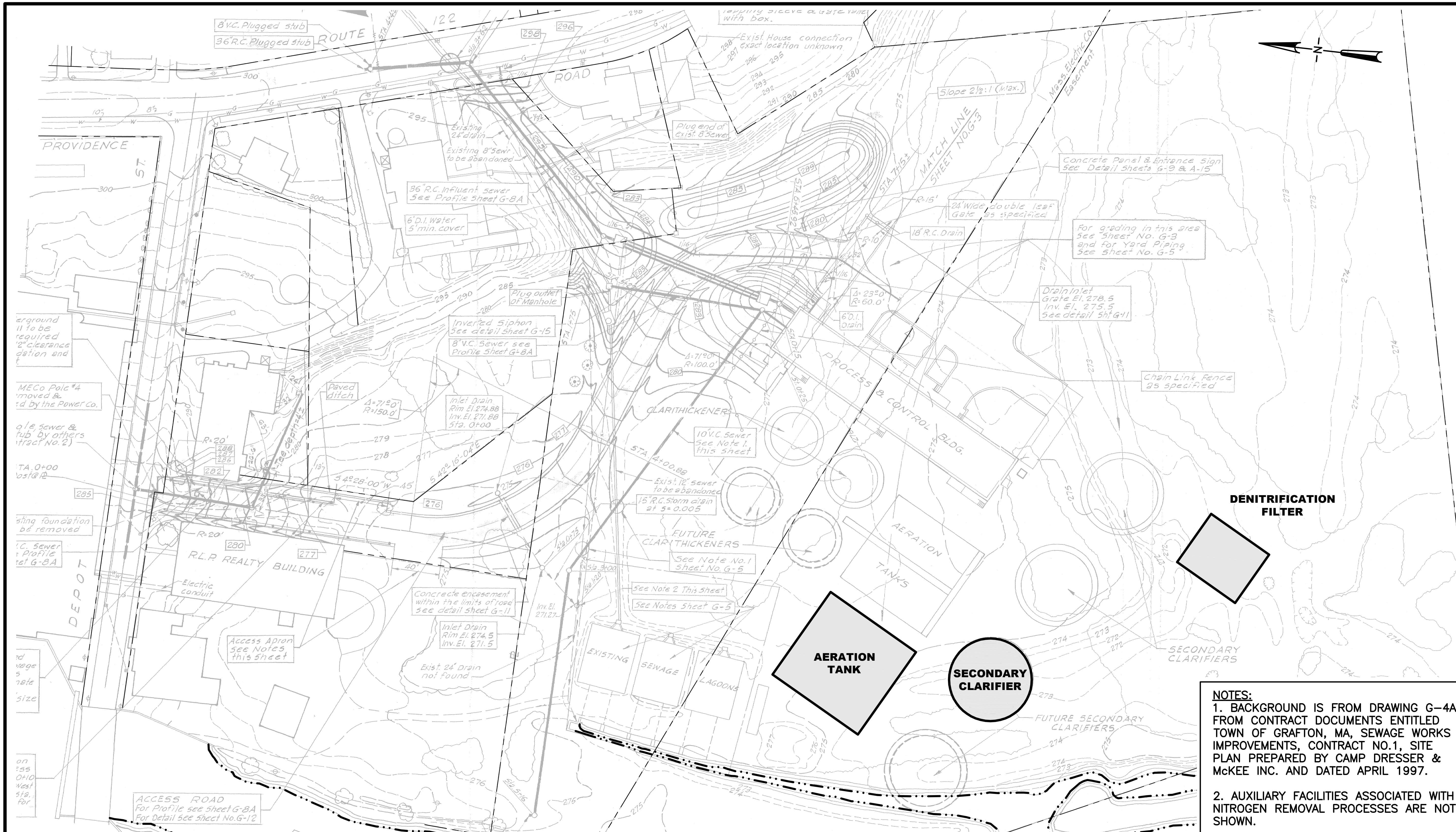
Table 3.3-5

RESULTS FOR SEASONAL LIMIT OF 8 mg/L

PARAMETER	VALUE
Aerobic SRT	7 days
Total SRT	7 days
First Anoxic Fraction	n/a
Total Anoxic Fraction	n/a
Reaeration HRT	n/a
RAS Rate	100%
Total Volume	1.34 MG
Nitrate Recycle Rate	n/a
Max MLSS at Loading Rate	3400 mg/L
Effluent TN	8 mg/L
Methanol Addition	Yes, in denitrification filter
Fixed Film Required?	No
Clarifiers?	Reuse existing and add one new one
Effluent Filtration Required?	Yes, denitrification filter

Other plant modifications may be needed including upgrades to sludge handling to accommodate the higher sludge production. However, all facilities outside of the activated sludge process are outside of the scope of this study.

b. **Annual Average.** As indicated above, at the assumed influent TN levels for this facility, an MLE process will not accomplish an average annual effluent TN level of 8 mg/L. The MLE process will yield an annual average effluent TN of about 11 mg/L. For the same reasons outlined above, the recommended process for this alternative is to add two additional aeration tanks for nitrification and denitrification filters. The denitrification filter complex would have an approximate footprint of



NOTES:
1. BACKGROUND IS FROM DRAWING G–4A FROM CONTRACT DOCUMENTS ENTITLED TOWN OF GRAFTON, MA, SEWAGE WORKS IMPROVEMENTS, CONTRACT NO.1, SITE PLAN PREPARED BY CAMP DRESSER & McKEE INC. AND DATED APRIL 1997.

2. AUXILIARY FACILITIES ASSOCIATED WITH NITROGEN REMOVAL PROCESSES ARE NOT SHOWN.

80 0 80 160
1"=80'–0"

SITE PLAN

SCALE: 1"=80'–0"

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ENGINEERING FEASIBILITY AND COST ANALYSES OF NITROGEN REDUCTION FROM SELECTED POTWS IN MASSACHUSETTS

GRAFTON, MASSACHUSETTS
FIGURE 3.3–3

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Latest Revision: Friday, April 04, 2008

2900 square feet with four cells that are approximately 14 ft square each. In addition, because of the low winter temperature, IFAS will be required in the aeration tanks. These nitrogen removal processes are shown in Figure 3.3-4 as follows.

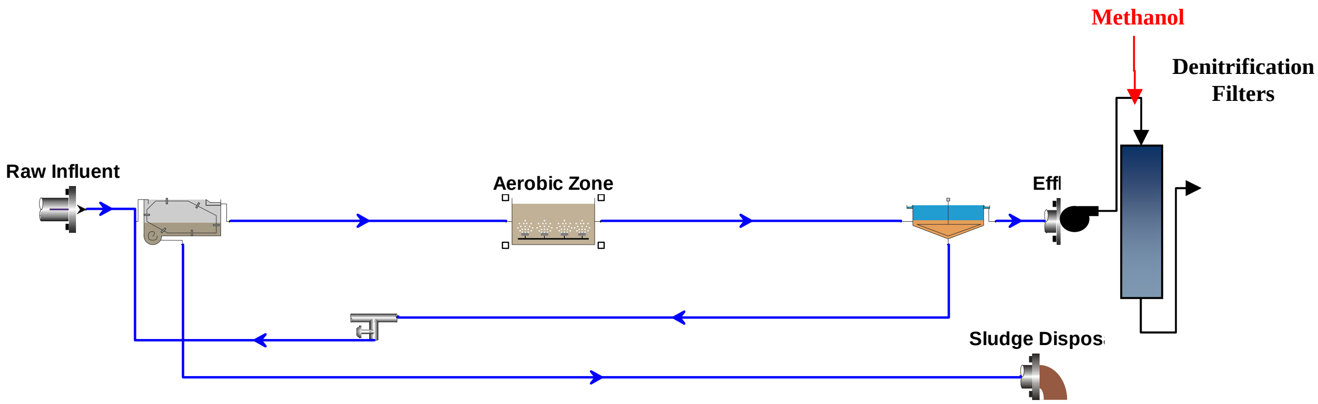


FIGURE 3.3-4:
NITROGEN REMOVAL PROCESSES – ANNUAL AVERAGE LIMIT OF 8 mg/L

In addition to the new aeration tanks and denitrification filters, it is anticipated that one additional secondary clarifier will be required to handle the MLSS concentration. The site plan has space reserved for this clarifier. Also, it should be noted that the clarifiers at this facility are twelve feet deep. According to TR-16, clarifiers at nitrogen removal facilities should be a minimum of 13 feet deep. The clarifiers meet the minimum requirements set forth in Section 2, but they will have to be further evaluated to consider if they will require replacement or derating because of the shallow depth.

As shown in the site plan in Figure 3.3-3, the site appears to have enough space for the additional aeration tanks, clarifier and denitrification filters. Specific information regarding the results of this analysis is shown in Table 3.3-6 as follows.

(continued)

<u>Table 3.3-6</u>

RESULTS FOR ANNUAL AVERAGE LIMIT OF 8 mg/L

PARAMETER	VALUE
Aerobic SRT	6 days
Total SRT	6 days
First Anoxic Fraction	n/a
Total Anoxic Fraction	n/a
Reaeration HRT	n/a
RAS Rate	100%
Total Volume	1.34 MG
Nitrate Recycle Rate	n/a
Max MLSS at loading rate	3600 mg/L
Effluent TN	8 mg/L
Methanol Addition	Yes, in denitrification filter
Fixed Film Required?	Yes, 40% fill
Clarifiers?	Reuse existing and add one new one
Effluent Filtration Required?	Yes, denitrification filter

Other plant modifications may be needed including upgrades to sludge handling to accommodate the higher sludge production. However, all facilities outside of the activated sludge process are outside of the scope of this study.

3. **Modifications Required to Meet a TN of 5.** The modifications to the facility that are required to meet an effluent TN of 5 mg/L on a seasonal and annual average basis are as follows.

a. **Seasonal.** At the assumed influent TN levels for this facility and for the same reasons outlined previously for part 3.3 C.2, the recommended alternative for this facility is to add two additional aeration tanks and denitrification filters. This configuration would allow the facility to achieve a seasonal effluent TN of 5 mg/L as shown in Figure 3.3-5.

