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Wastewater Renovation and Retrieval on Cape Cod

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WASTEWATER RENOVATION AND RETRIEVAL ON CAPE COD

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FOREWORD

The Environmental Protection Agency (EPA) was established to coordinate administration of the major Federal programs designed to protect the quality of our environment.

An important part of the agency's effort involves the search for information about environmental problems, management techniques and new technologies through which optimum use of the nation's land and water resources can be assured and the threat pollution poses to the welfare of the American people can be minimized.

EPA's Office of Research and Development conducts this search through a nationwide network of research facilities and by cooperative efforts with state agencies and private institutions. In this case, we are pleased to acknowledge the active participation of the Commonwealth of Massachusetts and the Woods Hole Oceanographic Institution, Woods Hole, Massachusetts.

The Robert S. Kerr Environmental Research Laboratory is responsible for the management of programs to: (a) investigate the nature, transport, fate and management of pollutants in groundwater; (b) develop and demonstrate methods for treating wastewaters with soil and other natural systems; (c) develop and demonstrate pollution control technologies for irrigation return flows; (d) develop and demonstrate pollution control technologies for animal production wastes; (e) develop and demonstrate technologies to prevent, control or abate pollution from the petroleum refining and petrochemical industries; and (f) develop and demonstrate technologies to manage pollution resulting from combinations of industrial wastewaters or industrial/municipal wastewaters.

This report contributes to the knowledge essential if the EPA is to meet the requirements of environmental laws that it establish and enforce pollution control standards which are reasonable, cost effective and provide adequate protection for the American public.

William C Galegar

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ABSTRACT

A rapidly increasing population on maritime Cape Cod has generated considerable interest in alternative wastewater disposal techniques which promise to maintain high groundwater quality and promote its conservation. Such deliberations, five years ago, led the authors to undertake an assessment of agricultural spray-irrigation as a potential means of lessening groundwater contamination and depletion. In the course of these studies individual components of an entire wastewater-cropping facility have been isolated and subjected to detailed examination. Experimental emphasis has been placed on variations in the rates and methods of wastewater application and in the types of rennovative agricultural crops placed under wastewater irrigation.

Results from these studies have been highly promising and suggest that under ideal circumstances, the coupling of secondary domestic effluent to animal forage crops can bring about a degree of wastewater renovation which exceeds direct disposal to sand filter beds and approaches the goals of tertiary treatments. Moreover, three desirable consequences, i.e., water conservation, crop irrigation and nourishment and wastewater renovation are simultaneously achievable. Further confirmation and extentions of these results could mean an elevation of domestic wastewaters into the category of a significant natural resource.

Geologically, Cape Cod is viewed as a glacial outwash plain connected to a series of drown river valleys. The local geohydrology features several hundred feet of glacial till overburdening deep basement rock, a condition ideally suited for wastewater irrigation. Also available is a considerable amount of undeveloped acreage which could be committed to wastewater recycling. The soil is generally sand and poor in an agricultural sense, yet usage and conditioning has resulted in dry forage grass yields in excess of 8.9 metric tons (four short tons) per hectare per year.

Relative to crop requirements, there is characteristically an excess of phosphorus over nitrogen in most secondary effluents. However, excess phosphorus which the plants are unable to utilize is readily bound within the uppermost foot of soil. A similar fate is accorded unassimilated heavy metal ions which are also stabilized within the soil and denied access to underlying groundwater. Distinct from the above behavior, other chemical elements of secondary effluent such as chloride, sodium, potassium and boron have been observed to penetrate the groundwater to a considerable extent. The ultimate impact of such penetration has not been fully resolved.

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LIST OF ABBREVIATIONS

Special

AFB	Air Force Base
Δ	Delta, difference between two values
DPD	Diethyl-p-phenylene diamine
E	East
EPA	Environmental Protection Agency
ET	Evapotranspiration
F-ratio	Significance level
HC	Hydraulic conductivity
I_c	Chlorination index - concentration of chlorine (mg per l) necessary to provide a 90 percent reduction in MS-2 concentration
K_1	Linear intercept
K_2	Linear slope
MS-2	Coliphage, culture designation
N:P	Nitrogen:phosphorus ratio
P4 X 6	Escherichia coil, culture designation
PFU	Plaque forming units
ROW	Retrieval observation well
R-value	Degree of chemical reduction
S	South
Sd	Standard deviation
SFB	Sand filter bed
SPSS	Statistical package for the social sciences
SY	Specific (hydraulic) yield
TEA	Total effluent applied
THL	Total hydraulic load

Quantity

cals	calories
cm	centimeter
gal	gallon
ha	hectare
in	inch
kg	kilogram
km	kilometer
l	liter
m	meter
m^3	cubic meter
mm	millimeters
Mi	mile
Mi^2	square mile
ml	milliliter
pH	-log hydrogen ion concentration
ppm	part per million
ppb	part per billion
μm	micrometer

LIST OF SYMBOLS

Miscellaneous

°C	Degrees Celsius
P	Protein
C	Carbohydrate
L	Lipid
>	More than
<	Less than
=	Equal to
ΣP	Total phosphorus

Chemical

B	Boron	Mg	Magnesium
C	Carbon	Mn	Manganese
Ca	Calcium	N	Nitrogen
Cd	Cadmium	NH_4	Ammonium
Cl	Chloride	NO_2	Nitrite
Cr	Chromium	NO_3	Nitrate
Cu	Copper	Na	Sodium
Fe	Iron	P	Phosphorus
H	Hydrogen	PO_4	Phosphate
K	Potassium	Zn	Zinc

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The Lockwood Corporation of Gering, Nebraska kindly provided a rotary irrigation machine at no cost to the project and rendered assistance with its errection and maintenance. Also, the Rainbird Company of Glendora, California was an important source of advice on sprinkler selection compatible with the irrigation requirements for the research activity.

We also acknowledge the cooperation received from the Groundwater Branch of the U.S. Geological Survey on matters relating to hydrological measurements and information concerning aquifer characteristics of the local Cape Cod groundwater. Prominent contributors in this area are Michael Frimter, Jack Guswa and Dennis LeBlanc.

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SECTION 1

INTRODUCTION

BACKGROUND

Between 1974-78 the Cape Cod Wastewater Renovation and Retrieval Project of the Woods Hole Oceanographic Institution investigated spray-irrigation-cropping as a means of furthering secondary wastewater treatment on Cape Cod. These efforts have been generously supported by the Research and Development Office of the U.S. Environmental Protection Agency, and by the Division of Water Pollution Control, Commonwealth of Massachusetts. A series of interim reports [1-4] prepared at this institution describes the background, concepts, research facilities, and scientific contributions attached to these efforts.

Coastal areas, such as Cape Cod, which have evolved geologically as terminal moraines, often present unique hydrological features which can markedly influence groundwater management. The topsoil of such areas is often a wind-blown sandy loam which overlies deposits of coarse sand and gravel extending to bedrock several hundred feet below the surface. The bulk of this overburden is water saturated and in some instances subdivided into an upper fresh-water lens which floats above a deeper and denser saltwater layer. The high permeability characteristic of these soils tends to favor the development of lakes and ponds rather than river formations; the former representing surface exposure of the local groundwater table [5, 6]. In this situation, groundwater is the only reliable source of freshwater available for domestic and industrial use.

Groundwater reserves are highly vulnerable to excessive exploitation and quality deterioration associated with rapid industrial development and population growth. Cape Cod, a summer recreational area of southeastern Massachusetts has a year round population of about 115,000. During the summer months a tenfold increase in population is not unusual. The native population, increasing each year by about 3.8 percent, is expected to double by the year 2000. Within the same time period, an average increase of 20 percent in daily individual water usage is predicted. To meet anticipated demand, community water facilities will need to double over the next 20 years.

In coastal areas a finite amount of recharge to groundwater is essential to maintain the subsurface hydraulic barrier which controls saltwater intrusion across the seawater/freshwater interface. Excessive groundwater losses, i.e., excessive wastewater disposal to the sea, can upset the existing freshwater-seawater equilibrium with damaging consequences. A case in point is that of Nassau County, Long Island where the combined effects of excessive groundwater removal by a burgeoning population has led to excessively high concentrations of sea salts and nitrates in the groundwater [7].

Many coastal or peninsula towns, typical of Cape Cod are slowly but surely approaching the maximum recommended rate of groundwater removal, which has been placed at about one half the annual amount of groundwater recharge [6]. Over the entire Cape area, present demand amounts to about 16% of the annual recharge volume but three communities are already withdrawing more than 30 percent of the recommended maximum. A return of a prolonged drought, such as was encountered during the mid 1960's, could dramatically increase the threat of a domestic water shortage on Cape Cod.

An additional challenge to Cape Cod's groundwater resource is the increasing amount of pollution which inevitably accompanies population growth. Short-term impactions of fast-moving natural waters, having relatively short flushing times are usually transitory whereas pollution of an underground aquifer can persist for a much longer period of time. Presently the most popular means of domestic wastewater disposal on Cape Cod is via on-site septic tanks, cesspools and/or leaching fields. Wastewater disposal via marine outfalls is not practiced to any appreciable extent. Where municipal collection and sewage treatment facilities are operative, terminal wastewater disposal is to groundwater via sand filter beds. Sludge separated during the treatment process is delivered to sludge drying beds and ultimately removed for burial.

In summary, groundwater deterioration on Cape Cod emanates from the following major considerations [8].

1. Inadequate municipal wastewater and sludge disposal techniques.

2. Leachates and run-off from poorly operated land-fills and septage ponds.

3. Encroachment of saltwater into wells designated to provide potable water due to excessive groundwater exploitation.

4. Contamination from pleasure boating in freshwater ponds.

5. Combined effects ranging from reduced recharge due to an increased amount of paved area, pond eutrophication and inadvertent industrial contamination.

6. Long-and short-term population instabilities which impose uncertain demands on municipal water supply and wastewater disposal.

By 1973 the above considerations led to deliberations concerning appropriate means of upgrading wastewater quality to advance groundwater utility and public health safety. The need for such measures was underlined by chemical observations on the status of soil - and groundwaters which receive secondary treated sewage effluent via sand filter beds at Otis Air Force Base, Cape Cod. In part, these observations revealed concentrations of inorganic combined nitrogen which greatly exceeded the potable water quality standard recommendations of the U.S. Environmental Protection Agency. Subsequently, a pilot scale agricultural spray-irrigation system employing animal forage grasses, soil infiltration and terminal groundwater deposition was proposed to the Office of Research and Development of the Environmental Protection Agency and to the Division of Water Pollution Control of the Commonwealth of Massachusetts.

In conventional wastewater spray-irrigation systems involving agricultural crops, the crop is but one of several renovative components which contribute to water quality improvement. The renovative process is also advanced by lagooning, atmospheric exchanges, soil interactions and dilution by groundwater. The nature and abundance of accepted chemical and biological indicators in influent wastewater, as opposed to the underlying groundwater, is a measure of the overall effectiveness of the combined system.

OBJECTIVES

The principal objective of the authors has been to demonstrate the long-term advantages of an agricultural wastewater spray-irrigation system on Cape Cod as a basis for encouraging increased wastewater recyling and groundwater conservation. A variety of experimental regimes affecting agricultural parameters along with the extent of soil and groundwater modifications have been scrutinized. Appropriate comparisons have been made for wastewater recharge systems which exclude agricultural crops and for agricultural crops denied wastewater irrigation.

The overall program has placed specific emphasis on the following criteria in order to encourage and help shape future wastewater-irrigation programs on Cape Cod.

1. Facilities design and season operations.

2. Agricultural acreage and irrigation rates.

3. Crop yields and irrigation rates employed.

4. Wastewater renovation attributable to crops.

5. Wastewater renovation attributable to soils.

6. Requirement for pathogen control.

7. Ultimate impact on groundwater quality.

SECTION 2

CONCLUSIONS

GENERAL

A favorable opinion is advanced that spray-irrigation cropping is preferable to direct sand filter percolation as a means of protecting and preserving groundwater resources on Cape Cod. The bulk of the chemical constituents of concern in secondary effluents are shown to be effectively removed by the combined action of an agricultural crop and the favorable depth of soil and gravel which overlies the water-saturated aquifer.

The single most important contribution of the agricultural component is likely to be nitrogen separation and removal whereas adsorption on soil, sand and gravel is probably the major consideration affecting heavy metal removal. Reaction times and saturation estimates for these interactions predict that a wastewater spray-irrigation facility on Cape Cod should have a life expectancy well in excess of 50 years.

HYDROGEOLOGY

1. Hydrogeologically the Falmouth area of Cape Cod can be considered a single, homogeneous, anisotropic aquifer with maximum hydraulic conductivity (HC) in the north-south direction roughly parallel to the direction of deposition of the outwash sand and gravels. The east-west HC component is considerably smaller and in a direction which is roughly perpendicular to that of general deposition. The north-south HC ranges between 43-51 m (140-167 ft) per day while the comparable movement in an east-west direction ranges from 5.3-6.4 m (17.5-20.9 ft) per day.

2. Four aquifer tests involving a series of groundwater observation wells showed specific hydraulic yields that ranged between 0.13 and 0.25.

3. The uppermost layer of water-saturated sand occurs at a depth of about 20 m (65 ft) just north of Otis Air Force Base. Comparable depths within the vicinity of the Otis spray-irrigation facility were reduced to about 15 m (50 ft) in accordance with a tendency for these depths to diminish in a seaward direction.

4. The saturation thickness of the glacial outwash aquifer in the vicinity of Otis Air Force Base measures between 70-76 m (230-250 ft).

5. Maximum estimated recharge rates for 1975 were respectively estimated to

be 73, 79 and 84 percent for the 2.54, 5.08 and 7.62 cm (1, 2, and 3 inch) per week plots of Site A. Minimum recharge estimates for the same areas, also during 1975, were 32, 49 and 34 percent respectively.

6. A digital model constructed to simulate the steady-state water table configuration has indicated that sewering the town of Falmouth and transporting the effluent for disposal at Otis would result in a 1.67 m (5.5 ft) rise in the underlying water table.

PHYSICAL CHARACTERISTICS OF THE SOIL

Baseline soil samples taken from the irrigation plots show a layer of surface loam underlain by about 1 m (3 ft) of windblown light, sandy loam. Occasionally, deposits of silt-clay, distinctly different in texture and color occur in clumps immediately beneath the surface. Below 1.8 m (6 ft) there is a shift from fine sandy loam to medium sand. Deeper cores indicate a shift from medium to coarse sand interspersed with cobblestones down to bedrock some 79 m (258 ft) below the surface. Typically the pH range for the upper 15.2 cm (6 in) of soil was 5.50-6.50.

RECHARGE TIME

Chloride changes observed in the saturated aquifer following the onset of spray-irrigation showed an S-shaped curve with time. At a hydraulic loading of 7.6 cm (3 in) per week, the arrival time for a measurable amount of chloride was under 200 days. For a lesser hydraulic loading of 3.1 cm (2 in) per week the arrival time estimate increased to something less than 275 days.

IRRIGATION WATER:CROP RELATIONS

1. For a given variety of forage grass and within the irrigation rates supplied, crop yields were consistently proportional to the amount of wastewater provided and the surplus amount of water added by atmospheric precipitation had an insignificant influence on crop yields.

2. On an annual basis, the highest rates of productivity were attained with reed canarygrass irrigated at 7.6 cm (3 in) per week, a combination which led to the production of about 8.8 metric tons per hectare (4.0 tons per acre).

3. The most favorable ratio between irrigation applied to crop yield (yield ratio) was recorded for the combined timothy-alfalfa crop which had the potential for supplementing available nitrogen via nitrogen fixation within alfalfa root nodules.

4. The calorific values of the wastewater-irrigated forage grasses ranged from 4800-4950 cals per gram of ash-free dry weight. The comparable range for protein was 9.5-12.8 percent.

5. Maximum elementary renovation in an agricultural spray-irrigation system was provided for manganese, potassium, nitrogen and zinc, the renovation efficiencies for these elements being in excess of 30 percent.

6. Minimum elementary renovation was recorded for iron, calcium, copper and sodium at a range of 0.30-10 percent.

7. Intermediate elementary efficiencies were noted for magnesium, phosphorus, cadmium and lead whose percent removal consistently ranged from 10-20 percent.

8. Domestic wastewater is not a well-balanced crop fertilizer due to the presence of excessive amounts of phosphorus relative to nitrogen. Forage grasses exhibit a nitrogen:phosphorus ratio, by weight, of about 4.5:1 while the same ratio in the wastewater is only about 1.25:1. Ultimately this imbalance leads to an underutilization of phosphorus.

CHEMICAL SOIL CHARACTERISTICS

Extended irrigation with secondary effluent has caused significant changes in the chemical composition of the upper 30 cm (1 ft) of topsoil. In part, these changes reflect mediated changes imposed by wastewater-crop interactions and in part they can be attributed to ionic exchanges between soil, sand and soil water. In accounting for the fate of those elements which fail to measurably accumulate in the groundwater, soil analysis can be an important means of determining the degree of renovation achieved. Among the elements we have observed to accumulate most consistently in Otis agricultural soils were phosphorus, iron, manganese, copper, cadmium, chromium, nickel and lead.

Presumably the excessive amounts of phosphorus over nitrogen in secondary effluent leads to the observed increase in adsorbable phosphorus within the soil column since each unit of crop nitrogen assimilated leads to a fixed amount of phosphorus being underutilized. Also the heavy metal enrichment of these irrigated soils is believed to follow an explanation not unlike that of phosphorus.

GROUNDWATER QUALITY CHANGES

1. Various elements have been observed to accumulate with time in the underlying groundwater but their present concentrations do not exceed EPA or US Public Health Service standards for potable waters.

2. Certain elements such as sodium, potassium and boron are continuing to appear at increasing concentrations and additional information on their ultimate stabilization levels is needed.

3. Groundwater concentrations of phosphate, nitrate, magnesium and calcium appear to have stabilized at levels which are in line with public health and esthetic considerations.

PUBLIC HEALTH CONSIDERATIONS

1. Proper public health safety would recommend that domestic wastewaters intended for agricultural spray-irrigation undergo protective disinfection prior to their release to the atmosphere and soil surface.

2. Chlorine is potentially a suitable chemical disinfectant for the above purpose providing that a favorable balance between the implications of pathogen control, overchlorination and crop damage can be maintained.

3. In the experience of the authors safe and satisfactory levels of chlorine can best be assured by diligent monitoring and quick reaction to changes in the water parameters describing pH, temperature and ammonia-nitrogen content.

SECTION 3

RECOMMENDATIONS

1. The concepts and documentation offered in this report offer a first-step toward the design of wastewater spray-irrigation agricultural systems for the Cape Cod area.

2. Maximum benefits from agricultural wastewater irrigation, in the form of better crop yields and extended chemical renovation, can be anticipated providing the plant nutrient components of secondary effluents can be modified and more precisely tailored to the nutritional requirements of the agricultural component.

3. To ensure safety and continuous operation during severe Cape Cod winters, a lagoon system providing three months storage capacity for the predicted rate of effluent release is an important consideration. Also the winter advantages of fixed nozzle irrigation over delivery by a center pivot rotary rig appear to be substantial.

4. The important renovative advantages provided by an agricultural crop over that of direct rapid infiltration via a sand filter bed has been clearly established and has important implications with regard to the ultimate protection of groundwater quality.

5. Inclusion of an effective, but safe method of wastewater disinfection prior to crop application is strongly recommended. Whether chlorination provides the ideal answer to this requirement cannot be fully established at this time.

6. The possibility that persistent organochlorine combinations having potentially detrimental public health implications are generated and dispersed during the chlorination of wastewater seems remote, yet conclusive information on this subject exceeds the scope of these studies.

7. The concentrations of certain ions on the groundwater underlying wastewater irrigated agricultural crops can be expected to increase in proportion to the irrigation rates employed. For this reason persistent and effective groundwater monitoring is a prime management responsibility with regard to all wastewater-irrigation systems.

8. The importance of the dilution phenomenon is frequently overlooked. As irrigation rates increase and land area decreases, the percent of the total hydraulic load made up of precipitation also decreases. The de-

creased dilution at higher irrigation rates is partly but not completely balanced by a commensurate decrease in evapotranspiration. The end result is that at higher irrigation rates, ionic concentrations in the recharge water are higher. It may be possible to compensate for decreased dilution at higher rates by maximizing dilution with groundwater. This could be accomplished by a facility design which orients long rectangular fields perpendicular to the ground-water gradient. The results would be a larger but less concentrated ground-water plume. Another approach would be to divide the irrigation operation into two or more sites.

9. Spray irrigation of perennial grasses and subsequent groundwater recharge should be considered a preferred alternative to direct sand filtration, which is currently the most commonly employed alternative for centralized wastewater disposal on Cape Cod.

SECTION 4

THE EXPERIMENTAL SITE

The geology of the Falmouth area of Cape Cod has been summarized in various reports [9-11]. In general, these reports describe a single, homogeneous, anisotropic aquifer with maximum hydraulic conductivity in a north-south direction and minimum hydraulic conductivity in the east-west direction.

Field observations of this program were conducted at Otis Air Force Base, Cape Cod, a military installation located 120 km (75 miles) south of Boston, Massachusetts. Geologically the site is constructed of a mass of unconsolidated gravel, sand and silt deposited by glacial outwash and underlain by impermeable consolidated bedrock roughly 260 feet below the surface. In a north-south direction, the bedrock maintains an average depth of 52 m (170 ft) below sea level; however, just east of the site, it drops to a depth of 122 m (400 ft) below sea level. Given this situation, the rates at which groundwater is transmitted through a unit width of the aquifer can be expected to vary in accordance with the thickness of the water-saturated layer.

The annual rainfall at Otis averages about 3100 m^3 per day per km^2 (2.14 million gallons per day per square mile), but evaporation and transpiration losses reduces the estimated amount of recharge to considerably less than 1550 m^3 per day per km^2 (1.07 million gallons per day per square mile). The result is a groundwater table which reaches a maximum height of 18.3 m (60 ft) above sea level north of Otis. Groundwater levels then subside in all directions towards the ocean. Monitoring wells installed within the project area reveal groundwater elevations ranging from 16.4-15.1 m (53.8-49.7 ft) above sea level in accordance with the north-south hydraulic gradient previously described by Meade and Vaccaro [12].

Base-line soil samples taken from the irrigation plots show a surface layer of loam underlain by roughly 1 m (3 ft) of windblown Enfield sandy loam. Quite frequently deposits of silt-clay, visually and mineralogically distinct from the surrounding sandy loam, occur in layers or clumps immediately beneath the surface. Below the 2 m (6 ft) depth, the topsoil grades from fine sandy loam to medium sand. Deep geological cores indicate a substrate of medium to coarse sand with occasional cobblestone layers to the vicinity of bedrock 78.6 m (258 ft) below the surface.

OTIS SEWAGE TREATMENT PLANT

The sewage treatment plant at Otis Air Force Base has been in operation since 1942 and processes wastewater generated at the base. Primary sewage treatment at the plant consists of a comminutor with a by-pass bar screen, a Parshall flume, a grease-skimming and flocculation tank and two Imhoff tanks. Two trickling filters of 1 m (3 ft) depth and two settling tanks or clarifiers comprise the secondary treatment component. The plant effluent is typically discharged onto sand filter beds for final disposal to the underlying ground water. Sludge removed from the Imhoff and settling tanks is flushed to sand drying beds and periodically removed for burial.

The plant was designed to accommodate an average summer flow of 14,000 m^3 (3.7 million gallons) per day and to serve a population of about 37,000. Its load has averaged substantially less than 3800 m^3 (one million gallons) per day for the past 10 years due to reduction of personnel and activities at the base. Presently, the plant treats slightly less than 189 m^3 (50,000 gallons) per day and is principally serving the stable but skeleton population which occupies base housing. Because the waste load is much less than the design capacity, the treated effluent is actually recycled in order to maintain minimum volumes. Only one Imhoff tank, one trickling filter and one secondary tank are currently being used at any one time.

Strengthwise, the secondary effluent of Otis Air Force Base is rather dilute and tends to be low in total dissolved solids. Concentrations of nitrogen, phosphorus and metallic cations are thus somewhat low in terms of national averages. Presumably this reflects the sparse population currently being serviced and the recirculation which reduces the concentrations of particulate bound cations to relatively low levels of iron, zinc, lead, cadmium and magnesium. Table 1 shows the results of some typical analyses of the chemical constituents in the secondary effluent of Otis Air Force Base. For comparative purposes some accepted national averages for secondary effluents are also included [13, 14].

Since irrigation was initiated, in the summer of 1974, a continuous log has been kept which records the amounts of wastewater irrigation applied to each of the agricultural subplots of Sites A and B. Unpredictable interruptions caused by equipment failures, weather extremes, or harvesting operations ensure that planned irrigation rates are rarely achieved and inevitably total less than planned. In a similar vein, a distinction must be made between total wastewater applied to crops and the total hydraulic load since the latter term includes the total amount of precipitation contributed by rainfall.

The original design of the Otis sewage treatment plant provided sand filter beds for the terminal disposal of secondary effluents. Over the past 33 years more than 22 million cubic meters (6 billion gals) of effluent have been discharged onto the 6.9 ha (17 acres) reserved for this purpose. The latter area consists of 22 separate beds which measure 61 m (200 ft) in length and 30.5 m (100 ft) in width. At full operation, 11,400 m^3 (3 million gallons) per day, the rate of application was 1400 m^3 per hectare (150,000 gallons per acre) per day. Effluent is delivered to the filter beds by gravity mains and distributed by wooden sluiceways. The depth of the water table at this location varies from 5.5-6.1 m (18-20 ft). Geographical relations between the Otis sewage treatment plant and surrounding facilities are also shown in Figure 1.

TABLE 1. WASTEWATER CHARACTERISTICS OF OTIS TREATMENT PLANT SECONDARY EFFLUENT (CONCENTRATIONS AS MG/1: PPM).

Constituent	Typical Secondary Treatment Effluent	Otis Secondary Effluent (mean; St. Dev.)
Nitrogen (as N)	20	
Total inorganic	--	17.90 ± 3.25
Nitrate	--	10.18 ± 5.17
Nitrite	--	0.29 ± 0.15
Ammonium	--	7.43 ± 5.46
Phosphorus (as P)		
Total dissolved	10	8.49 ± 0.83
Orthophosphate	--	6.93 ± 0.78
Other Elements*		
Cadmium	0.01-0.03	0.00024 ± 0.0001
Calcium	24	10.77 ± 0.70
Chloride	45	26.78 ± 2.39
Chromium (Cr^{+6} + Cr^{+3})	0.02-0.14	0.01
Copper	0.07-0.14	0.050 ± 0.020
Iron	0.10-4.3	0.502 ± 0.07
Lead	0.01-0.03	0.00054 ± 0.0001
Magnesium	17	3.79 ± 0.17
Manganese	0.02	0.021 ± 0.016
Mercury (Hg^{+2})	0.01	0.00027 ± 0.0001
Potassium	14	8.94 ± 1.09
Sodium	50	37.91 ± 6.34
Zinc	0.20-0.44	0.047 ± 0.025

*Typical values from Pound and Crites or from Driver *et al.*

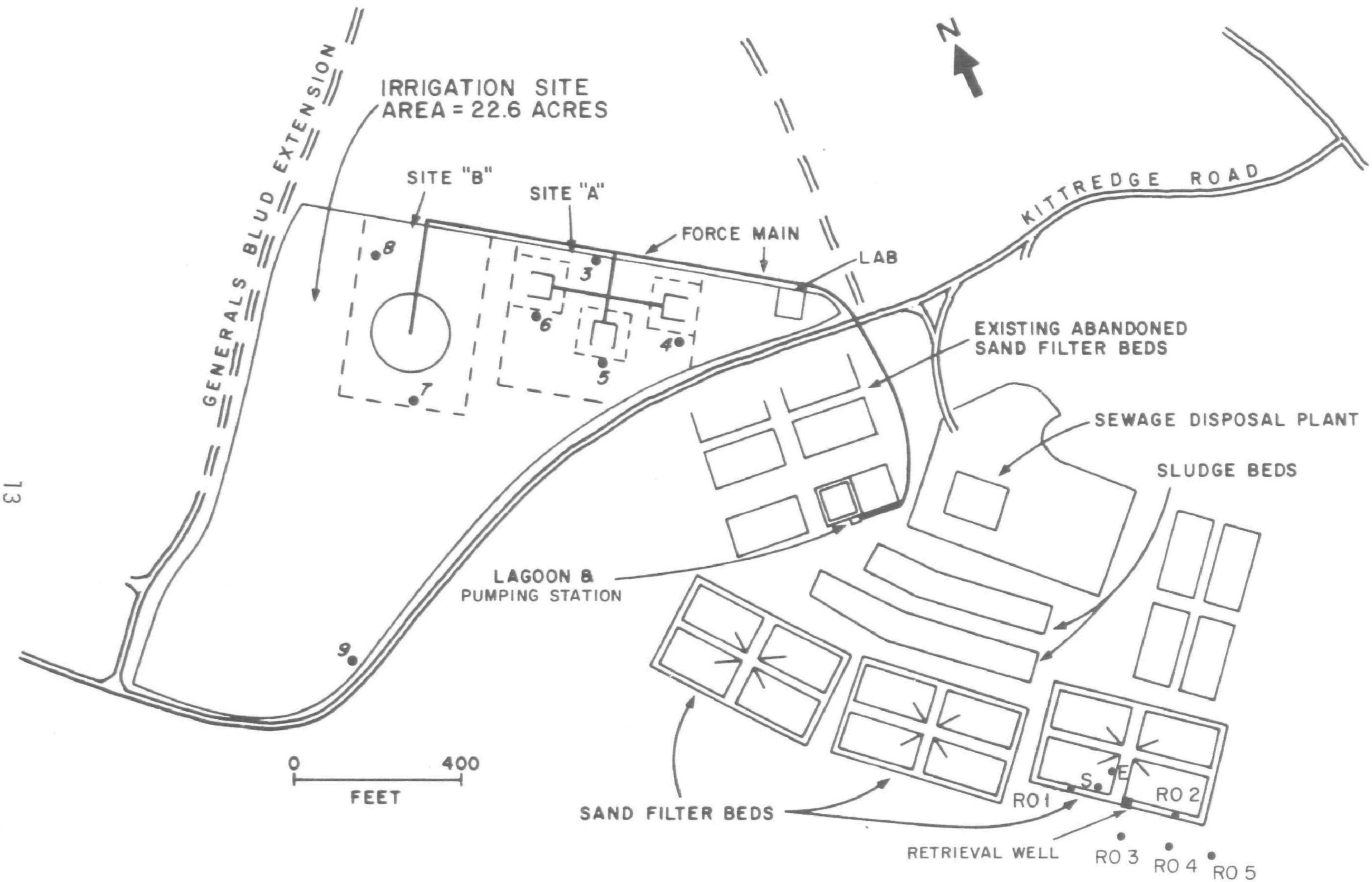

Figure 1. Plan of sewage treatment plant, sand filter beds, lagoon and irrigated sites.

SYSTEM DESIGN AND INSTALLATION

To ealuate a spray irrigation-cropping program for wastewater management, a pilot facility was assembled to provide year-round irrigation and to test the water quality effects of a holding basin, prechlorination and the performance of fixed versus rotary rigs for wastewater distribution. The supply of wastewater comes from the Otis Air Force Base sewage treatment plant, and enters a pair of holding basins or lagoons each having a capacity of 1100 m^3 (300,000 gallons) of secondary effluent, which represents but a small diversion of the total plant output. Residence, or holding time, in the lagoon is about three weeks.

The remainder of the system includes a pump house and control station, a 415 m (1360 ft) force main, the irrigation equipment and irrigated fields. The main pump has a capacity of .606 m^3 (160 gal) per min and is started with a secondary priming pump. Safety valves are installed to prevent high pressures and to provide automatic shutoff if pressure drops suddenly. A semi-automatic gas chlorinator is used for chlorination. The effluent is pumped through a 10.2 cm (4 in) Johns-Manville PVC force main to the irrigation site.

The relationship between the original Otis sewage treatment installation and the facilities added for experimental purposes is included in Figure 1. The figure shows two irrigation Sites A and B which have been seeded with forage crops. Irrigation Site A employs fixed deflection head sprinklers which supply three subplots at rates of application of 2.5-7.6 cm (1-3 in) per week to irrigate three equal areas of .11 hectares (0.268 acres). Site B contains a 45.7 m (150 ft) rotary irrigator anchored on a center pivot. Six deflection heads 8 ft apart mounted downward and of decreasing opening diameter toward the center deliver at the rate of 5.08 cm (2 in) of effluent per week to each of four subplots, each encompassing 0.18 ha (0.445 acres). Both Site A and Site B include appropriate control areas which are non-irrigated and whose monitoring provides a basis for background comparison. Each subplot is equipped with banks of lysimeters which are used to sample interstitial groundwater from depths of .15, .30, .60, .90, and 1.20 m (0.5, 1, 2, 3, and 4 ft). A total of six wells have been installed throughout the agricultural areas which are oriented according to groundwater flow so that groundwater monitoring can be provided.

Reed canarygrass is the crop at all Site A locations, while at Site B smooth brome, timothy, a mixture of timothy and alfalfa and reed canarygrass are grown. The control area at Site A is planted with reed canarygrass while control areas of Site B have been seeded with timothy.

Monitoring provides information on short- and long-term trends in terms of nitrogen, phosphorus and trace metals after various degrees of treatment. All wells are constructed of PVC plastic which allows sampling for groundwater nutrients, metals and pesticides and many other organic substances without undue contamination. Measurements at the sand filter beds show groundwater levels at 6.4 m (21 ft) below the surface and from 14.6-16.8 m (48-55 ft) below the surface of the experimental irrigation fields. The locations of nine groundwater sampling wells used to monitor these Sites are also numbered in Figure 1.

The principle field sampling effort of the authors has focussed on the time-related changes affecting the chemical composition of surface and subsurface waters, hay, turf, and soils. All water samples are collected in 2-liter polyethylene bottles, 200 ml aliquots being filtered (0.40 μm porosity) in the field through a vacuum assisted membrane filter unit. Filtered samples are refrigerated and within 24 hrs analyzed for the crop nutrients phosphate, ammonia, nitrite and nitrate.

Well water samples are obtained with a vacuum pressure apparatus designed for deep lysimeter sampling [15]. With this equipment, samples of groundwater from depths greater than 7.62 m (25 ft) below the surface are possible.

Lysimeters are used to collect interstitial soil water by applying vacuum to permeable ceramic cups (pore size ca 1.0 μm) buried below ground level. During dry periods, particularly in the nonirrigated control plots it was not always possible to accumulate an adequate volume of sample water on a routine basis.

Mature crops were cut, field dried, baled, and weighed according to accepted agricultural practice. During sample processing desiccated hay samples were macerated in a blender and stored pending chemical analysis for carbon, hydrogen, nitrogen and phosphorus content along with a variety of selected anions and cations. Soil samples were removed via a horizontal core taken from trench side walls exposed manually by shoveling or backhoe assistance.

Early water sampling was conducted on a bimonthly basis, but in 1977 and 1978 the sampling frequency was reduced to one complete sampling each month. Hay sampling was timed to coincide with crop maturation which led to three samplings per summer except for 1977 when only two hay crops were harvested. To date there have been a total of 10 hay crops which have been cut, dried and removed from the agricultural Sites. Nine of these have been subjected to complete chemical analyses. Turf and soil samples were collected on an annual basis in the fall of the year after the growing season was complete.

SECTION 5

CHEMICAL ANALYTICAL METHODS

In general chemical analytical methods used correspond to those described in the EPA Manual for the Chemical Analysis of Water and Wastes 16 . Where more sensitive methods have been necessary, particularly for well- and groundwater samples, such exceptions are noted and referenced below.

Certain major cations (Ca, Na, K, Mg) were analyzed using flame atomic absorption with direct aspiration of known standards or of sample unknowns by methods also recommended by the EPA [16]. Standard response curves prepared from multiple and known concentrations of each cation were used to interpolate the appropriate unknown concentrations.

Cations of trace metals (Mn, Cd, Cr, Cu, Fe, Pb) were originally analyzed by chelation-extraction using ammonium pyrrolidine dithiocarbamate and methyl isobutyl ketone [17]. Later, these elements were determined more efficiently via heated graphite atomization wherein a small amount of solution was injected into an electrically heated graphite furnace connected to an atomic absorption spectrophotometer.

The authors relied upon the method of standard additions to evaluate matrix interference in atomic absorption analyses conducted on various sample types. Except for calcium analyses, significant matrix interference has not occurred. For calcium calibration curves, interference associated with the use of the air-acetylene flame did require some corrective modification.

Boron was measured by the curcumen reagent technique as described in Standard Methods for the Examination of Water and Wastewater, 1971 [18].

Chloride was determined with a Buchler-Cotlove chloridometer [19] which supplies a constant direct current to a pair of ion generating electrodes which release silver ions at a constant rate. An end point is reached when all the chloride is precipitated as AgCl and the time elapsed in reaching this condition is directly proportional to the chloride concentration. Sulfate analyses were made according to the turbidiometric method described in Standard Methods for the Examination of Water and Wastewater, 1971 [18].

The inorganic plant nutrients phosphate-phosphorus and nitrite-, nitrate- and ammonia-nitrogen were all determined colorimetrically with a Beckman DU spectrophotometer. The colorimetric reagent used for phosphate analyses was acid molybdate [20]. Nitrite was analyzed in acid solution using sulfanilamide to produce a highly colored red azo-dye [20]. Nitrate was analyzed by a modification of the brucine method as described in the EPA Manual for the Chemical Analysis of Water and Wastes, 1974 [16]. Ammonia was determined by the phenolhypochlorite method [22].

Hay samples for each harvest were analyzed for organic carbon, nitrogen, phosphorus, calorie content and residual moisture after being coarsely ground in a Waring blender. Pre-weighed subsamples for major cation and trace metal analyses were ashed at 400°C and reweighed to determine the loss of weight on ignition. Nitric acid was added and evaporated off several times to complete digestion. Samples were solubilized in 50% hydrochloric acid and filtered through a 3 μm membrane filter and then diluted with deionized distilled water to a final volume of 25 mls. Trace metals were analyzed by flame atomic absorption via direct aspiration of unknown solutions and an ultimate comparison with comparable responses from known standard solutions.

Elementary analyses for carbon, nitrogen and hydrogen in hay samples were measured on material macerated (40 mesh) in Perkin-Elmer 240 elemental analyzer. Total elementary phosphorus was measured after ignition at 600°C for two hours and after wet digestion in acid persulfate at 15 lbs steam pressure (240°C) for 30 minutes [23]. The inorganic phosphate released by the above treatment was then measured with acid molybdate [20]. Analyses of plant material for caloric content were made with a Parr Calorimeter.

Turf and soil samples from irrigated and control plots were taken at the end of each growing season. For turf samples, a 15.2 cm (6 in) cube was cut from the soil surface and subdivided so as to obtain integrated samples from the upper, middle and lower thirds of the cube. Soil cores were taken at selected depths between 15.2 cm (6 in) and 122 cm (4 ft).

Soil samples were sieved and particle sizes greater than 2 mm (.08 in) were not analyzed. Turf samples included the roots and stubble of the harvested crop contained in the top 15.2 cm (6 in) of soil and were collected prior to the onset of winter. Soil and turf samples were treated and analyzed in the same manner as the hay samples except that in the case of soil pH measurements were included and calorific measurements excluded.

Early in these studies a single sand filter bed was selected for experimental observations on the dissipation of various constituents of secondary effluent in the absence of agricultural crops. Eight suction lysimeters, placed to sample a depth range of 0.15-1.22 m (0.5-4 ft), and two groundwater observation wells were installed for this purpose. Later the number of wells serving this location was increased to seven in support of additional studies on the local groundwater hydrology via draw-down and recovery observations. The wells were located at strategic points, downstream with respect to the flow of groundwater from beneath the sand filter bed. Descriptions of these facilities are shown in Figures 2 and 3.

In 1976 the project's analytical chemistry laboratory participated in the Quality Control Program administered by the EPA to evaluate techniques selected for the manual, Methods for Analysis of Water and Wastes. We

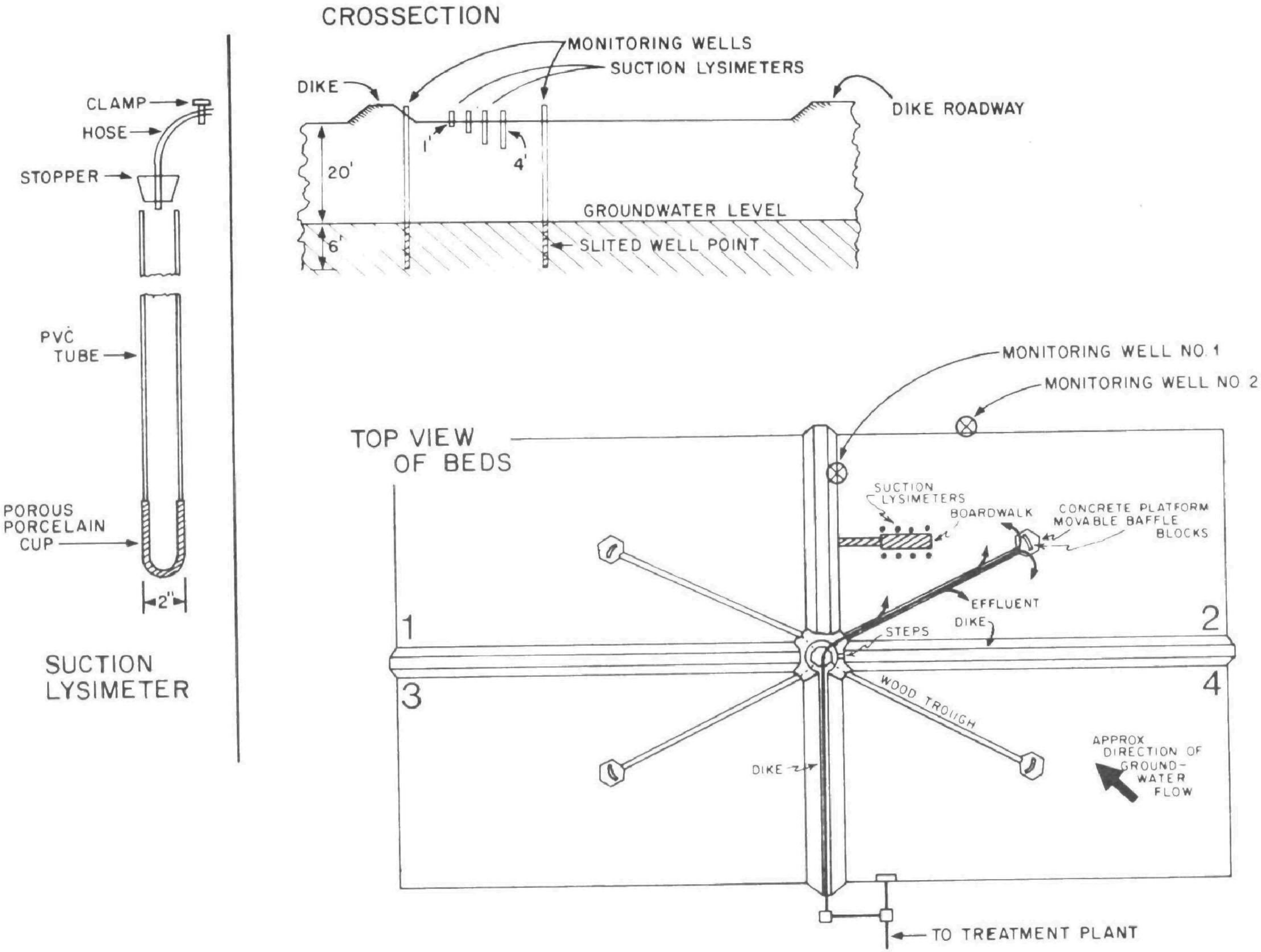

Figure 2. Sand filter bed with location of wells and lysimeters.

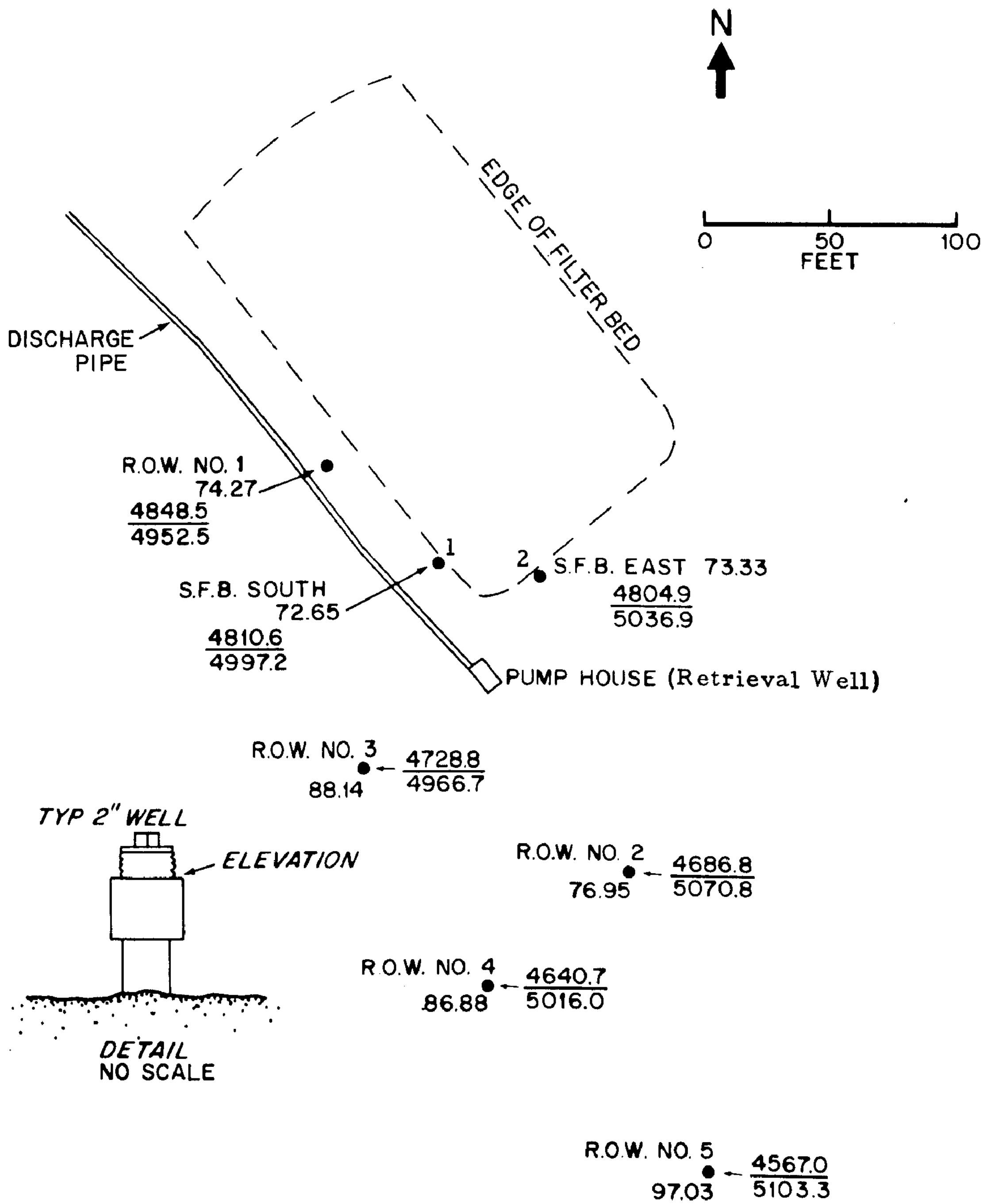

Figure 3. Location of monitoring wells adjacent to the sand filter bed. R.O.W. denotes retrieval observation well. Elevations in feet above mean sea level. Coordinates are in feet and are based on an arbitrary origin and magnetic bearings. The North coordinate is on top, East coordinate is on the bottom, both in feet relative to 5,000 at the origin.

received coded samples containing low and high concentrations of ammonia, nitrite and nitrate and a single sample for total phosphorus. A sealed envelope was also provided which was opened after completion of analyses to compare the laboratory results with the EPA reference sample standards. As summarized in Table 2, this exercise was highly successful since it validated the precision and accuracy of the laboratory nutrient chemistry. Differences between the laboratory values and the quoted EPA standards were generally comparable to the standard deviation of the laboratory methods, and generally differed by 5% or less from EPA quoted concentrations.

TABLE 2. LABORATORY INTERCALIBRATION: WOODS HOLE OCEANOGRAPHIC INSTITUTION AND ENVIRONMENTAL RESEARCH CENTER, CINCINNATI, OHIO

Ampule Number	Stated Range	NH_4-N mg/l ± Sd		NO_2-N mg/l ± Sd		PO_4-P mg/l ± Sd		ΣP mg/l ± Sd	
		W.H.O.I. RESULTS*							
1.	low	0.445 ± .006		0.179 ± .010		0.020 ± .0001		——	
2.	high	9.52 ± .009		1.06 ± .019		0.389 ± .002		0.723 ± .001	
		EPA REFERENCE SAMPLES, PARAMETER VALUES ENVIRONMENTAL RESEARCH CENTER							
			Δ		Δ		Δ		Δ
1.	low	0.44	.005	0.20	.021	0.021	.001	——	
2.	high	9.47	.05	1.11	.05	0.393	.004	0.713	.01

*Mean, five replicate analyses

SECTION 6

SAND FILTER BED PERFORMANCE

NITRATE, NITRITE, PHOSPHATE AND CHLORIDE MODIFICATION BY A SAND FILTER BED

At Otis, terminal wastewater disposal is accomplished by percolation of secondary effluent through sand and gravel down to groundwater level. Evaluation of the renovative capacity of a single, isolated sand filter bed was undertaken early in these studies. Information on the sand filter bed selected for this work and its location with regard to the field facilities provided is given in Figures 2 and 3.

The initial phase of this work was addressed to a dormant or inactive filter and was carried out between January and June of 1974. Samples of soil-water and groundwater from beneath the filter were removed at predetermined intervals to assess time-related changes for certain chemical constituents in the absence of active inundation. The most recent previous flooding of this bed had occurred in May of 1973 after which water application was limited to natural rainfall. On 15 occasions analyses were completed which provided measurements of the groundwater concentrations of nitrite, nitrate, ammonia, phosphate, and chloride. The results, shown in Figure 4, indicate that during the dormant period nitrate and ammonia gradually decreased with time, that chloride remained essentially unchanged while nitrite and phosphate showed intermittent pulses, but no consistent trends. It is significant that the nitrate concentration reached 55 parts per million (ppm) thereby exceeding the recommended limit (10 ppm) of the U.S. Public Health Service for potable waters.

On July 19, 1974 the same bed was inundated with secondary effluent at a maximum loading rate of 378 m^3 (100,000 gals) per day which corresponded to .204 m^3 per m^2 (5 gals per ft^2) per day until September when it was again deactivated for drying. A total volume of 16,430 m^3 (4.34 million gals) was applied during this 72 day interval.

Within a week following inundation, the arrival of recharged wastewater to groundwater level was indicated by an abrupt increase in chloride from 4 to 25 ppm (Figure 4). Also the nitrate and phosphate concentrations showed a corresponding increase which essentially duplicated their original concentration in the applied effluent. During the remainder of these observations phosphate concentrations stabilized at about 8 ppm but marked fluctuations in the nitrite, nitrate, and ammonia concentrations were observed.

The entire sand filter bed appears to act as an ion exchange column al-

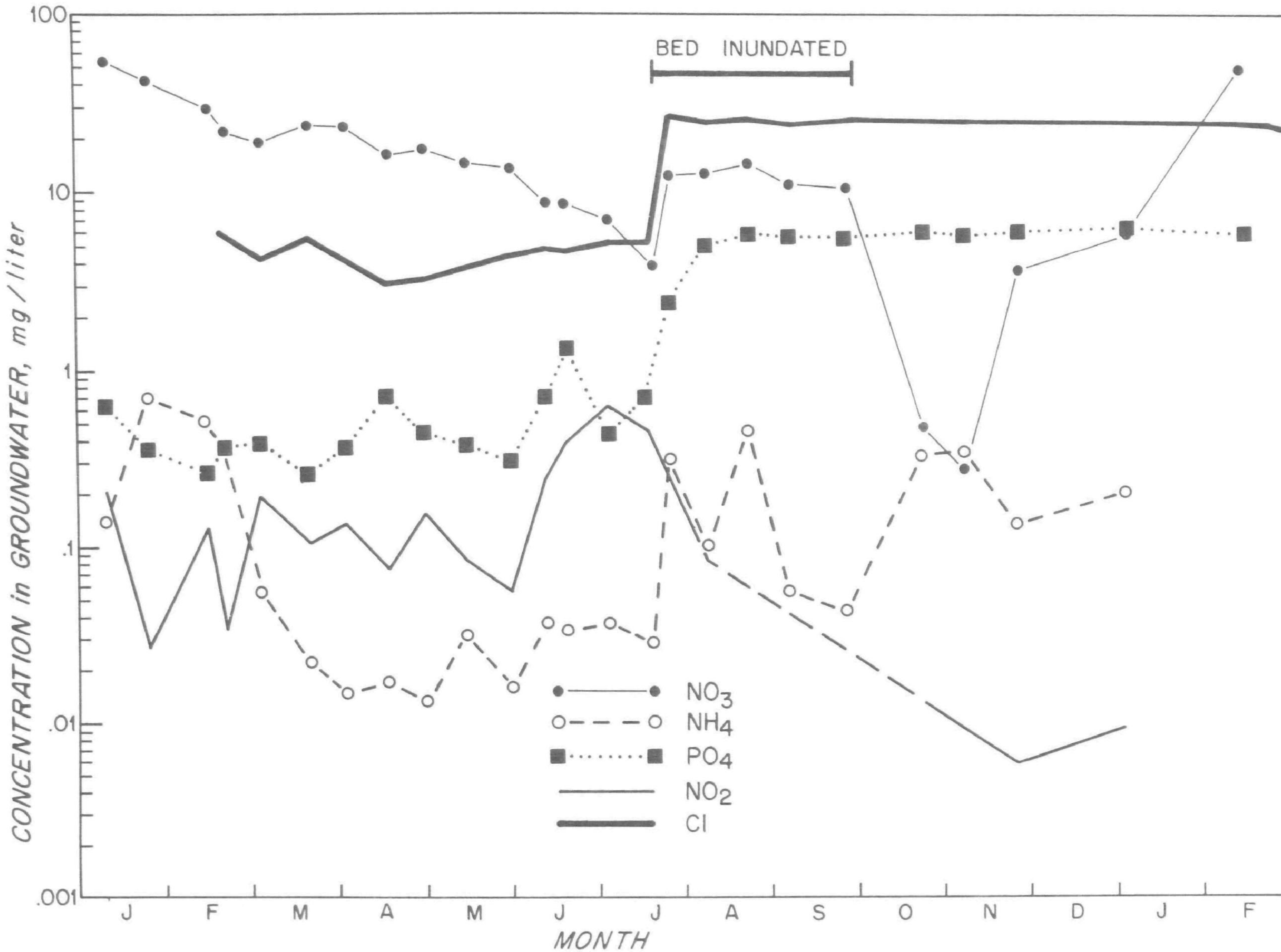

Figure 4. Groundwater quality beneath sand filter bed before, during and after inundation (July 17-September 27, 1974) with secondary treated effluent.

though nonadsorbable nitrate and chloride appear to escape the soil matrix. In this case, the tenfold decrease in ammonia, between the filter surface and the recharged groundwater, suggests that the bulk of the ammonia was retained within the filter. A rough estimate of the total amount of ammonia bound to the filter during inundation, based on ammonia-nitrogen input (2.10 ppm) vs output (0.19 ppm) comes to about 27 kg (60 lbs) for the 16,430 m^3 (4.34 million gals) of sewage plant effluent applied.

The concept of restricted ammonia passage is also supported by the failure of groundwater ammonia to increase during a subsequent period of low oxygen tension; a situation decidedly unfavorable for ammonia oxidation. As documented, anoxic conditions within the filter developed during the latter stages of inundation and were accompanied by a corresponding decrease in nitrate measured. This correspondence has been attributed to the microbial reduction of nitrate to molecular nitrogen during a period of reduced oxygen tension.

By November 1974 after a month of drying, aerobic conditions were restored and the nitrate content of the groundwater increased from a minimum of 0.28 ppm to a maximum of 50 ppm by mid February. Oxidation of adsorbed ammonia to nitrate within the filter during this period and a subsequent mobilization of nitrate by rainfall recharge presumably accounted for these changes.

An alternative possibility is that the elevated concentrations of nitrate which appeared late in these studies resulted from eluted nitrate being resolubilized in a smaller volume of water. The amount of rainfall recorded adjacent to the site between the end of inundation on September 27 and the nitrate peak in the recharge water on February 12 (138 days) was 39.4 cm (16.52 in). Assuming 50 percent recharge, the total volume for the area of the bed (100 x 200 ft; 30.5 x 61.0 m) would thus be 366 m^3 or 12,942 ft^3. The effluent applied was 42 times greater in terms of volume. If all the 29.7 kg (65.5 lbs) of adsorbed ammonia-nitrogen were converted to nitrate and dissolved in this volume of recharge rainwater, the nitrate-nitrogen concentration would be 76 ppm. Later, nitrate observations showed further increases to 67 and 57 ppm on March 12 and April 9, followed by a decrease to 34 and 33 ppm on May 7 and June 4 respectively. Thus, it appears that nitrification continued for at least 250 days, which compares with 72 days of inundation of the bed with effluent.

Sampling of soil water removed from the four-foot lysimeter revealed nitrate concentrations near 10 ppm prior to inundation. During the initial stages of flooding, the level of nitrate remained between 7 and 9 ppm. When water began to pond on the surface, nitrate decreased in the percolate to 5.5 ppm implying an onset of denitrification once anoxic conditions were established. A sample taken during the later drying stage showed a tenfold higher nitrate concentration, 77 ppm, while the ammonia concentration was reduced to a trace amount. These changes indicate reversals in the potential modification of combined nitrogen dependent upon oxygen availability which in turn is regulated by the prevailing rates of organic decomposition.

TRACE METAL MODIFICATIONS BY A SAND FILTER BED

The ability of sand filter beds to remove trace metals was also evaluated by sampling the subsoil at various depths and it has been observed that heavy metals tend to accumulate within the upper few centimeters of sand. The concentration in the effluent and the 33-year supply of copper, zinc, cadmium, lead and chromium to a typical sand filter bed is shown in Table 3. At Otis Air Force Base wet sludge is separated and deposited on sludge beds for drying and ultimate disposal by burial. Thus, the filter beds have been exposed to only a small fraction of the total heavy metal load produced by the treatment plant, the major concentration of these heavy metals being retained in the dried sludge material as compared with the secondary effluent (Table 3). In this case the sludge beds have not been evaluated as a possible source of groundwater contamination.

TABLE 3. HEAVY METAL SUPPLY TO EXPERIMENTAL SAND FILTER BED

	Metal Concentration				
	Cu	Zn	Cd	Pb	Cr*
Sample Source					
Secondary Effluent			(ppb)		
Soluble	80	55	0.24	0.50	<10
Particulate	32	12	0.58	9.30	0.6
			(ppm)		
Dry Otis Sludge	2,799	246	13	358	96
Total 33-yr Metal Loading			(g/m^2)		
Soluble	48.06	33.70	0.151	0.302	< 6.15
Particulate	19.66	7.24	0.356	5.72	0.012
Total	67.72	40.94	0.507	6.022	< 6.162

*Soluble chromium concentration was less than the sensitivity of the analytical method.

In terms of supply, the order of abundance for heavy metal additions to the sand filter bed was Cu > Zn > Cr = Pb > Cd. The surface enrichment factors, derived from appropriate comparisons with a nearby control soil, varied from 20- to 360-fold, the enrichment order being Cu > Cd > Pb = Zn > Cr.

By comparing the integrated amounts of these metals distributed within the upper 52 cm (20.4 in) with the heavy metal supply over the past 33 years it is possible to assign removal efficiencies for each of the five metals examined. As recorded in Table 4, the data of the authors indicate that 85 percent of the Cu, 49 percent of the Zn, 113 percent of the Cd, 129 percent of the Pb and > 62 percent of the Cr supplied are bound within the surface soil. Thus, of the metals examined only Zn and possibly Cr would appear to have a reasonable chance of becoming entrained in the groundwater some 740 cm (21 ft) below the surface.

TABLE 4. HEAVY METAL BUILD-up IN A SAND FILTER BED. METAL CONCENTRATIONS CORRECTED FOR APPROPRIATE CONTROL ANALYSIS

	Metal Concentration (mg/kg)				
Depth (cm)	Cu	Zn	Cd	Pb	Cr
Surf	679	320	10.5	166	82
0-4	236	67	1.7	28	4.7
4-6	272	60	1.8	26	10.0
14-16	7.2	5.5	0.11	0.00	0.10
24-26	6.1	9.3	0.25	0.00	2.30
29-31	2.4	1.3	0.09	0.00	0.00
44-46	2.5	3.9	0.07	0.80	0.90
50-52	0.7	0.0	0.07	0.00	0.00
Control Soil, Surf	1.9	5.8	0.07	2.70	4.30
Surface Enrichment Factor	360	56	150	60	20
Integrated Metal Content (g/m^2 to 52 cm)*	57.89	20.19	0.572	7.75	3.81
Percent Retention (Content/Loading) 100	85	49	113	129	62

*Assumes soil density of 1.85, i.e., 938 kg under a m^2 to a depth of 52 cm.

The major accumulation of heavy metals on Otis sand filter beds after 33 years of service occurs within the uppermost 6 cm (2.4 in) of sand. The extent of enrichment for Cd, Cr, Cu, Pb and Zn ranges from 20 to 360-fold. Excepting Zn and possibly Cr, more than 85 percent of the applied amounts of each of the above metals resides within the upper 52 cm (20.4 in) of sand.

SECTION 7

CHANGES IN NITROGEN AND PHOSPHORUS DURING AGRICULTURAL SPRAY-IRRIGATION

The removal of phosphorus from secondary effluent during agricultural spray-irrigation treatment increases with the stage of treatment. The phosphorus concentrations (as PO_4-P) in Otis secondary effluent before lagooning range from about 8 to 10 (mean = 9.25) ppm and are typically higher during winter than in summer (Fig. 5). Following chlorination and distribution over the irrigation field the phosphorus concentration was reduced to less than 0.5 ppm in the interstitial water recovered from 15.2 cm (6 in) below the surface. At successively greater depths, no significant changes in phosphorus were observed down to the depth of the groundwater sampling at 15.2 m (50 ft).

Nitrogen is more versatile than phosphorus chemically and is affected by a greater variety of biological processes. Gains or losses of nitrogen to or from the system are regulated by the relative importance of nitrogen fixation, ammonification, nitrification and denitrification. Thus, much greater uncertainty exists regarding nitrogen distributions as compared with phosphorus and phosphorus rather than nitrogen is the more appropriate element for mass balance analysis.

