THE EFFECT OF AMMONIA LOADING, SOLIDS RETENTION TIME AND OPERATING TEMPERATURE ON THE BIOLOGICAL NITRIFICATION AND DENITRIFICATION OF HIGH AMMONIA LANDFILL LEACHATE

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ABSTRACT

The effect of ammonia loading, solids retention time and operating temperature (20, 17, 14, 12 and 10 °C) on the treatment of high ammonia landfill leachate (200, 300, 600, 1000, 1500 and 2000 mg NH_4-N/L), was investigated. Two biological, single-sludge, nitrification-predenitrification systems were operated in parallel; one with a 10 day aerobic SRT, and the other with a 20 day aerobic SRT. The study consisted of two phases: an ammonia loading phase and a cold temperature phase.

From the ammonia loading phase, it was found that at an influent leachate ammonia level of 1500 mg N/L, both systems produced an effluent of <1 mg NH_4-N/L and approximately 170 mg NO_x^--N/L. Aerobic nitrite accumulation was observed and was likely a factor in a parallel decrease in the COD:NO_x ratio from approximately 6:1 to 4:1. At the leachate ammonia level of 1500 mg N/L, "free" ammonia levels in the anoxic reactor were estimated to have been 20 mg N/L. This elevated anoxic "free" ammonia level did not appear inhibitory to either the ammonia oxidizers (*Nitrosomonas*) or to the denitrifiers, but may have inhibited nitrite oxidizers (*Nitrobacter*), thereby resulting in nitrite accumulation. When the influent ammonia concentration was raised from 1500 to 2000 mg N/L, nitrification in both systems was observed to decrease from 100 % to approximately 20 %. Several factors may have contributed to the failure of nitrification including: insufficient dissolved oxygen, solids/foaming problems, and levels of anoxic "free" ammonia inhibitory to *Nitrosomonas*.

During the cold temperature phase, the temperature was decreased from 20 to 10 °C while maintaining the simulated leachate ammonia level at 1500 mg N/L. Aerobic nitrite accumulation and rising aerobic BOD_5 was observed to begin at 14 °C. When the temperature was decreased from 12 °C to 10 °C, nitrification was observed, in both SRT systems, to decrease from approximately 95 % to approximately 20 % . In the 10 day SRT system, denitrification decreased from 99 % to 30 %; in the 20 day SRT system, denitrification decreased from 99 % to 82 %. Based on the rise of aerobic nitrite, and only partial failure of denitrification, cold temperature was deemed responsible for nitrification failure, which for the 10 day SRT system, subsequently precipitated the failure of denitrification . In both awstems, nitrification was re-established at 10 °C, by ceasing to waste solids and by stopping methanol addition.

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Chapter 1

INTRODUCTION

Landfilling is the most common means of solid waste disposal. The significant environmental problems which may arise are methane gas explosions, low-level volatile gas generation, land use issues, odours, disease and pests, and leachate generation as water passes through the fill. Proper siting, design, construction and operation of landfills can usually deal with most aspects of these problems. The problem of leachate generation is usually most comprehensively solved by some form of treatment. The two components of landfill leachate that can have the most significant environmental impact on aquatic life are biodegradable organic compounds, and ammonia. As shall be explained in greater detail in the next section, leachates from older landfills typically have low BOD and high ammonia concentrations. Thus, the primary toxicant in leachate from older landfills is ammonia.

1.1 Leachate Generation, Landfill Age, and Leachate Characteristics

Leachate is generated primarily from the infiltration of rainfall, snowmelt, or groundwater into the landfill (Chian et al, 1985). The infiltrated rainwater serves as the transport phase for leaching, dissolution, and migration of contaminants from the solid waste. In addition to the rainwater, water is also available in the input solid waste, either immediately, or released from decomposition reactions. Leachate characteristics are a function of the amount of the infiltrated rainwater, landfill design and operation, input solid waste , landfill microbiology, waste compaction, cover material, and landfill age.

As a landfill ages, while in use or after closure, the leachate characteristics change according to the landfill stabilization sequence presented in Table 1.1. It should be kept in mind that this phase concept for landfill stabilization is subject to alterations due to physical, chemical and microbiological conditions. In addition, since landfills are most often operated in cells, phases often overlap, producing a leachate that is the average of several cells in different phases (Chian et al, 1985).

TABLE 1.1: **Landfill Stabilization Sequence (modified from Chian et al, 1985)**

Phase 1.	**Initial Adjustment** - initial waste placement - preliminary moisture accumulates until sufficiently present to support aerobic microbial decomposition of solid waste
Phase 2.	**Transition** - transition from aerobic to anoxic to anaerobic microbial decomposition - field capacity maybe exceeded resulting in leachate generation - intermediary volatile organic fatty acids appear in leachate with a corresponding rise in BOD_5
Phase 3.	**Acid Formation ("young" or "acetogenic" landfill)** - anaerobic decomposition is fully established - intermediary volatile organic fatty acids predominate - significant pH decrease with parallel dissolution of metals - ammonia and phosphorus are released and partially utilized by microbial metabolism and may result in high ammonia in leachate (phosphorus is almost completely utilized and nearly absent in many leachates) - leachate has high BOD_5 and high COD with BOD_5/COD ratio typically >0.4 (Ehrig 1985)
Phase 4.	**Methane Fermentation ("older" or "methanogenic" landfill)** - intermediary organics appearing during the acid formation phase are metabolized to methane and carbon dioxide - pH rises as landfill changes from a buffer system controlled by volatile organic fatty acids to a buffer system controlled by the bicarbonate system - high pH results in some metal species being involved in precipitation reactions, thus leachate metal concentrations decrease - ammonia concentrations in leachate are high - leachate BOD_5 and COD decrease markedly as methane production is increased - ratio of BOD_5/COD decreases to <0.1 (Ehrig 1985)
Phase 5.	**Final Maturation** - organic oxygen demand and methane production tapers and all but ceases - humic release may increase as more difficult compounds are degraded, may have concomitant increase in metals - high ammonia in leachate may continue for some time before ceasing - reappearance of oxygen and oxidized species with corresponding rise in ORP

1.2 Environmental Problems from Nitrogen Discharges

Nitrogen is essential to maintain natural ecosystems; however, some forms, at sufficient levels, are hazardous to man, animals, and the ecosystem itself. The major concerns of nitrogen discharges into the aquatic environment include accelerated eutrophication of receiving waters, toxicity to fish life, dissolved oxygen depletion in receiving waters, and contamination of drinking water.

Cultural eutrophication, also known as biostimulation, means excessive plant or algal growth resulting from fertilization of receiving waters by primarily, nitrogen or phosphorus. The impact of eutrophication includes aesthetic changes, and algal decomposition problems resulting in seasonal or diurnal dissolved oxygen depletion and odour problems. Dissolved oxygen depletion will usually occur at lower depths in the receiving water, and thus effect the deeper, cold water fish, which tend to be the favourite of commercial and recreational fishers. In general, freshwater systems tend to be phosphorus deficient and marine environments tend to be nitrogen deficient. Therefore nitrogen-induced eutrophication tends to occur more in marine environments such as bays and estuaries. Dissolved oxygen depletion can also occur as a result of ammonia being biologically oxidized to nitrate by nitrifying bacteria within the receiving water.

The toxicity of nitrogen discharges to fish life is primarily due to "free" ammonia (NH_3). The ratio of "free" ammonia to the ammonium ion (NH_4+) is greatly affected by pH. Increasing pH, increases the ratio of "free" ammonia to ammonium. The U.S. EPA (1975) reported that acute toxicity to "free" ammonia has been detected starting from between 0.01 mg/L to 2.0 mg/L.

In 1945, Comley first associated the consumption of drinking water that was high in nitrates, with the rare but sometimes fatal blood disorder, infant methemoglobinemia (Shuval and Gruener 1977). It was established that water, high in nitrite or nitrate, which was fed to babies directly or via baby formula, resulted in nitrite in the stomach. Nitrite inactivates haemoglobin and the infant suffocates, producing the diagnosis of "blue babies". Another adverse health impact, discovered more recently, is the recognition of nitrates as potentially cancer causing. A study by Mirvish (1977) concluded that N-Nitroso- compounds are strong carcinogens and may be derived from nitrates in drinking water sources.

1.3 High Ammonia Levels in Landfill Leachate

The emphasis at modern landfills is to lower rainwater infiltration. A simple mass balance analysis shows that this should result in lower leachate volumes but with higher concentrations of contaminants. In addition, higher ammonia levels can also be expected as more landfills are engineered to reach a methanogenic state (Knox 1985). The implications of a modelling study performed by Jasper et al (1985a), include the possibility that longer landfill retention times, due to lower infiltration and/or poor hydraulic removal, will result in producing an "older" leachate.

Henry (1985) reports that high ammonia levels (100 to 1000 mg N/L) may be expected from anaerobic landfills. Ehrig (1985) summarizes leachate data from landfills in West Germany and describes an increase in ammonia-N concentrations to 1600 mg/L as the landfill becomes methanogenic. Henderson (1993) measured the ammonia-N concentration to be 2140 mg/L in a leachate from a methanogenic landfill near Kaohsiung in south western Taiwan. Maris et al (1985) report an ammonia-N concentration as high as 990 mg/L in the leachate from a methanogenic landfill in northern England. Loizidou et al (1992) report ammonia-N concentrations ranging from 1650 to 3870 mg/L in the leachate from a methanogenic landfill near Athens, Greece. Robinson (1991) observed ammonia-N concentrations as high as 5000 mg/L in leachates from landfills in Hong Kong.

1.4 Nitrogen Removal from Landfill Leachate

Nitrogen removal (in a practical sense) from landfill leachate means either physical-chemical treatment to remove ammonia, biological assimilation, or aerobic biological nitrification with optional subsequent denitrification. Biological nitrification and denitrification is generally found to be the most effective, complete, and economic means of nitrogen removal for leachate from older landfills. Biological nitrification and denitrification processes also have several ancillary benefits, such as carbon oxidation and heavy metals removal.

Selection and design of a facility for landfill leachate treatment is not as simple as for sewage treatment. Leachate volume generation may vary significantly, and leachate characteristics vary with time as described in Table 1.1. Forgie (1988a, 1988b, 1988c) provided an excellent review of leachate treatment options and developed comprehensive flowcharts for selection of the appropriate treatment option, based on leachate characteristics and effluent requirements.

1.5 Carbon Removal vs Nitrogen Removal

The primary concern with leachate from young landfills, is carbon removal. The primary concern with leachate from older landfills, is nitrogen removal.

Forgie (1988a, 1988b, 1988c) suggested that anaerobic treatment, followed by optional aerobic treatment, is the most economical and effective treatment for carbon removal from "younger" leachate, that is, leachate with high biodegradable organics and a BOD_5/COD ratio greater than 0.4. For leachate with a BOD_5/COD ratio between 0.1 and 0.4, Forgie suggested aerobic biological treatment for BOD_5 and ammonia removal. Biological treatment of landfill leachate may still leave unacceptably high levels of refractory COD and colour. Removal of refractory COD and colour would require physical-chemical treatment. For leachate with a BOD_5/COD less than 0.1, unless high ammonia levels are present, biological treatment may not be viable, and physical-chemical treatment is suggested by Forgie. If ammonia levels are sufficiently high, then aerobic biological nitrification is possible.

As this thesis research is specifically focused on nitrogen removal from leachate from an older landfill, carbon removal will not be discussed any further, except as pertaining to biological denitrification and BOD_5 inhibition of nitrification.

1.6 Biological Nitrification and Denitrification

1.6.1 Nitrification Microbiology

Nitrification is an autotrophic aerobic process which utilizes an inorganic carbon source (carbonates), an inorganic electron donor or energy source (NH_4+ or NO_2^-), and elemental oxygen as a terminal electron acceptor. The complete oxidation of ammonium to nitrate occurs in two intermediary steps by two different genera of bacteria. The first step of oxidation of ammonium to nitrite is conducted by *Nitrosomonas*. The second step of oxidation of nitrite to nitrate is conducted primarily by *Nitrobacter*. The U.S. EPA (1975) states that *Nitrobacter* has a significantly higher growth rate than *Nitrosomonas*, therefore nitrite accumulation should not occur unless *Nitrobacter* is inhibited. Equations for synthesis and oxidation are as follows (U.S. EPA 1975):

Nitrosomonas $55NH_4^+ + 76O_2 + 109HCO_3^- \rightarrow C_5H_7NO_2 + 54NO_2^- + 57H_2O + 104H_2CO_3$

Nitrobacter $400NO_2^- + NH_4+ + 4H_2CO_3 + HCO_3^- + 195O_2 \rightarrow C_5H_7NO_2 + 3H_2O + 400NO_3^-$

The equations assume that the empirical formulation for these bacterial groups may be represented by $C_5H_7NO_2$. The equations also assume growth yields of 0.15 mg cells/mg NH_4^+-N for *Nitrosomonas* and 0.02 mg cells/mg NO_2^--N for *Nitrobacter*, and oxygen consumption ratios of 3.22 mg O_2/mg NH_4^+-N for *Nitrosomonas* and 1.11 mg O_2/mg NO_2^--N for *Nitrobacter*.

Alkalinity is only consumed by the first step involving ammonia oxidation. The theoretical alkalinity consumption for nitrification is calculated from the first reaction to be 7.14 g $CaCO_3$/g NH_4^+-N.

1.6.2 Denitrification Microbiology

Denitrification is an anoxic, heterotrophic process which utilizes an organic carbon source (such as methanol) for synthesis and as an electron donor, and nitrite or nitrate as the terminal electron acceptor. Complete denitrification occurs in two steps. First is the reduction of nitrate to nitrite, and second is the reduction of nitrite to nitrogen gas. The end product, being nitrogen gas, is significant since nitrogen gas has not been associated with any environmental problems. Unlike nitrification, the two steps are not distinctly associated with specific genera of bacteria; moreover, denitrification can be accomplished by a broad range of facultative bacteria, including *Pseudomonas*, *Micrococcus*, *Archromobacter*, and *Bacillus* (U.S. EPA 1975). Facultative bacteria prefer elemental oxygen to combined oxygen (such as nitrate and nitrite) as an electron acceptor. Therefore, it is important that the denitrification environment be free of elemental oxygen for nitrate and nitrite reduction to occur. Equations for nitrate and nitrite reduction can be represented as follows (U.S. EPA 1975):

Nitrate Reduction $NO_3^- + 0.33CH_3OH \rightarrow NO_2^- + 0.33H_2O + 0.33H_2CO_3$

Nitrite Reduction $NO_2^- + 0.5CH_3OH + 0.5H_2CO_3 \rightarrow 0.5N2 + HCO_3^- + H_2O$

The inclusion of synthesis (bacterial growth) increases the moles of methanol required per mole of complete nitrate reduction to 1.08 and to 0.67 per mole of nitrite reduction (McCarty et al, 1969). For complete nitrate reduction, this converts to 2.47 g CH_3OH/gNO_3^--N or 3.7 g COD/gNO_3^--N and for nitrite reduction, this converts to 1.53 g CH_3OH/gNO_2^--N or 2.3 g COD/gNO_2^--N.

Alkalinity is generated by the second step of denitrification. The stoichiometric quantity of alkalinity generated is 3.57 g $CaCO_3$/g NO_2^--$N_{denitrified}$.

1.6.3 Process Train Options for Implementation of Biological Nitrification and Denitrification

There are many different process train options that have been proven to achieve biological nitrification and denitrification (Forgie, 1988a, 1988b, 1988c). The process train selected for this study was the Modified Ludzack Ettinger (MLE) process train. The MLE process train is a single-sludge predenitrification-nitrification activated sludge system (see Figure 1.1). The MLE process offers the following advantages over other nitrification/denitrification systems:

- Having the anoxic (denitrification) reactor before the aerobic reactor (nitrification), may permit influent BOD_5 to be used as a carbon source for denitrification, thereby reducing carbon addition requirements. Also, the reduction in BOD_5 entering the aerobic zone, reduces aeration demands and sludge production.
- Having the aerobic stage prior to clarification, produces a less noxious aerobic effluent and reduces the possibility of rising sludge resulting from denitrification in the clarifier.

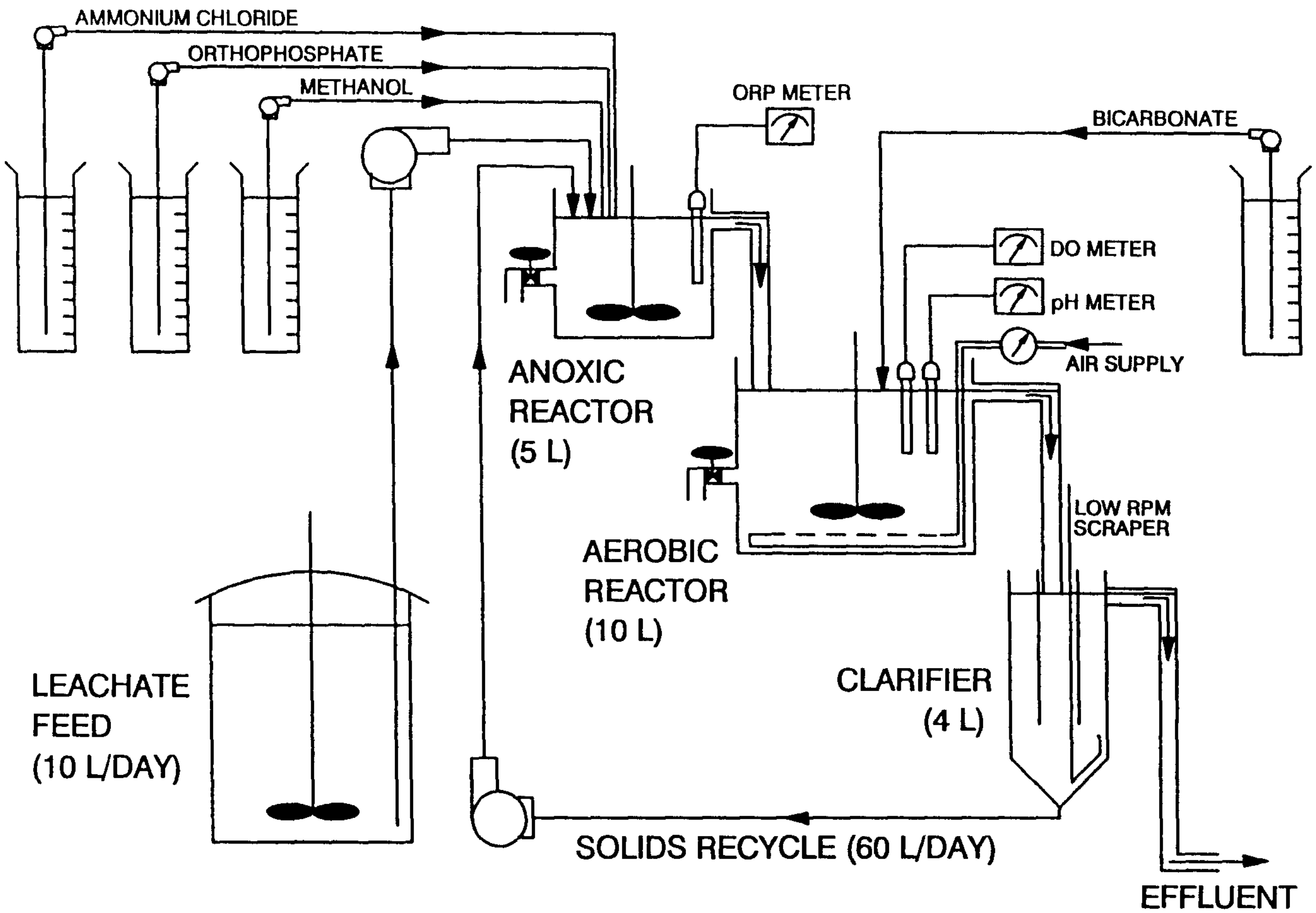


FIGURE 1.1: Leachate Treatment System Diagram

- The MLE arrangement reduces pH/alkalinity addition requirements, since 50% of the alkalinity consumed by nitrification is returned by denitrification.
- Dilution of the influent leachate with the aerobic/clarifier recycle, reduces the possibility of ammonia inhibition of denitrification. The converse of this is the exposure of denitrifiers to elevated levels of ammonia.
- The single-sludge aspect reduces tankage.
- Activated sludge nitrification and denitrification is well-studied and proven; primarily for sewage treatment but also in application to landfill leachate treatment.
- The greater biomass may permit shorter HRTs than in an aerated lagoon and therefore may require less space.

A major disadvantage of the MLE process is that effluent NO_x^--N levels may remain unacceptably high. The effluent NO_x^--N is approximately equal to the influent ammonia-N divided by one plus the solids recycle ratio (assuming no bacterial assimilation or air stripping). For example, an influent ammonia-N concentration of 1500 mg/L and a solids recycle ratio of 6:1, at best can result in an effluent NO_x^--N concentration of $1500/(1+6)=214$ mg N/L. If lower NO_x^--N levels are required, post-denitrification or higher recycle rates may be necessary.

Other suspended growth process train options that have been investigated for their nitrogen removal potential from landfill leachate include, the aerated lagoon, and the sequencing batch reactor (SBR). Robinson and Luo (1991) achieved excellent nitrification using SBR technology from leachate with ammonia-N levels as high as 2000 mg/L. Robinson (1991) has been involved in the development of a simple and robust automated aerated lagoon for bacterial nitrogen assimilation, nitrification and carbon oxidation of high ammonia leachate from methanogenic landfills in the United Kingdom. The plants are described as extended aeration and are said to provide some distinct advantages over activated sludge plants, including greater process stability due to longer HRTs (Robinson et al, 1992). Typical influent ammonia-N levels of 1000 mg/L are reported to be reduced to less than 5 mg/L in the effluent. Some plants are reported to use significant bacterial assimilation, while others achieve the majority of ammonia reduction by nitrification (Robinson 1991).

Several fixed growth systems are also available for nitrogen removal from landfill leachate. Fixed growth systems are generally regarded as more resistant to surges in hydraulic and organic loading, than for suspended growth systems, since washout of the biomass is less likely to occur. This is significant because changes in hydraulic loading are a notorious problem for landfill treatment design. Knox (1985) compared nitrification of an "older" leachate by an activated sludge pilot plant and a trickling filter pilot plant, operating in parallel. Knox concluded that less problems were encountered with the trickling filter. Several studies have also found RBC technology useful for nitrification of landfill leachate (Opatken and Bond 1991, Peddie and Atwater 1985). Spengel and Dzombak (1991) successfully nitrified and denitrified landfill leachate with an average ammonia-N level of 154 mg/L, using an aerobic RBC followed by an anoxic submerged RBC. Also using an RBC, Henderson (1993) attempted to treat a leachate with a BOD concentration of 705 mg/L and an ammonia-N concentration of 2140 mg/L. At an ammonia loading of 1.3 $g/m^2/day$, system ammonia removal was 97%. At higher loading rates, full nitrification could not be achieved. Forgie (1988c) indicates that caution must be given to application of RBCs to treatment of landfill leachate, because of the potential of calcium and iron precipitates to form on the disks, thereby interfering with substrate transfer to the biomass or raising the spectre of axle failure. It is possible that clogging by inorganic precipitates could also apply to other fixed growth systems as well, such as trickling filters (Ehrig 1991).

1.7 Other Nitrogen Removal Options

1.7.1 Recirculation

Recirculation of leachate, by collection and spraying over the landfill, was investigated by Robinson and Maris (1985). Their work supported other studies that recirculation promotes rapid stabilization of biodegradable organics, produces a more consistent leachate, and may reduce leachate volume by evaporation. However, ammonia, COD, and chloride, were found to remain relatively high. Robinson and Maris concluded that recirculation can reduce leachate strength and volume but cannot be a complete answer to the leachate problem. Further, they suggest that recirculation may be most applicable in combination with aerobic biological treatment. Robinson and Maris also suggest that recirculation may result in denitrification within the landfill.

1.7.2 Co-treatment

Co-treatment refers to placing the leachate into the local municipal sewerage system for treatment in the municipal sewage treatment plant. Obviously, this option may be limited by the nonexistence of sewage treatment. Co-treatment is most applicable to municipalities which have secondary or tertiary treatment, where organics, nitrogen and colour may be removed. Lema (1988) states that the addition of leachate to sewage may also be argued as a nitrogen nutrient source for municipal secondary treatment. If the municipal treatment plant is only primary treatment, then significant treatment of the leachate might not occur. However, as in the case of leachate from the Vancouver landfill (which is directed into the Annacis Island primary treatment plant), some advantages might still be obtained from dilution of the leachate in the sewage, and by good dilution into the receiving water due to efficient sewage outfall diffusers. Economic deterrents to co-treatment include the cost of building the necessary piping connections and/or paying a treatment fee to the municipal plant.

Lema (1988) lists the potential negative impacts of co-treatment on secondary treatment: excessive loading of organic and inorganic compounds, high effluent nitrogen, corrosion, poor settling, precipitation of inorganic ions, heavy metal inhibition, and heavy metal contamination of the sludge, thus rendering the sludge unfit for agricultural purposes. Lema suggests that co-treatment is only acceptable when the leachate makes up less than 5% of the total sewage input and leachate COD is less than 10000 mg/L. Accordingly, assuming a sewage COD of 300 mg/L, the leachate COD contribution must be less than 64% of the COD load.

Kelly (1987) investigated the effect of co-treatment on a pilot scale activated sludge plant treating domestic waste. For a leachate with 1167 mg COD/L and 71 mg NH_4-N/L, and a primary wastewater with a COD of 238 mg/L, process instability was not observed for leachate mixtures of 2, 4 and 16%

by volume. The COD contribution from leachate at a mixture of 16%, was only 48% (less than the 64% maximum suggested by Lema (1988)). However, Kelly observed that leachate additions increased heavy metals in the sludge and increased precipitation onto process equipment.

1.7.3 Spray Irrigation

Robinson (1983) suggested that spray irrigation, also known as land spraying, may either be used to treat relatively dilute raw leachates or to dispose of treated effluent. Lema (1988) stated that spray irrigation of landfill leachate is not a valid option because it risks polluting groundwater, renders the land unfit for agriculture, and may be toxic to plants.

1.7.4 Bacterial Assimilation

Robinson and Maris (1985) concluded that bacterial assimilation, in biological treatment of "young" leachate with high BOD_5 and low ammonia (down to BOD_5:NH_4-N ratios of 100:3.6), can be sufficient to achieve complete ammonia removal. Robinson (1988) reported a successful implementation of a nitrogen assimilation plant for removal of ammonia from landfill leachate, of approximately 700 mg NH_4-N/L, which produced an effluent with ammonia-N less than 2 mg/L. A supplementary BOD_5 source was used which was comprised of jam waste from a nearby jam-producing plant. In general, for nitrogen removal by bacterial assimilation to be economical, a cheap source of BOD_5 must be available, in addition to a disposal option for the ammonia-rich sludge.

1.7.5 Physical-Chemical Treatment

Potential physical-chemical methods for ammonia removal from landfill leachate include air stripping, reverse osmosis and ion exchange. Keenan (1979) reported that good carbon, heavy metals, and ammonia removal were obtained from pretreatment by chemical precipitation of heavy metals to prevent heavy metal inhibition, followed by air stripping to prevent ammonia inhibition, and then biological treatment for carbon oxidation and nitrification. Ehrig (1991) described the success in reverse osmosis removal as only an adjournment of a real treatment solution, since the process produces a liquid concentrate, which is usually passed back into the landfill. However, in combination with air stripping, reverse osmosis may be useful in ammonia removal from landfill leachate. Ion exchange may also be used for ammonia removal using a column of clinoptilolite, a zeolite with a high selectivity for ammonium ions and calcium ions (U.S. EPA 1975). Older leachate may be very high in calcium and may therefore not be well-suited for ion exchange for the purpose of ammonia removal. have reduce the ammonial removal. In addition, column regeneration will produce a concentrate which still requires disposal or treatment. Hence, like bacterial assimilation and reverse osmosis, ion exchange cannot be considered an ultimate treatment.

1.8 Study Objectives

In summary of this chapter:

1. Modern landfill design and operation of landfills, will produce leachates with high concentrations of ammonia.
2. Biological nitrification and denitrification is considered to be one of the most effective and economical methods of nitrogen removal from high ammonia leachate.
3. The MLE process (single-sludge predenitrification activated sludge, see Figure 1.1) is one particular implementation of biological nitrification and denitrification that has several advantages (see Section 1.6.3).

The potential increase in the ammonia concentrations of leachate from modern "older" landfills, raised the question, "To what ammonia level could the MLE process successfully operate, especially at colder temperatures when biological treatment is most challenged?" A particular concern was the exposure of nitrifiers and denitrifiers to elevated ammonia levels in the anoxic reactor. Based on the above reasoning this study had the following objectives:

1. Determine the effect and limit of increasing the influent leachate ammonia concentrations, on successful treatment by the MLE process shown in Figure 1.1.
2. Determine the effect of colder temperatures on treating the highest influent leachate ammonia concentration determined by Objective 1.
3. Determine the effect of solids retention time (SRT) on Objective 1 and 2.

Chapter 2

LITERATURE REVIEW

This literature review presents a short overview of research that has been published on the subject of biological nitrification and denitrification. Emphasis is given to research on landfill leachate treatment, cold temperature studies and other factors which affect nitrification and denitrification performance. Weight is also given to research on which the activated sludge process, or more specifically, the MLE process, was utilized.

2.1 Biological Nitrification and Denitrification of Landfill Leachate

Dedhar and Mavinic (1985) successfully nitrified leachate, with 288 mg NH_4-N/L, from an "older" landfill, to less than 1 mg/L. Denitrification, using glucose as an external carbon source for an MLE process, was achieved only on several occasions.

Robinson (1992), in a pilot study, successfully nitrified and denitrified landfill leachate with ammonia-N levels of 2000 mg/L, using the MLE process at 20 °C. A recycle ratio of 10:1 was found to produce an effluent NO_3^--N of approximately 95 mg/L and a NO_2^--N of approximately 0.2 mg/L.

2.2 Effect of Dissolved Oxygen on Nitrification

Stenstrom and Poduska (1980) investigated the dissolved oxygen (DO) concentration required for nitrification of municipal wastewater. They concluded that at higher SRTs, nitrification could be achieved at DO levels from 0.5 to 1.0 mg/L, and at lower SRTs, higher DO levels were required.

2.3 Effect of Temperature

Decreasing temperature results in decreased growth rate according to the Arrhenius relationship. Decreasing temperature also decreases the fraction of ammonia present that exists as "free" ammonia. Anthonisen et al (1976) calculated that for each 10 °C drop in temperature, the "free" ammonia present decreases by approximately one half.

Using a 3 stage biological process (carbon oxidation, nitrification, denitrification), to treat a synthetic municipal wastewater at 5 °C, Halmo and Eimhjellen (1981) found that nitrification was "unquestionably" the critical step. Nitrification at low temperatures was determined to be possible, but was vulnerable to changes in external conditions. Halmo and Eimhjellen also found that 98% denitrification could be obtained at 5 °C, with some encouragement of psychrophilic bacterial growth.

Randall and Buth (1984) studied the effect of temperature on nitrification of a synthetic municipal wastewater. Randall and Buth found that nitrification was very sensitive to small temperature changes between 10 to 17 °C. Temperature inhibition was more significant on nitrate formers (eg. *Nitrobacter*) than on nitrite formers (eg. *Nitrosomonas*); hence, nitrite accumulation was observed. Further, Randall and Buth concluded that nitrification was more temperature sensitive than heterotrophic activity.

Using mixed liquor from an activated sludge municipal wastewater treatment plant, Lewandowski (1982) found that the relationship between specific reaction rate for denitrification and temperature was linear within 5 to 35 °C. Below 5 °C, the reaction rate decreased more significantly. The specific reaction rate for methanol was found to be 1.83 h^{-1} at 20 °C and 0.93 h^{-1} at 10 °C.

Guo (1992) studied the effect of temperature on biological nitrification and denitrification of a high ammonia landfill leachate using the MLE process. Temperatures of 20 °C, 12 °C, and 4 °C, were studied, with aerobic SRTs ranging from 20 to 60 days. Guo found that at 12 °C, using a 20 day SRT, the system was capable of ammonia-N removal from 210 mg/L in the influent leachate to less than 0.5 mg/L in the treated effluent. An effluent ammonia-N level less than 1.9 mg/L was achieved at 4 °C, using a 60 day SRT.

2.4 Effect of pH, "Free" Ammonia, and Nitrous Acid

Anthonisen et al (1976) observed that nitrification was reduced by low pH due to nitrous (HNO_2) acid inhibition, and at high pH due to "free" ammonia (NH_3) inhibition. Both were shown to affect *Nitrobacter* at lower concentrations than for *Nitrosomonas*; thus the overall effect was nitrite accumulation. "Free" ammonia inhibition to *Nitrobacter* was observed to begin between 0.1 to 1.0 mg/L. For nitrosomanas, "free" ammonia inhibition was observed to begin between 10 to 150 mg/L. Nitrous acid inhibition to nitrifiers, was observed to begin between 0.22 and 2.8 mg/L. Anthonisen et al qualified these results by acknowledging that "free" ammonia and nitrous acid inhibition may be affected by acclimation, temperature, and the number of nitrifying organisms present.

Turk and Mavinic (1989) investigated process changes that could be used to maintain nitrite accumulation and overcome the effects of acclimitization to "free" ammonia, during nitrification and denitrification of landfill leachate and a synthetic waste. Parameters investigated included "free" ammonia, nitrous acid and dissolved oxygen. Only "free" ammonia (at 5 to 10 mg N/L) was found to be effective as a differential inhibitor of unacclimated nitrifiers. Predenitrification, in which nitrifiers are recycled through elevated "free" ammonia concentrations in the anoxic reactor, was suggested as the most effective measure for delaying acclimatization and extending nitrite accumulation.

Keenan et al (1979) performed a study of ammonia substrate inhibition on nitrification of landfill leachate. Keenan observed the ammonium ion (NH_4^+) to be the inhibitory form of ammonia and, conversely, Keenan did not observe inhibition of nitrification due to "free" ammonia.

Antoniu et al (1990) determined the optimal pH for nitrifying bacteria to be approximately 7.8. Painter and Loveless (1983) determined the optimum pH for nitrification to be in the range between 7.5 to 8.5, with an optimal growth rate occurring at pH 8.

The U.S. EPA (1975) suggests that pH may strongly affect nitrification by altering the amount of bicarbonate in solution. The U.S. EPA also found that the highest reported rates of denitrification were within the range of pH 7.0 to 7.5.

Beccari et al (1983) observed that elevated nitrite levels may inhibit denitrification. Nitrite inhibition was attributed to the level of nitrous acid.

2.5 Effect of Excess BOD_5 on Nitrification

Several nitrification studies have found that nitrification is inhibited by the presence of elevated levels of biodegradable organic matter. The explanation given for this inhibition, is that faster-growing heterotrophic bacteria outcompete slow-growing autotrophic nitrifiers for dissolved oxygen in the presence of elevated BOD_5. Hockenbury et al (1977) investigated the effect of simultaneous heterotrophic activity on nitrifier activity and concluded that no such inhibition takes place.

Carley and Mavinic (1991), using a predenitrification activated sludge setup for landfill leachate treatment, with a 4:1 solids recycle ratio, found that a denitrification COD:NO_x ratio of 20:1 resulted in significant carbon breakthrough and a resulting reduction of nitrification of up to 40%. A look at the raw data of this work (Carley, 1988) shows a corresponding increase in aerobic BOD_5, thus supporting the claim that elevated BOD_5s can inhibit nitrification.

Similar results have been observed with RBCs (Gonenc and Harrmoes, 1990) and with trickling filters (Figueroa and Silverstein, 1991). Gonenc and Harrmoes suggested that the ratio of BOD_5:DO must be less than 5:1 for uninhibited nitrification to occur. Parker and Richards (1986), in a study on nitrification in trickling filters, concluded that because of competition between heterotrophic bacteria and nitrifiers, nitrification is not initiated in the trickling filter tower until soluble BOD_5 is less than 20 mg/L.

2.6 Effect of Carbon Source and Quantity on Denitrification

Methanol has been widely used as an external carbon source for biological denitrification (U.S. EPA 1975). Reasons for this include: high reaction rate, abundance of supply, low sludge solids yield, and relatively low cost.

Manoharan (1989) found that glucose, as a carbon source, resulted in unstable denitrification, with fluctuations between 10 to 100%. However, methanol as a carbon source was found to provide for consistent and reliable, complete denitrification.

Carley and Mavinic (1991) tested methanol, acetate, glucose and a brewer yeast, as external carbon sources for denitrification of a carbon-limited landfill leachate. Their results indicated that methanol and acetate were equally effective and better overall than glucose and the brewer yeast. The $COD:NO_x$ ratio (mg COD:mg NO_x-N) required for complete denitrification was approximately 6.2:1 for methanol and 5.9:1 for acetate.

McCarty et.al (1969) proposed the following stoichiometric-based equation for methanol (Cm) requirements for complete denitrification (all variables are in mg/L):

$$Cm = 2.47*[NO_3^{-}\text{-}N] + 1.53*[NO_2^{-}\text{-}N] + 0.87*[\text{dissolved oxygen}]$$

The U.S. EPA Process Design Manual for Nitrogen Control (U.S. EPA 1975) suggests that, in general, a methanol requirement of 4.5 mg COD/mg NO_3^--N will enable complete denitrification. Studies have generally shown a $COD:NO_x$ requirement in the range of 4:1 to 6.5:1 (Narkis, 1979 and Carley, 1989).

As seen from McCarty's methanol requirement equation, complete denitrification of nitrite requires about 40% less methanol than complete denitrification of nitrate. The possibility of lower methanol requirements inspired Turk and Mavinic (1989) to investigate the feasibility of a shortened pathway for nitrogen removal based on inhibition of nitrite oxidizers (*Nitrobacter*). This would decrease aeration demands during nitrification, and decrease carbon demands during denitrification. High nitrite levels existed until acclimatization eventually occurred.

2.7 Heavy Metal Inhibition

The nitrification process is considered very sensitive to heavy metals (Mavinic and Randall, 1992). Zinc, a predominant metal in acetogenic landfill leachates, has been reported to result in nitrification inhibition at concentrations of approximately 17 mg/L (Dedhar and Mavinic, 1985, and Jasper et al, 1986). Martin and Richard (1982) found the nitrosomonas toxic threshold for zinc to be approximately 10 mg/L.

Mavinic and Randall (1990) investigated heavy metal inhibition of biological nitrification and denitrification of a high ammonia landfill leachate (188 mg N/L). Their results showed that when excess phosphorus was added to account for zinc phosphate precipitation, the system could handle zinc concentrations up to 130 mg/L at 20 °C with an aerobic SRT of 10 days. Inhibition from chromium and nickel was obvious at much lower levels.

2.8 Effect of HRT and Solids Recycle Ratio

The solids recycle ratio is defined as the volumetric rate of the clarifier solids underflow that is recycled back into the anoxic reactor, to the influent volumetric rate entering the anoxic reactor. A study by Elefsiniotis et al (1989), using the MLE train, varied the solids recycle ratio and found that beyond 6:1, nitrification and denitrification became unstable. Since solid recycle and effluent recycle were combined into one recycle, the reduction in HRT was suggested as the reason for poor performance at higher recycle ratios. Robinson (1992), also utilized a predenitrification arrangement, but with the aerobic reactor sequenced to also operate as a clarifier. While using HRTs that were considerably longer than the HRTs utilized by Elefsiniotis et al, Robinson successfully operated at a recycle ratio of 10:1.

Finally, Painter (1977) stated that, after exposure to aerobic conditions, most denitrifying organisms require a period of approximately 1/2 to 1 hour of adaption to nitrate under anoxic conditions for denitrification to occur.

Chapter 3

EXPERIMENTAL SETUP

Two parallel, identical, laboratory-scale, biological, single-sludge, predenitrification systems, with recycle, were used to study the effects of solids retention time (SRT), ammonia loading, and temperature, on the nitrification and denitrification of landfill leachate. Throughout the study, one system was operated at a 10 day aerobic SRT and the other system was operated at a 20 day aerobic SRT (based on the work of Mavinic and Randall (1990) and Guo (1992)). Each system consisted of an anoxic reactor, an aerobic reactor, and a clarifier with a recycle back to the anoxic reactor. The system is shown in Figure 1.1. The design and operating parameters of the system are shown in Table 3.1. The study was conducted in two phases. Phase one investigated the effects of increasing the ammonia loading. Phase two investigated the effects of cold temperature.

TABLE 3.1: Treatment System Design and Operating Parameters

Parameter	Value
Anoxic Volume (L)	5
Aerobic Volume (L)	10
Clarifier Volume (L)	4
System Volume (L)	20*
Influent Flow (L/days)	10
Recycle Flow (L/days)	60
Recycle Ratio (Recycle:Influent)	6:1
Daily Aerobic Wasting (L)	1/0.5
Aerobic SRT (days)	10/20
Anoxic Nominal HRT (hours)	12
Aerobic Nominal HRT (hours)	24
Clarifier Nominal HRT (hours)	9.6
System Nominal HRT (hours)	48
Anoxic Actual HRT (hours)	1.7
Aerobic Actual HRT (hours)	3.4
Clarifier Actual HRT (hours)	1.4
System Actual HRT (hours)	6.8

*1 L is estimated in each system for pumps and tubing.

A solids recycle ratio of 6:1 was selected based on the work of Elefsiniotis et al (1989). Both phases of the study were conducted within a temperature-controlled room. The temperature during the ammonia loading phase was maintained at 20 °C. The temperature during cold temperature phase was decreased from 20 °C to 10 °C.

3.1 Leachate

The leachate used in this study was collected from the City of Vancouver's Burns Bog Landfill in Delta, British Columbia. The leachate was collected monthly from a pumping station located in the southwest corner of the landfill. The collected leachate was stored in closed containers at 4 °C to limit biochemical changes while in storage.

The landfill began operation in 1966 and is still in use today. The leachate presently generated is typical of leachate from an older landfill, with low BOD_5, low BOD_5:COD ratio, low heavy metals, and a consistently high ammonia concentration. The basic characteristics of the leachate are shown in Table 3.2.

TABLE 3.2: Base Leachate Composition

Parameter	Concentration (mg/L)	
	Range	Mean
BOD_5	20-62	36
COD	285-464	371
Ammonia as N	128-256	186
NO_x^- as N	0.1-58.8	2.7
NO_2^- as N	0.0-3.3	0.3
Orthophosphate as P	0.0-0.8	0.4
Alkalinity as $CaCO_3$	1190-2120	1600
VSS	24-65	45
TSS	56-128	97
pH (pH units)	7.6-8.3	8.0
Cu (Guo, 1992)	0-0.71	0.13
Zn (Guo, 1992)	0-0.11	0.04

3.2 Leachate Feed

The leachate to both systems was fed from a common, covered, plastic bucket with a mechanical stirrer. Each system received leachate at approximately 10 L/day. In actuality, to maintain the aerobic HRT at approximately 3.4 hours and the anoxic HRT at approximately 1.7 hours, the rate of leachate addition was less than 10 L/day to account for the addition of ammonium chloride, orthophosphate, methanol, and bicarbonate.

Initially, leachate was poured into the bucket from the storage containers. To reduce the aeration of the leachate and possible instigation of nitrification within the feed bucket, this practice was changed to siphoning the leachate from the storage container into the feed bucket.

3.3 Chemical Addition

Orthophosphate, methanol, ammonium chloride and sodium bicarbonate, were all added to the systems during this study. In general, the concentrations of the feed solutions were as high as possible so that volumetric additions would be as low possible, thereby affecting the HRT as little as possible. In general, the lowest volumetric rate that the pumps could manage consistently was 5 to 10 mL/hr. Controlling the flowrate at these low levels proved to be a problem; therefore, the concentration of the chemical feed solution was altered instead of the flowrate.

3.3.1 Phosphate Addition

From the start of the study, disodium orthophosphate ($Na_2PO_4 \cdot 7H_2O$) was added to both systems to ensure that phosphorus was not a limiting nutrient. The objective of phosphate addition was to maintain the membrane-filtered orthophosphate levels above 0.5 mg P/L, as suggested by Mavinic and Randall (1992). For each system, phosphate feed solution was provided from a 1000 mL graduated cylinder into the anoxic reactor. A single double-headed pump was used to feed both systems. Volumetric delivery rates were determined daily by checking the volume change in the graduated cylinder. Phosphate mass dosing rates were altered by changing the concentration of the feed solution.

3.3.2 Methanol Addition

Methanol (CH_3OH) was added to the anoxic reactor as a carbon source for denitrification. The amount of methanol added was determined by the requirements for complete denitrification. For each system, methanol feed solution was fed from a 1000 mL graduated cylinder into the anoxic reactor. A single double-headed pump was used to feed both systems. Volumetric delivery rates were determined daily by checking the change in the graduated cylinder. Methanol mass dosing rates were altered by changing the concentration of the feed solution.

3.3.3 Ammonium Chloride Addition

Ammonium chloride (NH_4Cl) was added to the anoxic reactor to simulate leachate with higher ammonia levels. For each system, ammonium chloride feed solution was fed from a 4000 mL graduated plastic bottle into the anoxic reactor. A single double-headed pump was used to feed both systems. Volumetric delivery rates were determined daily by checking the change in the graduated cylinder. Ammonium mass dosing rates were altered by changing the concentration of the feed solution.

3.3.4 Sodium Bicarbonate (Alkalinity) Addition

Sodium bicarbonate ($NaHCO_3$) was added to the aerobic reactor to maintain the pH of the aerobic reactor at approximately 7.5. Sodium bicarbonate addition was not required until the influent leachate ammonia level was increased to 600 mg N/L. Initially, sodium bicarbonate addition was performed by a single dual-headed pump, which fed a sodium bicarbonate solution from two graduated plastic feed bottles to both aerobic reactors. The concentration of the bicarbonate solution was adjusted in response to too low or too high aerobic pHs. This method allowed some pH fluctuations below a pH of 7.0 and above 7.5. Therefore, early in the temperature phase, a Cole-Parmer Series 7142 pH/Pump Controller was added to each system. If the pH of the aerobic reactor decreased below the setpoint value, set at 7.5, the pH/pump controller would pump a solution of sodium bicarbonate into the aerobic reactor until the pH rose above the setpoint. The pH/pump controllers provided excellent control of pH in the aerobic reactors.

3.4 Anoxic Reactor

The purpose of the anoxic reactor was to denitrify the highly nitrified solids recycle from the bottom of the clarifier. In addition to the recycle, the anoxic reactor received the natural leachate, phosphate solution, methanol solution and ammonium chloride solution. The anoxic reactor was a cylindrical plastic container with a liquid volume of 5 L. At total leachate and chemical additions of 10 L/d, and with a recycle of 60 L/d, the anoxic reactor provided a nominal HRT of 12 hours and an actual HRT of 1.7 hours. The mixed liquor in the anoxic reactor was constantly mixed by a mechanical stirrer. An oxidation-reduction potential (ORP) probe was continuously submerged in the reactor to measure the redox potential of the mixed liquor. The anoxic mixed liquor flowed by gravity into the aerobic reactor.

3.5 Aerobic Reactor

The purpose of the aerobic reactor was to nitrify the high ammonia anoxic overflow. In addition to the anoxic overflow, the aerobic reactor also received sodium bicarbonate solution. Beginning early in the cold temperature phase, the pH of the aerobic mixed liquor was continuously monitored by a pH probe. The dissolved oxygen (DO) level of the aerobic mixed liquor was continuously monitored by a submerged DO probe. The DO level was maintained above 2.0 mg/L, according to the DO meter, by continuous aeration from a perforated plastic tubing at the bottom of the reactor. The perforated tubing was connected to the laboratory's compressed air supply. The flow of air was manually controlled by use of a flow valve. Early in the temperature phase, the perforated tubing was supplemented by two small porous stone air diffusers.

The aerobic reactor was a cylindrical plastic container with a liquid volume of 10 L. Aerobic SRT was controlled by wasting from the aerobic reactor through a valve. 1 L was wasted daily from the 10 day SRT system to provide a 10 day theoretical aerobic SRT. 0.5 L was wasted daily from the 20 day SRT system to provide a 20 day theoretical aerobic SRT. At total leachate and chemical additions of 10 L/d, and with a recycle of 60 L/d, the aerobic reactor provided a nominal HRT of 24 hours and an actual HRT of 3.4 hours. The reactor was kept constantly mixed by a mechanical stirrer. The aerobic mixed liquor flowed by gravity into the clarifier.

3.6 Clarifier

The clarifier was a 4 L cylindrical plexiglass container with a conical bottom. The purpose of the clarifier was to separate the suspended solids from the aerobic mixed liquor so as to produce a clear effluent supernatant, and also to allow thickening of the suspended solids, which could then be recycled back to the anoxic reactor. The aerobic reactor mixed liquor flowed by gravity into an inner sleeve within the clarifier. The inner sleeve prevented shortcircuiting of the mixed liquor to the supernatant exit. The solids recycle pump rate was set at 60 L/d, so as to produce a 6:1 solids recycle ratio. The recycle pump was initially operated on a cycle of two minutes on and two minutes off. This was later adjusted to one minute on and three minutes off. The purpose of this intermittent pumping was to decrease the possibility of blockages occurring within the recycle line. A scraper mechanism swept the conical surfaces of the clarifier bottom to prevent a buildup of settling solids.

3.7 System Start-up

On August 12, 1991, the aerobic reactor and clarifier of both systems, were filled with sludge from the aerobic zone of the University of British Columbia Bio-P sewage treatment pilot plant. The leachate, recycle, and phosphate lines initially bypassed the anoxic reactor and were added directly to the aerobic reactor. No wasting occurred from the aerobic reactor until good nitrification was observed. Wasting began in the 10 day SRT system on Day 24 and Day 22 for the 20 day SRT system. 1 L was wasted daily from the aerobic reactor of one system to provide a 10 day aerobic SRT and 0.5 L was wasted daily from the aerobic reactor of the second system to provide a 20 day aerobic SRT. Also, on Day 24 (10 day SRT system) and Day 22 (20 day SRT system), each anoxic reactor was reseeded and methanol additions were begun to the anoxic reactor. The methanol addition was increased until denitrification was observed and system NO_x^- levels began to fall. Methanol addition was then reduced until denitrification was affected. Methanol additions were then increased until complete denitrification was established. This procedure was necessary to establish the minimum amount of methanol required for denitrification. Complete and stable nitrification and denitrification of the natural leachate was established in both systems by Day 61.

3.8 System Operation

The study was divided into two phases. The objective of the loading phase was to determine the maximum simulated leachate ammonia level that could successful be nitrified and denitrified. The objective of the temperature phase was to observe the effects of cold temperature on nitrification and denitrification when treating leachate with the highest ammonia level successfully treated in the loading phase.

The loading phase began with the establishment of complete nitrification and denitrification of the natural leachate (approximately 200 mg NH_4-N/L), in both the 10 day SRT system and in the 20 day SRT system. On Day 61, ammonium chloride additions were started to the anoxic reactors of both systems to provide additional ammonia and thereby simulate a leachate with 300, 600, 1000, 1500, 2000 mg/L of ammonia-N. After each ammonium chloride increment, nitrification was allowed to stabilize, and the minimum methanol required for denitrification was determined. On Day 93, when 600 mg/L of ammonia-N was added, the aerobic reactor pH of both systems fell below 6.5 and nitrification was inhibited. On Day 103, sodium bicarbonate (alkalinity) additions were begun to the aerobic reactor to sustain the pH at approximately 7.5. The loading phase ended with an unsuccessful attempt to increase the influent leachate ammonia level to 2000 mg N/L from 1500 mg N/L (Section 5.1.6).

The cold temperature phase began on March 13, 1992 (Day 1 of the cold temperature phase). Once nitrification of influent leachate, with an ammonia level of 1500 mg N/L, was re-established, the anoxic reactors were reseeded with aerobic sludge from the U.B.C. Bio-P sewage treatment plant. Complete nitrification and denitrification was not re-established until Day 91. On Day 94, the temperature was decreased from 20 to 17 °C. The temperature was subsequently decreased from 17, to 14, to 12, and finally to 10 °C. The system was allowed to adjust to each temperature for approximately 10 days before the next temperature decrease was imposed. Starting on Day 132, the ability of nitrification to recover from elevated ammonia and BOD_5 levels at 10 °C with no aerobic wasting, and no methanol addition, was investigated. On Day 145, the air supply for the aerobic reactors was lost for approximately eight hours, thus causing both systems to fail. From this failure, only one system recovered. On Day 156, aerobic wasting was started to yield a theoretical aerobic SRT of 10 days. By Day 169, total failure was observed. On Day 170, another loss of the air supply occurred and the system was shutdown.

Chapter 4

ANALYTICAL METHODS

This chapter describes the sampling, preservation and analytical methods performed in this study. Initially, N and P samples were filtered by Whatman #4 and membrane. The Whatman #4 and membrane filtration results were found to be essentially equivalent. From then on, only Whatman #4 filtration was performed.

4.1 Temperature

The study was performed in a temperature-controlled room. The room temperature was measured by a mercury thermometer and a built-in temperature gauge. Both agreed within their accuracy limit of 0.5 °C. Initially the room temperature was checked daily, but once the stability of the temperature controller was recognized, room temperature was checked approximately once every second week during the loading phase. During the cold temperature phase, the room temperature was again checked daily.

Liquid temperatures were measured by a digital probe thermometer. During the temperature phase, liquid temperatures were measured the day following each temperature decrease.

4.2 Dissolved Oxygen (DO)

The DO levels in the aerobic reactors were measured by using a Yellow Springs Instruments Co. Model 54 ARC Dissolved Oxygen Meter with a Yellow Springs Instrument Co. 5739 submersible DO probe. The probe performance was checked and calibrated (if necessary) by using the air calibration method (Instruction Manual YSI Models 54 ARC and 54 ABP Dissolved Oxygen Meter). If calibration failed, the probe membrane was changed. A DO reading was taken every day or every second day, to ensure that DO levels were sufficient for nitrification ($>$ 2 mg/L). The DO levels were controlled by flow valve controllers attached to the laboratory air supply.

4.3 Oxidation-Reduction Potential (ORP)

ORP in the anoxic reactors was measured by using a Cole-Parmer Chemicadet pH meter connected to a Broadley James Corporation ORP Electrode. The ORP measurements were recorded in mV. The ORP probes were cleaned weekly using distilled water and cleaning paper. The ORP probes were calibrated approximately every two months using a pH-buffered quinhydrone method (Broadley James Corporation Electrode Instructions ORP (REDOX) Combination Electrode). An ORP probe was submersed into each anoxic reactors. ORP measurements were recorded every day or every second day. ORP measurements are used to indicate the redox and denitrification conditions of the anoxic mixed liquor.

4.4 pH

Throughout the loading phase and for the initial period of the temperature phase, the pH of the leachate, and the mixed liquor from the anoxic and aerobic reactors was measured using a Cole Parmer Digital pH Meter with a Cole Parmer Ag-AgCl combination electrode. Measurements were made by placing the probe directly into the reactor. Before measurements were started, the pH probe performance was checked, and calibrated if necessary, with two pH buffer solutions.

On Day 33 of the cold temperature phase, a pH/pump controller was installed for each aerobic reactor. The controller monitored the pH of the aerobic reactor from a submersed Ag-AgCl combination pH probe. The aerobic pH was read from the digital display of the controller. The performance of the probe was checked, and calibrated if necessary, by using two pH buffers. The pH of the anoxic reactor and the leachate were measured using a Beckman pH meter with a Fisher combination electrode, using an Ag-AgCl reference element. The probe was calibrated with two buffers each time before using.

pH values were recorded every day or every second day. The purpose of taking pH measurements was to observe the effect of pH on nitrification and denitrification, and vice versa.

4.5 Suspended Solids

Total Suspended Solids (TSS) and Volatile Suspended Solids (VSS) were measured on samples from the leachate, aerobic and anoxic mixed liquors and from the effluents. These were used to provide a representation of the mass of microorganisms present in the reactors. The procedure was a modified version of the suspended solids method in Standard Methods (A.P.H.A. et al, 1989). The modification used in the laboratory, was the replacement of the ceramic Gooch crucible filtration unit with a stainless steel microbiological filtration apparatus and an aluminum foil filter holder. The replacement of the ceramic holder with an aluminum holder decreased the possibility of error due to moisture absorption of the filter paper holder. Suspended solids testing was conducted two to three times a week.

4.6 Alkalinity

Alkalinity measurements were taken from each batch of leachate collected, to assess the alkalinity requirements of the process. Alkalinity was also measured, on several occasions, on samples from the anoxic and aerobic mixed liquors, during the latter months of the loading phase and the first month of the temperature phase. Alkalinity was conducted in accordance with Standard Methods (A.P.H.A. et al, 1989) except that the samples were filtered (Whatman #4). Filtration was necessary to prevent the pH from drifting upwards after acid titration. The pH drift was presumably due to the acid reacting with the solids present. Titrations were performed to a pH of 4.3. Titration curves developed for the mixed liquors and leachate, indicated an endpoint at approximately 4.5.

4.7 Chemical Oxygen Demand (COD)

COD tests were performed using the HACH Colorimeter Apparatus, filtered (Whatman #4) samples of leachate, anoxic and aerobic mixed liquors and effluent. For the temperature phase, effluent COD analysis was eliminated since throughout the loading phase, it was found to be virtually equivalent to the COD levels in the aerobic reactors. Samples were collected two to three times a week. Samples were immediately filtered into plastic bottles, preserved by addition of concentrated sulphuric acid to pH<2, and refrigerated at 4 °C. The high chloride levels in the leachate required the use of mercuric sulphate during digestion to suppress chloride interference.

4.8 Biochemical Oxygen Demand (BOD_5)

BOD_5 tests were performed in accordance with Standard Methods (A.P.H.A. et al, 1989) on centrifuged, filtered samples (Whatman #4) of the influent, anoxic and aerobic mixed liquor, and the effluent. For the temperature phase, effluent BOD_5 analysis was eliminated, since throughout the loading phase, effluent BOD_5 values were found to be essentially equivalent to aerobic BOD_5 values. Dilution water used in the test was seeded with approximately 1 mL of aerobic seed per 10 L of dilution water. Because the seed contained high amounts of nitrifiers, a nitrification inhibitor (Hach Company Formula 2533) was added to the dilution water at a concentration of 10 mg/L. The initial and final DO concentrations were measured using a Yellow Springs Instrument Co. Ltd. Model 54 Dissolved Oxygen Meter, with a self-mixing DO probe.

For the first half of the loading phase, BOD_5 tests were performed only after the system had stabilized and complete denitrification was suspected after an increase in methanol addition. Later in the loading phase, BOD_5 testing was performed once a week. During the temperature phase, once BOD_5 inhibition of nitrification was suspected, BOD_5 testing was performed two to three times a week.

4.9 Ammonia

The terms "ammonia, ammonia-N, NH_4, NH_4-N", in this work, refers to the sum of the "free" ammonia-N (NH_3-N) and the ammonium-N ion (NH_4^+-N). In some other works, the sum of the "free" ammonia-N and the ammonium-N ion, is referred to as ammoniacal-N.

Two analytical methods were employed to measure ammonia-N levels. An Orion ammonia electrode (Model 95-10) provided an immediate scanning method for ammonia levels in the influent, aerobic and anoxic reactors. In accordance with the Orion Ammonia Electrode Instruction Manual, unfiltered 50 mL samples and three ammonia standards, were adjusted to pH 11 by addition of 0.5 mL of 10 M

NaOH. The probe was inserted into the solution and the mV reading was read from a Cole Parmer Chemicadet pH meter. The readings for the three standards produced a calibration line from which the ammonia levels for the samples were calculated by linear regression. Ammonia levels were also measured using a Lachat Quikchem Automated Ion Analyzer in accordance with the Methods Manual for the Quikchem Automated Ion Analyzer (1987). Samples were immediately filtered (Whatman #4), preserved to $pH<2$ by the addition of several drops of concentrated sulphuric acid, and refrigerated in plastic bottles at 4 °C.

Ammonia samples were taken two to three times a week. Samples were collected from the leachate, aerobic mixed liquor, and the anoxic mixed liquor. During the loading phase, samples were also collected from the effluent, but since effluent ammonia levels were found to be virtually equivalent to the levels in the aerobic reactor, effluent ammonia sampling was not performed regularly during the temperature phase.

4.10 NO_x^-

NO_x^- is the sum of nitrite and nitrate. NO_x^- levels were analyzed from filtered samples using a Lachat Quikchem Automated Ion Analyzer in accordance with the Methods Manual for the Quikchem Automated Ion Analyzer (1987). Samples were filtered (Whatman #4), preserved to $pH<2$ by addition of several drops of concentrated sulphuric acid, and refrigerated in plastic bottles at 4 °C.

NO_x^- samples were taken two or three times a week. Samples were collected from the leachate, aerobic mixed liquor, and anoxic mixed liquor. During the loading phase, samples were also collected from the effluent, but since effluent ammonia levels were found to be virtually equivalent to the aerobic levels, effluent ammonia sampling was not performed regularly during the temperature phase.

A screening method for NO_x^-, in accordance with Standard Methods (A.P.H.A. et al, 1989), was attempted, but did not achieve results which were consistent with the Lachat results and hence the screening method was considered inaccurate for this particular application. The screening method's inaccuracy was attributed interference from the high level of refractory organics in the leachate, mixed liquors and effluent.

4.11 Nitrite (NO_2^-)

NO_2^- levels were analyzed from filtered samples using a Lachat Quikchem Automated Ion Analyzer in accordance with the Methods Manual for the Quikchem Automated Ion Analyzer (1987). Samples were filtered (Whatman #4), preserved by the addition of several drops of phenyl mercuric acetate, and refrigerated in plastic bottles at 4 °C. Preservation with mercuric acetate was found to maintain NO_2^- levels for at least two months. Samples were collected from the leachate, aerobic mixed liquor and the anoxic mixed liquor.

4.12 Total Kjeldahl Nitrogen (TKN)

TKN levels were measured on unfiltered and filtered (Whatman #4) samples of leachate, aerobic and anoxic mixed liquors, solids recycle liquor and effluent. Samples were preserved to $pH<2$ by addition of several drops of concentrated sulphuric acid and refrigerated in plastic bottles at 4 °C. The analytical procedure began with sample digestion in a Technicon Block Digester BD40. The digestion was performed following the instructions in the Technicon Block Industrial Method No. 376-75W(1975). The digested sample was then analyzed in accordance with the Technicon Methodology Nol 329-74W(1975). TKN analysis was only performed during the loading phase. Samples were collected after complete nitrification and denitrification had been established for each successive ammonia increase. The TKN results were not found to have been very reproducible and were frequently below the corresponding ammonia result for the sample.

4.13 Orthophosphate

Orthophosphate levels were analyzed from filtered samples (Whatman #4) using a Lachat Quikchem Automated Ion Analyzer in accordance with the Methods Manual for the Quikchem Automated Ion Analyzer (1987). Samples were filtered by Whatman #4, preserved to $pH<2$ by addition of several drops of concentrated sulphuric acid and refrigerated in plastic bottles at 4 °C. Orthophosphate samples were taken two to three times a week. Samples were collected from the leachate, aerobic mixed liquor, and the anoxic mixed liquor. During the loading phase, samples were also collected from the effluent, but since effluent orthophosphate levels were found to be virtually equivalent to the orthophosphate levels in the aerobic reactors, effluent sampling was not performed regularly during the temperature phase.

Chapter 5

RESULTS AND DISCUSSION

This chapter reports and discusses the results obtained from this study. As described in Chapter 3, this study used two identical, bench-scale, single-sludge, predenitrification systems, known as the Modified Ludzack-Ettinger (MLE) process. One system was operated at a 10 day aerobic SRT and the second system was operated at a 20 day aerobic SRT. The study was divided into two phases. The first phase was the ammonia loading phase, in which the effect of ammonia loading at 20 °C was investigated by incrementing the ammonia concentration in the leachate from the natural level of approximately 200 mg N/L to 2000 mg N/L. The raw spreadsheet data and calculations for the loading phase are presented in Appendix D. The second phase was the cold temperature phase, in which the effect of decrementing the operating temperature from 20 °C to 10 °C, was investigated. The raw spreadsheet data calculations for the temperature phase are presented in Appendix E.

5.1 Ammonia Loading Phase

NOTE: *Throughout the discussion of the results from the ammonia loading phase, tables (Tables 5.1 to 5.9) are used to summarize system parameters at each influent ammonia concentration. After each increment in influent ammonia concentration, the systems were optimized (w.r.t. alkalinity and methanol addition) and allowed time to stabilize (based on reactor VSS, reactor* NO_x^-*, and reactor ammonia). Once it was believed that a system was optimized and stabilized, approximately one week was allowed before imposing the next influent ammonia increment. The tabularized data is the average of the results collected during the final week of each influent ammonia concentration. During the failure period of the ammonia loading phase (influent ammonia level of 2000 mg N/L), the values given in the tables are the average of the last week of data of the failure period. The values, during this period, do not necessarily represent a stabilized system. Hence, the so-called failure period is primarily discussed in its own section (Section 5.1.6).*

5.1.1 Ammonia Levels

The terms "ammonia, ammonia-N, NH_4, and NH_4-N", in this work, refers to the sum of the "free" ammonia-N (NH_3-N) and the ammonium-N ion (NH_4^+-N). Some researchers prefer to use the term "ammoniacal-N" to refer to the sum of "free" ammonia and the ammonium ion.

The ammonia levels in the anoxic and aerobic reactors throughout the loading phase are shown in Figure 5.1 and Figure 5.2 for the 10 day and 20 day SRT systems. An ammonia spike was observable in the anoxic and aerobic reactors of both systems immediately after each ammonia loading increment. The ammonia spike was consistently lower in magnitude for the 20 day aerobic SRT system than for the 10 day aerobic SRT system. This may be due to the greater robustness of the 20 day aerobic SRT system, due to the presence of more biomass.

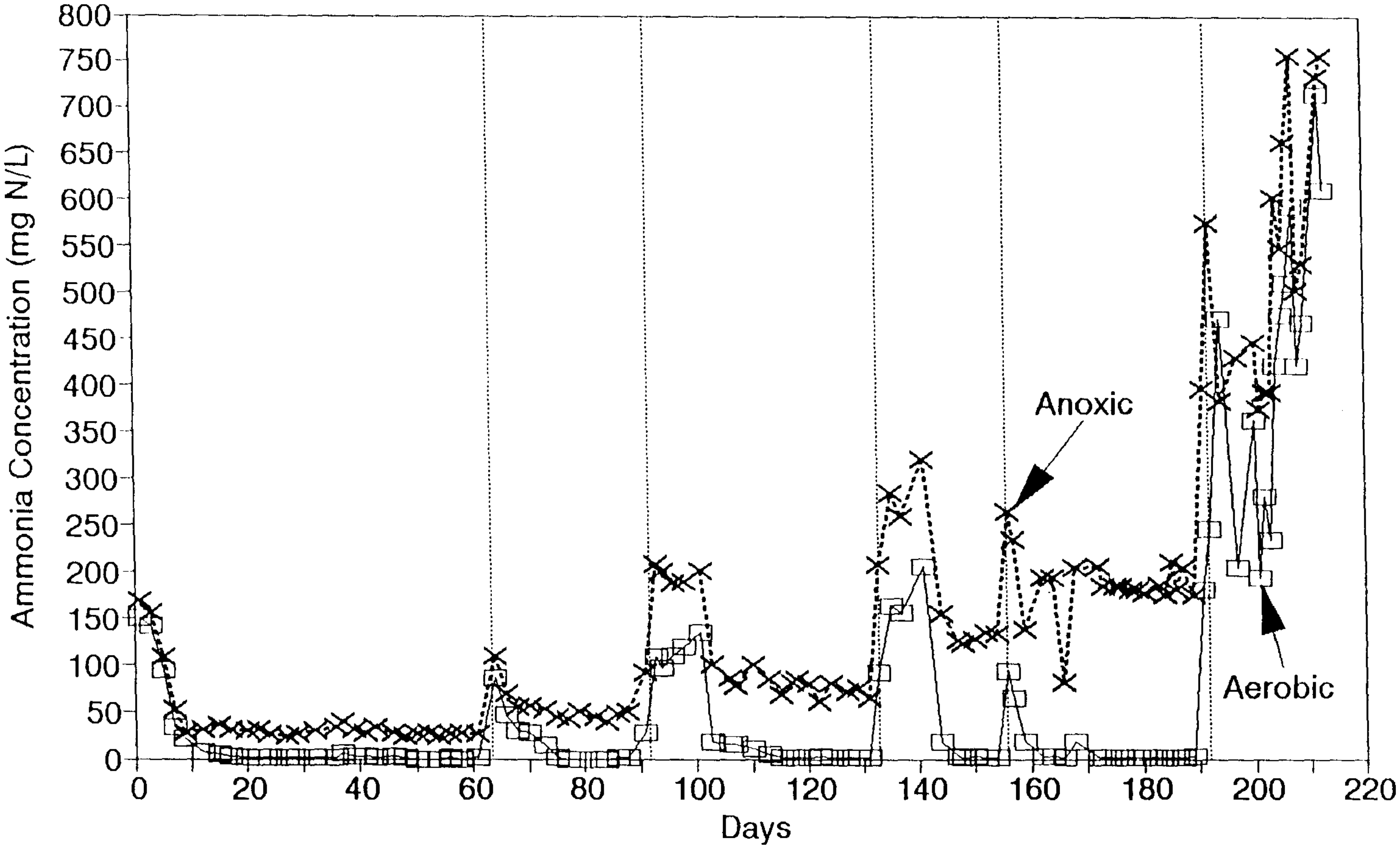
Table 5.1 summarizes the ammonia level data for the loading phase. For simulated influent ammonia levels from 200 mg N/L to 1500 mg N/L, once the system had been optimized and stabilized, the aerobic ammonia levels were found to be < 1 mg N/L. Meanwhile, the steady-state anoxic ammonia levels increased from approximately 25 mg N/L to approximately 180 mg N/L. When the simulated influent ammonia level was raised to 2000 mg N/L, aerobic ammonia levels rose to approximately 700 mg N/L and anoxic ammonia levels rose to approximately 750 mg N/L.

TABLE 5.1: Loading Phase - Ammonia Levels

Influent Ammonia (mg N/L)	10 Day SRT Anoxic (mg N/L)	10 Day SRT Aerobic (mg N/L)	20 Day SRT Anoxic (mg N/L)	20 Day SRT Aerobic (mg N/L)
200	25	<1	25	<1
300	50	<1	45	<1
600	70	<1	80	<1
1000	130	<1	140	<1
1500	180	<1	180	<1
2000	750	700	750	600

The % ammonia removal across the system, anoxic reactor and aerobic reactor, at each simulated leachate ammonia level after the systems were optimized and stabilized, are presented in Table 5.2.

