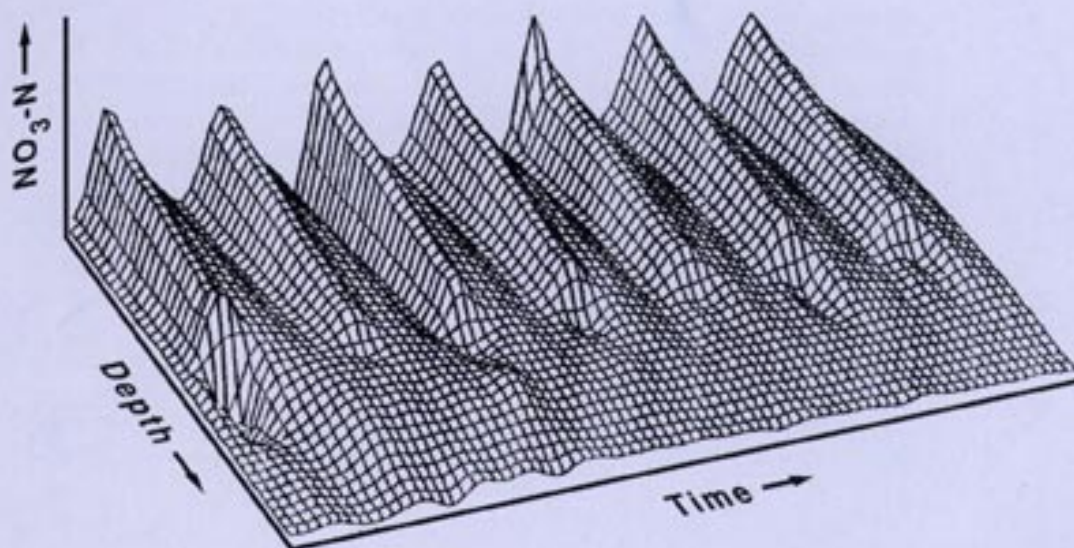




A Modeling-Based Evaluation of the Effect of Wastewater Application Practices on Groundwater Quality

Charles M. Reynolds and Iskandar K. Iskandar

February 1995

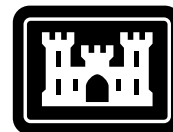


Abstract

The model WASTEN was used to compare several nitrogen input scenarios and to predict the levels of nitrate in groundwater for a proposed wastewater treatment facility at Fort Dix, New Jersey. The primary variables tested were input concentration of $\text{NO}_3\text{-N}$ (nitrate nitrogen) and $\text{NH}_4\text{-N}$ (ammonium nitrogen) and long-term application of wastewater. Two $\text{NO}_3\text{-N}$ loading rates, 4 and 10 mg $\text{NO}_3\text{-N/L}$, were tested for 168-day simulations. The system's response was estimated from the $\text{NO}_3\text{-N}$ concentration in water draining below 150 cm. For both input $\text{NO}_3\text{-N}$ concentrations, the predicted $\text{NO}_3\text{-N}$ concentrations in the leachate below 150 cm were less than 2 mg $\text{NO}_3\text{-N/L}$. The initial $\text{NO}_3\text{-N}$ in the soil profile represented typical background levels for this site. The final $\text{NO}_3\text{-N}$ in the soil profile was affected by both denitrification and leaching. The initial $\text{NH}_4\text{-N}$ in the simulated soil profile was equal to the extractable $\text{NH}_4\text{-N}$ from soil samples taken at the Fort Dix site. Because a portion of the extractable $\text{NH}_4\text{-N}$ exists as exchangeable rather than solution $\text{NH}_4\text{-N}$, the soil profile values for the solution $\text{NH}_4\text{-N}$ used in the simulation were greater than actual soil solution values would be. Moreover, by adjusting model coefficients, all the initial $\text{NH}_4\text{-N}$ was forced to leach in the model simulations rather than be subjected to nitrification, denitrification, immobilization or plant uptake. Due to the retardation effects on $\text{NH}_4\text{-N}$ mobility caused by soil-ion sorption, the $\text{NH}_4\text{-N}$ leaching was distributed over an extended time rather than moving rapidly below the unsaturated zone. With these assumptions, the WASTEN model predicted that the $\text{NO}_3\text{-N}$ at 150 cm would be less than 1 mg $\text{NO}_3\text{-N/L}$ if the applied $\text{NO}_3\text{-N}$ was 4 mg $\text{NO}_3\text{-N/L}$, and less than 2 mg $\text{NO}_3\text{-N/L}$ if 10 mg $\text{NO}_3\text{-N/L}$ was applied. The predicted concentration in the leachate was very low, even when an initial, uniform saturation of 5.0 mg $\text{NH}_4\text{-N/L}$ in the soil profile was assumed. In field situations there would be little, if any, NO_4^+ present following tertiary treatment of wastewater. Based on these calculations, the predicted NO_4^+ concentration of $\text{NH}_4\text{-N}$ in the applied effluent would remain within regulatory requirements.

Cover: Predicted soil nitrate distribution following pulsed wastewater application. The model output illustrates the combined effects of denitrification and nitrate transport.

For conversion of SI metric units to U.S./British customary units of measurement consult ASTM Standard E380-89a, *Standard Practice for Use of the International System of Units*, published by the American Society for Testing and Materials, 1916 Race St., Philadelphia, Pa. 19103.



**US Army Corps
of Engineers**

Cold Regions Research &
Engineering Laboratory

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Prepared for
OFFICE OF THE CHIEF OF ENGINEERS

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PREFACE

This report was prepared by Dr. Charles M. Reynolds, Research Physical Scientist, and Dr. Iskandar K. Iskandar, Chief, Geochemical Sciences Branch, Research Division, U.S. Army Cold Regions Research and Engineering Laboratory (CRREL). This work was initiated through the Numerical Model Maintenance Program, sponsored by HQUSACE #E8591S048. Major funding for the body of this work was provided by support from the U.S. Army Engineer District, Philadelphia, Project AT24-SS-020, *Chemical Species Transport Phenomena in Snow and Frozen Ground*, and Strategic Environmental Research and Development Program (SERDP), *Enhancing Bioremediation Processes in Cold Regions*.

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A Modeling-Based Evaluation of the Effect of Wastewater Application Practices on Groundwater Quality

CHARLES M. REYNOLDS AND ISKANDAR K. ISKANDAR

INTRODUCTION

Wastewater treatment in soil by land application is a proven and effective technology that advantageously uses the natural ability of soil to degrade organic molecules on a long-term, regenerative basis. Because there are numerous interacting processes involved, mechanistic dynamic simulation models can provide insight into a system's response to a number of conditions. The model WASTEN was developed by Selim and Iskandar (1981) to predict nitrogen transport and transformations in soils receiving wastewater.

CRREL has assisted the Philadelphia District of the Corps of Engineers by providing technical consultation and WASTEN simulations for conditions appropriate for a proposed treatment facility at Fort Dix, New Jersey. We compared several nitrogen input scenarios and predicted the levels of nitrate in the groundwater for the proposed site.

Overview

In recent years the combined impacts of intentional and accidental releases of chemicals and waste solutions in and on soils, and our awareness of the vulnerability of groundwater to pollution from surface sources, have received increased attention. The rate of movement or transport of chemicals in soil and subsoils can vary tremendously, and consequently the time required for a solute to reach a given depth varies. Transport determines the residence time of a compound in each particular soil zone. During a chemical's residence in a soil zone, the chemical is subject to a host of biological, chemical and physical processes that combine to ultimately determine its fate. The governing processes are intimately linked to one another in myriad, complex chains of reactions and

processes. Moreover, each process directly involved in altering a particular compound is, in turn, influenced by a multitude of other variables. Furthermore, the effects of these variables on different chemicals are not necessarily in the same magnitude or direction.

Many of the processes that occur are controlled by microbial, and thereby enzymatic, activity. The importance of microbial and enzymatic activities in transforming or degrading compounds containing energy or nutrient sources, such as nitrogen, carbon, phosphorus and sulfur, is reasonably intuitive. Nevertheless, physio-chemical processes, such as sorption-desorption and diffusion, are also important in determining the fate of compounds. Microbial or enzymatic processes can also influence compounds, such as metals, that are not used as nutrient or energy sources. In many instances, microbial-induced changes in microsite environments can induce fixation, immobilization or solvation of metals.

Bioremediation

The soil-mediated processes involved in the land treatment of wastewater are not new or unnatural. Microbes are known to adapt over time to transform or degrade compounds in their environment, and their enzymes can readily transform or completely degrade many non-anthropogenic organic compounds. Microbial enzyme systems may not be as efficient in transforming and breaking down more complex, anthropogenic molecules. However, there are enzymes that catalyze many of the reactions needed to degrade more recalcitrant, complex molecules. Often, a series of reactions must occur in a specific sequence to yield a desirable product. The conditions that favor any one of these processes may inhibit another pro-

cess, and the design and operation of a soil-based land treatment facility must consider these effects. Land treatment of wastewater is one of the earliest bioremediation techniques. The goal of the research preceding WASTEN was to understand how various soil conditions interact with processes, thereby enabling advantageous manipulation of soil conditions.

History

For early man, waste disposal was simple and without alternatives. In areas of sufficiently low population density, slight alterations of the earliest disposal methods may still suffice. However, as man became less nomadic and population centers developed, sanitation and health problems associated with ineffective waste disposal became more urgent. Land application to treat collected wastes and wastewater has been practiced for many years, and there are documented accounts of wastewater and sludge applications to soil during the 16th century (Wierzbicki 1977, Iskandar 1978). Pound and Crites (1975) cited currently operational systems in the United States that were started in approximately 1900.

Early practices of waste and wastewater application to soil were driven by the need to dispose of wastes. Although many soils have considerable natural capacity to treat wastes, little attention was given to operation or management. In the mid-1970s, research focused on identifying and understanding the controlling processes and their interactions. The inherent complexity of the overall process of soil-based remediation became increasingly apparent. Although useful empirical data could be obtained, the number of uncontrollable factors operating at any specific site or time made a strictly empirical approach intractable. To address these issues, modeling was incorporated into the research programs.

MODELING

Types

Many early models were primarily research oriented. Although model development and testing is still an active area for research, a number of design or management models have been spawned from earlier research programs. Management or operational models range from complex to fairly simple. Generally there is a compromise between the two extremes. More complex models require more input data and user knowledge and, being numerically complex, require more computer power and time to operate. Relatively simple models require less input data, less operator knowledge and less computing capabilities, but their output has less information about variations with soil depth. Safeguards are incorporated to prevent grossly erroneous output.

WASTEN

WASTEN is a dynamic simulation model developed at the Cold Regions Research and Engineering Laboratory by CRREL researchers and co-operating scientists (Selim and Iskandar 1981). Originally developed as a research tool, WASTEN incorporates a number of features not usually included in management-focused models. However, the increased capabilities and availability of computers has enabled the use of WASTEN for design, operation and management. In addition to the initial concentrations and distributions of $\text{NH}_4\text{-N}$ (ammonium nitrogen) and $\text{NO}_3\text{-N}$ (nitrate nitrogen) in the soil profile, wastewater application factors that can be input into WASTEN include the rate of application, the duration of application, the $\text{NH}_4\text{-N}$ and $\text{NO}_3\text{-N}$ concentrations and the wastewater application schedule or cycling. WASTEN can account for plant uptake, evapotranspiration, rainfall, soil layers and leaching. Nitrogen trans-

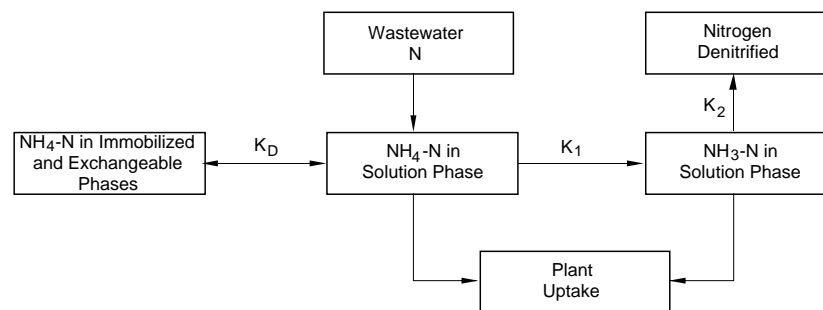


Figure 1. Nitrogen transformation processes considered in the nitrogen submodel. (After Selim and Iskandar 1981.)

formations addressed include nitrification of ammonium to nitrate, ammonium exchange on soil, and denitrification. Organic matter mineralization and immobilization are not specifically addressed by WASTEN, although control can be asserted through the nitrogen transformation rate constants. The relationships among these nitrogen forms and interacting processes are shown in Figure 1.

WASTEN includes a water transport submodel that is linked with a nitrogen submodel (Fig. 2). This linkage allows WASTEN to be used for steady-state and transient flow conditions, and it predicts water content and water flux throughout the soil profile and allows for upwards flow due to evapotranspiration.

The nitrogen submodel of WASTEN is built around the convective-dispersive transport equation, which couples the equation for continuity of mass with Fick's second law of diffusion. The resulting equation accounts for transport by diffusion, hydrodynamic dispersion and mass flow. For each nitrogen form treated by WASTEN, one analogous equation is developed (Fig. 3). Additionally, transformation processes are added onto each equation as source or sink terms. In use, WASTEN solves the resulting series of coupled equations by a modified, Crank-Nicolson, explicit-implicit finite-difference method. Integrated within the model is a water transport model that provides moisture content and flux at each node.

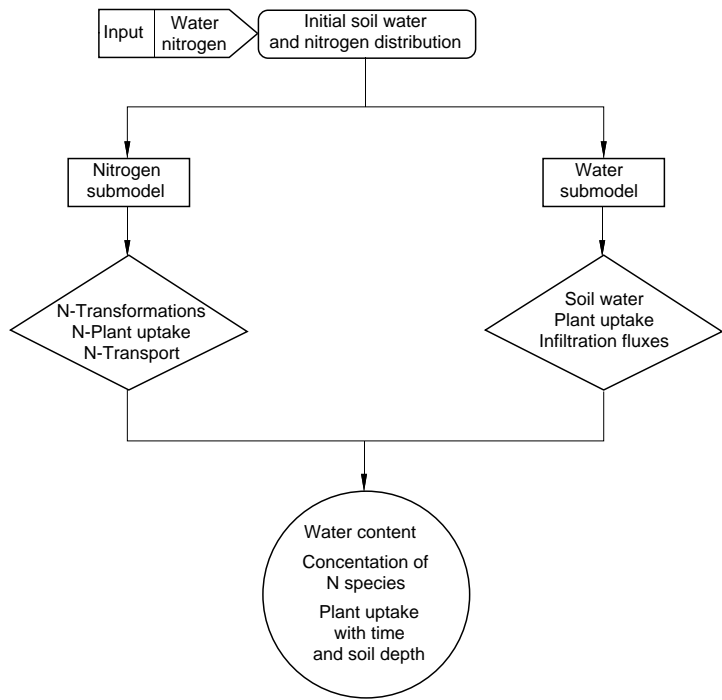


Figure 2. Simplified nitrogen model showing the water and nitrogen submodels. (After Selim and Iskandar 1980.)

$$\frac{\partial C}{\partial t} = \underbrace{D \frac{\partial^2 C}{\partial z^2}}_{\text{Dispersion + Mass Flow}} - \underbrace{V \frac{\partial C}{\partial z}}_{\text{Transport}} + \underbrace{\text{sources} - \text{sinks}}_{\text{Microbial Transformations}} - \text{plant uptake}$$

where D = dispersion coefficient

C = concentration

t = time

z = depth

V = average pore water velocity

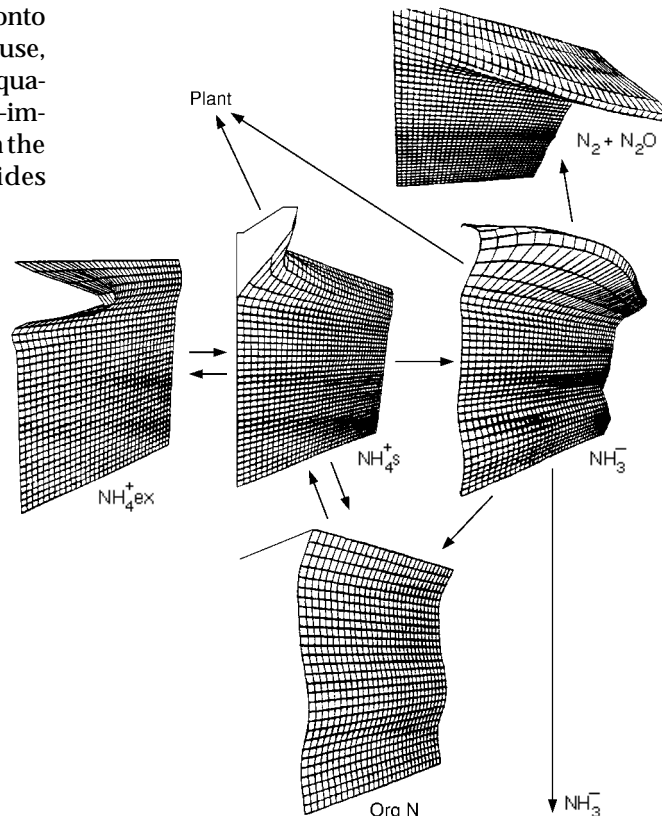


Figure 3. Interaction of nitrogen species and idealized model solution.

Validation

WASTEN has been extensively tested in both laboratory and field investigations. A listing of publications relating to WASTEN, its development and its testing is provided in Appendix A. WASTEN was recently used successfully and field-verified independently by researchers in Czechoslovakia to model the transport and transformation of nitrogen from fertilizer applications (Benes et al. 1989).

DENITRIFICATION

Introduction

A major component of WASTEN for wastewater treatment is denitrification—the microbial reduction of nitrate (NO_3^-) and nitrite (NO_2^-) to gaseous nitrogen (N) products, either as molecular N (N_2) or as oxides of N (NO , N_2O). Firestone (1982) depicted the overall pathway as:



WASTEN uses first-order kinetics to describe the rate of denitrification. The reaction kinetics are also linked to soil aeration, expressed as and calculated from soil moisture content. In this way, for the denitrification component of the model to be active, both nitrate and aeration criteria must be met.

Firestone (1982) reported that approximately 23 genera of bacteria can perform denitrification and that almost all denitrifying bacteria are aerobic organisms capable of anaerobic growth only in the presence of nitrogen oxides. The important consequence is that for land treatment of wastewater, the microbes responsible for denitrification are able to survive in the alternating saturated and nonsaturated conditions to which the soil profile is subjected. For denitrification to occur, several criteria must be met: obviously an NO_3^- source must exist, oxidation conditions must be reduced, and a carbon (C) source must be available.

Carbon

Given necessary nitrate levels and anaerobic conditions, other factors influencing denitrification include available C, pH and temperature. Of these, C is frequently the limiting factor. It is well established that C levels are important in controlling denitrification, both as a source of cell material and as electron donors. The form of C is also important. In general, more-soluble C sources have a more rapid and greater effect than less-soluble C

forms. Burford and Bremner (1975) observed positive correlations between denitrification and mineralizable C and also denitrification and water-soluble C. Stanford et al. (1975) found a positive correlation between denitrification and 0.01 M CaCl_2 extractable C. Because rhizosphere effects are generally thought to be caused by root excretions of C compounds, rhizosphere and root-soil interactions can also influence denitrification.

For soil systems that cycle between aerated and saturated conditions, C drives both the aerobic and the anaerobic processes. At the onset of saturation, dissolved O_2 in the soil solution creates aerobic conditions until the O_2 is depleted by microbial respiration. During respiration, O_2 consumption by microbial reduction requires C as an electron donor. As O_2 is depleted and soil atmosphere conditions become increasingly reduced, C oxidation will continue to occur, but NO_3^- serves as the electron acceptor. Consequently the cycling and denitrification of N is intimately linked with C metabolism.

