SECTION 6.0
NEWPCC CENTRATE TREATMENT

6.1 CENTRATE FLOWS AND LOADS

6.1.1 Background

The digested sludge dewatering system at the North End Water Pollution Control Centre (NEWPCC) operates on a continuous 24-hour basis. The number of centrifuges in operation, however, varies throughout the week. Current practice is to operate with one centrifuge on-line continuously, with a second centrifuge in operation from about noon on Mondays to about noon on Fridays. Thus, typically two units are in operation for a full four days per week and one centrifuge is in operation for the remaining full three days per week. This pattern is altered by turning on an additional centrifuge or shutting down a centrifuge as sludge production dictates.

The centrate flow from each centrifuge is approximately 16 L/s to 24 L/s. Thus the current long term average centrate flow rate averages 2.71 ML/d. This sidestream carries approximately 600 to 1,300 mg/L of TKN, with an average of about 800 mg/L. A plot of centrate TKN concentrations over the period June 1995 to April 2000 is presented in Figure 6.1. Note the periodic variations with peak concentrations occurring during the winter months.

In terms of the plant flow, this sidestream adds 5 to 10 mg/L of ammonia to the concentration in the raw wastewater. Total nitrogen load from centrate sidestream ranges from approximately 1,900 kg/d to 3,500 kg/d with an approximate average of 2,200 kg/d. This load constitutes a considerable fraction of total ammonia loading to the NEWPCC (almost 25% of the maximum month loading). As a result, with the use of a treatment system to eliminate the TKN in the centrate stream, there would be a significant reduction in ammonia concentration in the treated effluent discharged to the Red River from the plant.

Centrate treatment allows elimination of some of the ammonia in the plant effluent with minimal facility construction. Independent treatment of centrate also provides the opportunity to chemically precipitate the phosphorous released in anaerobic digestion should phosphorous removal be required in the future.

6.1.1 Centrate Characteristics

Table 6.1 summarizes the characteristics of the centrate stream used as a basis for the design and simulation of the centrate treatment process.