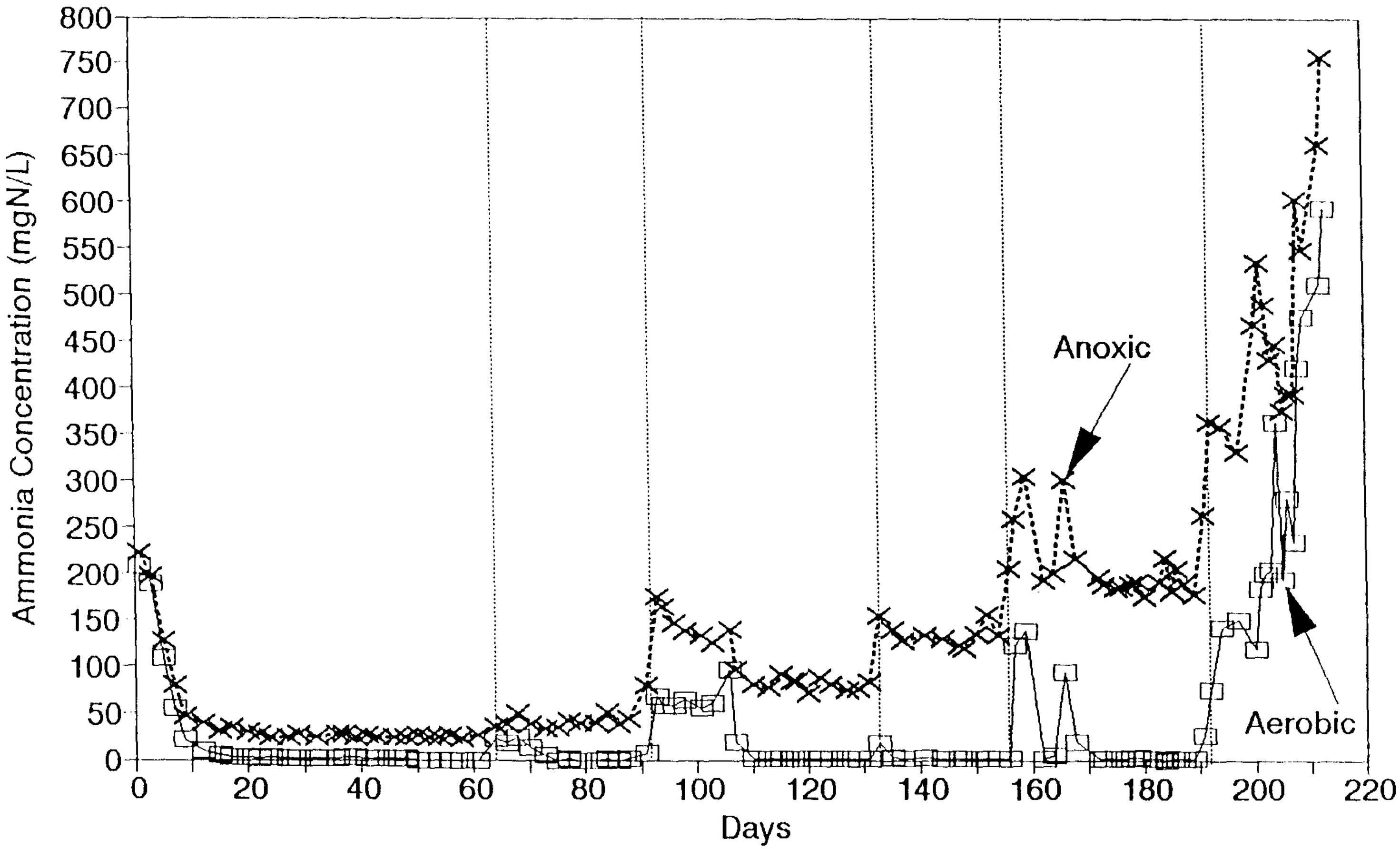
FIGURE 5.1: LOADING PHASE - 10 Day SRT System
Anoxic and Aerobic Ammonia Levels



200 (Natural)	300	600	1000	1500	2000

Simulated Ammonia Level in Influent Leachate (mg N/L)

FIGURE 5.2: LOADING PHASE - 20 Day SRT System
Anoxic and Aerobic Ammonia Levels



200 (Natural)	300	600	1000	1500	2000

Simulated Ammonia Level in Influent Leachate (mg N/L)

TABLE 5.2:	Loading Phase - % Ammonia Removal					
Influent Ammonia (mg N/L)	10 Day SRT Anoxic (%)	10 Day SRT Aerobic (%)	10 Day SRT System (%)	20 Day SRT Anoxic (%)	20 Day SRT Aerobic (%)	20 Day SRT System (%)
200	6	100	100	10	100	100
300	1	100	100	7	100	100
600	16	100	100	7	100	100
1000	9	100	100	10	100	100
1500	9	100	100	9	100	100
2000	20	11	72	13	21	75

Aerobic ammonia removal is due to a combination of nitrification, bacterial assimilation, and "free" ammonia stripping. According to Turk (1986), the percentage of "free" ammonia at pH 7.5 (the aerobic pH maintained in this study) and at 20 °C, is approximately 1%. Hence, ammonia stripping of un-ionized ammonia is assumed to be negligible. The anoxic ammonia removal is assumed to be entirely attributed to bacterial assimilation. For the influent ammonia levels that the systems successfully treated (ie. 200 to 1500 mg N/L), the anoxic ammonia removal averaged 8 %. This agrees well with the results from Carley (1988) who found anoxic ammonia removal for methanol to average 6 %, and with the results from Mavinic and Randall (1990), in which approximately 10 % anoxic ammonia removal was observed. Both studies used the same process train and the same leachate as in this study. The observed "high system removal" of approximately 70 %, at the influent ammonia level of 2000 mg N/L (despite much lower unit removals), was probably due to the time lag in ammonia buildup and the frequent clogging problems encountered during this period. The exit from the clarifier and anoxic reactor began plugging frequently when the influent ammonia level was increased to 2000 mg N/L. When the anoxic reactor exit clogged, the high ammonia anoxic liquor overflowed onto the floor instead of into the aerobic reactor. The data presented in the graphs and in the tables does not account for this loss of ammonia. This may have contributed to the time lag in ammonia buildup within the system.

5.1.2 pH and Alkalinity Addition

According to the theory presented in Chapter 1, nitrification consumes alkalinity and hence decreases pH. Conversely, denitrification returns alkalinity and increases pH. Figure 5.3 and 5.4 show the anoxic and aerobic pH levels throughout the loading phase for the 10 and 20 day SRT system. Table 5.3 summarizes the pH levels when the system was stabilized and optimized at each influent ammonia level. It is immediately evident from both graphs, that the anoxic pH was higher than the aerobic pH.

TABLE 5.3: Loading Phase - pH Levels and Alkalinity Addition

Influent	10 Day SRT			20 Day SRT		
Ammonia (mg N/L)	Anoxic pH	Aerobic pH	Alk:$N_{nitrified}$ ($mgCaCO_3/mgN$)	Anoxic pH	Aerobic pH	Alk:$N_{nitrified}$ ($mgCaCO_3/mgN$)
200	7.8	7.5	10.1	7.8	7.5	10.2
300	7.9	7.5	3.6	7.7	7.3	3.7
600	8.0	7.4	4.1	8.2	7.5	4.2
1000	8.3	7.3	4.4	8.2	7.3	3.8
1500	8.4	7.5	4.1	8.5	7.5	4.2
2000	8.5	8.5	4.4	8.6	w.4	6.2

Previous studies have reported that the optimum pH range for nitrification is from 7.5 to 8.5 (Painter and Loveless 1983), and the optimum pH range for denitrification is from 7 to 7.5 (U.S. EPA 1975). For the leachate ammonia levels of 200 mg N/L and 300 mg N/L, natural alkalinity alone was sufficient to maintain the aerobic pH at approximately 7.5. The prolonged elevated ammonia levels from Day 91 to Day 105, as observed in Figure 5.1 and 5.2, were attributed to nitrification inhibition due to low aerobic pH. Thus, pH control (alkalinity addition) was begun on Day 103 by adding sodium bicarbonate to the aerobic reactor to maintain the pH at approximately 7.5. A higher target aerobic pH was not selected, since this would result in a higher anoxic pH.

From Table 5.3, it is evident that, as the influent ammonia level was increased from 200 to 1500 mg N/L, the steady-state pH levels of the anoxic reactors increased from approximately 7.8 to 8.5. Thus, as the influent ammonia concentration increased, the anoxic pH moved further above the optimal pH

FIGURE 5.3: LOADING PHASE - 10 Day SRT System
Anoxic and Aerobic pH Levels

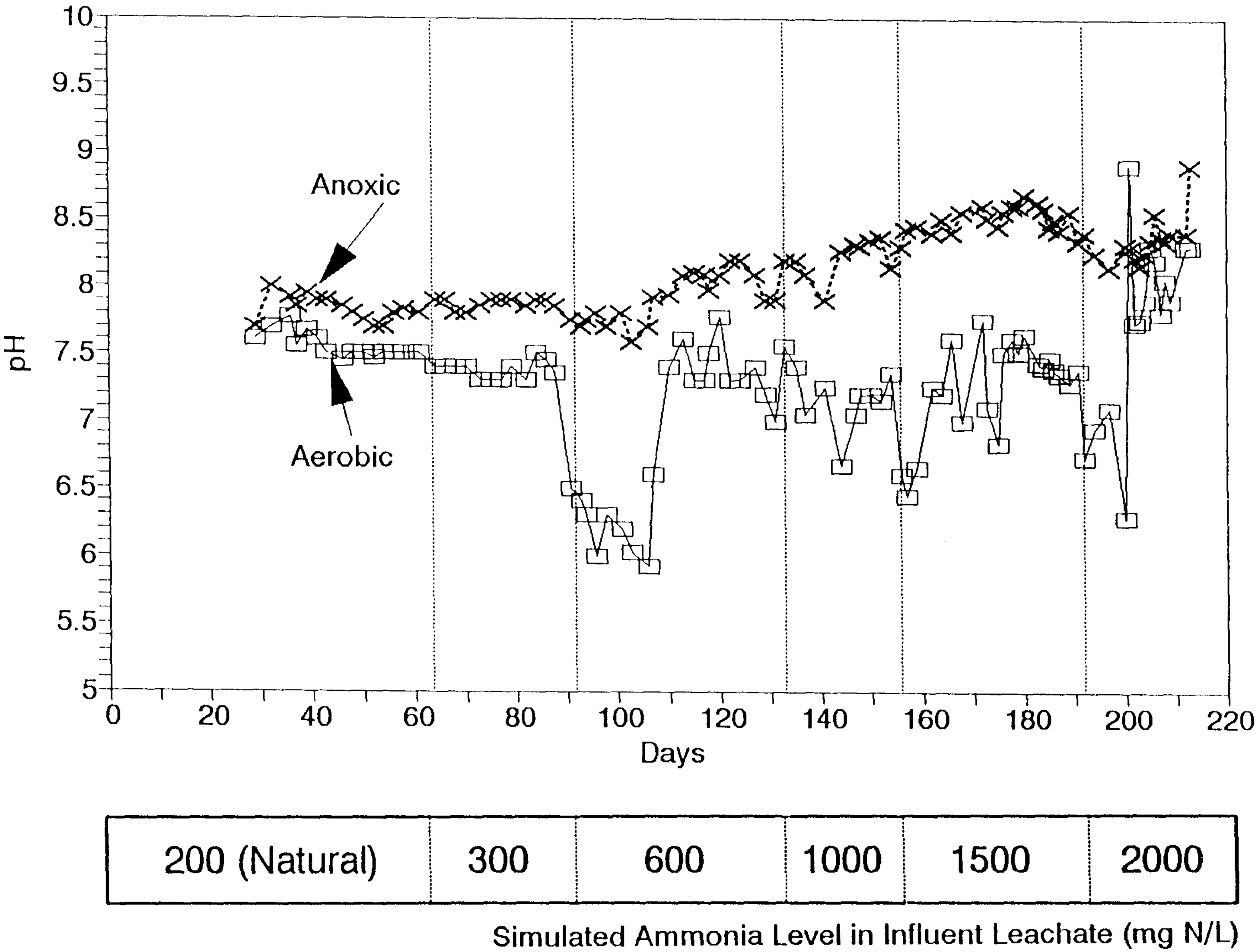
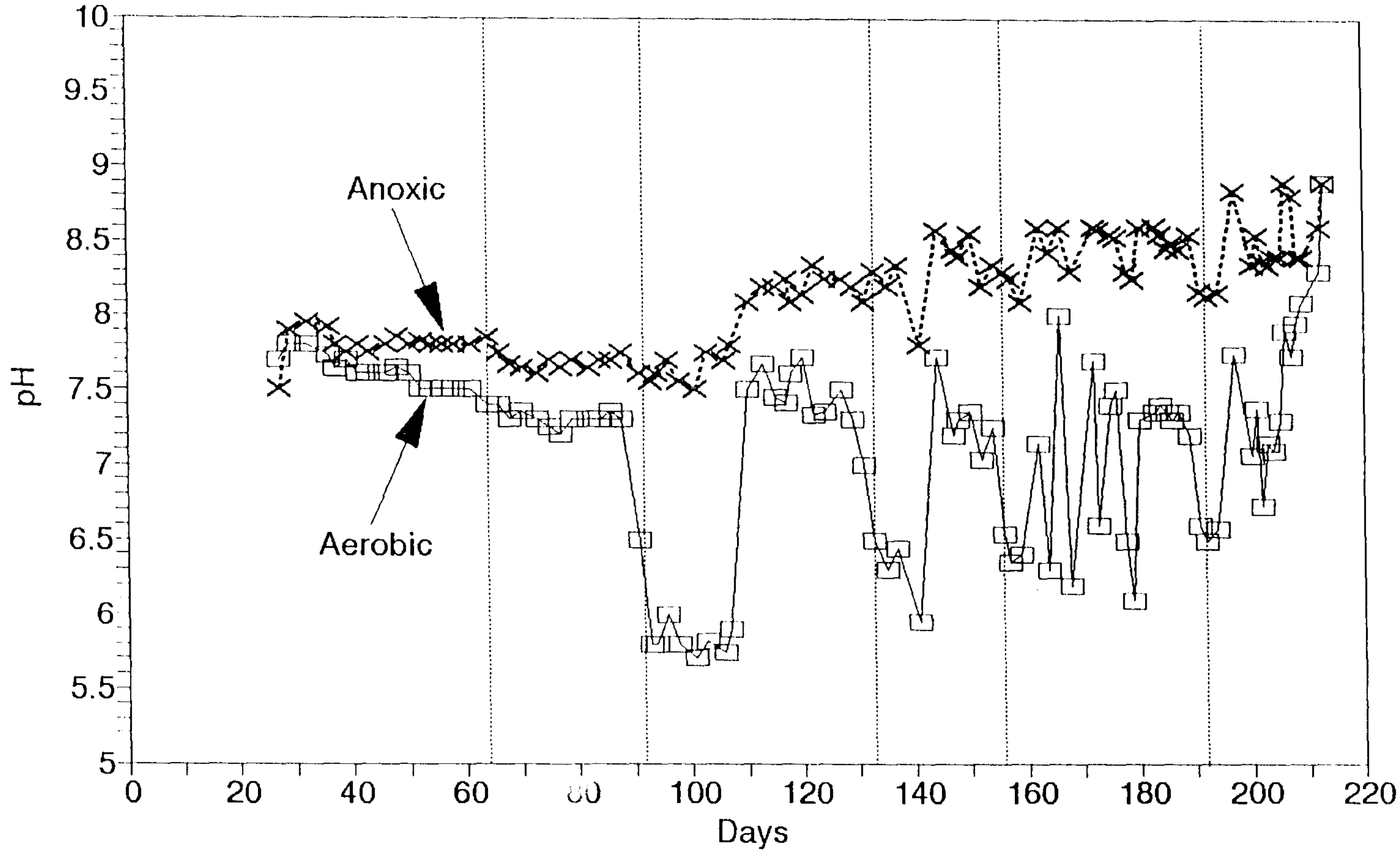


FIGURE 5.4: LOADING PHASE - 20 Day SRT System
Anoxic and Aerobic pH Levels



200 (Natural)	300	600	1000	1500	2000

Simulated Ammonia Level in Influent Leachate (mg N/L)

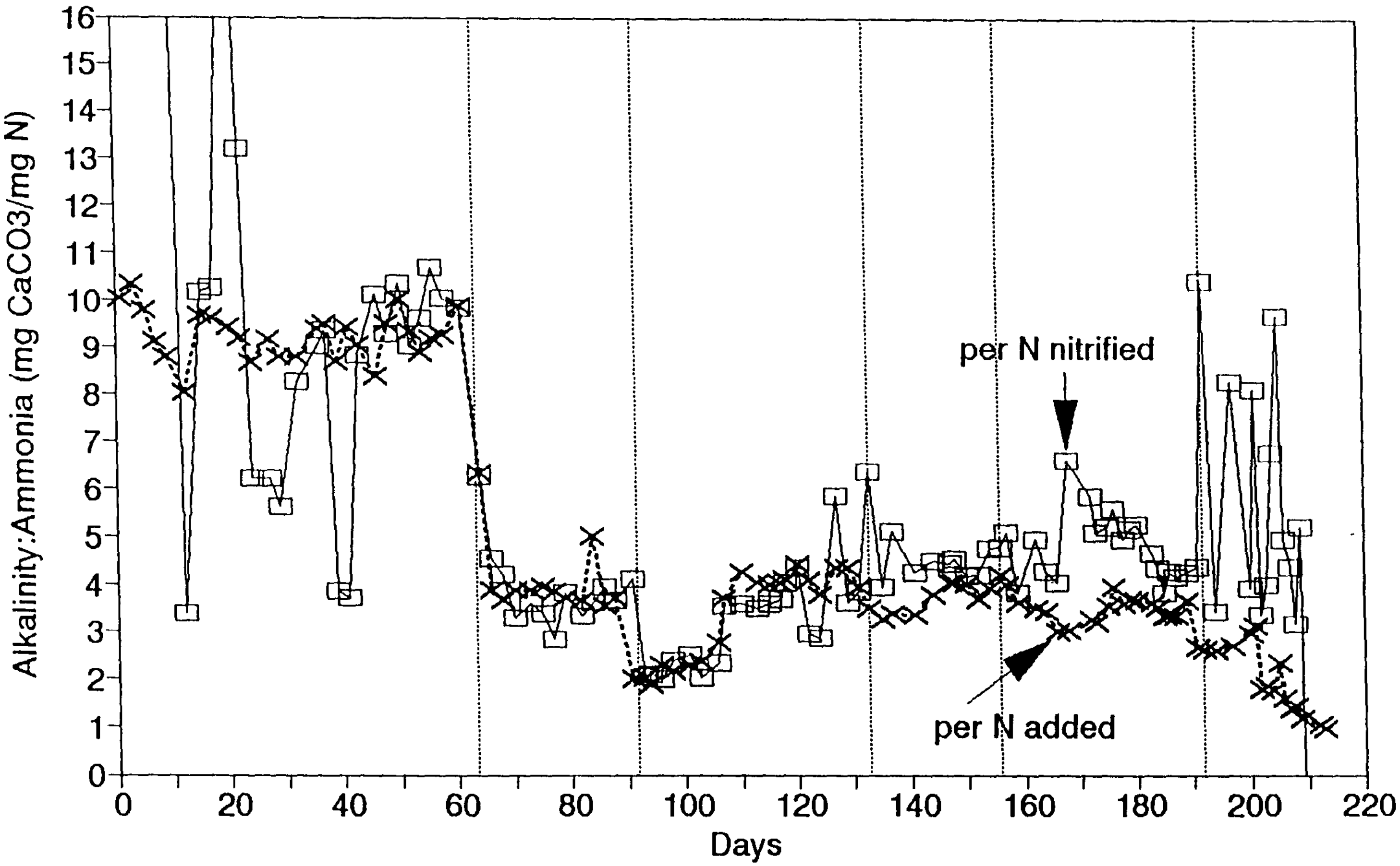
range for denitrification from 7.0 to 7.5 (U.S. EPA, 1975). Having the anoxic pH outside the optimal pH range for denitrification still allowed complete denitrification, but may have affected nitrification (as evidenced by nitrite accumulation). If higher ammonia loadings are to be treated, a higher anoxic pH would be expected. If this is sufficient to inhibit denitrification, acid addition for pH control of the anoxic reactor may be required.

The amount of alkalinity added to the system from the natural leachate alkalinity (approximately 1500 mg $CaCO_3$/L) and from bicarbonate addition, is given in Figure 5.5 and Figure 5.6, as a ratio to nitrogen nitrified (per $N_{nitrified}$) and as a ratio to ammonia added to the system from the simulated influent leachate (per N_{added}). Table 5.3 summarizes the results for alkalinity:$N_{nitrified}$. The theoretical alkalinity ratio is 3.57 mg $CaCO_3$ consumed/mg $N_{nitrified+denitrified}$ (U.S. EPA, 1975). Natural leachate alkalinity levels were sufficient to maintain the alkalinity ratio above the theoretical alkalinity ratio until the simulated leachate ammonia level was raised to 600 mg/L on Day 91. When the simulated leachate ammonia levels were increased to 600 mg N/L, thereby decreasing the alkalinity ratio to approximately 2 mg $CaCO_3$/mg N, the resulting effect was a reduction of aerobic pH to below 6.5. Bicarbonate addition to the aerobic reactor started on Day 103. For influent ammonia levels from 600 mg N/L to 1500 mg N/L, the alkalinity ratio found necessary to maintain an aerobic pH of 7.5 ranged from 3.8 to 4.4 mg $CaCO_3$/mg $N_{nitrified}$. These results are near to, but slightly higher than the theoretical alkalinity ratio of 3.57 mg $CaCO_3$/mg $N_{nitrified+denitrified}$.

5.1.3 Methanol Addition and NO_x^- Levels

The leachate used in this study had low biodegradable organics. Therefore an external carbon source was required for denitrification. Methanol was selected as the external carbon source simply because it is the most common external carbon source used for denitrification (U.S. EPA, 1975) and because it has been used in a similar study at U.B.C. (Guo, 1992). Without methanol addition, the approximate NO_x^- levels in the system would equal the simulated leachate ammonia concentration minus the ammonia consumed by bacterial assimilation and stripped in the aerobic reactor.

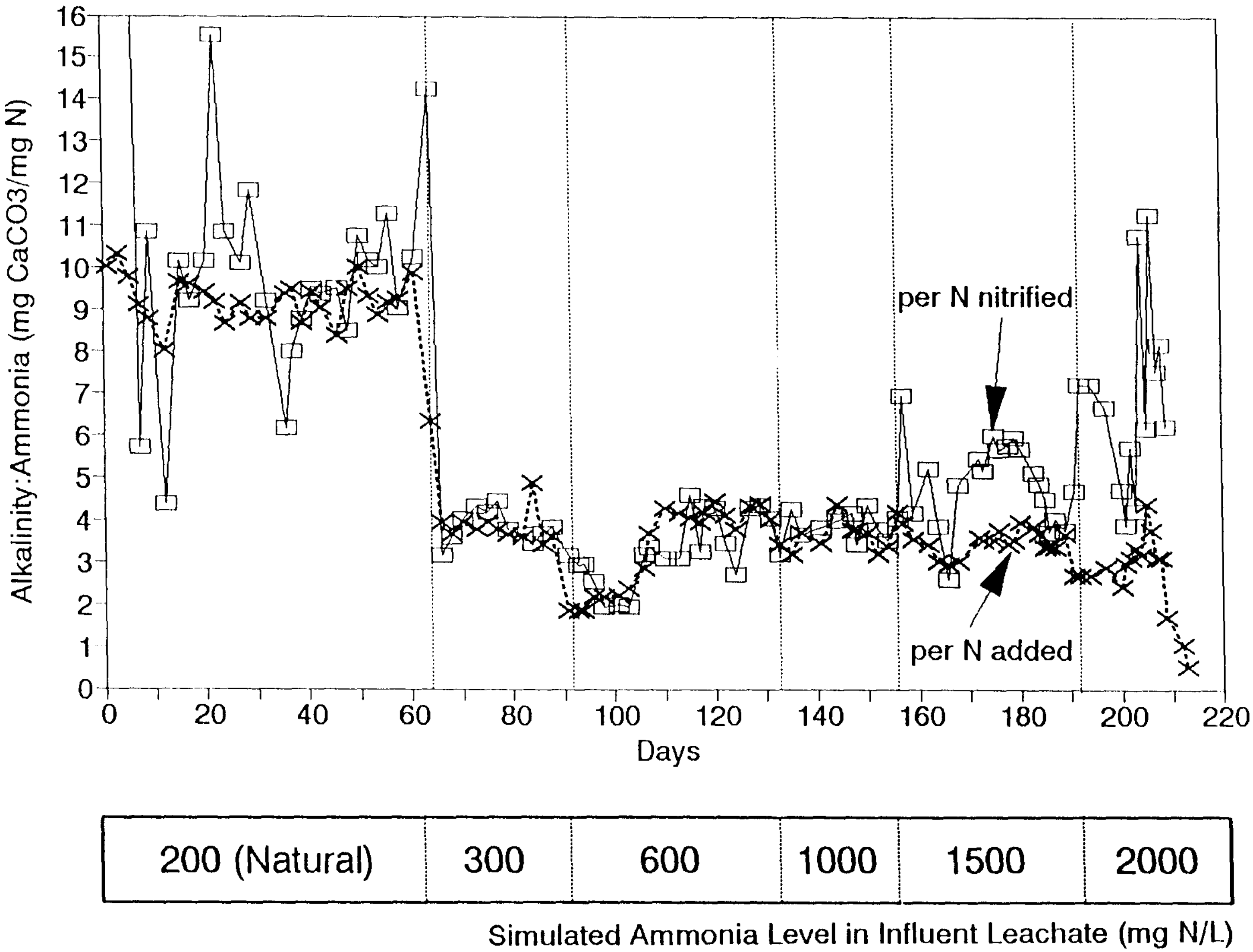
FIGURE 5.5: LOADING PHASE - 10 Day SRT System
Alkalinity Addition



200 (Natural)	300	600	1000	1500	2000

Simulated Ammonia Level in Influent Leachate (mg N/L)

FIGURE 5.6: LOADING PHASE - 20 Day SRT System
Alkalinity Addition



The amount of carbon source required for denitrification can be expressed by several different variations of the ratio of carbon source to nitrates and/or nitrites. The form selected here was COD:NO_x, primarily to allow direct comparison with previous studies (Carley and Mavinic 1991, Guo 1992). It should be noted that since the leachate used in this study had low biodegradable organics (see Table 3.2), the COD:NO_x ratio includes only the COD derived from the methanol added, and not the COD in the natural leachate. If the leachate contained significant biodegradable organics, it would have been better to include the biodegradable organics in the leachate and to express the methanol requirements as BOD_5:NO_x.

The NO_x^- levels throughout the loading phase of this study are presented in Figure 5.7 and Figure 5.8. The term NO_x^-, includes nitrites and nitrates. The COD:$NO_{x,removed}$ ratios and anoxic BOD_5 levels are shown in Figure 5.9 and 5.10. Methanol addition to the anoxic reactor, for both systems, was started on Day 27. Prior to methanol addition, the aerobic and anoxic NO_x^- levels (approximately 190 mg N/L) were approximately 5 % less than the incoming ammonia levels (220 mg N/L). Once the methanol addition had been optimized and the system stabilized, the anoxic NO_x^- levels were less than 1 mg N/L and the aerobic NO_x^- levels had decreased to approximately 25 mg N/L. The NO_x^- levels and the COD:NO_x ratio, at each simulated leachate ammonia level (once the system was optimized and stabilized), are summarized in Table 5.4.

FIGURE 5.7: LOADING PHASE - 10 Day SRT System
Anoxic and Aerobic NOx Levels

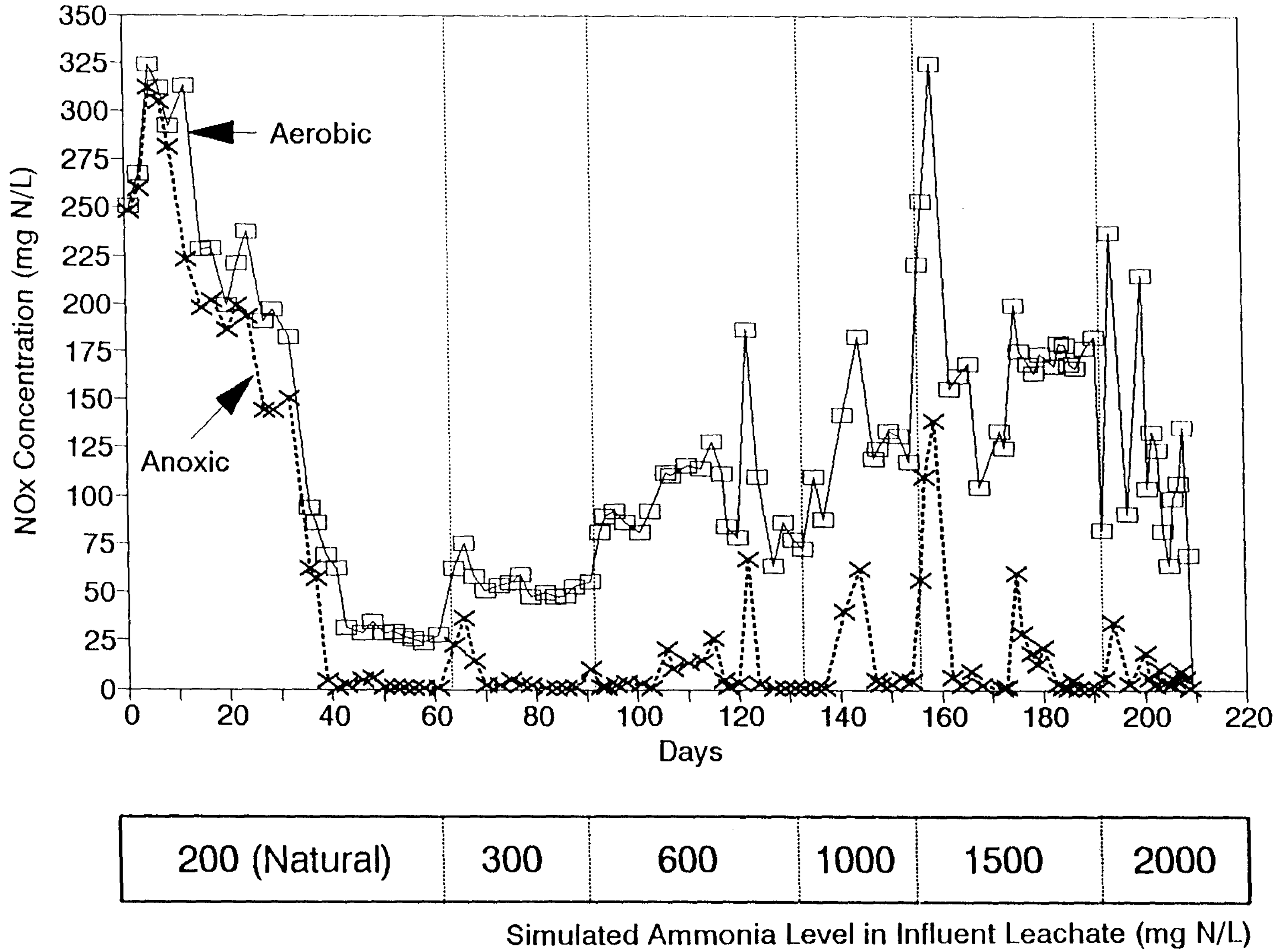


FIGURE 5.8: LOADING PHASE - 20 Day SRT System
Anoxic and Aerobic NOx Levels

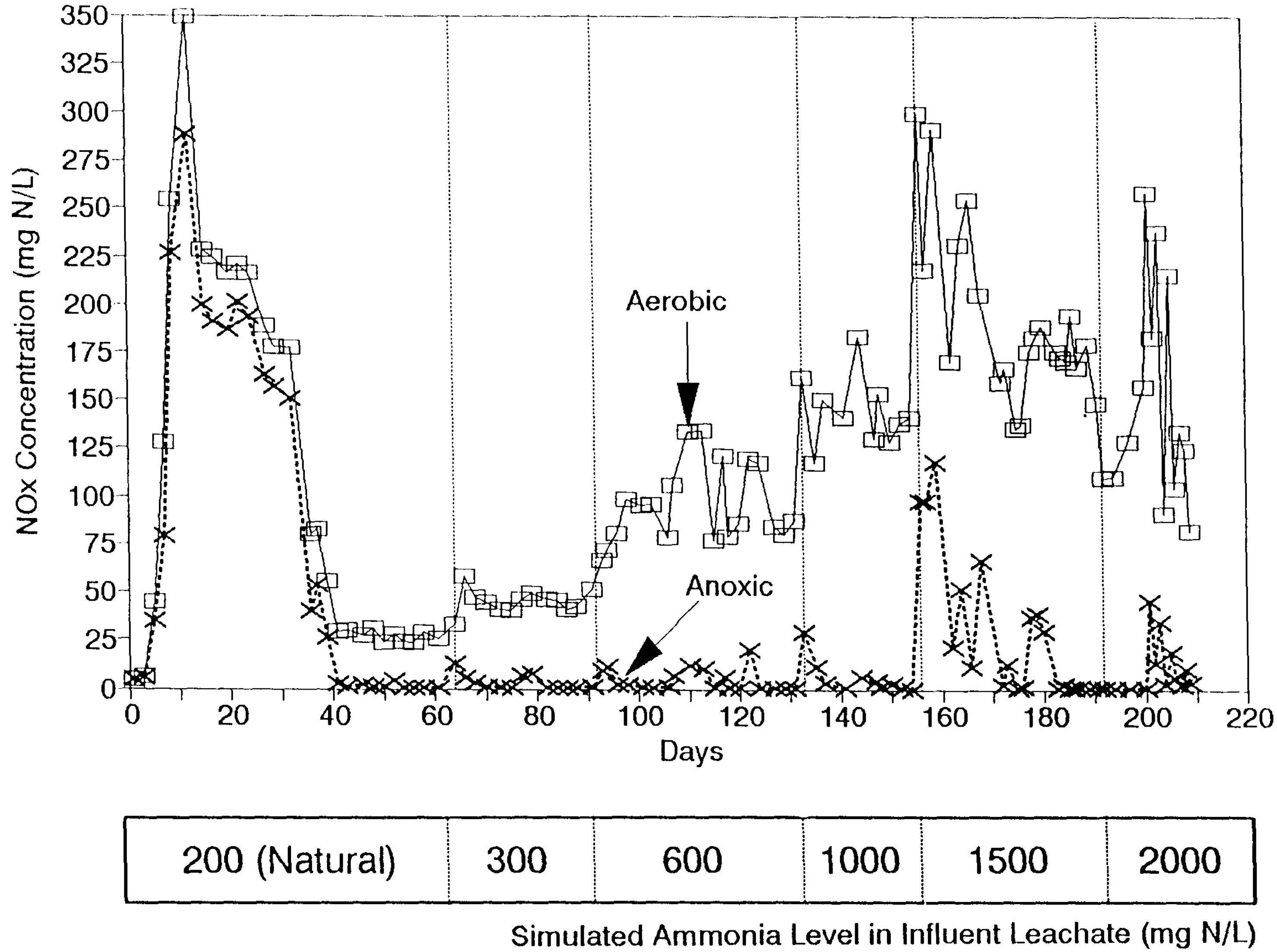


FIGURE 5.9: LOADING PHASE - 10 Day SRT System
Methanol Addition and Anoxic BOD

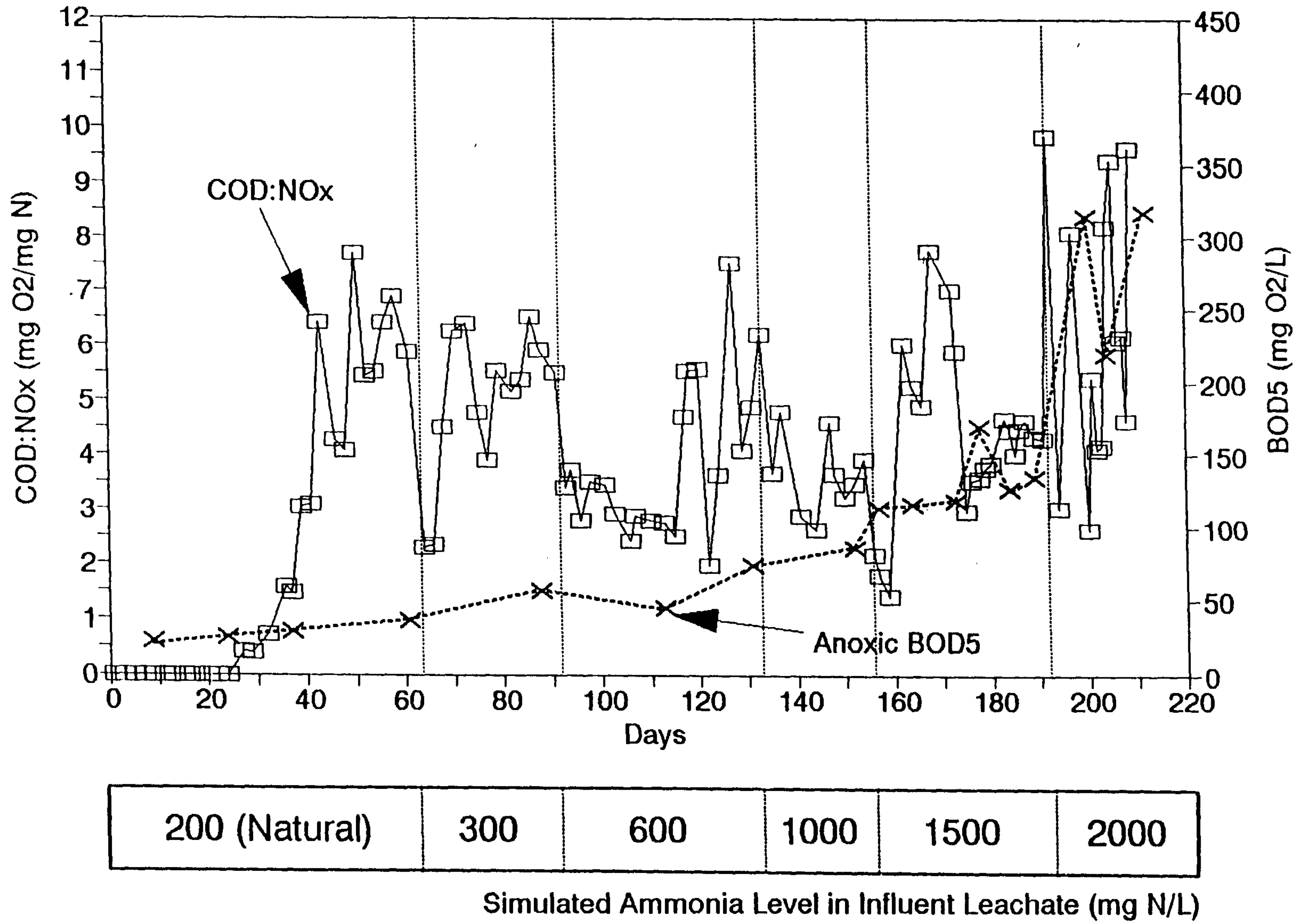


FIGURE 5.10: LOADING PHASE - 20 Day SRT System
Methanol Addition and Anoxic BOD5

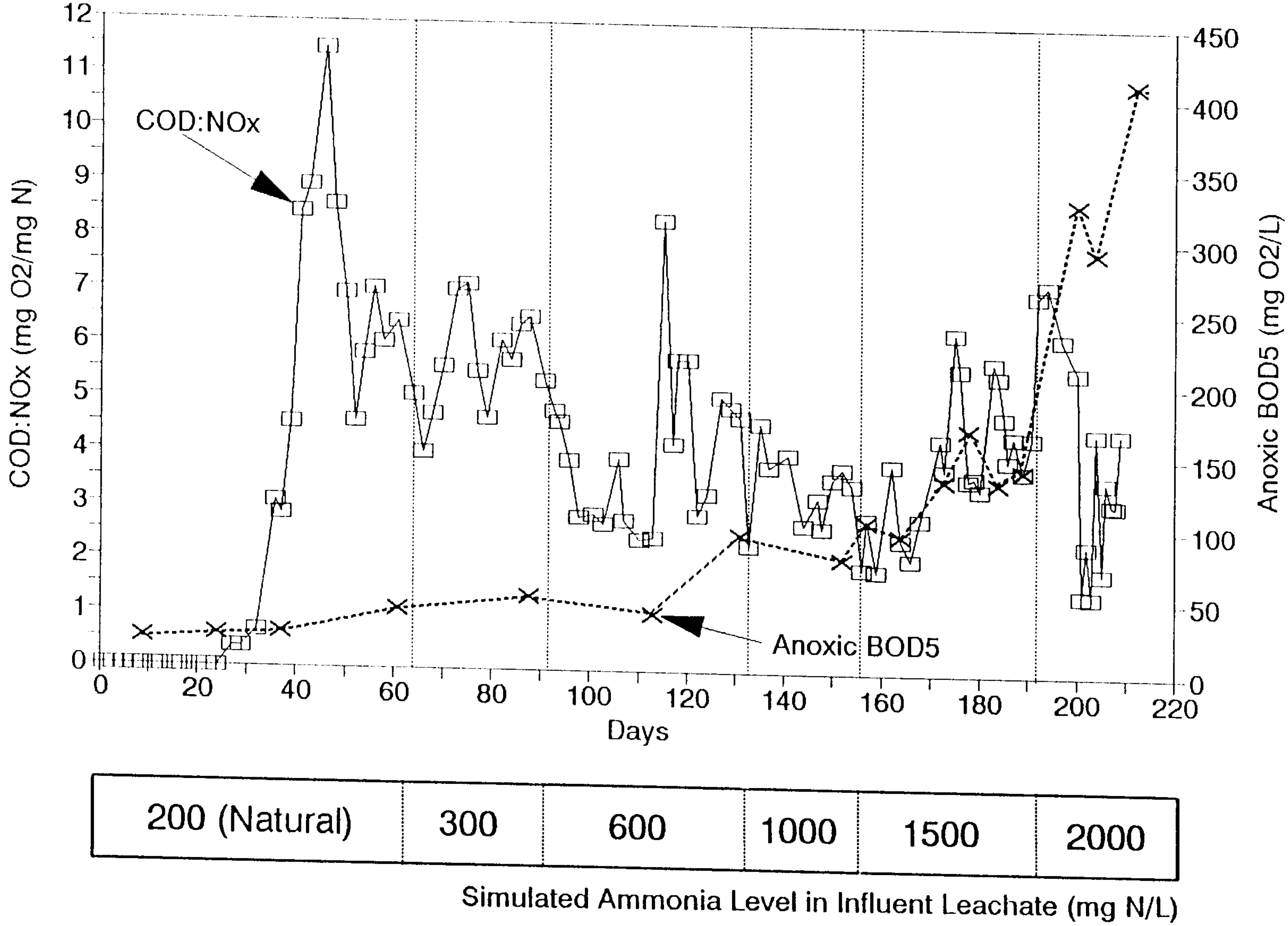


TABLE 5.4: Loading Phase - NO_x^- Levels and $COD:NO_x$ Ratio

Influent Ammonia (mg N/L)	10 Day SRT Anoxic (mg N/L)	Aerobic (mg N/L)	$COD:NO_x$ (mg/mg)	20 Day SRT Anoxic (mg N/L)	Aerobic (mg N/L)	$COD:NO_x$ (mg/mg)
200	<1	25	6.0	<1	25	6.2
300	<1	50	6.0	<1	45	6.4
600	<1	80	4.8	<1	80	4.8
1000	5	125	3.5	<1	135	3.5
1500	<1	170	4.5	<1	170	4.0
2000	<1	70	9.7	3.5	80	4.7

The $COD:NO_x$ ratios for influent ammonia levels of 200 and 300 mg N/L, agree well with the results from a study by Carley and Mavinic (1991). Carley and Mavinic determined that a $COD:NO_x$ ratio of 6.2:1 was required for complete denitrification when methanol was used as an external carbon source. The study by Carley and Mavinic used the same landfill leachate and the same MLE treatment process.

In general, denitrification studies have shown a $COD:NO_x$ requirement in the range of 4:1 to 6.5:1 (Narkis, 1979 and Carley, 1988). From Table 5.4, it is readily apparent that the methanol required to denitrify NO_x^- in the anoxic reactor, did not remain constant and that higher influent ammonia loadings resulted in lower ratios of $COD:NO_{x,removed}$. The decrease in the $COD:NO_x$ ratio is probably due in part to the increase in aerobic nitrite levels. As discussed in Chapter 1, nitrite requires approximately 40% less methanol for conversion to nitrogen relative to nitrate. Possible reasons for the accumulation of nitrites are given in the next section. Nitrite accumulation is probably not the only reason for a reduction in $COD:NO_x$, since in the temperature phase at 20 °C, the $COD:NO_x$ required for complete denitrification was approximately 5:1, yet no nitrites were present at that time.

Ideally, all methanol added to the anoxic reactor should be consumed in the anoxic reactor, so that none will bleed into the aerobic reactor. As can be seen in Figure 5.9 and 5.10, increasing methanol demands resulted in higher anoxic BOD_5 levels. As the influent ammonia level was increased from 200 mg/L to 1500 mg/L, the anoxic BOD_5 level increased from approximately 40 mg/L to 140 mg/L. The aerobic BOD_5 levels remained steady at approximately 10 mg/L. When the influent ammonia level was increased to 2000 mg/L, the aerobic BOD_5 rose to as high as 60 mg/L and the anoxic BOD_5 rose to as high as 400 mg/L. The increase in BOD_5 during this failure period was predominantly due to excess methanol addition and also some cell lysing.

5.1.4 Nitrite Accumulation and "Free" Ammonia Levels

Nitrite accumulation during nitrification is a result of greater inhibition of nitrite oxidizers (*Nitrobacter*), than of ammonia oxidizers (*Nitrosomonas*). This may be caused by high levels of "free" ammonia, high levels of nitrous acid, cold or hot temperature, low dissolved oxygen, high levels of metals, short sludge age, high COD loading, and phosphorus deficiency (Turk 1986). Figure 5.11 and 5.12 show the nitrite levels in the anoxic and aerobic reactors throughout the loading phase. Table 5.5 summarizes the nitrite results for both systems, at each influent ammonia level, once the systems were optimized and had stabilized.

TABLE 5.5: Loading Phase - Nitrite Levels

Influent	10 Day SRT			20 Day SRT		
Ammonia (mg N/L)	Anoxic (mg N/L)	Aerobic (mg N/L)	Aerobic NO_2^-/NO_x^-	Anoxic (mg N/L)	Aerobic (mg N/L)	Aerobic NO_2^-/NO_x^-
200	<1	<1	-	<1	<1	-
300	<1	<1	-	<1	<1	-
600	<1	15	19%	<1	20	25%
1000	2.1	85	68%	<1	80	59%
1500	<1	110	65%	<1	100	59%
2000	<1	65	93%	<1	75	94%

Aerobic nitrite levels began to rise in both SRT systems when the influent ammonia level was increased to 600 mg N/L. Nitrite levels continued to rise as the influent ammonia level was increased. Several factors may have contributed to the observed nitrite accumulation. The fluctuating aerobic pH (from

FIGURE 5.11: LOADING PHASE - 10 Day SRT System
Anoxic and Aerobic Nitrite Levels

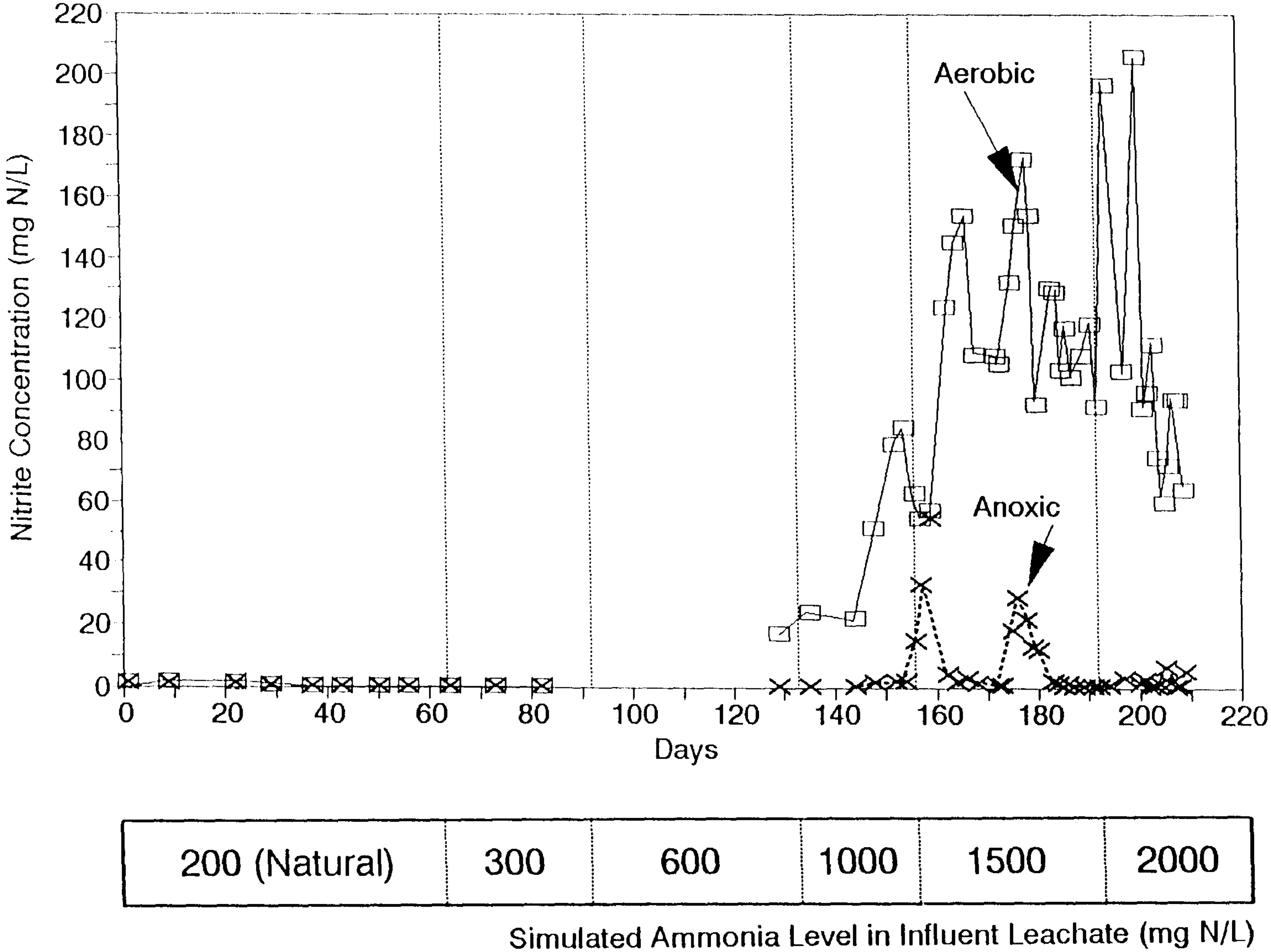
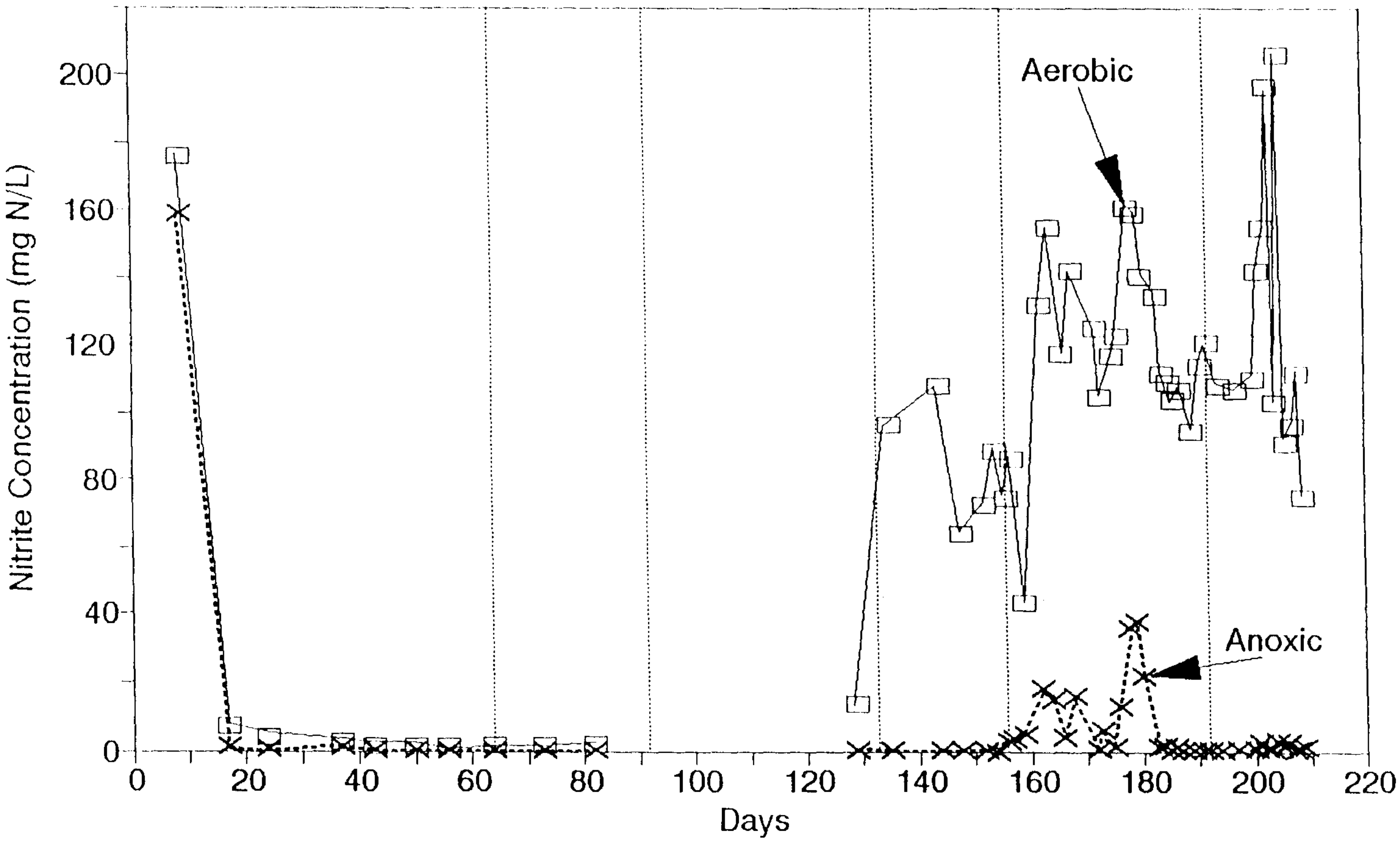


FIGURE 5.12: LOADING PHASE - 20 Day SRT System
Anoxic and Aerobic Nitrite Levels



200 (Natural)	300	600	1000	1500	2000

Simulated Ammonia Level in Influent Leachate (mg N/L)

approximately 6 to 8), as observed in Figures 5.3 and 5.4, may have contributed to nitrite oxidation inhibition. Aerobic pH was controlled manually by adjusting bicarbonate addition to the aerobic reactor, in response to aerobic pH levels which were considered inhibitory. Hence, the nitrifiers in the aerobic reactor were frequently exposed to fluctuating pH levels. As the aerobic nitrite concentration increased, low aerobic pHs may have contributed to the inhibition via nitrous acid formation. Another factor was the increasing anoxic ammonia levels (see Table 5.1) in combination with increasing anoxic pH (see Table 5.3); this would have resulted in elevated anoxic "free" ammonia levels. In the MLE process train, nitrifiers are constantly recycled through the anoxic reactor and exposed to the high "free" ammonia of the anoxic reactor. Table 5.6 presents the estimated "free" ammonia concentration at each influent ammonia level.

TABLE 5.6: Loading Phase - Estimated "Free" Ammonia Levels

Influent	10 Day SRT		*p1470X 20 Day SRT	
Ammonia (mg N/L)	Anoxic (mg N/L)	Aerobic (mg N/L)	Anoxic (mg N/L)	Aerobic (mg N/L)
200	0.6	<0.01	0.6	<0.01
300	1.5	<0.01	0.9	<0.01
600	2.7	<0.01	4.8	<0.01
1000	9.5	<0.01	8.4	<0.01
1500	16.2	<0.01	20.2	<0.01
2000	84.0	78.4	102.8	54.0

The anoxic "free" ammonia levels all surpassed the lower bound of the range of 0.1 to 1.0 mg N/L, suggested by Anthonisen et al (1976), at which "free" ammonia inhibition of *Nitrobacter* is initiated. Turk and Mavinic (1989) found that "free" ammonia inhibition of *Nitrobacter* began at 5 to 10 mg N/L. Anoxic "free" ammonia concentrations began to exceed the lower bound of this range when the influent ammonia level was increased to 1000 mg N/L. Turk and Mavinic concluded that internal denitrification, such as used in this study, was the most effective means of maintaining inhibition to an acclimated population of nitrite oxidizers. Another factor which may have contributed to the inhibition of nitrite oxidation, was low aerobic dissolved oxygen levels at the higher influent ammonia concentrations. Although the air supply was constantly adjusted to ensure that the in-situ dissolved oxygen meter read greater than 2 mg O_2/L, this reading was questionable at times due to the coarse aeration of the aerobic liquor.

5.1.5 Nitrification and Denitrification

Percent nitrification and percent denitrification, throughout the loading phase, are shown in Figure 5.13 and 5.14. The greater fluctuation of the % nitrification results and the existence of values in excess of 100%, is a direct consequence of the greater complexity of the % nitrification equation relative to the % denitrification equation. The % denitrification equation contains only two key variables of the same parameter:

$$\text{\% Denitrification (anoxic reactor)} = \frac{(NO_x^- \text{ in} - NO_x^- \text{ out})}{NO_x^- \text{ in}}$$

The % nitrification equation contains three key variables of two different parameters:

$$\text{\% Nitrification (aerobic reactor)} = \frac{(NO_x^- \text{ out} - NO_x^- \text{ in})}{NH_4^+ \text{ in}}$$

Hence, the % nitrification equation produces more fluctuations and on occasion, exceeds 100 %. In addition, the unknown contribution from the oxidation of organic nitrogen to NO_x^-, in the aerobic reactor, may have affected the % nitrification results. A term that is similar to nitrification is ammonia oxidation. % ammonia oxidation as used in this work is defined as:

$$\text{\% Ammonia Oxidation (aerobic reactor)} = \frac{(NO_3^- \text{ out} - NO_3^- \text{ in})}{NH_4^+ \text{ in}}$$

The important distinction between nitrification and ammonia oxidation is most evident when applied to nitrite accumulation in the aerobic reactor. During periods of nitrite accumulation due to inhibition

FIGURE 5.13: LOADING PHASE - 10 Day SRT System
% Utilization

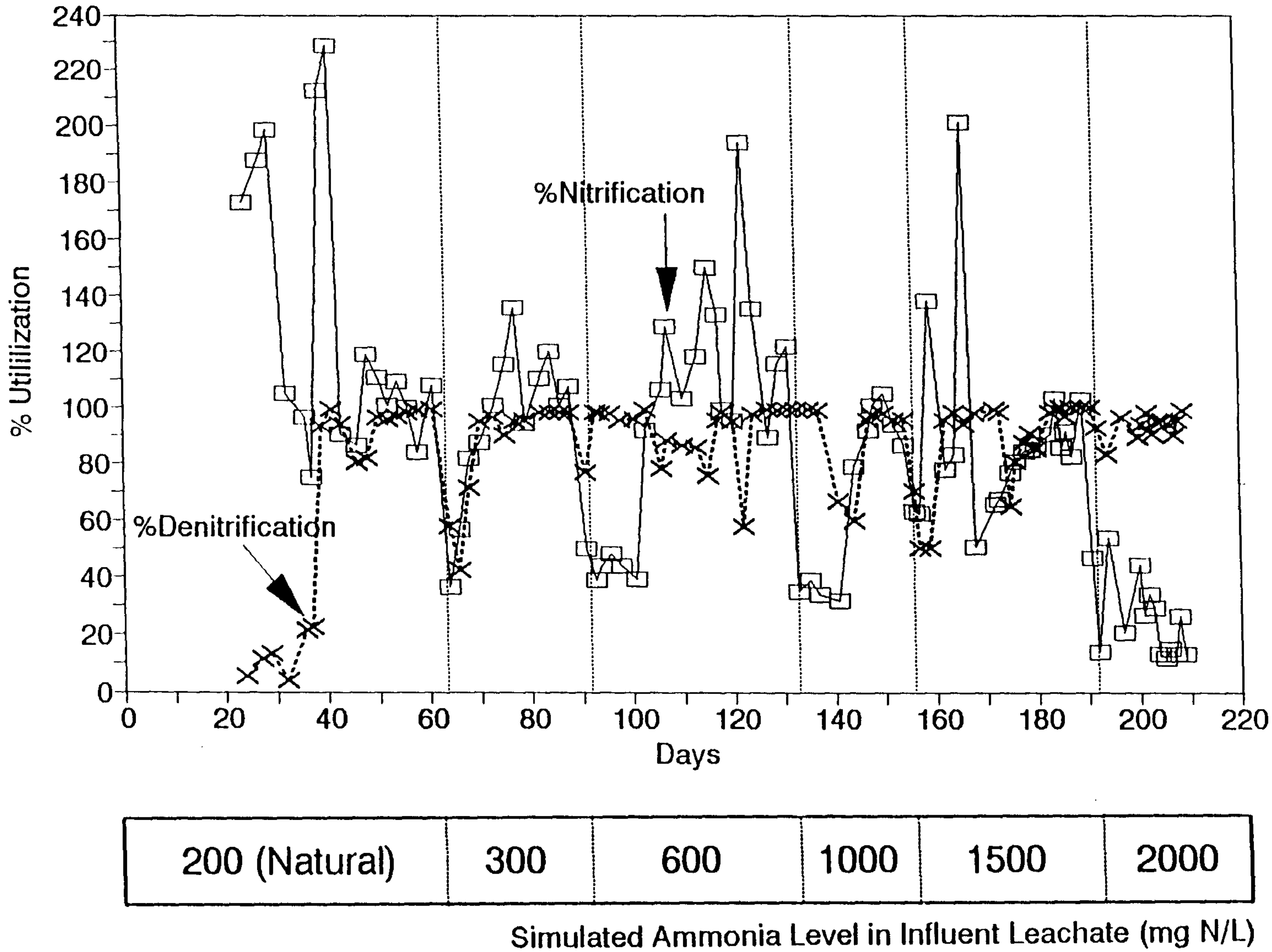
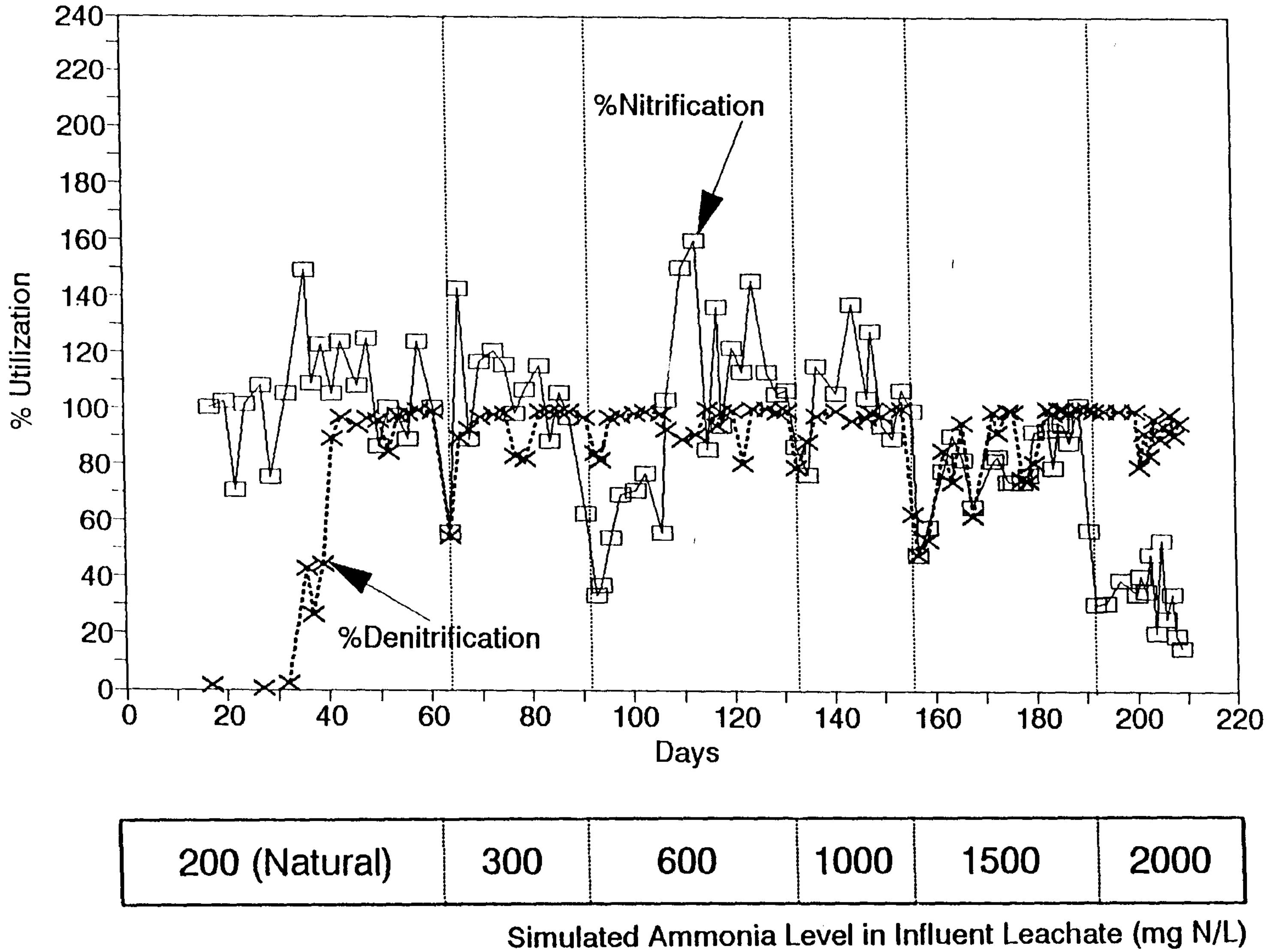


FIGURE 5.14: LOADING PHASE - 20 Day SRT System
% Utilization



of nitrobacter, it is still possible to have 100% nitrification, however, ammonia oxidation will remain less than 100% since some NO_x^- will be present as NO_2^- instead of NO_3^-.

The extended period of low % nitrification for both SRT systems, from Day 91 to 103, was probably due to low pH in the aerobic reactor, resulting from insufficient bicarbonate addition. Once alkalinity addition began (on Day 103), both systems showed considerable improvement in % nitrification. Since aerobic pH control was handled manually, by adjusting the alkalinity addition in response to low pH levels, the result of each influent ammonia level beyond 300 mg N/L, was an immediate drop in % nitrification due to low aerobic pH. A summary of nitrification results at each influent ammonia level, after the systems had been optimized and stabilized, is presented in Table 5.7.

TABLE 5.7: Loading Phase - Nitrification

Influent Ammonia (mg N/L)	10 Day SRT %	10 Day SRT Rate (mg N/d)	10 Day SRT Specific Rate (mgN/d/gVSS)	20 Day SRT %	20 Day SRT Rate (mg N/d)	20 Day SRT Specific Rate (mgN/d/gVSS)
200	100	1900	110	100	1800	80
300	100	3500	150	100	3100	110
600	100	6100	200	100	6300	180
1000	100	8400	230	100	9500	240
1500	100	12200	190	100	12800	190
2000	10	5000	80	20	6000	90

From Table 5.7, the failure of nitrification at the influent ammonia level of 2000 mg N/L, is quite clear. All three parameters, for both systems, show a sharp decline in value. When compared to the denitrification results (see Table 5.8), it is apparent that the failure of nitrification was not initiated by the failure of denitrification.

TABLE 5.8: Loading Phase - Denitrification

Influent Ammonia (mg N/L)	10 Day SRT %	10 Day SRT Rate (mg N/d)	10 Day SRT Specific Rate (mgN/d/gVSS)	20 Day SRT %	20 Day SRT Rate (mg N/d)	20 Day SRT Specific Rate (mgN/d/gVSS)
200	98	1700	200	98	1700	160
300	98	2900	280	99	2700	180
600	99	5200	400	100	5300	320
1000	99	7200	460	99	8000	400
1500	99	10500	380	95	10900	340
2000	97	5000	120	93	5000	200

Table 5.7 and 5.8 show that the specific nitrification and denitrification rates increased as the influent ammonia level rose from 200 to 1000 mg N/L. At 1500 mg N/L, the specific utilization rates decreased slightly, producing a peak value at the influent ammonia level of 1000 mg N/L. This trend in specific utilization rates may be due to several factors. Nitrite accumulation may have been a factor. The rise in aerobic nitrite meant that a lower population of nitrifiers and denitrifiers would be present with respect to the amount of ammonia oxidized and NO_x^- denitrified; this would produce higher specific nitrification and denitrification rates. Another factor may have been that excess methanol addition, at the lower influent ammonia levels, may have raised the VSS levels, thus decreasing the specific utilization rates at those influent ammonia levels.

Both systems showed nominal denitrification (0 to 11 %) until methanol addition was started on Day 27. With the addition of methanol, % denitrification rose until the minimum required amount of methanol was exceeded, at which point % denitrification equalled 100 %. Each increase in influent ammonia, resulted in a decrease in % denitrification as more NO_x^- was produced in the aerobic reactor. As methanol addition was increased to account for the increase in NO_x^-, % denitrification increased.

Prior to performing this study, there was some concern as to whether denitrification would be inhibited by high ammonia levels (especially "free" ammonia) in the anoxic reactor. As seen in Table 5.1 and 5.6, at an influent ammonia level of 1500 mg N/L, the anoxic ammonia level was approximately 180 mg N/L, and the "free" ammonia level could be as much as 20 mg N/L. 100 % denitrification was still achieved. Even more extreme was the high level of denitrification during the failure period, which occurred when the influent ammonia level was increased to 2000 mg N/L. Nitrification was significantly inhibited and anoxic ammonia levels had risen to approximately 750 mg N/L, with an anoxic pH of 8.5. As seen in Table 5.6, "free" ammonia levels are estimated to have been greater than 80 mg N/L, yet denitrification > 90 % was observed. However, due to the failure of nitrification, this occurred at lower denitrification rates and at lower specific denitrification rates (see Table 5.8).

5.1.6 System Failure

As seen in Table 5.7, nitrification, in both SRT systems, decreased from nearly 100 % to approximately 20%, when the simulated leachate ammonia level was raised from 1500 to 2000 mg N/L. Accordingly, system ammonia levels increased to substantial levels. The aerobic pH also rose to levels higher than the influent leachate pH, despite the reduction and eventual elimination of bicarbonate addition. Hence, in both Figure 5.5 and 5.6, during the period when the influent ammonia level was 2000 mg N/L, the Alkalinity:$N_{nitrified}$ ratio is significantly greater than the Alkalinity:N_{added} ratio. Complete denitrification of all available NO_x^- was still observed, despite anoxic "free" ammonia levels estimated to be above 80 mg N/L.

Several factors may have contributed to the failure of nitrification at the influent ammonia-N level of 2000 mg/L. Insufficient aeration may have been one cause. D.O. probe readings averaged above 2.0 mg/L. However, coarse bubbles may have been read by the probe as dissolved oxygen, resulting in an overestimation of the true dissolved oxygen levels. At higher solids levels line-clogging was observed to occur as a result of increased aerobic foaming, anoxic scum, and rising sludge in the clarifier. The resulting overflows and solid losses may have produced an unstable system. Another factor may have been that anoxic "free" ammonia was of sufficient levels to result in inhibition of *Nitrosomonas* (ammonia oxidation). According to Anthonisen et al (1976), "free" ammonia inhibition of *Nitrosomonas* begins between 10 to 150 mg N/L.

5.1.7 Solids

A characteristic of the single-sludge, predenitrification system is that it is a mixed culture system; anoxic heterotrophs and aerobic autotrophs and heterotrophs are cycled through the system. The effect of the influent leachate entering the anoxic reactor is to lower the anoxic VSS levels (by approximately $^{1}/_{7}{}^{th}$), since the leachate itself is very low in VSS. The effect of the solids recycle is to raise the VSS since the recycle is the thickened sludge of the aerobic mixed liquor. Figure 5.15 and 5.16 show the suspended solids levels throughout the loading phase. Table 5.9 provides a summary of the suspended solid levels at each ammonia loading once the systems had been optimized and stabilized.