Soil solution reaction

The effect of soil solution pH has been shown to influence denitrification activity (Firestone 1982). Denitrification has been observed in soils with a pH less than 5 (Gilliam and Gambrell 1978) and has even been observed in more acid soils of pH 3.5–4.0 (Klemmedtsson et al. 1978). It has been hypothesized that the effects of pH on denitrification may be related to interactions of pH and trace metal activity, especially molybdenum. Molybdenum is a necessary cofactor for nitrate reductase, a key enzyme in denitrification. There are numerous observations supporting denitrification over a wide pH range, and the most common influence is an increased proportion of N_2O produced as the pH decreases (Firestone 1982).

Temperature

Within limits, denitrification appears to follow the Arrhenius equation:

$$\ln v = (-\Delta H^*/RT) + C$$

where v = velocity

ΔH^* = activation energy

R = gas constant

T = temperature (K)

C = constant.

Although temperature affects the rate of chemical and biological processes, significant denitrifying activity has been found in soils at low tem-

peratures. Gamble et al. (1977) found that of 95 denitrifying isolates collected from diverse temperate soils, 65 were capable of growth and activity at 4°C, and 10 were capable of growth at 41°C. Most evidence indicates that, as a result of the diverse genera of bacteria involved, denitrifying organisms have adapted to a wide range of temperatures. Consequently, essentially all soils subjected to a range of temperatures demonstrate denitrification activity over that range.

METHODS

CRREL assisted the Philadelphia District of the Corps of Engineers by providing WASTEN simulations for conditions appropriate for a proposed treatment facility at Fort Dix. Both short-term and long-term steady-state simulations were run.

Initial short-term simulations

Input

The initial WASTEN simulations were based on conservative input data estimates, representing worse-than-expected conditions:

- The soil depth from the surface to the water table was set at 150 cm (4 ft).
- The soil was assumed to have three layers within the profile.
- The soil-water characteristics for the simulation were described using an equation developed by Green and Corey (1971), and the coefficients used were from Windsor sandy loam soil, B horizon, which has physical properties similar to the soil at the Fort Dix site.
- The plant uptake and evapotranspiration were set to zero.
- The loading rate for nitrogen was based on 4 mg NO₃-N/L in wastewater and approximately 21 cm of wastewater applied per cycle. This application was determined from the 5.6 million gallons/day (mgd) on a 25-acre surface.
- The initial conditions for the soil profile were (a) saturation throughout to provide maximal NO₃-N transport rates, and (b) negligible NO₃-N and NH₄-N concentrations.
- Denitrification was based on first-order kinetics and moisture content. The relatively conservative denitrification rate used was 0.01 hr⁻¹. Since no NH_x-N was applied, nitrification rates are not active in this simulation.

- The depth (cm) of wastewater applied and the concentration (mg/L) of NH₄-N and NO₃-N are listed for each simulation cycle.

The output obtained from the model included:

- The predicted NO₃-N concentrations for the entire profile to a depth of 150 cm at 2-cm increments;
- The amount of groundwater outflow during the cycle (cm); and
- The amount of NO₃-N leached below the unsaturated zone.

The concentration of N entering groundwater from the soil profile can be calculated from the water outflow and the amount of NO₃-N leached. Since the model output uses a 1000-cm² area, the mean concentration of N in water entering the saturated zone is:

$$\frac{\text{total N leached (mg N)} (1000\text{cm}^3)}{\text{total water outflow (cm)} \times \text{area} (1000\text{cm}^2) \times \text{L}} = \frac{\text{mg N}}{\text{L}}.$$

Results

Initially two simulations were run. Simulation 1 (App. B) represented 21 cm of 4 mg NO₃-N/L applied once, with the output listed every day for four days following application. The mean concentration of the output N was 0.97 mg N/L, which included and was “diluted” with the water initially in the profile. At day 4 the NO₃-N “bulge” is at approximately 35 cm. Also, the average total output, about 0.097 mg N/L, is less than the initial N concentration in the profile (0.1 mg N/L). That is, the leading edge of the incoming wastewater is being denitrified sufficiently so that it dilutes the already low N concentrations in the profile.

Simulation 2 (App. C) represented 21 cm of 4 mg NO₃-N/L water applied daily for four consecutive days, with the output given daily. This simulates repeated applications of all the wastewater on half the total acreage. Following the fourth day of N application, the output was continued for several more days of leaching. The final output estimated the NO₃-N concentrations in the lower profile to be 1.105 mg N/L, and the mean cumulative N concentration entering the groundwater was predicted to be 1.6 mg N/L.

Long-term steady-state simulations

Input

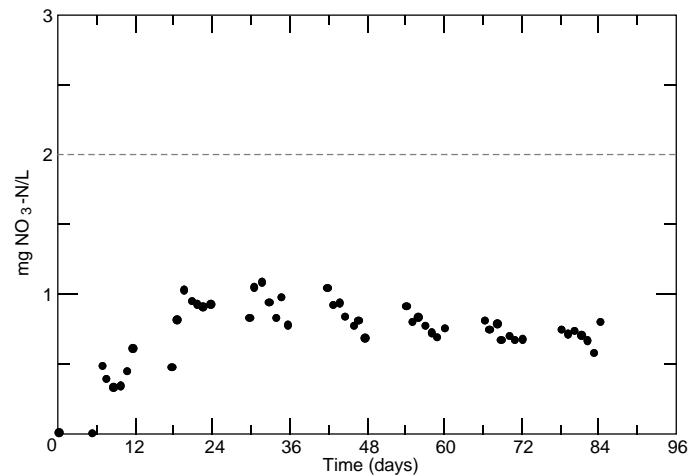
Based on the results of the first two simulations, further model simulations were conducted to provide insight into longer-term effects of land treat-

ment on the projected soil profile efflux $\text{NO}_3\text{-N}$ concentration levels at the site. Additionally, the wastewater dosages were changed to more accurately reflect those intended for the site. The simulations were continued until the long-term trend of the $\text{NO}_3\text{-N}$ outflow was discernible. The input data more accurately represented the proposed soil renovation treatment for wastewater:

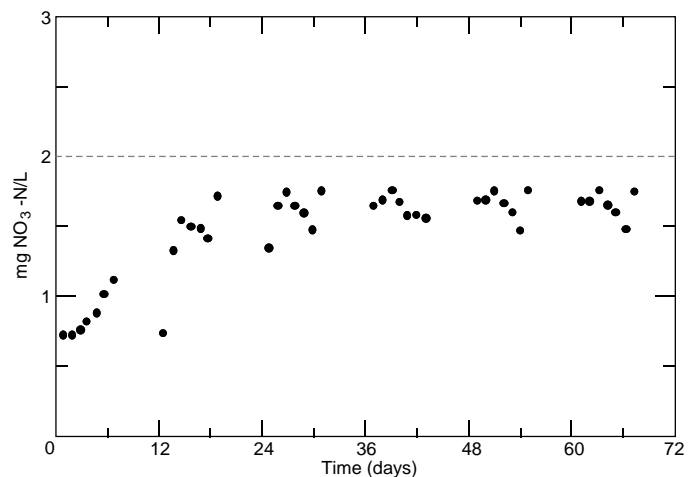
- The loading rates for nitrogen were based on either 4 or 10 mg $\text{NO}_3\text{-N/L}$ in wastewater and approximately 104 cm of wastewater applied per cycle. These two N concentrations were used to represent the design- and worst-case N levels in the effluent. (Earlier simulations used 4 mg $\text{NO}_3\text{-N/L}$ at a depth of 21 cm.)
- The application volume (ponding depth) was determined from a loading rate of 4.6 million gallons/day for two consecutive days, on an 8-acre surface (two cells, each having an area of 4 acres). The application was followed by a 10-day rest.
- From the data provided by the Philadelphia District of the Corps of Engineers, an initial concentration of 0.5 mg $\text{NO}_3\text{-N/L}$ was assumed in the entire soil profile.
- The simulations were conducted for seven 12-day cycles with 104 cm of 4 mg $\text{NO}_3\text{-N/L}$ applied each cycle, and also five 12-day cycles with 104 cm of 10-mg $\text{NO}_3\text{-N/L}$ wastewater applied each cycle.
- Additionally the two simulations were run sequentially, with applications of 4 mg $\text{NO}_3\text{-N/L}$ followed by a series of applications of 10 mg $\text{NO}_3\text{-N/L}$.
- The initial ammoniacal N was assumed to be 5.0 mg/L $\text{NH}_x\text{-N}$, based on data provided by the Philadelphia District of the Corps of Engineers.

The following input data and assumptions were the same as those used for the earlier simulations. As stated before, these are conservative assumptions and estimates, representing worse-than-expected conditions.

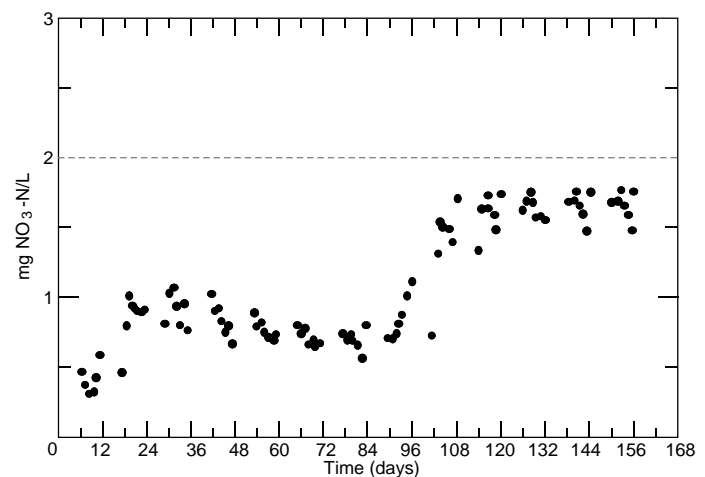
- The soil depth to the water table was set at 150 cm (4.9 ft), which is conservative. Temporary water table mounding during infiltration could conceivably raise the water table significantly for short periods. This effect would most likely increase denitrification by reducing the av-



a. 4 mg $\text{NO}_3\text{-N/L}$ applied.

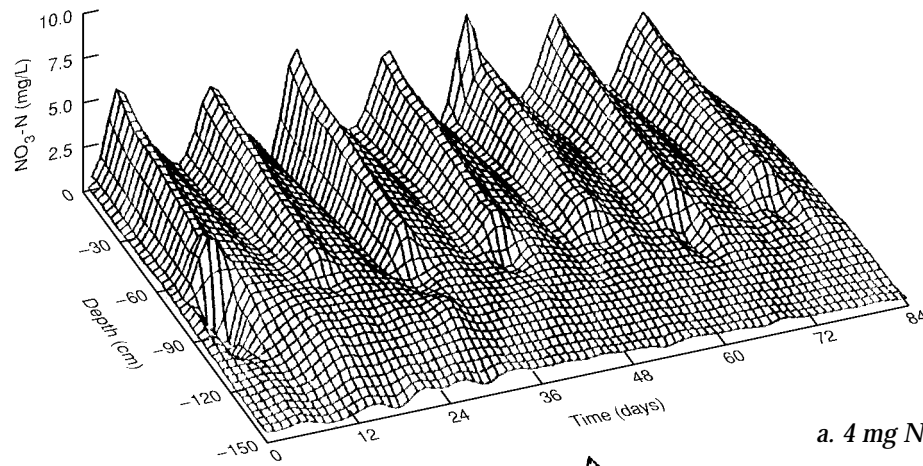


b. 10 mg $\text{NO}_3\text{-N/L}$ applied.

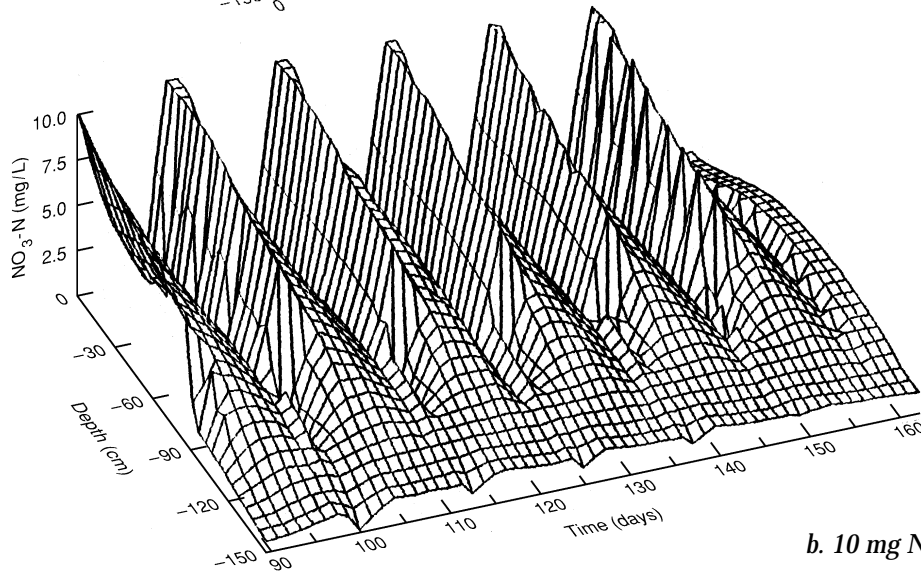


c. Days 1–89, 4 mg $\text{NO}_3\text{-N/L}$ in wastewater; days 90–156, 10 mg $\text{NO}_3\text{-N/L}$ in wastewater.

Figure 4. $\text{NO}_3\text{-N}$ efflux from the soil profile during wastewater application (12-day cycles).



a. 4 mg $\text{NO}_3\text{-N/L}$ applied.



b. 10 mg $\text{NO}_3\text{-N/L}$ applied.

Figure 5. $\text{NO}_3\text{-N}$ in the soil profile.

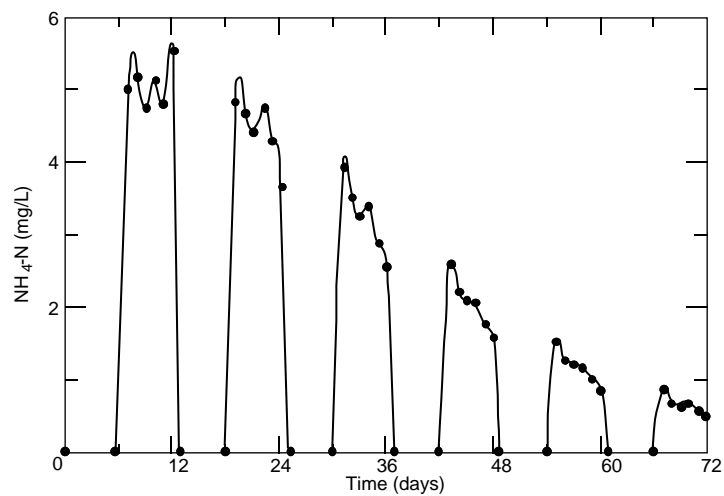
erage velocity of water movement. Moreover, denitrification would be promoted by saturated conditions.

- The soil was assumed to have three layers within the profile.
- The soil-water characteristics for the simulation were described using an equation developed by Green and Corey (1971) and using coefficients from Windsor sandy loam soil, B horizon, which is similar to the soil at the Fort Dix site.
- The plant uptake and evapotranspiration were set to zero. Ultimately these two processes will tend to reduce N levels in the soil, either by direct uptake or by increasing the conditions that promote denitrification. Setting coefficients for evapotranspiration and plant uptake of N forces the model to assume that N not lost by denitrification will be lost as $\text{NO}_3\text{-N}$ leachate.

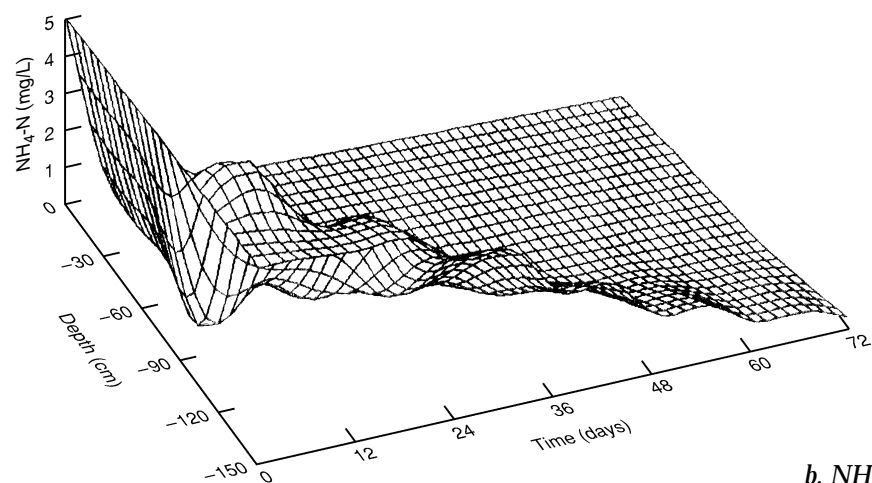
- Denitrification was based on first-order kinetics and moisture content. The relatively conservative denitrification rate used was 0.01 hr^{-1} .

Results

Figures 4–7 show the output from these simulations. The concentration values for the output were derived using the same technique as used in the short-term simulations. The WASTEN model simulations indicated that, under the conditions used for the computer simulations, the $\text{NO}_3\text{-N}$ concentrations in the soil solution leaving the upper 150 cm of the soil profile would not exceed 2.0 mg/L. This was true for both application rates: 4.0 and 10.0 mg/L $\text{NO}_3\text{-N}$ in the wastewater (Fig. 4a and b). Additionally, $\text{NO}_3\text{-N}$ output following 168 days of treatment (seven cycles each of 4.0 and 10.0 mg/L $\text{NO}_3\text{-N}$ in the wastewater) showed $\text{NO}_3\text{-N}$ efflux below 2 mg/L $\text{NO}_3\text{-N}$ (Fig. 4c).



a. $\text{NH}_4\text{-N}$ efflux from the soil profile.



b. $\text{NH}_4\text{-N}$ distribution in the soil profile.

Figure 6. $\text{NH}_4\text{-N}$ assuming a uniform initial concentration of 5 mg $\text{NH}_4\text{-N/L}$ and no transformations.

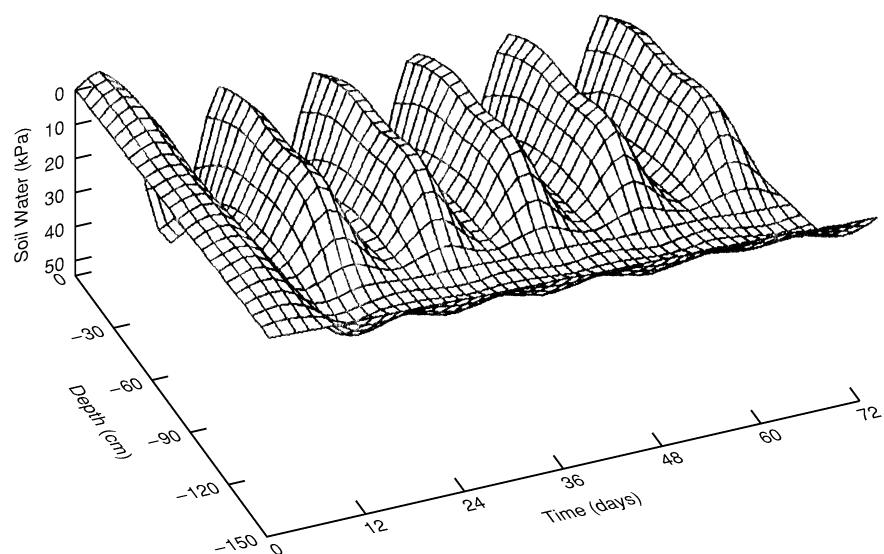


Figure 7. Soil-water potential distribution. Zero kPa indicates complete pore-space saturation.

