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Nitrogen Movement in Tile-Drained Clay and Sandy Agricultural Watersheds: Final Report on Project 13, Agricultural Watershed Studies: Task C, Canadian Section, Activity 1

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INTERNATIONAL REFERENCE GROUP ON GREAT LAKES POLLUTION FROM LAND USE ACTIVITIES

INTERNATIONAL
JOINT
COMMISSION

NITROGEN MOVEMENT IN TILE-DRAINED CLAY AND SANDY AGRICULTURAL WATERSHEDS

NITROGEN MOVEMENT IN TILE-DRAINED CLAY AND SANDY AGRICULTURAL WATERSHEDS

FINAL REPORT ON PROJECT 13

AGRICULTURAL WATERSHED STUDIES

Task C (Canadian Section) - Activity 1
International Reference Group on Great Lakes
Pollution from Land Use Activities
International Joint Commission

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DISCLAIMER

The study discussed in this document was carried out as part of the efforts of the International Reference Group on Great Lakes Pollution From Land Use Activities (PLUARG), an organization of the International Joint Commission (IJC), established under the Canada - U.S. Great Lakes Water Quality agreement of 1972. Funding for this study was provided through Agriculture Canada.

Findings and conclusions are those of the authors and do not necessarily reflect the views of the Reference Group or its recommendations to the Commission.

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SUMMARY

Two small watersheds were selected in southern Ontario near Leamington and nitrogen additions and losses under different cropping and fertilizing practices were monitored during the 1974 to April 1977 period. Average stream NO_3-N concentrations were 4.9 ± 3.2 mg/l for the sandy watershed AG-13 where vegetable and tobacco production were the predominant crops. Average stream NO_3-N concentrations were 3.6 ± 4.2 mg/l for the tile-drained clay watershed AG-01 where corn and soybean production dominated. Average dissolved NH_4-N concentrations were 0.34 ± 0.43 mg/l for AG-13 and 0.21 ± 0.31 for AG-01. Average total Kjeldahl N concentrations were similar; 1.4 ± 1.0 mg/l for both AG-13 and AG-01.

Estimated average annual total N losses were 29 and 22 kg N/ha for AG-13 and AG-01, respectively, of which dissolved nitrogen accounted for 87% and 64% of the total N losses, respectively. Approximately 60% of the dissolved nitrogen losses occurred during February-March at which time 70% of the annual runoff occurred. The higher losses from the sandy watershed AG-13 are believed to be a reflection of greater fertilizer input and greater annual runoff.

In order to monitor seasonal changes in nitrogen gains and losses under various cropping practices three plots were established in 1975 and 1976 on each of the two watersheds. The plots in AG-13 were established in potato, Burley tobacco and soybean-greenbean fields. Those in AG-01 were located in winter wheat-corn, corn-soybean and soybean fields. Soil samples to a depth of 75 cm were removed during the growing season and analyzed for NO_3-N and NH_4-N content. Plant samples were also taken to determine total N content and dry weight. The information was compiled and used to obtain a simplified balance sheet by adding and subtracting known mineral N inputs and outputs, and attributing the difference to leaching, denitrification and immobilization losses.

In the three plots located within the clay watershed the sum of the average annual N inputs from fertilization (17 to 135 kg/ha), rain (18 kg/ha) and net mineralization (130 to 140 kg/ha) ranged from 175 to 283 kg N/ha. Average annual N recovery by the plants (and soil) ranged from 114 to 202 kg N/ha. By subtracting the recovered N from the input N the estimated annual N losses (primarily by leaching and denitrification) were calculated to range from 61 to 91 kg N/ha.

In the three plots located within the sandy watershed AG-13 the sum of the average annual N inputs from fertilization (13 to 215 kg/ha), rain

(18 kg/ha) and net mineralization (70 to 100 kg/ha) ranged from 133 to 303 kg N/ha. Average annual recovery by plants (and soil) ranged from 136 to 270 kg N/ha. The estimated annual N losses for the potato, tobacco, and bean plots were 133, 33 and -3 kg/ha, respectively. It was estimated that denitrification could account for as much as 50% of the annual N losses. The monitored results indicated that leaching losses occurred primarily in the fall and winter. Some losses were noted in June in response to heavy rainstorms.

One of the objectives of this study was to develop a computer simulation model to predict nitrogen levels entering groundwater supplies from various cropping and fertilizer practices. The model was calibrated and tested on the 1975 and 1976 results from the Burley tobacco field in sandy watershed AG-13. Overall, the model gave a reasonable prediction but left considerable doubt in some aspects of N transformation processes. Denitrification was not modelled and as a result predicted NO_3-N masses tended to be larger than the measured masses. Major predicted leaching losses occurred in the fall (70 kg N/ha) and throughout winter with small losses in June (10 kg N/ha).

Remedial measures which might help improve the conservation of nitrogen and reduce pollution from agricultural land include: careful use of soluble N fertilizers to meet crop needs only, deleting the application of fall applied N, encouragement of rotations that do not require high rates of fertilizer-N addition, encouragement of field cover crops to reduce leaching, and establishment of grass or non-row crop buffer zones next to streams or where runoff is a problem.

OBJECTIVES

One of the primary objectives of the PLUARG Task C Detailed Watershed studies was to examine probable sources of nutrient pollution to the Great Lakes. Agricultural activities were suggested as major sources of nitrogen loads to the Great Lakes. As a result, the study presented here was initiated to examine some of the nitrogen transformation and transport processes on agricultural land in order to quantify and suggest remedial measures to help control nitrogen pollution to ground and surface waters. Two small agricultural watersheds were selected and nitrogen additions under different cropping and fertilizing practices were monitored. Also, at the mouth of the respective watersheds, N loss rates were monitored over time. The study was initiated with the following objectives in mind:

1. To monitor seasonal changes in nitrogen losses under various cropping and fertilizer practices.

2. To develop, where possible, nitrogen balance and simulation models to predict nitrogen levels entering groundwater supplies from various cropping and fertilizer practices by:

   (a) Utilization of soil nitrogen characterization data as an aid in quantifying nitrogen transformations (Kowalenko, 1977).

   (b) Utilization of field data defining soil water transport and storage properties (Topp, 1978).

3. To relate where possible, the collected information to groundwater nitrogen concentrations (Gillham et al., 1978) and nitrogen losses from the two watersheds studied.

4. To suggest remedial measures or alternative practices that might aid in the reduction of nitrogen loads from agriculture to surface and groundwater supplies.

FIELD STUDY

In order to monitor current agricultural practices and to obtain data to test and calibrate a computer model three small plots were established in May 1975 in each of a sandy loam Watershed (AG-13) and in a tile drained clay Watershed (AG-01), both near Leamington, Ontario (Figure 1). Watershed AG-01 was approximately 52 km^2, with land use predominantly corn, wheat, and soybeans and drained into the lower Thames River. Watershed AG-13 was approximately 21 km^2, of predominantly corn, tobacco, and horticultural crops and was drained by Hillman Creek directly into Lake Erie.

The three plots located on the sandy soils of AG-13 were in potato (Plot 1), tobacco (Plot 2), and soybean-greenbean (Plot 3) fields. The three plots located on Watershed AG-01 were in winter wheat-corn (Plot 4), corn-soybean (Plot 5), and soybean (Plot 6) fields. The size of each plot was approximately 1/40 hectare (15 m x 15 m). The location of these fields is marked on the maps in Figure 1. A more detailed description is given in the results section of this report.

1. Sampling

Once the plots were established, they were sampled periodically throughout the growing season. Soil samples were taken by auger from the 0-10, 10-20, 20-30, 30-45, 45-60, and 60-75 cm depths. In 1975, six replicates were sampled randomly from the plot area and each replicate was analyzed separately.

In 1976, the first three depths were replicated nine times, the last ones three times. Soybeans, greenbeans, corn, and wheat were sampled between the rows. The replicates of the potato plot were taken between the plants, after the ground had been levelled. In 1975, three paired replicates were removed from the tobacco plot, the first replicate of each pair centered on the side-dressed fertilizer band and the second of the pair centered about 30 cm out from the row, adjacent to the first replicate. In 1976, five replicates were sampled on the fertilizer band and the remaining four replicates were taken halfway between the rows.

In addition to soil sampling several other activities were conducted on each plot. Crop height and plant density were measured. Conditions of the crops and any anomalies in the crop or soil were noted. Date and type of farming operations on the plots were noted. Preliminary plant sampling was initiated in 1975. In 1976, the above-ground parts of each

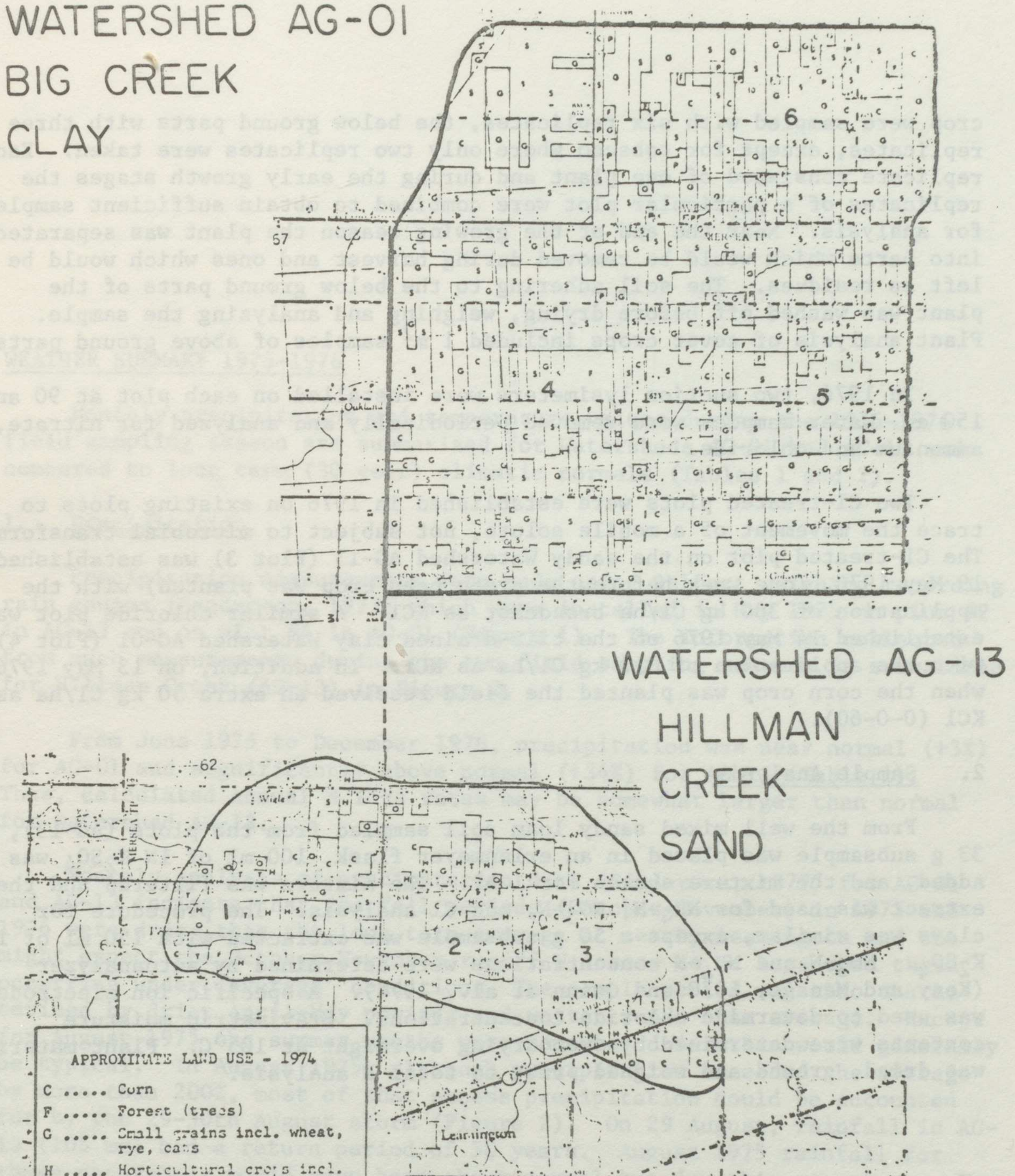

Figure 1. Maps of Watersheds AG-01 and AG-13 showing locations of field study plots

crop were sampled with six replicates, the below ground parts with three replicates, except for tobacco where only two replicates were taken. Each replicate consisted of one plant and during the early growth stages the replicates of a particular plot were combined to obtain sufficient sample for analysis. Near the end of the growing season the plant was separated into parts which would be removed during harvest and ones which would be left as residues. The soil adhering to the below ground parts of the plant was washed off before drying, weighing and analyzing the sample. Plant analysis of cover crops included 1 m^2 samples of above ground parts.

In 1976, two suction lysimeters were installed on each plot at 90 and 150 cm. Water samples were removed periodically and analyzed for nitrate, ammonium and chloride.

Two Cl-treated plots were established in 1976 on existing plots to trace the movement of a mobile solute, not subject to microbial transformations. The Cl-treated plot on the sandy Watershed AG-13 (Plot 3) was established 19 May 1976, (one week before the green bean crop was planted) with the application of 380 kg Cl/ha broadcast as KCl. A similar chloride plot was established 14 May 1976 on the tile-drained clay Watershed AG-01 (Plot 4) with the application of 317 kg Cl/ha as KCl. In addition, on 13 May 1976 when the corn crop was planted the field received an extra 50 kg Cl/ha as KCl (0-0-60).

2. Sample Analysis

From the well mixed sandy loam soil sampled from the plots (AG-13), a 33 g subsample was placed in an erlenmeyer flask, 100 ml of 1N K_2SO_4 was added, and the mixture shaken for 1 hr. The mixture was filtered and the extract was used for NH_4-N, NO_3-N, and Cl analysis. The procedure for clays was similar, except a 50 g subsample was extracted with 150 ml of 1N K_2SO_4. NO_3-N and NH_4-N concentrations were determined by autoanalyzer (Keay and Menage, 1970 and Quinn et al., 1974). A specific ion electrode was used to determine chloride concentrations. Gravimetric moisture contents were determined by oven-drying overnight at 105°C. Plant material was dried, ground and weighed prior to total N analysis.

WEATHER SUMMARY 1975-1976

Monthly precipitation and temperature values during the 1975-1976 field sampling season are summarized for Watersheds AG-01 and AG-13 and compared to long term (30 year) climatic normals (Tables 1 and 2).

1. Precipitation

Precipitation measurements were made using Belfort weighing recording rain gauges (Sanderson, 1977) which were installed in May 1975 on plot #2 in AG-13 and on plot #4 in AG-01 (Figure 1). The information collected from such measurements during the two field sampling seasons is summarized for Hillman Creek (AG-13) in Figure 2.

From June 1975 to December 1976, precipitation was near normal (+3%) for AG-01 and significantly above normal (+34%) for AG-13 (Table 1). Thus, calculated annual N loss rates may be somewhat larger than normal for watershed AG-13.

Monthly analysis of precipitation data (Sanderson, 1977) for AG-01 and AG-13 indicate that the fall periods (October-November) in 1975 and 1976 were drier than the long term average at nearby Leamington and one might expect the October-November runoff N losses to be less than those occurring under 'average' conditions. The sample period was also characterized by drier April-May periods and wetter Junes than average. Except for August 1975 the summer months were somewhat drier than would generally be typical. In August 1975, although precipitation exceeded the average by more than 200%, most of that excess precipitation could be accounted for by the 29-30th August storm (Figure 2). On 29 August, rainfall in AG-13 (105 mm) had a return period of 50 years. August 1975 rainfall for these watersheds would have been about normal but for this one storm. For the 1975-76 sample period, no other storm had a return period >5 years.

2. Temperature

Mean daily temperatures from May to November in 1975 and 1976 at Harrow, Ontario, were also recorded according to standard meteorological methods and are summarized for these time periods in Figure 2. These measurements were made using maximum and minimum thermometers in a Stevenson screen at Harrow which was about 32 km WSW of the two watersheds. Average monthly temperatures were similar to Leamington and were about normal for the two summer seasons but above normal during the winters of 1974-75 and

Table 1. Monthly precipitation totals for Watersheds AG-01, AG-13 and their percent deviation from long term norms at Leamington, Ontario

Time Period		Watershed AG-01 Precipitation mm	Watershed AG-01 Deviation* %	Watershed AG-13 Precipitation mm	Watershed AG-13 Deviation %
1975	Jan.	96**	+66	96**	+66
	Feb.	64**	+23	64**	+23
	Mar.	72**	+11	72**	+11
	Apr.	59**	-26	59**	-26
	May	48**	-40	48**	-40
	June	141	+65	106	+24
	July	30	-62	41	-48
	Aug.	211	+202	232	+232
	Sept.	67	-5	66	+10
	Oct.	31	-48	30	-50
	Nov.	52	-18	44	-30
	Dec.	77	+19	74	+14
1976	Jan.	48	-16	58	-1
	Feb.	64	+24	80	+55
	Mar.	117	+80	121	+147
	Apr.	68	-15	60	-25
	May	57	-28	52	-34
	June	94	+10	95	+11
	July	88	+11	87	+10
	Aug.	14	-80	16	77
	Sept.	87	+45	93	+55
	Oct.	57	-4	56	-6
	Nov.	18	-71	32	-49
	Dec.	17	-74	20	-69
June 75 to Dec. 76		1138	+3	1742	+34

* deviation from 30 year normal at Leamington expressed as a percent

**values were recorded at Leamington as rain gauges were not yet established on the watersheds.

Table 2. Mean monthly temperatures recorded at Leamington, Ontario and deviation from long term norms.

Time Period	Average Monthly Temperature C	Deviation from long term normal C
1975		
Jan.	-1.4	+2.7
Feb.	-1.9	+1.4
Mar.	+0.3	-0.7
Apr.	+4.7	-3.2
May	+17.1	+3.3
June	+20.2	+0.6
July	+23.1	+0.9
Aug.	+22.4	+0.9
Sept.	+15.5	+2.3
Oct.	+11.9	-0.2
Nov.	+7.7	+3.0
Dec.	-1.4	+0.3
1976		
Jan.	-6.4	-2.4
Feb.	+0.1	+3.2
Mar.	+3.9	+2.4
Apr.	+9.0	+0.7
May	+12.8	-1.4
June	+20.8	+1.1
July	+22.1	-0.1
Aug.	+21.0	-0.4
Sept.	+17.1	-0.8
Oct.	+8.9	-3.2
Nov.	+1.2	-3.5
Dec.	-5.6	-3.9

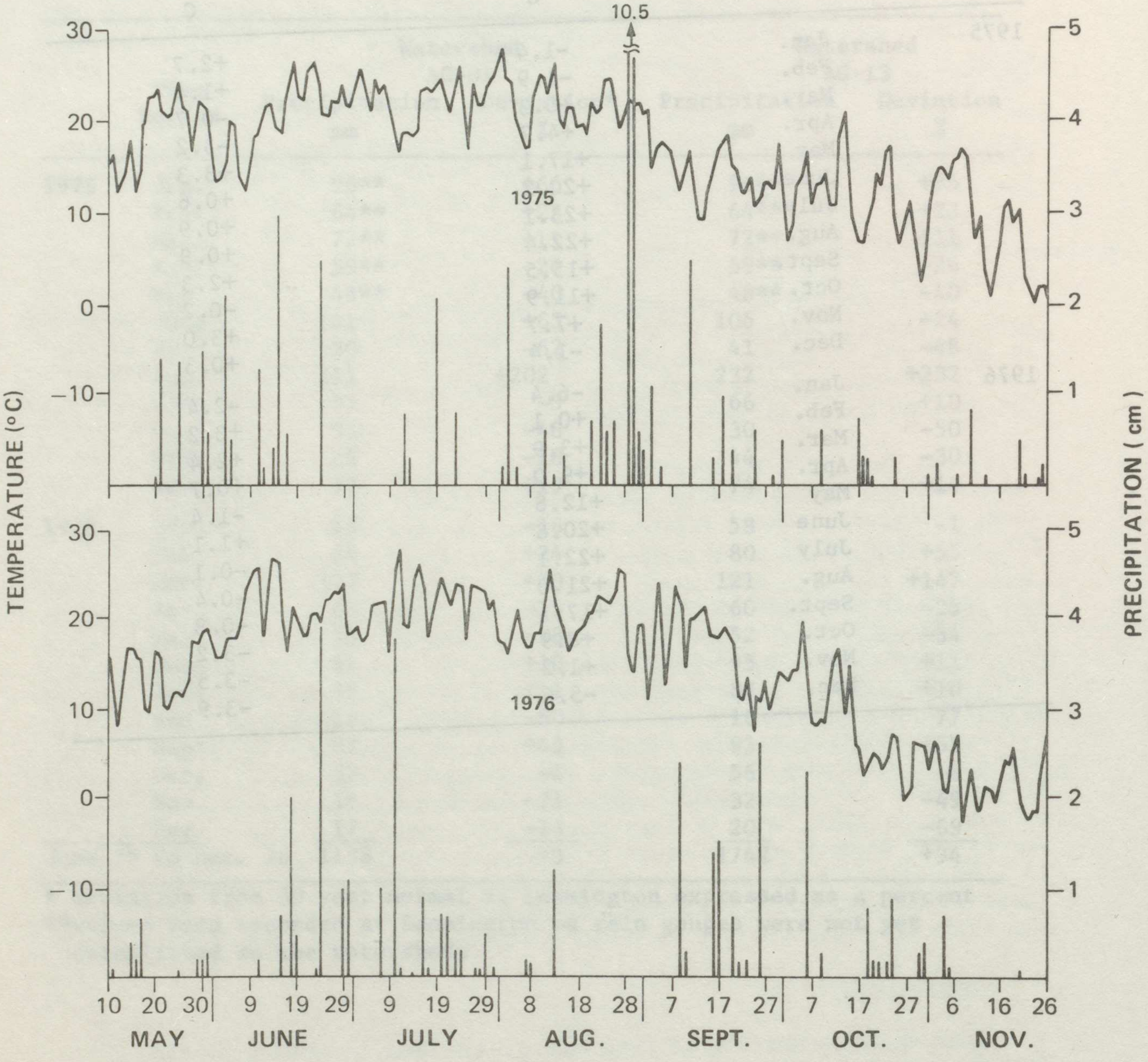

Figure 2. Mean daily temperatures at Harrow Research Station and precipitation as measured in Hillman Creek (AG-13) watershed.

1975-76 (Table 2). For example, February was warmer than expected, especially in 1976. The warmer February temperatures, coupled with higher than normal precipitation at these times, probably resulted in earlier and larger peak spring runoff events in these years. Normally these major runoff events in this part of southwestern Ontario occur early in March (Coulson, 1967). Peak runoff events occurred in both AG-01 and AG-13 on 24 February 1975 and on 16-17 February 1976. Consequently, spring N losses may be larger and earlier in the year than normally expected.

3. Precipitation Nitrogen Concentrations

The average total N concentration in the precipitation that fell on PLUARG watersheds AG-01 and AG-13 from May 1975 to May 1976 was 2.63 mg/l (Sanderson, 1977). Average NO_3-N was 1.27 mg/ℓ over the same period. NO_3-N analysis includes dissolved NO_3-N and NO_2-N. The measured NO_3-N concentration in the watershed precipitation was about 0.3 mg/ℓ less than the NO_3-N concentration mean over the Lake Ontario basin in 1970-1971 (Shiomi and Kurtz, 1973) but almost double that of rural Iowa rainfall in 1972-1973 (Tabatabai and Lafleur, 1976). Generally considerable variation in precipitation NO_3-N occurs even within one storm event (Cooper et al., 1976). Consequently, average precipitation N content values which have been used to calculate the loadings (Figure 3) were probably a reasonable long term approximation, although variation might be expected.

Using Sanderson's (1977) average total N and Kjeldahl N contents for the May 1975 - May 1976 period and precipitation data from the watersheds, total N and Kjeldahl N precipitation loads (kg/ha) were calculated for AG-01 and AG-13 and averaged. The cumulative values for both measurements is averaged for the two watersheds from May 1975 - April 1976 (Figure 3). The Kjeldahl N measurement included soluble and particulate organic-N and NH_4-N. Total N included these N forms plus NO_3-N and NO_2-N. Roughly equivalent amounts (12 kg N/ha) of N fell annually as NO_3-N and Kjeldahl N.

The Kjeldahl-N component was most important during the spring and early summer periods (Figure 3). Since this component includes organic N, as well as dissolved NH_4-N, it may be that washed-out suspended materials contribute more at this time than during late summer, fall and winter. Higher atmospheric particulate concentrations might be expected during periods of little crop cover and from cultivation that occurs in the spring and early summer period.

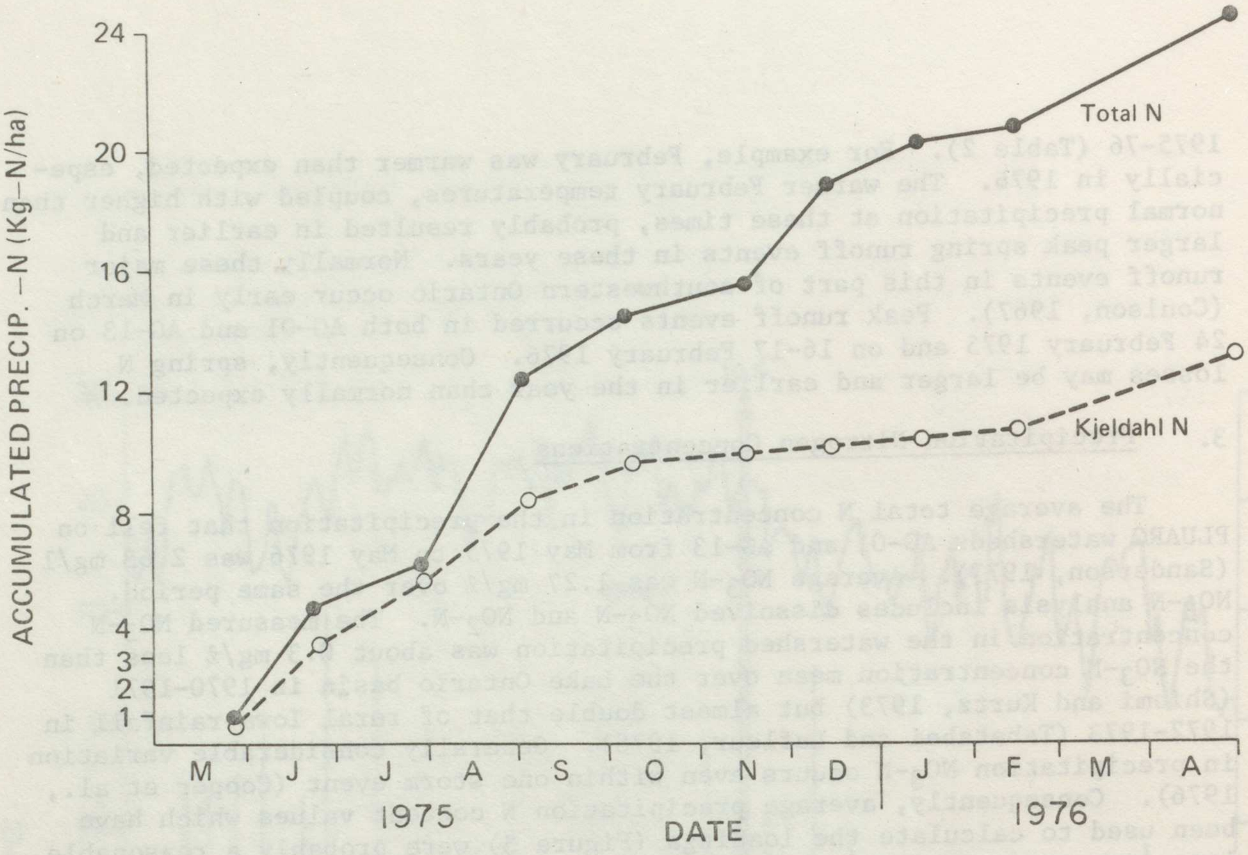

Figure 3. Cumulative average precipitation N input (kg/ha) to Watersheds AG-01 and AG-13, May 1975 to April 1976 (based on N concentration measurements by M. Sanderson, 1977).

Table 3. Means and standard deviations for nitrate (NO_3-N), total kjeldahl N (TKN), dissolved ammonium (NH_4-N and total N (TKN+NO_3-N) for Watersheds AG-01 and AG-13 during 1974-1977 sample period (stream concentrations)

Parameter	Watershed	Number of Samples	Mean* (mg N/l)	Standard Deviation
NO_3-N*	AG-01	395	3.35	4.17
	AG-13	306	4.86	3.22
TKN	AG-01	413	1.39	1.01
	AG-13	318	1.40	1.04
NH_4-N	AG-01	384	0.21	1.01
	AG-13	301	0.34	1.04
TOTAL N	AG-01	384	4.7	2.3
	AG-13	293	6.2	0.3

*Watersheds significantly different at the p=.01 level

STREAM NITROGEN CONCENTRATIONS AND LOADS

The N parameters measured in runoff from these watersheds included total Kjeldahl N (TKN) on the bulk water samples and dissolved NO_3-N and dissolved NH_4-N on water filtered through a 0.45 μ membrane. Although the method of chemical analysis for NO_3-N does not distinguish between NO_3-N and NO_2-N, it is likely that NO_3-N is the predominant chemical form. In the discussion which follows, this measurement will be referred to as NO_3-N. Also, the sum of dissolved NO_3-N + NH_4-N was considered dissolved N (DN). TKN + soluble NO_3-N was considered total N.

1. Concentration

Average NO_3-N concentrations were 4.86 mg/l for AG-13 and 3.35 mg/l for AG-01 with standard deviations of 3.22 and 4.17 mg/l respectively during the 1974 to April 1977 sample period (Table 3). Watershed AG-13 with the highest NO_3-N concentration had greater percent tobacco and vegetable land use, about the same corn proportion and slightly more estimated tile drained land than AG-01 (Frank and Ripley, 1977). There was little difference in average total Kjeldahl nitrogen concentrations (TKN) between watersheds with averages and standard deviations for AG-13 of 1.40±1.04 mg/l and of 1.39±1.01 mg/l for AG-01. Dissolved NH_4-N ranged from 0.34±0.43 mg/l for AG-13 to 0.21±0.31 mg/l for AG-01. The higher dissolved NH_4-N concentration in AG-13 may be a reflection of the higher rural housing density (17.3 houses/km^2) in this watershed as compared with AG-01 (4.1 houses/km^2). The N concentrations tended to be higher than the 0.22 to 2.07 mg/l average total inorganic N values reported for less intense agricultural watersheds in the St. Lawrence Lowlands (Neilsen and Mackenzie, 1977) but lower than the 10-20 mg/l NO_3-N concentration frequently found in subsurface discharge for intensively fertilized watersheds in Iowa (Burwell et al., 1976). It is apparent that NO_3-N comprises the bulk of readily available N lost in runoff and consequently most of the following discussion will be concerned with NO_3-N.

The drinking water standard for NO_3-N in Ontario is 10 mg NO_3-N/1.* Over the sampling period, this concentration was exceeded by 7.8% of the samples in AG-01 and by 7.5% of the samples in AG-13. Concentrations surpassed 5.0 mg NO_3-N/1 24% of the time in AG-01 and 47.4% of the time in AG-13 suggesting that runoff waters were often at concentrations close to, but not exceeding, the NO_3-N drinking water standard. The 0.3 mg/l N

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*Ontario Water Resource Commission, 1970. Guidelines and criteria for water quality management in Ontario. Toronto. 26 p.

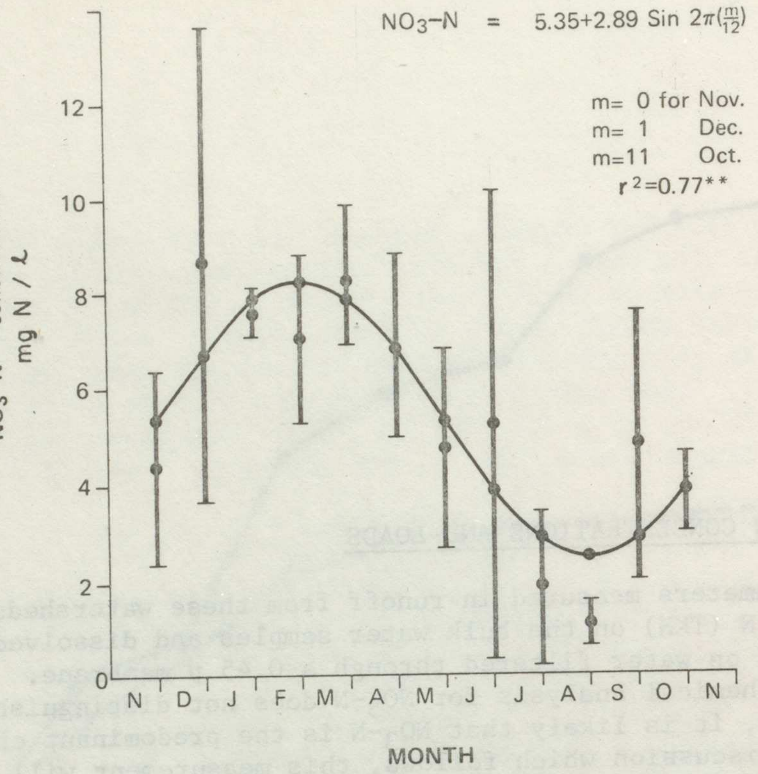

Figure 4. Mean monthly NO_3-N concentration and standard deviation for Hillman Creek (AG-13) during 1975-1976 sample period.

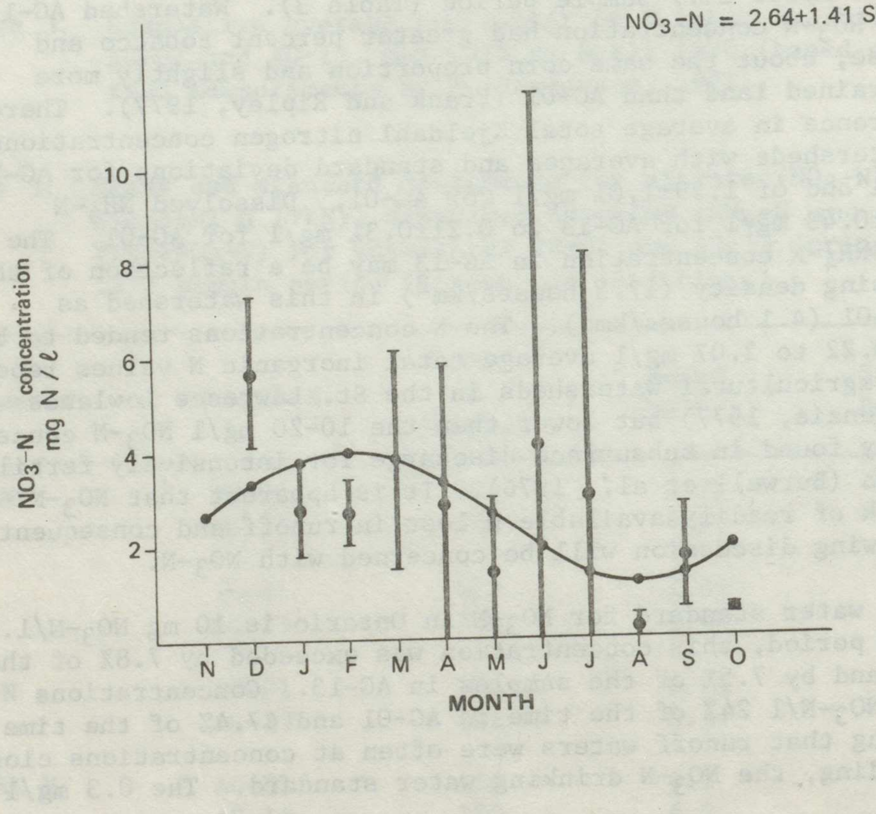

Figure 5. Mean monthly NO_3-N concentration and standard deviation for Big Creek Watershed (AG-01) during 1975-1976 sample period.

concentration, which has frequently been considered a critical threshold in accelerating eutrophication (Biggar and Corey, 1969) was exceeded 71.1% of the time in AG-01 and 97.7% of the time in AG-13. Therefore, in general NO_3-N concentrations of runoff waters consistently demonstrate magnitudes which would tend to accelerate algal growth if no other growth factors were limiting.

For both watersheds, monthly average NO_3-N stream concentrations tended to be higher during the fall and winter periods than during the summer months. NO_3-N concentrations were higher at times of greater runoff. The annual concentration pattern for AG-13 can be described using a sine curve relationship as suggested by Johnson et al. (1976) (Figure 4). This relationship was not as consistent for AG-01 (Figure 5) where June and July NO_3-N concentrations were extremely variable. In AG-01 about 50% of the water samples with concentrations exceeding the drinking water standard were collected during June and July while in AG-13 the comparable number was 20%. In AG-13 most samples exceeded the 10 mg/l standard during high flow periods of fall, winter and spring.

The seasonal pattern in the NO_3-N concentration means may also suggest different hydrologic sources of the runoff. During periods of low flow (generally the summer months) groundwater should be expected to contribute most to stream flow. For example, in both years, August sampling took place at times of low flow, at which time NO_3-N concentrations were also low. This suggested a low NO_3-N concentration in base flow from these two watersheds. June samples, however, were taken at times of much more variable flow rates. During June, large N sidedressings for corn and tobacco and high net mineralization occurred suggesting that large amounts of readily available N were stored within the watersheds at this time.

Also, plant cover and plant N uptake were not yet optimal and soil moisture contents were likely high resulting in greater runoff events of high N content in June than later in the growing season. The clay watershed, AG-01, which would have a greater tendency for surface runoff had a high variation in stream N concentration in June.

Johnson et al. (1976) also found watersheds in which highest NO_3-N concentrations occurred during June, July and August. He attributed this to the significant contributions of septic tank outflows to total stream flow during this time. This situation does not appear to occur in AG-01 or AG-13 as summer concentrations were low during low flow conditions.

In summary, the highest annual stream NO_3-N concentration tended to occur during times of the movement of large volumes of water. Similar seasonal observations have been reported for NO_3-N in Ontario by German (1967) in the Grand River, by Johnson and Owen (1971) for the Trent, Moira, Salmon and Napanne rivers and by Webber (1971) for Swan Creek near the Elora Research Station. Further details concerning these and other studies were reported by Hore and Maclean in the C.D.A. Task Force for implementation of the Great Lakes Water Quality Program.* During the summer, at times

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*Hore, F.R., and A.J. Maclean. CDA Task Force for Implementation of Great Lakes Water quality program. Section II Task Force Report on fertilizer nutrients and animal husbandry operations.

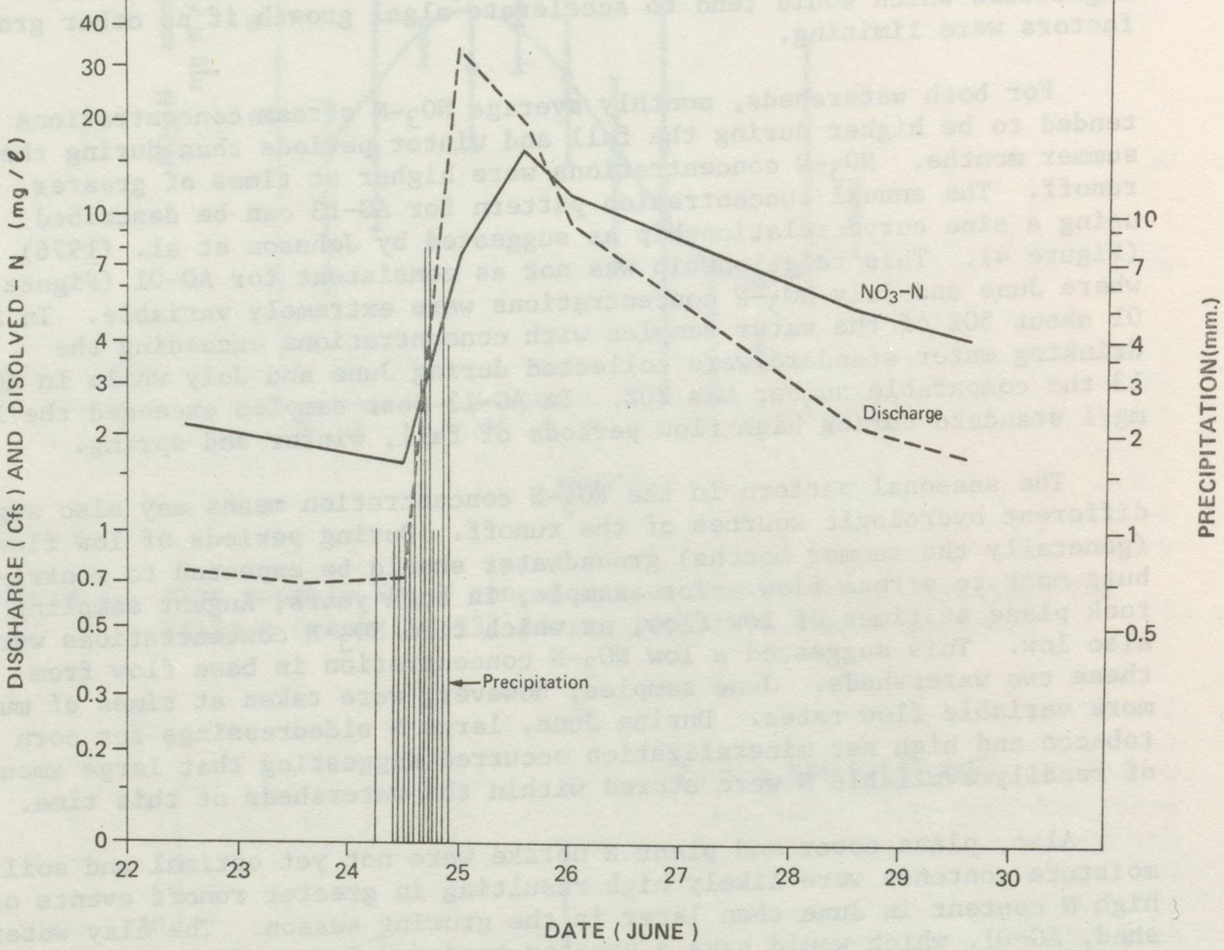

Figure 6. Relationship between mean daily discharge and NO$_3$-N concentrations prior to and after a storm on 24 June 1976 in Hillman Creek (AG-13) Watershed.

of low precipitation and excessive evapotranspiration, stream concentrations were generally low. With the decline in evapotranspiration and recharge of soil moisture in the fall, average stream concentrations increased and continued at a high level until spring runoff, at which time completion of leaching processes may have resulted in declining stream N concentrations. Deviations from this general pattern occurred in June and July when intense summer storms produced large volumes of surface runoff and high NO_3-N concentrations were present in the surface layers of watershed soils.

2. Flow-Concentration Relationships

On a seasonal basis, higher NO_3-N concentrations tended to occur at times of high flow from the watersheds. Increased N concentration at high flow was also demonstrated for a June storm in AG-13 (Figure 6). For this storm, NO_3-N concentration showed a pattern of increase similar to the increase in instantaneous discharge although peak NO_3-N concentration occurred about 12 hours after peak discharge. The magnitude of concentration increase, however, was much less than the relative increase in storm discharge.

