REDUCTION IN NUTRIENT DISCHARGES INTO DESIGNATED NUTRIENT - SENSITIVE WATERS

PHASE III

EAST BURLINGTON PLANT, BURLINGTON, NC

March 3, 1987 - June 19, 1987

by

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Carolyn Dunham and Janice Braxton, employees of UNC-CH, served as full-time technicians on the project. Their duties included sampling, analyses, and trailer operations. The City of Burlington East Burlington Plant personnel under the supervision of Mr. Clarence Sell performed the daily operation of the pilot plants as well as the hourly inspections and maintenance. Their proficiency and interest in the proper operation and maintenance of the pilot systems was outstanding. The City of Burlington Laboratory under the supervision of Mr. A. D. Isley conducted most of the non-nutrient analyses. The success of the pilot plant operation is largely a testament to their diligence and competence.

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ABSTRACT

The biological removal of phosphorus from municipal wastewaters is now recognized as an alternative to chemical precipitation under favorable circumstances. Several approaches to enhanced biological phosphorus removal have been described in the literature. Research by various individuals has focused on the identification of those parameters responsible for the successful operation of these processes.

This investigation explored the feasibility of operating an enhanced biological phosphorus removal system at the East Burlington Wastewater Treatment Plant . Influent to this plant is more than 50% industrial (principally textile finishing). Four continuous-flow, laboratory-scale pilot plants were operated simultaneously at this site from March 3, 1987 to June 19, 1987.

The four pilot plants were used to empirically evaluate three biological phosphorus removal processes. These were the UNC, A^2/O, and two modified UCT processes. One of the modified UCT systems was operated to evaluate the effect of virgin powdered activated carbon (PAC) addition on color removal. All pilot units received East Burlington primary clarifier effluent as influent at a flow rate of 200 mL/minute. The pilot influent averaged 7.4 mg/L total phosphorus, 9.6 mg/L ammonia nitrogen, and 150 mg/L $CBOD_5$. Simultaneous pilot operation eliminated some of the variables that would ordinarily interfere with the comparison of results.

The addition of neither Zimpro™ regenerated PAC nor virgin PAC was more effective in removing color from the wastewater than the process which received no PAC. PAC may have been effective in other, unmeasured ways.

This study evaluated the systems' performance in terms of phosphorus, ammonia, and BOD removal. Comparisons were based on the full-scale plant effluent discharge permit requirements. Results of the

investigation indicate that all of the pilot systems were capable of producing an effluent with less than the permit limit of 12 mg/L of BOD_5 and 4 mg/L of NH3-N. The systems were actually cabable of removing NH3-N to less than 1 mg/L.

All of the systems were also capable of removing phosphorus to values below the proposed effluent standard of 2.0 mg/L. The A^2/O and the modified UCT systems performed consistently and removed phosphorus to less than 1 mg/L while the UNC system performed less consistently and produced an average effluent phosphorus of 1-2 mg/L.

The performance of the A^2/O and modified UCT systems was not dependent upon the introduction of the Zimpro^{TM} regen stream with its high concentration of volatile acids. The performance of the UNC system was highly dependent upon the addition of this stream. While the Zimpro^{TM} regen stream provided an advantageous source of volatile acids, it also had a very high concentration of NH3-N (about doubling the NH3-N load). This very high NH3-N load exerted an oxygen demand and increased the concentration of nitrates which had to be removed from the anaerobic stages in order for phosphorus release to occur.

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REPORT ON PHASE III

I. INTRODUCTION

A two year study to examine a variety of methods for reducing the concentrations of nitrogen and phosphorus in effluents from municipal wastewater treatment plants was initiated by the North Carolina Urban Water Consortium in July 1985. This project is being administered by the N. C. Water Resources Research Institute and is being conducted by the Department of Environmental Sciences and Engineering at the University of North Carolina at Chapel Hill with the assistance of the participating wastewater treatment plants.

Participants in this investigation include the cities of Durham and Burlington and the Orange Water and Sewer Authority (OWASA) which serves Chapel Hill and Carrboro. These communities discharge into watersheds that have been designated as "nutrient sensitive" by the N. C. Division of Environmental Management. Because of this, their discharge permits are subject to special provisions. Currently, effluent phosphorus concentration limits are specified in the discharge permits for the OWASA and Durham Farrington Road treatment facilities and are anticipated for the East Burlington Wastewater Treatment Plant. As a result, the study design for this project placed priority on identifying strategies for controlling discharges of this nutrient. Recognizing that nitrogen is also an important nutrient, the reduction of nitrogen concentrations in treated effluents also received consideration in the experimental design.

The project is divided into three phases -- one for each treatment facility. Reports on the Phase I and II activities at the OWASA Mason Farm Road and Durham Farrington Road facilities are available. During Phase III, pilot scale treatment studies were conducted at the East Burlington Wastewater Treatment Plant. The pilot systems were designed to evaluate biological phosphorus removal processes and were operated on-site from March 3 to June 19, 1987. This progress report will focus on the Phase III pilot investigations.

II. PROJECT OBJECTIVES AND INVESTIGATIONAL APPROACH

The objective of this project is to provide the participating municipalities with information and recommendations on site-specific strategies for effluent nutrient control. Included in the scope of this project are an evaluation of current biological phosphorus removal processes; consideration of chemical precipitation for phosphorus removal; and investigation of the potential impact of "at source" nutrient control. This project is not designed as basic research on the mechanisms of phosphorus and nitrogen control.

The approach of the East Burlington Wastewater Treatment Plant investigation called for an empirical evaluation of several biological phosphorus removal processes by the simultaneous operation of multiple lab-scale pilot systems. Specific objectives for the pilot scale investigations are:

1. To design and construct continuous flow pilot plants suitable for evaluating multiple biological phosphorus removal (BPR) processes.

2. To operate the pilot plants on-site to evaluate the potential and applicability of simultaneous BPR and nitrogen control at Farrington Road.

3. To formulate site-specific recommendations for nutrient control based on the pilot investigation results.

4. To evaluate the need for possible back-up systems to insure regulatory compliance.

5. To identify areas for further investigation.

III. BACKGROUND ON BIOLOGICAL PHOSPHORUS REMOVAL

Biological phosphorus removal (BPR) has been widely discussed in the technical literature, and has been a source of controversy in many respects. Initial interest in this subject was regarded by some as scientific curiosity, with little chance of practical application in the wastewater treatment field. After several years, field data began to accumulate indicating that substantial removals of phosphorus actually could be obtained in some full-scale activated sludge plants, triggered by conditions that were not fully understood.

The surge in interest in BPR during the past decade has resulted in part from increased regulatory pressure for removal of nutrients, especially phosphorus, and partly because of enhancement of knowledge about BPR through research and BPR plant operations in South Africa and this country. A recent review of the state-of-the-art concluded that BPR often is capable of producing excellent phosphorus removals, but that existing knowledge was not adequate to insure consistent production of effluent concentrations of 1 mg/L or less (Lamb, 1984).

The literature review also revealed that where uncertainties about BPR design and operation can be resolved, this method for removing phosphorus offers certain advantages over chemical precipitation. First, BPR can minimize or eliminate the need for purchasing chemicals and controlling their feed to the treatment system. Second, and perhaps of even greater importance, BPR could avoid the major increases in sludge quantities and undesirable changes in quality associated with uses of large amounts of alum or other precipitating agents. Third, in plants where design engineers have had the foresight to provide adequate flexibility, the capital cost for initiating BPR can be minor, as contrasted with additional costs for chemical storage and feeding equipment and increased sludge handling expenses when chemical treatment is employed. Finally, implementation of BPR in most activated sludge plants is entirely compatible with simultaneous removal of nitrogen through biological nitrification and denitrification, which may be anticipated as a future requirement in many plants.

All biological processes are capable of removing some phosphorus from wastewaters through incorporating that essential nutrient into cell materials, which subsequently are removed from the system as waste sludge. The amount of phosphorus that can be removed in this fashion is determined by the amount of waste sludge produced and the phosphorus content of that sludge. In conventional activated sludge plants treating municipal wastewaters, phosphorus removal by biological action usually is limited to, perhaps, 10-30% of that in the influent to the plant (Anonymous, 1983; page 150).

A BPR system is a modified activated sludge process in which environmental conditions are adjusted to favor growth of organisms in the sludge that are capable of concentrating phosphorus in their cells to levels much higher than in organisms normally populating that type of system. The removal and separate disposal of waste sludge that is enriched in phosphorus content enhances removal of phosphorus from the wastewater.

Flow sheets for various BPR processes have been presented and explained in the report identified earlier (Lamb, 1984). All BPR processes are based on exposing the activated sludge alternately to anaerobic and aerobic conditions to "select" for the proper organisms in the system. A simplified interpretation of the mechanisms involved, supported to some degree by past research, is presented in the following paragraphs.

The organisms associated with enhanced biological phosphorus removal from wastewater are capable, under anaerobic conditions, of breaking down complex intracellular polyphosphates to meet their energy and metabolic requirements. This results in the release of orthophosphates from the cell. Accordingly, the orthophosphate concentration in the mixed liquor increases during passage through the anaerobic phase. This ability to function effectively under anaerobic conditions represents an advantage in competing for food supply to the BPR organisms.

Subsequently, under aerobic conditions, those same organisms have the capability to store more phosphorus than they need for normal metabolism and building of cell material. In doing so, they take up the phosphorus that had been released during the anaerobic phase, as well as most or all of that in the incoming wastewater. The excess phosphorus is stored within the organisms as complex polyphosphates, in the form of volutin granules.

There are some important aspects of the process that should be recognized in designing and operating a BPR system. Extensive phosphorus release occurs only under environmental conditions that favor development of a population that is capable of storing excess phosphorus as polyphosphates and subsequently using it in anaerobic metabolism. That type of population is capable of removing most or all of the dissolved phosphorus from the wastewater by storing it within cells. The operating parameter that has received most recognition is the need for maintaining absence of both dissolved oxygen and nitrates in the anaerobic phase. Apparently, as long as oxygen is available to the organisms in either of those forms, the utilization of polyphosphate as an energy source and release of orthophosphate by the cells does not occur, and BPR efficiency decreases. The anaerobic release of phosphorus indicates presence of the desired organisms, as well as environmental conditions favorable to their metabolism.

Completely anaerobic conditions may be achieved by endogenous respiration or as the result of oxidation of organic loading or a combination of both means. The conventional approach to the successful operation of the BPR process requires that organic loading (BOD) in the system must be high enough to utilize the available dissolved oxygen and nitrates. This has led some to conclude that a key parameter in determining BPR efficiency is the BOD loading, sometimes expressed as the BOD/P ratio. BOD loading clearly is important in generating anaerobic conditions, as well as in determining the amount of sludge production, which must bear some relation to the amount of phosphorus that can be removed through sludge wasting. However, it does not necessarily follow that the relationship of BOD to phosphorus removal can be expressed simply as the BOD/P ratio. To the contrary, data collected in this and other investigations show that efficient removal of phosphorus can occur across a range of BOD/P ratios, as long as adequate anaerobic conditions are maintained.

Another important factor that has been observed in these studies, as well as by other investigators, is the role of certain short chain organics in enhancing phosphorus removal. Acetate has been identified most often as beneficial to BPR efficiency (Gerber et al, 1986; Tracy and Flammino, 1985). Comeau, et al, (1986) proposed and tested metabolicic mechanism for the anaerobic release and aerobic uptake of phosphorus which accounts for the observation that acetate is an environmental factor that favors development of the desired population. It should be noted that acetates and other fermentation products can be formed during the anaerobic phase of a BPR process. Accordingly, production of acetate and other fermentation products can provide another reasonable hypothesis in attempting to explain the importance of anaerobiosis in the BPR process.

Successful operation of the process also depends upon maintenance of dissolved oxygen in the aerobic phase of the process. Only under those conditions can the uptake of phosphorus be rapid and complete. That, of course, is necessary because the basic mechanism of removal is through the incorporation of excess phosphorus into the cells, which subsequently are removed from the system for separate disposal.

It has been noted that very high concentrations of phosphorus (sometimes in excess of 10% of dry solids) can be attained in the sludge from some BPR plants. Clearly, there must be a limit to the extent to which phosphorus may be accumulated in cells. If efficient removal is to be maintained, sludge wasting from the system must be adequate to remove the phosphorus extracted from the wastewater. Also, the BOD loading and mode of plant operation must result in production of enough sludge to incorporate the phosphorus removed. This suggests that removal of phosphorus may be favored to some extent by high loadings and short sludge ages that produce more waste sludge. It also suggests that high BOD/P ratios might be helpful. However, in most systems that have been described in the literature, phosphorus concentrations in the waste sludge do not even approach the maximum attainable levels.

Finally, the level of phosphorus that can be attained in solids depends on the proportion of organisms in the population that can store excess phosphorus. This indicates that any process modifications that enhance "selection" of the desired organisms could also increase the potential for phosphorus removal in the system, if solids production is the limiting factor.

Surprisingly few details are available about effects of the variables outlined above, and others as well, on BPR performance. Accordingly, many of the BPR plants that have been placed in operation have been disappointing in performance and the state of knowledge that is available for correcting their deficiencies generally is unsatisfactory. In many instances, persistent failures can be attributed to plant designs that have not used desirable flow sheets for treating the wastewater in question and that also have neglected to include enough flexibility to permit meaningful changes in operation after startup.

Occasional failures of the BPR process might be expected, and suggest that chemical precipitation of effluent phosphorus as a backup to BPR should be considered. If the BPR process was consistent in removing phosphorus to a concentration just above or below the discharge permit limit, chemical dosage calculations and metering would be a relatively routine task. Isolated spikes of high phosphorus concentration in the effluent could be ignored, assuming that the effluent concentration, averaged over time, would be low enough to meet the permit requirements. Questions concerning when to use the chemical, its impact on other processes, the point of addition, sludge production and handling would still remain. However, with inconsistent BPR performance, chemical addition may become a complex issue. Operators, trying to match the alum dosage with the phosphorus concentration to achieve economical operation, may not be able to adjust the chemical dosage up or down fast enough. They are then faced with using enough chemical to insure compliance with the discharge permit limit on a continuous basis, negating many of the advantages of BPR. Therefore, to optimize the benefits of operating a BPR process, the inclusion of a chemical precipitation backup should be linked to the selection of the best BPR technology for the site in question.

IV. INVESTIGATIONAL METHODS

Several BPR systems have been described in the literature (Lamb, 1984), and some are patented in the U.S. Some information on full-scale performance of these systems is available, but performance varies from site to site and over time. Because so little is known about key design variables and methods for predicting their optimum ranges for designing a BPR plant, it was decided that the most productive way to evaluate the BPR potential for the wastewaters in question would be to follow an empirical approach. Therefore, these pilot studies are designed to simultaneously compare systems that might operate successfully at the participating municipal treatment plants. Simultaneous operation of the pilot units eliminates some variables that could invalidate the comparison of results of tests conducted at different times. For example, changes in wastewater characteristics, temperature variations, power outages, differences in operator techniques, and other factors would apply equally to all plants, allowing direct comparisons. Also, simultaneous collection and analyses of samples eliminates some of the variables associated with these activities. This experimental approach is highly appropriate for evaluating the relative desirability of the various processes.

A. Selection of Processes

In 1980, the East Burlington Wastewater Treatment Plant was upgraded to a 12 MGD activated sludge treatment plant. Included in the upgrade were the facilities for powdered activated carbon (PAC) addition and wet oxidation (Zimpro™ Process) of secondary, PAC-containing sludge. This plant combines several processes to treat the complex wastewater. Grit removal and bar screens are located upstream from a 3.5 million gallon equalization basin. Three primary clarifiers were used during the period of the pilot studies. Primary sludge is thickened in two small gravity thickeners and aerobically stabilized prior to land application. During the pilot studies, the aerobic digesters were being modified; and, as a result, much of the primary sludge was returned to the equalization basin where it was basically stored.

Carbon contact, as designed, would occur in two carbon contact clarifiers. However, these basins were being used or other purposes during the pilot study. Therefore, the primary effluent was combined with the return activated sludge, virgin PAC (for color removal), and effluent from the wet oxidation process in a pipe leading to the activated sludge basins. Two aeration basins with a combined capacity of 3 million gallons provided about 12 hours of aeration based on the influent flow. Aeration and mixing in the basins is achieved with coarse bubble diffusers. During the pilot studies, the mixed liquor suspended solids concentration in these basins averaged between 8000 and 9000 mg/L. More than half of this concentration was made up of PAC and ash.

The mixed liquor leaving the aeration basins is then contacted with polymer and routed to four secondary clarifiers. Effluent from the clarifiers is distributed to six gravity filters prior to chlorination and cascade aeration.

The choice of which processes were operated at the East Burlington site was based on considerations of their potential for success. The longer hydraulic detention time systems tested at OWASA and Farrington Road had shown little promise. Furthermore, the hydraulic detention time available at the East Burlington site is minimal. Therefore, these were not included at East Burlington.

The UNC, modified UCT, and A^2O systems which performed relatively well at the other sites were included at East Burlington. The use of the PAC process with wet air oxidation (Zimpro^{TM}) of the sludge and regeneration of the PAC is unique to the East Burlington Wastewater Treatment Plant. It was known that the "regen" stream from the Zimpro^{TM} process had a very high ammonia-nitrogen (NH3-N) and volatile acid concentration. The volatile acids would be expected to enhance BPR while the nitrate remaining after nitrification of the high NH3-N would be detrimental to the process. This Zimpro^{TM} regen stream was included in all pilot units during the first part of the study (March 3 - April 17). This feed was eliminated for the remainder of the study to determine its effect on the treatment process. In addition, the East Burlington Wastewater Treatment Plant adds virgin PAC to the process daily. It was not clear whether this virgin activated carbon was required for effective treatment; therefore, two modified UCT pilot plants were included to test the effect of addition of PAC. Initial system flow sheets are presented in Figure 1.

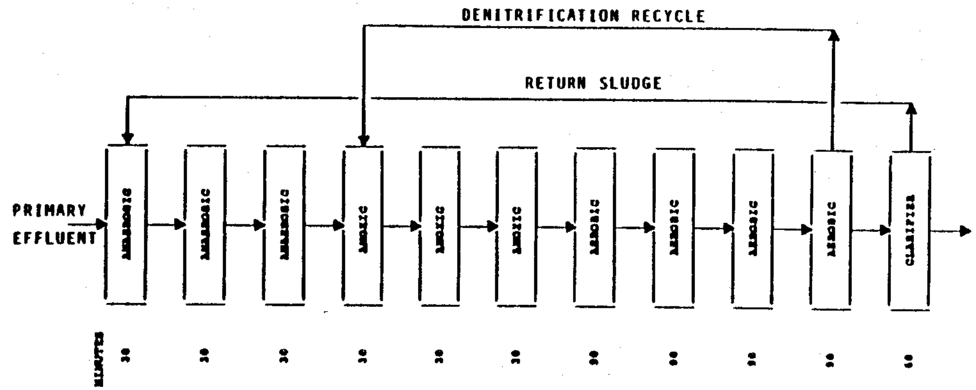
It should be pointed out that in all of the flow sheets discussed here the term "Aerobic" refers to a tank in which the contents are aerated sufficiently to maintain dissolved oxygen in the mixed liquor at all times. "Anoxic" is used to describe a tank that is mixed but not aerated. The anoxic tank typically would be free of dissolved oxygen, but not necessarily free of nitrates. "Anaerobic" tanks are mixed and operated to contain neither dissolved oxygen nor nitrates. This is to allow release of phosphorus from BPR microorganisms.

B. Experimental Facilities

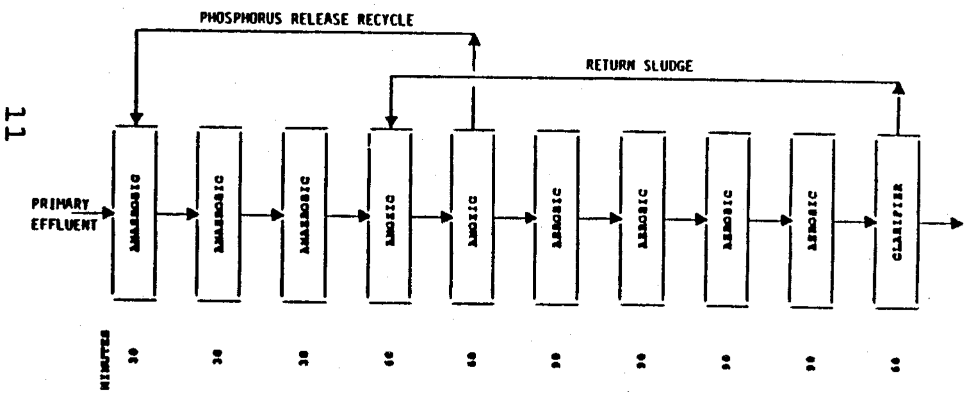
At the beginning of the project, the City of Durham provided a trailer large enough to house five, lab-scale pilot units. Equipment installed in the trailer for this project included two air compressors with an air distribution manifold, a heat pump, lights, timers, ventilation and drainage systems, and built-in lab counters to support the pilot units. The trailer operated as a self-contained unit with connections for the wastewater flow to the pilot units, tap water and electricity.

The research trailer was located adjacent to the full-scale primary clarifier at the East Burlington Wastewater Treatment Plant. Primary clarifier effluent was pumped into the trailer to serve as pilot unit influent. The wastewater was pumped through a pipe manifold at a flow rate exceeding that required by the pilot units to keep the pipes clear and insure minimal changes to the wastewater during transit. Pilot plant influent was pumped from sampling ports in the manifold system. Variable flow peristaltic pumps made by Masterflex™ were used to control pilot influent, internal recycle, sludge return, and waste activated sludge flows. Tygon™ tubing connected tanks, pumps, and drains.

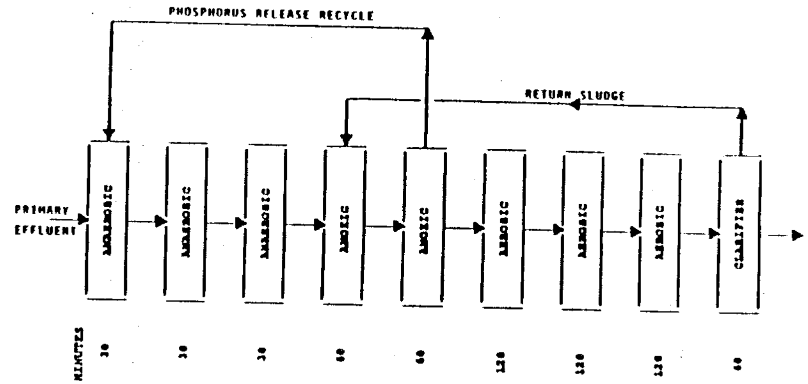
All of the pilot tanks were constructed of stainless steel cylinders with conical bottoms. These bottoms helped prevent the accumulation of solids at the bottom of the settling tanks.



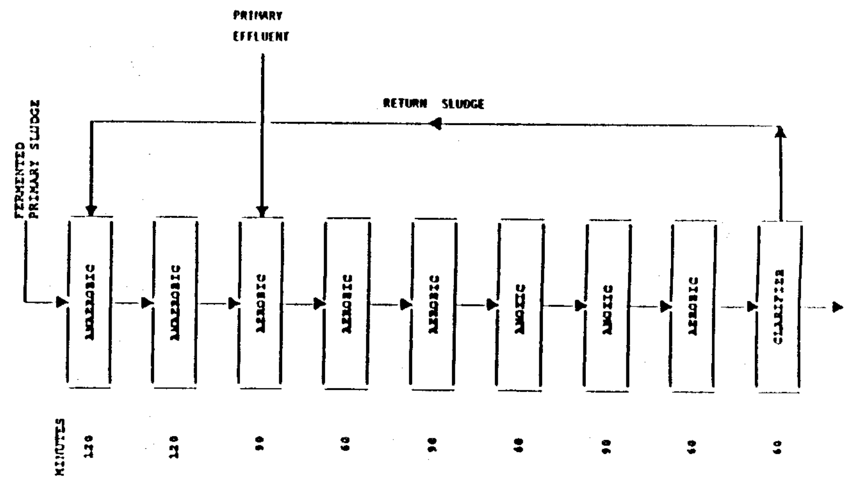
1A. FLOWSHEET FOR THE A^2/O PILOT PLANT



1B. FLOWSHEET FOR THE UCT PILOT PLANT



1C. FLOWSHEET FOR THE UCT-EXP PILOT PLANT



1D. FLOWSHEET FOR THE UNC PILOT PLANT

FIGURE 1. FLOW SHEETS FOR EAST BURLINGTON WASTEWATER TREATMENT PLANT BPR PILOT STUDIES.

Aerobic tanks were completely mixed by the upflow of air from the conical bottom. Air flow was adjusted to maintain a minimum dissolved oxygen concentration of 1 mg/L. Anaerobic and anoxic tanks were mechanically mixed by 200 rpm gear motors with impellers.

The air surface to liquid volume ratio in the small pilot anaerobic and anoxic tanks was calculated to be much larger than would be encountered in the full-scale plant. This could allow an increased transfer of oxygen into the pilot anaerobic and anoxic mixed liquor, preventing fully anaerobic or anoxic conditions. Therefore, the pilot anaerobic/anoxic tanks were fitted with floating styrofoam covers to reduce the air interface to volume ratio.

The pilot system's clarifier design and size were an important consideration when comparing the pilot effluent with the full-scale plant effluent. The investigators acknowledge that it is hydrodynamically impossible to fully compensate for the size and performance discrepancies between full-scale and pilot clarifiers. Although the pilot clarifier weir overflow rate was low (~580 gallons/day-ft), problems with effluent suspended solids, floating sludge and, even, phosphorus bleed out due to anaerobic sludge blankets were anticipated. Therefore, all pilot unit clarifiers were identical in design to minimize the hydraulic variables related to settling. In addition, all pilot systems received an influent flow of 200 mL/minute in an attempt to maintain uniform settling hydraulics in the clarifiers.

Since pilot clarifiers cannot adequately duplicate the hydraulic processes of full scale units, sludge wasting from the return sludge line is also subject to inconsistencies. Activated sludge was wasted from all of the pilot units as mixed liquor from the last aerated tank. The wasting was by an automatic, timer-controlled pump which wasted a portion of the system volume each day. The MCRT is calculated by dividing the volume of the system including the settling tanks by the volume wasted per day.

C. Sampling and Analyses

After an initial start-up phase (March 3-8), regular sampling and analysis began on March 9. Sampling of the four pilot units was performed by project technicians. The trailer influent sample was an aliquot of the primary clarifier effluent 24 hour composite collected by the East Burlington staff. Pilot plant grab samples were collected from the last anaerobic tank, the last aerobic tank, and the clarifier of each system. Anaerobic samples were used to determine the magnitude of the phosphorus release and to determine if nitrate was present. Samples were collected from the last aerobic tank and the clarifier to evaluate the overall nutrient, $CBOD_5$, and solids removal performance of the system. Collection frequency varied from two to three times a week depending on the work load of project personnel.

During Phase I, the pilot final settling tanks occasionally suffered problems with floating sludge, causing erratic discharges of suspended solids from the small tanks. Anaerobic conditions in the clarifier sludge blanket which was associated with the floating sludge also caused the release of stored phosphorus from the solids. This raised doubts about the validity of "as is" effluent samples for evaluating pilot BPR efficiency. It was thought that a more accurate approach would be to measure the nutrient concentration of filtered samples from the last aerobic tank.

Accordingly, soluble phosphorus (orthophosphorus) and total dissolved phosphorus (TDP) concentrations in the last aerobic tank have been used for evaluating pilot plant phosphorus removal in this study. The probable phosphorus discharge from a full-scale system can be estimated by adding to the values for filtered samples the amount of phosphorus that would be contained in the effluent suspended solids likely to be discharged from the plant. The phosphorus content of the effluent suspended solids is determined by dividing the total phosphorus concentration, minus the soluble fraction, in the final aerated tank by the mixed liquor suspended solids concentration in that tank.

Samples for the determination of dissolved nutrient concentrations were collected in acid-rinsed 50 mL polyethylene centrifuge tubes. The tubes were put in ice at the trailer. They were then transported to the East Burlington laboratory for centrifugation and filtration (Whatman GF/F) immediately after collection. These filtered samples were refrigerated in acid-rinsed polyethylene bottles. After determination of the dissolved, labile parameters (PO4-P, NH3-N and NO2+NO3-N), the filtered samples were acidified with concentrated sulfuric acid to pH <2 and refrigerated. These samples were then used for the analyses for total dissolved phosphorus and total dissolved Kjeldahl nitrogen if required. Unfiltered samples for total nutrient determinations were collected in acid-rinsed polyethylene bottles and put in ice at the trailer. They were acidified with H_2SO_4 to a pH <2 at the East Burlington laboratory soon after collection and kept under refrigeration until analyzed.

Care was taken to insure the integrity of the samples. Sampling hoses were allowed to flush out before collecting a sample. Anaerobic samples were collected in a manner to limit the introduction of air. Sample duplicates and spiked samples were analyzed with every set of samples collected as part of the quality control program.

Unless noted otherwise, all nutrient data cited in the text, tables, and graphs were derived from Orion™ autoanalyzer methods based on Standard Methods (Anonymous, 1981) or EPA-approved (Anonymous, 1971, 1979) methods. Brief descriptions of the methods used are presented in Appendix A. Nutrient concentration values reported as 0.02 mg/L represent concentrations that were not distinguishable from the baseline. They are equivalent to 0.02 +/- 0.02 mg/L, but to use this representation would result in a value of 0.00 mg/L during statistical evaluations. Similarly, the use of the "<" symbol (eg. <0.05 mg/L) also results in an assigned value of 0.00 mg/L when using the available statistical analyses.

Analyses for BOD_5, alkalinity, MLSS, MLVSS, and pH also followed procedures in Standard Methods. These samples were collected in clean polyethylene bottles and analyses were performed by laboratory staff at the East Burlington Wastewater

Treatment Plant. Volatile acids were measured by the East Burlington staff on samples of fermented primary sludge using a titration method described in Appendix A. Dissolved oxygen in the pilot aerobic tanks was measured using a YSI™ Model 54A meter and probe. Hydraulic flow rates were measured as the volume of liquid discharged during a specific time period.

Data on the influent characteristics and nutrient removal performance of the pilot units is presented in Appendices B-F.

D. Operation of the Pilot Units

The systems were filled and operation began on March 3, 1987. The study concluded on June 19, 1987. The operation of the pilot units was checked every two hours by the East Burlington Wastewater Treatment Plant staff to identify and correct problems. Once each day flow rates, dissolved oxygen, settleable solids, pump condition, mixers, temperature, and clarifier operation were checked and the results recorded on an operation log. Each systems's performance was evaluated and modifications to the operating parameters were recorded on these sheets as well. Chronological notes summarizing the pilot operations and operational data are included in Appendices B - F.

Initially, the pilots were seeded with waste solids from the York River Wastewater Treatment Plant of the Hampton Roads Sanitation District. This plant was achieving good BPR. However, because it has a very short hydraulic detention time, there was no nitrification. On March 20, all of the pilots were additionally seeded with return sludge from the East Burlington Wastewater Treatment Plant to provide the required nitrifiers. The pilot plants were seeded with BPR and nitrifying solids in order to decrease the time necessary for selecting the appropriate microbiological communities.

The pilot trailer was equipped with two air compressors. These had been sufficient to maintain adequate dissolved oxygen in Phases I and II; but early in the East Burlington study, it became apparent that there was insufficient oxygen to meet the oxygen demand of the higher primary effluent CBOD5 and the NH3-

N in the Zimpro™ regen stream. The pilot trailer was connected to the plant aeration system on March 31. After this time, dissolved oxygen was sufficient to meet the demand.

V. RESULTS AND DISCUSSION

The performance of the pilot systems is evaluated against the National Pollutant Discharge Elimination System (NPDES) permit effluent limits placed on the East Burlington Wastewater Treatment Plant by the North Carolina Environmental Management Commission. Those limits are for the summer (April 1 - October 31) as follows: BOD_5, 12 mg/L; Total Suspended solids, 30 mg/L; and Ammonia nitrogen, 4 mg/L. For the winter (November 1 - March 31), these limits are as follows: BOD_5, 24 mg/L; Total Suspended solids, 30 mg/L; and Ammonia nitrogen, 8 mg/L. The NC Environmental Management Commission is expected to establish an effluent Total Phosphorus standard of 2 mg/L.

The estimates of nutrient removal by the pilot systems incorporate the analyzed dissolved nutrient concentration from the final aerated tank plus an estimate for the effluent suspended solids nutrient concentration. The nitrogen concentration of effluent solids is estimated at 7% by weight (Anonymous, 1983; Metcalf and Eddy, 1979), and the phosphorus content is based on a calculated percent phosphorus in the mixed liquor solids. Estimates of total effluent nutrient concentration are based on a discharge permit maximum of 30 mg/L effluent suspended solids. This is viewed as a worst case estimate because effluent BOD_5 limits would almost certainly require a lower effluent suspended solids concentration. In the discussion of results, the estimate of the effluent nutrient concentration will be referred to as the estimated total effluent concentration.

It is important to note that the evaluation of the pilot processes does not include a cost analysis. The final selection of a process for testing and/or installation must consider both short and long range economic factors. Recommendations developed from this study are based on the wastewater treatment performance of the systems.

A. Characterization of the Pilot Plant Influent

Currently, the East Burlington Wastewater Treatment Plant operates at roughly half of the design flow capacity. During this study, the average influent flow was 4.8 MGD. Industrial sources account for more than 50% of the total flow. The predominant industry is textile finishing. Typically, the plant influent is highly colored, has high concentrations of organic compounds and fibers, and has a low ammonia concentration. The most pertinent (to BPR) influent characteristics are presented in Table 1. The average influent TP was 7.4 mg/L. This was higher than at either the OWASA or Farrington Road facilities tested in Phases I and II, respectively. The TDP was about 76% of the TP. The TKN was about the same as at the previously-studied facilities, but the NH3-N concentration was much lower. This suggests that the influent to the East Burlington Wastewater Treatment Plant has an unusually high organic nitrogen content. The average $CBOD_5$ was 150 mg/L. This was higher than at either of the first two facilities studied, and it also resulted in a $CBOD_5$:TP of 22 which was the highest of the three plants. These characteristics suggest that this wastewater is more readily treatable by BPR than either the OWASA or Farrington Road wastewaters.

The blow down from the Zimpro™ wet oxidation process which is used to treat secondary sludge and regenerate the PAC contained a very high concentration of volatile acids (Table 1). In addition, it had very high (6-7%) suspended solids. Due to the high solids, it was difficult to analyze for both suspended and soluble constituents. Therefore, the "regen" was only analyzed periodically. The results are tabulated in Appendix B-3. This stream was very high in NH3-N (1000-1400 mg/L). This was sufficient NH3-N to roughly double the NH3-N loading to the secondary units. While TP and TKN concentrations were also very high, these were largely associated with the suspended fraction and may not have impacted the process. Because the constituents of this stream may greatly impact the BPR process, it was included as an input to each system. The proportional amount was 1.67 mL/min. This

TABLE 1

CHARACTERISTICS OF THE PILOT PLANT INFLUENT
(EAST BURLINGTON WASTEWATER TREATMENT PLANT
PRIMARY EFFLUENT AND ZIMPRO™ REGEN STREAM)

	PRIMARY EFFLUENT							ZIMPRO	
MONTH	TP	TDP	TKN	NH3-N	$CBOD_5$	CBOD: TP	VOL ACID	VOL ACID	NH3-N
MARCH	6.2	5.4	28	7.7	159	20		5444	998
APRIL	8.6	5.5	31	6.7	147	22		4545	1171
MAY	7.4	6.0	25	7.7	166	24	144	3708	
JUNE	7.3	5.6	26	9.6	122	21	204	3366	1390
AVERAGE	7.4	5.6	26	9.6	150	22		4417	

Notes: All data in mg/L, except for BOD/P ratios. The complete data set is in Appendix B. Samples of primary effluent are aliquots of 24 hour composite. Samples of Zimpro are grabs of the feed solution. TP is Total Phosphorus. TDP is Total Dissolved Phosphorus. TKN is Total Kjeldahl Nitrogen. NH_3-N is Ammonia Nitrogen. $CBOD_5$ is Carbonaceous 5-day Biochemical Oxygen Demand. VOL ACID is Zimpro "regen" volatile acids was discontinued on April 17 to determine the degree to which system performance was related to the constituents of this stream.