Total inorganic nitrogen concentrations in Otis secondary effluent before lagooning range from about 12.5-18.5 (mean = 11.6) ppm and show a comparable reduction pattern to that of phosphorus following successive stages of treatment (Figures 6 and 7). During the winter-spring period, ammonia is the most abundant form of inorganic nitrogen in secondary effluent although appreciable amounts of oxidized nitrogen (nitrite or nitrate) also occur. During the summer-fall months the oxidized forms of nitrogen are more abundant than ammonia. In the interstitial soil water, ammonia is almost completely absorbed in the first foot of soil, but oxidized nitrogen penetrates at reduced concentrations to the ground water. The data on inorganic nitrogen distribution suggest that soil nitrification occurs throughout the year.

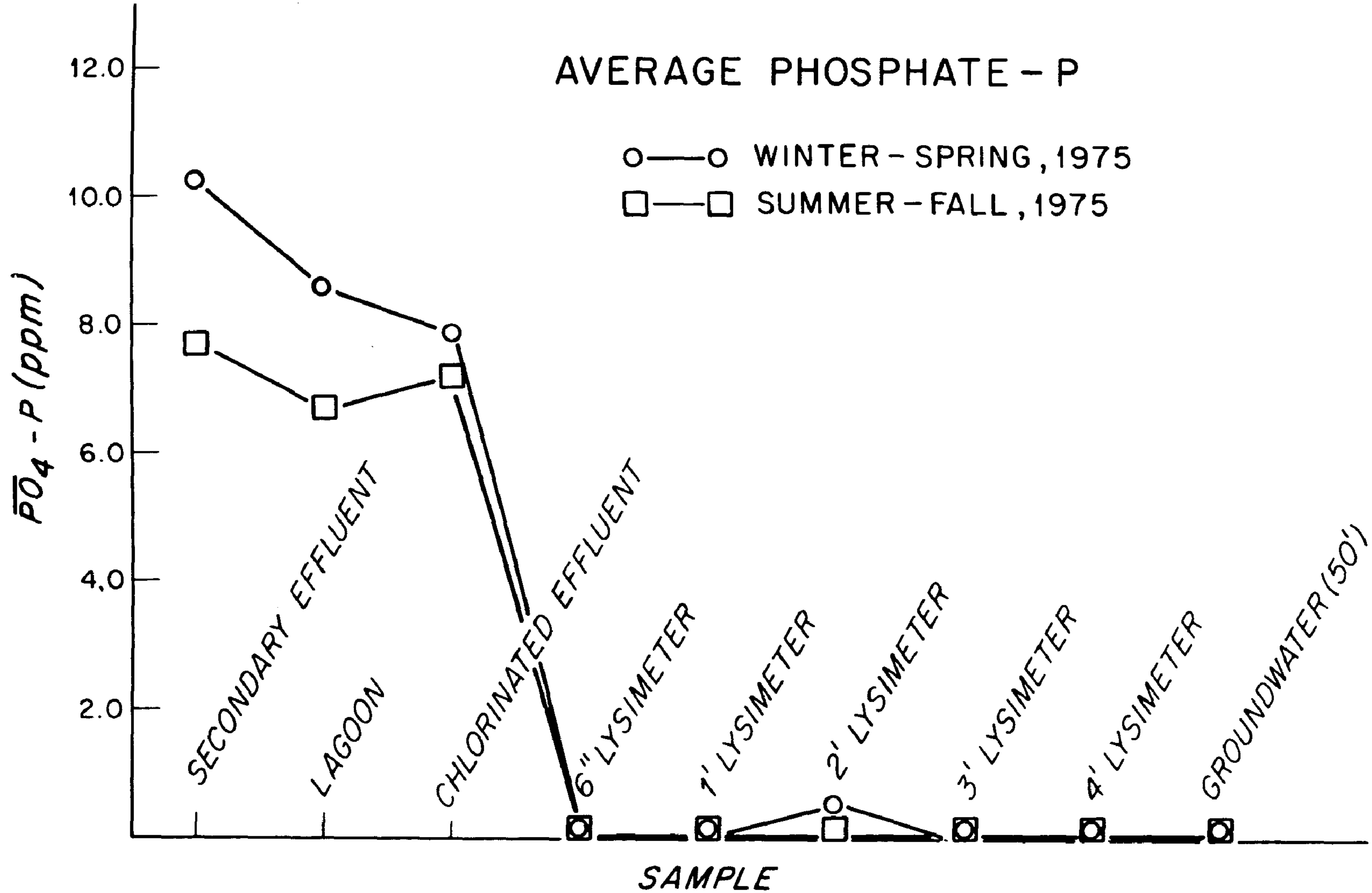

Figure 5. Winter and summer phosphate-phosphorus concentrations (ppm) for secondary effluent after lagooning, chlorination, irrigation and percolation through the ground. Site A-west; nominal rate of application 3 in./wk.

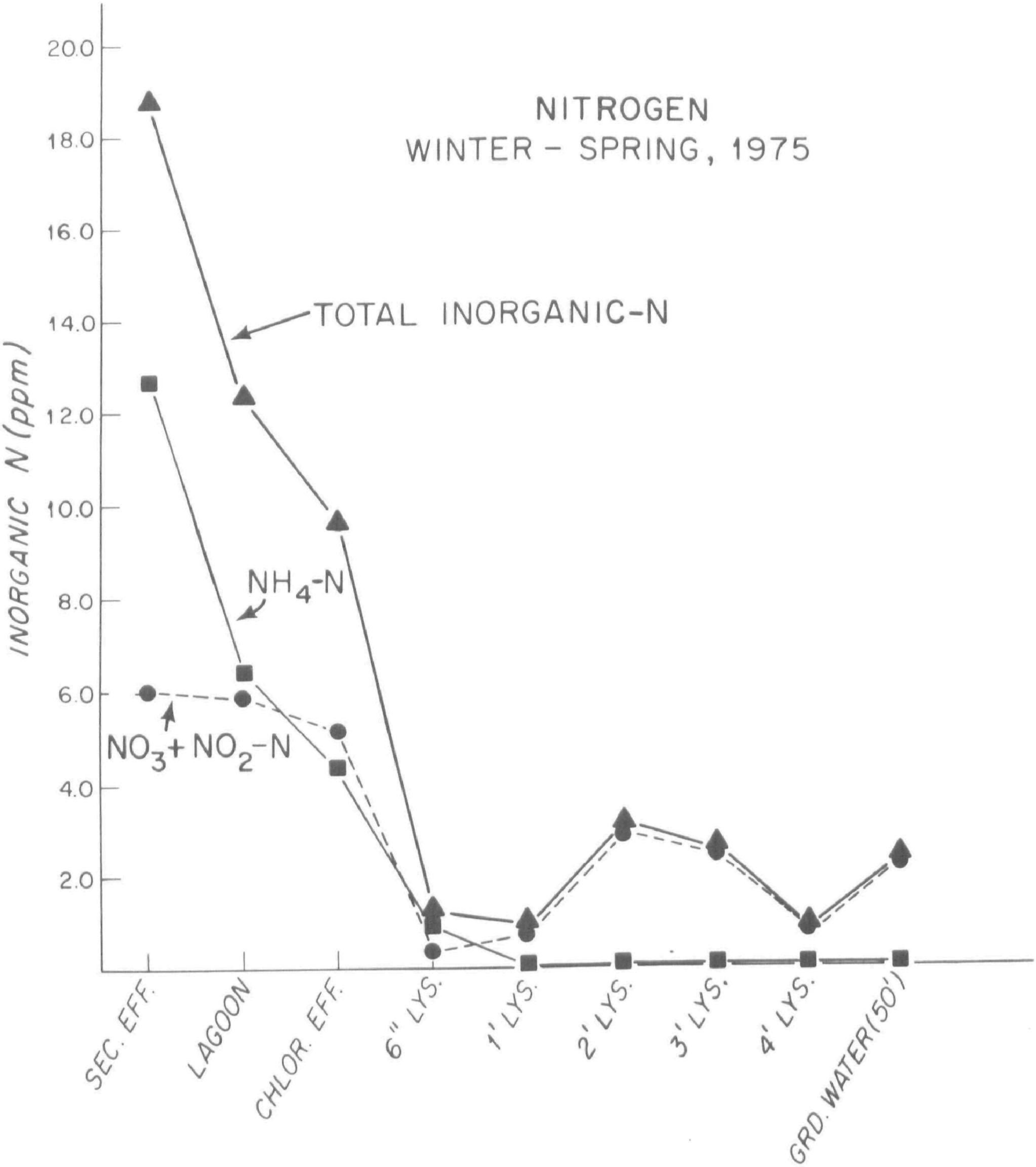

Figure 6. Winter-spring ammonia, oxidized and total inorganic nitrogen concentrations (ppm) for secondary effluent after lagooning, chlorination, irrigation and percolation through the ground. Site A-west; nominal rate of application 3 in./wk.

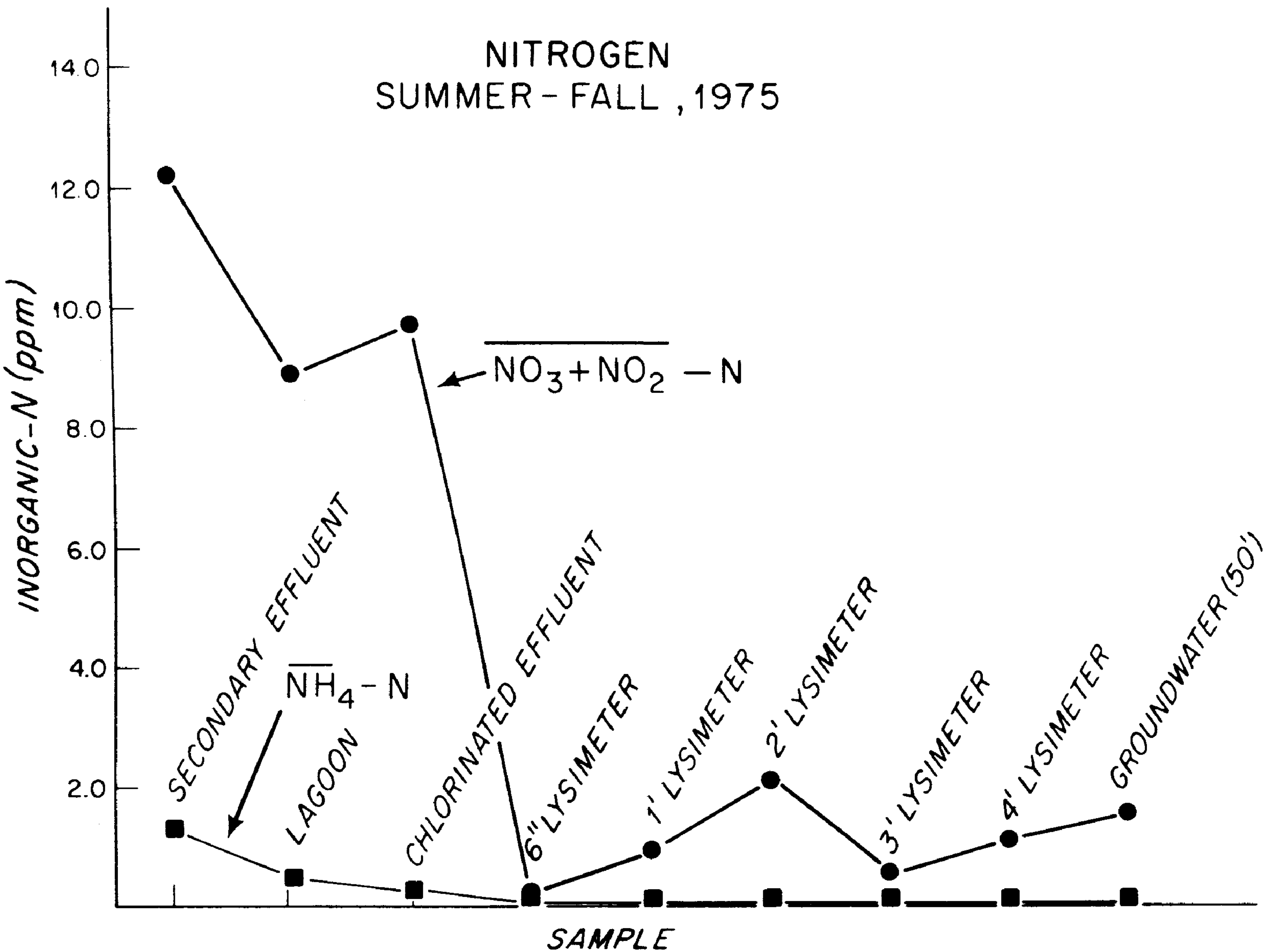

Figure 7. Summer-fall ammonia, oxidized and total inorganic nitrogen concentrations (ppm) for secondary effluent after lagooning, chlorination, irrigation and percolation through the ground. Site A-west; nominal rate of application 3 in./wk.

SECTION 8

IRRIGATION-CROP RELATIONS

Over a five year period irrigation-crop relations have been examined from nine cuttings of mature plants taken from 10 different agricultural subplots. As previously stated the experimental variables included the following.

1. Differences in rates of wastewater application (2.54, 5.08, 7.62 and 10.2 cm per week).
2. Differences in the wastewater delivery system, (fixed nozzle vs rotary rig).
3. Different varieties of forage grasses.
4. Control crops exposed to precipitation only.

Yield characteristics and renovative efficiencies observed in each of the above situations are discussed in this section.

CROP YIELDS VS IRRIGATION APPLIED

Tallying the accumulated amounts for crop yields vs total irrigation applied requires a distinction between total effluent applied (TEA) and total hydraulic loading (THL). The latter is always larger than a comparable TEA value since it represents the sum of TEA and the additional amount of crop watering provided by precipitation.

Data from Site A describing three different reed canarygrass plots treated with three different rates of wastewater application are shown in Figures 8 and 9. In Figure 8, marked proportionality between crop yields and TEA is demonstrated. When the same crop yields are plotted against THL, however, as in Figure 9, three different levels of proportionality result. In the latter case, crop yields were decided by the fractional amount of wastewater provided and the additional water increment supplied by precipitation had a minimal effect on crop size.

The overriding influence of TEA over THL in affecting crop growth has led the authors to adopt the following relation to express yield ratios.

$$\text{Yield Ratio} = \frac{\text{Harvested crop, kg/ha}}{\text{Wastewater applied, kg/ha}}$$

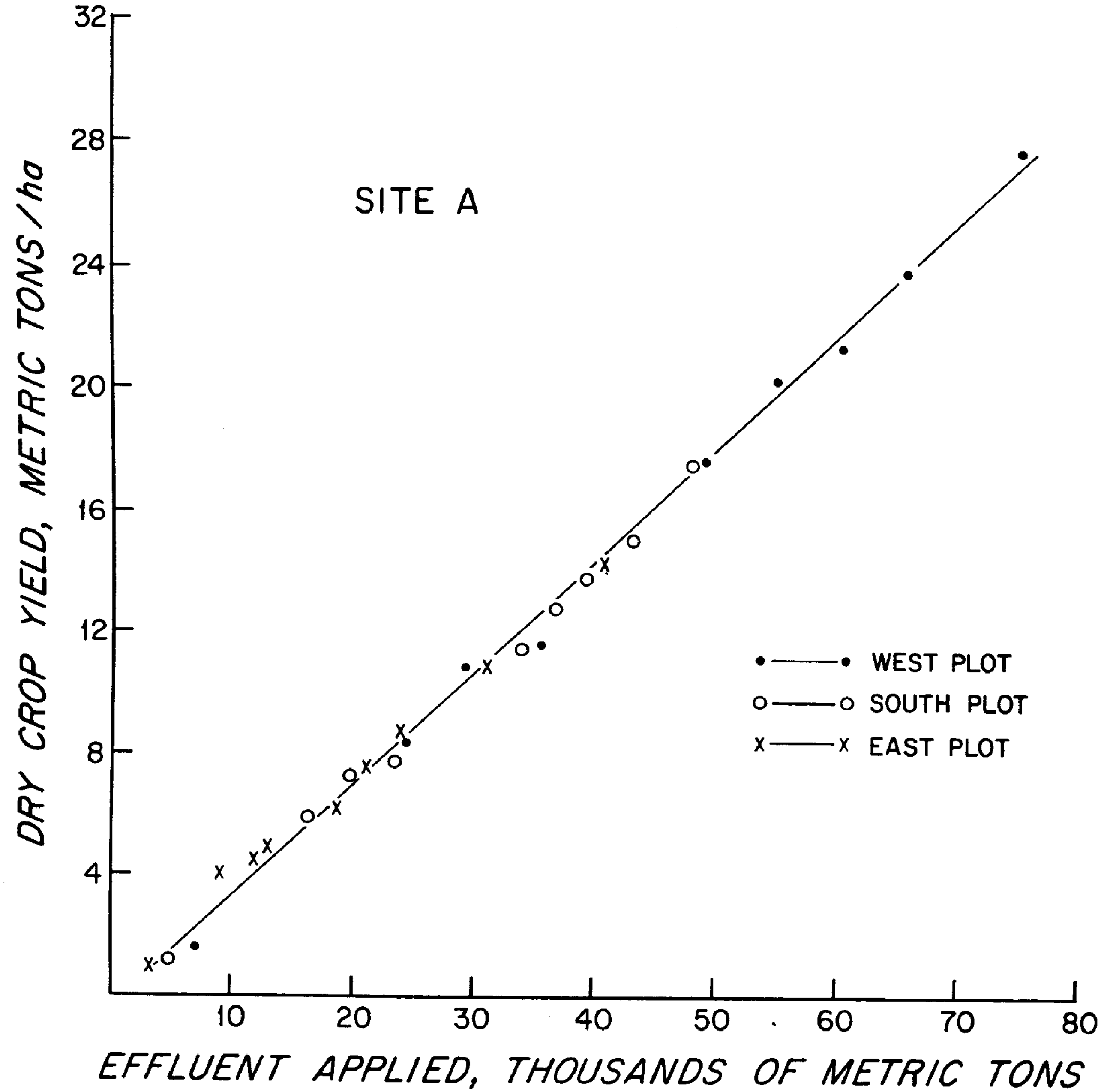

Figure 8. Relation between effluent applied and dry crop yields (accumulated values).

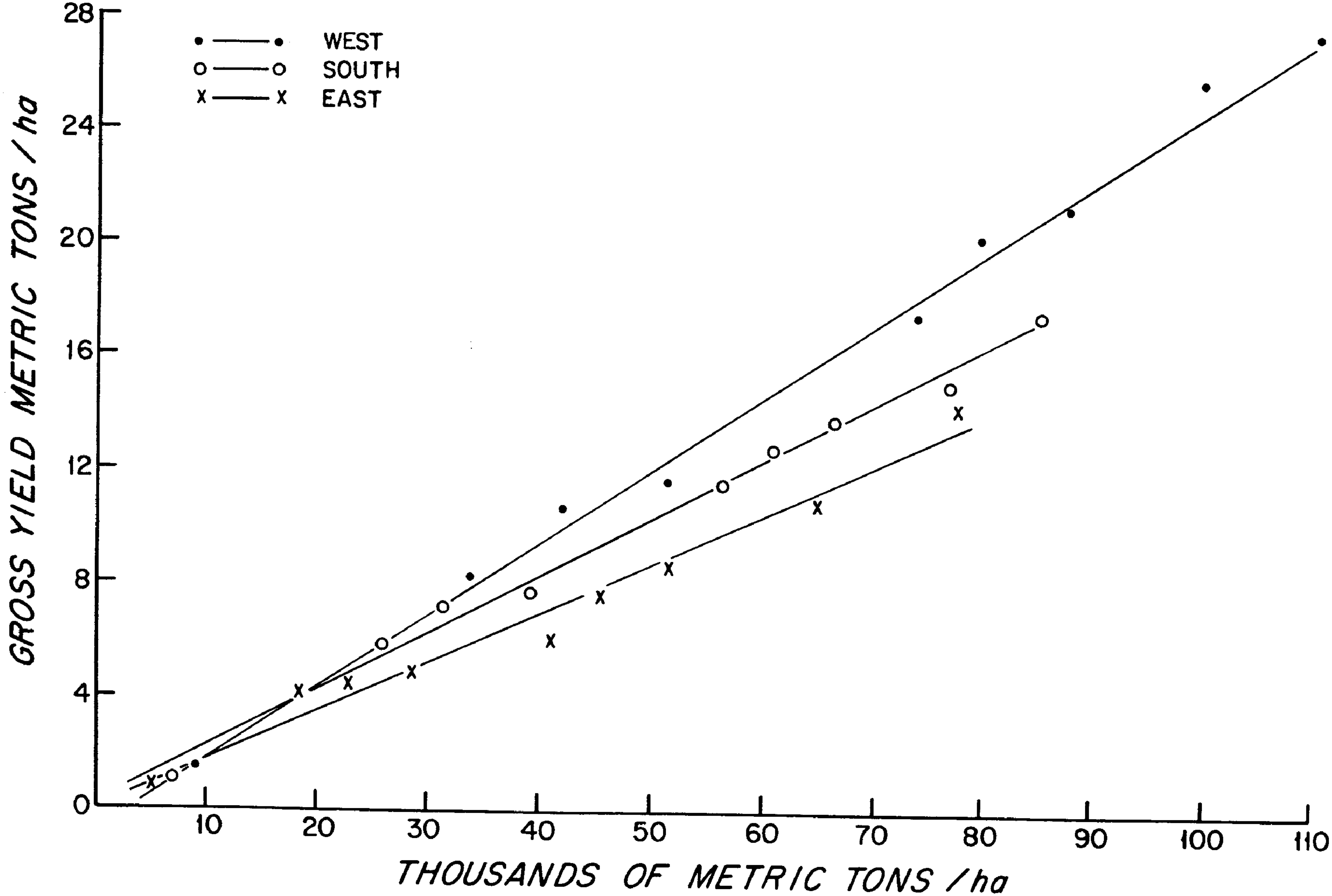

Figure 9. Relation between total hydraulic load and dry crop yields (accumlated values).

Thus, the yield ratio for Site A data, Figure 8, is 0.36, a value which is common to each of the three subplots.

Yield ratios calculated for Site B, where four different grass crops were irrigated at the same target rate of 5.08 cm (2 in) per week show a much wider variation than comparable Site A values. In part, this difference could reflect the inability of the investigators to maintain rotary irrigation of Site B during the three or four coldest winter months. Yield ratios for Site B crops were minimal for smooth brome (0.29) and maximum for mixed timothy-alfalfa (0.55) with intermediate values recorded for timothy (0.35) and reed canarygrass (0.40). A summary of the information on crop yields vs irrigation appears in Table 5.

Another significant parameter in agriculture is the tonnage of harvestable crop accumulated over an annual growing season. Efficient mid-western farms of this country readily produce about 4.54 metric tons (5 short tons) per acre per year. As shown in Table 5 none of our experimental areas attained the above level of productivity. Rather, the average annual yield of our most productive combination (reed canarygrass irrigated at 7.62 cm (3 in) per week) totaled 3.67 metric tons (4.04 short tons) per acre. The mixed crop of timothy-alfalfa irrigated at 5.08 cm (2 in) per week showed a lesser amount of production, 2.94 metric tons (3.24 tons) per acre, whereas the corresponding averages for timothy and smooth brome were consistently less than the above.

TABLE 5. ANNUAL PRODUCTIVITY AND YIELD RATIOS FOR WASTEWATER IRRIGATED FORAGE CROPS

	Irrigation Rate inches per week	Productivity Short Tons/Acre	Yield Ratio*
Site A			
Reed canarygrass	1.0	1.91	0.36
Reed canarygrass	2.0	2.60	0.36
Reed canarygrass	3.0	4.04	0.36
Site B			
Timothy-alfalfa	2.0	3.24	0.55
Reed canarygrass	2.0	2.36	0.40
Timothy	2.0	1.91	0.35
Smooth brome	2.0	1.71	0.29

*Weight of dry crop harvested ÷ weight total effluent applied.

Strictly speaking, extension of wastewater renovation by agricultural systems requires that the harvestable plant material, generated by wastewater irrigation, be collected and disassociated from the local biochemical cycle.

Thus, crop harvesting and dispersal are integral parts of the process. However, agricultural productivity also involves the development of considerable amounts of primary and secondary organic biomass which escape harvesting. Nonetheless the presence of non-harvested organic material represents at least a temporary change in phase for many chemical constituents supplied during the wastewater irrigation. For these reasons the authors have also calculated yield ratios on the basis of complete plant biomass; i.e., the sum of leaf plus turf. The latter term includes unharvested stubble and roots. Yield ratios calculated in this manner are shown in Table 6 and in general are about double the magnitude of those calculated for leaf structure alone.

TABLE 6. YIELD RATIOS FOR TOTAL PLANTS, LEAF PLUS TURF, PRODUCED PER UNIT IRRIGATION

1974 - 1977

	Yield Leaf (m tons/ha)	Yield Turf (m tons/ha)	Total	Yield Ratio Total Plant
Site A				
Reed Canary				
Reed canarygrass (E)	14.8	9.40	24.2	0.60
Reed canarygrass (S)	17.5	5.13	22.6	0.47
Reed canarygrass (W)	27.2	25.6	52.8	0.70
Site B				
Timothy-alfalfa	21.2	6.84	28.0	0.93
Reed canarygrass	16.0	18.8	34.8	0.87
Timothy	13.0	5.98	19.0	0.47
Smooth brome	11.6	8.55	20.2	0.50

CHEMICAL COMPOSITION AND NUTRIENT CHARACTERISTICS OF CROPS

Chemical elements such as carbon, hydrogen, nitrogen and phosphorus are major constituents of all plant and animal assemblages wherein their proportions vary according to molecular configurations, species origin and environmental conditions. Chemical constituents such as nitrogen and phosphorus along with an array of heavy metals are often the principle target elements of supplementary wastewater treatment systems. In practice the nutritional requirements of wastewater-irrigated-crops help determine the level of wastewater renovation achieved. Also the chemical composition of the various grasses determines their nutrient values as forage crops.

In terms of ash-free dry weight, carbon, which is somewhat more prominently represented than oxygen, is the most abundant element in the Otis crops. Together, these two elements account for about 90 percent of the ash-free dry weight. However, the bulk of the carbon probably originates from atmospheric rather than wastewater sources hence its presence in the plant is not a direct indication of wastewater attenuation. Together, the fractional percentages of nitrogen and phosphorus totaled less than 2.5 percent of the total dry weight, but each of these elements is more intimately involved in wastewater modification. Nitrogen, as shown in Table 7, presents the strongest contrast between irrigated and non-irrigated (control) crops and appears to be the element most likely limiting plant growth.

TABLE 7. ELEMENTARY COMPOSITION,* MAJOR ELEMENTS
OTIS FORAGE CROPS

1974 - 1977

	Ash-free dry wt.	C	H	N	P	O**
			PERCENT			
Site A, Reed canarygrass						
East-plot	91.34	43.86	6.87	2.00	.420	44.81
South-plot	91.30	46.26	6.67	1.58	.457	42.96
West-plot	92.13	46.50	6.78	1.93	.454	41.89
Control-plot	92.94	47.45	5.99	1.16	.384	42.88
Site B						
Timothy-alfalfa	92.80	46.34	6.77	2.05	.404	42.14
Reed canarygrass	92.74	46.22	6.13	1.79	.301	43.18
Timothy	93.18	47.65	6.92	1.53	.265	41.41
Smooth brome	92.90	47.05	6.77	1.89	.336	41.66
Control, timothy	92.86	46.21	6.41	1.65	.207	43.41

* Based on weighted means of ash-free dry weights

**Calculated from: 100 - [(%C) + (%H) + (%N)]

Green plants have the unique ability to use carbon dioxide and water as their principal raw materials from which they produce a multitude of organic compounds of varying complexity. The initial stages of the above process is accomplished by photosynthesis which from a chemical point of view is a process of reduction. An input of energy is required to bring about this reaction hence the reduced end products which are formed represent a potential energy source. The extent of the overall chemical reduction largely determines the level of plant-stored energy and can be expressed in terms of the R-value which quantifies the degree of carbon reduction in an organic compound in accordance with the percentages of carbon, hydrogen and oxygen [24]. The general formula for calculating R-values is given as:

$$\frac{[(\%\ C \times 2.66) + (\%\ H \times 1.936) - \%\ O] \times 100}{398.9} = \text{R-value.}$$

Although R-values are calculated on the relative abundance of specific elements, they express the energy content of organic materials and hence should compare with calorific value, the heat of combustion per gram. Small variations from linearity between these parameters are probably due to varying nitrogen content caused by different rates of nitrogen availability. In part, Table 8 summarizes the pertinent information on R-values and calorific values from nine cuttings of Otis forage crops. Calorific values for the irrigated sites ranged from about 4800-4950 cals per gram, ash-free dry weight basis, while the comparable range of R-values was 30.65-34.25.

Once elementary analyses and R-values are determined it is possible to estimate by calculation the approximate lipid, protein and carbohydrate content of an organic entity. First the percent nitrogen multiplied by 6.25 is used to estimate percent protein. Using values for percent protein as one constant and the R-values of the entire sample as another, an algebraic solution of two simultaneous equations can be used to estimate the percentages of carbohydrates and lipid [24]. These equations are:

$$(\%\ \underline{P} \times 42) + (\%\ \underline{C} \times 28) + (\%\ L \times 67.5) = \text{R-value} \times 100\%, \text{ and} \qquad (1)$$

$$\%\ \underline{P} + \%\ \underline{C} + \%\ L = 100 \qquad (2)$$

where $\underline{P}$ = protein; $\underline{C}$ = carbohydrate and L = lipid. The results of these calculations as applied to Otis hay samples also appear in Table 8.

NITROGEN:PHOSPHORUS BALANCE AND EXCHANGE

The total amounts of irrigation water and the equivalent amounts of available nitrogen and phosphorus provided for the crops of Sites A and B between 1974-1977, are shown in Figure 10. Unforeseeable interruptions in irrigation during crop drying and adverse weather conditions have meant that the actual amount of irrigation accomplished was typically less than planned. The available nitrogen application to Site A varied between 504 and 905 kg per ha (.227-.403 tons per acre), the range reflecting the three different rates of applied irrigation. The quadrants of Site B, which were all irrigated at a constant rate, received 491 kg/ha (.219 tons per acre) within the same time period. The amount of available phosphorus applied at Site A ranged from 358-642 kg per ha (.160-.286 tons per acre) while each subplot of Site B received, in common, 348 kg/ha (.155 tons per acre).

As iterated above, the value of an agricultural spray-irrigation system as an effective supplement to conventional sewage treatment largely depends upon the combined amounts of nitrogen and phosphorus intercepted by the crops and underlying soil, processes which deny these elements access to the exterior environment. Consequently, close attention should be given to the

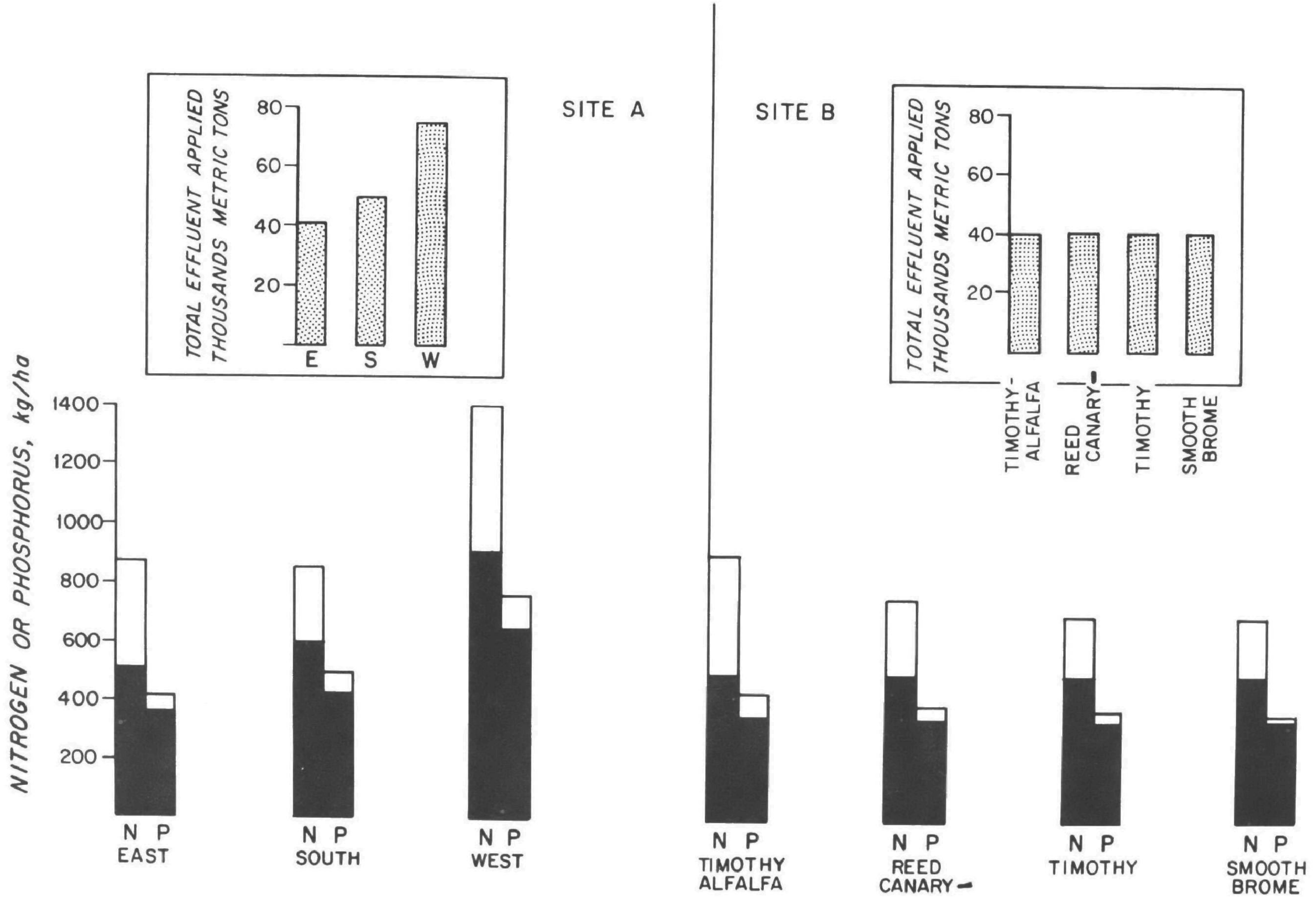

Figure 10. Total effluent delivered to subplots (inserts) and equivalent amounts of nitrogen and phosphorus applied (dark areas) and retained (clear areas) by crops 1974-1977.

TABLE 8. ENERGY AND NUTRITIONAL POTENTIAL,*
OTIS FORAGE CROPS

1975 - 1977

	R-Value	Cals per gm	Carbo.	Protein - Percent -	Lipid
Site A, Reed canarygrass					
East plot	30.65	4934	85.28	12.50	2.22
South plot	32.41	4809	82.46	9.88	7.66
West plot	32.88	4810	79.86	12.06	8.08
Control	31.97	4848	85.27	7.25	7.48
Site B					
Timothy-alfalfa	32.71	4807	79.76	12.81	7.43
Reed canarygrass	31.16	4808	84.78	11.19	4.03
Timothy	34.25	4936	78.01	9.56	12.43
Smooth brome	33.36	4823	78.81	11.81	9.38
Control	31.78	4701	83.77	10.31	5.92

*Based on weighted means of ash-free dry weights.

establishment of an effective quantitative balance between the supply (wastewater) of, and the demand (crops and soil) for, these nutrients within the overall system.

The data of Figure 10 also show that the total amounts of nitrogen and phosphorus intercepted by the irrigated crops varies with the rates of application. Nitrogen uptake is shown to be consistently higher than that of phosphorus both on an absolute and on a relative basis. The latter observation reinforces the earlier contention of the authors that nitrogen rather than phosphorus was the element more likely limiting to plant growth. A third revelation is that nitrogen:phosphorus ratios, by weight, consistently fall below a value of 2 in irrigation water whereas the same ratio increases by 3-6 fold in the mature crops. The above observation again stresses the marked imbalance between available nitrogen and phosphorus abundance in secondary effluent as opposed to the chemical make-up of these forage grasses.

Prior to October 1973, the Otis agricultural plots were woodlands yet to be cleared and planted in hay crops. In the fall of 1975, after the seeded crops had developed a firm root system, soil sampling profiles taken to a depth of 122 cm (4 ft) were examined for each subplot and in addition the uppermost 30 cm (1 ft) was subjected to soil and root analyses. Results for the observed amounts of phosphorus and nitrogen measured in these samples are given in Table 9. At each of the subplots, irrigation resulted in an increase in phosphorus content above that recorded for the corresponding soil

TABLE 9. NITROGEN-PHOSPHORUS CONTENT (GM/M^2) OF OTIS SOILS SAMPLED TO A DEPTH OF 30 CM

	Phosphorus	Nitrogen
Site A, Reed canarygrass		
East	108	234
South	115	207
West	122	213
Control	93.6	276
Site B		
Timothy-alfalfa	76.4	186
Reed canarygrass	102	224
Timothy	112	-
Smooth brome	88.3	231
Control	73.2	192

control sample. Phosphorus enrichment in the underlying soil was particularly apparent in the case of reed canarygrass and timothy subplots. Regarding nitrogen, the situation was not so clear-cut, however, unlike phosphorus, there was little or no indication of a nitrogen build-up in the upper-most foot of agricultural soil.

Nitrogen:phosphorus (N:P) ratios of leaf, turf and soil samples, collected from each of the agricultural plots, have also been examined. The resulting data, as summarized in Table 10, show that the turf of these grasses does not differ systematically from leaf material with regard to nitrogen and phosphorus aportionment. The mean N:P ratio observed for all irrigated crops was 5.03 whereas the comparable ratio in the irrigation water was only 1.48. Also the irrigated soils showed an N:P ratio of 1.66 whereas the soils on non-irrigated control plots showed a significantly higher average N:P ratio of 3.40. The above nitrogen:phosphorus relations when expressed in terms of a single unit of phosphorus, indicates that the nitrogen deficiency of secondary effluent corresponds to 3.40 units of nitrogen for each unit of phosphorus provided.

Nitrogen limitation not only reduces potential productivity, but also ensures an underutilization of phosphorus and possibly other elements. Furthermore, the low N:P ratios described for irrigated soils may reflect significant scavangering of soil nitrogen by nitrogen deficient crops and/or above-ambient adsorption of underutilized phosphorus to soil particles.

ADDITIONAL CHEMICAL ELEMENTS MEASURED IN OTIS FORAGE CROPS

Elementary chemical analyses of harvested crop material has also

TABLE 10. NITROGEN:PHOSPHORUS RATIOS (BY WT)
OTIS FORAGE CROPS

1974 - 1977

	Crop N:P	Turf N:P	Soil N:P
Site A, Reed canarygrass			
East	4.76	3.83	1.68
South	3.46	4.03	1.31
West	4.25	4.33	1.62
Control	3.02	5.47	4.04
Site B			
Timothy-alfalfa	5.07	5.21	1.50
Reed canarygrass	5.95	4.59	1.61
Timothy	6.12	4.96	1.83
Smooth brome	5.63	4.38	2.05
Control	7.98	6.33	2.75
Mean, irrigated plots	5.05	4.48	1.66
Mean, Otis secondary effluent	1.48		

included an evaluation of 10 additional elements besides carbon, hydrogen, nitrogen and phosphorus. These other entities can be conveniently divided into two groups, the major cations and the minor cations or elements present at trace concentration. Among the major cations measured were potassium, calcium, magnesium and sodium. The minor cations or trace elements included iron, manganese, zinc, copper, lead and cadmium.

The fractional proportions of major cations measured on an ash-free dry weight basis in the Otis crops are shown in Table 11 where the percentages entered reflect weighted means for all crops harvested between 1974 and 1977. The most abundantly represented element of this group was potassium which consistently represented between 1.50 and 2.00 percent of the harvested material. Sodium, on the other hand, was the least abundant of these elements, its highest concentration measuring less than 0.05 percent. The proportions of calcium and magnesium in these grasses were quite comparable at a concentration roughly intermediate between that of potassium and sodium. A significant aspect of these data is the extent to which these crops discriminate against sodium in favor of potassium. Another interesting point is that potassium and magnesium alone showed enrichment in the irrigated crops above that of the non-irrigated controls. The relative proportions of these elements does not appear to differ significantly for the unique grass species.

TABLE 11. ELEMENTARY COMPOSITION*, MAJOR CATIONS
OTIS FORAGE CROPS
1974 - 1977

	K	Ca	Mg	Na
		- Percent -		
Site A, Reed canarygrass				
East	--	.193	.192	.035
South	1.66	.142	.178	.026
West	1.88	.173	.234	.042
Control	1.45	--	.024	.011
Site B				
Timothy-alfalfa	1.70	.295	.165	--
Reed canarygrass	1.97	.169	.169	.049
Timothy	1.91	.165	.119	.025
Smooth brome	2.00	.164	.110	.012
Timothy, control	1.51	.202	.098	.018

*Based on weighted means of ash-free dry weight.

The representation of minor cations or trace elements, given in parts per million ash-free dry weight basis, is shown in Table 12. Again, the values entered represent weighted means for all irrigated and non-irrigated crops harvested between 1974 and 1977. In this case iron is the most prominent trace metal, followed by a preferential order of uptake whereby manganese exceeds zinc, copper, lead and cadmium. In terms of concentration, iron exceeds cadmium by three orders of magnitude whereas the remaining elements occur at concentrations about 100 times greater than that of cadmium. There is no consistent trend supporting luxury uptake by the irrigated crops of any of these cations over that observed for the non-irrigated control crops.

WASTEWATER RENOVATION BY CROPS

The renovation efficiency whereby crops remove a given chemical substance from wastewater is defined as:

$$\text{Efficiency, \%} = \frac{\text{mass in harvested crop}}{\text{mass in applied irrigation}} \times 100. \qquad (3)$$

Accumulated values describing the long-term renovative efficiencies for nitrogen, phosphorus, potassium, copper, cadmium and zinc are shown in Figures 11 and 12 and Table 13. Within the observed scatter and for the

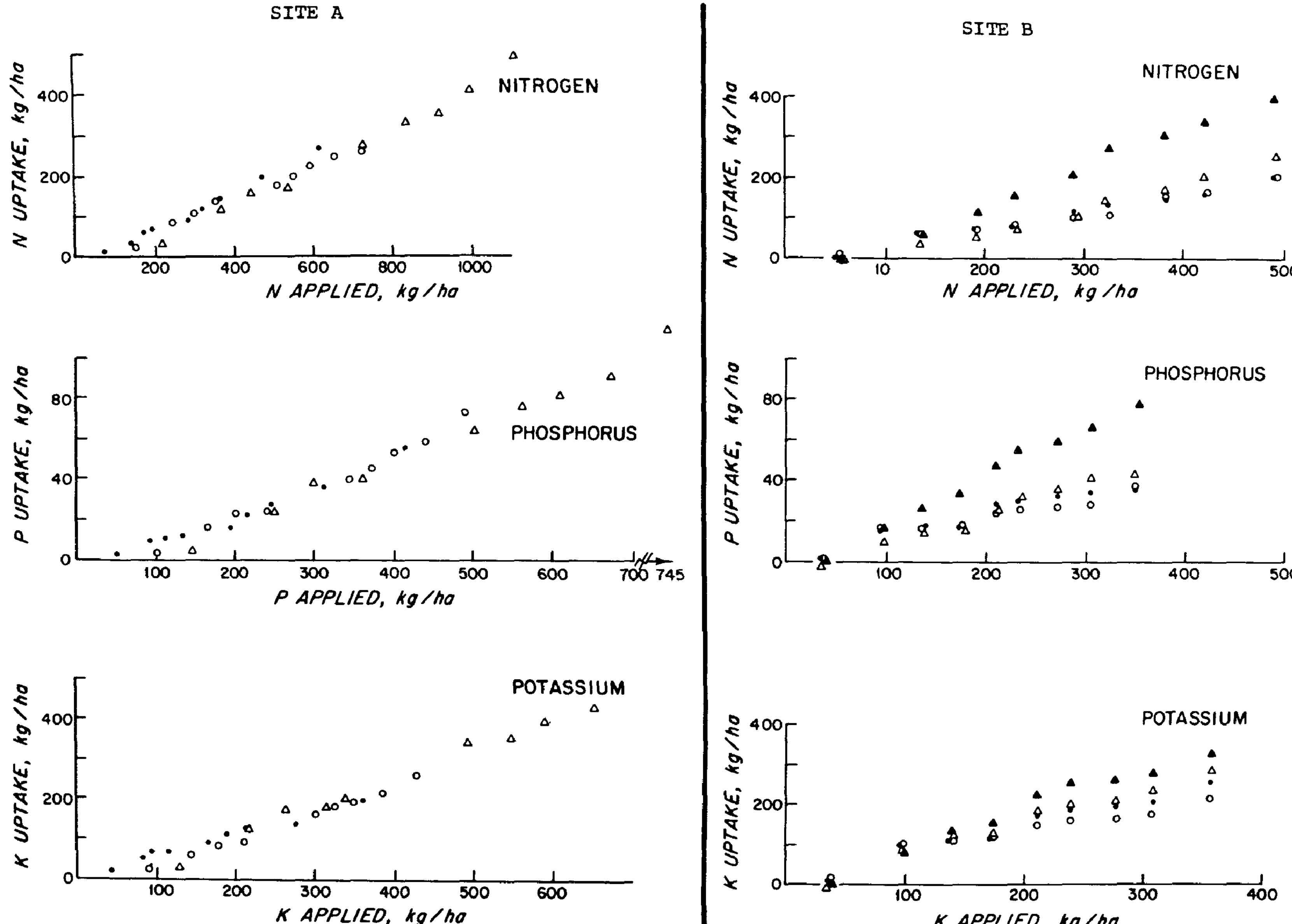

Figure 11. Long-term renovation efficiencies for nitrogen, phosphorus and potassium at three subplots of Site A and four subplots of Site B. Site A data correspond to different rates of reed canary grass irrigation; solid circles, 1 in per wk. 1974-76 and 4 in per wk., 1977; open circles 2-; and open triangles 3 in per wk. Site B data correspond to different forage crops irrigated at 2 in per wk.; solid triangles timothy-alfalfa; solid circles, timothy; open triangles, reed canary and open circles smooth brome.

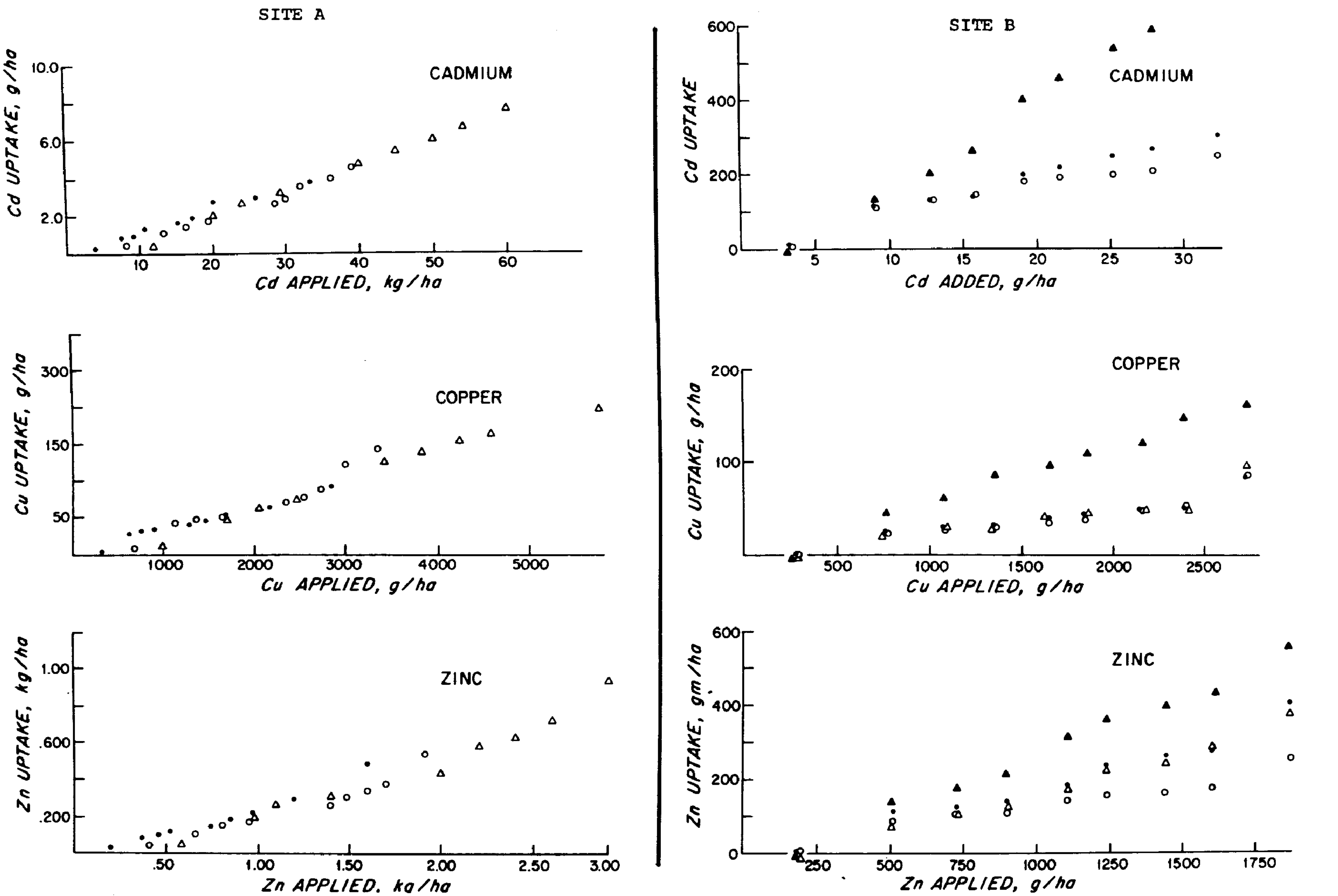

Figure 12. Long-term (1974-77) renovation efficiencies for cadmium, copper and zinc at three subplots of Site A and four subplots of Site B. Site A data correspond to different rates of reed canary grass irrigation; solid circles, 1 in per wk., 1974-76 and 4 in per wk., 1977; open circles 2-; and open triangles 3 in per wk. Site B data correspond to different forage crops irrigated at 2 in per wk.; solid triangles, timothy-alfalfa; solid circles, timothy; open triangles, reed canary and open circles smooth brome.

TABLE 12. ELEMENTARY COMPOSITION-TRACE ELEMENTS
OTIS FORAGE CROPS

1974 - 1977

	Fe	Mn	Zn	Cu	Pb	Cd
		- Parts per million -				
Site A, Reed canarygrass						
East	138	85	37	14	3	0.2
South	123	52	34	9	2	0.3
West	145	50	37	12	2	0.3
Control	--	--	46	16	3	0.4
Site B						
Timothy-alfalfa	178	23	29	11	2	0.3
Reed canarygrass	89	46	33	--	2	0.2
Timothy	78	21	31	6	2	0.2
Smooth brome	76	33	23	--	2	0.2
Timothy control	--	29	18	7	3	0.3

delivery rates applied, these data consistently describe a linear relation between the application and uptake variables. Other elements such as magnesium, calcium, and sodium were also observed to behave in a similar manner, whereas calcium and iron behaved differently and exhibited a unique response for each wastewater delivery rate.

Information on elementary efficiences for the four different crop varieties of Site B has also been compiled. In Figure 11 and Tables 13 and 14, nitrogen, phosphorus, and potassium exchanges are shown while Figure 12 provides information on copper, cadmium and zinc. In each of the above instances the maximum removal efficiency was accomplished by the mixed timothy-alfalfa crop. Other elements which were most effectively removed by the timothy-alfalfa crop were calcium, iron, and lead. Regarding other Site B crops there was little or no difference between the long term trends describing renovation efficiencies for the elements described in Figures 11 and 12. On the other hand, the individual crops of Site B showed separate uptake patterns for the elements zinc, manganese, sodium and magnesium.

Values representing the ultimate extent of renovation accomplished for all the chemical entities examined for Site A and B crops also appear in Tables 13 and 14 respectively. These combined data suggest that neither the irrigation rates, nor crop varieties employed, exclusively regulate the uptake behavior of these crops. The authors would anticipate, however, that irrigation rates in excess of some undefined, but critical level would ultimately lead to a breakdown in renovation efficiencies.

TABLE 13. RENOVATION EFFICIENCIES, PERCENT, FOR VARIOUS CHEMICAL ELEMENTS APPLIED TO CROPS OF SITE A*

1974 - 1977

Chemical Element	Reed Canarygrass Plot East	South	West
	- Percent -		
Manganese	144	92.3	92.7
Potassium	55.3	62.9	74.0
Nitrogen	51.8	42.8	54.7
Zinc	29.7	28.7	32.9
Magnesium	18.0	17.6	24.2
Phosphorus	15.3	17.4	18.0
Cadmium	11.7	11.5	13.0
Lead	14.1	10.0	10.7
Iron	8.97	8.38	10.1
Calcium	8.09	6.28	7.98
Copper	6.60	4.19	5.80
Sodium	0.29	0.23	0.39

*Irrigation rates: East 1 inch per week, 1974-1976
4 inches per week, 1977
South 2 inches per week, 1974-1977
West 3 inches per week, 1974-1977

TABLE 14. RENOVATION EFFICIENCIES, PERCENT, FOR VARIOUS CHEMICAL ELEMENTS APPLIED TO FOUR DIFFERENT CROPS OF SITE B

1974 - 1977

Chemical Element	Timothy-alfalfa	Reed canarygrass	Timothy	Smooth brome
	- Percent -			
Manganese	89.5	60.6	37.4	47.6
Potassium	82.2	95.2	72.0	62.1
Nitrogen	53.8	82.7	41.5	42.4
Zinc	26.0	30.5	22.0	13.7
Magnesium	16.7	21.7	10.6	8.07
Phosphorus	12.5	22.6	10.0	10.4
Cadmium	10.8	20.2	9.67	7.95
Lead	10.2	15.4	9.73	7.24
Iron	5.84	17.1	5.23	4.27
Calcium	7.97	19.6	7.48	6.08
Copper	5.74	3.84	2.99	2.95
Sodium	0.48	1.10	0.22	0.09

SECTION 9

GROUNDWATER HYDROLOGY AND THE IMPACT OF SPRAY-IRRIGATION

HYDROGEOLOGIC STUDIES

The geohydrography of Cape Cod (Figure 13) has been reviewed in reports by Oldale [9]; Mather *et al.* [10]; Mather *et al.* [11]; Strahler [5, 6]; and Palmer [25]. From these sources it can be inferred that the hydrogeology of the area can be considered a single, homogeneous, anisotropic aquifer with maximum hydraulic conductivity (HC) in the north-south direction roughly parallel to the direction of deposition of the outwash sands and gravels. The east-west HC is considerably smaller in a direction which is roughly perpendicular to that of glacial deposition. The water table map for the Falmouth area shown in Figure 14 and the saturation thickness map shown in Figure 15 have been used to prepare replicate estimates of the hydraulic conductivities in each of the above directions. This analysis provided a range of north-south HC values of 42.7-50.9 m (140-167 ft) per day and an east-west range of 18.9-24.7 m (62-81 ft) per day for annual recharge rates of 5.35-6.36 m (17.54-20.88 ft) per day.

Analyses of data from four aquifer tests, involving the array of groundwater observation wells shown in Figure 16, yielded an estimated range of 35.7-48.2 m (117-158 ft) per day for HC and 0.13-0.26 for specific yield (SY) defined as:

$$SY = \frac{\text{Volume water yielded by gravity from saturated rock}}{\text{Volume of rock source}}. \qquad (4)$$

The averages of four independent HC and SY measurements were 40.5 m (133 ft) per day for HC and 0.18 for SY.

Average annual recharge was estimated by three different methods: a Thornthwaite estimation of evapo-transpiration (ET), a flownet analysis, and a chloride balance method. These methods yielded estimates of 53.04, 42.27, 45.21 cm (20.88, 16.64 and 17.80 in) per year respectively. Maximum and minimum recharge rates for the irrigation plots were estimated using a Thornthwaite calculation (assuming no ET loss from the irrigation water) and a chloride balance method (using the maximum measured chloride concentration in the percolate) respectively. The maximum recharge rates for 1975 were respectively estimated to be 73%, 79% and 84% for the 2.54, 5.08, and 7.62 cm (1, 2, and 3 in) per week plots of Site A. For 1976 the maximum recharge rates were 68%, 75%, and 80% for the 2.54, 5.08 and 7.62 cm per week plots respectively. The minimum recharge for the same plots, respectively, are placed at 32%, 49% and 34% for 1975 and 33%, 57% and 53% for 1976.

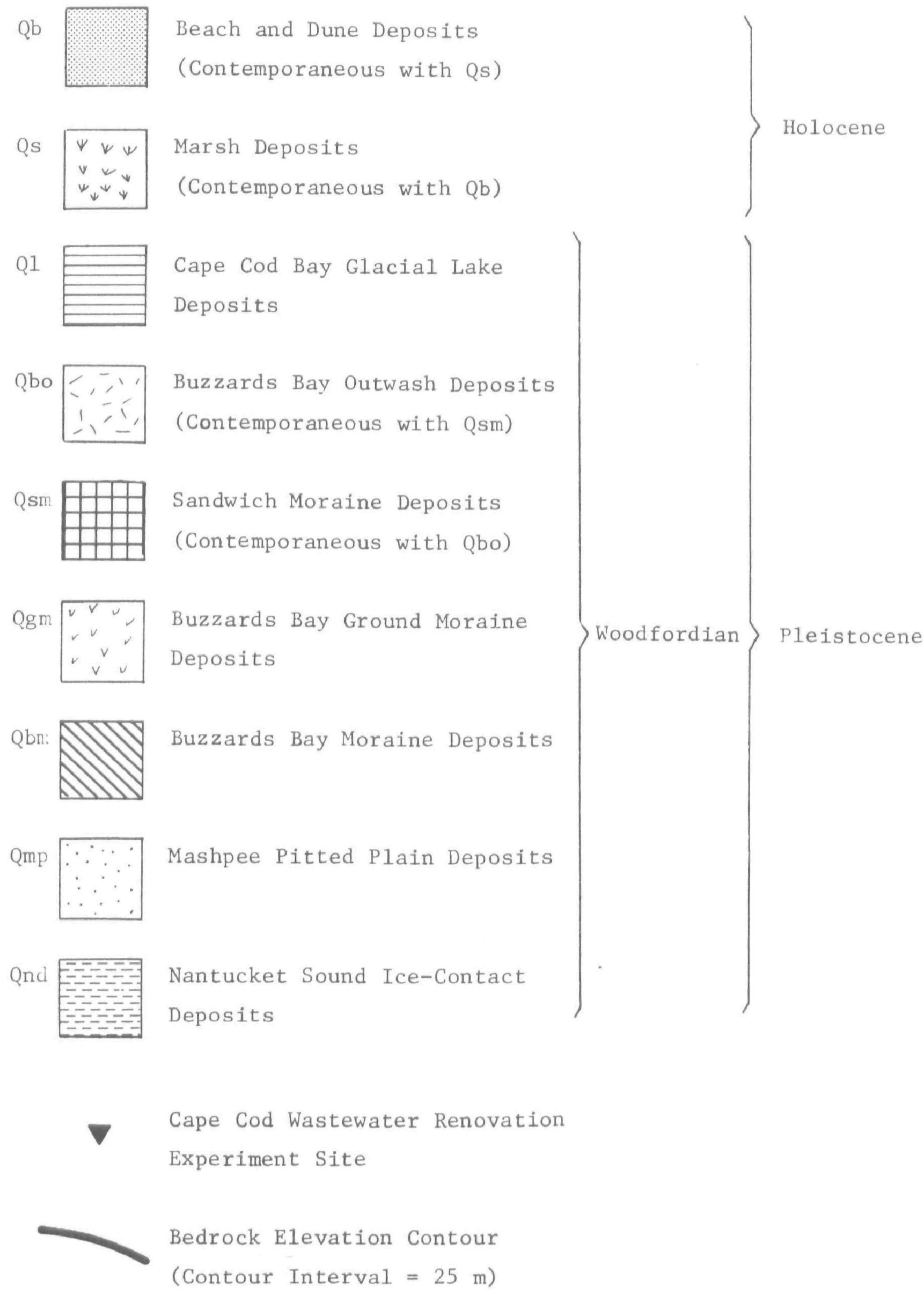

Figure 13. Legend

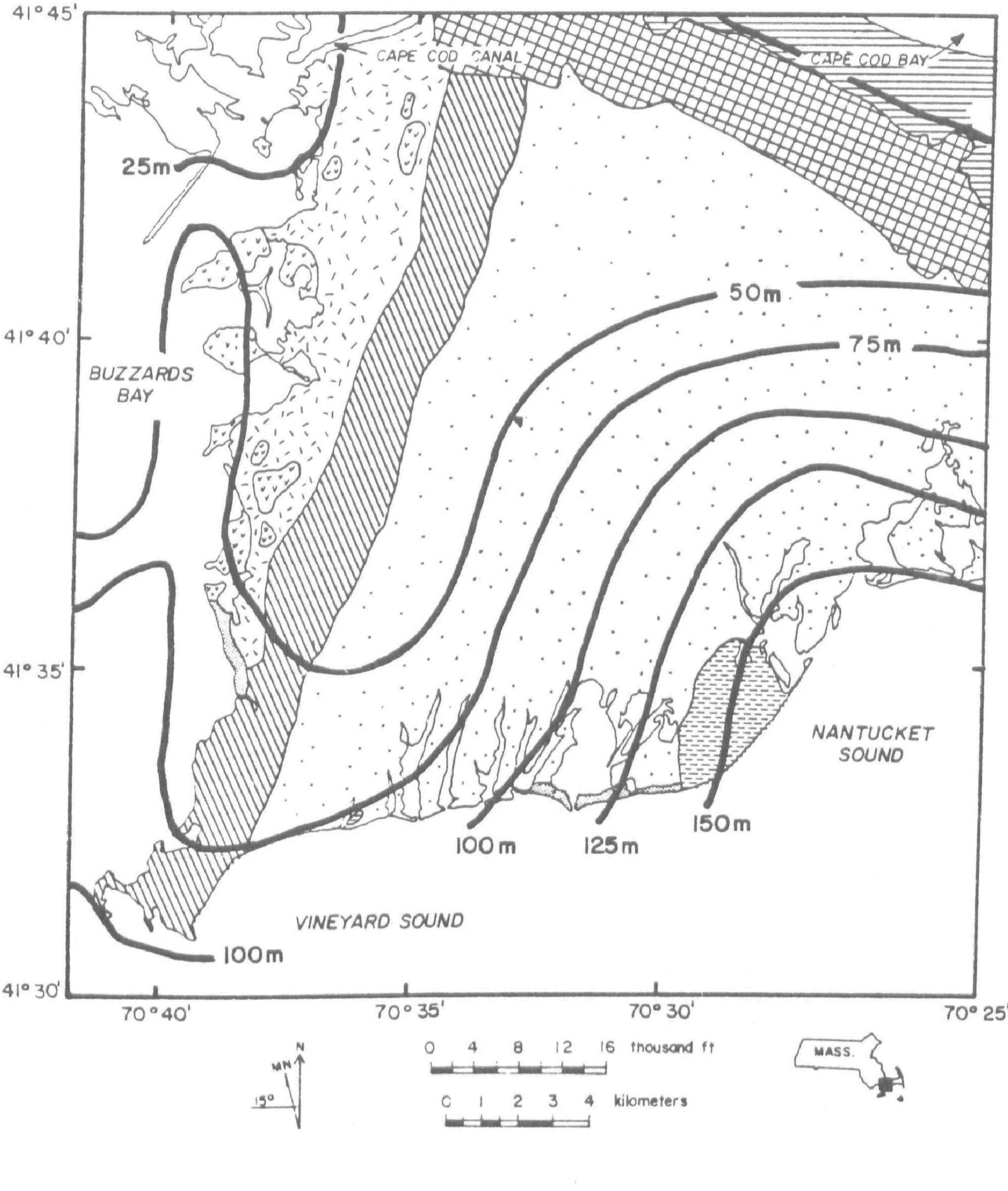

Figure 13. Geology of the Falmouth Area of Cape Cod, Massachusetts. (Legend continued.)