Best fit regression equations (Table 4) relating flow and dissolved and total N concentrations were of the form

$$\ln N = Bo + B_1 \ln Q - B_2 Q$$

where N = dissolved or total N concentration (mg/l)
Q = discharge rate (ft^3/sec)

The relationships between discharge and concentration showed considerable variation (r^2 ranged between .40 and .50). The form of the equations suggested that maximum stream concentration did not occur at maximum discharge. Maximum discharge in both years in both watersheds occurred during the February spring melt and although the sine curve relationship would predict maximum stream concentration during this month, actual mean monthly concentrations were lower than those at other times of the year (Figures 4 and 5). This reflected lower N concentrations in snowmelt runoff which had a more limited contact with the soil mass.

3. Loss Rates

Methods of Calculation

Soluble N loss rates can be calculated as:

$$N = kCQ$$

where N = nitrogen loss rate (mass/time)
Q = discharge (ft^3/sec)
C = concentration of nitrogen parameter of concern (mg/l)
k = constant to convert losses to mass/unit time (2.45 if losses were calculated in kg/day).

Table 4. Regression coefficients relating nitrogen concentration to instantaneous (Qi) and mean daily (Q_{AV}) flow for Watersheds AG-01 and AG-13 for January 1975 to March 1977.

		Total Nitrogen (TN)*					Dissolved Nitrogen (DN)**				
Watershed	Discharge	Coefficients			r^2	Observations	Coefficients			r^2	Observations
	Qi/QAV	Bo	B1	B2			Bo	B1	B2		
AG-01	Qi SE^+	.4563 (.0548)	.3154 (.0252)	.0011 (.0003)	.41	268	-1.250 (.1189)	-7120 (.0801)	.0030 (.0004)	.46	268
	QAV SE	.4468 (.0672)	.3233 (.0272)	.0008 (.0004)	.48	208	-1.267 (.1399)	.7167 (.0558)	.0027 (.0009)	.50	208
AG-13	Qi SE	.8939 (.0561)	.4180 (.0290)	.0049 (.0010)	.55	195	.3721 (.0908)	.5724 (.0470)	.0072 (.0017)	.47	195
	QAV SE	.9439 (.0576)	.4204 (.0828)	.0075 (.0014)	.51	192	.4361 (.0936)	.5816 (.0533)	.0114 (.0023)	.42	192

*TN = Kjeldahl-N + NO_3-N

**DN = NO_3-N + NH_4-N

SE^+ = standard error for the regression coefficient.

Since Watersheds AG-01 and AG-13 have been continuously monitored for discharge but not for N concentrations, accurate calculation of loss rates requires some way of estimating N concentrations on unsampled days. A number of methods have been used and will be discussed in this report.

First was the NAQUADAT Method, currently in use in the Federal Department of the Environment* which linearly interpolated the product of discharge (Q) and concentration (C) between sampling times. The second method required development of discharge (Q), concentration (C) regressions as illustrated in Table 4. The statistical equations were then used to estimate N concentration on unsampled days. The third method treated the estimation of loads over a given time interval (a year) as a sampling problem. Since daily discharge frequency distributions are often skewed for small watersheds (Chow, 1964), stratification of the overall sample flows was required to normalize subsample populations. For AG-01 and AG-13, two strata were found to adequately normalize the population. The first stratum consisted of the highest 15% of flows (55 days); the second consisted of the rest. Average daily loads were calculated within each stratum, and from these a weighted daily load for the year was determined (Hydroscience, 1976). The chief advantage of this method was the establishment of confidence intervals for the loss rates.

Annual loss rates for dissolved nitrogen (DN) and total nitrogen (TN) have been calculated by the three previously outlined methods (Table 5). DN represented soluble NO_3-N + NH_4-N but excludes dissolved organic N while TN was the sum of total Kjeldahl N and NO_3-N. The annual rates calculated by the NAQUADAT and regression methods were always less than the annual means calculated by the stratified sample method although not significantly as generally the loss rates fell within the confidence intervals.

Only the NAQUADAT and regression DN and TN loads of AG-13 in 1975 were below the lower confidence limit. However, it should be noted that no NAQUADAT, January 1975 losses could be calculated because of a lack of sampling at that time. If regressed values for that month were added to NAQUADAT loss rates, the summed monthly AG-13 loads approached the lower confidence limit. Since annual losses calculated by the stratified sample method offer the advantage of a confidence interval and do not appear to significantly differ from the other methods, these values will be referred to when comparing annual AG-01 and AG-13 N loss rates to other literature values.

Only the NAQUADAT and regression methods allowed calculation of monthly loss rates and neither methods yielded consistently higher or lower monthly losses. The accuracy of the NAQUADAT method depended upon the representativeness of the flow conditions at the sampling time while the accuracy of the regression method depended upon the validity of the flow-concentration function over the time interval of interest. The

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*Demayo, A. and E. Hunt. National Water Quality Data Bank - NAQUADAT. A description of the system. Environment Canada, Ottawa.

fulfillment of these two different conditions varied from month to month. However, such monthly differences did not result in marked annual loss rate differences between these two methods (Table 5). NAQUADAT loss rate values, which did not depend upon statistically derived Q-C relationships, will be referred to when discussing seasonal N loss variation.

Magnitude of Losses

The watershed N losses discussed in this section represent N which has moved past the stream sampling point at the drainage outlet of the watershed. Thus, the measurement does not include watershed N losses from denitrification or volatilization. Unit area N losses were calculated by equally distributing N loss over all parts of the watershed.

Average annual total N losses for 1975-1976 were 22.2 kg N/ha and 29.4 kg N/ha for AG-01 and AG-13, respectively. These annual losses were about double the 1961-1967 average losses from southern Ontario tile drains under fertilized continuous corn (Webber and Elrick 1967, Bolton et al. 1970) although N losses in excess of 30 kg N/ha/year were also reported. Similar high total N losses were found for a watershed with 33% corn acreage in the St. Lawrence lowlands (Neilsen and Mackenzie, 1977) and N losses as large as these have been reported in Iowa for small heavily fertilized watersheds seeded to corn (Burwell et al. 1974, 1976). The higher losses from AG-13 may reflect the greater fertilizer input primarily on corn, tobacco and potatoes in AG-13 (67.0 kg N/watershed hectare) compared to AG-01 (58.4 kg N/watershed hectare) (Frank and Ripley, 1977). In addition, 59% of AG-13 fertilizer N was applied under preplant conditions at times of low crop cover. Only 22% of N was similarly applied in AG-01. Some of the greater loss rates from AG-13 reflected greater annual runoff from this sandy watershed. In 1976, 32 centimeters ran off AG-13 compared to 25 centimeters from AG-01. Furthermore less excess N may have been lost due to denitrification from the sandy watershed. Nevertheless, total N loss rates from either of these two watersheds were not large when compared to the estimated 24 kg total N input/hectare from precipitation.

During the two year monitoring period, DN accounted for 87% and 64% of the total N losses in the sandy (AG-13) and clay (AG-01) watersheds, respectively. This implies that sediment associated N losses were relatively more important from the clay watershed which had a higher sediment loss rate than AG-13 despite lower discharges (580 kg/ha versus 414 kg/ha). Most of the dissolved N (93% for both watersheds over two years) was lost as NO_3-N indicating the predominance of N anion over N cation loss from these agricultural watersheds.

For both watersheds, DN and TN loss rates in 1975 exceeded those during 1976. This may in part have reflected higher runoff since 36 and 33 centimeters of runoff occurred from AG-13 during 1975 and 1976 respectively. The comparable figures for AG-01 were 32 centimeters in 1975 and 25 centimeters in 1976. Over the whole 1975-1976 period, average annual discharges exceeded long term norms for the area (Coulson, 1967) by 28 centimeters (100%) in AG-01 and by 41 centimeters (145%) in AG-13. Annual N loss rates calculated for this time period likely also represented above 'average' loss rates.

Table 5. Annual dissolved (DN) and total N(TN) loss rates as calculated by NAQUADAT, regression and stratified-sample methods for Watersheds AG-01 and AG-13, 1975 and 1976.

Watershed	N Parameter	Year	Annual NAQUADAT	Loss Rate Regression	Stratified-sample Method**
			kg/ha		kg/ha
AG-01	DN	1975	13.6*	15.7	18.0± 8.5
		1976	10.5	10.5	10.5± 4.0
	TN	1975	18.2*	22.2	28.6±12.4
		1976	15.7	14.3	15.8± 5.5
AG-13	DN	1975	21.8*	23.2	30.9±2.2
		1976	19.9	19.0	20.2± 2.6
	TN	1975	24.2*	26.5	34.5± 2.9
		1976	22.6	21.6	24.2± 3.2

*no January 1975 estimates of DN or TN included in annual NAQUADAT loss rate
**as calculated and supplied by B. Bodo Ministry of Environment, Ontario (does not include dissolved NH_4-N)

The monthly N loss rates closely followed the monthly distribution of runoff as indicated by the coincidence of peak monthly discharge and DN loss rates in February (Figure 7), the month of the peak spring runoff event in 1975 and 1976. In addition, DN loss rates were low during September to December 1976, at which time runoff comprised a small fraction of annual flow for these two watersheds. In 1976, 57.1% of AG-01 and 67.7% of AG-13 annual DN losses occurred during February and March during which time 74.2 and 67.7% of their respective annual runoff occurred. These results supported the conclusions of Sharpley et al. (1976) that variation in discharge rather than stream concentrations was the predominant cause of variation in loss rates. Since most of DN losses occurred during the December to March winter period, it was also clear that this season represented the most critical time for N loss. Reduction of soil N content prior to December could result in a maximum annual conservation of watershed N.

4. Summary

For the predominantly sandy (AG-13) and clay (AG-01) agricultural watersheds, the following conclusions could be drawn concerning stream N concentrations and losses.

The predominant N species lost from both these watersheds was NO_3-N, although the 10 mg/l Ontario drinking water standard was exceeded only 7% of the time. Nevertheless, especially for sandy watershed AG-13, a 0.3 mg/l N limited (for algal growth) level may prove extremely difficult to achieve. Although there was little difference between the 2 year average total Kjeldahl N concentrations between watersheds, 36% of total N losses occurred as Kjeldahl-N from the clay watersheds (compared to 13% from AG-13). This was associated with higher sediment losses from the clay watersheds.

For both watersheds, there was a positive relationship between discharge and NO_3-N concentration. This had the consequence that highest NO_3-N concentrations and losses occurred during non growing season months of high runoff (December-April). Also, increased NO_3-N concentration was associated with the increased discharge of storm runoff. This indicated both the mobility of N at times of excess moisture and the need to be concerned with reducing soil N content prior to the late fall, winter and spring runoff periods.

The positive association of NO_3-N - the predominant N species lost in runoff - with discharge helps explain the larger unit area total N losses during a wetter 1975 compared to 1976. Also, the greater runoff from the sandy watershed, as well as greater fertilizer rates and reduced denitrification losses within this watershed may explain the larger average annual (29 kg total N/watershed hectare) total N loss compared to the clay watershed (22 kg N/watershed hectare). Nevertheless, unit area losses were not large compared to estimated annual N inputs with precipitation (24.0 kg N/watershed hectare).

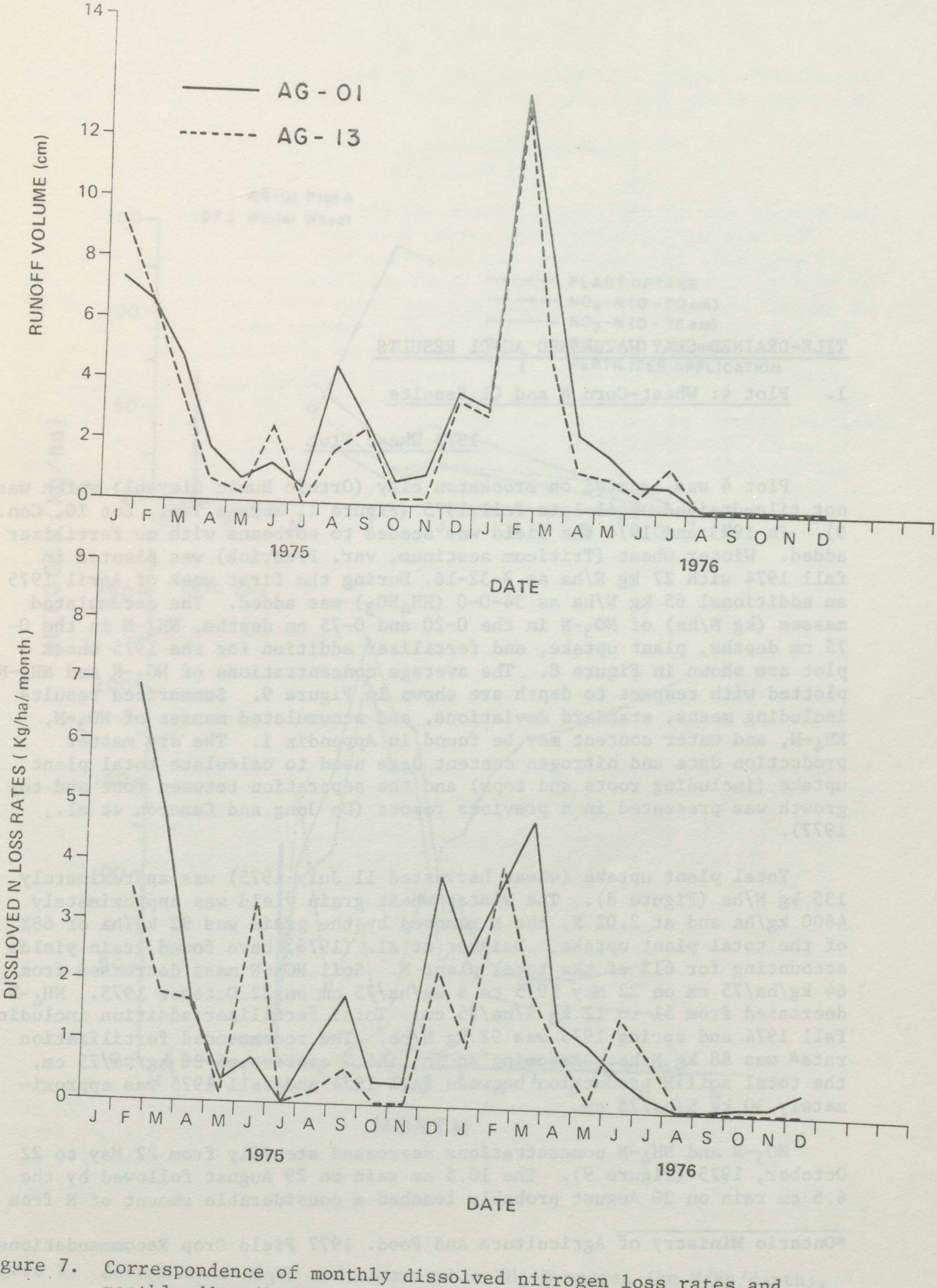

Figure 7. Correspondence of monthly dissolved nitrogen loss rates and monthly distribution of runoff for AG-01 and AG-13.

TILE-DRAINED CLAY WATERSHED AG-01 RESULTS

1. Plot 4: Wheat-Corn N and Cl Results

1975 Wheat Plot

Plot 4 was located on Brookston clay (Orthic Humic Gleysol) which was not tile-drained until late fall 1975 (Figure 1, Mersea Twp., Lot 10, Con. 9). In 1973 and 1974 the field was seeded to soybeans with no fertilizer added. Winter wheat (Triticum aestinum, var. Fredrick) was planted in fall 1974 with 27 kg N/ha as 8-32-16. During the first week of April 1975 an additional 65 kg N/ha as 34-0-0 (NH_4NO_3) was added. The accumulated masses (kg N/ha) of NO_3-N in the 0-20 and 0-75 cm depths, NH_4-N in the 0-75 cm depths, plant uptake, and fertilizer addition for the 1975 wheat plot are shown in Figure 8. The average concentrations of NO_3-N and NH_4-N plotted with respect to depth are shown in Figure 9. Summarized results including means, standard deviations, and accumulated masses of NO_3-N, NH_4-N, and water content may be found in Appendix I. The dry matter production data and nitrogen content data used to calculate total plant uptake (including roots and tops) and the separation between root and top growth was presented in a previous report (De Jong and Cameron et al., 1977).

Total plant uptake (wheat harvested 11 July 1975) was approximately 135 kg N/ha (Figure 8). The winter wheat grain yield was approximately 4600 kg/ha and at 2.0% N, the N removed by the grain was 92 kg/ha or 68% of the total plant uptake. Daigger et al. (1976) have found grain yields accounting for 61% of the total plant N. Soil NO_3-N mass decreased from 64 kg/ha/75 cm on 22 May 1975 to 5 kg/ha/75 cm on 22 October 1975. NH_4-N decreased from 51 to 12 kg N/ha/75 cm. Total fertilizer addition including fall 1974 and spring 1975 was 92 kg N/ha. The recommended fertilization rate* was 88 kg N/ha. Assuming an initial N content of 30 kg/ha/75 cm, the total soil N production between fall 1974 and fall 1975 was approximately 30 kg N/ha/75 cm.

NO_3-N and NH_4-N concentrations decreased steadily from 22 May to 22 October, 1975 (Figure 9). The 10.5 cm rain on 29 August followed by the 4.5 cm rain on 30 August probably leached a considerable amount of N from

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*Ontario Ministry of Agriculture and Food. 1977 Field Crop Recommendations.

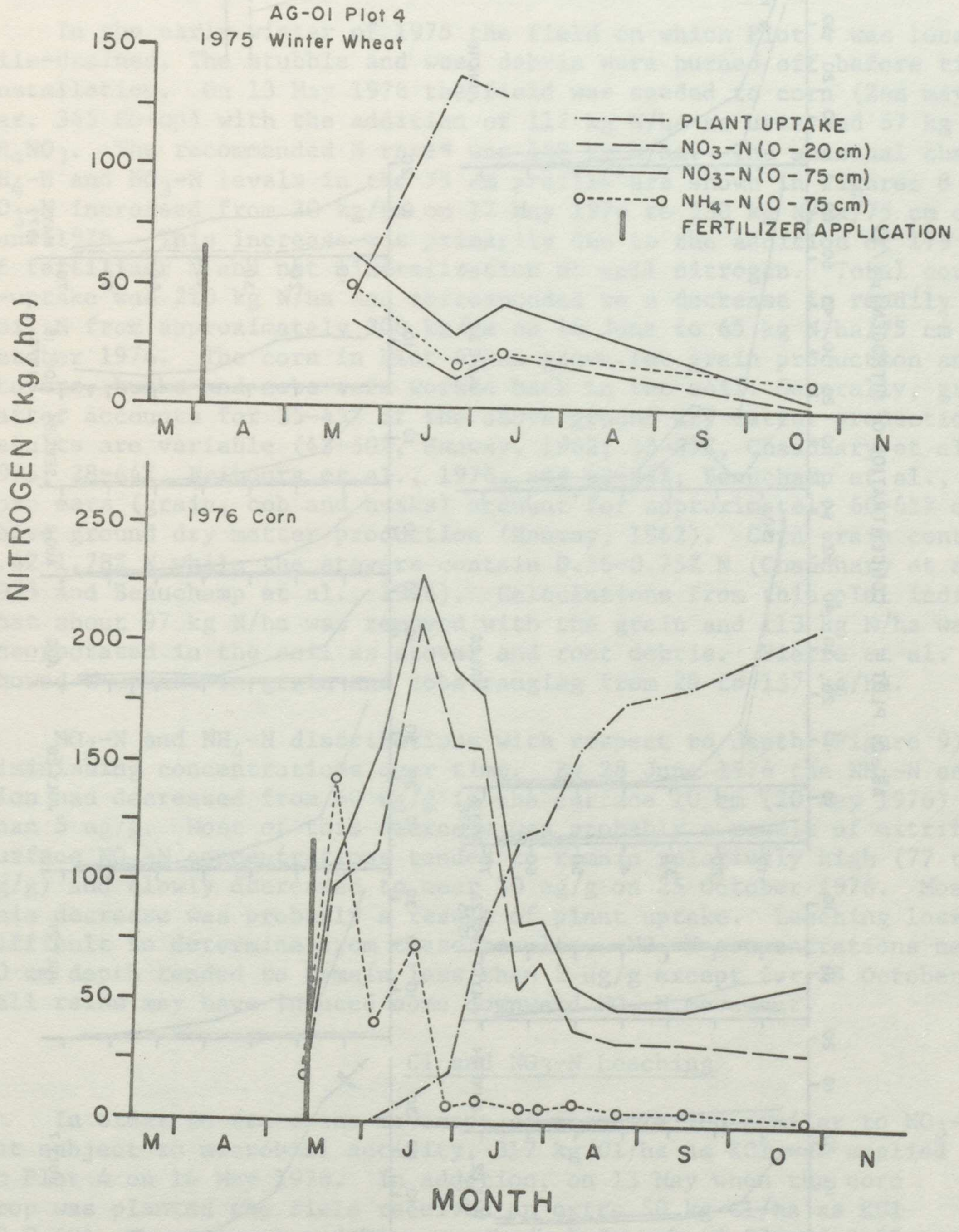

Figure 8. Accumulated NO_3-N and extractable NH_4-N masses (kg N/ha/depth), and fertilizer addition and crop uptake (kg N/ha) for the 1975 winter wheat and 1976 corn Plot 4, Watershed AG-01.

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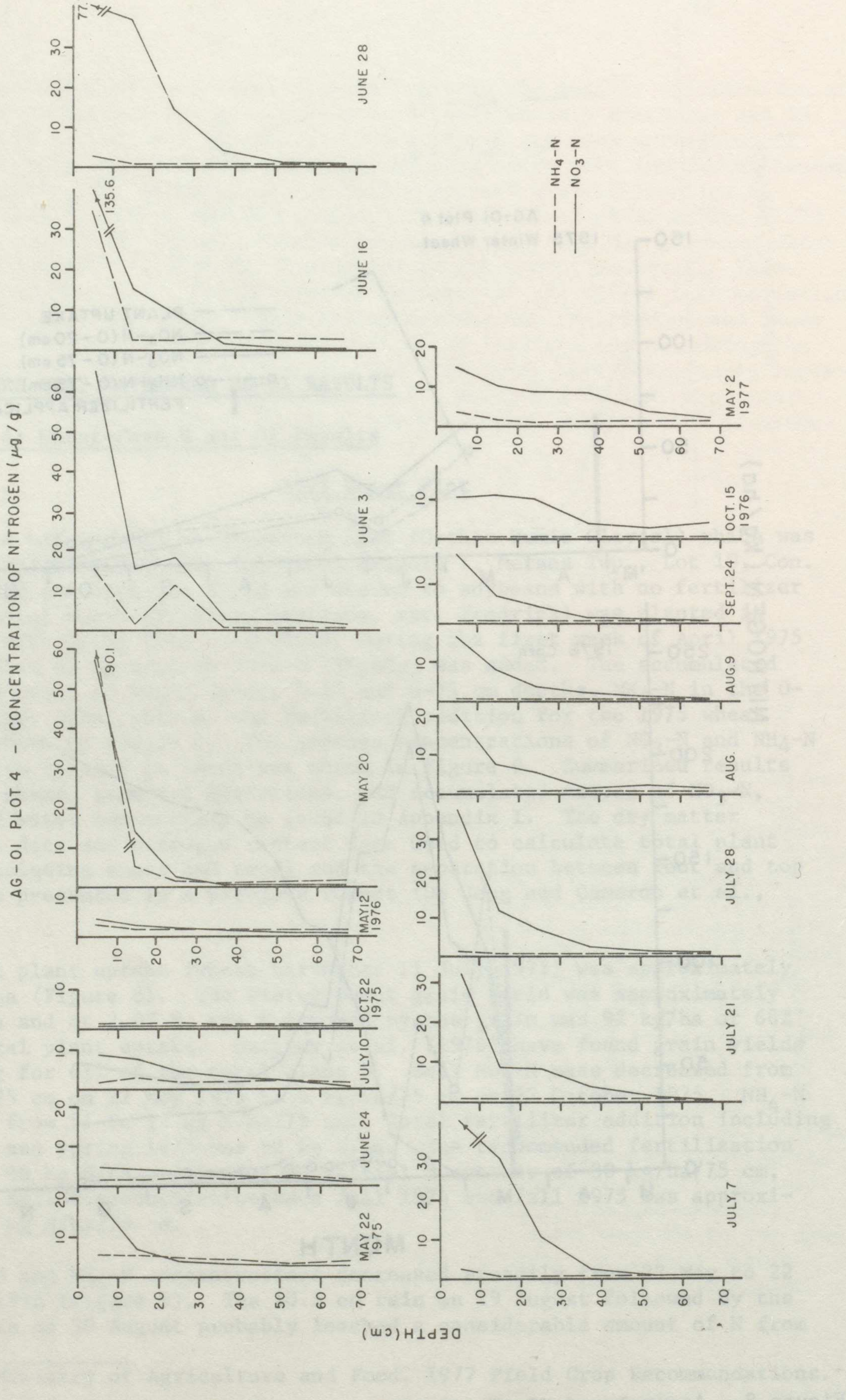

Figure 9. Nitrogen concentrations (ug/g) in the 0-75 cm profile of the 1975 winter wheat and 1976 corn Plot 4, Watershed AG-01.

the 75 cm profile. Field notes indicate abundant weed growth after harvest as the field was not cultivated. Some of the soil N was likely removed by the growing weeds.

1976 Corn Plot

In the early winter of 1975 the field on which Plot 4 was located was tile-drained. The stubble and weed debris were burned off before tile installation. On 13 May 1976 the field was seeded to corn (Zea mays L., var. 345 Co-op) with the addition of 112 kg N/ha as urea and 67 kg N/ha as NH_4NO_3. The recommended N rate* was 168 kg N/ha. The seasonal changes in NH_4-N and NO_3-N levels in the 75 cm profile are shown in Figures 8 and 9. NO_3-N increased from 20 kg/ha on 12 May 1976 to 230 kg N/ha/75 cm on 16 June 1976. This increase was primarily due to the addition of 179 kg/ha of fertilizer N and net mineralization of soil nitrogen. Total corn plant N-uptake was 210 kg N/ha and corresponded to a decrease in readily available soil N from approximately 300 kg/ha on 16 June to 65 kg N/ha/75 cm on 25 October 1976. The corn in Plot 4 was grown for grain production and the stovers, husks and cobs were worked back in the soil. Generally, grain dry matter accounts for 35-45% of the above ground dry matter production but results are variable (43-50%, Hanway, 1962; 33-35%, Chaudhary et al., 1975; 28-44%, Fribourg et al., 1976; and 42-64%, Beauchamp et al., 1976). Corn ears (grain, cob and husks) account for approximately 60-65% of the above ground dry matter production (Hanway, 1962). Corn grain contains 1.42-1.78% N while the stovers contain 0.56-0.75% N (Chaudhary et al., 1975 and Beauchamp et al., 1976). Calculations from this plot indicated that about 97 kg N/ha was removed with the grain and 113 kg N/ha was incorporated in the soil as stover and root debris. Pierre et al. (1971) showed N-uptake in grain and cobs ranging from 28 to 137 kg/ha.

NO_3-N and NH_4-N distributions with respect to depth (Figure 9) showed diminishing concentrations over time. By 28 June 1976 the NH_4-N concentration had decreased from 60 ug/g in the surface 10 cm (20 May 1976) to less than 5 ug/g. Most of this decrease was probably a result of nitrification. Surface NO_3-N concentrations tended to remain relatively high (77 to 136 ug/g) and slowly decreased to near 10 ug/g on 25 October 1976. Most of this decrease was probably a result of plant uptake. Leaching losses were difficult to determine from these results. NO_3-N concentrations near the 60 cm depth tended to remain less than 2 ug/g except for 25 October where fall rains may have induced some downward NO_3-N movement.

Cl and NO_3-N Leaching

In order to trace the movement of a mobile ion similar to NO_3-N, but not subject to microbial activity, 317 kg Cl/ha as KCl was applied to Plot 4 on 14 May 1976. In addition, on 13 May when the corn crop was planted the field received an extra 50 kg Cl/ha as KCl (0-0-60). The accumulated Cl mass (kg/ha) for the 0-20 and 0-75 cm

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*Ontario Ministry of Agriculture and Food. 1977 Field Crop Recommendations.

depth intervals and the corresponding concentration distributions for Cl with respect to depth for each of the sampling times are shown in Figure 10. The 3 June sampling showed that only 337 kg Cl/ha was recovered in the 0-75 cm layer. The 16 June sampling gave results which were high. The average of 16 June and 3 June chloride results might represent a reasonable recovery rate. The chloride mass in the clay plot decreased steadily throughout the summer from approximately 440 kg Cl/ha in early June to near 320 kg Cl/ha/75 cm by 15 September 1976. Chloride uptake by the corn amounted to 147 kg Cl/ha by 15 September 1976 which would account for the steady chloride decrease during the summer. The accumulated chloride mass in the soil increased to 395 kg Cl/ha/75 cm by 25 October 1976. This apparent increase may have been due to sampling error and also to chloride loss from the corn plant. The percent chloride in the corn stalks decreased from 2.25% on 15 September to 1.46% on 25 October 1976 resulting in a loss of 56 kg Cl/ha from the corn plants. The corn crop was harvested 30 October 1976. By 25 March 1977 the chloride mass had decreased to 185 kg/ha. In terms of added Cl (367 kg/ha) there was a 69% loss between application and early spring 1977. During the winter period between 25 October 1976 and 2 May 1977, the mineral N mass increased from 65 kg N/ha to 90 kg N/ha/75 cm. Presumably any N loss due to winter leaching and spring runoff was regained by early spring mineralization.

The chloride distribution patterns (Figure 10) on the clay Plot 4 tended to parallel those of NO_3-N (Figure 9) where most of the chloride was retained near the surface. The 25 Oct. 1976 and 24 March 1977 sampling showed signs of leaching beyond 60 cm.

The 90 cm and 150 cm suction lysimeters were installed 14 May 1975. Measured NO_3-N and Cl concentrations are given in Table 6. Although the profile distributions of NO_3-N and Cl did not indicate substantial leaching during the summer, both the 90 and 150 cm suction lysimeters showed definite concentration peaks of NO_3-N and Cl on 28 June and 7 July 1976. The tile drain concentrations (near Plot 4) also tended to peak at this time. The appearance of the early summer slug of salt was most likely induced by the heavy rains in late June (one storm yielded 4 cm of rain Figure 2). It is also possible that some of the salt could have been leached down the side of the lysimeter tube, but the nature of the clay soil suggests otherwise.

There are several factors that can enhance the movement of NO_3-N and Cl in the tile-drained clay soils. The period of late May to early June was relatively dry (Figure 2) allowing the clay soils to shrink, opening small fissures and cracks in the soil. With the onset of a heavy rainstorm these cracks could act as channels to conduct both water and mobile nutrients downward. It was suspected that even when these clay soils are wet and fully expanded, the fissures and cracks do not completely close and consequently can act as important transport channels. In addition, during spring, there is very little crop cover and precipitation losses due to interception are minimal, allowing all the rain to reach the soil. It was postulated that the concentration peaks measured with the lysimeters and at the tile drains were a direct result of NO_3-N and Cl movement from the surface down through the cracks and fissures in the soil.

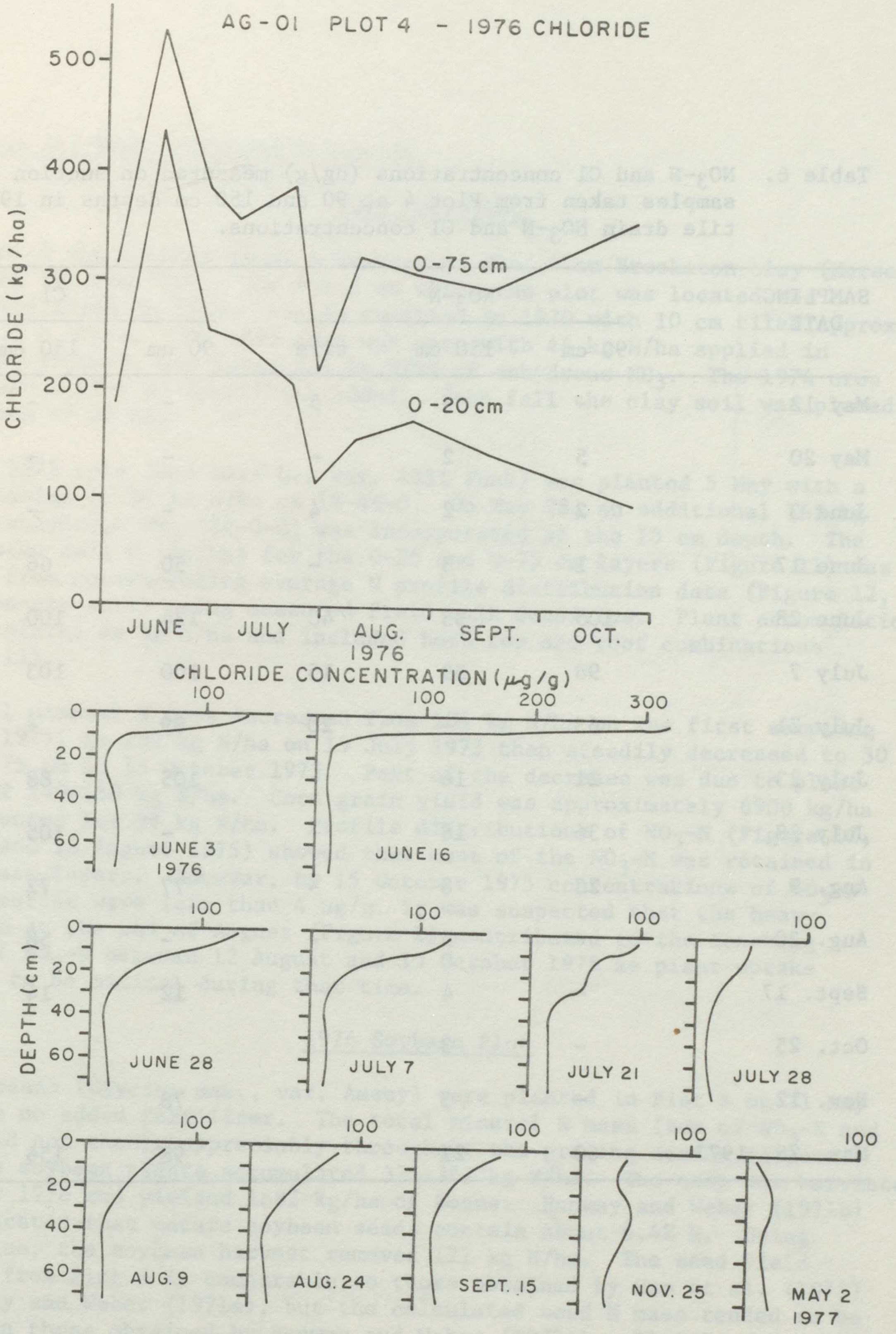

Figure 10. Cumulative chloride mass (kg/ha) for 0-20 and 0-75 cm depth intervals and the corresponding concentration distributions for Cl with respect to depth for each of the sampling times on 1975 corn Plot 4, Watershed AG-01.

Table 6. NO_3-N and Cl concentrations (ug/g) measured on suction lysimeter samples taken from Plot 4 at 90 and 150 cm depths in 1976 and tile drain NO_3-N and Cl concentrations.

SAMPLING DATE	NO_3-N			Cl		
	90 cm	150 cm	tile	90 cm	150 cm	tile
May 12	-	-	5	-	-	-
May 20	5	2	-	-	-	-
June 3	2	2	4	-	-	-
June 17	1	3	-	50	66	
June 28	105	33	40	124	100	89
July 7	98	39	15	100	103	89
July 21	63	-	20	89	-	82
July 23	21	16	-	105	88	
July 28	36	18	-	-	105	
Aug. 9	23	8	-	77	72	
Aug. 30	-	5	-	-	58	
Sept. 17	-	4		12	14	
Oct. 25	-	3				
Nov. 12	-	3		78		
Mar. 25, 1977	60	21		98	156	

2. Plot 5: Corn - Soybean N Results

1975 Corn Plot

Plot 5 was located about 4 km east of Plot 4 on Brookston clay (Mersea Twp., Lot 16, Con. 10). The field on which the plot was located was originally tiled in 1920. It was re-tiled in 1970 with 10 cm tiles approximately 9 m apart. The 1973 crop was corn with 44 kg N/ha applied in spring as 18-46-0, and later 224 kg N/ha of anhydrous NH_3. The 1974 crop was soybeans with no fertilizer added. Each fall the clay soil was plowed to a depth of 20 cm.

In 1975 corn (Zea mays L., var. 4321 Funk) was planted 5 May with a side-dressing of 38 kg N/ha as 18-46-0. On May 28, an additional 165 kg N/ha as anhydrous NH_3 (82-0-0) was incorporated at the 15 cm depth. The accumulated soil N (kg/ha) for the 0-20 and 0-75 cm layers (Figure 11) was derived from corresponding average N profile distribution data (Figure 12, µg/g oven-dry soil) using measured field bulk densities. Plant accumulation was calculated as kg N/ha and included both top and root combinations (Figure 11).

Soil mineral N mass increased from 105 kg N/ha on the first sampling (26 May 1975) to 192 kg N/ha on 15 July 1975 then steadily decreased to 30 kg N/ha/75 cm on 15 October 1975. Part of the decrease was due to plant uptake of 140-150 kg N/ha. Corn grain yield was approximately 6900 kg/ha and accounted for 98 kg N/ha. Profile distributions of NO_3-N (Figure 12, 15 July and 12 August 1975) showed that most of the NO_3-N was retained in the surface layers. However, by 15 October 1975 concentrations of NO_3-N in the profile were less than 4 µg/g. It was suspected that the heavy rainstorm at the end of August (Figure 2) contributed to the leaching losses of NO_3-N between 12 August and 15 October 1975 as plant uptake appeared to be minimal during that time.

1976 Soybean Plot

Soybeans (Glycine max., var. Amsoy) were planted in Plot 5 on 31 May 1976 with no added fertilizer. The total mineral N mass (sum of NO_3-N and NH_4-N) did not change appreciably throughout the growing season (Figure 11). The soybean plants accumulated 325-357 kg N/ha. The crop was harvested 7 October 1976 and yielded 1882 kg/ha of beans. Hanway and Weber (1971b) have indicated that mature soybean seeds contain about 6.4% N. Using their value, the soybean harvest removed 121 kg N/ha. The seed yield obtained from Plot 5 is comparable to those obtained by Ham et al. (1975) and Hanway and Weber (1971a), but the calculated seed N mass tended to be lower than those obtained by Hanway and Weber (1971c). Plot 5 seed N mass accounted for 39% of the above ground plant N, whereas Hanway and Weber (1971c) results showed seed N masses accounting for 62-69%.

The profile distribution patterns of NO_3-N (Figure 12) indicated little leaching; only 14 July 1976 showed any signs of leaching below 60 cm as the NO_3-N concentrations at this depth had increased from the previous

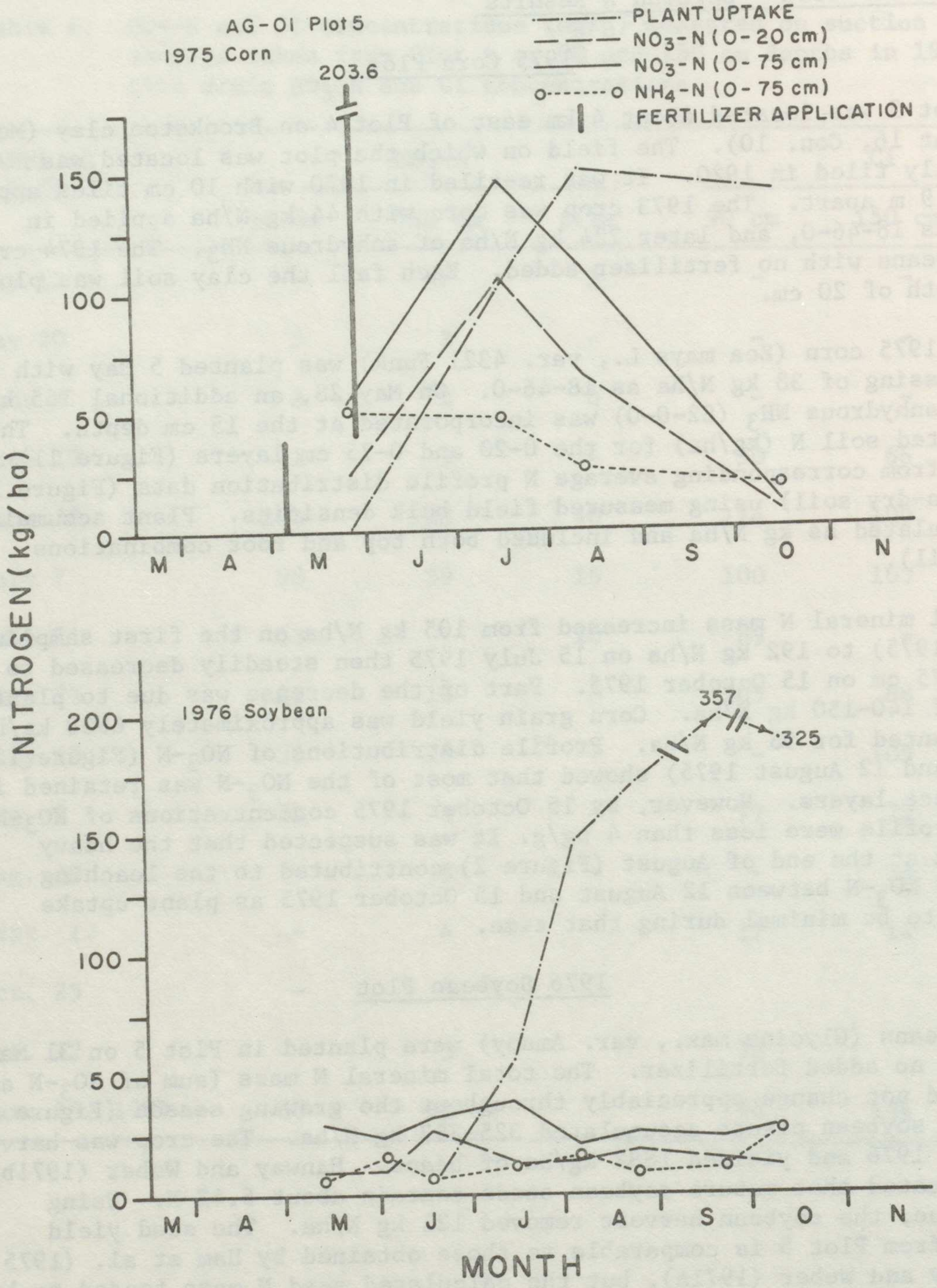

Figure 11. Accumulated NO_3-N and extractable NH_4-N masses (kg N/ha/depth), and fertilizer addition and crop uptake (kg N/ha) for the 1975 corn and 1976 soybean Plot 5, Watershed AG-01.