The profile distributions of $\text{NO}_3\text{-N}$ for both 4 and 10 mg/L $\text{NO}_3\text{-N}$ exhibited high initial concentrations of $\text{NO}_3\text{-N}$, essentially equivalent to that in the applied wastewater, in the upper profile (Fig. 5). During the cycle, $\text{NO}_3\text{-N}$ levels decreased as denitrification proceeded.

A high, uniform initial ammoniacal-N concentration of 5.0 mg/L $\text{NH}_x\text{-N}$ in the soil profile was also tested to demonstrate the release of $\text{NH}_4\text{-N}$ from the 150-cm profile. For this simulation the nitrification coefficient was set to zero, thereby forcing all $\text{NH}_4\text{-N}$ to leach. After an initial release the $\text{NH}_4\text{-N}$ had relatively insignificant effects on N concentrations in the leachate (Fig. 6a). Due to cation exchange processes between the soil and $\text{NH}_4\text{-N}$ cations, movement of $\text{NH}_4\text{-N}$ is slow in the soil profile (Fig. 6b). Even starting with a high, uniform distribution and setting model parameters to allow leaching as the only loss pathway, as was done in the simulation, N contributions to the leachate were diffused over an extended time and therefore made relatively minor contributions to leachate N levels.

Soil-water potential

Soil-water potential, expressed in tension values, are shown in Figure 7. At lower soil depths the soil remains essentially saturated. In the upper soil profile, above approximately 75 cm, the soil cycles between saturated and unsaturated conditions. It is the cycling conditions in the vadose zone that allow both aerobic and anaerobic processes to readily occur.

RECOMMENDATIONS

Wastewater treatment in soil by land application is a proven and effective technology. In addition to cost benefits, soil has a natural ability to recover from a wide variety of stresses it may encounter. Denitrification, the major microbial process for reducing $\text{NO}_3\text{-N}$, is well documented and occurs in virtually all soils under appropriate conditions.

Because denitrification is driven by microbial processes, it is carbon dependent. Eliminating all carbon from the applied wastewater could inhibit denitrification. Hence, excessive removal of all organics from the wastewater could be detrimental for nitrogen treatment. The alternating wet-dry, aerobic-anaerobic conditions that will occur in the vadose zone should provide for a wide range of

microbial processes to occur that will promote the metabolism of added organic material.

Like all dynamic simulation models that describe a series of complex, interrelated processes, WASTEN estimates the impacts that might result from changing input variables. The results from model simulations provide insight into the trends and direction of potential outcomes resulting from changing conditions. The model output is a legitimate means to express magnitude and direction, but it does not necessarily represent the exact values that will be measured in the field. This concept can be appreciated by considering the difficulty in accurately measuring existing properties and concentrations in field samples. Nevertheless the validity and utility of using models to estimate the impact of different design and operation options is well accepted.

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APPENDIX B: RESULTS OF SIMULATION 1.

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*****
*   Initial simulation number 1                                     *
*   SUMMARY INPUT                                                  *
*   21 CM Wastewater, 4 mg/L NO3-N, applied one time, output listed for 4 days. *
*****
      I N P U T   D A T A

INITIAL DT, HR =      .01000
INITIAL DZ , CM=     1.00000

TOTAL LENGTH OF SOIL PROFILE, CM = 150.00000
SOIL DEPTH TO THE FIRST SOIL LAYER, CM =  15.00000
SOIL DEPTH TO THE SECOND SOIL LAYER, CM =  45.00000

SOIL WATER PARAMETERS FOR THE FIRST  LAYER :      .9600E-05      .2763E+02      .1000E+03      .1000E+01
SOIL WATER PARAMETERS FOR THE SECOND LAYER :      .2200E-05      .3070E+02      .4000E+02      .1000E+01
SOIL WATER PARAMETERS FOR THE THIRD  LAYER :      .2100E-05      .3887E+02      .3000E+02      .1000E+01
FIRST LAYER ; BULK DENSITY =  1.60000      SATURATION =  .44000
SECOND LAYER ; BULK DENSITY =  1.60000      SATURATION =  .42000
THIRD  LAYER ; BULK DENSITY =  1.60000      SATURATION =  .34000

FIRST LAYER:      NH4-N EXCHANGEABLE COEFFICIENT, CM3/GM =  .25000
                  NITRIFICATION RATE COEF.,HR-1 =  .10000
                  DENITRIFICATION RATE COEF., HR-1 =  .01000
SECOND LAYER      NH4-N EXCHANGEABLE COEFFICIENT, CM3/GM =  .25000
                  NITRIFICATION RATE COEF.,HR-1 =  .10000
                  DENITRIFICATION RATE COEF., HR-1 =  .01000
THIRD LAYER:      NH4-N EXCHANGEABLE COEFFICIENT, CM3/GM =  .25000
                  NITRIFICATION RATE COEF.,HR-1 =  .10000
                  DENITRIFICATION RATE COEF., HR-1 =  .01000

SOLUTE DISPERSION COEFFICIENT, CM**2/HR =   2.50000

MICHAELIS CONSTANT, MG/LITRE   =   1.00000

INITIAL DISTRIBUTION OF PRESSURE HEAD,CM
.000   .000   .000   .000
AT THE CORRESPONDING SOIL DEPTHS OF, CM
7.500  40.000  75.000 150.000
INITIAL DISTRIBUTION OF NH4-N,MG/ML IN SOL
.010   .010   .010   .010   .010   .010
AT THE CORRESPONDING SOIL DEPTHS OF, CM
7.500  15.000  30.500  48.000  98.000 150.000
INITIAL DISTRIBUTION OF NO3-N,MG/ML IN SOL
.100   .100   .100   .100   .100   .100
AT THE CORRESPONDING SOIL DEPTHS OF, CM
7.500  15.000  30.500  48.000  98.000 150.000
TOTAL ELAPSED TIME =      .00  DAYS

      SOIL DEPTH      PRESSURE HEAD      SOIL-WATER CONTENT      WATER FLOW      AMMONIUM CONCENTRATION      NITRATE CONCENTRATION
      CM              CM              CM**3/CM**3      VELOCITY      IN SOIL SOLUTION      IN SOIL SOLUTION
                                CM/HR      MICROGRAMS-N/ML      MICROGRAMS-N /ML