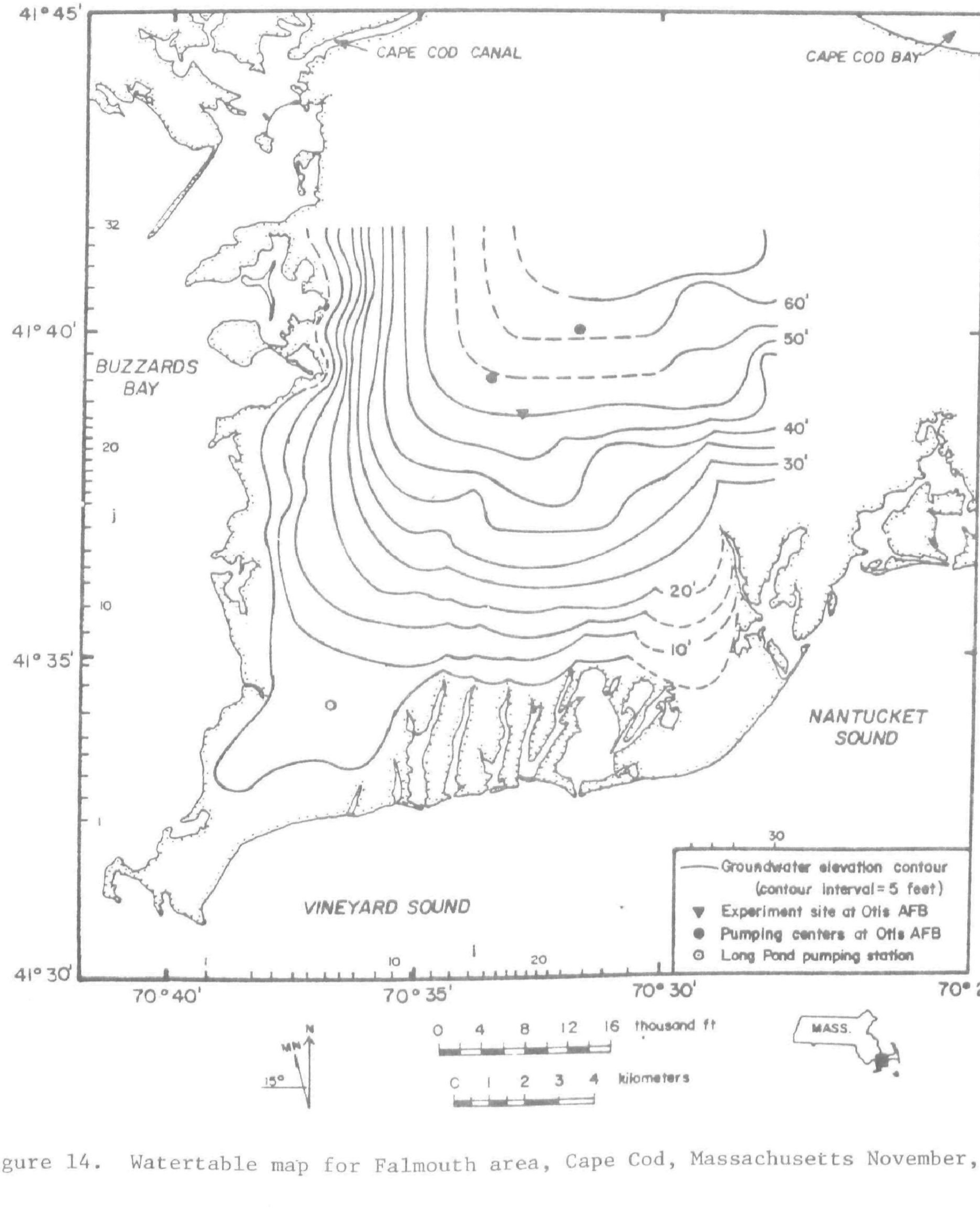

Figure 14. Watertable map for Falmouth area, Cape Cod, Massachusetts November, 1975.

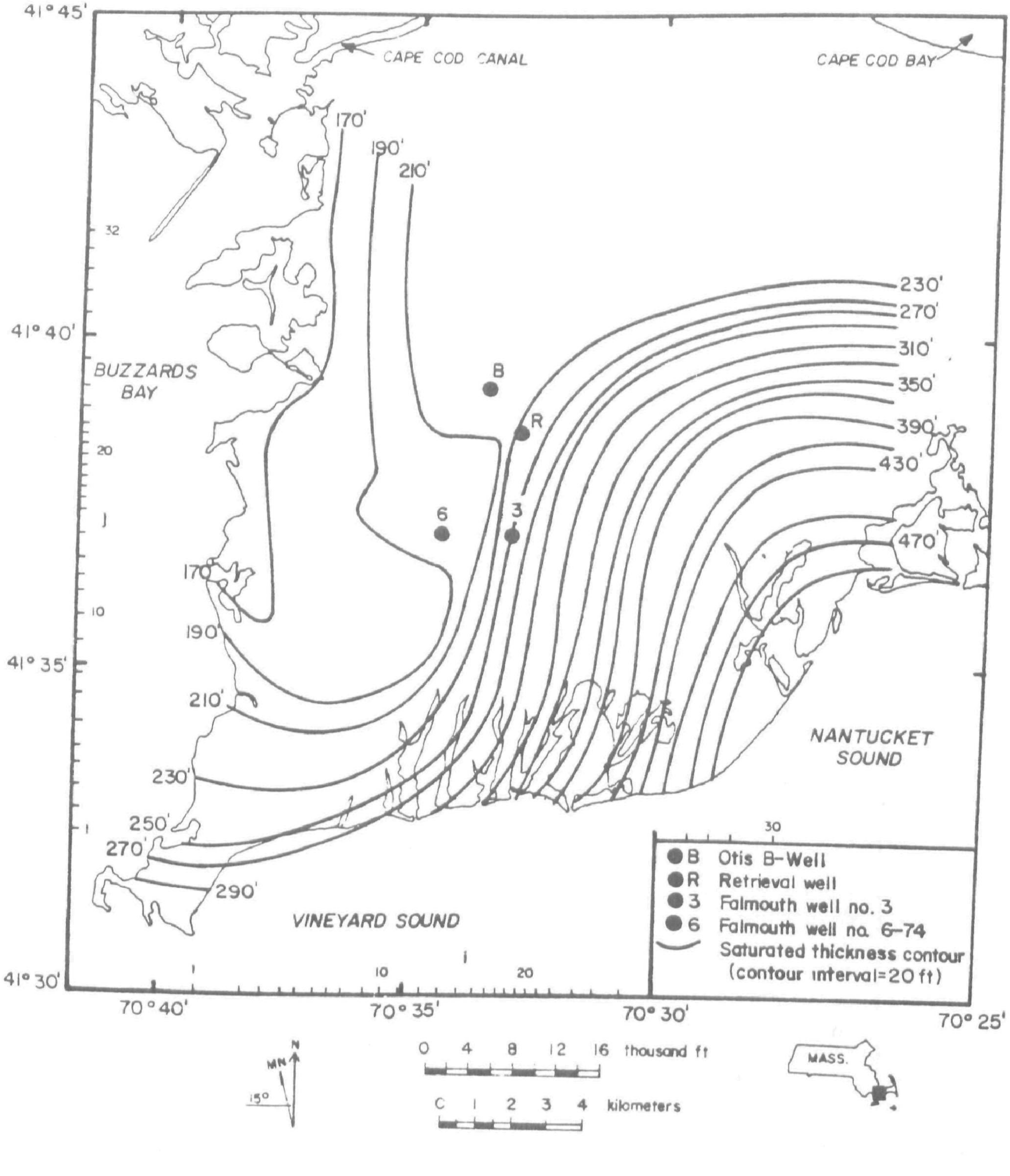

Figure 15. Saturated thickness map.

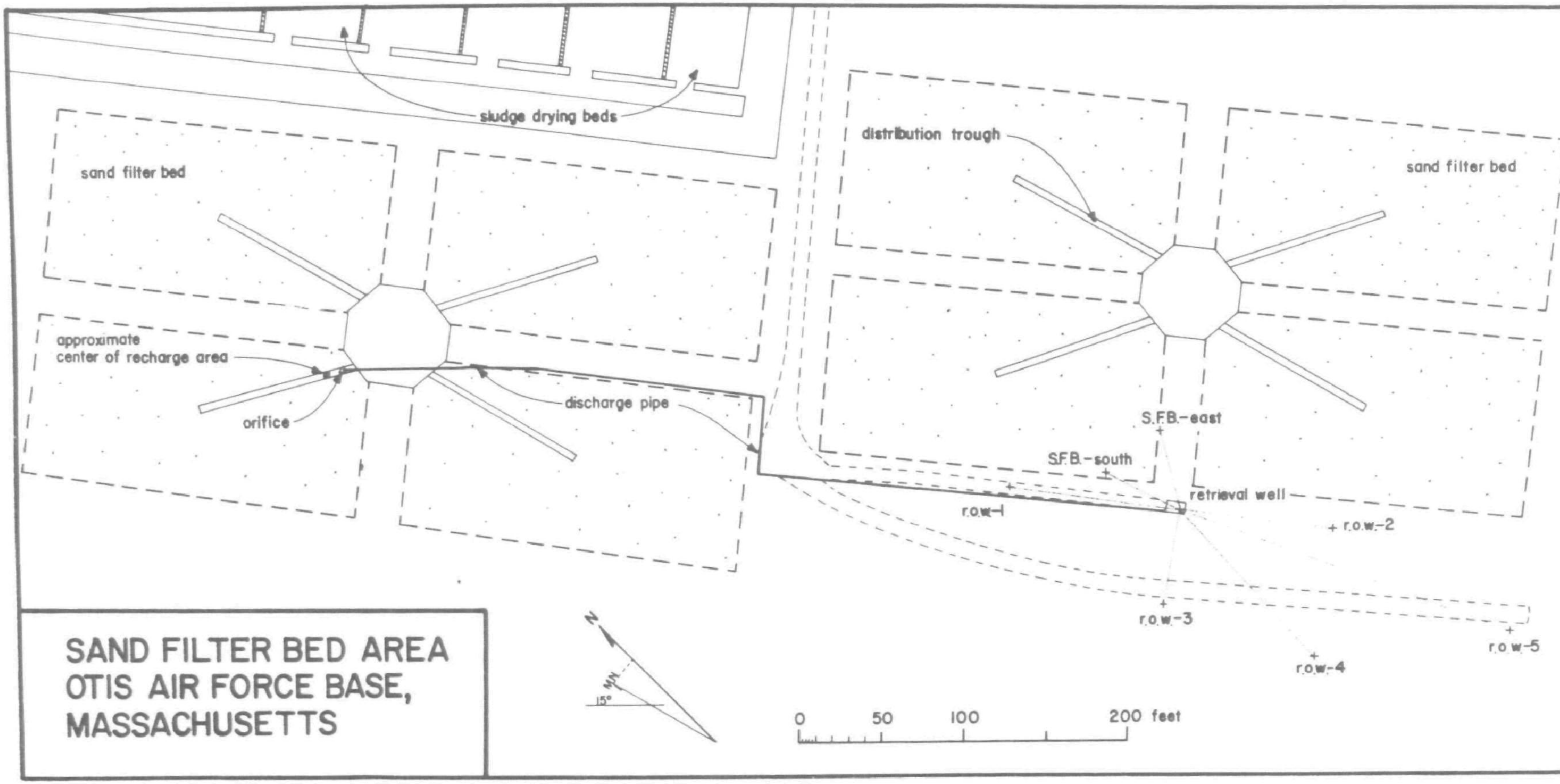

Figure 16. Map showing the location of the observation wells and discharge point with respect to the Retrieval Well, Otis AFB, Cape Cod, Massachusetts.

A digital model was proposed and was used to simulate a steady state watertable configuration based on existing conditions. This was obtained for a homogeneous, anisotropic aquifer with an east-west HC = 26.2 m (86 ft) per day and north-south HC = 38.1 m (125 ft) per day and with a recharge rate of 53.04 cm (20.88 in) per year. Thus far, no attempt has been made to model any other recharge rates. Recharge for spetic tanks in the Falmouth area was estimated from other reports [26] to be .089 cm (.035 in) per day. Pumping at Long Pond, the source of most of the municipal freshwater for Falmouth, was set at 10,370 m^3 (366,000 ft^3) per day. Pumping at Otis AFB was estimated to be 2082 m^3 (73,530 ft^3) per day and was distributed evenly over its two pumping centers and recharged evenly over the area of the sand filter beds, since the prepared irrigation plan called for a 5.08 cm (2 in) per week irrigation schedule, recharge rates of 49%, 69% and 79% of the total applied water (irrigation and precipitation) were simulated.

The results of those simulations were that regardless of whether ocean outfall or spray-irrigation are used as the wastewater management method, the effect of sewering will be the same within the sewered areas, i.e., up to 39.62 cm (1.3 ft) of groundwater level decline will result. Ocean outfall will have the effect of dropping the water level of Long Pond by 15.2 cm (0.5 ft) and spray-irrigation may reduce this drop to only 9.14 cm (0.3 ft). These effects will be greater during the summer months when pumping is greater and there is a net loss of water from the aquifer by ET. To evaluate the effects during the summer months a non-steady-state model would be required.

Areas around the Otis irrigation site that are not far above the present seasonably high water table may be affected by rising water levels resulting from increased recharge; up to 1.68 m (5.5 ft). In particular, areas on the west side of Ashumet Pond may be affected.

The model compiled has limitations. It needs further refinement of hydraulic conductivity values. It was modeled upon only one recharge value, and it is a steady-state model. Furthermore, it does not take into account the effects from large ponds on the water table configuration. Streams can also have a controlling influence on thewater table configuration, for stream flows may increase in response to increased recharge rather than waterlevels within a particular area. Better estimates of all parameters (recharge, specific yield, hydraulic conductivity, etc.) are also needed for formulation of an improved model along with validation studies involving more waterlevel measurements over a much longer period of time.

In spite of all of these short-comings the model presented should represent at least a first and best presently available approximation of the potential affects from a full scale wastewater-irrigation facility at Otis for the town of Falmouth.

GROUNDWATER QUALITY CHANGES

Groundwater samples have been routinely collected from wells located immediately down gradient from each Site A plot and also from upstream control sources. All wells were assembled with 1.82 m (6 ft) well points which intersect the top several feet of the aquifer where the greatest groundwater attenuation was anticipated.

Numerous cations and anions have been observed to occur at increased concentrations with time, but the abundance has not as yet exceeded either EPA or U.S. Public Health Service standards for potable waters. At the same time, however, this subject cannot be lightly dismissed since certain of the ions examined are continuing to appear at accelerated concentrations in the groundwater. The following paragraphs describe groundwater characteristics after the four years of wastewater irrigation.

Time related changes for chloride, nitrate, sodium, potassium and boron from beneath Site A plots prior to and after four years of irrigation are shown in Figures 17 through 21. These data have been expressed as three point running averages to help overcome background noise. Also we have purposely omitted data relating to the intermediate rates of irrigation, [south plot, irrigation 5.08 cm (2 in) per week], since these data consistently took an inbetween, but often overlapping position between results recorded for the minimum and maximum rates of irrigation.

Since chloride is one of the least likely ions to be intercepted by crops or soil, its increase in groundwater can provide a useful measure of the recharge time for irrigation water. At Otis the arrival of chloride in the wells followed an S-shaped curve and a mean arrival time has been defined as the interval between the start of irrigation and the arrival of one-half of initial plateau concentration. Using this technique, the fastest rate of irrigation corresponded to a recharge time of about 200 days or a descent of 7.6 cm (3 in) per day (Figure 17). Greater uncertainty is associated with the lesser rates of irrigation, but the data clearly suggest an arrival time in excess of 200 days. Information on recharge indicates a time requirement which is strongly influenced by the total hydraulic loading applied at the surface.

Starting about mid 1976 a second pulse of chloride arrival began to appear under the west plot and a maximum concentration of 40 ppm was reached during the first half of 1977. The very moderate increase in chloride associated with the east plot is probably an independent effect since the irrigation rate at this location was increased from 2.54 to 10.16 cm (1 to 4 in) per week during 1977. However, the reason for the secondary chloride pulse under the west plot cannot be satisfactorily explained at this time.

Data describing the appearance of nitrate-nitrogen in the groundwater under Site A are shown in Figure 18. Again the mid-point of the initial pulse under the west plot correspond to an arrival time of about 200 days. However, early in 1975 a marked decrease in nitrate concentration commenced and persisted well into 1976. During the latter half of 1976 and throughout 1977 the nitrate changes stabilized at 1.0 and 0.30 ppm respectively for the west and east plot groundwaters. There is reason to believe that the abrupt decrease in nitrate in 1975 corresponded to an increase in crop biomass and a more efficient nitrate uptake provided by a fully established root system.

Figure 19 shows comparable groundwater results for sodium and provides

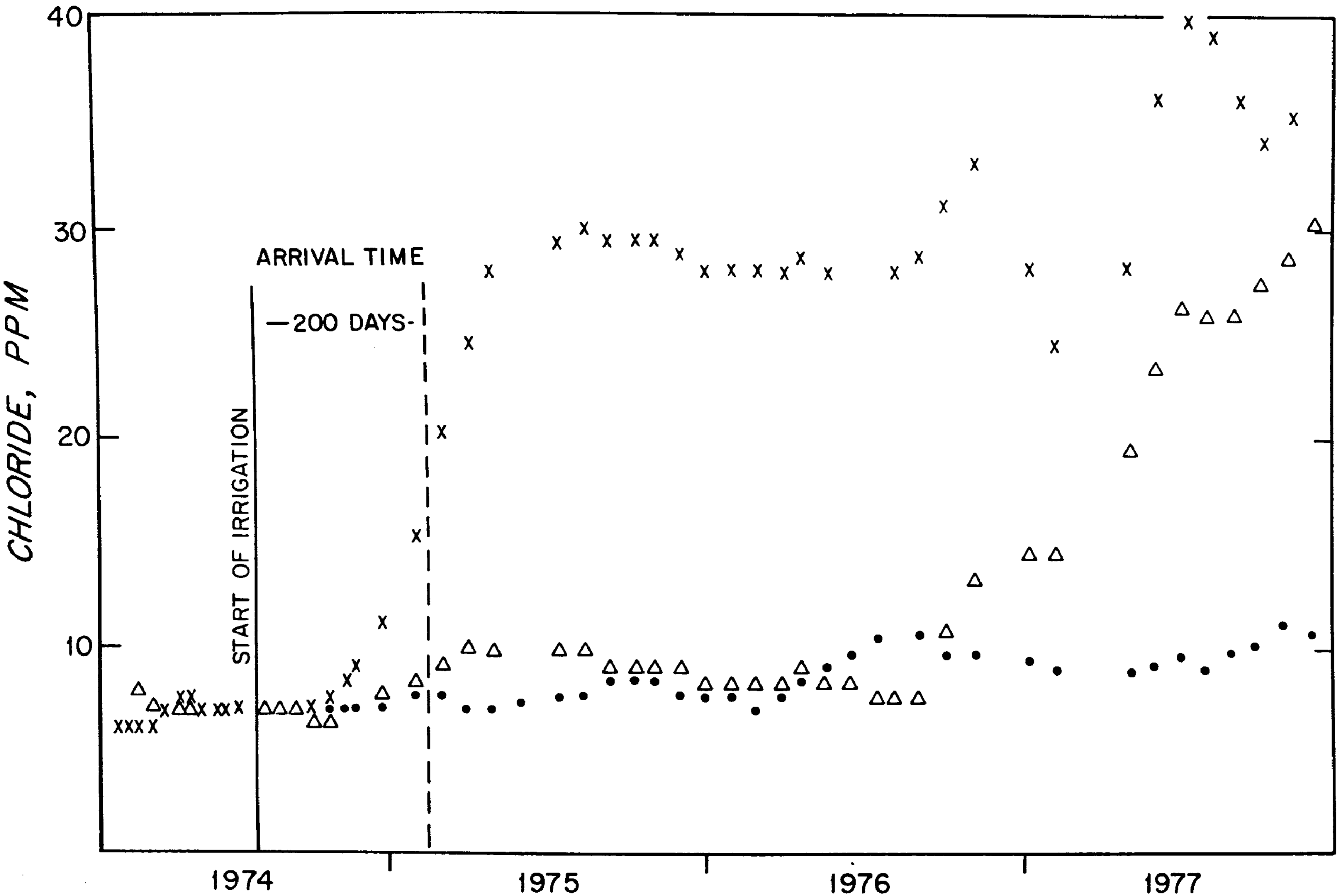

Figure 17. Chloride concentrations vs. time, Site A wells, located on west (crosses), south (triangles) and east (solid dots) subplots.

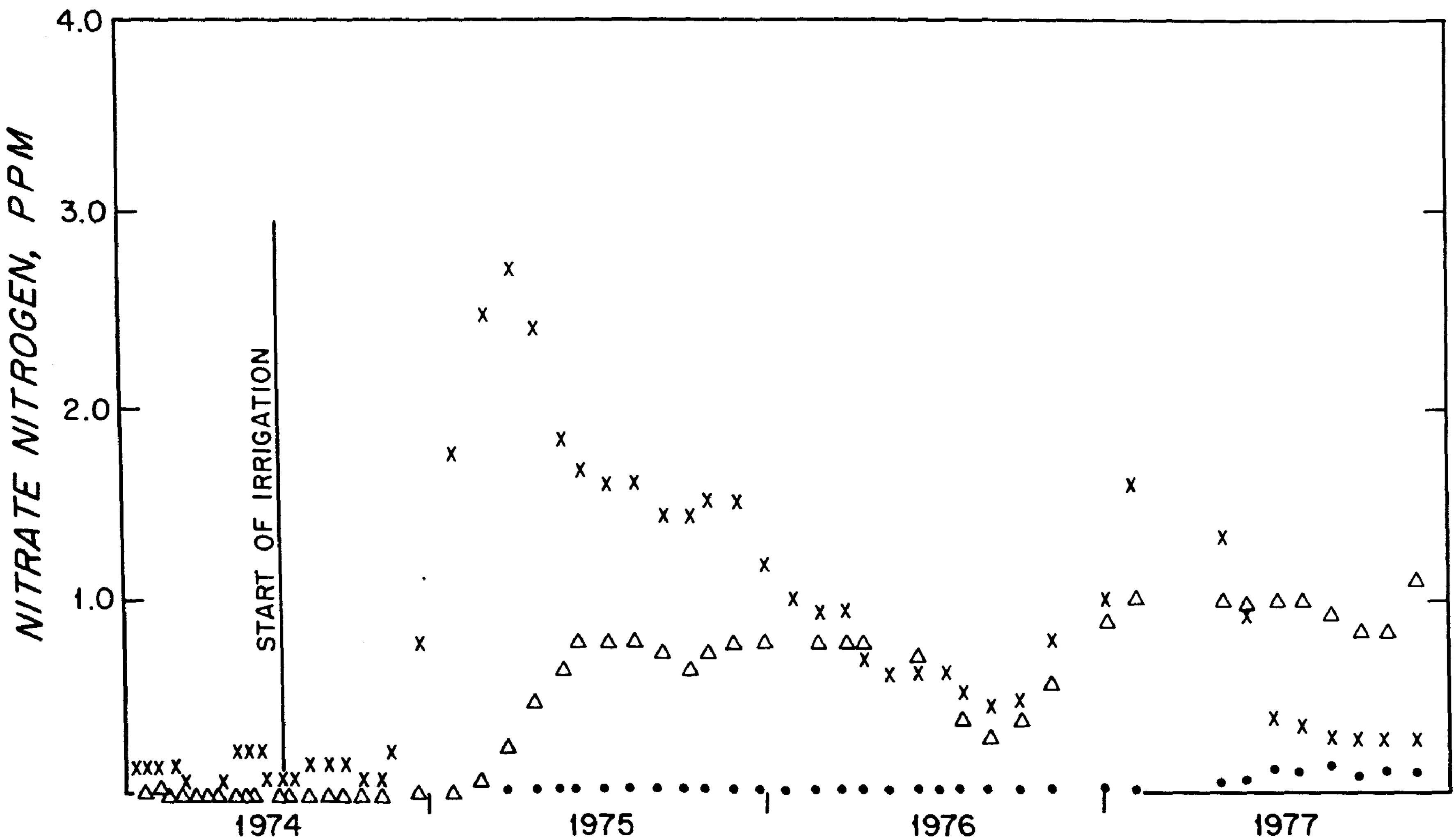

Figure 18. Nitrate-nitrogen concentrations vs. time, Site A wells located on west (crosses), south (triangles) and east (solid dots) subplots.

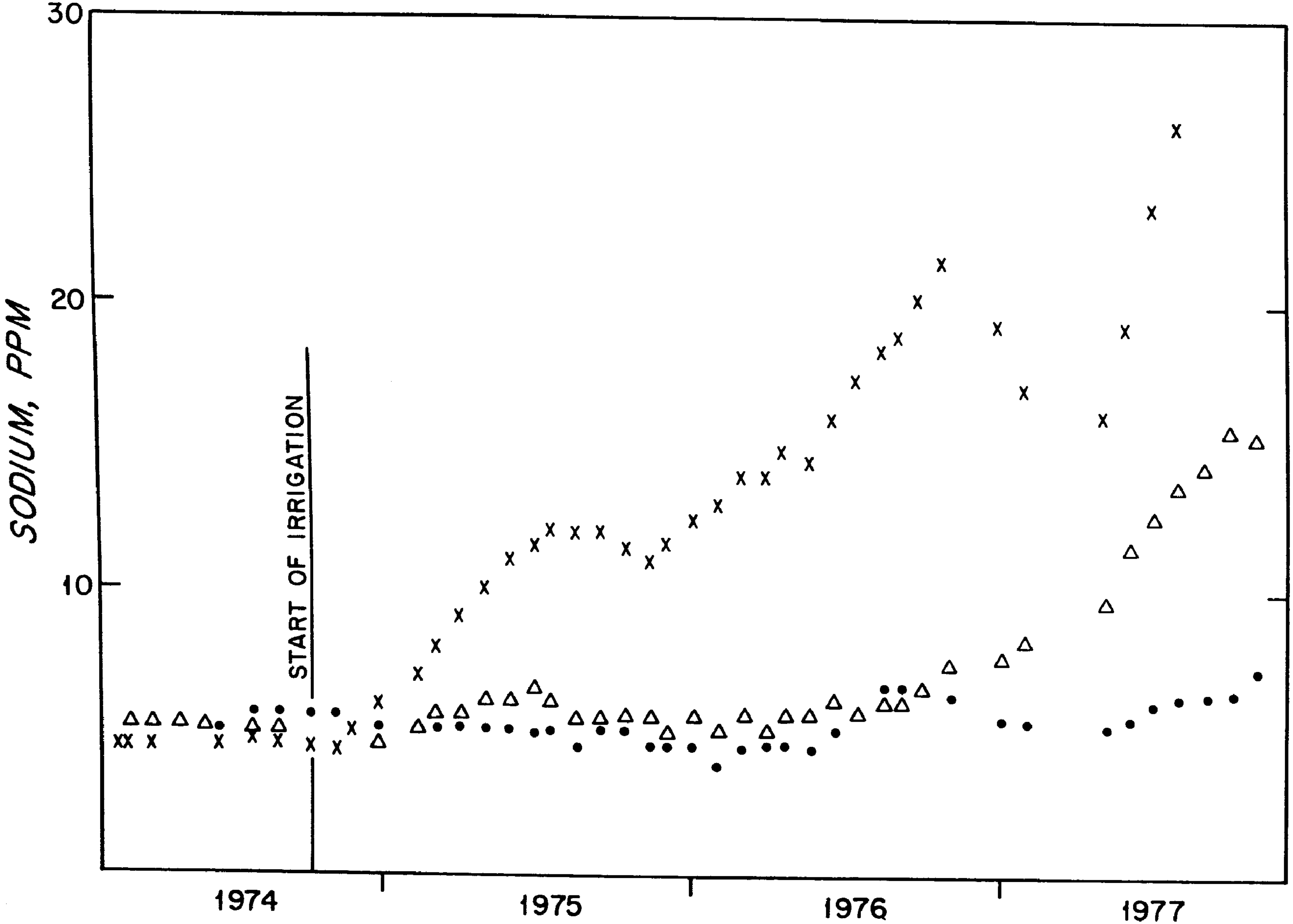

Figure 19. Sodium concentrations vs. time, Site A wells located on west (crosses), south (triangles), and east (solid dots) subplots.

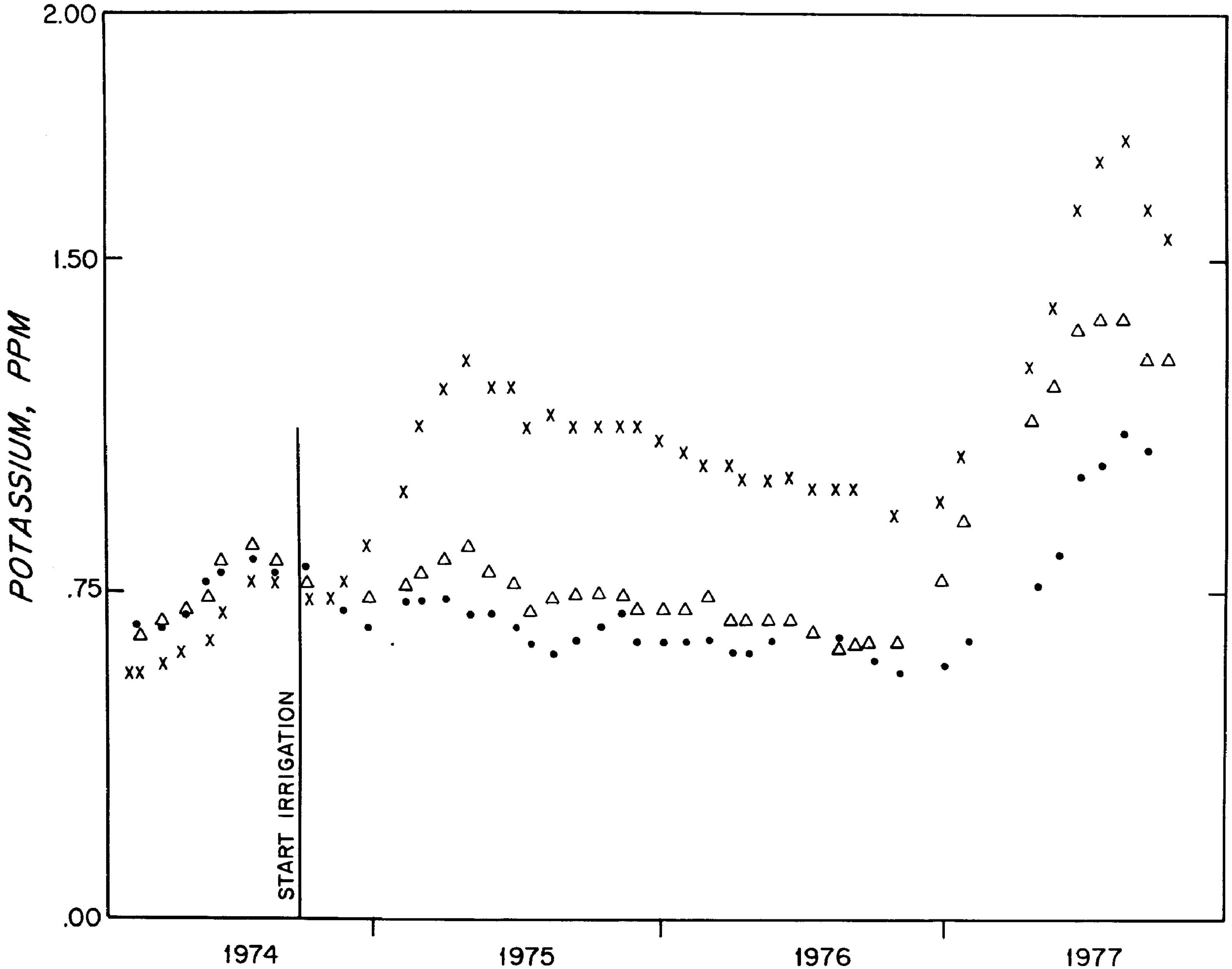

Figure 20. Potassium concentrations vs. time, Site A wells located on west (crosses), wouth (triangles) and east (solid dots) subplots.

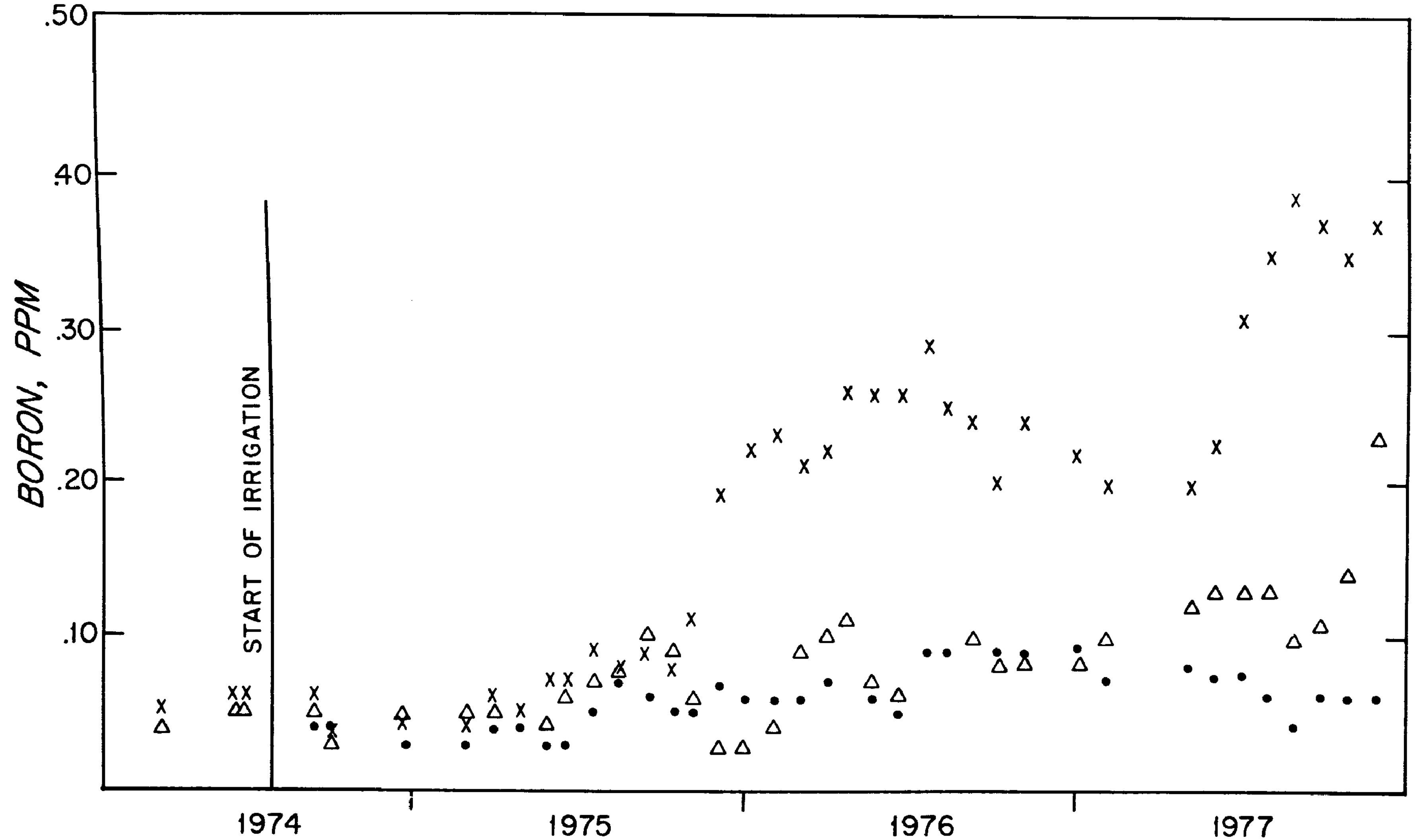

Figure 21. Boron concentrations vs. time, Site A wells located on west (crosses), south (triangles) and east (solid dots) subplots.

unmistakable evidence of a continuing increase in concentration (up to 27 ppm) and the prolonged period required for a steady state development. In view of recent adverse disclosures concerning the effects of sodium on hypertensive individuals, the incompleteness of the sodium record will remain a matter of concern unless follow-up analyses are completed. In Massachusetts the drinking water recommendation for sodium is under 20 ppm, which is significantly less than the current sodium content of the groundwater beneath the agricultural crops.

The time related changes for potassium as shown in Figure 20 also describe an initial arrival time of about 200 days. As was the case with chloride and nitrate, the maximum observed concentrations of potassium occurred during the first half of 1975. Late potassium changes during 1977 which demonstrated an accelerated increase in abundance are difficult to interpret in view of a simultaneous and inexplicable increase in the potassium content of the upstream control well. This is the only instance wherein such broad fluctuations were encountered in the control situation.

Groundwater changes in boron with time underneath Site A are shown in Figure 21. Among the elements examined boron demonstrated the longest groundwater arrival time; in excess of 500 days. Also, the pattern of boron enrichment was characterized by prominent pulses which appeared in mid 1976 and again in 1977.

The investigators had hoped to make mass balance analyses, describing the partitioning of some 15 critical chemical elements into crops, soil water, and groundwater, an integral part of these studies. However, the unexpected delay encountered with respect to steady-state arrivals in the groundwater presently preclude this possibility pending the appearance of constant concentrations of sodium, potassium, boron and chloride.

Distinct from the above, the Otis data also identify a second group of ions which includes phosphate, nitrate, magnesium and calcium that display groundwater concentrations which appear to have stabilized within the past year. Providing the behavior of these elements can be compared with the equilibrium behavior of more conservative ions, such as chloride, their potential as tracer ions can be more fully exploited. Ultimately, this should provide a much better understanding of the physical and biological phenomenon which regulate the movement and quality of the groundwater of the southern Cape Cod aquifer [27, 28].

SECTION 10

CHLORINATION OF AGRICULTURAL SYSTEMS IRRIGATED WITH DOMESTIC WASTEWATER

Spray irrigation of agricultural crops with partially treated wastewater is already a popular means of extending water renovation and improving its conservation. However, as with all waste disposal techniques, acceptance of this form of recycling requires pathogen elimination as well as an avoidance of other adverse environmental consequences.

Unfortunately, conventional wastewater treatments do not guarantee pathogen-free effluents unless their end products are subjected to terminal disinfection. In this country, chemical disinfection of wastewaters used for irrigation is generally achieved by chlorination, especially if crops intended for human consumption are involved. In the absence of chlorination, disease entities can be transmitted from incompletely disinfected irrigation waters by way of the following:

1. Inhalation of aerosols carrying pathogenic bacteria or viruses,

2. Consumption of contaminated food crops,

3. Ingestion of drinking water containing pathogenic organisms.

While terminal disinfection would appear mandatory for safe spray irrigation, chlorine usage can also lead to undesirable environmental effects. Chlorine residuals as low as 0.20 mg per l or less have been shown to be disruptive to many aquatic plants and animals. Also, free chlorine can seriously inhibit photosynthesis in higher agricultural crops. Even more disconcerting is the increasing number of references in the environmental literature which warn of biological hazards from persistent chloro-organic compounds in nature. Clearly, there is a need for improved criteria to restrain an overzealous use of chlorine for disinfecting purposes. Ultimately, it may even become desireable to assign optimal chlorine dosages which take into account the peculiarities of individual chlorination facilities.

During the past year, the authors have investigated the effects of chlorine on the inactivation of MS-2 bacteriophage at the spray-irrigation and agricultural facility located at Otis Air Force Base, Massachusetts. In this case, secondary effluent is lagooned for two to three weeks and then disinfected with liquid chlorine immediately before application to a series of experimental agricultural plots. A (10.2 cm) polyethylene force main 415 m (1360 ft) long, serves as an experimental contact chamber for chlorination and provides a controllable retention time (12 min. at a normal pumping rate of 265 l (70 gals) per minute). Initially, the chlorine dosage applied was fixed at 10 mg per l; but since 1976, after evaluating preliminary test results, a more flexible chlorination program was adopted whereby chlorine dosage is varied. Usually residual chlorine (free available chlorine) is maintained within the range of 1 to 2 mg per l.

The experimental studies of the authors with chlorine have emphasized viral rather than bacterial survival since the former typically display more resistance to chlorine. The virus of the bacterial species, *Escherichia coli* P4 X 6, known as MS-2, has become the test organism of choice. This virus has similar size and structure to Poliovirus 1 and is considered equally or more resistant to chlorine than most enteric viruses. The experience of the authors has verified that bacteriophage MS-2 is indeed more resistant to chlorine than is the coliform group of bacteria.

To assess the disinfection potential of chlorine at the Otis spray-irrigation facility, nine survival studies were conducted with MS-2 coliphage. In a typical experiment, a known concentration of coliphage in the density range 1×10^{10} to 1×10^{11} Plaque Forming Units (PFU) per ml was introduced continuously into the origin of the force main with a peristaltic pump. The static concentration of phage in the force main after its complete dispersal and dilution with lagoon effluent was typically reduced to 1×10^{5} to 1×10^{6} PFU/ml. Before initiating chlorination, a sufficient number of samples was taken over a 40-minute period to accurately establish the control MS-2 density in the absence of added chlorine. Subsequently, known and increasing increments of chlorine were applied, each for a 40-minute period, for ultimate comparison of MS-2 levels with the non-chlorinated control. At each chlorine concentration, four samples were taken at 10-minute intervals and immediately dechlorinated with sodium thiosulfate and preserved with chloroform. Finally, each sample was quantitatively assayed in the laboratory for MS-2 using the agar overlay method described by Adams [29]. To help clarify the experimental format, the record from a typical survival study is shown in Figure 22. Seasonal repetition of such observations along with other appropriate water analyses has enabled the authors to intercompare antiviral chlorine effectiveness with irrigation water parameters such as temperature, pH and ammonia content.

Free residual chlorine was measured colorimetrically by the DPD method, which uses the indicator solution diethyl-p-phenylene diamine. Either a pH meter or colorimeter was used to determine pH. Ammonia-nitrogen was determined, following Millipore filtration (0.45 μm porosity) of the primary water sample by the alkaline phenolhypochlorite method.

Reductions in MS-2 density on nine different occasions following timed exposures to experimentally added chlorine are shown in Figure 23. For each experiment the $\log_{10}$ of the surviving coliphage is plotted against the appropriate amount of experimentally added chlorine. The relative steepness of the negative slopes describes coliphage inactivation and provides an assessment of the relative effectiveness of chlorination on each of the indicated dates.

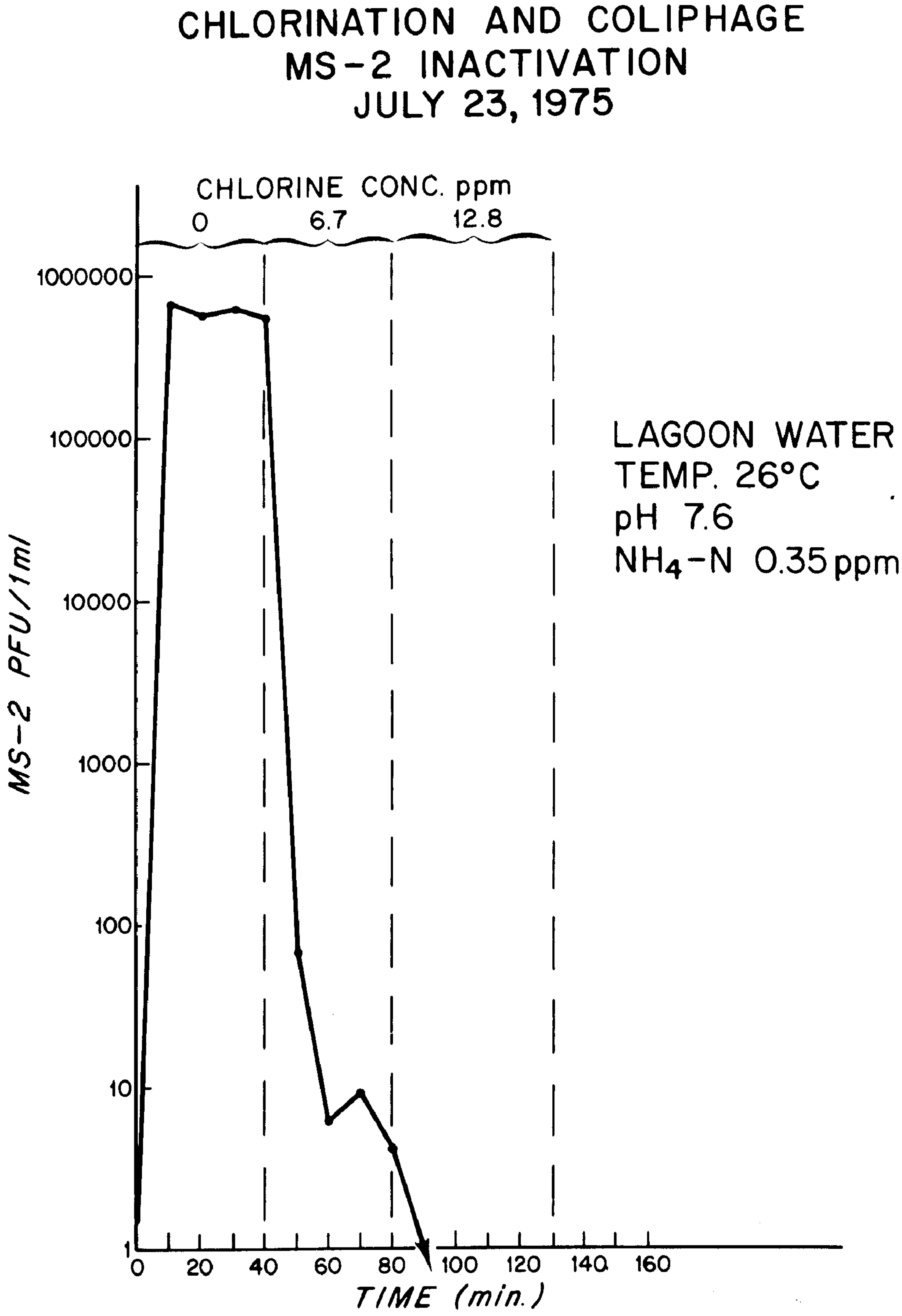

Figure 22. Typical experimental format for studying coliphage, MS-2, survival in response to controlled chlorine concentrations and contact times at Otis Air Force Base.

The amounts of chlorine dosage necessary to inactivate a majority of the MS-2 particles varied from 2 to 3 mg per l in November 1975 to 25 mg per l in February, 1976. Generally, the chlorine requirement for a comparable amount of disinfection was higher during winter than summer and maintenance of 1.0 to 2.0 mg per l free available chlorine residual in the effluent insured adequate disinfection. However, closer examination reveals that such high chlorine concentrations are not always required and may represent over-dosage.

Because each coliphage measurement shown in Figure 23 corresponds to a uniform contact period of 12 minutes, the slopes of the individual lines also correspond to the time rates of change for coliphage inactivation. The authors have expressed these data in terms of a chlorination index defined as the concentration of chlorine (mg per l) necessary to accomplish a 90 percent inactivation of the initially provided MS-2 concentration after 12 minutes contact. This index is inversely related to the effectiveness of chlorination since small chlorination indices correspond to relatively high chlorine efficiencies. The relations shown in Figure 24 record chlorination indices ranging from 0.4 mg per l chlorine (November 10, 1975) to 17.8 mg per l chlorine (February 27, 1976).

Seasonal changes in the environmental variables, temperature, pH and ammonia-nitrogen are linearly plotted in Figure 24 along with the nine chlorination indices derived from Figure 23. The pH varied from 6.5 to 9.6. Hence, as described by White [30, 31], most of the chlorine should have occurred as HOCl at the lower pH value but as OCl^- at the higher value. However, the relations shown in Figure 24 indicate that these pH changes *per se* do not have an overriding effect on chlorination efficiency although chemical theory predicts a significant role for this variable. Conversely, seasonal changes in ammonia do appear to impart significant variations on the chlorination index, with low indices corresponding to low ammonia concentrations and *vice versa*. As expected, temperature shows an inverse relation to the chlorination index since high temperatures play a dual role by enhancing both ammonia removal via oxidative nitrification and the disinfection process.

A large number of plausible mathematical relations were examined to evaluate the influence of variations in pH, temperature, and ammonia-nitrogen on the effectiveness of chlorination. Each of the empirical expressions was computer-tested for statistical significance by means of the multiple regression analysis available in the Statistical Package for Social Sciences (SPSS). The overall test for statistical goodness of fit in the SPSS program involves the calculation of an F-ratio which is distributed approximately as the F-distribution. In this case, an examined relationship becomes statistically significant to the .001 level only when the F-ratio is greater than or equal to the critical F of 29.00.

The above analysis has enabled the authors to identify the following emperical expressions 5 and 6 which have proven useful for evaluating the relative influence of pH, temperature, and ammonia-nitrogen on the variation of the chlorination index (I_c):

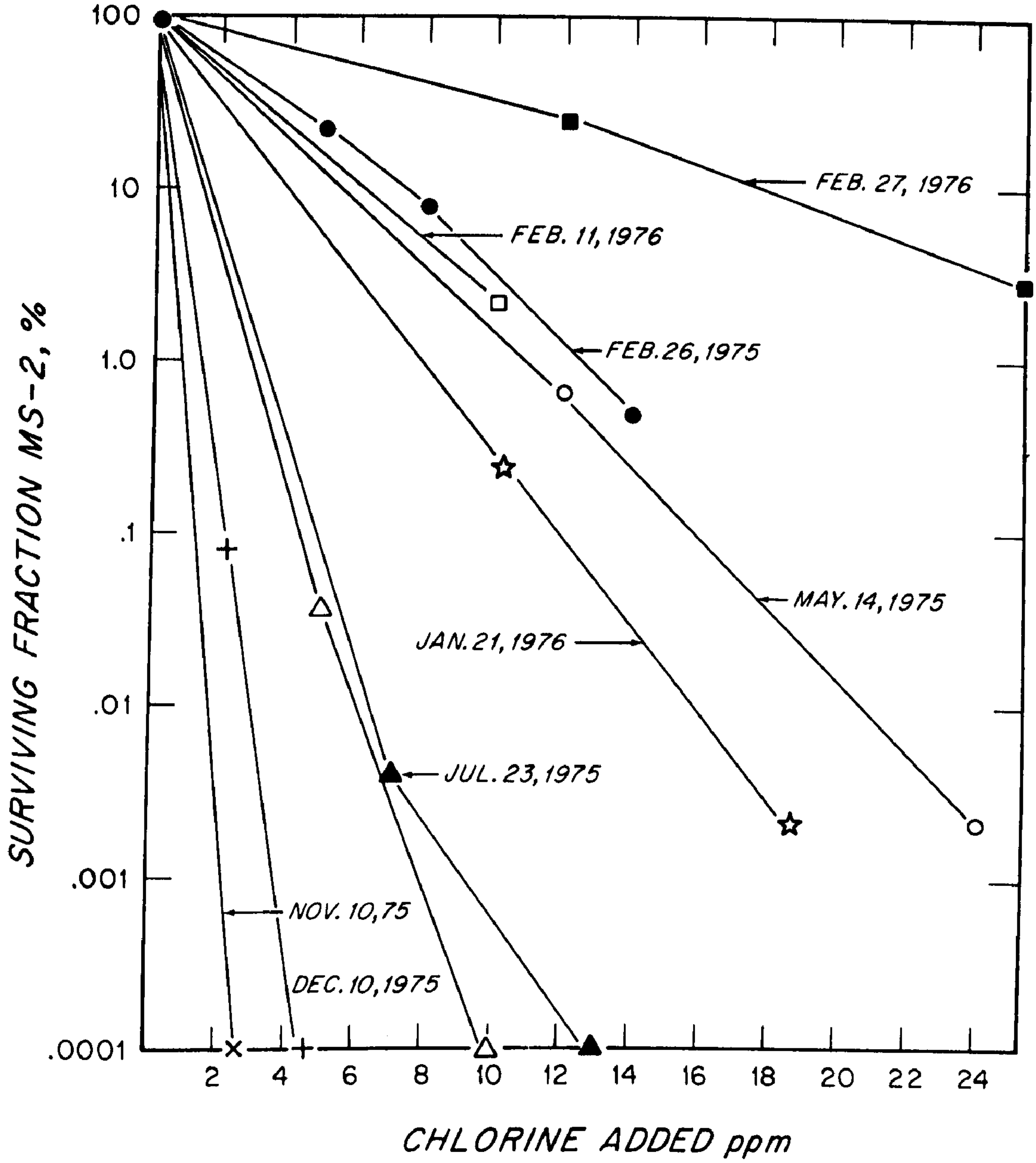

Figure 23.

Graphic presentations of coliphage, MS-2, survival in the presence of experimentally added chlorine concentrations at Otis Air Force Base. All contact times 12 minutes. The concentration of chlorine required for the initial 90 percent inactivation has been taken as the chlorination index.

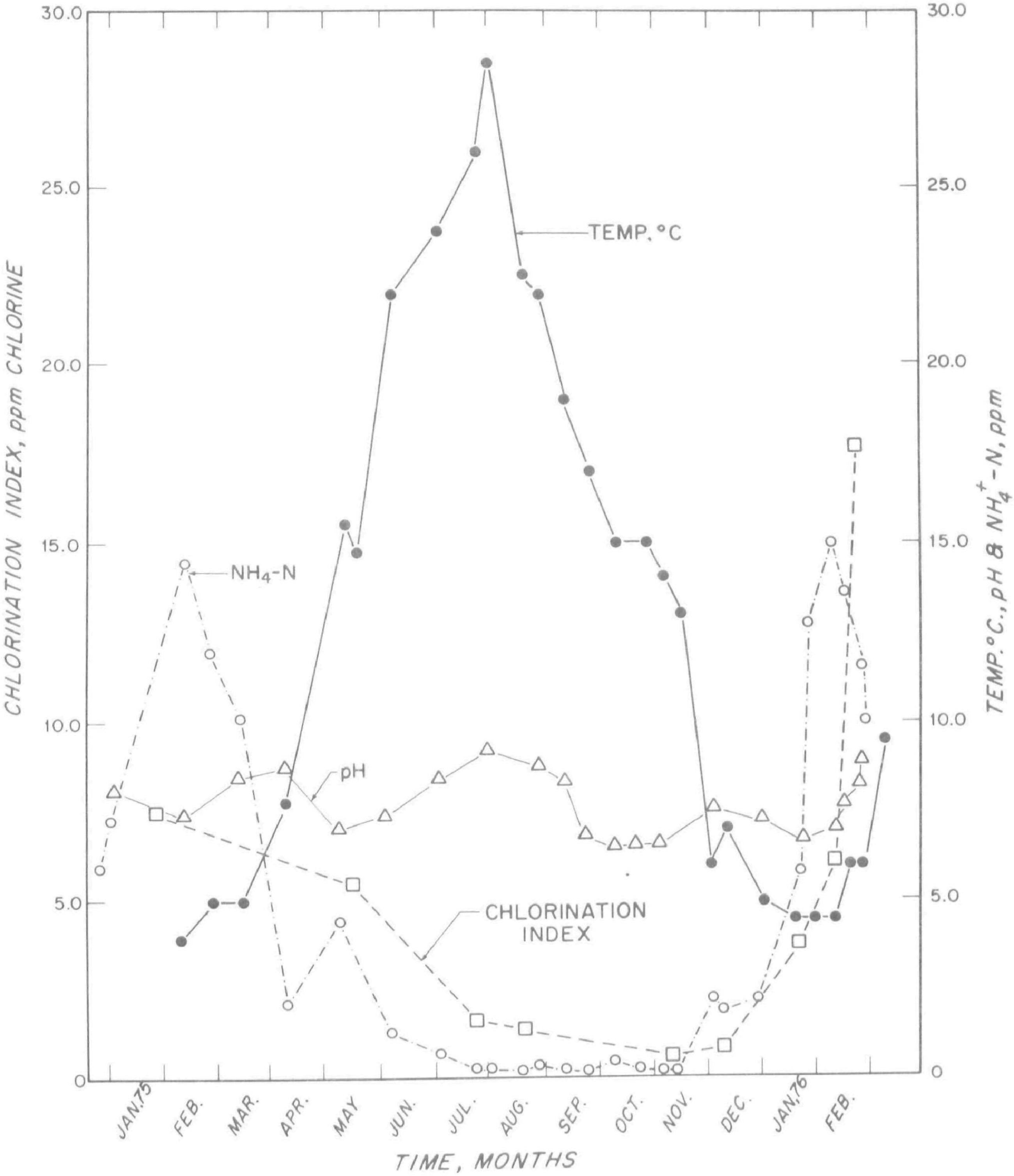

Figure 24. Seasonal variations in temperature, pH, ammonia-nitrogen and the corresponding chlorination indices for coliphage, MS-2, in lagoon water. Otis Air Force Base.

$$\mathrm{pH} - \frac{T}{4} \quad (5)$$

and

$$\mathrm{pH} + \frac{NH_4^+ - N}{4} \quad (6)$$

where temperature is in °C and ammonia-N in mg/l. The chlorination index, when plotted against these parameters, describes the two exponential relations shown in Figure 25a and 25c. For a statistical analysis of each of the above, a simple least squares bivariate regression was performed which provided the linearized relations shown in Figure 25b and 25d defined as:

$$I_c = K_1 + K_2\{e^{[\mathrm{pH}-(T/4)]}\} \text{ and}$$

$$F\text{-ratio} = 78.6 \quad (7)$$

$$I_c = K_1 + K_2\{e^{[\mathrm{pH}+(NH_4^+-N/4)]}\}$$

$$F\text{-ratio} = 58.6 \quad (8)$$

where K_1 and K_2 represent the intercepts and slopes respectively for each of the above expressions.

The F-ratio in both cases is much greater than the critical F of 29.00 discussed above, thus indicating an extremely good fit between the experimental observations and empirical relations proposed. An important implication of this analysis is that pH modification by either temperature or ammonia exerts a comparable influence on chlorination thereby suggesting that temperature and ammonia may also be interdependent. Verification of this concept is provided by a general acceptance that the oxidative conversion of ammonia to nitrite and nitrate via bacteria nitrification is indeed temperature dependent and proceeds most rapidly during the summer months. The above relations provide useful terms of reference for predicting chlorination indices at Otis when pH, temperature and ammonia content of the lagoon water are known. Presumably a more stringent use of these parameters to describe safer chlorine dosages can be obtained by redefining the chlorination index in terms of 99 rather than 90 percent removal of the test MS-2 concentration.

These chlorination studies have underlined the complexity of chlorine disinfection especially when overchlorination of secondary wastewater effluents is a matter of concern. Optimal chlorine dosage implies a studious avoidance of overchlorination as well as successful control of pathogenic agents. This definition is especially valid for spray-irrigation systems wherein chlorine-sensitive agricultural crops intended for consumption by animals along with soils and groundwaters are exposed to chlorinated wastewater effluents.

In the experience of the authors, sole reliance on a particular free-available chlorine residual to dictate chlorine dosage will not always guarantee a pathogen-free effluent. Also, such a practice can at times result in excessive overchlorination involving unnecessary cost and greater environmental hazard. Avoidance of this possibility emphasizes the need for vigilant

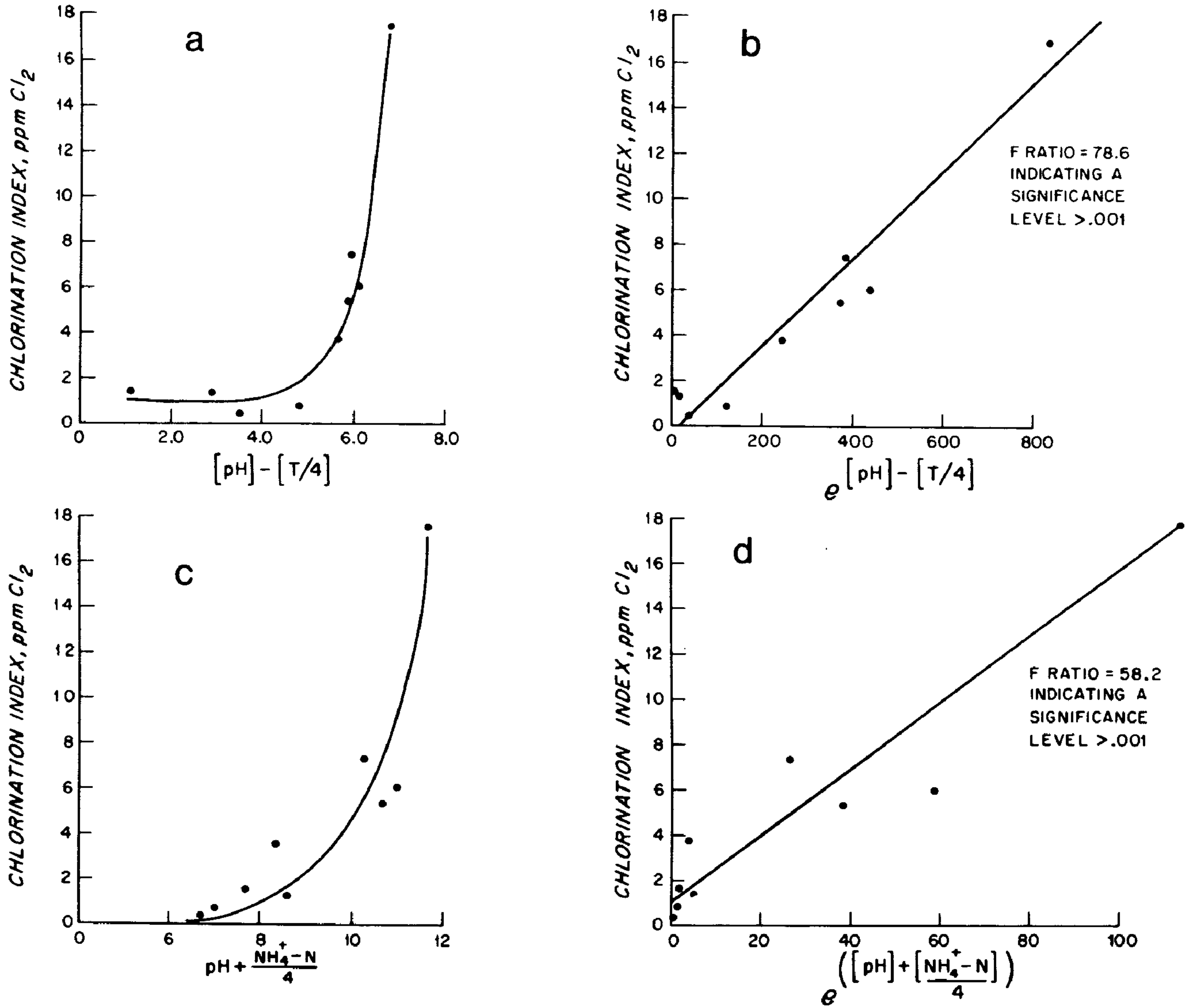

Figure 25. (Figures 25a, 25b) Computer-tested relations describing the combined effect of pH and temperature on the inactivation of coliphage, MS-2, by chlorine. Figure 25a, exponential form; Figure 25b, linear form having a significance level >0.001. (Figure 25c, 25d) Computer-tested relations describing the combined effect of pH and ammonia-nitrogen concentrations on the inactivation of coliphage, MS-2, by chlorine. Figure 25c, experimental form; Figure 25d, linear form having a significance level >0.001.

monitoring and assessment of additional water parameters besides free-available chlorine.