TABLE 5.9: Loading Phase - VSS Levels

Influent	10 Day SRT			20 Day SRT		
Ammonia (mg N/L)	Anoxic (mg/L)	Aerobic (mg/L)	Effluent (mg/L)	Anoxic (mg/L)	Aerobic (mg/L)	Effluent (mg/L)
200	1800	1700	20	2200	2200	40
300	2100	2200	40	3000	2900	40
600	2700	2900	70	3200	3500	90
1000	3100	3300	160	4000	3900	120
1500	5500	5600	150	6400	6400	100
2000	6200	6400	220	5400	4600	180

The increase in anoxic, aerobic, and effluent VSS levels, as influent ammonia is increased, is evident from Table 5.9. The difference in anoxic and aerobic VSS levels is nominal with the aerobic VSS levels being, on the average, slightly higher. The increase in effluent VSS is attributed to increased clarifier loading. The 20 day SRT VSS levels are on average 20 % higher than the 10 day SRT VSS levels. This difference is a reflection of the differences in aerobic wasting and SRT. As expected, the higher rate of wasting (1 L/day) from the 10 day SRT system, resulted in a lower VSS. Conversely the lower rate of wasting (0.5 L/day) from the 20 day SRT system, resulted in a higher VSS.

Figure 5.16 shows that, when the influent ammonia concentration was increased from 1500 mg/L to 2000 mg/L, the aerobic VSS levels for the 20 day SRT system, rose to nearly 13000 mg/L. Since

FIGURE 5.15: LOADING PHASE - 10 Day SRT System
Anoxic and Aerobic VSS

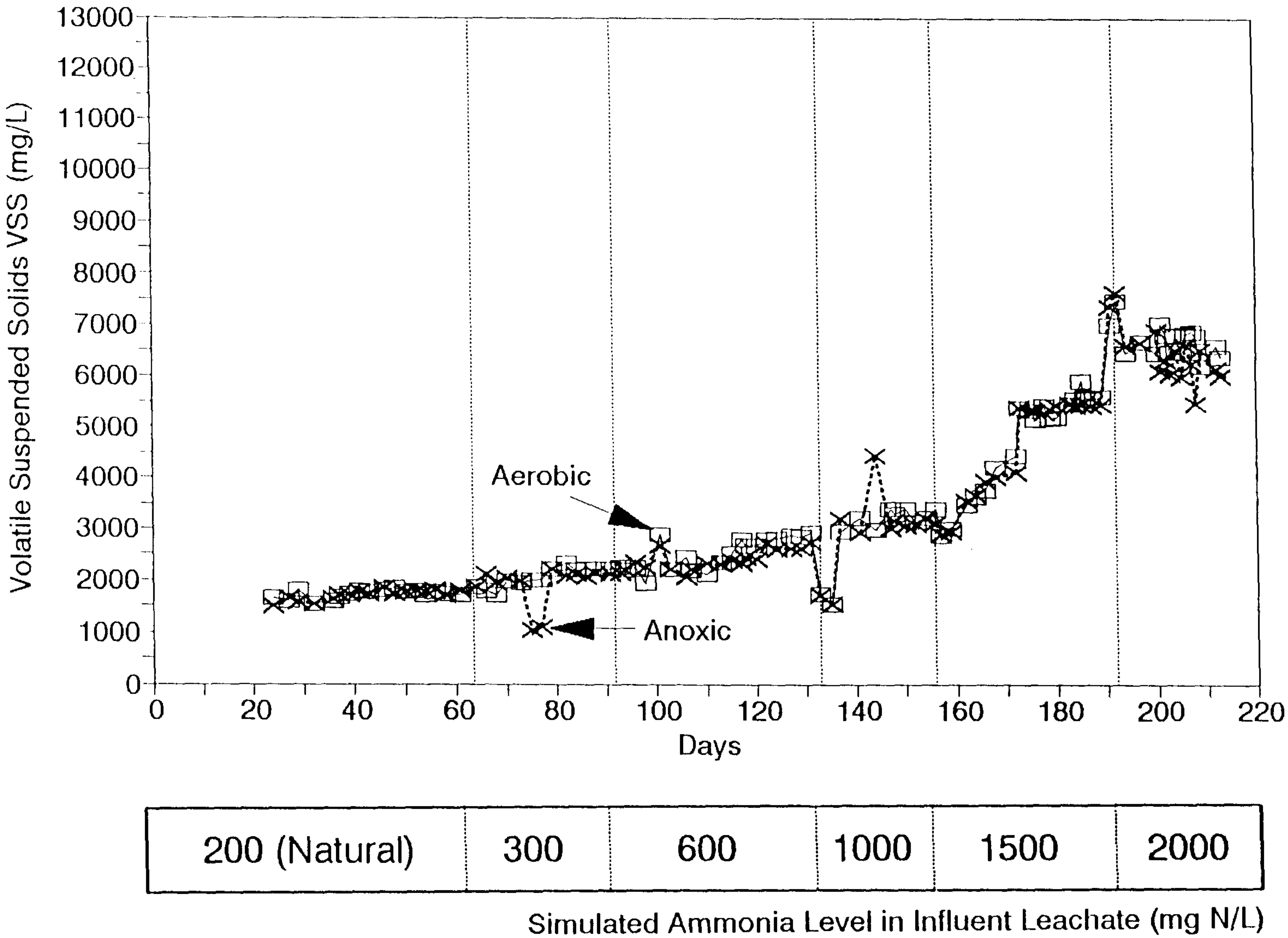
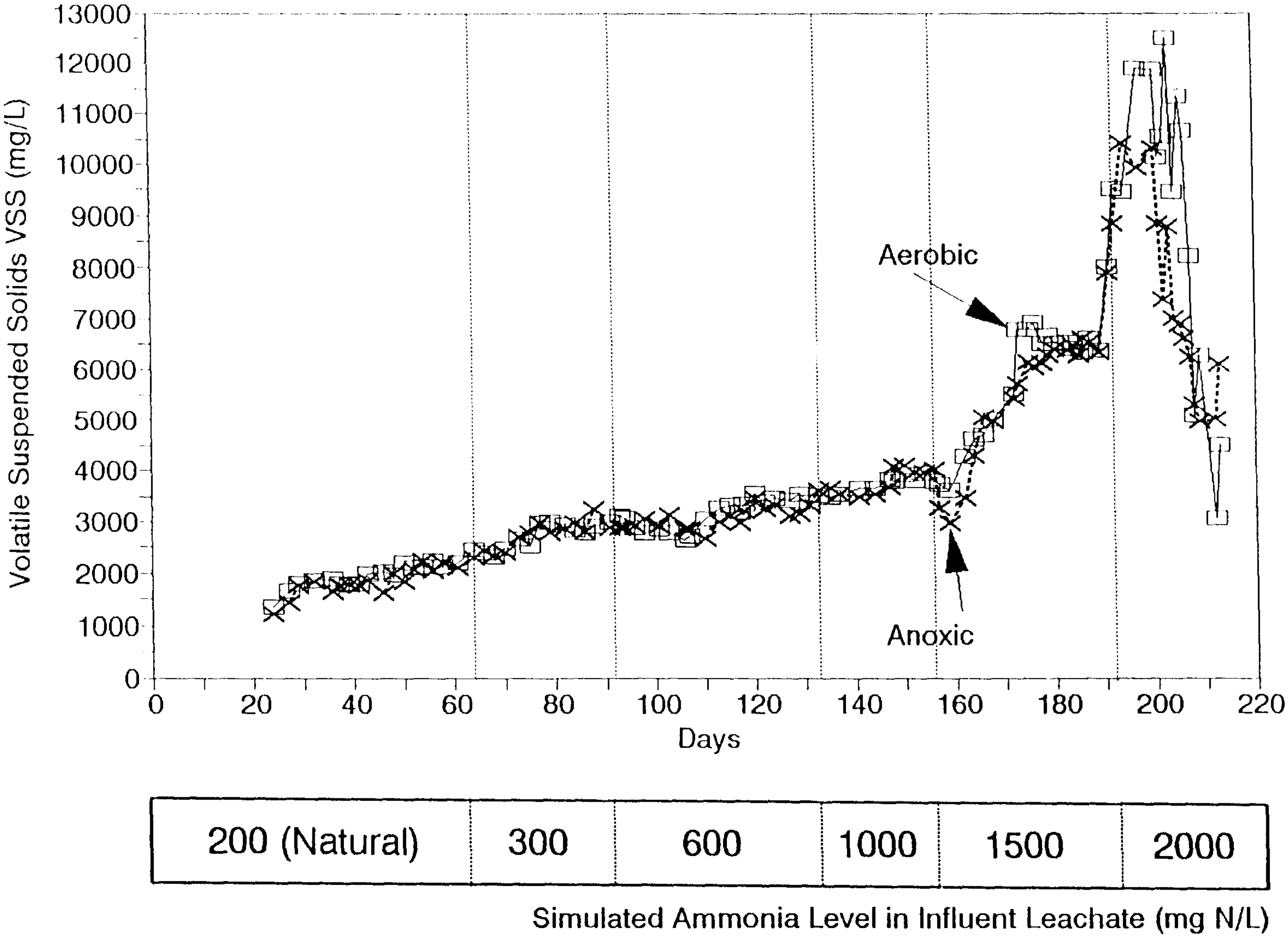


FIGURE 5.16: LOADING PHASE - 20 Day SRT System
Anoxic and Aerobic VSS



nitrification was very low at this period, the VSS increase is attributed to methanol bleeding into the aerobic reactor, resulting in aerobic heterotrophic growth. The lack of such a sharp increase in the 10 day SRT system may have been due in part to the higher wasting from the 10 day SRT system. Reactor overflows, which were frequent in both systems during this period, may have also played a significant role in determining reactor solids levels. For the 20 day SRT system, the aerobic VSS was lower than the anoxic VSS, for the last few days of the failure period. This maybe attributable to partial clogging in the anoxic reactor overflow, which may have been preventing the passage of solids but permitting the passage of liquid. Another reason may be that the sampling generally took place after the overflow was cleaned up and as best as possible placed back into the system. This may have resulted in some anomalies.

The ratio of VSS/TSS was found to remain between 0.7 to 0.9, with 0.85 being the average when the systems were stabilized and optimized. Towards the end of the failure period (influent ammonia level of 2000 mg/L), the VSS/TSS ratios were at their lowest (approximately 0.7).

5.1.8 Solids Retention Time

Two parallel systems were operated in this study: one with a 10 day aerobic SRT and the second with a 20 day aerobic SRT. The purpose of operating at two different SRTs was to observe if a longer SRT, resulting in higher VSS levels, would treat higher ammonia loadings. However, both systems failed when the influent ammonia level was raised from 1500 mg/L to 2000 mg/L. The only differences observed between the two SRT systems was that the longer SRT system (20 day), had approximately 20 % higher VSS levels, and lower system ammonia peaks, after each increase in ammonia loading (see Section 5.1.1).

Both systems were operated on the basis of "theoretical" aerobic SRT. The "theoretical" aerobic SRT is the volume of the aerobic reactor divided by the volume wasted daily. The actual system SRT may also be calculated. The actual system SRT is the total system VSS divided by the sum of the VSS lost by wasting and in the effluent. Both SRTs are shown for the loading phase in Figure 5.17 and 5.18.

FIGURE 5.17: LOADING PHASE - 10 Day SRT System
System and Theoretical Aerobic SRT

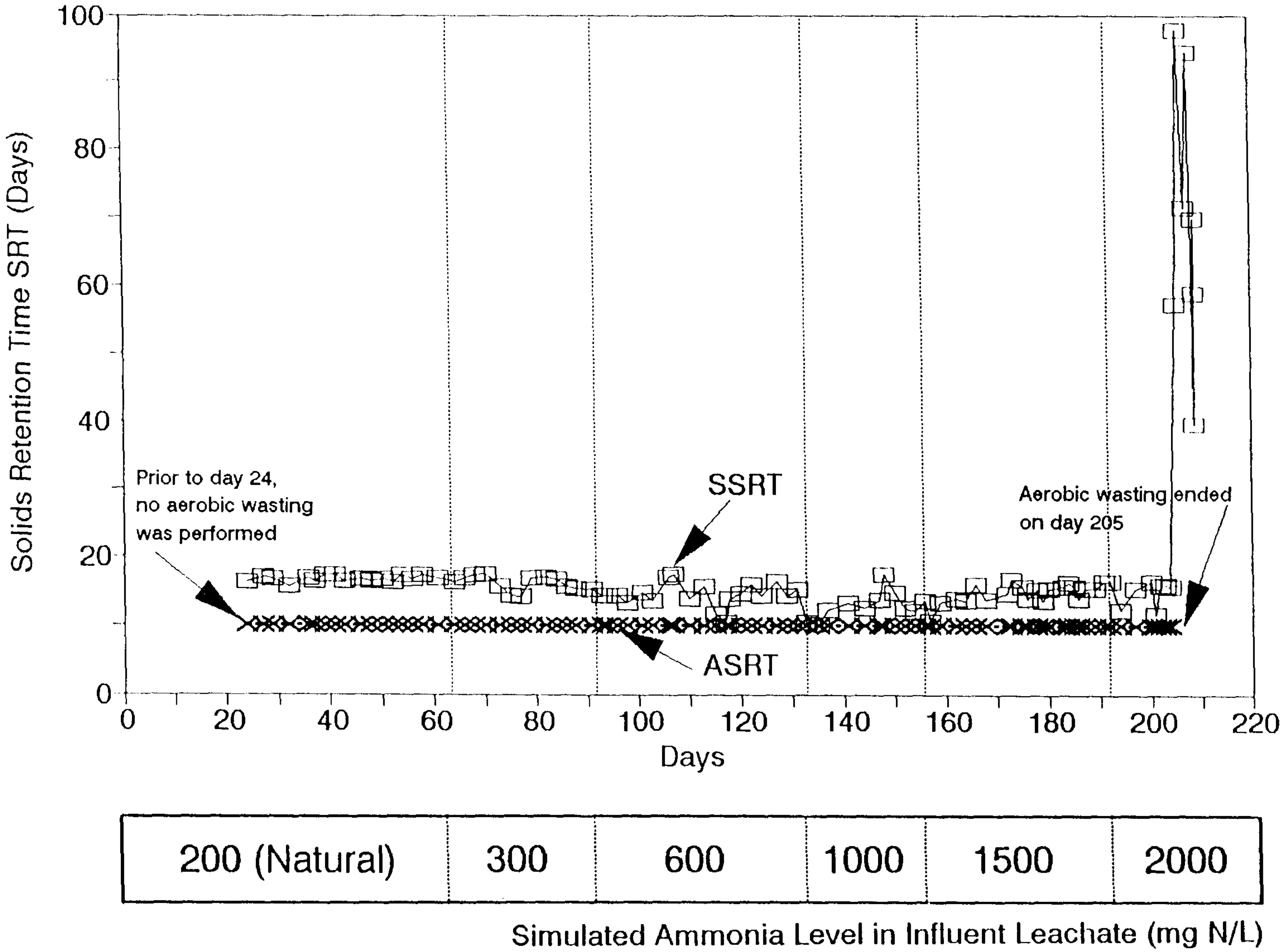
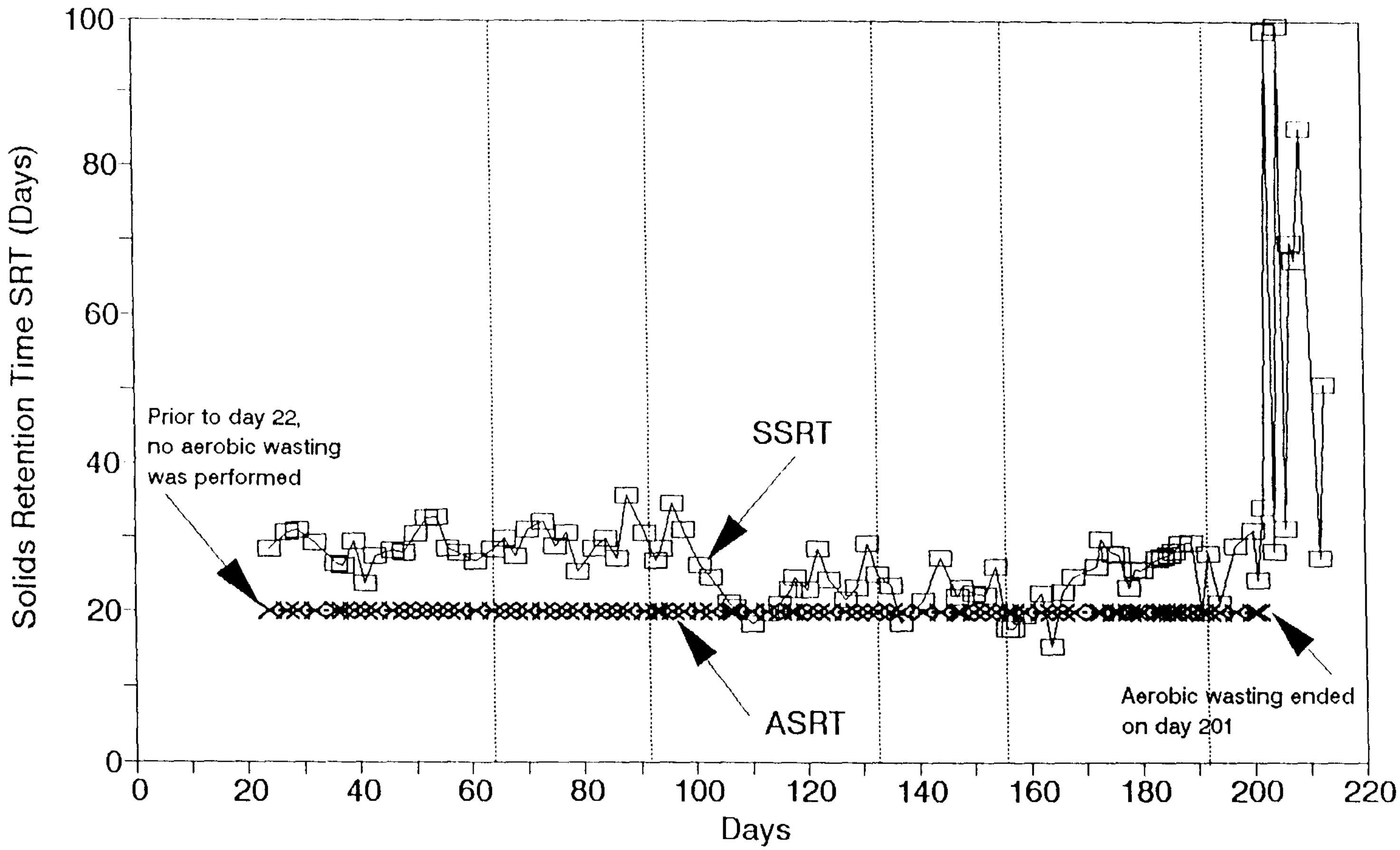


FIGURE 5.18: LOADING PHASE - 20 Day SRT System
System and Theoretical Aerobic SRT



200 (Natural)	300	600	1000	1500	2000

Simulated Ammonia Level in Influent Leachate (mg N/L)

When wasting was being performed, the actual system SRT was greater than the theoretical aerobic SRT due to the greater volumes involved. Despite the system volume being double the aerobic volume, the actual system SRT is not double the theoretical aerobic SRT, primarily due to the loss of VSS in the effluent. When no wasting was occurring, the theoretical aerobic SRT was equal to infinity. The actual system SRT is still calculable, due to the inclusion of the effluent VSS term in the denominator.

5.2 Cold Temperature Phase

The objective of the cold temperature phase was to test how the 10 and 20 day SRT treatment systems would respond as the temperature was decreased from 20 °C, when treating an influent leachate ammonia level of 1500 mg/L. This phase was divided into three periods: the 20 °C startup (Days 1 to 94), the cold temperature period (Days 83 to 130), and the 10 °C nitrification startup (Days 132 to 169). Day 1 of the cold temperature phase was March 12, 1992. Following the nitrification failure experienced at the end of the loading phase, and prior to decreasing the temperature, both systems were restarted using the natural base leachate of 200 mg NH_4-N/L and at 20 °C. As complete nitrification was regained, the influent ammonia level was increased, until the influent ammonia level reached 1500 mg N/L. Two small ceramic fine air diffusers were added to each aerobic reactor for ensuring sufficient dissolved oxygen; pH/pump controllers were used to control bicarbonate addition to the aerobic reactors, based on a pH setpoint of 7.5. During the 20 °C startup period of the cold temperature phase, while attempting to restart denitrification, two unanticipated observations were made: BOD_5 inhibition of nitrification, and a loss of nitrite accumulation.

5.2.1 BOD_5 Inhibition of Nitrification

Once nitrification was re-established (Day 19 for the 10 day SRT system, Day 14 for the 20 day SRT system), both anoxic reactors were reseeded and methanol addition was increased. In both systems, within several days of large boosts in methanol (Day 27 for the 10 day SRT system, Day 22 for the 20 day SRT system), % denitrification increased, the aerobic BOD_5 rose, aerobic ammonia levels increased, and % nitrification decreased (see Figure 5.19 and 5.20). The simulated influent ammonia levels and methanol addition were again cut to expedite removal of high levels of aerobic ammonia.

FIGURE 5.19: TEMPERATURE PHASE - 10 Day SRT System
Aerobic BOD5 and % Nitrification

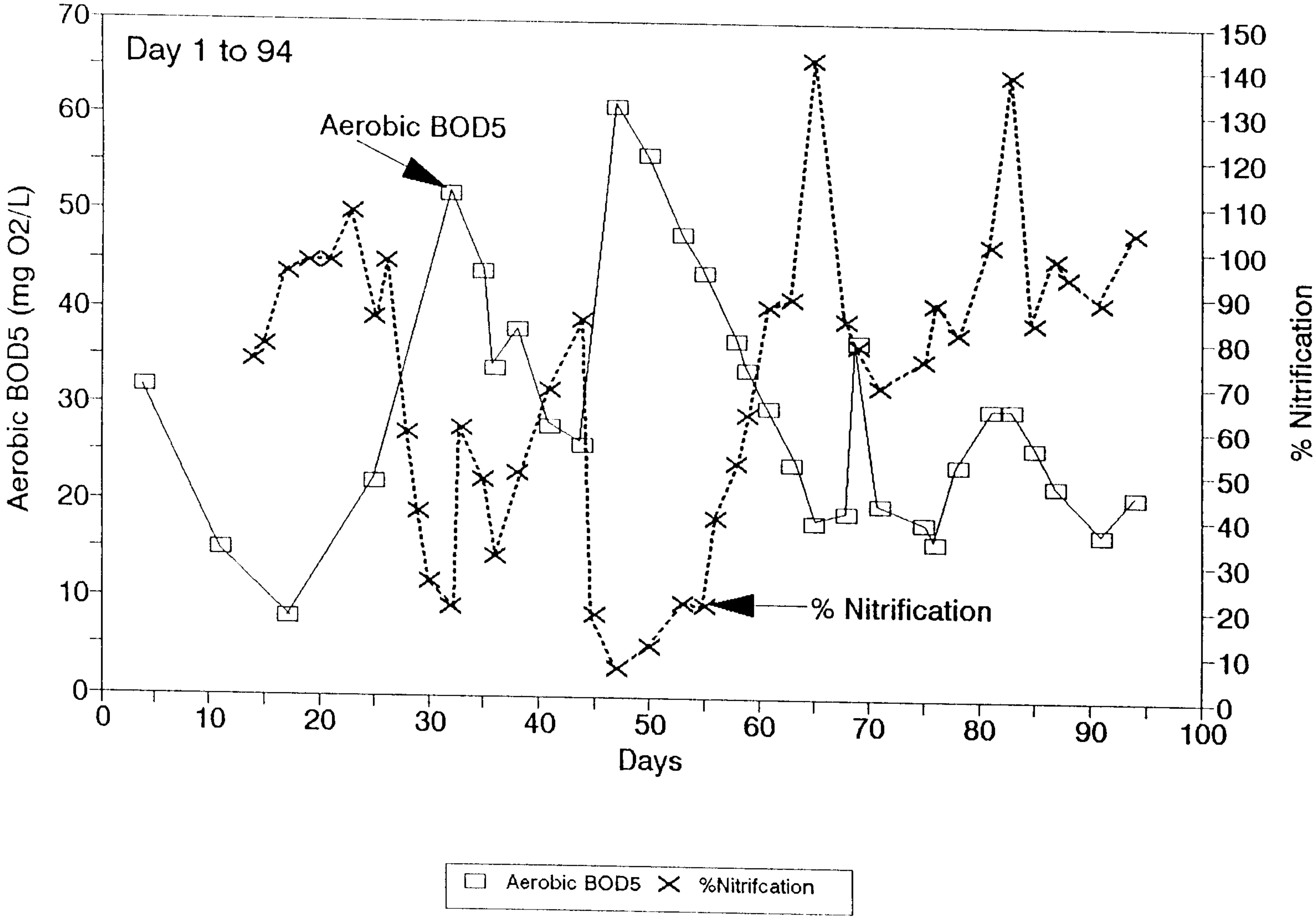
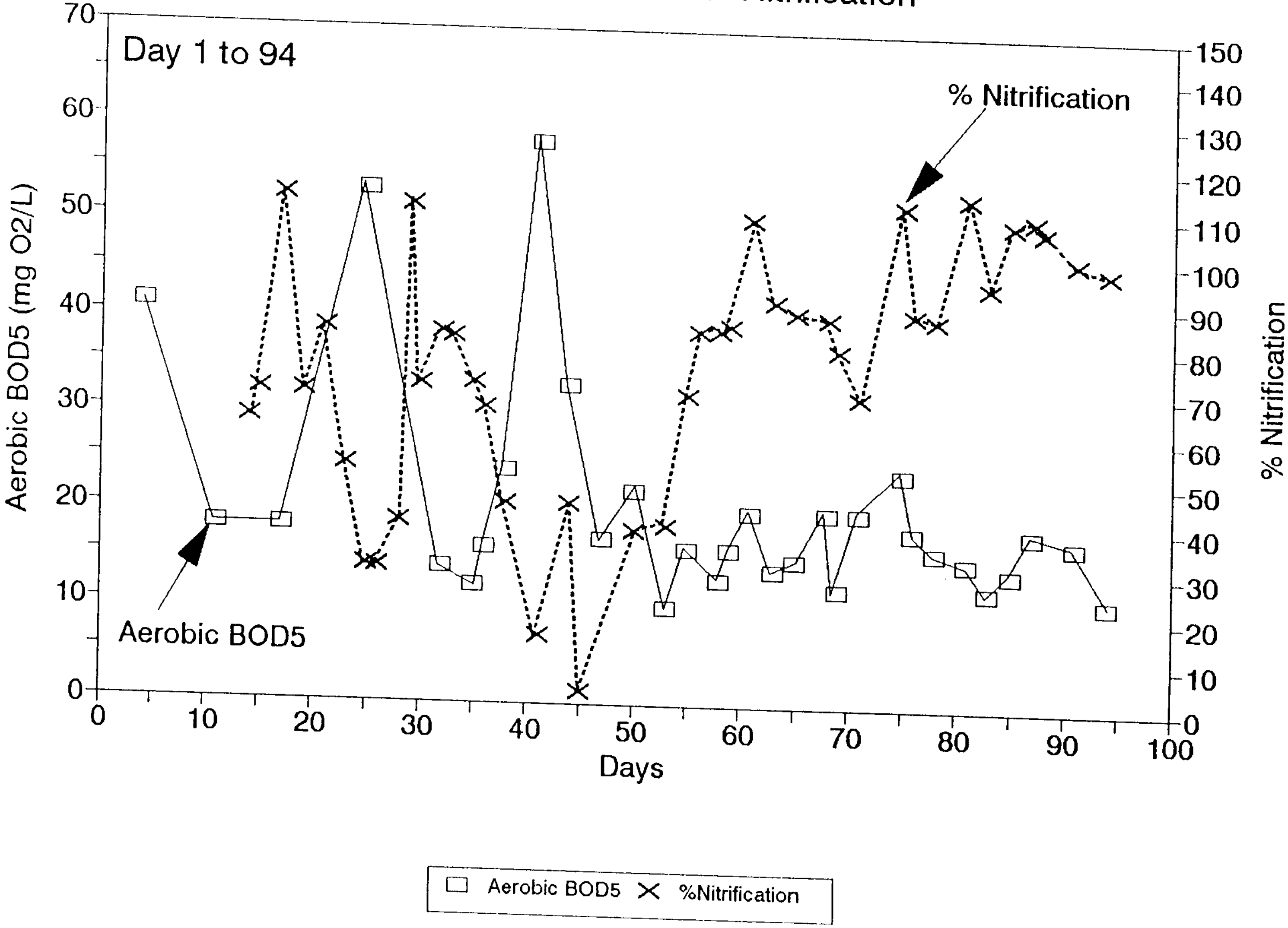


FIGURE 5.20: TEMPERATURE PHASE - 20 Day SRT System
Aerobic BOD5 and % Nitrification



The systems were again restarted in the same manner with a similar conclusion (Days 36 to 47 for the 10 Day SRT system, Days 28 to 41 for the 20 Day SRT system).

Figure 5.21 and 5.22 show the observed relationship between aerobic BOD_5, COD and % nitrification during the startup phase. Figure 5.23 shows the aerobic BOD_5 and % nitrification results compiled for both systems. From Figure 5.23, it appears that higher aerobic BOD_5 levels correlate with lower % nitrification, with aerobic BOD_5 levels over 30 mg/L correlating to 50 % nitrification or less. The COD results did not reflect the trend as significantly as BOD_5, presumably because of the lower accuracy of the COD test as a representation of biodegradable organics.

Figure 5.24 and 5.25 show the COD:NO_x ratios during this period. Methanol additions were made on the basis of the NO_x^- entering the anoxic reactor. However, the amount that is in excess, and will subsequently bleed into the aerobic reactor, will be determined by how much NO_x^- is being removed through denitrification. The difference in the two COD:NO_x values (with COD:$NO_{x,removed}$ > COD:$NO_{x,entering}$) represents the amount that would be bleeding through to the aerobic reactor. The difference between the two COD:NO_x ratios is most noticeable in the 10 Day SRT system. The peaks for COD:$NO_{x,removed}$, after day 50, is due to relatively small amounts of methanol being added and producing relatively low denitrification. The low levels of methanol addition were apparently insufficient to result in nitrification inhibition. The mechanism by which excess methanol addition resulted in nitrification inhibition may have been that heterotrophic growth, in the aerobic reactor, lowered the DO to inhibitory levels. The DO meter always reported that DO levels were sufficient; however, as in the failure period of the loading phase, these readings may have been falsely high due to the coarse aeration of the aerobic mixed liquor. Another explanation for the reduction in nitrification following large methanol increases, may be that excess methanol addition resulted in methanol toxicity to *Nitrosomonas*. A study by Hooper and Terry (1973) concluded that short-chain alcohols, such as methanol, were significant inhibitors of ammonia oxidation. A study by Carley and Mavinic (1989) found that excess methanol did not increase aerobic ammonia levels but did reduce nitrification by resulting in heterotrophic competition for ammonia. Since ammonia levels, in this study, were

FIGURE 5.21: TEMPERATURE PHASE - 10 Day SRT System
Aerobic BOD5, COD vs % Nitrification

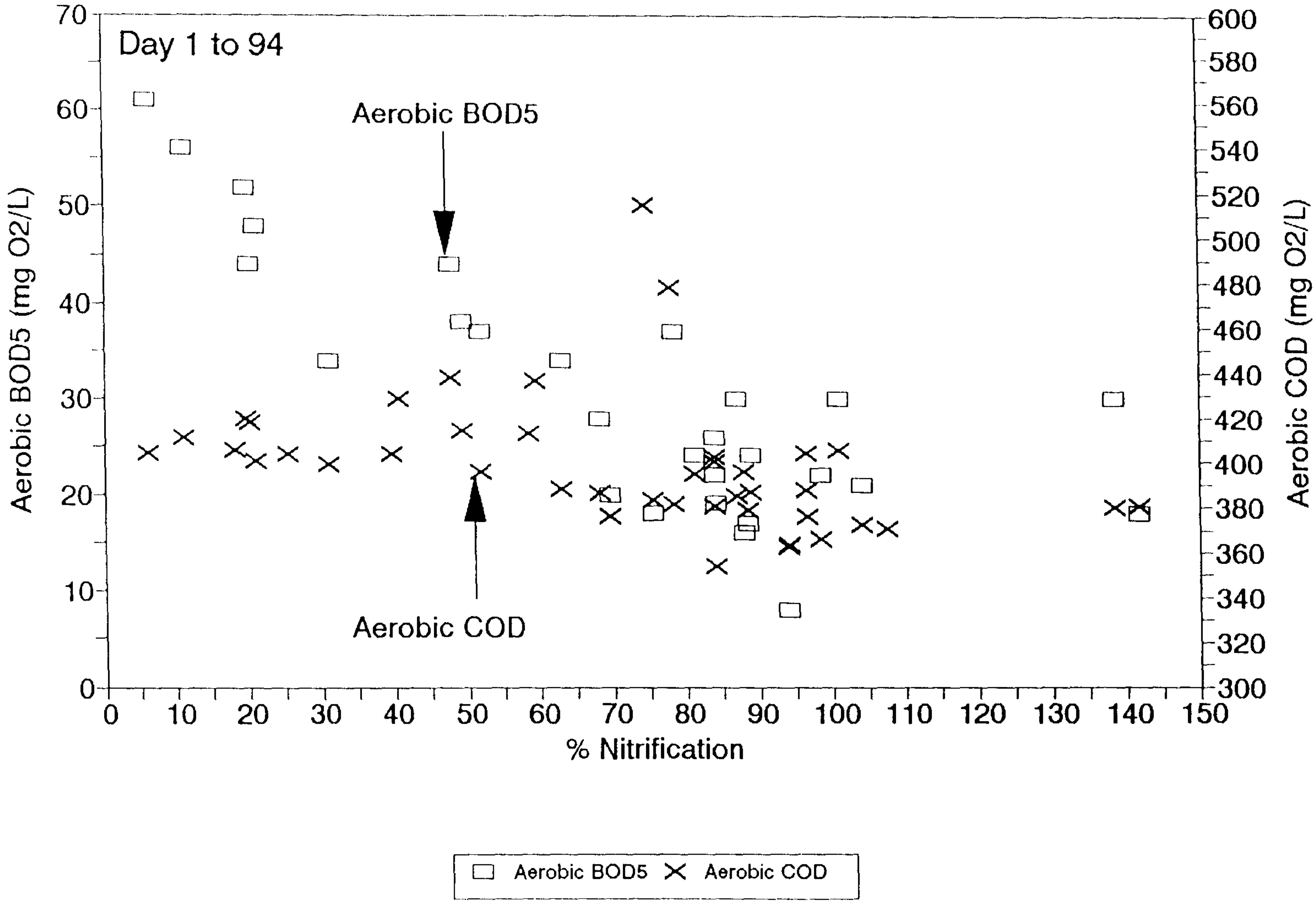


FIGURE 5.22: TEMPERATURE PHASE - 20 Day SRT System
Aerobic BOD5, COD vs % Nitrification

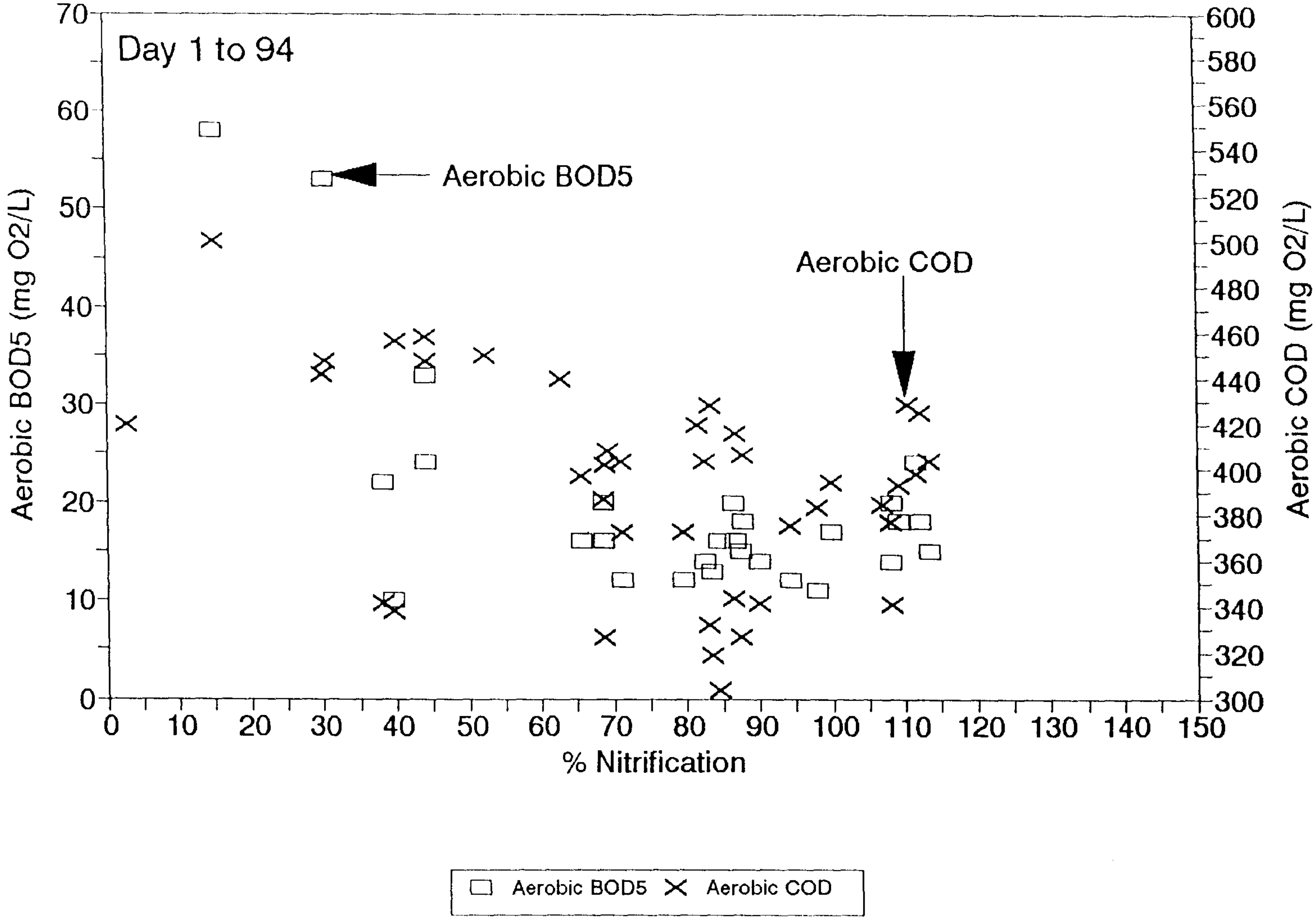


FIGURE 5.23: TEMPERATURE PHASE - 10 and 20 Day SRT
Aerobic BOD5 vs % Nitrification

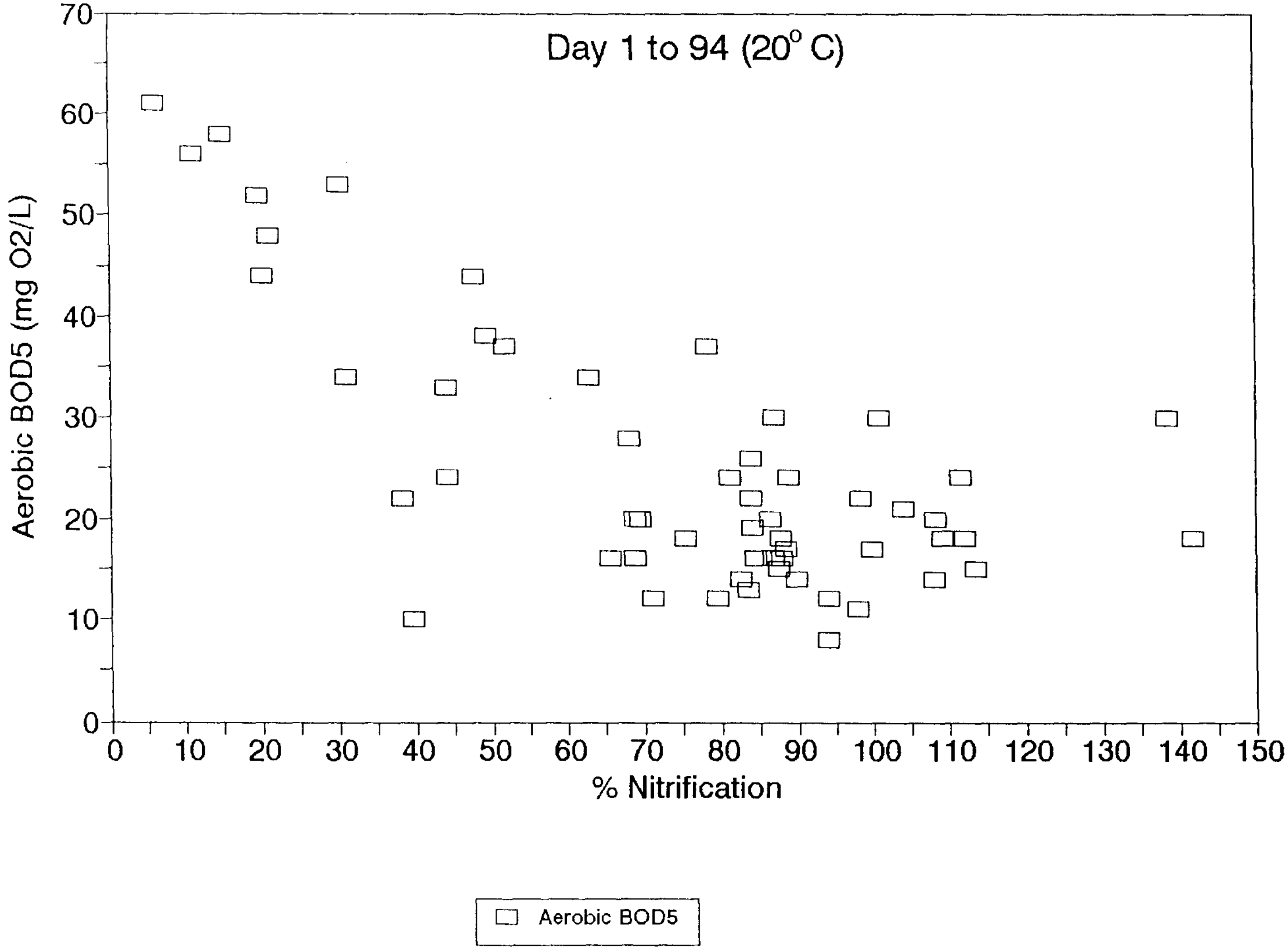


FIGURE 5.24: TEMPERATURE PHASE - 10 Day SRT System Methanol Addition during 20 C Startup

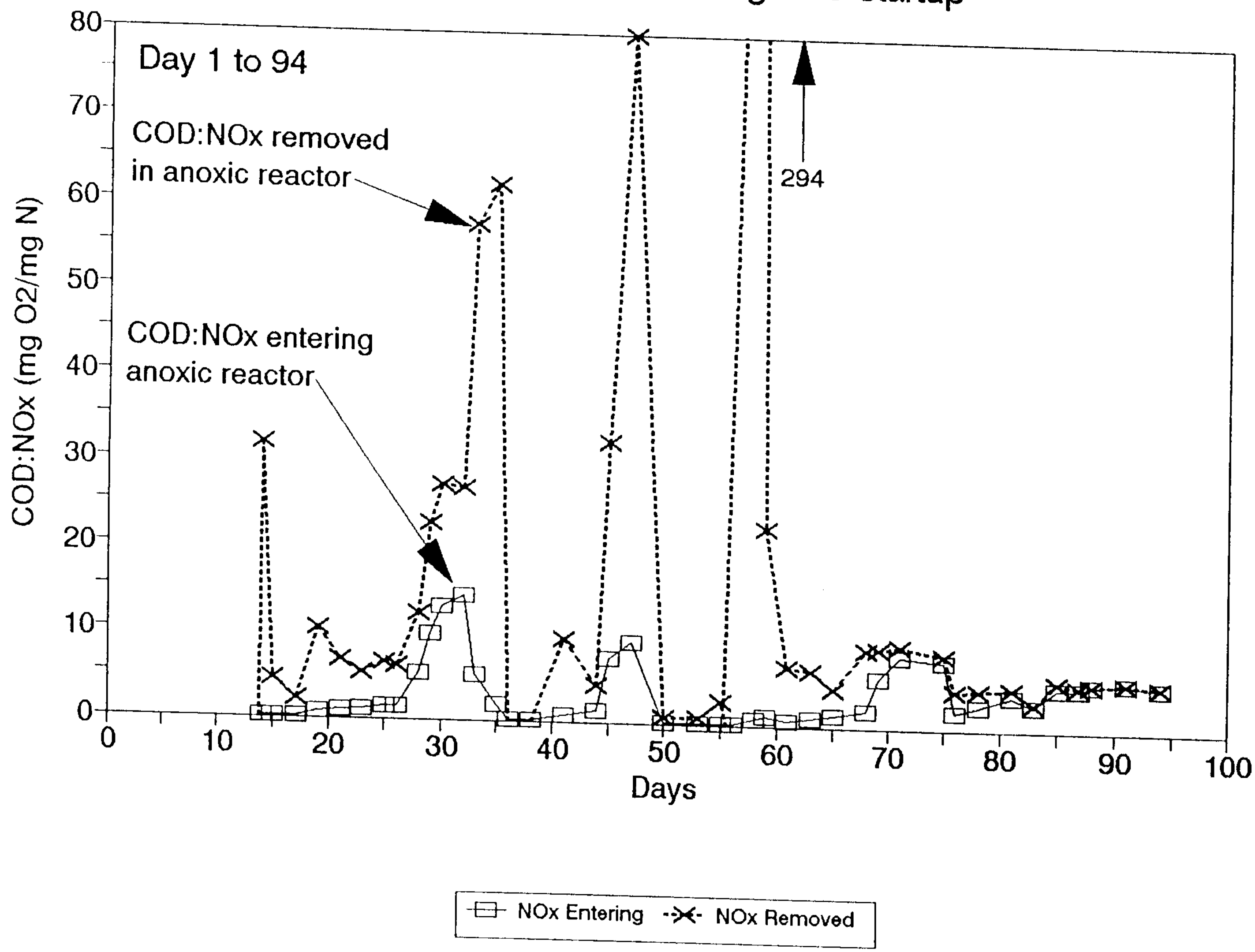
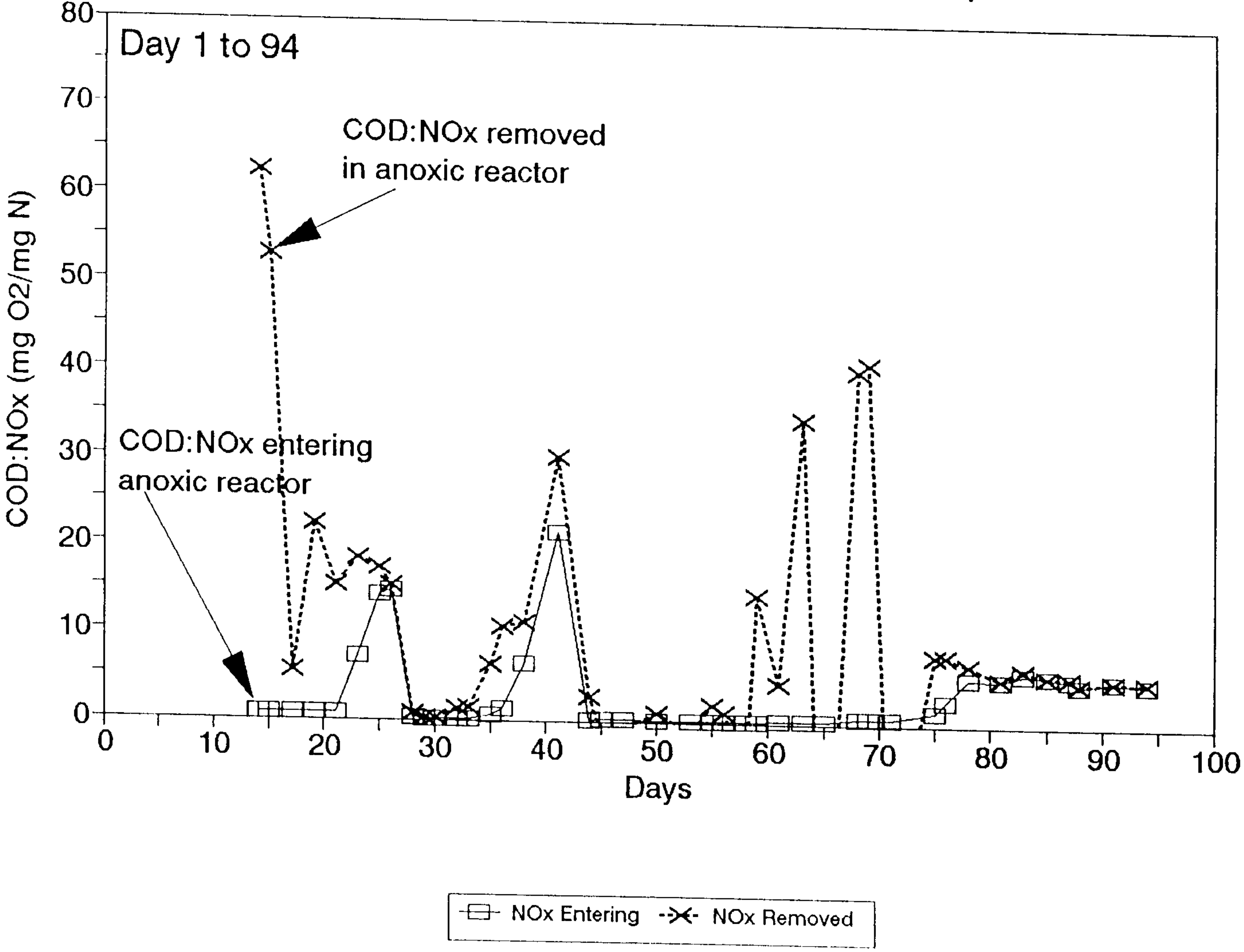


FIGURE 5.25: TEMPERATURE PHASE - 20 Day SRT System Methanol Addition during 20 C Startup



observed to increase, heterotrophic competition for ammonia was dismissed as a possible reason for the loss of nitrification.

After two failed attempts, both systems were restarted a third time (Day 58 for the 10 day SRT system, and Day 44 for the 20 day SRT system). This time, increments in methanol were conducted in a more slow and conservative manner. By Day 94, both systems were fully re-established at 20 °C and at an influent ammonia level of 1500 mg N/L.

5.2.2 Loss of Nitrite Accumulation

Aerobic nitrite accumulation had occurred during the higher influent ammonia levels of the loading phase (see Table 5.5). However, by the end of the 20 °C startup period of the temperature phase, aerobic nitrite levels had decreased to less than 1 mg N/L. Figure 5.26 and 5.27 show the aerobic nitrite levels and the aerobic pH. Possible explanations for the loss of nitrite accumulation are *Nitrobacter* acclimatization, increased dissolved oxygen levels due to the presence of the fine bubble diffusers, and the steady aerobic pH=7.5. On Day 33, pH/pump controllers were installed to continuously monitor and automatically control the aerobic pH, by pumping bicarbonate to the aerobic reactor when the pH decreased below the setpoint value of 7.5. The pH/pump controllers did not work successfully for approximately one month. The fault was primarily due to electrical grounding problems which resulted in an unstable pH reading. The solution was to insulate the controller from a direct metal-link to the large motors stirring the aerobic reactors. However, some fluctuation remained due to the stirrer-liquid-(pH)probe link. Despite the loss of aerobic nitrite, the COD:NO_x ratio remained low (approximately 5:1), but was marginally higher than for the latter period of the loading phase, when aerobic nitrite levels had increased substantially and COD:NO_x ratios were as low as 3.5:1 (see Table 5.4).

5.2.3 Effect of Cold Temperature and Failure

Once both systems were fully operational and had stabilized at 20 °C, with an influent ammonia level of 1500 mg N/L, the operating temperature was decreased from 20 °C, to 17, 14, 12, and finally to

FIGURE 5.26: TEMPERATURE PHASE - 10 Day SRT System
Aerobic pH and Nitrite

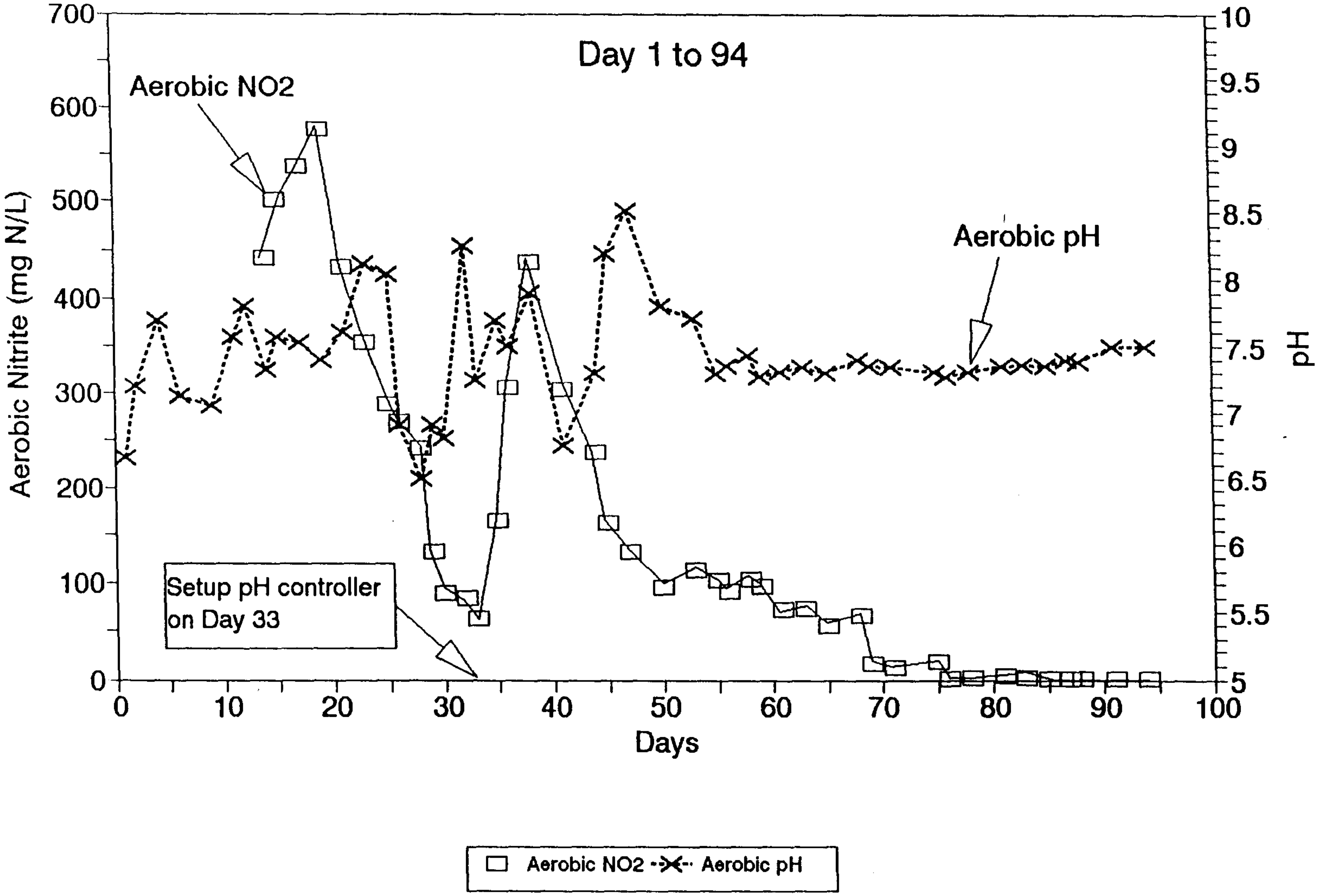
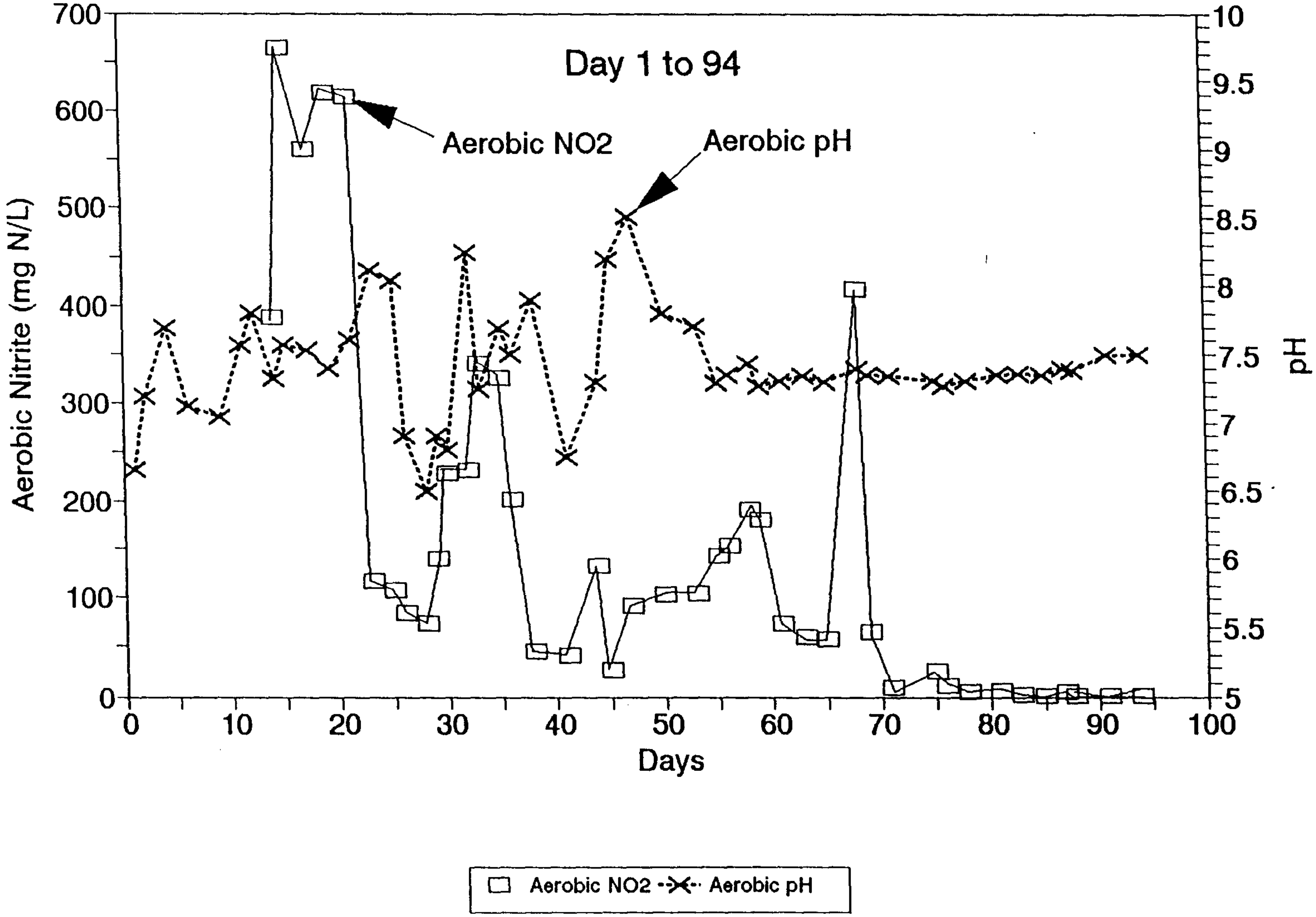


FIGURE 5.27: TEMPERATURE PHASE - 20 Day SRT System
Aerobic pH and Nitrite



10 °C. Each temperature was maintained for approximately 10 days to allow adjustment and acclimatization before the temperature was lowered further. The results for the cold temperature period of the temperature phase are shown in Figures 5.28 to 5.39. As the temperature was decreased from 20 to 12, the most apparent change was the rise in aerobic nitrite (Figure 5.28 and 5.29) and aerobic BOD_5 (Figure 5.30 and 5.31), both starting at 14 °C. It is possible that failure had begun at 14 °C, but not enough time was given for total failure to have occurred.

Failure in both SRT systems occurred quite dramatically when the temperature was decreased from 12 °C to 10 °C. Both nitrification and denitrification decreased considerably in the 10 day SRT system, while only nitrification failed in the 20 day SRT (See Figures 5.32 and 5.33). In the 10 day SRT system, the % nitrification decreased from 94 % at 12 °C, to 15 % at 10 °C. % Denitrification decreased from 99 % at 12 °C, to 30 % at 10 °C. For the 20 day SRT system, % nitrification decreased from 100 % at 12 °C, to 22 % at 10 °C. % Denitrification decreased from 99 % at 12 °C, to 82 % at 10 °C. The rising nitrite levels in both systems, as temperature decreased, and the continued high percentage of denitrification at 10 °C in the 20 day SRT system, suggest that nitrification failure occurred first, as had been observed in the loading phase. The resulting elevated ammonia levels may have precipitated the failure of denitrification in the 10 day SRT system.

Colder temperatures would have obviously been a factor in the failure of nitrification. Colder temperatures would have resulted in slower nitrification rates, although no obvious trend in rate, as a function of temperature (between 20 and 12 °C), is obvious from the results shown in Figure 5.34 and 5.35. The specific nitrification and denitrification rates are shown in Figure 5.36 and 5.37. Neither of the specific utilization rate graphs show any obvious trend as a function of temperature. The VSS results for the cold temperature period are shown in Figure 5.38 and 5.39. Lower utilization rates, due to temperature, were anticipated to have produced lower levels of biomass. A significant decrease in biomass is not evident from the graphs; however, the rise in aerobic nitrite accumulation may have resulted in unused methanol bleeding into the aerobic reactor, thereby promoting aerobic heterotrophic growth, and maintaining elevated VSS levels.