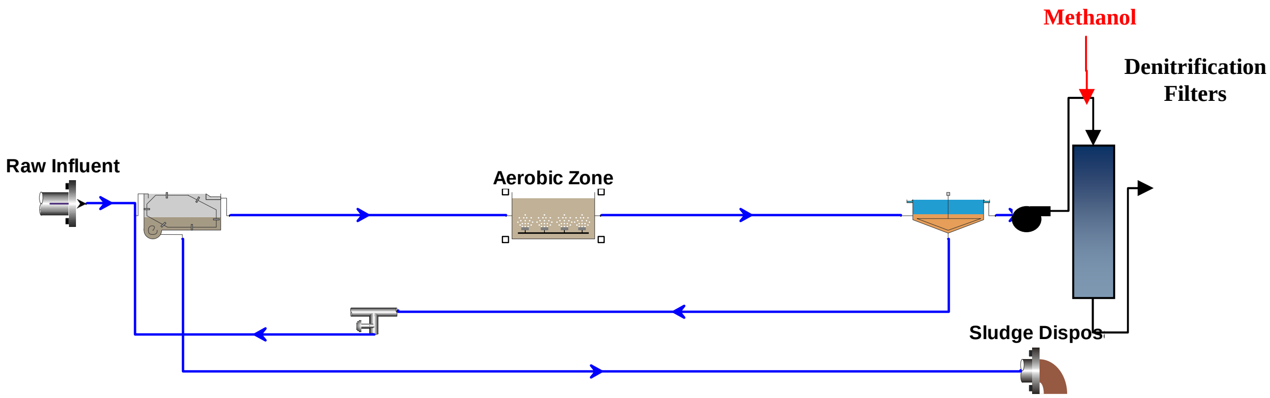


FIGURE 3.3-5: NITROGEN REMOVAL PROCESSES – SEASONAL LIMIT OF 5 mg/L

In addition to the new aeration tanks and denitrification filters, it is anticipated that one additional secondary clarifier will be required to handle the MLSS concentration. The site plan has space reserved for this clarifier. Also, it should be noted that the clarifiers at this facility are twelve feet deep. According to TR-16, clarifiers at nitrogen removal facilities should be a minimum of 13 feet deep. The clarifiers meet the minimum requirements set forth in Section 2, but they will have to be further evaluated to consider if they will require replacement or derating because of the shallow depth.

As shown in the site plan in Figure 3.3-3, the site appears to have enough space for the additional aeration tanks and denitrification filters. The denitrification filter complex would have an approximate footprint of 2900 square feet with four cells that are approximately 14 ft square each. Specific information regarding the results of this analysis is shown in Table 3.3-7 as follows.

(continued)

Table 3.3-7

RESULTS FOR SEASONAL LIMIT OF 5 mg/L

PARAMETER	VALUE
Aerobic SRT	7 days
Total SRT	7 days
First Anoxic Fraction	n/a
Total Anoxic Fraction	n/a
Reaeration HRT	n/a
RAS Rate	100%
Total Volume	1.34 MG
Nitrate Recycle Rate	n/a
Max MLSS at loading rate	3400 mg/L
Effluent TN	5 mg/L
Methanol Addition	Yes, in denitrification filter
Fixed Film Required?	No
Clarifiers?	Reuse existing and add one new one
Effluent Filtration Required?	Yes, denitrification filter

Other plant modifications may be needed including upgrades to sludge handling to accommodate the higher sludge production. However, all facilities outside of the activated sludge process are outside of the scope of this study.

b. **Annual Average.** At the assumed influent TN levels for this facility and for the same reasons outlined previously for part 3.3 C.2, the recommended alternative for this facility is to add two additional aeration tanks and denitrification filters. The denitrification filter complex would have an approximate footprint of 2900 square feet with four cells that are approximately 14 ft square each. In addition, because of the low winter temperature, IFAS will be required in the aeration tanks. This configuration would allow the facility to achieve a seasonal effluent TN of 5 mg/L as shown in Figure 3.3-6.

(continued)

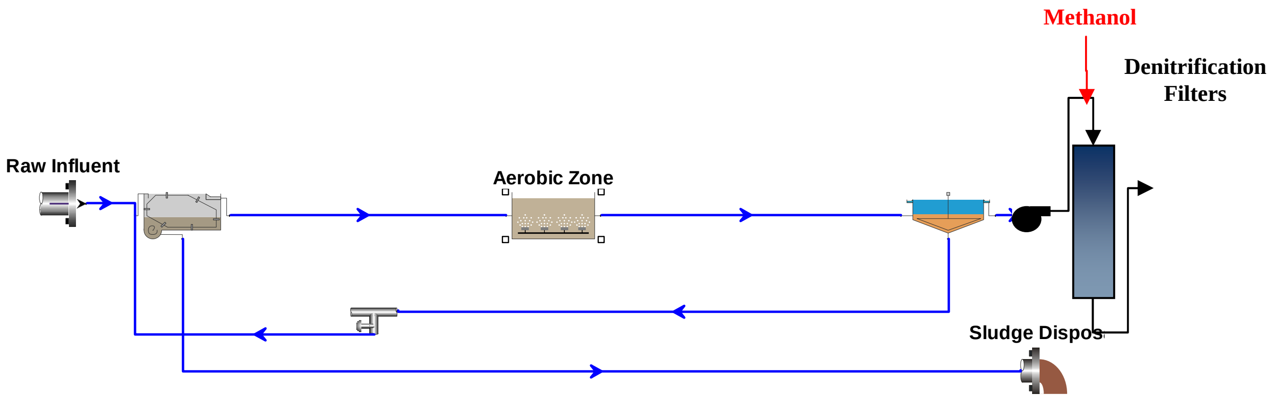


FIGURE 3.3-6:

NITROGEN REMOVAL PROCESSES – ANNUAL AVERAGE LIMIT OF 5 mg/L

In addition to the new aeration tanks and denitrification filter, it is anticipated that one additional secondary clarifier will be required to handle the MLSS concentration. The site plan has space reserved for this clarifier. Also, it should be noted that the clarifiers at this facility are twelve feet deep. According to TR-16, clarifiers at nitrogen removal facilities should be a minimum of 13 feet deep. The clarifiers meet the minimum requirements set forth in Section 2, but they will have to be further evaluated to consider if they will require replacement or derating because of the shallow depth.

As shown in the site plan in Figure 3.3-3, the site appears to have enough space for the additional aeration tanks, clarifier and denitrification filters. Specific information regarding the results of this analysis is shown in Table 3.3-8 as follows.

(continued)

Table 3.3-8

RESULTS FOR ANNUAL AVERAGE LIMIT OF 5 mg/L

PARAMETER	VALUE
Aerobic SRT	6 days
Total SRT	6 days
First Anoxic Fraction	n/a
Total Anoxic Fraction	n/a
Reaeration HRT	n/a
RAS Rate	100%
Total Volume	1.34 MG
Nitrate Recycle Rate	n/a
Max MLSS at loading rate	3600 mg/L
Effluent TN	5 mg/L
Methanol Addition	Yes, in denitrification filter
Fixed Film Required?	Yes, 40% fill
Clarifiers?	Reuse existing and add one new one
Effluent Filtration Required?	Yes, denitrification filter

Other plant modifications may be needed including upgrades to sludge handling to accommodate the higher sludge production. However, all facilities outside of the activated sludge process are outside of the scope of this study.

D. **Plant and Cost Summary.**

Table 3.3-9 presents flow data for the Grafton WWTP as well as the current nitrogen removal performance of the plant.

(continued)

Table 3.3-9

PLANT FLOW AND EFFLUENT LIMIT SUMMARY

Parameter	Value
Permitted Flow (mgd)	2.4
Existing Flow (2004-6)	2.0
% of existing capacity	84.2
Current average seasonal effluent TN (mg/L)[1]	13.5
Current average annual effluent TN (mg/L) [1]	14.3
Permit Limits Seasonal Nitrification (mg/L) Year-round nitrification (mg/L) Seasonal TN Limit Annual TN Limit	 Yes (5) Yes (5-15) No No

1. TKN was assumed to be 1.5 mg/L

Table 3.3-10 presents the nitrogen removal processes identified in this section to achieve the four different permit conditions considered. Based on the loading conditions established for this facility and the subsequent BioWin modeling performed using this data, the facility improvements include adding two additional aeration tanks and using these tanks for ammonia removal only. Other improvements include using IFAS if year-round nitrogen removal is required, installation of one additional secondary clarifier and a denitrification filter for nitrate removal. It also should be noted that influent nitrogen data was assumed for this facility.

Table 3.3-10

NITROGEN REMOVAL PROCESS SUMMARY FOR GRAFTON WWTP

Minor / Modifications or Retrofits	Process to Achieve Seasonal TN of 8 mg/L	Process to Achieve Annual Average TN of 8 mg/L	Process to Achieve Seasonal TN of 5 mg/L	Process to Achieve Annual Average TN of 5 mg/L
None	Nitrification in aeration tanks followed by denitrification filters	Nitrification in aeration tanks followed by denitrification filters	Nitrification in aeration tanks followed by denitrification filters	Nitrification in aeration tanks followed by denitrification filters

The modifications required at Grafton to convert to a new nitrogen removal process are summarized in Table 3.3-11. As noted previously, no minor modifications can be made to the treatment facility to improve nitrogen removal at the assumed influent nitrogen loads.

Table 3.3-11

REQUIRED MODIFICATIONS SUMMARY FOR GRAFTON WWTP

MODIFICATIONS TO ACHIEVE SEASONAL TN OF 8 MG/L	MODIFICATIONS TO ACHIEVE ANNUAL AVERAGE TN OF 8 MG/L	MODIFICATIONS TO ACHIEVE SEASONAL TN OF 5 MG/L	MODIFICATIONS TO ACHIEVE ANNUAL AVERAGE TN OF 5 MG/L	SPECIAL CONDITIONS
2 new aeration tanks, one new clarifier, denitrification filters	2 new aeration tanks with IFAS, one new clarifier, denitrification filters	2 new aeration tanks, one new clarifier, denitrification filters	2 new aeration tanks with IFAS, one new clarifier, denitrification filters	None

The cost estimating procedures established in Section 2 were used to estimate capital, annual O&M, and 20-year present worth costs associated with the process changes and facility modifications summarized above. The cost estimates are included in Table 3.3-12.

Table 3.3-12

COST SUMMARY FOR NITROGEN REMOVAL AT GRAFTON WWTP[1]

LIMIT	CAPITAL COSTS (IN MILLIONS)	TOTAL ANNUAL COSTS[2] (IN THOUSANDS)	20-YR PRESENT WORTH (IN MILLIONS)
Minor Modifications/Retrofits	None	n/a	n/a
Seasonal Effluent TN of 8 mg/L	$28	$260	$32
Annual Average Effluent TN of 8 mg/L	$41	$420	$47
Seasonal Effluent TN of 5 mg/L	$28	$270	$32
Annual Average Effluent TN of 5 mg/L	$41	$430	$47

1. It should be noted that these costs represent one method by which this facility can achieve the stated TN goals. It is not intended to be the most cost effective method nor the recommended method, but it represents a planning tool for MassDEP to estimate the fiscal impacts of establishing total nitrogen limits.
2. Represents incremental increase over current conditions.

(continued)

3.4 NORTHBRIDGE

A. **Introduction.** The Northbridge Wastewater Treatment Plant (WWTP) is located at 644 Providence Road in Northbridge, MA. It has a permitted annual average capacity of 2.0 mgd and serves the Town of Northbridge only.