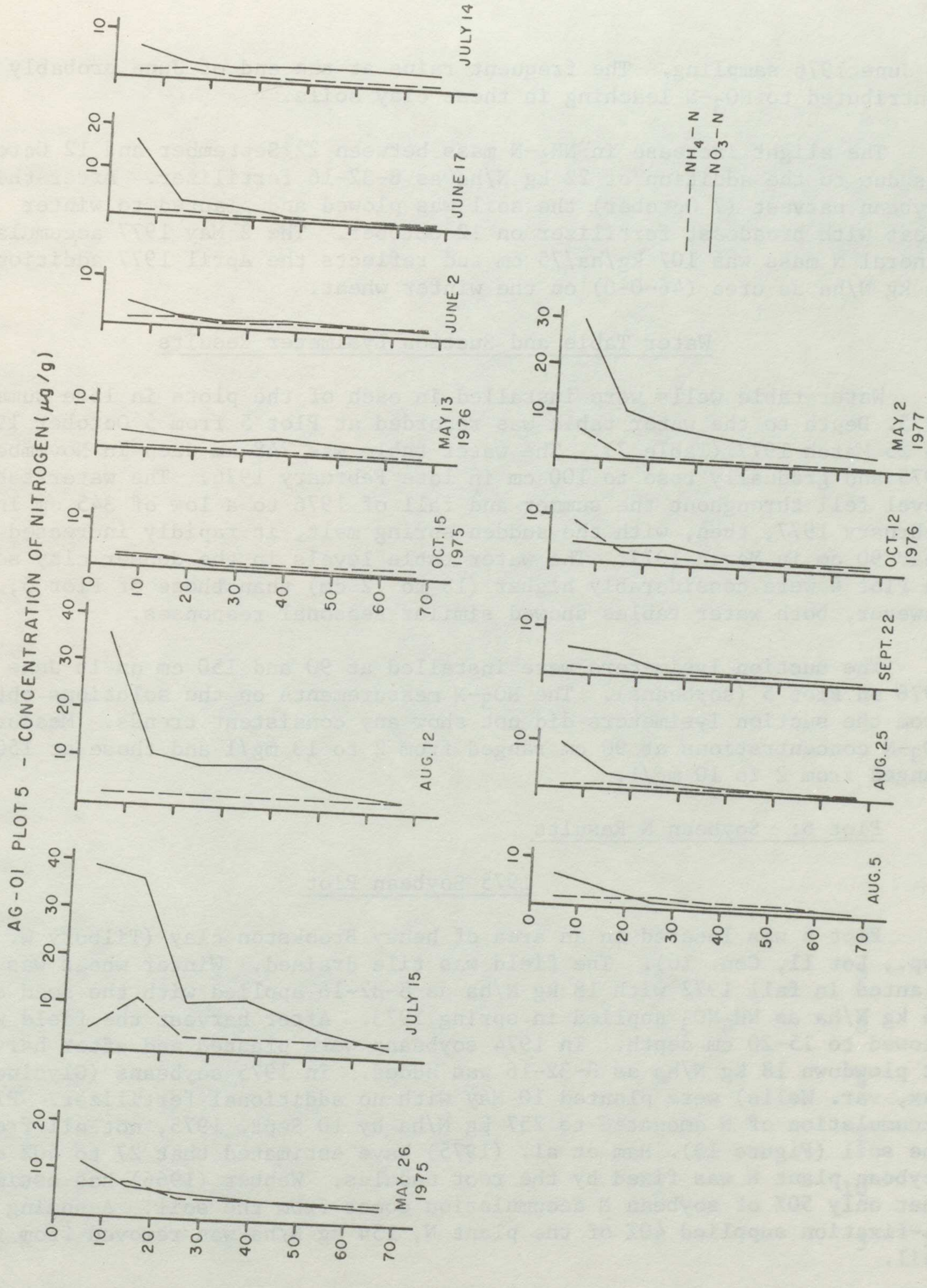

Figure 12. Nitrogen concentrations (ug/g) in the 0-75 cm profile of the 1975 corn and 1976 soybean Plot 5, Watershed AG-01.

17 June 1976 sampling. The frequent rains at the end of June probably contributed to NO_3-N leaching in these clay soils.

The slight increase in NH_4-N mass between 22 September and 12 October was due to the addition of 22 kg N/ha as 8-32-16 fertilizer. After the soybean harvest (7 October) the soil was plowed and planted to winter wheat with broadcast fertilizer on 12 October. The 2 May 1977 accumulated mineral N mass was 107 kg/ha/75 cm and reflects the April 1977 addition of 66 kg N/ha as urea (46-0-0) on the winter wheat.

Water Table and Suction Lysimeter Results

Water table wells were installed in each of the plots in late summer 1975. Depth to the water table was recorded at Plot 5 from 5 October 1975 to 25 March 1977 (Table 7). The water table was 248 cm deep in November 1975 and gradually rose to 100 cm in late February 1976. The water table level fell throughout the summer and fall of 1976 to a low of 345 cm in February 1977, then, with the sudden spring melt, it rapidly increased to near 90 cm in March 1977. The water table levels in the denser clay soils in Plot 6 were considerably higher (18 to 72 cm) than those of Plot 5, however, both water tables showed similar seasonal responses.

The suction lysimeters were installed at 90 and 150 cm on 16 June 1976 on Plot 5 (soybeans). The NO_3-N measurements on the solutions obtained from the suction lysimeters did not show any consistent trends. Measured NO_3-N concentrations at 90 cm ranged from 2 to 13 mg/l and those at 150 cm ranged from 2 to 10 mg/l.

3. Plot 6: Soybean N Results

1975 Soybean Plot

Plot 6 was located in an area of heavy Brookston clay (Tilbury W. Twp., Lot 11, Con. 10). The field was tile drained. Winter wheat was planted in fall 1972 with 18 kg N/ha as 8-32-16 applied with the seed and 56 kg N/ha as NH_4NO_3 applied in spring 1973. After harvest the field was plowed to 15-20 cm depth. In 1974 soybeans were planted and after harvest at plowdown 18 kg N/ha as 8-32-16 was added. In 1975 soybeans (Glycine max, var. Wells) were planted 10 May with no additional fertilizer. Plant accumulation of N amounted to 257 kg N/ha by 10 Sept. 1975, not all from the soil (Figure 13). Ham et al. (1975) have estimated that 27 to 40% of soybean plant N was fixed by the root nodules. Webber (1966) has estimated that only 50% of soybean N accumulation comes from the soil. Assuming the N_2-fixation supplied 40% of the plant N, 154 kg N/ha was removed from the soil.

Soil NO_3-N mass decreased from 75 kg/ha on 23 July 1975 to less than 25 kg/ha/75 cm on 10 September 1975 (Figure 13). Part of this decrease is due to plant uptake but the excessive rains on 29 August (10.5 cm) and 30 August (4.5 cm) may have contributed to much of this loss (Figure 2). The profile NO_3-N concentrations showed a definite decrease between 23 July and 10 September 1975.

Table 7. Water table levels for Plots 5 and 6 and suction lysimeter NO_3-N concentrations in Plot 5

SAMPLING DATE	Depth of Water Table (cm)		NO_3-N Concentrations (mg/l)	
	Plot 5	Plot 6	90 cm depth	150 cm depth
5 Oct. 75	235	62		
29 Oct. 75	248	72		
12 Nov. 75	248	61		
4 Dec. 75	235	60		
21 Dec. 75	198	66		
19 Jan. 76	147	59		
6 Feb. 76	105	52		
26 Feb. 76	100	18		
17 Mar. 76	105	28		
23 Mar. 76	123	52		
15 Apr. 76	130	38		
10 May 76	107			
8 June 76	143			
29 June 76	148		13	5
21 July 76	180		4	8
5 Aug. 76	183		9	4
17 Sept. 76	295		–	2
12 Oct. 76	302		2	10
12 Nov. 76	325		–	3
7 Jan. 77	330		–	–
11 Feb. 77	345		–	–
10 Mar. 77	89		–	–
25 Mar. 77	91		11	6

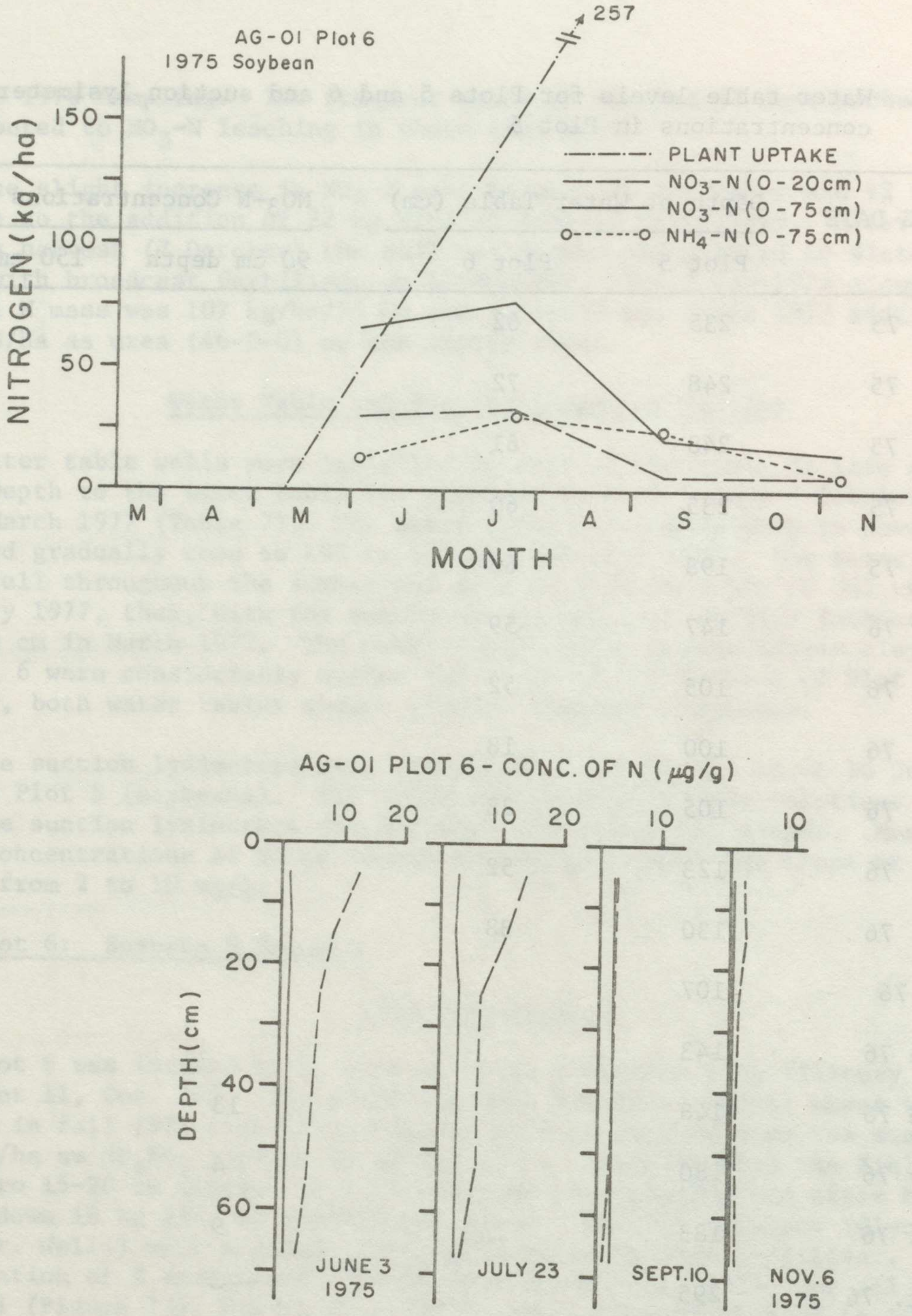

Figure 13. Accumulated NO_3-N and extractable NH_4-N masses (kg N/ha/depth), fertilizer addition, crop uptake and concentration distributions (ug/g) of NO_3-N and NH_4-N with respect to depth for each of the sampling times on 1975 soybean Plot 6, Watershed AG-01.

The soybean crop was harvested on 25 September 1975, the field plowed, and winter wheat planted on 30 September with 17 kg N/ha as 7-28-14 broadcast. Soybean seed yield was 2352 kg/ha (39% of above ground plant dry matter). The seeds removed 141 N/ha, leaving 116 kg N/ha to be incorporated into the field.

Plot 6 was discontinued in 1976.

4. Summary of Nitrogen Inputs, Recovery and Losses

In order to obtain estimates of annual nitrogen losses one can use a simplified balance sheet. The approach is approximate and only requires adding and subtracting known mineral N inputs and outputs, and attributing the difference to leaching, denitrification and immobilization losses. However, in order to compute an N balance some quantitative estimates of mineralization must be made.

Estimating Mineralization

The several methods of estimating mineralization are only approximate methods. Bremner (1965) has suggested that the amount of organic N mineralized during the growing season usually amounts to 1 to 3% of the total amount present (in the plow layer). Approximately 8860 (0.31%), 7830 (0.28%), and 5600 (0.20%) kg organic N/ha/20 cm was present in the clay soils in Plots 4, 5 and 6, respectively (Kowalenko, 1977). Bremner's percentages suggest 56 to 266 kg organic N/ha would be mineralized (Table 8). These values seem very large, but they are understood to approximate real mineralization as opposed to net mineralization which includes immobilization.

Another method for estimating mineralization is to assume that after many years of cultivation and cropping a dynamic equilibrium (of a sort) is reached where the inflow and outflow of organic N tends to balance itself (Stevenson, 1965). Thus, the amount of organic debris returned to the soil is approximately equivalent to net mineralization. Field studies show annual plant residues ranging from 52 to 236 kg N/ha (Table 8). Yearly mineralization might depend upon the amount and type of organic debris added in the past year.

The last method is to use net mineral N production rates calculated from field or laboratory data. Depending upon the conditions these rates can include leaching and denitrification losses. They almost always include immobilization. Ellis (1974) showed short term mineralization rates varying from -0.72 to 1.68, and averaging 0.70 kg N/ha/day on an old field in southern Ontario. Assuming a five month active period, Ellis' average rate would imply a net production of 107 kg mineral N/ha/year. Kowalenko (1977) has related mineral N production (after 21 days of incubation) to temperature and water content. The empirical relationship obtained for the clay soils was as follows:

$$\text{Net Mineralization} = 2.8\ (0.4177 + 0.015647\ \theta p + 0.002\ T\theta p - 0.025049\ T)$$

Table 8. Estimated annual net mineralization rates (kg/ha) for the tile-drained clay Watershed AG-01

Method	Plot 4	Plot 5	Plot 6
Bremner: 1 to 3% of organic N (kg/ha)	89 - 266	78 - 235	56 - 168
Stevenson - net mineralization equals plant organic debris returned	wheat 58 corn 113	corn 52 soybeans 236	soybeans 116
Ellis (1965): 0.70 kg/ha/day for 5 months	107	107	107
Kowalenko (1977) - regression of laboratory incubation study	1975 486 1976 404	486 404	486 404
Cameron *et al* (1978) - Ottawa clay loam	99 - 191	99 - 191	99 - 191

where net mineralization units are kg/ha/day/20 cm,
θp = percent water content (dry wt. basis) and
T = soil temperature C.

The regression coefficient r = 0.86 and standard deviation was 0.29. Over the period 1 May to 1 October using mean daily air temperatures and predicted water contents, the regression model predicted annual mineralization rates of 486 kg N/ha in 1975 and 404 kg N/ha in 1976. Relative to the other mineralization calculations, the laboratory incubation results tended to over-estimate net mineralization rates by 2 to 3 times.

Cameron et al. (1978) conducted a 3-year study on a clay loam soil (0.33% N) at Ottawa. The average daily NO_3-N production rates were 1.25, 1.14, and 0.65 kg N/ha/day for 1974, 1975 and 1976, respectively. Assuming these rates can be used to approximate the Leamington clay soils then with a 5-month active period net mineralization rates could range from 99 to 191 kg/N/ha/year.

Approximate N Balance

Approximate N balances for the clay soils were obtained by adding the inputs of readily available N from fertilization, rainfall, and net mineralization; subtracting the recovery of N in the plant and soil; and assuming the difference to be lost by leaching, denitrification, volatilization, or runoff. The separation of these losses requires more refined, intensive research. Losses by immobilization were assumed to be accounted for by net mineralization.

In drawing up an approximate balance sheet some intuitive judgement was needed. The crop year was chosen to run from the fall of the previous year to the fall of the current year. This roughly parallels the hydrological water year. In addition, it allowed a complete growing year for fall fertilized winter wheat. The estimation of the yearly net mineralization component was based on the estimates in Table 8 and adjusted depending upon the incorporation of plant material from the previous year. The adjustments were subjective but it was felt that a previous crop such as soybeans returned a fair amount of organic-N readily available for decomposition, more so than corn or wheat. Average masses of N incorporated from wheat, corn, and soybean debris were 58, 82 and 176 kg N/ha. Thus, fields previously sown to soybeans were estimated to mineralize about 180 kg organic N/ha while other fields only mineralized 80-90 kg N/ha/year.

Soil recovery was calculated as the difference between available N at the end of the season and that of the previous season. The authors realize some of these estimates are rather tenuous as the fall 1974 nitrogen results were unknown and had to be estimated. In addition, the point marking the end of a season and the beginning of another were not always consistent from year to year and depended on the crops grown. The soil recovery figure could easily be ±50% its estimated value (Table 9). More years of data are required to obtain reliable yearly estimates.

The nitrogen mass balance results including inputs, recovery, and losses are summarized in Table 9 for each of the clay plots. The results were averaged over the two years of the study where possible. Average annual N inputs from fertilization, rain and mineralization ranged from 175 to 283 kg/ha. On the average mineralization and fertilizer inputs were similar, although their relative importance varied considerably from year to year. Average annual nitrogen recovery by the plants and soil ranged from 114 to 202 kg N/ha. The estimated annual N losses (primarily by leaching and denitrification) ranged from 61 to 81 kg N/ha.

The division between denitrification and leaching is difficult to make. In a number of long-term experiments running for 8-16 years in New York and Connecticut, Allison (1955) indicated that average yearly denitrification losses can range from 24 to 47 kg N/ha. Firth et al. (1973) calculated a denitrification loss of approximately 41 kg N/ha from a corn field in 84 days. Kissel et al. (1976) calculated denitrification loss under sorghum to be 24 kg N/ha in 58 days. Kowalenko (1978) and Kowalenko and Cameron (1978) have shown that denitrification is most active in the spring and early summer seasons. Their denitrification losses were about 40% of the added fertilizer ^{15}N and amounted to about 45 kg N/ha in a clay loam soil near Ottawa. Chichester and Smith (1975) estimated loss by denitrification to range from 5 to 30% of the fertilizer applied. An accounting of the ^{15}N for the period of their field lysimeter study showed that approximately 30% was leached in percolate and less than 2% was moved in runoff.

On the basis of the above review, denitrification could account for approximately 50% of the 61 to 81 kg N/ha lost each year.

Table 9. Approximate nitrogen mass balances (kg N/ha/yr) for plots on tile-drained clay Watershed AG-01

		Inputs				Recovery			
		1975	1976	Ave.		1975	1976	Ave.	Loss
Plot 4	Fertilizer Added	92	179	135	Soil Recovery	-13	56	22	
	Rainfall N	18	18	18	Crop Recovery	150	210	180	
	Net Mineralization	180	80	130		137	266	202	81
		290	277	283					
Plot 5	Fertilizer Added	203	0	101	Soil Recovery	0	5	2	
	Rainfall N	18	18	18	Crop Recovery	150	214	182	
	Net Mineralization	180	90	135		75	119	184	70
		401	108	254					
Plot 6	Fertilizer Added	17			Soil Recovery	-40			
	Rainfall N	18			Crop Recovery	154			
	Net Mineralization	140				114			61
		175							

SANDY LOAM WATERSHED AG-13 RESULTS

1. Plot 1: Potato N Results

1975 Potato Plot

Plot 1 was located at the west end of AG-13 on Berrien sandy loam (Gleyed Brunisolic, Mersea Twp., Lot 3, Conc. 4). Winter wheat was planted in the fall of 1972 with 38 kg N/ha as 34-0-0 (NH_4NO_3) broadcast with the seed and 38 kg N/ha as 34-0-0 applied in the spring of 1973. In 1974 Flue tobacco was planted in the field with 22 kg N/ha band applied as 2-12-14. After the tobacco was harvested a cover crop of wheat with no fertilizer was planted. This cover crop was plowed under for green manure in the spring of 1975. Early potatoes (Solanum tuberosum L., var. Superior) were planted on 6 April 1975 with 112 kg N/ha as 10-20-30 band applied. This was almost double the recommended rate* of 67 kg N/ha for early potatoes.

Because the plot was established in July 1975 and the potatoes were harvested 11 July, no plant and soil samples were taken during the potato growing season. The first soil samples were taken 16 July 1975 and ryegrass was seeded on 10 August 1975. The nitrogen loss from the 0-75 cm profile between the first and second sampling was 91 kg/ha (see Figure 14) with 49 kg N/ha tied up in the ryegrass (De Jong and Cameron et al., 1977) and 20 kg N/ha remained in the soil. The net loss of 42 kg N/ha was thought to be mainly due to leaching. The soil had a large hydraulic conductivity (Topp, 1976) and was subject to some heavy rainstorms between the two sampling times (Figure 2).

The crop was disked on 20 November 1975. The increase in soil N content near the end of the year could be partly due to mineralization of freshly added ryegrass material.

1976 Potato Plot

In 1976 the potato plot was relocated to an adjacent field, which had the same previous cropping history as the 1975 potato plot. Early potatoes were planted in the field on 6 April 1976 with 168 kg N/ha as 15-15-15, sidedressed during planting time.

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*Ontario Ministry of Agriculture and Food. 1976. Vegetable production recommendations.

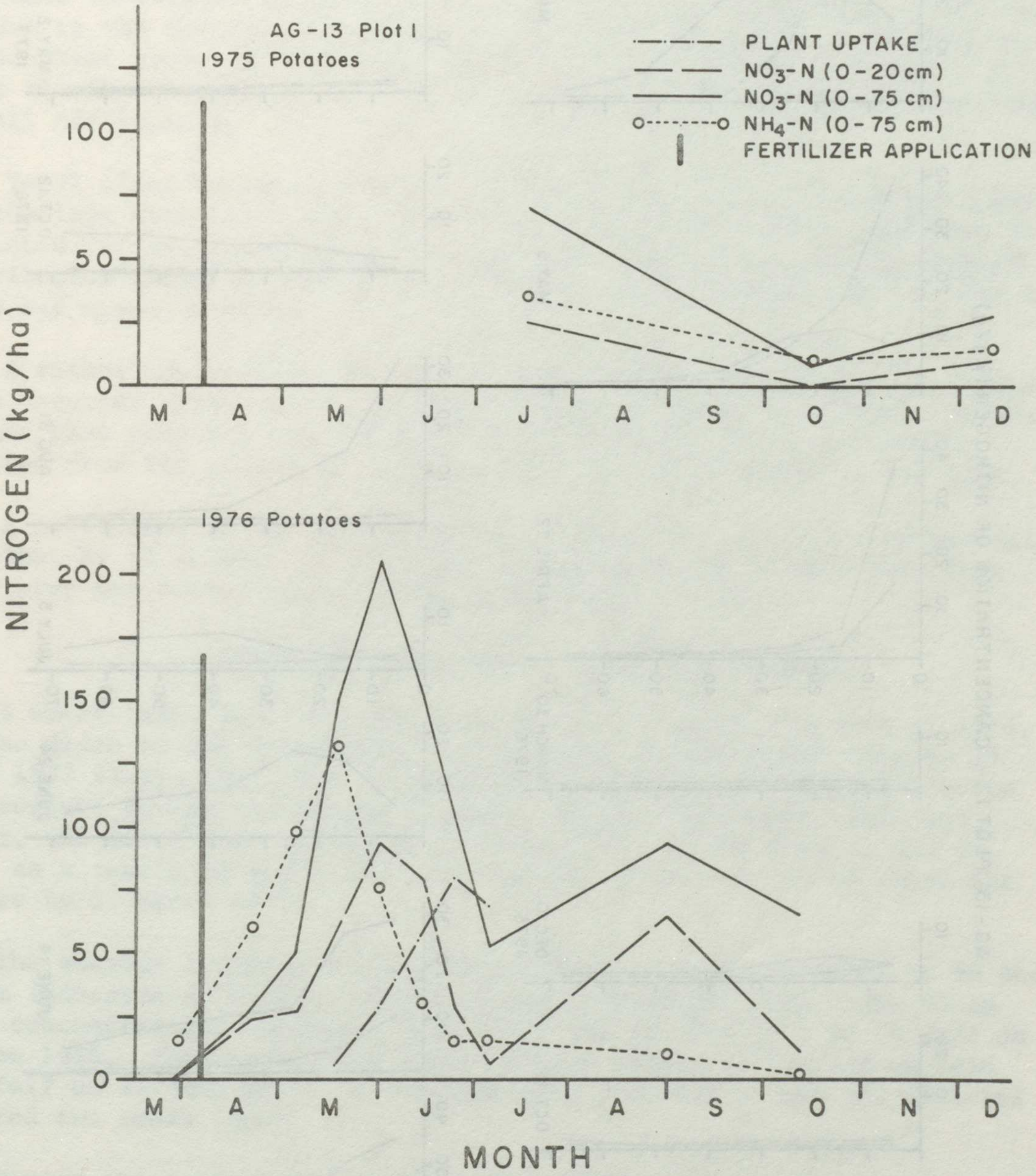

Figure 14. Accumulated NO_3-N and extractable NH_4-N masses (kg N/ha/depth), fertilizer addition and crop uptake (kg N/ha) for the 1975 and 1976 potato Plot 1, Watershed AG-13.

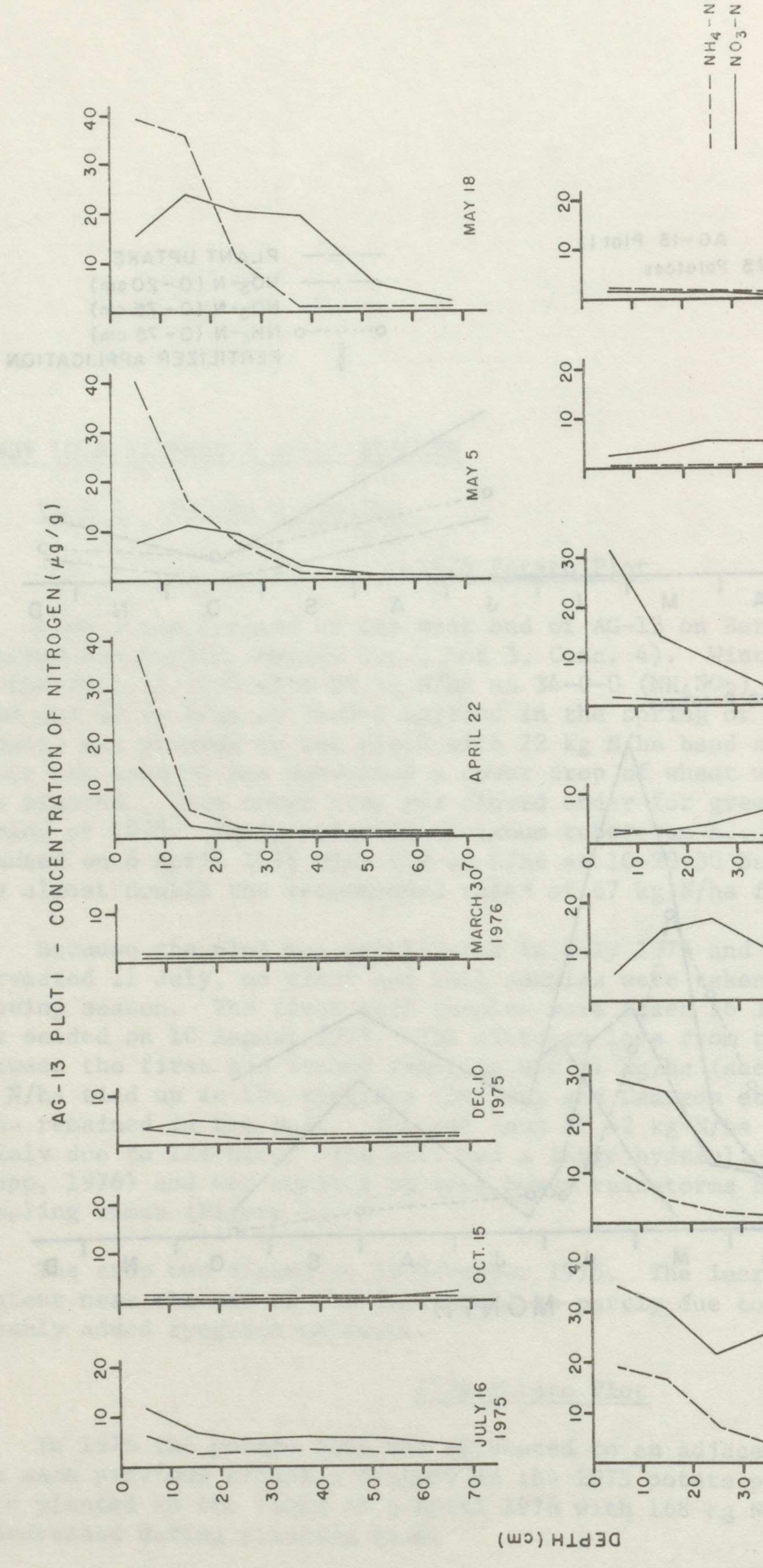

Figure 15. Nitrogen concentrations (ug/g) of the 0-75 cm proifle of the 1975 and 1976 potato Plot 1, Watershed AG-13.

The seasonal changes in NO_3-N and NH_4-N levels in the 75 cm profile are shown in Figures 14 and 15. The initial rapid increase in soil nitrogen was due to the fertilizer addition and mineralization of the plowed-under winter wheat crop. After 18 May 1975 the NH_4-N content decreased rapidly, while the NO_3-N continued to increase for another two weeks and then began to fall off rapidly.

Total plant uptake accounted for 80 kg N/ha, of which 55% was taken off the land with the tubers. Much of the 137 kg N/ha that could not be accounted for was believed to have leached from the profile. The NO_3-N distribution profiles on 14 June and 5 July 1976 indicated that a slug of NO_3-N had moved downward.

A rather unexpected increase in NO_3-N content of the surface 0-20 cm depth occurred after the potatoes were harvested on 5 July 1976. It was thought that possibly the 3.8 cm rain on 10 July 1976 washed soluble nitrates from the leaves and stalks which were left behind on the land.

A cover crop of rye was seeded on 14 September 1976 with no fertilizer addition. By 12 October 1976 the rye had accumulated 25 kg N/ha. This cover crop was plowed under in the early spring of 1977.

Water Table and Suction Lysimeter Results

A water table well was installed in Plot 1 during the fall of 1975, and the depth to the water table was recorded from 15 April 1976 to 25 March 1977 (Table 10). The water table was about 60 to 70 cm below the soil surface during the spring of 1976. During the summer, fall and winter, the level fell and by 11 February 1977, it was down to 152 cm. Then, as a result of spring melt and runoff it rose to 105 cm below the surface by 25 March 1977.

The suction lysimeters installed during the spring of 1976 at 90 and 150 cm indicated a "slug" of NO_3-N moving through the soil. The 90 cm NO_3-N concentrations increased from 9 mg/l on 14 June 1976 to 34 mg/l on 24 June 1976. This might have been a direct result of the 3.9 cm rain that fell on 24 June 1976. A corresponding increase at the 150 cm level occurred two weeks later.

During the fall of 1976 the NO_3-N concentrations remained high at the 90 cm level, but decreased over winter to 3 mg/l on 25 March 1977. The 150 cm readings were near 8 mg/l during the fall of 1976 and increased to 15 mg/l on 25 March 1977.

2. Plot 2: Tobacco N Results

1975 Tobacco Plot

Plot 2 was located on Berrien sandy loam (Mersea Twp., Lot 8, Con. 4) and was used during the past four years to grow Burley tobacco. In 1973 approximately 67 kg N/ha as 3-18-18 and 114 kg N/ha as 34-0-0 was applied.

Table 10. Water table levels and suction lysimeter NO_3-N concentrations in Plot 1

Sampling Date	Depth to Water Table (cm)	NO_3-N concentration (mg/l)	
		90 cm depth	150 cm depth
15 April 1976	70		
28 April 1976		1	3
5 May 1976		1	1
10 May 1976	62		
18 May 1976		1	1
31 May 1976		9	1
8 June 1976	72		
14 June 1976		9	1
24 June 1976		34	1
30 June 1976	82		
5 July 1976		36	9
27 July 1976	98		
5 Aug. 1976	87		
13 Sept. 1976	130		
17 Sept. 1976		21	5
25 Sept. 1976	115		
12 Nov. 1976		28	8
25 Nov. 1976	137		
17 Dec. 1976	145		
7 Jan. 1977	146		
11 Feb. 1977	152		
10 Mar. 1977	120		
25 Mar. 1977	105	3	15

In 1974 the fertilizer increment was 112 kg N/ha as 5-10-15 and 171 kg N/ha as 34-0-0. In both years a cover crop of wheat was seeded after the tobacco harvest was completed. The cover crop was plowed under when it was about 20 cm tall.

In 1975 Burley tobacco (Nicotiana tabacum, var. Kentucky 2110) was planted 22 May with a side dressing of 50 kg N/ha as 5-10-15. The soil was sampled for the first time 29 May 1975 and contained 163 kg N/ha (Figure 16). The nitrogen content on 19 June 1975 was 245 kg/ha and the total N addition between the first and second sampling time was 25 kg N/ha (on 18 June, sidedressed as 5-10-15). Since the nitrogen accumulation by the plants was only 4 kg N/ha, it appeared that about 61 kg N/ha was mineralized, provided that no nitrogen losses occurred in the system. However the profile distribution curves (Figure 17) showed that on 19 June 1975 a "slug" of NO_3-N was moving downward, most likely in response to the 3.0 cm rainfall on 15 June 1975.

On 27 June 1975 another 130 kg N/ha as 34-0-0 was applied, so that the total amount of fertilizer applied to the plot was 205 kg N/ha which was almost double the recommended rate of 112 kg N/ha.* The tobacco crop accumulated 196 kg N/ha (or about 93% of the added fertilizer) in the 83 days between planting and harvest time. During the harvest (13 August 1975) the leaves and stalks removed from the plot accounted for 89% of the total accumulated nitrogen.

A cover crop of winter wheat was seeded in early September 1975, with no fertilizer additions. The crop was plowed under for green manure in the spring of 1976.

1976 Tobacco Plot

Monitoring of the established plot in 1975 continued in 1976. Over winter losses of NO_3-N on the plot (Figure 16) between 19 November 1975 and 28 April 1976 amounted to 30 kg N/ha. Exchangeable NH_4-N increased from 13 kg N/ha on 19 November 1975 to 48 kg N/ha on 28 April 1976. This was thought to be due to the decomposition and ammonification of the plowed-under cover crop.

The tobacco was planted 24 May 1976 with 118 kg N/ha band applied as 5-10-15. Additional fertilizer increments of 93 kg N/ha as 34-0-0 and 14 kg N/ha as 5-10-5 were applied on 4 June 1976 and 22 June 1976, respectively.

The total nitrogen uptake by the tobacco crop during its 84 day growing season from 24 May to 16 August 1976 was 175 kg N/ha, which was 78% of the added fertilizer. At harvest time 152 kg N/ha was removed from the land through the leaves and stalks.

Definite signs of NO_3-N losses by leaching were evident by mid-summer and fall (Figure 17). Downward movement of NO_3-N on 21 June 1976 was due

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*Ontario Ministry of Agriculture and Food. 1977. Tobacco production recommendations.

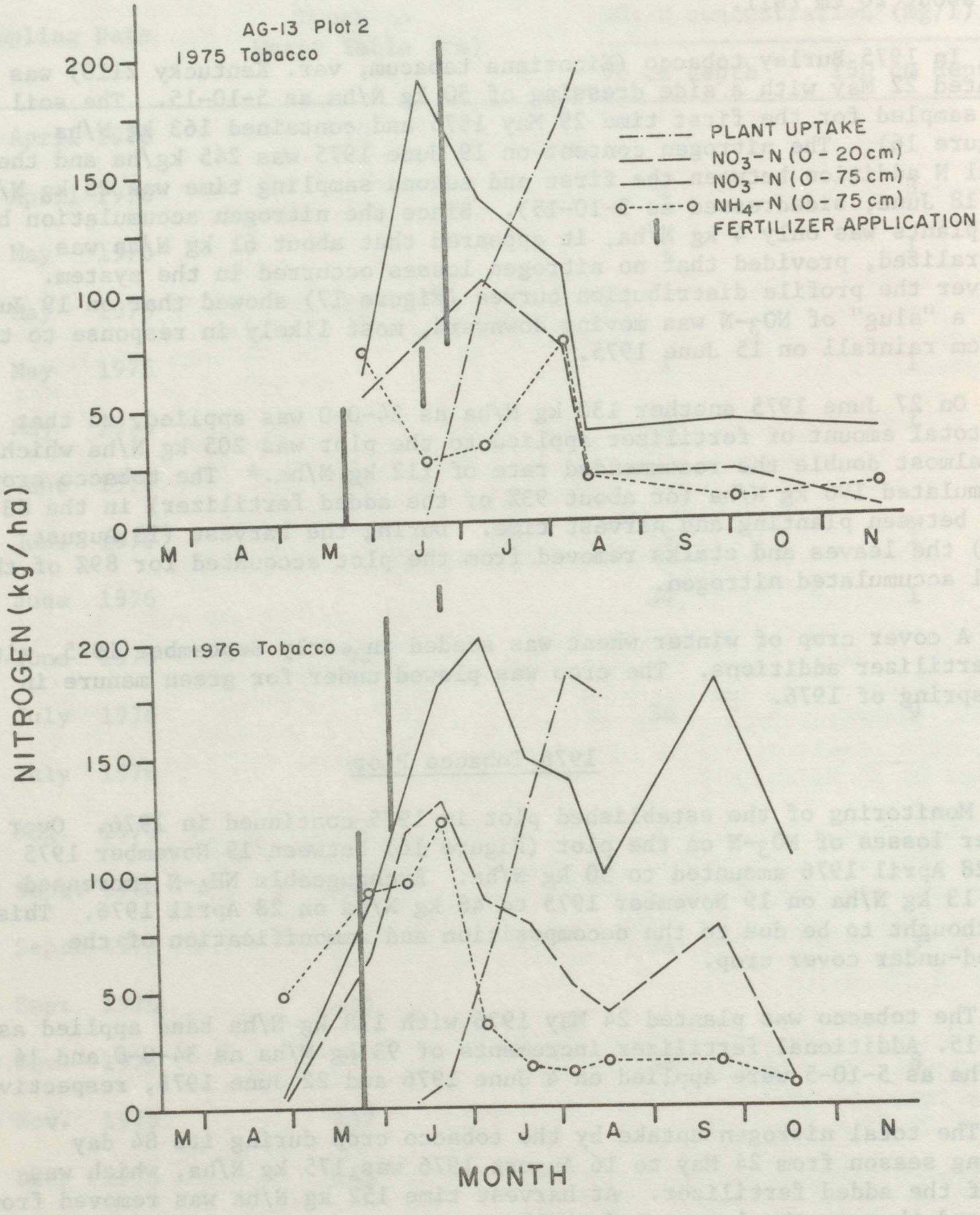

Figure 16. Accumulated NO_3-N and extractable NH_4-N masses (kg/ha/depth) fertilizer addition and crop uptake (kg N/ha) for the 1975 and 1976 tobacco Plot 2, Watershed AG-13.

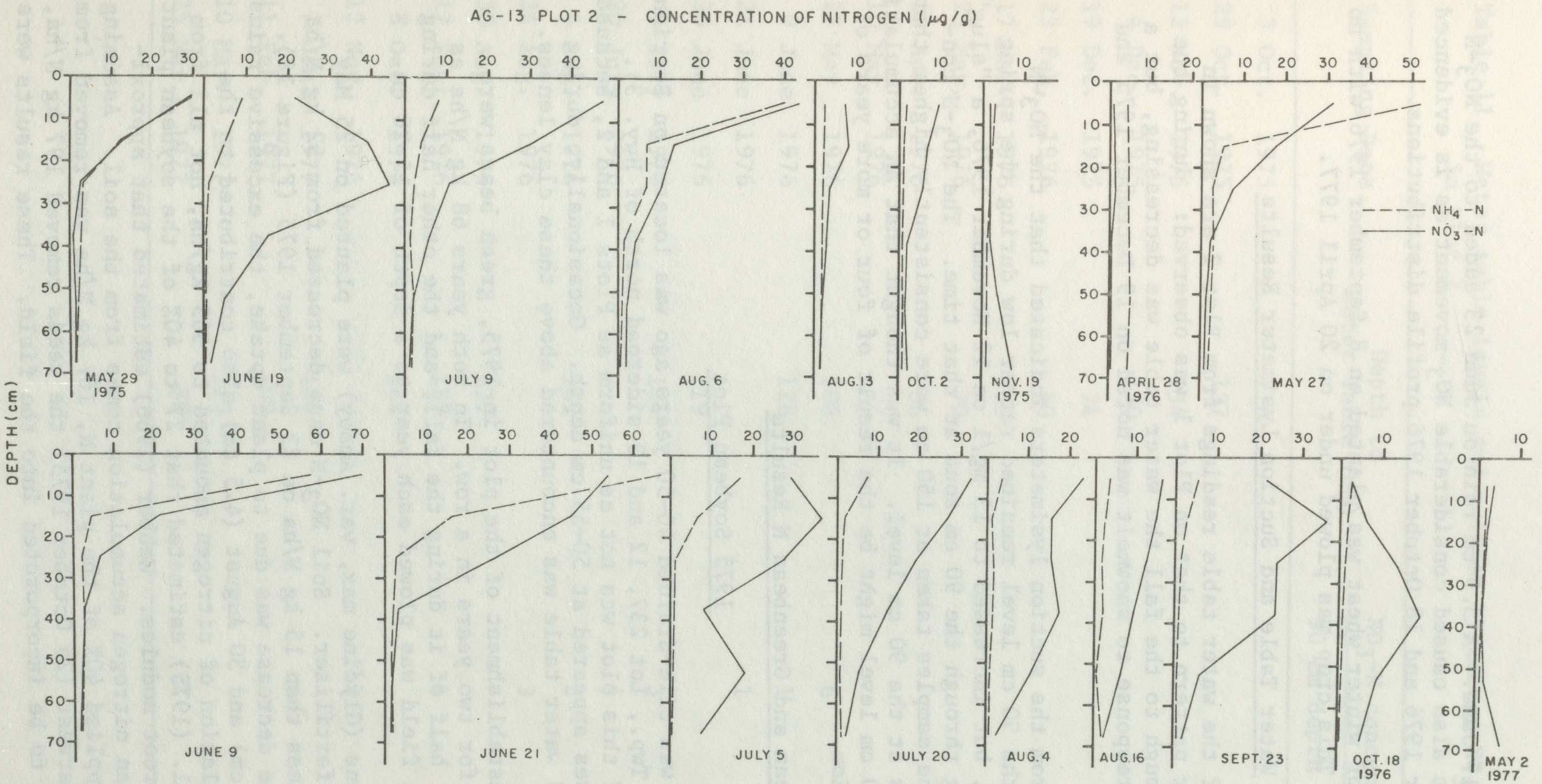

Figure 17. Nitrogen concentrations (ug/g) in the 0-75 cm profile of the 1975 and 1976 tobacco Plot 2, Watershed AG-13.

to a 2 cm rain on 17 June. A 3.9 cm rain on June 23 added to the NO_3-N losses. Fall rains also caused considerable NO_3-movement as is evidenced by the 23 September 1976 and 18 October 1976 profile distributions.

