SECTION 9.0
SEWPCC – SECOND PRIORITY CONTROL ALTERNATIVES

9.1 ALTERNATIVES CONSIDERED FOR SEWPCC

9.1.1 Preamble

Table 9.1 below indicates the target ammonia concentrations for the Second Priority Levels of Control for the South End Water Pollution Control Centre (SEWPCC).

Table 9.1: Second Priority Effluent Ammonia Targets

Standard	Target NH_3-N Level
Second Priority Level of Control	
High Level	8 mg/L
Modest Level	14 mg/L

As described in Section 4.0, the Best Practicable Level of Control of effluent ammonia (2 mg/L) requires full nitrification of the entire SEWPCC effluent flow (dry weather). Full ammonia oxidation is achieved by modifying the existing reactors, constructing additional reactor volume, and adding a secondary clarifier. Flow passes in series through the existing HPO plant to the new bioreactors. The Second Priority Levels of Control require less ammonia oxidation than the Best Practicable Level of Control; hence, should require less bioreactor volume or deletion of the new secondary clarifier.

Similar to the evaluation conducted of options for the North End Water Pollution Control Centre (NEWPCC), this section presents a long list of alternatives for the Second Priority Levels of Control. The discussion of each alternative facilitates the selection of the approach that is carried forward as the basis of the conceptual design for the second priority control alternatives.

The long list of alternatives is logically grouped into four categories as follows:

- **Construct a new treatment train in parallel to the existing HPO plant:** A portion of the primary effluent is diverted from the existing HPO plant and fed to a new parallel train. This new process is a single stage activated sludge process designed to fully nitrify. The fraction of primary effluent treated in the new train is varied to achieve the two second priority levels of ammonia control under consideration.
- **Reaerate the Return Activated Sludge (RAS) Flow:** The RAS flow from the existing HPO plant passes to a reaeration basin where the ammonia in the RAS would be nitrified.

- **Alter and expand the existing HPO bioreactors to a step feed configuration.** The existing HPO reactors would be converted to a step feed configuration. Because in step feed, the fraction of the influent that is fed to latter stages of a process does not have adequate contact time, incomplete nitrification occurs.
- **Construct a second stage treatment system using a fixed film process.** A fixed film biological treatment system would be added as a second stage to treat effluent from the existing HPO system. This second stage facility would be sized to treat a portion of the secondary effluent; the portion adjusted to provide a combined effluent that meets the desired level of control.

BioWin™ was used to develop preliminary sizing estimates for the single stage options. A literature review and information from equipment vendors was used to determine sizing estimates for the second stage fixed film processes. The alternatives are described in more detail in the following subsections.

9.1.2 New Treatment Train in Parallel to the Existing HPO Plant

In a conventional activated sludge process, it is nearly impossible to reliably achieve partial nitrification. A more practicable approach to meeting the Second Priority Levels of Control would be to provide nitrification to a portion of the primary effluent.

In this option, the existing HPO system would continue to provide complete carbonaceous organic removal of a portion of the primary effluent. A new parallel system would be constructed to fully nitrify the remaining portion of the primary effluent. Proportioning of the primary effluent between the two systems is established so that the blended effluent from the two biological treatment systems reliably achieves the second priority levels of ammonia control.

The configuration of the modified plant is comprised of the existing plant plus one new clarifier and two new nitrifying reactors. About 40 percent of the flow is directed to the existing four HPO reactors. The mixed liquor would then be discharged into the two existing 33.5 metre diameter clarifiers. The two new nitrifying reactors would discharge mixed liquor into the two 45.7 metre diameter clarifiers (one existing, one new). The projected effluent ammonia concentration from this plant configuration is less than 14 mg/L.

Based on initial, cursory modeling, the major tankage components (approximate sizing) that are required for this option are shown in Table 9.2.

Table 9.2: Approximate Tankage Requirements for Modest Level of Control

Component	Units	Value
New Bioreactors		
Number		2
Volume (Total)	m^3	~25,000
New Clarifier		
Number		1
Diameter	m	45.7

To meet the high level of control (8 mg/L ammonia in summer), a larger portion of the primary effluent would be treated in the new parallel treatment train. In this case, approximately 70 percent of the flow would be directed to the new parallel plant. The major tankage (approximate sizing) that would be added is as follows:

Table 9.3: Approximate Tankage Requirements for High Level of Control

Component	Units	Value
New Bioreactors		
Number		2
Volume (Total)	m^3	~30,000
New Clarifier		
Number		1
Diameter	m	45.7

A disadvantage of the parallel train approach is the increased complexity due to the need to operate two separate plants with substantially different operating characteristics and objectives.

Upgrading the process configuration to Biological Nutrient Removal is possible. Hence, this approach allows the flexibility that might be necessary to meet more stringent effluent limits, such as for nitrogen and phosphorus, if this is required in the future.

9.1.3 Reaerate the Return Activated Sludge (RAS) Flow

At the SEWPCC, simple RAS reaeration may not develop and maintain a sufficient nitrifier population required to provide reliable levels of ammonia oxidation, without a concentrated ammonia feed (such as centrate) into the RAS reaeration reactor. Centrate is not available at the SEWPCC. Therefore, for the purposes of this study, RAS reaeration has not been given further consideration.

9.1.4 Alter and Expand the Existing HPO Bioreactors to a Step Feed Configuration

As described in Section 4.0, for the Best Practicable Level of Control, an additional 30,000 m^3 of bioreactor volume was recommended along with one new 45.7 metre diameter clarifier. The step feed option for the Second Priority Level of Control is similar and it allows a staged approach to achieve ammonia reductions. Staging could be implemented so that effluent ammonia concentrations of less than 14 mg/L could be achieved initially, later improving treatment to limit ammonia concentrations to 8 mg/L, and ultimately implementing sufficient improvements to achieve the Best Practicable Level of Control. Staging is facilitated by constructing the bioreactor and clarifier additions in phases and by step feeding the primary effluent in an appropriate pattern. For comparative purposes, the additional tankage required to meet the possible effluent limits are compared to the Best Practicable Level of Control in the following table.

Table 9.4: Approximate Tankage Requirements in Step Feed Option

Level of Ammonia Control	Tankage	Units	Value
Best Practicable Level of Control (<2 mg/L)	Bioreactor Volume	m^3	30,000
	Final Clarifier		
	Number		1
	Diameter	m	45.7
High Level (<8 mg/L)	Bioreactor Volume	m^3	30,000
Modest Level (<14 mg/L)	Bioreactor Volume	m^3	20,000

Similar to the configuration envisioned for the Best Practicable Level of Control, the existing HPO bioreactors would be modified to form the initial stages of the new bioreactors (four in number). Mixed liquor would be discharged from the existing high purity oxygen basins into the new bioreactor sections that are constructed with sufficient volume to provide the necessary retention time.

All of the return activated sludge (RAS) and a portion of the primary effluent would be discharged into the first cell of the high purity oxygen basins. Relatively high MLSS concentrations would exist in this portion of the reactor, with the concentration becoming diluted as more primary effluent flow is introduced at intermediate feed points. Even with step feed in this pattern, the food:microorganism ratio in the initial cell(s) would be high. The high oxygen transfer capability of the HPO system would ensure that positive oxygen concentrations are maintained; hence, these initial bioreactor cells act as an aerobic selector, promoting the growth of floc forming bacteria in preference to filamentous bacteria.

In a step feed bioreactor configuration, longer aerobic sludge ages can be maintained than in conventional systems of the same volume, where the RAS and primary effluent are introduced together at the head of the bioreactor. In a step feed configuration, MLSS concentrations are higher at the head of the reactor, gradually lowering as more of the primary effluent is added along the length of the tank. Secondary clarifier loading is a function of the mixed liquor solids concentrations. Hence, step feed enables a larger solids inventory to be maintained in the same reactor volume due to the graduated mixed liquor concentrations which results in lower solids to the clarifiers.

Step feed can achieve intermediate levels of ammonia control. A sludge age sufficient to support a nitrifying population can be established, but ammonia bleeds through the system due to the short hydraulic retention times afforded primary effluent that is fed into the bioreactor at downstream points. Conversely, BOD removal occurs swiftly; thus, organic removal is not adversely affected by step feed operation.