A primary treatment wastewater facility was constructed prior to 1940. A trickling filter was added in the 1940s. Secondary clarifiers were constructed in the 1960s. In the 1970s, a dewatering process and chlorine disinfection were added to the facility. A UV system was constructed in 1997 and the dewatering process was decommissioned. Finally in 2002, the current sequencing batch reactor process was constructed along with related support facilities.

B. **Existing Facilities.**

1. **Description of Existing Facilities.** All flow to the treatment facility is conveyed via forcemain from the Rockdale Pump Station which is located on the treatment plant site. In addition to the pumps, this pump station contains a screenings grinder.

The first process at the treatment facility is primary treatment. After primary treatment, flow is conveyed by gravity to the sequencing batch reactors (SBRs). Each of the two SBRs is 80 feet square with a sidewater depth of 20.4 ft. The SBRs have fine bubble aeration. An equalization tank collects flow from the SBR decant system prior to the flow being conveyed by gravity through a magnetic meter and then to the sand beds. The sand beds act as a final filtration step prior to UV disinfection.

Aerial photo taken from www.google.com

All plant recycle flows are returned to the Rockdale Pump Station. The influent sampler is located just prior to primary treatment. The effluent sampler is located after disinfection.

Alum is used for phosphorus removal and soda ash for pH adjustment. Primary and waste activated sludges are co-thickened in the gravity thickener and then hauled off site for disposal. A process flow schematic is shown in Figure 3.4-1.

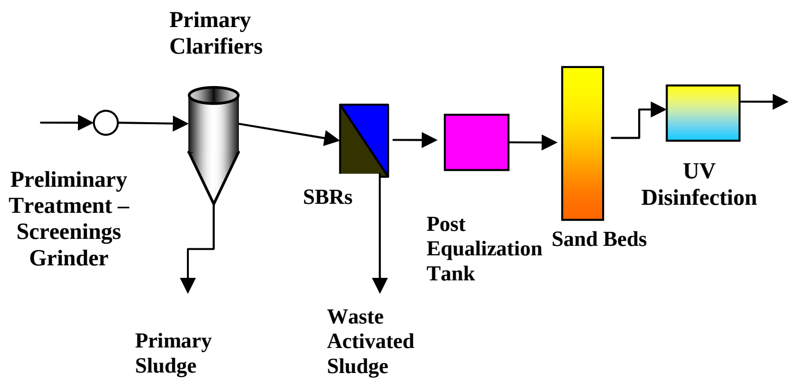


FIGURE 3.4-1: PROCESS FLOW SCHEMATIC – EXISTING FACILITY

The plant uses both of the SBRs at all times. Only one of the primary clarifiers is typically used; two primaries are used during high flow events. The only seasonal operational change that is made is that alum is not used in the winter.

The plant and collection system are maintained by 6 people (superintendent, administrative assistant and 4 operators)

Design flows and loads for the most recent upgrade are shown below in Table 3.4-1.

Table 3.4-1
DESIGN FLOWS AND LOADS

PARAMETER	VALUE
Average Monthly (design flow)	2 mgd
BOD	190 mg/L
TSS	166 mg/L
Ammonia-Nitrogen	17 mg/L
TKN	26 mg/L
TP	4 mg/L

2. **Summary of Plant Data.** Data from January 2004 through December 2006 was provided by the Town for this study. A summary of the monthly data is shown in Table 3.4-2. Seasonal and annual average and maximum month data is summarized in the table.

With a current average annual flow of 1.1 mgd and a permitted capacity of 2.0 mgd, this facility is operating at 55% of its permitted capacity. Based on the average BOD concentration of 210 mg/L, this wastewater would be considered medium strength.

Table 3.4-2

NORTHBRIDGE WWTP

Northbridge, Massachusetts

Monthly Averages 2004-2006

GENERAL		INFLUENT			EFFLUENT			
DATE		INF	BOD	TSS	BOD	TSS	NO2+ NO3	NH3
MONTH	YEAR	MGD	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L
January	2004	1.0	205	179	3.75	4.0	6.90	0.40
February	2004	1.0	189	150	4.25	6.0	5.30	6.70
March	2004	0.9	198	154	4.20	3.2	2.30	4.10
April	2004	1.7	129	152	4.20	1.9	8.60	
May	2004	1.2	163	87	4.00	1.5	1.80	2.20
June	2004	0.9	225	144	3.50	2.5	4.40	0.30
July	2004	0.8	266	112	2.00	2.2	3.40	0.00
August	2004	0.8	228	142	3.25	5.2	7.70	0.10
September	2004	0.9	263	181	2.40	3.2	4.20	0.50
October	2004	0.9	254	95	2.20	3.2	6.20	1.60
November	2004	0.9	369	148	9.00	3.2	7.70	0.30
December	2004	1.3	207	90	7.00	3.0	4.40	1.40
January	2005							
February	2005	1.4	164	101	10.00	2.0	2.00	3.70
March	2005	0.5	195	59	8.00	4.8	1.20	4.60
April	2005	1.6	184	106	7.50	2.2	2.60	6.20
May	2005	1.2	187	73	6.50	3.5	0.98	3.80
June	2005	0.9	332	207	9.00	5.2	0.50	1.60
July	2005	0.9	218	108	7.70	7.2	1.70	0.10
August	2005	0.8	333	208	7.00	6.5	2.90	0.90
September	2005	0.8	316	185	5.60	3.2	8.80	3.20
October	2005	1.6	154	130	6.00	3.2	6.30	4.70
November	2005	1.3	172	453	7.70	9.2	2.00	2.30
December	2005	1.3	141	141	5.00	4.4	2.00	8.00
January	2006	1.5	279	128	5.00	7.3	0.96	8.30
(continued)								

GENERAL		INFLUENT			EFFLUENT			
DATE		INF	BOD	TSS	BOD	TSS	NO2+ NO3	NH3
MONTH	YEAR	MGD	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L
February	2006	1.5	190	104	4.40	6.5	0.82	9.10
March	2006	0.9	191	209	6.00	3.4	0.51	9.40
April	2006	0.9	149	272	2.70	1.0	4.50	6.20
May	2006	1.3	146	190	5.50	2.3	9.50	0.80
June	2006	1.7	140	178	5.70	4.6	1.50	1.10
July	2006	0.9	200	179	5.80	5.0	0.68	1.30
August	2006	0.9	196	180	3.80	3.0	0.80	0.11
September	2006	0.9	144	219	3.00	2.0	2.90	0.10
October	2006	0.8	190	246	1.80	1.0	1.70	0.22
November	2006	1.0	196	206	2.00	1.0	3.20	0.03
December	2006	1.0	234	195	4.70	5.4	4.60	0.69
Min. Month		0.5	129	59	1.8	1.0	0.5	0.0
Seasonal Average		**1.0**	**220**	**159**	**4.7**	**3.6**	**3.7**	**1.3**
Average		**1.1**	**210**	**163**	**5.1**	**3.8**	**3.6**	**2.8**
Max. Month		1.7	369	453	10.0	9.2	9.5	9.4

3. **Permit Requirements and Current Performance.** The current permit for this facility has been in effect since September 13, 2006. Monthly permit limits that are relevant to this study are shown below in Table 3.4-3.

Table 3.4-3

SELECT MONTHLY PERMIT LIMITS

PARAMETER	LIMIT
BOD5	10 mg/L
TSS	10 mg/L
Ammonia-Nitrogen May – October Nov - April	 2 mg/L 9 mg/L
TKN, Nitrate-N, Nitrite-N	Report

The above BOD and TSS limits have been met in all of the months since the current permit became active.

4. **Nitrogen Removal Performance.** This facility does not collect influent nitrogen data. However, effluent nitrogen data is collected as can be seen in Table 3.4-2. Since the current permit took effect, the plant has met standards for nitrogen.

C. **Nitrogen Removal Alternatives.** The existing maximum month loads over the three-year data collection period were used to determine the BioWin input data; one outlier was found in the data and not included in the analysis. The influent data which correspond to maximum-month loads is shown in Table 3.4-4 below for each permitting scenario. The minimum temperature for the permit condition is also shown. In addition, due to a lack of influent nitrogen data, the TN/BOD ratio was estimated to be 0.18, and due to a lack of wastewater temperature data, the temperatures were assumed, both in accordance with the procedures outlined in Section 2.

Table 3.4-4

EXISTING INFLUENT PARAMETERS

PERMIT CONDITIONS	PARAMETER	VALUE
Annual Average	Flow, mgd	0.9
	BOD, mg/L	369
	TSS, mg/L	287
	TN, mg/L	66
	Temperature, F	46
Seasonal	Flow, mgd	0.9
	BOD, mg/L	332
	TSS, mg/L	258
	TN, mg/L	60
	Temperature, F	52

The existing plant data was then projected to the permitted capacity of the facility to develop model input parameters for the average annual and seasonal model runs. This projected data is shown in Table 3.4-5.

(continued)

Table 3.4-5
MODEL INPUT PARAMETERS AT PERMITTED CAPACITY

PERMIT CONDITIONS	PARAMETER	VALUE
Annual Average	Flow, mgd	1.66
	BOD, mg/L	369
	TSS, mg/L	287
	TN, mg/L	66
	Temperature, F	46
Seasonal	Flow, mgd	1.66
	BOD, mg/L	332
	TSS, mg/L	258
	TN, mg/L	60
	Temperature, F	52

The model input data was used to run uncalibrated simulations to determine planning level, order-of-magnitude costs for implementing different levels of nitrogen reduction at the facility. A discussion of operational changes or minor modifications that can be made to the facility to improve current nitrogen reduction performance as well as a presentation of the simulation results are presented in the following sections.

1. **Minor Modifications/Retrofits.** As shown in Table 3.4-2, since the current permit took effect, the plant has met effluent standards for ammonia. At the current assumed influent TN levels, the existing facility should be able to achieve an average effluent nitrogen level of 8 mg/L by cycling the air in the existing tanks up to approximately 1.3 mgd.

2. **Modifications Required to Meet TN of 8.** The modifications to the facility that are required to meet an effluent TN of 8 mg/L on a seasonal and annual average basis are as follows.

   a. **Seasonal.** At the assumed influent TN levels, the facility would be able to achieve a seasonal effluent TN level of 8 mg/L by cycling the air to achieve aerobic and anoxic conditions. This process would require a total of one additional SBR. The BioWin model for this process is as shown in Figure 3.4-2 as follows.