B. Performance of the Air Products and Chemicals, Inc. (A^2/O) Pilot Plant

The A^2/O pilot design was based on the recommendations of representatives of Air Products and Chemicals, Inc. The A^2/O pilot flowsheet is illustrated in Figure 1A. This system has been operated successfully at full-scale and was a successful pilot operation at the Farrington Road Wastewater Treatment Plant.

The staged anaerobic phase, utilizing three tanks, had a nominal detention time of 1.5 hours. Similarly, a three tank anoxic denitrification section which received the internal recycle had 1.5 hours detention time. The segmentation of the anaerobic and anoxic sections into small tanks served to minimize short-circuiting and promote plug flow conditions. The aerobic phase was divided into four tanks with a combined nominal aerobic detention time of approximately 6.0 hours.

Pilot plant influent (East Burlington Wastewater Treatment Plant primary effluent) was introduced into the first anaerobic tank at a flow rate of 200 mL/minute. Return sludge also entered the first anaerobic tank at a flow rate of 50% (100 mL/min) of the influent flow. The internal denitrification recycle was included for nitrogen removal and to lower the nitrate loading to the anaerobic phase. This recycle was maintained at approximately 50% of the influent flow rate. It was pumped from the last aerobic tank (Tank 10) into the first anoxic tank (Tank 4). The technical staff at Air Products and Chemicals, Inc. suggested that the recycle flow be adjusted with changes in BOD loading, MLSS concentration, and temperature to optimize nitrogen removal. However, the recycle flow in this system could not be varied.

There was very little difficulty in operating this system. On April 4, the air was disrupted to Tank 7. On April 13 and June 13, there was a large loss of solids. Operational notes are in Appendix C-1 while the Operation Log is in Appendix C-2.

A summary of the system's performance is presented as monthly averages in Table 2. Appendices C-3 and C-4 include a complete data set for the A^2/O system.

None of the pilot systems performed well during the first three weeks. This was apparently both due to the fact that the waste-secondary-sludge-seed from the Hampton Roads Sanitation District contained neither nitrifiers nor organisms adapted to the organic constituents in the East Burlington Wastewater Treatment Plant influent wastewater and due to the fact that the overall oxygen demand exceeded the amount which could be supplied by the trailer compressors. After seeding with East Burlington return sludge on March 20 and tying into the plant air system on March 31, the A^2/O system began removing $CBOD_5$ and nitrifying much more effectively (Figures 2 and 3). Monthly averages for filtered $CBOD_5$ in the final aeration basin all fell below the 12.0 mg/L discharge permit limit and NH3-N was less than 0.5 mg/L after this reseeding.

During most of the test phase the MCRT was maintained at about 10 days (Appendix C-2). This was sufficient for essentially complete nitrification. Even at a short MCRT (6.5 days) which was realized toward the end of the test (after May 28), the system was capable of good nitrification (Figure 3). The system averaged almost 60% nitrogen removal based on influent total nitrogen (51 mg/L) and the estimated total effluent total nitrogen (21 mg/L) while the Zimpro^{TM} regen stream was being added. After discontinuance of the Zimpro^{TM} regen stream feed, the influent total nitrogen was reduced to about 25 mg/L and the estimated effluent total nitrogen was 11 mg/L. Thus the total nitrogen removal removal was about the same as when the Zimpro^{TM} regen stream was being fed, but the total effluent nitrogen was decrease by 50%. Nitrogen removal might be optimized by adjusting the internal recycle flow, but this was not attempted.

Orthophosphorus was determined more frequently than TDP because of the ease of the analysis. Since the Orthophosphorus was only slightly less than the TDP (Appendix C-3), the concentration of orthophosphorus is indicative of the TDP concentration. With the exception of the early period and the

TABLE 2

A^2O PILOT PLANT PROCESS DATA

	TANK #10			FILTERED TANK #10					
MONTH	MLSS	SVI	F:M	CBOD5	NH3-N	NO2+ NO3-N	TDP	ANAER TDP	MCRT
MARCH	5397	63	0.14	27	15	1.9	0.3	43	10.0
APRIL	6394	52	0.12	10	0.4	7.0	0.4	36	9.7
MAY	4550	100	0.14	6	0.1	2.4	0.3	44	8.7
JUNE	3398	46	0.14	6	0.1	3.8	1.0	36	6.2
AVERAGE	5142	68	0.13	12	3.9	3.9	0.4	40	9.1

Notes: All data in mg/L except SVI (mL/g). The complete data set is in Appendix C. MLSS is Mixed Liquor Suspended Solids in Tank 10. SVI is Sludge Volume Index. F:M is Food to Microorganism ratio $CBOD_5$ is Carbonaceous 5-day Biochemical Oxygen Demand, Filtered in Tank 10. NH_3-N is Ammonia Nitrogen in Tank 10. NO_2+NO_3-N is Nitrite + Nitrate Nitrogen Tank in 10. TDP is Total Dissolved Phosphorus in Tank 10. ANAEROBIC TDP is Total Dissolved Phosphorus in Tank 3. MCRT is the mean cell residence time (hydraulically determined) in days.

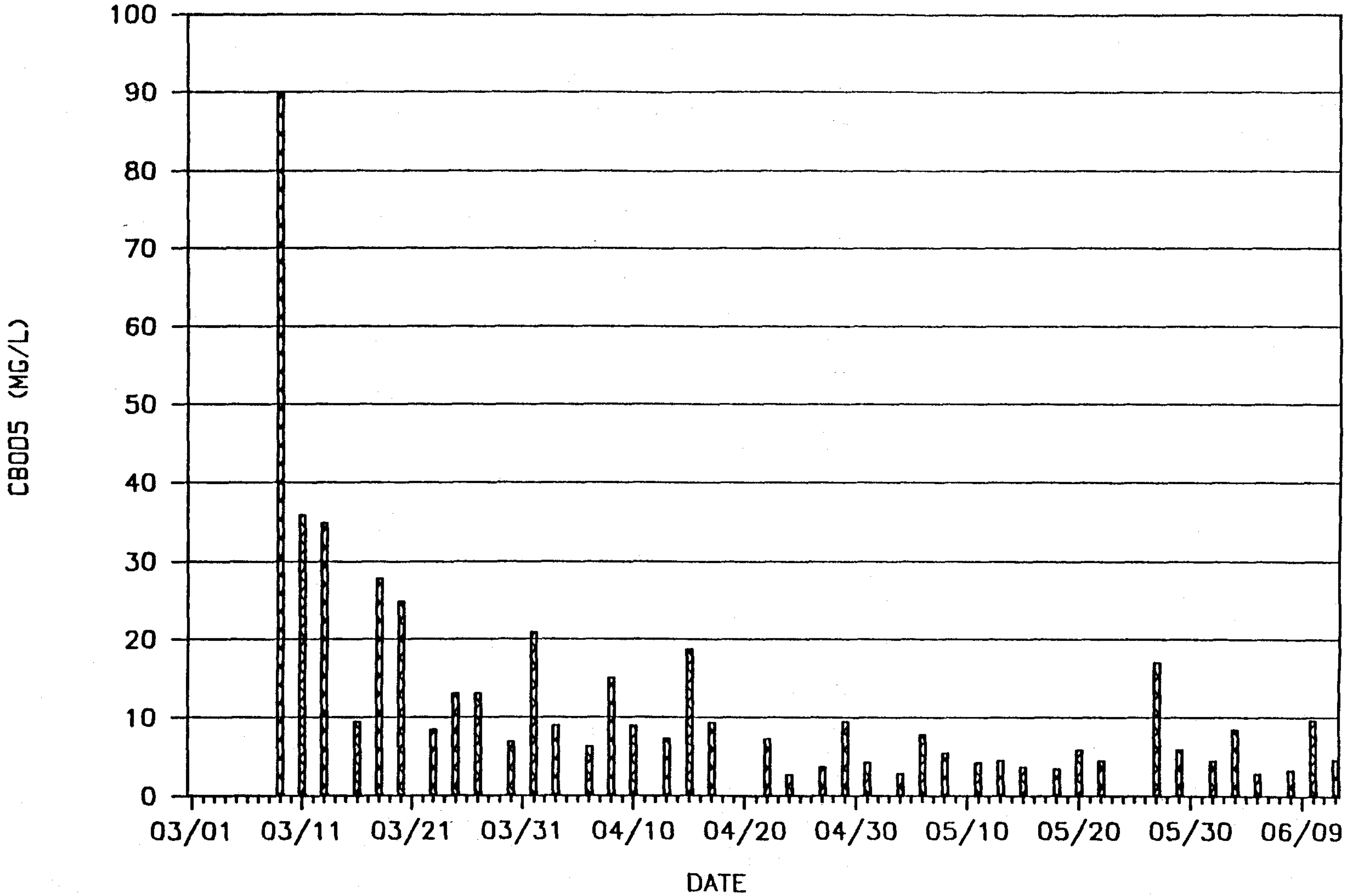


FIGURE 2. CBOD5 CONCENTRATION IN THE FINAL AERATED TANK OF THE A2/O PILOT PLANT.

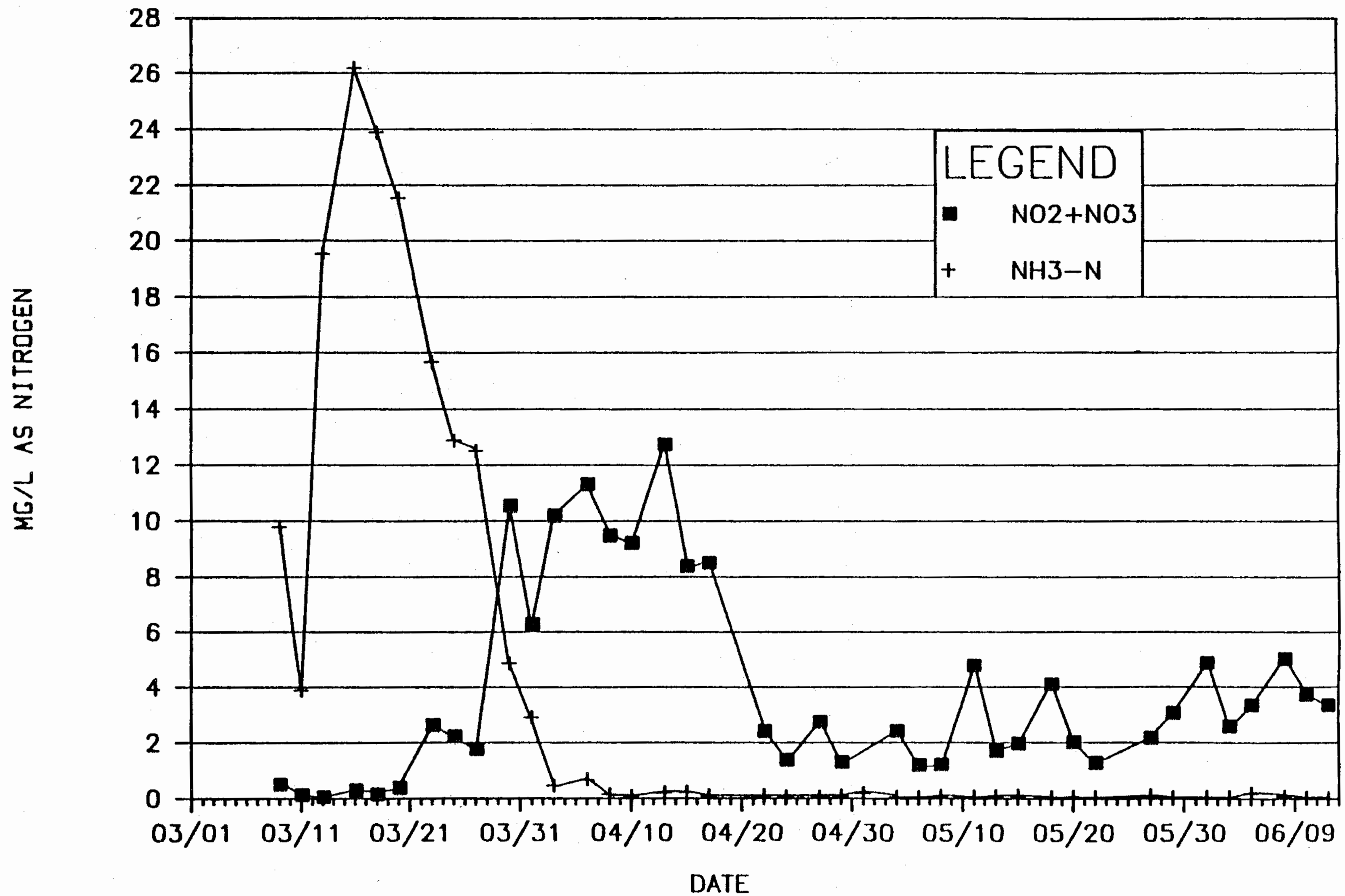


FIGURE 3. FILTRABLE LABILE NITROGEN CONCENTRATION IN THE FINAL AERATED TANK OF THE A2/O PILOT PLANT.

very late period when the MCRT was decreased to 6.5 days, orthophosphorus was well below 1.0 mg/L (Figure 4).

Figure 4 also illustrates that the BPR performance was not dependent upon the addition of the Zimpro™ regen stream. BPR was essentially the same with and without this stream. The only disruption of BPR occurred late in the study when the MCRT was about 6.5 days, and there was difficulty with clogging the tubing between tanks.

The average Anaerobic TDP concentration, 40.0 mg/L (Table 2), represents anaerobic phosphorus release. This was higher than during either Phase I for the A/O flow sheet or Phase II for the A^2/O flow sheet. The proportion of the TP which was released from microorganisms cannot be determined because the return sludge contained so much non-biological PAC, but it is quite likely that the proportion was higher than in the other phases as well.

The percent phosphorus in the mixed liquor solids averaged 3.1% (Appendix C-3). This contributed 0.9 mg/L of phosphorus to the effluent at an effluent suspended solids concentration of 30 mg/L. The TDP concentration in the final aerated tank averaged 0.4 mg/L (Table 2). The range of TDP concentrations was between 1.7 and <0.1 mg/L (Appendix C-3). The sum of these yield an estimate of 1.3 mg/L TP for the effluent including 30 mg/L total suspended solids. The percent removal, calculated using this estimate, is approximately 75%. If the removal efficiency is to be improved, the effluent solids must be removed because the effluent TDP is already very low (Table 2). Of course, the East Burlington Wastewater Treatment Plant has very effective tertiary filters which accomplish this.

The A^2/O pilot unit gave good BOD, ammonia, and phosphorus removal with few operational problems related to the design. This performance was not dependent upon the introduction of the Zimpro™ regen stream; therefore, it would likely perform well even if this method of sludge destruction were discontinued. In conclusion, this flow sheet would very likely allow the East Burlington Wastewater Treatment Plant to meet the most stringent effluent phosphorus, BOD, and ammonia requirements with significant nitrogen removal.

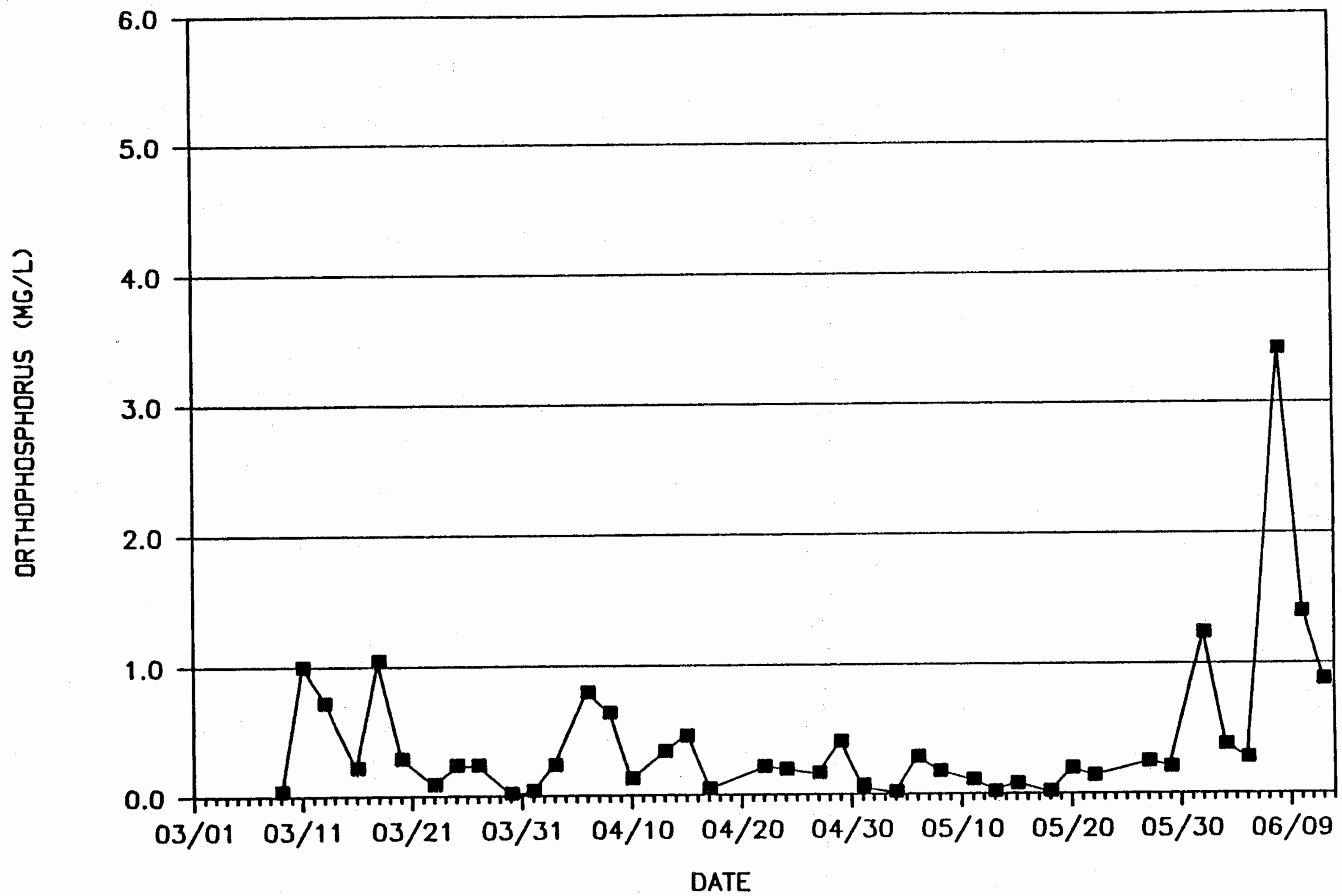


FIGURE 4. ORTHOPHOSPHORUS CONCENTRATION IN THE FINAL AERATED TANK OF THE A2/O PILOT PLANT.

C. Performance of the University of Capetown (UCT) Pilot Plant

A modified version of the University of Capetown (UCT) process was also included for evaluation at the East Burlington site. Selection of this process was based on the successful experience of investigators operating the pilot Virginia Initiative Plant (VIP) at the Lambert's Point Wastewater Treatment Plant in Norfolk, VA. The flowsheet of the modified UCT pilot system evaluated at East Burlington Wastewater Treatment Plant is shown in Figure 1B. This flowsheet is modified from the one used in Norfolk and the one evaluated during Phase I (OWASA), but it is the same as that used the Farrington Road Wastewater Treatment Plant (Phase II).

Referring to Figure 1B, the modified UCT system divided the anaerobic stage into three, 30 minute anaerobic tanks to eliminate short-circuiting and approach plug flow conditions. The pilot influent (200 mL/min), Zimpro^{TM} regen stream (1.67 mL/min), and a recycle flow (100 mL/min) from the second anoxic tank (Tank 5) entered the first anaerobic tank. The anaerobic tanks were followed by two anoxic tanks with a total detention time of two hours. Return sludge from the clarifier was pumped into the first anoxic tank (Tank 4). The return sludge flow rate was approximately 50% of the influent flow. Aerobic treatment was accomplished in four 90 minute tanks for a nominal system detention time of 9.5 hours.

The configuration of return sludge flow and internal recycle in the modified UCT system was unique among the pilot units. The recycle stream is the only means of introducing biological solids at the anaerobic head of the system. This flow pattern was designed to exclude nitrate from the anaerobic phase. The pilot configuration which was evaluated eliminated a second denitrification recycle (from Tank 9 to Tank 4) that was present during Phase I but also eliminated in Phase II. This recycle was eliminated to avoid overloading the anoxic section (Tanks 4 and 5) with nitrates.

The was very little difficulty in operating the modified UCT system. On April 26 and 27, there were leaks which caused some loss of solids. On June 1, the influent channel pipe clogged and both influent and recycle spilled on the floor with an indeterminate loss of solids. Operational notes are in Appendix D-1 while the Operation Log is in Appendix D-2.

Table 3 presents the monthly averages of several performance parameters. A complete data set for the modified UCT system is included in Appendices D-3 and D-4. With the exception of the early period (before March 31) when there may have been insufficient oxygen and inappropriate microorganisms, $CBOD_5$ removal by the UCT pilot system was sufficient to meet the 12.0 mg/L discharge permit limit. The results presented in Figure 5 demonstrate that $CBOD_5$ exceeded the permit limit only four times after the early period. Based on these data, $CBOD_5$ control should be adequate to meet the requirements of the full-scale plant.

The SVI is that of a well settling mixed liquor while the F:M was as expected for a conventional activated sludge plant (Table 3). This was true both with and without the Zimpro™ regen stream feed. The anaerobic TDP was less than in the A^2/O pilot system (compare Table 2 and Table 3). While this should be associated with a lower BPR performance, this was not the case as demonstrated by the average Tank 9 TDP (0.5 mg/L).

As was true for the A^2/O system, NH3-N decreased to extremely low levels after the early period (Figure 6). It was well within the effluent limits from late March to the end of the study. From mid-April to the conclusion of the study, the average NO2+NO3-N concentration at the end of aeration was 3.75 mg/L (Figure 6). This was after the Zimpro™ regen stream feed with its very high NH3-N load was discontinued.

This system averaged 57% total nitrogen removal based on influent total nitrogen (51 mg/L) and the estimated total effluent total nitrogen (22 mg/L) while the Zimpro™ regen stream was being added with sufficient air for nitrification (April 1 - April 17). After discontinuance of the Zimpro™ regen stream feed, the influent total nitrogen was reduced to about 25 mg/L while the effluent total nitrogen was about 12 mg/L. This resulted in equivalent removal, 52%, but the absolute amount of the effluent total nitrogen was 45% less.

TABLE 3

UCT PILOT PLANT PROCESS DATA

MONTH	TANK #9			FILTERED TANK #9					
	MLSS	SVI	F:M	CBOD5	NH3-N	NO2+ NO3-N	TDP	ANAER TDP	MCRT
MARCH	4302	78	0.13	23	12.5	3.1	0.5	32	10.5
APRIL	5673	58	0.13	8	0.8	8.3	0.4	29	9.4
MAY	3927	68	0.16	6	0.1	3.1	0.3	30	8.7
JUNE	3437	54	0.13	5	0.1	5.5	1.1	23	6.9
AVERAGE	4574	65	0.14	11	3.4	5.1	0.5	29	9.2

Notes: All data in mg/L except SVI (mL/g). The complete data set is in Appendix D. MLSS is Mixed Liquor Suspended Solids in Tank 9. SVI is Sludge Volume Index. F:M is Food to Microorganism ratio. $CBOD_5$ is Carbonaceous 5-day Biochemical Oxygen Demand, Filtered in Tank 9. NH_3-N is Ammonia Nitrogen in Tank 9. NO_2+NO_3-N is Nitrite + Nitrate Nitrogen in Tank 9. TDP is Total Dissolved Phosphorus in Tank 9. ANAEROBIC TDP is Total Dissolved Phosphorus in Tank 3. MCRT is the mean cell residence time (hydraulically determined) in days.

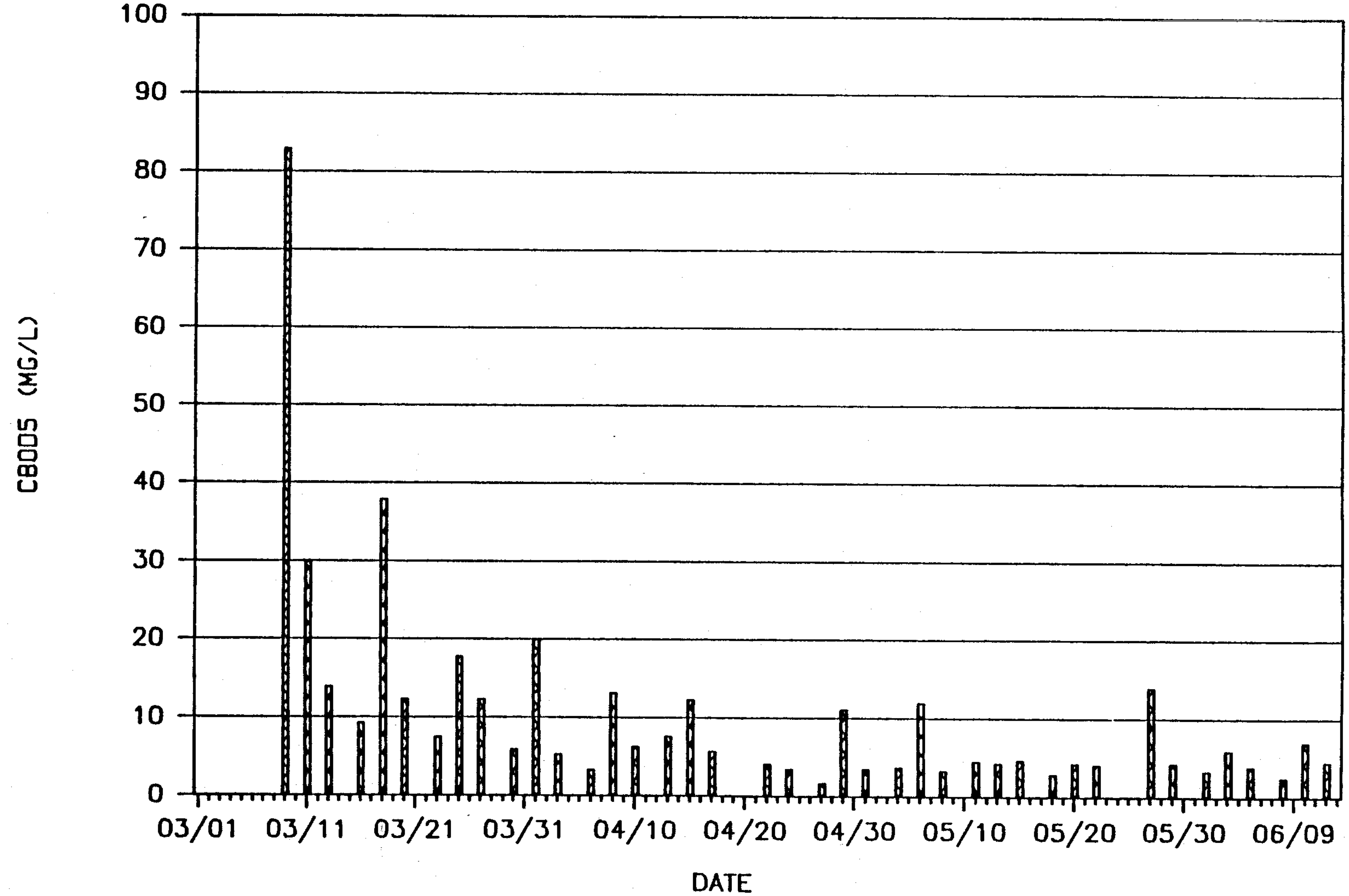


FIGURE 5. CBOD5 CONCENTRATION IN THE FINAL AERATED TANK OF THE MODIFIED UCT PILOT PLANT.

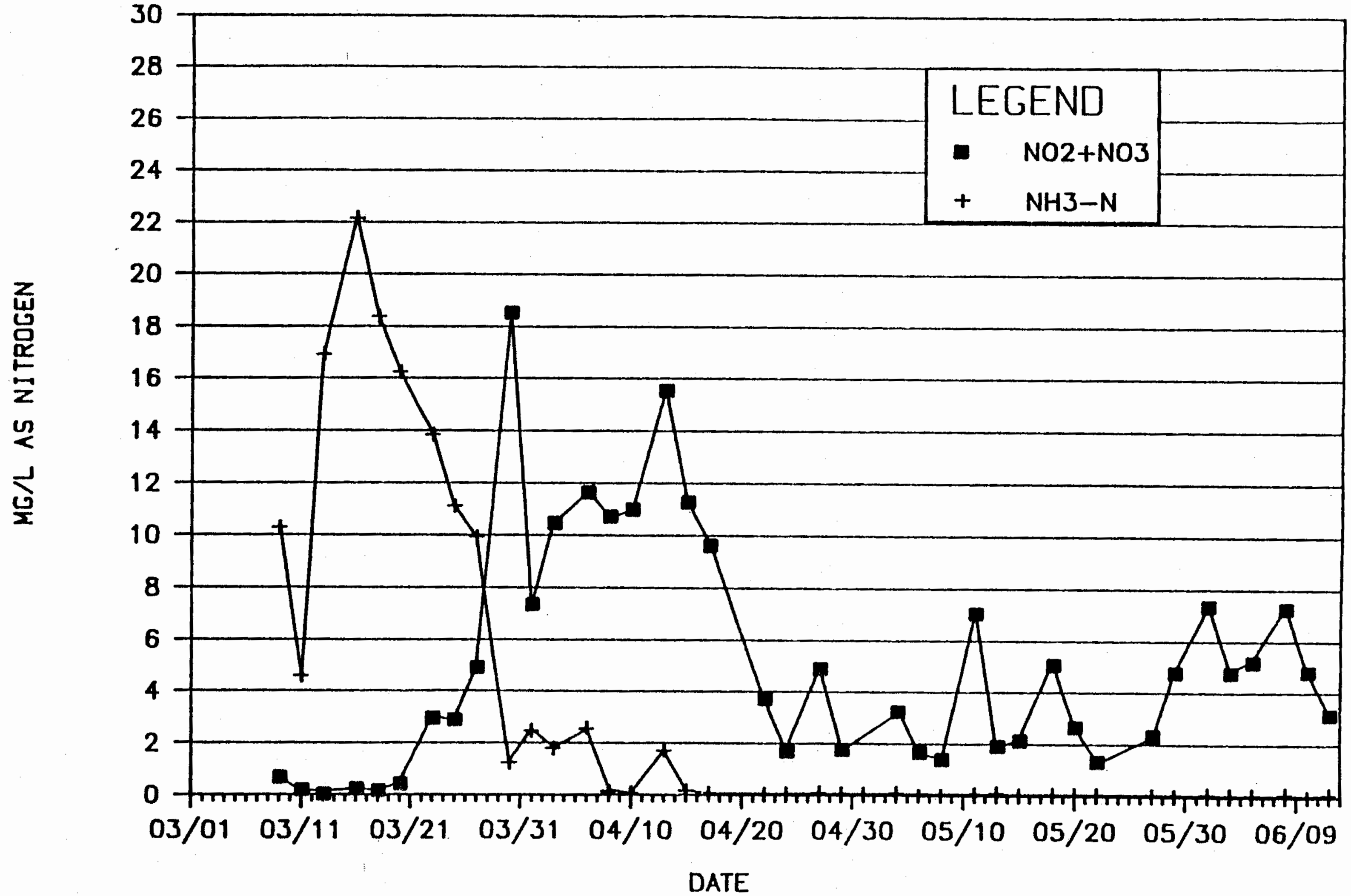


FIGURE 6. FILTRABLE LABILE NITROGEN CONCENTRATION IN THE FINAL AERATED TANK OF THE MODIFIED UCT PILOT PLANT.

Total nitrogen removal might have been increased by adding the second internal recycle flow, but this was not attempted.

During Phase I (OWASA), the unmodified UCT flow sheet did not maintain a high enough MLSS to allow satisfactory BPR. This was not a problem in Phase II either because of he flow sheet modifications or a difference in the pilot influent (primary effluent). There was likewise no difficulty maintaining MLSS at East Burlington (Figure 7). The decrease in MLSS after April 17 was due to the discontinuance of the addition of the Zimpro^{TM} regen stream which was high in both solids and CBOD. The further decrease in late May was because sludge wasting was increased to test the system at a shorter MCRT (approximately 7 days).

The UCT system's BPR performance was equivalent to that of the A^2/O pilot system. The average Tank 9 TDP was only 0.5 mg/L for the entire study period (Table 3). Complete phosphorus data for the UCT system are in Appendices D-3 and D-4. Orthophosphorus concentrations in the final aeration tank are presented in Figure 8. As with the A^2/O system, the modified UCT system consistently produced an effluent with less than 1.0 mg/L orthophosphorus until the MCRT was substantially decreased in late May. The BPR performance was not affected by the presence or absence of the Zimpro^{TM} regen stream. This suggests that the influent (primary effluent) CBOD was sufficient to produce conditions (anaerobiosis and acetate) which allow BPR to occur. Since the proposed discharge limit is 2 mg/L, the modified UCT process should be able to meet this limit.