FIGURE 5.28: TEMPERATURE PHASE - 10 Day SRT System
Aerobic Nitrite and % Nitrification

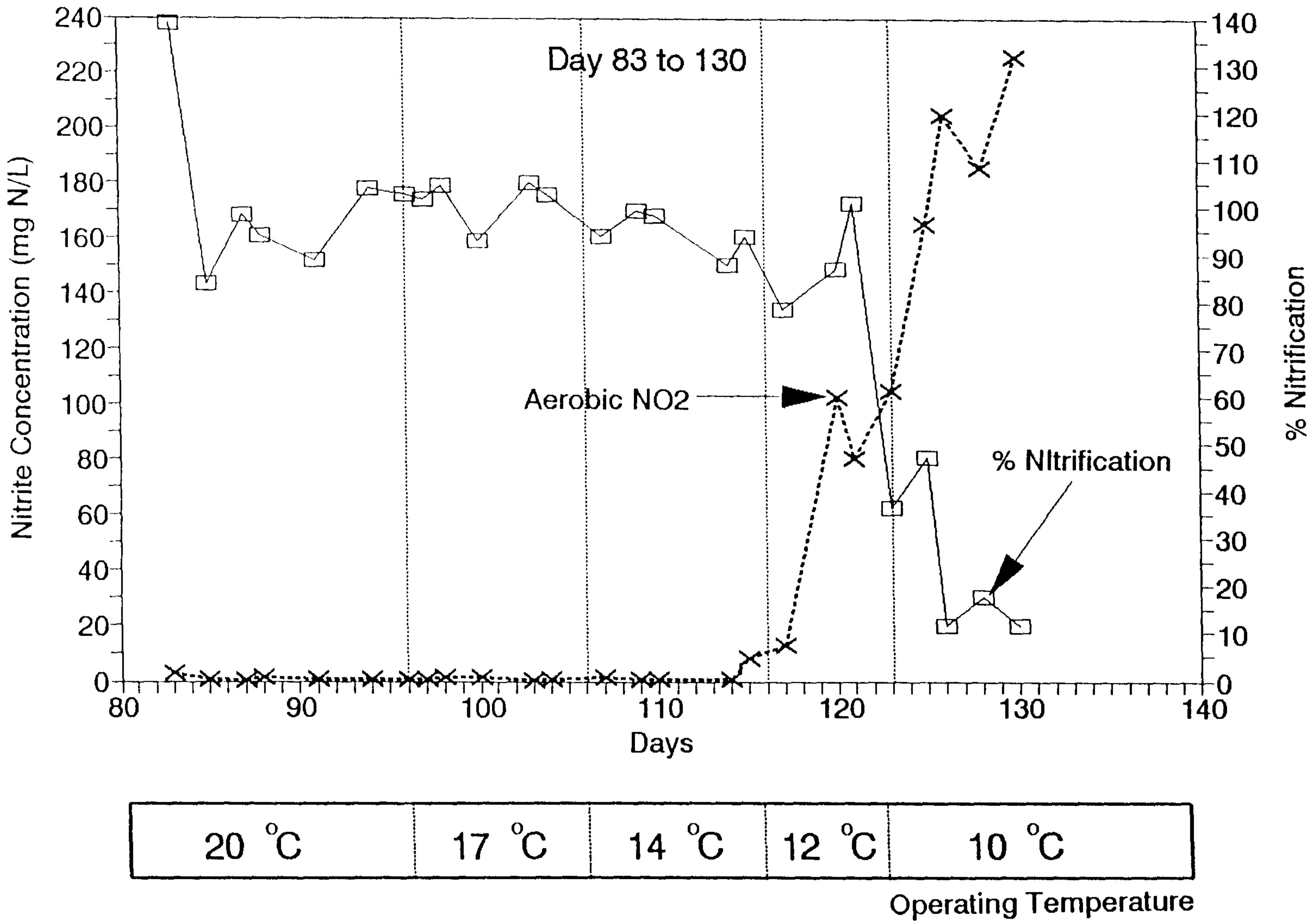


FIGURE 5.29: TEMPERATURE PHASE - 20 Day SRT System
Aerobic Nitrite and % Nitrification

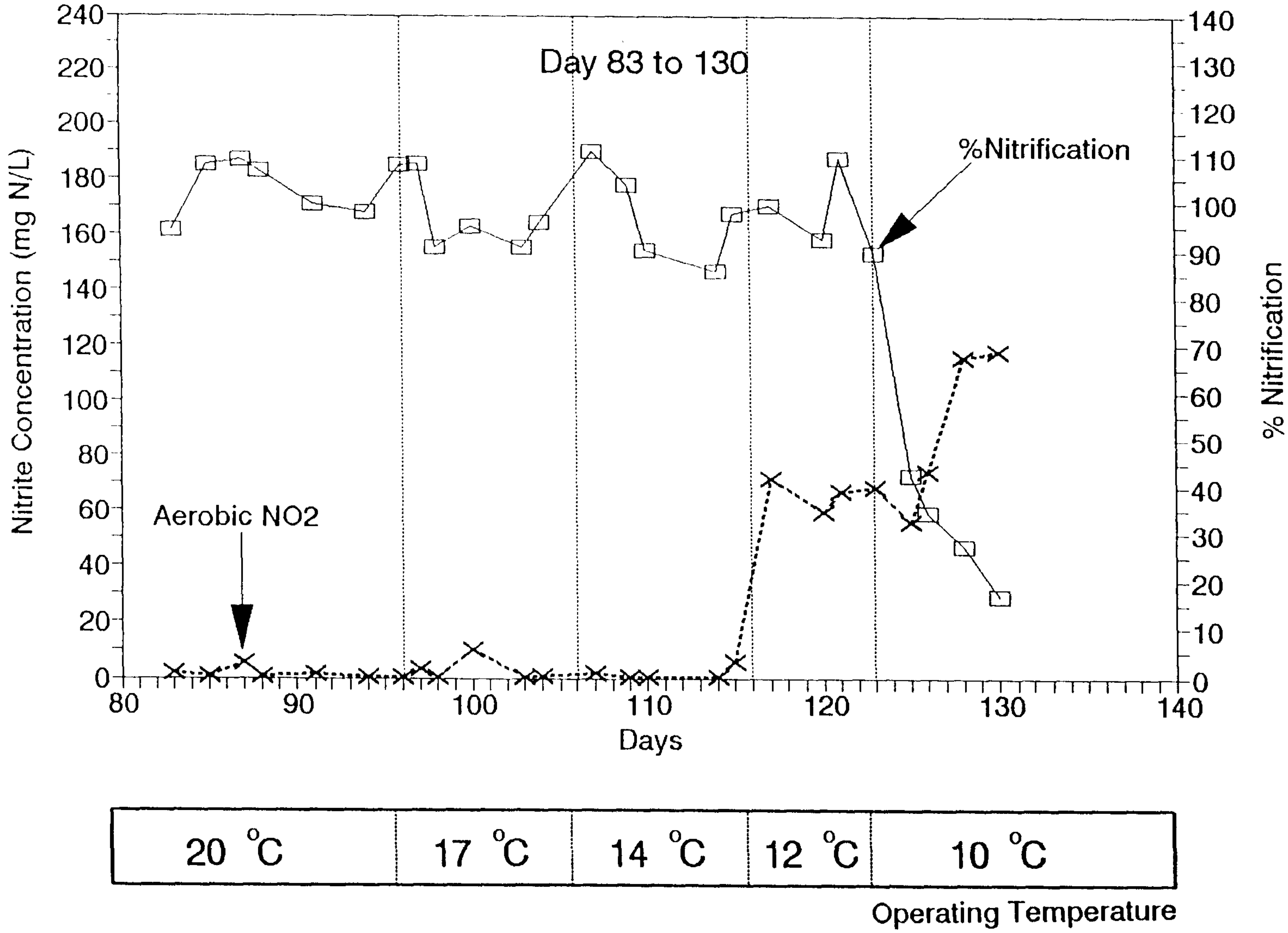


FIGURE 5.30: TEMPERATURE PHASE - 10 Day SRT System
Aerobic BOD5 and % Nitrification

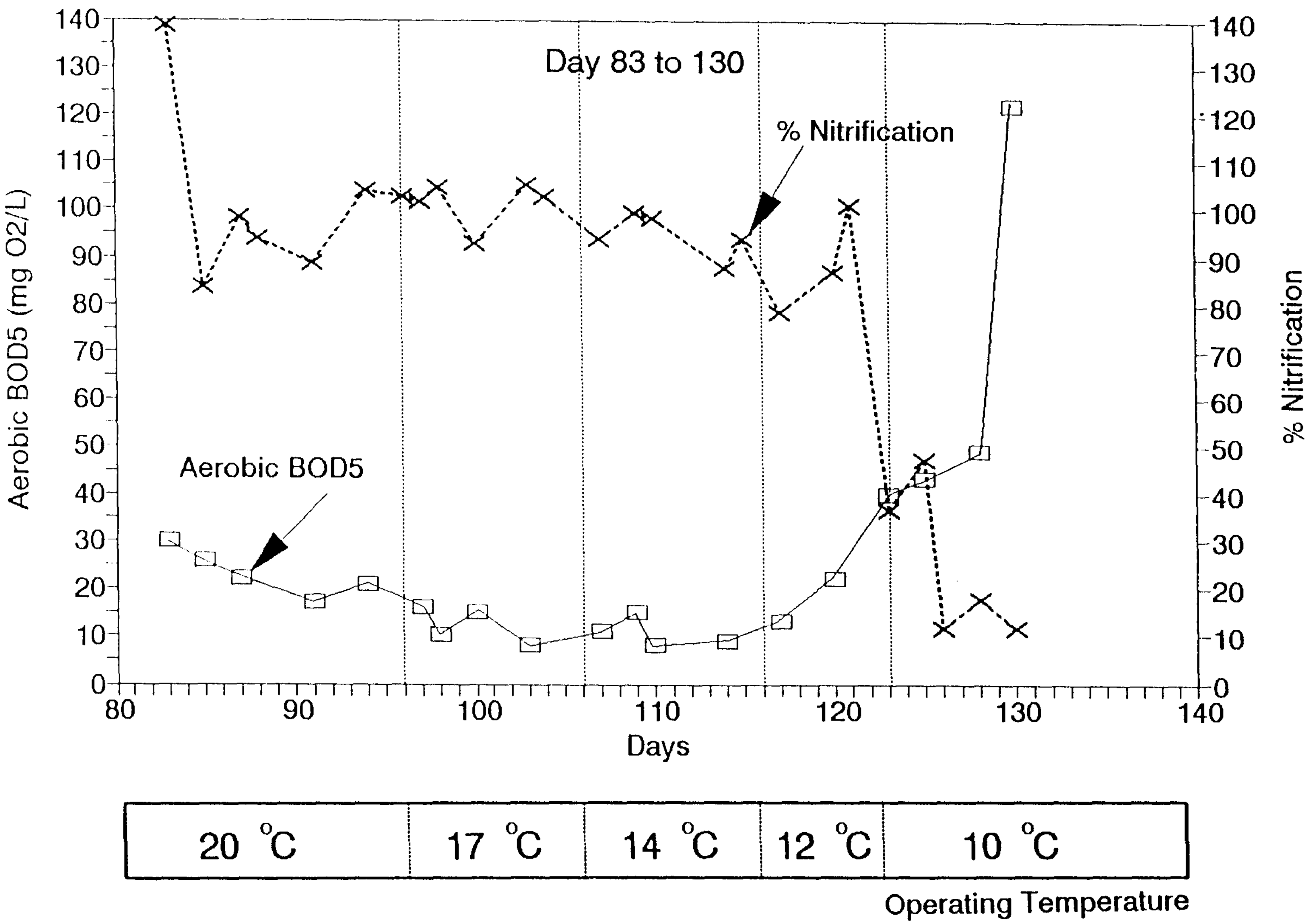


FIGURE 5.31: TEMPERATURE PHASE - 20 Day SRT System
Aerobic BOD5 and % Nitrification

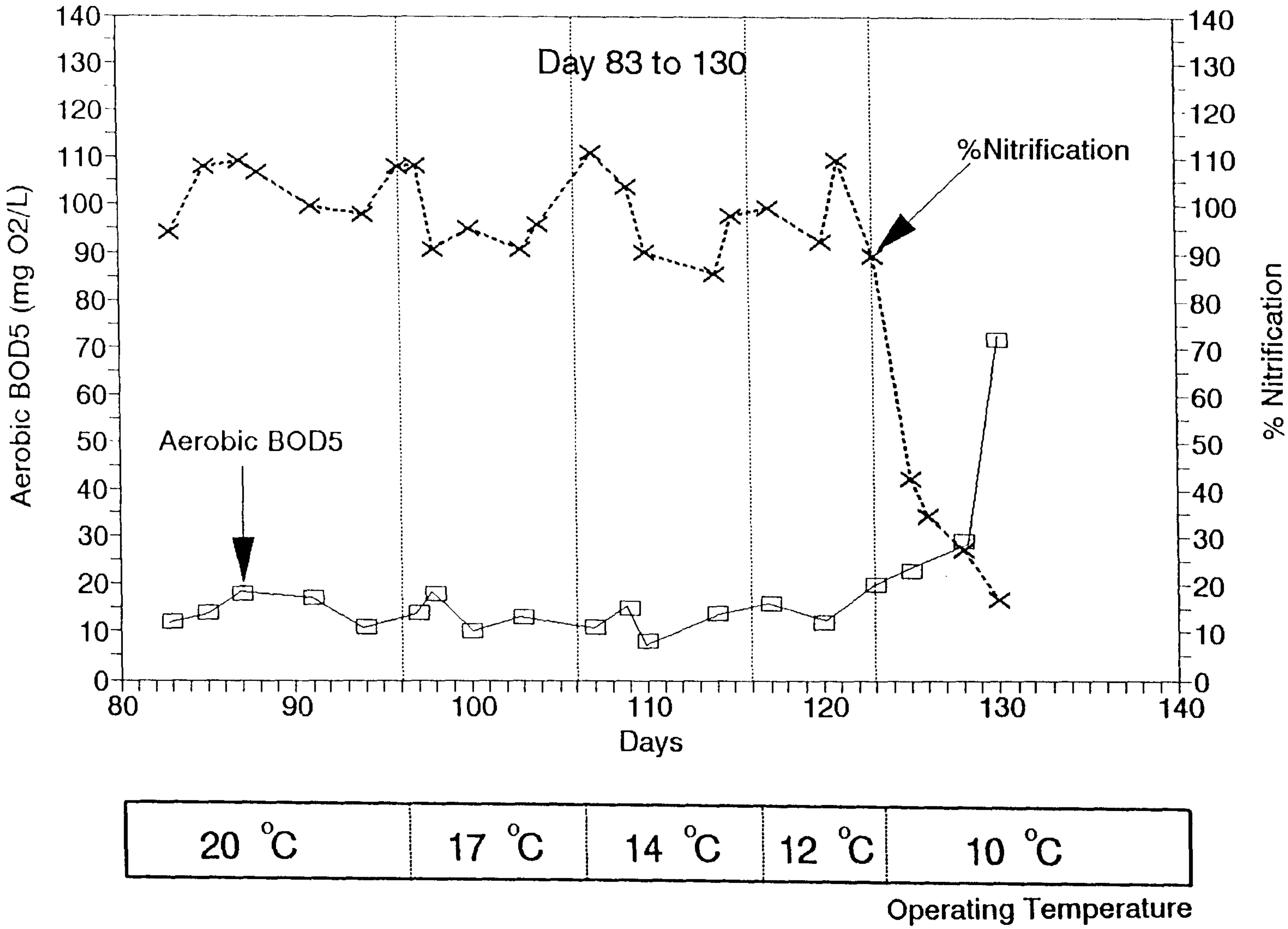


FIGURE 5.32: TEMPERATURE PHASE - 10 Day SRT System
% Denitrification and % Nitrification

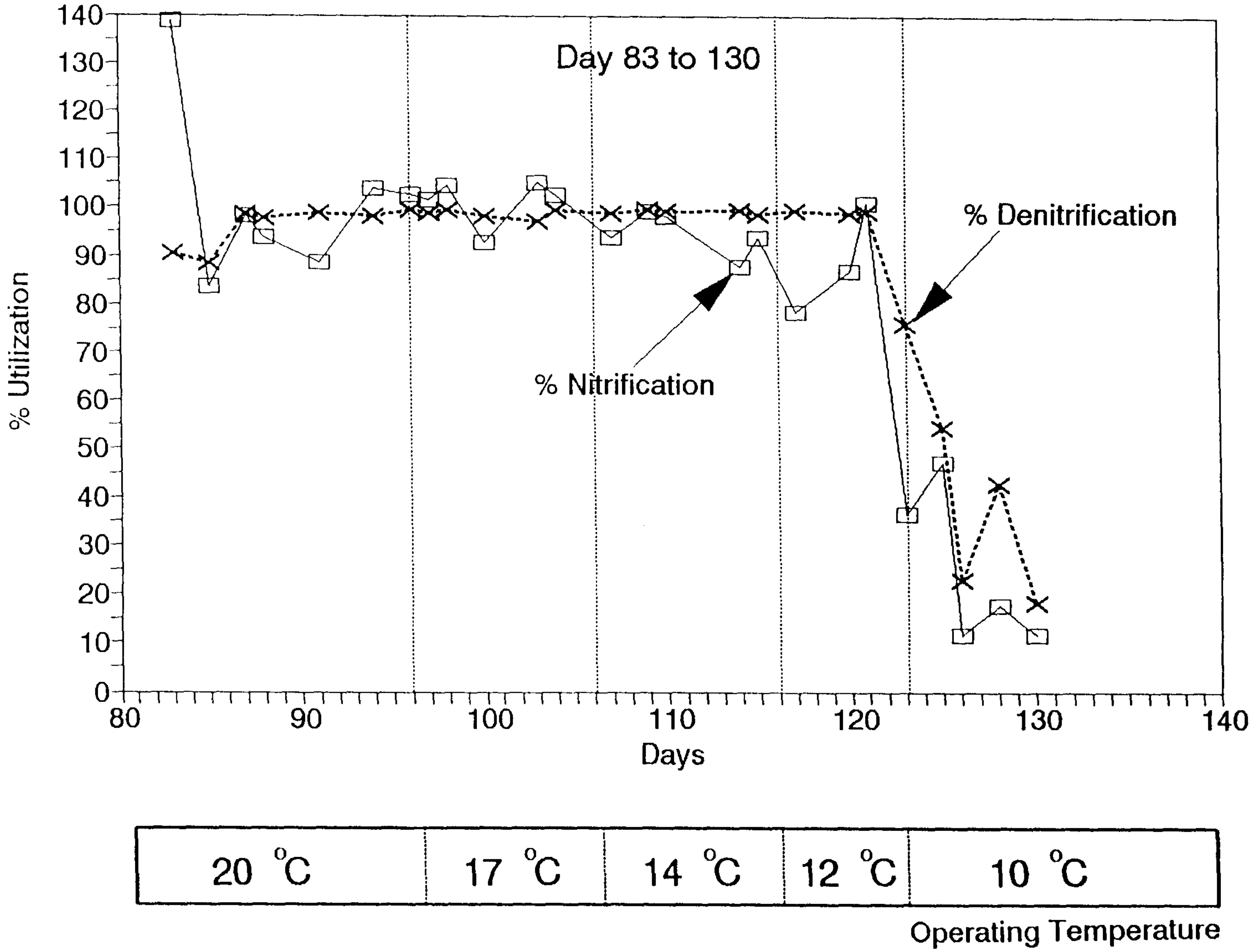


FIGURE 5.33: TEMPERATURE PHASE - 20 Day SRT System
% Denitrification and % Nitrification

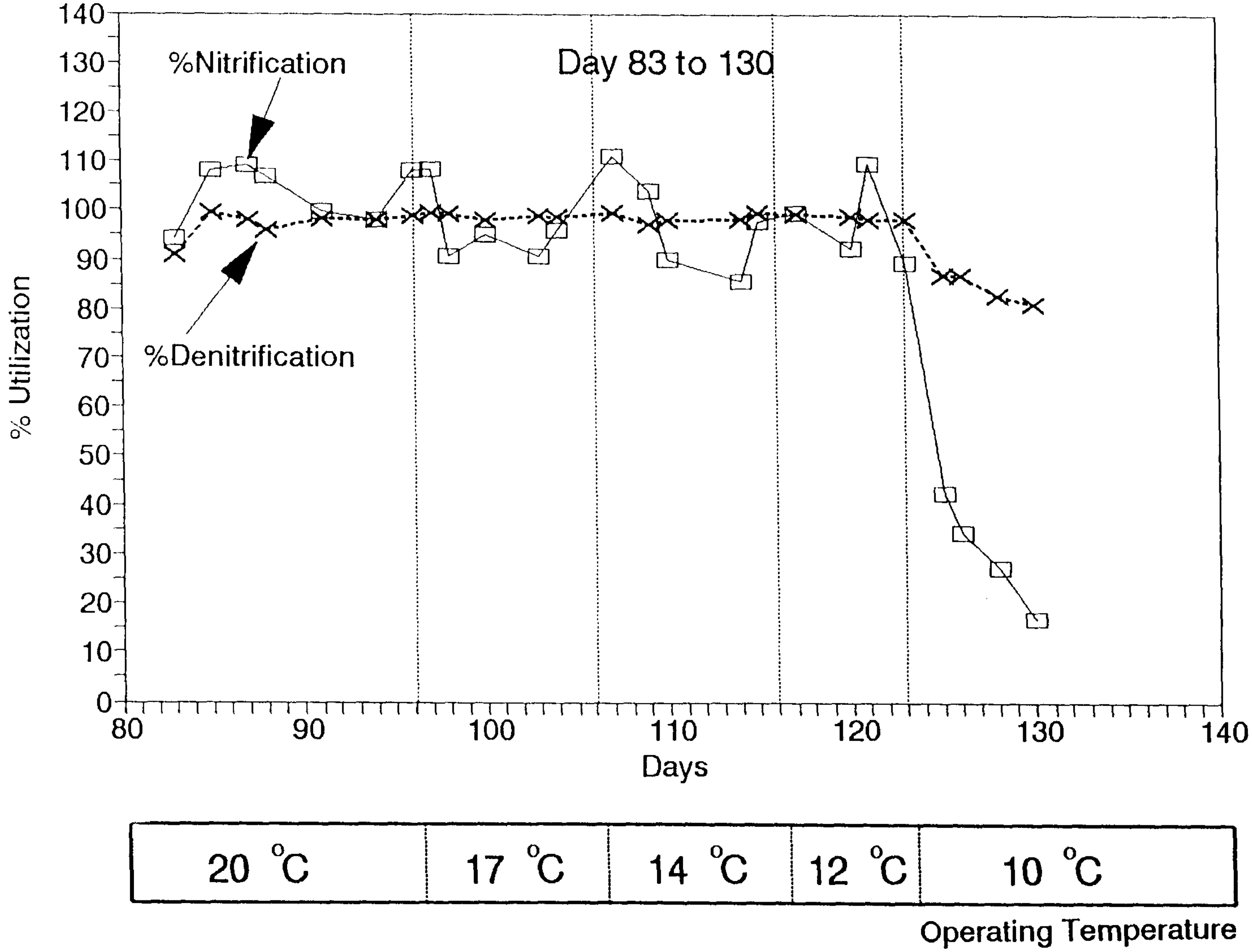


FIGURE 5.34: TEMPERATURE PHASE - 10 Day SRT System
Denitrification and Nitrification Rate

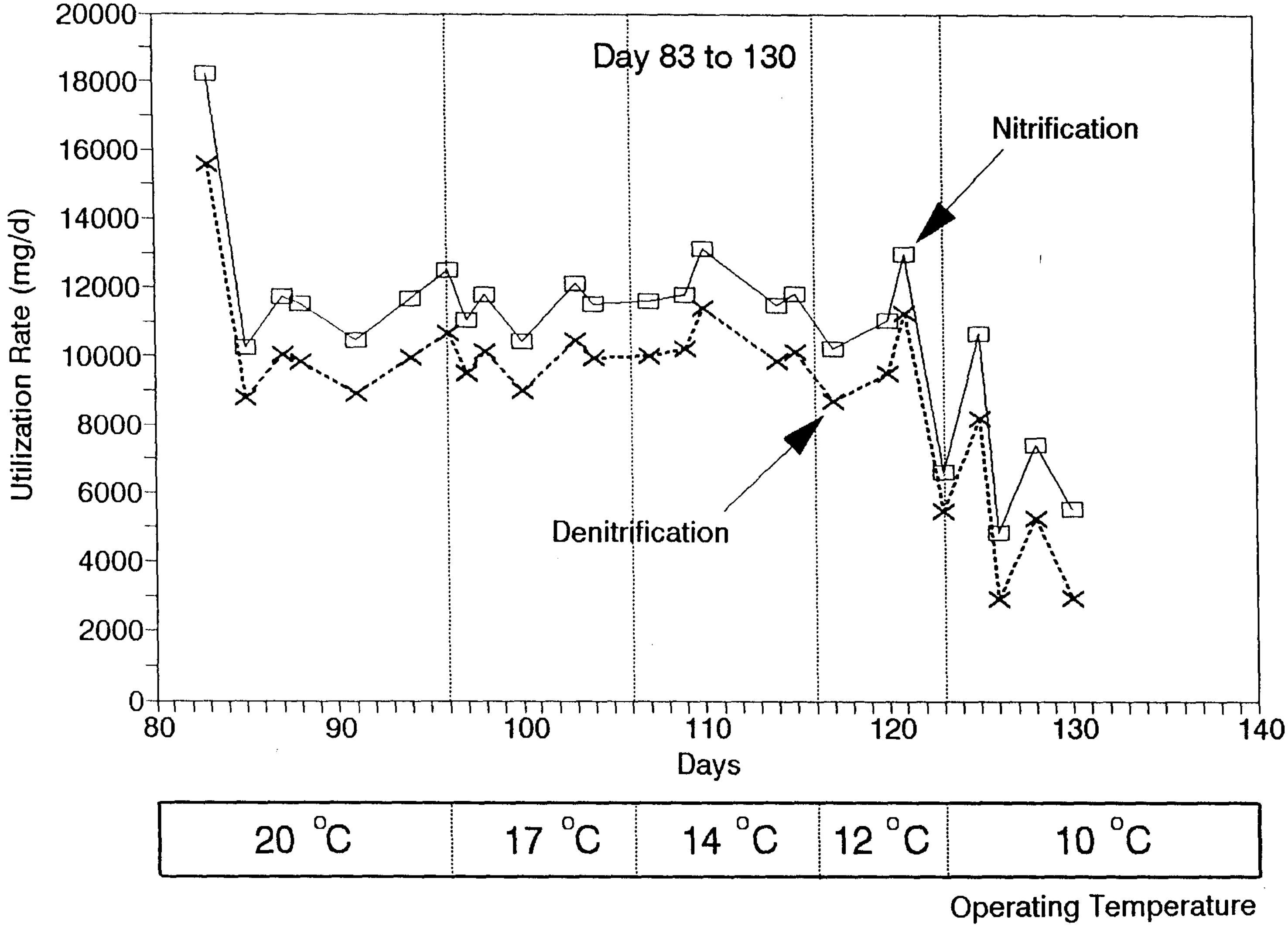


FIGURE 5.35: TEMPERATURE PHASE - 20 Day SRT System
Denitrification and Nitrification Rate

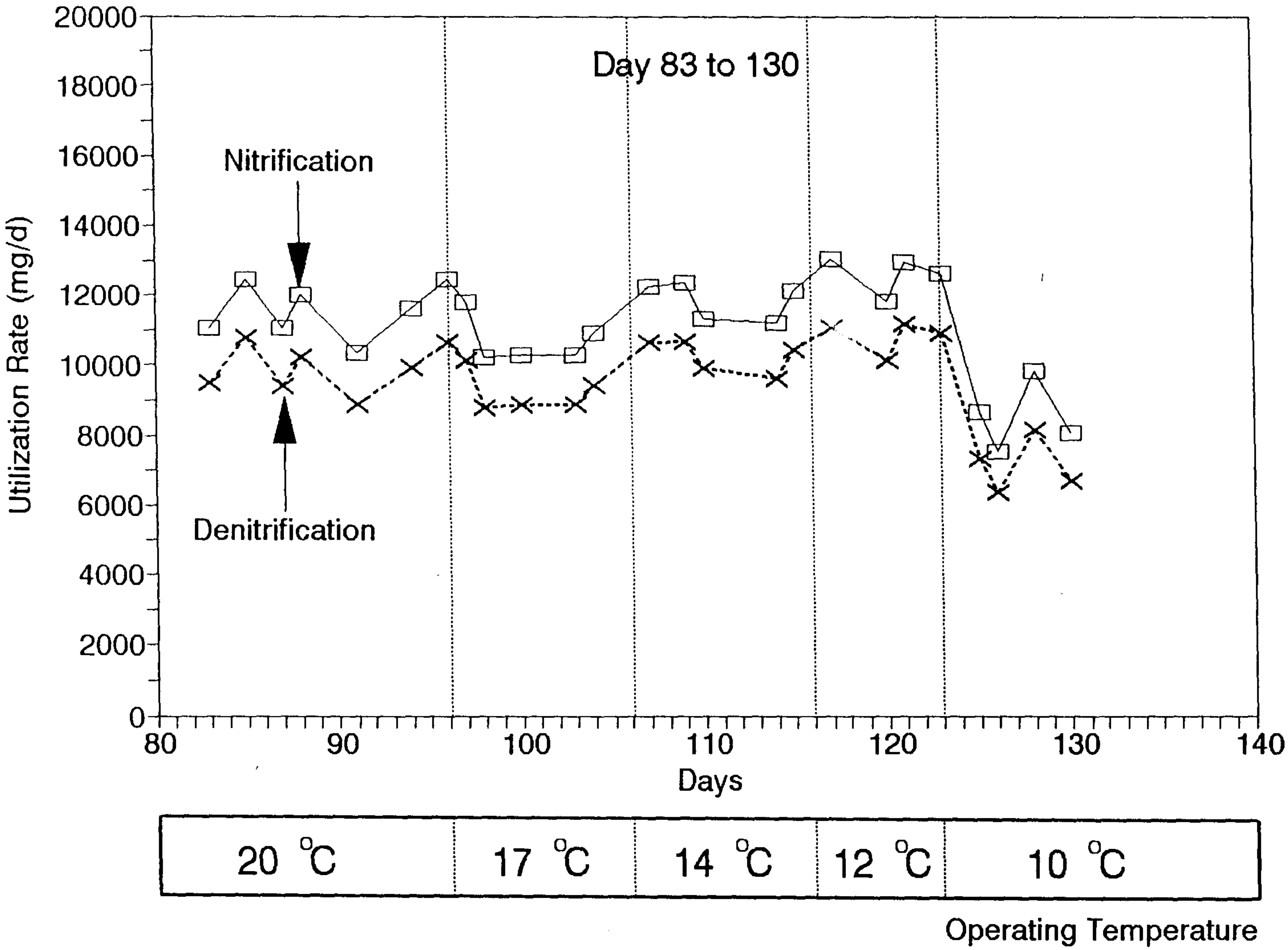


FIGURE 5.36: TEMPERATURE PHASE - 10 Day SRT System
Specific Utilization Rate

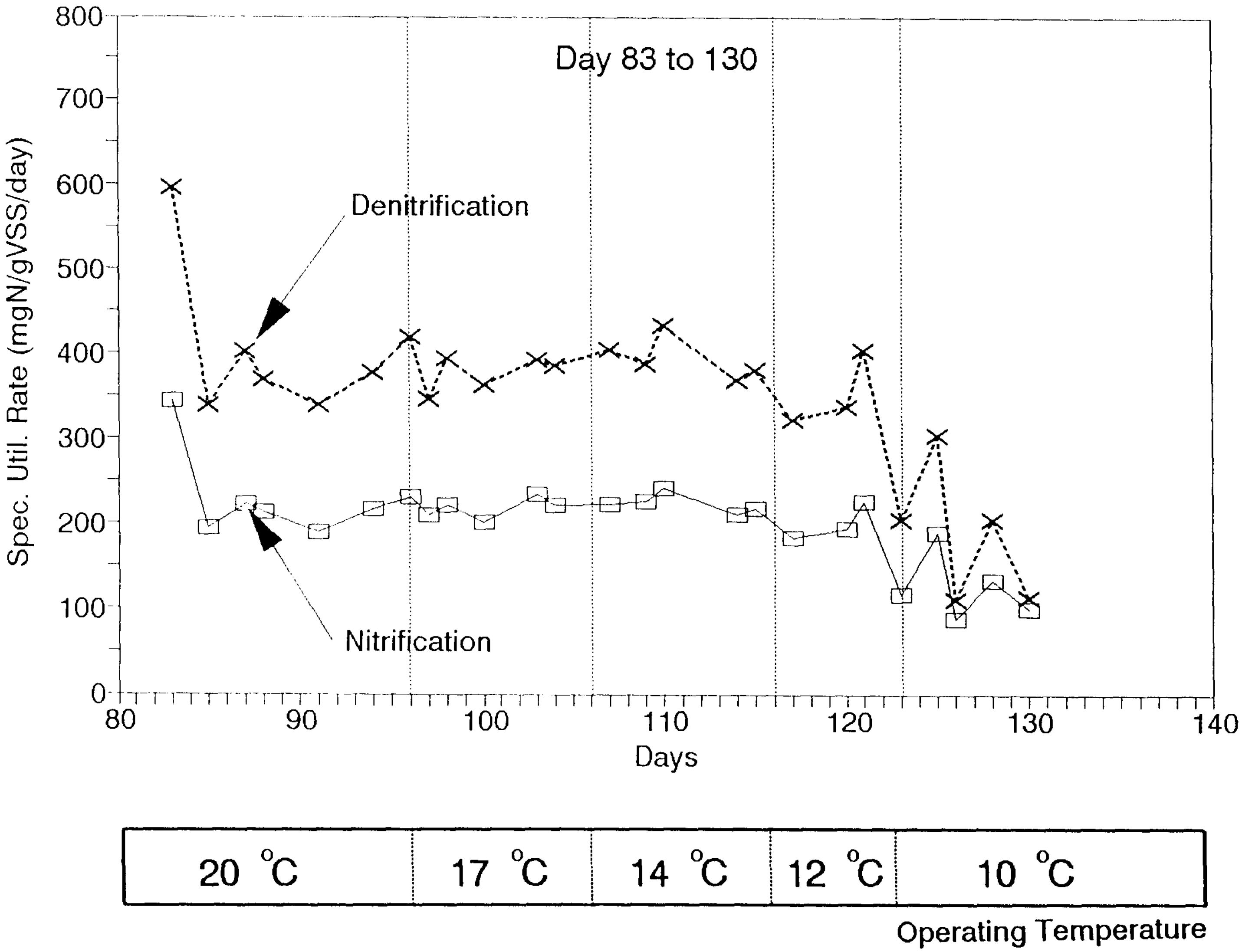


FIGURE 5.37: TEMPERATURE PHASE - 20 Day SRT System
Specific Utilization Rate

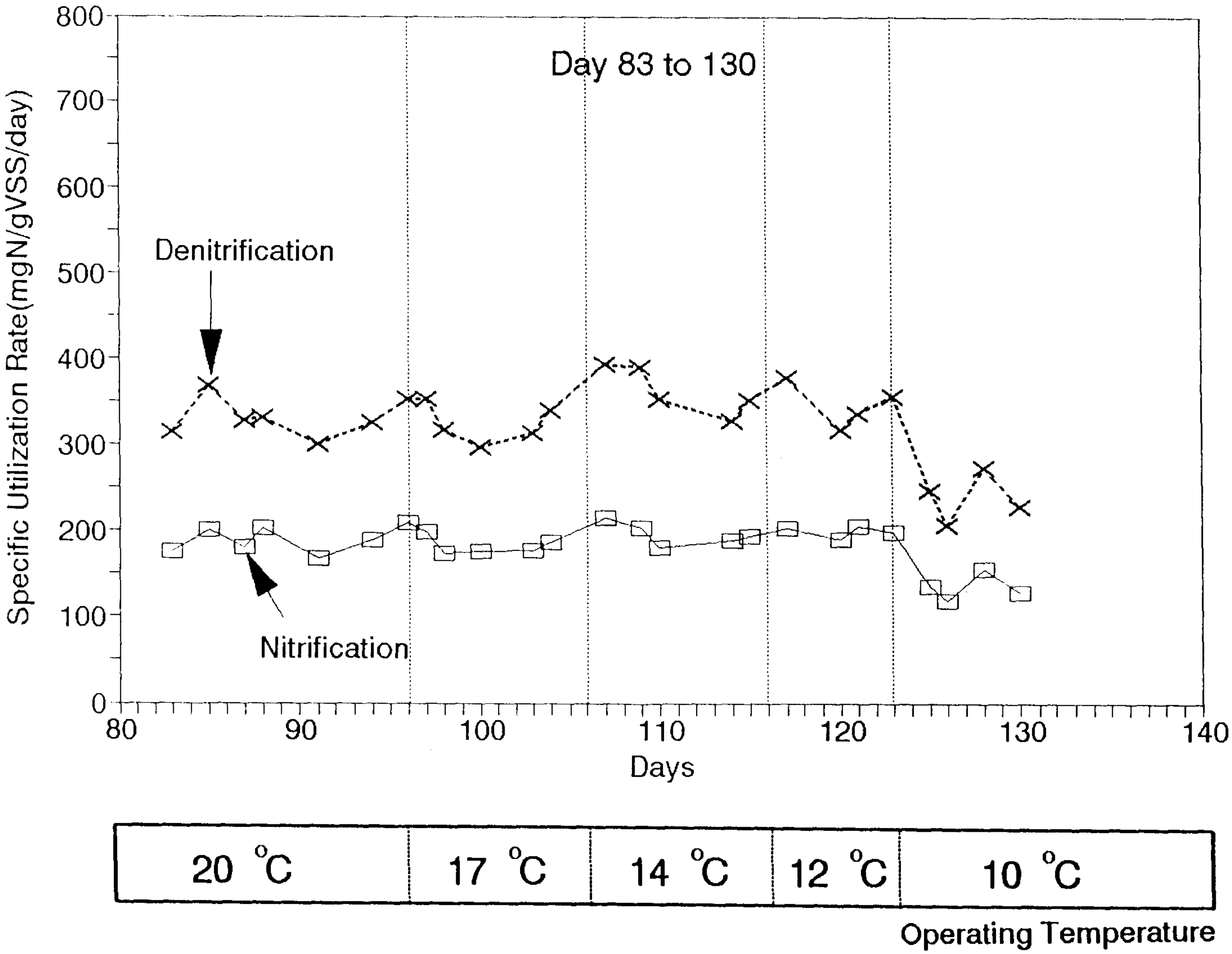


FIGURE 5.38: TEMPERATURE PHASE - 10 Day SRT System
Anoxic and Aerobic VSS

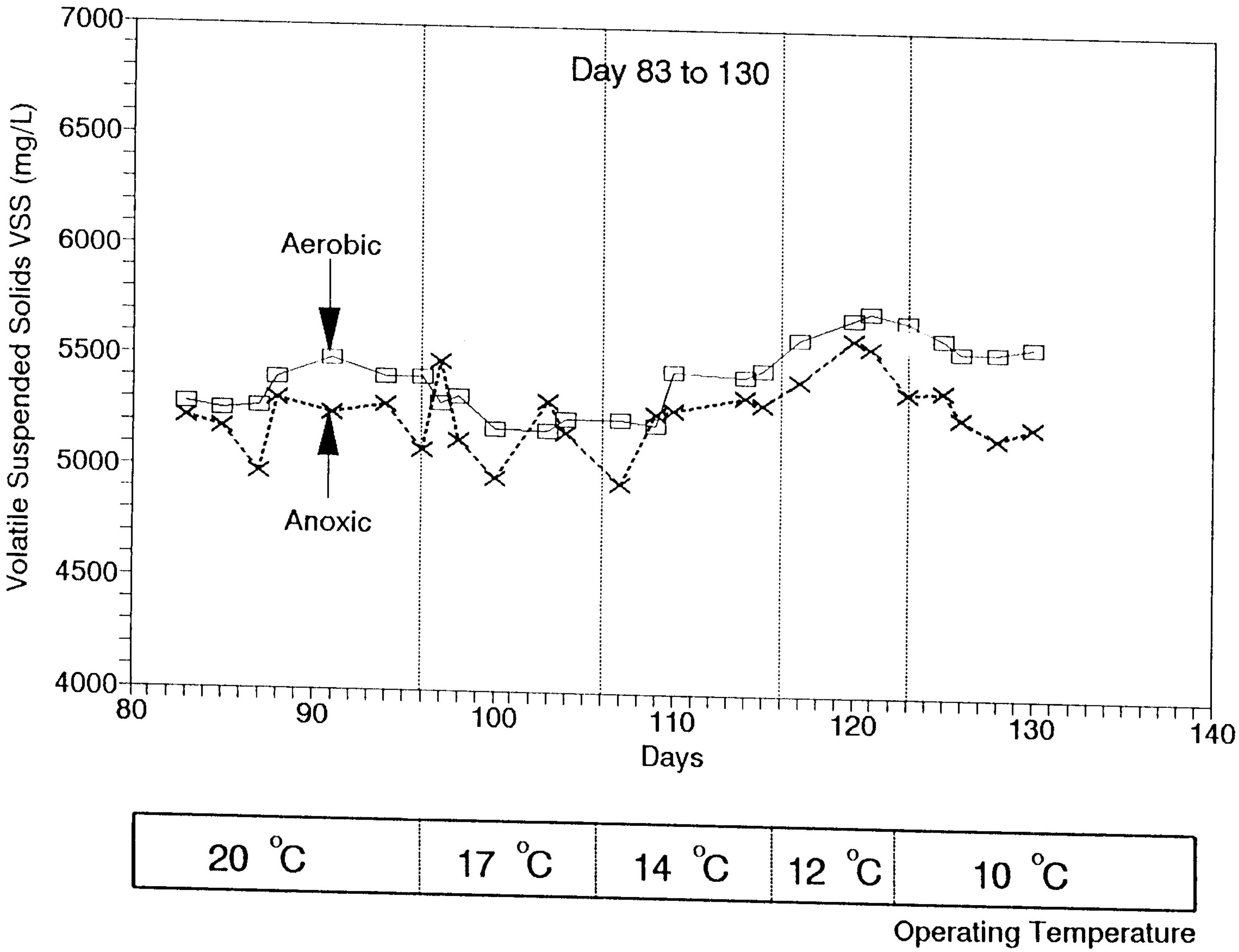
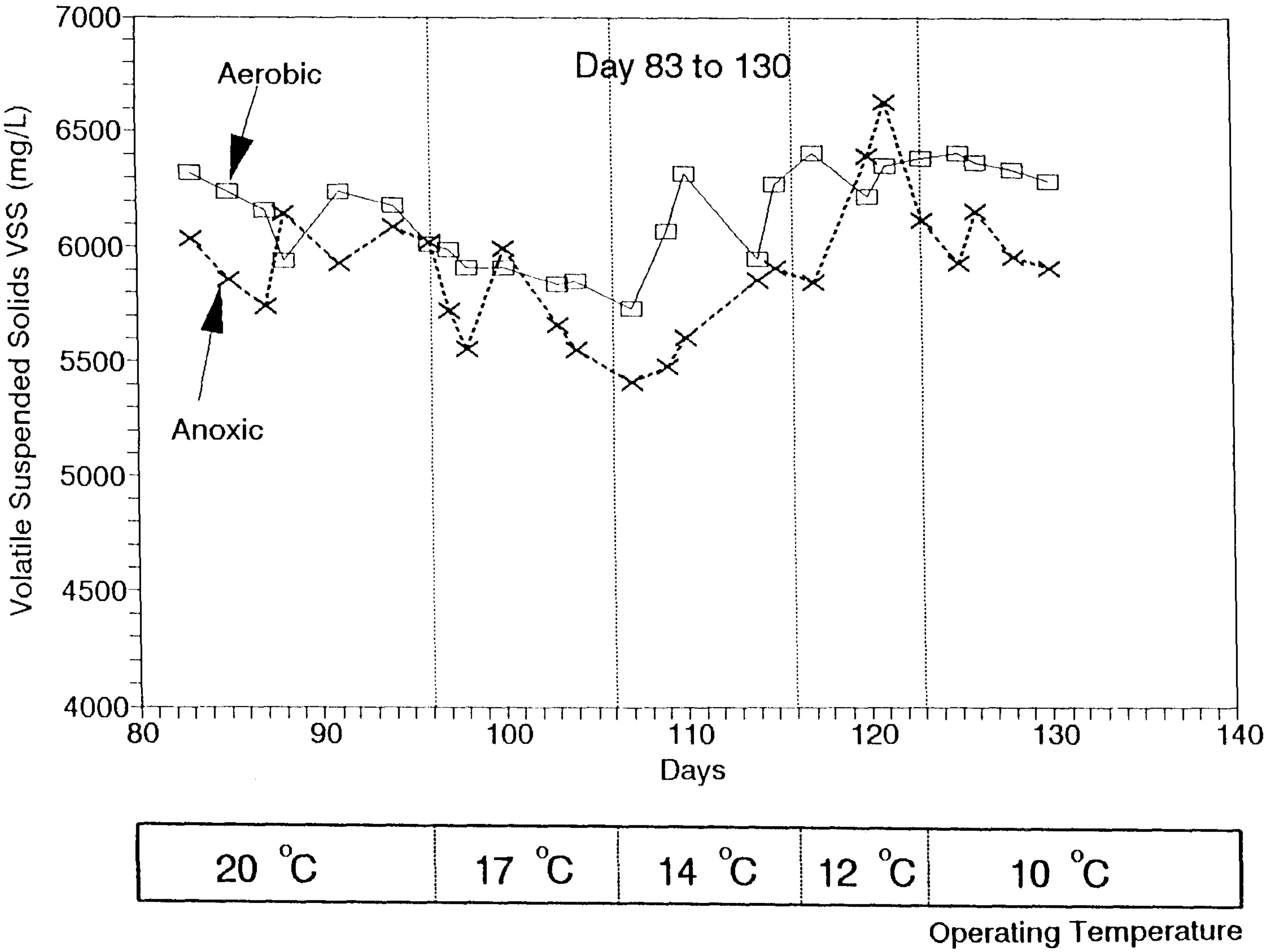


FIGURE 5.39: TEMPERATURE PHASE - 20 Day SRT System
Anoxic and Aerobic VSS



The effect of temperature may have also, to some degree, influenced the toxic effect of "free" ammonia and/or nitrous acid inhibition. The fraction of "free" ammonia decreases with decreasing temperature (therefore lowering the toxic effect of ammonia), while the fraction of nitrous acid increases with increasing temperature (therefore increasing the toxic effect of nitrous acid). The effect of aerobic BOD_5, which also increased as the temperature decreased, may have also played a role in nitrification failure. The increase in aerobic BOD_5 may have been due to enhanced carbon bleeding from the anoxic reactor as nitrite levels rose. The effect of aerobic SRT may have also been significant, as shown from the last part of the study.

5.2.4 10 °C Startups of Nitrification and SRT Failure

The objective of the last part of the study was to determine if nitrification could recover at 10 °C, with influent ammonia levels at 1500 mg N/L, under the conditions of no aerobic wasting and no methanol addition (ie. no denitrification). Figure 5.40 and 5.41 present the aerobic ammonia and % nitrification data for the 10 °C startup period of the cold temperature phase. The anoxic reactor was bypassed for the first few days until aerobic ammonia levels had been depleted, after which the anoxic reactor was re-introduced. After 10 days, nitrification in both systems was near 100 %, thus showing the ability of nitrification to recover at 10 °C from elevated reactor ammonia levels of approximately 500 mg N/L. The success of re-establishing nitrification at 10 °C, when it had failed earlier, may be due to no aerobic wasting (infinite theoretical aerobic SRT), or the lack of methanol addition and denitrification, or both. The lack of denitrification lowered the anoxic pH from 8.5 to 7.8, and consequently lowered the anoxic "free" ammonia by approximately 50 %. The lack of methanol addition also meant lower anoxic BOD_5 and less carbon bleeding, which would have resulted in higher aerobic dissolved oxygen levels.

Unfortunately, a failure in the air compressor for several hours on Day 145, resulted in complete nitrification failure and ammonia levels again rose to approximately 600 mg N/L. From this failure, while continuing not to waste from both systems and with no methanol addition, only one system recovered . The system which recovered was previously the "20 day SRT system". From Figure 5.41,

FIGURE 5.40: TEMPERATURE PHASE - 10 Day SRT System
Aerobic Ammonia and % Nitrification

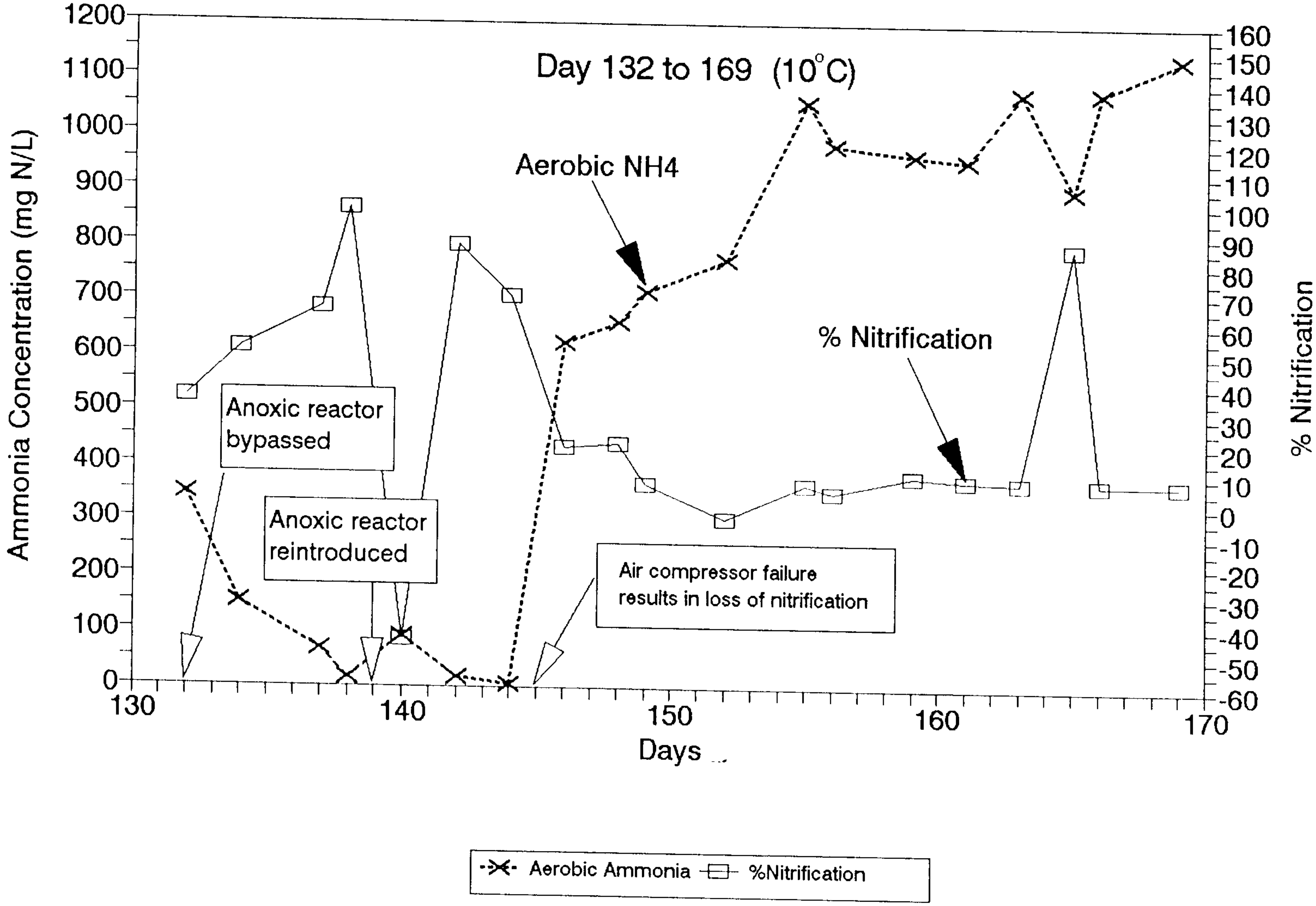
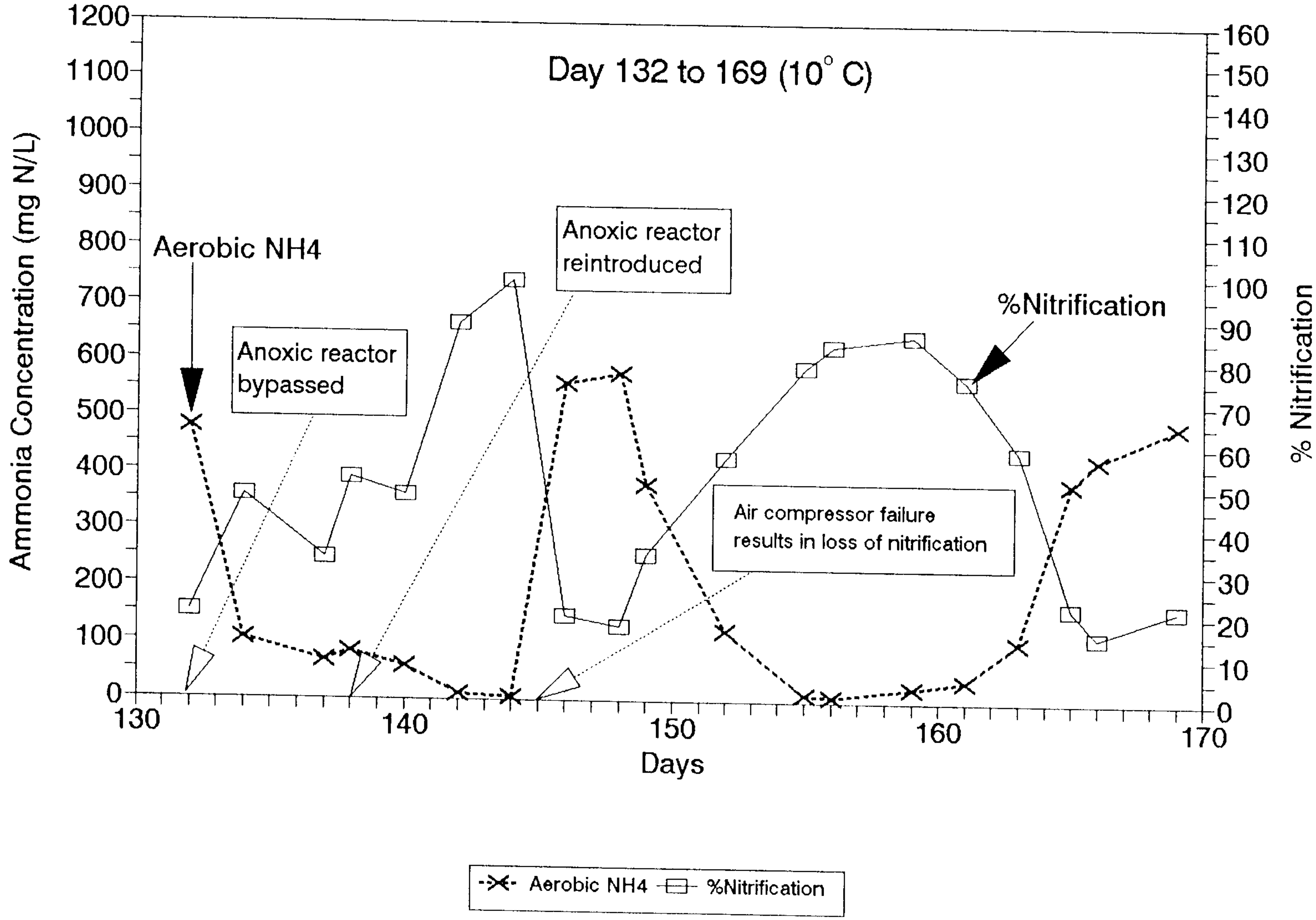


FIGURE 5.41: TEMPERATURE PHASE - 20 Day SRT System
Aerobic Ammonia and % Nitrification



it can be seen that by Day 155, the one remaining system had recovered to approximately 80 % nitrification. Throughout the recovery and the remainder of the study, the aerobic nitrite levels were approximately 200 mg N/L (see Figure 5.42 and 5.43) and the aerobic BOD_5 levels were approximately 50 mg/L. Meanwhile, in the system which did not recover (previously operated as the "10 day SRT system"), no wasting or methanol addition was performed, but % nitrification remained below 10 % and the aerobic ammonia levels climbed to 1000 mg/L and above (See Figure 5.40). The reason why one system recovered and the other failed is not clear.

To observe the effects of SRT, once complete nitrification was observed in the one working system, aerobic wasting was started on Day 156, to yield a 10 day aerobic SRT. SRT and % nitrification are shown in Figure 5.44. After only 14 days of wasting, aerobic ammonia levels had risen to 400 mg N/L. The failure may not have been entirely attributed to SRT alone, as high nitrite levels indicated the system was already stressed, and high aerobic BOD_5 levels (possible cell lysing) may have been associated with nitrification inhibition as previously observed. Another failure of the air supply, on Day 170, marked the end of the study, since no further lab time could be justified for this project.

FIGURE 5.42: TEMPERATURE PHASE - 10 Day SRT System
Aerobic Nitrite and % Nitrification

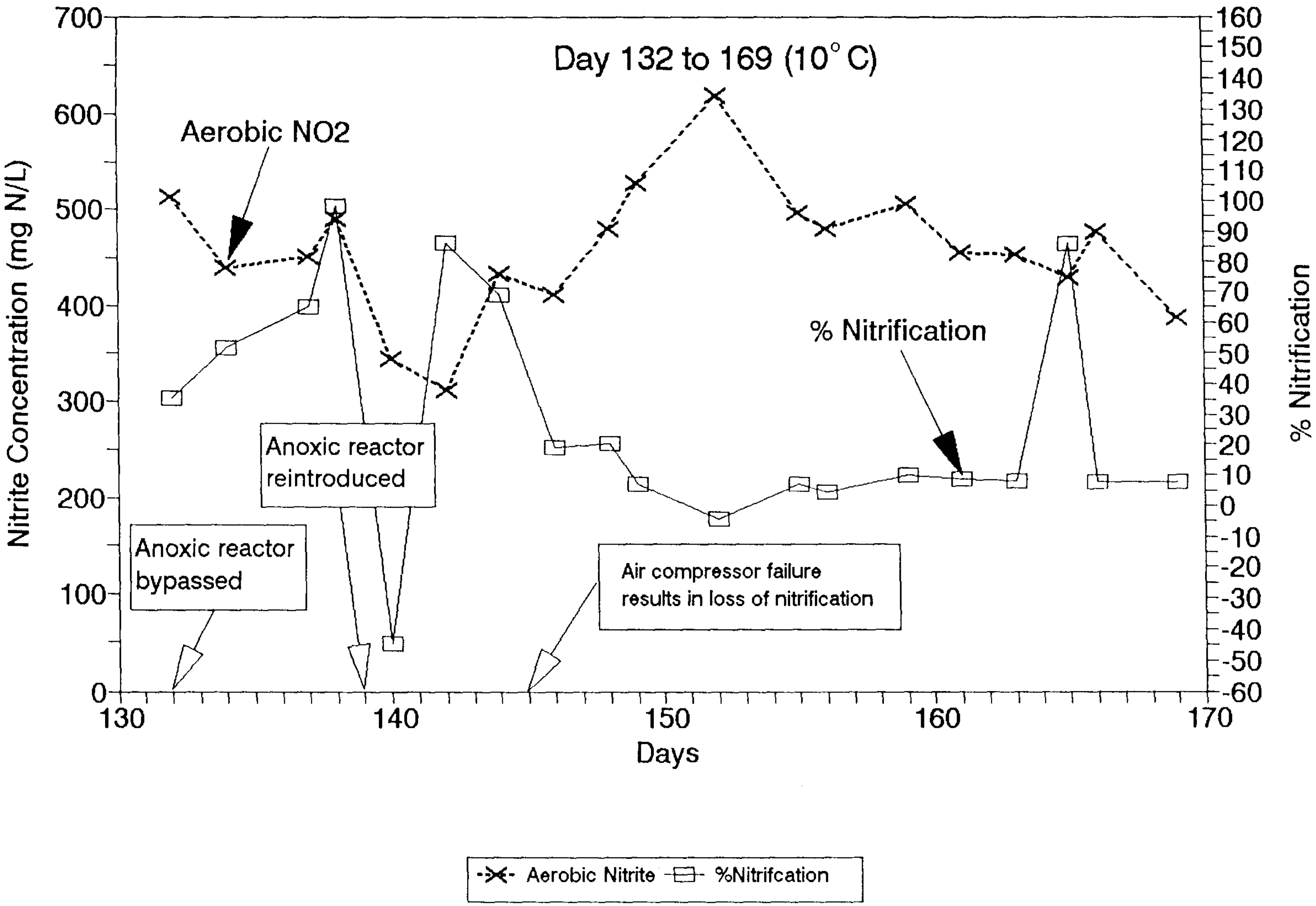


FIGURE 5.43: TEMPERATURE PHASE - 20 Day SRT System
Aerobic Nitrite and % Nitrification

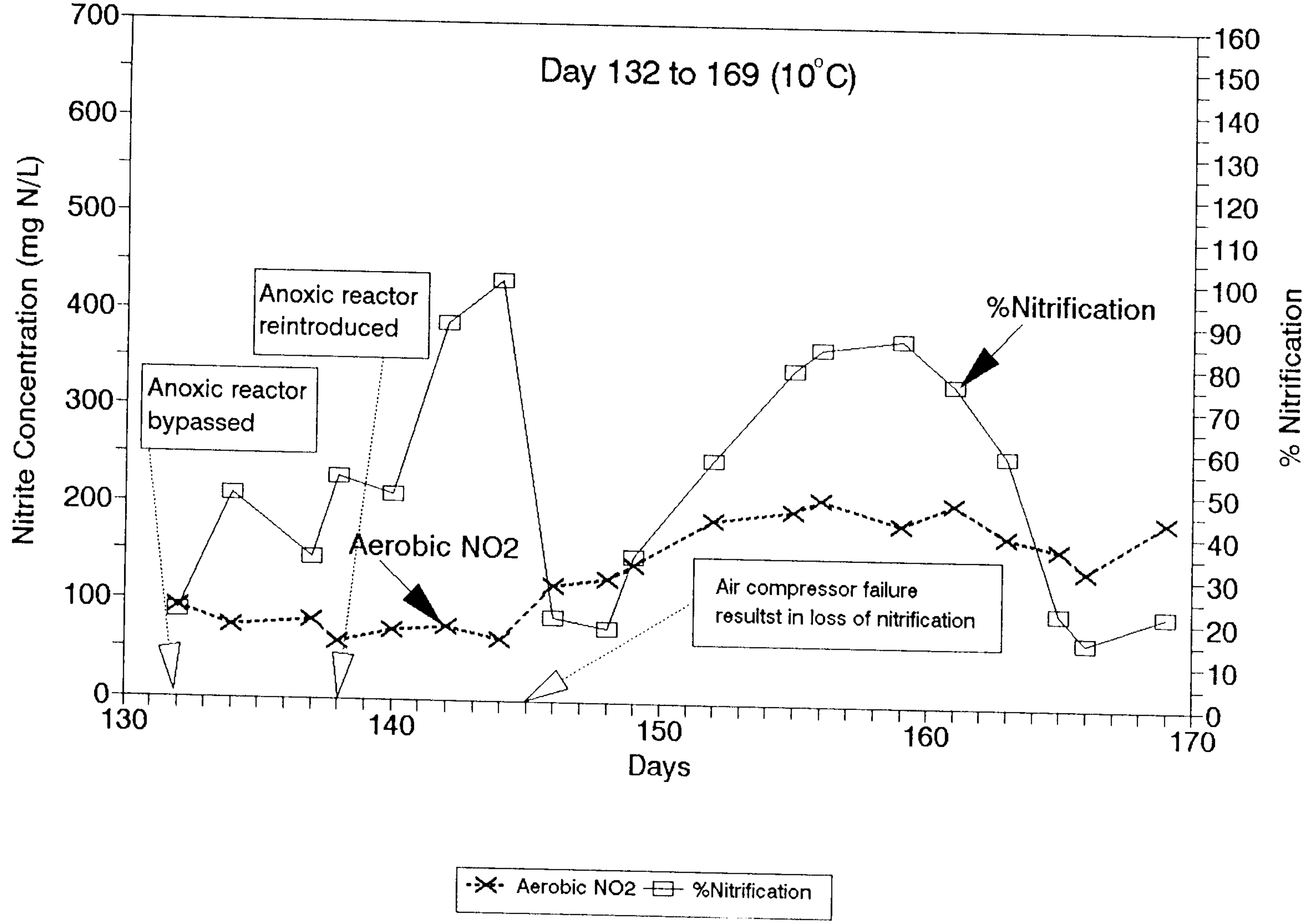
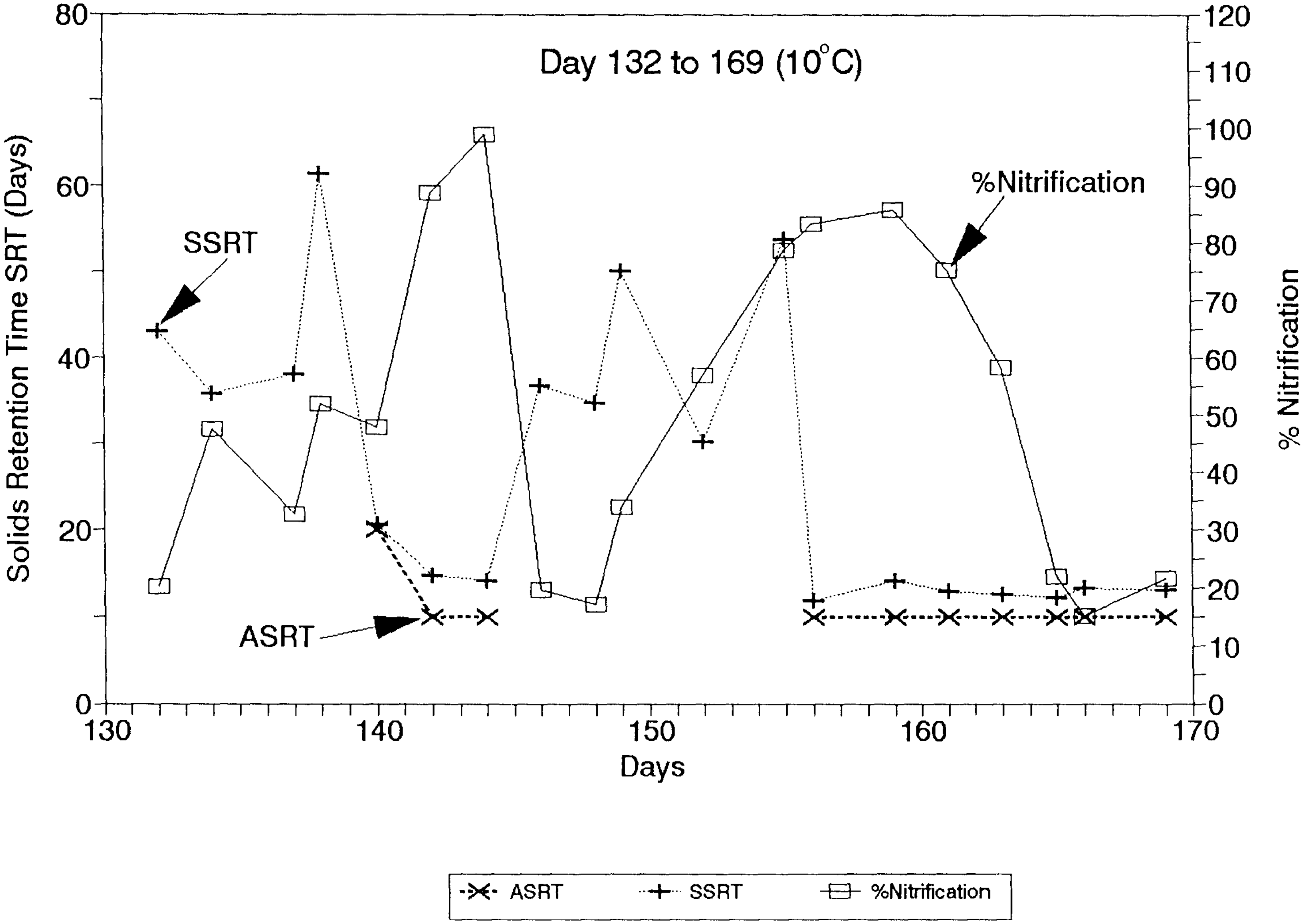


FIGURE 5.44: TEMPERATURE PHASE - 20 Day SRT System
ASRT, SSRT and % Nitrification



Chapter 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary of Results

Table 6.1 summarizes the key results obtained from this study. The table is placed here for quick referencing when reading the subsequent conclusions and recommendations.

6.2 Conclusions

The following conclusions can be made from the results of the two phases which comprised this study (the ammonia loading phase and the cold temperature phase):

1. A single-sludge, nitrification-predenitrification process, operating from 20 to 12 °C, with a recycle ratio of 6:1, an actual aerobic HRT of 3.4 hours, an actual anoxic HRT of 1.7 hours, and a theoretical aerobic SRT of either 10 or 20 days, was found capable of producing an effluent containing < 1 mg NH_4-N/L and approximately 170 mg NO_x^--N/L, from an influent leachate of 1500 mg NH_4-N/L (once the system had been optimized and stabilized at each influent ammonia level and at each temperature). MLE theory says that at a 6:1 recycle ratio, the effluent NO_x^- should be approximately 1500/(6+1) = 214 mg N/L. The difference is attributed to bacterial assimilation (ammonia stripping should be nominal).

2. At an influent ammonia level of 1500 mg N/L at 20 °C, for both the 10 and 20 day SRT systems, aerobic nitrite accumulation was observed to reach approximately 110 mg N/L (65% of aerobic NO_x^-). Increasing nitrite may have been a factor in the reduction of COD:NO_x from approximately 6:1 to 3.5:1. When both systems were restarted at 20 °C in the cold temperature phase, the nitrite accumulation had disappeared, and the COD:NO_x^- ratio was approximately 5:1.

3. When the influent ammonia concentration was increased from 200 to 1500 mg N/L in the leachate, the difference between the anoxic pH and the aerobic pH was observed to increase from

TABLE 6.1: Summary of Results

Ammonia Loading Phase @ 20 °C						
Influent NH_4 (mgN/L)	**200**	**300**	**600**	**1000**	**1500**	**2000***
10 Day SRT System						
Aerobic NH_4 (mgN/L)	<1	<1	<1	<1	<1	700
Aerobic NO_x^- (mgN/L)	25	50	80	125	170	70
Aerobic NO_2^- (mgN/L)	<1	<1	15	85	110	65
Aerobic pH	7.5	7.5	7.4	7.3	7.5	8.5
Anoxic NH_4 (mgN/L)	25	50	70	130	180	750
Anoxic NO_x^- (mgN/L)	<1	<1	<1	5	<1	<1
Anoxic pH	7.8	7.9	8.0	8.3	8.4	8.5
COD:NO_x (mgCOD/mgN)	6.0	6.0	4.8	3.5	4.5	9.7
% Nitrification	100	100	100	97	91	20
% Denitrification	98	98	99	99	99	97
20 Day SRT System						
Aerobic NH_4 (mgN/L)	<1	<1	<1	<1	<1	600
Aerobic NO_x^- (mgN/L)	25	45	80	135	170	80
Aerobic NO_2^- (mgN/L)	<1	<1	20	80	100	75
Aerobic pH	7.5	7.3	7.5	7.3	7.5	8.4
Anoxic NH_4 (mgN/L)	25	45	80	140	180	750
Anoxic NO_x^- (mgN/L)	<1	<1	<1	<1	<1	3.5
Anoxic pH	7.8	7.7	8.2	8.2	8.5	8.6
COD:NO_x (mgO_2/mgN)	6.2	6.4	4.8	3.5	4.0	4.7
% Nitrification	100	100	100	100	100	17
% Denitrification	98	99	100	99	95	93

Cold Temperature Phase @ 1500 mg NH_4-N/L in Influent					
Temperature (°C)	**20**	**17**	**14***	**12***	**10***
10 Day SRT System					
Aerobic NH_4 (mgN/L)	<1	<1	<1	<1	490
Aerobic NO_x^- (mgN/L)	170	165	170	175	260
Aerobic NO_2^- (mgN/L)	<1	<1	10	90	220
Aerobic BOD_5 (mgO_2/L)	20	12	10	35	120
Anoxic NH_4 (mgN/L)	170	160	180	180	680
Anoxic NO_x^- (mgN/L)	2	3	1	1	140
COD:NO_x (mgO_2/mgN)	5.2	4.9	4.9	4.8	13.2
% Nitrification	97	100	91	94	15
% Denitrification	99	99	100	99	30
20 Day SRT System					
Aerobic NH_4 (mgN/L)	<1	<1	<1	<1	560
Aerobic NO_x^- (mgN/L)	170	155	170	155	135
Aerobic NO_2^- (mgN/L)	<1	<1	<1	65	120
Aerobic BOD_5 (mgO_2/L)	14	12	11	15	56
Anoxic NH_4 (mgN/L)	180	165	175	160	680
Anoxic NO_x^- (mgN/L)	3	2	2	2	23
COD:NO_x (mgO_2/mgN)	5.0	5.5	4.8	4.5	6.3
% Nitrification	99	94	92	100	22
% Denitrification	98	99	99	99	82

*The measurements during these periods do not represent a stabilized system, especially at the influent ammonia level equal to 2000 mg N/L during the ammonia loading phase, and for the temperature equal to 10 °C during the cold temperature phase.

approximately 0.3 to 1.0. Since the aerobic pH was maintained at approximately 7.5, this corresponded to an increase in anoxic pH from approximately 7.8 to 8.5. This suggests that ifhigher ammonia concentrations are to be treated, higher anoxic pHs might be incurred, thus raising the possibility of pH and "free" ammonia inhibition of nitrification and denitrification in the anoxic reactor. Lowering the aerobic pH to 7.2 or 7.3 may provide sufficiently low anoxic pHs to avoid pH-associated toxicity problems in the anoxic reactor.

4. Aerobic nitrite accumulation during the ammonia loading phase may have had several causes including: low dissolved oxygen, aerobic nitrous acid, and anoxic "free" ammonia. Anoxic "free" ammonia levels are estimated to have reached 20 mg N/L at an influent ammonia level of 1500 mg N/L. Nitrifiers would have been exposed to these elevated "free" ammonia levels as they cycled through the anoxic reactor. Acclimatization of the nitrite oxidizers to the elevated "free" anoxic ammonia levels may have accounted for the disappearance of the nitrite accumulation during the 20 °C startup of the cold temperature phase. Other possible reasons for the disappearance of the nitrite accumulation are higher dissolved oxygen levels in the aerobic reactor, and a steady aerobic pH = 7.5.

5. When the leachate ammonia concentration was increased from 1500 to 2000 mg N/L, % nitrification decreased in both systems, from > 90 % to approximately 20 %. Possible reasons for the failure of nitrification include insufficient dissolved oxygen, solids/scum/foaming problems, and inhibition of the ammonia oxidizers (*Nitrosomonas*) due to cyclic exposure to elevated levels of "free" ammonia in the anoxic reactor.

6. During the loading failure period, when the leachate ammonia concentration was 2000 mg N/L, % denitrification continued to be greater than 90 %, despite "free" ammonia levels as high as 80 mg N/L.

7. During the cold temperature phase 20 °C startup, elevated aerobic BOD_5, associated with methanol, was observed to correspond to reduced nitrification. Inhibition may have been due to several possibilities including heterotrophic competition for limited dissolved oxygen, or methanol toxicity.

8. For both SRT systems, when the operating temperature was decreased from 12 °C to 10 °C, while treating a leachate with 1500 mg NH_4-N/L, % nitrification decreased from approximately 100 % to 20 %. For the 10 day SRT system at 10 °C, denitrification was reduced from 99 to 30 %. For the 20 day SRT system, denitrification was reduced from 99 % to 82 %. Rising aerobic nitrites and aerobic BOD_5, began at 14 °C, and were the only apparent signs of cold temperature inhibition. However, it is possible that failure had begun at 14 °C but insufficient time was given for more complete failure to occur. The rise in aerobic nitrites, and the failure of nitrification in both systems, suggests that cold temperature was more inhibitive to nitrification than to denitrification.

9. After failure of nitrification at 10 °C, aerobic wasting and methanol addition were ceased. Nitrification managed to re-establish itself at 10 °C, despite aerobic ammonia levels of approximately 500 mg N/L, and aerobic BOD_5 levels greater than 50 mg/L. Thus, short SRTs and/or methanol addition (resulting in elevated anoxic pH, elevated anoxic "free" ammonia, and possible carbon bleeding) were shown to have inhibitive effects at 10 °C. A test to determine the effect of shortening the theoretical aerobic SRT from infinite to 10 days resulted in complete system failure in only fourteen days. However, this result was complicated by elevated aerobic BOD_5 levels throughout the latter part of the study, presumably from cell lysing.

6.3 Recommendations

From the results of this study, the following recommendations for further research are made:

1. A study should be conducted to investigate the addition of post-denitrification to this system, to further reduce effluent NO_x^-. Post-denitrification will require the addition of another anoxic reactor for denitrification, and subsequent aerobic reactor for BOD_5 reduction and sweetening. Metcalf and Eddy (1991) suggest that both reactors may be placed after the first aerobic reactor. Therefore the process train still maintains only one clarifier. The solids underflow is recycled back to the anoxic reactor for MLVSS control. The aerobic mixed liquor from the first aerobic reactor can be recycled directly back to the first anoxic reactor for controlling the recycle ratio and the actual HRT.

2. Further investigations should be conducted to determine the maximum recycle ratio, to further reduce effluent NO_x^-. If higher maximum recycle ratios are achievable, the need for post-denitrification may be obviated. Elefsiniotis et al (1989) determined that the optimum recycle ratio for this system was about 6:1. Higher recycle ratios were found to result in system instability due to lower actual HRT. However, Robinson (1992) has successfully used a recycle ratio of 10:1, but with a considerably longer HRT. The study should investigate the maximum recycle ratio possible, while maintaining the same actual HRT (by decreasing influent flowrate). A more broad study might try several recycle ratios at a number of HRTs, while also investigating the effect of SRT. To avoid inefficient clarification at higher recycle ratios, and for better overall control, the addition of a direct recycle from the aerobic reactor to the anoxic reactor should be considered.

3. A study should be conducted to investigate ammonia, elevated pH, and "free" ammonia toxicity to denitrification. This aspect of the single-sludge predenitrification system is a fundamental concern when treating high ammonia leachate.

4. A continuation of the ammonia loading phase of this study should be conducted to determine if the reason for failure when the influent ammonia concentration was increased from 1500 mg N/L to 2000 mg N/L, was mechanical or biological. The two mechanical reasons (both problems of scale) that may have caused the system to fail were clogging (resulting in overflows) and low dissolved oxygen levels. Reactor tubing and overflows should be designed in advance to handle high solids, foaming in the aerobic reactor, and floating scum in the anoxic reactor. Fine bubble diffusers and aerobic reactors with greater height to width ratio might help achieve better dissolved oxygen. Eliminating the potential mechanical reasons for failure, a higher influent ammonia level might be treated, with the limit being biological instead of mechanical.

5. Further temperature studies should be conducted to determine the potential for treatment at temperatures colder than 12 °C, while operating at influent ammonia concentrations of 1500 mg N/L or higher. Long SRTs and careful control of methanol addition may result in establishing both complete nitrification and denitrification at temperatures below 12 °C.