      .00              .00              .44              .0000              .010              .100
      2.00              .00              .44              .0042              .010              .100
      4.00              .00              .44              .0042              .010              .100
      6.00              .00              .44              .0042              .010              .100
      8.00              .00              .44              .0042              .010              .100
     10.00              .00              .44              .0042              .010              .100
     12.00              .00              .44              .0042              .010              .100
     14.00              .00              .44              .0042              .010              .100
     16.00              .00              .42              1.8284              .010              .100
     18.00              .00              .42              .0014              .010              .100
     20.00              .00              .42              .0014              .010              .100
     22.00              .00              .42              .0014              .010              .100
     24.00              .00              .42              .0014              .010              .100
     26.00              .00              .42              .0014              .010              .100
     28.00              .00              .42              .0014              .010              .100
     30.00              .00              .42              .0014              .010              .100
     32.00              .00              .42              .0014              .010              .100
     34.00              .00              .42              .0014              .010              .100

```

| | | | | | |
|--------|-----|-----|-------|------|------|
| 36.00 | .00 | .42 | .0014 | .010 | .100 |
| 38.00 | .00 | .42 | .0014 | .010 | .100 |
| 40.00 | .00 | .42 | .0014 | .010 | .100 |
| 42.00 | .00 | .42 | .0014 | .010 | .100 |
| 44.00 | .00 | .42 | .0014 | .010 | .100 |
| 46.00 | .00 | .34 | .8754 | .010 | .100 |
| 48.00 | .00 | .34 | .0016 | .010 | .100 |
| 50.00 | .00 | .34 | .0016 | .010 | .100 |
| 52.00 | .00 | .34 | .0016 | .010 | .100 |
| 54.00 | .00 | .34 | .0016 | .010 | .100 |
| 56.00 | .00 | .34 | .0016 | .010 | .100 |
| 58.00 | .00 | .34 | .0016 | .010 | .100 |
| 60.00 | .00 | .34 | .0016 | .010 | .100 |
| 62.00 | .00 | .34 | .0016 | .010 | .100 |
| 64.00 | .00 | .34 | .0016 | .010 | .100 |
| 66.00 | .00 | .34 | .0016 | .010 | .100 |
| 68.00 | .00 | .34 | .0016 | .010 | .100 |
| 70.00 | .00 | .34 | .0016 | .010 | .100 |
| 72.00 | .00 | .34 | .0016 | .010 | .100 |
| 74.00 | .00 | .34 | .0016 | .010 | .100 |
| 76.00 | .00 | .34 | .0016 | .010 | .100 |
| 78.00 | .00 | .34 | .0016 | .010 | .100 |
| 80.00 | .00 | .34 | .0016 | .010 | .100 |
| 82.00 | .00 | .34 | .0016 | .010 | .100 |
| 84.00 | .00 | .34 | .0016 | .010 | .100 |
| 86.00 | .00 | .34 | .0016 | .010 | .100 |
| 88.00 | .00 | .34 | .0016 | .010 | .100 |
| 90.00 | .00 | .34 | .0016 | .010 | .100 |
| 92.00 | .00 | .34 | .0016 | .010 | .100 |
| 94.00 | .00 | .34 | .0016 | .010 | .100 |
| 96.00 | .00 | .34 | .0016 | .010 | .100 |
| 98.00 | .00 | .34 | .0016 | .010 | .100 |
| 100.00 | .00 | .34 | .0016 | .010 | .100 |
| 102.00 | .00 | .34 | .0016 | .010 | .100 |
| 104.00 | .00 | .34 | .0016 | .010 | .100 |
| 106.00 | .00 | .34 | .0016 | .010 | .100 |
| 108.00 | .00 | .34 | .0016 | .010 | .100 |
| 110.00 | .00 | .34 | .0016 | .010 | .100 |
| 112.00 | .00 | .34 | .0016 | .010 | .100 |
| 114.00 | .00 | .34 | .0016 | .010 | .100 |
| 116.00 | .00 | .34 | .0016 | .010 | .100 |
| 118.00 | .00 | .34 | .0016 | .010 | .100 |
| 120.00 | .00 | .34 | .0016 | .010 | .100 |
| 122.00 | .00 | .34 | .0016 | .010 | .100 |
| 124.00 | .00 | .34 | .0016 | .010 | .100 |
| 126.00 | .00 | .34 | .0016 | .010 | .100 |
| 128.00 | .00 | .34 | .0016 | .010 | .100 |
| 130.00 | .00 | .34 | .0016 | .010 | .100 |
| 132.00 | .00 | .34 | .0016 | .010 | .100 |
| 134.00 | .00 | .34 | .0016 | .010 | .100 |
| 136.00 | .00 | .34 | .0016 | .010 | .100 |
| 138.00 | .00 | .34 | .0016 | .010 | .100 |
| 140.00 | .00 | .34 | .0016 | .010 | .100 |
| 142.00 | .00 | .34 | .0016 | .010 | .100 |
| 144.00 | .00 | .34 | .0016 | .010 | .100 |
| 146.00 | .00 | .34 | .0016 | .010 | .100 |
| 148.00 | .00 | .34 | .0016 | .010 | .100 |
| 150.00 | .00 | .34 | .0016 | .010 | .100 |

TOTAL NO-3 NITROGEN IN SOIL SOLUTION PHASE , MICROGRAMS = 5.490

TOTAL NH-4 NITROGEN IN SOIL SOLUTION PHASE , MICROGRAMS = .549

TOTAL NH-4 NITROGEN IN EXCHANGEABLE PHASE , MICROGRAMS = .600

TOTAL NH-4 NITROGEN IN THE SOIL PROFILE , MICROGRAMS = 1.149

CUMULATIVE NITROGEN DENITRIFIED, MICROGRAMS = .00000

CUMULATIVE NITRATE NITROGEN UPTAKE, MICROGRAMS = .000

CUNULATIVE AMMONIUM NITROGEN UPTAKE, MICROGRAMS = .000

CUMULATIVE NO3-N LEACHED TO THE GROUND WATER TABLE, MG - N = .00000
 CUMULATIVE NH4-N LEACHED TO THE GROUND WATER TABLE, MG - N = .00000
 CUMULATIVE WATER OUTFLOW , CM = .00000

THIS IS CYCLE NUMBER = 1

AMOUNT OF WASTE WATER APPLIED , CM = 21.00000
 INFILTRATION TIME, I.E. DURATION OF WASTE WATER APPLICATION, DAYS = 1.00000
 SCHEDULE OF WASTE WATER APPLICATION, I.E. CYCLE DURATION ,DAYS = 4.00000

TIME AT WHICH OUTPUT DATA IS REQUESTED IN THIS CYCLE, DAYS = 1.00000

CONCENTRATION OF APPLIED NH4-N , MG/LITRE = .00000
 CONCENTRATION OF APPLIED NO3-N , MG/LITRE = 4.00000

NITROGEN UPTAKE RATE, MICROGRAM-N/CM OF ROOT LENGTH PER DAY = .00000

EVAPOTRANSPIRATION RATE, CM/DAY = .00000

TOTAL ELAPSED TIME = 1.00 DAYS

| SOIL DEPTH CM | PRESSURE HEAD CM | SOIL-WATER CONTENT CM**3/CM**3 | WATER FLOW VELOCITY CM/HR | AMMONIUM CONCENTRATION IN SOIL SOLUTION MICROGRAMS-N/ML | NITRATE CONCENTRATION IN SOIL SOLUTION MICROGRAMS-N /ML |
|------------------|---------------------|-----------------------------------|---------------------------------|---|---|
| .00 | -4.84 | .42 | .8750 | .000 | 3.989 |
| 2.00 | -4.50 | .42 | .8829 | .000 | 3.951 |
| 4.00 | -4.09 | .42 | .8829 | .000 | 3.914 |
| 6.00 | -3.61 | .42 | .8829 | .000 | 3.876 |
| 8.00 | -3.04 | .43 | .8829 | .000 | 3.839 |
| 10.00 | -2.37 | .43 | .8829 | .000 | 3.802 |
| 12.00 | -1.59 | .43 | .8829 | .000 | 3.765 |
| 14.00 | -.70 | .44 | .8829 | .000 | 3.728 |
| 16.00 | .08 | .42 | .8829 | .000 | 3.693 |
| 18.00 | .07 | .42 | .8829 | .000 | 3.658 |
| 20.00 | .07 | .42 | .8829 | .002 | 3.623 |
| 22.00 | .05 | .42 | .8829 | .003 | 3.588 |
| 24.00 | .04 | .42 | .8829 | .004 | 3.553 |
| 26.00 | .03 | .42 | .8829 | .005 | 3.517 |
| 28.00 | .01 | .42 | .8829 | .006 | 3.478 |
| 30.00 | -.00 | .42 | .8829 | .008 | 3.434 |
| 32.00 | -.02 | .42 | .8829 | .008 | 3.381 |
| 34.00 | -.06 | .42 | .8829 | .009 | 3.315 |
| 36.00 | -.11 | .42 | .8829 | .009 | 3.228 |
| 38.00 | -.18 | .42 | .8829 | .010 | 3.114 |
| 40.00 | -.30 | .42 | .8829 | .010 | 2.966 |
| 42.00 | -.48 | .42 | .8829 | .010 | 2.780 |
| 44.00 | -.76 | .42 | .8829 | .010 | 2.558 |
| 46.00 | -.90 | .34 | .8829 | .010 | 2.342 |
| 48.00 | -.90 | .34 | .8829 | .010 | 2.116 |
| 50.00 | -.90 | .34 | .8829 | .010 | 1.875 |
| 52.00 | -.90 | .34 | .8829 | .010 | 1.627 |
| 54.00 | -.90 | .34 | .8829 | .010 | 1.379 |
| 56.00 | -.90 | .34 | .8829 | .010 | 1.141 |
| 58.00 | -.90 | .34 | .8829 | .010 | .922 |
| 60.00 | -.90 | .34 | .8829 | .010 | .728 |
| 62.00 | -.90 | .34 | .8829 | .010 | .562 |
| 64.00 | -.89 | .34 | .8829 | .010 | .427 |
| 66.00 | -.88 | .34 | .8829 | .010 | .321 |
| 68.00 | -.87 | .34 | .8829 | .010 | .241 |
| 70.00 | -.84 | .34 | .8829 | .010 | .184 |
| 72.00 | -.79 | .34 | .8829 | .010 | .144 |
| 74.00 | -.71 | .34 | .8829 | .010 | .118 |
| 76.00 | -.58 | .34 | .8829 | .010 | .102 |
| 78.00 | -.36 | .34 | .8829 | .010 | .093 |
| 80.00 | .00 | .34 | .8829 | .010 | .090 |
| 82.00 | .00 | .34 | 1.1528 | .010 | .100 |
| 84.00 | .00 | .34 | .0016 | .010 | .100 |

| | | | | | |
|--------|-----|-----|-------|------|------|
| 86.00 | .00 | .34 | .0016 | .010 | .100 |
| 88.00 | .00 | .34 | .0016 | .010 | .100 |
| 90.00 | .00 | .34 | .0016 | .010 | .100 |
| 92.00 | .00 | .34 | .0016 | .010 | .100 |
| 94.00 | .00 | .34 | .0016 | .010 | .100 |
| 96.00 | .00 | .34 | .0016 | .010 | .100 |
| 98.00 | .00 | .34 | .0016 | .010 | .100 |
| 100.00 | .00 | .34 | .0016 | .010 | .100 |
| 102.00 | .00 | .34 | .0016 | .010 | .100 |
| 104.00 | .00 | .34 | .0016 | .010 | .100 |
| 106.00 | .00 | .34 | .0016 | .010 | .100 |
| 108.00 | .00 | .34 | .0016 | .010 | .100 |
| 110.00 | .00 | .34 | .0016 | .010 | .100 |
| 112.00 | .00 | .34 | .0016 | .010 | .100 |
| 114.00 | .00 | .34 | .0016 | .010 | .100 |
| 116.00 | .00 | .34 | .0016 | .010 | .100 |
| 118.00 | .00 | .34 | .0016 | .010 | .100 |
| 120.00 | .00 | .34 | .0016 | .010 | .100 |
| 122.00 | .00 | .34 | .0016 | .010 | .100 |
| 124.00 | .00 | .34 | .0016 | .010 | .100 |
| 126.00 | .00 | .34 | .0016 | .010 | .100 |
| 128.00 | .00 | .34 | .0016 | .010 | .100 |
| 130.00 | .00 | .34 | .0016 | .010 | .100 |
| 132.00 | .00 | .34 | .0016 | .010 | .100 |
| 134.00 | .00 | .34 | .0016 | .010 | .100 |
| 136.00 | .00 | .34 | .0016 | .010 | .100 |
| 138.00 | .00 | .34 | .0016 | .010 | .100 |
| 140.00 | .00 | .34 | .0016 | .010 | .100 |
| 142.00 | .00 | .34 | .0016 | .010 | .100 |
| 144.00 | .00 | .34 | .0016 | .010 | .100 |
| 146.00 | .00 | .34 | .0016 | .010 | .100 |
| 148.00 | .00 | .34 | .0016 | .010 | .100 |
| 150.00 | .00 | .34 | .0016 | .010 | .100 |

TOTAL NO-3 NITROGEN IN SOIL SOLUTION PHASE , MICROGRAMS = 78.575

TOTAL NH-4 NITROGEN IN SOIL SOLUTION PHASE , MICROGRAMS = .436

TOTAL NH-4 NITROGEN IN EXCHANGEABLE PHASE , MICROGRAMS = .497

TOTAL NH-4 NITROGEN IN THE SOIL PROFILE , MICROGRAMS = .933

CUMULATIVE NITROGEN DENITRIFIED, MICROGRAMS = 9.94938

CUMULATIVE NITRATE NITROGEN UPTAKE, MICROGRAMS = .000

CUMULATIVE AMMONIUM NITROGEN UPTAKE, MICROGRAMS = .000

CUMULATIVE NO3-N LEACHED TO THE GROUND WATER TABLE, MG - N = .00000

CUMULATIVE NH4-N LEACHED TO THE GROUND WATER TABLE, MG - N = .00000

CUMULATIVE WATER OUTFLOW , CM = .00000

TOTAL ELAPSED TIME = 2.00 DAYS

| SOIL DEPTH CM | PRESSURE HEAD CM | SOIL-WATER CONTENT CM**3/CM**3 | WATER FLOW VELOCITY CM/HR | AMMONIUM CONCENTRATION IN SOIL SOLUTION MICROGRAMS-N/ML | NITRATE CONCENTRATION IN SOIL SOLUTION MICROGRAMS-N /ML |
|------------------|---------------------|-----------------------------------|---------------------------------|---|---|
| .00 | -38.36 | .32 | .0000 | .000 | 3.151 |
| 2.00 | -36.41 | .32 | .0017 | .000 | 3.151 |
| 4.00 | -34.48 | .33 | .0024 | .000 | 3.164 |
| 6.00 | -32.58 | .33 | .0039 | .000 | 3.184 |
| 8.00 | -30.70 | .34 | .0055 | .000 | 3.207 |
| 10.00 | -28.84 | .34 | .0071 | .000 | 3.231 |
| 12.00 | -26.98 | .35 | .0088 | .000 | 3.256 |
| 14.00 | -25.12 | .35 | .0104 | .000 | 3.279 |
| 16.00 | -23.34 | .34 | .0122 | .000 | 3.288 |
| 18.00 | -22.60 | .34 | .0143 | .001 | 3.269 |
| 20.00 | -21.93 | .34 | .0164 | .002 | 3.233 |

| | | | | | |
|--------|--------|-----|-------|------|-------|
| 22.00 | -21.31 | .34 | .0186 | .002 | 3.187 |
| 24.00 | -20.73 | .35 | .0207 | .003 | 3.135 |
| 26.00 | -20.18 | .35 | .0227 | .004 | 3.081 |
| 28.00 | -19.66 | .35 | .0248 | .005 | 3.025 |
| 30.00 | -19.15 | .35 | .0268 | .005 | 2.967 |
| 32.00 | -18.65 | .35 | .0287 | .006 | 2.908 |
| 34.00 | -18.14 | .35 | .0306 | .007 | 2.848 |
| 36.00 | -17.62 | .36 | .0325 | .007 | 2.785 |
| 38.00 | -17.08 | .36 | .0343 | .008 | 2.719 |
| 40.00 | -16.49 | .36 | .0361 | .009 | 2.651 |
| 42.00 | -15.86 | .36 | .0378 | .009 | 2.582 |
| 44.00 | -15.16 | .37 | .0394 | .009 | 2.513 |
| 46.00 | -13.81 | .28 | .0409 | .009 | 2.450 |
| 48.00 | -13.62 | .28 | .0426 | .010 | 2.379 |
| 50.00 | -13.44 | .28 | .0443 | .010 | 2.296 |
| 52.00 | -13.26 | .28 | .0460 | .010 | 2.199 |
| 54.00 | -13.10 | .29 | .0477 | .010 | 2.092 |
| 56.00 | -12.94 | .29 | .0494 | .010 | 1.976 |
| 58.00 | -12.78 | .29 | .0510 | .010 | 1.851 |
| 60.00 | -12.64 | .29 | .0527 | .010 | 1.721 |
| 62.00 | -12.49 | .29 | .0544 | .010 | 1.587 |
| 64.00 | -12.35 | .29 | .0560 | .010 | 1.451 |
| 66.00 | -12.22 | .29 | .0576 | .010 | 1.314 |
| 68.00 | -12.09 | .29 | .0593 | .010 | 1.180 |
| 70.00 | -11.97 | .29 | .0609 | .010 | 1.050 |
| 72.00 | -11.85 | .29 | .0625 | .010 | .925 |
| 74.00 | -11.73 | .29 | .0641 | .010 | .808 |
| 76.00 | -11.61 | .29 | .0657 | .010 | .699 |
| 78.00 | -11.50 | .29 | .0673 | .010 | .599 |
| 80.00 | -11.39 | .29 | .0689 | .010 | .510 |
| 82.00 | -11.29 | .29 | .0705 | .010 | .431 |
| 84.00 | -11.19 | .29 | .0720 | .010 | .362 |
| 86.00 | -11.09 | .29 | .0736 | .010 | .303 |
| 88.00 | -10.99 | .29 | .0752 | .010 | .253 |
| 90.00 | -10.90 | .29 | .0767 | .010 | .213 |
| 92.00 | -10.80 | .29 | .0783 | .010 | .180 |
| 94.00 | -10.71 | .30 | .0798 | .010 | .153 |
| 96.00 | -10.63 | .30 | .0814 | .010 | .133 |
| 98.00 | -10.54 | .30 | .0829 | .010 | .117 |
| 100.00 | -10.45 | .30 | .0844 | .010 | .106 |
| 102.00 | -10.37 | .30 | .0860 | .010 | .097 |
| 104.00 | -10.29 | .30 | .0875 | .010 | .091 |
| 106.00 | -10.21 | .30 | .0890 | .010 | .087 |
| 108.00 | -10.13 | .30 | .0905 | .010 | .084 |
| 110.00 | -10.05 | .30 | .0920 | .010 | .082 |
| 112.00 | -9.98 | .30 | .0935 | .010 | .081 |
| 114.00 | -9.90 | .30 | .0950 | .010 | .080 |
| 116.00 | -9.82 | .30 | .0965 | .010 | .080 |
| 118.00 | -9.74 | .30 | .0980 | .010 | .080 |
| 120.00 | -9.66 | .30 | .0995 | .010 | .079 |
| 122.00 | -9.57 | .30 | .1010 | .010 | .079 |
| 124.00 | -9.47 | .30 | .1024 | .010 | .079 |
| 126.00 | -9.35 | .30 | .1038 | .010 | .079 |
| 128.00 | -9.21 | .30 | .1052 | .010 | .079 |
| 130.00 | -9.04 | .30 | .1066 | .010 | .079 |
| 132.00 | -8.81 | .30 | .1079 | .010 | .079 |
| 134.00 | -8.50 | .30 | .1092 | .010 | .079 |
| 136.00 | -8.08 | .31 | .1103 | .010 | .079 |
| 138.00 | -7.53 | .31 | .1114 | .010 | .079 |
| 140.00 | -6.79 | .31 | .1123 | .010 | .079 |
| 142.00 | -5.85 | .32 | .1130 | .010 | .079 |
| 144.00 | -4.69 | .32 | .1136 | .010 | .079 |
| 146.00 | -3.30 | .33 | .1139 | .010 | .079 |
| 148.00 | -1.73 | .33 | .1142 | .010 | .079 |
| 150.00 | .00 | .34 | .1143 | .010 | .079 |

TOTAL NO-3 NITROGEN IN SOIL SOLUTION PHASE , MICROGRAMS = 65.152

TOTAL NH-4 NITROGEN IN SOIL SOLUTION PHASE , MICROGRAMS = .368

TOTAL NH-4 NITROGEN IN EXCHANGEABLE PHASE , MICROGRAMS = .483

TOTAL NH-4 NITROGEN IN THE SOIL PROFILE , MICROGRAMS = .851

CUMULATIVE NITROGEN DENITRIFIED, MICROGRAMS = 22.61943

CUMULATIVE NITRATE NITROGEN UPTAKE, MICROGRAMS = .000

CUMULATIVE AMMONIUM NITROGEN UPTAKE, MICROGRAMS = .000

CUMULATIVE NO3-N LEACHED TO THE GROUND WATER TABLE, MG - N = 1.33980

CUMULATIVE NH4-N LEACHED TO THE GROUND WATER TABLE, MG - N = .14514

CUMULATIVE WATER OUTFLOW , CM = 14.51430

TOTAL ELAPSED TIME = 3.00 DAYS

| SOIL DEPTH CM | PRESSURE HEAD CM | SOIL-WATER CONTENT CM**3/CM**3 | WATER FLOW VELOCITY CM/HR | AMMONIUM CONCENTRATION IN SOIL SOLUTION MICROGRAMS-N/ML | NITRATE CONCENTRATION IN SOIL SOLUTION MICROGRAMS-N /ML |
|------------------|---------------------|-----------------------------------|---------------------------------|---|---|
| .00 | -42.62 | .31 | .0000 | .000 | 2.413 |
| 2.00 | -40.86 | .31 | .0079 | .000 | 2.373 |
| 4.00 | -39.02 | .32 | .0045 | .000 | 2.390 |
| 6.00 | -37.18 | .32 | .0051 | .000 | 2.419 |
| 8.00 | -35.34 | .33 | .0056 | .000 | 2.454 |
| 10.00 | -33.50 | .33 | .0062 | .000 | 2.495 |
| 12.00 | -31.64 | .33 | .0068 | .000 | 2.536 |
| 14.00 | -29.79 | .34 | .0074 | .000 | 2.577 |
| 16.00 | -27.99 | .32 | .0081 | .001 | 2.615 |
| 18.00 | -27.30 | .32 | .0090 | .002 | 2.646 |
| 20.00 | -26.64 | .32 | .0099 | .002 | 2.671 |
| 22.00 | -26.01 | .33 | .0109 | .003 | 2.691 |
| 24.00 | -25.39 | .33 | .0119 | .003 | 2.704 |
| 26.00 | -24.79 | .33 | .0129 | .004 | 2.713 |
| 28.00 | -24.21 | .33 | .0140 | .004 | 2.717 |
| 30.00 | -23.62 | .34 | .0150 | .005 | 2.714 |
| 32.00 | -23.03 | .34 | .0160 | .005 | 2.706 |
| 34.00 | -22.42 | .34 | .0171 | .006 | 2.667 |
| 36.00 | -21.78 | .34 | .0181 | .006 | 2.612 |
| 38.00 | -21.11 | .34 | .0190 | .007 | 2.547 |
| 40.00 | -20.38 | .35 | .0200 | .008 | 2.476 |
| 42.00 | -19.60 | .35 | .0209 | .008 | 2.404 |
| 44.00 | -18.74 | .35 | .0218 | .008 | 2.333 |
| 46.00 | -17.27 | .27 | .0226 | .009 | 2.270 |
| 48.00 | -17.06 | .27 | .0236 | .009 | 2.213 |
| 50.00 | -16.86 | .27 | .0246 | .009 | 2.153 |
| 52.00 | -16.67 | .27 | .0256 | .009 | 2.088 |
| 54.00 | -16.49 | .27 | .0265 | .009 | 2.017 |
| 56.00 | -16.31 | .27 | .0275 | .010 | 1.943 |
| 58.00 | -16.14 | .27 | .0284 | .010 | 1.856 |
| 60.00 | -15.98 | .27 | .0294 | .010 | 1.760 |
| 62.00 | -15.82 | .27 | .0303 | .010 | 1.658 |
| 64.00 | -15.66 | .27 | .0313 | .010 | 1.553 |
| 66.00 | -15.52 | .28 | .0322 | .010 | 1.445 |
| 68.00 | -15.37 | .28 | .0331 | .010 | 1.338 |
| 70.00 | -15.23 | .28 | .0341 | .010 | 1.230 |
| 72.00 | -15.10 | .28 | .0350 | .010 | 1.125 |
| 74.00 | -14.97 | .28 | .0359 | .010 | 1.023 |
| 76.00 | -14.84 | .28 | .0368 | .010 | .924 |
| 78.00 | -14.72 | .28 | .0377 | .010 | .830 |
| 80.00 | -14.60 | .28 | .0386 | .010 | .741 |
| 82.00 | -14.48 | .28 | .0396 | .010 | .658 |
| 84.00 | -14.37 | .28 | .0405 | .010 | .581 |
| 86.00 | -14.26 | .28 | .0414 | .010 | .510 |
| 88.00 | -14.15 | .28 | .0423 | .010 | .446 |
| 90.00 | -14.05 | .28 | .0432 | .010 | .389 |
| 92.00 | -13.94 | .28 | .0440 | .010 | .337 |
| 94.00 | -13.84 | .28 | .0449 | .010 | .292 |
| 96.00 | -13.75 | .28 | .0458 | .010 | .253 |
| 98.00 | -13.65 | .28 | .0467 | .010 | .220 |
| 100.00 | -13.55 | .28 | .0476 | .010 | .191 |
| 102.00 | -13.46 | .28 | .0485 | .010 | .167 |
| 104.00 | -13.37 | .28 | .0493 | .010 | .146 |
| 106.00 | -13.28 | .28 | .0502 | .010 | .130 |
| 108.00 | -13.19 | .29 | .0511 | .010 | .116 |
| 110.00 | -13.10 | .29 | .0519 | .010 | .105 |
| 112.00 | -13.01 | .29 | .0528 | .010 | .097 |
| 114.00 | -12.91 | .29 | .0537 | .010 | .090 |
| 116.00 | -12.81 | .29 | .0545 | .010 | .084 |
| 118.00 | -12.71 | .29 | .0553 | .010 | .080 |

| | | | | | |
|--------|--------|-----|-------|------|------|
| 120.00 | -12.59 | .29 | .0562 | .010 | .077 |
| 122.00 | -12.45 | .29 | .0570 | .010 | .074 |
| 124.00 | -12.29 | .29 | .0578 | .010 | .072 |
| 126.00 | -12.10 | .29 | .0585 | .010 | .071 |
| 128.00 | -11.85 | .29 | .0593 | .010 | .069 |
| 130.00 | -11.53 | .29 | .0600 | .010 | .068 |
| 132.00 | -11.12 | .29 | .0606 | .010 | .067 |
| 134.00 | -10.58 | .30 | .0612 | .010 | .066 |
| 136.00 | -9.89 | .30 | .0616 | .010 | .065 |
| 138.00 | -9.02 | .30 | .0620 | .010 | .064 |
| 140.00 | -7.95 | .31 | .0623 | .010 | .064 |
| 142.00 | -6.68 | .31 | .0625 | .010 | .063 |
| 144.00 | -5.22 | .32 | .0627 | .010 | .063 |
| 146.00 | -3.60 | .32 | .0627 | .010 | .063 |
| 148.00 | -1.85 | .33 | .0627 | .010 | .062 |
| 150.00 | .00 | .34 | .0627 | .010 | .062 |

TOTAL NO-3 NITROGEN IN SOIL SOLUTION PHASE , MICROGRAMS = 57.079

TOTAL NH-4 NITROGEN IN SOIL SOLUTION PHASE , MICROGRAMS = .346

TOTAL NH-4 NITROGEN IN EXCHANGEABLE PHASE , MICROGRAMS = .472

TOTAL NH-4 NITROGEN IN THE SOIL PROFILE , MICROGRAMS = .817

CUMULATIVE NITROGEN DENITRIFIED, MICROGRAMS = 30.64991

CUMULATIVE NITRATE NITROGEN UPTAKE, MICROGRAMS = .000

CUMULATIVE AMMONIUM NITROGEN UPTAKE, MICROGRAMS = .000

CUMULATIVE NO3-N LEACHED TO THE GROUND WATER TABLE, MG - N = 1.46579

CUMULATIVE NH4-N LEACHED TO THE GROUND WATER TABLE, MG - N = .16348

CUMULATIVE WATER OUTFLOW , CM = 16.34771

TOTAL ELAPSED TIME = 4.00 DAYS

| SOIL DEPTH CM | PRESSURE HEAD CM | SOIL-WATER CONTENT CM**3/CM**3 | WATER FLOW VELOCITY CM/HR | AMMONIUM CONCENTRATION IN SOIL SOLUTION MICROGRAMS-N/ML | NITRATE CONCENTRATION IN SOIL SOLUTION MICROGRAMS-N /ML |
|------------------|---------------------|-----------------------------------|---------------------------------|---|---|
| .00 | -44.85 | .30 | .0000 | .000 | 1.804 |
| 2.00 | -43.12 | .31 | .0080 | .000 | 1.763 |
| 4.00 | -41.30 | .31 | .0044 | .000 | 1.778 |
| 6.00 | -39.47 | .32 | .0047 | .000 | 1.803 |
| 8.00 | -37.64 | .32 | .0051 | .000 | 1.836 |
| 10.00 | -35.80 | .32 | .0055 | .000 | 1.874 |
| 12.00 | -33.95 | .33 | .0060 | .000 | 1.916 |
| 14.00 | -32.09 | .33 | .0064 | .001 | 1.959 |
| 16.00 | -30.29 | .31 | .0068 | .001 | 2.001 |
| 18.00 | -29.69 | .31 | .0074 | .002 | 2.040 |
| 20.00 | -29.10 | .32 | .0080 | .002 | 2.076 |
| 22.00 | -28.52 | .32 | .0086 | .002 | 2.109 |
| 24.00 | -27.95 | .32 | .0092 | .003 | 2.138 |
| 26.00 | -27.38 | .32 | .0099 | .003 | 2.163 |
| 28.00 | -26.80 | .32 | .0105 | .004 | 2.185 |
| 30.00 | -26.22 | .33 | .0111 | .004 | 2.203 |
| 32.00 | -25.60 | .33 | .0117 | .005 | 2.218 |
| 34.00 | -24.96 | .33 | .0123 | .005 | 2.228 |
| 36.00 | -24.29 | .33 | .0129 | .006 | 2.235 |
| 38.00 | -23.56 | .34 | .0135 | .006 | 2.235 |
| 40.00 | -22.77 | .34 | .0141 | .007 | 2.229 |
| 42.00 | -21.91 | .34 | .0147 | .007 | 2.198 |
| 44.00 | -20.98 | .35 | .0152 | .008 | 2.148 |
| 46.00 | -19.46 | .26 | .0158 | .008 | 2.091 |
| 48.00 | -19.25 | .26 | .0164 | .008 | 2.035 |
| 50.00 | -19.06 | .26 | .0170 | .008 | 1.977 |
| 52.00 | -18.87 | .26 | .0177 | .009 | 1.917 |
| 54.00 | -18.68 | .26 | .0183 | .009 | 1.854 |

| | | | | | |
|--------|--------|-----|-------|------|-------|
| 56.00 | -18.50 | .26 | .0189 | .009 | 1.790 |
| 58.00 | -18.33 | .26 | .0195 | .009 | 1.723 |
| 60.00 | -18.16 | .26 | .0202 | .009 | 1.653 |
| 62.00 | -18.00 | .27 | .0208 | .009 | 1.582 |
| 64.00 | -17.84 | .27 | .0214 | .009 | 1.508 |
| 66.00 | -17.68 | .27 | .0221 | .009 | 1.432 |
| 68.00 | -17.53 | .27 | .0227 | .009 | 1.354 |
| 70.00 | -17.39 | .27 | .0233 | .009 | 1.275 |
| 72.00 | -17.25 | .27 | .0240 | .009 | 1.196 |
| 74.00 | -17.11 | .27 | .0246 | .009 | 1.116 |
| 76.00 | -16.98 | .27 | .0252 | .010 | 1.038 |
| 78.00 | -16.85 | .27 | .0258 | .010 | .960 |
| 80.00 | -16.72 | .27 | .0265 | .010 | .884 |
| 82.00 | -16.60 | .27 | .0271 | .010 | .810 |
| 84.00 | -16.48 | .27 | .0277 | .010 | .739 |
| 86.00 | -16.36 | .27 | .0283 | .010 | .672 |
| 88.00 | -16.25 | .27 | .0290 | .010 | .608 |
| 90.00 | -16.14 | .27 | .0296 | .010 | .546 |
| 92.00 | -16.03 | .27 | .0302 | .010 | .488 |
| 94.00 | -15.92 | .27 | .0308 | .010 | .434 |
| 96.00 | -15.82 | .27 | .0314 | .010 | .385 |
| 98.00 | -15.71 | .27 | .0320 | .010 | .341 |
| 100.00 | -15.61 | .28 | .0327 | .010 | .301 |
| 102.00 | -15.51 | .28 | .0333 | .010 | .266 |
| 104.00 | -15.41 | .28 | .0339 | .010 | .235 |
| 106.00 | -15.31 | .28 | .0345 | .010 | .207 |
| 108.00 | -15.21 | .28 | .0351 | .010 | .184 |
| 110.00 | -15.11 | .28 | .0357 | .010 | .163 |
| 112.00 | -15.01 | .28 | .0363 | .010 | .145 |
| 114.00 | -14.90 | .28 | .0369 | .010 | .130 |
| 116.00 | -14.78 | .28 | .0374 | .010 | .117 |
| 118.00 | -14.64 | .28 | .0380 | .010 | .107 |
| 120.00 | -14.49 | .28 | .0386 | .010 | .098 |
| 122.00 | -14.31 | .28 | .0391 | .010 | .090 |
| 124.00 | -14.09 | .28 | .0397 | .010 | .084 |
| 126.00 | -13.81 | .28 | .0402 | .010 | .078 |
| 128.00 | -13.46 | .28 | .0407 | .010 | .074 |
| 130.00 | -13.02 | .29 | .0411 | .010 | .070 |
| 132.00 | -12.45 | .29 | .0415 | .010 | .066 |
| 134.00 | -11.74 | .29 | .0418 | .010 | .063 |
| 136.00 | -10.85 | .29 | .0421 | .010 | .060 |
| 138.00 | -9.77 | .30 | .0424 | .010 | .058 |
| 140.00 | -8.50 | .30 | .0425 | .010 | .056 |
| 142.00 | -7.06 | .31 | .0426 | .010 | .055 |
| 144.00 | -5.45 | .32 | .0427 | .010 | .053 |
| 146.00 | -3.72 | .32 | .0427 | .010 | .053 |
| 148.00 | -1.90 | .33 | .0427 | .010 | .052 |
| 150.00 | .00 | .34 | .0427 | .010 | .052 |

TOTAL NO-3 NITROGEN IN SOIL SOLUTION PHASE , MICROGRAMS = 48.889

TOTAL NH-4 NITROGEN IN SOIL SOLUTION PHASE , MICROGRAMS = .326

TOTAL NH-4 NITROGEN IN EXCHANGEABLE PHASE , MICROGRAMS = .457

TOTAL NH-4 NITROGEN IN THE SOIL PROFILE , MICROGRAMS = .782

CUMULATIVE NITROGEN DENITRIFIED, MICROGRAMS = 38.78701

CUMULATIVE NITRATE NITROGEN UPTAKE, MICROGRAMS = .000

CUMULATIVE AMMONIUM NITROGEN UPTAKE, MICROGRAMS = .000

CUMULATIVE NO3-N LEACHED TO THE GROUND WATER TABLE, MG - N = 1.53162

CUMULATIVE NH4-N LEACHED TO THE GROUND WATER TABLE, MG - N = .17527

CUMULATIVE WATER OUTFLOW , CM = 17.52757

W A T E R B A L A N C E

I N P U T ,

| | | |
|---|-------------|----------|
| AMOUNT OF WATER IN THE SOIL PROFILE FROM PREVIOUS | CYCLE, CM = | 54.90002 |
| AMOUNT OF WASTE WATER APPLIED OR RAINFALL IN THIS | CYCLE, CM = | 21.00000 |
| TOTAL WATER INPUT , CM | = | 75.90002 |

O U T P U T

| | | |
|---|------------------|---------------|
| AMOUNT OF WATER IN THE SOIL PROFILE AT THE END OF | THIS CYCLE, CM = | 43.84124 |
| TOTAL EVAPOTRANSPIRATION DURING THIS CYCLE, CM = | = | .00000 |
| AMOUNT OF GROUND WATER OUTFLOW DURING THIS CYCLE | = | 17.52757----- |
| TOTAL WATER OUTPUT , CM = | = | 61.36880 |

BALANCE = (OUTPUT - INPUT) * 100 / INPUT = -19.14520 PERCENT

N I T R O G E N B A L A N C E

I N P U T ,

| | | |
|---|----------|----------|
| TOTAL NITROGEN PRESENT IN THE SOIL PROFILE FROM PREVIOUS CYCLE, | MG - N = | 6.63900 |
| WASTE WATER NITROGEN APPLIED DURING THIS CYCLE , MG - N | = | 84.00000 |
| TOTAL NITROGEN INPUT , MG - N = | = | 90.63900 |

O U T P U T

| | |
|---|----------------|
| TOTAL NITROGEN PRESENT IN THE SOIL PROFILE AT THE END OF THIS CYCLE, MG - N = | 49.67073 |
| TOTAL NITROGEN UPTAKE DURING THIS CYCLE , MG - N | = .00000 |
| TOTAL NITROGEN LEACHED TO THE GROUND WATER TABLE | = 1.70690----- |
| TOTAL NITROGEN OUTPUT , MG - N = | = 90.16463 |

BALANCE = (OUTPUT - INPUT) * 100 / INPUT = -.52336 PERCENT

* 1.706 mg N / 17.5 cm H2O *

* yields 0.097 mg N / L *

APPENDIX C: RESULTS OF SIMULATION 2.