The primary advantage of step feed is that the bioreactor expansion is reduced to only that necessary to achieve the target effluent ammonia concentration. Other advantages are that it incurs lower cost while not precluding the ability to implement further plant modifications to meet more stringent effluent requirements in the future. Also, step feed does not compromise the possible expansion to biological phosphorus removal.

On the negative side, controlling the flow split to multiple basins with multiple feed points will require a higher degree of operator attention.

9.1.5 Construct a Second Stage Treatment System Using a Fixed Film Process

This option entails the construction of a fixed film biological treatment system as a second stage following the existing HPO system. These second stage facilities would be sized to treat that portion of the existing secondary effluent that, when combined with effluent not treated through the second stage, complies with the second priority levels of ammonia control. The two effluents would be blended to yield the requisite effluent ammonia quality. Fixed film processes that merit consideration include nitrifying trickling filters (NTF) and biological aerated filters (BAF). For the purpose of this analysis, it is assumed that BAFs would be installed. For comparative purposes Table 9.5 lists the number of BAF units required for each level of control. Each BAF unit would have a surface of 104 m^2 which is a standard size.

Table 9.5: Approximate Number of BAF Units Required for Different Level of Ammonia Control

Level of Ammonia Control	Number of Units
Best Practicable (<2 mg/L)	10
High Level (<8 mg/L)	8
Modest Level (<14 mg/L)	6

A significant advantage of this alternative is that construction could be accomplished with minimal interruption to normal plant operations. In addition, it is feasible to construct just enough facility so that the combined effluent meets the high and modest level of control objectives. Furthermore, a phased implementation program could be followed whereby six BAF units are installed initially to provide a modest level of ammonia control. Two additional BAF units could be added at any time in the future to provide a high level of ammonia control. Disadvantages include:

- If future changes in regulatory requirements mandate conversion of the plant to achieve the Best Practicable Level of Control, addition of a second stage treatment system would be required. Total costs for best practicable level of control using a second stage treatment system (e.g. BAFs) are expected to be higher than for an integrated solution.
- Future implementation of biological phosphorus control would be difficult without substantial modification to the initial carbonaceous nitrification stage.

9.2 COMPARISON OF ALTERNATIVES AND SELECTION OF OPTIONS TO CARRY FORWARD

This section provides a summary of the alternatives, as well as the rational for selecting an alternative upon which to base the conceptual design of the Second Priority Levels of Control for the SEWPCC.

The separate plant options are obviously more costly than the step feed options. For both the modest and high levels of ammonia control, the bioreactor capacities are similar. However, the separate plant options require that an additional secondary clarifier be constructed. A 45.7 metre diameter clarifier would involve capital costs over $3 million.

It is not expected that there would be a significant cost differential between the attached growth second stage (BAF) and step feed at a conceptual level. Rough estimating suggests that the step feed option would cost approximately $23.5 million to achieve high ammonia removals (less than 8 mg/L) and $17.5 million for modest reductions (less than 14 mg/L). The conceptual level cost estimates for a second stage BAF plant with eight modules (less than 8 mg/L) is $24.5 million; while the estimate for a second stage BAF facility with six modules (less than 14 mg/L) is $19 million. In neither case are the expected capital costs substantially different given the conceptual level at which they have been developed.

Advantages and disadvantages of each of the various options are summarized in Table 9.6. The noneconomic criteria listed in the table are extracted from the NEWPCC discussion. One exception is the criteria noted as space requirements. The location and size of the SEWPCC does not impose substantial site issues for the expansion of the plant using conventional technologies.

Noneconomic factors slightly favour the step feed option. The step feed option is compatible with potential nutrient removal in the future, it does not require intermediate pumping, and it is integrated with the existing plant. In addition, power consumption would not be as high as the power consumption of a BAF facility.

Table 9.6: Comparison of High Removal and Modest Removal Alternatives

Option	Level of Control	Major Components	Criteria Application	
New Treatment Train in Parallel to the Existing HPO Plant				
60% of PE to new parallel train	Modest	Bioreactors – 25,000 m^3 1 clarifier @ 47.5 m dia.	Complexity and operability: Robustness and reliability: Expandability – Flows and Loads: Expandability – Tighter NH3-N: Expandability – P Removal: Constructability during operation: Aesthetics	2 A/S plants to operate and maintain Acceptable Can readily add more parallel trains Can readily add more parallel trains Chem P by adding more clarifiers; Bio-P by adding more bioreactors Generally acceptable, some tie-ins Similar to existing
70 % of PE to new parallel train	High	Bioreactors – 30,000 m^3 1 clarifier @ 45.7 m dia.	Complexity and operability: Robustness and reliability: Expandability – Flows and Loads: Expandability – Tighter NH3-N: Expandability – P Removal: Constructability during operation: Aesthetics:	2 A/S plants to operate and maintain Acceptable Can readily add more parallel trains Can readily add more parallel trains Chem P by adding more clarifiers; Bio-P by adding more bioreactors Generally acceptable, some tie-ins Similar to existing
Alter and Expand the Existing HPO Bioreactors to a Step Feed Configuration				
Step Feed	Modest	Bioreactor – 20,000 m3	Complexity and operability: Robustness and reliability: Expandability – Flows and Loads: Expandability – Tighter NH3-N: Expandability – P Removal: Constructability during operation: Aesthetics:	Flow split complex Acceptable Can readily add more tankage Can readily add more tankage and reduce feed to back Can readily add more tankage and modify configuration Requires modifications within exist plant Similar to existing
Step Feed	High	Bioreactor – 30,000 m3	Complexity and operability: Robustness and reliability: Expandability – Flows and Loads: Expandability – Tighter NH3-N: Expandability – P Removal: Constructability during operation: Aesthetics:	Flow split complex Acceptable Add more tankage Add more tankage and reduce feed to back Add more tankage and modify configuration Requires modifications within exist plant Similar to existing

Table 9.6: Comparison of High Removal and Modest Removal Alternatives (continued)

Option	Level of Control	Major Components	Criteria Application	
Construct a Second Stage Treatment – BAF				
BAF	Modest	6 modules	Complexity and operability: Robustness and reliability: Expandability – Flows and Loads: Expandability – Tighter NH3-N: Expandability – P Removal: Constructability during operation: Aesthetics:	Much more complex Very robust due to attached growth Can readily add modules Can readily add modules Chemical P removal Few connections Site location would provide visual buffer
BAF	High	8 modules	Complexity and operability: Robustness and reliability: Expandability – Flows and Loads: Expandability – Tighter NH3-N: Expandability – P Removal: Constructability during operation: Aesthetics:	Much more complex Very robust due to attached growth Can readily add modules Can readily add modules Chemical P removal Few connections Site location would provide visual buffer

The BAF plant option also has advantages. Attached growth processes are more robust than suspended growth processes such as step feed. A BAF plant could be built without disrupting existing operations. In addition, the operation could be more readily moderated when effluent ammonia requirements were not as stringent at various times of the year.

Based on the foregoing, it is not possible to differentiate between the step feed and second stage BAF options. Conceptual designs have been developed for both. The separate plant options have not been pursued further due to the relatively high costs associated with these options. RAS reaeration will not be considered due to the possibility that this process will not achieve the effluent ammonia objectives on a reliable basis.

9.3 HIGH LEVEL OF CONTROL – STEP FEED

9.3.1 Process Configuration and Design

In this process configuration, the bioreactor is separated into four modules. The four existing bioreactors are rearranged to provide four clusters, each in a square pattern. Each cluster is associated with a long bioreactor that extends either north or south of the cluster. Primary effluent is fed along a new feed channel and into the bioreactor through a series of four gates. Each gate feeds different sectors of the bioreactor. Modeling was based on a 20% / 30% / 30% / 20% split; however, incorporated flexibility would allow the split to be modified to optimize system operation. Effluent from the bioreactor discharges into collection channels that traverse the north and south ends of the bioreactors, travel to the centre and rejoin the existing mixed liquor channel.

The new bioreactors are aerated rather than oxygenated. New blowers are located in a blower building on the south west side of the complex. The blowers feed an air header that distributes the air to a flexible membrane fine bubble aeration system. Design Data for bioreactors and aeration system are summarized in Table 9.7.