A cover crop of winter wheat was planted on 8 September 1976 with no added fertilizer. This crop was plowed under on 20 April 1977.

Water Table and Suction Lysimeter Results

The results of the water table readings from Plot 2 are shown in Table 11. A similar pattern to that on Plot 1 was observed: during the growing season through to the fall the water table was decreasing, but a rapid increase in response to snowmelt was noted on 19 December 1975 and 25 March 1977.

The results from the suction lysimeters indicated that the NO_3-N concentrations at the 90 cm level remained rather low during the spring and summer of 1976, but increased to 13 mg/l on 12 November 1976; a "slug" of NO_3-N was moving through the 90 cm zone at that time. The NO_3-N concentrations from the samples taken at 150 cm were consistently higher than the comparable ones at the 90 cm level. It was thought that an accumulation of NO_3-N at the 150 cm level might be the result of four or more years of heavy N fertilization.

3. Plot 3: Soybean and Greenbean N Results

1975 Soybean Plot

Plot 3, which was tile-drained 40-50 years ago was located on Berrien sandy loam (Mersea Twp., Lot 237, 12 and 13 sideroad north of Hwy. 3). The soil profile of this plot was not as uniform as Plots 1 and 2, because irregular clay lenses appeared at 50-55 cm depth. Occasionally, during sampling, a perched water table was encountered above these clay lenses.

Prior to the establishment of the plot in 1975, green beans were grown on the field for two years in a row. In both years 68 kg N/ha as 10-2-5 was applied, half of it during the fall, and the other half during planting time. The field was plowed each year to a depth of 15-20 cm.

In 1975 soybeans (Glycine max, var. Amsoy) were planted on 25 May with no additional fertilizer. Soil NO_3-N mass decreased from 52 kg N/ha on 4 June 1975 to less than 15 kg N/ha on 23 September 1975 (Figure 18). Although part of the decrease was due to plant uptake, the excessive rains on 29 August (10.5 cm) and 30 August (4.5 cm) also contributed to the loss. Plant accumulation of nitrogen amounted to 305 kg/ha, not all from the soil. Ham et al. (1975) estimated that 27 to 40% of the soybean plant N was fixed by the root nodules. Webber (1966) estimated that approximately 50% of soybean nitrogen accumulation comes from the soil. Assuming that N_2 fixation supplied 40% of the plant N, 167 kg N/ha was removed from the soil. During harvest (25 October 1975) the seeds removed 197 kg N/ha, leaving 108 kg N/ha to be incorporated into the field. These results were

Table 11. Water table levels and suction lysimeter NO_3-N concentrations in Plot 2

Sampling Date	Depth to Water Table (cm)	NO_3-N concentrations (mg/l)	
		90 cm depth	150 cm depth
3 Oct. 1975	116		
29 Oct. 1975	137		
12 Nov. 1975	134		
4 Dec. 1975	130		
19 Dec. 1975	74		
23 Feb. 1976	40		
17 Mar. 1976	66		
23 Mar. 1976	70		
15 Apr. 1976	86		
10 May 1976	76		
27 May 1976	108	6	21
9 June 1976	128	1	24
21 June 1976		1	19
30 June 1976	119		
5 July 1976	124	3	21
20 July 1976		4	20
4 Aug. 1976	162	4	18
24 Aug. 1976		3	18
30 Aug. 1976	177		
17 Sept. 1976	189	4	15
8 Oct. 1976	164		
12 Nov. 1976		13	15
7 Jan. 1977	160		
11 Feb. 1977	189		
10 Mar. 1977	119		
25 Mar. 1977	80	2	16

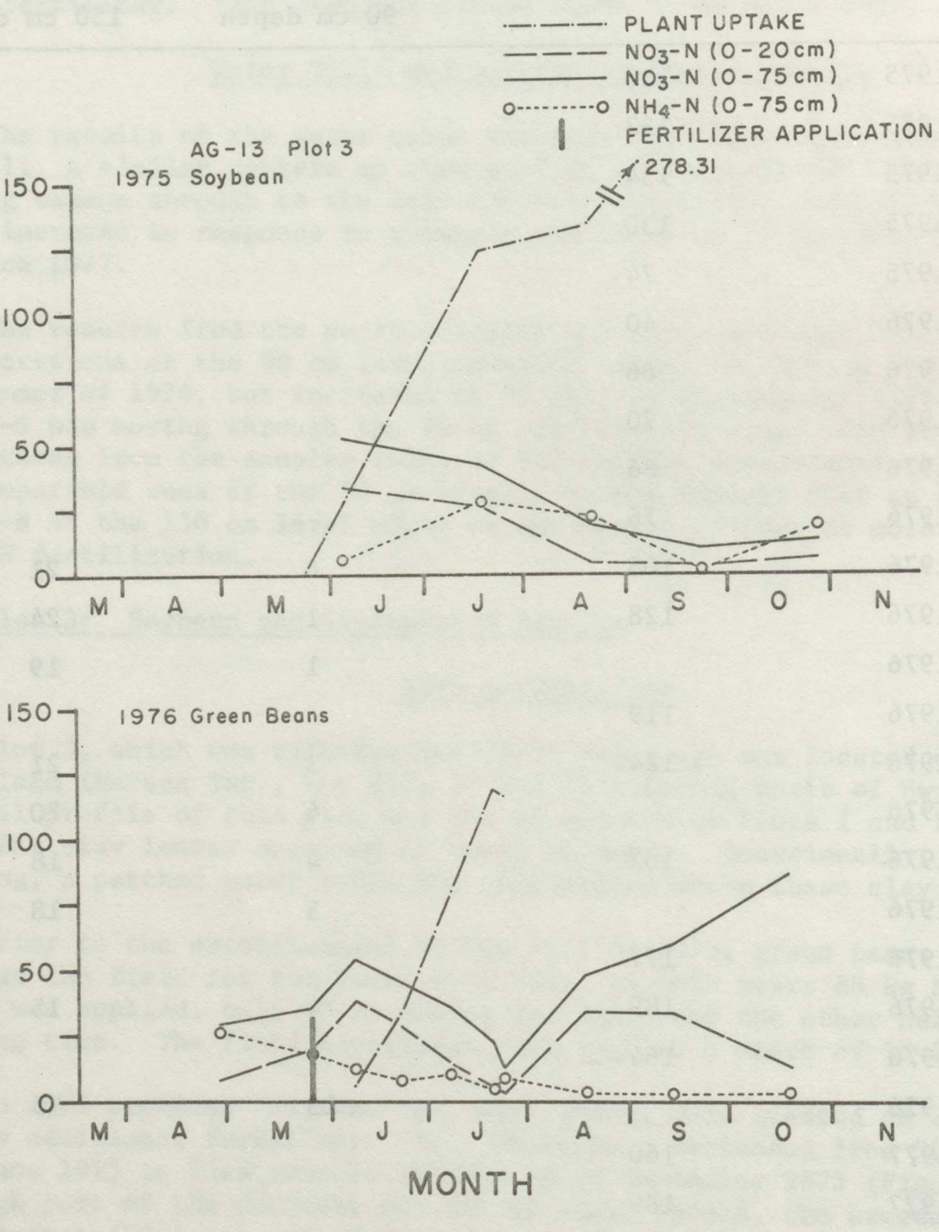

Figure 18. Accumulated NO_3-N and extractable NH_4-N masses (kg/ha/depth) fertilizer addition and crop uptake (kg N/ha) for the 1975 soybean and 1976 greenbean Plot 3, Watershed AG-13

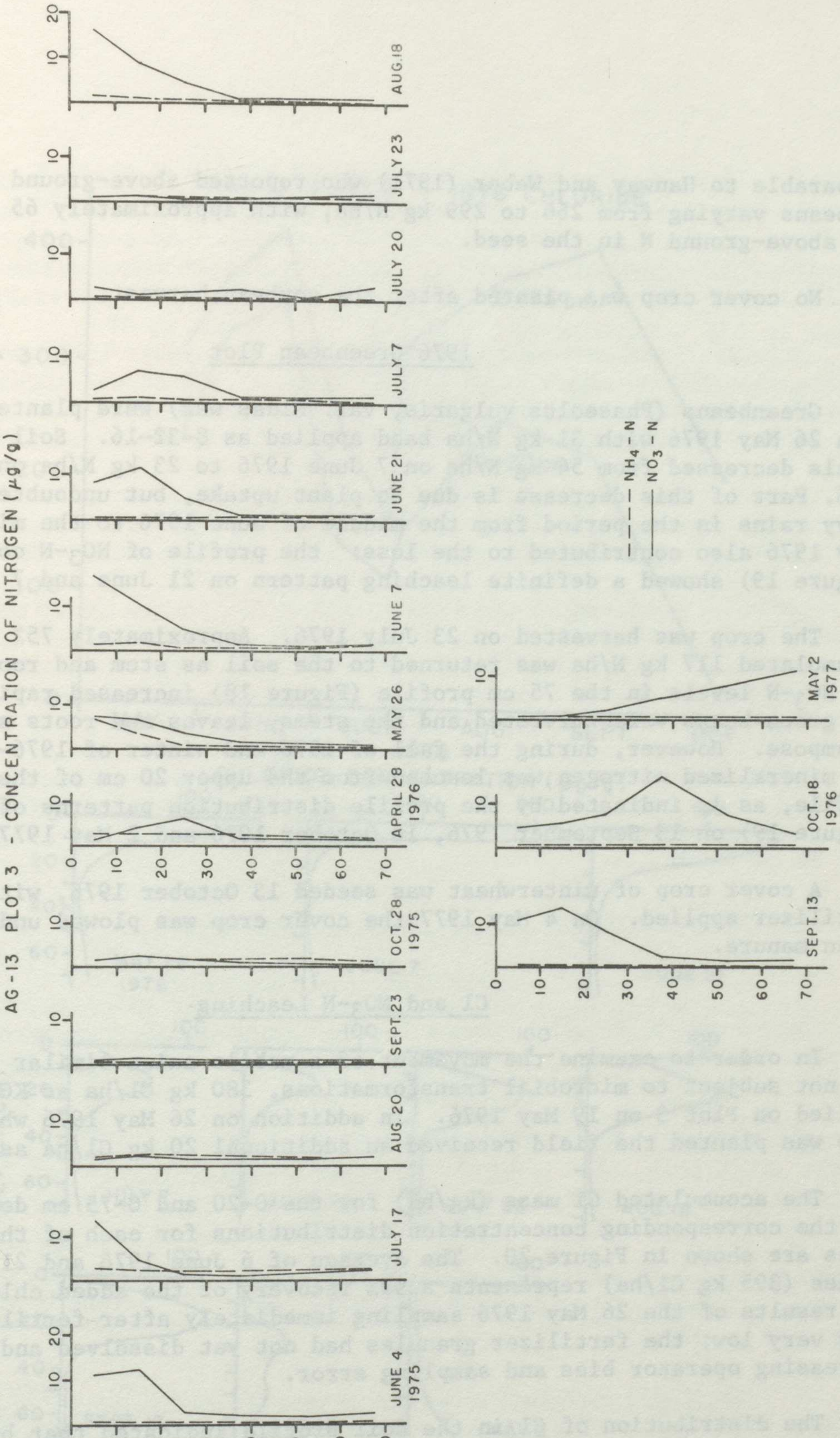

Figure 19. Nitrogen concentrations (ug/g) in the 0-75 cm profile of the 1975 soybean and the 1976 greenbean Plot 3, Watershed AG-13.

comparable to Hanway and Weber (1971) who reported above-ground uptake for soybeans varying from 266 to 299 kg N/ha, with approximately 65 to 85% of the above-ground N in the seed.

No cover crop was planted after the soybean harvest.

1976 Greenbean Plot

Greenbeans (Phaseolus vulgaris, var. Midas wax) were planted on Plot 3 on 26 May 1976 with 31 kg N/ha band applied as 8-32-16. Soil NO_3-N levels decreased from 54 kg N/ha on 7 June 1976 to 23 kg N/ha on 20 July 1976. Part of this decrease is due to plant uptake, but undoubtedly the heavy rains in the period from the middle of June 1976 to the middle of July 1976 also contributed to the loss: the profile of NO_3-N concentrations (Figure 19) showed a definite leaching pattern on 21 June and 7 July 1976.

The crop was harvested on 23 July 1976. Approximately 75% of the accumulated 117 kg N/ha was returned to the soil as stem and root mass. The NO_3-N levels in the 75 cm profile (Figure 18) increased rapidly after the green beans were harvested and the stems, leaves and roots started to decompose. However, during the fall of 1976 and winter of 1976-77, all of the mineralized nitrogen was leached from the upper 20 cm of the soil profile, as is indicated by the profile distribution patterns of NO_3-N (Figure 19) on 13 September 1976, 18 October 1976 and 2 May 1977.

A cover crop of winterwheat was seeded 13 October 1976, with no fertilizer applied. On 4 May 1977 the cover crop was plowed under for green manure.

Cl and NO_3-N Leaching

In order to examine the movement of a mobile anion similar to NO_3-N, but not subject to microbial transformations, 380 kg Cl/ha as KCl was applied on Plot 3 on 19 May 1976. In addition on 26 May 1976 when the crop was planted the field received an additional 20 kg Cl/ha as 8-32-16.

The accumulated Cl mass (kg/ha) for the 0-20 and 0-75 cm depth intervals and the corresponding concentration distributions for each of the sampling times are shown in Figure 20. The average of 6 June 1976 and 21 June 1976 values (395 kg Cl/ha) represents a 99% recovery of the added chloride. The results of the 26 May 1976 sampling immediately after fertilization were very low; the fertilizer granules had not yet dissolved and dispersed, increasing operator bias and sampling error.

The distribution of Cl in the soil profile indicated that by 7 July 1976 there was a definite slug of chloride peaking near 15 cm. The 3.8 cm rain on 10 July increased downward movement. During the same period the green beans showed maximum accumulation of nitrogen. Chloride could also have been accumulated by the plants. Although plant chloride analysis was not conducted, the chloride decrease in the soil may partly be a result of plant removal (Bernstein and Ayers, 1951). After plant harvest (23 July

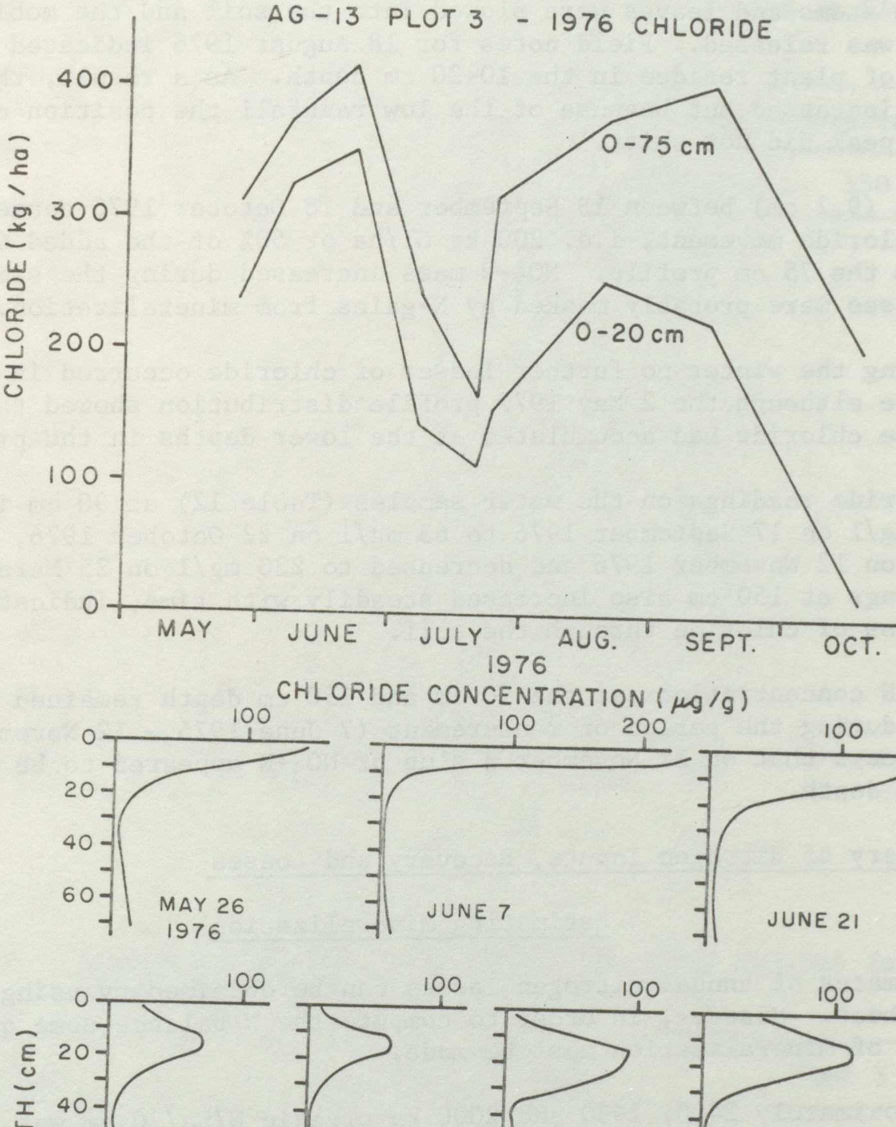

Figure 20. Cumulative chloride mass (kg/ha) for 0-20 and 0-75 cm depth intervals and corresponding concentration distributions for Cl with respect to depth for each of the sampling times on 1976 greenbean Plot 3, Watershed AG-13.

1976) the stems and leaves were plowed into the soil and the mobile plant chloride was released. Field notes for 18 August 1976 indicated considerable evidence of plant residue in the 10-20 cm depth. As a result, the soil chloride increased but because of the low rainfall the position of the chloride peak did not shift.

Rain (9.2 cm) between 13 September and 18 October 1976 caused appreciable chloride movement, i.e. 200 kg Cl/ha or 50% of the added Cl was lost from the 75 cm profile. NO_3-N mass increased during the same period and N-losses were probably masked by N-gains from mineralization.

During the winter no further losses of chloride occurred in the 0-75 cm profile although the 2 May 1977 profile distribution showed that almost all of the chloride had accumulated at the lower depths in the profile.

Chloride readings on the water samples (Table 12) at 90 cm increased from 12 mg/l on 17 September 1976 to 63 mg/l on 22 October 1976, then to 250 mg/l on 12 November 1976 and decreased to 220 mg/l on 25 March 1977. The readings at 150 cm also increased steadily with time, indicating a steady loss of chloride through the soil.

NO_3-N concentrations at the 90 cm and 150 cm depth remained fairly constant during the period of measurement (7 June 1976 - 12 November 1976), except that on 12 November a slug of NO_3-N appeared to be passing the 90 cm depth.

4. Summary of Nitrogen Inputs, Recovery and Losses

Estimating Mineralization

Estimates of annual nitrogen losses can be obtained by using a simplified balance sheet. However, in order to compute the N balance some quantitative estimates of mineralization must be made.

Approximately 2400, 2930 and 2000 kg organic N/ha/20 cm was present in the sandy loam soils on Plots 1, 2 and 3 respectively. Bremner's (1965) percentages, as discussed previously, suggested that 20 to 88 kg organic N/ha would be mineralized (Table 13, also see discussions for clay watershed).

Using Stevenson's (1965) approach the net mineralization rate ranged from about 63 kg N/ha for Plot 2 to 108 kg N/ha when soybeans were grown on Plot 3 in 1975.

Allison (1955) reviewed a number of long-term lysimeter studies on various soil types. The net mineralization rates (kg N/ha/year) on sandy loam soils ranged from 21 to 75 kg N/ha/year, with most rates falling between 34 and 45 kg N/ha/year.

Kowalenko (1977) related mineral N production in a laboratory study to temperature and water content. The empirical relationship obtained for the sandy loam soils was as follows:

Table 12. Suction lyismeter Cl and NO_3-N concentrations in Plot 3, Watershed AG-13

Sampling Date	Cl Concentration (mg/1)		NO_3-N concentration (mg/1)	
	90 cm depth	150 cm depth	90 cm depth	150 cm depth
7 June 1976			16	14
22 June 1976			15	15
7 July 1976			18	18
23 July 1976			18	19
3 Sept 1976	14	15	12	11
17 Sept 1976	12	14	4	15
22 Oct. 1976	63	38	16	14
12 Nov. 1976	250	46	34	18
25 Mar. 1977	220	86	34	27

Table 13. Estimated annual net mineralization rates (kg/ha) for the sandy loam Watershed AG-13

Method	Plot 1	Plot 2	Plot 3
Bremner: 1 to 3% of organic N (kg/ha)	24 - 72	29 - 88	20 - 60
Stevenson - net mineralization equals plant organic debris returned	potatoes 46 cover crop 40 86	tobacco 23 cover crop 40 63	soybeans 108 green beans 88
Allison - net mineralization	21 - 75	21 - 75	21 - 75
Kowalenko - regression of lab. incubation study	85 - 106	85 - 106	85 - 106

$$\text{Net mineralization} = 2.8\,(-0.01538 + 0.001470\,T\theta p - 0.004747\,T + 0.008489\,\theta p)$$

where net mineralization units are kg N/ha/day/20 cm, θp = percent water content (dry wt. basis), and T = soil temperature (C).

The regression coefficient $r = 0.45$ and the standard deviation was 0.19. Over the period 1 May to 1 October using daily mean air temperatures and predicted water contents, the regression model predicted annual mineralization rates of 106 kg N/ha in 1975 and 85 kg N/ha in 1976.

Approximate N Balance

Approximate N balances for the sandy loam soils were obtained in the same way as described for the clay soils earlier. Again it should be pointed out that the net mineralization estimates from Table 13 are approximate and could contain a fifty percent error.

The nitrogen mass balance results including inputs, recovery and losses are summarized in Table 14 for each of the sandy loam plots. Where possible the results were averaged over the two years of the study. Average annual N inputs from fertilization, rain and net mineralization ranged from 133 to 303 kg/ha. Average annual nitrogen recovery by the plants and soil ranged from 136 to 270 kg/ha. The estimated annual N losses were 133 and 33 kg/ha for Plots 1 and 2 respectively, while Plot 3 showed an average gain of 3 kg N/ha.

The average nitrogen gain in Plot 3 according to the N balance method is contradictory to the results obtained from the accumulated N-mass over time and profile distribution curves. This discrepancy is due to the fact that the N balance describes a static situation, while the other methods describe the dynamic situation which is actually occurring in the field.

A discussion on the division between denitrification and leaching was presented for the clay soils and is not repeated here.

Table 14. Approximate nitrogen mass balances (kg N/ha/yr) for plots on sandy loam Watershed AG-13

		INPUTS				RECOVERY			LOSSES
		1975	1976	Ave.		1975	1976	Ave.	
Plot 1	Fertilizer added		168		*Soil recovery		23		
	Rainfall N		18		Crop recovery		120		
	Net mineralization		90						
			276				143		133
Plot 2	Fertilizer added	205	225	215	Soil recovery	0	90	45	
	Rainfall N	18	18	18	Crop recovery	236	215	225	
	Net mineralization	70	70	70					
		293	313	303		236	305	270	33
Plot 3	Fertilizer added	0	31	13	Soil recovery	-20	31	5	
	Rainfall N	18	18	18	*Crop recovery	167	94	131	
	Net mineralization	90	110	100					
		108	159	133		147	125	136	-3
									AVE = 54

* Soil recovery calculated by averaging fall samplings taken after harvest and subtrating previous fall averages.

**Soybean crop recovery assumed 40% N-fixation and green bean recovery assumed 20% N-fixation.

TILE DRAINS

Approximately 85% of the clay Watershed AG-01 is tile-drained and greater than 90% of the sandy loam Watershed AG-13 is tile-drained. Thus, one can expect a large portion of the spring water and nutrient losses to be occurring through tile drains in these two watersheds. Although the study presented in this document was not originally set-up to specifically study tile drain losses, it is important to review and document the nature and quantities of nutrients lost through tile drains.

Nitrogen reaching the drainage tile is a product of three different processes:

1. Production of mineral nitrogen in the soil and the addition of fertilizers;
2. The utilization of nitrogen by plants or other sinks; and
3. The rate of movement of the nitrogen through the soil in the percolating water.

Because of the diffuse nature of agricultural land, it is difficult to estimate the amounts of nutrients in drainage water from these areas. Measurements of mobile nitrogen at different depths in the soil profile will give an indication of potential movement, but the amount actually entering the ground water or surface water (via tile drains) will depend on the rate of water movement through the soil, to the tile drain, and beyond the tile drain.

Recently, some investigators have measured nutrient loadings from various agricultural tile drain systems. A summary of the results of these investigations is given in Table 15. One of the initial studies carried out was by Bolton et al. (1970) on small tiled plots. The yearly average nitrogen concentrations (mg/l) from these tile drains ranged from 1.1 on fertilized bluegrass sod to 14.0 on fertilized corn on rotation. The mean annual loadings (kg/ha/yr) from the fertilized plots were 0.7 for bluegrass, 6.0 for oats and alfalfa, and 15.0 for corn. Bolton et al. (1970) indicated that in any one year the value could go as high as 30 kg/ha.

Erickson and Ellis (1971) obtained loading rates of 12.1 and 8.4 kg NO_3-N ha/yr from two farms in Michigan (Table 15). Their results represent only one year's data.

A large study was conducted by Miller (1975) who monitored tile drain effluent from both organic and mineral soils. A summary of some of his results for the mineral soils west of Chatham is given in Table 15. The weighted average yearly concentrations of NO_3-N from the tiles in these soils ranged from 4.4 to 15.7 mg/l. The organic and NH_4-N concentrations ranged from 0.60 to 3.10 mg/l. Average yearly nitrogen (NO_3+NH_4+org.) loads lost through tile drains ranged from 4.0 to 65.1 kg/ha.

The lowest loss of N from tile drains (4 kg/ha/yr) was from a sandy soil cropped to continuous corn with 150 kg N/ha applied each year. The largest losses were from an area with clay over SiCL (58.8 kg N/ha/year) and from high organic fine sandy soil over clay (65.1 kg N/ha/yr of which 10.4 kg were from the NH_4 and organic fractions). The clay over SiCL soils were fairly heavily fertilized, i.e., corn receiving 190 kg N/ha, soybeans receiving 15 kg N/ha, cucumbers receiving 190 kg N/ha, and wheat receiving 20 kg N/ha. The high organic sandy soil was continuously cropped to corn and received 215 kg N/ha/year. Miller (1975) has pointed out that fertilization at rates higher than recommended tend to result in a significant contribution of NO_3-N to ground water and/or tile drainage water.

Tile drain samples collected from the newly tiled field near the 1976 corn Plot 4 on Watershed AG-01 had NO_3-N concentrations ranging from 6 mg/l in May and early June, increasing to 60 mg/l at the end of June, and then rapidly dropping and remaining near 17 mg/l until the tiles stopped flowing in July. Tile drain samples collected from various points across Watershed AG-13 in the spring of 1977 (10-14 March) had NO_3-N concentrations ranging from 4.6 to 43.5 mg/l and averaging about 10 mg/l. Two samples collected from Watershed AG-01 during that time had NO_3-N concentrations of 17 and 24 mg/l.

Table 15. Summary of some literature results of yearly nitrogen concentration averages and loading from agricultural tile drains.

(a) Bolton et al (1970) - Brookston Clay - average annual losses for the time period 1961-67 (total nitrogen).

Crop Types	Not Fertilized		Fertilized	
	mg N/l	kg N/ha/yr	mg-N/l	kg-N/ha/yr
Rotation: corn	8.5	5.6	14.0	15.1
oats	6.4	4.3	8.5	5.7
2-yr alfalfa	7.8	4.8	8.0	6.3
Continuous corn	4.4	6.6	8.9	14.0
Bluegrass sod	3.5	0.3	1.1	0.7

(b) Erickson and Ellis (1971) - values for 1969 (NO_3-N)

Land Use	mg NO_3-N/l	kg NO_3-N/ha/yr
Michigan State Univ. Farm	1.0-9.0 (6.0)	12.1
Sugar Beets and Beans (Clay loam)	2.0-7.0 (5.0)	8.4

(c) Miller (1975) - soils west of Chatham, Ontario - average annual losses (1972-73)

Land Use	Average Yearly Conc. (mg/l)		Average Yearly Load (kg/ha)		Total Yearly N Load (kg/ha)
	NO_3-N	Org. + NH_4-N	NO_3-N	Org. + NH_4-N	
Site 5 - corn & soybeans - clay over SiCL	15.7	0.60	56.6	2.2	58.8
Site 6 - corn, soybeans & barley - clay	6.0	0.64	16.6	1.8	18.4
Site 7 - wheat & soybeans - clay	5.2	0.90	13.0	2.3	15.3
Site 8 - corn, beets & beans - clay	8.1	1.60	15.2	3.0	18.2
Site 9 - corn - deep sand loam	5.4	0.94	3.4	0.6	4.0
Site 10- corn - clay	4.4	0.72	8.1	1.4	9.5
Site 11- soybeans & corn - sandy loam over clay	9.4	0.91	13.8	1.2	15.0
Site 12- corn - sand over clay	15.8	3.10	54.7	10.4	65.1

WINTER MOVEMENT OF NO_3-N

The monitored NO_3-N and Cl results from the tile-drained clay Watershed AG-01 and sandy Watershed AG-13 suggested that there was not excessive movement of mobile salts during the summer, except perhaps during certain wet periods. Most of the leaching, tile-drain and run-off losses of Cl and NO_3-N probably occurred during fall, winter, and spring. However, the type of monitoring that was conducted in this study did not give a clear picture of the fall to spring losses.

In 1973 a study was initiated at the Harrow Research Station (Dr. W. Findlay) to continuously monitor NO_3-N movement using ceramic suction cups placed at 61, 122, 183, 244, and 305 cm depths below a corn field. The study was initiated on June 29, 1973, with the application of 560 kg N/ha as NH_4NO_3 and solution samples were removed periodically throughout the year for analysis.

1. Model Development

The data was also used to test and calibrate water and salt transport models, viz.

$$\frac{\partial\theta}{\partial t} = \frac{\partial}{\partial x} D(\theta)\frac{\partial\theta}{\partial x} - K(\theta) \qquad (1)$$

$$\frac{\partial\theta C}{\partial t} = \frac{\partial}{\partial x} D^1(v,\theta)\theta \frac{\partial C}{\partial x} - qC \qquad (2)$$

where θ = volumetric water content (cm^3/cm^3)
t = time
x = depth
$D(\theta)$ = diffusivity function (cm^2/day)
$K(\theta)$ = hydraulic conductivity function (cm/day)
C = solute concentration (mg/l)
$D^1(v,\theta)$ = hydrodynamic dispersion coefficient
q = water flux = cm^3/cm^2-day = cm/day

The hydraulic conductivity and diffusivity functions were derived from field-measured drying curves and field-measured saturated hydraulic conductivities using the Millington-Quirk procedure (Jackson, 1972). A brief summary of the field results including bulk densities, saturated hydraulic conductivities, % sand, % clay, and desorption curve data are

Table 16. Physical measurements and soil water desorption curve data for the Harrow fine sandy loam.

Depth (cm)	Bulk density (g/cm^3)	Saturated conductivity (cm/day)	% Sand	% Clay	Volumetric water contents at negative potentials					
					0	-10 cm	-40 cm	-100 cm	-225 cm	-500 cm
5	1.41	38	84	4	.412	.385	.308	.198	.164	.145
15	1.62	42	70	5	.346	.333	.326	.302	.254	.199
30	1.57	45	62	8	.375	.357	.347	.339	.292	.212
50	1.58	43	67	9	.363	.353	.336	.314	.282	.253
70	1.49	190	57	18	.392	.363	.346	.311	.262	.218
95	1.51	194	50	20	.353	.340	.320	.277	.239	.199
200			55	9						

Table 17. Values for the K(θ) and D(θ) functions used in the computer simulation model.

Layer	θ_s	K_s	a	D_o	b	Db
0 - 60 cm	.38	42	35.	45000	25	1.55
60 - 100 cm	.37	192	50.	40000	35	1.50
100 - 200 cm	.39	130	40.	52000	27	1.60

given in Table 16. Saturated hydraulic conductivities were measured with an air entry permeameter (Bouwer, 1966 and Topp and Binns, 1976).

For purposes of computer simulation the soil was divided into three layers, based primarily on the data in Table 17. The hydraulic conductivity and diffusivity functions were fitted to exponential functions:

$$K(\theta) = K_s \exp(-a(\theta_s - \theta)) \quad (3)$$

and

$$D(\theta) = D_o \exp(-b(\theta_s - \theta)) \quad (4)$$

where K_s = saturated hydraulic conductivity
a = slope-factor for conductivity function
θ_s = saturated water content
D_o = intercept of the diffusivity function
b = slope-factor for diffusivity function

The values for the $K(\theta)$ and $D(\theta)$ parameters used in the model are given in Table 17. The parameter magnitudes below 100 cm were estimated as field physical characterization did not extend this deep.

The explicit finite difference method was used to solve equations (1) and (2). Initial water contents and NO_3-N concentrations were defined for a 200 cm profile and the computer simulation was run on the data from 1 Nov. 1973 to 31 May 1974. The model was applied to this time period because most of the NO_3-N movement took place between late fall and early spring.

The surface flux boundary was derived from rainfall and snowmelt measurements made at the Harrow Research Station (Figure 21). All rainfall was assumed to enter the soil on the same day it fell and evaporation was considered to be negligible for this time period. The water equivalent of the snow was assumed to be 0.1 if it fell on a day with no rainfall. It was estimated that about 20% of this snow was lost due to wind and sublimation. Snow that fell on a rainy day was assumed to have a water equivalent of 0.15 and none was lost due to wind or sublimation. Snow was accumulated, but not melted when the average daily temperature was below 0.0 C. Snowmelt was arbitrarily defined to occur at a rate of 0.5 cm water/C/day.

2. Predicted Results

The predicted (solid lines) and measured results for Nov. 1973 to May 1974 are shown in Figure 22.By early December a "slug" of NO_3-N had reached the 61 cm suction cup; by early February the NO_3-N concentration peak was near 122 cm; and by early May the "slug" of NO_3-N appeared to peak at 183 cm. Both the predicted and observed results show similar trends. As the pulse of NO_3-N moved down the profile it became more diffuse; the peak concentration decreased with depth. On the whole, the computer simulation tended to show more of a spread than the original data.

The predicted NO_3-N concentrations at 61 and 122 cm compared favorably with the observed results, but the model appeared to predict the 183 cm NO_3-N peak too soon. There were a number of possible reasons for the difference between the observed results and predicted values near 183 cm. Early spring runoff could have decreased the net amount of water entering the soil. The model did not account for evaporation and April-May evaporation could have retarded net downward flux. In addition, increased spring lateral groundwater flow could easily have reduced net downward movement.

The Harrow SL soil is known to occasionally contain thin clay varves. These thin layers of clay often have a low permeability and can effectively retard flow. Clay varves are often the cause of transient perched water tables that occur in these light sandy soils. The presence of a clay varve between 122 and 183 cm could lower the hydraulic conductivity in this layer and cause the observed discrepancy.

The results have shown that a considerable amount of NO_3-N movement takes place between late fall and early spring (Figure 22). Between Nov. 1, 1973 and May 31, 1974, the NO_3-N peak had moved past the 183 cm depth. It was apparent from these results that any excessive amounts of fertilizer N in the soil by fall can easily be lost by leaching during winter.

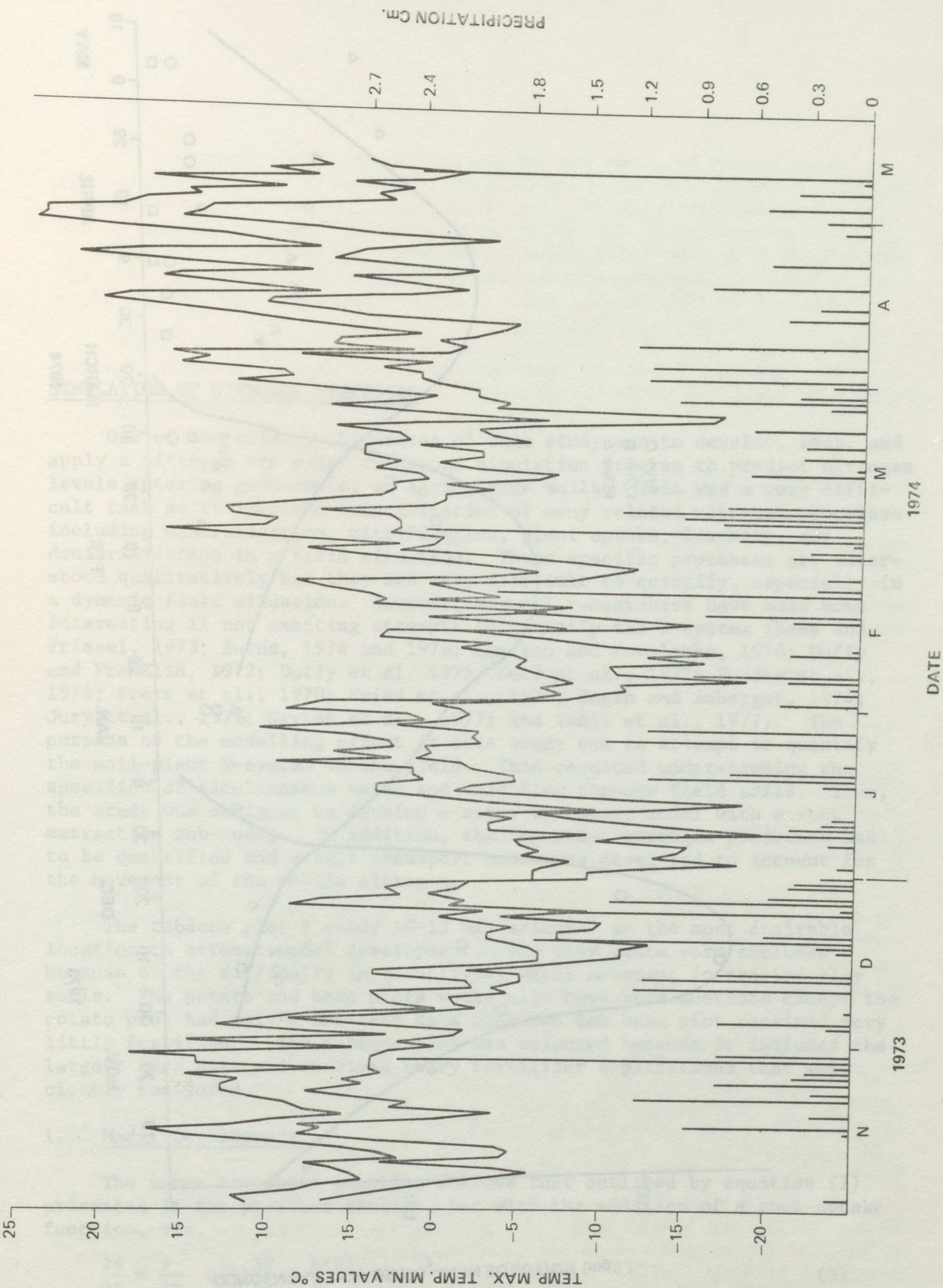

Figure 21. Harrow Research Station minimum and maximum temperature data and mean daily precipitation for the winter period of 1973-74.

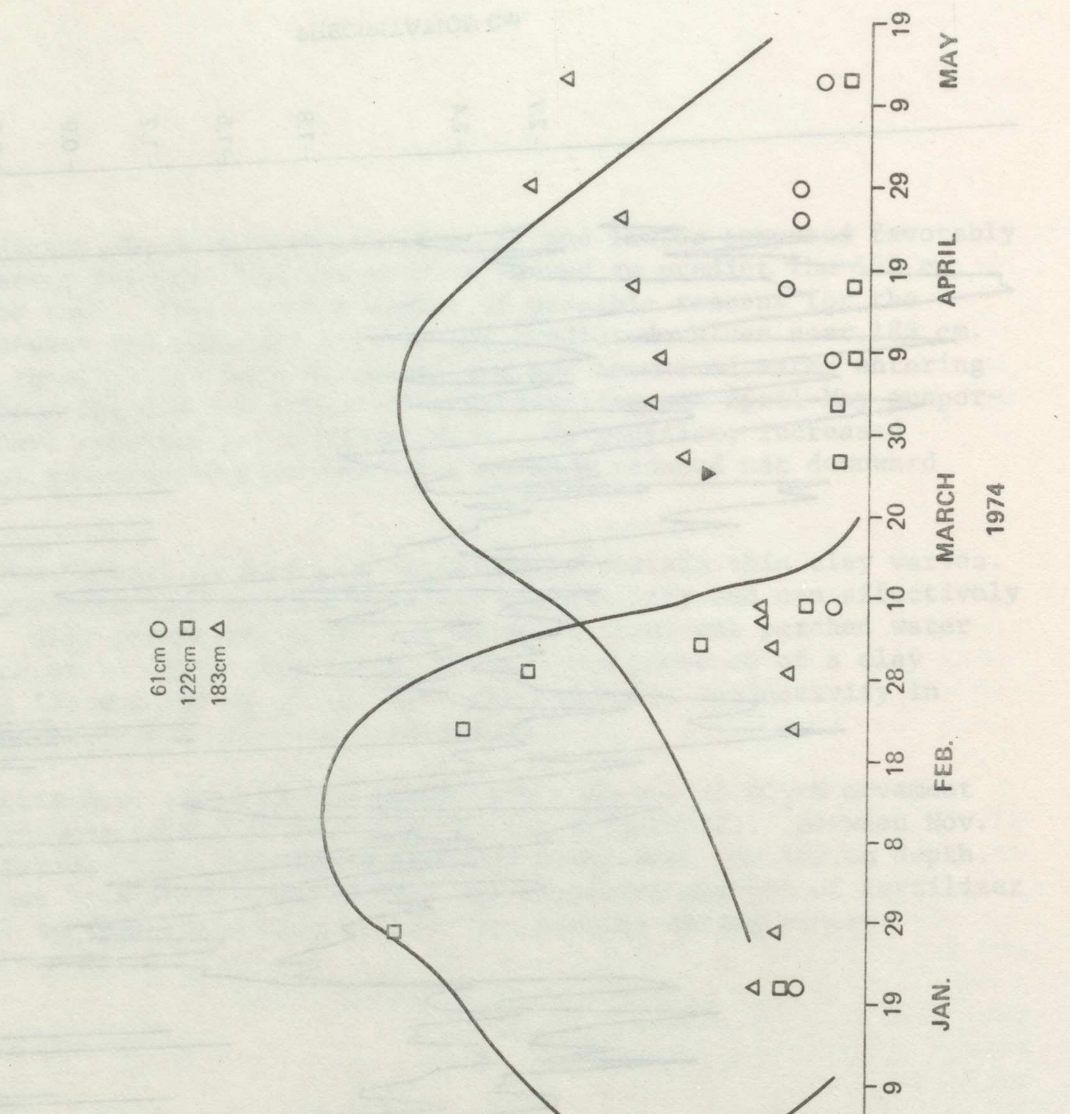

Figure 22. Predicted (solid line) and measured NO_3-N concentrations for Nov. 1973 to May 1974 for the 61, 122, and 183 cm depths.