```
*****
*   Initial simulation number 2   *
*                               *
*   SUMMARY INPUT               *
*   21 CM Wastewater, 4 mg/L NO3-N, applied daily for 4 days, *
*   output listed for 4 days.   *
*****
```

I N P U T D A T A

```
INITIAL DT, HR = .01000
INITIAL DZ , CM= 1.00000
```

```
TOTAL LENGTH OF SOIL PROFILE, CM = 150.00000
SOIL DEPTH TO THE FIRST SOIL LAYER, CM = 15.00000
SOIL DEPTH TO THE SECOND SOIL LAYER, CM = 45.00000
```

```
SOIL WATER PARAMETERS FOR THE FIRST LAYER :   .9600E-05   .2763E+02   .1000E+03   .1000E+01
SOIL WATER PARAMETERS FOR THE SECOND LAYER :   .2200E-05   .3070E+02   .4000E+02   .1000E+01
SOIL WATER PARAMETERS FOR THE THIRD LAYER :   .2100E-05   .3887E+02   .3000E+02   .1000E+01
FIRST LAYER ; BULK DENSITY = 1.60000          SATURATION = .44000
SECOND LAYER ; BULK DENSITY = 1.60000          SATURATION = .42000
THIRD LAYER ; BULK DENSITY = 1.60000          SATURATION = .34000
```

```
FIRST LAYER:      NH4-N EXCHANGEABLE COEFFICIENT, CM3/GM = .25000
                   NITRIFICATION RATE COEF.,HR-1 = .10000
                   DENITRIFICATION RATE COEF., HR-1 = .01000
SECOND LAYER      NH4-N EXCHANGEABLE COEFFICIENT, CM3/GM = .25000
                   NITRIFICATION RATE COEF.,HR-1 = .10000
                   DENITRIFICATION RATE COEF., HR-1 = .01000
THIRD LAYER:      NH4-N EXCHANGEABLE COEFFICIENT, CM3/GM = .25000
                   NITRIFICATION RATE COEF.,HR-1 = .10000
                   DENITRIFICATION RATE COEF., HR-1 = .01000
```