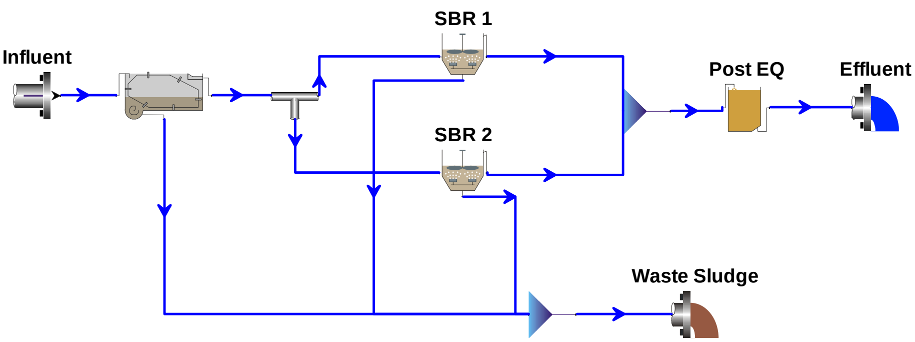


FIGURE 3.4-2: NITROGEN REMOVAL PROCESSES - SEASONAL LIMIT OF 8 mg/L

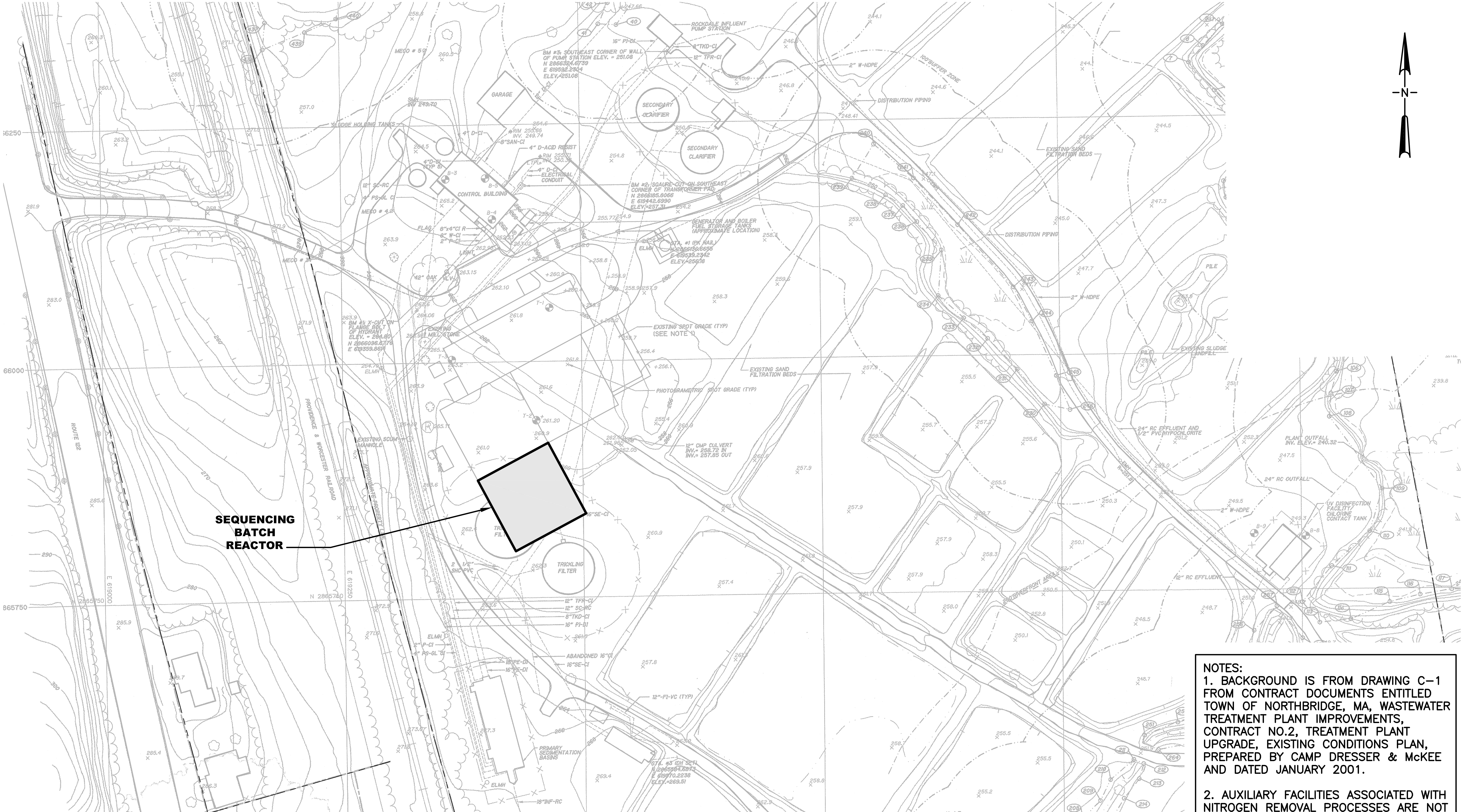
The new SBR would be the same size as the existing tanks. As shown in the site plan in Figure 3.4-3, the site has enough space for the additional SBR. Specific information regarding the results of this analysis is shown in Table 3.4-6 below.

Table 3.4-6

RESULTS FOR SEASONAL LIMIT OF 8 mg/L TN

Parameter	Value
Total SRT	21 days
Number of Cycles	4 per day/ basin
Cycle Duration	6 hrs/cycle
Total Tank Volume	2.9 MG
Max MLSS at Loading Rate	3500 mg/L
Effluent TN	8 mg/L
Methanol Addition	No
Effluent Filtration Required?	No

In addition to the additional SBR tank and the equipment required for that tank, the facility will require additional blowers and a new building to house the blowers and pumps. Other plant modifications may be needed including upgrades to sludge handling processes. However, all facilities outside of the activated sludge process are outside of the scope of this study.



NOTES:
1. BACKGROUND IS FROM DRAWING C–1 FROM CONTRACT DOCUMENTS ENTITLED TOWN OF NORTHBRIDGE, MA, WASTEWATER TREATMENT PLANT IMPROVEMENTS, CONTRACT NO.2, TREATMENT PLANT UPGRADE, EXISTING CONDITIONS PLAN, PREPARED BY CAMP DRESSER & McKEE AND DATED JANUARY 2001.

2. AUXILIARY FACILITIES ASSOCIATED WITH NITROGEN REMOVAL PROCESSES ARE NOT SHOWN.

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Filename: NORTHBRIDGE–CH3.dwg
Latest Revision: Friday, April 04, 2008

SITE PLAN
SCALE: 1"=80'–0"

STEARNS & WHELER LLC
Environmental Engineers & Scientists
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Hyannis, MA 02601
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ENGINEERING FEASIBILITY AND COST ANALYSES OF NITROGEN REDUCTION FROM SELECTED POTWS IN MASSACHUSETTS

NORTHBRIDGE, MASSACHUSETTS

FIGURE 3.4–3

b. **Annual Average.** At the assumed influent TN levels, the SBR would be able to achieve an average annual effluent TN level of 8 mg/L by cycling the air to achieve aerobic and anoxic conditions. Like the seasonal limit, the annual average limit would require a total of one additional SBR. The BioWin model for this process is as shown in Figure 3.4-4 below.

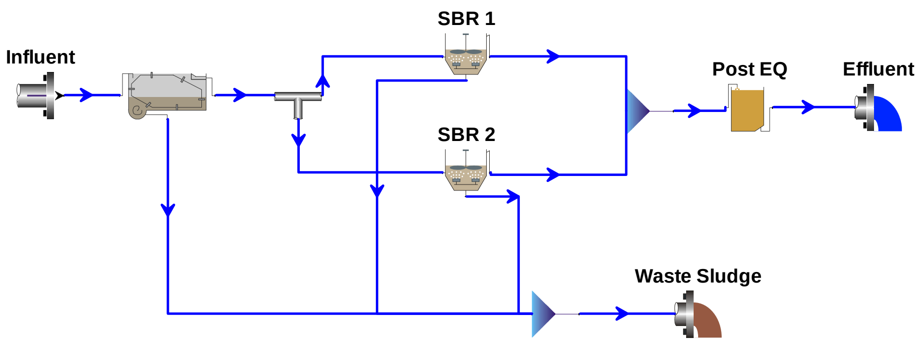


FIGURE 3.4-4: NITROGEN REMOVAL PROCESSES – ANNUAL AVERAGE LIMIT OF 8 mg/L

The new SBR would be the same size as the existing tanks. As shown in the site plan in Figure 3.4-3, the site has enough space for the additional SBRs. Information regarding the results of this analysis is shown in Table 3.4-7 below.

Table 3.4-7

RESULTS FOR ANNUAL AVERAGE LIMIT OF 8 mg/L TN

PARAMETER	VALUE
Total SRT	21 days
Number of Cycles	4 per day/ basin
Cycle Duration	6 hrs/cycle
Total Tank Volume	2.9 MG
Max MLSS at Loading Rate	3500 mg/L
Effluent TN	8 mg/L
Methanol Addition	No
Effluent Filtration Required?	No

In addition to the additional SBR tank and the equipment required for that tank, the facility will require additional blowers and a new building to house the blowers and pumps. Other plant modifications may be needed including upgrades to sludge handling processes. However, all facilities outside of the activated sludge process are outside of the scope of this study.

3. **Modifications Required to Meet a TN of 5.** The modifications to the facility that are required to meet an effluent TN of 5 mg/L on a seasonal and annual average basis are as follows.

a. **Seasonal.** At the assumed influent TN levels for this facility, the SBR would be able to achieve a seasonal effluent TN level of 5 mg/L by adding another SBR and cycling the air in the SBR to achieve aerobic and anoxic conditions. It would also require a new denitrification filter to remove an additional 3 mg/L of nitrates. These nitrogen removal processes are shown in Figure 3.4-5 below.