The percent phosphorus in the mixed liquor solids averaged 3.2% (Appendix D-3). This is essentially the same as the calculated percent phosphorus in the A^2/O solids. Using the estimated total effluent phosphorus concentration which includes 30 mg/L total suspended solids, the estimated removal efficiency as total phosphorus is 80%. As observed for the A^2/O system, with the dissolved phosphorus concentration near the detection limit at the end of aeration, the only way to lower the effluent phosphorus concentration is to control the effluent solids concentration. This is being done at the East Burlington Wastewater Treatment Plant and effluent TP from a

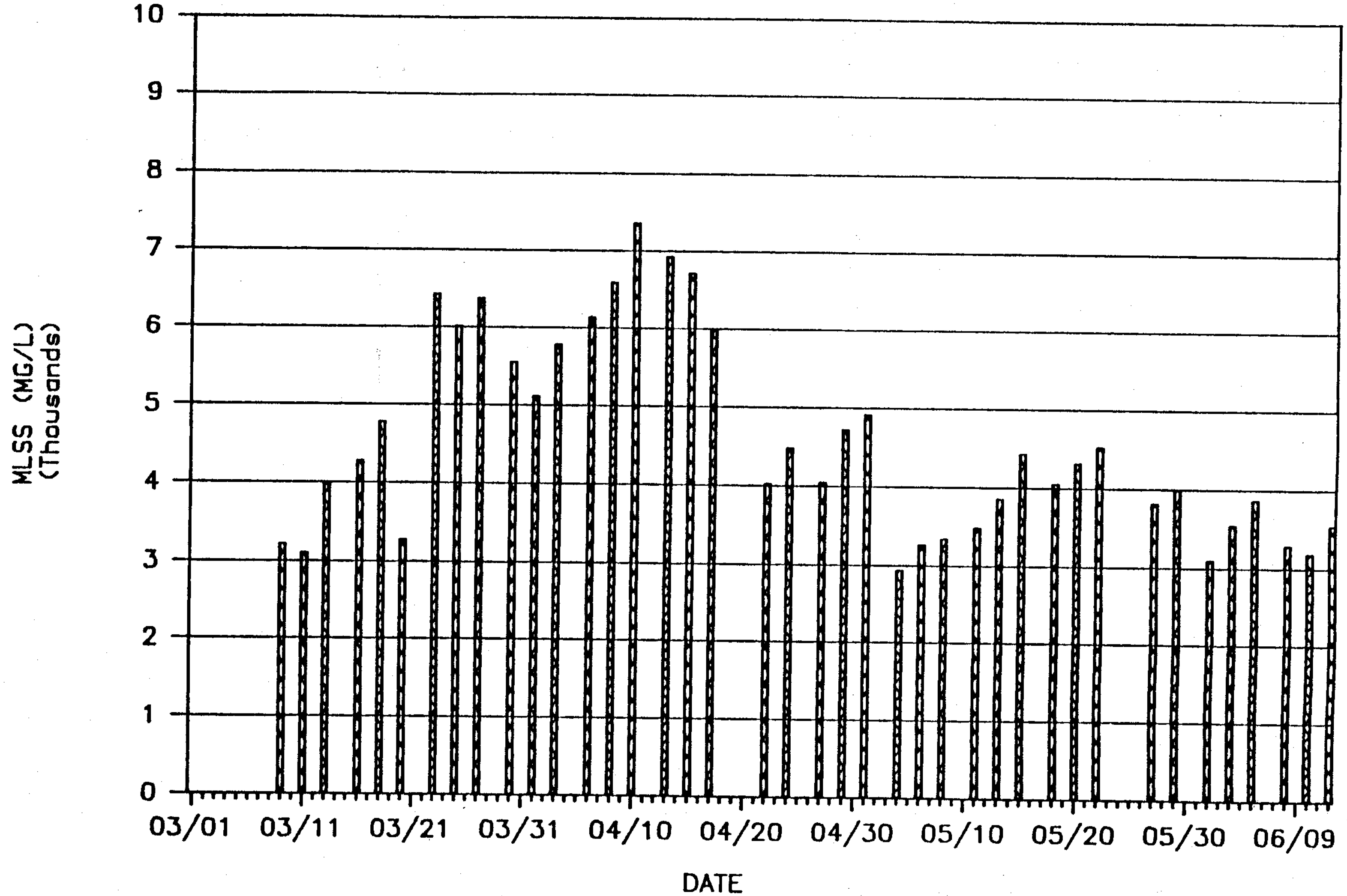


FIGURE 7. MLSS CONCENTRATION IN THE FINAL AERATED TANK OF THE MODIFIED UCT PILOT PLANT.

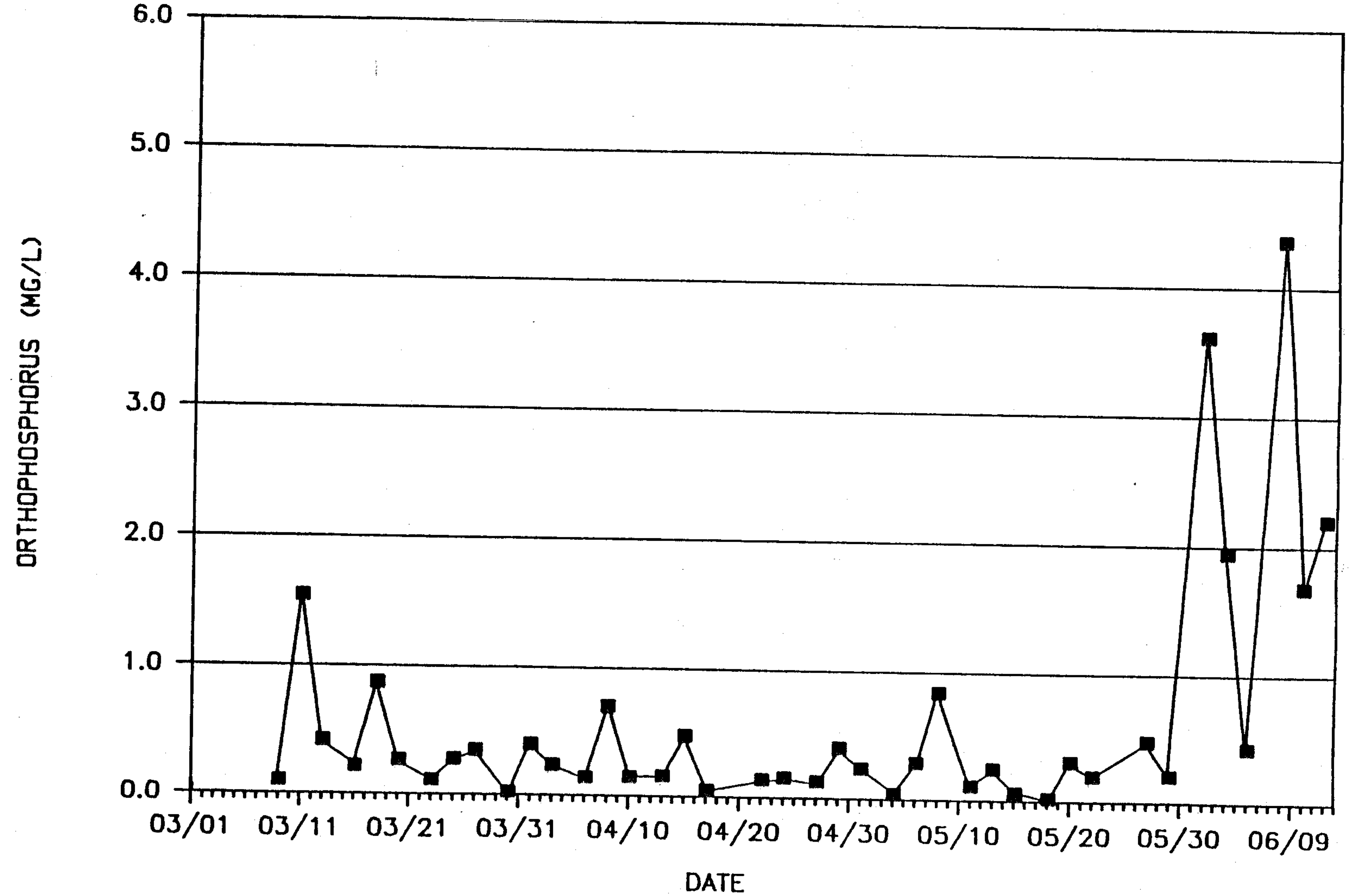


FIGURE 8. ORTHOPHOSPHORUS CONCENTRATION IN THE FINAL AERATED TANK OF THE MODIFIED UCT PILOT PLANT.

BPR system using this flow sheet would very likely be less than 1 mg/L.

The modified UCT pilot unit gave good $CBOD_5$, ammonia, and phosphorus removal with few operational problems related to the design. This performance was not dependent upon the introduction of the Zimpro^{TM} regen stream; therefore, it would likely perform well even if this method of sludge destruction were discontinued. In conclusion, this flow sheet would very likely allow the East Burlington Wastewater Treatment Plant to meet the most stringent effluent phosphorus, CBOD, and ammonia requirements with significant nitrogen removal.

D. Performance of the University of Capetown - Experimental (UCT-EXP) Pilot Plant

A second pilot system, the UCT-EXP system, using the modified UCT flow sheet was operated at the East Burlington Wastewater Treatment Plant. The flowsheet for this system is shown in Figure 1C. The only difference between this pilot system and the modified UCT system (Figure 1B) is that the UCT-EXP utilizes three tanks each with a 2 hour detention for the aerobic phase while the modified UCT uses four 1.5 hour detention time tanks. The total period of aeration was 6 hours in both systems. These differences were due to the availability of tanks.

The UCT-EXP was included to determine the reproducibility of performance with two essentially identical pilot systems and to evaluate the effect of adding virgin PAC on color removal. The carbon was the same as that used at the East Burlington Wastewater Treatment Plant during this study, and it was added in the same proportion (7 g/288 L or 7 g/day) as in the main plant. This would amount to 500 mg/L in the treatment system at a hydraulically-determined MCRT of 9 days.

This system lost much of its solids on March 10 and May 3 (Appendix E-1). It was also subject to unusual difficulties with clogging of the underflow hoses connecting the various tanks. The Operational Notes and Operational Log are Appendices E-1 and E-2, respectively. The analytical results are in Appendices E-3, E-4, and E-5 (color).

The UCT-EXP pilot system performance is tabulated in Table 4. This performance is generally quite comparable to that of the modified UCT pilot system (Table 3). The effluent (Tank 8) CBOD5, NH3-N, and TDP were higher during March in the UCT-EXP system (Table 4) than in the modified UCT system (Table 3). This was very likely due to the aforementioned loss of mixed liquor from the UCT-EXP system. The most significant difference was that the MLSS in the UCT-EXP system (5365 mg/L) was higher than that in the modified UCT pilot system (4574 mg/L). This was greater than the 500 mg/L accountable by the virgin PAC addition. The MLVSS values were more similar, however (Appendices D-4 and E-4). This confirms that the modified UCT flowsheet is capable of outstanding removal of phosphorus, $CBOD_5$, and total nitrogen.

Figure 9 is a comparison of the effluent color (Co-Pt units) for the modified UCT and UCT-EXP systems. From March 9 until April 17 both systems were receiving regenerated PAC in the Zimpro^{TM} regen stream. After this, the modified UCT system had no additions of PAC. During the entire period, the UCT-EXP system was dosed with 7 g of PAC daily. On May 28 an additional 400 g of virgin PAC was added to the UNC-EXP system to determine whether very large doses would have an effect. The addition of PAC either regenerated by Zimpro^{TM} or virgin did not affect the effluent color as measured by the Co-Pt standard method.

E. Performance of the University of North Carolina - (UNC) Pilot Plant

The UNC system was operated with the same configuration that was successful during Phase I. This design was originally conceived to overcome problems posed by the low CBOD concentration of the pilot influent at the OWASA site. The fermented sludge feed was expected to provide a high concentration of volatile acids independent of the amount of primary effluent CBOD It was believed that the advantages of this system in overcoming problems of this nature might insure consistent BPR performance at other sites as well.

The UNC flowsheet, shown in Figure 1D, included two, two-hour anaerobic tanks. The first anaerobic tank received return

TABLE 4

UCT-EXP PILOT PLANT PROCESS DATA

	TANK #8			FILTERED TANK #8					
MONTH	MLSS	SVI	F:M	CBOD5	NH3-N	NO2+ NO3-N	TDP	ANAER TDP	MCRT
MARCH	4302	48	0.35	35	13.6	2.0	2.5	15	10.3
APRIL	7469	46	0.11	10	0.3	6.8	0.3	25	9.9
MAY	4726	71	0.13	7	0.1	2.5	0.3	34	8.9
JUNE	4203	37	0.10	7	0.2	3.7	0.6	26	6.2
AVERAGE	5365	53	0.18	15	3.5	3.9	1.0	25	9.3

Notes: All data in mg/L except SVI (mL/g). The complete data set is in Appendix C. MLSS is Mixed Liquor Suspended Solids in Tank 8. SVI is Sludge Volume Index. F:M is Food to Microorganism ratio. $CBOD_5$ is Carbonaceous 5-day Biochemical Oxygen Demand, Filtered in Tank 8. NH_3-N is Ammonia Nitrogen in Tank 8. NO_2+NO_3-N is Nitrite + Nitrate Nitrogen Tank in 8. TDP is Total olved Phosphorus in Tank 8. ANAEROBIC TDP is Total Dissolved Phosphorus 3. MCRT is the mean cell residence time (hydraulically determined)

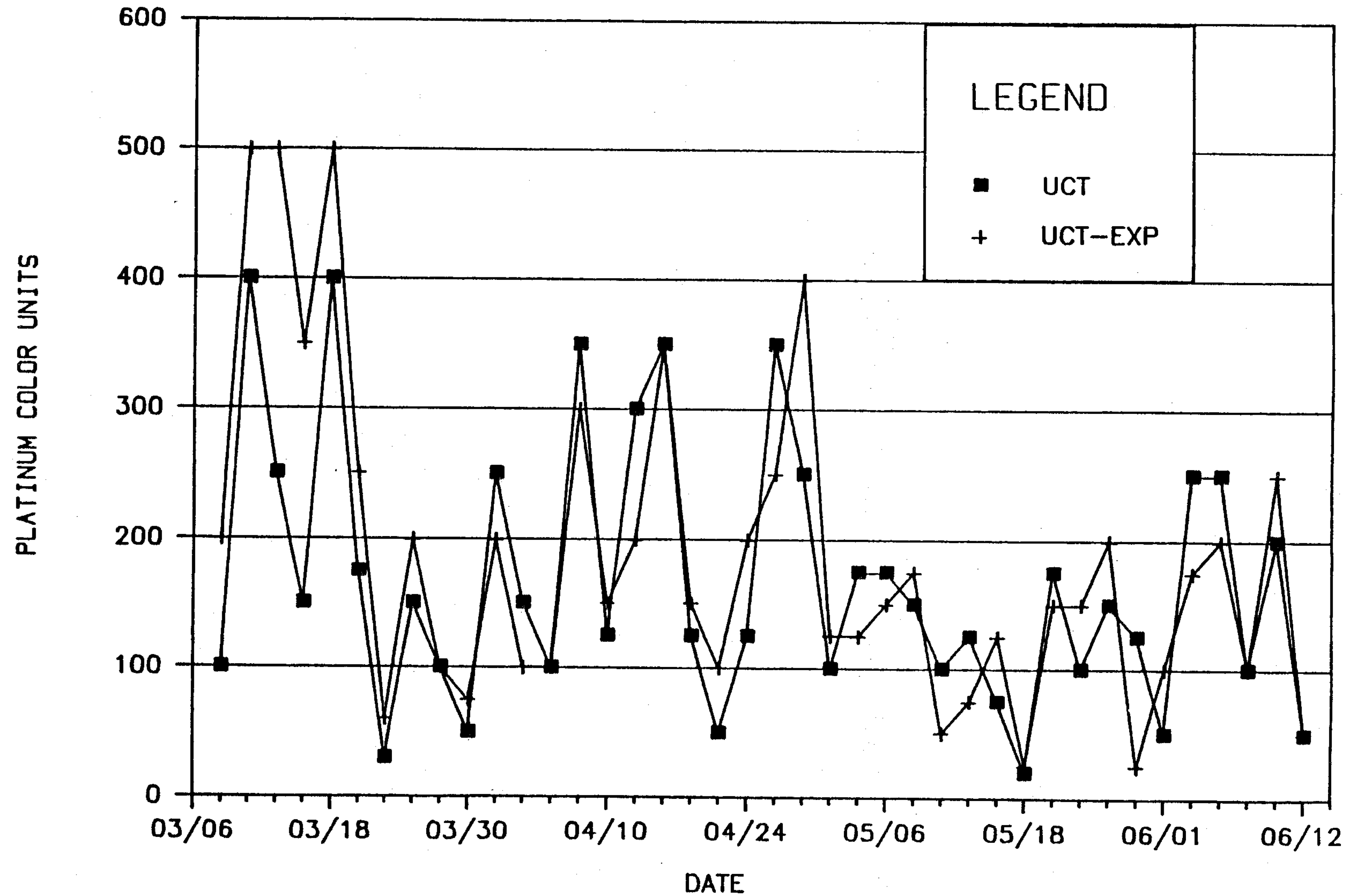


FIGURE 9. COLOR (Co-Pt Units) IN THE FINAL AERATED TANK OF THE MODIFIED UCT AND UCT-EXP PILOT PLANTS.

activated sludge at a flow rate maintained at 50% of the system influent flow. Control of the anaerobic detention time was achieved through control of the return sludge flow rate and was not affected by pilot influent flow rates. The Zimpro^{TM} regen stream (1.67 mL/min) or fermented primary sludge (1 mL/min) was added to either Tank 1 or 2. The reasons for these alternative feed points will be discussed below. Influent was introduced into the first aerobic tank (No. 3) to avoid dilution of the microorganisms in the anaerobic stage. It was thought that the concentrated return sludge, combined with the Zimpro^{TM} regen stream or fermented primary sludge, would produce higher volatile acids (acetate) and better anaerobic conditions for greater phosphorus release. Tanks 3, 4, and 5 were aerobic tanks with nominal detention times of 90, 60, and 90 minutes. This system had no internal recycle but included two anoxic tanks (Nos. 6 and 7) for mainstream denitrification. The nominal anoxic detention time was 2.5 hours. Tank 8 provided reaeration of the mixed liquor prior to the pilot clarifier.

As discussed previously, volatile acids, particularly acetic acid, are required by the BPR organisms in the anaerobic, release phase. The UNC flow sheet was developed to provide these in a tank which contained only the return sludge (concentrated). During Phases I and II these were provided by feeding fermented primary sludge with a volatile acid content of 1800 to 2400 mg/L. At East Burlington the Zimpro^{TM} regen stream had a very high volatile acid concentration (Table 1); therefore, it was likely a suitable source of these acids. The Zimpro^{TM} regen stream was added to tank 1 from March 3 to April 29 (1.67 mL/min). From April 29 to May 22, fermented primary sludge from the East Burlington Wastewater Treatment Plant was added instead of Zimpro^{TM} at an average rate of 1 mL/min. This was to determine whether the Zimpro^{TM} regen stream was a better source than the fermented primary sludge used at the other sites. From May 22 to June 19, the fermented primary sludge feed was discontinued and a settled (no PAC) Zimpro^{TM} regen stream feed was substituted. The primary clarifier sludge was fermented with a five day detention time as at the other sites. Both the Zimpro^{TM} regen stream and the fermented primary sludge were fed using a discontinuous, timer-controlled system because the required amounts were so low.

There were very few operational problems with the UNC system. The most significant were the loss of solids on March 23 and May 28; the interruption of aeration on March 19, March 23, and March 28; the interruption of fermented sludge feed on April 30, May 2, May 3, and May 5; the interruption of Zimpro^{TM} regen stream feed on June 2 and June 3; and the failure of the sludge return pump on April 24. Operational notes are in Appendix F-1 while the Operation Log is in Appendix F-2.

Table 5 presents the monthly averages of several performance parameters. A complete data set for the UNC system is included in Appendices F-3 and F-4. With the exception of the early period (before March 31) when there may have been insufficient oxygen and inappropriate microorganisms, $CBOD_5$ removal by the UNC pilot system was sufficient to meet the 12.0 mg/L discharge permit limit. The results presented in Figure 10 demonstrate that $CBOD_5$ exceeded the permit limit only five times after the early period. Based on these data, $CBOD_5$ control should be adequate to meet the requirements of the full-scale plant.

The SVI is that of a well settling mixed liquor while the F:M was as expected for a conventional activated sludge plant (Table 5). This was true both with the Zimpro^{TM} regen stream feed and the fermented primary sludge. The anaerobic TDP was higher than in any of the other systems tested, but the absolute amount was equivalent since the anaerobic system was undiluted with pilot plant influent. While this should be associated with a better BPR performance, this was not the case as demonstrated by the average TDP in Tank 8, 1.1 mg/L.

Figure 11 illustrates the concentration of MLSS in the UNC pilot system. During the early period (March 3 - April 29), the MLSS increased continuously. After reseeding on April 17 to enhance nitrification, the MLSS decreased somewhat. When the Zimpro^{TM} regen stream feed with its very high solids was replaced by a fermented primary sludge feed on April 29, the MLSS began to decrease. This decrease was also associated with an increase in the 30 min settleable solids (Appendix F-2) and SVI (Appendix F-4). It is clear that the MLSS tended toward a bulking condition while the fermented primary sludge was being fed to the anaerobic stages even though MLSS reached a stable

TABLE 5

UNC PILOT PLANT PROCESS DATA

	TANK #8			FILTERED TANK #8					
MONTH	MLSS	SVI	F:M	CBOD5	NH3-N	NO2+ NO3-N	TDP	ANAER TDP	MCRT
MARCH	4814	75	0.17	28	15	0.5	1.0	70	9.9
APRIL	7413	39	0.12	11	2.3	4.2	0.4	57	9.7
MAY	5258	131	0.13	6	0.3	0.9	1.8	40	8.7
JUNE	3915	95	0.12	4	0.5	3.1	1.5	43	6.5
AVERAGE	5512	84	0.14	12	4.5	2.1	1.1	54	8.9

Notes: All data in mg/L except SVI (mL/g). The complete data set is in Appendix C. MLSS is Mixed Liquor Suspended Solids in Tank 8. SVI is Sludge Volume Index. F:M is Food to Microorganism ratio. $CBOD_5$ is Carbonaceous 5-day Biochemical Oxygen Demand, Filtered in Tank 8. NH_3-N is Ammonia Nitrogen in Tank 8. NO_2+NO_3-N is Nitrite + Nitrate Nitrogen Tank in 8. TDP is Total Dissolved Phosphorus in Tank 8. ANAEROBIC TDP is Total Dissolved Phosphorus in Tank 2. MCRT is the mean cell residence time (hydraulically determined) in days.

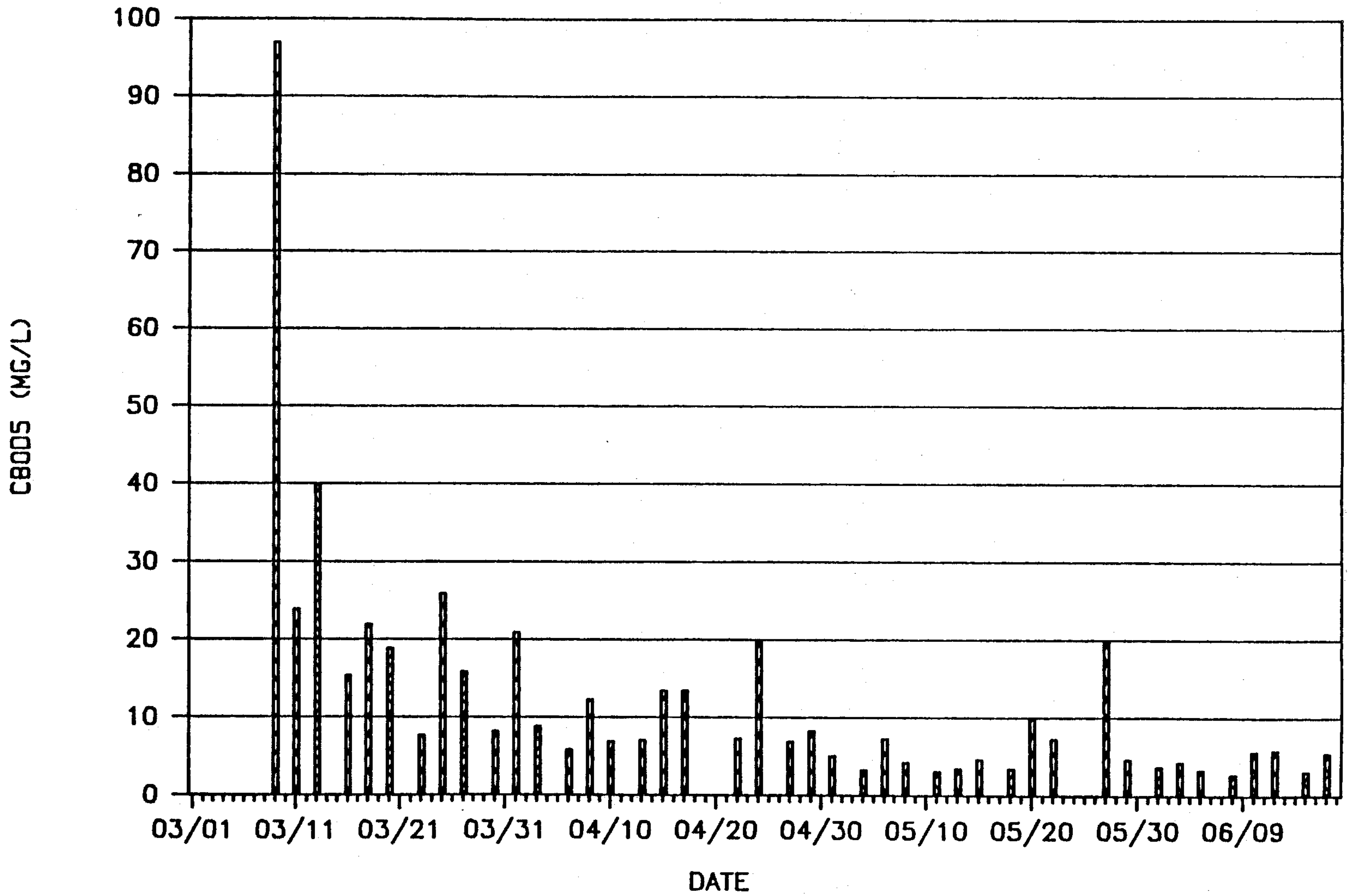


FIGURE 10. CBOD5 CONCENTRATION IN THE FINAL AERATED TANK OF THE UNC PILOT PLANT.

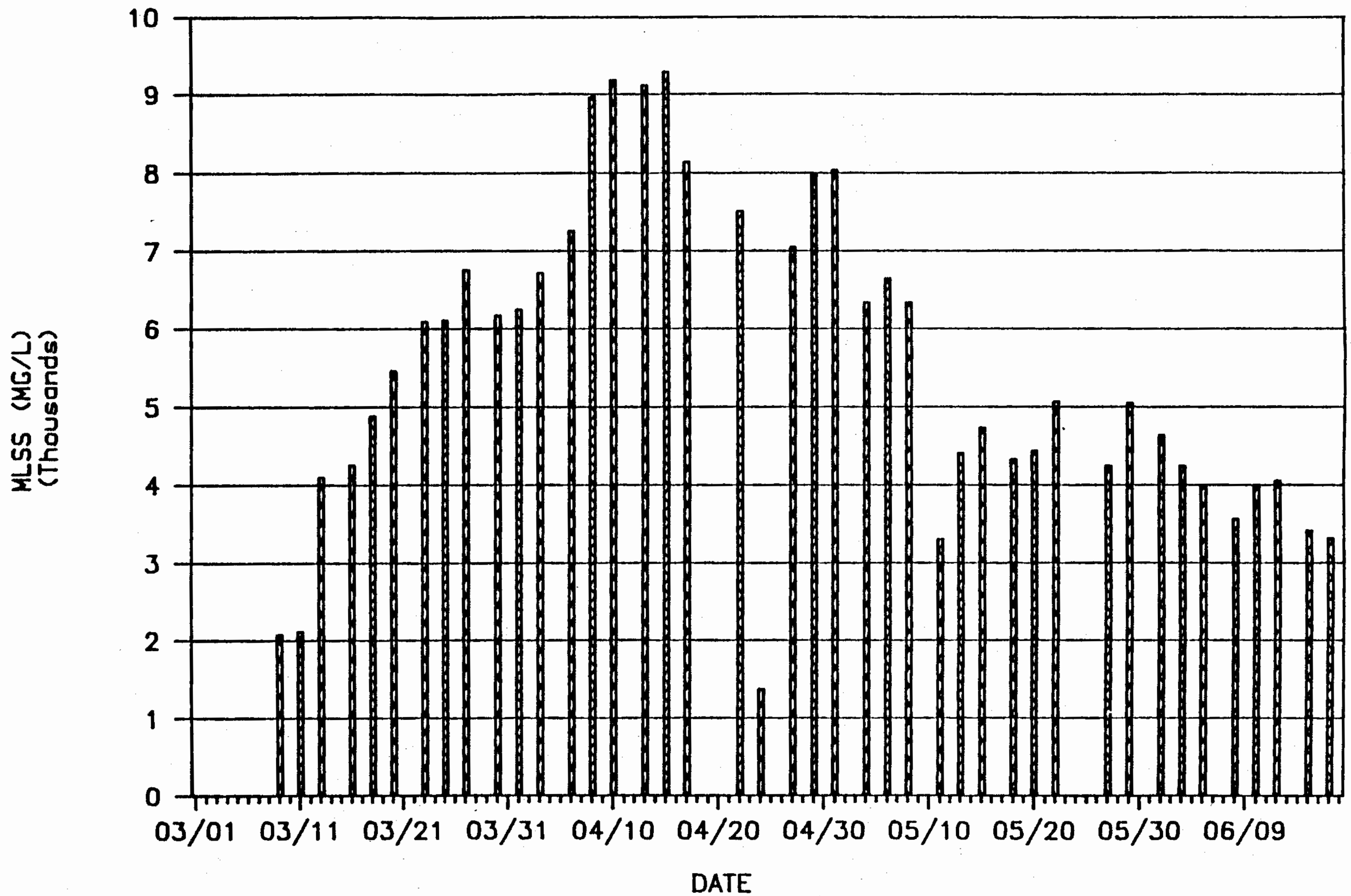


FIGURE 11. MLSS CONCENTRATION IN THE FINAL AERATED TANK OF THE UNC PILOT PLANT.

concentration of about 4000 mg/L after May 11. Sludge wasting was increased on May 20 in an attempt to control the bulking condition.

The hydraulically-calculated MCRT is illustrated in Figure 12. This was maintained at 9 - 10 days until late May when it was lowered to 7 days. The period during which the MCRT seemed to be at 8 days was during the time when the wasting pumps were being adjusted to the higher flow.

As was true for the A^2O and modified UCT systems, NH3-N decreased after the early period; however, the concentrations were higher than the other two pilot systems (Figure 12). On April 17, the system was reseeded with 2L each of A^2/O and modified UCT MLSS after removing 4L of MLSS from the UNC pilot system. NH3-N was well within the effluent limits from mid April to the end of the study. During this period of good nitrification, the average NO2+NO3-N concentration at the end of aeration was 2.21 mg/L (Figure 13). The highest values were during the period when Zimpro™ regen stream with its very high NH3-N load was being pumped into the anaerobic system (March 3 - April 16 and May 22 - June 17). Interestingly, during period of fermented sludge feed and the second period of Zimpro™ regen stream feed, the highest values of NO2+NO3-N were on Mondays while the lowest were on Fridays. This probably relates to the effectiveness of denitrification which, in turn, is determined by the concentration of BOD in the anoxic or anaerobic stages.

This UNC system averaged 71% nitrogen removal based on influent total nitrogen (51 mg/L) and the estimated total effluent total nitrogen (14 mg/L) while the Zimpro™ regen stream was being added with sufficient air for nitrification (April 1 - April 29). After substitution of the fermented primary sludge feed for the Zimpro™ regen stream feed, the influent total nitrogen was reduced to about 30 mg/L while the effluent total nitrogen was about 10 mg/L. This resulted in the same removal, 68%. After the settled Zimpro™ regen stream replaced the fermented primary sludge on May 23, nitrogen removal increased to 78% with an influent total nitrogen of 51

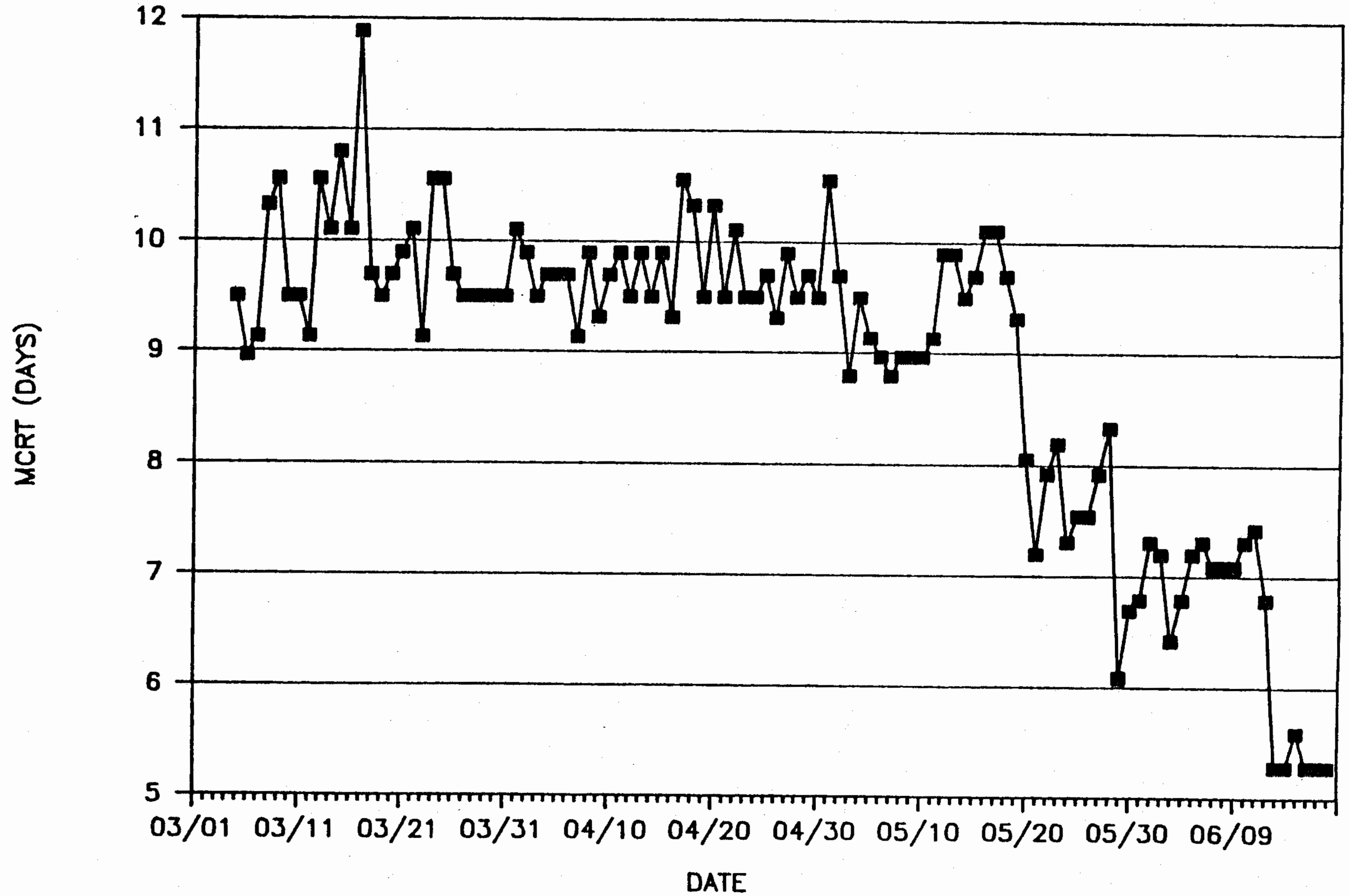


FIGURE 12. MCRT (HYDRAULICALLY-CALCULATED) IN THE UNC PILOT PLANT.