```
SOLUTE DISPERSION COEFFICIENT, CM**2/HR = 2.50000
```

```
MICHAELIS CONSTANT, MG/LITRE = 1.00000
```

```
INITIAL DISTRIBUTION OF PRESSURE HEAD,CM
.000 .000 .000 .000
AT THE CORRESPONDING SOIL DEPTHS OF, CM
7.500 40.000 75.000 150.000
INITIAL DISTRIBUTION OF NH4-N, MG/ML IN SOL
.010 .010 .010 .010 .010 .010
AT THE CORRESPONDING SOIL DEPTHS OF, CM
7.500 15.000 30.500 48.000 98.000 150.000
INITIAL DISTRIBUTION OF NO3-N, MG/ML IN SOL
.100 .100 .100 .100 .100 .100
AT THE CORRESPONDING SOIL DEPTHS OF, CM
7.500 15.000 30.500 48.000 98.000 150.000
```

TOTAL ELAPSED TIME = .00 DAYS

| SOIL DEPTH CM | PRESSURE HEAD | SOIL-WATER CONTENT **3/CM**3 | WATER FLOW VELOCITY CM/HR | AMMONIUM CONCENTRATION IN SOIL SOLUTION MICROGRAMS-N/ML | NITRATE CONCENTRATION IN SOIL SOLUTION MICROGRAMS-N /ML |
|------------------|---------------|---------------------------------|---------------------------------|---|---|
| .00 | .00 | .44 | .0000 | .010 | .100 |
| 2.00 | .00 | .44 | .0042 | .010 | .100 |
| 4.00 | .00 | .44 | .0042 | .010 | .100 |
| 6.00 | .00 | .44 | .0042 | .010 | .100 |
| 8.00 | .00 | .44 | .0042 | .010 | .100 |
| 10.00 | .00 | .44 | .0042 | .010 | .100 |
| 12.00 | .00 | .44 | .0042 | .010 | .100 |
| 14.00 | .00 | .44 | .0042 | .010 | .100 |
| 16.00 | .00 | .42 | 1.8284 | .010 | .100 |

| | | | | | |
|--------|-----|-----|-------|------|------|
| 18.00 | .00 | .42 | .0014 | .010 | .100 |
| 20.00 | .00 | .42 | .0014 | .010 | .100 |
| 22.00 | .00 | .42 | .0014 | .010 | .100 |
| 24.00 | .00 | .42 | .0014 | .010 | .100 |
| 26.00 | .00 | .42 | .0014 | .010 | .100 |
| 28.00 | .00 | .42 | .0014 | .010 | .100 |
| 30.00 | .00 | .42 | .0014 | .010 | .100 |
| 32.00 | .00 | .42 | .0014 | .010 | .100 |
| 34.00 | .00 | .42 | .0014 | .010 | .100 |
| 36.00 | .00 | .42 | .0014 | .010 | .100 |
| 38.00 | .00 | .42 | .0014 | .010 | .100 |
| 40.00 | .00 | .42 | .0014 | .010 | .100 |
| 42.00 | .00 | .42 | .0014 | .010 | .100 |
| 44.00 | .00 | .42 | .0014 | .010 | .100 |
| 46.00 | .00 | .34 | .8754 | .010 | .100 |
| 48.00 | .00 | .34 | .0016 | .010 | .100 |
| 50.00 | .00 | .34 | .0016 | .010 | .100 |
| 52.00 | .00 | .34 | .0016 | .010 | .100 |
| 54.00 | .00 | .34 | .0016 | .010 | .100 |
| 56.00 | .00 | .34 | .0016 | .010 | .100 |
| 58.00 | .00 | .34 | .0016 | .010 | .100 |
| 60.00 | .00 | .34 | .0016 | .010 | .100 |
| 62.00 | .00 | .34 | .0016 | .010 | .100 |
| 64.00 | .00 | .34 | .0016 | .010 | .100 |
| 66.00 | .00 | .34 | .0016 | .010 | .100 |
| 68.00 | .00 | .34 | .0016 | .010 | .100 |
| 70.00 | .00 | .34 | .0016 | .010 | .100 |
| 72.00 | .00 | .34 | .0016 | .010 | .100 |
| 74.00 | .00 | .34 | .0016 | .010 | .100 |
| 76.00 | .00 | .34 | .0016 | .010 | .100 |
| 78.00 | .00 | .34 | .0016 | .010 | .100 |
| 80.00 | .00 | .34 | .0016 | .010 | .100 |
| 82.00 | .00 | .34 | .0016 | .010 | .100 |
| 84.00 | .00 | .34 | .0016 | .010 | .100 |
| 86.00 | .00 | .34 | .0016 | .010 | .100 |
| 88.00 | .00 | .34 | .0016 | .010 | .100 |
| 90.00 | .00 | .34 | .0016 | .010 | .100 |
| 92.00 | .00 | .34 | .0016 | .010 | .100 |
| 94.00 | .00 | .34 | .0016 | .010 | .100 |
| 96.00 | .00 | .34 | .0016 | .010 | .100 |
| 98.00 | .00 | .34 | .0016 | .010 | .100 |
| 100.00 | .00 | .34 | .0016 | .010 | .100 |
| 102.00 | .00 | .34 | .0016 | .010 | .100 |
| 104.00 | .00 | .34 | .0016 | .010 | .100 |
| 106.00 | .00 | .34 | .0016 | .010 | .100 |
| 108.00 | .00 | .34 | .0016 | .010 | .100 |
| 110.00 | .00 | .34 | .0016 | .010 | .100 |
| 112.00 | .00 | .34 | .0016 | .010 | .100 |
| 114.00 | .00 | .34 | .0016 | .010 | .100 |
| 116.00 | .00 | .34 | .0016 | .010 | .100 |
| 118.00 | .00 | .34 | .0016 | .010 | .100 |
| 120.00 | .00 | .34 | .0016 | .010 | .100 |
| 122.00 | .00 | .34 | .0016 | .010 | .100 |
| 124.00 | .00 | .34 | .0016 | .010 | .100 |
| 126.00 | .00 | .34 | .0016 | .010 | .100 |
| 128.00 | .00 | .34 | .0016 | .010 | .100 |
| 130.00 | .00 | .34 | .0016 | .010 | .100 |
| 132.00 | .00 | .34 | .0016 | .010 | .100 |
| 134.00 | .00 | .34 | .0016 | .010 | .100 |
| 136.00 | .00 | .34 | .0016 | .010 | .100 |
| 138.00 | .00 | .34 | .0016 | .010 | .100 |
| 140.00 | .00 | .34 | .0016 | .010 | .100 |
| 142.00 | .00 | .34 | .0016 | .010 | .100 |
| 144.00 | .00 | .34 | .0016 | .010 | .100 |
| 146.00 | .00 | .34 | .0016 | .010 | .100 |
| 148.00 | .00 | .34 | .0016 | .010 | .100 |
| 150.00 | .00 | .34 | .0016 | .010 | .100 |

TOTAL NO-3 NITROGEN IN SOIL SOLUTION PHASE , MICROGRAMS = 5.490

TOTAL NH-4 NITROGEN IN SOIL SOLUTION PHASE , MICROGRAMS = .549

TOTAL NH-4 NITROGEN IN EXCHANGEABLE PHASE , MICROGRAMS = .600

TOTAL NH-4 NITROGEN IN THE SOIL PROFILE , MICROGRAMS = 1.149

CUMULATIVE NITROGEN DENITRIFIED, MICROGRAMS = .00000

CUMULATIVE NITRATE NITROGEN UPTAKE, MICROGRAMS = .000

CUMULATIVE AMMONIUM NITROGEN UPTAKE, MICROGRAMS = .000

CUMULATIVE NO3-N LEACHED TO THE GROUND WATER TABLE, MG - N = .00000

CUMULATIVE NH4-N LEACHED TO THE GROUND WATER TABLE, MG - N = .00000

CUMULATIVE WATER OUTFLOW , CM = .00000

THIS IS CYCLE NUMBER = 1

AMOUNT OF WASTE WATER APPLIED , CM = 21.00000

INFILTRATION TIME, I.E. DURATION OF WASTE WATER APPLICATION, DAYS = 1.00000

SCHEDULE OF WASTE WATER APPLICATION, I.E. CYCLE DURATION ,DAYS = 1.00000

TIME AT WHICH OUTPUT DATA IS REQUESTED IN THIS CYCLE, DAYS = 1.00000

CONCENTRATION OF APPLIED NH4-N , MG/LITRE = .00000

CONCENTRATION OF APPLIED NO3-N , MG/LITRE = 4.00000

NITROGEN UPTAKE RATE, MICROGRAM-N/CM OF ROOT LENGTH PER DAY = .00000

EVAPOTRANSPIRATION RATE, CM/DAY = .00000

TOTAL ELAPSED TIME = 1.00 DAYS

| SOIL DEPTH CM | PRESSURE HEAD | SOIL-WATER CONTENT **3/CM**3 | WATER FLOW VELOCITY CM/HR | AMMONIUM CONCENTRATION IN SOIL SOLUTION MICROGRAMS-N/ML | NITRATE CONCENTRATION IN SOIL SOLUTION MICROGRAMS-N /ML |
|------------------|---------------|---------------------------------|---------------------------------|---|---|
| .00 | -4.84 | .42 | .8750 | .000 | 3.989 |
| 2.00 | -4.50 | .42 | .8829 | .000 | 3.951 |
| 4.00 | -4.09 | .42 | .8829 | .000 | 3.914 |
| 6.00 | -3.61 | .42 | .8829 | .000 | 3.876 |
| 8.00 | -3.04 | .43 | .8829 | .000 | 3.839 |
| 10.00 | -2.37 | .43 | .8829 | .000 | 3.802 |
| 12.00 | -1.59 | .43 | .8829 | .000 | 3.765 |
| 14.00 | -.70 | .44 | .8829 | .000 | 3.728 |
| 16.00 | .08 | .42 | .8829 | .000 | 3.693 |
| 18.00 | .07 | .42 | .8829 | .000 | 3.658 |
| 20.00 | .07 | .42 | .8829 | .002 | 3.623 |
| 22.00 | .05 | .42 | .8829 | .003 | 3.588 |
| 24.00 | .04 | .42 | .8829 | .004 | 3.553 |
| 26.00 | .03 | .42 | .8829 | .005 | 3.517 |
| 28.00 | .01 | .42 | .8829 | .006 | 3.478 |
| 30.00 | -.00 | .42 | .8829 | .008 | 3.434 |
| 32.00 | -.02 | .42 | .8829 | .008 | 3.381 |
| 34.00 | -.06 | .42 | .8829 | .009 | 3.315 |
| 36.00 | -.11 | .42 | .8829 | .009 | 3.228 |
| 38.00 | -.18 | .42 | .8829 | .010 | 3.114 |
| 40.00 | -.30 | .42 | .8829 | .010 | 2.966 |
| 42.00 | -.48 | .42 | .8829 | .010 | 2.780 |
| 44.00 | -.76 | .42 | .8829 | .010 | 2.558 |
| 46.00 | -.90 | .34 | .8829 | .010 | 2.342 |
| 48.00 | -.90 | .34 | .8829 | .010 | 2.116 |
| 50.00 | -.90 | .34 | .8829 | .010 | 1.875 |

| | | | | | |
|--------|------|-----|--------|------|-------|
| 52.00 | -.90 | .34 | .8829 | .010 | 1.627 |
| 54.00 | -.90 | .34 | .8829 | .010 | 1.379 |
| 56.00 | -.90 | .34 | .8829 | .010 | 1.141 |
| 58.00 | -.90 | .34 | .8829 | .010 | .922 |
| 60.00 | -.90 | .34 | .8829 | .010 | .728 |
| 62.00 | -.90 | .34 | .8829 | .010 | .562 |
| 64.00 | -.89 | .34 | .8829 | .010 | .427 |
| 66.00 | -.88 | .34 | .8829 | .010 | .321 |
| 68.00 | -.87 | .34 | .8829 | .010 | .241 |
| 70.00 | -.84 | .34 | .8829 | .010 | .184 |
| 72.00 | -.79 | .34 | .8829 | .010 | .144 |
| 74.00 | -.71 | .34 | .8829 | .010 | .118 |
| 76.00 | -.58 | .34 | .8829 | .010 | .102 |
| 78.00 | -.36 | .34 | .8829 | .010 | .093 |
| 80.00 | .00 | .34 | .8829 | .010 | .090 |
| 82.00 | .00 | .34 | 1.1528 | .010 | .100 |
| 84.00 | .00 | .34 | .0016 | .010 | .100 |
| 86.00 | .00 | .34 | .0016 | .010 | .100 |
| 88.00 | .00 | .34 | .0016 | .010 | .100 |
| 90.00 | .00 | .34 | .0016 | .010 | .100 |
| 92.00 | .00 | .34 | .0016 | .010 | .100 |
| 94.00 | .00 | .34 | .0016 | .010 | .100 |
| 96.00 | .00 | .34 | .0016 | .010 | .100 |
| 98.00 | .00 | .34 | .0016 | .010 | .100 |
| 100.00 | .00 | .34 | .0016 | .010 | .100 |
| 102.00 | .00 | .34 | .0016 | .010 | .100 |
| 104.00 | .00 | .34 | .0016 | .010 | .100 |
| 106.00 | .00 | .34 | .0016 | .010 | .100 |
| 108.00 | .00 | .34 | .0016 | .010 | .100 |
| 110.00 | .00 | .34 | .0016 | .010 | .100 |
| 112.00 | .00 | .34 | .0016 | .010 | .100 |
| 114.00 | .00 | .34 | .0016 | .010 | .100 |
| 116.00 | .00 | .34 | .0016 | .010 | .100 |
| 118.00 | .00 | .34 | .0016 | .010 | .100 |
| 120.00 | .00 | .34 | .0016 | .010 | .100 |
| 122.00 | .00 | .34 | .0016 | .010 | .100 |
| 124.00 | .00 | .34 | .0016 | .010 | .100 |
| 126.00 | .00 | .34 | .0016 | .010 | .100 |
| 128.00 | .00 | .34 | .0016 | .010 | .100 |
| 130.00 | .00 | .34 | .0016 | .010 | .100 |
| 132.00 | .00 | .34 | .0016 | .010 | .100 |
| 134.00 | .00 | .34 | .0016 | .010 | .100 |
| 136.00 | .00 | .34 | .0016 | .010 | .100 |
| 138.00 | .00 | .34 | .0016 | .010 | .100 |
| 140.00 | .00 | .34 | .0016 | .010 | .100 |
| 142.00 | .00 | .34 | .0016 | .010 | .100 |
| 144.00 | .00 | .34 | .0016 | .010 | .100 |
| 146.00 | .00 | .34 | .0016 | .010 | .100 |
| 148.00 | .00 | .34 | .0016 | .010 | .100 |
| 150.00 | .00 | .34 | .0016 | .010 | .100 |

TOTAL NO-3 NITROGEN IN SOIL SOLUTION PHASE , MICROGRAMS = 78.575

TOTAL NH-4 NITROGEN IN SOIL SOLUTION PHASE , MICROGRAMS = .436

TOTAL NH-4 NITROGEN IN EXCHANGEABLE PHASE , MICROGRAMS = .497

TOTAL NH-4 NITROGEN IN THE SOIL PROFILE , MICROGRAMS = .933

CUMULATIVE NITROGEN DENITRIFIED, MICROGRAMS = 9.94938

CUMULATIVE NITRATE NITROGEN UPTAKE, MICROGRAMS = .000

CUMULATIVE AMMONIUM NITROGEN UPTAKE, MICROGRAMS = .000

CUMULATIVE NO3-N LEACHED TO THE GROUND WATER TABLE, MG - N = .00000

CUMULATIVE NH4-N LEACHED TO THE GROUND WATER TABLE, MG - N = .00000

CUMULATIVE WATER OUTFLOW , CM = .00000

W A T E R B A L A N C E

I N P U T ,

AMOUNT OF WATER IN THE SOIL PROFILE FROM PREVIOUS CYCLE, CM = 54.90002
AMOUNT OF WASTE WATER APPLIED OR RAINFALL IN THIS CYCLE, CM = 21.00000
TOTAL WATER INPUT , CM = 75.90002

O U T P U T

AMOUNT OF WATER IN THE SOIL PROFILE AT THE END OF THIS CYCLE, CM = 48.59818
TOTAL EVAPOTRANSPIRATION DURING THIS CYCLE, CM = .00000
AMOUNT OF GROUND WATER OUTFLOW DURING THIS CYCLE = 12.94017
TOTAL WATER OUTPUT , CM = 61.53835

BALANCE = (OUTPUT - INPUT) * 100 / INPUT = -18.92183 PERCENT

N I T R O G E N B A L A N C E

I N P U T ,

TOTAL NITROGEN PRESENT IN THE SOIL PROFILE FROM PREVIOUS CYCLE, MG - N = 6.63900
WASTE WATER NITROGEN APPLIED DURING THIS CYCLE , MG - N = 84.00000
TOTAL NITROGEN INPUT , MG - N = 90.63900

O U T P U T

TOTAL NITROGEN PRESENT IN THE SOIL PROFILE AT THE END OF THIS CYCLE, MG - N = 79.50768
TOTAL NITROGEN UPTAKE DURING THIS CYCLE , MG - N = .00000
TOTAL NITROGEN LEACHED TO THE GROUND WATER TABLE = 1.34106
TOTAL NITROGEN OUTPUT , MG - N = 98.38721

BALANCE = (OUTPUT - INPUT) * 100 / INPUT = 8.54843 PERCENT
THIS IS CYCLE NUMBER = 2

AMOUNT OF WASTE WATER APPLIED , CM = 21.00000
INFILTRATION TIME, I.E. DURATION OF WASTE WATER APPLICATION, DAYS = 1.00000
SCHEDULE OF WASTE WATER APPLICATION, I.E. CYCLE DURATION ,DAYS = 1.00000

TIME AT WHICH OUTPUT DATA IS REQUESTED IN THIS CYCLE, DAYS = 1.00000

CONCENTRATION OF APPLIED NH4-N , MG/LITRE = .00000
CONCENTRATION OF APPLIED NO3-N , MG/LITRE = 4.00000

NITROGEN UPTAKE RATE, MICROGRAM-N/CM OF ROOT LENGTH PER DAY = .00000

EVAPOTRANSPIRATION RATE, CM/DAY = .00000

TOTAL ELAPSED TIME = 2.50 DAYS

| SOIL DEPTH CM | PRESSURE HEAD CM | SOIL-WATER CONTENT CM**3/CM**3 | WATER FLOW VELOCITY CM/HR | AMMONIUM CONCENTRATION IN SOIL SOLUTION MICROGRAMS-N/ML | NITRATE CONCENTRATION IN SOIL SOLUTION MICROGRAMS-N /ML |
|------------------|---------------------|-----------------------------------|---------------------------------|---|---|
| .00 | -4.84 | .42 | .8750 | .000 | 3.989 |
| 2.00 | -4.50 | .42 | .8829 | .000 | 3.951 |
| 4.00 | -4.09 | .42 | .8829 | .000 | 3.914 |
| 6.00 | -3.61 | .42 | .8829 | .000 | 3.876 |
| 8.00 | -3.04 | .43 | .8829 | .000 | 3.839 |

| | | | | | |
|--------|-------|-----|-------|------|-------|
| 10.00 | -2.37 | .43 | .8829 | .000 | 3.802 |
| 12.00 | -1.59 | .43 | .8829 | .000 | 3.765 |
| 14.00 | -.70 | .44 | .8829 | .000 | 3.728 |
| 16.00 | .08 | .42 | .8829 | .000 | 3.693 |
| 18.00 | .07 | .42 | .8829 | .000 | 3.658 |
| 20.00 | .07 | .42 | .8829 | .000 | 3.623 |
| 22.00 | .05 | .42 | .8829 | .000 | 3.589 |
| 24.00 | .04 | .42 | .8829 | .000 | 3.555 |
| 26.00 | .03 | .42 | .8829 | .000 | 3.521 |
| 28.00 | .01 | .42 | .8829 | .000 | 3.487 |
| 30.00 | -.00 | .42 | .8829 | .000 | 3.453 |
| 32.00 | -.02 | .42 | .8829 | .000 | 3.419 |
| 34.00 | -.06 | .42 | .8829 | .000 | 3.384 |
| 36.00 | -.11 | .42 | .8829 | .000 | 3.347 |
| 38.00 | -.18 | .42 | .8829 | .000 | 3.308 |
| 40.00 | -.30 | .42 | .8829 | .001 | 3.267 |
| 42.00 | -.48 | .42 | .8829 | .002 | 3.223 |
| 44.00 | -.76 | .42 | .8829 | .002 | 3.176 |
| 46.00 | -.90 | .34 | .8829 | .003 | 3.135 |
| 48.00 | -.90 | .34 | .8829 | .003 | 3.095 |
| 50.00 | -.90 | .34 | .8829 | .004 | 3.053 |
| 52.00 | -.90 | .34 | .8829 | .005 | 3.012 |
| 54.00 | -.90 | .34 | .8829 | .006 | 2.971 |
| 56.00 | -.90 | .34 | .8829 | .006 | 2.930 |
| 58.00 | -.90 | .34 | .8829 | .007 | 2.891 |
| 60.00 | -.90 | .34 | .8829 | .008 | 2.854 |
| 62.00 | -.90 | .34 | .8829 | .008 | 2.818 |
| 64.00 | -.90 | .34 | .8829 | .009 | 2.783 |
| 66.00 | -.90 | .34 | .8829 | .009 | 2.749 |
| 68.00 | -.90 | .34 | .8829 | .009 | 2.716 |
| 70.00 | -.90 | .34 | .8829 | .010 | 2.684 |
| 72.00 | -.90 | .34 | .8829 | .010 | 2.651 |
| 74.00 | -.90 | .34 | .8829 | .010 | 2.619 |
| 76.00 | -.90 | .34 | .8829 | .010 | 2.586 |
| 78.00 | -.90 | .34 | .8829 | .010 | 2.553 |
| 80.00 | -.90 | .34 | .8829 | .010 | 2.519 |
| 82.00 | -.90 | .34 | .8829 | .010 | 2.481 |
| 84.00 | -.90 | .34 | .8829 | .010 | 2.435 |
| 86.00 | -.90 | .34 | .8829 | .010 | 2.353 |
| 88.00 | -.90 | .34 | .8829 | .010 | 2.173 |
| 90.00 | -.90 | .34 | .8829 | .010 | 1.835 |
| 92.00 | -.90 | .34 | .8829 | .010 | 1.367 |
| 94.00 | -.90 | .34 | .8829 | .010 | .892 |
| 96.00 | -.90 | .34 | .8829 | .010 | .526 |
| 98.00 | -.90 | .34 | .8829 | .010 | .302 |
| 100.00 | -.90 | .34 | .8829 | .010 | .188 |
| 102.00 | -.90 | .34 | .8829 | .010 | .135 |
| 104.00 | -.90 | .34 | .8829 | .010 | .111 |
| 106.00 | -.90 | .34 | .8829 | .010 | .099 |
| 108.00 | -.90 | .34 | .8829 | .010 | .092 |
| 110.00 | -.90 | .34 | .8829 | .010 | .088 |
| 112.00 | -.90 | .34 | .8829 | .010 | .086 |
| 114.00 | -.90 | .34 | .8829 | .010 | .085 |
| 116.00 | -.90 | .34 | .8829 | .010 | .085 |
| 118.00 | -.90 | .34 | .8829 | .010 | .085 |
| 120.00 | -.90 | .34 | .8829 | .010 | .085 |
| 122.00 | -.90 | .34 | .8829 | .010 | .085 |
| 124.00 | -.90 | .34 | .8829 | .010 | .085 |
| 126.00 | -.90 | .34 | .8829 | .010 | .085 |
| 128.00 | -.90 | .34 | .8829 | .010 | .085 |
| 130.00 | -.90 | .34 | .8829 | .010 | .085 |