Table 9.7: Design Data for High Level Control – Step Feed

Description	Units	Value
Bioreactors		
Number		4
Volume per bioreactor	m^3	10,740
Volume, existing oxygen reactors	m^3	3,240
Volume, new aerated reactors	m^3	7,500
Aeration System		
Maximum oxygen uptake rates		
Cell 5	mg/L/h	42
Cell 6	mg/L/h	37
Cell 7	mg/L/h	34
Peak oxygen demand per module	kg/h	285
SOTE	%	29.5
Total air requirement	m^3/h	29,200
Blowers		
Number		3
Capacity	m^3/h	14,600
Size	kW	400

The model configuration of this option is shown in Figure 9.1.

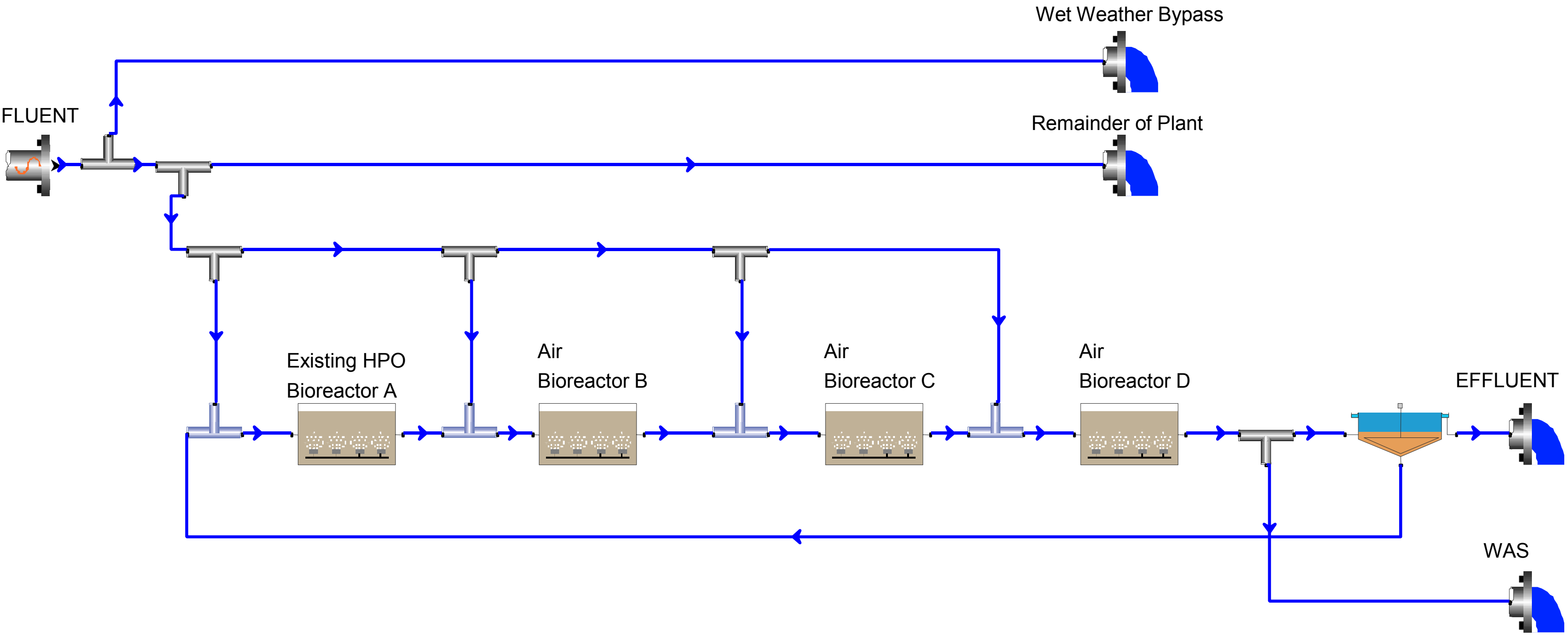


Figure 9.1: SEWPCC- Model Configuration for High Removal Level – Step Feed

9.3.2 Sludge Thickening

This option includes waste activated sludge withdrawal from the mixed liquor channel, prior to the secondary clarifiers. This location is selected to allow preferential wasting of floating organisms through a near surface withdrawal mechanism.

The waste activated sludge is directed to three dissolved air flotation (DAF) thickeners where it is thickened to between 3.5 and 4.5 percent prior to storage. The sludge generation rates and design data for DAF thickeners are summarized in Table 9.8.

Table 9.8: SEWPCC - WAS Generation Rates and DAF Design Data (High Level of Control – Step Feed)

Description	Units	Value
WAS Production		
Average	kg/d	6,800
Maximum	kg/d	13,600
DAF Thickeners		
Loading rates		
Average	$kg/m^2/h$	5
Maximum	$kg/m^2/h$	10
Number		3
Surface area per unit	m^2	20

9.3.3 Site Layout

Site plans of this high level control option are shown in Dwg. SE-9.1 and Dwg. SE-9.2. The process flow diagram and sludge thickening process flow diagram are illustrated in Dwg. SE-9.3 and Dwg. SE-9.4, respectively.

9.4 HIGH LEVEL OF CONTROL - BIOLOGICAL AERATED FILTER (BAF) TREATMENT

This option consists of a second stage treatment system comprised of eight BAF cells. This second stage would be located in the southeast area of the site, between the secondary clarifiers and the existing UV disinfection system. The secondary treatment system would be expanded as necessary to provide carbonaceous BOD removal (two additional oxygen reactors). A fourth clarifier is not necessary to handle the additional flow; the overflow rates and surface loading rates associated with the three existing clarifiers do not appear excessive.

A biological aerated filter (BAF) consists of a granular media filter bed. Wastewater is introduced at the bottom of the bed through a plenum and distributed across the bed by series of nozzles. It flows upward through the bed and discharges over a weir at the top water surface. Air is introduced at the bottom of the filter bed through a series of diffusers and flows concurrently with the wastewater toward the surface.

At regular intervals, the BAF is backwashed by introducing high flows to the bottom of the filter bed. Intermittently, high backwash air scouring augments the water flow to enhance interparticle shear. Backwash is required once per three or four days; however, in many instances, more frequent backwashing is conducted.

Backwash water is drawn from a treated wastewater reservoir specifically provided for this service. To minimize the impact of return flow surges due to backwashing, the BAF backwash wastewater is collected in a backwash waste basin and then pumped at lower constant flows to the head of the plant. A minimum of 1.5 metres of head is consumed by BAF treatment. To overcome these headlosses, plus those incurred by the transfer of flows to and from the facility, a low head pump station would be required between the secondary effluent conduit and the BAF facility. This facility would consist of three low lift, vertical, axial flow pumps.

Design data for this option covering bioreactors, aeration system, pumping station, and BAF units and their components are summarized in Table 9.9.

This option will include DAF thickening of waste activated sludge. This process will be similar to that described in the previous option, although somewhat greater in capacity to handle the increased sludge generation rates from high rate carbonaceous removal secondary treatment. WAS production rates and design data for DAF thickening system are presented in Table 9.10.

Table 9.9: Design Data for High Level Control – BAF

Description	Units	Value
Bioreactors		
Number		6
Volume per bioreactor	m^3	3,240
Volume, existing oxygen reactors	m^3	3,240
Volume, new aerated reactors	m^3	3,240
Oxygen System		
Existing capacity	Tonnes/d	20
New capacity	Tonnes/d	30
Intermediate Pump Station		
Number of Pumps		3
Capacity	L/s	700
Size	kW	37.5
BAF		
Number		8
Surface Area per BAF	m^2	104
Media depth	m	4.0
BAF Blowers		
Number		8
Capacity	m^3/h	1,260
BAF Backwash Pumps		
Number		3
Capacity	m^3/h	1,040
BAF Backwash Blowers		
Number		2
Capacity		7,500

Table 9.10: SEWPCC - WAS Generation Rates and Sludge Thickening Design Data (High Level of Control – BAF)

Description	Units	Value
WAS Production		
Average	kg/d	8,000
Maximum	kg/d	16,000
DAF Thickeners		
Loading rates		
Average	$kg/m^2/h$	5
Maximum	$kg/m^2/h$	10
Number		3
Surface area per unit	m^2	24

9.5 MODEST LEVEL OF CONTROL – STEP FEED

This option is identical to that described for the High Level of Control – Step Feed option other than the bioreactor is smaller. Less volume is necessary to achieve the ammonia oxidation to reliably meet the limit of 14 mg/L. Accordingly, the additional bioreactor for each of the four treatment modules is only about 65 percent of that required for the high level of control. The size reduction was achieved by eliminating the last of the three cells into which this bioreactor extension had been segregated in the high level option. Design data for the bioreactors and aeration system in this option is summarized in Table 9.11. The site layout and plant layout are shown on Dwg. SE-9.5 and Dwg. SE-9.6 WAS production and sludge thickening process design are similar to those described for High Level of Control – Step Feed option.