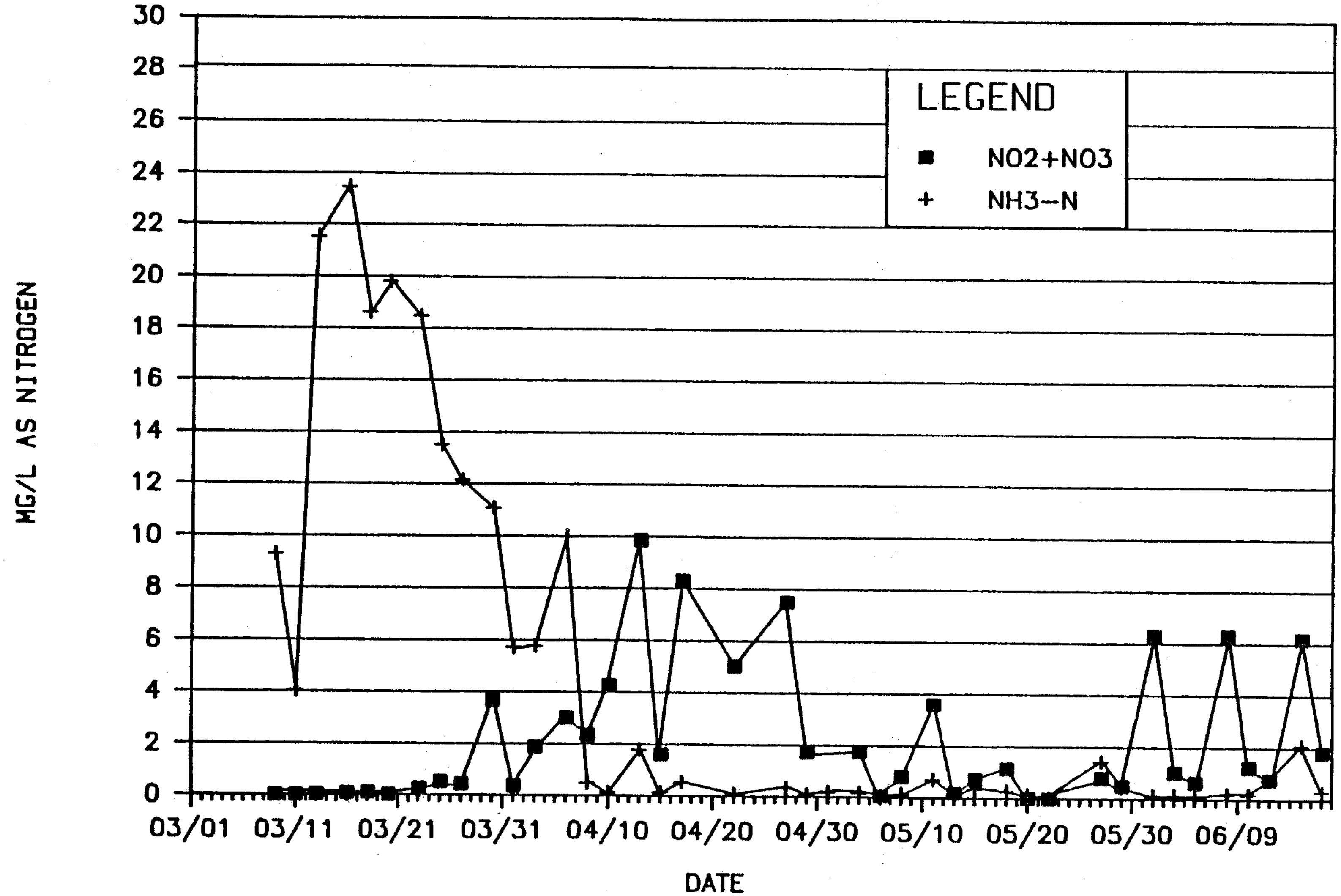


FIGURE 13. FILTRABLE LABILE NITROGEN CONCENTRATION IN THE FINAL AERATED TANK OF THE UNC PILOT PLANT.

mg/L and an effluent total nitrogen of 11 mg/L. Overall the UNC pilot system removed a higher proportion of total nitrogen than the other systems tested.

Figure 14 illustrates the concentration of orthophosphorus in the second anaerobic tank of the UNC pilot system. During the early period when there the system nitrification was apparently limited by both dissolved oxygen and the concentration of nitrifying bacteria, the anaerobic release was quite high. After these limitations were both alleviated by March 31, the released orthophosphorus concentration decreased somewhat. When the Zimpro™ regen stream feed was replaced by the fermented sludge feed on April 17, the amount of release decreased substantially. In an effort to decrease the amount of nitrate in Tank 2, the fermented primary sludge feed was moved to that tank on May 13. This converted Tank 1 to an endogenous denitrification tank. This seemed to enhance the release slightly. The resumption of settled Zimpro™ regen stream feed on May 23 followed by the increase in the sludge wasting rate on May 28 did result in an apparent increase in the anaerobic orthophosphorus release.

The concentration of orthophosphorus in Tank 8 (Figure 15) reflected the often-observed relationship between anaerobic release and effluent orthophosphorus. When the anaerobic release was high (Figure 14), the effluent orthophosphorus was low (Figure 15). During the period of fermented primary sludge feed (April 30 -May 22), the effluent orthophosphorus was high (Figure 15) while the anaerobic release was relatively low (Figure 14). After the fermented primary sludge feed was replaced by the settled Zimpro™ regen stream feed on May 23, the effluent orthophosphorus immediately decreased. However, the loss of solids due to operational problems and difficulties with the Zimpro™ regen stream feed apparently caused the effluent phosphorus to increase again. The last two data points are low once again, but it cannot be determined whether the system was stable.

The anaerobic release (Figure 14) and aerobic uptake (Figure 15) is related to the concentration of volatile acids which were being added to the anaerobic system. The concentration of volatile acids during the four performance

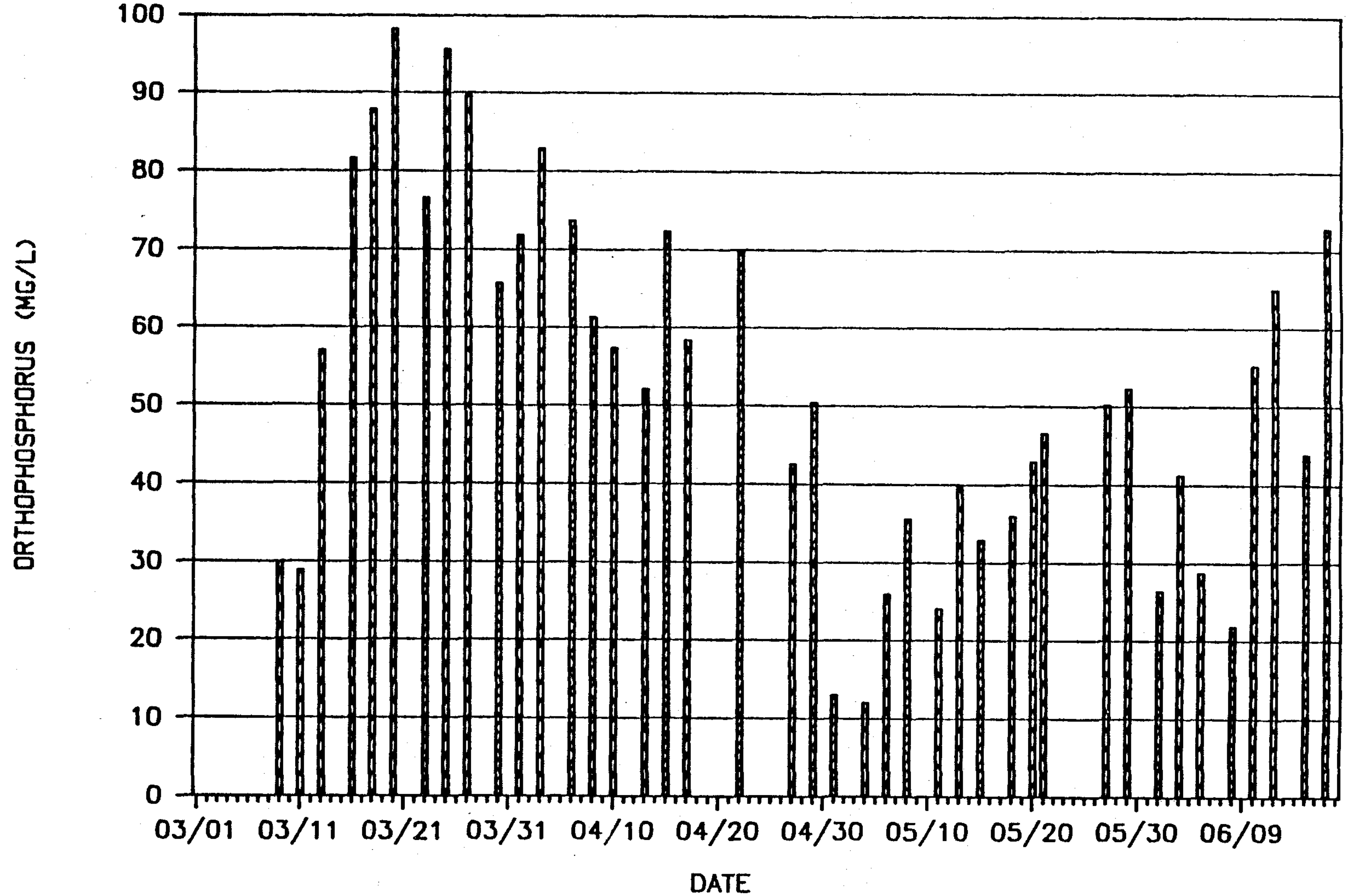


FIGURE 14. ORTHOPHOSPHORUS CONCENTRATION IN THE FINAL ANAEROBIC TANK OF THE UNC PILOT PLANT.

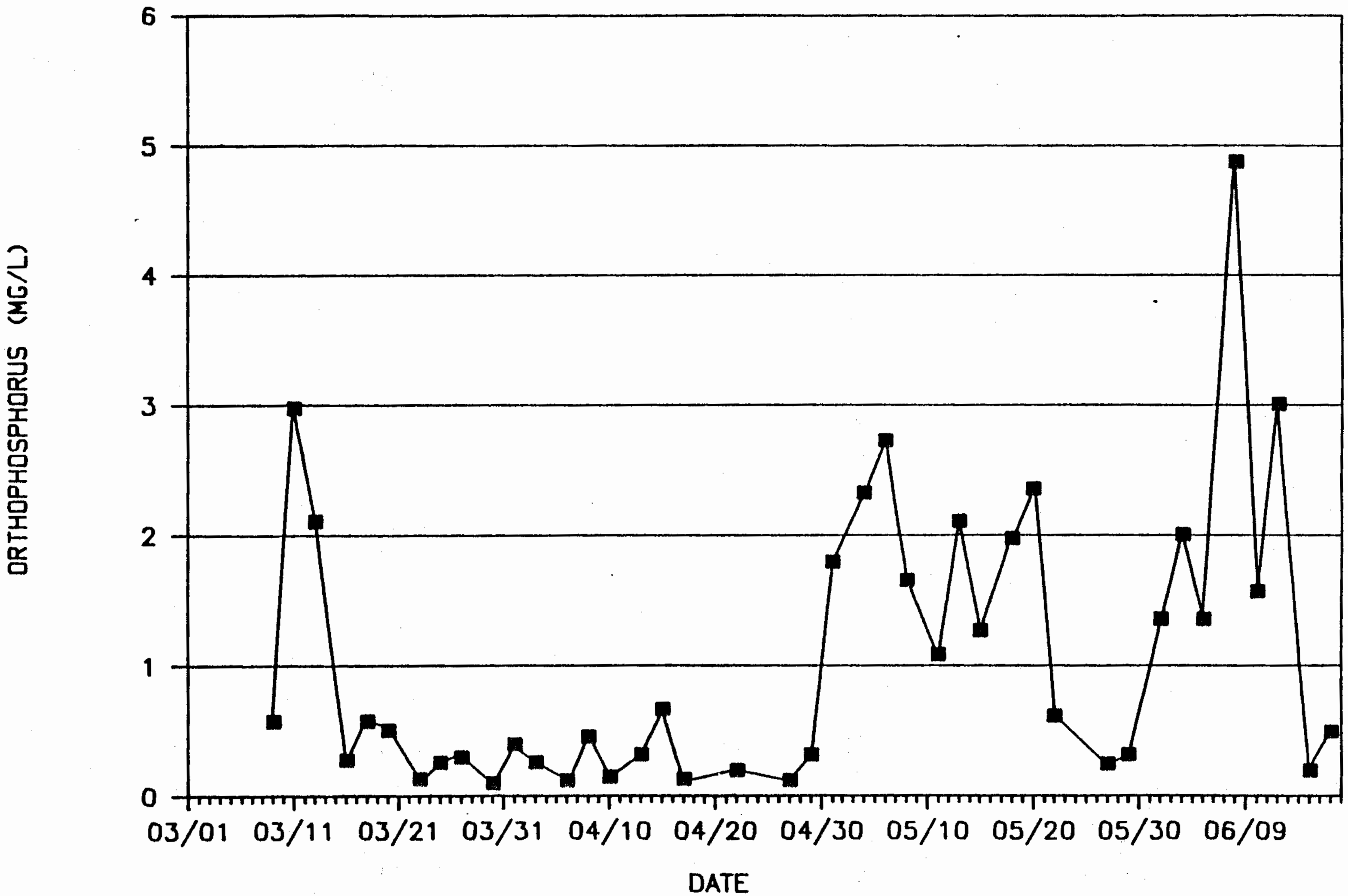


FIGURE 15. ORTHOPHOSPHORUS CONCENTRATION IN THE FINAL AERATED TANK OF THE UNC PILOT PLANT.

periods is presented in Table 6. The volatile acid concentration of the fermented primary sludge was only 1048 mg/L while that of the Zimpro™ regen stream exceeded 3000 mg/L. The concentration of volatile acids in the fermented primary sludge was less than that in either of the two previous studies (OWASA and Farrington Road). This may have been due to the fact that the East Burlington Wastewater Treatment Plant was experiencing severe sludge disposal problems which necessitated the storage of sludge in the primary settling tanks. It is likely that this old sludge was partially digested; and, therefore, was not representative of the volatile acids which would be expected from fermented primary sludge at the East Burlington Wastewater Treatment Plant under more normal conditions.

TABLE 6
VOLATILE ACID FEED TO THE UNC PILOT SYSTEM

DATE	SOURCE	VOL ACID mg/L
March 3 - March 31	Zimpro	5544
April 1 - April 29	Zimpro	4390
April 30 - May 22	Primary	1048
May 23 - June 17	Zimpro	3751

The percent phosphorus in the mixed liquor solids averaged 2.7% (Appendix F-3). This is less than the calculated percent phosphorus in the A^2/O or modified UCT solids. Using the estimated total effluent phosphorus concentration (1.91 mg/L) which includes 30 mg/L total suspended solids, the estimated removal efficiency as total phosphorus is 74%. This was a lower removal than the other systems tested. However, if only the optimal period (April 1 - April 29) is considered, the total estimated effluent phosphorus decreases to 1.32 mg/L and the percent removal increases to 85%.

The UNC pilot system gave good $CBOD_5$, ammonia, and total nitrogen removal with few operational problems related to the design. Even though this system did not perform as well as or as reliably as the other systems tested, it still produced an effluent phosphorus which would meet the proposed standard. The phosphorus removal performance was strongly dependent upon the concentration of volatile acids in the feed to the anaerobic unit. This was much higher in the Zimpro^{TM} regen stream than the fermented primary sludge. However, the volatile acids in the fermented primary sludge were unusually low because of sludge disposal problems at the East Burlington Wastewater Treatment Plant. Therefore, it is expected that the performance with a normal primary sludge would be better. In conclusion, this flow sheet would very likely allow the East Burlington Wastewater Treatment Plant to meet the most stringent CBOD and ammonia requirements with significant nitrogen removal. It is also likely that the expected effluent phosphorus would be less than 1.0 mg/L even if the Zimpro^{TM} sludge destruction process were discontinued.

VI. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS OF THE PILOT BPR STUDY

Simultaneous removal of phosphorus and nitrogen was achieved in the pilot scale treatment plants operated at the East Burlington Wastewater Treatment Plant. The performance of each of the systems in removing TDP is compared in Figure 16. Each of the systems was capable of significant phosphorus removal. The lowest final tank TDP was realized in April and May for all systems except UNC. Since the Zimpro^{TM} regen stream with its very high volatile acids was discontinued on April 17, it is apparent that the systems are capable of generating sufficient volatile acids from the primary effluent in the anaerobic stage to allow BPR. The UNC system, on the other hand, received a fermented primary sludge feed which was relatively low in volatile acids from April 17 to May 22, and the primary effluent was introduced into the aerobic system not the anaerobic system. This resulted in significantly lower BPR efficiency. In June, the MCRT of all systems was decrease, and this disrupted BPR.

Figure 17 illustrates the change in filtrable total nitrogen from the influent to the final aerated tank for each of the systems tested for each month. During March, nitrification was limited by the lack of nitrifiying organisms.

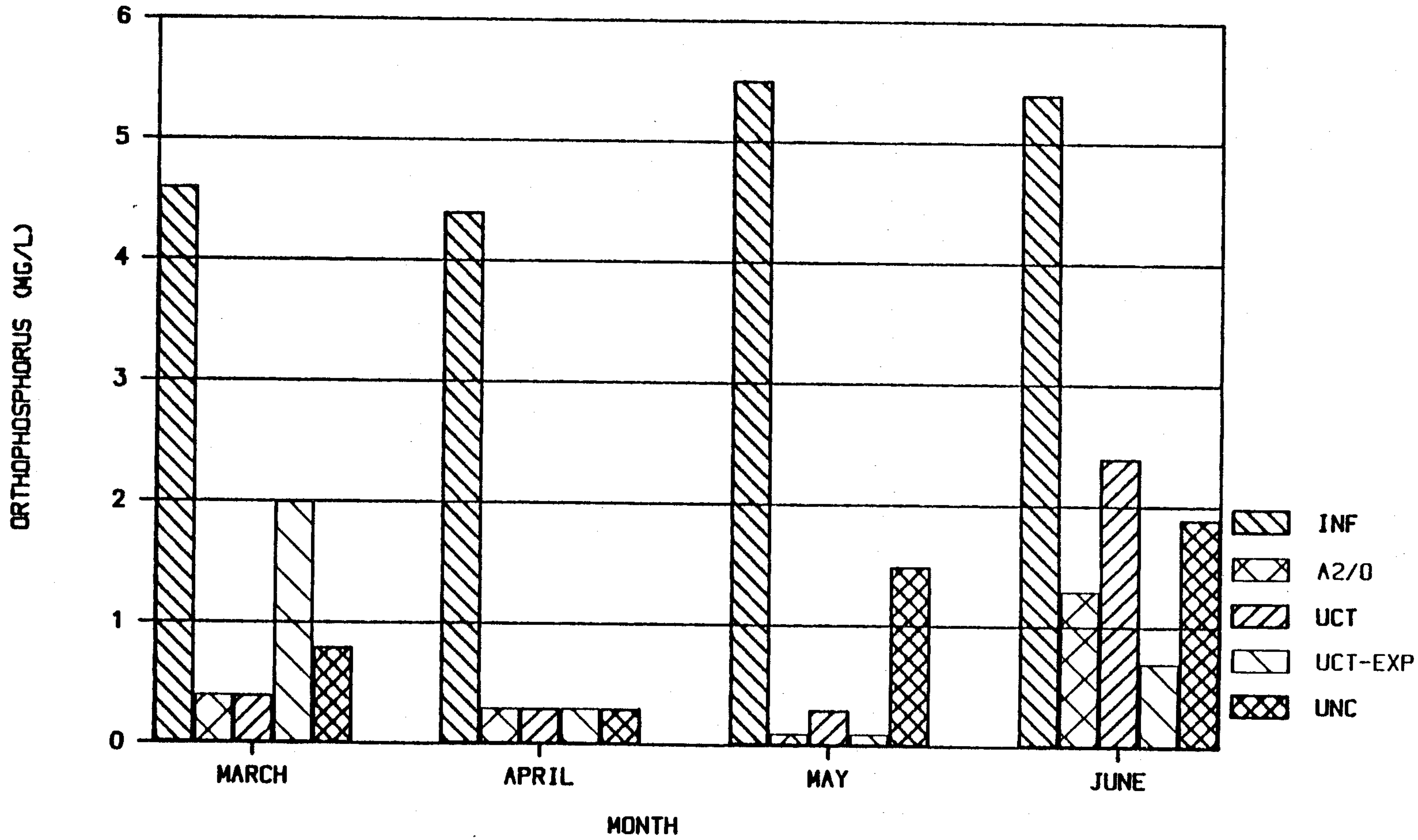


FIGURE 16. MONTHLY AVERAGE ORTHOPHOSPHORUS CONCENTRATION IN PILOT INFLUENT vs. FINAL AERATED TANK.

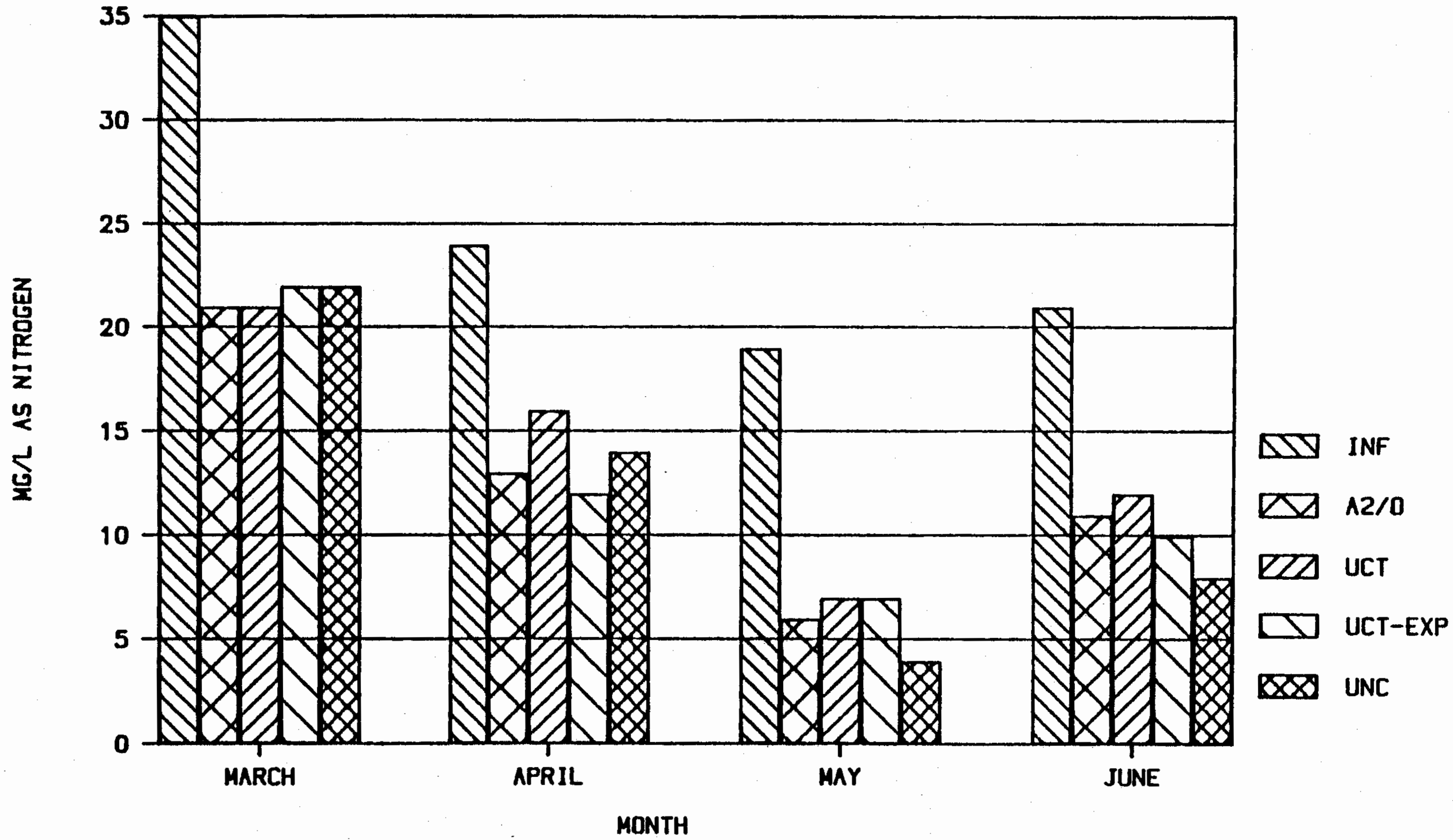


FIGURE 17. MONTHLY AVERAGE PILOT INFLUENT TDKN vs. FINAL AERATED TANK FILTRABLE NITROGEN.

Without nitrification, nitrogen removal was only by bilogical incorporation into the sludge which was then wasted. During April, there was nitrification, but denitrification did not seem to remove significantly more nitrogen. The Zimpro™ regen stream with its high TDKN was being added until April 17. After eliminating the Zimpro™ regen stream, nitrogen removal by dentrification seemed to be enhanced. With the failure of nitrification due to a short MCRT in May, the removal of filtrable total nitrogen decreased as well.

While all three systems tested at the East Burlington Wastewater Treatment Plant were successful in meeting the present and proposed effluent limits, the A^2/O and the modified UCT systems performed more consistently and resulted in lower effluent TDP concentrations than the UNC system. The performance of the the A^2/O and the modified UCT systems was not greatly affected by the presence or absence of the Zimpro™ regen stream with its extremely high concentration of volatile acids. This was very likely due to the fact that the primary effluent $CBOD_5$ was sufficiently high to allow the production of the required concentration of volatile acids in the anaerobic stages.

The comparison of effluent color between the modified UCT and UCT-EXP systems establishes that the addition of neither PAC regenerated by Zimpro™ wet oxidation nor virgin PAC enhanced color removal from the East Burlington Wastewater Treatment Plant primary effluent.

The performance of the UNC system was highly dependent upon the concentration of volatile acids in the feed to the anaerobic unit. When the Zimpro™ regen stream with its very high volatile acids was being added to the anaerobic stages, BPR performance was much better than when the lower-volatile-acid fermented primary sludge was being added. In addition, during the period with the fermented primary sludge addition, the system tended toward a bulking condition. This system may have performed more reliably had the primary sludge at the East Burlington Wastewater Treatment Plant been "fresher". The long storage of primary sludge necessitated by inadequate sludge disposal facilities very likely allowed considerable destruction of primary sludge CBOD before it was fermented. This would, of course, decrease the potential amount of volatile acids which could be produced.

Conclusions from this study should only be applied to the East Burlington Wastewater Treatment Plant. The site specific nature of the influent characteristics and their impact on the BPR processes does not allow extrapolation of these results to other sites. It is important to re-emphasize that no cost analyses were performed as a part of this study.

Since volatile acids are so important to the success of any BPR system, the designer of a full scale implementation would be well advised to include provision for enhancing the production of volatile acids to be introduced into the anaerobic stages. This might be with a primary sludge fermentation system as used in the UNC system or by the "activated primary tank" described by Barnard (1984).

With the tankage available at the East Burlington Wastewater Treatment Plant, the A^2/O and/or modified UCT systems should be tested at full scale before committing to plant design. This testing should particularly be designed to confirm whether the volatile acids from the Zimpro™ regen stream are necessary to success of BPR. If, as demonstrated by this pilot study, they are not; the designer would have an additional amount of flexibility in the overall design parameters

The pilot study suggests that the potential for BPR at the East Burlington Wastewater Treatment Plant is so great that no additional phosphorus removal facilities should be required. If this is confirmed by subsequent plant-scale studies, the designer should make provisions for the addition of chemical removal of phosphorus after the present final clarifier. It should not be necessary to build this, however.

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APPENDIX A

TERMS AND DESCRIPTION OF ANALYSES

ALKALINITY - An unfiltered grab sample was collected from the clarifier. The staff at the East Burlington laboratory then titrated the sample using 0.1N H_2SO4 soon after collection. The method is No. 403 in Standard Methods. Data was reported as mg/L as $CaCO_3$.

AMMONIA - (AutoAnalyzer) - A grab sample was filtered through a Whatman GF/F filter immediately after collection, refrigerated, and analyzed within 24 hours. On occasion these samples were analyzed on the same day as collected. An automated salicylate-nitroprusside method developed for the Orion Scientific autoanalyzer was used for the analyses. Data is reported as mg/L as nitrogen.

$CBOD_5$ - An unfiltered grab sample was collected from the last aerated tank. The sample was settled and poured through a Reeve Angle 802 filter paper to remove large solids. The samples were refrigerated until they could be prepared for incubation and nitrification inhibited when ready to incubate. Incubation was for 5 days at 20 centigrade. The procedure followed the method in Standard Methods (No. 507).

BPR - An abbreviation for biological phosphorus removal.

ESTIMATED TOTAL EFFLUENT CONCENTRATION - The estimate of the effluent nutrient concentration is derived by adding to the dissolved nutrient concentration in the final aerated tank, the nutrient concentration contributed by an estimated concentration of effluent suspended solids. For the comparisons in this report an effluent suspended solids concentration of 30 mg/L was assumed for all systems. This represents the "worst case" estimate.

MCRT - Mean Cell Residence Time (Days). Calculated by dividing the volume of the mixed liquor wasted daily by the total mixed liquor volume (excluding the clarifier).

MLSS - Mixed Liquor Suspended Solids. A grab sample was collected from the last aerated tank of the system. The actual analyses were performed by the East Burlington laboratory staff. It was filtered and the filter + solids was dried at 105 centigrade and weighed, according to method 209.C in Standard Methods. Data is reported as mg/L.

APPENDIX A (CONTINUED)

NITRATE + NITRITE - (AutoAnalyzer) - A grab sample was filtered through a Whatman GF/F filter immediately after collection, refrigerated, and analyzed within 24 hours. On occasion these samples were analyzed on the same day as collected. The analysis was performed using a cadmium reduction method. Both EPA (1979) method 353.2 and Standard Methods method 418.F describe this method. Data reported as mg/L as nitrogen.

ORGANIC AND VOLATILE ACIDS - The East Burlington treatment plant laboratory used the extraction and chromatographic separation method for organic acids (Method 504.A) in Standard Methods (16th ed.).

ORTHOPHOSPHORUS - (AutoAnalyzer) - A grab sample was filtered through a Whatman GF/F filter immediately after collection, refrigerated, and analyzed within 24 hours. On occasion these samples were analyzed on the same day as collected. An ascorbic acid automated technique derived from EPA (1979) No. 365 and Standard Methods No. 424.G was used for this analysis. Data reported as mg/L as phosphorus.

TDKN - (Total Dissolved Kjeldahl Nitrogen) - A grab sample was filtered through a Whatman GF/F filter immediately after collection, and refrigerated. The sample was acidified to pH <2 after analysis for labile parameters. If it was analyzed within 7 days, the sample was stored in the refrigerator, otherwise it was frozen until analyzed. The sample was digested with an EPA (1979) mecuric oxide - potassium sulfate block digestor technique (No. 351.2) prior to analysis. Analysis was by a salicylate - nitroprusside automated method developed by Orion Scientific for use with their equipment. Data reported as mg/L as nitrogen.

TKN - (Total Kjeldahl Nitrogen) - An unfiltered grab sample was acidified to pH <2. If it was analyzed within 7 days, the sample was stored in the refrigerator, otherwise it was frozen until analyzed. The sample was digested with an EPA (1979) mecuric oxide - potassium sulfate block digestor technique (No. 351.2) prior to analysis. Analysis was by a salicylate - nitroprusside automated method developed by Orion Scientific for use with their equipment. Data reported as mg/L as nitrogen.

APPENDIX A (CONTINUED)

TDP - (Total Dissolved Phosphorus) - A grab sample was filtered through a Whatman GF/F filter immediately after collection, and refrigerated. The sample was acidified to pH <2 using H_2SO_4 after analysis for labile parameters. If it was not analyzed within 7 days, the sample was frozen until analyzed. The sample was digested with an EPA mecuric oxide - potassium sulfate block digestor technique prior to analysis. Analysis was by an ascorbic acid automated method derived from EPA (1979) method 365.4. Data reported as mg/L phosphorus.

TP - (Total Phosphorus) - An unfiltered grab sample was acidified to pH <2. If it was analyzed within 7 days the sample was stored in the refrigerator, otherwise it was frozen until analyzed. The sample was digested with an EPA mecuric oxide potassium sulfate block digestor technique prior to analysis. Analysis was by the ascorbic acid automated method used for TDP. Data reported as mg/L phosphorus.

TABLE B-1

OPERATION NOTES : BURLINGTON, N. C.
MARCH 1 - JUNE 19,1987

DATE	TRAILER OPERATIONS
03/03/87	System start-up for all pilots. All pilots seeded with waste solids from the York River wastewater treatment plant in the Hampton Roads Sanitation District.
03/05/87	Trailer influent pump broke down and was out of operation for approximately 4 hours.
03/09/87	Began sampling all pilot systems for nutrient removal performance.
03/11/87	Started feeding Zimpro regeneration effluent to all pilot systems (~70 mL/30 min).
03/15/87	Trailer influent pump broke down and was repaired within a few hours.
03/20/87	Seeded all pilot systems with ~5L of Burlington return sludge to improve nitrification. Reduced Zimpro effluent feed rate from ~70 mL/30 min to ~50 mL/30 min.
03/31/87	Switched over to house air supply.
04/03/87	Trailer influent hose leaking. Pump shut down momentarily while hose connections were tightened.
05/04/87	Trailer influent pump off for about 2 hours.
05/19/87	Trailer influent pump off for about 2 hours.
06/02/87	Trailer influent pump off for 1/2 hour.
06/05/87	Trailer influent pump off for less than 2 hours.