| 132.00 | -.90 | .34 | .8829 | .010 | .085 |
| 134.00 | -.89 | .34 | .8829 | .010 | .085 |
| 136.00 | -.88 | .34 | .8829 | .010 | .085 |
| 138.00 | -.87 | .34 | .8829 | .010 | .085 |
| 140.00 | -.84 | .34 | .8829 | .010 | .085 |
| 142.00 | -.79 | .34 | .8829 | .010 | .085 |
| 144.00 | -.71 | .34 | .8829 | .010 | .085 |
| 146.00 | -.58 | .34 | .8829 | .010 | .085 |
| 148.00 | -.36 | .34 | .8829 | .010 | .085 |
| 150.00 | .00 | .34 | .8829 | .010 | .085 |

TOTAL NO-3 NITROGEN IN SOIL SOLUTION PHASE , MICROGRAMS = 113.348
 TOTAL NH-4 NITROGEN IN SOIL SOLUTION PHASE , MICROGRAMS = .330
 TOTAL NH-4 NITROGEN IN EXCHANGEABLE PHASE , MICROGRAMS = .391
 TOTAL NH-4 NITROGEN IN THE SOIL PROFILE , MICROGRAMS = .720

 CUMULATIVE NITROGEN DENITRIFIED, MICROGRAMS = 37.85138

 CUMULATIVE NITRATE NITROGEN UPTAKE, MICROGRAMS = .000
 CUMULATIVE AMMONIUM NITROGEN UPTAKE, MICROGRAMS = .000

 CUMULATIVE NO3-N LEACHED TO THE GROUND WATER TABLE, MG - N = 1.21165
 CUMULATIVE NH4-N LEACHED TO THE GROUND WATER TABLE, MG - N = .12940
 CUMULATIVE WATER OUTFLOW , CM = 12.94017

W A T E R B A L A N C E

I N P U T ,
 AMOUNT OF WATER IN THE SOIL PROFILE FROM PREVIOUS CYCLE, CM = 48.59818
 AMOUNT OF WASTE WATER APPLIED OR RAINFALL IN THIS CYCLE, CM = 21.00000
 TOTAL WATER INPUT , CM = 69.59818

 O U T P U T
 AMOUNT OF WATER IN THE SOIL PROFILE AT THE END OF THIS CYCLE, CM = 48.59818
 TOTAL EVAPOTRANSPIRATION DURING THIS CYCLE, CM = .00000
 AMOUNT OF GROUND WATER OUTFLOW DURING THIS CYCLE = 12.94016
 TOTAL WATER OUTPUT , CM = 61.53834

 BALANCE = (OUTPUT - INPUT) * 100 / INPUT = -11.58052 PERCENT

N I T R O G E N B A L A N C E

I N P U T ,
 TOTAL NITROGEN PRESENT IN THE SOIL PROFILE FROM PREVIOUS CYCLE, MG - N = 79.50768
 WASTE WATER NITROGEN APPLIED DURING THIS CYCLE , MG - N = 84.00000
 TOTAL NITROGEN INPUT , MG - N = 163.50770

 O U T P U T
 TOTAL NITROGEN PRESENT IN THE SOIL PROFILE AT THE END OF THIS CYCLE, MG - N = 114.06890
 TOTAL NITROGEN UPTAKE DURING THIS CYCLE , MG - N = .00000
 TOTAL NITROGEN LEACHED TO THE GROUND WATER TABLE = 1.15399
 TOTAL NITROGEN OUTPUT , MG - N = 164.58610

 BALANCE = (OUTPUT - INPUT) * 100 / INPUT = .65957 PERCENT
 THIS IS CYCLE NUMBER = 3

AMOUNT OF WASTE WATER APPLIED , CM = 21.00000
 INFILTRATION TIME, I.E. DURATION OF WASTE WATER APPLICATION, DAYS = 1.00000
 SCHEDULE OF WASTE WATER APPLICATION, I.E. CYCLE DURATION ,DAYS = 1.00000

TIME AT WHICH OUTPUT DATA IS REQUESTED IN THIS CYCLE, DAYS = 1.00000

CONCENTRATION OF APPLIED NH4-N , MG/LITRE = .00000
 CONCENTRATION OF APPLIED NO3-N , MG/LITRE = 4.00000

NITROGEN UPTAKE RATE, MICROGRAM-N/CM OF ROOT LENGTH PER DAY = .00000

EVAPOTRANSPIRATION RATE, CM/DAY = .00000

TOTAL ELAPSED TIME = 4.00 DAYS

| SOIL DEPTH CM | PRESSURE HEAD CM | SOIL-WATER CONTENT CM**3/CM**3 | WATER FLOW VELOCITY CM/HR | AMMONIUM CONCENTRATION IN SOIL SOLUTION MICROGRAMS-N/ML | NITRATE CONCENTRATION IN SOIL SOLUTION MICROGRAMS-N /ML |
|------------------|---------------------|-----------------------------------|---------------------------------|---|---|
| .00 | -4.84 | .42 | .8750 | .000 | 3.989 |
| 2.00 | -4.50 | .42 | .8829 | .000 | 3.951 |
| 4.00 | -4.09 | .42 | .8829 | .000 | 3.914 |
| 6.00 | -3.61 | .42 | .8829 | .000 | 3.876 |
| 8.00 | -3.04 | .43 | .8829 | .000 | 3.839 |
| 10.00 | -2.37 | .43 | .8829 | .000 | 3.802 |
| 12.00 | -1.59 | .43 | .8829 | .000 | 3.765 |
| 14.00 | -.70 | .44 | .8829 | .000 | 3.728 |
| 16.00 | .08 | .42 | .8829 | .000 | 3.693 |
| 18.00 | .07 | .42 | .8829 | .000 | 3.658 |
| 20.00 | .07 | .42 | .8829 | .000 | 3.623 |
| 22.00 | .05 | .42 | .8829 | .000 | 3.589 |
| 24.00 | .04 | .42 | .8829 | .000 | 3.555 |
| 26.00 | .03 | .42 | .8829 | .000 | 3.521 |
| 28.00 | .01 | .42 | .8829 | .000 | 3.487 |
| 30.00 | -.00 | .42 | .8829 | .000 | 3.453 |
| 32.00 | -.02 | .42 | .8829 | .000 | 3.419 |
| 34.00 | -.06 | .42 | .8829 | .000 | 3.384 |
| 36.00 | -.11 | .42 | .8829 | .000 | 3.347 |
| 38.00 | -.18 | .42 | .8829 | .000 | 3.308 |
| 40.00 | -.30 | .42 | .8829 | .000 | 3.267 |
| 42.00 | -.48 | .42 | .8829 | .000 | 3.223 |
| 44.00 | -.76 | .42 | .8829 | .000 | 3.176 |
| 46.00 | -.90 | .34 | .8829 | .000 | 3.135 |
| 48.00 | -.90 | .34 | .8829 | .000 | 3.095 |
| 50.00 | -.90 | .34 | .8829 | .000 | 3.054 |
| 52.00 | -.90 | .34 | .8829 | .000 | 3.012 |
| 54.00 | -.90 | .34 | .8829 | .000 | 2.971 |
| 56.00 | -.90 | .34 | .8829 | .000 | 2.931 |
| 58.00 | -.90 | .34 | .8829 | .000 | 2.892 |
| 60.00 | -.90 | .34 | .8829 | .000 | 2.855 |
| 62.00 | -.90 | .34 | .8829 | .000 | 2.819 |
| 64.00 | -.90 | .34 | .8829 | .001 | 2.785 |
| 66.00 | -.90 | .34 | .8829 | .001 | 2.752 |
| 68.00 | -.90 | .34 | .8829 | .002 | 2.720 |
| 70.00 | -.90 | .34 | .8829 | .002 | 2.690 |
| 72.00 | -.90 | .34 | .8829 | .003 | 2.660 |
| 74.00 | -.90 | .34 | .8829 | .004 | 2.631 |
| 76.00 | -.90 | .34 | .8829 | .005 | 2.602 |
| 78.00 | -.90 | .34 | .8829 | .006 | 2.575 |
| 80.00 | -.90 | .34 | .8829 | .007 | 2.548 |
| 82.00 | -.90 | .34 | .8829 | .008 | 2.522 |
| 84.00 | -.90 | .34 | .8829 | .009 | 2.496 |
| 86.00 | -.90 | .34 | .8829 | .009 | 2.471 |
| 88.00 | -.90 | .34 | .8829 | .009 | 2.446 |
| 90.00 | -.90 | .34 | .8829 | .010 | 2.419 |
| 92.00 | -.90 | .34 | .8829 | .010 | 2.389 |
| 94.00 | -.90 | .34 | .8829 | .010 | 2.357 |
| 96.00 | -.90 | .34 | .8829 | .010 | 2.323 |
| 98.00 | -.90 | .34 | .8829 | .010 | 2.289 |
| 100.00 | -.90 | .34 | .8829 | .010 | 2.255 |
| 102.00 | -.90 | .34 | .8829 | .010 | 2.223 |
| 104.00 | -.90 | .34 | .8829 | .010 | 2.190 |
| 106.00 | -.90 | .34 | .8829 | .010 | 2.157 |
| 108.00 | -.90 | .34 | .8829 | .010 | 2.121 |
| 110.00 | -.90 | .34 | .8829 | .010 | 2.080 |
| 112.00 | -.90 | .34 | .8829 | .010 | 2.031 |
| 114.00 | -.90 | .34 | .8829 | .010 | 1.970 |
| 116.00 | -.90 | .34 | .8829 | .010 | 1.894 |

| | | | | | |
|--------|------|-----|-------|------|-------|
| 118.00 | -.90 | .34 | .8829 | .010 | 1.800 |
| 120.00 | -.90 | .34 | .8829 | .010 | 1.686 |
| 122.00 | -.90 | .34 | .8829 | .010 | 1.552 |
| 124.00 | -.90 | .34 | .8829 | .010 | 1.401 |
| 126.00 | -.90 | .34 | .8829 | .010 | 1.237 |
| 128.00 | -.90 | .34 | .8829 | .010 | 1.066 |
| 130.00 | -.90 | .34 | .8829 | .010 | .897 |
| 132.00 | -.90 | .34 | .8829 | .010 | .736 |
| 134.00 | -.89 | .34 | .8829 | .010 | .590 |
| 136.00 | -.88 | .34 | .8829 | .010 | .463 |
| 138.00 | -.87 | .34 | .8829 | .010 | .357 |
| 140.00 | -.84 | .34 | .8829 | .010 | .273 |
| 142.00 | -.79 | .34 | .8829 | .010 | .209 |
| 144.00 | -.71 | .34 | .8829 | .010 | .161 |
| 146.00 | -.58 | .34 | .8829 | .010 | .128 |
| 148.00 | -.36 | .34 | .8829 | .010 | .106 |
| 150.00 | .00 | .34 | .8829 | .010 | .097 |

TOTAL NO-3 NITROGEN IN SOIL SOLUTION PHASE , MICROGRAMS = 138.038

TOTAL NH-4 NITROGEN IN SOIL SOLUTION PHASE , MICROGRAMS = .250

TOTAL NH-4 NITROGEN IN EXCHANGEABLE PHASE , MICROGRAMS = .297

TOTAL NH-4 NITROGEN IN THE SOIL PROFILE , MICROGRAMS = .546

CUMULATIVE NITROGEN DENITRIFIED, MICROGRAMS = 72.36671

CUMULATIVE NITRATE NITROGEN UPTAKE, MICROGRAMS = .000

CUMULATIVE AMMONIUM NITROGEN UPTAKE, MICROGRAMS = .000

CUMULATIVE NO3-N LEACHED TO THE GROUND WATER TABLE, MG - N = 2.23624

CUMULATIVE NH4-N LEACHED TO THE GROUND WATER TABLE, MG - N = .25880

CUMULATIVE WATER OUTFLOW , CM = 25.88033

W A T E R B A L A N C E

I N P U T ,

| | |
|---|----------------------|
| AMOUNT OF WATER IN THE SOIL PROFILE FROM PREVIOUS | CYCLE, CM = 48.59818 |
| AMOUNT OF WASTE WATER APPLIED OR RAINFALL IN THIS | CYCLE, CM = 21.00000 |
| TOTAL WATER INPUT , CM | = 69.59818 |

O U T P U T

| | |
|---|---------------------------|
| AMOUNT OF WATER IN THE SOIL PROFILE AT THE END OF | THIS CYCLE, CM = 48.59818 |
| TOTAL EVAPOTRANSPIRATION DURING THIS CYCLE, CM = | = .00000 |
| AMOUNT OF GROUND WATER OUTFLOW DURING THIS CYCLE | = 12.94016 |
| TOTAL WATER OUTPUT , CM = | = 61.53834 |

BALANCE = (OUTPUT - INPUT) * 100 / INPUT = -11.58053 PERCENT

N I T R O G E N B A L A N C E

I N P U T ,

| | |
|---|------------------------------------|
| TOTAL NITROGEN PRESENT IN THE SOIL PROFILE FROM | PREVIOUS CYCLE, MG - N = 114.06890 |
| WASTE WATER NITROGEN APPLIED DURING THIS CYCLE | , MG - N = 84.00000 |
| TOTAL NITROGEN INPUT , MG - N = | = 198.06890 |

O U T P U T

TOTAL NITROGEN PRESENT IN THE SOIL PROFILE AT THE END OF THIS CYCLE, MG - N = 138.58430
 TOTAL NITROGEN UPTAKE DURING THIS CYCLE , MG - N = .00000
 TOTAL NITROGEN LEACHED TO THE GROUND WATER TABLE = 6.47231
 TOTAL NITROGEN OUTPUT , MG - N = 231.64220

BALANCE = (OUTPUT - INPUT) * 100 / INPUT = 16.95035 PERCENT
 THIS IS CYCLE NUMBER = 4

AMOUNT OF WASTE WATER APPLIED , CM = 21.00000
 INFILTRATION TIME, I.E. DURATION OF WASTE WATER APPLICATION, DAYS = 1.00000
 SCHEDULE OF WASTE WATER APPLICATION, I.E. CYCLE DURATION ,DAYS = 4.00000

TIME AT WHICH OUTPUT DATA IS REQUESTED IN THIS CYCLE, DAYS = 1.00000

CONCENTRATION OF APPLIED NH4-N , MG/LITRE = .00000
 CONCENTRATION OF APPLIED NO3-N , MG/LITRE = 4.00000

NITROGEN UPTAKE RATE, MICROGRAM-N/CM OF ROOT LENGTH PER DAY = .00000

EVAPOTRANSPIRATION RATE, CM/DAY = .00000

TOTAL ELAPSED TIME = 5.50 DAYS

| SOIL DEPTH CM | PRESSURE HEAD CM | SOIL-WATER CONTENT CM**3/CM**3 | WATER FLOW VELOCITY CM/HR | AMMONIUM CONCENTRATION IN SOIL SOLUTION MICROGRAMS-N/ML | NITRATE CONCENTRATION IN SOIL SOLUTION MICROGRAMS-N /ML |
|------------------|---------------------|-----------------------------------|---------------------------------|---|---|
| .00 | -4.84 | .42 | .8750 | .000 | 3.989 |
| 2.00 | -4.50 | .42 | .8829 | .000 | 3.951 |
| 4.00 | -4.09 | .42 | .8829 | .000 | 3.914 |
| 6.00 | -3.61 | .42 | .8829 | .000 | 3.876 |
| 8.00 | -3.04 | .43 | .8829 | .000 | 3.839 |
| 10.00 | -2.37 | .43 | .8829 | .000 | 3.802 |
| 12.00 | -1.59 | .43 | .8829 | .000 | 3.765 |
| 14.00 | -.70 | .44 | .8829 | .000 | 3.728 |
| 16.00 | .08 | .42 | .8829 | .000 | 3.693 |
| 18.00 | .07 | .42 | .8829 | .000 | 3.658 |
| 20.00 | .07 | .42 | .8829 | .000 | 3.623 |
| 22.00 | .05 | .42 | .8829 | .000 | 3.589 |
| 24.00 | .04 | .42 | .8829 | .000 | 3.555 |
| 26.00 | .03 | .42 | .8829 | .000 | 3.521 |
| 28.00 | .01 | .42 | .8829 | .000 | 3.487 |
| 30.00 | -.00 | .42 | .8829 | .000 | 3.453 |
| 32.00 | -.02 | .42 | .8829 | .000 | 3.419 |
| 34.00 | -.06 | .42 | .8829 | .000 | 3.384 |
| 36.00 | -.11 | .42 | .8829 | .000 | 3.347 |
| 38.00 | -.18 | .42 | .8829 | .000 | 3.308 |
| 40.00 | -.30 | .42 | .8829 | .000 | 3.267 |
| 42.00 | -.48 | .42 | .8829 | .000 | 3.223 |
| 44.00 | -.76 | .42 | .8829 | .000 | 3.176 |
| 46.00 | -.90 | .34 | .8829 | .000 | 3.135 |
| 48.00 | -.90 | .34 | .8829 | .000 | 3.095 |
| 50.00 | -.90 | .34 | .8829 | .000 | 3.054 |
| 52.00 | -.90 | .34 | .8829 | .000 | 3.012 |
| 54.00 | -.90 | .34 | .8829 | .000 | 2.971 |
| 56.00 | -.90 | .34 | .8829 | .000 | 2.931 |
| 58.00 | -.90 | .34 | .8829 | .000 | 2.892 |
| 60.00 | -.90 | .34 | .8829 | .000 | 2.855 |
| 62.00 | -.90 | .34 | .8829 | .000 | 2.819 |
| 64.00 | -.90 | .34 | .8829 | .000 | 2.785 |
| 66.00 | -.90 | .34 | .8829 | .000 | 2.752 |
| 68.00 | -.90 | .34 | .8829 | .000 | 2.720 |
| 70.00 | -.90 | .34 | .8829 | .000 | 2.690 |

| | | | | | |
|--------|------|-----|-------|------|-------|
| 72.00 | -.90 | .34 | .8829 | .000 | 2.660 |
| 74.00 | -.90 | .34 | .8829 | .000 | 2.631 |
| 76.00 | -.90 | .34 | .8829 | .000 | 2.602 |
| 78.00 | -.90 | .34 | .8829 | .000 | 2.575 |
| 80.00 | -.90 | .34 | .8829 | .000 | 2.548 |
| 82.00 | -.90 | .34 | .8829 | .001 | 2.522 |
| 84.00 | -.90 | .34 | .8829 | .002 | 2.496 |
| 86.00 | -.90 | .34 | .8829 | .002 | 2.471 |
| 88.00 | -.90 | .34 | .8829 | .003 | 2.446 |
| 90.00 | -.90 | .34 | .8829 | .004 | 2.419 |
| 92.00 | -.90 | .34 | .8829 | .005 | 2.390 |
| 94.00 | -.90 | .34 | .8829 | .005 | 2.358 |
| 96.00 | -.90 | .34 | .8829 | .006 | 2.325 |
| 98.00 | -.90 | .34 | .8829 | .007 | 2.292 |
| 100.00 | -.90 | .34 | .8829 | .008 | 2.260 |
| 102.00 | -.90 | .34 | .8829 | .008 | 2.230 |
| 104.00 | -.90 | .34 | .8829 | .009 | 2.202 |
| 106.00 | -.90 | .34 | .8829 | .009 | 2.175 |
| 108.00 | -.90 | .34 | .8829 | .009 | 2.150 |
| 110.00 | -.90 | .34 | .8829 | .010 | 2.125 |
| 112.00 | -.90 | .34 | .8829 | .010 | 2.102 |
| 114.00 | -.90 | .34 | .8829 | .010 | 2.079 |
| 116.00 | -.90 | .34 | .8829 | .010 | 2.056 |
| 118.00 | -.90 | .34 | .8829 | .010 | 2.033 |
| 120.00 | -.90 | .34 | .8829 | .010 | 2.011 |
| 122.00 | -.90 | .34 | .8829 | .010 | 1.988 |
| 124.00 | -.90 | .34 | .8829 | .010 | 1.965 |
| 126.00 | -.90 | .34 | .8829 | .010 | 1.941 |
| 128.00 | -.90 | .34 | .8829 | .010 | 1.917 |
| 130.00 | -.90 | .34 | .8829 | .010 | 1.891 |
| 132.00 | -.90 | .34 | .8829 | .010 | 1.865 |
| 134.00 | -.89 | .34 | .8829 | .010 | 1.838 |
| 136.00 | -.88 | .34 | .8829 | .010 | 1.809 |
| 138.00 | -.87 | .34 | .8829 | .010 | 1.778 |
| 140.00 | -.84 | .34 | .8829 | .010 | 1.745 |
| 142.00 | -.79 | .34 | .8829 | .010 | 1.707 |
| 144.00 | -.71 | .34 | .8829 | .010 | 1.665 |
| 146.00 | -.58 | .34 | .8829 | .010 | 1.617 |
| 148.00 | -.36 | .34 | .8829 | .010 | 1.562 |
| 150.00 | .00 | .34 | .8829 | .010 | 1.530 |

TOTAL NO-3 NITROGEN IN SOIL SOLUTION PHASE , MICROGRAMS = 150.058

TOTAL NH-4 NITROGEN IN SOIL SOLUTION PHASE , MICROGRAMS = .192

TOTAL NH-4 NITROGEN IN EXCHANGEABLE PHASE , MICROGRAMS = .228

TOTAL NH-4 NITROGEN IN THE SOIL PROFILE , MICROGRAMS = .420

CUMULATIVE NITROGEN DENITRIFIED, MICROGRAMS =111.19380

CUMULATIVE NITRATE NITROGEN UPTAKE, MICROGRAMS = .000

CUMULATIVE AMMONIUM NITROGEN UPTAKE, MICROGRAMS = .000

CUMULATIVE NO3-N LEACHED TO THE GROUND WATER TABLE, MG - N = 8.57915

CUMULATIVE NH4-N LEACHED TO THE GROUND WATER TABLE, MG - N = .38820

CUMULATIVE WATER OUTFLOW , CM = 38.82050

TOTAL ELAPSED TIME = 6.50 DAYS

| SOIL DEPTH CM | PRESSURE HEAD CM | SOIL-WATER CONTENT CM**3/CM**3 | WATER FLOW VELOCITY CM/HR | AMMONIUM CONCENTRATION IN SOIL SOLUTION MICROGRAMS-N/ML | NITRATE CONCENTRATION IN SOIL SOLUTION MICROGRAMS-N /ML |
|------------------|---------------------|-----------------------------------|---------------------------------|---|---|
|------------------|---------------------|-----------------------------------|---------------------------------|---|---|

| | | | | | |
|--------|--------|-----|-------|------|-------|
| .00 | -38.36 | .32 | .0000 | .000 | 3.151 |
| 2.00 | -36.41 | .32 | .0017 | .000 | 3.151 |
| 4.00 | -34.48 | .33 | .0024 | .000 | 3.165 |
| 6.00 | -32.58 | .33 | .0039 | .000 | 3.184 |
| 8.00 | -30.70 | .34 | .0055 | .000 | 3.207 |
| 10.00 | -28.84 | .34 | .0071 | .000 | 3.232 |
| 12.00 | -26.98 | .35 | .0088 | .000 | 3.257 |
| 14.00 | -25.12 | .35 | .0104 | .000 | 3.280 |
| 16.00 | -23.34 | .34 | .0122 | .000 | 3.291 |
| 18.00 | -22.60 | .34 | .0143 | .000 | 3.274 |
| 20.00 | -21.93 | .34 | .0164 | .000 | 3.240 |
| 22.00 | -21.31 | .34 | .0186 | .000 | 3.196 |
| 24.00 | -20.73 | .35 | .0207 | .000 | 3.149 |
| 26.00 | -20.18 | .35 | .0227 | .000 | 3.100 |
| 28.00 | -19.66 | .35 | .0248 | .000 | 3.052 |
| 30.00 | -19.15 | .35 | .0268 | .000 | 3.005 |
| 32.00 | -18.65 | .35 | .0287 | .000 | 2.959 |
| 34.00 | -18.14 | .35 | .0306 | .000 | 2.916 |