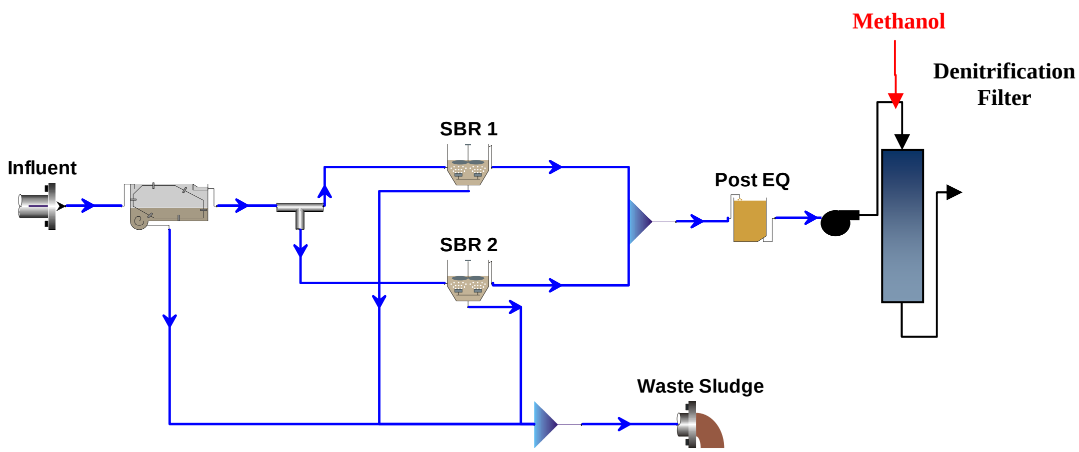
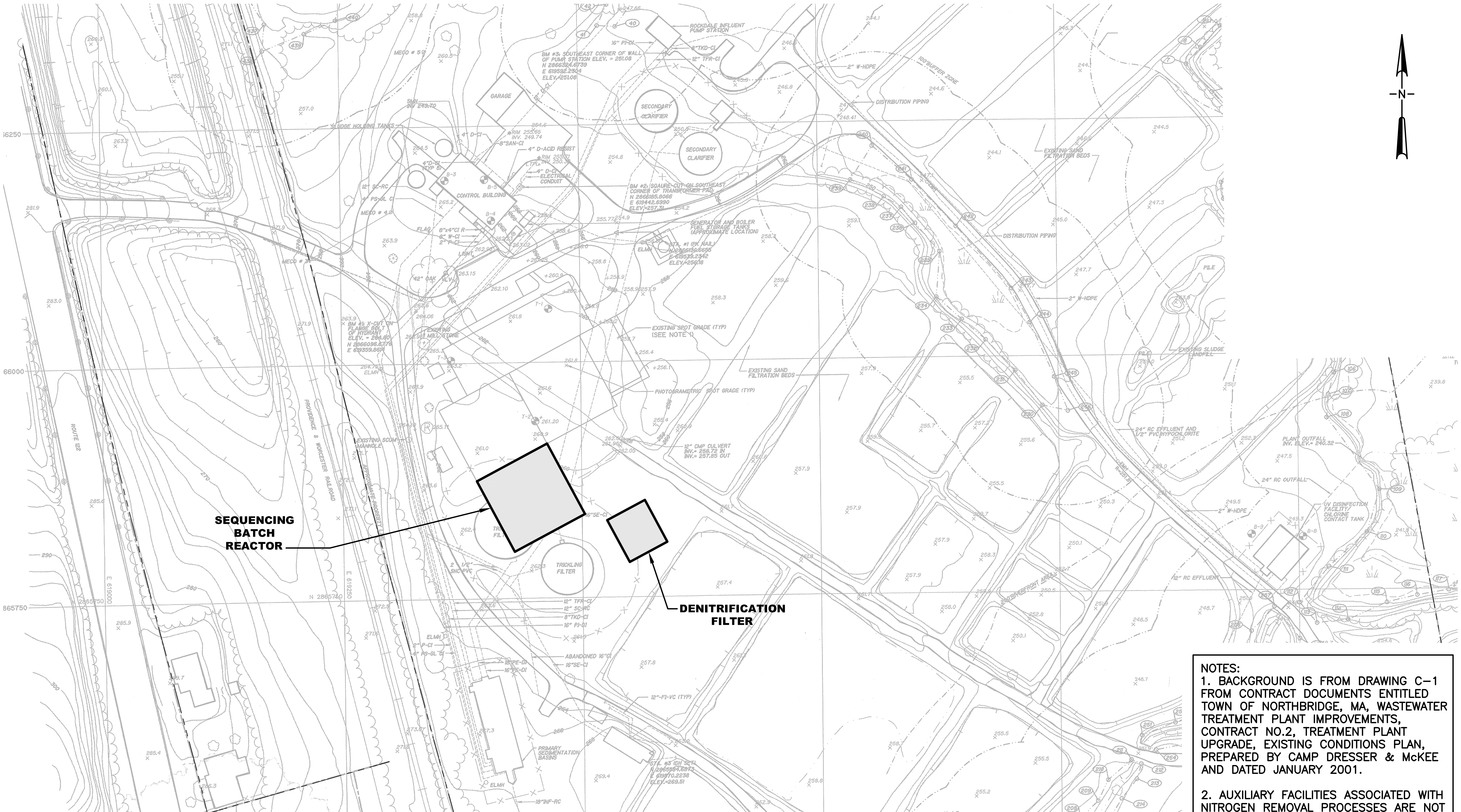


FIGURE 3.4-5: NITROGEN REMOVAL PROCESSES – SEASONAL LIMIT OF 5 mg/L

The new SBR would be the same size as the existing tanks. The denitrification filter complex would have a footprint of approximately 2150 square feet with two cells at approximately 14 feet square each. As shown on the site plan in Figure 3.4-6, the site has enough space for the additional SBR and denitrification filter. Specific information regarding the results of this analysis is shown in Table 3.4-8 as follows.



NOTES:
1. BACKGROUND IS FROM DRAWING C–1 FROM CONTRACT DOCUMENTS ENTITLED TOWN OF NORTHBRIDGE, MA, WASTEWATER TREATMENT PLANT IMPROVEMENTS, CONTRACT NO.2, TREATMENT PLANT UPGRADE, EXISTING CONDITIONS PLAN, PREPARED BY CAMP DRESSER & McKEE AND DATED JANUARY 2001.

2. AUXILIARY FACILITIES ASSOCIATED WITH NITROGEN REMOVAL PROCESSES ARE NOT SHOWN.

100 0 100 200
1"=100'–0"

SITE PLAN
SCALE: 1"=100'–0"

Login name: JDF
Filename path: J:\60000\61265 MADEP\10\Drawings\Fig
Filename: NORTHBRIDGE–CH3.dwg
Latest Revision: Friday, April 04, 2008

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ENGINEERING FEASIBILITY AND COST ANALYSES OF NITROGEN REDUCTION FROM SELECTED POTWS IN MASSACHUSETTS

NORTHBRIDGE, MASSACHUSETTS

FIGURE 3.4–6

Table 3.4-8

RESULTS FOR SEASONAL LIMIT OF 5 mg/L TN

PARAMETER	VALUE
Total SRT	21 days
Number of Cycles	4 per day/ basin
Cycle Duration	6 hrs/cycle
Total Tank Volume	2.9 MG
Max MLSS at Loading Rate	3500 mg/L
Effluent TN	5 mg/L
Methanol Addition	Yes, in denitrification filter
Effluent Filtration Required?	Yes, denitrification filter

In addition to the additional SBR tank and the equipment required for that tank, the facility will require additional blowers and a new building to house the blowers and pumps. Other plant modifications may be needed including upgrades to sludge handling processes. However, all facilities outside of the activated sludge process are outside of the scope of this study.

b. **Annual Average.** At the assumed influent TN levels for this facility, the SBR would be able to achieve an average annual effluent TN level of 5 mg/L by adding another SBR and cycling the air in the SBR to achieve aerobic and anoxic conditions. It would also require a new denitrification filter to remove an additional 3 mg/L of nitrates. These nitrogen removal processes are shown in Figure 3.4-7 as follows.

(continued)

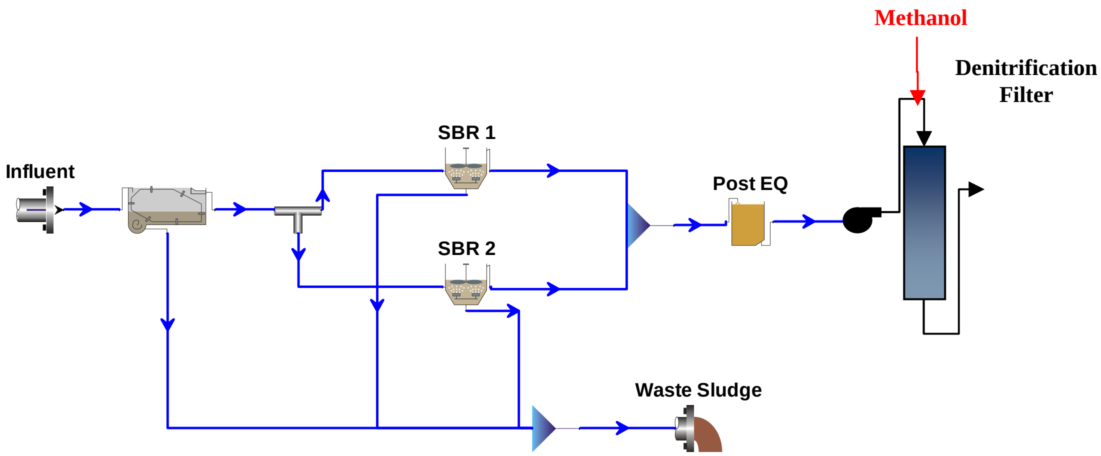


FIGURE 3.4-7:
NITROGEN REMOVAL PROCESSES – ANNUAL AVERAGE LIMIT OF 5 mg/L

Like the seasonal limit, the annual average limit would require one additional SBR. The new SBR would be the same size as the existing tanks. The denitrification filter complex would have a footprint of approximately 2150 square feet with two cells at approximately 14 feet square each. As shown on the site plan in Figure 3.4-6, the site has enough space for the additional SBR and denitrification filter. Specific information regarding the results of this analysis is shown in Table 3.4-9 below.

Table 3.4-9
RESULTS FOR ANNUAL AVERAGE LIMIT OF 5 mg/L TN

PARAMETER	VALUE
Total SRT	21 days
Number of Cycles	4 per day/ basin
Cycle Duration	6 hrs/cycle
Total Tank Volume	2.9 MG
Max MLSS at Loading Rate	3500 mg/L
Effluent TN	5 mg/L
Methanol Addition	Yes, in denitrification filter
Effluent Filtration Required?	Yes, denitrification filter

In addition to the additional SBR tank and the equipment required for that tank, the facility will require additional blowers and a new building to house the blowers and pumps. Other plant modifications may be needed including upgrades to sludge handling processes. However, all facilities outside of the activated sludge process are outside of the scope of this study.

D. **Plant and Cost Summary.** Table 3.4-10 presents flow data for the Northbridge WWTP as well as the current nitrogen removal performance of the plant.

Table 3.4-10

PLANT FLOW AND EFFLUENT LIMIT SUMMARY

PARAMETER	VALUE
Permitted Flow (mgd)	2.0
Existing Flow (2004-6)	1.1
% of existing capacity	55
Current average seasonal effluent TN (mg/L)[1]	6.5
Current average annual effluent TN (mg/L) [1]	7.9
Permit Limits Seasonal Nitrification (mg/L) Year-round nitrification (mg/L) Seasonal TN Limit Annual TN Limit	 Yes (2) Yes (2-9) No No

1. Assumes effluent TKN is 1.5 mg/L

Table 3.4-11 presents the nitrogen removal processes identified in this section to achieve the four different permit conditions considered. Based on the loading conditions established for this facility and the subsequent BioWin modeling performed using this data, the facility improvements include adding one SBR tank to meet an effluent Nitrogen limit of 8 mg/L and one SBR tank and a denitrification filter to meet an effluent Nitrogen limit of 5 mg/L.