Figure 6.1: NEWPCC Centrate TKN Concentrations 1995-2000

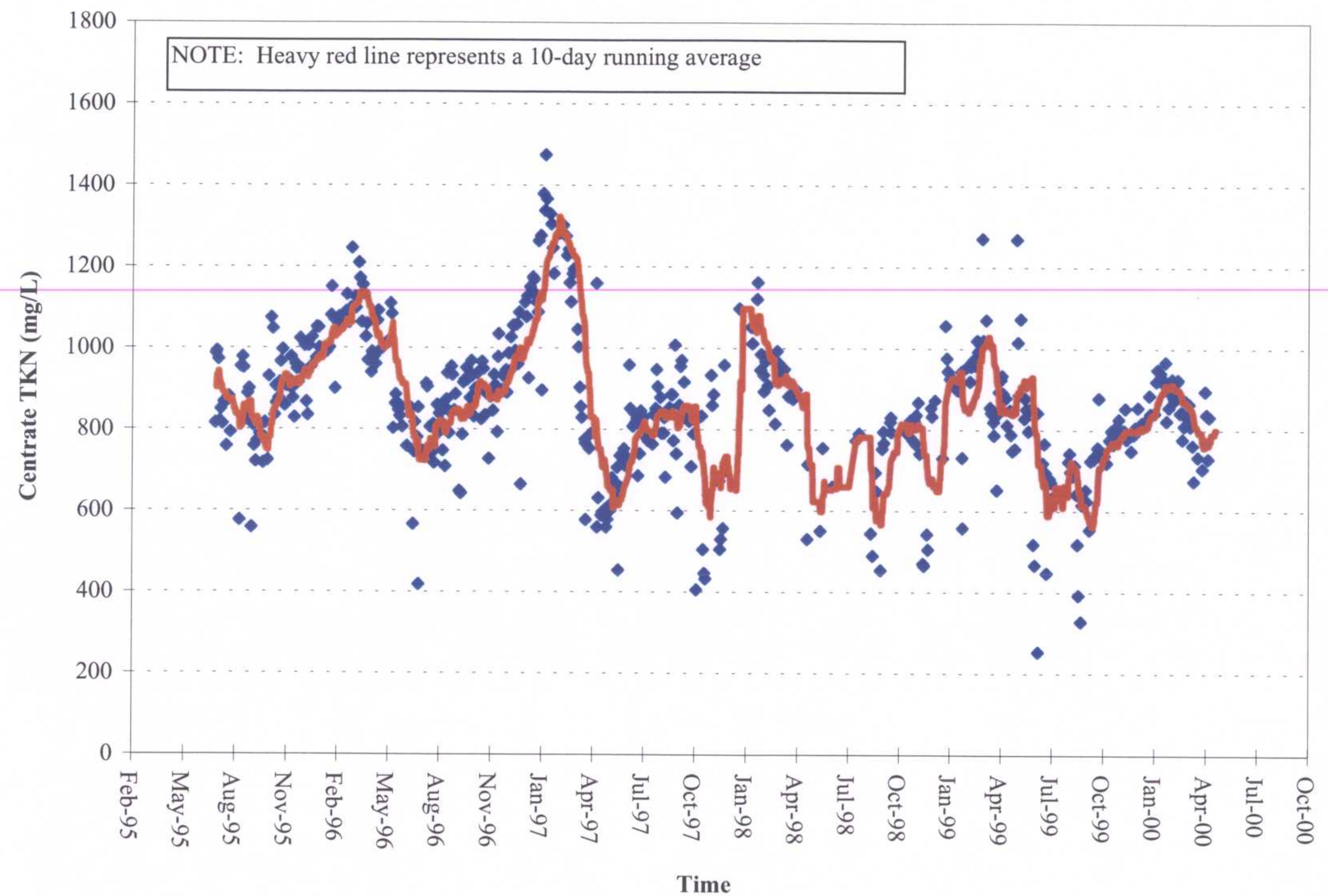


Table 6.1: Centrate Stream Characteristics

Variable	Value	Parameter	Value	Parameter	Value
Flow, ML/d	2.71	F_{bs}	0.20	F_{nox}	0.50
COD, mg/L	1000	F_{ac}	0.00	F_{nu}	0.00
TKN, mg/L	800	F_{xsp}	0.75	F_{upN}	0.068
Total P, mg/L	50	F_{us}	0.20	F_{upP}	0.021
ISS, mg/L	25	F_{up}	0.30	$\mu_{max,a}$, d^{-1}	0.50
Alkalinity, mmol/L	120	F_{na}	0.90	Temp., °C (in bioreactor)	10
D.O., mg/L	0.0				

6.2 CENTRATE TREATMENT CONCEPTUAL DESIGN

6.1.2 Centrate Treatment: Process Description

Centrate treatment will use completely mixed activated sludge basins, each with its own final clarifier. A completely mixed regime in the bioreactors is desirable in this application so that the high ammonia concentration in the centrate stream does not cause an inhibitory effect on the biological process. A process schematic for the centrate treatment system is illustrated in Figure 6.2.