These experiments again demonstrate that pH, temperature and ammonia-nitrogen play an important role among the factors which control the effectiveness of chlorination. How these same parameters affect the general environmental toxicity of chlorine is, however, less certain. The inverse influence of temperature as opposed to ammonia is clearly discernible in the data presented. The authors attributed this difference to the accelerated rates of biological ammonia oxidation which lead to ammonia removal during the warmer months of the year. Thus, both temperature and ammonia-nitrogen appear to exert comparatively long-term but opposite influences on chlorination. Also, variations in pH, which can occur within a much shorter time frame by relatively rapid fluctuations in algal photosynthesis or by inputs of industrial waste, can also have a profound influence.

Regression analysis has been used to isolate empirical parameters which incorporate both long- and short-term variables as a means of predicting chlorination efficiency. The results of these calculations are encouraging and demonstrate a high degree of statistical significance. Future studies are contemplated to measure the effect of different chlorine contact times on the disinfection index of the authors. Also, for those involved in wastewater irrigation, more and better information on the uptake and tolerance characteristics of agricultural crops exposed to known chlorine residuals is needed.

REFERENCES

1. Kerfoot, W. B. and B. H. Ketchum. Cape Cod Waste Water Renovation and Retrieval System, A Study of Water Treatment and Conservation. Technical Report, WHOI 74-13, Woods Hole Oceanographic Institution, 1974.

2. Kerfoot, W. B., B. H. Ketchum, P. Kallio, P. Bowker, A. Mann, and C. Scolari. Cape Cod Wastewater Renovation and Retrieval System, A Study of Water Treatment and Conservation. Technical Report, WHOI 75-32, Woods Hole Oceanographic Institution, 1975.

3. Ketchum, B. H., R. F. Vaccaro, P. E. Kallio, A. Mann, P. L. Deese, and C. Palmer. Cape Cod Wastewater Renovation and Retrieval System, A Study of Water Treatment and Conservation. Technical Report, WHOI 76-39, Woods Hole Oceanographic Institution, 1976.

4. Ketchum, B. H., R. F. Vaccaro, P. E. Kallio, A. Mann, P. L. Deese, C. Palmer, M. R. Dennett, P. C. Bowker, and N. Corwin. Cape Cod Wastewater Renovation and Retrieval System, A Study of Water Treatment and Conservation. Technical Report, WHOI 77-32, Woods Hole Oceanographic Institution, 1977.

5. Strahler, A. N. The environmental impact of ground water use on Cape Cod. Prepared for the Association for the Preservation of Cape Cod, Orleans, Massachusetts, 1971.

6. Strahler, A. R. A geologist's view of Cape Cod, Natural History Press (Double Day Company) Garden City, New York, 115 p.

7. McGuinness, W. V. and R. Pitchai. Integrated water supply and waste water disposal on Long Island. The Center for the Environment and Man, Inc., Hartford, Conn., 1972.

8. Lawson, B. R. and D. Dupee. Can Cape Cod Solve Its Water Problems? Country Journal, August, 1978.

9. Oldale, R. N. Geologic Map of the Hyannis Quadrangle, Barnstable County, Cape Cod, Massachusetts, U. S. Geol. Surv. Geol. Quad. map GQ-1158, Scale 1:24,000. 1974.

10. Mather, K. F., R. P. Goldthwait and L. R. Theismeyer. Preliminary report on the Geology of Western Cape Cod, Massachusetts: Mass. Dept. of Public Works Bull. 2, 1940.

11. Mather, K. F., R. P. Goldthwait and L. R. Theismeyer. Pleistocene geology of Western Cape Cod, Massachusetts. Bul. Geol. Soc. Am., 3: 1127-1174, 1942.

12. Meade, R. and R. F. Vaccaro. Sewage disposal in Falmouth, Massachusetts. III. Predicted Effects of Inland Disposal and Sea Outfall on Groundwater, J. Boston Soc. Civ. Eng., 58: 278-297, 1971

13. Driver, C. H., B. F. Hrutfiord, D. E. Spyridakis, E. B. Welch and D. D. Wooridge. Assessment of the effectiveness and effects of land methodologies of waste water management. University of Washington, Final Report, Contract Nos. DACW 73-73-C-00 41 through 0043 for the Office of the Chief of Engineers, U. S. Army Corps of Engineers, 1972.

14. Pound, C. E. and R. W. Crites. Wastewater treatment and reuse by land application. Environmental Protection Technology Series EPA-660/2-73-006a, Office of Research and Development, U.S.E.P.A., Washington, D.C. 1973.

15. Wood, W. W. A technique using porous cups for Water Sampling at Any Depth in the Unsaturated Zone. Water Resource. Res. 9: 486-488, 1973.

16. Environmental Protection Agency. Manual of Methods for Chemical Analysis of Water and Wastes. EPA-625-/6-74003, U.S. Environmental Protection Agency, NERC Analytical Control Laboratory, Cincinnati, Ohio 45268, 1974.

17. Brewer, P. G., D. W. Spencer, and C. L. Smith. Determinations of trace metals in seawater by Atomic Absorption Spectrophotometry. Special Technical Report 443, American Society for Testing Materials, 1969.

18. Standard Methods for the Examination of Water and Wastewater, 13th Edition. American Public Health Association, Publication Office, Washington, D.C., 1971.

19. Cotlove, E., H. V. Trantham, and R. L. Bowman. An Instrument for and Method for automatic rapid, accurate and sensitive titration of chloride in biological samples. J. Lab. and Clin. Med., 51: 461-468, 1958.

20. Murphy, J. and J. P. Riley. A Modified Single Solution Method for the Determination of Phosphate in Natural Waters. Anal. Chim. Acta. 26: 31-36, 1962.

21. Strickland, J. D. H. and T. R. Parsons. A Practical Handbook for Sea Water Analyses. Fish. Res. Bd. Canada, Bulletin 167, 1968. 311 pp.

22. Solorozano, L. Determination of Ammonia in natural waters by the phenol-hypochlorite method. Limnol. Oceanogr. 14: 799-801, 1969.

23. Menzel, D. W. and N. Corwin. The Measurement of Total Phosphorus in Seawater based on the liberation of organically bound fractions by persulfate oxidation. Limnol. Oceanog., 10: 280-282, 1965.

24. Spoehr, H. A. and H. W. Milner. The chemical composition of chlorella; effects of environmental conditions. Plant Physiol., 24: 120-149, 1948.

25. Palmer, C. D. Hydrogeological Implications of Various Wastewater Management Proposals for the Falmouth Area of Cape Cod, Massachusetts. Masters Thesis, Dept. of Geology, Penn. State University, College Park, Pennsylvania, 1977.

26. Bauer, W. J. Wastewater Management Engineering Report Town of Falmouth, Massachusetts, Bauer Engineering, Inc., Boston, Massachusetts, 1972.

27. Ketchum, B. H. and R. F. Vaccaro. The Removal of Nutrients and Trace Metals by Spray Irrigation and in a Sand Filter Bed. In: Land as a Waste Management Alternative. R. C. Loehr, Ed. Ann Arbor Science Publ. Inc., Ann Arbor, Mich., 1977. 811 pp.

28. Deese, P. L., R. F. Vaccaro, B. H. Ketchum, P. C. Bowker, and M. R. Dennett. Ionic Distributions in a Spray-Irrigation System. In: Food, Fertilization and Agricultural Residues. R. C. Loehr, Ed. Ann Arbor Science Publ. Inc., Ann Arbor, Mich., 1977. 727 pp.

29. Adams, M. H. Bacteriophages. Interscience Publ. Inc., New York, New York, 1959. 592 pp.

30. White, G. C. Handbook of Chlorination. Van Nostrand Reinhold Co., New York, New York, 1972. 713 pp.

31. White, G. C. Chlorination and Dechlorination: A Scientific and Practical Approach. J. Am. Water Works Assoc. 60: 540-555, 1968.

DATA APPENDIX

The principle field sampling effort has focussed on the time-related changes affecting the chemical composition of surface and subsurface waters, hay, turf, and soils. All water samples are collected in 2-liter polyethylene bottles, 200 ml aliquots being filtered (0.40 μm porosity) in the field through a vacuum assisted membrane filter unit. Filtered samples are refrigerated and within 24 hrs analyzed for the crop nutrients phosphate, ammonia, nitrite and nitrate.

Well water samples are obtained with a vacuum pressure apparatus modified from the design of Wood (1967) for deep lysimeter sampling. With this equipment, samples of groundwater from depths greater than 25 ft below the surface are possible.

Lysimeters are used to collect interstitial soil water by applying vacuum to permeable ceramic cups (pore size ca 1.0 μm) buried below ground level. During dry periods, particularly in the non-irrigated control plots it was not always possible to accumulate an adequate volume of sample water on a routine basis.

Mature crops were cut, field dried, baled, and weighed according to accepted agricultural practice. During sample processing desiccated hay samples were macerated in a blender and stored pending chemical analysis for carbon, hydrogen, nitrogen and phosphorus content along with a variety of selected anions and cations. Soil samples were removed via a horizontal core taken from trench side walls exposed manually by shoveling or backhoe assistance.

Early water sampling was conducted on a biomonthly basis, but in 1977 and 1978 the sampling frequency was reduced to one complete sampling each month. Hay sampling was timed to coincide with crop maturation which led to three samplings per summer except for 1977 when only two hay crops were harvested. To date there have been a total of 10 hay crops which have been cut, dried, and removed from the agricultural sites. Only nine of these have been subjected to complete chemical analyses. Turf and soil samples were collected on an annual basis in the fall of the year after the growing season was complete. Identifications of the analytical techniques employed appears in Section 5.

Since irrigation was initiated, in the summer of 1974, a continuous log has been kept which records the amounts of wastewater irrigation applied to each of the agricultural subplots of Sites A and B. Unpredictable interruptions caused by equipment failures, weather extremes, or harvesting operations ensure that planned irrigation rates are rarely achieved and inevitably total less than the planned application totals. In a similar vein, differentiation must be made between total wastewater applied to crops and the total hydraulic load since the latter term includes the total amount of precipitation contributed by rainfall.

The time-related, accumulated, amounts of secondary effluent applied to the east, south and west subplots of Site A between July, 1974 and August, 1977 are shown in Figure 8, Section 8. The respective totals amount to 40, 49 and 62 million kgs per hectare (.109, .133, and .168 million tons per acre). The total hydraulic loadings (irrigation plus rainfall) for the same subplots during this period are shown in Figure 9, Section 8, and respectively amounted to 76, 85 and 109 million kgs per hectare (.207, .232 and .297 million tons per acre). These data demonstrate that, on Cape Cod, rainfall provides a significant fraction of the total amount of water applied, given irrigation rates ranging from one to four inches per week. Percentage-wise the fractional rainfall contribution amounted to 30-50 percent of the total hydraulic loading.

TABLE A-1 OTIS TREATMENT PLANT, SECONDARY EFFLUENT

ANALYSIS / DATE	21 I 74	13 II 74	20 III 74	3 IV 74	17 IV 74	30 IV 74	14 V 74	30 V 74	12 VI 74	19 VI 74	3 VII 74	17 VII 74	24 VII 74	7 VIII 74	21 VIII 74	5 IX 74	25 IX 74	22 X 74	6 XI 74	26 XI 74	2 I 75	12 II 75	12 III 75	9 IV 75	7 V 75	4 VI 75
pH	7.3	7.4	7.3	7.2	7.3	7.2	7.2	7.0	6.4		6.8	7.4	7.6	6.6	6.4	6.8	6.8	6.9	6.6	6.7	7.5	7.3	7.4	7.4	6.9	6.8
CONDUCTANCE µMho/cm																					292	426	422	437	362	373
INORG. NITROGEN ppm																										
$NO_2^- + NO_3^-$-N		1.14	3.61	2.99	3.25	3.98	7.47	11.80	17.06	10.05	14.52	14.20		13.43	12.82	10.72	10.70	13.72	16.10	14.76	6.44	4.33	3.29	3.94	6.18	12.23
NO_2-N		.14	.12	.15	.15	.19	.23	.28	.28	.46	.52	.46		.53						.24	.07	.05	.09	.12	.11	.30
NH_4-N		14.2	11.3	16.0	15.1	16.7	9.28	8.04	4.72	5.29	4.43	9.39	2.02	1.64	2.42	1.48	2.18	3.57	2.65	7.62	11.5	15.0	18.1	16.5	7.96	7.35
PO_4-P		5.83	5.54	7.32	6.84	7.75	7.11	7.11	7.11	5.81	6.40	6.20	6.21	5.98	5.77	6.68	7.35	7.35	8.11	7.70	6.32	7.42	7.87	15.4	8.42	16.7
CATIONS, ppm																										
CALCIUM		5.17	7.36	6.86	6.72	7.13	6.72	7.04	7.92		7.94	8.62	8.45	8.80	8.71	8.62	8.10	8.18	7.80	8.36	5.46	5.81	5.63	5.46	4.58	4.75
MAGNESIUM		3.89	3.75	3.72	3.81	3.90	3.90	3.80	4.15		3.68	3.71	3.70		4.00	3.50	3.82	3.80	3.75	3.98	3.33	3.45	3.40	3.40	2.71	2.81
MANGANESE ppb		20	8	18	8	6	18	24	69		33	12	6	45	21	15	18	12	18	24						
POTASSIUM		9.3	10.1	9.3	9.8	11.0	9.4	10.1	9.6		8.5	7.8	8.7	7.3	7.2	7.1	8.5	8.8	9.2	9.8	8.7	2.5	10.7	10.8	9.4	10.9
SODIUM		36.9	46.8	48.0	46.7	47.4	41.2	41.2	35.2		31.6	30.4	32.8	31.8	29.4	30.6	34.9	36.2	39.6	38.0	32.4	36.8	37.3	40.8	38.5	37.9
CATIONS, ppb																										
CADMIUM	1.60		.05	.05	.55	.05	.05	.05	1.65		1.10	.10	.05	.10	.05	.05	.05	.05	.05	.05						
CHROMIUM			10	10	10	10	10	10	10	.05	10	10	10	10	10	10	10	10	10	10						
COPPER	18		55	50	42	30	45	49	102	4	30	53	60	46	35	42	92	55	49	79						
IRON		30		132	107	100	115	110	149		275	150	205	250	205	100	50	200	100	275						
LEAD	7.6		.9		2.3	.2	.2	.2	.2	.2	.2	.2	.2	1.4	.2	1.3	.2	.2	.2							
ZINC																										
Boron ppm																										
ANIONS, ppm																										
CHLORIDE - Cl			29.0	27.4	27.7	30.9	26.5	26.4	25.1	25.3	24.9	30.5	24.9	23.4	24.1	23.0	26.1	27.1	29.1	29.0	27.1	30.8	31.5	31.4	28.8	29.5
SULFATE - SO_4																										

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

(CONTINUED)

TABLE A-I (CONTINUED)

ANALYSIS / DATE	2 VII 75	30 VII 75	27 VIII 75	10 IX 75	8 X 75	23 X 75	5 XI 75	3 XII 75	30 XII 75	28 I 76	25 II 76	24 III 76	21 IV 76
pH	6.6	6.6	6.6	6.6	6.0	6.2	6.0	7.6	6.2	6.9	7.0	7.4	6.8
CONDUCTANCE µMho/cm	386	330	300	344	324	332	326	300	289	290	394	395	411
INORG. NITROGEN ppm													
$NO_2^- + NO_3$-N	15.86	8.16	15.72	9.87	12.50	10.52	12.94	12.71	1.28	1.13	1.96	2.38	8.92
NO_2-N	.308	.420	.141	.225	.139	.099	.004	.216	.217	.111	.246	.077	.287
NH_4-N	3.308	1.057	.388	.538	.470	.609	.714	3.986	6.536	13.461	17.966	23.286	4.88
PO_4-P	8.46	7.16	6.76	7.70	8.22	7.51	8.42	7.66	6.40	5.65	8.18	10.88	9.04
CATIONS, ppm													
CALCIUM	12.1	11.6	10.7	11.3	13.6	13.4	12.0	7.2	6.5	9.0	5.3	6.0	5.8
MAGNESIUM	3.7	3.4	3.3	3.3	4.4	3.9	3.6	3.5	3.2	2.9	2.4	2.8	2.6
MANGANESE ppb	13.3		7.7	15.7	24.5	47.0	41.0	29.0	21.6	22.3	22.9	25.4	18.9
POTASSIUM	10.0	8.8	8.4	8.4	9.6	9.5	9.2	9.2	9.0	8.2	10.2	10.5	10.1
SODIUM	36.0	34.0	36.0	40.0	33.5	33.0	34.5	33.5	28.0	30.5	42.5	49.5	48.0
CATIONS, ppb													
CADMIUM				.40				.52	.68			.54	
CHROMIUM													
COPPER	38.6	15.5	31.5	17.0	36.1	44.3	46.4	42.0	40.0	57.2	58.8	30.0	36.1
IRON	100	216	82	100	74	122	98	261	258	273	285	234	104
LEAD				.30				1.28	1.95			2.05	
ZINC	25	50	25	25	75	50	50	50	50	50	25	50	50
BORON (ppm)	.48	.43	.41	.51	.74	.73	.55	.69	.37	.41	.54	.63	.70
ANIONS, ppm													
CHLORIDE-Cl	29.6	26.2	28.6	29.4	29.4	29.1	29.3	28.4	26.7	26.7	30.2	31.3	29.9
SULFATE-SO_4	27	22	18	27				27	25	29	28	26	28

ANALYSIS / DATE	19 V 76	16 VI 76	14 VII 76	11 VIII 76	8 IX 76	6 X 76	15 XII 76	20 I 77	19 IV 77	19 V 77	22 VI 77	14 VIII 77
pH	6.5	6.7	6.8	6.6	6.7	6.8	7.3	7.1	7.2	7.2	7.1	7.0
CONDUCTANCE µMho/cm	341	398	313	244	332	280	340	341	400	358	441	380
INORG. NITROGEN ppm												
$NO_2^- + NO_3$-N	4.38	11.49	12.46	10.15	9.03	10.95	9.53	1.73	2.21	2.78	4.42	7.92
NO_2-N	.260	.108	.385	.227	.313	.204	.011	.080	.148		.505	.449
NH_4-N	.745	4.86	2.58	.322	1.49	.234	7.12	16.21	14.91	9.85	7.77	3.00
PO_4-P	9.00	7.83	7.56	6.26	6.98	5.65	6.39	5.86	6.69	7.09	7.55	6.21
CATIONS, ppm												
CALCIUM	7.0	6.4	7.7	7.2	7.7	7.5	5.9	5.7	3.7	3.5	5.2	10.1
MAGNESIUM	2.9	2.9	3.4	3.1	3.1	3.2	2.2	2.3	1.6	1.5	2.9	5.1
MANGANESE ppb	22.1	14.0	21.5	14.8	14.8	8.1	11.8		31.2	23.5	33.0	21.0
POTASSIUM	9.8	10.5	7.8	6.5	6.9	6.4	6.3	6.0	8.0	8.4	9.5	8.5
SODIUM	46.0	46.0	45.0	38.0	47.0	45.0	52.3	49.0	51.0	54.5	51.5	64.8
CATIONS, ppb												
CADMIUM		.56			.72		.62					
CHROMIUM												
COPPER	22.7	16.0	13.7	37.5	9.0	25.8	18.0		35	34	31	24
IRON	90	78	98	85	113	110	198	426	525	398	423	270
LEAD		1.04			1.04		1.51		2.3	1.2	2.5	2.1
ZINC	50	50	25	25	25	25						
BORON (ppm)	.68	.56	.58	.60	.03	.55	.65	.61	.55	.63	.60	.63
ANIONS, ppm												
CHLORIDE-Cl	31.9	34.1	27.9	25.4	27.5	26.0	29.8	29.6	31.0	31.0	32.8	30.2
SULFATE-SO_4	36	31	25	22	24	23	26	20	16	16	22	20.4

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

(CONTINUED)

TABLE A-1 (CONTINUED)

ANALYSIS / DATE	18 VIII 77	22 IX 77	20 X 77	17 XI 77	20 XII 77	19 I 78	16 II 78	16 III 78
pH	6.7	7.1	6.8	7.2	7.0	7.3	7.5	6.5
CONDUCTANCE μMho/cm	314	283	267	341	290	312	447	229
INORG. NITROGEN ppm								
NO_2^- + NO_3-N	6.88	10.93	10.08	12.82	9.42	4.74	4.62	1.82
NO_2-N	.564	.420	.365	.350	.215	.252	.126	.095
NH_4-N	3.68	1.25	1.29	1.28	4.67	8.47	11.28	6.96
PO_4-P	6.68	5.94	5.79	7.70	7.04	5.75	7.25	3.61
CATIONS, ppm								
CALCIUM	11.8	10.3	6.2	5.9	7.7	7.7	5.8	4.6
MAGNESIUM	4.9	4.1	3.9	3.8	4.5	4.0	4.7	2.9
MANGANESE ppb	28.5	11.0	10.1	11.5	10.0	16.0	16.5	16.0
POTASSIUM	9.3	8.6	8.2	8.9	8.6	8.1	11.7	6.3
SODIUM	38.0	46.0	49.5	57.2	56.0	46.5	52.5	27.5
CATIONS, ppb								
CADMIUM								
CHROMIUM								
COPPER	27	15	13	17.5	19	18.5	38.5	25.5
IRON	270	280	265	285	215			
LEAD								
ZINC								
BORON (ppm)	.64	.45	.44	.59	.60	.59	.62	.39
ANIONS, ppm								
CHLORIDE-Cl	28.5	24.1	23.5	29.0	31.5	26.0	33.7	20.0
SULFATE-SO_4	21	26	24	22	26	30	32	16

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-2 LAGOONED SECONDARY EFFLUENT

ANALYSIS / DATE	12 VI 74	19 VI 74	17 VII 74	24 VII 74	7 VIII 74	21 VIII 74	5 IX 74	25 IX 74	22 X 74	6 XI 74	26 XI 74	2 I 75	12 II 75	12 III 75	9 IV 75	7 V 75	4 VI 75	2 VII 75	30 VII 75	27 VIII 75	10 IX 75	24 IX 75	9 X 75	23 X 75	5 XI 75	3 XII 75
pH			8.0		7.3				6.5	6.4		8.1	7.3	8.4	8.7	7.0	7.4	8.3	9.2	8.8	8.6	6.8	6.5	6.6	6.5	7.5
CONDUCTANCE µMho/cm												235	401	352	296	347	312	351	273	295	312	261	320	306	320	389
INORG. NITROGEN ppm																										
$NO_2^- + NO_3$-N	.51	.24	.15	.67	6.43	2.18	10.6	10.8	13.2	3.50	15.4	7.99	5.15	3.88	5.80	6.86	5.46	11.88	3.58	7.15	8.30	10.05	9.61	9.09	11.19	9.96
NO_2-N	.07	.14	.14		.31						.22	.15	.06	.08	.09	.10	.27	.199	.133	.193	.192	.060	.115	.023	.001	.156
NH_4-N	.05	.01	.13	2.65	.94	1.89	2.15	.05	2.48	2.10	5.96	6.24	14.5	10.1	2.06	4.56	1.33	.861	.066	.396	.013	.012	.516	.144	.010	2.260
PO_4-P	.17	.04	.19	1.64	5.34	6.52	6.08	5.83	6.64	6.32	6.48	5.53	7.11	7.35	6.32	8.02	17.8	7.87	4.11	6.48	5.81	6.08	7.83	7.43	7.47	7.70
CATIONS, ppm																										
CALCIUM				4.6	5.7	5.7	5.4	5.6	5.8	5.6	5.6	4.8	4.8	4.6	5.1	4.6	4.7	11.4	7.6	11.3	10.2	10.2	13.0	12.7	13.0	7.8
MAGNESIUM				3.90	3.97	4.03	3.70	3.66	3.50	3.53	3.90	3.15	3.45	3.88	3.10	2.80	2.80	3.5	3.0	3.3	3.3	2.8	4.1	3.9	4.1	3.4
MANGANESE ppb				8	3	1	25	25	34	25	26	5	13	4				2.5	1.3	0.9	1.4	6.5	20.4	17.5	23.7	42.0
POTASSIUM				3.8	7.2	7.4	7.2	7.2	9.0	9.2	9.9	8.6	9.5	9.8	9.7	9.7	9.5	9.5	8.3	8.3	8.4	7.3	9.1	8.8	9.3	9.0
SODIUM				17.9	29.9	30.5	28.0	28.3	34.3	37.2	37.2	31.8	37.2	36.2	36.2	38.0	40.1	38.0	33.5	35.0	38.0	28.5	32.0	32.0	33.0	30.5
CATIONS, ppb																										
CADMIUM																										
CHROMIUM																										
COPPER				52	67	63	61	97	75	85	72	59	96	93				32	16	32	17	19	25	44	20	50
IRON				210	90	160	121	100	210	120	360	100	270	210				45	17	22	29	34	65	48	38	120
LEAD																										
ZINC																		25	25	25	25	25	50	75	50	100
BORON ppm																		.51	.43	.49	.39	.48	.64	.54	.70	.62
ANIONS, ppm																										
CHLORIDE-Cl	11.3	11.2	11.8	17.4	23.9	25.4	22.7	22.9	27.0	28.5	29.5	26.4	29.3	29.4	28.5	28.8	28.4	29.9	25.5	27.1	37.6	23.3	27.6	26.6	28.2	28.4
SULFATE-SO_4																		26	24	22		17				22
TEMP. °C						25.0	20.5						4.0	5.0	7.8	15.5	22.0	19.6	21.9	22.0	19.0	17.0	15.0	15.0	14.0	6.0

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

(CONTINUED)

TABLE A-2 (CONTINUED)

ANALYSIS \ DATE	30 XII 75	28 I 76	17 II 76	25 II 76	24 III 76	21 IV 76	19 V 76	16 VI 76	14 VII 76	11 VIII 76	8 IX 76	6 X 76	15 XII 76
pH	7.3	6.7	7.9	8.3	7.8	7.6	7.1	6.8	7.6	8.8	9.2	9.7	10.3
CONDUCTANCE µMho/cm	232	303	297	321	322	325	348	410	294	239	288	309	239
INORG. NITROGEN ppm													
$NO_2^- + NO_3^-$-N	11.66	2.53	1.66	1.52	2.02	5.61	9.97	10.98	15.17	6.62	4.96	4.89	1.36
NO_2-N	.193	.144	.114	.134	.209	.227	.248	.196	.208	.131	.146	.401	.003
NH_4-N	2.221	12.747	13.587	11.501	11.431	3.590	.301	3.79	.619	.100	.018	.016	.006
PO_4-P	7.15	6.40	6.64	7.12	11.26	8.46	8.49	7.91	5.04	5.05	3.36	2.30	1.67
CATIONS, ppm													
CALCIUM	7.8	9.3	5.3	5.3	5.4	5.8	6.3	6.7	5.1	6.9	4.2	4.1	2.4
MAGNESIUM	3.5	3.0	2.4	2.3	2.4	2.6	2.6	2.9	2.8	3.0	2.6	2.5	1.6
MANGANESE ppb	39.0	21.0	17.7	14.0	5.0	15.0	7.0	9.3	1.5	0.4	0.6	0.6	0.3
POTASSIUM	8.9	9.3	9.0	9.1	9.3	10.3	9.1	10.6	7.9	6.9	7.4	6.6	4.3
SODIUM	32.5	32.0	35.5	37.5	41.5	48.5	49.0	46.0	47.0	40.0	44.5	45.5	40.7
CATIONS, ppb													
CADMIUM													
CHROMIUM													
COPPER	45	42	39	33	25	23	17	22	14	12	8	6	8
IRON	101	164	120	79		97	33	51	21	7	15	4	9
LEAD													
ZINC	75	75	50	25	25	25	25	25	25	25	25	25	
BORON ppm	.53	.50	.51	.53	.50	.67	.72	.60	.57	.60	.28	.59	.54
ANIONS, ppm													
CHLORIDE-Cl	28.5	28.2	58.6	29.1	29.2	31.3	31.4	34.4	29.3	26.1	29.3	27.5	26.0
SULFATE-SO_4	23	31	30	7	19	30	27	35	27	23	24	24	18
TEMP °C	6.0	4.5	6.0	6.0	8.0	15.6	17.5	20.5	23.0	23.5	19.5		

ANALYSIS \ DATE	20 I 77	19 III 77	19 V 77	22 VI 77	14 VII 77	18 VIII 77	22 IX 77	20 X 77	17 XI 77	20 XII 77	19 I 78	16 II 78	16 III 78
pH	6.5	9.9	10.0	7.15	10.2	9.7	8.3	6.9	7.39	9.4	6.8	7.5	7.4
CONDUCTANCE µMho/cm	220	189	272	420	346	285	275	287	310	295	350	295	46.5
INORG. NITROGEN ppm													
$NO_2^- + NO_3^-$-N	1.16	0.11	2.71	4.16	5.05	5.06	5.71	7.17	9.23	7.86	4.73	3.42	0.35
NO_2-N	.069	.003		.50	.34	.43	.13	.09	.20	.07	.18	.07	.01
NH_4-N	7.20	.01	2.73	6.70	.31	.01	.05	.32	.77	.07	5.86	4.29	.61
PO_4-P	2.77	5.03	4.60	6.96	1.74	3.78	5.07	5.81	6.98	6.24	5.44	6.40	.67
CATIONS, ppm													
CALCIUM	5.4	3.9	2.0	5.2	3.6	7.5	9.3	6.0	6.5	8.0	8.1	5.8	1.4
MAGNESIUM	1.6	1.3	1.2	2.7	4.9	4.2	3.9	3.8	4.1	4.1	3.9	4.0	0.5
MANGANESE ppb		14.5	9.4	14.3	2.0	3.0	1.0	7.5	6.0	2.0	12.5	22.5	6.0
POTASSIUM	3.3	3.1	7.3	8.1	7.7	9.5	8.1	7.9	8.7	7.8	7.9	7.9	1.1
SODIUM	31.6	33.5	51.5	53.0	58.8	43.0	44.0	45.0	56.0	50.0	42.5	42.5	32.5
CATIONS, ppb													
CADMIUM													
CHROMIUM													
COPPER		25	39	38	19	17	52.5	9.0	30.0	30.0	100	22.5	10.0
IRON	175	633	783	195	20.3	40	55	170	195	110			
LEAD		5.9	1.8	1.8	0.4								
ZINC													
BORON ppm	.34	.32	.49										
ANIONS, ppm													
CHLORIDE-Cl	26.7	18.7	32.2	31.6	30.6	28.9	33.1	24.4	28.4	27.5	29.5	26.2	6.0
SULFATE-SO_4	11	10	20	24.0	23.5	20.8	30	26	24	26	27	21	2
TEMP °C			16.2	23.4	22.8	22.3	15.4	12.4		5.1		4	6

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-3 CHLORINATED IRRIGATION WATER

ANALYSIS / DATE	25 IX 74	22 X 74	26 XI 74	18 XII 74	12 III 75	9 IV 75	4 VI 75	2 VII 75	30 VII 75	27 VIII 75	10 IX 75	24 IX 75	9 X 75
pH	x	5.1	x	6.7	7.3	7.5	6.8	6.4	7.2	7.3	7.1	6.2	5.2
CONDUCTANCE µMho/cm	x	x	x	265	370	296	315	357	303	305	335	273	328
INORG. NITROGEN PPM													
$NO_2^- + NO_3^-$-N	11.5	14.7	15.6	7.33	3.74	5.64	6.40	12.22	6.60	6.93	9.42	10.35	10.52
NO_2-N	x	x	.008	.002	.030	.013	.001	.001	.003	.001	.001	.020	.0003
NH_4-N	.05	.33	5.18	280	10.0	2.20	1.11	.987	.091	.046	.008	.058	.086
PO_4-P	608	7.32	5.47	6.52	7.90	7.08	8.97	7.83	6.96	7.23	7.00	6.04	7.15
CATIONS, ppm													
CALCIUM	5.07	5.18	5.50	4.66	4.42	5.30	4.60	11.6	10.6	12.3	11.4	10.2	13.4
MAGNESIUM	3.9	3.5	3.9	3.4	3.3	3.1	2.8	3.6	3.5	3.6	3.3	2.8	4.1
MANGANESE ppb	10	25	235	13	16			24.0	12.2	12.9	11.1	7.6	27.6
POTASSIUM	7.3	8.8	10.2	9.2	10.2	9.8	9.5	9.8	8.4	8.5	8.6	7.3	9.1
SODIUM	29.1	35.5	37.2	33.7	36.9	34.0	39.6	37.0	32.5	33.5	38.5	30.5	33.5
CATIONS, ppb													
CADMIUM								.40	.27	.28	.22	.31	.62
CHROMIUM													
COPPER	103	115	104	82	75			33	13	18	9	16	36
IRON	180	250	250	280	430			62	35	38	62	42	132
LEAD								.19	<.15	.23	.23	.23	.90
ZINC								50	25	25	25	50	75
BORON ppm								.52	.53	.51	.44	.49	.67
ANIONS, ppm													
CHLORIDE-Cl	32.7	36.0	38.2	39.8	x	40.6	37.9	39.7	35.0	36.7	37.6	32.2	36.3
SULFATE-SO_4								25	17	20	32		
TEMP °C						7.6							

ANALYSIS / DATE	23 X 75	9 XII 75	30 XII 75	28 I 76	17 II 76	25 II 76	24 III 76	21 IV 76	19 V 76	16 VI 76	14 VII 76	11 VIII 76
pH	6.2	x	6.8	6.1	7.3	6.6	6.5	6.5	6.3	6.4	6.2	6.3
CONDUCTANCE µMho/cm	311	x	274	307	300	311	311	385	359	410	316	255
INORG. NITROGEN PPM												
$NO_2^- + NO_3^-$-N	6.84	14.84	13.14	2.66	1.70	1.50	2.15	6.12	10.84	10.40	14.68	6.28
NO_2-N	.0004	x	.001	.004	.003	.004	.004	.002	.002	.003	.0003	.001
NH_4-N	.010	1.478	1.730	12.775	12.680	10.861	10.384	3.43	.010	3.75	.014	.027
PO_4-P	7.55	7.90	7.23	6.44	6.68	7.39	11.38	8.69	8.49	7.70	6.57	6.51
CATIONS, ppm												
CALCIUM	12.5	8.5	7.8	9.0	5.4	5.3	5.6	5.8	6.4	6.6	6.0	7.4
MAGNESIUM	3.8	3.5	3.6	2.9	2.4	2.4	2.4	2.7	2.6	2.9	3.0	3.0
MANGANESE ppb	22.4	39.0	42.0	24.9	25.1	25.6	17.4	25.9	11.5	17.4	9.3	21.7
POTASSIUM	8.8	9.2	9.2	9.3	9.2	9.2	9.3	10.3	9.3	10.6	8.2	7.1
SODIUM	31.0	32.5	32.5	32.0	35.5	37.5	40.5	48.0	49.0	46.0	46.0	39.0
CATIONS, ppb												
CADMIUM	.37	1.24	.87	1.07	.48	.45	.44	1.01	.77	.50	.31	1.52
CHROMIUM												
COPPER	23	58	76	50	35	22	26	25	16	22	9	6
IRON	38	165	135	255	270	207	165	114	204	204	207	31
LEAD	.17	.76	.57	.61	.81	.65	.81	.27	.44	.25	.36	.30
ZINC	50	100	125	75	25	25	25	25	25	25	25	25
BORON ppm	.58	.67	.59	.49	.46	.52	.53	.68	.70	.55	.53	.57
ANIONS, ppm												
CHLORIDE-Cl	32.4	36.4	35.9	49.5	50.5	50.1	52.5	48.0	46.6	43.1	54.1	41.8
SULFATE-SO_4		26	25	26	6	28	25	27	30	33	27	22
TEMP °C												

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

(CONTINUED)

TABLE A-3 (CONTINUED)

ANALYSIS / DATE	8 IX 76	6 X 76	15 XII 76	19 IV 77	19 V 77	22 VI 77	14 VII 77	18 VIII 77	22 IX 77	20 X 77	17 XI 77	20 XII 77	19 I 78
pH	8.9	8.4	9.7	8.6	10.0	6.3	9.4	7.8	8.4	6.5	6.65	7.2	6.4
CONDUCTANCE μMho/cm	281	315	212	183	272	408	330	299	268	267	349	263	322
INORG. NITROGEN ppm													
$NO_2^- + NO_3$-N	4.41	6.12	1.44	.105	2.62	4.38	5.67	5.32	5.96	7.14	9.23	7.80	4.82
NO_2-N	.111	.001	.001	.004		.002	.148	.004	.005	.001	.004	.003	.006
NH_4-N	.071	.005	.008	.064	2.573	6.132	.506	.203	.060	.006	.013	.019	6.118
PO_4-P	3.51	5.25	2.05	5.665	4.355	6.922	3.153	5.53	5.15	5.78	7.26	6.25	5.75
CATIONS, ppm													
CALCIUM	6.0	7.2	2.7	3.9	2.0	5.4	5.5	9.7	9.3	5.9	6.4	7.9	7.8
MAGNESIUM	2.6	3.1	1.6	1.7	1.2	2.7	4.6	4.6	3.9	3.9	4.2	4.1	3.8
MANGANESE ppb	1.2	0.6	0.8	10.2	1.3	17.9	2.3	4.0	1.0	15.0	6.0	3.0	14.0
POTASSIUM	7.3	7.0	4.8	4.0	7.2	8.6	8.1	9.7	8.3	7.8	9.1	7.8	7.8
SODIUM	45.5	45.0	41.2	33.0	51.0	53.0	61.2	42.5	46.0	54.0	55.5	51.0	43.0
CATIONS, ppb													
CADMIUM	.14	.31	.39										
CHROMIUM													
COPPER	7	10	8	29	30	36	13	13.5	12.0	10.0	17.5	6.0	24.0
IRON	24	3	20	460	95.5	258	40.3	80.0	550	95.0	210	110	
LEAD	<.15	.15	.36	5.3	1.2	1.6	0.4						
ZINC	25	25											
BORON ppm	.28	.59	.77	.35	.53	.61	.59	.48	.57	.46	.53	.53	.52
ANIONS, ppm													
CHLORIDE-Cl	31.5	36.3	39.4	29.7	31.1	58.3	41.7	37.9	29.2	32.1	42.5	33.7	42.5
SULFATE-SO_4	23	25	23	10	24	21	22.8	23.5	26	32	30	26	28

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-4 TAP WATER, OTIS TREATMENT PLANT

ANALYSIS / DATE	12 VI 74	19 VI 74	17 VII 74	24 VII 74	7 VIII 74	21 VIII 74	5 IX 74	25 X 74	22 X 74	6 XI 74	26 XI 74	18 XII 74	24 IV 75	21 V 75	18 VI 75	16 VII 75	13 VIII 75	10 IX 75	8 X 75	6 XI 75	3 XII 75	30 XII 75	28 I 76	25 II 76	24 III 76
pH	x	x	6.4	x	6.7	x	x	x	6.5	6.6	x	6.8	6.4	6.6	6.6	6.2	6.4	6.8	6.2	6.3	7.8	5.9	6.8	6.8	6.7
CONDUCTANCE µMho/cm	x	x	x	x	x	x	x	x	x	x	x	109	110	111	123	143	156	147	122	131	112	117	110	109	140
INORG. NITROGEN ppm																									
$NO_2^- + NO_3$-N	.42	1.57	.10	2.10	2.57	.01	.93	.51	.01	.08	.01	.03	.50	.03	.01	2.79	3.02	2.68	.776	3.11	.013	.027	.050	.120	1.55
NO_2-N	.006	.040	.044	x	.020	x	x	x	x	x	x	x	.003	.002	x	.008	.002	.082	.020	.001	.001	.003	.004	.017	.101
NH_4-N	.22	.06	.02	.02	.02	.02	.21	.22	.30	.11	3.29	.84	.01	.01	.06	.024	.009	.037	.397	.011	.387	.254	.200	.178	.012
PO_4-P	.01	.07	1.40	.07	.07	.07	.01	.03	.01	.03	.01	.04	.05	.10	x	.041	.100	.050	.003	.038	.001	.002	.002	.003	.043
CATIONS, ppm																									
CALCIUM			7.7			7.7		7.2	7.9		8.3	8.4	3.7	3.5	3.7	6.76	5.54	7.27	7.13	7.90	5.5	1.5	2.73	2.78	2.90
MAGNESIUM			4.7			4.6		4.4	4.5		4.7	4.7	2.2	1.6	2.2	4.22	3.24	4.30	4.20	4.33	4.5	2.8	4.19	3.22	2.97
MANGANESE ppb																									
POTASSIUM																1.39	1.21	1.40	1.39	1.28	.86	.86	1.12	1.18	1.47
SODIUM			7.7			8.3		7.5	7.0		6.7	6.8	11.7	13.1	13.5	10.6	14.6	10.0	7.4	7.3	6.5	7.0	6.6	12.1	19.4
CATIONS, ppb																									
CADMIUM																									
CHROMIUM																									
COPPER																									
IRON																									
LEAD																									
ZINC																									
BORON ppm																.18	.10	.13	.15	.06	.12	.07	.13	.14	.20
ANIONS, ppm																									
CHLORIDE - Cl	12.2	10.5	12.4	13.1	12.2	12.9	13.6	13.5	14.1	12.7	13.7	14.4	11.6	12.1	12.2	13.1	12.8	13.0	14.7	13.1	15.2	15.2	12.8	13.4	13.6
SULFATE - SO_4																15	15	15			24	23	15	5	14

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

(CONTINUED)

TABLE A-4 (CONTINUED)

ANALYSIS / DATE	21 IV 76	19 V 76	16 VI 76	14 VII 76	11 VIII 76	8 IX 76	6 X 76	19 IV 77	19 V 77	22 VI 77	14 VII 77	18 VIII 77	22 IX 77	20 X 77	17 XI 77	20 XII 77	19 I 78	16 II 78	16 III 78
pH	6.0	6.5	6.2	6.7	6.1	6.3	6.8	6.5	6.8	6.4	6.8	6.9	7.1	6.5	6.4	6.8	6.6	6.4	7.2
CONDUCTANCE μMho/cm	179	150	169	150	112	185	169	159	137	230	185	150	155	142	158	150	142	160	155
INORG. NITROGEN ppm																			
$NO_2^- + NO_3^-$-N	2.86	1.64	3.82	4.68	3.77	4.47	2.84	.324	.350	3.09	3.23	2.88	2.56	1.39	2.11	1.515	.409	2.465	3.094
NO_2-N	.002	.145	.010	.018	.038	.001	.125	.001		.007	.071	.129	.065	.043	.054	.038	.024	.145	.081
NH_4-N	.015	.110	.033	.036	.137	.006	.088	.008	.034	.763	.280	.329	.307	.290	.238	.291	.424	.321	.126
PO_4-P	.070	.429	.121	.091	.139	.132	.080	.269	.198	.025	.212	.107	.108	.137	.056	.126	.138	.059	.017
CATIONS, ppm																			
CALCIUM	3.18	5.16	6.09	6.00	7.04	7.92	8.27	2.29	2.73	6.86	7.22	10.65	7.71	4.10	6.07	6.25	7.22	7.30	8.10
MAGNESIUM	3.30	3.39	4.25	4.00	4.49	4.20	4.05	1.07	1.19	4.45	5.50	6.20	4.75	4.63	5.30	4.82	5.00	5.66	5.90
MANGANESE ppb								9.5	15.0	50	29.0	37.5	32.5	27.5	31.5	27.5	27.5	35.5	38.0
POTASSIUM	1.24	1.32	1.35	1.26	1.22	1.33	1.35	1.00	1.00	1.75	1.40	1.55	1.65	1.58	1.60	1.50	1.62	1.70	1.70
SODIUM	19.3	19.8	16.3	17.6	9.0	20.0	15.0	18.2	23.6	33.0	21.2	9.20	21.0	19.9	15.6	24.0	23.0	21.5	22.5
CATIONS, ppb																			
CADMIUM																			
CHROMIUM																			
COPPER								64.0	35.4	4.3	46.3	110	11.5	6.5	17.5	45	9	17	5
IRON												390	135	225	145				
LEAD																			
ZINC																			
BORON ppm	.15	.15	.13	.14	.14	.08	.17	.07	.08	.21	.31?	.19	.14	.16	.21	.15	.19	.15	.14
ANIONS, ppm																			
CHLORIDE-Cl	13.6	13.7	13.2	12.5	11.7	12.7	13.9	16.6	15.1	20.2	14.5	13.3	12.5	13.8	13.9	14.2	15.3	13.6	13.0
SULFATE-SO_4	11	15	14	12	11	14	12	14	12	27	13.8	13.3	15	13	13	15	17	17	12

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-5 TAP WATER, OTIS FIELD LABORATORY

ANALYSIS \ DATE	18XII74	30I75	26II75	26III75	24IV75	21V75	18VI75	16VII75	13VIII75	10IX75	8X75	6XI75	3XII75	30XII75	28I76	25II76	24III76	21IV76	19V76	16VI76	14VII76	11VIII76	8IX76	6X76	19IV77
pH	x	6.0	6.3	6.2	5.7	5.7	5.7	6.2	6.0	6.1	5.9	6.3	7.3	6.1	5.9	5.9	5.8	6.0	5.8	5.8	6.2	6.0	7.1	6.4	6.4
CONDUCTANCE μMho/cm	x	150	133	130	148	128	129	147	123	122	118	138	80.5	91.3	112	89.2	109	90.2	96.5	121	121	128	171	177	195
INORG. NITROGEN ppm																									
$NO_2^- + NO_3$-N	.13	.73	.01	.01	.01	.03	.02	.028	.013	.008	.025	.020	.136	.175	.052	.136	.137	.147	.025	.025	.024	.281	.277	.148	.098
NO_2-N	.018	.009	.002	.001	.001	.002	<.001	.002	.005	.002	.011	.004	.001	.019	.003	.009	.013	.018	.005	.010	.004	.015	.020	.006	.017
NH_4-N	.05	.02	.01	.01	.01	.02	.01	.028	.013	.011	.013	.026	.027	.025	.018	.019	.013	.008	.014	.029	.019	.009	.031	.024	.141
PO_4-P	.004	.005	.004	.005	.005	.007	.004	.004	.005	.001	.003	.004	.003	.002	.002	.001	.001	.002	.019	.001	.003	.001	.001	.002	.003
CATIONS, ppm																									
CALCIUM	6.7	7.4	4.9	4.9	6.5	6.9	5.1	3.77	3.75	3.47	3.61	3.12	2.20	2.10	2.73	2.78	2.90	3.18	2.64	2.82	4.08	4.61	6.60	6.92	2.43
MAGNESIUM	3.9	4.4	3.0	2.8	3.8	4.8	3.1	1.88	1.87	1.93	1.91	1.89	1.80	1.90	2.78	1.65	1.83	1.97	1.76	1.87	2.67	3.18	3.39	3.15	2.07
MANGANESE ppb																									
POTASSIUM								.80	.88	.77	.83	.82	.79	.73	.62	.61	.66	.65	.61	.64	.65	.65	.75	.61	.85
SODIUM	6.8	7.5	6.5	6.4	7.3	7.3	6.5	5.6	6.0	5.8	6.3	5.5	5.1	5.3	5.3	4.9	5.4	5.7	5.0	5.1	7.2	7.8	7.2	6.8	6.5
CATIONS, ppb																									
CADMIUM																									
CHROMIUM																									
COPPER																									35
IRON																									
LEAD																									
ZINC																									
Boron ppm								.07	.03	.04	.04	.06	.02	<.01	.07	.04	.12	.06	.02	.05	.06	.06	.22	.10	.05
ANIONS, ppm																									
CHLORIDE-Cl	19.1	20.1	12.2	11.4	17.0	15.6	11.5	9.3	9.4	8.6	9.1	7.6	7.7	7.6	7.5	7.3	8.4	9.1	8.4	9.3	10.9	10.6	10.6	10.7	12.5
SULFATE-SO_4								11	16	14			21	21	5	16	11	12	14	14	11	10	10	10	7

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

(CONTINUED)

TABLE A-5 (CONTINUED)

ANALYSIS / DATE	19 V 77	22 VI 77	14 VII 77	18 VIII 77	22 IX 77	20 X 77	17 XI 77	20 XII 77	19 I 78	16 II 78	16 III 78
pH	6.4	5.9	6.1	6.5	6.2	6.1	6.9	6.2	6.1	6.0	6.6
CONDUCTANCE µMho/cm	128	157	181	179	193	181	154	137	105	9.2	107
INORG. NITROGEN ppm											
$NO_2^- + NO_3$-N	.318	.073	.088	.267	.165	.130	.047	.014	.014	.109	.085
NO_2-N	X	.003	.006	.001	.008	X	.002	.001	.003	.002	.006
NH_4-N	.046	.008	.077	.016	.007	.008	.002	.018	.019	.001	.017
PO_4-P	.0003	.0003	.0002	.002	.002	.001	.001	.0006	.0003	.001	.002
CATIONS, ppm											
CALCIUM	2.08	3.31	4.58	5.98	5.46	3.26	2.34	2.90	3.34	2.01	2.87
MAGNESIUM	1.85	2.25	3.80	3.65	3.60	3.12	3.00				
MANGANESE ppb				1100	1100	1200	1250	1150	1000	1000	1050
POTASSIUM	.90	.80	.90	.72	.80	1.70	.72	.60	.70	.70	.70
SODIUM	5.8	5.2	5.5	5.4	5.8	9.1	5.8	4.3	5.0	5.4	5.6
CATIONS, ppb											
CADMIUM											
CHROMIUM											
COPPER	52	5.5	2.0	7.0	2.0	2.0	25	1.0	3.0	1.0	1.0
IRON				2750	4000.	1000	7000	4600			
LEAD											
ZINC											
BORON ppm	.10	.07	.08	.06	.10	.10	.16	.20	.09	<.1	.12
ANIONS, ppm											
CHLORIDE-Cl	10.6	9.9	10.4	11.0	8.2	8.4	9.0	7.7	9.5	13.7	9.4
SULFATE-SO_4	10	3	7.4	9.5	11	9	5	6	5	5	5

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-6 TAP WATER, WOODS HOLE POTABLE WATER SUPPLY

ANALYSIS / DATE	12 VI 74	19 VI 74	17 VII 74	7 VIII 74	21 VIII 74	5 IX 74	22 X 74	6 XI 74	26 XI 74	18 XII 74	30 I 75	26 II 75	26 III 75	24 IV 75	21 V 75	18 VI 75	16 VII 75	13 VIII 75	10 IX 75	8 X 75	6 XI 75	3 XII 75	30 XII 75	28 I 76	25 II 76	
pH	x	x	6.5	6.6	x	x	6.7	x	x	x	6.6	6.6	6.7	6.7	6.5	6.8	6.8	6.9	6.6	6.6	6.2	7.8	7.0	7.2	6.7	
CONDUCTANCE μMho/cm											67.6	67.3	65.7	68.0	65.8	70.2	66.9	70.0	70.4	68.8	66.9	65.9	63.2	66.0	62.4	
INORG. NITROGEN																										
$NO_2^- + NO_3$-N ppm	.006	.005	.88	.013	.085	.116	.009	.007	.005	x	x	.011	.010	.014	.03	.03	.067	.139	.098	.063	.106	.123	x	x	.293	
NO_2-N ppb	1.3	2.9	3.2	2.7	x	x	x	x	.60	x	x	x	.60	.80	1.0	<.14	.98	.81	.70	.14	.42	23.8	x	x	.90	
NH_4-N ppm	.03	.007	.004	.005	.005	.03	.22	.02	.04	x	x	.01	.01	.02	.02	.01	.018	.009	.011	.007	.001	.012	x	x	.002	
PO_4-P ppm	.17	x	.07	.78	.17	.24	.23	.22	.16	x	x	.04	.15	.05	.10	.07	.130	.174	.190	.284	.278	.291	x	x	.135	
CATIONS, ppm																										
CALCIUM																	4.14	4.40	4.86	4.93	4.31	1.80	3.90	4.33	4.49	
MAGNESIUM			1.0		1.0		1.0		1.0	1.0	1.1	1.1	1.0	1.0	1.0	1.0	.88	.87	.82	.80	.88	.80	.80	.88	.86	
MANGANESE ppb																										
POTASSIUM																	.59	.66	.63	.60	.60	.66	.56	.60	.60	
SODIUM			7.3		7.2		7.4		7.4	7.3	7.3	7.4	7.2	7.3	7.1	6.9	6.5	6.6	6.6	6.5	6.6	6.5	6.6	6.5	6.6	
CATIONS, ppb																										
CADMIUM																										
CHROMIUM																										
COPPER																										
IRON																										
LEAD																										
ZINC																										
Boron ppm																	.04	.02	<.01	.07	.05	.07	.07	.02	.04	
ANIONS, ppm																										
CHLORIDE - Cl	11.2	11.3	11.4	12.2	12.9	11.5	11.2	11.1	11.1	11.6	11.0	11.0	11.4	11.5	11.3	11.2	11.3	11.6	11.7	11.1	11.2	11.2	11.5	11.0	11.0	
SULFATE - SO_4																	9	9	8			9	17	10	11	

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

(CONTINUED)

TABLE A-6 (CONTINUED)

ANALYSIS / DATE	24 III 76	21 IV 76	19 V 76	16 VI 76	14 VII 76	11 VIII 76	8 IX 76	6 X 76	19 IV 77	19 V 77	22 VI 77	14 VII 77	18 VIII 77	22 IX 77	20 X 77	17 XI 77	20 XII 77	19 I 78	16 II 78	16 III 78
pH	6.4	6.5	6.9	6.6	7.0	7.1	8.6	8.3	6.0	6.5	6.2	6.5	7.2	7.1	6.7	6.8	6.7	6.4	7.5	6.4
CONDUCTANCE µMho/cm	59.1	62.0	68.1	63.3	68.8	61.1	68.4	73.8	57.2	67.8	67.8	66.6	70.0	65.5	62.8	65.0	44.5	70.2	77.5	63.6
INORG. NITROGEN																				
$NO_2^- + NO_3^-$-N ppm	.118	.099	.199	.186	.108	.501	.060	.162	.059	.291	.106	.006	.196	.080	.067	.172	.120	.258	.085	.092
NO_2-N ppb	.95	.64	1.37	<.14	.56	.50	.16	.40	1.0		0.6	0.6	1.0	0.9	0.6	0.9	0.7	0.3	0.6	1.0
NH_4-N ppm	.001	.008	.001	.001	.006	.005	.009	.006	.006	.009	.020	.002	.005	.005	.004	<.001	<.001	.023	.001	.013
PO_4-P ppm	.209	.227	.163	.224	.261	.161	.300	.179	.064	.047	.174	.212	.197	.174	.115	.044	.082	.043	.059	.070
CATIONS, ppm																				
CALCIUM	4.31	4.52	4.58	4.22	4.86	4.86	6.24	4.74	2.82		2.90	4.14	4.52	5.58	4.05	3.87	4.75	4.31	3.34	3.84
MAGNESIUM	.86	.88	.85	.88	.78	.73	.83	.76	.63		.60	1.10	1.00	.90	.90	1.00	1.05	1.00	1.12	1.13
MANGANESE ppb													3.0	2.0	2.0	2.0	2.0	1.0	1.5	2.0
POTASSIUM	.57	.60	.60	.57	.55	.55	.65	.59	.80		.90	.65	.80	.82	.65	.70	.60	.70	.70	.70
SODIUM	6.8	6.6	6.6	6.4	7.8	7.8	7.9	7.8	7.4		7.5	8.5	8.2	8.1	7.5	8.5	7.8	8.3	7.8	8.8
CATIONS, ppb																				
CADMIUM																				
CHROMIUM																				
COPPER									405		96	146	145	75	160	390	275	275	285	200
IRON													130	60	105	85		180		
LEAD																				
ZINC																				
Boron ppm	.08	.01	.03	.02	.02	.03	.02	.03	.04		.08	.04	.03	.02	.05	.11	<.1	.09	.10	.10
ANIONS, ppm																				
CHLORIDE-Cl	11.2	11.2	11.3	11.4	11.3	10.7	10.4	11.7	11.5		11.7	11.7	12.6	9.7	11.0	11.2	11.4	11.5	11.3	12.2
SULFATE-SO_4	4	5	5	7	5	4	7	5	5		5	7.6	5.8	4	5	3	4	4	5	3

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-7 SURFACE WATER, ASHUMET POND

ANALYSIS / DATE	12 VI 74	17 VII 74	24 VII 74	7 VIII 74	21 VIII 74	5 IX 74	25 IX 74	22 X 74	6 XI 74	26 XI 74	18 XII 74	30 I 75	26 II 75	26 III 75	24 IV 75	21 V 75	18 VI 75	16 VII 75	13 VIII 75	10 IX 75	8 X 75	6 XI 75	3 XII 75	30 XII 75	28 I 76
pH	x	7.5	x	x	x	x	x	6.7	7.1	x	7.1	6.5	6.8	6.4	6.5	6.8	6.7	6.7	6.8	6.5	6.3	6.5	7.9	6.5	6.2	
CONDUCTANCE µMho/cm	x	x	x	x	x	x	x	x	x	x	82.9	98.7	94.3	91.2	93.1	94.9	95.3	94.7	98.8	96.5	88.9	93.8	86.5	81.6	82.5	
INORG NITROGEN ppm																										
$NO_2^- + NO_3$-N	.58	.41	.60	1.09	.94	.81	.70	.75	.16	.76	.54	.73	1.77	.65	x	.56	.43	.399	.724	x	.417	.577	.622	.500	.455	
NO_2-N	.009	.028	x	.028	x	x	x	x	x	.009	.007	x	.006	.006	x	.007	.006	.006	.006	x	.012	.001	.005	.001	.004	
NH_4-N	1.60	7.24	1.03	.38	2.27	.39	1.13	.97	.83	1.57	.71	.37	.21	.22	x	.34	.16	.216	.454	x	.203	.421	.506	.170	.159	
PO_4-P	.002	.155	.007	.310	.004	.008	.004	.004	.004	.002	.001	.001	.001	.003	x	.002	.001	.005	.003	x	.003	.003	.005	.002	.003	
CATIONS, ppm																										
CALCIUM		3.9			3.7		3.7	3.7		3.9	3.9	3.5	3.5	3.5	3.5	3.5	3.5	5.02	4.72	4.79	4.63	4.35	3.60	4.10	4.93	
MAGNESIUM		2.2			2.2		2.2	2.2		2.3	2.3	2.2	1.6	2.1	2.1	1.6	1.6	1.88	1.87	1.93	1.91	1.89	2.00	2.10	1.90	
MANGANESE ppb																										
POTASSIUM		3.3			2.9		2.4	2.4		2.1	3.3	1.8	1.7	1.6	1.8	1.8	1.6	1.63	1.80	1.75	1.57	1.70	1.80	1.40	1.42	
SODIUM		10.8			10.9		10.0	9.9		9.5	9.5	8.8	8.3	8.4	8.5	8.7	8.5	8.0	8.4	8.2	7.8	7.8	7.9	7.9	7.7	
CATIONS, ppb																										
CADMIUM																										
CHROMIUM																										
COPPER																				4.9			1.8	4.5		
IRON																										
LEAD																										
ZINC																										
Boron ppm																		.06	.07	.06	.06	.04	.11	.06	.06	
ANIONS, ppm																										
CHLORIDE - Cl	12.9	12.9	12.4	11.8	12.7	11.3	11.9	11.8	11.4	11.3	11.8	11.2	11.0	11.2	11.6	13.0	11.1	11.5	11.8	11.9	13.4	11.6	11.8	11.7	11.9	
SULFATE - SO_4																		12	12	11	12		18	19	30	

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

(CONTINUED)

TABLE A-7 (CONTINUED)

ANALYSIS / DATE	25 II 76	24 III 76	21 IV 76	19 V 76	16 VI 76	14 VII 76	11 VIII 76	8 IX 76	6 X 76	19 IV 77	19 V 77	22 VI 77	14 VII 77	18 VIII 77	22 IX 77	20 X 77	17 XI 77	20 XII 77	19 I 78	16 II 78	16 III 78
pH	7.2	6.0	6.9	6.1	6.7	6.8	6.7	7.6	7.2	7.0	6.3	6.8	6.3	7.3	6.3	6.9	6.4	6.9	6.5	6.4	6.7
CONDUCTANCE μMho/cm	76.0	76.1	113	83.0	96.4	86.3	80.6	94.9	95.0	90.8	85.8	96.9	95.2	100	83.0	71.5	85.5	71.5	78.9	87.2	80.2
INORG. NITROGEN ppm																					
$NO_2^- + NO_3$-N	.865	.619	1.51	.494	1.014	.658	.620	.540	.897	.559	.414	.389	.445	.739	.392	.315	.340	.455	.326	.367	.398
NO_2-N	.005	.002	.008	.006	.006	.006	.019	.019	.009	.006		.006	.006	.006	.010	.006	.005	.004	.004	.004	.005
NH_4-N	.493	.265	4.00	.484	.852	.425	.486	.520	.869	.428	.475	.382	.428	.553	.148	.260	.160	.160	.129	.094	.107
PO_4-P	.007	.001	.002	.001	.002	.001	.001	.001	.032	.002	.001	<.001	.002	.002	.002	.003	.001	.001	.007	.011	.001
CATIONS, ppm																					
CALCIUM	4.77	4.51	4.54	4.54	4.43	4.24	4.40	5.28	4.66	3.29	3.31	3.26	4.66	4.75	4.75	3.26	3.34	4.93	4.31	3.84	3.61
MAGNESIUM	1.83	1.80	1.74	1.77	1.72	1.68	1.76	1.93	1.66	1.27	1.30	1.70	2.25	2.05	2.10	2.10	2.05	2.15	2.30	2.37	2.20
MANGANESE ppb										64.0	54.0	18.5	25.1	550	56.0	115	60.0	45.0	27.5	26.0	20.0
POTASSIUM	1.69	1.47	2.30	1.60	1.88	1.55	1.52	1.60	1.75	1.85	1.70	1.75	1.55	2.15	1.70	1.70	1.60	1.60	2.60	2.25	1.75
SODIUM	7.9	7.7	9.0	7.7	7.9	9.2	9.4	9.7	9.6	9.5	8.8	8.8	10.3	10.8	9.1	9.1	9.4	9.4	10.0	10.1	9.7
CATIONS, ppb																					
CADMIUM																					
CHROMIUM																					
COPPER		4.5			5.7			2.7		4.2	4.7	6.1	3.9	3.0	2.0	4.0	2.5	3.0	5.5	5.0	5.0
IRON														.50	50	50	40	20			
LEAD																					
ZINC																					
BORON ppm	.08	.12	.07	.07	.06	.06	.09	.04	.11	.11	.09	.05	.05	.14	.17	.07	.07	.11	.07	<.1	<.1
ANIONS, ppm																					
CHLORIDE-Cl	11.1	11.6	12.5	11.3	11.8	11.6	10.9	10.7	11.6	12.0	11.9	12.1	12.4	12.9	12.5	11.2	12.3	11.7	12.4	13.3	11.7
SULFATE-SO_4	30	9	10	11	11	10	10	10	9	12	11	12	11.3	8.9	10	8	8	10	9	11	8