TABLE B - 2

INFLUENT TO ALL BPR PILOT PLANTS
(EAST BURLINGTON PRIMARY EFFLUENT)
MARCH 1 - JUNE 19, 1987

INFLUENT Date	BOD (mg/l)	SS (mg/l)	pH	ALKALINITY mg/L CaCO3	TKN (AA) (mg/l)	TDKN (AA) (mg/l)	TP (AA) (mg/l)	TDP (AA) (mg/l)	Ortho-P (AA) (mg/l)	NO3-N (AA) (mg/l)	NH3-N (AA) (mg/l)	INFL CBOD: TP	ZIMPRO VOL ACID (mg/L)
03/01/87													
03/02/87													
03/03/87													
03/04/87													
03/05/87													
03/06/87													
03/07/87													
03/08/87													
03/09/87	149	68	7.8	240					4.02	0.02	8.8		
03/10/87													
03/11/87	247	80	8.7	325	32	30	8.4	8.0	5.40	0.02	8.7	29	5928
03/12/87													
03/13/87	189	109	9.0	340					5.16	0.82	8.6		5736
03/14/87													
03/15/87													
03/16/87	129	48	7.6	250	44	35	7.2	5.7	4.35	0.09	8.0	18	6936
03/17/87													
03/18/87	199	80	9.2	290					5.59	0.12	7.6		6120
03/19/87													
03/20/87	160		8.2	340					4.21	0.02	7.0		5400
03/21/87													
03/22/87													
03/23/87	73		7.4	335	16	13	4.7	4.0	3.32	0.05	6.5	16	5376
03/24/87													
03/25/87	210		8.5	440					5.69	0.05	7.0		4464
03/26/87													
03/27/87	153		8.3	395					4.43	0.09	7.0		4848
03/28/87													
03/29/87													
03/30/87	83		7.6	320	18	14	4.6	3.7	3.83	0.02	8.1	18	5088
03/31/87													
04/01/87	179	140	8.4	400					4.00	0.02	6.1		3960
04/02/87													
04/03/87	128	155	8.1	400					3.63	0.10	7.1		4992
04/04/87													
04/05/87													
04/06/87	92	82	7.6	220					3.23	0.10	6.4		4752

TABLE B - 2 (continued)

INFLUENT TO ALL BPR PILOT PLANTS
(EAST BURLINGTON PRIMARY EFFLUENT)
MARCH 1 - JUNE 19, 1987

INFLUENT Date	BOD (mg/l)	SS (mg/l)	pH	ALKALINITY mg/L CaCO3	TKN (AA) (mg/l)	TDKN (AA) (mg/l)	TP (AA) (mg/l)	TDP (AA) (mg/l)	Ortho-P (AA) (mg/l)	NO3-N (AA) (mg/l)	NH3-N (AA) (mg/l)	INFL CBOD: TP	ZIMPRO VOL ACID (mg/L)
04/07/87													
04/08/87	219	227	8.7	370	24	18	7.0	5.6	4.40	0.07	6.1	31	4704
04/09/87													
04/10/87	112	83	7.8	325					4.50	0.22	5.6		4392
04/11/87													
04/12/87													
04/13/87	113	69	7.9	270	25	19	6.8	5.5	5.67	0.15	10.6	17	3984
04/14/87													
04/15/87	207	235	9.3	570					6.43	0.18	6.4		4632
04/16/87													
04/17/87	47	287	7.6	275					1.51	0.78	1.4		4944
04/18/87													
04/19/87													
04/20/87													
04/21/87													
04/22/87	178	123	7.7	310	51	19	14.8	6.1	4.65	0.08	7.3	12	4560
04/23/87													
04/24/87	110		8.0	320					5.55	0.03	7.2		4080
04/25/87													
04/26/87													
04/27/87	163	58	7.7	275	25	20	5.8	4.9	4.22	0.08	10.1	28	3984
04/28/87													
04/29/87	215	200	8.4	370					4.74	0.02	6.5		3696
04/30/87													
05/01/87	162	88	8.7	445					5.98		8.0		
05/02/87													
05/03/87													
05/04/87	140	77	7.6	335					5.03	0.13	9.3		
05/05/87													
05/06/87	197	188	8.1	375	26	21	7.9	6.7	5.82	0.03	7.9	25	
05/07/87													
05/08/87	186	128	8.0	365					5.37	0.09	9.0		
05/09/87													
05/10/87													
05/11/87	137	53	7.5	300					4.68	0.09	9.4		
05/12/87													
05/13/87	173	113	7.8	320					5.71	0.02	7.4		
05/14/87													
05/15/87	192	78	7.8	350	26	20	7.3	6.0	6.31	0.07	7.0	26	

TABLE B - 2 (continued)

INFLUENT TO ALL BPR PILOT PLANTS
(EAST BURLINGTON PRIMARY EFFLUENT)
MARCH 1 - JUNE 19, 1987

INFLUENT Date	BOD (mg/l)	SS (mg/l)	pH	ALKALINITY mg/L CaCO3	TKN (AA) (mg/l)	TDKN (AA) (mg/l)	TP (AA) (mg/l)	TDP (AA) (mg/l)	Ortho-P (AA) (mg/l)	NO3-N (AA) (mg/l)	NH3-N (AA) (mg/l)	INFL CBOD: TP	ZIMPRO VOL ACID (mg/L)
05/16/87													
05/17/87													
05/18/87	184	104	7.5	270					4.86	0.10	5.8		
05/19/87													
05/20/87	196	108	7.6	325	23	17	8.1	5.9	4.93	0.03	6.1	24	
05/21/87													
05/22/87	204	80	7.6	385					6.80	0.06	7.2		
05/23/87													
05/24/87													
05/25/87													
05/26/87													
05/27/87	90	97	7.6	280					5.40	0.12	7.0		4080
05/28/87													
05/29/87	129	137	7.8	330	24	19	6.3	5.3	5.09	0.06	8.8	21	3336
05/30/87													
05/31/87													
06/01/87	63		7.6	360					3.92	0.04	11.3		2136
06/02/87													
06/03/87	154	136	7.8	320					6.02	0.04	10.0		1152
06/04/87													
06/05/87	148	140	8.4	320	25	21	6.8	5.9	5.11	0.07	9.2	22	480
06/06/87													
06/07/87													
06/08/87	53	104	7.5	265					4.52	0.06	10.7		528
06/09/87													
06/10/87	155	190	7.5	345	28	21	7.8	5.4	4.98	0.01	8.2	20	4800
06/11/87													
06/12/87	182	77	7.9	430					7.17	0.02	9.7		6120
06/13/87													
06/14/87													
06/15/87	77	68	7.9	300					4.60	0.10	7.9		5280
06/16/87													
06/17/87	143	90	8.2	395					7.25	0.05	9.9		6432
06/18/87													
06/19/87													
06/20/87													

TABLE B - 2 (CONTINUED)

INFLUENT TO ALL BPR PILOT PLANTS
(EAST BURLINGTON PRIMARY EFFLUENT)
MARCH 1 - JUNE 19, 1987

INFLUENT Date	BOD (mg/l)	SS (mg/l)	pH	ALKALINITY mg/L CaCO3	TKN (AA) (mg/l)	TDKN (AA) (mg/l)	TP (AA) (mg/l)	TDP (AA) (mg/l)	Ortho-P (AA) (mg/l)	NO3-N (AA) (mg/l)	NH3-N (AA) (mg/l)	INFL CBOD: TP	ZIMPRO VOL ACID (mg/L)
AVERAGES													
TOTAL	150	117		338	28	21	7.4	5.6	5.0	0.1	7.8	22	4417
-BY MONTH-													
MARCH	159	77		328	28	23	6.2	5.4	4.6	0.1	7.7	20	5544
APRIL	147	151		342	31	19	8.6	5.5	4.4	0.2	6.7	22	4390
MAY	166	104		340	25	19	7.4	6.0	5.5	0.1	7.7	24	3708
JUNE	122	115		342	26	21	7.3	5.6	5.4	0.0	9.6	21	3366
MAXIMUM	247	287	9.3	570	51	35	15	8.0	7.3	0.8	11.3	31	6936
MINIMUM	47	48	7.4	220	16	13	4.6	3.7	1.5	0.0	1.4	12	480

TABLE B - 3

ZIMPRO FEED DATA

ZIMPRO Date	TKN (AA) (mg/l)	TDKN (AA) (mg/l)	TP (AA) (mg/l)	TDP (AA) (mg/l)	Ortho-P (AA) (mg/l)	NO3-N (AA) (mg/l)	NH3-N (AA) (mg/l)
03/20/87					65		998
03/30/87	4804	404	3544	45	42		
04/01/87					41	0.30	1162
04/06/87					22		1189
04/08/87	2667	1760	2154		45		1148
04/15/87					47		1121
04/22/87	2049	1880	1625	54	53		1236
06/10/87	2390	1970	1820		80	0.02	1390
06/15/87	2580	1930	3180		64		1278

TABLE C-1

OPERATION NOTES : BURLINGTON, N. C.
MARCH 1 - JUNE 19,1987

DATE	A^2/O PILOT SYSTEM
03/03/87	System start-up.
03/13/87	Zimpro effluent feed interrupted.
04/04/87	Air line feeding Tank #7 came loose twice with the loss of aeration and mixing.
04/13/87	Leak in Tank #1 with large spill of return sludge and influent.
04/17/87	Discontinued Zimpro feed to 1st anaerobic tank.
04/20/87	Large spill of return sludge and influent from 1st anaerobic tank.
05/20/87	Increased wasting rate.
05/28/87	Increased wasting rate.
06/11/87	Tygon tubes clogging between tanks.
06/13/87	Tygon tubes clogging between tanks, causing overflow from Tank #3.

TABLE C -2

A2/O PILOT PLANT OPERATIONS LOG

DATE 1987 MNTH/DAY	FLOATING SLUDGE? Y/N, SOME?	FINAL TANK MIXER OK? YES/NO	SLUDGE BLNKT DPTH (inches)	TEMP DEGREES oC	ANAEROBIC MIXERS OK? YES/NO	MLSS SETTLEABL ML/L/30M	PUMPS OK? INFLUENT Y/N	RET SLDGE Y/N	SLDG FD Y/N	WASTE ML Y/N
03/01/87										
03/02/87										
03/03/87										
03/04/87										
03/05/87	NO	YES	5	20	YES	350	Y	Y	Y	Y
03/06/87	NO	YES	6	20	YES	370	Y	Y	Y	Y
03/07/87	NO	YES	6	20	YES	380	Y	Y	Y	Y
03/08/87	NO	YES	5	18	YES	350	Y	Y	Y	Y
03/09/87	NO	YES	6	19	YES	340	Y	Y	Y	Y
03/10/87	NO	YES	8	15	YES	330	Y	Y	Y	Y
03/11/87	NO	YES	8	14	YES	300	Y	Y	Y	Y
03/12/87	NO	YES	5	17	YES	350	Y	Y	Y	Y
03/13/87	NO	YES	7	18	YES	370	Y	Y	Y	Y
03/14/87	NO	YES	4	15	YES	370	Y	Y	Y	Y
03/15/87	NO	YES	5	15	YES	335	Y	Y	Y	Y
03/16/87	NO	YES	6	15	YES	320	Y	Y	Y	Y
03/17/87	NO	YES	6	15	YES	300	Y	Y	Y	Y
03/18/87	NO	YES	6	17	YES	310	Y	Y	Y	Y
03/19/87	NO	YES	5	20	YES	305	Y	Y	Y	Y
03/20/87	TRACE	YES	5	19	YES	280	Y	Y	Y	Y
03/21/87	NO	YES	5	17	YES	330	Y	Y	Y	Y
03/22/87	NO	YES	4	17	YES	320	Y	Y	Y	Y
03/23/87	NO	YES	6	18	YES	310	Y	Y	Y	Y
03/24/87	NO	YES	5	19	YES	320	Y	Y	Y	Y
03/25/87	NO	YES	6	21	YES	320	Y	Y	Y	Y
03/26/87	NO	YES	5	21	YES	320	Y	Y	Y	Y
03/27/87	TRACE	YES	7	20	YES	310	Y	Y	Y	Y
03/28/87	NO	YES	6	21	YES	300	Y	Y	Y	Y
03/29/87	TRACE	YES	8	19	YES	320	Y	Y	Y	Y
03/30/87	SOME	YES	5	19	YES	300	Y	Y	Y	Y
03/31/87	NO	YES	3	21	YES	305	Y	Y	Y	Y
04/01/87	TRACE	YES	5	17	YES	300	Y	Y	Y	Y
04/02/87	SOME	YES	5	22	YES	290	Y	Y	Y	Y
04/03/87	NO	YES	5	19	YES	300	Y	Y	Y	Y
04/04/87	TRACE	YES	7	17	YES	330	Y	Y	Y	Y
04/05/87	NO	YES	6	14	YES	295	Y	Y	Y	Y
04/06/87	NO	YES	5	15	YES	295	Y	Y	Y	Y
04/07/87	NO	YES	2	20	YES	280	Y	Y	Y	Y
04/08/87	NO	YES	5	19	YES	320	Y	Y	Y	Y

TABLE C -2 (continued)

A2/O PILOT PLANT OPERATIONS LOG

DATE 1987 MNTH/DAY	FLOATING SLUDGE? Y/N, SOME?	FINAL TANK MIXER OK? YES/NO	SLUDGE BLNKT DPTH (inches)	TEMP DEGREES oC	ANAEROBIC MIXERS OK? YES/NO	MLSS SETTLEABL ML/L/30M	PUMPS OK? INFLUENT Y/N	RET SLDGE Y/N	SLDG FD Y/N	WASTE ML Y/N
04/09/87	NO	YES	5	18	YES	330	Y	Y	Y	Y
04/10/87	NO	YES	6	21	YES	340	Y	Y	Y	Y
04/11/87	NO	YES	5	17	YES	330	Y	Y	Y	Y
04/12/87	SOME	YES	5	17	YES	340	Y	Y	Y	Y
04/13/87	NO	YES	6	17	YES	320	Y	Y	Y	Y
04/14/87	NO	YES	7	18	YES	270	Y	Y	Y	Y
04/15/87	NO	YES	6	20	YES	290	Y	Y	Y	Y
04/16/87	NO	YES	5	18	YES	280	Y	Y	Y	Y
04/17/87	NO	YES		16	YES	320	Y	Y	Y	Y
04/18/87	SOME	YES		17	YES	300	Y	Y	Y	Y
04/19/87	SOME	YES	5	18	YES	300	Y	Y	Y	Y
04/20/87	YES	YES	5	20	YES	270	Y	Y	Y	Y
04/21/87	SOME	YES	3	22	YES	240	Y	Y	Y	Y
04/22/87	TRACE	YES	5	20	YES	290	Y	Y	Y	Y
04/23/87	SOME	YES	5	22	YES	275	Y	Y	Y	Y
04/24/87	SOME	YES	6	23	YES	290	Y	Y	Y	Y
04/25/87	NO	YES	5	17	YES	285	Y	Y	Y	Y
04/26/87	NO	YES	5	16	YES	320	Y	Y	Y	Y
04/27/87	TRACE	YES	9	14	YES	210	Y	Y	Y	Y
04/28/87	SOME	YES	6	20	YES	350	Y	Y	Y	Y
04/29/87	NO	YES	7	16	YES	550	Y	Y	Y	Y
04/30/87	NO	YES	4	26	YES	290	Y	Y	Y	Y
05/01/87	NO	YES	5	20	YES	360	Y	Y	Y	Y
05/02/87	NO	YES	11	21	YES	640	Y	Y	Y	Y
05/03/87	NO	YES	11	20	YES	360	Y	Y	Y	Y
05/04/87	NO	YES	10	20	YES	720	Y	Y	Y	Y
05/05/87	NO	YES	9	17	YES	435	Y	Y	Y	Y
05/06/87	NO	YES	10	17	YES	790	Y	Y	Y	Y
05/07/87	NO	YES	10	20	YES	720	Y	Y	Y	Y
05/08/87	NO	YES	9	22	YES	690	Y	Y	Y	Y
05/09/87	NO	YES	10	18	YES	350	Y	Y	Y	Y
05/10/87	NO	YES	11	20	YES	430	Y	Y	Y	Y
05/11/87	NO	YES	8	22	YES	290	Y	Y	Y	Y
05/12/87	NO	YES	10	21	YES	370	Y	Y	Y	Y
05/13/87	NO	YES	8	22	YES	630	Y	Y	Y	Y
05/14/87	NO	YES	8	23	YES	525	Y	Y	Y	Y
05/15/87	NO	YES	6	21	YES	360	Y	Y	Y	Y
05/16/87	NO	YES	5	23	YES	310	Y	Y	Y	Y
05/17/87	NO	YES	5	21	YES	470	Y	Y	Y	Y

TABLE C -2 (continued)

A2/O PILOT PLANT OPERATIONS LOG

DATE 1987 MNTH/DAY	FLOATING SLUDGE? Y/N, SOME?	FINAL TANK MIXER OK? YES/NO	SLUDGE BLNKT DPTH (inches)	TEMP DEGREES oC	ANAEROBIC MIXERS OK? YES/NO	MLSS SETTLEABL ML/L/30M	PUMPS OK? INFLUENT Y/N	RET SLDGE Y/N	SLDG FD Y/N	WASTE ML Y/N
05/18/87	NO	YES	10	22	YES	360	Y	Y	Y	Y
05/19/87	TRACE	YES	2	20	YES	360	Y	Y	Y	Y
05/20/87	NO	YES	8	22	YES	370	Y	Y	Y	Y
05/21/87	NO	YES	12	21	YES	370	Y	Y	Y	Y
05/22/87	NO	YES	8	22	YES	380	Y	Y	Y	Y
05/23/87	NO	YES	8	24	YES	320	Y	Y	Y	Y
05/24/87	NO	YES	11	23	YES	300	Y	Y	Y	Y
05/25/87	NO	YES	8	23	YES	240	Y	Y	Y	Y
05/26/87	NO	YES	7	20	YES	260	Y	Y	Y	Y
05/27/87	NO	YES	10	21	YES	250	Y	Y	Y	Y
05/28/87	NO	YES	6	23	YES	280	Y	Y	Y	Y
05/29/87	NO	YES	7	21	YES	280	Y	Y	Y	Y
05/30/87	NO	YES	5	21	YES	260	Y	Y	Y	Y
05/31/87	NO	YES	6	21	YES	240	Y	Y	Y	Y
06/01/87	NO	YES	3	20	YES	220	Y	Y	Y	Y
06/02/87	NO	YES	4	24	YES	190	Y	Y	Y	Y
06/03/87	NO	YES	5	22	YES	190	Y	Y	Y	Y
06/04/87	NO	YES	1	21	YES	170	Y	Y	Y	Y
06/05/87	NO	YES	10	21	YES	130	Y	Y	Y	Y
06/06/87	NO	YES	4	22	YES	160	Y	Y	Y	Y
06/07/87	NO	YES	4	22	YES	150	Y	Y	Y	Y
06/08/87	NO	YES	2	21	YES	140	Y	Y	Y	Y
06/09/87	NO	YES	5	22	YES	140	Y	Y	Y	Y
06/10/87	NO	YES	3	21	YES	130	Y	Y	Y	Y
06/11/87	NO	YES	1	21	YES	150	Y	Y	Y	Y
06/12/87	NO	YES	2	22	YES	120	Y	Y	Y	Y

TABLE C -2 (continued)

A2/O PILOT PLANT OPERATIONS LOG

DATE 1987 MNTH/DAY	FLOW RATES (ML) INFLUENT ML/MIN	RET SLDGE ML/MIN	RECYCLE ML/MIN	ZIMPRO ML/30MIN	WASTE ML ML/30MIN	DISSOLVED OXYGEN MG/L TANK 1	TANK 2	TANK 3	TANK 4	MCRT (DAYS)
03/01/87										
03/02/87										
03/03/87										
03/04/87										
03/05/87	206	190	110		260	1.2	1.0	3.3	2.6	8.7
03/06/87	195	100	110		100	0.8	0.8	3.5	3.1	22.5
03/07/87	195	100	105		140	2.1	3.9	4.3	3.5	16.1
03/08/87	200	100	110		265	4.5	5.9	6.6	6.0	8.5
03/09/87	195	100	105		245	3.8	5.6	6.0	5.3	9.2
03/10/87	195	95	100	70	250	3.9	4.0	3.9	4.2	9.0
03/11/87	195	95	100		250	3.8	4.0	3.9	4.1	9.0
03/12/87	180	95	100		270	0.8	0.8	0.5	0.5	8.3
03/13/87	180	95	100		270	0.6	0.2	0.3	0.2	8.3
03/14/87	195	90	100		230	3.5	2.5	4.6	5.4	9.8
03/15/87	180	90	90		235	6.0	5.0	4.7	5.3	9.6
03/16/87	180	95	110		240	7.5	7.8	6.2	6.5	9.4
03/17/87	220	90	110		230	1.6	4.9	4.9	5.0	9.8
03/18/87	200	100	110		245	0.9	2.4	1.6	3.8	9.2
03/19/87	205	95	115		245	0.3	1.8	0.8	5.3	9.2
03/20/87	200	95	115	50	250	0.3	2.1	4.4	5.2	9.0
03/21/87	205	100	105		225	0.4	3.1	4.2	5.3	10.0
03/22/87	195	80	105		220	2.8	5.8	6.7	7.3	10.2
03/23/87	195	85	100		240	2.1	5.4	6.5	7.0	9.4
03/24/87	220	100	110		265	1.4	2.3	3.2	4.1	8.5
03/25/87	195	90	100	40	265	0.5	0.7	2.0	3.3	8.5
03/26/87	195	95	100		230	0.3	0.3	0.5	0.6	9.8
03/27/87	200	90	100	45	235	0.3	0.4	4.3	3.6	9.6
03/28/87	205	85	100		230	0.4	2.1	5.2	4.3	9.8
03/29/87	205	90	100		230	1.7	2.1	4.7	4.1	9.8
03/30/87	200	90	100	40	230	2.1	4.2	6.0	5.5	9.8
03/31/87	205	70	95		235	1.8	2.1	4.6	2.1	9.6
04/01/87	200	85	100	40	225	3.2	6.3	6.8	6.9	10.0
04/02/87	200	85	100		225	1.8	5.0	5.3	5.6	10.0
04/03/87	200	85	100	42	225	2.9	6.0	6.3	6.4	10.0
04/04/87	185	85	95		220	4.0	4.4	5.1	5.8	10.2
04/05/87	185	85	95		225	4.7	7.0	7.2	6.5	10.0
04/06/87	190	90	95	40	225	5.4	6.4	6.7	6.5	10.0
04/07/87	210	85	100		215	3.2	4.1	5.4	4.6	10.5
04/08/87	200	85	95	40	230	2.0	3.3	4.2	4.1	9.8

TABLE C -2 (continued)

A2/O PILOT PLANT OPERATIONS LOG

DATE	FLOW RATES (ML)					DISSOLVED OXYGEN MG/L				MCRT
1987 MNTH/DAY	INFLUENT ML/MIN	RET SLDGE ML/MIN	RECYCLE ML/MIN	ZIMPRO ML/30MIN	WASTE ML ML/30MIN	TANK 1	TANK 2	TANK 3	TANK 4	(DAYS)
04/09/87	200	80	95		235	2.4	4.3	5.7	5.3	9.6
04/10/87	190	95	100	38	235	3.9	5.5	6.7	6.3	9.6
04/11/87	185	80	95		240	3.1	4.6	5.1	5.1	9.4
04/12/87	185	85	95		240	3.9	5.4	6.1	6.0	9.4
04/13/87	185	85	95	41	235	3.8	5.5	5.7	5.5	9.6
04/14/87	185	90	95		235	4.1	5.7	6.0	6.1	9.6
04/15/87	190	85	100	48	235	3.8	4.9	4.8	5.3	9.6
04/16/87	190	95	95		230	5.9	6.7	6.8	6.7	9.8
04/17/87	185	85	95	40	225	6.6	6.9	6.7	6.5	10.0
04/18/87	195	90	115		220	6.7	8.0	7.7	7.7	10.2
04/19/87	190	90	110		240	6.8	7.8	7.5	7.5	9.4
04/20/87	205	95	115		235	6.7	7.9	7.4	7.3	9.6
04/21/87	210	100	95		230	4.8	4.9	4.5	4.7	9.8
04/22/87	215	100	115		245	3.1	2.3	0.3	0.0	9.2
04/23/87	210	95	110		240	5.6	6.1	7.1	6.9	9.4
04/24/87	205	100	110		240	5.3	6.1	7.1	6.9	9.4
04/25/87	195	95	110		235	7.1	7.5	8.1	8.3	9.6
04/26/87	200	95	105		230	4.2	5.3	7.5	7.2	9.8
04/27/87	200	100	105		230	6.4	7.1	8.0	8.0	9.8
04/28/87	205	100	90		240	4.1	4.9	5.8	5.6	9.4
04/29/87	200	95	100		235	2.7	4.0	5.2	4.7	9.6
04/30/87	200	100	110		235	3.2	4.1	5.2	4.4	9.6
05/01/87	200	100	110		240	1.7	2.8	4.4	4.7	9.4
05/02/87	205	95	105		235	1.8	3.3	5.0	4.7	9.6
05/03/87	205	100	105		260	2.6	4.4	5.6	5.0	8.7
05/04/87	205	100	105		260	3.6	5.2	6.4	6.1	8.7
05/05/87	205	100	110		235	4.3	5.4	6.4	6.2	9.6
05/06/87	200	100	105		240	2.4	3.6	5.0	4.3	9.4
05/07/87	195	100	110		240	1.6	3.3	4.8	4.6	9.4
05/08/87	200	100	110		265	1.7	3.2	5.1	4.4	8.5
05/09/87	200	100	110		250	3.9	4.4	5.6	5.4	9.0
05/10/87	205	100	110		250	4.4	5.3	6.1	5.8	9.0
05/11/87	200	105	105		260	4.0	5.1	6.2	5.7	8.7
05/12/87	195	95	100		230	1.9	3.3	3.7	3.2	9.8
05/13/87	200	100	100		245	2.0	3.4	3.5	3.0	9.2
05/14/87	185	95	105		240	0.6	1.1	1.0	0.4	9.4
05/15/87	200	100	100		245	6.5	5.4	5.7	6.0	9.2
05/16/87	195	95	115		230	6.6	5.3	5.4	4.4	9.8
05/17/87	190	100	110		235	7.5	6.6	6.9	5.8	9.6

TABLE C -2 (continued)

A2/O PILOT PLANT OPERATIONS LOG

DATE	FLOW RATES (ML)					DISSOLVED OXYGEN MG/L				MCRT
1987 MNTH/DAY	INFLUENT ML/MIN	RET SLDGE ML/MIN	RECYCLE ML/MIN	ZIMPRO ML/30MIN	WASTE ML ML/30MIN	TANK 1	TANK 2	TANK 3	TANK 4	(DAYS)
05/18/87	195	95	115		245	5.7	5.2	5.7	5.0	9.2
05/19/87	185	100	115		240	7.6	7.2	7.1	5.5	9.4
05/20/87	190	100	115		265	6.7	6.0	6.1	4.5	8.5
05/21/87	195	100	115		270	7.7	6.2	6.4	4.3	8.3
05/22/87	195	100	100		270	6.1	5.1	5.3	0.8	8.3
05/23/87	195	100	105		270	5.9	4.8	5.1	3.4	8.3
05/24/87	200	100	115		285	6.4	5.6	5.9	4.5	7.9
05/25/87	200	95	110		270	5.8	4.6	5.1	3.6	8.3
05/26/87	200	100	115		270	6.5	5.4	5.9	4.0	8.3
05/27/87	200	95	110		270	5.1	4.0	4.1	2.1	8.3
05/28/87	190	95	110		270	6.1	5.1	5.4	3.2	8.3
05/29/87	200	100	115		350	5.5	4.7	5.2	3.8	6.4
05/30/87	190	100	110		350	6.6	5.7	6.2	4.9	6.4
05/31/87	190	95	115		340	6.6	6.2	6.3	5.6	6.6
06/01/87	205	100	115		360	6.6	6.3	6.7	6.0	6.3
06/02/87	195	95	110		375	6.8	5.1	5.4	3.7	6.0
06/03/87	205	100	110		365	6.9	5.5	5.9	4.4	6.2
06/04/87	205	105	95		350	6.0	5.2	5.6	3.8	6.4
06/05/87	205	100	105		355	5.9	4.9	5.4	4.0	6.3
06/06/87	205	105	115		350	6.4	5.5	5.9	4.8	6.4
06/07/87	200	100	115		350	6.6	5.8	5.9	4.8	6.4
06/08/87	200	100	115		355	7.0	5.7	6.6	6.0	6.3
06/09/87	200	100	115		360	6.0	4.2	4.8	3.1	6.3
06/10/87	200	110	110		340	6.7	5.0	6.2	4.4	6.6
06/11/87	210	110	120		440	7.2	5.1	6.0	3.8	5.1
06/12/87	200	100	100		360	6.0	3.7	4.1	2.0	6.3

TABLE C - 3

DATA FROM THE A2/O PILOT PLANT FINAL AERATED TANK
MARCH 9 - JUNE 12, 1987

TNK 10 AER Date	BOD (mg/l)	MLSS (mg/l)	MLVSS (mg/l)	TKN (AA) (mg/l)	TDKN (AA) (mg/l)	TP (AA) (mg/l)	TDP (AA) (mg/l)	Ortho-P (AA) (mg/l)	NO3-N (AA) (mg/l)	NH3-N (AA) (mg/l)	% P in MIX LIQ SOLIDS	FILTBLE NITROGEN (mg/L)
03/01/87												
03/02/87												
03/03/87												
03/04/87												
03/05/87												
03/06/87												
03/07/87												
03/08/87												
03/09/87	90	3040	2290					0.04	0.50	9.8		
03/10/87												
03/11/87	36	3170	2370	254	12	115	1.0	1.00	0.13	3.9	3.6%	12.4
03/12/87												
03/13/87	35	5130	3140					0.72	0.05	20		
03/14/87												
03/15/87												
03/16/87	10	5220	3120	166	29	95	0.2	0.22	0.30	26	1.8%	29.6
03/17/87												
03/18/87	28	5580	3380					1.05	0.14	24		
03/19/87												
03/20/87	25	5520	3380					0.29	0.38	22		
03/21/87												
03/22/87												
03/23/87	9	6570	3730	188	20	112	0.1	0.09	2.7	16	1.7%	23.1
03/24/87												
03/25/87	13	6380	3660					0.24	2.2	12.9		
03/26/87												
03/27/87	13	6940	3970					0.24	1.8	12.5		
03/28/87												
03/29/87												
03/30/87	7	6420	3530	353	9.2	221	0.02	0.02	10.5	4.87	3.4%	19.7
03/31/87												
04/01/87	21	6520	3600					0.04	6.3	2.92		
04/02/87												
04/03/87	9	6650	3620					0.24	10.2	0.46		
04/04/87												
04/05/87												
04/06/87	6	6910						0.80	11.3	0.7		
04/07/87												

TABLE C - 3 (continued)

DATA FROM THE A2/O PILOT PLANT FINAL AERATED TANK
MARCH 9 - JUNE 12, 1987

TNK 10 AER Date	BOD (mg/l)	MLSS (mg/l)	MLVSS (mg/l)	TKN (AA) (mg/l)	TDKN (AA) (mg/l)	TP (AA) (mg/l)	TDP (AA) (mg/l)	Ortho-P (AA) (mg/l)	NO3-N (AA) (mg/l)	NH3-N (AA) (mg/l)	% P in MIX LIQ SOLIDS	FILTBLE NITROGEN (mg/L)
04/08/87	15	7780	4090	320	8.4	254	0.6	0.64	9.5	0.1	3.3%	17.9
04/09/87												
04/10/87	9	8260	4150					0.13	9.2	0.1		
04/11/87												
04/12/87												
04/13/87	7	8320	4190	326	5.2	264	0.2	0.34	12.7	0.2	3.2%	17.9
04/14/87												
04/15/87	19	6620	3400					0.46	8.4	0.2		
04/16/87												
04/17/87	10	6790	3500					0.05	8.5	0.1		
04/18/87												
04/19/87												
04/20/87												
04/21/87												
04/22/87	7	4580	2490	251	5.9	156	0.5	0.22	2.43	0.1	3.4%	8.4
04/23/87												
04/24/87	3	4600	2660					0.20	1.39	0.1		
04/25/87												
04/26/87												
04/27/87	4	4350	2690	267	4.2	144	0.2	0.17	2.76	0.1	3.3%	6.9
04/28/87												
04/29/87	10	5350	3340					0.41	1.3	0.1		
04/30/87												
05/01/87	4	4360	2790					0.07		0.2		
05/02/87												
05/03/87												
05/04/87	3	4290	2950					0.02	2.4	0.1		
05/05/87												
05/06/87	8	4730	3160	362	7.1	178	0.3	0.29	1.2	0.0	3.8%	8.3
05/07/87												
05/08/87	6	4930	3330					0.18	1.2	0.1		1.2
05/09/87												
05/10/87												
05/11/87	4	3970	2780					0.11	4.8	0.1		4.8
05/12/87												
05/13/87	5	4730	3230					0.02	1.7	0.1		1.7
05/14/87												
05/15/87	4	4860	3380	358	6.5	166	0.2	0.08	2.0	0.1	3.4%	8.5
05/16/87												
05/17/87												

TABLE C - 3 (continued)

DATA FROM THE A2/O PILOT PLANT FINAL AERATED TANK
MARCH 9 - JUNE 12, 1987

TNK 10 AER Date	BOD (mg/l)	MLSS (mg/l)	MLVSS (mg/l)	TKN (AA) (mg/l)	TDKN (AA) (mg/l)	TP (AA) (mg/l)	TDP (AA) (mg/l)	Ortho-P (AA) (mg/l)	NO3-N (AA) (mg/l)	NH3-N (AA) (mg/l)	% P in MIX LIQ SOLIDS	FILTBLE NITROGEN (mg/L)
05/18/87	4	4640	3320					0.02	4.1	0.1		4.1
05/19/87												
05/20/87	6	4660	3290	278	5.7	156	0.5	0.20	2.0	0.1	3.3%	7.8
05/21/87												
05/22/87	5	4890	3530					0.14	1.3	0.0		
05/23/87												
05/24/87												
05/25/87												
05/26/87												
05/27/87	17	3970	2990					0.25	2.2	0.1		
05/28/87												
05/29/87	6	4570	3270	309	5.2	148	0.4	0.21	3.1	0.0	3.2%	8.2
05/30/87												
05/31/87												
06/01/87	5	3630	2540					1.24	4.9	0.1		
06/02/87												
06/03/87	9	3480	2550					0.38	2.6	0.1		
06/04/87												
06/05/87	3	3530	2500	218	6.1	114	0.4	0.28	3.4	0.2	3.2%	9.4
06/06/87												
06/07/87												
06/08/87	3	2990	2070					3.41	5.0	0.1		
06/09/87												
06/10/87	10	3200	2090	178	8.5	96	1.7	1.40	3.7	0.1	3.0%	12.2
06/11/87												
06/12/87	5	3560	2430					0.88	3.4	0.0		
06/13/87												
MONTHLY AVERAGE												
MARCH	27	5397	3257	240	18	136	0.3	0.4	1.9	15	2.6%	21
APRIL	10	6394	3430	291	6	205	0.4	0.3	7.0	0.4	3.3%	13
MAY	6	4550	3168	327	6	162	0.3	0.1	2.4	0.1	3.4%	6
JUNE	6	3398	2363	198	7	105	1.0	1.3	3.8	0.1	3.1%	11
MAXIMUM	90	8320	4190	362	29	264	1.7	3.4	12.7	26	3.8%	30
MINIMUM	3	2990	2070	166	4	95	0.0	0.0	0.1	0.0	1.7%	1
AVG (TOTAL)	12	5142	3141	273	10	158	0.4	0.4	3.9	3.9	3.1%	11

TABLE C - 4

A2/O PILOT PLANT ANAEROBIC, EFFLUENT, AND OPERATIONS DATA
MARCH 9 - JUNE 12, 1987

TNK 3 ANA Date	TDKN (AA) (mg/l)	TDP (AA) (mg/l)	Ortho-P (AA) (mg/l)	NO3-N (AA) (mg/l)	NH3-N (AA) (mg/l)	EFFLUENT VALUES Alkalinity (mg/l)	pH	TSS (mg/l)	SLUDGE VOLUME INDEX	FOOD: MASS RATIO
03/01/87										
03/02/87										
03/03/87										
03/04/87										
03/05/87										
03/06/87										
03/07/87										
03/08/87										
03/09/87			27	0.02	10.2	160	7.4	45	112	0.17
03/10/87										
03/11/87	21	57	42	0.02	9.4	260	7.8	58	95	0.28
03/12/87										
03/13/87			48	0.02	24	350	7.5	360	72	0.16
03/14/87										
03/15/87										
03/16/87	42	43	43	0.05	29	250	7.6	433	61	0.11
03/17/87										
03/18/87			54	0.02	25	375	7.6	467	56	0.16
03/19/87										
03/20/87			56	0.05	25	300	7.7	453	51	0.13
03/21/87										
03/22/87										
03/23/87	29	40	40	0.05	20	195	7.5	327	47	0.05
03/24/87										
03/25/87			53	0.07	18	395	7.6	389	50	0.15
03/26/87										
03/27/87			50	0.02	18	370	7.8	260	45	0.10
03/28/87										
03/29/87										
03/30/87	24	30	30	0.02	14.8	200	7.6	200	47	0.06
03/31/87										
04/01/87			46	0.02	12.0	325	7.9	240	46	0.13
04/02/87										
04/03/87			39	0.02	12.8	300	7.7	130	45	0.09
04/04/87										
04/05/87										
04/06/87			28	0.02	12.9	135	7.5	452	43	
04/07/87										

TABLE C - 4 (continued)

A2/O PILOT PLANT ANAEROBIC, EFFLUENT, AND OPERATIONS DATA
MARCH 9 - JUNE 12, 1987

TNK 3 ANA						EFFLUENT VALUES				
Date	TDKN (AA) (mg/l)	TDP (AA) (mg/l)	Ortho-P (AA) (mg/l)	NO3-N (AA) (mg/l)	NH3-N (AA) (mg/l)	Alkalinity (mg/l)	pH	TSS (mg/l)	SLUDGE VOLUME INDEX	FOOD: MASS RATIO
04/07/87										
04/08/87	24	40	40	0.11	12.3	345	7.7	330	41	0.14
04/09/87										
04/10/87			45	0.05	12.1	300	7.8	347	41	0.07
04/11/87										
04/12/87										
04/13/87	27	35	35	0.09	14.0	175	7.3	373	38	0.07
04/14/87										
04/15/87			59	0.08	13.0	475	7.9	280	44	0.16
04/16/87										
04/17/87			19	0.02	8.9	135	7.7	293	47	0.04
04/18/87										
04/19/87										
04/20/87										
04/21/87										
04/22/87	15	39	38	0.03	5.7	240	7.7	63	63	0.19
04/23/87										
04/24/87			50	0.06	5.5	250	8.0	48	63	0.11
04/25/87										
04/26/87										
04/27/87	14	30	30	0.07	5.4	195	7.6	43	48	0.16
04/28/87										
04/29/87			39	0.10	5.7	345	7.9	71	103	0.17
04/30/87										
05/01/87			44		6.6	340	8.0	24	83	0.15
05/02/87										
05/03/87										
05/04/87			36	0.05	6.6	210	7.6	12	168	0.13
05/05/87										
05/06/87	18	49	47	0.03	6.4	390	7.8	56	167	0.17
05/07/87										
05/08/87			40	0.05	6.8	375	7.8	21	140	0.15
05/09/87										
05/10/87										
05/11/87			21	0.06	8.1	170	7.6	22	73	0.13
05/12/87										
05/13/87			47	0.02	5.0	350	7.7	48	133	0.14
05/14/87										
05/15/87	14.9	40	41	0.03	5.6	275	8.1	184	74	0.15
05/16/87										

TABLE C - 4 (continued)

A2/O PILOT PLANT ANAEROBIC, EFFLUENT, AND OPERATIONS DATA
MARCH 9 - JUNE 12, 1987

TNK 3 ANA Date	TDKN (AA) (mg/l)	TDP (AA) (mg/l)	Ortho-P (AA) (mg/l)	NO3-N (AA) (mg/l)	NH3-N (AA) (mg/l)	EFFLUENT VALUES Alkalinity (mg/l)	pH	TSS (mg/l)	SLUDGE VOLUME INDEX	FOOD: MASS RATIO
05/17/87										
05/18/87			41	0.02	9.0	200	7.4	38	78	0.15
05/19/87										
05/20/87	14.4	44	44	0.05	5.1	255	7.7	20	79	0.16
05/21/87										
05/22/87			47	0.02	6.3	285	7.7	12	78	0.15
05/23/87										
05/24/87										
05/25/87										
05/26/87										
05/27/87			38	0.03	6.3	275	7.5	42	63	0.08
05/28/87										
05/29/87	17.1	43	43	0.03	8.3	275	7.6	22	61	0.11
05/30/87										
05/31/87										
06/01/87			25	0.02	7.5	205	7.6	30	61	0.07
06/02/87										
06/03/87			39	0.06	8.7	285	7.7	10	55	0.16
06/04/87										
06/05/87	17.3	32	31	0.05	8.0	265	7.7	32	37	0.16
06/06/87										
06/07/87										
06/08/87			23	0.01	9.3	180	7.7	24	47	0.07
06/09/87										
06/10/87	22.0	39	38	0.02	8.4	255	7.8	26	41	0.20
06/11/87										
06/12/87			40	0.02	8.0	315	7.8	20	34	0.20
06/13/87										
MONTHLY AVERAGE										
MARCH	29	43	44	0.03	19	286		299	63	0.14
APRIL	20	36	39	0.06	10	268		223	52	0.12
MAY	16	44	41	0.04	7	283		42	100	0.14
JUNE	20	36	32	0.03	8	251		24	46	0.14
MAXIMUM	42	57	59	0.11	29	475	8	467	168	0.28
MINIMUM	14	30	19	0.01	5	135	7	10	34	0.04
AVG (TOTAL)	21	40	40	0.04	11	275	8	158	68	0.13

TABLE D-1

OPERATION NOTES : BURLINGTON, N. C.
MARCH 1 - JUNE 19,1987

DATE	UCT PILOT SYSTEM
03/03/87	System start-up.
03/23/87	Return sludge hose out of place spilling sludge onto counter top.
04/08/87	Mixer arm for Tank #3 and system clarifier disconnected.
04/17/87	Discontinued Zimpro feed to 1st anaerobic tank.
04/26/87	Leak in system.
04/27/87	Leak in system.
05/04/87	Tygon tubes connecting tanks underneath clogged.
05/08/87	Mixer in Tank #5 off.
05/11/87	Recycle pump off for about 9 hours. Replaced.
05/20/87	Increased wasting rate.
05/28/87	Increased wasting rate.
06/01/87	Pipe for influent and recycle flow into anaerobic tank clogged. Influent and recycle spilling onto floor.
06/09/87	Tygon tubes clogging between tanks.
06/10/87	Tygon tubes clogging between tanks. Found screw nut from pump head assembly inside tube between Tanks #8 & 9.
06/11/87	Tygon tubes clogging between tanks.