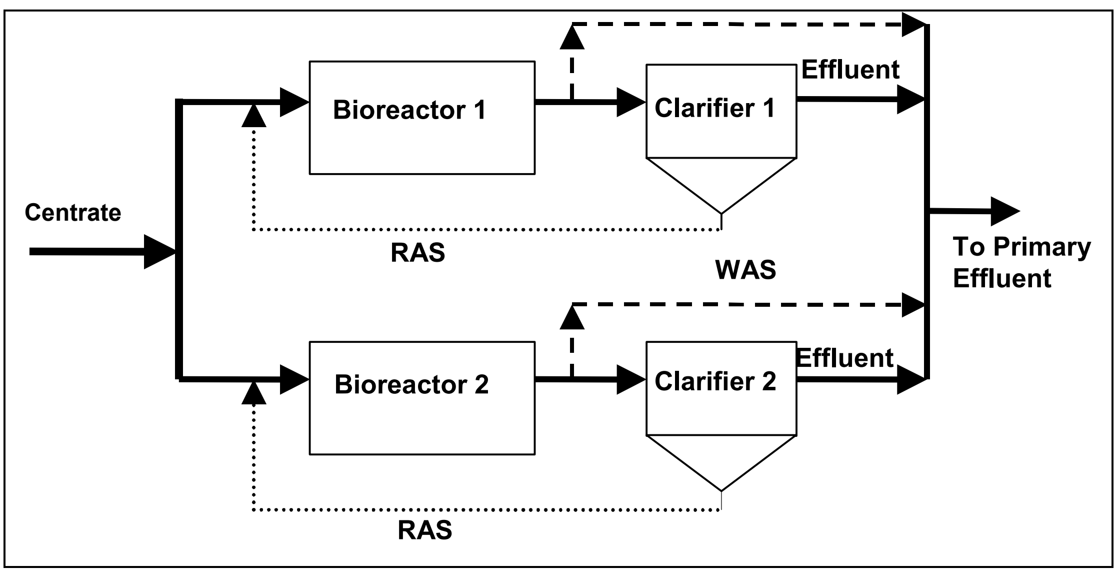


Figure 6.2: Centrate Treatment Process Schematic

The process design and operating specifications for the proposed activated sludge system to treat the centrate stream are presented in Table 6.2. The table presents the sizing of the processing units and the operating conditions.

Each bioreactor would be square in shape, 20 m side-length and 6 m side wall depth, with a volume of 2,400 m^3. The bioreactors will provide an average hydraulic retention time of about 42 hours. Each clarifier would be 12 m in diameter with a side water depth of 5 m. Waste activated sludge would be withdrawn from the common mixed liquor channel leading to both clarifiers. The WAS would be directed to the primary effluent channel en route to the bioreactors of the mainstream treatment train along with the treated effluent from the centrate treatment system.

The main function of the centrate treatment plant is to provide a reduction in the ammonia content of the centrate. Because the effluent from the centrate treatment plant and the WAS will be directed to the main treatment train, there will be little concern over the BOD and TSS concentrations in the effluent from the centrate treatment plant.

Aeration would be provided by a fine bubble diffused air system. Two blowers, each rated at 2.4 nm^3/s, would be provided – one as a duty blower and the other as a 100 percent standby. The driver for each blower would be rated at 180 kW.

A heat exchanger will be used to recover heat from the warm (~35°C) centrate stream and use the recovered heat either for process heating or for space heating. Operation of the treatment system at the temperature of the mainstream treatment process will result in the development of strains of nitrifying organisms that could be used as a seed to improve ammonia removal across the mainstream treatment process. The bioreactors and clarifiers would be enclosed to facilitate winter operation.

Table 6.2: Design Data for Centrate Treatment System

Description	Units	Value
Bioreactors		
Number		2
Volume per bioreactor	m^3	2400
L x W x D	m	20 x 20 x 6
Clarifiers		
Number		2
Diameter	m	12
SWD	m	5
SLR (average)	$kg/m^2/d$	84
SOR (average)	$m^3/m^2/h$	0.50
Aeration System		
Type		Fine bubble diffused air system
Blowers		
Number		2
Capacity	nm^3/s	2.4
Size	kW	180
SRT	d	15

HRT (average)	h	42

6.2.2 Location of Centrate Treatment System

The centrate treatment system, as shown in Dwg. CE-6.1, would be located in the open space immediately to the west of primary digester Nos. 13 and 14. Dwg. CD-6.2 present plant layout for this treatment option. A process flow diagram is illustrated in Dwg. CE-6.3.

6.3 CENTRATE TREATMENT MODELING

6.3.1 Model Output

Computer simulation of the NEWPCC performance for the year 2041 using centrate treatment resulted in the projections shown in Figures 6.3 and 6.4. The vertical bandwidth of each parameter plotted on these figures is indicative of the daily diurnal variation of the parameter.

Centrate treatment reduces TKN loading on the secondary treatment processes as shown by projections of the 2041 primary effluent TKN concentrations under two conditions of “without centrate treatment” and “with centrate treatment” in Figure 6.3. The upper curve presents variation in TKN concentrations when centrate returns directly to the main flow. The lower curve presents TKN concentrations when centrate treatment is included. Both curves follow the general pattern specified for the NEWPCC concentrations (highest in winter and lowest in spring). Centrate treatment on an average reduces about 25 percent of TKN load to the biological reactors. This will significantly improve the treatment plant effluent quality with respect to TKN and ammonia contents.