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-8 WELL WATER, WELL #4

ANALYSIS / DATE	21 I 74	19 II 74	4 III 74	20 III 74	3 IV 74	17 IV 74	30 IV 74	14 V 74	30 V 74	12 VI 74	19 VI 74	17 VII 74
pH	x	x	x	x	x	x	x	x	x	x	x	6.2
CONDUCTANCE µMho/cm	x	x	x	x	x	x	x	x	x	x	x	x
INORG NITROGEN												
$NO_2^- + NO_3$-N ppm	.026	.015	.016	.014	.016	.012	.010	.011	.006	.013	.025	.007
NO_2-N ppb	5	1	1	.3	1	.8	2	1	3	1.1	1	1.3
NH_4-N ppm	.015	.001	.005	.003	<.001	.008	.009	.009	.011	.092	.006	.024
PO_4-P ppm	.015	.005	.006	.005	.008	.012	.009	.010	.016	.009	.005	.010
CATIONS, ppm												
CALCIUM	.92	.95		1.55		1.55		1.46		1.48		1.39
MAGNESIUM	1.57	1.75		1.54		1.49		1.66		1.63		1.57
MANGANESE												
POTASSIUM	.6	.6		.7		.69		.69		.80		.98
SODIUM	5.5	5.2		5.1		5.2		5.4		5.4		5.8
CATIONS, ppb												
CADMIUM												
CHROMIUM												
COPPER	0.7											
IRON	<30	<30	<30									
LEAD												
ZINC												
Boron ppm												
ANIONS, ppm												
CHLORIDE-Cl	x	7.6	7.9	7.6	7.5	7.6	7.7	7.6	7.7	7.6	7.7	7.5
SULFATE-SO_4												
TEMP °C												13.0
ELEVATION FT	52.66	53.12	53.17	52.95	52.95	52.99	52.95	52.87	52.87	52.79	52.70	52.24

ANALYSIS / DATE	24 VII 74	21 VIII 74	5 IX 74	25 IX 74	22 X 74	6 XI 74	18 XII 74	30 I 75	26 II 75	26 III 75	24 IV 75	21 V 75	18 VI 75
pH	x	x	x	x	6.2	6.2	6.2	6.0	6.2	6.0	6.5	6.0	6.0
CONDUCTANCE µMho/cm	x	x	x	x	x	x	40.3	55.3	58.1	61.3	61.5	66.2	68.4
INORG NITROGEN													
$NO_2^- + NO_3$-N ppm	.013	.022	.016	.026	.018	.027	.039	.072	.125	.160	.507	.850	.670
NO_2-N ppb	x	x	x	x	x	x	.3	.7	<.14	.6	.8	.1	1.0
NH_4-N ppm	.473	.116	.071	.039	.028	.021	.011	.009	.010	.010	.006	.006	.053
PO_4-P ppm	.006	.014	.012	.012	.012	.013	.009	.009	.009	.012	.008	.010	.008
CATIONS, ppm													
CALCIUM		1.39		1.35	1.51		1.65	1.50	1.44	1.86	1.86	1.95	
MAGNESIUM		1.48		1.40	1.40		1.50	1.58	1.71	1.70	1.85	2.01	
MANGANESE													
POTASSIUM		.78		.72	.76		.72	.75	.80	.85	.79	.89	
SODIUM		5.2		4.9	4.8		4.9	5.0	5.5	6.0	6.0	7.1	
CATIONS, ppb													
CADMIUM													
CHROMIUM													
COPPER													
IRON													
LEAD													
ZINC													
Boron ppm													
ANIONS, ppm													
CHLORIDE-Cl	7.9	7.3	7.6	6.7	6.9	7.1	8.2	8.8	9.6	10.3	10.6	12.0	10.5
SULFATE-SO_4													
TEMP °C	x	15.0	11.5	12.5	12.0	11.0	10.0	10.5	11.0	11.0	12.0	13.5	14.5
ELEVATION FT	52.16	51.78	51.41	51.12	50.74	50.50	49.45	49.66	49.66	49.91	50.16	50.37	50.36

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

(CONTINUED)

TABLE A-8 (CONTINUED)

ANALYSIS / DATE	16 VII 75	13 VIII 75	10 IX 75	8 X 75	5 XI 75	3 XII 75	30 XII 75	28 I 76	25 II 76	24 III 76	21 IV 76	19 V 76	16 VI 76	14 VII 76	11 VIII 76	8 IX 76	6 X 76	15 XII 76	20 I 77	21 IV 77	19 V 77	22 VI 77	14 VII 77	18 VIII 77	22 IX 77
pH	6.2	5.9	6.2	6.1	6.7	7.5	6.4	6.2	6.1	6.3	5.6	5.5	5.3	6.5	5.9	6.4	6.6	6.5	5.6	5.9	6.2	5.7	6.1	5.6	6.7
CONDUCTANCE μMho/cm	63.8	65.2	63.3	60.2	62.0	54.1	57.0	59.2	55.9	61.4	68.2	56.1	62.0	51.4	47.0	56.9	59.5	64.9	63.5	76.7	79.3	132	119	115	52.5
INORG. NITROGEN																									
$NO_2^- + NO_3$-N ppm	.882	.999	.578	.692	.748	.861	.985	.753	.895	.930	.790	.746	.951	.623	.377	.217	.368	.536	.816	1.300	.906	.945	1.116	1.093	.927
NO_2-N ppb	1.68	.70	.87	.24	.28	.36	.70	<.14	.50	.42	.36	.31	<.14	1.8	.50	.26	.30	.30	.48	.57		0.6	0.4	4.3	1.6
NH_4-N ppm	.015	.008	.009	.006	.006	.012	.015	.008	.011	.008	.014	.012	.013	.007	.008	.007	.005	.005	.012	.003	.009	.017	.008	.012	.009
PO_4-P ppm	.011	.008	.008	.011	.008	.009	.010	.010	.009	.009	.009	.008	.010	.009	.005	.010	.008	.009	.008	.008	.009	.009	.008	.025	.027
CATIONS, ppm																									
CALCIUM	1.07	1.10	1.01	1.06	1.02	1.20	1.20	1.62	1.58	1.78	1.41	1.37	1.18	1.55	1.27	.79	1.76	1.55	1.76	1.06	1.14	1.85	2.82	3.39	3.26
MAGNESIUM	1.8	1.7	1.7	1.7	1.7	1.7	1.9	1.8	1.6	1.8	1.4	1.5	1.3	1.3	1.3	1.3	1.4	1.3	1.4	1.4	1.5	2.5	4.1	3.6	3.7
MANGANESE ppb	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	8.8	9.5	13.8	14.2	12.0	14.5
POTASSIUM	.73	.70	.73	.73	.73	.73	.69	.73	.72	.72	.61	.68	.73	.62	.60	.60	.65	.63	.60	1.10	1.00	1.30	1.30	1.4	1.4
SODIUM	6.1	5.8	5.6	5.8	5.6	5.4	5.3	6.0	5.1	5.5	5.8	6.1	5.8	6.2	6.0	5.9	6.2	7.8	8.0	7.8	8.8	12.4	13.0	13.0	15.8
CATIONS, ppb																									
CADMIUM			8.0			7.5	8.5			9.2			7.1			7.5		9.6							
CHROMIUM																									
COPPER			4.8			2.8	3.2			3.4			4.1			2.0		2.9		4.0	5.2	7.8	5.2	10.0	8.0
IRON			14.3			6.9	5.9			17.0			7.8			11.4		8.7		15.5	9.5	15.0	13.5	19.5	11.0
LEAD																				0.6	0.6	0.6	0.5	x	x
ZINC			25			25	25			25			25			25		25							
BORON (ppm)	.08	.08	.10	.13	.05	.02	.02	.05	.05	.18	.09	.08	.06	.04	.19	.04	.09	.10	.06	.10	.14	.12	.12	.15	.11
ANIONS, ppm																									
CHLORIDE-Cl	10.2	10.1	9.3	9.5	9.1	8.9	9.3	8.1	8.5	9.8	8.6	9.7	8.7	8.6	7.5	7.2	9.5	14.6	15.1	13.1	16.1	29.3	25.8	24.2	28.0
SULFATE-SO_4	8	8	7			16	16	9	7	5	5	6	6	6	4	5	4	5	5	6	6	4	6.2	7.4	9
TEMP °C	14.0	13.5	13.0	13.0	12.0	9.5	8.8	10.0	12.0	12.5	12.5	11.0	15.0	15.0	15.5	13.0	12.1	10.5	10.0	13.0	12.5	15.0	15.0	14.0	11.1
ELEVATION FT	50.20	50.16	49.23	49.28	49.09	49.28	49.63	50.55	51.85	51.39	51.16	50.93	50.61	50.23	50.61	50.21	48.42	49.02	49.26	50.35	50.80	51.15	51.22	50.90	50.53

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

(CONTINUED)

TABLE A-8 (CONTINUED)

ANALYSIS / DATE	20 X 77	17 XI 77	20 XII 77	19 I 78	16 II 78	16 III 78
pH	5.5	5.7	6.0	6.0	6.0	6.2
CONDUCTANCE μMho/cm	120	125	122	166	89.5	91.3
INORG. NITROGEN						
$NO_2^- + NO_3$-N ppm	.920	.780	.955	1.774	1.128	1.119
NO_2-N ppb	0.8	1.7	1.0	0.9	4.5	0.8
NH_4-N ppm	.009	.004	.004	.014	.005	.020
PO_4-P ppm	.010	.012	.011	.012	.013	.017
CATIONS, ppm						
CALCIUM	2.01	2.15	2.99	3.70	2.43	2.55
MAGNESIUM	3.30	3.45	3.95	4.35	2.40	2.61
MANGANESE, ppb	16.0	20.0	15.0	14.5	9.0	9.5
POTASSIUM	1.30	1.20	1.30	1.40	1.05	0.79
SODIUM	14.6	17.0	15.0	21.0	14.0	13.5
CATIONS, ppb						
CADMIUM						
CHROMIUM						
COPPER	6.0	6.0	7.5	7.5	9.0	8.0
IRON	35.0	46.0	18.5	X	X	X
LEAD						
ZINC						
Boron ppm	.05	.18	.19	.32	.14	.18
ANIONS, ppm						
CHLORIDE-Cl	26.4	29.2	31.3	31.0	13.8	16.1
SULFATE-SO_4	9	5	7	11	10	6
TEMP. °C	11.1	10.9	10.8		10.3	10.8
ELEVATION FT.	50.42	50.51	50.59	51.91	53.02	53.09

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-9 SOIL WATER FROM 6", LYSIMETER

ANALYSIS / DATE	24 VII 74	15 VIII 74	30 VIII 74	10 X 74	30 XI 74	30 I 75	26 III 75	24 IV 75	21 V 75	18 VI 75	16 VII 75	13 VIII 75	10 IX 75	26 IX 75	24 X 75	20 XI 75	16 XII 75	10 II 76	18 II 76	10 III 76	7 V 76	18 VI 76	24 VI 76	29 VI 76	2 VII 76	
pH						7.7	8.2	7.3	7.9	7.4	7.4	7.3	7.2	6.6	7.1	6.1	6.1	6.8	6.2	6.4	6.6	7.2	7.1	7.1	7.1	
CONDUCTANCE µMho/cm						374	401	228	362	428	453	610	589	618	433	310	295	439	198	277	452	423	735	743	981	
INORG. NITROGEN																										
$NO_2^- + NO_3$-N ppm	18.6	13.8	1.3	.31	.06	x	.04	.01	.23	.16	.349	.031	.014	.221	.094	.080	.144	.770	305	.410	.155	.266	1.98	.190	.196	
NO_2-N ppb							2.0	x	x	2.0	2.52	X	.31	.22	.28	X	1.68	19.6	.70	8.40	2.66	2.50	280.6	8.7	2.4	
NH_4-N ppm	.34	.06	.17	.04	.01	.01	.04	.01	x	.01	.034	X	.002	.015	.006	.007	.007	.473	.009	.003	.012	.013	.014	.029	.003	
PO_4-P ppb	3.7	<.62	1.6	<.62	5.0	1.6	<.62	x	x	<.62	2.85	X	<.62	<.62	1.24	X	5.27	1209	12.1	19.2	55.5	37.5	505.6	422.8	32.9	
CATIONS, ppm																										
CALCIUM		100.7									x	x	118.0	114.4	93.3	76.6	67.8	x	26.8	29.6	121	42.2	73.0	61.0	163.7	
MAGNESIUM		14.2	9.0								x	x	3.22	3.17	2.12	1.85	2.20	x	3.83	3.62	2.93	2.28	3.26	3.35	4.40	
MANGANESE ppb		.025									x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
POTASSIUM		2.6									x	x	.36	.42	.18	.24	.22	x	1.41	1.80	.41	.35	2.98	2.63	.66	
SODIUM		6.9									x	x	37.5	64.0	28.2	x	16.7	x	14.0	20.1	31.0	30.5	43.5	48.5	72.2	
CATIONS, ppb																										
CADMIUM											x	x				x		x								
CHROMIUM											x	x				x		x								
COPPER											x	x				x		x								
IRON											x	x				x		x								
LEAD											x	x				x		x								
ZINC											x	x				x		x								
Boron ppm											x	x	.34	.28	.28	x	.18	x	.18	.24	.27	.37	.50	.46	x	
ANIONS, ppm																										
CHLORIDE-Cl	x	152.6	72.3	31.1	29.7	12.6	x	32.1	<3.9	<3.9	x	80.3	78.5	78.2	26.3	48.1	7.4	49.6	32.0	43.6	69.5	40.8	78.0	x	195	
SULFATE-SO_4											x	x	34	x	x	x	23	27	19	16	13	41	51	50	40	

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

(CONTINUED)

TABLE A-9 (CONTINUED)

ANALYSIS / DATE	13 VII 76	4 VIII 76	31 VIII 76	23 IX 76	21 IV 77	22 VI 77	14 VII 77	18 VIII 77	22 IX 77	20 X 77	17 XI 77
pH	6.8	7.7	6.6	6.2	6.9	6.6	6.8	6.8	6.7	6.6	6.8
CONDUCTANCE µMho/cm	990	1000	843	610	294	441	512	569	473	425	315
INORG. NITROGEN											
$NO_2^- + NO_3$-N ppm	.097	.157	.115	.095	.143	.173	.140	.125	.487	.118	.258
NO_2-N ppb	.4	x	1.5	.4	x	8.8	6.8	4.7	3.7	0.9	1.5
NH_4-N ppm	.013	.011	.019	.005	.003	.054	.012	.014	.014	.009	.004
PO_4-P ppb	18.6	120.0	31.6	15.5	27.9	303.5	107.6	54.6	193.1	36.3	40.0
CATIONS, ppm											
CALCIUM	x	x	101.2	88.8	x	x	65.1	88.0	79.2	22.7	17.4
MAGNESIUM	3.74	x	3.95	4.67	3.10	x	5.60	6.95	6.70	6.02	5.10
MANGANESE ppb	x	x	x	x	4.0	x	12.0	1.8	6.0	8.0	1.1
POTASSIUM	.50	x	12.1	1.15	.50	x	0.75	.85	1.10	.63	.40
SODIUM	99.5	x	86.0	70.5	x	x	57.0	61.0	52.0	40.0	63.5
CATIONS, ppb											
CADMIUM	x	x				x	x	x	x	x	x
CHROMIUM	x	x				x	x	x	x	x	x
COPPER	x	x			35.5	x	11.5	34.5	18.0	21.5	12.5
IRON	x	x				x	x	230	93	75	60
LEAD	x	x				x	x	x	x	x	x
ZINC	x	x				x	x	x	x	x	x
Boron ppm	.48	.89	x	.56	.34	x	.52	.56	.55	.34	.28
ANIONS, ppm											
CHLORIDE-Cl	202	x	88.5	52.4	29.6	46.3	81.4	62.5	37.0	20.7	48.6
SULFATE-SO_4	39	x	42	29	7	16	24.2	17.6	26	16	22

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-10 SOIL WATER FROM 1′. LYSIMETER

ANALYSIS / DATE	24 VII 74	15 VIII 74	30 VIII 74	4 X 74	30 I 75	26 III 75	24 IV 75	16 VII 75	13 VIII 75	10 IX 75	26 IX 75	24 X 75	16 XII 75	18 II 76	10 III 76	7 V 76	24 VI 76	29 VI 76	2 VII 76	13 VII 76	4 VIII 76	31 VIII 76	23 IX 76	21 IV 77
pH	x	x	x	x	7.2	7.5	7.0	7.1	6.8	6.8	6.2	6.6	5.8	5.7	6.4	6.5	6.5	6.6	6.8	6.6	7.0	6.3	6.1	6.4
CONDUCTANCE μMho/cm	x	x	x	x	229	264	180	300	365	335	313	230	265	153	223	295	1,125	718	615	531	460	480	420	309
INORG NITROGEN																								
$NO_2^- + NO_3$-N ppm	7.60	15.75	2.24	.93	.24	.06	.12	.350	.144	.690	.066	.344	.321	.123	.122	.148	45.7	.553	.403	.181	.424	.038	.087	.095
NO_2-N ppb	x	x	x	x	2.0	1.5	x	x	x	1.55	<.14	.14	1.54	.50	7.84	2.94	447	6.8	7.1	.90	23.7	1.3	.80	1.4
NH_4-N ppm	1.06	.23	.06	.03	.04	.07	.03	.031	x	.006	.015	.004	.023	.007	.004	.035	.196	.024	.051	.039	.153	.034	.006	.010
PO_4-P ppb	.90	<.62	9.60	<.62	1.60	3.40	14.0	x	x	2.37	<.62	4.96	22.3	6.20	13.4	88.0	412	122	148	167	156	90.2	121	65.1
CATIONS, ppm																								
CALCIUM		78.0						x	x	33.4	37.7	36.1	47.5	16.0	22.0	37.3	77.4	21.6	37.5	31.0	30.4	33.4	32.9	x
MAGNESIUM		11.0	6.8					x	x	3.12	2.50	2.70	5.25	2.52	2.72	3.77	8.20	4.30	3.50	2.68	2.70	4.17	4.25	x
MANGANESE		.125						x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
POTASSIUM		3.6						x	x	1.12	.93	.48	.66	.68	.96	.34	3.72	1.13	1.74	2.46	2.43	4.47	5.25	x
SODIUM		8.8						x	x	34.5	39.5	16.2	16.5	12.4	19.9	34.5	98.5	79.5	87.5	99.5	77.0	54.5	53.5	x
CATIONS, ppb																								
CADMIUM								x	x													x		x
CHROMIUM								x	x													x		x
COPPER								x	x													x		x
IRON								x	x													x		x
LEAD								x	x													x		x
ZINC								x	x													x		x
																								x
Boron ppm								x	x	.34	.28	.27	.29	.18	.28	.40	.89	.70	x	.63	.70	.61	.59	x
ANIONS, ppm																								
CHLORIDE-Cl	126.7	108.3	44.1	27.9	20.6	19.1	7.1	x	x	45.7	37.4	21.8	20.5	25.5	46.7	25.7	122.2	x	x	70.6	47.4	45.2	39.1	39.2
SULFATE-SO_4								x	x	x	15	x	21	22	18	13	40	32	34	32	39	32	25	x

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-11 SOIL WATER FROM 2', LYSIMETER

ANALYSIS / DATE	24 VII 74	15 VIII 74	30 VIII 74	4 X 74	30 I 75	26 III 75	21 IV 75	18 VI 75	16 VII 75	13 VIII 75	10 IX 75	26 IX 75	24 X 75
pH					6.8	6.7	6.5	6.3	5.7	5.7	5.8	5.8	6.1
CONDUCTANCE µMho/cm					145	158	83.0	64.7	195	222	273	239	173
INORG. NITROGEN													
$NO_2^- + NO_3^-$-N ppm	2.77	2.30	1.66	2.95	.07	.02	.08	.05	.081	.055	.130	.070	.563
NO_2-N ppb	x	x	x	x	2.0	1.0	1.0	x	.98	1.06	1.12	.98	.98
NH_4-N ppb	530	300	80	30	4	11	9	x	<.7	21.8	6.22	4.44	5.32
PO_4-P ppb									<.62	<.62	<.62	<.62	2.48
CATIONS, ppm													
CALCIUM		11.1							18.3	13.7	14.8	16.7	17.1
MAGNESIUM		1.8	2.1						1.13	.85	1.10	1.18	1.20
MANGANESE		.100	.040						x	x	x	x	x
POTASSIUM		2.7							.34	.48	.44	.42	.28
SODIUM		6.9							21.3	29.5	54.6	54.5	18.0
CATIONS, ppb													
CADMIUM													
CHROMIUM													
COPPER													
IRON													
LEAD													
ZINC													
Boron (ppm)									.49	.41	.37	.31	.25
ANIONS, ppm													
CHLORIDE-Cl	30.4	43.9	31.7	x	19.4	19.6	<3.9	<3.9	30.7	36.7	38.0	35.1	19.0
SULFATE-SO_4									x	x	41	x	x

ANALYSIS / DATE	24 X 75	20 XI 75	16 XII 75	18 II	10 III 76	6 IV 76	7 V 76	18 VI 76	24 VI 76	29 VI 76	2 VII 76	13 VII 76	4 VIII 76	31 VIII 76
pH	6.1	5.6	6.2	6.3	5.9	6.2	6.3	6.0	6.0	6.3	6.0	6.3	6.3	
CONDUCTANCE µMho/cm	138	196	199	198	218	223	248	566	479	481	440	421	397	
INORG. NITROGEN														
$NO_2^- + NO_3^-$-N ppm	.078	.659	.161	.223	.108	.112	.255	7.61	.259	.098	.181	.150	.092	
NO_2-N ppb	2.27	1.12	1.51	13.2	x	1.40	5.9	30	1.7	1.8	6.0	13.9	1.5	
NH_4-N ppb	70.6	5.32	94.1	23.2	63.1	18.8	404	106	49.4	28.8	14.6	28.6	19.6	
PO_4-P ppb	3.47	8.06	186	101	150	61.7	308	86.5	35.0	15.2	67.3	57.7	30.1	
CATIONS, ppm														
CALCIUM	12.7	26.6	24.5	26.8	20.6	23.2	18.5	26.0	14.9	33.1	23.6	20.4	21.1	
MAGNESIUM	.90	2.70	3.28	2.80	2.25	2.32	2.61	3.44	2.95	3.24	2.23	1.85	2.39	
MANGANESE	x	x	x	x	x	x	x	x	x	x	x	x	x	
POTASSIUM	.90	.22	.83	.62	.73	.26	3.77	1.11	.67	.92	.77	1.11	1.35	
SODIUM	16.8	16.5	14.8	19.6	18.9	28.5	36.0	51.5	54.0	79.5	65.5	66.0	55.0	
CATIONS, ppb														
CADMIUM					x									
CHROMIUM					x									
COPPER					x									
IRON					x									
LEAD					x									
ZINC					x									
Boron (ppm)	x	.26	.23	.27	x	.42	.60	.68	.65	x	.60	.67	.89	
ANIONS, ppm														
CHLORIDE-Cl	7.8	23.1	30.5	45.5	29.9	30.8	49.9	83.2	x	x	70.0	62.6	47.5	
SULFATE-SO_4	x	21	23	x	x	16	33	32	29	38	33	42	29	

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-12 SOIL WATER FROM 3′, LYSIMETER

ANALYSIS	DATE	24 VII 74	15 VIII 74	30 VIII 74	4 X 74	30 XI 74	30 I 75	26 III 75	24 IV 75	21 V 75	18 VI 75	16 VII 75	13 VIII 75	10 IX 75	26 IX 75	24 X 75	20 XI 75	16 XII 75	18 II 75	10 III 76	6 IV 76	7 V 76	18 VI 76	24 VI 76	29 VII 76	2 VII 76	
pH	x	x	x	x	x	6.2	6.4	6.1	6.3	6.3	5.7	6.1	5.9	6.3	6.0	6.2	6.0	6.4	6.0	6.2	6.3	6.2	5.9	6.2	6.4	
CONDUCTANCE μMho/cm	x	x	x	x	x	117	143	160	97.4	101	232	191	215	172	131	98.3	171	281	186	192	178	196	395	339	311	
INORG. NITROGEN																										
$NO_2^- + NO_3^-$-N ppm	1.39	2.30	4.11	3.61	7.55	1.54	2.90	5.86	31.4	.14	.907	.132	.221	.115	.228	.064	.830	.140	.281	.043	.178	.316	4.41	.227	.125	
NO_2-N ppb	x	x	x	x	x	1.16	1.10	x	1.00	1.00	1.40	1.34	1.54	1.40	.56	.19	.56	2.80	26.04	x	1.04	1.10	2.30	2.30	.90	
NH_4-N ppm	.61	.30	.33	.12	.10	.20	.29	.25	.02	.01	.126	.032	.007	.011	.009	.022	.003	.084	.026	.022	.017	.025	.021	.042	.039	
PO_4-P ppb	3.00	<.62	3.10	<.62	x	<.62	<.62	5.30	<.62	<.62	<.62	<.62	<.62	1.33	5.27	<.62	6.20	430	234	13.9	11.8	99.2	11.2	216	10.8	
CATIONS, ppm																										
CALCIUM		10.8	x								15.3	9.5	10.2	8.6	8.3	9.0	19.7	36.1	32.0	13.7	12.8	10.4	14.8	8.3	13.6	
MAGNESIUM		2.1	1.9	1.5	2.1						1.80	1.19	1.37	1.15	1.02	1.13	2.73	6.50	3.75	2.07	1.72	1.69	2.39	2.27	1.75	
MANGANESE		1.01	.46	.118	.054						x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
POTASSIUM		1.8	1.5	1.3	1.6						2.54	1.66	1.70	1.25	.68	.76	.85	.89	.82	1.06	.57	1.02	.95	1.62	.90	
SODIUM		11.7	20.2	15.6	29.3						26.2	21.0	30.0	25.2	14.8	11.7	16.4	13.6	21.8	19.4	23.6	30.5	41.5	40.5	46.0	
CATIONS, ppb																										
CADMIUM																										
CHROMIUM																										
COPPER		14	x	12	14																					
IRON		175	x	162	246																					
LEAD																										
ZINC																										
BORON ppm											.53	.36	.36	.31	.29	.11	.22	.19	.27	.27	.39	.54	.62	.64	x	
ANIONS, ppm																										
CHLORIDE - Cl	x	43.9	30.8	25.5	38.8	15.8	22.2	15.7	7.3	7.7	41.4	25.1	32.0	22.4	14.1	<3.9	23.9	36.5	45.0	33.7	26.5	35.6	61.0	67.0	52.0	
SULFATE - SO_4											x	x	31	x	x	x	22	23	18	14	17	27	25	25	31	

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

(CONTINUED)

TABLE A-12 (CONTINUED)

ANALYSIS / DATE	13 VII 76	4 VIII 76	31 VIII 76	23 IX 76	21 IV 77
pH	6.2	6.4	5.8	6.4	6.4
CONDUCTANCE μMho/cm	284	267	305	245	194
INORG NITROGEN					
$NO_2^- + NO_3$-N ppm	.070	.162	.125	.070	.041
NO_2-N ppb	.60	.60	2.3	.40	0.9
NH_4-N ppm	.026	.021	.012	.005	.018
PO_4-P ppb	12.4	12.7	22.6	21.4	9.9
CATIONS, ppm					
CALCIUM	11.6	10.7	14.6	13.0	X
MAGNESIUM	1.38	1.43	1.92	1.85	X
MANGANESE	X	X	X	X	X
POTASSIUM	.78	1.17	3.00	1.95	X
SODIUM	44.5	43.5	41.0	40.5	X
CATIONS, ppb					
CADMIUM					
CHROMIUM					
COPPER					
IRON					
LEAD					
ZINC					
Boron ppm	.58	.62	.58	.52	X
ANIONS, ppm					
CHLORIDE-Cl	40.6	36.8	40.8	35.3	X
SULFATE-SO_4	28	31	27	23	X

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-13 SOIL WATER FROM 4', LYSIMETER

ANALYSIS	DATE	24 VII 74	15 VIII 74	30 VIII 74	4 X 74	30 XI 74	12 I 75	30 I 75	26 III 75	24 IV 75	21 V 75	18 VI 75	16 VII 75	13 VIII 75	10 IX 75	26 IX 75	24 X 75	20 XI 75	16 XII 75	18 II 76	10 III 76	7 V 76	18 VI 76	24 VI 76	29 VII 76	2 VIII 76
pH	x	x	x	x	x	x	6.4	6.4	7.0	7.2	7.3	6.0	6.8	6.6	6.0	6.2	6.9	6.5	6.5	6.0	6.4	6.3	6.3	6.5	6.8	
CONDUCTANCE µMho/cm	x	x	x	x	x	x	132	192	152	150	146	272	252	248	161	165	X	230	383	214	216	210	460	431	391	
INORG. NITROGEN																										
NO_2^- + NO_3-N ppm	1.39	6.02	10.2	6.17	8.49	.10	2.38	3.85	6.45	.99	.55	1.960	.263	.477	.196	.351	.170	1.338	.099	.059	.347	.792	5.64	.288	.617	
NO_2-N ppb	x	x	x	x	x	.98	1.4	1.8	x	x	x	9.24	X	3.39	2.46	.84	X	.84	2.18	10.36	1.26	9.5	25.5	2.5	13.6	
NH_4-N ppm	1.45	.83	.44	.03	.03	.06	.04	1.2	x	x	x	.054	.026	.016	.017	.014	.068	.006	.130	.037	.016	.117	.048	.031	.104	
PO_4-P ppm	.012	<.00062	<.00062	.005	<.00062	.002	.002	x	x	x	x	.082	X	.030	.021	.014	X	.023	.302	.152	.016	.078	.034	.026	.046	
CATIONS, ppm																										
CALCIUM		26.53										22.2	X	17.2	11.4	19.4	X	33.1	48.4	66.9	20.1	19.4	18.5	12.4	20.8	
MAGNESIUM		4.41	3.4	1.8	2.4	1.2						2.30	X	1.81	1.15	1.86	X	4.10	3.07	2.13	2.38	2.98	2.76	2.93	2.60	
MANGANESE ppb		1.9	.6	.1	.03	.02						X	X	x	x	x	X	x	x	x	x	x	x	x	x	
POTASSIUM		5.03	3.9	2.5	2.9	2.5						4.44	X	3.00	1.77	1.32	X	1.73	.82	.48	.70	1.58	1.48	1.23	2.14	
SODIUM		16.6	25.0	18.2	33.1	16.3						30.0	X	45.0	19.4	14.3	X	15.6	19.3	17.3	29.5	42.5	50.5	51.5	60.5	
CATIONS, ppb																										
CADMIUM													X				X									
CHROMIUM													X				X									
COPPER		20	19	12	11	12							X				X									
IRON		230	257	215	191	156							X				X									
LEAD													X				X									
ZINC													X				X									
BORON ppm												.57	x	.42	.22	.33	X	.26	.24	.20	.45	.65	.75	.65	x	
ANIONS, ppm																										
CHLORIDE-Cl	X	82.6	47.6	31.1	38.2	19.6	16.4	23.7	16.1	X	9.0	41.2	27.8	31.0	14.2	12.9	X	28.2	34.3	46.5	18.5	49.4	58.4	75.9	63.0	
SULFATE-SO_4												x	X	x	x	x	X	22	25	22	18	29	30	26	30	

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

(CONTINUED)

TABLE A-13 (CONTINUED)

ANALYSIS / DATE	13 VII 76	4 VIII 76	31 VIII 76	23 IX 76	21 IV 77	19 V 77	22 VI 77	14 VII 77	18 VIII 77	22 IX 77	20 X 77	17 XI 77	20 XII 77
pH	6.4	6.7	5.9	6.4	6.4	7.0	6.1	6.5	6.6	6.4	6.4	6.4	6.5
CONDUCTANCE μMho/cm	323	312	358	318	259	293	376	310	227	185	227	342	313
INORG NITROGEN													
$NO_2^- + NO_3$-N ppm	.339	.508	1.33	.601	.286	.652	1.624	2.225	.690	2.177	2.856	4.28	3.25
NO_2-N ppb	1.4	10.8	3.2	19.0	1.45	X	12.3	3.7	1.3	1.7	1.1	1.8	0.9
NH_4-N ppm	.063	.020	.014	.017	.008	.024	.030	.022	.016	.024	.045	.015	.016
PO_4-P ppm	.102	.034	.201	.924	.065	.556	2.034	2.865	.301	1.916	1.652	2.28	3.40
CATIONS, ppm													
CALCIUM	16.7	18.1	20.1	15.8	22.2	33.9	19.0	17.3	11.7	14.9	11.5	13.6	13.8
MAGNESIUM	1.90	2.11	3.07	3.42	5.80	6.00	5.90	6.20	4.50	4.50	5.13	9.20	6.10
MANGANESE	X	X	X	X	0.5	2.7	1.5	2.0	1.0	0.8	1.8	1.5	1.8
POTASSIUM	1.60	1.12	4.83	5.00	6.10	6.30	8.30	8.00	6.00	5.58	4.30	5.40	6.10
SODIUM	49.0	48.0	43.5	43.5	24.2	46.8	51.0	57.0	31.0	26.0	31.8	51.5	45
CATIONS, ppb													
CADMIUM													
CHROMIUM													
COPPER					12.0	37.0	18.5	20.3	13.0	15.0	23.0	19.0	12.5
IRON					X	X	X	X	17	10	11	50	33
LEAD													
ZINC													
Boron ppm	.54	.53	.56	.53	.33	.39	.49	.68	.40	.29	.30	.47	.50
ANIONS, ppm													
CHLORIDE - Cl	37.7	37.4	42.4	38.6	36.6	43.1	52.7	58.5	24.7	14.5	22.4	63.5	37.0
SULFATE - SO_4	22	24	22	19	13	18	20	20	13	12	10	26	24
TEMP °C													
ELEVATION FT													

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-14 WELL WATER, WELL #5

ANALYSIS / DATE	21 I 74	19 II 74	4 III 74	20 III 74	3 IV 74	17 IV 74	30 IV 74	14 V 74	30 V 74	12 VI 74	19 VI 74	17 VII 74	24 VII 74
pH	X	X	X	X	X	X	X	X	X	X	X	6.5	X
CONDUCTANCE μMho/cm	X	X	X	X	X	X	X	X	X	X	X	X	X
INORG. NITROGEN													
$NO_2^- + NO_3$-N ppm	.009	.013	.010	.007	.007	.006	.005	.004	.005	.007	.013	.015	.009
NO_2-N ppb	6	1	1	3	7	7	1	1	2	1.1	.7	.7	X
NH_4-N ppm	.015	<.0007	.003	.005	<.0007	.006	.004	.010	.007	.030	.013	.038	.008
PO_4-P ppm	.013	.002	.002	.005	.005	.010	.007	.006	.007	.007	.002	.013	.003
CATIONS, ppm													
CALCIUM	.87	.51		.70		.70		.63		.74		.77	
MAGNESIUM	1.13	1.08		.86		.83		.93		.95		.95	
MANGANESE													
POTASSIUM	.9	.8		.8		.81		.86		1.12		1.30	
SODIUM	5.7	5.3		5.0		4.8		4.9		5.1		5.2	
CATIONS, ppb													
CADMIUM													
CHROMIUM													
COPPER	.7												
IRON	<30	<30											
LEAD	6.8												
ZINC													
Boron (PPM)													
ANIONS, ppm													
CHLORIDE-Cl	X	7.1	6.2	6.0	6.0	6.5	6.9	7.0	8.0	7.3	7.5	7.1	7.7
SULFATE-SO_4													
TEMP °C	X	X	X	X	X	X	X	X	X	X	X	14.0	X
ELEVATION FT	52.80	53.22	53.47	53.13	53.05	53.13	53.05	X	52.97	52.84	52.72	52.38	52.30

ANALYSIS / DATE	21 VIII 74	5 IX 74	25 IX 74	22 X 74	6 XI 74	20 XI 74	18 XII 74	30 I 75	26 II 75	26 III 75	24 IV 75	21 V 75	18 VI 75
pH	X	X	X	5.9	6.2	X	6.3	6.3	6.1	6.2	6.3	5.8	5.9
CONDUCTANCE μMho/cm	X	X	X	X	X	X	42.5	61.2	64.5	58.2	66.1	76.4	85.4
INORG. NITROGEN													
$NO_2^- + NO_3$-N ppm	.048	.024	.135	.030	.047	.064	.148	.533	.893	.632	1.07	.890	.970
NO_2-N ppb	X	X	X	X	X	.4	5.6	.8	<.14	1	4.3	<.14	1
NH_4-N ppm	.021	.039	.039	.024	.022	.011	.013	.011	.006	.009	.016	<.0007	.010
PO_4-P ppm	.007	.011	.007	.008	.008	.007	.007	.005	.005	.007	.010	.003	.004
CATIONS, ppm													
CALCIUM	.79		1.35	.86		.90	.86	1.07	1.13	.97	1.48	1.53	
MAGNESIUM	1.02		1.08	1.10		1.15	1.21	1.46	1.67	1.44	1.78	2.12	
MANGANESE													
POTASSIUM	1.06		.98	.94		.79	.82	.84	.86	.81	.93	.94	
SODIUM	5.4		5.7	5.5		5.4	5.6	6.1	6.7	6.4	6.9	7.3	
CATIONS, ppb													
CADMIUM													
CHROMIUM													
COPPER													
IRON													
LEAD													
ZINC													
Boron (PPM)													
ANIONS, ppm													
CHLORIDE-Cl	8.3	7.8	8.4	8.1	7.4	7.6	8.4	10.7	12.0	10.5	12.8	X	14.6
SULFATE-SO_4													
TEMP °C	14.0	11.5	12.0	11.0	11.0	10.5	10.0	10.5	11.0	11.5	11.5	13.0	14.0
ELEVATION FT	51.76	51.55	51.26	50.84	50.59	50.38	49.97	49.72	49.70	49.97	50.30	50.48	49.46

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

(CONTINUED)

TABLE A-14 (CONTINUED)

ANALYSIS / DATE	16 VII 75	13 VIII 75	10 IX 75	8 X 75	5 XI 75	3 XII 75	30 XII 75	28 I 76	25 II 76	24 III 76	21 IV 76	19 V 76	16 VI 76	14 VII 76	11 VIII 76	8 IX 76	6 X 76	15 XII 76	20 I 77	21 IV 77	19 V 77	22 VI 77	14 VII 77	18 VIII 77	22 IX 77
pH	6.5	5.9	6.2	5.8	5.9	7.4	5.9	6.0	6.0	6.6	5.1	5.7	6.0	6.3	6.1	8.0	6.3	5.9	5.5	5.8	6.3	5.7	6.3	5.5	5.7
CONDUCTANCE µMho/cm	90.8	91.0	88.3	97.3	112.0	89.6	82.0	77.2	69.0	63.8	109	80.9	101	96.8	90.2	104	105	79.8	80.7	68.4	74.2	141	140	157	140
INORG. NITROGEN																									
$NO_2^- + NO_3$-N ppm	1.379	1.184	.860	1.088	1.947	1.534	1.063	.715	.735	.377	.984	.438	.987	1.033	.676	.874	.741	.659	.866	.287	.286	.784	.659	.743	.725
NO_2-N ppb	.70	.84	.56	.31	.25	.45	.64	<.14	.53	.62	.73	.42	1.7	.45	.40	.42	<.14	.40	.31	.31	X	0.7	0.3	6.9	3.5
NH_4-N ppm	.013	.019	.009	.008	.007	.014	.020	.006	.012	.008	.010	.006	.022	.004	.007	.007	.005	.007	.008	.004	.019	.019	.011	.017	.012
PO_4-P ppm	.004	.006	.003	.005	.002	.004	.006	.005	.004	.004	.004	.003	.009	.003	.004	.004	.004	.005	.004	.004	.006	.018	.005	.016	.014
CATIONS, ppm																									
CALCIUM	1.09	1.20	1.09	1.28	1.44	1.40	1.16	1.37	1.37	1.14	2.02	1.71	1.85	2.11	1.81	2.11	2.11	1.32	1.44	.53	.62	1.06	1.85	2.64	2.59
MAGNESIUM	2.8	2.7	2.7	3.2	3.7	3.0	2.0	1.9	1.8	1.5	2.6	2.4	2.6	2.7	2.5	2.6	2.4	1.5	1.4	1.1	1.1	1.7	3.6	3.6	3.3
MANGANESE	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	13.3	12.0	24.0	18.8	18.5	17.0
POTASSIUM	.85	.85	.81	.95	1.02	1.05	1.02	.83	.98	.73	.98	.90	1.05	.93	.88	.96	.96	.80	.88	1.10	.95	1.60	1.45	1.90	1.89
SODIUM	8.0	7.5	7.5	8.6	9.4	8.8	7.9	7.3	7.1	6.6	8.4	8.3	8.6	10.8	10.8	11.4	11.5	10.6	11.3	8.3	9.2	16.3	18.2	22.5	22.5
CATIONS, ppb																									
CADMIUM			22.1			18.9	20.7			12.2			16.0			18.3		20.8							
CHROMIUM																									
COPPER			7.9			4.7	5.3			3.7			3.9			2.1		2.2		4.2	5.2	10.4	9.8	21.0	23.0
IRON			7.1			12.2	8.6			4.6			8.4			12.5		10.8		14.3	15.5	15.0	15.8	38.0	32.0
LEAD			x			x	x			x			x			x		x		0.3	0.2	1.1	0.6	x	X
ZINC			25			25	25			25			25			25									
BORON (ppm)	.04	.09	.04	.03	.14	.07	.14	.05	.10	.07	.10	.06	.08	.10	.17	.06	.10	.13	.09	.11	.12	.17	.20	.21	.22
ANIONS, ppm																									
CHLORIDE-Cl	19.7	19.0	18.5	21.2	24.3	21.9	18.9	16.7	15.7	13.3	22.5	22.2	24.7	24.9	25.4	23.3	22.7	19.2	19.4	14.5	16.2	31.6	31.6	33.3	32.1
SULFATE-SO_4	7	8	16	x	x	16	17	6	6	5	3	4	3	5	4	5	4	7	6	5	7	6	9	9	12
TEMP °C	15	13.5	12.0	13.0	11.5	9.5	9.5	10.0	12.0	12.0	12.5	11.0	15.0	13.0	15.5	13.0	12.5	10.0	10.0	13.5	12.0	15.0	15.5	13.5	11.0
ELEVATION FT	50.20	49.24	49.32	49.35	49.16	49.35	49.72	50.61	51.96	51.48	51.26	51.03	50.71	50.32	50.70	50.30	49.86	49.11	48.73	50.43	50.88	51.23	51.32	50.99	50.62

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

(CONTINUED)

TABLE A-14 (CONTINUED)

ANALYSIS / DATE	20 X 77	17 XI 77	20 XII 77	19 I 78	16 II 78	16 III 78
pH	5.4	5.3	6.2	6.3	5.9	6.0
CONDUCTANCE μMho/cm	149	162	150	160	129	103
INORG. NITROGEN						
NO_2^- + NO_3-N ppm	.683	.815	.675	.857	.685	.207
NO_2-N ppb	2.9	2.6	1.8	1.5	2.4	5.3
NH_4-N ppm	.008	.003	.007	.007	.006	.009
PO_4-P ppm	.007	.008	.014	.007	.008	.010
CATIONS, ppm						
CALCIUM	2.02	1.85	1.55	2.64	2.15	1.72
MAGNESIUM	3.50	3.30	2.84	3.70	2.57	2.29
MANGANESE	22.0	24.5	21.5	26.0	13.0	12.0
POTASSIUM	1.90	1.80	1.90	2.00	1.52	1.39
SODIUM	29.2	26.0	25.5	26.5	21.0	17.0
CATIONS, ppb						
CADMIUM						
CHROMIUM						
COPPER	16.5	11.5	8.5	7.5	10.0	8.0
IRON	X	23.5	33.0	X	X	X
LEAD						
ZINC						
Boron ppm	.19	36	26	40	16	.12
ANIONS, ppm						
CHLORIDE - Cl	33.5	34.9	35.4	37.0	26.2	21.0
SULFATE - SO_4	14	18	17	19	19	X
TEMP °C	—	10.7	10.5	—	10.3	10.9
ELEVATION FT.	50.42	50.69	50.33	51.42	53.13	53.19

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-15 SOIL WATER FROM 6", LYSIMETER

ANALYSIS / DATE	24 VII 74	28 VIII 74	1 X 74	30 XI 74	26 III 75	21 V 75	18 VI 75	13 VIII 75	10 IX 75	26 IX 75	21 X 75	20 II 76	12 III 76
pH	X	X	X	X	7.0	7.3	7.4	6.6	6.6	6.5	6.6	6.6	5.9
CONDUCTANCE µMho/cm	X	X	X	X	316	156	190	273	300	270	178	183	276
INORG. NITROGEN													
$NO_2^- + NO_3$-N PPM	12.37	.006	.47	.88	3.33	.16	.11	.264	.732	.175	1.043	.197	.322
NO_2-N PPb	X	4.5	X	X	7.1	X	X	2.80	5.46	.56	.59	11.70	X
NH_4-N PPM	.56	X	.03	X	.31	X	.01	X	.017	.079	.017	.194	.284
PO_4-P PPM	.005	.004	<.0006	X	.002	X	X	.014	.528	.075	.098	.094	1.37
CATIONS, ppm													
CALCIUM									1.64	18.1	17.1	17.2	10.4
MAGNESIUM		9.2							2.5	2.53	2.15	3.58	X
MANGANESE									X	X	X	X	X
POTASSIUM									0.8	.58	.14	1.28	4.24
SODIUM									36.0	39.0	20.5	16.7	33.0
CATIONS, ppb													
CADMIUM													X
CHROMIUM													X
COPPER													X
IRON													X
LEAD													X
ZINC													X
BORON (ppm)									.46	.48	.30	.25	X
ANIONS, ppm													
CHLORIDE-Cl	X	74.3	26.4	42.6	39.8	X	<3.9	36.2	40.6	26.5	12.6	24.0	47.0
SULFATE-SO_4								X	X	X	X	22	X

ANALYSIS / DATE	4 V 76	15 VI 76	29 VI 76	31 VIII 76	23 IX 76	19 V 77	22 VI 77	14 VII 77	18 VIII 77	22 IX 77	20 X 77	17 XI 77	20 XII 77
pH	6.5	6.5	7.0	6.3	6.6	7.8	7.1	6.8	6.6	6.5	6.5	6.8	6.7
CONDUCTANCE µMho/cm	337	425	340	309	298	278	309	362	308	177	165	240	205
INORG. NITROGEN													
$NO_2^- + NO_3$-N PPM	2.11	3.64	.378	.074	.148	.192	.290	.316	.175	.168	.140	.221	1.704
NO_2-N PPb	X	8.1	1.0	1.1	0.9	X	X	0.8	X	3.2	X	X	2.7
NH_4-N PPM	.026	.030	.012	.006	.008	.035	X	.025	.017	.020	.017	.099	.031
PO_4-P PPM	X	.719	.413	.180	.142	X	X	.024	.071	.164	.243	X	1.00
CATIONS, ppm													
CALCIUM	11.1	13.6	8.7	21.7	17.8	X	X	24.6	13.7	12.6	9.0	8.4	10.1
MAGNESIUM	3.26	3.56	2.86	4.00	3.50	4.85	X	X	4.50	3.46	3.70	4.40	4.50
MANGANESE	X	X	X	X	X	X	X	X	3.2	0.6	1.4	2.0	8.0
POTASSIUM	1.07	1.16	.55	.75	3.20	1.90	X	1.70	1.05	0.90	0.52	1.40	1.70
SODIUM	47.5	51.5	X	38.5	46.5	X	X	X	46.0	30.0	35.0	39.0	33.0
CATIONS, ppb													
CADMIUM													
CHROMIUM													
COPPER						X	X	16.0	17.0	20.0	18.0	19.0	12.5
IRON						X	X	X	80	90	73	370	410
LEAD													
ZINC													
BORON (ppm)	.71	.65	.72	.60	.55	X	X	.56	X	.33	.28	.35	.30
ANIONS, ppm													
CHLORIDE-Cl	46.7	54.1	41.9	37.7	49.5	43.3	56.9	72.4	51.3	8.5	28.6	X	27.5
SULFATE-SO_4	21	38	X	22	22	X	19	25	24	18	24	X	24

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-16 SOIL WATER FROM 1', LYSIMETER

ANALYSIS / DATE	15 VI 76	29 VI 76	31 VIII 76	23 IX 76	21 IV 77
pH	6.8	7.6	6.9	6.5	6.9
CONDUCTANCE μMho/cm	483	327	410	320	245
INORG NITROGEN					
$NO_2^- + NO_3^-$-N ppm	9.19	.491	.094	.375	.122
NO_2-N ppm	x	x	x	x	x
NH_4-N ppm	.129	x	.050	.027	.012
PO_4-P ppm	x	x	x	.056	x
CATIONS, ppm					
CALCIUM	19.0	7.6	28.3	25.5	x
MAGNESIUM	x	4.80	x	6.75	x
MANGANESE	x	x	x		x
POTASSIUM	3.90	3.32	x	3.82	x
SODIUM	49.0	x	x	43.0	x
CATIONS, ppb					
CADMIUM			x		x
CHROMIUM			x		x
COPPER			x		x
IRON			x		x
LEAD			x		x
ZINC			x		x
BORON (ppm)	.73	.64	.90	.55	x
ANIONS, ppm					
CHLORIDE - Cl	61.0	33.3	x	45.3	35.2
SULFATE - SO_4	x	x	22	x	x

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-17 SOIL WATER FROM 2′, LYSIMETER

ANALYSIS / DATE	24 VIII 74	15 VIII 74	28 VIII 74	1 X 74	30 XI 74	3 XII 74	12 II 75	26 III 75	24 IV 75	21 V 75	18 VI 75	16 VII 75	13 VIII 75	10 IX 75	26 IX 75	21 X 75	15 I 76	20 II 76	4 V 76	15 VI 76	29 VI 76	31 VIII 76	23 IX 76	21 IV 77		
pH	x	x	x	x	x	7.4	6.5	7.0	7.0	7.5	7.3	6.7	6.4	6.3	6.3	6.5	6.0	6.2	6.3	6.2	6.8	6.4	6.4	6.3		
CONDUCTANCE µMho/cm	x	x	x	x	x	249	168	x	134	86.5	73.9	112	238	265	210	222	32.6	169	253	418	335	398	325	203		
INORG NITROGEN																										
$NO_2^- + NO_3^-$-N ppm	15.75	4.19	2.25	3.85	.54	1.78	.60	.33	.06	.11	x	.115	.387	.435	1.112	1.617	.260	.106	.386	2.66	.168	.197	.288	.153		
NO_2-N ppb	x	x	4.6	x	x	1.5	<.14	3.4	x	x	x	x	3.72	3.22	1.62	.70	2.10	1.62	8.26	3.4	x	x	9.4	2.3		
NH_4-N ppb	3300	180	80	80	30	20	10	60	x	x	x	x	15.96	<.7	7.10	18.34	37.94	47.04	239	126	42.4	153	4.3	10.9		
PO_4-P ppb	.9	<.62	2.5	<.62	<.62	3.7	<.62	3.4	x	x	x	x	1.26	<.62	1.67	2.85	49.91	3.16	102	103	x	169	651	33.2		
CATIONS, ppm																										
CALCIUM		23.1										x	13.9	16.7	12.7	18.8	3.0	17.2	15.7	14.4	6.2	x	19.5	x		
MAGNESIUM		3.9	3.1									x	1.47	1.77	1.43	1.90	.63	2.67	2.44	2.44	1.92	x	3.10	x		
MANGANESE		.14	.06									x	x	x	x	x	x	x	x	x	x	x	x	x		
POTASSIUM		11.0										x	.60	.46	.33	.16	.40	.53	.49	.67	.73	x	.65	x		
SODIUM		9.5										x	33.0	34.5	32.5	24.0	2.5	16.1	37.0	53.0	x	52.5	49.5	x		
CATIONS, ppb																										
CADMIUM												x														
CHROMIUM												x														
COPPER												x														
IRON												x														
LEAD												x														
ZINC												x														
Boron (PPM)												x	.47	.46	.42	.37	.01	.23	.63	.72	.77	.50	.59			
ANIONS, ppm																										
CHLORIDE-Cl	72.9	26.3	35.1	29.6	x	32.9	18.6	x	17.2	x	<3.9	x	26.1	36.4	16.0	23.0	<3.9	24.6	38.1	61	45	x	45.1	33.2		
SULFATE-SO_4												x	x	x	18	x	15	22	18	32	x	x	28	x		

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-18 SOIL WATER FROM 3', LYSIMETER

ANALYSIS / DATE	24 VII 74	15 VIII 74	28 VIII 74	1 X 74	30 XI 74	3 XII 74	12 II 75	26 III 75	24 IV 75	21 V 75	16 VII 75	13 VIII 75	10 IX 75	26 IX 75	21 X 75	20 XI 75	18 XII 75	20 II 76	12 III 76	4 V 76	15 VI 76	29 VI 76	4 VIII 76	31 VIII 76	23 IX 76	21 IV 77
pH	x	x	x	x	x	6.9	6.2	6.6	6.4	6.7	6.3	6.1	6.1	6.3	6.2	6.9	5.6	6.6	6.1	6.3	6.0	6.8	6.4	6.5	6.3	5.9
CONDUCTANCE µMho/cm	x	x	x	x	x	256	178	208	155	65.3	962	213	276	161	216	152	218	149	243	228	359	329	372	310	314	200
INORG. NITROGEN																										
$NO_2^- + NO_3^-$-N ppm	6.57	4.19	.27	1.13	1.20	1.70	1.04	.40	.18	.10	.120	.106	.161	.109	1.525	.108	7.714	.067	.286	.126	.392	.193	.266	.158	.106	.090
NO_2-N ppb	X	x	3.2	X	X	1.4	<.14	1.1	x	x	1.96	1.48	1.54	1.62	.92	x	.98	.73	.47	2.80	.80	x	x	x	1.1	0.62
NH_4-N ppm	.20	.18	.02	.03	.07	.01	x	.03	.03	x	.038	.020	.012	.020	.016	.141	.015	.046	.028	.060	.025	.015	.014	.023	.010	.009
PO_4-P ppb	7	<.62	1.9	<.62	2.5	<.62	<.62	1.9	8.4	x	<.62	9.17	1.11	4.50	2.85	x	7.60	12.34	9.95	18.0	14.9	17.4	20.2	18.6	23.9	13.4
CATIONS, ppm																										
CALCIUM		10.9									8.2	12.1	13.7	7.9	18.8	x	25.0	16.2	19.5	13.7	13.9	x	x	11.8	15.8	X
MAGNESIUM		2.7	2.5	2.4		2.2					.82	1.16	1.69	.96	2.00	x	2.90	2.04	2.46	1.53	1.70	1.38	x	1.28	1.28	X
MANGANESE		.11	.03	.02		.01										x						x	x	x	X	X
POTASSIUM		4.8	1.6	1.0		.6					.27	.26	.55	.25	.18	x	.20	.20	.16	.32	.22	.29	x	x	.33	x
SODIUM		5.5	7.6	19.4		35						32.5	40.0	22.4	22.1	x	19.7	14.8	23.6	33.0	46.5	x	x	47.0	53.5	x
CATIONS, ppb																										
CADMIUM																X						x	x	x		X
CHROMIUM																X						x	x	x		X
COPPER		4	11	14		12										X						x	x	x		X
IRON		95	149	211		288										X						x	x	x		X
LEAD																X						x	x	x		X
ZINC																X						x	x	x		X
Boron (ppm)											.63	.37	.40	.32	.38	x	.28	.19	.32	.59	.75	.90	.60	.44	.48	x
ANIONS, ppm																										
CHLORIDE-Cl	25.5	26.3	18.4	27.6	X	40.5	25.2	39.6	16.5	<3.9	4.1	26.7	41.2	10.9	25.3	X	26.8	23.4	45.6	29.5	57.3	x	x	45.1	50.5	38.1
SULFATE-SO_4											x	x	28	x	X	X	20	17	17	22	28	x	29	10	23	X

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-19 SOIL WATER FROM 4', LYSIMETER

ANALYSIS / DATE	24 VII 74	15 VIII 74	28 VIII 74	1 X 74	30 XI 74	3 XII 74	12 I 75	12 II 75	26 III 75	24 IV 75	21 V 75	18 VI 75	16 VII 75
pH	X	X	X	X	X	6.7	X	6.3	7.0	6.8	6.8	6.4	5.8
CONDUCTANCE µMho/cm	X	X	X	X	X	257	X	173	190	199	89.9	78.9	100
INORG. NITROGEN													
$NO_2^- + NO_3$-N ppm	2.54	1.90	1.61	3.40	X	1.54	.08	1.82	3.09	1.73	.17	.09	.077
NO_2-N ppb	X	X	8.7	X	X	.80	X	<.14	1.4	2.4	X	1.0	1.26
NH_4-N ppm	.37	.14	.06	.05	X	.01	.05	.01	.01	.01	X	.01	.017
PO_4-P ppb	.90	<.62	2.5	<.62	X	<.62	1.9	<.62	2.2	2.2	X	2.0	<.62
CATIONS, ppm													
CALCIUM		8.1											2.6
MAGNESIUM		3.7	9.4	4.7	X	5.5	3.9						1.00
MANGANESE		.04	.09	.01	X	.04	.02						X
POTASSIUM		2.6	4.4	2.4	X	2.3	1.9						.50
SODIUM		7.7	12.0	7.8	X	24.7	25.6						X
CATIONS, ppb													
CADMIUM													
CHROMIUM													
COPPER		6	6	10	X	9	24						
IRON		115	128	140	X	226	218						
LEAD													
ZINC													
Boron ppm													.54
ANIONS, ppm													
CHLORIDE-Cl	37.4	23.4	37.8	28.0	X	41.9	29.0	19.4	30.8	34.3	<3.9	<3.9	4.0
SULFATE-SO_4													X

ANALYSIS / DATE	13 VIII 75	10 IX 75	26 IX 75	21 X 75	20 II 76	12 III 76	6 IV 76	4 V 76	15 VI 76	29 VI 76	4 VIII 76	31 VIII 76	23 IX 76
pH	5.9	5.8	5.7	6.2	6.2	6.0	6.2	6.5	6.2	6.3	5.8	5.9	6.3
CONDUCTANCE µMho/cm	178	217	182	190	109	203	190	174	218	228	235	210	215
INORG. NITROGEN													
$NO_2^- + NO_3$-N ppm	.080	.494	.049	2.416	.046	.440	.074	.070	.104	.120	.094	.077	.064
NO_2-N ppb	1.48	1.29	.50	1.81	.56	.47	X	.84	.80	4.1	1.7	1.5	1.3
NH_4-N ppm	.004	.015	.013	.024	.034	.021	.065	.160	.056	.183	.055	.043	.023
PO_4-P ppb	2.21	<.62	.83	1.58	1.74	2.85	18.7	13.0	179	133	45.6	19.8	22.3
CATIONS, ppm													
CALCIUM	4.0	4.6	3.3	5.8	3.3	8.6	X	5.5	3.5	2.9	3.5	3.2	3.5
MAGNESIUM	1.62	1.76	1.30	1.68	1.17	2.24	X	1.47	1.54	1.79	.98	.83	1.05
MANGANESE	X	X	X	X	X	X	X	X	X	X	X	X	X
POTASSIUM	1.38	1.45	1.11	.74	.43	.50	X	.49	2.77	1.79	.95	1.65	.87
SODIUM	22.1	48.9	27.5	24.5	16.2	23.9	X	24.4	28.0	X	42.5	34.5	39.5
CATIONS, ppb													
CADMIUM							X						
CHROMIUM							X						
COPPER							X						
IRON							X						
LEAD							X						
ZINC							X						
Boron ppm	.43	.44	.37	.49	.29	.29	X	.45	.60	.72	.64	.60	.47
ANIONS, ppm													
CHLORIDE-Cl	20.9	34.0	22.6	25.0	8.7	42.2	37.0	27.1	35.2	48.2	31.2	18.8	31.4
SULFATE-SO_4	X	31	X	X	24	12	X	18	15	22	33	19	22

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

(CONTINUED)

TABLE A-19 (CONTINUED)

ANALYSIS / DATE	21 IV 77	19 V 77	22 VI 77	14 VII 77	18 VIII 77	22 IX 77	20 X 77	17 XI 77	20 XII 77	19 I 78
pH	6.5	6.1	5.9	6.1	6.2	6.0	6.1	6.5	6.4	7.5
CONDUCTANCE µMho/cm	148	208	157	159	235	139	199	192	212	115
INORG. NITROGEN										
$NO_2^- + NO_3$-N ppm	.122	.092	.364	.174	.158	.112	1.743	.381	2.633	.473
NO_2-N ppb	2.7	X	26.6	1.4	1.2	3.8	0.4	0.5	5.1	X
NH_4-N ppm	.056	.021	.138	.051	.040	.013	.010	.003	.203	X
PO_4-P ppb	73.2	45.6	558.0	240.6	70.8	33.5	15.8	22.0	2142.1	? X
CATIONS, ppm										
CALCIUM	4.9	7.7	2.9	3.0	8.6	5.0	5.6	4.6	7.0	3.3
MAGNESIUM	1.50	2.20	1.30	1.25	2.00	1.05	1.90	1.80	2.80	3.30
MANGANESE	2.0	1.5	4.3	0.5	0.7	1.7	3.4	1.1	1.2	X
POTASSIUM	0.65	0.65	3.40	0.70	0.60	0.50	0.45	0.31	2.45	0.70
SODIUM	27.0	42.0	22.8	31.2	39.0	31.0	36.5	32.5	37.0	18.5
CATIONS, ppb										
CADMIUM										
CHROMIUM										
COPPER	11.5	16.5	19.5	11.0	8.0	16.5	18.0	6.5	14.0	X
IRON	X	X	X	X	14	10	12	15	49	X
LEAD										
ZINC										
BORON (ppm)	.31	.27	.30	.52	.41	.32	.28	.33	.33	X
ANIONS, ppm										
CHLORIDE-Cl	24.0	44.6	15.3	20.4	49.7	31.7	28.6	47.5	31.5	X
SULFATE-SO_4	7	9	15	9	12	18	24	16	16	X