Table 9.11: Design Data for Moderate Level Control – Step Feed

Description	Units	Value
Bioreactors		
Number		4
Volume per bioreactor	m^3	7,240
Volume, existing oxygen reactors	m^3	3,240
Volume, new aerated reactors	m^3	5,000
Aeration System		
Maximum oxygen uptake rates		
Cell 5	mg/L/h	58
Cell 6	mg/L/h	40
Peak oxygen demand	kg/h	245
SOTE	%	30
Total air requirement	m^3/h	25,900
Blowers		
Number		3
Capacity, m^3/h	m^3/h	12,950
Size, kW	kW	350
DAF Thickeners		
WAS Production		
Average	kg/d	6,800
Maximum	kg/d	13,600
Loading rates		
Average	$kg/m^2/h$	5
Maximum	$kg/m^2/h$	10
Number		3
Surface area per unit	m^2	20

9.6 MODEST LEVEL OF CONTROL – BAF

As with the step feed option, this option is similar to that entailed for the high level BAF option; however, there are fewer BAF units required. Six BAF units are provided for the modest level of control compared to the eight required for the high level of control. Other ancillaries are identical. Design data for this option is summarized in Table 9.12.

Table 9.12: Design Data for Modest Level Control – BAF

Description	Units	Value
Bioreactors		
Number		6
Volume per bioreactor	m^3	3,240
Volume, existing oxygen reactors	m^3	3,240
Volume, new aerated reactors	m^3	3,240
Oxygen System		
Existing capacity	Tonnes/day	20
New capacity	Tonnes/day	30
Intermediate Pump Station		
Number of Pumps		3
Capacity	L/s	700
Size	L/s	37.5
BAF		
Number		6
Surface Area per BAF	m^2	104
Media depth	m	4.0
BAF Blowers		
Number		6
Capacity	m^3/h	1,260
BAF Backwash Pumps		
Number		3
Capacity	m^3/h	1,040
BAF Backwash Blowers		
Number		2
Capacity	m^3/h	7,500
DAF Thickeners		
Waste Activated Sludge Production		
Average	kg/d	8,000
Peak	kg/d	16,000
Loading rates		
Average	$kg/m^2/h$	5
Maximum	$kg/m^2/h$	10
Number		3
Surface Area per unit	m^2	24.0

9.7 HIGH LEVEL OF CONTROL - MODEL OUTPUT

Model projections for the high level of control - Step Feed, are shown in Figures 9.2 through 9.5. The vertical bandwidth of each parameter plotted on these figures is indicative of the daily diurnal variation of the parameter.

Figure 9.2 presents diurnal variations of the influent and effluent ammonia concentrations. Effluent ammonia concentrations, as illustrated in the figure, remain below 8 mg/L throughout the year regardless of the variations associated with the influent ammonia concentrations. TKN diurnal variations (Figure 9.3) follow patterns similar to the ammonia variations.

Projections of the MLSS, shown in Figure 9.4, indicate variations in the range of 1,500 to 6,000 mg/L in different bioreactor modules. This is expected in a step feed configuration with the return of RAS to the head modules. The highest concentration will occur in the existing HPO reactors. The concentration of MLSS decreases gradually in the sequence of the bioreactor modules following the HPO reactors. In practice, the MLSS concentrations in the initial modules will be considerably less than the model projected value of 6,000 mg/L because the bioreactor content is mixed consistently with the diluted influent.

The projected year 2041 final clarifiers operating parameters are illustrated in Figure 9.5. Solids loading rate (SLR) is shown in green color and surface over flow rate (SOR) in red.

The surface overflow rates show limited diurnal variations within the acceptable range of 0.5 to 2 m/hr, even during Maximum Week and Maximum Day flows. Solids loading rates also project reasonable values except for the spring and summer Maximum Day when the model projects loads higher than 6 $kg/m^2/h$. The variations in SLR are the results of variations in flow and MLSS. The high values observed for Maximum Days of spring and summer are the theoretical projections of the model on the basis of pre-set input data values. In practice, the loads will be moderated through control parameters such as sludge wastage.

9.8 MODEST LEVEL OF CONTROL - MODEL OUTPUT

The year 2041 SEWPCC projections for implementation of the Modest Level of Control - Step Feed option are shown in Figures 9.6 to 9.9. These figures present performance and operating parameters such as influent/effluent ammonia concentrations, influent/effluent TKN concentrations, bioreactor MLSS, and the final clarifier solids loading rates and surface overflow rates. The vertical bandwidth of each parameter plotted on these figures is indicative of the daily diurnal variation of the parameter.

Comparison between influent and effluent ammonia concentration (Figure 9.6) shows a highly efficient system in regard to ammonia removal. This treatment option provides ammonia concentrations of less than 14 mg/L during different seasons. The interpretations of other figures are similar to those described in previous section for the figures associated with the High Level of Control.

9.9 STATISTICAL ANALYSIS

9.9.1 High Level of Control - Statistical Analysis

The procedure followed in statistical analysis of the data related to the SEWPCC is the same as the one used for the data analysis of the NEWPCC. The procedure is described in Section 4.0.

Table 9.13 summarizes the results of statistical analysis of the projected effluent ammonia concentrations for the High Level of Control - Step Feed option. From the results it can be concluded that:

- The effluent ammonia has greater variations during summer (June, July and August) than other seasons.
- 95 percent of the samples taken during each month will have ammonia concentrations equal to or less than the value reported in the Exp (GM 95th%) column for that month.

Table 9.13: SEWPCC - Results of Statistical Analysis on Effluent Ammonia (Year 2041 - High Level of Control)

Month	Monthly AA (mg/L)	Ln (GM)	σ/GM	σ	s(30 days)	GM of 30 day averages	95th% 30 day GM	Exp (GM 95th%)
June	5.17	1.62	0.12	0.195	0.036	1.643	1.702	5.48
July	3.50	1.15	0.18	1.207	0.038	1.170	1.232	3.43
August	7.17	1.93	0.12	0.232	0.042	1.958	2.028	7.60
September	4.96	1.59	0.06	0.095	0.017	1.590	1.618	5.04
October	5.12	1.61	0.09	0.145	0.026	1.619	1.662	5.27
November	4.49	1.48	0.06	0.089	0.016	1.488	1.515	4.55
December	5.02	1.60	0.06	0.096	0.017	1.600	1.629	5.10
January	5.26	1.63	0.04	0.065	0.012	1.636	1.656	5.24
February	4.74	1.54	0.06	0.092	0.017	1.542	1.569	4.80
March	3.66	1.26	0.04	0.051	0.009	1.264	1.280	3.60
April	4.38	1.44	0.06	0.086	0.016	1.442	1.468	4.34
May	4.57	1.50	0.04	0.060	0.011	1.502	1.520	4.57

AA = Arithmetic Average
GM = Geometric Mean
σ = Population Standard Deviation
s = Sample Standard Deviation

Figure 9.2: SEWPCC - Influent Versus Effluent Ammonia Concentration
(High Level of Ammonia Control)