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APPENDICES

Appendix A:	Calculation Definitions
Appendix B:	Raw and Calculated Data

APPENDIX A:

CALCULATION DEFINITIONS

ANOXIC OVERFLOW (L/d) = INFLUENT FLOW (L/d) + RECYCLE FLOW (L/d) + [NH4CL FEED FLOW (mL/h) + METHANOL FEED FLOW (mL/h) + PHOSPHATE FEED FLOW (mL/h)] x 24 (h/d) x 1/1000 (L/mL)

AEROBIC OVERFLOW (L/d) = ANOXIC OVERFLOW (L/d) + BICARBONATE FEED FLOW (mL/h) x 24 (h/d) x 1/1000 (L/mL)

SIMULATED INFLUENT NH4 CONCENTRATION (mgN/L) = [NH4CL FEED FLOW (mL/h) x NH4CL FEED CONCENTRATION (gNH4Cl/L) x 1/1000 (L/mL) x 24 (h/d)x 14/53.5 (gN/gNH4Cl) x 1000 (mg/g) + INFLUENT NH4 CONCENTRATION (mgN/L) x INFLUENT FLOW (L/d)] / [INFLUENT FLOW (L/d) + NH4CL FEED FLOW (mL/h) x 24 (h/d) x 1/1000 (L/mL)]

NITRIFICATION RATE (mgN/d) = AEROBIC NOX CONCENTRATION (mgN/L) x AEROBIC OVERFLOW (L/d) - ANOXIC NOX CONCENTRATION (mgN/L) x ANOXIC OVERFLOW (L/d)

ANOXIC NOX LOAD (mgN/d) = INFLUENT NOX CONCENTRATION (mgN/L) x INFLUENT FLOW (L/d) + AEROBIC NOX CONCENTRATION (mgN/L) x RECYCLE FLOW (L/d)

DENITRIFICATION RATE (mgN/d) = ANOXIC NOX LOAD (mgN/d) - ANOXIC NOX CONCENTRATION (mgN/L) x ANOXIC OVERFLOW (L/d)

% NITRIFICATION = NITRIFICATION RATE (mgN/d) / [ANOXIC NH4 CONCENTRATION (mgN/L) x ANOXIC OVERFLOW (L/d)]

% DENITRIFICATION = DENITRIFICATION RATE / [INFLUENT NOX CONCENTRATION (mgN/L) x INFLUENT FLOW (L/d) + AEROBIC NOX CONCENTRATION (mgN/L) x RECYCLE FLOW (L/d)]

SPECIFIC NITRIFICATION RATE (mgN/d/gVSS) = NITRIFICATION RATE (mgN/d) / AEROBIC VSS CONCENTRATION (mgVSS/L) / 10 (L) x 1000 (mg/g) x 1/24 (d/h)

SPECIFIC DENITRIFICATION RATE (mgN/d/gVSS) = DENITRIFICATION RATE (mgN/d) / ANOXIC VSS CONCENTRATION (mgVSS/L) / 5 (L) x 1000 (mg/g) x 1/24 (d/h)

TOTAL ALKALINITY ADDED (mgCaCO3/d) = INFLUENT ALKALINITY CONCENTRATION (mg CaCO3/L) x INFLUENT FLOW (mL/h) + BICARBONATE FEED CONCENTRATION (g NaHCO3/L) x BICARBONATE FEED FLOW (mL/h) x 24 (h/d) x 1/1000 (L/mL) x 50/84 (mgCaCO3/mgNaHCO3)

ALKALINITY:NH4 ADDED (mgCaCO3/mgN) = TOTAL ALKALINITY ADDED (mgCaCO3/d) / SIMULATED INFLUENT NH4 CONCENTRATION (mg N/L) x {INFLUENT + NH4CL} FLOW (L/d)

ALKALINITY:N NITRIFIED (mgCaCO3/mgN) = TOTAL ALKALINITY ADDED (mgCaCO3/d) / NITRIFICATION RATE (mgN/d)

ANOXIC METHANOL COD LOAD (mgCOD/d) = METHANOL FEED CONCENTRATION (mL CH3OH/L) x METHANOL FEED FLOW (mL/h) x 791.5 (mgCH3OH/mLCH3OH) x 1.5 (mgCOD/mgCH3OH) x 1/1000 (L/mL) x 24 (h/d)

COD:NOX ENTERING ANOXIC REACTOR (mgCOD/mgN) = ANOXIC METHANOL COD LOAD (mgCOD/d) / ANOXIC NOX LOAD (mgN/d)

COD:NOX REMOVED IN ANOXIC REACTOR (mgCOD/mgN) = ANOXIC METHANOL COD LOAD (mgCOD/d) / [ANOXIC NOX LOAD (mgN/d) - ANOXIC NOX CONCENTRATION (mgN/L) x ANOXIC OVERFLOW (L/d)]

ANOXIC NH4 REMOVAL RATE (mgN/d) = INFLUENT NH4 CONCENTRATION (mgN/L) x INFLUENT FLOW (L/d) + NH4CL FEED CONCENTRATION (mgN/L) x NH4CL FEED FLOW (L/d) + AEROBIC NH4 CONCENTRATION (mgN/L) x RECYCLE FLOW (L/d) - ANOXIC NH4 CONCENTRATION (mgN/L) x ANOXIC OVERFLOW (L/d)

AEROBIC NH4 REMOVAL RATE (mgN/d) = ANOXIC NH4 CONCENTRATION (mgN/L) x ANOXIC OVERFLOW (L/d) - AEROBIC NH4 CONCENTRATION (mgN/L) x AEROBIC OVERFLOW (L/d)

% ANOXIC NH4 REMOVAL = [INFLUENT NH4 CONCENTRATION (mgN/L) x INFLUENT FLOW (L/d) + NH4CL FEED CONCENTRATION (mgN/L) x NH4CL FEED FLOW (L/d) + AEROBIC NH4 CONCENTRATION (mgN/L) x RECYCLE FLOW (L/d) - ANOXIC NH4 CONCENTRATION (mgN/L) x ANOXIC OVERFLOW (L/d)] / [INFLUENT NH4 CONCENTRATION (mgN/L) x INFLUENT FLOW (L/d) + NH4CL FEED CONCENTRATION (mgN/L) x NH4CL FEED FLOW (L/d) + AEROBIC NH4 CONCENTRATION (mgN/L) x RECYCLE FLOW (L/d)]

% AEROBIC NH4 REMOVAL (mgN/d) = ANOXIC NH4 CONCENTRATION (mgN/L) x ANOXIC OVERFLOW (L/d) - AEROBIC NH4 CONCENTRATION (mgN/L) x AEROBIC OVERFLOW (L/d) / [ANOXIC NH4 CONCENTRATION (mgN/L) x ANOXIC OVERFLOW (L/d)]

SSRT (d) = [ANOXIC VSS CONCENTRATION (mgVSS/L) x 5 (L) + AEROBIC VSS CONCENTRATION (mgVSS/L) x 15 (L)] / [AEROBIC VSS CONCENTRATION (mgVSS/L) x AEROBIC VOLUME WASTED (L) + EFFLUENT VSS CONCENTRATION (mgVSS/L) x [AEROBIC OVERFLOW (L/d) - RECYCLE FLOW (L/d)]]

APPENDIX B:

RAW AND CALCULATED DATA

Ammonia Loading Phase

- Influent Characteristics
- 10 Day Aerobic SRT System
- 20 Day Aerobic SRT System

Cold Temperature Phase

- Temperature and Influent Characteristics
- 10 Day Aerobic SRT System
- 20 Day Aerobic SRT System

AMMONIA LOADING PHASE (10 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Influent pH	Influent Alkalinity (mgCaCO3/L)	Influent VSS (mg/L)	Influent TSS (mg/L)	Influent PO4 (mgP/L)	Influent NH4 (mgN/L)	Influent NOx (mgN/L)
91	08	12	1		2120	24	56	0.2	211	3.1
91	08	14	3					0.3	205	1.2
91	08	16	5					0.2	216	1.1
91	08	18	7		1980			0.3	217	1.1
91	08	20	9	7.9				0.4	225	2.4
91	08	23	12					0.4	246	2.7
91	08	26	15		2060			0.1	213	58.8
91	08	28	17	7.8				0.2	214	21.3
91	08	31	20	7.6				0.2	218	2.2
91	09	2	22	8.3				0.3	224	4.6
91	09	4	24	8.1	1910			0.3	220	4.6
91	09	7	27	7.9				0.4	208	6.3
91	09	9	29	8.0				0.3	217	3.4
91	09	12	32	8.2				0.3	217	2.2
91	09	16	36	8.0		28	68	0.2	203	1.8
91	09	17	37	8.1	1860	54	115	0.4	196	1.0
91	09	19	39	8.2				0.4	214	0.7
91	09	21	41	8.0				0.4	197	0.4
91	09	23	43	8.1				0.4	205	1.8
91	09	26	46	8.2				0.3	221	0.9
91	09	28	48					0.4	196	0.2
91	09	30	50					0.4	185	0.2
91	10	2	52	8.1				0.4	199	5.3
91	10	4	54					0.3	209	13.3
91	10	6	56					0.4	202	13.3
91	10	8	58	8.3				0.4	201	8.7
91	10	11	61			45	109	0.4	188	5.8
91	10	14	64					0.4	194	2.2
91	10	16	66	7.9	1200	31	58	0.4	206	1.1
91	10	18	68					0.5	233	0.3
91	10	20	70					0.6	207	0.3
91	10	23	73	7.8				0.5	217	0.6
91	10	25	75					0.5	204	0.4
91	10	27	77					0.5	215	0.8
91	10	29	79	7.8				0.5	226	1.0
91	11	1	82					0.5	233	0.6
91	11	3	84					0.5	195	0.9
91	11	5	86					0.6	222	1.0
91	11	7	88	7.9				0.7	228	1.0
91	11	10	91					0.6	228	0.8
91	11	12	93					0.6	211	0.5
91	11	13	94	7.8				0.6	213	0.5
91	11	15	96	8.0	1360	44	104	0.6	190	0.3
91	11	17	98					0.7	198	0.3
91	11	20	101					0.7	203	0.3
91	11	22	103	7.9				0.7	204	0.2

AMMONIA LOADING PHASE (10 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Influent pH	Influent Alkalinity (mgCaCO3/L)	Influent VSS (mg/L)	Influent TSS (mg/L)	Influent PO4 (mgP/L)	Influent NH4 (mgN/L)	Influent NOx (mgN/L)
91	11	25	106					0.6	194	0.4
91	11	26	107					0.6	233	0.4
91	11	29	110	8.1				0.5	182	0.2
91	12	2	113					0.5	190	0.3
91	12	4	115					0.7	205	0.1
91	12	6	117	8.0				0.7	200	0.3
91	12	7	118					0.7	203	0.5
91	12	9	120					0.6	177	0.6
91	12	11	122					0.7	196	0.6
91	12	13	124	7.9				0.7	196	0.4
91	12	16	127		1650	32	118	0.6	139	0.2
91	12	18	129					0.5	137	0.3
91	12	20	131	8.1				0.4	153	0.7
91	12	22	133	7.7				0.4	174	0.4
91	12	24	135					0.3	183	0.3
91	12	26	137					0.2	148	1.0
91	12	30	141	7.9				0.2	56	0.7
92	01	2	144					0.2	151	0.9
92	01	5	147					0.1	137	0.6
92	01	6	148					0.1	156	0.7
92	01	8	150					0.0	184	0.6
92	01	10	152					0.1	161	0.8
92	01	12	154					0.1	152	1.2
92	01	14	156					0.2	150	0.6
92	01	15	157	7.8				0.2	177	0.8
92	01	17	159	7.9	1310	60	124	0.3	212	0.6
92	01	20	162					0.3	201	0.7
92	01	22	164					0.3	225	0.4
92	01	24	166					0.2	188	0.4
92	01	26	168					0.2	225	1.0
92	01	30	172					0.1	210	0.8
92	01	31	173					0.2	215	0.7
92	02	2	175					0.2	207	0.4
92	02	3	176					0.2	200	1.0
92	02	5	178					0.3	188	1.2
92	02	6	179					0.2	183	0.7
92	02	7	180					0.2	183	1.1
92	02	10	183					0.1	230	0.9
92	02	11	184					0.1	210	0.5
92	02	12	185					0.2	207	0.5
92	02	13	186					0.3	207	1.1
92	02	14	187					0.2	217	1.0
92	02	16	189	8.0	1325	48	95	0.2	131	1.0
92	02	18	191	7.8				0.2	143	2.4
92	02	19	192					0.3	157	3.8
92	02	21	194					0.2	155	3.8

AMMONIA LOADING PHASE (10 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Influent pH	Influent Alkalinity (mgCaCO3/L)	Influent VSS (mg/L)	Influent TSS (mg/L)	Influent PO4 (mgP/L)	Influent NH4 (mgN/L)	Influent NOx (mgN/L)
92	02	24	197					0.3	138	4.0
92	02	27	200					0.2	143	4.1
92	02	28	201					0.2	136	3.4
92	02	29	202					0.1	128	3.0
92	03	1	203					0.1	135	3.8
92	03	2	204					0.2	163	4.3
92	03	3	205					0.3	164	2.3
92	03	4	206					0.3	144	2.9
92	03	5	207					0.2	137	3.2
92	03	6	208					0.2	137	3.5
92	03	7	209					0.2	149	2.3
92	03	10	212						163	
92	03	11	213						129	

AMMONIA LOADING PHASE (10 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Influent NO2 (mgN/L)	Influent BOD (mg/L)	Influent COD (mg/L)
91	08	12	1			
91	08	14	3		21	452
91	08	16	5			
91	08	18	7			
91	08	20	9	0.5	24	442
91	08	23	12			
91	08	26	15			
91	08	28	17	3.3		
91	08	31	20			
91	09	2	22			
91	09	4	24	0.5	23	464
91	09	7	27			
91	09	9	29			
91	09	12	32			
91	09	16	36			
91	09	17	37	0.0	38	334
91	09	19	39			
91	09	21	41			
91	09	23	43	0.3		
91	09	26	46			
91	09	28	48			
91	09	30	50	0.0		
91	10	2	52			
91	10	4	54			
91	10	6	56	2.3		
91	10	8	58			
91	10	11	61		35	342
91	10	14	64	0.1		
91	10	16	66			
91	10	18	68			
91	10	20	70			
91	10	23	73	0.1		
91	10	25	75			
91	10	27	77			
91	10	29	79			
91	11	1	82	0.1		
91	11	3	84			
91	11	5	86			
91	11	7	88		41	368
91	11	10	91			
91	11	12	93			
91	11	13	94			
91	11	15	96			
91	11	17	98			
91	11	20	101			
91	11	22	103			

AMMONIA LOADING PHASE (10 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Influent NO2 (mgN/L)	Influent BOD (mg/L)	Influent COD (mg/L)
91	11	25	106			
91	11	26	107			
91	11	29	110			
91	12	2	113		28	421
91	12	4	115			
91	12	6	117			
91	12	7	118			
91	12	9	120			
91	12	11	122			
91	12	13	124			
91	12	16	127			
91	12	18	129	0.0		
91	12	20	131		62	354
91	12	22	133			
91	12	24	135	0.1		
91	12	26	137			
91	12	30	141			
92	01	2	144	0.1		
92	01	5	147			
92	01	6	148	0.1		
92	01	8	150			
92	01	10	152	0.0	58	415
92	01	12	154	0.1		
92	01	14	156	0.1		
92	01	15	157	0.0		
92	01	17	159	0.1		
92	01	20	162	0.0		
92	01	22	164		42	436
92	01	24	166			
92	01	26	168			
92	01	30	172			
92	01	31	173			
92	02	2	175			
92	02	3	176	0.1		
92	02	5	178			
92	02	6	179			
92	02	7	180			
92	02	10	183			
92	02	11	184		38	374
92	02	12	185	0.0		
92	02	13	186			
92	02	14	187	0.0		
92	02	16	189		20	334
92	02	18	191	0.1		
92	02	19	192			
92	02	21	194			

AMMONIA LOADING PHASE (10 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Flowrate Influent (L/d)	Flowrate NH4Cl (mL/h)	Flowrate CH3OH (mL/h)	Flowrate NaHCO3 (mL/h)	Flowrate PO4 (mL/h)	Flowrate Recycle (L/d)	Flowrate Aerobic Wasting (L/d)	Flowrate Anoxic Overflow (L/d)
91	08	12	1	10.1	0	0	0	3.5	55	0	65
91	08	14	3	10.1	0	0	0	4.1	66	0	76
91	08	16	5	9.8	0	0	0	4.8	64	0	74
91	08	18	7	9.9	0	0	0	5.2	65	0	75
91	08	20	9	9.3	0	0	0	5.1	53	0	63
91	08	23	12	10.1	0	0	0	5.1	55	0	66
91	08	26	15	10.0	0	0	0	5.0	57	0	67
91	08	28	17	9.2	0	0	0	4.8	59	0	69
91	08	31	20	10.0	0	0	0	5.0	55	0	65
91	09	2	22	10.2	0	0	0	4.8	62	0	73
91	09	4	24	10.4	0	0	0	4.8	61	1	71
91	09	7	27	9.8	0	6	0	4.7	54	1	64
91	09	9	29	10.1	0	6	0	5.1	55	1	65
91	09	12	32	9.2	0	11	0	5.2	59	1	69
91	09	16	36	9.2	0	11	0	5.2	53	1	63
91	09	17	37	10.7	0	11	0	5.3	62	1	73
91	09	19	39	9.4	0	11	0	5.1	60	1	69
91	09	21	41	9.1	0	5.4	0	5.0	64	1	73
91	09	23	43	10.0	0	5.4	0	5.0	60	1	70
91	09	26	46	9.6	0	6.9	0	4.8	63	1	73
91	09	28	48	9.8	0	7	0	5.1	56	1	66
91	09	30	50	10.2	0	7.1	0	4.9	54	1	64
91	10	2	52	9.4	0	6.8	0	4.8	58	1	68
91	10	4	54	10.1	0	7.2	0	5.2	63	1	74
91	10	6	56	10.0	0	7.4	0	5.0	59	1	69
91	10	8	58	9.4	0	7.8	0	5.0	65	1	75
91	10	11	61	10.6	0	7.3	0	4.8	60	1	71
91	10	14	64	10.0	8.4	6.5	0	5.0	64	1	74
91	10	16	66	9.6	8.2	6.8	0	4.9	55	1	65
91	10	18	68	10.2	8	6.8	0	4.8	56	1	66
91	10	20	70	9.5	8	6.8	0	5.1	61	1	71
91	10	23	73	10.8	8.2	7	0	5.1	58	1	69
91	10	25	75	9.8	8	7.2	0	5.2	59	1	69
91	10	27	77	10.1	8.2	7.1	0	5.2	65	1	76
91	10	29	79	9.9	8	7.1	0	5.4	57	1	67
91	11	1	82	10.3	8.2	6.9	0	5.4	64	1	75
91	11	3	84	10.9	4	6.9	0	5.4	64	1	76
91	11	5	86	10.3	3.45	7.2	0	5.2	55	1	66
91	11	7	88	10.3	3.2	7	0	5.3	54	1	64
91	11	10	91	10.0	6.9	6.9	0	5.1	55	1	65
91	11	12	93	10.3	7.1	7.3	0	5.2	64	1	74
91	11	13	94	9.8	7.5	7.4	0	5.3	54	1	64
91	11	15	96	10.2	7.4	7	0	5.2	65	1	76
91	11	17	98	9.6	7.5	6.9	0	5.3	55	1	65
91	11	20	101	10.2	7.3	7	0	5.3	60	1	71
91	11	22	103	9.3	7	7	4.6	4.6	63	1	73

AMMONIA LOADING PHASE (10 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Flowrate Influent (L/d)	Flowrate NH4Cl (mL/h)	Flowrate CH3OH (mL/h)	Flowrate NaHCO3 (mL/h)	Flowrate PO4 (mL/h)	Flowrate Recycle (L/d)	Flowrate Aerobic Wasting (L/d)	Flowrate Anoxic Overflow (L/d)
91	11	25	106	9.3	6.9	7.2	4.3	4.3	64	1	74
91	11	26	107	10.1	7.3	7.3	14.9	14.9	56	1	67
91	11	29	110	9.2	7.3	7.5	15.3	15.3	56	1	66
91	12	2	113	8.7	7.4	7.4	15	15.0	57	1	67
91	12	4	115	9.1	7.4	7.4	15	15.0	56	1	66
91	12	6	117	10.2	7.8	7.3	15.2	15.2	54	1	65
91	12	7	118	9.0	6.9	7.2	14.4	14.4	59	1	69
91	12	9	120	9.4	6.8	7.2	14.7	14.7	63	1	73
91	12	11	122	8.9	7.4	7.4	15.3	15.3	58	1	67
91	12	13	124	9.8	7.5	7.5	15.1	15.1	64	1	75
91	12	16	127	9.9	7.5	7.6	15.5	15.5	54	1	65
91	12	18	129	9.6	7.4	7.3	15.3	15.3	65	1	75
91	12	20	131	9.1	7.7	7.2	14.7	14.7	65	1	74
91	12	22	133	9.7	6.6	7.4	14.8	14.8	56	1	67
91	12	24	135	10.0	7.3	7.4	15.3	15.3	63	1	73
91	12	26	137	10.0	7.3	7.4	15.1	15.1	60	1	71
91	12	30	141	10.0	7.3	7.4	15.1	15.1	62	1	73
92	01	2	144	9.3	7.3	7.6	31	31.0	54	1	65
92	01	5	147	8.8	7.5	7.7	30.9	30.9	64	1	74
92	01	6	148	8.8	7.2	7.5	30	30.0	57	1	66
92	01	8	150	9.0	7.2	7.4	31	31.0	59	1	69
92	01	10	152	9.3	7.3	7.3	29	29.0	59	1	70
92	01	12	154	9.1	7	7.4	30	30.0	59	1	69
92	01	14	156	8.7	28.9	8.2	41.3	41.3	63	1	74
92	01	15	157	9.0	29	8	39	39.0	66	1	76
92	01	17	159	9.2	29	7.8	38	38.0	63	1	74
92	01	20	162	8.7	29	7.5	36	36.0	57	1	67
92	01	22	164	8.4	29	7.4	36	36.0	62	1	72
92	01	24	166	8.9	28	7.2	36	36.0	62	1	73
92	01	26	168	9.1	27	7.4	36	36.0	58	1	69
92	01	30	172	9.0	26.9	7.9	37.3	37.3	54	1	64
92	01	31	173	8.4	26	7.5	35	35.0	65	1	75
92	02	2	175	9.1	25.6	7	34.4	34.4	61	1	71
92	02	3	176	9.4	26	7.3	37.5	37.5	61	1	72
92	02	5	178	8.5	27	7.4	38	38.0	63	1	73
92	02	6	179	9.1	27.3	7.4	39.5	39.5	62	1	73
92	02	7	180	8.5	26	7.4	37	37.0	57	1	67
92	02	10	183	8.8	25	7.6	36	36.0	58	1	68
92	02	11	184	8.7	26	7.6	37	37.0	57	1	67
92	02	12	185	8.5	27	7.7	36	36.0	64	1	75
92	02	13	186	8.2	26	7.6	35	35.0	60	1	70
92	02	14	187	8.5	26	7.9	34.8	34.8	61	1	71
92	02	16	189	9.0	25.8	7.4	36	36.0	58	1	69
92	02	18	191	8.9	26	7.3	36	36.0	55	1	66
92	02	19	192	8.6	26	7.5	36	36.0	54	1	65
92	02	21	194	7.9	26	7.7	36	36.0	64	1	74

AMMONIA LOADING PHASE (10 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Flowrate Aerobic Overflow (L/d)	Feed Conc. NH4Cl (g/L)	Feed Conc. Simulated Influent (mgN/L)	Feed Conc. CH3OH (mL/L)	Feed Conc. o-PO4 (gP/L)	Feed Conc. NaHCO3 (g/L)
91	08	12	1	65	0	209	0	0.816	0
91	08	14	3	76	0	203	0	0.816	0
91	08	16	5	74	0	214	0	0.816	0
91	08	18	7	75	0	214	0	0.816	0
91	08	20	9	63	0	222	0	0.816	0
91	08	23	12	66	0	243	0	0.816	0
91	08	26	15	67	0	210	0	0.816	0
91	08	28	17	69	0	211	0	0.816	0
91	08	31	20	65	0	215	0	0.816	0
91	09	2	22	73	0	221	0	0.816	0
91	09	4	24	71	0	218	0	0.816	0
91	09	7	27	64	0	203	25	0.816	0
91	09	9	29	65	0	211	25	0.816	0
91	09	12	32	69	0	208	25	0.816	0
91	09	16	36	63	0	195	25	0.816	0
91	09	17	37	73	0	189	25	0.816	0
91	09	19	39	69	0	206	40	0.816	0
91	09	21	41	73	0	192	80	0.816	0
91	09	23	43	70	0	200	80	0.816	0
91	09	26	46	73	0	215	40	0.816	0
91	09	28	48	66	0	190	40	0.816	0
91	09	30	50	64	0	180	60	0.816	0
91	10	2	52	68	0	193	50	0.816	0
91	10	4	54	74	0	203	50	0.816	0
91	10	6	56	69	0	196	50	0.816	0
91	10	8	58	75	0	195	50	0.816	0
91	10	11	61	71	0	183	50	0.816	0
91	10	14	64	74	19.1	281	50	0.816	0
91	10	16	66	65	19.1	294	50	0.816	0
91	10	18	68	66	19.1	312	75	0.816	0
91	10	20	70	71	19.1	294	100	0.816	0
91	10	23	73	69	19.1	295	100	0.816	0
91	10	25	75	69	19.1	288	75	0.816	0
91	10	27	77	76	19.1	298	75	0.816	0
91	10	29	79	67	19.1	308	75	0.816	0
91	11	1	82	75	19.1	313	85	0.816	0
91	11	3	84	76	19.1	231	85	0.816	0
91	11	5	86	66	55.3	326	85	0.816	0
91	11	7	88	64	48	310	85	0.816	0
91	11	10	91	65	88	582	85	0.816	0
91	11	12	93	74	88	566	85	0.816	0
91	11	13	94	64	88	606	85	0.816	0
91	11	15	96	76	88	567	85	0.816	0
91	11	17	98	65	88	600	85	0.816	0
91	11	20	101	71	88	579	85	0.816	0
91	11	22	103	73	88	598	85	0.816	14.7

AMMONIA LOADING PHASE (10 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Flowrate Aerobic Overflow (L/d)	Feed Conc. NH4Cl (g/L)	Feed Conc. Simulated Influent (mgN/L)	Feed Conc. CH3OH (mL/L)	Feed Conc. o-PO4 (gP/L)	Feed Conc. NaHCO3 (g/L)
91	11	25	106	74	88	583	85	0.816	47
91	11	26	107	67	88	611	85	0.245	47
91	11	29	110	66	88	596	85	0.245	53.5
91	12	2	113	67	88	636	85	0.245	53.5
91	12	4	115	66	88	628	85	0.245	53.5
91	12	6	117	65	88	599	135	0.245	53.5
91	12	7	118	69	88	604	135	0.245	53.5
91	12	9	120	73	88	558	135	0.245	53.5
91	12	11	122	68	88	630	100	0.245	53.5
91	12	13	124	75	88	597	120	0.245	45
91	12	16	127	65	88	538	120	0.245	35
91	12	18	129	76	88	543	110	0.245	35
91	12	20	131	75	88	597	120	0.245	35
91	12	22	133	67	171.75	879	120	0.408	70
91	12	24	135	74	171.75	941	120	0.408	70
91	12	26	137	71	171.75	901	120	0.408	70
91	12	30	141	73	171.75	913	120	0.408	70
92	01	2	144	65	171.75	962	120	0.204	45
92	01	5	147	75	171.75	1012	160	0.204	52.5
92	01	6	148	67	171.75	1002	120	0.204	52.5
92	01	8	150	70	171.75	1012	120	0.204	52.5
92	01	10	152	70	187	1046	130	0.204	52.5
92	01	12	154	70	187	1014	130	0.204	52.5
92	01	14	156	75	69	1442	130	0.245	75
92	01	15	157	77	69	1435	130	0.245	75
92	01	17	159	75	69	1436	130	0.245	75
92	01	20	162	68	69	1492	250	0.202	75
92	01	22	164	73	69	1559	250	0.202	75
92	01	24	166	73	80	1615	250	0.202	68.75
92	01	26	168	70	80	1578	225	0.202	68.75
92	01	30	172	65	80	1571	225	0.202	72.5
92	01	31	173	76	80	1615	225	0.202	72.5
92	02	2	175	72	80	1492	180	0.231	82.5
92	02	3	176	73	80	1462	180	0.231	87.5
92	02	5	178	74	80	1630	180	0.231	80
92	02	6	179	74	80	1553	180	0.231	80
92	02	7	180	68	80	1572	180	0.231	80
92	02	10	183	69	80	1518	210	0.231	80
92	02	11	184	68	80	1564	210	0.231	77.5
92	02	12	185	75	80	1642	210	0.231	77.5
92	02	13	186	71	80	1639	210	0.231	77.5
92	02	14	187	72	80	1601	210	0.231	77.5
92	02	16	189	69	80	1444	210	0.231	77.5
92	02	18	191	67	115	2060	210	0.231	80
92	02	19	192	66	115	2142	210	0.231	80
92	02	21	194	75	115	2294	210	0.231	80

AMMONIA LOADING PHASE (10 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Flowrate Aerobic Overflow (L/d)	Feed Conc. NH4Cl (g/L)	Feed Conc. Simulated Influent (mgN/L)	Feed Conc. CH3OH (mL/L)	Feed Conc. o-PO4 (gP/L)	Feed Conc. NaHCO3 (g/L)
92	02	24	197	74	115	1940	210	0.231	80
92	02	27	200	75	115	1923	164.5	0.231	87.5
92	02	28	201	72	115	1886	164.5	0.231	87.5
92	02	29	202	74	115	1898	164.5	0.231	40
92	03	1	203	77	115	1940	164.5	0.231	40
92	03	2	204	67	115	2094	164.5	0.231	40
92	03	3	205	75	115	2028	164.5	0.231	40
92	03	4	206	72	115	2460	164.5	0.231	30
92	03	5	207	67	115	2352	164.5	0.231	30
92	03	6	208	71	115	2280	164.5	0.231	30
92	03	7	209	68	115	2088	164.5	0.231	20
92	03	10	212	67	115	2123	164.5	0.231	20
92	03	11	213	69	115	2381	164.5	0.231	20

AMMONIA LOADING PHASE (10 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	System Loading CH3OH (gCOD/d)	System Loading o-PO4 (gP/d)	System Loading NaHCO3 (gCaCO3/d)	Anoxic ORP (mV)	Anoxic pH
91	08	12	1	0.00	0.069	2102	-130	
91	08	14	3	0.00	0.081	2099	-25	
91	08	16	5	0.00	0.093	2096	-57	
91	08	18	7	0.00	0.101	1955	-100	
91	08	20	9	0.00	0.099	1954	-40	
91	08	23	12	0.00	0.099	1957	-5	
91	08	26	15	0.00	0.098	2036	20	
91	08	28	17	0.00	0.094	2034	5	7.6
91	08	31	20	0.00	0.098	2036	20	
91	09	2	22	0.00	0.094	2037	43	
91	09	4	24	0.00	0.095	1889	49	
91	09	7	27	4.27	0.093	1861	8	7.9
91	09	9	29	4.27	0.099	1861	-41	7.7
91	09	12	32	7.84	0.103	1833	-86	8.0
91	09	16	36	7.84	0.102	1832	-105	7.9
91	09	17	37	7.84	0.103	1795	-100	7.9
91	09	19	39	12.54	0.100	1786	-95	8.0
91	09	21	41	12.31	0.098	1810	-95	7.9
91	09	23	43	12.31	0.098	1815	-127	7.9
91	09	26	46	7.86	0.094	1807	-120	7.9
91	09	28	48	7.98	0.100	1806	-133	7.8
91	09	30	50	12.14	0.096	1809	-132	7.8
91	10	2	52	9.69	0.094	1807	-121	7.7
91	10	4	54	10.26	0.101	1807	-155	7.7
91	10	6	56	10.54	0.097	1807	-195	7.8
91	10	8	58	11.11	0.099	1801	-168	7.8
91	10	11	61	10.40	0.095	1810	-173	7.8
91	10	14	64	9.26	0.097	1776	-100	7.9
91	10	16	66	9.69	0.095	1143	-86	7.9
91	10	18	68	14.53	0.094	1147	-112	7.8
91	10	20	70	19.38	0.099	1142	-147	7.8
91	10	23	73	19.95	0.099	1148	-145	7.9
91	10	25	75	15.39	0.101	1143	-140	7.9
91	10	27	77	15.17	0.102	1144	-145	7.9
91	10	29	79	15.17	0.106	1143	-158	7.9
91	11	1	82	16.71	0.107	1145	-165	7.9
91	11	3	84	16.71	0.106	1158	-180	7.9
91	11	5	86	17.44	0.102	1157	-175	7.9
91	11	7	88	16.95	0.104	1158	-133	7.9
91	11	10	91	16.71	0.099	1148	-152	7.8
91	11	12	93	17.68	0.102	1148	-137	7.7
91	11	13	94	17.92	0.104	1143	-108	7.8
91	11	15	96	16.95	0.101	1300	-154	7.8
91	11	17	98	16.71	0.105	1296	-139	7.7
91	11	20	101	16.95	0.103	1316	-164	7.8
91	11	22	103	16.95	0.090	1413	-194	7.6

AMMONIA LOADING PHASE (10 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	System Loading CH3OH (gCOD/d)	System Loading o-PO4 (gP/d)	System Loading NaHCO3 (gCaCO3/d)	Anoxic ORP (mV)	Anoxic pH
91	11	25	106	17.44	0.084	1612	-180	7.7
91	11	26	107	17.68	0.088	2271	-155	7.9
91	11	29	110	18.16	0.090	2529	-135	7.9
91	12	2	113	17.92	0.088	2579	-145	8.1
91	12	4	115	17.92	0.088	2515	-150	8.1
91	12	6	117	28.08	0.089	2409	-150	8.1
91	12	7	118	27.70	0.085	2490	-237	8.0
91	12	9	120	27.70	0.086	2472	-152	8.1
91	12	11	122	21.09	0.090	2570	-146	8.2
91	12	13	124	25.64	0.089	2268	-168	8.2
91	12	16	127	25.99	0.091	2347	-195	8.1
91	12	18	129	22.88	0.090	2359	-220	7.9
91	12	20	131	24.62	0.086	2364	-310	7.9
91	12	22	133	25.30	0.145	3071	-179	8.2
91	12	24	135	25.30	0.150	3078	-280	8.2
91	12	26	137	25.30	0.148	3048	-245	8.1
91	12	30	141	25.30	0.148	3055	-230	7.9
92	01	2	144	25.99	0.152	3655	-199	8.3
92	01	5	147	35.10	0.151	4108	-183	8.3
92	01	6	148	25.64	0.147	4055	-188	8.3
92	01	8	150	25.30	0.152	4088	-171	8.4
92	01	10	152	27.04	0.142	3850	-180	8.4
92	01	12	154	27.41	0.147	3964	-205	8.2
92	01	14	156	30.37	0.243	6110	-200	8.3
92	01	15	157	29.63	0.229	5738	-152	8.4
92	01	17	159	28.89	0.223	5219	-179	8.5
92	01	20	162	53.43	0.175	5212	-175	8.4
92	01	22	164	52.71	0.175	5346	-177	8.5
92	01	24	166	51.29	0.175	4825	-238	8.4
92	01	26	168	47.44	0.175	4776	-203	8.6
92	01	30	172	50.65	0.181	5140	-208	8.6
92	01	31	173	48.08	0.170	5134	-185	8.5
92	02	2	175	35.90	0.191	5309	-150	8.5
92	02	3	176	37.44	0.208	5793	-166	8.6
92	02	5	178	37.95	0.211	5866	-182	8.6
92	02	6	179	37.95	0.219	5760	-178	8.6
92	02	7	180	37.95	0.205	5743	-189	8.7
92	02	10	183	45.48	0.200	5484	-196	8.6
92	02	11	184	45.48	0.205	5499	-201	8.6
92	02	12	185	46.07	0.200	5464	-220	8.4
92	02	13	186	45.48	0.194	5495	-240	8.5
92	02	14	187	47.27	0.193	5332	-250	8.4
92	02	16	189	44.28	0.200	5286	-236	8.6
92	02	18	191	43.68	0.200	5442	-248	8.3
92	02	19	192	44.88	0.200	5591	-165	8.4
92	02	21	194	46.07	0.200	5922	-132	8.3

AMMONIA LOADING PHASE (10 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Anoxic VSS (mg/L)	Anoxic TSS (mg/L)	Anoxic o-PO4 (mgP/L)	Anoxic NH4 (mgN/L)	Anoxic NOx (mgN/L)	Anoxic NO2 (mgN/L)	Anoxic BOD (mg/L)	Anoxic COD (mg/L)
91	08	12	1			3.6	170	248	1.0		
91	08	14	3			3.1	156	260			401
91	08	16	5			3.5	107	312			
91	08	18	7			4.7	52	304			
91	08	20	9			4.0	28	281	1.2	22	432
91	08	23	12			4.4	31	223			
91	08	26	15			3.7	36	198			
91	08	28	17			4.5	31	202			570
91	08	31	20			4.7	30	186			
91	09	2	22			5.2	31	199	1.0		
91	09	4	24	1480	1934	4.7	26	193		25	405
91	09	7	27	1630	1978	4.1	25	144			
91	09	9	29	1550	1896	3.7	27	144	0.7		465
91	09	12	32	1540	1804	4.1	30	151			
91	09	16	36	1620	1892	4.0	32	63			
91	09	17	37	1700	2092	4.2	39	57	0.3	29	413
91	09	19	39	1690	1930	3.8	31	4			
91	09	21	41	1750	2153	4.3	27	0			
91	09	23	43	1710	1995	4.5	33	2	0.1		445
91	09	26	46	1830	2263	4.2	28	5			
91	09	28	48	1720	1982	4.9	25	5			349
91	09	30	50	1750	2073	5.3	26	1	0.0		
91	10	2	52	1770	2134	4.6	28	1			
91	10	4	54	1760	2060	3.8	24	1			280
91	10	6	56	1810	2082	3.9	25	0	0.0		
91	10	8	58	1690	2037	4.1	28	0			
91	10	11	61	1780	2115	3.4	26	0		36	260
91	10	14	64	1850	2054	4.2	110	23	0.1		
91	10	16	66	2100	2516	4.3	69	37			
91	10	18	68	1930	2365	3.6	54	14			388
91	10	20	70	2020	2486	4.5	55	2			
91	10	23	73	1980	2396	3.9	52	2	0.0		362
91	10	25	75	1010	1271	4.8	44	5			
91	10	27	77	1070	1284	5.1	42	3			418
91	10	29	79	2200	2531	4.5	49	2			
91	11	1	82	2080	2604	4.1	45	1	0.0		
91	11	3	84	2110	2493	4.6	40	1			370
91	11	5	86	2060	2394	4.4	47	1			
91	11	7	88	2140	2456	3.9	49	1		56	375
91	11	10	91	2090	2341	3.4	90	11			
91	11	12	93	2130	2440	3.8	208	1			
91	11	13	94	2190	2599	4.1	200	1			
91	11	15	96	2350	2562	4.3	188	2			403
91	11	17	98	2240	2594	4.6	189	3			
91	11	20	101	2660	2711	3.8	201	3			
91	11	22	103	2200	2585	3.9	100	0			

AMMONIA LOADING PHASE (10 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Anoxic VSS (mg/L)	Anoxic TSS (mg/L)	Anoxic o-PO4 (mgP/L)	Anoxic NH4 (mgN/L)	Anoxic NOx (mgN/L)	Anoxic NO2 (mgN/L)	Anoxic BOD (mg/L)	Anoxic COD (mg/L)
91	11	25	106	2060	2555	3.9	86	21			366
91	11	26	107	2200	2515	4.2	78	11			
91	11	29	110	2310	2656	4.8	100	13			
91	12	2	113	2280	2572	4.0	85	14		45	394
91	12	4	115	2370	2754	3.9	68	27			
91	12	6	117	2310	2758	3.3	80	4			
91	12	7	118	2440	2796	3.6	84	1			450
91	12	9	120	2400	2811	3.8	79	4			
91	12	11	122	2710	3125	4.2	62	68			
91	12	13	124	2580	3011	4.6	80	2			430
91	12	16	127	2630	2912	3.7	71	0			
91	12	18	129	2610	3032	3.8	74	1	0.3		
91	12	20	131	2730	2662	3.5	64	0		74	510
91	12	22	133	1700	2044	5.5	208	0			
91	12	24	135	1520	1685	5.7	285	1	0.3		
91	12	26	137	3180	3774	6.8	260	1			
91	12	30	141	2920	3329	5.6	322	40			480
92	01	2	144	4430	5260	5.0	155	62	0.4		
92	01	5	147	3010	3456	7.1	126	5			
92	01	6	148	3160	3663	7.6	122	3	1.5		481
92	01	8	150	3050	3535	6.3	127	2			417
92	01	10	152	3090	3462	5.9	135	5	2.2	86	409
92	01	12	154	3180	3641	5.5	133	4	2.1		454
92	01	14	156	3120	3629	8.5	264	56	15.0		
92	01	15	157	2880	3341	11.1	235	110	33.3	113	523
92	01	17	159	2940	3386	12.3	137	139	54.7		
92	01	20	162	3530	4109	9.8	195	6	4.4		
92	01	22	164	3640	4146	8.1	194	2	1.7	116	477
92	01	24	166	3910	4429	9.2	80	9	3.0		
92	01	26	168	3990	4722	8.0	205	2	1.2		
92	01	30	172	4120	4552	9.6	206	0	0.6		
92	01	31	173	5400	6043	9.5	185	1	0.7	119	531
92	02	2	175	5340	6265	10.5	185	60	18.1		
92	02	3	176	5340	6409	8.2	184	29	29.3		
92	02	5	178	5280	6164	8.1	181	18	21.9	170	508
92	02	6	179	5350	6104	9.4	181	13	13.0		
92	02	7	180	5410	6472	10.2	178	22	12.4		
92	02	10	183	5460	6382	8.6	186	2	2.2		438
92	02	11	184	5410	6255	7.6	175	1	1.0	126	417
92	02	12	185	5450	6138	8.8	211	0	0.0		527
92	02	13	186	5500	6633	8.3	182	5	1.1		
92	02	14	187	5410	6036	7.2	205	0	0.1		
92	02	16	189	5450	6243	9.6	174	0	0.1	135	573
92	02	18	191	7340	7840	9.3	396	0	0.1		634
92	02	19	192	7610	8980	10.8	575	5	0.1		
92	02	21	194	6590	8690	11.4	384	34	0.7		

AMMONIA LOADING PHASE (10 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Anoxic VSS (mg/L)	Anoxic TSS (mg/L)	Anoxic o-PO4 (mgP/L)	Anoxic NH4 (mgN/L)	Anoxic NOx (mgN/L)	Anoxic NO2 (mgN/L)	Anoxic BOD (mg/L)	Anoxic COD (mg/L)
92	02	24	197	6630	7650	10.3	430	3	3.1		588
92	02	27	200	6870	8860	10.7	447	19	1.3	315	
92	02	28	201	6096	9120	11.2	375	5	2.5		
92	02	29	202	6320	9900	10.1	394	2	0.1		
92	03	1	203	6040	9211	11.6	394	11	0.9		
92	03	2	204	6500	9298	11.8	603	4	1.2	219	
92	03	3	205	5990	8840	14.0	548	3	6.8		744
92	03	4	206	6610	8215	15.7	662	5	1.8		
92	03	5	207	6240	8339	11.5	758	9	0.2		
92	03	6	208	5470	7860	11.9	503	5	0.8		
92	03	7	209	6490	8450	10.6	532	1	5.2		
92	03	10	212	6140	8542		734			318	650
92	03	11	213	6020	8395		758				

AMMONIA LOADING PHASE (10 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Aerobic DO (mg/L)	Aerobic pH	Aerobic VSS (mg/L)	Aerobic TSS (mg/L)	Aerobic o-PO4 (mgP/L)	Aerobic NH4 (mgN/L)	Aerobic NOx (mgN/L)
91	08	12	1	4.0				3.6	149	251
91	08	14	3	5.0				2.8	141	268
91	08	16	5	4.5		2730	3459	3.8	95	324
91	08	18	7	4.0				4.0	33	312
91	08	20	9	4.0	7.2	2580	3680	3.6	21	292
91	08	23	12	4.0				3.9	8	313
91	08	26	15	4.0				3.5	4	228
91	08	28	17	4.6	7.2			4.0	3	229
91	08	31	20	4.1	7.2			4.3	2	199
91	09	2	22	3.8	7.3			4.7	1	221
91	09	4	24	4.9	7.5	1650	2181	5.1	0	238
91	09	7	27	3.8	7.8	1600	1990	3.7	0	191
91	09	9	29	4.5	7.6	1800	2243	4.0	1	197
91	09	12	32	4.0	7.7	1520	1808	4.3	1	182
91	09	16	36	4.0	7.8	1590	1887	4.7	1	94
91	09	17	37	4.0	7.6	1680	2084	4.5	5	86
91	09	19	39	3.4	7.7	1710	1965	4.5	2	69
91	09	21	41	2.2	7.6	1770	2205	4.5	2	63
91	09	23	43	3.7	7.5	1740	2075	4.6	1	32
91	09	26	46	3.5	7.5	1810	2257	4.9	2	29
91	09	28	48	3.2	7.5	1820	2132	4.3	1	35
91	09	30	50	3.3	7.5	1760	2085	4.9	0	29
91	10	2	52	4.0	7.5	1790	2159	5.3	0	30
91	10	4	54	4.0	7.5	1690	2003	4.6	0	27
91	10	6	56	4.2	7.5	1760	2041	4.2	0	26
91	10	8	58	3.5	7.5	1710	1992	4.5	0	24
91	10	11	61	4.0	7.5	1700	2090	3.6	0	28
91	10	14	64	2.9	7.4	1850	1994	4.6	86	63
91	10	16	66	3.3	7.4	1780	2162	3.8	46	76
91	10	18	68	3.0	7.4	1690	2100	3.7	29	58
91	10	20	70	3.5	7.4	1970	2445	4.6	28	51
91	10	23	73	3.1	7.3	1930	2323	3.6	14	54
91	10	25	75	3.2	7.3	2000	2504	5.2	0	55
91	10	27	77	3.2	7.3	1990	2371	5.2	0	59
91	10	29	79	3.5	7.4	2210	2538	4.0	0	48
91	11	1	82	3.5	7.3	2310	2897	4.0	0	50
91	11	3	84	3.5	7.5	2190	2587	3.9	0	48
91	11	5	86	3.5	7.5	2220	2624	4.2	0	48
91	11	7	88	3.5	7.4	2200	2588	3.8	0	53
91	11	10	91	1.9	6.5	2220	2542	3.3	27	56
91	11	12	93	3.5	6.4	2250	2635	3.3	107	82
91	11	13	94	3.2	6.3	2180	2601	3.7	96	89
91	11	15	96	3.2	6.0	2250	2693	3.9	109	93
91	11	17	98	2.5	6.3	1930	2579	4.4	119	86
91	11	20	101	2.8	6.2	2890	2717	3.4	134	82
91	11	22	103	3.0	6.0	2220	2592	3.6	18	92

AMMONIA LOADING PHASE (10 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Aerobic DO (mg/L)	Aerobic pH	Aerobic VSS (mg/L)	Aerobic TSS (mg/L)	Aerobic o-PO4 (mgP/L)	Aerobic NH4 (mgN/L)	Aerobic NOx (mgN/L)
91	11	25	106	4.0	5.9	2430	2555	3.5	16	113
91	11	26	107	3.5	6.6	2180	2507	3.4	15	111
91	11	29	110	4.0	7.4	2090	2420	5.2	10	116
91	12	2	113	4.5	7.6	2360	2676	3.7	5	114
91	12	4	115	4.0	7.3	2510	2930	4.3	1	128
91	12	6	117	3.5	7.3	2770	3310	3.1	0	111
91	12	7	118	2.5	7.5	2680	3139	3.7	0	85
91	12	9	120	2.2	7.8	2680	3155	4.4	0	79
91	12	11	122	5.0	7.3	2790	3269	4.6	2	187
91	12	13	124	2.5	7.3	2810	3292	5.0	1	110
91	12	16	127	4.0	7.4	2870	3246	4.0	0	64
91	12	18	129	2.5	7.2	2840	3300	3.7	0	87
91	12	20	131	3.0	7.0	2910	3344	3.7	0	78
91	12	22	133	5.0	7.6	1720	2070	5.3	91	72
91	12	24	135	3.0	7.4	1520	1716	5.2	163	110
91	12	26	137	3.0	7.1	2940	3528	6.4	156	88
91	12	30	141	4.0	7.3	3220	3709	4.9	207	142
92	01	2	144	2.4	6.7	2980	3543	5.6	18	183
92	01	5	147	2.6	7.1	3370	3924	6.2	3	120
92	01	6	148	2.7	7.2	3290	3816	6.2	1	125
92	01	8	150	3.4	7.2	3390	3918	5.8	2	134
92	01	10	152	3.0	7.2	3140	3903	5.6	1	131
92	01	12	154	3.0	7.4	3220	3845	4.8	0	118
92	01	14	156	1.0	6.6	3370	3964	8.0	93	221
92	01	15	157	1.5	6.5	2870	3379	10.8	65	254
92	01	17	159	3.4	6.7	3000	3462	11.0	18	325
92	01	20	162	2.2	7.3	3450	4035	10.1	2	156
92	01	22	164	2.4	7.2	3610	4120	8.8	2	162
92	01	24	166	1.8	7.6	3760	4278	9.4	1	169
92	01	26	168	3.0	7.0	4200	5011	7.5	18	105
92	01	30	172	2.0	7.8	4440	5026	8.8	0	134
92	01	31	173	2.0	7.1	5400	6198	9.6	0	125
92	02	2	175	2.5	6.8	5330	6383	11.7	1	200
92	02	3	176	2.6	7.5	5150	6191	10.1	0	176
92	02	5	178	2.8	7.6	5420	6438	9.3	0	169
92	02	6	179	2.9	7.5	5180	5997	8.1	0	164
92	02	7	180	4.2	7.6	5200	6229	9.3	0	174
92	02	10	183	3.7	7.4	5470	6522	8.4	1	168
92	02	11	184	3.7	7.4	5540	6465	6.9	0	180
92	02	12	185	3.1	7.5	5890	6734	9.0	0	179
92	02	13	186	3.5	7.4	5610	6730	9.2	0	169
92	02	14	187	2.9	7.3	5540	6351	8.2	0	167
92	02	16	189	4.0	7.3	5610	6435	9.8	2	177
92	02	18	191	3.5	7.4	6980	9300	8.5	181	183
92	02	19	192	3.5	6.7	7460	9890	11.8	246	83
92	02	21	194	4.0	7.0	6440	8840	13.0	473	238

AMMONIA LOADING PHASE (10 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Aerobic DO (mg/L)	Aerobic pH	Aerobic VSS (mg/L)	Aerobic TSS (mg/L)	Aerobic o-PO4 (mgP/L)	Aerobic NH4 (mgN/L)	Aerobic NOx (mgN/L)
92	02	24	197	3.9	7.1	6650	8010	11.0	204	91
92	02	27	200	4.0	6.3	6440	8620	12.4	364	215
92	02	28	201	5.0	8.9	7010	9260	10.1	195	104
92	02	29	202	4.7	7.7	6800	8890	9.9	282	133
92	03	1	203	5.0	7.8	6480	9125	11.3	235	124
92	03	2	204	5.2	7.9	6770	9275	10.5	421	82
92	03	3	205	3.0	8.3	6470	9202	11.7	477	65
92	03	4	206	4.0	8.2	6830	9445	13.8	512	99
92	03	5	207	3.0	7.8	6840	9176	12.5	593	107
92	03	6	208	2.5	8.1	6780	9783	11.1	422	136
92	03	7	209	5.5	7.9	6210	8275	11.6	468	70
92	03	10	212	7.0	8.3	6570	9299		715	
92	03	11	213	8.0	8.3	6370	8887		612	

AMMONIA LOADING PHASE (10 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Aerobic NO2 (mgN/L)	Aerobic BOD (mg/L)	Aerobic COD (mg/L)	Effluent VSS (mg/L)	Effluent TSS (mg/L)	Effluent NH4 (mgN/L)	Effluent NOx (mgN/L)
91	08	12	1	1.3					147	248
91	08	14	3			246			142	271
91	08	16	5				19	24	94	325
91	08	18	7						31	311
91	08	20	9	1.5	6	317	33	47	20	291
91	08	23	12						7	296
91	08	26	15						3	234
91	08	28	17			455			2	218
91	08	31	20						1	204
91	09	2	22	1.1					1	225
91	09	4	24		8	284	24	32	0	234
91	09	7	27				21	26	1	201
91	09	9	29	0.8		340	20	25	1	199
91	09	12	32				36	43	1	180
91	09	16	36				24	28	1	94
91	09	17	37	0.4	8	309	25	31	1	82
91	09	19	39				19	22	3	65
91	09	21	41				20	25	2	63
91	09	23	43	0.3		346	26	31	1	54
91	09	26	46				27	33	2	33
91	09	28	48			280	28	32	1	30
91	09	30	50	0.1			24	28	0	30
91	10	2	52				33	40	0	29
91	10	4	54			266	20	24	0	27
91	10	6	56	0.1			28	32	0	27
91	10	8	58				19	22	0	24
91	10	11	61		12	225	23	28	0	28
91	10	14	64	0.3			31	35	84	63
91	10	16	66				33	40	47	76
91	10	18	68			293	24	29	28	55
91	10	20	70				21	26	26	53
91	10	23	73	0.2		261	41	49	15	54
91	10	25	75				32	40	0	55
91	10	27	77			290	35	42	0	57
91	10	29	79				29	34	0	52
91	11	1	82	0.3			20	25	0	52
91	11	3	84			218	28	33	0	48
91	11	5	86				41	48	0	46
91	11	7	88		10	275	49	57	0	53
91	11	10	91				53	61	27	56
91	11	12	93				68	79	105	78
91	11	13	94				72	85	100	90
91	11	15	96			304	73	87	107	90
91	11	17	98				97	112	117	86
91	11	20	101				75	92	129	79
91	11	22	103				93	106	17	92

AMMONIA LOADING PHASE (10 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Aerobic NO2 (mgN/L)	Aerobic BOD (mg/L)	Aerobic COD (mg/L)	Effluent VSS (mg/L)	Effluent TSS (mg/L)	Effluent NH4 (mgN/L)	Effluent NOx (mgN/L)
91	11	25	106			330	21	24	16	111
91	11	26	107				20	23	15	111
91	11	29	110				85	96	0	116
91	12	2	113		10	350	55	61	6	112
91	12	4	115				157	180	1	126
91	12	6	117				193	230	1	109
91	12	7	118			350	94	110	0	85
91	12	9	120				74	87	0	79
91	12	11	122				52	61	3	183
91	12	13	124			320	82	94	1	103
91	12	16	127				36	40	0	65
91	12	18	129	17.5			87	100	0	86
91	12	20	131		8	340	71	84	0	82
91	12	22	133				141	166	91	73
91	12	24	135	24.3			127	140	160	112
91	12	26	137				160	190	154	86
91	12	30	141			375	125	144	2	145
92	01	2	144	22.2			208	241	17	112
92	01	5	147				121	140	3	123
92	01	6	148	51.5		315	29	34	1	122
92	01	8	150			333	91	103	1	129
92	01	10	152	79.3	9	316	160	179	1	125
92	01	12	154	84.7		435	186	214	1	116
92	01	14	156	63.2			123	145	92	221
92	01	15	157	55.0	14	327	216	254	64	249
92	01	17	159	57.7			118	134	17	325
92	01	20	162	123.8			126	147	2	153
92	01	22	164	145.3	14	333	153	176	2	164
92	01	24	166	154.2			74	83	1	167
92	01	26	168	108.4			145	172	17	103
92	01	30	172	108.1			122	136	0	132
92	01	31	173	105.3	11	364	82	93	0	128
92	02	2	175	132.0			117	137	1	208
92	02	3	176	151.0			184	222	0	173
92	02	5	178	172.3	14	345	138	159	0	173
92	02	6	179	153.9			207	235	0	163
92	02	7	180	92.7			130	155	0	175
92	02	10	183	130.3		345	121	143	1	165
92	02	11	184	128.8	12	401	92	108	0	184
92	02	12	185	103.4		382	118	132	0	180
92	02	13	186	116.8			208	248	0	166
92	02	14	187	101.1			130	148	0	169
92	02	16	189	108.3	8	329	128	146	2	178
92	02	18	191	118.2		406	121	141	192	185
92	02	19	192	91.4			127	167	249	79
92	02	21	194	197.0			382	490	478	232

AMMONIA LOADING PHASE (10 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Aerobic NO2 (mgN/L)	Aerobic BOD (mg/L)	Aerobic COD (mg/L)	Effluent VSS (mg/L)	Effluent TSS (mg/L)	Effluent NH4 (mgN/L)	Effluent NOx (mgN/L)
92	02	24	197	103.0		423	148	180	210	88
92	02	27	200	206.0	37		111	153	369	206
92	02	28	201	91.2			391	499	198	100
92	02	29	202	96.0			153	194	285	128
92	03	1	203	112.0			122	174	231	118
92	03	2	204	75.0	56		145	199	422	80
92	03	3	205	60.2		531	200	282	484	69
92	03	4	206	72.5			135	183	497	103
92	03	5	207	93.8			184	246	578	112
92	03	6	208	93.9			133	191	422	128
92	03	7	209	64.7			277	365	384	70
92	03	10	212		38	573	167	235	719	
92	03	11	213				200	272	578	

AMMONIA LOADING PHASE (10 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Effluent BOD (mg/L)	Effluent COD (mg/L)	Anoxic VSS/TSS	Anoxic NO2/NOX	Anoxic NOX Load (gN/d)	Anoxic COD:NOX Entering (gCOD/gN)	Anoxic COD:NOX Removed (gCOD/gN)
91	08	12	1				0.00	13.9	0.0	
91	08	14	3		250			17.7	0.0	
91	08	16	5					20.6	0.0	
91	08	18	7					20.4	0.0	
91	08	20	9	8	301		0.00	15.6	0.0	
91	08	23	12					17.4	0.0	
91	08	26	15					13.6	0.0	
91	08	28	17		462			13.8	0.0	0.0
91	08	31	20					11.0	0.0	0.0
91	09	2	22				0.01	13.9	0.0	0.0
91	09	4	24	8	280	0.77		14.4	0.0	0.0
91	09	7	27			0.82		10.4	0.4	3.7
91	09	9	29		324	0.82	0.00	10.8	0.4	3.0
91	09	12	32			0.85		10.8	0.7	19.4
91	09	16	36			0.86		5.0	1.6	7.4
91	09	17	37	8	302	0.81	0.00	5.3	1.5	6.6
91	09	19	39			0.88		4.1	3.0	3.3
91	09	21	41			0.81		4.0	3.1	3.1
91	09	23	43		325	0.86	0.05	1.9	6.4	6.8
91	09	26	46			0.81		1.8	4.3	5.3
91	09	28	48		267	0.87		2.0	4.1	5.0
91	09	30	50			0.84	0.00	1.6	7.7	8.0
91	10	2	52			0.83		1.8	5.5	5.7
91	10	4	54		265	0.85		1.9	5.5	5.7
91	10	6	56			0.87	0.00	1.6	6.4	6.5
91	10	8	58			0.83		1.6	6.9	7.0
91	10	11	61	10	238	0.84		1.8	5.9	5.9
91	10	14	64			0.90	0.00	4.0	2.3	4.0
91	10	16	66			0.83		4.2	2.3	5.5
91	10	18	68		290	0.82		3.2	4.5	6.3
91	10	20	70			0.81		3.1	6.3	6.6
91	10	23	73		253	0.83	0.01	3.1	6.4	6.6
91	10	25	75			0.79		3.2	4.8	5.3
91	10	27	77		301	0.83		3.9	3.9	4.1
91	10	29	79			0.87		2.7	5.6	5.8
91	11	1	82			0.80	0.00	3.2	5.2	5.3
91	11	3	84		225	0.85		3.1	5.4	5.4
91	11	5	86			0.86		2.7	6.5	6.6
91	11	7	88	8	276	0.87		2.9	5.9	6.0
91	11	10	91			0.89		3.0	5.5	7.1
91	11	12	93			0.87		5.2	3.4	3.4
91	11	13	94			0.84		4.8	3.7	3.8
91	11	15	96		285	0.92		6.0	2.8	2.9
91	11	17	98			0.86		4.8	3.5	3.7
91	11	20	101			0.98		4.9	3.5	3.6
91	11	22	103			0.85		5.8	2.9	2.9

AMMONIA LOADING PHASE (10 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Effluent BOD (mg/L)	Effluent COD (mg/L)	Anoxic VSS/TSS	Anoxic NO2/NOX	Anoxic NOX Load (gN/d)	Anoxic COD:NOX Entering (gCOD/gN)	Anoxic COD:NOX Removed (gCOD/gN)
91	11	25	106		312	0.81		7.2	2.4	3.1
91	11	26	107			0.87		6.2	2.9	3.2
91	11	29	110			0.87		6.5	2.8	3.2
91	12	2	113	11	367	0.89		6.5	2.7	3.2
91	12	4	115			0.86		7.2	2.5	3.3
91	12	6	117			0.84		6.0	4.7	4.9
91	12	7	118		345	0.87		5.0	5.5	5.6
91	12	9	120			0.85		5.0	5.6	5.9
91	12	11	122			0.87		10.8	2.0	3.4
91	12	13	124		303	0.86		7.1	3.6	3.7
91	12	16	127			0.90		3.5	7.5	7.5
91	12	18	129			0.86	0.41	5.6	4.1	4.1
91	12	20	131	9	358	1.03		5.0	4.9	4.9
91	12	22	133			0.83		4.1	6.2	6.2
91	12	24	135			0.90	0.60	6.9	3.7	3.7
91	12	26	137			0.84		5.3	4.8	4.8
91	12	30	141		355	0.88		8.8	2.9	4.3
92	01	2	144			0.84	0.01	9.9	2.6	4.4
92	01	5	147			0.87		7.6	4.6	4.8
92	01	6	148		310	0.86	0.57	7.0	3.6	3.7
92	01	8	150		321	0.86		7.9	3.2	3.3
92	01	10	152	10	319	0.89	0.42	7.8	3.5	3.6
92	01	12	154		437	0.87	0.50	7.0	3.9	4.1
92	01	14	156			0.86	0.27	14.0	2.2	3.1
92	01	15	157	12	327	0.86	0.30	16.6	1.8	3.5
92	01	17	159			0.87	0.39	20.4	1.4	2.8
92	01	20	162			0.86	0.72	8.9	6.0	6.3
92	01	22	164	9	330	0.88	0.81	10.0	5.3	5.3
92	01	24	166			0.88	0.35	10.5	4.9	5.2
92	01	26	168			0.85	0.70	6.1	7.8	7.9
92	01	30	172			0.91	1.18	7.2	7.0	7.1
92	01	31	173	13	373	0.89	0.50	8.2	5.9	6.0
92	02	2	175			0.85	0.30	12.1	3.0	4.6
92	02	3	176			0.83	1.01	10.7	3.5	4.3
92	02	5	178	14	356	0.86	1.19	10.6	3.6	4.1
92	02	6	179			0.88	1.04	10.2	3.7	4.1
92	02	7	180			0.84	0.57	9.8	3.9	4.5
92	02	10	183		353	0.86	0.95	9.7	4.7	4.8
92	02	11	184	6	394	0.86	0.86	10.3	4.4	4.5
92	02	12	185		377	0.89	0.11	11.5	4.0	4.0
92	02	13	186			0.83	0.25	10.1	4.5	4.6
92	02	14	187			0.90	0.54	10.2	4.6	4.6
92	02	16	189	11	334	0.87	0.54	10.3	4.3	4.3
92	02	18	191		389	0.94	0.67	10.2	4.3	4.3
92	02	19	192			0.85	0.01	4.5	9.9	10.6
92	02	21	194			0.76	0.02	15.3	3.0	3.6

AMMONIA LOADING PHASE (10 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Effluent BOD (mg/L)	Effluent COD (mg/L)	Anoxic VSS/TSS	Anoxic NO2/NOX	Anoxic NOX Load (gN/d)	Anoxic COD:NOX Entering (gCOD/gN)	Anoxic COD:NOX Removed (gCOD/gN)
92	02	24	197		428	0.87	1.19	5.7	8.1	8.4
92	02	27	200	44		0.78	0.07	13.7	2.6	2.9
92	02	28	201			0.80	0.47	6.3	5.4	5.8
92	02	29	202			0.77	0.06	8.3	4.1	4.2
92	03	1	203			0.72	0.08	8.2	4.2	4.6
92	03	2	204	51		0.71	0.33	4.6	8.2	8.6
92	03	3	205		510	0.78	2.65	4.1	9.4	9.9
92	03	4	206			0.74	0.39	6.1	6.1	6.4
92	03	5	207			0.76	0.02	6.1	6.2	6.9
92	03	6	208			0.77	0.15	8.1	4.6	4.8
92	03	7	209			0.77	10.16	3.9	9.6	9.7
92	03	10	212	43	573	0.70				
92	03	11	213			0.79				

AMMONIA LOADING PHASE (10 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Anoxic Denitrn Rate (mgN/d)	Anoxic %Denitrn	Anoxic Specific Denitrn Rate (mgN/d/gVSS)	Anoxic NH4 Removal Rate (mgN/d)	Anoxic % NH4 Removal	Aerobic VSS/TSS
91	08	12	1				-758	-7	
91	08	14	3				-483	-4	
91	08	16	5				293	4	0.79
91	08	18	7				367	9	
91	08	20	9				1467	45	0.70
91	08	23	12				912	31	
91	08	26	15				-67	-3	
91	08	28	17	-90	-1		2	0	
91	08	31	20	-1146	-10		310	14	
91	09	2	22	-638	-5		86	4	
91	09	4	24	741	5	100	456	20	0.76
91	09	7	27	1154	11	142	458	22	0.80
91	09	9	29	1432	13	185	499	22	0.80
91	09	12	32	404	4	52	18	1	0.84
91	09	16	36	1063	21	131	-90	-5	0.84
91	09	17	37	1181	22	139	-427	-18	0.81
91	09	19	39	3832	93	453	-5	-0	0.87
91	09	21	41	3967	99	453	-64	-3	0.80
91	09	23	43	1803	94	211	-229	-11	0.84
91	09	26	46	1486	81	162	212	9	0.80
91	09	28	48	1611	82	187	348	17	0.85
91	09	30	50	1526	97	174	237	13	0.84
91	10	2	52	1707	96	193	-47	-3	0.83
91	10	4	54	1799	97	204	332	16	0.84
91	10	6	56	1617	98	179	279	14	0.86
91	10	8	58	1591	99	188	-186	-10	0.86
91	10	11	61	1755	99	197	138	7	0.81
91	10	14	64	2337	58	253	234	3	0.93
91	10	16	66	1767	43	168	1033	19	0.82
91	10	18	68	2301	71	238	1428	29	0.80
91	10	20	70	2949	95	292	672	15	0.81
91	10	23	73	3007	97	304	553	13	0.83
91	10	25	75	2901	90	574	-39	-1	0.80
91	10	27	77	3682	95	688	-2	-0	0.84
91	10	29	79	2610	96	237	-87	-3	0.87
91	11	1	82	3183	98	306	13	0	0.80
91	11	3	84	3067	99	291	-390	-15	0.85
91	11	5	86	2626	98	255	394	11	0.85
91	11	7	88	2810	98	263	202	6	0.85
91	11	10	91	2347	77	225	1692	22	0.87
91	11	12	93	5136	99	482	-2567	-20	0.85
91	11	13	94	4725	98	432	-1409	-12	0.84
91	11	15	96	5928	98	505	-1134	-9	0.84
91	11	17	98	4572	96	408	272	2	0.75
91	11	20	101	4720	96	355	-59	-0	1.06
91	11	22	103	5806	100	528	-376	-5	0.86

AMMONIA LOADING PHASE (10 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Anoxic Denitrn Rate (mgN/d)	Anoxic %Denitrn	Anoxic Specific Denitrn Rate (mgN/d/gVSS)	Anoxic NH4 Removal Rate (mgN/d)	Anoxic % NH4 Removal	Aerobic VSS/TSS
91	11	25	106	5638	78	547	318	5	0.95
91	11	26	107	5479	89	498	2070	29	0.87
91	11	29	110	5625	87	487	-265	-4	0.86
91	12	2	113	5587	86	490	378	6	0.88
91	12	4	115	5425	76	458	1579	26	0.86
91	12	6	117	5702	95	494	1189	19	0.84
91	12	7	118	4909	98	402	-99	-2	0.85
91	12	9	120	4716	95	393	-343	-6	0.85
91	12	11	122	6229	58	460	1855	31	0.85
91	12	13	124	6881	97	533	169	3	0.85
91	12	16	127	3446	100	262	919	17	0.88
91	12	18	129	5575	99	427	-135	-2	0.86
91	12	20	131	5029	100	368	928	16	0.87
91	12	22	133	4063	100	478	159	1	0.83
91	12	24	135	6858	99	902	-828	-4	0.89
91	12	26	137	5229	99	329	431	2	0.83
91	12	30	141	5907	67	405	-1038	-5	0.87
92	01	2	144	5942	60	268	358	3	0.84
92	01	5	147	7305	96	485	260	3	0.86
92	01	6	148	6877	98	435	1176	13	0.86
92	01	8	150	7710	98	506	898	9	0.87
92	01	10	152	7428	95	481	771	8	0.80
92	01	12	154	6683	96	420	525	5	0.84
92	01	14	156	9916	71	636	465	2	0.85
92	01	15	157	8357	50	580	680	4	0.85
92	01	17	159	10260	50	698	5651	36	0.87
92	01	20	162	8446	95	479	1493	10	0.85
92	01	22	164	9884	99	543	785	5	0.88
92	01	24	166	9839	94	503	10031	64	0.88
92	01	26	168	6000	98	301	2725	16	0.84
92	01	30	172	7169	100	348	2349	15	0.88
92	01	31	173	8052	99	298	1122	8	0.87
92	02	2	175	7884	65	295	1783	12	0.84
92	02	3	176	8613	81	323	1932	13	0.83
92	02	5	178	9291	88	352	2127	14	0.84
92	02	6	179	9254	91	346	2412	16	0.86
92	02	7	180	8403	85	311	2919	20	0.83
92	02	10	183	9569	98	350	2076	14	0.84
92	02	11	184	10173	99	376	3279	22	0.86
92	02	12	185	11504	100	422	-214	-1	0.87
92	02	13	186	9833	97	358	2212	15	0.83
92	02	14	187	10231	100	378	437	3	0.87
92	02	16	189	10235	100	376	2505	18	0.87
92	02	18	191	10155	100	277	4282	14	0.75
92	02	19	192	4218	93	111	-3176	-9	0.75
92	02	21	194	12774	84	388	22355	44	0.73

AMMONIA LOADING PHASE (10 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Anoxic Denitrn Rate (mgN/d)	Anoxic %Denitrn	Anoxic Specific Denitrn Rate (mgN/d/gVSS)	Anoxic NH4 Removal Rate (mgN/d)	Anoxic % NH4 Removal	Aerobic VSS/TSS
92	02	24	197	5501	97	166	1610	5	0.83
92	02	27	200	12241	90	356	9616	23	0.75
92	02	28	201	5927	94	194	3714	12	0.75
92	02	29	202	8201	98	260	7346	21	0.84
92	03	1	203	7395	90	245	4310	13	0.71
92	03	2	204	4344	95	134	4109	10	0.72
92	03	3	205	3937	95	131	9579	19	0.70
92	03	4	206	5769	95	175	6089	12	0.74
92	03	5	207	5455	90	175	4601	9	0.75
92	03	6	208	7754	95	283	11190	24	0.69
92	03	7	209	3855	99	119	11930	25	0.75
92	03	10	212				12371	21	0.71
92	03	11	213				7118	12	0.72