The projected secondary effluent TKN concentration of the NEWPCC for the year 2041 “with” and “without” centrate treatment is presented in Figure 6.4. Centrate treatment eliminates approximately 29 to 35 percent of the effluent TKN during various seasons. The effect of centrate treatment on effluent ammonia is the same, as effluent TKN is comprised of approximately 95 percent ammonia. Nitrification of the centrate would reduce the full 2041 plant flow effluent ammonia concentration to the approximate concentrations summarized in Table 6.3.

Figure 6.3: Primary Effluent TKN Projection (With and Without Centrate Treatment)

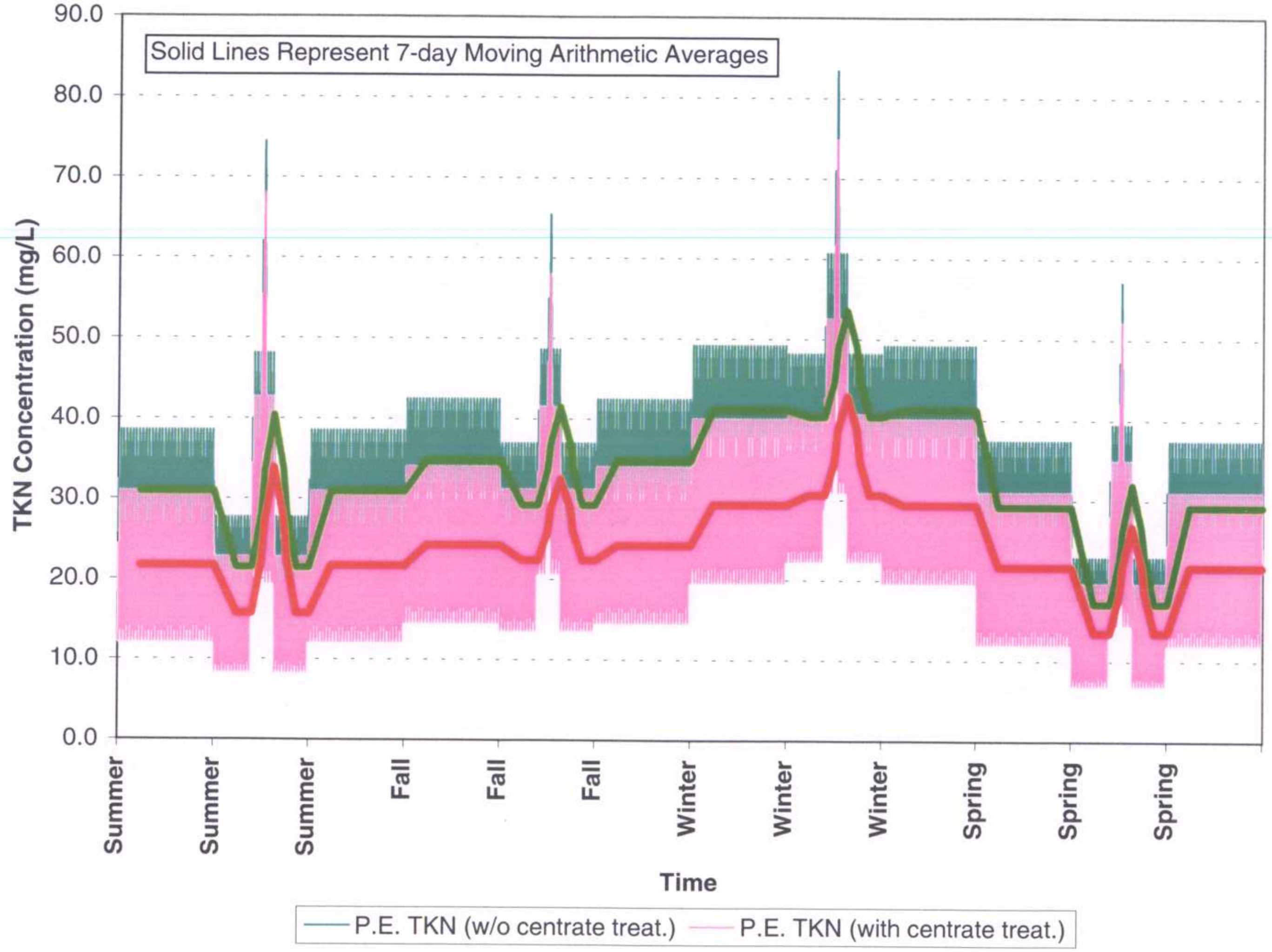
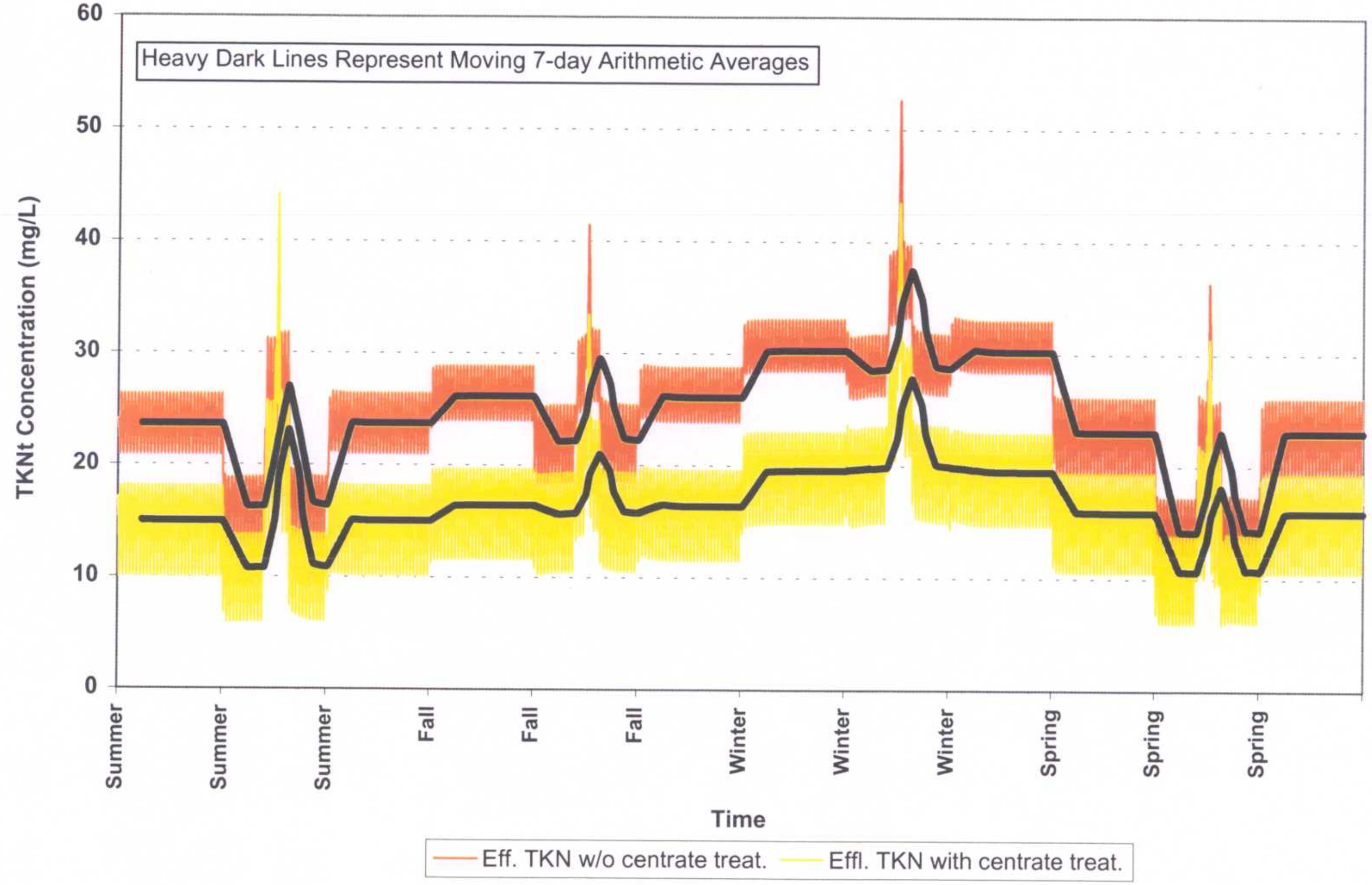