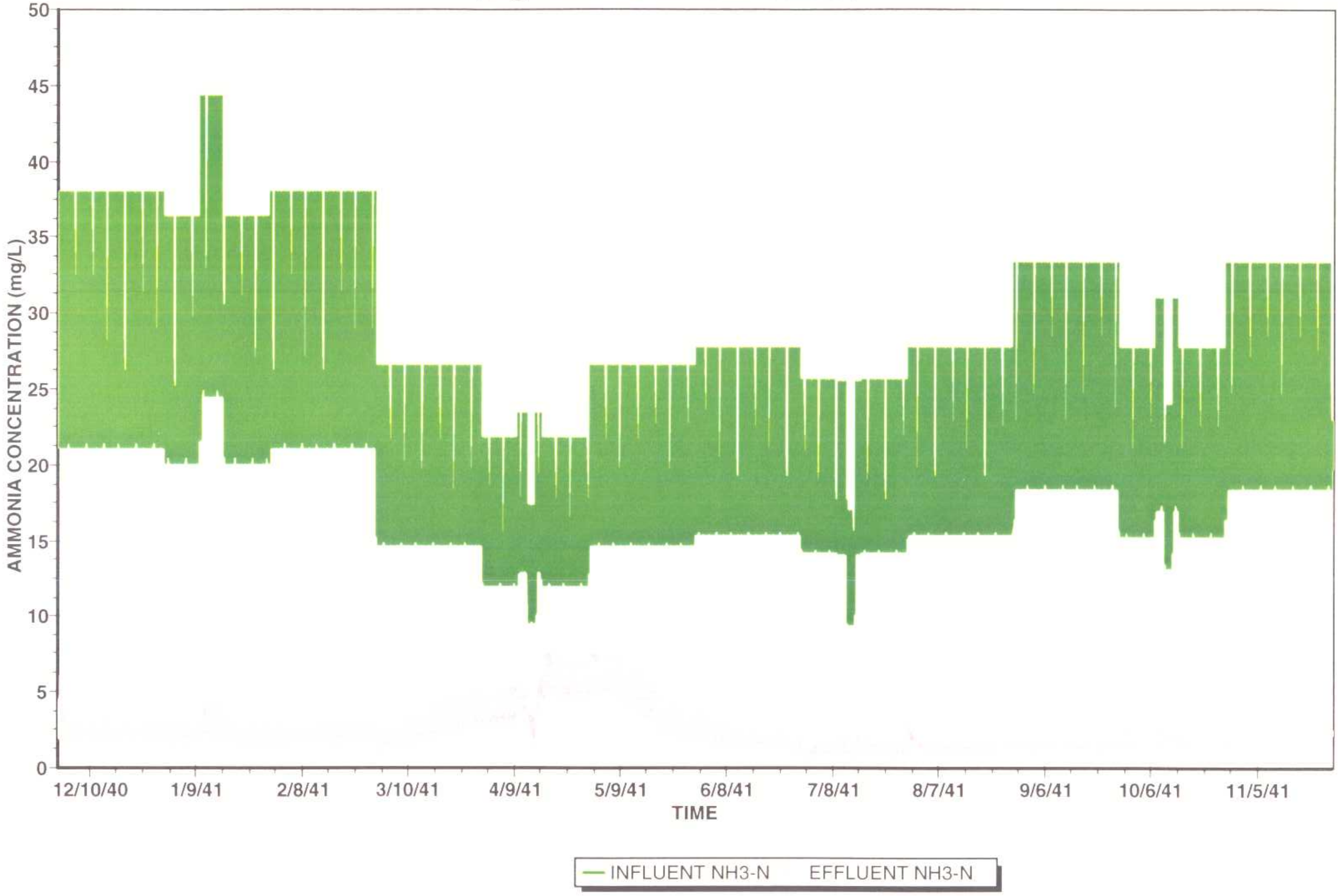


Figure 9.3 : SEWPCC - Influent Versus Effluent TKN Concentration
(High Level of Ammonia Control)

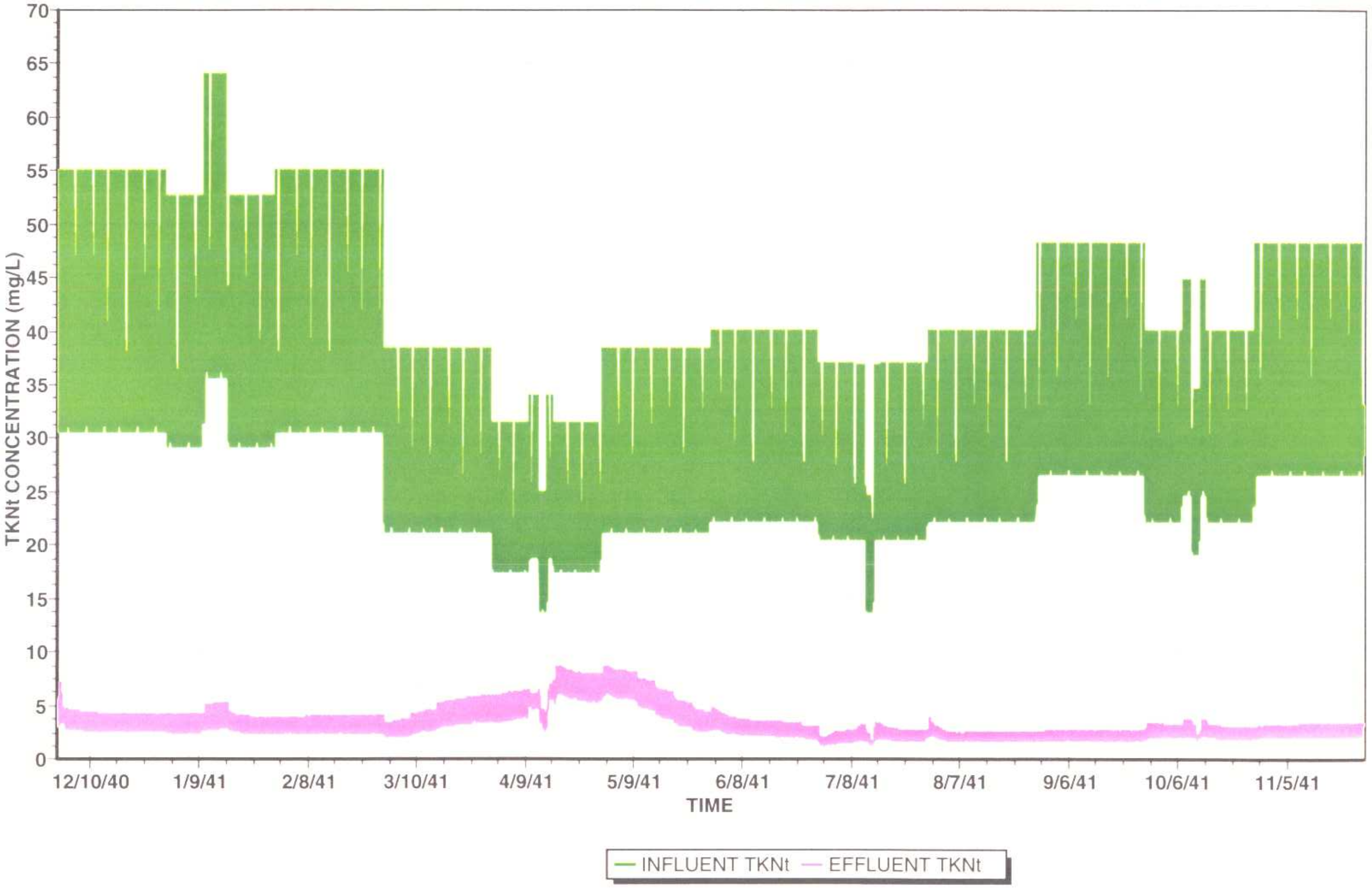


Figure 9.4: SEWPCC - Bioreactor MLSS (High Level of Ammonia Control)