AMMONIA LOADING PHASE (10 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Aerobic NO2/NOX	Aerobic ALK:NH4 Added (gCaCO3/gN)	Aerobic ALK:NH4 Nitrified (gCaCO3/gN)	Aerobic Nitrn Rate (mg/d)	Aerobic %Nitrn	Aerobic Specific Nitrn Rate (mgN/d/gVSS)
91	08	12	1	0.01	10.05	109.44			
91	08	14	3		10.34	35.16			
91	08	16	5		9.81	23.54			-366
91	08	18	7		9.12	32.54			
91	08	20	9	0.00	8.80	26.63			-388
91	08	23	12		8.05	3.40			
91	08	26	15		9.67	10.16			
91	08	28	17		9.63	10.26	1851	87	
91	08	31	20		9.45	24.34	846	43	
91	09	2	22	0.01	9.20	13.20	1586	70	
91	09	4	24		8.68	6.22	3196	173	194
91	09	7	27		9.18	6.21	3015	188	188
91	09	9	29	0.00	8.80	5.61	3445	199	191
91	09	12	32		8.80	8.26	2132	105	140
91	09	16	36		9.41	9.02	1941	97	122
91	09	17	37	0.00	9.49	9.37	2125	75	126
91	09	19	39		8.69	3.87	4496	213	263
91	09	21	41		9.44	3.73	4550	229	257
91	09	23	43	0.01	9.07	8.82	2108	91	121
91	09	26	46		8.42	10.15	1766	87	98
91	09	28	48		9.49	9.29	1962	119	108
91	09	30	50	0.00	10.05	10.37	1830	111	104
91	10	2	52		9.35	9.02	1945	101	109
91	10	4	54		8.90	9.64	1949	110	115
91	10	6	56	0.00	9.21	10.69	1748	100	99
91	10	8	58		9.25	10.06	1738	84	102
91	10	11	61		9.89	9.84	2001	108	118
91	10	14	64	0.00	6.32	6.27	2973	36	161
91	10	16	66		3.89	4.57	2519	57	142
91	10	18	68		3.67	4.21	2916	82	173
91	10	20	70		3.89	3.29	3449	88	175
91	10	23	73	0.00	3.89	3.59	3608	101	187
91	10	25	75		3.97	3.40	3463	115	173
91	10	27	77		3.84	2.82	4303	136	216
91	10	29	79		3.71	3.83	3098	94	140
91	11	1	82	0.01	3.65	3.32	3718	110	161
91	11	3	84		5.02	3.63	3601	120	164
91	11	5	86		3.55	3.95	3133	101	141
91	11	7	88		3.73	3.67	3366	108	153
91	11	10	91		1.97	4.12	2921	50	132
91	11	12	93		2.03	2.06	6011	39	267
91	11	13	94		1.89	2.09	5638	44	259
91	11	15	96		2.29	2.00	6909	48	307
91	11	17	98		2.16	2.40	5439	44	282
91	11	20	101		2.27	2.49	5579	39	193
91	11	22	103		2.36	2.03	6706	92	302

AMMONIA LOADING PHASE (10 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Aerobic NO2/NOX	Aerobic ALK:NH4 Added (gCaCO3/gN)	Aerobic ALK:NH4 Nitrified (gCaCO3/gN)	Aerobic Nitrn Rate (mg/d)	Aerobic %Nitrn	Aerobic Specific Nitrn Rate (mgN/d/gVSS)
91	11	25	106		2.77	2.31	6730	106	277
91	11	26	107		3.72	3.56	6673	129	306
91	11	29	110		4.24	3.58	6777	104	324
91	12	2	113		4.05	3.49	6653	118	282
91	12	4	115		4.01	3.58	6686	150	266
91	12	6	117		4.02	3.69	6919	134	250
91	12	7	118		4.12	4.06	5725	100	214
91	12	9	120		4.43	4.35	5504	95	205
91	12	11	122		4.08	2.97	8021	195	287
91	12	13	124		3.80	2.87	8034	135	286
91	12	16	127		4.36	5.85	4121	89	144
91	12	18	129	0.20	4.35	3.64	6467	116	228
91	12	20	131		3.96	3.87	5790	122	199
91	12	22	133		3.50	6.40	4811	35	280
91	12	24	135	0.22	3.27	3.95	8029	39	528
91	12	26	137		3.38	5.14	6163	34	210
91	12	30	141		3.35	4.25	7418	32	230
92	01	2	144	0.12	3.80	4.50	7834	79	263
92	01	5	147		4.06	4.45	8486	92	252
92	01	6	148	0.41	4.05	4.57	8095	101	246
92	01	8	150		4.04	4.20	9051	105	267
92	01	10	152	0.61	3.68	4.22	8773	94	279
92	01	12	154	0.72	3.91	4.77	7875	86	245
92	01	14	156	0.29	4.24	4.78	12249	63	363
92	01	15	157	0.22	4.00	5.10	11093	63	387
92	01	17	159	0.18	3.63	3.82	13839	139	461
92	01	20	162	0.79	3.49	4.96	10071	78	292
92	01	22	164	0.89	3.43	4.30	11527	84	319
92	01	24	166	0.91	2.99	4.04	11629	202	309
92	01	26	168	1.03	3.03	6.63	7120	51	170
92	01	30	172	0.81	3.27	5.86	8594	66	194
92	01	31	173	0.84	3.18	5.08	9302	68	172
92	02	2	175	0.66	3.56	5.23	10022	77	188
92	02	3	176	0.86	3.96	5.61	10562	81	205
92	02	5	178	1.02	3.60	4.95	11006	84	203
92	02	6	179	0.94	3.71	5.17	11027	85	213
92	02	7	180	0.53	3.65	5.25	10167	87	196
92	02	10	183	0.78	3.61	4.66	11320	90	207
92	02	11	184	0.72	3.52	4.35	12043	104	217
92	02	12	185	0.58	3.33	3.83	13326	86	226
92	02	13	186	0.69	3.35	4.31	11489	91	205
92	02	14	187	0.61	3.33	4.17	11918	82	215
92	02	16	189	0.61	3.66	4.27	12113	103	216
92	02	18	191	0.65	2.64	4.39	12073	47	173
92	02	19	192	1.10	2.61	10.43	5038	14	68
92	02	21	194	0.83	2.58	3.44	15024	54	233

AMMONIA LOADING PHASE (10 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Aerobic NO2/NOX	Aerobic ALK:NH4 Added (gCaCO3/gN)	Aerobic ALK:NH4 Nitrified (gCaCO3/gN)	Aerobic Nitrn Rate (mg/d)	Aerobic %Nitrn	Aerobic Specific Nitrn Rate (mgN/d/gVSS)
92	02	24	197	1.13	2.68	8.30	6484	21	98
92	02	27	200	0.96	2.96	3.94	14557	44	226
92	02	28	201	0.88	3.12	8.13	6989	27	100
92	02	29	202	0.72	1.78	3.37	9558	34	141
92	03	1	203	0.90	1.86	3.98	8665	29	134
92	03	2	204	0.91	1.76	6.79	5167	13	76
92	03	3	205	0.93	2.33	9.71	4625	12	71
92	03	4	206	0.73	1.60	4.97	6719	15	98
92	03	5	207	0.88	1.39	4.39	6472	13	95
92	03	6	208	0.69	1.40	3.17	9087	26	134
92	03	7	209	0.93	1.16	5.24	4596	13	74
92	03	10	212		1.06				
92	03	11	213		0.94				

AMMONIA LOADING PHASE (10 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Aerobic NH4 Removal Rate (mgN/d)	Aerobic % NH4 Removal	ASRT (days)	System SSRT (days)	System % NH4 Removal
91	08	12	1	1374	12			29
91	08	14	3	1112	9			30
91	08	16	5	882	11			56
91	08	18	7	1453	37			85
91	08	20	9	428	24			90
91	08	23	12	1497	74			97
91	08	26	15	2147	89			98
91	08	28	17	1947	92			99
91	08	31	20	1855	95			99
91	09	2	22	2180	97			100
91	09	4	24	1830	99	10	16.1	100
91	09	7	27	1578	98	10	17.0	100
91	09	9	29	1691	97	10	16.5	100
91	09	12	32	1975	97	10	15.6	100
91	09	16	36	1941	97	10	16.8	99
91	09	17	37	2468	87	10	16.4	97
91	09	19	39	1989	94	10	17.2	99
91	09	21	41	1841	93	10	17.2	99
91	09	23	43	2271	98	10	16.5	100
91	09	26	46	1899	93	10	16.7	99
91	09	28	48	1560	95	10	16.3	99
91	09	30	50	1650	100	10	16.7	100
91	10	2	52	1924	100	10	16.2	100
91	10	4	54	1779	100	10	17.2	100
91	10	6	56	1750	100	10	16.5	100
91	10	8	58	2076	100	10	17.2	100
91	10	11	61	1851	100	10	16.9	100
91	10	14	64	1821	22	10	16.2	70
91	10	16	66	1464	33	10	16.9	84
91	10	18	68	1601	45	10	17.2	91
91	10	20	70	1970	50	10	17.4	91
91	10	23	73	2614	73	10	15.5	95
91	10	25	75	2998	100	10	14.3	100
91	10	27	77	3157	100	10	14.2	100
91	10	29	79	3279	100	10	16.8	100
91	11	1	82	3371	100	10	17.0	100
91	11	3	84	2995	100	10	16.5	100
91	11	5	86	3088	99	10	15.7	100
91	11	7	88	3108	99	10	15.3	100
91	11	10	91	4125	70	10	15.0	95
91	11	12	93	7512	49	10	14.2	81
91	11	13	94	6650	52	10	14.3	84
91	11	15	96	5995	42	10	14.4	81
91	11	17	98	4575	37	10	13.2	80
91	11	20	101	4754	33	10	14.7	77
91	11	22	103	5971	82	10	13.5	97

AMMONIA LOADING PHASE (10 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Aerobic NH4 Removal Rate (mgN/d)	Aerobic % NH4 Removal	ASRT (days)	System SSRT (days)	System % NH4 Removal
91	11	25	106	5144	81	10	16.9	97
91	11	26	107	4156	80	10	17.4	97
91	11	29	110	5879	90	10	14.0	98
91	12	2	113	5312	94	10	15.5	99
91	12	4	115	4376	98	10	11.6	100
91	12	6	117	5169	100	10	10.4	100
91	12	7	118	5735	100	10	13.9	100
91	12	9	120	5756	100	10	14.5	100
91	12	11	122	3957	96	10	16.1	100
91	12	13	124	5888	99	10	14.3	100
91	12	16	127	4601	100	10	16.5	100
91	12	18	129	5539	100	10	14.2	100
91	12	20	131	4721	99	10	15.2	100
91	12	22	133	7700	56	10	10.3	89
91	12	24	135	8783	42	10	10.1	82
91	12	26	137	7245	40	10	12.3	82
91	12	30	141	8255	35	10	13.2	77
92	01	2	144	8731	88	10	12.5	98
92	01	5	147	9011	98	10	13.7	100
92	01	6	148	7943	99	10	17.4	100
92	01	8	150	8498	98	10	14.6	100
92	01	10	152	9287	100	10	12.5	100
92	01	12	154	9080	100	10	12.0	100
92	01	14	156	12376	64	10	13.5	93
92	01	15	157	12777	72	10	10.5	95
92	01	17	159	8685	87	10	13.3	99
92	01	20	162	12803	99	10	13.9	100
92	01	22	164	13651	99	10	13.4	100
92	01	24	166	5698	99	10	16.0	100
92	01	26	168	12686	91	10	13.7	99
92	01	30	172	13049	100	10	14.5	100
92	01	31	173	13740	100	10	16.6	100
92	02	2	175	12954	99	10	15.5	100
92	02	3	176	13009	100	10	13.8	100
92	02	5	178	13025	100	10	15.1	100
92	02	6	179	12964	100	10	13.4	100
92	02	7	180	11699	100	10	15.4	100
92	02	10	183	12507	100	10	15.5	100
92	02	11	184	11616	100	10	16.2	100
92	02	12	185	15541	100	10	15.5	100
92	02	13	186	12543	100	10	13.9	100
92	02	14	187	14468	100	10	15.3	100
92	02	16	189	11616	99	10	15.2	100
92	02	18	191	13859	54	10	16.4	90
92	02	19	192	20776	57	10	16.3	87
92	02	21	194	-6886	-25	10	12.3	77

AMMONIA LOADING PHASE (10 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Aerobic NH4 Removal Rate (mgN/d)	Aerobic % NH4 Removal	ASRT (days)	System SSRT (days)	System % NH4 Removal
92	02	24	197	16200	52	10	15.3	89
92	02	27	200	5784	18	10	16.3	79
92	02	28	201	12418	47	10	11.6	89
92	02	29	202	7824	28	10	15.8	84
92	03	1	203	11746	40	10	16.0	87
92	03	2	204	11378	29	10	15.5	78
92	03	3	205	4488	11		57.4	73
92	03	4	206	9788	21		97.8	76
92	03	5	207	10139	21		71.5	72
92	03	6	208	5129	15		94.4	79
92	03	7	209	3727	11		39.5	75
92	03	10	212	634	1		69.9	63
92	03	11	213	9298	18		59.0	72

AMMONIA LOADING PHASE (20 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Flowrate Influent (L/d)	Flowrate NH4Cl (mL/h)	Flowrate CH3OH (mL/h)	Flowrate NaHCO3 (mL/h)	Flowrate o-PO4 (mL/h)	Flowrate Recycle (L/d)	Flowrate Aerobic Wasting (L/d)	Flowrate Anoxic Overflow (L/d)
91	08	12	1	9.9	0	0	0	5.0	59	0	69
91	08	14	3	9.7	0	0	0	5.1	58	0	67
91	08	16	5	9.6	0	0	0	5.3	53	0	63
91	08	18	7	9.8	0	0	0	5.3	60	0	70
91	08	20	9	10.1	0	0	0	5.4	55	0	66
91	08	23	12	9.8	0	0	0	5.0	63	0	73
91	08	26	15	10.0	0	0	0	5.2	62	0	72
91	08	28	17	9.9	0	0	0	5.0	55	0	65
91	08	31	20	10.0	0	0	0	5.3	57	0	68
91	09	2	22	10.0	0	0	0	5.4	56	0.5	66
91	09	4	24	9.8	0	0	0	5.4	62	0.5	72
91	09	7	27	10.0	0	6	0	5.2	62	0.5	73
91	09	9	29	10.0	0	6	0	5.3	66	0.5	77
91	09	12	32	9.8	0	11	0	5.0	68	0.5	78
91	09	16	36	9.6	0	11	0	5.1	64	0.5	74
91	09	17	37	9.8	0	11	0	5.3	66	0.5	76
91	09	19	39	10.0	0	11	0	5.3	61	0.5	72
91	09	21	41	9.8	0	5.4	0	5.2	61	0.5	71
91	09	23	43	9.9	0	5.4	0	4.9	56	0.5	66
91	09	26	46	9.6	0	6.9	0	5.0	61	0.5	71
91	09	28	48	9.5	0	7	0	4.9	60	0.5	70
91	09	30	50	9.4	0	7.1	0	5.2	62	0.5	72
91	10	2	52	9.7	0	6.8	0	5.3	64	0.5	74
91	10	4	54	9.9	0	7.2	0	5.1	67	0.5	77
91	10	6	56	9.6	0	7.4	0	4.9	58	0.5	68
91	10	8	58	9.9	0	7.8	0	5.2	61	0.5	71
91	10	11	61	10.0	0	7.3	0	5.0	61	0.5	71
91	10	14	64	10.1	8.4	6.5	0	4.9	55	0.5	65
91	10	16	66	10.1	8.2	6.8	0	4.8	62	0.5	73
91	10	18	68	10.0	8	6.8	0	4.8	65	0.5	75
91	10	20	70	10.0	8	6.8	0	5.1	58	0.5	68
91	10	23	73	10.0	8.2	7	0	5.3	58	0.5	68
91	10	25	75	9.8	8	7.2	0	5.0	60	0.5	70
91	10	27	77	9.7	8.2	7.1	0	5.2	56	0.5	66
91	10	29	79	9.4	8	7.1	0	5.0	61	0.5	71
91	11	1	82	9.6	8.2	6.9	0	4.8	59	0.5	69
91	11	3	84	9.6	4	6.9	0	5.1	63	0.5	73
91	11	5	86	9.4	3.45	7.2	0	5.1	66	0.5	75
91	11	7	88	9.4	3.2	7	0	5.1	60	0.5	70
91	11	10	91	9.2	6.9	6.9	0	5.0	60	0.5	70
91	11	12	93	9.0	7.1	7.3	0	5.1	54	0.5	64
91	11	13	94	9.4	7.5	7.4	0	5.2	53	0.5	63
91	11	15	96	9.4	7.4	7	0	5.4	54	0.5	63
91	11	17	98	9.7	7.5	6.9	0	5.3	60	0.5	70
91	11	20	101	9.8	7.3	7	4.8	4.8	61	0.5	72

AMMONIA LOADING PHASE (20 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Flowrate Influent (L/d)	Flowrate NH4Cl (mL/h)	Flowrate CH3OH (mL/h)	Flowrate NaHCO3 (mL/h)	Flowrate o-PO4 (mL/h)	Flowrate Recycle (L/d)	Flowrate Aerobic Wasting (L/d)	Flowrate Anoxic Overflow (L/d)
91	11	22	103	9.6	7	7	4.6	4.6	64	0.5	74
91	11	25	106	9.9	6.9	7.2	4.3	4.3	56	0.5	66
91	11	26	107	9.7	7.3	7.3	14.9	14.9	60	0.5	70
91	11	29	110	9.6	7.3	7.5	15.3	15.3	56	0.5	66
91	12	2	113	9.6	7.4	7.4	15	15.0	54	0.5	64
91	12	4	115	9.6	7.4	7.4	15	15.0	59	0.5	69
91	12	6	117	9.6	7.8	7.3	15.2	15.2	55	0.5	66
91	12	7	118	9.6	6.9	7.2	14.4	14.4	61	0.5	71
91	12	9	120	9.7	6.8	7.2	14.7	14.7	56	0.5	66
91	12	11	122	9.5	7.4	7.4	15.3	15.3	62	0.5	72
91	12	13	124	9.7	7.5	7.5	15.1	15.1	61	0.5	72
91	12	16	127	9.8	7.5	7.6	15.5	15.5	56	0.5	66
91	12	18	129	9.9	7.4	7.3	15.3	15.3	58	0.5	69
91	12	20	131	9.5	7.7	7.2	14.7	14.7	55	0.5	65
91	12	22	133	9.4	6.6	7.4	14.8	14.8	62	0.5	72
91	12	24	135	9.5	7.3	7.4	15.3	15.3	58	0.5	69
91	12	26	137	9.6	7.3	7.4	15.1	15.1	55	0.5	66
91	12	30	141	9.7	7.3	7.4	15.1	15.1	56	0.5	66
92	01	2	144	9.4	7.3	7.6	31	31.0	52	0.5	63
92	01	5	147	9.3	7.5	7.7	30.9	30.9	63	0.5	73
92	01	6	148	9.5	7.2	7.5	30	30.0	63	0.5	74
92	01	8	150	9.2	7.2	7.4	31	31.0	60	0.5	70
92	01	10	152	9.0	7.3	7.3	29	29.0	52	0.5	62
92	01	12	154	8.9	7	7.4	30	30.0	56	0.5	66
92	01	14	156	8.7	28.9	8.2	41.3	41.3	61	0.5	71
92	01	15	157	8.5	29	8	39	39.0	55	0.5	66
92	01	17	159	8.5	29	7.8	38	38.0	61	0.5	71
92	01	20	162	8.3	29	7.5	36	36.0	54	0.5	64
92	01	22	164	8.4	29	7.4	36	36.0	61	0.5	71
92	01	24	166	8.6	28	7.2	36	36.0	64	0.5	74
92	01	26	168	8.7	27	7.4	36	36.0	59	0.5	70
92	01	30	172	8.7	26.9	7.9	37.3	37.3	54	0.5	64
92	01	31	173	8.6	26	7.5	35	35.0	56	0.5	66
92	02	2	175	8.5	25.6	7	34.4	34.4	54	0.5	64
92	02	3	176	8.6	26	7.3	37.5	37.5	62	0.5	72
92	02	5	178	8.8	27	7.4	38	38.0	55	0.5	66
92	02	6	179	8.7	27.3	7.4	39.5	39.5	52	0.5	63
92	02	7	180	9.0	26	7.4	37	37.0	54	0.5	65
92	02	10	183	8.7	25	7.6	36	36.0	53	0.5	63
92	02	11	184	8.9	26	7.6	37	37.0	56	0.5	67
92	02	12	185	9.1	27	7.7	36	36.0	57	0.5	68
92	02	13	186	8.8	26	7.6	35	35.0	59	0.5	70
92	02	14	187	8.8	26	7.9	34.8	34.8	64	0.5	75
92	02	16	189	8.9	25.8	7.4	36	36.0	66	0.5	77
92	02	18	191	8.6	26	7.3	36	36.0	68	0.5	78

AMMONIA LOADING PHASE (20 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Flowrate Influent (L/d)	Flowrate NH4Cl (mL/h)	Flowrate CH3OH (mL/h)	Flowrate NaHCO3 (mL/h)	Flowrate o-PO4 (mL/h)	Flowrate Recycle (L/d)	Flowrate Aerobic Wasting (L/d)	Flowrate Anoxic Overflow (L/d)
92	02	19	192	8.8	26	7.5	36	36.0	58	0.5	69
92	02	21	194	8.5	26	7.7	36	36.0	58	0.5	68
92	02	24	197	8.7	26	7.7	36	36.0	58	0.5	68
92	02	27	200	8.6	26.2	8.2	32.6	32.6	56	0.5	66
92	02	28	201	8.6	23.5	7.3	36	36.0	55	0.5	65
92	02	29	202	8.5	25.3	7.8	41.4	41.4	52	0	62
92	03	1	203	8.7	24	7.3	40	40.0	61	0	71
92	03	2	204	8.5	25.6	8	41.2	41.2	56	0	66
92	03	3	205	8.5	24.7	8.3	58.4	58.4	59	0	70
92	03	4	206	8.4	27.4	7.9	54.3	54.3	60	0	71
92	03	5	207	8.4	26.9	8	42	42.0	54	0	64
92	03	6	208	8.6	26.9	8	42	42.0	58	0	69
92	03	7	209	8.6	26.9	8	42	42.0	62	0	72
92	03	10	212	8.9	26.4	6.6	35	35.0	60	0	70
92	03	11	213	9.0	30	7.2	35	35.0	55	0	66

AMMONIA LOADING PHASE (20 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Flowrate Aerobic Overflow (L/d)	Feed Conc. NH4Cl (g/L)	Feed Conc. Simulated Influent NH4 (mgN/L)	Feed Conc. CH3OH (mL/L)	Feed Conc. o-PO4 (gP/L)	Feed Conc. NaHCO3 (g/L)
91	08	12	1	69	0	208	0	0.816	0
91	08	14	3	67	0	202	0	0.816	0
91	08	16	5	63	0	213	0	0.816	0
91	08	18	7	70	0	214	0	0.816	0
91	08	20	9	66	0	222	0	0.816	0
91	08	23	12	73	0	243	0	0.816	0
91	08	26	15	72	0	210	0	0.816	0
91	08	28	17	65	0	211	0	0.816	0
91	08	31	20	68	0	215	0	0.816	0
91	09	2	22	66	0	221	0	0.816	0
91	09	4	24	72	0	217	0	0.816	0
91	09	7	27	73	0	203	25	0.816	0
91	09	9	29	77	0	211	25	0.816	0
91	09	12	32	78	0	209	25	0.816	0
91	09	16	36	74	0	195	50	0.816	0
91	09	17	37	76	0	188	50	0.816	0
91	09	19	39	72	0	206	50	0.816	0
91	09	21	41	71	0	192	100	0.816	0
91	09	23	43	66	0	200	100	0.816	0
91	09	26	46	71	0	215	100	0.816	0
91	09	28	48	70	0	190	80	0.816	0
91	09	30	50	72	0	179	50	0.816	0
91	10	2	52	74	0	193	43	0.816	0
91	10	4	54	77	0	203	50	0.816	0
91	10	6	56	68	0	196	50	0.816	0
91	10	8	58	71	0	195	50	0.816	0
91	10	11	61	71	0	183	50	0.816	0
91	10	14	64	65	19	281	50	0.816	0
91	10	16	66	73	19	290	75	0.816	0
91	10	18	68	75	19	314	75	0.816	0
91	10	20	70	68	19	289	75	0.816	0
91	10	23	73	68	19	301	84	0.816	0
91	10	25	75	70	19	288	84	0.816	0
91	10	27	77	66	19	301	70	0.816	0
91	10	29	79	71	19	312	70	0.816	0
91	11	1	82	69	19	320	84	0.816	0
91	11	3	84	73	19	236	84	0.816	0
91	11	5	86	75	55	336	84	0.816	0
91	11	7	88	70	48	318	84	0.816	0
91	11	10	91	70	88	614	84	0.816	0
91	11	12	93	64	88	615	84	0.816	0
91	11	13	94	63	88	620	84	0.816	0
91	11	15	96	63	88	596	84	0.816	0
91	11	17	98	70	88	597	84	0.816	0
91	11	20	101	72	88	595	84	0.816	0

AMMONIA LOADING PHASE (20 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Flowrate Aerobic Overflow (L/d)	Feed Conc. NH4Cl (g/L)	Feed Conc. Simulated Influent NH4 (mgN/L)	Feed Conc. CH3OH (mL/L)	Feed Conc. o-PO4 (gP/L)	Feed Conc. NaHCO3 (g/L)
91	11	22	103	75	88	587	84	0.816	15
91	11	25	106	66	88	560	84	0.816	47
91	11	26	107	70	88	625	84	0.245	47
91	11	29	110	66	88	582	84	0.245	54
91	12	2	113	65	88	595	84	0.245	54
91	12	4	115	70	88	610	180	0.245	54
91	12	6	117	66	88	625	135	0.245	54
91	12	7	118	71	88	578	135	0.245	54
91	12	9	120	67	88	547	135	0.245	54
91	12	11	122	72	88	605	100	0.245	54
91	12	13	124	72	88	601	110	0.245	45
91	12	16	127	67	88	543	110	0.245	35
91	12	18	129	69	88	533	110	0.245	35
91	12	20	131	65	88	579	110	0.245	35
91	12	22	133	72	175	910	110	0.408	70
91	12	24	135	69	175	988	150	0.408	70
91	12	26	137	66	175	950	150	0.408	90
91	12	30	141	66	190	1021	150	0.408	90
92	01	2	144	63	190	1034	120	0.204	65
92	01	5	147	74	190	1059	120	0.204	53
92	01	6	148	74	190	1025	120	0.204	53
92	01	8	150	71	190	1080	130	0.204	53
92	01	10	152	63	190	1090	130	0.204	43
92	01	12	154	67	190	1047	130	0.204	43
92	01	14	156	72	70	1463	150	0.245	75
92	01	15	157	67	70	1515	150	0.245	75
92	01	17	159	72	70	1546	150	0.245	75
92	01	20	162	65	70	1565	165	0.202	75
92	01	22	164	72	80	1782	165	0.202	75
92	01	24	166	75	80	1664	165	0.202	69
92	01	26	168	71	80	1623	165	0.202	69
92	01	30	172	65	80	1611	165	0.202	83
92	01	31	173	67	80	1579	165	0.202	83
92	02	2	175	65	80	1581	230	0.231	83
92	02	3	176	73	80	1571	230	0.231	83
92	02	5	178	67	80	1580	165	0.231	75
92	02	6	179	64	80	1599	165	0.231	75
92	02	7	180	66	80	1504	165	0.231	88
92	02	10	183	64	80	1541	245	0.231	88
92	02	11	184	68	80	1535	245	0.231	83
92	02	12	185	69	80	1558	210	0.231	78
92	02	13	186	71	80	1542	210	0.231	78
92	02	14	187	76	80	1559	210	0.231	78
92	02	16	189	78	80	1464	210	0.231	78
92	02	18	191	79	115	2122	210	0.231	83

AMMONIA LOADING PHASE (20 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Flowrate Aerobic Overflow (L/d)	Feed Conc. NH4Cl (g/L)	Feed Conc. Simulated Influent NH4 (mgN/L)	Feed Conc. CH3OH (mL/L)	Feed Conc. o-PO4 (gP/L)	Feed Conc. NaHCO3 (g/L)
92	02	19	192	69	115	2093	210	0.231	83
92	02	21	194	69	115	2154	210	0.231	83
92	02	24	197	69	115	2099	210	0.231	90
92	02	27	200	67	115	2140	210	0.231	80
92	02	28	201	66	115	1950	100	0.231	83
92	02	29	202	63	115	2086	100	0.231	83
92	03	1	203	72	115	1953	100	0.231	88
92	03	2	204	67	115	2129	100	0.231	88
92	03	3	205	71	115	2072	100	0.231	88
92	03	4	206	72	115	2281	100	0.231	88
92	03	5	207	65	115	2236	100	0.231	88
92	03	6	208	70	115	2194	100	0.231	88
92	03	7	209	73	115	2205	100	0.231	40
92	03	10	212	71	115	2124	100	0.231	20
92	03	11	213	67	115	2302	100	0.231	0

AMMONIA LOADING PHASE (20 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy mm dd)			Day	System Loading CH3OH (gCOD/d)	System Loading o-PO4 (gP/d)	System Loading NaHCO3 (gCaCO3/d)	Anoxic ORP (mV)	Anoxic pH
91	08	12	1	0.00	0.098	2095	30	
91	08	14	3	0.00	0.100	2094	4	
91	08	16	5	0.00	0.104	2092	22	
91	08	18	7	0.00	0.104	1955	30	
91	08	20	9	0.00	0.106	1955	30	
91	08	23	12	0.00	0.098	1956	20	
91	08	26	15	0.00	0.101	2035	20	
91	08	28	17	0.00	0.099	2035	19	7.5
91	08	31	20	0.00	0.103	2034	29	
91	09	2	22	0.00	0.105	2034	54	
91	09	4	24	0.00	0.106	1885	47	
91	09	7	27	4.27	0.102	1860	-28	7.5
91	09	9	29	4.27	0.104	1860	-80	7.9
91	09	12	32	7.84	0.097	1838	-113	8.0
91	09	16	36	15.67	0.100	1836	-105	7.9
91	09	17	37	15.67	0.103	1788	-100	7.8
91	09	19	39	15.67	0.104	1790	-117	7.8
91	09	21	41	15.39	0.103	1813	-106	7.8
91	09	23	43	15.39	0.097	1815	-110	7.8
91	09	26	46	19.66	0.097	1806	-135	7.8
91	09	28	48	15.96	0.097	1806	-126	7.9
91	09	30	50	10.12	0.102	1803	-141	7.8
91	10	2	52	8.33	0.103	1806	-128	7.8
91	10	4	54	10.26	0.100	1806	-165	7.8
91	10	6	56	10.54	0.095	1805	-160	7.8
91	10	8	58	11.11	0.102	1803	-174	7.8
91	10	11	61	10.40	0.099	1806	-184	7.8
91	10	14	64	9.26	0.096	1776	-90	7.9
91	10	16	66	14.53	0.095	1146	-92	7.8
91	10	18	68	14.53	0.095	1146	-112	7.7
91	10	20	70	14.53	0.100	1145	-154	7.7
91	10	23	73	16.75	0.104	1144	-188	7.6
91	10	25	75	17.23	0.099	1143	-140	7.7
91	10	27	77	14.16	0.101	1142	-175	7.7
91	10	29	79	14.16	0.098	1141	-199	7.7
91	11	1	82	16.52	0.094	1143	-215	7.7
91	11	3	84	16.52	0.099	1154	-186	7.7
91	11	5	86	17.23	0.099	1154	-207	7.7
91	11	7	88	16.75	0.100	1155	-207	7.8
91	11	10	91	16.52	0.098	1144	-128	7.6
91	11	12	93	17.47	0.099	1141	-124	7.6
91	11	13	94	17.71	0.102	1142	-105	7.6
91	11	15	96	16.75	0.105	1295	-124	7.7
91	11	17	98	16.52	0.104	1297	-164	7.6
91	11	20	101	16.75	0.094	1314	-209	7.5

AMMONIA LOADING PHASE (20 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	System Loading CH3OH (gCOD/d)	System Loading o-PO4 (gP/d)	System Loading NaHCO3 (gCaCO3/d)	Anoxic ORP (mV)	Anoxic pH
91	11	22	103	16.75	0.090	1411	-227	7.8
91	11	25	106	17.23	0.084	1597	-415	7.7
91	11	26	107	17.47	0.088	2305	-162	7.8
91	11	29	110	17.95	0.090	2489	-135	8.1
91	12	2	113	17.71	0.088	2466	-138	8.2
91	12	4	115	37.95	0.088	2467	-145	8.2
91	12	6	117	28.08	0.089	2476	-150	8.3
91	12	7	118	27.70	0.085	2416	-229	8.1
91	12	9	120	27.70	0.086	2438	-204	8.2
91	12	11	122	21.09	0.090	2499	-169	8.4
91	12	13	124	23.51	0.089	2277	-205	8.3
91	12	16	127	23.82	0.091	2355	-329	8.3
91	12	18	129	22.88	0.090	2343	-330	8.2
91	12	20	131	22.57	0.086	2336	-290	8.1
91	12	22	133	23.19	0.145	3106	-200	8.3
91	12	24	135	31.63	0.150	3139	-180	8.2
91	12	26	137	31.63	0.148	3545	-222	8.4
91	12	30	141	31.63	0.148	3531	-215	7.8
92	01	2	144	25.99	0.152	4526	-200	8.6
92	01	5	147	26.33	0.151	3989	-207	8.5
92	01	6	148	25.64	0.147	3882	-201	8.4
92	01	8	150	27.41	0.152	4031	-182	8.6
92	01	10	152	27.04	0.142	3478	-221	8.2
92	01	12	154	27.41	0.147	3553	-156	8.4
92	01	14	156	35.05	0.243	6116	-160	8.3
92	01	15	157	34.19	0.229	5933	-100	8.3
92	01	17	159	33.34	0.223	5509	-134	8.1
92	01	20	162	35.15	0.175	5371	-210	8.6
92	01	22	164	34.69	0.175	5365	-209	8.4
92	01	24	166	33.75	0.175	4946	-283	8.6
92	01	26	168	34.69	0.175	4892	-156	8.3
92	01	30	172	37.03	0.181	5812	-163	8.6
92	01	31	173	35.15	0.170	5565	-132	8.6
92	02	2	175	45.88	0.191	5584	-150	8.6
92	02	3	176	47.84	0.208	5895	-145	8.5
92	02	5	178	34.69	0.211	5426	-118	8.3
92	02	6	179	34.69	0.219	5614	-108	8.3
92	02	7	180	34.69	0.205	5932	-176	8.6
92	02	10	183	53.06	0.200	5968	-209	8.6
92	02	11	184	53.06	0.205	5681	-180	8.6
92	02	12	185	46.07	0.200	5219	-208	8.5
92	02	13	186	45.48	0.194	5214	-210	8.5
92	02	14	187	47.27	0.193	5210	-215	8.5
92	02	16	189	44.28	0.200	5345	-190	8.5
92	02	18	191	43.68	0.200	5711	-234	8.2

AMMONIA LOADING PHASE (20 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	System Loading CH3OH (gCOD/d)	System Loading o-PO4 (gP/d)	System Loading NaHCO3 (gCaCO3/d)	Anoxic ORP (mV)	Anoxic pH
92	02	19	192	44.88	0.200	5620	-241	8.1
92	02	21	194	46.07	0.200	5757	-235	8.2
92	02	24	197	46.07	0.200	6074	-197	8.9
92	02	27	200	49.07	0.181	5166	-236	8.4
92	02	28	201	20.80	0.200	5783	-150	8.5
92	02	29	202	22.23	0.230	6467	-142	8.4
92	03	1	203	20.80	0.222	6493	-142	8.3
92	03	2	204	22.80	0.229	6726	-159	8.4
92	03	3	205	23.65	0.324	9076	-160	8.4
92	03	4	206	22.51	0.301	8576	-190	8.9
92	03	5	207	22.80	0.233	6910	-135	8.8
92	03	6	208	22.80	0.233	6799	-144	8.4
92	03	7	209	22.80	0.233	3762	-117	8.4
92	03	10	212	18.81	0.194	2252	-128	8.6
92	03	11	213	20.52	0.194	1206	-117	8.9

AMMONIA LOADING PHASE (20 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Anoxic VSS (mg/L)	Anoxic TSS (mg/L)	Anoxic o-PO4 (mgP/L)	Anoxic NH4 (mgN/L)	Anoxic NOx (mgN/L)	Anoxic NO2 (mgN/L)	Anoxic BOD (mg/L)	Anoxic COD (mg/L)
91	08	12	1			4.4	223	4			
91	08	14	3			4.3	198	5			338
91	08	16	5			4.6	128	35			
91	08	18	7			4.6	80	79			
91	08	20	9			4.1	45	227	159.0	19	359
91	08	23	12			3.9	39	288			
91	08	26	15			3.4	32	200			
91	08	28	17			3.4	34	191	1.3		362
91	08	31	20			3.8	29	187			
91	09	2	22			3.7	28	201			
91	09	4	24	1210	1539	4.1	24	193	0.7	22	347
91	09	7	27	1420	1770	3.8	24	163			
91	09	9	29	1750	2238	4.1	28	157			355
91	09	12	32	1820	2292	3.9	25	151			
91	09	16	36	1640	2041	4.5	27	40			
91	09	17	37	1760	2240	4.5	27	53	1.0	24	347
91	09	19	39	1770	2075	4.1	24	27			
91	09	21	41	1760	2023	5.1	26	3			
91	09	23	43	1860	2143	4.8	24	1	0.0		329
91	09	26	46	1605	1762	5.3	24	1			
91	09	28	48	1990	2189	4.1	24	1			330
91	09	30	50	1840	2190	4.5	26	1	0.0		
91	10	2	52	2070	2300	5.3	24	4			
91	10	4	54	2240	2867	4.6	25	1			341
91	10	6	56	2060	2396	4.6	26	0	0.0		
91	10	8	58	2200	2845	4.0	23	0			
91	10	11	61	2110	2536	5.0	25	0		41	348
91	10	14	64	2280	2502	5.3	36	13	0.3		
91	10	16	66	2420	2869	4.9	37	5			
91	10	18	68	2360	2904	5.3	50	3			354
91	10	20	70	2410	2646	4.2	37	1			
91	10	23	73	2690	2986	3.9	33	1	0.0		341
91	10	25	75	2790	3929	4.3	35	1			
91	10	27	77	2980	3383	3.7	40	7			369
91	10	29	79	2780	3419	4.8	39	8			
91	11	1	82	2850	3159	4.7	40	0	0.0		
91	11	3	84	2960	3849	5.2	51	0			335
91	11	5	86	2800	3262	5.1	38	0			
91	11	7	88	3230	3992	5.3	44	0		50	392
91	11	10	91	2890	3660	4.6	80	1			
91	11	12	93	2880	3757	3.7	174	9			
91	11	13	94	2900	3399	3.5	164	11			
91	11	15	96	2930	3716	3.8	146	2			370
91	11	17	98	3040	3589	4.8	138	2			
91	11	20	101	2930	3563	3.8	133	1			

AMMONIA LOADING PHASE (20 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Anoxic VSS (mg/L)	Anoxic TSS (mg/L)	Anoxic o-PO4 (mgP/L)	Anoxic NH4 (mgN/L)	Anoxic NOx (mgN/L)	Anoxic NO2 (mgN/L)	Anoxic BOD (mg/L)	Anoxic COD (mg/L)
91	11	22	103	3140	3937	4.3	125	1			
91	11	25	106	2870	3513	4.0	139	1			366
91	11	26	107	2860	3515	3.2	96	7			
91	11	29	110	2680	3175	3.6	81	12			
91	12	2	113	2990	3758	3.0	78	10		39	385
91	12	4	115	3120	3933	3.6	91	0			
91	12	6	117	2960	3415	3.5	85	6			
91	12	7	118	3210	3686	3.0	84	1			397
91	12	9	120	3450	4120	3.8	70	0			
91	12	11	122	3230	4031	3.9	88	20			
91	12	13	124	3330	3845	3.4	80	0			421
91	12	16	127	3110	3583	3.5	75	0			
91	12	18	129	3160	3933	4.0	76	1	0.0		
91	12	20	131	3330	3790	3.4	82	0		94	431
91	12	22	133	3610	4403	4.1	154	30			
91	12	24	135	3660	4466	4.5	139	12	0.2		
91	12	26	137	3530	4153	6.5	128	3			
91	12	30	141	3490	3905	7.5	133	1			555
92	01	2	144	3530	3980	7.3	130	6	0.0		
92	01	5	147	3690	4220	5.9	123	4			
92	01	6	148	4090	4669	6.6	120	1	0.0		444
92	01	8	150	4120	4816	5.9	135	3			426
92	01	10	152	3980	4739	5.8	156	0	0.0	78	440
92	01	12	154	3980	4895	5.2	133	0	0.0		407
92	01	14	156	4040	4955	8.1	207	98	2.9		
92	01	15	157	3260	4204	8.3	260	97	3.7	105	473
92	01	17	159	2980	3638	10.4	305	118	4.9		
92	01	20	162	3450	4356	9.4	193	22	18.0		
92	01	22	164	4300	5276	9.4	201	52	15.1	95	507
92	01	24	166	5070	6130	9.1	302	11	4.6		
92	01	26	168	4980	5884	6.8	217	67	15.6		
92	01	30	172	5410	6704	7.2	196	2	0.7		
92	01	31	173	5700	6765	8.4	188	13	6.1	134	533
92	02	2	175	6140	7836	7.7	184	0	1.3		
92	02	3	176	6050	7089	6.6	186	1	12.9		
92	02	5	178	6110	7705	6.0	189	38	36.0	170	594
92	02	6	179	6280	7427	6.1	191	39	38.0		
92	02	7	180	6400	7779	6.0	174	31	22.0		
92	02	10	183	6370	7776	5.6	192	0	1.2		457
92	02	11	184	6486	8358	6.5	218	2	1.4	133	502
92	02	12	185	6290	8008	7.1	181	0	0.1		578
92	02	13	186	6600	8303	7.2	207	0	1.1		
92	02	14	187	6530	8519	6.6	190	1	0.2		
92	02	16	189	6350	7652	6.4	178	0	0.4	141	486
92	02	18	191	7880	10004	5.0	263	0	0.4		672

AMMONIA LOADING PHASE (20 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Anoxic VSS (mg/L)	Anoxic TSS (mg/L)	Anoxic o-PO4 (mgP/L)	Anoxic NH4 (mgN/L)	Anoxic NOx (mgN/L)	Anoxic NO2 (mgN/L)	Anoxic BOD (mg/L)	Anoxic COD (mg/L)
92	02	19	192	8840	11088	6.4	363	1	0.2		
92	02	21	194	10410	13713	5.1	358	1	0.3		
92	02	24	197	9930	13308	6.5	332	1	0.5		758
92	02	27	200	10290	13678	8.4	468	1	0.7	327	
92	02	28	201	8830	11781	7.3	536	45	2.4		
92	02	29	202	7360	9634	7.9	491	13	0.6		
92	03	1	203	8780	11683	10.2	430	34	0.7		
92	03	2	204	7000	9661	11.0	447	3	3.1	294	
92	03	3	205	6870	9103	13.6	375	19	1.3		892
92	03	4	206	6610	9206	14.4	394	5	2.5		
92	03	5	207	6240	8506	12.1	394	2	0.1		
92	03	6	208	5310	7424	10.4	603	11	0.9		
92	03	7	209	4990	6310	8.6	548	4	1.2		
92	03	10	212	5010	6572		662			410	808
92	03	11	213	6090	8143		758				

AMMONIA LOADING PHASE (20 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Aerobic DO (mg/L)	Aerobic pH	Aerobic VSS (mg/L)	Aerobic TSS (mg/L)	Aerobic o-PO4 (mgP/L)	Aerobic NH4 (mgN/L)	Aerobic NOx (mgN/L)
91	08	12	1	4.0				4.8	208	5
91	08	14	3	3.0				3.8	189	6
91	08	16	5	3.5		2730	3898	3.9	108	45
91	08	18	7	4.0				4.2	55	128
91	08	20	9	3.5	7.2	2580	3471	4.4	21	255
91	08	23	12	4.2				3.7	9	349
91	08	26	15	4.0				3.8	4	228
91	08	28	17	4.8	7.3			3.3	2	225
91	08	31	20	4.1	7.8			3.9	2	217
91	09	2	22	4.0	7.7			4.1	2	221
91	09	4	24	4.5	7.8	1344	1737	4.0	2	217
91	09	7	27	4.3	7.7	1660	2111	4.1	0	189
91	09	9	29	4.5	7.8	1800	2330	4.6	0	178
91	09	12	32	4.2	7.8	1850	2350	3.5	0	177
91	09	16	36	4.0	7.7	1880	2395	4.5	1	80
91	09	17	37	4.0	7.6	1810	2354	5.0	3	83
91	09	19	39	4.4	7.7	1790	2140	4.1	2	56
91	09	21	41	2.0	7.6	1800	2121	4.8	1	30
91	09	23	43	3.7	7.6	1990	2288	4.9	0	30
91	09	26	46	3.5	7.6	2010	2257	5.5	1	28
91	09	28	48	3.0	7.7	1970	2222	4.5	0	31
91	09	30	50	3.3	7.6	2220	2652	4.1	0	24
91	10	2	52	3.8	7.5	2110	2345	4.4	0	28
91	10	4	54	3.0	7.5	2140	2724	5.1	0	25
91	10	6	56	3.8	7.5	2230	2629	4.2	0	24
91	10	8	58	3.8	7.5	2130	2747	3.8	0	29
91	10	11	61	3.0	7.5	2200	2661	4.2	0	26
91	10	14	64	3.0	7.4	2460	2742	4.4	22	33
91	10	16	66	3.3	7.4	2410	2849	5.4	17	58
91	10	18	68	3.0	7.3	2310	2849	4.6	25	47
91	10	20	70	3.0	7.4	2490	2807	4.6	12	45
91	10	23	73	4.9	7.3	2670	2991	3.8	5	41
91	10	25	75	4.5	7.3	2530	3541	4.6	0	41
91	10	27	77	4.0	7.2	2980	3455	3.3	1	46
91	10	29	79	3.2	7.3	3000	3670	3.9	0	50
91	11	1	82	2.5	7.3	2950	3357	4.0	0	46
91	11	3	84	3.0	7.3	2840	3758	5.4	0	46
91	11	5	86	2.0	7.4	2790	3333	5.0	0	41
91	11	7	88	3.5	7.3	2920	3592	6.0	0	43
91	11	10	91	4.5	6.5	2990	3861	4.9	8	51
91	11	12	93	4.5	5.8	3120	4065	4.2	68	67
91	11	13	94	3.9	5.8	3080	3651	4.0	58	72
91	11	15	96	3.4	6.0	2880	3750	3.4	57	81
91	11	17	98	3.5	5.8	2790	3305	5.2	64	98
91	11	20	101	4.0	5.7	2850	3444	4.0	56	95

AMMONIA LOADING PHASE (20 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Aerobic DO (mg/L)	Aerobic pH	Aerobic VSS (mg/L)	Aerobic TSS (mg/L)	Aerobic o-PO4 (mgP/L)	Aerobic NH4 (mgN/L)	Aerobic NOx (mgN/L)
91	11	22	103	3.0	5.8	2780	3561	4.7	62	96
91	11	25	106	4.5	5.8	2650	3277	3.8	96	79
91	11	26	107	3.8	5.9	2720	3395	3.7	20	106
91	11	29	110	4.0	7.5	3040	3630	3.4	0	133
91	12	2	113	4.5	7.7	3270	4190	3.5	0	134
91	12	4	115	3.5	7.5	3330	4198	4.0	0	77
91	12	6	117	3.5	7.4	3200	3786	3.8	0	121
91	12	7	118	2.5	7.6	3340	3917	3.2	0	80
91	12	9	120	4.0	7.7	3560	4365	3.7	0	86
91	12	11	122	5.0	7.3	3390	4206	4.4	0	120
91	12	13	124	2.5	7.4	3460	4083	3.8	0	117
91	12	16	127	4.0	7.5	3420	4047	3.4	0	84
91	12	18	129	3.0	7.3	3550	4510	3.5	0	80
91	12	20	131	3.0	7.0	3380	3910	3.9	0	88
91	12	22	133	5.0	6.5	3510	4272	3.9	18	162
91	12	24	135	4.0	6.3	3480	4259	3.9	3	117
91	12	26	137	3.5	6.5	3550	4209	5.5	0	150
91	12	30	141	2.5	6.0	3660	4100	6.2	2	141
92	01	2	144	3.0	7.7	3650	4119	7.8	0	183
92	01	5	147	3.0	7.2	3840	4413	7.1	0	130
92	01	6	148	2.7	7.3	3780	4341	5.9	0	153
92	01	8	150	2.5	7.4	3910	4594	5.1	0	128
92	01	10	152	3.0	7.0	3820	4668	5.4	0	138
92	01	12	154	4.0	7.3	3940	4941	5.1	0	141
92	01	14	156	1.5	6.5	3780	4699	6.7	1	299
92	01	15	157	2.2	6.4	3740	4849	7.3	122	218
92	01	17	159	4.6	6.4	3610	4455	10.7	138	291
92	01	20	162	3.8	7.2	4280	5402	8.9	1	170
92	01	22	164	3.1	6.3	4640	5684	8.0	5	231
92	01	24	166	2.4	8.0	4720	5861	7.5	94	255
92	01	26	168	5.0	6.2	5020	5902	6.7	19	205
92	01	30	172	3.0	7.7	5530	7000	7.8	0	159
92	01	31	173	1.8	6.6	6780	8060	9.1	0	166
92	02	2	175	2.5	7.4	6760	8710	8.6	0	135
92	02	3	176	2.2	7.5	6920	8072	7.7	0	137
92	02	5	178	2.4	6.5	6500	8407	6.2	2	175
92	02	6	179	2.3	6.1	6660	8064	6.4	2	182
92	02	7	180	5.4	7.3	6490	7949	5.5	0	188
92	02	10	183	3.5	7.4	6520	7928	5.5	0	175
92	02	11	184	2.5	7.4	6410	8256	7.2	0	172
92	02	12	185	2.3	7.4	6530	8408	6.2	0	170
92	02	13	186	2.2	7.3	6340	8039	6.1	0	194
92	02	14	187	1.9	7.4	6600	8565	7.4	0	167
92	02	16	189	2.5	7.2	6360	7778	6.2	0	179
92	02	18	191	1.7	6.6	7990	10282	5.5	26	148

AMMONIA LOADING PHASE (20 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Aerobic DO (mg/L)	Aerobic pH	Aerobic VSS (mg/L)	Aerobic TSS (mg/L)	Aerobic o-PO4 (mgP/L)	Aerobic NH4 (mgN/L)	Aerobic NOx (mgN/L)
92	02	19	192	1.7	6.5	9510	12071	6.9	74	110
92	02	21	194	1.1	6.6	9450	12463	5.1	141	110
92	02	24	197	1.2	7.7	11900	16330	5.8	150	128
92	02	27	200	0.8	7.1	11880	16024	9.2	120	157
92	02	28	201	5.0	7.4	10130	13502	7.9	185	258
92	02	29	202	2.7	6.7	10540	14159	9.0	200	182
92	03	1	203	4.0	7.2	12490	16956	9.8	204	238
92	03	2	204	1.8	7.1	9470	13154	10.2	364	91
92	03	3	205	5.0	7.3	11340	15244	10.9	195	215
92	03	4	206	2.0	7.9	10650	14790	15.6	282	104
92	03	5	207	5.0	7.7	8210	11258	12.6	235	133
92	03	6	208	0.5	8.0	5090	7149	11.0	421	124
92	03	7	209	6.0	8.1	6280	8098	9.8	477	82
92	03	10	212	9.0	8.3	3080	4072		512	
92	03	11	213	9.5	8.9	4520	6063		593	

AMMONIA LOADING PHASE (20 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Aerobic NO2 (mgN/L)	Aerobic BOD (mg/L)	Aerobic COD (mg/L)	Effluent VSS (mg/L)	Effluent TSS (mg/L)	Effluent NH4 (mgN/L)	Effluent NOx (mgN/L)
91	08	12	1						212	5
91	08	14	3			281			187	6
91	08	16	5				118	168	105	43
91	08	18	7						55	127
91	08	20	9	176.0	13	274	94	125	21	257
91	08	23	12						12	306
91	08	26	15						4	235
91	08	28	17	7.2		318			2	215
91	08	31	20						2	216
91	09	2	22						1	218
91	09	4	24	3.9	14	273	21	27	2	217
91	09	7	27				16	20	0	193
91	09	9	29			286	20	26	0	176
91	09	12	32				28	35	0	177
91	09	16	36				37	46	1	82
91	09	17	37	2.3	11	268	41	53	3	85
91	09	19	39				26	31	2	53
91	09	21	41				54	63	1	29
91	09	23	43	1.0		270	36	41	0	30
91	09	26	46				29	32	1	28
91	09	28	48			258	37	41	0	30
91	09	30	50	0.9			23	28	0	23
91	10	2	52				18	20	0	27
91	10	4	54			273	19	24	0	24
91	10	6	56	0.9			35	41	0	23
91	10	8	58				40	50	0	29
91	10	11	61		6	290	45	56	0	26
91	10	14	64	1.4			38	42	22	33
91	10	16	66				32	37	17	55
91	10	18	68			264	44	51	24	45
91	10	20	70				26	29	12	42
91	10	23	73	1.7		248	25	28	5	42
91	10	25	75				45	51	0	41
91	10	27	77			271	37	43	1	40
91	10	29	79				73	90	0	47
91	11	1	82	2.0			48	54	0	38
91	11	3	84			285	42	52	0	45
91	11	5	86				59	65	0	43
91	11	7	88		11	292	15	18	0	41
91	11	10	91				37	46	8	51
91	11	12	93				65	83	69	71
91	11	13	94				49	60	57	71
91	11	15	96			281	16	21	56	83
91	11	17	98				36	43	63	98
91	11	20	101				66	80	54	90

AMMONIA LOADING PHASE (20 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Aerobic NO2 (mgN/L)	Aerobic BOD (mg/L)	Aerobic COD (mg/L)	Effluent VSS (mg/L)	Effluent TSS (mg/L)	Effluent NH4 (mgN/L)	Effluent NOx (mgN/L)
91	11	22	103				84	107	58	93
91	11	25	106			291	108	133	93	78
91	11	26	107				116	145	20	100
91	11	29	110				151	184	0	113
91	12	2	113		6	291	141	186	0	124
91	12	4	115				127	159	0	75
91	12	6	117				99	116	0	123
91	12	7	118			279	87	104	0	79
91	12	9	120				112	137	0	81
91	12	11	122				54	68	0	119
91	12	13	124			286	93	111	0	109
91	12	16	127				119	144	0	86
91	12	18	129	13.5			100	127	0	84
91	12	20	131		12	331	51	57	0	88
91	12	22	133				95	115	18	159
91	12	24	135	96.5			110	134	2	123
91	12	26	137				184	220	1	148
91	12	30	141			385	136	149	1	138
92	01	2	144	108.0			68	76	0	180
92	01	5	147				132	148	0	127
92	01	6	148	64.2		352	121	143	0	140
92	01	8	150			343	138	167	0	126
92	01	10	152	73.0	19	329	141	169	0	144
92	01	12	154	89.0		389	94	116	0	139
92	01	14	156	74.5			215	268	1	296
92	01	15	157	86.4	12	381	196	259	120	209
92	01	17	159	43.5			152	189	135	281
92	01	20	162	132.0			130	164	1	170
92	01	22	164	155.0	8	333	333	402	5	215
92	01	24	166	118.0			164	200	94	263
92	01	26	168	142.0			131	152	21	204
92	01	30	172	125.0			121	157	0	153
92	01	31	173	105.0	11	411	76	88	0	159
92	02	2	175	117.0			115	146	0	126
92	02	3	176	123.0			114	131	0	132
92	02	5	178	161.0	14	405	190	243	2	173
92	02	6	179	159.0			144	178	2	184
92	02	7	180	141.0			150	188	0	194
92	02	10	183	135.0		363	127	154	0	180
92	02	11	184	112.0	14	368	120	147	0	160
92	02	12	185	109.0		382	111	147	0	175
92	02	13	186	104.0			113	142	0	199
92	02	14	187	107.0			98	129	0	167
92	02	16	189	95.0	18	356	90	110	0	187
92	02	18	191	114.0		480	353	456	26	153

AMMONIA LOADING PHASE (20 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Aerobic NO2 (mgN/L)	Aerobic BOD (mg/L)	Aerobic COD (mg/L)	Effluent VSS (mg/L)	Effluent TSS (mg/L)	Effluent NH4 (mgN/L)	Effluent NOx (mgN/L)
92	02	19	192	121.0			155	197	74	109
92	02	21	194	108.0			392	524	143	111
92	02	24	197	107.0		504	151	208	138	126
92	02	27	200	110.0	38		111	152	124	147
92	02	28	201	142.0			260	347	175	264
92	02	29	202	155.0			528	731	194	174
92	03	1	203	197.0			214	257	210	232
92	03	2	204	103.0	40		582	796	169	88
92	03	3	205	206.0		604	183	245	198	206
92	03	4	206	91.2			560	798	185	100
92	03	5	207	96.0			206	281	231	128
92	03	6	208	112.0			140	194	322	118
92	03	7	209	75.0			128	164	384	80
92	03	10	212		58	563	239	309	497	
92	03	11	213				172	233	578	

AMMONIA LOADING PHASE (20 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Effluent BOD (mg/L)	Effluent COD (mg/L)	Anoxic VSS/TSS	Anoxic NO2/NOX	Anoxic NOX Load (gN/d)	Anoxic COD:NOX Entering (gCOD/gN)	Anoxic COD:NOX Removed (gCOD/gN)
91	08	12	1					0.3	0.0	
91	08	14	3		264			0.4	0.0	
91	08	16	5					2.4	0.0	
91	08	18	7					7.6	0.0	
91	08	20	9	14	284		0.70	14.1	0.0	
91	08	23	12					22.0	0.0	
91	08	26	15					14.7	0.0	
91	08	28	17		322		0.01	12.5	0.0	0.0
91	08	31	20					12.5	0.0	0.0
91	09	2	22					12.4	0.0	0.0
91	09	4	24	12	270	0.79	0.00	13.5	0.0	0.0
91	09	7	27			0.80		11.9	0.4	1020.6
91	09	9	29		272	0.78		11.9	0.4	-23.5
91	09	12	32			0.79		12.0	0.7	32.1
91	09	16	36			0.80		5.1	3.1	7.1
91	09	17	37	11	265	0.79	0.02	5.5	2.8	10.9
91	09	19	39			0.85		3.5	4.5	10.2
91	09	21	41			0.87		1.8	8.5	9.5
91	09	23	43		276	0.87	0.06	1.7	9.0	9.2
91	09	26	46			0.91		1.7	11.5	12.3
91	09	28	48		262	0.91		1.9	8.6	8.9
91	09	30	50			0.84	0.04	1.5	6.9	7.2
91	10	2	52			0.90		1.8	4.6	5.4
91	10	4	54		267	0.78		1.8	5.8	6.0
91	10	6	56			0.86	0.04	1.5	7.1	7.2
91	10	8	58			0.77		1.8	6.1	6.1
91	10	11	61	5	294	0.83		1.6	6.4	6.5
91	10	14	64			0.91	0.03	1.8	5.1	9.3
91	10	16	66			0.84		3.6	4.0	4.5
91	10	18	68		246	0.81		3.1	4.7	5.1
91	10	20	70			0.91		2.6	5.6	5.8
91	10	23	73		241	0.90	0.04	2.4	7.0	7.2
91	10	25	75			0.71		2.4	7.1	7.2
91	10	27	77		280	0.88		2.6	5.5	6.6
91	10	29	79			0.81		3.0	4.7	5.7
91	11	1	82			0.90	0.02	2.7	6.1	6.1
91	11	3	84		271	0.77		2.9	5.7	5.8
91	11	5	86			0.86		2.7	6.4	6.4
91	11	7	88	10	297	0.81		2.6	6.5	6.6
91	11	10	91			0.79		3.1	5.3	5.5
91	11	12	93			0.77		3.6	4.8	5.7
91	11	13	94			0.85		3.9	4.6	5.6
91	11	15	96		269	0.79		4.3	3.9	4.0
91	11	17	98			0.85		5.9	2.8	2.9
91	11	20	101			0.82		5.9	2.9	2.9

AMMONIA LOADING PHASE (20 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Effluent BOD (mg/L)	Effluent COD (mg/L)	Anoxic VSS/TSS	Anoxic NO2/NOX	Anoxic NOX Load (gN/d)	Anoxic COD:NOX Entering (gCOD/gN)	Anoxic COD:NOX Removed (gCOD/gN)
91	11	22	103			0.80		6.2	2.7	2.7
91	11	25	106		295	0.82		4.4	3.9	4.0
91	11	26	107			0.81		6.3	2.8	3.0
91	11	29	110			0.84		7.4	2.4	2.7
91	12	2	113	8	278	0.80		7.2	2.4	2.7
91	12	4	115			0.79		4.5	8.3	8.4
91	12	6	117			0.87		6.7	4.2	4.5
91	12	7	118		267	0.87		4.8	5.7	5.8
91	12	9	120			0.84		4.8	5.7	5.8
91	12	11	122			0.80		7.4	2.9	3.6
91	12	13	124		289	0.87		7.2	3.3	3.3
91	12	16	127			0.87		4.7	5.1	5.1
91	12	18	129			0.80	0.02	4.7	4.9	4.9
91	12	20	131	11	342	0.88		4.8	4.7	4.7
91	12	22	133			0.82		10.0	2.3	2.9
91	12	24	135			0.82	0.02	6.9	4.6	5.2
91	12	26	137			0.85		8.3	3.8	3.9
91	12	30	141		387	0.89		7.9	4.0	4.1
92	01	2	144			0.89	0.00	9.6	2.7	2.8
92	01	5	147			0.87		8.2	3.2	3.3
92	01	6	148		357	0.88	0.03	9.6	2.7	2.7
92	01	8	150		350	0.86		7.7	3.6	3.7
92	01	10	152	23	333	0.84	0.02	7.2	3.8	3.8
92	01	12	154		384	0.81		7.9	3.5	3.5
92	01	14	156			0.82	0.03	18.2	1.9	3.1
92	01	15	157	10	388	0.78	0.04	12.1	2.8	5.9
92	01	17	159			0.82	0.04	17.8	1.9	3.5
92	01	20	162			0.79	0.83	9.1	3.9	4.5
92	01	22	164	8	325	0.81	0.29	14.1	2.5	3.3
92	01	24	166			0.83	0.40	16.2	2.1	2.2
92	01	26	168			0.85	0.23	12.2	2.9	4.6
92	01	30	172			0.81	0.45	8.6	4.3	4.4
92	01	31	173	14	406	0.84	0.49	9.3	3.8	4.1
92	02	2	175			0.78	3.15	7.3	6.3	6.3
92	02	3	176			0.85	10.49	8.5	5.6	5.7
92	02	5	178	11	415	0.79	0.96	9.7	3.6	4.8
92	02	6	179			0.85	0.97	9.5	3.7	4.9
92	02	7	180			0.82	0.72	10.2	3.4	4.2
92	02	10	183		362	0.82	8.51	9.2	5.7	5.8
92	02	11	184	16	358	0.78	0.73	9.7	5.5	5.6
92	02	12	185		388	0.79	0.26	9.7	4.8	4.8
92	02	13	186			0.79	2.61	11.5	3.9	4.0
92	02	14	187			0.77	0.14	10.8	4.4	4.4
92	02	16	189	16	345	0.83	0.93	11.8	3.7	3.7
92	02	18	191		478	0.79	1.10	10.0	4.4	4.4

AMMONIA LOADING PHASE (20 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Effluent BOD (mg/L)	Effluent COD (mg/L)	Anoxic VSS/TSS	Anoxic NO2/NOX	Anoxic NOX Load (gN/d)	Anoxic COD:NOX Entering (gCOD/gN)	Anoxic COD:NOX Removed (gCOD/gN)
92	02	19	192			0.80	0.36	6.4	7.0	7.1
92	02	21	194			0.76	0.43	6.4	7.2	7.3
92	02	24	197		484	0.75	0.81	7.4	6.2	6.2
92	02	27	200	29		0.75	1.01	8.8	5.6	5.6
92	02	28	201			0.75	0.05	14.2	1.5	1.8
92	02	29	202			0.76	0.04	9.4	2.4	2.6
92	03	1	203			0.75	0.02	14.6	1.4	1.7
92	03	2	204	41		0.72	1.19	5.1	4.5	4.6
92	03	3	205		624	0.75	0.07	12.7	1.9	2.1
92	03	4	206			0.72	0.47	6.3	3.6	3.8
92	03	5	207			0.73	0.06	7.2	3.2	3.2
92	03	6	208			0.72	0.08	7.3	3.1	3.5
92	03	7	209			0.79	0.33	5.1	4.5	4.7
92	03	10	212	63	576	0.76				
92	03	11	213			0.75				

AMMONIA LOADING PHASE (20 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Anoxic Denitrn Rate (mgN/d)	Anoxic %Denitrn	Anoxic Specific Denitrn Rate (mgN/d/gVSS)	Anoxic NH4 Removal Rate (mgN/d)	Anoxic % NH4 Removal	Aerobic VSS/TSS
91	08	12	1				-1057	-7	
91	08	14	3				-461	-4	
91	08	16	5				-230	-3	0.70
91	08	18	7				-134	-2	
91	08	20	9				485	14	0.74
91	08	23	12				163	5	
91	08	26	15				70	3	
91	08	28	17	162	1	-16	36	2	
91	08	31	20	-154	-1	15	311	14	
91	09	2	22	-868	-7	87	461	20	
91	09	4	24	-389	-3	-321	595	26	0.77
91	09	7	27	4	0	3	370	17	0.79
91	09	9	29	-182	-2	-104	53	2	0.77
91	09	12	32	244	2	134	237	11	0.79
91	09	16	36	2196	43	1339	39	2	0.79
91	09	17	37	1438	26	817	3	0	0.77
91	09	19	39	1530	44	864	528	24	0.84
91	09	21	41	1627	89	924	166	8	0.85
91	09	23	43	1665	97	895	471	23	0.87
91	09	26	46	1604	94	1000	440	20	0.89
91	09	28	48	1788	97	899	214	11	0.89
91	09	30	50	1398	96	760	-135	-8	0.84
91	10	2	52	1536	84	742	173	9	0.90
91	10	4	54	1716	97	766	184	9	0.79
91	10	6	56	1470	98	714	164	8	0.85
91	10	8	58	1819	99	827	349	18	0.78
91	10	11	61	1602	99	759	81	4	0.83
91	10	14	64	991	54	435	1804	43	0.90
91	10	16	66	3254	90	1345	1450	35	0.85
91	10	18	68	2842	92	1204	1142	23	0.81
91	10	20	70	2511	97	1042	1173	32	0.89
91	10	23	73	2337	98	869	1152	34	0.89
91	10	25	75	2381	98	853	543	18	0.71
91	10	27	77	2144	83	720	483	15	0.86
91	10	29	79	2492	82	896	301	10	0.82
91	11	1	82	2688	99	943	489	15	0.88
91	11	3	84	2860	99	966	-1364	-57	0.76
91	11	5	86	2674	99	955	398	12	0.84
91	11	7	88	2536	99	785	77	2	0.81
91	11	10	91	2998	97	1037	792	12	0.77
91	11	12	93	3051	84	1059	-1559	-16	0.77
91	11	13	94	3140	81	1083	-1135	-12	0.84
91	11	15	96	4208	97	1436	-340	-4	0.77
91	11	17	98	5739	98	1888	223	2	0.84
91	11	20	101	5761	98	1966	-60	-1	0.83

AMMONIA LOADING PHASE (20 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Anoxic Denitrn Rate (mgN/d)	Anoxic %Denitrn	Anoxic Specific Denitrn Rate (mgN/d/gVSS)	Anoxic NH4 Removal Rate (mgN/d)	Anoxic % NH4 Removal	Aerobic VSS/TSS
91	11	22	103	6158	99	1961	502	5	0.78
91	11	25	106	4324	98	1507	1914	17	0.81
91	11	26	107	5823	92	2036	800	11	0.80
91	11	29	110	6619	89	2470	479	8	0.84
91	12	2	113	6590	91	2204	930	16	0.78
91	12	4	115	4538	100	1454	-178	-3	0.79
91	12	6	117	6309	94	2132	703	11	0.85
91	12	7	118	4771	99	1486	-162	-3	0.85
91	12	9	120	4799	99	1391	822	15	0.82
91	12	11	122	5931	80	1836	-326	-5	0.81
91	12	13	124	7159	100	2150	332	5	0.85
91	12	16	127	4686	100	1507	611	11	0.85
91	12	18	129	4643	99	1469	248	5	0.79
91	12	20	131	4785	99	1437	427	7	0.86
91	12	22	133	7871	79	2180	-1004	-10	0.82
91	12	24	135	6076	89	1660	435	4	0.82
91	12	26	137	8130	98	2303	1104	12	0.84
91	12	30	141	7808	99	2237	1580	15	0.89
92	01	2	144	9168	96	2597	2093	21	0.89
92	01	5	147	7925	97	2148	1296	13	0.87
92	01	6	148	9564	99	2338	1334	13	0.87
92	01	8	150	7490	97	1818	912	9	0.85
92	01	10	152	7179	100	1804	607	6	0.82
92	01	12	154	7914	100	1988	1040	11	0.80
92	01	14	156	11316	62	2801	-521	-4	0.80
92	01	15	157	5771	48	1770	4172	20	0.77
92	01	17	159	9447	53	3170	1503	7	0.81
92	01	20	162	7762	85	2250	2333	16	0.79
92	01	22	164	10477	74	2437	2591	15	0.82
92	01	24	166	15389	95	3035	-390	-2	0.81
92	01	26	168	7550	62	1516	1695	10	0.85
92	01	30	172	8458	99	1563	2962	19	0.79
92	01	31	173	8511	91	1493	2605	17	0.84
92	02	2	175	7263	100	1183	3008	21	0.78
92	02	3	176	8408	99	1390	1532	10	0.86
92	02	5	178	7228	75	1183	3066	20	0.77
92	02	6	179	7093	75	1130	3615	23	0.83
92	02	7	180	8218	81	1284	3623	25	0.82
92	02	10	183	9223	100	1448	2622	18	0.82
92	02	11	184	9541	99	1471	573	4	0.78
92	02	12	185	9656	100	1535	3353	22	0.78
92	02	13	186	11493	100	1741	611	4	0.79
92	02	14	187	10669	99	1634	902	6	0.77
92	02	16	189	11817	100	1861	648	5	0.82
92	02	18	191	9986	100	1267	1532	7	0.78

AMMONIA LOADING PHASE (20 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Anoxic Denitrn Rate (mgN/d)	Anoxic %Denitrn	Anoxic Specific Denitrn Rate (mgN/d/gVSS)	Anoxic NH4 Removal Rate (mgN/d)	Anoxic % NH4 Removal	Aerobic VSS/TSS
92	02	19	192	6365	99	720	-132	-1	0.79
92	02	21	194	6353	99	610	4195	15	0.76
92	02	24	197	7390	99	744	6305	22	0.73
92	02	27	200	8733	99	849	-3636	-14	0.74
92	02	28	201	11276	79	1277	-6116	-22	0.75
92	02	29	202	8612	91	1170	-230	-1	0.74
92	03	1	203	12127	83	1381	653	2	0.74
92	03	2	204	4933	97	705	11085	28	0.72
92	03	3	205	11365	90	1654	5146	17	0.74
92	03	4	206	5925	94	896	10615	28	0.72
92	03	5	207	7098	98	1137	8352	25	0.73
92	03	6	208	6559	90	1235	4309	10	0.71
92	03	7	209	4844	95	971	11162	22	0.78
92	03	10	212				5119	10	0.76
92	03	11	213				6238	11	0.75