(continued)

Table 3.4-11

NITROGEN REMOVAL PROCESS SUMMARY FOR NORTHBRIDGE WWTP

MINOR/ MODIFICATIONS OR RETROFITS	PROCESS TO ACHIEVE SEASONAL TN OF 8 MG/L	PROCESS TO ACHIEVE ANNUAL AVERAGE TN OF 8 MG/L	PROCESS TO ACHIEVE SEASONAL TN OF 5 MG/L	PROCESS TO ACHIEVE ANNUAL AVERAGE TN OF 5 MG/L
Cyclical aeration in both existing SBRs up to 1.3 mgd	Cyclical aeration in three SBRs	Cyclical aeration in three SBRs	Cyclical aeration in three SBRs plus a denitrification filter	Cyclical aeration in three SBRs plus a denitrification filter

The modifications required at Northbridge to convert to a new nitrogen removal process are summarized in Table 3.4-12.

Table 3.4-12

REQUIRED MODIFICATIONS SUMMARY FOR NORTHBRIDGE WWTP

MODIFICATIONS TO ACHIEVE SEASONAL TN OF 8 MG/L	MODIFICATIONS TO ACHIEVE ANNUAL AVERAGE TN OF 8 MG/L	MODIFICATIONS TO ACHIEVE SEASONAL TN OF 5 MG/L	MODIFICATIONS TO ACHIEVE ANNUAL AVERAGE TN OF 5 MG/L	SPECIAL CONDITIONS
One new SBR and a building addition	One new SBR and a building addition	One new SBR and a building addition, denitrification filter	One new SBR and a building addition, denitrification filter	None

The cost estimating procedures established in Section 2 were used to estimate capital, annual O&M, and 20-year present worth costs associated with the process changes and facility modifications summarized above. The cost estimates are included in Table 3.4-13.

Table 3.4-13

COST SUMMARY FOR NITROGEN REMOVAL AT NORTHBRIDGE WWTP[1]

LIMIT	CAPITAL COSTS (IN MILLIONS)	TOTAL ANNUAL COSTS[2] (IN THOUSANDS)	20-YR PRESENT WORTH (IN MILLIONS)
Minor Modifications/Retrofits	Minor	n/a	n/a
Seasonal Effluent TN of 8 mg/L	$6	$100	$7.8
Annual Average Effluent TN of 8 mg/L	$6	$110	$7.8
Seasonal Effluent TN of 5 mg/L	$16	$190	$18
Annual Average Effluent TN of 5 mg/L	$16	$220	$18.4

1. It should be noted that these costs represent one method by which this facility can achieve the stated TN goals. It is not intended to be the most cost effective method nor the recommended method, but it represents a planning tool for MassDEP to estimate the fiscal impacts of establishing total nitrogen limits.
2. Represents incremental increase over current conditions.

3.5 DOUGLAS

A. **Introduction.** The Douglas Wastewater Treatment Facility (WWTF) is located at 29 Charles Street in Douglas, MA. It has a permitted average annual capacity of 0.60 mgd and mostly serves the Town of Douglas and one single commercial property in Uxbridge. The facility does not accept septage.

The current facility is still under construction, but was activated on December 3, 2005. It replaced a facility that was constructed in 1972.

B. **Existing Facilities.**

1. **Description of Existing Facilities.** All flow is pumped to the Douglas Wastewater Treatment Facility (WWTF) where it first enters the Screenings and Grit Facility which consists of a fine mechanical screen and a vortex grit chamber. From there, flow enters a Parshall flume by gravity for flow measurement.

Aerial photo taken from www.google.com

After preliminary treatment, the flow is conveyed by gravity to the sequencing batch reactors (SBRs). Each of the three SBRs is 42 feet square with a side water depth of 20.5 feet. Aeration is accomplished by fine bubble aeration. The post equalization tanks collect flow from the SBR decant system prior to pumping it to the effluent filters.

The effluent filtration and UV disinfection consist of cloth disk filters and a closed vessel UV system. After disinfection, the flow passes through a Parshall flume for flow measurement and is then conveyed by gravity to the Mumford River. Plant recycle flows are introduced after the influent sampler. The effluent sampler is located after disinfection.

Alum is used for phosphorus removal and sodium hydroxide is available for adding alkalinity. Sludge is stored in holding tanks and then hauled for disposal. A process flow schematic is shown in Figure 3.5-1.

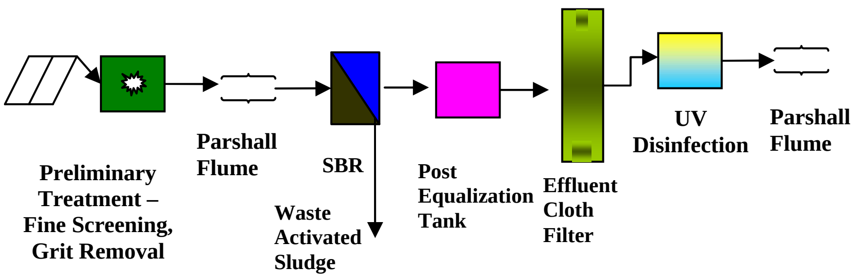


FIGURE 3.5-1: PROCESS FLOW SCHEMATIC – EXISTING FACILITY

Two of the three SBRs are in use at all times. The plant does not try to suppress nitrification at any time of the year.

The facility has two full-time employees. This crew serves the plant and four pump stations.

Design flows and loads for the most recent upgrade are shown below in Table 3.5-1.

Table 3.5-1
DESIGN FLOWS AND LOADS

PARAMETER	VALUE
Average Monthly (design flow)	0.6 mgd
BOD	250

Table 3.5-1 (continued)
DESIGN FLOWS AND LOADS

PARAMETER	VALUE
TSS	150
Ammonia	17
TKN	30
TP	4

2. **Summary of Plant Data.** Data from January 2004 through December 2006 was provided by the Town for this study. A summary of the monthly data is shown in Table 3.5-2. Seasonal and annual average and maximum month data is summarized in the table.

Table 3.5-2
DOUGLAS WWTF
Douglas, Massachusetts
Monthly Averages 2004-2006

GENERAL		INFLUENT					EFFLUENT						
DATE		INF	PH	BOD	TSS	TEMP	BOD	TSS	FECAL	NO2 + NO3	TKN	NH3	TN
MONTH	YEAR	MGD		MG/L	MG/L	DEG F	MG/L	MG/L	COLI.	MG/L	MG/L	MG/L	MG/L
January	2004	0.17	7.7	249	233	59	10	11		5.3	7.50	1.40	12.76
February	2004	0.15	7.7	220	228	59	10	10		1.0	1.30	0.49	2.25
March	2004	0.17	7.7	269	225	61	10	11		5.6	2.70	0.52	8.29
April	2004	0.32	7.5	210	184	59	10	9	2	0.1	9.70	8.50	9.78
May	2004	0.24	7.6	213	217	61	10	10	28	0.1	19.00	18.00	19.06
June	2004	0.18	7.7	216	205	61	10	15	27	1.6	5.60	4.20	7.17
July	2004	0.18	7.7	262	226	64	10	13	26	4.4	3.90	2.80	8.34
August	2004	0.16	7.7	263	248	66	11	13	52	1.3	2.70	0.95	3.95
September	2004	0.17	7.7	222	246	64	10	12	35	0.7	12.00	11.00	12.66
October	2004	0.17	7.7	248	250	64	11	11	27	0.1	5.40	4.30	5.51
November	2004	0.16	7.7	256	254	63	11	11		1.2	5.40	3.90	6.59
December	2004	0.22	7.7	225	237	61	10	10		0.1	14.00	12.00	14.08
January	2005	0.26	7.6	244	232	52	10	9		1.1	12.00	11.00	13.11
February	2005	0.22	7.7	217	219	54	10	10		0.1	21.00	18.00	21.09
March	2005	0.23	7.7	239	223	52	12	11		1.0	17.00	16.00	17.99
April	2005	0.30	7.7	213	232	52	9	9	0	0.2	11.20	9.70	11.36
May	2005	0.22	7.7	241	233	55	11	10	19	0.7	14.00	13.00	14.66
June	2005	0.17	7.7	226	226	66	10	11	10	1.2	15.00	14.00	16.21
July	2005	0.16	7.7	238	246	72	11	11	16	1.0	3.70	2.30	4.71
August	2005	0.16	7.7	231	232	72	10	10	30	0.1	13.00	10.00	13.14
September	2005	0.15	7.7	230	232	70	10	10	36	0.9	3.80	2.50	4.66
October	2005	0.30	7.6	206	206	66	10	9	12	0.5	1.90	0.70	2.37
November	2005	0.25	7.7	222	226	63	9	9		0.5	10.00	8.90	10.45

Table 3.5-2 (continued)

DOUGLAS WWTF

Douglas, Massachusetts

Monthly Averages 2004-2006

GENERAL		INFLUENT					EFFLUENT						
DATE		INF	pH	BOD	TSS	TEMP	BOD	TSS	FECAL	NO2 + NO3	TKN	NH3	TN
MONTH	YEAR	MGD		MG/L	MG/L	DEG F	MG/L	MG/L	COLI.	MG/L	MG/L	MG/L	MG/L
December	2005	0.22	7.7	229	268	61	6	8		4.2	5.00	1.10	9.23
January	2006	0.27	7.7	287	293	61	8	5		2.4	1.70	0.46	4.13
February	2006	0.23	7.7	221	241	57	8	8		0.6	17.00	16.00	17.60
March	2006	0.28	7.7	253	386	55	4	3		0.4	2.60	1.80	3.01
April	2006	0.23	7.7	260	406	59	6	5	10	1.1	4.90	2.50	6.03
May	2006	0.27	7.7	312	423	61	5	4	17	1.5	3.30	0.79	4.78
June	2006	0.35	7.7	303	401	63	8	5	22	1.2	1.50	1.10	2.65
July	2006	0.15	7.8	272	317	66	5	4	3	1.0	2.50	0.96	3.49
August	2006	0.11	7.1	247	340	70	5	5	3	1.3	2.20	0.47	3.49
September	2006	0.14	7.7	229	250	70	5	3	6	1.5	1.40	0.60	2.91
October	2006	0.12	7.7	305	290	70	5	3	4	1.0	2.10	0.99	3.09
November	2006	0.20	7.7	326	419	65	6	4		8.5	0.93	0.60	9.44
December	2006	0.17	7.7	293	297	61	5	5		0.0	1.60	0.77	1.62
Min. Month		0.11	7.09	0	184	51.80	4	3	0	0.02	0.93	0.46	1.62
Seasonal Average		**0.19**	**7.66**	**248**	**266**	**65.60**	**8.72**	**8.83**	**20.72**	**1.10**	**6.28**	**4.93**	**7.38**
Average		**0.21**	**7.67**	**247**	**266**	**62.03**	**8.64**	**8.53**	**18.33**	**1.48**	**7.18**	**5.62**	**8.66**
Max. Month		0.35	7.76	326	423	71.60	12.00	15.00	52.00	8.51	21.00	18.00	21.09

With a current average annual flow of 0.21 mgd and a permitted capacity of 0.60 mgd, this facility is operating at 35% of its permitted capacity.

Based on the average BOD concentration of 247 mg/L, this wastewater would be considered medium strength.