TABLE D - 2

UCT PILOT PLANT OPERATIONS LOG

DATE 1987 MNTH/DAY	FLOATING SLUDGE? Y/N, SOME?	FINAL TANK MIXER OK? YES/NO	SLUDGE BLNKT DPTH (inches)	TEMP DEGREES oC	ANAEROBIC MIXERS OK? YES/NO	MLSS SETTLEABL ML/L/30M	PUMPS OK? INFLUENT Y/N	RET SLDGE Y/N	SLDG FD Y/N	WASTE ML Y/N
03/01/87										
03/02/87										
03/03/87										
03/04/87										
03/05/87	NO	YES	10	20	YES	360	Y	Y	Y	Y
03/06/87	NO	YES	6	20	YES	390	Y	Y	Y	Y
03/07/87	NO	YES	7	20	YES	460	Y	Y	Y	Y
03/08/87	NO	YES	9	18	YES	390	Y	Y	Y	Y
03/09/87	NO	YES	10	19	YES	370	Y	Y	Y	Y
03/10/87	NO	YES	10	14	YES	370	Y	Y	Y	Y
03/11/87	NO	YES	8	13	YES	340	Y	Y	Y	Y
03/12/87	NO	YES	6	16	YES	400	Y	Y	Y	Y
03/13/87	NO	YES	7	17	YES	410	Y	Y	Y	Y
03/14/87	NO	YES	7	16	YES	390	Y	Y	Y	Y
03/15/87	NO	YES	7	15	YES	380	Y	Y	Y	Y
03/16/87	NO	YES	8	16	YES	330	Y	Y	Y	Y
03/17/87	NO	YES	8	15	YES	320	Y	Y	Y	Y
03/18/87	NO	YES	7	16	YES	320	Y	Y	Y	Y
03/19/87	NO	YES	10	20	YES	305	Y	Y	Y	Y
03/20/87	NO	YES	5	20	YES	310	Y	Y	Y	Y
03/21/87	NO	YES	8	18	YES	380	Y	Y	Y	Y
03/22/87	NO	YES	7	16	YES	360	Y	Y	Y	Y
03/23/87	NO	YES	8	17	YES	330	Y	Y	Y	Y
03/24/87	NO	YES	6	19	YES	355	Y	Y	Y	Y
03/25/87	NO	YES	6	21	YES	380	Y	Y	Y	Y
03/26/87	NO	YES	5	20	YES	320	Y	Y	Y	Y
03/27/87	NO	YES	6	21	YES	310	Y	Y	Y	Y
03/28/87	NO	YES	5	21	YES	300	Y	Y	Y	Y
03/29/87	NO	YES	5	19	YES	300	Y	Y	Y	Y
03/30/87	NO	YES	4	19	YES	270	Y	Y	Y	Y
03/31/87	NO	YES	5	21	YES	295	Y	Y	Y	Y
04/01/87	NO	YES	4	16	YES	270	Y	Y	Y	Y
04/02/87	NO	YES	3	20	YES	260	Y	Y	Y	Y
04/03/87	NO	YES	5	18	YES	270	Y	Y	Y	Y
04/04/87	NO	YES	4	16	YES	270	Y	Y	Y	Y
04/05/87	NO	YES	7	14	YES	270	Y	Y	Y	Y
04/06/87	NO	YES	5	15	YES	285	Y	Y	Y	Y
04/07/87	NO	YES	5	21	YES	290	Y	Y	Y	Y
04/08/87	NO	YES	5	19	YES	315	Y	Y	Y	Y

TABLE D - 2 (continued)

UCT PILOT PLANT OPERATIONS LOG

DATE 1987 MNTH/DAY	FLOATING SLUDGE? Y/N, SOME?	FINAL TANK MIXER OK? YES/NO	SLUDGE BLNKT DPTH (inches)	TEMP DEGREES oC	ANAEROBIC MIXERS OK? YES/NO	MLSS SETTLEABL ML/L/30M	PUMPS OK? INFLUENT Y/N	RET SLDGE Y/N	SLDG FD Y/N	WASTE ML Y/N
04/09/87	NO	YES	5	18	YES	310	Y	Y	Y	Y
04/10/87	NO	YES	4	18	YES	320	Y	Y	Y	Y
04/11/87	NO	YES	4	17	YES	290	Y	Y	Y	Y
04/12/87	NO	YES	4	16	YES	300	Y	Y	Y	Y
04/13/87	TRACE	YES	5	17	YES	300	Y	Y	Y	Y
04/14/87	NO	YES	6	18	YES	290	Y	Y	Y	Y
04/15/87	NO	YES	6	20	YES	330	Y	Y	Y	Y
04/16/87	NO	YES	5	18	YES	290	Y	Y	Y	Y
04/17/87	NO	YES	6	16	YES	350	Y	Y	Y	Y
04/18/87	TRACE	YES	7	17	YES	305	Y	Y	Y	Y
04/19/87	TRACE	YES	6	18	YES	300	Y	Y	Y	Y
04/20/87	TRACE	YES	4	19	YES	245	Y	Y	Y	Y
04/21/87	SOME	YES	6	21	YES	230	Y	Y	Y	Y
04/22/87	SOME	YES	5	21	YES	290	Y	Y	Y	Y
04/23/87	TRACE	YES	6	22	YES	270	Y	Y	Y	Y
04/24/87	NO	YES	5	23	YES	280	Y	Y	Y	Y
04/25/87	NO	YES	7	17	YES	300	Y	Y	Y	Y
04/26/87	NO	YES	8	16	YES	320	Y	Y	Y	Y
04/27/87	NO	YES	7	15	YES	330	Y	Y	Y	Y
04/28/87	NO	YES	7	20	YES	350	Y	Y	Y	Y
04/29/87	NO	YES	8	16	YES	450	Y	Y	Y	Y
04/30/87	NO	YES	3	26	YES	350	Y	Y	Y	Y
05/01/87	NO	YES	6	21	YES	510	Y	Y	Y	Y
05/02/87	SOME	YES	7	22	YES	375	Y	Y	Y	Y
05/03/87	NO	YES	17	21	YES	125	Y	Y	Y	Y
05/04/87	NO	YES	5	21	YES	190	Y	Y	Y	Y
05/05/87	NO	YES	12	17	YES	220	Y	Y	Y	Y
05/06/87	NO	YES	4	18	YES	210	Y	Y	Y	Y
05/07/87	NO	YES	3.5	20	YES	210	Y	Y	Y	Y
05/08/87	NO	YES	5	22	YES	200	Y	Y	Y	Y
05/09/87	NO	YES	7	19	YES	230	Y	Y	Y	Y
05/10/87	NO	YES	6	20	YES	215	Y	Y	Y	Y
05/11/87	NO	YES	7	21	YES	240	Y	Y	Y	Y
05/12/87	NO	YES	10	22	YES	225	Y	Y	Y	Y
05/13/87	NO	YES	8	23	YES	240	Y	Y	Y	Y
05/14/87	NO	YES	10	23	YES	265	Y	Y	Y	Y
05/15/87	NO	YES	8	21	YES	280	Y	Y	Y	Y
05/16/87	NO	YES	7	24	YES	320	Y	Y	Y	Y
05/17/87	NO	YES	4	21	YES	420	Y	Y	Y	Y

TABLE D - 2 (continued)

UCT PILOT PLANT OPERATIONS LOG

DATE 1987 MNTH/DAY	FLOATING SLUDGE? Y/N, SOME?	FINAL TANK MIXER OK? YES/NO	SLUDGE BLNKT DPTH (inches)	TEMP DEGREES oC	ANAEROBIC MIXERS OK? YES/NO	MLSS SETTLEABL ML/L/30M	PUMPS OK? INFLUENT Y/N	RET SLDGE Y/N	SLDG FD Y/N	WASTE ML Y/N
05/18/87	NO	YES	9	23	YES	290	Y	Y	Y	Y
05/19/87	NO	YES	3	21	YES	320	Y	Y	Y	Y
05/20/87	NO	YES	6	22	YES	300	Y	Y	Y	Y
05/21/87	NO	YES	9	21	YES	300	Y	Y	Y	Y
05/22/87	NO	YES	6	23	YES	310	Y	Y	Y	Y
05/23/87	NO	YES	7	24	YES	270	Y	Y	Y	Y
05/24/87	NO	YES	11	24	YES	245	Y	Y	Y	Y
05/25/87	NO	YES	5	24	YES	230	Y	Y	Y	Y
05/26/87	NO	YES	7	21	YES	240	Y	Y	Y	Y
05/27/87	NO	YES	7	21	YES	250	Y	Y	Y	Y
05/28/87	NO	YES	5	28	YES	270	Y	Y	Y	Y
05/29/87	NO	YES	5	22	YES	220	Y	Y	Y	Y
05/30/87	NO	YES	3	22	YES	250	Y	Y	Y	Y
05/31/87	NO	YES	5	21	YES	240	Y	Y	Y	Y
06/01/87	NO	YES	3	21	YES	200	Y	Y	Y	Y
06/02/87	NO	YES	4	24	YES	190	Y	Y	Y	Y
06/03/87	NO	YES	5	22	YES	180	Y	Y	Y	Y
06/04/87	NO	YES	3	21	YES	200	Y	Y	Y	Y
06/05/87	NO	YES	6	23	YES	200	Y	Y	Y	Y
06/06/87	NO	YES	5	23	YES	190	Y	Y	Y	Y
06/07/87	NO	YES	6	23	YES	170	Y	Y	Y	Y
06/08/87	NO	YES	7	22	YES	160	Y	Y	Y	Y
06/09/87	NO	YES	7	23	YES	190	Y	Y	Y	Y
06/10/87	NO	YES	6	22	YES	210	Y	Y	Y	Y
06/11/87	NO	YES	3	22	YES	140	Y	Y	Y	Y
06/12/87	NO	YES	4	23	YES	150	Y	Y	Y	Y

TABLE D - 2 (continued)

UCT PILOT PLANT OPERATIONS LOG

DATE 1987 MNTH/DAY	INFLUENT ML/MIN	RET SLDGE ML/MIN	RECYCLE ML/MIN	ZIMPRO ML/30MIN	WASTE ML ML/30MIN	TANK 1	TANK 2	TANK 3	TANK 4	MCRT (DAYS)
	FLOW RATES (ML)					DISSOLVED OXYGEN MG/L				
03/01/87										
03/02/87										
03/03/87										
03/04/87										
03/05/87	190	105	200		150					15.8
03/06/87	200	105	200		125	0.5	1.2	2.0	1.0	19.0
03/07/87	195	105	200		460	1.2	2.8	4.6	5.2	5.2
03/08/87	195	105	180		150	3.7	4.6	6.6	7.2	15.8
03/09/87	195	100	190	70	130	3.7	4.7	6.0	7.0	18.3
03/10/87	205	100	200	70	250	4.2	3.9	5.0	7.3	9.5
03/11/87	200	95	195		240	4.1	2.0	4.5	7.5	9.9
03/12/87	200	150	215		245	0.8	0.7	0.8	3.7	9.7
03/13/87	190	100	195		235	0.2	0.5	2.4	3.8	10.1
03/14/87	210	95	190		230	1.0	0.5	6.2	6.0	10.3
03/15/87	200	95	190		230	5.8	3.2	3.9	5.4	10.3
03/16/87	200	100	185		250	6.0	6.5	7.0	6.0	9.5
03/17/87	210	95	200		220	7.2	4.8	7.1	4.9	10.8
03/18/87	200	100	190		240	5.0	2.0	2.2	4.5	9.9
03/19/87	210	100	200		280	4.7	2.8	1.9	3.6	8.5
03/20/87	205	100	195	50	255	4.1	2.5	2.8	3.5	9.3
03/21/87	200	100	180		250	3.1	2.3	2.1	2.3	9.5
03/22/87	200	95	195		245	5.6	5.3	5.2	5.9	9.7
03/23/87	200	100	190		260	5.0	4.5	4.6	5.3	9.1
03/24/87	210	105	190		260	2.9	2.1	1.8	2.9	9.1
03/25/87	210	105	190	40	240	1.8	0.6	0.5	1.5	9.9
03/26/87	205	110	190		260	1.0	2.1	4.9	5.2	9.1
03/27/87	205	100	190	45	270	0.2	0.2	4.1	4.0	8.8
03/28/87	210	110	190		260	0.2	1.7	5.2	5.4	9.1
03/29/87	205	110	190		265	1.1	2.0	5.0	5.1	9.0
03/30/87	200	100	185	40	265	2.4	4.3	7.0	6.8	9.0
03/31/87	200	100	190		265	0.0	1.0	4.0	4.5	9.0
04/01/87	200	100	185	35	250					9.5
04/02/87	205	100	190		260					9.1
04/03/87	200	100	185	35	260					9.1
04/04/87	195	95	185		260	4.7	5.5	8.2	7.4	9.1
04/05/87	190	90	185		250	5.8	6.5	6.4	7.5	9.5
04/06/87	195	115	190	39	250	5.4	6.1	6.1	6.0	9.5
04/07/87	225	115	190		265	4.1	4.6	5.8	5.1	9.0
04/08/87	190	120	185	37	255	3.3	3.6	3.7	4.5	9.3

TABLE D - 2 (continued)

UCT PILOT PLANT OPERATIONS LOG

DATE 1987 MNTH/DAY	FLOW RATES (ML) INFLUENT ML/MIN	RET SLDGE ML/MIN	RECYCLE ML/MIN	ZIMPRO ML/30MIN	WASTE ML ML/30MIN	DISSOLVED OXYGEN MG/L TANK 1	TANK 2	TANK 3	TANK 4	MCRT (DAYS)
04/09/87	195	110	180		260	4.7	5.2	5.3	5.6	9.1
04/10/87	180	110	200	40	245	5.7	5.7	6.3	6.7	9.7
04/11/87	185	115	195		260	5.3	5.2	5.4	5.6	9.1
04/12/87	185	110	185		255	5.6	5.8	6.3	6.4	9.3
04/13/87	180	110	185	40	250	5.7	5.6	5.5	5.8	9.5
04/14/87	185	110	190		260	5.2	4.8	5.2	6	9.1
04/15/87	180	110	190	44	255	4.8	4.5	5	5.7	9.3
04/16/87	175	100	180		225	6.4	6.1	6	6.5	10.6
04/17/87	180	105	200	36	240	7.7	7.7	7.6	8	9.9
04/18/87	180	105	180		255	6.2	7.2	7.6	7.9	9.3
04/19/87	175	100	195		250	6.5	7.6	7.9	8.1	9.5
04/20/87	185	105	185		265	6.3	7.7	7.8	7.9	9.0
04/21/87	190	105	180		250	4.2	5.1	5.1	6.2	9.5
04/22/87	190	110	185		250	4.7	5.1	4.8	5.3	9.5
04/23/87	195	110	190		255	4.3	5.2	4.7	5.3	9.3
04/24/87	190	125	185		260	3.2	5.1	4.6	5.7	9.1
04/25/87	195	120	175		265	4.7	6.2	6.5	6.3	9.0
04/26/87	195	105	185		250	3.1	5.4	4.9	6.9	9.5
04/27/87	190	105	185		250	6.7	7.5	6.6	7.6	9.5
04/28/87	195	110	195		266	3.5	5.6	5.1	5.4	8.9
04/29/87	190	100	180		245	1.2	3.7	2.8	4.1	9.7
04/30/87	195	190	195		245	1.4	3.2	1.8	3.0	9.7
05/01/87	195	185	190		235	2.9	4.1	3.6	5.0	10.1
05/02/87	195	185	185		240	0.7	2.5	1.9	3.5	9.9
05/03/87	195	165	185		255	2.1	4.6	5.3	4.8	9.3
05/04/87	190	175	185		255	5.4	5.1	5.9	6.0	9.3
05/05/87	195	145	190		260	6.3	5.8	6.3	6.5	9.1
05/06/87	195	95	185		275	4.4	4.3	4.9	4.7	8.6
05/07/87	195	110	195		300	4.1	4.2	5.2	5.0	7.9
05/08/87	195	100	195		265	3.6	4.2	5.0	4.9	9.0
05/09/87	195	100	195		260	4.7	5.2	5.7	5.7	9.1
05/10/87	195	100	190		280	5.8	6.2	6.3	6.1	8.5
05/11/87	200	100	200		270	4.5	5.5	6.0	5.9	8.8
05/12/87	195	100	195		255	2.3	3.1	4.0	4.0	9.3
05/13/87	200	100	180		250	2.2	3.6	4.3	4.2	9.5
05/14/87	195	100	185		255	0.4	1.0	2.1	0.8	9.3
05/15/87	200	100	190		245	4.7	5.6	6.0	5.8	9.7
05/16/87	200	85	185		240	5.1	5.2	5.6	4.8	9.9
05/17/87	185	95	185		250	5.8	6.4	7.2	6.1	9.5

TABLE D - 2 (continued)

UCT PILOT PLANT OPERATIONS LOG

DATE 1987 MNTH/DAY	FLOW RATES (ML) INFLUENT ML/MIN	RET SLDGE ML/MIN	RECYCLE ML/MIN	ZIMPRO ML/30MIN	WASTE ML ML/30MIN	DISSOLVED OXYGEN MG/L TANK 1	TANK 2	TANK 3	TANK 4	MCRT (DAYS)
05/18/87	200	100	195		260	4.4	5.6	6.0	5.2	9.1
05/19/87	200		190		250	6.2	6.8	6.9	5.2	9.5
05/20/87	190	100	195		250	5.6	6.3	6.7	4.7	9.5
05/21/87	200	105	195		300	5.4	6.1	7.1	4.3	7.9
05/22/87	195	100	200		280	4.1	5.2	5.9	1.6	8.5
05/23/87	195	100	195		305	4.4	5.4	6.0	2.1	7.8
05/24/87	195	95	200		320	5.0	5.4	5.6	3.0	7.4
05/25/87	200	100	195		285	4.2	4.8	5.6	3.2	8.3
05/26/87	195	100	195		275	5.3	5.4	6.5	3.6	8.6
05/27/87	200	105	195		295	4.0	4.2	4.3	1.2	8.1
05/28/87	190	100	195		345	4.7	5.4	6.0	3.3	6.9
05/29/87	185	110	195		350	4.9	5.0	5.9	3.2	6.8
05/30/87	190	110	195		355	5.5	5.8	6.7	4.3	6.7
05/31/87	180	110	195		335	5.9	6.1	6.9	4.6	7.1
06/01/87	190	110	205		320	5.8	6.0	6.6	4.1	7.4
06/02/87	190	110	200		365	4.7	5.5	6.4	1.8	6.5
06/03/87	190	110	210		350	4.9	5.7	6.4	7.1	6.8
06/04/87	195	105	205		330	4.9	5.1	6.3	5.8	7.2
06/05/87	200	105	205		330	4.4	4.5	5.7	4.7	7.2
06/06/87	200	115	210		350	5.6	5.3	6.1	4.9	6.8
06/07/87	190	105	200		325	5.3	5.2	6.1	5.1	7.3
06/08/87	200	100	220		350	5.7	5.9	6.9	5.7	6.8
06/09/87	200	100	215		350	5.0	5.9	6.3	4.7	6.8
06/10/87	200	105	210		340	4.4	5.0	6.3	4.9	7.0
06/11/87	210	100	215		400	5.2	5.5	6.4	4.1	5.9
06/12/87	200	100	200		325	3.3	4.2	5.6	2.3	7.3

TABLE D - 3

DATA FROM THE UCT PILOT PLANT FINAL AERATED TANK
MARCH 9 - JUNE 12, 1987

TNK 9 AER Date	BOD (mg/l)	MLSS (mg/l)	MLVSS (mg/l)	TKN (AA) (mg/l)	TDKN (AA) (mg/l)	TP (AA) (mg/l)	TDP (AA) (mg/l)	Ortho-P (AA) (mg/l)	NO3-N (AA) (mg/l)	NH3-N (AA) (mg/l)	% P in MIX LIQ SOLIDS	FILTBLE NITROGEN (mg/L)
03/01/87												
03/02/87												
03/03/87												
03/04/87												
03/05/87												
03/06/87												
03/07/87												
03/08/87												
03/09/87	83	3230	2350					0.10	0.70	10		
03/10/87												
03/11/87	30	3120	2330	281	15	120	1.7	1.54	0.22	4.6	3.8%	15.7
03/12/87												
03/13/87	14	4000	2680					0.42	0.05	17		
03/14/87												
03/15/87												
03/16/87	9	4290	2640	146	25	83	0.3	0.22	0.25	22	1.9%	25.3
03/17/87												
03/18/87	38	4800	2960					0.87	0.18	18		
03/19/87												
03/20/87	12	3290	5540					0.27	0.46	16		
03/21/87												
03/22/87												
03/23/87	8	6440	3620	169	18	110	0.1	0.11	2.98	14	1.7%	21.3
03/24/87												
03/25/87	18	6030	3540					0.28	2.91	11		
03/26/87												
03/27/87	12	6390	3680					0.35	4.96	10		
03/28/87												
03/29/87												
03/30/87	6	5570	3070	283	5	191	0.02	0.02	19	1.3	3.4%	23.7
03/31/87												
04/01/87	20	5130	2900					0.40	7.4	2.5		
04/02/87												
04/03/87	5	5800	3290					0.24	10.5	1.8		
04/04/87												
04/05/87												
04/06/87	3	6150						0.14	11.7	2.6		
04/07/87												

TABLE D - 3 (continued)

DATA FROM THE UCT PILOT PLANT FINAL AERATED TANK
MARCH 9 - JUNE 12, 1987

TNK 9 AER Date	BOD (mg/l)	MLSS (mg/l)	MLVSS (mg/l)	TKN (AA) (mg/l)	TDKN (AA) (mg/l)	TP (AA) (mg/l)	TDP (AA) (mg/l)	Ortho-P (AA) (mg/l)	NO3-N (AA) (mg/l)	NH3-N (AA) (mg/l)	% P in MIX LIQ SOLIDS	FILTBLE NITROGEN (mg/L)
04/08/87	13	6600	3530	366	9	239	0.6	0.70	10.8	0.2	3.6%	19.5
04/09/87												
04/10/87	6	7370	3720					0.15	11.0	0.1		
04/11/87												
04/12/87												
04/13/87	8	6940	3490	336	8.7	255	0.3	0.16	15.6	1.7	3.7%	24.3
04/14/87												
04/15/87	12	6730	3420					0.48	11.3	0.2		
04/16/87												
04/17/87	6	6010	3220					0.05	9.7	0.1		
04/18/87												
04/19/87												
04/20/87												
04/21/87												
04/22/87	4	4040	2210	213	5.8	139	0.5	0.14	3.8	0.1	3.4%	9.6
04/23/87												
04/24/87	4	4500	2620					0.16	1.7	0.1		
04/25/87												
04/26/87												
04/27/87	2	4060	2520	247	4.1	140	0.2	0.13	4.9	0.1	3.5%	9.1
04/28/87												
04/29/87	11	4740	2990					0.40	1.8	0.1		
04/30/87												
05/01/87	4	4930	3110					0.24		0.1		
05/02/87												
05/03/87												
05/04/87	4	2950	1960					0.04	3.3	0.1		
05/05/87												
05/06/87	12	3280	2140	195	7.4	108	0.3	0.29	1.7	0.0	3.3%	9.1
05/07/87												
05/08/87	3	3360	2240					0.84	1.4	0.0		1.4
05/09/87												
05/10/87												
05/11/87	5	3500	2420					0.11	7.1	0.1		7.1
05/12/87												
05/13/87	4	3870	2590					0.25	2.0	0.1		2.0
05/14/87												
05/15/87	5	4450	3130	294	6.6	138	0.1	0.06	2.2	0.1	3.1%	8.7
05/16/87												
05/17/87												

TABLE D - 3 (continued)

DATA FROM THE UCT PILOT PLANT FINAL AERATED TANK
MARCH 9 - JUNE 12, 1987

TNK 9 AER Date	BOD (mg/l)	MLSS (mg/l)	MLVSS (mg/l)	TKN (AA) (mg/l)	TDKN (AA) (mg/l)	TP (AA) (mg/l)	TDP (AA) (mg/l)	Ortho-P (AA) (mg/l)	NO3-N (AA) (mg/l)	NH3-N (AA) (mg/l)	% P in FILTBLE MIX LIQ SOLIDS	NITROGEN (mg/L)
05/18/87	3	4070	2860					0.02	5.1	0.1		5.1
05/19/87												
05/20/87	4	4330	3090	302	5.7	164	0.5	0.31	2.7	0.1	3.8%	8.4
05/21/87												
05/22/87	4	4540	3230					0.20	1.4	0.1		
05/23/87												
05/24/87												
05/25/87												
05/26/87												
05/27/87	14	3830	2930					0.48	2.4	0.1		
05/28/87												
05/29/87	4	4010	2840	239	5.5	118	0.3	0.21	4.8	0.0	2.9%	10.3
05/30/87												
05/31/87												
06/01/87	3	3110	2130					3.61	7.4	0.1		
06/02/87												
06/03/87	6	3560	2570					1.95	4.8	0.1		
06/04/87												
06/05/87	4	3880	2740	221	6.1	120	0.4	0.43	5.2	0.1	3.1%	11.3
06/06/87												
06/07/87												
06/08/87	3	3310	2320					4.36	7.3	0.1		
06/09/87												
06/10/87	7	3200	2090	191	8.0	100	1.9	1.68	4.9	0.0	3.1%	12.9
06/11/87												
06/12/87	5	3560	2430					2.20	3.2	0.1		
06/13/87												
MONTHLY AVERAGES												
MARCH	23	4716	3241	220	16	126	0.5	0.4	3.1	12.5	2.7%	21
APRIL	8	5673	3083	290	7	194	0.4	0.3	8.3	0.8	3.6%	16
MAY	6	3927	2712	258	6	132	0.3	0.3	3.1	0.1	3.3%	7
JUNE	5	3437	2380	206	7	110	1.1	2.4	5.5	0.1	3.1%	12
MAXIMUM	83	7370	5540	366	25	255	1.9	4.4	18.6	22	3.8%	25
MINIMUM	2	2950	1960	146	4	83	0.0	0.0	0.1	0.0	1.7%	1
AVG (TOTAL)	11	4574	2901	249	9	145	0.5	0.6	5.1	3.4	3.2%	12

TABLE D - 4

UCT PILOT PLANT ANAEROBIC, EFFLUENT, AND OPERATIONS DATA
MARCH 9 - JUNE 12, 1987

TNK 3 ANA Date	TDKN (AA) (mg/l)	TDP (AA) (mg/l)	Ortho-P (AA) (mg/l)	NO3-N (AA) (mg/l)	NH3-N (AA) (mg/l)	EFFLUENT VALUES Alkalinity (mg/l)	pH	TSS (mg/l)	OPERATIONS SVI INDEX	FOOD:MASS RATIO
03/01/87										
03/02/87										
03/03/87										
03/04/87										
03/05/87										
03/06/87										
03/07/87										
03/08/87										
03/09/87			27	0.02	11.2	160	7.5	26	115	0.16
03/10/87										
03/11/87	20	37	28	0.02	6.7	280	7.8	58	109	0.27
03/12/87										
03/13/87			31	0.02	23	325	7.7	196	103	0.18
03/14/87										
03/15/87										
03/16/87	37	31	30	0.18	24	235	7.7	347	77	0.12
03/17/87										
03/18/87			35	0.23	21	360	7.6	247	67	0.17
03/19/87										
03/20/87			36	0.04	21	310	7.7	196	94	0.07
03/21/87										
03/22/87										
03/23/87	28	32	32	0.07	17	235	7.3	180	51	0.05
03/24/87										
03/25/87			37	0.09	18	395	7.6	156	63	0.15
03/26/87										
03/27/87			33	0.04	19	410	7.9	253	49	0.11
03/28/87										
03/29/87										
03/30/87	25	28	27	0.02	15.7	175	7.7	90	48	0.07
03/31/87										
04/01/87			28	0.02	13.4	345	8.0	210	53	0.16
04/02/87										
04/03/87			28	0.02	15.9	225	7.8	135	47	0.10
04/04/87										
04/05/87										
04/06/87			28	0.02	14.2	140	7.5	264	46	
04/07/87										

TABLE D - 4 (continued)

UCT PILOT PLANT ANAEROBIC, EFFLUENT, AND OPERATIONS DATA
MARCH 9 - JUNE 12, 1987

TNK 3 ANA						EFFLUENT VALUES			OPERATIONS	
Date	TDKN (AA) (mg/l)	TDP (AA) (mg/l)	Ortho-P (AA) (mg/l)	NO3-N (AA) (mg/l)	NH3-N (AA) (mg/l)	Alkalinity (mg/l)	pH	TSS (mg/l)	SVI INDEX	FOOD:MASS RATIO
04/08/87	29	29	30	0.07	14.7	335	7.7	253	48	0.16
04/09/87										
04/10/87			31	0.05	14.6	320	7.8	220	43	0.08
04/11/87										
04/12/87										
04/13/87	27.8	32	32	0.13	16.7	160	7.2	247	43	0.08
04/14/87										
04/15/87			39	0.08	15.4	410	8.0	207	49	0.15
04/16/87										
04/17/87			23	0.02	11.0	150	7.8	165	58	0.04
04/18/87										
04/19/87										
04/20/87										
04/21/87										
04/22/87	16.4	29	27	0.06	7.2	280	7.9	27	72	0.20
04/23/87										
04/24/87			32	0.06	7.6	250	8.0	26	62	0.11
04/25/87										
04/26/87										
04/27/87	17.1	28	27	0.08	7.3	160	7.4	23	81	0.16
04/28/87										
04/29/87			28	0.10	7.6	315	7.9	29	95	0.18
04/30/87										
05/01/87			29		7.7	355	7.9	28	103	0.13
05/02/87										
05/03/87										
05/04/87			24	0.05	8.4	215	7.6	26	64	0.18
05/05/87										
05/06/87	21.7	25	24	0.05	8.2	345	7.9	60	64	0.23
05/07/87										
05/08/87			24	0.05	9.2	330	7.9	20	60	0.21
05/09/87										
05/10/87										
05/11/87			21	0.08	10.8	165	7.6	22	69	0.14
05/12/87										
05/13/87			32	0.02	7.2	375	7.8	42	62	0.17
05/14/87										
05/15/87	20.1	31	33	0.03	8.8	300	8.1	36	63	0.15
05/16/87										
05/17/87										

TABLE D - 4 (continued)

UCT PILOT PLANT ANAEROBIC, EFFLUENT, AND OPERATIONS DATA
MARCH 9 - JUNE 12, 1987

TNK 3 ANA Date	TDKN (AA) (mg/l)	TDP (AA) (mg/l)	Ortho-P (AA) (mg/l)	NO3-N (AA) (mg/l)	NH3-N (AA) (mg/l)	EFFLUENT VALUES Alkalinity (mg/l)	pH	TSS (mg/l)	OPERATIONS SVI INDEX	FOOD:MASS RATIO
05/18/87			34	0.05	10.1	170	7.8	34	71	0.16
05/19/87										
05/20/87	17.4	34	34	0.08	7.4	225	7.7	16	69	0.16
05/21/87										
05/22/87			37	0.02	8.3	285	7.8	24	68	0.16
05/23/87										
05/24/87										
05/25/87										
05/26/87										
05/27/87			28	0.02	8.8	285	7.6	12	65	0.08
05/28/87										
05/29/87	18.4	28	28	0.05	9.9	270	7.7	8	55	0.11
05/30/87										
05/31/87										
06/01/87			21	0.03	8.9	185	7.6	16	64	0.07
06/02/87										
06/03/87			25	0.07	10.6	250	7.9	10	51	0.15
06/04/87										
06/05/87	20.1	21	22	0.06	10.3	255	7.7	26	52	0.14
06/06/87										
06/07/87										
06/08/87			21	0.02	11.0	175	7.7	32	48	0.06
06/09/87										
06/10/87	21.5	24	24	0.02	9.8	250	7.8	36	66	0.19
06/11/87										
06/12/87			22	0.02	10.5	325	7.9	14	42	0.19
06/13/87										
MONTHLY AVERAGES										
MARCH	28	32	32	0.07	18	289		175	78	0.13
APRIL	22	29	29	0.06	12	258		151	58	0.13
MAY	19	30	29	0.05	9	277		27	68	0.16
JUNE	21	23	22	0.04	10	240		22	54	0.13
MAXIMUM	37	37	39	0.23	24	410	8.1	347	115	0.27
MINIMUM	16	21	21	0.02	7	140	7.2	8	42	0.04
AVG (TOTAL)	23	29	29	0.06	12	268		100	65	0.14

TABLE E-1

OPERATION NOTES : BURLINGTON, N. C.
MARCH 1 - JUNE 19,1987

DATE	UCT-EXP PILOT SYSTEM
03/03/87	System start-up.
03/05/87	Started carbon addition (7g PAC/day).
03/10/87	Solids build up in the clarifier. Problem identified as a disconnected mixer arm. In the process of repair, the overflow stand pipe was pulled out. System lost approximately 25 - 30 liters of settled sludge and mixed liquor.
03/13/87	Zimpro effluent feed interrupted. Increased return sludge flow rate from 100 mL/min to 200 mL/min. Reseeded system with approximately 10L of solids from other pilots.
03/17/87	Clarifier mixer arm stuck on stand pipe. Solids build up in clarifier.
03/27/87	Clarifier mixer arm disconnected.
04/02/87	Hose from Tank #3 crimped, blocking flow.
04/04/87	Mixer for Tank #3 stopped.
04/17/87	Discontinued Zimpro feed to 1st anaerobic tank.
04/19/87	Recycle/return sludge pump not operating. Repaired.
04/20/87	No activated carbon added to the system.
04/22/87	Recycle/return sludge pump out of service. Repaired.
04/28/87	System filling up due to clogged hoses connecting tanks. Recycle/return sludge pump shut down twice due to clogged lines.
05/01/87	Recycle/return sludge pump lines clogged. Clarifier mixer arm hung up.
05/02/87	Recycle/return sludge pump out of service. Clarifier mixer arm snagged on stand pipe. Both problems contributed to solids build up in clarifier.
05/03/87	Large spill of return sludge with loss of solids. Recycle hose clogged.
05/15/87	Tank #5 mixer out. Repaired.
05/20/87	Increased wasting rate.
05/28/87	Increased wasting rate. Added 400 grams activated carbon to system to increase total carbon in system.