Figure 6.4: NEWPCC 2041 Secondary Effluent TKN Projections (With/Without Centrate Treatment)



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TKN - Fig 6.4 (CDRPT)

Table 6.3: Effluent Ammonia Concentration With and Without Centrate Treatment

Season	Without Centrate Treatment Average Effluent NH3-N (mg/L)	With Centrate Treatment Effluent NH3-N (mg/L)
Summer	21.1	13.7
Fall	24.5	15.8
Winter	29.6	19.5
Spring	19.4	13.6

The effluent ammonia concentrations are not sufficiently low enough to comply directly with the first priority target levels of ammonia control. Nonetheless, this approach provides a convenient method to achieve a substantial amount of ammonia reduction at a relatively modest cost. This approach also has the advantage that it can be integrated into one of treatment options described in the following sections, to form part of the overall approach to meet greater levels of ammonia control. The waste activated sludge generated by the centrate treatment system would be a source of nitrifying organisms to seed the mainstream treatment train.

Centrate treatment also reduces approximately 2,700 kg/d of COD load (about 4 percent) to the biological reactors. However, this would not affect the operational conditions of the HPO reactors significantly. The projections of bioreactor average MLSS (Figure 6.5) show similar values for both options of without centrate treatment vs. with treatment. Centrate treatment also does not influence the operational conditions (SLR and SOR) and performance of the existing final clarifiers because it does not affect the flow and MLSS significantly. Projections of the solids loading rates in Figure 6.6 verify the relatively insignificant impact of centrate treatment on existing clarifier operating conditions.

The effluent and WAS from the centrate treatment system is returned to the main secondary treatment facilities. This solids carryover, rich in nitrifying organism population, would continuously seed the HPO system with nitrifiers. An indeterminate amount of additional nitrification would most likely take place in the mainstream treatment system.

6.3.2 Statistical Analysis of the Projected Effluent Ammonia

Statistical analysis was performed on the projected final effluent ammonia concentrations. The procedure for a statistical analysis was described in Section 4.0. The results, shown in Table (below), indicate that:

- Variation in effluent ammonia concentration is higher during summer months than other months.
- 95 percent of the samples in each month would have ammonia concentrations equal or less than the related value shown in the last column of Table 6.4.

Figure 6.5: Average MLSS in H.P.O. Reactors (With or Without Centrate Treatment)