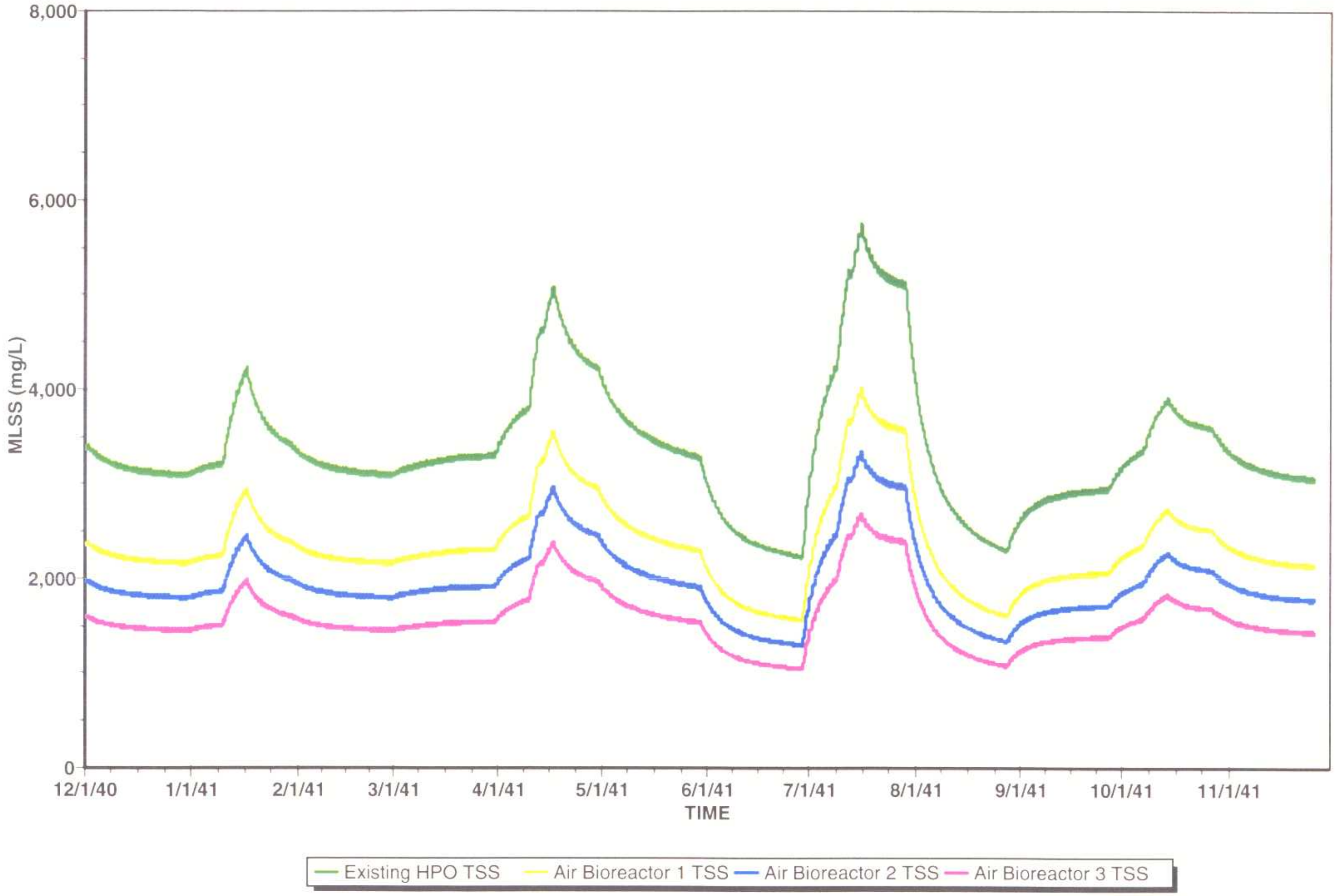


Figure 9.5: SEWPCC - Secondary Clarifier Operating Parameters (High Level of Ammonia Control)

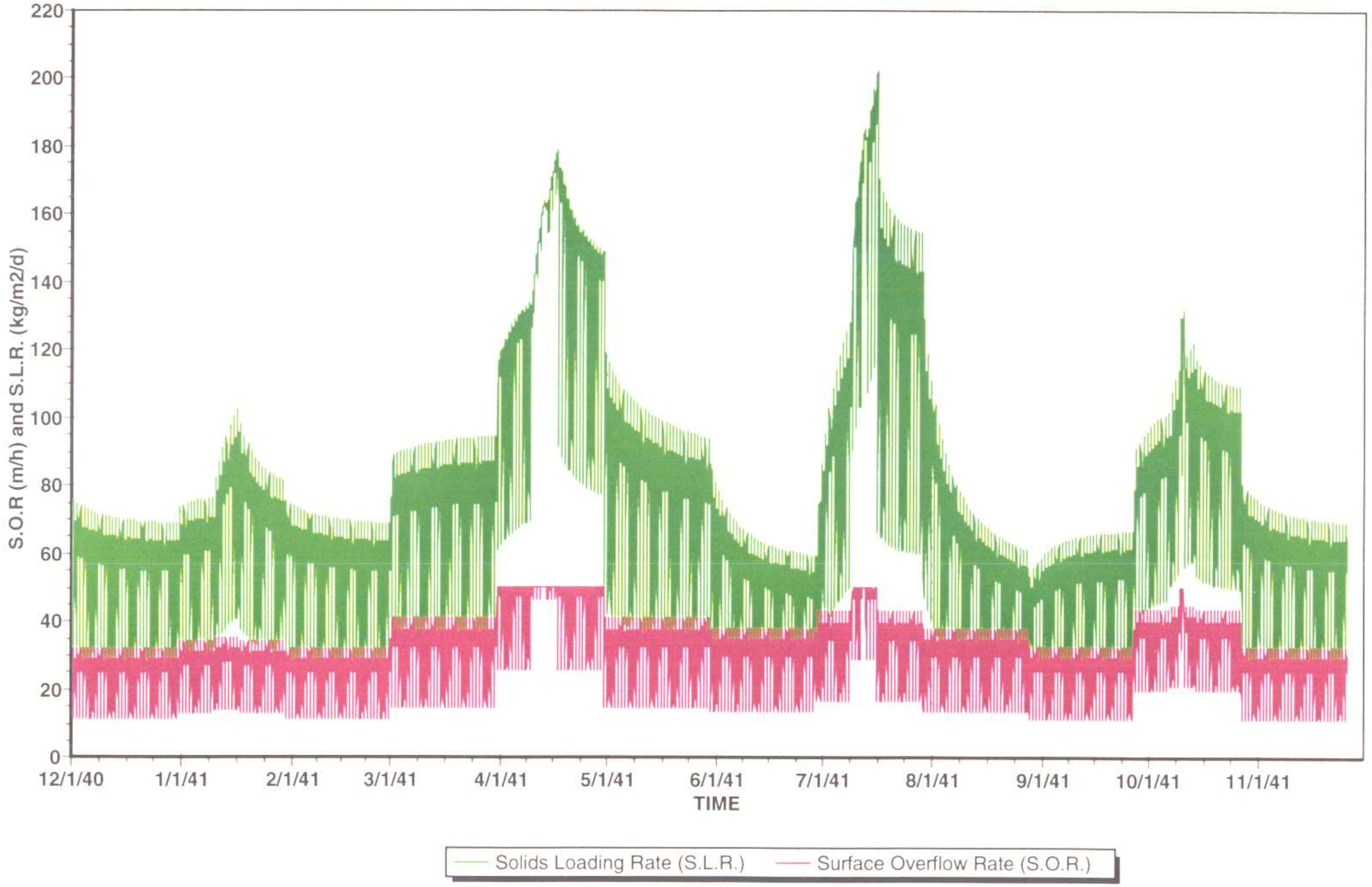


Figure 9.6: SEWPCC - Influent Versus Effluent Ammonia Concentration (Modest Level of Control)