3. **Permit Requirements and Current Performance.** The current permit for this facility has been in effect since September 3, 1999. Monthly permit limits that are relevant to this study are shown below in Table 3.5-3

Table 3.5-3

SELECT MONTHLY PERMIT LIMITS

PARAMETER	LIMIT
BOD5	
November –April	20 mg/L
May – October	10 mg/L

Table 3.5-3 (continued)

SELECT MONTHLY PERMIT LIMITS

PARAMETER	LIMIT
TSS November –April May – October	 20 mg/L 10 mg/L
Ammonia-Nitrogen May – October	 5 mg/L
Ammonia, TKN, Nitrate, Nitrite	Report

Since the new facility was activated in December of 2005, all of the above limits have been met.

4. **Nitrogen Removal Performance.** This facility does not collect influent nitrogen data. However, effluent nitrogen data is collected and, as can be seen in Table 3.5-3 the facility has met standards for ammonia nearly all the time since the new facility was activated.

C. **Nitrogen Removal Alternatives.** The existing maximum month loads over the three-year data collection period were used to determine the BioWin input data; one outlier was found in the data and not included in the analysis. The influent data which correspond to maximum-month loads is shown in Table 3.5-4 below for each permitting scenario. The minimum temperature for the permit condition is also shown. In addition, due to a lack of influent nitrogen data, the TN/BOD ratio was estimated to be 0.18.

Table 3.5-4

EXISTING INFLUENT PARAMETERS

PERMIT CONDITION	PARAMETER	VALUE
Annual Average	Flow, mgd	0.27
	BOD, mg/L	312
	TSS, mg/L	336
	TN, mg/L	56
	Temperature, F	52
Seasonal	Flow, mgd	0.27
	BOD, mg/L	312
	TSS, mg/L	336
	TN, mg/L	56
	Temperature, F	55

The existing plant data was then projected to the permitted capacity of the facility to develop model input parameters for the average annual and seasonal model runs. This projected data is shown in Table 3.5-5.

Table 3.5-5

MODEL INPUT PARAMETERS AT PERMITTED CAPACITY

PERMIT CONDITION	PARAMETER	VALUE
Annual Average	Flow, mgd	0.77
	BOD, mg/L	312
	TSS, mg/L	336
	TN, mg/L	56
	Temperature, F	52
Seasonal	Flow, mgd	0.77
	BOD, mg/L	312
	TSS, mg/L	336
	TN, mg/L	56
	Temperature, F	55

The model input data was used to run uncalibrated simulations to determine planning level, order-of-magnitude costs for implementing different levels of nitrogen reduction at the facility. A discussion of operational changes or minor modifications that can be made to the facility to improve current nitrogen reduction performance as well as a presentation of the simulation results are presented in the following sections.

1. **Minor Modifications/Retrofits.** As shown in Table 3.5-2, with the exception of one month, the existing facility has achieved effluent nitrogen levels less than 10 mg/L since December 2005. At the current assumed influent TN levels, the existing facility should be able to achieve an average effluent nitrogen level of 8 mg/L up to a flow of approximately 0.35 mgd.

2. **Modifications Required to Meet TN of 8.** The modifications to the facility that are required to meet an effluent TN of 8 mg/L on a seasonal and annual average basis are as follows.

a. **Seasonal.** At the assumed influent TN levels for this facility, the SBR would be able to achieve a seasonal effluent TN level of 8 mg/L by cycling the air to achieve aerobic and anoxic conditions. The BioWin model for this process is as shown in Figure 3.5-2 below.

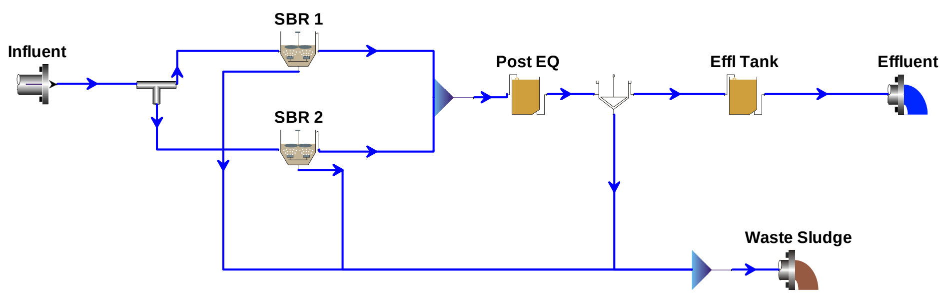


FIGURE 3.5-2: NITROGEN REMOVAL PROCESS - SEASONAL LIMIT OF 8 mg/L

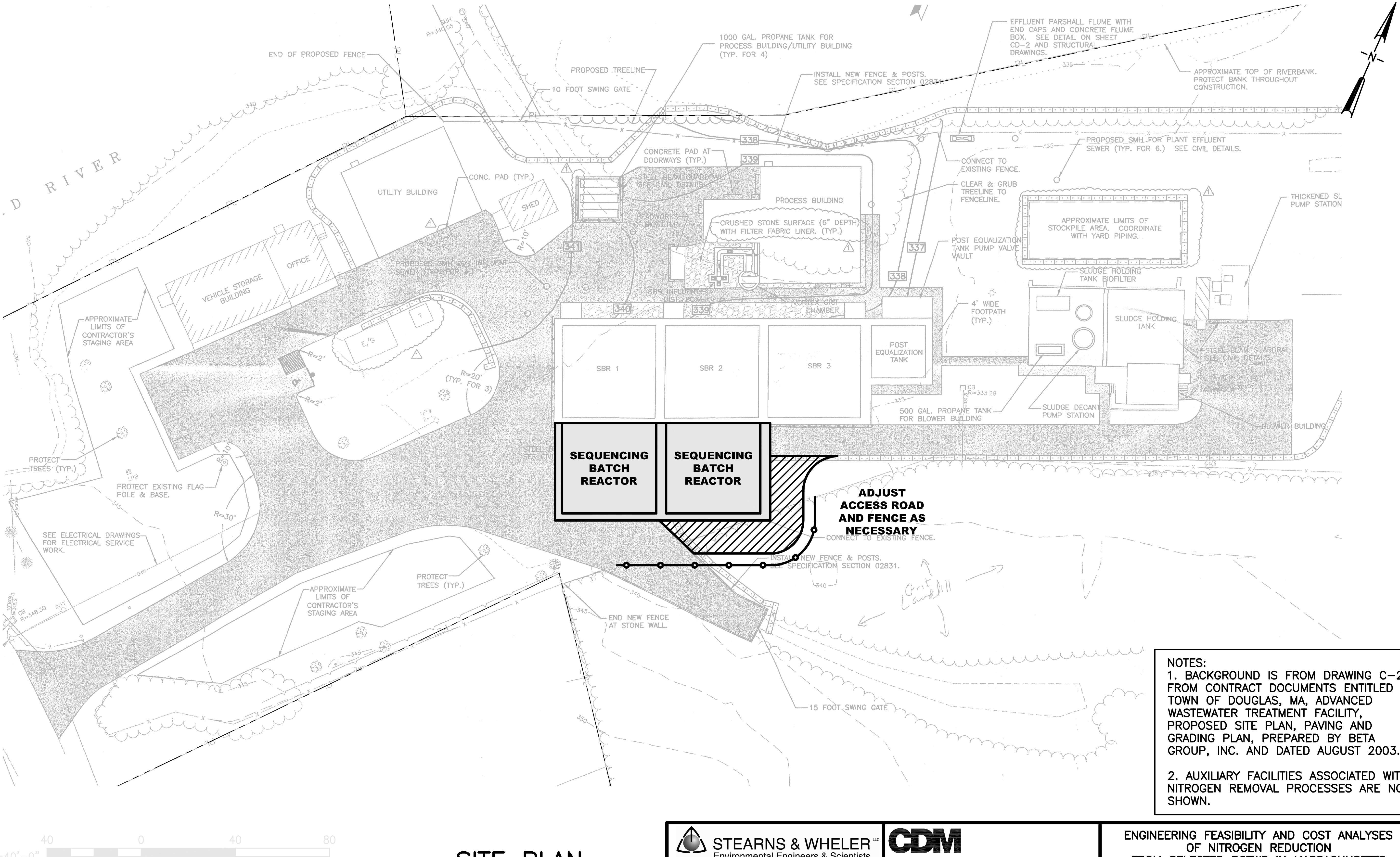
This process would require a total of two additional SBRs. Each of the new SBRs would be the same size as the existing tanks. As shown in the site plan in Figure 3.5-3, the site has enough space for the additional SBRs. Specific information regarding the results of this analysis is shown in Table 3.5-6 as follows.

Table 3.5-6

RESULTS FOR SEASONAL LIMIT OF 8 mg/L TN

PARAMETER	VALUE
Total SRT	20 days
Number of Cycles	5 per day/ basin
Cycle Duration	4.5 hrs/cycle
Total Tank Volume	1.35 MG
Max MLSS at Loading Rate	4500 mg/L
Effluent TN	8 mg/L
Methanol Addition	No
Effluent Filtration Required?	Existing, no additional

The proposed location for the new SBRs will either be at or across the fence. This is not the property line and thus it is assumed that new tanks can be constructed here and the road and fence relocated.



NOTES:
1. BACKGROUND IS FROM DRAWING C–2 FROM CONTRACT DOCUMENTS ENTITLED TOWN OF DOUGLAS, MA, ADVANCED WASTEWATER TREATMENT FACILITY, PROPOSED SITE PLAN, PAVING AND GRADING PLAN, PREPARED BY BETA GROUP, INC. AND DATED AUGUST 2003.

2. AUXILIARY FACILITIES ASSOCIATED WITH NITROGEN REMOVAL PROCESSES ARE NOT SHOWN.

SITE PLAN

SCALE: 1"=40'-0"

Login name: JDF
Filename path: J:\60000\61265 MADEP\10\Drawings\Fig
Filename: DOUGLAS–CH3.dwg
Latest Revision: Friday, April 04, 2008

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ENGINEERING FEASIBILITY AND COST ANALYSES OF NITROGEN REDUCTION FROM SELECTED POTWS IN MASSACHUSETTS

DOUGLAS, MASSACHUSETTS

FIGURE 3.5–3

In addition to the additional tanks and the equipment required for those tanks, the facility will require valve replacements and additional blowers. Other plant modifications may be needed including upgrades to sludge handling processes. However, all facilities outside of the activated sludge process are outside of the scope of this study.

b. **Annual Average.** At the assumed influent TN levels for this facility, the SBR would be able to achieve an average annual effluent TN level of 8 mg/L by cycling the air to achieve aerobic and anoxic conditions. The BioWin model for this process is as shown in Figure 3.5-4 below.