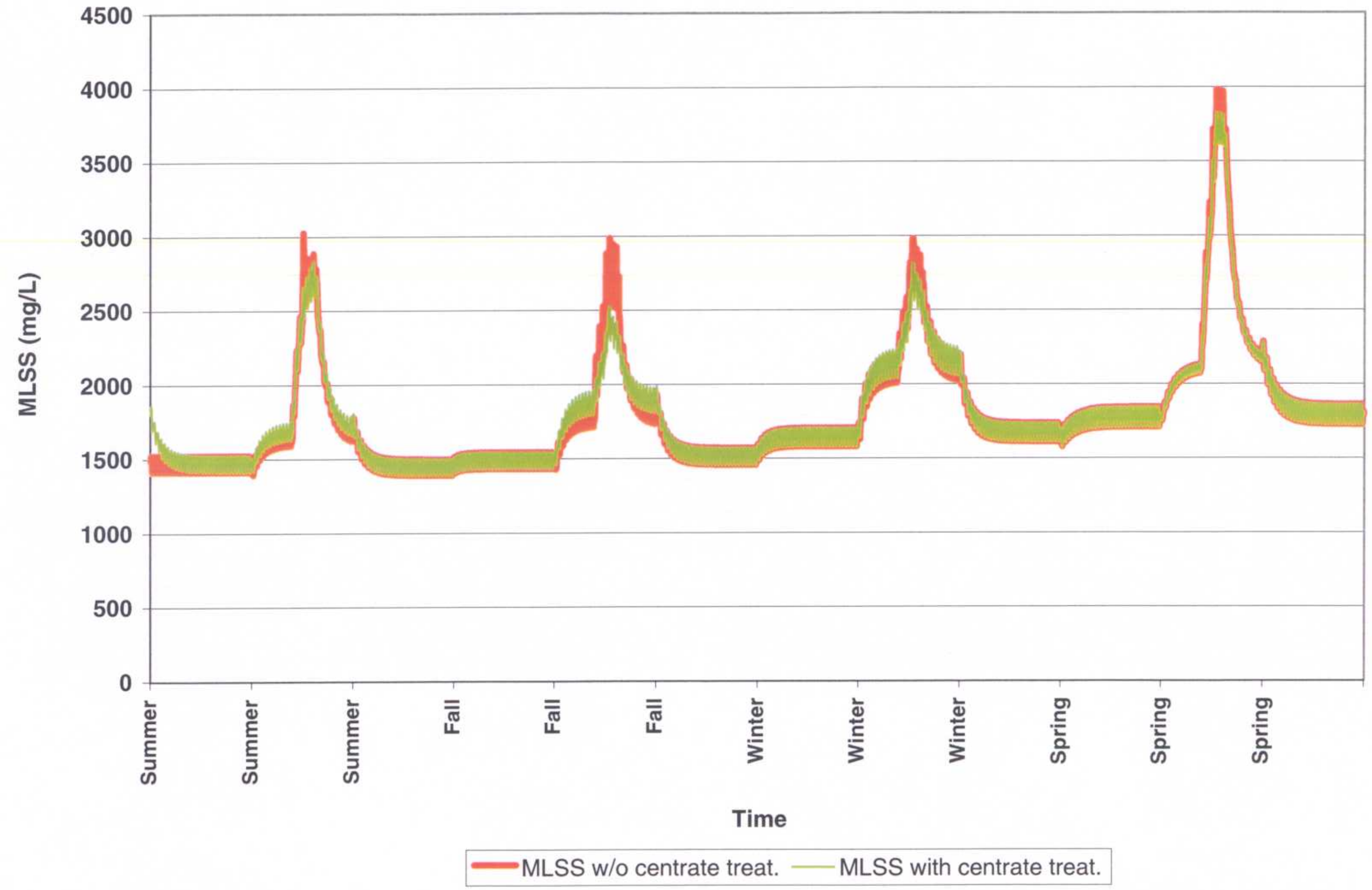

Figure 6.6: Clarifiers Solid Loading Rate (SLR)
(With and Without Centrate Treatment)