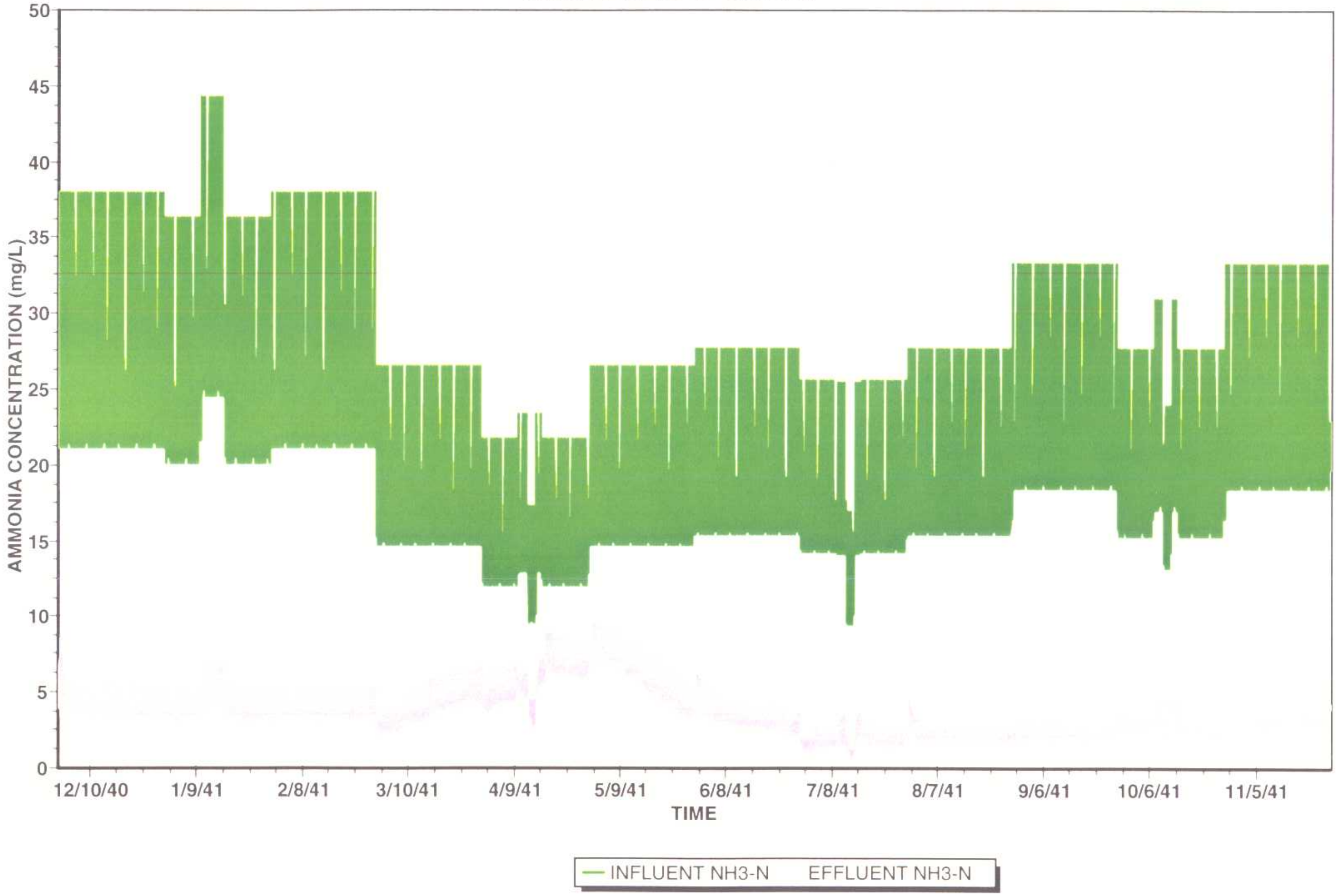


Figure 9.7: SEWPCC - Influent Versus Effluent TKN Concentration (Modest Level of Control)

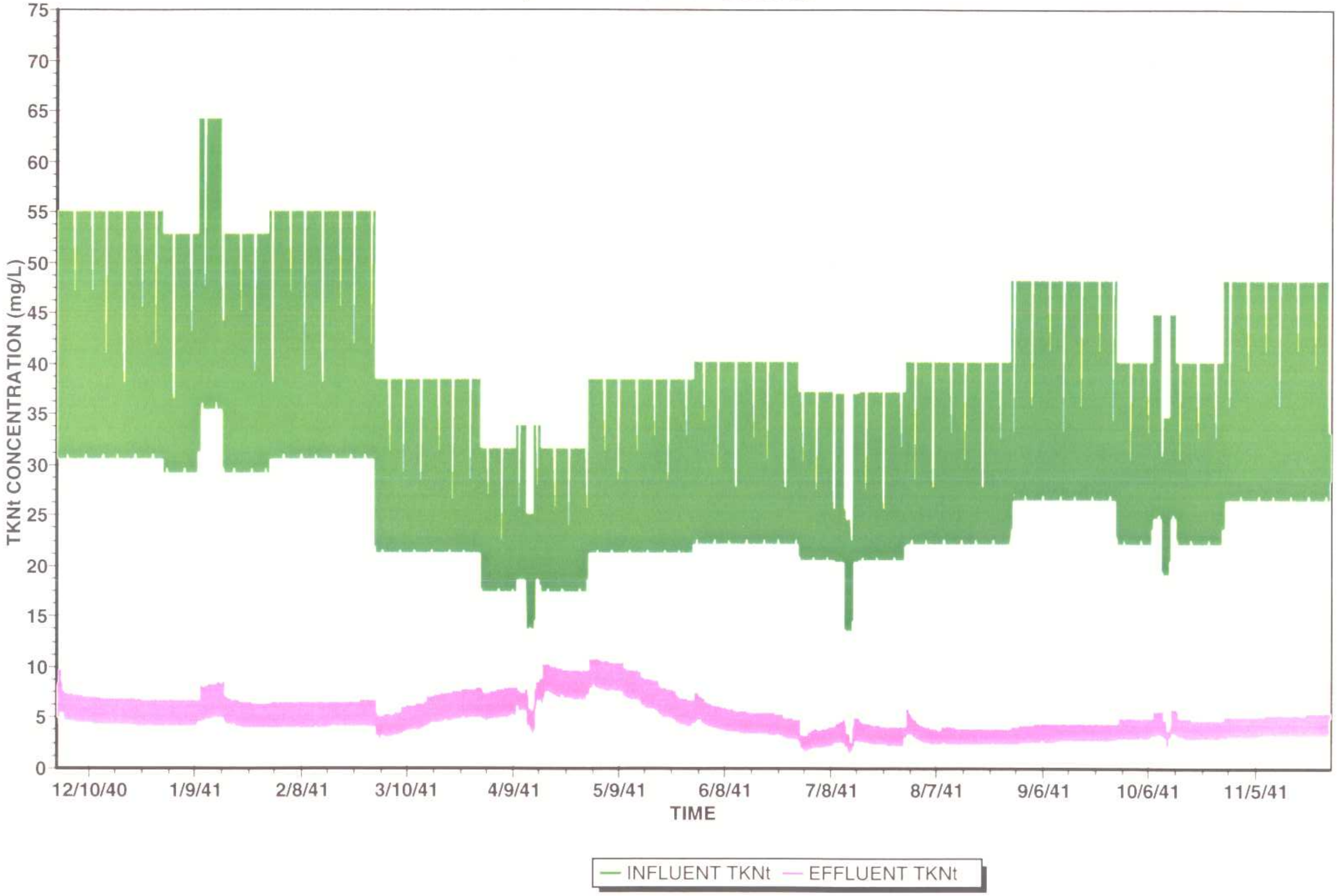


Figure 9.8: SEWPCC - Bioreactor MLSS (Modest Level of Ammonia Control)