| 36.00 | -17.62 | .36 | .0325 | .000 | 2.874 |
| 38.00 | -17.08 | .36 | .0343 | .000 | 2.835 |
| 40.00 | -16.49 | .36 | .0361 | .000 | 2.799 |
| 42.00 | -15.86 | .36 | .0378 | .000 | 2.768 |
| 44.00 | -15.16 | .37 | .0394 | .000 | 2.744 |
| 46.00 | -13.81 | .28 | .0409 | .000 | 2.732 |
| 48.00 | -13.62 | .28 | .0426 | .000 | 2.722 |
| 50.00 | -13.44 | .28 | .0443 | .000 | 2.705 |
| 52.00 | -13.26 | .28 | .0460 | .000 | 2.684 |
| 54.00 | -13.10 | .29 | .0477 | .000 | 2.659 |
| 56.00 | -12.94 | .29 | .0494 | .000 | 2.631 |
| 58.00 | -12.78 | .29 | .0510 | .000 | 2.601 |
| 60.00 | -12.64 | .29 | .0527 | .000 | 2.570 |
| 62.00 | -12.49 | .29 | .0544 | .000 | 2.538 |
| 64.00 | -12.35 | .29 | .0560 | .000 | 2.505 |
| 66.00 | -12.22 | .29 | .0576 | .000 | 2.473 |
| 68.00 | -12.09 | .29 | .0593 | .000 | 2.441 |
| 70.00 | -11.97 | .29 | .0609 | .000 | 2.409 |
| 72.00 | -11.85 | .29 | .0625 | .000 | 2.378 |
| 74.00 | -11.73 | .29 | .0641 | .000 | 2.348 |
| 76.00 | -11.61 | .29 | .0657 | .000 | 2.318 |
| 78.00 | -11.50 | .29 | .0673 | .000 | 2.290 |
| 80.00 | -11.39 | .29 | .0689 | .000 | 2.262 |
| 82.00 | -11.29 | .29 | .0705 | .000 | 2.234 |
| 84.00 | -11.19 | .29 | .0720 | .000 | 2.208 |
| 86.00 | -11.09 | .29 | .0736 | .001 | 2.182 |
| 88.00 | -10.99 | .29 | .0752 | .001 | 2.157 |
| 90.00 | -10.90 | .29 | .0767 | .002 | 2.133 |
| 92.00 | -10.80 | .29 | .0783 | .002 | 2.109 |
| 94.00 | -10.71 | .30 | .0798 | .003 | 2.086 |
| 96.00 | -10.63 | .30 | .0814 | .003 | 2.063 |
| 98.00 | -10.54 | .30 | .0829 | .004 | 2.041 |
| 100.00 | -10.45 | .30 | .0844 | .005 | 2.019 |
| 102.00 | -10.37 | .30 | .0860 | .005 | 1.997 |
| 104.00 | -10.29 | .30 | .0875 | .006 | 1.975 |
| 106.00 | -10.21 | .30 | .0890 | .007 | 1.953 |
| 108.00 | -10.13 | .30 | .0905 | .007 | 1.931 |
| 110.00 | -10.05 | .30 | .0920 | .008 | 1.909 |
| 112.00 | -9.98 | .30 | .0935 | .008 | 1.887 |
| 114.00 | -9.90 | .30 | .0950 | .009 | 1.865 |
| 116.00 | -9.82 | .30 | .0965 | .009 | 1.844 |
| 118.00 | -9.74 | .30 | .0980 | .009 | 1.822 |
| 120.00 | -9.66 | .30 | .0995 | .009 | 1.800 |
| 122.00 | -9.57 | .30 | .1010 | .010 | 1.779 |
| 124.00 | -9.47 | .30 | .1024 | .010 | 1.758 |
| 126.00 | -9.35 | .30 | .1038 | .010 | 1.737 |
| 128.00 | -9.21 | .30 | .1052 | .010 | 1.717 |
| 130.00 | -9.04 | .30 | .1066 | .010 | 1.696 |
| 132.00 | -8.81 | .30 | .1079 | .010 | 1.676 |
| 134.00 | -8.50 | .30 | .1092 | .010 | 1.656 |
| 136.00 | -8.08 | .31 | .1103 | .010 | 1.637 |
| 138.00 | -7.53 | .31 | .1114 | .010 | 1.619 |
| 140.00 | -6.79 | .31 | .1123 | .010 | 1.602 |
| 142.00 | -5.85 | .32 | .1130 | .010 | 1.586 |

| | | | | | |
|--------|-------|-----|-------|------|-------|
| 144.00 | -4.69 | .32 | .1136 | .010 | 1.572 |
| 146.00 | -3.30 | .33 | .1139 | .010 | 1.560 |
| 148.00 | -1.73 | .33 | .1142 | .010 | 1.553 |
| 150.00 | .00 | .34 | .1143 | .010 | 1.551 |

TOTAL NO-3 NITROGEN IN SOIL SOLUTION PHASE , MICROGRAMS = 112.507

TOTAL NH-4 NITROGEN IN SOIL SOLUTION PHASE , MICROGRAMS = .149

TOTAL NH-4 NITROGEN IN EXCHANGEABLE PHASE , MICROGRAMS = .196

TOTAL NH-4 NITROGEN IN THE SOIL PROFILE , MICROGRAMS = .345

CUMULATIVE NITROGEN DENITRIFIED, MICROGRAMS =136.36470

CUMULATIVE NITRATE NITROGEN UPTAKE, MICROGRAMS = .000

CUMULATIVE AMMONIUM NITROGEN UPTAKE, MICROGRAMS = .000

CUMULATIVE NO3-N LEACHED TO THE GROUND WATER TABLE, MG - N = 32.99165

CUMULATIVE NH4-N LEACHED TO THE GROUND WATER TABLE, MG - N = .53334

CUMULATIVE WATER OUTFLOW , CM = 53.33479

TOTAL ELAPSED TIME = 7.50 DAYS

| SOIL DEPTH CM | PRESSURE HEAD CM | SOIL-WATER CONTENT CM**3/CM**3 | WATER FLOW VELOCITY CM/HR | AMMONIUM CONCENTRATION IN SOIL SOLUTION MICROGRAMS-N/ML | NITRATE CONCENTRATION IN SOIL SOLUTION MICROGRAMS-N /ML |
|------------------|---------------------|-----------------------------------|---------------------------------|---|---|
| .00 | -42.62 | .31 | .0000 | .000 | 2.415 |
| 2.00 | -40.86 | .31 | .0079 | .000 | 2.374 |
| 4.00 | -39.02 | .32 | .0045 | .000 | 2.392 |
| 6.00 | -37.18 | .32 | .0051 | .000 | 2.421 |
| 8.00 | -35.34 | .33 | .0056 | .000 | 2.457 |
| 10.00 | -33.50 | .33 | .0062 | .000 | 2.498 |
| 12.00 | -31.64 | .33 | .0068 | .000 | 2.542 |
| 14.00 | -29.79 | .34 | .0074 | .000 | 2.585 |
| 16.00 | -27.99 | .32 | .0081 | .000 | 2.625 |
| 18.00 | -27.30 | .32 | .0090 | .000 | 2.660 |
| 20.00 | -26.64 | .32 | .0099 | .000 | 2.689 |
| 22.00 | -26.01 | .33 | .0109 | .000 | 2.714 |
| 24.00 | -25.39 | .33 | .0119 | .000 | 2.735 |
| 26.00 | -24.79 | .33 | .0129 | .000 | 2.753 |
| 28.00 | -24.21 | .33 | .0140 | .000 | 2.768 |
| 30.00 | -23.62 | .34 | .0150 | .000 | 2.778 |
| 32.00 | -23.03 | .34 | .0160 | .000 | 2.786 |
| 34.00 | -22.42 | .34 | .0171 | .000 | 2.766 |
| 36.00 | -21.78 | .34 | .0181 | .000 | 2.732 |
| 38.00 | -21.11 | .34 | .0190 | .000 | 2.691 |
| 40.00 | -20.38 | .35 | .0200 | .000 | 2.649 |
| 42.00 | -19.60 | .35 | .0209 | .000 | 2.609 |
| 44.00 | -18.74 | .35 | .0218 | .000 | 2.574 |
| 46.00 | -17.27 | .27 | .0226 | .000 | 2.553 |
| 48.00 | -17.06 | .27 | .0236 | .000 | 2.543 |
| 50.00 | -16.86 | .27 | .0246 | .000 | 2.536 |
| 52.00 | -16.67 | .27 | .0256 | .000 | 2.528 |
| 54.00 | -16.49 | .27 | .0265 | .000 | 2.519 |
| 56.00 | -16.31 | .27 | .0275 | .000 | 2.511 |
| 58.00 | -16.14 | .27 | .0284 | .000 | 2.493 |
| 60.00 | -15.98 | .27 | .0294 | .000 | 2.467 |
| 62.00 | -15.82 | .27 | .0303 | .000 | 2.437 |
| 64.00 | -15.66 | .27 | .0313 | .000 | 2.405 |
| 66.00 | -15.52 | .28 | .0322 | .000 | 2.372 |
| 68.00 | -15.37 | .28 | .0331 | .000 | 2.338 |
| 70.00 | -15.23 | .28 | .0341 | .000 | 2.303 |

| | | | | | |
|--------|--------|-----|-------|------|-------|
| 72.00 | -15.10 | .28 | .0350 | .000 | 2.269 |
| 74.00 | -14.97 | .28 | .0359 | .000 | 2.235 |
| 76.00 | -14.84 | .28 | .0368 | .000 | 2.201 |
| 78.00 | -14.72 | .28 | .0377 | .000 | 2.168 |
| 80.00 | -14.60 | .28 | .0386 | .000 | 2.135 |
| 82.00 | -14.48 | .28 | .0396 | .000 | 2.103 |
| 84.00 | -14.37 | .28 | .0405 | .000 | 2.072 |
| 86.00 | -14.26 | .28 | .0414 | .001 | 2.042 |
| 88.00 | -14.15 | .28 | .0423 | .001 | 2.012 |
| 90.00 | -14.05 | .28 | .0432 | .002 | 1.983 |
| 92.00 | -13.94 | .28 | .0440 | .002 | 1.955 |
| 94.00 | -13.84 | .28 | .0449 | .003 | 1.928 |
| 96.00 | -13.75 | .28 | .0458 | .003 | 1.901 |
| 98.00 | -13.65 | .28 | .0467 | .004 | 1.875 |
| 100.00 | -13.55 | .28 | .0476 | .004 | 1.850 |
| 102.00 | -13.46 | .28 | .0485 | .005 | 1.825 |
| 104.00 | -13.37 | .28 | .0493 | .005 | 1.801 |
| 106.00 | -13.28 | .28 | .0502 | .006 | 1.777 |
| 108.00 | -13.19 | .29 | .0511 | .006 | 1.753 |
| 110.00 | -13.10 | .29 | .0519 | .007 | 1.730 |
| 112.00 | -13.01 | .29 | .0528 | .007 | 1.706 |
| 114.00 | -12.91 | .29 | .0537 | .008 | 1.683 |
| 116.00 | -12.81 | .29 | .0545 | .008 | 1.660 |
| 118.00 | -12.71 | .29 | .0553 | .008 | 1.637 |
| 120.00 | -12.59 | .29 | .0562 | .009 | 1.614 |
| 122.00 | -12.45 | .29 | .0570 | .009 | 1.590 |
| 124.00 | -12.29 | .29 | .0578 | .009 | 1.566 |
| 126.00 | -12.10 | .29 | .0585 | .009 | 1.541 |
| 128.00 | -11.85 | .29 | .0593 | .010 | 1.516 |
| 130.00 | -11.53 | .29 | .0600 | .010 | 1.489 |
| 132.00 | -11.12 | .29 | .0606 | .010 | 1.461 |
| 134.00 | -10.58 | .30 | .0612 | .010 | 1.432 |
| 136.00 | -9.89 | .30 | .0616 | .010 | 1.403 |
| 138.00 | -9.02 | .30 | .0620 | .010 | 1.375 |
| 140.00 | -7.95 | .31 | .0623 | .010 | 1.349 |
| 142.00 | -6.68 | .31 | .0625 | .010 | 1.328 |
| 144.00 | -5.22 | .32 | .0627 | .010 | 1.312 |
| 146.00 | -3.60 | .32 | .0627 | .010 | 1.300 |
| 148.00 | -1.85 | .33 | .0627 | .010 | 1.293 |
| 150.00 | .00 | .34 | .0627 | .010 | 1.292 |

TOTAL NO-3 NITROGEN IN SOIL SOLUTION PHASE , MICROGRAMS = 96.202

TOTAL NH-4 NITROGEN IN SOIL SOLUTION PHASE , MICROGRAMS = .138

TOTAL NH-4 NITROGEN IN EXCHANGEABLE PHASE , MICROGRAMS = .186

TOTAL NH-4 NITROGEN IN THE SOIL PROFILE , MICROGRAMS = .324

CUMULATIVE NITROGEN DENITRIFIED, MICROGRAMS =150.09140

CUMULATIVE NITRATE NITROGEN UPTAKE, MICROGRAMS = .000

CUMULATIVE AMMONIUM NITROGEN UPTAKE, MICROGRAMS = .000

CUMULATIVE NO3-N LEACHED TO THE GROUND WATER TABLE, MG - N = 35.55190

CUMULATIVE NH4-N LEACHED TO THE GROUND WATER TABLE, MG - N = .55166

CUMULATIVE WATER OUTFLOW , CM = 55.16819

TOTAL ELAPSED TIME = 8.50 DAYS

| | | | | | |
|------------|---------------|--------------------|------------|------------------------|-----------------------|
| SOIL DEPTH | PRESSURE HEAD | SOIL-WATER CONTENT | WATER FLOW | AMMONIUM CONCENTRATION | NITRATE CONCENTRATION |
| CM | CM | CM**3/CM**3 | VELOCITY | IN SOIL SOLUTION | IN SOIL SOLUTION |
| | | | CM/HR | MICROGRAMS-N/ML | MICROGRAMS-N /ML |

| | | | | | |
|--------|--------|-----|-------|------|-------|
| .00 | -44.85 | .30 | .0000 | .000 | 1.809 |
| 2.00 | -43.12 | .31 | .0080 | .000 | 1.767 |
| 4.00 | -41.30 | .31 | .0044 | .000 | 1.783 |
| 6.00 | -39.47 | .32 | .0047 | .000 | 1.809 |
| 8.00 | -37.64 | .32 | .0051 | .000 | 1.843 |
| 10.00 | -35.80 | .32 | .0055 | .000 | 1.883 |
| 12.00 | -33.95 | .33 | .0060 | .000 | 1.927 |
| 14.00 | -32.09 | .33 | .0064 | .000 | 1.973 |
| 16.00 | -30.29 | .31 | .0068 | .000 | 2.019 |
| 18.00 | -29.68 | .31 | .0074 | .000 | 2.063 |
| 20.00 | -29.10 | .32 | .0080 | .000 | 2.105 |
| 22.00 | -28.52 | .32 | .0086 | .000 | 2.145 |
| 24.00 | -27.95 | .32 | .0092 | .000 | 2.182 |
| 26.00 | -27.38 | .32 | .0099 | .000 | 2.218 |
| 28.00 | -26.80 | .32 | .0105 | .000 | 2.251 |
| 30.00 | -26.22 | .33 | .0111 | .000 | 2.284 |
| 32.00 | -25.60 | .33 | .0117 | .000 | 2.315 |
| 34.00 | -24.96 | .33 | .0123 | .000 | 2.344 |
| 36.00 | -24.29 | .33 | .0129 | .000 | 2.372 |
| 38.00 | -23.56 | .34 | .0135 | .000 | 2.397 |
| 40.00 | -22.77 | .34 | .0141 | .000 | 2.419 |
| 42.00 | -21.91 | .34 | .0147 | .000 | 2.416 |
| 44.00 | -20.98 | .35 | .0152 | .000 | 2.397 |
| 46.00 | -19.46 | .26 | .0158 | .000 | 2.374 |
| 48.00 | -19.25 | .26 | .0164 | .000 | 2.355 |
| 50.00 | -19.06 | .26 | .0170 | .000 | 2.338 |
| 52.00 | -18.87 | .26 | .0177 | .000 | 2.322 |
| 54.00 | -18.68 | .26 | .0183 | .000 | 2.307 |
| 56.00 | -18.50 | .26 | .0189 | .000 | 2.294 |
| 58.00 | -18.33 | .26 | .0195 | .000 | 2.280 |
| 60.00 | -18.16 | .26 | .0202 | .000 | 2.267 |
| 62.00 | -18.00 | .27 | .0208 | .000 | 2.254 |
| 64.00 | -17.84 | .27 | .0214 | .000 | 2.239 |
| 66.00 | -17.68 | .27 | .0221 | .000 | 2.224 |
| 68.00 | -17.53 | .27 | .0227 | .000 | 2.209 |
| 70.00 | -17.39 | .27 | .0233 | .000 | 2.191 |
| 72.00 | -17.25 | .27 | .0240 | .000 | 2.173 |
| 74.00 | -17.11 | .27 | .0246 | .000 | 2.154 |
| 76.00 | -16.98 | .27 | .0252 | .000 | 2.135 |
| 78.00 | -16.85 | .27 | .0258 | .000 | 2.114 |
| 80.00 | -16.72 | .27 | .0265 | .000 | 2.092 |
| 82.00 | -16.60 | .27 | .0271 | .000 | 2.071 |
| 84.00 | -16.48 | .27 | .0277 | .000 | 2.047 |
| 86.00 | -16.36 | .27 | .0283 | .001 | 2.024 |
| 88.00 | -16.25 | .27 | .0290 | .001 | 2.002 |
| 90.00 | -16.14 | .27 | .0296 | .002 | 1.974 |
| 92.00 | -16.03 | .27 | .0302 | .002 | 1.942 |
| 94.00 | -15.92 | .27 | .0308 | .002 | 1.911 |
| 96.00 | -15.82 | .27 | .0314 | .003 | 1.879 |
| 98.00 | -15.71 | .27 | .0320 | .003 | 1.848 |
| 100.00 | -15.61 | .28 | .0327 | .004 | 1.818 |
| 102.00 | -15.51 | .28 | .0333 | .004 | 1.788 |
| 104.00 | -15.41 | .28 | .0339 | .005 | 1.758 |
| 106.00 | -15.31 | .28 | .0345 | .005 | 1.730 |
| 108.00 | -15.21 | .28 | .0351 | .006 | 1.701 |
| 110.00 | -15.11 | .28 | .0357 | .006 | 1.673 |
| 112.00 | -15.01 | .28 | .0363 | .007 | 1.646 |
| 114.00 | -14.90 | .28 | .0369 | .007 | 1.618 |
| 116.00 | -14.78 | .28 | .0374 | .007 | 1.590 |
| 118.00 | -14.64 | .28 | .0380 | .008 | 1.561 |
| 120.00 | -14.49 | .28 | .0386 | .008 | 1.532 |
| 122.00 | -14.31 | .28 | .0391 | .008 | 1.502 |
| 124.00 | -14.09 | .28 | .0397 | .009 | 1.471 |
| 126.00 | -13.81 | .28 | .0402 | .009 | 1.438 |
| 128.00 | -13.46 | .28 | .0407 | .009 | 1.404 |
| 130.00 | -13.02 | .29 | .0411 | .009 | 1.368 |
| 132.00 | -12.45 | .29 | .0415 | .009 | 1.331 |
| 134.00 | -11.74 | .29 | .0419 | .010 | 1.293 |
| 136.00 | -10.85 | .29 | .0421 | .010 | 1.254 |
| 138.00 | -9.77 | .30 | .0424 | .010 | 1.217 |
| 140.00 | -8.50 | .30 | .0425 | .010 | 1.183 |
| 142.00 | -7.06 | .31 | .0426 | .010 | 1.154 |

| | | | | | |
|--------|-------|-----|-------|------|-------|
| 144.00 | -5.45 | .32 | .0427 | .010 | 1.131 |
| 146.00 | -3.72 | .32 | .0427 | .010 | 1.116 |
| 148.00 | -1.90 | .33 | .0427 | .010 | 1.107 |
| 150.00 | .00 | .34 | .0427 | .010 | 1.105 |

TOTAL NO-3 NITROGEN IN SOIL SOLUTION PHASE , MICROGRAMS = 83.362

TOTAL NH-4 NITROGEN IN SOIL SOLUTION PHASE , MICROGRAMS = .130

TOTAL NH-4 NITROGEN IN EXCHANGEABLE PHASE , MICROGRAMS = .178

TOTAL NH-4 NITROGEN IN THE SOIL PROFILE , MICROGRAMS = .308

CUMULATIVE NITROGEN DENITRIFIED, MICROGRAMS =161.48120

CUMULATIVE NITRATE NITROGEN UPTAKE, MICROGRAMS = .000

CUMULATIVE AMMONIUM NITROGEN UPTAKE, MICROGRAMS = .000

CUMULATIVE NO3-N LEACHED TO THE GROUND WATER TABLE, MG - N = 36.93754

CUMULATIVE NH4-N LEACHED TO THE GROUND WATER TABLE, MG - N = .56342

CUMULATIVE WATER OUTFLOW , CM = 56.34806

W A T E R B A L A N C E

I N P U T ,

| | |
|---|----------------------|
| AMOUNT OF WATER IN THE SOIL PROFILE FROM PREVIOUS | CYCLE, CM = 48.59818 |
| AMOUNT OF WASTE WATER APPLIED OR RAINFALL IN THIS | CYCLE, CM = 21.00000 |
| TOTAL WATER INPUT , CM | = 69.59818 |

O U T P U T

| | |
|---|---------------------------|
| AMOUNT OF WATER IN THE SOIL PROFILE AT THE END OF | THIS CYCLE, CM = 43.84124 |
| TOTAL EVAPOTRANSPIRATION DURING THIS CYCLE, CM = | = .00000 |
| AMOUNT OF GROUND WATER OUTFLOW DURING THIS CYCLE | = 17.52756 |
| TOTAL WATER OUTPUT , CM = | = 61.36880 |

BALANCE = (OUTPUT - INPUT) * 100 / INPUT = -11.82412 PERCENT

N I T R O G E N B A L A N C E

I N P U T ,

| | |
|---|------------------------------------|
| TOTAL NITROGEN PRESENT IN THE SOIL PROFILE FROM | PREVIOUS CYCLE, MG - N = 138.58430 |
| WASTE WATER NITROGEN APPLIED DURING THIS CYCLE | , MG - N = 84.00000 |
| TOTAL NITROGEN INPUT , MG - N = | = 222.58430 |

O U T P U T

| | |
|---|-------------|
| TOTAL NITROGEN PRESENT IN THE SOIL PROFILE AT THE END OF THIS CYCLE, MG - N = | 83.66983 |
| TOTAL NITROGEN UPTAKE DURING THIS CYCLE , MG - N | = .00000 |
| TOTAL NITROGEN LEACHED TO THE GROUND WATER TABLE | = 28.53361 |
| TOTAL NITROGEN OUTPUT , MG - N = | = 273.68470 |

BALANCE = (OUTPUT - INPUT) * 100 / INPUT = 22.95776 PERCENT

13. ABSTRACT (cont'd.)

150 cm would be less than 1 mg $\text{NO}_3\text{-N/L}$ if the applied $\text{NO}_3\text{-N}$ was 4 mg $\text{NO}_3\text{-N/L}$, and less than 2 mg $\text{NO}_3\text{-N/L}$ if 10 mg $\text{NO}_3\text{-N/L}$ was applied. The predicted NO_4^+ concentration in the leachate was very low, even when an initial, uniform saturation of 5.0 mg $\text{NH}_4\text{-N/L}$ in the soil profile was assumed. In field situations there would be little, if any, NO_4^+ present following tertiary treatment of wastewater. Based on these calculations, the predicted concentration of $\text{NH}_4\text{-N}$ in the applied effluent would remain within regulatory requirements.