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE-A 20 WELL WATER, WELL #6

ANALYSIS / DATE	21 I 74	13 II 74	19 II 74	4 III 74	20 III 74	3 IV 74	17 IV 74	30 IV 74	14 V 74	30 V 74	12 VI 74	19 VI 74	3 VII 74
pH	x	x	x	x	x	x	x	x	x	x	x	x	x
CONDUCTANCE μMho/cm	x	x	x	x	x	x	x	x	x	x	x	x	x
INORG NITROGEN													
$NO_2^- + NO_3$-N ppm	.18	.25	.17	.20	.16	.16	.04	.04	.06	.14	.63	.13	.11
NO_2-N ppb	11	1	1	1	.4	.7	.6	1	1	2	1.1	45.5	38.5
NH_4-N ppm	.009	.011	<.0007	<.0007	.006	<.0007	.008	.004	.008	.008	.034	.106	.021
PO_4-P ppm	.015	.006	.005	.005	.008	.009	.012	.006	.006	.008	.007	.310	.007
CATIONS, ppm													
CALCIUM	1.09	.76	.78		1.20		1.16		1.07		1.14		
MAGNESIUM	1.16	1.08	1.09		1.00		1.03		1.15		1.19		
MANGANESE													
POTASSIUM	.6	.5	.5		.61		.63		.63		.70		
SODIUM	5.2	4.9	5.0		4.6		4.8		4.7		4.9		
CATIONS, ppb													
CADMIUM													
CHROMIUM													
COPPER	1.8												
IRON	<30	<30	<30										
LEAD													
ZINC													
Boron ppm													
ANIONS, ppm													
CHLORIDE-Cl	6.9	6.4	6.6	6.5	6.9	7.0	7.9	7.9	7.7	6.7	7.7	7.4	7.3
SULFATE-SO_4													
TEMP °C	x	x	x	x	x	x	x	x	x	x	x	x	x
ELEVATION FT	5295	53.32	53.45	53.74	53.40	53.32	53.20	5324	x	5320	52.99	52.95	5278

ANALYSIS / DATE	17 VII 74	24 VII 74	21 VIII 74	5 IX 74	25 IX 74	22 X 74	6 XI 74	20 XI 74	18 XII 74	30 I 75	26 II 75	26 III 75	
pH	6.5	x	x	x	x	5.9	6.2	x	6.2	6.1	6.0	5.9	
CONDUCTANCE μMho/cm	x	x	x	x	x	x	x	x	48.4	82.8	103	112	
INORG NITROGEN													
$NO_2^- + NO_3$-N ppm	.04	.10	.22	.23	.19	.10	.14	.22	.42	1.80	3.08	2.79	
NO_2-N ppb	4.6	x	x	x	x	x	x	.4	.6	1	<.14	.8	
NH_4-N ppm	.018	.006	.016	.039	.034	.022	.028	.015	.011	.012	.017	.013	
PO_4-P ppm	.085	.003	.007	.010	.007	.008	.007	.007	.006	.004	.004	.005	
CATIONS, ppm													
CALCIUM	1.02		1.02		.98	1.09		1.16	1.37	1.65	2.25	3.18	
MAGNESIUM	.89		1.15		1.13	1.22		1.47	1.57	2.35	3.50	4.25	
MANGANESE													
POTASSIUM	.82		.76		.71	.74		.79	.79	1.01	1.13	1.29	
SODIUM	5.4		4.7		4.4	4.4		6.2	5.9	7.6	8.5	9.3	
CATIONS, ppb													
CADMIUM													
CHROMIUM													
COPPER													
IRON													
LEAD													
ZINC													
Boron ppm													
ANIONS, ppm													
CHLORIDE-Cl	7.5	7.9	7.8	6.9	7.0	7.8	8.3	9.1	10.5	15.2	20.5	25.2	
SULFATE-SO_4													
TEMP °C	14.0	x	12.0	11.0	12.5	12.0	11.0	11.0	10.0	9.0	11.5	11.0	
ELEVATION FT	52.61	52.49	51.87	x	51.45	51.03	50.82	50.91	50.11	49.86	49.95	50.20	

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

(CONTINUED)

TABLE A-20 (CONTINUED)

ANALYSIS / DATE	24 IV 75	21 V 75	18 VI 75	16 VII 75	13 VIII 75	10 IX 75	8 X 75	5 XI 75	3 XII 75	30 XII 75	28 I 76	25 II 76	24 III 76	21 IV 76	19 V 76	16 VI 76	14 VII 76	11 VIII 76	8 IX 76	6 X 76	15 XII 76	20 I 77	21 IV 77	19 V 77	22 VI 77
pH	6.1	5.7	5.9	6.0	5.9	5.8	5.9	5.7	7.2	6.1	5.8	6.0	6.0	6.0	5.7	6.0	6.4	5.9	7.4	6.8	5.9	5.2	5.8	6.3	5.7
CONDUCTANCE μMho/cm	120	139	85.4	133	130	137	129	130	115	119	127	112	122	120	119	137	131	119	144	156	147	135	92	121	173
INORG NITROGEN																									
$NO_2^- + NO_3$-N ppm	2.39	2.02	1.28	1.784	1.796	1.295	1.344	1.788	1.051	1.176	.787	1.309	.815	.785	.606	.720	.686	.605	.486	.540	.433	1.230	1.550	2.037	.315
NO_2-N ppb	3.1	4	1	.84	1.20	1.46	.14	.76	.36	1.32	.34	.64	.70	.34	.45	<.14	.42	.50	.36	.40	.40	.31	.67	x	0.8
NH_4-N ppm	.016	<.0007	.008	.021	.014	.014	.006	.007	.017	.011	.010	.033	.013	.008	.004	.013	.004	.011	.005	.006	.006	.006	.003	.020	.018
PO_4-P ppm	.009	.003	.004	.005	.005	.003	.003	.002	.004	.008	.012	.008	.010	.008	.005	.008	.006	.008	.007	.005	.006	.005	.004	.006	.009
CATIONS, ppm																									
CALCIUM	3.33	3.33	x	1.88	1.60	1.78	1.92	2.06	2.20	1.70	2.24	2.60	2.08	2.50	2.18	2.32	2.55	2.11	2.82	3.34	2.50	2.20	.88	1.41	1.85
MAGNESIUM	4.42	4.72	x	3.9	3.3	3.8	3.95	4.0	3.6	3.1	2.6	2.7	2.4	2.6	2.5	2.4	2.6	2.3	2.5	2.8	2.0	1.8	1.3	1.3	1.7
MANGANESE ppb				x	x	17.5	x	x	135	165	x	x	114	x	x	6.9	x	x	10.6	x	16.0	x	10.5	14.0	9.8
POTASSIUM	1.25	1.32	x	1.20	1.10	1.14	1.10	1.11	1.13	1.14	1.00	1.06	1.00	1.00	1.00	1.02	1.00	.90	1.00	1.00	.92	.86	1.05	1.25	1.45
SODIUM	10.6	11.3	x	12.3	12.2	12.4	11.7	11.0	10.9	13.4	13.9	12.5	16.0	13.7	15.6	14.3	18.6	20.2	17.7	19.1	23.8	22.5	12.2	16.5	19.5
CATIONS, ppb																									
CADMIUM						1.2			1.1	1.3			.94			1.9			4.0		1.2		X		
CHROMIUM																									
COPPER						6.3			3.7	5.9			6.9			2.7			4.4		2.2		3.7	7.8	9.7
IRON						x			x	x			x			x			x		x		15	14.3	5.5
LEAD						.25			.45	.19			<.05			.09			.26		.05		0.1	.3	.8
ZINC						25			25	75			25			25			50		X		X		
Boron ppm				.08	.11	.07	.09	.10	.16	.32	.20	.18	.25	.24	.29	.25	.24	.39	.13	.20	.28	.25	.15	.21	.24
ANIONS, ppm																									
CHLORIDE-Cl	28.6	30.8	31.9	31.6	28.5	30.8	30.0	29.4	28.9	28.1	28.8	28.3	28.6	28.8	28.8	28.9	28.9	27.7	28.3	30.5	36.3	32.1	16.8	25.7	42.2
SULFATE-SO_4				7	8	7	x	X	x	15	14	13	12	8	14	12	14	17	13	14	21	18	9	9	4
TEMP °C	12.0	13.5	14.5	16.0	13.5	13.0	13.0	12.0	9.0	9.5	10.0	13.0	12.5	13.5	11.5	16.0	13.5	15.0	13.0	13.0	10.5	10.0	15.0	12.0	14.0
ELEVATION FT.	50.49	50.96	50.64	15.35	50.43	49.49	49.54	49.35	49.53	49.86	50.74	52.17	51.41	51.47	51.25	50.94	50.53	50.88	50.48	50.07	49.26	48.87	50.58	51.06	51.42

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

(CONTINUED)

TABLE A-20 (CONTINUED)

ANALYSIS / DATE	14 VII 77	18 VIII 77	22 IX 77	20 X 77	17 XI 77	20 XII 77	19 I 78	16 II 78	16 III 78
pH	6.3	5.6	5.6	5.4	5.6	6.2	5.8	5.9	5.9
CONDUCTANCE μMho/cm	178	188	166	180	168	171	182	196	223
INORG NITROGEN									
$NO_2^- + NO_3^-$-N ppm	.360	.344	.309	.242	.220	.260	.185	.204	.449
NO_2-N ppb	0.4	4.3	2.2	0.9	2.6	0.9	0.4	0.7	1.5
NH_4-N ppm	.011	.016	.006	.008	.007	.005	.011	.003	.010
PO_4-P ppm	.009	.015	.023	.011	.015	.014	.013	.016	.001
CATIONS, ppm									
CALCIUM	3.34	4.40	3.61	2.64	2.60	2.02	3.34	3.85	3.85
MAGNESIUM	4.5	4.1	3.8	3.5	3.1	3.2	3.5	4.1	3.7
MANGANESE ppb	10.5	10.0	6.5	9.0	9.0	6.0	9.0	10.0	9.0
POTASSIUM	1.45	1.89	1.75	1.60	1.45	1.50	1.50	1.65	1.90
SODIUM	21.8	29.5	27.5	34.5	26.0	31.5	32.5	35.0	37.5
CATIONS, ppb									
CADMIUM									
CHROMIUM									
COPPER	17.0	16.5	20.0	X	16.0	8.5	10.5	11.5	14.5
IRON	9.3	26.0	57.0	50.0	X	24.5	X	X	X
LEAD	.7	X	X						
ZINC									
Boron ppm	.26	.43	.36	.38	.37	.31	.43	.36	.49
ANIONS, ppm									
CHLORIDE-Cl	42.5	40.6	35.2	33.6	35.2	39.0	43.5	43.7	40.5
SULFATE-SO_4	8	10	27	25	17	22	23	21	28
TEMP °C	15.5	16.0	11.3	11.1	11.3	10.4	X	10.0	10.7
ELEVATION FT	51.52	51.22	50.80	50.67	50.87	50.87	51.55	53.36	53.41

X NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-21 SOIL WATER FROM 6", LYSIMETER

ANALYSIS / DATE	24 VII 74	15 VIII 74	30 VIII 74	1 X 74	30 XI 74	24 III 75	26 III 75	21 V 75	18 VI 75	13 VIII 75	10 IX 75	26 IX 75	21 X 75	20 XI 75	18 XII 75	18 II 76	12 III 76	4 V 76	15 VI 76	2 VII 76	31 VIII 76	23 IX 76	21 IV 77	14 VII 77	18 VIII 77	
pH	x	x	x	x	x	7.5	7.4	7.2	7.3	6.9	6.9	6.5	6.9	6.4	5.8	6.5	6.1	6.4	6.5	7.0	6.5	6.6	6.[illegible]	6.[illegible]	6.6	
CONDUCTANCE µMho/cm	x	x	x	x	x	x	328	232	215	416	402	389	252	183	247	339	313	384	525	479	379	353	300	509	416	
INORG NITROGEN																										
NO_2^- + NO_3-N ppm	1.30	1.82	.47	1.33	.07	1.42	.01	.23	.12	.358	.204	.176	.084	.228	.603	.094	.161	.137	1.27	.255	.070	.098	.116	.099	.083	
NO_2-N ppb	x	x	x	x	x	<.14	2.2	x	x	1.60	.39	.14	.28	1.00	2.10	2.10	2.38	2.77	4.2	2.5	.90	.40	1.6	1.7	1.7	
NH_4-N ppm	.19	.16	.23	.03	x	2.73	.02	x	.01	.010	.005	.026	.007	.016	.016	.037	.020	.017	.116	.045	.010	.006	.013	.016	.007	
PO_4-P ppm	.003	<.0006	.009	<.0006	x	.320	.003	x	.001	.078	.002	.004	.004	.008	.008	.018	.019	.082	.151	.054	.032	.030	.024	.105	.089	
CATIONS, ppm																										
CALCIUM		39.8								62.5	54.6	59.8	50.2	10.4	47.5	39.4	48.4	57.2	31.5	39.8	36.6	34.3	46.3	52.1	47.5	
MAGNESIUM		6.2	6.9							2.86	2.75	2.90	1.92	.95	2.55	5.30	x	2.85	3.02	2.55	3.00	2.80	3.30	6.10	4.80	
MANGANESE ppb		.03								x	x	x	x	x	x	x	x	x	x	x	x	x	2.0	2.0	2.5	
POTASSIUM		1.1								.44	.20	.28	.22	.46	.19	.26	2.34	4.29	.80	.33	.37	.44	.30	.30	.50	
SODIUM		7.2								41.5	59.5	42.0	19.7	23.6	15.7	19.1	21.2	43.0	51.5	70.5	44.4	45.5	20.0	61.8	52.5	
CATIONS, ppb																										
CADMIUM																	x									
CHROMIUM																	x									
COPPER																	x						14.0	10.5	11.5	
IRON																	x						x	x	70	
LEAD																	x									
ZINC																	x									
BORON ppm										.58	.43	.43	.29	.37	.22	.28	x	.63	.74	.82	.56	.57	.30	.59	.56	
ANIONS, ppm																										
CHLORIDE-Cl	25.7	28.8	33.4	17.0	33.7	x	x	<3.9	x	36.6	42.4	29.8	9.0	24.8	25.7	21.8	x	27.2	69.2	56.2	42.9	38.6	34.7	73.3	52.5	
SULFATE-SO_4										x	x	24	x	x	21	20	x	22	44	54	22	21	11	26	24	

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

(CONTINUED)

TABLE A-21 (CONTINUED)

ANALYSIS / DATE	22 IX 77	20 X 77	17 XI 77	20 XII 77	19 I 78
pH	6.8	6.8	6.7	6.8	7.3
CONDUCTANCE μMho/cm	221	233	272	260	280
INORG NITROGEN					
$NO_2^- + NO_3$-N ppm	.203	.119	1.789	.315	.157
NO_2-N ppb	3.8	X	X	1.8	X
NH_4-N ppm	.013	.014	.004	.041	X
PO_4-P ppm	.158	.041	.255	.428	X
CATIONS, ppm					
CALCIUM	33.4	15.6	12.6	25.3	19.9
MAGNESIUM	3.60	3.93	3.50	4.10	4.26
MANGANESE ppb	1.8	3.3	1.0	8.5	X
POTASSIUM	.65	.30	.32	.25	.35
SODIUM	35.5	32.5	34.5	40.0	35.0
CATIONS, ppb					
CADMIUM					
CHROMIUM					
COPPER	17.0	32.0	13.5	14.0	X
IRON	63	34	90	155	X
LEAD					
ZINC					
BORON ppm	.51	.29	.31	.28	X
ANIONS, ppm					
CHLORIDE - Cl	8.0	X	X	35.5	X
SULFATE - SO_4	26	18	X	24	X

X: NO SAMPLE, BLANK: ANALYSIS NOT COMPLETE

TABLE A-22 SOIL WATER FROM 1', LYSIMETER

ANALYSIS / DATE	24 VII 74	15 VIII 74	30 VIII 74	1 X 74	30 X 74	24 III 75	26 III 75	21 V 75	18 VI 75	16 VII 75	13 VIII 75	10 IX 75	26 IX 75	21 X 75	18 XII 75	18 II 76	4 V 76	15 VI 76	2 VII 76	4 VIII 76	31 VIII 76	23 IX 76	21 IV 77
pH	x	x	x	x	x	6.9	7.5	7.2	7.1	6.5	6.5	6.6	6.5	6.4	6.6	5.7	6.5	6.4	6.7	6.9	6.4	6.5	6.7
CONDUCTANCE µMho/cm	x	x	x	x	x	187	188	70.8	74.6	294	279	282	231	196	225	267	257	450	474	298	387	320	231
INORG. NITROGEN																							
NO_2^- + NO_3-N ppm	.56	.93	.64	.73	.07	2.12	.59	.13	.17	.202	.154	.161	.172	1.317	3.844	.109	.150	.603	.196	.195	.172	.083	.151
NO_2-N ppb	x	x	x	x	x	<.14	2.4	x	x	5.88	1.82	0.34	x	.64	1.68	1.04	x	1.4	5.5	x	.40	.40	1.15
NH_4-N ppm	x	.04	.25	.03	x	.59	.02	x	.01	.014	.003	.009	x	.034	.027	.029	.040	.106	.038	.006	.011	.006	.007
PO_4-P ppm	.005	<.0006	.009	<.0006	x	.220	.014	x	x	.013	.016	.007	x	.022	.01	.015	x	.037	.034	.032	.017	.023	.014
CATIONS, ppm																							
CALCIUM		17.4								x	15.8	15.1	13.0	20.1	23.1	29.7	12.2	18.1	21.8	x	24.3	20.2	x
MAGNESIUM		2.6	2.1							x	1.58	1.98	1.61	1.86	3.00	5.60	2.35	2.74	2.56	x	3.58	3.00	x
MANGANESE		.02								x	x	x	x	x	x	x	x	x	x	x	x	x	
POTASSIUM		2.2								x	.30	.22	.47	.08	.21	.10	.89	.30	.27	x	.37	.79	x
SODIUM		9.8								x	39.0	57.6	35.5	21.1	24.0	20.6	38.5	57.5	80.5	x	47.5	48.0	x
CATIONS, ppb																							
CADMIUM										x										x			x
CHROMIUM										x										x			x
COPPER										x										x			x
IRON										x										x			x
LEAD										x										x			x
ZINC										x										x			x
BORON ppm										x	.45	.41	.38	.36	.36	.32	.70	.85	.76	.73	.59	.63	x
ANIONS, ppm																							
CHLORIDE-Cl	x	52.1	42.5	25.6	46.8	30.4	30.8	<3.9	x	40.4	39.3	42.6	30.0	19.6	34.4	46.7	25.2	62.3	63.8	x	50.7	49.5	x
SULFATE-SO_4										x	x	x	x	x	24	20	x	48	50	34	26	24	x

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-23 SOIL WATER FROM 2', LYSIMETER

ANALYSIS / DATE	24 VII 74	15 VIII 74	30 VIII 74	1 X 74	30 XI 74	3 XII 74	12 II 75	26 II 75	21 V 75	18 VI 75	16 VII 75	13 VIII 75	10 IX 75	26 IX 75	21 X 75	18 XII 75	18 I 76	12 III 76	4 V 76	15 VI 76	2 VII 76	4 VIII 76	31 VIII 76	23 IX 76	21 IV 77
pH	x	x	x	x	x	7.1	6.7	6.9	7.5	7.2	6.8	6.5	6.6	6.3	6.4	5.5	6.1	6.0	6.4	6.2	7.0	6.9	6.3	6.6	7.0
CONDUCTANCE µMho/cm	x	x	x	x	x	278	184	305	112	117	345	308	334	162	266	287	296	270	240	471	452	263	374	304	226
INORG. NITROGEN																									
$NO_2^- + NO_3$-N ppm	14.9	1.18	1.15	2.41	3.36	4.21	1.50	10.0	.16	.09	.782	.292	.235	.158	2.692	8.708	.188	.888	.197	2.20	.410	.350	.193	.167	.137
NO_2-N ppb	x	x	x	x	x	2.2	x	8.5	x	x	x	2.30	1.12	.84	.64	2.63	2.80	4.76	4.06	10.6	1.4	1.7	.30	.50	x
NH_4-N ppm	1.70	0.19	.25	.06	x	.01	.10	.28	x	x	.035	.004	.018	.012	.015	.013	.317	.033	.023	.027	.033	.008	.009	.008	.013
PO_4-P ppm	.0009	<.0006	.009	<.0006	x	.008	.530	.711	x	x	.139	.079	.076	.066	.092	.463	1.472	2.379	1.27	1.11	.081	.783	.529	.454	x
CATIONS, ppm																									
CALCIUM		21.2									x	38.7	27.3	15.5	30.1	25.2	27.3	9.9	14.3	18.1	21.8	x	28.2	x	x
MAGNESIUM		2.8	1.5								x	3.32	2.94	1.60	3.18	3.70	6.25	2.78	2.49	3.69	2.96	2.70	4.76	x	x
MANGANESE		.13									x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
POTASSIUM		2.9									x	.36	.43	.10	.06	.20	1.20	2.18	1.40	.61	.39	.28	.39	x	x
SODIUM		14.5									x	25.0	57.5	19.1	21.6	32.0	21.6	31.5	36.0	57.0	71.5	37.5	39.0	x	x
CATIONS, ppb																									
CADMIUM											x								x			x	x	x	x
CHROMIUM											x								x			x	x	x	x
COPPER											x								x			x	x	x	x
IRON											x								x			x	x	x	x
LEAD											x								x			x	x	x	x
ZINC											x								x			x	x	x	x
Boron ppm											x	.45	.81	.28	.37	.48	.37	.46	x	.79	.70	.47	.54	.53	x
ANIONS, ppm																									
CHLORIDE-Cl	x	53.1	28.9	31.5	x	29.3	18.7	31.3	x	x	33.8	35.0	40.6	9.4	27.7	36.9	52.5	43.5	x	64.7	52.0	x	42.1	39.6	32.9
SULFATE-SO_4											x	x	34	x	x	38	23	x	x	40	44	x	22	x	x

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-24 SOIL WATER FROM 3', LYSIMETER

ANALYSIS / DATE	24 VII 74	15 VIII 74	30 VIII 74	1 IX 74	30 XI 74	3 XII 74	12 II 75	26 II 75	24 IV 75	21 V 75	18 VI 75	16 VII 75	13 VIII 75	10 IX 75	26 IX 75	21 X 75	18 II 76	12 II 76	4 V 76	15 VI 76	2 VII 76	31 VIII 76	23 IX 76	21 IV 77	
pH	x	x	x	x	x	6.6	6.5	7.1	6.9	6.7	6.7	6.2	6.8	6.2	6.4	6.4	6.1	6.0	6.2	6.5	6.6	6.3	6.3	6.9		
CONDUCTANCE μMho/cm	x	x	x	x	x	283	262	312	230	120	120	188	248	281	221	278	228	271	318	440	433	378	320	252		
INORG. NITROGEN																										
$NO_2^- + NO_3^-$-N ppm	25.7	1.47	1.66	1.62	3.48	2.41	3.73	2.46	.98	.17	.15	.145	.125	.151	.118	2.397	.146	.629	.136	1.85	.189	.189	.126	.094		
NO_2-N ppb	x	x	x	x	x	.8	<.14	1.3	8	1.0	<.14	1.26	1.60	1.57	0.95	.64	1.82	1.00	1.48	.30	2.5	.50	.40	0.9		
NH_4-N ppm	.41	.15	.35	.08	.03	x	.01	.03	.01	.02	.01	.042	.018	.014	.009	.031	.458	.078	.039	.040	.021	.016	.017	.036		
PO_4-P ppb	4.0	<.62	9.6	<.62	2.5	.9	<.62	1.9	3.1	<.62	1.0	<.62	3.95	2.37	3.17	3.64	656	217	164	81.5	43.2	546	55.2	3.8		
CATIONS, ppm																										
CALCIUM		33.0										23.6	27.5	25.7	25.3	36.1	22.2	21.6	19.4	20.2	29.0	27.3	27.1	x		
MAGNESIUM		4.8	3.3	2.6		2.2						1.44	1.62	2.02	2.91	2.45	3.67	2.92	2.26	2.92	3.23	3.50	3.84	x		
MANGANESE		.119	.039	.008		.014						x	x	x	x	x	x	x	x	x	x	x	x	x		
POTASSIUM		1.6	1.1	.8		.6						.42	.40	.47	.27	.15	.93	.36	7.95	.34	.28	.52	.75	x		
SODIUM		7.0	12.1	18.1		29.3						12.9	26.1	55.0	25.5	21.6	18.9	27.0	40.0	49.0	91.0	44.5	47.5	x		
CATIONS, ppb																										
CADMIUM																										
CHROMIUM																										
COPPER		3	14	14		8																				
IRON		181	175	205		260																				
LEAD																										
ZINC																										
Boron ppm												.65		.41	.33	.47	.28	.39	.61	.77	1.02	.59	.57	x		
ANIONS, ppm																										
CHLORIDE-Cl		35.8	24.0	23.3	46d	32.4	28.4	36.2	27.7	<3.9	<3.9	15.8	17.4	32.7	12.3	24.4	26.6	41.3	26.4	59.1	59.5	46.7	44.5	x		
SULFATE-SO_4												x	x	x	12	x	18	24	15	x	44	17	23	x		

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-25 SOIL WATER FROM 4′, LYSIMETER

ANALYSIS / DATE	24 VII 74	15 VIII 74	30 VIII 74	1 X 74	30 XI 74	3 XII 74	12 II 75	26 III 75	24 IV 75	21 V 75	18 VI 75	16 VII 75	10 IX 75	26 IX 75	21 X 75	20 XI 75	18 XII 75	15 I 76	18 II 76	12 III 76	6 IV 76	4 V 76	15 VI 76	2 VII 76	4 VIII 76	
pH	x	x	x	x	x	x	x	6.3	5.9	6.2	6.3	5.7	5.7	6.1	6.1	7.3	5.4	5.7	5.9	6.1	6.0	6.1	6.1	6.5	6.6	
CONDUCTANCE µMho/cm								186	192	132	130	188	250	223	223	173	225	187	229	243	227	277	383	371	332	
INORG. NITROGEN																										
$NO_2^- + NO_3$-N ppm	1.74	.93	5.27	2.92	3.48	3.51	.88	1.11	.98	.39	.27	.210	.301	.179	1.441	.144	4.329	.904	.162	.347	.186	.157	2.05	.2	.942	
NO_2-N ppb	x	x	x	x	x	.31	.56	.7	.8	1.0	<.14	1.26	1.48	2.38	.92	X	1.57	X	.98	.78	x	4.34	21.3	24.9	20.0	
NH_4-N ppm	.15	.06	.35	.05	.03	.02	.05	.01	.02	.01	.02	.042	.017	.028	.017	.002	.022	.047	.150	.078	.097	.251	.234	.317	.067	
PO_4-P ppb	1.6	<.62	7.3	<.62	2.5	<.62	<.62	1.6	1.2	<.62	2.0	.63	<.62	7.83	1.74	X	3.97	11.78	66.34	35.09	29.1	80.9	106	140	89.6	
CATIONS, ppm																										
CALCIUM		2.5										11.3	12.7	13.4	23.0	X	26.2	17.8	21.1	18.1	14.2	15.3	15.3	15.8	13.4	
MAGNESIUM		.45	4.8	1.78	1.70	x	1.33					1.13	1.23	1.21	1.62	X	2.48	1.65	3.32	2.28	1.85	1.97	2.65	2.27	1.90	
MANGANESE		.021	.178	.090	.068	x	.038					x	x	x	x	X	x	x	x	x	x	x	x	x	x	
POTASSIUM		.83	1.83	1.13	1.00	x	.75					.60	.90	.63	.30	X	.50	.42	.55	.18	.64	10.35	1.68	1.23	.47	
SODIUM		4.6	14.8	15.4	33.7	x	26.2					21.2	33.5	46.5	21.9	X	15.5	15.5	18.3	24.5	24.4	34.5	45.5	57.5	50.0	
CATIONS, ppb																										
CADMIUM																X					x					
CHROMIUM																X					x					
COPPER																X					x					
IRON																X					x					
LEAD																X					x					
ZINC																X					x					
																X					x					
BORON ppm												.58	.47	.35	.38	x	.34	.32	.28	.26	x	.58	.72	.75	.75	
ANIONS, ppm																										
CHLORIDE - Cl	6.8	8.6	48.7	30.6	46.1	x	31.2	31.2	33.4	14.0	9.7	x	37.0	19.1	24.7	X	31.2	x	35.4	41.6	39.0	x	51.8	49.2	46.7	
SULFATE - SO_4												x	x	24	x	X	27	24	25	x	x	x	34	39	31	

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

(CONTINUED)

TABLE A-25 (CONTINUED)

ANALYSIS / DATE	31 VIII 76	23 IX 76	21 IV 77	19 V 77	22 VI 77	14 VII 77	18 VIII 77	22 IX 77	20 X 77	17 XI 77	20 XII 77
pH	6.2	6.2	6.5	6.2	6.3	6.3	6.6	6.3	6.1	6.4	6.5
CONDUCTANCE μMho/cm	340	314	203	278	247	288	325	190	235	270	215
INORG NITROGEN											
$NO_2^- + NO_3$-N ppm	.190	.174	.196	.133	.209	.209	.167	1.012	1.947	1.883	2.612
NO_2-N ppb	1.5	.40	1.06	X	2.2	1.5	1.3	2.3	0.6	0.6	X
NH_4-N ppm	.057	.011	.028	.026	.051	.033	.012	.023	.022	.005	.025
PO_4-P ppb	58.3	34.4	86.2	45.6	55.8	50.8	4.5	164.3	45.6	39.7	88.7
CATIONS, ppm											
CALCIUM	14.6	15.8	14.4	22.7	15.1	19.0	29.0	20.8	10.9	11.1	18.7
MAGNESIUM	2.00	2.03	3.30	4.15	2.88	3.20	4.25	3.30	3.15	3.40	4.05
MANGANESE ppb	X	X	X	X	X	X	X	X	X	X	X
POTASSIUM	.80	.52	1.10	.70	.65	.90	.80	1.00	.40	.30	.30
SODIUM	50.5	52.0	33.0	42.0	37.8	43.8	46.5	36.0	36.0	35.0	40.0
CATIONS, ppb											
CADMIUM											
CHROMIUM			8.0	16.0	19.3	7.8	11.0	11.0	17.0	11.0	6.0
COPPER											
IRON											
LEAD											
ZINC											
BORON (ppm)	.64	.55	.29	.34	.38	.49	.50	.46	.44	.32	.40
ANIONS, ppm											
CHLORIDE-Cl	42.7	44.8	20.9	45.4	29.0	47.9	53.1	24.7	26	64.5	37
SULFATE-SO_4	25	29	17	10	11	13	18	22	26	24	26

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-26 WELL WATER, WELL #3

ANALYSIS / DATE	21 I 74	19 II 74	4 III 74	20 III 74	3 IV 74	17 IV 74	30 IV 74	14 V 74	30 V 74	12 VI 74	19 VI 74	3 VII 74	17 VII 74
pH	x	x	x	x	x	x	x	x	x	x	x	x	6.4
CONDUCTANCE µMho/cm	x	x	x	x	x	x	x	x	x	x	x	x	x
INORG. NITROGEN													
NO_2^- + NO_3-N ppm	.024	.013	.013	.008	.008	.009	.007	.006	.009	.011	.002	.068	.006
NO_2-N ppb	10	1	1	.4	1	.7	1	2	2	1.1	1.3	17.5	1.3
NH_4-N ppm	.014	<.0007	.006	.0007	<.0007	.008	.003	.011	.008	.059	.006	.018	.015
PO_4-P ppm	.025	.022	.005	.005	.003	.009	.002	.002	.006	.006	.002	.017	.005
CATIONS, ppm													
CALCIUM	.73	.69		1.07		1.11		.98		1.02			.90
MAGNESIUM	1.25	1.29		1.19		1.17		1.29					
MANGANESE ppb													
POTASSIUM	.7	.6		.7		.68		.71		.86			.80
SODIUM	6.0	5.4		5.1		5.1		5.2		5.5			5.6
CATIONS, ppb													
CADMIUM													
CHROMIUM													
COPPER													
IRON	<30	<30											
LEAD	6.0												
ZINC													
Boron ppm													
ANIONS, ppm													
CHLORIDE-Cl	x	7.3	7.3	7.4	7.3	7.4	8.6	7.5	7.2	7.5	6.9	7.0	7.1
SULFATE-SO_4													
TEMP °C													14.5
ELEVATION FT	53.25	x	53.67	53.25	53.58	53.50	53.50	x	53.50	53.38	53.21	53.17	53.00

ANALYSIS / DATE	24 VII 74	21 VIII 74	5 IX 74	25 IX 74	22 X 74	6 XI 74	20 XI 74	18 XII 74	30 I 75	26 II 75	26 III 75	24 IV 75	21 V 75
pH	x	x	x	x	5.9	6.2	x	6.2	6.5	6.4	6.3	6.5	6.1
CONDUCTANCE µMho/cm	x	x	x	x	x	x	x	39.1	52.1	52.0	52.0	51.5	52.3
INORG. NITROGEN													
NO_2^- + NO_3-N ppm	.007	.020	.012	.020	.009	.008	.009	.011	.024	.025	.017	.024	.018
NO_2-N ppb	x	x	x	x	x	x	.4	.14	8	x	.4	.8	1
NH_4-N ppm	1.15	.136	.071	.029	.022	.021	.009	.011	.014	.019	.014	.011	.015
PO_4-P ppm	.003	.006	.009	.006	.006	.007	.007	.005	.007	.006	.006	.006	.007
CATIONS, ppm													
CALCIUM		.98		.98	1.06		1.18	.93	1.25	1.00	.97	1.18	1.06
MAGNESIUM				1.21	.82		1.21	1.18	1.20	1.26	1.27	1.35	1.37
MANGANESE ppb													
POTASSIUM		.80		.78	.78		.67	.69	.70	.78	.72	.70	.70
SODIUM		5.5		5.6	5.5		5.4	5.2	5.3	5.5	5.3	5.4	5.3
CATIONS, ppb													
CADMIUM													
CHROMIUM													
COPPER													
IRON													
LEAD													
ZINC													
Boron ppm													
ANIONS, ppm													
CHLORIDE-Cl	7.7	7.5	7.5	7.6	7.7	7.7	7.4	7.6	7.7	7.9	7.9	7.2	8.0
SULFATE-SO_4													
TEMP °C	x	14.0	12	12.5	12.0	11.5	11.5	10.0	10.5	11.0	11.0	11.5	13.0
ELEVATION FT	52.83	52.79	52.00	51.75	51.29	51.17	50.85	50.33	50.08	50.13	50.22	50.63	51.19

X: NO SAMPLE, BLANK: ANALYSIS NOT COMPLETE

(CONTINUED)

TABLE A-26 (CONTINUED)

ANALYSIS / DATE	16 VII 75	13 VIII 75	10 IX 75	8 X 75	5 XI 75	3 XII 75	30 XII 75	28 I 76	25 II 76	24 III 76	21 IV 76	19 V 76	16 VI 76	14 VII 76	11 VIII 76	8 IX 76	6 X 76	15 XII 76	20 I 77	21 IV 77	19 V 77	22 VI 77	14 VII 77	18 VIII 77	22 IX 77
pH	5.6	6.0	6.3	6.1	5.8	7.0	6.3	7.9	6.5	7.4	7.0	5.8	6.0	6.3	6.5	6.8	7.8	6.1	5.7	5.9	7.3	5.7	6.5	6.0	5.7
CONDUCTANCE µMho/cm	54.1	54.2	54.2	54.3	55.3	48.2	47.5	51.2	47.8	48.0	49.0	42.5	56.8	58.0	56.6	64.4	60.9	47.3	44.2	49.1	47.8	61.1	55.3	62.3	52.5
INORG. NITROGEN																									
NO_2^- + NO_3-N ppm	.043	.031	.021	.014	.014	.028	.027	.036	.042	.025	.010	.017	.014	.004	.007	.022	.020	.017	.020	.003	.028	.150	.022	.175	.150
NO_2-N ppb	.84	.64	.45	.17	.28	.50	.50	.25	.53	.42	.22	.56	<.14	.40	.30	<.14	.20	.30	.48	.34	x	0.3	0.2	8.1	1.6
NH_4-N ppm	.021	.015	.010	.007	.009	.015	.021	.006	.016	.007	.007	.006	.012	.009	.013	.008	.006	.005	.008	.009	.015	.016	.019	.021	.006
PO_4-P ppm	.008	.009	.006	.007	.004	.004	.006	.005	.004	.005	.004	.005	.003	.004	.004	.005	.006	.008	.006	.005	.008	.015	.006	.015	.015
CATIONS, ppm																									
CALCIUM	.70	.62	.70	.70	.70	.90	1.80	1.23	1.20	1.20	1.02	.88	1.00	1.28	1.13	1.23	1.23	.92	.84	.51	.53	0.40	1.06	1.76	1.41
MAGNESIUM	1.4	1.4	1.4	1.6	1.6	1.6	1.6	1.4	1.4	1.3	1.2	1.2	1.4	1.5	1.4	1.4	1.3	0.9	0.9	0.8	0.8	0.9	1.8	1.6	1.6
MANGANESE ppb	x	x	136	x	x	104	101	x	x	103	x	x	103	x	x	124	x	125	x	15.3	8.8	9.0	8.0	10.0	6.0
POTASSIUM	.64	.63	.61	.71	.66	.70	.61	.62	.67	.61	.60	.65	.67	.66	.62	.65	.59	.53	.52	.70	.65	.90	.90	1.20	1.00
SODIUM	5.0	5.0	5.0	5.1	5.0	4.7	4.5	4.5	4.5	4.7	4.7	4.7	4.9	6.2	6.8	6.8	6.8	5.7	5.7	5.3	5.2	5.5	6.0	6.4	6.1
CATIONS, ppb																									
CADMIUM			.76			1.2	2.4			.54			3.8			3.2		1.8		x	x	1.9	1.9	x	x
CHROMIUM																									
COPPER			5.7			2.2	5.7			3.0			4.4			4.3		5.8		7.3	14.2	22.6	9.1	23.5	19.8
IRON																				19.5	13.5	48.0	15.0	21.0	23.5
LEAD			.18			.14	.52			.10			.16			.12		.27		.5	.4	.3	.4	x	x
ZINC			25			25	200			50			25			25		x							
BORON (ppm)	.04	.10	.08	.02	.05	.08	.08	.04	.07	.07	.07	.09	.03	.05	.19	.05	.09	.12	.05	.09	.07	.07	.07	.06	.04
ANIONS, ppm																									
CHLORIDE-Cl	7.8	8.2	8.6	9.1	8.6	8.0	8.4	7.2	7.5	8.0	8.8	8.5	11.0	11.6	11.3	10.2	10.3	9.2	9.5	8.6	8.6	9.4	9.0	10.1	8.0
SULFATE-SO_4	11	11	9	x	x	19	17	5	6	7	6	7	6	4	5	7	6	9	6	7	7	7	7.7	10.8	7
TEMP °C	12.0	15.5	13.5	13.0	12.5	10.0	10.0	8.5	12.5	12.0	13.5	11.0	16.0	14.0	15.0	14.0	13.0	10.0	11.0	12.0	12.5	13.0	13.0	14.0	11.8
ELEVATION FT.	47.44	51.62	49.75	49.79	49.59	49.77	50.49	51.03	52.37	51.89	51.70	51.47	51.15	50.76	51.11	50.73	50.29	49.29	49.69	50.79	51.27	51.59	51.72	51.42	51.03

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

(CONTINUED)

TABLE A-26 (CONTINUED)

ANALYSIS / DATE	20 X 77	17 XI 77	20 XII 77	19 I 78	16 II 78	16 III 78
pH	5.5	5.5	6.7	6.1	5.9	6.3
CONDUCTANCE μMho/cm	55.5	60.9	65.4	74.2	56.5	53.3
INORG. NITROGEN						
$NO_2^- + NO_3$-N ppm	.051	.070	.178	.034	.181	.035
NO_2-N ppb	1.7	2.4	3.8	0.8	0.6	0.6
NH_4-N ppm	.010	.008	.016	.018	.009	.015
PO_4-P ppm	.011	.024	.011	.477?	.015	.001
CATIONS, ppm						
CALCIUM	1.58	1.28	1.23	1.32	1.58	1.41
MAGNESIUM	1.8	1.6	1.6	1.7	1.8	1.8
MANGANESE ppb	10.5	10.0	10.0	9.0	8.5	8.0
POTASSIUM	1.10	1.10	1.55	1.30	1.05	0.95
SODIUM	6.6	7.3	8.0	7.1	6.5	6.6
CATIONS, ppb						
CADMIUM						
CHROMIUM						
COPPER	20.0	13.3	48.0	12.5	12.0	10.0
IRON	14.0	20.0	20.0	X	X	X
LEAD						
ZINC						
Boron ppm	.02	.11	<.1	.20	<.1	<.1
ANIONS, ppm						
CHLORIDE-Cl	11.0	10.5	11.6	9.8	9.2	9.4
SULFATE-SO_4	7	5	7	5	5	5
TEMP °C	11.2	11.4	10.5	10.7	10.0	10.8
ELEVATION FT	50.92	51.11	51.09	51.84	53.59	53.64

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-27 SOIL WATER FROM 6", LYSIMETER

ANALYSIS / DATE	24 VII 74	30 VIII 74	1 X 74	30 XI 74	3 XII 74	30 I 75	26 III 75	24 IV 75	21 V 75	18 VI 75	26 IX 75	23 X 75	6 VIII 76	3 IX 76	21 IV 77	19 V 77	22 IX 77	20 X 77
pH	X	X	X	X	6.2	6.1	6.0	6.1	6.3	5.7	5.5	5.4	6.8	5.6	6.5	7.0	5.6	6.6
CONDUCTANCE µMho/cm	X	X	X	X	52.9	34.9	71.3	53.5	42.1	54.6	100	70.5	109	66	48.2	43.8	299	193
INORG. NITROGEN																		
$NO_2^- + NO_3$-N ppm	64.3	5.29	3.27	2.88	.14	.25	.11	.01	.33	.19	.291	.246	.259	.189	.109	.090	.196	.081
NO_2-N ppb	X	X	X	X	2	1	4	X	X	X	<.14	1.40	X	.40	—	—	5.9	2.7
NH_4-N ppb	1023	430	20	20	6	1	20	X	X	3	5.33	7.70	4.3	4.8	16.8	30.2	11.6	5.0
PO_4-P ppb	5.6	2.8	<.62	.9	13.6	5.9	14	X	X	X	5.16	9.92	1.1	18.8	—	—	5.4	10.9
CATIONS, ppm																		
CALCIUM											19.4	13.4	X	13.2			41.6	19.4
MAGNESIUM											2.51	1.86	X	1.85			14.0	12.2
MANGANESE ppb											X	X	X	X	X	X	X	8.1
POTASSIUM											1.39	1.76	X	1.83			1.10	0.30
SODIUM											3.9	2.0	X	3.0			5.9	1.18
CATIONS, ppb																		
CADMIUM													X					
CHROMIUM													X					
COPPER													X					16.3
IRON													X					47.5
LEAD													X					
ZINC													X					
Boron (ppm)											.09	.04	.14	.19				.09
ANIONS, ppm																		
CHLORIDE - Cl	X	X	1.9	X	3.9	<3.9	12.6	6.5	X	<3.9	6.4	<3.9	X	<3.9	4.4	<3.9		5.2
SULFATE - SO_4											X	X	18	9	X	X		2

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-28 SOIL WATER FROM 1', LYSIMETER

ANALYSIS \ DATE	30 VIII 74	1 X 74	30 XI 74	30 I 75	26 III 75	24 IV 75	21 V 75	18 VI 75	26 IX 75	23 X 75	20 XI 75	22 IX 77	20 X 77	17 XI 77	20 XII 77	19 I 78
pH	X	X	X	6.2	6.4	6.8	6.5	6.4	5.7	6.0	6.0	6.2	18.5	6.6	6.9	7.2
CONDUCTANCE μMho/cm	X	X	X	85.3	87.2	515	50.6	69.5	101	92.8	73.0	132	122	138	110	113
INORG NITROGEN																
$NO_2^- + NO_3^-$-N ppm	5.27	4.37	5.15	.08	.03	.01	.03	.19	.238	.171	.070	.174	.133	.106	.098	.078
NO_2-N ppb	X	X	X	4	2	X	X	X	<.14	.98	.70	X	2.3	1.8	X	X
NH_4-N ppb	310	20	40	5	6	X	X	3	<.70	6.28	12.60	21.7	6.0	3.1	340.5?	X
PO_4-P ppb	13	<.62	<.62	6.3	3.6	X	X	1	1.83	2.79	5.36	9.1	9.4	2.8	308.5?	X
CATIONS, ppm																
CALCIUM									32.4	21.3	X	26.3	16.1	14.8	20.6	X
MAGNESIUM									2.96	1.92	X	6.0	5.7	6.6	6.0	5.3
MANGANESE ppb									X	X	X	31.5	10.0	1.3	4.3	X
POTASSIUM									.43	.26	X	.59	.50	.25	1.60	X
SODIUM									3.6	0.9	X	5.0	2.7	1.2	1.3	X
CATIONS, ppb																
CADMIUM											X					
CHROMIUM											X					
COPPER											X	18.9	22.0	12.5	15.0	X
IRON											X	177	130	380	45	X
LEAD											X					
ZINC											X					
Boron (ppm)									.10	.01	x	.06	.07	.04	<.01	X
ANIONS, ppm																
CHLORIDE-Cl	X	14.8	X	<3.9	10.6	X	<3.9	<3.9	<3.9	<6.0	x	6.1	3.3	8.0	0.9	X
SULFATE-SO_4									X	X	X	32	14	8	X	X

X NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-29 SOIL WATER FROM 2′, LYSIMETER

ANALYSIS / DATE	30 VIII 74	1 X 74	30 XI 74	3 XII 74	30 I 75	26 III 75	24 IV 75	21 V 75	18 VI 75	16 VII 75	13 VIII 75	10 IX 75	26 IX 75	23 X 75	2 VII 76	6 VIII 76	19 V 77	22 VI 77	14 VII 77	22 IX 77	20 X 77	17 XI 77	20 XII 77
pH	X	X	X	6.2	5.9	6.4	6.1	6.4	5.4	5.7	5.6	5.1	5.3	5.4	7.0	6.0	6.6	6.1	6.3	5.9	5.5	6.6	6.9
CONDUCTANCE µMho/cm	X	X	X	140	95.7	79.9	64.7	56.0	37.3	67.8	67.7	69.8	67.0	52.6	48.0	54.9	61.1	131	40.1	53.9	58.0	53.5	42.0
INORG. NITROGEN																							
$NO_2^- + NO_3$-N PPM	.64	1.43	.02	.19	.14	.53	.03	.20	.19	.088	.152	.122	.108	.098	.118	.116	.077	.063	.099	.105	.099	.129	.097
NO_2-N PPb	X	X	X	.9	1.3	.7	X	X	1	X	1.71	X	.70	.70	X	1.6	X	X	0.4	1.6	0.8	X	X
NH_4-N PPb	390	80	X	11	2	7	7	X	1	146.2	1.12	2.66	11.54	<.70	X	.80	25.2	X	4.3	1.6	7.6	16.5	X
PO_4-P PPb	13	<.62	<.62	<.62	.9	3.1	4.6	X	2	X	<.62	1.42	<.62	<.62	X	2.0	X	X	1.1	2.8	7.2	X	X
CATIONS, ppm																							
CALCIUM										X	X	7.0	8.1	5.8	X	5.1				9.0	5.4	6.3	5.0
MAGNESIUM										X	X	1.15	.98	.75	X	1.10				1.38	0.98	1.40	1.10
MANGANESE ppb										X	X	X	X	X	X	X				5.0	12.5	X	5.0
POTASSIUM										X	X	1.02	.72	.62	X	.72				.55	.50	.70	1.80
SODIUM										X	X	2.3	2.9	1.9	X	2.7				4.4	3.6	4.1	2.9
CATIONS, ppb																							
CADMIUM										X	X				X	X				X	X	X	X
CHROMIUM										X	X				X	X				X	X	X	X
COPPER										X	X				X	X				18.0	19.0	X	20.1
IRON										X	X				X	X				X	X	X	X
LEAD										X	X				X	X				X	X	X	X
ZINC										X	X				X	X				X	X	X	X
Boron (PPM)										X	X	.04	.05	.07	.11	.17	X	X	X	.05	.24	X	<.01
ANIONS, ppm																							
CHLORIDE - Cl	X	24.5	X	8.9	<3.9	<3.9	X	<3.9	<3.9	<3.9	X	<3.9	<3.9	<3.9	<3.9	4.5	6.7			3.2	4.3	X	4.4
SULFATE - SO_4										X	X	X	X	X	X	6	X			X	X	X	X

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-30 SOIL WATER FROM 3′, LYSIMETER

ANALYSIS / DATE	30 VIII 74	1 X 74	30 XI 74	3 XII 74	30 I 75	26 III 75	24 IV 75	21 V 75	18 VI 75	16 VII 75	13 VIII 75	10 IX 75	26 IX 75
pH	x	x	x	5.4	5.6	6.2	6.5	5.4	6.3	6.3	5.2	5.1	5.6
CONDUCTANCE µMho/cm	x	x	x	168	113	102	114	79.9	89.3	57.1	65.8	65.1	108
INORG. NITROGEN													
$NO_2^- + NO_3^-$-N ppm	2.41	12.8	.06	8.46	3.92	.73	.73	1.25	.59	.881	.398	.430	.124
NO_2-N ppb	x	x	x	.8	1.4	.8	x	x	1	.70	.92	.53	.50
NH_4-N ppb	920	60	45	30	4	40	8	x	30	23.9	<.70	4.44	7.10
PO_4-P ppb	3.1	<.62	x	.6	<.62	1.2	<.62	x	<.62	<.62	<.62	<.62	<.62
CATIONS, ppm													
CALCIUM										3.3	2.1	7.6	15.2
MAGNESIUM		3.5		4.5						.87	x	1.20	1.66
MANGANESE ppb				.255						x	x	x	x
POTASSIUM		4.6		3.7						.80	1.17	1.54	1.20
SODIUM		5.9		5.5						2.4	x	3.7	3.6
CATIONS, ppb													
CADMIUM													
CHROMIUM													
COPPER		25		14									
IRON		79		127									
LEAD													
ZINC													
Boron (PPM)										.09	.08	.01	.08
ANIONS, ppm													
CHLORIDE - Cl	x	29.4	x	22.5	14.2	<3.9	<3.9	<3.9	<3.9	<3.9	<3.9	<3.9	<3.9
SULFATE - SO_4										x	x	x	x

ANALYSIS / DATE	26 IX 75	23 X 75	20 XI 75	20 II 76	7 V 76	2 VII 76	6 VIII 76	27 IX 76	21 IV 77	22 VI 77	14 VII 77	22 IX 77	20 X 77	17 XI 77
pH		5.5	6.2	5.6	6.3	6.9	5.3	5.9	6.3	5.7	6.1	6.5	5.8	6.5
CONDUCTANCE µMho/cm		115	81.0	80.0	155	148	78.2	83.0	95.7	83.9	69.2	83.1	109.0	74.5
INORG. NITROGEN														
$NO_2^- + NO_3^-$-N ppm		.106	.183	.084	.109	.204	.153	.160	.091	.123	.102	.103	.087	.126
NO_2-N ppb		.28	x	x	x	x	.30	1.0	1.26	1.50	1.10	1.10	0.2	1.5
NH_4-N ppb		6.46	6.72	11.34	x	10.8	4.8	6.3	36.1	15.4	7.6	7.8	20.3	24.8
PO_4-P ppb		<.62	3.63	x	x	x	.90	2.5	13.3	7.4	7.3	3.9	2.9	7.1
CATIONS, ppm														
CALCIUM		6.0	x	7.2	21.5	5.8	4.9	6.2	x	x	4.93	11.40	8.80	4.58
MAGNESIUM		1.48	x	x	2.89	1.85	1.60	x	x	x	1.75	2.30	2.85	1.85
MANGANESE ppb		x	x	x	x	x	x	x	x	x	26.0	16.8	4.1	31.5
POTASSIUM		1.44	x	x	2.41	1.50	1.23	x	x	x	1.80	1.05	0.58	1.20
SODIUM		2.8	x	x	4.7	2.9	3.1	3.5	x	x	4.0	4.3	3.5	4.5
CATIONS, ppb														
CADMIUM			x	x										
CHROMIUM			x	x										
COPPER			x	x							7.0	20.0	13.5	12.5
IRON			x	x							x	7.0	17.0	11.0
LEAD			x	x										
ZINC			x	x										
Boron (PPM)		.05	x	x	.06	.07	.18	.10	x	x	.10	.06	.05	.12
ANIONS, ppm														
CHLORIDE - Cl		<3.9	x	<3.9	18.8	<3.9	<3.9	4.7	x	5.2	3.2	3.5	3.3	7.5
SULFATE - SO_4		x	x	28	29	x	16	15.0	x	x	13.3	16	28	14

X NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-31 SOIL WATER FROM 4′, LYSIMETER

ANALYSIS / DATE	30 VIII 74	1 X 74	3 XI 74	12 I 75	30 I 75	26 III 75	24 IV 75	21 V 75	18 VI 75	16 VII 75	13 VIII 75	10 IX 75	26 IX 75	23 X 75	18 XII 75	20 II 76	12 III 76	6 IV 76	2 VII 76	6 VIII 76	3 IX 76	21 IV 77	19 V 77	22 VI 77	14 VII 77
pH	X	X	X	X	6.4	5.9	6.1	5.2	5.3	5.3	5.2	4.8	5.6	5.4	5.1	4.8	6.3	5.8	6.2	5.9	5.6	5.8	6.2	6.2	5.7
CONDUCTANCE μMho/cm	X	X	X	X	155	72.2	77.5	57.1	56.2	57.1	68.0	73.4	101	131	103	63.2	65.9	61.0	80.0	73.8	73.0	69.5	70.3	159	87.1
INORG. NITROGEN																									
NO_2^- + NO_3-N ppm	2.86	1.21	0.17	0.10	.20	.07	.08	.10	.09	.115	.112	.094	.065	.047	.043	.036	.027	.039	.062	.034	.025	.046	.045	.057	.059
NO_2-N ppb	X	X	X	.6	1.3	.2	1.7	<.14	<.14	.56	.78	.50	.31	.63	.18	.56	.28	.62	2.3	.30	<.14	0.4	X	X	0.4
NH_4-N ppb	310	80	X	50	5	8	3	1	1	13.44	4.48	3.55	.89	<2.36	10.01	5.74	10.50	10.22	16.5	1.5	8.8	7.6	26.0	X	15.8
PO_4-P ppb	13	<.62	4.6	1.9	<.62	<.62	1.6	<.62	<.62	.63	<.62	<.62	<.62	3.56	.81	2.54	12.18	3.47	1.1	1.1	7.7	1.6	5.5	X	1.7
CATIONS, ppm																									
CALCIUM	X									3.7	4.2	4.4	4.6	9.0	8.3	6.2	4.9	5.1	5.1	4.6	5.6	6.5	17.6	X	4.8
MAGNESIUM	X	3.7		1.9						1.90	.90	1.05	1.36	1.70	1.31	1.19	1.05	1.02	1.25	1.26	1.07	1.30	2.40	X	1.25
MANGANESE ppb	X	63		42						X	X	X	X	X	X	X	X	X	X	X	X	118	X	X	8.3
POTASSIUM	X	6.2		3.0						2.70	3.42	4.75	3.90	3.43	25.30	3.84	4.34	4.01	4.15	4.33	5.35	4.10	0.90	X	4.45
SODIUM	X	3.6		2.5						2.0		3.5	3.8	3.8	2.6	2.1	1.9	1.7	2.7	2.4	2.9	3.2	X	X	3.5
CATIONS, ppb																									
CADMIUM																									
CHROMIUM																									
COPPER		12		10																					
IRON		79		70																		73	X	X	6.3
LEAD																									
ZINC																									
Boron (PPM)										.07	.09	.03	.01	.03	.07	.09	.02	.04	.07	.17	.13	.10	X	X	.11
ANIONS, ppm																									
CHLORIDE-Cl		12.3		8.6	24.8	<3.9	<3.9	<3.9		<3.9	<3.9	<3.9	<4.8	12.4	7.1	4.0	<3.9	<3.9	4.7	<3.9	6.1	4.0	4.7	12.3	2.5
SULFATE-SO_4										X	X	25	16	X	28	23	18	14	22	13	16	16	27	X	15

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

(CONTINUED)

TABLE A-31 (CONTINUED)

ANALYSIS / DATE	18 VIII 77	22 IX 77	20 X 77	17 XI 77	20 XII 77	19 I 78
pH	6.2	6.3	5.8	6.0	6.5	7.6
CONDUCTANCE μMho/cm	73.1	96.5	101.2	75.8	64.9	87.6
INORG NITROGEN						
$NO_2^- + NO_3$-N ppm	.064	.047	.044	.059	.066	X
NO_2-N ppb	0.8	0.7	0.05	0.6	0.7	X
NH_4-N ppb	1.1	14.3	13.4	58.8	65.8	X
PO_4-P ppb	1.9	3.5	2.7	1.7	18.3	X
CATIONS, ppm						
CALCIUM	6.7	16.1	7.6	4.1	8.6	X
MAGNESIUM	2.10	2.17	1.80	1.30	1.28	X
MANGANESE ppb	4.3	5.1	8.3	10.0	11.5	X
POTASSIUM	4.26	2.73	3.15	4.05	4.03	X
SODIUM	3.0	4.5	4.4	3.4	3.5	X
CATIONS, ppb						
CADMIUM						
CHROMIUM						
COPPER	6.2	9.0	15.8	6.0	13.8	X
IRON	25	8.5	8.5	52	47.5	X
LEAD						
ZINC						
Boron (PPM)	.05	.02	.08	.11	.07	X
ANIONS, ppm						
CHLORIDE - Cl	2.5	2.9	6.7	5.9	4.1	X
SULFATE - SO_4	14.8	16	14	10	10	X

X NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-32 SOIL WATER FROM 6", LYSIMETER

ANALYSIS / DATE	15 VIII 74	28 VIII 74	9 IX 74	2 X 74	5 XII 74	30 I 75	26 III 75	21 V 75	16 VII 75	10 IX 75	26 IX 75	22 X 75	20 II 76	1 VIII 76	1 IX 76	22 IX 76
pH	X	X	X	X	7.3	7.9	7.9	7.2	7.2	7.2	7.1	7.4	6.9	7.2	7.5	7.0
CONDUCTANCE μMho/cm	X	X	X	X	465	226	316	374	569	549	427	379	328	555	566	505
INORG. NITROGEN																
$NO_2^- + NO_3^-$-N ppm	7.05	35.4	6.82	.54	9.89	.31	.24	.42	.787	.409	.511	.267	.211	X	.447	.265
NO_2-N ppb		13			3	2	1	2	2.80	<.14	<.14	.42	X	1.4	X	.60
NH_4-N ppm	.11	.03	.04	.04	.03	.02	.07	.01	.008	.004	.011	.014	.042	.016	.022	.002
PO_4-P ppb	<.62	3.1	<.62		10	1.6	12	<.62	1.42	<.62	<.62	5.27	31.6	43.4	32.6	25.4
CATIONS, ppm																
CALCIUM	95.1		82.5						105.6	112.6	89.8	88.9	X	43.6	X	82.7
MAGNESIUM	3.35	3.0	2.35						.93	1.19	1.15	1.16	X	2.04	X	3.30
MANGANESE	.05														X	
POTASSIUM	.6		1.2						.42	.35	.25	.34	X	.57	X	.50
SODIUM	7.1		24.5						52.5	55.8	53.0	20.8	X	66.5	X	40.5
CATIONS, ppb																
CADMIUM													X		X	
CHROMIUM													X		X	
COPPER													X		X	
IRON													X		X	
LEAD													X		X	
ZINC													X		X	
Boron (PPm)									.52	.28	.34	.38	X	.68	.40	.54
ANIONS, ppm																
CHLORIDE-Cl	115.7	75.6		2.92	45.0	3.4	10.2	13.5	37.8	49.4	28.8	6.2	X	50.8	X	35.2
SULFATE-SO_4										28	25		X	42	34	24

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-33 SOIL WATER FROM 1′, LYSIMETER

ANALYSIS / DATE	28 VIII 74	9 IX 74	2 X 74	30 I 75	26 III 75	21 V 75	18 VI 75	16 VII 75	13 VIII 75	10 IX 75	26 IX 75	22 X 75	1 VII 76	1 IX 76	22 IX 76
pH	X	X	X	7.8	8.0	7.2	7.5	6.8	7.1	7.1	6.8	6.8	7.0	7.6	6.9
CONDUCTANCE μMho/cm	X	X	X	336	302	411	468	556	382	552	470	339	453	321	420
INORG. NITROGEN															
$NO_2^- + NO_3^-$-N ppm	.01	8.19	.59	.50	.16	.23	.49	1.11	.567	.249	.825	.179	X	.088	.203
NO_2-N ppb	X	X	X	2	2	1		2.00	2.60	0.50	0.36	0.56	4.0	X	X
NH_4-N ppb	40	73	27	3	2	5	42	11.0	<.7	19.5	6.22	6.84	14.1	X	13.9
PO_4-P ppb	3.1	<.62	X	1.6	<.62	<.62		1.0	<.62	<.62	<.62	4.34	25.1	X	33.8
CATIONS, ppm															
CALCIUM		90.3						111.8	X	108.2	88.9		41.4	38.7	72.2
MAGNESIUM	2.6	1.9						1.71	X	2.26	2.88		1.47	2.14	2.84
MANGANESE									X					X	
POTASSIUM		.7						.62	.30	.35	.27		.54	X	.67
SODIUM		12.9						49.5	X	56.5	34.0		51.0	27.5	28.0
CATIONS, ppb															
CADMIUM									X					X	
CHROMIUM									X					X	
COPPER									X					X	
IRON									X					X	
LEAD									X					X	
ZINC									X					X	
Boron (ppm)								.59	X	.38	.38		.62	.35	.30
ANIONS, ppm															
CHLORIDE-Cl	90.2	36.7	16.4	7.2	<3.9	9.6	X	43.6	29.4	53.2	35.0	<3.9	48.9	40.6	42.8
SULFATE-SO_4									X	33	28		41	5	18
									X						