SIMULATION OF NITROGEN PROCESSES

One of the primary objectives of this study was to develop, test, and apply a nitrogen and water transport simulation program to predict nitrogen levels entering groundwater on agriculture soils. This was a very difficult task as it involved quantification of many related nitrogen processes including mineralization, nitrification, plant uptake, leaching, and denitrification in a field situation. These specific processes are understood qualitatively but they are very difficult to quantify, especially in a dynamic field situation. However, several researchers have made some interesting if not exacting attempts to quantify the N-system (Beek and Frissel, 1973; Burns, 1974 and 1976; Cameron and Kowalenko, 1976; Duffy and Franklin, 1972; Duffy et al. 1975; Dutt et al., 1972; Feddes et al., 1974; Frere et al., 1970; Fried et al., 1976; Hagin and Amberger, 1974; Jury et al., 1976; Saxton et al., 1977; and Tanji et al., 1977). The purpose of the modelling effort in this study was to attempt to quantify the soil-plant N-system in the field. This required understanding the specifics of simultaneous water and salt flow through field soils. Thus, the study was designed to develop a water transport model with a root extraction sub-model. In addition, the important nitrogen processes had to be quantified and a salt transport model was developed to account for the movement of the mobile nitrogen.

The tobacco plot 2 sandy AG-13 was selected as the most desirable location to attempt model development. The clay plots were excluded because of the difficulty in quantifying water movement in cracked clay soils. The potato and bean plots would also have been adequate except the potato plot had only a one-year data base and the bean plot received very little fertilizer. The tobacco plot was selected because it included the largest data base and received heavy fertilizer applications that were closely monitored.

1. Model Development

The water transport equation follows that outlined by equation (1) presented in the previous section, but with the addition of a root-uptake function, viz.

$$\frac{\partial\theta}{\partial t} = \frac{\partial}{\partial x} \; D(\theta)\frac{\partial\theta}{\partial x} - K(\theta) - R \qquad (5)$$

where R = root uptake function (cm H_2O/day).

Water uptake by roots was defined by the following function:

$$R = Kr(\theta).P(t).D_r(t)/\Delta x \qquad (6)$$

where $K_r(\theta)$ = root-soil interface conductivity (cm/day)
$P(t)$ = potential transpiration (cm/day)
$D_r(t)$ = rooting density and
Δx = depth increment (cm)

The root-soil interface conductivity was assumed to decrease exponentially as available water was depleted, i.e.

$$K_r(\theta) = 1.0 - \exp\ (-6.0\ \theta_{avail}) \qquad (7)$$

and available water was calculated as

$$\theta_{avail} = (\theta - \theta_1)/(\theta_{fc} - \theta_1) \qquad (8)$$

where θ_1 was the limiting water content at which roots could no longer absorb more water and θ_{fc} was the water content at field capacity where plants could easily absorb water.

Potential transpiration was calculated as

$$P(t) = 0.7 \times P_f(t) * PE \qquad (9)$$

where $P_f(t)$ was a partitioning factor which divided the potential evapotranspiration between the plant and soil. $P_f(t)$ was a function of measured plant growth and for nine sequential 10-day increments the values of $P_f(t)$ were 0.05, 0.098, 0.170, 0.433, 0.775, 0.938, 0.787, 0.998 and 0.952. After harvest of the crop $P_f(t)$ was set to zero.

Potential evaporation was derived from a regression relationship:

$$PE = 0.09457 + 0.00121\ TS + 0.00003185\ TW \qquad (10)$$

where T = average daily temperature C
S = hours of bright sunlight, and
W = windspeed (km/day)

Rooting densities $D_r(t)$ for Burley tobacco were taken from Zartman et al. (1978). The rooting density at each depth in each of 9 sequential time intervals was determined as a proportionality factor by dividing by root density totals.

Hydraulic conductivity functions and diffusivity functions for the 0-22 cm, 22-55, and 55-110 cm depth intervals were derived from respective soil water desorption curves and field measured saturated permeabilities presented by Topp (1978).

The salt transport equation was similar to that presented in equation (2) of the previous section but was modified to include a bimodal pore size distribution and a number of source-sink terms to simulation nitrogen transformations in the soil. Two rates of net mineralization were used; one to account for the rapid release of NH_4-N from decomposition of fresh plant materials (i.e. roots and cover crops) and the second to account for the slow release of N from the indigenous organic material present in the soil. The two rates are given below:

$$\frac{dNH_4\text{-}N}{dt} = 0.1\ k_1\ ON_f \text{ (fast mineralization)} \tag{11}$$

$$\frac{dNH_4\text{-}N}{dt} = 0.003\ k_1\ ON_i \text{ (slow mineralization)} \tag{12}$$

where ON_f = mass of fresh or recently added organic material

ON_i = mass of indigenous or slowing decomposing organic materials

The rate coefficient for mineralization k_1 was a function of temperature and water content (Kowalenko, 1977), viz.,

$$k_1 = 0.025 + 0.002\ T\Theta - 0.008\ T \tag{13}$$

The rate of nitrification was given by the following relationship:

$$\frac{dNO_3\text{-}N}{dt} = k_2\ (NH_4\text{-}N) \tag{14}$$

where the nitrification rate coefficient k_2 was a function of temperature and water content, i.e.

$$k_2 = 0.0007\ T\Theta \tag{15}$$

Most of the available ammonium was assumed to remain on the soil exchange and considered to be relatively immobile. Downward transport of N was predominantly through the NO_3-N ion. Uptake of N by roots was set proportional to the measured N uptake in the field. The removal from the soil was a function of rooting density and salt concentration, similar to the methodology discussed for water uptake.

An important nitrogen function that was not accounted for by the model was denitrification. It is known that the rate of this process is dependent upon the degree of aeration, supply of readily available carbon, and temperature. However, the quantitative relationship for a given field situation is not known and difficult to measure. In this study the lack of denitrification will be reflected in a build-up of NO_3-N and eventually in the leaching losses of NO_3-N.

2. Model Results

A comparison of the 1975 simulation results and field measured for NO_3-N mass balance and profile distributions are shown in Figures 23 and 24, respectively. The predicted NO_3-N masses were generally higher than NO_3-N masses measured in the field (Figure 23). Increases in NO_3-N were closely related to fertilizer additions and nitrification, and decreases corresponded to crop uptake and leaching. Large losses of nitrogen by leaching occurred during the 29 August (10.5 cm) and 30 August (4.5 cm) rainstorms amounting to nearly 90 kg N/ha. Some of this loss may have included simultaneous denitrification which was not accounted for in the model.

Predicted profile distributions of NO_3-N with respect to depth were usually within the range of field measured concentrations (Figure 24). The wide range in field measured concentrations of NO_3-N especially near the soil surface was a reflection of the sampling procedure. In 1975 three samples were removed from the area where the fertilizer band was applied and a corresponding set of three samples were taken adjacent to the band.

The pronounced concentration peak at 20 cm predicted for the 6 August 1977 was a result, in part, of the bimodal concept employed in the model development. This concept has not been tested very thoroughly, especially for sandy soils, and could easily be in error. However, the predicted peak may also have been a result of the fact that the model did not account for denitrification and concentration peaks of NO_3-N were not reduced.

The 1976 simulation shows similar results to that of 1975 (Figures 25 and 26). Predicted NO_3-N masses tended to be larger than the measured masses. A small amount of leaching (10 kg/ha/75 cm) was observed in late June and early July. Major leaching losses at the end of September and in early October amounted to nearly 70 kg NO_3-N/ha/75 cm. In both the 1975 and 1976 simulations major losses of NO_3-N tended to take place in the fall. Results from the previous section indicated that this leaching can continue throughout the winter into early spring.

However, direct interpretation of modelling results must be done with caution. The simulation and modelling approaches to quantifying the field nitrogen system are an excellent research tool in that it allows one to examine a large number of related and integrated physical, chemical, and biological soil processes that would be difficult to study otherwise. However, the soil nitrogen system is very complex and the exact quantification of all the various nitrogen-related processes is difficult. At best, one can usually only obtain approximate relationships for the N-system. Thus, model results are themselves only approximate and not exact values.

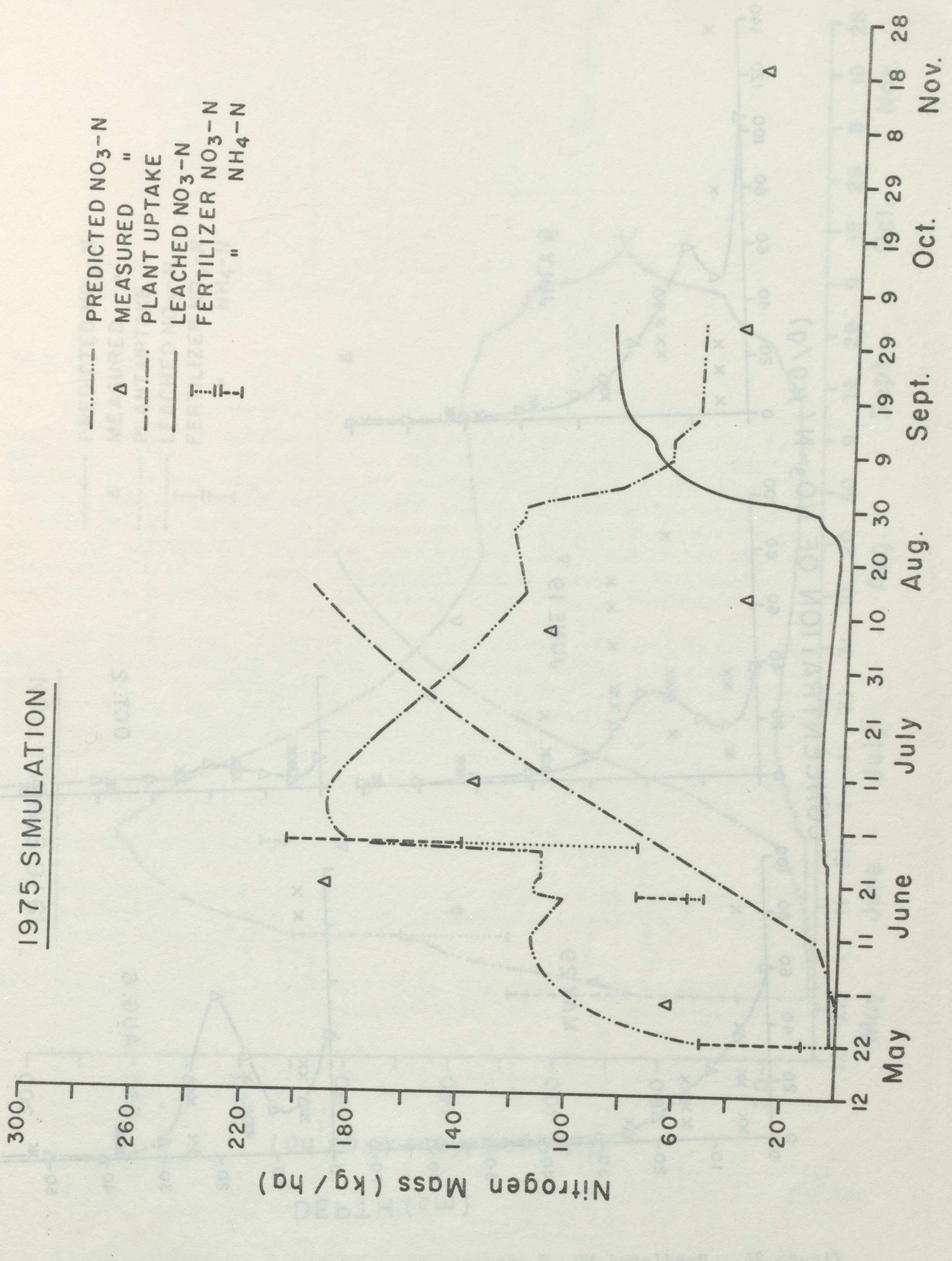

Figure 23. Prediced NO$_3$-N mass in soil and predicted NO$_3$-N mass leached from the 1975 tobacco plot (AG-13).

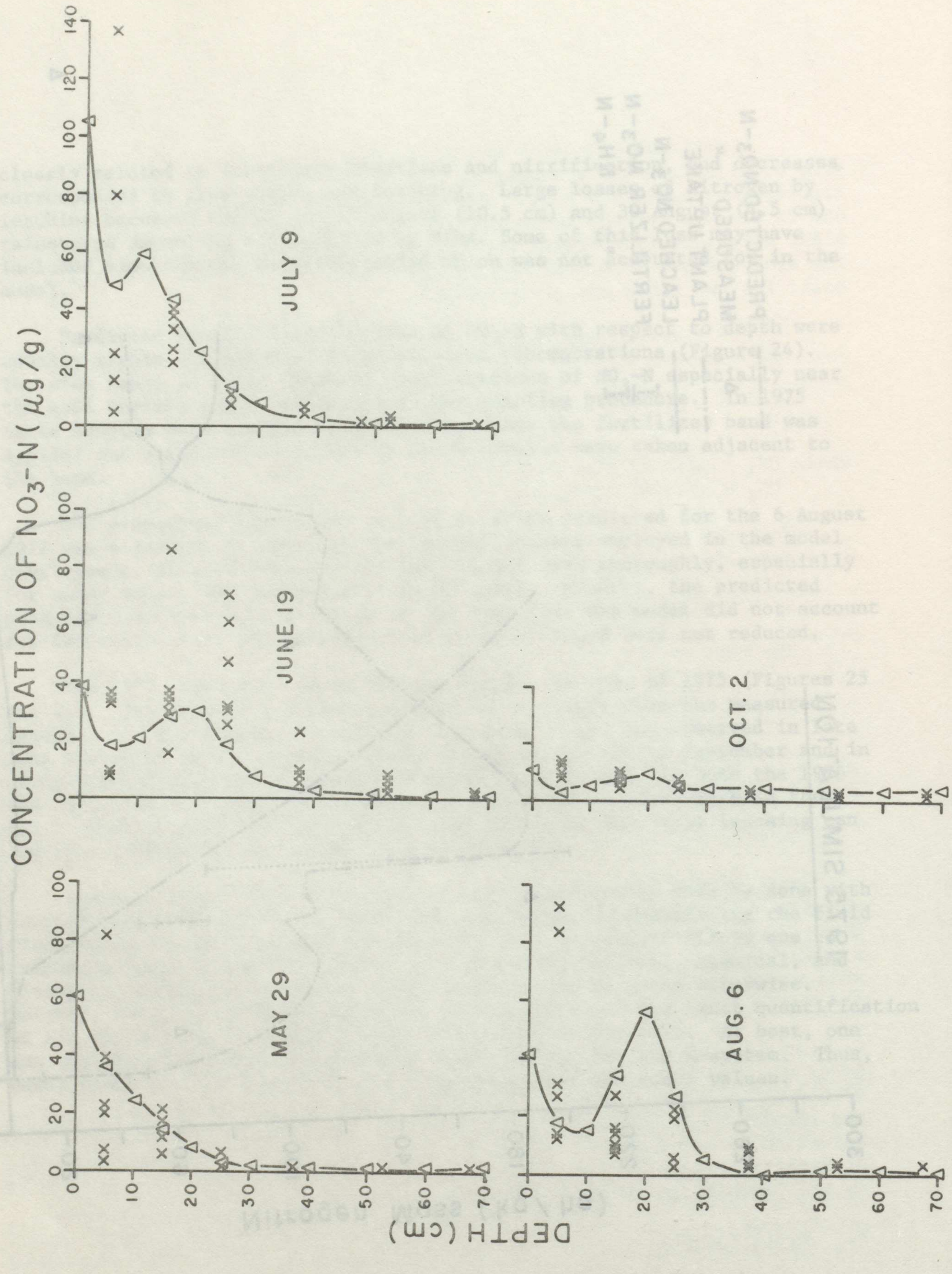

Figure 24. Predicted NO_3-N concentrations with respect to depth for the 1975 sampling times (measured NO_3-N values are marked by x's).

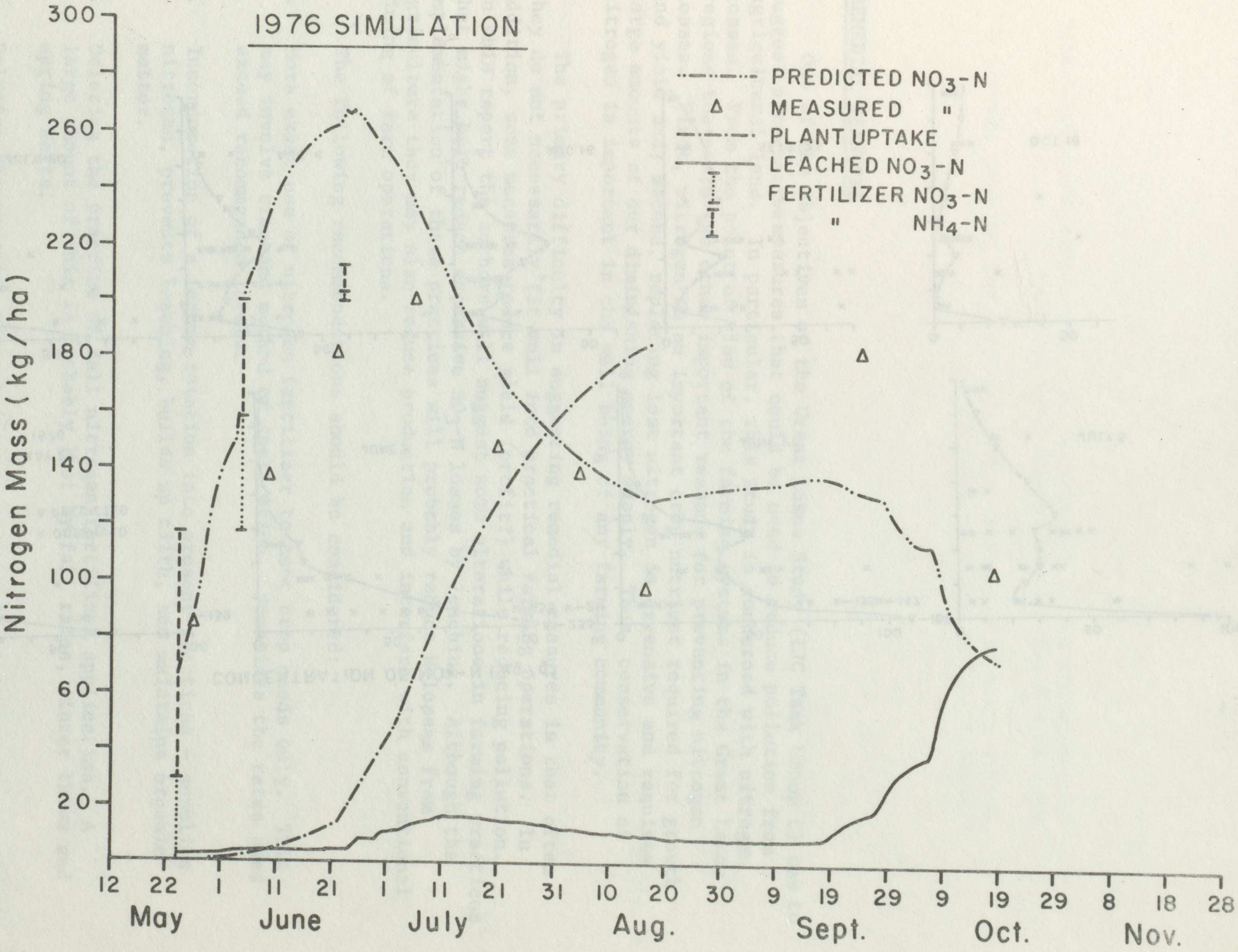

Figure 25. Predicted NO_3-N mass in soil and predicted NO_3-N mass leached from the 1976 tobacco plot (AG-13).

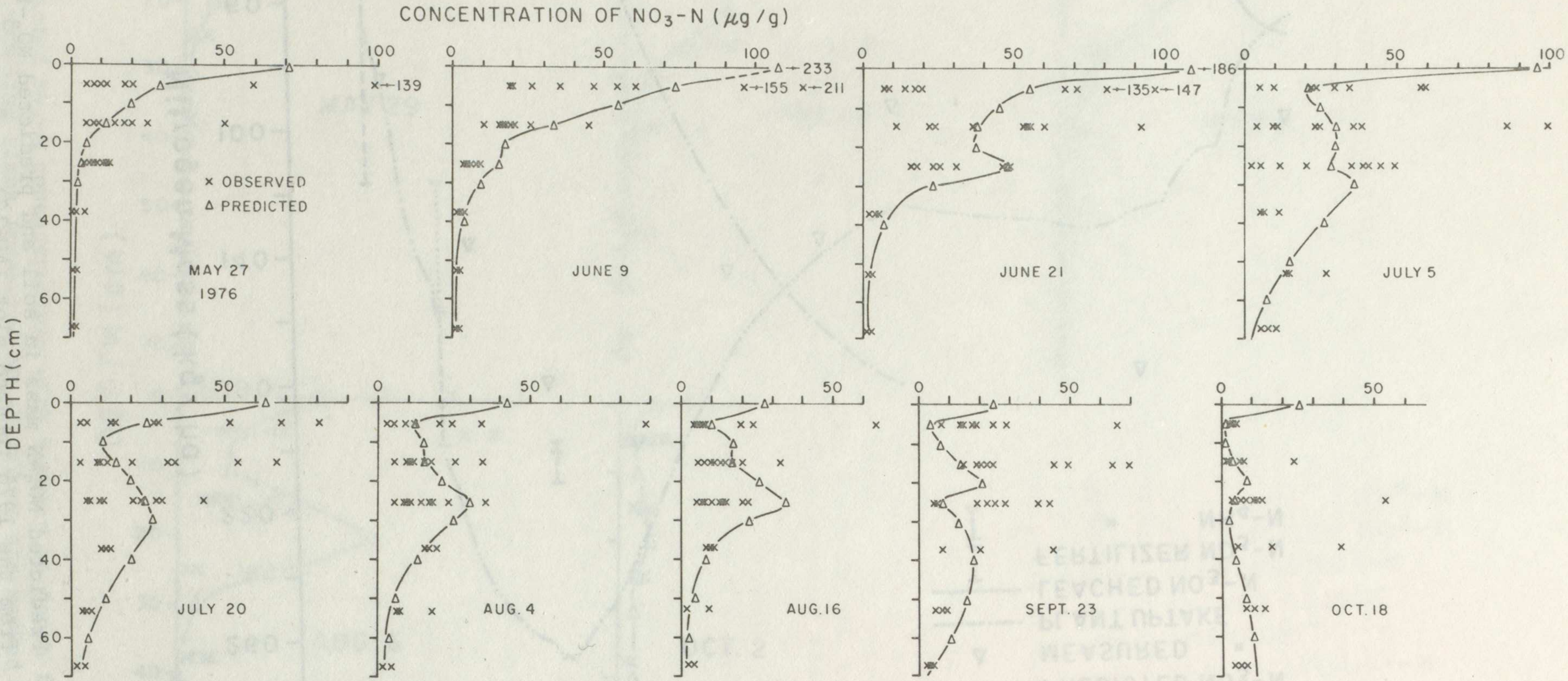

Figure 26. Predicted NO_3-N concentrations with respect to depth for the 1976 sampling times (measured NO_3-N values are marked by x's).

REMEDIAL MEASURES

One of the objectives of the Great Lakes Study (IJC Task Group C) was to suggest alternative measures that could be used to reduce pollution from agricultural land. In particular, this study is concerned with nitrogen losses. From the point of view of the farming systems in the Great Lakes regions there are two other important reasons for preventing nitrogen losses. First, nitrogen is an important crop nutrient required for growth and yield and, second, replacing lost nitrogen is expensive and requires large amounts of our diminishing energy supply. Thus, conservation of nitrogen is important in the well being of any farming community.

The primary difficulty in suggesting remedial measures is that often they do not necessarily fit well into practical farming operations. In addition, some measures reduce yield (profit?) while reducing pollution. In this report the authors will suggest some alterations in farming practices that might help reduce excessive NO_3-N losses by leaching. Although the implementation of these practices will probably reduce N-losses from agriculture they may also reduce production and interfere with conventional timing of farm operations.

The following recommendations should be considered:

1. More exact use of nitrogen fertilizer to meet crop needs only. This may involve time and method of application. Sometimes the rates used exceed recommended levels.
2. Incorporation of a legume rotation into present practices - supplies nitrogen, prevents leaching, builds up tilth, and maintains organic matter.
3. Deleting the practice of fall nitrogen fertilizer application. A large amount of this is probably lost by fall rains, winter thaws and spring melts.
4. Deleting the practice of applying manure to a field during the winter - manure is best applied late spring and summer and should be incorporated in order to obtain maximum benefits.
5. Encouragement of the use of slow release nitrogen fertilizers (if available) where release could be timed for maximum plant uptake.

6. Encouragement of the planting of fall cover crops which assimilate available N and help to prevent fall leaching.

7. Buffer zones of grasses or other non-row crops may help prevent N pollution where runoff is a problem.

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APPENDIX I

Measured NO_3-N and NH_4-N Concentrations (ug N/g-oven dry soil) and Percent Water Contents (mass basis) for Each of the Plots in Watersheds AG-13 and AG-01

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YEAR MO. DAY TEX. PLOT REP.              NO3-N                              NH4-N                          WATER CONTENT
 75   7   16   S    1   1    11.4  5.8  2.3  1.3  2.4  4.3     9.0  2.4  3.0  2.7  2.1  1.8     7.8  9.0  8.1  7.2  9.7 13.1
 75   7   16   S    1   2     9.8  7.1  5.8  5.4  3.1  2.9     6.4  4.4  2.7  3.1  3.1  2.5     8.6  8.4  9.9  9.3 10.2 13.9
 75   7   16   S    1   3    10.7  6.8  3.0  2.0  3.0  2.8     4.4  2.4  2.3  2.3  3.0  2.1     7.9  8.7  7.0  6.2  8.2 11.7
 75   7   16   S    1   4     9.4  6.8  5.2  4.4  3.1  2.2     6.0  1.7  2.1  2.7  2.7  2.2     8.0  9.7 10.6  9.4 10.0 14.0
 75   7   16   S    1   5    11.2  7.2  4.4  2.0  0.7  1.1     3.4  2.4  2.7  3.0  3.1  2.5     9.2 10.1  8.7  7.8  9.4 15.0
 75   7   16   S    1   6    18.4  7.4 10.9 20.1 20.8 11.0     8.3  2.1  5.2  4.8  2.2  5.3    10.8 12.6 17.8 15.5 17.1 19.1
                    MEANS    11.8  6.8  5.3  5.9  5.5  4.0     6.2  2.6  3.0  3.1  2.7  2.7     8.7  9.7 10.3  9.2 10.8 14.5
                STD. DEV.     3.3  0.6  3.1  7.2  7.5  3.6     2.2  0.9  1.1  0.9  0.5  1.3     1.1  1.5  3.9  3.3  3.2  2.5
YEAR MO. DAY TEX. PLOT REP.              NO3-N                              NH4-N                          WATER CONTENT
 75  10   15   S    1   1     0.3  0.3  0.7  0.7  0.3  1.4     3.3  0.7  0.3  0.3  0.3  0.4     7.6  8.9  8.9  8.4  8.5 13.3
 75  10   15   S    1   2     0.3  0.3  0.3  0.3  0.3  1.4     0.7  1.7  0.7  1.0  1.0  0.0     8.5  8.7  8.8  9.0  8.4 12.0
 75  10   15   S    1   3     0.3  0.3  0.3  0.7  0.7  1.5     0.7  0.7  0.7  1.0  0.4  0.7     7.4  9.2 10.4 11.0 14.9 17.4
 75  10   15   S    1   4     0.0  0.3  0.7  1.0  0.7  2.6     3.6  3.8  3.1  4.5  3.5  0.7     7.1  9.4  9.7 10.5 10.9 17.7
 75  10   15   S    1   5     0.3  0.3  0.3  0.7  0.7  1.8     1.4  0.7  0.7  0.0  0.0  0.0    10.2 11.3 11.3 13.2 12.5 16.5
 75  10   15   S    1   6     0.7  0.7  0.7  0.7  0.7  2.2     0.7  1.4  0.3  0.3  0.4  0.0    10.8 11.4 11.4  7.7 12.8 16.7
                    MEANS     0.3  0.4  0.5  0.7  0.6  1.8     1.7  1.5  1.0  1.2  0.9  0.3     8.6  9.8 10.1 10.0 11.3 15.6
                STD. DEV.     0.2  0.2  0.2  0.2  0.2  0.5     1.4  1.2  1.1  1.7  1.3  0.3     1.6  1.2  1.1  2.0  2.6  2.4
YEAR MO. DAY TEX. PLOT REP.              NO3-N                              NH4-N                          WATER CONTENT
 75  12   10   S    1   1     1.8  3.7  2.2  1.8  2.2  1.5     3.7  2.6  1.1  0.4  1.5  0.8    16.0 16.4 15.1 16.5 16.1 19.5
 75  12   10   S    1   2     2.2  4.8  3.7  1.9  1.8  1.9     4.1  1.9  1.1  0.7  2.2  1.9    17.0 16.9 15.7 17.2 15.6 16.4
 75  12   10   S    1   3     2.2  3.0  2.9  1.5  2.2  1.9     2.0  3.7  1.1  0.7  0.4  1.1    15.8 16.5 15.3 16.7 15.8 17.5
 75  12   10   S    1   4     3.6  5.8  5.4  1.4  1.1  1.1     2.9  2.5  0.7  0.7  0.4  0.0    15.1 14.9 13.7 12.2 14.3 16.9
 75  12   10   S    1   5     4.1  6.6  4.3  1.1  1.1  1.5     3.3  1.1  1.1  1.1  0.7  0.7    16.9 15.4 12.9 13.7 14.4 17.3
 75  12   10   S    1   6     5.5  6.1  5.4  1.1  1.1  1.1     3.3  1.4  0.7  0.7  0.4  0.4    15.0 14.2 13.7 12.7 14.5 17.9
                    MEANS     3.2  5.0  4.0  1.5  1.6  1.5     3.3  2.2  1.0  0.7  0.9  0.8    16.0 15.7 14.4 14.8 15.1 17.9
                STD. DEV.     1.4  1.4  1.3  0.3  0.5  0.4     0.5  0.9  0.2  0.2  0.8  0.6     0.9  1.1  1.1  2.2  0.8  0.9
YEAR MO. DAY TEX. PLOT REP.              NO3-N                              NH4-N                          WATER CONTENT
 76   3   30   S    1   1     0.0  0.4  0.4  0.4  0.4  0.0     1.4  2.5  1.8  1.1  1.5  0.8    14.4 14.4 14.2 14.1 18.5 21.6
 76   3   30   S    1   2     0.0  0.4  0.7  0.4  0.4  0.0     1.5  1.5  2.2  1.5  1.5  1.5    15.9 15.8 14.4 14.9 19.6 20.2
 76   3   30   S    1   3     0.4  0.0  0.4  0.4  0.0  0.0     1.4  1.4  1.1  1.1  0.7  1.5    13.0 13.7 14.8 17.9 15.5 18.0
 76   3   30   S    1   4     0.4  0.4  0.4  0.0  0.0  0.0     1.4  1.8  1.4  1.9  1.8  0.8    13.3 13.9 14.7 17.9 15.8 18.9
 76   3   30   S    1   5     0.0  0.0  0.0  0.0  0.0  0.0     1.8  1.4  1.5  1.2  1.2  1.1    13.3 13.7 14.8 21.8 20.0 19.0
 76   3   30   S    1   6     0.4  0.4  0.0  0.0  0.0  0.0     1.8  1.8  1.8  2.0  1.2  1.1    13.0 13.7 16.2 21.7 20.6 19.1
                    MEANS     0.2  0.3  0.3  0.2  0.1  0.0     1.5  1.7  1.6  1.5  1.3  1.1    13.8 14.2 14.8 18.0 18.3 19.5
                STD. DEV.     0.2  0.2  0.3  0.2  0.2  0.0     0.2  0.4  0.4  0.4  0.4  0.3     1.1  0.8  0.7  3.3  2.2  1.3
YEAR MO. DAY TEX. PLOT REP.              NO3-N                              NH4-N                          WATER CONTENT
 76   4   22   S    1   1    11.1  1.7  0.7  1.0  0.3  0.0    51.1  3.1  1.4  0.7  1.0  1.1     8.3  9.3 10.5  8.2  8.9 12.0
 76   4   22   S    1   2     7.1  3.4  0.7  0.0  2.4  0.4    20.6  5.1  1.4  1.0  0.7  0.7     8.4  9.4 10.3  8.3  9.0 13.0
 76   4   22   S    1   3    28.5  3.6  0.7  0.3  0.3  0.3    65.8  6.0  2.8  0.7  1.0  0.7     9.9 13.1 12.4 10.6 10.8 11.4
 76   4   22   S    1   4    16.2  5.0  0.7  0.3  0.3  0.0    19.7  9.2  1.4  1.0  1.0  1.1    10.5 13.0 12.6 10.7 11.3 11.7
 76   4   22   S    1   5    13.6  1.7  1.7  0.3  0.0  0.4    36.6  6.9  3.1  1.4  1.0  0.7     9.0 10.2 10.9  8.6 11.5 10.2
 76   4   22   S    1   6     7.8  1.4  1.4  0.7  0.3  0.4    29.1  3.1  2.4  1.3  0.7  0.7     8.8 10.3 10.8  8.5 10.3 17.1
                    MEANS    14.0  2.8  1.0  0.4  0.6  0.2    37.1  5.6  2.1  1.0  0.9  0.8     9.1 10.9 11.2  9.1 10.3 13.6
                STD. DEV.     7.9  1.4  0.4  0.4  0.9  0.2    18.2  2.3  0.8  0.3  0.2  0.2     0.9  1.7  1.0  1.2  1.1  2.5
YEAR MO. DAY TEX. PLOT REP.              NO3-N                              NH4-N                          WATER CONTENT
 76   5    5   S    1   1     0.0  8.4 15.6  3.2  1.1  0.0    44.4 37.7  3.9  1.4  1.1  1.1     9.0 11.4 13.0 13.6 14.1 16.0
 76   5    5   S    1   2     3.7  9.7  6.7  4.7  0.7  0.4    41.7 18.4  3.9  1.1  1.1  1.1     9.0 11.1 12.1 13.7 13.9 15.3
 76   5    5   S    1   3    11.2 24.3  6.9  0.7  0.0  0.0    20.2  9.2  1.8  1.1  1.1  1.1    11.4  9.6 14.6 15.6 15.8 17.0
 76   5    5   S    1   4    13.8 10.0  5.5                   26.0  3.2  1.1                   12.6 13.1 16.5
 76   5    5   S    1   5    16.1  5.0  8.7                   64.0  7.1 12.1                   11.6 12.6 10.7
 76   5    5   S    1   6     6.6 17.0  3.7                   20.3 20.8  2.4                   11.6 12.2  8.6
 76   5    5   S    1   7     8.3  9.1 18.8                   68.0 11.8 18.5                   10.4 11.2 11.3
 76   5    5   S    1   8     5.5 10.4 17.1                   45.2 18.4 14.7                   10.5 11.1 11.4
 76   5    5   S    1   9     5.4  4.8  3.8                   27.9 15.5  8.9                    9.3 10.3 10.1
                    MEANS     7.8 11.0  9.6  2.9  0.6  0.1    40.0 15.8  7.5  1.2  1.1  1.1    10.6 11.4 12.0 14.3 14.6 16.1
                STD. DEV.     5.1  6.2  5.9  2.0  0.6  0.2    17.6 10.1  6.3  0.2  0.0  0.0     1.3  1.1  2.4  1.1  1.0  0.9
YEAR MO. DAY TEX. PLOT REP.              NO3-N                              NH4-N                          WATER CONTENT
 76   5   18   S    1   1    23.0 11.4 15.3 43.2  5.3  1.8    45.6 23.1 13.1  1.2  0.7  1.1    12.5 13.0 12.9 24.1 13.2 13.9
 76   5   18   S    1   2     7.4 19.7 15.0 11.4  9.7  4.0     6.3 12.2  2.1  1.0  1.0  1.1    11.7 13.7 13.3 10.3 10.7 14.3
 76   5   18   S    1   3    29.7 44.6 24.3  4.3  1.8  0.7    62.3 66.8  5.7  1.1  1.1  1.5    12.6 13.4 13.3 12.9 13.7 17.5
 76   5   18   S    1   4    23.9 25.0 27.2                   70.0 53.1 15.0                   10.8 11.0 11.2
 76   5   18   S    1   5     3.5 20.8 25.1                    4.5 30.3  7.8                   10.7 12.3 12.7
 76   5   18   S    1   6    15.6 25.4 21.8                   42.5 31.7 10.4                   10.6 11.2 10.8
 76   5   18   S    1   7     6.9 20.1 21.6                   40.6 52.7 28.5                   11.0 10.8 10.0
 76   5   18   S    1   8    13.2 24.0 16.0                   36.6 24.0 10.1                   11.2 11.0 11.3
 76   5   18   S    1   9    19.7 25.2 17.8                   41.9 27.6  8.7                   10.7 11.5 11.6
                    MEANS    15.9 24.0 20.5 19.6  5.6  2.2    39.1 35.7 11.3  1.1  0.9  1.2    11.3 12.0 11.9 15.8 12.5 15.2
                STD. DEV.     8.9  8.9  4.6 20.7  4.0  1.7    21.9 17.7  7.5  0.1  0.2  0.2     0.8  1.1  1.2  7.3  1.6  2.0
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YEAR MO. DAY TEX. PLOT REP.              NO3-N                                 NH4-N                              WATER CONTENT
 76   5   31   S     1   1     35.2 26.5 24.3 40.3 17.5  2.6     10.5  6.5  7.5  3.5  1.6  1.8      8.8  9.2  9.7 20.0 23.7 34.3
 76   5   31   S     1   2     32.0 22.0 29.8 30.6  2.3  0.7     55.4 19.6 27.0  4.0  0.7  0.7      9.2  8.7  9.7  8.2  8.1 10.1
 76   5   31   S     1   3     71.8 26.1 22.9  9.4  2.0  3.2     29.7 10.0  4.2  1.7  1.7  1.1      9.6 10.0 10.8  8.5  8.2 11.9
 76   5   31   S     1   4     31.6 34.1 34.6                    11.7 16.0  7.6                    10.1  9.5 10.7
 76   5   31   S     1   5     40.9 27.7 16.1                    12.4 16.3  8.6                    18.0 10.6  9.7
 76   5   31   S     1   6     10.0 10.8  8.8                    11.2  3.0  2.7                     0.0  8.7  8.9
 76   5   31   S     1   7     40.8 15.1 12.4                    30.7  3.8  2.8                    10.5 10.0 10.4
 76   5   31   S     1   8     21.8 45.3 25.5                     7.9 58.3  2.1                    10.5  9.9 10.4
 76   5   31   S     1   9     31.7 68.9 21.6                     4.9 14.3  6.6                    11.2 11.1 11.4
                     MEANS     35.1 30.7 21.8 26.8  7.3  2.2     19.4 16.4  7.7  3.1  1.3  1.2      9.8  9.7 10.2 12.2 13.3 16.8
                 STD. DEV.     16.8 17.5  8.2 15.8  8.9  1.3     16.3 16.8  7.6  1.2  0.6  0.6      4.6  0.8  0.8  6.7  9.0 13.5

YEAR MO. DAY TEX. PLOT REP.              NO3-N                                 NH4-N                              WATER CONTENT
 76   6   14   S     1   1      6.2  5.2  4.6  4.6  5.0  1.4      1.6  2.9  0.7  1.0  0.7  0.7      5.5  5.9  6.8  7.1  6.9 10.2
 76   6   14   S     1   2      7.8 13.9 36.5 17.6 10.4  5.0      2.4  2.7  0.3  1.7  1.0  0.7      8.6  9.2 10.3  8.6  8.0  7.8
 76   6   14   S     1   3     64.8 40.0  6.4  9.6  9.6  7.6     38.5  7.8  2.0  0.7  0.7  0.7      8.6  8.9  7.9  6.7  6.7  6.8
 76   6   14   S     1   4     32.9 26.5 15.9                     6.1  4.4  2.4                     8.9  9.1 10.6
 76   6   14   S     1   5      8.3  3.3  7.6                     6.2  3.0  3.6                    10.7  7.5  6.9
 76   6   14   S     1   6     51.0 46.1 11.0                    11.9  4.0  2.0                     7.0  7.1  7.6
 76   6   14   S     1   7     23.1 15.9  4.0                     8.8  3.6  2.3                     5.6  6.9  6.9
 76   6   14   S     1   8     44.7 47.8 13.0                    12.5  8.3  3.2                     6.4  7.2  5.2
 76   6   14   S     1   9     20.3 34.7  9.8                     7.0  6.0  3.0                     7.2  7.6  8.3
                     MEANS     28.8 26.2 12.1 10.6  8.3  4.7     10.6  4.7  2.2  1.1  0.8  0.7      7.6  7.7  7.8  7.5  7.2  8.3
                 STD. DEV.     21.0 17.2  9.9  6.6  2.9  3.1     11.1  2.1  1.1  0.5  0.2  0.0      1.7  1.1  1.7  1.0  0.7  1.7

YEAR MO. DAY TEX. PLOT REP.              NO3-N.                                NH4-N                              WATER CONTENT
 76   6   24   S     1   1      6.6 18.2  7.1  1.3  0.7  0.0      2.6  7.6  2.4  0.7  0.7  1.0      6.4  6.7  8.4  8.4 10.1 10.1
 76   6   24   S     1   2      2.0 33.9 36.3 24.5 15.7  7.7      3.0  5.4  1.4  0.7  0.7  0.7      6.8  8.1  8.9  8.0  7.7  8.1
 76   6   24   S     1   3      5.1  6.8  5.2  3.0  6.0  7.2      1.7  1.0  1.0  0.7  0.7  0.3      8.9  9.4 10.2  8.2  8.2  9.3
 76   6   24   S     1   4     12.4 13.1 16.3                     6.7  2.4  0.7                     7.7  8.3  8.9
 76   6   24   S     1   5      0.3  1.4  0.7                     1.3  1.0  1.0                     8.3 10.1  9.4
 76   6   24   S     1   6     12.2 21.6 15.7                     0.7  2.1  0.7                     9.2 10.0  9.6
 76   6   24   S     1   7      1.7 16.3 27.7                     1.7  2.4  5.7                     9.1  9.2  7.7
 76   6   24   S     1   8      2.7 11.5 28.4                     1.0  3.4  3.4                     8.2  8.6  9.7
 76   6   24   S     1   9      5.3  7.6 11.7                     1.3  0.7  1.3                     7.5  7.3  7.9
                     MEANS      5.4 14.5 16.6  9.6  7.5  5.0      2.2  2.9  2.0  0.7  0.7  0.7      8.0  8.6  9.0  8.2  8.7  9.2
                 STD. DEV.      4.4  9.6 12.0 12.9  7.6  4.3      1.8  2.3  1.7  0.0  0.0  0.4      1.0  1.2  0.8  0.2  1.3  1.0