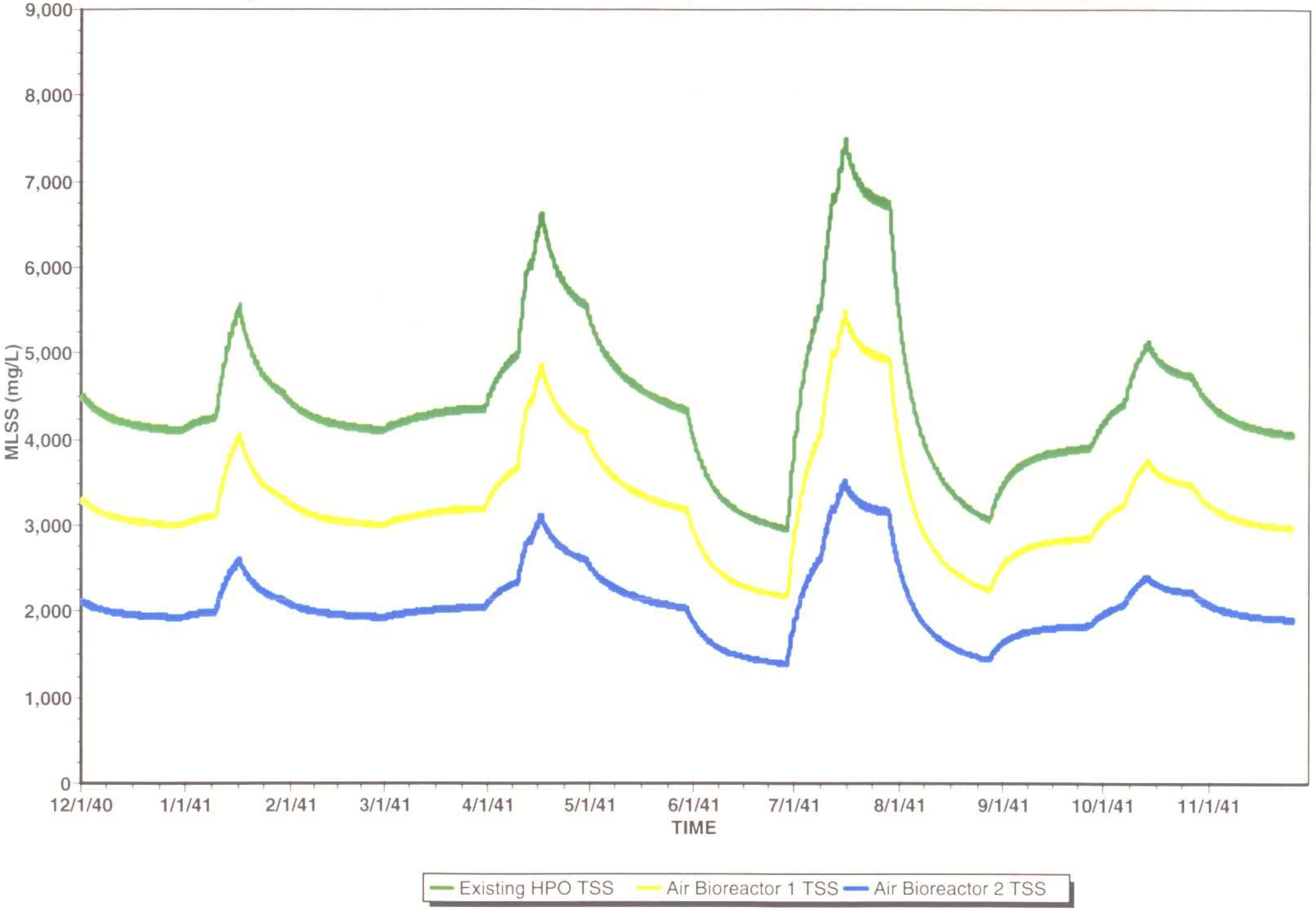
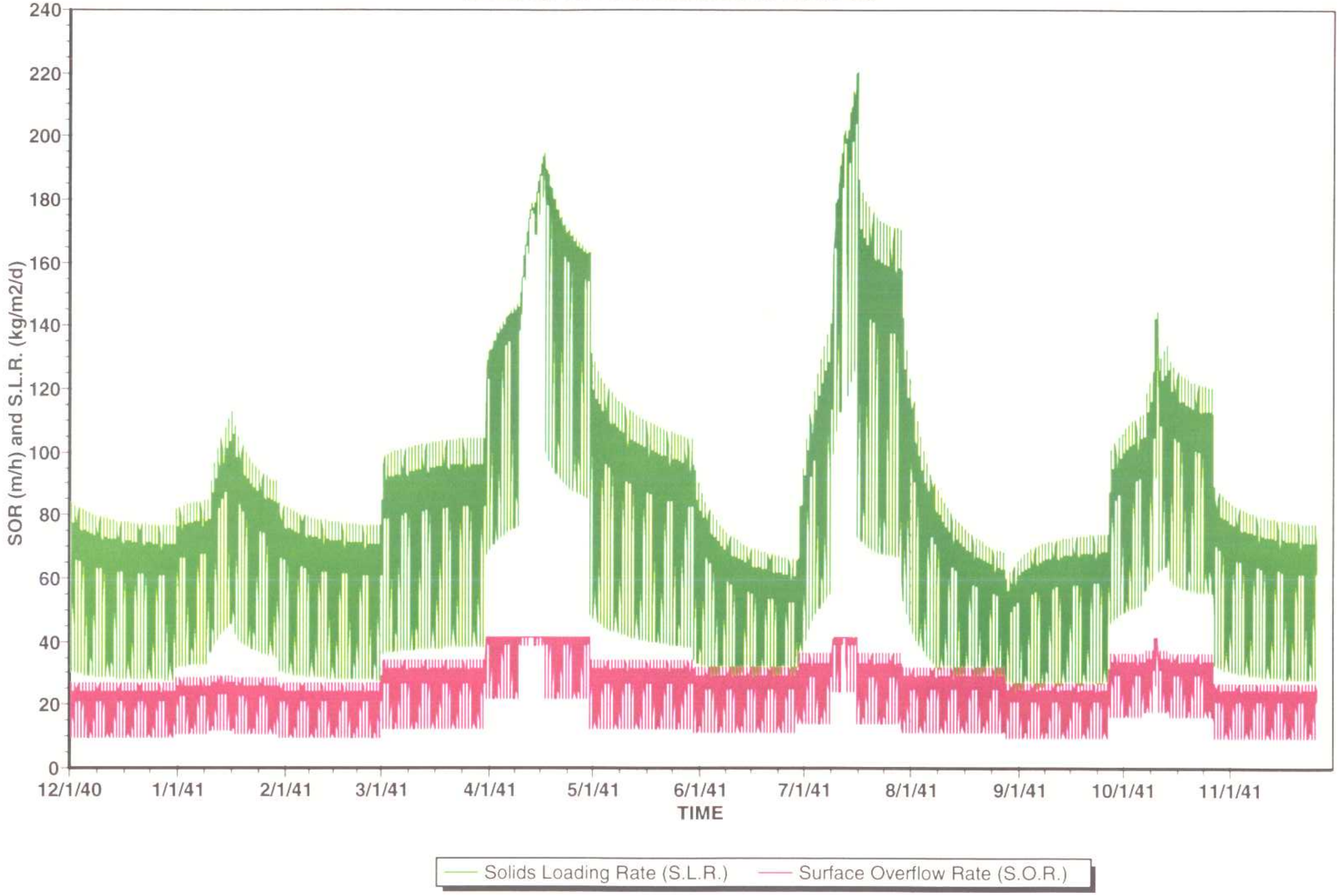


Figure 9.9: SEWPCC - Secondary Clarifier Operating Parameters
(Modest Level of Ammonia Control)



9.8.2 Modest Level of Control - Statistical Analysis

The results of statistical analysis on the effluent ammonia concentrations projected for the Modest Level of Control - Step Feed option are shown in Table 9.14. The procedure and conclusions are the same as discussed in previous section for the High Level of Control option.

Table 9.14: SEWPCC - Results of Statistical Analysis on Effluent Ammonia (Year 2041- Modest Level of Control

Month	Monthly AA (mg/L)	Ln (GM)	σ/GM	σ	s(30 days)	GM of 30 day averages	95th% 30 day GM	Exp (GM 95th%)
June	7.48	2.00	0.12	0.240	0.044	2.031	2.104	8.20
July	4.89	1.53	0.18	0.275	0.050	1.562	1.644	5.18
August	9.71	2.25	0.12	0.270	0.049	2.289	2.370	10.70
September	7.66	2.03	0.06	0.122	0.022	2.036	2.073	7.95
October	7.26	1.97	0.09	0.177	0.032	1.984	2.037	7.67
November	7.04	1.94	0.06	0.117	0.021	1.950	1.986	7.28
December	8.82	2.17	0.06	0.130	0.024	2.177	2.216	9.17
January	8.37	2.11	0.04	0.084	0.015	2.155	2.141	8.51
February	7.65	2.03	0.06	0.122	0.022	2.033	2.069	7.92
March	5.40	1.67	0.04	0.067	0.012	1.671	1.691	5.42
April	5.78	1.73	0.06	0.104	0.019	1.735	1.766	5.85
May	6.60	1.88	0.04	0.075	0.014	1.880	1.902	6.70

AA = Arithmetic Average
GM = Geometric Mean
σ = Population Standard Deviation
s = Sample Standard Deviation

9.10 ESTIMATED COSTS

The cost estimating approach set out in Section 2.4 has been used to develop representative estimates of the total cost of ownership of the facilities required to achieve the Second Priority Levels of Control for the SEWPCC. The details of the estimates are presented in Appendix A. The 95 percent confidence limit estimates are summarized in Table 9.15.

Table 9.15: Summary of Estimated Costs - Second Priority Level of Control

	Modest Level of Control	High Level of Control
Target Effluent Ammonia Concentration (Summer Dry Weather)	14 mg/L	8 mg/L
Capital Cost	$14,100,000	$20,500,000
O&M Cost	$440,000	$490,000
Total Cost (Net Present Value – 4% Discount Rate)	$23,300,000	$30,900,000