TABLE E - 2

UCT-EXP PILOT PLANT OPERATIONS LOG

DATE 1987 MNTH/DAY	FLOATING SLUDGE? Y/N, SOME?	FINAL TANK MIXER OK? YES/NO	SLUDGE BLNKT DPTH (inches)	TEMP DEGREES oC	ANAEROBIC MIXERS OK? YES/NO	MLSS SETTLEABL ML/L/30M	PUMPS OK? INFLUENT Y/N	RET SLDGE Y/N	SLDG FD Y/N	WASTE ML Y/N
03/01/87										
03/02/87										
03/03/87										
03/04/87										
03/05/87	NO	YES	2	19	YES	310	Y	Y	Y	Y
03/06/87	NO	YES	7	19	YES	340	Y	Y	Y	Y
03/07/87	NO	YES	8	19	YES	270	Y	Y	Y	Y
03/08/87	NO	YES	12	17	YES	220	Y	Y	Y	Y
03/09/87	NO	YES	14	17	YES	140	Y	Y	Y	Y
03/10/87	NO	YES	2	15	YES	60	Y	Y	Y	Y
03/11/87	NO	YES	3	13	YES	50	Y	Y	Y	Y
03/12/87	NO	YES	3	16	YES	25	Y	Y	Y	Y
03/13/87	NO	YES	3	17	YES	10	Y	Y	Y	Y
03/14/87	NO	YES	1	14	YES	95	Y	Y	Y	Y
03/15/87	NO	YES	1	14	YES	110	Y	Y	Y	Y
03/16/87	NO	YES	2	15	YES	110	Y	Y	Y	Y
03/17/87	NO	YES	2	14	YES	135	Y	Y	Y	Y
03/18/87	NO	YES	1	16	YES	190	Y	Y	Y	Y
03/19/87	NO	YES	1	18	YES	200	Y	Y	Y	Y
03/20/87	NO	YES	2	15	YES	220	Y	Y	Y	Y
03/21/87	NO	YES	3	17	YES	280	Y	Y	Y	Y
03/22/87	NO	YES	3	16	YES	280	Y	Y	Y	Y
03/23/87	SOME	YES	2	18	YES	260	Y	Y	Y	Y
03/24/87	NO	YES	1	18	YES	240	Y	Y	Y	Y
03/25/87	SOME	YES	3	19	YES	270	Y	Y	Y	Y
03/26/87	NO	YES	2	20	YES	280	Y	Y	Y	Y
03/27/87	SOME	YES	3	21	YES	270	Y	Y	Y	Y
03/28/87	SOME	YES	3	21	YES	300	Y	Y	Y	Y
03/29/87	SOME	YES	5	19	YES	280	Y	Y	Y	Y
03/30/87	SOME	YES	4	19	YES	280	Y	Y	Y	Y
03/31/87	SOME	YES	4	20	YES	310	Y	Y	Y	Y
04/01/87	SOME	YES	3	16	YES	270	Y	Y	Y	Y
04/02/87	YES	YES	3	20	YES	280	Y	Y	Y	Y
04/03/87	SOME	YES	4	19	YES	290	Y	Y	Y	Y
04/04/87	SOME	YES	3	16	YES	280	Y	Y	Y	Y
04/05/87	SOME	YES	5	14	YES	285	Y	Y	Y	Y
04/06/87	SOME	YES	5	16	YES	270	Y	Y	Y	Y
04/07/87	SOME	YES	4	22	YES	300	Y	Y	Y	Y
04/08/87	SOME	YES	4	19	YES	320	Y	Y	Y	Y

TABLE E - 2 (continued)

UCT-EXP PILOT PLANT OPERATIONS LOG

DATE 1987 MNTH/DAY	FLOATING SLUDGE? Y/N, SOME?	FINAL TANK MIXER OK? YES/NO	SLUDGE BLNKT DPTH (inches)	TEMP DEGREES oC	ANAEROBIC MIXERS OK? YES/NO	MLSS SETTLEABL ML/L/30M	PUMPS OK? INFLUENT Y/N	RET SLDGE Y/N	SLDG FD Y/N	WASTE ML Y/N
04/09/87	SOME	YES	4	18	YES	330	Y	Y	Y	Y
04/10/87	YES	YES	6	18	YES	340	Y	Y	Y	Y
04/11/87	SOME	YES	4	18	YES	340	Y	Y	Y	Y
04/12/87	SOME	YES	2	17	YES	340	Y	Y	Y	Y
04/13/87	SOME	YES	6	18	YES	370	Y	Y	Y	Y
04/14/87	SOME	YES	6	18	YES	370	Y	Y	Y	Y
04/15/87	NO	YES	6	20	YES	370	Y	Y	Y	Y
04/16/87	NO	YES	5	18	YES	370	Y	Y	Y	Y
04/17/87	SOME	YES	6	16	YES	400	Y	Y	Y	Y
04/18/87	SOME	YES	7	17	YES	430	Y	Y	Y	Y
04/19/87	SOME	YES	9	17	YES	250	Y	Y	Y	Y
04/20/87	YES	YES	3	20	YES	225	Y	Y	Y	Y
04/21/87	SOME	YES	3	21	YES	220	Y	Y	Y	Y
04/22/87	YES	YES	5	20	YES	250	Y	Y	Y	Y
04/23/87	SOME	YES	4	22	YES	235	Y	Y	Y	Y
04/24/87	SOME	YES	4	23	YES	290	Y	Y	Y	Y
04/25/87	NO	YES	5	18	YES	310	Y	Y	Y	Y
04/26/87	SOME	YES	3	17	YES	330	Y	Y	Y	Y
04/27/87	NO	YES	15	15	YES	370	Y	Y	Y	Y
04/28/87	NO	YES	10	19	YES	20	Y	Y	Y	Y
04/29/87	NO	YES	5	16	YES	260	Y	Y	Y	Y
04/30/87	SOME	YES	6	26	YES	300	Y	Y	Y	Y
05/01/87	YES	YES	5	20	YES	260	Y	Y	Y	Y
05/02/87	YES	NO	15	21	YES	30	Y	Y	Y	Y
05/03/87	YES	YES	4	21	YES	250	Y	Y	Y	Y
05/04/87	YES	YES	6	21	YES	250	Y	Y	Y	Y
05/05/87	YES	YES	5	18	YES	265	Y	Y	Y	Y
05/06/87	TRACE	YES	5	18	YES	280	Y	Y	Y	Y
05/07/87	SOME	YES	4	20	YES	300	Y	Y	Y	Y
05/08/87	SOME	YES	4	22	YES	300	Y	Y	Y	Y
05/09/87	SOME	YES	5	18	YES	330	Y	Y	Y	Y
05/10/87	SOME	YES	5	20	YES	360	Y	Y	Y	Y
05/11/87	SOME	YES	5	20	YES	320	Y	Y	Y	Y
05/12/87	TRACE	YES	5	21	YES	330	Y	Y	Y	Y
05/13/87	NO	YES.	4	22	YES	360	Y	Y	Y	Y
05/14/87	NO	YES	6	23	YES	420	Y	Y	Y	Y
05/15/87	TRACE	YES	6	20	YES	680	Y	Y	Y	Y
05/16/87	NO	YES	7	23	YES	310	Y	Y	Y	Y
05/17/87	NO	YES	6	22	YES	550	Y	Y	Y	Y

TABLE E - 2 (continued)

UCT-EXP PILOT PLANT OPERATIONS LOG

DATE 1987 MNTH/DAY	FLOATING SLUDGE? Y/N, SOME?	FINAL TANK MIXER OK? YES/NO	SLUDGE BLNKT DPTH (inches)	TEMP DEGREES oC	ANAEROBIC MIXERS OK? YES/NO	MLSS SETTLEABL ML/L/30M	PUMPS OK? INFLUENT Y/N	RET SLDGE Y/N	SLDG FD Y/N	WASTE ML Y/N
05/18/87	TRACE	YES	4	22	YES	320	Y	Y	Y	Y
05/19/87	TRACE	YES	2	21	YES	350	Y	Y	Y	Y
05/20/87	NO	YES	4	22	YES	340	Y	Y	Y	Y
05/21/87	NO	YES	3	20	YES	320	Y	Y	Y	Y
05/22/87	NO	YES	2	23	YES	350	Y	Y	Y	Y
05/23/87	SOME	YES	4	23	YES	380	Y	Y	Y	Y
05/24/87	YES	YES	2	23	YES	290	Y	Y	Y	Y
05/25/87	NO	YES	5	23	YES	245	Y	Y	Y	Y
05/26/87	NO	YES	5	21	YES	380	Y	Y	Y	Y
05/27/87	NO	YES	3	22	YES	270	Y	Y	Y	Y
05/28/87	NO	YES	5	22	YES	280	Y	Y	Y	Y
05/29/87	YES	YES	2	22	YES	230	Y	Y	Y	Y
05/30/87	SOME	YES	1	22	YES	200	Y	Y	Y	Y
05/31/87	SOME	YES	4	20	YES	180	Y	Y	Y	Y
06/01/87	NO	YES	2	20	YES	160	Y	Y	Y	Y
06/02/87	NO	YES	5	24	YES	150	Y	Y	Y	Y
06/03/87	TRACE	YES	3	21	YES	160	Y	Y	Y	Y
06/04/87	NO	YES	3	21	YES	170	Y	Y	Y	Y
06/05/87	NO	YES	5	22	YES	160	Y	Y	Y	Y
06/06/87	NO	YES	5	22	YES	160	Y	Y	Y	Y
06/07/87	NO	YES	4	22	YES	160	Y	Y	Y	Y
06/08/87	NO	YES	5	19	YES	140	Y	Y	Y	Y
06/09/87	NO	YES	0	22	YES	150	Y	Y	Y	Y
06/10/87	NO	YES	1	21	YES	150	Y	Y	Y	Y
06/11/87	NO	YES	4	21	YES	140	Y	Y	Y	Y
06/12/87	NO	YES	5	23	YES	160	Y	Y	Y	Y

TABLE E - 2 (continued)

UCT-EXP PILOT PLANT OPERATIONS LOG

DATE 1987 MNTH/DAY	FLOW RATES (ML) INFLUENT ML/MIN	RET SLDGE ML/MIN	RECYCLE ML/MIN	ZIMPRO ML/30MIN	WASTE ML ML/30MIN	DISSOLVED OXYGEN MG/L TANK 1	TANK 2	TANK 3	TANK 4	MCRT (DAYS)
03/01/87										
03/02/87										
03/03/87										
03/04/87										
03/05/87	200	200	175		280					8.5
03/06/87	205	110	190		110	0.7	0.7	0.7		21.6
03/07/87	210	105	185		140	1.1	4.4	3.3		17.0
03/08/87	200	105	195		255	4.6	6.8	6.2		9.3
03/09/87	200	105	175		250	5.8	6.8	6.7		9.5
03/10/87	200	105	215	70	250	6.1	6.5	6.7		9.5
03/11/87	200	105	195		250	4.4	4.4	4.0		9.5
03/12/87	205	100	235		255	0.5	0.6	0.8		9.3
03/13/87	200	100	195		250	2.6	0.7	1.4		9.5
03/14/87	200	200	190		240	0.6	0.4	0.6		9.9
03/15/87	195	195	195		230	6.9	7.2	7.6		10.3
03/16/87	200	195	195		250	6.7	8.0	7.6		9.5
03/17/87	220	185	200		230	7.5	6.6	3.1		10.3
03/18/87	210	200	200		250	7.1	5.2	0.5		9.5
03/19/87	220	200	205		250	6.4	5.2	6.0		9.5
03/20/87	215	200	200	50	250	5.5	5.0	5.7		9.5
03/21/87	220	205	205		240	6.0	4.1	5.2		9.9
03/22/87	210	200	210		255	7.8	5.9	6.8		9.3
03/23/87	210	205	200		240	7.0	5.6	6.5		9.9
03/24/87	230	210	210		270	5.3	2.4	3.9		8.8
03/25/87	225	200	190	50	285	5.4	1.7	2.8		8.3
03/26/87	220	205	210		230	4.7	2.9	2.9		10.3
03/27/87	220	200	205	50	240	5.7	1.0	1.9		9.9
03/28/87	220	200	210		240	6.0	2.7	2.1		9.9
03/29/87	220	200	205		235	5.7	3.5	3.9		10.1
03/30/87	220	200	200	52	240	3.4	2.9	3.7		9.9
03/31/87	220	205	195		245	0.8	0.7	1.1		9.7
04/01/87	220	205	205	48	235	4.9	6.0	6.8		10.1
04/02/87	220	205	210		230	3.3	2.8	5.6		10.3
04/03/87	220	205	215	50	230	4.2	2.3	5.7		10.3
04/04/87	195	200	195		240	4.9	2.9	6.5		9.9
04/05/87	195	200	195		225	5.7	3.6	5.6		10.6
04/06/87	205	205	200	49	230	5.3	5.0	6.0		10.3
04/07/87	215	200	205		235	3.1	4.0	4.8		10.1
04/08/87	205	205	205	50	240	2.9	1.9	4.5		9.9

TABLE E - 2 (continued)

UCT-EXP PILOT PLANT OPERATIONS LOG

DATE 1987 MNTH/DAY	FLOW RATES (ML) INFLUENT ML/MIN	RET SLDGE ML/MIN	RECYCLE ML/MIN	ZIMPRO ML/30MIN	WASTE ML ML/30MIN	DISSOLVED OXYGEN MG/L TANK 1	TANK 2	TANK 3	TANK 4	MCRT (DAYS)
04/09/87	205	200	215		235	3.4	3.4	6.2		10.1
04/10/87	195	200	205	49	245	5.0	5.1	5.7		9.7
04/11/87	200	200	195		240	4.5	4.7	5.5		9.9
04/12/87	185	195	200		240	5.6	5.7	6.1		9.9
04/13/87	195	200	200	49	245	5.3	5.4	5.9		9.7
04/14/87	195	200	200		240	5.4	5.4	6.1		9.9
04/15/87	195	205	200	55	245	4.7	4.8	5.2		9.7
04/16/87	1185	195	190		240	6.7	6.5	6.3		9.9
04/17/87	185	200	195	48	245	7.0	6.5	6.0		9.7
04/18/87	200	210	195		225	5.1	6.9	7.2		10.6
04/19/87	195	200	195		235	6.6	8.1	8.7		10.1
04/20/87	205	215	240		245	5.6	7.5	7.8		9.7
04/21/87	215	225	245		245	2.6	3.7	5.4		9.7
04/22/87	215	200	215		240	3.8	3.0	2.0		9.9
04/23/87	215	190	205		280	2.2	3.0	3.7		8.5
04/24/87	200	180	210		250	2.3	2.5	3.7		9.5
04/25/87	220	175	190		245	2.0	5.0	5.6		9.7
04/26/87	190	170	170		230	1.1	2.8	4.1		10.3
04/27/87	205	170	175		240	3.2	5.4	6.6		9.9
04/28/87	215	370	255		245	3.1	3.5	4.9		9.7
04/29/87	205	220	165		240	0.8	1.8	2.8		9.9
04/30/87	200	235	160		245	0.5	0.5	0.7		9.7
05/01/87	205	215	175		240	1.7	4.5	6.0		9.9
05/02/87	205	215	145		255	0.3	1.6	4.8		9.3
05/03/87	205	210	245		265	2.7	4.9	6.0		9.0
05/04/87	210	205	230		260	4.0	5.6	6.6		9.1
05/05/87	210	210	225		240	5.2	5.6	6.5		9.9
05/06/87	200	200	210		240	2.5	3.7	5.2		9.9
05/07/87	210	215	210		245	2.1	3.6	5.0		9.7
05/08/87	205	205	210		265	1.6	3.5	5.2		9.0
05/09/87	210	200	210		260	3.6	4.6	6.1		9.1
05/10/87	210	200	210		255	4.4	5.3	6.3		9.3
05/11/87	200	200	210		270	4.2	5.3	6.6		8.8
05/12/87	195	200	200		250	2.0	3.6	5.2		9.5
05/13/87	200	200	200		245	2.2	3.8	5.2		9.7
05/14/87	195	195	200		260	0.3	1.1	2.7		9.1
05/15/87	200	200	200		250	5.4	6.1	6.0		9.5
05/16/87	200	195	195		255	5.7	5.3	4.2		9.3
05/17/87	195	195	195		255	6.4	6.8	5.6		9.3

TABLE E - 2 (continued)

UCT-EXP PILOT PLANT OPERATIONS LOG

DATE 1987 MNTH/DAY	FLOW RATES (ML) INFLUENT ML/MIN	RET SLDGE ML/MIN	RECYCLE ML/MIN	ZIMPRO ML/30MIN	WASTE ML ML/30MIN	DISSOLVED OXYGEN MG/L TANK 1	TANK 2	TANK 3	TANK 4	MCRT (DAYS)
05/18/87	195	200	200		255	4.6	5.6	4.7		9.3
05/19/87	195	200	210		250	7.7	7.7	3.0		9.5
05/20/87	195	195	200		295	5.0	6.6	2.0		8.1
05/21/87	195	195	200		255	5.9	6.6	2.6		9.3
05/22/87	200	200	200		270	4.1	5.2	0.2		8.8
05/23/87	195	200	200		275	4.6	5.1	3.4		8.6
05/24/87	200	185	200		295	5.6	6.2	4.0		8.1
05/25/87	200	195	195		270	4.4	5.5	2.8		8.8
05/26/87		195			260	5.4	5.7	3.4		9.1
05/27/87	200	195	195		285	4.2	4.4	0.6		8.3
05/28/87	185	195	190		265	4.7	5.2	2.7		9.0
05/29/87	200	195	195		360	5.2	5.6	4.3		6.6
05/30/87	195	195	195		360	6.1	6.3	4.9		6.6
05/31/87	200	195	190		350	6.2	6.4	5.2		6.8
06/01/87	200	190	190		380	6.6	6.9	6.0		6.3
06/02/87	190	195	190		400	5.3	5.6	3.5		5.9
06/03/87	205	190	190		390	5.3	5.9	3.2		6.1
06/04/87	210	185	185		355	5.0	5.7	2.7		6.7
06/05/87	205	200	185		350	4.9	5.3	3.3		6.8
06/06/87	200	185	190		365	5.2	5.4	3.7		6.5
06/07/87	210	185	190		370	5.7	5.9	4.3		6.4
06/08/87	210	185	180		370	6.0	5.7	5.3		6.4
06/09/87	210	185	185		375	4.7	5.2	2.3		6.3
06/10/87	210	185	195		375	6.3	6.5	5.2		6.3
06/11/87	220	195	200		450	5.8	6.0	3.4		5.3
06/12/87	205	180	190		405	4.5	4.6	1.5		5.9

TABLE E - 3

DATA FROM THE UCT-EXP PILOT PLANT FINAL AERATED TANK
MARCH 9 - JUNE 12, 1987

TNK 8 AER Date	BOD (mg/l)	MLSS (mg/l)	MLVSS (mg/l)	TKN (AA) (mg/l)	TDKN (AA) (mg/l)	TP (AA) (mg/l)	TDP (AA) (mg/l)	Ortho-P (AA) (mg/l)	NO3-N (AA) (mg/l)	NH3-N (AA) (mg/l)	% P in MIX LIQ SOLIDS	FILTBLE NITROGEN (mg/L)
03/01/87												
03/02/87												
03/03/87												
03/04/87												
03/05/87												
03/06/87												
03/07/87												
03/08/87												
03/09/87	83	1150	920					0.49	0.02	8.3		
03/10/87												
03/11/87	70	640	590	54	15	18	6.7	6.17	0.07	3.2	2.9%	14.6
03/12/87												
03/13/87	72	930	420					3.45	0.05	17		
03/14/87												
03/15/87												
03/16/87	23	3630	1760	96	33	67	2.8	2.87	0.11	27	1.8%	33.5
03/17/87												
03/18/87	42	4450	2440					5.70	0.06	23		
03/19/87												
03/20/87	7	4980	2790					0.62	0.07	20		
03/21/87												
03/22/87												
03/23/87	9	6480	3510	152	22	98	0.3	0.04	1.4	16	1.5%	23.0
03/24/87												
03/25/87	21	6200	3470					0.34	2.4	11.3		
03/26/87												
03/27/87	18	7210	3950					0.30	3.9	8.6		
03/28/87												
03/29/87												
03/30/87	7	7350	3770	247	3	214	0.2	0.04	12.4	0.21	2.9%	15.8
03/31/87												
04/01/87	25	7250	3790					0.50	6.1	2.0		
04/02/87												
04/03/87	9	7770	4060					0.26	13.8	0.16		
04/04/87												
04/05/87								0.12	9.8	0.24		
04/06/87	7	8120										
04/07/87												

TABLE E - 3 (continued)

DATA FROM THE UCT-EXP PILOT PLANT FINAL AERATED TANK
MARCH 9 - JUNE 12, 1987

TNK 8 AER Date	BOD (mg/l)	MLSS (mg/l)	MLVSS (mg/l)	TKN (AA) (mg/l)	TDKN (AA) (mg/l)	TP (AA) (mg/l)	TDP (AA) (mg/l)	Ortho-P (AA) (mg/l)	NO3-N (AA) (mg/l)	NH3-N (AA) (mg/l)	% P in MIX LIQ SOLIDS	FILTBLE NITROGEN (mg/L)
04/08/87	13	9080	4660	329	6	261	0.5	0.58	8.4	0.1	2.9%	14.8
04/09/87												
04/10/87	7	9400	4610					0.07	7.5	0.1		
04/11/87												
04/12/87												
04/13/87	5	10060	5040	337	4.7	305	0.1	0.16	11.60	0.1	3.0%	16.3
04/14/87												
04/15/87	10	10300	5130					0.44	7.91	0.2		
04/16/87												
04/17/87	7	8920	4510					0.05	8.23	0.0		
04/18/87												
04/19/87												
04/20/87												
04/21/87												
04/22/87	8	4720	2460	221	5.7	152	0.5	0.18	2.16	0.1	3.2%	7.9
04/23/87												
04/24/87	4	4870	2720					0.26	0.98	0.1		
04/25/87												
04/26/87												
04/27/87	4	4580	2830	179	3.9	128	0.2	0.17	4	0.2	2.8%	7.9
04/28/87												
04/29/87	22	4560	2710					0.47	0.9	0.1		
04/30/87												
05/01/87	4	4260	2720					0.24		0.1		
05/02/87												
05/03/87												
05/04/87	5	3550	2440					0.02	2.6	0.0		
05/05/87												
05/06/87	22	4180	2440	255	6.7	126	0.3	0.18	1.7	0.1	3.0%	8.3
05/07/87												
05/08/87	4	4500	3080					0.13	1.6	0.1		
05/09/87												
05/10/87												
05/11/87	4	4240	3000					0.11	5.1	0.1		
05/12/87												
05/13/87	4	4650	3160					0.02	2.0	0.1		
05/14/87												
05/15/87	8	5200	3590	323	5.4	147	0.2	0.04	1.9	0.1	2.8%	7.3
05/16/87												
05/17/87												

TABLE E - 3 (continued)

DATA FROM THE UCT-EXP PILOT PLANT FINAL AERATED TANK
MARCH 9 - JUNE 12, 1987

TNK 8 AER Date	BOD (mg/l)	MLSS (mg/l)	MLVSS (mg/l)	TKN (AA) (mg/l)	TDKN (AA) (mg/l)	TP (AA) (mg/l)	TDP (AA) (mg/l)	Ortho-P (AA) (mg/l)	NO3-N (AA) (mg/l)	NH3-N (AA) (mg/l)	% P in MIX LIQ SOLIDS	FILTBLE NITROGEN (mg/L)
05/18/87	4	4780	3420					0.08	4.4	0.1		
05/19/87												
05/20/87	5	4510	3230	301	5.1	163	0.5	0.24	1.4	0.1	3.6%	6.5
05/21/87												
05/22/87	4	4640	3400					0.18	0.3	0.0		
05/23/87												
05/24/87												
05/25/87												
05/26/87												
05/27/87	18	4520	3460					0.25	2.1	0.1		
05/28/87												
05/29/87	4	7680	5810	295	1.4	148	0.3	0.11	4.8	0.1	1.9%	6.2
05/30/87												
05/31/87												
06/01/87	5	4540	3360					1.15	5.3	0.1		
06/02/87												
06/03/87	9	4480	3500					0.29	3.0	0.0		
06/04/87												
06/05/87	4	4420	3240	239	5.2	124	0.3	0.28	4.0	0.1	2.8%	9.1
06/06/87												
06/07/87												
06/08/87	4	3670	2640					1.33	5.2	0.7		
06/09/87												
06/10/87	10	3810	2610	228	7.5	119	1.0	0.81	3.1	0.0	3.1%	10.6
06/11/87												
06/12/87	8	4300	3070					0.25	1.9	0.0		
MONTHLY AVERAGES												
MARCH	35	4302	2362	137	18	99	2.5	2.0	2.0	13.6	2.3%	22
APRIL	10	7469	3865	266	5	211	0.3	0.3	6.8	0.3	3.0%	12
MAY	7	4726	3313	293	5	146	0.3	0.1	2.5	0.1	2.8%	7
JUNE	7	4203	3070	234	6	122	0.6	0.7	3.7	0.2	3.0%	10
MAXIMUM	83	10300	5810	337	33	305	6.7	6.2	13.8	27	3.6%	33
MINIMUM	4	640	420	54	1	18	0.1	0.0	0.0	0.0	1.5%	6
AVG (TOTAL)	15	5365	3187	232	9	148	1.0	0.7	3.9	3.5	2.7%	13

TABLE E - 4

UCT-EXP PILOT PLANT ANAEROBIC, EFFLUENT, AND OPERATIONS DATA
MARCH 9 - JUNE 12, 1987

TNK 3 ANA Date	TDKN (AA) (mg/l)	TDP (AA) (mg/l)	Ortho-P (AA) (mg/l)	NO3-N (AA) (mg/l)	NH3-N (AA) (mg/l)	EFFLUENT VALUES Alkalinity (mg/l)	pH	TSS (mg/l)	SLUDGE VOLUME INDEX	FOOD: MASS RATIO
03/01/87										
03/02/87										
03/03/87										
03/04/87										
03/05/87										
03/06/87										
03/07/87										
03/08/87										
03/09/87			8	0.02	9.7	475	6.7	9950	122	0.41
03/10/87										
03/11/87	34	8	7	0.09	12.0	245	7.5	50	78	1.06
03/12/87										
03/13/87			6	0.42	22	335	7.5	62	11	1.14
03/14/87										
03/15/87										
03/16/87	42	10	10	0.04	28	260	7.5	427	30	0.19
03/17/87										
03/18/87			13	0.06	23	330	7.6	327	43	0.21
03/19/87										
03/20/87			16	0.05	23	325	7.7	440	44	0.14
03/21/87										
03/22/87										
03/23/87	28	21	20	0.04	17	185	7.0	307	40	0.05
03/24/87										
03/25/87			24	0.07	18	425	7.6	235	44	0.15
03/26/87										
03/27/87			22	0.04	17	395	7.8	367	37	0.10
03/28/87										
03/29/87										
03/30/87	24	22	21	0.02	13.2	190	7.4	120	38	0.06
03/31/87										
04/01/87			23	0.02	12.5	350	7.9	180	37	0.12
04/02/87										
04/03/87			23	0.02	14.3	235	7.7	165	37	0.08
04/04/87										
04/05/87										
04/06/87			22	0.02	12.4	130	7.5	396	33	
04/07/87										

TABLE E - 4 (continued)

UCT-EXP PILOT PLANT ANAEROBIC, EFFLUENT, AND OPERATIONS DATA
MARCH 9 - JUNE 12, 1987

TNK 3 ANA Date	TDKN (AA) (mg/l)	TDP (AA) (mg/l)	Ortho-P (AA) (mg/l)	NO3-N (AA) (mg/l)	NH3-N (AA) (mg/l)	EFFLUENT VALUES Alkalinity (mg/l)	pH	TSS (mg/l)	SLUDGE VOLUME INDEX	FOOD: MASS RATIO
04/08/87	29	24	24	0.09	13.8	355	7.8	400	35	0.12
04/09/87										
04/10/87			25	0.05	12.9	300	7.8	327	36	0.06
04/11/87										
04/12/87										
04/13/87	26	28	28	0.02	15.2	150	7.2	273	37	0.06
04/14/87										
04/15/87			37	0.02	10.1	425	7.8	253	36	0.10
04/16/87										
04/17/87						140	7.7	347	45	0.03
04/18/87										
04/19/87										
04/20/87										
04/21/87										
04/22/87	16	24	24	0.05	6.3	290	7.7	66	53	0.18
04/23/87										
04/24/87			25	0.06	7.1	265	7.8	44	60	0.10
04/25/87										
04/26/87										
04/27/87	17	25	25	0.08	6.6	135	7.4	28	81	0.15
04/28/87										
04/29/87			18	0.10	6.6	295	7.7	93	57	0.20
04/30/87										
05/01/87			23		6.8	450	7.9	50	61	0.15
05/02/87										
05/03/87										
05/04/87			25	0.05	7.4	210	7.7	22	70	0.14
05/05/87										
05/06/87	19	30	30	0.03	7.5	375	7.9	50	67	0.20
05/07/87										
05/08/87			29	0.03	7.9	320	7.9	38	67	0.15
05/09/87										
05/10/87			22	0.06	8.4					
05/11/87						165	7.6	48	75	0.12
05/12/87			32	0.02	5.9					
05/13/87						325	7.8	30	77	0.14
05/14/87										
05/15/87	18	33	33	0.03	7.9	325	8.1	86	131	0.14
05/16/87										
05/17/87										

TABLE E - 4 (continued)

UCT-EXP PILOT PLANT ANAEROBIC, EFFLUENT, AND OPERATIONS DATA
MARCH 9 - JUNE 12, 1987

TNK 3 ANA Date	TDKN (AA) (mg/l)	TDP (AA) (mg/l)	Ortho-P (AA) (mg/l)	NO3-N (AA) (mg/l)	NH3-N (AA) (mg/l)	EFFLUENT VALUES Alkalinity (mg/l)	pH	TSS (mg/l)	SLUDGE VOLUME INDEX	FOOD: MASS RATIO
05/18/87			41	0.02	4.6	155	7.4	28	67	0.14
05/19/87										
05/20/87	16	39	38	0.06	6.0	320	7.6	20	75	0.15
05/21/87										
05/22/87			40	0.02	6.6	295	7.7	42	75	0.15
05/23/87										
05/24/87										
05/25/87										
05/26/87										
05/27/87			37	0.02	7.5	230	7.6	34	60	0.07
05/28/87										
05/29/87	11	35	36	0.02	7.6	265	7.7	123	30	0.06
05/30/87										
05/31/87										
06/01/87			25	0.02	7.3	195	7.6	74	35	0.05
06/02/87										
06/03/87			30	0.04	9.5	250	7.6	50	36	0.11
06/04/87										
06/05/87	19	26	25	0.04	9.1	210	7.5	46	36	0.12
06/06/87										
06/07/87										
06/08/87			23	0.02	9.7	170	7.7	34	38	0.05
06/09/87										
06/10/87	21	26	25	0.02	8.5	265	7.7	44	39	0.15
06/11/87										
06/12/87			29	0.02	9.6	330	7.8	50	37	0.15
MONTHLY AVERAGES										
MARCH	32	15	15	0.09	18	317		1229	49	0.35
APRIL	22	25	25	0.05	11	256		214	46	0.11
MAY	16	34	32	0.03	7	286		48	71	0.13
JUNE	20	26	26	0.03	9	237		50	37	0.10
MAXIMUM	42	39	41	0.42	28	475	8.1	9950	131	1.14
MINIMUM	11	8	6	0.02	5	130	6.7	20	11	0.03
AVG (TOTAL)	23	25	25	0.05	11	277		393	53	0.18

TABLE E - 5

COLOR DETERMINATION (Co-Pt Units)
IN THE FINAL AERATED TANK OF THE
MODIFIED UCT AND UCT-EXP PILOT PLANTS

DATE MO/DA/YR	UCT COLOR	UCT-EXP COLOR
03/09/87	100	200
03/11/87	400	500
03/13/87	250	500
03/16/87	150	350
03/18/87	400	500
03/20/87	175	250
03/23/87	30	60
03/25/87	150	200
03/27/87	100	100
03/30/87	50	75
04/01/87	250	200
04/03/87	150	100
04/06/87	100	100
04/08/87	350	300
04/10/87	125	150
04/13/87	300	200
04/15/87	350	350
04/17/87	125	150
04/22/87	50	100
04/24/87	125	200
04/27/87	350	250
04/29/87	250	400

DATE MO/DA/YR	UCT COLOR	UCT-EXP COLOR
05/01/87	100	125
05/04/87	175	125
05/06/87	175	150
05/08/87	150	175
05/11/87	100	50
05/13/87	125	75
05/15/87	75	125
05/18/87	20	25
05/20/87	175	150
05/22/87	100	150
05/27/87	150	200
05/29/87	125	25
06/01/87	50	100
06/03/87	250	175
06/05/87	250	200
06/08/87	100	100
06/10/87	200	250
06/12/87	50	50

TABLE F-1

OPERATION NOTES : BURLINGTON, N. C.
MARCH 1 - JUNE 19,1987

DATE	UNC PILOT SYSTEM
03/03/87	System start-up.
03/19/87	Air line feeding UNC tank #8 came loose with the loss of aeration and mixing in that tank.
03/23/87	Hose connecting UNC #2 and #3 blocked with spillover onto floor. Tank #1 mixer failed.
03/27/87	Air line feeding UNC #4 came loose with the loss of aeration and mixing in that tank. UNC clarifier mixer arm disconnected.
03/28/87	Air line feeding UNC tank #5 came loose with the loss of aeration and mixing in that tank.
04/01/87	Mixer for Tank #6 failed. Replaced.
04/06/87	Mixer for Tank #2 failed. Repaired.
04/17/87	System seeded with 2L from both A^2/O and UCT after removing 4L of mixed liquor to boost nitrification.
04/24/87	Sludge return pump out of service with build up of solids in clarifier. Repaired.
04/29/87	Discontinued Zimpro feed and began feeding fermented primary sludge to first anaerobic tank.
04/30/87	Sludge feed line clogged, not feeding fermented sludge.
05/02/87	Fermented sludge feed interrupted.
05/03/87	Fermented sludge feed interrupted.
05/05/87	Fermented sludge feed interrupted.
05/10/87	Return sludge pump out of service.
05/13/87	Switched fermented sludge feed introduction to Tank #2 instead of Tank #1.
05/20/87	Increased wasting rate.
05/22/87	Discontinued fermented primary sludge feed and began feeding settled Zimpro effluent.
05/28/87	Increased wasting rate.
05/28/87	Hose connecting anaerobic tank to aerobic tank clogged. Anaerobic tank backing up and spilling onto floor.
06/02/87	Zimpro feed interrupted.
06/04/87	Zimpro feed interrupted.
06/12/87	Increased wasting rate.