YEAR MO. DAY TEX. PLOT REP.              NO3-N                                 NH4-N                              WATER CONTENT
 76   7    5   S     1   1      1.6  4.0  5.7  9.2  8.6  5.1      2.3  1.0  2.0  1.0  1.0  1.0      5.3  7.4  7.8  6.1  6.5  8.8
 76   7    5   S     1   2      1.0  1.3  0.7  1.0  1.6  1.0      1.0  2.3  1.7  1.0  1.3  0.7      6.4  6.7  9.0  7.3  6.5  8.5
 76   7    5   S     1   3      2.7  8.9 17.1 10.8  8.6  6.6      2.3  2.0  1.0  1.4  1.0  1.4      7.2  9.4  9.8  8.9 10.6 10.5
 76   7    5   S     1   4      1.0  1.7  1.0                     3.7  2.0  1.4                     7.2  9.3  8.8
 76   7    5   S     1   5      2.3  2.1  1.2                     3.0  1.4  1.6                     7.0  9.7 21.0
 76   7    5   S     1   6      2.0  1.0  1.7                     3.0  2.0  2.0                     7.6  8.2  8.1
 76   7    5   S     1   7      1.7  1.7  2.0                     3.0  3.0  1.7                     7.5  8.8  9.2
 76   7    5   S     1   8      2.3  2.3  2.3                     3.0  2.3  1.3                     6.9  7.9  7.7
 76   7    5   S     1   9      1.0  1.3  2.8                     1.6  3.0  1.4                     6.3  7.5 10.9
                     MEANS      1.7  2.7  3.8  7.0  6.3  4.2      2.5  2.1  1.6  1.1  1.1  1.0      6.8  8.3 10.3  7.4  7.9  9.3
                 STD. DEV.      0.6  2.5  5.2  5.3  4.0  2.9      0.8  0.7  0.3  0.2  0.2  0.4      0.7  1.0  4.2  1.4  2.4  1.1

YEAR MO. DAY TEX. PLOT REP.              NO3-N                                 NH4-N                              WATER CONTENT
 76   8   31   S     1   1     18.8 15.5 14.5  3.5  2.1  0.7      1.6  1.3  1.4  1.3  1.1  0.9      3.8  6.6  8.2 12.2 12.3  8.8
 76   8   31   S     1   2     11.7 11.5  7.3  1.6  1.0  0.7      0.6  1.0  1.0  0.7  0.7  1.0      5.2  6.4  7.5  5.6  5.6  7.6
 76   8   31   S     1   3     26.2 10.8  4.2  3.8  2.9  3.0      0.5  0.9  0.8  0.5  0.6  0.6      3.0  6.2  5.8  4.3  4.7  6.2
 76   8   31   S     1   4     18.9 16.1 10.7                     1.0  0.8  1.0                     4.3  6.3  5.1
 76   8   31   S     1   5     35.5  9.0 10.0                     2.1  1.1  1.1                     2.7  7.0  7.8
 76   8   31   S     1   6     60.1 14.3 10.9                     3.9  1.4  0.7                     3.3  9.3  9.6
 76   8   31   S     1   7     28.2 14.3  8.6                     1.2  0.6  0.5                     4.3  7.2  7.3
 76   8   31   S     1   8     69.5 16.2 12.2                     3.0  1.3  1.0                     3.5  8.8  9.0
 76   8   31   S     1   9     15.2 16.0  8.7                     0.7  1.0  0.7                     5.3  7.4  7.4
                     MEANS     31.6 13.8  9.7  3.0  2.0  1.5      1.6  1.0  0.9  0.8  0.8  0.8      3.9  7.2  7.5  7.4  7.5  7.5
                 STD. DEV.     20.3  2.5  3.0  1.2  1.0  1.3      1.2  0.3  0.3  0.4  0.3  0.2      0.9  1.1  1.4  4.2  4.2  1.3

YEAR MO. DAY TEX. PLOT REP.              NO3-N.                                NH4-N                              WATER CONTENT
 76  10   12   S     1   1      0.7  2.2  6.0  6.7  7.0  6.9      0.4  0.4  0.4  0.2  0.1  0.3      8.0  8.5  9.0  7.8  6.6  9.0
 76  10   12   S     1   2      0.8  2.3  4.3  7.0  6.8  6.5      0.3  0.2  0.4  0.2  0.1  0.0      7.7  8.4  8.8  7.8  6.2  8.7
 76  10   12   S     1   3      1.3  0.8  2.3  2.7  8.4  9.4      0.2  0.2  0.0  0.1  0.1  0.1      7.5  8.6  8.0  7.3  6.8 11.8
 76  10   12   S     1   4      1.1 12.8 15.2                     0.4  0.6  0.5                     9.0 10.0 12.2
 76  10   12   S     1   5      1.0  1.0  1.4                     0.4  0.3  0.3                     7.8  8.9  8.5
 76  10   12   S     1   6      1.3  1.4 14.3                     0.4  0.3  0.2                     8.8 10.0 10.0
 76  10   12   S     1   7      1.3 11.6  4.8                     0.3  0.3  0.1                     8.6 10.2 10.3
 76  10   12   S     1   8     13.3  0.7  1.8                     0.4  0.4  0.2                     7.8  8.8  8.1
 76  10   12   S     1   9      3.8  2.4  3.5                     0.5  0.0  0.1                     8.1  8.8  7.8
                     MEANS      2.7  3.9  6.0  5.5  7.4  7.6      0.4  0.3  0.2  0.2  0.1  0.1      8.1  9.1  9.2  7.6  6.5  9.8
                 STD. DEV. [illegible] [illegible] 5.2 [illegible] 0.9 [illegible]   0.1 [illegible] 0.2 0.1 0.0 0.2   0.5 0.7 1.4 0.3 [illegible] 1.7
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YEAR MO. DAY TEX. PLOT REP.          NO3-N                                NH4-N                              .WATER CONTENT
 77   5   2   S    1    1    0.4  1.4  1.3  0.0  0.8  0.5     3.3  2.5  2.3  1.2  1.5  1.5      5.7  8.8  9.9  9.2 13.3 18.5
 77   5   2   S    1    2    2.8  1.1  1.5  0.7  0.4  0.5     2.5  4.3  2.2  1.9  0.8  1.4      6.2  9.3 10.2 12.0 17.0 17.2
 77   5   2   S    1    3    2.1  2.3  1.8  0.5  0.7  0.4     2.2  3.0  1.7  0.9  0.9  0.6      6.1  9.1 11.2 17.5 15.6 14.7
 77   5   2   S    1    4    1.8  1.0  1.3  2.0  1.1  1.4     1.3  1.3  1.6  1.1  0.9  1.1      6.5  9.6 10.3 15.0 19.4 21.4
 77   5   2   S    1    5    1.4  0.7  2.0  0.7  0.4  0.4     1.2  1.2  1.6  1.0  0.7  0.8      5.6  9.9 10.1 13.8 15.2 13.2
 77   5   2   S    1    6    1.8  0.9  1.2  0.5  0.5  0.5     1.8  1.0  1.3  0.6  1.1  1.1      4.9  9.4  9.8  9.0 12.3 16.5
                    MEANS    1.7  1.2  1.5  0.7  0.6  0.6     2.0  2.2  1.8  1.1  1.0  1.1      5.8  9.3 10.2 12.7 15.5 16.9
               STD. DEV.     0.8  0.6  0.3  0.7  0.3  0.4     0.8  1.3  0.4  0.4  0.3  0.3      0.6  0.4  0.5  3.3  2.6  2.9

YEAR MO. DAY TEX. PLOT REP.          NO3-N                                NH4-N                              .WATER CONTENT
 75   5  29   S    2    1   38.6 21.4  6.0  0.0  1.5  1.1    54.5  4.3  1.8  2.9  1.8  1.9     10.4 13.5 12.6 13.3 15.3 17.5
 75   5  29   S    2    3   22.4 12.4  0.8  1.8  0.7  0.4    22.1  4.0  3.1  3.0  2.2  2.2     11.7 15.4 20.2 16.5 15.0 17.1
 75   5  29   S    2    5   81.2  4.6  4.3  0.8  1.2  1.8    90.9 20.9  3.6  3.0  2.3  1.8     12.5 12.6 14.4 19.4 21.0 12.9
 75   5  29   S    2    2   19.5 11.2  1.4  1.1  1.3  0.4     6.0  1.8  2.5  1.8  2.1  1.9     12.6 14.5 12.9 13.5 30.2 19.1
 75   5  29   S    2    4    7.1 16.5  1.5  0.4  0.7  1.2     2.5 24.3  2.7  3.7  1.9  2.3     13.3 17.7 20.1 15.8 16.7 21.0
 75   5  29   S    2    6    2.9 11.9  0.7  0.4  1.1  0.0     0.7 20.3  3.0  1.5  0.7  1.1     14.9 11.8 16.9 18.9 15.5 19.8
                    MEANS   28.6 13.0  2.4  0.7  1.1  0.8    29.4 12.6  2.8  2.6  1.8  1.9     12.6 14.2 16.2 16.2 18.9 17.9
               STD. DEV.    28.7  5.6  2.2  0.6  0.3  0.7    36.2 10.2  0.6  0.8  0.6  0.4      1.5  2.1  3.4  2.6  5.9  2.8

YEAR MO. DAY TEX. PLOT REP.          NO3-N                                NH4-N                              .WATER CONTENT
 75   6  19   S    2    1   35.2 85.6 70.4  5.7  2.3  1.2     8.2 12.8  1.1  0.8  1.6  0.8     17.8 20.9 19.8 18.6 21.6 24.3
 75   6  19   S    2    3   32.8 29.8 25.8  9.3  4.0  1.5    28.9  1.5  1.1  1.4  1.1  1.1     12.4 14.9 13.8 13.5 15.5 17.0
 75   6  19   S    2    5   34.3 34.5 60.4 22.1  6.9  2.2    12.9 10.9  3.9  0.7  1.1  0.4     11.6 14.8 12.9 14.8 14.7 16.2
 75   6  19   S    2    2    9.3 32.4 30.4  8.6  8.6  2.4     1.2  1.2  2.4  0.7  0.8  0.8     20.5 23.0 22.7 17.4 21.5 24.5
 75   6  19   S    2    4    8.9 37.0 46.9 22.4  4.7  1.5     2.1  2.4  1.1  1.1  1.1  1.1     13.4 25.8 14.4 14.3 15.4 17.9
 75   6  19   S    2    6    8.6 15.4 31.4 22.9  2.9  1.1     0.7  0.7  0.7  0.4  0.4  0.4     13.9 13.8 14.4 13.7 13.8 16.6
                    MEANS   21.5 39.1 44.2 15.2  4.9  1.6     9.0  4.9  1.7  0.8  1.0  0.8     14.9 18.9 16.3 15.4 17.1 19.4
               STD. DEV.    13.8 24.0 18.2  8.1  2.4  0.5    10.9  5.4  1.2  0.4  0.4  0.3      3.5  5.0  4.0  2.1  3.5  3.9

YEAR MO. DAY TEX. PLOT REP.          NO3-N                                NH4-N                              .WATER CONTENT
 75   7   9   S    2    1   25.0 26.3  7.7  5.0  2.4  1.5     2.0  1.7  2.3  2.0  2.4  1.8      5.5  7.5  7.8  8.1  8.5 15.1
 75   7   9   S    2    3   24.9 20.9  7.0  6.4  2.0  1.1     2.3  1.7  2.3  1.7  2.7  2.9      5.2  7.1  7.4  7.9  8.6 14.7
 75   7   9   S    2    5  136.4 39.8 11.3  4.6  1.4  1.5     4.7  4.9  2.2  1.8  1.7  1.8      8.2 12.2 15.0 13.4 11.0 15.4
 75   7   9   S    2    2    4.3 21.7 12.3  7.7  2.1  1.1     2.6  3.4  3.3  1.7  1.7  1.9      7.0 10.2  7.4  7.4  9.9 17.0
 75   7   9   S    2    4   15.5 33.8 12.6  7.0  2.4  1.5     2.6  9.0  1.7  1.3  4.2  1.9      6.7  7.9  9.1  7.5 11.2 17.0
 75   7   9   S    2    6   79.6 40.5 10.9  4.5  1.7  1.4    33.5  3.2  2.2  1.7  1.7  2.2      7.1 12.2 15.0 10.8 10.5 14.5
                    MEANS   47.6 30.5 10.3  5.9  2.0  1.3     7.9  4.0  2.3  1.7  2.4  2.1      6.6  9.5 10.3  9.2  9.9 15.6
               STD. DEV.    50.7  8.8  2.4  1.4  0.4  0.2    12.6  2.7  0.5  0.2  1.0  0.4      1.1  2.3  3.7  2.4  1.2  1.1

YEAR MO. DAY TEX. PLOT REP.          NO3-N                                NH4-N                              .WATER CONTENT
 75   8   6   S    2    1   31.1  6.1  4.9  2.1  0.1  2.0    22.4  2.4  2.1  1.1  1.4  0.7     10.5  9.3 11.0 13.6  9.4  9.1
 75   8   6   S    2    3   92.2 27.9 22.0  8.7  3.7  2.7    92.2 18.9 18.5  2.1  1.0  1.0      8.0 10.3 10.0 11.1  8.6  8.6
 75   8   6   S    2    5   83.7 15.4 19.3  7.8  2.7  2.7    93.8  8.9 15.5  3.2  0.7  0.7      7.9  9.7 10.2 12.5  8.2  8.4
 75   8   6   S    2    2   26.5 13.0  5.2  2.1  3.1  2.0    25.2  8.9  2.4  1.1  1.4  0.7      9.2  9.3 11.4 13.2  9.2  9.0
 75   8   6   S    2    4   12.6  8.4  3.7  2.0  2.3  2.0     1.0  1.0  0.7  0.7  0.7  0.3      7.4  7.7  8.4  7.0  7.7  7.9
 75   8   6   S    2    6   13.6  9.7  5.6  2.7  2.0  2.7     1.3  1.0  1.7  1.0  0.7  1.0      7.4  7.7  6.9  7.2  7.6  7.4
                    MEANS   43.3 13.5 10.1  4.3  2.3  2.3    39.3  6.8  6.8  1.5  1.0  0.7      8.4  9.0  9.6 10.8  8.4  8.4
               STD. DEV.    35.4  7.8  8.2  3.1  1.2  0.4    42.8  7.0  8.0  0.9  0.3  0.3      1.2  1.1  1.7  3.0  0.8  0.7

YEAR MO. DAY TEX. PLOT REP.          NO3-N                                NH4-N                              .WATER CONTENT
 75   8  13   S    2    1    6.9  6.9  2.3  2.3  1.7  1.3     3.0  3.3  1.7  1.7  1.7  1.7      6.5  6.7  6.7  6.8  7.1  7.1
 75   8  13   S    2    3    6.6  6.9  3.3  3.3  1.7  1.7     1.7  2.3  2.0  1.7  1.3  1.3      7.0  6.7  6.6  6.8  7.1  7.5
 75   8  13   S    2    5    7.3  6.6  3.3  2.3  2.0  1.3     2.3  1.7  1.6  1.6  2.0  1.3      6.8  6.7  5.5  5.5  5.9  6.6
 75   8  13   S    2    2    6.6  5.9  2.6  3.0  1.7  1.7     2.0  2.0  1.7  1.3  1.3  1.3      6.4  6.6  6.8  6.8  6.9  7.4
 75   8  13   S    2    4    7.6  9.3  5.5  2.9  2.3  2.3     2.0  2.0  2.0  2.0  1.6  2.0      6.9  7.1  5.6  5.6  5.9  6.6
 75   8  13   S    2    6    7.0 12.0  2.3  2.6  1.3  1.3     2.6  1.7  1.6  1.6  1.6  1.3      7.0  7.0  5.7  5.6  6.0  6.7
                    MEANS    7.0  8.0  3.2  2.7  1.8  1.6     2.3  2.2  1.8  1.6  1.6  1.5      6.8  6.8  6.1  6.2  6.5  7.0
               STD. DEV.     0.4  2.5  1.2  0.4  0.3  0.4     0.5  0.6  0.2  0.2  0.3  0.3      0.3  0.2  0.6  0.7  0.6  0.4

YEAR MO. DAY TEX. PLOT REP.          NO3-N                                NH4-N                              .WATER CONTENT
 75  10   2   S    2    1    3.9  4.2  5.0  1.7  1.0  2.6     1.1  1.4  1.1  0.7  0.7  0.7     12.9 12.6 13.2 11.5 11.4 17.5
 75  10   2   S    2    3   12.1  9.2  5.8  1.8  1.8  2.2     1.8  0.7  0.7  0.7  0.7  0.7     12.8 12.9 14.4 13.1 13.2 13.9
 75  10   2   S    2    0    9.4  6.8  5.7  1.9  1.7  2.2     1.7  1.0  0.9  0.8  0.7  0.7     12.7 12.8 13.4 12.4 12.4 15.3
 75  10   2   S    2    2    7.8  5.7  4.2  1.8  1.8  1.8     1.1  0.7  0.7  1.1  0.7  0.7     12.6 12.6 11.7 11.7 12.0 15.7
 75  10   2   S    2    4   13.8  8.2  7.6  2.1  2.1  2.2     2.8  1.1  1.1  0.7  0.7  0.7     12.4 12.9 14.1 13.3 13.0 13.9
 75  10   2   S    2    0    9.4  6.8  5.7  1.9  1.7  2.2     1.7  1.0  0.9  0.8  0.7  0.7     12.7 12.8 13.4 12.4 12.4 15.3
                    MEANS    9.4  6.8  5.7  1.9  1.7  2.2     1.7  1.0  0.9  0.8  0.7  0.7     12.7 12.8 13.4 12.4 12.4 15.3
               STD. DEV.     3.4  1.8  1.1  0.1  0.4  0.3     0.6  0.3  0.2  0.2  0.0  0.0      0.2  0.1  0.9  0.7  0.7  1.3
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YEAR MO. DAY TEX. PLOT REP.             NO3-N.                               NH4-N                              , WATER CONTENT
 75   11   19   S    2    1    0.7  0.4  0.7  1.4  3.1  8.2     2.1  2.1  1.8  1.0  1.0  0.7     12.1 12.4 12.9 10.0 10.5 12.8
 75   11   19   S    2    3    1.4  2.5  2.8  2.4  3.5  5.4     2.8  2.8  1.4  1.0  1.0  0.7     11.7 12.3 13.1  9.9 10.5 13.5
 75   11   19   S    2    5    1.4  3.2  1.0  2.4  4.8  9.8     1.4  1.4  1.7  0.7  0.7  0.7     10.9 12.5 10.4  8.6  9.0 11.6
 75   11   19   S    2    2    1.4  1.1  1.1  1.4  4.1  8.9     2.1  1.4  1.4  1.0  1.4  1.4     11.8 12.4 12.2  9.6 10.5 12.9
 75   11   19   S    2    4    1.8  1.4  2.1  1.7  3.5  5.0     2.6  2.1  1.1  1.4  0.7  0.7     11.9 12.2 12.5  9.9 10.5 14.2
 75   11   19   S    2    6    3.5  2.1  2.4  2.0  6.0  8.4     3.5  1.4  1.4  0.7  0.7  1.8     11.3 11.9 10.5  8.5  7.7 11.7
                        MEANS   1.7  1.8  1.7  1.9  4.2  7.6     2.4  1.9  1.5  1.0  0.9  1.0     11.6 12.3 11.9  9.4  9.9 12.8
                   STD. DEV.    1.0  1.0  0.9  0.5  1.1  2.0     0.7  0.6  0.3  0.3  0.3  0.5      0.4  0.2  1.2  0.7  1.1  1.0
YEAR MO. DAY TEX. PLOT REP.             NO3-N                                NH4-N                              , WATER CONTENT
 76    4   28   S    2    1    0.4  1.1  1.8  0.0  0.0  0.4     5.7  3.3  5.5  4.2  4.3  3.5     13.5 15.7 16.3 18.9 21.6 21.4
 76    4   28   S    2    2    0.4  1.9  0.7  0.0  0.0  0.4     5.0  4.8  5.9  4.6  5.6  4.1     14.1 16.8 17.0 19.0 23.7 26.8
 76    4   28   S    2    3    1.1  1.9  1.5  1.6  0.4  0.4     5.0  3.7  4.0  4.7  4.8  5.4     14.1 16.8 16.1 22.0 24.4 27.3
 76    4   28   S    2    4    0.4  1.1  1.1                    4.0  3.3  3.2                    14.8 16.9 14.2
 76    4   28   S    2    5    0.7  0.4  0.7                    4.1  4.5  3.7                    16.3 17.6 15.7
 76    4   28   S    2    6    0.7  1.5  1.5                    3.7  5.6  5.2                    15.5 17.5 17.1
 76    4   28   S    2    7    1.1  0.7  1.5                    2.9  4.0  6.3                    14.0 15.5 16.5
 76    4   28   S    2    8    1.1  0.7  0.7                    3.9  5.0  3.6                    12.6 14.2 14.8
 76    4   28   S    2    9    1.1  1.5  1.5                    3.3  4.9  2.6                    15.0 19.2 16.5
                        MEANS   0.8  1.2  1.2  0.5  0.1  0.4     4.2  4.3  4.4  4.5  4.9  4.3     14.4 16.7 16.0 20.0 23.2 25.2
                   STD. DEV.    0.3  0.5  0.4  0.9  0.2  0.0     0.9  0.8  1.3  0.3  0.7  1.0      1.1  1.4  1.0  1.8  1.5  3.3
YEAR MO. DAY TEX. PLOT REP.             NO3-N.                               NH4-N                              , WATER CONTENT
 76    5   27   S    2    1   18.4 13.9  8.3  4.1  2.1  1.5     3.1  3.2  2.2  2.4  2.5  1.2     11.1 13.5 13.9 10.6 12.1 20.0
 76    5   27   S    2    2   58.6 25.2 12.6  1.8  0.7  0.4     7.0  2.9  3.2  2.5  2.9  3.6     11.3 14.0 13.8 13.0 15.9 25.0
 76    5   27   S    2    3   12.1  9.4  3.2  0.7  1.1  1.2     3.8  1.8  1.4  1.8  1.5  1.2     10.9 14.1 12.1 14.9 16.3 22.8
 76    5   27   S    2    4    5.2  6.0 11.7                    2.4  2.5  2.8                    10.2 12.9 12.5
 76    5   27   S    2    5    8.4 18.0  5.0                    2.1  0.0  3.2                    11.3 14.2 13.4
 76    5   27   S    2    6    7.9  8.9  4.2                    1.7  2.9  1.8                    10.5 13.4 12.3
 76    5   27   S    2    7   20.6 50.8  7.0                    1.7 19.0  4.2                     8.6 12.3 12.2
 76    5   27   S    2    8    9.6  7.9  7.8                    2.7  2.2  2.8                    10.1 14.4 13.1
 76    5   27   S    2    9  130.1 20.1 11.1                  441.1  2.2  2.5                     9.2 14.0 13.8
                        MEANS  31.1 17.8  7.9  2.2  1.3  1.0    51.7  5.1  2.7  2.2  2.3  2.0     10.4 13.6 13.0 12.8 14.8 22.6
                   STD. DEV.   43.6 13.9  3.4  1.7  0.7  0.6   146.0  5.7  0.8  0.4  0.7  1.4      0.9  0.7  0.7  2.2  2.3  2.5
YEAR MO. DAY TEX. PLOT REP.             NO3-N                                NH4-N                              , WATER CONTENT
 76    6    9   S    2    1  155.6 19.6  8.4  2.8  2.1  2.2   110.8  5.2  3.5  2.1  1.7  2.2      5.9 11.5 11.5 11.2 11.6 15.6
 76    6    9   S    2    2   47.1 17.2  3.2  2.1  1.4  0.7    19.6  6.0  2.1  2.4  1.7  1.4     10.2 12.1 11.8 10.0  9.2 13.7
 76    6    9   S    2    3   61.0 19.8  4.5  1.4  1.0  0.7    86.6  6.3  3.1  2.0  2.1  0.7      7.1 11.2 10.6  9.3  9.6 17.1
 76    6    9   S    2    4   53.6 16.3  8.4                   82.4  4.3  2.8                    10.0 12.8 11.2
 76    6    9   S    2    5  211.1 25.8  6.3                  210.7  9.2  2.1                     6.9 12.4 11.2
 76    6    9   S    2    6   18.8 45.0  6.3                    1.4  1.1  0.7                     9.6 13.4 11.5
 76    6    9   S    2    7   25.7 15.7  5.7                    5.0  2.8  0.7                     7.5 11.6 12.5
 76    6    9   S    2    8   18.5 10.0  5.7                    1.7  0.7  0.7                    10.0 13.5 12.8
 76    6    9   S    2    9   35.1 17.8  7.4                    2.3  0.7  1.4                     6.9 13.2 12.0
                        MEANS  69.6 20.8  6.2  2.1  1.5  1.2    57.8  4.0  1.9  2.2  1.8  1.4      8.2 12.4 11.7 10.2 10.1 15.5
                   STD. DEV.   67.6 10.0  1.7  0.7  0.6  0.9    71.8  2.9  1.1  0.2  0.2  0.8      1.7  0.9  0.7  1.0  1.3  1.7
YEAR MO. DAY TEX. PLOT REP.             NO3-N.                               NH4-N                              , WATER CONTENT
 76    6   21   S    2    1   19.0 23.3 25.4  1.8  1.4  0.7    15.6  3.5  1.8  1.8  1.0  1.0     10.6 12.4 13.6 12.0 10.8 11.5
 76    6   21   S    2    2    7.0 35.7 31.4  3.5  1.4  0.7     2.5  4.3  1.4  1.7  1.4  2.1     11.9 13.5 14.4 11.2  9.9 12.7
 76    6   21   S    2    3   17.4 22.0 46.3  4.2  2.5  1.8     1.8  2.5  1.8  1.8  1.1  1.5     12.9 14.4 13.2 11.9 12.6 14.9
 76    6   21   S    2    4   13.5 54.1 16.2                    0.4 44.9  1.8                    13.2 12.5 12.3
 76    6   21   S    2    5    7.8 11.3 15.4                    0.0  0.0  1.7                    12.4 15.4 11.5
 76    6   21   S    2    6   66.6 59.9 22.8                   62.7  9.8  1.8                    11.3 14.9 11.9
 76    6   21   S    2    7  134.9 92.1 17.5                  207.7 20.4  3.2                    10.0 13.4 11.8
 76    6   21   S    2    8   70.6 52.7 48.3                   68.5 43.7  9.2                    11.5  7.0 12.3
 76    6   21   S    2    9  147.1 54.3 15.6                  239.5 17.4  2.1                    10.3 14.6 12.9
                        MEANS  53.8 45.0 26.5  3.2  1.8  1.1    66.5 16.3  2.8  1.8  1.2  1.5     11.6 13.1 12.7 11.7 11.1 13.0
                   STD. DEV.   55.0 24.7 12.9  1.2  0.6  0.6    93.2 17.3  2.5  0.1  0.2  0.6      1.1  2.5  0.9  0.4  1.4  1.7
YEAR MO. DAY TEX. PLOT REP.             NO3-N.                               NH4-N                              , WATER CONTENT
 76    7    5   S    2    1    9.9  4.2  2.4  5.2 13.7  5.2     4.4  1.1  0.7  0.7  0.4  0.4      9.7 11.7  9.6 11.3 12.0 17.1
 76    7    5   S    2    2   22.1 11.3  5.5 13.1 25.9  7.5     7.9  1.1  1.0  0.7  0.7  0.4      0.0 12.1 10.1 10.5 10.3 16.0
 76    7    5   S    2    3    4.4  9.9 12.4  6.2 13.5 10.6     1.0  1.1  1.0  0.7  0.7  0.4      9.7 12.5 10.1  9.7 10.9 15.5
 76    7    5   S    2    4   22.9 38.0 20.1                   12.4  1.7  1.0                     8.2 11.4 10.7
 76    7    5   S    2    5   58.4 99.0 35.7                   34.3  0.2  2.1                     5.8  9.8 10.1
 76    7    5   S    2    6   57.7 85.6 40.9                   72.9 37.0  3.3                     8.6 12.2 15.4
 76    7    5   S    2    7   28.9 36.4 49.3                    5.7  2.4  1.0                     8.2 10.0 10.3
 76    7    5   S    2    8   22.0 23.9 44.7                    7.0  1.7  1.0                     7.6 10.5  9.5
 76    7    5   S    2    9   33.5 24.4 37.7                    5.6  2.4  1.0                    12.2 11.4  9.0
                        MEANS  28.9 37.0 27.6  8.2 18.0  7.8    16.8  6.4  1.3  0.7  0.6  0.4      7.8 11.3 10.5 10.5 11.1 16.9
                   STD. DEV.   18.7 33.6 17.7  4.3  7.7  2.7    23.2 11.8  0.8  0.0  0.2  0.0      3.4  0.9  1.9  0.6  0.9  1.3
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YEAR MO. DAY TEX. PLOT REP.                 NO3-N                            NH4-N                            WATER CONTENT
 76   7   20   S    2    1     27.7 20.2 20.5 13.3  4.7  1.8     9.5  1.4  1.0  0.7  0.7  0.7     5.7  9.7  9.6  9.3  8.7 12.1
 76   7   20   S    2    2     26.8 31.9 22.4 12.1  6.5  1.8    17.0  1.7  1.4  0.7  0.7  1.1     5.9  9.8  8.9  8.4  9.8 13.4
 76   7   20   S    2    3     51.8 53.8 28.6 10.7  4.0  4.3     8.0  2.0  1.7  0.7  0.3  1.1    11.1  7.2  8.4  8.0  7.8 13.7
 76   7   20   S    2    4     81.0 34.2 26.8                   14.8  2.1  0.7                    6.5  9.6  6.9
 76   7   20   S    2    5     67.8 67.2 43.2                    9.4  2.5  0.7                    7.7 11.7 11.2
 76   7   20   S    2    6      6.0  9.3 11.0                    1.4  1.0  0.7                   12.4  7.2 10.3
 76   7   20   S    2    7      3.7  2.7  5.1                    1.7  0.7  0.7                    7.3  9.9  8.7
 76   7   20   S    2    8     12.7  9.0  9.3                    2.0  1.0  0.7                    7.6 10.3 10.6
 76   7   20   S    2    9     13.6 11.6  5.4                    1.7  1.4  1.0                    9.1 11.9  9.2
                      MEANS    32.3 26.7 19.1 12.0  5.1  2.6     7.3  1.5  1.0  0.7  0.6  1.0     8.1  9.7  9.3  8.6  8.8 13.1
                 STD. DEV.     28.1 22.1 12.7  1.5  1.3  1.4     6.0  0.6  0.4  0.0  0.2  0.2     2.3  1.6  1.3  0.7  1.0  0.9

YEAR MO. DAY TEX. PLOT REP.                 NO3-N                            NH4-N                            WATER CONTENT
 76   8    4   S    2    1      9.4 11.5 17.1 18.6  7.1  1.7     1.0  0.7  0.7  0.7  0.7  0.7     7.8  8.6  9.7 10.1  9.1  9.3
 76   8    4   S    2    2      5.3  8.9  5.1 15.5 17.8  4.4     0.7  0.7  0.3  0.7  0.3  0.3     6.9  9.9 10.0  8.5  8.0  8.7
 76   8    4   S    2    3     11.6 15.5 17.4 16.4  7.4  1.4     1.0  0.7  0.7  3.0  1.0  1.0     6.8  8.2  8.0  8.1  8.2 11.2
 76   8    4   S    2    4     11.3 10.0  9.6                    1.3  1.0  1.0                    5.2  7.6  9.9
 76   8    4   S    2    5     88.0 25.2  8.8                    5.7  3.8  1.4                    7.5  9.4  9.1
 76   8    4   S    2    6     23.8 34.4 36.0                    7.2  2.0  8.3                    5.6  6.9  6.7
 76   8    4   S    2    7     20.1 16.7 22.9                   11.8  1.3  1.0                    4.0  6.2  6.1
 76   8    4   S    2    8     34.0 14.5 11.2                    2.6  1.0  1.0                    5.9  8.3  8.8
 76   8    4   S    2    9      5.5  5.3 13.6                    1.3  1.0  2.0                    5.7  7.2  7.2
                      MEANS    23.2 15.8 15.7 16.8 10.8  2.5     3.6  1.4  1.8  1.5  0.7  0.7     6.2  8.0  8.4  8.9  8.4  9.7
                 STD. DEV.     26.0  9.0  9.3  1.6  6.1  1.7     3.8  1.0  2.5  1.3  0.4  0.4     1.2  1.2  1.5  1.1  0.6  1.3

YEAR MO. DAY TEX. PLOT REP.                 NO3-N                            NH4-N                            WATER CONTENT
 76   8   16   S    2    1     64.5 32.8 22.1  8.0  2.3  2.3     9.7  3.4  1.4  2.0  0.7  2.6     7.7  9.5  9.0  7.1  6.5  6.2
 76   8   16   S    2    2     19.4 19.9 19.9  9.6  8.6  2.4     2.6  3.2  1.6  2.3  0.7  2.4     6.2  4.6  5.6  4.6  6.5 10.6
 76   8   16   S    2    3     23.9 16.5 14.3 10.6  8.5  3.6     2.9  2.4  2.0  2.3  0.7  1.0     6.0  8.4  5.5  4.6  6.4  6.7
 76   8   16   S    2    4      4.0  5.6  5.1                    1.7  1.7  3.2                    8.0  6.8  4.6
 76   8   16   S    2    5      7.5 13.9 12.8                    5.1  2.4  1.3                    9.0  9.2  8.5
 76   8   16   S    2    6      5.0 11.5  9.8                    3.3  1.7  1.7                    7.9  9.0  8.5
 76   8   16   S    2    7      5.7 12.9 12.9                    2.0  3.4  1.4                    8.2  9.0  9.0
 76   8   16   S    2    8      6.6  9.9  6.6                    3.6  2.7  1.3                    7.0  7.0  7.1
 76   8   16   S    2    9      7.0  7.3  7.0                    2.7  2.3  2.7                    7.3  7.6  7.2
                      MEANS    16.0 14.5 12.3  9.4  6.5  2.8     3.7  2.6  1.8  2.2  0.7  2.0     7.5  7.9  7.2  5.4  6.5  7.8
                 STD. DEV.     19.6  8.2  5.9  1.3  3.6  0.7     2.4  0.7  0.7  0.2  0.0  0.9     1.0  1.6  1.7  1.4  0.1  2.4

YEAR MO. DAY TEX. PLOT REP.                 NO3-N                            NH4-N                            WATER CONTENT
 76   9   23   S    2    1     14.0 18.7 22.8  7.5  3.0  1.7     3.5  2.1  1.4  1.7  1.0  1.4    11.5 12.5 10.5  9.9  9.9  9.5
 76   9   23   S    2    2     14.4 49.0 28.1 20.4  7.7  2.6     2.1  1.4  1.0  1.0  1.0  0.7    12.0 11.7  9.9  9.3  7.5  6.7
 76   9   23   S    2    3     24.4 43.7 43.1 44.5  7.2  3.0    11.2 10.3  1.4  1.1  1.4  1.3    11.4 13.0 13.2 12.5 10.2  7.9
 76   9   23   S    2    4     66.1 63.8 24.9                   19.9  3.5  1.8                   13.0 12.7 13.2
 76   9   23   S    2    5     16.4 21.1  4.6                    2.9  1.8  1.8                   14.1 13.4 13.4
 76   9   23   S    2    6     28.5 69.2 38.9                    2.8  1.8  1.4                   12.1 12.9 11.1
 76   9   23   S    2    7      7.4 22.6 24.9                    1.4  1.4  1.0                   12.2 13.8 10.7
 76   9   23   S    2    8      2.8 13.5 11.4                    1.4  1.4  1.0                   12.8 12.8 10.3
 76   9   23   S    2    9     17.5 24.3 18.7                    2.8  1.8  1.7                   11.9 12.3 10.8
                      MEANS    21.5 36.2 24.2 24.1  6.1  2.4     5.3  2.8  1.4  1.3  1.1  1.1    12.3 12.8 11.5 10.6  9.2  8.0
                 STD. DEV.     18.5 20.8 12.1 18.8  2.4  0.7     6.2  2.9  0.3  0.4  0.2  0.4     0.8  0.6  1.4  1.7  1.5  1.4

YEAR MO. DAY TEX. PLOT REP.                 NO3-N                            NH4-N                            WATER CONTENT
 76  10   18   S    2    1      4.0 22.8 53.5 37.7 12.8  7.1     3.7  2.4  1.7  1.0  0.7  0.7     8.2 10.6 11.5 10.7 10.4  8.7
 76  10   18   S    2    2      1.7  1.7  3.1  4.4  6.8  5.4     1.7  1.0  0.7  0.7  0.3  0.3     8.7 10.5  9.0  8.9  9.3  8.9
 76  10   18   S    2    3      1.7  5.2  9.3 15.9  9.0  3.3     2.0  1.7  1.0  0.7  0.3  0.3     9.3 10.9 10.4  9.0  7.8  7.7
 76  10   18   S    2    4      1.4  1.7  3.0                    2.0  1.0  0.7                    8.7 10.7  8.6
 75  10   18   S    2    5      2.1  4.8  9.7                    2.4  1.7  1.4                    9.7 10.7 10.6
 76  10   18   S    2    6      4.7  7.0 10.8                    2.0  2.1  0.7                    8.8 11.5  8.4
 76  10   18   S    2    7      2.0  6.6 11.4                    2.0  2.1  1.4                    8.9 11.4 10.7
 76  10   18   S    2    8      1.0  1.8  6.0                    2.4  1.8  1.8                    9.8 11.8 12.7
 76  10   18   S    2    9      3.1  7.3 12.5                    2.0  1.7  1.4                    9.5 11.3  8.8
                      MEANS     2.4  6.5 13.3 19.3  9.5  5.3     2.2  1.7  1.2  0.8  0.4  0.4     9.1 11.0 10.1  9.5  9.2  8.4
                 STD. DEV.      1.3  6.5 15.5 16.9  3.0  1.9     0.6  0.5  0.4  0.2  0.2  0.2     0.5  0.5  1.5  1.0  1.3  0.6