AMMONIA LOADING PHASE (20 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Aerobic NO2/NOX	Aerobic ALK:NH4 Added (gCaCO3/gN)	Aerobic ALK:NH4 Nitrified (gCaCO3/gN)	Aerobic Nitrn Rate (mg/d)	Aerobic %Nitrn	Aerobic Specific Nitrn Rate (mgN/d/gVSS)
91	08	12	1		10.05	495.87	42	0	
91	08	14	3		10.34	638.78	32	0	
91	08	16	5		9.81	33.48	607	8	22
91	08	18	7		9.12	5.74	3375	61	
91	08	20	9	0.69	8.80	10.89	1835	62	71
91	08	23	12		8.05	4.38	4451	157	
91	08	26	15		9.67	10.17	2019	89	
91	08	28	17	0.03	9.63	9.25	2202	100	
91	08	31	20		9.45	10.19	2028	102	
91	09	2	22		9.20	15.56	1324	71	
91	09	4	24	0.02	8.68	10.87	1728	102	129
91	09	7	27		9.18	10.15	1890	108	114
91	09	9	29		8.80	11.85	1610	75	89
91	09	12	32		8.80	9.25	2029	105	110
91	09	16	36		9.41	6.17	2979	150	158
91	09	17	37	0.03	9.49	7.99	2272	109	126
91	09	19	39		8.69	8.81	2104	123	118
91	09	21	41		9.44	9.49	1924	105	107
91	09	23	43	0.03	9.07	9.41	1956	124	98
91	09	26	46		8.42	9.53	1869	108	93
91	09	28	48		9.49	8.50	2088	125	106
91	09	30	50	0.04	10.05	10.78	1624	87	73
91	10	2	52		9.35	10.20	1762	101	83
91	10	4	54		8.90	10.03	1834	97	86
91	10	6	56	0.04	9.21	11.30	1576	89	71
91	10	8	58		9.25	9.07	2027	124	95
91	10	11	61		9.89	10.28	1808	101	82
91	10	14	64	0.04	6.33	14.25	1316	56	54
91	10	16	66		3.96	3.15	3859	143	160
91	10	18	68		3.65	3.59	3333	89	144
91	10	20	70		3.96	4.03	2978	117	120
91	10	23	73	0.04	3.80	4.33	2762	121	103
91	10	25	75		3.97	4.19	2793	116	110
91	10	27	77		3.79	4.45	2607	98	87
91	10	29	79		3.66	3.80	2973	107	99
91	11	1	82	0.04	3.57	3.65	3147	115	107
91	11	3	84		4.89	3.47	3308	89	116
91	11	5	86		3.43	3.68	3066	106	110
91	11	7	88		3.63	3.82	2944	97	101
91	11	10	91		1.86	3.15	3483	63	116
91	11	12	93		1.85	2.93	3682	33	118
91	11	13	94		1.84	2.94	3852	37	125
91	11	15	96		2.17	2.55	5002	54	174
91	11	17	98		2.17	1.96	6731	70	241
91	11	20	101		2.21	1.97	6733	71	236

AMMONIA LOADING PHASE (20 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Aerobic NO2/NOX	Aerobic ALK:NH4 Added (gCaCO3/gN)	Aerobic ALK:NH4 Nitrified (gCaCO3/gN)	Aerobic Nitrn Rate (mg/d)	Aerobic %Nitrn	Aerobic Specific Nitrn Rate (mgN/d/gVSS)
91	11	22	103		2.40	1.97	7124	77	256
91	11	25	106		2.85	3.18	5136	56	194
91	11	26	107		3.69	3.36	6920	103	254
91	11	29	110		4.28	3.09	7986	151	263
91	12	2	113		4.14	3.07	7966	160	244
91	12	4	115		4.04	4.59	5330	85	160
91	12	6	117		3.96	3.27	7556	136	236
91	12	7	118		4.18	4.32	5588	94	167
91	12	9	120		4.46	4.29	5681	122	160
91	12	11	122		4.13	3.44	7146	114	211
91	12	13	124		3.79	2.73	8374	146	242
91	12	16	127		4.34	4.29	5571	114	163
91	12	18	129	0.17	4.39	4.36	5489	105	155
91	12	20	131		4.03	4.06	5673	107	168
91	12	22	133		3.41	3.20	9508	86	271
91	12	24	135	0.82	3.18	4.26	7277	77	209
91	12	26	137		3.73	3.64	9669	116	272
91	12	30	141		3.46	3.82	9263	106	253
92	01	2	144	0.59	4.38	4.00	11089	138	304
92	01	5	147		3.77	4.15	9271	104	241
92	01	6	148	0.42	3.79	3.41	11170	128	296
92	01	8	150		3.73	4.36	8799	94	225
92	01	10	152	0.53	3.19	3.79	8554	89	224
92	01	12	154	0.63	3.39	3.54	9312	107	236
92	01	14	156	0.25	4.18	4.05	14470	99	383
92	01	15	157	0.40	3.92	6.96	8021	48	214
92	01	17	159	0.15	3.56	4.17	12448	58	345
92	01	20	162	0.78	3.43	5.23	9469	78	221
92	01	22	164	0.67	3.01	3.87	12805	90	276
92	01	24	166	0.46	2.97	2.59	18008	82	382
92	01	26	168	0.69	3.01	4.84	9681	65	193
92	01	30	172	0.79	3.61	5.48	10107	81	183
92	01	31	173	0.63	3.52	5.15	10213	83	151
92	02	2	175	0.87	3.53	5.99	8619	74	128
92	02	3	176	0.90	3.75	5.65	9812	74	142
92	02	5	178	0.92	3.43	5.77	9062	74	139
92	02	6	179	0.87	3.51	5.97	9003	76	135
92	02	7	180	0.75	3.94	5.68	10213	92	157
92	02	10	183	0.77	3.87	5.11	11018	92	169
92	02	11	184	0.65	3.70	4.87	11363	79	177
92	02	12	185	0.64	3.35	4.51	11485	95	176
92	02	13	186	0.54	3.38	3.72	13520	95	213
92	02	14	187	0.64	3.34	4.03	12403	88	188
92	02	16	189	0.53	3.65	3.77	13691	101	215
92	02	18	191	0.77	2.69	4.69	11489	57	144

AMMONIA LOADING PHASE (20 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Aerobic NO2/NOX	Aerobic ALK:NH4 Added (gCaCO3/gN)	Aerobic ALK:NH4 Nitrified (gCaCO3/gN)	Aerobic Nitrn Rate (mg/d)	Aerobic %Nitrn	Aerobic Specific Nitrn Rate (mgN/d/gVSS)
92	02	19	192	1.10	2.68	7.23	7482	30	79
92	02	21	194	0.98	2.67	7.22	7441	31	79
92	02	24	197	0.84	2.89	6.66	8684	39	73
92	02	27	200	0.70	2.41	4.72	10299	34	87
92	02	28	201	0.55	2.97	3.88	13869	40	137
92	02	29	202	0.85	3.10	5.74	10457	35	99
92	03	1	203	0.83	3.33	4.22	14579	48	117
92	03	2	204	1.13	3.16	10.76	5836	20	62
92	03	3	205	0.96	4.38	6.18	13642	53	120
92	03	4	206	0.88	3.76	11.29	6994	26	66
92	03	5	207	0.72	3.09	7.54	8429	34	103
92	03	6	208	0.90	3.10	8.16	7819	19	154
92	03	7	209	0.91	1.71	6.22	5678	15	90
92	03	10	212		1.06	-2.59			
92	03	11	213		0.52	-1.42			

AMMONIA LOADING PHASE (20 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Aerobic NH4 Removal Rate (mgN/d)	Aerobic % NH4 Removal	ASRT (days)	System SSRT (days)	System % NH4 Removal
91	08	12	1	1062	7			0
91	08	14	3	593	4			7
91	08	16	5	1252	16			49
91	08	18	7	1712	31			74
91	08	20	9	1566	53			90
91	08	23	12	2169	77			96
91	08	26	15	2016	89			98
91	08	28	17	2058	94			99
91	08	31	20	1856	94			99
91	09	2	22	1763	94	20		99
91	09	4	24	1548	91	20	28.4	99
91	09	7	27	1716	98	20	30.7	100
91	09	9	29	2110	99	20	30.9	100
91	09	12	32	1888	98	20	29.1	100
91	09	16	36	1903	96	20	26.5	99
91	09	17	37	1881	90	20	26.0	99
91	09	19	39	1587	93	20	29.3	99
91	09	21	41	1759	96	20	23.7	100
91	09	23	43	1552	98	20	27.5	100
91	09	26	46	1667	97	20	28.2	100
91	09	28	48	1654	99	20	28.0	100
91	09	30	50	1878	100	20	30.4	100
91	10	2	52	1751	100	20	32.5	100
91	10	4	54	1882	100	20	32.7	100
91	10	6	56	1770	100	20	28.6	100
91	10	8	58	1637	100	20	27.9	100
91	10	11	61	1797	100	20	26.6	100
91	10	14	64	930	39	20	28.3	92
91	10	16	66	1436	53	20	29.8	94
91	10	18	68	1886	50	20	27.5	92
91	10	20	70	1731	68	20	31.1	96
91	10	23	73	1943	85	20	32.0	98
91	10	25	75	2408	100	20	28.7	100
91	10	27	77	2568	97	20	30.5	100
91	10	29	79	2784	100	20	25.3	100
91	11	1	82	2726	100	20	28.5	100
91	11	3	84	3703	99	20	29.8	100
91	11	5	86	2887	100	20	27.1	100
91	11	7	88	3026	100	20	35.7	100
91	11	10	91	5034	90	20	30.6	99
91	11	12	93	6738	61	20	26.8	89
91	11	13	94	6716	65	20	28.6	91
91	11	15	96	5650	61	20	34.6	90
91	11	17	98	5190	54	20	31.0	89
91	11	20	101	5505	58	20	26.1	90

AMMONIA LOADING PHASE (20 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Aerobic NH4 Removal Rate (mgN/d)	Aerobic % NH4 Removal	ASRT (days)	System SSRT (days)	System % NH4 Removal
91	11	22	103	4705	51	20	24.6	89
91	11	25	106	2827	31	20	21.2	83
91	11	26	107	5294	79	20	20.5	97
91	11	29	110	5298	100	20	18.3	100
91	12	2	113	4978	100	20	19.8	100
91	12	4	115	6227	100	20	21.1	100
91	12	6	117	5528	100	20	22.8	100
91	12	7	118	5931	100	20	24.6	100
91	12	9	120	4644	100	20	22.9	100
91	12	11	122	6271	100	20	28.5	100
91	12	13	124	5710	100	20	24.2	100
91	12	16	127	4892	100	20	21.5	100
91	12	18	129	5190	100	20	23.3	100
91	12	20	131	5282	100	20	29.1	100
91	12	22	133	9723	88	20	24.8	98
91	12	24	135	9310	98	20	23.5	100
91	12	26	137	8329	100	20	18.4	100
91	12	30	141	8620	99	20	21.3	100
92	01	2	144	8045	100	20	27.2	100
92	01	5	147	8923	100	20	22.1	100
92	01	6	148	8729	100	20	23.3	100
92	01	8	150	9368	100	20	22.5	100
92	01	10	152	9541	100	20	22.2	100
92	01	12	154	8665	100	20	25.9	100
92	01	14	156	14525	100	20	17.7	100
92	01	15	157	8823	52	20	17.7	91
92	01	17	159	11634	54	20	19.5	90
92	01	20	162	12080	100	20	22.5	100
92	01	22	164	13806	97	20	15.3	100
92	01	24	166	15101	69	20	22.7	94
92	01	26	168	13647	91	20	24.7	99
92	01	30	172	12377	100	20	26.1	100
92	01	31	173	12308	100	20	29.7	100
92	02	2	175	11603	100	20	27.8	100
92	02	3	176	13246	100	20	27.6	100
92	02	5	178	12132	99	20	23.3	100
92	02	6	179	11688	99	20	25.9	100
92	02	7	180	11082	100	20	25.5	100
92	02	10	183	11927	100	20	27.1	100
92	02	11	184	14368	100	20	27.4	100
92	02	12	185	12097	100	20	27.7	100
92	02	13	186	14280	100	20	28.1	100
92	02	14	187	14067	100	20	29.1	100
92	02	16	189	13476	100	20	29.4	100
92	02	18	191	18216	90	20	19.9	99

AMMONIA LOADING PHASE (20 DAY AEROBIC SRT SYSTEM, 20 C)

Date (yy	mm	dd)	Day	Aerobic NH4 Removal Rate (mgN/d)	Aerobic % NH4 Removal	ASRT (days)	System SSRT (days)	System % NH4 Removal
92	02	19	192	19515	79	20	27.9	96
92	02	21	194	14463	60	20	21.2	93
92	02	24	197	12120	54	20	28.9	92
92	02	27	200	22562	74	20	31.0	94
92	02	28	201	22370	65	20	24.3	90
92	02	29	202	17538	59		34.2	89
92	03	1	203	15733	52		98.5	88
92	03	2	204	5035	17		28.0	81
92	03	3	205	12004	47		99.3	89
92	03	4	206	7418	27		31.1	86
92	03	5	207	9823	39		69.9	88
92	03	6	208	11912	29		67.6	79
92	03	7	209	4581	12		85.3	76
92	03	10	212	10018	22		27.3	74
92	03	11	213	10214	21		50.9	72

COLD TEMPERATURE PHASE

Date (yy	mm	dd)	Day	Operating Temp (C)	Influent pH	Influent Alkalinity (mgCaCO3/L)	Influent VSS (mg/L)	Influent TSS (mg/L)	Influent PO4 (mgP/L)
92	03	12	1	20					
92	03	13	2	20					
92	03	15	4	20					
92	03	17	6	20					
92	03	20	9	20					
92	03	22	11	20					
92	03	23	12	20		1580	58	115	0.2
92	03	25	14	20					
92	03	26	15	20					
92	03	28	17	20	7.8				
92	03	30	19	20					
92	04	1	21	20					
92	04	3	23	20					
92	04	5	25	20					
92	04	6	26	20					
92	04	8	28	20					
92	04	9	29	20					
92	04	10	30	20					
92	04	12	32	20					
92	04	13	33	20					
92	04	15	35	20					
92	04	16	36	20					
92	04	18	38	20					
92	04	21	41	20					
92	04	24	44	20					
92	04	25	45	20					
92	04	27	47	20	8.0	1190	31	61	0.5
92	04	30	50	20					
92	05	3	53	20					
92	05	5	55	20					
92	05	6	56	20					
92	05	8	58	20					
92	05	9	59	20					
92	05	11	61	20					
92	05	13	63	20					
92	05	15	65	20					
92	05	18	68	20					
92	05	19	69	20					
92	05	21	71	20					
92	05	25	75	20					
92	05	26	76	20					
92	05	28	78	20					
92	05	31	81	20	7.8	1420	44	87	0.4
92	06	2	83	20					
92	06	4	85	20					

COLD TEMPERATURE PHASE

Date (yy	mm	dd)	Day	Operating Temp (C)	Influent pH	Influent Alkalinity (mgCaCO3/L)	Influent VSS (mg/L)	Influent TSS (mg/L)	Influent PO4 (mgP/L)
92	06	6	87	20					
92	06	7	88	20					
92	06	10	91	20					
92	06	13	94	20					
92	06	15	96	17					
92	06	16	97	17					
92	06	17	98	17					
92	06	19	100	17					
92	06	22	103	17					
92	06	23	104	17					
92	06	26	107	14					
92	06	28	109	14					
92	06	29	110	14					
92	07	3	114	14	7.9	1370	65	128	0.1
92	07	4	115	14					
92	07	6	117	12					
92	07	9	120	12					
92	07	10	121	12					
92	07	12	123	10					
92	07	14	125	10					
92	07	15	126	10					
92	07	17	128	10					
92	07	19	130	10					
92	07	21	132	10					
92	07	23	134	10					
92	07	26	137	10					
92	07	27	138	10					
92	07	29	140	10					
92	07	31	142	10					
92	08	2	144	10					
92	08	4	146	10	7.7	1540	59	119	0.3
92	08	6	148	10					
92	08	7	149	10					
92	08	10	152	10					
92	08	13	155	10					
92	08	14	156	10					
92	08	17	159	10					
92	08	19	161	10					
92	08	21	163	10					
92	08	23	165	10					
92	08	24	166	10					
92	08	27	169	10					

COLD TEMPERATURE PHASE

Date (yy	mm	dd)	Day	Influent NH4 (mgN/L)	Influent NOx (mgN/L)	Influent NO2 (mgN/L)	Influent BOD (mg/L)	Influent COD (mg/L)
92	03	12	1	158				
92	03	13	2	133				
92	03	15	4	161				
92	03	17	6	164				
92	03	20	9	155				
92	03	22	11	141				
92	03	23	12	173	8.8	0.2	61	285
92	03	25	14	181				
92	03	26	15	195				
92	03	28	17	176				
92	03	30	19	167				
92	04	1	21	135				
92	04	3	23	149				
92	04	5	25	182				
92	04	6	26	191				
92	04	8	28	179				
92	04	9	29	193				
92	04	10	30	198				
92	04	12	32	186				
92	04	13	33	196				
92	04	15	35	197				
92	04	16	36	189				
92	04	18	38	169				
92	04	21	41	173				
92	04	24	44	164				
92	04	25	45	151				
92	04	27	47	229	11.2	0.4	37	343
92	04	30	50	176				
92	05	3	53	176				
92	05	5	55	256				
92	05	6	56	185				
92	05	8	58	191				
92	05	9	59	192				
92	05	11	61	174				
92	05	13	63	178				
92	05	15	65	172				
92	05	18	68	187				
92	05	19	69	176				
92	05	21	71	173				
92	05	25	75	186				
92	05	26	76	167				
92	05	28	78	169				
92	05	31	81	162	15.6	0.3	29	329
92	06	2	83	166				
92	06	4	85	156				

COLD TEMPERATURE PHASE

Date (yy	mm	dd)	Day	Influent NH4 (mgN/L)	Influent NOx (mgN/L)	Influent NO2 (mgN/L)	Influent BOD (mg/L)	Influent COD (mg/L)
92	06	6	87	166				
92	06	7	88	177				
92	06	10	91	175				
92	06	13	94	176				
92	06	15	96	163				
92	06	16	97	181				
92	06	17	98	159				
92	06	19	100	171				
92	06	22	103	178				
92	06	23	104	157				
92	06	26	107	180				
92	06	28	109	171				
92	06	29	110	168				
92	07	3	114	180	3.7	0.1	35	350
92	07	4	115	183				
92	07	6	117	199				
92	07	9	120	177				
92	07	10	121	197				
92	07	12	123	192				
92	07	14	125	192				
92	07	15	126	183				
92	07	17	128	203				
92	07	19	130	201				
92	07	21	132	179				
92	07	23	134	194				
92	07	26	137	199				
92	07	27	138	189				
92	07	29	140	198				
92	07	31	142	196				
92	08	2	144	181				
92	08	4	146	201	7.7	0.1	22	318
92	08	6	148	193				
92	08	7	149	200				
92	08	10	152	200				
92	08	13	155	197				
92	08	14	156	193				
92	08	17	159	189				
92	08	19	161	207				
92	08	21	163	181				
92	08	23	165	190				
92	08	24	166	203				
92	08	27	169	184				

COLD TEMPERATURE PHASE (10 DAY AEROBIC SRT SYSTEM, 1500 mg NH4-N/L IN INFLUENT)

Date (yy	mm	dd)	Day	Flowrate Influent (L/d)	Flowrate NH4Cl (mL/h)	Flowrate CH3OH (mL/h)	Flowrate NaHCO3 (mL/h)	Flowrate o-PO4 (mL/h)	Flowrate Recycle (L/d)	Flowrate Aerobic Wasting (L/d)	Flowrate Anoxic Overflow (L/d)
92	03	12	1	9.7	27	6.5	41	41	57	0	68
92	03	13	2	9.5	24.4	6.4	42	42	57	0	68
92	03	15	4	9.4	27.5	6.3	37	37	57	0	68
92	03	17	6	9.5	25	6.6	39	39	57	0	68
92	03	20	9	9.3	24.6	6.65	36	36	63	0	74
92	03	22	11	9.3	23.8	6.7	41	41	63	0	74
92	03	23	12	9.4	19.5	6.9	43	43	60	0	71
92	03	25	14	9.0	23	6.5	42	42	60	0	71
92	03	26	15	9.1	21	6.5	39	39	60	0	71
92	03	28	17	8.9	20	6.4	39	39	59	1	69
92	03	30	19	9.0	20	6.4	39	39	59	1	70
92	04	1	21	8.9	19.5	6.8	47	47	59	1	70
92	04	3	23	8.7	16	6.9	38	38	59	1	69
92	04	5	25	8.8	15.4	6.6	44	44	56	1	66
92	04	6	26	8.7	26	6.7	48	48	56	1	67
92	04	8	28	8.6	26	6.8	46	46	56	1	66
92	04	9	29	8.6	26.8	7.4	44	44	56	1	66
92	04	10	30	8.4	25	6.8	37	37	63	1	73
92	04	12	32	8.7	25	7	45	45	63	0	74
92	04	13	33	8.9	25	6.8	14	11.7	63	0	73
92	04	15	35	8.9	25	6.7	28	11.5	58	0	68
92	04	16	36	8.5	24	6.5	37	11.8	58	0.5	68
92	04	18	38	7.9	26	6.5	80	11.4	58	1	67
92	04	21	41	8.2	27	6.8	32	11.2	58	1	67
92	04	24	44	8.2	26	6.6	32	11.1	58	1	67
92	04	25	45	8.3	24.5	6.5	25	11.0	64	0	73
92	04	27	47	8.5	26.5	6.7	22	10.9	64	0	74
92	04	30	50	8.5	28	6.6	12	10.8	64	0	74
92	05	3	53	8.6	26.7	6.8	16.7	11.0	64	0	74
92	05	5	55	8.7	24.6	6.7	12	11.5	64	0	74
92	05	6	56	8.6	27	6.6	17	11.4	64	1	74
92	05	8	58	8.6	28	6.9	22	11.8	59	1	69
92	05	9	59	8.3	25	6.3	34	11.7	59	1	68
92	05	11	61	8.1	26	6.2	53	11.7	62	1	71
92	05	13	63	8.0	28	7	68	12.1	62	1	71
92	05	15	65	8.1	26.5	6.6	41	12.1	62	1	71
92	05	18	68	8.2	25.7	6.5	34	11.9	62	1	71
92	05	19	69	8.6	25.5	6.9	26	12.1	65	1	75
92	05	21	71	8.5	23.9	6.4	41.3	12.2	65	1	75
92	05	25	75	8.5	24	6.7	40	11.6	65	1	75
92	05	26	76	8.5	23	6.9	43	12.1	65	1	75
92	05	28	78	8.3	25.1	6.8	35.2	12.0	63	1	72
92	05	31	81	8.3	24.8	6.8	55	12.5	63	1	72
92	06	2	83	8.0	23.6	6.5	47	12.7	63	1	72
92	06	4	85	8.1	23.5	6.7	47	12.7	63	1	72

COLD TEMPERATURE PHASE (10 DAY AEROBIC SRT SYSTEM, 1500 mg NH4-N/L IN INFLUENT)

Date (yy	mm	dd)	Day	Flowrate Influent (L/d)	Flowrate NH4Cl (mL/h)	Flowrate CH3OH (mL/h)	Flowrate NaHCO3 (mL/h)	Flowrate o-PO4 (mL/h)	Flowrate Recycle (L/d)	Flowrate Aerobic Wasting (L/d)	Flowrate Anoxic Overflow (L/d)
92	06	6	87	8.3	24.6	6.5	39	12.2	57	1	66
92	06	7	88	8.5	25.5	6.9	44	11.8	57	1	67
92	06	10	91	8.3	24.2	6.4	55	11.7	57	1	66
92	06	13	94	8.1	24.1	6.7	48	11.4	57	1	66
92	06	15	96	8.1	25.8	6.8	57	11.3	57	1	66
92	06	16	97	8.3	22.6	6.6	42	11.7	57	1	66
92	06	17	98	8.3	21	6.7	42	12.0	57	1	66
92	06	19	100	8.3	22.1	6.5	39	12.5	60	1	69
92	06	22	103	7.9	23.1	6.8	53	12.7	60	1	69
92	06	23	104	8.1	20.3	6.8	47	13.0	60	1	69
92	06	26	107	8.0	20.9	5.9	59	12.8	60	1	69
92	06	28	109	8.2	21.2	6.2	40	12.9	60	1	69
92	06	29	110	8.1	21.9	6	54	13.4	64	1	73
92	07	3	114	7.9	33.7	5.9	46	13.8	61	1	70
92	07	4	115	8.2	31.7	5.85	37	13.9	61	1	70
92	07	6	117	8.1	32.3	6	58	13.6	61	1	70
92	07	9	120	7.9	31	6.1	43	13.3	61	1	70
92	07	10	121	7.8	29.2	5.9	44	13.3	64	1	73
92	07	12	123	8.1	29.2	6	35	13.9	64	1	73
92	07	14	125	8.4	30.1	6.1	42	13.4	64	1	74
92	07	15	126	8.2	30	6	25	13.5	64	1	73
92	07	17	128	8.3	29.1	5.8	47	13.9	61	1	70
92	07	19	130	8.2	27.5	6.1	31	14.5	61	0	70
92	07	21	132	7.7	29.2	0	113	14.9	61	0	70
92	07	23	134	7.6	29.7	0	89.1	14.9	61	0	70
92	07	26	137	7.5	26.8	0	95.2	14.5	61	0	69
92	07	27	138	7.3	23.1	0	89	15.1	61	1	69
92	07	29	140	7.7	29.4	0	0	14.9	61	1	70
92	07	31	142	7.6	29.7	0	83.8	14.5	61	1	70
92	08	2	144	7.7	25.4	0	79.6	14.3	55	1	64
92	08	4	146	8.1	25.8	0	33.9	14.1	55	0	64
92	08	6	148	7.6	27.2	0	90.5	13.9	62	0	71
92	08	7	149	7.6	28.6	0	47.1	14.0	62	0	71
92	08	10	152	8.4	28.5	0	0	14.1	58	0	67
92	08	13	155	8.5	28.6	0	44	14.4	58	0	68
92	08	14	156	8.4	29.9	0	22	14.1	58	0	67
92	08	17	159	8.4	29.9	0	56.8	14.6	58	0	67
92	08	19	161	8.2	28.1	0	58	14.9	55	0	64
92	08	21	163	8.3	28.6	0	51.9	14.4	55	0	64
92	08	23	165	7.8	27.8	0	95.5	14.9	55	0	64
92	08	24	166	7.7	27.9	0	53.9	14.7	55	0	64
92	08	27	169	7.9	28.9	0	50.8	15.0	55	0	64

COLD TEMPERATURE PHASE (10 DAY AEROBIC SRT SYSTEM, 1500 mg NH4-N/L IN INFLUENT)

Date (yy	mm	dd)	Day	Flowrate Aerobic Overflow (L/d)	Feed Conc. NH4Cl (g/L)	Feed Conc. Simulated Influent NH4 (mgN/L)	Feed Conc. CH3OH (mL/L)	Feed Conc. o-PO4 (gP/L)
92	03	12	1	69	0	146	10	0.231
92	03	13	2	69	0	123	10	0.231
92	03	15	4	69	0	148	10	0.231
92	03	17	6	69	25	536	10	0.231
92	03	20	9	75	25	529	10	0.231
92	03	22	11	75	25	502	10	0.231
92	03	23	12	72	50	771	10	0.231
92	03	25	14	72	80	1363	10	0.231
92	03	26	15	72	100	1529	10	0.231
92	03	28	17	70	100	1484	10	0.231
92	03	30	19	71	110	1589	200	0.231
92	04	1	21	71	110	1544	200	0.231
92	04	3	23	70	120	1437	200	0.231
92	04	5	25	67	125	1467	200	0.231
92	04	6	26	68	80	1558	200	0.231
92	04	8	28	68	80	1558	500	0.231
92	04	9	29	68	80	1607	500	0.231
92	04	10	30	74	80	1553	500	0.231
92	04	12	32	75	80	1497	500	0.231
92	04	13	33	73	0	180	200	0.361
92	04	15	35	69	25	569	200	0.361
92	04	16	36	68	50	931	10	0.361
92	04	18	38	69	80	1404	10	0.361
92	04	21	41	68	80	1592	150	0.361
92	04	24	44	68	80	1536	150	0.361
92	04	25	45	74	80	1460	500	0.361
92	04	27	47	74	80	1608	500	0.361
92	04	30	50	74	50	1118	10	0.361
92	05	3	53	74	25	605	10	0.361
92	05	5	55	74	25	648	10	0.361
92	05	6	56	74	0	169	10	0.361
92	05	8	58	69	25	630	100	0.361
92	05	9	59	69	50	987	200	0.361
92	05	11	61	72	80	1480	200	0.361
92	05	13	63	73	80	1537	200	0.361
92	05	15	65	72	80	1544	300	0.361
92	05	18	68	72	80	1521	300	0.361
92	05	19	69	75	80	1476	400	0.361
92	05	21	71	76	80	1352	400	0.361
92	05	25	75	75	80	1375	400	0.361
92	05	26	76	76	90	1438	200	0.361
92	05	28	78	73	90	1627	200	0.361
92	05	31	81	74	90	1525	250	0.361
92	06	2	83	73	90	1527	250	0.361
92	06	4	85	73	90	1496	250	0.361

COLD TEMPERATURE PHASE (10 DAY AEROBIC SRT SYSTEM, 1500 mg NH4-N/L IN INFLUENT)

Date (yy	mm	dd)	Day	Flowrate Aerobic Overflow (L/d)	Feed Conc. NH4Cl (g/L)	Feed Conc. Simulated Influent NH4 (mgN/L)	Feed Conc. CH3OH (mL/L)	Feed Conc. o-PO4 (gP/L)
92	06	6	87	67	90	1573	265	0.361
92	06	7	88	68	90	1597	265	0.361
92	06	10	91	68	90	1511	265	0.361
92	06	13	94	67	90	1554	265	0.361
92	06	15	96	68	90	1607	265	0.361
92	06	16	97	67	90	1462	265	0.361
92	06	17	98	67	90	1347	265	0.361
92	06	19	100	70	100	1584	265	0.361
92	06	22	103	70	100	1643	265	0.361
92	06	23	104	70	100	1442	265	0.361
92	06	26	107	70	100	1471	265	0.361
92	06	28	109	70	100	1527	265	0.361
92	06	29	110	74	100	1537	290	0.361
92	07	3	114	71	73	1772	290	0.361
92	07	4	115	71	73	1661	290	0.361
92	07	6	117	72	73	1643	290	0.361
92	07	9	120	71	73	1654	290	0.361
92	07	10	121	74	73	1590	290	0.361
92	07	12	123	74	73	1582	290	0.361
92	07	14	125	75	73	1557	290	0.361
92	07	15	126	74	73	1632	290	0.361
92	07	17	128	72	73	1511	290	0.361
92	07	19	130	71	73	1503	290	0.361
92	07	21	132	72	73	1366	0	0.361
92	07	23	134	72	73	1491	0	0.361
92	07	26	137	72	73	1356	0	0.361
92	07	27	138	71	73	1217	0	0.361
92	07	29	140	70	73	1853	0	0.361
92	07	31	142	72	73	1506	0	0.361
92	08	2	144	66	73	1307	0	0.361
92	08	4	146	65	73	1447	0	0.361
92	08	6	148	73	73	1366	0	0.361
92	08	7	149	72	73	1605	0	0.361
92	08	10	152	67	73	1682	0	0.361
92	08	13	155	69	73	1486	0	0.361
92	08	14	156	68	73	1641	0	0.361
92	08	17	159	69	73	1506	0	0.361
92	08	19	161	66	73	1454	0	0.361
92	08	21	163	66	73	1472	0	0.361
92	08	23	165	66	73	1354	0	0.361
92	08	24	166	65	73	1528	0	0.361
92	08	27	169	65	73	1542	0	0.361

COLD TEMPERATURE PHASE (10 DAY AEROBIC SRT SYSTEM, 1500 mg NH4-N/L IN INFLUENT)

Date (yy	mm	dd)	Day	Feed Conc. NaHCO3 (g/L)	System Loading CH3OH (gCOD/d)	System Loading o-PO4 (gP/d)	System Loading NaHCO3 (gCaCO3/d)	Anoxic ORP (mV)
92	03	12	1	44	1.85	0.228	3671	-156
92	03	13	2	56	1.82	0.233	4537	-109
92	03	15	4	56	1.80	0.205	4121	-17
92	03	17	6	50	1.88	0.217	3952	53
92	03	20	9	81	1.89	0.200	5402	66
92	03	22	11	81	1.91	0.228	5958	121
92	03	23	12	81	1.97	0.239	6442	73
92	03	25	14	100	1.85	0.233	7672	50
92	03	26	15	100	1.85	0.217	7163	11
92	03	28	17	100	1.82	0.217	7331	16
92	03	30	19	100	36.47	0.217	7253	-30
92	04	1	21	100	38.75	0.261	8543	-44
92	04	3	23	100	39.32	0.211	7326	-29
92	04	5	25	100	37.61	0.244	8228	-39
92	04	6	26	75	38.18	0.267	6893	10
92	04	8	28	75	96.88	0.255	6708	-86
92	04	9	29	50	105.43	0.244	4783	-107
92	04	10	30	50	96.88	0.205	4334	-91
92	04	12	32	13	99.73	0.250	2300	-55
92	04	13	33	75	38.75	0.102	3002	-62
92	04	15	35	75	38.18	0.100	4414	-34
92	04	16	36	75	1.85	0.103	5403	-51
92	04	18	38	75	1.85	0.099	9575	-42
92	04	21	41	75	29.06	0.097	5021	-75
92	04	24	44	75	28.21	0.097	5034	-91
92	04	25	45	75	92.61	0.095	4292	-110
92	04	27	47	75	95.45	0.095	3552	-114
92	04	30	50	75	1.88	0.093	2495	-81
92	05	3	53	75	1.94	0.095	2984	-44
92	05	5	55	75	1.91	0.099	2469	21
92	05	6	56	75	1.88	0.099	3016	-3
92	05	8	58	75	19.66	0.102	3529	-8
92	05	9	59	75	35.90	0.101	4840	-15
92	05	11	61	75	35.33	0.101	6793	-32
92	05	13	63	75	39.89	0.105	8172	-49
92	05	15	65	75	56.42	0.105	5623	-36
92	05	18	68	75	55.56	0.103	4866	-114
92	05	19	69	75	78.64	0.105	3927	-124
92	05	21	71	75	72.94	0.106	5455	-110
92	05	25	75	75	76.36	0.101	5342	-166
92	05	26	76	75	39.32	0.105	5607	-142
92	05	28	78	75	38.75	0.105	4966	-130
92	05	31	81	75	48.44	0.108	7020	-129
92	06	2	83	75	46.30	0.110	6426	-160
92	06	4	85	75	47.73	0.110	6363	-160

COLD TEMPERATURE PHASE (10 DAY AEROBIC SRT SYSTEM, 1500 mg NH4-N/L IN INFLUENT)

Date (yy	mm	dd)	Day	Feed Conc. NaHCO3 (g/L)	System Loading CH3OH (gCOD/d)	System Loading o-PO4 (gP/d)	System Loading NaHCO3 (gCaCO3/d)	Anoxic ORP (mV)
92	06	6	87	75	49.08	0.106	5518	-136
92	06	7	88	75	52.10	0.102	5938	-151
92	06	10	91	75	48.33	0.102	7057	-166
92	06	13	94	75	50.59	0.099	6499	-172
92	06	15	96	75	51.35	0.098	7334	-151
92	06	16	97	75	49.84	0.101	5817	-190
92	06	17	98	75	50.59	0.104	5803	-200
92	06	19	100	75	49.08	0.108	5544	-185
92	06	22	103	75	51.35	0.110	7027	-154
92	06	23	104	75	51.35	0.113	6366	-160
92	06	26	107	75	44.55	0.111	7536	-164
92	06	28	109	75	46.82	0.112	5659	-183
92	06	29	110	75	49.58	0.116	7051	-171
92	07	3	114	75	48.75	0.120	6353	-169
92	07	4	115	75	48.34	0.120	5308	-174
92	07	6	117	75	49.58	0.118	7374	-140
92	07	9	120	75	50.41	0.115	6067	-158
92	07	10	121	75	48.75	0.116	6201	-161
92	07	12	123	75	49.58	0.121	5174	-187
92	07	14	125	75	50.41	0.116	5742	-234
92	07	15	126	75	49.58	0.117	4095	-258
92	07	17	128	75	47.93	0.121	6245	-207
92	07	19	130	75	50.41	0.126	4714	-226
92	07	21	132	75	0.00	0.129	12253	-119
92	07	23	134	75	0.00	0.129	10526	-30
92	07	26	137	75	0.00	0.126	11120	-8
92	07	27	138	75	0.00	0.131	10779	-5
92	07	29	140	75	0.00	0.129	1309	5
92	07	31	142	75	0.00	0.126	10053	15
92	08	2	144	75	0.00	0.124	9667	39
92	08	4	146	75	0.00	0.123	5277	-15
92	08	6	148	75	0.00	0.121	10717	30
92	08	7	149	75	0.00	0.121	6860	21
92	08	10	152	75	0.00	0.122	1480	40
92	08	13	155	75	0.00	0.125	6087	45
92	08	14	156	75	0.00	0.123	3935	46
92	08	17	159	75	0.00	0.127	7307	42
92	08	19	161	75	0.00	0.129	7504	54
92	08	21	163	75	0.00	0.125	6926	35
92	08	23	165	75	0.00	0.129	10952	49
92	08	24	166	75	0.00	0.128	7454	47
92	08	27	169	75	0.00	0.131	7027	57

COLD TEMPERATURE PHASE (10 DAY AEROBIC SRT SYSTEM, 1500 mg NH4-N/L IN INFLUENT)

Date (yy	mm	dd)	Day	Anoxic pH	Anoxic VSS (mg/L)	Anoxic TSS (mg/L)	Anoxic o-PO4 (mgP/L)	Anoxic NH4 (mgN/L)	Anoxic NOx (mgN/L)	Anoxic NO2 (mgN/L)	Anoxic BOD (mg/L)
92	03	12	1	7.5	6115	8127		45			
92	03	13	2	7.3	6090	7974		29			
92	03	15	4	7.8	5660	7036		25			267
92	03	17	6	7.3	5802	7372		108			
92	03	20	9	7.4	6232	8146		84			
92	03	22	11	7.6	6093	8540		83			161
92	03	23	12	7.5	5700	8204		146			
92	03	25	14	7.7	5114	8799	14.5	206	865	293.6	
92	03	26	15	7.7	4679	7209	10.5	220	926	265.8	
92	03	28	17	7.9	4608	6893	9.9	208	1028	310.0	74
92	03	30	19	8.2	4485	4839	10.3	193	704	274.2	
92	04	1	21	8.1	4970	5496	9.6	195	485	278.1	
92	04	3	23	8.5	5291	5134	7.2	181	400	236.9	
92	04	5	25	8.6	5815	5895	8.7	198	327	288.9	117
92	04	6	26	8.3	6132	6571	9.2	183	339	256.7	
92	04	8	28	8.2	6126	6550	7.6	298	155	134.9	
92	04	9	29	8.3	6371	6773	6.8	246	95	69.7	
92	04	10	30	8.3	6451	7163	5.9	255	55	52.2	
92	04	12	32	8.7	6192	6632	6.8	336	45	35.7	285
92	04	13	33	8.7	6180	6767	4.9	42	94	53.1	
92	04	15	35	8.2	6736	6907	4.0	143	324	261.5	258
92	04	16	36	8.2	6658	7124	3.4	201	587	360.0	219
92	04	18	38	8.2	6388	7466	3.1	276	1122	577.0	180
92	04	21	41	8.2	6491	7758	3.9	201	484	123.1	86
92	04	24	44	8.4	6663	8260	3.3	188	236	115.5	116
92	04	25	45	8.6	6335	7536	3.0	359	135	62.5	
92	04	27	47	8.5	6094	7571	2.6	620	127	81.6	364
92	04	30	50	8.1	7663	11039	2.7	661	246	106.8	292
92	05	3	53	8.5	5878	7941	3.3	348	224	104.3	250
92	05	5	55	8.0	5335	7267	2.8	266	282	109.0	152
92	05	6	56	8.0	5190	7240	3.5	57	198	63.6	
92	05	8	58	7.6	4863	6661	3.3	118	355	114.0	113
92	05	9	59	8.0	4630	6271	4.2	176	495	139.9	129
92	05	11	61	8.3	4439	6272	4.2	227	672	149.9	104
92	05	13	63	8.0	4174	5091	4.2	215	518	98.6	127
92	05	15	65	7.9	4292	5048	3.9	198	405	64.2	121
92	05	18	68	7.9	4450	5268	3.5	183	317	41.6	114
92	05	19	69	8.0	4516	5055	3.1	186	72	32.6	227
92	05	21	71	8.0	4669	5304	3.1	177	15	9.6	183
92	05	25	75	8.3	4721	5196	3.4	191	9	1.0	175
92	05	26	76	8.4	4835	5344	2.9	187	140	3.7	146
92	05	28	78	8.3	4917	5529	2.5	188	91	0.4	118
92	05	31	81	8.7	5301	5758	2.9	168	30	1.8	214
92	06	2	83	8.9	5217	5740	2.3	181	23	1.8	182
92	06	4	85	8.4	5171	5715	2.9	168	16	0.6	198

COLD TEMPERATURE PHASE (10 DAY AEROBIC SRT SYSTEM, 1500 mg NH4-N/L IN INFLUENT)

Date (yy	mm	dd)	Day	Anoxic pH	Anoxic VSS (mg/L)	Anoxic TSS (mg/L)	Anoxic o-PO4 (mgP/L)	Anoxic NH4 (mgN/L)	Anoxic NOx (mgN/L)	Anoxic NO2 (mgN/L)	Anoxic BOD (mg/L)
92	06	6	87	8.4	4977	5545	2.4	179	2	0.2	216
92	06	7	88	8.4	5308	5888	2.5	183	3	0.3	
92	06	10	91	8.4	5243	5709	2.1	176	1	1.0	175
92	06	13	94	8.6	5280	5857	2.1	168	3	0.3	193
92	06	15	96	8.5	5078	5742	2.8	182	1	0.2	
92	06	16	97	8.3	5480	6445	2.8	163	2	0.9	154
92	06	17	98	8.4	5123	5839	2.6	169	1	0.5	133
92	06	19	100	8.3	4958	5814	2.6	161	2	0.4	155
92	06	22	103	8.4	5305	6256	2.7	166	4	1.6	162
92	06	23	104	8.4	5168	5908	2.7	161	1	0.5	
92	06	26	107	8.4	4938	5671	2.9	177	1	0.8	187
92	06	28	109	8.4	5258	6196	3.3	171	0	0.1	180
92	06	29	110	8.5	5272	5855	3.3	181	1	0.9	173
92	07	3	114	8.3	5339	5947	2.7	186	1	0.5	169
92	07	4	115	8.3	5307	5946	3.0	179	2	1.9	
92	07	6	117	8.4	5410	5994	3.1	184	0	0.4	205
92	07	9	120	8.3	5609	6216	2.6	181	2	0.5	188
92	07	10	121	8.4	5566	6172	2.3	176	1	0.7	
92	07	12	123	8.4	5363	5891	2.9	248	24	17.1	162
92	07	14	125	8.2	5377	6176	2.8	305	93	46.1	196
92	07	15	126	8.2	5253	5992	3.1	578	133	137.3	
92	07	17	128	8.3	5171	5849	2.7	595	100	87.2	198
92	07	19	130	8.2	5221	5851	3.3	679	186	159.8	213
92	07	21	132	8.0	4122	5149	3.6	527	930	0.5	501
92	07	23	134	8.1	4311	6113	4.8	535	836	0.4	340
92	07	26	137	8.1	2508	3154	5.0	507	825	0.4	307
92	07	27	138	7.9	3198	4072	4.8	581	799	0.5	
92	07	29	140	7.8	3317	4372	4.6	249	872	64.8	248
92	07	31	142	7.6	3190	4588	4.4	221	932	71.6	270
92	08	2	144	7.5	3306	4664	3.7	204	923	30.9	217
92	08	4	146	7.7	3293	4437	3.4	652	754	308.8	594
92	08	6	148	7.4	3278	4370	3.4	719	823	365.0	361
92	08	7	149	7.5	3381	4367	3.4	785	723	506.0	
92	08	10	152	7.5	3375	4342	2.7	830	649	660.0	300
92	08	13	155	7.5	3332	4251	3.0	1013	603	441.0	
92	08	14	156	7.7	3330	4259	3.4	924	520	448.0	205
92	08	17	159	7.5	3268	4335	2.8	1078	504	415.3	
92	08	19	161	7.5	3176	4171	3.1	1069	442	367.5	340
92	08	21	163	7.6	3419	4603	3.6	1199	390	358.3	
92	08	23	165	7.7	3459	4385	4.0	963	412	374.3	296
92	08	24	166	7.6	3424	4665	3.8	1054	453	402.0	
92	08	27	169	7.5	3304	4460	3.7	1228	448	316.0	

COLD TEMPERATURE PHASE (10 DAY AEROBIC SRT SYSTEM, 1500 mg NH4-N/L IN INFLUENT)

Date (yy	mm	dd)	Day	Anoxic COD (mg/L)	Aerobic DO (mg/L)	Aerobic pH	Aerobic VSS (mg/L)	Aerobic TSS (mg/L)	Aerobic o-PO4 (mgP/L)	Aerobic NH4 (mgN/L)
92	03	12	1	652	9.1	6.7	6361	8614		32
92	03	13	2	708	8.0	7.2	6290	8346		14
92	03	15	4	715	8.2	7.7	6520	8072		7
92	03	17	6	670	7.8	7.1	6225	7998		41
92	03	20	9	744	8.7	7.1	5924	7697		14
92	03	22	11	667	9.0	7.6	5290	7544		16
92	03	23	12	536	8.6	7.8	5030	7244		58
92	03	25	14	624	5.5	7.3	4090	7119	14.3	55
92	03	26	15	504	5.5	7.6	4350	6680	9.9	20
92	03	28	17	488	8.0	7.5	4364	6488	10.4	17
92	03	30	19	469	7.0	7.4	5690	6256	8.5	5
92	04	1	21	477	7.0	7.6	5702	6412	9.7	13
92	04	3	23	482	7.5	8.1	6592	6504	6.2	0
92	04	5	25	505	7.5	8.0	6507	6752	8.9	12
92	04	6	26	459	6.0	6.9	6461	6932	9.6	6
92	04	8	28	485	5.0	6.5	6550	7059	6.9	148
92	04	9	29	536	5.5	6.9	6625	7203	6.8	120
92	04	10	30	578	5.0	6.8	6592	7323	5.1	177
92	04	12	32	626	5.0	8.3	6852	7428	6.1	255
92	04	13	33	656	4.5	7.3	6770	7515	5.8	22
92	04	15	35	634	7.5	7.7	7362	7645	5.0	59
92	04	16	36	634	7.0	7.5	7325	7889	3.2	116
92	04	18	38	592	7.5	7.9	6820	8062	3.2	139
92	04	21	41	561	7.5	6.8	6798	8073	3.2	18
92	04	24	44	533	6.5	7.3	6373	8109	3.7	6
92	04	25	45	613	5.0	8.2	6503	7933	2.9	272
92	04	27	47	709	6.7	8.5	6109	7787	2.7	525
92	04	30	50	717	7.0	7.8	5036	7230	2.4	547
92	05	3	53	652	9.8	7.7	5077	6875	3.2	261
92	05	5	55	629	7.5	7.3	4788	6608	2.4	210
92	05	6	56	576	7.3	7.4	4428	6308	2.8	27
92	05	8	58	510	5.8	7.4	4337	6014	3.6	53
92	05	9	59	468	6.1	7.3	4253	5868	3.9	54
92	05	11	61	435	5.8	7.3	3985	5698	4.7	29
92	05	13	63	447	5.0	7.3	4514	5504	4.3	13
92	05	15	65	446	4.7	7.3	4682	5484	3.9	5
92	05	18	68	483	5.0	7.4	4645	5491	4.1	5
92	05	19	69	489	5.3	7.4	4858	5494	3.0	3
92	05	21	71	490	5.5	7.3	4853	5547	3.0	1
92	05	25	75	507	4.0	7.3	5098	5604	3.4	13
92	05	26	76	487	7.5	7.3	5064	5692	2.9	1
92	05	28	78	503	8.4	7.3	5067	5756	2.7	4
92	05	31	81	533	6.6	7.4	5288	5802	3.3	4
92	06	2	83	550	6.8	7.4	5283	5889	2.5	2
92	06	4	85	548	6.5	7.4	5253	5944	3.0	5

COLD TEMPERATURE PHASE (10 DAY AEROBIC SRT SYSTEM, 1500 mg NH4-N/L IN INFLUENT)

Date (yy	mm	dd)	Day	Anoxic COD (mg/L)	Aerobic DO (mg/L)	Aerobic pH	Aerobic VSS (mg/L)	Aerobic TSS (mg/L)	Aerobic o-PO4 (mgP/L)	Aerobic NH4 (mgN/L)
92	06	6	87	572	6.0	7.4	5270	5993	2.5	0
92	06	7	88	579	5.8	7.4	5397	6031	2.3	1
92	06	10	91	574	6.6	7.5	5489	6095	2.1	1
92	06	13	94	574	6.3	7.5	5407	6157	1.9	0
92	06	15	96	554	6.0	7.4	5408	6192	2.9	1
92	06	16	97	527	5.7	7.4	5296	6211	3.1	1
92	06	17	98	523	6.6	7.4	5325	6204	2.9	3
92	06	19	100	539	7.1	7.4	5178	6194	2.8	0
92	06	22	103	514	7.5	7.4	5177	6158	2.7	1
92	06	23	104	568	6.5	7.4	5230	6127	2.5	1
92	06	26	107	532	6.5	7.3	5232	6131	2.9	2
92	06	28	109	500	6.8	7.3	5208	6129	3.4	1
92	06	29	110	511	7.0	7.4	5452	6136	2.9	1
92	07	3	114	526	6.9	7.3	5429	6200	3.0	1
92	07	4	115	519	7.3	7.3	5460	6240	3.4	0
92	07	6	117	524	7.2	7.3	5605	6252	2.8	31
92	07	9	120	526	6.4	7.4	5701	6325	2.5	2
92	07	10	121	517	6.2	7.3	5733	6401	2.2	1
92	07	12	123	545	7.1	7.3	5690	6392	2.4	139
92	07	14	125	566	7.2	7.3	5612	6427	2.8	151
92	07	15	126	586	6.3	7.3	5554	6358	3.4	495
92	07	17	128	554	6.6	7.3	5558	6335	2.7	471
92	07	19	130	584	5.7	7.3	5583	6309	3.3	562
92	07	21	132	709	5.1	7.3	4885	6247	3.2	344
92	07	23	134	676	6.5	7.3	4326	6185	4.3	149
92	07	26	137	648	7.0	7.3	4701	5922	5.2	66
92	07	27	138	665	7.2	7.3	4545	5819	5.0	14
92	07	29	140	617	5.9	7.3	4372	5767	4.8	88
92	07	31	142	636	6.4	7.3	3930	5691	4.5	15
92	08	2	144	625	6.2	7.3	3871	5500	3.5	3
92	08	4	146	811	0.0	7.3	3851	5201	3.4	620
92	08	6	148	759	6.3	7.3	3748	5112	3.0	657
92	08	7	149	703	6.7	7.3	3685	4868	3.1	713
92	08	10	152	678	7.4	7.4	3644	4665	2.9	774
92	08	13	155	681	7.1	7.5	3704	4832	3.1	1058
92	08	14	156	619	6.7	7.4	3632	4684	3.4	982
92	08	17	159	640	6.4	7.4	3644	4957	2.6	962
92	08	19	161	707	6.6	7.4	3599	4784	3.0	955
92	08	21	163	739	6.5	7.4	3528	4725	3.0	1076
92	08	23	165	689	6.9	7.4	3546	4616	3.5	901
92	08	24	166	669	6.1	7.4	3451	4680	4.0	1078
92	08	27	169	717	6.3	7.3	3418	4583	3.2	1138

COLD TEMPERATURE PHASE (10 DAY AEROBIC SRT SYSTEM, 1500 mg NH4-N/L IN INFLUENT)

Date (yy	mm	dd)	Day	Aerobic NOx (mgN/L)	Aerobic NO2 (mgN/L)	Aerobic BOD (mg/L)	Aerobic COD (mg/L)	Effluent VSS (mg/L)	Effluent TSS (mg/L)	Effluent NH4 (mgN/L)
92	03	12	1				744	137	188	
92	03	13	2				588	148	190	
92	03	15	4			32	496	157	197	
92	03	17	6				469	172	218	
92	03	20	9				568	197	251	
92	03	22	11			15	451	218	303	
92	03	23	12				502	198	284	
92	03	25	14	1004	441.8		515	251	428	
92	03	26	15	1083	501.8		478	140	223	
92	03	28	17	1207	537.1	8	362	123	181	
92	03	30	19	878	577.0		387	147	158	
92	04	1	21	662	434.0		404	159	177	
92	04	3	23	587	354.0		371	150	147	
92	04	5	25	485	289.0	22	380	143	147	
92	04	6	26	507	269.1		376	150	159	
92	04	8	28	324	241.6		413	126	135	
92	04	9	29	192	132.6		429	127	140	
92	04	10	30	118	89.3		404	127	141	
92	04	12	32	110	83.3	52	420	131	147	
92	04	13	33	118	62.9		437	155	170	
92	04	15	35	389	164.6	44	438	131	139	
92	04	16	36	644	305.9	34	399	152	162	
92	04	18	38	1247	437.0	38	414	202	233	
92	04	21	41	615	304.0	28	386	133	164	
92	04	24	44	390	237.2	26	402	186	236	
92	04	25	45	198	162.7		406	150	188	
92	04	27	47	163	132.1	61	404	184	239	
92	04	30	50	317	95.6	56	411	233	339	
92	05	3	53	294	113.8	48	401	163	231	
92	05	5	55	333	103.4	44	418	200	269	
92	05	6	56	219	91.8		403	182	253	
92	05	8	58	412	104.6	37	395	155	219	
92	05	9	59	600	97.7	34	388	148	198	
92	05	11	61	862	72.1	30	385	170	237	
92	05	13	63	703	74.0	24	387	130	157	
92	05	15	65	680	56.1	18	380	145	167	
92	05	18	68	467	65.8	19	354	148	170	
92	05	19	69	216	17.2	37	381	138	154	
92	05	21	71	137	13.1	20	376	126	145	
92	05	25	75	152	18.8	18	383	138	146	
92	05	26	76	302	0.4	16	395	145	158	
92	05	28	78	242	2.5	24	395	147	165	
92	05	31	81	198	3.7	30	405	141	155	
92	06	2	83	271	2.6	30	380	158	171	1.52
92	06	4	85	155	0.9	26	400	155	172	

COLD TEMPERATURE PHASE (10 DAY AEROBIC SRT SYSTEM, 1500 mg NH4-N/L IN INFLUENT)

Date (yy	mm	dd)	Day	Aerobic NOx (mgN/L)	Aerobic NO2 (mgN/L)	Aerobic BOD (mg/L)	Aerobic COD (mg/L)	Effluent VSS (mg/L)	Effluent TSS (mg/L)	Effluent NH4 (mgN/L)
92	06	6	87	176	0.4	22	366	139	155	
92	06	7	88	174	1.4		363	156	176	
92	06	10	91	156	0.8	17	378	128	141	
92	06	13	94	176	0.6	21	372	148	166	
92	06	15	96	186	0.6		360	137	154	
92	06	16	97	166	0.6	16	364	163	184	
92	06	17	98	176	1.5	10	347	141	162	
92	06	19	100	151	1.0	15	355	157	183	0.14
92	06	22	103	177	0.4	8	378	139	160	
92	06	23	104	165	1.0		382	124	144	
92	06	26	107	167	1.1	11	380	134	152	
92	06	28	109	169	0.8	15	369	140	165	
92	06	29	110	178	0.6	8	370	141	155	
92	07	3	114	162	1.0	9	360	132	145	
92	07	4	115	168	8.5		354	124	142	
92	07	6	117	143	12.6	13	341	137	147	
92	07	9	120	157	103.2	22	378	149	163	
92	07	10	121	177	80.2		403	127	142	
92	07	12	123	113	104.8	40	390	127	142	
92	07	14	125	235	165.7	43	417	150	170	
92	07	15	126	198	205.0		446	139	164	
92	07	17	128	203	186.1	49	411	151	172	
92	07	19	130	262	226.3	122	457	149	176	
92	07	21	132	1108	513.0	69	487	244	312	
92	07	23	134	1053	439.2	5	491	251	365	
92	07	26	137	920	450.4	4	491	187	249	
92	07	27	138	953	490.7		491	204	270	
92	07	29	140	753	343.8	64	455	180	249	
92	07	31	142	1112	312.2	38	414	188	272	
92	08	2	144	1054	432.9	35	402	141	207	3.06
92	08	4	146	873	411.0	155	465	158	228	
92	08	6	148	961	480.4	202	536	207	292	
92	08	7	149	775	528.3		557	199	278	
92	08	10	152	607	618.4	265	621	198	280	
92	08	13	155	668	496.4		642	182	258	
92	08	14	156	555	480.3	200	621	176	251	
92	08	17	159	605	506.0		582	183	270	
92	08	19	161	530	455.6	200	597	202	294	
92	08	21	163	484	451.9		561	178	265	
92	08	23	165	1228	428.7	165	557	163	235	
92	08	24	166	528	477.5		578	192	273	
92	08	27	169	539	387.1		607	180	265	

COLD TEMPERATURE PHASE (10 DAY AEROBIC SRT SYSTEM, 1500 mg NH4-N/L IN INFLUENT)

Date (yy	mm	dd)	Day	Effluent NOx (mgN/L)	Effluent BOD (mg/L)	Effluent COD (mg/L)	Anoxic VSS/TSS	Anoxic NO2/NOX	Anoxic NOX Load (gN/d)	Anoxic COD:NOX Entering (gCOD/gN)
92	03	12	1				0.75			
92	03	13	2				0.76			
92	03	15	4				0.80			
92	03	17	6				0.79			
92	03	20	9				0.77			
92	03	22	11				0.71			
92	03	23	12				0.69			
92	03	25	14				0.58	0.34	60.3	0.0
92	03	26	15				0.65	0.29	65.0	0.0
92	03	28	17				0.67	0.30	71.3	0.0
92	03	30	19				0.93	0.39	51.9	0.7
92	04	1	21				0.90	0.57	39.1	1.0
92	04	3	23				1.03	0.59	34.7	1.1
92	04	5	25				0.99	0.88	27.2	1.4
92	04	6	26				0.93	0.76	28.4	1.3
92	04	8	28				0.94	0.87	18.2	5.3
92	04	9	29				0.94	0.74	10.8	9.8
92	04	10	30				0.90	0.95	7.5	12.9
92	04	12	32				0.93	0.79	7.0	14.3
92	04	13	33				0.91	0.56	7.5	5.2
92	04	15	35				0.98	0.81	22.7	1.7
92	04	16	36				0.93	0.61	37.4	0.0
92	04	18	38				0.86	0.51	72.4	0.0
92	04	21	41				0.84	0.25	35.7	0.8
92	04	24	44				0.81	0.49	22.7	1.2
92	04	25	45				0.84	0.46	12.7	7.3
92	04	27	47				0.80	0.64	10.5	9.1
92	04	30	50				0.69	0.43	20.4	0.1
92	05	3	53				0.74	0.47	18.9	0.1
92	05	5	55				0.73	0.39	21.4	0.1
92	05	6	56				0.72	0.32	14.1	0.1
92	05	8	58				0.73	0.32	24.4	0.8
92	05	9	59				0.74	0.28	35.5	1.0
92	05	11	61				0.71	0.22	53.5	0.7
92	05	13	63				0.82	0.19	43.7	0.9
92	05	15	65				0.85	0.16	42.2	1.3
92	05	18	68				0.84	0.13	29.0	1.9
92	05	19	69				0.89	0.45	14.1	5.6
92	05	21	71				0.88	0.63	9.0	8.1
92	05	25	75				0.91	0.11	10.0	7.7
92	05	26	76				0.90	0.03	19.7	2.0
92	05	28	78				0.89	0.00	15.3	2.5
92	05	31	81				0.92	0.06	12.6	3.8
92	06	2	83	265.6			0.91	0.08	17.2	2.7
92	06	4	85				0.90	0.04	9.9	4.8

COLD TEMPERATURE PHASE (10 DAY AEROBIC SRT SYSTEM, 1500 mg NH4-N/L IN INFLUENT)

Date (yy	mm	dd)	Day	Effluent NOx (mgN/L)	Effluent BOD (mg/L)	Effluent COD (mg/L)	Anoxic VSS/TSS	Anoxic NO2/NOX	Anoxic NOX Load (gN/d)	Anoxic COD:NOX Entering (gCOD/gN)
92	06	6	87				0.90	0.12	10.2	4.8
92	06	7	88				0.90	0.10	10.0	5.2
92	06	10	91				0.92	0.74	9.0	5.4
92	06	13	94				0.90	0.12	10.2	5.0
92	06	15	96				0.88	0.27	10.7	4.8
92	06	16	97				0.85	0.59	9.6	5.2
92	06	17	98				0.88	0.86	10.2	5.0
92	06	19	100	153.3			0.85	0.19	9.2	5.4
92	06	22	103				0.85	0.37	10.8	4.8
92	06	23	104				0.87	0.86	10.0	5.1
92	06	26	107				0.87	0.58	10.1	4.4
92	06	28	109				0.85	0.37	10.2	4.6
92	06	29	110				0.90	0.68	11.5	4.3
92	07	3	114				0.90	0.89	9.9	4.9
92	07	4	115				0.89	0.89	10.3	4.7
92	07	6	117				0.90	0.92	8.8	5.7
92	07	9	120				0.90	0.31	9.6	5.2
92	07	10	121				0.90	0.58	11.4	4.3
92	07	12	123				0.91	0.72	7.2	6.9
92	07	14	125				0.87	0.50	15.1	3.3
92	07	15	126				0.88	1.03	12.7	3.9
92	07	17	128				0.88	0.87	12.4	3.9
92	07	19	130				0.89	0.86	16.0	3.1
92	07	21	132				0.80	0.00		0.0
92	07	23	134				0.71	0.00		0.0
92	07	26	137				0.80	0.00		0.0
92	07	27	138				0.79	0.00		0.0
92	07	29	140				0.76	0.07	45.9	0.0
92	07	31	142				0.70	0.08	67.8	0.0
92	08	2	144	992.5			0.71	0.03	58.0	0.0
92	08	4	146				0.74	0.41	48.1	0.0
92	08	6	148				0.75	0.44	59.6	0.0
92	08	7	149				0.77	0.70	48.1	0.0
92	08	10	152				0.78	1.02	35.3	0.0
92	08	13	155				0.78	0.73	38.8	0.0
92	08	14	156				0.78	0.86	32.2	0.0
92	08	17	159				0.75	0.82	35.1	0.0
92	08	19	161				0.76	0.83	29.2	0.0
92	08	21	163				0.74	0.92	26.7	0.0
92	08	23	165				0.79	0.91	67.6	0.0
92	08	24	166				0.73	0.89	29.1	0.0
92	08	27	169				0.74	0.70	29.7	0.0

COLD TEMPERATURE PHASE (10 DAY AEROBIC SRT SYSTEM, 1500 mg NH4-N/L IN INFLUENT)

Date (yy	mm	dd)	Day	Anoxic COD:NOX Removed (gCOD/gN)	Anoxic Denitrn Rate (mgN/d)	Anoxic %Denitrn	Anoxic Specific Denitrn Rate (mgN/d/gVSS)	Anoxic NH4 Removal Rate (mgN/d)	Anoxic % NH4 Removal
92	03	12	1					291	9
92	03	13	2					113	5
92	03	15	4					260	13
92	03	17	6					554	7
92	03	20	9					51	1
92	03	22	11					-64	-1
92	03	23	12					1044	9
92	03	25	14	31.9	58	0	2	2130	13
92	03	26	15	4.5	415	1	18	847	5
92	03	28	17	2.1	858	1	37	826	5
92	03	30	19	10.3	3556	7	159	2347	15
92	04	1	21	6.6	5914	15	238	2104	14
92	04	3	23	5.3	7391	21	279	1002	7
92	04	5	25	6.4	5876	22	202	1477	10
92	04	6	26	6.1	6267	22	204	3084	20
92	04	8	28	12.0	8050	44	263	3413	15
92	04	9	29	22.9	4611	43	145	5752	26
92	04	10	30	27.3	3550	47	110	6942	27
92	04	12	32	27.0	3698	53	119	5894	19
92	04	13	33	57.6	673	9	22	73	2
92	04	15	35	62.1	614	3	18	-621	-7
92	04	16	36	-0.8	-2408	-6	-72	2238	14
92	04	18	38	-0.4	-4188	-6	-131	3646	16
92	04	21	41	9.4	3096	9	95	2498	16
92	04	24	44	4.2	6790	30	204	2075	14
92	04	25	45	32.5	2852	22	90	4657	15
92	04	27	47	80.0	1193	11	39	3303	7
92	04	30	50	0.8	2374	12	62	-3093	-7
92	05	3	53	0.8	2465	13	84	-3122	-14
92	05	5	55	2.7	720	3	27	-1	-0
92	05	6	56	-4.2	-446	-3	-17	-856	-26
92	05	8	58	294.2	67	0	3	1051	11
92	05	9	59	22.8	1575	4	68	567	4
92	05	11	61	6.7	5292	10	238	-51	-0
92	05	13	63	6.3	6305	14	302	814	5
92	05	15	65	4.3	13257	31	618	840	6
92	05	18	68	8.7	6380	22	287	1702	12
92	05	19	69	9.0	8750	62	388	619	4
92	05	21	71	9.3	7868	87	337	307	2
92	05	25	75	8.2	9295	93	394	152	1
92	05	26	76	4.3	9241	47	382	454	3
92	05	28	78	4.4	8712	57	354	2176	14
92	05	31	81	4.7	10403	82	392	3316	21
92	06	2	83	3.0	15577	91	597	1631	11
92	06	4	85	5.4	8770	88	339	2645	18

COLD TEMPERATURE PHASE (10 DAY AEROBIC SRT SYSTEM, 1500 mg NH4-N/L IN INFLUENT)

Date (yy	mm	dd)	Day	Anoxic COD:NOX Removed (gCOD/gN)	Anoxic Denitrn Rate (mgN/d)	Anoxic %Denitrn	Anoxic Specific Denitrn Rate (mgN/d/gVSS)	Anoxic NH4 Removal Rate (mgN/d)	Anoxic % NH4 Removal
92	06	6	87	4.9	10054	99	404	3361	22
92	06	7	88	5.3	9824	98	370	3728	23
92	06	10	91	5.4	8923	99	340	3384	22
92	06	13	94	5.1	9974	98	378	3867	26
92	06	15	96	4.8	10668	99	420	3774	24
92	06	16	97	5.3	9479	99	346	3460	24
92	06	17	98	5.0	10119	100	395	2063	15
92	06	19	100	5.5	9000	98	363	4086	27
92	06	22	103	4.9	10448	97	394	4404	28
92	06	23	104	5.1	9978	100	386	2829	20
92	06	26	107	4.4	10019	99	406	2309	16
92	06	28	109	4.6	10220	100	389	2864	19
92	06	29	110	4.3	11414	99	433	1784	12
92	07	3	114	4.9	9873	100	370	3740	22
92	07	4	115	4.8	10144	99	382	3318	21
92	07	6	117	5.7	8723	100	322	5156	28
92	07	9	120	5.3	9501	99	339	2885	18
92	07	10	121	4.3	11271	99	405	1959	13
92	07	12	123	9.0	5497	76	205	5542	23
92	07	14	125	6.1	8212	54	305	2456	10
92	07	15	126	17.0	2914	23	111	4479	10
92	07	17	128	9.1	5287	43	204	1485	3
92	07	19	130	17.2	2933	18	112	632	1
92	07	21	132	0.0					
92	07	23	134	0.0					
92	07	26	137	0.0					
92	07	27	138	0.0					
92	07	29	140	0.0	-14252	-31	-859	3086	15
92	07	31	142	0.0	1712	3	107	264	2
92	08	2	144	0.0	-1873	-3	-113	-128	-1
92	08	4	146	0.0	-399	-1	-24	5589	12
92	08	6	148	0.0	265	0	16	2719	5
92	08	7	149	0.0	-3302	-7	-195	2963	5
92	08	10	152	0.0	-7987	-23	-473	4175	7
92	08	13	155	0.0	-2078	-5	-125	7285	10
92	08	14	156	0.0	-2744	-9	-165	10026	14
92	08	17	159	0.0	817	2	50	-2366	-3
92	08	19	161	0.0	507	2	32	-2429	-4
92	08	21	163	0.0	1363	5	80	-4103	-6
92	08	23	165	0.0	40641	60	2350	675	1
92	08	24	166	0.0	-36	-0	-2	5745	8
92	08	27	169	0.0	779	3	47	-1976	-3

COLD TEMPERATURE PHASE (10 DAY AEROBIC SRT SYSTEM, 1500 mg NH4-N/L IN INFLUENT)

Date (yy	mm	dd)	Day	Aerobic VSS/TSS	Aerobic NO2/NOX	Aerobic ALK:NH4 Added (gCaCO3/gN)	Aerobic ALK:NH4 Nitrified (gCaCO3/gN)	Aerobic Nitrn Rate (mg/d)	Aerobic %Nitrn	Aerobic Specific Nitrn Rate (mgN/d/gVSS)
92	03	12	1	0.74		25.17				
92	03	13	2	0.75		36.78				
92	03	15	4	0.81		27.80				
92	03	17	6	0.78		7.38				
92	03	20	9	0.77		10.20				
92	03	22	11	0.70		11.87				
92	03	23	12	0.69		8.36				
92	03	25	14	0.57	0.44	5.63	6.93	10696	74	262
92	03	26	15	0.65	0.46	4.69	5.87	11950	78	275
92	03	28	17	0.67	0.44	4.94	5.21	13394	94	307
92	03	30	19	0.91	0.66	4.57	5.48	12766	96	224
92	04	1	21	0.89	0.66	5.53	6.31	12871	96	226
92	04	3	23	1.01	0.60	5.10	5.12	13307	107	202
92	04	5	25	0.96	0.60	5.61	7.09	10834	84	167
92	04	6	26	0.93	0.53	4.42	5.63	11559	97	179
92	04	8	28	0.93	0.75	4.30	5.53	11366	58	174
92	04	9	29	0.92	0.69	2.98	6.88	6540	41	99
92	04	10	30	0.90	0.75	2.79	8.51	4666	25	71
92	04	12	32	0.92	0.76	1.54	4.56	4778	20	70
92	04	13	33	0.90	0.53	16.66	16.08	1808	59	27
92	04	15	35	0.96	0.42	7.76	9.46	4652	48	63
92	04	16	36	0.93	0.47	5.80	12.59	4213	31	58
92	04	18	38	0.85	0.35	6.82	10.55	9310	49	137
92	04	21	41	0.84	0.49	3.15	5.13	9209	68	135
92	04	24	44	0.79	0.61	3.28	4.45	10620	84	167
92	04	25	45	0.82	0.82	2.94	8.42	4733	18	73
92	04	27	47	0.78	0.81	2.21	12.27	2750	6	45
92	04	30	50	0.70	0.30	2.23	4.25	5411	11	107
92	05	3	53	0.74	0.39	4.93	5.28	5328	21	105
92	05	5	55	0.72	0.31	3.81	5.88	3939	20	82
92	05	6	56	0.70	0.42	17.90	17.11	1662	40	38
92	05	8	58	0.72	0.25	5.60	8.06	4196	52	97
92	05	9	59	0.72	0.16	4.90	6.11	7588	63	178
92	05	11	61	0.70	0.08	4.59	4.69	14161	87	355
92	05	13	63	0.82	0.11	5.32	5.98	13771	89	305
92	05	15	65	0.85	0.08	3.64	2.67	20073	142	429
92	05	18	68	0.85	0.14	3.20	4.20	11014	84	237
92	05	19	69	0.88	0.08	2.66	3.50	10883	78	224
92	05	21	71	0.87	0.10	4.03	5.90	9218	69	190
92	05	25	75	0.91	0.12	3.88	4.91	10793	75	212
92	05	26	76	0.89	0.00	3.90	4.56	12342	88	244
92	05	28	78	0.88	0.01	3.05	4.29	11084	81	219
92	05	31	81	0.91	0.02	4.60	5.71	12387	101	234
92	06	2	83	0.90	0.01	4.21	3.39	18211	139	345
92	06	4	85	0.88	0.01	4.25	6.04	10243	84	195