TABLE F -2

UNC PILOT PLANT OPERATIONS LOG

DATE 1987 MNTH/DAY	FLOATING SLUDGE? Y/N, SOME?	FINAL TANK MIXER OK? YES/NO	SLUDGE BLNKT DPTH (inches)	TEMP DEGREES oC	ANAEROBIC MIXERS OK? YES/NO	MLSS SETTLEABL ML/L/30M	PUMPS OK? INFLUENT Y/N	RET SLDGE Y/N	SLDG FD Y/N	WASTE ML Y/N
03/01/87										
03/02/87										
03/03/87										
03/04/87										
03/05/87	NO	YES	5		YES	280	Y	Y	Y	Y
03/06/87	NO	YES	3	21	YES	250	Y	Y	Y	Y
03/07/87	NO	YES	3	21	YES	260	Y	Y	Y	Y
03/08/87	NO	YES	5	18	YES	280	Y	Y	Y	Y
03/09/87	NO	YES	5	21	YES	260	Y	Y	Y	Y
03/10/87	NO	YES	7	14	YES	270	Y	Y	Y	Y
03/11/87	NO	YES	6	15	YES	290	Y	Y	Y	Y
03/12/87	NO	YES	5	19	YES	330	Y	Y	Y	Y
03/13/87	NO	YES	1	18	YES	350	Y	Y	Y	Y
03/14/87	NO	YES	5	16	YES	315	Y	Y	Y	Y
03/15/87	NO	YES	5	15	YES	340	Y	Y	Y	Y
03/16/87	SOME	YES	7	16	YES	330	Y	Y	Y	Y
03/17/87	NO	YES	7	17	YES	315	Y	Y	Y	Y
03/18/87	TRACE	YES	7	19	YES	330	Y	Y	Y	Y
03/19/87	NO	YES	7	20	YES	330	Y	Y	Y	Y
03/20/87	TRACE	YES	6	20	YES	310	Y	Y	Y	Y
03/21/87	NO	YES	7	19	YES	370	Y	Y	Y	Y
03/22/87	NO	YES	6	18	YES	350	Y	Y	Y	Y
03/23/87	SOME	YES	7	18	YES	310	Y	Y	Y	Y
03/24/87	NO	YES	5	20	YES	325	Y	Y	Y	Y
03/25/87	SOME	YES	6	21	YES	340	Y	Y	Y	Y
03/26/87	NO	YES	6	19	YES	310	Y	Y	Y	Y
03/27/87	TRACE	YES	6	22	YES	310	Y	Y	Y	Y
03/28/87	SOME	YES	5	23	YES	290	Y	Y	Y	Y
03/29/87	SOME	YES	6	19	YES	280	Y	Y	Y	Y
03/30/87	SOME	YES	6	20	YES	290	Y	Y	Y	Y
03/31/87	SOME	YES	5	21	YES	270	Y	Y	Y	Y
04/01/87	SOME	YES	5	18	YES	270	Y	Y	Y	Y
04/02/87	SOME	YES	5	23	YES	270	Y	Y	Y	Y
04/03/87	SOME	YES	5	20	YES	290	Y	Y	Y	Y
04/04/87	SOME	YES	5	17	YES	290	Y	Y	Y	Y
04/05/87	SOME	YES	6	15	YES	270	Y	Y	Y	Y
04/06/87	SOME	YES	7	17	YES	290	Y	Y	Y	Y
04/07/87	SOME	YES	6	22	YES	330	Y	Y	Y	Y
04/08/87	SOME	YES	6	20	YES	330	Y	Y	Y	Y

TABLE F -2 (continued)

UNC PILOT PLANT OPERATIONS LOG

DATE 1987 MNTH/DAY	FLOATING SLUDGE? Y/N, SOME?	FINAL TANK MIXER OK? YES/NO	SLUDGE BLNKT DPTH (inches)	TEMP DEGREES oC	ANAEROBIC MIXERS OK? YES/NO	MLSS SETTLEABL ML/L/30M	PUMPS OK? INFLUENT Y/N	RET SLDGE Y/N	SLDG FD Y/N	WASTE ML Y/N
04/09/87	SOME	YES	6	21	YES	330	Y	Y	Y	Y
04/10/87	YES	YES	4	20	YES	340	Y	Y	Y	Y
04/11/87	SOME	YES	6	20	YES	310	Y	Y	Y	Y
04/12/87	SOME	YES	6	19	YES	320	Y	Y	Y	Y
04/13/87	SOME	YES	6	19	YES	310	Y	Y	Y	Y
04/14/87	SOME	YES	6	19	YES	315	Y	Y	Y	Y
04/15/87	TRACE	YES	6	21	YES	320	Y	Y	Y	Y
04/16/87	SOME	YES	6	17	YES	295	Y	Y	Y	Y
04/17/87	SOME	YES	7	16	YES	320	Y	Y	Y	Y
04/18/87	SOME	YES	7	17	YES	280	Y	Y	Y	Y
04/19/87	SOME	YES	7	17	YES	270	Y	Y	Y	Y
04/20/87	YES	YES	5.5	19	YES	245	Y	Y	Y	Y
04/21/87	YES	YES	6	22	YES	250	Y	Y	Y	Y
04/22/87	YES	YES	6	21	YES	260	Y	Y	Y	Y
04/23/87	SOME	YES	5.5	22	YES	275	Y	Y	Y	Y
04/24/87	TRACE	YES	11	23	YES	40	Y	Y	Y	Y
04/25/87	SOME	YES	5	20	YES	280	Y	Y	Y	Y
04/26/87	SOME	YES	6	20	YES	320	Y	Y	Y	Y
04/27/87	SOME	YES	7	18	YES	320	Y	Y	Y	Y
04/28/87	SOME	YES	6	20	YES	280	Y	Y	Y	Y
04/29/87	SOME	YES	7	19	YES	375	Y	Y	Y	Y
04/30/87	SOME	YES	6	26	YES	370	Y	Y	Y	Y
05/01/87	YES	YES	7	22	YES	730	Y	Y	Y	Y
05/02/87	YES	YES	5	22	YES	745	Y	Y	Y	Y
05/03/87	YES	YES	5	22	YES	765	Y	Y	Y	Y
05/04/87	YES	YES	6	22	YES	760	Y	Y	Y	Y
05/05/87	YES	YES	7	18	YES	815	Y	Y	Y	Y
05/06/87	SOME	YES	7	21	YES	830	Y	Y	Y	Y
05/07/87	SOME	YES	7	25	YES	810	Y	Y	Y	Y
05/08/87	SOME	YES	10	22	YES	760	Y	Y	Y	Y
05/09/87	TRACE	YES	10	19	YES	415	Y	Y	Y	Y
05/10/87	NO	YES	10	21	YES	70	Y	Y	Y	Y
05/11/87	NO	YES	8	22	YES	230	Y	Y	Y	Y
05/12/87	NO	YES	6	22	YES	290	Y	Y	Y	Y
05/13/87	NO	YES	10	25	YES	360	Y	Y	Y	Y
05/14/87	NO	YES	11	23	YES	765	Y	Y	Y	Y
05/15/87	NO	YES	10	25	YES	790	Y	Y	Y	Y
05/16/87	NO	YES	10	25	YES	320	Y	Y	Y	Y
05/17/87	NO	YES	7	24	YES	710	Y	Y	Y	Y

TABLE F -2 (continued)

UNC PILOT PLANT OPERATIONS LOG

DATE 1987 MNTH/DAY	FLOATING SLUDGE? Y/N, SOME?	FINAL TANK MIXER OK? YES/NO	SLUDGE BLNKT DPTH (inches)	TEMP DEGREES oC	ANAEROBIC MIXERS OK? YES/NO	MLSS SETTLEABL ML/L/30M	PUMPS OK? INFLUENT Y/N	RET SLDGE Y/N	SLDG FD Y/N	WASTE ML Y/N
05/18/87	NO	YES	17	26	YES	640	Y	Y	Y	Y
05/19/87	SOME	YES	11	21	YES	870	Y	Y	Y	Y
05/20/87	NO	YES	12	26	YES	470	Y	Y	Y	Y
05/21/87	NO	YES	14	24	YES	820	Y	Y	Y	Y
05/22/87	NO	YES	10	25	YES	890	Y	Y	Y	Y
05/23/87	NO	YES	11	26	YES	320	Y	Y	Y	Y
05/24/87	NO	YES	12	24	YES	370	Y	Y	Y	Y
05/25/87	NO	YES	17	24	YES	665	Y	Y	Y	Y
05/26/87	NO	YES	15	21	YES	890	Y	Y	Y	Y
05/27/87	NO	YES	17	24	YES	860	Y	Y	Y	Y
05/28/87	NO	YES	17	27	YES	890	Y	Y	Y	Y
05/29/87	NO	YES	17	26	YES	890	Y	Y	Y	Y
05/30/87	NO	YES	8	23	YES	850	Y	Y	Y	Y
05/31/87	NO	YES	9	22	YES	840	Y	Y	Y	Y
06/01/87	NO	YES	9	23	YES	380	Y	Y	Y	Y
06/02/87	NO	YES	9	27	YES	345	Y	Y	Y	Y
06/03/87	NO	YES	11	25	YES	360	Y	Y	Y	Y
06/04/87	NO	YES	7	22	YES	390	Y	Y	Y	Y
06/05/87	NO	YES	14	26	YES	390	Y	Y	Y	Y
06/06/87	NO	YES	7	24	YES	350	Y	Y	Y	Y
06/07/87	NO	YES	6	24	YES	320	Y	Y	Y	Y
06/08/87	NO	YES	7	24	YES	310	Y	Y	Y	Y
06/09/87	SOME	YES	11	24	YES	330	Y	Y	Y	Y
06/10/87	SOME	YES	10	24	YES	350	Y	Y	Y	Y
06/11/87	NO	YES	11	23	YES	340	Y	Y	Y	Y
06/12/87	TRACE	YES	5	25	YES	380	Y	Y	Y	Y
06/13/87	TRACE	YES	8	23	YES	410	Y	Y	Y	Y
06/14/87	NO	YES	9	23	YES	430	Y	Y	Y	Y
06/15/87	NO	YES	10	22	YES	400	Y	Y	Y	Y
06/16/87	NO	YES	10	21	YES	410	Y	Y	Y	Y
06/17/87	NO	YES	10	28	YES	380	Y	Y	Y	Y
06/18/87	NO	YES	9	25	YES	430	Y	Y	Y	Y

TABLE F - 2 (continued)

UNC PILOT PLANT OPERATIONS LOG

DATE 1987 MNTH/DAY	FLOW RATES (ML) INFLUENT ML/MIN	RET SLDGE ML/MIN	RECYCLE ML/MIN	ZIMPRO ML/30MIN	WASTE ML ML/30MIN	DISSOLVED OXYGEN MG/L TANK 1	TANK 2	TANK 3	TANK 4	MCRT (DAYS)
03/01/87										
03/02/87										
03/03/87										
03/04/87										
03/05/87	195	95			250					9.5
03/06/87	190	95			265	0.4	0.6	0.8	1.6	9.0
03/07/87	190	100			260	0.8	3.8	4.8	5.3	9.1
03/08/87	190	105			230	2.3	5.8	6.8	7.0	10.3
03/09/87	190	95		70	225	0.8	5.5	6.3	6.5	10.6
03/10/87	195	95		70	250	2.8	6.9	6.5	7.0	9.5
03/11/87	200	95			250	2.7	6.0	5.5	6.4	9.5
03/12/87	170	95			260	0.6	0.8	0.8	0.8	9.1
03/13/87	190	90			225	0.3	0.7	1.5	1.0	10.6
03/14/87	210	85			235	0.3	3.2	4.5	4.5	10.1
03/15/87	190	80			220	3.3	5.5	6.5	6.1	10.8
03/16/87	200	85			235	6.0	7.5	8.0	8.5	10.1
03/17/87	210	95			200	3.5	6.2	7.0	6.3	11.9
03/18/87	205	95			245	2.5	5.5	6.5	7.0	9.7
03/19/87	230	100			250	1.4	5.5	6.0	5.5	9.5
03/20/87	210	95		50	245	1.1	4.7	5.8	4.8	9.7
03/21/87	205	95			240	1.8	5.8	5.8	5.4	9.9
03/22/87	205	105			235	4.4	7.2	7.6	7.2	10.1
03/23/87	205	95			260	2.8	6.1	6.5	6.8	9.1
03/24/87	195	90			225	2.3	5.8	5.9	5.6	10.6
03/25/87	210	100		40	225	1.8	5.0	4.8	4.5	10.6
03/26/87	210	80			245	3.4	3.5	0.3	2.0	9.7
03/27/87	210	85		50	250	0.3	4.4	3.2	4.1	9.5
03/28/87	215	85			250	1.9	4.8	4.0	4.1	9.5
03/29/87	210	85			250	3.3	4.3	5.1	4.9	9.5
03/30/87	200	85		52	250	2.1	5.4	6.5	5.3	9.5
03/31/87	205	80			250	2.8	5.4	6.4	5.1	9.5
04/01/87	210	85		47	235	2.5	6.0	5.5	6.8	10.1
04/02/87	215	85			240	2.3	5.1	4.6	4.8	9.9
04/03/87	210	85		51	250	3.1	5.5	5.3	5.6	9.5
04/04/87	195	80			245	3.8	6.1	5.8	6.0	9.7
04/05/87	190	80			245	5.1	6.7	6.3	6.2	9.7
04/06/87	195	90		51	245	3.6	5.3	4.9	5.3	9.7
04/07/87	205	95			260	1.1	2.7	0.4	1.0	9.1
04/08/87	200			47	240	1.5	3.6	4.6	4.5	9.9

TABLE F - 2 (continued)

UNC PILOT PLANT OPERATIONS LOG

DATE 1987 MNTH/DAY	FLOW RATES (ML) INFLUENT ML/MIN	RET SLDGE ML/MIN	RECYCLE ML/MIN	ZIMPRO ML/30MIN	WASTE ML ML/30MIN	DISSOLVED OXYGEN MG/L TANK 1	TANK 2	TANK 3	TANK 4	MCRT (DAYS)
04/09/87	200	95			255	1.3	4.6	5.7	5.2	9.3
04/10/87	200	110		46	245	2.8	6.8	7.6	7.2	9.7
04/11/87	195	105			240	2.5	6.4	6.7	6.4	9.9
04/12/87	195	105			250	4.3	7.1	7.2	6.6	9.5
04/13/87	190	110		50	240	3.8	6.6	6.6	6.5	9.9
04/14/87	190	105			250	4.4	7.8	7.5	5.4	9.5
04/15/87	195	105		52	240	3.2	6.9	6.7	6.8	9.9
04/16/87	195	100			255	4.8	7.6	7.3	6.4	9.3
04/17/87	190	105		48	225	6.5	8.5	8.3	8.1	10.6
04/18/87	195	105			230	5.8	7.7	7.5	6.9	10.3
04/19/87	190	105			250	6.2	7.9	7.6	7.3	9.5
04/20/87	205	105			230	5.6	7.5	7.1	6.2	10.3
04/21/87	215	105			250	3.5	4.7	4.3	5.8	9.5
04/22/87	215	100		52	235	3.9	4.6	4.9	5.3	10.1
04/23/87	220	100			250	3.7	5.3	5.2	6.2	9.5
04/24/87	220			50	250	7.0	7.5	7.2	7.5	9.5
04/25/87	200	100			245	4.1	6.3	7.3	7.8	9.7
04/26/87	200	100			255	2.7	5.3	5.5	6.6	9.3
04/27/87	205	100		52	240	4.8	7.0	7.3	7.8	9.9
04/28/87	215	105			250	4.7	5.8	6.3	6.6	9.5
04/29/87	210	100		48	245	1.9	3.5	4.6	5.5	9.7
04/30/87	215	200			250	2.2	4.7	4.6	4.1	9.5
05/01/87	210	190			225	3.6	5.5	6.0	5.4	10.6
05/02/87	215	190			245	2.0	4.4	5.1	4.6	9.7
05/03/87	210	195			270	2.8	4.9	5.2	4.7	8.8
05/04/87	210	200			250	4.7	6.2	6.4	6.1	9.5
05/05/87	215	125			260	5.6	6.1	6.8	6.4	9.1
05/06/87	210	125			265	3.2	5.1	5.5	5.4	9.0
05/07/87	215	120			270	2.9	4.9	5.7	5.4	8.8
05/08/87	215	100			265	2.9	4.7	5.3	4.9	9.0
05/09/87	220	105			265	4.3	6.1	6.6	6.6	9.0
05/10/87	215	110			265	5.8	5.9	5.8	6.0	9.0
05/11/87	210	100			260	4.6	5.9	6.2	6.4	9.1
05/12/87	210	95			240	3.2	4.7	5.4	5.7	9.9
05/13/87	210	100			240	2.9	4.9	5.5	5.4	9.9
05/14/87	210	100			250	1.2	3.7	4.6	4.7	9.5
05/15/87	215	100			245	2.9	5.2	5.8	5.6	9.7
05/16/87	210	85			235	3.4	5.5	6.1	4.1	10.1
05/17/87	205	95			235	4.1	6.4	7.0	5.0	10.1

TABLE F - 2 (continued)

UNC PILOT PLANT OPERATIONS LOG

DATE 1987 MNTH/DAY	FLOW RATES (ML) INFLUENT ML/MIN	RET SLDGE ML/MIN	RECYCLE ML/MIN	ZIMPRO ML/30MIN	WASTE ML ML/30MIN	DISSOLVED OXYGEN MG/L TANK 1	TANK 2	TANK 3	TANK 4	MCRT (DAYS)
05/18/87	210	100			245	2.6	5.3	5.9	4.7	9.7
05/19/87	210	110			255	0.5	4.9	6.0	4.1	9.3
05/20/87	205	105		28	295	1.7	2.0	4.2	3.2	8.1
05/21/87	210	100			330	1.8	1.9	3.3	2.3	7.2
05/22/87	210	100		30	300	0.2	0.7	3.1	1.3	7.9
05/23/87	210	105			290	0.4	1.9	5.3	2.7	8.2
05/24/87	205	95			325	1.5	5.5	6.3	4.0	7.3
05/25/87	205	100			315	0.2	2.5	5.0	3.1	7.5
05/26/87	205	105			315	0.9	2.7	5.7	3.5	7.5
05/27/87	205	115		30	300	0.9	2.0	4.3	2.0	7.9
05/28/87	200	110			285	2.0	2.4	4.7	2.5	8.3
05/29/87	205	110		31	390	0.3	1.9	4.3	2.4	6.1
05/30/87	205	115			355	1.1	3.6	5.9	3.8	6.7
05/31/87	205	115			350	1.6	5.4	6.5	4.6	6.8
06/01/87	205	105		30	325	1.1	4.8	6.0	4.4	7.3
06/02/87	200	115			330	1.0	3.4	5.2	3.8	7.2
06/03/87	200	105		34	370	0.5	3.0	5.5	4.1	6.4
06/04/87	195	105			350	0.3	2.4	5.3	2.9	6.8
06/05/87	195	105		31	330	0.8	2.7	5.4	3.5	7.2
06/06/87	190	95			325	1.2	4.4	6.1	4.5	7.3
06/07/87	180	100			335	1.6	4.9	6.1	4.3	7.1
06/08/87	185	100			335	0.7	4.8	6.4	5.5	7.1
06/09/87	190	105			335	1.2	3.3	5.5	3.7	7.1
06/10/87	190	100		30	325	0.6	2.7	5.3	3.9	7.3
06/11/87	190	115			320	1.2	3.8	6.5	5.0	7.4
06/12/87	195	105		30	350	0.6	1.6	4.1	2.0	6.8
06/13/87	185	95			450	0.5	2.8	5.6	3.5	5.3
06/14/87	185	120			450	2.6	5.8	6.9	5.6	5.3
06/15/87	185	105		30	425	1.5	4.7	6.4	5.8	5.6
06/16/87	185	100			450	1.6	3.2	5.7	5.4	5.3
06/17/87	185	100		30	450	1.0	2.2	4.2	3.0	5.3
06/18/87	185	100			450	2.0	3.3	5.2	3.8	5.3

TABLE F - 3

DATA FROM THE UNC PILOT PLANT FINAL AERATED TANK
MARCH 9 - JUNE 17, 1987

TNK 8 AER Date	BOD (mg/l)	MLSS (mg/l)	MLVSS (mg/l)	TKN (AA) (mg/l)	TDKN (AA) (mg/l)	TP (AA) (mg/l)	TDP (AA) (mg/l)	Ortho-P (AA) (mg/l)	NO3-N (AA) (mg/l)	NH3-N (AA) (mg/l)	% P in MIX LIQ SOLIDS	FILTBLE NITROGEN (mg/L)
03/01/87												
03/02/87												
03/03/87												
03/04/87												
03/05/87												
03/06/87												
03/07/87												
03/08/87												
03/09/87	97	2090	1560					0.58	0.02	9.3		
03/10/87												
03/11/87	24	2130	1590	179	15	78	3.3	2.98	0.02	4.0	3.7%	15.4
03/12/87												
03/13/87	40	4110	2440					2.11	0.05	22		
03/14/87												
03/15/87												
03/16/87	16	4270	2460	131	28	72	0.4	0.28	0.09	23	1.7%	28.1
03/17/87												
03/18/87	22	4900	2820					0.58	0.11	19		
03/19/87												
03/20/87	19	5470	3120					0.51	0.04	20		
03/21/87												
03/22/87												
03/23/87	8	6100	3370	164	25	104	0.2	0.13	0.29	18	1.7%	24.9
03/24/87												
03/25/87	26	6120	3340					0.26	0.54	13.5		
03/26/87												
03/27/87	16	6770	3690					0.30	0.46	12.2		
03/28/87												
03/29/87												
03/30/87	8	6180	3250	109	16	81	0.02	0.10	3.69	11.1	1.3%	19.8
03/31/87												
04/01/87	21	6260	3340					0.40	0.40	5.7		
04/02/87												
04/03/87	9	6730	3570					0.26	1.90	5.8		
04/04/87												
04/05/87												
04/06/87	6	7270						0.12	3.03	10.0		
04/07/87												

TABLE F - 3 (continued)

DATA FROM THE UNC PILOT PLANT FINAL AERATED TANK
MARCH 9 - JUNE 17, 1987

TNK 8 AER Date	BOD (mg/l)	MLSS (mg/l)	MLVSS (mg/l)	TKN (AA) (mg/l)	TDKN (AA) (mg/l)	TP (AA) (mg/l)	TDP (AA) (mg/l)	Ortho-P (AA) (mg/l)	NO3-N (AA) (mg/l)	NH3-N (AA) (mg/l)	% P in MIX LIQ SOLIDS	FILTBLE NITROGEN (mg/L)
04/08/87	12	8970	4560	304	9	278	0.6	0.46	2.40	0.5	3.1%	11.4
04/09/87												
04/10/87	7	9190	4450					0.15	4.30	0.1		
04/11/87												
04/12/87												
04/13/87	7	9130	4470	342	7.3	310	0.3	0.32	9.88	1.8	3.4%	17.2
04/14/87												
04/15/87	14	9300	4590					0.67	1.64	0.2		
04/16/87												
04/17/87	14	8150	4070					0.13	8.32	0.6		
04/18/87												
04/19/87												
04/20/87												
04/21/87												
04/22/87	7	7520	3530	184	7.8	234	0.3	0.20	5.06	0.1	3.1%	12.9
04/23/87												
04/24/87	20	1390	760									
04/25/87												
04/26/87												
04/27/87	7	7060	3600	330	5.9	223	0.2	0.12	7.52	0.4	3.2%	13.4
04/28/87												
04/29/87	8	7990	4050					0.32	1.75	0.1		
04/30/87												
05/01/87	5	8050	4220					1.80		0.2		
05/02/87												
05/03/87												
05/04/87	3	6350	3550					2.33	1.8	0.2		
05/05/87												
05/06/87	7	6660	3750	359	7.4	197	3.0	2.73	0.1	0.0	3.0%	7.5
05/07/87												
05/08/87	4	6350	3710					1.66	0.8	0.2		0.8
05/09/87												
05/10/87												
05/11/87	3	3320	2040					1.09	3.6	0.7		3.6
05/12/87												
05/13/87	4	4420	2690					2.11	0.2	0.1		0.2
05/14/87												
05/15/87	5	4750	3050	257	6.5	115	1.4	1.27	0.7	0.4	2.4%	7.3
05/16/87												
05/17/87												
05/18/87	4	4340	2830					1.98	1.2	0.3		1.2
05/19/87												

TABLE F - 3 (continued)

DATA FROM THE UNC PILOT PLANT FINAL AERATED TANK
MARCH 9 - JUNE 17, 1987

TNK 8 AER Date	BOD (mg/l)	MLSS (mg/l)	MLVSS (mg/l)	TKN (AA) (mg/l)	TDKN (AA) (mg/l)	TP (AA) (mg/l)	TDP (AA) (mg/l)	Ortho-P (AA) (mg/l)	NO3-N (AA) (mg/l)	NH3-N (AA) (mg/l)	% P in FILTBLE MIX LIQ SOLIDS	NITROGEN (mg/L)
05/20/87	10	4450	2950	212	5.7	123	2.5	2.36	0.0	0.2	2.8%	5.8
05/21/87												
05/22/87	7	5080	3370					0.62	0.0	0.0		
05/23/87												
05/24/87												
05/25/87												
05/26/87												
05/27/87	20	4260	3070					0.25	0.8	1.5		
05/28/87												
05/29/87	5	5060	3370	301	6.0	131	0.4	0.32	0.5	0.5	2.6%	6.5
05/30/87												
05/31/87												
06/01/87	4	4650	2950					1.36	6.3	0.1		
06/02/87												
06/03/87	4	4260	2780					2.01	1.0	0.2		
06/04/87												
06/05/87	3	3990	2610	245	5.4	120	1.3	1.36	0.7	0.1	3.0%	6.1
06/06/87												
06/07/87												
06/08/87	3	3580	2400					4.88	6.3	0.2		
06/09/87												
06/10/87	6	4010	2530	233	8.5	109	1.7	1.57	1.3	0.2	2.7%	9.7
06/11/87												
06/12/87	6	4070	2660					3.01	0.8	0.8		
06/13/87												
06/14/87												
06/15/87	3	3430	2130					0.20	6.2	2.1		
06/16/87												
06/17/87	6	3330	2220					0.50	1.9	0.3		
06/18/87												
MONTHLY AVERAGES												
MARCH	28	4814	2764	146	21	84	1.0	0.8	0.5	15	2.1%	22
APRIL	11	7413	3726	290	7	261	0.4	0.3	4.2	2.3	3.2%	14
MAY	6	5258	3217	282	6	142	1.8	1.5	0.9	0.3	2.7%	4
JUNE	4	3915	2535	239	7	115	1.5	1.9	3.1	0.5	2.9%	8
MAXIMUM	97	9300	4590	359	28	310	3.3	4.9	9.9	23	3.7%	28
MINIMUM	3	1390	760	109	5	72	0.0	0.1	0.0	0.0	1.3%	0.2
AVG (TOTAL)	12	5512	3110	239	11	155	1.1	1.1	2.1	4.5	2.7%	11

TABLE F - 4

UNC PILOT PLANT ANAEROBIC, EFFLUENT, AND OPERATIONS DATA
MARCH 9 - JUNE 17, 1987

TNK 2 ANA Date	TDKN (AA) (mg/l)	TDP (AA) (mg/l)	Ortho-P (AA) (mg/l)	NO3-N (AA) (mg/l)	NH3-N (AA) (mg/l)	EFFLUENT VALUES Alkalinity (mg/l)	pH	TSS (mg/l)	OPERATIONS SVI INDEX	FOOD:MASS RATIO	ANAER VOL. ACID FEED (mg/L)
03/01/87											
03/02/87											
03/03/87											
03/04/87											
03/05/87											
03/06/87											
03/07/87											
03/08/87											
03/09/87			30	0.02	11.9	155	7.5	42	124	0.24	
03/10/87											
03/11/87	15	39	29	0.02	6.4	265	7.8	53	136	0.39	5928
03/12/87											
03/13/87			57	0.02	54	345	7.6	360	85	0.20	5736
03/14/87											
03/15/87											
03/16/87	93	99	82	0.05	59	225	7.6	467	77	0.13	6936
03/17/87											
03/18/87			88	0.02	53	370	7.7	553	67	0.18	6120
03/19/87											
03/20/87			98	0.07	57	310	7.9	420	57	0.13	5400
03/21/87											
03/22/87											
03/23/87	59	75	77	0.04	49	235	7.5	413	51	0.05	5376
03/24/87											
03/25/87			96	0.04	44	325	7.7	420	56	0.16	4464
03/26/87											
03/27/87			90	0.02	43	420	7.9	447	46	0.10	4848
03/28/87											
03/29/87											
03/30/87	45	65	66	0.02	34	235	7.8	280	47	0.06	5088
03/31/87											
04/01/87			72	0.02	30	300	8.0	320	43	0.14	3960
04/02/87											
04/03/87			83	0.02	34	285	7.8	400	43	0.09	4992
04/04/87											
04/05/87											
04/06/87			74	0.02	37	250	7.8	480	40		4752
04/07/87											

TABLE F - 4 (continued)

UNC PILOT PLANT ANAEROBIC, EFFLUENT, AND OPERATIONS DATA
MARCH 9 - JUNE 17, 1987

TNK 2 ANA	TDKN	TDP	Ortho-P	NO3-N	NH3-N	EFFLUENT VALUES			OPERATIONS		ANAER VOL.
Date	(AA) (mg/l)	(AA) (mg/l)	(AA) (mg/l)	(AA) (mg/l)	(AA) (mg/l)	Alkalinity (mg/l)	pH	TSS (mg/l)	SVI INDEX	FOOD:MASS RATIO	ACID FEED (mg/L)
04/08/87	31	58	61	0.02	18	390	7.9	550	37	0.12	4704
04/09/87											
04/10/87			57	0.03	16	250	7.9	547	37	0.06	4392
04/11/87											
04/12/87											
04/13/87	30	53	52	0.02	18	195	7.4	487	34	0.06	3984
04/14/87											
04/15/87			72	0.05	18	445	8.1	200	34		4632
04/16/87											
04/17/87			59	0.02	17	165	7.7	407	39	0.03	4944
04/18/87											
04/19/87											
04/20/87											
04/21/87											
04/22/87	38.6	72	70	0.02	22	225	7.8	260	35	0.13	4560
04/23/87											
04/24/87						280	7.7	164	29	0.37	4080
04/25/87											
04/26/87											
04/27/87	32.1	45	43	0.02	18	165	7.4	200	45	0.11	3984
04/28/87											
04/29/87			51	0.02	15	310	7.9	287	47	0.13	3696
04/30/87											FERMENTED
05/01/87			13		1.8	335	7.9	93	91	0.10	SLUDGE
05/02/87											UNC FEED
05/03/87											SWITCH
05/04/87			12	0.02	1.4	205	7.6	40	120	0.10	1368
05/05/87											
05/06/87	8.9	28	26	0.02	1.5	390	7.9	100	125	0.13	1992
05/07/87											
05/08/87			36	0.02	3.9	315	7.9	62	120	0.13	1320
05/09/87											
05/10/87											
05/11/87			24	0.02	4.0	260	7.7	64	69	0.17	1344
05/12/87											
05/13/87			40	0.02	5.2	345	7.8	50	81	0.16	1128
05/14/87											
05/15/87	13.2	33	33	0.03	4.7	420	7.9	1840	166	0.16	744
05/16/87											
05/17/87											
05/18/87			36	0.05	8.7	210	7.5	152	147	0.16	456
05/19/87											

TABLE F - 4 (continued)

UNC PILOT PLANT ANAEROBIC, EFFLUENT, AND OPERATIONS DATA
MARCH 9 - JUNE 17, 1987

TNK 2 ANA Date	TDKN (AA) (mg/l)	TDP (AA) (mg/l)	Ortho-P (AA) (mg/l)	NO3-N (AA) (mg/l)	NH3-N (AA) (mg/l)	EFFLUENT VALUES Alkalinity (mg/l)	pH	TSS (mg/l)	OPERATIONS SVI INDEX	FOOD:MASS RATIO	ANAER VOL. ACID FEED (mg/L)
05/20/87	10.5	44	43	0.03	3.4	300	7.6	30	106	0.17	456
05/21/87			47	0.02	2.8						
05/22/87						315	7.8	30	175	0.15	624
05/23/87											RESTART
05/24/87											SETTLED
05/25/87											ZIMPRO
05/26/87											UNC FEED
05/27/87			50	0.02	14.7	275	7.5	83	202	0.07	4080
05/28/87											
05/29/87	18.3	54	52	0.02	9.8	260	7.6	28	176	0.10	3336
05/30/87											
05/31/87											
06/01/87			27	0.02	7.6	220	7.5	94	82	0.05	1152
06/02/87											
06/03/87			41	0.02	6.6	270	7.6	40	85	0.14	5304
06/04/87											
06/05/87	8.6	31	29	0.02	2.5	280	7.7	56	98	0.14	480
06/06/87											
06/07/87											
06/08/87			22	0.02	4.7	185	7.6	46	87	0.06	528
06/09/87											
06/10/87	25.9	55	55	0.02	13.3	270	7.8	68	87	0.15	4800
06/11/87											
06/12/87			65	0.02	17.0	390	7.8	50	93	0.17	6120
06/13/87											
06/14/87											
06/15/87			44	0.02	17.3	230	7.4	72	117	0.09	5280
06/16/87											
06/17/87			73	0.02	16.5	245	7.6	92	114	0.16	6432
06/18/87											
MONTHLY AVERAGES											
MARCH	53	70	71	0.03	41	289		346	75	0.17	5544
APRIL	33	57	63	0.02	22	272		359	39	0.12	4052
MAY	13	40	34	0.02	5	303		214	131	0.13	936
JUNE	17	43	45	0.02	11	261		65	95	0.12	3762
MAXIMUM	93	99	98	0.07	59	445	8	1840	202	0.39	6936
MINIMUM	9	28	12	0.02	1.4	155	7	28	29	0.03	0
AVG (TOTAL)	31	54	53	0.03	20	283		258	84	0.14	3115