YEAR MO. DAY TEX. PLOT REP.                 NO3-N                            NH4-N                            WATER CONTENT
 77   5    2   S    2    1      5.3  5.0  2.3  2.0  4.3  6.1     3.0  3.9  1.8  2.5  2.4  2.0    14.8 17.4 24.6 27.2 27.8 24.5
 77   5    2   S    2    3      2.0  2.4  4.9  2.3  4.1 12.5     2.3  0.6  1.7  0.9  0.9  1.0    11.1 13.2 20.9 19.5 23.7 21.5
 77   5    2   S    2    5      1.7  1.9  1.2  0.6  0.9  0.6     1.2  1.3  1.4  1.3  1.1  0.7    12.7 15.4 23.6 28.6 30.2 16.2
 77   5    2   S    2    2      5.5  2.7  3.3  2.0  1.8 17.9     3.1  2.6  3.9  1.7  2.0  1.1    14.6 17.0 20.5 19.4 22.0 22.8
 77   5    2   S    2    4      4.9  2.4  1.8  0.7  1.3  2.6     1.4  1.6  1.3  0.8  1.0  0.7    14.0 18.6 22.5 21.3 24.5 20.0
 77   5    2   S    2    6      3.7  2.0  0.9  1.3  1.8  0.8     1.5  1.7  1.4  0.9  1.1  0.9     6.9 14.8 20.5 21.9 23.2 22.4
                      MEANS     3.8  2.7  2.4  1.5  2.4  6.7     2.1  1.9  1.9  1.3  1.4  1.1    12.3 16.1 22.1 23.0 25.2 21.2
                 STD. DEV.      1.7  1.1  1.5  0.7  1.5  7.0     0.8  1.2  1.0  0.7  0.6  0.5     3.0  2.0  1.7  4.0  3.1  2.9
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YEAR MO. DAY TEX. PLOT REP.                  NO3-N                                    NH4-N                                 WATER CONTENT
 75   6   4   S    3    1     16.0  7.4  3.2  2.2  1.9  1.9     1.0  0.7  0.4  0.7  0.4  0.4     11.3 12.2 14.4 16.4 19.3 20.7
 75   6   4   S    3    2     15.4 12.5  3.6  2.9  1.5  1.5     0.3  1.1  0.4  0.4  0.4  0.4      9.8 13.1 13.6 14.5 19.3 18.2
 75   6   4   S    3    3      2.8 10.9  2.1  2.2  2.7  3.4     0.7  0.7  0.4  0.4  0.4  0.4     11.5 14.9 11.9 14.5 19.5 19.4
 75   6   4   S    3    4      3.8 13.4  1.7  1.6  1.4  2.0     1.0  0.7  0.3  0.4  0.4  0.4     10.5 12.6 11.3 21.2 14.6 22.1
 75   6   4   S    3    5     19.2 19.9  3.5  2.8  1.8  2.3     0.7  1.1  0.4  0.4  0.4  0.4     12.9 12.9 11.8 12.9 14.2 18.5
 75   6   4   S    3    6      9.0  9.2  3.2  2.2  2.2  3.1     0.3  0.7  0.4  0.4  0.4  0.8     10.6 12.3 14.2 14.4 15.4 21.6
                     MEANS    11.0 12.2  2.9  2.3  1.9  2.4     0.7  0.8  0.4  0.4  0.4  0.5     11.1 13.0 12.9 15.6 17.0 20.1
                 STD. DEV.     6.9  4.3  0.8  0.5  0.5  0.7     0.3  0.2  0.0  0.1  0.0  0.2      1.1  1.0  1.4  2.9  2.6  1.6
YEAR MO. DAY TEX. PLOT REP.                  NO3-N                                    NH4-N                                 WATER CONTENT
 75   7  17   S    3    1      9.4  2.9  1.6  1.6  2.8  4.5     2.5  2.6  1.9  2.6  1.7  2.7      2.2  4.7  4.2  6.4 11.5 18.8
 75   7  17   S    3    2     21.5  8.1  3.6  2.1  1.8  1.9     2.2  2.6  2.3  2.7  2.6  2.3      4.4  5.4  6.8 10.1 15.6 19.2
 75   7  17   S    3    3     19.3  7.4  1.6  1.4  2.6  3.0     3.9  1.0  2.9  2.1  3.0  3.0      4.5  5.1  5.5 10.6 16.7 18.5
 75   7  17   S    3    4      6.7  3.5  1.0  1.0  2.4  2.5     1.9  2.6  2.3  2.0  2.0  3.2      4.3  4.6  5.4  6.3  9.1 14.1
 75   7  17   S    3    5      6.7  2.0  1.3  1.7  1.0  1.8     4.5  1.9  2.0  3.1  2.3  2.1      4.2  4.3  6.8  9.7  6.8 13.0
 75   7  17   S    3    6     19.0  4.5  1.3  0.6  1.1  1.5     2.2  2.6  1.6  2.3  2.9  2.7      3.5  4.9  4.7  5.3 15.0 18.9
                     MEANS    13.8  4.8  1.7  1.4  1.9  2.5     2.9  2.4  2.2  2.5  2.4  2.7      3.8  4.9  5.6  8.1 12.4 17.1
                 STD. DEV.     6.9  2.4  0.9  0.5  0.8  1.1     1.1  0.4  0.4  0.4  0.5  0.4      0.9  0.4  1.1  2.3  4.0  2.8
YEAR MO. DAY TEX. PLOT REP.                  NO3-N                                    NH4-N                                 WATER CONTENT
 75   8  20   S    3    1      1.9  2.8  1.6  1.3  1.1  0.7     2.2  2.2  2.5  2.5  2.2  1.5      3.0  3.0  2.7  3.8 14.6 17.0
 75   8  20   S    3    2      1.9  2.8  1.9  1.0  1.7  1.1     0.6  1.6  1.3  3.2  1.4  1.8      2.9  3.3  3.1  4.5 10.9 15.3
 75   8  20   S    3    3      0.9  1.9  2.7  2.0  2.1  3.5     1.9  2.6  2.3  2.7  1.0  1.8      3.3  4.2  7.1  7.4 11.0 12.6
 75   8  20   S    3    4      0.6  2.5  1.3  1.0  1.4  1.1     3.1  2.5  2.5  1.0  1.7  1.1      2.8  3.8  3.4  8.2  9.7 15.7
 75   8  20   S    3    5      0.6  1.9  2.3  2.3  2.1  4.3     1.9  2.9  2.3  2.7  3.1  1.1      3.0  4.2  7.3  7.4 11.0 14.1
 75   8  20   S    3    6      1.3  1.3  1.0  1.6  1.3  1.0     1.3  2.2  2.6  2.4  1.3  1.4      3.1  3.3  6.6 22.0 29.0 10.9
                     MEANS     1.2  2.2  1.8  1.5  1.6  1.9     1.8  2.3  2.3  2.4  1.8  1.4      3.0  3.6  5.0  8.9 14.4 14.3
                 STD. DEV.     0.6  0.6  0.6  0.5  0.4  1.5     0.8  0.4  0.5  0.7  0.8  0.3      0.2  0.5  2.2  6.7  7.4  2.2
YEAR MO. DAY TEX. PLOT REP.                  NO3-N                                    NH4-N                                 WATER CONTENT
 75   9  23   S    3    1      0.7  1.8  1.5  1.1  0.8  0.8     0.4  0.4  0.0  0.0  0.0  0.0     12.4 13.3 14.0 14.6 21.7 18.8
 75   9  23   S    3    2      0.7  1.4  1.4  0.7  0.8  0.8     0.0  0.0  0.0  0.0  0.0  0.0     12.9 13.6 14.5 13.8 19.4 19.2
 75   9  23   S    3    3      0.7  1.1  0.7  0.8  0.8  0.8     0.7  0.4  0.0  0.0  0.0  0.0     14.3 14.2 14.7 16.1 18.7 24.4
 75   9  23   S    3    4      0.7  1.4  0.7  0.8  1.1  0.8     0.7  0.7  0.7  0.8  1.1  0.8     14.6 14.6 14.8 18.8 17.8 24.4
 75   9  23   S    3    5      0.7  1.1  0.7  0.4  0.4  0.8     0.0  0.0  0.0  0.0  0.0  0.0     13.7 14.9 15.4 17.3 16.6 19.7
 75   9  23   S    3    6      1.8  1.4  1.1  0.7  0.7  1.1     0.0  0.0  0.7  0.0  0.0  0.0     11.9 12.6 14.5 16.8 17.7 18.3
                     MEANS     0.9  1.4  1.0  0.7  0.8  0.8     0.3  0.2  0.2  0.1  0.2  0.1     13.3 13.9 14.7 16.6 18.6 20.8
                 STD. DEV.     0.4  0.3  0.4  0.2  0.2  0.1     0.3  0.3  0.4  0.3  0.4  0.3      1.1  0.9  0.4  2.0  1.8  2.8
YEAR MO. DAY TEX. PLOT REP.                  NO3-N                                    NH4-N                                 WATER CONTENT
 75  10  28   S    3    1      1.0  2.6  2.5  0.7  1.4  0.4     0.7  2.1  2.1  1.1  3.2  1.2     10.7 11.2 11.9 12.9 14.2 20.5
 75  10  28   S    3    2      1.4  2.6  2.1  2.1  0.7  0.4     2.4  0.7  1.1  0.7  2.1  0.8     10.6 11.6 11.9 12.6 13.7 20.5
 75  10  28   S    3    3      3.1  4.2  2.1  0.7  0.0  1.1     0.7  0.7  2.5  0.7  3.8  1.5     11.2 12.5 12.5 12.3 18.2 19.6
 75  10  28   S    3    4      1.7  3.2  1.8  1.1  0.8  0.0     1.7  5.0  1.8  2.1  0.4  1.1     11.2 13.0 12.7 12.1 18.1 19.6
 75  10  28   S    3    5      1.7  2.5  1.4  0.7  0.7  0.4     1.7  4.6  2.5  4.2  1.1  1.5     11.2 12.3 12.7 12.0 16.1 20.7
 75  10  28   S    3    6      0.7  1.8  1.1  0.7  1.1  0.8     2.1  2.1  1.1  1.4  1.1  1.5     11.2 12.1 12.7 12.2 15.8 20.6
                     MEANS     1.6  2.9  1.8  1.0  0.8  0.5     1.5  2.5  1.8  1.7  1.9  1.3     11.0 12.1 12.4 12.3 16.0 20.3
                 STD. DEV.     0.8  0.8  0.5  0.6  0.5  0.4     0.7  1.9  0.6  1.3  1.3  0.3      0.3  0.6  0.4  0.3  1.9  0.5
YEAR MO. DAY TEX. PLOT REP.                  NO3-N                                    NH4-N                                 WATER CONTENT
 76   4  28   S    3    1      0.7  6.4  4.5  2.2  1.5  1.2     2.9  2.6  2.6  2.6  2.2  1.5     14.3 17.6 18.4 17.3 16.5 20.1
 76   4  28   S    3    2      0.7  1.9  3.4  1.8  1.9  2.3     2.5  2.2  3.4  2.6  2.3  2.3     13.5 17.5 18.5 15.7 18.7 21.9
 76   4  28   S    3    3      1.8  5.2  6.0  1.9  2.3  1.5     1.8  1.9  3.8  2.3  1.9  1.5     14.6 17.6 18.0 18.1 19.1 20.5
 76   4  28   S    3    4      1.1  4.5  5.7                    2.9  2.3  3.0                    13.8 18.1 18.6
 76   4  28   S    3    5      1.1  5.3  8.8                    3.3  3.0  2.7                    15.5 19.3 20.0
 76   4  28   S    3    6      1.5  4.9  9.2                    2.9  3.0  3.4                    15.2 19.1 19.9
 76   4  28   S    3    7      1.4  3.3  5.7                    2.5  2.6  2.3                    13.1 16.6 18.9
 76   4  28   S    3    8      1.8  2.6  5.7                    4.6  2.2  2.3                    13.0 17.3 18.4
 76   4  28   S    3    9      1.4  3.4  6.4                    2.6  2.6  2.6                    12.6 17.2 17.9
                     MEANS     1.3  4.2  6.2  2.0  1.9  1.7     2.9  2.5  2.9  2.5  2.1  1.8     14.0 17.8 18.7 17.0 18.1 20.8
                 STD. DEV.     0.4  1.5  1.8  0.2  0.4  0.6     0.8  0.4  0.5  0.2  0.2  0.5      1.0  0.9  0.8  1.2  1.4  0.9
YEAR MO. DAY TEX. PLOT REP.                  NO3-N                                    NH4-N                                 WATER CONTENT
 76   5  26   S    3    1      8.6  6.5  4.7  1.8  1.5  1.5     0.7  0.7  0.4  0.4  0.4  0.4     13.5 15.1 14.2 14.3 20.3 19.4
 76   5  26   S    3    2      8.5  4.7  4.7  2.2  1.5  1.2     0.7  0.4  1.8  0.4  0.4  0.8      8.8 15.3 14.4 16.1 18.3 21.1
 76   5  26   S    3    3      6.4  4.7  3.6  1.4  1.2  1.2     0.7  0.4  0.4  0.4  0.0  0.0     13.2 14.5 13.8 14.2 20.4 20.5
 76   5  26   S    3    4      5.3  5.7  1.9                    0.4  0.7  0.8                    12.8 13.7 18.8
 76   5  26   S    3    5      7.1  9.4  2.6                    1.1 21.6  0.7                    12.3 14.3 15.2
 76   5  26   S    3    6      7.5  5.9  2.5                    3.6  1.1  0.7                    13.6 16.7 12.6
 76   5  26   S    3    7      5.0 10.4  5.1                   18.1  1.1  0.7                    12.8 16.9 15.2
 76   5  26   S    3    8     11.2  6.3  3.7                   33.7  1.1  0.7                    14.8 16.9 15.8
 76   5  26   S    3    9      7.2  5.5  3.4                    2.2  0.7  1.1                    14.0 16.2 17.4
                     MEANS     7.4  6.6  3.6  1.8  1.4  1.3     6.8  3.1  0.8  0.4  0.3  0.4     12.9 15.5 15.3 14.9 19.7 20.3
                 STD. DEV.     1.9  2.0  1.1  0.4  0.2  0.2    11.6  6.9  0.4  0.0  0.2  0.4      1.7  1.2  1.9  1.1  1.2  0.9
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YEAR MO. DAY TEX. PLOT REP.               NO3-N                              NH4-N                          WATER CONTENT
 76   6    7   S    3    1    23.3 13.6  5.7  1.4  1.1  1.6     1.0  0.7  0.7  0.7  0.4  3.1     7.4 13.7 13.9 12.4 17.7 21.7
 76   6    7   S    3    2    14.4 11.0  5.4  1.8  1.5  1.5     1.7  1.1  0.7  0.7  0.7  1.5     9.8 12.6 14.3 13.3 17.3 19.9
 76   6    7   S    3    3    19.6  8.1  4.2  1.1  0.8  1.5     1.4  1.4  0.7  0.7  0.4  0.4     8.8 12.7 12.2 12.8 18.4 20.7
 76   6    7   S    3    4    19.9  7.2  3.6                    1.0  1.1  0.7                   11.5 13.6 13.5
 76   6    7   S    3    5    12.4 11.9  7.1                    1.7  4.0  1.1                   10.0 14.3 13.0
 76   6    7   S    3    6    12.7  8.6  5.8                    1.4  3.9  0.4                   10.0 13.5 14.0
 76   6    7   S    3    7    10.3  7.5  4.5                    1.4  1.1  0.7                   12.6 14.0 17.6
 76   6    7   S    3    8     7.7  6.1  2.2                    1.0  1.8  0.7                   11.3 13.6 14.2
 76   6    7   S    3    9    28.7 18.7  3.9                    1.7  2.5  0.7                   10.5 13.9 12.5
                     MEANS    16.6 10.3  4.7  1.4  1.1  1.5     1.4  2.0  0.7  0.7  0.5  1.7    10.2 13.5 13.9 12.8 17.8 20.8
                STD. DEV.      6.8  4.0  1.5  0.4  0.4  0.1     0.3  1.2  0.2  0.0  0.2  1.4     1.5  0.6  1.6  0.5  0.6  0.9
YEAR MO. DAY TEX. PLOT REP.               NO3-N                              NH4-N                          WATER CONTENT
 76   6   21   S    3    1     5.6 15.1  6.8  1.7  1.8  1.1     0.4  0.0  0.0  0.7  0.4  0.4    12.0 13.9 14.2 11.1 13.2 19.3
 76   6   21   S    3    2    20.0 13.6  7.5  1.4  1.1  1.5     0.0  0.0  0.0  1.0  1.8  1.2    11.8 13.6 14.0 11.0 14.5 20.9
 76   6   21   S    3    3     8.1  9.0  3.6  1.4  1.1  1.9     1.8  1.8  0.0  1.1  1.1  1.5    11.8 14.4 13.0 11.9 19.0 20.7
 76   6   21   S    3    4     4.0 10.1  6.6                    0.0  0.4  0.0                   12.6 14.2 15.3
 76   6   21   S    3    5     7.4  9.7  4.0                    0.0  0.4  1.8                   12.5 14.3 14.2
 76   6   21   S    3    6     3.2 11.2  6.8                    0.0  0.0  2.3                   12.8 14.7 18.5
 76   6   21   S    3    7    12.3  6.9  2.2                    0.0  0.0  0.0                   12.3 14.6 14.0
 76   6   21   S    3    8     8.2 13.3  2.4                    0.4  0.4  0.0                   13.0 13.8 10.0
 76   6   21   S    3    9     5.6 17.6  6.0                    1.1  0.4  0.0                   12.3 13.7 12.5
                     MEANS     8.3 11.8  5.1  1.5  1.3  1.5     0.4  0.4  0.5  0.9  1.1  1.0    12.3 14.1 14.0 11.3 15.6 20.3
                STD. DEV.      5.1  3.3  2.1  0.2  0.4  0.4     0.6  0.6  0.9  0.2  0.7  0.6     0.4  0.4  2.3  0.5  3.0  0.9
YEAR MO. DAY TEX. PLOT REP.               NO3-N                              NH4-N                          WATER CONTENT
 76   7    7   S    3    1     3.1  1.4  2.1  1.0  1.4  1.9     0.7  1.1  0.7  0.7  0.4  0.8     9.3 12.0 11.3 10.9 14.5 21.2
 76   7    7   S    3    2     3.1  6.7  4.5  2.8  2.2  2.3     1.0  1.1  1.0  1.0  1.1  0.4     9.3 12.0 11.3 10.9 14.5 21.2
 76   7    7   S    3    3     1.0  6.0  6.3  1.7  1.1  1.6     0.7  1.4  1.4  1.4  0.7  0.8     9.3 12.0 11.3 10.9 14.5 21.2
 76   7    7   S    3    4     1.4 10.9  8.7                    0.3  2.5  0.3                    9.3 12.0 11.3
 76   7    7   S    3    5     4.1  4.9  8.0                    0.7  1.1  0.7                    9.3 12.0 11.3
 76   7    7   S    3    6     3.1  4.6  3.8                    0.7  1.4  1.4                    9.3 12.0 11.3
 76   7    7   S    3    7     2.0  7.4  5.9                    1.4  1.4  0.7                    9.3 12.0 11.3
 76   7    7   S    3    8     2.4  9.2  7.3                    1.7  1.1  1.0                    9.3 12.0 11.3
 76   7    7   S    3    9     6.1 14.4  8.7                    1.4  1.8  1.7                    9.3 12.0 11.3
                     MEANS     2.9  7.3  6.1  1.8  1.6  1.9     1.0  1.4  1.0  1.0  0.7  0.7     9.3 12.0 11.3 10.9 14.5 21.2
                STD. DEV.      1.5  3.8  2.3  0.9  0.6  0.4     0.5  0.5  0.4  0.4  0.4  0.2     0.0  0.0  0.0  0.0  0.0  0.0
YEAR MO. DAY TEX. PLOT REP.               NO3-N                              NH4-N                          WATER CONTENT
 76   7   20   S    3    1     2.0  1.0  1.7  6.0  1.4  1.2     0.7  0.3  0.3  0.3  0.4  0.0     8.0  9.6  8.8  7.1 14.7 20.8
 76   7   20   S    3    2    11.0  1.4  1.8  1.0  0.3  7.9     0.3  0.0  0.0  0.7  0.7  0.4     9.9 11.7 11.7  7.3 10.2 22.2
 76   7   20   S    3    3     1.0  2.1  1.0  1.4  0.0  0.8     0.7  1.0  1.0  0.3  0.7  0.0    11.4  9.8  9.3  8.8 17.3 21.1
 76   7   20   S    3    4     1.0  1.0  1.4                    0.7  0.3  0.0                    8.2  9.8  9.3
 76   7   20   S    3    5     4.1  0.7  1.3                    1.7  0.7  0.7                    8.9 10.4  7.2
 76   7   20   S    3    6     0.7  0.7  0.7                    1.0  1.0  0.7                   10.1 11.5 11.3
 76   7   20   S    3    7     1.0  0.7  0.7                    0.3  0.0  0.7                    6.5  7.7  6.3
 76   7   20   S    3    8     2.0  1.0  8.0                    0.7  0.3  0.7                    7.8  9.1  7.8
 76   7   20   S    3    9     0.3  1.4  1.0                    1.0  0.7  0.0                    8.5  9.6  9.1
                     MEANS     2.6  1.1  2.0  2.8  0.6  3.3     0.8  0.5  0.5  0.4  0.6  0.1     8.9  9.9  9.0  7.7 14.1 21.4
                STD. DEV.      3.4  0.5  2.3  2.8  0.7  4.0     0.4  0.4  0.4  0.2  0.2  0.2     1.4  1.2  1.8  0.9  3.6  0.7
YEAR MO. DAY TEX. PLOT REP.               NO3-N                              NH4-N                          WATER CONTENT
 76   7   23   S    3    1     0.7  1.7  1.0  0.3  2.5  1.2     0.7  2.1  1.0  1.0  0.4  1.5    11.8 10.2  6.0  5.7 13.3 20.0
 76   7   23   S    3    2     0.7  0.4  0.4  1.0  0.4  1.9     0.7  1.4  1.1  1.0  0.7  0.4    13.3 13.5 13.5  7.7 12.3 19.6
 76   7   23   S    3    3     1.1  1.1  0.7  0.7  1.0  1.7     1.1  1.1  1.1  0.7  1.0  1.0    13.3 12.2 12.2  8.6 10.1 11.4
 76   7   23   S    3    4     0.7  0.7  0.4                    1.1  1.4  1.1                   13.6 13.5 12.2
 76   7   23   S    3    5     0.3  0.3  0.7                    1.0  1.0  0.7                   11.4 11.0  8.1
 76   7   23   S    3    6     2.1  1.8  1.0                    0.4  0.7  0.3                   12.0 12.4 10.5
 76   7   23   S    3    7     0.7  4.7  1.8                    0.7  0.7  0.4                   13.8 15.0 14.7
 76   7   23   S    3    8     1.1  1.0  0.7                    0.4  1.4  0.7                   11.8 11.5  9.5
 76   7   23   S    3    9     1.4  1.4  1.0                    1.0  1.1  1.0                    8.7 12.6 11.2
                     MEANS     1.0  1.5  0.9  0.7  1.3  1.6     0.8  1.2  0.8  0.9  0.7  1.0    12.2 12.4 10.9  7.3 11.9 17.0
                STD. DEV.      0.5  1.3  0.4  0.4  1.1  0.4     0.3  0.4  0.3  0.2  0.3  0.6     1.6  1.5  2.7  1.5  1.6  4.9
YEAR MO. DAY TEX. PLOT REP.               NO3-N                              NH4-N                          WATER CONTENT
 76   8   18   S    3    1    11.3  6.1  3.3  0.7  0.4  1.1     0.3  0.3  0.3  0.0  0.0  0.0     7.1  9.9  6.7  5.6  6.0 14.5
 76   8   18   S    3    2    18.3 10.9  5.0  1.3  1.1  1.1     1.3  0.7  0.3  0.0  0.0  0.0     7.3  9.7  8.3  5.2 13.8 18.9
 76   8   18   S    3    3    14.3 10.3  7.1  0.7  1.8  1.1     0.7  0.7  0.3  0.3  0.0  0.0     7.4  9.6  8.9  5.8 12.5 18.8
 76   8   18   S    3    4    19.5  8.4  6.3                    1.0  0.4  0.7                    7.0 11.7 11.8
 76   8   18   S    3    5    13.5  7.2  3.3                    2.6  1.4  0.7                    6.6  9.3  6.6
 76   8   18   S    3    6    16.8 12.3  6.7                    0.7  0.7  0.7                    8.0 11.5 12.5
 76   8   18   S    3    7    15.2  7.8  5.2                    1.3  1.0  0.7                    5.0  9.2  5.7
 76   8   18   S    3    8    17.0  7.5  4.2                    1.0  0.7  0.7                    7.6  8.9  5.8
 76   8   18   S    3    9    18.4  6.2  2.0                    1.3  1.4  0.7                    7.8  9.8  8.4
                     MEANS    16.0  8.5  4.8  0.9  1.1  1.1     1.1  0.8  0.6  0.1  0.0  0.0     7.1 10.0  8.3  5.5 10.8 17.4
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YEAR MO. DAY TEX. PLOT REP.               NO3-N.                              NH4-N                                  .WATER CONTENT
 76   9   13   S    3    1     20.8 12.5 10.9  2.7  1.6  1.9     0.7  0.1  0.5  0.1  0.5  0.1      6.9 12.5 13.0 12.9 10.9 16.3
 76   9   13   S    3    2     25.9 10.1 10.8  2.6  1.6  1.9     0.7  0.1  0.5  0.4  0.3  0.1      9.6 12.6 13.3 12.8 11.4 15.5
 76   9   13   S    3    3      4.3  8.6  6.3  1.9  1.7  2.0     0.4  0.6  0.7  0.2  0.1  0.0      6.1 11.7 10.2 15.9  8.9 16.3
 76   9   13   S    3    4      5.8 13.9  9.3                    0.2  0.4  0.5                     8.9 11.4  9.2
 76   9   13   S    3    5      5.9 11.7  6.6                    0.7  0.5  0.7                     9.0  9.6  9.3
 76   9   13   S    3    6      6.6 15.4  8.6                    0.4  0.3  0.2                     8.8 17.5 10.2
 76   9   13   S    3    7      7.1 12.8  5.3                    0.1  0.2  0.0                     9.5 10.0 10.9
 76   9   13   S    3    8      8.0 13.8  8.8                    0.6  0.4  0.3                    10.8  9.6  8.9
 76   9   13   S    3    9      8.2 13.8  7.5                    0.8  0.7  0.4                     2.7 11.5 10.5
                     MEANS     10.3 13.2  8.2  2.4  1.6  1.9     0.5  0.4  0.4  0.2  0.3  0.1      8.0 11.8 10.6 13.9 10.4 16.0
                STD. DEV.       7.6  2.2  2.0  0.4  0.1  0.1     0.2  0.2  0.2  0.2  0.2  0.1      2.4  2.4  1.6  1.8  1.3  0.5
YEAR MO. DAY TEX. PLOT REP.               NO3-N.                              NH4-N                                  .WATER CONTENT
 76  10   18   S    3    1      4.5  5.3  8.8 19.2  6.7  1.9     0.7  0.7  0.7  0.4  0.4  0.4     10.8 12.1  9.2 13.2 16.5 20.0
 76  10   18   S    3    2      3.7  4.6  7.1 19.2  9.9  3.8     0.7  0.4  0.4  0.4  0.0  0.4      7.7 12.3 12.5 13.0 16.2 20.3
 76  10   18   S    3    3      2.1  4.3  6.4 10.9  5.0  3.5     0.3  0.4  0.4  0.0  0.4  0.0     10.9 13.6 13.3 12.0 13.7 21.9
 76  10   18   S    3    4      4.2  5.7  6.0                    0.7  0.4  0.4                    11.1 12.5 12.3
 76  10   18   S    3    5      3.1  4.7  6.0                    0.3  0.4  0.4                    10.9 13.8 12.9
 76  10   18   S    3    6      4.4  7.8 10.7                    0.3  0.7  0.4                     9.2 12.7 12.9
 76  10   18   S    3    7      3.2  4.0  6.4                    0.4  0.4  0.4                    11.7 14.0 13.5
 76  10   18   S    3    8      6.0  7.6  9.4                    0.7  0.7  0.7                    11.7  6.6 14.2
 76  10   18   S    3    9      4.9  7.4  9.1                    0.7  0.7  0.7                    11.9 12.5 11.3
                     MEANS      4.0  5.7  7.8 16.4  7.2  3.1     0.5  0.5  0.5  0.3  0.3  0.3     10.7 12.2 12.5 12.7 15.5 20.7
                STD. DEV.       1.1  1.5  1.8  4.6  2.5  1.0     0.2  0.2  0.1  0.2  0.2  0.2      1.4  2.2  1.5  0.6  1.5  1.0
YEAR MO. DAY TEX. PLOT REP.               NO3-N                               NH4-N                                  .WATER CONTENT
 77   5    2   S    3    1      0.7  0.6  1.7  9.2 11.1 10.0     0.7  0.6  0.4  0.4  0.4  0.4     15.2 15.7 16.9 19.7 21.1 23.3
 77   5    2   S    3    2      0.6  0.9  2.1  3.4  5.8 13.1     0.8  0.6  0.6  0.4  0.5  0.5     16.4 16.4 17.9 18.8 17.4 17.6
 77   5    2   S    3    3      0.9  1.1  4.9 10.7 16.4 22.3     1.1  0.9  0.9  0.6  0.8  0.5     16.5 16.8 18.3 18.5 20.2 21.9
 77   5    2   S    3    4      1.1  1.0  2.5  5.1  8.4 10.3     1.0  0.7  0.7  0.5  0.5  0.5     17.8 18.0 18.9 16.9 17.0 19.1
 77   5    2   S    3    5      0.6  1.0  1.1  1.8  3.4  5.0     0.9  1.0  0.6  0.5  0.6  0.8     15.9 16.1 14.4 16.0 18.3 22.3
 77   5    2   S    3    6      1.0  0.9  1.0  0.7  2.7  6.5     0.8  0.9  0.8  0.6  0.6  0.6     12.3 15.2 18.3 19.3 19.5 23.6
                     MEANS      0.8  0.9  2.2  5.1  8.0 11.2     0.9  0.8  0.7  0.5  0.6  0.5     15.7 16.4 17.4 18.5 19.1 21.3
                STD. DEV.       0.2  0.2  1.4  4.0  5.2  6.2     0.1  0.2  0.2  0.1  0.1  0.1      1.9  1.0  1.6  1.3  1.4  2.5
YEAR MO. DAY TEX. PLOT REP.               NO3-N                               NH4-N                                  .WATER CONTENT
 75   5   22   C    4    1     12.5  5.8  3.9  5.3  4.6  4.9     5.1  5.5  5.5  5.3  5.7  6.2     22.7 22.4 22.7 20.5 20.7 28.1
 75   5   22   C    4    2     13.2  8.2  6.4  4.7  3.8  4.2     5.4  5.9  5.6  5.4  5.3  5.4     22.3 22.6 24.4 22.0 20.0 20.7
 75   5   22   C    4    3     15.3  9.0  5.2  4.2  3.1  2.7     5.0  5.5  6.3  6.1  3.1  6.2     25.6 22.6 17.8 19.6 21.6 22.0
 75   5   22   C    4    4     37.2  5.9  4.7  4.5  1.9  2.0     6.1  5.5  5.8  5.7  1.9  5.5     26.2 23.1 21.9 19.7 21.9 23.2
 75   5   22   C    4    5     19.7  5.7  3.4  2.6  2.6  2.7     5.8  5.7  6.0  5.9  5.8  5.7     21.6 20.7 18.4 17.4 16.3 19.9
 75   5   22   C    4    6     15.9  8.5  2.9  1.1  4.5  4.3     5.7  5.8  1.1  1.1  0.0  0.0     19.8 21.8 17.1 18.9 18.8 21.8
                     MEANS     19.0  7.2  4.4  3.7  3.4  3.5     5.6  5.6  5.0  4.9  3.6  4.8     23.0 22.2 20.4 19.7 19.0 22.0
                STD. DEV.       9.3  1.5  1.3  1.0  1.1  1.2     0.3  0.2  2.0  1.9  2.4  2.4      2.4  0.8  3.0  1.5  2.1  2.9
YEAR MO. DAY TEX. PLOT REP.               NO3-N                               NH4-N                                  .WATER CONTENT
 75   6   24   C    4    1      7.5  6.2  4.6  3.8  2.7  1.5     1.1  3.5  1.1  1.1  0.8  1.2     18.8 22.1 20.8 20.5 19.9 21.3
 75   6   24   C    4    2      5.7  7.0  4.9  3.0  3.8  0.8     1.1  2.3  1.9  0.8  3.1  0.8     20.5 20.6 19.5 20.0 20.7 21.1
 75   6   24   C    4    3      3.0  4.1  2.6  1.1  2.9  1.1     0.7  0.8  0.7  0.7  2.9  0.7     17.9 19.1 16.8 17.8 16.9 17.8
 75   6   24   C    4    4      3.4  1.6  5.2  3.7  1.1  1.1     1.1  0.7  4.8  2.6  1.1  0.8     19.0 17.5 17.3 17.3 17.7 16.9
 75   6   24   C    4    5      3.7  2.6  2.9  2.1  1.5  1.1     0.7  0.7  1.1  2.5  3.7  2.2     16.6 17.4 15.9 14.2 17.5 16.0
 75   6   24   C    4    6      5.8  2.9  3.3  3.3  1.5  1.9     2.9  1.1  2.9  2.2  2.2  3.3     16.2 16.5 16.3 16.5 16.5 17.9
                     MEANS      4.8  4.2  3.9  2.8  2.3  1.3     1.3  1.5  2.1  1.6  2.3  1.5     18.2 18.9 17.8 17.7 18.2 19.2
                STD. DEV.       1.8  2.3  1.1  1.0  1.0  0.4     0.8  1.1  1.5  0.9  1.2  1.0      1.6  2.2  1.9  2.3  1.7  1.6
YEAR MO. DAY TEX. PLOT REP.               NO3-N.                              NH4-N                                  .WATER CONTENT.
 75   7   10   C    4    1      6.8 11.1  3.4  1.9  1.9  0.7     1.4  7.8  2.2  2.6  3.3  1.5     14.9 17.3 18.2 18.4 17.8 18.5
 75   7   10   C    4    2      8.2  6.6  3.8  2.2  1.1  0.4     1.1  1.5  1.9  1.5  3.8  1.9     14.4 16.4 19.2 18.7 20.0 18.4
 75   7   10   C    4    3      7.5  7.7  6.3  3.4  2.6  0.8     1.4  1.8  1.5  2.6  3.3  2.3     14.0 16.9 18.2 18.5 17.7 19.4
 75   7   10   C    4    4      8.7  6.9  5.7  4.3  2.9  1.6     1.5  2.3  1.5  2.8  1.9  2.7     19.8 20.4 19.3 43.5  5.3 23.0
 75   7   10   C    4    5      7.9  7.3  4.6  4.1  4.3  1.9     2.3  1.0  1.5  1.5  2.0  3.8     19.6 20.6 20.6 18.3 23.2 20.6
 75   7   10   C    4    6     12.2  5.7  4.3  3.5  3.5  1.2     1.6  1.0  1.9  2.0  2.3  2.3     26.5 20.7 22.5 22.9 22.1 20.9
                     MEANS      8.5  7.5  4.7  3.2  2.7  1.1     1.5  2.0  1.7  2.2  2.8  2.4     18.3 18.7 19.7 23.4 17.7 20.1
                STD. DEV.       1.9  1.9  1.1  1.0  1.1  0.6     0.4  2.4  0.3  0.6  0.8  0.8      4.8  2.0  1.6 10.0  6.5  1.7
YEAR MO. DAY TEX. PLOT REP.               NO3-N.                              NH4-N                                  .WATER CONTENT.
 75  10   22   C    4    1      0.4  1.3  1.3  0.4  0.0  0.0     1.7  2.2  2.1  1.2  2.8  0.8     33.8 35.8 31.3 26.2 20.8 24.6
 75  10   22   C    4    2      0.9  0.9  1.3  0.8  0.4  0.0     1.3  1.3  2.1  0.8  0.8  2.0     33.1 35.5 31.5 26.0 20.0 24.2
 75  10   22   C    4    3      0.4  0.4  0.8  0.8  0.4  0.0     0.9  0.9  0.8  0.8  0.8  1.6     32.9 33.1 28.0 27.3 25.5 23.5
 75  10   22   C    4    4      0.0  0.4  0.4  0.4  0.4  0.4     1.3  2.2  0.8  1.2  0.6  1.6     32.9 33.0 29.4 26.4 24.7 23.0
 75  10   22   C    4    5      0.0  0.4  0.0  0.0  0.0  0.0     0.8  0.8  0.8  0.4  0.4  0.8     27.6 28.9 24.6 22.5 23.0 22.5
 75  10   22   C    4    6      0.4  0.8  0.4  0.4  0.0  0.0     0.8  2.0  1.6  0.8  0.8  0.8     25.5 26.6 25.7 22.8 22.4 21.6
                     MEANS      0.3  0.7  0.7  0.5  0.2  0.1     1.1  1.6  1.4  0.9  1.1  1.3     31.0 32.1 28.4 25.2 23.0 23.2
                STD. DEV.       0.3  0.4  0.5  0.3  0.2  0.2     0.4  0.6  0.6  0.3  0.9  0.5      3.5  3.7  2.9  2.0  1.1  1.1
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YEAR MO. DAY TEX. PLOT REP.              NO3-N.                                     NH4-N                                        WATER CONTENT
 76   5   12   C    4    1      9.9   4.7   3.3   1.6   0.8   0.4        2.1   2.1   0.8   1.6   1.6   1.6        27.4 31.3 27.6 25.8 24.7 23.3
 76   5   12   C    4    2      1.7   1.2   1.2   1.2   0.4   0.4        1.7   1.6   1.2   1.2   1.3   1.7        27.2 24.8 23.8 23.2 29.7 28.3
 76   5   12   C    4    3      3.0   2.0   2.4   1.2   1.2   1.3        2.6   1.6   1.6   1.6   0.8   1.7        30.6 25.8 23.1 22.8 25.5 30.2
 76   5   12   C    4    4      4.2   3.5   2.1                          1.7   2.2   1.7                          28.9 33.1 30.0
 76   5   12   C    4    5      4.5   4.5   2.1                          1.1   1.7   2.5                          18.6 31.8 28.1
 76   5   12   C    4    6      4.2   3.4   2.5                          1.7   1.3   0.8                          28.1 30.7 29.8
 76   5   12   C    4    7      5.1   1.7   2.1                          3.4   1.3   1.3                          30.0 33.2 29.5
 76   5   12   C    4    8      3.9   1.7   1.7                          2.6   1.7   0.8                          31.2 32.7 28.3
 76   5   12   C    4    9      1.7   1.3   1.7                          8.0   1.3   2.6                          31.7 33.9 31.2
                      MEANS     4.2   2.6   2.1   1.3   0.8   0.7        2.8   1.6   1.5   1.5   1.2   1.7        28.2 30.8 27.9 23.9 26.6 27.3
                  STD. DEV.     2.4   1.3   0.6   0.2   0.4   0.5        2.3   0.3   0.7   0.2   0.4   0.1         3.9  3.3  2.8  1.6  2.7  3.6
YEAR MO. DAY TEX. PLOT REP.              NO3-N.                                     NH4-N                                        WATER CONTENT
 76   5   20   C    4    1    115.1  46.6   2.6   0.4   0.8   0.4      209.5  25.5   0.9   0.8   0.8   2.4        29.0 33.8 33.5 26.3 26.3 23.2
 76   5   20   C    4    2     98.0  20.0   3.4   0.8   0.0   0.0      250.9   3.1   1.7   1.6   1.6   2.0        32.9 35.0 30.0 25.4 25.8 22.6
 76   5   20   C    4    3     52.7   7.6   1.3   0.4   0.0   0.0       46.4   4.3   1.7   0.8   2.0   1.2        30.2 32.5 31.8 26.4 24.7 22.9
 76   5   20   C    4    4    112.5   6.7   4.3                         39.5   2.2   2.1                          29.0 32.4 30.6
 76   5   20   C    4    5     16.4   7.6   2.1                         15.9   2.7   0.4                          31.7 35.7 30.5
 76   5   20   C    4    6     25.5  10.0   1.3                         18.0   3.5   0.8                          28.4 32.6 30.1
 76   5   20   C    4    7     18.2   3.9   3.4                         13.6   0.4   1.7                          29.9 32.6 31.7
 76   5   20   C    4    8     30.3   4.8   2.1                          4.5   3.0   3.4                          26.3 32.8 31.3
 76   5   20   C    4    9     51.4  17.5   5.6                        210.6   1.8   1.7                          31.0 33.4 32.4
                      MEANS    57.8  14.1   2.9   0.5   0.3   0.1       90.1   5.2   1.6   1.1   1.5   1.9        29.8 33.4 31.3 26.0 25.6 22.9
                  STD. DEV.    40.4  13.3   1.4   0.2   0.5   0.2      101.7   7.7   0.9   0.5   0.6   0.6         1.9  1.2  1.2  0.6  0.8  0.3
YEAR MO. DAY TEX. PLOT REP.              NO3-N.                                     NH4-N                                        WATER CONTENT
 76   6    3   C    4    1    113.0  19.5   3.7   1.7   1.2   0.8       26.6   4.3   0.0   0.4   0.4   0.4        20.5 32.3 27.2 27.5 24.8 23.9
 76   6    3   C    4    2     39.6   7.8   3.8   2.1   1.2   1.2       16.7   0.0   0.4   0.0   0.0   0.4        28.2 32.4 30.9 27.6 27.2 24.1
 76   6    3   C    4    3    102.2  22.5   8.7   5.7   7.4   4.0       40.0   4.2   0.0   0.4   0.4   0.0        16.7 30.2 33.1 26.7 33.4 36.2
 76   6    3   C    4    4    106.6  19.3   3.3                          3.8   0.4   0.0                          20.3 29.1 27.9
 76   6    3   C    4    5      5.1  20.3   4.2                          0.0   3.4   0.8                          21.6 30.0 28.1
 76   6    3   C    4    6     26.8   9.1   6.6                          1.5   0.4   0.4                          19.8 32.6 27.7
 76   6    3   C    4    7     67.7   9.2   6.4                         18.6   0.4   0.4                          20.8 28.2 30.0
 76   6    3   C    4    8     48.5  14.0127.5                         17.7   2.1104.0                          22.6 30.4 30.6
 76   6    3   C    4    9     78.8  13.8   5.1                         14.7   0.0   0.4                          26.1 31.6 30.9
                      MEANS    65.4  15.7  18.8   3.2   3.3   2.0       15.5   1.7  11.8   0.3   0.3   0.3        21.8 30.8 29.6 27.3 28.5 28.1
                  STD. DEV.    38.0   6.5  40.8   2.2   3.6   1.7       12.8   1.8  34.6   0.2   0.2   0.2         3.4  1.6  2.0  0.5  4.4  7.0
YEAR MO. DAY TEX. PLOT REP.              NO3-N.                                     NH4-N                                        WATER CONTENT
 76   6   16   C    4    1     44.9  17.0   3.7   1.2   1.2   0.4        3.2   3.0   2.5   3.2   2.5   3.2        24.3 30.2 26.8 25.5 26.6 25.4
 76   6   16   C    4    2    107.3  17.0   4.7   2.0   0.8   0.8       15.9   2.6   3.0   3.7   3.6   3.3        28.4 33.0 29.7 25.7 23.9 26.2
 76   6   16   C    4    3    107.8   3.0   5.2   2.1   0.4   0.8       63.6   6.8   2.2   2.9   2.8   2.4        25.4 30.6 31.9 28.5 24.1 23.9
 76   6   16   C    4    4    298.1  15.8  10.6                         59.9   2.5   2.2                          23.3 28.0 33.9
 76   6   16   C    4    5    136.8  10.1  12.1                         21.0   2.1   1.7                          27.0 28.8 28.0
 76   6   16   C    4    6    109.5  17.7   5.9                         19.3   1.7   0.4                          26.6 32.1 30.2
 76   6   16   C    4    7     74.8  12.0   7.3                          7.0   1.2   1.3                          27.3 27.5 30.9
 76   6   16   C    4    8    128.4  15.6   6.9                         12.3   1.7   1.7                          19.9 29.2 32.1
 76   6   16   C    4    9    212.4  28.0  28.8                        108.4   2.5   6.7                          22.6 29.0 28.5
                      MEANS   135.6  15.2   9.5   1.8   0.8   0.7       34.6   2.7   2.4   3.3   3.0   3.0        24.9 29.8 30.2 26.6 24.9 25.2
                  STD. DEV.    76.3   6.9   7.7   0.5   0.4   0.2       35.2   1.6   1.8   0.4   0.6   0.5         2.7  1.8  2.2  1.7  1.5  1.2
YEAR MO. DAY TEX. PLOT REP.              NO3-N.                                     NH4-N                                        WATER CONTENT
 76   6   28   C    4    1     56.4  30.9  11.2   5.6   1.2   1.2        0.4   0.9   0.4   0.4   0.4   0.4        29.3 32.7 27.9 24.2 22.8 24.9
 76   6   28   C    4    2     63.9  14.5   4.5   3.6   0.4   0.4        2.9   0.4   0.4   0.4   0.4   0.4        26.5 29.7 27.2 23.7 21.2 23.0
 76   6   28   C    4    3     19.8  62.0   7.8   2.4   1.2   0.4        0.4   0.4   0.0   0.4   0.4   0.4        29.4 26.3 26.1 24.7 23.3 22.3
 76   6   28   C    4    4     46.3  23.8   6.7                          1.2   0.4   0.4                          25.5 26.8 22.4
 76   6   28   C    4    5    123.3  44.6  22.6                          1.3   0.4   0.4                          29.2 30.1 28.6
 76   6   28   C    4    6    114.0  38.7  34.6                          9.8   0.4   0.4                          18.2 29.1 29.6
 76   6   28   C    4    7    121.7  40.4  14.1                          4.8   0.9   0.4                          23.8 30.4 31.2
 76   6   28   C    4    8     82.0  27.0   9.0                          2.8   0.4   0.4                          23.6 31.0 31.5
 76   6   28   C    4    9     71.5  37.6  16.3                          1.2   0.9   0.0                          26.8 32.1 31.4
                      MEANS    77.7  36.3  14.1   3.9   0.9   0.7        2.8   0.6   0.3   0.4   0.4   0.4        25.8 29.8 28.4 24.2 22.4 23.4
                  STD. DEV.    36.0  14.2   9.5   1.6   0.5   0.5        3.0   0.2   0.2   0.0   0.0   0.0         3.6  2.2  3.0  0.5  1.1  1.3
YEAR MO. DAY TEX. PLOT REP.              NO3-N                                      NH4-N                                        WATER CONTENT
 76   7    7   C    4    1    125.8  69.0   9.9   3.7   1.6   0.4        2.0   0.9   0.4   0.4   0.4   0.8        23.0 31.8 31.4 28.1 26.8 24.1
 76   7    7   C    4    2     89.8  21.7  12.4   2.4   0.8   2.4        3.7   0.4   0.4   0.4   0.8   0.8        26.6 24.4 31.1 24.7 24.0 24.9
 76   7    7   C    4    3     49.4  25.5   8.4   2.0   0.0   0.0        1.2   0.4   0.4   0.8   0.8   0.8        26.2 31.9 28.8 24.1 23.7 21.7
 76   7    7   C    4    4     38.0   9.3   1.6                          3.2   0.4   0.4                          24.1 29.7 25.8
 76   7    7   C    4    5     29.3  26.0  11.4                          1.2   0.8   0.4                          23.2 24.7 25.6
 76   7    7   C    4    6     28.1  20.0   8.7                          0.8   0.9   0.4                          24.4 30.4 27.4
 76   7    7   C    4    7    159.0  30.4  16.2                          4.9   0.9   0.4                          26.0 34.3 27.9
 76   7    7   C    4    8    134.3  31.7   9.3                          5.1   0.4   0.4                          21.7 34.0 25.5
 76   7    7   C    4    9     89.2  32.6  16.6                          0.8   0.4   0.4                          28.7 32.8 30.5
                      MEANS    82.5  30.3  10.5   2.7   0.8   0.9        2.5   0.6   0.4   0.5   0.7   0.8        24.9 30.4 28.2 25.6 25.0 23.6
                  STD. DEV.    49.2  16.1   4.5   0.9   0.8   1.3        1.7   0.3   0.0   0.2   0.2   0.0         2.2  3.7  2.4  2.2  1.6  1.7
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YEAR MO. DAY TEX. PLOT REP.                  NO3-N                                  NH4-N                              WATER CONTENT
 76   7   21   C    4    1      19.0  6.5 10.8  7.6  4.0  0.8      0.4  0.8  0.4  0.4  0.4  0.4      29.5 25.6 24.0 23.5 23.3 21.8
 76   7   21   C    4    2      51.0 11.9 16.1  3.6  1.2  0.8      0.4  0.4  1.2  0.4  0.4  0.4      32.9 30.7 24.5 23.2 24.6 22.3
 76   7   21   C    4    3      26.7 11.8  4.1  0.8  0.0  0.4      0.0  0.4  0.4  1.2  1.2  0.8      35.1 33.4 26.0 26.6 23.4 20.6
 76   7   21   C    4    4      56.1  6.6 11.3                    0.4  0.8  0.4                     31.1 26.4 25.3
 76   7   21   C    4    5      42.2  6.5  6.0                    0.8  1.2  0.4                     25.6 25.2 23.4
 76   7   21   C    4    6      21.0  2.4  1.6                    1.2  0.8  0.4                     26.8 24.1 23.0
 76   7   21   C    4    7      42.0 22.6 16.7                    1.3  0.8  0.8                     29.0 26.7 25.6
 76   7   21   C    4    8      22.6  2.9  3.3                    0.9  1.2  0.8                     32.6 27.5 26.3
 76   7   21   C    4    9      14.0  4.9  6.4                    0.9  0.8  0.8                     33.0 18.1 30.1
                        MEANS   32.7  8.7  8.5  4.0  1.7  0.7      0.7  0.8  0.6  0.7  0.7  0.5      30.6 26.4 25.4 24.4 23.8 23.6
                    STD. DEV.   15.3  6.2  5.5  3.4  2.1  0.2      0.4  0.3  0.3  0.5  0.5  0.2       3.1  4.3  2.1  1.9  0.7  2.6