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-34 SOIL WATER FROM 2′, LYSIMETER

ANALYSIS / DATE	15 VIII 74	28 VIII 74	9 IX 74	2 X 74	5 XII 74	30 I 75	26 III 75	24 IV 75	21 V 75	18 VI 75	16 VII 75	13 VIII 75	10 IX 75	26 IX 75	22 X 75	17 XII 75	4 VI 76	1 VIII 76	22 IX 76							
pH	X	X	X	X	6.8	7.8	8.1	7.2	6.9	7.2	7.0	7.1	7.2	6.5	6.8	5.8	6.8	6.5	6.7							
CONDUCTANCE μMho/cm	X	X	X	X	305	189	X	95	192	250	536	207	289	263	267	290	123	348	248							
INORG. NITROGEN																										
$NO_2^- + NO_3$-N ppm	24.1	27.7	6.82	3.16	2.17	.63	.07	.07	.08	.14	.607	.320	.202	.385	.298	2859	.097	X	.234							
NO_2-N ppb	X	5.9	X	X	.8	1.5	X	X	X	X	168	X	X	.28	.28	X	X	.90	X							
NH_4-N ppb	620	X	40	70	3	2	18	X	X	80	4.62	<.7	<.7	6.22	24.37	21.57	22.7	3.4	12.9							
PO_4-P ppb	<.62	2.2	<.62	X	1.9	1.6	X	X	X	X	1.58	X	X	<.62	3.72	17.05	X	10.5	X							
CATIONS, ppm																										
CALCIUM	54.9		58.2								X	X	X	37.5	X	41.4	21.6	23.8	X							
MAGNESIUM	2.9		10.5								X	X	X	1.00	X	1.43	.79	.93	X							
MANGANESE	.23		.05								X	X	X		X	X			X							
POTASSIUM	4.5		2.0								X	X	X	.45	X	.38	.21	.35	X							
SODIUM	7.7		8.3								X	X	X	50.5	X	15.6	8.7	46.0	X							
CATIONS, ppb																										
CADMIUM											X	X	X		X	X			X							
CHROMIUM											X	X	X		X	X			X							
COPPER											X	X	X		X	X			X							
IRON											X	X	X		X	X			X							
LEAD											X	X	X		X	X			X							
ZINC											X	X	X		X	X			X							
Boron (ppm)											X	X	X	.36	X	X	.20	.55	X							
ANIONS, ppm																										
CHLORIDE-Cl	68.0	X	X	X	31.4	3.9	X	X	X	6.0	X	X	X	15.4	X	X	7.2	44.1	24.1							
SULFATE-SO_4											X	X	X		X	X	22	29	X							

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-35 SOIL WATER FROM 3′, LYSIMETER

ANALYSIS / DATE	15 VIII 74	28 VIII 74	9 IX 74	2 X 74	5 XII 74	30 I 75	26 III 75	24 IV 75	21 V 75	18 VI 75	16 VII 75	13 VIII 75	10 IX 75	26 IX 75	22 X 75	20 XI 75	17 XII 75	20 II 76	12 III 76	8 IV 76	4 V 76	16 VI 76	1 VII 76	3 VIII 76	1 IX 76	22 IX 76
pH	X	X	X	X	5.7	6.6	5.9	6.6	5.9	5.9	5.4	5.3	5.5	5.4	5.3	5.5	5.7	5.1	6.0	5.2	6.1	4.8	5.1	4.4	5.4	5.2
CONDUCTANCE µMho/cm	X	X	X	X	165	158	138	116	99.9	103	121	206	249	260	181	139	143	92.3	98.3	94.8	112	152	200	224	263	282
INORG. NITROGEN																										
$NO_2^- + NO_3^-$-N ppm	20.1	29.6	14.0	20.2	1.29	.60	.15	.19	.21	.27	.336	.344	.423	.140	.101	.165	.148	.050	.042	.150	.172	.122	.269	.150	.270	.245
NO_2-N ppb	X	3.6	X	X	.3	.8	.8	.7	1	1	1.40	1.54	1.34	1.54	X	.42	.34	.42	.42	1.06	1.26	<.14	.30	.30	1.5	.60
NH_4-N ppb	385	63	37	39	7	8	11	6	15	1	6.72	8.40	<.7	4.44	.86	20.16	4.20	1.96	12.18	9.8	9.5	.80	4.8	4.8	5.3	3.4
PO_4-P ppb	<.62	1.2	<.62	X	8.9	.9	<.62	.9	<.62	<.62	<.62	<.62	<.62	<.62	<.62	.78	1.86	.81	2.54	4.28	1.9	4.7	.90	1.2	1.6	1.9
CATIONS, ppm																										
CALCIUM	9.52		18.03								7.7	6.3	4.9	5.6	7.9	5.6	5.3	5.1	5.5	5.3	6.2	8.4	10.0	4.0	4.7	4.6
MAGNESIUM	1.28	1.33	2.25	4.20	.99						.60	.43	.36	.42	.31	.25	.26	.28	.32	.26	.27	.38	.35	.14	.22	.20
MANGANESE	.260	.195	.190	.215	.040																					
POTASSIUM	2.25	2.09	2.12	2.09	1.30						1.40	2.00	5.75	2.03	1.22	1.28	1.30	.86	1.02	1.07	1.12	1.58	1.62	.72	.93	.96
SODIUM	5.45	4.75	6.35	8.40	19.55						12.1	25.7	40.0	40.5	21.0	19.1	17.6	11.0	11.2	10.5	12.3	18.7	27.0	37.5	43.5	46.0
CATIONS, ppb																										
CADMIUM																										
CHROMIUM																										
COPPER	14	19	15	4	11																					
IRON	120	78	111	163	214																					
LEAD																										
ZINC																										
Boron (PPM)											.38		.41	.36	.24	.32	.23	.19	.15	.16	.24	.32	.34	.59	.61	.52
ANIONS, ppm																										
CHLORIDE-Cl	20.0	16.7	17.4	16.4	36.0	27.8	6.8	<3.9	<3.9	6.5	22.2	37.2	37.5	42.8	24.7	21.7	16.6	5.2	6.2	5.8	15.1	41.8	22.5	30.9	34.8	42.8
SULFATE-SO_4													50	53			38	34	25	24	6	12	17	48	53	56

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-36 SOIL WATER FROM 4', LYSIMETER

ANALYSIS / DATE	15 VIII 74	28 VIII 74	9 IX 74	2 X 74	5 XII 74	12 I 75	30 I 75	26 III 75	24 IV 75	21 V 75	18 VI 75	16 VII 75	13 VIII 75	10 IX 75	26 IX 75	22 X 75	17 XII 75	20 II 76	12 III 76	4 V 76	1 VII 76	3 VIII 76	1 IX 76	22 IX 76
pH	x	x	x	x	6.4	x	7.2	7.6	6.2	6.4	6.1	5.7	5.9	5.7	6.1	5.8	5.7	4.8	5.8	6.4	5.0	5.7	5.2	5.1
CONDUCTANCE µMho/cm	x	x	x	x	191	x	185	134	122	122	113	115	198	222	244	177	137	93.8	94.7	128	172	218	262	305
INORG. NITROGEN																								
$NO_2^- + NO_3^-$-N ppm	6.81	10.2	25.7	24.7	1.27	.07	.58	.33	.32	.34	.32	.627	.685	.435	.179	.125	.344	.267	.137	.207	.225	.192	.280	.214
NO_2-N ppb	x	3	x	x	1	1	1	1	x	1	1	2.38	.92	1.26	.42	.84	.90	.42	.70	.62	.50	.70	.50	.90
NH_4-N ppm	.39	.30	.03	.05	.02	.05	.02	.01	.02	.01	.01	.026	.012	.005	.007	.009	.012	.009	.011	.011	.040	.012	.011	.014
PO_4-P ppb	<.62	<.62	<.62	<.62	<1	1.9	1.6	.9	3.7	<.62	1	4.27	<.62	1.86	<.62	.93	22.6	9.18	4.74	8.1	8.7	9.0	7.2	9.3
CATIONS, ppm																								
CALCIUM	9.34		21.5									7.6	7.7	5.1	10.4	7.2	5.6	4.0	3.9	4.8	8.6	5.1	6.2	6.5
MAGNESIUM	4.1	1.6	2.8	2.6	0.6	0.7						.35	.39	.29	.55	.31	.32	.23	.18	.27	.38	.26	.33	.40
MANGANESE	.060	.060	.080	.080																				
POTASSIUM	3.5	3.4	4.9	5.1	2.5	2.3						4.45	5.54	6.50	5.00	3.40	2.80	1.86	1.86	2.07	2.65	1.95	2.23	2.23
SODIUM	6.45	6.80	9.8	11.0	22.6	22.4						10.1	21.1	30.5	53.0	19.3	16.9	12.2	11.0	14.3	22.2	37.0	40.0	46.5
CATIONS, ppb																								
CADMIUM																								
CHROMIUM																								
COPPER	3	11	<.1	12	6	12																		
IRON	115	95	<1.0	147	190	191																		
LEAD																								
ZINC																								
Boron ppm												.35	.39	.42	.04	.24	.27	.17	.17	.24	.31	.62	.60	.53
ANIONS, ppm																								
CHLORIDE-Cl	27.9	19.6	13.9	29.8	31.7	26.6	24.2	6.3	<3.9	6.5	<3.9	13.9	33.5	22.4	34.1	18.4	12.7	7.8	<3.9	19.1	38.2	36.6	25.6	43.2
SULFATE-SO_4															60		37	33	27	22	17	40	57	54

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-37 SOIL WATER FROM 6", LYSIMETER

ANALYSIS / DATE	5 XII 74	30 I 75	26 III 75	22 X 75	20 XI 75	17 XII 75	20 II 76	3 VIII 76	1 IX 76	22 IX 76
pH	7.4	8.0	8.0	7.3	6.8	6.3	6.7	6.9	7.2	6.8
CONDUCTANCE µMho/cm	405	248	242	292	172	416	250	216	341	350
INORG. NITROGEN										
$NO_2^- + NO_3$-N ppm	3.39	.58	.60	.480	.829	5.020	.174	.531	.371	.183
NO_2-N ppb	2	2	x	<.14	x	x	x	1.5	x	.90
NH_4-N ppm	.01	.02	x	.016	.022	.020	.091	.011	.011	.004
PO_4-P ppm	.004	.002	x	.017	x	.015	x	.047	x	.018
CATIONS, ppm										
CALCIUM				x	x	x	36.3	x	38.4	34.8
MAGNESIUM				x	x	x	1.91	x	2.10	2.15
MANGANESE				x	x	x		x		
POTASSIUM				x	x	x	3.36	x	.44	.37
SODIUM				x	x	x	19.7	x	30.5	35.0
CATIONS, ppb										
CADMIUM				x	x	x		x		
CHROMIUM				x	x	x		x		
COPPER				x	x	x		x		
IRON				x	x	x		x		
LEAD				x	x	x		x		
ZINC				x	x	x		x		
BORON ppm				x	x	x	.28	x	.43	.54
ANIONS, ppm										
CHLORIDE - Cl	54.5	16.2	x	12.1	x	x	4.7	x	28.3	31.6
SULFATE - SO_4				x	x	x	18	17	13	22

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-38 SOIL WATER FROM 1′, LYSIMETER

ANALYSIS / DATE	15 VIII 74	28 VIII 74	9 IX 74	23 X 74	5 XII 74	30 I 75	26 III 75	21 V 75	22 X 75	20 XI 75	4 V 76	1 VII 76	1 IX 76	22 IX 76
pH	x	x	x	x	7.4	7.7	7.7	7.5	6.8	7.0	6.1	6.5	7.5	6.9
CONDUCTANCE µMho/cm	x	x	x	x	339	218	228	221	270	168	233	373	221	286
INORG. NITROGEN														
$NO_2^- + NO_3$-N ppm	26.5	.009	4.51	.60	2.28	.74	.26	.20	.270	.064	.701	x	.147	.216
NO_2-N ppb	x	x	x	x	2	2	2	x	.28	x	x	1.1	x	x
NH_4-N ppm	.74	.017	.041	.034	.007	.011	.047	x	.019	.005	.021	.018	.017	.009
PO_4-P ppm	<.0006	.002	<.0006	x	.012	.002	.002	x	.082	x	.039	.041	x	x
CATIONS, ppm														
CALCIUM	95.9	x	105.4						55.4	x	53.7	41.9	x	28.2
MAGNESIUM	7.72	x	5.55						.77	x	1.68	1.03	x	.80
MANGANESE	.225	x	.025							x			x	
POTASSIUM	3.9	x	.3						.28	x	.30	.40	x	.52
SODIUM	2.7	x	2.1						19.8	x	10.5	41.5	x	38.5
CATIONS, ppb														
CADMIUM										x				
CHROMIUM										x				
COPPER										x				
IRON										x				
LEAD										x				
ZINC										x				
BORON ppm									.33	x	.36	.58	.45	.40
ANIONS, ppm														
CHLORIDE-Cl	76.9	x	45.3	x	33.4	3.4	<3.9	x	4.1	x	32.6	44.2	x	31.2
SULFATE-SO_4										x	8	41	11	10

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-39 SOIL WATER FROM 3′. LYSIMETER

ANALYSIS / DATE	15 VIII 74	28 VIII 74	9 IX 74	2 X 74	5 XII 74	12 I 75	30 I 75	26 III 75	24 IV 75	21 V 75	18 VI 75	16 VII 75	13 VIII 75	10 IX 75	26 IX 75	22 X 75	20 XI 75	17 XII 75	12 III 76	8 IV 76	4 V 76	16 VI 76	1 VII 76	3 VIII 76	1 IX 76	22 IX 76
pH	x	x	x	x	7.1	x	7.2	7.3	6.4	6.2	6.5	6.2	6.2	6.1	5.8	6.2	6.4	5.7	6.1	6.3	6.3	5.9	5.7	6.1	6.1	6.7
CONDUCTANCE µMho/cm	x	x	x	x	345	x	300	245	227	217	227	272	248	248	257	197	155	173	113	112	108	149	254	163	198	212
INORG NITROGEN																										
$NO_2^- + NO_3^-$-N ppm	5.12	16.7	14.8	1.18	.44	.05	.14	.08	.09	.11	.04	.109	.112	.087	.062	.070	.151	.105	.050	.165	.043	.060	x	.400	.710	.538
NO_2-N ppb	x	4	x	x	2	1	1	1	x	2	3	1.40	1.34	1.20	.56	.56	.59	.50	.36	x	.98	x	1.0	1.0	1.5	1.7
NH_4-N ppb	139	x	35	40	5	42	14	4	16	x	x	8.68	14.3	.89	2.66	1.37	5.04	6.02	6.86	47.6	9.1	4.2	7.3	11.2	7.1	14.8
PO_4-P ppb	<.62	2.5	<.62	x	2.5	1.9	1.6	1.6	2.2	<.62	<.62	1.10	0.95	1.86	<.62	2.17	2.20	3.41	7.91	40.1	4.3	x	7.1	5.3	16.1	6.5
CATIONS, ppm																										
CALCIUM	21.34		45.5									56.3	40.5	29.6	35.9	28.5	25.7	22.4	16.2	13.9	17.1	17.1	33.3	15.5	16.9	17.6
MAGNESIUM	1.40	2.09	2.27	1.88	2.31							1.00	.75	.97	.95	.50	.45	.55	.40	.40	.40	.50	.66	.31	.40	.44
MANGANESE	.082	.040	.020																							
POTASSIUM	.58	1.21	1.15	.83	.95							.70	.80	.69	.65	.42	.36	.30	.24	.77	.27	.39	.49	.33	.57	.55
SODIUM	6.55	7.10	7.00	5.10	13.2							11.5	11.7	14.4	18.3	13.5	12.4	12.8	9.3	9.1	9.3	11.1	21.5	20.0	23.5	270
CATIONS, ppb																										
CADMIUM																										
CHROMIUM																										
COPPER		27	14	11	16																					
IRON	132	197	177	137	199																					
LEAD																										
ZINC																										
BORON ppm												.33		.35	.31	.22	.13	.19	.14	.18	.20	.28	.30	.43	.40	.40
ANIONS, ppm																										
CHLORIDE-Cl	31.6	26.0	33.0	27.8	35.0	25.6	21.0	<3.9	<3.9	<3.9	<3.9	29.9	13.3	23.0	27.4	19.4	18.4	14.8		<3.9	4.3	23.3	28.2	12.9	48.8	24.7
SULFATE-SO_4																		39	24	22	25	16	20	35	27	19

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-40 SOIL WATER FROM 6", LYSIMETER

ANALYSIS / DATE	28 VIII 74	2 X 74	5 XII 74	30 I 75	26 III 75	21 V 75	13 VIII 75	10 IX 75	22 X 75	20 XI 75	20 II 76	4 V 76	16 VI 76	1 VII 76	3 VIII 76	22 IX 76
pH	x	x	7.8	8.0	7.6	7.2	7.9	7.3	7.1	6.3	6.3	6.5	6.8	6.9	7.2	7.0
CONDUCTANCE μMho/cm	x	x	435	235	280	328	352	410	322	210	275	348	570	457	275	400
INORG. NITROGEN																
$NO_2^- + NO_3$-N ppm	64.4	.24	1.90	.09	.03	.22	.335	.256	.125	.106	.119	.118	1.70	x	2.73	.221
NO_2-N ppb	11	x	3	2	3	3	x	<.14	.42	1.68	1.68	1.82	x	.90	1.0	.50
NH_4-N ppm	x	.026	.028	.053	.001	.005	x	.013	.016	.081	.054	.009	.013	.013	.004	.009
PO_4-P ppb	5.3	x	4.6	5.0	1.2	<.62	x	<.62	4.65	14.5	17.4	12.4	.030	.016	.018	.010
CATIONS, ppm																
CALCIUM							x	85.4	80.1	55.4	41.0	83.6	40.0	39.4	32.6	x
MAGNESIUM	6.73						x	.54	.45	.46	1.20	1.29	1.15	.86	.80	x
MANGANESE							x									x
POTASSIUM							x	.30	.15	.18	.34	.07	.44	.23	.15	x
SODIUM							x	36.5	17.7	13.2	15.5	17.8	59.0	65.5	40.5	x
CATIONS, ppb																
CADMIUM							x									x
CHROMIUM							x									x
COPPER							x									x
IRON							x									x
LEAD							x									x
ZINC							x									x
Boron ppm							x	.40	.30		.23	.29	.70	.74		.60
ANIONS, ppm																
CHLORIDE-Cl	134.8	23.6	45.8	5.2	12.1	5.3	13.8	35.0	<3.9	<3.9	22.8	35.6	87.5	43.8	11.5	35.9
SULFATE-SO_4							x				19	12	17	39	25	x

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-41 SOIL WATER FROM 1', LYSIMETER

ANALYSIS / DATE	28 VIII 74	9 IX 74	2 X 74	5 XII 74	30 I 75	26 III 75	24 IV 75	21 V 75	18 VI 75	16 VII 75	10 IX 75	4 V 76	16 VI 76	1 VII 76	3 VIII 76	1 IX 76	22 IX 76
pH	x	x	x	6.7	7.5	7.2	7.2	7.1	6.7	6.5	6.5	6.5	6.6	6.4	7.0	6.9	6.7
CONDUCTANCE µMho/cm	x	x	x	335	215	181	106	167	118	294	327	192	375	498	249	357	325
INORG. NITROGEN																	
$NO_2^- + NO_3$-N ppm	.007	18.94	.245	.370	.696	.158	.0	.180	.081	.319	.420	.162	.238	.265	x	.361	.225
NO_2-N ppb	x	x		2.0	2.0	2.0	x	x	x	.84	.67	2.38	x	.50	.60	x	1.0
NH_4-N ppm	.128	.034	.033	.012	.068	.040	x	x	x	.007	.014	.017	x	.035	.017	.022	.022
PO_4-P ppb	1.9	<.62	x	8.7	2.5	1.2	x	x	<.62	.63	<.62	14.9	x	50.5	22.3	23.0	15.2
CATIONS, ppm																	
CALCIUM	x	105.44					x	x	x	x	59.8	32.9	57.2	53.0	x	25.9	x
MAGNESIUM	x	5.00					x	x	x	x	.58	.35	.52	.43	x	.47	x
MANGANESE	x	.050					x	x	x	x							x
POTASSIUM	x	1.2					x	x	x	x	.43	.13	.45	.45	x	.75	x
SODIUM	x	6.8					x	x	x	x	27.0	13.9	31.0	53.0	x	52.0	x
CATIONS, ppb																	
CADMIUM	x						x	x	x	x					x		x
CHROMIUM	x						x			x					x		x
COPPER	x						x	x	x	x					x		x
IRON	x						x	x	x	x					x		x
LEAD	x						x	x	x	x					x		x
ZINC	x						x	x	x	x					x		x
							x	x	x								
BORON ppm										x	.48	.24	.51	.71	.55	.66	.54
ANIONS, ppm																	
CHLORIDE-Cl	x	96.5	24.1	33.6	14.8	<4.0	<4.0	<3.9	x	52.8	49.4	17.9	76.0	67.0	x	47.1	36.2
SULFATE-SO_4							x	x	x	x		10	19	72	x	21	x

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-42 SOIL WATER FROM 2′, LYSIMETER

ANALYSIS / DATE	9 IX 74	2 X 74	5 XII 74	30 I 75	26 III 75	24 IV 75	21 V 75	18 VI 75	16 VII 75	13 VIII 75	10 IX 75	26 IX 75	22 X 75	12 XII 75	4 II 76	1 VII 76
pH	X	X	7.0	7.3	7.8	7.1	7.3	7.3	6.9	7.0	7.1	6.3	6.8	6.0	6.4	7.3
CONDUCTANCE μMho/cm	X	X	465	233	193	123	163	131	160	242	237	355	320	332	213	648
INORG. NITROGEN																
$NO_2^- + NO_3$-N PPM	48.17	5.92	1.64	1.22	.187	.030	.15	.085	.224	.267	.039	.862	.213	.987	.181	X
NO_2-N PPb	X	X	1.4	<.14	X	<.14	X	X	X	X	X	1.15	.28	1.62	X	X
NH_4-N PPM	.05	.06	.005	.029	.040	.008	X	.009	.016	.020	X	.003	.007	.069	.051	.137
PO_4-P PPb	X	X	10	3.0	4.0	X	X	X	X	X	X	<.62	4.03	76.3	X	24.5
CATIONS, ppm																
CALCIUM	100.71	X		X	X	X	X	X	X	X	X	79.2	75.7	62.5	50.2	X
MAGNESIUM	6.55	X		X	X	X	X	X	X	X	X	.35	.24	.57	.39	X
MANGANESE	.100	X		X	X	X	X	X	X	X	X					X
POTASSIUM	4.0	X		X	X	X	X	X	X	X	1.95	.28	.20	.35	.91	X
SODIUM	12.4	X		X	X	X	X	X	X	X	X	23.4	17.6	15.2	12.6	X
CATIONS, ppb																
CADMIUM		X		X	X	X	X	X	X	X	X					X
CHROMIUM		X		X	X	X	X	X	X	X	X					X
COPPER		X		X	X	X	X	X	X	X	X					X
IRON		X		X	X	X	X	X	X	X	X					X
LEAD		X		X	X	X	X	X	X	X	X					X
ZINC		X		X	X	X	X	X	X	X	X					X
Boron (PPM)									X	X	X	.38	.31	.21	.27	.59
ANIONS, ppm																
CHLORIDE-Cl	139.0	X	30.3	11.2	X	<4.0	<3.9	X	X	19.6	13.6	23.9	13.4	33.6		X
SULFATE-SO_4		X	X	X	X	X	X	X	X	X	X	14		23		X

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-43 SOIL WATER FROM 3′, LYSIMETER

ANALYSIS / DATE	28 VIII 74	9 IX 74	2 X 74	5 XII 74	30 I 75	26 III 75	24 IV 75	21 V 75	18 VI 75	16 VII 75	13 VIII 75	10 X 75	26 IX 75	22 X 75	20 XI 75	20 II 76	12 III 76	8 IV 76	4 V 76	16 VI 76	1 VII 76	3 VIII 76	1 IX 76	22 IX 76		
pH	x	x	x	6.7	6.8	6.7	6.3	5.9	6.0	5.4	5.6	5.6	5.6	6.1	5.8	6.1	6.1	6.0	6.0	5.6	5.2	5.7	5.6	6.0		
CONDUCTANCE µMho/cm	^	x	x	315	293	190	143	124	97	180	171	232	200	171	129	73	94.3	848	88.1	96.0	203	167	173	210		
INORG NITROGEN																										
$NO_2^- + NO_3$-N ppm	5.08	10.9	13.4	.45	.34	.10	.15	.25	.13	.235	.130	.353	.322	.169	.239	.084	.083	.731	.350	.244	.315	1.08	.337	.281		
NO_2-N ppb	5.2	x	x	11	1.5	.7	.7	1	1	.98	1.34	1.15	.62	.42	1.40	2.80	.50	x	2.27	1.70	1.00	1.20	.40	1.40		
NH_4-N ppm	.10	.03	.03	.01	.02	.01	.02	.01	.01	.005	.008	.004	.003	.007	.346	.571	.244	.172	.058	.053	.029	.013	.007	.010		
PO_4-P ppb	2.2	1.2	x	1.2	1.6	<.62	.9	1.2	1.2	7.9	<6.2	<6.2	<6.2	9.3	32.1	198	122	108	849	59.8	35.7	36.3	32.9	25.7		
CATIONS, ppm																										
CALCIUM		37.	x							27.1	14.6	13.4	13.2	12.5	9.0	3.9	4.0	x	3.3	3.9	17.8	7.0	6.0	6.0		
MAGNESIUM	2.49	3.86	x	2.15						.89	.36	.42	.34	.26	.27	1.04	.75	x	.51	.46	.82	.28	.20	.20		
MANGANESE	.215	.235	x	.060														x								
POTASSIUM	2.1	2.8	x	1.5						1.48	1.22	1.95	1.15	.50	.68	1.96	1.66	x	.92	1.15	1.20	.44	.37	.37		
SODIUM	7.7	9.1	x							11.1	16.6	46.5	23.0	19.2	16.5	7.3	9.7	x	11.3	11.3	22.7	33.0	29.0	35.0		
CATIONS, ppb																										
CADMIUM																		x								
CHROMIUM																		x								
COPPER	19	8	x	4														x								
IRON	185	183	x	212														x								
LEAD																		x								
ZINC																		x								
BORON ppm										.26	.37	.36	.36	.27	.19	.07	.09	x	.21	.35	.34	.54	.52	.48		
ANIONS, ppm																										
CHLORIDE-Cl	41.0	39.9	x	29.0	20.7	<13.9	<13.9	x	6.6	35.6	21.0	28.6	22.0	17.8	17.0	9.2	6.7	5.5	4.0	12.2	26.6	26.9	25.1	35.4		
SULFATE-SO_4																18	14	x	18	13	12	25	22	17		

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-44 SOIL WATER FROM 4′, LYSIMETER

ANALYSIS / DATE	28 VIII 74	9 IX 74	2 X 74	5 XII 74	12 I 75	30 I 75	26 III 75	24 IV 75	21 V 75	18 VI 75	16 VII 75	13 VIII 75	10 IX 75	26 IX 75	22 X 75	20 XI 75	17 XII 75	4 V 76	1 VII 76	3 VIII 76	1 IX 76	22 IX 76
pH	x	x	x	6.4	x	6.9	7.3	6.6	6.2	6.8	6.4	7.8	6.6	6.4	7.1	6.3	5.9	5.2	6.5	6.9	6.7	6.9
CONDUCTANCE μMho/cm	x	x	x	310	x	192	145	128	155	122	342	202	293	278	249	173	393	112	231	141	287	272
INORG. NITROGEN																						
$NO_2^- + NO_3^-$-N ppm	15.0	14.2	19.9	1.37	.34	1.11	.23	.18	.22	.12	.732	.623	.531	1.123	.189	.398	6.762	.077	.280	.305	.263	.246
NO_2-N ppb	2.2	x	x	2.8	2.2	1.3	x	x	x	x	x	3.28	2.44	.67	.84	.70	.90	x	x	x	.80	x
NH_4-N ppb	260	250	111	30	80	330	x	x	x	30	42.14	<.7	15.98	1.78	4.96	8.40	32.48	23.1	38.5	21.1	21.6	16.5
PO_4-P ppb	x	<.62	<.62	1.2	1.9	.9	x	x	x	x	.95	.63	.62	.62	1.55	5.21	10.50	x	5.6	x	23.6	19.8
CATIONS, ppm																						
CALCIUM		43.1	x								x	28.0	31.2	43.1		29.2	59.8	x	26.6	x	18.3	20.1
MAGNESIUM		4.3	x	1.6	1.1						x	.18	.20	.35		.42	1.72	x	.89	x	.57	.78
MANGANESE		x	x	.020	.020						x							x		x		
POTASSIUM		4.2	x	1.3	1.3						x	.52	.60	.32		.30	.40	x	.33	x	.78	.39
SODIUM		10.4	16.6	12.1	15.9						x	16.5	30.0	37.5		18.0	19.8	x	22.5	x	34.5	38.5
CATIONS, ppb																						
CADMIUM											x							x		x		
CHROMIUM											x							x		x		
COPPER		<.01		12	2.6						x							x		x		
IRON		<.01		187	160						x							x		x		
LEAD											x							x		x		
ZINC											x							x		x		
Boron ppm											x	.28	.39	.37		.23	.24	x	.38	.49	.51	.49
ANIONS, ppm																						
CHLORIDE-Cl		62.5	x	54.3	x	23.8	x	<3.9	x	4.7	49.4	14.9	39.6	17.1	11.8	12.1	42.8	x	34.8	x	26.8	37
SULFATE-SO_4											x						23.0	x	12	x	6	9

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-45 SOIL WATER FROM 6", LYSIMETER

ANALYSIS / DATE	5 XII 74	30 I 75	22 X 75	4 V 76	3 VIII 76	22 IX 76
pH	7.7	8.3	7.1	6.7	6.5	6.9
CONDUCTANCE μMho/cm	411	x	205	227	205	354
INORG. NITROGEN						
$NO_2^- + NO_3^-$-N ppm	3.28	.53	.218	.150	.238	.116
NO_2-N ppb	2	x	x	2.38	2.90	.50
NH_4-N ppm	.027	.063	.021	.038	.001	.001
PO_4-P ppm	.004	.005	.015	.014	.023	.022
CATIONS, ppm						
CALCIUM			x	36.6	18.3	25.3
MAGNESIUM			x	2.71	1.42	3.15
MANGANESE			x			
POTASSIUM			x	.13	.40	.33
SODIUM			x	14.6	30.0	50.0
CATIONS, ppb						
CADMIUM			x			
CHROMIUM			x			
COPPER			x			
IRON			x			
LEAD			x			
ZINC			x			
Boron ppm			x	.25	.35	.62
ANIONS, ppm						
CHLORIDE-Cl	55.0	14.1	8.2	19.6	18.4	30.8
SULFATE-SO_4			X		20	28

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-46 SOIL WATER FROM 1′, LYSIMETER

ANALYSIS / DATE	28 VIII 74	9 IX 74	2 X 74	5 XII 74	30 I 75	26 III 75	24 IV 75	21 V 75	18 VI 75	16 VII 75	13 VIII 75	10 IX 75	26 IX 75	22 X 75	17 XII 75	4 V 76	1 VII 76	3 VIII 76	1 IX 76	22 IX 76
pH	x	x	x	7.7	7.7	7.5	7.2	6.9	7.0	7.4	6.8	7.0	6.7	6.8	6.0	6.4	6.3	7.1	6.7	6.8
CONDUCTANCE μMho/cm	x	x	x	349	234	200	119	169	159	285	345	402	412	299	289	261	409	261	461	419
INORG. NITROGEN																				
$NO_2^- + NO_3$-N ppm	.013	2.51	.270	.711	.535	.092	.105	.105	.075	.218	.130	.154	.136	.672	1.918	.160	.098	.280	.309	.239
NO_2-N ppb	x	x	x	1.7	1.4	1.4	x	x	x	x	2.18	.36	.25	.42	x	x	.40	7.6	7.3	2.0
NH_4-N ppm	.38	.076	.021	.007	.060	.047	x	x	x	x	.002	.004	.022	.010	.203	.011	.024	.171	.027	.008
PO_4-P ppb	1.9	<.62	x	3.1	29	<.62	x	x	x	x	.016	.002	<.62	.015	x	17.1	6.5	225	225	113
CATIONS, ppm																				
CALCIUM	x	75.2								x	x	64.2	65.1	53.7	45.8	51.0	37.4	27.3	38.4	x
MAGNESIUM	4.47	3.40								x	x	.60	.60	.57	.93	1.46	.92	.76	1.46	x
MANGANESE	.22	.120								x	x				x					x
POTASSIUM	x	1.3								x	x	.28	.29	.08	.22	.40	.22	1.26	.37	x
SODIUM	x	6.8								x	x	38.5	42.5	1.00	18.7	18.2	42.0	36.0	50.5	x
CATIONS, ppb																				
CADMIUM										x	x				x					
CHROMIUM										x	x				x					
COPPER										x	x				x					
IRON										x	x				x					
LEAD										x	x				x					
ZINC										x	x				x					
BORON ppm										x	x	.41	.49	.47	x		.67	.59	.52	.56
ANIONS, ppm																				
CHLORIDE-Cl	98.5	41.7	13.0	36.8	8.0	5.5	<3.9	<3.9	<3.9	x	x	42.0	35.3	18.3	27.8	23.5	49.6	17.7	59.4	41.9
SULFATE-SO_4										x	x		29		x	17	30	25	24	x

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-47 SOIL WATER FROM 2', LYSIMETER

ANALYSIS / DATE	28 VIII 74	9 IX 74	2 X 74	5 XII 74	30 I 75	26 III 75	24 IV 75	21 V 75	18 VI 75	16 VII 75
pH	x	x	x	6.7	7.6	8.0	7.3	7.2	6.7	6.5
CONDUCTANCE µMho/cm	x	x	x	327	190	220	145	178	159	296
INORG NITROGEN										
$NO_2^- + NO_3^-$-N ppm	32.8	35.3	1.27	4.25	.23	.16	.08	.18	.15	.171
NO_2-N ppb	1	x	x	2	1	2	x	x	1	1.96
NH_4-N ppb	248	41	21	5	84	97	20	x	3	10.2
PO_4-P ppb	4.6	<.62	x	1.6	5.9	1.9	x	x	2	2.37
CATIONS, ppm										
CALCIUM		70.4								59.8
MAGNESIUM		1.80	3.45							.55
MANGANESE		.09	.06							
POTASSIUM		x	1.9							.34
SODIUM		x	6.2							14.7
CATIONS, ppb										
CADMIUM										
CHROMIUM										
COPPER										
IRON										
LEAD										
ZINC										
Boron ppm										.46
ANIONS, ppm										
CHLORIDE - Cl	84.7	42.8	9.5	3.8	7.3	x	<3.9	<3.9	<3.9	29.6
SULFATE - SO_4										

ANALYSIS / DATE	13 VIII 75	10 IX 75	26 IX 75	22 X 75	20 II 76	4 VI 76	1 VII 76	3 VIII 76	1 IX 76	22 IX 76
pH	6.6	6.6	6.3	6.6	6.8	6.9	6.5	6.8	6.7	6.6
CONDUCTANCE µMho/cm	271	341	325	272	166	187	338	215	397	375
INORG NITROGEN										
$NO_2^- + NO_3^-$-N ppm	.238	.172	.213	.553	.126	.087	.098	.120	.106	.113
NO_2-N ppb	2.04	1.40	.62	.98	x	x	1.2	.90	.40	2.0
NH_4-N ppb	<.70	16.9	3.6	7.8	x	5.7	9.4	6.4	1.5	4.2
PO_4-P ppb	13.0	<.62	3.00	5.27	x	x	27.3	9.9	10.2	9.9
CATIONS, ppm										
CALCIUM	37.1	33.3	43.1	40.5	23.1	31.1	38.4	22.2	36.3	30.6
MAGNESIUM	.45	.68	.56	.45	x	.93	1.29	.76	1.75	1.97
MANGANESE					x					
POTASSIUM	.42	.43	.25	.10	x	.10	.22	.17	.25	.25
SODIUM	28.0	36.5	38.0	23.4	x	14.0	32.5	30.5	43.5	44.5
CATIONS, ppb										
CADMIUM					x					
CHROMIUM					x					
COPPER					x					
IRON					x					
LEAD					x					
ZINC					x					
Boron ppm	.43	.32	.33	.45	x	.24	.61	.49	.50	.57
ANIONS, ppm										
CHLORIDE - Cl	14.7	40.4	33.0	20.9	<.39	15.9	45.7	14.0	56.4	43.6
SULFATE - SO_4		26	26		19	10	22	19	17	25

X NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-48 SOIL WATER FROM 3′, LYSIMETER

ANALYSIS / DATE	28 VIII 74	9 IX 74	2 X 74	5 XII 74	30 I 75	26 III 75	24 IV 75	21 V 75	18 VI 75	16 VII 75	10 IX 75	26 IX 75	22 X 75	20 XI 75	20 II 76	12 III 76	8 IV 76	4 V 76	16 VI 76	1 VII 76	3 VIII 76	1 IX 76	22 IX 76			
pH	x	x	x	6.7	7.2	7.2	6.4	6.5	6.4	6.0	6.2	6.1	6.3	5.0	6.6	6.1	6.2	6.3	5.8	6.2	6.3	6.2	6.3			
CONDUCTANCE µMho/cm	x	x	x	369	329	285	232	226	202	229	294	332	250	185	140	149	147	177	132	208	285	365	370			
INORG. NITROGEN																										
$NO_2^- + NO_3^-$-N ppm	16.8	35.3	21.5	.36	.19	.08	.08	.14	.12	.141	.139	.122	.028	.085	.088	.400	.091	.099	.091	.083	.085	.050	.106			
NO_2-N ppb	3.9	x	x	1.4	.8	.7	1.0	1.0	1.0	1.26	1.20	.81	.28	.56	.95	.70	x	.76	1.7	2.5	.50	.60	1.3			
NH_4-N ppm	.05	.04	.02	.01	.05	.01	.003	.03	.01	.015	.004	.008	.010	.006	.004	.032	.018	.010	.017	.038	.006	.004	.006			
PO_4-P ppb	1.2	<.62	x	1.2	1.9	<.62	1.6	<.62	<.62	1.58	<.62	<.62	.93	220	54.6	19.5	34.0	18.9	32.9	31.0	13.0	11.3	11.5			
CATIONS, ppm																										
CALCIUM		73.3								39.1	31.7	49.3	40.8	32.7	20.2	22.4	20.2	28.3	17.4	28.0	30.6	32.7	31.7			
MAGNESIUM	2.37	3.25	3.37	1.70						.70	.75	1.88	.55	.48	.80	.53	.50	.51	.38	.47	.42	.56	.55			
MANGANESE	.105	.08	.08	.02																						
POTASSIUM	3.85	2.83	3.11	.92						.86	1.08	1.17	.62	.58	.80	.68	.80	.47	.34	.30	.67	.76	.60			
SODIUM	22.1	20.5	17.0	14.3						10.9	23.8	53.5	18.3	14.9	13.1	12.7	12.4	14.3	11.8	18.1	32.5	41.0	43.4			
CATIONS, ppb																										
CADMIUM																										
CHROMIUM																										
COPPER	15	20	14	11																						
IRON	311	296	302	220																						
LEAD																										
ZINC																										
BORON ppm										.25	.33	.33	.30		.16	.14	.15	.17	.24	.28	.40	.44	.43			
ANIONS, ppm																										
CHLORIDE-Cl	53.4	46.4	40.9	36.0	27.8	9.9	6.5	<3.9	<3.9	21.5	31.0	37.1	19.3	15.5	6.1	<3.9	5.6	11.0	5.5	34.7	35.3	32.1	48.9			
SULFATE-SO_4												74			30	26	25	21	20	21	37	33	33			

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-49 SOIL WATER FROM 4', LYSIMETER

ANALYSIS / DATE	28 VIII 74	9 IX 74	23 X 74	5 XII 74	12 I 75	30 I 75	26 III 75	24 IV 75	21 V 75	18 VI 75	16 VII 75	13 VIII 75	10 IX 75	26 IX 75	22 X 75	17 XII 75	20 II 76	12 III 76	16 VI 76	3 VIII 76	1 IX 76	22 IX 76
pH	x	x	x	6.4	x	6.7	7.4	6.3	6.0	5.8	5.6	5.6	5.8	6.0	5.8	6.2	6.0	6.0	5.9	6.3	5.8	6.2
CONDUCTANCE µMho/cm	x	x	x	319	x	265	195	161	135	126	197	248	274	282	220	179	135	138	135	251	304	322
INORG NITROGEN																						
$NO_2^- + NO_3^-$-N ppm	13.1	28.9	14.5	4.51	.23	.35	.41	.339	.29	.28	.168	.144	.126	.188	.167	.836	.304	.085	.146	.134	.134	.080
NO_2-N ppb	1.3	x	x	1	1	1	1	1	1	1	.70	.87	.95	.70	.42	x	.95	1.70	2.0	.60	.50	.80
NH_4-N ppm	.08	.05	.02	.01	.04	x	.01	.01	.01	.01	.031	.002	.006	.010	.001	.032	.025	.009	.007	.018	.007	.009
PO_4-P ppb	1.2	<.62	<.62	1.9	1.9	2.9	1.2	1.6	1.2	<.62	1.26	<.62	<.62	<.62	.93	x	26.9	14.8	48.4	14.9	50.2	23.6
CATIONS, ppm																						
CALCIUM		41.6									42.2	21.3	18.1	21.8	17.8	x	x	14.3	11.1	20.1	17.6	18.1
MAGNESIUM	2.6	3.1	x	1.4	1.1						.67	.52	.53	.54	.28	x	x	.38	.37	.41	.49	.55
MANGANESE	.060	.060	.040	.020	x											x	x					
POTASSIUM	1.3	1.5	1.1	0.9	.95						1.14	1.02	1.12	1.02	.54	x	x	.38	.46	.25	.60	.50
SODIUM	14.5	18.1	x	23.5	23.5						15.7	24.5	33.5	55.0	23.1	x	x	13.8	14.7	33.5	43.5	46.5
CATIONS, ppb																						
CADMIUM																x	x					
CHROMIUM																x	x					
COPPER	9	<.01	11	4	20											x	x					
IRON	259	<1.0	226	229	214											x	x					
LEAD																x	x					
ZINC																x	x					
BORON ppm											.37	.41	.39		.35	x	x	.18	.28	.51	.65	.48
ANIONS, ppm																						
CHLORIDE - Cl	50.9	55.2	46.9	40.8	31.6	28.4	9.1	5.5	4.7	5.8	39.4	36.6	37.0	38.2	30.7	x	x	11.6	18.9	46.1	46.4	49.7
SULFATE - SO_4													60			x	x	29	x	27	41	31

X NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-50 WELL WATER, WELL #8

ANALYSIS / DATE	21 I 74	13 II 74	19 II 74	4 III 74	20 III 74	3 IV 74	17 IV 74	30 IV 74	14 V 74	30 V 74	12 VI 74	19 VI 74	3 VII 74	17 VII 74	24 VII 74	7 VIII 74	21 VIII 74	5 IX 74	25 IX 74	22 X 74	6 XI 74	20 XI 74	18 XII 74	30 I 75	26 II 75	
pH	x	x	x	x	x	x	x	x	x	x	x	x	x	6.4	x	6.6	x	x	x	5.9	6.2	x	6.2	6.4	5.8	
CONDUCTANCE µMho/cm	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	37.5	48.3	45.7	
INORG. NITROGEN																										
$NO_2^- + NO_3$-N ppm	.22	.07	.11	.04	.08	.09	.17	.31	.34	.32	.21	.21	.38	.02	.13	.17	.29	.22	.19	.09	.13	.10	.12	.06	.03	
NO_2-N ppb	4	1	1	1	.6	.8	.8	1	1	2	1.1	35	35	x	x	4.2	x	x	x	x	x	.4	.3	1.0	<.14	
NH_4-N ppm	.001	<.001	<.001	.004	.002	<.001	.009	.003	.018	.010	.035	.007	.016	.004	.028	.025	.058	.039	.034	.022	.028	.006	.010	.009	.012	
PO_4-P ppm	.005	.001	.001	.003	.004	.006	.012	.002	.004	.006	.007	.31	.010	.003	.007	x	.007	.010	.007	.008	.007	.011	.009	.010	.010	
CATIONS, ppm																										
CALCIUM	1.45	.60	.58	.	1.90		1.02		1.16		1.20			.86			.98		.95	.93		1.00	.57	1.13	.97	
MAGNESIUM	1.19	1.02	1.03		.95		1.03		1.24		1.27			1.11			1.06		1.03	1.02		1.08	1.22	1.04	1.07	
MANGANESE ppb																										
POTASSIUM	1.2	.59	.59		.64		.66		.73		.84			.86			.82		.71	.68		.62	.70	.62	.69	
SODIUM	6.55	5.1	5.3		4.4		4.44		4.56		5.80			6.3			5.89		5.38	5.0		4.83	5.30	5.34	5.42	
CATIONS, ppb																										
CADMIUM	2.5																									
CHROMIUM																										
COPPER	3.8																									
IRON	<30	<30	<30																							
LEAD	8.4																									
ZINC																										
Boron ppm																										
ANIONS, ppm																										
CHLORIDE-Cl	10.3	5.7	6.0	5.8	5.9	6.2	7.4	9.8	9.2	8.1	7.5	7.1	6.7	6.4	6.6	6.2	6.9	6.8	6.3	6.2	6.6	6.5	7.3	7.3	8.5	
SULFATE-SO_4																										
TEMP °C	x	x	x	x	x	x	x	x	x	x	x	x	x	14	x	15	13	11	12	12	11.5	11.5	10.1	11	11.5	
ELEVATION FT.	53.77	54.02	54.11	54.23	54.02	54.02	53.90	x	x	53.81	53.88	53.73	53.52	53.36	53.27	52.94	52.73	52.48	52.15	51.69	51.48	51.23	50.81	50.44	50.48	

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

(CONTINUED)

TABLE A-50 (CONTINUED)

ANALYSIS / DATE	26 III 75	24 IV 75	21 V 75	18 VI 75	16 VII 75	13 VIII 75	10 IX 75	8 X 75	6 XI 75	3 XII 75	30 XII 75	28 I 76	25 II 76	24 III 76	21 IV 76	19 V 76	16 VI 76	14 VII 76	11 VIII 76	8 IX 76	6 X 76
pH	6.1	6.1	6.0	6.4	7.2	6.2	6.6	6.2	6.0	7.5	5.7	6.0	6.1	6.0	5.6	6.1	5.8	6.7	6.0	6.5	8.6
CONDUCTANCE µMho/cm	425	49.1	52.2	58.0	56.4	57.8	57.7	56.1	58.3	55.7	52.3	53.3	50.0	48.2	53.5	46.2	54.9	45.6	44.0	52.8	53.8
INORG NITROGEN																					
$NO_2^- + NO_3$-N ppm	.15	.58	.03	.39	.325	.378	.350	.266	.470	.444	.402	.235	.400	.428	.298	.286	.409	.260	.209	.197	.150
NO_2-N ppb	.7	1.4	1	1	.98	2.2	1.60	1.19	.31	.17	.62	<.14	.42	.62	.37	.42	<.14	.45	.50	.14	.20
NH_4-N ppm	.013	.007	.019	.018	.028	.038	.002	.005	.008	.011	.017	.007	.012	.013	.010	.009	.016	.008	.005	.006	.005
PO_4-P ppm	.012	.012	.017	.013	.011	.017	.004	.005	.012	.009	.011	.010	.008	.013	.010	.008	.009	.008	.008	.011	.010
CATIONS, ppm																					
CALCIUM	.97	1.14	1.0		.58	.67	.67	.77	.50	.70	.70	.99	1.02	1.06	.99	1.02	.91	.97	.97	1.01	1.02
MAGNESIUM	1.10	1.11	1.15		1.2	1.2	1.2	1.2	1.2	1.3	1.2	1.05	1.08	1.05	.97	1.11	1.08	1.00	.94	1.00	.98
MANGANESE ppb							8.6			9.0	9.2			8.9			17.5			9.6	
POTASSIUM	.75	.64	.65		.61	.62	.61	.64	.65	.69	.56	.58	.60	.57	.55	.55	.67	.60	.53	.60	.51
SODIUM	5.84	5.50	5.75		6.0	6.2	6.1	6.1	6.4	6.1	5.7	6.0	5.6	5.3	5.0	5.2	5.1	6.0	6.2	6.3	6.3
CATIONS, ppb																					
CADMIUM							.89			1.52	1.07			.78							
CHROMIUM																					
COPPER							6.6			3.5	5.3			7.0			9.6			4.1	
IRON							6.6			2.5	6.1			8.9			3.1			8.2	
LEAD																					
ZINC							25			125	50			25			75			75	
BORON ppm					.04	.06	.14	.02	.04	.07	.04	.05	.07	.01	.06	.08	.04	.09	.04	.04	.06
ANIONS, ppm																					
CHLORIDE-Cl	8.2	8.0	8.7	8.6	8.3	8.8	9.0	9.3	9.1	9.9	9.3	10.0	9.0	8.2	7.8	9.2	8.6	7.3	6.4	6.9	8.0
SULFATE-SO_4					9	10	17			17	17	4	3	6	4	7	7	4	7	6	5
TEMP °C	11.5	11.5	12.5	12.5	13	13	12	12.5	12	11	10.5	11.5	13	13	13	12	15.5	12.5	14.0	13.5	13.5
ELEVATION FT	50.73	51.02	51.25	51.27	50.99	50.97	50.10	50.11	49.92	50.06	50.46	51.29	52.14	52.28	52.08	51.87	51.55	51.15	51.42	51.07	50.65

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-51 SOIL WATER FROM 6" LYSIMETER

ANALYSIS / DATE	30 VIII 74	9 IX 74	1 X 74	30 I 75	26 III 75	18 VI 75	16 VII 75	26 IX 75	23 X 75	7 V 76	2 VII 76	6 VIII 76	3 IX 76
pH	X	X	X	7.0	8.2	7.5	7.6	7.2	7.5	6.5	8.3	7.8	5.8
CONDUCTANCE μMho/cm	X	X	X	195	231	321	292	217	340	212	280	137	136
INORG. NITROGEN													
$NO_2^- + NO_3^-$-N ppm	5.14	10.3	4.37	.72	.32	.23	3.034	.103	.118	.294	.381	.277	.130
NO_2-N ppb	X	X	X	1	X	X	X	.62	.56	X	X	X	1.5
NH_4-N ppb	378	583	21	32	26	8	X	X	1.20	X	X	15.5	3.1
PO_4-P ppb	9.6	<.62	<.62	4.7	X	X	X	X	.93	X	X	X	1.9
CATIONS, ppm													
CALCIUM	X	95.1					X	X	111	73.0	X	X	35.5
MAGNESIUM	X	3.07					X	X	.32	.40	X	X	.53
MANGANESE	X	X					X	X					
POTASSIUM	X	.40					X	X	.13	.68	X	X	.45
SODIUM	X	2.2					X	X	1.7	1.6	X	X	3.0
CATIONS, ppb													
CADMIUM							X	X			X	X	
CHROMIUM							X	X			X	X	
COPPER							X	X			X	X	
IRON							X	X			X	X	
LEAD							X	X			X	X	
ZINC							X	X			X	X	
Boron (ppm)							X	X	.06	.07	.07	.15	.11
ANIONS, ppm													
CHLORIDE-Cl	X	62.5	5.1	6.0	X	X	X	<3.9	<3.9	<3.9	X	X	<3.9
SULFATE-SO_4							X	X			X	14	6

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-52 SOIL WATER FROM 1' LYSIMETER

ANALYSIS / DATE	26 IX 75	23 X 75	6 VII 76
pH	7.2	7.5	7.7
CONDUCTANCE μMho/cm	268	392	382
INORG NITROGEN			
$NO_2^- + NO_3^- $-N ppm	.427	.206	.426
NO_2-N ppb	.28	.56	x
NH_4-N ppb	x	2.74	6.4
PO_4-P ppb	x	.62	6.0
CATIONS, ppm			
CALCIUM	102	127	x
MAGNESIUM	.72	.65	x
MANGANESE			
POTASSIUM		.14	x
SODIUM	2.0	0.9	x
CATIONS, ppb			
CADMIUM			x
CHROMIUM			x
COPPER			x
IRON			x
LEAD			x
ZINC			x
BORON (ppm)	.02	.03	.18
ANIONS, ppm			
CHLORIDE - Cl		7.4	x
SULFATE - SO_4			x

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-53 SOIL WATER FROM 2' LYSIMETER

ANALYSIS / DATE	30 VIII 74	9 IX 74	3 XII 74	30 I 75	26 III 75	24 IV 75	21 V 75	18 VI 75	16 VII 75	13 VIII 75	10 IX 75	26 IX 75	23 X 75	20 XI 75	20 II 76	12 III 76	7 V 76	18 VI 76	2 VII 76	6 VIII 76
pH	X	X	6.9	6.7	6.6	6.6	7.2	6.8	6.5	6.7	6.7	6.6	6.4	6.3	6.6	6.2	5.7	6.1	7.3	7.2
CONDUCTANCE µMho/cm	X	X	718	405	391	232	226	250	200	242	223	210	216	164	250	183	160	155	140	181
INORG. NITROGEN																				
$NO_2^- + NO_3^-$-N ppm	5.14	10.3	40.9	16.1	1.43	2.45	1.28	.55	.767	.344	.257	.250	.174	.157	.050	.256	.153	.217	.235	.217
NO_2-N ppb	X	X	2.3	<.14	2.2	1.5	1	1	2.38	1.82	2.00	1.11	.42	.70	1.04	3.02	1.34	.80	X	1.0
NH_4-N ppm	.58	.189	.017	.007	.008	.011	.006	X	.034	.008	.005	.014	.004	.005	.006	.009	.006	.010	.028	.003
PO_4-P ppb	9.6	X	2.8	.9	2.7	.9	<.62	<.62	.63	.63	1.86	<.62	<.62	.96	2.85	11.38	2.36	2.50	13.6	<.64
CATIONS, ppm																				
CALCIUM	X	63.9							40.1	52.3	35.2	43.1	58.1	53.7	47.9	57.2	58.3	35.4	38.7	50.2
MAGNESIUM	X	3.62							.43	.50	.43	.42	.37	.40	.65	.44	.32	.25	.28	.30
MANGANESE	X	.025																		
POTASSIUM	X	.60							.26	.20	.23	.19	.10	.13	.17	.06	.12	.28	.41	.11
SODIUM	X	3.6							1.2		1.5	1.3	0.7	0.7	0.6	0.5	0.6	0.8	2.5	1.4
CATIONS, ppb																				
CADMIUM																				
CHROMIUM																				
COPPER																				
IRON																				
LEAD																				
ZINC																				
Boron (ppm)									.02	.07	.09	.02	.07	.15	.03	.03	.05	.06	.04	.15
ANIONS, ppm																				
CHLORIDE-Cl	X	44.1	25.6	11.4	4.2	<3.9	<3.9	<3.9	<3.9	7.1	7.4	<5.6	<3.9	<3.9	<3.9	<3.9	11.5	10.2	13.2	11.1
SULFATE-SO_4														28	23	19	26	27	19	

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-54 SOIL WATER FROM 3' LYSIMETER

ANALYSIS / DATE	30 VIII 74	9 IX 74	1 X 74	3 XII 74	30 I 75	26 III 75	24 IV 75	21 V 75	18 VI 75	16 VII 75	13 VIII 75	10 IX 75	26 IX 75	23 X 75	20 II 76	8 IV 76	7 VI 76	18 VI 76	2 VII 76	6 VIII 76	3 IX 76
pH	X	X	X	5.4	6.8	6.7	6.8	6.5	6.0	6.8	6.6	6.9	6.8	6.8	6.7	6.0	5.7	5.8	5.1	5.6	5.4
CONDUCTANCE μMho/cm	X	X	X	168	236	191	162	152	160	112	148	149	145	121	111	125	83.1	84.7	66.0	99.2	96.0
INORG NITROGEN																					
$NO_2^- + NO_3$-N ppm	5.14	6.09	12.8	25.6	8.61	.55	.69	.86	.33	X	.455	.234	.157	.111	.882	.080	.075	.145	.470	.338	.364
NO_2-N ppb	X	X	X	2	1	1	1	1	2	X	1.20	1.48	.90	.28	.45	.70	.72	1.6	X	2.6	.90
NH_4-N ppb	500	601	63	33	18	13	7	7	1	6.02	<.70	1.78	6.22	<.70	3.92	6.3	8.12	9.1	X	35.2	35.0
PO_4-P ppb	1.9	<.62	<.62	<.62	<.62	<.62	.9	<.62	<.62	X	<.62	<.62	<.62	<.62	2.05	3.6	2.90	1.40	.90	1.0	1.8
CATIONS, ppm																					
CALCIUM	X	32.9	X	X						X	36.2	25.0	30.6	28.7	26.9	31.7	28.7	23.2	X	22.3	X
MAGNESIUM		1.49	1.56	2.73						X	.42	.42	.42	.30	.48	.51	.42	.65	1.00	.80	1.55
MANGANESE		.040	.020	X						X											
POTASSIUM		.45	.35	.28						X	.18	.20	.15	.10	.16	.25	.25	.30	.55	.44	1.05
SODIUM		2.95	3.53	3.80						X		1.8	1.7	1.1	1.3	1.3	1.2	1.6	2.9	2.4	2.9
CATIONS, ppb																					
CADMIUM										X											
CHROMIUM										X											
COPPER	X	2	9	6						X											
IRON	X	145	136	170						X											
LEAD										X											
ZINC										X											
Boron (ppm)										X	.05	.04	.05	.08	.03	.01	.05	.05	.03	.12	.15
ANIONS, ppm																					
CHLORIDE - Cl	X	37.1	24.1	46.5	12.9	<3.9	X	<3.9	<3.9	X	5.1	6.0	6.9	<3.9	<3.9	17.0	15.0	14.0	12.0	13.4	18.7
SULFATE - SO_4										X		29			33	18	12	15	10	11	12

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-55 SOIL WATER FROM 4' LYSIMETER

ANALYSIS	DATE	30 VIII 74	9 IX 74	1 X 74	3 XII 74	12 I 75	30 I 75	26 III 75	24 IV 75	21 V 75	18 VI 75	16 VII 75	13 VIII 75	10 IX 75	26 IX 75	23 X 75	20 XI 75	18 XII 75	20 II 76	8 IV 76	7 V 76	18 VI 76	3 VII 76	6 VIII 76	3 IX 76	27 IX 76
pH	x	x	x	6.8	x	5.9	6.4	6.3	6.5	6.6	5.5	6.4	5.3	5.0	5.4	5.3	5.1	4.7	6.0	5.4	6.1	6.3	6.2	5.0	5.3	
CONDUCTANCE μMho/cm	x	x	x	359	x	304	300	248	230	264	33.1	38.4	42.0	44.1	44.8	41.0	37.0	45.5	47.7	47.5	50.2	64.0	61.2	69.0	77.0	
INORG. NITROGEN																										
$NO_2^- + NO_3^-$-N ppm	.85	1.83	1.21	.57	.46	12.2	6.61	3.88	3.83	4.03	.279	.745	.531	.791	.253	.221	.139	.064	.099	.105	.148	.148	.192	.210	.333	
NO_2-N ppb	x	x	x	.8	3.4	2.2	1.3	1.7	1	5	1.12	.84	1.40	.64	.42	.22	.36	.34	.36	.73	.30	x	.40	.40	.30	
NH_4-N ppm	.33	.61	.08	.01	.04	.01	.01	.01	.03	.01	.009	.002	.004	.003	.003	.005	.004	.003	.004	.008	.007	.008	.002	.010	.005	
PO_4-P ppb	8.1	<.62	<.62	.9	1.9	.9	2.6	3.2	<.62	<.62	8.85	.63	<.62	<.62	.62	3.32	1.43	1.89	2.5	2.36	1.20	<.64	<.64	1.4	1.6	
CATIONS, ppm																										
CALCIUM											1.8	2.2	2.5	2.8	3.3	3.7	3.9	5.1	5.6	5.5	4.6	4.7	5.1	8.6	7.7	
MAGNESIUM	x	2.3	.9	.6							.20	.24	.32	.35	.37	.37	.46	.64	.63	.62	.52	.45	.50	.60	.65	
MANGANESE																										
POTASSIUM	x	.6	.6	.3							.56	.46	.43	.46	.36	.40	.21	.20	.27	.46	.29	.27	.32	.71	.43	
SODIUM	x	5.0	3.7	2.9							1.7		3.0	2.8	1.8	1.7	1.5	1.5	1.4	1.5	1.6	2.0	2.3	2.7	2.8	
CATIONS, ppb																										
CADMIUM																										
CHROMIUM																										
COPPER	x	<0.1	5	3																						
IRON	x	<1.0	120	79																						
LEAD																										
ZINC																										
Boron (ppm)											.13	.07	.07	.02	.03	.06	.06	.04	.02	.01	.06	.05	.17	.12	.10	
ANIONS, ppm																										
CHLORIDE-Cl	x	23.8	8.4	7.6	20.1	20.9	9.0	8.1	7.8	7.3	<3.9	4.2	4.3	5.4	5.9	4.0	<3.9	3.9	2.6	<3.9	4.0	<3.9	<3.9	10.2	5.6	
SULFATE-SO_4													7				19	23	14	15	17	19	9	10	10	

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-56 WELL WATER, WELL #7

ANALYSIS / DATE	21 I 74	13 II 74	19 II 74	4 III 74	20 III 74	3 IV 74	17 IV 74	30 IV 74	14 V 74	30 V 74	12 VI 74	19 VI 74	3 VII 74
pH	x	x	x	x	x	x	x	x	x	x	x	x	x
CONDUCTANCE µMho/cm	x	x	x	x	x	x	x	x	x	x	x	x	x
INORG NITROGEN													
$NO_2^- + NO_3^-$-N PPM	.02	.15	.01	.01	.01	.01	.02	.01	.02	.01	.02	.02	.03
NO_2-N PPb	4	1	1	1	.4	.8	.7	1	2	3	1.1	1.4	1.8
NH_4-N PPM	.001	.012	.004	.005	.003	.001	.005	.003	.011	.012	.037	.003	.019
PO_4-P PPM	.005	.006	.003	.003	.003	.002	.006	.005	.005	.009	.006	.003	.007
CATIONS, ppm													
CALCIUM	.58	.40	.37		.58		.63		.58		.65		
MAGNESIUM	.80	1.28	.78		.62		.73		.83		.90		
MANGANESE ppb													
POTASSIUM	.44	.41	.35		.58		.59		.46		.62		
SODIUM	4.75	4.5	4.55		4.15		4.22		4.26		4.50		
CATIONS, ppb													
CADMIUM	31												
CHROMIUM													
COPPER	<.1												
IRON	<30	<30	<30										
LEAD	76												
ZINC													
Boron (PPM)													
ANIONS, ppm													
CHLORIDE-Cl	X	4.9	5.0	5.0	4.6	4.9	5.0	6.1	5.8	6.1	6.6	6.4	6.9
SULFATE-SO_4													
TEMP °C	x	x	x	x	x	x	x	x	x	x	x	x	x
ELEVATION FT	52.67	53.17	53.21	53.33	53.21	53.08	53.12	53.08	X	52.92	52.63	52.79	52.67