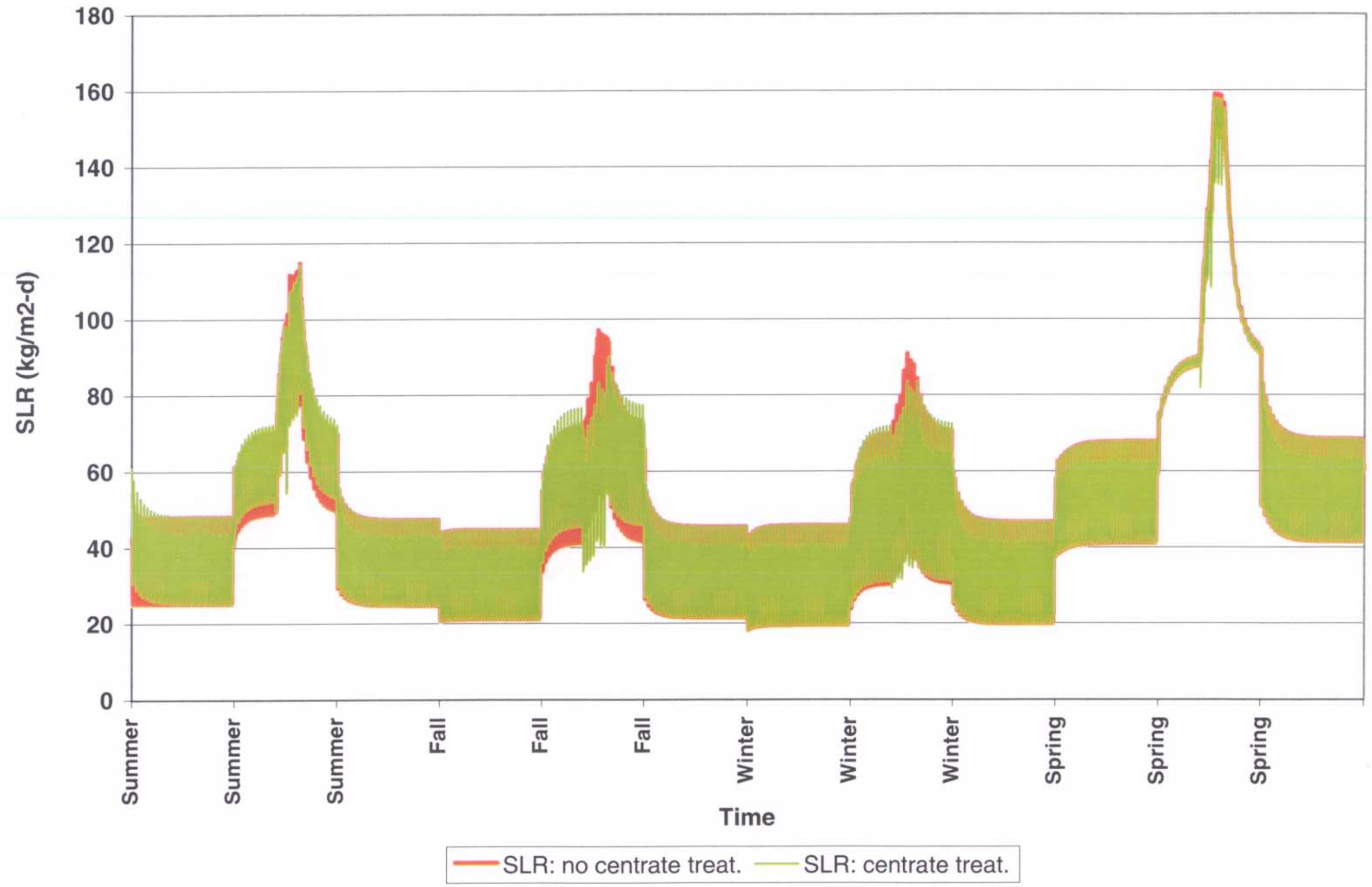

Table 6.4: NEWPCC - Results of Statistical Analysis of the Effluent Ammonia (Year 2041 - Use of Centrate Treatment)

Month	Monthly AA (mg/L)	Ln (GM)	σ/GM	σ	$s_{(30\ days)}$	GM of 30 Day Averages	95^{th}% 30 day GM	Exp (GM-95^{th}%)
June	14.16	2.64	0.12	0.316	0.058	2.685	2.780	16.12
July	12.62	2.43	0.18	0.438	0.08	2.527	2.658	14.27
August	14.16	2.64	0.12	0.316	0.058	2.684	2.779	16.11
September	15.61	2.74	0.06	0.164	0.030	2.750	2.779	16.44
October	16.08	2.75	0.09	0.248	0.045	2.783	2.857	17.41
November	15.61	2.74	0.06	0.164	0.030	2.750	2.799	16.43
December	18.74	2.92	0.06	0.175	0.032	2.938	2.990	19.89
January	21.00	3.02	0.04	0.121	0.022	3.032	3.068	21.50
February	18.79	2.93	0.06	0.176	0.032	2.941	2.993	19.95
March	15.04	2.70	0.04	0.108	0.020	2.701	2.734	15.39
April	10.02	2.22	0.06	0.133	0.024	2.229	2.269	9.67
May	14.9	2.69	0.04	0.107	0.020	2.691	2.723	15.23

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

Thus, it is seen that centrate treatment done at the NEWPCC will result in a treated effluent quality that complies with neither the first nor the second priority levels of ammonia control.

6.4 ESTIMATED COSTS

The cost estimating approach set out in Section 2.4 has been used to develop a representative estimate of the total cost of ownership of the facilities required to implement separate ammonia control of the centrate generated at the biosolids dewatering facilities. The details of the estimate are presented in Appendix A. The 95 percent confidence limit estimates are summarized in Table 6.5.

Table 6.5: Summary of Estimated Costs - Centrate Treatment

Capital Cost	$9,300,000
O&M Cost	$610,000
Total Cost (Net Present Value – 4% Discount Rate)	$21,800,000