YEAR MO. DAY TEX. PLOT REP.                  NO3-N                                  NH4-N                              WATER CONTENT
 76   7   28   C    4    1      59.0 11.5  3.3  1.6  0.8  0.8      0.8  0.4  0.4  0.4  0.4  1.1      21.8 26.4 26.1 23.3 23.3 18.9
 76   7   28   C    4    2      24.2 14.1  7.1  3.9  1.6  1.2      0.4  0.0  0.4  0.4  0.4  0.4      26.5 28.0 23.1 22.8 24.7 23.4
 76   7   28   C    4    3       3.2  2.1  1.6  1.2  0.8  0.4      1.2  0.4  0.4  0.4  0.4  0.4      25.5 26.6 24.7 20.7 21.6 21.2
 76   7   28   C    4    4      32.3 10.6  2.7                    0.8  0.8  0.4                     22.6 25.5 21.8
 76   7   28   C    4    5      20.9  8.1  5.1                    0.8  0.8  0.8                     24.7 25.8 22.0
 76   7   28   C    4    6      36.4 11.8 12.1                    1.7  0.8  0.8                     28.6 29.8 28.2
 76   7   28   C    4    7      98.0 34.2 20.4                    0.9  0.4  0.4                     30.5 33.7 32.4
 76   7   28   C    4    8      34.8  6.5  2.3                    3.9  0.8  0.8                     20.7 25.0 21.1
 76   7   28   C    4    9      25.6  4.8  3.2                    1.2  0.8  0.4                     22.6 23.9 24.9
                        MEANS   37.2 11.5  6.4  2.2  1.1  0.8      1.3  0.6  0.5  0.4  0.4  0.6      24.8 27.2 24.9 22.3 23.2 21.2
                    STD. DEV.   27.2  9.3  6.2  1.5  0.5  0.4      1.0  0.3  0.2  0.0  0.0  0.4       3.3  3.0  3.6  1.4  1.6  2.3

YEAR MO. DAY TEX. PLOT REP.                  NO3-N                                  NH4-N                              WATER CONTENT
 76   8    9   C    4    1      13.4  4.3  2.4  1.5  1.5  0.8      1.9  0.8  0.4  0.8  0.8  0.8      17.1 22.8 22.2 19.1 18.9 18.3
 76   8    9   C    4    2      35.8  8.7  7.1  1.5  3.8  2.7      0.8  0.4  1.2  0.8  0.8  1.2      21.2 22.6 22.2 19.1 20.2 20.2
 76   8    9   C    4    3      10.2  3.1  3.2  1.5  1.1  1.2      1.2  0.4  0.8  0.8  0.8  0.4      22.6 19.5 23.9 19.7 19.6 20.4
 76   8    9   C    4    4      14.6  2.4  2.4                    0.8  0.8  0.8                     17.8 22.1 22.4
 76   8    9   C    4    5      10.2  5.5  3.1                    0.4  0.8  0.8                     22.1 22.2 21.0
 76   8    9   C    4    6       8.8  2.7  1.5                    1.1  0.4  1.5                     19.6 20.5 19.8
 76   8    9   C    4    7      19.6  5.9  2.7                    1.1  0.8  2.7                     11.8 21.9 22.1
 76   8    9   C    4    8      51.7 35.7 25.0                    0.8  0.8  0.8                     23.5 24.2 24.8
 76   8    9   C    4    9      18.3  3.1  2.8                    0.8  0.8  0.4                     21.3 20.5 22.8
                        MEANS   20.3  7.9  5.6  1.5  2.1  1.6      1.0  0.7  1.0  0.8  0.8  0.8      19.7 21.8 22.4 19.3 19.6 19.6
                    STD. DEV.   14.3 10.6  7.5  0.0  1.5  1.0      0.4  0.2  0.7  0.0  0.0  0.4       3.6  1.4  1.5  0.3  0.7  1.2

YEAR MO. DAY TEX. PLOT REP.                  NO3-N                                  NH4-N                              WATER CONTENT
 76   8   24   C    4    1      27.6 37.5 10.9  5.2  2.6  0.8      0.4  0.8  0.4  0.7  0.7  0.8      16.2 19.8 18.0 17.5 17.3 18.0
 76   8   24   C    4    2      36.7  2.7  3.4  1.1  0.7  0.7      1.4  0.4  0.4  0.7  0.4  0.4      13.1 19.1 19.1 16.9 16.9 16.3
 76   8   24   C    4    3       4.4  7.2  1.5  0.4  0.4  0.4      0.4  0.4  0.4  0.7  0.4  0.4      16.8 19.4 19.1 16.6 16.6 16.6
 76   8   24   C    4    4      11.1  6.0  3.1                    0.0  0.4  0.0                     13.5 18.6 21.2
 76   8   24   C    4    5      16.2  3.8  3.0                    1.1  0.0  0.4                     14.3 19.5 18.9
 76   8   24   C    4    6       4.6  1.9  1.5                    0.7  0.4  0.4                     13.3 19.2 17.7
 76   8   24   C    4    7       4.3  1.8  1.9                    0.7  0.4  0.4                     14.3 16.5 19.4
 76   8   24   C    4    8      22.9  6.8  4.9                    0.4  0.4  0.0                     17.8 19.8 18.9
 76   8   24   C    4    9      22.6  3.1  4.5                    0.7  0.0  0.0                     14.0 21.1 18.7
                        MEANS   16.7  8.1  3.9  2.2  1.2  0.6      0.6  0.4  0.3  0.7  0.5  0.5      14.8 19.2 19.0 17.0 16.9 17.0
                    STD. DEV.   11.6 11.3  2.9  2.6  1.2  0.2      0.4  0.2  0.2  0.0  0.2  0.2       1.7  1.2  1.0  0.5  0.4  0.9

YEAR MO. DAY TEX. PLOT REP.                  NO3-N                                  NH4-N                              WATER CONTENT
 76   9   15   C    4    1      14.3  4.1  5.7  1.3  1.6  1.4      1.7  0.5  0.3  0.7  0.6  1.3      20.5 20.8 19.6 19.1 17.6 17.7
 76   9   15   C    4    2       2.3  9.8  1.9  1.7  1.2  0.7      0.3  0.3  0.2  0.6  0.5  0.4      20.8 20.9 18.9 17.2 17.9 17.7
 76   9   15   C    4    3      15.4  6.7 14.5  1.6  1.0  0.8      0.4  0.5  0.3  0.4  0.5  0.6      21.6 21.0 19.7 19.9 17.0 17.3
 76   9   15   C    4    4      25.7  5.1  5.0                    0.5  0.3  0.3                     17.1 18.2 17.5
 76   9   15   C    4    5      33.4  2.4  1.1                    0.4  0.3  0.3                     22.1 17.7 18.3
 76   9   15   C    4    6      23.4  6.2  4.8                    0.5  0.4  0.2                     21.1 21.3 19.2
 76   9   15   C    4    7       4.1 12.5  1.8                    0.4  0.2  0.2                     17.4 18.0 16.7
 76   9   15   C    4    8      35.0  4.1  1.9                    0.6  0.3  0.3                     18.7 19.1 17.8
 76   9   15   C    4    9       4.0 11.9  1.7                    0.2  0.4  0.2                     20.2 21.9 19.4
                        MEANS   17.5  7.0  4.3  1.5  1.3  1.0      0.6  0.4  0.3  0.6  0.5  0.8      19.9 19.9 18.6 18.7 17.5 17.6
                    STD. DEV.   12.6  3.6  4.2  0.2  0.3  0.4      0.4  0.1  0.1  0.2  0.1  0.5       1.8  1.6  1.1  1.4  0.5  0.2

YEAR MO. DAY TEX. PLOT REP.                  NO3-N                                  NH4-N                              WATER CONTENT
 76  10   25   C    4    1      14.6 11.7 10.7  7.2  3.5  3.8      0.3  0.1  0.2  0.2  0.2  0.2      35.0 33.1 27.3 25.8 23.9 23.4
 76  10   25   C    4    2      11.9 11.5 11.1  5.0  1.8  7.3      0.2  0.1  0.1  0.1  0.5  0.1      33.8 30.4 30.6 25.8 21.6 19.7
 76  10   25   C    4    3      13.4 12.4 11.0  1.1  3.9  3.6      0.3  0.1  0.1  0.5  0.2  0.2      36.9 32.8 26.6 25.6 24.6 23.4
 76  10   25   C    4    4      12.4 12.5 11.0                    0.2  0.1  0.1                     32.9 30.7 30.1
 76  10   25   C    4    5       6.3  4.2  4.3                    0.2  0.1  0.2                     31.3 32.4 29.3
 76  10   25   C    4    6      14.5 13.1  8.8                    0.2  0.2  0.2                     33.5 30.9 28.3
 76  10   25   C    4    7       8.4 18.0 12.3                    0.2  0.2  0.2                     32.4 31.9 28.6
 76  10   25   C    4    8      10.7 12.7 17.4                    0.2  0.2  0.3                     33.1 31.7 28.7
 76  10   25   C    4    9       4.6  5.0  4.8                    0.2  0.1  0.2                     30.7 31.4 28.3
                        MEANS   10.8 11.2 10.2  4.4  3.1  4.9      0.2  0.1  0.2  0.3  0.3  0.2      33.3 31.7 28.6 25.7 23.4 22.2
                    STD. [illegible]   [illegible]                 [illegible]                        1.0 [illegible] 1.3  0.1 [illegible]
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YEAR MO. DAY TEX. PLOT REP.                   NO3-N                                 NH4-N                               ,WATER CONTENT
 77   5   2    C    4    1     4.8  7.2  8.3  5.2  2.8  1.6     1.1  1.1  1.0  1.2  0.8  0.9     29.0 31.3 30.0 25.8 24.8 24.2
 77   5   2    C    4    2     6.6  3.6  5.7  4.5  3.5  2.4     1.1  1.2  1.2  1.1  1.1  1.0     25.9 31.7 31.7 27.0 24.7 24.4
 77   5   2    C    4    3    13.5  7.1  9.3  6.7  4.6  2.8     2.5  1.3  0.9  1.0  1.9  1.2     28.0 33.1 31.9 26.8 26.2 25.1
 77   5   2    C    4    4    11.6 10.4 11.6  6.2  4.6  2.2     0.8  1.0  0.8  0.9  0.8  0.8     28.6 33.1 33.8 27.5 25.2 24.8
 77   5   2    C    4    5     8.0  6.0 10.5  8.3  3.4  1.4     1.3  1.1  1.0  1.0  1.0  0.9     28.8 32.1 33.5 28.2 26.7 24.1
 77   5   2    C    4    6    44.6 27.0  6.1 17.1  2.1  1.6    14.2  3.7  1.0  1.4  0.5  0.7     29.0 31.5 32.9 29.4 27.0 26.6
                     MEANS    14.8 10.2  8.6  8.3  3.5  2.0     3.5  1.6  1.0  1.1  1.0  0.9     28.4 32.1 32.3 27.4 25.8 24.9
                 STD. DEV.    14.9  8.5  2.4  4.6  1.0  0.6     5.3  1.1  0.1  0.2  0.5  0.2      1.4  0.8  1.4  1.2  1.0  0.9
YEAR MO. DAY TEX. PLOT REP.                   NO3-N                                 NH4-N                               ,WATER CONTENT
 75   5  26    C    5    1    11.1  6.1  3.0  3.7  3.7  2.9     6.9  9.7  6.0  5.9  6.3  5.5     20.3 26.1 18.0 17.3 17.4 16.7
 75   5  26    C    5    2    11.4  7.5  7.3  3.4  4.8  4.6     5.1  7.2  6.9  6.9  2.0  7.7     16.0 19.3 16.4 20.5 24.3 20.8
 75   5  26    C    5    3     9.5  5.0  3.8  3.8  3.4  3.1     5.3  7.5  6.5  6.5  6.9  6.2     20.2 29.4 20.3 21.1 20.2 21.7
 75   5  26    C    5    4    12.0  8.4  7.1  5.4  4.4  2.4     6.4  8.4  1.6  2.3  2.0  3.2     25.2 29.5 23.5 22.0 25.2 25.7
 75   5  26    C    5    5     6.5  4.7  6.8  4.6  4.2  4.2     6.5  6.0  2.0  1.9  2.3  1.9     26.0 31.3 24.9 20.3 21.4 20.3
 75   5  26    C    5    6    16.9  4.7  4.1  3.7  2.6  2.3     6.9  5.9  2.6  2.6  1.9  2.0     21.3 22.6 19.3 18.1 18.4 22.6
                     MEANS    11.2  6.1  5.3  4.1  3.8  3.2     6.2  7.4  4.3  4.3  3.6  4.4     21.6 26.4 20.4 19.9 21.1 21.3
                 STD. DEV.     3.4  1.6  1.9  0.8  0.8  0.9     0.8  1.5  2.4  2.3  2.4  2.4      3.4  4.6  3.3  1.8  3.1  3.0
YEAR MO. DAY TEX. PLOT REP.                   NO3-N                                 NH4-N                               ,WATER CONTENT
 75   7  15    C    5    1    27.4 10.6  5.9  5.9  4.8  5.7     3.0  2.7  2.6  2.9  2.9  3.8     18.9 19.9 16.9 16.7 16.8 20.5
 75   7  15    C    5    2    75.9 87.7 11.8  7.8  3.0  2.7    11.1 40.0  3.0  3.7  4.1  3.9     17.6 20.3 19.8 18.1 18.2 21.5
 75   7  15    C    5    3    14.7 13.6  3.5  2.5  4.5  2.6     3.4  2.0  3.2  3.2  3.4  3.3     19.0 14.3 13.3 13.4 19.5 17.9
 75   7  15    C    5    4     3.7  3.7  2.9  2.6  2.3  2.3     3.7  1.8  2.2  3.3  2.7  3.1     18.0 17.0 16.6 16.6 21.0 20.7
 75   7  15    C    5    5    21.6  9.0  3.2  1.8  2.3  1.9     3.7  2.6  2.5  2.9  3.8  3.5     17.9 19.2 15.1 15.7 20.9 21.9
 75   7  15    C    5    6    40.6 95.0 35.4 11.0  5.5  3.4     4.1 17.7  5.7  2.9  3.7  2.3     28.0 13.5  9.2 16.0 16.5 19.6
                     MEANS    39.0 36.7 10.4  5.4  3.7  3.1     4.8 11.3  3.2  3.1  3.4  3.3     19.9 17.4 15.1 16.1 18.8 20.4
                 STD. DEV.    35.5 42.8 12.7  3.8  1.4  1.4     3.1 15.3  1.3  0.3  0.5  0.6      4.0  2.9  3.6  1.6  2.0  1.4
YEAR MO. DAY TEX. PLOT REP.                   NO3-N                                 NH4-N                               ,WATER CONTENT
 75   8  12    C    5    1    29.8  4.5  3.3 18.4  1.8  0.8     1.9  1.9  1.8  3.0  2.6  1.9     19.2 19.0 16.8 17.2 16.4 19.3
 75   8  12    C    5    2    17.8  4.9  4.4  9.4  2.9  1.5     1.9  3.0  3.3  1.9  2.2  2.3     19.6 18.5 17.0 19.0 16.3 16.4
 75   8  12    C    5    3    39.7 12.5 11.7  1.9  2.2  2.2     3.6  1.5  1.9  2.6  1.5  1.5     19.5 19.0 19.6 17.6 16.9 16.3
 75   8  12    C    5    4    54.3 27.4  8.3 10.2 12.2  4.0     2.0  3.3  2.5  2.5  3.2  2.2     17.9 16.0 15.4 15.9 14.5 [illegible]
 75   8  12    C    5    5    25.4 13.3 12.1  2.2  1.1  2.2     2.7  2.3  2.6  2.2  4.8  2.0     19.9 20.1 19.5 18.4 16.5 16.6
 75   8  12    C    5    6    46.3  1.9 12.9 13.5  6.1  2.9     1.8  4.8  2.2  2.0  2.2  2.9     15.4 17.7 17.5 15.9 14.8 14.4
                     MEANS    35.5 10.8  8.8  9.3  4.4  2.3     2.4  2.8  2.4  2.5  2.8  2.3     18.6 18.8 17.6 17.3 15.9 16.9
                 STD. DEV.    13.7  9.5  4.1  6.4  4.2  1.1     0.8  1.2  0.5  0.4  1.1  0.6      1.7  0.9  1.6  1.3  1.0  1.9
YEAR MO. DAY TEX. PLOT REP.                   NO3-N                                 NH4-N                               ,WATER CONTENT
 75  10  15    C    5    1     0.0  0.4  0.0  0.0  0.0  0.4     0.8  0.4  1.1  1.5  0.8  0.4     28.1 22.8 20.5 20.7 23.1 21.0
 75  10  15    C    5    2     0.4  0.4  0.0  0.0  0.0  0.0     0.8  1.1  0.8  0.8  0.4  0.4     22.6 20.6 20.1 21.2 21.7 21.3
 75  10  15    C    5    3     2.3  2.0  0.0  0.0  0.0  0.0     1.6  0.8  1.2  0.8  1.1  0.4     22.9 24.2 23.4 23.5 20.4 22.1
 75  10  15    C    5    4     6.7  7.1  0.8  0.4  0.4  0.4     2.3  2.0  2.8  1.6  3.1  1.5     22.9 23.6 24.1 22.3 22.7 19.8
 75  10  15    C    5    5     2.0  1.6  0.8  0.8  3.8  0.0     4.4  2.8  1.9  1.6  1.5  4.2     23.0 25.1 22.4 23.4 21.2 20.9
 75  10  15    C    5    6     4.8  3.1  0.8  1.6  0.0  0.0     2.2  5.1  2.4  2.5  2.6  5.3     17.3 23.4 24.1 14.7 17.5 19.7
                     MEANS     2.7  2.4  0.4  0.5  0.7  0.1     2.0  2.0  1.7  1.5  1.6  2.0     22.9 23.3 22.4 21.0 21.1 20.8
                 STD. DEV.     2.6  2.5  0.4  0.7  1.5  0.2     1.3  1.7  0.8  0.6  1.1  2.2      3.4  1.5  1.8  3.3  2.0  0.9
YEAR MO. DAY TEX. PLOT REP.                   NO3-N                                 NH4-N                               ,WATER CONTENT
 76   5  13    C    5    1     6.1  4.7  4.2  3.6  2.8  2.0     0.8  0.4  0.4  0.8  0.4  0.4     26.3 30.6 28.2 23.7 22.7 23.9
 76   5  13    C    5    2     2.9  1.8  0.8  1.6  1.2  0.4     1.2  0.9  0.4  0.4  0.4  0.4     27.4 34.4 25.9 24.3 23.6 22.0
 76   5  13    C    5    3     2.3  4.2  3.3  5.2  4.0  3.6     0.8  0.4  0.8  0.4  0.4  1.2     19.2 28.9 27.1 24.6 24.5 25.1
 76   5  13    C    5    4     4.7  3.9  1.3                   0.4  0.9  0.0                   30.0 33.1 29.1
 76   5  13    C    5    5     3.0  1.7  0.8                   1.3  0.4  0.4                   20.6 29.9 26.4
 76   5  13    C    5    6     2.4  2.0  1.7                   0.4  0.8  0.8                   25.4 23.5 29.5
 76   5  13    C    5    7     3.6  1.3  1.6                   0.8  0.0  0.4                   23.1 34.3 25.8
 76   5  13    C    5    8     3.4  4.3  2.9                   0.4  0.4  0.4                   29.4 32.5 27.3
 76   5  13    C    5    9     5.2  3.0  4.3                   0.8  0.9  0.8                   23.5 30.5 21.8
                     MEANS     3.7  3.0  2.3  3.5  2.7  2.0     0.8  0.7  0.5  0.5  0.4  0.7     26.0 30.9 26.8 24.2 23.6 23.7
                 STD. DEV.     1.3  1.3  1.4  1.8  1.4  1.6     0.3  0.3  0.3  0.2  0.0  0.5      3.6  3.4  2.3  0.5  0.9  1.6
YEAR MO. DAY TEX. PLOT REP.                   NO3-N                                 NH4-N                               ,WATER CONTENT
 76   6   2    C    5    1     9.9  2.1  1.6  1.1  1.2  1.6     0.7  1.3  0.8  1.5  1.5  2.3     15.6 28.8 22.7 19.2 20.2 21.6
 76   6   2    C    5    2     7.6  4.5  2.7  2.7  1.9  1.2     0.8  2.0  2.3  1.5  0.8  2.4     24.1 26.5 21.1 20.2 20.0 22.8
 76   6   2    C    5    3     6.3  2.5  2.4  3.1  2.3  1.6     0.8  0.8  0.4  1.6  1.9  0.8     22.2 28.9 23.1 21.8 20.8 23.8
 76   6   2    C    5    4     4.3  1.7  1.2                   1.3  2.1  1.2                   32.6 27.3 21.3
 76   6   2    C    5    5     5.8  1.2  0.8                   1.0  0.8  1.7                   27.1 26.8 28.4
 76   6   2    C    5    6     3.5  1.2  0.8                   1.7  1.6  1.0                   33.0 23.4 26.8
 76   6   2    C    5    7     4.2  3.7  1.2                   0.8  7.7  0.4                   28.9 26.0 27.1
 76   6   2    C    5    8     1.3  1.6  0.8                   1.7  1.2  0.4                   28.2 22.1 23.6
 76   6   2    C    5    9     1.6  1.7  1.2                   2.4  0.9  0.4                   25.8 32.0 24.0
                     MEANS     4.9  2.2  1.4  2.3  1.8  1.5     1.3  2.0  1.0  1.5  1.4  1.8     26.4 26.9 24.2 20.4 20.3 22.7
                 STD. DEV.     2.8  1.1  0.7  1.1  0.6  0.2     0.6  2.2  0.7  0.1  0.6  0.9      5.4  3.0  2.6  1.3  0.4  1.1
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YEAR MO. DAY TEX. PLOT REP.                  NO3-N                                     NH4-N                              .WATER CONTENT
 76   6   17   C    5    1      13.2  1.2  0.8  0.4  0.0  0.0       1.8  1.6  0.8  0.8  0.8  0.4       13.5 26.4 24.4 23.3 21.7 21.0
 76   6   17   C    5    2       3.4  0.8  1.2  0.4  0.4  0.4       0.4  1.6  0.8  0.4  0.4  0.4       19.2 25.1 25.4 23.0 19.5 20.3
 76   6   17   C    5    3       6.0  2.4  1.6  0.8  0.4  0.4       0.4  0.8  0.4  0.4  0.4  0.4       23.6 23.8 23.8 20.9 19.7 20.8
 76   6   17   C    5    4      14.9  2.1  2.0                      0.8  1.2  0.4                      22.2 27.8 25.1
 76   6   17   C    5    5      13.8  0.8  1.3                      0.8  2.0  1.7                      20.2 26.2 28.3
 76   6   17   C    5    6      11.6  7.6  5.4                      1.2  0.8  0.8                      20.6 23.9 21.1
 76   6   17   C    5    7      28.3  6.1  5.2                      0.8  0.8  0.4                      18.5 26.0 23.7
 76   6   17   C    5    8      21.1  2.5  1.6                      1.1  0.8  0.0                      18.5 26.8 24.1
 76   6   17   C    5    9      30.5  4.0  4.2                      0.8  0.0  0.0                      19.3 28.0 28.1
                     MEANS      15.9  3.1  2.6  0.5  0.3  0.3       0.9  1.1  0.6  0.5  0.5  0.4       19.5 26.1 24.9 22.4 20.3 20.7
                STD. DEV.        9.2  2.4  1.8  0.2  0.2  0.2       0.4  0.6  0.5  0.2  0.2  0.0        2.8  1.6  2.2  1.3  1.2  0.4
YEAR MO. DAY TEX. PLOT REP.                  NO3-N                                     NH4-N                              .WATER CONTENT
 76   7   14   C    5    1      12.5  9.5  5.9  3.9  4.4  3.6       0.8  1.2  0.4  0.8  0.8  0.8       21.7 27.5 23.0 22.0 23.4 24.9
 76   7   14   C    5    2       4.0  2.0  1.2  2.3  2.7  2.3       1.2  0.8  0.8  0.8  0.8  0.8       24.0 26.3 21.2 21.0 21.2 21.5
 76   7   14   C    5    3       5.6  4.8  4.4  3.9  3.6  4.0       0.8  0.8  0.8  0.8  0.8  0.8       24.1 25.0 24.2 22.8 23.7 23.8
 76   7   14   C    5    4       3.2  1.6  0.8                      1.2  6.6  0.8                      24.2 27.1 25.1
 76   7   14   C    5    5       1.9  0.8  0.8                      4.3  5.3  0.8                      20.8 26.1 21.2
 76   7   14   C    5    6       5.1  2.9  2.0                      0.8  1.3  1.2                      21.7 28.3 22.9
 76   7   14   C    5    7       5.1  3.7  4.7                      1.0  1.2  0.8                      22.7 26.2 22.8
 76   7   14   C    5    8       8.9  2.5  2.0                      0.8  0.8  0.4                      25.2 29.9 24.0
 76   7   14   C    5    9      10.2  3.0  4.8                      0.8  1.3  0.8                      22.4 29.5 24.0
                     MEANS       6.3  3.4  3.0  3.4  3.6  3.3       1.4  2.1  0.8  0.8  0.8  0.8       23.0 27.3 23.2 21.9 22.8 23.4
                STD. DEV.        3.5  2.0  2.0  0.9  0.9  0.9       1.1  2.2  0.2  0.0  0.0  0.0        1.5  1.6  1.3  0.9  1.4  1.7
YEAR MO. DAY TEX. PLOT REP.                  NO3-N                                     NH4-N                              .WATER CONTENT
 76   8    5   C    5    1      15.1  4.7  1.9  1.5  1.5  1.1       0.7  1.2  1.1  0.8  0.8  0.8       16.0 21.9 17.9 18.1 19.6 19.6
 76   8    5   C    5    2       8.8  2.7  0.8  1.1  1.1  0.8       1.5  1.9  3.4  1.1  0.4  0.8       15.7 20.3 19.6 18.4 19.4 21.1
 76   8    5   C    5    3      15.1 16.3  1.1  0.0  0.4  0.8       1.8  0.7  2.3  3.1  3.0  0.4       11.9 12.2 19.0 10.1 18.8 23.3
 76   8    5   C    5    4       1.8  0.7  0.4                      2.6  3.7  3.2                      16.5 15.9 12.3
 76   8    5   C    5    5       1.9  1.5  0.7                      3.7  2.6  0.7                      16.8 18.1 16.8
 76   8    5   C    5    6       7.7  1.2  0.4                      1.1  1.5  1.1                      16.1 20.4 19.6
 76   8    5   C    5    7       2.9  1.1  1.1                      2.5  3.4  3.0                      13.6 18.3 16.6
 76   8    5   C    5    8       4.9  1.5  1.1                      0.7  1.5  3.3                      11.4 18.1 15.5
 76   8    5   C    5    9       1.1  0.8  2.9                      2.1  1.1  1.5                      12.5 17.8 16.1
                     MEANS       6.6  3.0  1.2  0.9  1.0  0.9       1.9  2.0  2.2  1.7  1.4  0.7       14.5 18.1 17.0 15.5 19.3 21.3
                STD. DEV.        5.5  5.0  0.8  0.8  0.6  0.2       1.0  1.1  1.1  1.3  1.4  0.2        2.1  2.8  2.3  4.7  0.4  1.9
YEAR MO. DAY TEX. PLOT REP.                  NO3-N.                                    NH4-N                              .WATER CONTENT
 76   8   25   C    5    1       5.6  2.2  1.8  2.2  1.1  0.0       1.0  0.8  0.7  0.7  0.7  1.5       11.0 17.8 16.1 15.6 15.9 15.9
 76   8   25   C    5    2      12.3  1.5  1.8  1.1  0.7  0.4       1.1  0.7  0.7  0.7  1.1  0.7       12.1 17.3 12.0 16.7 15.9 16.1
 76   8   25   C    5    3      10.1  1.5  1.9  1.1  0.4  0.0       0.7  2.3  0.4  0.7  1.5  0.7       14.2 18.3 17.1 16.2 16.3 15.4
 76   8   25   C    5    4       4.9  2.6  2.6                      0.7  0.7  0.7                      12.1 17.2 17.5
 76   8   25   C    5    5       6.9  3.3  1.9                      1.1  0.7  1.1                      15.4 16.3 16.6
 76   8   25   C    5    6       5.8  2.3  1.9                      0.4  1.1  0.7                      15.4 17.9 17.6
 76   8   25   C    5    7      14.1  7.2  2.6                      0.0  1.9  0.7                      16.9 19.0 17.5
 76   8   25   C    5    8       9.0  5.2  1.9                      0.4  0.4  0.8                      14.2 17.2 18.1
 76   8   25   C    5    9      19.6  3.0  2.6                      1.1  0.8  1.1                      11.7 17.8 18.4
                     MEANS       9.8  3.2  2.1  1.5  0.7  0.1       0.7  1.0  0.8  0.7  1.1  1.0       13.7 17.6 16.8 16.2 16.0 15.8
                STD. DEV.        4.8  1.9  0.4  0.6  0.4  0.2       0.4  0.6  0.2  0.0  0.4  0.5        2.0  0.8  1.9  0.6  0.2  0.4
YEAR MO. DAY TEX. PLOT REP.                  NO3-N.                                    NH4-N                              .WATER CONTENT
 76   9   22   C    5    1      23.7 11.3  3.3  1.5  1.1  1.4       0.4  0.8  0.7  0.7  1.1  1.0       22.9 21.2 15.9 15.5 15.7 11.3
 76   9   22   C    5    2       2.3  4.0  2.2  1.4  1.4  1.1       1.5  1.5  0.7  1.1  1.1  0.7       19.2 20.1 16.8 13.4 12.9 12.8
 76   9   22   C    5    3       1.5  2.0  1.9  1.1  0.8  0.4       1.5  1.5  0.7  1.1  0.8  0.7       18.3 16.5 17.2 15.5 18.7 17.1
 76   9   22   C    5    4       5.6  4.0  2.3                      2.0  0.8  0.8                      24.6 23.2 19.5
 76   9   22   C    5    5       8.1  4.0  1.6                      1.2  0.8  1.2                      25.6 23.9 23.2
 76   9   22   C    5    6       3.2  2.8  2.0                      2.4  1.6  1.2                      25.6 23.7 22.5
 76   9   22   C    5    7       4.1  3.4  2.0                      2.0  2.6  1.2                      26.5 31.3 21.6
 76   9   22   C    5    8       2.9  3.7  1.5                      1.2  0.8  0.8                      28.1 25.6 20.5
 76   9   22   C    5    9       2.1  4.1  0.8                      1.3  0.8  0.8                      28.2 27.5 18.9
                     MEANS       5.9  4.0  2.0  1.3  1.1  1.0       1.5  1.2  0.9  1.0  1.0  0.8       24.3 23.7 19.6 14.8 15.8 13.7
                STD. DEV.        7.0  2.6  0.7  0.2  0.3  0.5       0.6  0.6  0.2  0.2  0.2  0.2        3.6  4.3  2.6  1.2  2.9  3.0
YEAR MO. DAY TEX. PLOT REP.                  NO3-N                                     NH4-N                              .WATER CONTENT
 76  10   12   C    5    1       4.2  4.4  4.8  2.0  1.7  1.5       0.9  0.8  0.8  1.1  1.2  1.0       26.3 26.3 24.1 20.7 20.6 16.9
 76  10   12   C    5    2       4.7  4.0  5.6  1.1  1.8  2.8       2.7  1.2  4.5  2.6  1.5  1.2       25.3 28.0 25.6 20.2 21.0 21.5
 76  10   12   C    5    3       4.6  4.0  4.9  1.7  2.0  1.6       2.3  0.7  0.4  0.9  1.4  0.9       20.7 26.2 24.6 20.5 20.1 19.3
 76  10   12   C    5    4       5.6  4.2  5.1                     10.4  0.7  1.4                      27.0 26.8 24.5
 76  10   12   C    5    5       3.9  3.7  3.7                      5.5  1.7  1.1                      26.7 29.0 25.5
 76  10   12   C    5    6       3.8  3.3  5.7                     10.8  0.8  2.0                      24.1 27.2 25.9
 76  10   12   C    5    7       3.5  3.0  2.9                     16.6  2.5  0.9                      26.0 29.8 25.3
 76  10   12   C    5    8       4.6  4.0  4.6                     15.4  1.7  0.8                      23.5 24.3 23.2
 76  10   12   C    5    9       2.5  5.0  3.6                     15.5 12.5  1.2                      26.5 29.3 26.5
                     MEANS       4.2  4.0  4.5  1.6  1.8  2.0       8.9  2.5  1.5  1.5  1.4  1.0       25.1 27.4 25.0 20.5 20.6 19.9
                STD. DEV.        0.9  0.6  1.0  0.5  0.2  0.7       6.2  3.8  1.2  0.9  0.2  0.2        2.0  1.8  1.0  0.3  0.5 [illegible]
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YEAR MO. DAY TEX. PLOT REP.                 NO3-N                                     NH4-N                                    .WATER CONTENT
 77   5    2   C    5    1       9.5  4.0  4.4  4.8  3.0  2.7       0.9  0.8  0.9  1.0  0.4  0.7       32.7 26.9 25.7 21.0 17.5 20.8
 77   5    2   C    5    2      27.5 11.9  7.7  5.7  4.3  2.6       5.6  1.3  0.7  0.7  0.7  0.5       20.5 23.5 25.1 23.3 25.3 22.0
 77   5    2   C    5    3      24.0  5.1  4.0  4.6  5.3  4.2       3.6  0.8  0.9  0.7  0.6  0.7       19.3 25.5 26.2 24.5 25.3 23.4
 77   5    2   C    5    4      51.5 13.5  7.6  5.5  5.1  2.4      17.6  0.7  0.9  0.9  0.8  0.5       22.5 27.3 26.2 25.5 23.4 22.1
 77   5    2   C    5    5      42.0 10.8  9.6  5.7  3.4  3.4       7.2  0.9  1.0  0.9  1.0  0.9       22.7 26.8 29.5 25.0 23.9 26.3
 77   5    2   C    5    6      24.8 16.6  9.9  6.1  3.0  2.5       1.4  1.0  0.9  0.7  0.7  0.8       22.4 26.1 26.6 22.8 22.1 23.5
                         MEANS  29.9 10.3  7.2  5.4  4.0  3.0       6.1  0.9  0.9  0.8  0.7  0.7       23.3 26.0 26.5 23.7 22.9 23.0
                     STD. DEV.  14.8  4.9  2.5  0.6  1.0  0.7       6.1  0.2  0.1  0.1  0.2  0.2        4.8  1.4  1.5  1.7  2.9  1.9
YEAR MO. DAY TEX. PLOT REP.                 NO3-N.                                    NH4-N                                    .WATER CONTENT
 75   6    3   C    6    1       0.8 13.8 10.0  8.4  8.0  5.6       0.8  0.8  0.4  1.6  0.8  0.8       25.1 29.5 25.0 24.8 25.4 24.7
 75   6    3   C    6    2      14.7  9.9  6.5  5.5  4.8  3.2       0.8  1.7  0.8  0.8  0.4  1.2       24.2 32.1 26.7 24.0 25.1 25.3
 75   6    3   C    6    3      20.7 10.6  6.7  6.3  5.9  3.9       0.4  0.8  0.8  0.4  1.6  0.8       20.9 27.3 23.6 23.8 23.1 22.5
 75   6    3   C    6    4      11.4  2.9  4.1  3.6  2.4  2.0       1.6  2.4  2.4  1.6  1.6  1.6       26.8 26.9 26.7 25.1 24.5 22.7
 75   6    3   C    6    5      14.3  7.5  6.2  4.7  4.4  2.8       1.2  2.5  1.6  0.8  1.6  1.6       27.4 28.5 22.5 22.9 25.5 24.3
 75   6    3   C    6    6      12.2  7.2  4.7  5.1  4.0  2.3       1.6  2.1  1.6  1.6  1.6  1.6       26.3 31.1 23.9 23.0 24.3 22.7
                         MEANS  12.3  8.6  6.4  5.6  4.9  3.3       1.1  1.7  1.3  1.1  1.3  1.3       25.1 29.2 24.7 23.9 24.6 23.7
                     STD. DEV.   6.5  3.7  2.1  1.0  1.9  1.3       0.5  0.8  0.7  0.5  0.5  0.4        2.4  2.1  1.7  0.9  0.9  1.2
YEAR MO. DAY TEX. PLOT REP.                 NO3-N                                     NH4-N                                    .WATER CONTENT
 75   7   23   C    6    1      19.3 12.7  6.3  6.1  5.7  3.1       3.5  2.2  2.9  3.0  3.8  2.7       12.7 16.0 17.0 20.2 19.3 22.1
 75   7   23   C    6    2       7.1  7.3  4.9  5.6  5.1  4.2       2.8  2.2  3.4  3.3  3.1  2.8       13.7 16.4 18.4 17.7 22.3 13.1
 75   7   23   C    6    3      22.3 15.2  7.1  9.2  9.0  6.0       2.2  2.9  2.6  3.7  2.2  2.4       16.2 15.3 18.2 16.9 18.5 25.7
 75   7   23   C    6    4      14.8 11.7  8.1  7.6 11.9  4.6       2.5  2.9  2.6  2.2  2.5  4.2       15.3 16.7 17.5 15.6 15.5 20.7
 75   7   23   C    6    5      10.3  7.6  6.0  4.5  3.3  2.7       2.8  2.9  3.8  3.3  3.7  4.2       13.5 16.0 19.0 17.9 17.3 20.6
 75   7   23   C    6    6       8.7  7.4  7.4  4.8  3.0  2.7       2.8  2.2  3.3  3.0  2.6  2.3       12.1 17.5 17.8 17.3 17.5 19.8
                         MEANS  13.7 10.3  6.6  6.3  6.3  3.9       2.8  2.5  3.1  3.1  3.0  3.1       13.9 16.3 18.0 17.6 18.4 20.3
                     STD. DEV.   6.1  3.4  1.1  1.6  3.5  1.3       0.4  0.3  0.5  0.5  0.7  0.9        1.6  0.7  0.7  1.5  2.3  4.1
YEAR MO. DAY TEX. PLOT REP.                 NO3-N                                     NH4-N                                    .WATER CONTENT
 75   9   10   C    6    1       2.3  2.0  2.0  1.2  1.2  0.8       2.3  2.0  2.0  2.0  2.4  1.6.      22.1 24.6 24.8 24.6 24.6 22.6
 75   9   10   C    6    2       2.8  2.4  2.4  2.4  2.8  2.0       3.2  2.8  3.2  3.2  2.8  3.1       23.8 24.3 24.7 24.8 23.6 22.7
 75   9   10   C    6    3       1.9  1.6  2.0  2.4  2.0  1.2       3.1  2.4  3.2  2.4  2.0  2.3       22.1 25.5 25.6 23.9 25.1 22.3
 75   9   10   C    6    4       3.2  2.9  2.4  1.6  1.6  1.2       2.4  2.0  2.8  2.4  2.0  2.4       25.3 27.4 26.3 24.2 23.8 23.2
 75   9   10   C    6    5       3.2  2.5  2.4  2.0  2.0  1.2       2.4  1.6  1.6  1.6  2.4  2.0       24.2 27.4 26.2 25.2 25.6 24.8
 75   9   10   C    6    6       2.3  2.0  2.0  2.9  2.4  1.6       2.7  1.6  2.0  2.9  2.4  2.0       22.7 25.5 25.9 27.2 24.8 24.6
                         MEANS   2.6  2.2  2.2  2.1  2.0  1.3       2.7  2.1  2.5  2.4  2.3  2.2       23.4 25.8 25.6 25.0 24.6 23.4
                     STD. DEV.   0.5  0.5  0.2  0.6  0.6  0.4       0.4  0.5  0.7  0.6  0.3  0.5        1.3  1.3  0.7  1.2  0.8  1.1
YEAR MO. DAY TEX. PLOT REP.                 NO3-N                                     NH4-N                                    .WATER CONTENT
 75  11    6   C    6    1       1.6  1.2  1.6  1.6  0.8  1.2       0.4  0.8  0.4  0.4  0.8  0.4       23.2 27.5 26.0 27.5 24.8 23.9
 75  11    6   C    6    2       1.2  1.2  1.6  0.8  1.2  4.0       0.4  3.2  0.8  0.8  0.8  0.4       23.5 26.0 24.8 24.3 24.5 24.4
 75  11    6   C    6    3       1.2  4.1  3.6  1.2  1.2  0.8       0.8  0.4  1.2  0.4  0.4  3.1       25.8 26.8 24.8 24.9 24.6 22.9
 75  11    6   C    6    4       3.6  3.6  1.2  0.8  1.2  0.4       0.4  0.4  0.4  0.4  0.4  0.4       24.5 25.0 23.7 23.6 24.5 22.7
 75  11    6   C    6    5       2.3  2.0  1.2  0.8  1.2  0.4       0.4  0.4  0.4  0.4  0.4  0.4       22.5 23.6 22.7 24.2 23.7 21.7
 75  11    6   C    6    6       2.4  2.8  1.6  1.2  0.8  0.4       1.2  0.4  0.4  0.4  0.4  0.4       24.4 24.3 22.0 24.1 24.6 21.5
                         MEANS   2.0  2.5  1.8  1.1  1.1  1.2       0.6  0.9  0.6  0.5  0.5  0.8       24.0 25.5 24.0 24.8 24.4 22.8
                     STD. DEV.   0.9  1.2  0.9  0.3  0.2  1.4       0.3  1.1  0.3  0.2  0.2  1.1        1.2  1.5  1.5  1.4  0.4  1.2
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