ANALYSIS / DATE	17 VII 74	24 VII 74	7 VIII 74	20 XI 74	18 XII 74	30 I 75	26 II 75	26 III 75	24 IV 75	21 V 75	18 VI 75	16 VII 75	13 VIII 75
pH	6.5	X	6.7	X	6.2	6.3	6.2	6.1	6.3	5.9	6.6	6.3	6.0
CONDUCTANCE µMho/cm	x	x	x	x	x	41.0	45.2	47.9	51.5	59.5	57.5	59.2	58.5
INORG NITROGEN													
$NO_2^- + NO_3^-$-N PPM	.10	.02	.08	.03	.03	.09	.18	.35	.58	.48	.43	.448	.550
NO_2-N PPb	3.5	x	14	.7	.7	.4	<.14	.7	.8	1	1	1.26	.90
NH_4-N PPM	.004	.021	.025	.010	.010	.011	.016	.033	.054	.049	.030	.030	.027
PO_4-P PPM	.003	.006	<.001	.010	.010	.013	.007	.008	.008	.008	.006	.011	.007
CATIONS, ppm													
CALCIUM	.69			1.2	.93	1.04	.81	.93	1.14	1.23		1.0	.81
MAGNESIUM	.93			1.23	1.13	.97	1.00	1.15	1.30	1.56		1.6	1.5
MANGANESE ppb													
POTASSIUM	.74			.59	.58	.56	.58	.57	.61	.68		.61	.61
SODIUM	5.38			5.80	5.38	4.83	4.83	5.30	5.66	5.84		5.8	5.3
CATIONS, ppb													
CADMIUM													
CHROMIUM													
COPPER													
IRON													
LEAD													
ZINC													
Boron (PPM)												.05	.06
ANIONS, ppm													
CHLORIDE-Cl	7.1	8.4	7.4	7.3	7.8	6.8	7.6	9.4	X	10.3	9.2	9.7	9.3
SULFATE-SO_4												9	9
TEMP °C	13	X	X	11	10	10	11	11.5	11.5	12.0	13.5	14	13.5
ELEVATION FT	52.42	52.33	52.17	50.67	50.25	49.92	50.00	50.25	50.54	50.74	50.73	50.47	50.44

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

(CONTINUED)

TABLE A-56 (CONTINUED)

ANALYSIS / DATE	10 IX 75	8 X 75	6 XI 75	3 XII 75	30 XII 75	28 I 76	25 II 76	24 III 76	21 IV 76	19 V 76	16 VI 76	14 VII 76	11 VIII 76	8 IX 76	6 X 76
pH	6.1	6.3	6.2	7.7	6.0	6.4	5.9	5.9	5.7	6.3	6.3	6.8	6.3	6.4	7.9
CONDUCTANCE μMho/cm	61.4	64.3	70.3	76.4	78.9	93.5	89.0	86.6	72.1	59.2	72.7	81.7	71.3	93.2	94.4
INORG. NITROGEN															
$NO_2^- + NO_3^-$-N ppm	.382	.693	1.24	1.30	1.67	1.60	1.43	1.13	.407	.848	1.72	2.20	2.09	1.87	1.39
NO_2-N ppb	2.44	.31	1.12	.22	.84	1.12	.70	.85	.50	.64	<.14	.39	2.0	.89	.20
NH_4-N ppm	.036	.006	.006	.005	.017	.013	.023	.018	.008	.013	.016	.005	.007	.007	.005
PO_4-P ppm	.008	.007	.005	.005	.006	.006	.004	.005	.005	.005	.004	.004	.004	.005	.005
CATIONS, ppm															
CALCIUM	.76	1.1	1.1	1.6	5.5	2.3	2.4	2.1	1.4	1.4	1.5	2.3	2.1	2.6	2.8
MAGNESIUM	1.6	1.9	2.3	2.5	4.6	2.7	2.7	2.5	1.6	1.8	2.1	2.6	2.5	2.8	2.8
MANGANESE ppb	7.0			8.3				8.9			8.1			20.2	
POTASSIUM	.63	.64	.71	.85	1.1	.84	.88	.83	.72	.68	.77	.76	.73	.85	.80
SODIUM	5.8	6.1	6.7	6.9	6.5	7.7	7.7	7.9	5.9	6.0	5.8	8.2	7.6	8.1	8.7
CATIONS, ppb															
CADMIUM	.67			1.85	.18			.72							
CHROMIUM															
COPPER	6.3			6.3				2.9			4.7			3.2	
IRON	8.5			10.7				4.6			9.0			15.2	
LEAD															
ZINC	75			25	25			25			25			50	
Boron ppm	.12	.04	.03	.02	.05	.05	.09	.16	.06	.08	.06	.06	.04	.05	.05
ANIONS, ppm															
CHLORIDE-Cl	9.9	11.7	14.4	16.8	12.8	20.4	20.8	20.2	13.0	12.6	15.3	16.7	13.8	16.1	18.3
SULFATE-SO_4	7			15	16	9	10	3	4	5	3	7	3	3	3
TEMP. °C	14	13	13	10	9.5	10	13	12	13	11.5	15.5	14.5	13.0	13.0	13.0
ELEVATION FT.	49.58	49.60	49.42	49.83	49.94	50.83	52.25	51.73	51.56	51.41	51.03	50.64	50.92	50.57	50.13

X: NO SAMPLE; BLANK: ANALYSIS NOT COMPLETE

TABLE A-57 REED CANARY, EAST PLOT

DATE \ ANALYSIS	ORGANIC CARBON (% dry wt.)	ORGANIC NITROGEN (% dry wt.)	PROTEIN* (% dry wt.)	ORGANIC PHOSPHORUS (% dry wt.)	CALORIE CONTENT (cal/gm)	CALCIUM (mg/kg)	MAGNESIUM (mg/kg)	POTASSIUM (mg/kg)	SODIUM (mg/kg)	CADMIUM (mg/kg)	CHROMIUM (mg/kg)	COPPER (mg/kg)	IRON (mg/kg)	LEAD (mg/kg)	MANGANESE (mg/kg)	NICKEL (mg/kg)	ZINC (mg/kg)	CROP YIELD (m Tons/ha)	ACCUM. HYDRAULIC LOAD (kg x 10^6/ha)
'74 HARVEST I	42.3	1.87	11.69	.251	ⓧ	1,862	1,568	18,816	307	.27	5.7	5.0	194	2.4	232	3.5	30	.92	2.5
'75 HARVEST II	42.5	1.11	6.94	.208	4,584	1,049	1,122	11,663	73	.18	9.5	7.0	107	1.7	33	5.1	18	3.14	9.2
'75 HARVEST III	40.7	1.51	9.44	.400	4,518	1,521	2,012	22,572	140	.30	5.4	6.5	186	1.6	245	5.5	31	.43	10.8
'75 HARVEST IV	41.1	1.74	10.88	.262	4,031	10,396	5,711	4,198	146	.78	6.1	8.0	1,362	7.9	183	28	38	.40	13.1
'75 TURF	36.2	.98	6.13	.110	ⓧ	3,013	1,753	1,135	128	.52	8.0	7.9	3,260	11.0	32	7.1	36	ⓧ	14.6
'76 HARVEST V	43.8	1.49	9.31	.334	4,168	1,468	1,991	18,116	129	.23	3.5	4.4	55	1.9	31	2.2	20	1.30	18.6
'76 HARVEST VI	45.1	2.25	14.06	.382	4,390	1,348	1,877	14,920	267	.22	5.9	4.3	125	1.6	71	3.9	29	1.41	21.0
'76 HARVEST VII	43.5	2.18	13.63	.535	4,373	1,960	1,544	15,680	436	.30	2.4	20.4	64	1.9	88	1.9	34	1.03	24.8
'76 TURF	40.2	.91	5.69	.115	ⓧ	2,363	742	1,542	436	.36	4.6	160	2,763	7.2	51	269	58	ⓧ	25.7
'77 HARVEST VIII	43.5	2.39	14.94	.379	4,616	1,400	1,450	21,300	356	.29	3.3	49	65	3.1	43	2.9	34	2.17	31.2
'77 HARVEST IX	44.4	2.03	12.69	.564	4,645	1,300	1,990	18,500	620	.23	2.6	8.0	68	4.0	53	2.6	55	3.43	40.7
'77 TURF	40.7	0.92	5.75	.241	ⓧ	8,600	4,850	1,980	355	.94	7.7	25.5	4,150	20.5	95	5.9	50	ⓧ	45.0

* EST. AS % N x 6.25 ⓧ: NO DATA X: NO SAMPLE

TABLE A-58 REED CANARY, SOUTH PLOT

DATE \ ANALYSIS	ORGANIC CARBON (% dry wt.)	ORGANIC NITROGEN (% dry wt.)	PROTEIN* (% dry wt.)	ORGANIC PHOSPHORUS (% dry wt.)	CALORIE CONTENT (cal/gm)	CALCIUM (mg/kg)	MAGNESIUM (mg/kg)	POTASSIUM (mg/kg)	SODIUM (mg/kg)	CADMIUM (mg/kg)	CHROMIUM (mg/kg)	COPPER (mg/kg)	IRON (mg/kg)	LEAD (mg/kg)	MANGANESE (mg/kg)	NICKEL (mg/kg)	ZINC (mg/kg)	CROP YIELD (mTons/ha)	ACCUM. HYDRAULIC LOAD (kg x 10^6/ha)
'74 HARVEST I	42.0	2.16	13.50	.362	⊗	1,541	1,690	22,315	410	.40	2.4	7.2	86	2.0	90	2.1	40	1.05	4.5
'75 HARVEST II	40.7	1.29	8.06	.266	4,529	816	1,011	7,927	138	.85	2.3	7.0	46	1.6	22	5.1	13	4.82	16.2
'75 HARVEST III	39.9	1.47	9.19	.442	4,551	1,442	2,089	19,295	358	.28	5.1	5.4	194	1.3	179	3.1	33	1.39	19.3
'75 HARVEST IV	37.7	1.90	11.88	.343	4,070	6,448	4,644	8,597	254	.60	78	8.9	1,050	5.4	109	42	36	.47	23.7
'75 TURF	37.0	.70	4.38	.105	⊗	1,143	974	1,110	169	.44	9.3	11.0	4,324	5.9	20	5.1	35	⊗	25.9
'76 HARVEST V	43.2	1.58	9.88	.423	4,082	882	1,693	21,083	250	.25	2.5	5.0	38	1.1	20	1.6	24	3.70	33.8
'76 HARVEST VI	44.9	1.87	11.69	.411	4,348	1,236	1,712	13,033	209	.23	8.0	5.0	86	1.2	57	5.0	32	1.35	36.5
'76 HARVEST VII	43.1	2.17	13.56	.750	4,271	1,732	2,147	14,835	503	.44	2.5	33	54	2.1	23	2.5	44	1.03	39.9
'76 TURF	41.4	.70	4.38	.094	⊗	2,010	1,237	804	407	.73	5.8	24	2,938	9.3	47	4.8	76	⊗	40.7
'77 HARVEST VIII	42.4	1.71	10.69	.385	4,575	15,000	15,300	19,200	183	.28	4.9	29	66.3	3.1	28	4.2	31	1.21	43.2
'77 HARVEST IX	44.1	2.06	12.88	.595	4,611	15,000	20,400	18,700	228	.25	2.8	8.0	56.3	3.5	15	3.0	65	2.64	48.1
'77 TURF	42.3	0.87	5.44	.217	⊗	4,210	2,600	3,500	676	1.63	9.91	34.3	3,770	27.9	133	6.5	113	⊗	50.3

*EST. AS % N x 6.25 ⊗: NO DATA x: NO SAMPLE

TABLE A-59 REED CANARY, WEST PLOT

DATE / ANALYSIS	ORGANIC CARBON (% dry wt.)	ORGANIC NITROGEN (% dry wt.)	PROTEIN * (% dry wt.)	ORGANIC PHOSPHORUS (% dry wt.)	CALORIE CONTENT (cal/gm)	CALCIUM (mg/kg)	MAGNESIUM (mg/kg)	POTASSIUM (mg/kg)	SODIUM (mg/kg)	CADMIUM (mg/kg)	CHROMIUM (mg/kg)	COPPER (mg/kg)	IRON (mg/kg)	LEAD (mg/kg)	MANGANESE (mg/kg)	NICKEL (mg/kg)	ZINC (mg/kg)	CROP YIELD (M Tons/ha)	ACCUM. HYDRAULIC LOAD (kg x 10^6/ha)
'74 HARVEST I	41.9	2.26	14.13	.370	⊗	1,750	1,700	22,500	556	.32	1.8	6.8	451	4.5	62	1.8	35	1.59	6.5
'75 HARVEST II	42.6	1.26	7.88	.296	4,401	1,187	2,053	14,392	242	.25	13	6.3	183	1.5	20	6.7	24	6.73	24.4
'75 HARVEST III	39.6	1.66	10.38	.533	4,512	1,538	1985	20,845	600	.25	4.3	5.5	89	1.3	79	3.2	24	2.45	29.5
'75 HARVEST IV	41.8	2.26	14.13	.415	4,080	9,489	8,076	9,826	385	.61	44	15	651	5.4	84	25	47	.87	35.7
'75 TURF	39.5	1.12	7.00	.126	⊗	1,022	847	1,645	543	.58	7.1	18	2,293	5.1	22	6.9	47	⊗	39.5
'76 HARVEST V	42.8	1.79	11.19	.405	4345	1,241	2,134	20,154	496	.27	3.4	7.9	55	1.1	25	2.1	23	5.97	51.3
'76 HARVEST VI	44.8	1.93	12.06	.419	4,390	1,122	1,838	14,802	279	.22	8.0	5.7	79	.76	39	5.2	52	2.76	55.3
'76 HARVEST VII	43.0	2.27	14.19	.567	4,297	1,756	2,041	13,478	650	.29	3.0	20.4	52	2.4	26	2.2	28	1.03	60.7
'76 TURF	40.8	1.11	6.94	.219	⊗	2,285	1,540	2,136	591	.58	4.9	35.8	2,732	10.9	21	9.5	60	⊗	61.6
'77 HARVEST VIII	43.8	2.51	15.69	.383	4,639	1,300	1,430	16,200	168	.25	5.4	42	61.3	2.3	19	3.2	33	2.46	65.8
'77 HARVEST IX	44.0	2.05	12.81	.584	4,606	1,500	2,140	19,200	430	.27	3.4	8.5	61.0	4.4	38	3.0	60	3.85	72.9
'77 TURF	38.8	0.91	5.69	.195	⊗	7,630	4,950	2,320	551	1.53	16.8	25.0	3,870	13.5	56	6.1	41	⊗	75.5

* EST. AS % N x 6.25 ⊗: NO DATA X: NO SAMPLE

TABLE A-60 REED CANARY, CONTROL PLOT

DATE \ ANALYSIS	ORGANIC CARBON (% dry wt.)	ORGANIC NITROGEN (% dry wt.)	PROTEIN* (% dry wt.)	ORGANIC PHOSPHORUS (% dry wt.)	CALORIE CONTENT (cal/gm)	CALCIUM (mg/kg)	MAGNESIUM (mg/kg)	POTASSIUM (mg/kg)	SODIUM (mg/kg)	CADMIUM (mg/kg)	CHROMIUM (mg/kg)	COPPER (mg/kg)	IRON (mg/kg)	LEAD (mg/kg)	MANGANESE (mg/kg)	NICKEL (mg/kg)	ZINC (mg/kg)	CROP YIELD (M Tons/ha)	ACCUM. HYDRAULIC LOAD (kg x 10⁶/ha)
'74 HARVEST I	40.7	1.57	9.81	.402	⊗	2,161	1,024	37,062	366	.42	1.5	8.3	155	3.3	110	1.5	35	.09	⊗
'75 HARVEST II	43.0	1.00	6.25	.229	4,616	2,136	1,639	17,735	84	.28	4.6	7.5	129	3.3	77	3.2	20	.09	⊗
'75 HARVEST III	42.0	1.00	6.25	.457	⊗	1,344	1,866	24,183	162	.34	9.4	6.7	100	1.6	142	5.5	42	.07	⊗
'75 HARVEST IV	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	.04	⊗
'75 TURF	36.4	.77	4.81	.102	⊗	1,305	1,027	1,330	148	.70	15	10.0	5,222	7.2	22	5.7	27	⊗	⊗
'76 HARVEST V	44.6	1.70	10.63	.294	4172	1,927	2,026	21,992	106	.35	6.9	4.6	1,003	2.6	95	4.3	22	.09	⊗
'76 HARVEST VI	46.5	2.13	13.31	.283	4,479	2,211	1,998	8,298	84	.25	21	8.0	204	2.0	131	10.0	33	.07	⊗
'76 HARVEST VII	45.0	2.04	12.75	.320	4,386	2,654	2,108	10,319	139	.53	2.6	20.3	114	2.6	153	3.0	36	.04	⊗
'76 TURF	42.7	.85	5.31	.127	⊗	4,048	965	1,342	86	.73	5.7	36.6	3,105	18.4	35	5.2	61	⊗	⊗
'77 HARVEST VIII	44.5	3.18	19.88	.190	4,654	1,500	1,100	10,900	145	.25	4.0	19.0	83.8	3.1	57	4.2	26	.09	⊗
'77 HARVEST IX	44.9	2.01	12.56	.331	4,243	1,900	2,380	13,500	123	.18	3.4	7.8	70.0	5.8	107	3.7	53	.04	⊗
'77 TURF	39.6	1.19	7.43	.218	⊗	7,120	2,780	2,210	192	.65	5.0	19.2	2,880	22.8	78	5.4	67	⊗	⊗

* EST. AS % N x 6.25 ⊗: NO DATA X: NO SAMPLE

TABLE A-61 TIMOTHY

DATE \ ANALYSIS	ORGANIC CARBON (% dry wt.)	ORGANIC NITROGEN (% dry wt.)	PROTEIN * (% dry wt.)	ORGANIC PHOSPHORUS (% dry wt.)	CALORIE CONTENT (cal/gm)	CALCIUM (mg/kg)	MAGNESIUM (mg/kg)	POTASSIUM (mg/kg)	SODIUM (mg/kg)	CADMIUM (mg/kg)	CHROMIUM (mg/kg)	COPPER (mg/kg)	IRON (mg/kg)	LEAD (mg/kg)	MANGANESE (mg/kg)	NICKEL (mg/kg)	ZINC (mg/kg)	CROP YIELD (mTons/ha)	ACCUM. HYDRAULIC LOAD (kg x 10⁶/ha)
'74 HARVEST I	43.4	1.60	10.00	.271	⊗	1,389	962	25,260	282	.25	2.4	6.1	90	3.4	50	2.1	19	.54	3.3
'75 HARVEST II	44.9	1.10	6.88	.282	4,681	1,412	991	17,346	206	.21	4.6	5.7	69	1.1	22	3.1	21	5.02	10.5
'75 HARVEST III	39.7	1.59	9.94	.303	4,559	2,116	1,796	20,500	298	.32	5.1	5.4	197	2.6	36	4.0	23	.49	15.6
'75 HARVEST IV	44.8	1.60	10.00	.270	4,621	3,132	1,541	8,254	157	.30	24	6.8	388	3.1	34	15	41	.43	20.0
'75 TURF	34.3	1.10	6.88	.239	⊗	14,757	7,133	5,017	605	.92	12	11.0	3,099	5.5	59	5.7	41	⊗	20.8
'76 HARVEST V	44.1	1.59	9.94	.374	4,220	1,163	860	23,561	194	.24	2.0	4.4	29	0.9	20	1.3	18	2.51	23.0
'76 HARVEST VI	46.0	2.01	12.56	.302	4397	1,788	1,316	14,203	184	.23	9.6	7.7	124	1.7	17	7.1	65	.85	25.8
'76 HARVEST VII	44.7	2.25	14.06	.391	4,491	2,495	1,472	15,219	230	.58	2.5	15.0	50	3.0	8.5	2.0	34	.49	30.8
'76 TURF	43.3	.92	5.75	.209	⊗	3,596	1,141	1,501	1,141	.50	8.9	13.4	2,502	4.8	27	2.5	32	⊗	31.5
'77 HARVEST VIII	43.1	2.13	13.31	.305	4,592	1,600	800	18,000	243	.26	2.0	5.5	74.5	3.0	13	1.6	20	.60	34.0
'77 HARVEST IX	44.5	1.36	8.50	.342	4,808	1,700	1,320	15,400	292	.13	1.7	5.0	43	4.1	11	2.5	41	3.34	39.0
'77 TURF	42.5	1.46	9.13	.295	⊗	12,500	5,966	5,410	668	.94	7.1	144	1,660	15.6	65	7.1	67	⊗	41.0

* EST. AS % N x 6.25 ⊗: NO DATA X: NO SAMPLE

TABLE A-62 SMOOTH BROME

DATE / ANALYSIS	ORGANIC CARBON (% dry wt.)	ORGANIC NITROGEN (% dry wt.)	PROTEIN* (% dry wt.)	ORGANIC PHOSPHORUS (% dry wt.)	CALORIE CONTENT (cal/gm)	CALCIUM (mg/kg)	MAGNESIUM (mg/kg)	POTASSIUM (mg/kg)	SODIUM (mg/kg)	CADMIUM (mg/kg)	CHROMIUM (mg/kg)	COPPER (mg/kg)	IRON (mg/kg)	LEAD (mg/kg)	MANGANESE (mg/kg)	NICKEL (mg/kg)	ZINC (mg/kg)	CROP YIELD (m Tons/ha)	ACCUM. HYDRAULIC LOAD (kg x 10^6/ha)
'74 HARVEST I	42.8	1.46	9.13	.344	⊗	1,746	985	29,940	225	.30	2.4	5.1	90	2.0	57	1.4	16	.49	3.3
'75 HARVEST II	42.9	1.17	7.31	.286	4,521	1,348	764	18,231	238	.22	3.8	6.4	39	1.2	31	2.3	17	4.73	10.5
'75 HARVEST III	41.0	1.31	8.19	.275	4,542	1,709	1,319	19,194	352	.27	6.0	5.4	220	2.0	115	3.3	23	.61	15.6
'75 HARVEST IV	44.6	1.76	11.00	.287	4,449	3,662	1,385	7,471	203	.31	25	5.7	381	3.3	39	14	28	.22	20.0
'75 TURF	36.4	2.79	17.44	.248	⊗	3,892	1,133	3,694	709	.41	12	8.9	2,512	4.3	90	3.9	29	⊗	20.8
'76 HARVEST V	44.0	1.49	9.31	.332	4,243	1,423	835	19,928	173	.23	6.2	4.4	135	1.5	22	3.4	18	1.82	23.0
'76 HARVEST VI	46.3	1.90	11.88	.329	4,302	1,417	1,193	15,410	162	.22	11	4.8	114	1.8	17	6.3	24	.70	25.8
'76 HARVEST VII	43.7	2.18	13.63	.465	4,254	2,136	1,416	18,878	790	.47	4.6	78	55	3.0	11	2.8	27	.18	30.8
'76 TURF	39.8	.80	5.00	.172	⊗	6,324	2,273	2,569	781	.41	5.6	9.9	1,976	5.9	32	4.2	44	⊗	31.5
'77 HARVEST VIII	42.3	2.73	17.06	.280	4,428	1,800	1,170	17,700	216	.25	4.2	7.5	100	3.2	14	1.9	20	.45	34.0
'77 HARVEST IX	45.3	1.67	10.19	.342	4,611	1,700	1,430	17,800	344	.15	1.7	6.0	25	3.1	17	2.2	32	2.64	37.0
'77 TURF	43.9	1.01	6.31	.2304	⊗	7,320	3,500	2,800	533	.78	10.8	11.1	3,750	19.5	40	6.9	47	⊗	41.0

* EST. AS % N x 6.25 ⊗ : NO DATA X : NO SAMPLE

TABLE A-63 TIMOTHY ALFALFA

DATE \ ANALYSIS	ORGANIC CARBON (% dry wt.)	ORGANIC NITROGEN (% dry wt.)	PROTEIN* (% dry wt.)	ORGANIC PHOSPHORUS (% dry wt.)	CALORIE CONTENT (cal/gm)	CALCIUM (mg/kg)	MAGNESIUM (mg/kg)	POTASSIUM (mg/kg)	SODIUM (mg/kg)	CADMIUM (mg/kg)	CHROMIUM (mg/kg)	COPPER (mg/kg)	IRON (mg/kg)	LEAD (mg/kg)	MANGANESE (mg/kg)	NICKEL (mg/kg)	ZINC (mg/kg)	CROP YIELD (mtons/ha)	ACCUM. HYDRAULIC LOAD (kg x 10^6/ha)
'74 HARVEST I	42.8	1.68	10.50	.292	⊗	2,100	1,072	26,000	253	.28	2.6	6.5	220	4.5	77	2.0	22	.45	3.3
'75 HARVEST II	43.3	1.45	9.06	.365	4,436	1,882	1,173	16,766	2,810	.26	3.4	12	44	1.6	21	2.7	28	4.85	10.5
'75 HARVEST III	41.6	2.00	12.50	.394	4,633	2,371	1,457	22,127	1,926	.32	2.2	6.3	59	1.6	20	1.7	18	2.38	15.6
'75 HARVEST IV	40.4	3.13	19.56	.510	4,271	7,025	2,343	12,859	702	.51	52	9.4	745	3.6	28	27	29	1.21	20.0
'75 TURF	41.8	1.42	8.88	.298	⊗	10,478	5,910	2,433	1,256	.75	8.4	13	2,731	7.2	81	4.3	48	⊗	20.8
'76 HARVEST V	41.0	1.72	10.75	.347	4,220	2,949	1,547	17,596	723	.34	2.6	4.2	102	2.0	34	1.7	24	4.13	23.0
'76 HARVEST VI	45.1	2.04	12.75	.337	4,409	3,219	1,981	8,666	745	.27	21	5.9	228	2.0	12	14	24	2.31	25.8
'76 HARVEST VII	44.2	3.29	20.56	.575	4,422	6,250	2,689	12,948	4,183	.80	1.7	13	65	3.0	10	1.6	30	1.01	30.8
'76 TURF	36.4	1.31	8.19	.280	⊗	11,707	4,720	1,926	1,171	1.02	5.7	16	4,267	13	31	4.9	37	⊗	31.5
'77 HARVEST VIII	43.3	2.40	15.00	.364	4,685	2,000	820	11,700	203	.31	2.0	7.5	46.9	2.1	12	1.4	24	1.50	34.0
'77 HARVEST IX	44.9	1.60	10.00	.345	4,695	1,800	1,480	14,800	560	.15	1.6	5.0	45.0	3.3	12	2.8	37	3.49	39.0
'77 TURF	41.1	1.48	9.25	.283	⊗	16,700	16,700	4,620	1,874	.66	9.4	8.8	3,520	⊗	37	5.5	38	⊗	41.0

* EST. AS % N x 6.25 ⊗: No DATA X: No SAMPLE

TABLE A-64 REED CANARY

DATE \ ANALYSIS	ORGANIC CARBON (% dry wt.)	ORGANIC NITROGEN (% dry wt.)	PROTEIN* (% dry wt.)	ORGANIC PHOSPHORUS (% dry wt.)	CALORIE CONTENT (cal/gm)	CALCIUM (mg/kg)	MAGNESIUM (mg/kg)	POTASSIUM (mg/kg)	SODIUM (mg/kg)	CADMIUM (mg/kg)	CHROMIUM (mg/kg)	COPPER (mg/kg)	IRON (mg/kg)	LEAD (mg/kg)	MANGANESE (mg/kg)	NICKEL (mg/kg)	ZINC (mg/kg)	CROP YIELD (M Tons/ha)	ACCUM. HYDRAULIC LOAD (kg x 10^6/ha)
'74 HARVEST I	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	.31	3.3
'75 HARVEST II	43.0	1.07	6.69	.260	4,431	1,358	834	22,010	186	.23	4.8	6.0	86	1.3	60	2.9	18	4.53	10.5
'75 HARVEST III	42.1	1.58	9.88	.408	4,471	1,244	2,488	22,396	610	.29	3.9	9.0	60	1.4	50	2.8	35	1.12	15.6
'75 HARVEST IV	44.4	2.39	14.94	.364	4,661	3,514	2,123	7,906	424	.30	16	5.8	376	3.4	63	9.6	26	.47	20.0
'75 TURF	30.9	1.14	7.13	.155	⊗	3,202	2,038	2,377	728	.69	13	12	3,493	7.9	39	5.8	29	⊗	20.8
'76 HARVEST V	43.7	1.76	11.00	.369	4,184	1,129	1,669	20,966	341	.23	2.6	5.6	39	1.3	42	1.5	21	2.62	23.0
'76 HARVEST VI	45.6	1.85	11.56	.352	4,393	1,728	1,901	11,602	306	.22	3.8	4.3	74	1.4	28	3.1	26	1.82	25.8
'76 HARVEST VII	44.2	2.71	16.94	.550	4,341	4,616	2,482	13,899	3,872	1.94	2.5	16.4	89	3.3	16	2.0	32	.54	30.8
'76 TURF	40.5	.88	5.50	.211	⊗	2,520	1,248	2,345	684	.55	4.5	16.5	3,593	7.4	24	4.3	31	⊗	31.5
'77 HARVEST VIII	43.3	2.38	14.88	.352	4,766	1,400	1,310	17,400	285	.28	3.3	10	58.2	2.2	19	2.6	24	1.66	34.0
'77 HARVEST IX	43.8	1.85	11.56	.476	4.569	1,700	2,170	17,300	533	.17	2.2	6.5	50	4.1	40	2.6	68	2.84	39.0
'77 TURF	40.9	1.00	6.25	.225	⊗	4,750	3,500	2,530	4,750	.77	10.0	25.5	5,050	14.0	39	6.2	43	⊗	41.0

* EST. AS % N x 6.25 ⊗: NO DATA X: NO SAMPLE

TABLE A-65 CONTROL PLOT

DATE	ORGANIC CARBON (% dry wt.)	ORGANIC NITROGEN (% dry wt.)	PROTEIN * (% dry wt.)	ORGANIC PHOSPHORUS (% dry wt.)	CALORIE CONTENT (cal/gm)	CALCIUM (mg/kg)	MAGNESIUM (mg/kg)	POTASSIUM (mg/kg)	SODIUM (mg/kg)	CADMIUM (mg/kg)	CHROMIUM (mg/kg)	COPPER (mg/kg)	IRON (mg/kg)	LEAD (mg/kg)	MANGANESE (mg/kg)	NICKEL (mg/kg)	ZINC (mg/kg)	CROP YIELD (M Tons/ha)	ACCUM. HYDRAULIC LOAD (kg x 10⁶/ha)
'74 HARVEST I	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	.13	⊗
'75 HARVEST II	⊗	⊗	⊗	.219	4,331	1,898	899	18,581	125	.26	6.4	7.1	400	2.5	32	5.4	14	.92	⊗
'75 HARVEST III	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	.04	⊗
'75 HARVEST IV	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	.04	⊗
'75 TURF	34.6	1.22	7.63	.169	⊗	6,545	1,966	2,471	660	.56	7.9	7.6	2,107	5.1	48	5.6	20	⊗	⊗
'76 HARVEST V	44.2	1.35	8.44	.273	4258	1,991	1,111	17,548	329	.27	8.9	4.3	213	1.6	21	5.0	16	.11	⊗
'76 HARVEST VI	45.0	1.16	7.25	.243	4,274	3,104	1,404	13,254	325	.36	4.6	3.7	202	2.6	24	4.4	24	.09	⊗
'76 HARVEST VII	44.1	1.41	8.81	.221	4,276	4,967	1,566	8,452	283	1.05	6.3	32.3	457	4.6	20	4.7	26	.04	⊗
'76 TURF	39.2	.79	4.94	.128	⊗	21,900	8,423	1,634	164	.92	7.8	5.4	3,369	12.5	60	3.9	32	⊗	⊗
'77 HARVEST VIII	43.1	1.98	12.38	.224	4,780	2,000	610	18,500	170	.29	1.5	7.0	32.6	2.7	24	1.3	21	⊗	⊗
'77 HARVEST IX	46.2	0.74	4.63	1.43	4.624	2,200	850	6,300	237	.17	2.0	4.5	100	4.7	9.2	2.5	24	.22	⊗
'77 TURF	43.2	0.72	4.50	.114	⊗	10,300	3,780	2,610	190	.58	9.5	6.5	4,270	20.9	31	6.7	17	⊗	⊗

* EST. AS % N x 6.25 ⊗: NO DATA x: NO SAMPLE

TABLE A-66 EAST PLOT

DATE	DEPTH, in.	pH	ORGANIC CARBON (% dry wt.)	ORGANIC NITROGEN (% dry wt.)	ORGANIC PHOSPHORUS (% dry wt.)	CALCIUM (mg/kg)	MAGNESIUM (mg/kg)	POTASSIUM (mg/kg)	SODIUM (mg/kg)	CADMIUM (mg/kg)	CHROMIUM (mg/kg)	COPPER (mg/kg)	IRON (mg/kg)	LEAD (mg/kg)	MANGANESE (mg/kg)	NICKEL (mg/kg)	ZINC (mg/kg)
AUG. 1973 (PRE-IRRIGATION)	0-6	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	12	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
DEC. 1975	0-6	5.7	1.61	.04	.031	1,287	908	183	28	.27	3.2	1.2	5,693	8.1	7.7	1.8	5.5
"	0-3	5.7	2.87	.14	.031	1,462	239	175	25	.27	3.0	1.4	5,505	x	10	1.8	6.4
"	3-6	5.2	1.60	.21	.018	105	91	172	26	.20	2.7	.93	4,035	4.0	3.1	1.6	4.3
"	6	4.8	.83	.02	.022	9.9	148	168	26	.24	3.3	.81	6,775	3.2	8.6	1.9	4.5
"	12	4.8	.19	.01	.013	7.9	320	182	17	.16	3.8	.94	3,745	3.2	16	2.5	5.0
"	24	4.7	.07	<.01	.012	6.0	303	149	12	.11	2.8	1.4	3,032	2.2	57	2.5	5.4
"	36	4.7	.07	.01	.016	4.0	439	319	21	.18	4.2	3.0	5,989	3.0	167	3.5	16
"	48	4.6	.04	.02	.011	5.5	638	319	22	.17	3.4	2.3	2,543	3.1	32	2.9	8.6
NOV. 1976	0-6	⊗	3.24	.11	.029	1,219	995	278	102	.39	6.1	2.2	8,854	9.5	13	3.5	11
"	0-3	⊗	4.45	.14	.038	5,612	2,511	315	91	.49	5.8	3.2	8,221	12.7	22	3.9	14
"	3-6	⊗	2.16	.07	.017	136	325	187	118	.35	5.2	1.5	9,803	7.3	8.5	3.4	8.9
"	12	⊗	.05	.46	.013	19.5	400	185	61	.29	4.7	1.7	10,390	5.7	23	3.4	10
NOV. 1977	0-6	⊗	2.89	.09	.054	1,500	2,050	425	135	.44	9.8	2.6	11,800	15.5	25.5	6.4	11.5
"	0-3	⊗	3.97	.14	.071	4,850	3,810	415	100	.55	7.7	3.3	10,400	18.5	28.0	6.1	13.0
"	3-6	⊗	1.38	.05	.024	370	750	525	110	.44	10.2	1.7	13,100	12.0	21.0	7.3	8.5
"	12	⊗	0.32	.01	.017	20	1,250	375	90	.31	10.6	2.6	12,200	10.5	40.0	7.9	13.0

X: NO SAMPLE
⊗: NO DATA

TABLE A-67 SOUTH PLOT

DATE	ANALYSIS / DEPTH, in.	pH	ORGANIC CARBON (% dry wt.)	ORGANIC NITROGEN (% dry wt.)	ORGANIC PHOSPHORUS (% dry wt.)	CALCIUM (mg/kg)	MAGNESIUM (mg/kg)	POTASSIUM (mg/kg)	SODIUM (mg/kg)	CADMIUM (mg/kg)	CHROMIUM (mg/kg)	COPPER (mg/kg)	IRON (mg/kg)	LEAD (mg/kg)	MANGANESE (mg/kg)	NICKEL (mg/kg)	ZINC (mg/kg)
Aug. 1973	0-6	⊗	⊗	⊗	⊗	16.9	50	169	31	.19	1.9	1.1	3,967	6.3	4.5	1.5	5.2
"	12	⊗	⊗	⊗	⊗	4.9	208	267	36	.20	3.4	1.1	5,398	4.4	10.0	3.0	5.8
Dec. 1975	0-6	5.9	1.58	.04	.034	804	666	343	44	.17	3.4	1.4	7,355	4.8	4.0	2.3	5.2
"	0-3	5.9	1.44	.08	.029	653	610	343	45	.12	3.3	1.4	7,975	3.8	1.4	2.0	4.8
"	3-6	5.5	⊗	⊗	.023	64	188	332	39	.12	3.9	.84	7,872	3.8	4.7	2.8	5.0
"	6	5.5	.28	.01	.014	22	190	272	33	.09	4.2	.84	5,942	3.0	4.7	2.5	4.5
"	12	4.9	.16	.05	.015	5.5	368	323	35	.10	6.2	1.5	7,348	4.2	15	3.6	7.7
"	24	4.8	.07	.04	.010	4.0	772	336	34	.15	5.8	2.7	7,421	4.6	29	4.8	10
"	36	5.1	.06	.02	.005	5.8	726	296	37	.08	5.2	1.8	4,520	4.5	26	3.1	7.5
"	48	5.1	.05	.03	.012	7.5	978	308	36	.10	5.9	3.5	6,850	4.2	40	4.2	10
Nov. 1976	0-6	⊗	3.01	.11	.028	598	747	169	77	.34	2.8	2.1	5,083	8.3	11	2.0	10
"	0-3	⊗	6.08	.23	.041	2,762	1,889	227	132	.52	3.4	4.9	4,722	16.5	24	3.3	20
"	3-6	⊗	1.80	.07	.016	55	154	219	72	.30	3.1	1.1	6,969	5.3	5.0	2.2	7.5
"	12	⊗	.39	.01	.017	30	294	269	48	.24	4.0	1.1	8,159	4.6	17	9.5	5.0
Nov. 1977	0-6	⊗	2.26	.09	.025	655	950	355	110	.49	5.9	3.3	9,150	21.0	32.0	50	25.0
" "	0-3	⊗	4.36	.16	.048	4,055	3,500	300	100	.55	4.8	4.7	5,750	25.0	30.0	4.2	20.0
" "	3-6	⊗	1.92	.04	.091	350	360	200	800	.45	5.3	2.2	7,200	17.5	23.5	4.1	22.0
" "	12	⊗	0.49	.01	.020	485	350	350	75	.29	7.4	1.4	9400	12.5	29.5	10.2	11.0

X : No Sample

⊗: No Data

TABLE A-68 WEST PLOT

DATE	DEPTH, in.	pH	ORGANIC CARBON (% dry wt.)	ORGANIC NITROGEN (% dry wt.)	ORGANIC PHOSPHORUS (% dry wt.)	CALCIUM (mg/kg)	MAGNESIUM (mg/kg)	POTASSIUM (mg/kg)	SODIUM (mg/kg)	CADMIUM (mg/kg)	CHROMIUM (mg/kg)	COPPER (mg/kg)	IRON (mg/kg)	LEAD (mg/kg)	MANGANESE (mg/kg)	NICKEL (mg/kg)	ZINC (mg/kg)
Aug. 1973	0-6	⊗	⊗	⊗	⊗	16.9	60	154	29	.20	1.8	1.1	4,480	6.7	3.2	1.5	6.7
"	12	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Dec. 1975	0-6	5.4	1.30	.05	.031	771	1,007	232	57	.29	4.0	2.0	8,960	5.7	8.1	2.3	6.4
"	0-3	5.4	3.22	.10	.042	3,952	2,421	168	50	.32	2.9	1.8	6,323	5.8	8.4	1.5	6.3
"	3-6	5.4	1.62	.06	.020	100	150	290	53	.30	4.3	1.2	11,093	4.8	6.5	3.2	5.6
"	6	5.4	.54	.01	.015	45	114	159	35	.25	3.7	.65	8,010	3.6	6.5	2.1	4.8
"	12	4.7	.31	<.01	.015	13	238	208	24	.21	5.0	.94	8,369	3.2	15	2.3	5.4
"	24	4.4	.06	<.01	.009	3.6	346	258	23	.18	4.0	1.6	6,875	3.4	24	3.0	6.4
"	36	4.4	.10	<.01	.012	6.9	514	316	29	.22	5.4	2.0	9,348	4.3	26	3.7	8.5
"	48	4.6	.07	<.01	.034	3.0	638	434	35	.20	4.5	3.3	5,188	4.7	34	4.3	12
Nov. 1976	0-6	⊗	1.94	.07	.031	928	1,393	223	58	.29	3.7	1.9	6,499	5.7	8.2	2.6	8.7
"	0-3	⊗	2.88	.10	.048	2,295	2,046	215	62	.35	3.6	2.5	5,738	7.4	11	2.7	10
"	3-6	⊗	1.34	.04	.022	169	159	129	64	.19	3.2	.94	6,853	4.0	4.9	2.0	6.0
"	12	⊗	.35	.03	.01	37	236	222	50	.22	3.3	.97	6,396	4.1	11	13	7.3
Nov. 1977	0-6	⊗	2.78	.10	.062	2,750	2,125	250	80	.39	4.6	2.3	6,700	12.0	18.5	3.8	9.0
" "	0-3	⊗	3.98	.16	.080	5,500	3,950	305	95	.58	6.1	4.4	6,900	18.0	26.5	4.1	15.5
" "	3-6	⊗	2.67	.09	.029	575	350	190	50	.15	4.2	0.80	7,400	8.0	8.0	2.7	4.0
" "	12	⊗	0.44	.02	.023	65	290	200	50	.13	6.1	0.85	7,900	7.0	17.5	3.1	5.0

TABLE A-69 CONTROL PLOT

DATE	DEPTH, in.	pH	ORGANIC CARBON (% dry wt.)	ORGANIC NITROGEN (% dry wt.)	ORGANIC PHOSPHORUS (% dry wt.)	CALCIUM (mg/kg)	MAGNESIUM (mg/kg)	POTASSIUM (mg/kg)	SODIUM (mg/kg)	CADMIUM (mg/kg)	CHROMIUM (mg/kg)	COPPER (mg/kg)	IRON (mg/kg)	LEAD (mg/kg)	MANGANESE (mg/kg)	NICKEL (mg/kg)	ZINC (mg/kg)
AUG. 1973 (PRE-IRRIGATION)	0-6	⊗	⊗	⊗	⊗	59	59	187	28	.16	1.6	.93	3,884	27.0	4.82	1.4	4.9
	12	⊗	⊗	⊗	⊗	9.0	149	199	29	.19	2.6	.80	4,233	2.7	7.87	2.0	4.6
DEC. 1975	0-6	5.0	.90	.03	.016	439	299	174	21	.10	3.7	1.0	7,281	3.8	0.50	2.1	4.1
"	0-3	6.2	1.27	.04	.026	826	594	149	15	.11	2.7	2.1	5,361	4.8	3.47	1.5	4.0
"	3-6	5.5	.45	.03	.015	42	103	147	20	.10	3.8	.83	6,011	3.5	0.98	2.3	3.9
"	6	4.8	.82	.06	.016	10	114	179	20	.12	4.1	.75	6,024	3.0	1.74	2.3	3.7
"	12	4.6	.30	.06	.014	5.0	310	104	14	.08	4.1	.74	5,307	2.7	10.2	2.2	4.0
"	24	4.6	.12	.07	.033	.48	347	196	14	.16	4.6	2.6	20,701	3.6	6.23	2.9	7.3
"	36	4.3	.10	<.01	.025	8.0	848	588	37	.12	6.2	3.8	6,004	4.0	41.0	5.7	10
"	48	4.3	.13	.05	.015	9.0	863	641	45	.12	6.4	3.2	5,474	4.1	38.0	5.2	10
NOV. 1976	0-6	⊗	3.99	.14	.032	1,649	849	170	26	.30	2.9	6.7	5,239	9.8	10.9	2.1	8.7
"	0-3	⊗	3.57	.11	.035	2,619	1,433	163	23	.30	2.4	4.5	4,201	6.8	11.1	1.9	7.0
"	3-6	⊗	2.93	.10	.023	487	209	154	24	.24	2.4	3.9	5,066	6.5	6.21	2.0	6.3
"	12	⊗	.54	.02	.044	3.0	148	163	25	.20	2.9	.79	5,737	3.9	5.34	4.0	5.2
NOV. 1977	0-6	⊗	2.96	.11	.027	1,100	2,100	350	50	.30	4.7	3.3	7,800	11.5	15.0	3.5	9.5
" "	0-3	⊗	3.33	.12	.029	5,000	3,950	230	50	.32	3.4	3.9	4,650	11.5	17.0	3.3	7.0
" "	3.6	⊗	1.44	.06	.022	60	300	300	50	.29	5.4	0.9	8,900	7.5	9.5	3.5	5.0
" "	12	⊗	0.54	.03	.022	11.5	310	305	33	.21	6.5	1.4	7,850	8.0	14.0	5.1	5.5

X: NO SAMPLE

⊗: NO DATA

TABLE A-70 NORTHEAST PLOT, TIMOTHY

DATE \ ANALYSIS	DEPTH, in.	pH	ORGANIC CARBON (% dry wt.)	ORGANIC NITROGEN (% dry wt.)	ORGANIC PHOSPHORUS (% dry wt.)	CALCIUM (mg/kg)	MAGNESIUM (mg/kg)	POTASSIUM (mg/kg)	SODIUM (mg/kg)	CADMIUM (mg/kg)	CHROMIUM (mg/kg)	COPPER (mg/kg)	IRON (mg/kg)	LEAD (mg/kg)	MANGANESE (mg/kg)	NICKEL (mg/kg)	ZINC (mg/kg)
*Aug. 1973	0-6	⊗	⊗	⊗	⊗	15.7	101	217	37	.23	2.5	1.3	6,109	11.8	6.0	2.2	6.9
"	12	⊗	⊗	⊗	⊗	3.4	254	280	41	.25	3.8	1.4	7,859	4.6	15.6	3.8	7.9
Dec. 1975	0-6	6.6	.47	.03	.025	493	513	140	34	.24	3.3	1.3	6,384	4.3	6.8	1.7	4.5
"	0-3	6.6	.71	.03	.041	521	545	124	36	.25	3.4	1.6	5,752	4.6	8.4	1.4	4.7
"	3-6	6.5	.49	.01	.014	133	133	120	36	.24	3.3	1.1	7,007	4.0	11	2.2	4.5
"	6	6.4	.28	.01	.015	54	171	132	30	.21	3.7	.88	6,020	3.2	16	2.2	4.1
"	12	5.0	.20	.01	.015	4.8	286	210	20	.20	4.1	1.4	6,775	3.4	18	3.0	6.2
"	24	4.8	.15	<.01	.007	2.5	286	183	15	.16	2.8	1.4	4,594	2.5	65	2.8	5.4
"	36	4.7	.04	<.01	.012	2.9	234	131	11	.14	2.4	1.4	4,040	1.7	70	2.0	4.6
"	48	5.0	.10	.01	.013	6.7	497	330	32	.20	3.9	2.0	6,648	3.8	34	3.4	8.2
Nov. 1976	0-6	⊗	1.87	.07	.036	599	226	128	39	.20	2.6	1.1	5,500	3.3	5.3	2.0	4.5
"	0-3	⊗	2.02	.13	.018	1,130	429	138	42	.28	2.7	1.5	6,289	4.4	5.9	1.5	5.9
"	3-6	⊗	1.25	.05	.026	228	119	99	61	.23	2.8	1.1	6,628	3.9	4.0	2.2	5.2
"	12	⊗	.33	.02	.025	25	158	138	32	.15	2.9	1.2	4,243	3.0	13	3.6	5.5
Nov. 1977	0-6	⊗	2.24	.09	.032	1,350	825	250	70	.29	3.9	1.8	7,150	11.5	11.5	3.3	8.5
"	0-3	⊗	2.38	.11	.062	2,250	1,325	300	80	.32	4.3	2.1	7,350	11.5	14.5	3.4	27.0
"	3-6	⊗	1.31	.07	.037	585	325	180	100	.34	5.4	1.3	10,100	9.5	16.0	4.9	5.0
"	12	⊗	0.37	.02	.019	100	330	210	60	.18	6.3	1.3	7,450	7.0	21.0	4.7	5.5

X: NO SAMPLE

⊗: NO DATA

*AVG. OF 4 SAMPLES

TABLE A-71 SOUTHEAST PLOT, SMOOTH BROME

DATE \ ANALYSIS	DEPTH, in.	pH	ORGANIC CARBON (% dry wt.)	ORGANIC NITROGEN (% dry wt.)	ORGANIC PHOSPHORUS (% dry wt.)	CALCIUM (mg/kg)	MAGNESIUM (mg/kg)	POTASSIUM (mg/kg)	SODIUM (mg/kg)	CADMIUM (mg/kg)	CHROMIUM (mg/kg)	COPPER (mg/kg)	IRON (mg/kg)	LEAD (mg/kg)	MANGANESE (mg/kg)	NICKEL (mg/kg)	ZINC (mg/kg)
*Aug. 1973	0-6	⊗	⊗	⊗	⊗	15.7	101	217	37	.23	2.5	1.3	6,109	11.8	6.0	2.2	6.9
"	12	⊗	⊗	⊗	⊗	3.4	254	280	41	.25	3.8	1.4	7,859	4.6	15.6	3.8	7.9
Dec. 1975	0-6	6.2	5.74	.19	.016	2,749	268	180	38	.27	2.8	1.9	4,096	8.9	9.2	1.8	5.9
"	0-3	6.8	2.13	.08	.013	4,712	309	147	29	.29	2.6	1.7	3,779	7.6	13	1.7	5.3
"	3-6	5.8	3.04	.08	.012	819	135	184	42	.28	2.7	1.5	5,273	9.0	7.8	1.8	5.1
"	6	4.7	.60	.02	.008	2.4	116	212	31	.20	3.4	1.0	5,746	3.8	5.1	2.2	3.1
"	12	4.8	.15	<.01	.009	3.9	173	227	23	.18	3.5	.74	5,036	3.2	18	2.1	3.8
"	24	4.5	.11	<.01	.003	3.9	223	144	20	.12	2.0	.83	2,583	3.3	14	1.8	3.7
"	36	4.8	.14	.06	.008	3.0	733	812	77	.36	8.9	3.0	15,398	5.9	29	6.3	14
"	48	4.6	.33	.01	.016	2.4	1,056	596	55	.25	5.3	2.9	7,549	4.5	35	7.8	14
Nov. 1976	0-6	⊗	2.86	.11	.045	1,324	799	175	44	.29	3.1	2.1	5,695	6.7	9.7	2.1	7.3
"	0-3	⊗	3.62	.15	.050	3,650	819	129	32	.29	2.1	2.1	3,426	8.2	9.9	1.5	6.9
"	3-6	⊗	1.66	.09	.025	361	128	183	51	.24	3.1	1.2	6,776	3.7	4.5	3.7	5.3
"	12	⊗	.34	.01	.017	30	208	169	35	.16	3.2	1.3	4,965	3.7	17	3.7	5.9
Nov. 1977	0-6	⊗	1.66	.09	.044	700	700	260	90	.37	6.2	1.6	9,500	11.0	15.5	4.3	8.5
"	0-3	⊗	2.77	.11	.035	4,800	1,525	125	70	.30	2.6	2.1	3,750	12.0	13.5	2.0	11.5
"	3-6	⊗	1.57	.07	.028	525	250	180	75	.26	5.1	1.1	10,400	8.5	9.5	3.6	4.5
"	12	⊗	0.22	.02	.020	50	600	153	60	.15	7.0	1.5	8,300	7.5	33.5	5.3	3.0

X: No Sample

⊗: No Data

*Avg. of 4 Samples

TABLE A-72 SOUTHWEST PLOT, TIMOTHY ALFALFA

DATE	DEPTH, in.	pH	ORGANIC CARBON (% dry wt.)	ORGANIC NITROGEN (% dry wt.)	ORGANIC PHOSPHORUS (% dry wt.)	CALCIUM (mg/kg)	MAGNESIUM (mg/kg)	POTASSIUM (mg/kg)	SODIUM (mg/kg)	CADMIUM (mg/kg)	CHROMIUM (mg/kg)	COPPER (mg/kg)	IRON (mg/kg)	LEAD (mg/kg)	MANGANESE (mg/kg)	NICKEL (mg/kg)	ZINC (mg/kg)
*AUG. 1973	0-6	⊗	⊗	⊗	⊗	15.7	101	217	37	.23	2.5	1.3	6,109	11.8	6.0	2.2	6.9
"	12	⊗	⊗	⊗	⊗	3.4	254	280	41	.25	3.8	1.4	7,859	4.6	15.6	3.8	7.9
DEC. 1975	0-6	6.2	2.25	.01	.019	510	434	236	66	.30	4.6	1.8	8,959	9.1	7.7	2.5	8.6
"	0-3	6.7	3.10	.09	.024	2,550	917	162	69	.33	4.4	2.4	7,307	12	12	2.4	21
"	3-6	6.0	1.25	.05	.010	147	187	169	55	.27	4.6	1.0	8,459	4.9	8.0	2.6	6.5
"	6	4.5	.53	.02	.010	1.9	223	256	31	.25	4.9	.97	8,180	4.7	8.6	3.0	6.2
"	12	4.4	.24	.06	.012	2.3	424	400	40	.26	5.7	2.1	9,081	4.9	14	4.3	9.3
"	24	4.3	.18	.01	.007	4.4	935	628	53	.26	6.5	3.4	8,108	5.6	31	6.7	15
"	36	4.7	.02	<.01	.013	8.6	378	210	19	.16	2.7	2.2	3,442	2.2	75	3.0	6.6
"	48	4.8	.16	.22	.009	6.6	302	118	10	.14	2.1	2.0	2,736	1.9	71	2.4	5.0
NOV. 1976	0-6	⊗	1.57	.06	.031	633	273	158	46	.23	2.5	1.3	7,143	4.2	6.6	2.0	6.3
"	0-3	⊗	1.51	.06	.033	1,115	471	89	35	.22	2.0	1.3	4,956	4.7	6.2	1.2	5.3
"	3-6	⊗	1.31	.04	.031	322	132	136	51	.25	2.6	1.2	8,284	3.8	8.3	2.3	6.9
"	12	⊗	.35	.04	.021	10	160	95	25	.18	2.4	1.1	6,135	3.3	21	3.1	6.6
NOV. 1977	0-6	⊗	2.49	.11	.075	850	700	170	95	.32	4.4	1.6	8,600	15.0	15.0	3.5	6.5
"	0-3	⊗	3.27	.16	.047	8,100	1,365	160	100	.37	3.7	2.2	6,610	18.0	15.0	3.4	7.5
"	3-6	⊗	1.62	.08	.032	360	250	110	90	.33	4.9	0.85	12,100	9.5	14.0	4.3	6.5
"	12	⊗	0.57	.02	.018	70	500	173	70	.13	6.6	1.3	8,400	8.5	25.0	6.0	7.5

X: NO SAMPLE

⊗: NO DATA

*AVG. OF 4 SAMPLES

TABLE A-73 NORTHWEST PLOT, REED CANARY

DATE	ANALYSIS: DEPTH, in.	pH	ORGANIC CARBON (% dry wt.)	ORGANIC NITROGEN (% dry wt.)	ORGANIC PHOSPHORUS (% dry wt.)	CALCIUM (mg/kg)	MAGNESIUM (mg/kg)	POTASSIUM (mg/kg)	SODIUM (mg/kg)	CADMIUM (mg/kg)	CHROMIUM (mg/kg)	COPPER (mg/kg)	IRON (mg/kg)	LEAD (mg/kg)	MANGANESE (mg/kg)	NICKEL (mg/kg)	ZINC (mg/kg)
*AUG. 1973	0-6	⊗	⊗	⊗	⊗	15.7	101	217	37	.23	2.5	1.3	6,109	11.8	6.0	2.2	6.9
"	12	⊗	⊗	⊗	⊗	3.4	254	280	41	.25	3.8	1.4	7,859	4.6	15.6	3.8	7.9
DEC. 1975	0-6	6.5	2.41	.09	.024	828	449	269	46	.29	3.9	1.6	7,582	6.8	10	2.1	6.0
"	0-3	6.6	3.15	.11	.028	2,794	520	196	48	.29	2.9	1.9	4,460	7.8	10	1.6	6.2
"	3-6	6.6	.85	.02	.016	332	117	281	53	.28	3.6	1.2	9,362	4.0	4.9	2.0	4.4
"	6	5.8	.86	.02	.014	49	108	167	34	.24	3.5	.76	7,818	3.2	5.9	2.2	4.7
"	12	5.4	.10	.01	.013	4.4	188	168	16	.17	3.8	.96	5,346	2.6	12	2.3	4.1
"	24	4.8	⊗	⊗	.005	5.4	475	342	31	.19	4.3	1.6	4,209	3.1	22	3.7	7.4
"	36	4.8	.07	.05	.008	5.0	583	522	50	.24	5.0	2.5	7,747	4.6	29	4.7	11
"	48	4.6	.02	.06	.007	1.9	139	52	7.7	.10	1.5	.98	1,922	1.0	29	1.1	2.4
NOV. 1976	0-6	⊗	1.80	.06	.026	567	399	128	55	.26	3.0	1.3	6,260	5.0	7.9	2.2	6.7
"	0-3	⊗	2.37	.09	.027	2,334	929	179	53	.33	3.7	2.2	6,805	7.3	9.7	1.9	7.9
"	3-6	⊗	1.13	.34	.019	326	143	207	62	.22	3.1	1.2	7,102	4.0	6.5	2.8	4.9
"	12	⊗	.31	.01	.016	24	223	97	37	.18	3.2	1.3	5,281	3.3	16	3.6	5.8
Nov. 1977	0-6	⊗	.071	.03	.025	190	500	310	70	.35	8.0	1.4	11,400	11.0	26.5	5.4	8.0
"	0-3	⊗	2.60	.12	.063	1,900	2,300	380	100	.37	6.5	3.3	10,600	16.0	27.5	5.5	11.0
"	3-6	⊗	1.15	.05	.037	600	1,100	390	95	.30	7.7	2.1	10,400	11.5	25.5	5.1	9.0
"	12	⊗	0.22	.01	.014	90	525	300	60	.18	7.6	1.5	13,700	9.0	31.0	5.4	8.5

X: NO SAMPLE

⊗: NO DATA

* AVG. OF 4 SAMPLES

TABLE A-74 CONTROL PLOT, TIMOTHY

DATE	DEPTH, in.	pH	ORGANIC CARBON (% dry wt.)	ORGANIC NITROGEN (% dry wt.)	ORGANIC PHOSPHORUS (% dry wt.)	CALCIUM (mg/kg)	MAGNESIUM (mg/kg)	POTASSIUM (mg/kg)	SODIUM (mg/kg)	CADMIUM (mg/kg)	CHROMIUM (mg/kg)	COPPER (mg/kg)	IRON (mg/kg)	LEAD (mg/kg)	MANGANESE (mg/kg)	NICKEL (mg/kg)	ZINC (mg/kg)
AUG. 1973	0-6	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
"	12	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
DEC. 1975	0-6	5.5	1.62	.06	.016	422	139	99	13	.23	1.8	.89	6,252	3.9	6.4	1.7	3.8
"	0-3	6.8	2.81	.11	.025	2,671	307	99	13	.26	2.7	1.4	5,638	4.8	6.7	1.3	3.9
"	3-6	5.5	1.24	1.54	.014	84	117	101	16	.22	3.1	.92	6,754	3.7	8.8	1.9	4.7
"	6	5.1	.46	.01	.011	25	206	166	17	.22	4.4	.86	7,148	3.7	12	2.7	4.8
"	12	4.4	.19	.05	.008	6.0	366	195	18	.19	4.6	1.8	6,621	3.5	20	3.4	7.4
"	24	5.9	.14	.01	.009	3.0	388	243	16	.19	3.9	2.8	6,703	2.8	70	3.6	7.5
"	36	4.9	.06	<.01	.007	8.0	957	780	51	.25	6.6	3.9	6,562	6.3	48	7.5	17
"	48	4.9	.05	.04	.007	5.0	494	323	24	.17	3.8	2.2	3,962	3.6	32	3.4	8.8
NOV. 1976	0-6	⊗	1.60	.05	.019	586	586	159	24	.24	2.5	.86	5,250	3.8	48	1.7	4.4
"	0-3	⊗	1.70	.05	.015	2,714	987	163	26	.26	2.0	1.2	4,290	3.7	8.5	1.3	4.4
"	3-6	⊗	1.88	.07	.022	178	128	198	33	.27	2.6	1.2	8,256	4.4	2.7	2.4	5.9
"	12	⊗	.31	.01	.021	9.9	192	128	20	.20	3.1	1.3	6,011	3.6	12	3.6	6.2
Nov. 1977	0-6	⊗	1.62	.06	.016	1,950	675	100	50	.24	3.4	0.8	6.400	8.0	9.5	2.4	4.5
"	0-3	⊗	2.38	.09	.021	4,500	1,200	145	50	.32	3.5	1.3	6.350	9.0	12.0	2.6	5.0
"	3-6	⊗	0.91	.04	.023	375	275	185	50	.20	4.9	0.85	8.400	7.5	10.5	4.0	5.0
"	12	⊗	0.27	.02	.026	7.0	350	178	50	.17	6.0	1.5	9,800	7.0	24.5	5.7	6.5

X : NO SAMPLE
⊗ : NO DATA

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

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16. ABSTRACT

A rapidly increasing population on maritime Cape Cod has generated considerable interest in alternative wastewater disposal techniques which promise to maintain high groundwater quality and promote its conservation. Such deliberations, five years ago, led the authors to undertake an assessment of agricultural spray-irrigation as a potential means of lessening groundwater contamination and depletion. In the course of these studies individual components of an entire wastewater-cropping facility have been isolated and subjected to detailed examination. Experimental emphasis has been placed on variations in the rates and methods of wastewater application and in the types of renovation agricultural crops placed under wastewater irrigation.

Results from these studies have been highly promising and suggest that under ideal circumstances, the coupling of secondary domestic effluent to animal forage crops can bring about a degree of wastewater renovation which exceeds direct disposal to sand filter beds and approaches the goals of tertiary treatments. Moreover, three desirable consequences, i.e., water conservation, crop irrigation and nourishment and wastewater renovation are simultaneously achievable.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Land use, water quality	Slow rate land treatment	43F
Sewage treatment	Sewage effluents	91A
Trace elements	Spray irrigation	68D
Nutrient removal	Secondary pre-treatment (wastewater)	
Water reclamation		
Groundwater recharge		

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