COLD TEMPERATURE PHASE (10 DAY AEROBIC SRT SYSTEM, 1500 mg NH4-N/L IN INFLUENT)

Date (yy	mm	dd)	Day	Aerobic VSS/TSS	Aerobic NO2/NOX	Aerobic ALK:NH4 Added (gCaCO3/gN)	Aerobic ALK:NH4 Nitrified (gCaCO3/gN)	Aerobic Nitrn Rate (mg/d)	Aerobic %Nitrn	Aerobic Specific Nitrn Rate (mgN/d/gVSS)
92	06	6	87	0.88	0.00	3.51	4.57	11741	98	223
92	06	7	88	0.89	0.01	3.72	5.13	11532	94	214
92	06	10	91	0.90	0.01	4.67	6.76	10446	89	190
92	06	13	94	0.88	0.00	4.18	5.40	11652	104	216
92	06	15	96	0.87	0.00	4.56	5.81	12497	103	231
92	06	16	97	0.85	0.00	3.98	5.14	11060	102	209
92	06	17	98	0.86	0.01	4.31	4.82	11801	105	222
92	06	19	100	0.84	0.01	3.50	5.14	10404	93	201
92	06	22	103	0.84	0.00	4.28	5.61	12138	105	234
92	06	23	104	0.85	0.01	4.41	5.36	11535	103	221
92	06	26	107	0.85	0.01	5.12	6.42	11627	94	222
92	06	28	109	0.85	0.00	3.70	4.62	11802	99	227
92	06	29	110	0.89	0.00	4.59	5.28	13131	98	241
92	07	3	114	0.88	0.01	3.58	5.22	11507	88	212
92	07	4	115	0.88	0.05	3.20	4.29	11856	94	217
92	07	6	117	0.90	0.09	4.49	7.16	10223	78	182
92	07	9	120	0.90	0.66	3.67	5.14	11061	87	194
92	07	10	121	0.90	0.45	3.90	4.44	13017	101	227
92	07	12	123	0.89	0.93	3.27	7.35	6603	36	116
92	07	14	125	0.87	0.71	3.69	5.29	10661	47	190
92	07	15	126	0.87	1.04	2.51	7.83	4862	11	88
92	07	17	128	0.88	0.92	4.13	8.34	7400	18	133
92	07	19	130	0.88	0.86	3.14	8.01	5546	12	99
92	07	21	132	0.78	0.46	8.97			35	
92	07	23	134	0.70	0.42	7.06			52	
92	07	26	137	0.79	0.49	8.20			65	
92	07	27	138	0.78	0.51	8.86			98	
92	07	29	140	0.76	0.46	0.71	-1.37	-7692	-45	-176
92	07	31	142	0.69	0.28	6.67	7.39	13560	86	345
92	08	2	144	0.70	0.41	7.40	10.43	9184	69	237
92	08	4	146	0.74	0.47	3.65	5.99	8147	19	212
92	08	6	148	0.73	0.50	7.85	10.27	10583	20	282
92	08	7	149	0.76	0.68	4.28	14.83	4191	8	114
92	08	10	152	0.78	1.02	0.88	-5.49	-2346	-4	-64
92	08	13	155	0.77	0.74	4.10	12.22	4926	7	133
92	08	14	156	0.78	0.87	2.40	13.34	2740	4	75
92	08	17	159	0.74	0.84	4.85	10.12	7291	10	200
92	08	19	161	0.75	0.86	5.16	12.30	6081	9	169
92	08	21	163	0.75	0.93	4.71	10.67	6404	8	181
92	08	23	165	0.77	0.35	8.09	2.11	54218	86	1529
92	08	24	166	0.74	0.90	4.88	13.42	5185	8	150
92	08	27	169	0.75	0.72	4.56	10.75	6196	8	181

COLD TEMPERATURE PHASE (10 DAY AEROBIC SRT SYSTEM, 1500 mg NH4-N/L IN INFLUENT)

Date (yy	mm	dd)	Day	Aerobic NH4 Removal Rate (mgN/d)	Aerobic % NH4 Removal	ASRT (days)	System SSRT (days)	System % NH4 Removal
92	03	12	1	873	29		76.7	76
92	03	13	2	987	51		72.0	87
92	03	15	4	1177	70		68.6	95
92	03	17	6	4465	62		61.0	92
92	03	20	9	5099	84		53.6	97
92	03	22	11	4946	81		43.6	97
92	03	23	12	6063	59		45.3	92
92	03	25	14	10457	73		31.1	96
92	03	26	15	13905	91		56.3	99
92	03	28	17	13126	92	10	15.0	99
92	03	30	19	12926	98	10	14.2	100
92	04	1	21	12418	93	10	14.2	99
92	04	3	23	12355	100	10	14.7	100
92	04	5	25	12087	94	10	15.1	99
92	04	6	26	11571	97	10	15.1	100
92	04	8	28	9635	49	10	15.6	89
92	04	9	29	8115	50	10	15.8	92
92	04	10	30	5508	30	10	15.9	88
92	04	12	32	5595	23		92.2	81
92	04	13	33	1448	48		79.5	87
92	04	15	35	5667	58		99.5	89
92	04	16	36	5698	42	20	26.0	87
92	04	18	38	9237	49	10	14.2	89
92	04	21	41	12305	91	10	15.8	99
92	04	24	44	12273	97	10	15.0	100
92	04	25	45	6216	24		83.1	80
92	04	27	47	6648	15		62.4	65
92	04	30	50	7978	16		47.4	47
92	05	3	53	6191	24		61.6	54
92	05	5	55	3985	20		47.3	66
92	05	6	56	2170	52	10	14.1	83
92	05	8	58	4450	55	10	14.4	91
92	05	9	59	8333	69	10	14.4	94
92	05	11	61	14222	87	10	13.6	98
92	05	13	63	14529	94	10	14.3	99
92	05	15	65	13822	98	10	14.2	100
92	05	18	68	12703	97	10	14.3	100
92	05	19	69	13677	98	10	14.5	100
92	05	21	71	13166	99	10	14.8	100
92	05	25	75	13359	93	10	14.6	99
92	05	26	76	13961	100	10	14.5	100
92	05	28	78	13374	98	10	14.6	100
92	05	31	81	12004	98	10	14.9	100
92	06	2	83	13027	99	10	14.6	100
92	06	4	85	11860	97	10	14.6	100

COLD TEMPERATURE PHASE (10 DAY AEROBIC SRT SYSTEM, 1500 mg NH4-N/L IN INFLUENT)

Date (yy	mm	dd)	Day	Aerobic NH4 Removal Rate (mgN/d)	Aerobic % NH4 Removal	ASRT (days)	System SSRT (days)	System % NH4 Removal
92	06	6	87	11921	100	10	14.8	100
92	06	7	88	12172	99	10	14.6	100
92	06	10	91	11733	99	10	15.1	100
92	06	13	94	11175	100	10	14.8	100
92	06	15	96	12117	100	10	14.9	100
92	06	16	97	10806	99	10	14.6	100
92	06	17	98	11100	98	10	14.9	100
92	06	19	100	11202	100	10	14.4	100
92	06	22	103	11508	99	10	15.1	100
92	06	23	104	11185	100	10	15.3	100
92	06	26	107	12243	99	10	14.9	100
92	06	28	109	11844	99	10	15.0	100
92	06	29	110	13319	100	10	14.9	100
92	07	3	114	13005	99	10	15.2	100
92	07	4	115	12615	100	10	15.3	100
92	07	6	117	10820	83	10	15.0	98
92	07	9	120	12604	99	10	15.0	100
92	07	10	121	12869	100	10	15.5	100
92	07	12	123	7901	43	10	15.4	91
92	07	14	125	11261	50	10	14.7	90
92	07	15	126	5727	14	10	15.1	67
92	07	17	128	8460	20	10	14.6	67
92	07	19	130	7869	16		69.9	60
92	07	21	132					73
92	07	23	134					89
92	07	26	137					95
92	07	27	138			10		99
92	07	29	140	11054	64	10	13.2	95
92	07	31	142	14587	93	10	12.0	99
92	08	2	144	13045	99	10	13.3	100
92	08	4	146	1672	4		45.3	54
92	08	6	148	4044	8		30.9	49
92	08	7	149	4627	8		35.4	52
92	08	10	152	3206	6		36.8	50
92	08	13	155	-3781	-5		35.8	24
92	08	14	156	-4607	-7		38.6	36
92	08	17	159	7161	10		34.2	32
92	08	19	161	6762	10		30.9	30
92	08	21	163	7273	9		35.5	22
92	08	23	165	3456	5		37.2	29
92	08	24	166	-2266	-3		34.3	24
92	08	27	169	5014	6		35.3	21

COLD TEMPERATURE PHASE (20 DAY AEROBIC SRT SYSTEM, 1500 mg NH4-N/L IN INFLUENT)

Date (yy	mm	dd)	Day	Flowrate Influent (L/d)	Flowrate NH4Cl (mL/h)	Flowrate CH3OH (mL/h)	Flowrate NaHCO3 (mL/h)	Flowrate o-PO4 (mL/h)	Flowrate Recycle (L/d)	Flowrate Aerobic Wasting (L/d)	Flowrate Anoxic Overflow (L/d)
92	03	12	1	9.8	27.0	6.5	41	41	57	0.0	69
92	03	13	2	9.2	23.9	6.3	42	42	57	0.0	68
92	03	15	4	8.9	27.5	6.3	37	37	57	0.0	68
92	03	17	6	8.8	27.0	6.6	39	39	57	0.0	68
92	03	20	9	9.0	24.6	6.7	36	36	63	0.0	74
92	03	22	11	9.0	23.8	6.7	41	41	63	0.0	74
92	03	23	12	9.0	19.5	6.7	43	43	60	0.0	71
92	03	25	14	8.9	23.0	6.5	42	42	60	0.0	71
92	03	26	15	8.7	21.0	6.7	39	39	60	0.0	70
92	03	28	17	8.9	20.0	6.4	39	39	59	0.5	69
92	03	30	19	8.6	20.0	6.4	39	39	59	0.5	69
92	04	1	21	8.8	19.5	6.8	47	47	59	0.5	70
92	04	3	23	9.0	16.0	7.0	38	38	59	0.5	69
92	04	5	25	8.8	15.4	6.9	44	44	56	0.5	66
92	04	6	26	8.9	25.0	6.8	48	48	56	0.5	67
92	04	8	28	8.7	25.8	6.8	46	46	56	0.5	67
92	04	9	29	8.6	24.0	6.8	44	44	56	0.5	66
92	04	10	30	8.6	27.0	6.7	37	37	63	0.5	73
92	04	12	32	8.4	25.0	6.9	45	45	63	0.0	73
92	04	13	33	8.4	25.0	6.7	44	11.7	63	0.0	72
92	04	15	35	8.4	25.0	6.7	48	11.5	58	0.0	67
92	04	16	36	8.2	24.0	6.5	40	11.8	58	0.5	67
92	04	18	38	8.3	26.0	6.5	38	11.4	58	0.5	67
92	04	21	41	8.3	27.0	6.8	32	11.2	58	0.5	67
92	04	24	44	8.6	26.0	6.6	32	11.1	58	0.5	68
92	04	25	45	8.5	25.9	6.5	45	11.0	64	0.0	74
92	04	27	47	8.2	26.9	6.7	42	10.9	64	0.0	73
92	04	30	50	8.6	27.0	6.3	12	10.8	64	0.0	74
92	05	3	53	8.8	26.7	6.8	17	11.0	64	0.0	74
92	05	5	55	8.8	24.6	6.6	12	11.5	64	0.0	74
92	05	6	56	9.0	27.0	6.6	17	11.4	64	0.5	74
92	05	8	58	8.9	27.0	6.7	22	11.8	59	0.5	69
92	05	9	59	8.5	25.0	6.2	34	11.7	59	0.5	69
92	05	11	61	8.2	25.0	6.2	53	11.7	62	0.5	71
92	05	13	63	8.0	25.5	7.0	68	12.1	62	0.5	71
92	05	15	65	8.2	27.1	6.6	41	12.1	62	0.5	71
92	05	18	68	8.5	24.8	6.5	34	11.9	62	0.5	72
92	05	19	69	8.6	26.0	6.8	26	12.1	65	0.5	75
92	05	21	71	8.3	22.6	6.5	44	12.2	65	0.5	74
92	05	25	75	8.5	24.0	6.6	39	11.6	65	0.5	75
92	05	26	76	8.3	23.0	7.2	35	12.1	65	0.5	74
92	05	28	78	8.3	25.0	6.8	35	12.0	63	0.5	72
92	05	31	81	8.4	25.0	6.8	55	12.5	63	0.5	72
92	06	2	83	8.3	23.6	7.0	47	12.7	63	0.5	72
92	06	4	85	8.5	25.2	7.0	47	12.7	63	0.5	73

COLD TEMPERATURE PHASE (20 DAY AEROBIC SRT SYSTEM, 1500 mg NH4-N/L IN INFLUENT)

Date (yy	mm	dd)	Day	Flowrate Influent (L/d)	Flowrate NH4Cl (mL/h)	Flowrate CH3OH (mL/h)	Flowrate NaHCO3 (mL/h)	Flowrate o-PO4 (mL/h)	Flowrate Recycle (L/d)	Flowrate Aerobic Wasting (L/d)	Flowrate Anoxic Overflow (L/d)
92	06	6	87	8.6	25.5	7.1	39	12.2	57	0.5	67
92	06	7	88	8.5	25.5	6.9	44	11.8	57	0.5	67
92	06	10	91	8.4	24.2	6.4	35	11.7	57	0.5	66
92	06	13	94	8.5	24.1	6.3	48	11.4	57	0.5	67
92	06	15	96	8.6	23.0	7.1	47	11.3	57	0.5	67
92	06	16	97	8.4	23.8	6.5	42	11.7	57	0.5	66
92	06	17	98	8.3	25.6	6.5	32	12.0	57	0.5	66
92	06	19	100	8.3	25.1	6.5	39	12.5	60	0.5	69
92	06	22	103	8.4	25.8	6.6	43	12.7	60	0.5	69
92	06	23	104	8.4	23.6	6.7	41	13.0	60	0.5	69
92	06	26	107	8.2	22.8	6.4	36	12.8	60	0.5	69
92	06	28	109	8.2	21.2	6.2	40	12.9	60	0.5	69
92	06	29	110	8.1	19.0	6.0	44	13.4	64	0.5	73
92	07	3	114	8.1	29.7	5.8	36	13.8	61	0.5	70
92	07	4	115	8.2	31.6	5.7	37	13.9	61	0.5	70
92	07	6	117	8.2	32.3	5.6	58	13.6	61	0.5	70
92	07	9	120	8.2	30.9	5.7	47	13.3	61	0.5	70
92	07	10	121	8.2	29.2	5.7	44	13.3	64	0.5	73
92	07	12	123	8.0	29.2	5.3	48	13.9	64	0.5	73
92	07	14	125	8.3	30.1	5.6	42	13.4	64	0.5	73
92	07	15	126	8.4	30.2	5.7	35	13.5	64	0.5	74
92	07	17	128	8.3	29.1	5.5	47	13.9	61	0.5	70
92	07	19	130	8.3	27.5	5.7	31	14.5	61	0.0	70
92	07	21	132	7.9	29.2	0.0	113	14.9	61	0.0	70
92	07	23	134	7.6	28.5	0.0	89	14.9	61	0.0	70
92	07	26	137	7.4	28.8	0.0	95	14.5	61	0.0	69
92	07	27	138	7.2	23.8	0.0	89	15.1	61	0.0	69
92	07	29	140	7.3	28.9	0.0	74	14.9	61	0.5	69
92	07	31	142	7.6	30.8	0.0	44	14.5	61	1.0	70
92	08	2	144	8.0	26.3	0.0	37	14.3	55	1.0	64
92	08	4	146	8.3	26.3	0.0	34	14.1	55	0.0	64
92	08	6	148	8.6	28.6	0.0	41	13.9	62	0.0	72
92	08	7	149	8.4	28.6	0.0	47	14.0	62	0.0	71
92	08	10	152	8.1	29.8	0.0	57	14.1	58	0.0	67
92	08	13	155	8.3	29.0	0.0	64	14.4	58	0.0	67
92	08	14	156	8.3	30.8	0.0	52	14.1	58	1.0	67
92	08	17	159	8.2	30.3	0.0	37	14.6	58	1.0	67
92	08	19	161	8.5	27.3	0.0	16	14.9	55	1.0	64
92	08	21	163	8.6	24.7	0.0	31	14.4	55	1.0	65
92	08	23	165	8.3	22.2	0.0	46	14.9	55	1.0	64
92	08	24	166	8.3	20.4	0.0	34	14.7	55	1.0	64
92	08	27	169	8.4	21.3	0.0	31	15.0	55	1.0	64

COLD TEMPERATURE PHASE (20 DAY AEROBIC SRT SYSTEM, 1500 mg NH4-N/L IN INFLUENT)

Date (yy	mm	dd)	Day	Flowrate Aerobic Overflow (L/d)	Feed Conc. NH4Cl (g/L)	Feed Conc. Simulated Influent NH4 (mgN/L)	Feed Conc. CH3OH (mL/L)	Feed Conc. o-PO4 (gP/L)
92	03	12	1	70	13	346	10	0.231
92	03	13	2	69	13	313	10	0.231
92	03	15	4	68	25	592	10	0.231
92	03	17	6	68	25	591	10	0.231
92	03	20	9	74	50	937	10	0.231
92	03	22	11	75	83	1398	10	0.231
92	03	23	12	72	90	1302	10	0.231
92	03	25	14	72	90	1517	200	0.231
92	03	26	15	71	100	1588	200	0.231
92	03	28	17	70	100	1486	200	0.231
92	03	30	19	70	110	1651	200	0.231
92	04	1	21	71	110	1559	200	0.231
92	04	3	23	70	120	1404	500	0.231
92	04	5	25	67	125	1472	500	0.231
92	04	6	26	68	90	1642	500	0.231
92	04	8	28	68	0	164	10	0.231
92	04	9	29	67	25	580	10	0.231
92	04	10	30	74	50	1083	10	0.231
92	04	12	32	74	80	1534	10	0.231
92	04	13	33	73	80	1441	10	0.361
92	04	15	35	69	80	1422	100	0.361
92	04	16	36	68	80	1415	200	0.361
92	04	18	38	68	80	1499	400	0.361
92	04	21	41	68	80	1582	400	0.361
92	04	24	44	68	50	980	10	0.361
92	04	25	45	75	0	128	10	0.361
92	04	27	47	74	0	195	10	0.361
92	04	30	50	74	25	619	10	0.361
92	05	3	53	74	25	597	10	0.361
92	05	5	55	74	50	1052	10	0.361
92	05	6	56	75	60	1200	10	0.361
92	05	8	58	70	75	1459	25	0.361
92	05	9	59	69	75	1370	50	0.361
92	05	11	61	73	88	1525	100	0.361
92	05	13	63	73	80	1412	100	0.361
92	05	15	65	72	80	1559	100	0.361
92	05	18	68	72	80	1445	200	0.361
92	05	19	69	75	80	1512	200	0.361
92	05	21	71	75	80	1305	200	0.361
92	05	25	75	75	80	1381	300	0.361
92	05	26	76	75	80	1350	300	0.361
92	05	28	78	73	80	1449	300	0.361
92	05	31	81	74	80	1370	300	0.361
92	06	2	83	73	80	1339	300	0.361
92	06	4	85	74	80	1391	300	0.361

COLD TEMPERATURE PHASE (20 DAY AEROBIC SRT SYSTEM, 1500 mg NH4-N/L IN INFLUENT)

Date (yy	mm	dd)	Day	Flowrate Aerobic Overflow (L/d)	Feed Conc. NH4Cl (g/L)	Feed Conc. Simulated Influent NH4 (mgN/L)	Feed Conc. CH3OH (mL/L)	Feed Conc. o-PO4 (gP/L)
92	06	6	87	68	80	1424	250	0.361
92	06	7	88	68	80	1431	250	0.361
92	06	10	91	67	80	1409	250	0.361
92	06	13	94	68	80	1347	270	0.361
92	06	15	96	68	80	1273	270	0.361
92	06	16	97	67	80	1372	265	0.361
92	06	17	98	67	80	1493	265	0.361
92	06	19	100	70	80	1445	265	0.361
92	06	22	103	71	80	1461	265	0.361
92	06	23	104	70	80	1335	265	0.361
92	06	26	107	70	80	1363	265	0.361
92	06	28	109	70	95	1464	290	0.361
92	06	29	110	74	95	1323	290	0.361
92	07	3	114	71	73	1588	290	0.361
92	07	4	115	71	73	1655	290	0.361
92	07	6	117	72	73	1619	290	0.361
92	07	9	120	72	73	1587	290	0.361
92	07	10	121	74	73	1534	290	0.361
92	07	12	123	74	73	1549	290	0.361
92	07	14	125	74	73	1569	290	0.361
92	07	15	126	74	73	1577	290	0.361
92	07	17	128	72	73	1507	290	0.361
92	07	19	130	71	73	1487	290	0.361
92	07	21	132	73	73	1338	0	0.361
92	07	23	134	72	73	1428	0	0.361
92	07	26	137	72	73	1456	0	0.361
92	07	27	138	71	73	1263	0	0.361
92	07	29	140	71	73	1555	0	0.361
92	07	31	142	71	73	1722	0	0.361
92	08	2	144	65	73	1457	0	0.361
92	08	4	146	65	73	1437	0	0.361
92	08	6	148	73	73	1481	0	0.361
92	08	7	149	73	73	1488	0	0.361
92	08	10	152	69	73	1547	0	0.361
92	08	13	155	69	73	1464	0	0.361
92	08	14	156	69	73	1580	0	0.361
92	08	17	159	68	73	1632	0	0.361
92	08	19	161	65	73	1540	0	0.361
92	08	21	163	65	73	1318	0	0.361
92	08	23	165	65	90	1452	0	0.361
92	08	24	166	65	90	1391	0	0.361
92	08	27	169	65	95	1507	0	0.361

COLD TEMPERATURE PHASE (20 DAY AEROBIC SRT SYSTEM, 1500 mg NH4-N/L IN INFLUENT)

Date (yy	mm	dd)	Day	Feed Conc. NaHCO3 (g/L)	System Loading CH3OH (gCOD/d)	System Loading o-PO4 (gP/d)	System Loading NaHCO3 (gCaCO3/d)	Anoxic ORP (mV)
92	03	12	1	44	1.85	0.228	3648	-156
92	03	13	2	56	1.80	0.233	4636	-109
92	03	15	4	56	1.80	0.205	4276	-17
92	03	17	6	50	1.88	0.217	4109	53
92	03	20	9	81	1.89	0.200	5518	66
92	03	22	11	81	1.91	0.228	6116	121
92	03	23	12	81	1.91	0.239	6639	73
92	03	25	14	50	37.04	0.233	4577	5
92	03	26	15	50	38.18	0.217	4440	-11
92	03	28	17	50	36.47	0.217	4407	-16
92	03	30	19	50	36.47	0.217	4486	-30
92	04	1	21	50	38.75	0.261	5047	-44
92	04	3	23	50	99.73	0.211	4332	-129
92	04	5	25	50	98.30	0.244	4870	-93
92	04	6	26	50	96.88	0.267	5012	-90
92	04	8	28	63	1.94	0.255	5777	-86
92	04	9	29	75	1.94	0.244	6482	-107
92	04	10	30	83	1.91	0.205	6085	-91
92	04	12	32	93	1.97	0.250	7905	-55
92	04	13	33	93	1.91	0.102	7242	-62
92	04	15	35	75	19.09	0.100	6472	-34
92	04	16	36	75	37.04	0.103	5805	-51
92	04	18	38	75	74.08	0.099	5579	-42
92	04	21	41	75	77.50	0.097	4996	-75
92	04	24	44	75	1.88	0.097	4897	-91
92	04	25	45	75	1.85	0.095	6182	-110
92	04	27	47	75	1.91	0.095	5689	-114
92	04	30	50	75	1.80	0.093	2485	-81
92	05	3	53	75	1.94	0.095	2950	-44
92	05	5	55	75	1.88	0.099	2456	21
92	05	6	56	75	1.88	0.099	2934	-3
92	05	8	58	75	4.77	0.102	3458	-8
92	05	9	59	75	8.83	0.101	4758	-15
92	05	11	61	75	17.67	0.101	6695	-32
92	05	13	63	75	19.95	0.105	8174	-49
92	05	15	65	75	18.81	0.105	5570	-36
92	05	18	68	75	37.04	0.103	4782	-114
92	05	19	69	75	38.75	0.105	3949	-124
92	05	21	71	75	37.04	0.106	5858	-110
92	05	25	75	75	56.42	0.101	5255	-166
92	05	26	76	75	61.55	0.105	4942	-142
92	05	28	78	75	58.13	0.105	4942	-130
92	05	31	81	75	58.13	0.108	6973	-92
92	06	2	83	75	59.84	0.110	6283	-90
92	06	4	85	75	59.84	0.110	6204	-106

COLD TEMPERATURE PHASE (20 DAY AEROBIC SRT SYSTEM, 1500 mg NH4-N/L IN INFLUENT)

Date (yy	mm	dd)	Day	Feed Conc. NaHCO3 (g/L)	System Loading CH3OH (gCOD/d)	System Loading o-PO4 (gP/d)	System Loading NaHCO3 (gCaCO3/d)	Anoxic ORP (mV)
92	06	6	87	75	50.58	0.106	5400	-136
92	06	7	88	75	49.15	0.102	5919	-151
92	06	10	91	75	45.59	0.102	5108	-166
92	06	13	94	75	48.47	0.099	6290	-172
92	06	15	96	75	54.62	0.098	6147	-151
92	06	16	97	75	49.08	0.101	5795	-190
92	06	17	98	75	49.08	0.104	4850	-200
92	06	19	100	75	49.08	0.108	5519	-185
92	06	22	103	75	49.84	0.110	5862	-154
92	06	23	104	75	50.59	0.113	5662	-160
92	06	26	107	75	48.33	0.111	5292	-164
92	06	28	109	75	51.23	0.112	5677	-183
92	06	29	110	75	49.58	0.116	6111	-171
92	07	3	114	75	47.93	0.120	5265	-169
92	07	4	115	75	47.10	0.120	5305	-174
92	07	6	117	75	46.27	0.118	7273	-140
92	07	9	120	75	47.10	0.115	6297	-158
92	07	10	121	75	47.10	0.116	6008	-161
92	07	12	123	75	43.80	0.121	6511	-187
92	07	14	125	75	46.27	0.116	5781	-234
92	07	15	126	75	47.10	0.117	5056	-258
92	07	17	128	75	45.45	0.121	6232	-207
92	07	19	130	75	47.10	0.126	4673	-226
92	07	21	132	75	0.00	0.129	11994	-119
92	07	23	134	75	0.00	0.129	10462	-30
92	07	26	137	75	0.00	0.126	11194	-8
92	07	27	138	75	0.00	0.131	10894	-5
92	07	29	140	75	0.00	0.129	9457	5
92	07	31	142	75	0.00	0.126	6366	15
92	08	2	144	75	0.00	0.124	5448	39
92	08	4	146	75	0.00	0.123	5176	-15
92	08	6	148	75	0.00	0.121	5713	30
92	08	7	149	75	0.00	0.121	6419	21
92	08	10	152	75	0.00	0.122	7447	40
92	08	13	155	75	0.00	0.125	8021	45
92	08	14	156	75	0.00	0.123	6871	46
92	08	17	159	75	0.00	0.127	5533	42
92	08	19	161	75	0.00	0.129	3255	54
92	08	21	163	75	0.00	0.125	4774	35
92	08	23	165	75	0.00	0.129	6324	49
92	08	24	166	75	0.00	0.128	5170	47
92	08	27	169	75	0.00	0.131	4851	57

COLD TEMPERATURE PHASE (20 DAY AEROBIC SRT SYSTEM, 1500 mg NH4-N/L IN INFLUENT)

Date (yy	mm	dd)	Day	Anoxic pH	Anoxic VSS (mg/L)	Anoxic TSS (mg/L)	Anoxic o-PO4 (mgP/L)	Anoxic NH4 (mgN/L)	Anoxic NOx (mgN/L)	Anoxic NO2 (mgN/L)	Anoxic BOD (mg/L)
92	03	12	1	7.5	5780	8078		268			
92	03	13	2	7.3	5674	7412		133			
92	03	15	4	7.8	5458	7216		116			307
92	03	17	6	7.3	5306	6977		86			
92	03	20	9	7.4	5380	6806		134			
92	03	22	11	7.6	5756	6566		189			184
92	03	23	12	7.5	4850	7066		174			
92	03	25	14	7.7	4626	6347	14.5	196	644.0	292.0	
92	03	26	15	7.7	4620	6358	10.4	215	802.0	238.0	
92	03	28	17	7.9	4789	6105	10.2	198	614.0	210.0	88
92	03	30	19	8.2	4898	6440	8.0	208	674.0	194.6	
92	04	1	21	8.1	4883	6416	9.2	207	731.0	167.0	
92	04	3	23	8.5	4614	5364	6.9	218	125.9	87.0	
92	04	5	25	8.6	4650	5258	7.2	348	19.7	14.3	218
92	04	6	26	8.3	4540	5437	7.1	384	4.4	0.4	
92	04	8	28	8.2	4339	5249	6.5	138	72.0	27.0	
92	04	9	29	8.3	4639	5505	5.9	196	344.7	138.0	
92	04	10	30	8.3	4699	5530	6.5	229	338.0	143.0	
92	04	12	32	8.7	4758	5911	6.7	206	897.0	226.0	208
92	04	13	33	8.7	4677	5438	5.3	198	843.0	251.0	
92	04	15	35	8.2	4704	5547	4.2	199	489.0	254.0	108
92	04	16	36	8.2	4792	5346	3.8	189	369.2	91.0	119
92	04	18	38	8.2	4756	5201	2.9	289	71.0	21.9	310
92	04	21	41	8.2	4736	4996	3.3	309	15.4	14.4	328
92	04	24	44	8.4	4776	5466	3.2	201	437.0	103.4	245
92	04	25	45	8.6	4897	5680	3.4	35	117.0	18.3	
92	04	27	47	8.5	4738	5529	3.3	27	171.0	19.2	114
92	04	30	50	8.1	4307	5435	3.1	233	396.0	33.0	86
92	05	3	53	8.5	4008	5003	3.4	128	494.0	47.0	62
92	05	5	55	8.0	4163	5174	3.2	155	593.0	66.0	66
92	05	6	56	8.0	4167	5058	2.8	166	676.0	60.0	
92	05	8	58	7.6	4140	4714	2.6	172	885.0	158.0	72
92	05	9	59	8.0	4222	4900	3.0	189	857.0	156.0	66
92	05	11	61	8.3	4246	4745	3.1	191	845.0	24.0	104
92	05	13	63	8.0	4345	4681	3.5	193	961.0	15.6	97
92	05	15	65	7.9	4412	5112	3.3	163	921.0	13.5	83
92	05	18	68	7.9	4280	4443	3.8	178	844.3	3.5	127
92	05	19	69	8.0	4544	4623	4.0	183	838.7	3.3	127
92	05	21	71	8.0	4769	5117	3.1	154	879.2	2.0	136
92	05	25	75	8.3	5250	5076	3.0	162	427.0	0.4	186
92	05	26	76	8.4	5360	5394	3.4	175	202.2	0.6	218
92	05	28	78	8.3	5600	5316	2.6	163	36.1	0.8	196
92	05	31	81	8.7	6150	5857	2.3	154	3.8	0.1	212
92	06	2	83	8.9	6029	6027	2.3	161	12.6	0.6	183
92	06	4	85	8.4	5859	6191	2.8	158	0.9	0.2	193

COLD TEMPERATURE PHASE (20 DAY AEROBIC SRT SYSTEM, 1500 mg NH4-N/L IN INFLUENT)

Date (yy	mm	dd)	Day	Anoxic pH	Anoxic VSS (mg/L)	Anoxic TSS (mg/L)	Anoxic o-PO4 (mgP/L)	Anoxic NH4 (mgN/L)	Anoxic NOx (mgN/L)	Anoxic NO2 (mgN/L)	Anoxic BOD (mg/L)
92	06	6	87	8.4	5737	6112	2.5	151	2.6	1.4	206
92	06	7	88	8.4	6143	7045	3.0	168	6.3	0.5	
92	06	10	91	8.4	5924	6351	2.4	155	2.3	1.2	185
92	06	13	94	8.6	6090	6686	2.0	177	2.9	0.9	173
92	06	15	96	8.5	6018	6853	2.2	172	1.9	0.1	
92	06	16	97	8.3	5716	6653	2.4	163	0.8	0.0	184
92	06	17	98	8.4	5554	6553	2.0	169	1.0	0.0	168
92	06	19	100	8.3	5992	6909	2.7	155	2.7	0.6	172
92	06	22	103	8.4	5655	6646	2.7	162	1.2	0.0	194
92	06	23	104	8.4	5550	6463	3.1	163	1.7	0.0	
92	06	26	107	8.4	5408	6499	3.3	159	0.8	0.1	193
92	06	28	109	8.4	5480	6181	3.0	171	4.6	1.9	188
92	06	29	110	8.5	5606	5977	3.5	171	2.8	0.1	179
92	07	3	114	8.3	5857	6830	3.1	186	2.3	1.2	204
92	07	4	115	8.3	5910	6471	3.5	176	0.8	0.0	
92	07	6	117	8.4	5847	6446	2.6	184	1.4	0.2	205
92	07	9	120	8.3	6393	7268	2.3	181	1.5	0.1	185
92	07	10	121	8.4	6635	7318	3.0	161	2.6	0.0	
92	07	12	123	8.4	6118	6890	2.7	192	2.7	0.7	223
92	07	14	125	8.2	5935	6671	2.8	278	15.0	1.5	189
92	07	15	126	8.2	6160	6880	2.7	298	13.0	9.7	
92	07	17	128	8.3	5960	6729	2.7	506	23.6	2.1	236
92	07	19	130	8.2	5910	6715	3.1	685	22.1	3.9	248
92	07	21	132	8.0	6046	7309	3.6	507	8.7	1.3	361
92	07	23	134	8.1	5734	7964	3.7	493	8.4	0.4	328
92	07	26	137	8.1	5359	7936	4.3	450	8.5	0.4	330
92	07	27	138	7.9	4858	6699	4.9	281	316.0	14.6	
92	07	29	140	7.8	4700	6671	5.1	308	621.0	26.4	205
92	07	31	142	7.6	4745	6523	4.3	209	932.0	71.6	263
92	08	2	144	7.5	4763	6751	3.3	194	957.0	69.2	190
92	08	4	146	7.7	4429	6249	3.7	718	746.0	308.8	625
92	08	6	148	7.4	4163	5775	3.4	680	870.0	463.0	468
92	08	7	149	7.5	3973	5325	2.8	505	1086.0	497.0	
92	08	10	152	7.5	3910	5512	3.2	310	905.6	530.0	300
92	08	13	155	7.5	3941	5153	3.3	207	902.5	427.5	
92	08	14	156	7.7	3880	5266	2.7	199	972.0	498.1	205
92	08	17	159	7.5	3812	5070	2.8	225	1014.0	446.4	
92	08	19	161	7.5	3855	4979	3.3	249	903.0	355.0	232
92	08	21	163	7.6	3550	4743	3.5	256	821.0	368.9	
92	08	23	165	7.7	3474	4594	3.1	507	696.0	358.8	241
92	08	24	166	7.6	3452	4600	3.5	531	626.0	336.7	
92	08	27	169	7.5	3297	4224	3.8	649	698.0	214.3	

COLD TEMPERATURE PHASE (20 DAY AEROBIC SRT SYSTEM, 1500 mg NH4-N/L IN INFLUENT)

Date (yy	mm	dd)	Day	Anoxic COD (mg/L)	Aerobic DO (mg/L)	Aerobic pH	Aerobic VSS (mg/L)	Aerobic TSS (mg/L)	Aerobic o-PO4 (mgP/L)	Aerobic NH4 (mgN/L)
92	03	12	1	702	9.10	6.7	5970	8320		239
92	03	13	2	828	8.00	7.2	6079	7905		81
92	03	15	4	685	8.20	7.7	5680	7643		53
92	03	17	6	798	7.80	7.1	5569	7350		4
92	03	20	9	704	8.70	7.1	5625	7131		8
92	03	22	11	642	9.00	7.6	6010	7023		17
92	03	23	12	605	8.60	7.8	4890	7085		3
92	03	25	14	641	5.50	7.3	4902	6832	14.3	5
92	03	26	15	651	5.50	7.6	4839	6646	11.9	14
92	03	28	17	679	8.00	7.5	5100	6470	9.5	2
92	03	30	19	644	7.00	7.4	4900	6408	9.4	4
92	04	1	21	597	7.00	7.6	4765	6312	10.5	1
92	04	3	23	750	7.50	8.1	5152	6113	7.7	94
92	04	5	25	727	7.50	8.0	5240	6034	8.3	237
92	04	6	26	690	6.00	6.9	4922	6008	6.4	263
92	04	8	28	669	5.00	6.5	4810	5864	6.5	68
92	04	9	29	637	5.50	6.9	4806	5753	6.6	92
92	04	10	30	620	5.00	6.8	4811	5750	6.4	36
92	04	12	32	610	5.00	8.3	4540	5751	6.5	14
92	04	13	33	607	4.50	7.3	4760	5681	5.2	7
92	04	15	35	599	7.50	7.7	4830	5683	3.5	4
92	04	16	36	591	7.00	7.5	5120	5693	3.9	6
92	04	18	38	729	7.50	7.9	5240	5707	3.0	165
92	04	21	41	820	7.50	6.8	5350	5677	3.2	248
92	04	24	44	677	6.50	7.3	4970	5758	2.8	65
92	04	25	45	679	5.00	8.2	4813	5619	3.1	22
92	04	27	47	541	6.70	8.5	4660	5484	2.9	6
92	04	30	50	487	7.00	7.8	4320	5435	3.0	120
92	05	3	53	453	9.80	7.7	4259	5281	3.4	51
92	05	5	55	494	7.50	7.3	4140	5177	3.3	41
92	05	6	56	504	7.30	7.4	4095	5096	2.9	15
92	05	8	58	500	5.80	7.4	4320	5027	2.1	10
92	05	9	59	434	6.10	7.3	4360	5035	2.4	17
92	05	11	61	500	5.80	7.3	4550	5053	2.7	19
92	05	13	63	500	5.00	7.3	4660	5124	3.2	7
92	05	15	65	475	4.70	7.3	4490	5176	3.3	7
92	05	18	68	516	5.00	7.4	4960	5199	4.0	12
92	05	19	69	547	5.30	7.4	5110	5324	3.6	13
92	05	21	71	523	5.50	7.3	5070	5431	2.5	7
92	05	25	75	628	4.00	7.3	5580	5537	3.1	5
92	05	26	76	654	7.50	7.3	5620	5740	2.7	2
92	05	28	78	652	8.40	7.3	6200	5920	2.5	6
92	05	31	81	647	6.60	7.4	6350	6172	1.9	1
92	06	2	83	570	6.82	7.4	6320	6409	1.7	2
92	06	4	85	607	6.47	7.4	6240	6578	2.6	9

COLD TEMPERATURE PHASE (20 DAY AEROBIC SRT SYSTEM, 1500 mg NH4-N/L IN INFLUENT)

Date (yy	mm	dd)	Day	Anoxic COD (mg/L)	Aerobic DO (mg/L)	Aerobic pH	Aerobic VSS (mg/L)	Aerobic TSS (mg/L)	Aerobic o-PO4 (mgP/L)	Aerobic NH4 (mgN/L)
92	06	6	87	630	5.97	7.4	6160	6696	2.0	1
92	06	7	88	637	5.83	7.4	5940	6793	2.5	1
92	06	10	91	592	6.56	7.5	6240	6810	2.5	1
92	06	13	94	650	6.27	7.5	6180	6915	2.2	1
92	06	15	96	543	6.05	7.4	6016	6979	1.8	0
92	06	16	97	569	5.74	7.4	5990	6981	1.8	1
92	06	17	98	543	6.63	7.4	5910	6985	1.8	1
92	06	19	100	619	7.12	7.4	5910	6953	2.0	0
92	06	22	103	681	7.51	7.4	5840	6931	2.0	5
92	06	23	104	579	6.50	7.4	5850	6903	2.2	0
92	06	26	107	623	6.52	7.3	5730	6877	3.1	2
92	06	28	109	622	6.78	7.3	6073	6846	2.8	1
92	06	29	110	594	7.00	7.4	6318	6902	3.1	1
92	07	3	114	616	6.90	7.3	5950	7017	2.7	1
92	07	4	115	585	7.32	7.3	6275	7017	2.6	0
92	07	6	117	565	7.17	7.3	6410	7100	2.5	1
92	07	9	120	588	6.39	7.4	6220	7192	2.1	1
92	07	10	121	600	6.20	7.3	6360	7198	2.2	0
92	07	12	123	675	7.12	7.3	6390	7273	2.7	2
92	07	14	125	666	7.17	7.3	6410	7252	2.5	156
92	07	15	126	706	6.27	7.3	6370	7211	2.4	199
92	07	17	128	632	6.55	7.3	6340	7298	2.7	305
92	07	19	130	746	5.69	7.3	6290	7268	2.4	558
92	07	21	132	812	5.08	7.3	5890	7121	2.7	481
92	07	23	134	734	6.53	7.3	5150	7333	3.8	103
92	07	26	137	829	7.03	7.3	4840	7300	3.9	66
92	07	27	138	707	7.19	7.3	5020	6993	4.2	81
92	07	29	140	633	5.89	7.3	4760	6862	4.4	56
92	07	31	142	670	6.42	7.3	4754	6633	4.3	8
92	08	2	144	633	6.15	7.3	4550	6449	3.2	4
92	08	4	146	1093	0.00	7.3	4330	6228	3.0	560
92	08	6	148	946	6.33	7.3	4220	5944	3.5	578
92	08	7	149	882	6.72	7.3	4187	5707	2.5	380
92	08	10	152	776	7.37	7.4	3920	5576	2.9	121
92	08	13	155	737	7.08	7.5	4060	5393	2.9	12
92	08	14	156	617	6.66	7.4	3910	5289	3.0	5
92	08	17	159	646	6.38	7.4	3840	5174	2.2	23
92	08	19	161	661	6.64	7.4	3950	5068	3.2	36
92	08	21	163	703	6.54	7.4	3680	4976	3.0	105
92	08	23	165	724	6.94	7.4	3550	4813	2.5	386
92	08	24	166	746	6.11	7.4	3490	4638	2.8	426
92	08	27	169	762	6.31	7.3	3460	4523	3.4	487

COLD TEMPERATURE PHASE (20 DAY AEROBIC SRT SYSTEM, 1500 mg NH4-N/L IN INFLUENT)

Date (yy	mm	dd)	Day	Aerobic NOx (mgN/L)	Aerobic NO2 (mgN/L)	Aerobic BOD (mg/L)	Aerobic COD (mg/L)	Effluent VSS (mg/L)	Effluent TSS (mg/L)	Effluent NH4 (mgN/L)
92	03	12	1				491	155	211	
92	03	13	2				485	153	194	
92	03	15	4			41	456	182	248	
92	03	17	6				433	147	194	
92	03	20	9				385	144	178	
92	03	22	11			18	399	138	160	
92	03	23	12				381	255	372	
92	03	25	14	756	387.5		440	150	208	
92	03	26	15	938	608.5		408	119	159	
92	03	28	17	825	507.6	18	425	138	173	
92	03	30	19	806	571.0		402	170	222	
92	04	1	21	889	709.9		428	151	202	
92	04	3	23	237	115.9		450	148	178	
92	04	5	25	123	107.0	53	447	148	176	
92	04	6	26	117	84.3		442	181	224	
92	04	8	28	125	86.5		456	161	196	
92	04	9	29	552	139.6		429	129	157	
92	04	10	30	495	228.5		403	126	154	
92	04	12	32	1051	231.5	14	403	167	212	
92	04	13	33	996	341.9		420	125	153	
92	04	15	35	625	326.4	12	372	125	149	
92	04	16	36	489	201.2	16	397	130	147	
92	04	18	38	197	45.7	24	448	157	171	
92	04	21	41	61	42.2	58	500	139	152	
92	04	24	44	521	132.5	33	458	185	221	
92	04	25	45	117	27.0		420	181	212	
92	04	27	47	154	109.3	17	369	190	240	
92	04	30	50	481	102.3	22	342	209	274	
92	05	3	53	540	104.6	10	338	168	211	
92	05	5	55	694	142.8	16	327	174	219	
92	05	6	56	807	152.6		332	140	176	
92	05	8	58	1019	190.3	13	318	159	186	
92	05	9	59	1008	180.6	16	303	143	166	
92	05	11	61	1043	73.2	20	341	133	147	
92	05	13	63	1125	61.2	14	342	121	136	
92	05	15	65	1054	57.6	15	327	152	172	
92	05	18	68	990	484.3	20	343	150	158	
92	05	19	69	976	64.4	12	373	146	151	
92	05	21	71	978	9.4	20	387	144	152	
92	05	25	75	603	25.0	24	398	128	127	
92	05	26	76	353	11.1	18	406	130	135	
92	05	28	78	176	5.5	16	416	129	126	
92	05	31	81	177	6.0	15	404	135	131	
92	06	2	83	163	2.0	12	375	149	152	2
92	06	4	85	170	0.8	14	377	143	148	

COLD TEMPERATURE PHASE (20 DAY AEROBIC SRT SYSTEM, 1500 mg NH4-N/L IN INFLUENT)

Date (yy	mm	dd)	Day	Aerobic NOx (mgN/L)	Aerobic NO2 (mgN/L)	Aerobic BOD (mg/L)	Aerobic COD (mg/L)	Effluent VSS (mg/L)	Effluent TSS (mg/L)	Effluent NH4 (mgN/L)
92	06	6	87	166	5.0	18	393	136	146	
92	06	7	88	184	0.6		384	155	177	
92	06	10	91	156	1.1	17	394	143	154	
92	06	13	94	175	0.3	11	384	125	139	
92	06	15	96	186	0.4		400	174	205	
92	06	16	97	176	3.1	14	370	133	158	
92	06	17	98	153	0.4	18	358	131	155	
92	06	19	100	149	10.0	10	370	120	143	0
92	06	22	103	147	0.1	13	400	138	162	
92	06	23	104	157	0.6		392	129	150	
92	06	26	107	176	2.0	11	413	164	198	
92	06	28	109	181	0.4	15	398	154	169	
92	06	29	110	156	0.4	8	382	134	144	
92	07	3	114	160	0.3	14	379	182	217	
92	07	4	115	171	5.8		365	149	168	
92	07	6	117	183	71.2	16	383	142	156	
92	07	9	120	167	59.3	12	372	175	205	
92	07	10	121	177	67.0		386	137	151	
92	07	12	123	173	68.4	20	447	130	145	
92	07	14	125	131	55.7	23	421	146	165	
92	07	15	126	114	73.8		433	123	143	
92	07	17	128	161	116.1	29	401	129	151	
92	07	19	130	135	118.0	72	523	150	174	
92	07	21	132	808	92.2	84	549	224	277	
92	07	23	134	815	73.1	55	472	262	383	
92	07	26	137	484	79.7	41	496	233	345	
92	07	27	138	458	58.0		488	151	214	
92	07	29	140	761	71.2	142	464	199	283	
92	07	31	142	1106	75.2	35	415	144	205	
92	08	2	144	1138	62.0	35	409	175	246	5
92	08	4	146	878	117.2	155	697	223	317	
92	08	6	148	977	125.0	202	648	218	306	
92	08	7	149	1246	139.9		550	149	204	
92	08	10	152	1071	186.7	42	474	235	329	
92	08	13	155	1055	197.0		446	132	173	
92	08	14	156	1126	209.0	32	416	217	295	
92	08	17	159	1195	184.8		396	136	185	
92	08	19	161	1080	206.5	53	420	186	243	
92	08	21	163	962	172.7		432	181	241	
92	08	23	165	801	160.3	38	464	187	264	
92	08	24	166	701	138.4		437	150	201	
92	08	27	169	832	189.7		463	149	200	

COLD TEMPERATURE PHASE (20 DAY AEROBIC SRT SYSTEM, 1500 mg NH4-N/L IN INFLUENT)

Date (yy	mm	dd)	Day	Effluent NOx (mgN/L)	Effluent BOD (mg/L)	Effluent COD (mg/L)	Anoxic VSS/TSS	Anoxic NO2/NOX	Anoxic NOX Load (gN/d)	Anoxic COD:NOX Entering (gCOD/gN)
92	03	12	1				0.72			
92	03	13	2				0.77			
92	03	15	4				0.76			
92	03	17	6				0.76			
92	03	20	9				0.79			
92	03	22	11				0.88			
92	03	23	12				0.69			
92	03	25	14				0.73	0.45	45.4	0.8
92	03	26	15				0.73	0.30	56.4	0.7
92	03	28	17				0.78	0.34	48.8	0.7
92	03	30	19				0.76	0.29	47.6	0.8
92	04	1	21				0.76	0.23	52.5	0.7
92	04	3	23				0.86	0.69	14.1	7.1
92	04	5	25				0.88	0.73	7.0	14.1
92	04	6	26				0.84	0.09	6.6	14.6
92	04	8	28				0.83	0.38	7.1	0.3
92	04	9	29				0.84	0.40	31.0	0.1
92	04	10	30				0.85	0.42	31.2	0.1
92	04	12	32				0.80	0.25	66.3	0.0
92	04	13	33				0.86	0.30	62.8	0.0
92	04	15	35				0.85	0.52	36.3	0.5
92	04	16	36				0.90	0.25	28.4	1.3
92	04	18	38				0.91	0.31	11.5	6.4
92	04	21	41				0.95	0.94	3.6	21.4
92	04	24	44				0.87	0.24	30.3	0.1
92	04	25	45				0.86	0.16	7.6	0.2
92	04	27	47				0.86	0.11	9.9	0.2
92	04	30	50				0.79	0.08	30.9	0.1
92	05	3	53				0.80	0.10	34.7	0.1
92	05	5	55				0.80	0.11	44.5	0.0
92	05	6	56				0.82	0.09	51.7	0.0
92	05	8	58				0.88	0.18	60.2	0.1
92	05	9	59				0.86	0.18	59.6	0.1
92	05	11	61				0.90	0.03	64.8	0.3
92	05	13	63				0.93	0.02	69.8	0.3
92	05	15	65				0.86	0.01	65.4	0.3
92	05	18	68				0.96	0.00	61.5	0.6
92	05	19	69				0.98	0.00	63.5	0.6
92	05	21	71				0.93	0.00	63.7	0.6
92	05	25	75				1.03	0.00	39.3	1.4
92	05	26	76				0.99	0.00	23.0	2.7
92	05	28	78				1.05	0.02	11.2	5.2
92	05	31	81				1.05	0.01	11.3	5.2
92	06	2	83	159			1.00	0.05	10.4	5.8
92	06	4	85				0.95	0.24	10.8	5.5

COLD TEMPERATURE PHASE (20 DAY AEROBIC SRT SYSTEM, 1500 mg NH4-N/L IN INFLUENT)

Date (yy	mm	dd)	Day	Effluent NOx (mgN/L)	Effluent BOD (mg/L)	Effluent COD (mg/L)	Anoxic VSS/TSS	Anoxic NO2/NOX	Anoxic NOX Load (gN/d)	Anoxic COD:NOX Entering (gCOD/gN)
92	06	6	87				0.94	0.55	9.6	5.3
92	06	7	88				0.87	0.08	10.6	4.6
92	06	10	91				0.93	0.50	9.0	5.1
92	06	13	94				0.91	0.31	10.1	4.8
92	06	15	96				0.88	0.06	10.7	5.1
92	06	16	97				0.86	0.01	10.2	4.8
92	06	17	98				0.85	0.04	8.9	5.5
92	06	19	100	153			0.87	0.21	9.1	5.4
92	06	22	103				0.85	0.03	9.0	5.6
92	06	23	104				0.86	0.01	9.6	5.3
92	06	26	107				0.83	0.10	10.7	4.5
92	06	28	109				0.89	0.41	11.0	4.7
92	06	29	110				0.94	0.02	10.1	4.9
92	07	3	114				0.86	0.52	9.8	4.9
92	07	4	115				0.91	0.01	10.5	4.5
92	07	6	117				0.91	0.15	11.2	4.1
92	07	9	120				0.88	0.07	10.2	4.6
92	07	10	121				0.91	0.00	11.4	4.1
92	07	12	123				0.89	0.26	11.1	3.9
92	07	14	125				0.89	0.10	8.4	5.5
92	07	15	126				0.90	0.75	7.3	6.4
92	07	17	128				0.89	0.09	9.8	4.6
92	07	19	130				0.88	0.18	8.3	5.7
92	07	21	132				0.83	0.14		0.0
92	07	23	134				0.72	0.05		0.0
92	07	26	137				0.68	0.05		0.0
92	07	27	138				0.73	0.05	28.0	0.0
92	07	29	140				0.70	0.04	46.4	0.0
92	07	31	142				0.73	0.08	67.5	0.0
92	08	2	144	1002			0.71	0.07	62.6	0.0
92	08	4	146				0.71	0.41	48.4	0.0
92	08	6	148				0.72	0.53	60.6	0.0
92	08	7	149				0.75	0.46	77.3	0.0
92	08	10	152				0.71	0.59	62.2	0.0
92	08	13	155				0.76	0.47	61.3	0.0
92	08	14	156				0.74	0.51	65.4	0.0
92	08	17	159				0.75	0.44	69.4	0.0
92	08	19	161				0.77	0.39	59.5	0.0
92	08	21	163				0.75	0.45	53.0	0.0
92	08	23	165				0.76	0.52	44.1	0.0
92	08	24	166				0.75	0.54	38.6	0.0
92	08	27	169				0.78	0.31	45.8	0.0

COLD TEMPERATURE PHASE (20 DAY AEROBIC SRT SYSTEM, 1500 mg NH4-N/L IN INFLUENT)

Date (yy	mm	dd)	Day	Anoxic COD:NOX Removed (gCOD/gN)	Anoxic Denitrn Rate (mgN/d)	Anoxic %Denitrn	Anoxic Specific Denitrn Rate (mgN/d/gVSS)	Anoxic NH4 Removal Rate (mgN/d)	Anoxic % NH4 Removal
92	03	12	1					-823	-5
92	03	13	2					-1184	-15
92	03	15	4					1033	12
92	03	17	6					176	3
92	03	20	9					-77	-1
92	03	22	11					894	6
92	03	23	12					656	5
92	03	25	14	62.6	592	1	26	1272	9
92	03	26	15	53.1	719	1	31	802	5
92	03	28	17	5.4	6693	14	280	633	4
92	03	30	19	22.3	1635	3	67	1302	8
92	04	1	21	15.3	2531	5	104	553	4
92	04	3	23	18.4	5432	39	235	3980	21
92	04	5	25	17.3	5679	82	244	4266	16
92	04	6	26	15.3	6341	96	279	5362	18
92	04	8	28	0.8	2361	33	109	-3660	-68
92	04	9	29	0.2	8452	27	364	-2227	-21
92	04	10	30	0.3	6766	22	288	-4157	-33
92	04	12	32	1.3	1515	2	64	148	1
92	04	13	33	1.4	1408	2	60	228	2
92	04	15	35	6.2	3072	8	131	926	6
92	04	16	36	10.7	3469	12	145	1168	8
92	04	18	38	11.1	6696	58	282	4487	19
92	04	21	41	30.1	2577	71	109	8530	29
92	04	24	44	2.8	679	2	28	-281	-2
92	04	25	45	-1.7	-1091	-14	-45	109	4
92	04	27	47	-0.7	-2642	-27	-112	238	11
92	04	30	50	1.0	1857	6	86	-3644	-27
92	05	3	53	-1.1	-1703	-5	-85	-399	-4
92	05	5	55	2.0	942	2	45	1201	10
92	05	6	56	1.0	1813	4	87	562	4
92	05	8	58	-6.4	-742	-1	-36	3180	21
92	05	9	59	14.4	611	1	29	1406	10
92	05	11	61	4.5	3963	6	187	2585	16
92	05	13	63	34.7	574	1	26	722	5
92	05	15	65	-34.8	-540	-1	-24	3812	25
92	05	18	68	40.3	918	1	43	2043	14
92	05	19	69	41.1	943	1	41	1745	11
92	05	21	71	-17.6	-2105	-3	-88	1747	13
92	05	25	75	7.7	7318	19	279	1822	13
92	05	26	76	7.7	7957	35	297	-7	-0
92	05	28	78	6.8	8559	77	306	2495	17
92	05	31	81	5.3	11004	98	358	2708	19
92	06	2	83	6.3	9480	91	314	1607	12
92	06	4	85	5.6	10778	99	368	3007	21

COLD TEMPERATURE PHASE (20 DAY AEROBIC SRT SYSTEM, 1500 mg NH4-N/L IN INFLUENT)

Date (yy	mm	dd)	Day	Anoxic COD:NOX Removed (gCOD/gN)	Anoxic Denitrn Rate (mgN/d)	Anoxic %Denitrn	Anoxic Specific Denitrn Rate (mgN/d/gVSS)	Anoxic NH4 Removal Rate (mgN/d)	Anoxic % NH4 Removal
92	06	6	87	5.4	9422	98	328	4179	29
92	06	7	88	4.8	10198	96	332	3111	22
92	06	10	91	5.1	8861	98	299	3340	24
92	06	13	94	4.9	9906	98	325	1767	13
92	06	15	96	5.1	10607	99	353	1429	11
92	06	16	97	4.9	10110	99	354	2643	20
92	06	17	98	5.6	8783	99	316	2991	21
92	06	19	100	5.5	8882	98	296	3228	23
92	06	22	103	5.6	8867	99	314	3410	23
92	06	23	104	5.4	9432	99	340	1795	14
92	06	26	107	4.5	10632	99	393	1977	15
92	06	28	109	4.8	10667	97	389	2190	16
92	06	29	110	5.0	9904	98	353	166	1
92	07	3	114	5.0	9631	98	329	1929	13
92	07	4	115	4.5	10404	99	352	3485	22
92	07	6	117	4.2	11074	99	379	3343	20
92	07	9	120	4.7	10111	99	316	2751	18
92	07	10	121	4.2	11170	98	337	3070	21
92	07	12	123	4.0	10903	98	356	803	5
92	07	14	125	6.3	7308	87	246	4804	19
92	07	15	126	7.4	6369	87	207	6053	22
92	07	17	128	5.6	8151	83	274	-2315	-7
92	07	19	130	7.0	6713	81	227	-92	-0
92	07	21	132	0.0					
92	07	23	134	0.0					
92	07	26	137	0.0					
92	07	27	138	0.0	5650	20	233	-2724	-16
92	07	29	140	0.0	2735	6	116	-3665	-20
92	07	31	142	0.0	2245	3	95	1386	9
92	08	2	144	0.0	1173	2	49	1173	9
92	08	4	146	0.0	237	0	11	-1857	-4
92	08	6	148	0.0	-1926	-3	-93	1637	3
92	08	7	149	0.0	-745	-1	-37	1964	5
92	08	10	152	0.0	759	1	39	1188	5
92	08	13	155	0.0	-237	-0	-12	1379	9
92	08	14	156	0.0	-623	-1	-32	2443	15
92	08	17	159	0.0	1031	1	54	1507	9
92	08	19	161	0.0	1482	2	77	224	1
92	08	21	163	0.0	-159	-0	-9	2017	11
92	08	23	165	0.0	-929	-2	-53	2513	7
92	08	24	166	0.0	-1764	-5	-102	2400	7
92	08	27	169	0.0	836	2	51	-800	-2

COLD TEMPERATURE PHASE (20 DAY AEROBIC SRT SYSTEM, 1500 mg NH4-N/L IN INFLUENT)

Date (yy	mm	dd)	Day	Aerobic VSS/TSS	Aerobic NO2/NOX	Aerobic ALK:NH4 Added (gCaCO3/gN)	Aerobic ALK:NH4 Nitrified (gCaCO3/gN)	Aerobic Nitrn Rate (mg/d)	Aerobic %Nitrn	Aerobic Specific Nitrn Rate (mgN/d/gVSS)
92	03	12	1	0.72		10.53				
92	03	13	2	0.77		14.82				
92	03	15	4	0.74		7.22				
92	03	17	6	0.76		6.95				
92	03	20	9	0.79		5.89				
92	03	22	11	0.86		4.38				
92	03	23	12	0.69		5.10				
92	03	25	14	0.72	0.51	3.02	5.15	8561	63	175
92	03	26	15	0.73	0.65	2.80	4.04	10313	69	213
92	03	28	17	0.79	0.62	2.96	2.75	15226	112	299
92	03	30	19	0.76	0.71	2.72	4.25	9762	69	199
92	04	1	21	0.75	0.80	3.24	4.02	11809	83	248
92	04	3	23	0.84	0.49	3.09	5.28	7831	52	152
92	04	5	25	0.87	0.87	3.31	6.58	6875	30	131
92	04	6	26	0.82	0.72	3.05	6.42	7526	30	153
92	04	8	28	0.82	0.69	35.18	15.19	3609	40	75
92	04	9	29	0.84	0.25	11.18	4.30	14136	110	294
92	04	10	30	0.84	0.46	5.62	4.86	11776	71	245
92	04	12	32	0.79	0.22	5.15	5.94	12255	83	270
92	04	13	33	0.84	0.34	5.02	6.07	11744	81	247
92	04	15	35	0.85	0.52	4.55	6.73	9623	71	199
92	04	16	36	0.90	0.41	4.10	6.66	8383	66	164
92	04	18	38	0.92	0.23	3.72	6.23	8647	44	165
92	04	21	41	0.94	0.69	3.16	15.17	3124	15	58
92	04	24	44	0.86	0.25	5.00	7.95	6018	44	121
92	04	25	45	0.86	0.23	48.19	846.80	73	3	2
92	04	27	47	0.85	0.71	29.18	-47.52	-1152	-58	-25
92	04	30	50	0.79	0.21	4.01	3.53	6541	38	151
92	05	3	53	0.81	0.19	4.94	7.59	3732	40	88
92	05	5	55	0.80	0.21	2.34	2.97	7831	69	189
92	05	6	56	0.80	0.19	2.45	2.84	10200	83	249
92	05	8	58	0.86	0.19	2.37	3.46	9891	83	229
92	05	9	59	0.87	0.18	3.47	4.24	10993	85	252
92	05	11	61	0.90	0.07	4.39	4.48	14871	108	327
92	05	13	63	0.91	0.05	5.79	6.58	12509	90	268
92	05	15	65	0.87	0.05	3.57	5.26	10214	87	227
92	05	18	68	0.95	0.49	3.31	4.21	11039	86	223
92	05	19	69	0.96	0.07	2.61	3.50	10856	79	212
92	05	21	71	0.93	0.01	4.49	7.25	7921	69	156
92	05	25	75	1.01	0.04	3.81	3.84	13526	112	242
92	05	26	76	0.98	0.03	3.66	4.14	11442	88	204
92	05	28	78	1.05	0.03	3.41	4.64	10268	87	166
92	05	31	81	1.03	0.03	5.09	5.54	12777	113	201
92	06	2	83	0.99	0.01	4.69	5.62	11055	94	175
92	06	4	85	0.95	0.00	4.46	5.01	12458	108	200

COLD TEMPERATURE PHASE (20 DAY AEROBIC SRT SYSTEM, 1500 mg NH4-N/L IN INFLUENT)

Date (yy	mm	dd)	Day	Aerobic VSS/TSS	Aerobic NO2/NOX	Aerobic ALK:NH4 Added (gCaCO3/gN)	Aerobic ALK:NH4 Nitrified (gCaCO3/gN)	Aerobic Nitrn Rate (mg/d)	Aerobic %Nitrn	Aerobic Specific Nitrn Rate (mgN/d/gVSS)
92	06	6	87	0.92	0.03	3.79	4.89	11050	109	179
92	06	7	88	0.87	0.00	4.14	4.93	12019	107	202
92	06	10	91	0.92	0.01	3.63	4.79	10329	100	166
92	06	13	94	0.89	0.00	4.67	5.46	11641	98	188
92	06	15	96	0.86	0.00	4.83	5.02	12469	108	207
92	06	16	97	0.86	0.02	4.22	4.82	11808	108	197
92	06	17	98	0.85	0.00	3.25	4.51	10200	91	173
92	06	19	100	0.85	0.07	3.82	5.21	10289	95	174
92	06	22	103	0.84	0.00	4.01	5.64	10282	91	176
92	06	23	104	0.85	0.00	4.24	5.11	10939	96	187
92	06	26	107	0.83	0.01	3.88	4.09	12269	111	214
92	06	28	109	0.89	0.00	3.88	4.40	12369	104	204
92	06	29	110	0.92	0.00	4.62	5.17	11345	90	180
92	07	3	114	0.85	0.00	3.32	4.42	11225	86	189
92	07	4	115	0.89	0.03	3.20	4.19	12145	98	194
92	07	6	117	0.90	0.39	4.49	5.64	13030	100	203
92	07	9	120	0.86	0.36	3.97	5.20	11838	92	190
92	07	10	121	0.88	0.38	3.92	4.50	12984	109	204
92	07	12	123	0.88	0.40	4.20	4.93	12651	90	198
92	07	14	125	0.88	0.43	3.68	6.51	8649	42	135
92	07	15	126	0.88	0.65	3.21	6.51	7525	34	118
92	07	17	128	0.87	0.72	4.13	6.29	9824	27	155
92	07	19	130	0.87	0.87	3.14	5.53	8061	17	128
92	07	21	132	0.83	0.11	8.97			20	
92	07	23	134	0.70	0.09	7.33			47	
92	07	26	137	0.66	0.16	7.69			33	
92	07	27	138	0.72	0.13	8.63	10.20	10309	52	205
92	07	29	140	0.69	0.09	6.08	8.55	10383	48	218
92	07	31	142	0.72	0.07	3.70	4.41	12999	89	273
92	08	2	144	0.71	0.05	3.74	4.06	12340	99	271
92	08	4	146	0.70	0.13	3.60	5.42	9068	20	209
92	08	6	148	0.71	0.13	3.86	6.77	8366	17	198
92	08	7	149	0.73	0.11	4.31	5.13	12356	34	295
92	08	10	152	0.70	0.17	4.81	6.10	11984	57	306
92	08	13	155	0.75	0.19	5.48	7.31	11125	79	274
92	08	14	156	0.74	0.19	4.35	6.02	11288	84	289
92	08	17	159	0.74	0.15	3.39	3.98	13068	86	340
92	08	19	161	0.78	0.19	2.11	2.48	12073	76	306
92	08	21	163	0.74	0.18	3.62	4.79	9696	59	263
92	08	23	165	0.74	0.20	4.36	8.51	7223	22	203
92	08	24	166	0.75	0.20	3.72	9.49	5181	15	148
92	08	27	169	0.77	0.23	3.22	5.06	9062	22	262

COLD TEMPERATURE PHASE (20 DAY AEROBIC SRT SYSTEM, 1500 mg NH4-N/L IN INFLUENT)

Date (yy	mm	dd)	Day	Aerobic NH4 Removal Rate (mgN/d)	Aerobic % NH4 Removal	ASRT (days)	System SSRT (days)	System % NH4 Removal
92	03	12	1	1724	10		63.1	25
92	03	13	2	3397	38		68.5	71
92	03	15	4	4156	54		55.7	90
92	03	17	6	5466	95		67.5	99
92	03	20	9	9106	94		69.7	99
92	03	22	11	12530	91		76.8	99
92	03	23	12	11896	98		34.1	100
92	03	25	14	13288	97		57.6	100
92	03	26	15	13945	94		74.3	99
92	03	28	17	13473	99	20	24.0	100
92	03	30	19	13912	98	20	22.4	100
92	04	1	21	14082	99	20	23.0	100
92	04	3	23	8434	56	20	23.2	93
92	04	5	25	6965	31	20	23.4	82
92	04	6	26	7626	30	20	20.9	82
92	04	8	28	4496	50	20	21.8	54
92	04	9	29	6702	52	20	24.2	82
92	04	10	30	13970	84	20	24.7	96
92	04	12	32	13842	93		51.0	99
92	04	13	33	13896	96		69.5	99
92	04	15	35	13250	98		69.1	100
92	04	16	36	12385	97	20	24.7	100
92	04	18	38	8286	42	20	23.1	88
92	04	21	41	3956	19	20	24.3	83
92	04	24	44	9176	67	20	21.3	93
92	04	25	45	933	36		48.2	82
92	04	27	47	1579	79		45.8	97
92	04	30	50	8204	48		39.6	79
92	05	3	53	5605	59		46.5	91
92	05	5	55	8352	73		45.2	96
92	05	6	56	11122	91	20	22.3	99
92	05	8	58	11132	94	20	21.3	99
92	05	9	59	11836	91	20	22.5	99
92	05	11	61	12393	90	20	23.2	99
92	05	13	63	13438	97	20	24.1	100
92	05	15	65	11142	95	20	22.4	99
92	05	18	68	11877	93	20	22.7	99
92	05	19	69	12687	93	20	23.4	99
92	05	21	71	10969	95	20	23.7	99
92	05	25	75	11768	97	20	25.4	100
92	05	26	76	12927	99	20	25.7	100
92	05	28	78	11417	96	20	26.1	100
92	05	31	81	11199	99	20	26.0	100
92	06	2	83	11611	99	20	25.3	100
92	06	4	85	10881	94	20	25.2	99

COLD TEMPERATURE PHASE (20 DAY AEROBIC SRT SYSTEM, 1500 mg NH4-N/L IN INFLUENT)

Date (yy	mm	dd)	Day	Aerobic NH4 Removal Rate (mgN/d)	Aerobic % NH4 Removal	ASRT (days)	System SSRT (days)	System % NH4 Removal
92	06	6	87	10047	99	20	25.6	100
92	06	7	88	11199	99	20	24.8	100
92	06	10	91	10285	100	20	25.6	100
92	06	13	94	11834	100	20	26.6	100
92	06	15	96	11523	100	20	23.6	100
92	06	16	97	10815	99	20	25.8	100
92	06	17	98	11174	99	20	25.9	100
92	06	19	100	10803	100	20	27.0	100
92	06	22	103	10997	97	20	25.3	100
92	06	23	104	11377	100	20	25.8	100
92	06	26	107	10927	99	20	23.9	100
92	06	28	109	11847	100	20	24.6	100
92	06	29	110	12515	99	20	26.0	100
92	07	3	114	13040	100	20	23.5	100
92	07	4	115	12404	100	20	25.2	100
92	07	6	117	12988	99	20	25.2	100
92	07	9	120	12760	100	20	24.1	100
92	07	10	121	11836	100	20	26.7	100
92	07	12	123	14006	99	20	26.7	100
92	07	14	125	8855	43	20	25.3	89
92	07	15	126	7158	33	20	27.0	86
92	07	17	128	14011	39	20	26.2	78
92	07	19	130	8591	18		77.4	60
92	07	21	132					62
92	07	23	134					92
92	07	26	137					95
92	07	27	138	14084	71		61.6	93
92	07	29	140	17700	82	20	20.7	96
92	07	31	142	14050	96	10	14.7	99
92	08	2	144	12208	98	10	14.0	100
92	08	4	146	9838	21		36.8	58
92	08	6	148	6917	14		34.8	58
92	08	7	149	8724	24		50.2	73
92	08	10	152	12732	61		30.2	92
92	08	13	155	13326	94		53.8	99
92	08	14	156	13134	97	10	12.0	100
92	08	17	159	13598	90	10	14.0	98
92	08	19	161	13602	85	10	13.0	97
92	08	21	163	9711	59	10	12.5	92
92	08	23	165	7651	23	10	12.3	72
92	08	24	166	6565	19	10	13.3	68
92	08	27	169	10193	24	10	13.2	66