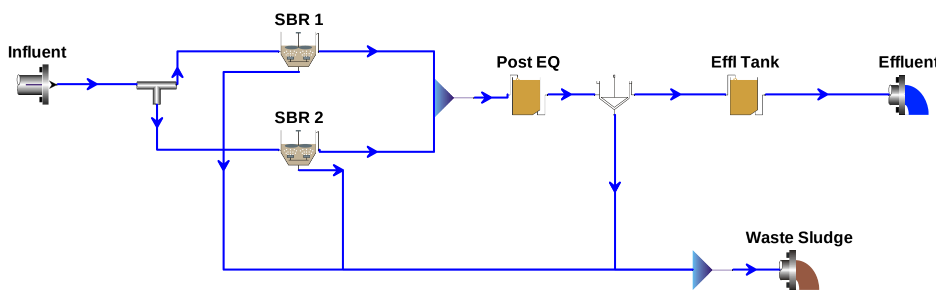

FIGURE 3.5-4: NITROGEN REMOVAL PROCESSES – ANNUAL AVERAGE LIMIT OF 8 mg/L

Like the seasonal limit, the annual average limit would require a total of two additional SBRs. Each of the new SBRs would be the same size as the existing tanks. As shown in the site plan in Figure 3.5-3, the site has enough space for the additional SBRs. Specific information regarding the results of this analysis is shown in Table 3.5-7 below.

(continued)

<u>Table 3.5-7</u>

RESULTS FOR ANNUAL AVERAGE LIMIT OF 8 mg/L TN

PARAMETER	VALUE
Total SRT	20 days
Number of Cycles	5 per day/ basin
Cycle Duration	4.5 hrs/cycle
Total Tank Volume	1.35 MG
Max MLSS at Loading Rate	4500 mg/L
Effluent TN	8 mg/L
Methanol Addition	No
Effluent Filtration Required?	Existing, no additional

The proposed location for the new SBRs will either be at or across the fence. This is not the property line and thus it is assumed that new tanks can be constructed here and the road and fence relocated.

In addition to the additional tanks and the equipment required for those tanks, the facility will require valve replacements and additional blowers. Other plant modifications may be needed including upgrades to sludge handling processes. However, all facilities outside of the activated sludge process are outside of the scope of this study.

3. **Modifications Required to Meet a TN of 5.** The modifications to the facility that are required to meet an effluent TN of 5 mg/L on a seasonal and annual average basis are as follows.

a. **Seasonal.** At the assumed influent TN levels for this facility, the SBR would be able to achieve a seasonal effluent TN level of 5 mg/L by cycling the air to achieve aerobic and anoxic conditions and by using the existing cloth filtration system for additional particulate nitrogen removal. The BioWin model for this process is as shown in Figure 3.5-5 below.

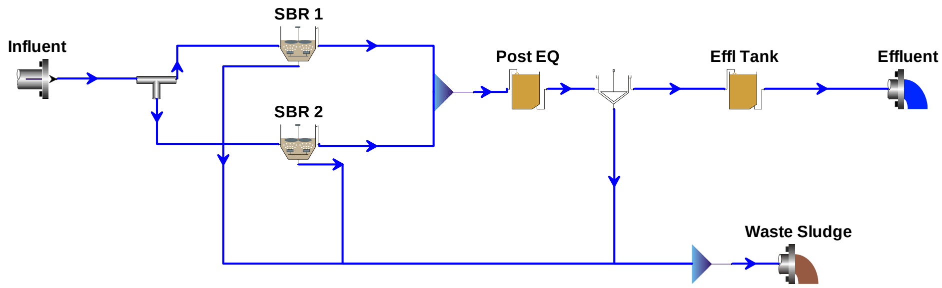

FIGURE 3.5-5:
NITROGEN REMOVAL PROCESSES – SEASONAL LIMIT OF 5 mg/L

This process would require a total of two additional SBRs. Each of the new SBRs would be the same size as the existing tanks. As shown in the site plan in Figure 3.5-3, the site has enough space for the additional SBRs. Specific information regarding the results of this analysis is shown in Table 3.5-8 below.

Table 3.5-8
RESULTS FOR SEASONAL LIMIT OF 5 mg/L TN

PARAMETER	VALUE
Total SRT	18 days
Number of Cycles	4 per day/ basin
Cycle Duration	6 hrs/cycle
Total Tank Volume	1.35 MG
Max MLSS at Loading Rate	4500 mg/L
Effluent TN	5 mg/L
Methanol Addition	No
Effluent Filtration Required?	Yes, use existing cloth filters

The proposed location for the new SBRs will either be at or across the fence. This is not the property line and thus it is assumed that new tanks can be constructed here and the road and fence relocated.

In addition to the additional tanks and the equipment required for those tanks, the facility will require valve replacements and additional blowers. The existing SBRs and post equalization capacity can be reused. Other plant modifications may be needed including upgrades to sludge handling processes. However, all facilities outside of the activated sludge process are outside of the scope of this study.

b. **Annual Average.** At the assumed influent TN levels for this facility, the SBR would be able to achieve an average annual effluent TN level of 5 mg/L by cycling the air to achieve aerobic and anoxic conditions and by using the existing cloth filtration system for additional particulate nitrogen removal. The BioWin model for this process is as shown in Figure 3.5-6 below.

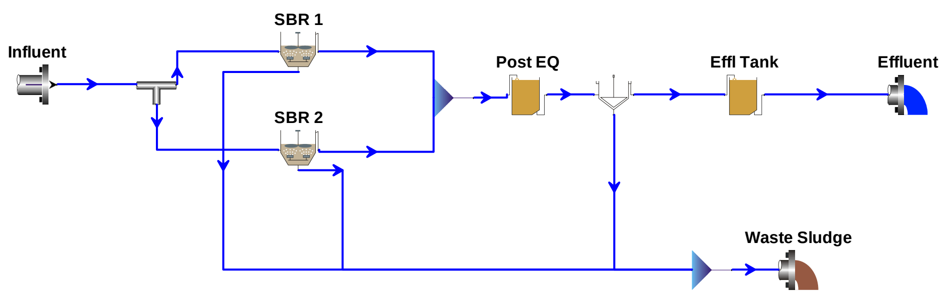

FIGURE 3.5-6:
NITROGEN REMOVAL PROCESSES – ANNUAL AVERAGE LIMIT OF 5 mg/L

Like the seasonal limit, the annual average limit would require a total of two additional SBRs. Each of the new SBRs would be the same size as the existing tanks. As shown in the site plan in Figure 3.5-3, the site appears to have enough space for the additional SBRs. Specific information regarding the results of this analysis is shown in Table 3.5-9 as follows.

(continued)

Table 3.5-9

RESULTS FOR ANNUAL AVERAGE LIMIT OF 5 mg/L TN

PARAMETER	VALUE
Total SRT	18 days
Number of Cycles	4 per day/ basin
Cycle Duration	6 hrs/cycle
Total Tank Volume	1.35 MG
Max MLSS at Loading Rate	4500 mg/L
Effluent TN	5 mg/L
Methanol Addition	No
Effluent Filtration Required?	Yes, use existing cloth filters

The proposed location for the new SBRs will either be at or across the fence. This is not the property line and thus it is assumed that new tanks can be constructed here and the road and fence relocated.

In addition to the additional tanks and the equipment required for those tanks, the facility will require valve replacements and additional blowers. The existing SBRs and post equalization capacity can be reused. Other plant modifications may be needed including upgrades to sludge handling processes. However, all facilities outside of the activated sludge process are outside of the scope of this study.

(continued)

D. **Plant and Cost Summary.**

Table 3.5-10 presents flow data for the Douglas WWTF as well as the current nitrogen removal performance of the plant.

Table 3.5-10

PLANT FLOW AND EFFLUENT LIMIT SUMMARY

PARAMETER	VALUE
Permitted Flow (mgd)	0.60
Existing Flow (2004-6)	0.21
% of existing capacity	35
Current average seasonal effluent TN (mg/L)[1]	3.4
Current average annual effluent TN (mg/L) [1]	5.2
Permit Limits Seasonal Nitrification (mg/L) Year-round nitrification (mg/L) Seasonal TN Limit Annual TN Limit	 Yes (5) No No No

1. Includes January 2006-December 2006 only, the time since the new plant was activated.

Table 3.5-11 presents the nitrogen removal processes identified in this section to achieve the four different permit conditions considered. Based on the loading conditions established for this facility and the subsequent BioWin modeling performed using this data, the facility improvements include adding additional SBRs.

Table 3.5-11

NITROGEN REMOVAL PROCESS SUMMARY FOR DOUGLAS WWTF

MINOR/ MODIFICATIONS OR RETROFITS	PROCESS TO ACHIEVE SEASONAL TN OF 8 MG/L	PROCESS TO ACHIEVE ANNUAL AVERAGE TN OF 8 MG/L	PROCESS TO ACHIEVE SEASONAL TN OF 5 MG/L	PROCESS TO ACHIEVE ANNUAL AVERAGE TN OF 5 MG/L
Currently achieving nitrogen removal	Cyclical Aeration in SBR	Cyclical Aeration in SBR	Cyclical Aeration in SBR	Cyclical Aeration in SBR

The modifications required at Douglas to convert to a new nitrogen removal process are summarized in Table 3.5-12.

Table 3.5-12

REQUIRED MODIFICATIONS SUMMARY FOR DOUGLAS WWTF

MODIFICATIONS TO ACHIEVE SEASONAL TN OF 8 MG/L	MODIFICATIONS TO ACHIEVE ANNUAL AVERAGE TN OF 8 MG/L	MODIFICATIONS TO ACHIEVE SEASONAL TN OF 5 MG/L	MODIFICATIONS TO ACHIEVE ANNUAL AVERAGE TN OF 5 MG/L	SPECIAL CONDITIONS
2 new SBRs	2 new SBRs	2 new SBRs	2 new SBRs	None

The cost estimating procedures established in Section 2 were used to estimate capital, annual O&M, and 20-year present worth costs associated with the process changes and facility modifications summarized above. The cost estimates are included in Table 3.5-13.

Table 3.5-13

COST SUMMARY FOR NITROGEN REMOVAL AT DOUGLAS WWTF[1]

LIMIT	CAPITAL COSTS (IN MILLIONS)	TOTAL ANNUAL COSTS[2] (IN THOUSANDS)	20-YR PRESENT WORTH (IN MILLIONS)
Minor Modifications/Retrofits	None	n/a	n/a
Seasonal Effluent TN of 8 mg/L	\$4.4	\$72	\$5.4
Annual Average Effluent TN of 8 mg/L	\$4.4	\$79	\$5.4
Seasonal Effluent TN of 5 mg/L	\$4.4	\$72	\$5.4
Annual Average Effluent TN of 5 mg/L	\$4.4	\$79	\$5.4

1. It should be noted that these costs represent one method by which this facility can achieve the stated TN goals. It is not intended to be the most cost effective method nor the recommended method, but it represents a planning tool for MassDEP to estimate the fiscal impacts of establishing total nitrogen limits.
2. Represents incremental increase over current conditions.

(continued)